ICES WGIPS REPORT 2011

SCICOM Steering group on ecosystem surveys and technology

ICES CM 2011/SSGESST:02

Ref. SCICOM, WGISUR, ACOM & HAWG

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

17-21 January 2011

Bergen, Norway

ICES International Council for the Exploration of the Sea
CIEM Conseil International pour l'Exploration de la Mer

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

Recommended format for purposes of citation:

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

Contents

Executive summary

The Working Group for International Pelagic Surveys (WGIPS, formerly PGHERS) met at the Marine Institute, Bergen, Norway from 17.01.11 – 21.01.11 under the chairman Karl-Johan Stæhr (DTU-Aqua, Hirtshals, Denmark: to coordinate acoustic and larvae surveys in the North Sea, Malin Shelf and Western Baltic; to combine recent survey results for assessment purposes and to clarify parameters influencing these calculations. The group consisted of 11 participants from seven different nations.

Review of larvae surveys in 2009/2010: Six survey métiers were covered in the North Sea. The herring larvae sampling period was still in progress at the time of WGIPS meeting, thus sample examination and larvae measurements have 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 2011. The same is true for Larvae Surveys from the Baltic.

Results from larvae survey in the Irish Sea indicate a similar distribution pattern for 2010 as seen in previous years, with the highest abundance of herring larvae to the east and north of the Isle of Man. A difference in distribution pattern is, however, evident to the north of the Isle of Man with a westward expansion not routinely observed. The point estimate of production in the north eastern Irish Sea was slightly below the time series average.

North Sea, West of Scotland and Malin Shelf summer acoustic surveys in 2010: Seven acoustic surveys were carried out during late June and July 2010 covering the North Sea, West of Scotland and Malin Shelf area. The estimate of the North Sea, autumn spawning herring, spawning stock is at 3.0 million tonnes. This is 15% higher than the estimate from the previous year (2.6 million tonnes).

The West of Scotland estimate of SSB is 253 000 tonnes. This was lower than the estimate from the previous year. The survey detected a strong 2009 year-class that dominates the estimate of immature fish. The strong 2007 year-class observed in the previous year showed up in the estimate again this year.

This is the third year of the synoptic survey, covering what is currently considered the Malin Shelf population of herring. This provided an estimate comprising four herring stocks to the west of the British Isles: the West of Scotland in Division VIaN; the Clyde; Divisions VIaS and VIIb, c; and the Irish Sea. The SSB estimate was 303 000 tonnes and is largely dominated by the West of Scotland estimate. Compared to the previous year, when no 0-group fish were detected, a strong year class of 0-group fish, dominating the numbers and biomass of immature fish of the Malin Shelf population, was observed this year.

The estimates of Western Baltic spring-spawning herring SSB were 101 000 tonnes and 981 million herring, which is lower than last year's estimate. The stock is dominated by 1 and 2 ring fish; however this year's estimated abundance of 1 and 2 ringers is considerably less than previous years, dating back to 2002.

Sprat: The total abundance in 2010 of North Sea sprat provided an estimated biomass of 354 000 tonnes. This is a decrease by nearly 50% in terms of biomass when compared to last year and is at a medium-level in the 2000–2010 time series. In terms of abundance, it is the sixth highest estimate. In 2006–2008, there was a downward trend

in North Sea sprat. The majority of the stock consists of mature sprat. The sprat stock is dominated by 1- and 2-year old fish representing more than 90% of the biomass.

In Division IIIa, sprat was abundant in both the Kattegat and Skagerrak (44F9). The biomass has significantly decreased to 18 500 tonnes, about half of the estimate from 2009.

Western Baltic acoustic surveys in autumn 2010: A joint German-Danish acoustic survey was carried out with RV "Solea" in the Western Baltic in October 2010. The estimate of Western Baltic spring-spawning herring is about 208 900 tonnes in Subdivisions 22–24. As in former years, young herring dominated the abundance estimates. However, total abundance and biomass estimates increased significantly, compared to the record low values from 2009.

The estimated total sprat stock is around 109,900 tonnes. The present high estimates of sprat in number and biomass are caused by a strong, new year class, which is about 5 times greater than in 2009.

1 Opening of the meeting

The Working Group for International Pelagic Surveys met in Bergen, Norway from 17–21 January 2011 to:

a) Combine the 2010 survey data to provide indices of abundance for the population of herring and sprat within the area, using the FishFrameAcoustics database;

b) Coordinate the timing, area and effort allocation and methodologies for acoustic and larvae surveys for herring and sprat in the North Sea, Malin Shelf and Western Baltic in 2011;

c) Examine the interpretation of echograms between the participants of the 2010 acoustic surveys to ensure quality control and proper exchange of experience;

d) Review the progress of FishFrame;

e) 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;

f) Prepare methods for delivery of the following information to assessment working groups in 2012:

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.

g) "Initiate and complete planning with WGNAPES so that the two Working Groups can be merged at the start of 2012. Proposed 2012 ToRs for the new WG should be drafted and the new WG should be co-chaired by the current WGNAPES and WGIPS chairs.

WGIPS will report by 3 March 2011 (via SSGESST) for the attention of the SCICOM, WGISUR, ACOM and HAWG.

2 Adoption of the agenda

The agenda was presented and adopted by WGIPS on the very first day. Participants 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
Cindy van Damme	common member	Netherlands
Norbert Rohlf	common member	Germany
Matthias	common member	Germany
Phil Copland	common member	UK
Eric Armstrong	common member	UK
Cecilie Kvamme	host	Norway
Ciaran O'Donnell	common member	Ireland

Sascha Fässler	common member	Netherlands
Pieter-Jan Schon	common member	UK
Dominik Gloe	common member	Germany
Teunis Jansen*	common member	Denmark

*by correspondence.

3 Herring larvae surveys

3.1 Review of larvae surveys in 2010

3.1.1 Western Baltic

The inshore waters of Strelasund and Greifswalder Bodden (ICES area 24) are considered the main spawning area of Western Baltic spring-spawning (WBSS) herring. The German Thünen-Institute of Baltic Sea Fisheries (vTI-OSF), Rostock, and its predecessor monitors the density of herring larvae as a vector of recruitment success since 1977 within the framework of the Rügen Herring Larvae Survey (RHLS). This survey delivers a unique high-resolution dataset on the herring larvae ecology in the Western Baltic, both temporally and spatially. On-board the research vessel "FK Clupea" a sampling grid of 35 stations is sampled weekly using ichthyoplankton sampling 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. The recruitment index (0 wr) is then utilized as a fishery-independent indicator of stock development by the ICES herring assessment working group (HAWG).

The baseline of the *N-20* recruitment index is built by strong correlations found among the amount of 20 mm (TL) herring larvae (0 wr) in the Greifswalder Bodden and abundance of subadults (1 wr and 2 wr) in consecutive years as obtained by acoustic surveys.

The strong correlations point to 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 for 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 raised 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 likely return to the western Baltic for spawning 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 has been used by HAWG since 2008 as the only 0-group recruitment index for the assessment of Western Baltic Spring-spawning herring.

Because of the harsh winter conditions with extended periods of ice cover, the 2010 herring fishery on the Greifswalder Bodden spawning ground started only in late March, which is some weeks later than usual. The local fishery on the spawning ground took its quota within 4 weeks, due to a further, significantly reduced TAC for 2010. The larvae survey was conducted from late-March (about 10 days later than usual due to ice cover) through to the end of June, over 15 weeks. The recruitment index derived from the 2010 survey is 7037 million larvae, slightly higher than 2009 but about four times higher than calculated for 2008 (Table 3.1.1 and Figure. 3.1.1). Like in 2009, the index is within the range of the geometric mean of the time series. (5190 million including 2009).

Table 3.1.1. N20 recruitment index for Western Baltic Spring-spawning herring, derived from the Rügen herring larvae survey.

YEAR	N20 (MILL)
1992	1060
1993	3044
1994	12515
1995	7930
1996	21012
1997	4872
1998	16743
1999	20364
2000	3026
2001	4845
2002	11324
2003	5507
2004	5640
2005	3887
2006	3774
2007	1829
2008	1622
2009	6464
2010	7037

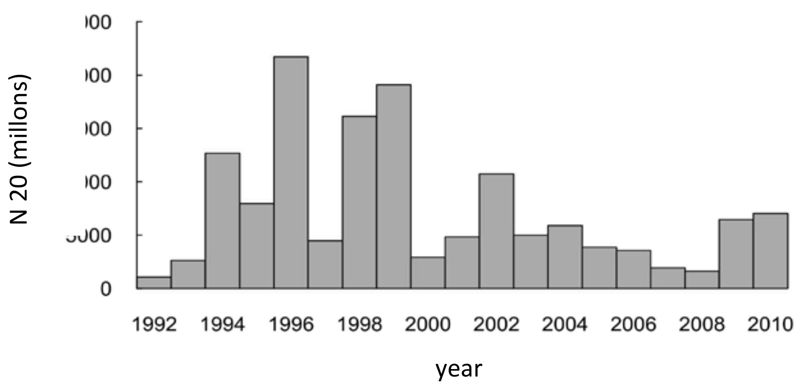


Figure 3.1.1. Estimates of larval herring abundance of the Western Baltic Spring-spawning from 1992 to 2010.

An additional herring larvae survey was conducted in mid-November to monitor any potential, existing autumn spawning activity, which was documented as the dominant spawning season in the pre-war period data but is for unknown reasons of minor relevance today. Limited numbers of larvae of all size classes were present and subsamples were stored in Ethanol for analysis of population genetics. However, data are not yet available since sample processing has not been finished.

3.1.2 North Sea

In the reporting period, the Netherlands and Germany participated in the larvae surveys. In total six units and time periods out of ten were covered in the North Sea, as given below.

Table 3.1.2.1. Areas and time periods covered during the 2010/2011 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 was 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 yet possible to give an overview on the final larvae survey results.

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 2011.

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 on-board the RV "Corystes" since 2005, and prior to that on the smaller RV "Lough Foyle".

Sampling is carried out on a systematic grid of stations covering the spawning grounds and surrounding regions in the NE and NW Irish Sea (Figure 3.1.3.1). Larvae are sampled using a Gulf-VII high-speed plankton sampler with 280 µm net. Mean catch-rates (nos.m^{-2}) are calculated over stations to give separate indices of abundance for the NE and NW Irish Sea. Larval production rates (standardized to a larva of 6 mm), and birth-date distributions, are computed based on the mean density of larvae by length class. A growth rate of 0.35 mm day^{-1} and instantaneous mortality of 0.14 day^{-1} are assumed based on estimates made in 1993–1997.

The results for 2010 indicate a similar distribution pattern to previous years in relation to the highest abundance of herring larvae being to the east and north of the Isle of Man (Figure 3.1.3.1). A difference in distribution pattern is, however, evident to the north of the Isle of Man with a westward expansion not routinely observed. The point estimate of production in the north eastern Irish Sea for 2010 (2.04×10^{12} larvae) was slightly below the time series average. The index is used as an indicator of spawning-stock biomass in the assessment of Irish Sea herring by the Herring Assessment Working Group (HAWG).

The 2011 survey is scheduled to take place 7–13 November.

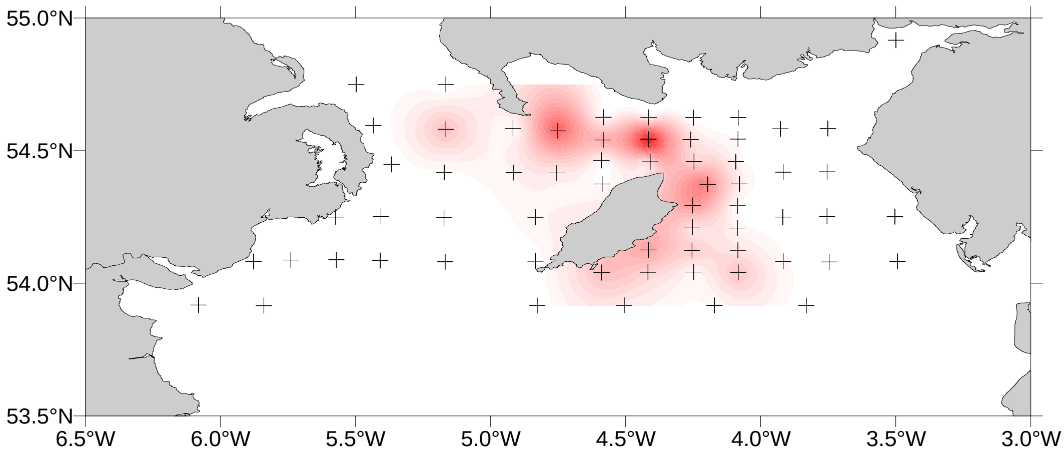


Figure 3.1.3.1. Estimates of larval herring abundance in the Northern Irish Sea in 2010. Crosses indicate sampling stations. Areas of shading are proportional to larva abundance (maximum = 143 per m²).

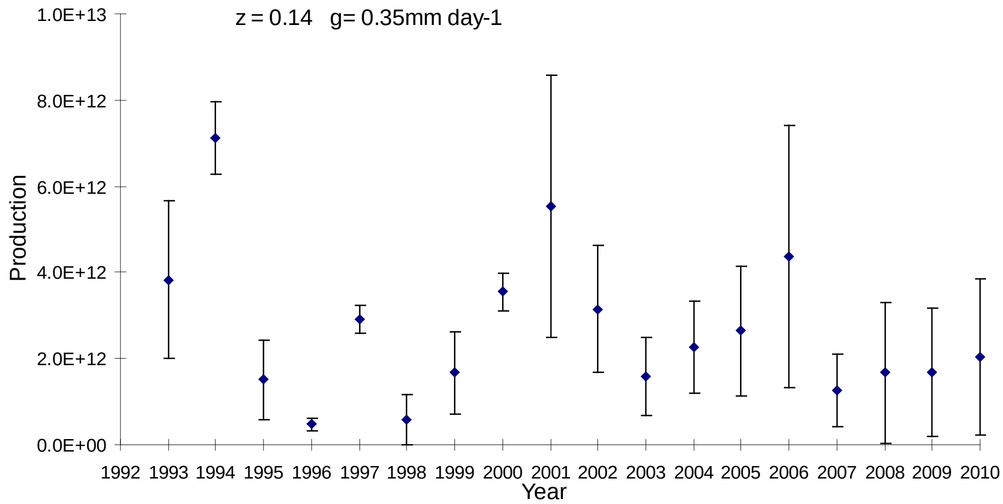


Figure 3.1.3.2. Estimates of larval herring production in the NE Irish Sea from 1993 to 2010. Error bars denote 1 standard error (calculated from coefficients of variation of the estimates of abundance, but not including uncertainty in growth or mortality).

3.2 Coordination of larvae surveys in 2011

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, coverage of the Orkney/Shetland area will not be possible in the first time window, but will be covered in the second time window by Germany. The Netherlands are able to cover the Buchan area and the Central North Sea in the second time window. The coverage of the last time window 1–15 October will not be possible in any of the areas. A preliminary timetable for the next sampling period is presented as follows:

Table 3.2.1. Areas and time periods for the 2011 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

Survey results should be sent to Norbert Rohlf (vTI, Institute of Sea Fisheries, Hamburg), for inclusion into the IHLS database. SF is responsible to calculate and report the summarized results and the updated series of MLAI-values to the HAWG.

3.3 Ichthyoplankton data in a central ICES database

SGSIPS (ICES, 2010a) and WGDIM (ICES, 2010b) recommended, and made a plan, to adjust the ICES DATRAS database in such a way, that ichthyoplankton data can also be uploaded. In 2010 people from the ICES Data Centre participated in the WGEGGS meeting to compile an overview of the parameters needed for the ichthyoplankton data. In 2011 the data Centre will incorporate the parameters of ichthyoplankton surveys. In future it will be possible to upload herring larvae survey data into the ICES database. Every institute participating in the herring larvae surveys will upload their data. This ensures central storage of the herring larvae survey data.

3.4 Workshop on the Identification of Fish Larvae (WKIDFL)

Herring Larvae surveys provide essential data for the assessment of pelagic stocks in the North Sea, the Irish Sea and the western Baltic (Divisions VIIaN, IV, VIa, IIIa, and Western Baltic). They are currently carried out by different countries and the results of these surveys are of direct importance for the herring assessment.

In recent years, abundance of anchovies and sardines has again increased in the North Sea, and there is evidence to believe that these species also spawn there. With regards to climate change, the occurrence of sprat larvae may have shifted northwards as well. Since clupeid larvae can be easily misidentified, effective quality control and proper larvae identification is essential to the survey results.

In September 2011 a workshop on the identification of fish larvae, with special emphasis on clupeoid, flatfish, gadoid larvae and species that can be categorized with these groups, will take place in IJmuiden, The Netherlands, in 2011 with the following terms of reference:

2010/2/SSGESST17 The **Workshop on the identification of clupeoid, flatfish, gadoids and other fish larvae (**WKIDFL), chaired by Cindy van Damme*, the Netherlands, and Matthias Kloppmann*, Germany, and will meet in IJmuiden, the Netherlands, 5–9 September 2011 to:

a) Review available information on the identification of fish larvae in the North Sea and adjacent areas, considering larvae's appearance in the light of ongoing development, with special emphasis on clupeoid, flatfish and gadoid larvae;

b) Identify sources of misidentification of larvae;

c) Establish an agreed identification key for clupeoid, flatfish and gadoid larvae;

d) Review methods of proper preservation of fish larvae.

The workshop will include both the review of available information on the identification, as well as identifying larvae under a microscope, by all participants. This will give the opportunity of identifying sources of misidentification and establishing internationally agreed identification keys on clupeoid, gadoid and flatfish larvae. Scientists and technicians involved in identifying fish larvae in the North Sea and adjacent areas will participate in this meeting. WGIPS recommends that those involved in the herring larvae surveys should participate in the WKIDFL.

3.5 Combining herring larvae surveys and WGEGGS sampling

The Working Group for cod and plaice egg surveys has put a recommendation forward to undertake an ichthyoplankton survey every 3 years in conjunction with IBTS and IHLS surveys for monitoring spawning areas of the main fish species, which has been recommended as a high priority for the Ecosystem Based Approach to Management by the Bergen Declaration Meeting of Scientific Experts.

