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

3–7 December 2012

ICES Headquarters, Copenhagen, Denmark

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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Executive summary

The Working Group of International Pelagic Surveys (WGIPS) met at ICES Headquarters, Copenhagen, Denmark from 1–7 December 2012 under the chairmanship of Karl-Johan Stæhr, Denmark and Ciaran O'Donnell, Ireland: to report on herring larvae surveys in 2012 and to coordinate herring larvae survey activities for 2013 in the North Sea, Irish Sea and Western Baltic; to report on acoustic surveys in 2012 and to coordinate acoustic survey activities for 2013 on herring, blue whiting, sprat, mackerel and boarfish in the Northeast Atlantic, North Sea and Western Baltic.

This meeting was the first meeting of the new WGIPS where all surveys reported and coordinated by the two old working groups WGIPS and WGNAPES were handled within one WG. 14 persons from nine countries participated in the meeting.

Review of larvae surveys in 2012 and coordination of larvae survey in 2013. 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 2013.

Reporting on survey results from 2012 and coordination of surveys in 2013 for herring larvae in North Sea, Irish Sea and Western Baltic are given in Section 3 of this report.

Review of acoustic surveys in 2012 and coordination of acoustic surveys in 2013. During the meeting 4 internationally coordinated acoustic surveys and 5 individual acoustic surveys were reported to assessment groups for 2012 surveys. Furthermore planning for 2013 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 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 2012 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 2012 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 June-July 2012 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, lumpfish and marine mammals collected during the survey was reported.

Western Baltic Acoustic Survey This is a survey conducted by Germany in October 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. As the survey ended late October 2012 abundance estimates were not available for this meeting. 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 2011 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 2012 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 2012 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 2012. The survey provides abundance data on pelagic species in the area such as herring, sardine, anchovy, mackerel and boarfish. As the survey ended November 2012 abundance estimates were not available for this meeting. The survey has been reported in Section 4.3.5 of this report.

Coordination of acoustic surveys in 2013. Coordination of the 4 internationally coordinated acoustic surveys and 5 individual acoustic surveys are given in Section 4.2 and Section 4.3 of this report.

During this meeting of WGIPS the survey manual for acoustic surveys have been revised and the new acoustic survey protocol is given in Annex 7.

1 Opening of the meeting

The new Working Group for International Pelagic Surveys met in Copenhagen, Denmark from 3–7 December 2012 to:

a) Combine the 2012 survey data to provide indices of abundance for the populations of herring, sprat and blue whiting within the area, using the FishFrameAcoustics database and WGNAPES database;

b) Review the 2012 survey data and provide the following data for the Herring Assessment Working Group (HAWG) and Working Group for Widely Distributed Stocks (WGWIDE):

- i) Stock indices of blue whiting, sprat, Norwegian spring-spawning herring, North Sea autumn-spawning herring and Western Baltic spring-spawning herring,
- ii) Zooplankton biomass to allow the calculation of a short-term projection of Norwegian spring-spawning herring growth,
- iii) Hydrographic and zooplankton conditions for ecological considerations in the Norwegian sea,
- iv) Spatial distribution of pelagic species such as mackerel in the Norwegian Sea.

c) Coordinate the timing, area and effort allocation and methodologies for acoustic and larvae surveys on pelagic resources in the North Sea, Malin Shelf, Western Baltic and Northeast Atlantic in 2012 including:

- i) The herring larval surveys in the North Sea and the Channel,
- ii) The international acoustic survey covering the main spawning grounds of blue whiting in March-April 2013,
- iii) The international coordinated survey on Norwegian spring-spawning herring in May-June 2013,
- iv) The international coordinated acoustic survey in the Skagerrak and Kattegat, the North Sea, west of Scotland and the Malin Shelf area in June-July 2013.

d) Examine the interpretation of echograms between the participants of the 2012 acoustic surveys to ensure quality control and proper exchange of experience;

e) Review the progress of FishFrame and WGNAPES databases;

f) Review survey manual

g) Review and consider the incorporation of new models of depth based target strength for Atlantic herring, herring in the North Sea, the Malin Shelf and IIIa;

h) Delivery of the following information to assessment working groups in 2013:

- i) Proportion of fish larger than the mean size of first sexual maturation,
- ii) Mean maximum length of fish found in research vessel surveys,
- iii) 95th percentile of the fish length distribution observed.

The information should be provided for all major fish stocks covered by the survey.

i) Ensure that the most recent version of the survey manual is submitted to the Series of ICES Survey Protocols (SISP).

WGIPS will report by 11 January 2013 (via SSGESST) for the attention of the 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
Norbert Rohlf	common member	Germany
Susan Mærsk Lusseau	common member	UK
Eric Armstrong	common member	UK
Cecilie Kvamme	common member	Norway
Jens Christian Holst**	chair invited	Norway
Sascha Fässler	common member	Netherlands
Sven Gastauer	common member	Netherlands
Pieter-Jan Schon*	common member	UK
Mathieu Lundy	chair invited	UK
Gudmundur J Oskarsson*	common member	Iceland
Alexander Krysov	common member	Russia

***by correspondence.**

**** part time.**

3 Herring larvae surveys

3.1 Review of larvae surveys in 2012

3.1.1 Western Baltic

The inshore waters of Strelasund/Greifswalder Bodden (ICES Area 24) are considered the main spawning area of Western Baltic spring-spawning (WBSS) herring. The German 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 frame work 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 "FK Clupea" a grid including 35 stations is sampled weekly using ichthyoplankton-gear (Bongo-net) during the main recruitment period from March to June. The weekly assessment of the entire sampling area is conducted within two days. The data collected provide an important baseline for detailed investigation of spawning- and recruitment ecology of WBSS herring stocks. As a fishery-independent indicator of stock development, the recruitment index is then incorporated into the HAWG advice.

The baseline of the N-20 recruitment index is built by strong correlations found among the amount of 20 mm (TL) herring larvae in the Greifswalder Bodden and monitoring data on subadult abundance (1wr and 2wr year-classes) received by acoustic surveys in Arkona - and Belt Sea.

The strong correlations point on the underlying hypothesis that the majority of natural mortality occurs before larvae reach a total length of 20 mm supporting the validity of the index. The N-20 recruitment index is calculated every year based on data received by 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 week of the survey 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. The sum of 20 mm larvae caught over the investigation period in the entire area results in the N20 recruitment index for those herring that will most probably return to their spawning grounds two or three years later.

Calculation procedures have been reviewed and re-established in recent years and the recalculated index for the time-series from 1991 onwards was used by HAWG since 2008 as the only 0-group recruitment index for the assessment of Western Baltic Spring-spawning herring.

The larvae survey was conducted from late February through the end of June over a 16 weeks period. On 26 April the new vessel FFS Clupea replaced the retired ship FFK Clupea and the weekly survey period was extended for two weeks of parallel ichthyoplankton fishery investigating potential effects of individual vessels on catch efficiency. This survey resulted in no significant differences of larval numbers due to the change of vessels (working document in preparation). The recruitment index cannot yet be derived since data validation procedures will not be accomplished until early January 2013.

An additional herring larvae survey (RAWS) was conducted in early-November (5th-13th) to monitor any potentially existing autumn spawning activity as it is documented to represent the historically dominant spawning season, for unknown reasons of minor relevance today. The definite results on larval numbers cannot yet be demonstrated since sample processing is ongoing. However, early life stage larvae were found during the survey (in comparably small numbers). Additionally, spawning herring (maturity stage 5/6/7) was observed in Greifswald Bay during gillnet sampling additionally conducted simultaneously to ichthyoplankton sampling.

3.1.2 North Sea

The total area included in the International herring larvae surveys in the North Sea is divided into 4 subareas corresponding to the main spawning grounds. These subareas have to be sampled in different given time intervals. The sampling grid is standardized and stations are approximately 10 nautical miles apart. The standard gear is a GULF III or GULF VII sampler. 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 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 unit and provide the larval abundance per unit for a given time interval.

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

During the period 2011/12, they plan to cover in total six units and time periods out of ten, as given below.

Table 3.1.2.1. Areas and time periods covered during the 2011/2012 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

The herring larvae sampling period is still in progress during the WGIPS meeting. For most of the 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 larvae survey results. Figure 3.1.2.1 shows the herring larvae distribution resulting from the German survey in the Orkney/Shetland area in the second half of September 2012.

However, as in previous years, 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 2013.

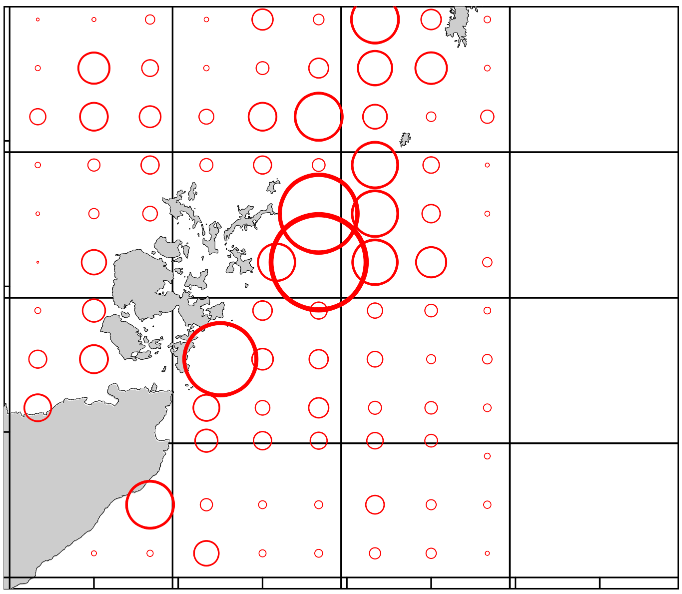


Figure 3.1.2.1. Herring larvae abundance (numbers per square metre, left panel), as obtained from the survey in the Orkney/Shetland area in the second half of September 2012. Symbol size in left panel is proportional to square root scaling (maximum value = 10 000 n/m²).

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.

Results for the 2012 Irish Sea herring larvae survey indicate a similar distribution pattern to previous years, with greatest abundance of herring larvae to the east and north of the Isle of Man (Figure 3.1.3.1). Few larvae were caught along the eastern Irish coastline despite evidence from fishing samples of herring spawning in the area. The point estimate of production in the north eastern Irish Sea for 2012 (1.12 x 1013 larvae) was the highest in the time-series (Figure 3.1.3.2). Many larger larvae (>15mm) were observed in the samples in 2012, suggesting a higher survival rate compared to recent years. 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). Results and analysis of the 2011 Irish Sea herring larvae survey are presented in Annex 6b.

The 2013 survey is scheduled to take place 4–10 November.

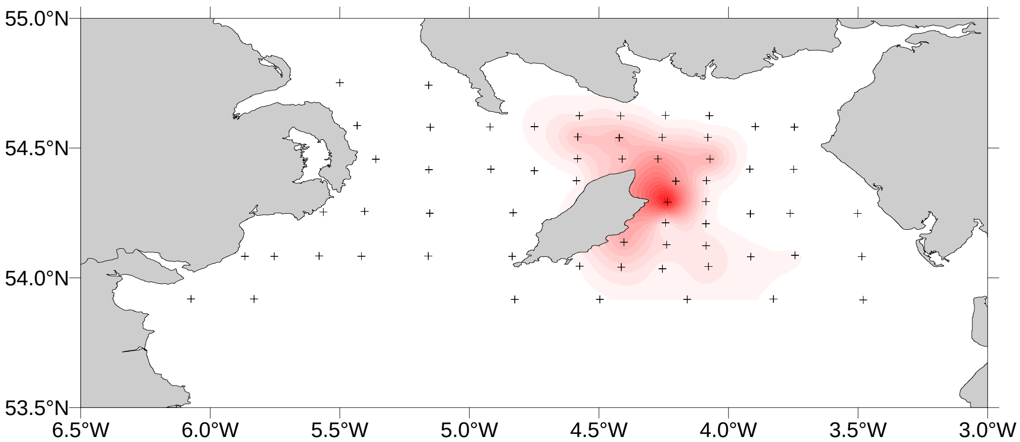


Figure 3.1.3.1. Estimates of larval herring abundance in the Northern Irish Sea in 2012. Crosses indicate sampling stations. Intensity of shading is proportional to larva abundance (maximum = 446.7 per m²).

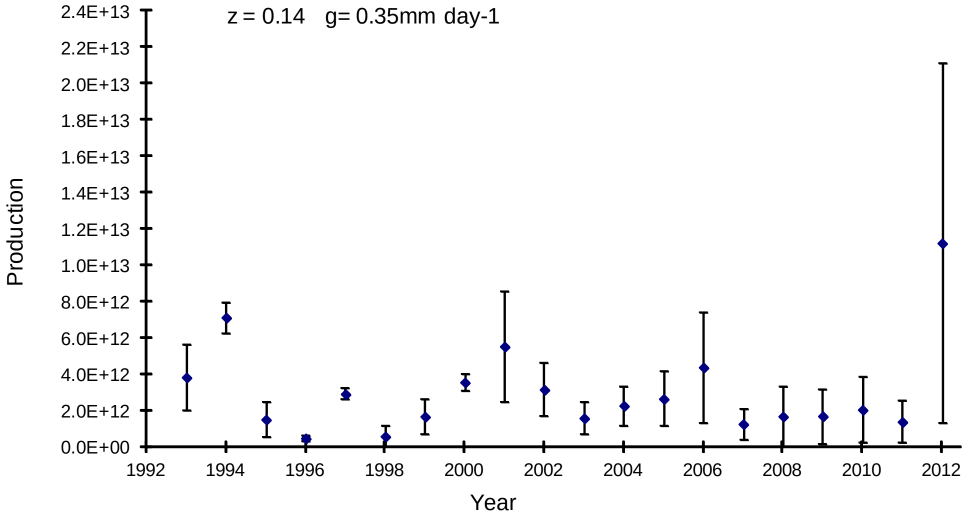


Figure 3.1.3.2. Estimates of larval herring production in the NE Irish Sea from 1993 to 2012. Error bars denote 1 standard error (calculated from coefficients of variation of the estimates of abundance, but not including uncertainty in growth or mortality).

3.2 Coordination of larvae surveys in the North Sea in 2013

At present for the larvae surveys in the North Sea only the participation of the Netherlands and Germany is confirmed in the upcoming period. Due to available ship time, none of the areas will be covered in the first half of September. 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 coverage of the last time window 1–15 October will not be possible in any of the areas. The whole spawning activity of Downs herring will be monitored in three surveys from the middle of December 2013 to the end of January 2014. A preliminary timetable for the next sampling period is presented as follows:

Table 3.2.1. Areas and time periods for the 2013 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

3.3 Incorporation of the IHLS time-series into ICES DATRAS database

During the WGIPS 2010 it was concluded to upload the IHLS database into the DATRAS system. Meanwhile the development of an egg and larvae database was finalised and the IHLS database was submitted to ICES DATRAS in June 2012.

4 Acoustic surveys

4.1 Combined estimates of the international acoustic surveys in 2012

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 surveys, attached as Annex 5c. The combined survey results provide spatial distributions of herring abundance by number and biomass at age by statistical rectangle; and distributions of mean weight and fraction mature at age.

The Norwegian part of the survey failed to cover 6 of the 39 squares allocated (Figure 4.1.1.1). One of these uncovered squares (46F5) was interpolated from estimates in neighbouring squares. The remaining 5 squares were on the outer edge of the survey area and did not have enough surveyed neighbouring squares to allow interpolation. It must be emphasized that the interpolation process reduces the quality of the estimate, and the participants are asked to ensure that coverage of the agreed survey areas, as shown in Table 4.2.1.1 is completed as far as possible.

Herring

The estimate of the North Sea autumn spawning herring spawning stock at 2.3 million tonnes is slightly lower (6.7%) than the previous year (2.4 million tonnes), and 12.668 million herring (12.03 million in 2011). The 2008 and 2009 year-classes seem to be strong and still persistent in this year's estimate.

The estimates of Western Baltic spring-spawning herring SSB were 97 000 tonnes and 777 million herring, which is lower than last year's low estimate (125 000 tonnes and 983 million herring). The stock is dominated by 1 and 2 ring and, to a lesser extent, 3 ring fish. The abundances of 1 ringers decreased by a factor of 3 when compared to last years' estimate.

The West of Scotland estimates of SSB are 375 000 tonnes and 1 964 million herring. This was lower than observed in 2011 and is more in line with 2010 estimates. 3 and 4 winter ring fish dominate the age composition of the standing stock and immature fish were better represented than in 2011.

This is the fifth year of the synoptic coverage by the Malin Shelf survey. The SSB estimate for the Malin Shelf area (divisions VIaN-S and VIIb,c) was 427 000 tonnes and 2 321 million fish. The estimate is dominated by 3 and 4 winter rings. The contribution of immature fish to total abundance was considerably higher than observed in 2011.

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

Sprat in the North Sea and Division IIIa

Sprat data were available from RV "Solea", RV "Tridens", and RV "Dana". RV Scotia observed a few specimens in one haul at the southern border of their survey area, whereas RV "Johan Hjort" observed no sprat in the northeastern North Sea. In the 2012 acoustic surveys, sprat were concentrated in the southern part of the North Sea, with the highest abundances and biomass in an area between 2° and 9° E and between 53° and 54.5° N. The survey area this year reached the southern limit (52° N), as opposed to last year. 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. The sprat distribution in the North Sea in terms of abundance and biomass is shown in Figure 4.1.1.2.

The total abundance of North Sea sprat in 2012 was estimated to be 45,466 million individuals and the biomass 408,859 tonnes (Table 4.1.1.5). This is a decrease of about 8% in terms of biomass when compared to last year (ICES, 2012). It is higher than the average for the period. In terms of abundance, it is the fourth highest estimate (Table 4.1.1.6). The amount of immature and mature sprat is about the same. The sprat stock is dominated by 1- and 2-year old fish representing 76% of the biomass.

An age-disaggregated time-series of North Sea sprat abundance and biomass (ICES area IVa-c), as obtained from the acoustic survey, is given in Table 4.1.1.6. Note that for 2003, information on sprat distribution is available from one nation only. This year, immature 0-group sprat data were delivered in FishFrame (NL). This probably reflects maturity staging problems, and all 0-group sprat were thus defined as immature as mature 0-group sprat is unlikely.

In Division IIIa, sprat was found in both the Skagerrak and Kattegat area. Last year sprat were abundant only in Kattegat. The abundance was estimated to be 1,902 mill individuals, a 21% increase compared to 1,574 million individuals in 2011 (Table 4.1.1.7). The biomass was estimated to be 37,596 tonnes, an increase of about 37%. Most sprat were 3+ group (78%), and all were mature. The sprat samples in this area are too few to estimate length- and weight-at-age split by immature and mature.

Abundance, biomass, mean length and mean weight per age and strata are given in Table 4.1.1.7.

Table 4.1.1.1. Total numbers (millions of fish) and biomass (thousands of tonnes) of North Sea autumn spawning herring in the area surveyed in the acoustic surveys July 2012, with mean weights and mean lengths by age ring.

Age (ring)	Numbers	Biomass	Maturity	weight(g)	Length (cm)
0	2936	16	0.00	5.3	9.2
1	7437	357	0.00	48.1	18.3
2	4719	588	0.91	124.7	23.9
3	4067	782	0.99	192.4	27.3
4	1738	340	1.00	195.4	27.7
5	1209	256	1.00	211.6	28.4
6	593	137	1.00	231.5	29.2
7	247	60	1.00	241.9	29.6
8	218	52	1.00	239.0	29.6
9+	478	116	1.00	242.8	29.7
Immature	10973	435		39.6	15.9
Mature	12668	2269		179.1	26.8
Total	23641	2704	0.54	114.38	21.77

Table 4.1.1.2. Total numbers (millions of fish) and biomass (thousands of tonnes) of Western Baltic spring-spawning herring in the area surveyed in the acoustic surveys July 2012, with mean weights, mean length and fraction mature by age ring.

Age (ring)	Numbers	Biomass	Maturity	weight(g)	Length (cm)
0	1	0	0.00	3.0	8.5
1	1018	44	0.00	42.9	18.2
2	1081	87	0.37	80.4	21.7
3	236	26	0.72	110.6	24.0
4	87	12	0.85	142.9	26.2
5	76	13	1.00	170.8	27.5
6	33	6	1.00	182.0	28.4
7	14	3	1.00	194.0	29.3
8	20	4	1.00	207.9	29.6
9+	40	10	1.00	239.0	30.5
Immature	1828	107		58.7	19.2
Mature	777	97		124.9	25.7
Total	2605	204	0.30	78.48	21.18

Table 4.1.1.3. Total numbers (millions) and biomass (thousands of tonnes) of autumn spawning of West of Scotland herring in the area surveyed in the acoustic surveys July 2012, with mean weights, mean lengths and fraction mature by age ring.

Age (ring)	Numbers	Biomass	Maturity	weight(g)	Length (cm)
0	0	0	0.00	0.0	
1	792	52	0.00	65.9	19.5
2	179	27	0.85	150.1	25.0
3	729	133	1.00	182.8	27.0
4	471	89	1.00	188.8	27.7
5	241	50	1.00	205.9	28.4
6	107	23	1.00	216.4	29.2
7	107	23	1.00	213.5	29.3
8	56	12	1.00	217.9	29.2
9+	105	22	1.00	214.4	29.3
Immature	824	57		68.9	19.7
Mature	1964	375		190.9	27.7
Total	2788	432	0.70	154.84	25.29

Table 4.1.1.4. Total numbers (millions) and biomass (thousands of tonnes) of Malin Shelf herring (VIaN-S, VIIb,c) June/July 2012, with mean weights, mean lengths and fraction mature by age ring.

Age (ring)	Numbers	Biomass	Maturity	weight(g)	Length (cm)
0					
1	796	53	0.00	66.8	19.6
2	548	72	0.66	132.1	24.2
3	832	149	0.99	178.8	26.9
4	517	97	1.00	187.8	27.6
5	249	51	1.00	205.2	28.4
6	115	25	1.00	214.4	29.1
7	111	24	1.00	213.0	29.3
8	57	12	1.00	217.7	29.1
9+	105	22	1.00	214.4	29.3
Immature	1009	79		77.9	20.0
Mature	2321	427		184.0	27.5
Total	3330	506	0.70	151.86	25.20

Table 4.1.1.5. Sprat in the North Sea. Abundance, biomass, mean weight and mean length by age and maturity from the summer 2012 North Sea acoustic survey.

Age	Abundance (million)	Biomass (1000 t)	Mean weight (g)	Mean length (cm)
0i	7,807.2	27.5	3.5	7.2
1i	11,632.1	68.3	5.9	9.3
1m	10,280.3	108.7	10.6	11.1
2i	1,889.8	19.7	10.4	11.4
2m	10,651.5	130.1	12.2	11.3
3m	3,023.1	50.8	16.8	13.2
4m	181.7	3.8	20.9	14.4
5m	0.2	0.0	12.8	14.3
Immature	21,329.1	115.4	5.4	8.7
Mature	24,136.8	293.4	12.2	11.4
Total	45,465.8	408.9	9.0	10.2

Table 4.1.1.6. Time-series of sprat abundance and biomass (ICES areas IVa-c) as obtained from the summer North Sea acoustic survey. 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
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 4.1.1.7. Sprat in Division IIIa: Abundance, biomass, mean weight and length by age and maturity from the summer 2012 North Sea acoustic survey.

Age	Abundance (million)	Biomass (tonnes)	mean weight (g)	mean length (cm)
0i	0.3	0	1.5	6.5
1i	121.5	1,156	9.5	10.2
1m	2.4	17	9.5	10.2
2i	252.4	4,380	17.4	12.8
2m	37.7	651	17.4	12.8
3m+	1488.0	31,392	21.1	13.8
Immature	374.2	5536	14.8	11.9
Mature	1528.2	32,060	21.0	13.7
Total	1902.4	37,596	19.8	13.4

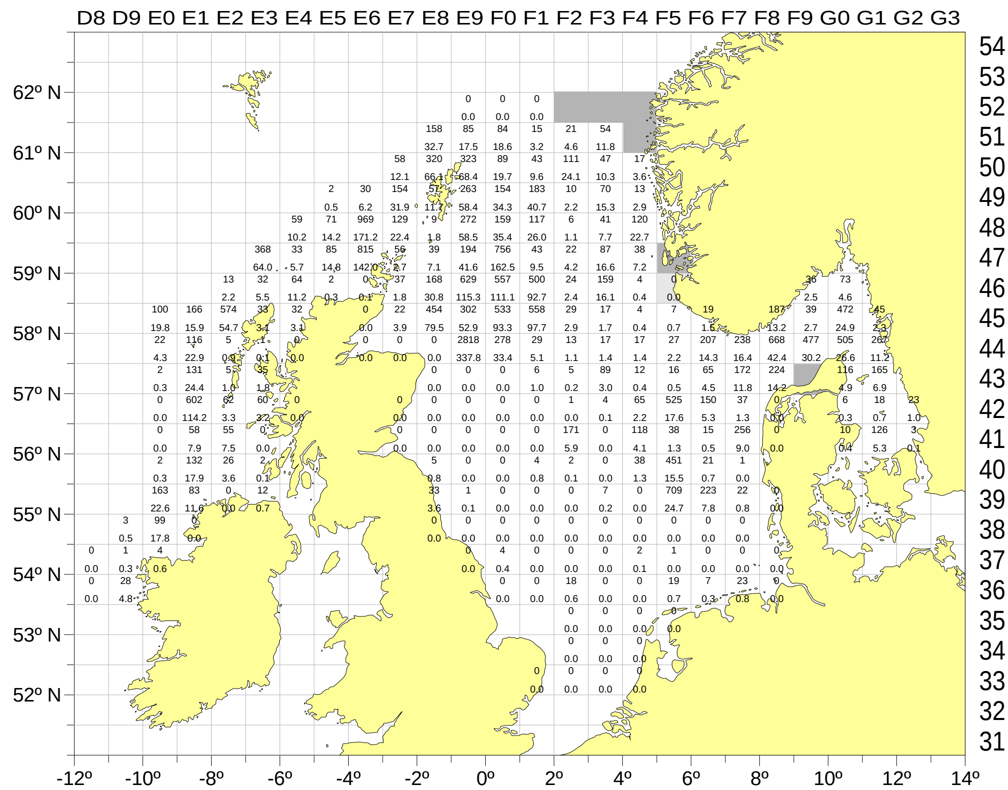


Figure 4.1.1.1. Abundance of autumn spawning herring (winter ring 1–9+) from the combined acoustic survey in June-July 2012. Numbers (millions, upper figure) and biomass (thousands of tonnes, lower figure). Dark grey rectangles were not surveyed. Light grey rectangles were interpolated.

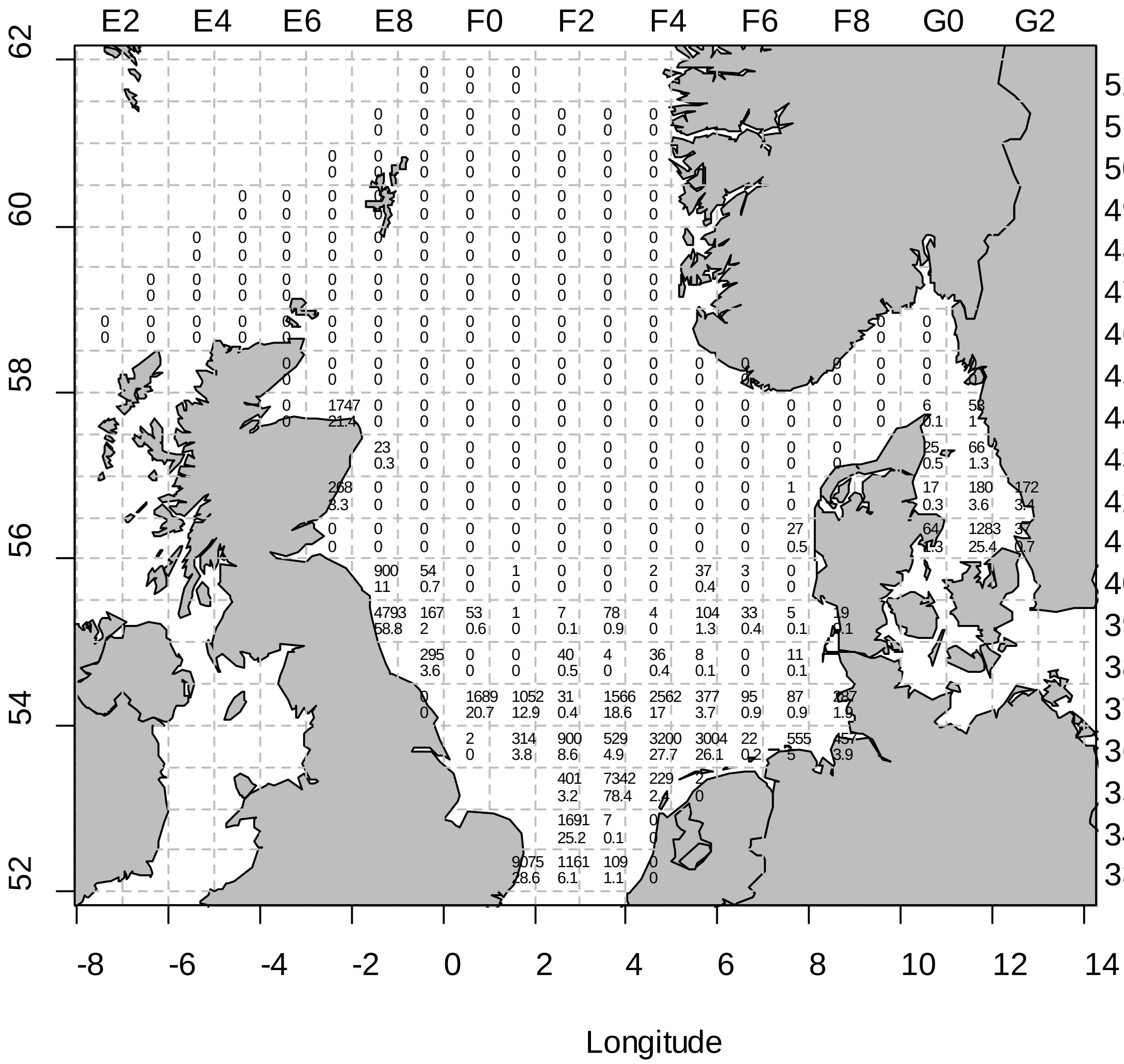


Figure 4.1.1.2. North Sea Sprat. Abundance (upper figure, in millions) and biomass (lower figure, in 1000 t) per statistical rectangle as obtained by the acoustic survey 2012. Blank rectangles are not sampled.

4.1.2 International blue whiting spawning stock survey (IBWSS)

Coordination of the survey was initiated in the meeting of the Working Group on Northeast Atlantic Pelagic Ecosystem Surveys (WGNAPES, ICES, 2011) and continued by correspondence until the start of the survey. The 2012 survey was designed in a way to allocate maximum effort in the area that contained the majority of blue whiting concentrations over the past 4 years (subarea III, Hebrides). 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 favourable weather conditions throughout the survey period and full vessel availability, the survey resulted in 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 2 weeks. 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 2012 international survey was 2.22 million tonnes, representing an abundance of 18.2x109 individuals (Figure 4.1.2.1, Tables 4.1.2.1). Spawning stock was estimated at 2.12 million tonnes and 16.5x109 individuals. Compared with the 2011 survey estimate, there is a significant increase (+38%) in the observed stock biomass and a related increase in stock numbers (+50%; Figure 4.1.2.2).

The Hebrides core area was found to contain 71% of the total biomass observed during the survey and is consistent with but slightly lower than, the result of last year's survey (76% in 2011 relative to total-stock biomass for that year). The Faroes/Shetland and north Porcupine areas ranked second and third highest contributing 16% and 11% to the total respectively. The breakdown of blue whiting biomass estimated by the survey by subarea is shown in Table 4.1.2.3.

Stock distribution

Unlike in the previous year's survey, the Rockall subarea was covered in 2012. However, observed densities of blue whiting in that area were low. Blue whiting were recorded in all areas surveyed. In total 8,629 nm (nautical miles) of survey transects were completed. The total area of all the sub-survey areas covered was 88,746 nm^2 (Figure 4.1.2.1, Tables 4.1.2.1 & 4.1.2.3).

Compared to the combined survey in 2011, the survey coverage was up by 29% overall. The majority of this increase was attributed to coverage of the Rockall area and an increase in the Faroese area. The S. Porcupine area saw an increase in coverage by 28% and the Hebrides area were covered in the same extent as the year before.

The highest concentrations of blue whiting were recorded in the Hebrides core area which remains consistent with the results from previous surveys (Figure 4.1.2.1, Table 4.1.2.2). Overall the bulk of the stock was centred in the core area as in 2012 (Table 4.1.2.2 and 4.1.2.3). Medium and high density registrations were concentrated along the shelf slope. Medium to high density were distributed almost entirely within a narrowband running close the shelf edge.

Stock composition

Individuals of ages 1 to 13 years were observed during the survey. The stock biomass within the survey area was dominated by age classes 3, 7, 8 and 6 of the 2009, 2005, 2004 and 2006 year-classes respectively (Table 4.1.2.4), contributing over 65% of spawning-stock biomass.

The Hebrides area remains the most productive in the current survey time-series and has consistently contributed over 50% to the total SSB. The age profiles of the other subareas were additionally represented by younger age classes (3, 2 and 1-year old). The Faroe/Shetland and Porcupine subareas were strongly dominated by 1–3 year old fish.

Young blue whiting were represented to various extents in all subareas in 2012. Maturity analysis of survey samples indicate that 25% of 1-year old, 59% of 2-year old and 97% of 3-year old fish were mature as compared to the 2011 estimates, where 8%

of 1-year old fish, 22% of 2-year old fish and 84% of 3-year old fish were considered mature (Table 4.1.2.4).

From the survey data, the Faroese/Shetland subarea was found to contain significant proportions of young blue whiting (1–3 years). They represented 75% (275,000t) of the total biomass and 86% (3199 million individuals) of the total abundance in that area.

Overall, immature blue whiting from the estimate represented less than 3% (65,000t) of the total biomass and less than 10% (1732 million) of the total abundance recorded during the survey (Table 4.1.2.3).

For the full post cruise report for International blue whiting spawning stock survey (IBWSS) see Annex 5a.

Table 4.1.2.1. Temporal trends in abundance and biomass of blue whiting estimated by the IB-WSS.

		2004	2005	2006	2007	2008	2009	2010	2011	2012	Change from 2011 (%)
Biomass	Total	3.6	2.6	3.4	3.6	2.6	2	1.3	1.6	2.2	38%
(mill. t)	Mature	3.6	2.4	3.3	3.6	2.6	2	1.3	1.5	2.2	47%
Numbers	Total	41.9	29	34.7	33.5	22.1	15.2	9.3	12.1	18.2	50%
(10^9)	Mature	39.2	26.7	33.8	32.9	21.7	15.0	8.9	9.7	16.5	70%
Survey area (nm^2)		149,000	172,000	170,000	135,000	127,000	133,900	109,320	68,851	88,746	29%

Table 4.1.2.2. Differences in blue whiting biomass by survey subarea estimated by the IBWSS in 2011 and 2012.

		Biomass (million tonnes)				
		2011		2012		
	Sub-area		% of total		% of total	Change (%)
I	S. Porcupine Bank	0.01	1	0.01	1	0%
II	N. Porcupine Bank	0.08	5	0.25	11	213%
III	Hebrides	1.20	76	1.58	71	32%
IV	Faroes/Shetland	0.28	18	0.37	16	32%
V	Rockall	-	-	0.01	0	NA

Table 4.1.2.3. Assessment factors of blue whiting for different survey subareas covered by the IBWSS in 2012.

	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	5,483	0.11	0.13	85	0.012	0.013	92	98.5	26.3	2.4
II	N. Porcupine Bank	20,242	2.22	2.63	84	0.239	0.254	94	96.6	26.1	12.5
III	Hebrides	35,894	10.96	11.66	94	1.554	1.576	99	135	29.4	43.9
IV	Faroes/Shetland	19,467	3.10	3.71	84	0.338	0.365	93	98.3	24.7	18.7
V	Rockall	7,660	0.08	0.08	100	0.011	0.011	100	138.3	30.0	1.4
Tot.		88,746	16.47	18.21	90	2.154	2.219	97	121.8	28	25.0

Table 4.1.2.4. Blue whiting maturity fraction, mean weight, abundance and biomass by length and age estimated by the IBWSS in 2012.

Length	Age in years (year class)										Numbers	Biomass	Mean weight	Prop. mature*
	1	2	3	4	5	6	7	8	9	10+				
(cm)	2011	2010	2009	2008	2007	2006	2005	2004	2003		(*10^{-6})	(10^6 kg)	(g)	(%)
11.0 – 12.0											0			
12.0 – 13.0											0			
13.0 – 14.0	9	0	0	0	0	0	0	0	0	0	9	0.1	12	0
14.0 – 15.0	6	5	0	0	0	0	0	0	0	0	11	0.2	15	0
15.0 – 16.0	65	19	5	0	0	0	0	0	0	0	89	2	22	4
16.0 – 17.0	90	88	27	0	0	0	0	0	0	0	205	4.9	24	12
17.0 – 18.0	226	141	21	0	0	0	0	0	0	0	388	11.1	29	17
18.0 – 19.0	298	121	54	0	0	0	0	0	0	0	473	16.1	34	9
19.0 – 20.0	182	197	23	0	0	0	0	0	0	0	402	15.9	40	22
20.0 – 21.0	150	129	13	7	0	0	0	0	0	0	299	14	47	37
21.0 – 22.0	73	90	31	4	0	0	0	0	0	0	198	11.1	56	67
22.0 – 23.0	46	116	65	0	0	0	0	0	0	0	227	14.9	66	92
23.0 – 24.0	26	263	398	29	3	0	0	0	0	0	719	55.3	77	94
24.0 – 25.0	7	254	1186	67	3	0	0	0	0	0	1517	124.2	82	98
25.0 – 26.0	0	205	1867	39	0	0	0	6	0	0	2117	187.2	88	99
26.0 – 27.0	0	106	1459	97	6	0	0	0	0	0	1668	158.7	95	100
27.0 – 28.0	0	75	943	178	15	7	7	0	0	0	1225	128.8	105	100
28.0 – 29.0	0	17	482	227	44	20	0	8	0	0	798	92.4	116	100
29.0 – 30.0	0	6	72	223	60	74	131	54	23	22	665	90.6	136	100
30.0 – 31.0	0	0	23	78	162	261	225	102	90	91	1032	152.6	148	100
31.0 – 32.0	0	0	3	35	109	319	449	305	242	135	1597	251.9	158	100
32.0 – 33.0	0	0	6	23	99	301	481	275	209	164	1558	266.7	172	100
33.0 – 34.0	0	0	0	6	18	214	333	296	230	182	1279	237	185	100
34.0 – 35.0	0	0	0	0	16	90	255	142	131	173	807	162.7	201	100
35.0 – 36.0	0	0	0	0	0	22	112	163	96	104	497	109.2	220	100
36.0 – 37.0	0	0	0	0	9	20	76	50	24	71	250	60.2	240	100
37.0 – 38.0	0	0	0	0	0	9	8	16	24	42	99	25.5	257	100
38.0 – 39.0	0	0	0	0	0	6	0	24	7	7	44	12.6	287	100
39.0 – 40.0	0	0	0	0	0	0	0	3	0	22	25	7.9	323	100
40.0 – 41.0	0	0	0	0	0	0	0	0	2	5	7	2.3	342	100
41.0 – 42.0	0	0	0	0	0	0	0	0	0	4	4	1.6	376	100
42.0 – 43.0	0	0	0	0	0	0	0	0	0	0	0	0	.	100
43.0 – 44.0	0	0	0	0	0	0	0	0	0	3	3	1.5	434	100
44.0 – 45.0														
TSN (10^6)	1178	1832	6678	1013	544	1343	2077	1444	1078	1025	18212	2219		
TSB (10^6 kg)	45.9	121.4	606.9	117.9	82.1	226.7	364.1	262.3	194.5	197.1	2219			
Mean length (cm)	18.8	22.2	25.8	28.1	30.9	32.1	32.6	33	33	34				
Mean weight (g)	39	66.3	90.9	116.4	150.9	168.4	175.5	181.7	180.4	210				
Condition (g/dm^3)														
% mature*	25	59	97	99	100	100	100	100	100	100				

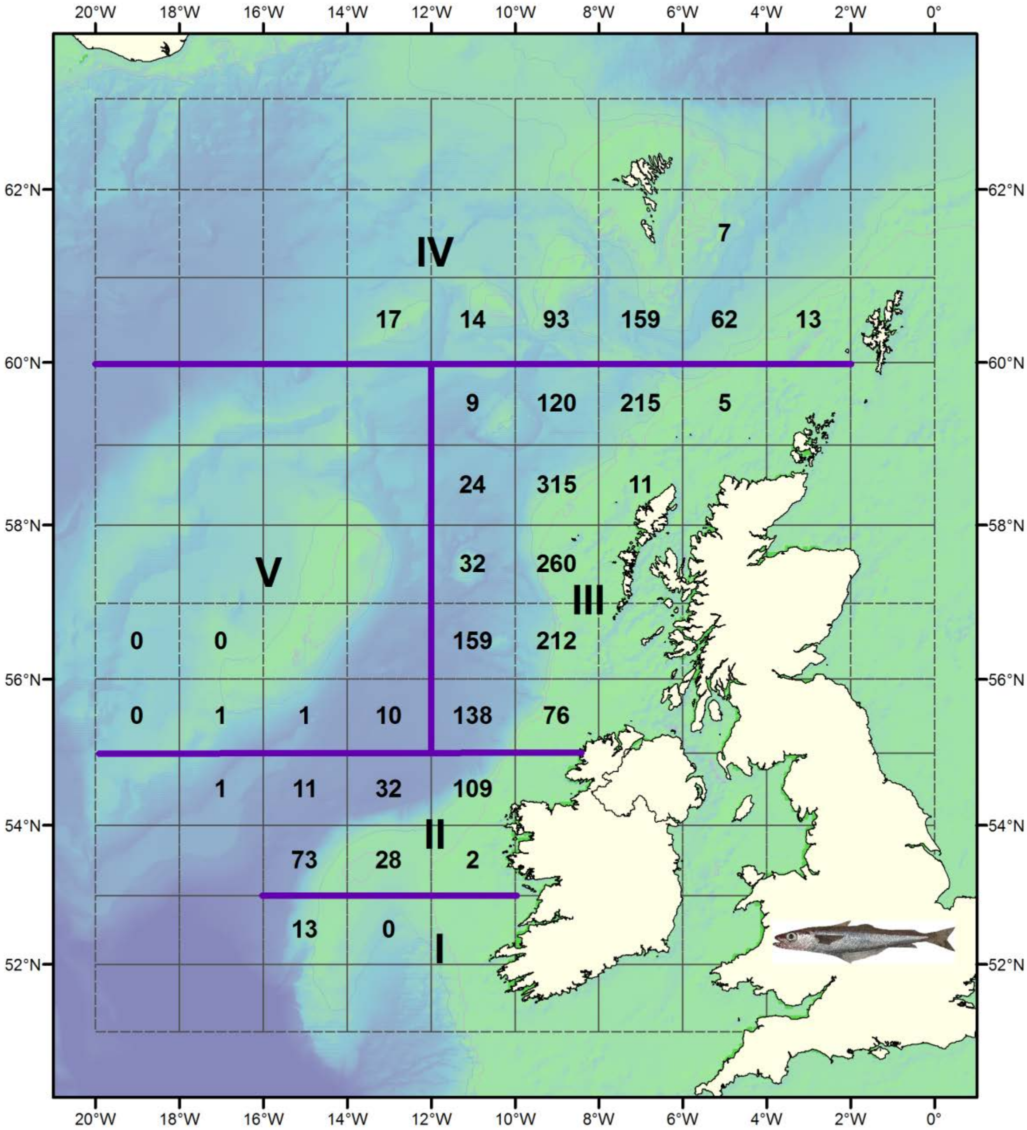


Figure 4.1.2.1. Blue whiting biomass (x1000 tonnes) by survey subareas estimated by the IBWSS in 2012.

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 2012 is given as Annex 5b in this report.

Hydrography:

In May, during IESNS, the temperatures at the surface ranged between < 1°C in the western part and > 8°C in the southern part of the survey area.

The Arctic front was encountered slightly below 65°N east of Iceland extending eastwards towards the 0° meridian, where it turned almost straight northwards to 70°N. The front was visible throughout the observed water column but was most pronounced at greater depths. With depth, temperatures decreased to values < 0°C particularly north and west of the Arctic front because here it is located in Arctic water masses while south and east of the front the temperature drop was not as pronounced as it is more influenced by Atlantic water masses.

The warmer North Atlantic water formed a broad tongue that stretched far northwards along the Norwegian coast with temperatures > 6 °C in the surface layers.

Relative to an 18 years long-term mean, from 1995 to 2012, the temperatures at 100 m depth southeast of Iceland and north of the Faroese were considerable lower in May 2012 compared to the long-term mean. There, the anomalies were in some areas less than -1°C. Northeast of Iceland the temperature anomalies were, however, above 1°C. In contrast to 2012 the temperatures at 100 m depth for 2011 were close to the long-term-mean for nearly the whole area. Thus, the temperature difference at 100 m depth between the years 2012 and 2011 had approximately the same pattern as the temperature anomaly for 2012; negative anomalies in a band southeast of Iceland and positive anomalies northeast of Iceland.

Plankton:

Sampling stations in May 2012 (IESNS) were relatively evenly spread over the area, and most oceanographic regions were covered. The zooplankton biomass was relatively uniform over the whole area and still at low level even if it is higher than the lowest recorded value in the time-series in 2009 (Figure 16, Annex 5b).

Recorded zooplankton biomass in the two areas west and east of 2°W equalled 4.7 and 6.7 g dry weight m-2, while total mean was 5.9 g dry weight m^{-2}.

The zooplankton biomass in the Barents Sea was low in all areas, with mean biomass of 1.7 dry weight m^{-2}.

Norwegian Spring-spawning herring:

Survey coverage in the Norwegian Sea was considered adequate in 2012 and in line with previous years. The herring in 2012 was found in the highest concentrations in two distinct areas, in the southeastern part of the Norwegian Sea and in the western part. The third main concentration was in the north (70°N and 15°E) and consisted mainly of 2 and 3 year old herring. Overall the herring density was relatively low and herring was never observed in big schools. In the western part it was mainly found at 100–400m depth, even if shallower registrations existed, but generally shallower in the eastern part. There were some differences in the herring distribution this year compared to 2011, even if the areas with herring registrations were more or less the same. Compared to the southeast and westerly main distribution in 2012, the herring was more concentrated in the central part of the Norwegian Sea in 2011 and with the highest acoustic values recorded there.

In 2012, like in 2011, almost no herring were observed north of 70ºN, while it was found further north in 2010. Because of this, the center of gravity of the acoustic recordings shifted in a southeasterly direction compared to 2011 (Figure 18, IESNS survey report 2012).

The herring stock is now dominated by 8 year old herring (2004 year-class) in numbers but 6, 7, 9 and 8 year old herring (the 2006, 2005, 2003 and 2002 year-classes) are also numerous (Table 2, Annex 5b). The 2009 year-class appears to be largest of the younger age groups even if it is relatively small in historical perspective. The five year-classes from 2002 to 2006 contribute 14%, 12%, 26%, 13% and 10%, respectively, of the total biomass.

The total biomass estimate of herring from the 2012 survey came to 4.6 million tons. This estimate is 1.8 million tons lower than in 2011. The biomass estimates in recent four years has fluctuated, or 10.7 million tons in 2009, 5.8 million tons in 2010, 7.4 million tons in 2011 and now 4.6 million tons. The uncertainty, or the CV, of the estimates is unknown, but might be considerable considering the recent fluctuations, even if the downward trend in the biomass is apparent.

Herring was only observed in the western most part of the Barents Sea. The total abundance estimates were low, at 370 millions of age 1 (mean length of 17.4 cm and mean weight of 32.8 g) and 120 millions of age 2 herring (mean length of 23.5 cm and mean weight of 83.0 g). Older herring was not observed there.

The total number of herring recorded in the Norwegian Sea in May 2012 was 12.8 billion in the northeastern area and 7.2 billion in the southwestern area, compared to 22.7 billion and 7.9 billion in last year, respectively.

Thus the reduction in the abundance estimate compare to 2011 is apparently mainly in the northeastern area, or 44% compare to 9% in the southwestern area.

Blue Whiting:

The total biomass of blue whiting registered during the May 2012 survey was 0.87 million tons, which is three times the biomass estimate in 2011 when accounting for the new TS used in this year's survey.

The total biomass estimate is now comparable to the 2007 estimate. The stock estimate in number for 2012 is 15.7 billion, which is more than five times the 2011 estimate and more than 28 times the 2010 estimate.

The main reason for an increased estimate of blue whiting is the high estimate of 1 year old, which came to 11.1 billions individuals. The number of other recruits was 3.2 billions of 2 year olds, and 0.5 billions of 3 year olds. These three year-classes constituted to 94% of the total number and 76% of the total biomass.

Such high values of recruits have not been seen since the survey in 2006 which had similar values when considering the changes in the TS (i.e. around 3.3 times the current values corresponds to the old value).

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" showed that the blue whiting there was dominated by fish at age 1 but also considerable amount of age 2. Blue whiting were observed both in connection with the continental slopes of Norway and south and southwest Iceland and in the in the open sea in the southern part of the Norwegian Sea. It should be noted that the spatial survey design was not intended to cover the whole blue whiting stock during this period.

Mackerel:

In later years an increasing amount of mackerel has been observed in the Norwegian Sea during the combined survey in May targeting herring and blue whiting. The edge of the distribution has also been found progressively further north and west. In 2012 the mackerel was mainly found in the eastern part of the survey area up to 68°N. In the western part, or west of 0°E, it was only observed in two trawl hauls and not in the northwestern part of the survey area as in 2011. This changed distribution in May relative to last year is probably caused by the relatively cold temperature in the southwestern part of the area.

Workshop:

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 scruitinization are following the same general procedure. The workshop should preferably take place during the autumn/winter 2012/2013, or prior to the surveys in 2013.

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

The full post-cruise report from the Coordinated Nordic Seas ecosystem survey (IESSNS) in July-August in 2012 is given as Annex 5d in this report

Hydrography:

In the July-August 2012 (IESSNS), the temperature in the upper layers (10m and 20m) showed warm-water of Atlantic origin covering most of the survey area. The temperature was highest southwest of Iceland where it reached 13°C, and in the southeastern Norwegian Sea where it was 12°C.

The front between the cold East Iceland Current (EIC) and the warmer Atlantic water (the Iceland-Faroe Front, IFF) which usually is located in the southwestern Norwegian Sea, was clearly visible in these layers. The warm Atlantic water extended north beyond the 70 degrees in the eastern Norwegian Sea, as well as north of Iceland. North/northwest of Iceland the temperature was lower and reaching 4°C.

The temperature distribution at 50m depth was similar as the surface layers but with cooler water, especially in the southwestern Norwegian Sea, where the cold EIC and features like the IFF was clearly detected. In deeper layers below 100m the same main features were detected as described for 50m depth. South and west of Iceland, warm Atlantic water dominated the entire water column with temperature of 7–9°C at 400m depth. In the eastern Norwegian Sea warm Atlantic water was also detected down to 400m depth. The appearance of the IFF in the upper layers indicates less stratification in the surface waters in summer 2012 compared to 2011, and also weaker thermocline between 20 and 50 m depths. It seems as the surface waters in the southern Norwegian were (more than one degree) cooler in 2012 than in 2011, most likely due to the persistent northeasterly winds during most of spring and summer. This was also observed in the IESNS survey in May 2012 in the same area (see above). The surface waters southwest of Iceland seemed to be warmer in 2012, however, this difference disappeared at depths below 50–100m. In waters deeper than 100m the influence of the EIC is more pronounced and extends further south into Faroese and especially east into Norwegian waters.

Plankton:

In July-August 2012 (IESSNS), the zooplankton biomass was generally low with an average plankton biomass of 6.0 g/m2 over all stations throughout the survey area. The plankton concentrations were lowest in the central Norwegian Sea. This was a comparable pattern to what observed during the 2011 surveys. The biomass was slightly higher in the southwestern Norwegian Sea and west of Iceland in the frontal area between the warm Atlantic water and the colder Arctic water.

Herring:

The acoustic biomass estimate of NSS herring was 7.3 million tons in July-August 2012. Herring was distributed across the whole survey area except for the middle part of the Norwegian Sea. The concentrations were low in the northern and eastern areas.

The highest concentrations were in the southern areas north of the Faroes and in the western part where NSS herring extended all the way to 20°W north of Iceland and around 14°W south of Iceland. The periphery of the distribution of NSS herring towards north were probably not reached between 20°W and 8°E.

Herring was in the surface waters in most area feeding and possibly above the transducer (acoustic dead zone) and therefore poorly represented in the acoustic measurements. This could be the case for other areas as well where the herring is staying high in the water column actively.

The previous acoustic abundance estimates of NSS herring from this survey were 13.6 million tonnes in 2009 and 10.7 million tonnes in 2010 (not adequate coverage in 2011). Thus the trend in the July survey clearly follows the negative trend in the biomass estimates from the assessment.

Blue Whiting:

Acoustic estimates of blue whiting were used to construct a geographical distribution of the stock in July-August 2012. However, it must be considered that blue whiting was not the main target species in the survey so dedicated trawl samples from schools of blue whiting at greater depths than surface were very few.

The total biomass estimate of blue whiting from the acoustic survey was 766 thousand tons, whereas 43% of it was fish at age 1. Of the total number (10.7 billions), 65% were of age 1, 15% age 2 and 11% age 3.

These figures of the composition of the stock should though be taken with great caution due to low sampling effort of blue whiting in the survey. This survey confirmed the presence of immature blue whiting in the feeding areas during summer.

Mackerel:

The total swept-area estimate of mackerel in summer 2012 was 5.1 million tonnes based on a coverage of 1.5 million square kilometres in the Nordic Seas from about 61 degrees up to 70 degrees north and from the Norwegian coast in east and west to the fishery border between Iceland and Greenland. The 2006 year-class contributed to more than 20% in number followed by equally abundant 2005, 2007 and 2008-year-classes around 15% each, respectively. The 2010 year-class was very well represented in the catches, or 12% of the total number. The mackerel was distributed in most of the surveyed area, and the zero boundaries were only found in the southwestern area in the Faroe zone and in the southern Icelandic zone. In the northern area the zero boundary was not reached.

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 2012. The 2006-year-class of mackerel dominated the catches with >20% of the mackerel in numbers, followed by equally strong 2005, 2007 and 2008-year-classes around 15% each, respectively.

The 2010 year-class seems to be very strong, since it was represented with around 12% of the individual mackerel in numbers from the scientific trawl hauls from the Norwegian Sea and surrounding waters.

4.2 Coordination of international acoustic surveys in 2013

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 2012 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. However, with regard to the reduced herring stock size, the spatial fish distribution in 2013 may differ from the historical picture. Thus participants should be encouraged to adapt their survey effort, avoiding an imbalance between transect spacing and the occurrence of fish schools.

Survey effort should be allocated to 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 2013 acoustic surveys.

Vessel	Period	Area	Rectangles
Celtic Explorer (IRE)	21 June – 10 July	53°30'-58°30'N ,12°-5°W	36D8-D9, 37D8-E1, 38D9-E1, 39E0-E2, 40E0-E3, 41E0-E3, 42E0-E4, 43E0-E4, 44E0-E4, 45E0-E4
Scotia (SCO)*	30 June – 19 July	58°30'-62°N, 8°W-2°E	46E2-F1, 47E3-F1, 48E4-F1, 49E5-F1, 50E7-F1, 51E8-F1
Johan Hjort (NOR)	1 July – 30 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
Dana (DEN)	25 June – 5 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)	24 June – 19July	54°– 58°30'N, 4° W–2°/ 6°E	37E9-F1, 38E8-F1, 39E8-F1, 40E8-F5, 41E7-F5, 42E7-F1, 43E7-F1, 44E6-F1, 45E6-F1
Solea (GER)	28 June – 17 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
Corystes (NIR)	28 August -14 September	53°-55°N, 6°-3°W	35E4-E6, 36E3-E6, 37E4-E6, 38E4-E6
Celtic Explorer (IRE)	06 – 26 Oct	51°-52°30'N ,11°-6°30W	31D9-E2, 31D9-E3, 33D9, 33E2-E3,

*** Provisional survey coverage.**

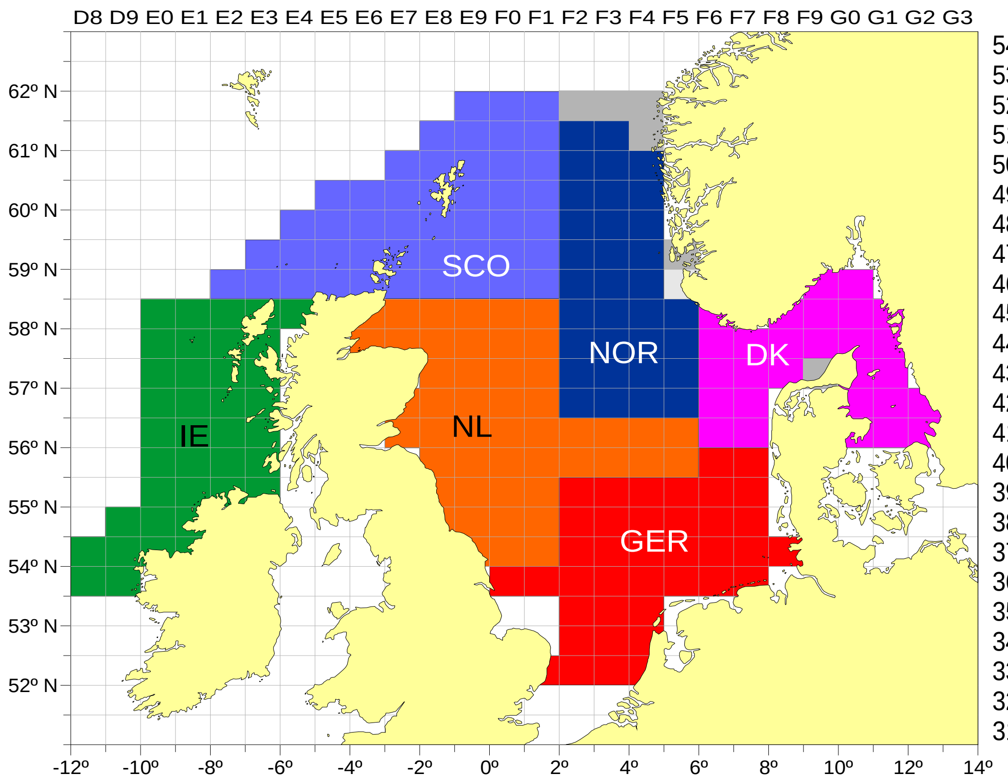


Figure 4.2.1.1. Survey area layouts for all participating vessel in the 2013 acoustic survey of the North Sea and adjacent areas. (IE = Celtic Explorer; SCO = Scotia; NOR = Johan Hjort; DK = Dana; NL = Tridens; GER = Solea).

North Sea surveys

Susan Mærsk Lusseau will be coordinator for the acoustic surveys in June-July 2013. Participants in 2013 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 2013**; 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. Susan Mærsk Lusseau **has agreed to act as coordinator during the 2013 survey.**

During the meeting WGIPS had a request from HAWG for splits between spawning components within the North Sea. The HAWG wants to be able to distinguish between the Downs winter spawning component and the autumn spawning components in the acoustic indices.

These splits between the spawning stocks are defined using known techniques based on otolith shapes calibrated to microstructure analyses of a subsample of otoliths. This methodology has been used within the Danish acoustic survey in Skagerrak and Kattegat for the last 11 years to distinguish between North Sea and Western Baltic herring in the acoustic abundances from this area.

WG members responsible for acoustic surveys in the North Sea have 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. During the spring of 2013, the survey coordinator in cooperation with HAWG and DTU-Aqua will distribute a detailed description of the sampling required. It should be done as an experiment in 2013 and 2014

As the new WGIPS has to deal with a large number of surveys and has a limited time available to achieve this, it is recommended that a two day post cruise meeting should be established, just before the WGIPS meeting in January 2014, to upload data to FishFrame and collate combined survey data. The meeting would 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. In 2013, neither the Scottish charter vessel survey (west of Scotland) nor the Northern Ireland coverage of VIaN/North Channel/Firth of Clyde will take place.

The provisional 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 2013. 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 accordingly to account for the increased area coverage in 2013 and will be confirmed during the planning phase.

WGIPS, while acknowledging the difficult economic circumstances under which these decisions on survey effort are made, strongly recommends that survey effort and intensity should be maintained in its present form.

RV Celtic Explorer and RV Scotia will continue to collect photographs and otoliths to prepare for splitting the acoustic index into VIaN and VIaS stock components. WGIPS anticipates that HAWG will be able to provide results from this exercise in March 2013.

The results from the national acoustic surveys in June-July 2013 will be collated, and the results from the entire survey combined, at the next WGIPS in January 2014. Individual national survey results for sprat and herring should be uploaded to FishFrame no later than **30 November 2013**. This early deadline is to facilitate the planned WGIPS meeting in January 2014. Additionally, participants should be prepared to deliver their remaining raw data to the stage 1 module.

4.2.2 International blue whiting spawning stock survey (IBWSS)

Five vessels representing the Faroe Islands, the Netherlands (EU-coordinated), Ireland (EU-coordinated), Norway and Russia are scheduled to participate in the 2013 spawning stock survey.

Survey timing and design were discussed during the 2012 IBWSS post-cruise meeting. The group decided that in 2013, the survey design should follow the one used during the 2012 survey. The focus will be on a good coverage of the shelf slope in areas II and III, as it is evident that the bulk of the spawning aggregation was found there during the past few years when the stock size was declining (2008–2011). On the other hand, during the first four years of the internationally coordinated survey (2004–2007), when the size of the stock was high, blue whiting aggregations were distributed more evenly over the whole survey area. The adapted survey design in 2012 attempted to take into account this shift in stock distribution. 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 7.5 nm in the core survey area (subarea III, Hebrides; Figure 4.2.2.1). From past surveys it was evident that huge areas in the west of the Rockall Trough contained, if at all, only sporadic and small blue whiting concentrations. The western borders of the transects in subarea III will therefore extend to just 11° W in order to put more effort on the continental slope. To avoid replication, transects were allocated systematically with a random start location.

The aim is to have all but the Faroese vessel start surveying in the north of subarea II (North Porcupine) at the time when the Norwegian vessel begins the survey there (27.03.2013; Table 4.2.2.1). That way, the core survey subarea III can be covered synoptically by 4 vessels with a similar temporal progression.

It was decided that the Dutch and Russian vessels would start the survey in the southern subareas I and II (Porcupine). The Irish Celtic Explorer would first cover subarea IV (on southwest Rockall Bank). 2–4 days after beginning their individual surveys, these vessels will join the Norwegian vessel surveying the north of subarea II and afterwards subarea III from the south progressing northwards. Once the Norwegian 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. Survey extension in terms of coverage (52–61° N) will be in line with the time-series 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 4 vessels covering the core Hebrides area are present on station in the north of subarea II (just north of Porcupine Bank) on 27 March 2013 (Table 4.2.2.1). Nonetheless, if some vessels are found to lack behind others, the tight 7.5 nm 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.

Preliminary cruise tracks for the 2013 survey are presented in Figure 4.2.2.1. As survey coordinator in 2013, Sascha Fässler (Netherlands) has been tasked with coordinating contact between participants prior to and during the survey. Detailed cruise lines for each ship will be circulated by the coordinator to the group as soon as final vessel availability and dates have been communicated (end of January 2013).

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 was circulated to participants at the January 2012 WGIPS meeting.

Table 4.2.2.1. Individual vessel dates for the 2013 International Blue Whiting Spawning stock Survey (IBWSS).

Ship	Nation	Active survey time (days)	Preliminary survey dates
G.O. Sars	Norway	17	27.3.2013 – 12.4.2013
Fridjof Nansen	Russia	19	23.3.2013 – 10.4.2013
Celtic Explorer	Ireland (EU)	19	23.3.2013 – 10.4.2013
Tridens	Netherlands (EU)	17	25.3.2013 – 10.4.2013
Magnus Heinason	Faroes	17	27.3.2013 – 12.4.2013

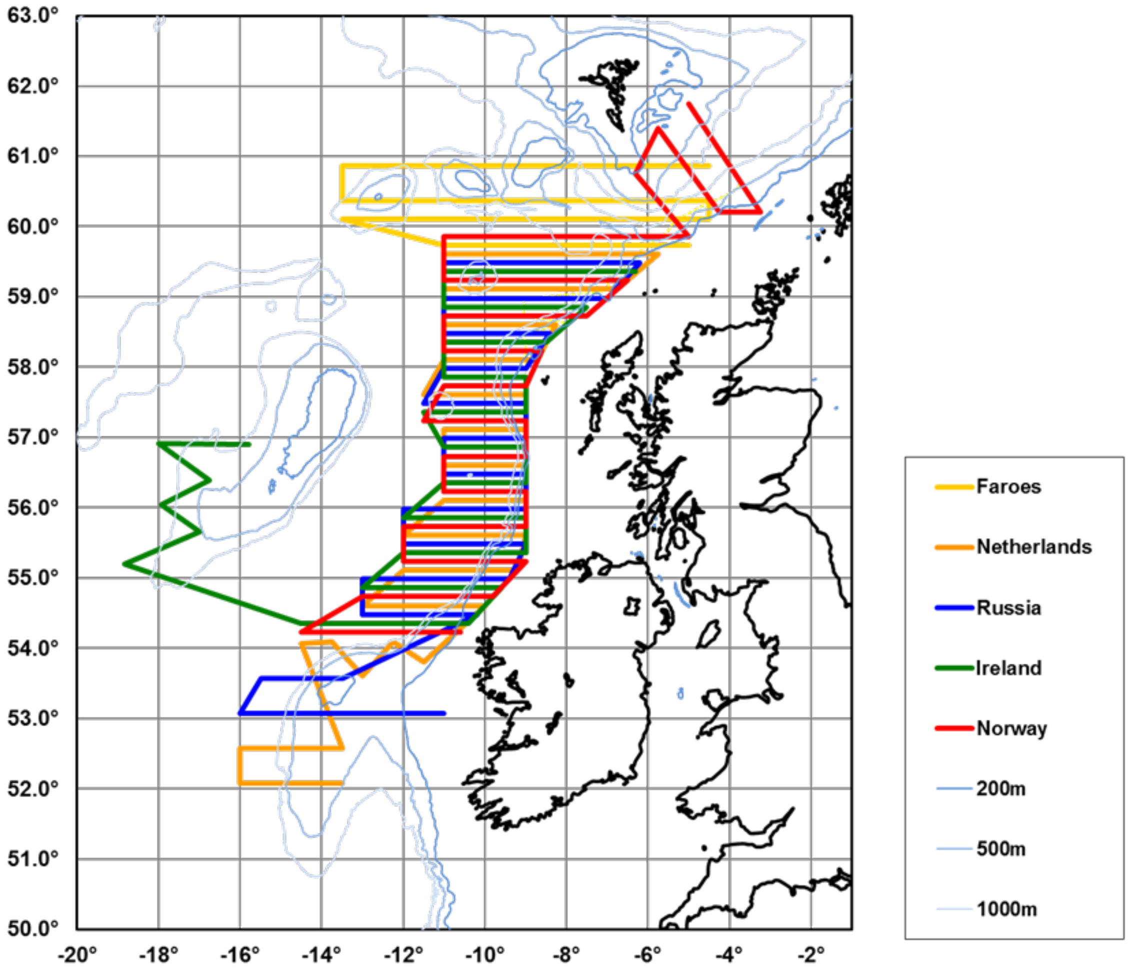


Figure 4.2.2.1. Planned survey tracks for the combined 2013 International Blue Whiting Spawning stock Survey (IBWSS).

4.2.3 International ecosystem survey in the Nordic Seas (IESNS)

It is planned that five parties; Denmark (EU-coordinator), Faroe Islands, Iceland, Russia and Norway, will contribute to the survey of pelagic fish and the environment in the Norwegian Sea and the Barents Sea in May 2013. The area covered by the international survey is divided into two standard areas defining the Norwegian Sea and one standard area defining the Barents Sea. The two subareas are limited by the 20°E north of northern Norway.

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

The following subjects should be targeted:

Herring abundance and distribution

Blue whiting abundance and distribution

Plankton abundance and distribution

Temperature and salinity

If possible the participating vessels should be rigged for surface trawling. Herring scales should be utilized for age-reading of the Norwegian spring-spawning stock, and if possible the codend of the trawls should be equipped with some device (soft liner or other method) to reduce scale losses.

Øyvind Tangen, Norway has been appointed as coordinator of the survey for 2013. Final dates and vessels shall be communicated to the coordinator no later than 15 January 2013. Each participating vessel shall also inform the coordinator on harbour for departure and embarkation together with date and harbour for eventual exchange of crew during the survey. Detailed cruise tracks for each ship will be provided by the coordinator by the end of January 2013.

A post-cruise meeting will be held in (Place to be decided) 25–27 June 2012 where the results will be analysed and a joint survey report will be compiled.

Ship	Nation	Vessel time (days)	Active survey time (days)	Preliminary dates
Johan Hjort	Norway	30	28	1/5 – 30/5
Vilnius	Russia	21	21	15/5 – 05/6
Dana	Denmark (EU)	30	26	30/4 – 29/5
Magnus Heinason	Faroes	14	12	1/5 – 15/5
Arni Fridriksson	Iceland	26	23	29/4 – 23/5

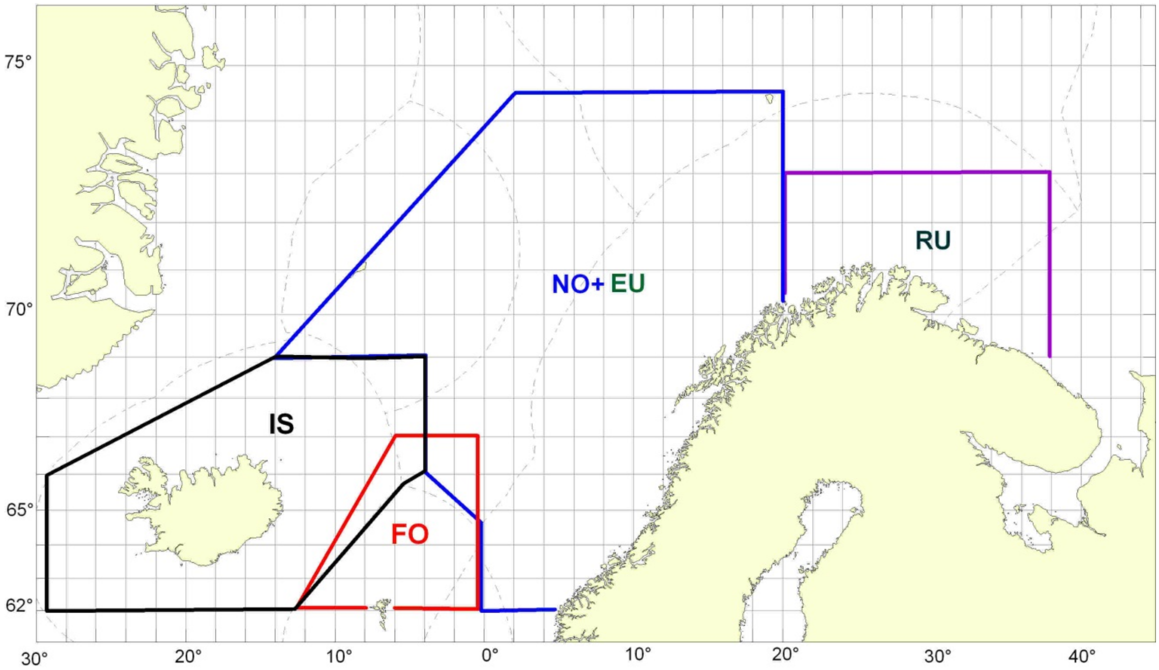


Figure 4.2.3.1. Areas to cover for each nation for the 2013 International ecosystem survey in the Nordic Seas in May.

More details of the planned survey can be found in the WGNAPES report (ICES 2011).

4.2.4 Coordinated Nordic Seas ecosystem survey (IESSNS) in July-August 2013

A list of recommendations, to the participants in the 2013 survey, was made in the 2012 IESSNS survey report. This list was made to encourage and secure further standardization among the participants in all operational aspects relevant to the survey. The agreed survey period in 2013 was preferably a five weeks period between 7 July – 15 August. The newly designed pelagic sampling trawl for scientific purposes (Multpelt 832), should continue to be used as the standard sampling trawl for pelagic fish onboard all vessels participating in IESSNS in 2013 as previously done in 2012. Standardization of the survey has not been fully reached yet, but steady progress has been made from the conducted 2012 IESSNS intercalibration procedure of trawling and acoustic instrumentation among the four vessels involved. The intercalibration involve trawling and trawl rigging, and it includes the following parameters: towing time and speed, type of trawl doors, rigging of the trawl doors, best functional warp length, sweep lines, rigging of the headlines (floats, buoys, kite) and sensors on the trawl doors and headline to measure the three-dimensional trawl geometry and codend. The plan is to address this at a formal meeting and model testing of the Multpelt 832 trawl with gear experts, scientists and skippers in Hirtshals, Denmark at the end of February 2013 well in advance of the 2013 survey. Intercalibration experiments during the 2013 survey will be prioritized for several days in order to secure that all parties use and operate the Multpelt 832 trawl in a similar manner and so that the results from the vessels are comparable across countries. This goal has not been fully reached yet, but we intend to finalize most aspects during the 2013 IESSNS survey.

The preliminary plan for the nations participating in the 2013 survey has now been announced and is as follows:

Faroe Islands

Chartered vessel: tentatively 1 - 21 July

Iceland

RV “Árni Friðriksson”: 10 July – 10 August

Norway

Chartered vessel number 1: 4 July – 5 August

Chartered vessel number 2: 4 July – 5 August

EU

Chartered vessels: July-August (to be decided later)

The plan is to extend the survey transects to reach beyond the summer distribution of the NEA mackerel. Especially we aim to also include major EU waters in the 2013 IESSNS survey for a comprehensive geographical coverage and abundance estimation of the NEA mackerel stock.

A post-cruise meeting, to analyse the results and compile a joint survey report, is planned in late August 2013, but the time and venue still need to be decided upon.

4.3 Individual acoustic surveys summary results 2012 and planning for 2013

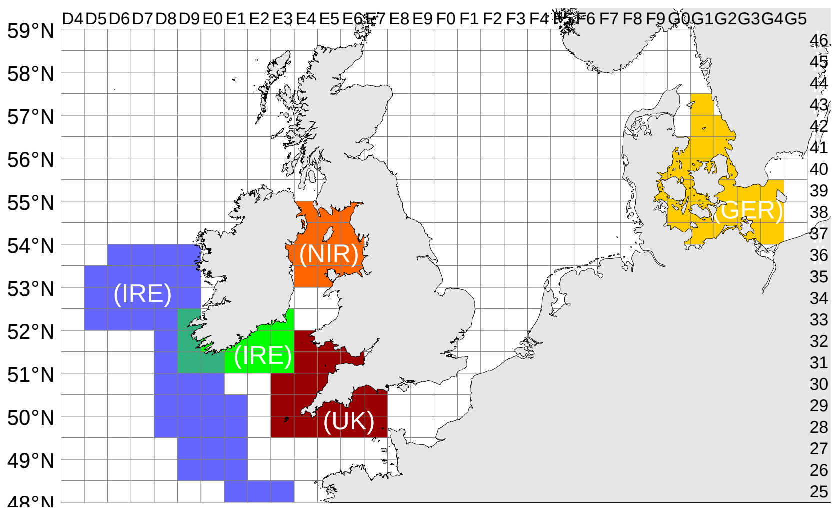


Figure 4.3.1.1. Survey coverage of acoustic surveys planned in 2013 (blue = Boarfish survey BFAS [Ireland]; green = Celtic Sea Herring Acoustic Survey CSHAS [Ireland]; orange = Irish Sea survey [Northern Ireland]; golden = Western Baltic Acoustic Surveys [Germany]; brickred = PELTIC [UK])

4.3.1 Western Baltic Acoustic survey

A joint German-Danish acoustic survey was carried out with FRV “SOLEA” during 2–21 October 2012 in the Western Baltic (Subdivisions 21–24). This survey is traditionally coordinated within the framework of the Baltic International Acoustic Survey (BIAS) to supply 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.

As in previous years, acoustic recording and trawling was in general done during the night-time. Some additional replicate transects were done during the day to reveal possible differences in small-scale clupeid distribution behaviour. These replicates indicated similar overall NASC values compared to night-time sampling.

A Simrad EK60 scientific echosounder with a hull mounted ES38B transducer was used to collect acoustic data which were then processed using Echoview software (ver. 5.3). Cruise track length during night-time recording was 1 280 nm plus 184 nm daytime replicate transects. To identify the target species and determine the length and weight distribution of fish, 56 trawl hauls were carried out. Samples of herring and sprat were frozen for subsequent analysis in the lab. After each haul and on additional stations, hydrographic measurements were taken with a CTD probe. Overall, 80 vertical profiles of temperature, salinity and oxygen concentration were measured.

The survey ended in late October and the final analysis of the hydroacoustic data will be accomplished by the end of 2012. Thus, with regard to the timing of WGIPS in December (compared to January as in previous years) it is not possible to give final estimates or a detailed survey report yet.

4.3.2 Irish Sea 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 29 August 2011 to 12 October 2011. The main results of the survey are summarized below and reported in full in Annex 6b. The survey was repeated in 2012; at present analysis of these data is ongoing.

<u>Results</u>

Sampling intensity was high during the 2011 survey with 38 successful trawls completed. In total thirty seven hauls contained herring, but only 29 hauls contained large numbers/proportions of herring. The resulting weight-length relationship for herring was calculated from the sampling information as $W = 0.00243*L^{3.390}$ (length measured in cm). The age length key used indicated that the population is composed of juveniles and adult fish (age 0–9). The estimated biomass and number of herring was 173,177 t and sprat 238,369 t. A full breakdown of biomass by strata is given in Annex 6b.4. The total number estimate comprises of ~65% age 0, ~28% age 1, ~5% age 2, ~1% age 3, <1% age 4 and ~1% age 5+.

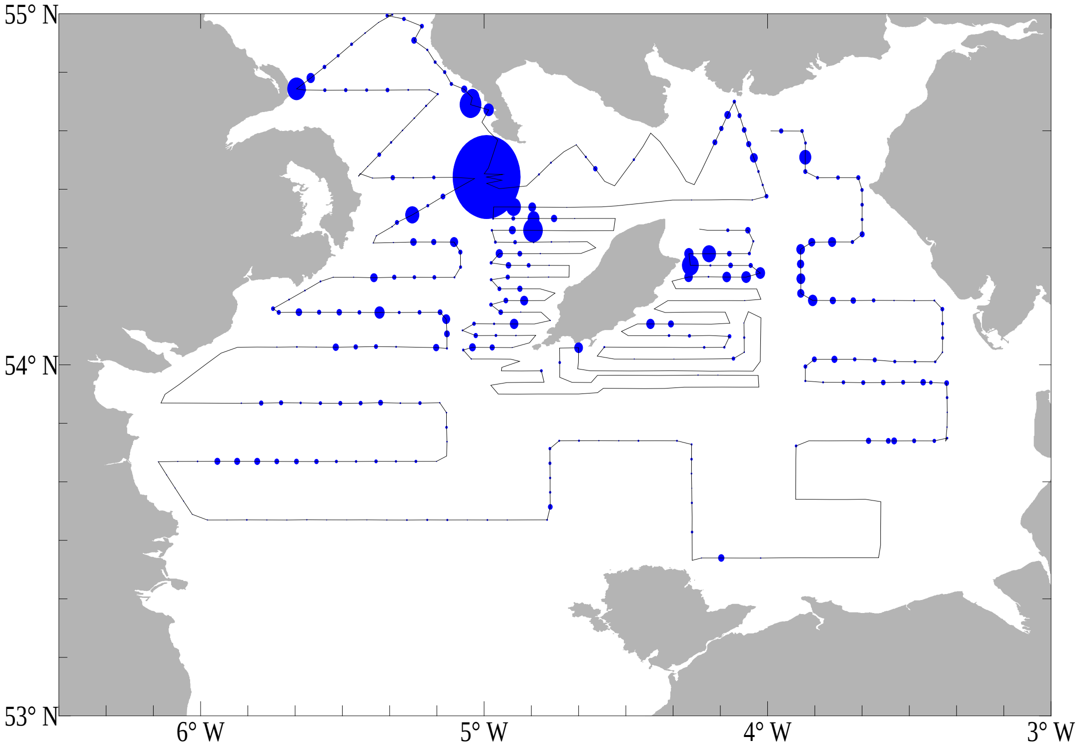


Figure 4.3.2.1. Map of the Irish Sea and North Channel with a post plot showing the distribution of NASC values for assigned herring only (size of elipses is proportional to square root of the NASC value per 15-minute interval) obtained during the 2011 acoustic survey on RV "Corystes" (maximum value was 41480).

The major contribution of ages to the total estimates is from ages 0 fish by number and age 2 by weight. The estimated total herring stock (173,177 t or 6.8 x 10^9 individuals). The largest herring aggregations were found around the Isle of Man and off the Mull of Galloway on the Scottish coast. Sprat and 0-group herring were distributed around the periphery of the Irish Sea, with the abundance of 0-group herring noticeably higher in the eastern Irish Sea compared to the previous year. The bulk of 1+ herring targets in 2011 were observed off the Mull of Galloway with a scattered lesser abundance observed throughout the Irish Sea. The length frequencies generated from trawls highlight spatial heterogeneous nature of herring age groups in the Irish Sea.

The estimate of herring SSB of 49,128 t for 2011 is a significant reduction from the 2010 estimate. This is expected considering that the timing of the survey did not coincide with the migration patterns of the spawning adult population. The biomass estimate of 131,527 t for 1+ ringers is similar to the 2010 estimate, which was the highest in the time-series. Similar to the 2007 survey, more than half of the 1+biomass estimate was to the north of the Isle of Man.

4.3.3 Celtic Sea herring acoustic survey (CSHAS)

Following the recommendation from HAWG that the acoustic survey used for tuning Celtic Sea herring stock is now coordinated by WGIPS. The survey was carried out from the 9–29 October 2012 and is reported in full in Annex 6c. The main results of the survey are summarized below.

<u>Results</u>

Twenty directed trawls were undertaken during the survey with 13 hauls containing herring and 10 of which contained >50% herring by weight of catch. A total of 546 herring were aged from survey samples in addition to 4,318 length measurements and 1,108 length-weight measurements Herring age samples ranged from 0–9 winter-rings

In total, the survey accounted for 3,402nmi; with approximately 3,100nmi of integrateable acoustic transect available for analysis.

In general, large high density herring echotraces were most abundant within 20nmi of the coast from the Helvick Head east to Waterford Harbour and in a clear band running southeast to the Smalls (Figure 4.3.3.1).

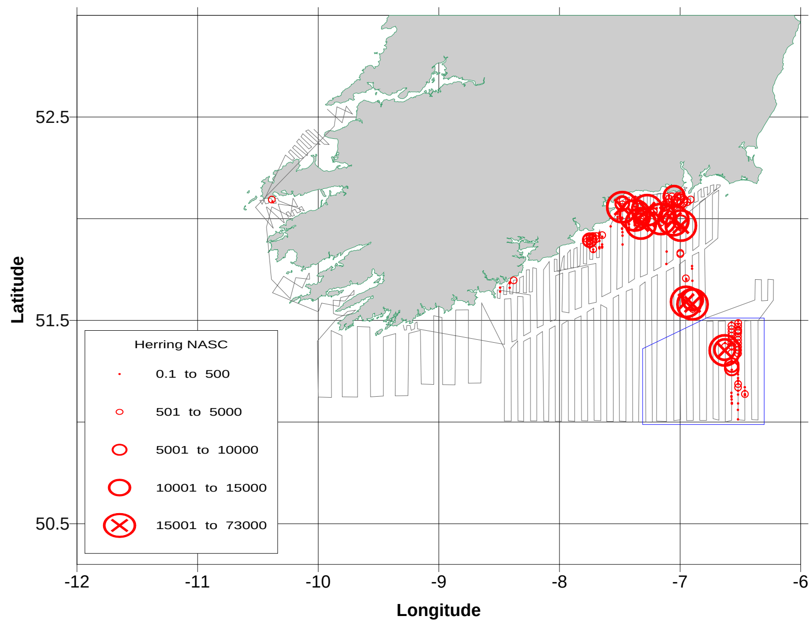


Figure 4.3.3.1. NASC plot of herring distribution in the Celtic Sea, 2012.

Herring TSB (total-stock biomass) and abundance (TSN) estimates were 269,244t (CV 25.9%) and 2,322 million individuals (CV 24.7%), respectively. The overall SSB (spawning-stock biomass) observed during the survey was 246,373t (CV 26.9%), composed of a spawning abundance (SSN) of 1,972 million individuals.

Herring of the 2 winter-ring age group dominated the survey estimate representing over 31% of TSB and 37% of TSN. The 3 winter-ring age group were ranked second representing 30% of TSB and 27% of TSN. The third most dominate age group was the 4 winter-ring group contributing 18% to the TSB and 14% to TSN.

As previous strong year-classes grow, older age classes are becoming more evident in the standing stock with age classes of 5 to 8 winter-ring groups well represented in this year's survey and contributing 14% of the total biomass (Table 4.3.3.1). Age readings of commercial landings and survey samples show close correlation. Maturity analysis indicate the majority (>91%) of the TSB as sexually mature.

The 2012 survey estimate shows an increase of 88% in terms of biomass and 79% in terms of abundance as compared to 2011. This significant increase in abundance may be related to an underestimate in 2011 combined with the continued growth of the stock. However, an underestimate of the stock in 2011 is not easily visible from survey data as both the stock and the fishery were well contained within the survey area. This stock has shown a marked change in behaviour in recent years in terms of offshore distribution and this may have affected the ability of the survey to track the stock effectively.

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

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

4.3.4 Boarfish acoustic survey (BFAS)

The second dedicated boarfish acoustic survey was carried out over 33 days in July 2012 using a commercial charter vessel the FV *Father McKee* and acoustic data collected onboard the RV *Celtic Explorer* during the Malin Shelf survey. 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 *C Explorer* to coincide with the hours of daylight when boarfish are most often observed in homogenous schools. This was a change in design from the pilot survey carried out in 2011. During the hours of darkness boarfish schools tend to disperse into mixed species scattering layers.

Surveys were timed to ensure a continuous, quasi-synoptic, coverage of the combined area over 33 days from north (59°N) to south (47°30′N). Both surveys used calibrated echosounders but no inter-vessel acoustic or fishing intercalibration exercises were carried out due to time restraints.

In total 3,921 nmi (nautical miles) of cruise track was undertaken over 61 transects relating to a total area coverage of 51,555nmi². Transect spacing was set at 15nmi for the *Father McKee* and 7.5nmi for the *Explorer* component. For the area covered by the *Explorer* only strata bordering the shelf edge were considered during the analysis.

Thirty six hauls (*Father McKee:* 29; *Explorer*: 7) were carried out during the survey 26 of which contained boarfish. In total, 5,952 lengths and 1,997 length/weight measurements were taken in addition to 897 individual boarfish otiliths collected for aging.

A total of 1,168 boarfish schools were identified during the survey (Figure 4.3.4.1).

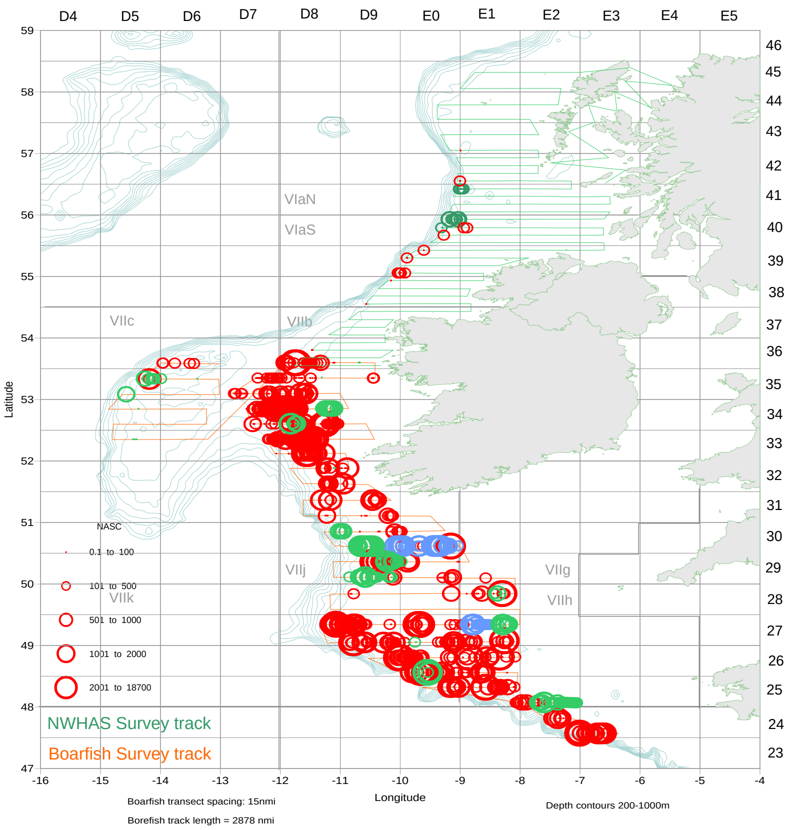


Figure 4.3.4.1. NASC plot of boarfish distribution 2012.

Boarfish TSB (total-stock biomass) and abundance (TSN) estimates were 820,935t (CV 10.7%) and 13,554 million individuals (CV 10.6%), respectively. The overall SSB (spawning-stock biomass) observed during the survey was 819,126t (CV 10.6%), composed of a spawning abundance (SSN) of 13,468 million individuals (Table 4.3.4.1).

Age distribution as determined from survey samples indicate that the stock is dominated by the following age classes in terms of abundance: 20+, 12, 10 and 9 and 13 year old fish and 20+, 12, 16 and 10 years in terms of biomass respectively. Very few immature (< 9.7 cm TL) boarfish were observed during the survey (0.2% of TSB and 0.6% of TSN).

Comprehensive trawl coverage allowed for positive identification of boarfish schools which increased the precision of the stock estimate. The increase in the number of schools observed in 2012 resulted in a lesser abundance CV of 10.6% as compared to 17.6% in 2011.

In 2012 the survey methodology was further refined by switching to daylight surveying. The switch to daylight surveying has no doubt led to an increase in school detection more so than could be attributed to year effects alone.

Table 4.3.4.1. Boarfish acoustic survey time-series. Note: 2011 pilot survey was conducted over 24hrs and 2012 survey only during daylight hours.

Years	2011	2012
0	-	-
1	4.7	20.4
2	10.7	10.2
3	51.5	165.5
4	167.3	61.6
5	384.7	90.3
6	1015.2	699.8
7	1000.1	925.8
8	601.3	721.5
9	899.4	806.8
10	790.7	908.8
11	246.8	618.8
12	434.6	1045.6
13	267.7	815
14	244.5	623.5
15	119.9	414.2
16	193.3	724.9
17	49.7	476.4
18	147.0	695.5
19	294.0	230.7
20+	855.8	3499.3
TSN (mil)	7,779	13,554
TSB ('000t)	433,584	820,935
SSB ('000t)	432,882	819,126
CV	17.6	10.6

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

An 18 day multidisciplinary pelagic survey was undertaken in the western English Channel and Eastern Celtic Sea between the 23rd of October and the 10th of November 2012 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 first 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 4 ringnets, each with different mesh. Regular cast with a Rosette/CTD were also taken to provide high resolution oceanographic data on the water column.

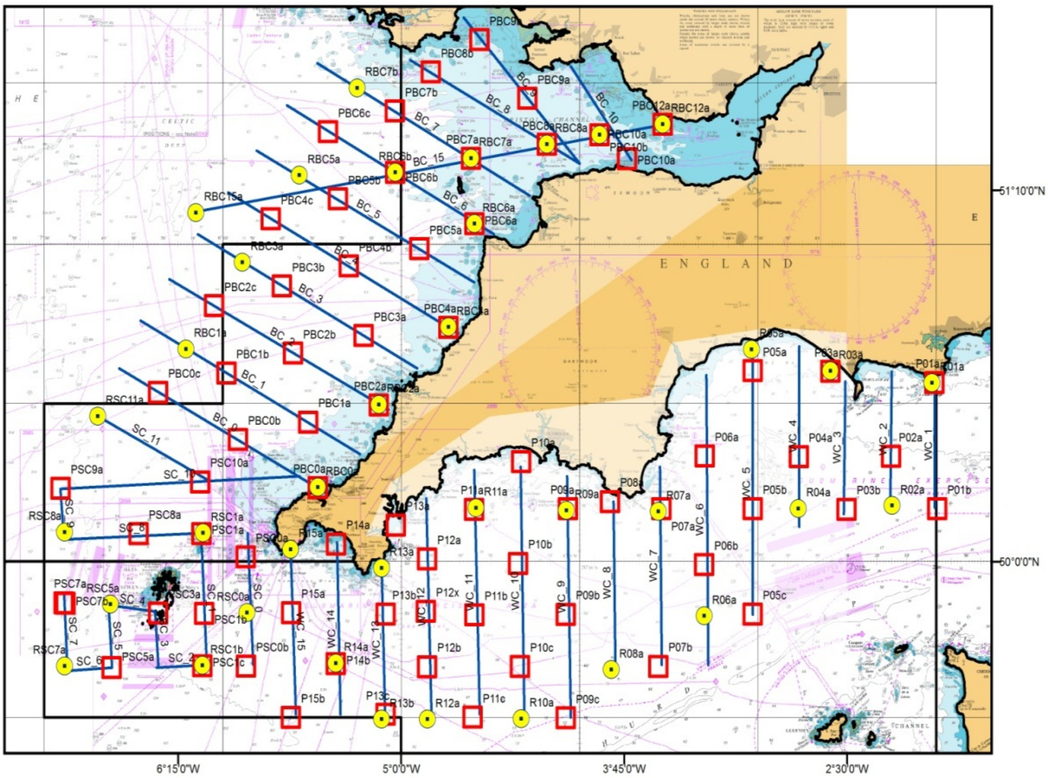


Figure 4.3.5.1. Survey design with acoustic transects (blue lines), zooplankton stations (red squares) and oceanographic stations (yellow circles).

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. The inner part of the Bristol Channel was surveyed using a zigzag transect approach to maximize area coverage. Calibrated acoustic data were collected continuously (24 hours) 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 µs for all three frequencies and the ping rate was set to 0.5 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 pending. A general description is provided here. Acoustic data were generally of very high standard despite fairly constant strong windy conditions. 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 1451 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 (*sensu* Ballon *et al*., 2011), eventually resulting in separate echograms for each of the echotypes. For mackerel a separate dedicated algorithm was used (*sensu* Korneliussen, 2010).

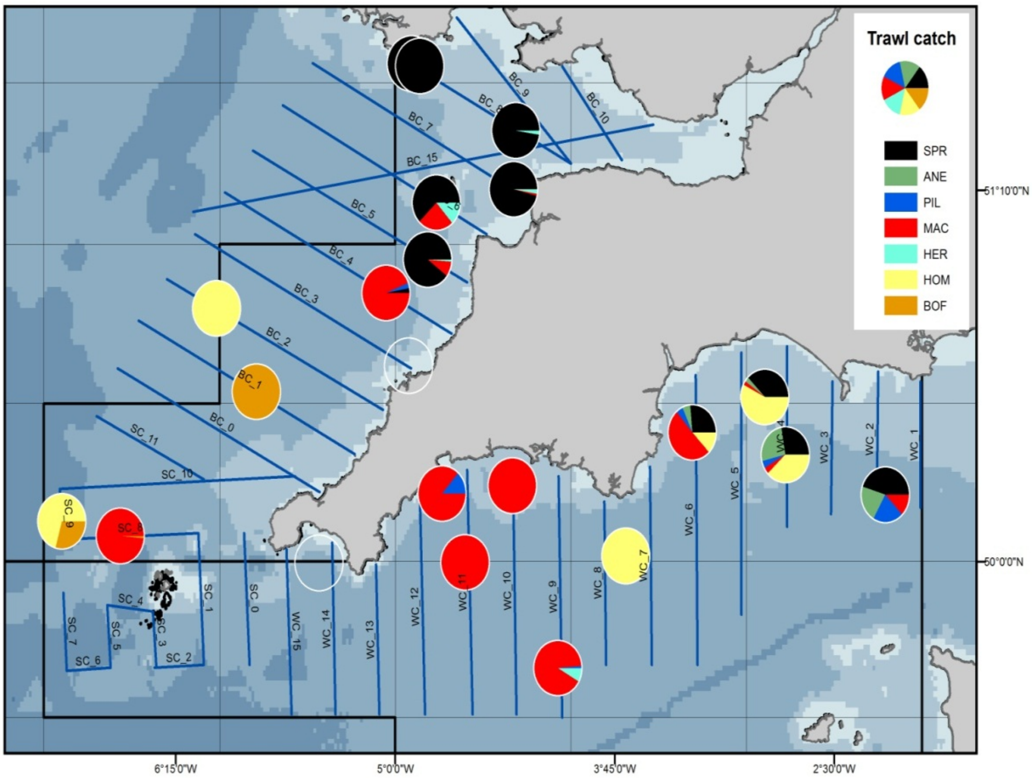


Figure 4.3.5.2. Map of the survey area. Acoustic transects (blue lines) and trawl catches (pies) with relative catch composition by key species. Three letter codes:, SPR=sprat, ANE=anchovy, PIL=sardine, MAC=mackerel, HER=herring, HOM= horse mackerel, BOF=boarfish.

A total of 22 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 and particularly in the southwestern component of the survey area, there was no opportunity to trawl for various reasons: presence of large amounts of static gear, target schools too close to the seabed, water column depth too shallow, 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. Large schools in the Bristol Channel appeared to consist mainly of juvenile sprat, whereas those in the English Channel also included larger size classes. Sardines (*Sardina pilchardus*) were caught on both sides of the Cornish Peninsula, whereas anchovy (*Engraulis encrasicolus*) was only found in the eastern part of the western Channel. Mackerel (*Scomber scombrus*), predominantly juveniles, were seen mainly in the western areas of the survey. Herring (*Clupea harengus*) was mainly found in the Bristol Channel, with the majority consisting of smaller specimens. Small numbers of predominantly older herring were caught in the western English Channel. Boarfish (*Capros aper*) was most dominant in the deeper waters (>75m) around the Isles of Scilly.

Table 4.3.1.1. Preliminary planning table for individual surveys in 2013.

Survey	Vessel	Timing 2013	Area	Rectangles
BIAS (GER)	Solea	30 September – 19 October	SD 21–24	43G1, 42G1-G2, 41G0-G2, 40F9-G2, 39F9-G4, 38G0-G4, 37G0-G4
BFAS (IRE)	Commercial charter	21 June – 10 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
Corystes (NIR)	Corystes	28 August - 14 September	53 □-55 □N 6°-3°W	35E4-E6, 36E3-E6, 37E4-E6, 38E4-E6
CSHAS (IRE)	Celtic Explorer (IRE)	06 – 26 October	51°-52°30'N ,11°-6°30W	33D9, 33E2-E3, 32D9-E3, 31D9-E2
PELTIC (UK)	Cefas Endeavour	10–29 October	49° 30–51° 45'N 7° - 2° W	28E3-E7, 29E3-E7, 30E3-E7, 31E4-E6, 32E4-E6

4.4 Delivery of information to the assessment working groups in 2012 and addressing recommendations from other groups

4.4.1 Delivery of depth stratified acoustic data into Fish Frame (stage 1 format; HAWG)

This is dependent on the future of development of FishFrame as currently there is no capacity within the database to store raw acoustic data, only aggregated data.

4.4.2 The Malin Shelf Acoustic Survey (MSHAS) delivery to the HAWG

The Malin Shelf Acoustic Survey (MSHAS) will be delivered to the HAWG in the following format as requested:

- West of Scotland (VIaN only) herring stock, acoustic tuning index.
- Malin shelf (VIaN-S, VIIb).

4.4.3 WKCATDAT 2012 table is filled in by country and survey (WGISUR).

This exercise was carried out in 2012.

4.4.4 Bird and mammal observers on surveys (WGISUR)

The provision of bird and mammal observation data from ichthyoplankton and acoustic surveys is carried out during some of the surveys that already reporting within this group already and is available within the cruise reports. Space for observers will be available on all surveys by request.

4.4.5 Adoption of new TS-length relationship for blue whiting (WKTBLUES, WGIPS)

The new blue whiting TS (Pedersen *et. al.*, 2011) has been adopted by the IBWSS and the group and applied to the survey time-series during the WKTSBLUES workshop. The survey participants have been encouraged to collect *in-situ* TS measurements during future surveys.

4.4.6 Delivery of sprat survey indices from the Celtic Seas ecoregion (HAWG)

The provision of these data are being investigated by the Marine Institute (Ireland) but will not be available for 2012. Data has been historically provided for sprat as aggregated biomass and abundance.

4.4.7 Request for data North Sea horse mackerel (WGWIDE)

Only small amounts of horse mackerel are currently encountered in the WGIPS coordinated surveys. These surveys are not really designed to cover typical areas and times where horse mackerel are aggregated. However, technically it would be possible to survey horse mackerel with the currently used standard acoustic survey approaches (e.g. like during the PELGAS survey in the Bay of Biscay). If there is a need for it, a new survey would have to be set up to specifically target the areas (English Channel/Celtic Sea) where horse mackerel are distributed in Q4.

4.4.8 Nordic deep-water surveys sampling protocol (WGNEACS)

The standardization of all WGIPS-coordinated sampling protocols, with particular focus on echogram scrutinisation, will be dealt with in a future workshop.

The time of the IBWSS survey is slightly too early to encounter the core aggregations of greater silver smelt. Acoustic data collected by IMARES from a Dutch pelagic freezer trawler fishing on silver smelt showed that they were distributed in the northern region (Faroe/Shetland region) in the second half of April. As greater silver smelt are possibly also extended further north, they are spatially and temporally not fully contained by the combined IBWSS survey coverage. However, there is the technical capacity and possibility to report on greater silver smelt encountered by the IBWSS if deemed necessary – however, it has to be emphasized again that their whole distribution area is currently not fully covered. A quick WGNAPES database enquiry shows that so far greater silver smelt was only encountered by the Faroese vessel during the 2008 IBWSS.

4.4.9 Calculation of sampling variance from survey data (WGMG)

The current structure of FishFrame does not allow for the submission of raw data, only aggregated data. To that end it is not possible for variance to be calculated for survey reporting to the group.

4.4.10 Delivery of MFSD ecosystem indicators from survey data (ToR h)

Data collected during research vessel surveys are focused primarily on single species and not fish communities within the geographical area(s) covered. The ecosystem indicator data requested are relevant only when taken in the context of fish communities and not at the single-stock level. Each of the requirements is discussed below;

i) Proportion of fish larger than the mean size of first sexual maturation

As no growth data is available at species level particular to the stocks surveyed it is not possible to report these data at this time. Metrics addressing a Probabilistic Maturation Reaction Norm Indicators (PMNRI) would need to be determined at stock level prior to providing an accurate indicator.

ii) Mean maximum length of fish found in research vessel surveys

It is understood that this is an indicator for the scope for growth of a species within a community. As survey data reports for single species only this does not account for multiple species interactions within communities. This indicator was not deemed relevant to single species survey data.

iii) 95th % percentile of the fish length distribution observed

Length frequency distribution at the 95^{th} % percentile determined by stock is in theory available from research survey data. However, historically and currently the data are only provided to WGIPS from the national laboratories aggregated by age and maturity, not by length.

WGIPS does not think it would be appropriate to calculate the 95% percentile of the fish length distribution based directly on the average fish length distributions observed in individual trawl catches.

WGIPS suggests that national acoustically derived abundances should be requested disaggregated only by length for each strata/stock unit surveyed by each nation. These abundances at length should then be combined following the procedure used to produce the age and maturity disaggregated abundances for each stock and the resulting estimated combined length distribution for each stock used to provide the 95% percentile of the fish length distribution for each species. WGIPS would like to seek clarification if this is deemed an appropriate way to produce the information requested before proceeding to request this additional level of information from all survey participants.

Target species from coordinated surveys include; herring, sprat, mackerel, blue whiting and boarfish.

5 Review and update of the WGIPS survey manual

The WGIPS manual for acoustic surveys have been revised during the December meeting of the WG. The revised manual is given in Annex 7 and will be submitted to the Series of ICES Survey Protocols (SISP).

6 WGIPS databases

6.1 FishFrame

At PGHERS 2004 and 2005 it was decided to initiate the development of a full system to store and process the data from the acoustic surveys. The input data level should be scrutinized NASC values and complete information from trawl hauls. The output level should be global stock estimates. The system was regarded as consisting of three stages:

Stage I: Basic, disaggregated fisheries and acoustics data.

Stage II: Data manipulation and aggregation tools.

Stage III: Aggregated database and tools to derive global estimates from national, aggregated data.

A stepwise development and implementation approach was chosen. Stage I and III have been finished. In 2007 PGHERS began using FishFrame as the groups' standard calculation procedure.

WGIPS has FishFrame as its only platform for producing the combined results for the surveys in the North Sea, West of Scotland and Malin Shelf based on national survey results (Stage 3) data. WGIPS furthermore wants to have FishFrame as the database for storing the raw acoustic and biological data (Stage 1) for these surveys. These Stage 1 data are essential to making the precision calculation for the North Sea, West of Scotland and Malin Shelf. Furthermore, WGIPS are unable to output a total compilation of the acoustic result, based on stage 1 data within FishFrame, but are required to use an external program employing data exported from FishFrame.

Therefore WGIPS in 2010 asked DTU-Aqua to give an estimate of the cost for:

Making the export of tables, from stage 3, platform-independent.

Making the server capable of automatically refreshing the reports of global estimates after the calculation procedure has completed.

Feedback showing successful data erasure

A full update of FishFrame Acoustic to ver. 5

DTU-Aqua has, since the meeting in 2010, estimated this work to be 1222 man hours at approx. 85 Euro per hour. DTU-Aqua will not have the resources to do this work. And other resources to fund this work cannot be found by the WG.