In 2004 and 2009 dedicated WGEGGS surveys for the sampling of North Sea cod and plaice eggs have been carried out (ICES, 2010c). In 2004 and 2009 The Netherlands and Germany also contributed the egg and larvae data from the herring larvae surveys carried out in December and January in the Channel and southern North Sea. This data was useful for the WGEGGS. WGEGGS therefore requests to work up all the samples of the December and January herring larvae surveys for ichthyoplankton every three years. This does require extra staff time to sort out and identify all fish larvae and eggs apart from the clupeoid larvae that are sorted out routinely for the herring larvae surveys. The Netherlands and Germany will probably participate in a WGEGGS 2012 survey and contribute the ichthyoplankton data from the December and January herring larvae surveys.

4 Acoustic surveys

4.1 Combined estimates of the acoustic survey

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

The surveys are reported individually in the Appendices 5A-5H of this report. A combined report has been prepared from the data from all surveys, attached as Annex 6. 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 4 of the 39 squares (Figure 6.1). These uncovered squares were interpolated from estimates in neighbouring squares. 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 4.3.1.1 is completed as far as possible.

The estimate of North Sea autumn spawning herring spawning stock is about 15% higher, when compared to the previous year, at 3.0 million tonnes and 14 231 million herring. The strong 2000 year-class of herring is now incorporated in the 9+ group. The 2008 year-class seems to be strong and persistent in this year's estimate.

The estimates of Western Baltic spring-spawning herring SSB were 101 000 tonnes and 981 million herring, which is lower than last year's estimate. The stock is dominated by 1 and 2 ring fish; however this year's estimated abundance of 1 and 2 ringers is considerably less than previous years, dating back to 2002.

The West of Scotland estimates of SSB are 253 000 tonnes and 1 319 million herring. This was lower compared to the estimates from the previous year. The survey detected a strong 2009 year-class that dominates the estimate of immature fish. The strong 2007 year-class observed in the previous year showed up in the estimate again this year. To ensure that the west of Scotland results were consistent with the time series, they were derived from squares above 56°N only.

This is the third year of the synoptic survey, covering what is currently considered the Malin Shelf population of herring. This provided an estimate comprising four herring stocks to the west of the British Isles: the West of Scotland in Division VIaN; the Clyde; Divisions VIaS and VIIb, c; and the Irish Sea. The SSB estimate was 303 000 tonnes and 1 616 million fish and is largely dominated by the West of Scotland estimate. Compared to the previous year, when no 0-group fish were detected, a strong year-class of 0-group fish, dominating the numbers and biomass of immature fish of the Malin Shelf population, was observed this year.

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 2010, with mean weights and mean lengths by age ring.

Age (ring)	Numbers	Biomass	Maturity	weight(g)	Length (cm)
0	12,226	69	0.00	5.7	9.4
1	14,577	560	0.01	38.4	16.9
2	4,237	583	0.45	137.7	24.9
3	4,216	772	0.90	183.1	27.1
4	2,453	562	1.00	229.2	28.9
5	1,246	305	0.98	244.9	29.4
6	1,332	311	1.00	233.1	29.0
7	688	163	1.00	237.4	29.2
8	1,110	280	1.00	251.9	29.7
9+	1,619	407	1.00	251.2	29.6
Immature	29,473	985		33.4	14.5
Mature	14,231	3,027		212.7	28.2
Total	43,705	4,011	0.33	91.8	19.0

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 2010, with mean weights, mean length and fraction mature by age ring.

Age (ring)	Numbers	Biomass	Maturity	weight(g)	Length (cm)
0					
1	999	53	0.11	52.7	18.9
2	511	34	0.80	65.8	20.4
3	254	28	0.82	111.4	23.8
4	115	17	0.88	150.9	26.5
5	65	11	1.00	175.6	27.9
6	24	5	1.00	198.0	28.8
7	28	6	1.00	215.9	29.9
8+	34	8	1.00	234.8	30.2
Immature	1,049	60		57.6	19.4
Mature	981	101		103.4	22.9
Total	2,030	162	0.48	79.8	21.1

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 2010, with mean weights, mean lengths and fraction mature by age ring.

Age (ring)	Numbers	Biomass	Maturity	weight(g)	Length (cm)
0	1,559	2	0.00	1.6	5.9
1	425	25	0.00	60.0	18.8
2	489	60	0.50	124.6	24.0
3	398	73	0.97	185.1	27.4
4	150	29	0.98	198.7	28.0
5	143	30	1.00	212.1	28.6
6	95	20	1.00	214.2	28.9
7	63	13	1.00	210.2	28.6
8	48	10	1.00	218.2	29.0
9+	188	40	1.00	214.9	28.7
Immature	2,242	53		23.6	10.3
Mature	1,319	253		191.8	27.7
Total	3,561	307		86.2	16.7

Table 4.1.1.4. Total numbers (millions) and biomass (thousands of tonnes) of Malin Shelf herring in the area surveyed in the acoustic surveys July 2010, with mean weights, mean lengths and fraction mature by age ring.

Age (ring)	Numbers	Biomass	Maturity	weight(g)	Length (cm)
0	3,707	6	0.00	1.6	5.9
1	659	35	0.00	53.9	18.0
2	793	96	0.41	121.6	23.8
3	462	83	0.96	179.8	27.2
4	202	38	0.98	191.1	27.8
5	185	38	1.00	206.6	28.5
6	120	25	1.00	212.8	28.9
7	83	17	1.00	209.7	28.8
8	65	14	1.00	218.8	29.3
9+	192	41	1.00	214.9	28.8
Immature	4,856	93		19.2	9.3
Mature	1,616	303		187.5	27.5
Total	6,473	397		61.3	13.8

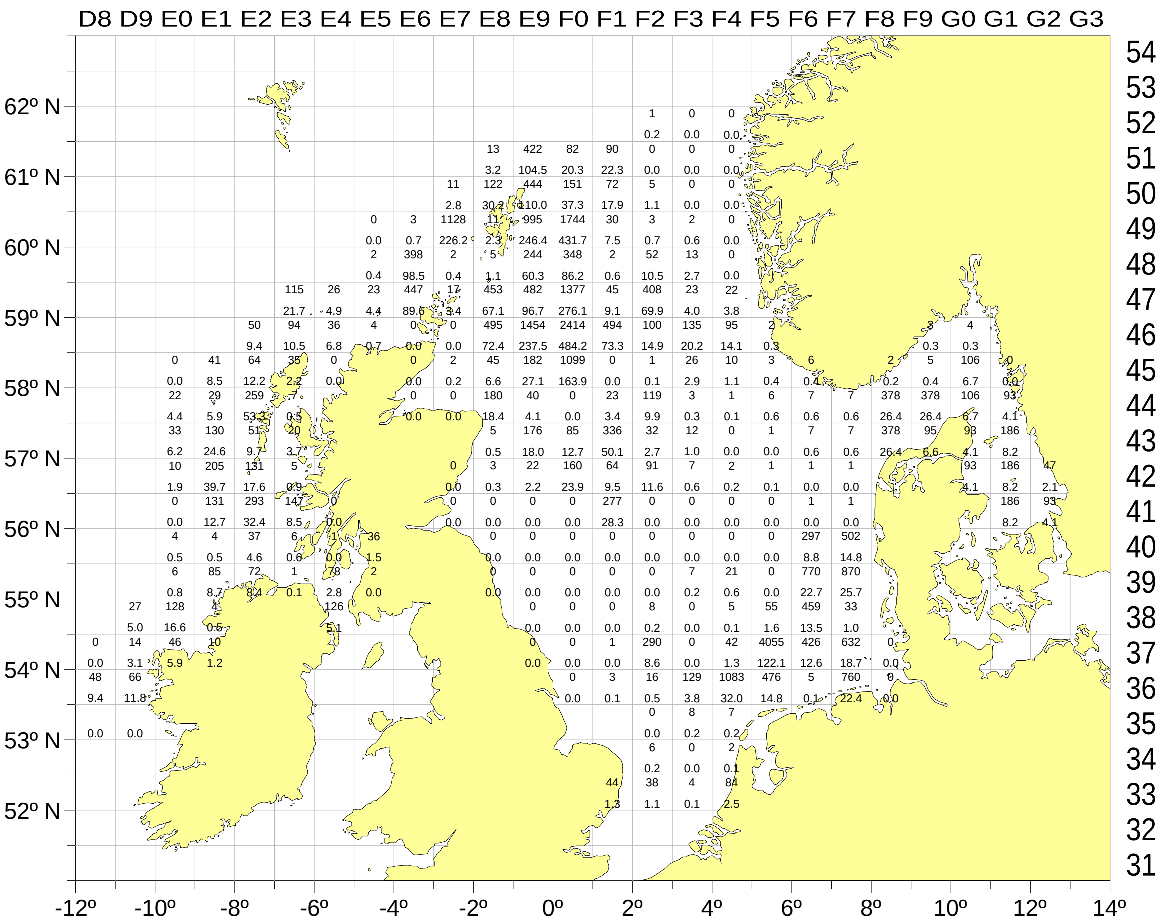


Figure 4.1.1.1. Abundance of autumn spawning herring (winter ring 1–9+) from the combined acoustic survey in June-July 2010. Numbers (millions, upper figure) and biomass (thousands of tonnes, lower figure). Blank and interpolated rectangles are not surveyed. Interpolated rectangles are mark in Figure 6.1, Annex 6.

4.1.2 Western Baltic acoustic survey

A joint German-Danish acoustic survey was carried out with FRV "SOLEA" 4–22 October 2010 in the Western Baltic (SD21–24). This survey is traditionally coordinated within the framework of the Baltic International Acoustic Survey (BIAS) to supply the ICES:

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

with an index value for the stock size of herring (Western Baltic Spring Spawner WBSS) and sprat in the Western Baltic area. As in previous years, acoustic recording and trawling was done only during the night. An EK60 echosounder with a hull mounted ES38B transducer and EchoView4 integrator software were used to collect and process acoustic data. The cruise track was 1242 nautical miles long and represents an area of 13206 nautical square miles. To identify the target species and determine the length and weight distributions of fish, 57 trawl hauls were carried out. Samples of herring and sprat were frozen for subsequent analysis in the lab. After each haul hydrographic measurements were taken with a CTD-O_2 probe. Additional CTD casts in the Femern Belt led to an overall 61 CTD-profiles.

The herring stock in Subdivisions 21–24 was estimated to be 7.2 x 10^9 fish with a biomass of 208.9 x 10^3 tonnes. For the area including Subdivisions 22–24, the number of herring was calculated to be 6.6 x 10^9 fish with a biomass of 200.8 x 10^3 tonnes. As in former years, young herring dominated the abundance estimates. However, total abundance and biomass estimates have increased significantly, compared to the record low values from 2009.

The estimated sprat stock in Subdivisions 21–24 was 24.4 x 10^9 fish with a biomass of 109.9 x 10^3 tonnes. For the area including Subdivisions 22–24, the number of sprat was calculated to be 24.2 x 10^9 fish with a biomass of 108.6 x 10^3 tonnes. The present high estimates of sprat, in numbers and biomass, are caused by a strong new year class, which is about 5 times greater than in 2009.

Analyses of herring length-at-age showed a distinct fraction of Central Baltic Herring in the catches originating mainly from SD24. This could partly explain the significantly increased biomass/abundance in that area. Further analyses are pending, and possible methods to remove the CBH-fraction in survey subdivisions with occurrence of both WBSS and CBH will be presented to the HAWG meeting.

A detailed survey report is provided in Annex 5.

4.2 Sprat in the North Sea and Division IIIa

Sprat data were available from RV *Solea*, RV *Tridens,* RV *Dana and* RV *Scotia.* RV *Johan Hjort* observed no sprat in the northern North Sea. In the 2010 acoustic surveys, sprat concentrated in the southern part of the North Sea, with highest abundances and biomass in an area between 1° and 5° E and between 52.5° and 54.5° N. The survey area was again limited to north of 52° N. There is no indication that the southern limit of the sprat stock distribution has been reached; it is likely that sprat can be found even further south in the English Channel. The sprat distribution in the North Sea in terms of abundance and biomass is shown in Figure 4.2.1.

The total abundance in 2010 was estimated to be 34,032 million individuals and the biomass 354,000 tonnes (Table 4.2.1). This is a decrease of nearly 50% in terms of biomass when compared to last year (ICES 2010) and is at a medium-level in the 2000–2010 time series (Table 4.2.2). In terms of abundance, it is the sixth highest estimate. In 2006–2008, there was a downward trend in North Sea sprat (Table 4.2.2). The majority of the stock consists of mature sprat. The sprat stock is dominated by 1- and 2-year old fish representing more than 90% 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 4.2.2. Note that for 2003, information on sprat distribution is available from one nation only.

In Div. IIIa, sprat was abundant in both the Kattegat (ICES squares 41G1-G2, 42G0-G2, 43G0-G1 and 44G1) and the Skagerrak area (43F8-F9, 44F8-F9). The abundance was estimated to be 1,556 million individuals (Table 4.2.3), a decrease compared to the 2,233 million sprat estimated in 2009. The biomass was estimated to be 18,500 tonnes, about half the estimate from last year. Most sprat were one-year old fish, and 81% of them were immature. The sprat samples in this area are too few to estimate length- and weight-at-age split by immature and mature.

WGIPS were asked by HAWG 2010 to revisit the table given for IIIa sprat in the 2009 WGIPS report. The numbers in this table are now recalculated by the method used for the 2010 survey, and the revised numbers are presented in Table 4.2.4.

Table 4.2.1. Sprat in the North Sea: Abundance, biomass, mean weight and mean length by age and maturity from summer 2010 North Sea acoustic survey.

Age	Abundance (million)	Biomass (1000 t)	mean weight (g)	mean length (cm)
1i	1,864	11	6.1	9.1
1m	17,627	152	8.6	10.3
2i	3	0	12.0	11.7
2m	13,740	177	12.9	12.2
3m	798	14	17.6	13.7
4m	0	0	-	-
immature	1,867	11	6.1	9.1
mature	32,165	343	10.7	11.2
grand total	34,032	354	10.4	11.1

Table 4.2.2. Time-series of sprat abundance and biomass (ICES areas IVa-c) as obtained from summer North Sea acoustic survey. The surveyed area has increased over the years. Only figures for the last 6 years are roughly 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
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 4.2.3. Sprat in Division IIIa: Abundance, biomass, mean weight and length by age and maturity from summer 2010 North Sea acoustic survey-

Age	Abundance (Million)	Biomass (1000 t)	Mean Weight (g)	Mean length (cm)
1i	677.5	5.9	8.6	10.7
1m	158.6	1.4	8.6	10.7
2i	189.2	2.7	14.4	12.9
2m	154.6	2.2	14.4	12.9
3m	195.8	3.1	15.9	13.3
4m	121.5	2.2	18.3	13.9
5m	46.8	0.9	18.4	14.3
6m	9.2	0.2	17.7	14.5
7m	3.0	0.0	13.0	13.5
Immature	866.7	8.6	9.9	11.2
Mature	689.3	10.0	14.5	12.8
Total	1,556.0	18.5	11.9	11.9

Table 4.2.4. Sprat in Division IIIa: Revised 2009 abundance, biomass, mean weight and length by age and maturity from summer North Sea acoustic survey.

Age	Abundance (Million)	Biomass (1000 t)	Mean Weight (g)	Mean length (cm)
1i	169.5	1.8	10.7	11.6
2i	408.0	6.1	14.9	12.9
2m	24.4	0.4	14.9	12.9
3m	1206.9	20.0	16.6	13.4
4m	279.1	5.4	19.4	14.1
5m	127.9	2.5	19.2	14.4
6m	18.0	0.4	20.0	14.8
Immature	577.4	7.9	13.7	12.5
Mature	1,656.3	28.6	17.3	13.6
Total	2,233.7	36.5	16.3	13.3

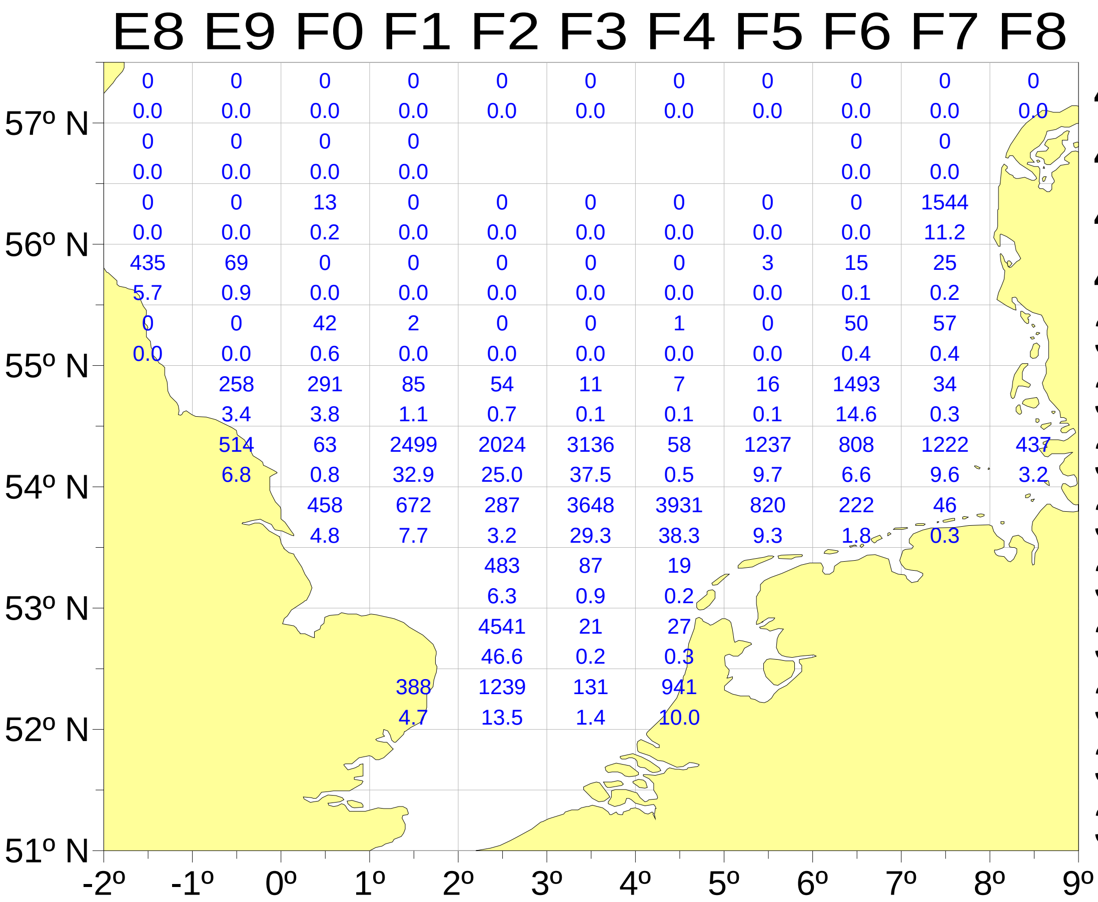


Figure 4.2.1. North Sea Sprat. Abundance (upper figure, in millions) and biomass (lower figure, in 1000 t) per statistical rectangle as obtained by the acoustic survey 2010. Blank rectangles are not sampled.

4.3 Coordination of acoustic surveys in 2011

4.3.1 Survey coverage

Acoustic surveys in the North Sea, West of Scotland, Malin Shelf, Irish and Celtic Sea in 2011 will be carried out in the periods and areas given in Table 4.3.1.1 and Figure 4.3.1.1. 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 in the areas, should be the same as in most recent years (Figure 4.3.1.2). However, with regard to the reduced herring stock size, the spatial fish distribution in 2010 may differ from the historical picture. Thus participants should be encouraged to adapt their survey effort, avoiding a misbalance between transect spacing and occurrence of fish schools.

Survey effort should 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 4.3.1.1. Time periods, areas and rectangles to be covered in the 2011 acoustic surveys.

Vessel	Period	Area	Rectangles
Celtic Explorer (IRE)	18 June – 07 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)*	28 June – 18 July	58°30'-62°N, 8°W-2°E	46E2-F1, 47E3-F1, 48E4-F1, 49E5-F1, 50E7-F1, 51E8-F1
Johan Hjort (NOR)	28 June – 25 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)	13 June – 11 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)	27 June – 22 July	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 – 18 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)	26 August -14 September	53°-55°N, 6°-3°W	35E4-E6, 36E3-E6, 37E4-E6, 38E4-E6
Celtic Explorer (IRE)	08 – 28 Oct	51°-52°30'N ,11°-6°30W	31D9-E2, 32D9-E3, 33D9, 33E2-E3,

* Provisional survey coverage

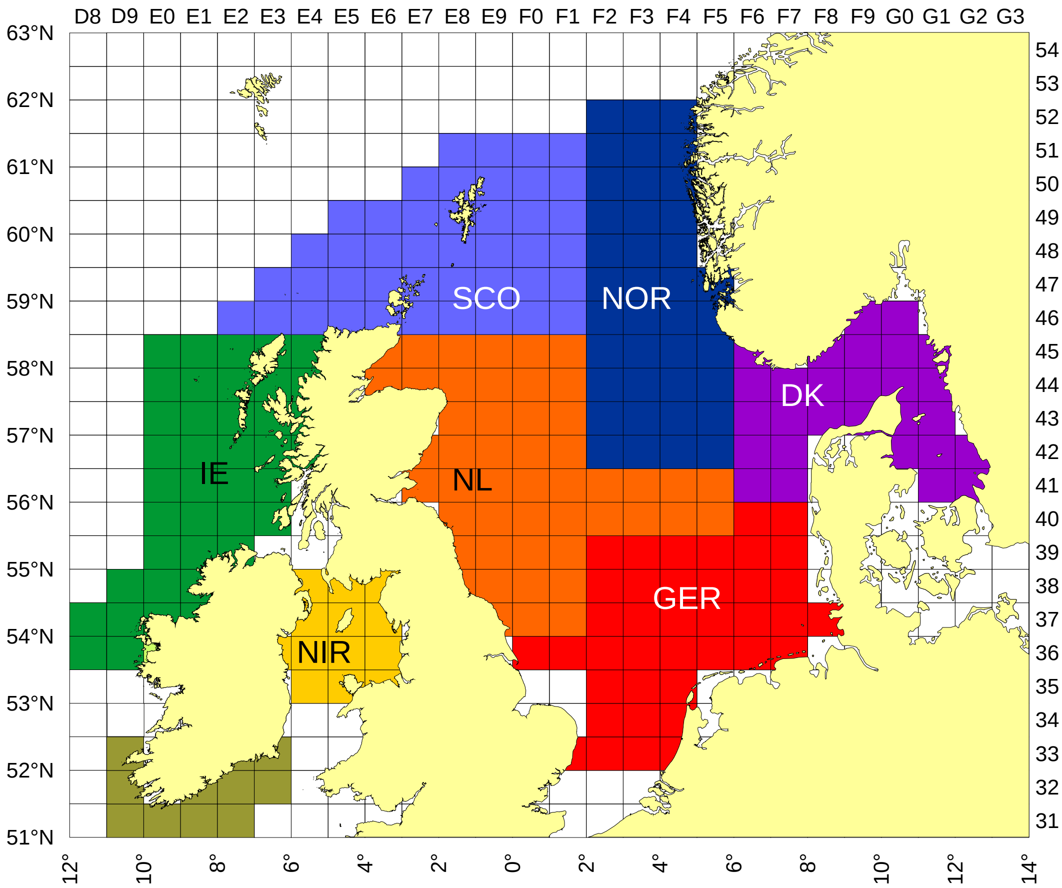


Figure 4.3.1.1. Survey area layouts for all participating vessel in the 2011 acoustic survey of the North Sea and adjacent areas. (NIR = Corystes; IE = Celtic Explorer; SCO = Scotia; NOR = Johan Hjort; DK = Dana; NL = Tridens; GER = Solea).

4.3.2 North Sea, West of Scotland and Malin Shelf

North Sea surveys

Participants in 2011 should exchange tentative cruise tracks prior to the survey, for further coordination. **Copies of all cruise tracks should also be sent to Paul Fernandes, Aberdeen, not later than 30 May 2011**; he will then contact individual cruise leaders to discuss possible amendments.

Additionally, vessels should be in daily radio contact during the cruise at **1730** hrs **UTC** on MW frequency 3333 KHz 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. Due to the long distances between the vessels while surveying, some participants have difficulties in receiving the radio communication. Thus, e-mails with cruise track and trawl information should be exchanged every second day. Cruise leaders should circulate their e-mail addresses for the duration of the cruise, **particularly** if it is not their normal contact address. **Paul Fernandes and Karl-Johan Stæhr have agreed to act as coordinators during the 2011 survey. They can be reached by e-mail or phone between 25 June and 18 July**.

Considering the time constraints to achieve objectives of an amalgamated meeting of WGIPS and WGNAPES, it is proposed that a two day post cruise meeting should be established soon after the survey to compile and collate combined survey data and to upload it to FishFrame. The meeting would allow WGIPS members to evaluate survey data and discuss issues arising from the survey and conclude on recommendations to improve survey precision.

Malin Shelf surveys

The synoptic survey of what is currently considered 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"). SGHERWAY 2010 evaluated this survey and recommended that the survey should be continued to allow provision of acoustic and biological data and splitting of the constituent population components. Although the current assessments of herring stocks in this area can continue uninterrupted, SGHERWAY recommended that 4 or 5 years of continuous survey data should be collected for a proper evaluation of the utility of the synoptic survey in tuning.

Under current proposals, the survey coverage and intensity will be reduced in 2011 due to financial constraints in Scotland and Northern Ireland. The proposals are currently provisional while possible alternatives are investigated to maintain survey effort. The VIaN/North Channel/Firth of Clyde survey was a new survey started in 2008 by Northern Ireland with the allocation of additional ship time, but unfortunately they will not be able to conduct this survey in 2011. 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 be modified to encompass both the North Sea and parts of the west of Scotland. Scotland will reduce survey effort to the west of Scotland covering only as far south as 58°30'N, but Ireland has agreed to expand survey effort northwards to this latitude to maintain overall survey coverage. Transect spacing will be adjusted accordingly to account for the increased area coverage in 2011 and will be confirmed during the planning phase.

WGIPS, whilst acknowledging the difficult economic circumstances under which these decisions on survey effort are made, strongly recommends that survey effort and intensity should be maintained. Alternative means to ensure the continuation of this survey time series should be considered.

The results from the national acoustic surveys in June-July 2011 will be collated and the result of the entire survey will be combined at the next WGIPS. Individual or combined survey results for sprat and herring should be uploaded to FishFrame no later than **30 November 2011**. This earlier deadline is to facilitate the planned meeting in December 2011 of the proposed amalgamation of WGIPS and WGNAPES. Participants should also be prepared to additionally deliver their remaining raw data to the stage 1 module.

4.3.3 Irish and Celtic Sea

Following the recommendation from HAWG that the acoustic surveys used for tuning Celtic Sea and Irish Sea stocks be coordinated by WGIPS, it was agreed to coordinate these surveys from 2011 onwards. The surveys are, however, spawning surveys that are conducted later in the year and can thus not form part of the temporal coordination of the other surveys. Given that these surveys are not otherwise dealt with, within ICES survey working groups, it is important that these surveys are considered within WGIPS in terms of overall spatial coverage of acoustic surveys used for the assessment of herring stocks by HAWG and for quality assurance. Results and reporting structure will be presented annually at WGIPS. Survey design, sampling procedures, data sharing (FishFrame database) and reporting structure would be adhered to, where possible, as laid out in the WGIPS acoustic survey manual. The latest cruise reports for these surveys are presented in Annex 5I for the Celtic Sea herring survey and Annex 5J for the Irish Sea survey.

Acoustic surveys in the Celtic and Irish Sea in 2011 will be carried out in the periods and areas given in Table 4.3.1.1 and Figure 4.3.1.1.

4.4 Hydrographic Data

WGIPS proposes to collect hydrographic data from the International Herring Acoustic Surveys (IHAS) in 2011. The hydrographic data from previous years is incomplete and was not included in the ICES Oceanographic Database from all members due to the method of data collection.

The Ocean Data View (Schlitzer 2006, http://odv.awi.de/en/software/download/) format was selected as the standard format for WGIPS. This standard text file can be used from all other applications to visualize the data. In future it is planned to put the data in a database which will be available to all participants on the WGIPS sharepoint. The data should be provided on the sharepoint by the participants after the surveys, by the end of September. Members are requested to make data available from previous surveys.

Table 4.4.1., gives an overview of the hydrographic data available during the WGIPS meeting. The missing data will be delivered subsequently.

Table 4.4.1. Overview of the IHAS hydrographic data available during the WGIPS meeting 2010.

Participant	Hydrographic data 2010
Denmark	--
Germany	++
Ireland	--
Norway	--
Northern Ireland	--
Scotland	++
The Netherlands	++
West of Scotland Charter	No data collected

The following figures give an overview of the hydrographic situation in the survey area in 2010. Figures were produced with Ocean Data View (ODV, Schlitzer, 2006)

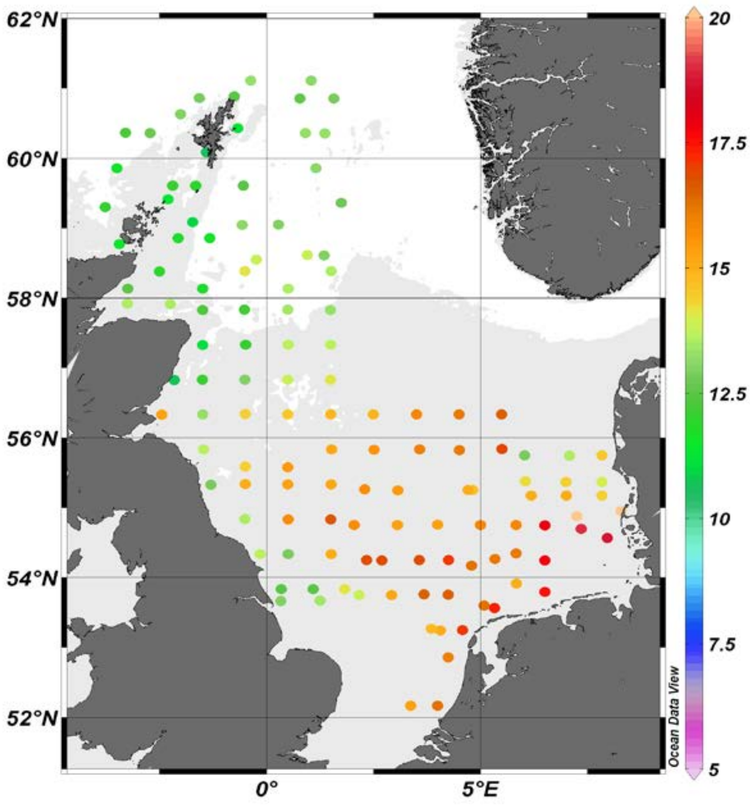


Figure 4.4.1. Sea surface temperature [°C] in the survey area 2010.

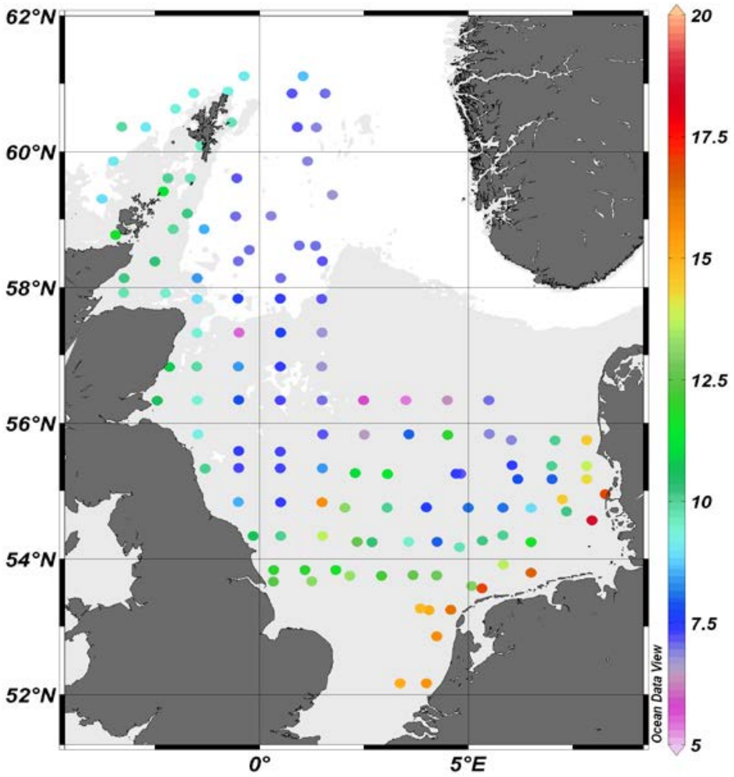


Figure 4.4.2. Sea bottom temperature [°C] in the survey area 2010.

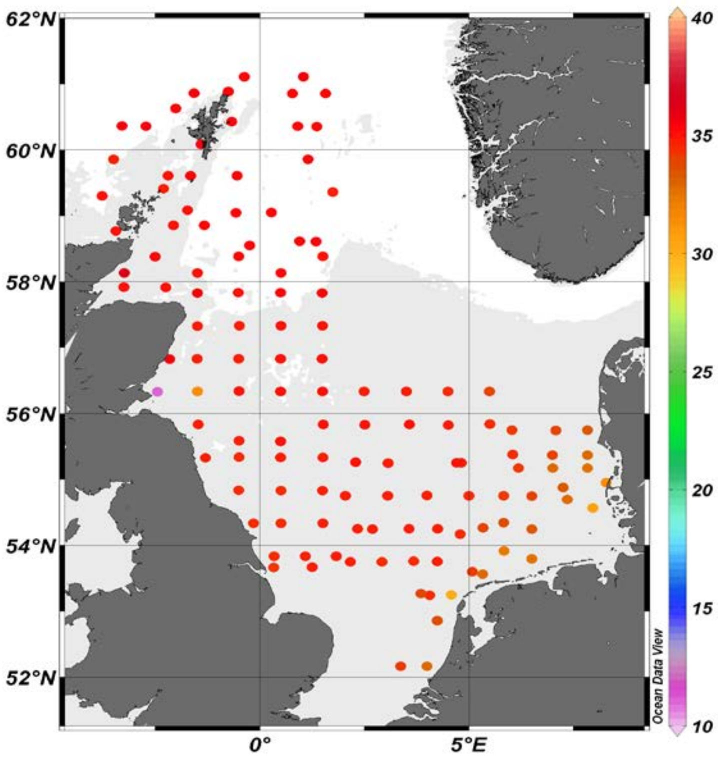


Figure 4.4.3. Sea surface salinity [PSU] in the survey area 2010.