The WGIPS in 2011 discussed the possibility of ICES Data Centre taking over the responsibility of running and further developing FishFrameAcoustic for stage I and III. This means the storage of basic, disaggregated fisheries and acoustics data from the acoustic surveys and storage of aggregated national survey results and the tools used to derive global estimates from national, aggregated data.

During the 2012 January meeting of WGIPS a meeting with the head of the ICES Data Centre was conducted to investigate the possibilities of moving the FishFrameAcoustic database from DTU-Aqua to ICES and have its maintenance and development in future become the responsibility of ICES Data Centre.

The group was informed that it was decided to move FishFrame 5.0 with data from commercial fisheries into ICES Data Centre, but a decision on moving acoustic survey data and functionality should be taken by the Regional Database Steering Group for the area that the database should cover.

It was decided within the WG to submit a proposal to provide a solution to this dilemma, where responsibilities for acoustic survey data (and possibly also processing) were moved into ICES Data Centre.

It was intended that this proposal should be ready for the WGIPS meeting in December 2012 and should be confirmed by the WG before being submitted to the Regional Database Steering Groups. Unfortunately this proposal was not ready for the December meeting of WGIPS.

The proposal shall be made during spring and send around by mail for approval by the members of the WG.

The proposal shall consist of two documents, one concerning data policy, the other describing the technical aspects of a future migration and development. The needs and wishes, from other surveys that currently use FishFrame (such as the BIAS survey in the Baltic Sea), should also be described. Furthermore, it should be investigated in what way the WGNAPES database could be linked to this database.

At the WGIPS meeting in December 2012 it was agreed that from 2013 onwards acoustic, biological and hydrographic data should be submitted in WGNAPES data format for all national "herring" surveys covering the North Sea, West of Scotland and Malin Shelf. Availability of data in such a disaggregated form (c.f. the aggregated data contained in FishFrame) would greatly facilitate e.g. survey precision estimates or biological data statistics for the combined international surveys. A conversion of these data into FishFrame stage 3 format will be possible by use of e.g. a simple R script.

6.2 WGNAPES database

Internet database

The WGNAPES Internet database (Oracle 10g Express platform) was initially designed at the PGSPFN postcruise meeting in Bergen 2001. It was established at Faroe Marine Research Institute before the IBWSS post-cruise meeting in IJmuiden, April 2007.

Data from IBWSS, IESNS and IESSNS surveys are now submitted routinely from the participating nations.

Assessment calculation application

As is, the assessment calculations are made by the Norwegian part of the group, using the BEAM application, using data from the WGNAPES database. A raw assessment calculation is also made by the Faroese part of the group, allocating the mean length and weight from all trawl stations to the whole area. Comparing the results from BEAM and the raw assessment calculation, gives the group a good indication of the quality of calculations.

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

Future Effort

A continuous effort has to be made to streamline the national data systems to be able to produce data tables in the WGNAPES exchange format, immediately after the national cruises.

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

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

7 Modelling

7.1 Target strength modelling

Work on the depth-dependent TS model continues, but at this time there is no further progress to report since the last update in January 2012 (WGIPS 2012a). The further development of FishFrame to accommodate the storage of depth stratified data is still required to facilitate the potential use of the depth-dependent TS model.

7.2 Blue whiting distribution

Acoustic depth stratified NASC values and environmental data (CTD information) were retrieved from the PGNAPES database for the years 2006–2012. Information about the strength of the sub polar gyre was extracted as described in Hátún *et al.* (2005), and received through personal communication with Hjálmar Hátún (University of Washington). Acoustic and environmental data including gyre information were sampled down to ICES rectangles (0.5° Latitude x 1° Longitude) and merged together, in order to get a combined dataset.

The sub polar Atlantic gyre was low (0.03 – 0.15) for the years 2006–2009 and high for the years 2010 and 2011 (0.31 – 0.32; Figure 7.2.1). Environmental variables fluctuated largely over the analysed years. When sampled down to ICES rectangles temperature and Latitude were highly correlated (P. Co. > 0.5) and could not be modelled together for reasons of colinearity. Lowest mean temperature values were recorded in 2012 Figure 7.2.2).

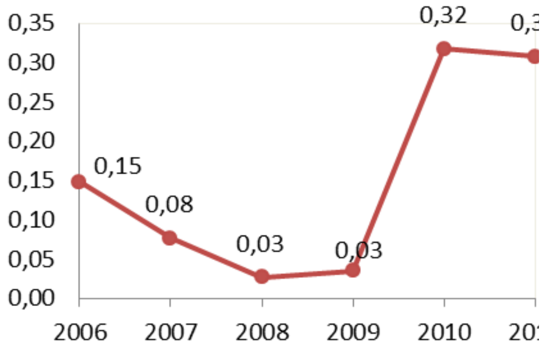


Figure 7.2.1. Sub polar gyre index 2006–2011.

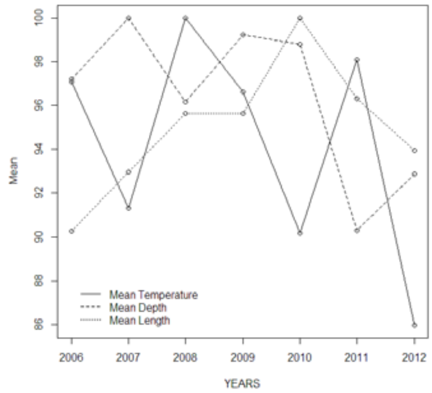


Figure 7.2.2. Temperature, mean depth of occurrence and mean length of blue whiting for the years 2006 – 2012 relative to the maximum in percent.

Generalized Additive Models (GAM) were fitted to the data, with year as a random effect in order to detect year effects. The acoustic cross section was used as an offset value, s are smoother functions:

$$\log(SA+1) \sim s(LONGITUDE) + s(TEMPERATURE) + s(SALINITY) + s(DEPTH) + YEAR + offset(OFFSET)$$

with $Offset = \sigma \times 4 \times \pi$ where $\sigma = 10^{TS/10}$ (TS = target strength) and the number of fish

$$N = = SA/_{\sigma * 4 * \pi} .$$

Results revealed all variables to be highly significant ($P < 0.001$) with R-sq.(adj) = 0.35 and deviance explained = 37.7%. Although significant year effects were detected. In a further step each year was modelled separately (Table 7.2.1). Temperature was a significant factor at a level of at least 0.01 except for the year 2012 (p 0.67), while longitude and depth entered the models as relevant factors each year at a significance level of at least 1%. Salinity significantly contributed to the model for the years 2009–2012 (Table 7.2.1).

Table 7.2.1. GAM model significance for the years 2006–2012.

YEAR	R2	Expl. Dev.	LON	TEMP	SAL	DEPTH
2006	0.49	53	<0.001	<0.001	0.43	0.001
2007	0.33	40.2	<0.001	0.015	0.39	0.01
2008	0.39	45.3	<0.001	0.007	<0.001	<0.001
2009	0.51	57.1	<0.001	<0.001	0.001	0.008
2010	0.36	48.4	0.023	0.005	0.002	0.188
2011	0.67	75.6	<0.001	0.001	0.013	0.005
2012	0.4	49	0.003	0.666	0.008	0.007

In general the model fitted the data relatively well (R2 0.33 – 0.67; Figure 7.2.3 – Figure 7.2.4). In order to take the modelling approach a step further, Zero-inflated models and geostatistical tools will be used to study the distribution of blue whiting and the influence of the environment on the latter.

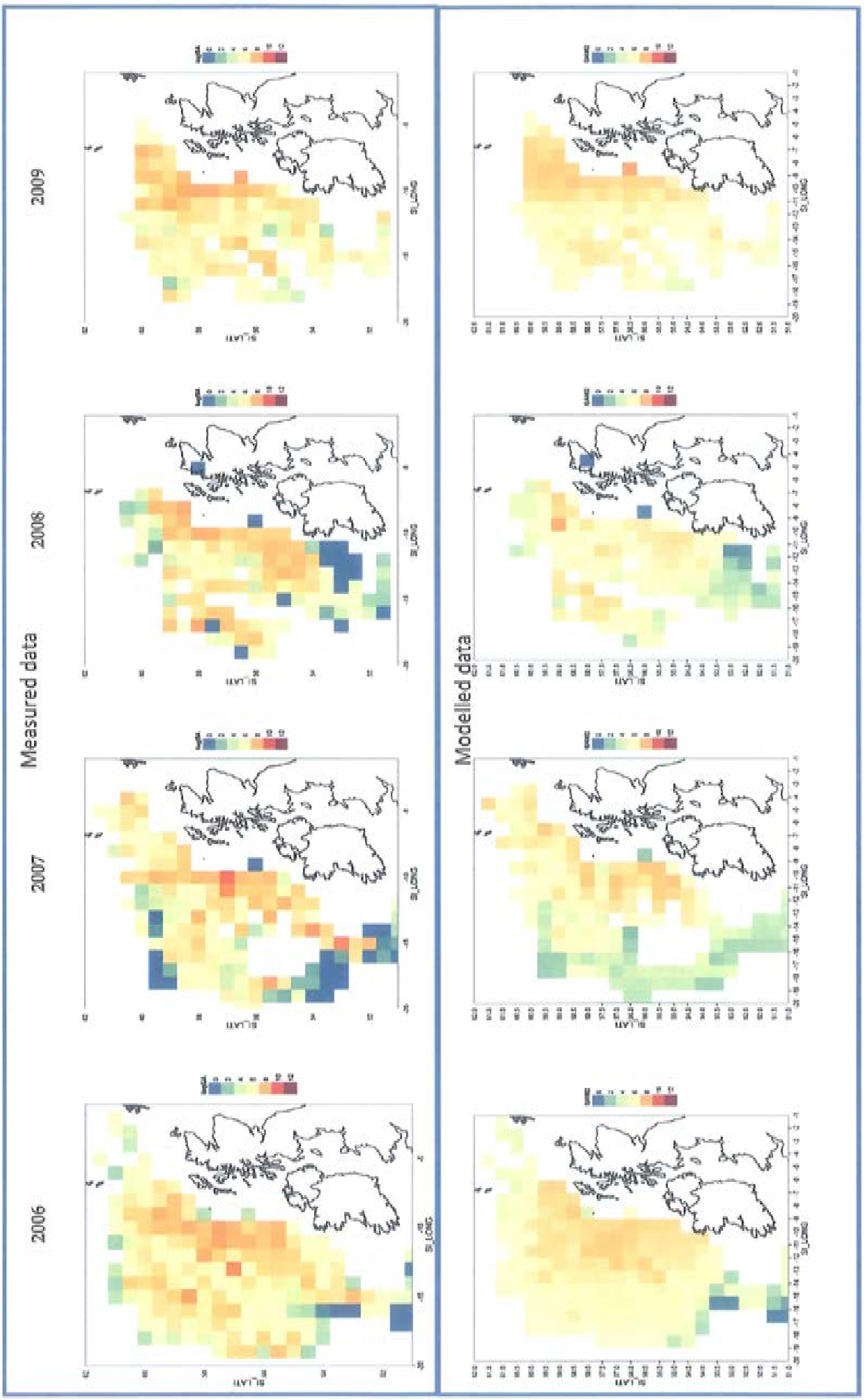


Figure 7.2.3. Modelled vs. measured blue whiting distribution maps for the years 2006–2012.

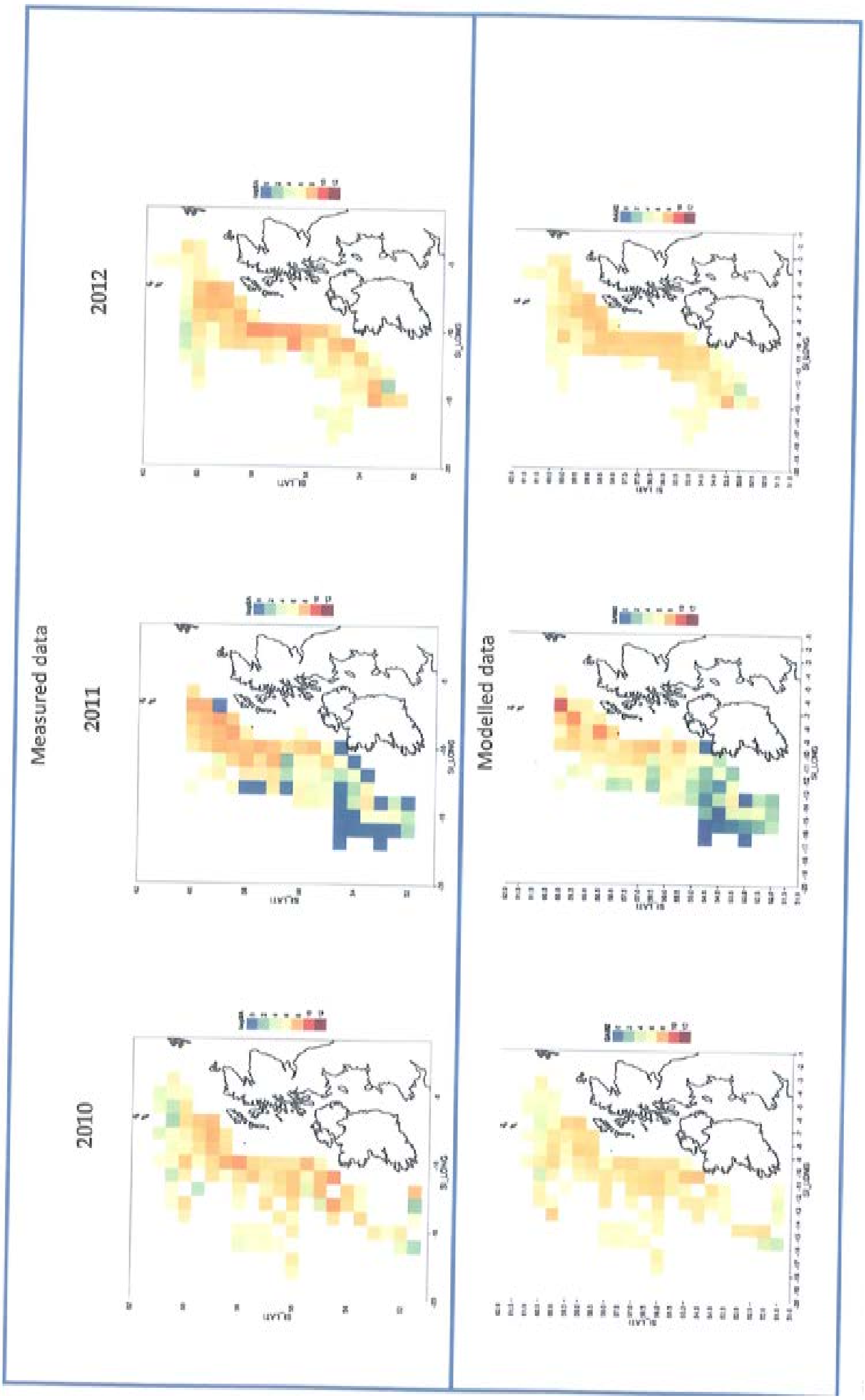
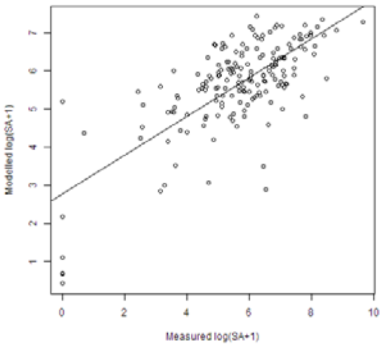
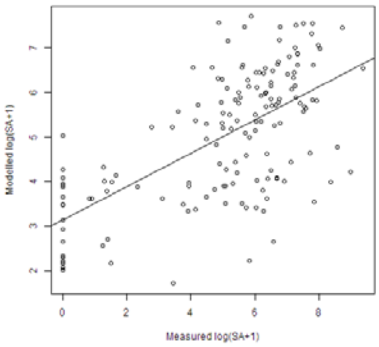


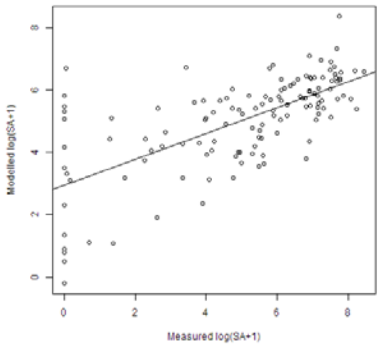
Figure7.2.3 continued. Modelled vs. measured blue whiting distribution maps for the years 2006–2012.



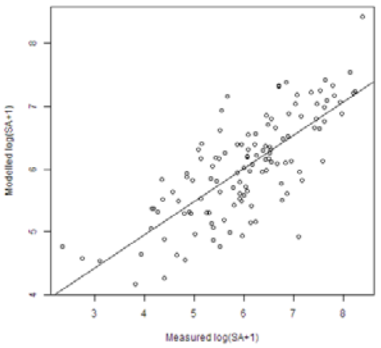
2006



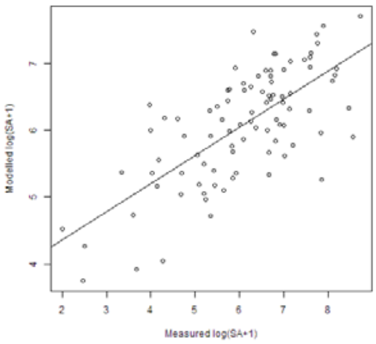
2007



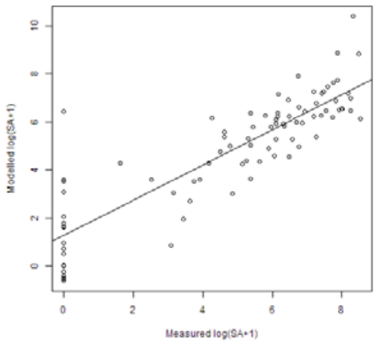
2008



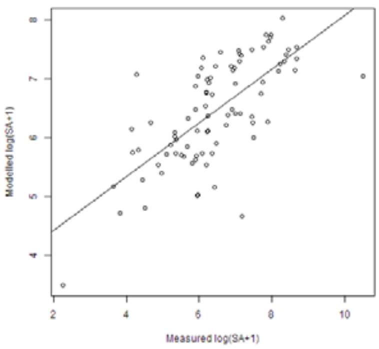
2009



2010



2011



2012

Figure 7.2.4. Residual plots, modelled blue whiting distribution vs. acoutically measured blue whiting distribution for the years 2006–2012.

8 References

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Annex 1: List of participants to Working Group on International Pelagic Surveys (WGIPS) – Biscay Room, ICES Headquarters, 3–7 December 2012

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Annex 2: Agenda WGIPS Meeting December 2012

Agenda for ICES WGIPS, ICES headquarters, 3–7 December 2012

Monday 3rd December

10:00

- Meeting opens
- Review of ToR for this year
- Review of recommendations for WGIPS from other expert groups
- Data availability for tasks in ToR and precision estimates

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 2012 and plan for 2013
  - Western Baltic
  - North Sea
  - Irish Sea

Tuesday 4th December

09:00

- Report status
- Review and update of the Acoustic Manual (generic sections and survey specifics)
- Review of coordinated Acoustic surveys in 2012 and plan for 2013:
  - 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
  - Celtic Sea herring (CSHAS)

14:00

- International blue whiting spawning stock survey(IBWSS)
- International ecosystem survey in the Nordic Seas (IESNS)
- Coordinated Nordic Seas ecosystem survey (IESSNS)
- Boarfish acoustic survey (BFAS)
- Review and status of databases WGNAPES and FishFrame

Wednesday 5th December

09:00

- Report status
- Review of Acoustic Manual
  - Review and update of generic sections

- Update of survey specific texts (survey coordinator led)

14:00

- Review of answers to recommendations for WGIPS from other expert groups
- 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.
- Upcoming working groups
  - Working Group on the Integrated Assessment of the Norwegian Sea (WGINOR
  - Workshop of SSGESST expert groups Chairs (WKSESST)

Thursday 6th December

09:00

- Report status
- Review of Acoustic Manual
- ToR for next meeting
- Recommendations

14:00

- Collection of material for the final report
- IMR presentation on Ecosystem methods
- AOB

Friday 7th December

09:00

- Review of final report and Acoustic Manual

12:00

- Meeting closes

Annex 3: ToR for WGIPS in 2014

Working Group of International Pelagic Surveys, (WGIPS) chaired by Karl-Johan Stæhr, Denmark, and Ciaran O'Donnell, Ireland will meet at ICES Headquarters, Copenhagen, 20–24 January 2014 to:

a) Combine the 2013 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 2013 survey data and provide the following data for the Herring Assessment Working Group (HAWG) and Working Group for Widely Distributed Stocks (WGWIDE):

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

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

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

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

c) 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 2014 including:

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

  vi) The international acoustic survey covering the main spawning grounds of blue whiting in March-April 2014 (IBWSS),

  vii) The international coordinated survey on Norwegian spring-spawning herring in May-June 2014 (IESNS),

  viii) The international coordinated acoustic survey in the Skagerrak and Kattegat, the North Sea, west of Scotland and the Malin Shelf area in June-July 2014 (HERAS).

  ix) Coordinated Nordic Seas ecosystem survey (IESSNS) in July-August 2014

d) Review the progress of FishFrame and WGNAPES databases;

e) Review the methodologies used for scrutinization for the different surveys coordinated by the WG;

f) Identify currently collected additional environmental data collected during the different surveys coordinated by the WG.

WGIPS will report by XX March 2014 (via SSGESST) for the attention of the SCICOM, WGISUR, ACOM, WGWIDE and HAWG.

Supporting Information

Priority	The International Acoustic and Larvae surveys in the North Sea, and adjacent waters provide essential data for the assessment of pelagic stocks in and around the North Sea (Divisions IV, VIa, IIIa, and Western Baltic). The coordination of acoustic surveys in the Northeast Atlantic has strongly enhanced the posibillity to assess abunda and provide essential input for the main pelagic species in Northeast Atlantic.
Scientific justification	**Term of reference a) and b)** Surveys for herring are currently carried out by six different countries, covering the whole of the North Sea, Western Baltic, the west coast of Scotland and the Malin Shelf. Effective coordination and quality control for these surveys is essential and while data combination can be managed by mail, a meeting is required to ensure that the larvae database is being used correctly and that the acoustic surveys are being carried out and analysed on a consistent basis. **Term of reference c)** Interpretation of echograms is subject to different national institutes. Exchange of experience is one of the vital interest of the WG to enable all involved participants a comparable background information and to reduce the risk of loss of information because of changing personnel. **Term of reference d)** FishFrame is the standard software for index calculation and data archiving used by WGIPS. New developments may require a meeting to familiarise all participants with these tools. **Term of reference e)** At present, no correction is made for any change in depth depending swimbladder volmue of the target strength of herring. Incorporation of such models could have huge impacts on the abundance and biomass estimates. Thus the group should have scientific guidance on this modern approach. **Term of reference i)** The Series of ICES Survey Protocols (SISP) is an online, web-accessible series of ecosystem (fishery) survey manuals, covering the protocols and procedures used in ICES coordinated fisheries and ecosystem surveys, including trawl, acoustic, and ichthyoplankton surveys http://www.ices.dk/products/surveyprotocols.asp). The aim is to have all ICES coordinated surveys allocated an ISSN number and become openly available.
Relation to strategic plan	Directly relevant – it allows ICES to respond to requested advice on blue whiting, herring and sprat fisheries.
Resource requirements	No specific resource requirements beyond the need for members to prepare for and participate in the meeting
Participants	At least one scientist (preferably the cruise leader) from each survey; hence a minimum of 15 members.
Secretariat facilities	None
Financial	None
Linkages to advisory committees	The survey data are prime inputs to the assessments which provide ACOM with information required for responding to requests for advice/information from NEAFC and EC DG MARE.
Linkages to other committees or groups	Survey results are conveyed directly to the Herring Assessment Working Group for the Area South of 62°N (HAWG) and Working Group for Widely Distributed Distributed Stocks (WGWIDE) HAWG and WGWIDE to see this report

Linkages to other organizations	None

Annex 4: Recommendations

Recommendation	For follow up by:
1. WGIPS recommend that the IESSNS survey methodology be added to the WGISDAA 2013 ToR's and that the appropriate specialists from this survey attend the WGISDAA meeting in January 2014.	SCICOM, WGISDAA, Expert Group members
2. WGIPS recommends to extend the analysis of the IHLS survey every third year to obtain information of ichthyoplankton abundance and distribution in conjunction with IBTS surveys for monitoring spawning areas of the main fish species.	WGEGGS2, IBTSWG, Expert group members
3. WGIPS agrees that a proposal is formulated within the group regarding the alignment of current data collection polices under the umbrella of the ICES data centre.	RCM NS&EA, RCM Baltic, WGIPS
4. WGIPS suggests that national acoustically derived abundances should be requested aditionaly disaggregated only by length for each strata/stock unit surveyed by each nation. These abundances at length should then be combined following the procedure used to produce the age and maturity disaggregated abundances for each stock and the resulting estimated combined length distribution for each stock used to provide the 95% percentile of the fish length distribution for each species. WGIPS would like to seek clarification if this is deemed an appropriate way to produce the information requested before proceeding to request this additional level of information from all survey participants.	SCICOM, WGISDAA, Expert Group members
5. 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 – 333 kHz) to facilitate species identification. In addition, scientific multibeam echosounders should be used to increase the sampled volume.	Expert group members
6.. For combined coordinated surveys the group recommends that post cruise meetings take place prior to the WGIPS 2014 meeting. The purpose of the meeting is to evaluate the data, upload to the relevant database and compile a joint report.	Expert group members
7. WGIPS recommends **that cruise tracks are submitted to the relevant survey coordinators one month prior to the survey start date. Deviations from agreed cruise plans and/or dates should be communicated via the survey coordinator as soon as possible to allow for effort reallocation.**	Expert group members
8. A workshop on scrutinizing of acoustic data from the IESNS survey is highly recommended by WGIPS. The workshop should preferably take place during autumn/winter 2012/2013, or prior to the surveys in 2013.	Expert group members

Annex 5: 2012 Post Cruise Reports

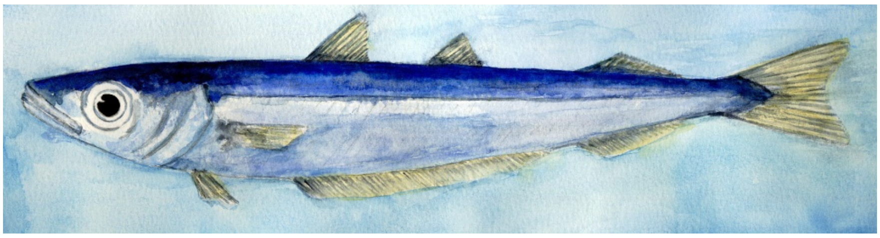
Annex 5a: International Blue Whiting Spawning Stock Survey (IBWSS)

Working Group on International Pelagic Surveys

Copenhagen, Denmark, 3–7 December 2012

Working Group on Widely Distributed Stocks

Lowestoft, UK, 21–27 August 2012



INTERNATIONAL BLUE WHITING SPAWNING STOCK SURVEY (IBWSS)

SPRING 2012

Sascha Fässler[1^*], Sven Gastauer[1*], Thomas Pasterkamp[1], Kees Bakker[1], Dirk Thijssen[8], Eric Armstrong[6]

RV Tridens

Ciaran O'Donnel[5*], Eugene Mullins[5], Graham Johnston[5] , Cormac Nolan[5], John Power[5] and Matthias Schaber[7]

RV Celtic Explorer

Maxim Rybakov[3], Valery Ignashkin[3*], Sergeeva Tatiana[3], Yuri Firsov[3], Velikzhanin Alexey[3], Dolgolenko Ilya[3], Gavrilik Tatiana[3], Krivosheya Pavel[3], Murashko Ekaterina[3], Sergey Kharlin[3].

RV Fridtjof Nansen

Åge Høines[2*], Valantine Anthonypillai[2*], Øyvind Tangen[2*], Jan de Lange[2], Elna Meland[2], Gunnar Lien[2]

M/S Brennholm

Jan Arge Jacobsen[4], Ebba Mortensen[4], Mourits Mohr Joensen[4], Leon Smith[4*]

RV Magnus Heinason

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3 PINRO, Murmansk, Russia
4 Faroe Marine Research Institute, Tórshavn, Faroe Islands
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
* Participated in post cruise meeting
^ Survey coordinator

Material and methods

Survey planning and Coordination

Coordination of the survey was initiated in the meeting of the Working Group on Northeast Atlantic Pelagic Ecosystem Surveys (WGNAPES, ICES 2011) 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 a day. Participating vessels together with their effective survey periods are listed below:

Vessel	Institute	Survey period
Fridtjof Nansen	PINRO, Murmansk, Russia	24/3 – 6/4
Celtic Explorer	Marine Institute, Ireland	24/3 – 5/4
Brennholm	Institute of Marine Research, Bergen, Norway	28/3 – 8/4
Magnus Heinason	Faroe Marine Research Institute, Faroe Islands	31/3–8/4
Tridens	Institute for Marine Resources & Ecosystem Studies (IMARES), the Netherlands	26/3–5/4

The survey design used and described in ICES (2011) allowed for a flexible setup of transects and good coverage of the spawning aggregations. Due to favourable weather conditions throughout the survey period and full vessel availability, 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 2 weeks.

Cruise tracks and trawl stations for each participant vessel are shown in Figure 1. Figure 2 shows combined CTD stations. All vessels, apart from Magnus Heinason 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 salient properties of which are given in Table 5. Acoustic equipment for data collection and processing are also presented in Table 5. The survey and abundance estimate are based on acoustic data collected through scientific echosounders using 38 kHz frequency. All transducers were calibrated with a standard calibration sphere (Foote *et al.*, 1987) prior to the survey. Acoustic settings by vessel are summarized in Table 2.

Acoustic Intercalibration

Inter-vessel acoustic calibrations are carried out when participant vessels are working within the same general area and time and weather conditions allow for an exercise to be carried out. The procedure follows the methods described by Simmonds and MacLennan 2007. This year, an inter-calibration was carried out involving the Celtic Explorer and Tridens. Results of this exercise are described in Appendix 3.

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 5.

Hydrographic sampling

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

On Magnus Heinason, acoustic data were scrutinised every 24 hrs. on board using Sonar data's Echoview (V 5.1) post-processing software. Data were partitioned into the following categories: plankton (<200 m depth layer), mesopelagic species, blue whiting and krill. Partitioning of data into the above categories was based on trawl samples.

On Tridens, acoustic data were backed up continuously and scrutinized every 24–48 hrs. using the Large Scale Survey System LSSS (V 1.5.1) post-processing software. Blue whiting were identified and separated from other recordings based on trawl catch information and characteristics of the recordings.

Acoustic data analysis

The acoustic trawl data were analysed with a SAS based routine called "BEAM" (Totland and Godø 2001) and used to calculate age and length stratified estimates of total biomass and abundance (numbers of individuals) within the survey area as a whole and within subareas (i.e. the main areas in the terminology of BEAM). Strata of 1º latitude by 2º longitude were used. The area of a stratum was adjusted, when necessary, to correspond 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 target strength (TS)-to-fish length (L) relationship (Pedersen *et al.*, 2011) used is:

$$TS = 20 \log_{10} (L) - 65.2$$

For conversion from acoustic density (s_A, m^2/n.m.^{2}) to fish density (ρ) the following relationship was used:

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

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

Inter-calibration results

One inter-calibration exercise was carried out between the *RV Celtic Explorer* and the *RV Tridens* on the 5th April in the northern survey area along the shelf edge. The results of this exercise are presented in Appendix 3.

Distribution of blue whiting

Unlike in the previous year's survey, the Rockall subarea was covered in 2012. However, observed densities of blue whiting in that area were low. Blue whiting were recorded in all areas surveyed. In total 8,629 n.m. (nautical miles) of survey transects were completed. The total area of all the sub-survey areas covered was 88,746 n.m.^{2} (Figure 1, Tables 1 and 3).

Compared to the combined survey in 2011, the survey coverage was up by 29% overall. The majority of this increase was attributed to coverage of the Rockall area and an increase in the Faroese area. The S. Porcupine area saw an increase in coverage by 28% and the Hebrides area were covered in the same extent as the year before.

The highest concentrations of blue whiting were recorded in the Hebrides core area which remains consistent with the results from previous surveys (Figure 7, Table 3a). Overall the bulk of the stock was centred in the core area as in 2011 (Figures 4 and 5). Medium and high density registrations were concentrated along the shelf slope. Medium to high density were distributed almost entirely within a narrowband running close the shelf edge.

Stock size

The estimated total abundance of blue whiting for the 2012 international survey was 2.22 million tonnes, representing an abundance of 18.2x10^9 individuals (Figure 6, Tables 3 and 4). Spawning stock was estimated at 2.12 million tonnes and 16.5x10^9 individuals. Compared with the 2011 survey estimate, there is a significant increase (+38%) in the observed stock biomass and a related increase in stock numbers (+50%).

		2004	2005	2006	2007	2008	2009	2010	2011	2012	Change from 2011 (%)
Biomass	Total	3.6	2.6	3.4	3.6	2.6	2	1.3	1.6	2.2	38%
(mill. t)	Mature	3.6	2.4	3.3	3.6	2.6	2	1.3	1.5	2.2	47%
Numbers	Total	41.9	29	34.7	33.5	22.1	15.2	9.3	12.1	18.2	50%
(10^9)	Mature	39.2	26.7	33.8	32.9	21.7	15.0	8.9	9.7	16.5	70%
Survey area (nm^2)		149,000	172,000	170,000	135,000	127,000	133,900	109,320	68,851	88,746	29%

The Hebrides core area was found to contain 71% of the total biomass observed during the survey and is consistent but slightly lower with the result of last year's surveys (76% in 2011 relative to total-stock biomass for that year). The Faroes/Shetland and north Porcupine areas ranked second and third highest contributing 16% and 11% to the total respectively. The breakdown of survey biomass by subarea is shown below:

		Biomass (million tonnes)				
		2011		2012		
	Sub-area		% of total		% of total	Change (%)
I	S. Porcupine Bank	0.01	1	0.01	1	0%
II	N. Porcupine Bank	0.08	5	0.25	11	213%
III	Hebrides	1.20	76	1.58	71	32%
IV	Faroes/Shetland	0.28	18	0.37	16	32%
V	Rockall	-	-	0.01	0	NA

Stock composition

Individuals of ages 1 to 13 years were observed during the survey. A comparison of age reading between nations was carried out and the results are presented in Appendix 2. Results show good agreement across participants for all age classes with a broad range of lengths for the youngest and oldest fish in the range.

The stock biomass within the survey area is dominated by age classes 3, 7, 8 and 6 of the 2009, 2005, 2004 and 2006 year-classes respectively (Table 4), contributing over 65% of spawning-stock biomass.

The Hebrides area remains the most productive in the current survey time-series and has consistently contributed over 50% to the total SSB (Figure 6). The age profiles of the other subareas were additionally represented by younger age classes (3, 2 and 1-year old). The Faroe/Shetland and Porcupine subareas were strongly dominated by 1-3 year old fish.

Young blue whiting were represented to various extents in all subareas in 2012 (Figure 9). Maturity analysis of survey samples indicate that 25% of 1-year old, 59% of 2-year old and 97% of 3-year old fish were mature as compared to the 2011 estimates, where 8% of 1-year old fish, 22% of 2-year old fish and 84% of 3-year old fish were considered mature (Tables 4).

From the survey data, the Faroese/Shetland subarea was found to contain significant proportion of young blue whiting (1–3 years). This together represents 75% (275,000t) of the total biomass and 86% (3199 million individuals) of the total abundance in this area.

Overall, immature blue whiting from the estimate represented less than 3% (65,000t) of the total biomass and less than 10% (1732 million) of the total abundance recorded during the survey.

Hydrography

A combined total of 150 CTD casts were undertaken over the course of the survey. Horizontal plots of temperature and salinity at depths of 10m, 50m, 100 and 200m as derived from vertical CTD casts are displayed in Figures 10–13 respectively.

Concluding remarks

Main results

- The 9th International Blue Whiting Spawning stock Survey 2012 shows an increase when compared to the 2011 estimate. The updated survey time-series shows a recovery from the declining trend observed since 2007.
- Favourable weather conditions, full vessel availability and a survey design with increased focus on the majority of spawning aggregations resulted in a successful coverage of the whole survey area. The survey design would have allowed for flexible adaptation of transect coverage in case of vessel loss or delay, however given the aforementioned reasons, such action was not necessary, resulting in a high quality coverage of the survey area in space and time.
- The survey was carried out over 14 days this year, which is the same as in the previous year. This is well within the 21 daytime window recommended to cover the spawning stock.
- Estimated uncertainty around the mean acoustic density is the lowest observed in the time-series so far. It is about half as large as those observed in previous years with the exception of 2007 when a much higher uncertainty was recorded.

- The stock biomass within the survey area is dominated by age classes 3, 7, 8 and 6 of the 2009, 2005, 2004 and 2006 year-classes respectively, contributing over 65% of spawning-stock biomass
- Mean length (28.1 cm) and weight (123.5 g) are lower than the previous years. This can be attributed to the progression of the 3 dominate year-classes and increasing contribution of young fish to the total-stock biomass.
- A positive signal of 2 and 3-year old fish continues to be observed across all areas and the latter is now considered fully recruited to the spawning stock.

Interpretation of the results

- Compared to the main spawning area, densities of blue whiting aggregations observed in the Rockall area were low. Coverage will be continued as in previous surveys since this area is still considered important.
- The chosen survey design covered the area within 2 weeks with good temporal progression and degree of spatial coverage. Together with the 2011 survey, it was the shortest period required to complete coverage of the survey area.
- The 2012 estimate of abundance for the survey can be considered robust for those areas covered. Over 99% of the total biomass was observed in subareas surveyed by more than one vessel.
- Survey timing is fixed annually to coincide with peak spawning of the stock. In 2012 as in the three previous years, the time of peak spawning varied. However, in all these years the stock was contained within the survey area due to the extensive survey area and so estimates of abundance are credible.

Recommendations

- Participants are encouraged to share experience in otolith age reading and personnel on surveys. It is recommended that an age reading workshop is scheduled to improve consistency across survey participants (WGIPS).
- The same maturity scale needs to be used by all participants. To increase experience and consistency in maturity classification, a maturity workshop should run concurrently with the age reading workshop.
- The 2013 survey will be carried out as detailed in Appendix 4.
- 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 survey manual.

Achievements

- The whole survey area was covered within 14 days. In previous years (except 2011) the minimum time for achieved coverage was 28 days.
- Delivery of survey data in the PGNAPES format to Leon Smith was achieved in a timely fashion.
- Calibrated acoustic data were collected from 2 Dutch freezer trawlers actively involved in the fishery. The availability of these data may aid survey planning in future and give additional information about blue whiting distribution on the spawning grounds.

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Table 1. Survey effort by vessel. March-April 2012.

Vessel	Effective survey period	Length of cruise track (nmi)	Trawl stations	CTD stations	Plankton sampling	Aged fish	Length-measured fish
Fridtjof Nansen	24/3 - 6/4	1,939	17	58	'	748	2,866
Celtic Explorer	24/3 - 5/4	1,808	15	19	'	680	2,049
Brennholm	28/3 - 8/4	1,925	15	28	27	421	1,600
Magnus Heinason	31/3 - 8/4	1,230	9	21	20	495	1,132
Tridens	26/3 - 5/4	1,727	13	24	'	850	950
Total		8,629	69	150	47	3,194	8,597

Table 2. Acoustic instruments and settings for the primary frequency. March-April 2012.

	Fridtjof Nansen	Celtic Explorer	Brennholm	Magnus Heinason	Tridens
Echo sounder	Simrad EK60	Simrad EK 60	Simrad EK 60	Simrad EK60	Simrad EK 60
Frequency (kHz)	**38, 120**	**38**, 18, 120, 200	**38**, 18, 200, 333	**38**	**38**, 120
Primary transducer	ES38B	ES 38B	ES38B	ES38B	ES 38B
Transducer installation	Hull	Drop keel	Drop keel	Hull	Towed body
Transducer depth (m)	4.5	8.7	8	3	7
Upper integration limit (m)	10	15	10	7	15
Absorption coeff. (dB/km)	10	9.7	-	10.1	9.3
Pulse length (ms)	1.024	1.024	1.024	1.024	1.024
Band width (kHz)	2.425	2.425	-	2.43	2.43
Transmitter power (W)	2000	2000	2000	2000	2000
Angle sensitivity (dB)	21.9	21.9	-	21.9	21.9
2-way beam angle (dB)	-20.79	-20.6	-	-20.9	-20.5
Sv Transducer gain (dB)					
Ts Transducer gain (dB)	25.53	25.89	-	24.85	26.17
s_A correction (dB)	-0.58	-0.62	-	-0.59	-0.58
3 dB beam width (dg)					
alongship:	6.96	6.91	-	7.24	6.67
athw. ship:	6.95	6.92	-	7.12	7.04
Maximum range (m)	750	750	750	750	750
Post processing software	FAMAS	Sonardata Echoview	LSSS	Sonardata Echoview	LSSS

Table 3. Assessment factors of blue whiting for IBWSS March-April 2012.

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	5,483	0.11	0.13	85	0.012	0.013	92	98.5	26.3	2.4
II	N. Porcupine Bank	20,242	2.22	2.63	84	0.239	0.254	94	96.6	26.1	12.5
III	Hebrides	35,894	10.96	11.66	94	1.554	1.576	99	135	29.4	43.9
IV	Faroes/Shetland	19,467	3.10	3.71	84	0.338	0.365	93	98.3	24.7	18.7
V	Rockall	7,660	0.08	0.08	100	0.011	0.011	100	138.3	30.0	1.4
Tot.		88,746	16.47	18.21	90	2.154	2.219	97	121.8	28	25.0

Table 4. Survey stock estimate of blue whiting, March-April 2012.

Length (cm)	Age in years (year class) 1 2011	2 2010	3 2009	4 2008	5 2007	6 2006	7 2005	8 2004	9 2003	10+	Numbers (*10-^{6})	Biomass (10^6 kg)	Mean weight (g)	Prop. mature* (%)
11.0 – 12.0											0			
12.0 – 13.0											0			
13.0 – 14.0	9	0	0	0	0	0	0	0	0	0	9	0.1	12	0
14.0 – 15.0	6	5	0	0	0	0	0	0	0	0	11	0.2	15	0
15.0 – 16.0	65	19	5	0	0	0	0	0	0	0	89	2	22	4
16.0 – 17.0	90	88	27	0	0	0	0	0	0	0	205	4.9	24	12
17.0 – 18.0	226	141	21	0	0	0	0	0	0	0	388	11.1	29	17
18.0 – 19.0	298	121	54	0	0	0	0	0	0	0	473	16.1	34	9
19.0 – 20.0	182	197	23	0	0	0	0	0	0	0	402	15.9	40	22
20.0 – 21.0	150	129	13	7	0	0	0	0	0	0	299	14	47	37
21.0 – 22.0	73	90	31	4	0	0	0	0	0	0	198	11.1	56	67
22.0 – 23.0	46	116	65	0	0	0	0	0	0	0	227	14.9	66	92
23.0 – 24.0	26	263	398	29	3	0	0	0	0	0	719	55.3	77	94
24.0 – 25.0	7	254	1186	67	3	0	0	0	0	0	1517	124.2	82	98
25.0 – 26.0	0	205	1867	39	0	0	0	6	0	0	2117	187.2	88	99
26.0 – 27.0	0	106	1459	97	6	0	0	0	0	0	1668	158.7	95	100
27.0 – 28.0	0	75	943	178	15	7	7	0	0	0	1225	128.8	105	100
28.0 – 29.0	0	17	482	227	44	20	0	8	0	0	798	92.4	116	100
29.0 – 30.0	0	6	72	223	60	74	131	54	23	22	665	90.6	136	100
30.0 – 31.0	0	0	23	78	162	261	225	102	90	91	1032	152.6	148	100
31.0 – 32.0	0	0	3	35	109	319	449	305	242	135	1597	251.9	158	100
32.0 – 33.0	0	0	6	23	99	301	481	275	209	164	1558	266.7	172	100
33.0 – 34.0	0	0	0	6	18	214	333	296	230	182	1279	237	185	100
34.0 – 35.0	0	0	0	0	16	90	255	142	131	173	807	162.7	201	100
35.0 – 36.0	0	0	0	0	0	22	112	163	96	104	497	109.2	220	100
36.0 – 37.0	0	0	0	0	9	20	76	50	24	71	250	60.2	240	100
37.0 – 38.0	0	0	0	0	0	9	8	16	24	42	99	25.5	257	100
38.0 – 39.0	0	0	0	0	0	6	0	24	7	7	44	12.6	287	100
39.0 – 40.0	0	0	0	0	0	0	0	3	0	22	25	7.9	323	100
40.0 – 41.0	0	0	0	0	0	0	0	0	2	5	7	2.3	342	100
41.0 – 42.0	0	0	0	0	0	0	0	0	0	4	4	1.6	376	100
42.0 – 43.0	0	0	0	0	0	0	0	0	0	0	0	0	.	100
43.0 – 44.0	0	0	0	0	0	0	0	0	0	3	3	1.5	434	100
44.0 – 45.0														
TSN (10^6)	1178	1832	6678	1013	544	1343	2077	1444	1078	1025	18212	2219		
TSB (10^6 kg)	45.9	121.4	606.9	117.9	82.1	226.7	364.1	262.3	194.5	197.1	2219			
Mean length (cm)	18.8	22.2	25.8	28.1	30.9	32.1	32.6	33	33	34				
Mean weight (g)	39	66.3	90.9	116.4	150.9	168.4	175.5	181.7	180.4	210				
Condition (g/dm^3)														
% mature*	25	59	97	99	100	100	100	100	100	100				

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

Table 5. Country and vessel specific details, March-April 2012.

	Fridtjof Nansen	Celtic Explorer	Brennholm	Magnus Heinason	Tridens
Trawl dimensions					
Circumference (m)	716	768	2300	640	1120
Vertical opening (m)	50	50	110	40	30-70
Mesh size in codend (mm)	16	20	40	40	±20
Typical towing speed (kn)	3.2-4.2	3.5-4.0	3.0-3.5	3.0-4.0	3.5-4.0
Plankton sampling	0	5	27	16	0
Sampling net	-	Gulf Sampler	WP2 plankton net	WP2 plankton net	-
Standard sampling depth (m)	-	200	400	200	-
Hydrographic sampling					
CTD Unit	SBE19plus	SBE911	SAIV	SBE911	SBE911
Standard sampling depth (m)	1000	1000	1000	1000	1000

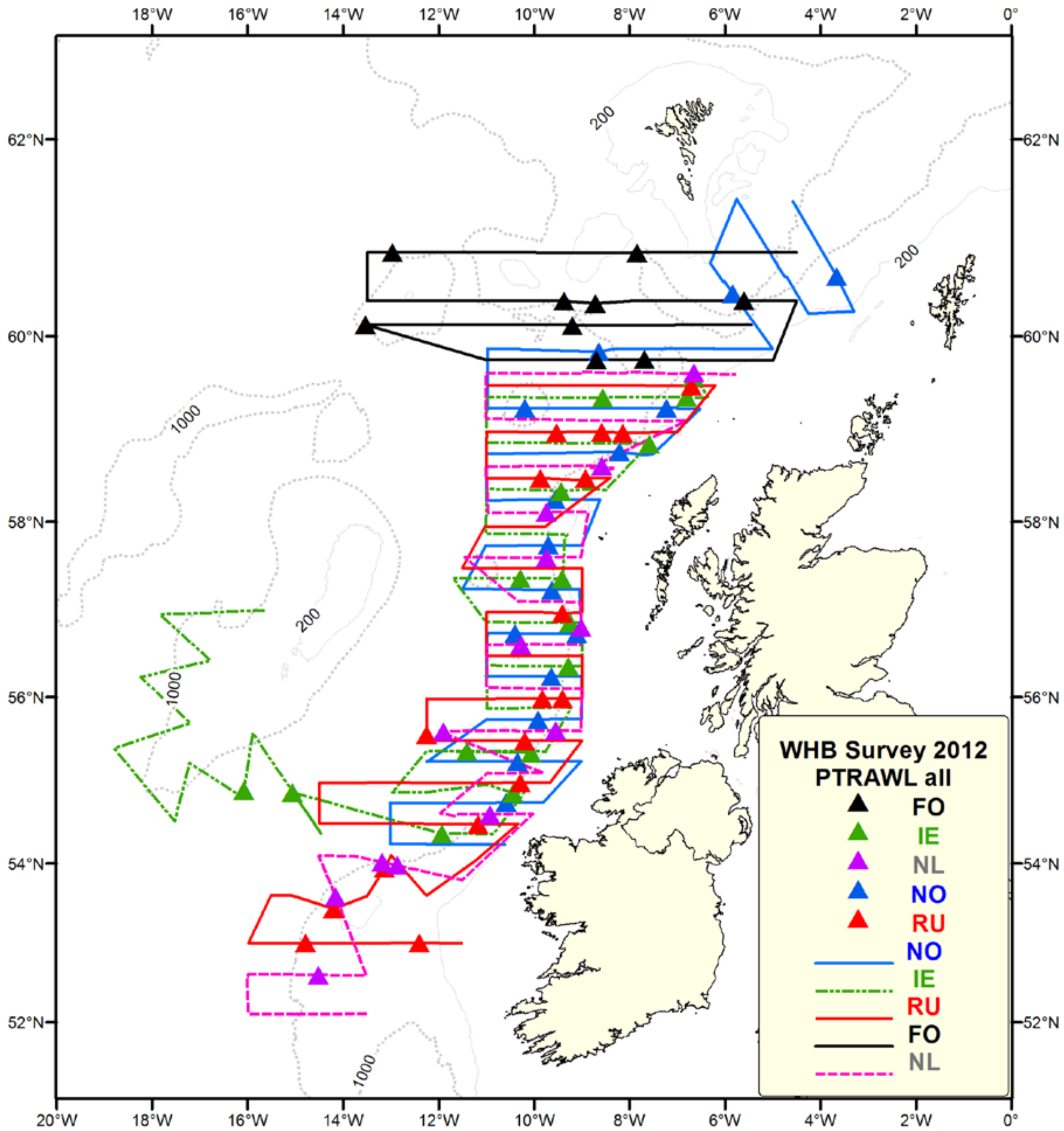


Figure 1. Vessel cruise tracks and trawl stations of the International Blue Whiting Spawning stock Survey (IBWSS) from March-April 2012. PT: Indicates pelagic trawl station. IE: Ireland (Celtic Explorer); FO: Faroese (Magnus Heinason); NL: Netherlands (Tridens); RU: Russia (Fridtjof Nansen): NO: Norway (Brennholm).

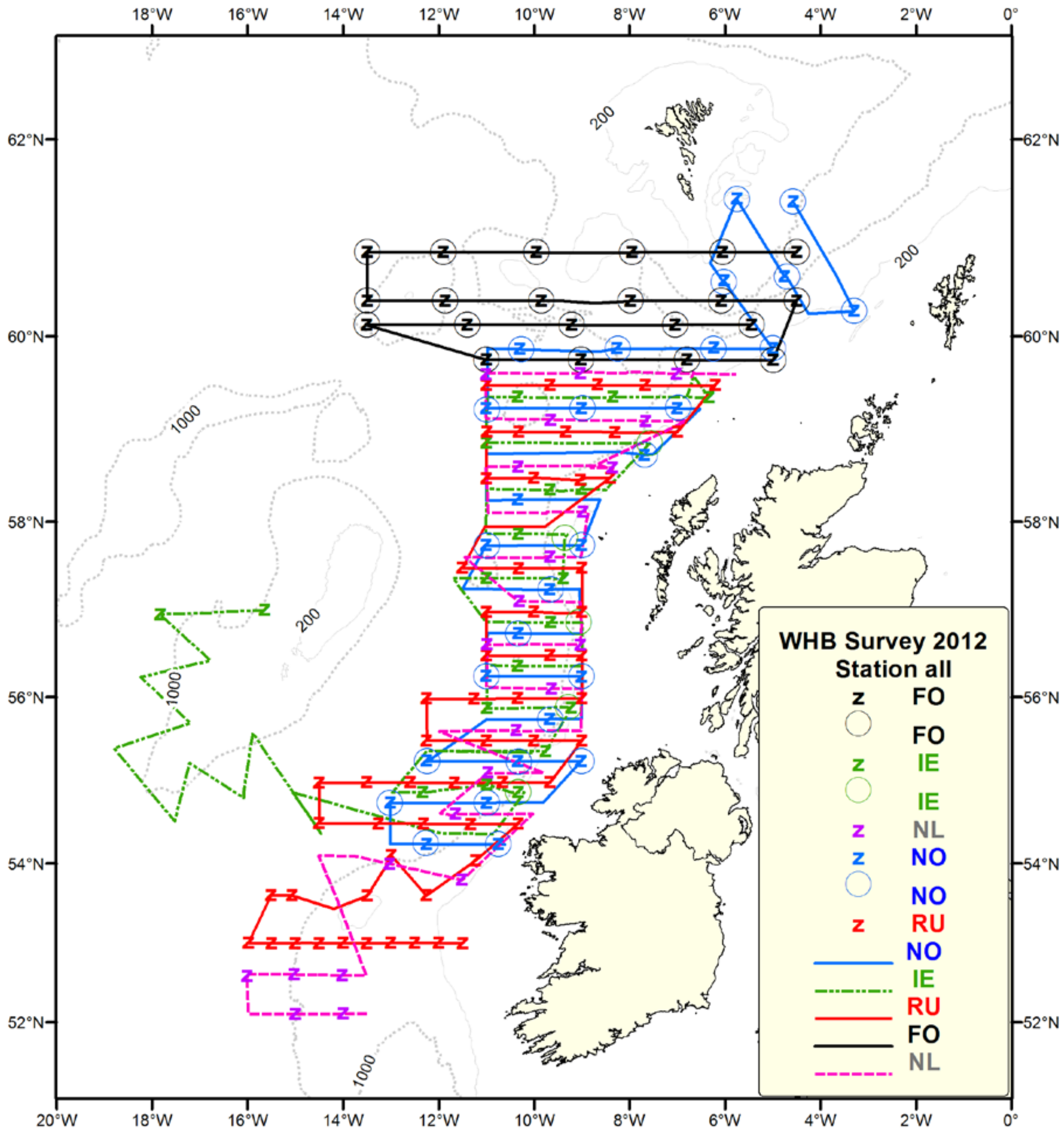


Figure 2. CTD stations overlaid onto vessel cruise tracks for the combined survey. WP II: plankton trawl. green: Celtic Explorer; black: Magnus Heinason; purple: Tridens; red: Fridtjof Nansen: blue: Brennholm. March-April 2012.

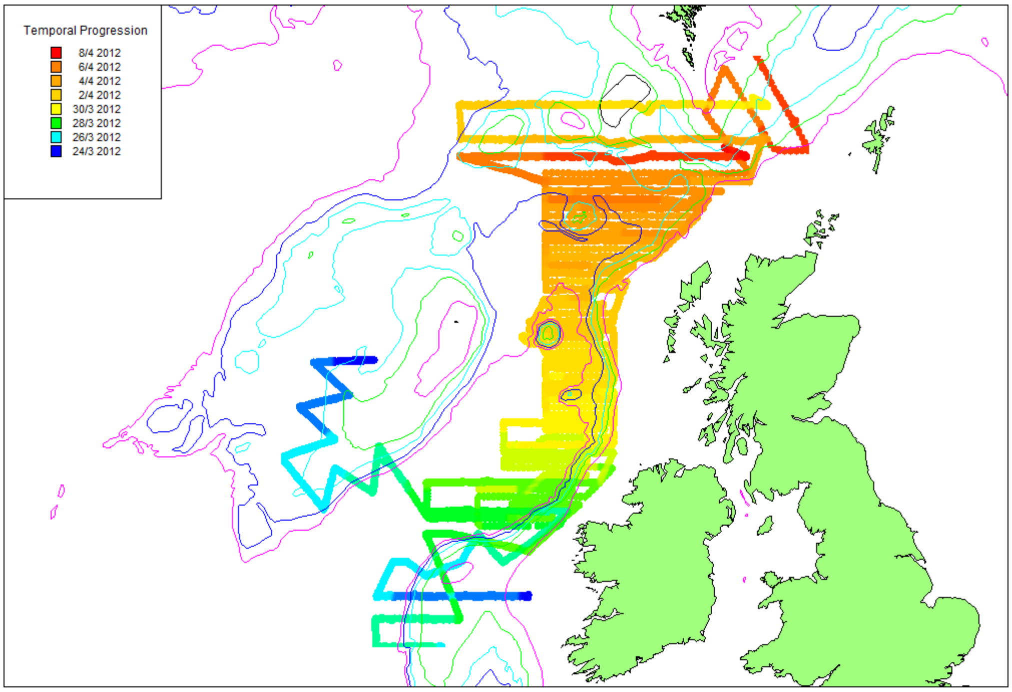


Figure 3. Temporal progression for the International Blue Whiting Spawning stock Survey (IB-WSS), 24 March – 8 April 2012.

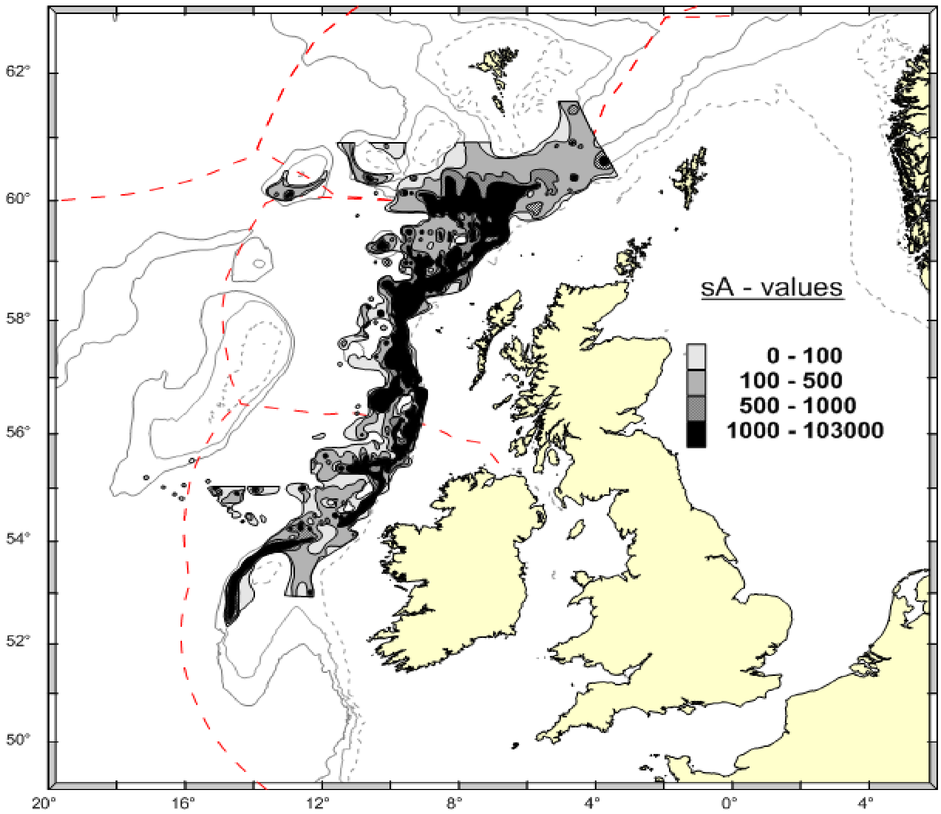


Figure 4. Map of blue whiting acoustic density (s_A, m²/n.m.²), 24 March – 8 April 2012.

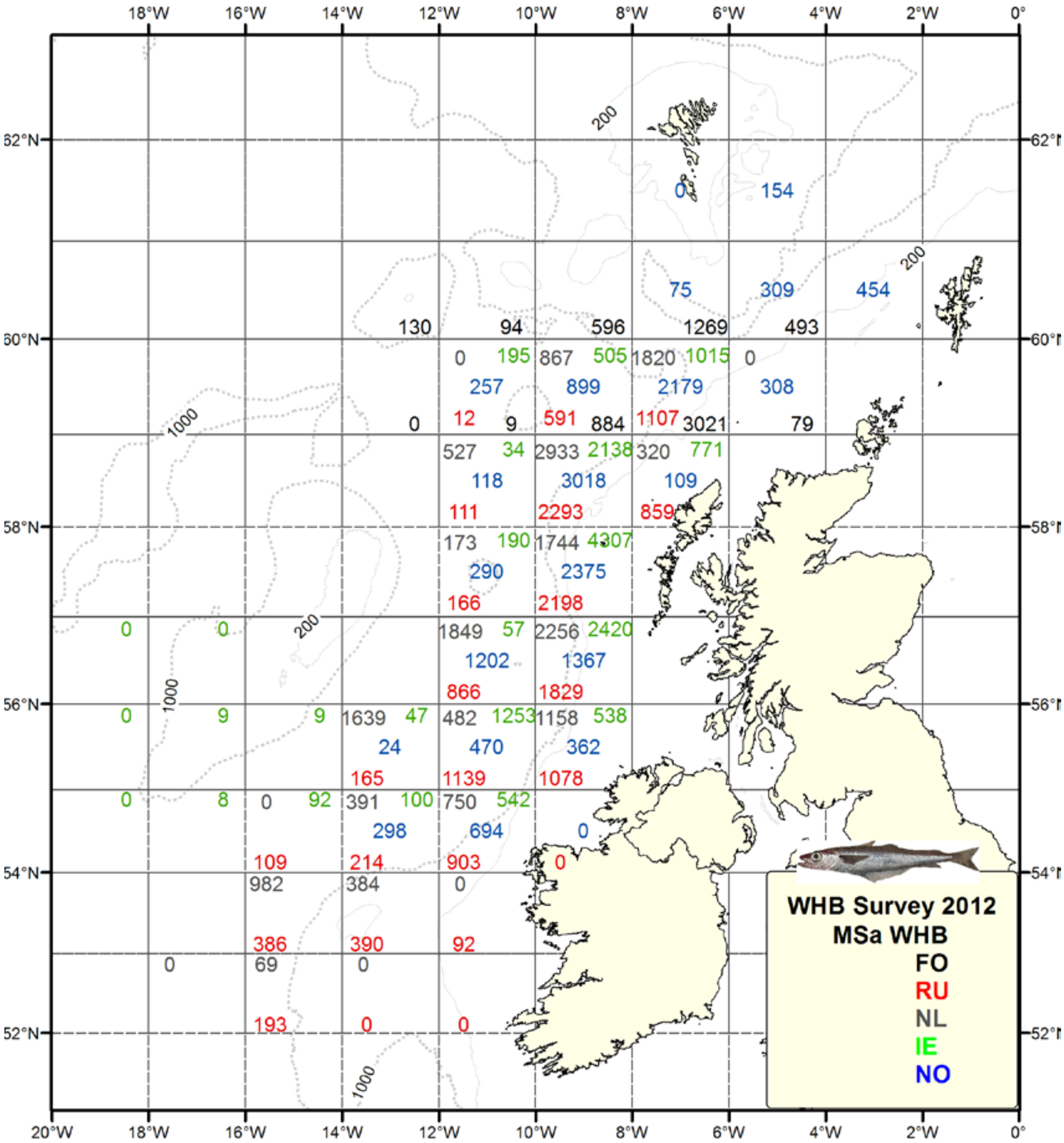


Figure 5. Mean blue whiting acoustic density (sA, m²/n.m.²) for IBWSS 2012 by individual vessel: Celtic Explorer: green, Magnus Heinason: black, Tridens: grey, Fridtjof Nansen: red, Brennholm: blue. March-April 2012.

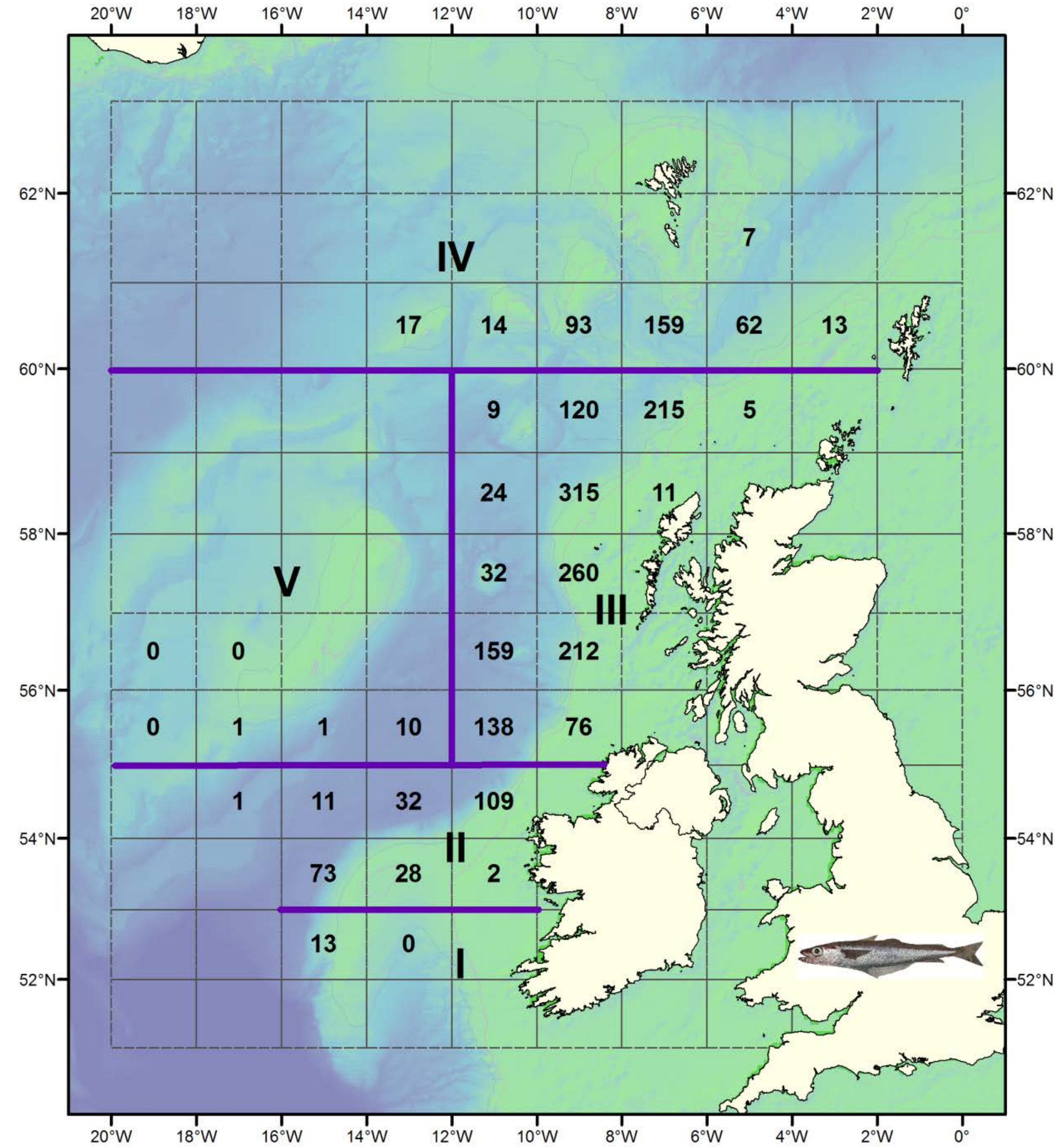
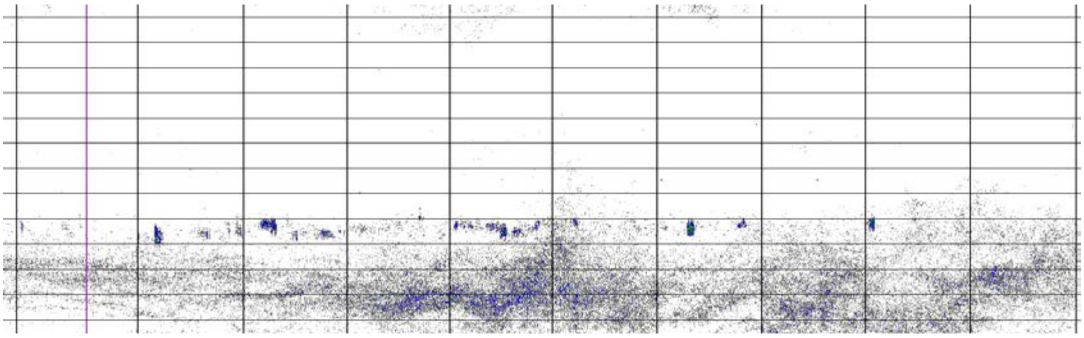
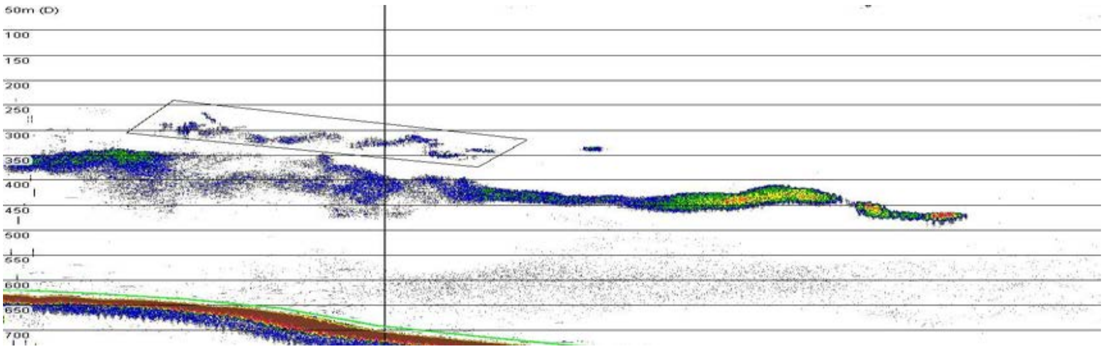


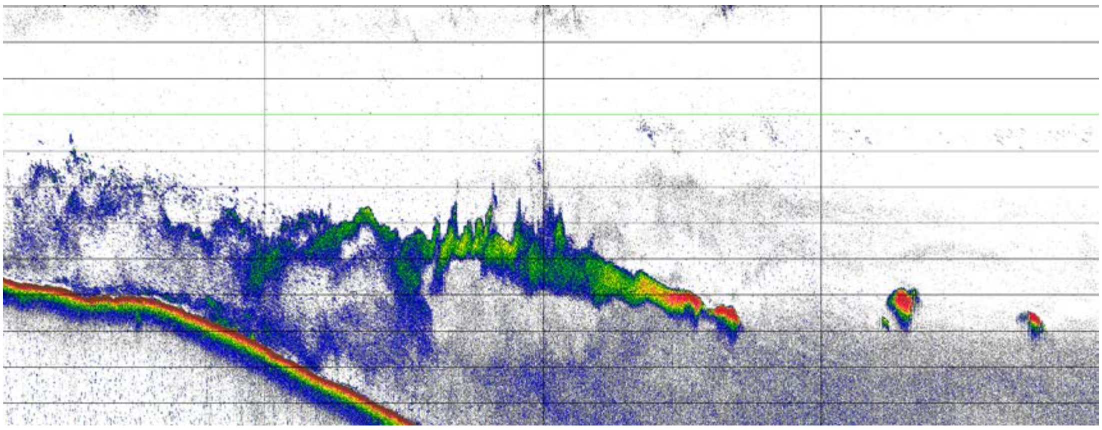
Figure 6. Blue whiting biomass by subarea as used in the assessment.



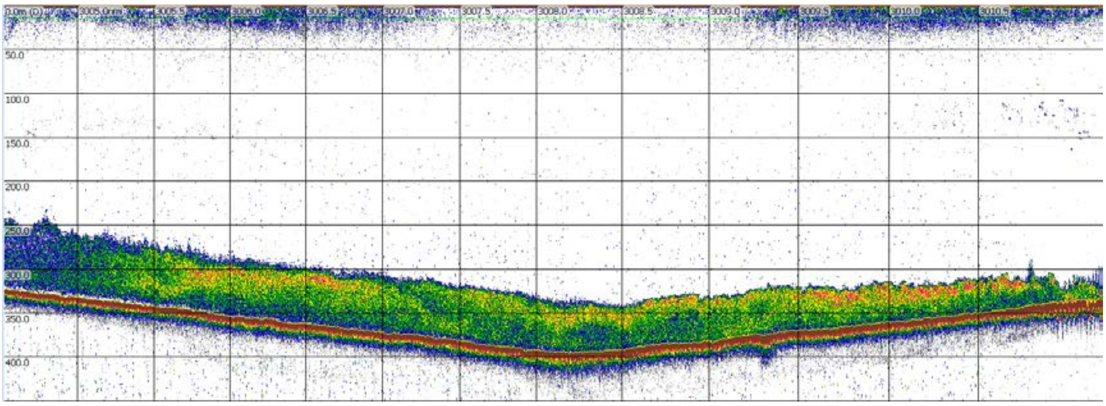
a). Low density blue whiting echotraces recorded to the southwest of the Rockall Bank by the RV *Celtic Explorer*. Such echotraces were typical of those encountered in the area.



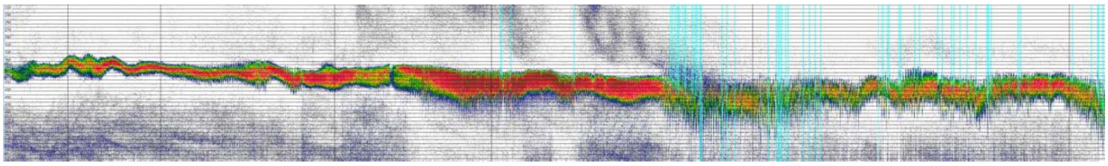
b). High density shelf edge echotrace recorded by the RV *Celtic Explorer*. The haul targeted the upper schools as outlined by the black box and yielded almost 100% 1-year old fish.



c) Blue whiting aggregation encountered by RV *Tridens* on 29.03. 14:41 UTC at 54°36′N 10°55′W.



d) Blue whiting school observed by RV *Tridens* on 28.03 at 6:44 UTC at 53.59N 14.15W.



e) Biggest blue whiting school observed in the survey (by RV *Tridens*), with a length of approximately 21 n.m., including Trawl 8, encountered on 01.04 at 5:40 UTC at 56.61N 10.27W.

Figure 7. Echograms of interest encountered during the combined International blue whiting survey in March-April 2012.

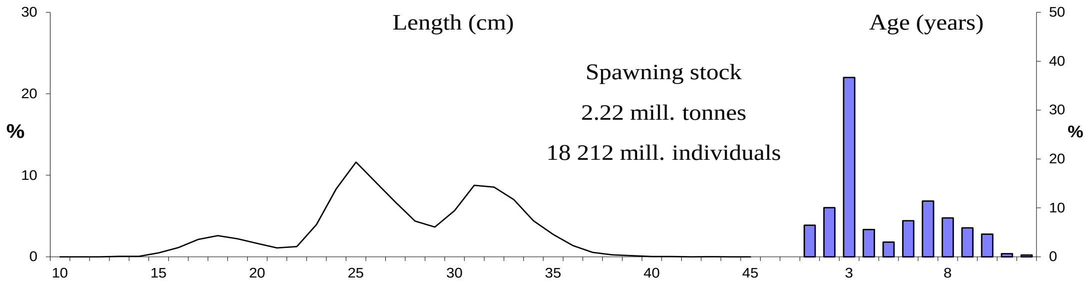


Figure 8. Length and age distributions (numbers) of total stock of blue whiting. Spawning-stock biomass is given. March-April

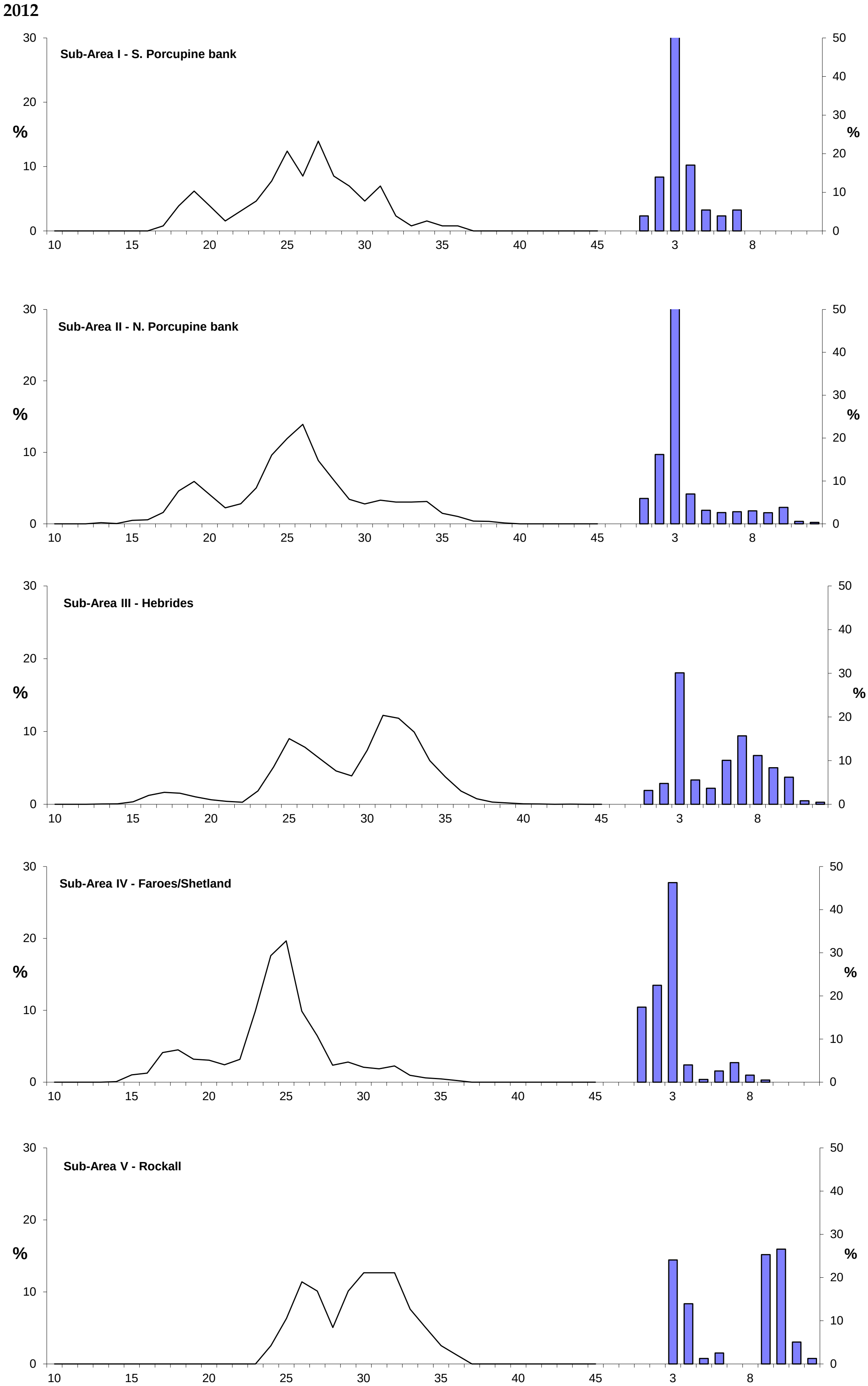


Figure 9. Length and age distribution (numbers) of blue whiting by covered subarea (I–V). March-April 2012.

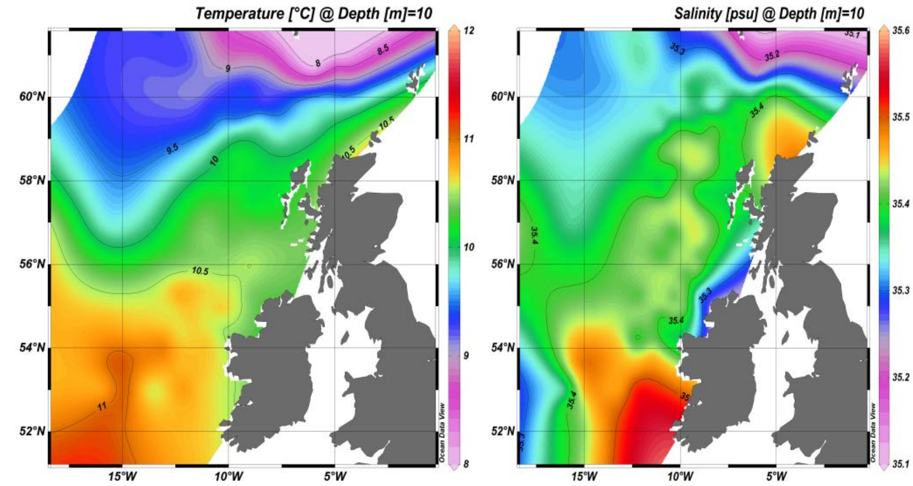


Figure 10. Horizontal temperature (left) and salinity (right) at 10m subsurface as derived from vertical CTD casts. March-April 2012.

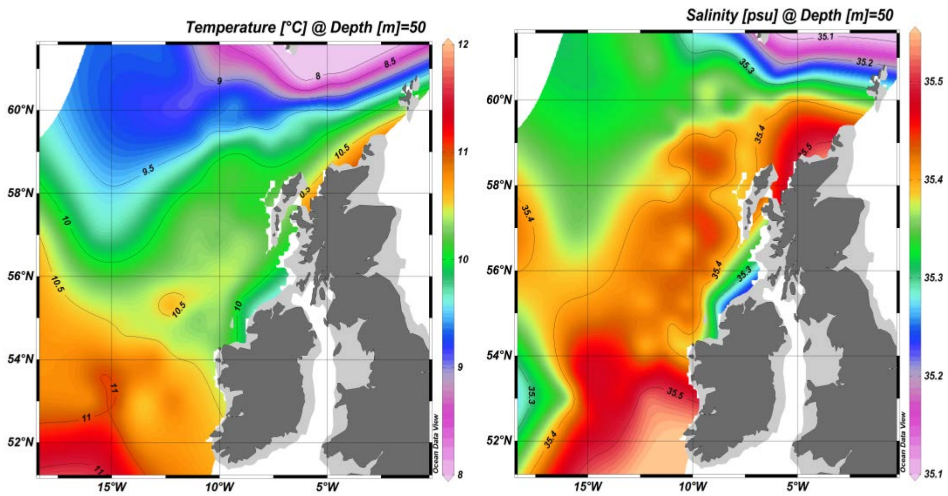


Figure 11. Horizontal temperature (left) and salinity (right) at 50m as derived from vertical CTD casts. March-April 2012.

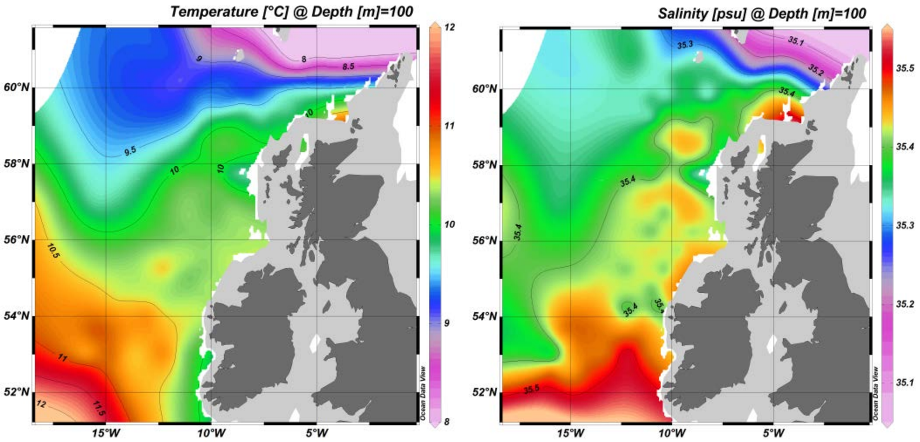


Figure 12. Horizontal temperature (left) and salinity (right) at 100m as derived from vertical CTD casts. March-April 2012.

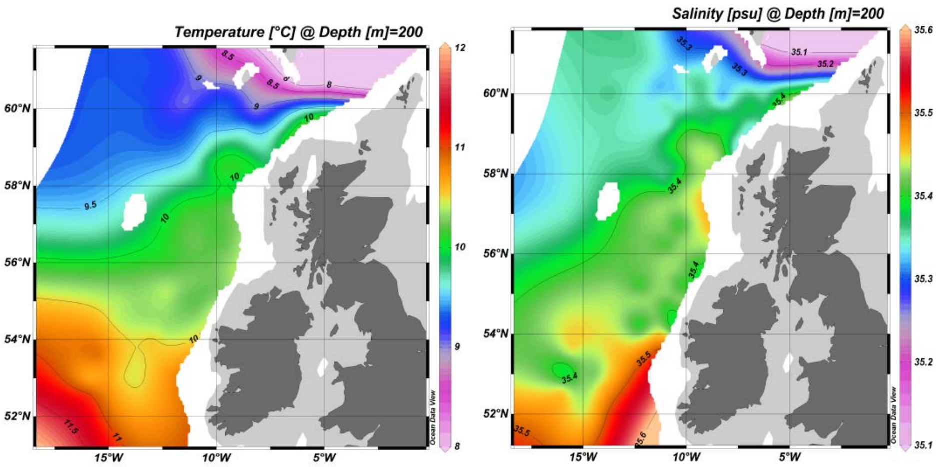


Figure 13. Horizontal temperature (left) and salinity (right) at 200m as derived from vertical CTD casts. Yellow circles indicate CTD positions. March-April 2012.

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

Sascha Fässler and Ciaran O'Donnell

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

When calculating stock estimates from acoustic surveys, the data (acoustics density [s_A] 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 2012 survey as well as eight earlier international surveys. Mean acoustic density over the survey area was 651.6 m^2/n.m.^{2} (as compared to 562.8 m^2/n.m.^{2} in 2011) with 95% confidence interval being 609.4 (lower) and 699.7 (upper) m^2/n.m.^{2}. Relative to the mean, the approximate 95% confidence limits are –6.5% and +7.4%, and 50% confidence limits are –2.3% and +2.2%. This level of uncertainty in acoustic densities is the lowest observed in the time-series so far. It is about half as large as those observed in previous years with the exception of 2007 when a much higher uncertainty was recorded. Overall mean acoustic density has shown a consistent decrease annually since 2007 to 2010 and is now showing an increasing trend over the last two years.

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 2012 estimate shows an increasing trend of the stock as determined from survey data for the first time again since 2007.

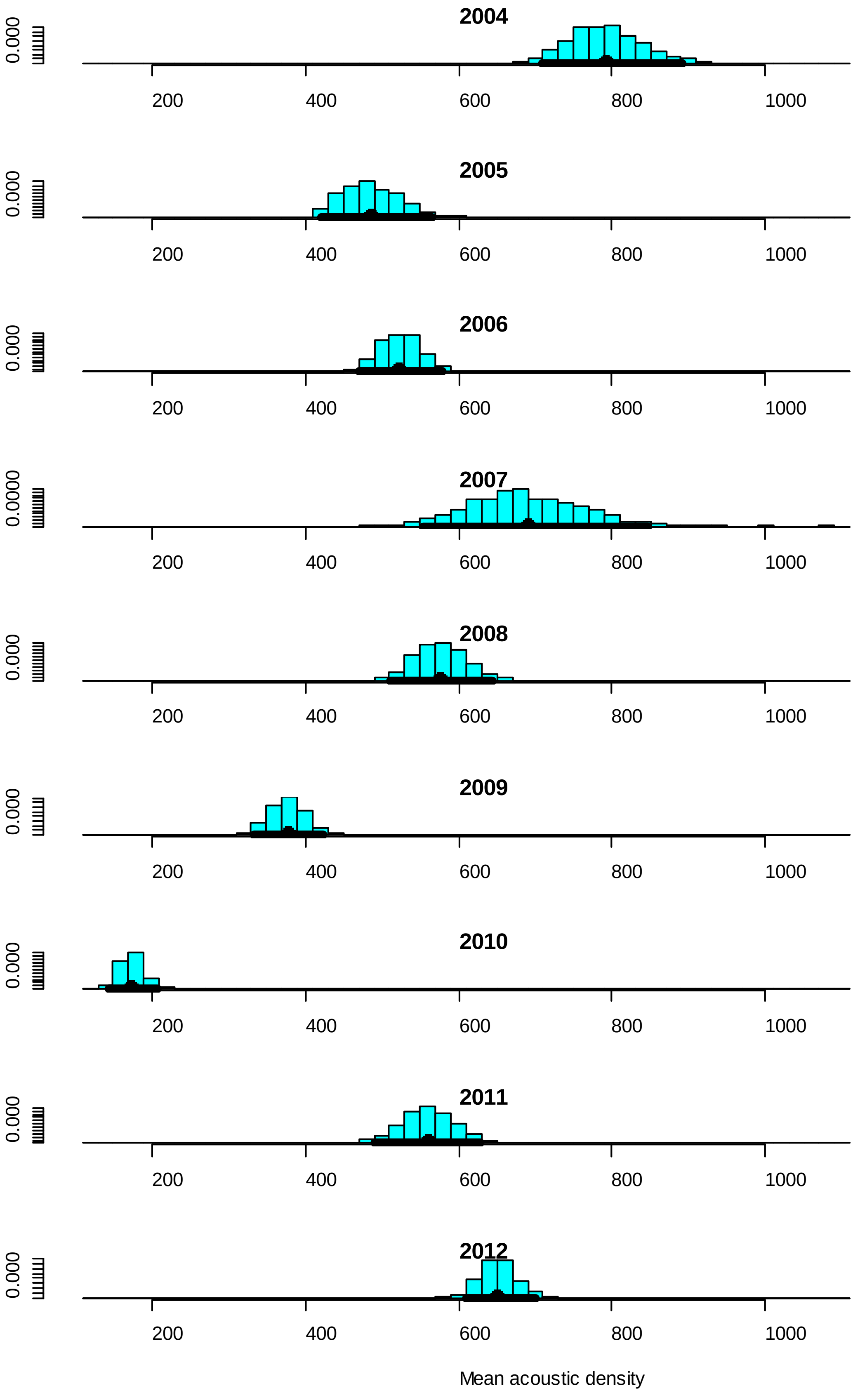


Figure 1. Distribution of mean acoustic density (in m²/n.m.²) by year based on 1000 bootstrap replicates of acoustic data from blue whiting surveys. Mean acoustic density is indicated with a black dot on the x-axis, while the horizontal bar shows 95% confidence limits.

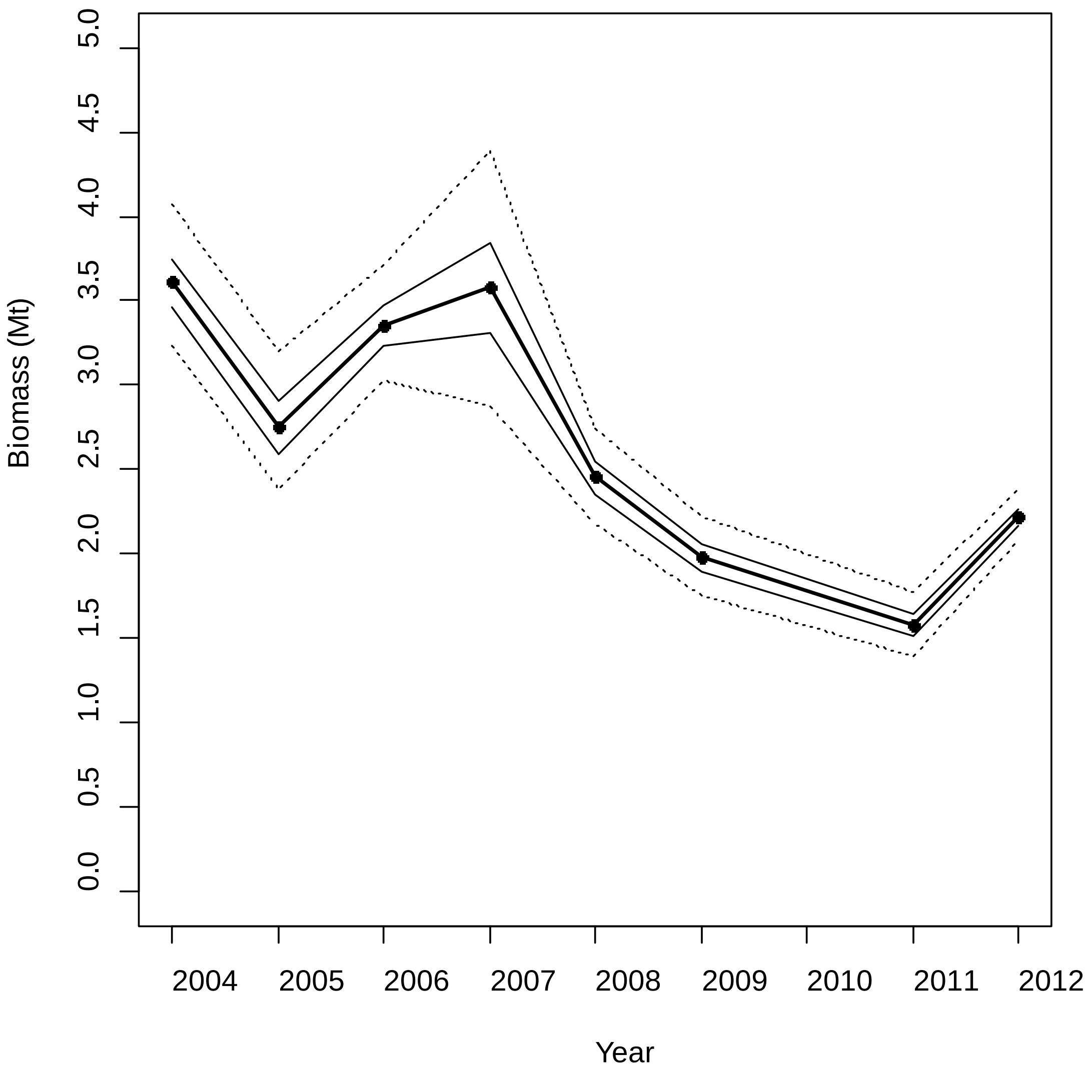


Figure 2. Approximate 50% and 95% confidence limits for blue whiting biomass estimates. The confidence limits are based on the assumption that confidence limits for annual estimates of mean acoustic density can be translated to confidence limits of biomass estimates by expressing them as relative deviations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

Ciaran O'Donnell and Åge Høines

A review of consistency of age readings was carried out using data collected from all nations during 2012. Results show relatively good agreement across age classes and are generally well group when compared to previous years (Figure 1). A broad range of lengths were observed for the oldest (>10 yrs) and youngest (2–3 yrs) age classes which also corresponds to the dominate age groups within the stock. Three year old fish (2009 year-class) had the broadest length range from 15–32.5cm and this can be attributed to the difficulty in aging younger fish due to the mis-interpretation of the Bailey ring. The oldest fish observed from samples was 13 years.

Exchange of expertise is encouraged and an age reading workshop has been recommended to further improve consistency.

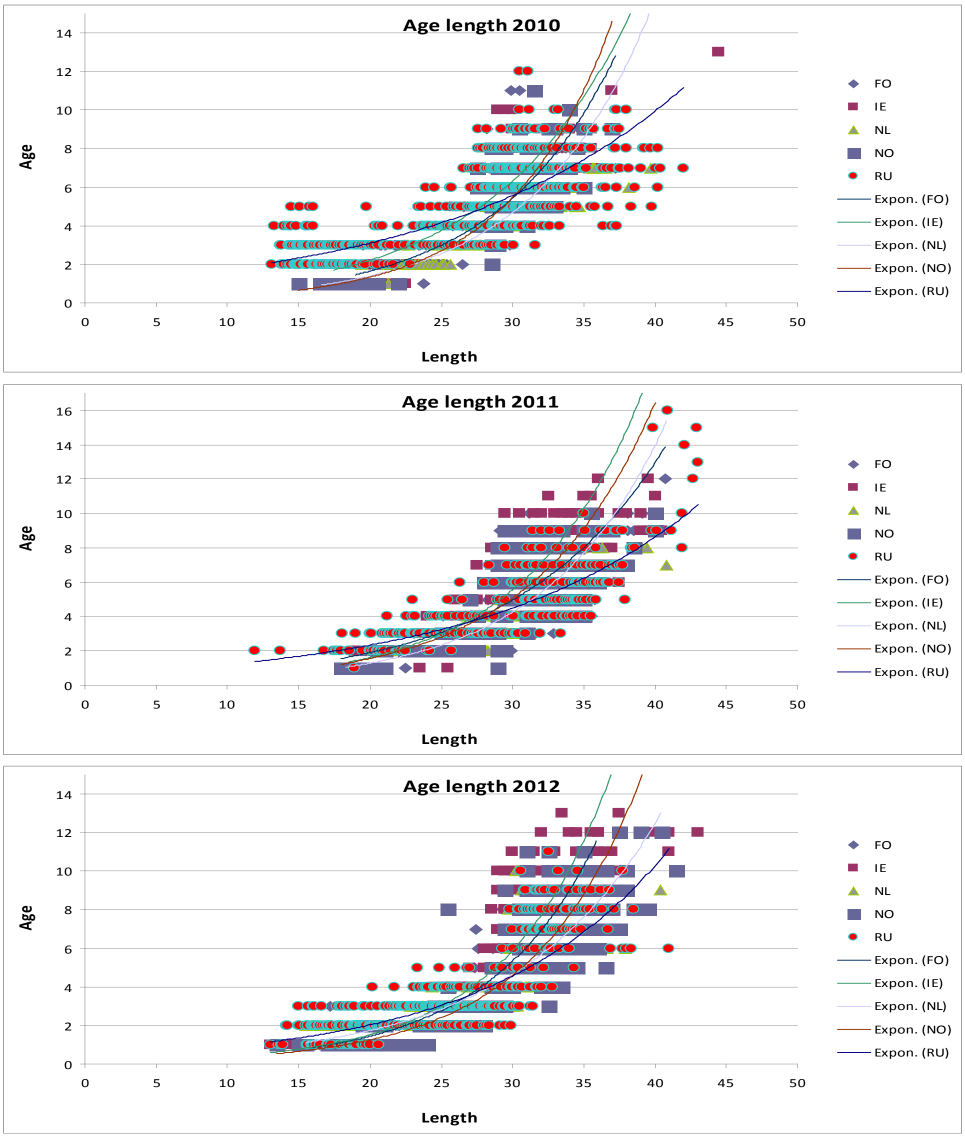


Figure 1. Profile of length-at-age by nation of blue whiting collected during individual surveys from 2010- 2012 (FO; Faroes, IE; Ireland, NL: Netherlands, NO; Norway and RU; Russia).

Appendix 3. Inter-calibration exercise between the RV Celtic Explorer and RV Tridens

Sven Gastauer and Ciaran O'Donnell

Acoustic inter-calibration between RV Celtic Explorer and RV Tridens was conducted on 5 April between 16:00 and 21:00 close to the shelf slope in depths from 600–850 m. The exercise was centred on 59º 35'N and 006º 39'W. Two 10 n.m. transects were undertaken. The first transect was conducted with the Tridens acting as the lead vessel cruising at approximately 10 Kts while the C. Explorer maintained a position of 0.5 n.m. astern and 0.5 n.m. off Tridens starboard quarter. A second 10n.m. transect was then carried out with the C. Explorer as the lead vessel and Tridens following with the same approximate distance and position. Weather conditions were good with light NE winds of 10–15 knots and a northerly swell of 1–2 m.

The main acoustic features in the area were (1) a relatively constant area of blue whiting schools with variable density in depths between 250 and 520 m, (2) a layer of presumed macro-zooplankton from depths over 400 metres, partly mixed with the blue whiting layer in some areas, and (3) mesopelagic fish, in the uppermost of the echogram at 100 to 240 m and a plankton layer to the surface.

Data analysis focused on acoustic densities (c, $m^2/n.m.^2$) allocated to blue whiting (Figure 1). On both vessels the routine procedures were followed for scrutinizing the data. Recordings show variable agreement, as is to be expected from experience of previous exercises. The *Tridens* tended to record much higher acoustic densities during the first 1–12 n.m. than the Explorer, for distances of 12–20 n.m. acoustic densities are more comparable in value (Figure 2). However, it should be noted that this is more likely a result of the geographical distance between the ships on both transects and thus the density of schools observed rather than actual differences in recording capability. When comparing portions of the track which were more closely aligned *Tridens* appears to record higher acoustic densities than the *C Explorer* for similar observations. Again this may be accounted for by the spatial heterogeneity of the patchy schools encountered.

At the end of the acoustic inter-calibration a comparative trawl exercise was undertaken. Both vessels turned and towed in parallel over the reciprocal course at a distance of about 0.8 n.m. apart. Both vessels actively towed for 20 minutes with the trawl headline at c.320 m. *Celtic Explorers'* total catch was 500 kg and composed of blue whiting, *Tridens* had a very similar catch of 490 Kg.

Comparing the size distribution of catches both vessels recorded 15 different length groups (14.5–40 cm). However, *C Explorer* was observed to catch a more varied profile with 3 modal groups dominated by a larger mode of older fish (Figure 3). Mean length of blue whiting was 25.4 for *Tridens* and 29.3 for *C. Explorer. Tridens* catch was dominated by one mode of smaller, younger fish. Comparing trawl gear *Tridens* has a net with a vertical opening of c.90 m as compared to c.45 m for the *C Explorer.* Differences in catchability and of the schools encountered by the trawl are the most likely explanations for the differences in catch profile.

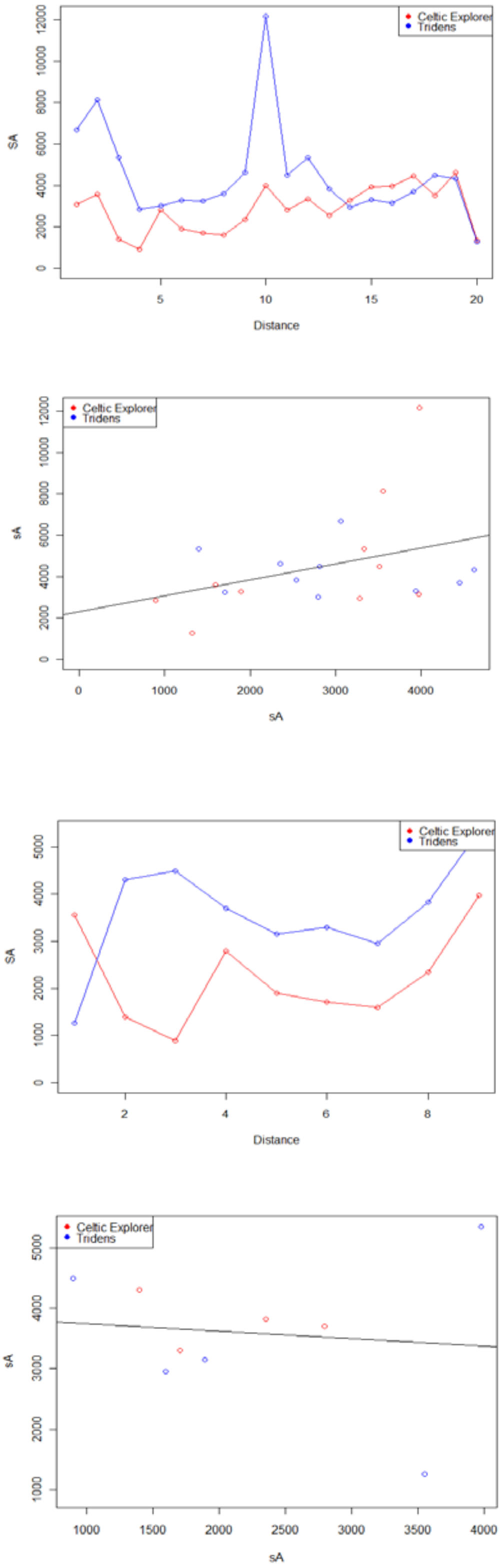


Figure 1. Comparison of blue whiting acoustic densities recorded by vessel for the entire exercise (upper panels) and for those most geographically aligned (lower panels).

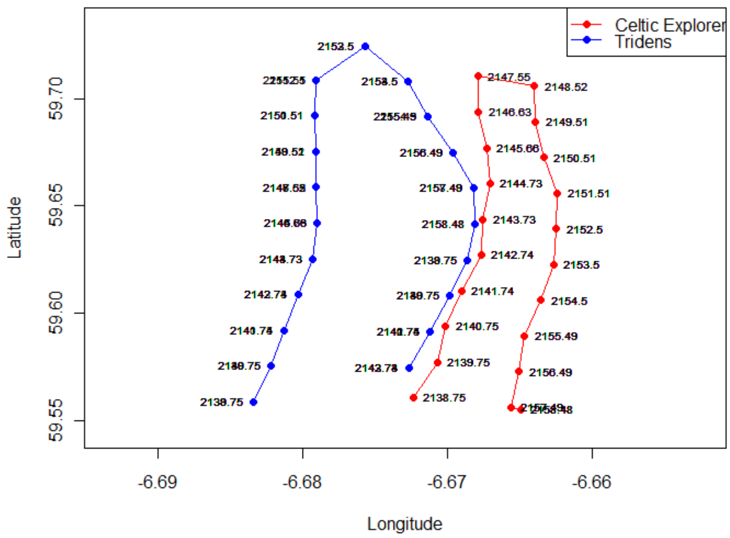


Figure 2. Plot of geographical positions by 1 n.m. log intervals during the inter-calibration track for the entire exercise.

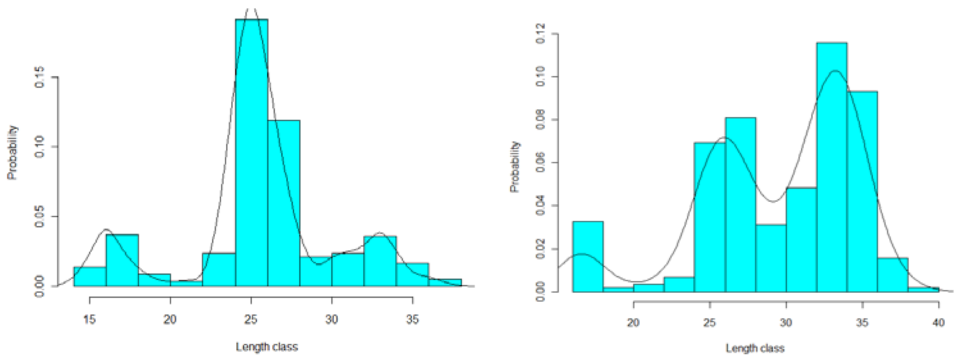


Figure 3. Length distributions from the trawls hauls by *Tridens* (left panel) and *Celtic Explorer* (right panel). Smoothing is obtained by normal kernel density estimates.