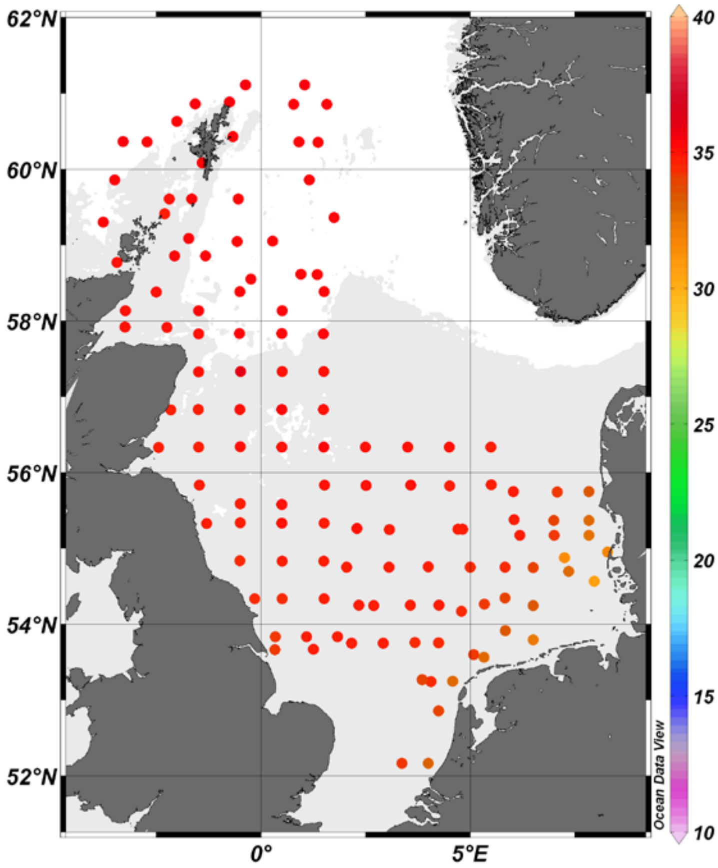


Figure 4.4.4. Sea bottom salinity [PSU] in the survey area 2010.

4.5 Workshop on sexual maturity staging of herring and sprat (WKMSHS)

From the 20–23 June 2011 a Workshop on Sexual Maturity Staging of Herring and Sprat (WKMSHS) will be conducted in Copenhagen, Denmark. The terms of reference include, to propose standardized maturity scales for herring and sprat for common use among laboratories including a comparison of existing scales and identification of reliable maturity determination criteria for females and males. WGIPS supports the workshop and encourages WGIPS members to participate in the workshop.

4.6 Delivery of information to WG in 2012

Survey participants within WGIPS coordinated surveys have been requested to make available to the HAWG the following information for target species (herring and sprat) for surveys carried out in 2011–2012:

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

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

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

In order to provide these data in a structured format it is suggested that the above data be prepared by survey participants prior to the December 2011 WGIPS meeting and made available during the meeting for compilation and communication to the HAWG. Data from individual surveys will be grouped as follows:

North Sea

Malin Shelf

Western Baltic

Celtic Sea

5 Review and update of WGIPS manuals

5.1 Larval survey manual

The manual for the international herring larvae surveys is regularly updated and a new version (3.1) has been published in 2010. No recent changes have occurred in the herring larvae surveys; therefore the manual has not been updated.

SGSIPS (ICES 2010a) has recommended to ICES that they create a page on the ICES website for storing ICES coordinated (ichthyoplankton) surveys manuals as stand-alone documents, with a report number. Usually manuals are published as an annex to the ICES WG reports and can be difficult to find. Storing the manuals on the ICES website will allow easy access, for everyone, to the latest version of the (ichthyoplankton) manuals.

5.2 Combined acoustic survey manual

During the meeting the acoustic manual was revisited to update from the previous version (V1.0, 2007) and this work is ongoing. Significant work was initially carried out to combine acoustic manuals for WGIPS and WGNAPES as it was deemed more concise to have a single manual common to both groups. During the next WGNAPES meeting in August 2011 members will be asked to review the content and update as required. Members of WGIPS have been tasked with updating survey specifics (including larval and hydrographic sampling, data repositories i.e. FishFrame and survey procedures) outside the meeting so that the updated version will be ready for adoption by the group during the next WGIPS meeting in December 2011.

6 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.

Under the "Studies for carrying out the common fisheries policy: Open call for tenders No MARE/2008/10. Lot 1." a proposal was put forward to fund developments in the FishFrame database: more specifically, "The establishment of a data portal and warehouse for regional coordination of the sampling of data used for fish stock assessment and fisheries management." The partners in this proposal were the co-ordinator, Danish Technical University/ Danish Institute for Fisheries Research (DTU-

AQUA); Centre for Environment, Fisheries & Aquaculture Science (Cefas), England (UK); Institut Français pour la Recherche et l'Exploitation de la Mer (Ifremer), France; Fisheries Research Services (FRS), Scotland (UK); Wageningen Institute for Marine Resources and Ecosystem Studies (IMARES), The Netherlands; and Instituto Ricerche Economiche per la Pesca e l'Acquacoltura (IREPA ONLUS), Italy

The EU did not grant the funding to allow Fishframe to be upgraded to version 5 for acoustics and to develop new estimation modules. The acoustic surveys are still in version 4.3 of FishFrame. A new version 5.0 has been deployed for commercial fisheries data. Version 5.0 offers a range of new features and is browser and platform independent for the user.

The decision by DTU-Aqua, not to develop the acoustic part of FishFrame further than ver. 4.3 has a number of implications for the WGIPS.

At the moment FishFrame is a very important tool for WGIPS as it is used for compilation of the combined survey result for herring and sprat by area based on the national survey results (stage 3 data) entered in Fish Frame.

In FishFrame ver 4.3 the Pivot tables run in a web-component that comes packaged with office 2000. Microsoft changed the interface of this component in office 2003 cutting the backwards compatibility. This means that only computers with office 2000 are able to produce the output tables to be used for the WG-report.

During the meeting in 2010 and 2011, members of WGIPS were required to contact the operator in DTU-Aqua, whenever small changes in the input data were made, to get him to refresh the FishFrame server, to allow the correct production of the output tables,.

WGIPS has FishFrame as its only platform for producing the combined results for the surveys 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). 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:

1) Making the export of tables, from stage 3, platform-independent.
2) Allowing the server to be refreshed after data updates without external operator assistance.
3) Feedback showing successful data erasure
4) A full update of FishFrame Acoustic to ver. 5

DTU-Aqua has, since the meeting in 2011, 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 discussed the possibility of ICES Data Center 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.

Seen in the light of the plan to merge WGIPS and WGNAPES, the working group recommends that WGDIM should ensure that a data base is established to store basic, disaggregated fisheries and acoustics data from the acoustic surveys and the storage of aggregated national survey results and the tools used to derive global estimates from national, aggregated data for acoustic surveys covered by both working groups, WGIPS and WGNAPES, within the ICES Data Centre.

7 Target strength modelling

7.1 Depth-dependent TS models

A simple relationship of the form TS = 20log10(L)-b20 is currently used to estimate mean target strength (TS) from fish length (L) using a species-specific value for b20. The TS-L relationship currently applied to estimate abundances of North Sea herring (*Clupea harengus*) was determined empirically about 30 years ago: Nakken and Olsen (1977) ensonified stunned and tethered herring at 38 kHz and determined a mean TS-L relationship of TS = 13.6log10(L)-62.8. Edwards and Armstrong (1981) measured the TS at 38 kHz of live herring in a cage at 17.5 m depth. They obtained mean TS of -33.8 dB per kg of fish. The Planning Group on ICES - Coordinated Herring and Sprat Acoustic Surveys (ICES, 1982) subsequently converted Nakken and Olsen's (1977) TS-L relationship into TS per kg (-34.6 dB per kg) and decided that the mean of the two TS estimates (-34.2 dB per kg) should be used together with length-weight data from northwest North Sea herring to derive TS = 20log10(L)-71.2 (dB).

There is evidence that pressure (and thus fish depth) modulates the TS of Atlantic herring (Edwards *et al*., 1984; Ona, 2003) and this dependence may bias acoustic survey results if not taken into account (Løland *et al*., 2007). Herring are physostomes and thus do not have a gas gland that enables them to alter the swimbladder volume actively. Their swimbladder will therefore decrease in volume with increasing water pressure, leading to a steady decrease in TS with increasing depth. Using magnetic resonance imaging (MRI) observations of a herring in a pressure chamber, Fässler *et al*. (2009a) showed that the decrease in swimbladder volume with pressure is in accordance with Boyle's law. However, the swimbladder compression with depth is not isometric: the cross-sectional surface contracts more slowly than the volume.

Fässler *et al*. (2009b) described a method that uses acoustic backscatter models to predict mean TS as a function of fish orientation, size, physical properties and acoustic frequency. Through collaboration between scientists at IMR (Bergen, Norway) and IMARES (IJmuiden, Netherlands), a depth-dependent herring TS will be developed using the most advanced backscatter models (Kirchhoff approximation (Foote 1985); Kirchhoff ray-mode (Clay and Horne 1994); Finite Element Method (FEM)) together with high-resolution representations of herring swimbladders at various water pressures from MRI scans (Figure 7.1). Since the currently available scans represent large herring (>25 cm), further scans of sprat and young herring will improve the TS relationship for smaller sizes of Clupeids.

In order to use a depth-dependent TS model to analyse acoustic data it is important to collect Nautical Area Scattering Coefficients (NASCs) stratified by depth. To facilitate this, participating nations are required to record acoustic Equivalent Distance Sampling Unit (EDSU) herring data at a depth resolution of at least 5 m. Currently, several countries (Germany, Denmark, and Norway) already collect acoustic data by depth bins (resolution 1 m). Irish acoustic data is collected as mean school depth for each allocated school over each 1 nautical mile ESDU. Consultation with the FishFrame developing consortium confirmed the possibility to implement data in the requested depth-stratified format. Required information would be: the proportion of

NASC within each EDSU for each 5 m depth interval throughout the water column. While development of the database to further versions is pending due to lack of finances, all nations should for now make available acoustic data ready to be put into the desired format by 1 April 2011. To include estimates in the assessment of herring abundance for the whole North Sea stock, abundances would have to be calculated for the whole survey area.

A potential switch over to a depth- based acoustic survey index for the North Sea herring assessment would require a parallel data collection for over one generation of fish ages (approx. 5 years).

7.2 Implementing TS models on survey data

Data compilation and code development have been done to address WGIPS 2010 recommendation #1: "*WGIPS recommends that consideration be given to incorporating depth into new target strength models for North Sea herring. The FishFrame database will have to be modified to accept input data in the form of NASC proportions by 5 m depth intervals for every EDSU. Existing and future acoustic data should be put into this format by all participating nations, to be included as depth stratified acoustic data in FishFrame stage 3.*".

A data exchange format "DD" was defined and requests for data were circulated in the group. The DD is a reduced version of the stage 1 SA format. The main data is NASC and the aggregation level is the same, the format has been stripped for some meta data fields in order to ease the data delivery for this exercise.

Fields:

- DataType (fixed to "DD")
- Survey (fixed to "HERAS")
- Year (YYYY)
- Ship (code)
- Log counter (optional. Running log counter during the whole trip. In nmi.)
- Species (Latin)
- DateTimePositionType (String: "S"(=Start) or "M"(=Middle) or "E"(=End)) (Describe where the date, time and position were measured on the track.)
- Date (String: "1900-01-01" to "2020-12-31"). "YYYY-MM-DD" (ISO 8601). Date of the track integrated in this record
- Time (Integer: 0 to 2359)
- Pos.Lat.dec. (Dec(5), 20.00000 to 80.00000; Position of the track integrated in this record: in decimal degrees of Latitude)
- Pos.Lon.dec. degrees (Dec(5), -31.00000 to 31.00000 (Position of the track integrated in this record: in decimal degrees of Longitude)
- Statistical rectangle
- Sub stat. rect
- Biol. subarea
- Depth layer upper limit (m)
- Depth layer lower limit (m)
- Water depth (Mean depth in meters from surface to bottom)
- NASC (Nautical Area Scattering Coefficient in m2/nmi2)

- Mean length (can be left out, but only if you are sure that the right mean length can be found in the corresponding SD)

Notes:

File format: CSV (","-separated fields, "." as decimal).

Depth layer in 5 m bins (or 1 meter bins).

Codes for Ship, Species, Statistical rectangle, Sub stat. Rect, Biol subarea should be like in the formats AB and SD. Valid codes are listed in FishFrame 4.3 in the online report found in the menu under Reports -> Strata definitions.

Example:

```
DataType,Survey,Year,Ship,LogCounter,Species,DateTimePositionType,Date,Time,LatDecDegrees,LonDecDegrees,
StatisticalRectangle,SubStatisticalRectangle,BiologicalSubArea,DepthLayerUpper,DepthLayerLower,WaterDepth,NASC,
MeanLength

DD,HERAS,2008,SCO2,2,Clupea harengus,M,2008-06-29,1237,58.58679,-2.96918,46E7,D,B,5,10,74.464385,0,

DD,HERAS,2008, SCO2,2, Clupea harengus,M,2008-06-29,1237,58.58679,-2.96918,46E7,D,B,10,15,74.464385,0,

DD,HERAS,2008, SCO2,2, Clupea harengus,M,2008-06-29,1237,58.58679,-2.96918,46E7,D,B,15,20,74.464385,0,

DD,HERAS,2008, SCO2,2, Clupea harengus,M,2008-06-29,1237,58.58679,-2.96918,46E7,D,B,20,25,74.464385,0,
```

Some data were delivered before the meeting (Table 7.1). The available data were enough to initiate the development of a data processing script in R, but insufficient to be conclusive about the effect of changing the TS-model.

The input data to the script is AB, SD and DD data from FishFrame. It can perform a stage 2 processing except that catch data stem from stage 3 SD data. The script can also be used for Stage 3 processing as it is done in FishFrame, with the extension that different TS-models can be selected.

The aim for 2011 is to get all data and complete the evaluation using the following TS-models of the form TS=20Log(Length)+a*(Depth)+b:

- ICES (1982): TS = 20*(Log(Length)) -0*(Depth) -71.2
- Ona (2003): TS = 20*(Log(Length)) -2.3*(Depth) -65.4
- Fässler (2010): TS = 20*(Log(Length)) -3.9*(Depth) -69.26

Table 7.1. *=Data delivered, but errors were found during the meeting.

	DEN		GER		NED		SCO	
DD - DATA	Herring	Sprat	Herring	Sprat	Herring	Sprat	Herring	Sprat
2010					√	√	(√)*	
2009					√	√	(√)*	
2008							(√)*	
2007							(√)*	
2006							(√)*	
2005							(√)*	
2004								
2003								
2002								

Preliminary results from calculations done during the meeting are tabulated in Table 7.2. The results from the depth-dependent TS formula based on Fässler's (2010) scanning experiments is in the expected direction and magnitude. More fish is expected because compression of the swimbladder causes TS to reduce. An earlier calculation based on herring data from Scotia in 2007, gave a similar difference of +23%. Sprat is typically found in the southern, shallower part of the North Sea, therefore the lesser effect. Given the lower parameter values in the TS formula from Ona (2003), TS values are higher, hence abundance estimates are lower. However, Ona's (2003) relationship is based on measurements of large (30+ cm) Atlanto-Scandian herring, which may have resulted in a relationship not representative of the typical North Sea herring size range. The parameter b in the simplified depth-**in**dependent Fässler (2010) relationship is adjusted to -71.2 to make it comparable to the ICES (1982) relationship.

Table 7.2. Abundance estimates using depth dependant TS-models. ICES (1982) is set to 100%. Preliminary results based on Dutch data from "Tridens".

SPECIES	HERRING		SPRAT	
TS MODEL	ONA (2003)	FÄSSLER (2010)	ONA (2003)	FÄSSLER (2010)
2010	- 60%	+ 25%	- 48%	+ 10%
2009	- 57%	+ 23%		

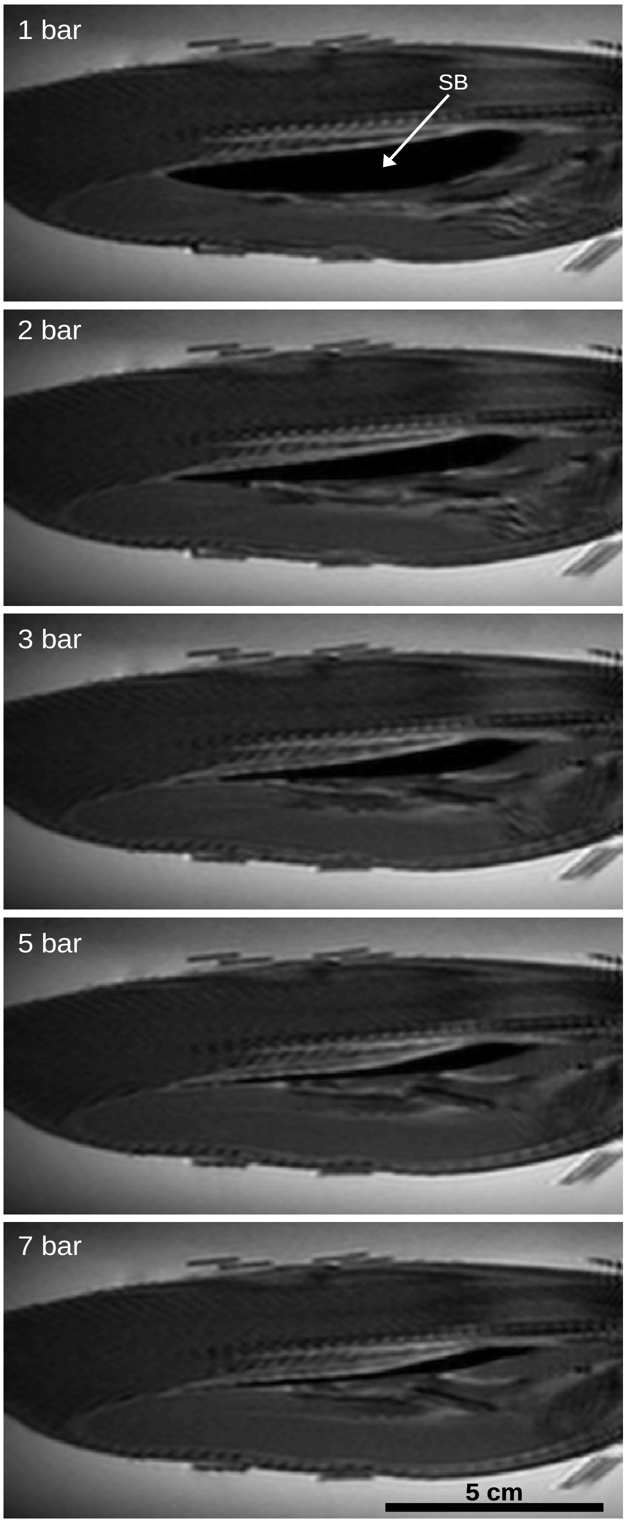


Figure 7.1. Sequence of equivalent sagittal MR images of a North Sea herring at a range of water pressures (1 – 7 bar), showing the swimbladder (SB) as a dark object in the centre of the fish (Fässler *et al.*, 2009a).

7.3 18kHz herring TS model

Collaborative work is being carried out by scientists at the Marine Institute (Galway, Ireland) and IMARES (IJmuiden, Netherlands) to assess the utility of using 18 kHz data for herring biomass estimation in situations when 38 kHz data is unavailable or unusable. The background to this investigation began in Ireland as a result of a transducer cable failure during the 2010 Celtic Sea herring survey on-board the RV *Celtic Explorer* that rendered the 38 kHz data unusable for robust assessment purposes.

Since the arrival of the RV *Celtic Explorer* in 2005 acoustic data has been collected routinely using 4 frequencies (18, 38, 120, 200 kHz). 18 kHz is a suitable frequency for estimating herring biomass, but is seldom used because 38 kHz is usually the default approach. Herring data from the Celtic Sea time-series is currently being re-analysed at 18 kHz using a geometrically adjusted TS relationship for herring to quantify the difference in biomass estimates derived from 18 and 38 kHz data. Work is also being conducted to derive a more empirical 18 kHz TS relationship based on backscatter modelling using MRI scans of herring swimbladders (Figure 7.1). This will also be assessed throughout the time-series. The overall aim of this work is to provide a viable working alternative to the 38 kHz model, as a back-up should a problem occur at sea but also as an exploratory exercise in the feasibility of utilizing this lower frequency for routine clupeid surveys.

Results of the findings will be presented to the newly amalgamated group during the December 2012 meeting.

8 Merging of survey WG in 2012

SCICOM concluded in the ToR, in advance of the 2011 WGIPS, to merge WGIPS and WGNAPES groups in 2012.

2010/2/SSGESST02

g) *Initiate and complete planning with WGNAPES so that the two Working Groups can be merged at the start of 2012. Proposed 2012 ToRs for the new WG should be drafted and the new WG should be co-chaired by the current WGNAPES and WGIPS chairs.*

Discussions took place during WGIPS focusing on when best to place the meeting in the calendar to allow for the participation of all members while allowing an acceptable time window for the delivery of data to the assessment working groups. A provisional date of 16–20January 2012 was agreed upon for the first meeting which is to be held at ICES HQ.

The requirement for the first merged meeting to take place in January 2012 is to facilitate planning for WGIPS surveys taking place in 2012. However, participation of WGNAPES members will not be necessary as this group will have already reported to ICES in September 2011 and planning for 2012 survey will be complete. It is recommended both chairs attend the January 2012 meeting to allow for the smooth transition of the new meeting and report formats, and to be involved in discussions regarding data pooling. Next meeting of the merged groups is planned for December 2012.

The ToR for the amalgamated group is complete and presented in Annex 3 of this report. It is proposed that ICES retain the existing name Working Group of International Pelagic Surveys for the newly merged groups.

A number of concerns were raised within the groups regarding the time frame over which the meeting would take place and also the workload of persons common to both groups. It was agreed the best way forward was to begin the process and address the problems as and when they arise. It was also agreed that an increase in group size would be positive in terms of an increase in expertise and streamlining of compatible surveys.

In order to facilitate the proceedings at the forthcoming meeting the group asks members to consider a post cruise meeting in 2012 for the North Sea and Malin Shelf surveys to compile cruise reports, upload data to FishFrame and produce global abundance estimates prior to the main meeting. This would ease the workload at the 2012 WG meeting and allow more time for planning and discussion.

9 References

Clay, C. S., and Horne, J. K. 1994. Acoustic models of fish: the Atlantic cod (*Gadus morhua*). Journal of the Acoustical Society of America, 96: 1661–1668.

Edwards, J. I., and Armstrong, F. 1981. Measurement of the target strength of live herring and mackerel. ICES Document CM 1981/B: 26. 5 pp.

Edwards, J. I., Armstrong, F., Magurran, A. E., and Pitcher, T. J. 1984. Herring, mackerel and sprat target strength experiments with behavioural observations. ICES CM 1984/B: 34, 21 pp.

Fässler, S.M.M., Brierley, A.S., and Fernandes, P.G. 2009b. A Bayesian approach to estimating target strength. ICES Journal of Marine Science, in press.

Fässler, S.M.M., Fernandes, P.G., Semple, S.I.K., and Brierley, A.S. 2009a. Depth-dependent swimbladder compression in herring Clupea harengus observed using magnetic resonance imaging. Journal of Fish Biology 74: 296–303.

ICES. 1982. Report of the 1982 planning group on ICES-coordinated herring and sprat acoustic surveys. ICES Document CM 1982/H: 04.

ICES. 2010a. Report of the Study Group on Ichthyoplankton surveys (SGSIPS), ICES CM 2010/SSGESST:2, 25 pp.

ICES. 2010b. Report of the Working Group on Data and Information Management (WGDIM), ICES CM 2010/SCICOM:05, 41 pp.

ICES. 2010c. Report of the Working Group on North Sea Cod and Plaice Egg Surveys in the North Sea (WGEGGS), ICES CM 2010/SSGESST:23, 29 pp.

Løland, A., Aldrin, M., Ona, E., Hjellvik, V., and Holst, J. C. 2007. Estimating and decomposing total uncertainty for survey-based abundance estimates of Norwegian spring-spawning herring. ICES Journal of Marine Science, 64: 1302–1312.

Nakken, O., and Olsen, K. 1977. Target strength measurements of fish. Rapports et Procès-Verbaux des Réunions du Conseil International pour l'Exploration de la Mer, 170: 52–69.

Ona, E. 2003. An expanded target-strength relationship for herring. ICES Journal of Marine Science, 60: 493–499.

Annex 1: List of participants

Name	Address	Phone/Fax	E-mail
Norbert Rohlf	Johann Heinrich von Thünen-Institute (vTI-SF) Institute of Sea Fisheries Palmaille 9 D- 22767 Hamburg Germany	Tel: +49 40 38905 166 Fax: +49 40 38905 263	norbert.rohlf@vti.bund.de
Matthias Schaber	Johann Heinrich von Thünen-Institute (vTI-SF) Institute of Sea Fisheries Palmaille 9 D- 22767 Hamburg Germany	Tel: +49 40 38905 173 Fax: +49 40 38905 264	matthias.schaber@vti.bund.de
Phil Copland	Marine Scotland Science Marine Laboratory Aberdeen PO Box 101 Victoria Road Aberdeen AB11 9DB UK	Tel: +44 1224 295361 Fax: +44 1224 295511	coplandp@marlab.ac.uk
Cecilie Kvamme	Institute of Marine Reasearch PO. Box 1870 Nordnes N-5817 Bergen Norway	Tel: +47 55 23 69 31 Fax: + 47 55 23 85 31	cecilie.kvamme@imr.no
Eric Armstrong	Marine Scotland Science Marine Laboratory Aberdeen PO Box 101 Victoria Road Aberdeen AB11 9DB UK	Tel: +44 1224 295362 Fax: +44 1224 295511	e.armstrong@marlab.ac.uk
Ciaran O'Donnell	Marine Institute Fisheries Science Services Rinville Oranmore Galway Ireland	Tel: +353 91 387 424 Fax: +353 91 387 201 Mobile: + 353 87 968 1954	Ciaran.odonnell@marine.ie
Karl-Johan Stæhr **(Chair)**	DTU National Institute of Aquatic Resources (DTU Aqua) Section for Monitoring North Sea Centre, PO Box 101 DK-9850 Hirtshals Denmark	Tel: +45 35883271 Fax: +45 35883260	kjs@aqua.dtu.dk

Name	Address	Phone/Fax	E-mail
Cindy van Damme	Institute for Marine Resources and Ecosystem Studies (IMARES) PO Box 68 1970 AB IJmuiden The Netherlands	Tel: +31 317 487078 Fax: +31 317 487326	Cindy.vandamme@wur.nl
Sascha Fässler	Institute for Marine Resources and Ecosystem Studies (IMARES) PO Box 68 1970 AB IJmuiden The Netherlands	Tel: +31 317 487474 Fax: +31 317 487326	sascha.fassler@wur.nl
Dominik Gloe	Institute for Hydrobiology and Fisheries Science University of Hamburg Grosse Elbstrasse 133 D-22767 Hamburg Germany	Tel: +49 40 42838 6658	dominik.gloe@uni-hamburg.de
Teunis Jansen **(by correspondence)**	DTU National Institute of Aquatic Resources (DTU Aqua) Section for Ocean Ecology Charlottenlund castle DK 2920 Charlottenlund Denmark	Tel: +45 30 66 78 40 Fax: +45 33 96 33 33	tej@aqua.dtu.dk

Annex 2: Agenda

Agenda for ICES WGIPS, Bergen, 17–21 January 2011

Monday 17.01.11, 13.00

- Start of meeting
- Status on data availability
- Review of recommendations for WGIPS from other expert groups
- First discussion of merging WGIPS and WGNAPES from 2011 (Tor g)

Tuesday 18.01.10, 09:00

- Review of individual larvae surveys 2010
- Herring larvae determination workshop
- Coordination of larvae surveys 2011 (ToR b)

14:00

- Scottish Working Document on Combined West of Scotland and North Sea herring acoustic survey
- Work allocation to review and update WGIPS manuals for larvae and acoustic surveys (in subgroups if necessary, ToR b), will be continued during the meeting every then and now
- Review of individual acoustic surveys 2010 and echogram interpretation exercise (ToR c)

Wednesday 19.01.10, 09:00

- More individual acoustic surveys and echograms
- Status and future of FishFrame (ToR d)
- Herring maturity staging workshop 2011
- Coordination of the acoustic survey in 2011 (ToR b)

14:00

- Request for deliveries to WG's from 2012
- Joint estimate of the NS acoustic survey for herring and sprat (ToR a)
- Conclusion on review interpretation of echograms (ToR c)

Thursday 20.01.10, 09:00

- Review and consideration on incorporation of new models of depth based target strength in the acoustic survey (ToR e)
- Recommendations

14:00

- Collation of material for the final report
- Recommendations
- Review of combined report

Friday, 21.01.10, 09:00

- Review of final report

12:00

- End of meeting

Annex 3: WGIPS terms of reference for the next meeting of the merged WGIPS and WGNAPES

The combined **Working Group for International Pelagic Surveys** (WGIPS), and **Working Group on North East Atlantic Pelagic Ecosystem Surveys (WGNAPES)** co-chaired by Karl-Johan Stæhr, Denmark, and Ciaran O'Donnell, Ireland will meet at ICES headquarter, Copenhagen, Denmark 16–20 January 2012 to:

a) Combine the 2011 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 2011 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 for making short term projection of Norwegian spring-spawning herring growth
- iii) Hydographic and zooplankton conditions for ecological considerations in the Norwegian sea
- iv) Aerial 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, the Malin Shelf and the Western Baltic North-East 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 2012
- iii) The international coordinated survey on Norwegian spring-spawning herring in May-June 2012
- 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 2012

d) Examine the interpretation of echograms between the participants of the 2011 acoustic surveys to ensure quality control and proper exchange of experience;

e) Review the progress of FishFrame and WGNAPES data base

f) 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;

g) Delivery of the following information to assessment working groups in 2012:

- 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.

WGIPS-WGNAPES will report by XX March 2012 (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 North-east 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 due to 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.
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

Note that the recommendations below are sorted so that recommendations 1 to 5 are addressed to parties outside the WGIPS and recommendations 6 to 14 are addressed to the expert group members. Bold text refers to specific action required by WGIPS members.

RECOMMENDATION	FOR FOLLOW UP BY:
1. WGIPS acknowledges SCICOM's decision to merge WGIPS and WGNAPES. A first meeting of the amalgamed group is proposed to take place in January 2012 in Copenhagen. After that meetings are planned for December starting in December 2012.	SCICOM, WGNAPES, Expert Group members
2. WGIPS recommends that the joint group should be named WGIPS.	SCICOM, WGNAPES, Expert Group members
3. WGIPS recommends that consideration be given to incorporating depth into new target strength models for North Sea herring. Existing and future acoustic data should be included as depth stratified acoustic data in FishFrame (deadline April 2011).	Expert Group members and DTU-Aqua
4. WGIPS recommends that an archive system should be established by the ICES datacenter to store disaggregated fisheries and acoustics data as required by both working groups.	WGDIM, WGNAPES, ICES datacenter
5. 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.	WGEGGS, IBTSWG, Expert group members
6. WGIPS recommends that the survey area around the Orkney/Shetlands and West of Scotland should continue to be monitored in an adequate manner.	Expert group members
7. In light of data needed to survey the whole ecosystem, WGIPS recommends that all participants in the International North Sea Herring Acoustic Survey should collect the data at multiple frequencies (minimum 4; between 18 – 200 kHz) to facilitate species identification. In addition, scientific multibeam echosounders should be used to increase the sampled volume.	Expert group members
8. WGIPS recommends that **all participants in the International North Sea Herring Acoustic Survey should exchange trawl data soon after the surveys have been completed**. In cases where trawl data are lacking in one particular area, trawl information from an adjacent area collected by a different participant, may be used.	Expert group members
9. For the December 2011 meeting, WGIPS recommends that the acoustic manual should be updated by WGIPS and that all **participants should bring echograms** for interpretation transparancy.	Expert group members
10. All participants in the 2011 herring acoustic survey should upload their survey estimates to the Fishframe database by 30 November 2011 for stage 3.	Expert group members
11. WGIPS recommends **that cruise leaders participating in the International North Sea Herring Acoustic Survey should radio contact each other every day at 1730 UTC. Communication should be through medium frequency radio at 3333 kHz. In addition, e-mail correspondence should be exchanged every second day.**	Expert group members
12. To determine possible shifts in spawning WGIPS	Expert group members

recommends that all areas in the herring larvae surveys should be covered.	
13. WGIPS recommends participants in the herring surveys should participate in the workshop on Sexual maturity staging of herring and sprat (WKMSHS) in June 2011	Expert group members
14. WGIPS recommends participants in the herring larvae surveys should participate in the workshop for identification of fish larvae (WKIDFL) in September 2011.	Expert group members

Annex 5: 2010 Individual Acoustic Survey Reports

ANNEX 5A: Scotland (West)

Survey report for MFV *Prowess*

28 June – 17 July 2010

Eric Armstrong, Marine Scotland-Science, Marine Laboratory, Aberdeen

1. INTRODUCTION

An acoustic survey for herring was carried out by the Marine Laboratory on the west coast of Scotland (ICES Division VIa(N)) from the 28 June to the 17 July 2010. The survey was conducted on the chartered fishing vessel MFV *Prowess*. The main objective of the survey was to provide an abundance estimate for herring in this area and to map the distribution of this species.

The survey was carried out as a part of the ICES coordinated herring acoustic survey of the North Sea and adjacent waters. The data from this survey were combined with other surveys in the North Sea and to the west of the British Isles to provide an age disaggregated abundance index for use in the assessment process. The assessments will be carried out by the ICES Herring Assessment Working Group (HAWG) to be held in March 2011.

This survey has been carried out every year, at this time, by the Marine Laboratory, since 1991. With the exception of 1991 and 1997 the survey has always been conducted using chartered commercial fishing vessels.

2. SURVEY DESCRIPTION and METHODS

2.1 Personnel

Eric Armstrong Cruise Leader

Emma Hatfield

Craig Davis

Susan Lusseau

Melanie Harding

Michael Stewart

Jessica Hommelhof

2.2 Narrative

Loading of the vessel and installation of a wet lab container and equipment was carried out on the 25 June. The vessel left Fraserburgh at 0030 on the 28 June and proceeded to Loch Eriboll where an attempt was made to calibrate the echosounder. Due to high winds and rough seas the calibration proved to be unsatisfactory. Survey work began at Cape Wrath at 0300 hrs on the morning of the 29 June. The survey continued in generally unsettled weather until around the 3 July when the weather deteriorated to the point where it was decided to alter the track, to survey in a more sheltered part of the planned survey. While making way to more sheltered water, Michael Stewart was thrown across the bridge and hit his head on a plate glass window and his back on a handrail, resulting in a split above his eye and a broken rib. The vessel steamed to Castle Bay on Barra to allow him to receive medical attention. It was not possible for him to accompany us on the rest of the cruise so a replacement was requested. Due to the worsening weather, and forecast, the vessel remained in Castle Bay and resumed the survey at 1800 hrs of the 4 July. The survey continued till 1430 hrs on the 6 July at which point passage was made to Castle Bay to pick up Jessica Hommelhof. Unfortunately the weather took another turn for the worse and the survey was not able to resume until 1900 hrs on the 8 July.

At 1000 hrs on the 11th July, on reaching the end of the last transect of the first half, the boat made for Ullapool for a mid cruise break and a crew change. The vessel departed at 1500 hrs on the 12 July anchoring in Loch Broom, where a second calibration was carried out in near perfect conditions. On finishing at 2100 hrs, the vessel made passage to the Butt of Lewis to complete the northern part of the survey area. The survey continued from the 13th covering the full survey area up to 60°N 4°W. The survey was successfully completed at 0700 hrs on the 16 July. The vessel then steamed to Fraserburgh for off loading of personnel and equipment on the morning of the 17th. No time was lost to mechanical breakdown but approximately 4 days were lost due to weather.

2.3 Survey design

The survey was designed to cover the area in two levels of sampling intensity based on herring densities found in previous years. The survey design was adhered to in the southern part of the cruise around Barra Head, but the number of transects north of Barra Head was reduced to account for lost time. Areas with highest intensity sampling had a transect spacing of 7.5 nautical miles, and lower intensity areas a transect spacing of 15 nautical miles. The track layout was systematic, with a random start point. Between-track data were discarded at the end of all transects. The survey area was within an area defined by 56° and 60° 30′ N, and the shelf break in the west to approx. 250 m depth and the Scottish coast or the 4° W line in the east (Figure IIA.1). Six tracks were interlaced with the Irish vessel Celtic Explorer between 55° 30′ N and 57°N.