Appendix 4. Planned acoustic survey of the NE Atlantic blue whiting spawning grounds (IBWSS) in 2013

Sascha Fässler

Five vessels representing the Faroe Islands, the Netherlands (EU-coordinated), Ireland (EU-coordinated) Norway and Russia are scheduled to participate in the 2013 spawning stock survey.

Survey timing and design were discussed during the meeting. The group decided that in 2013, the survey design should follow the one used during the 2012 survey. The focus will be on a good coverage of the shelf slope in areas II and III, as it is evident that the bulk of the spawning aggregation was found there during the past few years when the stock size was declining (2008–2011). On the other hand, during the first four years of the internationally coordinated survey (2004–2007), when the size of the stock was high, blue whiting aggregations were distributed more evenly over the whole survey area. The adapted survey design in 2012 attempted to take into account this shift in stock distribution. The design is based on variable transect spacing, ranging from 30 n.m. in areas containing less dense aggregation (e.g. subarea I, south Porcupine), to 7.5 n.m. in the core survey area (subarea III, Hebrides; Figure 1). From past surveys it was evident that huge areas in the west of the Rockall Trough contained, if at all, only sporadic and small blue whiting concentrations. The western borders of the transects in subarea III will therefore extend to just 11ºW in order to put more effort on the continental slope. To ensure transect coverage was not replicated, transects were allocated systematically with a random start location.

The aim is to have all but the Faroese vessel start surveying in the north of subarea II (North Porcupine) at the time when the Norwegian vessel begins the survey there (27.03.2013; Table 1). That way, the core survey subarea III can be covered synoptically by 4 vessels with a similar temporal progression.

It was decided that the Dutch and Russian vessels would start the survey in the southern subareas I and II (Porcupine). The Irish Celtic Explorer would first cover subarea IV (on southwest Rockall Bank). 2–4 days after beginning their individual surveys, these vessels will join the Norwegian vessel surveying the north of subarea II and afterwards area III from the south progressing northwards. Once the Norwegian 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. Survey extension in terms of coverage (52–61ºN) will be in line with the time-series 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 4 vessels covering the core Hebrides area are present on station in the north of subarea II (just north of Porcupine Bank) on 27 March 2013 (Table 1). Nonetheless, if some vessels are found to lack behind others, the tight 7.5 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.

Preliminary cruise tracks for the 2012 survey are presented in Figure 1. As survey coordinator in 2013, Sascha Fässler (Netherlands) has been tasked with coordinating contact between participants prior to and during the survey. Detailed cruise lines for each ship will be circulated by the coordinator to the group as soon as final vessel availability and dates have been communicated (end of January 2013).

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 2012 WGIPS meeting. The survey will be carried out according to survey procedures described in the "Manual for Acoustic Surveys on Norwegian Spring-spawning Herring in the Norwegian Sea and Acoustic Surveys on Blue whiting in the Eastern Atlantic" (PGNAPES report 2008).

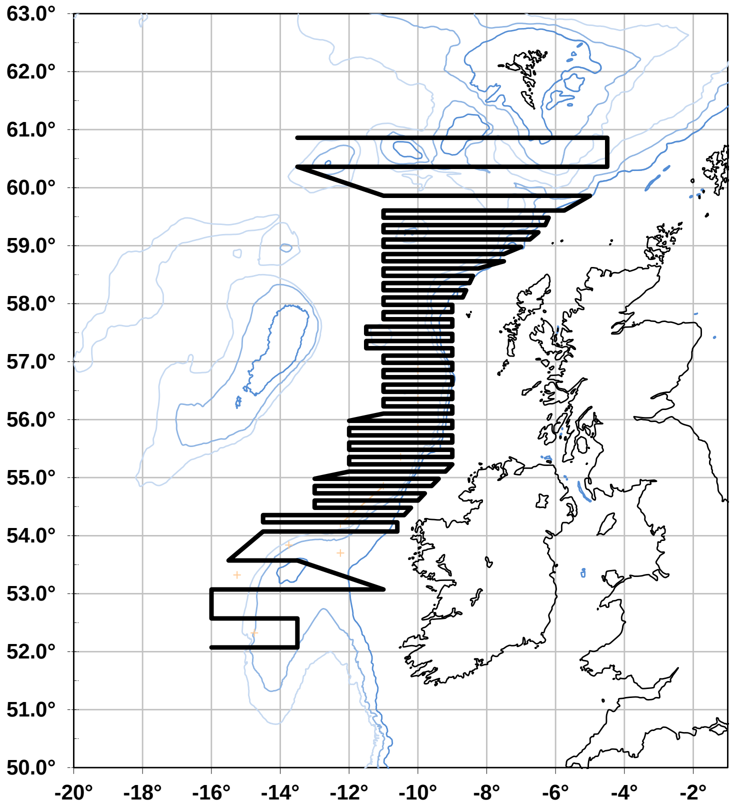


Figure 1. Preliminary survey tracks for the combined 2013 International Blue Whiting Spawning stock Survey (IBWSS). Additional transects in the Rockall and Faroes/Shetland areas will be planned later by the respective participants covering those areas.

Table 1. Individual vessel dates for the 2013 International Blue Whiting Spawning stock Survey (IBWSS).

Ship	Nation	Active survey time (days)	Preliminary survey dates
G.O. Sars	Norway	17	27.3.2013 – 12.4.2013
Fridjof Nansen	Russia	19	23.3.2013 – 10.4.2013
Celtic Explorer	Ireland (EU)	19	23.3.2013 – 10.4.2013
Tridens	Netherlands (EU)	17	25.3.2013 – 10.4.2013
Magnus Heinason	Faroes	17	27.3.2013 – 12.4.2013

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

Working Document

Working Group on International Pelagic Surveys

Reykjavík, Iceland, June 2012

Working Group on Widely distributed Stocks

INTERNATIONAL ECOSYSTEM SURVEY IN NORDIC SEA (IESNS) IN April – June 2012

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Introduction

In April-June 2012, 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 Johan Hjort, 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 Faroes, Iceland, Norway and Russia in 1995. Since 1997 also the EU participated (except 2002 and 2003) and from 2004 onwards it was more integrated into an ecosystem survey. This report is compilation of data from this International survey stored in the PGNAPES databases and supported by national survey reports from each survey (Dana: Anonymous 2012a, Magnus Heinason: FAMRI 2012, Arni Friðriksson: Oskarsson and Sveinbjornsson 2012, Fridtjof Nansen: PINRO 2012 and G. O. Sars: not (yet) available.

Material and methods

Coordination of the survey was initiated at the meeting of the Working Group on Northeast Atlantic Pelagic Ecosystem Surveys (WGNAPES) in August 2011 (ICES CM 2012/SSGESST:22), and continued by correspondence until the start of the survey. The participating vessels together with their effective survey periods are listed in the table below:

Vessel	Institute	Survey period
Dana	Danish Institute for Fisheries Research, Denmark	24/4–23/5
Johan Hjort	Institute of Marine Research, Bergen, Norway	3/5–30/5
Fridtjof Nansen	PINRO, Russia	17/5–2/6
Magnus Heinason	Faroe Marine Research Institute, Faroe Islands	2–15/5
Arni Friðriksson	Marine Research Institute, Island	2/5–25/5

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 eastern area the weather conditions were generally excellent during the survey.

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

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

	Dana	J. Hjort	Arni Friðriksson	Magnus Heinason	Fridtjof Nansen
Echosounder	Simrad EK 60	Simrad EK 60	Simrad EK60	Simrad EK60	ER 60
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	8.7	8	3	7
Upper integration limit (m)	5	15	15	7	10
Absorption coeff. (dB/km)	6.9	9.6	10	10	10
Pulse length (ms)	Medium	1.024	1.024	1.024	1.024
Bandwidth (kHz)	Wide	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	-20.9	-20.9
Sv Transducer gain (dB)					27.3
Ts Transducer gain (dB)		27.64	24.64	24.85	27.64
s_A correction (dB)		-0.73	-0.84	-0.59	-0.61
3 dB beam width (dg)					
alongship:	6.8	6.9	7.31	7.24	6.9
athw. ship:	6.86	6.8	6.95	7.12	6.8
Maximum range (m)	500	500	750	500	750
Post-processing software	LSSS	LSSS	LSSS	Sonardata Echoview 5.1	FAMAS

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

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

Catches from trawl hauls was sorted and weighed; fish were identified to species level, when possible, and other taxa to higher taxonomic levels. Normally a subsample of 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). Traditionally the following target strength (TS) function has been 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

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

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

Results

Hydrography

The temperature distributions in the ocean at selected depths between the surface and 400 m are shown in Figures 4–9. The temperatures at the surface ranged between < 1°C in the western part and > 8°C in the southern part of the survey area. 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 but was most pronounced at greater depths. With depth, temperatures decreased to values < 0°C particularly north and west of the Arctic front because here it is located in Arctic water masses while south and east of the front the temperature drop was not as pronounced as it is more influenced by Atlantic water masses. The warmer North Atlantic water formed a broad tongue that stretched far northwards along the Norwegian coast with temperatures > 6 °C in the surface layers. Relative to an 18 years long-term mean, from 1995 to 2012, the temperatures at 100 m depth southeast of Iceland and north of the Faroese were considerable lower in 2012 compared to the long-term mean (Figure 10a). There, the anomalies were in some areas less than -1°C. Northeast of Iceland the temperature anomalies were, however, above 1°C. In contrast to 2012 the temperatures at 100 m depth for 2011 were close to the long-term-mean for nearly the whole area (Figure 10b). Thus, the temperature difference at 100 m depth between the years 2012 and 2011 (Figure 11) had approximately the same pattern as the temperature anomaly for 2012; negative anomalies in a band southeast of Iceland and positive anomalies northeast of Iceland.

Time-series of temperature

Temperature and salinity measurements are taken regularly at several standard hydrographic sections around Iceland (Figure 12). At the Langanes-NE section, the temperature during spring, averaged between 0–50 m depth, increased from 2011 to 2012 at station 5 on the shelf (Figure 13a). Further offshore, the temperature (0–50 m) at the stations 6–7 dropped substantial (0.7–1.2 °C) from 2011 to 2012 (Figure 13b,c). In contrast, the time-series of temperature averaged between 80 and 120 m depth (instead of 0–50 m) showed a warming from 2011 to 2012 at station 7. This is also consistent with the temperature difference (2012–2011) at 100 m depth (see Figure 11).

Zooplankton

Biomass of zooplankton and sampling stations are shown in Figure 15. 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 and still at low level even if it is higher than the lowest recorded value in the time-series in 2009 (Figure 16). Recorded zooplankton biomass in the two areas west and east of 2°W equaled 4.7 and 6.7 g dry weight m^{-2}, while total mean was 5.9 g dry weight m^{-2}.

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

Norwegian Spring-spawning herring

Survey coverage in the Norwegian Sea was considered adequate in 2012 and in line with previous years. The herring in 2012 was found in the highest concentrations in two distinct areas, in the southeastern part of the Norwegian Sea and in the western part (Figure 17). The third main concentration was in the north (70°N and 15°E) and consisted mainly of 2 and 3 year old herring. Overall the herring density was relatively low and herring was never observed in big schools. In the western part it was mainly found at 100–400m depth, even if shallower registrations existed, but generally shallower in the eastern part (Figure 23). There were some differences in the herring distribution this year (Figure 17) compared to 2011, even if the areas with herring registrations were more or less the same. Compare to the southeast and westerly main distribution in 2012, the herring was more concentrated in the central part of the Norwegian Sea in 2011 and with the highest acoustic values recorded central there. In 2012, like in 2011, almost no herring were observed north of 70°N, while it was found further north in 2010. Because of this, the center of gravity of the acoustic recordings shifted in a southeasterly direction compared to 2011 (Figure 18).

As in previous years the smallest fish were found in the northeastern area where size and age were found to increase to the west and south (Figure 19). Correspondingly, it was mainly older herring that appeared in the southwestern areas (area III), especially the 2002 and 2004 year-classes, compare to mainly the 2004 year-class further east and the 2009 year-class furthest north.

The herring stock is now dominated by 8 year old herring (2004 year-class) in numbers but 6, 7, 9 and 8 year old herring (the 2006, 2005, 2003 and 2002 year-classes) are also numerous (Table 2). The 2009 year-class appears to be largest of the younger age groups even if it is relatively small in historical perspective. The five year-classes from 2002 to 2006 contribute to 14%, 12%, 26%, 13% and 10%, respectively, of the total biomass.

The total biomass estimate of herring from the 2012 survey came to 4.6 million tons. This estimate is 1.8 million tons lower than in 2011. The biomass estimates in recent four years has fluctuated, or 10.7 million tons in 2009, 5.8 million tons in 2010, 7.4 million tons in 2011 and now 4.6 million tons. The uncertainty, or the CV, round the estimates is unknown, but might be considerable considering the recent fluctuations, even if the downward trend in the biomass is apparent.

The investigations of herring in the Barents Sea covered the area from 40°E to the 20°30′ E, or similar coverage as in last year. Herring was only observed in the western most part of the Barents Sea. The total abundance estimates were low, or 370 millions of age 1 (mean length of 17.4 cm and mean weight of 32.8 g) and 120 millions of age 2 herring (mean length of 23.5 cm and mean weight of 83.0 g). Older herring was not observed there.

The total number of herring recorded in the Norwegian Sea was 12.8 billion in the northeastern area and 7.2 billion in the southwestern area, compared to 22.7 billion and 7.9 billion in last year, respectively. Thus the reduction in the abundance estimate compare to 2011 is apparently mainly in the northeastern area, or 44% compare to 9% in the southwestern area.

Blue whiting

The total biomass of blue whiting registered during the May 2012 survey was 0.87 million tons (Table 3), which is three times the biomass estimate in 2011 when accounting for the new TS used in this year's survey (see above). The total biomass estimate now is comparable to the 2007 estimate. The stock estimate in number for 2012 is 15.7 billion, which is more than five times the 2011 estimate and more than 28 times the 2010 estimate. The main reason for an increased estimate of blue whiting is the high estimate of 1 year old, which came to 11.1 billions individuals. The number of other recruits was 3.2 billions of 2 year olds, and 0.5 billions of 3 year olds. These three year-classes constituted to 94% of the total number and 76% of the total biomass. Such high values of recruits have not been seen since the survey in 2006 which had a similar values when considering the changes in the TS (i.e. around 3.3 times the current values corresponds to the old value).

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 1 but also considerable amount of age 2.

Blue whiting were observed both in connection with the continental slopes of Norway and south and southwest Iceland and in the in the open sea in the southern part of the Norwegian Sea (Figure 20). The mean length of blue whiting is shown in Figure 21. It should be noted that the spatial survey design was not intended to cover the whole blue whiting stock during this period.

Mackerel

In later years an increasing amount of mackerel has been observed in the Norwegian Sea during the combined survey in May targeting herring and blue whiting. The edge of the distribution has also been found progressively further north and west. In 2012 the mackerel was mainly found in the eastern part of the survey area up to 68°N (Figure 22). In the western part, or west of 0°E, it was only observed in two trawl hauls and not in the northwestern part of the survey area as in 2011. This changed distribution relative to last year is probably caused by the relatively cold temperature in the southwestern part of the area.

Discussion

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

Hydrography

Discussions related to the oceanographic condition in April/July 2012 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

Recent years decrease in zooplankton biomass until 2010 (Figure 16) have been dramatic in the sense that biomass in the cold water has decreased by 80% since 2003, while in the warmer water biomass has decreased by 55% since 2002. The reason for this drop in biomass is not obvious to us. The unusually high biomass of pelagic fish feeding on zooplankton has been suggested to be one of the main causes for the reduction in zooplankton biomass (ICES, 2008). However, carnivorous zooplankton and not pelagic fish are the main predators of zooplankton in the Norwegian Sea (Skjoldal *et al.*, 2004), and we do not have good data on the development of the carnivorous zoo-plankton stocks. A fairly strong relationship between NAO and zooplankton biomass was observed, particularly during the late 1990s (ICES, 2006). However, this relation-ship seems to be less pronounced now. During 2008 and 2009 the western part of the Norwegian Sea cooled due to input of more Arctic water. The eastern Norwegian Sea has become warmer mainly due to input of warmer Atlantic water. In 2010 the southeastern Norwegian Sea cooled a bit (probably surface cooling during the cold winter this year). The Arctic water masses in the west spread further eastward compared to 2009. The warming of the Atlantic water masses did not seem to be in favour of in-creased zooplankton production in the Norwegian Sea. The cooling of the eastern Norwegian Sea was followed by increased biomass in 2010. This increase flattened in 2011, but then we saw a markedly increase in the zooplankton biomass of the western Norwegian Sea. The increase in the western part happened despite the water masses still being cool in this region. This increase was large enough to bring about an increase for the whole area. Now in 2012 the mean zooplankton dry weight over the whole area is a bit lower than in 2011, and it is mainly due to decrease in the western part from 6.8 g m^{-2} in 2011 to 4.7 g m^{-2}. In the eastern part it was in fact increase in the mean dry weight from 6.0 g m^{-2} in 2011 to 6.7 g m^{-2}. Summing up, the reason for the observed changes in zooplankton biomass is not clear to us and more research to reveal this is recommended.

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 situation in the feeding areas in May.
Similarly to the previous seven years, it was decided not to draw up a suggested herring migration pattern for 2012 due to lack of data. However, the general migration pattern is believed to resemble that of 2003 with the exception that the herring as in the previous years had a somewhat more southerly and westerly distribution than in 2003. There was, however, a southeastward shift of the center of gravity of the distribution in 2012 compared to 2011 and the herring was more concentrated in the southeasterly and southwesterly part of the Norwegian Sea.

The amount of herring measured in the 2012 survey was 40% lower than in 2011. The biomass estimates in recent four years has fluctuated, or 10.7 million tons in 2009, 5.8 in 2010, 7.4 in 2011 and now 4.6 million tons. The uncertainty, or the CV, round the estimates is unknown, but might be considerable considering the recent fluctuations, even if the downward trend in the biomass is apparent. Considering these recent fluctuations, work to estimate the CV of the acoustic estimate in the survey is required and encouraged. Thus, if the low abundance estimate is a consequence of high CV of the survey or possible increase in natural mortality due to diseases, parasites, or other reasons cannot be evaluated at present.

Concerns were raised in last two years WGNAPES reports about the ageing of the herring, particularly the numerous 2002 year-classes, because the age distribution from the different participants shows some difference. This is likely due to variable growth conditions for the stock and consequently growth rate as seen on the fish scales and otoliths. The effects of this are that there are shifts between years in the relative proportions of the different year-classes. Consequently, the survey group recommends that a workshop should be held as soon as possible, preferable in winter 2012/2013, for all age readers of herring that participate in this survey and those ageing catch samples from the stock to verify this issue and standardize their methodology.

Blue whiting

The abundance estimate of blue whiting indicates that a big year-class is finally appearing after period of small year-classes since 2004. 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. This positive sign continues now on a higher level. The number of 1 year old in the standard area (Table 4) is at similar level as the 2002 year-class measured in the 2003 survey when accounting for the new TS and it comes to 63% and 58% of the corresponding estimates for the 2003 and 2004 year-classes, respectively.

General recommendations and comments

- The survey group involved in the International ecosystem survey in the Nordic Seas in May (IESNS) strongly recommends that the WGNAPES will be reinstated. Because of the emerge of the WGNAPES with WGIPS in 2011, the data from the survey have to be compiled, analysed, and reported during a post cruise meeting so the results will be available for WGWIDE in August. The same group of scientist participating in this work during WGNAPES are needed for the post cruise meeting, but that is apparently not always fulfilled. What remains then after the post-cruise meeting is the planning of the survey for next year, which is the only subject of WGIPS in practice for this survey but still needs participations of the same scientists. Furthermore, data from the International summer ecosystem survey in the Nordic Seas (IESSNS) have also been compiled and reported during the WGNAPES meetings. That work is now also done during another post-cruise meeting prior to the WGWIDE in August and partly with the same scientists as working on IESNS. Thus, considering the timing of the surveys (IESNS and also IESSNS), the deadline for reports for WGWIDE, requirements and presence of scientists to work on the data and reports, and total meeting days, the survey group request that WGNAPES will be reinstated.

- 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 scruitinization are following the same general procedure. The workshop should preferably take place during autumn/winter 2012/2013, or prior to the surveys in 2013.
- In the northern part of the survey area in 2012 the number of trawl hauls was less than needed to have required knowledge of the combination of the acoustic recordings. This was because the trawl winches of RV Dana broke down in the latter part of the survey.

Concluding remarks

- The estimate of NSSH was considerable lower compared to last year
- NSSH was dominated by the 2004 year-class
- 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 much higher than previous years and at a level compare to 2006.
- The blue whiting stock shows a clear signs of improved recruiting with numerous 1 year old fish (2011 year-class).
- Total biomass estimate of blue whiting was five times higher now than in 2011 mainly due to recruiting year-classes (age 1), which have hardly been seen in the most recent years, except for a clear improvement in 2011 (age 1 and 2).
- The increased southwesterly distribution of mackerel in recent years was less apparent in 2012, while it was found towards north in the eastern part as in recent years.

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Tables

Table 1. Survey effort by vessel for the International ecosystem survey in the Nordic Seas in April-June 2012.

Vessel	Effective survey period	Length of cruise track (nm)	Trawl stations	CTD stations	Plankton station
Dana	29/4-18/5	3317	10	35	35
J. Hjort	3/5-30/5	4067	46	83	80
Fridjof Nansen	17/5-2/6	2185	19	96	85
Magnus Heinason	3/5-15/5	1790	17	28	25
Arni Friðriksson	2/5-25/5	4576	29	61	61
Total	29/4-2/6	15935	121	303	286

Table 2. Age and length-stratified abundance estimates of Norwegian spring-spawning herring in April-June 2012 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	118	0	0	0	0	0	0	0	0	0	0	0	0	0	0	118	3.1	25.9
17	171	33	0	0	0	0	0	0	0	0	0	0	0	0	0	204	6.7	33
18	82	278	139	0	0	0	0	0	0	0	0	0	0	0	0	499	21.4	42.8
19	0	897	0	0	0	0	0	0	0	0	0	0	0	0	0	897	44.8	50
20	0	290	48	0	0	0	0	0	0	0	0	0	0	0	0	338	19.8	58.6
21	0	62	62	0	0	0	0	0	0	0	0	0	0	0	0	124	9.2	74.1
22	0	16	79	0	0	0	0	0	0	0	0	0	0	0	0	95	8	84.8
23	0	118	301	17	0	0	0	0	0	0	0	0	0	0	0	436	39.3	90.2
24	0	0	309	12	0	0	0	0	0	0	0	0	0	0	0	321	33.2	103.3
25	0	0	471	0	0	0	0	0	0	0	0	0	0	0	0	471	54.4	115.5
26	0	12	533	12	0	0	0	0	0	0	0	0	0	0	0	557	72.9	130.6
27	0	0	375	20	10	0	0	0	0	0	0	0	0	0	0	405	59.7	147.4
28	0	0	294	40	0	13	0	0	0	0	0	0	0	0	0	347	55.8	160.5
29	0	0	269	92	46	0	0	0	0	0	0	0	0	0	0	407	74.7	183.3
30	0	0	58	73	54	69	35	10	0	0	0	0	0	0	0	299	61.5	205.3
31	0	0	35	94	176	236	142	95	0	23	0	23	0	0	0	824	185.2	224.3
32	0	0	23	47	393	870	677	675	59	23	0	0	23	0	0	2790	677.6	242.8
33	0	0	0	12	131	440	963	1881	421	240	36	24	12	0	0	4160	1090.7	262.3
34	0	0	0	0	26	175	415	1381	899	951	42	42	31	8	0	3970	1112.4	280.3
35	0	0	0	0	5	44	139	442	413	702	119	180	86	33	10	2173	647.1	297.7
36	0	0	0	0	0	4	4	79	72	231	97	172	85	25	11	780	249.1	319.6
37	0	0	0	0	0	0	0	3	14	51	6	85	45	23	11	238	80.3	337.2
38	0	0	0	0	0	0	0	0	0	0	0	5	21	10	16	52	18.8	361.4
39	0	0	0	0	0	0	0	0	4	0	4	0	0	0	0	8	2.9	384.6
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0.4	424.9
41																0		
42																0		
N mill.	371	1706	2996	419	841	1851	2375	4566	1882	2221	304	531	303	99	49	20514	4629	

Table 2. (cont'd)

Area 1

Age	1	2	3	4	5	6	7	8	9	10	11	12+	Total
Number 10^6	371	118											489
Biomass 10^3	12.2	9.8											22.0
Mean length (cm)	17.4	23.5											18.9
Mean weight (g)	32.8	83											44.9

Area 2

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
Number 10^6	0	1588	2976	390	684	1327	1441	2832	639	671	84	108	62	14	11	12827
Biomass 10^3		82	377	74	157	322	369	748	179	189	24	31	18	5	4	2577.9
Mean length (cm)		20	26	30	32	33	34	34	35	35	35	35	35	38	39	. 30.0
Mean weight (g)		52	127	189	229	242	256	264	280	282	289	282	286	334	380	200.9

Area 3

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
Number 10^6	0	0	21	29	156	522	935	1737	1243	1551	220	422	241	84	37	7198
Biomass 10^3	0.0	0.0	3.7	7.1	41	135	246	475	354	455	67	132	75	27	12	2028.9
Mean length (cm)	0	0	29	32	33	33	33	34	34	35	36	36	36	36	37	34.3
Mean weight (g)	0	0	181	245	260	259	264	274	285	293	305	313	313	316	325	282

Area 3 and 4 (Norwegian Sea)

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
Number 10^6	0	1588	2995	415	844	1835	2321	4346	1890	2338	329	615	344	112	54	20026
Biomass 10^3	0.0	82	381	80	200	454	598	1159	531	674	98	188	106	35	18	4605
Mean length (cm)	0	20	26	30	32	33	33	34	35	35	36	36	36	37	37	31.5
Mean weight (g)	0	54	127	193	235	247	259	268	283	290	301	306	307	318	340	229.9

Total all areas

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
Number 10^6	371	1706	2996	419	841	1851	2375	4566	1882	2221	304	531	303	99	49	20514
Biomass 10^3	12	92	381	81	197	457	615	1223	533	644	91	163	93	31	16	4629
Mean length (cm)	17	20	26	30	32	33	33	34	35	35	36	36	36	37	38	31.2
Mean weight (g)	33	54	127	193	235	247	259	268	283	290	301	306	307	318	335	225.6

Table 3. Age and length-stratified abundance estimates of blue whiting in April-June 2012, west of 20°E for total area and abstracts of estimates for subareas II and III.

Length	1	2	3	4	5	6	7	8	9	10	11	12+	Number	Biomass	Weight
10													0		
11													0		
12													0		
13													0		
14													0		
15	14	14	0	0	0	0	0	0	0	0			28	0.6	20.8
16	164	119	0	0	0	0	0	0	0	0			283	6.5	22.9
17	1309	565	0	0	0	0	0	0	0	0			1874	51.4	27.4
18	2309	799	0	0	0	0	0	0	0	0			3108	100.6	32.4
19	1985	380	0	0	0	0	0	0	0	0			2365	91.2	38.6
20	1934	340	0	0	0	0	0	0	0	0			2274	101.8	44.8
21	1915	367	0	0	0	0	0	0	0	0			2282	117.7	51.6
22	1036	275	2	0	0	0	0	0	0	0			1313	77.5	59
23	276	241	22	0	0	0	0	0	0	0			539	37.3	69.3
24	85	5	42	0	0	0	0	0	0	0			132	10.6	80.7
25	33	38	53	46	0	0	0	0	0	0			170	16.1	94.8
26	1	17	62	15	0	0	0	0	0	0			95	10	105.6
27	0	4	246	23	0	0	0	0	0	0			273	32.8	120
28	0	0	54	62	0	0	0	0	0	0			116	16.3	139.5
29	0	0	5	29	6	3	8	2	0	0			53	7.9	150.3
30	0	0	1	27	25	33	7	4	1	0			98	16.8	172.2
31	0	0	23	1	33	42	5	25	0	0			129	23.3	179
32	0	0	0	16	5	49	18	0	0	0			88	18	201.5
33	0	0	0	0	27	101	57	21	0	0			206	47.8	233.1
34	0	0	0	0	42	48	72	4	0	0			166	42.3	255.6
35	0	0	0	0	0	21	30	6	0	0			57	15.9	276.7
36	0	0	0	0	0	33	10	5	0	0			48	13.2	272.3
37	0	0	0	0	0	14	0	14	0	0			28	7.7	269.6
38	0	0	0	0	0	4	0	0	0	0			4	1.5	374
39	0	0	0	0	0	0	4	4	0	0			8	2.7	319
40	0	0	0	0	0	0	0	0	0	3			3	1	350
41													0		
42													0		
43													0		
Number 10^6	11061	3164	510	219	138	348	211	85	1	3	0	0	15740	869	

Total area

Age	1	2	3	4	5	6	7	8	9	10	11	12+	Number	Biomass
Biomass 10^3	468	131.6	58.7	29.8	29.4	79.5	50.6	19.7	0.2	1			869	868.5
Length cm	20	19.8	27.1	28.3	32.6	33.6	34	34	30.5	40.5				21
Weight g	42.3	41.6	115.1	136.1	211.9	227.9	239.9	232.1	170.6	350				55.2

Area II

Age	1	2	3	4	5	6	7	8	9	10	11	12+	Number	Biomass
Biomass 10^3	408.3	128.5	49	25.3	23	55.4	32.4	14.7					736.6	736.7
Length cm	19.8	19.7	27.1	28.2	32.8	33.6	34.4	33.9						20.6
Weight g	40.8	41	114	133.7	221.3	238.1	262.8	234.4						51.6

Area III

Age	1	2	3	4	5	6	7	8	9	10	11	12+	Number	Biomass
Biomass 10^3	59.7	3.1	9.6	4.5	6.4	24.2	18.2	4.9	0.2	1			131.8	131.8
Length cm	21.5	25.5	27	29.3	31.8	33.6	33.5	34.6	30.5	40.5				24.2
Weight g	56.6	102.6	120.9	151.4	183.9	207.7	207.7	225.6	170.6	350				90.4

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

Length	1	2	3	4	5	6	7	8	9	10	11	12+	Number	Biomass	Weight
10													0		
11													0		
12													0		
13													0		
14													0		
15	14	14	0	0	0	0	0	0					28	0.6	21
16	164	119	0	0	0	0	0	0					283	6.5	23
17	1282	553	0	0	0	0	0	0					1835	50	27
18	2165	820	0	0	0	0	0	0					2985	96.2	32
19	1698	383	0	0	0	0	0	0					2081	79.6	38
20	1507	340	0	0	0	0	0	0					1847	81.6	44
21	1515	355	0	0	0	0	0	0					1870	95	51
22	829	276	0	0	0	0	0	0					1105	64.3	58
23	181	249	23	0	0	0	0	0					453	30.9	68
24	48	0	48	0	0	0	0	0					96	7.6	80
25	22	22	44	44	0	0	0	0					132	12.4	93
26	0	11	43	11	0	0	0	0					65	6.8	106
27	0	0	201	25	0	0	0	0					226	27.2	120
28	0	0	45	45	0	0	0	0					90	12.4	139
29	0	0	0	9	0	0	0	0					9	1.3	154
30	0	0	0	14	14	14	0	0					42	7.1	173
31	0	0	23	0	23	23	0	0					69	13.3	189
32	0	0	0	5	0	10	0	0					15	3.5	223
33	0	0	0	0	12	47	23	12					94	22.5	241
34	0	0	0	0	38	38	57	0					133	35	262
35	0	0	0	0	0	5	18	5					28	8.1	298
36	0	0	0	0	0	28	0	0					28	8.4	296
37	0	0	0	0	0	0	0	14					14	4.1	289
38	0	0	0	0	0	4	0	0					4	1.5	374
39													0		
40													0		
41													0		
42													0		
43													0		
Number 10^6	9425	3142	427	153	87	169	98	31	0	0	0	0	13532	675.9	

Age	1	2	3	4	5	6	7	8	9	10	11	12+	Number	Biomass
Biomass 10^3	383.8	128.5	48.8	19.4	19.6	41.6	26	8.3					292.2	676
Length cm	19.8	19.7	27	27.7	32.9	33.8	34.4	35.7						20.5
Weight g	40.7	40.9	114.4	126.9	225.4	245.8	263.6	271.9						50

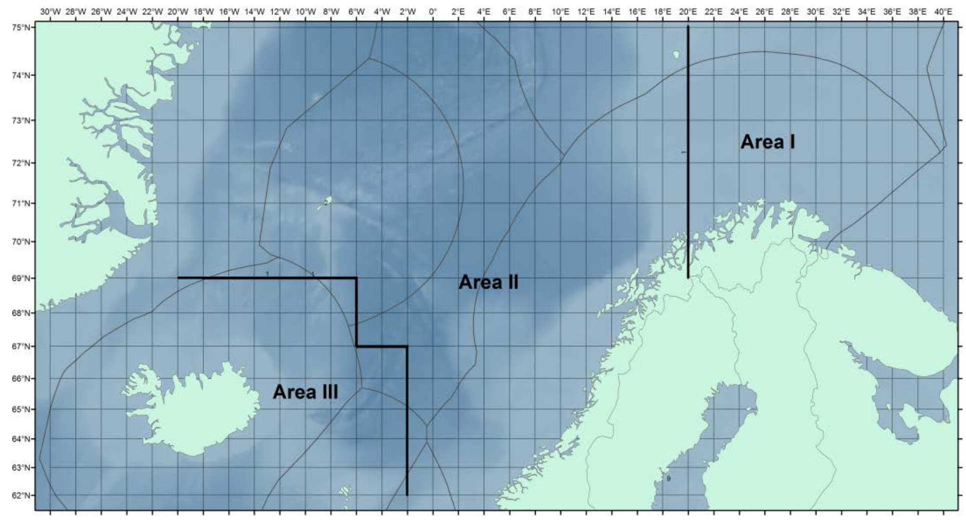

Figure 1. Areas defined for acoustic estimation of blue whiting and Norwegian spring-spawning herring in the Nordic Seas.

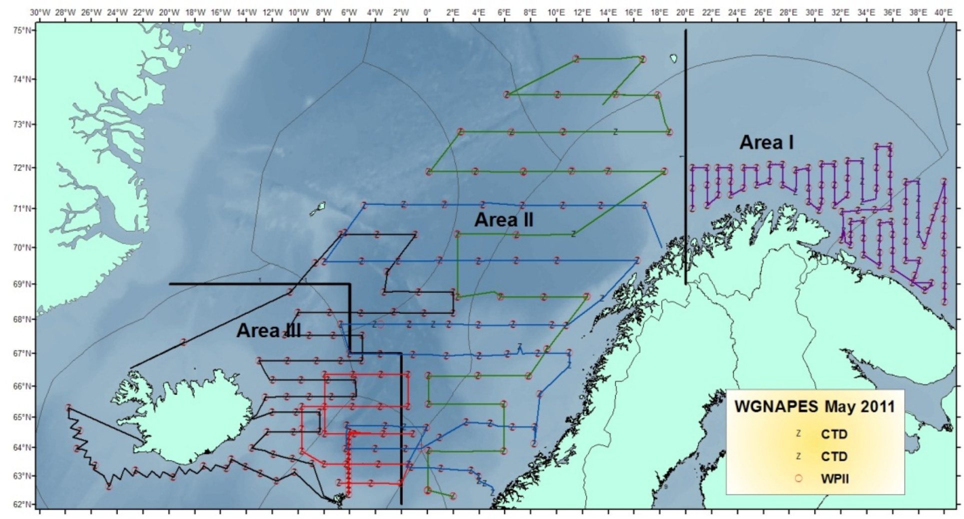

Figure 2. Cruise track and CTD stations by country for the International ecosystem survey in the Nordic Seas in April-June 2012.

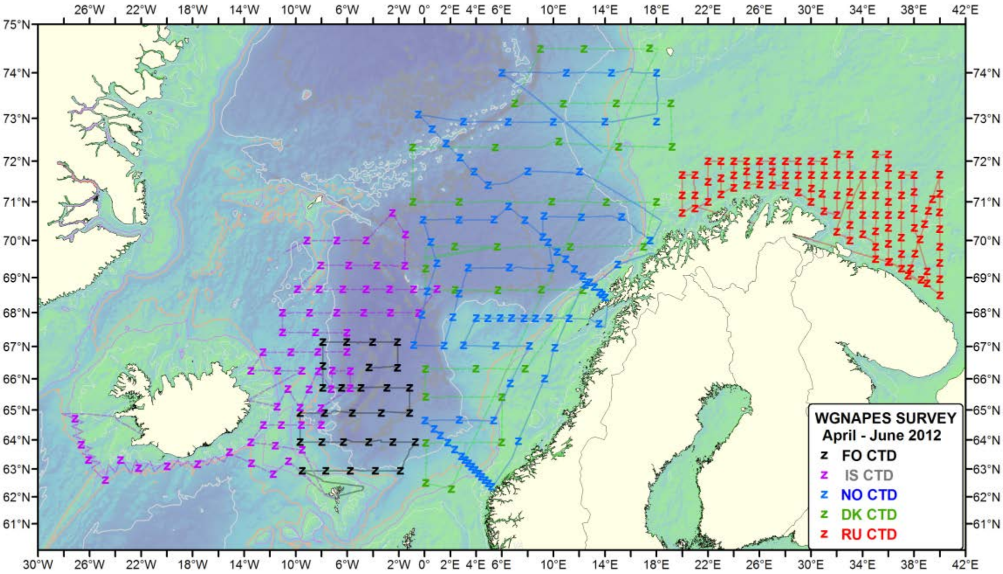

Figure 3. Cruise tracks during the International North East Atlantic Ecosystem Survey in April-May 2012 and location of trawl stations.

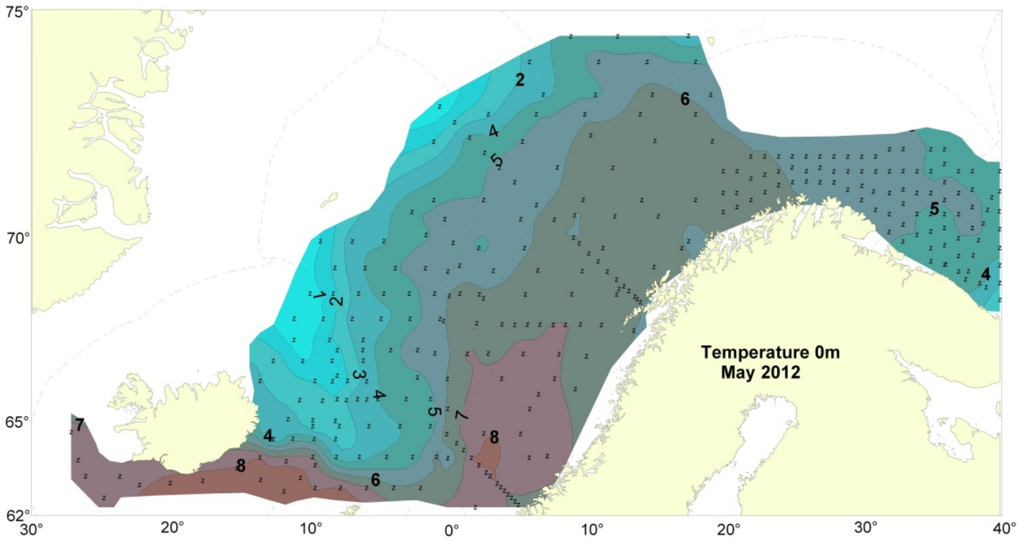

Figure 4. The horizontal sea surface temperature distribution in April-June 2012.

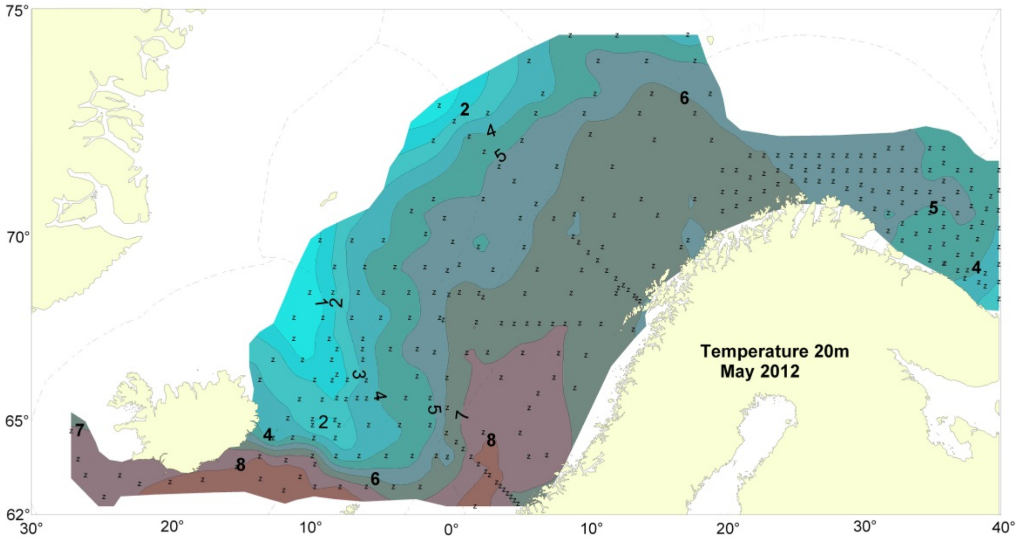

Figure 5. The horizontal distribution of temperatures at 20 m depth in April-June 2012.

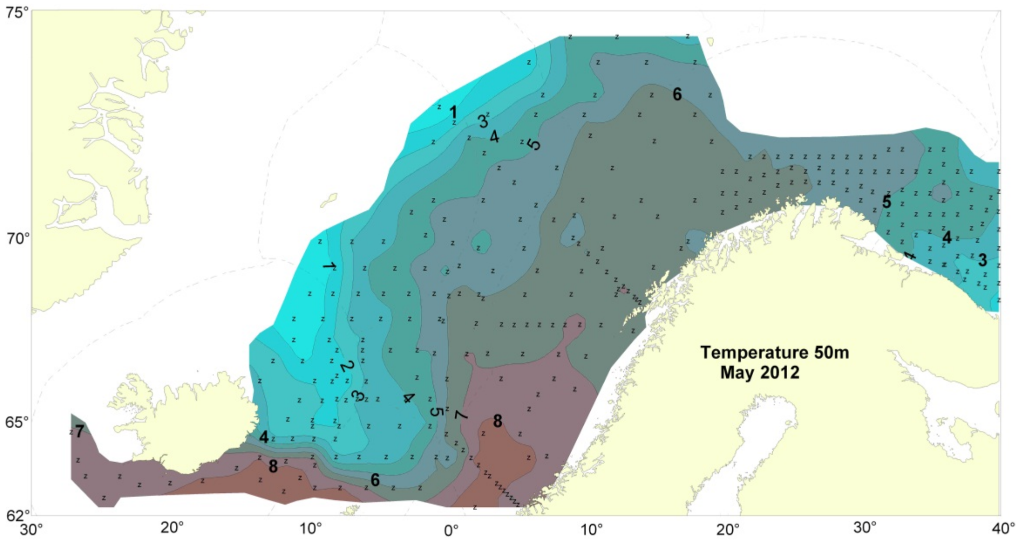

Figure 6. The horizontal distribution of temperatures at 50 m depth in April-June 2012.

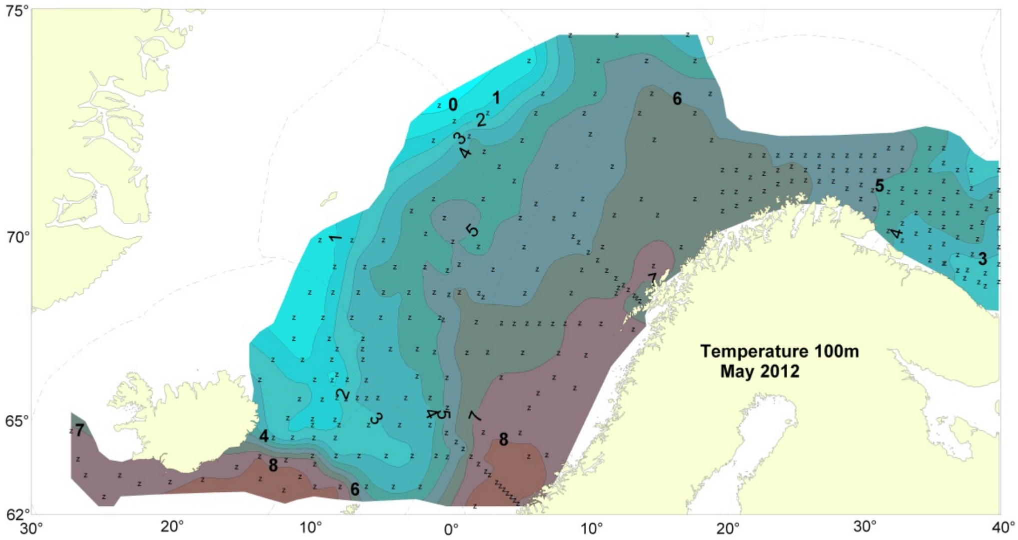

Figure 7. The horizontal distribution of temperatures at 100 m depth in April-June 2012.

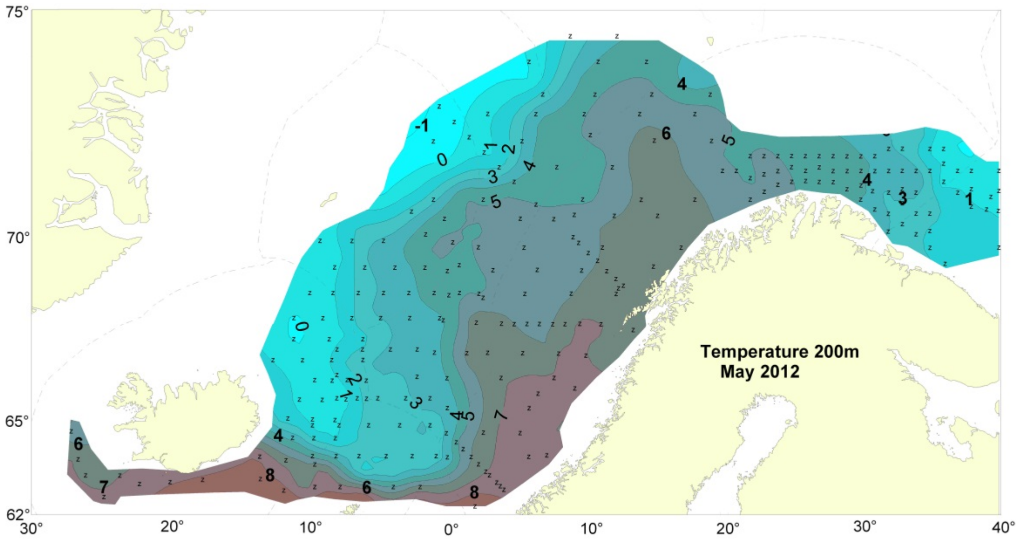

Figure 8. The horizontal distribution of temperatures at 200 m depth in April-June 2012.

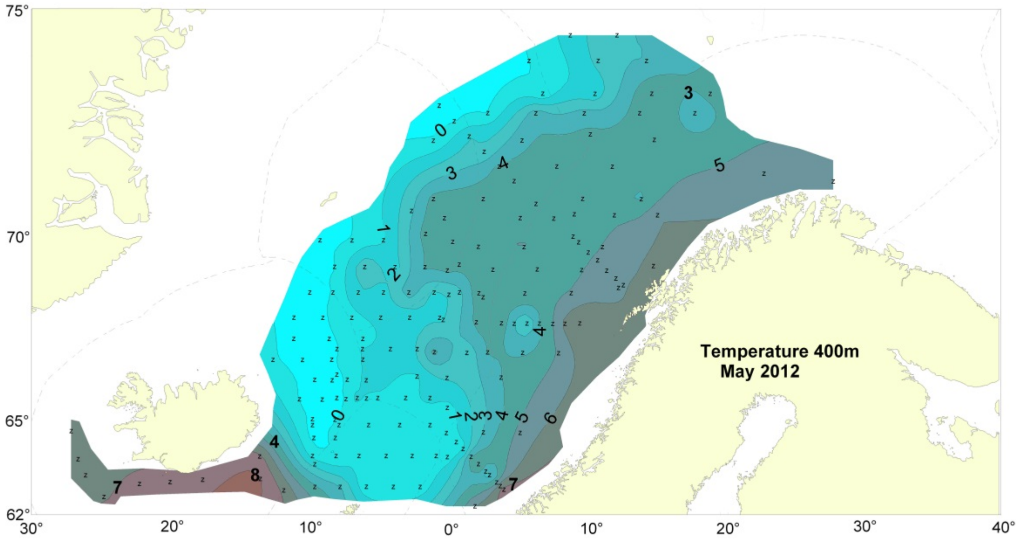

Figure 9. The horizontal distribution of temperatures at 400 m depth in April-June 2012.

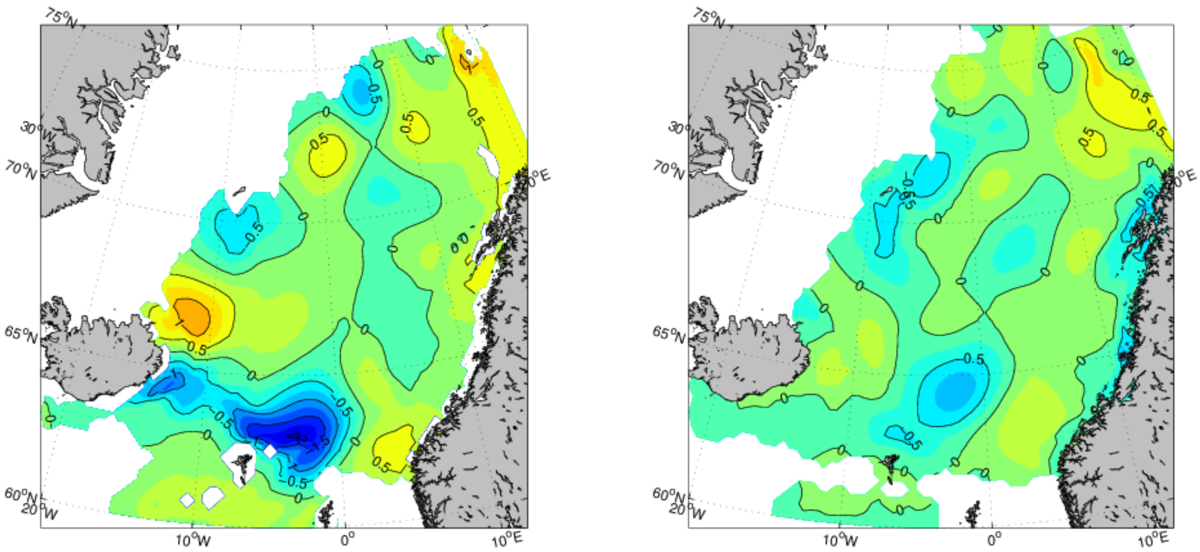

Figure 10. Temperature anomaly at 100 m depth in May for a) 2012 (left) and b) 2011 (right).

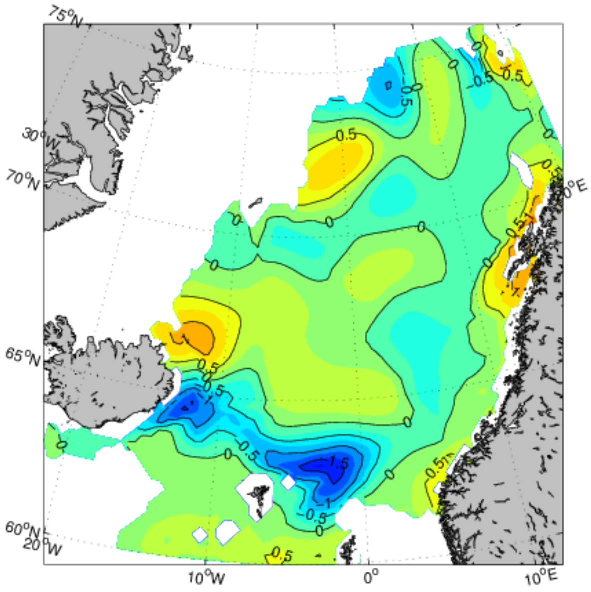

Figure 11. Temperature difference at 100 m depth in May between 2012 and 2011.

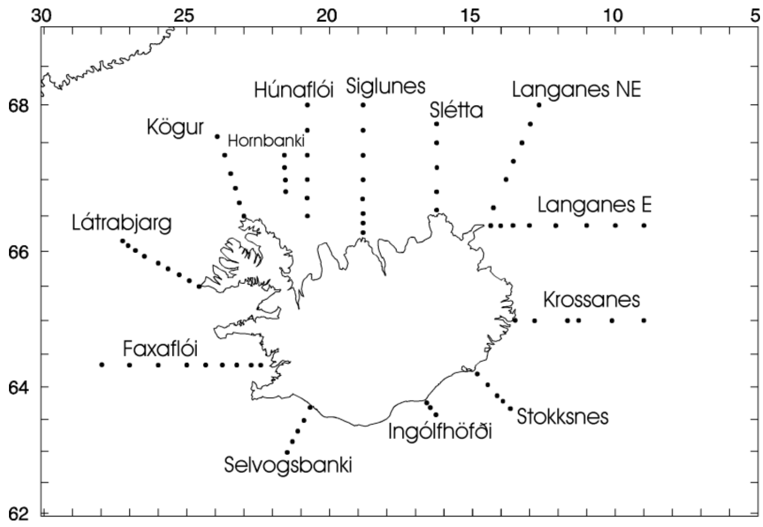

Figure 12. Icelandic standardized hydrographic sections.

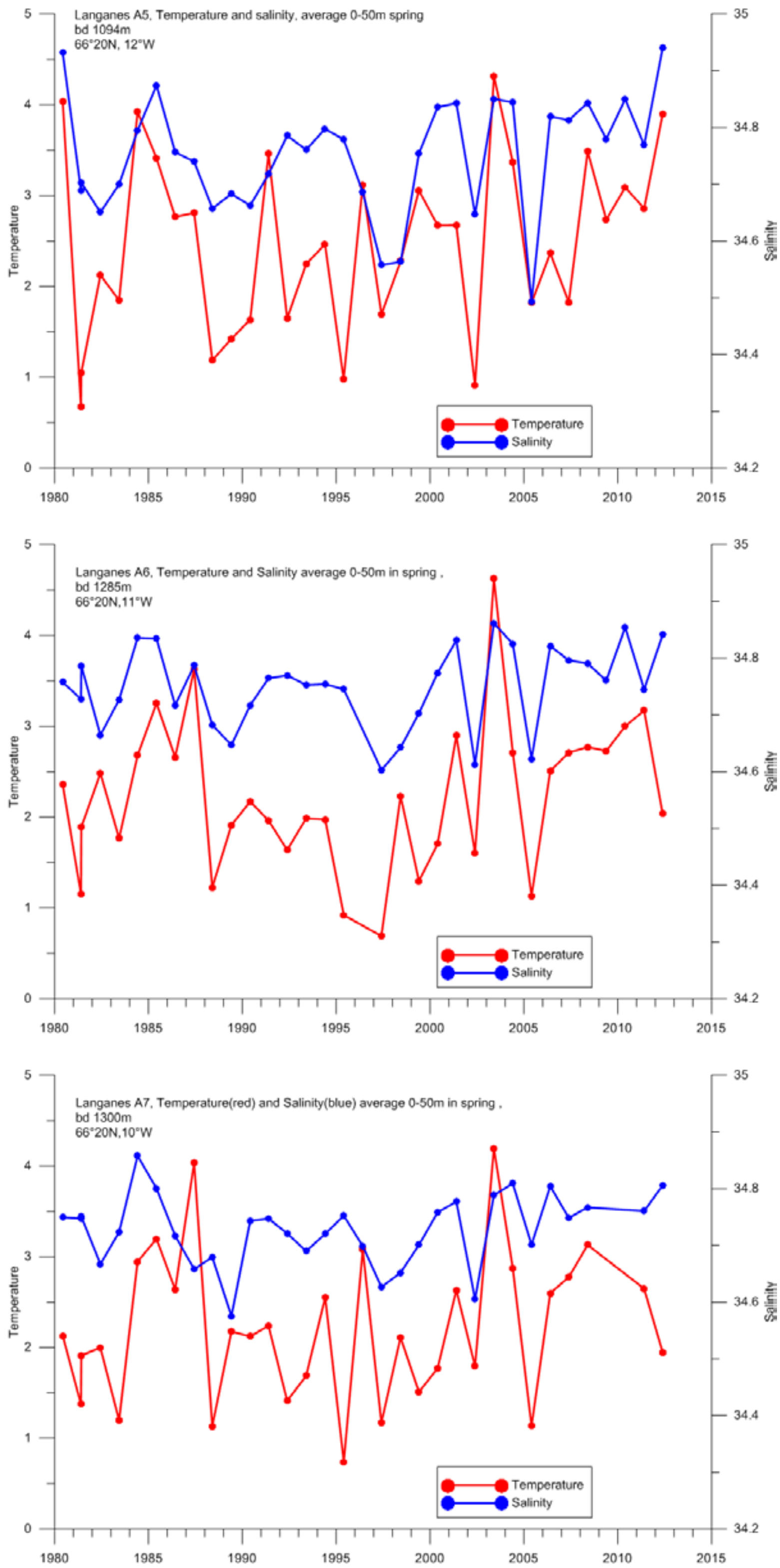

Figure 13. Time-series of temperature and salinity in spring, averaged between 0–50 m depth, at the Langanes-NE section for a) station A5 (upper figure), b) station A6 (middle figure), and c) station A7 (lower figure).

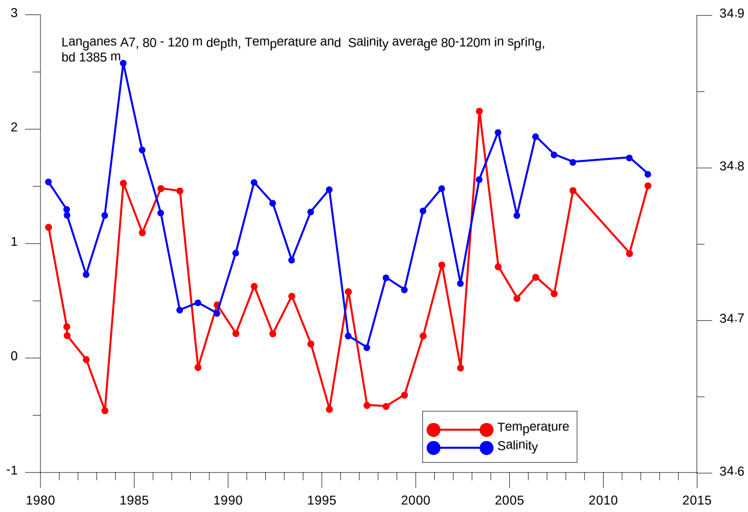

Figure 14. Time-series of temperature and salinity in spring, averaged between 80–120 m depth, at the Langanes-NE section for station A7.

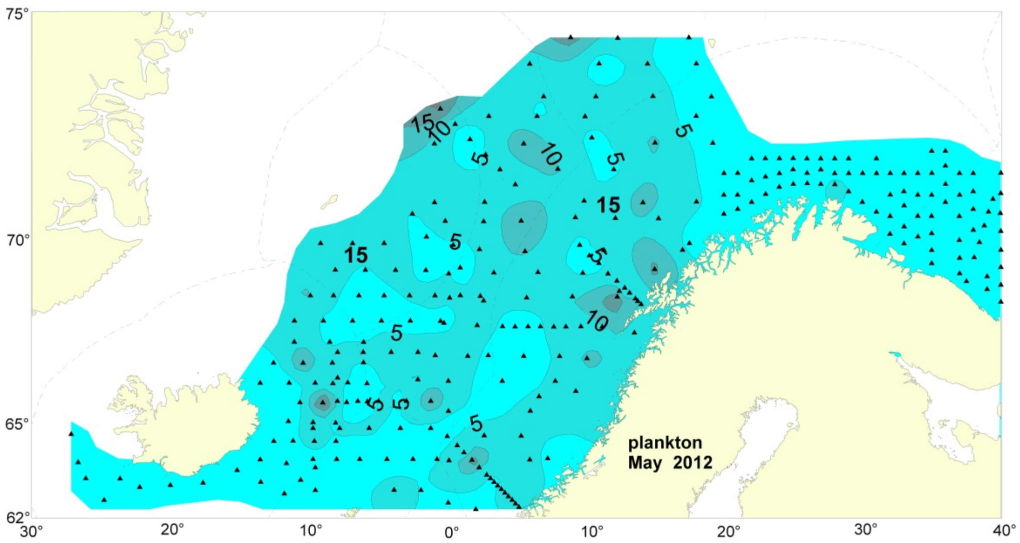

Figure 15. Zooplankton biomass (g dw m-2; 200–0 m in April-June 2012.

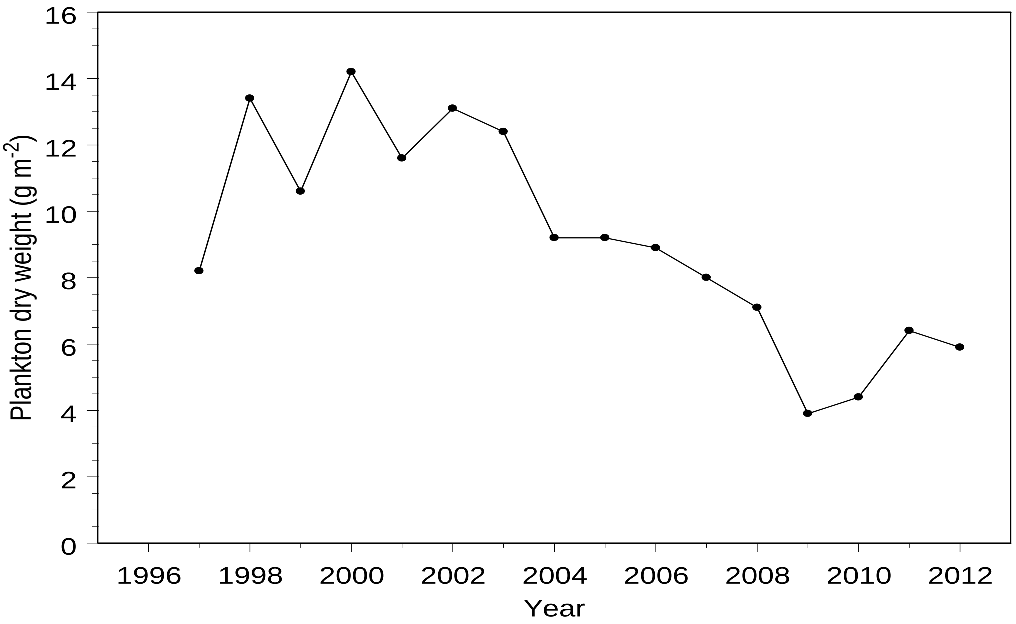

Figure 16. The annual mean dry weight of zooplankton across the whole coverage area in the May surveys in the Norwegian Sea and adjacent waters from 1997 to 2012.

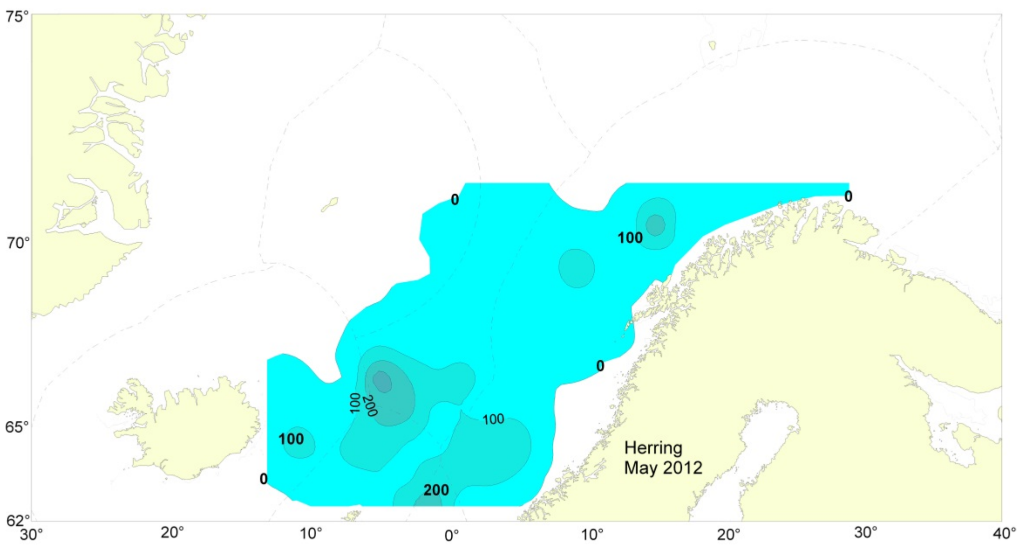

Figure 17. Distribution of Norwegian spring-spawning herring as measured during the International survey in April-June 2012 in terms of s_A-values (m^2/nm^2) based on combined 5 nm values.

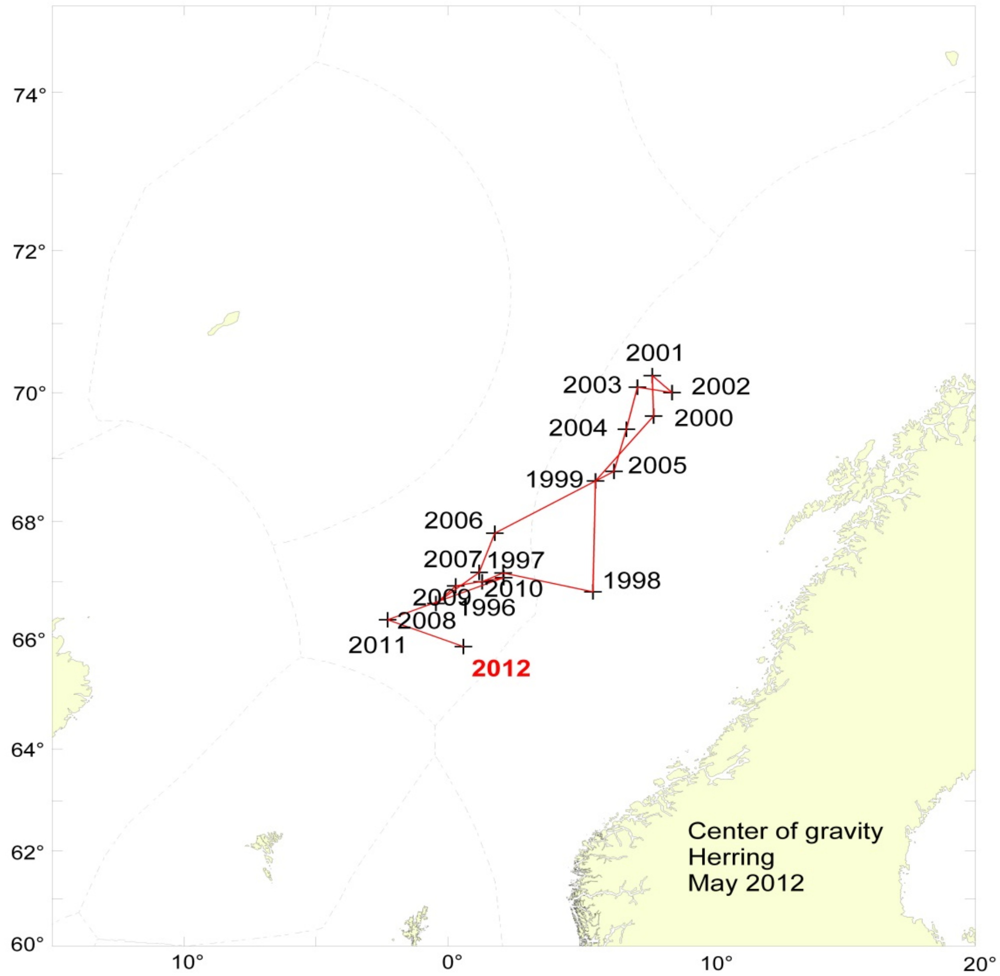

Figure 18 Centre of gravity of herring during the period 1996–2012 derived from acoustic. Acoustic data from area II and III only, i.e. west of 20° E

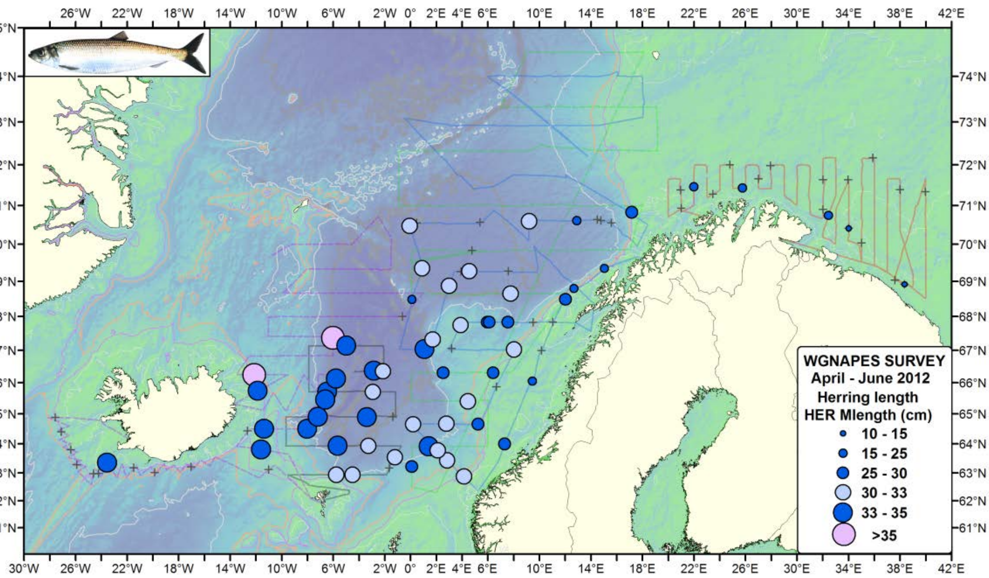

Figure 19. Mean length of Norwegian spring-spawning herring as measured during the International survey in April-June 2012.

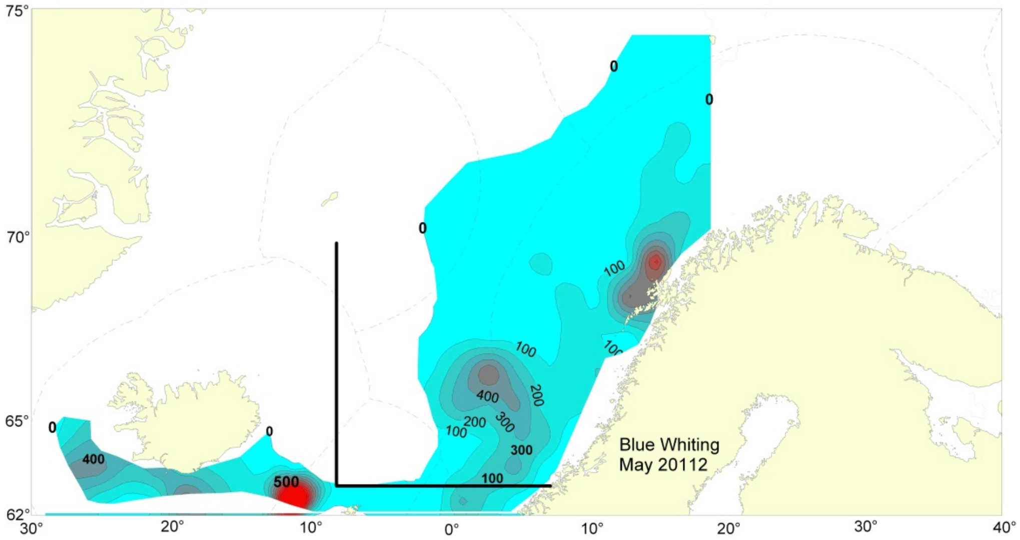

Figure 20. Distribution of blue whiting as measured during the International survey in April-June 2012 in terms of sA-values (m²/nm²) based on combined 5 nm values. The standard area used in assessment (NPBWWG) is shown on the map.

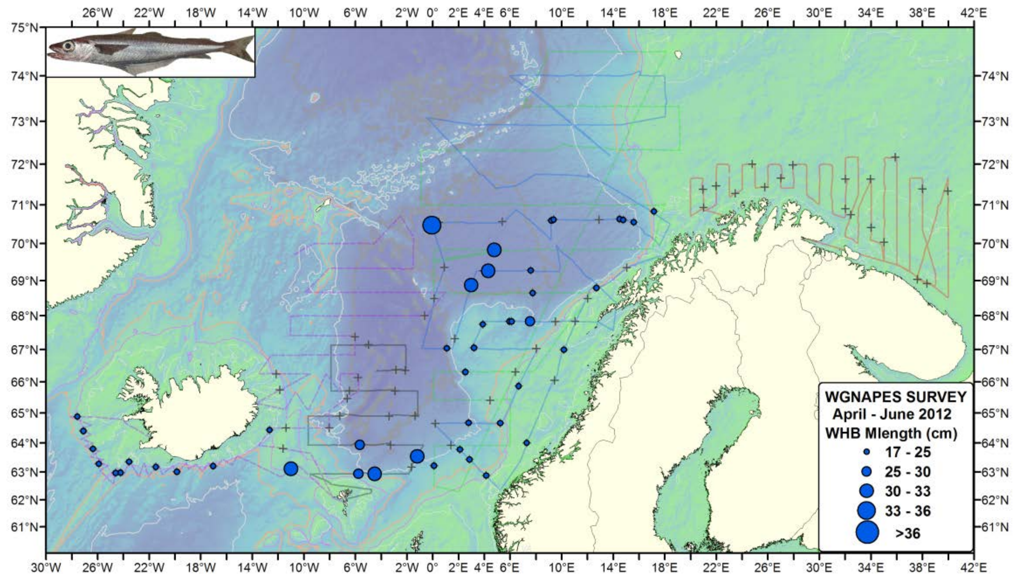

Figure 21. Mean length (cm) of blue whiting recorded in the Northeast Atlantic Ecosystem Survey in April–June 2012.

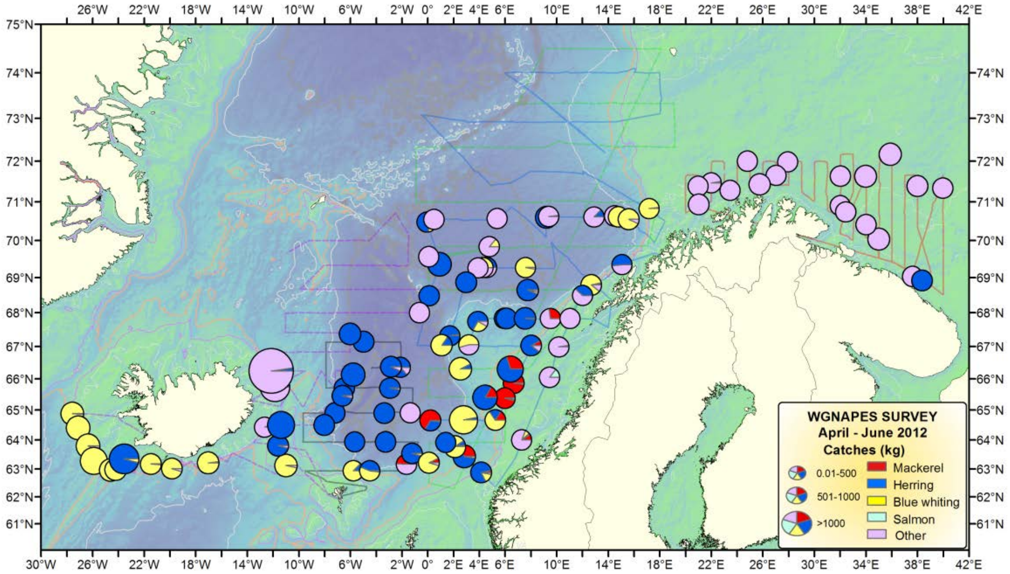

Figure 22. Distribution and spatial overlap between mackerel (red), herring (blue), blue whiting (yellow) and salmon (violet) according to trawl catches of the vessels participating in the survey during April-June. Note that "other" in the Barents Sea indicates juvenile herring.

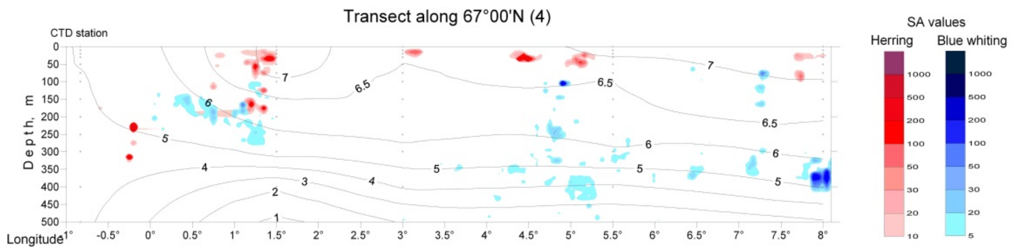

Figure 23. Distribution of acoustic sigthings of herring and blue whitting relativ to depth along the 67º 00N transect

Annex 5c: The 2012 ICES Coordinated Acoustic Survey in the Skagerrak and Kattegat, the North Sea, West of Scotland and the Malin Shelf area

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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. The global estimate of herring from these surveys is reported here. The global survey results provide spatial distributions of herring 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 is 6.7% lower compared to the previous year, at 2.3 million tonnes and 12 668 million herring (2011: 2.4 million tonnes and 12 033 million herring). The 2008 and 2009 year-classes seem to be strong and still persistent in this year's estimate.

The estimates of Western Baltic spring-spawning herring SSB were 97 000 tonnes and 777 million herring, which is slightly lower than last year's estimate, confirming a steady decrease in stock size over the past few years. The stock is dominated by 1 and 2 ring fish. This year's estimated abundance of 1 ringers is lower than the previous two years.

The West of Scotland estimate (VIaN) of SSB is 375 000 and 1 964 million herring. This is lower than observed in 2011. 3 and 4 winter ring fish dominate the age composition of the standing stock and immature fish were better represented than in 2011.

The SSB estimate for the Malin Shelf area (Divisions VIaN-S and VIIb,c) 427 000 tonnes and 2 321 million fish. The estimate is dominated by 3 and 4 winter ringers. The contribution of immature fish to total abundance was higher than that observed in 2011.

The Irish Sea survey program will now be 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 2012 herring acoustic surveys.

Vessel	Period	Area	Rectangles
Celtic Explorer (IR)	09 July – 26 July	53°-58.6°N ,12°-7°W	35D8-D9, 36D8-D9, 37D9-E1, 38D9-E1, 39E0-E2, 40E0-E2,41E0-E3, 42E0-E3, 43E0-E3, 44E0-E3, 45E0-E4
Scotia & Charter vessel* (SCO)	30 June – 23 July	58°30′-62°N, 4°W-2°E	46E2-F1, 47E3-F1, 48E4-F1, 49E5-F1, 50E7-F1, 51E8-F1
Johan Hjort (NOR)	25 June – 23 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
Tridens (NED)	25 June – 20 July	54°09– 58°16′N, 3° W–6°E	37E9-F1, 38E8-F1, 39E8-F1, 40E8-F5, 41E7-F5, 42E7-F1, 43E7-F1, 44E6-F1, 45E6-F1
Solea (GER) DBFH	29 June – 19 July	52°-56°N, Eng to Den/Ger coasts	34F2-F4, 35F2-F4, 36F3-F7, 37F2-F8, 38F3-F7, 39F3-F7, 40F6-F7
Dana (DEN) OXBH	3 July – 16 July	Kattegat and North of 56°N, east of 6°E	41 F6-F7, 41G1-G2, 42F6-F7, 42G0-G2, 43F6-G1, 44F6-G1, 45F8-G1, 46F9-G0

*Scottish charter vessel the FV *Krossfjord* covered the same area and rectangles as RV *Scotia* using interlaced transects.

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).

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), Sonardata 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

Combined Acoustic Survey Results for 2012

Herring

The estimate of North Sea autumn spawning herring spawning stock is 6.7% higher compared to the previous year at 2.3 million tonnes and 12 668 million herring (Table 5.2). The abundance of the 2009 year-class (3-winter ringers this year) is consistent with a strong estimate of 1-wr fish in 2010. The current estimate also confirms the strong 2008 year-class already observed in the previous year.

The estimate of Western Baltic spring-spawning herring SSB is 97 000 tonnes and 777 million herring (Table 5.3), which is slightly lower than last year's estimate (125 000 tonnes and 983 mill fish), confirming a steady decrease in stock size over the past few years. The stock is once again dominated by 1 ring and 2 ring fish. The abundances of 1 ringers decreased by a factor of 3 when compared to last years' estimate (Table 5.7).

The West of Scotland estimate of SSB is 375 000 tonnes and 1 964 million herring (Table 5.4). This is lower than in 2011 and more similar to the levels observed in 2010 (Table 5.8). Abundance is dominated by mature fish of the 3 and 4 winter rings classes. Immature fish are well represented in 2012 unlike as in 2011.

The SSB estimate for the Malin Shelf area (divisions VIaN-S and VIIb,c) is 427 000 tonnes and 2 321 million fish. The estimate is dominated by 3 and 4 winter rings. The contribution of immature fish to total abundance was considerably higher than observed in 2011 (Table 5.5 and 5.9).

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

The estimates were combined in the same manner as the surveys in the North Sea, with weighting applied to individual survey estimates at ICES statistical rectangle according to the amount of survey effort in the rectangle measured in nautical miles.

The area covered during the individual acoustic surveys is given in Figure 5.1. The spatial distribution of the abundance (numbers and biomass) of autumn spawning herring is 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 distribution of adult herring in the North Sea is still concentrated in the areas east of Scotland close to the Fladen Grounds. The bulk of the distribution seems to stretch out towards the north and northwest, around the Shetland Islands. A few large concentrations are situated in isolated rectangles at the northwestern boundary of the combined survey area.

The time-series of abundance for all three stocks (North Sea autumn spawners, Western Baltic spring spawners and West of Scotland 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", RV "Tridens", and RV "Dana". RV Scotia observed a few specimens in one haul at the southern border of their survey area, whereas RV "Johan Hjort" observed no sprat in the northeastern North Sea. In the 2012 acoustic surveys, sprat were concentrated in the southern part of the North Sea, with the highest abundances and biomass in an area between 2° and 9° E and between 53° and 54.5° N. The survey area this year reached the southern limit (52° N), as opposed to last year. 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. The sprat distribution in the North Sea in terms of abundance and biomass is shown in Figure 5.15.

The total abundance of North Sea sprat in 2012 was estimated to be 45,466 million individuals and the biomass 408,859 tonnes (Table 5.10). This is a decrease of about 8% in terms of biomass when compared to last year (ICES, 2012). It is higher than the average for the period. In terms of abundance, it is the fourth highest estimate (Table 5.11). The amount of immature and mature sprat is about the same. The sprat stock is dominated by 1- and 2-year old fish representing 76% of the biomass.

An age-disaggregated time-series of North Sea sprat abundance and biomass (ICES area IVa-c), as obtained from the acoustic survey, is given in Table 5.11. Note that for 2003, information on sprat distribution is available from one nation only. This year, immature 0-group sprat data were delivered in FishFrame (NL). This probably reflects maturity staging problems, and all 0-group sprat were thus defined as immature as mature 0-group sprat is unlikely.

In Div IIIa, sprat was found in both the Skagerrak and Kattegat area. Last year sprat were abundant only in Kattegat. The abundance was estimated to be 1,902 mill individuals, a 21% increase compared to 1,574 million individuals in 2011 (Table 4.2.3). The biomass was estimated to be 37,596 tonnes, an increase of about 37%. Most sprats were 3+ group (78%), and all were mature. The sprat samples in this area are too few to estimate length- and weight-at-age split by immature and mature.

Abundance, biomass, mean length and mean weight per age and strata are given in Table 4.2.3.

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 2012 with mean weights and mean lengths by age ring.

Age (ring)	Numbers	Biomass	Maturity	weight(g)	Length (cm)
0	2936	16	0.00	5.3	9.2
1	7437	357	0.00	48.1	18.3
2	4719	588	0.91	124.7	23.9
3	4067	782	0.99	192.4	27.3
4	1738	340	1.00	195.4	27.7
5	1209	256	1.00	211.6	28.4
6	593	137	1.00	231.5	29.2
7	247	60	1.00	241.9	29.6
8	218	52	1.00	239.0	29.6
9+	478	116	1.00	242.8	29.7
Immature	10973	435		39.6	15.9
Mature	12668	2269		179.1	26.8
Total	23641	2704	0.54	114.38	21.77

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 2012, with mean weights, mean length and fraction mature by age ring.

Age (ring)	Numbers	Biomass	Maturity	weight(g)	Length (cm)
0	1	0	0.00	3.0	8.5
1	1018	44	0.00	42.9	18.2
2	1081	87	0.37	80.4	21.7
3	236	26	0.72	110.6	24.0
4	87	12	0.85	142.9	26.2
5	76	13	1.00	170.8	27.5
6	33	6	1.00	182.0	28.4
7	14	3	1.00	194.0	29.3
8	20	4	1.00	207.9	29.6
9+	40	10	1.00	239.0	30.5
Immature	1828	107		58.7	19.2
Mature	777	97		124.9	25.7
Total	2605	204	0.30	78.48	21.18

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 2012, with mean weights, mean lengths and fraction mature by age ring.

Age (ring)	Numbers	Biomass	Maturity	weight(g)	Length (cm)
0					
1	792	52	0.00	65.9	19.5
2	179	27	0.85	150.1	25.0
3	729	133	1.00	182.8	27.0
4	471	89	1.00	188.8	27.7
5	241	50	1.00	205.9	28.4
6	107	23	1.00	216.4	29.2
7	107	23	1.00	213.5	29.3
8	56	12	1.00	217.9	29.2
9+	105	22	1.00	214.4	29.3
Immature	824	57		68.9	19.7
Mature	1964	375		190.9	27.7
Total	2788	432	0.70	154.84	25.29

Table 5.5. Total numbers (millions) and biomass (thousands of tonnes) of Malin Shelf herring (VIaN-S, VIIb,c) June-July 2012. Mean weights, mean lengths and fraction mature by age ring.

Age (ring)	Number	Weight	Maturity	Weight(g)	Length(cm)
0					
1	796	53	0.00	66.8	19.6
2	548	72	0.66	132.1	24.2
3	832	149	0.99	178.8	26.9
4	517	97	1.00	187.8	27.6
5	249	51	1.00	205.2	28.4
6	115	25	1.00	214.4	29.1
7	111	24	1.00	213.0	29.3
8	57	12	1.00	217.7	29.1
9+	105	22	1.00	214.4	29.3
Immature	1009	79		77.9	20.0
Mature	2321	427		184.0	27.5
Total	3330	506	0.70	151.86	25.20

Table 5.6. Estimates of North Sea autumn spawners (millions) at age from acoustic surveys, 1986–2012. 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 2012 estimates are from summer surveys in Divisions IVa,b and IIIa excluding estimates of Division IIIa/Baltic spring spawners. For 1999 and 2000 the Kattegat was excluded from the results because it was not surveyed.

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

Table 5.7. Numbers-at-age (millions) of Western Baltic Spring-spawning herring at age (rings) from acoustic surveys 1992 to 2012. 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

Table 5.8. Numbers-at-age (millions) and SSB of West of Scotland Autumn Spawning herring at age (rings) from acoustic surveys 1993 to 2012. 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

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 2012.

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	808	550	832	518	249	115	111	57	105	427

Table 5.10. Sprat in the North Sea: Abundance, biomass, mean weight and mean length by age and maturity from the summer 2012 North Sea acoustic survey.

Age	Abundance (million)	Biomass (1000 t)	Mean weight (g)	Mean length (cm)
0i	7,807.2	27.5	3.5	7.2
1i	11,632.1	68.3	5.9	9.3
1m	10,280.3	108.7	10.6	11.1
2i	1,889.8	19.7	10.4	11.4
2m	10,651.5	130.1	12.2	11.3
3m	3,023.1	50.8	16.8	13.2
4m	181.7	3.8	20.9	14.4
5m	0.2	0.0	12.8	14.3
Immature	21,329.1	115.4	5.4	8.7
Mature	24,136.8	293.4	12.2	11.4
Total	45,465.8	408.9	9.0	10.2

Table 5.11. Time-series of sprat abundance and biomass (ICES areas IVa-c) as obtained from the summer North Sea acoustic survey. 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
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 the summer 2012 North Sea acoustic survey.

Age	Abundance (million)	Biomass (tonnes)	mean weight (g)	mean length (cm)
0i	0.3	0	1.5	6.5
1i	121.5	1,156	9.5	10.2
1m	2.4	17	9.5	10.2
2i	252.4	4,380	17.4	12.8
2m	37.7	651	17.4	12.8
3m+	1488.0	31,392	21.1	13.8
Immature	374.2	5536	14.8	11.9
Mature	1528.2	32,060	21.0	13.7
Total	1902.4	37,596	19.8	13.4

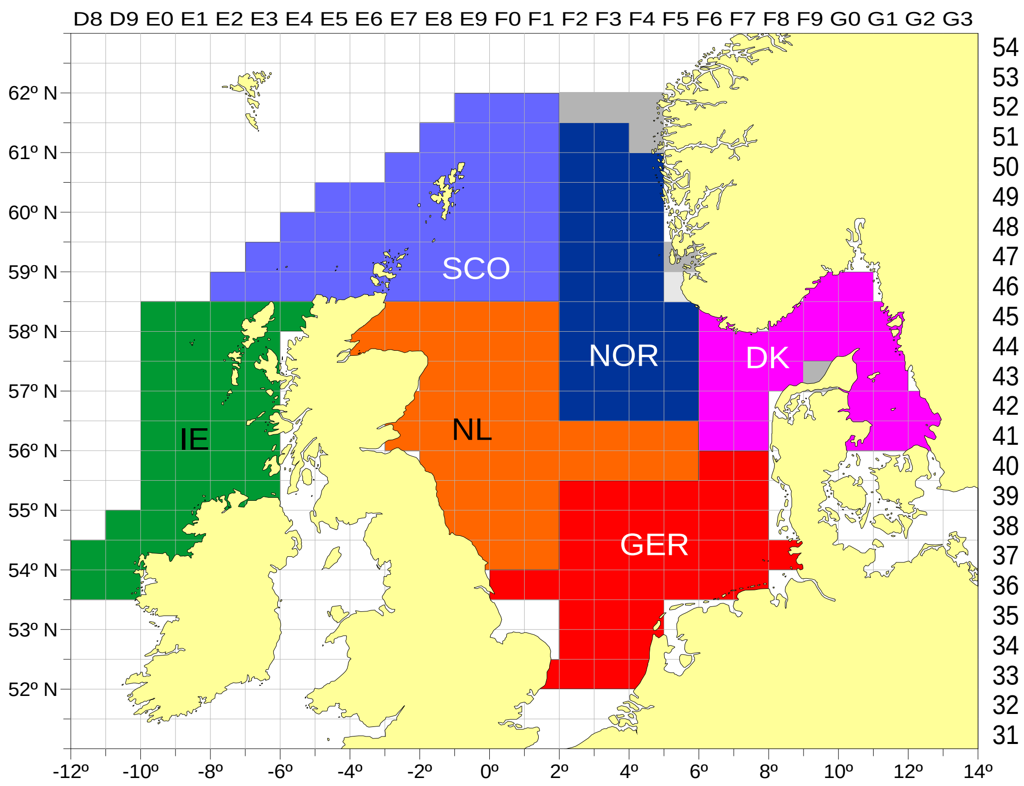

Figure 5.1. Survey area coverage in the pelagic acoustic surveys in 2012, by rectangle and nation (IR = Celtic Explorer; SCO = Scotia; NOR = Johan Hjort; DK = Dana; NL = Tridens; GER = Solea). Rectangle 46F5 (light grey) was interpolated from surrounding ones. Rectangles in dark grey were not uncovered.

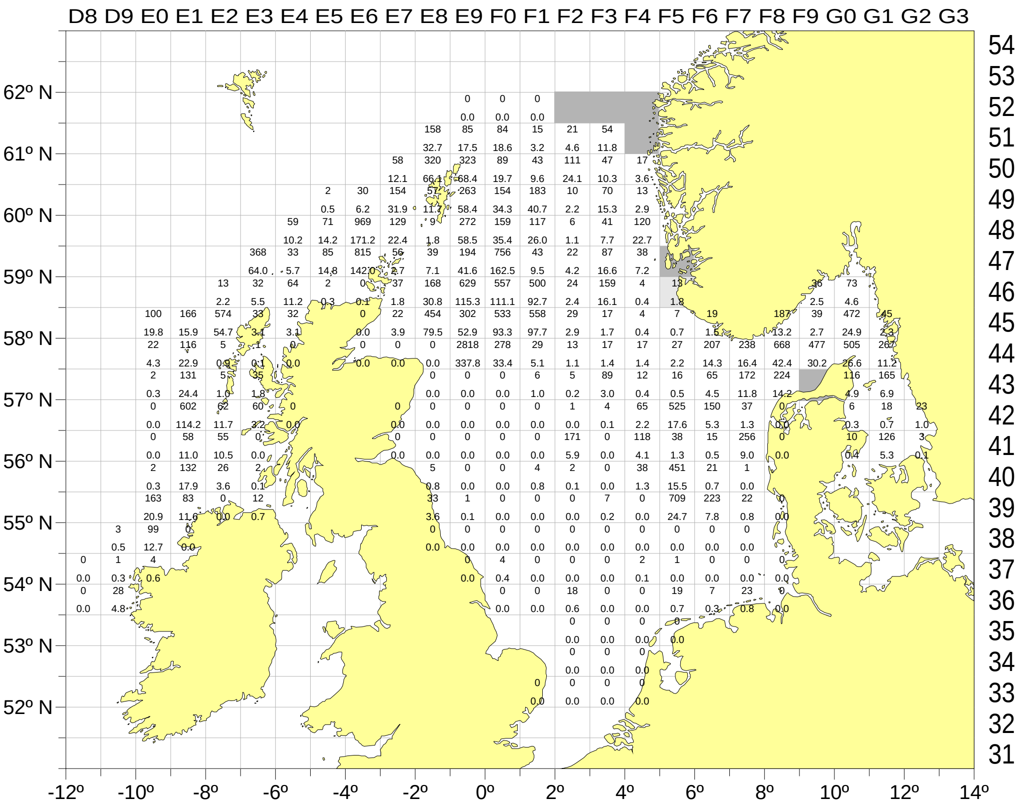

Figure 5.2. Abundance of autumn spawning herring (winter ring 1–9+) from the combined acoustic survey in June-July 2012. Numbers (millions, upper figure) and biomass (thousands of tonnes, lower figure). Dark grey rectangles were not surveyed. Light grey rectangles were interpolated.

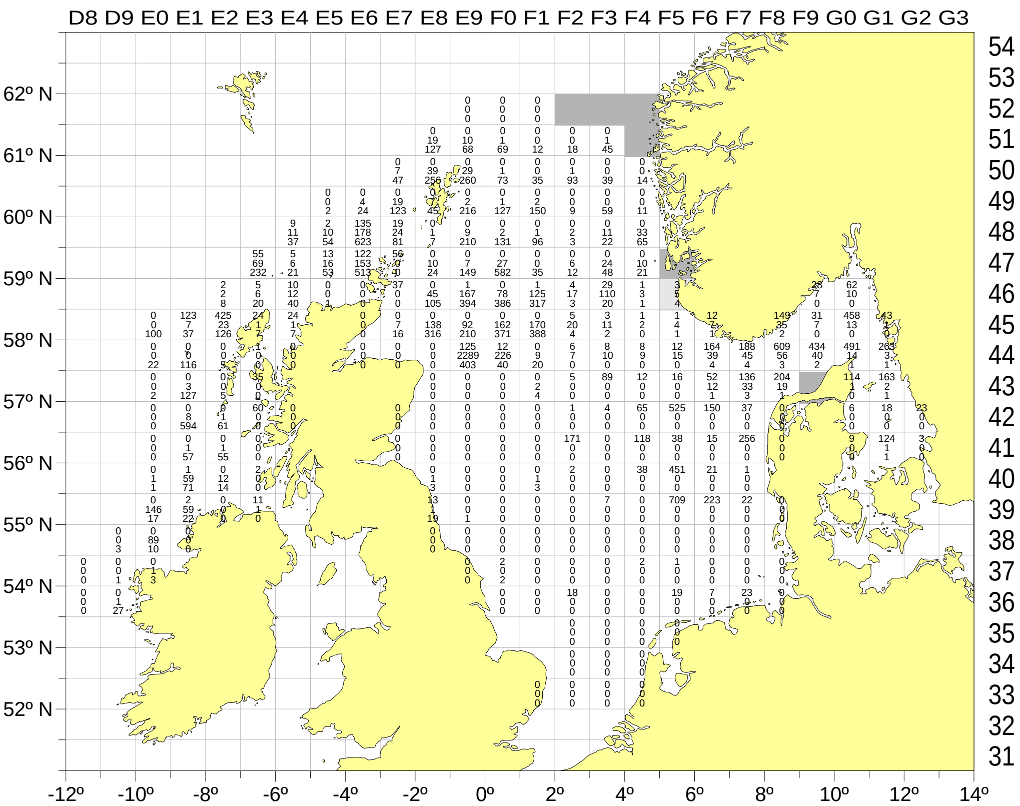

Figure 5.3. Numbers (millions) of autumn spawning herring from combined acoustic survey June – July 2012. 1 winter ring (upper figure), 2 ring (centre figure), 3+ (lower figure). Dark grey rectangles were not surveyed. Light grey rectangles were interpolated.

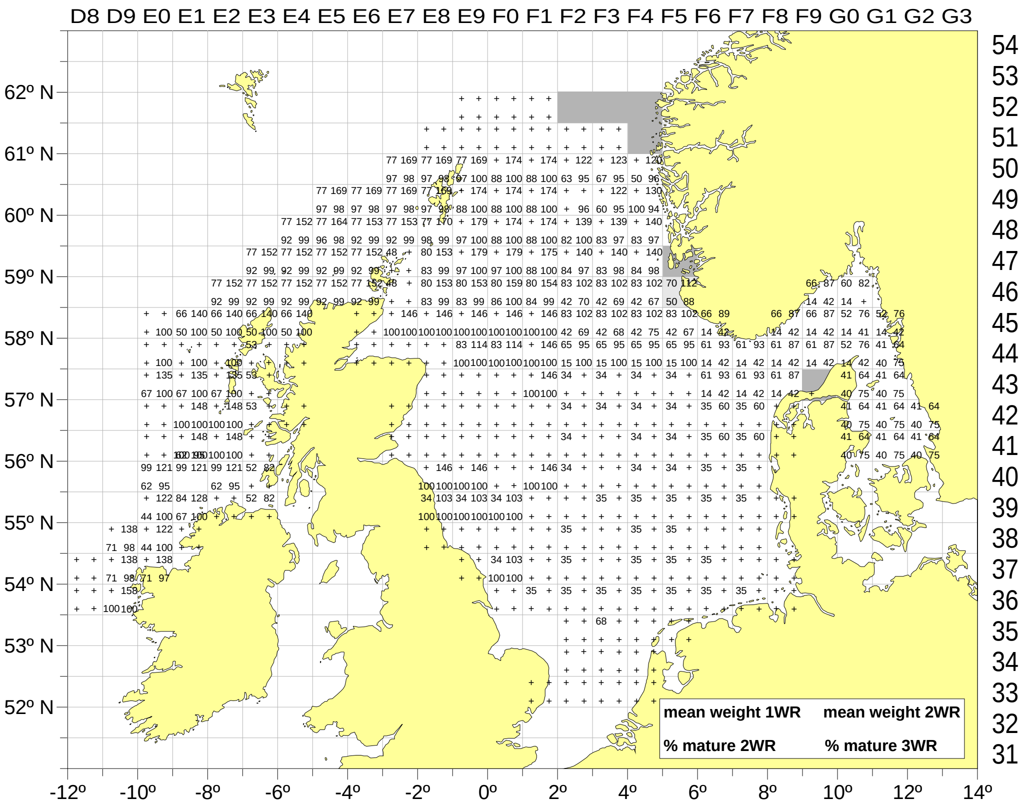

Figure 5.4. Mean weight and maturity of autumn spawning herring from combined acoustic survey June – July 2012. Four values per ICES rectangle, percentage mature of 2 ring (lower left) and 3 ring fish (lower right), mean weights (grams) of 1 ring (upper left) and 2 ring fish (upper right). Light grey rectangles were interpolated, + indicates surveyed with zero abundance, blank indicates an un-surveyed rectangle, dark grey rectangles were unsurveyed planned survey rectangles.

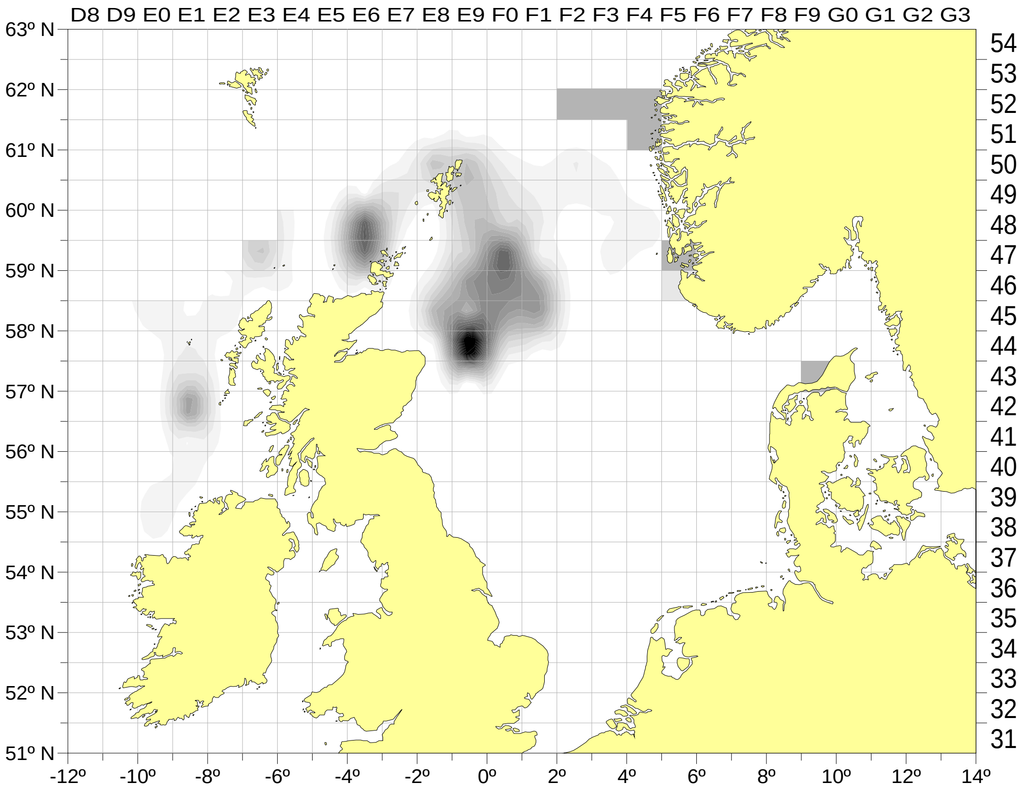

Figure 5.5. Biomass of mature autumn spawning herring from the combined acoustic survey in June – July 2012 (maximum value = 220 000).

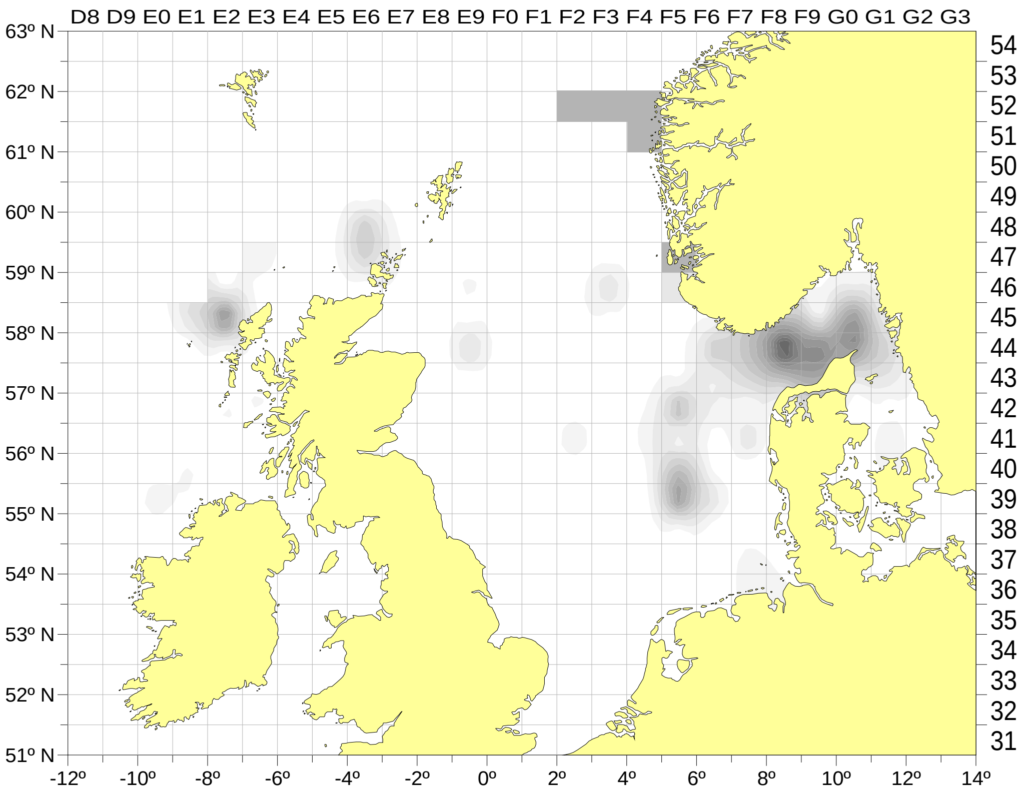

Figure 5.6. Biomass of immature autumn spawning herring from the combined acoustic survey in June – July 2012 (maximum value = 57 500).