2.4 Calibration

One calibration was unsuccessfully attempted in Loch Eriboll, prior to the start of the survey (28 June), a later one in the middle (11 July) in Loch Broom was performed in near perfect conditions. The constant calculated from the second calibration of the 38 kHz integrating frequency was used. The results from both calibrations are given in Table IIA.1. All procedures were according to those defined in the survey manual.

2.5 Acoustic data collection

The survey was carried out using a Simrad EK60 38 kHz sounder echo integrator, the system settings are given in Table IIA.1. Further data analysis was carried out using SonarData Echoview and Marine Laboratory Analysis systems. Data from the echo integrator were summed over quarter hour periods (2.5 n.mi. at 10 knots). The survey was generally restricted to hours of daylight between 0300 hrs and 2300 hrs UTC. A total of 2050 nautical miles of track were recorded. Echo integrator data were collected from 10 metres below the surface (transducer at 5.5 m depth) to 0.5 m above the seabed. Data were processed on a daily basis, then archived as Echoview files (*.raw,*.evi) and stored on DVD and external hard drive.

2.6 Biological data - fishing trawls

16 trawl hauls (Figure IIA.1 and Table IIA.2) were carried out opportunistically during the survey on the denser echotraces. All trawls were carried out using a PT160 pelagic trawl with a 20 mm codend liner. A scanning netsonde was mounted on the headline. Each haul was sampled for length, age, maturity and weight of individual herring. Up to 702 fish were measured at 0.5 cm intervals from each haul. A new sampling method for the collecting of age/maturity data were instituted, as recommended by the SGHERWAY project. This replaced the stratified sampling method of previous years. Due to a miscommunication in the way the method was to be undertaken, a random sample of 120 fish were taken only from 23cm to 31cm, from each haul for age/maturity, together with a range of morphological and other measurements. Consequently, some of the smaller and none of the larger fish were aged, apart from haul 10 which was predominantly of small fish. To compensate for lengths with missing age/maturity data, a representative, random sample was taken from the data gathered by the Irish boat in the same area. An eight stage maturity scale was used. Immature fish were defined as stages 1 and 2. Fish weights were collected at sea for all fish aged.

2.7 Data analysis

EDSUs were defined by 15 minute intervals which represented 2.5 n.mi. per EDSU, assuming a survey speed of 10 knots. The data were divided into three categories: "definitely herring traces"; "probably herring traces" and "possibly herring traces" (which were identified with enough uncertainty as to not be included in the estimate). Data were analysed using rectangles of 15′ by 30′.

Target strength to length relationships used were those recommended by the acoustic survey planning group (ICES 1994).

For herring $TS = 20\log_{10}L-71.2$ dB per individual

For mackerel $TS = 20\log_{10}L-84.9$ dB per individual

For gadoids $TS = 20\log_{10}L-67.5$ dB per individual

For sprat $TS = 20\log_{10}L-71.2$ dB per individual

The herring data from the trawl hauls were used to divide the area into five strata based on length distributions and geographic criteria. The five regions (Figure IIA.3) were:

I. Greater part of Survey

II. Upper Minch

III. St Kilda

IV South

V Irish Waters

Trawling in the Inner Minch area was again very difficult, except in the most northerly and southerly parts, due to seabed conditions likely to cause net damage. The length frequencies are presented in Table IIA.3. The overall age length key is presented in Table IIA.4.

3. RESULTS

3.1 Acoustic data

The geographical distribution of the NASC values assigned to herring are presented in Figure IIA.2. The majority of herring were detected to the south and west of Barra Head. The main areas of concentration were north of 57° 30′ N along the shelf and south and east of Barra Head.

3.2 Biological data

A total of 16 trawl hauls were carried out. Table IIA.2 gives the positions and characteristics of these trawl hauls. 11 hauls contained sufficient herring to define the 5 survey subareas (Figure IIA.3). Herring were present in 11 hauls. All major concentrations were adequately characterized from these trawls. One haul was all pout (haul 4), and four hauls caught nothing (hauls 11, 13, 14 and 16).

The weight of herring at length was determined from length frequencies recorded from a random sample from each trawl haul and were measured in 0.5 cm intervals to the nearest 0.5 cm below. The resulting weight-length relationship for herring was:

$$W = 0.0043L^{3.2054} \qquad \text{L measured in cm}$$

Samples of fish were aged in the laboratory by counting winter rings. These were then used to compile an age–length key (Table IIA.4) to determine the proportion at age for each length class.

3.3 Biomass estimates

The results for the survey were:

Total herring biomass	331,671 **tonnes**	
Total herring numbers	1,908 million	
Spawning stock biomass	313,503 tonnes	94.52%
Immature	18,169tonnes	5.48%

The results for ICES Division VIa(N) were:

Definitely herring	221,170 tonnes	68%
Probably herring	104,222 tonnes	32%
Total herring biomass	325,392 **tonnes**	
Total herring numbers	1,865 million	
Spawning stock biomass	308,055 tonnes	94.67%
Immature	17,337tonnes	5.33%

A breakdown of the estimates by age class is given in Table IIA.5. The survey included all of ICES Division VIa(N) and part of VIa(S).

4. DISCUSSION

The stock estimate for VIa(N) has decreased by approximately 46% from 2009 (from 604,895 tonnes to 325,392 tonnes).

The distributions were broadly similar to previous years, with the significant quantities of fish seen south and west of Barra Head and the remains along the shelf edge north of St Kilda.

5. REFERENCES

ICES. 1994. Report of the Planning Group for Herring Surveys. ICES CM 1994/H:3. 26 pp.

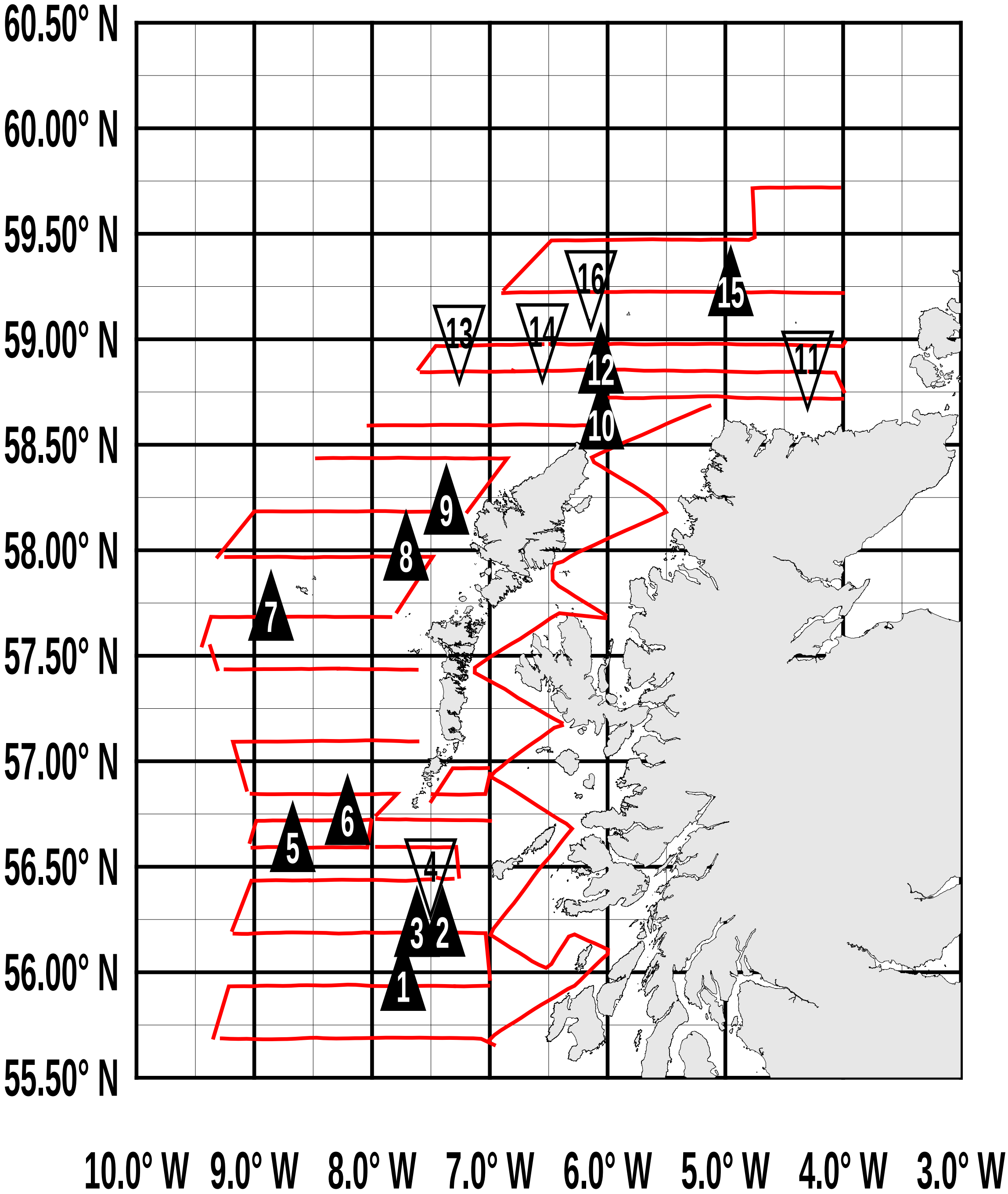


Figure IIA.1. Map of the west of Scotland showing cruise track and positions of fishing trawls undertaken during the July 2010 west coast acoustic survey on MFV *Prowess*. Filled triangles indicate trawls in which significant numbers of herring were caught, whilst open triangles indicate trawls with few or no herring.

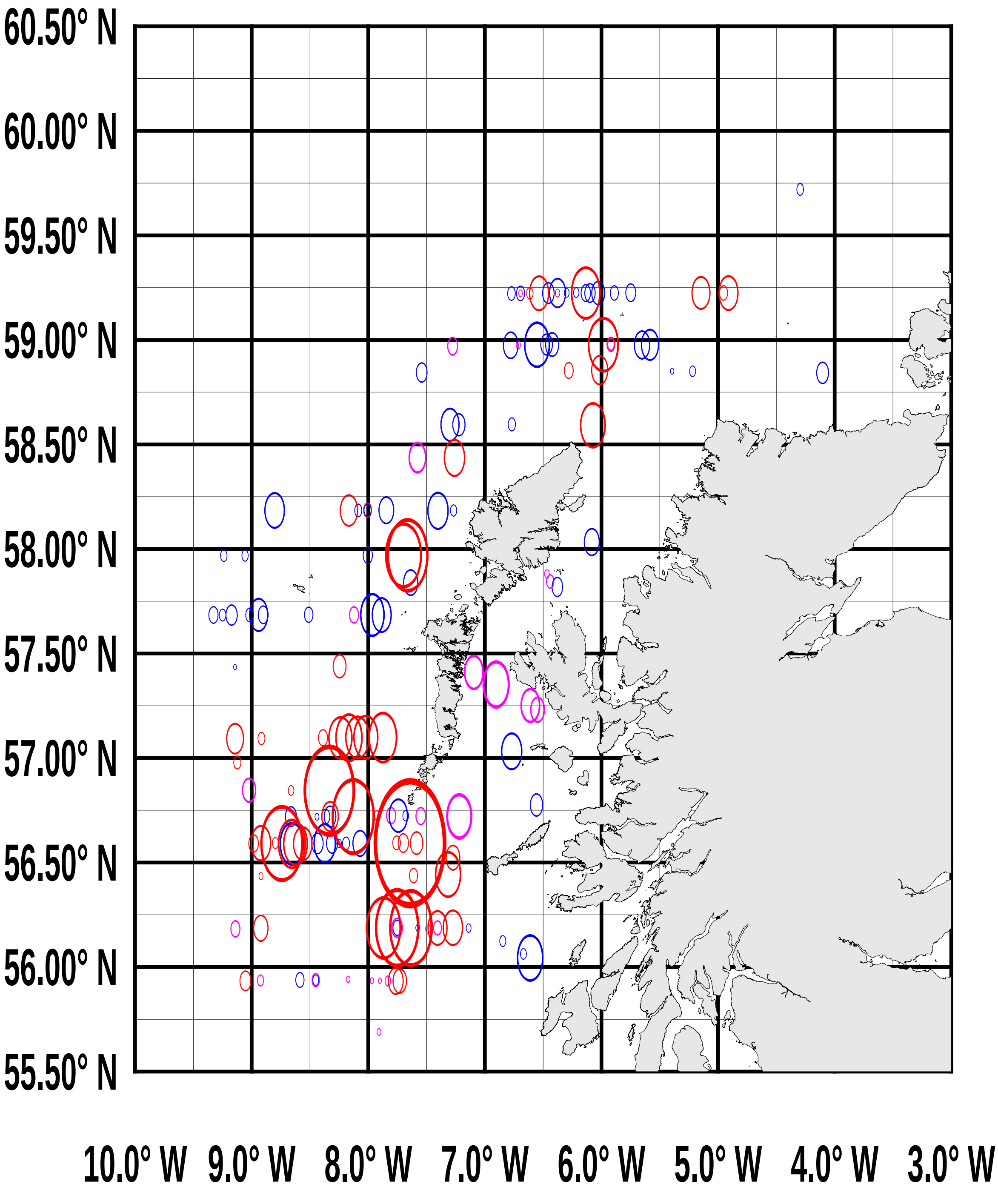


Figure IIA.2. Map of the west of Scotland with a post-plot showing the distribution of herring NASC values (on a proportional square root scale relative to a value of 7500) obtained during the July 2010 west coast acoustic survey on MFV *Prowess*. Red circles are 'Definitely herring', blue 'Probably herring' and pink 'Possibly herring'.

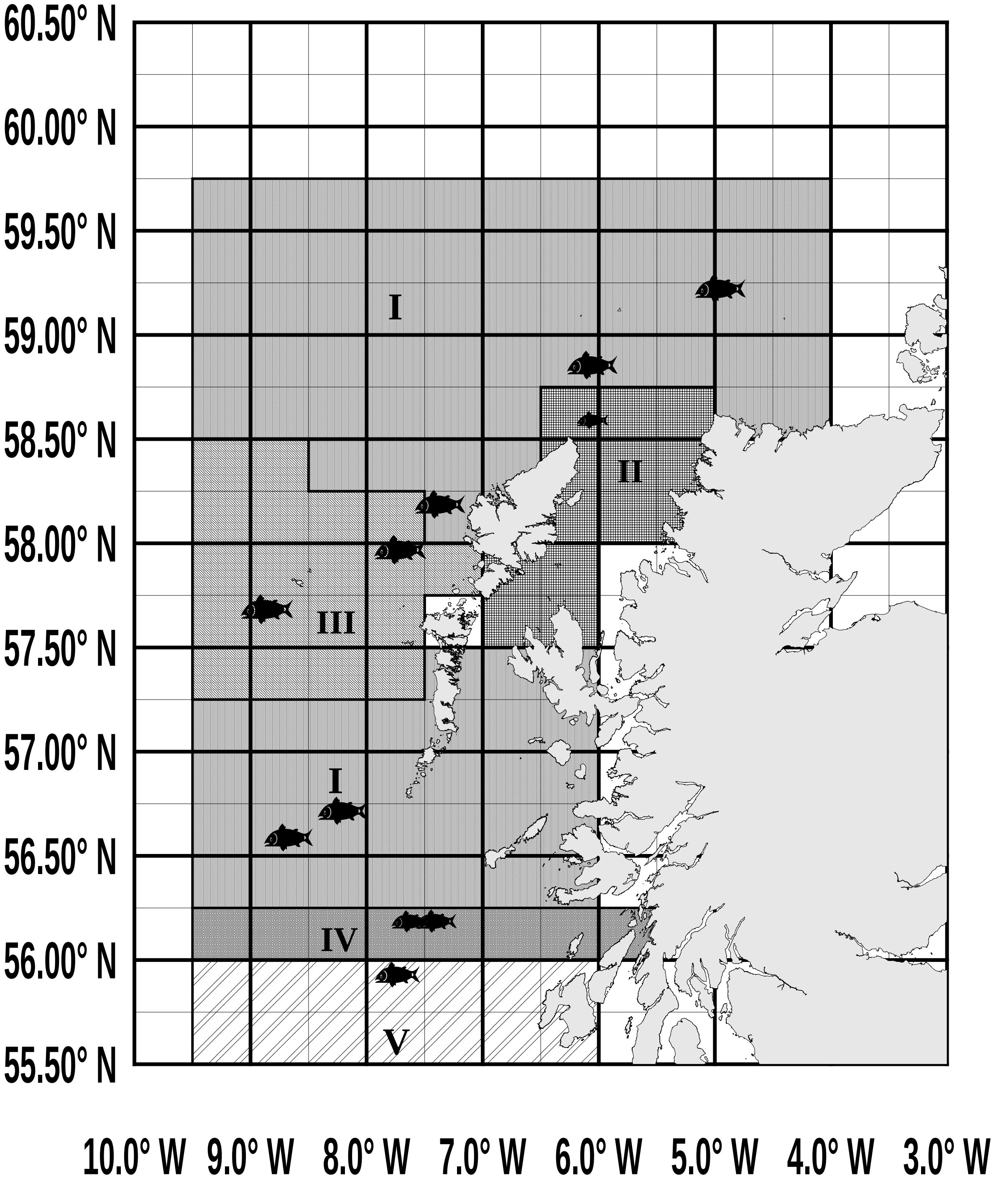


Figure IIA.3. Map of the west of Scotland with a post-plot showing the mean length of herring caught in the trawl hauls carried out during the July 2010 west coast acoustic survey on MFV *Prowess*, along with the area strata (indicated by shaded areas with Roman numerals I to VI used for combining data from the trawl hauls.