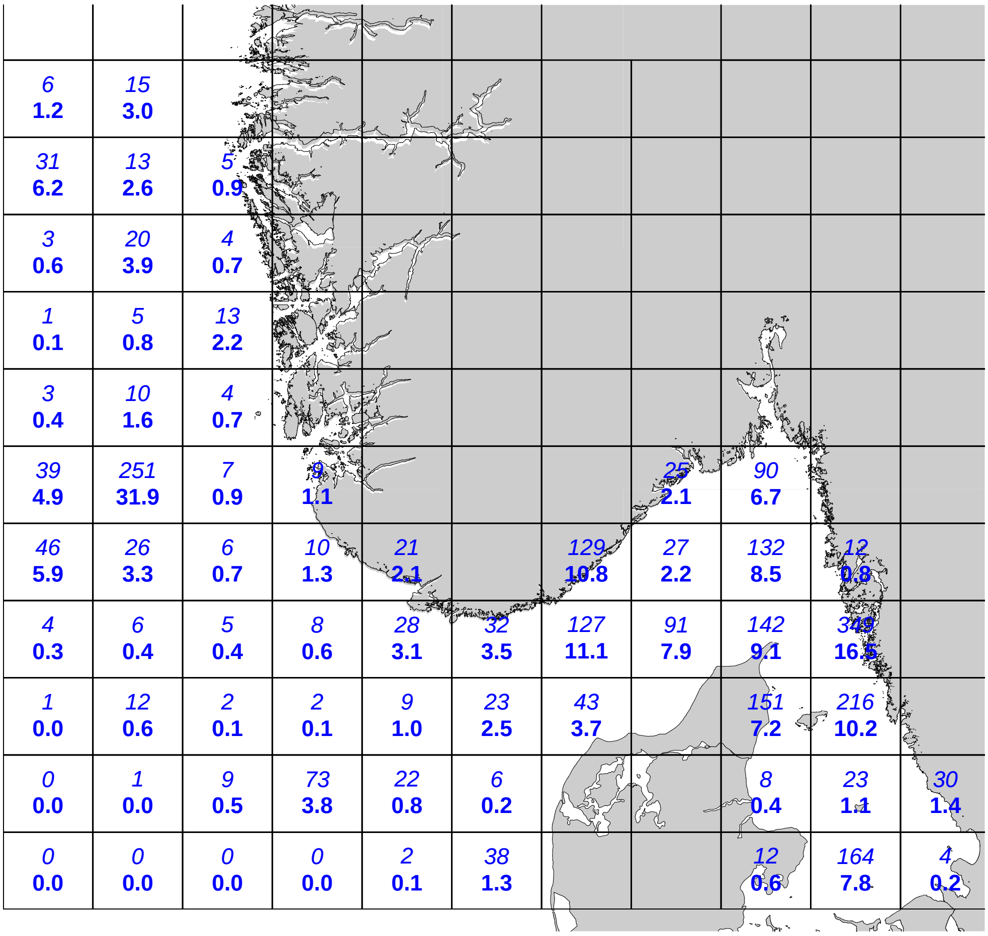

Figure 5.7. Abundance of western Baltic spring-spawning herring 1–9+ from combined acoustic survey July 2012. Numbers (millions, upper figure) and biomass (thousands of tonnes, lower figure).

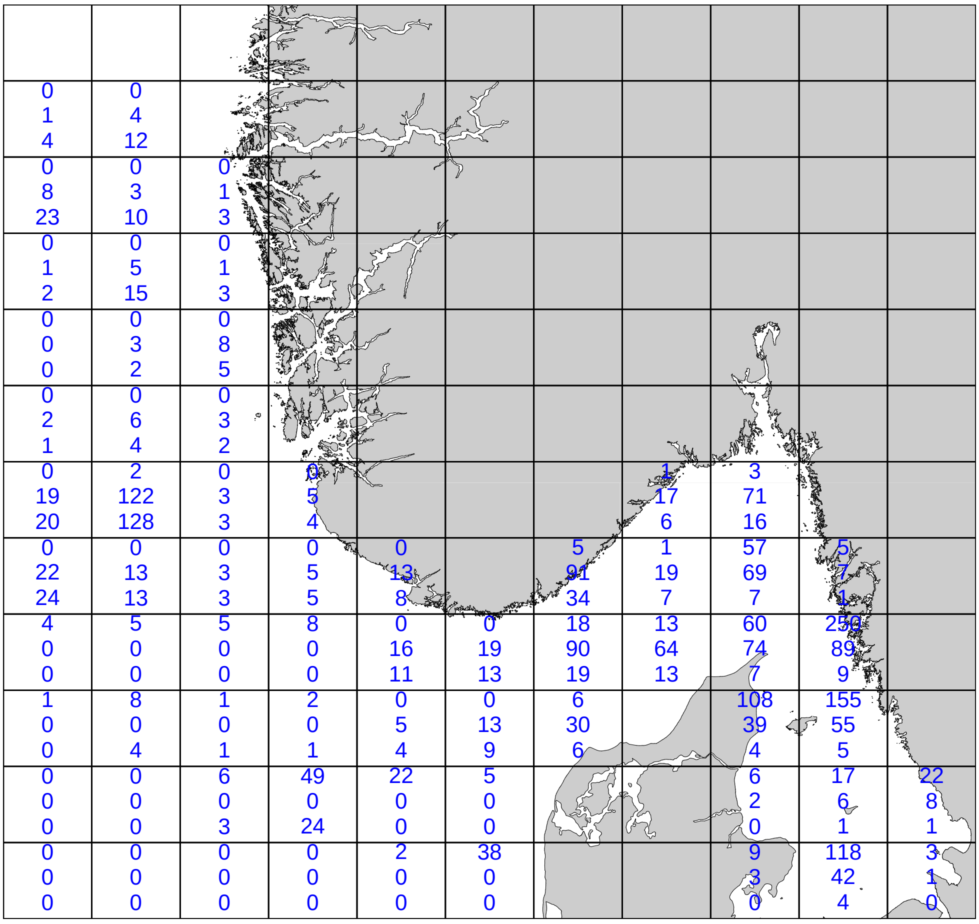

Figure 5.8. Numbers (millions) of western Baltic spring-spawning herring from combined acoustic survey June – July 2012. 1 ring (upper figure), 2 ring (centre figure), 3+ (lower figure).

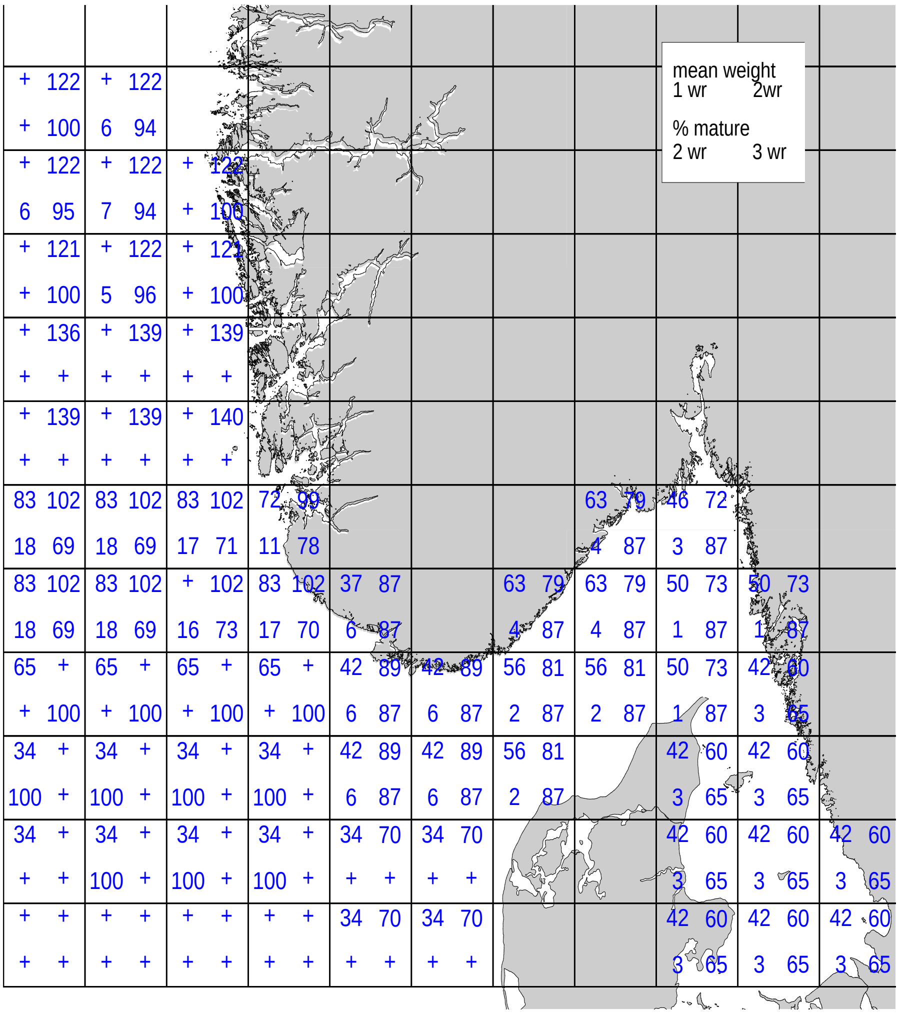

Figure 5.9. Mean weight and maturity of western Baltic spring-spawning herring from combined acoustic survey June – July 2012. Four values per ICES rectangle, percentage mature of 2 ring (lower left) and 3 ring fish (lower right), mean weights gram of 1 ring (upper left) and 2 ring fish (upper right), + indicates surveyed with zero abundance, blank indicates an unsurveyed rectangle.

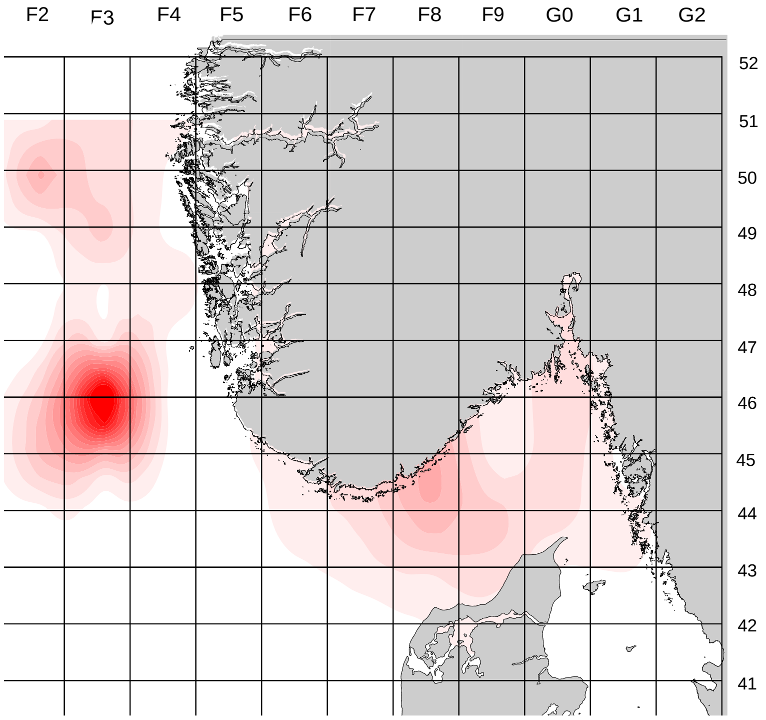

Figure 5.10. Biomass of mature western Baltic spring-spawning herring from combined acoustic survey in June – July 2012 (maximum = 23 000 t).

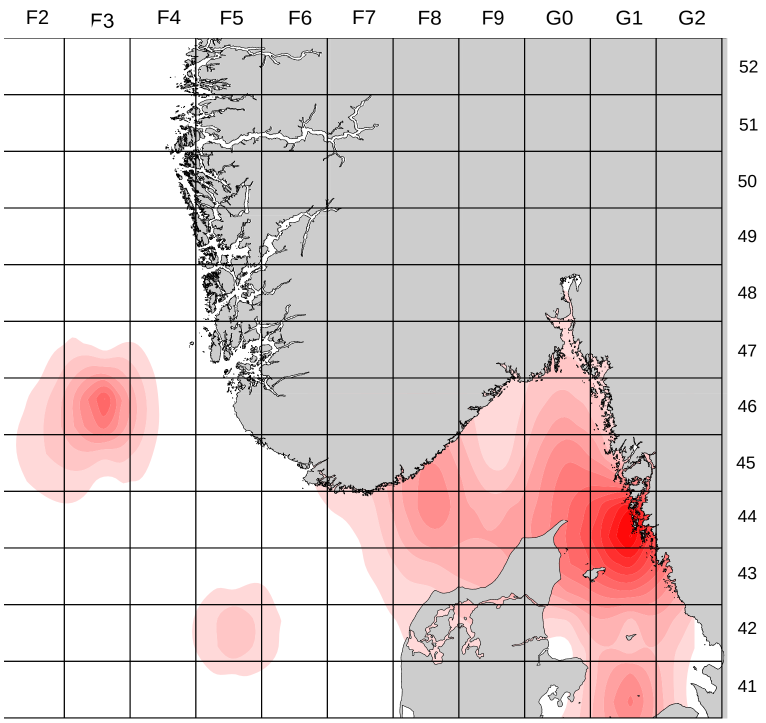

Figure 5.11. Biomass of immature western Baltic spring-spawning herring from combined acoustic survey in June – July 2012 (maximum = 15 000 t).

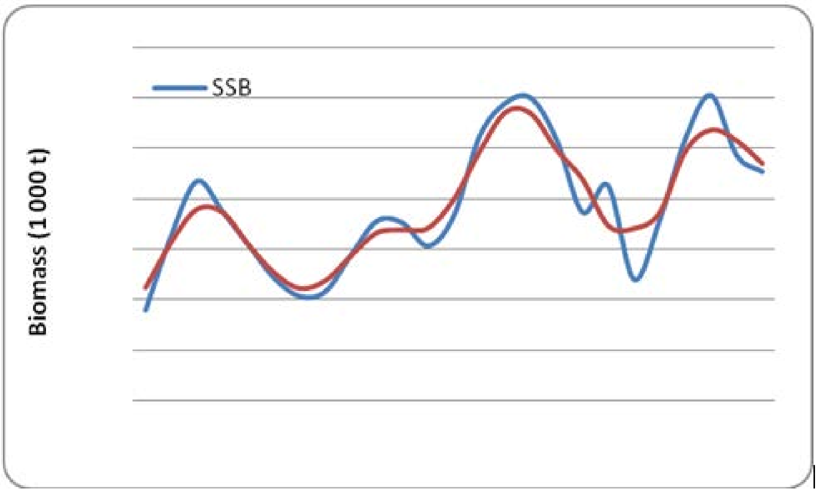

Figure 5.12. Time-series of SSB of North Sea autumn spawning herring with three year running mean.

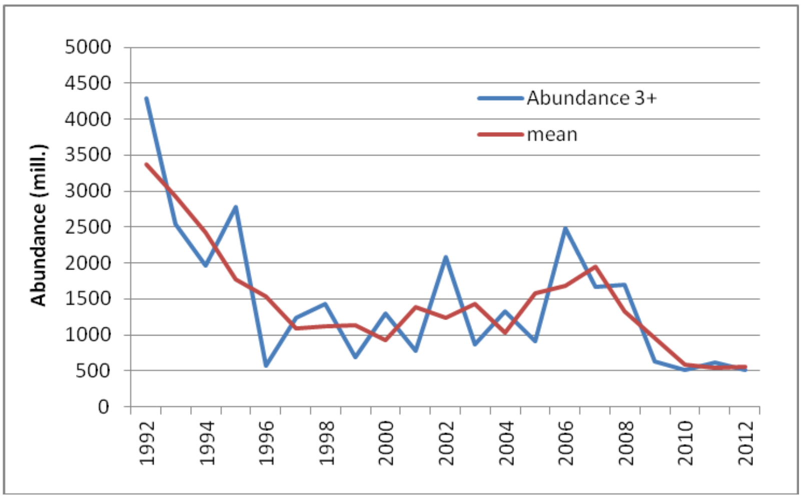

Figure 5.13. Time-series of 3+ abundance of Western Baltic spring-spawning herring with three year running mean.

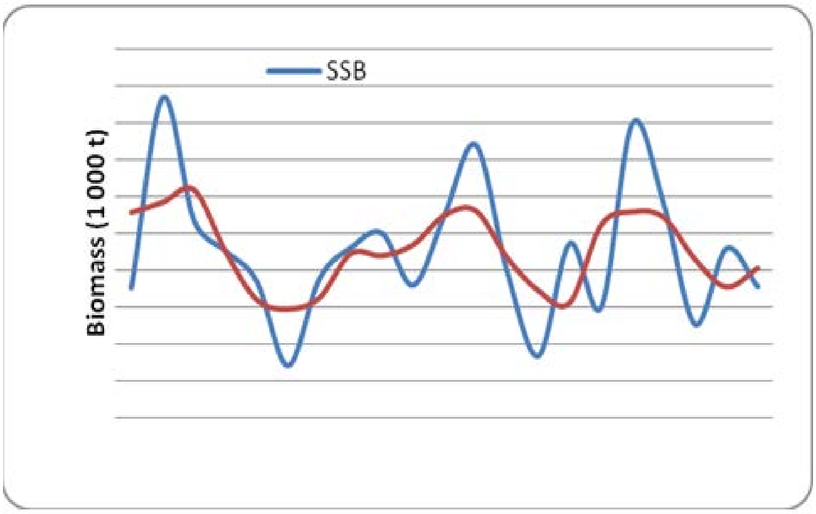

Figure 5.14. Time-series of SSB of West of Scotland herring with three year running mean.

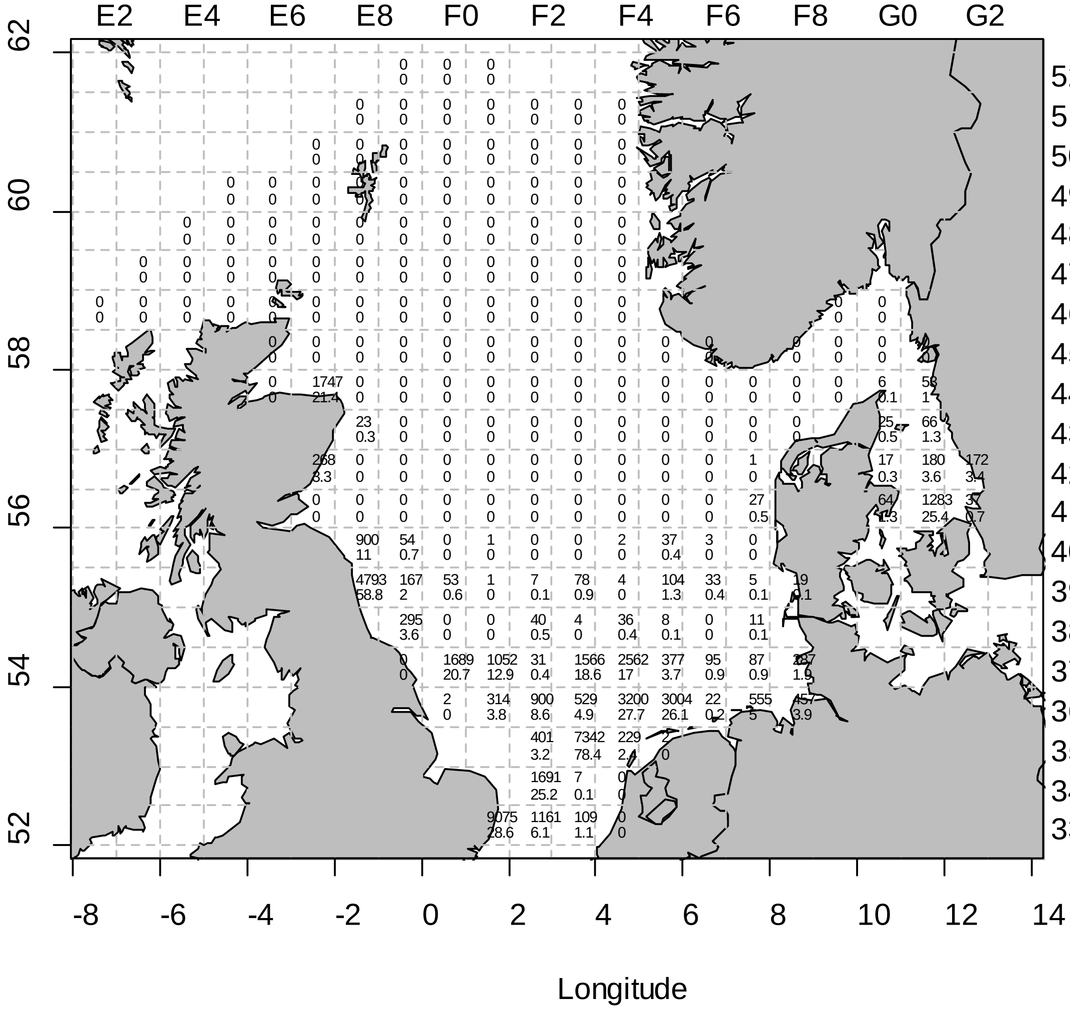

Figure 5.15. North Sea Sprat. Abundance (upper figure, in millions) and biomass (lower figure, in 1000 t) per statistical rectangle as obtained by the acoustic survey 2012. Blank rectangles are not sampled.

Annex 5d: Coordinated Nordic Seas ecosystem survey (IESSNS) in July-August

Annex 5D

Working Document to

ICES Working Group on International Pelagic Surveys (WGIPS), ICES Headquarters, Copenhagen, Denmark, 3-7 December 2012

ICES Working Group on Widely distributed Stocks (WGWIDE) Lowestoft, UK, 21-27 August 2012

Cruise report from the coordinated ecosystem survey (IESSNS) with R/V ”G. O. Sars”, M/V “Brennholm”; M/V “Christian í Grótinum” and R/V “Arni Fridriksson” in the Norwegian Sea and surrounding waters, 1 July-10 August 2012

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Abstract

The international coordinated ecosystem survey in the Norwegian Sea and adjacent areas (IESSNS) was performed during 1 July to 10 August 2012 by four vessels from Norway (2), Iceland (1) and Faroese (1). A standardised pelagic trawl swept area method has been developed and used to estimate a swept area abundance estimate of NEA mackerel in the Nordic Seas in recent 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 2012 was 5.1 million tonnes based with a coverage of 1.5 million square kilometres in the Nordic Seas from about 61 degrees up to 70 degrees north and from the Norwegian coast in east and west to the fishery border between Iceland and Greenland. The 2006 year class contributed to more than 20% in number followed by equally abundant 2005, 2007 and 2008-year classes around 15% each, respectively. The 2010 year class was very well represented in the catches, or 12% of the total number. The mackerel was distributed in most of the surveyed area, and the zero boundaries were only found in the south-western area in the Faroe zone and in the southern Icelandic zone. In the northern area the zero boundary was not reached.

The geographical coverage and survey effort in 2012 was largely comparable to the survey in 2010, while the coverage in 2011 was less, as it did not cover the northern part of the Norwegian Sea properly. Therefore it is possible to compare the swept area estimates of 4.8 million tonnes in 2010 with the 5.1 million tonnes estimate in 2012. Thus, these estimates indicate that the NEA mackerel remain at a stable level. Both these biomass estimates must be considered to be underestimations and only represent part of the stock north of approximately 62°N. The overlap between mackerel and NSS herring was highest in the south-western part of the Norwegian Sea (Faroe and east Icelandic area).

Acoustic estimations of herring and blue whiting were also done during the survey from calibrated echousounder data. The biomass of Norwegian spring-spawning herring was estimated to 7.3 million tonnes in July-August 2012. The previous acoustic abundance estimates of NSS herring from the survey were 13.6 million tonnes in 2009 and 10.7 million tonnes in 2010. Thus, the trend in the July survey clearly follows the negative trend in the biomass estimates from the assessment. The herring was mainly found in the outskirt of the Norwegian Sea; i.e. from north of the Faroes, the east Icelandic area and north in the Jan Mayen area, with small concentrations in the central and eastern areas.

This survey confirmed the presence of young blue whiting (ages 1-3) in the summer feeding areas. The concentrations were highest in the eastern Norwegian Sea and in the area south and southwest of Iceland.

The temperatures in the Nordic Seas in 2012 are still well above long-term average. Especially in the area west of Iceland and in the Irminger Sea the surface temperatures were up to three degrees higher than the long-term average. However, the south-western Norwegian Sea seems a bit cooler in summer 2012 compared to the last two years.

The concentrations of zooplankton are still at a low level compared to historic values.

Whale observations were done by the two Norwegian vessels during the survey. The number of marine mammal sightings was very low as compared to previous years, with very few sightings of fin and humpback whales in the Norwegian Sea.

The swept area methodology for abundance estimation of NEA mackerel was further developed by dedicated experiments. In order to be able to use the results from the different vessels in a combined swept area estimate, it is necessary to calibrate the pelagic trawl catch efficiency and acoustic equipment among the different vessels. This inter-calibration was done during two days of the survey in a pre-agreed area. The newly designed pelagic sampling trawl (Multpelt 832) was used by all vessels, and seven inter-calibration hauls were performed with the four vessels during this exercise. An acoustic intercalibration was also performed just after finishing the trawl experiments. The ultimate goal to use this combined swept area estimate as an abundance index in the assessment of NEA mackerel will require allocation of survey time dedicated for inter-calibration between the participating vessels in future surveys.

Introduction

In July-August 2012, four vessels; R/V “G. O. Sars” and one chartered trawler/purse seiner, M/V “Brennholm” (Norway), M/V “Christian í Grótinum” (Faroe Islands), and the research vessel R/V “Arni Friðriksson” (Iceland) participated in the joint ecosystem survey (IESSNS) in the Norwegian Sea and surrounding waters. The six weeks cruises from 2 July to 10 August are 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 and blue whiting, oceanographic conditions and prey communities. Whale observers were operating on the Norwegian vessels to collect data on distribution and aggregation of marine mammals. The survey was initiated by Norway in the Norwegian Sea in 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.

Material and methods

Coordination of the survey was done by correspondence during the spring and summer 2012. The participating vessels together with their effective survey periods are listed in Table 1.

Figure 1 shows the cruise tracks and the trawl stations and Figure 2 the cruise tracks and the CTD/WP-2 stations.

In general, the weather was mostly calm with good survey conditions for oceanographic monitoring, plankton sampling, acoustic registrations and pelagic trawling. Some bad weather with gail force and storm in the northern and northeastern part of the survey area, did to some extent affect the survey with reduced survey speed and deleting some planned predefined stations for a fewdays period in total for one vessel. Overall, the weather conditions did not affect the quality of the various scientific data collection during the survey for the involved survey vessels, except for Brennholm which experienced bad weather at the shelf off northern Norway.

During this year’s survey a new pelagic trawl, Multpelt 832, was used by all four participating vessels. This trawl is a product of a cooperation of participating institutes in designing and construction of a standardized sampling trawl for this survey in the future for all participants. The work lead by John Willy Valdemarsen, Institute of Marine Research (IMR), Bergen, Norway, has been in progress for two 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.

Table 1. Survey effort by each of the four vessels in the July-August survey in 2012.

Vessel	Effective survey period	Length of cruise track (nmi)	Trawl stations	CTD stations	Plankton station
Arni Friðriksson	12/7-10/8	5955	104	91	91

Christian í Grótinum	3/7- 18/7	1825	37	28	28
G.O. Sars	2/7-20/7	2754	57	49	48
Brennholm	6/7-27/7	3722	50	40	40
Total	2/7-10/8	14256	248	208	207

Hydrography and Zooplankton

The hydrographical and plankton stations by all vessels combined are shown in Figure 2. G. O. Sars and Arni Fridriksson were equipped with a SEABIRD CTD sensor with a water rosette that was applied during the entire cruise. On G. O. Sars and Árni Friðdirksson CTD profiles were taken down to 500 m depth when depth allowed. Christian í Grótinum was equipped with a mini SEABIRD SBE 25+ CTD sensor, recording temperature, salinity, fluorescence and pressure (depth) from the surface down to 500 m, or when applicable as linked to maximum bottom depth. Brennholm was equipped with a SAIV SD200 CTD sensor recording temperature, salinity, 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 (G. O. Sars and Brennholm) and 200 μm (Arni Fridriksson and Christian í Grótinum). 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.

Zooplankton sampling was performed on each predefined station; 48 stations on G. O. Sars, 40 stations on Brennholm, 91 stations on Arni Fridriksson and 28 stations on Christian í Grótinum.

Trawl sampling

Catches from trawl hauls 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.

Table 2. Summary of biological sampling in the survey from 1st of July to 10th of August 2012 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	10	50	25
	Herring	10	50	25
	Blue whiting	10	50	25
	Other fish sp.	10*	10*	0
Otoliths/scales collected	Mackerel	10	50	25
	Herring	10	50	25
	Blue whiting	10	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*

*Depends on species

All vessels used the newly designed and constructed Multpelt 832 pelagic trawl aimed for standardization of fishing gear used in the survey The most important properties of the trawls during the survey and their operation were as shown Table 3.

Table 3. Trawl settings and operation details during the international mackerel survey in the Nordic Seas in July-August 2012. The column for influence indicates observed differences between vessels likely to influence performance during intercalibration. Influence is categorized as 0 (no influence), + (some influence) and ++ (high influence).

Properties	**G.O. Sars**	**Arni Fridriksson**	**Brennholm**	**Christian í Grótinum**	Influence
Trawl producer	Egersund Trawl AS	Tornet	Egersund Trawl AS	Vónin	0
Warp in front of doors	Steel wire, 24 mm	Dynex-34 mm	Dynema -36 mm	Dynex – 34mm	++
Warp length during towing	340 m (320-360 m)	350 m	340 m	350 m	0
Difference in warp length port/starboard	3-12 m	15-40 m	5-10 m	5-12 m	0
Weight at the lower wing ends	250 kg	No weights	400 kg	375 kg	++
Setback in metres	4 m	0	4 m	8 m	++
Type of trawl door	ET Speed	Polar.Jupiter t4	Seaflex w. adjustable hatches	Thyborøn V-doors	0
Weight of traw door	1200 kg	2000 kg	2000 kg	2000 kg	+
Area trawl door	7.5 m²	6 m²	9 m² 65-75% hatches	8 m²	++
Towing speed (GPS) in knots	4.7 (4.7-4.8)	5.1 (4.7-5.2)	5.1 (5-5.2)	4.7 (4.1-5.1)	+
Setting time	15 min	12 min	5-10 min	15 min	+
Trawl height	25.5 (20-38)	27-30	28-30	~ 30.7 (SE = 0.33)	+
Door distance	110 m	98-104 m	115 m	Not measured	++
Trawl width*	-	62 m	-	70 m	+
Turn radius	2-4 degrees turn	2700-2800 m	5 degrees turn	5-10 degrees turn	+
Hauling time warp	6 min	4-5 min	5 min	8 min	+
Hauling time trawl	20 min	17 min	15 min	10 min	++
Trawl door depth (port and starboard)	0-10, 5-15 m	8-13, 10-15 m	10-15 m	Not measured	+
Headline depth	0-2 m	0-1 m	0-2 m	0 m	+
Float arrangements on the headline	Kite + 2 buoys on wings	Kite	Kite + 2 buoys on wings	Dynex float rope, whole headline (382 kg buoyancy) + 2 buoys on wings and 2 in middle (2880 kg buoyancy)	+
Weighing of catch	All weighted	All weighted	Codend weighted with large scale digital weight	Semi quantitative estimate (larger hauls estimated)	+

* Trawl width was not estimated constantly during intercalibration, for Christian í Grótinum it was done during the two first hauls of the trip

Marine mammal observations

The two Norwegian vessels, G. O. Sars and Brennholm, conducted observations of marine mammals. Two dedicated marine mammal observers were present on board both G. O. Sars and Brennholm, respectively. The observations wer done from the roof/outdoor or from the bridge when the weather conditions were unfavourable. Two observers were watching permanently. Among the equipment were: angle boards, binoculars 7x50 with reticles, portable two-way radio for communication with bridge, GPS device, microphones connected to personal computers with special software for the sound recording and simultaneous registration of the vessel's position. Each observer monitored a 90 degree sector, starboard and port side respectively, in the line of the course. They shifted the sides every hour and took short breaks every two hours. The main sector of observation was 45 degrees port and starboard of the course line. The priority periods of observing were during the transport stretches from one trawl station to another. When the weather conditions were nearly excellent, observing was also conducted during the trawl stations with the purpose of tracking marine mammals, which could possibly appear. Weather conditions were noted every hour of observation. Sightings were spoken into a microphone. Later, the recordings were transcribed to a special Sighting form. Fields in the sighting form included date, time, position, species, number, group size, behaviour, angle from the vessel course and swimming direction. A diary summarizing each day's activities was produced by the observers. Data were summarized and presented in tables and a distribution map. Scientific personnel and crew members on board G. O. Sars and Brennholm also recorded incidental sightings of marine mammals more or less continuously on the bridge. Digital filming and photos were taken whenever possible for each registration from scientists onboard.

Meteorology

Wind conditions as derived from the Beaufort scale, air temperature, weather, cloud coverage and sea state were monitored and noted in the cruise logger program at each station onboard the vessels.

Digital photos and filming

Digital photography with Nikon D70 and D200 in addition to digital filming with Sony TCR TRV50 was done throughout the cruise for documentation of trawl catches, various scientific activities and visual observations of marine mammals and seabirds along the cruise tracks on board G. O. Sars and Brennholm.

Acoustics

The acoustic equipment onboard G.O. Sars were calibrated July 2012 for 38, 70, 120 and 200 kHz. Brennholm was calibrated in April 2012 for 18, 38, 70 120 and 200 kHz. Arni Fridriksson was also calibrated in April 2012 for all frequencies 18, 38, 120 and 200 kHz, whereas Christian í Grótinum was calibrated for 38,120 and 200 kHz prior to the cruise. All vessels used standard hydro-acoustic 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. Salient acoustic settings are summarized in the text table below.

Sonar recordings

M/V "Brennholm" was equipped with the new Simrad fisheries sonars SH90 (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 omni-directional 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.

MS70 – Multibeam sonar

Onboard G.O. Sars the Simrad MS 70 recorded sonar data from the entire survey (1-21 July 2012). Post-processing and analyses of these data will be explored in more detail later.

ME70 – Multibeam echosounder

During the first leg of the Brennholm survey, multibeam acoustic data was collected from the Simrad ME70 echosounder, which operates in a range of frequencies between 70 to 120 kHz. These data have not been processed yet.

Acoustic doppler current profiler (ADCP)

R/V "G. O. Sars", R/V "Arni Fridriksson" and 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 between the four surveying vessels

The procedure and results of the intercalibration of the Multpelt 832 pelagic trawl, which was used by all the four vessels in the survey, are provided in Annex 1. Shortcomings and recommendations for future use of the trawl in the survey are also given there.

Acoustic intercalibration between the four surveying vessels

Immediately after finalizing the intercalibration for the pelagic trawling with Multpelt 832 close to the surface, we decided to perform an acoustic intercalibration between G. O. Sars, Brennholm, Christian í Grótinum and Arni Fridriksson. The direction of the intercalibration was from east to west starting at the continental shelf off Iceland. The weather conditions were extremely favorable for acoustic intercalibration with calm sea and 0-1 m wave height during the entire intercalibration.

The convoy structure shown with fixed distances and angles between the vessels during the acoustic intercalibration 17th of July 2012 in Icelandic waters. The photo is taken onboard G.O. Sars and show R/V "Arni Fridriksson", followed by M/V "Christian í Grótinum" and M/V "Brennholm" in front of the convoy. Photo: Leif Nøttestad, Institute of Marine Research, Norway.

The acoustic intercalibration started 17th of July 2012 at 07:05 UTC and ended at 13:30 UTC. The practical performance of the intercalibration were done in the following manner: G. O. Sars started in front of the "convoy" with a normal cruising speed of 10 knots in a straight east-west direction. Brennholm followed 0.8 cables (~150 m) and 100 degrees angle to G. O. Sars in front. Christian í Grótinum came third in the convoy and Arni Fridriksson was the last vessel in the convoy when the acoustic intercalibration started (see picture for illustration). When all vessels were in position in relation to each other and maintained a cruising speed of about 10 knot, the actual acoustic intercalibration could start. Contact between the vessels during the entire intercalibration was maintained continuous via the VHF system on Channel 16 and 67. One hour after G. O. Sars had leaded the way westwards, the vessels changed positions. Arni Fridriksson as the last vessel moved in front with full speed, while the other vessels slowed down to 5 knots. The same procedure was repeated six times, always with the last vessel moving up in front. Only data from the acoustic intercalibration when all vessels where aligned with a certain distance and angle to each other and the survey speed was 10 knots for all vessels will be used in the later analyses of these data. In the area of intercalibration we recorded mackerel and herring in the surface region and blue whiting deeper down in the water column. Consequently the data should be highly applicable to compare acoustic s_A values and biomass estimates for at least herring and blue whiting (and possibly mackerel at a later stage) between the acoustic echosounder recordings onboard G. O. Sars, Brennholm, Christian í Grótinum and Arni Fridriksson. The data on the acoustic intercalibration will be explored and analysed in more detail in the near future. The aim is to write scientific articles on both the trawling intercalibration and acoustic intercalibration from the IEESNS survey between the four participating vessels from July 2012.

Cruise tracks

G. O. Sars, Brennholm, Christian í Grótinum and Arni Fridriksson followed predetermined survey lines with pre-selected pelagic trawl stations. On a few stations performed G. O. Sars pelagic trawl stations on registration from acoustics (herring and blue whiting) (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.

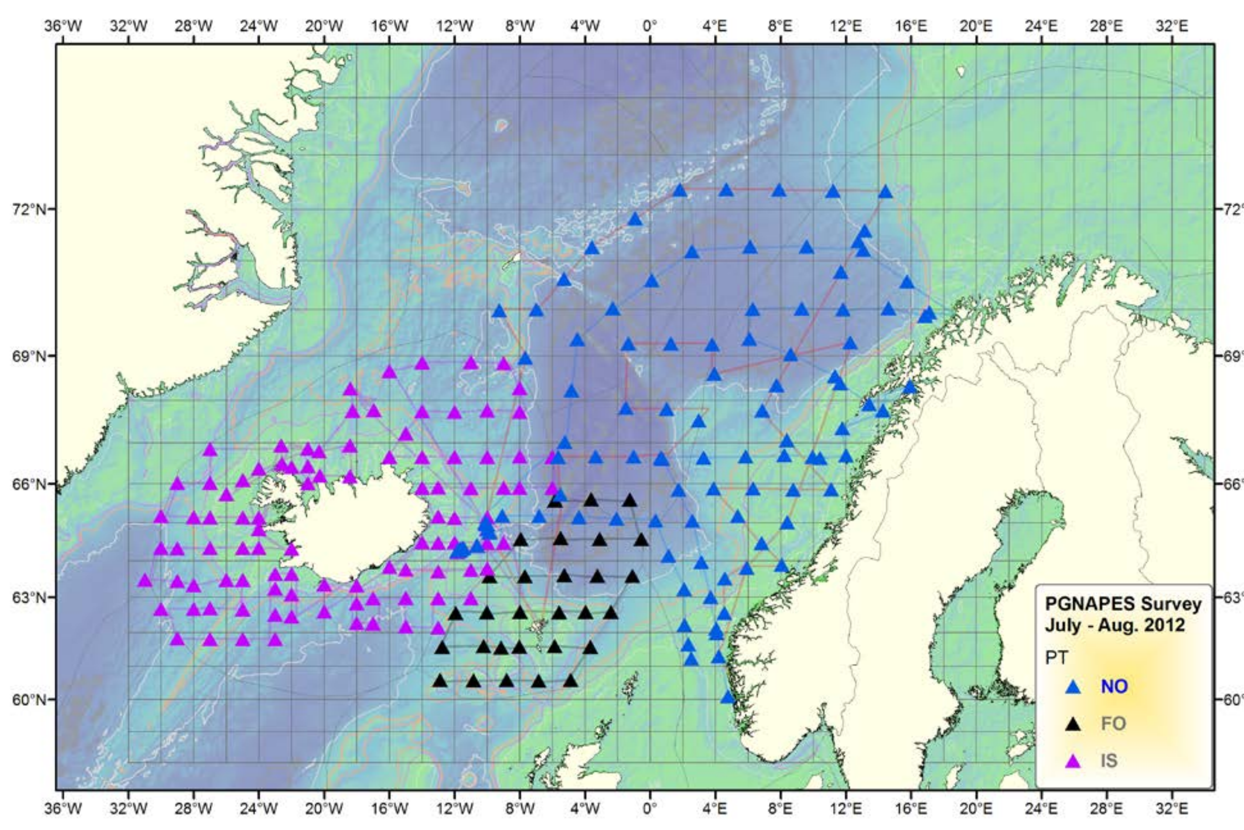

Figure 1. Cruise tracks and pelagic trawl stations shown for R/V "G. O. Sars" in green, M/V "Brennholm" (Norway) in blue, M/V "Christian í Grótinum"" (Faroe Islands) in black R/V "Arni Fridriksson" (Iceland) in red within the covered areas of the Norwegian Sea and surrounding waters from 2nd of July to 10th of August 2012.

CTD sensors in combination with WP2 plankton net samples from the surface and down to maximum 200 m depth were taken systematically on almost every pelagic trawl station onboard all four vessels (Figure 2).

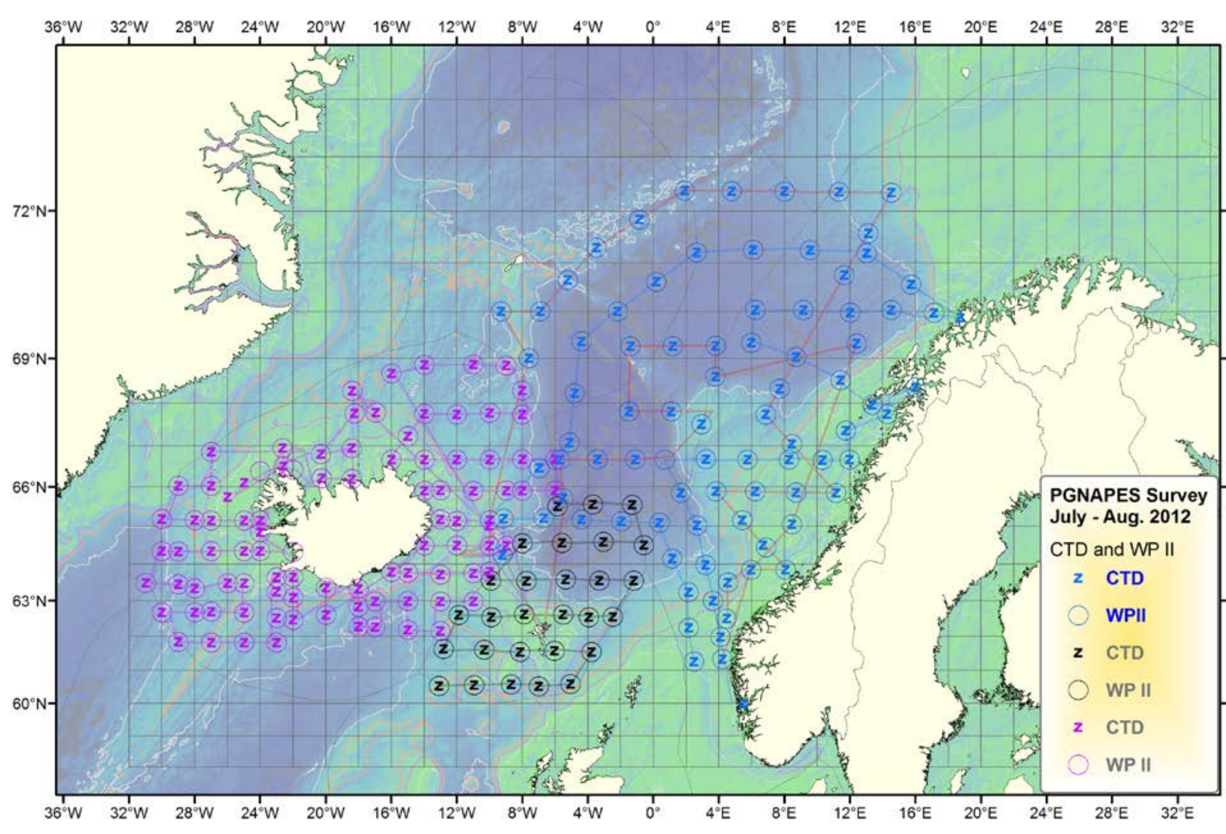

Figure 2. CTD stations (0-500 m) using SEABIRD SBE 37 (G. O. Sars and Arni Fridriksson) SEABIRD SB 25+ and SAIV SD200 (Brennholm) CTD sensors and WP2 plankton net samples (0-200 m). These were taken systematically on every pelagic trawl station on all four vessels

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

Table 4. Acoustic instruments and settings for the primary frequency in the July/August survey in 2012.

	R/V G.O. Sars	R/V Arni Friðriksson	M/V Brennholm	M/V Christian í Grótinum
Echo sounder	Simrad EK60	Simrad EK 60	Simrad EK 60	Simrad EK 60
Frequency (kHz)	**18, 38, 70,** 120, 200, 333	**38**, 18, 120, 200	18, **38**, 70, 120, 200	38,120, 200
Primary transducer	ES38B	ES38B	ES38B serial	ES38B
Transducer installation	Drop keel	Drop keel	Drop keel	Hull
Transducer depth (m)	9	8	6	5
Upper integration limit (m)	15	15	15	12
Absorption coeff. (dB/km)	9.9	10	9.9	9.9
Pulse length (ms)	1.024	1.024	1.024	1.024
Band width (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	26.16
s_A correction (dB)	-0.60	-0.84	-0.65	-0.68
alongship:	6.89	7.31	7.01	7.05
athw. ship:	6.87	6.95	7.11	6.98
Maximum range (m)	500	750	750	500
Post processing software	LSSS	LSSS	LSSS	Sonardata Echoview 5.1

Generally, acoustic recordings were scrutinized using the LSSS onboard G.O. Sars, Brennholm and Arni Fridriksson and scrutinized using Echoview software onboard Christian í Grótinum on daily basis. 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.

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 2012). The acoustic methods were unchanged from last year (ICES 2012).

Swept area index and biomass estimation

The swept area estimate is based on catches in the whole area covered in the survey, or between 60°N and 73°N and 30°W and 18°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 and 2011, i.e.: **a)** allocation of sea area to EEZs is based on a table taken from a NEAFC blue whiting report, and **b)** sea area proportion of rectangles overlapping land were calculated with polygon clipping in R using packages 'geoextras' and 'geo' (available on http://r-forge.r-project.org) and 'maps', 'mapdata' (available on http://cran.r-project.org) (Jónsson et al. 2011; Björnsson 2010; Becker and Wilks 2010, R Development Core Team 2011). Estimation of sea area proportion was improved from that used in 2010.

An experimental bootstrap approach to estimating uncertainty was used this year. The bootstrap units were the 1° lat by 2° lon rectangle biomass estimates themselves, across the whole area. The total biomass for each bootstrap replicate was summed and stored in a vector of bootstrap biomass estimates, yielding bootstrap CV and 90% CI. Number of replicates was 100 thousands. For this report we bootstrapped only occupied rectangles but not and interpolated rectangle values (Fig. 19).

Exclusive Economic Zone's (EEZ's) in the Northeast Atlantic shown as overlays on some of the figures in this report were taken from shape files on http://www.vliz.be/vmdcdata/marbound/.

Results

Hydrography

There have been considerable changes in the temperature regime in the Norwegian Sea and adjacent waters the last few years compared to a 20 years average. However, in July/August 2012 these changes seem to be less pronounced compared to previous periods, although with a pronounced exception in the western and northern part of Icelandic and Greenland waters, where surface temperatures were considerable higher (up to 3°C) compared with the 20 year average (Figure 3). 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 one month part (Figures 3 and 4).

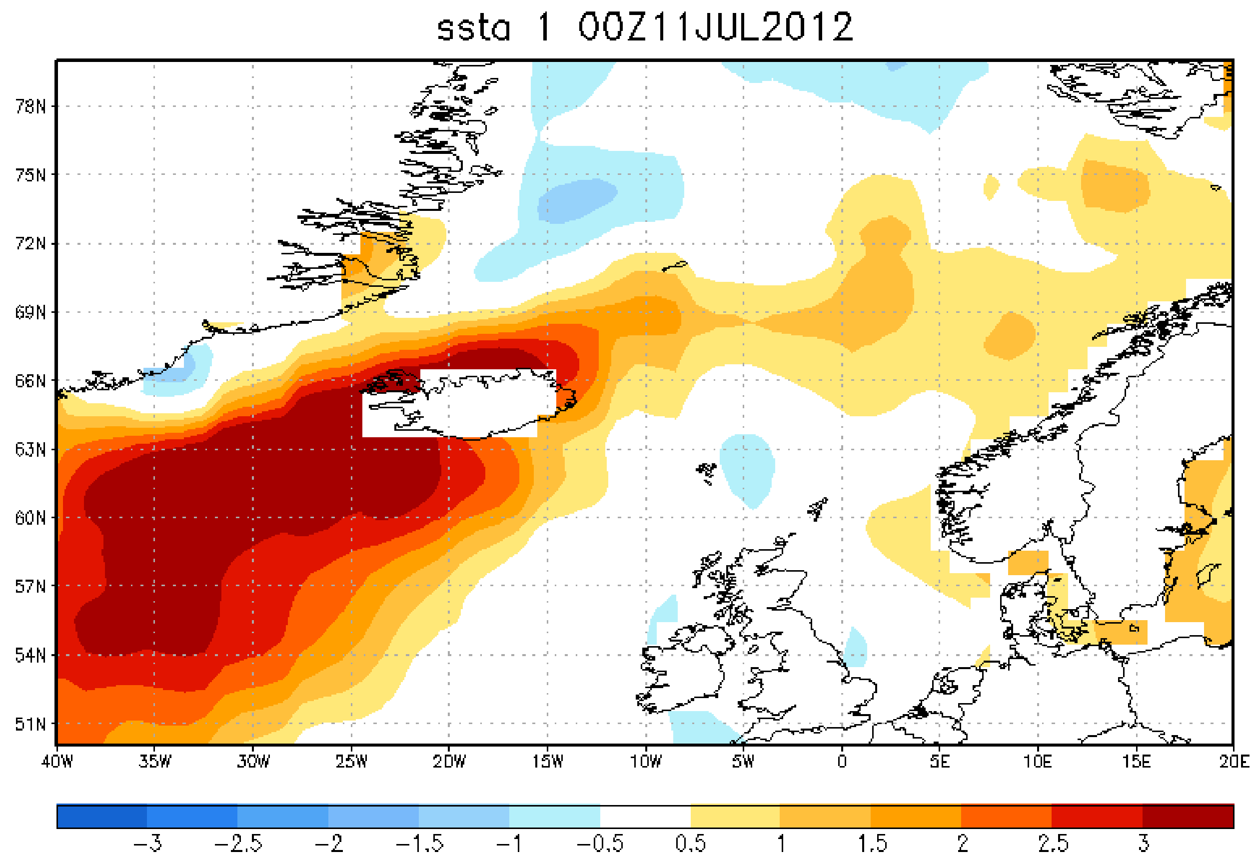

Figure 3. Sea surface temperature anomalies (°C; centered in week 28, mid July 2012) showing warm and cold conditions in comparison to a 20 year average.

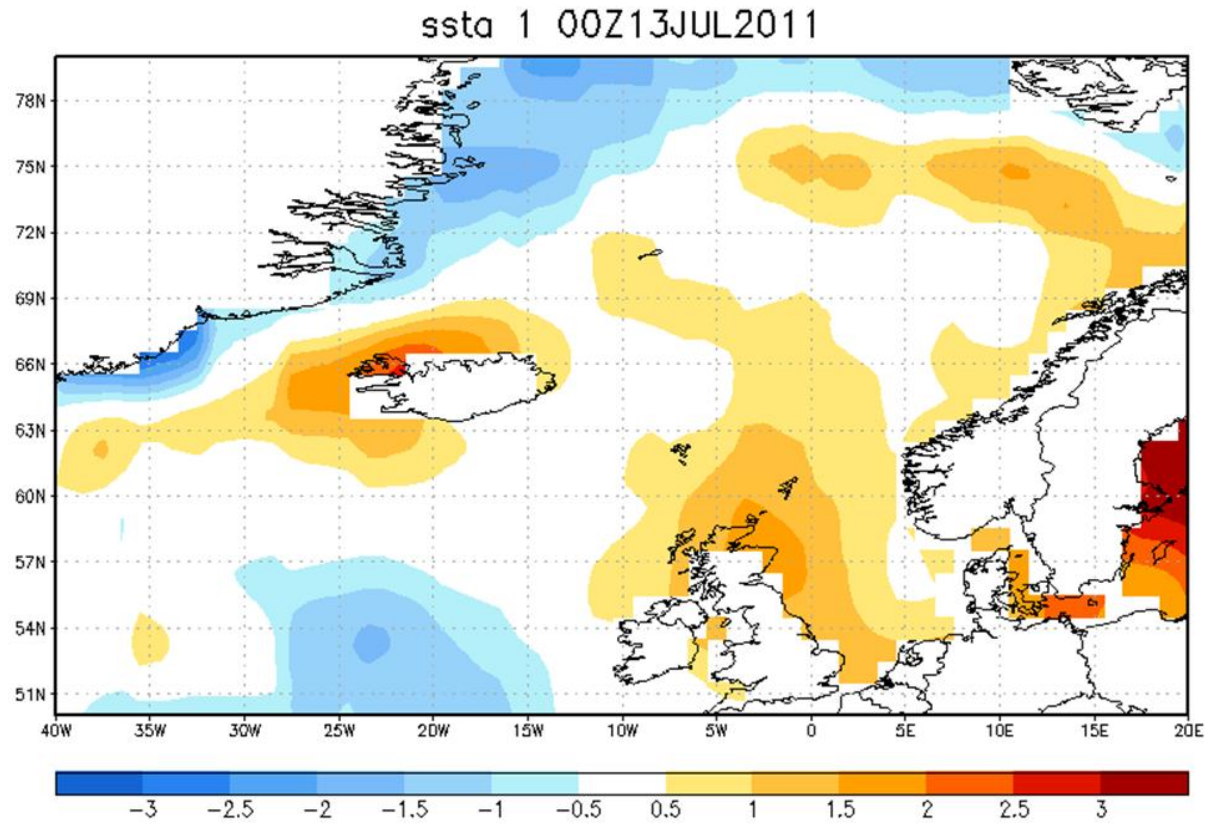

Figure 4. Sea surface temperature anomalies (°C; centered in week 28, mid July 2011) showing warm and cold conditions in comparison to a 20 year average.

The temperature at depth based on CTD measurements from the four participating vessels is shown in Figures 5 - 10. The temperature in the upper layers (10m and 20m) shows warm water of Atlantic origin covering most of the survey area. The temperature was highest southwest of Iceland where it reached 13°C, and in the southeastern Norwegian Sea where it was 12°C. The front between the cold East Iceland Current (EIC) and the warmer Atlantic water (the Iceland-Faroe Front, IFF) which usually is located in the south western Norwegian Sea, was clearly visible in these layers. The warm Atlantic water extended north beyond the 70 degrees in the eastern Norwegian Sea, as well as north of Iceland. North/northwest of Iceland the temperature was lower and reaching 4°C. The temperature distribution at 50m depth was similar as the surface layers but with cooler water, especially in the south-western Norwegian Sea, where the cold EIC and features like the IFF was clearly detected. In deeper layers below 100m the same main features were detected as described for 50m depth. South and west of Iceland, warm Atlantic water dominated the entire water column with temperature of 7-9°C at 400m depth. In the eastern Norwegian Sea warm Atlantic water was also detected down to 400m depth.

The appearance of the IFF in the upper layers indicates less stratification in the surface waters in summer 2012 compared to 2011, and also weaker thermocline between 20 and 50 m depths. It seems as the surface waters in the southern Norwegian were (more than one degree) cooler in 2012 than in 2011, most likely due to the persistent north-easterly winds during most of the spring and summer. This was also observed in the IESNS survey in May 2012 in the same area (ICES 2012). The surface waters southwest of Iceland seemed to be warmer in 2012, however, this difference disappeared at depths below 50-100m. In waters deeper than 100m the influence of the EIC is more pronounced and extends further south into Faroese and especially east into Norwegian waters. This can clearly be seen at 400m depth, where the eastern extension of the EIC reaches the Norwegian coast at 63°N (Fig. 10).

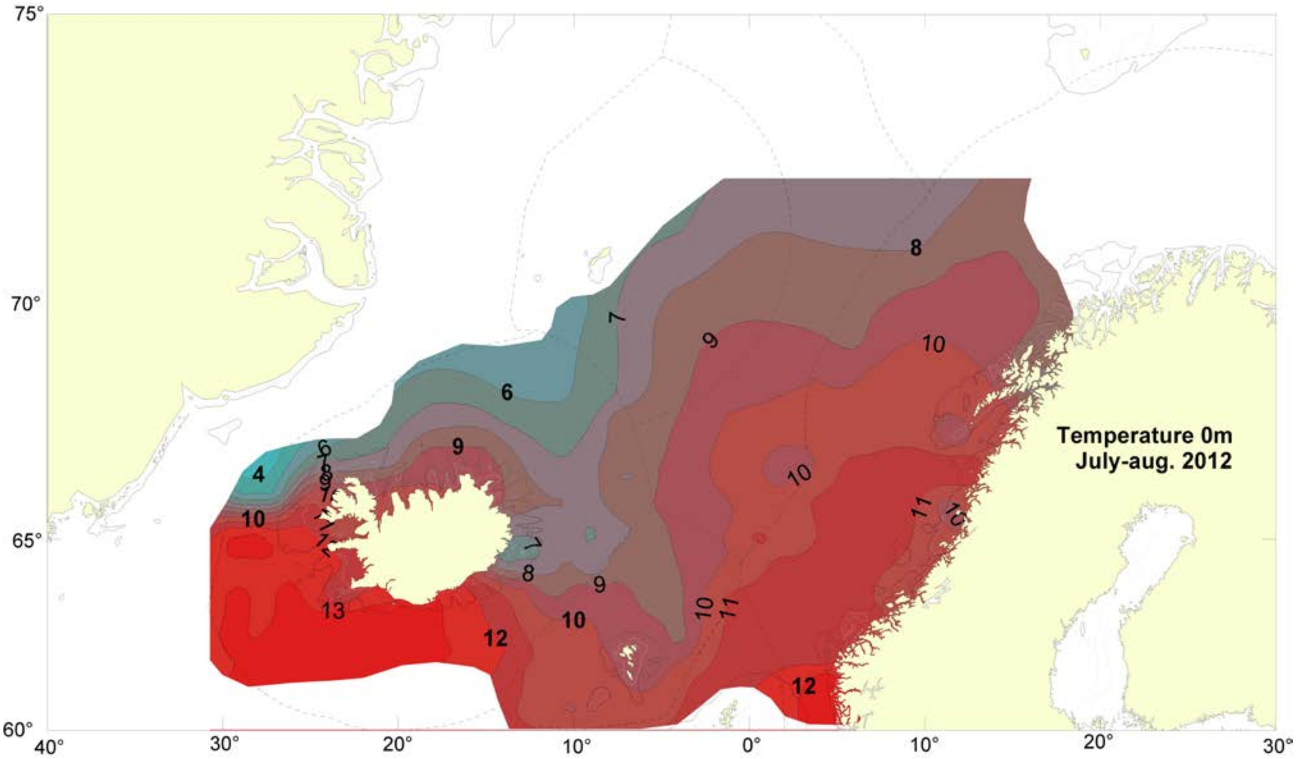

Figure 5. Temperature (°C) at 10 m depth in the Norwegian Sea and surrounding waters in July/August 2012.

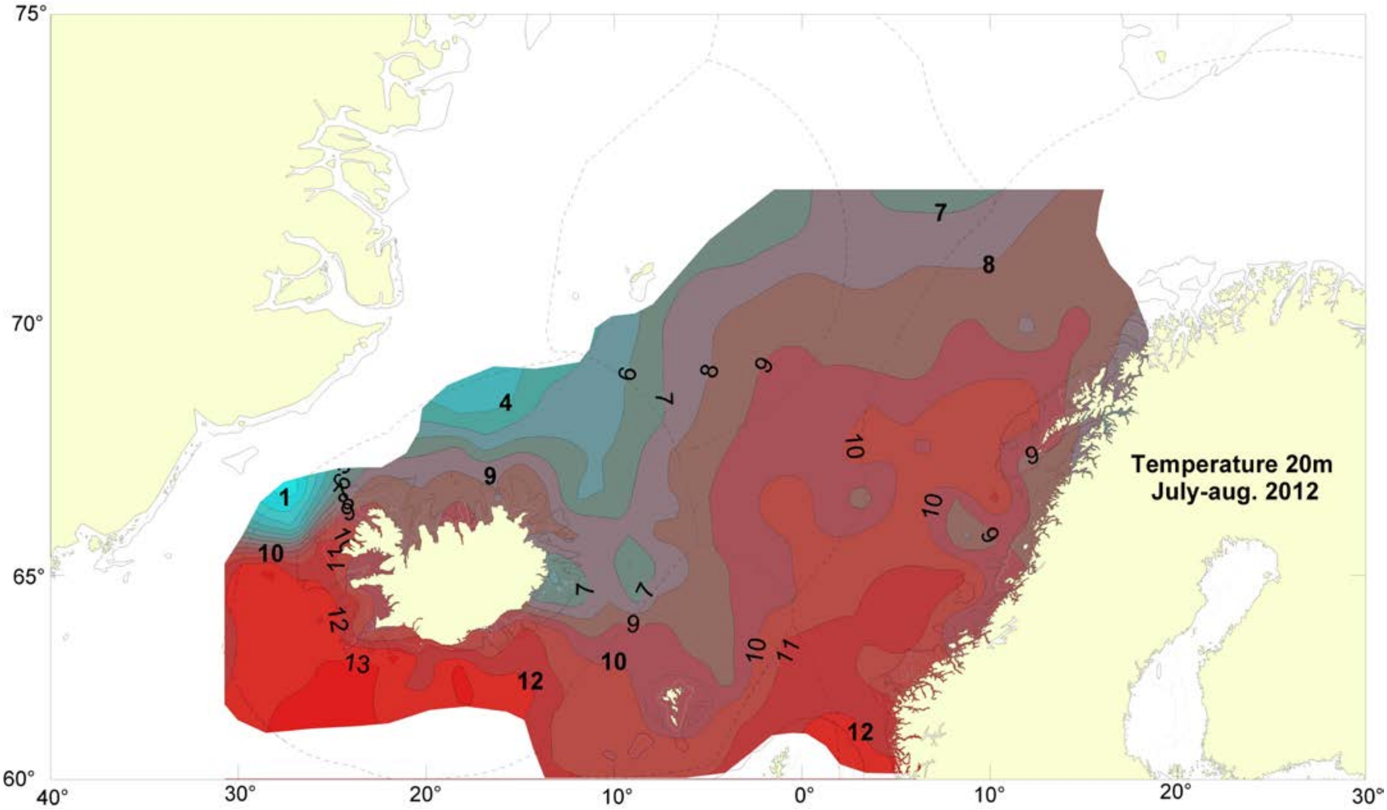

Figure 6. Temperature (°C) at 20 m depth in the Norwegian Sea and surrounding waters in July/August 2012.

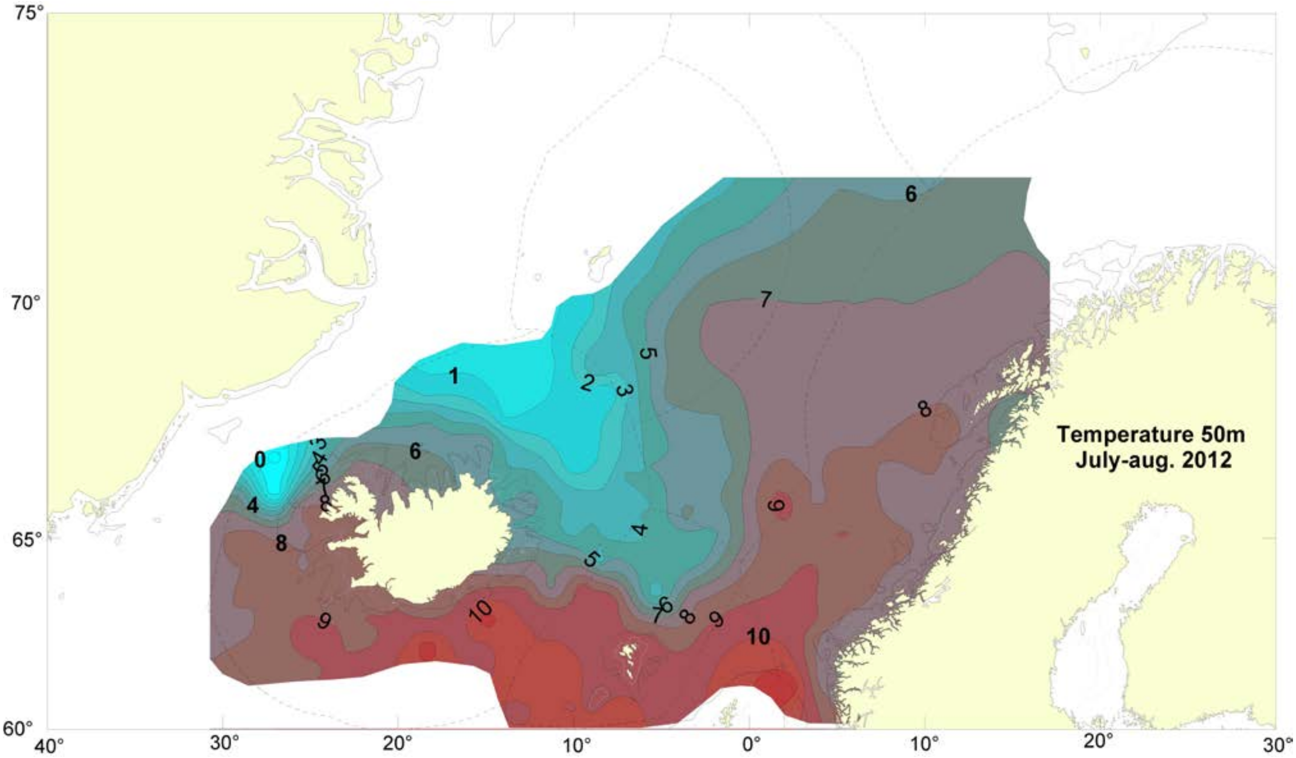

Figure 7. Temperature (°C) at 50 m depth in the Norwegian Sea and surrounding waters in July/August 2012.

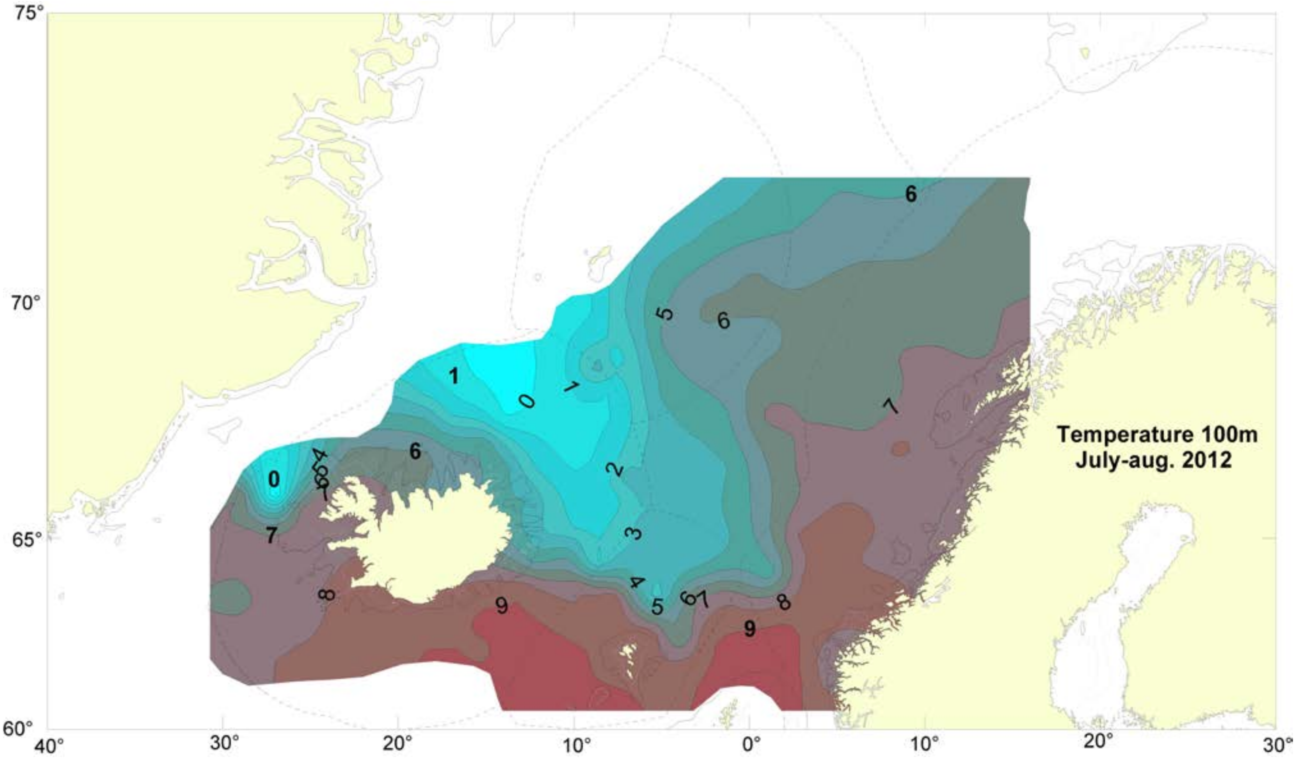

Figure 8. Temperature (°C) at 100 m depth in the Norwegian Sea and surrounding waters in July/August 2012.

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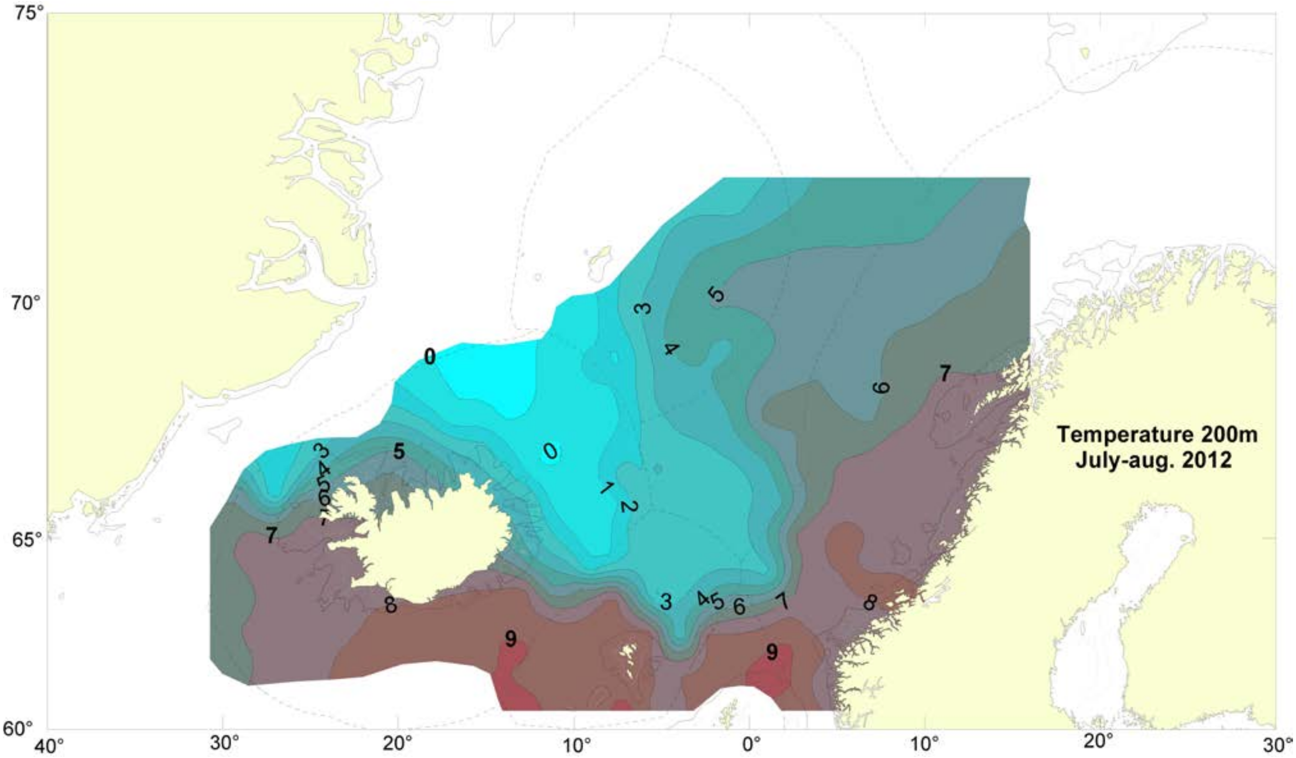

Figure 9. Temperature (°C) at 200 m depth in the Norwegian Sea and surrounding waters in July/August 2012.

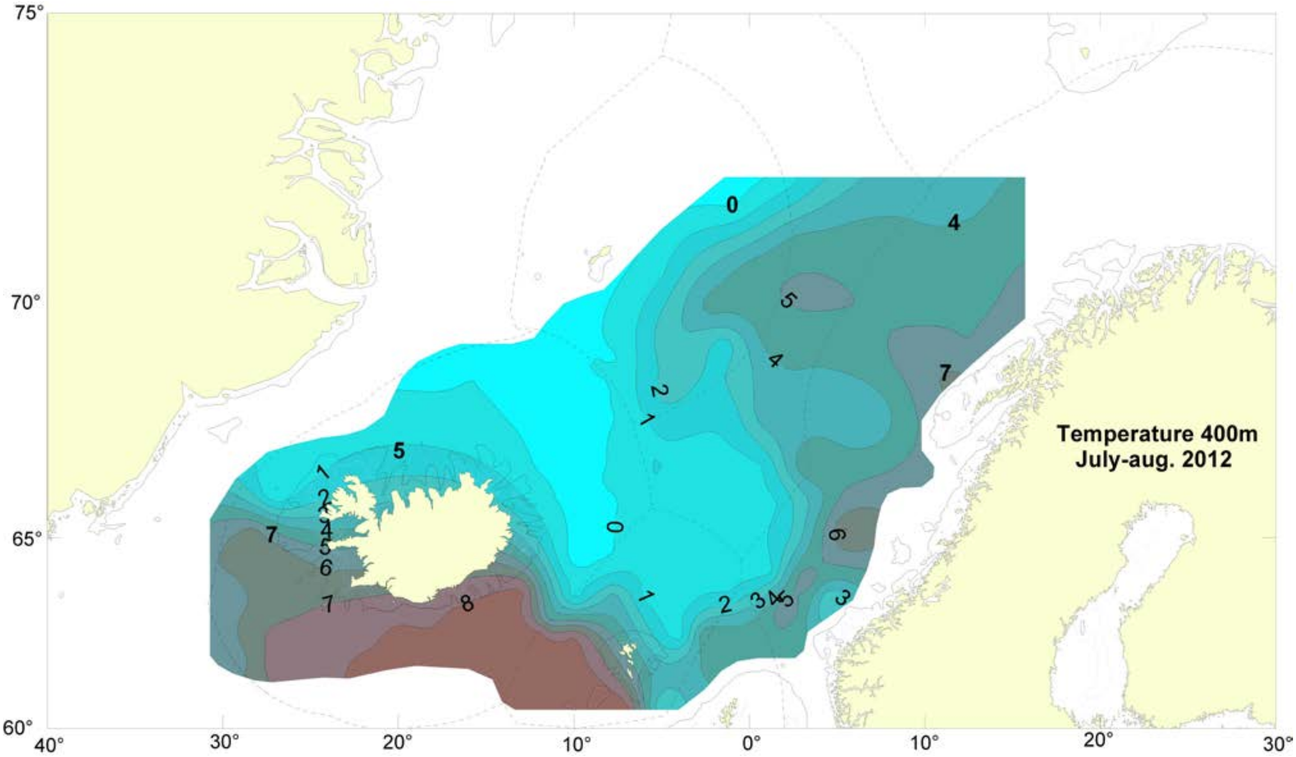

Figure 10. Temperature (°C) at 400 m depth in the Norwegian Sea and surrounding waters in July/August 2012.

Zooplankton

The zooplankton biomass was generally low with an average plankton biomass of 4.3 g/m^2 throughout the survey area, excluding the westernmost area around Iceland (see Figure 11). The plankton concentrations were lowest in the central Norwegian Sea (Fig. 11). This is a comparable pattern that was observed during the 2011 surveys. The biomass was slightly higher in the south western Norwegian Sea, and west of Iceland in the frontal area between the warm Atlantic water and the colder Arctic water. The zooplankton samples for species identification have not been examined in detail, but the general impression was that Chaetognatha partly dominated the samples in the central Norwegian Sea with some concentrations of Gastropoda along the shelf and shelf break. *Calanus finmarchicus* was generally found in small concentrations in the western survey area, while *Calanus hyperboreus* was sampled in the northern and northwestern part of the Norwegian Sea. Krill and amphipods were found in small quantities in most areas except in the westernmost areas. In the central and eastern part of the Norwegian Sea we detected more phaeocystis (phytoplankton flagellates) in the WP 2 net samples compared to previous years.

The low biomass of zooplankton is in agreement with the decreasing trend that has been observed in the zooplankton biomass in the Norwegian Sea in the May survey for more than a decade (ICES 2011). In May 2012 the plankton concentrations were 4.7 g/m^2 west of 2°W and 6.7 g/ m^2 east of 2°W (ICES 2012)

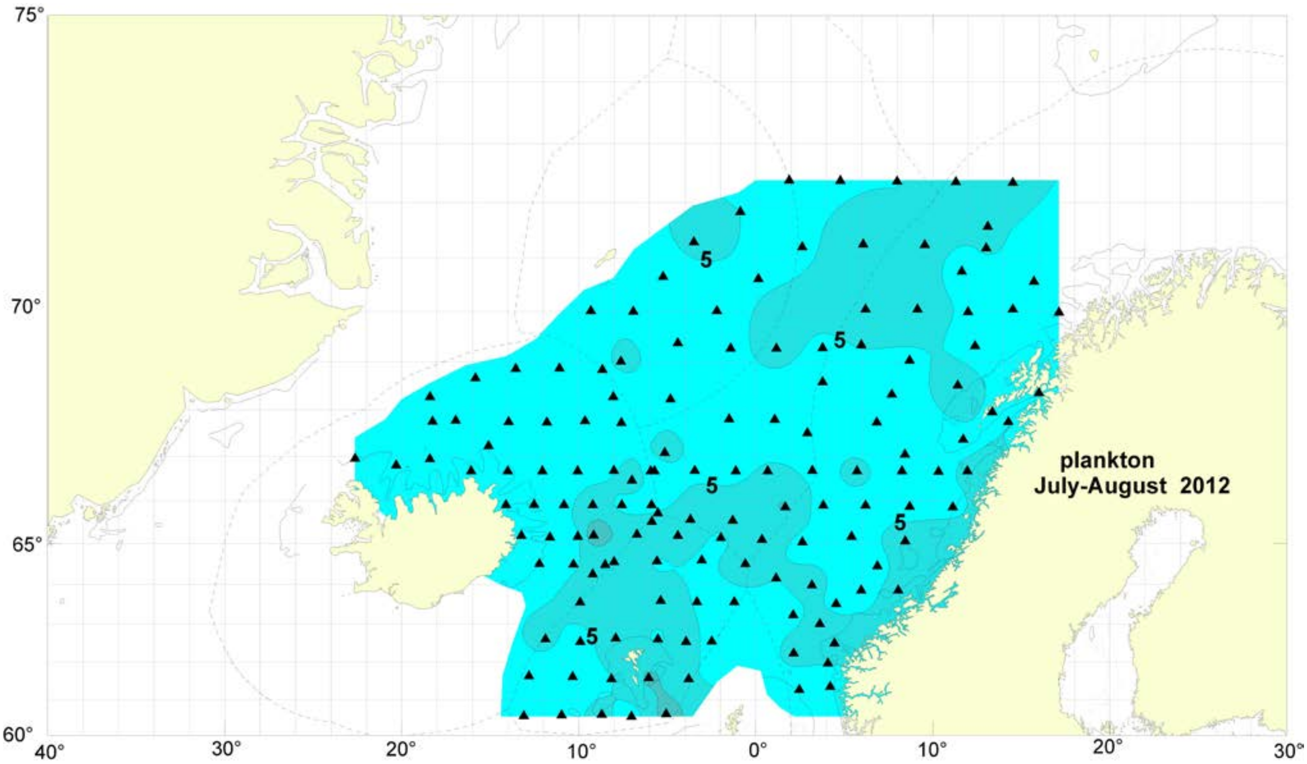

Figure 11. Zooplankton biomass (g dw/m^2, 0-200 m) in the Norwegian Sea and surrounding waters, 2 July - 10 August 2012. (The Icelandic plankton data in the southern and western area will very soon be available!)

Pelagic fish species

Mackerel

The total mackerel catches (kg) taken during the joint ecosystem survey is presented in standardized rectangles in Figure 12. The map is showing different concentrations of mackerel from zero catch to more than 500 kg.

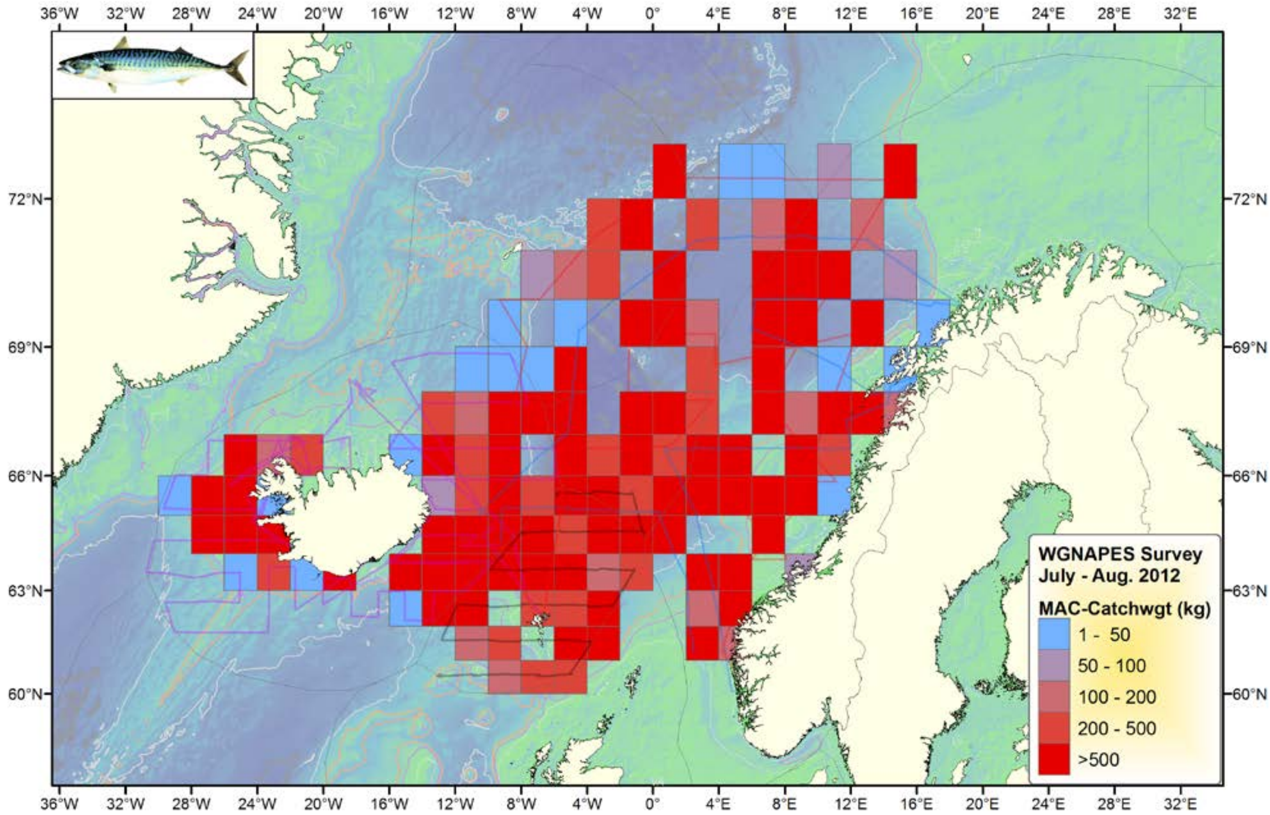

Figure 12. Catches of mackerel in kg represented in standardized rectangles. Light blue represents small catches (1-50 kg), while dark red represents catches of more than 500 kg mackerel. Vessel tracks are shown as continuous lines.

The mackerel catch rates (kg/nmi) from pelagic trawling onboard Brennholm, G.O. Sars, Christian í Grótinum and Arni Fridriksson from 2 July to 10 August 2012 are shown in Figure 13.

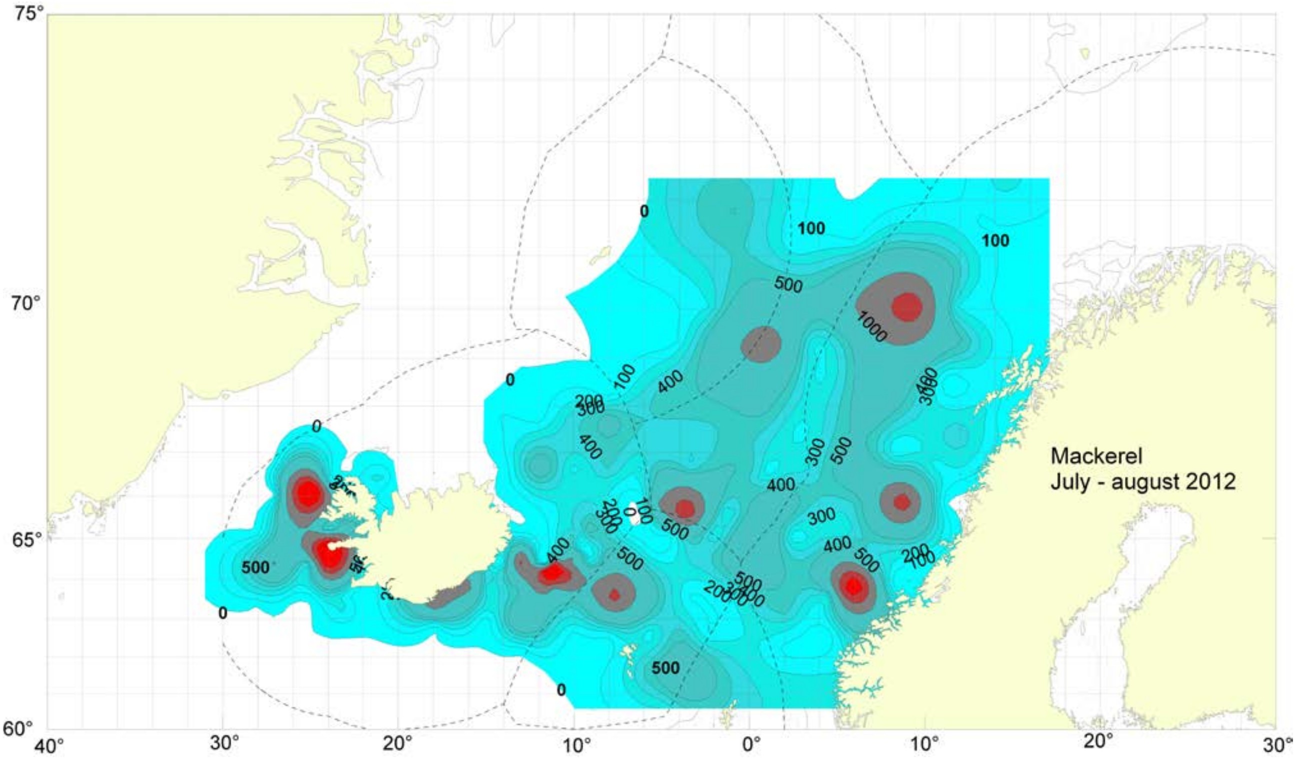

Figure 13. A contour plot of mackerel catch rates (kg/nmi) in July/August 2012.

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 2012 (Figure 14).

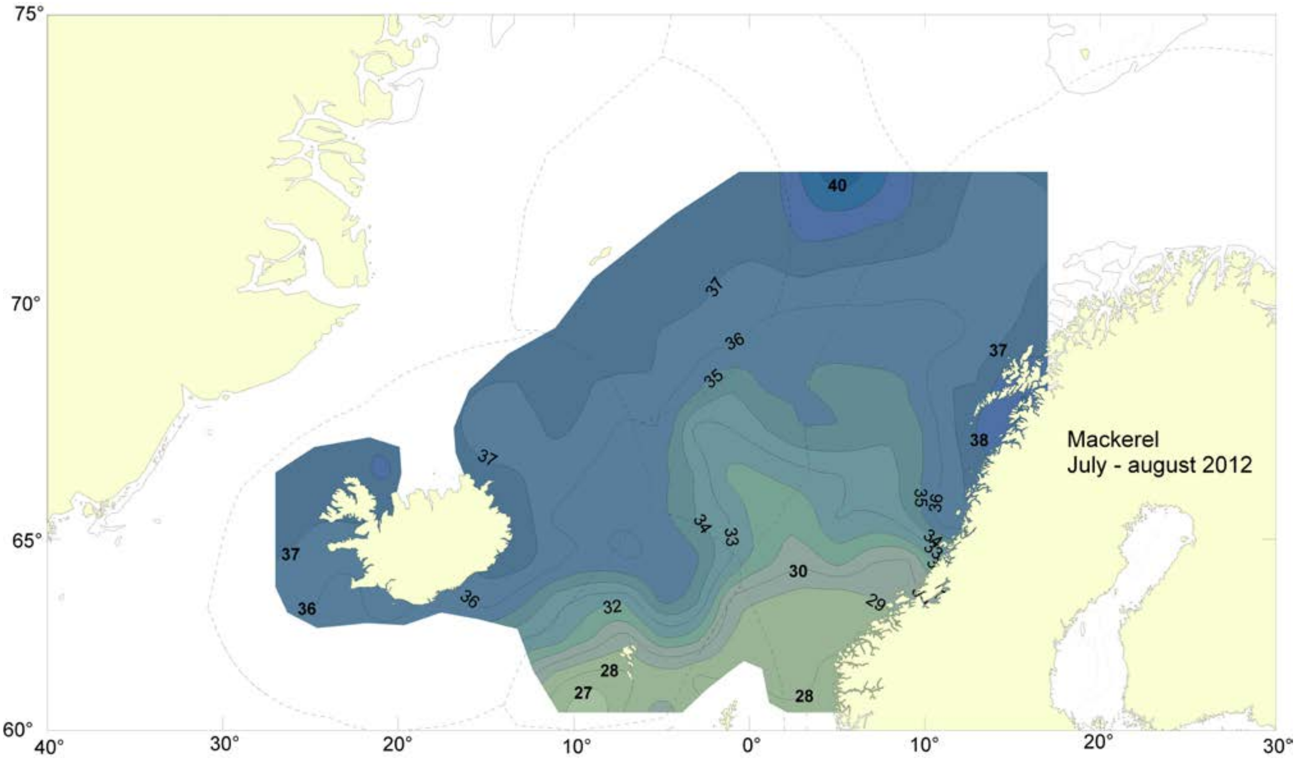

Figure 14. Average length distribution of NEA mackerel from the joint ecosystem survey with R/V "G. O. Sars", M/V "Brennholm", M/V "Christian í Grótinum" and R/V "Arni Fridriksson" in the Norwegian Sea and surrounding waters between 1st of July and 10th of August 2012.

Mackerel caught in the pelagic trawl hauls on the four vessels varied from 5 cm to 43 cm in length with the individuals between 33-37 cm dominating in the abundance. The mackerel weight (g) varied between 10 to 760 g (Figure 15).

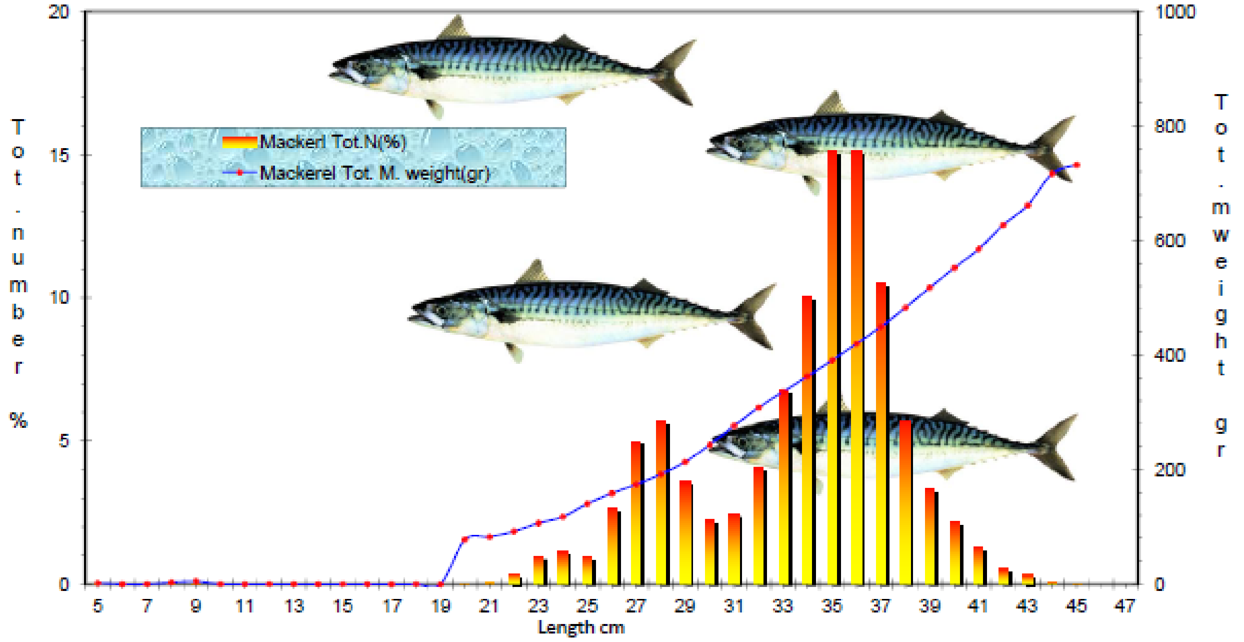

Figure 15. Total length (cm) and weight (g) distribution in percent (%) for mackerel in all catches.

The 2006-year class of mackerel dominated the catches with >20% of the mackerel in numbers, followed by equally strong 2005, 2007 and 2008-year classes around 15% each, respectively (Figure 16). The 2010 year class seems to be very strong, since it was represented with around 12% of the individual mackerel in numbers from the scientific trawl hauls from the Norwegian Sea and surrounding waters.

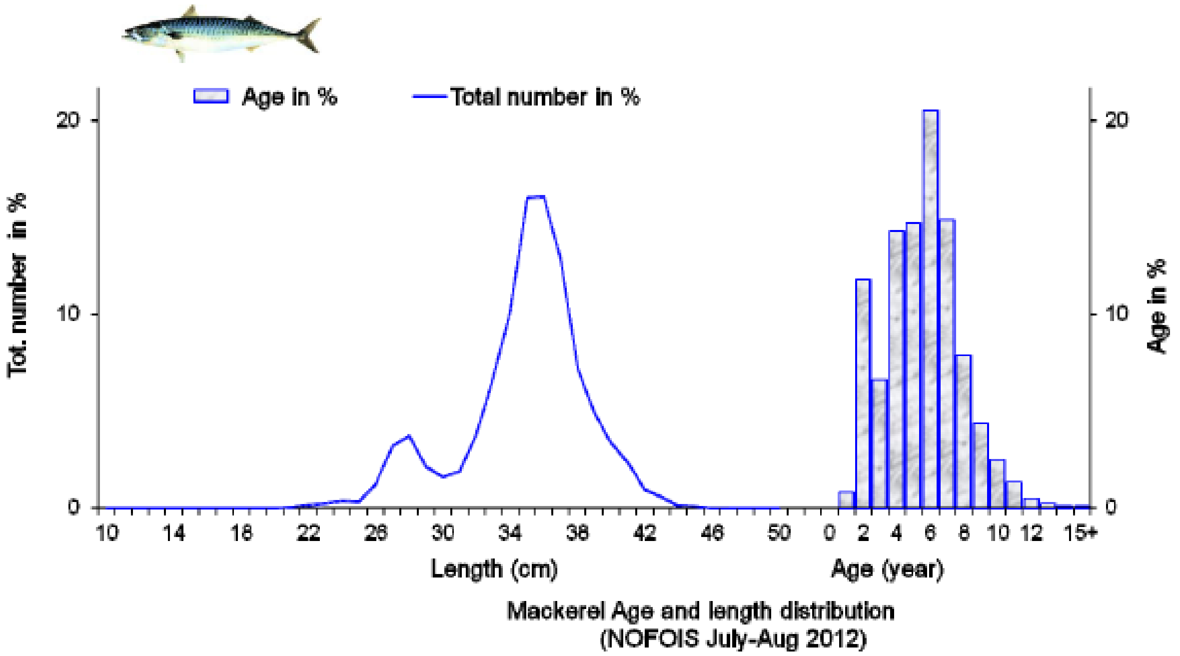

Figure 16. Age and length distribution in percent (%) of Atlantic mackerel in the Norwegian Sea and surrounding waters from 1st of July to 10th of August 2012.

The spatial distribution and overlap between the major pelagic fish species from the joint ecosystem survey in the Nordic Seas are shown in Figure 17.

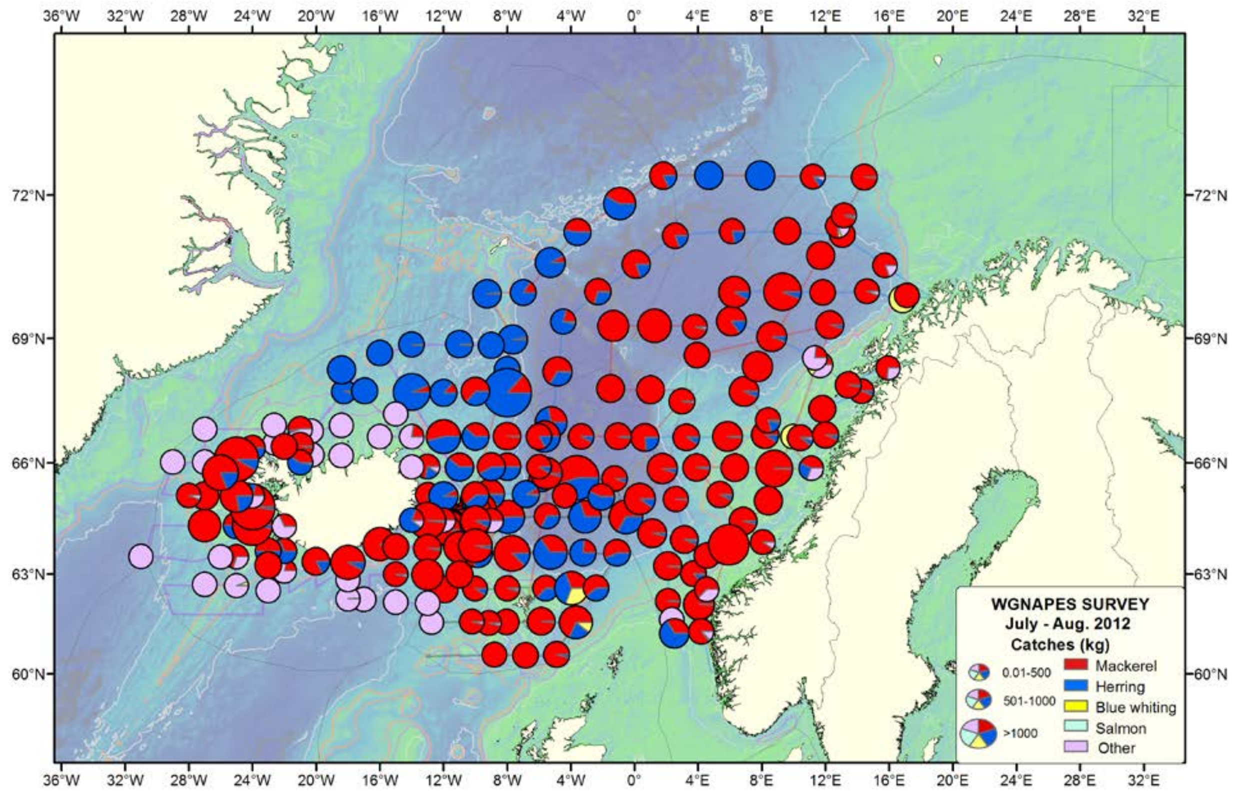

Figure 17. Distribution and spatial overlap between mackerel (red), herring (blue), blue whiting (yellow) and salmon (violet) from joint ecosystem surveys conducted onboard R/V "G. O. Sars"and M/V "Brennholm" (Norway), M/V "Christian í Grótinum" (Faroe Islands) and R/V "Arni Fridriksson" (Iceland) in the Norwegian Sea and surrounding waters between 1st of July and 10th of August 2012. Vessel tracks are shown as continuous lines.

Sonar recordings

Along the analyzed transects in the central Norwegian Sea, the schools detected were of medium to small size with generally few detections of each school along the sonar 600 m range. Medium size schools were detected better at longer ranges (between 450 and 200 m) and smaller schools at shorter ranges (10 to 150 m). This detection pattern observed in the sonar together with the detection probability from Lybin and the echo sounder data, allow elaborating the following; medium sized schools is most likely herring located at depths between 20 to 80 m, and are detected with the sonar at larger ranges, being below the sonar beam at shorter ranges. In contrary, the small schools could be mackerel schools located shallower from the surface to 30 m, and are better detected at short ranges because of their low acoustic strength.

Swept area analyses from standardized pelagic trawling with Multpelt 832

The swept area estimates of mackerel biomass were based on average catches of mackerel within rectangles of 1° latitude and 2° longitude and measurements of horizontal opening of the trawls (Table above), which gave catch indices (kg/km^2; Fig. 18). 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 35 (Fig. 19). The interpolation was done by taking the average values of all adjacent rectangles. The swept area estimates for the different rectangles is shown in Fig. 19 and in more graphical manners in Fig. 20. Biomass estimates were also done for the different EEZs and the total estimate came to 5.1 million tons (Table 5). The bootstrap of the biomass estimate was only done on rectangles with measured values where the total estimate was 4.354 million tons with CV=1.0, and 95% CI of 3.670 and 5.080.

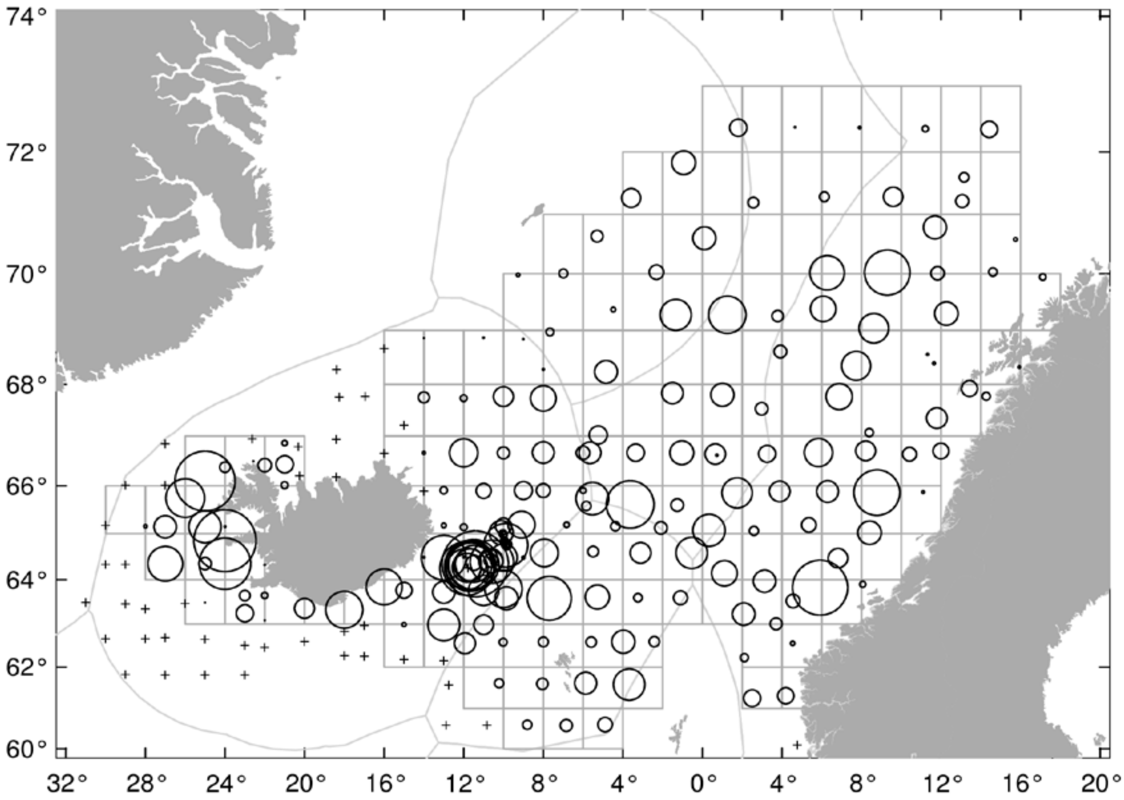

Figure 18. Stations and catches of mackerel in July/August 2012 where the circles size is proportional to square root of catch (kg/km²) and stations with zero catches are denoted with +.

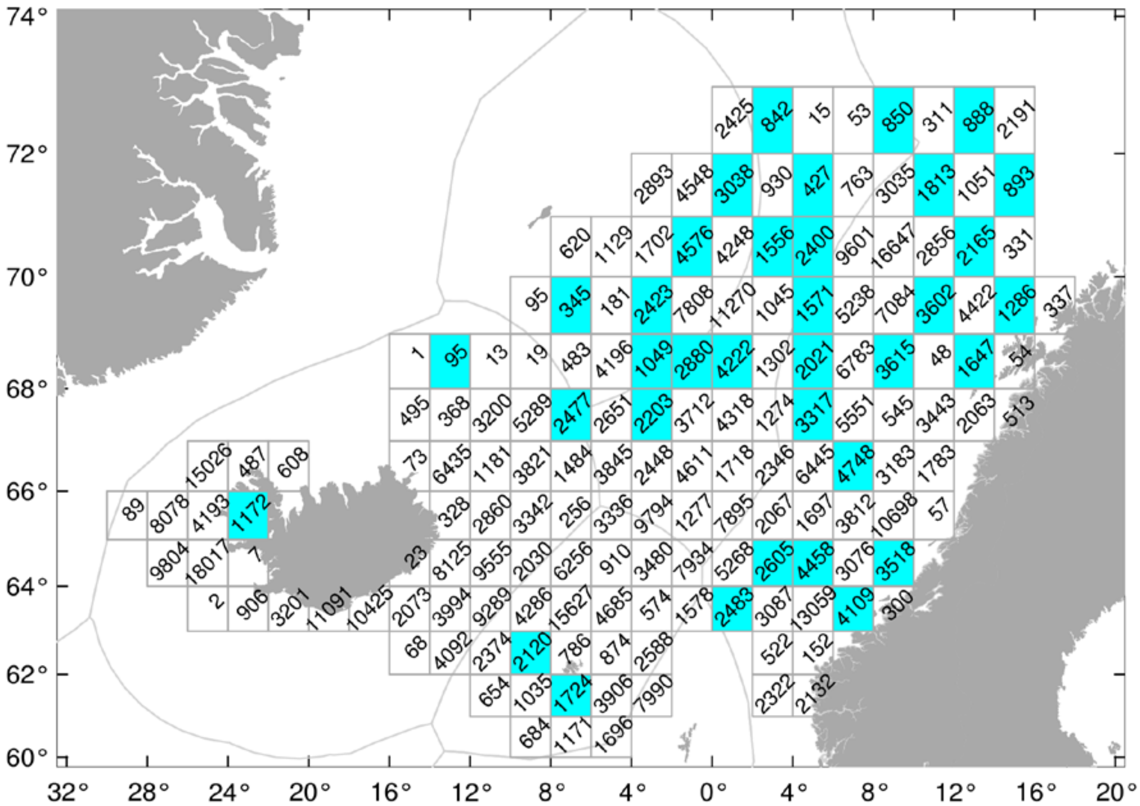

Figure 19. Mean mackerel catch index (kg/km) in 1° lat. by 2° lon. rectangles from swept area estimates in July/August 2012, where interpolated rectangles are denoted with blue shading.

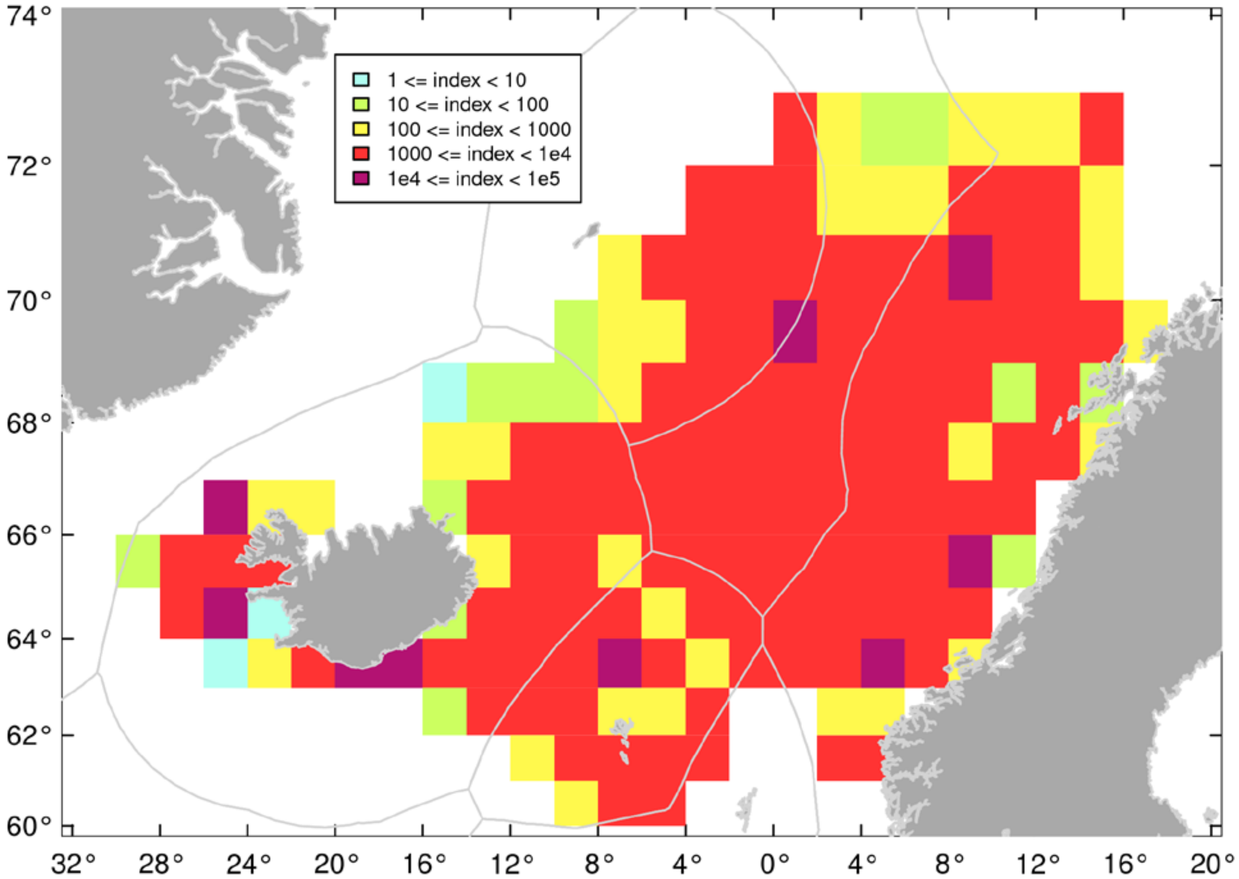

Figure 20. Mean mackerel catch index (kg/km²) for mackerel the July/August 2012 survey represented graphically. Colouring of index levels is the same as in the last IESSNS survey report (ICES 2011).

Table 5. Swept area estimates of NEA mackerel biomass in the different EEZs according to the coordinated ecosystem survey in July-August 2012.

	Area (1000 km²)	Biomass (1000 tonnes)	Biomass (%)
Total	1528	5079	100
Faroese EEZ	234	746	14.7
Icelandic EEZ	395	1496	29.5
Norwegian EEZ	495	1680	33.1
Jan Mayen EEZ	149	395	7.8
EU EEZ	23	101	2.0
International waters	230	663	13.0

Norwegian Spring-spawning herring

The Norwegian spring-spawning (NSS) herring (*Clupea harengus*) was acoustically recorded and biological samples were taken at all pelagic trawl stations where herring was present in the upper water masses. A biomass estimate was performed on NSS herring based on the acoustic recordings using the primary frequency of 38 kHz. The biomass estimate on NSS herring was 7.3 million tons in July-August 2012.

Norwegian summer spawning herring were also sampled and acoustically monitored along the northeastern part of the Norwegian Sea and in the Vestfjord and Lofoten area in northern Norway, while Icelandic summer spawning herring were sampled in the west, south and southeast of Iceland.

The s_A values shows that herring was distributed across the whole survey area except for the middle part of the Norwegian Sea (Figure 21). The concentrations were low in the northern and eastern areas. The highest concentrations were in the southern areas north of the Faroes and in the western part where NSS herring extended all the way to 20°W north of Iceland and around 14°W south of Iceland. West of these locations there were Icelandic summer spawners according to trawl samples. The periphery of the distribution of NSS herring towards north were probably not reached between 20°W and 8°E.

Herring was in the surface waters in most area feeding and possibly above the transducer (acoustic dead zone) and therefore poorly represented in the acoustic measurements. This could be the case for other areas as well where the herring is staying high in the water column actively.

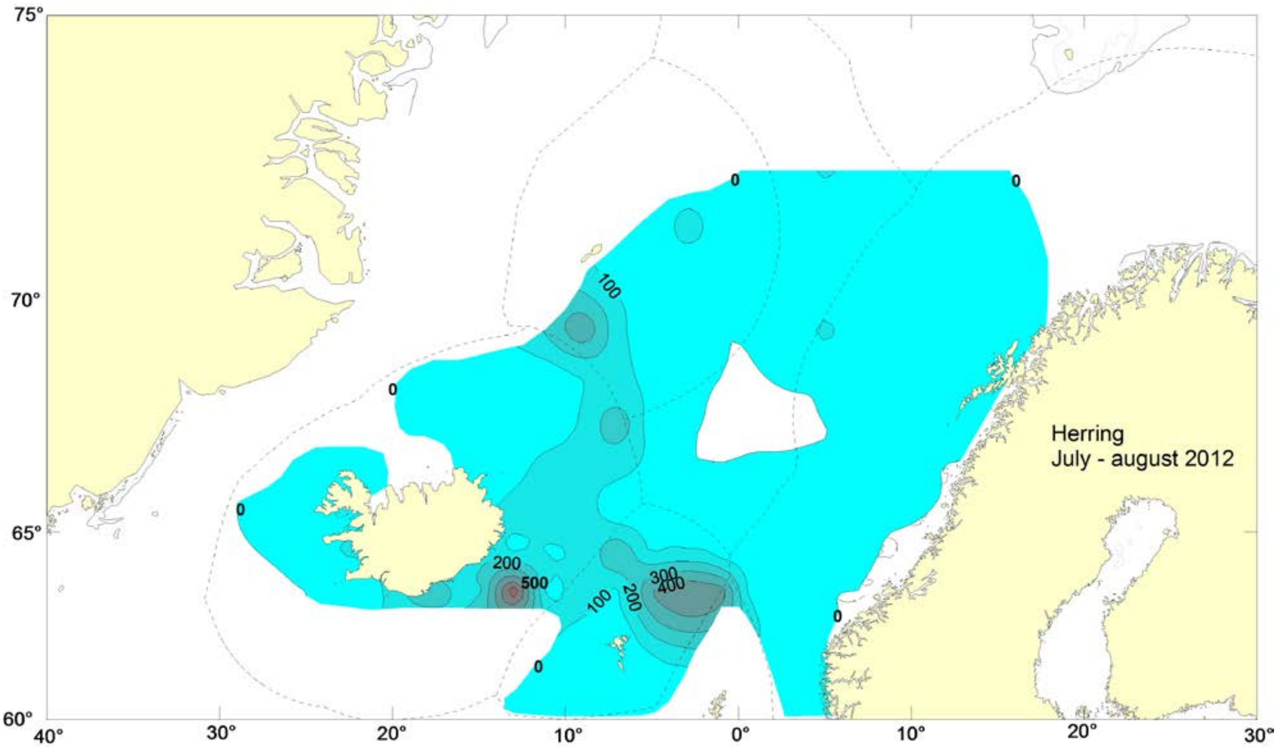

Figure 21. Contours of S_A/Nautical Area Scattering Coefficient (NASC) values of herring along the cruise track, 1 July -10 August 2012. The high density southeast of Iceland was a mixture of NSS and Icelandic summer spawning herring and herring southwest and south of 62°N of the Faroes are local Faroese autumn-spawning herring.

Norwegian spring-spawning herring had a length distribution from 20-38 cm with a peak at 33 cm individual length (Figure 22), and mean weight at age ranging from 60-480 gram (Figure 23). The age distribution in NSS herring shows dominance of the 2004 year class with about 18% in numbers of the acoustic estimate, followed by the 2003 year class (15%) and 2009 year class (13%) (Figure 22).

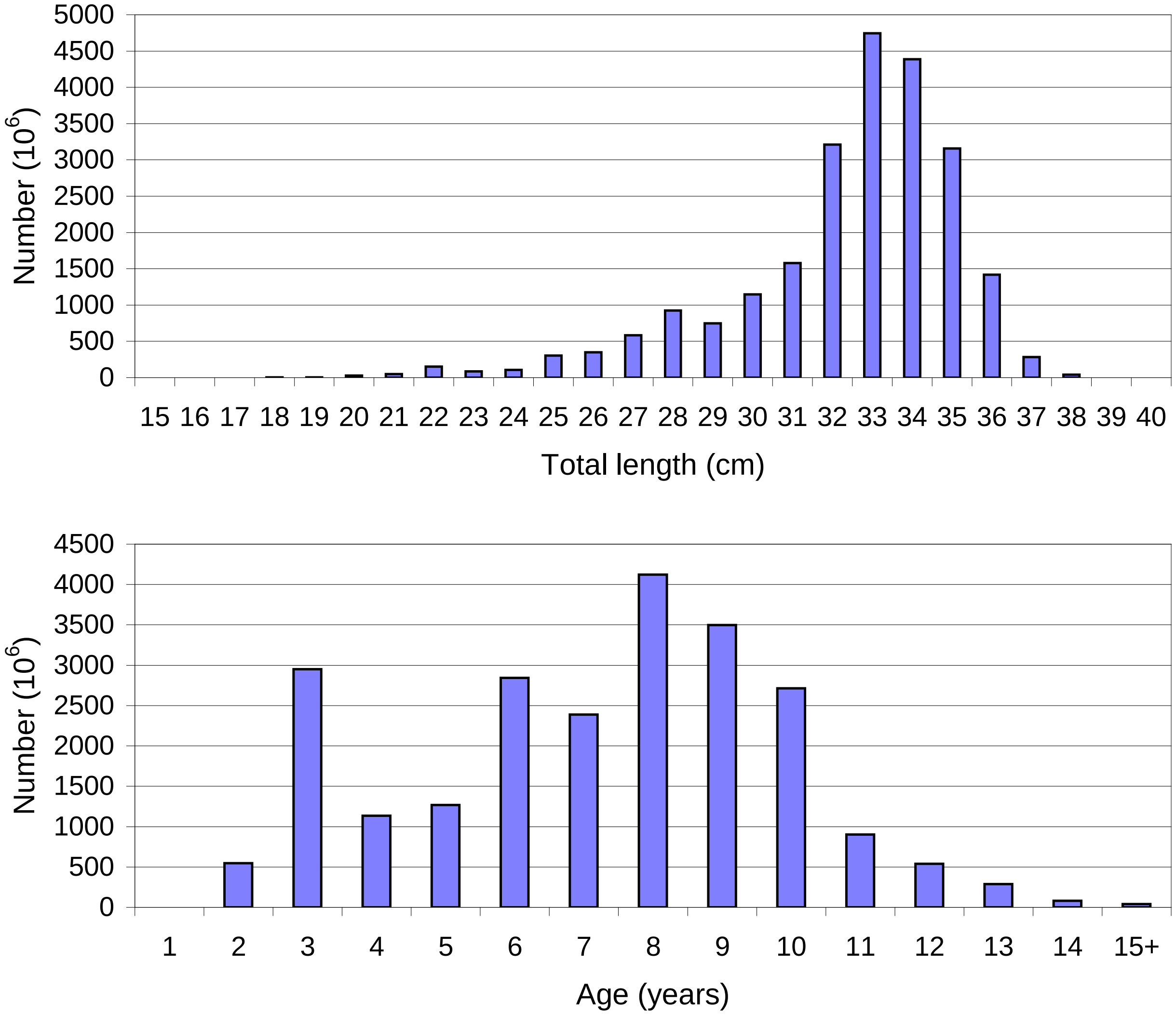

Figure 22. Number at length (upper pannel) and age (lower pannel) of NSS herring according to the acoustic estimate of the stock in July/august 2012.

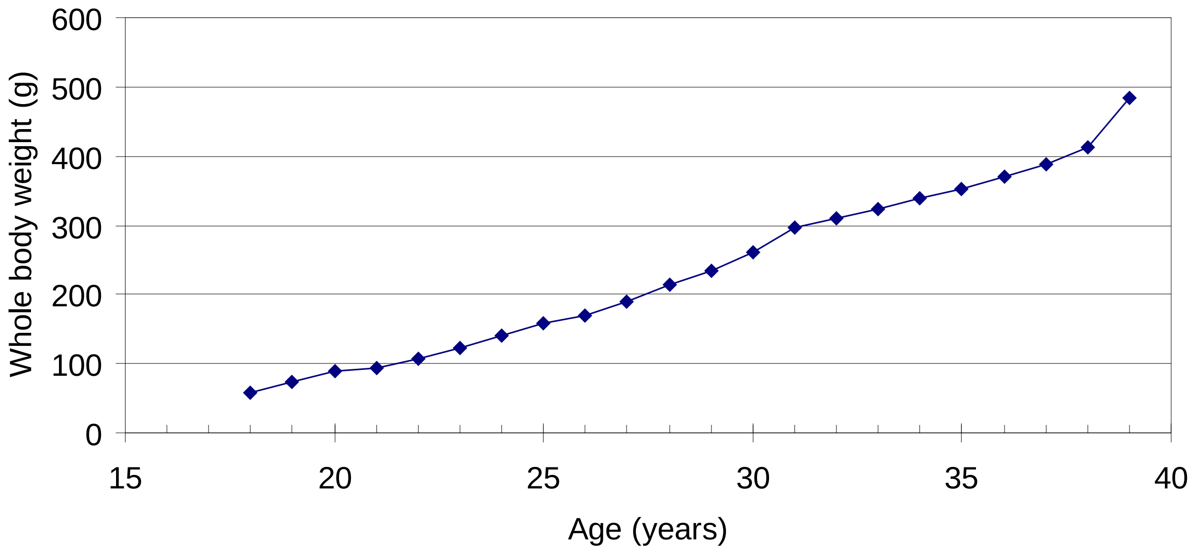

Figure 23. The mean whole body weight (g) of NSS herring in the July/August 2012 survey.

The length distribution measured on herring showed overall a pronounced length dependent migration pattern, with the largest individuals (34 cm) swam furthest west and northwest (Fig. 24). Large herring were also found in the eastern Norwegian Sea, which has been observed the last few years.

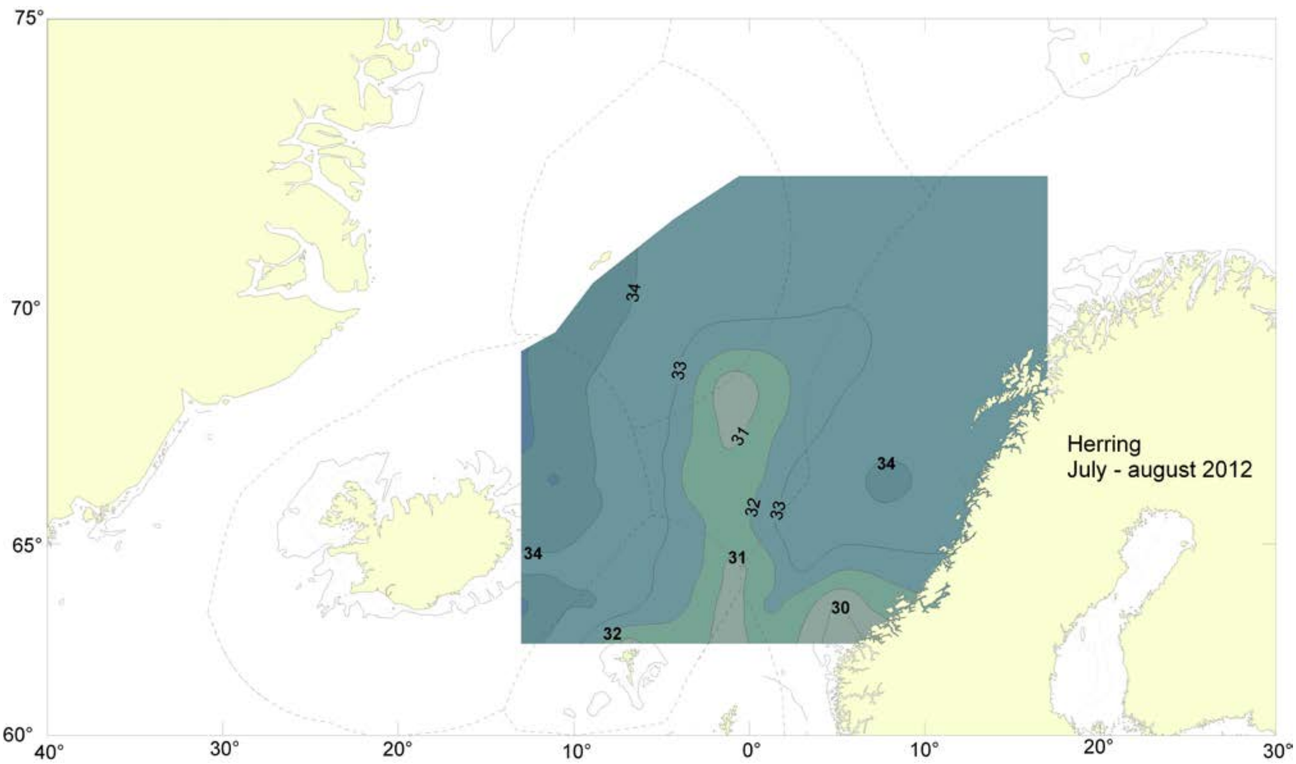

Figure 24. Length distribution of Norwegian spring-spawning herring during the coordinated ecosystem survey 1 July to 12 August 2012.

Blue whiting

Acoustic estimates of blue whiting were used to construct a geographical distribution of the stock (Figure 25). It must be considered that blue whiting was not the main target species in the survey so dedicated trawl samples from schools of blue whiting at greater depths than surface were very few. The total biomass estimate of blue whiting from the acoustic survey was 766 thousand tons, whereas 43% of it was fish at age 1. Of the total number (10.7 billions), 65% were of age 1, 15% age 2 and 11% age 3. These figures of the composition of the stock should though be taken with great cautious due to how sampling effort of blue whiting in the survey.

This survey confirm the presence of immature blue whiting in the feeding areas during summer.

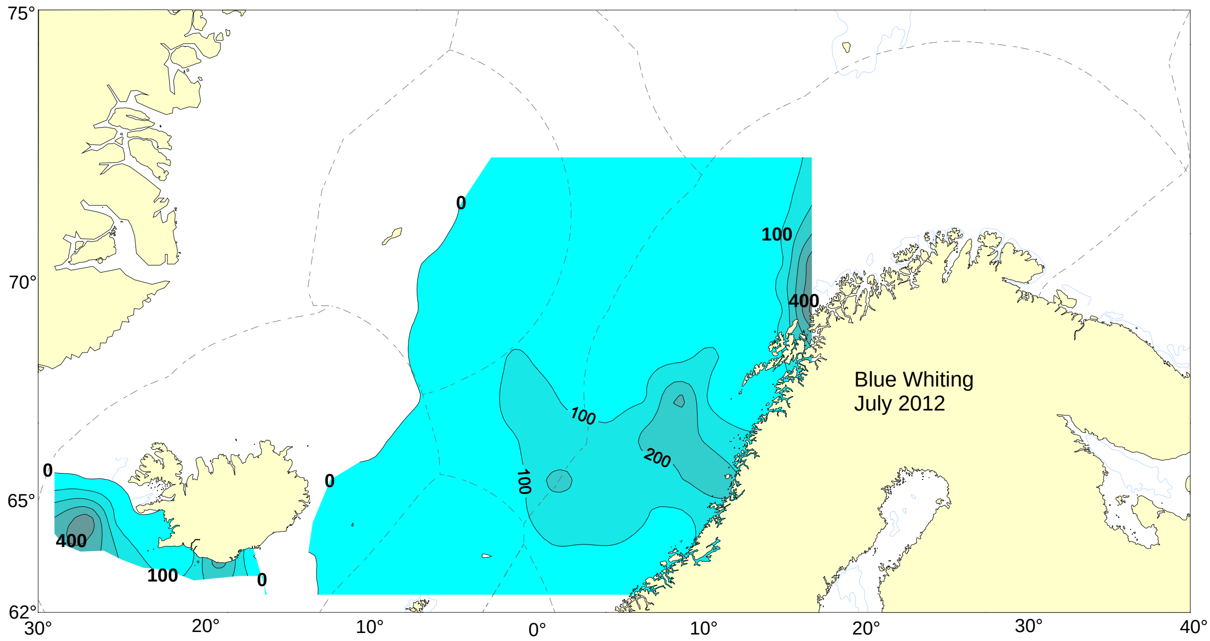

Figure 25. Contours of sA (Nautical Area Scattering Coefficient) values of blue whiting along the cruise track, 1st of July -10th of August 2012.

Lumpfish

Lumpfish (*Cyclopterus lumpus*) is among the most widely distributed species caught in the IESSNS survey. Swept area estimates indicate highest concentrations of lumpfish near the coastal spawning grounds of Norway and Iceland, yet a widely pelagic distribution of fish is noted (Figure 26). No lumpfish was caught in the southern most parts of the survey, i.e. south of Iceland and Faroe Island, and the lowest concentrations were in the central part of the Norwegian Sea. Variations in the distance from shore of various length classes could be an indicator of year class distribution or favourable feeding grounds for different life-history stages. A wide range of lumpfish sizes were caught in the surveys (6-54cm) and adults (>25cm) were found throughout the survey area, from costal to pelagic waters. The widely distribution of the species raises some important management questions which will be addressed with further analyses of the IESSNS lumpfish data and with genetic analysis in the future.

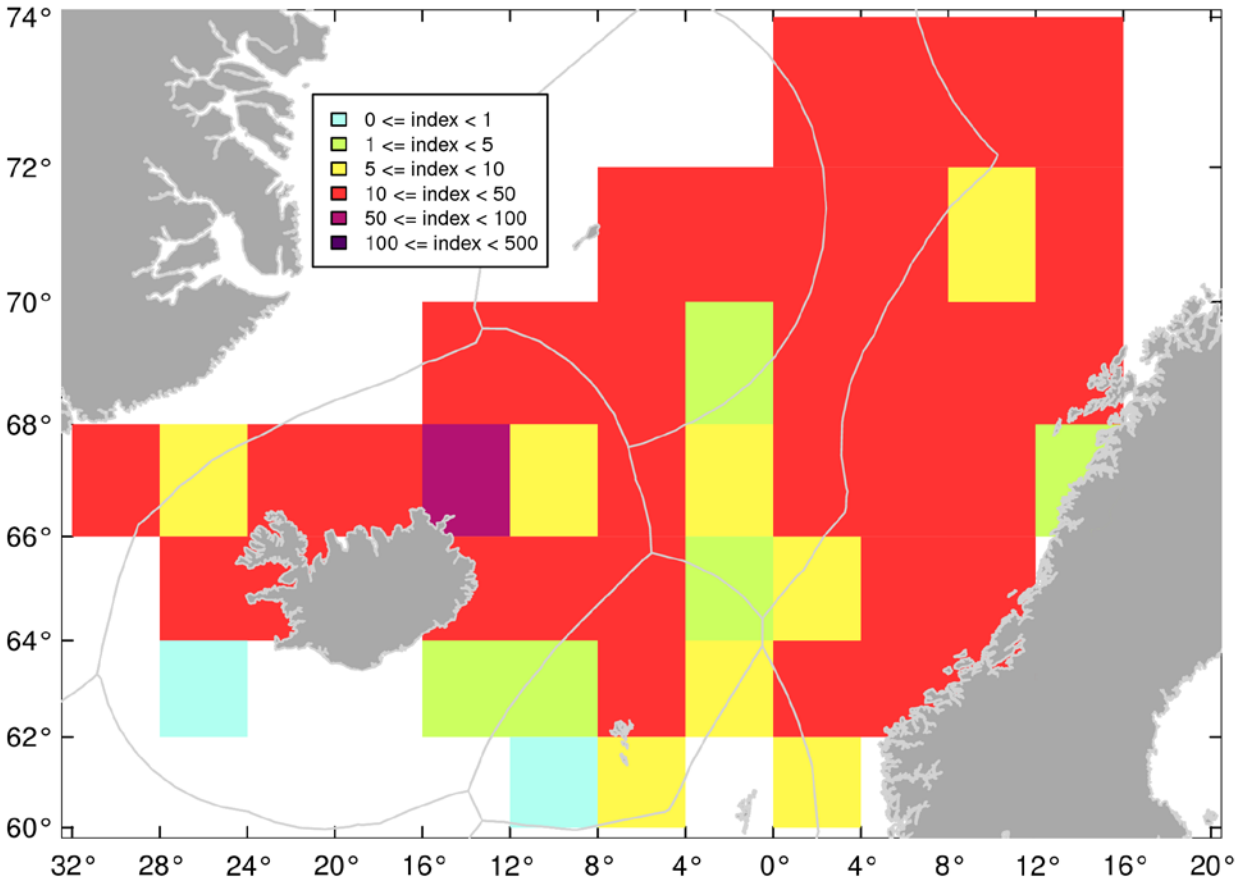

Figure 26. Rectangle average swept area index (kg/km²) for lumpfish in the July/August 2012 survey in 2°lattitude and 4° longitude rectangles.

Marine Mammal Observations

The overall impression was that very few marine mammals were sighted onboard R/V "G. O. Sars" and M/V "Brennholm" in the Norwegian Sea and surrounding waters from 2 to 27 July 2012 (Fig. 27). Totally 385 marine mammals and 10 different speices were observed. A total number of 119 pilot whales in seven groups were seen in coastal waters, whereas 20 bottlenose whales in six groups were found in the northwestern and western part of the survey area.

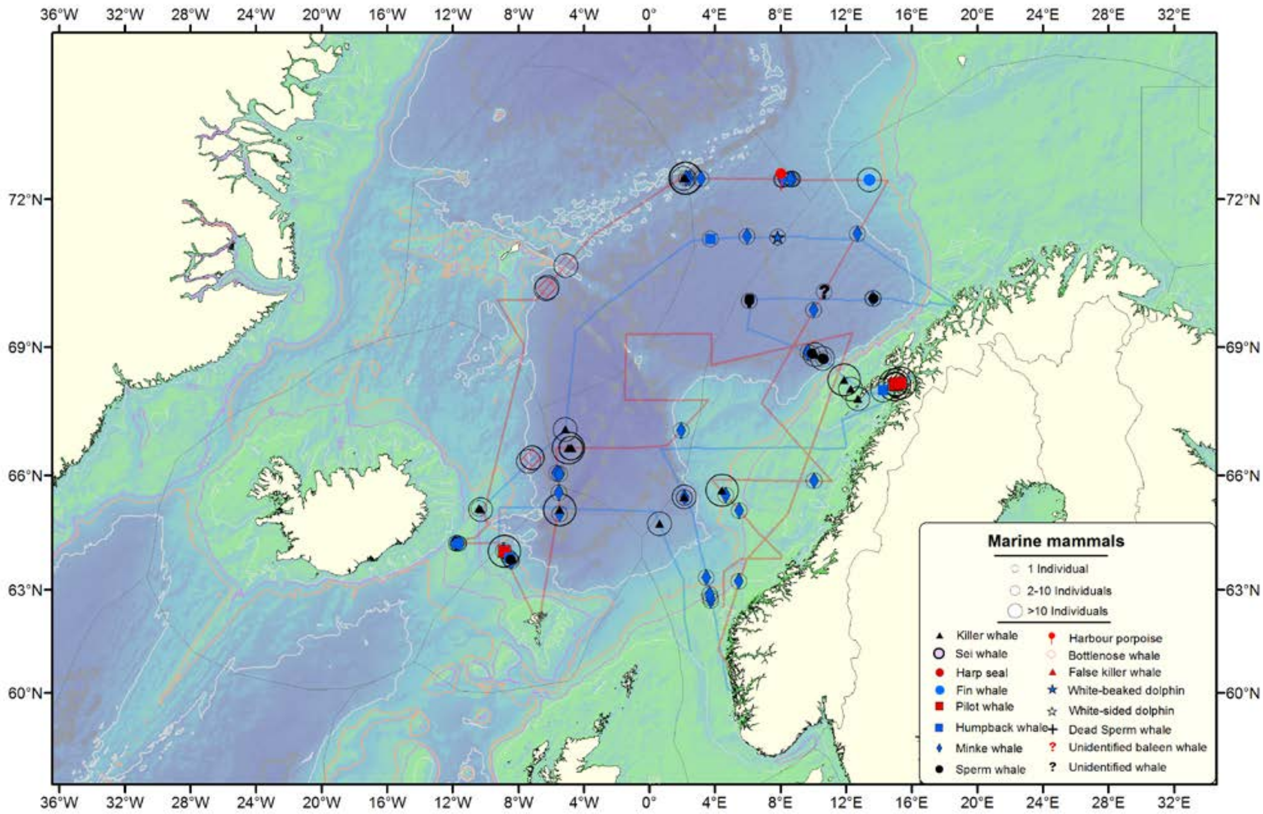

Fig. 27. Overview of all marine mammals sighted onboard R/V "G. O. Sars" and M/V "Brennholm" in the Norwegian Sea and surrounding waters from 2 to 27 July 2012. No marine mammal sightings were done onboard the Icelandic and Faroese vessels.

Extremely few sightings of large baleen whales with on 2 fin whales and 8 humpback whales were sighted during the survey with the two Norwegian vessels (Fig. 28).

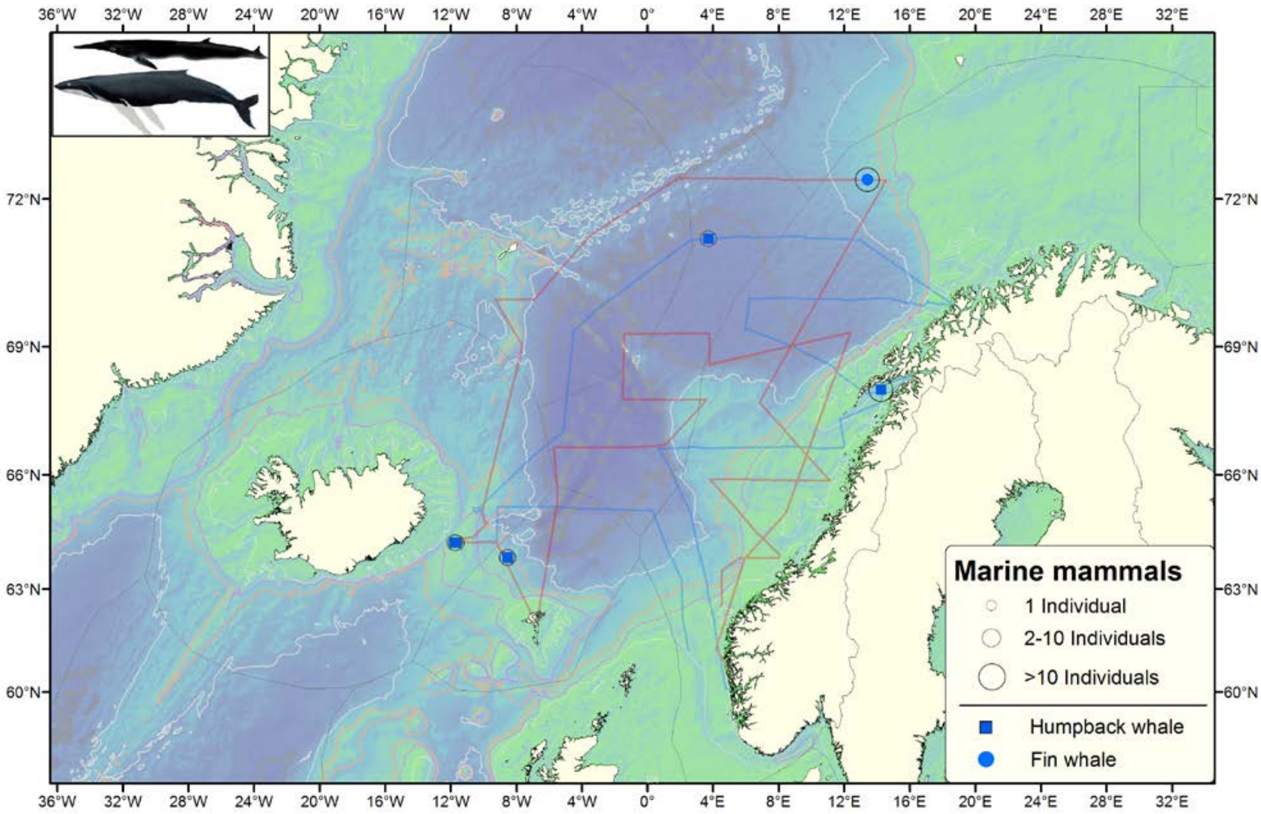

Fig. 28. Sightings of humpback whales and fin whales onboard R/V "G. O. Sars" and M/V "Brennholm" in the Norwegian Sea and surrounding waters from 2 to 27 July 2012.

A total number of 193 killer whales in 21 groups (average pod size = 9.2 ind (± 6.1 SD) were observed in different areas including the eastern central, western and northern part of the Norwegian Sea (Fig. 29). They were spread out geographically and overlapped spatially predominantly with NEA mackerel present close to the surface.

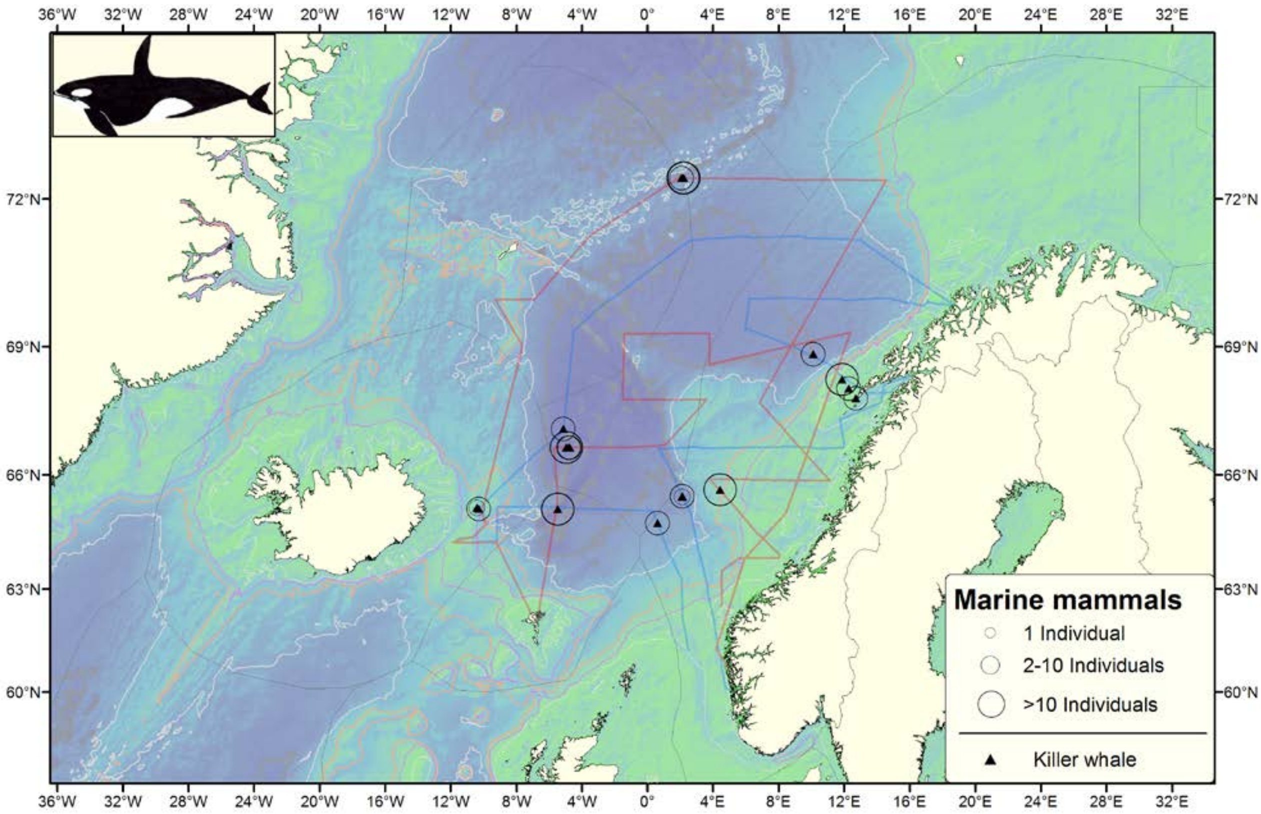

Fig. 29. Sightings of killer whales onboard R/V "G. O. Sars" and M/V "Brennholm" in the Norwegian Sea and surrounding waters from 2nd to 27th of July 2012.

Discussion

The international coordinated ecosystem survey in the Norwegian Sea and adjacent areas (IESSNS) was performed during 1 July to 12 August 2012 by four vessels from Norway (2), Iceland (1) and Faroese (1). A standardised pelagic trawl swept area method has been developed and used to estimate a swept area abundance estimate of NEA mackerel in the Nordic Seas in recent 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 2012 was 5.1 million tonnes based on a coverage of 1.5 million square kilometres in the Nordic Seas from about 61 degrees up to 70 degrees north and from the Norwegian coast in east and west to the fishery border between Iceland and Greenland. The 2006 year class contributed to more than 20% in number followed by equally strong 2005, 2007 and 2008-year classes around 15% each, respectively. The 2010 year class was very well represented in the catches, or 12% of the total number. The mackerel was distributed in most of the surveyed area, and the zero boundaries were only found in the south-western area in the Faroe zone and in the southern Icelandic zone. In the northern area the zero boundary was not reached.

The geographical coverage and survey effort in 2012 was largely comparable to the survey in 2010, while the coverage in 2011 was less (only three vessels), as it did not cover the northern part of the Norwegian Sea properly. Therefore it is possible to compare the swept area estimates of 4.8 million tonnes in 2010 with the 5.1 million tonnes estimate in 2012. Thus, these estimates indicate that the NEA mackerel remain at a stable level. Both these biomass estimates must be considered to be underestimations and only represent part of the stock north of approximately 62°N.

The overlap between mackerel and NSS herring was highest in the south-western part of the Norwegian Sea (Faroe and east Icelandic area). A high overlap between the species might increase the inter-specific competition between the species for food in the area, especially in a period with low abundance of zooplankton, as observed in recent years. 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.

Acoustic estimation of herring and blue whiting was also done during the survey. The biomass of Norwegian spring-spawning herring was estimated to 7.3 million tonnes. The previous acoustic abundance estimates of NSS herring from the survey were 13.6 million tonnes in 2009 and 10.7 million tonnes in 2010. Thus the trend in the July survey clearly follows the negative trend in the biomass estimates from the assessment. The herring was mainly found in the southern and western parts of the covered area, i.e. from north of the Faroes, the east Icelandic area and north into Jan Mayen area, with less concentration in the central and eastern areas.

This survey confirmed the presence of young blue whiting (ages 1-3) in the summer feeding areas. The concentrations were highest in the eastern Norwegian Sea and in the area south and southwest of Iceland.

The temperatures in the Nordic Seas in 2012 are still well above long-term average. Especially in the area west of Iceland and in the Irminger Sea the surface temperatures were up to three degrees higher than the long-term average. However, the south-western Norwegian Sea seems a bit cooler in 2012 compared to the last two years.

The concentrations of zooplankton are still at a low level compared to historic values.

Whale observations were done by the two Norwegian vessels during the survey. The number of sightings was very low as compared previous years, especially for large baleen whales such as fin and humpback whales. Systematic observations of marine mammals onboard all the vessels is encouraged as they can provide important ecological information.

One of the main aims of this joint survey is to map the distribution and estimate abundance of NEA mackerel, NSS herring and blue whiting in the Norwegian Sea and surrounding waters. This goal was partly achieved as there are areas outside of the covered area where mackerel can be expected to feed during this period, e.g. in the eastern part of the Greenlandic EEZ where a mackerel fishery was ongoing. Ideally we should strive to reach beyond the distribution of all target species in all directions. In order to reach this goal and to obtain a more holistic and comprehensive understanding of mackerel abundance and distribution, participation by EU and Greenland is encouraged.

The shallow distribution and absence of dense schooling behaviour in both mackerel and herring within most of the study area in July-August, makes the quantitative estimation of especially mackerel and herring challenging. Based on multibeam sonar and visual observations, concentrations of these species occurred above and close to the transducer depth and would therefore not be detected by the downward oriented echosounders. Furthermore, vessel avoidance during summer feeding may complicate these studies even further. Nevertheless, we are steadily progressing in this area of science, and recommend the further use of acoustics (echosounders and sonars) for the coordinated ecosystem survey in the years to come (see Nøttestad and Jacobsen 2009 and Nøttestad et al. 2010; Nøttestad et al. 2011).

Information on stomach content of the three main pelagic species (mackerel, herring and blue whiting), combined with concurrent information on zooplankton and the hydrographical conditions are of paramount importance for a more thorough and detailed understanding of the feeding ecology, potential inter-specific feeding competition, spatiotemporal overlap and migration patterns of mackerel, herring and blue whiting in the Norwegian Sea and surrounding waters. Although only parts of these data are currently available at the different institutes, they might prove very valuable in the future. We therefore recommend continuing systematic sampling and diet analyses on the coordinated ecosystem surveys.

The survey period extended for about six weeks from 1st July to 10th August in 2012. Due to the fact that the mackerel is a highly migratory species, the different countries should strive to minimize the total period spent at the joint ecosystem survey to maximum five weeks, in order to obtain as good and robust data on mackerel abundance and distribution as possible. The group agreed that the period from 7th of July to 15th of August was suitable as the maximum time window in the future. The distance between each trawl station should be around 50-60 nm by all countries in order to obtain comparable and representative samples, be able to cover extensive areas and reach the zero lines for selected target species. It would also be beneficial to standardize the survey design in the direction of performing predominantly east-west courses, in order to enable comparison between vessels and optimise coverage in relation to vessel effort.

In order to be able to use the results from the different vessels in a combined swept area estimate, it is necessary to calibrate the acoustic equipment and the pelagic trawl catch efficiency among the different vessels. This inter-calibration was done during two days of the survey in a pre-agreed area. The newly designed pelagic sampling trawl (Multpelt 832) was used by all vessels, and seven inter-calibration hauls were performed with the four vessels during this exercise (Appendix 1). The ultimate goal to use this combined swept area estimate as an abundance index in the assessment of NEA mackerel, will require allocation of survey time dedicated for inter-calibration between the participating vessels in future surveys.

Recommendations

General recommendations

- Participation by EU in the survey is recommended and encouraged by the group in order to be able to expand the survey coverage to cover the entire distribution of the stock and thereby obtain a more holistic and comprehensive understanding of mackerel abundance and distribution.

To the participants in the survey

- Inter-calibration of the pelagic trawl catch efficiency and acoustic equipment should be performed each year and sufficient time should be allocated for each vessel on this vital task in order to be able to use the results in a combined swept area estimate.
- Specific recommendations to the trawling operation are given in Appendix 1.
- The transects should in general be spaced with a distance of around 50-60 nmi between them in east-west direction. When working in coastal waters some compromise needs to be done in some areas with perpendicular north-south transects to the coast.
- Next year's survey should preferably take place within a five weeks period from 7th of July to 15th of August.
- In order to have as good information as possible about the summer distribution of the NEA mackerel survey transects should be extended to reach beyond the distribution; in western, northern, eastern and southern areas.
- When the time frame and duration of the various national surveys has been decided a meeting, e.g. video-conference meeting, should be organised at which a general survey and inter-calibration plan for all participating vessels should be drawn up.
- Standardization of software used for scrutinizing would be an improvement and LSSS is recommended for this purpose.
- It is recommended that the number of fish taken to biological measurements and determination should be standardized in the survey, or as follows for mackerel, herring, blue whiting and capelin: Length and weight measurements 100; Ageing 25; Stomach sampling 10.

- Work on scientific manuscript intended for publication in high standard journal and based on data from the inter-calibration during the IESSNS 2012 survey should be initiated as soon as possible in order to strengthen and improve the scientific background and recognition of the survey.
- Systematic observations of marine mammals should be done onboard the vessels during the survey as they can provide important information in ecological context.

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Appendix 1

Intercalibration of the Multpelt 832 pelagic trawl between four vessels

During the ecosystem survey in July 2012, seven pairwise pelagic trawl comparison hauls at the surface were conducted between the four vessels: the research vessels G. O. Sars and Arni Fridriksson, and the commercial vessels Christian í Grótinum and Brennholm (Appendix 2). Catch differences were in favour of the commercial vessels (Table 1) and there were statistically significant differences in mackerel (t-test, $p<0.05$) and herring (t-test, $p<0.05$) catches between the two groups (commercial vessels versus. research vessels). For the t-test for herring, a square root transformation of the catches was performed to conform with the assumption of normality in the data. The vessels used the same type of trawl (Multpelt 832), made by different producers (Vónin, Egersund Trawl and Tornet).

Table 1. Total and average catches (kg) of Herring and Mackerel for the four vessels for all seven hauls.

	Herring (kg)		Mackerel (kg)	
Vessel	Total	Mean	Total	Mean
G. O. Sars	5151	736	3529	504
Arni Fridriksson	3509	502	6907	986
Brennholm	8372	1196	13840	1977
Christian í Grótinum	9070	1295	15097	2156

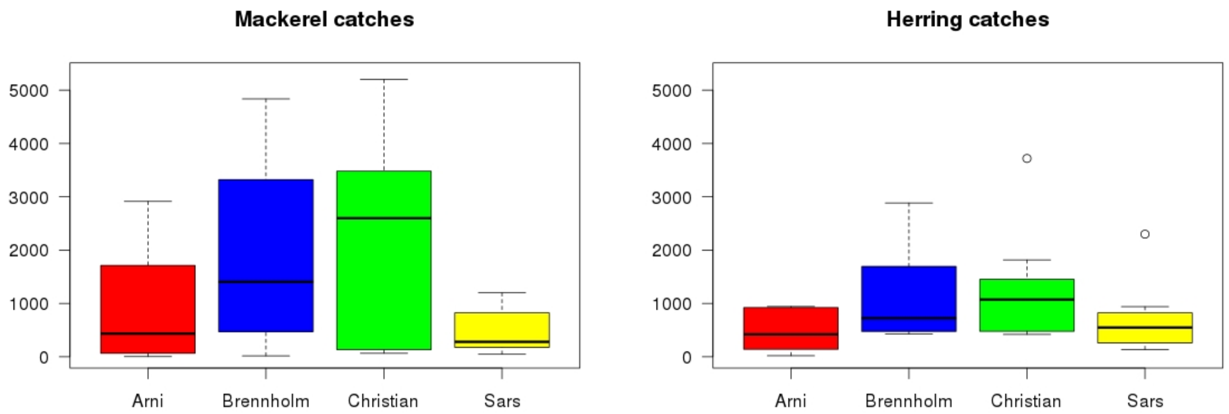

Figure 1. Boxplot of herring and mackerel catches (kg) for Arni Fridriksson, Brennholm, Christian í Grótinum and G. O. Sars.

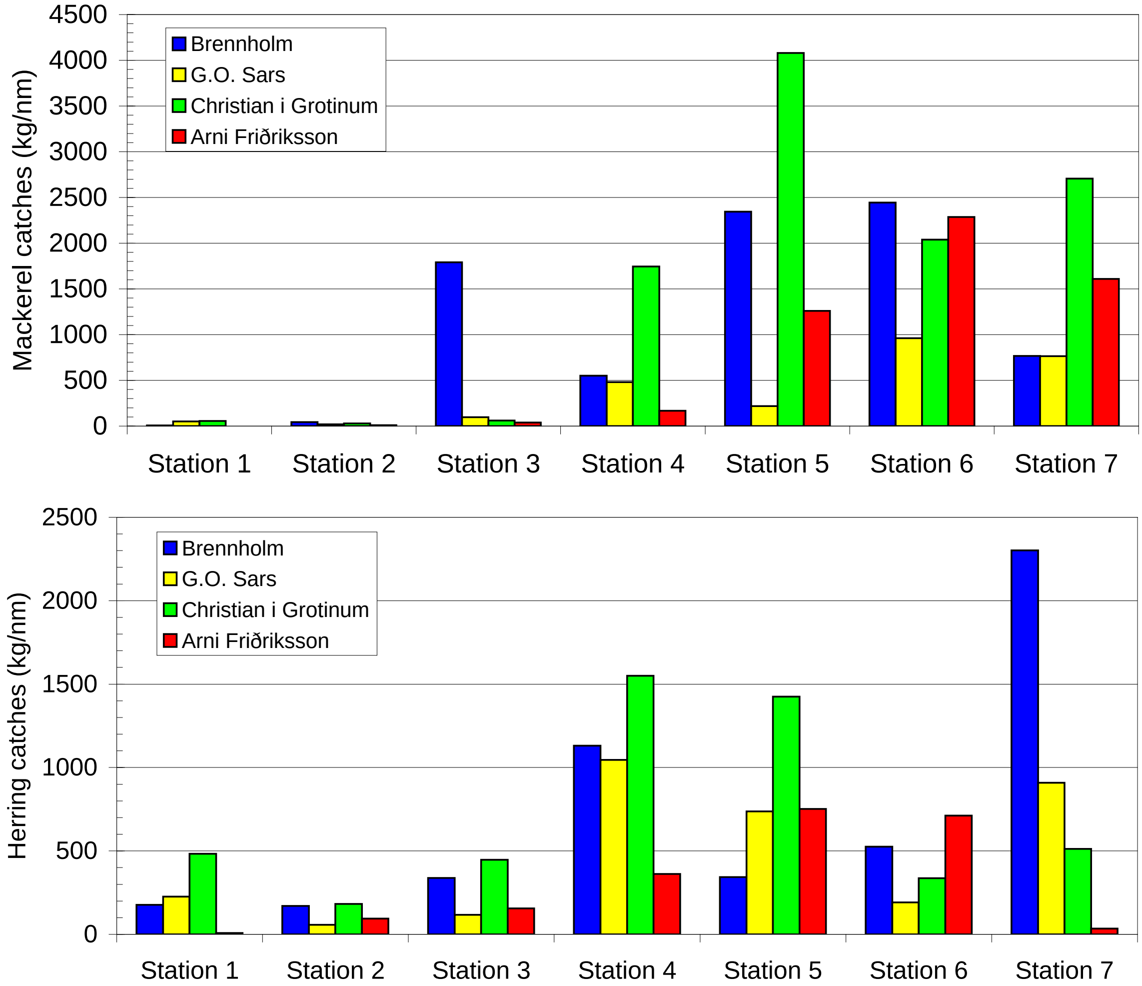

Figure 2. Individual catches of mackerel (upper graph) and herring (lower graph) from all vessels. The towing duration was 30 min for stations 1-4 and 15 min for stations 5-7.

When catching schooling fish, catches from different vessels will vary due to logistic reasons. The catch differences, however, were consistently larger for the commercial vessels, thus it is unlikely that this is related to chance only. Sources for the differences may be related to differences between vessels, e.g. in vessel sound generation, gear parameters (rigging) and catch procedures. Our concern and focus at this stage is related to gear parameters and catch procedures.

Swept-area abundance estimates for mackerel are based on catches from pelagic trawls covering approximately the layer from surface down to 30 m times the with of the trawl. Therefore, all parameters affecting trawl geometry, speed and time are sources for variation and thus bias in catch pr. unit effort.

Table 2. Trawl settings and operation details during the international mackerel survey in the Nordic Seas in July-August 2012. The column for influence indicates observed differences between vessels likely to influence performance during intercalibration. Influence is categorized as 0 (no influence), + (some influence) and ++ (high influence).

Properties	**G.O. Sars**	**Arni Fridriksson**	**Brennholm**	**Christian í Grótinum**	Influence
Trawl producer	Egersund Trawl AS	Tornet	Egersund Trawl AS	Vónin	0
Warp in front of doors	Steel wire, 24 mm	Dynex-34 mm	Dynema -36 mm	Dynex – 34mm	++
Warp length during towing	340 m (320-360 m)	350 m	340 m	350 m	0
Difference in warp length port/starboard	3-12 m	15-40 m	5-10 m	5-12 m	0
Weight at the lower wing ends	250 kg	No weights	400 kg	375 kg	++
Setback in metres	4 m	0	4 m	8 m	++
Type of trawl door	ET Speed	Polar.Jupiter t4	Seaflex w. adjustable hatches	Thyborøn V-doors	0
Weight of traw door	1200 kg	2000 kg	2000 kg	2000 kg	+
Area trawl door	7.5 m^2	6 m^2	9 m^2 65-75% hatches	8 m^2	++
Towing speed (GPS) in knots	4.7 (4.7-4.8)	5.1 (4.7-5.2)	5.1 (5-5.2)	4.7 (4.1-5.1)	+
Setting time	15 min	12 min	5-10 min	15 min	+
Trawl height	25.5 (20-38)	27-30	28-30	~ 30.7 (SE = 0.33)	+
Door distance	110 m	98-104 m	115 m	Not measured	++
Trawl width*	-	62 m	-	70 m	+
Turn radius	2-4 degrees turn	2700-2800 m	5 degrees turn	5-10 degrees turn	+
Hauling time warp	6 min	4-5 min	5 min	8 min	+
Hauling time trawl	20 min	17 min	15 min	10 min	++
Trawl door depth (port and starboard)	0-10, 5-15 m	8-13, 10-15 m	10-15 m	Not measured	+
Headline depth	0-2 m	0-1 m	0-2 m	0 m	+
Float arrangements on the headline	Kite + 2 buoys on wings	Kite	Kite + 2 buoys on wings	Dynex float rope, whole headline (382 kg buoyancy) + 2 buoys on wings and 2 in middle (2880 kg buoyancy)	+
Weighing of catch	All weighted	All weighted	Codend weighted with large scale digital weight	Semi quantitative estimate (larger hauls estimated)	+

* Trawl width was not estimated constantly during intercalibration, for Christian í Grótinum it was done during the two first hauls of the trip.

Trawl design

The trawl design was identical and all trawls were produced using the same drawings. Some minor differences in the weight per length of the tread were observed in parts of the net material, although they had the same nominal descriptions.

Trawl doors

All vessels used different trawl doors. The smallest doors were used by Arni Fridriksson and the largest doors by Christian í Grótinum. This might affect the catching efficiency of the vessels.

Trawl rigging

Table 2 shows some differences in rigging of the trawl on the various vessels.

As these differences in rigging might affect the trawl catch, the important parameters are commented for each vessel below.

Flotation

G. O. Sars and Brennholm used both 4.8 m kite in the center of the headline and two bouys on each wing. Christian í Grótinum used both floatline along the whole headline and fenders on the wings and at the centre of the headline. Arni Fridriksson had kite on the centre of the headline and no buoys. The other vessels used bouys to monitor that the headline was at the surface during the trawl haul. This information was important to monitor when shooting the warps.

Sweep arrangement and weights

The two Norwegian vessels had 4 m extension of the lower bridles. The Faroese trawler had 8.3 m extension whereas the Icelandic vessel had no difference in length between upper and lower bridle. The weights used by the four vessels varied from 0 (no weights for Arni Fridriksson) to 400 kg,

Towing warp

G. O. Sars used 24 mm diameter steel warp whereas the other vessels used 340-350 m Dyneema/Dynex (floating) ropes in front of the trawl doors. The effect of this difference is unknown but the steel and Dynema/Dynex warp might herd fish differently in the path of the trawl.

Trawling procedure

The procedure for swept area tows was to shoot the net while the flotation bouys/fenders were kept at the surface. The shooting of the 350 m warp took from 10 till 20 minutes. During shooting the vessel was heading straight forward. When the 350 m warp was paid out the vessel turned to port to keep the starboard trawl door in the propeller wake. This was also the time when recording of tow started. After a tow duration of 15 or 30 minutes the haul back procedure started. This time interval was then recorded as the towing time for that haul. The four vessels towed the trawls in parallel tracks in 2-10°turn and the position of vessels were shifted between the hauls to level out possible herding effects of the different vessels (Figure 3). The haul back of the warp took 4-8 minutes. The haul-back of the trawl took between 10 and 20 minutes on the various vessels. During intake of the trawl, several stops occurred on some vessels.

Possible effects of differences in the trawl procedures;

1. During shooting of the warp, the trawl can be catching fish. Therefore, a long shooting time may contribute significantly to the total catch. This effect is more important for shorter (15 minutes) than for longer tows (30 minutes).
2. The turning procedure is meant to catch fish avoiding the passing vessel horizontally. The catch efficiency might then be effected both by the trawl path in relation to the vessel and difference in

avoidance stimulation by the various vessels.

3. During hauling, the trawl can potentially continue fishing. The hauling speed and timing should thus be standardized.
4. If trawl speed is reduced during haul-back, fish, especially mackerel has been observed to swim out of the trawl codend and could escape through the large meshes placed at the trawl belly.
5. The procedure of quantifying the total catch weight varied between vessels and must be standardized.

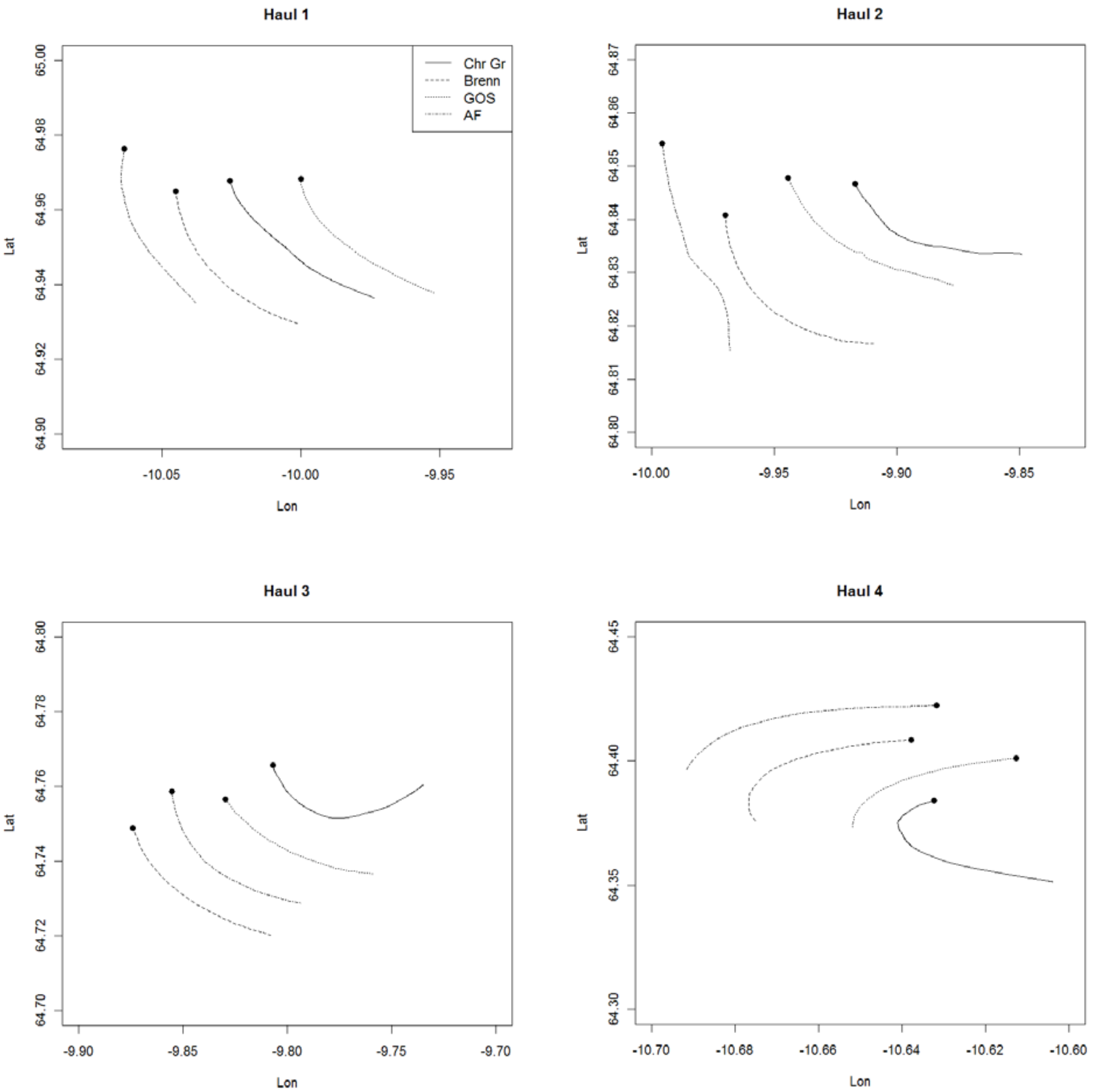

Figure 3. The tracks of the four vessels during the seven inter-calibration trawl hauls on 16-17 August 2012.

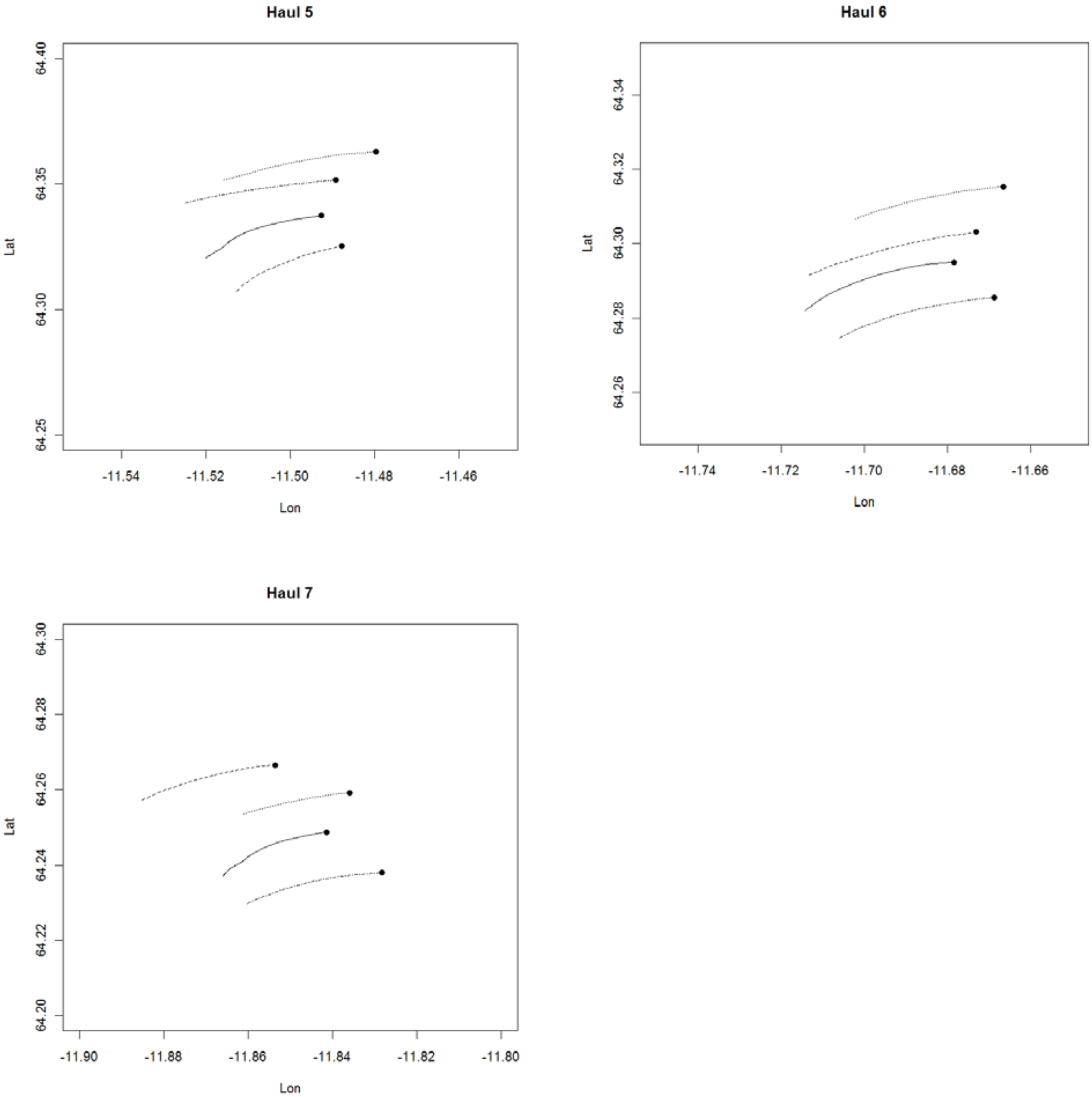

Figure 3. continues.

Recommendations

1. Towing time should be standardized to 30 minutes.
2. Towing speed should nominal be 5 knots.
3. Trawl doors should have identical performance during surface trawling (115 m spread with 80 m bridles and the depth of doors should be the same (10-15 m) for all vessels)
4. Vertical opening of the trawl mouth should be around 30 m and the horizontal opening around 70 m for optimal performance of the Multpelt 832 trawl. These parameters should be measured and documented.
5. The differences between upper and lower bridles (setback) should be equal for all vessels (6 m)
6. The weights on the lower wings should be equal for all vessels (400 kg on each side).
7. 350 m of Dynema warp in front of doors should be used by all vessels.
8. The inner door should be in the propeller wake or at the edge of the inside of the wake while towing (i.e. if turning to the starboard, the port door should be at the starboard edge of the wake).
9. Bouys/fenders should always be used on the wings
10. Bouys/fenders should always be visual on the surface while shooting the warps and during towing
11. Arrangement to keep the whole length of the headline in surface should be used (e.g. floating rope tied to the whole headline)
12. The shooting time of the warp should be recorded and be the same for all vessels
13. Hauling time and speed should be recorded and be the same for all vessels.
14. The catch estimation should be based on weights of total catch and not by visual judgement.
15. Intercalibration of catching performance between vessels should be done in 3-4 days, preferably prior to survey.

Appendix 2

Practical procedure for the intercalibration between the sampling trawls – Multpelt 832 and echosounder Simrad EK 60 data in July 2012

1) All vessels meet at the agreed meeting point 65°N and 10°W on Monday 16th of July 12:00 UTC. Please adapt your ongoing survey and station work to this previously agreed plan!
2) We divide the area for repeated trawling between the vessels into three different agreed squared regions of similar size and name them inter-calibration trawling Area 1, 2 and 3 from east to west. We intend to trawl for approximately 7 hours constantly in Area 1, before all vessels move to Area 2 and finally after 7 more hours move to Area 3 and repeat 30 min hauls for about 7 hours.
3) All vessels start the standardized pelagic trawling with Multpelt 832 arbitrarily within area 1 with a towing direction from east to west. The vessels should not come closer than 300 m during the trawling exercise.
4) All vessels trawl for 30 minutes using the agreed and detailed trawling and rigging procedure for each trawl haul. The trawl catch are taken onboard and each vessel continue directly and continuously with new trawl hauls until 7 hours after starting time. All vessels move then to the next defined area and each vessel trawl in the same way for 7 more hours. Then all vessels move from Area 2 to Area 3 after 7 new hours. Finish the trawling exercise in area 3 after 8 hours (Tuesday 17th of July 09:00 UTC).
5) All vessels are kindly requested to keep all the acoustic echosounder instrumentation onboard in operation mode in the same way as during the regular survey prior to and after the inter-calibration session. **Please turn off the sonars and other instrumentation (e.g. ADCP) during the entire intercalibration period!**
6) Please mark each trawl haul (start and stop time for pelagic trawling) on the acoustic instrumentations, in order to be able to compare the acoustic echosounder data from diffferent frequencies available onboard the various vessels.
7) The catch from each trawl haul is sorted and total weight for each species measured. Furthermore, measure weight and length of up to 100 individuals for each species per trawl haul!

Practical procedure for the intercalibration between the acoustic instrumentation – Simrad EK 60, 38 kHz and 200 kHz including other frequencies if available.

1) The different vessels line up with 300 m perpendicular distance at the starboard side of each other and 10° angle between each vessel. G.O. Sars followed by Arni Fridriksson, Brennholm and Christian í Grótinum.
2) All vessels start at the same time agreed via online communication at the location.
3) All vessels navigate at 10 knots speed and 90 degrees direction (east to west).
4) All vessels keep the same settings on the echosounder as set during the regular survey.
5) All vessels change positions every 1 hour of being in front and at the back of the line when cruising at 10 knots.
6) All vessels participate on this acoustic intercalibration for 6 hours.

Data availability for analyses and results between vesssels.

All acoustic data from the available echosounder frequencies are made available for all countries after each vessel has finished their survey to be included in the WGNAPES database.
All biological data from the different trawl hauls on each participating vessel are also to be included after each vessel has finished their survey to be included in the WGNAPES database.

Annex 6: Cruise reports from other acoustic surveys in the area

Annex 6a: Western Baltic acoustic survey

Institut für Seefischerei

Johann Heinrich von Thünen-Institut
Bundesforschungsinstitut für Ländliche Räume, Wald und Fischerei

Palmaille 9, 22767 Hamburg Telefon 040 38905-173 Telefax 040 38905-263 Az.: Dr.Scha./vS/3534 16.11.2012

Cruise Report
FRV „SOLEA" Cruise 662
02.10. - 21.10.2012

Scientist in charge: Dr. Matthias Schaber

Hydroacoustic survey for the assessment of small pelagics in the Baltic Sea

1. In a nutshell

The cruise was part of an international hydroacoustic survey providing information on stock parameters of small pelagics in the Baltic Sea, coordinated by the ICES Planning Group for Herring Surveys. FRV "Solea" participated for the 25th time. The survey area covered the western Baltic Sea including Kattegat, Belt Sea, Öre Sound and Arkona Sea (ICES Subdivisions 21, 22, 23 and 24). Altogether, 1280 nm of regular and 184 nm of additional trial hydroacoustic transects were covered.

NASC values per nautical mile were -like in the previous year- below the long time average values in some parts of the survey area especially in SD 21, 22 and 24. However, NASC values were distinctly above the values measured in the previous survey in 2011. Only in four rectangles of subdivisions 24 and 21 values were notably below those from 2011. As in the previous year, dense aggregations of herring could be recorded in the Öre Sound (SD 23). High scattering values were also recorded in different parts of the Arkona Sea (SD 24), which is in accordance with the high catches yielded in this area (see below). NASC values from SD 22 were slightly above or distinctly higher (according to statistical rectangle) than corresponding values measured in the previous years. NASC values recorded in SD 21 (southern Kattegat) were mostly below the long term average but exceeded mean values in one rectangle. Additionally, values were also higher than those recorded in 2011 in northerly rectangles of the subdivision.

For species allocation and identification, altogether 56 fishery hauls were conducted.

Distribution list:
Schiffsführung FFS "Solea"
TI - Institut für Seefischerei
Saßnitzer Seefischerei e. G.
Deutscher Hochseefischerei-Verband e.V.
DFFU

e-mail:
Bundesanstalt für Landwirtschaft und Ernährung, Hamburg
BMELV, Ref. 614,
TI – Präsidialbüro (Michael Welling)
TI – Verwaltung Hamburg
TI - Institut für Fischereiökologie
TI - Institut für Ostseefischerei Rostock
TI – FIZ-Fischerei
TI - PR

TI – Reiseplanung Forschungsschiffe (N. Rohlf)
MRI - BFEL HH, FB Fischqualität
Fahrtteilnehmer
Bundesamt für Seeschifffahrt und Hydrographie, Hamburg
Mecklenburger Hochseefischerei GmbH,
RostockDoggerbank Seefischerei GmbH, Bremerhaven
Deutscher Fischerei - Verband e. V., Hamburg
Leibniz-Institut für Meereswissenschaften IFM-GEOMAR
H. Cammann-Oehne, BSH

2. Cruise objectives

The following objectives were planned for SB662:

- Hydroacoustic measurements for the assessment of small pelagics in Kattegat and western Baltic Sea including Belt Sea, Öre Sound and Arkona Sea (ICES SD 21, 22, 23, 24)
- (Pelagic) trawling according to hydroacoustic measurements
- Hydrographic measurements on hydroacoustic transects and after each fishery haul
- Identification and recording of species- and length-composition of trawl catches
- Collection of biological samples of herring, sprat and additionally European anchovy and cod for further analyses
- Day time replicates of transect sections for comparison of night vs. day distribution patterns of small pelagics

3. Cruise narrative and preliminary results

3.1 Cruise narrative (Matthias Schaber)

FRV “Solea” was equipped with all hydroacoustic equipment and biological sampling gear on October 2nd. On the same evening, „Solea” left Marienehe port for the calibration of hydroacoustic equipment. The calibration site off Kühlungsborn was chosen according to prevailing weather conditions providing ideal conditions for calibration for the remaining day and evening. Both the 38 and 120 kHz transducer were calibrated with calibration values regarded as very good. After calibration FRV “Solea” returned to Marienehe port early the next morning for preparation of further equipment and embarkation of rest of scientific crew. Leaving of port and start of survey was scheduled for October 4th. Then, FRV “Solea” left the port at 04:00 PM and steamed towards the south-easterly start point of the hydroacoustic transect in SD 22 where survey operations commenced at 06:00 PM.

Generally, survey operations were conducted during nighttime to account for the more pelagic distribution of clupeids during that time. After accomplishing all transects in SD 22 with only minor delay (several hours due to unfavorable weather conditions during one night), the survey commenced in SD 24 after a short diversion to Warnemünde port during daytime due to failure/repair of oceanographic equipment. Also in SD 24 and afterwards in SD 23 weather conditions were favorable allowing accomplishing all transects and comparative day-recordings on selected transect sections. Survey operations in SD 21 had to be interrupted during one night due to unfavorable weather conditions but could be accomplished afterwards without further loss of time.

On October 20th, 01:30 AM the scientific program was finished near Kullen area (Kattegat) and FRV “Solea” left the survey area to steam to Copenhagen port (disembarking of one member of scientific crew) and onward to Marienehe port, where the ship arrived in the afternoon of the same day.

Altogether, the following survey schedule was accomplished:

- Belt Sea (SD 22) 04. - 09.10.
- Arkona Sea (SD 24) 10. - 15.10.
- Öre Sound (SD 23) 15. - 16.10.
- Kattegat (SD 21) 16. - 20.10.

Total survey time	17 nights (daytime replicates on 4 days)
Fishery hauls	56
CTD-casts	80
Hydroacoustic transects	1280 nm (+ 184 nm daytime replicate transect sections)

Overall hydroacoustic transect length was 1464 nm including daytime replicates. Regular transect length was 1280 nm (2011: 1175 nm).

3.2 Hydroacoustic sampling (Matthias Schaber)

Hydroacoustic data were recorded with a Simrad EK60 scientific echosounder with hull-mounted 38 kHz and 120 kHz transducers. Post-processing and analysis were accomplished with Sonardata EchoView software. The transducer settings applied were in accordance with the specifications provided in ICES (2012).

Calibration of both 38 and 120 kHz transducer took place off Kühlungsborn at good overall weather conditions. Accordingly, resulting calibration parameters were considered as very good.

During the survey, hydroacoustic data were recorded at a ship speed of 10 to 11 kn leading to daily transect lengths of roughly 90 to 100 nm. Figure 1 depicts the spatial distribution of mean NASC values (5 nm intervals) measured on hydroacoustic transects covered in 2012. Mean values were below the long time survey average (1999-2011) in SD 22 and most parts of SD 21 but partially distinctly higher in SD 23 and 24. However, compared to results from 2011, mean NASC values recorded were distinctly higher in most parts of the survey area with the exception of the southern Kattegat (SD 21) and some parts of the central Arkona Basin (SD 24) where values were lower than in the previous year. In SD 22, NASC values were still below the long time average and below values measured in 2010, but exceeded the comparatively low levels measured in 2011 in all but one statistical rectangles of SD 22. Also in SD 23, the large aggregations of big herring usually recorded in the Öre Sound near Ven Island were again present in autumn 2012 and indicated an expansion north- and southward. In SD 24, NASC values measured were again higher than the increased levels observed in most rectangles of the subdivision in the previous year, with two exceptions in central and easterly rectangles of the Arkona Basin. Altogether, increased fish densities were recorded north and east of Rügen Island as well as south of the Swedish coast and in westerly regions of the Arkona Sea.
Preliminary analysis of daytime replicate transects revealed different small-scale distribution patterns of clupeids but indicated similar overall NASC values as compared to night-time sampling.
The final analysis of hydroacoustic data will be accomplished by end of 2012.

3.3 Biological sampling (Tomas Gröhsler)

To validate and allocate echorecordings, altogether 56 fishery hauls were conducted (Figure 2). Average trawling time was 30 minutes, which in case of very high fish densities was shortened accordingly. On all stations a pelagic trawl net „Krake" (PSN 388) was employed.

Fishery hauls according to ICES Subdivision:

Subdivision	Hauls (n)
21	13
22	18
23	4
24	21

The following samples were collected for further processing at vTI-OSF to identify additional biological parameters of stock structure (e. g. sex, maturity, age):

- Frozen samples: 1.635 herring, 932 sprat und 39 European anchovies

Further frozen samples for stock discrimination and (mixed species) student courses were collected for DTU aqua, Charlottenlund, DK:

- 46 herring (*Clupea harengus*) samples
- 17 whiting (*Merlangius merlangus*) samples
- 4 cod (*Gadus morhua*) samples
- 1 anchovy (*Engraulis encrasicolus*) sample
- 12 mixed species samples

Altogether, the following species were sampled and processed:

Species	Length measurements	Number of hauls
AGONUS CATAPHRACTUS	3	3
ANGUILLA ANGUILLA	4	4
CLUPEA HARENGUS	12643	53
CRANGON CRANGON	159	15
CRYSTALLOGOBIUS LINEARIS	271	17
CTENOLABRUS RUPESTRIS	7	3
CYCLOPTERUS LUMPUS	10	8
ENGRAULIS ENCRASICOLUS	63	10
EUTRIGLA GURNARDUS	6	3
GADUS MORHUA	160	30
GASTEROSTEUS ACULEATUS	763	28
GOBIUS NIGER	4	3
HIPPOGLOSSOIDES PLATESSOIDES	3	3
MERLANGIUS MERLANGUS	396	39
MERLUCCIUS MERLUCCIUS	14	6
PLATICHTHYS FLESUS	17	10
PLEURONECTES PLATESSA	3	3
POMATOSCHISTUS MINUTUS	484	37
SCOMBER SCOMBRUS	76	11
SPRATTUS SPRATTUS	6834	47
SQUALUS ACANTHIAS	5	3
SYNGNATHUS ROSTELLATUS	3	3
TRACHINUS DRACO	301	17
TRACHURUS TRACHURUS	421	41
TRISOPTERUS ESMARKI	39	5
Others	12	83

The overall catch composition (kg 0.5 h^{-1}) per trawl haul according to ICES Subdivision 21, 22, 23 and 24 is given in Tables 1-4. Altogether, 43 different species were recorded. Herring were caught in 53, sprat in 47 hauls. Mean catch rates per station (kg 0.5 h^{-1}) were lowest in SD 22 as in the previous year. All other subdivisions were characterized by distinctly higher catch rates. Higher catch levels (as compared to data from most of the previous surveys) were yielded in SD 24. As in last year, sardines (*Sardina pilchardus*) were not recorded in the survey area. Greater weever (*Trachinus draco*) showed a similar distribution pattern as in the last two years with no catches south of the Belt Sea.

Figures 3 and 4 show relative length-frequency distributions of herring and sprat in ICES subdivisions 21, 22, 23 and 24 for the years 2011 and 2012. Compared to results from the previous survey in 2011, the following conclusions for herring can be drawn (Fig. 3):

- Catches in SD 21 were dominated by the incoming year class. In contrast to 2011, when a bimodal distribution indicated presence of both new year class and one year old fishes, the latter were mostly absent in 2012.
- In SD 22, the length-frequency distribution revealed several modes. The incoming year class showed a trimodal distribution with modes at 9.25 cm, 12.75 cm and 14.75 cm, while older fishes showed another mode at 18.25 cm.
- In SD23, big herring (> 25 cm) dominated catches with modes at 27.25 cm and 28.75 cm. Herring of the incoming year class (mode at ca. 13.25 cm) contributed to a lesser extent to catches as compared to 2011, while one year old herring (mode at 18.75 cm) and older herring clearly dominated.
- In SD24, the herring length-frequency distribution was similar to 2011 with a bimodal distribution of both incoming year class and one year old herring. The latter contributed to a higher extent as compared to 2011.

Relative length-frequency distributions of sprat in the years 2011 and 2012 (Fig. 4) can be characterized as follows:

- Altogether, the present year class (< 10 cm) seemed to be very weak with a possible exception in SD 21 (different sub-population?)
- In SD 21, sprat > 12 cm were almost absent as compared to 2011 when catches almost exclusively consisted of sprat of corresponding size/age.
- In SD 22, 23 and 24, growth of the 2011 year class led to the dominance of bigger sprat as compared to 2011. However, the 2012 incoming year class was virtually absent.

3.4 Hydrography (Matthias Schaber)

After each fishery haul hydrographic parameters temperature, salinity and oxygen concentration were measured with a vertically deployed “Sea-Bird SBE 19 plus” CTD-probe. Additional water samples were collected daily with the probe mounted water-sampler in different depth layers for calibration of salinity measures and ambient oxygen concentration (the latter with Winkler titration). As technical problems with the probe deployed were encountered towards the end of the survey, consecutive CTD casts were conducted with a “Sea-Bird SBE 19 plus”-profiler with no oxygen probe mounted.

Altogether, 80 CTD-profiles were measured. CTD stations as well as horizontal gradients of temperature, salinity and oxygen concentration (on stations with available oxygen data) both at the surface and at the seafloor are displayed in Figure 5. Surface temperatures ranged from ca. 10 °C in the Arkona Sea (SD 24) to ca. 14 °C in Mecklenburg Bight and 13 °C in the western Belt Sea and Kiel Bight (SD 22). Bottom temperatures were generally warmer in most parts of the survey area with the exception of comparatively cold water (< 6 °C) in the eastern Arkona Sea close to the Bornholm Basin. Surface salinities ranged from ca. 26 psu in the Kattegat to ca. 7 psu in the eastern Arkona Sea. Bottom salinities showed a similar gradient but were generally higher in the range of > 33 psu (SD 21) to ca. 8 psu (SD 24). Surface layers were well oxygenated throughout the surface area. Signs of oxygen depletion were evident in bottom layers of SD 22 (Kiel Bight and western Mecklenburg Bight) and SD 21 (Kattegat). In SD 22, oxygen depletion in some areas had proceeded to almost anoxic conditions near the seafloor.

4. Cruise Participants

Name	Function	Institute
02.-04.10.2012 / Calibration of hydroacoustic equipment		
Dr. M. Schaber	Hydroacoustics, Cruise leader	vTI-SF
S.-E. Levinsky	Fishery biology	DTU Aqua, Charlottenlund, (DK)
B. Stefanowitsch	Student assistant	vTI-OSF
04.-21.10.2012 / Survey		
Dr. M. Schaber	Hydroacoustics, Cruise leader	vTI-SF
M. Koth	Fishery biology	vTI-OSF
S.-E. Levinsky	Fishery biology	DTU Aqua, Charlottenlund, (DK)
M. Mertzen	Student volunteer	vTI-SF
A. K. M. Püts	Student volunteer	vTI-SF
I. Rottgardt	Student assistant	vTI-OSF
B. Stefanowitsch	Student assistant	vTI-OSF

5. Acknowledgments

I hereby thank all participants, the crew of FRV “Solea” and Captain V. Koops for their outstanding cooperation and commitment.

6. Literature

ICES (2012) Manual for International Baltic Acoustic Surveys (IBAS). Report of the Baltic International Fish Survey Working Group (WGBIFS). ICES CM 2012/SSGESST:02

Dr. Matthias Schaber
(Scientist in charge)
Hamburg, 16.11.2012

Figures

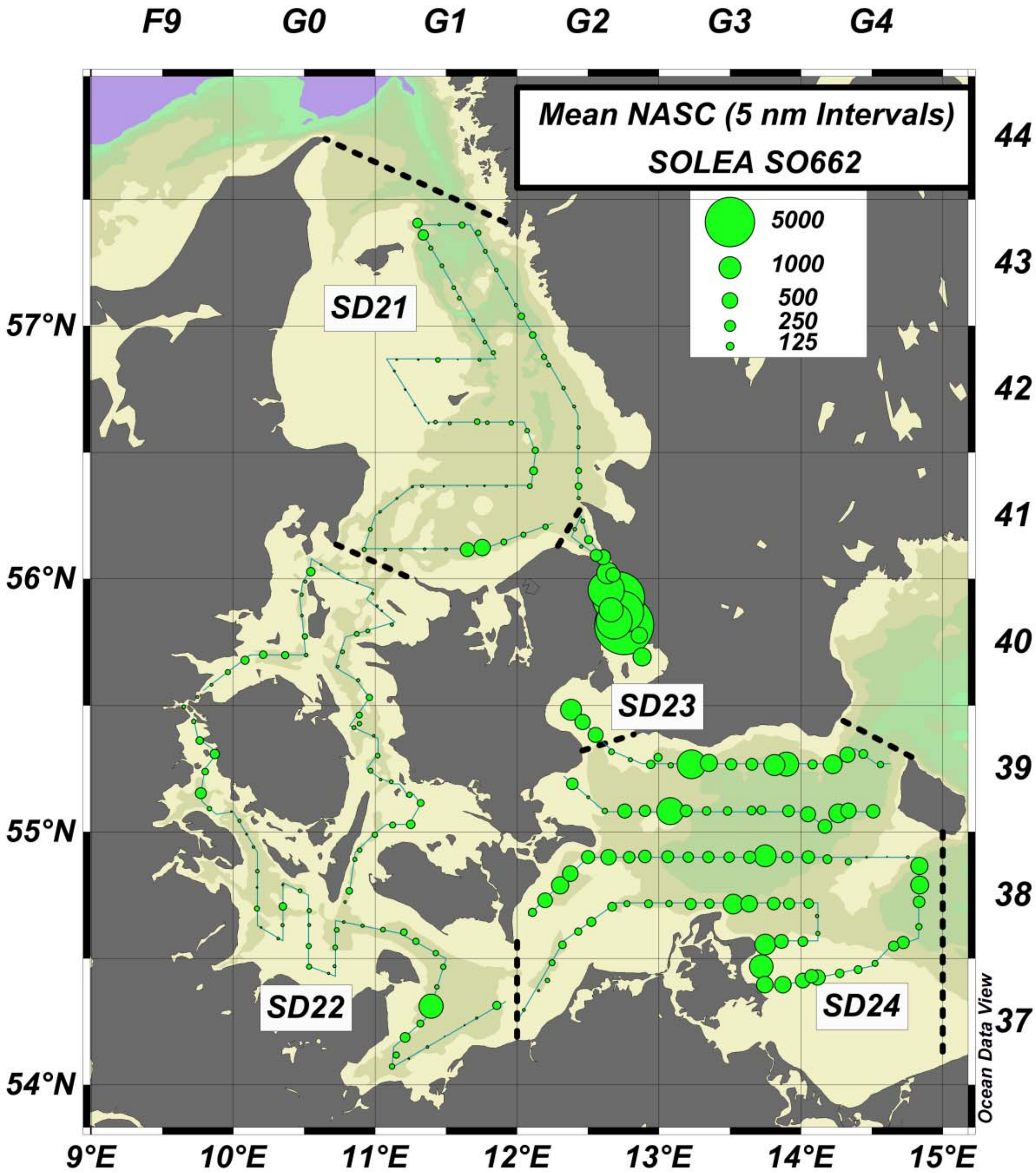

Figure 1: Cruisetrack (lines) and mean NASC (5nm intervals) of FRV "Solea" cruise 662. ICES statistical rectangles are indicated in the top and right axis. Thick dashed lines separate ICES subdivisions (SD).

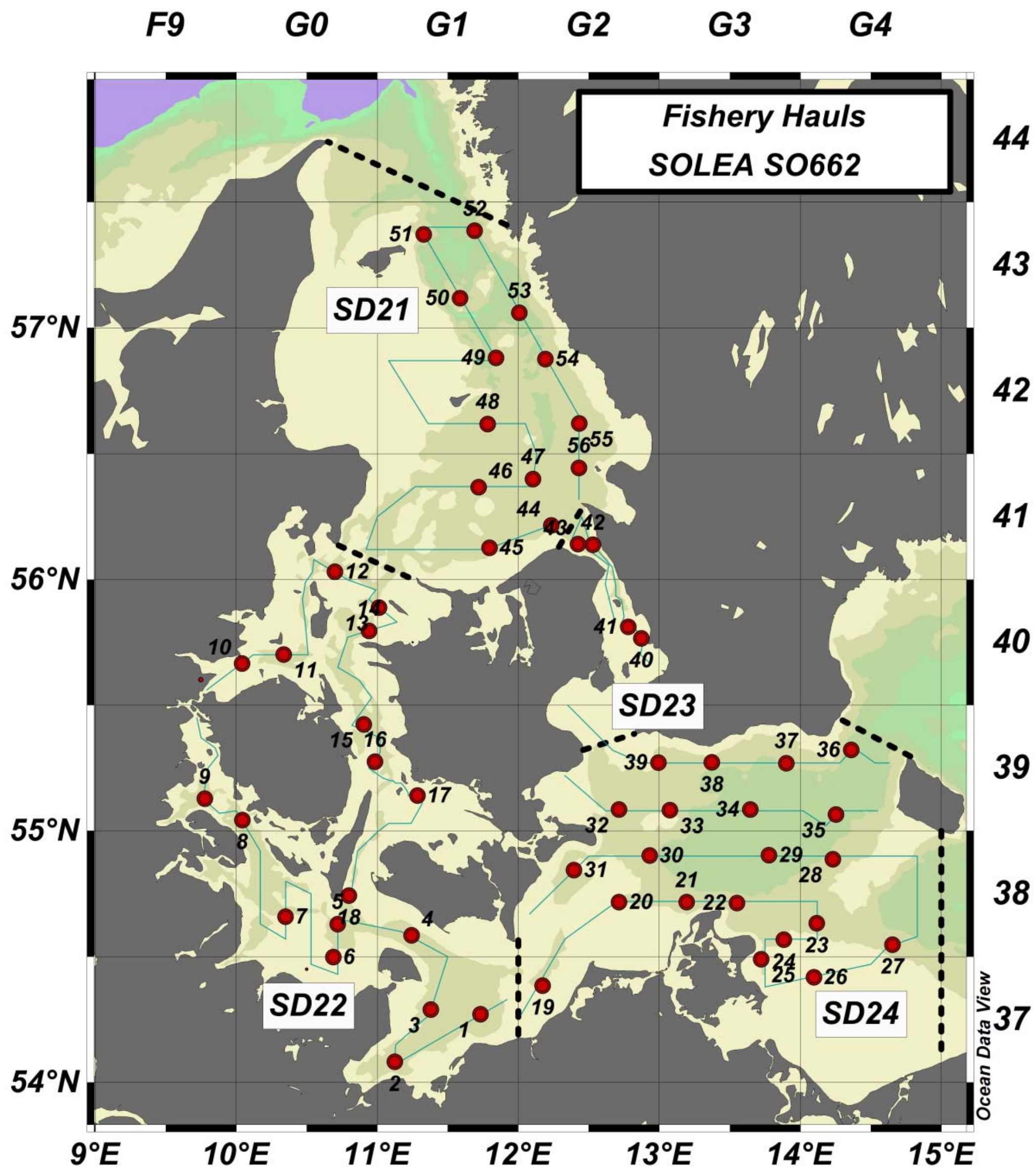

Figure 2: Cruisetrack (lines) and fishery hauls (red dots) of FRV "Solea" cruise 662. ICES statistical rectangles are indicated in the top and right axis. Thick dashed lines separate ICES subdivisions (SD).

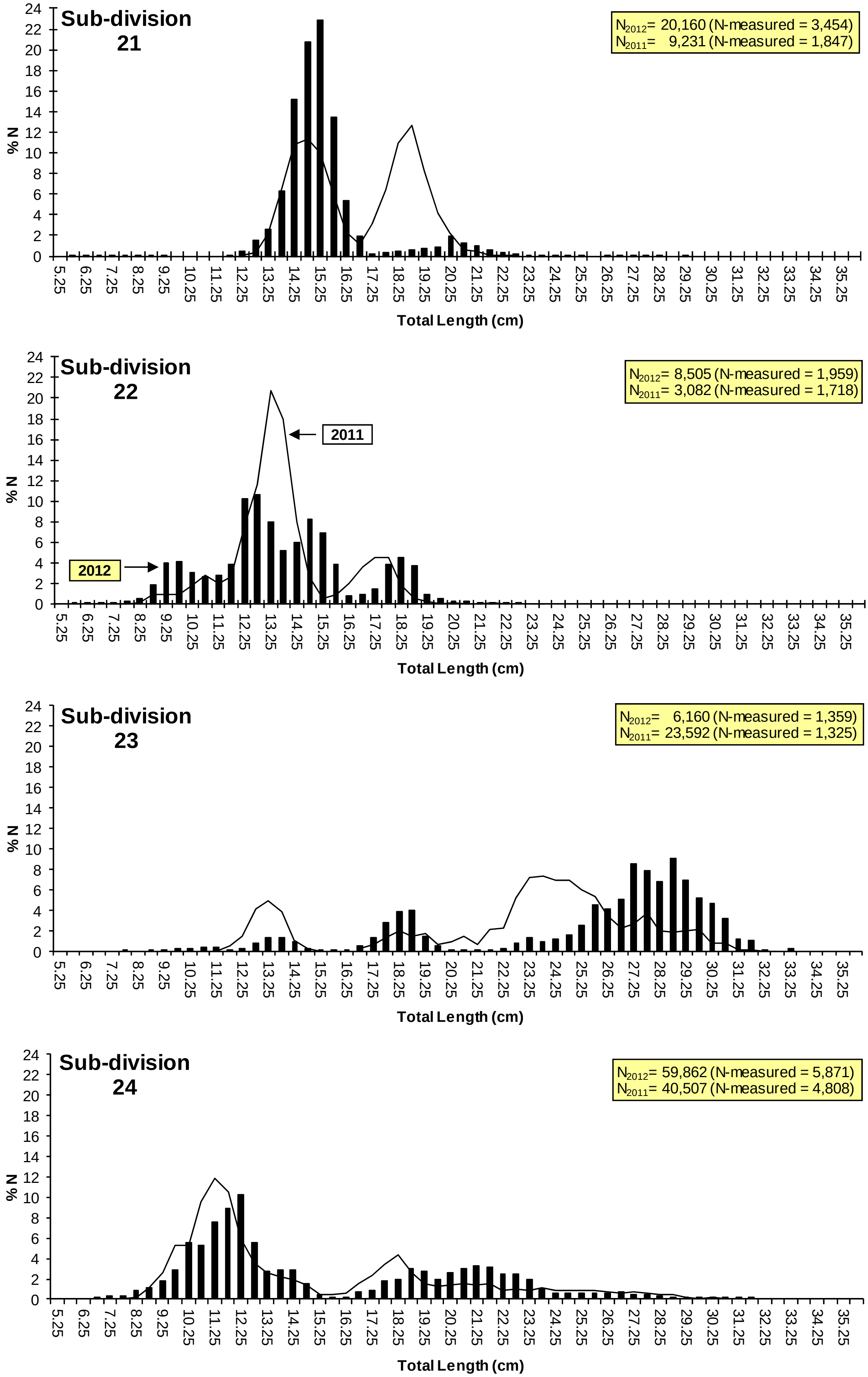

Figure 3: FRV "Solea" cruise 662: Herring (*Clupea harengus*) length-frequency distribution (compared to cruise 646, 2011).

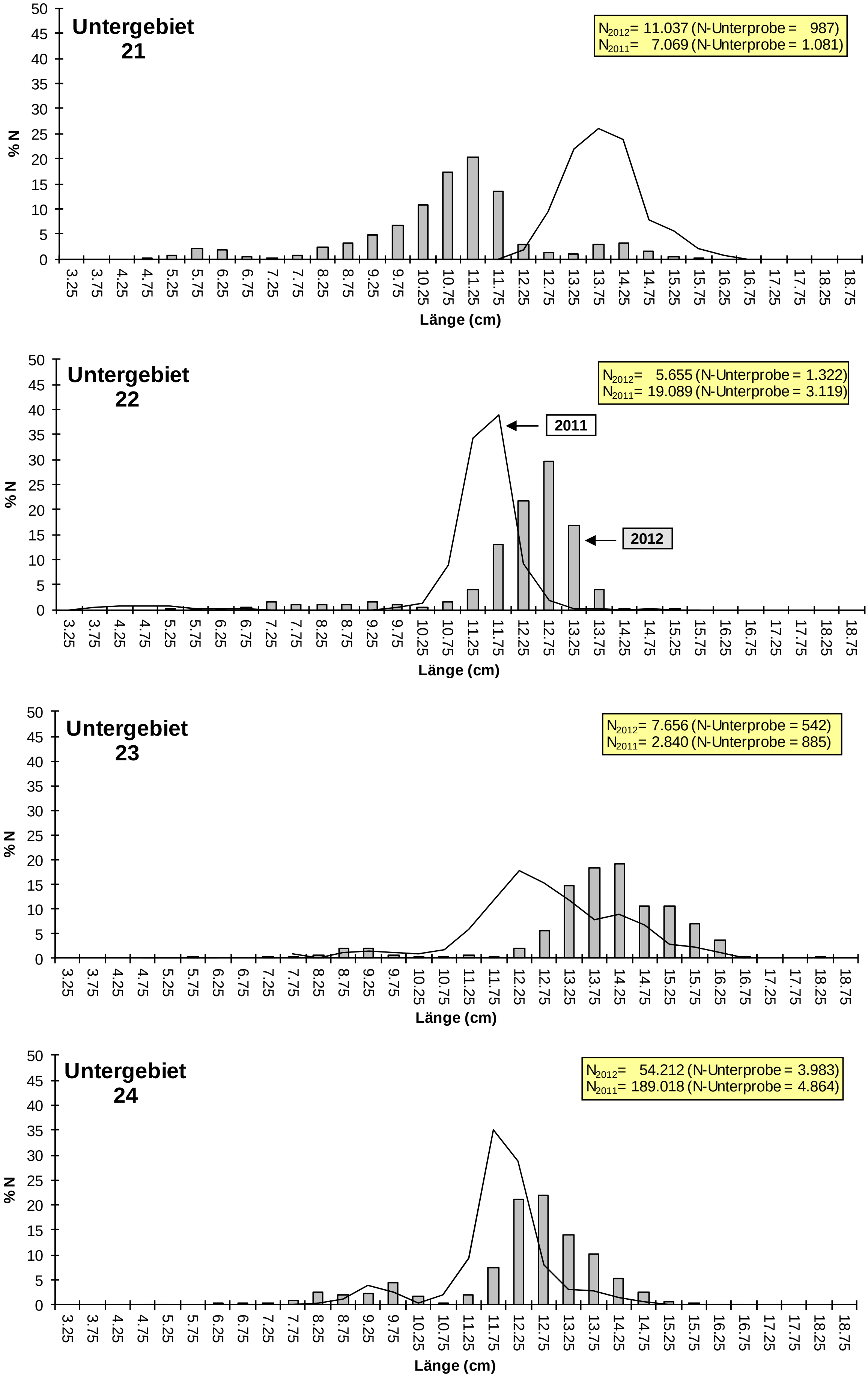

Figure 4: FRV "Solea" cruise 662: Sprat (*Sprattus sprattus*) length-frequency distribution (compared to cruise 646, 2011).

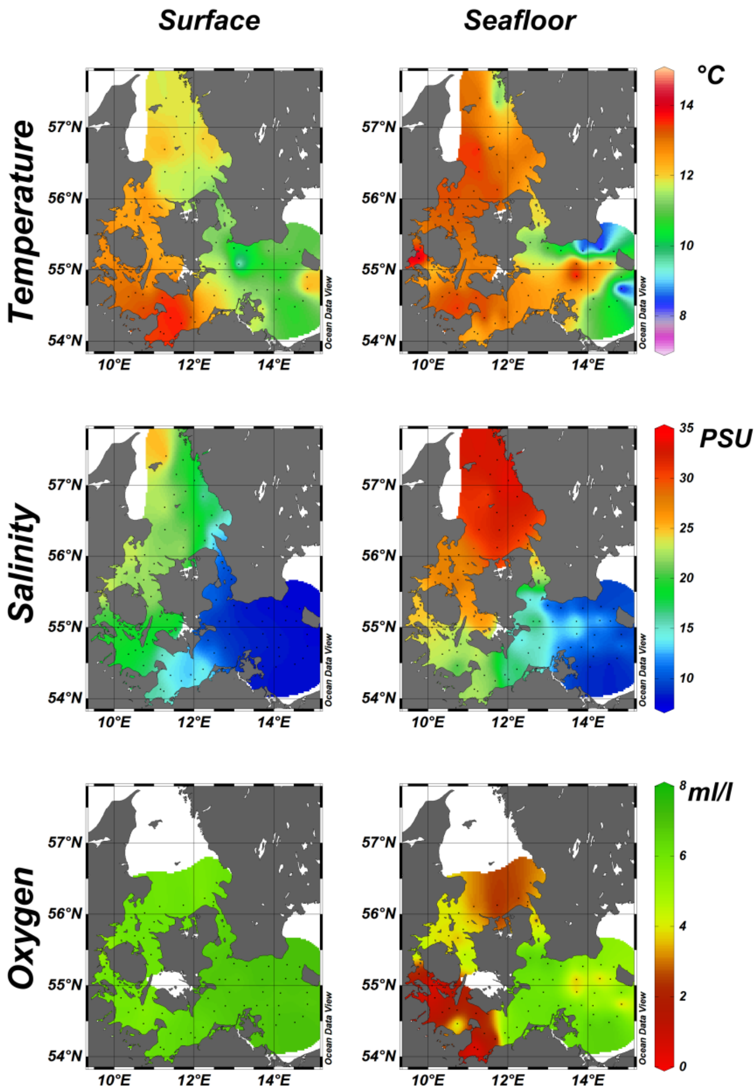

Figure 5: FRV "Solea" cruise 662: Hydrography. Temperature (°C, top panels), salinity (PSU, middle panels and oxygen concentration (ml/l, lower panels) at the surface (left) and near the seafloor (right). Note that no oxygen measurements are available for parts of the Kattegat.

Table 1: Catch composition (kg 0.5 h^{-1}) by trawl haul in Subdivision 21 (FRV "Solea" 662, October 2012).