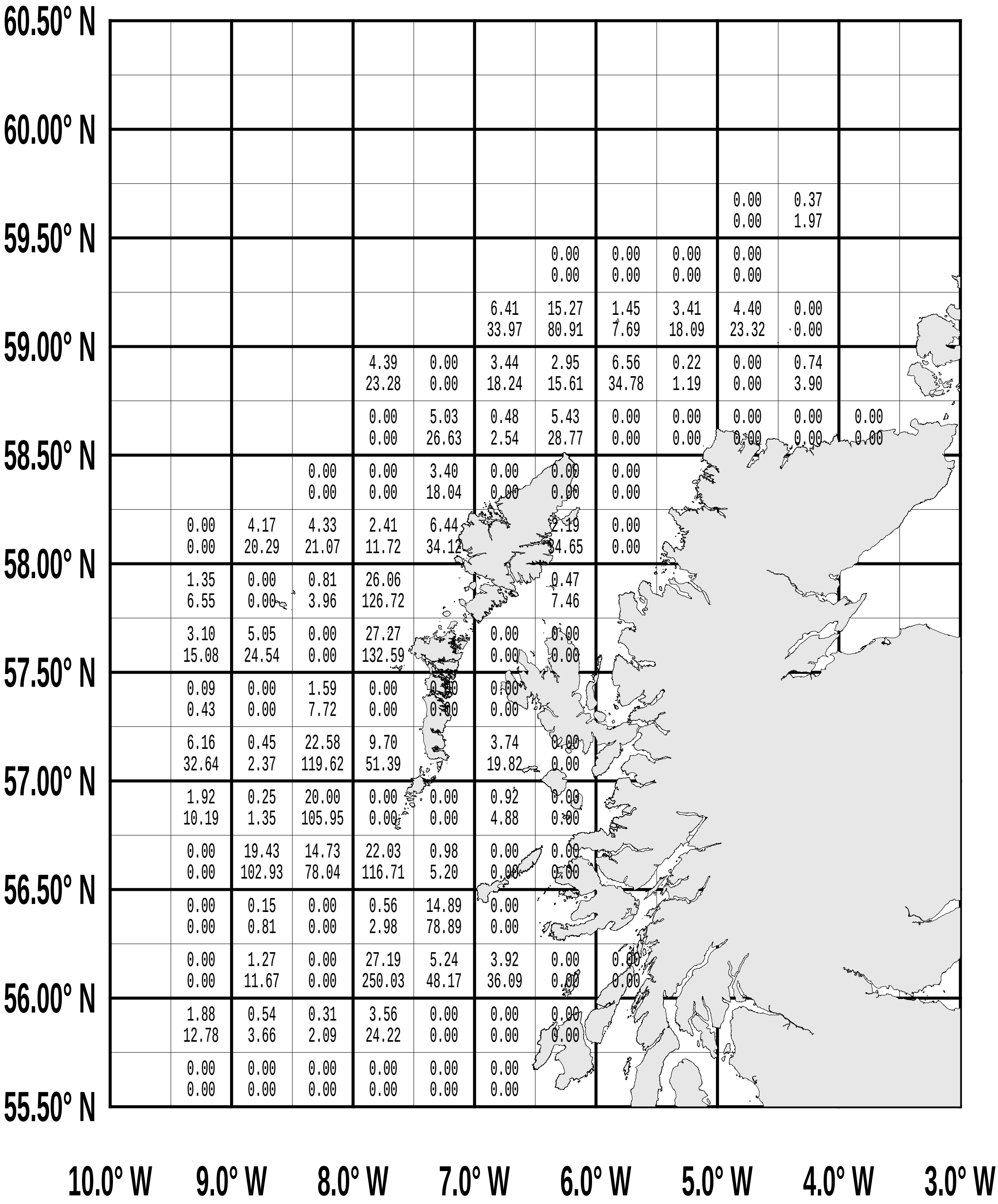


Figure IIA.4. Map of the west of Scotland with a plot showing the herring numbers in millions (bottom) and biomass in thousands of tonnes (top) by quarter ICES rectangle obtained during the July 2010 west coast acoustic survey on MFV *Prowess*.

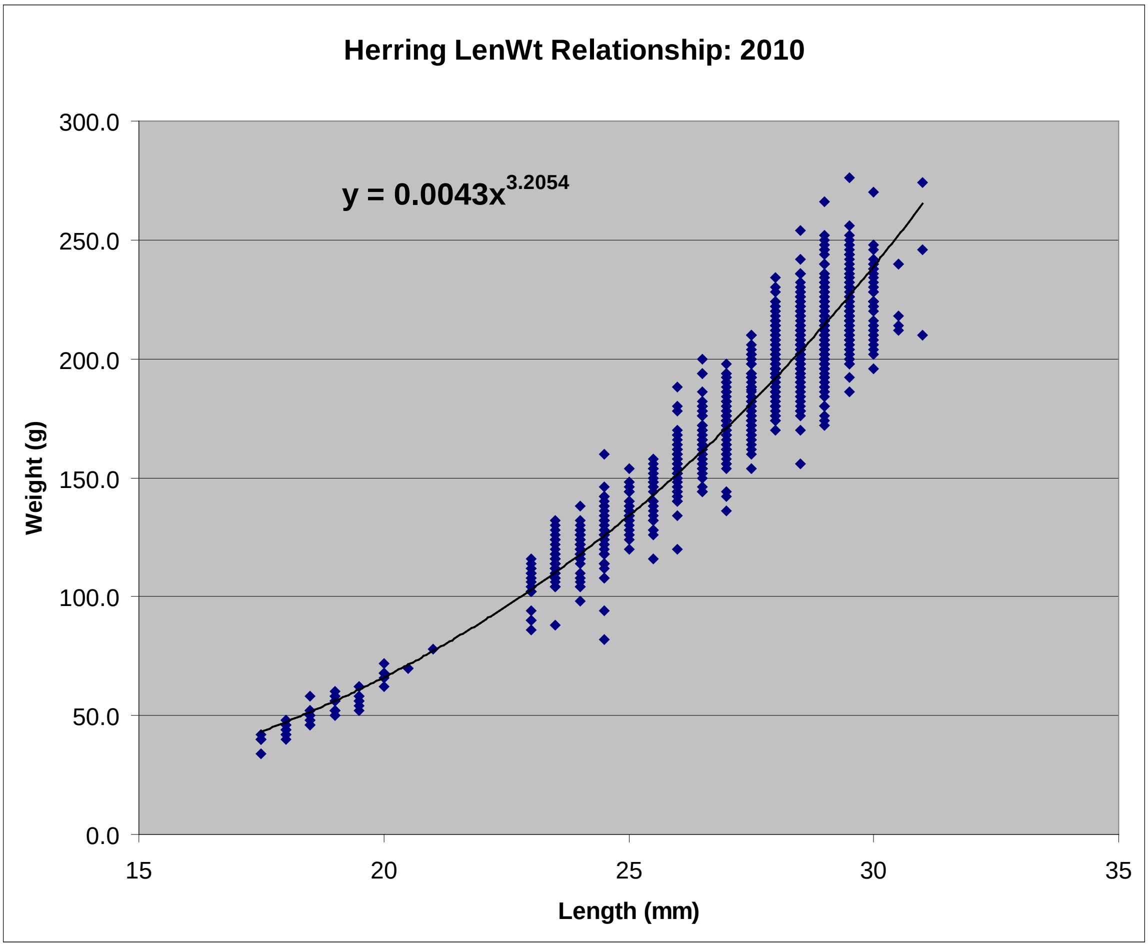


Figure IIA.5. Weight-length relationship obtained during the July 2010 west coast acoustic survey on MFV *Prowess*.

Table IIA.1. Simrad EK60 and analysis settings used on the July 2010 west coast of Scotland herring acoustic survey on MFV *Prowess*. Calibrations a) Loch Eriboll 28 June; and b) Loch Broom 11 July. *Milap factor based on a Simrad factor of 1 because calibration settings were incorporated into the Echoview post-processing package.

Transceiver Menu	
Frequency	38 kHz
Sound speed	1493.7
Max. Power	2000 W
Equivalent two-way beam angle	-21 dB
Default Transducer Sv gain	22.91 dB
3 dB Beamwidth	7.1°
Calibration details	
TS of sphere	-42.4 dB
Range to sphere in calibration	11.29m, 10.01m.
Measured NASC value for calibration	2658a, 3204b.
Calibration factor for NASCs	1
Calibration constant for MILAP (optional)*	1.1005 at -35 dB
Log Menu	
Integration performed in Echoview post-processing based on 15 minute EDSUs	
Operation Menu	
Ping interval	1 s at 100 m range 1.5 s at 250 m range 2.5 at 500 m range
Analysis settings	
Bottom margin (backstep)	0.5 m
Integration start (absolute) depth	11 m
Sv gain threshold	-70 dB

Table IIA.2. Details of the fishing trawls taken during the west Coast acoustic survey, July 2010; Trawl depth = depth (m) of headrope; Gear type P=pelagic; Duration of trawl (minutes); Total catch (number of baskets); Use H=used to qualify herring acoustic data, (blank if not).

Haul	Date	Latitude	Longitude	Time	Duration	Water Depth	Trawl Depth	Gear Type	Use	Total Catch
1	1/7	55° 55.84' N	7° 44.15' W	19:53	25	147	140	PT160	H	1
2	2/7	56° 11.23' N	7° 24.10' W	06:50	40	99	97	PT160	H	20
3	2/7	56° 11.15' N	7° 37.14' W	10:06	35	103	109	PT160	H	8
4	3/7	56° 26.41' N	7° 30.17' W	06:30	40	131	123	PT160		28
5	5/7	56° 35.31' N	8° 40.41' W	10:13	15	128	130	PT160	H	40
6	5/7	56° 42.98' N	8° 12.47' W	17:10	48	132	134	PT160	H	13
7	9/7	57° 41.07' N	8° 51.47' W	10:48	20	147	152	PT160	H	1
8	9/7	57° 58.15' N	7° 42.68' W	18:21	20	81	85	PT160	H	30
9	10/7	58° 11.24' N	7° 22.11' W	12:21	42	70	82	PT160	H	55
10	11/7	58° 35.47' N	6° 03.16' W	09:18	30	109	102	PT160	H	15
11	13/7	58° 50.80' N	4° 18.11' W	11:54	30	66	56	PT160		0
12	13/7	58° 51.33' N	6° 03.39' W	18:52	30	102	n/a	PT160	H	21
13	14/7	58° 58.18' N	7° 15.57' W	07:14	30	155	n/a	PT160		0
14	14/7	58° 58.58' N	6° 33.20' W	11:50	23	114	n/a	PT160		0
15	15/7	59° 13.36' N	4° 57.24' W	06:10	12	97	94	PT160	H	50
16	15/7	59° 13.69' N	6° 08.54' W	11:32	30	95	n/a	PT160		0

Table IIA.3. Herring length frequency proportion by trawl haul by sub- area for west coast acoustic survey MFV *Prowess* (28 June - 17 July 2010). Length in cm, weight in g, TS=target strength in dB.

	I						II	
L(CM)	005	006	009	012	015	MEAN	010	MEAN
17.00						0.00	0.03	0.03
17.50						0.00	0.08	0.08
18.00						0.00	0.19	0.19
18.50						0.00	0.23	0.23
19.00						0.00	0.22	0.22
19.50						0.00	0.10	0.10
20.00		0.00				0.00	0.05	0.05
20.50		0.01				0.00	0.02	0.02
21.00		0.01				0.00	0.01	0.01
21.50	0.00	0.02	0.00			0.00	0.00	0.00
22.00	0.02	0.02	0.00			0.01	0.01	0.01
22.50	0.01	0.01	0.00			0.00	0.00	0.00
23.00	0.02	0.00	0.01			0.01	0.00	0.00
23.50	0.02	0.01	0.00			0.01	0.00	0.00
24.00	0.05	0.02	0.01	0.00		0.02	0.00	0.00
24.50	0.04	0.02	0.02	0.01	0.00	0.02	0.01	0.01
25.00	0.06	0.04	0.02	0.01	0.02	0.03	0.00	0.00
25.50	0.03	0.02	0.04	0.03	0.03	0.03	0.01	0.01
26.00	0.05	0.06	0.05	0.09	0.08	0.07	0.00	0.00
26.50	0.07	0.05	0.06	0.10	0.08	0.07	0.01	0.01
27.00	0.12	0.12	0.11	0.11	0.12	0.12	0.01	0.01
27.50	0.10	0.13	0.12	0.13	0.10	0.11	0.00	0.00
28.00	0.14	0.14	0.21	0.18	0.18	0.17	0.00	0.00
28.50	0.11	0.13	0.18	0.11	0.13	0.13	0.00	0.00
29.00	0.11	0.14	0.14	0.15	0.15	0.14	0.00	0.00
29.50	0.04	0.04	0.03	0.04	0.07	0.05	0.00	0.00
30.00	0.01	0.01	0.01	0.02	0.04	0.02	0.00	0.00
30.50	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
31.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Number	5616	438	2855	2060	8233		774	
mean length	27.41	27.66	28.14	28.17	28.31	27.99	19.67	19.67
mean weight	177.56	183.12	191.33	191.84	194.97	188.73	63.13	63.13
TS/individual	-42.42	-42.34	-42.20	-42.20	-42.15	-42.25	-45.27	-45.27
TS/kilogramme	-34.91	-34.97	-35.02	-35.03	-35.05	-35.00	-33.27	-33.27

Table IIA.3(continued). Herring length frequency proportion by trawl haul by sub- area for west coast acoustic survey MFV *Prowess* (28 June - 17 July 2010). Length in cm, weight in g, TS=target strength in dB.

	III			IV			V	
L(CM)	007	008	MEAN	002	003	MEAN	001	MEAN
17.00			0.00			0.00		0.00
17.50			0.00			0.00		0.00
18.00			0.00		0.01	0.00		0.00
18.50			0.00	0.01	0.02	0.01		0.00
19.00			0.00	0.02	0.07	0.04		0.00
19.50			0.00	0.03	0.04	0.04		0.00
20.00			0.00	0.08	0.10	0.09		0.00
20.50			0.00	0.01	0.04	0.02	0.01	0.01
21.00			0.00	0.10	0.04	0.08	0.04	0.04
21.50			0.00	0.08	0.06	0.07	0.04	0.04
22.00			0.00	0.05	0.07	0.06	0.05	0.05
22.50			0.00	0.05	0.08	0.06	0.05	0.05
23.00			0.00	0.05	0.08	0.06	0.04	0.04
23.50			0.00	0.07	0.10	0.08	0.05	0.05
24.00			0.00	0.13	0.13	0.13	0.07	0.07
24.50	0.00		0.00	0.05	0.07	0.06	0.08	0.08
25.00	0.00		0.00	0.05	0.03	0.04	0.04	0.04
25.50	0.00	0.00	0.00	0.04	0.03	0.03	0.07	0.07
26.00	0.00	0.00	0.00	0.09	0.02	0.06	0.09	0.09
26.50	0.00	0.02	0.01	0.05	0.01	0.03	0.12	0.12
27.00	0.03	0.05	0.05	0.03	0.01	0.02	0.07	0.07
27.50	0.05	0.15	0.15	0.02	0.00	0.01	0.05	0.05
28.00	0.19	0.24	0.24	0.01	0.00	0.00	0.01	0.01
28.50	0.28	0.25	0.25	0.00	0.01	0.00	0.01	0.01
29.00	0.30	0.19	0.20	0.00	0.00	0.00	0.01	0.01
29.50	0.10	0.08	0.08	0.00	0.01	0.00	0.03	0.03
30.00	0.03	0.01	0.01	0.01	0.00	0.00	0.01	0.01
30.50	0.01	0.00	0.00	0.00	0.00	0.00	0.03	0.03
31.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.01
31.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Number	245	4520		197	160		75	
mean length	29.09	28.81	28.83	23.80	22.89	23.39	25.71	25.71
mean weight	211.76	205.32	205.65	114.92	101.14	108.74	146.85	146.85
TS/individual	-41.92	-42.01	-42.00	-43.63	-43.97	-43.78	-42.96	-42.96
TS/kilogramme	-35.18	-35.13	-35.13	-34.23	-34.02	-34.14	-34.63	-34.63

Table IIA.4. Age/maturity-length key for herring (numbers of fish sampled MFV *Prowess* , 28 June - 17 July 2010). Numbers in brackets signifies the contribution to the total, made from manufactured data based on lengths measured.