Haul No.	44	45	46	47	48	49	50	51	52	53	54	55	56	Total
Species/ICES Rectangle	**41G2**	**41G1**	**41G1**	**41G2**	**42G1**	**42G1**	**43G1**	**43G1**	**43G1**	**43G2**	**42G2**	**42G2**	**41G2**	
ARGENTINA SPHYRAENA					+									**+**
CARCINUS								+	0.02		+			**0.02**
CLUPEA HARENGUS	1.80	46.78		52.35	9.62	1.01	9.47	241.17	15.43	62.94	8.67	9.32	39.14	**497.70**
CRANGON CRANGON					+				0.06	0.01	0.03		0.01	**0.11**
CRYSTALLOGOBIUS LINEARIS	+	+					+		0.05	+	0.06	+	0.01	**0.12**
CYCLOPTERUS LUMPUS											2.03			**2.03**
ENGRAULIS ENCRASICOLUS	+	0.11			0.04			0.01		0.01	0.01	0.01	0.01	**0.20**
EUTRIGLA GURNARDUS					0.02								+	**0.02**
GADUS MORHUA						2.77						7.47		**10.24**
GASTEROSTEUS ACULEATUS		0.01	+			+								**0.01**
HIPPOGLOSSOIDES PLATESSOIDES		0.03			0.02				+					**0.05**
LIMANDA LIMANDA					1.07			0.30	0.14				0.18	**1.69**
LOLIGO FORBESI		0.02	0.02	0.04	0.05	0.02	0.04	0.96	0.25	0.01	0.19	0.04	0.01	**1.65**
MERLANGIUS MERLANGUS		0.01	0.01	0.04	0.58		0.01	0.01	0.07	0.01		0.10	0.16	**1.00**
MERLUCCIUS MERLUCCIUS								0.02	0.01	0.12	0.09	+	+	**0.24**
MYSIDACEA								+	0.03					**0.03**
POLLACHIUS VIRENS								0.15						**0.15**
POMATOSCHISTUS MINUTUS		+			+	+	+		0.01	+	0.01	+	0.01	**0.03**
SCOMBER SCOMBRUS				0.33		0.24	0.45	2.02	0.12		0.05	0.41	0.16	**3.78**
SEPIOLA							+		0.01	0.02	0.03	+	+	**0.06**
SPRATTUS SPRATTUS	0.06	1.96		16.04	1.50	0.28		90.87		0.03		0.05	3.54	**114.33**
SQUALUS ACANTHIAS					3.06		2.01			4.18				**9.25**
SYNGNATHUS TYPHLE	+													**+**
TRACHINUS DRACO		0.08	5.28	5.23	4.51	0.18	2.72	1.57		0.87	0.27	0.09	0.08	**20.88**
TRACHURUS TRACHURUS	0.02	0.08		0.01	0.07	0.02	0.03	0.04	+	0.01	0.03	0.04	0.07	**0.42**
TRISOPTERUS ESMARKI							+	0.04	0.13		0.03	0.01		**0.21**
TRISOPTERUS MINUTUS					0.09									**0.09**
Total	**1.88**	**49.08**	**5.31**	**74.04**	**20.63**	**4.52**	**14.73**	**337.16**	**16.33**	**68.21**	**11.50**	**17.54**	**43.38**	**664.31**
Medusae	1.66	4.01	5.88	2.98	0.84	4.58	0.85	2.66	1.80	2.40	0.79	0.01	1.08	**29.53**

+ = < 0.01 kg

Table 2: Catch composition (kg 0.5 h^{-1}) by trawl haul in Subdivision 22 (FRV "Solea" 662, October 2012).

Haul No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Species/ICES Rectangle	37G1	37G1	37G1	38G1	38G0	37G0	38G0	39G0	39F9	40G0	40G0	41G0	40G1	40G0
AGONUS CATAPHRACTUS											0.01			+
ANGUILLA ANGUILLA														
BELONE BELONE														
CLUPEA HARENGUS	0.11	1.16	10.51	26.93	0.49	0.82	0.38		9.96	64.11	29.73	0.63		0.05
CRANGON CRANGON														
CRYSTALLOGOBIUS LINEARIS						+				+	+	+		+
CTENOLABRUS RUPESTRIS														
CYCLOPTERUS LUMPUS							0.34							
ENGRAULIS ENCRASICOLUS														
EUTRIGLA GURNARDUS														
GADUS MORHUA		0.49	0.01	0.04			0.39		0.01	0.35	0.06			0.03
GASTEROSTEUS ACULEATUS		25.80	1.52	0.03	+		0.01	8.58	69.22	0.99				
GOBIUS NIGER														
LEANDER										+	+			0.01
LIMANDA LIMANDA				1.87	0.07		0.53	0.17		0.17	0.04			0.05
LOLIGO FORBESI										+	+			
MERLANGIUS MERLANGUS	+	0.01	0.03	0.07		0.05	0.06	0.01	0.13	1.02	0.65			0.01
MULLUS SURMULETUS														+
PLATICHTHYS FLESUS				0.09										
POMATOSCHISTUS MINUTUS		+	+	+		+	+	+		0.01	+			0.01
SCOMBER SCOMBRUS		0.02												
SPINACHIA SPINACHIA							+							
SPRATTUS SPRATTUS	0.04		7.50	0.02	1.40	0.87	0.88		19.33	24.24	6.46	0.03		
SYNGNATHUS ROSTELLATUS					+									
TRACHINUS DRACO										0.09		0.15		0.11
TRACHURUS TRACHURUS	0.03		0.06		0.01	0.02	0.04			0.01	0.03	0.02	0.01	+
Total	**0.18**	**27.48**	**19.63**	**29.05**	**1.97**	**1.76**	**2.63**	**8.76**	**98.65**	**90.99**	**36.98**	**0.83**	**0.01**	**0.27**
Medusae	4.1	6.9	6.5	3.4	2.9	3.2	10.8	0.6	4.8	2.5	3.7	4.4	10.0	5.0

Haul No.	15	16	17	18	Total
Species/ICES Rectangle	39G0	39G0	39G1	38G0	
AGONUS CATAPHRACTUS		0.02			**0.03**
ANGUILLA ANGUILLA		0.51			**0.51**
BELONE BELONE				0.50	**0.50**
CLUPEA HARENGUS	3.29	4.82	0.11	0.10	**153.20**
CRANGON CRANGON		+	+		**+**
CRYSTALLOGOBIUS LINEARIS	+	+	0.06		**0.06**
CTENOLABRUS RUPESTRIS	+	0.01	0.03		**0.04**
CYCLOPTERUS LUMPUS		1.32		0.28	**1.94**
ENGRAULIS ENCRASICOLUS	0.01		0.01		**0.02**
EUTRIGLA GURNARDUS			0.01		**0.01**
GADUS MORHUA	+		0.08	0.08	**1.54**
GASTEROSTEUS ACULEATUS	+	+		+	**106.15**
GOBIUS NIGER		+			**+**
LEANDER	+				**0.01**
LIMANDA LIMANDA	0.11	0.05	0.50	0.36	**3.92**
LOLIGO FORBESI			+		**0.00**
MERLANGIUS MERLANGUS	0.01	0.03	0.02		**2.10**
MULLUS SURMULETUS	+				**+**
PLATICHTHYS FLESUS		0.54	0.54		**1.17**
POMATOSCHISTUS MINUTUS	+	0.01	0.05	+	**0.08**
SCOMBER SCOMBRUS				0.42	**0.44**
SPINACHIA SPINACHIA					**+**
SPRATTUS SPRATTUS	0.23	12.31	0.14	0.12	**73.57**
SYNGNATHUS ROSTELLATUS			+		**+**
TRACHINUS DRACO	0.12				**0.47**
TRACHURUS TRACHURUS	0.01	0.01	0.01	0.06	**0.32**
Total	**3.78**	**19.63**	**1.56**	**1.92**	**346.08**
Medusae	4.7	7.8	2.2	6.1	**89.7**

+ = < 0.01 kg

Table 3: Catch composition (kg 0.5 h^{-1}) by trawl haul in Subdivision 23 (FRV "Solea" 662, October 2012).

Haul No.	40	41	42	43	Total
Species/ICES Rectangle	40G2	40G2	41G2	41G2	
ANGUILLA ANGUILLA		0.87			**0.87**
CLUPEA HARENGUS	44.64	778.02	41.82	1.84	**866.32**
CRYSTALLOGOBIUS LINEARIS				+	**+**
GADUS MORHUA	201.25	138.82			**340.07**
GASTEROSTEUS ACULEATUS	0.01		0.05	0.05	**0.11**
LABRUS BERGYLTA				0.03	**+**
LIMANDA LIMANDA			0.17	0.56	**0.73**
LOLIGO FORBESI				0.01	**0.01**
MERLANGIUS MERLANGUS	0.18	0.06	0.12	0.02	**0.38**
POMATOSCHISTUS MINUTUS				+	**+**
SCOMBER SCOMBRUS		0.65			**0.65**
SPRATTUS SPRATTUS	13.14	136.44	0.67	0.07	**150.32**
SYNGNATHUS ROSTELLATUS			+		**0.00**
TRACHINUS DRACO			0.08	0.01	
TRACHURUS TRACHURUS	0.01	0.03	0.02	0.05	**0.11**
Total	**259.23**	**1054.89**	**42.93**	**2.64**	**1359.69**
Medusae	0.8	2.6	0.3	1.7	**5.4**

+ = < 0.01 kg

Table 4: Catch composition (kg 0.5 h^{-1}) by trawl haul in Subdivision 24 (FRV "Solea" 662, October 2012).

Haul No.	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Species/ICES Rectangle	37G2	38G2	38G3	38G3	38G4	38G3	37G3	37G4	38G4	38G4	38G3	38G2	38G2	39G2
ANGUILLA ANGUILLA							0.29							
CLUPEA HARENGUS	1.00	2.80	3.21	65.54	0.69	15.37	40.00	0.25	54.10	6.50	16.48	49.56	92.45	19.62
CRANGON CRANGON		+	+			+	+		+	+				+
CYCLOPTERUS LUMPUS		0.22			0.42								0.55	
GADUS MORHUA		0.05	0.03	13.90	0.59	11.50	19.84		2.76	1.11		+		0.01
GASTEROSTEUS ACULEATUS	+	0.05	0.08	0.04		+		+				0.08	0.04	0.06
GOBIUS NIGER							0.01							0.01
HYPEROPLUS LANCEOLATUS				0.06										
LIMANDA LIMANDA		+												
MERLANGIUS MERLANGUS	0.01	0.01		0.02			11.08			4.56	4.68		0.01	0.01
OSMERUS EPERLANUS							1.12							
PLATICHTHYS FLESUS				1.90		0.26	0.11	0.10		0.31				0.30
PLEURONECTES PLATESSA											0.15			
POMATOSCHISTUS MINUTUS		+	+	+		0.02	0.02			0.01	+	0.01		0.03
SALMO TRUTTA							3.46	2.23						
SPRATTUS SPRATTUS	0.70	0.62	0.23	77.00	5.09	49.23	32.90	1.36	11.80	6.39	158.00	10.63	4.79	1.29
STIZOSTEDION LUCIOPERCA							12.51							
TRACHURUS TRACHURUS	0.01	0.01	0.05			+	+				0.01	+ +	+	
Total	**1.72**	**3.76**	**3.60**	**158.46**	**6.79**	**76.38**	**121.34**	**3.94**	**68.66**	**18.88**	**179.32**	**60.28**	**97.84**	**21.33**
Medusae	16.20	10.10	12.76	2.80	9.42	31.10	35.64	12.77	0.88	4.91	2.68	2.81	72.19	20.01

Haul No.	33	34	35	36	37	38	39	Total
Species/ICES Rectangle	39G3	39G3	39G4	39G4	39G3	39G3	39G2	
ANGUILLA ANGUILLA	2.41							**2.70**
CLUPEA HARENGUS	97.35	22.52	45.06	290.50	797.72	360.84	2.26	**1983.82**
CRANGON CRANGON	+							**+**
CYCLOPTERUS LUMPUS						0.63		**1.82**
GADUS MORHUA	+	0.44		0.07	2.00		0.41	**52.71**
GASTEROSTEUS ACULEATUS	0.01	+						**0.36**
GOBIUS NIGER								**0.02**
HYPEROPLUS LANCEOLATUS								**0.06**
LIMANDA LIMANDA								**+**
MERLANGIUS MERLANGUS		5.83	4.57				0.02	**30.80**
OSMERUS EPERLANUS								**1.12**
PLATICHTHYS FLESUS				0.17				**3.15**
PLEURONECTES PLATESSA		0.36	0.18					**0.69**
POMATOSCHISTUS MINUTUS	0.05	0.01	+		+		0.02	**0.17**
SALMO TRUTTA								**5.69**
SPRATTUS SPRATTUS	32.73	12.53	94.48	11.04	89.64	95.76		**696.21**
STIZOSTEDION LUCIOPERCA								**12.51**
TRACHURUS TRACHURUS	0.10						0.01	**0.19**
Total	**132.65**	**41.69**	**144.29**	**301.78**	**889.36**	**457.23**	**2.72**	**2792.02**
Medusae	7.93	3.22	11.98	1.40	2.59	2.90	9.80	**274.1**

+ = < 0.01 kg

Annex 6b: Northern Ireland (Irish Sea and North Channel)

Survey report for RV Corystes

26 August–10 September 2011, 11–12 October 2011,

Pieter-Jan Schön, Agri-Food and Biosciences Institute (AFBI), Belfast, Northern Ireland

1. 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.

2. SURVEY DESCRIPTION and METHODS

2.1 Personnel

Pieter-Jan Schön (SIC)
Bill Clarke
Steven Beggs
Peter McCorriston
Ian McCausland
David Garland
Enda O'Callaghan

2.2 Narrative

The vessel departed Belfast at 2200 on the 25th August and proceeded to the east coast of the Isle of Man for acoustic calibration off Laxey on the 26th August. An additional survey was conducted from 27–28 August. The survey started off the northwest coast of the Isle of Man at 0300 on the 29th August and was completed at 1215 on the 12th October. The bulk of the acoustic survey in 2011 was carried out over the period 29 August - 10 September. The survey was severely affected by adverse weather conditions and transecting was discontinuous (transecting was interrupted for 3–4 days on three occasions and stitched together including data from the extended series conducted 27–28 August). Transecting off the English coast (stratum 10 and 6) could only be completed 11–12 October, but this area historically has very low occurrence of adult herring. The area is characterized by mixed clupeoid abundance composed of 0-gp herring and sprat and abundance estimates will be less influenced by survey timing.

2.3 Survey design

The survey design of systematic, parallel transects covers approximately 610 nm (Figure 6b.1). The survey design for the September acoustic survey of stratified; systematic transects covers approximately 1200 nm in recent years (Figure 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 PGHERS/WGIPS acoustic survey manual.

2.4 Calibration

The hull mounted transducer ES38B was calibrated on the 26th 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.

2.5 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 (0600–2100). 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.

2.6 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.

2.7 Hydrographic data

Surface temperature and salinity were recorded using the through-flow thermosalinograph, and logged together with DGPS position at 1-minute intervals.

2.8 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.

3. RESULTS

3.1 Biological data

Sampling intensity was high during the 2011 survey with 38 successful trawls completed. Table 6b.2 gives the positions, catch composition and mean length by species for these trawl hauls. Thirty seven hauls contained herring to be used in the analysis, but only 29 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 $W = 0.00243*L^{3.390}$ (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 0–9).

3.2 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.

3.3 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 ~65% age 0, ~28% age 1, ~5% age 2, ~1% age 3, <1% age 4 and ~1% age 5+.

4. DISCUSSION

The herring stock estimate in the survey area (Irish Sea/North Channel) was estimated to be 173,177 t or 6.8×10^9 individuals. The major contribution of ages to the total estimates is from ages 0 fish by number and age 2 by weight. The largest herring aggregations were found in around the Isle of Man and off the Mull of Galloway on the Scottish coast.

Sprat and 0-group herring were distributed around the periphery of the Irish Sea, with the abundance of 0-group herring noticeably higher in the eastern Irish Sea compared to last year. The bulk of 1+ herring targets in 2011 were observed off the Mull of Galloway (southwestern corner of stratum 5; Figure 6b.1 and 4), with a fairly scattered lower 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 49 128 t for 2011 is a significant reduction from the 2010 estimate. This is expected considering that the timing of the survey did not coincide with the migration patterns of the spawning adult population (virtually no abundance of adult fish to the east and southwest of the Isle of Man compared to recent surveys estimates). The biomass estimate of 131 527 t for 1+ ringers is similar to the 2010 estimate, which was the highest in the time-series. Similar to the 2007 survey, more than half 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 coupled with the survey being severely affected by adverse weather conditions; suggest poor reflection of the current age structure and abundance of the herring population in the Irish Sea.

5 TABLES AND FIGURES

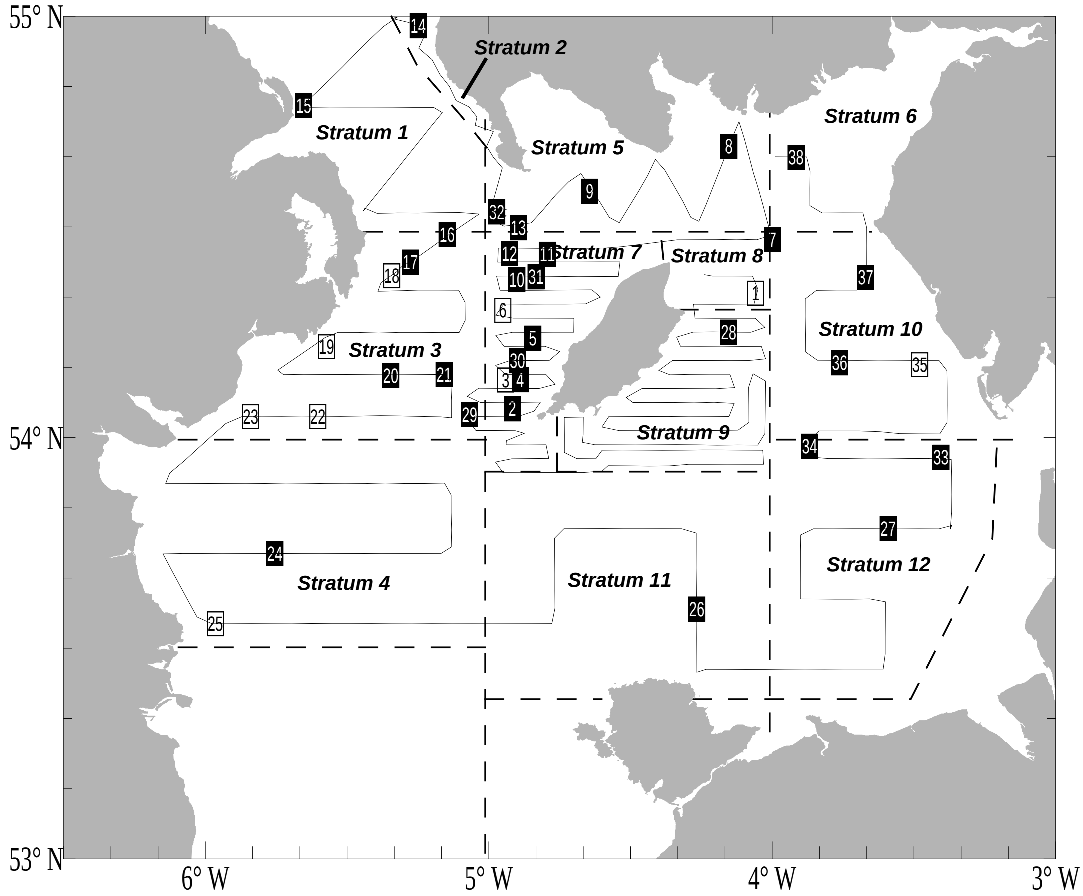

Figure 6b.1. Acoustic survey tracks with trawl positions of the 2011 Irish Sea and North Channel survey on RV "Corystes". Filled squares indicate trawls in which significant numbers of herring were caught or trawls with a large proportion of herring, while open squares indicate trawls with few or no herring.

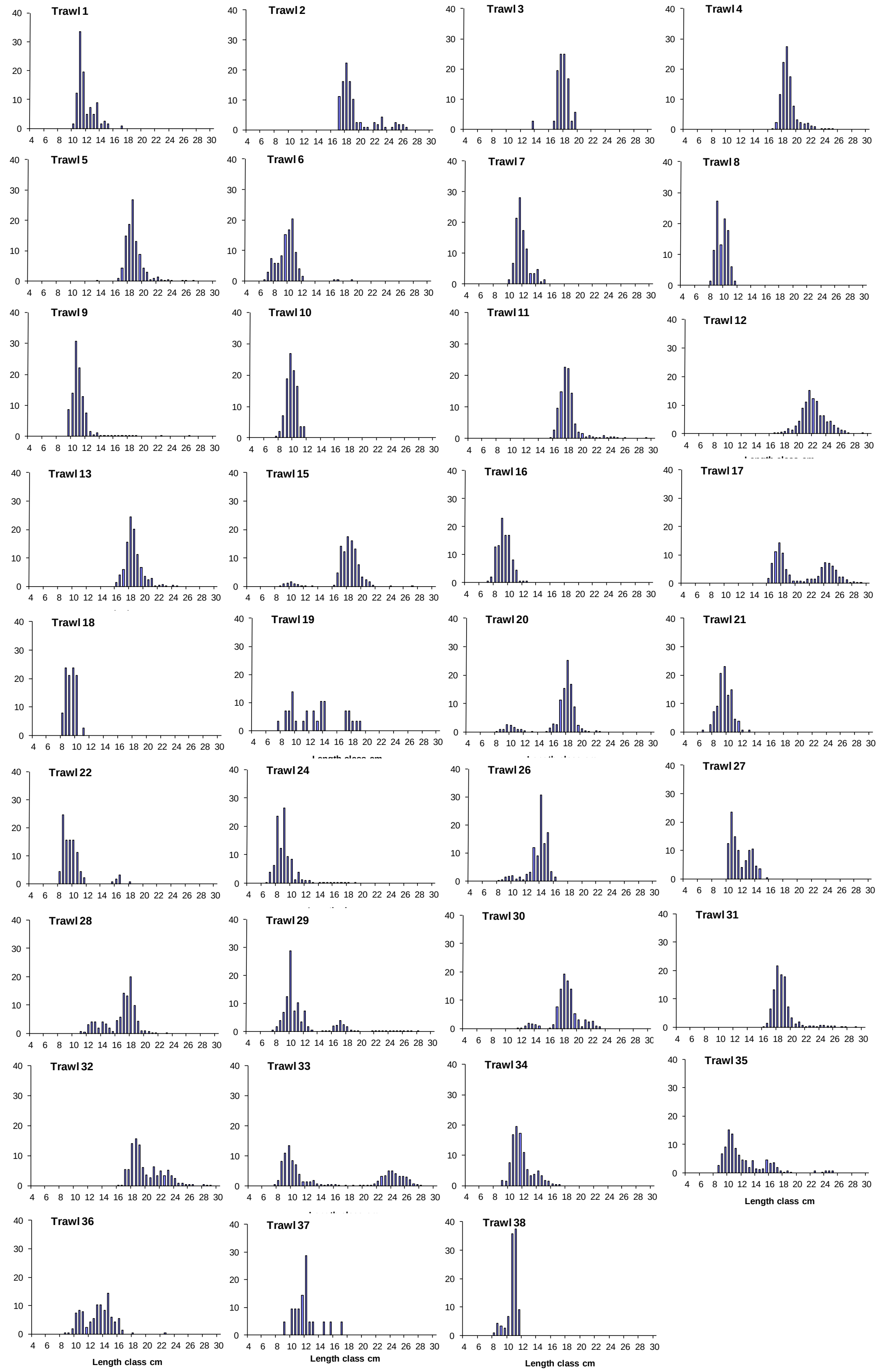

Figure 6b.2. Percentage length compositions of herring in each trawl sample in the September 2011 Irish Sea and North Channel acoustic survey on RV "Corystes".

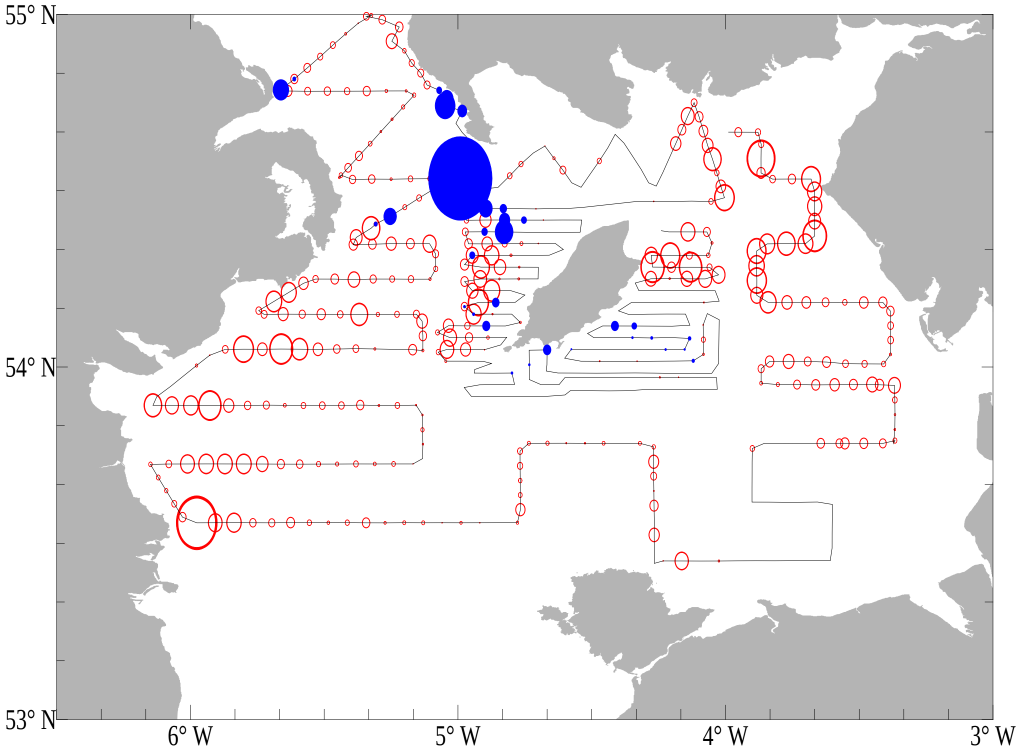

Figure 6b.3. Map of the Irish Sea and North Channel with a post plot showing the distribution of NASC values (size of ellipses is proportional to square root of the NASC value per 15-minute interval) obtained during the 2011 acoustic survey on RV "Corystes". (a) Solid circles are for herring NASC values (maximum value was 41480) and (b) open circles are for clupeoid mix NASC, which include juvenile herring and sprat (maximum value was 17325).

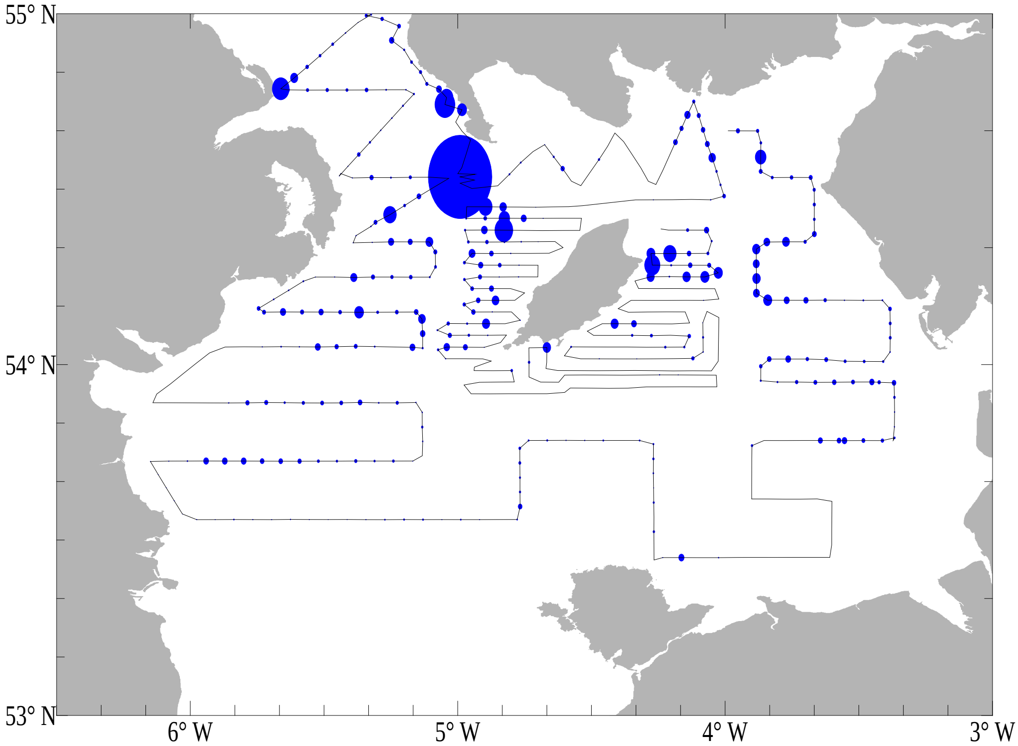

Figure 6b.4. Map of the Irish Sea and North Channel with a post plot showing the distribution of NASC values for assigned herring only (size of ellipses is proportional to square root of the NASC value per 15-minute interval) obtained during the 2011 acoustic survey on RV "Corystes" (maximum value was 41480).

Table 6b.1. Simrad EK60 and analysis settings used on the September 2011 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	24.77 dB
3 dB Beam width	6.97°
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 2011.

Tow	Date	Shooting details				Total fish	percentage composition of fish by weight							Mean length (cm)		Invertebrate catch (kg)
		Time	Lat	Long	depth (m)	catch (kg)	sprat	herring	mackerel	scad	anchovy	whiting	other fish	sprat	herring	
1	26/08	2226	54 20.7	4 3.8	34	979	97.2	2.8	0.1	0.0	0.0	0.0	0.0	11.3	12.0	
2	26/08	0456	54 04.1	4 55.1	46	124	1.1	5.6	92.7	0.00	0.00	0.00	0.6	13.5	19.4	
3	28/08	0822	54 8.2	4 55.9	75	415	98.0	1.9	0.0	0.0	0.0	0.0	0.0	12.2	18.0	
4	26/08	1137	54 8.0	4 53.4	48	692	0.0	100.0	0.0	0.0	0.0	0.0	0.0		19.0	
5	26/08	1329	54 14.3	4 51.3	56	935	0.0	100.0	0.0	0.0	0.0	0.0	0.0		18.9	
6	26/08	1616	54 18.0	4 58.0	108	54	88.7	11.2	0.0	0.0	0.0	0.1	0.0	8.0	10.0	
7	26/08	1920	54 28.1	3 59.9	47	207	98.1	1.9	0.0	0.0	0.0	0.0	0.0	11.9	12.1	
8	27/08	0111	54 42.0	4 8.4	32	236	70.9	29.0	0.0	0.0	0.0	0.0	0.1	7.9	9.9	
9	27/08	0839	54 35.2	4 39.1	45	163	67.8	30.1	0.3	0.0	0.0	0.0	1.7	10.3	11.1	
10	27/08	1633	54 21.9	4 54.0	80	29	60.6	36.3	1.4	0.0	0.0	1.6	0.0	8.0	9.9	
11	27/08	1829	54 26.1	4 47.8	60	600	0.0	100.0	0.0	0.0	0.0	0.0	0.0		18.2	
12	28/08	1135	54 26.3	4 56.4	87	156	0.0	100.0	0.0	0.0	0.0	0.0	0.0		22.3	
13	31/08	0925	54 29.9	4 53.4	67	255	0.0	100.0	0.0	0.0	0.0	0.0	0.0		18.6	
14	31/08	1237	54 58.8	5 15.7	62	13	15.0	77.6	7.4	0.0	0.0	0.0	0.0	9.3	17.5	
15	31/08	1417	54 47.5	5 39.5	67	301	4.1	95.1	0.0	0.0	0.0	0.4	0.3	9.3	18.0	
16	31/08	1708	54 28.3	5 9.8	125	140	29.4	69.9	0.4	0.0	0.0	0.2	0.1	8.3	9.5	
17	01/09	0726	54 25.1	5 16.6	72	650	0.0	95.0	1.6	0.0	0.0	3.4	0.0		20.9	
18	01/09	1024	54 23.2	5 20.7	79	155	99.0	0.3	0.8	0.0	0.0	0.0	0.0	7.9	9.4	
19	01/09	1233	54 12.8	5 34.5	22	23	94.2	2.2	0.0	0.0	0.0	3.5	0.0	10.6	13.0	
20	01/09	1534	54 8.7	5 20.7	65	1056	14.6	84.8	0.6	0.0	0.0	0.0	0.0	8.2	17.3	
21	01/09	1846	54 9.0	5 9.0	128	93	38.7	61.0	0.0	0.0	0.0	0.0	0.3	7.0	9.8	
22	02/09	1547	54 3.0	5 36.5	63	240	99.6	0.3	0.0	0.0	0.0	0.1	0.0	7.9	10.1	
23	02/09	1828	54 3.0	5 50.5	37	401	99.8	0.0	0.2	0.0	0.0	0.0	0.0	11.7		
24	02/09	2033	53 43.5	5 45.8	70	151	78.2	19.3	1.6	0.0	0.0	0.0	0.9	7.1	9.2	
25	03/09	0819	53 33.7	5 57.9	33	140	99.8	0.0	0.2	0.0	0.0	0.0	0.0	6.6	9.6	
26	03/09	1220	53 35.4	4 16.1	50	111	72.6	22.7	0.1	0.0	2.1	0.3	2.2	6.6	14.0	
27	03/09	1528	53 47.1	3 35.8	34	300	44.1	54.5	0.1	0.0	1.3	0.0	0.0	8.1	11.9	
28	03/09	1818	54 15.0	4 9.7	27	55	35.9	62.9	0.0	0.0	0.8	0.0	0.5	12.6	16.9	
29	08/09	0125	54 2.9	5 4.1	63	158	63.8	35.4	0.5	0.0	0.0	0.1	0.2	8.5	11.6	
30	08/09	0545	54 11.0	4 53.7	72	280	84.3	15.7	0.0	0.0	0.0	0.0	0.0	10.4	18.5	
31	08/09	0929	54 22.8	4 49.9	43	180	0.0	100.0	0.0	0.0	0.0	0.0	0.0		19.0	
32	08/09	1656	54 32.2	4 58.5	77	627	0.0	100.0	0.0	0.0	0.0	0.0	0.0		20.2	
33	09/09	0200	53 57.2	3 23.8	27	182	45.1	50.7	0.0	0.0	0.1	4.1	0.0	7.9	15.5	
34	09/09	0624	53 59.2	3 52.2	41	117	58.5	37.6	0.1	0.0	3.8	0.0	0.0	8.9	11.9	
35	09/09	1020	54 10.5	3 29.2	22	115	93.5	4.1	0.0	0.0	0.0	2.4	0.0	8.9	12.3	
36	09/09	1237	54 10.5	3 45.4	27	42	56.7	42.9	0.0	0.0	0.0	0.0	0.4	9.6	13.3	
37	09/09	1716	54 23.4	3 40.3	30	603	92.9	7.1	0.0	0.0	0.0	0.0	0.0	8.5	12.2	
38	11/09	1433	54 39.9	3 55.4	37	328	73.7	26.3	0.0	0.0	0.0	0.0	0.0	9.5	10.8	

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	total
7	7											7
8	23											23
9	30											30
10	34											34
11	27											27
12	23											23
13	20											20
14	27											27
15	10	11										21
16	8	66										74
17	1	122										123
18		149	1									150
19		92	2									94
20		54	20									74
21		12	53									65
22		1	62	3								66
23			45	7		1						53
24			23	15	3	4	1					46
25			14	11	9	8	2					44
26			7	10	7	6	2	4	1			37
27			1	3	6	7	3	1				21
28					2	2	2	2		1		9
29				1	1	1		1				4
TOTAL	210	507	228	50	28	29	10	8	1	1	0	1072

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 2011.

Stratum	No. sprat	Biomass sprat	No. Her	Biomass Her
1	1024533	5560	328974	8100
2	352709	1997	185710	7676
3	8019114	36993	1127205	19236
4	18002183	66086	738082	6745
5	1781502	13161	1492136	72520
6	3220379	20513	351234	3037
7	1508874	12895	240089	9762
8	342648	4518	124574	4536
9	458863	5730	152164	6587
10	9149045	46492	1230173	20826
11	5010724	15856	434688	6899
12	1886186	8567	388030	7253
Total	50756762	238369	6793058	173177

Annex 6c: Celtic Sea surveys

Annex 6c: Celtic Sea herring acoustic survey

FSS Survey Series: 2012/05

Celtic Sea Herring Acoustic Survey Cruise Report 2012

09 - 29 October, 2012

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1 Introduction

In the southwest of Ireland and the Celtic Sea (ICES Divisions VIIaS, g & j), herring are an important commercial species to the pelagic and polyvalent fleet. The local fleet is composed of dry hold polyvalent vessels and a smaller number of large purpose built refrigerated seawater vessels (RSW). The stock is composed of both autumn and winter spawning components and the fishery targets pre-spawning and spawning aggregations. The Irish commercial fishery has historically taken place within 1-20 nmi (nautical miles) of the coast. Since the mid 2000s RSW vessels have actively targeted offshore summer feeding aggregations in the south Celtic Sea. In VIIj, the fishery traditionally begins in mid September and is concentrated within several miles of the coast. The VIIaS fishery peaks towards the year end in December, but may be active from mid October depending on location. In VIIg, along the south coast herring are targeted from October to January at a number of known spawning sites and surrounding areas. Overall, the protracted spawning period of the two components extends from October through to January, with annual variation of up to 3 weeks. Spawning occurs in successive waves in a number of well known locations including large scale grounds and small discreet spawning beds. Since 2008 ICES division VIIaS (spawning box C) has been closed to fishing for vessels over 15m to protect first time spawners. For those vessels less than 15m a small allocation of the quota is given to this 'sentinel' fishery operating within spawning box C.

The stock structure and discrimination of herring in this area has been investigated recently. Hatfield et al. (2007) has shown the Celtic Sea stock to be fairly discrete. However, it is known that fish in the eastern Celtic Sea recruit from nursery areas in the Irish Sea, returning to the Celtic Sea as young adults (Brophy et al. 2002; Molloy et al., 1993). The stock identity of VIIj herring is less clear, though there is evidence that they have linkages with VIIb and VIaS (ICES, 1994; Grainger, 1978). Molloy (1968) identified possible linkages between young fish in VIIj and those of the Celtic Sea herring. For the purpose of stock assessment and management divisions VIIaS, VIIg and VIIj have been combined since 1982.

For a period in the 1970s and1980s, larval surveys were conducted for herring in this area. However, since 1989, acoustic surveys have been carried out, and currently are the only tuning indices available for this stock. In the Celtic Sea and VIIj, herring acoustic surveys have been carried out since 1989, and this survey is the 20th in the overall acoustic series or the seventh in the modified time series and conducted in October.

The geographical confines of the annual 21 day survey have been modified in recent years to include areas to the south of the main winter spawning grounds in an effort to identify the whereabouts of winter spawning fish before the annual inshore spawning migration. Spatial resolution of acoustic transects has been increased over the entire south coast survey area. The acoustic component of the survey has been further complimented since 2004 by detailed hydrographic and marine mammal and seabird surveys.

2 Materials and Methods

2.1 Scientific Personnel

Organisation	Name	Capacity	Leg
FEAS	Ciaran O'Donnell	Acoustics (SIC)	All
FEAS	Cormac Nolan	Acoustics	All
FEAS	Robert Bunn	Acoustics	All
FEAS	Macdara O'Cuaig	Acoustics	All
FEAS	Tobi Rapp	Biologist	All
FEAS	Grainne Ni Choncuir	Biologist	All
FEAS	Dermot Fee	Biologist	All
FEAS	Aimee Black	Biologist	1
FEAS	Turloch Smith	Biologist	2
FEAS	Helen McCormick	Biologist	2
GMIT	Eamonn O'Sullivan	SBO	All
GMIT	Stephen Mc Avoy	SBO	All
GMIT	Sarah Ingham	SBO	All
IWDG	Enda McKeogh	MMO	All
IS&W FPO	John Regan	Industry Rep	All

*SBO- Seabird observer, MMO- marine mammal observer

2.2 Survey Plan

2.2.1 Survey objectives

The primary survey objectives are listed below:

- Carry out a pre-determined survey cruise track
- Determine an age stratified estimate of relative abundance of herring within the survey area (ICES Divisions VIIj, VIIg and VIIaS)
- Collect biological samples from directed trawling on insonified fish echotraces to determine age structure and maturity state of the herring stock
- Determine estimates of biomass and abundance for other small pelagic species within the survey area
- Collect physical oceanography data from vertical profiles from a deployed sensor array.
- Survey by visual observations marine mammals and seabird abundance and distribution during the survey

2.2.2 Area of operation

The autumn 2012 survey covered the area from Loop Head in ICES Division VIIb (Figure 1) in Co. Clare and extended south along the western seaboard covering the main bays and inlets in Divisions VIIj & VIIg. The survey started in the southwest and worked in an easterly direction along the south coast to coincide with temporal alignment of movements of the stock towards the coast.

The survey was broken into 2 main components (Table 1). The first, a broad scale survey, was carried out to contain the stock within the survey confines and was based on the distribution of herring from previous years surveys (O'Donnell *et al.,* 2004). A broad scale survey composed of 9 strata formed the boundary component of the survey. Broad scale outer lying areas are important transit areas for herring migrating to inshore spawning areas and from offshore summer feeding grounds. The second component focused exclusively on known spawning areas and was made up of 9 strata.

2.2.3 Survey design

A parallel transect design was adopted with transects running perpendicular to the coastline and lines of bathymetry, where possible within each strata. Offshore extension reached up to 70nmi (nautical miles). Transect resolution was set at between 2 - 4nmi for the broad scale survey and increased to 1nmi for the spawning ground surveys. Bay areas were surveyed using a zigzag transect approach to maximise area coverage. Transect start points within each stratum are randomised each year within established baseline stratum bounds.

The adaptive stratum covering the 'Smalls' ground (2011) was continued in 2012. The Smalls is a traditional prawn fishing ground which since 2009 has been increasingly targeted by the RSW fleet searching for offshore herring aggregations in addition to the traditional areas such as the Labadie Bank and the Rigs areas. For the fourth successive year the offshore fishery has almost exclusively been focused on the Smalls area. Survey effort was reallocated from the southwest broadscale area, which historically has not contributed to the overall estimate of biomass.

In total, the combined survey accounted for 3,402nmi; with approximately 3,100nmi of integrateable acoustic transect available (Table 1).

2.3 Equipment and system details and specifications

2.3.1 Acoustic array

Equipment settings for the acoustic equipment were determined before the start of the survey program and were based on established settings employed by FEAS on previous surveys (O'Donnell *et al.,* 2004). The settings used on the *Celtic Explorer* acoustic array are shown in Table 2.

Acoustic data were collected using the Simrad EK60 scientific echosounder. The Simrad split-beam transducers are mounted within the vessel's drop keel and lowered to the working depth of 3.3m below the vessel's hull or 8.8m sub surface. Four operating frequencies were used during the survey (18, 38, 120 and 200 kHz) for trace recognition purposes, with the 38 kHz data used to generate the abundance estimate.

While on survey track the vessel is normally propelled using DC twin electric motor propulsion system with power supplied from 1 main diesel engine, so in effect providing "silent cruising" as compared to normal operations (Anon, 2002). During fishing operations normal 2 engine operations were employed to provide sufficient power to tow the net.

2.3.2 Calibration of acoustic equipment

Calibration of the EK60 was carried out in Dunmanus Bay on the 7th of October during hours of daylight. Good calibration results were obtained for all frequencies. Results of the 38kHz calibration and survey settings are shown in Table 2.

2.4 Survey protocols

2.4.1 Acoustic data acquisition

Acoustic data were observed and recorded onto the hard-drive of the processing unit using the equipment settings from previous surveys (Table 2). The "RAW files" were logged via a continuous Ethernet connection to the vessels server and the ER60 hard drive as a backup in the event of data loss. In addition, as a further back up a hard copy was stored on DVD. Sonar Data's Echoview® Echolog (Version 4) live viewer was used to display the echogram during data collection to allow the scientists to scroll through echograms noting the locations and depths of fish shoals. A member of the scientific crew monitored the equipment continually. Time and location (GPS position) data was recorded for each transect within each strata. This log was used to monitor the time spent off track during fishing operations and hydrographic stations plus any other important observations.

2.4.2 Echogram scrutinisation

Acoustic data was backed up every 24 hrs and scrutinised using Sonar data's Echoview® (V 4) post processing software. Partitioning of data into the categories shown below was largely subjective and was viewed by a scientist experienced in viewing echograms.

The NASC (Nautical Area Scattering Coefficient) values from each herring region were allocated to one of 4 categories after inspection of the echograms. Categories identified on the basis of trace recognition were as follows:

1. "Definitely herring" echo-traces or traces were identified on the basis of captures of herring from the fishing trawls which had sampled the echo-traces directly, and on large marks which had the characteristics of "definite" herring traces (i.e. very high intensity (red), narrow inverted tear-shaped marks either directly on the bottom or in midwater and in the case of spawning shoals very dense aggregations in close proximity to the seabed).

2. "Probably herring" were attributed to smaller echo-traces that had not been fished but which had the characteristic of "definite" herring traces.

3. "Herring in a mixture" were attributed to NASC values arising from all fish traces in which herring were thought to be contained, owing to the presence of a proportion of herring within the nearest trawl haul or within a haul that had been carried out on similar echo-traces in similar water depths.

4. "Possibly herring" were attributed to small echo-traces outside areas where fishing was carried out, but which had the characteristics of definite herring traces.

The RAW files were imported into Echoview for post-processing. The echograms were divided into transects. Echo integration was performed on a region which were defined by enclosing selecting marks or scatter that belonged to one of the four categories above. The echograms were analysed at a threshold of -70 dB and where necessary plankton was filtered out by thresholding at –65 dB.

The allocated echo integrator counts (NASC values) from these categories were used to estimate the herring numbers according to the method of Dalen and Nakken (1983).

The TS/length relationships used predominantly for the Celtic Sea Herring Survey are those recommended by the acoustic survey planning group based at 38 kHz (Anon, 1994):

Herring	TS =	20logL – 71.2 dB per individual (L = length in cm)
Sprat	TS =	20logL – 71.2 dB per individual (L = length in cm)
Mackerel	TS =	20logL – 84.9 dB per individual (L = length in cm)
Horse mackerel	TS =	20logL – 67.5 dB per individual (L = length in cm)
Anchovy	TS =	20logL – 71.2 dB per individual (L = length in cm)

The TS length relationship used for gadoids was a general physoclist relationship (Foote, 1987):

Gadoids	TS =	20logL – 67.5 dB per individual (L = length in cm)

2.4.3 Biological sampling

A single pelagic midwater trawl with the dimensions of 19m in length (LOA) and 6m at the wing ends and a fishing circle of 330 m was employed during the survey (Figure 22). Mesh size in the wings was 3.3 m through to 5 cm in the cod-end. The net was fished with a vertical mouth opening of approximately 9 m, which was observed using a cable linked “BEL Reeson” netsonde (50 kHz). The net was also fitted with a Scanmar depth sensor. Spread between the trawl doors was monitored using Scanmar distance sensors, all sensors being configured and viewed through a Scanmar Scanbas system.

All components of the catch from the trawl hauls were sorted and weighed; fish and other taxa were identified to species level. Fish samples were divided into species composition by weight. Species other than the herring were weighed as a component of the catch. Length frequency and length weight data were collected for each component of the catch. Length measurements of herring, sprat and pilchard were taken to the nearest 0.5 cm below. Age, length, weight, sex and maturity data were recorded for individual herring within a random 50 fish sample from each trawl haul, where possible. All herring were aged onboard. The appropriate raising factors were calculated and applied to provide length frequency compositions for the bulk of each haul.

Decisions to fish on particular echo-traces were largely subjective and an attempt was made to target marks in all areas of concentration not just high density shoals. No bottom trawl gear was used during this survey. However, the small size of the midwater gear used and its manoeuvrability in relation to the vessel power allowed samples at or below 1m from the bottom to be taken in areas of clean ground.

2.4.4 Oceanographic data collection

Oceanographic stations were carried out during the survey at predetermined locations along the track. Data on temperature, depth and salinity were collected using a calibrated Seabird 911 sampler at 1m subsurface and 3m above the seabed.

2.4.5 Marine mammal and seabird observations

Marine Mammal sighting survey

During the survey an observer kept a daylight watch on marine mammal and seabird sightings from the crow's nest (18m above sea level).

During cetacean observations, watch effort was focused on an area dead ahead of the vessel and 45^{o} to either side using a transect approach. Sightings in an area up to 90^{o} either side of the vessel were recorded. The area was constantly scanned during these hours by eye and with binoculars. Ship's position, course and speed were recorded, environmental conditions were recorded every 15 minutes and included, sea state, visibility, cloud cover, swell height, precipitation, wind speed and wind direction. For each sighting the following data were recorded: time, location, species, distance, bearing and number of animals (adults, juveniles and calves) and behaviour. Relative abundance (RA) of cetaceans was calculated in terms of number of animals sighted per hour surveyed (aph). RA calculations for porpoise, dolphin species and minke whales were made using data collected in ≤ Beaufort sea state 3. RA calculations for large whale species were made using data collected in ≤ Beaufort Sea state 5.

Seabird sighting survey

A standardized line transect method with sub-bands to allow correction for species detection bias and 'snapshots' to account for flying birds was used (following recommendations of Tasker *et al.* 1984; Komdeur *et al*.1992; Camphuysen *et al*. 2004), as outlined below.

Two observers (a primary observer and a primary recorder, who also acted as a secondary observer), in rotation from a pool of three surveyors, were allocated to survey shifts of two hours, surveying from 08.00 (or first light) to 18.00 hours (dusk) each day. Environmental conditions, including wind force and direction, sea state, swell height, visibility and cloud cover, and the ship's speed and heading were recorded at 2-hourly intervals during surveys. In the intervening time, any changes to environmental conditions were also noted, so that a discreet set of environmental conditions was obtained for each 5-minute interval. No surveys were conducted in conditions greater than sea state five, when high swell made working on deck unsafe or when visibility was reduced to less than 300m.

The seabird observation platform was the wheelhouse deck, which is 10.5m above the waterline and provided a good view of the survey area. The survey area was defined as a 300m wide band operated on one side (in a 90° arc from bow to beam) and ahead of the ship. This survey band was sub-divided (A = 0-50m from the ship, B = 50-100m, C = 100-200m, D = 200-300m, E > 300m) to subsequently allow correction of differences in detection probability with distance from the observer. A fixed-interval range finder (Heinemann 1981) was used to periodically check distance estimates. The area was scanned by eye, with binoculars used only to confirm species identification.

All birds seen on the water within the survey area were counted, and those recorded within the 300m band, were noted as ‘in transect’. All flying birds within the survey area were also noted, but only those recorded during a ‘snapshot’ were regarded as ‘in transect’. This method avoids overestimating bird numbers in flight (Tasker *et al*. 1984). The frequency of the snapshot scan was ship-speed dependent, such that they were timed to occur at the moment the ship passed from one survey block (300m x 300m) to the next. Survey time intervals were set at 5 minutes. Additional bird species observed outside the survey area were also recorded and added to the species list for the research cruise, but these will not be included in maps of seabird abundance or density.

On acoustic survey transects the vessel had an average speed of 10 knots, while speed was reduced to 4 knots for trawling effort. Tows lasted around 45 minutes and were mostly separated by extended sessions of steaming at 10 knots, so that few birds were attracted to the ship. CTD stations were conducted on some transects, during which the vessel remained stationary for, on average, 18 minutes. Seabird surveying was interrupted while the ship was stationary at CTD stations and while towing since this can attract large numbers of birds. Where fish sampling operations were prolonged or at close intervals, seabird surveying was only recommenced after a period (45min – 1hr) of prolonged steaming at 10 knots, allowing the associating birds to disperse. Any bird recorded in the survey area that stayed with the ship for more than 2 minutes was regarded as being associated with the survey vessel (Camphuysen *et al.* 2004) and was coded as such (to be excluded from abundance and density calculations).

In this report, the daily total count data per day for each species is presented along with the daily survey effort. It is envisaged that this data will be analysed in the future and the seabird abundance (birds per km traveled), and seabird density (birds per km2) will be mapped per 1⁄4 ICES square (15° latitude x 30° longitude), allowing comparison to the results of previous seabird surveys in Irish waters (e.g. Hall *et al*. in press, Mackey *et al*. 2004, Pollock *et al*. 1997). Through further analysis, species-specific correction factors will be applied to birds observed on the water. It is also hoped to combine this analysis with the results of the cetacean observation and acoustic survey. The binomial species names for the birds recorded are presented in the species accounts.

2.5 Analysis methods

2.5.1 Echogram partitioning

The analysis produced density values of numbers and biomass per nautical mile squared for each transect and mark category for each target species. These were then averaged over each stratum (weighted by transect length) and a biomass and abundance estimated by applying the stratum area and summing the strata estimates. Note that interconnecting inshore and offshore inter-transects were not included in the analysis. Total estimates and age and maturity breakdowns were calculated. Coefficient of variation (cv, standard error divided by the estimate) was estimated in the usual way after assuming that transects were identically distributed within a stratum and that they were statistically independent. CV were not reported for quantities that were unlikely to be used in a stock assessment (e.g., biomass of spent fish).

Biomass was calculated from numbers using length-weight relationships determined from the trawl samples taken during the survey for each of the analysis areas.

Herring weight (grams) = $0.0261 * L^{3.356}$ (L = length in cm)

Mackerel weight (grams) = $0.0094 * L^{2.919}$ (L = length in cm)

Sprat weight (grams) = $0.0039 * L^{3.309}$ (L = length in cm)

2.5.2 Abundance estimate

The recordings of area back scattering strength (NASC) per nautical mile were averaged over a one nautical mile EDSU (Elementary distance sampling unit), and the allocation of NASC values to herring and other acoustic targets was based on the composition of the trawl catches and the appearance of the echotraces.

To estimate the abundance, the allocated NASC values were averaged by survey strata. For each stratum, the unit area density of fish (S_A) in number per square nautical mile ($N * nmi^{-2}$) was calculated using standard equations (Foote et al. 1987, Toresen *et al*. 1998).

NASC values assigned according to scrutinisation methods (section 2.3.5) were used to estimate the target species numbers according to the method of Dalen and Nakken (1983).

To estimate the total abundance of fish, the unit area abundance for each stratum was multiplied by the number of square nautical miles within the strata and then summed for all strata to provide the total survey area. Biomass estimation was calculated by multiplying abundance in numbers by the average weight of the fish in each strata and then sum of all squares by strata and summed for the total area.

3 Results

3.1 Celtic Sea herring stock

3.1.1 Herring biomass and abundance

Herring	Millions	Biomass (t)	% contribution
Total estimate			
Definitely	2,096	246,681	91.6
Mixture	26	982	0.4
Probably	200	21,581	8.0
Total estimate	2,322	269,244	100
Possibly	1	75	
SSB Estimate			
Definelty	1805	226,505	91.9
Probably	163	19,334	7.8
Mixture	4	534	0.2
SSB estimate	1972	246,373	100

Total herring biomass shown above was determined from 18 survey strata of which 10 contained herring (Tables 1 & 10). Survey biomass and abundance was derived from 263 echotraces identified as herring with the aid of 20 directed trawls (Figure 2). Of the total number of echotraces attributed to herring, over 91% were identified as ‘definitely herring’ and 8% as ‘probably herring’ and less than 0.5% of ‘mixed herring’ (Table 10).

Herring TSB (total stock biomass) and abundance (TSN) estimates were 269,244t (CV 25.9%) and 2,322 million individuals (CV 24.7%), respectively. The overall SSB (spawning stock biomass) observed during the survey was 246,373t (CV 26.9%), composed of a spawning abundance (SSN) of 1,972 million individuals.

Herring stock abundance and biomass estimates are further broken down by age, maturity, size and stratum in Tables 5-10.

3.1.2 Herring distribution

A total of 20 trawl hauls were carried out during the survey (Figure 2), with 13 hauls containing herring and 10 of which contained >50% herring by weight of catch (Table 3).

In general, large high density herring echotraces were most abundant within 20nmi of the coast from the Helvick Head east to Waterford Harbour and in a clear band running southeast to the Smalls (Figure 3). A further localised area of medium/high density echotraces was located around Ballycotton.

Few herring echotraces were encountered west of 08°W along the south and southwest coasts and those that were were of low acoustic density. Herring echotraces were observed on the north side of Dingle Bay (strata 17) as single species schools categorised as ‘probably’ herring and contributed less than 1% to the total biomass. Further south, in Dunmanus Bay, a medium density scattering layer of juvenile herring and sprat was observed at night. The herring component contributed 0.2% to the total biomass (Table 10, Figure 6b).

Along the south coast west of 08°W, several low density herring schools were observed around the Old Head of Kinsale within the spawning box stratum (strata 14) contributing less than 0.5% to the TSB. Samples from this area contained the only spent fish observed during the survey (haul 20: spent n=4, sample n=50).

Over 95% of the observed herring echotraces were distributed in the eastern survey area and contained within 5 strata running from offshore (Smalls) to close inshore (Table 10, Figure 3). Combined, these echotraces accounted for over 99% of the observed TSB and TSN respectively.

The offshore broadscale stratum containing the Smalls (strata 8) contributed over 56,000t to the total biomass (>21%) and 20% of the TSN. Within this area high density echotraces of mature herring dominated, some of which extended over 2nmi in length. The second highest acoustic density echotrace recorded during the survey was observed in this stratum (Figure 6e). Biomass was determined from 68 echotraces, 36 of which were categorised as ‘definitely’ and 32 as ‘probably’ herring. The contribution of the ‘probably’ category represented 15% of the total biomass.

Strata 7 (Celtic Sea offshore) contributed 37,400t (14%) to the TSB and 11% to the TSN. This strata was characterised by a low number (n=12) of high density herring echotraces concentrated in the northeast of the stratum. No herring were observed in the south or west of 07°W as would have been the long term trend pre-2010.

Strata 9 (Celtic Sea inshore) contained the largest biomass observed during the survey of 124,700t (46%) of TSB and 48% of TSN. This stratum also contained the largest biomass in 2011 (90,200t or 68% of TSB). A total of 79 echotraces made up the estimate (61 'definitely', 9 'mix' and 9 'probably') and over 99% of biomass was categorised as 'definitely' herring. In general echotraces were of very high density and one particularly large off-transect echotrace of over 2nmi in length was observed (Figure 6f).

Strata 11 (Tramore) contained 42,400t (16%) of the TSB and 17% of the TSN. This area was characterised by a large number (n=51) of mixed density echotraces within this relatively small stratum (Tables 1& 10). This stratum was also found to contain the single largest on-track echotrace observed (Figure 6d).

3.1.3 Herring stock composition

A total of 546 herring were aged from survey samples in addition to 4,318 length measurements and 1,108 length-weight measurements (Table 4). Herring age samples ranged from 0-9 winter-rings (Tables 5 & 6, Figure 5).

Herring of the 2 winter-ring age group dominated the survey estimate representing over 31% of TSB and 37% of TSN (Table 5 and 6). The 3 winter-ring age group were ranked second representing 30% of TSB and 27% of TSN. The third most dominate age group was the 4 winter-ring group contributing 18% to the TSB and 14% to TSN.

As previous strong year classes grow, older age classes are becoming more evident in the standing stock with age classes of 5 to 8 winter-ring groups well represented in this years survey and contributing 14% of the total biomass. Age readings of commercial landings and survey samples show close correlation.

Maturity analysis indicate the majority (>91%) of the TSB as sexually mature (Tables 7 & 8, Figure 5). Several spent fish were encountered around the Old Head of Kinsale and are no doubt part of the much smaller autumn spawning component of this stock. Mature herring (stages 3 to 8) sampled during the survey were in a pre-spawning state and was predominantly comprised of stage 4 individuals.

The biomass of immature herring observed was comparable over recent years (2010: 32,000t, 2011: 21,1000t, 2012: 22,8000t). However, the overall TSB is significantly larger in 2012 (88%) and so the contribution of juveniles is therefore smaller. In 2012 the immature component showed an increased proportion of the 0-group fish that came from two particular areas and were taken mixed with sprat (Tables 3 & 4, Figure 2).

3.2 Other pelagic species

3.2.1 Sprat

Sprat	Millions	Biomass (t)	% contribution
Total estimate			
Definitely	4,259	31,136	88.7
Mixture	162	1,498	4.3
Probably	168	2,480	7.1
Total estimate	4,589	35,114	100

Sprat were found in 11 of 18 survey strata during the survey and sampled in 13 of 20 hauls (Figure 4, Table 3). In total 1,718 individual length measurements and 1,108 length/weight measurements were recorded. Mean length was 10.8cm and mean weight was 12g. Individuals ranged from 6 to 15cm in length and 2 to 28g in weight.

In total 272 sprat echotraces were identified during the survey (Table 12). The highest concentration of biomass was observed inshore in the southwest and accounted for over 53% of the total biomass and over 57% of the total abundance (Figure 4, Table 12). A low number of high density schools made up of juvenile sprat (mean length 5cm) dominated this stratum (Figure 6a). Dingle Bay contributed <1% of the TSB as compared to 2011 where 35% of the TSB was observed.

Further east, a broader range of length classes were observed and mean length was greater from both inshore and offshore waters. The second largest component of the biomass came from the offshore stratum (stratum 7) to the east of 07°30W and accounted for over 25% of TSB and over 23% of TSN. Offshore distribution follows a similar pattern to that observed in terms of biomass (20% in 2011) and distribution.

TSB is 11% higher than in 2011 (31Kt and 35Kt respectively) and TSN is 21% lower (5,832 million in 2011 and 4,589 in 2012). This can be accounted for by the contribution of larger individuals to the estimate than in 2011, most of which were located to the east of 08°W.

3.3 Oceanography

A total of 62 CTD stations were carried. Surface plots of temperature and salinity are presented for the 5, 20, 40 and the >60 m depth profiles in Figures 7-10.

Sea surface temperature taken at 5m shows the temperature profile to be relatively consistent along the south coast with the warmest areas in the central area between 7-9°W (Figure 7). Cooler localised areas are visible inshore and are no doubt a result of river input/runoff. The southwest corner has a much cooler surface profile and appears more influenced by shelf edge currents than the Celtic shelf waters. Salinity follows a similar pattern to temperature with full strength seawater dominating the eastern edge of the survey area.

At 20m depth a similar temperature and salinity profile is observed. At 40m depth, warmer waters (c.13.5°C) are mainly found to the north of 51.30°N along the south coast and the influence of cooler water (<12°C) from the south is more evident. Salinity remains relatively uniform throughout the survey area at this depth. The 40-50m depth range showed a clear drop in temperature of around 3°C and marked the position of a deep thermocline.

Temperature and salinity at depths of 40m and 60m were overlaid with acoustic densities values from herring echotraces (Figures 9 & 10). This depth profile was chosen as the majority of echotraces were observed in waters of >40m depth. As almost all of the herring biomass observed during the survey is located in the eastern extreme of the survey area the conditions here are of most interest. With the exception of the 60m profile all herring appear to be most closely associated with the warmer (c.12-14°C) body of water. Salinity in the same profiles is relatively consistent and doesn't appear to be as dynamic as temperature. This easterly distribution was also observed in 2011 along with a similar warmer frontal area in the east.

3.4 Marine mammal and seabird observations

3.4.1 Marine mammal sightings

Environmental data was collected at 568 stations. Beaufort Sea state was recorded at ≤ 3 at 54.8% of the environmental stations and at ≥ 4 at 45.2% of the stations. Visibility of ≤ 5km was recorded at 16.5% of the stations, 6 – 10km at 9.5% of the stations, 11 – 15km at 10% of the stations, and at 16 – 20km+ at 63.9% of the stations. A light swell of 0 – 1m was recorded at 34.5%, a moderate swell of 1 – 2m at 52.5% and a heavy swell of 2m+ at 13.0% of the stations. Rainfall was recorded at 7.2% of stations while fog/mist was recorded at 10.9% of stations.

One full day was lost due to weather conditions; 8m swell and force 9 winds. One half day was lost due to calibration of equipment and another half day was lost due to a change of personnel mid-way through the survey.125.75 hours of survey time were logged with 54.8% (68.9 hrs) of this at Beaufort sea state three or less; 74.5% (93.7 hrs) at Beaufort sea state four or less and 87.1% (109.5 hrs) at Beaufort sea state five or less. 93 sightings of at least five cetacean species, totalling 484 individuals were recorded

A total of 485 animals were recorded during the survey. Identified cetacean species were common dolphin (Delphinus delphis), harbour porpoise (Phocoena phocoena), fin whale (Balaenoptera physalus), bottlenose dolphin (Tursiops truncates) and minke whale (Balaenoptera acutorostrata). The basking shark (Cetorhinus maximus) was the only other positively identified species (Table 14). The distribution of effort and sightings during the survey are presented in Figure 12.

3.4.2 Seabird sightings

Observation effort

A total of 128hr of seabirds-at-sea survey data was gathered over a 17-day period from 10th October to 27th October 2012 (Figure 11). The weather and visibility were mostly good. Sea conditions were good (force 1-3) for 5 days, moderate (force 4-5) for 7 days and rough (force 5-6) for 5 days. Surveying was carried out on all but one day (17th Oct) when conditions were extremely rough (wind force 8-10). A total of 46 species were recorded, including 21 seabirds, 8 coastal/inshore species and 17 terrestrial species (Table 13). The transect route covered a range of depths but was conducted entirely over the continental shelf (Figure 1). The highest daily count of birds (n=2,697) was observed on 19th October, when survey transects passed through a part of the south-east Celtic Sea where the fishery was active.

Northern gannets comprised approximately 39% (n=8,105) of all birds observed on the survey transects. During offshore portions of the survey route (>20 nautical miles from shore), northern fulmars (n=3,651) and black-legged kittiwakes (n=1,714) were the next most abundant species. In coastal inshore waters, a large number of auks were recorded (n=4,624). Over any great distance, auks in flight are extremely difficult, and often virtually impossible to identify to species level. Half of those recorded were positively identified and of those, the great majority (92.7%) were common guillemots, with small numbers of razorbills, Atlantic puffins and black guillemots. Lesser black-backed gulls, great black-backed gulls, herring gulls and great skua account for the majority of the remaining observations. Small numbers of sooty shearwaters, shags, common gulls, storm petrels, black-headed gulls, cormorants, common scoters, manx shearwaters, Arctic skua, red-throated divers and great northern divers were recorded along with single observations of long-tailed duck, great shearwater, pomarine skua and grey phalarope. Of the 17 terrestrial migrants, starlings (n=21), meadow pipits (n=9) and redwing (n=7) were the most numerous.

4 Discussion and Conclusions

4.1 Discussion

The aims and objectives of the survey were carried out as planned and comprehensive trawl sampling was undertaken. Weather conditions overall were excellent and this allowed for additional CTD casts and extra adaptive area coverage. One 24hr period was lost due to poor weather but this was absorbed into the survey without issue.

Information received by a demersal trawler working an area outside of our scheduled tracks indicated a high abundance of herring. Additional transects were carried out (c.30nmi²) but no herring were encountered. This was possibly due to the high tidal range (spring tides) in this area at the time of coverage. During spring tides and peak tidal phase herring have been observed during previous surveys to carpet the seabed to maintain position and conserve energy. Close to the seabed (<0.3m) fish are out of the range of the acoustic equipment and within the acoustic 'dead zone'. Information from the herring fleet working the offshore area reported similar behaviour with fish shoaling most during periods of lowest tidal range. As the fishery was underway during the survey real-time positional information was available as to where the fleet were operating and where catches were taken. Area coverage during the survey contained both the fishery and the stock within its boundaries.

The 2012 survey shows an 88% increase in TSB and 79% increase in TSN as compared to 2011. Biomass across all comparable strata showed an increase in 2012 with the exception of 2 strata (13 & 14). The largest contributing stratum in 2011 (Celtic Sea inshore) was also the largest contributor in 2012. In 2011 this represented 90,200t (68% TSB) and in 2012 this was 125,000t (46%TSB) for the same geographical area. The stock was considered to be well contained within the survey area and all strata were surveyed with the same effort (transect spacing) and area coverage with the exception of the Smalls ground (strata 8). The large increase in biomass cannot therefore be attributed to a change in effort within this stratum.

In 2011 the Smalls stratum was added to the historic survey coverage in response to changes in the pre-spawning distribution of the stock, first reported in 2009. This trend has continued into 2012, with the offshore fishery exclusively concentrated in this area for the fourth consecutive year and away from a more traditional westerly distribution. The absence of herring from summer feeding grounds was confirmed during the July 2011 and 2012 boarfish acoustic surveys which covered the south Celtic Sea (O'Donnell *et al.* 2011 & 2012).

In 2011 the Smalls contributed 7% to the TSB (9,900t) as compared to 21% (56,400t) in 2012, the second highest contributor this year. The geographical area covered in 2012 was increased to the east by 285nmi² (from 714 to 999nmi²) while maintaining the same effort (transect spacing). This stratum had a high ratio of 'probably' to 'definitely' herring echotraces assigned (32 to 36 respectively), which was due to high sprat abundance also in the area. As it was not possible to trawl on all the echotraces due to the large number encountered, a 'probably' assignment was applied. However, the positive identification of echotraces by trawl station is represented in the herring allocation for the stratum ('probably': 8,500t, stratum total: 56,400t), while the sprat biomass represented 3,800t.

The age structure of the stock shows continuity between years but not in terms of biomass or abundance. Ages up to 8 winter rings are now well represented in the stock. In 2011, the 2, 3, and 1-winter ring fish dominated in terms of biomass and in 2012 the 2, 3 and 4-winter ring fish rank highest. For three successive surveys 2-winter ring fish have dominated the estimate indicating a period of sustained positive recruitment As no recruitment index exists for this stock and the survey is generally not considered a reliable indicator of pre-recruit (juvenile) biomass.

It is possible that the significant increase in survey biomass resulted from an underestimate of the stock in 2011. However, commercial catch data (position) and herring distribution from survey data show good containment of the stock within the survey boundaries.

For the survey to accurately track abundance a degree of plasticity in design is needed to take into account changes in the behaviour of the stock. The drivers for the change in offshore distribution are not understood but may be related to changes in larger scale hydrographic conditions in the Celtic Sea and prey availability during the summer feeding phase. Taking this into consideration it is recommended that the offshore stratum covering the Smalls be incorporated and reported as part of the core survey.

4.2 Conclusions

- Herring TSB (total stock biomass) and abundance (TSN) estimates as determined from survey data was 269,244t (CV 25.9%) and 2,322 million individuals (CV 24.7%), respectively. Spawning stock biomass (SSB) was 246,373t (CV 26.9%) and spawning abundance (SSN) was 1,972 million individuals.
- Survey derived TSB increased by 88% from 2011, while abundance increased by 79%.
- All comparable survey strata showed an increase in biomass and abundance in 2012, with the exception of strata 13 & 14. The largest contributing stratum in 2011 was also the largest in 2012 containing 46% of the biomass.
- Survey effort and geographical coverage remained the same for all core areas with the exception of the smalls stratum where the area was increased by 285nmi² to the east.
- The Smalls stratum contributed 7% (9,900t) to the TSB in 2011 and 21% (56,400t) in 2012.
- 2-winter ring fish remain dominant for the third successive year within the survey indicating a continued period of strong recruitment for the stock.
- The age structure of the stock shows continuity between years but not in terms of biomass or abundance due to the large increases observed in 2012.
- Older fish of the 5-8 winter-ring groups are well represented in the 2012 estimate totaling 14% of the TSB.

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5 Tables and Figures

Table 1. Survey Strata details. Celtic Sea herring acoustic survey, October 2012.

Strata no.	Strata name	Survey type	Transect type	Active transects	Transect spacing	Transect mileage (nmi)	Strata area (nmi2)
1	Inside Shann(	Broad scale	Zigzag	7	na	59.4	43
2	Dingle	Broad scale	Zigzag	8	na	54.2	88
3	Kenmare	Broad scale	Zigzag	7	na	44.2	91
4	Bantry	Broad scale	Zigzag	9	na	37.7	53
5	Dunmanus	Broad scale	Zigzag	4	na	14.7	11
6	Mizen	Broad scale	Parallel	14	4	313.0	1,162
7	Offshore CS	Broad scale	Parallel	31	2	1,224.0	1,878
8	Smalls	Broad scale	Parallel	9	2	244.6	999
9 (a,b,c,d,e)	CS Inshore	Broad scale	Parallel	34	2	593.6	1,265
10	Baginbun	Spawning grd	Parallel	9	1	55.0	39
11	Tramore	Spawning grd	Parallel	17	1	104.1	102
12	Waterford	Spawning grd	Zigzag	4	na	14.0	3
13	Ballycotton	Spawning grd	Parallel	16	1	128.2	113
14	Daunt	Spawning grd	Parallel	12	1	81.1	80
15	Stags	Spawning grd	Parallel	5	1	12.0	11
16	Dingle_S	Spawning grd	Parallel	6	1	24.6	14
17	Dingle_N	Spawning grd	Parallel	6	1	21.4	12
18	Kerry Head	Spawning grd	Parallel	12	1	81.7	77
			Total	210		3,107.5	6,040

Table 2. Calibration report: Simrad EK60 echosounder at 38 kHz, employed during the Celtic Sea herring acoustic survey, October 2012.

Vessel : R/V Celtic Explorer		Date : 11/10/2012	
Echo sounder : ER60 PC		Locality : Dunmanus Bay	
Type of Sphere : CU-38,1	TS_{Sphere}: -33.50 dB (Corrected for soundvelocity or t,S)	Depth(Sea floor) : 26 m	

Calibration Version 2.1.0.11

Comments:
Dunmanus Bay, Survey start

Reference Target:			
TS	-33.50 dB	Min. Distance	10.00 m
TS Deviation	5.0 dB	Max. Distance	15.00 m
Transducer: ES38B Serial No. 30227			
Frequency	38000 Hz	Beamtype	Split
Gain	26.5 dB	Two Way Beam Angle	-20.6 dB
Athw. Angle Sens.	21.90	Along. Angle Sens.	21.90
Athw. Beam Angle	7.10 deg	Along. Beam Angle	7.10 deg
Athw. Offset Angle	0.00 deg	Along. Offset Angl	0.00 deg
SaCorrection	0.00 dB	Depth	8.8 m
Transceiver: GPT 38 kHz 009072033933 1 ES38B			
Pulse Duration	1.024 ms	Sample Interval	0.190 m
Power	2000 W	Receiver Bandwidth	2.43 kHz
Sounder Type:			
ER60 Version 2.2.1			
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.	9.2 dB/km	Sound Velocity	1504.2 m/s
Beam Model results:			
Transducer Gain =	25.95 dB	SaCorrection =	-0.67 dB
Athw. Beam Angle =	6.85 deg	Along. Beam Angle =	6.81 deg
Athw. Offset Angle =	-0.05 deg	Along. Offset Angle=	-0.05 deg

Data deviation from beam model:
RMS = 0.18 dB
Max = 0.42 dB No. = 145 Athw. = 4.0 deg Along = 3.2 deg
Min = -0.72 dB No. = 315 Athw. = -4.8 deg Along = -1.9 deg

Data deviation from polynomial model:
RMS = 0.12 dB
Max = 0.40 dB No. = 253 Athw. = -4.2 deg Along = -3.1 deg
Min = -0.67 dB No. = 102 Athw. = 3.5 deg Along = 3.9 deg

Comments :

Wind Force : 3 **Wind Direction** NW
Raw Data File: \\Expfileclstr\ER-60_Data\CSHAS_2011\RAW ER60 Files\Calibration\CSHAS_2012
Calibration File: \\Expfileclstr\ER-60_Data\ER-60\Calibrations_2012\CSHAS 2011\38 KHZ

Calibration : Ciaran O'Donnell

Table 3. Catch table from directed trawl hauls during the Celtic Sea herring acoustic survey, October 2012.

No.	Date	Lat. N	Lon. W	Time	Bottom (m)	Target (m)	Bulk Catch (Kg)	Herring %	Mackerel %	Scad %	Sprat %	Pilchard %	Others* %
1	10.10.12	52 02.23	010 21.53	19:00	53	5	<1		60.0		35.0		5.0
2	11.10.12	51 32.77	009 41.25	7:35	45	0	100.0	1.3	0.8		97.0		0.8
3	11.10.12	51 17.69	009 48.21	22:05	96	45	3.0		25.0		63.0		12.0
4	15.10.12	51 23.76	007 33.27	14:52	81	0	24.0		72.4	0.4	23.5		3.7
5	15.10.12	51 37.46	007 31.05	17:45	76	0-45	150.0				100.0		
6	16.10.12	51 17.27	007 16.97	16:45	87	0-10	0.5			1.5	74.5		24.0
7	16.10.12	51 14.92	007 03.38	11:14	87	25	3.5	2.2	4.4			9.4	84.0
8	18.10.12	51 43.34	006 57.74	21:40	72	0-45	250.0	59.4	16.3		1.7	5.0	17.6
9	19.10.12	51 35.24	006 53.77	7:26	71	13-40	6000.0	99.2	0.4			0.1	0.3
10	20.10.12	51 21.24	006 37.78	2:23	80	0-18	1500.0	82.5	0.6		0.2		16.6
11	20.10.12	51 15.87	006 34.37	7:43	110	60	6.4		48.5	14.3	28.1		9.2
12	20.10.12	51 18.50	006 34.05	9:15	90	0-15	-						
13	20.10.12	51 21.98	006 34.39	11:21	85	0-5	2500.0	100.0					
14	21.10.12	52 03.30	006 43.99	19:55	45	15-35	33.7	22.5	19.7		25.1	0.4	32.2
15	22.10.12	51 50.38	006 59.91	05::05	65	0-4	3000.0	83.8			0.3		15.9
16	22.10.12	52 00.43	006 59.80	7:20	49	0-18	2500.0	94.8	5.0			0.3	
17	22.10.12	52 02.03	007 10.10	17:20	44	0-35	7000.0	93.8	5.0			1.2	
18	23.10.12	51 59.97	007 19.57	8:37	46	0-12	4500.0	81.0	19.0				
19	23.10.12	52 02.46	007 28.70	16:21	30	0-15	5000.0	98.1	1.3		0.6		
20	25.10.12	51 38.44	008 30.79	16:10	30	0-20	33.1	58.8	32.0		0.1	0.4	8.8

* Including demersal fish and invertebrates

Table 4. Length-frequency of herring hauls used for calculating 'definitely', 'probably' and 'mixed' abundance categories. Celtic Sea herring acoustic survey, October 2012.

Haul	**2**	**8**	**9**	**10**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	
length (cm)													Total
11						1							
11.5						1							
12						9							
12.5	2					11							13
13	1					16							17
13.5						33							33
14	11			1		28							40
14.5	13					60							73
15	14					25							39
15.5	9					14							23
16	5												5
16.5	1												1
17										1			1
17.5											1	1	2
18					1	1				1	2		5
18.5						2				6	13		21
19					1					14	22	1	38
19.5				3	2					17	30	4	56
20				3	17			4		27	44	1	96
20.5			1	11	12	1		4	4	35	34	2	104
21				23	44	1	1	7	5	58	47	11	197
21.5		1	3	16	26		2	26	12	60	44	17	207
22		6	1	23	60		4	28	7	46	60	22	257
22.5		11	18	22	34		12	32	27	35	32	27	250
23		12	8	25	38	1	8	31	17	19	31	17	207
23.5		29	10	32	22		10	30	36	23	26	15	233
24		21	7	28	21		25	36	34	37	34	11	254
24.5		35	37	53	26		36	30	60	54	30	15	376
25		60	20	55	31		47	60	49	33	32	14	401
25.5		52	60	60	18		60	58	53	29	34	15	439
26		44	15	57	15		56	56	37	19	44	3	346
26.5		33	32	31	8		29	32	25	20	25	4	239
27		23	12	23	1		23	16	21	14	16	4	153
27.5		24	13	9	2		15	11	11	2	16	1	104
28		6	5	1			7	6	3	2	7		37
28.5			1				1	2	2		1		7
29		3		1	1								5
29.5												1	1
30		1											1
30.5													0
31					1								1
31.5													0
32													0
32.5													0
33													0
Total	**56**	**361**	**243**	**477**	**381**	**202**	**336**	**469**	**403**	**552**	**625**	**186**	**4,291**

Table 5. Total biomass (000's tonnes) of herring at age (winter rings), by strata as derived from acoustic estimate of abundance**.** Celtic Sea herring acoustic survey, October 2012.

Strata	0	1	2	3	4	5	6	7	8	9	10	Total
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0.1	0.2	0.1	0	0.1	0	0	0	0	0.5
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0.5	7.4	12.4	8.6	1.8	4.4	1	1	0.2	0	37.4
8	0	3.6	18.3	17.3	10.3	1.5	3.8	0.8	0.6	0.1	0	56.4
9	0.5	10.5	40.3	36	21.2	3.5	8.7	1.9	2	0.3	0	124.7
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	4.7	15.3	11.9	6.1	0.9	2.5	0.5	0.5	0	0	42.4
12	0	0	0	0	0	0	0	0	0	0	0	0
13	0	1	2.3	1.4	1	0.2	0.5	0.1	0.1	0	0	6.6
14	0	0.1	0.5	0.3	0.1	0	0	0	0	0	0	1
15	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0
17	0.2	0	0	0	0	0	0	0	0	0	0	0.2
18	0	0	0	0	0	0	0	0	0	0	0	0
Total	0.7	20.4	84.3	79.4	47.3	8	20	4.4	4.2	0.6	0	269.2
%	0.2	7.6	31.3	29.5	17.6	3	7.4	1.6	1.6	0.2	0	100

Table 6. Herring abundance (millions) at age (winter rings), by strata as derived from acoustic estimate of abundance. Celtic Sea herring acoustic survey, October 2012.

Strata	0	1	2	3	4	5	6	7	8	9	10	Total
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0.0
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	1	1	1	0	0	0	0	0	0	3.7
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	5	66	92	58	11	26	6	5	1	0	270.2
8	1	44.9	183.1	133.2	71.0	9.5	23.6	4.5	3.2	0.6	0	474.2
9	22	140.5	413.6	280.3	149.0	20.9	53	10.7	11	1	0	1102.2
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
11	0	64	162	94	44	6	15	3	3	0	0	391.1
12	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.0
13	0	14	26	11	7	1	3	1	1	0	0	63.8
14	0	1.0	5.0	2.2	0.7	0.1	0.2	0.1	0.0	0.0	0	9.3
15	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0
16	0	0	0	0	0	0	0	0	0	0	0	0.0
17	7	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	7.3
18	0	0	0	0	0	0	0	0	0	0	0	0.0
Total	30.5	269.8	855.8	614.5	330.5	48.5	121.4	24.8	22.7	3.3	0.0	2321.8
%	1.3	11.6	36.9	26.5	14.2	2.1	5.2	1.1	1.0	0.1	0.0	100
Cv (%)	67.9	23.8	23	27	28.9	31	30	31	31.7	34.6	NA	NA

Table 7. Herring biomass (000's tonnes) at maturity by strata. Celtic Sea herring acoustic survey, October 2012.

Strata	Imm	Mature	Spent	Total
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	0.5	0	0.5
6	0	0	0	0
7	0.4	36.6	0.4	37.4
8	3.3	52.7	0.4	56.4
9	12.1	111.8	0.8	124.7
10	0	0	0	0
11	5.5	36.7	0.2	42.4
12	0	0	0	0
13	1.2	5.4	0	6.6
14	0.1	0.9	0	1
15	0	0	0	0
16	0	0	0	0
17	0.2	0	0	0.2
18	0	0	0	0
Total	22.8	244.6	1.8	269.2
%	8.5	90.9	0.7	100

Table 8. Herring abundance (millions) at maturity by strata. Celtic Sea herring acoustic survey, October 2012.

Strata	Imm	Mature	Spent	Total
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0.0	3.6	0.0	3.7
6	0	0	0	0
7	5.0	262.4	2.7	270.2
8	45.9	425.6	2.8	474.2
9	192.1	904.0	6.1	1102.2
10	0	0	0	0
11	79.8	309.4	1.9	391
12	0	0	0	0
13	18.5	45.0	0.3	63.8
14	1.2	8.0	0.1	9.3
15	0	0	0	0
16	0	0	0	0
17	7.3	0	0	7.3
18	0	0	0	0
Total	349.8	1958.1	14	2321.8
%	15.1	84.3	1	100

Table 9. Herring length at age (winter rings) as abundance (millions) and biomass (000's tonnes). Celtic Sea herring acoustic survey, October 2012.

Length	Age (Rings)											Abund	Biomass	Mn wt
(cm)	0	1	2	3	4	5	6	7	8	9	10	(mils)	000's t	(g)
11	0.11											0.11	0.0	8.8
11.5	0.11											0.11	0.0	10.2
12	0.98											0.98	0.01	11.7
12.5	1.45											1.45	0.02	13.4
13	1.87											1.87	0.03	15.3
13.5	3.58											3.58	0.06	17.3
14	5.2											5.2	0.1	19.5
14.5	8.2											8.2	0.18	21.9
15	4.53											4.53	0.11	24.5
15.5	2.69											2.69	0.07	27.3
16	0.65											0.65	0.02	30.3
16.5	0.13											0.1	0.0	33.5
17	1.02											1.02	0.04	37
17.5		0.48										0.48	0.02	40.7
18		2.32										2.32	0.1	44.7
18.5		12										12.0	0.6	48.9
19		24.2										24.2	1.3	53.5
19.5			36.2									36.2	2.1	58.3
20		40			20							59.9	3.8	63.4
20.5		49.4	19.8									69.3	4.8	68.8
21		40.3	80.8									121.2	9.0	74.5
21.5		38.5	76.8	25.6								140.9	11.4	80.5
22		39.7	111									150.9	13.1	86.9
22.5		4.29	121	17.3								142.9	13.4	93.7
23			103	14.1								117.1	11.8	100.8
23.5		3.25	84.6	32.5								120.4	13.0	108.2
24		5.04	70.1	55.1	5.04		5.04					140.2	16.3	116.1
24.5			79.8	144	5.26							228.6	28.4	124.3
25			41.1	130	34.2		3.34					208.7	27.7	132.9
25.5		4.17	25.2	101	97.3	8.33	8.33					244.8	34.8	141.9
26		6.27	3.14	57.2	98.5	6.27	12.7					184.1	27.9	151.4
26.5			2.77	32.5	54.2	8.16	32.5	5.39	2.77			138.3	22.3	161.3
27				3.27	9.87	13.2	33	9.87	6.61			75.9	13.0	171.7
27.5				2.04	6.16	10.3	18.5	6.16	2.04	2.04		47.2	8.6	182.5
28						2.23	6.69	2.23	8.93			20.1	3.9	193.7
28.5							0.87	0.87	1.73	0.87		4.3	0.9	205.5
29							0.24	0.24	0.48	0.24		1.2	0.3	217.7
29.5							0.01	0.01	0.02	0.01		0.05	0.01	230.5
30														
30.5														
31							0.06	0.06	0.13	0.06		0.32	0.09	271.8
31.5														
32														
32.5														
33														
33.5										0.05		0.05	0.02	352
SSN (mil)		117	724	600	311	48.5	121	24.8	22.7	3.3		1971.9		
SSB ('000s t)		10.5	74.5	78.1	46.1	8.0	20.0	4.4	4.2	0.6			246.4	
Mn Wt (g)	21.3	75.5	98.4	129	143	166	165	176	184	196				
Mn length (cm)	14.5	21.2	23	25	25.7	26.9	26.9	27.4	27.8	28.3				

Table 10. Herring biomass and abundance by survey strata. Celtic Sea herring acoustic survey, October 2012.

Category Stratum	No. transects	No. schools	Def schools	Mix schools	Prob schools	% zeros	Def Biomass	Mix Biomass	Prob Biomass	Biomass ('000t)	SSB ('000t)	Abundance millions
1	5	0	0	0	0	100	0	0	0	0	0	0.0
2	9	0	0	0	0	100	0	0	0	0	0	0.0
3	7	0	0	0	0	100	0	0	0	0	0	0.0
4	8	0	0	0	0	100	0	0	0	0	0	0.0
5	6	4	0	4	0	67	0	0.5	0	0.5	0.5	3.7
6	14	0	0	0	0	100	0	0	0	0	0	0.0
7	32	12	12	0	0	94	37.4	0	0	37.4	36.9	270.2
8	9	68	36	0	32	56	47.9	0	8.5	56.4	53.1	474.2
9	34	79	61	9	9	62	123.5	0.5	0.7	124.7	112.6	1102.2
10	9	0	0	0	0	100	0	0	0	0	0	0.0
11	17	52	34	0	18	0	34.4	0	8.1	42.4	37	391.1
12	3	0	0	0	0	100	0	0	0	0	0	0.0
13	16	39	8	0	31	62	2.7	0	3.9	6.6	5.4	63.8
14	12	7	3	0	4	67	0.7	0	0.3	1	0.9	9.3
15	5	0	0	0	0	100	0	0	0	0	0	0.0
16	6	0	0	0	0	100	0	0	0	0	0	0.0
17	6	2	0	0	2	83	0	0	0.2	0.2	0	7.3
18	12	0	0	0	0	100	0	0	0	0	0	0.0
Total	210	263	154	13	96	77	246.6	1	21.6	269.2	246.4	2321.8
Cv (%)	-	-	-	-	-	-	-	-	-	25.9	26.9	24.7

Table 11. Celtic Sea and VIIj Herring acoustic survey time series (Abundance (millions), TSN and SSB (000's tonnes). Age in winter rings. Estimate includes 'Smalls' strata from 2011 onwards.

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

Note: 2009/2010 values are derived from 18 kHz data.

Table 12. Sprat biomass and abundance by survey strata. Celtic Sea herring acoustic survey, October 2012.

Category Stratum	No. transects	No. schools	Def schools	Mix schools	Prob schools	% zeros	Def Biomass	Mix Biomass	Prob Biomass	Biomass ('000t)	Abundance millions
1	5	0	0	0	0	100	0	0	0	0.0	0.0
2	9	42	8	34	0	0	0.2	0.9	0	1.1	70.7
3	7	0	0	0	0	100	0	0	0	0.0	0.0
4	8	7	0	0	7	62	0	0	0.9	0.9	56.7
5	6	0	0	0	0	100	0	0	0	0.0	0.0
6	14	35	31	0	4	43	18.2	0	0.6	18.8	2654.9
7	32	79	70	7	2	78	8.2	0.6	0.1	8.9	1068.4
8	9	50	50	0	0	22	3.8	0	0	3.8	609.1
9	34	12	12	0	0	97	0.2	0	0	0.2	20.0
10	9	30	30	0	0	22	0.4	0	0	0.4	39.7
11	17	0	0	0	0	100	0	0	0	0.0	0.0
12	3	5	5	0	0	67	0.1	0	0	0.1	13.9
13	16	9	0	0	9	69	0	0	0.3	0.3	24.3
14	12	2	0	0	2	83	0	0	0	0.0	6.7
15	5	0	0	0	0	100	0	0	0	0.0	0.0
16	6	0	0	0	0	100	0	0	0	0.0	0.0
17	6	1	0	0	1	83	0	0	0.4	0.4	24.5
18	12	0	0	0	0	100	0	0	0	0.0	0.0
Total	210	272	206	41	25	76	31.1	1.5	2.5	35.1	4,589
Cv (%)	-	-	-	-	-	-	-	-	-	29.4	35.4

Table 13. Total numbers of bird species recorded during the Celtic Sea Herring Acoustic Survey 2012.

Family	Species	Recorded in Survey Area	Total Observations
Seabirds			
Petrels	Northern fulmar	Y	3651
	Sooty shearwater	Y	113
	European storm petrel	Y	31
	Manx shearwater	Y	12
	Great shearwater	Y	1
Gannets	Northern gannet	Y	8105
Cormorants and Allies	Shag	Y	47
	Cormorant	Y	16
Skuas	Great skua	Y	225
	Arctic skua	Y	8
	Pomarine skua	Y	1
Gulls	Lesser black-backed gull	Y	618
	Black-legged kittiwake	Y	1714
	Great black-backed gull	Y	554
	Herring gull	Y	313
	Black-headed gull	Y	26
	Common gull	Y	40
Auks	Common guillemot	Y	2133
	Razorbill	Y	167
	Atlantic puffin	Y	25
	Black guillemot	Y	2
Coastal/Inshore Birds			
Divers	Red-throated diver	Y	4
	Great northern diver	Y	2
Ducks, Swans and Geese	Common scoter	Y	14
	Brent goose	N	3
	Long-tailed duck	Y	1
Waders	Grey phalarope	Y	1
	Golden plover	Y	1
	Woodcock	Y	1
Terrestrial Birds			
Herons and Allies	Grey heron	Y	1
Falcons and Allies	Merlin	Y	1
Martins	Sand martin	Y	1
Songbirds	Starling	Y	21
	Meadow pipit	Y	9
	Redwing	Y	7
	Unidentified finch	Y	5
	Black redstart	Y	4
	Chaffinch	Y	4
	Snow bunting	Y	2
	Jackdaw	Y	2
	Common redstart	Y	1
	Skylark	Y	1
	Linnet	Y	1
	Rock pipit	Y	1

Table 14. Sightings, counts and group size ranges for cetacean and shark species sighted during the visual survey.

Species	No. Sightings	No. Individuals	Range of Group Size
Common dolphin	52	411	2-30
Bottlenose dolphin	2	6	1-5
Minke whale	6	6	-
Fin whale	20	7-12	1-2
Harbour porpoise	5	17	2-5
Basking shark	1	1	-
Unidentified dolphin	6	29	1-10
Unidentified whale	2	3	1-2
Unidentified shark	1	1	-

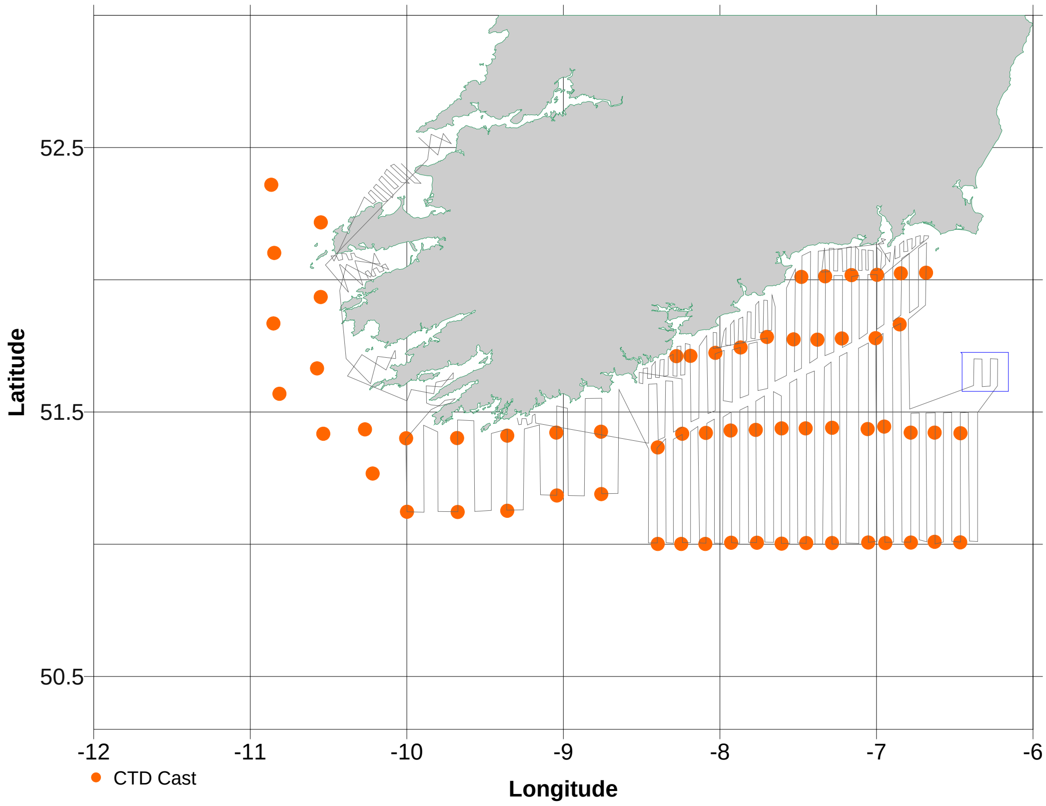


Figure 1. Cruise track (grey line) with CTD casts in orange. Blue box indicates adaptive strata not included in the estimate.

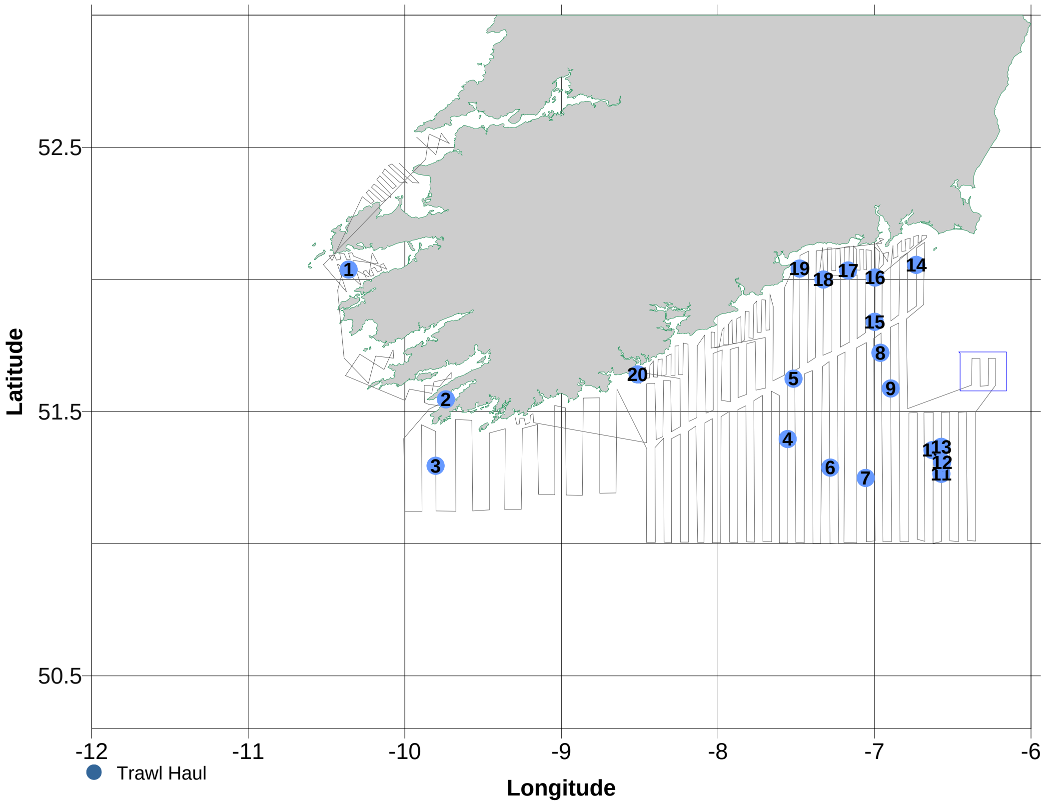


Figure 2. Haul positions. Celtic Sea herring acoustic survey, October 2012.

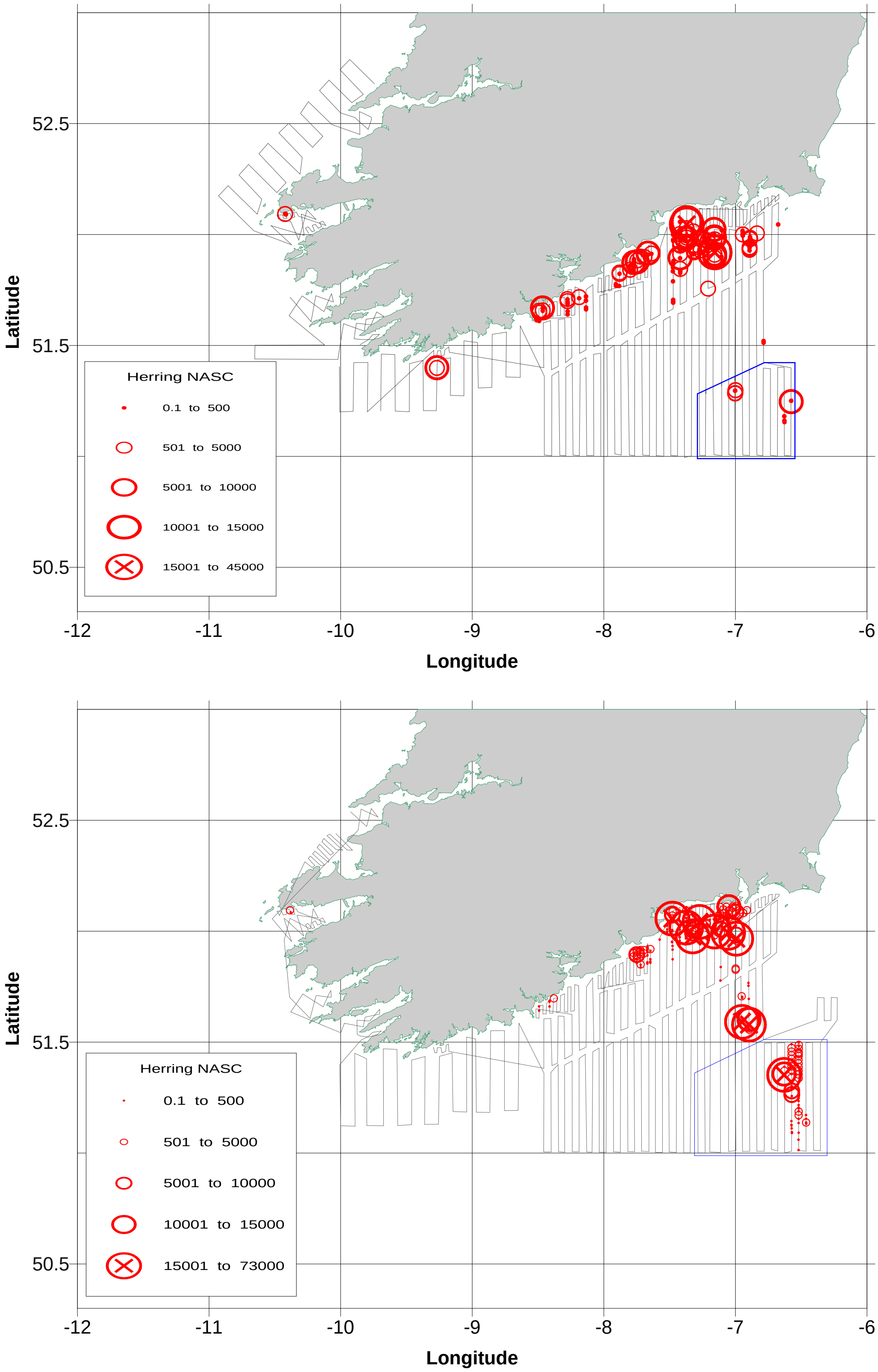


Figure 3. Weighted herring NASC (Nautical area scattering coefficient) plot showing the distribution of "definitely" and "probably" categories. Top Panel 2011, bottom panel 2012. Blue box denotes 'Smalls' area stratum.

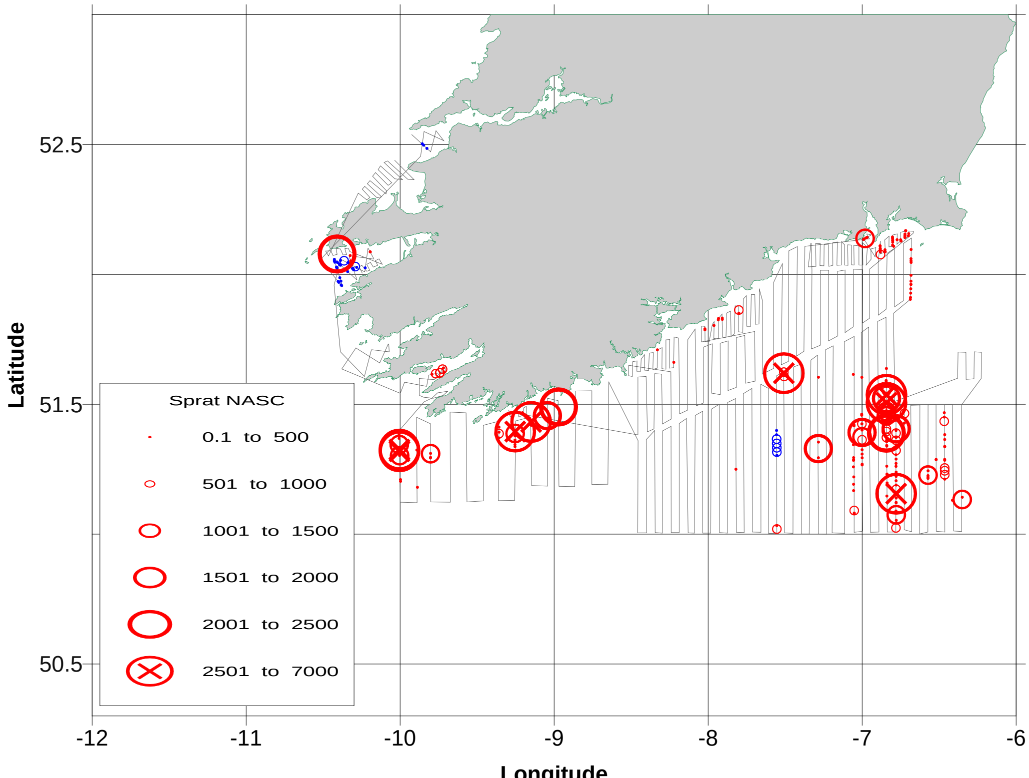


Figure 4. Weighted Sprat NASC (Nautical area scattering coefficient) distribution of “definitely” and “probably” categories (red) and “mixed” species schools (blue). Celtic Sea herring acoustic survey, October 2012.

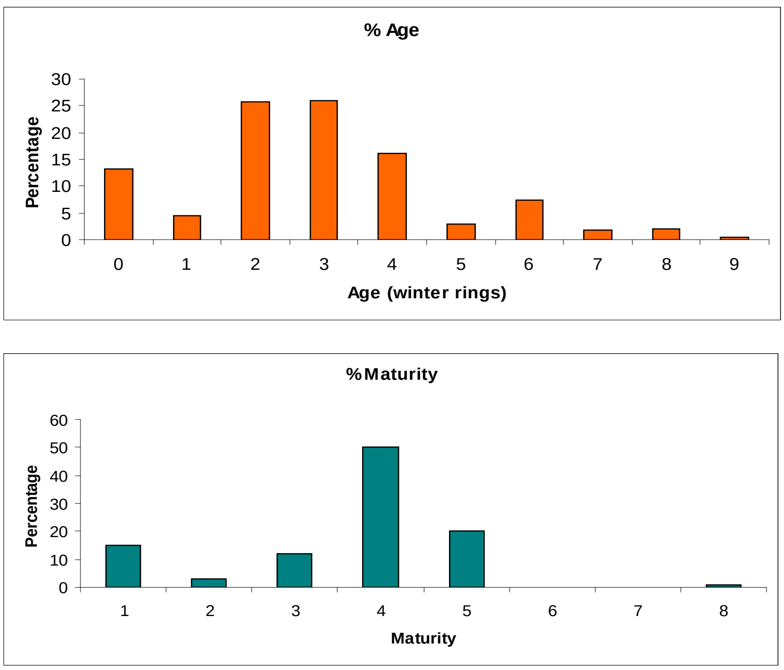
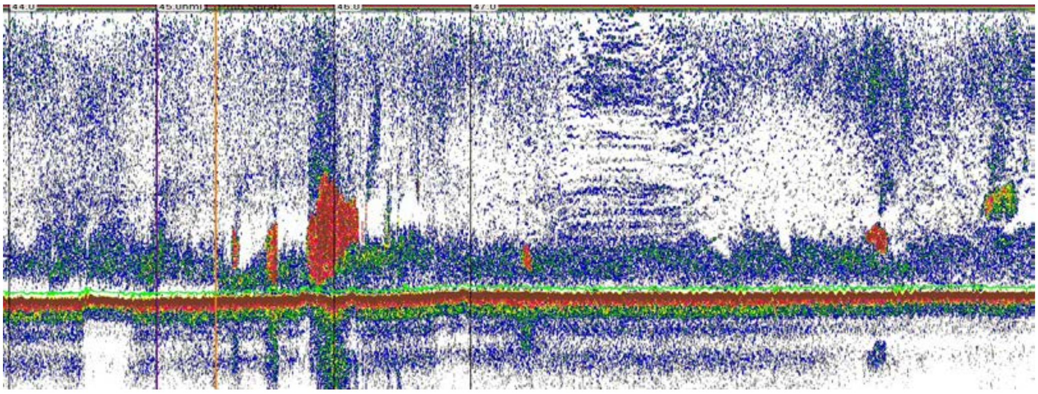
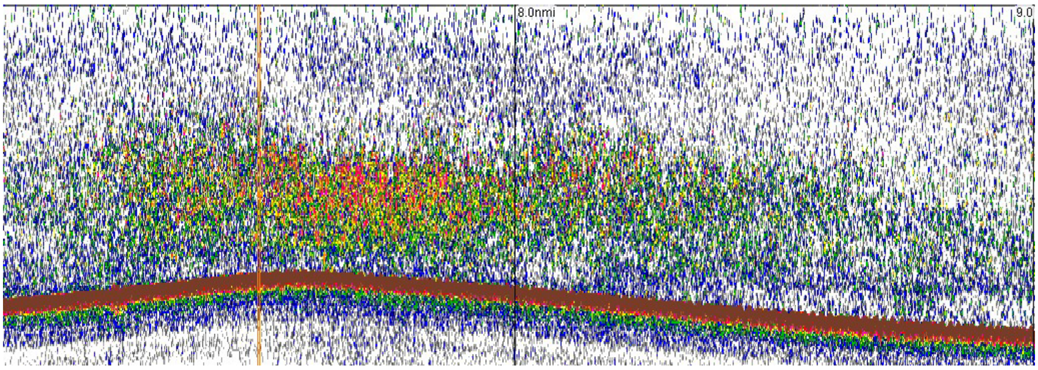


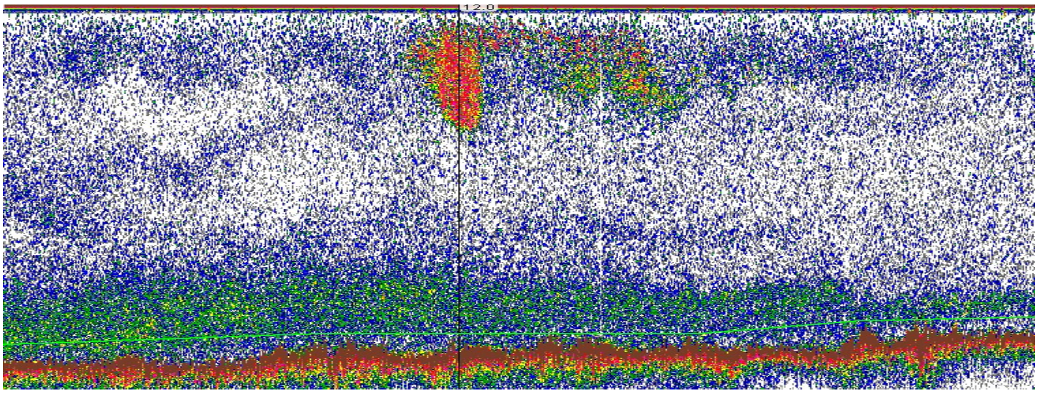
Figure 5. Percentage age and maturity of aged herring samples used in the analysis (n=577). Celtic Sea herring acoustic survey, October 2012.



a). *High density sprat echotrace recorded prior to Haul 05 observed offshore during daylight hours, water depth 76m.*

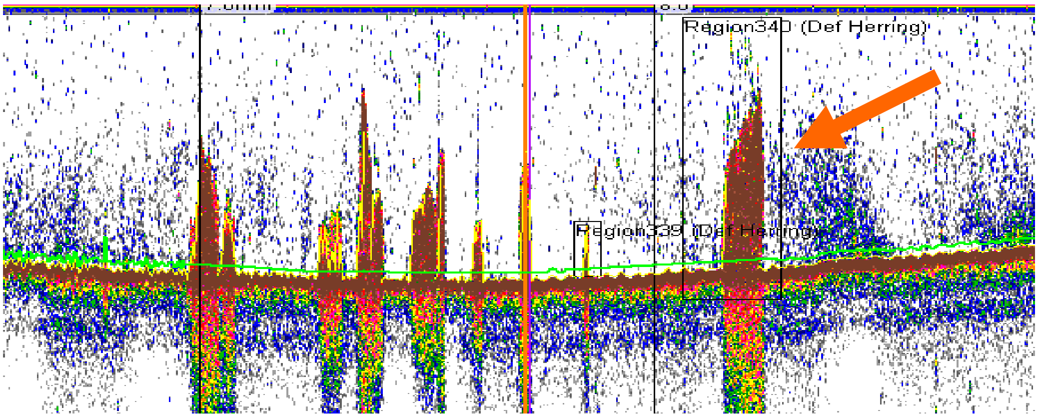


b). *High density pre-dawn surface scattering layer of sprat (97% by weight)and juvenile herring (1.3%) located in Dunmanus Bay, prior to Haul 02. Water depth 45m.*

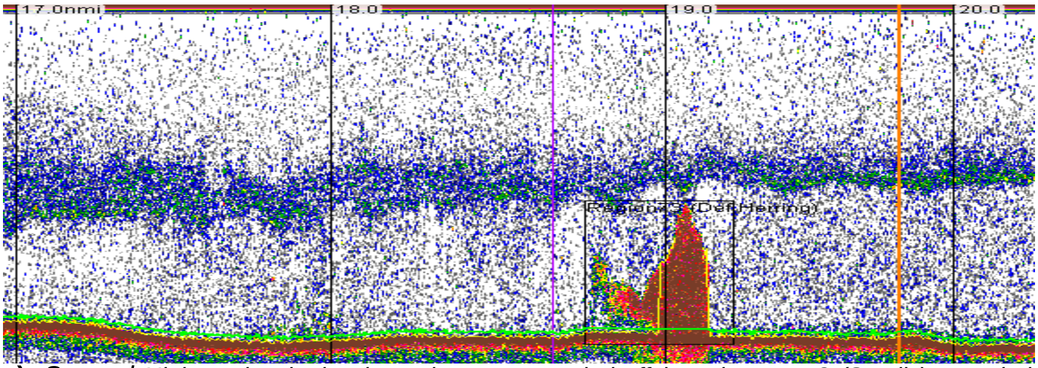


c). *High density surface sprat echotrace recorded prior to Haul 03 at night south of Mizen Head.*

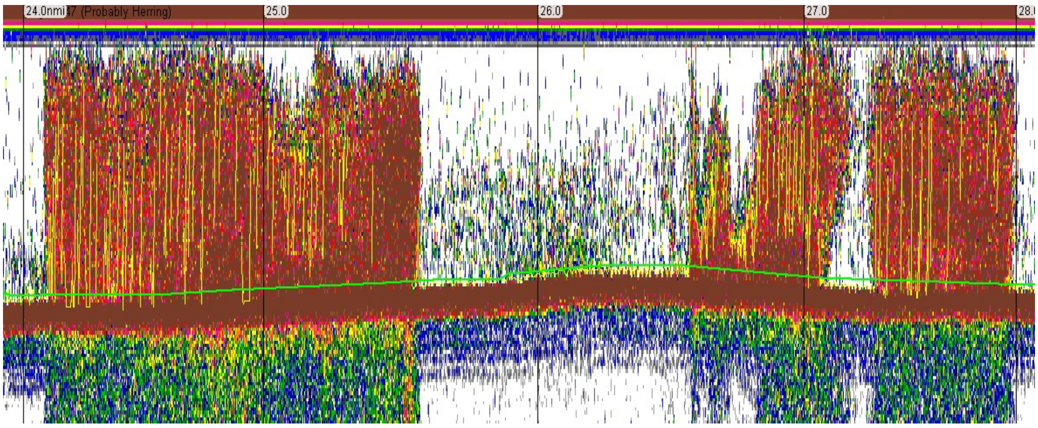
Figure 6a-f. Echograms recorded prior to trawling (EK60, 38 kHz). Celtic Sea herring acoustic survey, October 2012.



d). *Single highest density herring on-transect echotrace (orange arrow) recorded during the survey in strata 11 (Tramore).*



e). *Second Highest density herring echotrace recorded offshore in strata 8 (Smalls) recorded prior to Haul 12 on the Smalls. Water depth 80m.*



f). *Very high density inshore herring school recorded off transect within the closed area (north of 52°N) close to Helvick. This school was encountered at night close inshore. Water depth 38m. Vertical black markers represent 1nmi.*

Figure 6a-f. Continued.

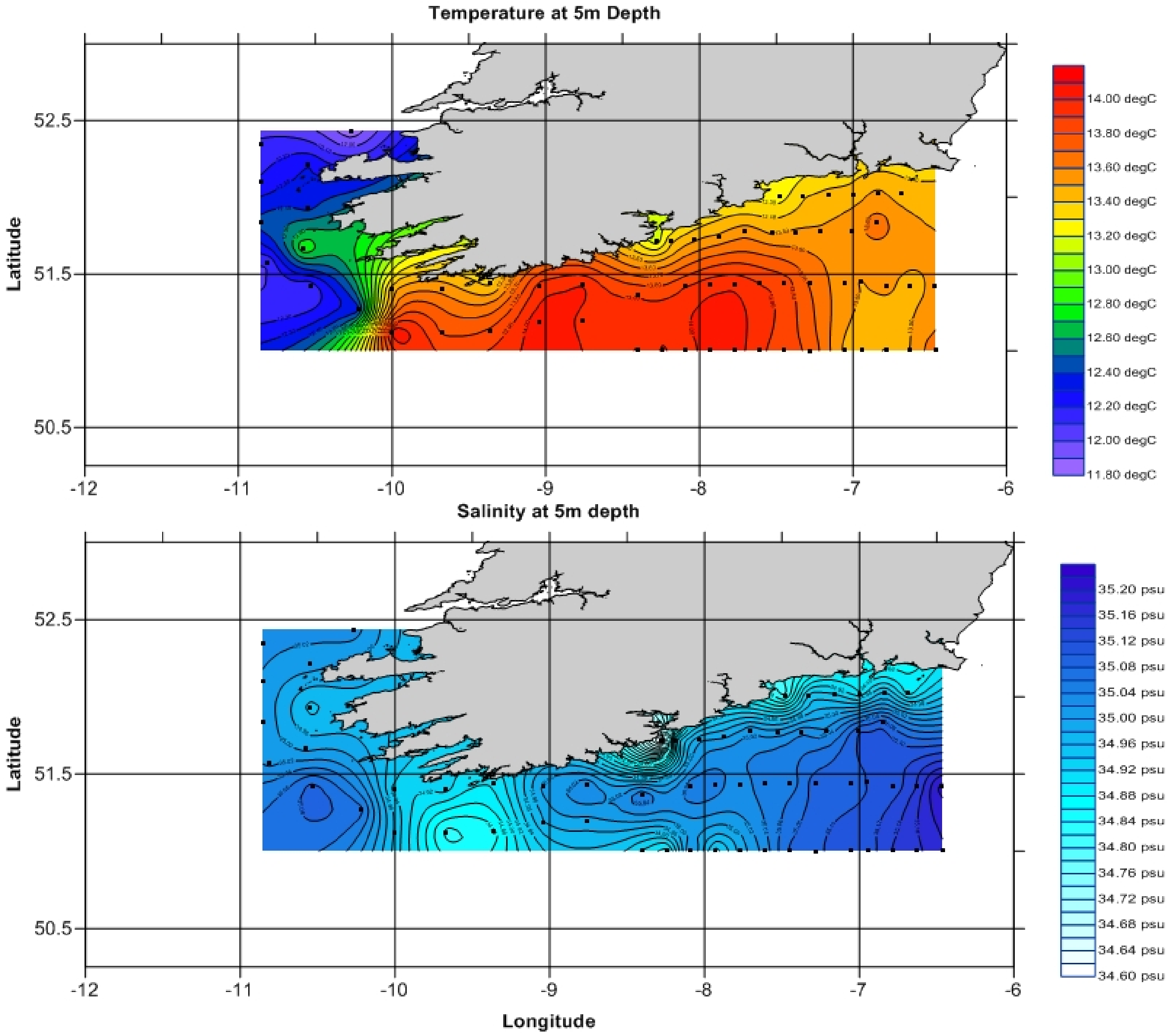


Figure 7. Surface plots of temperature (above) and salinity (below) at 5 m from combined CTD cast data. Celtic Sea herring acoustic survey, October 2012.

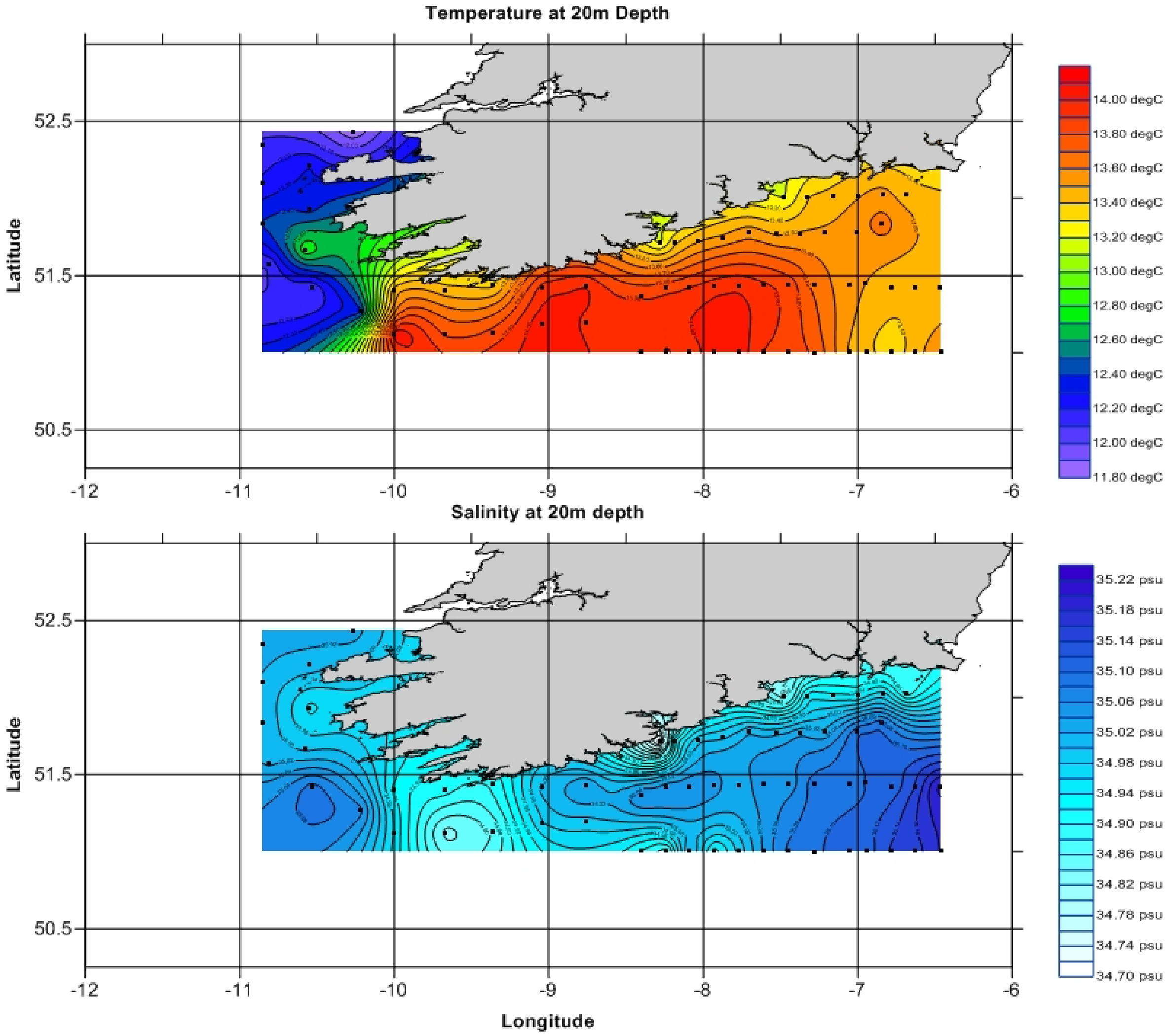


Figure 8. Surface plots of temperature (above) and salinity (below) at 20 m from combined CTD cast data. Celtic Sea herring acoustic survey, October 2012.

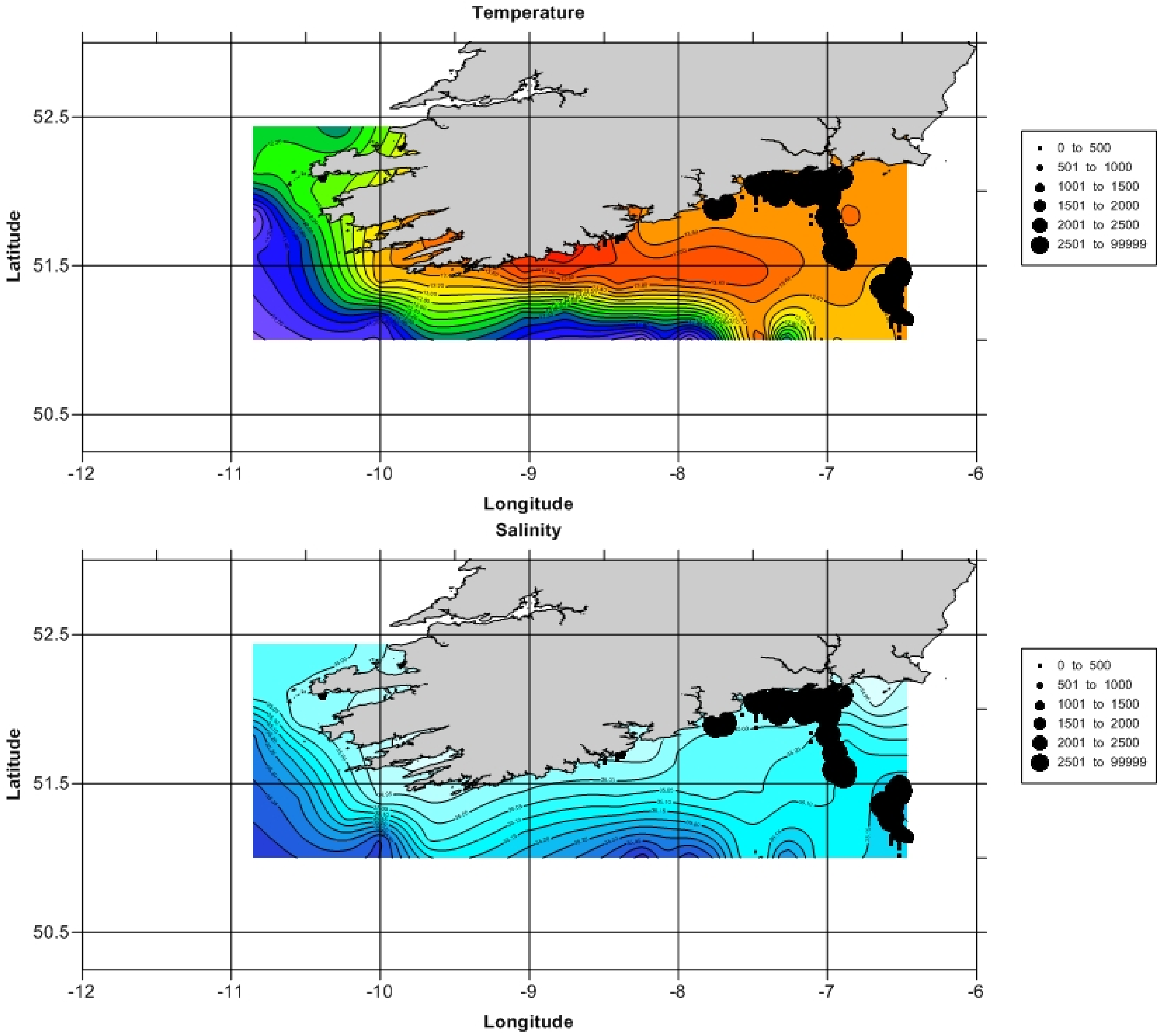


Figure 9. Habitat plots of temperature (above) and salinity (below) at 40m overlaid with herring NASC values (acoustic density) shown as black circles. Celtic Sea herring acoustic survey, October 2012.

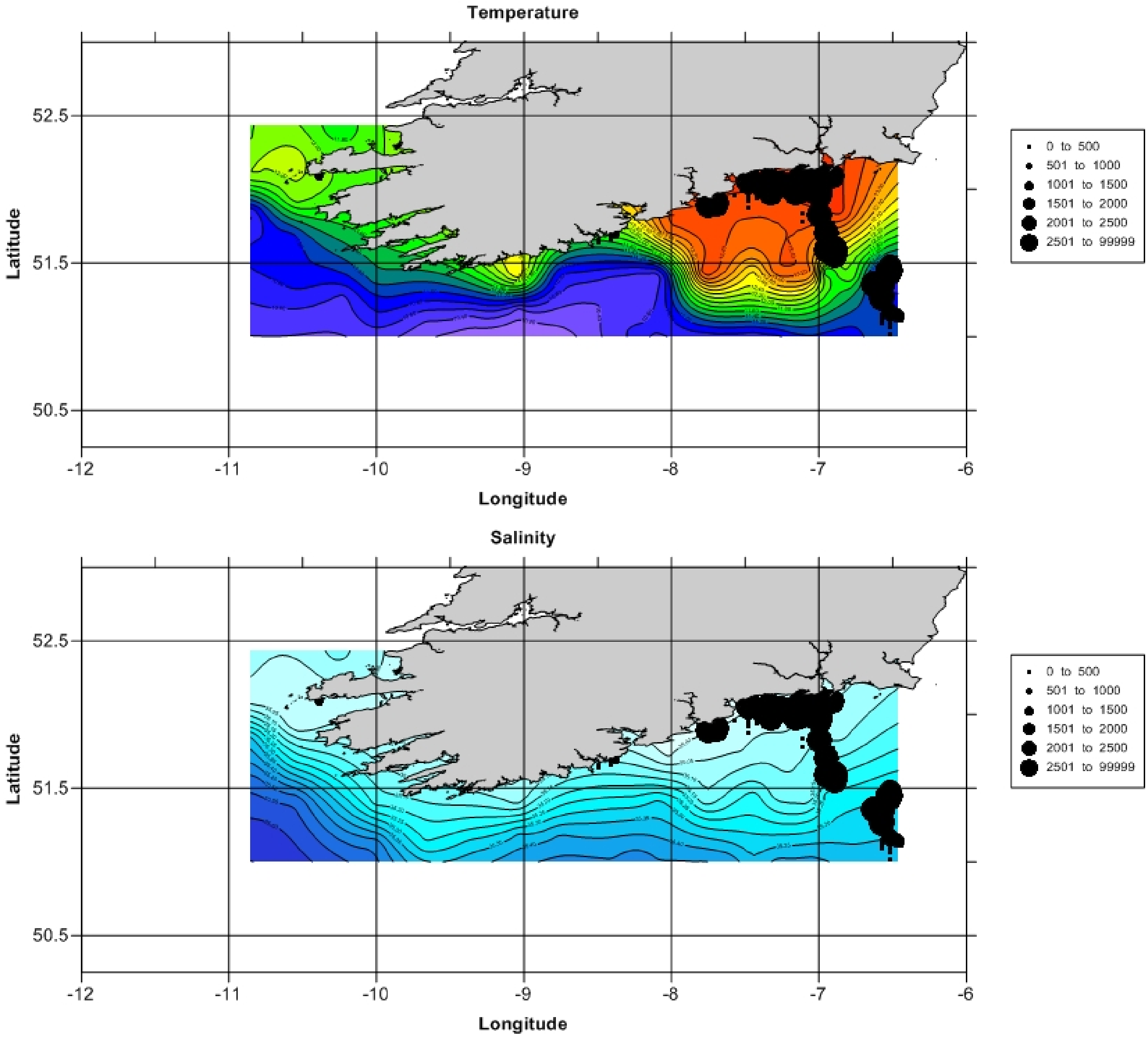


Figure 10. Habitat plots of temperature (above) and salinity (below) at 60m overlaid with herring NASC values (acoustic density) shown as black circles. Celtic Sea herring acoustic survey, October 2012.

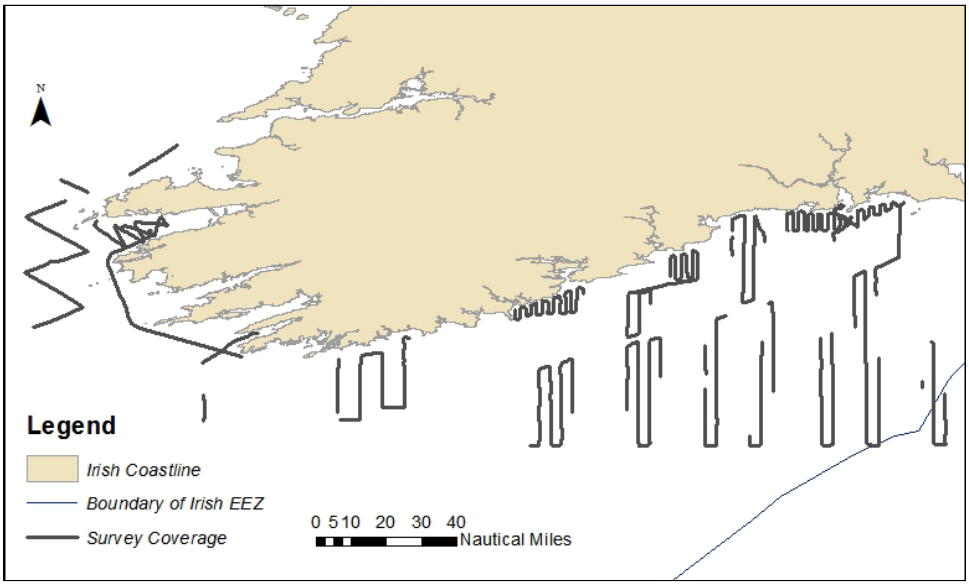


Figure 11. Seabird surveying coverage (daylight hours).

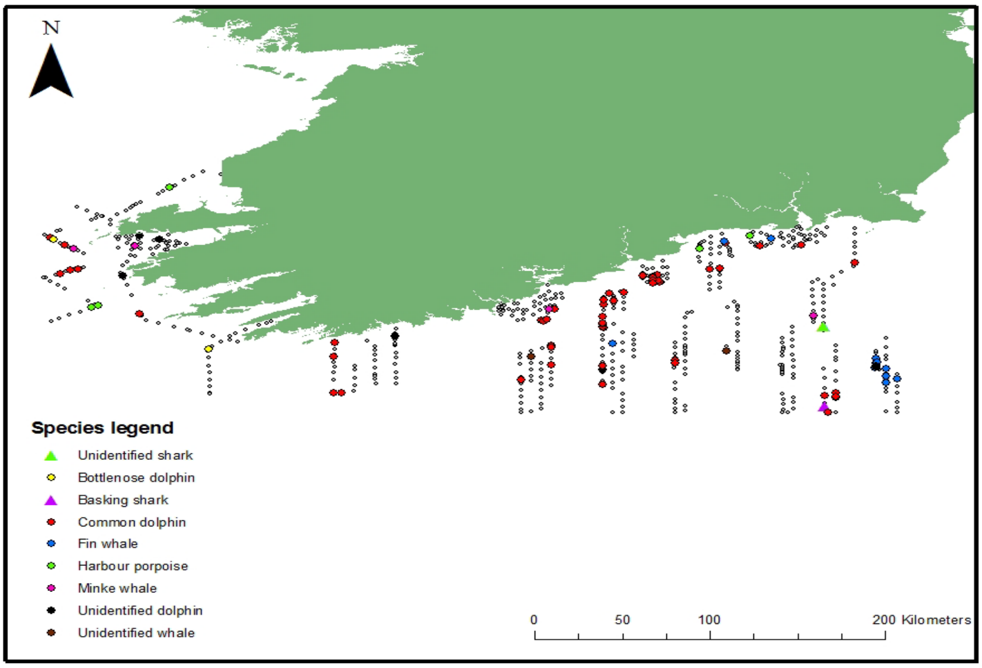


Figure 12. Distribution of cetacean and shark species recorded during the survey

HERRING MIDWATER TRAWL

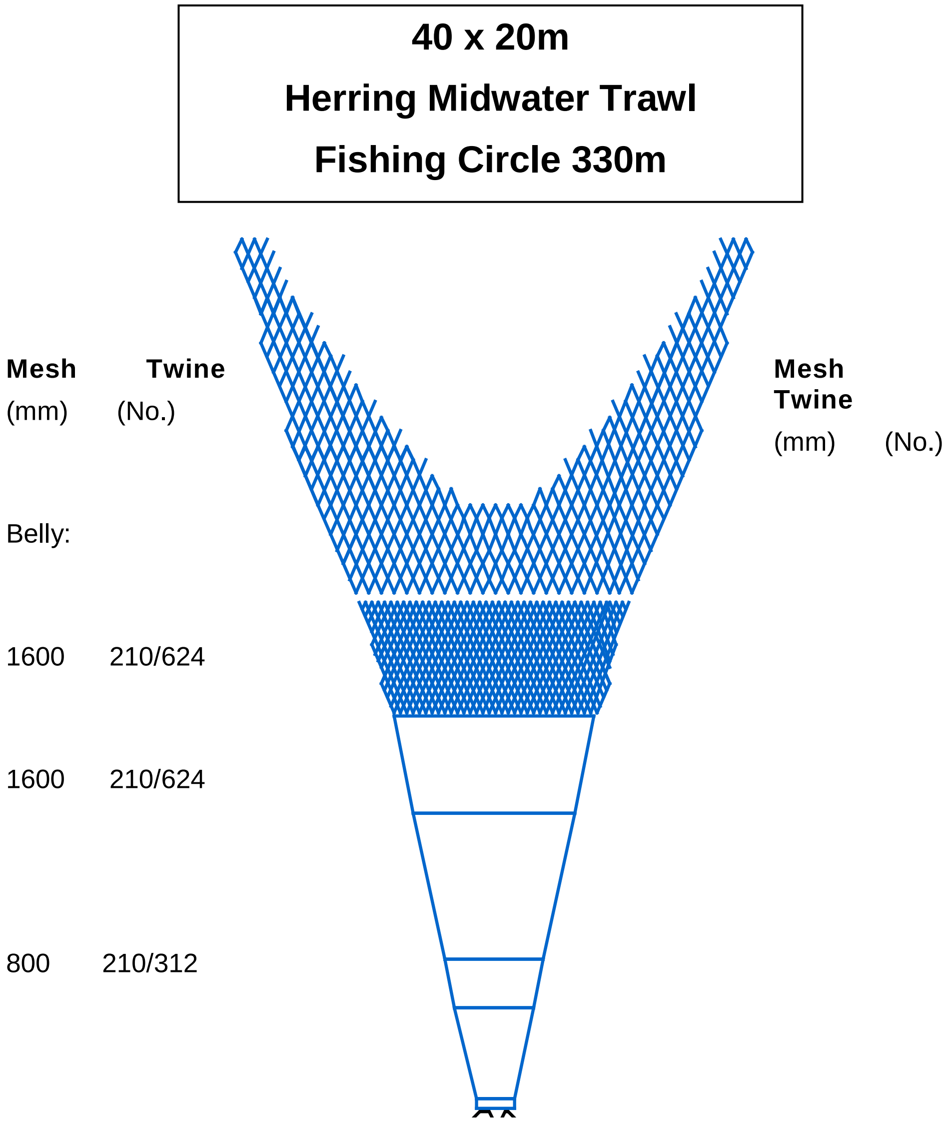


Figure 13. Single herring midwater trawl net plan and layout. Celtic Sea herring acoustic survey, October 2012.

Note: All mesh sizes given in half meshes, schematic does not show 32m brailer

Annex 6d: Boarfish survey

Annex 6d: Boarfish acoustic survey 2012

FSS Survey Series: 2012/03

Boarfish Acoustic Survey

Cruise Report

09 July – 26 July, 2012

MFV Father McKee

Ciaran O'Donnell[1], Edward Farrell[2], Cormac Nolan[1] and Andy Campbell[1]

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1 Introduction

From the early 1970s the abundance of boarfish (*Capros aper*) was seen to increase exponentially and distribution ever increasingly spread northwards along the western seaboard and Bay of Biscay (Blanchard and Vandermeirsch, 2005). At the same time, boarfish were caught in increasing quantities in both pelagic and demersal fisheries. This in turn resulted in damage to more commercially valuable target species. Exploratory fishing for boarfish by Irish vessels began in the later 1980s when commercial quantities were encountered during the spring horse mackerel (*Trachurus* trachurus) and mackerel (*Scrombrus scomber*) fishery in northern Biscay. Several landings were made into Ireland for fishmeal during this time but due to logistical problems related to handling (prominent dorsal spines) this species was not favoured by processors. Interest increased again around the mid 1990s when Dutch pelagic vessels landed frozen samples to determine if a market could be developed for human consumption.

During the early 2000s the Irish landings were relatively small (<700t per yr) and it was not until 2006 that a directed fishery developed. Fishing was undertaken primarily by vessels from the Castletownbere and Killybegs based RSW fleets (refrigerated seawater vessels) which targeted boarfish from northern Biscay to the southern Celtic Sea. In 2007-08 vessels from Scotland and Denmark also began targeting boarfish in quantity. Irish landings are primarily landed into fishmeal plants in Denmark and the Faroe Islands with increasing amounts being landed in Killybegs in recent years. The boarfish fishery bridged an important gap between the short season fisheries for horse mackerel, mackerel and blue whiting (*Micromesistius poutassou*) affectively extending the fishing season for the RSW fleet from late August through to May.

A precautionary interim management plan was adopted in November 2010 covering ICES Divisions VI, VII and VIII and an EU TAC of 33,000t was set. Of this the Irish allocation for 2011 was 22,000t. This precautionary TAC was based on 50-75% of total landings from the period 2007-2009 which peaked at over 83,400t (2009). Landings in 2010 reached over 137,000t prior to the introduction of TAC control. In addition to the TAC, seasonal closures were implemented; from September 1-October 31 ICES (area VIIg) to protect herring feeding and pre spawning aggregations and from March 15–August 31 where mackerel are frequently encountered as a large bycatch. A catch rule ceiling of 5% bycatch was also implemented within the fishery where boarfish are taken with other TAC controlled species. In 2012 the EU TAC was set at 82,000t with an Irish allocation of 56,666t.

This survey represents the second exploratory research survey for boarfish undertaken along the western seaboard of Ireland. The commercial fishing vessel the MFV *Father McKee,* an active participant in the fishery, was equipped with a calibrated scientific echosounder (Simrad EK 60) and transducer within a towed body.

Data from this survey, in addition to the extensive biological research carried out on this species forms part of a larger program aimed at increasing the knowledge of this species and its abundance outside of the commercial fishery. Data from this survey will be presented for inclusion into the ICES Planning Group meeting for North Atlantic Pelagic Ecosystem Surveys in December 2012 (WGIPS) and for the ICES assessment Working Group for Widely Distributed Stocks (WGWIDE) meeting in August 2012.

2 Materials and Methods

2.1 Scientific Personnel

Organisation	Name	Capacity
FEAS	Ciaran O'Donnell	Acoustics (SIC)
KFO	Edward Farrell	Biologist
FEAS	Turloch Smith	Biologist
Contractor	Nigel Griffen	Fisheries Obs

2.2 Survey Plan

2.2.1 Survey objectives

The primary survey objectives of the survey are listed below:

- Collect integrated and calibrated acoustic data on boarfish (*Capros aper*) aggregations within the pre-determined survey area
- Determine the biomass and abundance of boarfish within the survey area
- Collect biological samples from directed trawling on insonified echotraces to determine age structure and maturity state of survey stock as well as to identify echotrace to species.
- Determine the extent and behaviour of boarfish aggregations within the survey area to aid the design of future surveys
- Dovetail with the RV Celtic Explorer in the northern area to ensure close spatio-temporal alignment and increase effective area coverage

2.2.2 Area of operation and survey design

The survey started in the Porcupine Bank area before moving to survey the shelf area between 53°'30N and 47°'30N from north to south following a pre-determined cruise plan (Figure 1). Area coverage was based on the distribution of catches from the IBTS survey time series, catch data and from the previous survey (O'Donnell *et al* 2011).Timing was planned to coincide with the arrival of the RV *Celtic Explorer* in the northern survey area to ensure a continuous, quasi-synoptic, coverage of the combined area.

In total 3,921nmi (nautical miles) of cruise track was undertaken by both vessels over 61 transects relating to a total area coverage of 51,555nmi^2. Transect spacing was set at 15nmi for the *Father McKee* and 7.5nmi for the *Explorer* component. For the area covered by the *Explorer* only strata bordering the shelf edge were considered during the analysis.

Coverage extended in coastal areas from the c.50m contour to the shelf slope (250m). An elementary distance sampling unit (EDSU) of 1nmi was used during the analysis of combined survey data.

The survey was carried out from 04:00–00:00 each day in line with the *Explorer* to coincide with the hours of daylight when boarfish are most often observed in homogenous schools. During the hours of darkness boarfish schools tend to disperse into mixed species scattering layers.

2.3 Sampling protocols and equipment specifications

2.3.1 Acoustic equipment

Equipment settings were determined before the start of the survey and are based on established settings employed on previous surveys (O'Donnell *et al.,* 2004 & 2011).

Acoustic data were collected using a Simrad EK 60 scientific echosounder topside unit. A Simrad ES-38B (38 KHz) split-beam transducer was mounted within a towbody frame and deployed on the port side via a towing boom to a working depth of 3-3.5m (Appendix 1).

Cruising speed was largely determined by the weather and the affects on the quality of acoustic data. Where possible cruising speed was maintained at 10kts.

2.3.2 Calibration of acoustic equipment

The EK 60 was calibrated in Killybegs Harbour on 08 July prior to the start of the survey. The calibration was carried out using standard methodology as described by Foote *et al.* (1987) Results of the calibration are presented in Table 1. The calibration was successful and results were in line with those of previous calibrations.

2.3.4 Acoustic data acquisition

Acoustic data were recorded onto the hard-drive of the processing unit. The "RAW files" were logged via a continuous Ethernet connection as "EK5" files to laptop and a HDD hard drive as a backup. Sonar Data's Myriax Echoview® Live viewer (Version 5.0) was used to display the echogram during data collection to allow the scientists to scroll through echograms noting the locations and depths of target schools to a log file. A member of the scientific crew monitored the equipment continually. Time and location were recorded for each transect start/end position within each stratum. This log was also used to monitor "off track events" such as fishing operations.

2.3.5 Echogram scrutinisation

Acoustic data was backed up every 24 hrs and scrutinised using Sonar data's Echoview® (V 5.0) post processing software. The scrutiny process involved the allocation of echotraces (schools) to particular species or species mix categories, based on the information from the directed trawl hauls.

The NASC (Nautical Area Scattering Coefficient) values from each boarfish echotrace were allocated to one of 4 categories after scrutiny of the echograms. Categories identified on the basis of echotrace scrutiny were as follows:

1. "Definitely boarfish" echotraces were identified on the basis of captures of boarfish from the fishing trawls which were sampled directly. Based on the directly sampled schools we also characterised echotrace as definitely boarfish which appeared very similar on the echogram i.e. , large marks which showed as very high intensity (red), located high in the water column (day) and as strong circular schools.

2. "Probably boarfish" were attributed to smaller echotraces that had not been fished but which had similar characteristics to "definite" boarfish traces.

3. "Boarfish in a mixture" were attributed to NASC values arising from all fish traces in which boarfish were contained, based on the presence of a proportion of boarfish in the catch or within the nearest trawl haul. Boarfish were often taken during trawling in mixed species layers during the hours of darkness.

4. "Possibly boarfish" were attributed to small echotraces outside areas where fishing was carried out, but which had the characteristics of definite boarfish traces.

This set of categories allowed us to present the biomass estimates in terms of the best estimate (Cats 1-3), the minimum estimate Cat 1 + 3), and the maximum estimate (Cats 1-4).

Echograms were divided into transects and off track events, including trawl hauls and hydrographic stations were excluded. Echo integration was performed on regions which were defined by enclosing selected parts of the echogram that corresponded to one of the four categories above. The echograms were generally analysed and echo-integrals calculated, at a threshold of -70 dB, where necessary heavy backscatter from plankton was filtered out by thresholding at –65 dB.

2.3.6 Biological sampling

A single pelagic midwater trawl with the dimensions of 398m in total length with a 72m brailer was used during the survey. The horizontal net spread was averaged 120m from wing to wing. Mesh size in the wings was 12.8m through to 2cm in the cod-end liner. The net was fished with a vertical mouth opening averaging 50m, which was observed using a cable linked Simrad FS 70 net sonar (200 kHz). The net was fitted with Marport catch and tunnel sensors to monitor the amount catch entering the trawl.

All components of the catch were sorted to species and weight by species. For species other than boarfish, length and weight measurements were taken for 100 individuals per trawl in addition to a 300 fish length frequency sample. Length, weight, sex and maturity data were recorded for individual boarfish in a random 50 fish sample from each trawl haul. In addition a further 100 length/weight and 300 fish length frequency measurements were taken from each haul. Due to the complexity of aging boarfish, no aging was carried out onboard and samples were analysed back in the lab. The appropriate raising factors were calculated and applied to provide length frequency compositions for the bulk of each haul.

The decision to fish on particular echotraces was based on both the distance from other fishing operations on similar schools, and on the difference between recently observed echotraces and others previously sampled.

2.4 Analysis methods

2.4.1 Abundance estimates

The recordings of area back scattering strength (NASC) per nautical mile were averaged over a one nautical mile EDSU (Elementary sampling distance unit), and the allocation of NASC values to boarfish and other acoustic targets was based on the composition of the trawl catches and the appearance of the echotraces.

To estimate the abundance, the allocated NASC values were averaged for ICES statistical rectangles (1° latitude by 2° longitude). For each statistical area, the unit area density of fish (S_A) in number per square nautical mile ($N{*}nmi^{-2}$) was calculated using standard equations (Foote et al. 1987, Toresen *et al*. 1998).

NASC values assigned according to scrutinisation methods (section 2.3.5) were used to estimate the boarfish numbers according to the method of Dalen and Nakken (1983).

The following TS-length relationships used were those recommended by the acoustic survey planning group (ICES, 1994):

Herring	TS =	$20\log_{10}L$ – 71.2 dB per individual (L = length in cm)
Sprat	TS =	$20\log_{10}L$ – 71.2 dB per individual (L = length in cm)
Mackerel	TS =	$20\log_{10}L$ – 84.9 dB per individual (L = length in cm)
Horse mackerel	TS =	$20\log_{10}L$ – 67.5 dB per individual (L = length in cm)

The TS length relationship used for gadoids was a general physoclist relationship (Foote, 1987):

Gadoids	TS =	$20\log_{10}L$ – 67.4 dB per individual (L = length in cm)

For boarfish (*Capros aper*) a species specific TS length relationship was applied based on theoretical swimbladder modelling from as yet unpublished data (Fassler *et al.* in review).

Boarfish TS = $20\log_{10}L - 65.98$ dB per individual (L = length in cm)

To estimate the total abundance of fish, the unit area abundance for each statistical rectangle was multiplied by the number of square nautical miles in each statistical square and then summed for all statistical rectangles for the total area. Biomass estimation was calculated by multiplying abundance in numbers by the average weight of the fish in each statistical rectangle and then sum of all squares by rectangle and summed for the total area.

3 Results

3.1 Boarfish abundance and distribution

The results presented here are a composite of data collected during this survey and on the northwest herring survey (RV *Celtic Explorer*). Surveys were timed to ensure a continuous, quasi-synoptic, coverage of the combined area over 33 days from north (59°N) to south (47°30'N). Both surveys used calibrated echosounders but no inter-vessel acoustic or fishing intercalibration exercises were carried out due to time restraints.

Thirty six hauls (*Father McKee:* 29; *Explorer*: 7) were carried out during the survey 26 of which contained boarfish (Figure 1, Table 2). In total, 5,952 lengths and 1,997 length/weight measurements were taken in addition to 897 individual boarfish otiliths collected for aging.

3.1.2 Boarfish biomass and abundance

A full breakdown of the surveyed stock structure is presented by strata, age, length, biomass, abundance and area in Tables 4, 5 & 6 and Figures 3 & 4.

Boarfish	Millions	Biomass (t)	% contribution
Total estimate			
Definitely	11,106	673,047	82.0
Probably	1,969	117,612	14.3
Mixture	479	30,276	3.7
Total estimate	**13,554**	**820,935**	**100**
Possibly	15	967	
SSB Estimate			
Definelty	11,041	671,680	82.0
Probably	1,949	117,197	14.3
Mixture	478	30,249	3.7
SSB estimate	**13,468**	**819,126**	**100**
Possibly	15	967	

Biomass derived using a modelled boarfish TS-Length relationship (-65.98dB).

3.1.3 Boarfish distribution

A total of 1,168 boarfish schools were identified during the survey. Of this 82 % were categorised as 'definitely' boarfish, 14% as 'probably', 4% 'boarfish in a mixture' and 0.6% as 'possibly'. A full breakdown of school categorisation, abundance and biomass by ICES statistical rectangle is provided in Table 9.

In the northernmost area and Porcupine Bank boarfish were observed in small low density clusters (Figure 2 & Figure 5a,b). Three percent of the total number of schools observed were found within the 16 strata covered. In total, the northern area contained 1.2% to the TSB and 1.1% of TSN. Although important in terms of western and northern stock containment these areas would not be considered core spawning areas for boarfish.

Two areas of high core abundance were noted during the survey. The Western area; along the west coast of Ireland (52°-54°N) contained over 47% of the total number of schools detected within 20 strata. This area was characterised by large number of high density monospecific schools and numerous smaller high density schools (Figure 5c). This area contained the 2 highest biomass strata of the survey (Figure 2 & Table 9). Boarfish in this area were predominantly distributed in water depths between 70-140m and schools were often located higher in the water column (c.40m from surface) than in areas further south (Figure 5e). In total the Western area contributed 42.3% to the TSB and 41.8% to the TSN.

Moving south into the Celtic Sea, the second highest density core area was located between 49°'30N and 47° 30'N (Southern area). This area covered the largest area (26 strata) and also contained numerous high density monospecific schools representing 50% of the total observed. The main area was centred on the shelf edge and contained the third and fifth largest contributing strata respectively. As well as a high concentration of fish along the shelf edge spawning schools were also located on shelf to the east in a bathymetrically complex area characterised by Banks and canyons. The Banks complex which characterises this region would be regarded as an important over-wintering and nursery habitat for boarfish. In total the Southern area contributed 56.5% to the TSB and 57.2% to the TSN.

Within the Southern area a sub area of high distribution was defined between 50°-51°N around an area associated with the commercial fishery and known locally as the redfish Bank (Figure 5d). The distribution of schools in this area was more centred on a Bank complex which is the main bathymetric feature in the area and not so much on the shelf edge as in the western or southern core areas. Schools in this area were made up of a mixture of numerous high and medium density schools. The fourth largest contributing stratum was located around the redfish Bank contrasting to the much lower abundance observed in this area in 2011 (Figure 5d, Table 9).

July is the peak of the spawning period as determined from histological analysis of catch samples. It can be inferred from distribution observed during the survey that movements to the shelf edge are part of an annual spawning pattern. Immature fish do not appear to undertake the movement to the shelf edge in great number and stay on shelf year round until maturity. During the survey all mature individuals were observed to be spawning i.e. in either a ripe or running state.

3.1.4 Boarfish stock structure

An age length key compiled primarily from commercial samples collected during 2011/2012 fishery was applied during the analysis of survey data. This ALK was used in place of a survey derived ALK due to the unavailability of aged samples during the analysis. The ALK is considered comprehensive covering a wide range of lengths (2.5-18cm) including those encountered during this survey (7.5-18cm).

Age distribution as determined from survey samples indicate that the stock is dominated by the following age classes in terms of abundance: 20+, 12, 10 and 9 &13 year old fish and 20+, 12, 16 and 10 years in terms of biomass respectively (Figure 3, Table 5 & 6).

Very few immature (< 9.7 cm TL) boarfish were observed during the survey (0.2% of TSB and 0.6% of TSN). Immature fish were primarily located on shelf on the Banks complex south of 51°N (Table 7 & 8, Figures 2 & 4). Survey data did not indicate the presence of aggregations of juveniles or potential hotspots of juvenile distribution.

3.2 Other pelagics

3.2.1 Herring

Few herring (*Clupea* harengus) echotraces were observed during the survey and only one trawl sample yielded herring (Table 2, Figure 5f). No biomass or abundance calculation was made for this species.

A total of 276 herring were measured and 100 length and weights were recorded. The modal length of herring was 26.5cm (range 21-30.5cm) and mean weight was 177g.

3.2.2 Horse mackerel

Horse mackerel (*Trachurus trachurus*) were encountered in 41% of survey hauls and were most frequently encountered in deeper waters (>80m) and often occurred in catches with boarfish (Table 2). No biomass or abundance calculation was made for this species.

A total of 817 horse mackerel were measured and 494 length and weights were recorded. The modal length of horse mackerel was 28cm (range 20-38cm) and mean weight was 222g.

Horse mackerel were widely distributed throughout the survey area from the Porcupine Bank to the southern Celtic Sea occurring mainly as medium density schools spaced over a wide area. In 2011, in the southern area horse mackerel were found mixed with boarfish in high density bottom layers over a wide area. It was not possible to accurately determine horse mackerel from boarfish in these layers by acoustic means alone as both species have a very similar TS range. Furthermore it was not always possible to trawl due to poor ground in this bathymetrically complex area. This year horse mackerel and boarfish layers were more easily discerned as separate layers as the latter tended to be further off the bottom and separate from the more demersally orientated horse mackerel.

Cursory analysis of stomach contents would suggest that horse mackerel were feeding on recently spawned boarfish eggs. This would in part explain the presence of horse mackerel in and around boarfish spawning aggregations.

3.2.3 Blue whiting

Blue whiting (*Mircomesistius poutassou*) were encountered in 35% of trawls (Table 2). No calculation of biomass was determined from survey data at this time.

A total of 992 blue whiting were measured and 877 length and weights were recorded. The modal lengths of mackerel occurred at 13cm and 19cm (range 11-26cm) and mean weight was 27g.

Blue whiting were found widely distributed along the shelf edge. Large high density schools of mature fish were observed along the offshore inter-transects south of 51°N but were not actively targeted by trawling during the survey (Figure 5h). In addition numerous high density on shelf schools of 1-group immature fish were observed from 53°N southwards with the high concentration south of 51°N and were trawl sampled for verification purposes (Figure 5g). The presence of numerous high density schools of immature blue whiting is a positive signal for the stock, which appears to be emerging from a prolonged period of poor recruitment (O'Donnell *et al*. 2012).

4 Discussion and conclusions

4.1 Discussion

Overall, the survey can be considered as having been a success with all components of the work program completed as planned with no downtime. The cruise track was adapted to account for real time observations. Easterly extension in the mid and southern Celtic Sea was reduced where required and effort was reallocated further south along the shelf edge, where the likelihood of encountering boarfish was greatest.

The geographical distribution of boarfish across surveys shows a similar pattern for the same level of survey effort with the 2 highest abundance areas dominating between years (southern and western areas). The total number of schools detected in 2012 was 17% higher than in 2011, whereas school allocation to the def category remained comparable with 80% (+/-1%) in both years. Allocation of schools to the def category was aided by comprehensive trawl coverage throughout the survey

The main difference between years related to school size (NASC value) with 3 individual schools observed this year of higher NASC value than the largest school recorded in 2011. The largest of which was over 52% greater than the maximum recorded in 2011. The increased number and size of schools observed in 2012 is reflected by the 47% increase in biomass between years.

The increase in detection of schools maybe accounted for primarily by the change in survey methodology to survey only during daylight hours which has no doubt played a large part in increasing positive detection of monospecific boarfish schools. The daytime behaviour of boarfish in relation to proximity to the seabed showed differences between years and this will have also species allocation and therefore abundance. In 2011 boarfish schools along the shelf break in the southern region (48°-49°'30N) were located close to/on the bottom and often mixed with horse mackerel in high density homogeneous layers. This area is a known hot spot for horse mackerel in the commercial fishery. In these high abundance areas trawling close to the bottom was not always possible due to the complex bathymetry and possibility of gear damage. In such instances this would have left a portion of the stock unaccounted for. In 2012 boarfish schools in this area were observed to occupy a position slightly off the bottom, allowing for effective trawl sampling and accurate categorisation.

Boarfish behaviour in terms of school positioning in the water column showed geographical differences from north to south. In the western area boarfish schools were exclusively located on shelf and were observed higher in the water column. In the southern area schools located on the shelf edge were closer to the seabed when in comparable water depths. As boarfish are spawning during the survey this behaviour maybe a spawning strategy related to ambient hydrographic conditions encountered for exposed sites on the shelf edge.

Size structure of boarfish within trawl catches showed a trend towards larger fish further north and a broader length range further south possibly due to coverage of nursery habitat. This size trend is consistent with previous observations from 2011 and with commercial catch data.

The stock was considered to be sufficiently well contained within the survey area. Reports from the PELGAS acoustic survey in the Bay of Biscay (mid May to mid June) reported only blue whiting and mackerel echotraces north of 47°N (Pierre Pettitgas *pers comm.*). However, this survey does not routinely report boarfish abundance. Geographical overlap was therefore achieved but with a temporal gap of over one month. Hydrographic conditions as reported by the PELGAS survey indicate that the water column was poorly stratified and that phytoplankton and zooplankton biomass was low. No CEFAS acoustic survey in the Celtic Sea this year.

4.2 Conclusions

Acoustically derived estimates of abundance are used as a relative index of abundance of the stock present within the survey area at the time of surveying. The survey therefore acts as a 'snapshot' of the stock and should not be considered as a measure of absolute stock abundance. The use of an abundance index allows for the percentage change between successive estimates to be tracked over time to reveal trends in stock abundance as the time series develops.

The 2011 pilot survey was used to determine a baseline from which to base future surveys. Geographical coverage can now be considered as established in all but the southern boundary. Southern containment of the stock is a potential weak spot and continued coverage is a requirement. As the French survey (PELGAS mid May-mid June) does not routinely report boarfish distribution it is not possible to determine the southern extent of the survey boundary prior to actual surveying and as a result it is difficult to plan the survey temporally without this information.

In 2012 the survey methodology was further refined by switching to daylight surveying. The switch to daylight surveying has no doubt led to an increase in school detection more so than could be attributed to year effects alone. The daylight sampling protocol has increased the precision of the survey estimate and should be maintained in the future.

Comprehensive trawl coverage, as in the previous survey, allowed for positive identification of boarfish schools which increased the precision of the stock estimate. The increase in the number of schools observed in 2012 resulted in a lower abundance CV of 10.6% as compared to 17.6% in 2011.

The daytime behaviour of boarfish in relation to proximity to the seabed should also be considered here as it is a trait that may affect the precision of future estimates due to limitations on effective sampling (species composition). This behaviour is most pronounced in the southern region which also contains the largest proportion of the stock. As boarfish and horse mackerel are very similar acoustically this compounds problems associated with determining species composition of mixed species scattering layers without the means of trawl sampling.

4.3 Recommendations

The following recommendations are based on observations made during the survey and are provided as a means of improving the precision of future surveys.

- Daylight sampling protocol (04:00-23:00) should be continued to allow for the most effective detection of boarfish. Crepuscular changes in behaviour are rapid and during the hours of darkness detection cannot be accurately determined. Optimum conditions would allow for surveying to stop at first onset of dawn/dusk. However, the practicalities of this would not allow for effective geographical coverage in the time available.
- Focus on core spawning areas. With 2 surveys now in place core abundance areas are now more easily recognised. Increased transect resolution is recommended to more accurately determine abundance in these core areas. To accommodate this in terms of survey effort coverage in peripheral areas such as the Porcupine Bank could be dropped/reduced.
- The timing of the survey should continue to be aligned with the northwest herring survey to extend the area coverage in the northern area and ensure northern containment of the stock.
- Southern containment of the stock needs to be further investigated to increase the precision of future estimates in terms of stock containment.

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Table 1. Survey settings and calibration report (38kHz) for the tow body system (Simrad ER60 echosounder).

Echo Sounder System Calibration

Vessel : F/V Father McKee		Date : 8/7/2012	
Echo sounder : EK60 Tow Body		Locality : Killybegs	
Type of Sphere : CU 64	TS_{Sphere}: -33.50 dB (Corrected for soundvelocity or t,S)	Depth(Sea floor) : 16 m	

Calibration Version 2.1.0.12

Comments:
Killybegs 08.07.12. Good conditions

Reference Target:

TS	-33.50 dB	Min. Distance	8.0m
TS Deviation	5 dB	Max. Distance	11.5m

Transducer: ES38B Serial No.

Frequency	38000 Hz	Beamtype	Split
Gain	26.50 dB	Two Way Beam Angle	-20.6 dB
Athw. Angle Sens.	21.90	Along. Angle Sens.	21.90
Athw. Beam Angle	7.10 deg	Along. Beam Angle	6.99 deg
Athw. Offset Angle	-0.07 deg	Along. Offset Angl	-0.15 deg
SaCorrection	-0.62 dB	Depth	3.00 m

Transceiver: GPT 38 kHz 009072033933 1 ES38B

Pulse Duration	1.024 ms	Sample Interval	0.190 m
Power	2000 W	Receiver Bandwidth	2.43 kHz

Sounder Type:
ER60 Version 2.2.1

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.	9.3 dB/km	Sound Velocity	1503.6 m/s

Beam Model results:

Transducer Gain =	24.97 dB	SaCorrection =	-0.61 dB
Athw. Beam Angle =	7.42 deg	Along. Beam Angle =	7.27 deg
Athw. Offset Angle =	0.28 deg	Along. Offset Angle=	0.03 deg

Data deviation from beam model:
RMS = 0.21 dB
Max = 0.63 dB No. = 345 Athw. = -1.0 deg Along = 0.3 deg
Min = -0.99 dB No. = 61 Athw. = -2.2 deg Along = 2.2 deg

Data deviation from polynomial model:
RMS = 0.18 dB
Max = 0.76 dB No. = 345 Athw. = -1.5 deg Along = 0.3 deg
Min = -0.98 dB No. = 61 Athw. = 2.2 deg Along = -2.2 deg

Comments :
Flat calm conditions
Wind Force : 5 kn. **Wind Direction :** NE (45 degrees)
Raw Data File: C:\Program files\Simrad\Scientific\EK60\Data\Calibration 08.07.12
Calibration File: C:\Program files\Simrad\Scientific\EK60\Data\Calibration 08.07.12

Calibration : Ciaran O'Donnell

Table 2. Catch composition and position of hauls undertaken by the MFV *Father McKee* and for the Celtic Explorer.

Father McKee

No.	Date	Lat. N	Lon. W	Time	Bottom (m)	Target btm (m)	Bulk Catch (Kg)	Boarfish %	Mackerel %	Herring %	H Mack %	Others^ %
1	09.07.11	53 32.83	014 03.93	20:10	340	120	150	78.7	10.0		7.7	3.5
2	10.07.12	53 04.52	013 30.36	17:05	255	240	3		12.4		20.9	66.7
3	11.07.12	52 50.79	013 35.02	10:30	229	225	5,000		3.4		96.6	
4	12.07.12	53 35.40	011 36.53	14:17	221	180	2,500		0.9		2.1	97.0
5	12.07.12	53 20.91	010 44.50	23:00	114	0-65	100			73.6		26.4
6	13.07.12	53 14.72	012 26.42	10:57	355	250	2,000	62.4	5.5		32.0	
7	13.07.12	53 05.13	011 47.32	18:03	180	80	300	95.6	1.9		0.9	1.6
8	14.07.12	52 51.61	011 59.62	10:00	216	120-200	10,000	100.0				
9	14.07.12	52 36.06	011 28.97	19:41	145	90	1,000	88.6	11.0		0.3	
10	15.07.11	52 21.05	010 54.91	06:45	119	90	1,000					100.0
11	15.07.11	52 21.04	011 25.45	10:09	150	120	10,000	99.9	0.1			
12	16.07.12	51 37.32	011 16.73	09:00	204	144	2,000	99.9			0.1	
13	16.07.12	51 06.17	011 31.43	23:04	582	520	2,500					100.0
14	17.07.12	51 06.61	010 57.00	06:30	176	30-50	500		6.7		93.3	
15	17.07.12	51 06.10	010 16.57	10:35	136	70	2,000	98.2	1.8			
16	18.07.12	50 36.38	009 59.75	08:48	136	0-20	1,000	14.1	60.2		0.1	25.7
17	18.07.12	50 36.54	009 11.06	13:20	90	0-25	2,000	100.0				
18	19.07.12	50 06.04	009 10.56	11:27	105	0-25	4,000	71.1	2.5		26.4	
19	20.07.12	49 50.15	010 44.23	07:36	153	0-20	2,000		0.8			99.2
20	20.07.11	49 34.72	011 00.94	13:11	202	0-40	4,000		0.7			99.3
21	20.07.12	49 35.10	010 07.44	18:10	122	0-11	2,500		0.3			97.7
22	21.07.12	49 20.29	008 47.83	07:32	147	0-12	1,500	5.2	2.1		92.7	
23	21.07.12	49 20.50	010 47.50	15:47	162	10-150	4,500	100.0				
24	21.07.12	49 02.40	010 46.60	22:21	160	20-80	4,500	67.3				32.7
25	22.07.12	49 02.69	010 04.71	08:06	126	20-80	750	100.0				
26	22.07.12	49 03.17	008 16.36	16:19	149	95	5,500	100.0				
27	23.07.12	48 33.43	009 44.69	14:47	180	0-100	8,000	100.0				
28	24.07.12	47 48.57	007 28.68	10:07	243	0-40	1,000	100.0				
29	25.07.12	48 18.82	009 25.43	00:15	141	0-50	2,000	100.0				

^ Includes non target pelagic/demersal species and other taxa

Table 2. Continued

Celtic Explorer

No.	Date	Lat. N	Lon. W	Time	Bottom (m)	Target btm (m)	Bulk Catch (Kg)	Boarfish %	Mackerel %	Herring %	H Mack %	Others^ %
8	27.06.12	56.793	8.953	15:47	123	107	400	66.9	4.7	26.3	1.9	0.2
10	28.06.12	56.414	9.042	21:44	144	114	300	61.7	22.4	0.8	2.2	12.9
14	01.07.12	55.923	9.142	07:39	170	60	1,500	88.5	3.1	0.0	8.3	0.0
15	01.07.12	55.783	9.092	10:54	133	128	3,500	1.1	7.7	0.4	90.9	0.0
20	03.07.12	55.417	9.589	17:51	188	50	2,000	8.6	86.4	0.0	5.0	0.0
27	07.07.12	53.803	10.675	21:34	124	104	33	2.3	0.4	39.0	0.0	58.4
29	08.07.12	53.545	11.397	15:28	177	97	25	0.9	79.4	0.0	7.2	12.6

^ Includes non target pelagic/demersal species and other taxa

Table 3. Age length key compiled from commercial catch and survey samples collected during 2011-2012. This ALK was applied to boarfish samples collected during the survey.

Length (cm)	Age (years) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.5	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8.5	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9.5	0.0	0.2	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.6	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.5	0.0	0.0	0.6	0.2	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.2	0.1	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.5	0.0	0.0	0.0	0.0	0.1	0.5	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.5	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
13.5	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.1
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.3
14.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.4
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.1	0.0	0.5
15.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.8
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
16.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
17.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0

Table 4. Boarfish length at age (years) as abundance (millions) and biomass (000's tonnes).

Length (cm)	Age (years) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+	Abundance (millions)	Biomass (000s t)	Mn wt (g)
4.5																							
5																							
5.5																							
6																							
6.5																							
7																							
7.5	6.9																				6.9	0.1	10.6
8	13.5																				13.5	0.2	17.7
8.5		10.2	51.2																		61.5	1.3	20.6
9			70.9	26.6	17.7																115.2	2.8	23.9
9.5			39.6	11.3		11.3	5.7														67.8	1.9	27.4
10			3.8	19.1	11.4	22.9	11.4	11.4													80.0	2.5	31.3
10.5				4.7	28.2	112.8	47.0	28.2	9.4												230.3	8.2	35.5
11					11.1	188.8	155.5	133.3	100.0	55.5		11.1									655.3	26.3	40.1
11.5					21.8	218.3	327.5	174.6	196.5	152.8	152.8	43.7									1288.0	58.0	45.0
12						145.7	255.0	291.4	291.4	291.4	182.2	291.4	72.9	72.9	72.9	36.4		109.3	36.4	36.4	2185.8	110.1	50.4
12.5							123.8	82.5	165.0	247.5	165.0	330.0	247.5	206.3	82.5	82.5	206.3	165.0	41.3	288.8	2433.9	136.6	56.1
13									44.5	89.1	89.1	267.2	356.3	133.6	222.7	178.1	44.5	89.1	89.1	578.9	2182.0	135.9	62.3
13.5										72.4		72.4	108.6	181.0	36.2	181.0	72.4	144.8		543.0	1411.7	97.2	68.8
14											29.8	29.8	29.8	29.8		178.6	119.1	119.1	29.8	595.2	1160.7	88.0	75.8
14.5																68.3	34.2	68.3	34.2	649.0	853.9	71.1	83.3
15																				424.7	424.7	38.8	91.2
15.5																				246.5	246.5	24.6	99.7
16																				26.2	26.2	2.9	108.6
16.5																				23.2	23.2	2.7	118.0
17																				7.2	7.2	0.9	127.9
17.5																				80.1	80.1	11.1	138.4
18																							
18.5																							
19																							
19.5																							
20																							
TSN	20.43	10.24	165.5	61.63	90.29	699.8	925.8	721.5	806.8	908.8	618.8	1046	815	623.5	414.2	724.9	476.4	695.5	230.7	3499	13,554.5		
TSB	0.3	0.2	4	1.7	3.2	29.8	43	33.9	39.9	48.2	33.1	59.5	49.5	38.3	24.7	49.2	31.2	45	14.8	271.6		820.9	
SSN	0	4.1	116.6	55.19	86.74	698.7	925.2	721.5	806.8	908.8	618.8	1046	815	623.5	414.2	724.9	476.4	695.5	230.7	3499	13,467.4		
SSB	0	0.085	2.871	1.549	3.126	29.74	42.94	33.88	39.9	48.21	33.12	59.48	49.47	38.28	24.65	49.25	31.2	45	14.8	271.6		819.1	
Mn wt (g)	15.3	20.6	23.9	27.7	35.6	42.5	46.4	47	49.5	53	53.5	56.9	60.7	61.4	59.5	67.9	65.5	64.7	64.2	77.6			
Mn L (cm)	8.7	9.8	10.2	10.8	11.7	12.5	12.9	12.9	13.1	13.5	13.5	13.8	14.1	14.2	14	14.7	14.5	14.4	14.4	15.3			

Table 5. Boarfish total biomass (000's tonnes) at age (years) by ICES statistical rectangle.

Region	Strata	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+	Total
Western	36D6	0	0	0	0	0	0	0.1	0.1	0.2	0.3	0.2	0.4	0.4	0.3	0.2	0.4	0.2	0.3	0.1	1.6	4.9
	35D5	0	0	0	0	0	0.1	0.4	0.3	0.5	0.8	0.6	1.2	1.2	0.9	0.6	1.1	0.7	0.9	0.3	4.6	14.3
	35D6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.3
	34D9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	34D5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2
	34D6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	33D5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1
	33D6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	36D8	0	0	0	0	0	1	1.9	1.6	2.1	2.8	2	3.8	3.4	2.5	1.8	2.9	1.7	2.6	0.9	12	43
	36D9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1
	35D9	0	0	0	0	0	0	0	0	0	0.1	0	0.1	0.1	0	0	0.1	0	0	0	0.2	0.8
	35D8	0	0	0	0	0	0.3	0.6	0.5	0.7	0.9	0.6	1.3	1.1	0.8	0.6	0.9	0.5	0.8	0.3	3.8	13.7
	35D7	0	0	0	0	0	0.3	0.5	0.4	0.6	0.8	0.5	1	0.9	0.7	0.5	0.9	0.6	0.8	0.3	4	12.8
	34D8	0	0	0.1	0.1	0.3	3.7	5.5	4.3	5.1	6.1	4.2	7.4	6.2	4.6	3.2	5.4	3.3	5	1.7	24.3	90.7
	34D7	0	0	0	0	0.1	1	1.5	1.2	1.5	2	1.4	2.6	2.5	1.8	1.3	2.2	1.3	1.9	0.7	10.5	33.3
	33D9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	33D8	0	0	0	0	0.1	2	3.9	3.4	4.5	5.9	4.1	8.2	7.1	5.1	3.6	5.8	3.8	5.4	1.9	33.2	98
	33D7	0	0	0	0	0	0.2	0.4	0.3	0.4	0.6	0.4	0.8	0.7	0.5	0.4	0.6	0.4	0.5	0.2	3.2	9.6
	32D9	0	0	0	0	0	0.2	0.3	0.3	0.3	0.5	0.3	0.6	0.5	0.5	0.3	0.6	0.4	0.5	0.2	3.6	9
	32D8	0	0	0	0	0	0.3	0.6	0.5	0.6	0.9	0.6	1.1	1	0.9	0.5	1.1	0.7	1	0.3	6.6	16.5
Southern	31D9	0	0	0	0	0	0.2	0.3	0.3	0.4	0.5	0.3	0.6	0.5	0.4	0.3	0.6	0.4	0.5	0.2	4.2	9.8
	31D8	0	0	0	0	0	0.1	0.2	0.2	0.2	0.3	0.2	0.4	0.3	0.3	0.2	0.4	0.2	0.3	0.1	2.3	5.7
	31E0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	30E0	0.1	0.1	1.1	0.4	0.4	2.3	3	2.1	2.4	2.7	1.9	3.1	2.6	1.9	1.3	2.2	1.5	2	0.7	12	43.6
	30D9	0	0	0.1	0	0.1	0.7	1.2	1	1.2	1.6	1	2	1.8	1.5	0.9	2.1	1.2	1.8	0.5	13.4	32.1
	30D8	0	0	0	0	0	0	0.1	0	0.1	0.1	0.1	0.1	0.1	0.1	0	0.1	0.1	0.1	0	0.7	1.6
	29E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2
	29E0	0	0	0.4	0.1	0.1	0.7	0.8	0.6	0.6	0.6	0.4	0.5	0.3	0.2	0.2	0.2	0.2	0.3	0.1	0.9	7.2
	29D9	0.1	0	0.8	0.3	0.3	2.1	2.8	2.1	2.3	2.6	1.7	2.8	2.1	1.7	1.1	1.9	1.3	1.9	0.6	10.9	39.4
	29D8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	28E1	0.1	0	0.7	0.2	0.2	1.2	1.3	1	1	0.9	0.6	0.8	0.5	0.4	0.3	0.4	0.3	0.4	0.1	1.6	12.2
	28E0	0	0	0	0	0	0.1	0.1	0.1	0.1	0.1	0	0.1	0	0	0	0	0	0	0	0.1	0.8
	28D9	0	0	0	0	0	0	0.1	0	0	0.1	0	0.1	0	0	0	0	0	0	0	0.1	0.6
	28D8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	27E1	0	0	0.1	0.1	0.2	2	2.2	1.7	1.7	1.6	1	1.4	0.7	0.6	0.4	0.5	0.3	0.7	0.2	2.5	17.9
	27E0	0	0	0.1	0.1	0.1	0.9	1	0.8	0.8	0.7	0.6	0.7	0.4	0.3	0.2	1.8	1.1	1.7	0.7	24.8	36.8
	27D9	0	0	0.2	0.1	0.2	1.7	2.4	1.8	2.1	2.4	1.6	2.7	2.1	1.8	1	2.4	1.6	2.3	0.7	16.1	43.2
	27D8	0	0	0.1	0.1	0.1	0.8	1	0.8	0.9	1	0.7	1.1	0.8	0.6	0.4	0.5	0.4	0.6	0.2	2.2	12
	26E1	0	0	0.1	0.1	0.4	3.4	3.9	3.1	3	2.8	1.8	2.6	1.4	1.1	0.8	1	0.7	1.3	0.4	4.4	32.3
	26E0	0	0	0	0	0.2	2.5	3.7	2.9	3.4	4	2.7	4.6	3.6	2.8	1.8	2.7	1.9	2.8	0.9	11.3	51.8
	26D9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0.1	0.1	0.1	2.3	2.9
	25E1	0	0	0	0	0.1	0.7	0.9	0.7	0.8	1	0.6	1.2	1	0.8	0.4	0.8	0.6	0.8	0.2	3	13.8
	25E0	0	0	0	0	0.1	0.5	0.6	0.5	0.6	0.8	0.5	0.9	0.8	0.7	0.3	0.5	0.4	0.5	0.1	1.6	9.3
	25E2	0	0	0	0	0	0.2	0.5	0.4	0.7	1.2	1	2.1	2.1	1.8	0.9	3.6	2.3	3	0.9	20.6	41.3
	24E2	0	0	0	0	0	0.1	0.2	0.2	0.3	0.5	0.4	0.9	0.9	0.8	0.4	1.5	1	1.2	0.4	8.7	17.4
	24E3	0	0	0	0	0	0.2	0.4	0.3	0.5	1	0.8	1.6	1.7	1.4	0.7	2.9	1.8	2.3	0.7	16.2	32.5
N & Porc	37D9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	37D8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	37E0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	37E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	38E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	38E0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	38D9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	39E0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.4
	39E0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.4
	39D9	0	0	0	0	0	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0	0.1	0	0.2	1.5
	40E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2
	40E0	0	0	0	0	0	0.1	0.2	0.1	0.2	0.3	0.2	0.4	0.3	0.3	0.2	0.4	0.2	0.3	0.1	1.4	4.6
	41E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0.3
	41E0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.9	1.2
	42E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	42E0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.9	1.2
	Total	0.3	0.2	4	1.7	3.2	29.8	43	33.9	39.9	48.2	33.1	59.5	49.5	38.3	24.7	49.2	31.2	45	14.8	271.6	820.9
	%	0	0	0.5	0.2	0.4	3.6	5.2	4.1	4.9	5.9	4	7.2	6	4.7	3	6	3.8	5.5	1.8	33.1	100

Table 6. Boarfish total abundance (millions) at age (years) by ICES statistical rectangle.

Region	Strata	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+	Total
Western	36D6	0.0	0.0	0.0	0.0	0.1	1.1	2.6	2.1	3.2	4.7	3.3	7.0	6.7	4.8	3.3	5.6	3.8	4.9	1.7	22.0	76.9
	35D5	0.0	0.0	0.0	0.0	0.2	3.1	7.7	6.1	9.4	13.8	9.7	20.6	19.5	14.0	9.6	16.3	11.1	14.5	5.0	64.5	224.9
	35D6	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.3	0.2	0.4	0.4	0.3	0.2	0.3	0.2	0.3	0.1	1.3	4.4
	34D9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	34D5	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.2	0.1	0.2	0.1	0.7	2.4
	34D6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	33D5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.3	1.1
	33D6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	36D8	0.0	0.0	0.0	0.0	1.1	21.1	39.2	32.5	41.2	51.7	36.0	66.8	55.6	40.4	29.3	43.8	27.1	40.7	14.1	167.2	707.6
	36D9	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.0	0.1	0.0	0.2	1.0
	35D9	0.0	0.0	0.0	0.0	0.0	0.4	0.7	0.6	0.8	0.9	0.7	1.2	1.0	0.7	0.5	0.8	0.5	0.7	0.3	2.9	12.8
	35D8	0.0	0.0	0.0	0.0	0.3	6.8	12.7	10.6	13.4	16.8	11.7	21.8	18.1	12.9	9.6	13.8	8.5	12.9	4.6	52.4	227.1
	35D7	0.0	0.0	0.0	0.0	0.3	5.9	10.8	8.6	10.9	14.0	9.6	17.9	15.2	11.9	7.5	13.8	8.8	12.6	3.9	54.9	206.8
	34D8	0.0	0.4	3.8	2.7	8.7	86.2	119.0	90.7	103.2	115.2	80.3	130.6	102.5	75.6	53.8	81.6	51.6	78.3	27.0	334.6	1546.0
	34D7	0.0	0.0	0.0	0.1	2.0	22.3	32.3	24.7	30.0	36.2	25.1	45.6	40.0	28.6	20.9	33.0	19.9	29.4	10.5	142.7	543.4
	33D9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	33D8	0.0	0.0	0.0	0.1	2.6	44.3	80.3	67.8	86.3	108.6	74.4	142.8	117.4	84.0	61.1	88.1	59.3	85.8	30.8	431.6	1565.4
	33D7	0.0	0.0	0.0	0.0	0.3	4.3	7.8	6.6	8.4	10.6	7.3	13.9	11.4	8.2	6.0	8.6	5.8	8.4	3.0	42.1	152.6
	32D9	0.0	0.0	0.0	0.1	0.3	3.8	6.6	5.2	6.5	8.5	5.7	10.5	8.8	7.5	4.3	8.9	5.6	8.2	2.3	45.8	138.6
	32D8	0.0	0.0	0.0	0.2	0.6	6.9	12.0	9.6	11.9	15.6	10.4	19.3	16.2	13.7	7.8	16.3	10.3	15.0	4.3	83.8	253.8
Southern	31D9	0.0	0.1	0.9	0.2	0.4	4.8	7.4	6.2	7.1	8.7	5.7	10.6	8.7	7.1	4.4	9.2	5.4	8.2	2.5	52.0	149.5
	31D8	0.0	0.0	0.0	0.1	0.2	2.4	4.2	3.3	4.1	5.4	3.6	6.7	5.6	4.7	2.7	5.6	3.5	5.2	1.5	28.9	87.6
	31E0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	30E0	4.8	3.0	47.1	13.8	12.4	56.9	66.1	47.4	50.1	51.8	35.8	54.0	42.5	31.2	21.5	33.6	22.8	31.6	10.6	157.9	794.9
	30D9	0.0	0.4	3.1	0.8	1.4	16.3	24.6	20.2	23.5	28.7	19.1	35.3	29.8	23.7	15.0	30.2	18.0	26.7	8.3	168.4	493.4
	30D8	0.0	0.0	0.2	0.0	0.1	0.8	1.2	1.0	1.2	1.4	0.9	1.7	1.4	1.2	0.7	1.5	0.9	1.3	0.4	8.6	24.6
	29E1	0.1	0.0	0.6	0.2	0.1	0.5	0.6	0.4	0.4	0.4	0.2	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.4	4.9
	29E0	1.9	1.2	17.8	5.0	4.1	17.0	17.9	12.9	12.4	11.2	7.5	9.3	5.3	4.1	2.8	3.5	2.8	4.3	1.4	13.4	155.7
	29D9	3.0	2.1	33.0	10.3	9.7	51.2	61.1	46.4	48.2	49.6	33.5	50.4	35.3	27.5	18.3	29.0	19.7	29.6	9.5	142.3	709.7
	29D8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	28E1	3.3	2.0	30.1	8.4	7.0	28.8	30.3	21.8	20.9	18.9	12.8	15.7	8.9	7.0	4.8	5.9	4.7	7.2	2.3	22.8	263.7
	28E0	0.2	0.1	2.1	0.6	0.5	2.0	2.1	1.5	1.4	1.3	0.9	1.1	0.6	0.5	0.3	0.4	0.3	0.5	0.2	1.6	18.2
	28D9	0.0	0.0	0.2	0.1	0.2	0.9	1.2	0.9	0.9	1.0	0.7	1.0	0.7	0.5	0.4	0.4	0.3	0.5	0.2	1.6	11.6
	28D8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	27E1	0.0	0.0	2.4	2.4	5.8	47.6	49.4	38.9	36.2	31.8	20.2	26.3	12.4	9.9	7.6	8.3	5.5	11.5	3.9	34.0	354.2
	27E0	0.2	0.1	3.2	1.7	3.1	22.6	23.1	17.9	16.6	14.4	10.5	12.9	6.7	5.7	3.3	23.6	13.7	22.5	9.1	258.3	469.2
	27D9	0.1	0.0	7.3	4.6	6.1	41.0	52.4	39.3	42.2	45.6	31.4	47.4	34.2	28.6	16.6	35.1	24.1	34.9	10.8	193.9	695.5
	27D8	0.0	0.0	3.8	2.4	2.9	18.2	22.7	17.3	18.3	18.8	13.1	19.3	12.9	9.4	6.8	8.0	6.5	9.3	3.3	31.0	224.1
	26E1	0.0	0.0	4.1	4.2	10.2	83.5	87.2	68.5	64.3	57.4	36.4	48.5	24.2	19.5	14.2	15.8	11.0	21.6	7.1	61.0	638.9
	26E0	0.0	0.0	1.0	1.5	5.0	56.7	79.5	62.2	69.7	75.8	50.4	82.2	60.1	45.8	30.8	42.1	31.0	45.0	14.7	157.0	910.4
	26D9	0.0	0.0	0.2	0.1	0.1	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.0	2.0	1.1	1.7	0.7	24.0	32.0
	25E1	0.2	0.0	1.1	1.1	2.2	17.2	20.7	15.4	16.9	19.2	11.9	20.9	16.4	13.9	7.5	11.8	9.8	12.7	3.4	43.6	245.9
	25E0	0.0	0.0	0.7	0.8	1.4	11.1	14.0	10.1	11.6	13.9	8.5	15.5	12.7	10.8	5.6	8.0	7.2	8.9	2.2	25.3	168.3
	25E2	3.1	0.3	1.3	0.1	0.5	4.5	9.6	8.0	12.3	21.0	15.6	34.0	33.5	28.0	14.4	50.4	32.1	41.6	12.7	263.2	586.0
	24E2	1.3	0.1	0.5	0.0	0.2	1.9	4.0	3.4	5.2	8.9	6.6	14.3	14.1	11.8	6.1	21.2	13.5	17.6	5.4	110.9	247.0
	24E3	2.4	0.2	1.0	0.0	0.4	3.5	7.6	6.3	9.7	16.5	12.3	26.8	26.4	22.1	11.4	39.6	25.3	32.8	10.0	207.2	461.4
N & Porc	37D9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	37D8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	37E0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	37E1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	38E1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	38E0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	38D9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	39E0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	39E0	0.0	0.0	0.0	0.0	0.0	0.3	0.5	0.6	0.6	0.7	0.4	0.8	0.4	0.3	0.3	0.3	0.1	0.4	0.1	0.9	6.9
	39D9	0.0	0.0	0.0	0.0	0.0	1.2	2.1	2.4	2.5	2.7	1.7	3.1	1.5	1.3	1.0	1.3	0.5	1.6	0.5	3.4	26.7
	40E1	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.3	0.4	0.4	0.3	0.5	0.2	0.2	0.2	0.2	0.1	0.2	0.1	0.6	4.1
	40E0	0.0	0.0	0.0	0.0	0.1	1.7	3.1	3.0	3.6	4.9	3.3	6.7	5.6	4.3	3.0	5.4	2.9	4.7	1.5	19.5	73.1
	41E1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.2	0.1	0.1	0.1	2.5	3.9
	41E0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.3	0.4	0.3	0.6	0.5	0.4	0.3	0.6	0.4	0.5	0.2	9.2	14.2
	42E1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	42E0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.3	0.4	0.3	0.6	0.5	0.4	0.3	0.6	0.4	0.5	0.2	9.0	13.9
	Total	20.4	10.2	165.5	61.6	90.3	699.8	925.8	721.5	806.8	908.8	618.8	1045.6	815.0	623.5	414.2	724.9	476.4	695.5	230.7	3499.3	######
	%	0.2	0.1	1.2	0.5	0.7	5.2	6.8	5.3	6.0	6.7	4.6	7.7	6.0	4.6	3.1	5.3	3.5	5.1	1.7	25.8	100.0
	Cv (%)	26.2	33.5	30.0	23.7	16.5	13.7	12.1	12.2	12.1	11.4	11.4	11.5	12.4	11.5	12.4	11.4	10.6	10.6	11.4	12.3	NA

Table 7. Boarfish biomass (000's tonnes) by maturity by ICES statistical rectangle.

Region	Strata	Imm	Mature	Spent	Total
Western	36D6	0	4.9	0	4.9
	35D5	0	14.3	0	14.3
	35D6	0	0.3	0	0.3
	34D9	0	0	0	0
	34D5	0	0.2	0	0.2
	34D6	0	0	0	0
	33D5	0	0.1	0	0.1
	33D6	0	0	0	0
	36D8	0	43	0	43
	36D9	0	0.1	0	0.1
	35D9	0	0.8	0	0.8
	35D8	0	13.7	0	13.7
	35D7	0	12.8	0	12.8
	34D8	0	90.7	0	90.7
	34D7	0	33.3	0	33.3
	33D9	0	0	0	0
	33D8	0	98	0	98
	33D7	0	9.6	0	9.6
	32D9	0	9	0	9
	32D8	0	16.5	0	16.5
Southern	31D9	0	9.7	0	9.8
	31D8	0	5.7	0	5.7
	31E0	0	0	0	0
	30E0	0.5	43.1	0	43.6
	30D9	0	32	0	32.1
	30D8	0	1.6	0	1.6
	29E1	0	0.2	0	0.2
	29E0	0.2	7	0	7.2
	29D9	0.4	39	0	39.4
	29D8	0	0	0	0
	28E1	0	12	0	12
	28E0	0	1	0	1
	28D9	0	1	0	1
	28D8	0	0	0	0
	27E1	0	18	0	18
	27E0	0	36.8	0	36.8
	27D9	0.1	43.1	0	43.2
	27D8	0	12	0	12
	26E1	0	32.3	0	32.3
	26E0	0	51.8	0	51.8
	26D9	0	2.9	0	2.9
	25E1	0	13.8	0	13.8
	25E0	0	9.3	0	9.3
	25E2	0.1	41.2	0	41.3
	24E2	0	17.4	0	17.4
	24E3	0	32.5	0	32.5
N & Porc	37D9	0	0	0	0
	37D8	0	0	0	0
	37E0	0	0	0	0
	37E1	0	0	0	0
	38E1	0	0	0	0
	38E0	0	0	0	0
	38D9	0	0	0	0
	39E0	0	0	0	0
	39E0	0	0.4	0	0.4
	39D9	0	1.5	0	1.5
	40E1	0	0.2	0	0.2
	40E0	0	4.6	0	4.6
	41E1	0	0.3	0	0.3
	41E0	0	1.2	0	1.2
	42E1	0	0	0	0
	42E0	0	1.2	0	1.2
	Total	1.8	819.1	0	820.9
	%	0.2	99.8	0	100

Table 8. Boarfish abundance (millions) by maturity by ICES statistical rectangle.

Region	Strata	Imm	Mature	Spent	Total
Western	36D6	0	76.9	0	76.9
	35D5	0	224.9	0	224.9
	35D6	0	4.4	0	4.4
	34D9	0	0	0	0
	34D5	0	2.4	0	2.4
	34D6	0	0	0	0
	33D5	0	1.1	0	1.1
	33D6	0	0	0	0
	36D8	0	707.6	0	707.6
	36D9	0	1.0	0	1.0
	35D9	0	12.8	0	12.8
	35D8	0	227.1	0	227.1
	35D7	0	206.8	0	206.8
	34D8	1.7	1544.3	0	1546.0
	34D7	0	543.4	0	543.4
	33D9	0	0.0	0	0.0
	33D8	0	1565.4	0	1565.4
	33D7	0	152.6	0	152.6
	32D9	0	138.6	0	138.6
	32D8	0	253.8	0	253.8
Southern	31D9	0.6	148.9	0	149.5
	31D8	0	87.6	0	87.6
	31E0	0	0	0	0
	30E0	24.4	770.5	0	794.9
	30D9	1.7	491.7	0	493.4
	30D8	91.0	24.5	0	24.6
	29E1	0.3	4.6	0	4.9
	29E0	9.5	146.2	0	155.7
	29D9	16.8	692.9	0	709.7
	29D8	0	0	0	0
	28E1	16.0	247.6	0	263.7
	28E0	1.1	17.1	0	18.2
	28D9	53.0	11.5	0	11.6
	28D8	0	0	0	0
	27E1	0.4	353.8	0	354.2
	27E0	1.2	468.0	0	469.2
	27D9	2.1	693.4	0	695.5
	27D8	1.0	223.1	0	224.1
	26E1	0.6	638.3	0	638.9
	26E0	0.2	910.2	0	910.4
	26D9	0.1	31.9	0	32.0
	25E1	0.4	245.6	0	245.9
	25E0	0.1	168.2	0	168.3
	25E2	4.0	582.1	0	586.0
	24E2	1.7	245.4	0	247.0
	24E3	3.1	458.3	0	461.4
N & Porc	37D9	0	0	0	0
	37D8	0	0	0	0
	37E0	0	0	0	0
	37E1	0	0	0	0
	38E1	0	0	0	0
	38E0	0	0	0	0
	38D9	0	0	0	0
	39E0	0	0	0	0
	39E0	0	6.9	0	6.9
	39D9	0	26.7	0	26.7
	40E1	0	4.1	0	4.1
	40E0	0	73.1	0	73.1
	41E1	0	3.9	0	3.9
	41E0	0	14.2	0	14.2
	42E1	0	0	0	0
	42E0	0	13.9	0	13.9
	Total	87.1	13,467	0	13,555
	%	0.6	99.4	0	100

Table 9. Boarfish biomass and abundance by ICES statistical rectangle.

Region	Category Stratum	No. transects	No. schools	Def schools	Prob schools	Mix schools	% zeros	Def Biomass	Prob Biomass	Mix Biomass	Biomass (000't)	SSB (000't)	Abundance millions
Western	36D6	1	5	5	0	0	0	4.9	0	0	4.9	4.9	76.9
	35D5	2	12	2	10	0	0	6.4	7.9	0	14.3	14.3	224.9
	35D6	2	3	0	3	0	50	0	0.3	0	0.3	0.3	4.4
	34D9	2	0	0	0	0	100	0	0	0	0	0	0.0
	34D5	2	1	0	1	0	50	0	0.2	0	0.2	0.2	2.4
	34D6	2	0	0	0	0	100	0	0	0	0	0	0.0
	33D5	1	3	0	3	0	0	0	0.1	0	0.1	0.1	1.1
	33D6	1	0	0	0	0	100	0	0	0	0	0	0.0
	36D8	1	42	42	0	0	0	43	0	0	43	43	707.6
	36D9	1	3	0	3	0	0	0	0.1	0	0.1	0.1	1.0
	35D9	1	6	6	0	0	0	0.8	0	0	0.8	0.8	12.8
	35D8	2	60	59	1	0	0	13.7	0	0	13.7	13.7	227.1
	35D7	2	70	70	0	0	0	12.8	0	0	12.8	12.8	206.8
	34D8	2	110	92	18	0	0	77.7	13	0	90.7	90.7	1546.0
	34D7	2	55	55	0	0	0	33.3	0	0	33.3	33.3	543.4
	33D9	2	0	0	0	0	100	0	0	0	0	0	0.0
	33D8	2	105	105	0	0	0	98	0	0	98	98	1565.4
	33D7	2	22	22	0	0	0	9.6	0	0	9.6	9.6	152.6
	32D9	2	9	9	0	0	0	9	0	0	9	9	138.6
	32D8	2	27	25	2	0	0	16.3	0.2	0	16.5	16.5	253.8
Southern	31D9	2	16	16	0	0	0	9.8	0	0	9.8	9.7	149.5
	31D8	2	9	9	0	0	0	5.7	0	0	5.7	5.7	87.6
	31E0	1	0	0	0	0	100	0	0	0	0	0	0.0
	30E0	2	34	9	0	25	0	18.3	0	25.3	43.6	43.1	794.9
	30D9	2	32	9	20	3	0	2.5	24.9	4.7	32.1	32	493.4
	30D8	2	1	0	1	0	50	0	1.6	0	1.6	1.6	24.6
	29E1	2	1	1	0	0	50	0.2	0	0	0.2	0.2	4.9
	29E0	2	21	21	0	0	0	7.2	0	0	7.2	7	155.7
	29D9	2	49	19	30	0	0	20.3	19.1	0	39.4	39	709.7
	29D8	2	0	0	0	0	100	0	0	0	0	0	0.0
	28E1	2	21	16	5	0	50	10	2.2	0	12.2	11.8	263.7
	28E0	2	2	2	0	0	50	0.8	0	0	0.8	0.8	18.2
	28D9	2	3	3	0	0	50	0.6	0	0	0.6	0.6	11.6
	28D8	2	0	0	0	0	100	0	0	0	0	0	0.0
	27E1	2	46	19	10	17	0	10.5	7.2	0.2	17.9	17.9	354.2
	27E0	2	40	37	3	0	0	36.5	0.3	0	36.8	36.8	469.2
	27D9	2	82	82	0	0	0	43.2	0	0	43.2	43.1	695.5
	27D8	2	11	11	0	0	50	12	0	0	12	12	224.1
	26E1	2	36	36	0	0	0	32.3	0	0	32.3	32.3	638.9
	26E0	2	69	65	4	0	0	44.6	7.2	0	51.8	51.8	910.4
	26D9	1	1	1	0	0	0	2.9	0	0	2.9	2.9	32.0
	25E1	2	21	21	0	0	50	13.8	0	0	13.8	13.8	245.9
	25E0	1	7	7	0	0	0	9.3	0	0	9.3	9.3	168.3
	25E2	1	39	14	25	0	0	11.5	29.8	0	41.3	41.2	586.0
	24E2	1	6	6	0	0	0	17.4	0	0	17.4	17.4	247.0
	24E3	1	17	17	0	0	0	32.5	0	0	32.5	32.5	461.4
N & Porc	37D9	4	0	0	0	0	100	0	0	0	0	0	0.0
	37D8	1	0	0	0	0	100	0	0	0	0	0	0.0
	37E0	1	0	0	0	0	100	0	0	0	0	0	0.0
	37E1	0	0	0	0	0	100	0	0	0	0	0	0.0
	38E1	0	0	0	0	0	100	0	0	0	0	0	0.0
	38E0	4	0	0	0	0	100	0	0	0	0	0	0.0
	38D9	4	0	0	0	0	100	0	0	0	0	0	0.0
	39E0	0	0	0	0	0	100	0	0	0	0	0	0.0
	39E0	4	3	0	3	0	50	0	0.4	0	0.4	0.4	6.9
	39D9	1	5	0	5	0	0	0	1.5	0	1.5	1.5	26.7
	40E1	4	3	1	2	0	50	0	0.2	0	0.2	0.2	4.1
	40E0	4	13	11	2	0	25	4.2	0.4	0	4.6	4.6	73.1
	41E1	4	4	4	0	0	75	0.3	0	0	0.3	0.3	3.9
	41E0	4	2	2	0	0	75	1.2	0	0	1.2	1.2	14.2
	42E1	4	0	0	0	0	100	0	0	0	0	0	0.0
	42E0	3	3	0	3	0	67	0	1.2	0	1.2	1.2	13.9
	Total	122	1130	931	154	45	43	673	117.6	30.3	821	819.1	13,554.5
	Cv (%)	-	-	-	-	-	-	-	-	-	10.7	NA	10.6

Table 9. Boarfish survey time series.

Years	2011	2012
0	-	-
1	4.7	20.4
2	10.7	10.2
3	51.5	165.5
4	167.3	61.6
5	384.7	90.3
6	1015.2	699.8
7	1000.1	925.8
8	601.3	721.5
9	899.4	806.8
10	790.7	908.8
11	246.8	618.8
12	434.6	1045.6
13	267.7	815
14	244.5	623.5
15	119.9	414.2
16	193.3	724.9
17	49.7	476.4
18	147.0	695.5
19	294.0	230.7
20+	855.8	3499.3
TSN (mil)	7,779	13,554
TSB ('000t)	433,584	820,935
SSB ('000t)	432,882	819,126
CV	17.6	10.6

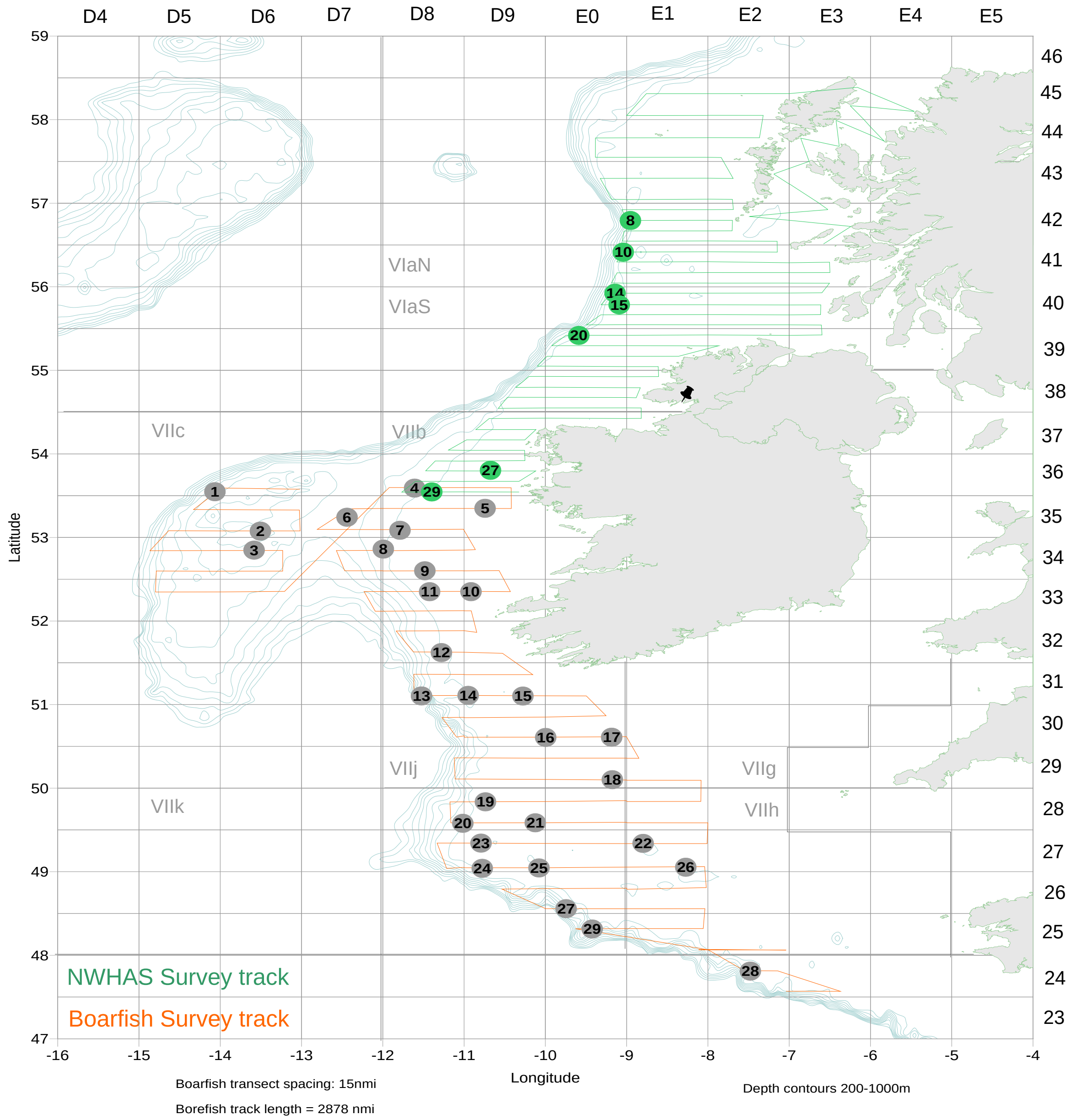


Figure 1. Cruise tracks and haul positions for the FV *Father McKee* (orange) and RV *Celtic Explorer* (green). Note: Only hauls containing boarfish are shown for Celtic Explorer. Black pin represent calibration site.

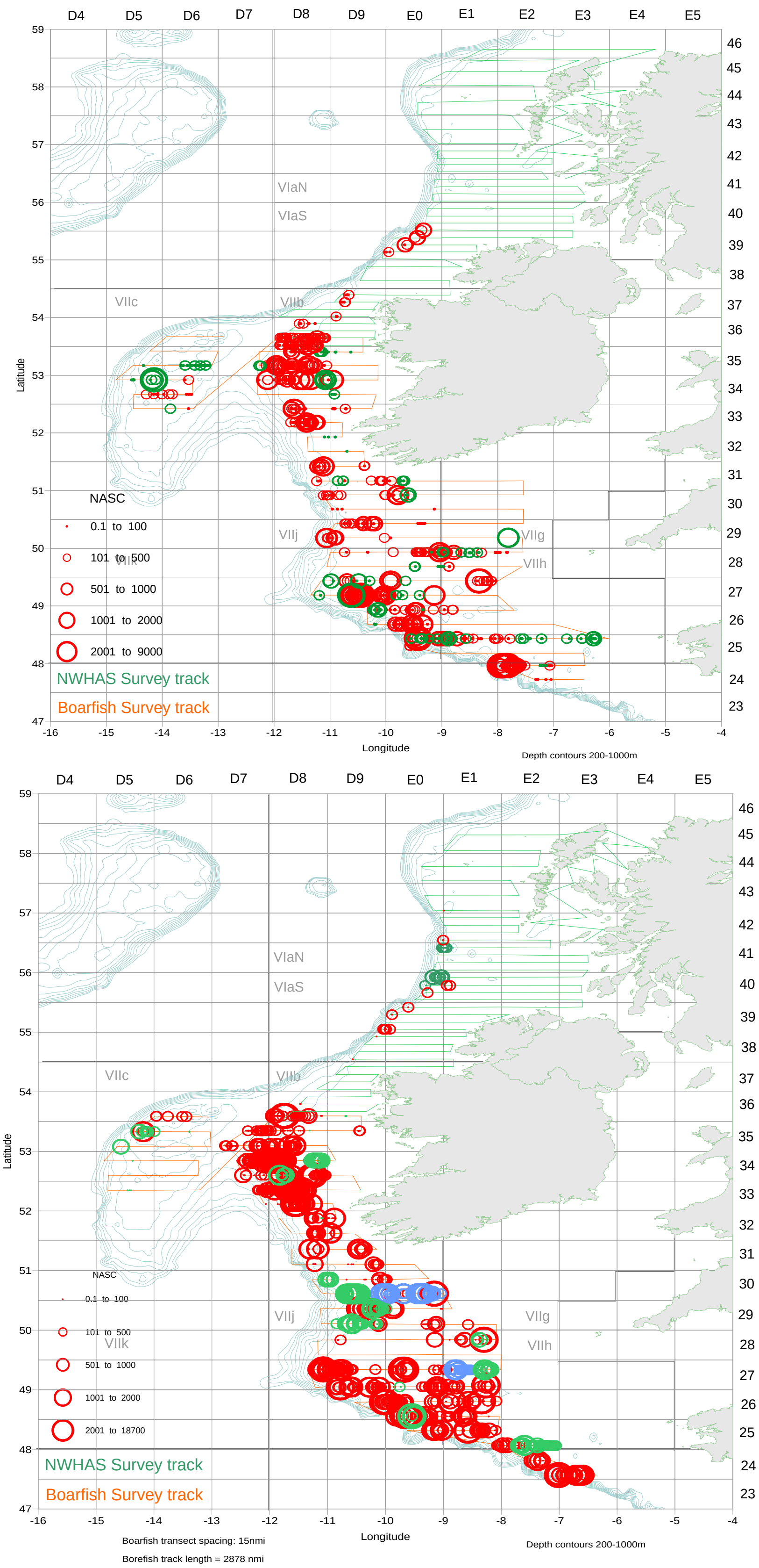


Figure 2. NASC plot of boarfish distribution Top panel 2011 and bottom panel 2012 results. Note: Circle size proportional to NASC value. Red circles represent 'definitely' boarfish category, green 'probably boarfish' and blue 'boarfish in a mix.

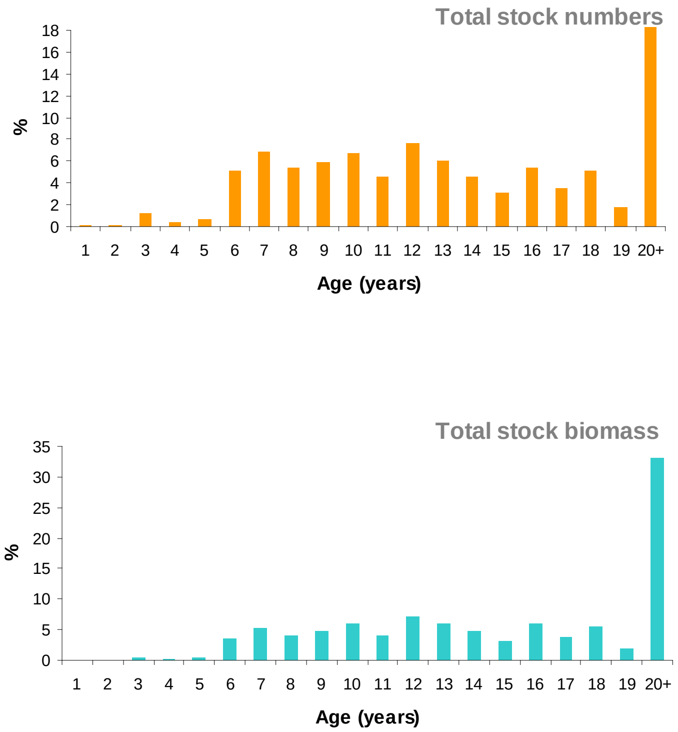


Figure 3. Percentage breakdown of TSN (top) and TSB (bottom) of survey stock.

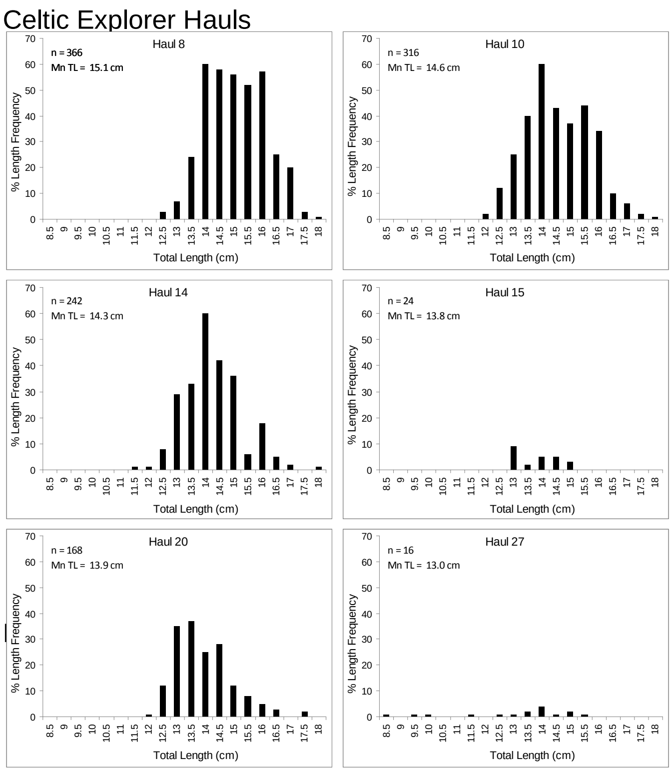


Figure 4. Percentage composition of boarfish by haul for survey area, Celtic Explorer 57°N-54°N and Father McKee 54°N-47°30'N.

Father McKee Hauls

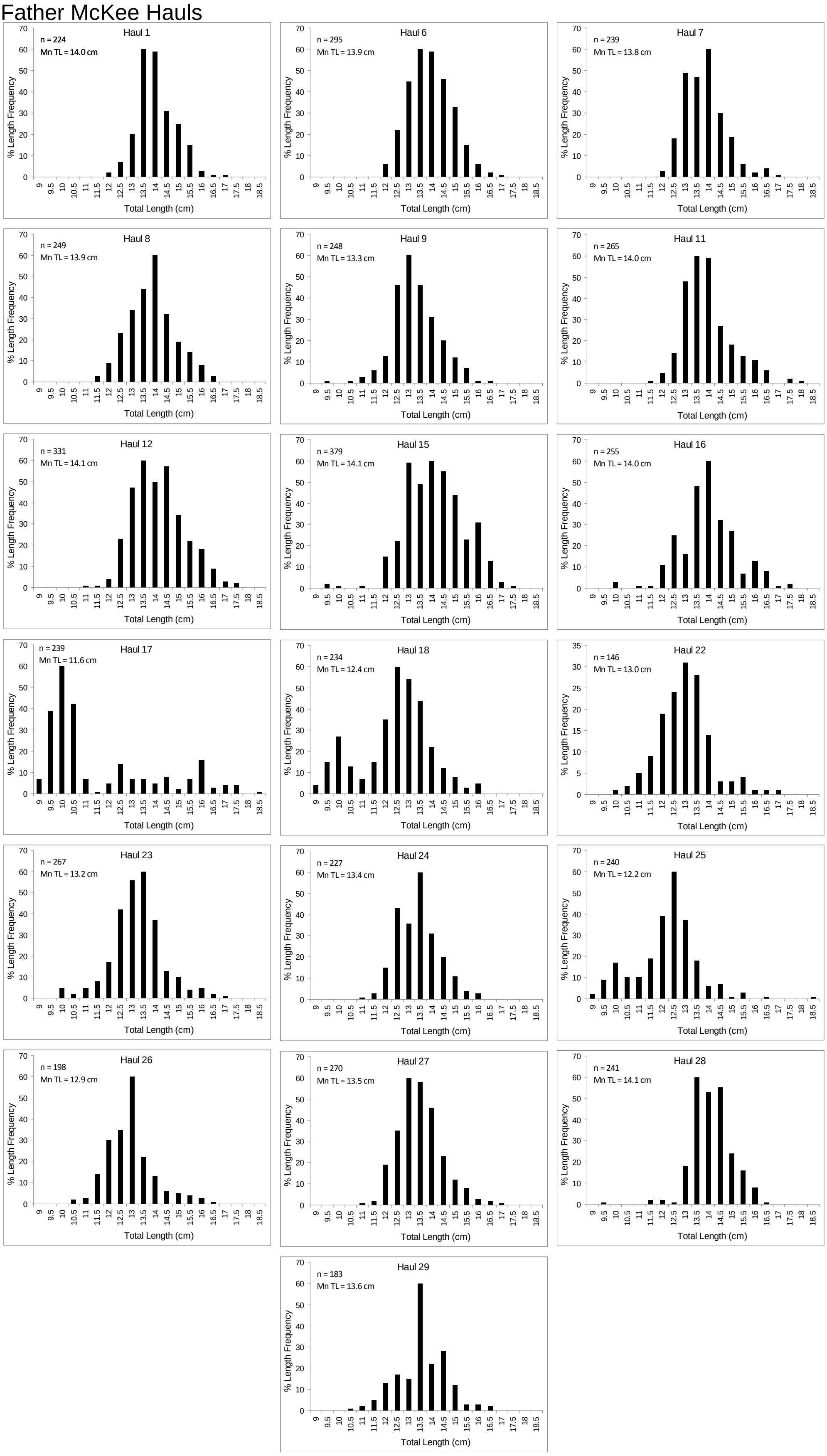
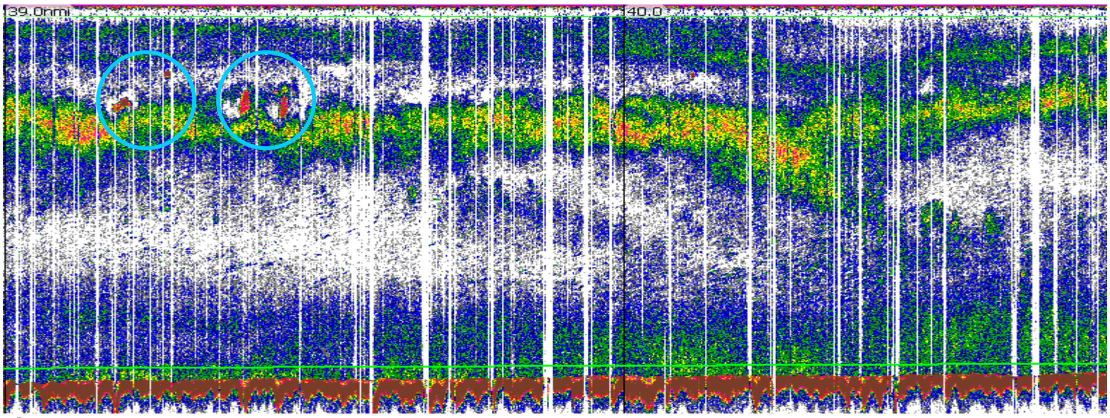
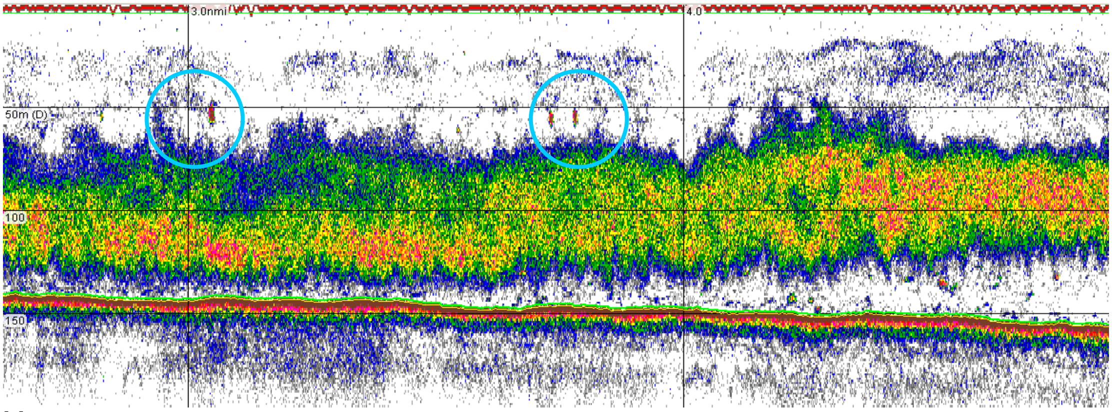


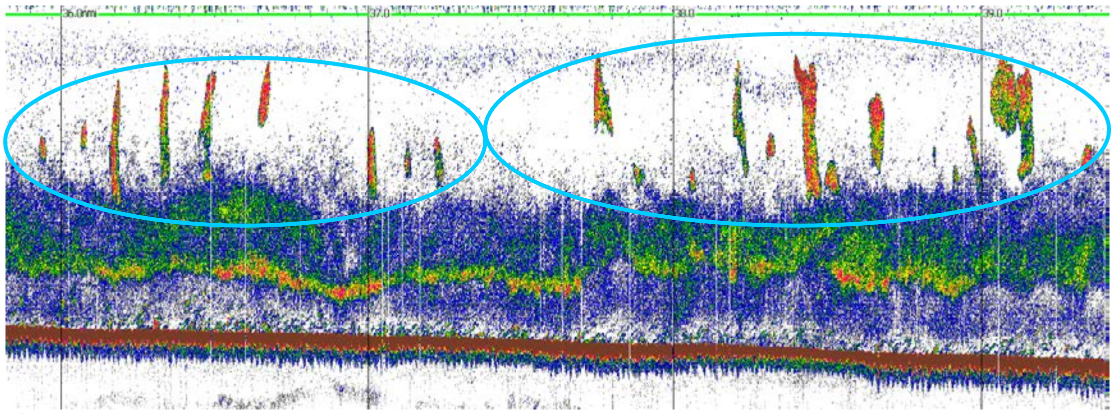
Figure 4. Continued



a). Northern Porcupine Bank scattering layer recorded prior to Haul 01. Heavy plankton layer dominates the picture with small/medium high density schools of boarfish occurring above this layer (circled) that were targeted during the trawl. Bottom depth is 320m with targets occurring at 80m.

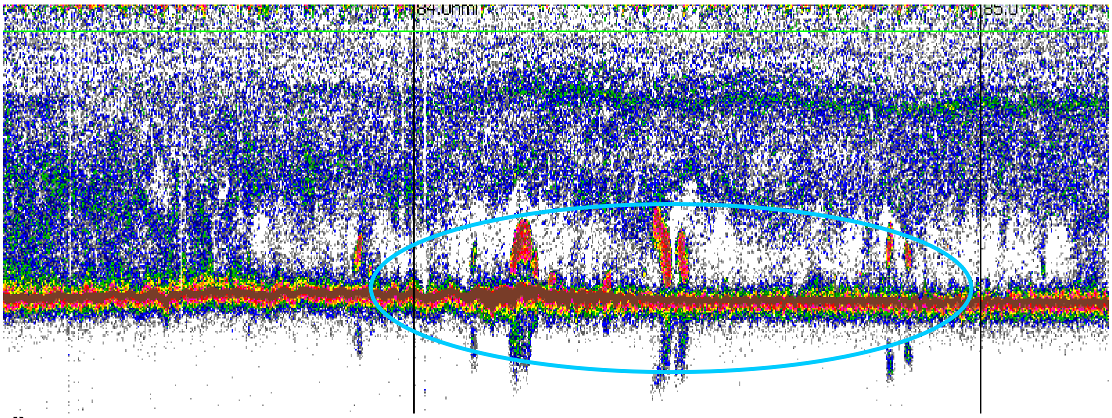


b). Boarfish schools from **northern area** (north of 54°-57°N) recorded prior to Haul 14 by the *Celtic Explorer.* Bottom depth is 170m with targets at 50m.

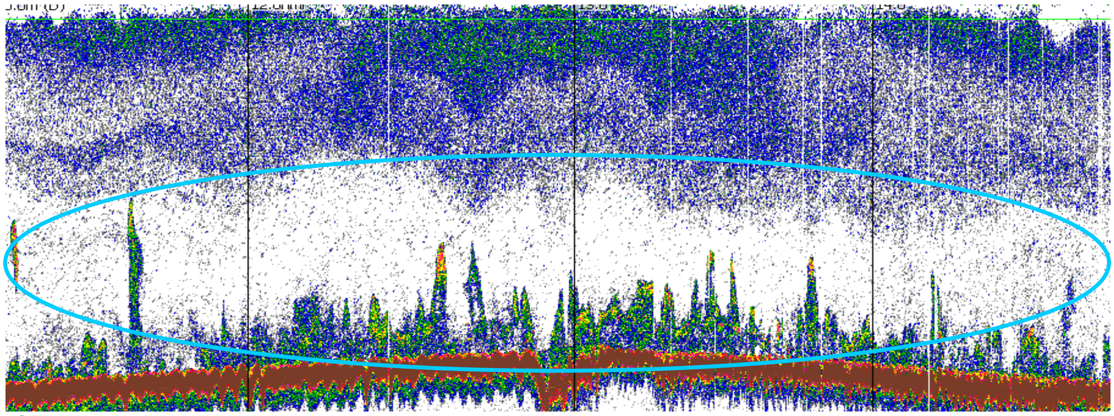


c). High-density midwater boarfish schools (circled) encountered in the high density **western area** (51°-54°N) prior to Haul 09. Bottom depth is 135m with targets occurring within 30m of the surface, some of the largest schools shown here have a vertical height of 50m. Note: echogram extends over 3.5nmi.

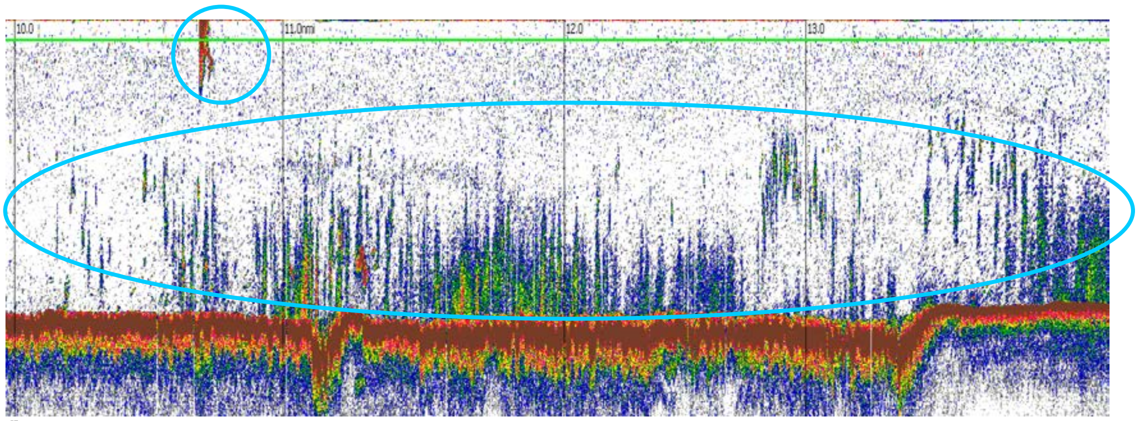
Figures 5a-h. Echotraces recorded prior to directed trawls. Boarfish survey, July 2012. Note: vertical bands on echograms represent 1nmi (nautical mile) intervals recorded at 38 kHz.



d). High density bottom schools of boarfish located in an area known commercially as the **redfish (boarfish) Bank** (30E0) which is targeted frequently during the fishery. Echogram recorded prior to Haul 17. Bottom depth is 65m with targets extending from 0-180m off the bottom.

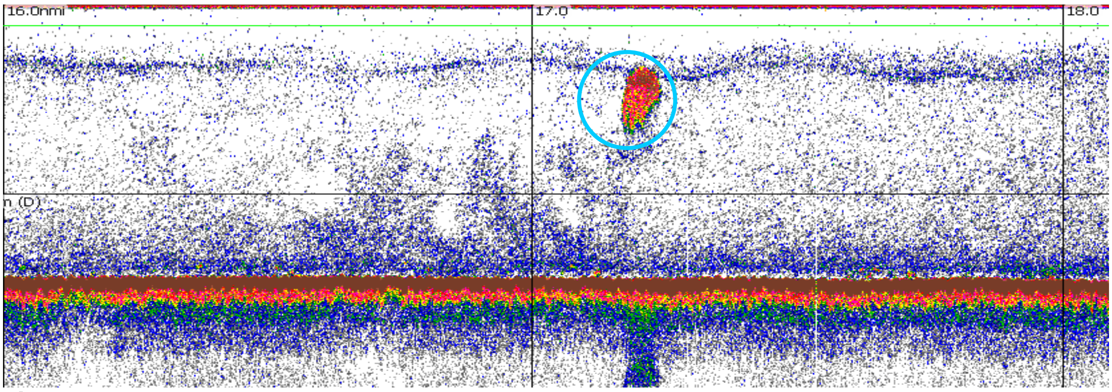


e). High density bottom layer of boarfish typical of those encountered in the **southern area** (south of 50°N). Echogram recorded prior to Haul 27. Bottom depth is 180m with targets extending from 0-100m off the bottom.

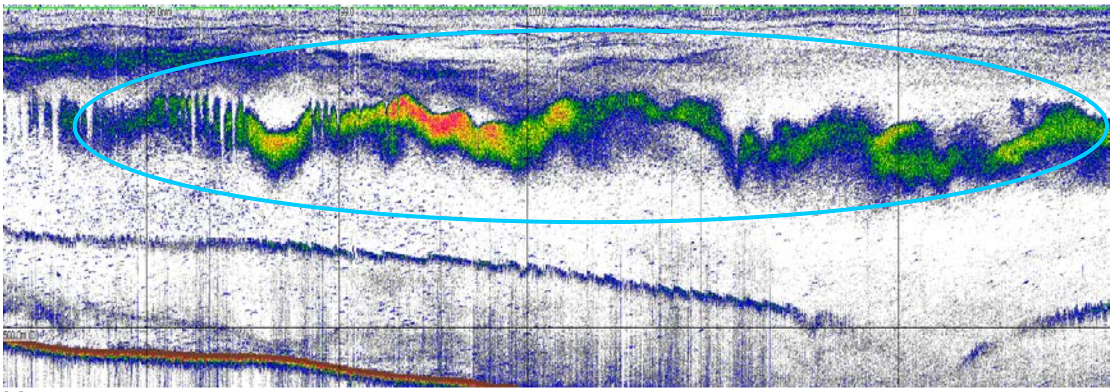


f). High density layer containing herring, sprat and 0-group sprat targeted during the trawl (**Haul 05**). Echotraces were recorded at dusk as the targets were beginning to rise from the bottom to feed in surface waters. Bottom depth is 76m with targets extending from 0-60m off the bottom and one surface school.

Figures 5a-h. continued.



g). Large very high density school of 1-group blue whiting targeted during Haul 10. Bottom depth is 70m, school height 19m.



h). High-density off shelf schools of blue whiting recorded during an offshore inter-transect in strata 28D8. Mark intensity and size typical of those encountered south of 51°N. Note: echogram extends over 6nmi.

Figures 5a-h. continued.

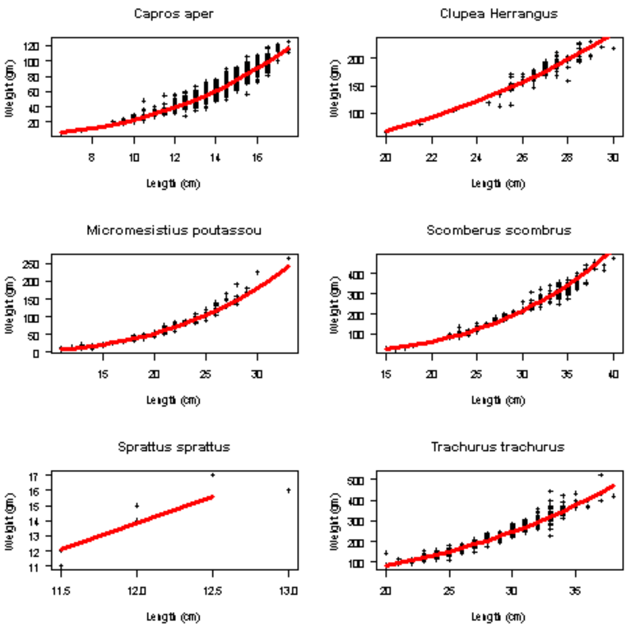


Figure 6. Length weight plots of major trawl component species used during the analysis.

Appendix 1

Details of the charter vessel and tow body set up used during the survey.

Figure 1. FV *Father McKee* (SO 708). 65m LOA

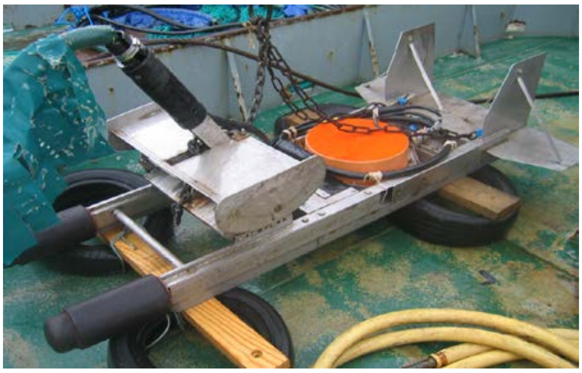


Figure 2. Tow sled with 38 kHz split beam transducer (orange centre screen).

Figure 3. Towing boom c.3m long with support stays.

Figure 4. Top side monitoring station located on the bridge. (L-R) Laptop running Sodena© navigation package, second laptop running Echoview© (Live viewing) and EK 60 topside PC unit.

Annex 7: Manual for International Pelagic Surveys

WGIPS Manual for Acoustic Surveys, Version 1.01

MANUAL FOR INTERNATIONAL PELAGIC SURVEYS (IPS)

VERSION 1.01

Copenhagen, Denmark

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

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Contents

1 Introduction

This manual was developed through the ICES Working Group of International Pelagic surveys (WGIPS) as a guide to the methodologies adhered to during the planning, execution and analysis phases of WGIPS surveys.

The group coordinates 29 individual surveys undertaken in the Northeast Atlantic by ten countries (Ireland, Germany, Scotland, UK, Russian Federation, Norway, Netherlands, Faroe Islands, Denmark and Iceland), accounting for 519 at-sea survey days per annum.

Combined, the group reports on the distribution and age disaggregated abundance of stocks of herring, blue whiting, mackerel, boarfish, sprat, sardine and anchovy to ICES for assessment purposes, where applicable, from 52°N to 74°N and from 30°E to 18°W. In addition to biological data from target species the group also routinely collects data over a range of environmental parameters both biotic and abiotic.

Due to the number of surveys covered by this group it is not possible to provide a manual which covers every aspect of every survey. Details on survey specific methods are reported annually in the cruise reports that appear in the WGIPS report:

WGIPS: http://www.ices.dk/workinggroups/ViewWorkingGroup.aspx?ID=429

Details of the ICES assessment working groups to which WGIPS report can be found at:

WGWIDE: http://www.ices.dk/workinggroups/ViewWorkingGroup.aspx?ID=273

HAWG: http://www.ices.dk/workinggroups/ViewWorkingGroup.aspx?ID=25

2 Surveys

2.1 Coordinated surveys

2.1.1 International blue whiting spawning stock survey (IBWSS)

The IBWSS survey is carried out annually in March/April to determine the distribution and abundance of blue whiting during the spawning season to the west of Britain and Ireland (Figure 2.1.1). This estimate is used as a tuning index by ICES to determine the size of the population and the results are submitted annually to WGWIDE. Survey data are submitted to the WGNAPES online database. Coordination and planning of blue whiting surveys is undertaken during the annual survey post cruise meeting and reported to WGIPS (http://hdl.handle.net/10793/844). The International survey time-series was established in 2004 and is carried out by vessel from Russia, Norway, Ireland, Faroes and the Netherlands.

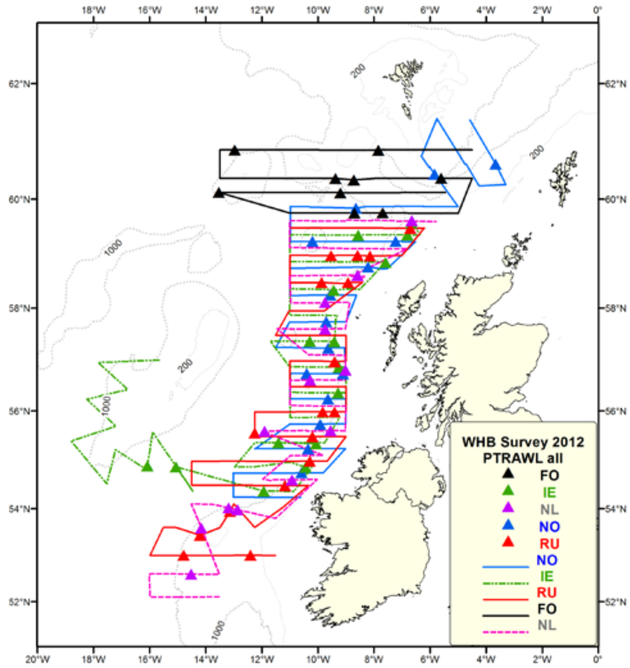


Figure 2.1.1. Vessel cruise tracks and trawl stations of the IBWSS survey 2012. PT: Indicates pelagic trawl station. IE: Ireland; FO: Faroese; NL: Netherlands; RU: Russia; NO: Norway.

2.1.2 International ecosystem survey in the Nordic Seas (IESNS)

The aim of the survey is 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 (Figure 2.1.2). The survey was initiated by the Faroes, Iceland, Norway and Russia in 1995. Since 1997 also the EU participated (except 2002 and 2003) and from 2004 onwards it was more integrated into an ecosystem survey. The report is a compilation of data from the international survey stored in the WGNAPES online database.

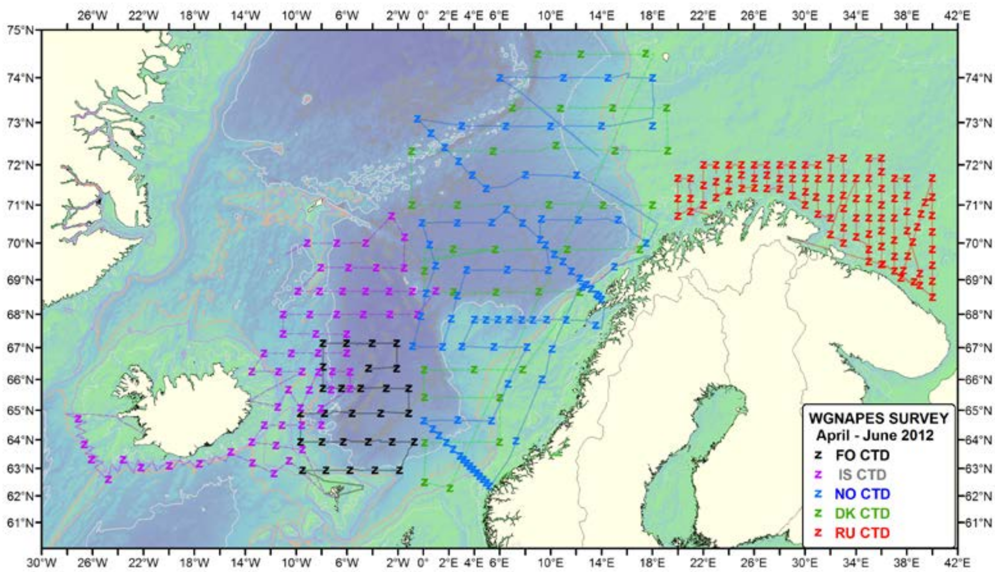


Figure 2.1.2. Vessel cruise tracks and CTD stations of the IESNS survey 2012.

2.1.3 Coordinated Nordic Seas ecosystem survey (IESSNS)

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 and blue whiting, oceanographic conditions and prey communities. Whale observers operate on the Norwegian vessels to collect data on distribution and aggregation of marine mammals. Area coverage is in Figure 2.1.3.

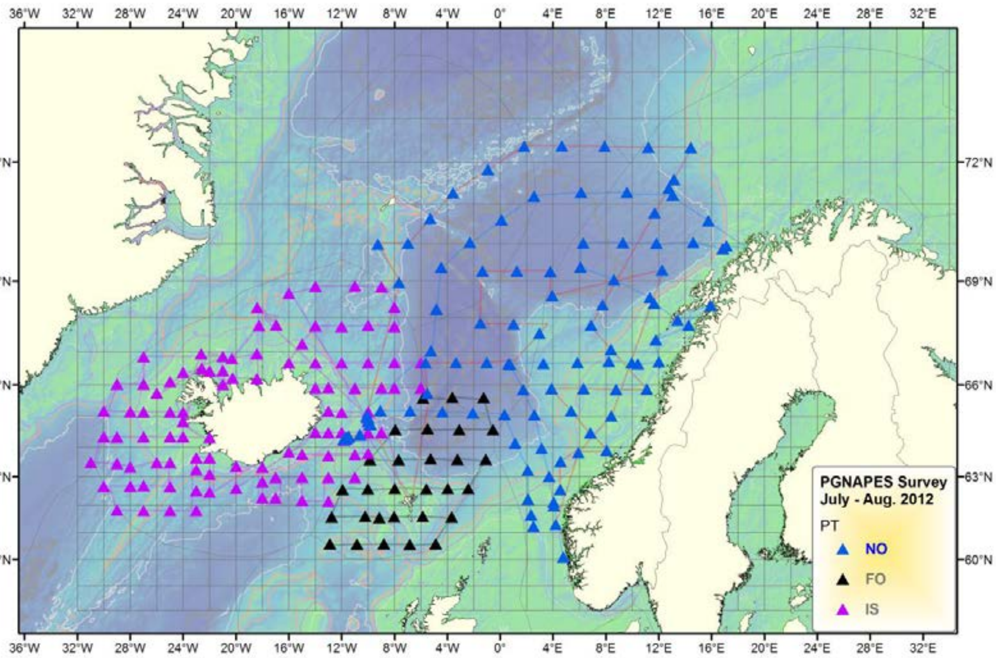


Figure 2.1.3. Vessel cruise tracks and trawl stations of the IESSNS survey 2012.

2.1.4 International acoustic survey in the North Sea, West of Scotland and Malin Shelf (HERAS)

The HERAS survey is carried annually in June/July to determine the distribution and abundance of herring and sprat. The survey covers the continental shelf north of 52°N in the North Sea and west of Scotland and Ireland to a northern limit of 62°N (Figure 2.1.4). The survey area is bounded to the east by the Norwegian, Danish, Swedish and German coastline and to the west by the shelf edge between 200 and 400 m depth. Acoustic estimates are used as a tuning index by ICES to determine the size of the population and the results are submitted annually to HAWG. Coordination and planning of the surveys are undertaken during the annual meeting in WGIPS. The international surveys time-series for North Sea autumn spawning herring was established in 1986, for Western Baltic spring-spawning herring in 1992 and for sprat in 2000. The survey is carried out by vessels from Denmark, Germany, Netherlands, Ireland, Norway and Scotland.

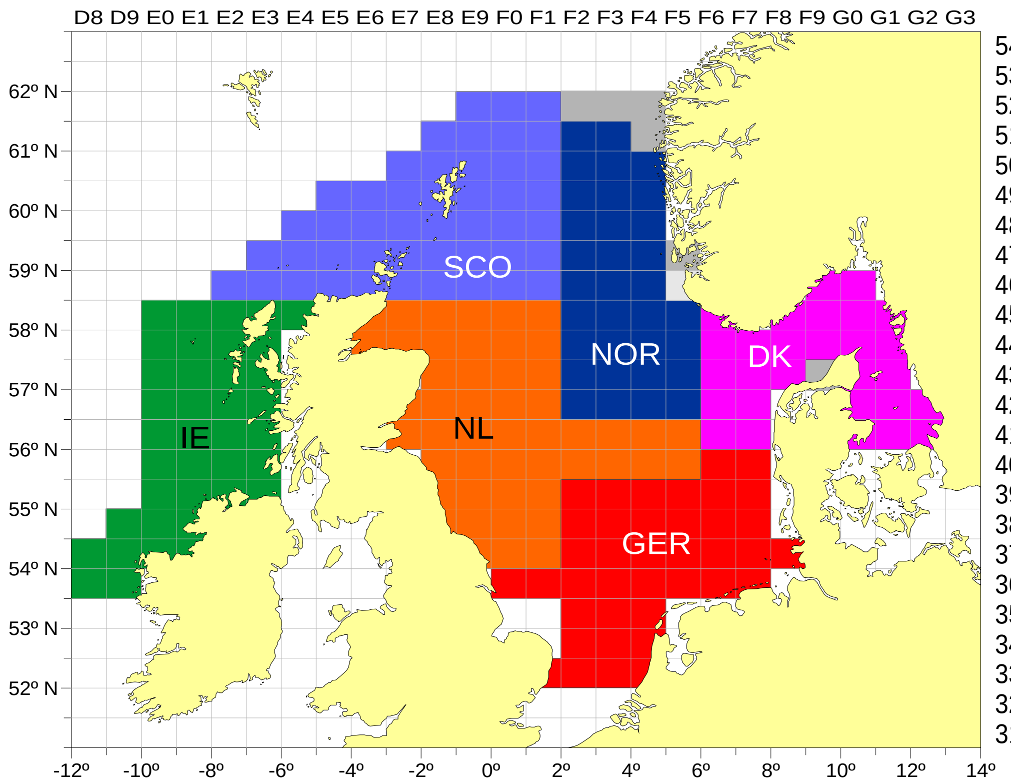


Figure 2.1.4. Area coverage by the surveys within HERAS. IE: Ireland, SCO: Scotland; NL: Netherlands; NOR: Norway; GER: Germany and DK: Denmark.

2.2 Individual surveys

In addition to the coordinated multi-vessel surveys listed above a number of other national acoustic survey programs also report through and are coordinated by WGIPS. Individual surveys also provide annual tuning data to the assessment working group for stock specific surveys.

2.2.1 Western Baltic acoustic survey

The Western Baltic acoustic survey is carried out annually within 3 weeks in October. The main aim is to determine the distribution and abundance of spring-spawning herring and sprat in the Western Baltic. The survey focuses on Subdivisions 21-24 and the time-series exists since 1992. The survey is traditionally coordinated within the Baltic International Acoustic Survey (BIAS) to supply the Herring Assessment Working Group (HAWG) and Baltic Fisheries Assessment Working Group (WGBFAS) with stock size indices. Germany and Denmark cooperate within the WBSS acoustic survey.

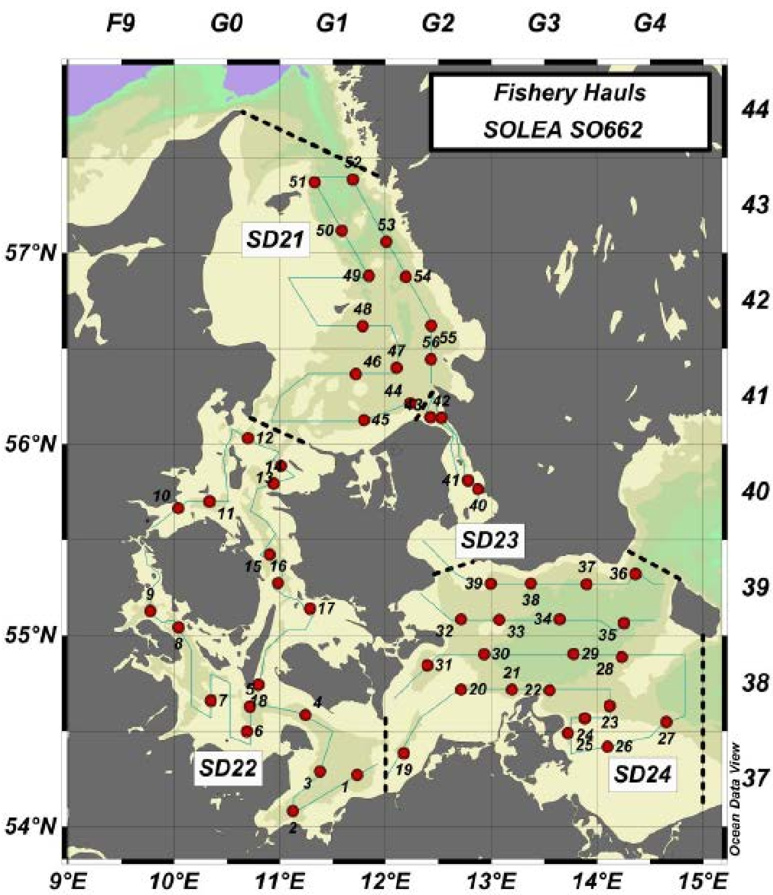


Figure 2.1.5. Area coverage for the Western Baltic acoustic survey.

2.2.2 The Irish Sea acoustic survey

The Irish Sea acoustic survey (ICES area VIIaN) is carried by the Agri-Food and Biosciences Institute (AFBI) on board the RV *Corsytes* to provide annual indices of abundance of demersal and/or pelagic fish. The survey design of stratified, systematic transects covers approximately 1200 nm and is conducted during September. The position of transects, spaced 8-10 nm, 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. Targets identified during acoustic survey are sampled by directed midwater trawling, where feasible. Survey coverage is outlined in Figure 2.1.6.

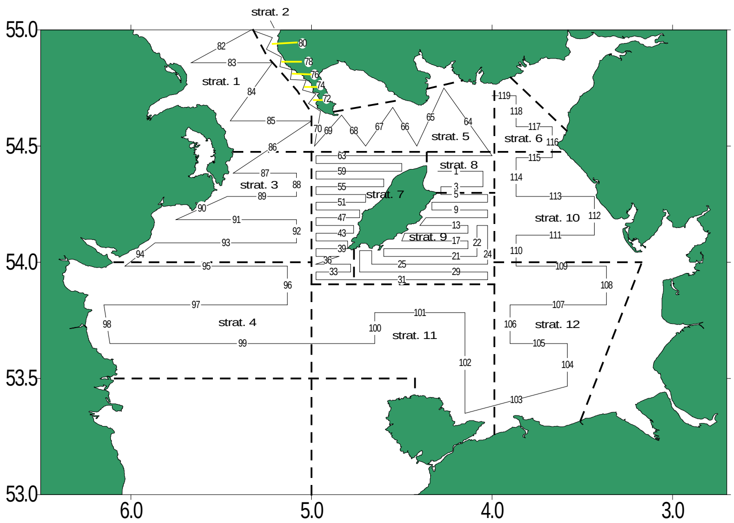


Figure 2.1.6. Area coverage during the Irish Sea acoustic survey.

2.2.3 Celtic Sea herring acoustic survey (CSHAS)

The CSHAS has been carried out annually since 2004 onboard the RV *Celtic Explorer* over 21 days in October to determine the distribution and abundance of autumn and winter spawning components of the herring stock within Divisions VIIj-g and VIIaS (Figure 2.1.7). The survey also reports the abundance of other small pelagics including sprat and pilchard. Detailed hydrographic sampling is undertaken in addition to marine mammal and seabird distribution surveys. Survey estimates and age structure of herring are used as a tuning index submitted annually to the HAWG. Further details on the survey are provided in the survey cruise report (http://hdl.handle.net/10793/842)

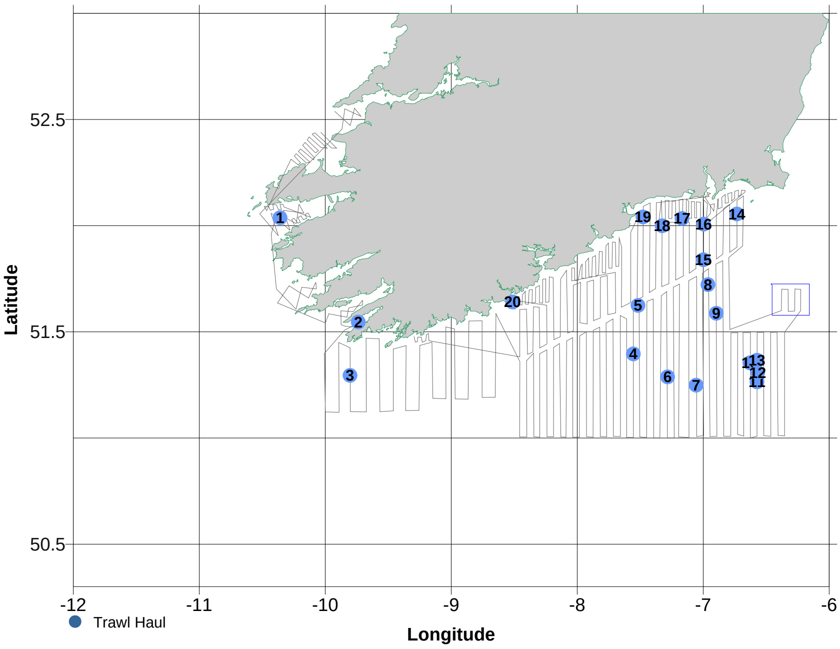


Figure 2.1.7. Annual area coverage during the CSHAS survey.

2.2.4 Boarfish acoustic survey (BFAS)

The BFAS was first carried out as a pilot survey in 2011 and was continued in 2012 onboard a commercial charter vessel. The survey is used to determine the distribution of abundance of spawning aggregations of boarfish within the core spawning areas to the west of Ireland and the Celtic Sea (Figure 2.1.8). The results of the survey are submitted annually to WGWIDE. Further details on the survey are provided in the survey cruise report (http://oar.marine.ie/handle/10793/822)

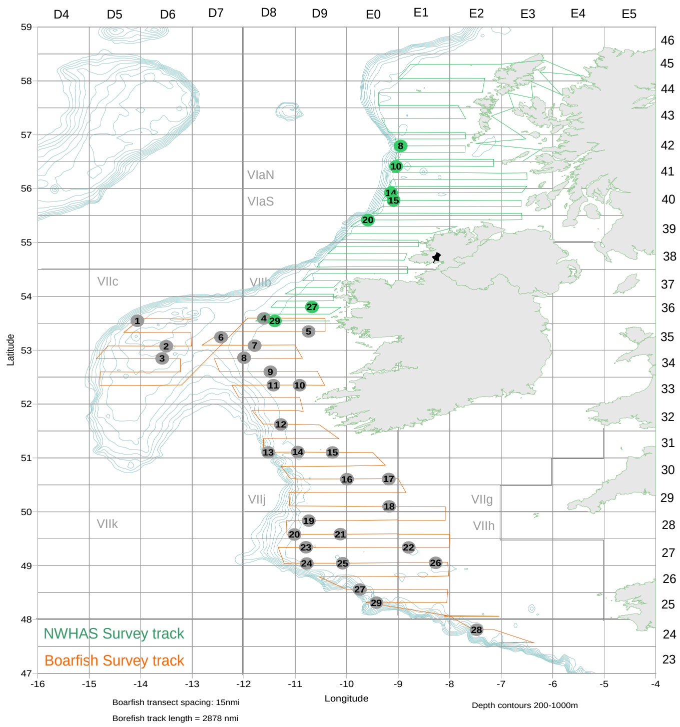


Figure 2.1.8. Area coverage during the BFAS survey.

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

The 2012 PELTIC survey, conducted by the RV Cefas Endeavour, is the first 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 2.1.9). The pelagic fish community is surveyed using a combination of fisheries acoustics and pelagic trawling. Comprehensive sampling of the plankton community was conducted at 70 stations, using 4 ringnets, each with different mesh sizes. Regular cast with a Rosette/CTD were also taken to provide high resolution oceanographic data on the water column.

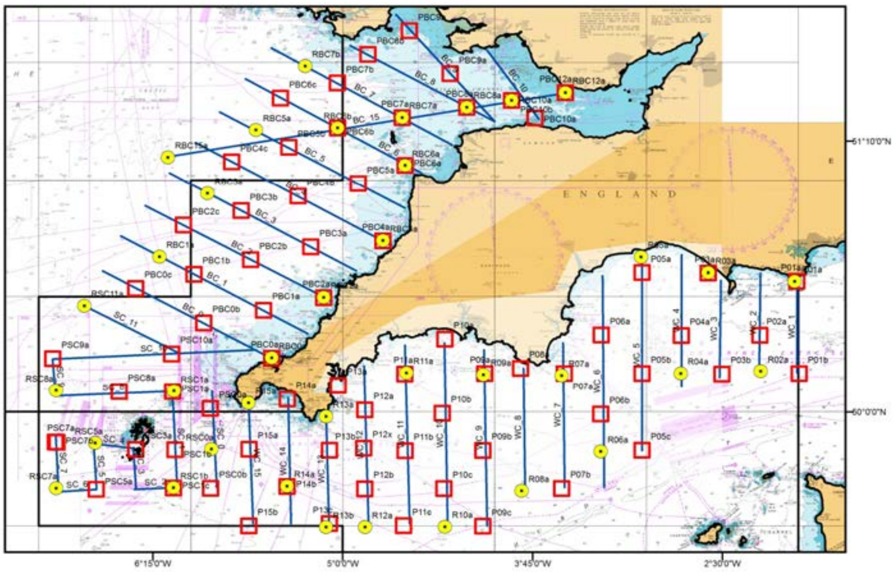


Figure 2.1.9. Area coverage during the PELTIC survey.

2.3 Survey design

Survey stratification is based on ICES statistical rectangles with a range of 0.5 degrees in latitude and 1 degree in longitude unless otherwise stated within the survey individual reports. Data reporting, in terms of resolution, should be to ICES statistical rectangle as a minimum for coordinated surveys.

Transect orientation and designs for coordinated and individual surveys are determined following methodologies outlined in McLennan and Simmonds (2005). Transect spacing for coordinated and individual surveys are decided by participants to provide best coverage and containment of the stock within the survey area.

Survey timing should remain consistent across years with as little variation as possible. Survey coordinators are tasked with the communication and organization of participants to ensure the temporal alignment of survey effort.

2.4 Survey planning and coordination

The main forum for the coordinated surveys is the post cruise meeting which is undertaken as close as possible to the end of the at-sea survey period.

Participants are asked to attend the meeting with the necessary information, quality checked, at national level for calculation of 'global' estimates from compiled data. Survey coordinators will define the deadlines for uploading of survey data to central databases and data reporting. The report provides detailed information of age disaggregated abundance, distribution and maturity of target species.

The whole assessment process from data retrieval from the database to the final accepted assessment should be transparent to all participants in the survey. The usual method where one participant runs an assessment programme on top of the survey data and reports it back to the group must be fully documented so it is possible to re-run the assessment (also by other participants). If the assessment process generates a new set of data (i.e. disaggregated data such as average s_A or biomass estimates per square or strata, as is currently done for HERAS in FishFrameAcoustic, see Section 7), such data should be part of the assessment documentation.

Survey planning should be carried out for the following year during the post cruise meeting for coordinated surveys. Preliminary plans should then be finalized during the WGIPS meeting for inclusion into the final report.

For planning purposes participants should provide details on the resources that they can offer for a survey to allow effective planning of the next survey. Details should include:

- Vessel(s)
- Vessel time (effective survey days)
- Possible/impossible dates and areas of operation
- Possibilities for sharing expertise through exchange of personnel

Other individual surveys should include planning details in the survey report for inclusion into the WGIPS report.

3 Acoustic measurements

3.1 Equipment

The standard equipment used for surveying is the Simrad EK60 operating a split-beam transducer at 38 kHz.

3.1.1 Acoustic equipment requirements for wider ecosystem surveys

Advanced dynamic models of ecosystem interactions, required by an ecosystem-based fishery management (EBFM), must be based on the analysis of the spatial and temporal distributions of key species in relation to predators, prey, and topographic and oceanographic features. Such an approach inevitably increases the monitoring data needs and poses considerable challenges to oceanographers and fishery scientists. Acoustic methods are among the most promising to meet these scientific challenges and increased data needs for the pelagic ecosystem, if used in conjunction with other oceanographic tools and appropriate models (Koslow, 2009). The acoustic frequencies best suited for detection of organisms in the size range from euphausids and large copepods to micronekton and nekton – approximately 12–333 kHz – are also able to sample effectively from 100 to 500 m through the water, depending on the frequency used. No other sampling tool can “see” through so much of the water column.

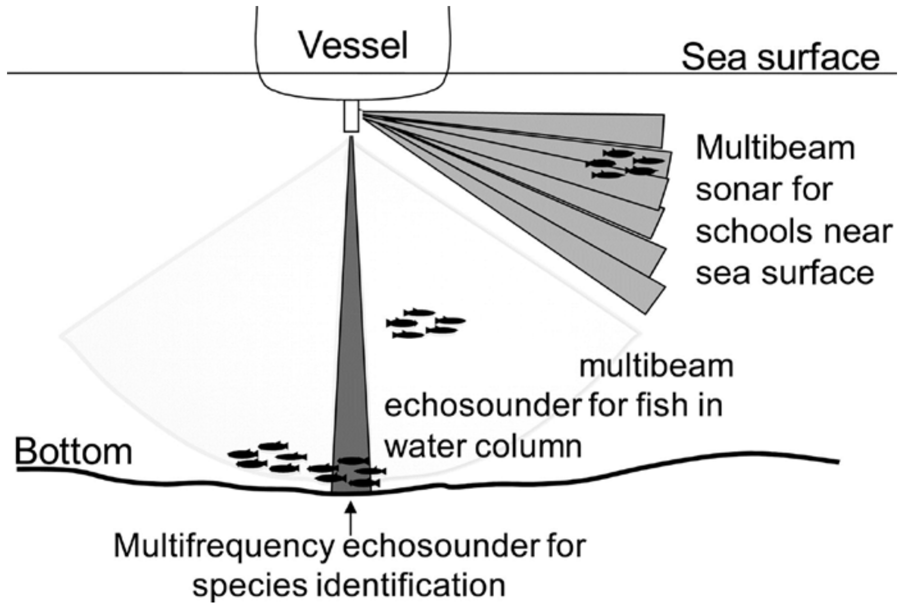
To fulfil the data needs for single species stock assessment models (abundance and biomass of target species at length and age), acoustic survey equipment requirements can be reduced to the bare minimum: a single-beam 38 kHz echosounder. However, in order to monitor the wider pelagic ecosystem, acoustic techniques employed during research surveys will have to be extended to the full potential. This essentially covers two fundamental aspects that will become more important:

(A) increase of data quantity in space and time;

(B) improved methods to remotely identify (additional) organisms;

Point (A) can be achieved by use of multibeam systems that can scan a far bigger water volume than the currently used single-beam systems. Point (B) can be achieved by multifrequency (or broadband) acoustic approaches to identify species. This means simultaneous use of more transducers operating at different frequencies (ideally 4 or more) spanning a wide as possible frequency range (e.g. from 18 kHz to

333 kHz). An illustration of an integrated approach combining several acoustic monitoring techniques is shown below:



Multibeam

Multibeam sonars have been developed to observe near-surface schooling fish that might otherwise avoid the vessel and acoustic detection. Viewing the schools in three dimensions, rather than two, enhances the study of school structure and behaviour. However, the sampling volume and the related data are increased by an order of magnitude compared with those of conventional vertically profiling sounders. These systems are generally deployed in conjunction with downwards-looking echosounders.

Multifrequency

Multifrequency acoustic systems are used to separate organisms with markedly different sound-scattering characteristics, based on their different reflectance at low and high frequencies. Examples of the types of organism successfully discriminated in this way include fish with swimbladders (e.g. herring), distinguished from euphausids, layers of copepods, small fish and large fish without swimbladders. Another technology providing "true multifrequency" data is broadband acoustics, allowing acoustic instruments to probe the environment over a continuous frequency band simultaneously.

3.2 Instrument settings

Some instrument settings do have a significant influence on acoustic measurements and have to be adjusted at the start of each survey (or compensated for in the post-processing of the data). Instrument settings and the acoustic capacity of participant vessels reporting through WGIPS are provided in Tables 3.1.1–3.1.5. It is vital that settings for the acoustic recording of survey data are the same as those used during the calibration.

Table 3.1.1. IBWSS participant vessels and acoustic capacity.

	Fridtjof Nansen	Celtic Explorer	G.O. Sars	Magnus Heinason	Tridens
Echo sounder	Simrad	Simrad	Simrad	Simrad	Simrad
	EK60	EK 60	EK 60	EK 60	EK 60
Frequency (kHz)	**38, 120**	**38,** 18, 120, 200	**38**, 18, 70, 120, 200, 333	**38,** 200	**38**
Primary transducer	ES38B	ES 38B	ES 38B - SK	ES38B	ES 38B
Pulse length (ms)	1.024	1.024	1.024	1.024	1.024
Power (W)	2000	2000	2000	2000	2000
Transducer installation	Hull	Drop keel	Drop keel	Hull	Towed body
Transducer depth (m)	4.5	8.7	8.5	3	7
Upper integration limit (m)	10	15	15	7	15
Maximum range (m)	750	750	750	750	750
Post-processing software	FAMAS	Myriax Echoview	MAREC LSSS	Myriax Echoview	MAREC LSSS

Table 3.1.2 IESNS participant vessels and acoustic capacity.

	Fridtjof Nansen	Dana	Johan Hjort	Magnus Heinason	Arni Friðriksson
Echo sounder	Simrad	Simrad	Simrad	Simrad	Simrad
	EK60	EK 60	EK 60	EK 60	EK 60
Frequency (kHz)	**38**, 120	**38,** 18, 120	**38**, 18, 70, 120, 200, 333	**38,** 200	**38,** 120
Primary transducer	ES 38B	ES 38P	ES 38B - SK	ES38B	ES 38B
Pulse length (ms)	1.024	1.024	1.024	1.024	1.024
Power (W)	2000	2000	2000	2000	2000
Transducer installation	Hull mounted	Towed Body	Drop keel	Hull	Hull mounted
Transducer depth (m)	7	3.5	8.5	3	7
Maximum range (m)	750	500	500	750	750
Post-processing software	FAMAS	MAREC LSSS / EchoN	MAREC LSSS	Myriax Echoview	MAREC LSSS

Table 3.1.3. IESSNS participant vessels and acoustic capacity.

	G.O. Sars	Arni Friðriksson	Brennholm	Christian í Grótinum
Echo sounder	Simrad	Simrad	Simrad	Simrad
	EK 60	EK 60	EK 60	EK 60
Frequency (kHz)	**38**,18, 70, 120, 200, 333	**38**, 18, 120, 200	**38**,18, 70, 120, 200	**38**, 120,200
Primary transducer	ES 38B	ES 38B	ES 38B	ES 38B
Pulse length (ms)	1.024	1.024	1.024	1.024
Power (W)	2000	2000	2000	2000
Transducer installation	Drop keel	Drop keel	Drop keel	Hull mounted
Transducer depth (m)	9	8	6	5
Maximum range (m)	500	750	750	500
Post-processing software	MAREC LSSS	MAREC LSSS	MAREC LSSS	Myriax Echoview

Table 3.1.4. HERAS participant vessels and acoustic capacity.

	Scotia	SOLEA	Celtic Explorer	Tridens	Johan Hjort	Dana
Echo sounder	Simrad	Simrad	Simrad	Simrad	Simrad	Simrad
	EK 60	EK 60	EK 60	EK 60	EK 60	EK 60
Frequency (kHz)	**38**, 18, 120, 200	**38**, 120	**38**, 18, 120, 200	**38**	**38**, 18, 70, 120, 200, 333	**38**, 18, 120
Primary transducer	ES 38B	ES 38B	ES 38B	ES 38B	ES 38B - SK	ES 38P
Pulse length (ms)	1.024	1.024	1.024	1.024	1.024	1.024
Power (W)	2000	2000	2000	2000	2000	2000
Transducer installation	Drop keel	Hull mounted	Drop keel	Towed body	Drop keel	Towed Body
Transducer depth (m)	8.5	4	8.7	7	8.5	3.5
Maximum range (m)	250	150	250	250	500	500
Post-processing software	Myriax Echoview	Myriax Echoview	Myriax Echoview	Myriax Echoview	MAREC LSSS	Myriax Echoview / EchoN

Table 3.1.5. Individual acoustic survey vessels and acoustic capacity.

	SOLEA	Celtic Explorer	Celtic Explorer	Corystes	Cefas Endeavour
Survey	Western Baltic	CSHS	BFAS	Irish Sea	PELTIC
Echo sounder	Simrad	Simrad	Simrad	Simrad	Simrad
	EK 60	EK 60	EK 60	EK 60	EK 60
Frequency (kHz)	**38,** 120	**38,** 18, 120, 200	**38,** 18, 120, 200	**38,** 120	**38,** 120, 200
Primary transducer	ES 38B	ES 38B	ES 38B	ES 38B	ES 38B
Transducer installation	Hull mounted	Drop keel	Drop keel	Hull	Drop keel
Transducer depth (m)	4	8.7	8.7	4.5	8.7
Maximum range (m)	150	250	500	300	150
Post-processing software	Myriax Echoview	Myriax Echoview	Myriax Echoview	Myriax Echoview	Myriax Echoview

Consequently, information about transducer gain and sA correction settings have to be determined through calibration (see Section 3.3).

It is recommended that regular recordings of these settings are undertaken, to create a log of the main functionality of the acoustic measuring system.

It is also recommended that each year the same settings (Min Sv = -60dB) are used for the printer in order to facilitate comparison of echogram.

The Elementary Distance Sampling Unit (EDSU) is the length of cruise track, where acoustic measurements are averaged to give one sample. The majority of surveys reporting through WGIPS use an EDSU of 1nmi (nautical mile).

The ping rate should be set according to the local circumstances. Due to the nature of the measuring unit (i.e. the nautical area scattering coefficient; see Section 6.2), changing the ping rate does not affect the accuracy of the measured fish densities. However, to obtain a consistent number of pings per distance sampling unit, a fixed ping rate should be chosen. Setting the ping rate to "maximum" would result in varying different numbers of pings per EDSU, depending on the water depths. Thus, an optimal fixed ping rate will keep data quantity within acceptable limits and avoid secondary seabed echoes contaminating the recordings in deep water. Usually, values of $1s^{-1}$ or higher are chosen for surveys in shelf seas shallower than 200m, while lower ping rates should be used in deeper waters.

3.3 Calibration

The calibration of transducers must be conducted at least once during the survey using the same settings as during data collection. If possible, the transducer should be calibrated both at the beginning and the end of the survey. Calibration procedures are described in "Simrad ER60 Scientific echo sounder reference manual". (http://www.simrad.com/www/01/NOKBG0397.nsf/AllWeb/F2AB311B3F6E6B15C1257106003E0806/$file/164692ad_ek60_reference_manual_english_lores.pdf).

A table of calibration results should be included in all national survey reports and made available if requested for inclusion into coordinated surveys.

3.4 Intercalibration

During coordinated surveys using multiple vessels collecting acoustic and biological data in the same area it is recommended that acoustic and trawl intercalibrations are carried out following methods detailed in MacLennan and Simmonds (2005).

An example of reporting structure for intercalibrations is provided from the IBWSS survey report (http://hdl.handle.net/10793/844)

4 Trawl sampling

4.1 Trawl gear

Proper species allocation of the acoustic records cannot be guaranteed if no corresponding biological information from trawling is available. The principal objective is to obtain a sample from the school or the layer that appears as an echotrace on the sounder by means of directed trawling. During trawling it is important to take note of the traces on the echo sounder and the netsonde in order to judge if the target-school entered the net or if some other traces contaminate the sample. If a target is missed during a haul, the catch composition should not be used for species allocation.

Directed trawling on insonified echotraces using a single pelagic midwater trawl is the main method of collecting biological data during WGIPS surveys. This type of trawl allows sample collection of midwater echotraces as well as those occurring close to the bottom.

As no standardized single pelagic midwater trawl exists for the majority of WGIPS surveys, a range of trawls of different dimensions are employed. The type of midwater trawl must be deemed suitable to catch a qualitatively representative sample of the target-school or layer.

As the IESSNS survey reports abundance by means of swept-area methods (non-directed trawling at predetermined locations) a standardized single pelagic midwater trawl is used.

The details of trawls used in coordinated and national survey programs are reported in the Annex's of the WGIPS annual report:

http://www.ices.dk/workinggroups/ViewWorkingGroup.aspx?ID=429

4.2 Biological sampling

4.2.1 Species composition

The first step of trawl catch analysis is to determine species composition. This can be carried out by separating the catch into species components by weight and number either by exhaustive sampling, subsampling (raising to the total catch) or by a combination of both. If the catch contains specimens which differ significantly from the main catch, e.g. by size or low abundance, these may be set aside from the total catch, before handling the remaining catch.

Second step is to record biological parameters of the target species within the catch (length, age, sex, sexual maturity and individual weight measurements). Biological variables routinely collected for each survey are listed in Table 4.2.1.

Table 4.2.1. Sampling levels for target species by survey. O=otoliths, S=scales, L=length, M=maturity, G=gender.

	IBWSS	IESNS	HERAS	IESSNS	BIAS	Irish Sea	PELTIC	CSHAS	BFAS
Herring	-	SOLMG	OLMG	OLMG	OLMG	OLMG	OLMG	OLMG	OLMG
Sprat	-	-	OLMG	-	OLMG	OLMG	OLMG	LMG	LMG
Blue whiting	OLMG	OLMG	-	OLMG	-	-	-	LMG	LMG
Boarfish	-	-	-	-	-	-	-	LMG	OLMG
Mackerel	-	OL	-	OLMG	-	-	OLMG	LMG	LMG
Horse mackerel	-	-	-	-	-	-	OLMG	LMG	LMG
Sardine	-	-	-	-	-	-	OLMG	OLMG	OLMG
Anchovy	-	-	-	-	-	-	OLMG	OLMG	OLMG

4.2.2 Length measurements

The length measured should be the total length of the fish as shown in Figure 4.2.1 below, rounding down towards the nearest length interval. Clupeid and boarfish measurements are typically recorded to the nearest 0.5 cm below and other species to the whole cm below although some participants will measure other species at the higher resolution.

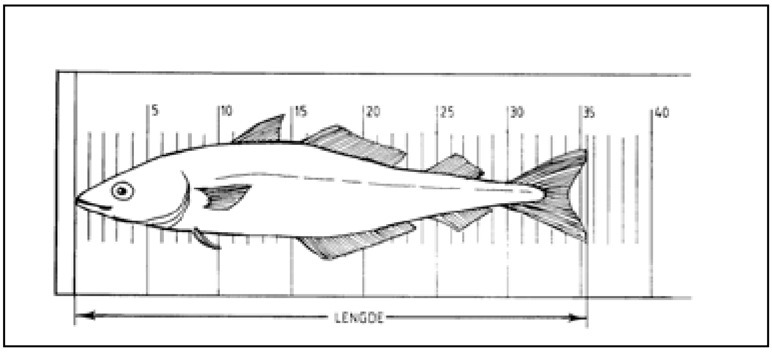


Figure 4.2.1. Total length measurement of fish.

Mackerel is measured with the tip of the caudal fin stretched backwards as shown in Figure 4.2.2.

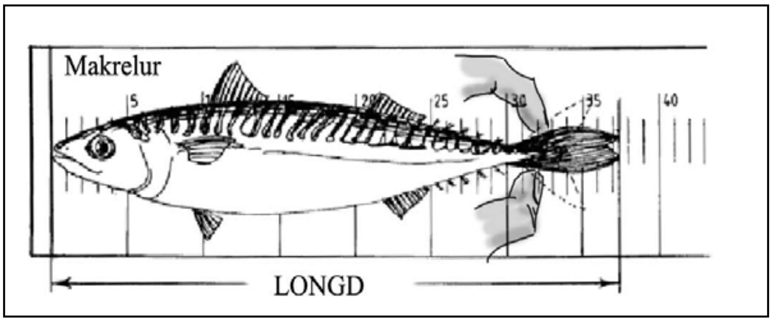


Figure 4.2.2. Total length measurement of mackerel.

4.2.3 Maturity analysis

Maturity should be determined by experienced personnel to internationally accepted standards and where possible following recommendations from ICES species-specific maturity workshops. Within each coordinated survey it is recommended that the participating institutes agree on the maturity scales used for each species. If different scales are used there should be agreement on how to convert between them.

4.2.4 Age sampling

Age determination is done by reading winter growth rings on the sagittal otoliths or in the case of Norwegian Spring-spawning herring, scales. Aging may be done onboard using standard procedure for otolith or scale reading or they may be examined at a later stage in the institute laboratories. Age reading protocols used should again be agreed among institutes participating in each survey and should follow recommendations from the latest advice from the most recent exchange for each species:

http://www.ices.dk/reports/acfm/pgccdbs/PGCCDBSdocrepository.asp

5 Hydrographic sampling

5.1 Hydrographic data

Temperature, salinity and oxygen content in the water column should be measured with a CTD probe either at predetermined positions or at least in connection with each haul.

For the IBWSS, IESNS and IESSNS surveys the positions for CTD stations are predetermined by the survey coordinator and CTD stations are taken down to a maximum depth of 1000m.

Participants are encouraged to ensure if no water samples are collected for validation purposes that the sensor suite is calibrated annually.

5.2 Plankton sampling

For the IESNS and IESSNS surveys plankton are sampled at predetermined positions by WP2 nets with 180 or 200 µm mesh size and 56 cm aperture. The net is hauled vertically from 200 m or the bottom to the surface at a speed of 0.5 m s^{-1}.

For the IBWSS, IESNS and IESSNS surveys the positions for WP2 stations are predetermined by the survey coordinator.

5.3 Ichthyoplankton sampling

With regard to clupeid larvae in the North Sea and adjacent waters, an internationally coordinated larvae sampling program exists under the auspices of ICES since 1972. The survey covers the main spawning grounds of autumn and winter spawning herring in the North Sea. For the International Herring Larvae Surveys (IHLS) there is a dedicated manual available. This manual is updated whenever needed; last time in 2010. The manual is available from the WGIPS report 2010 (ICES, 2010).

5.4 Other

If possible, continuous underway measurements of surface temperature and salinity as well as metrological parameters such as wind direction and windspeed should be collected and stored.

6 Data analysis

6.1 Target strengths

The target strength to length relationships applied during the analysis of survey data are listed in Table 6.1.1.

Participants are encouraged to collect *in-situ* TS measurements of target species where it is possible during surveys.

Table 6.1.1. Species-specific target strength to length relationships.

Species	Target Strength	Reference
Blue whiting	TS = 20 log10 (L) - 65.2	Pedersen et al. 2011
Herring	TS = 20 log10 (L) - 71.2	ICES, 1982
Herring (ASH)	TS = 20 log10 (L) - 71.9	Foote, 1987
Sprat	TS = 20 log10 (L) - 71.2	ICES, 1982
H. mackerel	TS = 20 log10 (L) - 67.5	Foote, 1987
Anchovy	TS = 20 log10 (L) - 71.2	ICES, 1982
Pilchard	TS = 20 log10 (L) - 71.2	ICES, 1982
Mackerel	TS = 20 log10 (L) - 84.9	Edwards et al., 1984
Boarfish	TS = 20 log10 (L) - 66.24	Fässler *et al.*, 2012
Physoclist	TS = 20 log10 (L) - 67.5	Foote, 1987

6.2 Scrutinisation

The process of echogram scrutinisation, i.e. the allocation of nautical area scattering coefficient (acronym: NASC; symbol: s_A) values to species, is primarily a subjective process that should be carried out by an experienced expert. This person will have to be familiar with the scrutinisation process, the survey area and the target species. Species may vary greatly in the way in which they aggregate and temporal and geographical features specific to the situation need to be taken into account (Figures 6.2.1. and 6.2.2.).

Given the potential sources of error associated with the scrutinisation process, it is preferable to have additional information available. This information may be obtained from targeted trawling, multi-frequency acoustic data or known behavioural characteristics of the target species. The use of trawling information should be treated with caution, as gear catchability may differ between species. One has to judge whether the catch-composition is a true reflection of the real species composition of the logged school/layer data and whether the allocated percentage species composition can be justified.

In light of the increased data need as a consequence of surveying the wider ecosystem, an effort will have to be made to scrutinize as many species as possible. Methods of determining species allocation are often highly specific to the survey being undertaken. The method used depends largely upon the schooling behaviour of the target species, and the mixing with other species. For example, in the North Sea and Division VIa the species allocation is based mainly on the identification of individual schools on the echogram. In the Skagerrak-Kattegat area and southern North Sea, the identification is based on the composition of trawl catches. A few typical target species echograms are shown below.

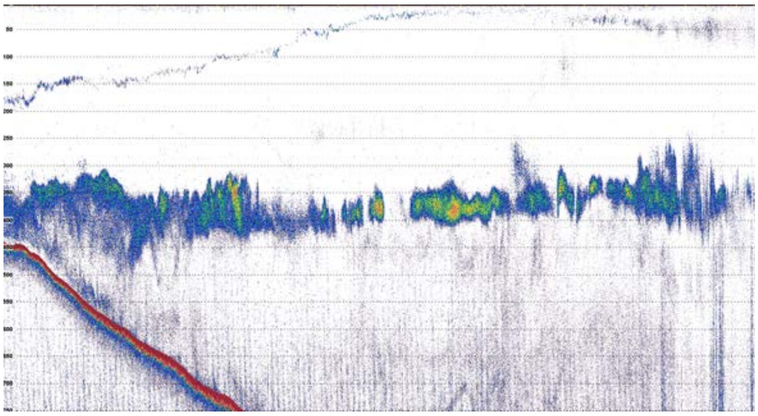


Figure 6.2.1. An example of a typical blue whiting echotrace from the IBWSS. Frequency: 38 kHz; threshold: -70dB.

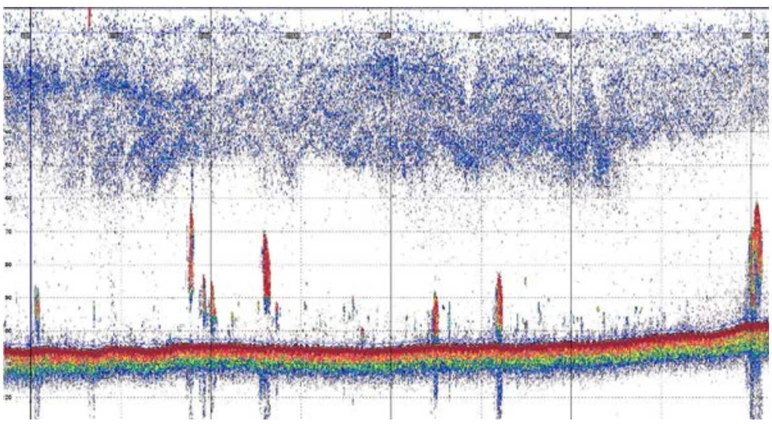


Figure 6.2.2. Example of a typical herring echotrace from HERAS. Frequency: 38 kHz; threshold: -70dB.

Primarily, decisions made during the scrutinising process will be based on subjective criteria. However, joint sessions of scientists scrutinising each other's data has shown that their estimated quantities of herring were within a range of 10%, if the acoustic data has adequate trawl information to go with it (Reid *et al.*, 1998).

Some of the factors that may facilitate the decision-making process include visual clues in the echograms, consulting historical echograms of the same species/area, removal of unwanted echoes by lowering the threshold, composition of trawl catches, and comparing echoes from different frequencies if available. It is often useful to look at observations over an extended period of time/distance, as patterns may emerge that help in making a decision on the allocation of species.

At the end of the scrutinisation process it is also important to exclude invalid acoustic data that cannot and/or must not be used for further analysis. This includes data recorded during shooting/hauling of the net, trawling or CTD operations or while steaming between transect lines. If this is not done, resulting biomass estimates may be overestimated. Equally, areas containing 'bad data' such as lost pings or noise caused by air bubbles in bad weather, which can contaminate potential fish traces, may need to be filtered out.

6.3 Software

Of the several commercially available post-processing software packages, Echoview (http://www.echoview.com/) and the Large Scale Survey System, known as LSSS (http://www.marec.no/) are the most commonly used within the group.

User manuals containing full details are available through the links provided.

6.4 Abundance estimation

This section describes the calculation of numbers and biomass by species from the echo integrator data and trawl data. From Simmonds *et al.* (1992).

The symbols used in this section are defined in the text but for completeness they have been collated and are given below:

F_i	estimated area density of species i
K	equipment physical calibration factor
$<\sigma_i>$	mean acoustic cross-section of species i
E_i	partitioned echo-integral for species i
E_m	echo-integral of a species mixture
c_i	echo-integrator conversion factor for species i
TS	target strength
TS_n	target strength of one fish
TS_w	target strength of unit weight of fish
a_i, b_i	constants in the target strength to fish length formula
a_n, b_n	constants in formula relating TS_n to fish length
a_w, b_w	constants in formula relating TS_w to fish length
a_f, b_f	constants in the fish weight-length formula
L	fish length
W	weight
L_j	fish length at midpoint of size class j
f_{ij}	relative length frequency for size class j of species i
w_i	proportion of species i in trawl catches
A_k	area of the elementary statistical sampling rectangle k
Q	total biomass
Q_i	total biomass for species i

The objective is to estimate the density of targets from the observed echo integrals. This may be done using the following equation from Foote *et al.* (1987):

$$F_i = \left(\frac{K}{<\sigma_i>}\right)E_i \qquad \textbf{(1)}$$

The subscript i refers to one species or category or target. K is a calibration factor, $<\sigma_i>$ is the mean acoustic cross section of species i, E_i is the mean echo integral after partitioning and F_i is the estimated area density of species i. The quantity is the number or weight of species i, depending on whether σ_i is the mean cross section per fish or unit weight. $c_i = (K/<\sigma_i>)$ is the integrator conversion factor, which may be different for each species. Furthermore, c_i depends upon the size-distribution of the insonified target, and if this differs over the whole surveyed area, the calculated conversion factors must take the regional variation into account.

K is determined from the physical calibration of the equipment, which is described in Section 1 above. K does not depend upon the species or biological parameters. Several calibrations may be performed during a survey. The measured values of K or the settings of the EK60 may be different but they should be within 10% of each other. If two successive measurements are very different the cause should be investigated since the equipment may be malfunctioning. Otherwise, K should be taken as the average of two measurements before and after the relevant part of the survey.

Conversion factors for a single species

The mean cross section $<\sigma_i>$ should be derived from a function which describes the length-dependence of the target-strength, normally expressed in the form:

$$TS = a_i + b_i Log_{10}(L) \qquad \textbf{(2)}$$

Where a_i and b_i are constants for the i'th species, which by agreement with the other participants in the survey are given in Table 6.1.1

The equivalent formula for the cross section is:

$$\sigma_i = 4\pi 10^{\left(\left(a_i + b_i Log(L)\right)/10\right)} \qquad \textbf{(3)}$$

The mean cross section is calculated as the σ average over the size distribution of the insonified fish. Thus L_j is the midpoint of the j'th size class and f_{ij} is the corresponding frequency as deduced from the fishing samples by the method described earlier. The echo integrator conversion factor is $c_i = K/<\sigma_i>$. The calculation may be repeated for any species with a target strength function.

$$<\sigma_i> = 4\pi \sum_j f_{ij} 10^{\left(\left(a_i + b_i Log(L_j)\right)/10\right)} \qquad \textbf{(4)}$$

Note that it is the cross section that is averaged, not the target-strength. The arithmetic average of the target-strengths gives a geometric mean, which is incorrect. The term "mean target-strength" may be encountered in the literature, but this is normally the target-strength equivalent to $<\sigma_i>$, calculated as $10\log_{10}(<\sigma_i>/4\pi)$. Some authors refer to TS as 10 $\log(\sigma_{bs})$ the definition of σ is different from σ_{bs} and should not be confused.

Conversion factors for mixed species layers or categories

Sometimes several species are found in mixed concentrations such that the marks on the echogram due to each species cannot be distinguished. From inspection of the echogram, the echo integrals can be partitioned to provide data for the mixture as one category, but not for the individual species. However, further partitioning to species level is possible by reference to the composition of the trawl catches (Nakken and Dommasnes, 1975).

Suppose E_m is the echo integral of the mixture, and w_i is the proportion of the i'th species, calculated from fishing data. It is necessary to know the target-strength or the acoustic cross section, which may be determined in the same manner as for single species above. The fish density contributed by each species is proportional to w_i. Thus the partitioned fish densities are:

$$F_i = \frac{w_i K}{(\sum_i w_i < \sigma_i >)} E_m \tag{5}$$

The w_i may be expressed as the proportional number or weight of each species, according to the units used for $<\sigma_i>$ and c_i. Consistent units must be used throughout the analysis, but the principles are the same whether it is the number of individuals or the total weight that is to be estimated.

Using weight-length relationships

The abundance is expressed either as the total weight or the number of fish in the stock. When considering the structure of the stock, it is convenient to work with the numbers at each age. However, an assessment of the commercial fishing opportunities would normally be expressed as the weight of stock yield. Consistent units must be used throughout the analysis. Thus if the abundance is required as a weight while the target-strength function is given for individual fish, the latter must be converted to compatible units. This may be done by reference to the weight-length relationship for the species in question.

For a fish of length L, the weight W is variable but the mean relationship is given by an equation of the form:

$$W = a_f L^{b_f} \tag{6}$$

Where a_f and b_f are taken as constants for one species. However, a_f and b_f could be considered as variables varying differently with stock and time of year as well as species. Suppose the target-strength of one fish is given as:

$$TS_n = a_n + b_n \log_{10}(L) \tag{7}$$

The corresponding function TS_w, the target-strength of unit weight of fish has the same form with different constants:

$$TS_w = a_w + b_w \log_{10}(L) \tag{8}$$

The number of individuals in a unit weight of fish is (1/W), so the constant coefficients are related to the formulae:

$$b_w = b_n - 10b_f \tag{9}$$

$$a_w = a_n - 10\log_{10}(a_f) \tag{10}$$

Abundance estimation

So far the analysis has produced an estimate of the mean density of the insonified fish, for each part of the area surveyed, and for each species considered. The next step is to determine the total abundance in the surveyed area. The abundance is calculated independently for each species or category of target for which data have been obtained by partitioning the echo integrals. The calculations are the same for each category:

$$Q_i = \sum_{k=1}^{n} A_k F_i \tag{11}$$

The total biomass for all species is:

$$Q = \sum_i Q_i \tag{12}$$

The F_i are the mean densities and A_k are the elements of the area that have been selected for spatial averaging. The may be calculated from the shape of an area or measured, depending upon the complexity of the area. The presence of land should be taken into account, possibly by measuring the proportions of land and sea.

7 Data exchange and database

Currently, two types of database are used by WGIPS coordinated surveys as a repository for acoustic, biological and hydrographic data. Both databases are accessible online and the data stored within are analysed to provide the estimates of abundance for the target species involved.

7.1 WGNAPES database

Overview and exchange format

At the PGSPFN meeting in Bergen 2001 the group agreed to set up a common database for the data collected in the 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 web server (Oracle 10g express edition) was set up at "Faroe Marine Research Institute" The coordinated surveys of the IBWSS and IESSNS groups 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 fit right into the central database on the Internet.

Data files can be interchanged between the vessels using the *.csv format (comma-separated-values) with tables arranged as described by the WGNAPES database format.

Complete national cruise databases in Access format (*.mdb) are submitted to the Faroe Marine Research institute when all data are produced.

Internet access to the data:

Data are stored in an Oracle 10g Express edition database (freeware). The database server is based at the "Faroe Marine Research Institute" (FAMRI), Tórshavn, Faroe Islands.

By executing SQL queries through the Application Express web-interface, the user can extract data in any form.

URL: http://oracle.frs.fo/apex

Usernames and passwords are given to every nation participating in the surveys. User access is limited to select data from the database.

Insert, update and delete operations can only be performed by the schema owner (Database_owner).

7.2 FishFrame database

Since 2007, WGIPS has been using FishFrameAcoustic as the groups' standard database for basic, disaggregated fisheries and acoustics data (stage 1 data) and aggregated national data (stage 3 data) from the HERAS survey.

FishFrameAcoustic is at the moment hosted by DTU-Aqua and accessed through the web page:

http://dmz-web08.dfu.min.dk/NorthSea/FishFrame/ and the user's manual is given on web page:

http://dmz-web08.dfu.min.dk/NorthSea/FishFrame/Info/Documentation/FishFrame%20user%20manual.pdf

WGIPS use FishFrameAcoustic as a tool to derive global estimates from national, aggregated data (stage 3 data).

8 References

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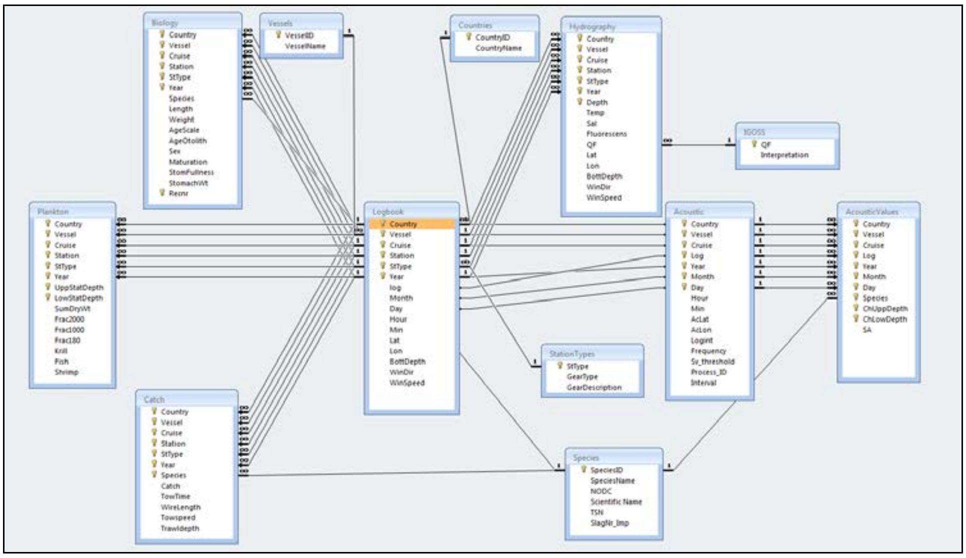
Annex 1: WGNAPES database

Table 8.2.1.1. WGNAPES access database constraints.



Parameters in **bold** indicate primary key variables, and used together they form a unique key from the logbook to the other sheets, except to the acoustic table. The acoustic table can be linked to the logbook by the cruise identifier together with country, vessel, Cruise, log, year and month.

Logbook:

Country	Post code, 2 chars according to countries table
Vessel	Call sign, 2 or 6 digits acc. to Vessels table
Cruise	Cruise identifier
Station	National station number
StType	Geartype/activity: one line per activity at the same station: National definition of station type
Year	YYYY (4 digits)
Log	Value from the acoustic log (Nm)
Month	MM
Day	DD
Hour	HH, time GMT 0-24
Min	MM

Lat	Decimal degrees, negative latitude south 0° ”0.0000”
Lon	Decimal degrees, negative longitude west of 0° “0.0000”
BottDepth	Bottom depth (m)
WinDir	Compass degrees
WinSpeed	m/s

Acoustic:

Country	Post code, 2 chars according to countries table
Vessel	Call sign, 2 or 6 digits acc. to Vessels table
Cruise	Cruise identifier
Log	Min 4 digits (Nm)
Year	YYYY (4 digits)
Month	MM
Day	DD
Hour	HH, time GMT 0-24
Min	MM
AcLat	Decimal degrees, negative latitude south 0° “0.0000” The position refers to the beginning of the interval.
AcLon	Decimal degrees, negative longitude west of 0° “0.0000” The position refers to the beginning of the interval.
Logint	Nm, Log_end-Log start
Frequency	KHz
Sv.Threshold	DB

AcousticValues:

Country	Post code, 2 chars according to countries table
Vessel	Call sign, 2 or 6 digits acc. to Vessels table
Cruise	Cruise identifier
Log	Min 4 digits (Nm)
Year	YYYY (4 digits)
Month	MM
Day	DD
Species	Species code: HER, BLU,…
ChUppDepth	Upper channel depth (m) Rel. to surface
ChLowDepth	Lower channel depth (m) Rel. to surface
SA	Acoustic readings (m^2/nm^2)

Hydrography:

Country	Post code, 2 chars according to countries table
Vessel	Call sign, 2 or 6 digits acc. to Vessels table
Cruise	Cruise identifier
Station	National station numbers
StType	Geartype/activity: National definition of station type
Year	YYYY (4 digits)
Depth	Depth of measurement (m)
Temp	°C (at least 2 decimals)
Sal	Salinity (psu, at least 3 decimals)
QF	Quality of salinity data: 0-5 (IGOSS quality flags)
Fluorescens	Volt

Plankton:

Country	Post code, 2 chars according to countries table
Vessel	Call sign, 2 or 6 digits acc. to Vessels table
Cruise	Cruise identifier
Station	National station numbers
StType	Geartype/activity: National definition of station type
Year	YYYY (4 digits)
UppStatDepth	Upper station depth (m)
LowStatDepth	Lower station depth (m), if only one depth then same as upper
SumDryWt	Plankton mg dry weight/m^2 in each interval
Frac2000	Size graded values, 2000 my sieve
Frac1000	1000 my sieve
Frac180	180 my sieve
Krill	From 2000 my sieve
Fish	-"-
Shrimp	-"-

Catch:

Country	Post code, 2 chars according to countries table
Vessel	Call sign, 2 or 6 digits acc. to Vessels table
Cruise	Cruise identifier
Station	National station numbers
StType	Geartype/activity: National definition of station type
Year	YYYY (4 digits)
Species	Species code: HER, BLU,…
Catch	Kg

Towtime	Minutes
Wirelength	(m)
TowSpeed	Knots
Trawldepth	(m)

Biology:

Country	Post code, 2 chars according to countries table
Vessel	Call sign, 2 or 6 digits acc. to Vessels table
Cruise	Cruise identifier
Station	National station numbers
StType	Geartype/activity: National definition of station type
Year	YYYY (4 digits)
Species	Species code: HER, BLU,…
Length	Cm with one decimal (dot as decimal sign)
Weight	G
AgeScale	Year from scale readings
AgeOtholit	Year from otolith
Sex	Empty means not sexed, 1= Female, 2= Male, 0= not possible to determine sex
Maturation	Maturation scale: Herring 1-8, Blue whiting 1-7
StomFullness	Stomach fullness, visual scale 1-5 (ICES)
StomachWt	Weight of stomach with content (g)
Recnr	Serial number identifying the fish

Supporting tables:

Countries:

CountryID	Postal code:FO,DE,NL,NO,IS,RU,SE,IE,DK
Countryname	Countryname

Values in Countries table:

CountryId	Countryname
FO	Faroe Islands
DE	Germany
NL	Netherlands
NO	Norway
IS	Iceland
RU	Russia
SE	Sweden
IE	Ireland
DK	Denmark

Vessels:

VesselID	Callsign
Vesselname	Vesselname

Values in Vesseltable:

VESSELID	VESSELNAME
LJBD	Nybo
LIWG	Brennholm
DBFR	Walter Herwig III
EIGB	Celtic Explorer

LDGJ	Johan Hjort
LHUW	Michael Sars
LLZG	G.O. Sars (old)
LMEL	G.O.Sars (new)
OW2252	Magnus Heinason
OXBH	Dana
PBVO	Tridens
SEPI	Argos
TFEA	Bjarni Sæmundsson
TFJA	Arni Fridriksson (old)
TFNA	Arni Fridriksson
UANA	Fritjof Nansen
UFJJ	Smolensk
UHOB	Atlantniro
UALU	Atlantida
XPXP	Finnur Fríði
OW2140	Christian í Grótinum
TFLF	Hoffell
LIVA	EROS
LMOG	Gardar
LMQI	Libas

IGOSS:

QF	Quality Flag
Interpretation	Interpretation

Species:

SpeciesID	3 character code
SpeciesName	Species name in English
NODC	NODC-code
Scientific name	Scientific name latin
Name_NO	Norwegian Name

Gear:

STtype	Geartype/activity: National definition of station type
GearType	PLANKTON,CTD, or TRAWL (mandatory)
Geardescription	Informative desription of gear

Example of data export from Access

To make exports from the base will ensure that data exported are ready to import into the other participants databases.

Exporting plankton, hydrography, biology, or catch data always implies the export of the logbook table as it is the parent table of these underlying tables.

Exporting acoustic values always implies the export of the Acoustic tables as the acoustic table is a parent table of the acousticvalues table.

Is important to have the structure of the database in mind when exporting and supplying other participants with exported data.

Exporting data from access:

Mark the table you want to export (Figure A)

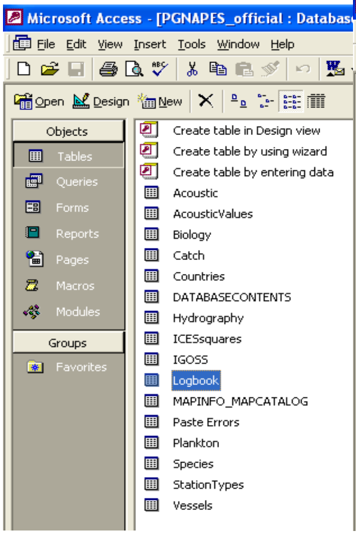
Go to File/export (Figure B)

Save as "TEXT format, supply file name

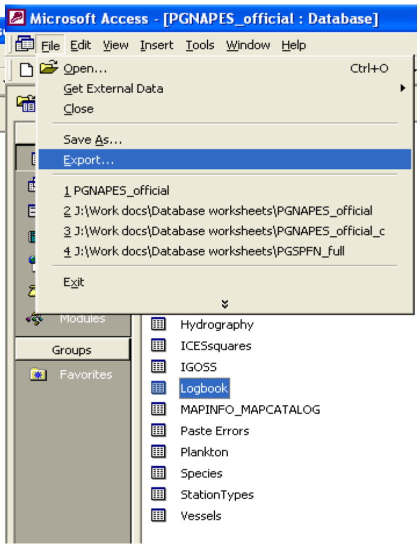
Save as delimited

Make sure it is comma delimited (Figure C), and include Fields Names on first row is tagged (Figure D)

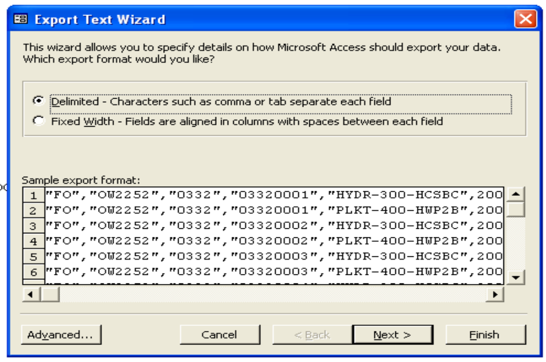
Press finish

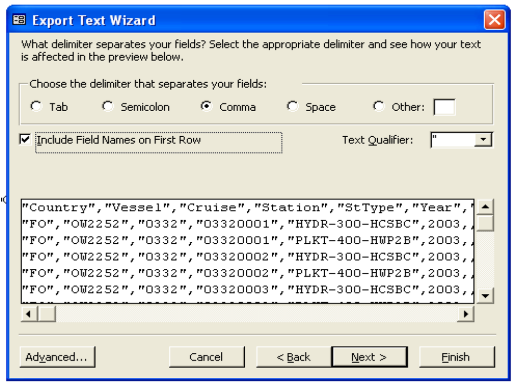


A



B





C D

The file format is ordinary *ASCII*-format. The data values within the files are arranged as Comma-Separated-Values (*.csv) as shown in the example below.

"Country","Vessel","Cruise","Station","StType","Year","log","Month","Day","Hour","Min","Lat","Lon","BottDepth","WinDir","WinSpeed"

"FO","OW2252","0332","03320001","HYDR-300-HCSBC",2003,,5,3,1,11,61.83,-7.00,77,45,15

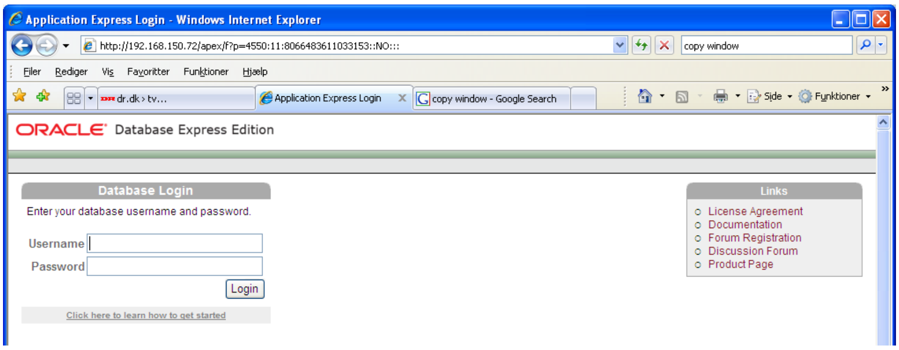
"FO","OW2252","0332","03320001","PLKT-400-HWP2B",2003,,5,3,1,45,61.83,-7.00,77,45,15

"FO","OW2252","0332","03320002","HYDR-300-HCSBC",2003,,5,3,3,20,61.66,-7.30,130,45,15

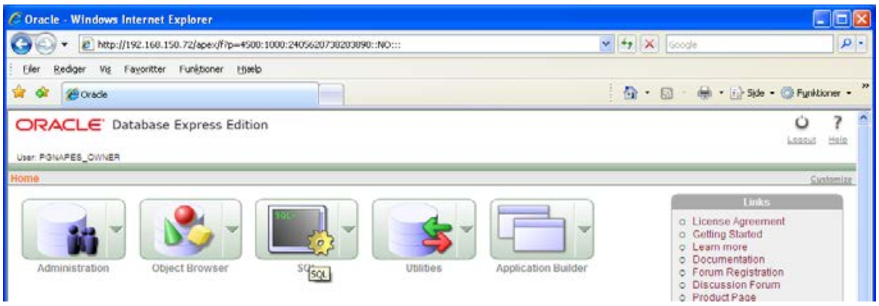
Internet access to the data:

URL: *http://oracle.frs.fo/apex*

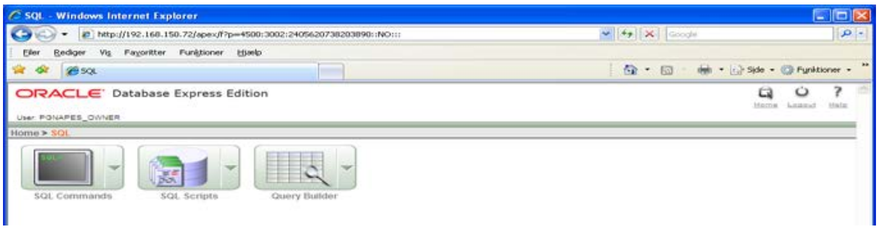
Log in on first page:



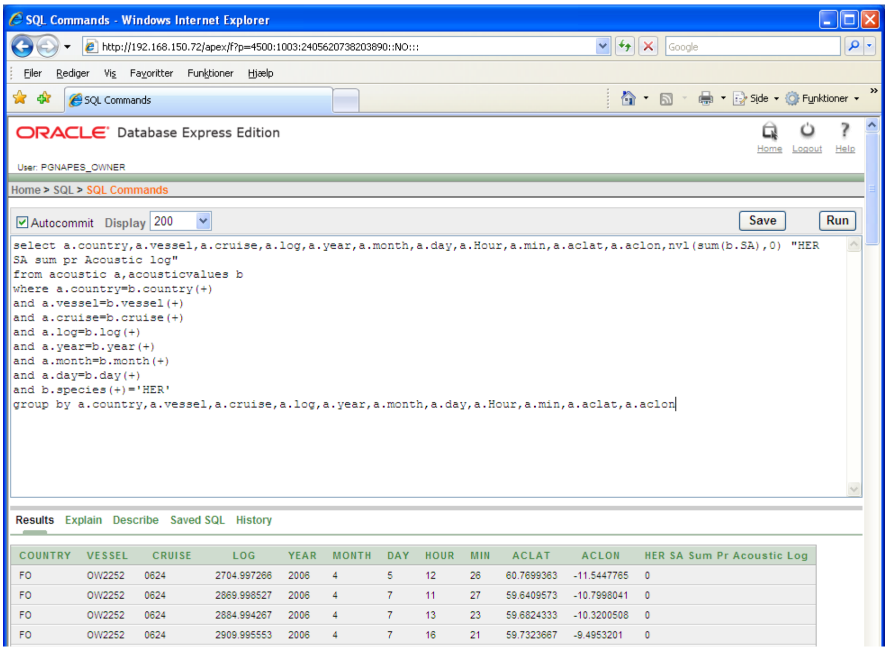
Select the SQL button



Select the SQL Commands button



Write or paste your SQL statement into the SQLtext box and press the RUN button. Number of rows displayed are default 10, but can be changed in the Display drop down field.



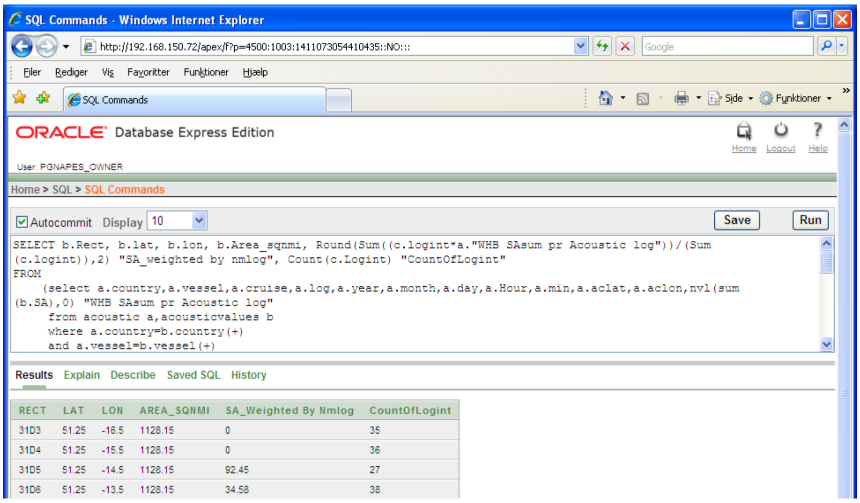
Saving SQL-statements:

It is possible to save your SQL statements, by pressing the "SAVE" button.. Retrieve your saved SQL's by pressing the "Saved SQL" button.

It is recommended to copy and paste the SQL statements on page 7 and onwards, to get a feel of the system.

Exporting from database:

It is possible to download data from the database. After the SQL is executed the link csv export pops up below the results pane. By clicking the CSV export link data will be downloaded to your computer. The user will be prompted, to choose to look at the data or to store the data locally.



Observe that the format of the browser output and CSV file (decimal sign, thousands separator, text qualifier, etc.) depends on the language settings of your browser (Internet Explorer 'Internet options/language).

Standard Query Language

Writing SQL statements is relatively easy. Basically a select statement is divided into 3 parts.

Select clause: What do you want to see.

From clause: From which table(s) are you selecting data

Where clause: Conditions on data selected.

Tutorials are easily found on the web

http://www.w3schools.com/sql/default.asp

http://www.sqlcourse.com/

http://www.1keydata.com/sql/sql.html

http://www.geocities.com/SiliconValley/Vista/2207/sql1.html

Preliminary sample selects. (more will evolve over time)

Copy and paste these selects into the SQL-query webinterface.

Planktonstations	Trawlstations	CTDstations
select l.* from logbook l,stationtypes s where l.sttype=s.sttype and s.geartype='PLANKTON'	select l.* from logbook l,stationtypes s where l.sttype=s.sttype and s.geartype='TRAWL'	select l.* from logbook l,stationtypes s where l.sttype=s.sttype and s.geartype='CTD'

Herring : SA sum pr acoustic log	Herring: Average SA per statistical square
Select a.country,a.vessel,a.cruise,a.log,a.year,a.month,a.day,a.Hour,a.min,a.aclat,a.aclon,nvl(sum(b.SA),0) "HER SA sum pr Acoustic log" from acoustic a,acousticvalues b where a.country=b.country(+) and a.vessel=b.vessel(+) and a.cruise=b.cruise(+) and a.log=b.log(+) and a.year=b.year(+) and a.month=b.month(+) and a.day=b.day(+) and b.species(+)='HER' and a.cruise in('list of cruises','cruise1','cruise2','cruise3') group by a.country,a.vessel,a.cruise,a.log,a.year,a.month,a.day,a.Hour,a.min,a.aclat,a.aclon	SELECT b.Rect, b.lat, b.lon, b.Area_sqnmi, Sum((c.logint*a."WHB SAsum pr Acoustic log"))/(Sum(c.logint)) "SA_weighted by nmlog", Count(c.Logint) "CountOfLogint" FROM (select a.country,a.vessel,a.cruise,a.log,a.year,a.month,a.day,a.Hour,a.min,a.aclat,a.aclon,nvl(sum(b.SA),0) "WHB SAsum pr Acoustic log" from acoustic a,acousticvalues b where a.country=b.country(+) and a.vessel=b.vessel(+) and a.cruise=b.cruise(+) and a.log=b.log(+) and a.year=b.year(+) and a.month=b.month(+) and a.day=b.day(+) and b.species(+)='HER' and a.cruise in('list of cruises','cruise1','cruise2','cruise3') group by a.country,a.vessel,a.cruise,a.log,a.year,a.month,a.day,a.Hour,a.min,a.aclat,a.aclon) a, ICESsquares b, Acoustic c WHERE a.country=c.country(+) and a.vessel=c.vessel(+) and a.cruise=c.cruise(+) and a.log=c.log(+) and

	a.year=c.year(+) and a.month=c.month(+) and a.day=c.day(+) and ((c.AcLat Between b.lat_min And b.lat_max) AND (c.AcLon Between b.lon_min And b.lon_max)) GROUP BY b.Rect, b.lat, b.lon, b.Area_sqnmi order by b.rect

Blue whiting : SA sum pr acoustic log	Blue whiting: Avg SA pr statistical square
select a.country,a.vessel,a.cruise,a.log,a.year,a.month,a.day,a.Hour,a.min,a.aclat,a.aclon,nvl(sum(b.SA),0) "WHB SAsum pr Acoustic log" from acoustic a,acousticvalues b where a.country=b.country(+) and a.vessel=b.vessel(+) and a.cruise=b.cruise(+) and a.log=b.log(+) and a.year=b.year(+) and a.month=b.month(+) and a.day=b.day(+) and b.species(+)='WHB' and a.cruise in('list of cruises','cruise1','cruise2','cruise3') group by a.country,a.vessel,a.cruise,a.log,a.year,a.month,a.day,a.Hour,a.min,a.aclat,a.aclon	SELECT b.Rect, b.lat, b.lon, b.Area_sqnmi, Round(Sum((c.logint*a."WHB SAsum pr Acoustic log"))/(Sum(c.logint)),2) "SA_weighted by nmlog", Count(c.Logint) "CountOfLogint" FROM (select a.country,a.vessel,a.cruise,a.log,a.year,a.month,a.day, a.Hour,a.min,a.aclat,a.aclon,nvl(sum(b.SA),0) "WHB SAsum pr Acoustic log" from acoustic a,acousticvalues b where a.country=b.country(+) and a.vessel=b.vessel(+) and a.cruise=b.cruise(+) and a.log=b.log(+) and a.year=b.year(+) and a.month=b.month(+) and a.day=b.day(+) and b.species(+)='WHB' and a.cruise in('list of cruises','cruise1','cruise2','cruise3') group by a.country,a.vessel,a.cruise,a.log,a.year,a.month,a.day, a.Hour,a.min,a.aclat,a.aclon) a, ICESsquares b, Acoustic c WHERE a.country=c.country(+) and a.vessel=c.vessel(+) and

	a.cruise=c.cruise(+) and a.log=c.log(+) and a.year=c.year(+) and a.month=c.month(+) and a.day=c.day(+) and ((c.AcLat Between b.lat_min And b.lat_max) AND (c.AcLon Between b.lon_min And b.lon_max)) GROUP BY b.Rect, b.lat, b.lon, b.Area_sqnmi order by b.rect

Select all data from a table	Records in database, overview
Select * from <tablename>	Select a.country,a.year,a.vessel,a.cruise,a.log,b.catch,c.bio,d.hydr,e.acoustic,f.acousticval,g.pl from (select country,year,vessel,cruise,count(station)LOG from logbook group by country,year,vessel,cruise order by country,year,vessel,cruise) a, (select country,year,cruise,count(station)catch from catch group by country,year,cruise order by country,year,cruise) b, (select country,year,cruise,count(station)bio from biology group by country,year,cruise)c, (select country,year,cruise,count(station)hydr from hydrography group by country,year,cruise)d, (select country,year,cruise,count(log) acoustic from acoustic group by country,year,cruise) e, (select country,year,cruise,count(log) acousticval

	from acousticvalues group by country,year,cruise) f, (select country,year,cruise,count(station) pl from plankton group by country,year,cruise) g where a.country=b.country (+)and a.year=b.year(+) and a.cruise=b.cruise(+) and a.country=c.country(+) and a.year=c.year(+) and a.cruise=c.cruise(+) and a.country=d.country(+) and a.year=d.year(+) and a.cruise=d.cruise(+) and a.country=e.country(+) and a.year=e.year(+) and a.cruise=e.cruise(+) and a.country=f.country(+) and a.year=f.year(+) and a.cruise=f.cruise(+) and a.country=g.country(+) and a.year=g.year(+) and a.cruise=g.cruise(+) order by a.country,a.year,a.vessel,a.cruise