	NUMBER AT AGE/MATURITY												
LENGTH (CM)	0	1I	2I	2M	3I	3M	4	5	6	7	8	9+	GRAND TOTAL
17.0		1											1
17.5		5											5
18.0		11											11
18.5		11											11
19.0		12											12
19.5		8											8
20.0		5											5
20.5		3	2(2)										5
21.0		2(1)	3(3)										5
21.5			7(7)										7
22.0		1(1)	5(5)										6
22.5			5(5)										5
23.0			4	19	1								24
23.5			2	35		2							39
24.0			2	41		3							46
24.5				38		4	3						45
25.0				30		2	3						35
25.5				19		6	2	1					28
26.0				37		20	2	1	1				61
26.5				27		25	3		1	1			57
27.0				21		46	6	3	1	1			78
27.5				4		48	9	4	1	2		1	69
28.0				5		46	19	13	8	8	4	21	124
28.5				3		27	26	30	15	8	10	51	170
29.0						20	25	39	18	13	14	48	177
29.5						3	6	17	16	9	7	29	87
30.0						5	2	6	7	1	4	16	41
30.5							1	1	1		1	1	5
31.0								1	1		1		3
31.5													0
32.0												1(1)	1
32.5													0
33.0										1(1)		6(6)	7
33.5												1(1)	1
Total		59	30	279	1	257	107	116	70	44	41	175	1179

Table IIA.5. Mean length, mean weight, biomass (thousands of tonnes) and numbers (millions) breakdown by age and maturity obtained during the MFV *Prowess* 2010 herring acoustic survey for the complete survey i) and for VIa(N) ii)

i)

Breakdown of age and maturity for complete survey						
Age(ring)	Mean Length(cm)	Mean Weight(g)	Numbers X10^6	%	Biomass X10^3 T	%
1	19.52	64.36	121	6.35	7.8	2.35
2I	21.93	92.15	111	5.82	10.2	3.09
2M	25.33	145.76	409	21.41	59.5	17.95
31	23.00	106.60	1	0.07	0.1	0.04
3M	27.37	185.00	491	25.71	90.8	27.36
4	27.97	198.05	174	9.09	34.4	10.36
5	28.58	211.51	165	8.64	34.9	10.51
6	28.72	214.94	94	4.95	20.3	6.12
7	28.47	209.02	65	3.38	13.5	4.07
8	28.93	219.71	54	2.82	11.8	3.56
9	28.75	215.39	225	11.77	48.4	14.59
Mean	26.58	173.81				
Total			1908.29	100.00	331.67	100.00
Immature			233.52	12.24	18.17	5.48
Mature			1674.76	87.76	313.50	94.52

ii)

Breakdown of age and maturity for VIa(N)						
Age(ring)	Mean Length(cm)	Mean Weight(g)	Numbers X10^6	%	Biomass X10^3 T	%
1	19.50	64.15	120	6.42	7.7	2.36
2I	21.93	92.13	103	5.54	9.5	2.93
2M	25.35	146.08	391	20.93	57.0	17.53
31	23.00	106.60	1	0.06	0.1	0.04
3M	27.39	185.29	482	25.84	89.3	27.45
4	27.98	198.26	171	9.19	34.0	10.45
5	28.57	211.43	163	8.76	34.6	10.62
6	28.71	214.76	93	5.00	20.0	6.16
7	28.47	209.06	64	3.43	13.4	4.12
8	28.91	219.32	53	2.85	11.6	3.58
9	28.75	215.30	223	11.97	48.1	14.78
Mean	26.62	174.42				
Total			1865.53	100.00	325.39	100.00
Immature			224.37	12.03	17.34	5.33
Mature			1641.15	87.97	308.06	94.67

ANNEX 5B: Denmark

Acoustic Herring Survey report for RV "DANA"

3 July 2010 – 13 July 2010

Karl Johan Stæhr

DTU-Aqua, National Institute of Aquatic Resources

Cruise summary

Total days	14
Days of monitoring	11
Number of acoustic samples, ESDU	1578
Number of trawl hauls	38
Number of CTD stations	38
Number of measured fish	21404
Number of aged and race-splitted herring.	3678
Number of aged sprat	635

1. INTRODUCTION

Since 1991 the DTU National Institute of Aquatic Resources (DTU AQUA) has participated in the ICES coordinated herring acoustic survey of the North Sea and adjacent waters with the responsibility for the surveying the Skagerrak and Kattegat area.

The actual 2010-survey with RV "DANA", covering the Skagerrak and Kattegat, was conducted in the period July 5 to July 16 2010, while calibration was done during July 3 to July 5 2010.

2. SURVEY

2.1 Personnel

During calibration 3/7 – 5/7-2010

Karl-Johan Stæhr	(cruise leader)
Bo Lundgren	(assisting cruise leader)
Torben Filt Jensen	
Thyge Dyrnesli	
Peter Faber	
Jesper Knudsen	
Mads Larsen	
Bjarne Stage	
Helle Rasmussen	
Claus Halle	
An Hoai Pham	
Jønne Marcher	
Martin Petrella	

During acoustic monitoring 5/7 - 16/7-2009

Karl-Johan Stæhr	(cruise leader)
Bjarne Stage	(assisting cruise leader)
Torben Filt Jensen	
Lise Sindahl	
Helle Rasmussen	
Helle Andersen	
Nina Fuglsang	
Thyge Dyrnesli	
Jønne Marcher	
Martin Petrella	

2.2 Narrative

The survey of RV "Dana" started on July 3 at 10.00 UTC with departure from Hirtshals heading towards Bornö in Gullmar Fjord, Sweden for calibration of the acoustic equipment. The vessel was anchored at Bornö in the Gullmar Fjord, Sweden early in the evening of July 3. The calibration was initiated in the morning of July 4 and continued until the morning of July 5.

At July 5 noon the scientific crew was exchanged outside the harbour of Skagen. At this point a technician from Ødegaard and Danneskjold-Samsøe was taken on-board to do noise measurements on the trawl deck. These noise measurements were conducted north of Skagen during setting and hauling of a trawl and continued until 16.00 UTC after which the ship returned to Skagen with the technician. After the short break, RV "Dana" steamed west towards the border between Skagerrak and the North Sea. The acoustic integration was initiated on July 6 at 0503 UTC at 57º15'N, 07º34'E.

The North Sea and western Skagerrak area was covered during the period July 5 – 10, eastern Skagerrak during July 11 – 13 and Kattegat during July 14 – 16. The acoustic integration was ended July 16 at 57º25'N, 10º46'E at 04.48 UTC. RV "Dana" arrived at Hirtshals at 1100 UTC on July 16.

Totally the survey covered about 2000 nautical miles. Data from the 38 kHz echosounder were recorded mainly using a 38 kHz paravane transducer running at depths of 3 – 5 m, the depth depending on the sea state and sailing direction relative to the waves. Simultaneously, data from the 120 kHz and 18 kHz echosounders using hull-mounted transducers were also recorded. The quality of the latter data is strongly dependent on the weather conditions, but this year the weather was calm, so no data had to be excluded due to the weather. During trawling hull-mounted transducers were used for all three frequencies.

2.3 Survey design

The survey was carried out in the Kattegat and Skagerrak area, east of 6° E and north of 56° N (Figure 1). The area is split into 8 subareas.

In principal the survey is designed with parallel survey tracks at right angles to the depth lines with a spacing of 10–15 nm in the area west of 10°E. Due to limitations regarding available time periods and places for fishing (late morning, early afternoon and immediately before and after midnight; and a limited amount of fishable positions for bottom-trawl hauls) this structure cannot not be kept strictly. Along the Swedish coast the transects are planned as east-west transects with a spacing of 10 nm approximately at right angles to the coastline. In Kattegat the survey track was made in a zigzag pattern adapted to the depth curves and the relatively heavy ship traffic.

2.4 Calibration

The echosounders were calibrated at Bornö in the Gullmar Fjord, Sweden during July 3 - July 5 2010. The calibration was performed according to the procedures established for EK60 with three frequencies (18, 38 and 120 kHz). This was the second calibration of the year, the previous one just before a cruise to the Norwegian Sea in May. The calibration of the paravane split-beam transducer at 38 kHz was done against a 60 mm copper sphere. The calibration of the three hull-mounted split-beam transducers at 18, 38 and 120 kHz were carried out against 63mm, 60 mm and 23 mm copper spheres, respectively. The results were close to those from the previous calibration earlier in May, and for 38 kHz on the towed body close to results from previous years. The calibration and setup data of the EK60 38 kHz used during the survey are shown in Table 1.

The impedance data for the hull-mounted 38 kHz transducer showed that two of the four segments had significantly lower values than normal. Therefore, this transducer has been replaced during docking in October 2010

2.5 Acoustic data collection

Acoustic data were collected using mainly the Simrad EK60 38 kHz echosounder with the transducer (Type ES 38 7x7 degrees main lobe) in a towed body. The towed body runs at approx. 3 m depth in good weather and down to about 6 -7 m, as needed, depending on the weather conditions, this year mostly at 4 – 5 m. The speed of the vessel during acoustic sampling was 9 – 11 knots. Also EK60 18 kHz and 120 kHz data were collected. They have not been directly used for the survey estimate, but as an aid during judging when distinguishing between fish and plankton. The acoustic data were recorded as raw data on hard disk 24 hours a day also during fishing operations. During trawl hauls the towed body is taken aboard and the EK60 38 kHz echosounder run on the hull transducer, but data taken during fishing periods are not used for the biomass estimate. The sampling unit (ESDU) was one nautical mile (nm). For the purpose of the later judging process, raw data is pre-integrated into 1 m meter samples for each ping. These samples are stored in separate files one for each ESDU. Integration is conducted from 3 m below the transducer to 1 m above the bottom or to max 300 m depth.

2.6 Biological data - fishing trawls

The trawl hauls were carried out during the survey for species identification. Pelagic hauls were carried out using a FOTÖ trawl (16 mm in the codend), while demersal hauls were carried out using an EXPO trawl (16 mm in the codend). Trawling was carried out in the time intervals 1000 to 1600 and 2030 to 0300 UTC , usually two day hauls (pelagic on larger depth and demersal in shallow waters) and two night hauls (mostly surface or midwater). The strategy was to cover most depth zones within each geographical stratum with trawl hauls. One-hour hauls were used as a standard during the survey.

The total weight of each catch was estimated and the catch sorted into species. Total weight per species and length measurements were made. The clupeid fish were measured to the nearest 0.5 cm total length below, other fish to 1 cm, and the weight to the nearest 0.1g wet weight. From each trawl haul 10 herring (if available) per 0.5 cm length class were collected and frozen for individual determination in land-laboratory of length, weight, age, race (North Sea autumn spawners or Baltic Sea spring spawners) and maturity. Fourier Shape Analyses calibrated to micro-structure formed in the otoliths during the larval period was used for the discrimination of herring race. Maturity was determined according to an 8-stage scale as also used by Scotland.

2.7 Hydrographic data

CTD profiles with a Seabird 911 were made immediately before or after each trawl haul. Salinity and temperature were measured continuously during the cruise at an intake at about 5 m depth. Data is stored together with position and weather data in the vessel's general information system The distribution of CTD stations is similar to trawl hauls and shown in Figure 2.

2.8 Data analysis

The raw data is pre-integrated into 1 m samples for each ping and divided into 1 mile datasets and stored on harddisk as files. Scrutiny of the acoustic data is done for a fixed set of layers (3–6 m, 6- 10, 10 – 20 etc.) for each mile, using special judging software. The software allows ignoring data from layers and/or intervals with interference from wave- or ship wake-bubbles or rarely with interference from bottom-integration. In areas with heavy abundance of jellyfish or zooplankton, usually krill, manually adjustable thresholds are applied separately to each layer to suppress background echoes.

For each subarea (56E06 – 58E08, C – E in Figure 1) the mean backscattering cross section was estimated for herring, sprat, gadoids and mackerel based on the standardized TS-relationships given in the Manual for Herring Acoustic Surveys in ICES Division III, IV, and IVa (ICES 2000):

$$\text{Herring TS} = 20 \log L - 71.2 \text{ dB}$$

$$\text{Sprat TS} = 20 \log L - 71.2 \text{ dB}$$

$$\text{Gadoids TS} = 20 \log L - 67.5 \text{ dB}$$

$$\text{Mackerel TS} = 20 \log L - 84.9 \text{ dB}$$

where L is the total length in cm. The number of fish per species is assumed to be in proportion to the contribution of the given species in the trawl hauls. Therefore, the relative density of a given species is estimated by subarea using the species composition in the trawl hauls. The nearest trawl hauls are allocated to subareas with uniform depth strata. The length-race and length-age distributions for herring are assumed to be in accordance with combined length-race and length-age distributions in the allocated trawl hauls.

Length-age and length weight relationships by race for the herring were made based on the age and race analysis made on the frozen samples of single fish after the cruise.

3. RESULTS and DISCUSSION

3.1 Acoustic data

The total number of acoustic sample units of 1 nm (ESDU's) used in the stock size calculation is 11578. The numbers of ESDU's per stratum are given in Table 2. Table 2 also shows the mean Sa and mean TS per stratum used in the abundance estimation. The outline of the strata is shown in Figure 1 and the cruise track for the survey is shown in Figure 2.

Historically, herring and sprat have not been observed in midwater trawl hauls at depths below 150 meters. Therefore, layers below 150 meter have been excluded from the estimation.

The relative herring density in numbers per nm^2 along the cruise track is shown in Figure 3. The main concentration of herring is in 2010 primarily distributed in ICES squares 43F8, 44F9, 44G0, 44G1. This distribution is quite different from 2008 when the main concentration was further west (west of 8° E ; see Figure 5). The main distribution pattern is more like the pattern in 2009 except that a larger part is found in Skagerrak along the Danish coast and in Kattegat than in 2009 (see Figure 4).

3.2 Biological data

During the survey in 2010 38 hauls were conducted, 26 surface hauls and 12 bottom hauls. The geographical distribution of hauls is shown in Figure 2 and details on the hauls and catches are given in Table 3 and 4.

The total catch for the survey was 29.2 tons. Herring was present in 32 hauls with a total catch of 19.4 tons or 66% of the total catch. In 2010, like in the last three years, herring was fished best during daytime in surface hauls in the deeper parts of Skagerrak. Length distributions of herring per haul are given in Table 5.

Sprat was present in the hauls in the North Sea (ICES square 41F7, Skagerrak west of Hirtshals (ICES square 44F9 and Kattegat (stratum E). For the total survey area herring, mackerel and sprat contributed to the total catch by 66%, 8% and 4% respectively.

Herring maturity

Based on the frozen single fish herring samples (3678 specimens) from each haul, where race analysis of the otoliths was used to differentiate between North Sea herring and Western Baltic herring, a maturity by age key was made for both races. It is given in the text table below. For North Sea autumn spawners specimens with maturity stage ≥3 and/or age ≥5 are regarded as mature and for Baltic spring spawners specimens with maturity stage ≥2 and/or age ≥5 are regarded as mature.

North Sea autumn spawners:

Skagerrak												
WR	0	1i	1m	2i	2m	3i	3m	4i	4m	5	6	7
%	100.00	99.76	0.24	79.55	20.45	85.19	14.81	60.00	40.00	100.00	100.00	100.00

Kattegat							
WR	0	1i	1m	2i	2m	3i	3m
%	100.00	99.20	0.80	27.27	72.73	40.00	60.00

North Sea					
WR	0	1i	1m	2i	2m
%	100	100	0	50	50

Baltic Sea spring spawners:

Skagerrak																	
WR	0	1i	1m	2i	2m	3i	3m	4i	4m	5	6	7	8	9	10	11	12
%	100.00	79.41	20.59	11.43	88.57	2.43	97.57	0.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Kattegat													
WR	0	1i	1m	2i	2m	3i	3m	4i	4m	5	6	7	8
%	100.00	87.69	12.31	24.23	75.77	21.62	78.38	6.90	93.10	100.00	100.00	100.00	100.00

North Sea							
WR	0	1i	1m	2i	2m	3i	3m
%	100	100	0	0	100	0	100

Sprat maturity

Based on 635 sprat collected over all length classes and hauls including sprat age, weight and maturity keys were established. The maturity key for sprat is shown in the text table below. Sprat with maturity stage ≥3 and/or age ≥3 are regarded as mature

WR	0	1i	1m	2i	2m	3	4	5	6
%	100.00	81.03	18.97	55.03	44.97	100.00	100.00	100.00	100.00

Ichthyophonus

The herring sampled for race analyses were also visually inspected for Ichthyophonus. At 6 stations in the western Skagerrak and Kattegat (see Figure 6) Ichthyophonus was found at herring smaller than 18 cm.

3.3 Biomass estimates

Herring

The total herring biomass estimate for the Danish acoustic survey with RV "Dana" in July 2010 is 237,542 tonnes of which 62.7% or 148,946 tonnes is North Sea autumn spawners and 37.3% or 88,597 tonnes is Baltic Sea spring spawners.

For the total number of herring the survey results give 4,184 mill, of which 65.1% are North Sea autumn spawners and 34.9% are Baltic Sea spring spawners.

The estimated total number of herring, mean weight, mean length and biomass per age and maturity stage in each of the surveyed strata are given in Table 6 and 7 for North Sea autumn spawners and Baltic spring spawners respectively.

A comparison for the results of the last three years surveys are given in the text table below.

	2006	2007	2008	2009	2010
Autumn spawners					
Number in mill.	1530	4443	4473	9679	2723
Biomass in tons	98786	315176	80469	157707	148946
Spring spawners					
Number in mill.	6407	8847	7367	1326	1461
Biomass in tons	471850	614048	450505	146590	88597

North Sea autumn spawners

From 2006 to 2007 there was an increase in the abundance of autumn spawners of 190% and in the biomass of 219%. The age structure in the abundance for 2006 and 2007 showed the same pattern with 86% and 91% of the total abundance as 1 WR for the two years respectively (see Table 8). This increase corresponds to an overall increase of the abundance of autumn spawners in the survey area.

From 2007 to 2008 the abundance of autumn spawners showed an increase of 0.7% whereas the biomass showed a decrease of 74%. As it can be seen from Table 8 this contradictory development between abundance and biomass is the result of a dramatic change in age composition of the abundance from 2007 to 2008. In 2007 1 WR contributed to 91% of the abundance of autumn spawners, whereas the 0 WR contributes to 88% of the abundance in 2008. (Table 8).

From 2008 to 2009 the abundance of autumn spawners showed an increase of 116% and the biomass showed an increase of 96%. As it can be seen from Table 8 the abundance in 2009 is dominated by 0 and 1 WR (81 and 19% respectively. The abundance of 0 WR are the double of what was seen in 2008 and 1 WR are than 4 times the abundance in 2008.

From 2009 to 2010 the abundance of autumn spawners has decreased by 72% where as the biomass has decreased with 6%. From Table 8 it can be seen that the abundance is dominated by 1 WR in 2010 where it was dominated by 0 WR in 2008 and 2009. It looks as if the age structure in the abundance is on its way back to the structure seen in 2006 and 2007 (see Table 8)

Baltic Sea spring spawners

For spring spawners no large changes in the age structure over the years from 2006 to 2008 have been seen (see Table 9).

From 2008 to 2009 there has been a decrease in the abundance of 82% and in the biomass of 67%. From Table 9 it can be seen that the major part of the difference in abundance between 2008 and 2009 lies in a decrease in the abundance of 0–3 WR.

From2009 to 2010 the abundance has increased with 9%, whereas the biomass has decreased with 39.6%. From Table 9 it can be seen that there has been a change in the age structure of spring spawners from 2009 to 2010. The abundance of 0–3 WR has increased with 39% and the abundance of 4–13 WR has decreased with 83%. This shift in the age structure of the abundance is reflected in the biomass.

Sprat

The total abundance estimate of sprat for the Danish acoustic survey with RV "Dana" in July 2010 is 3102.65 million with 1543.93 millions in ICES square 41F7 (Stratum 560E06), 1558.29 millions in Kattegat (Stratum E) and 0.42 millions in 44F9 (Stratum 570E08).

Abundance, biomass, mean length and mean weight per WR and strata are given in Table 10.

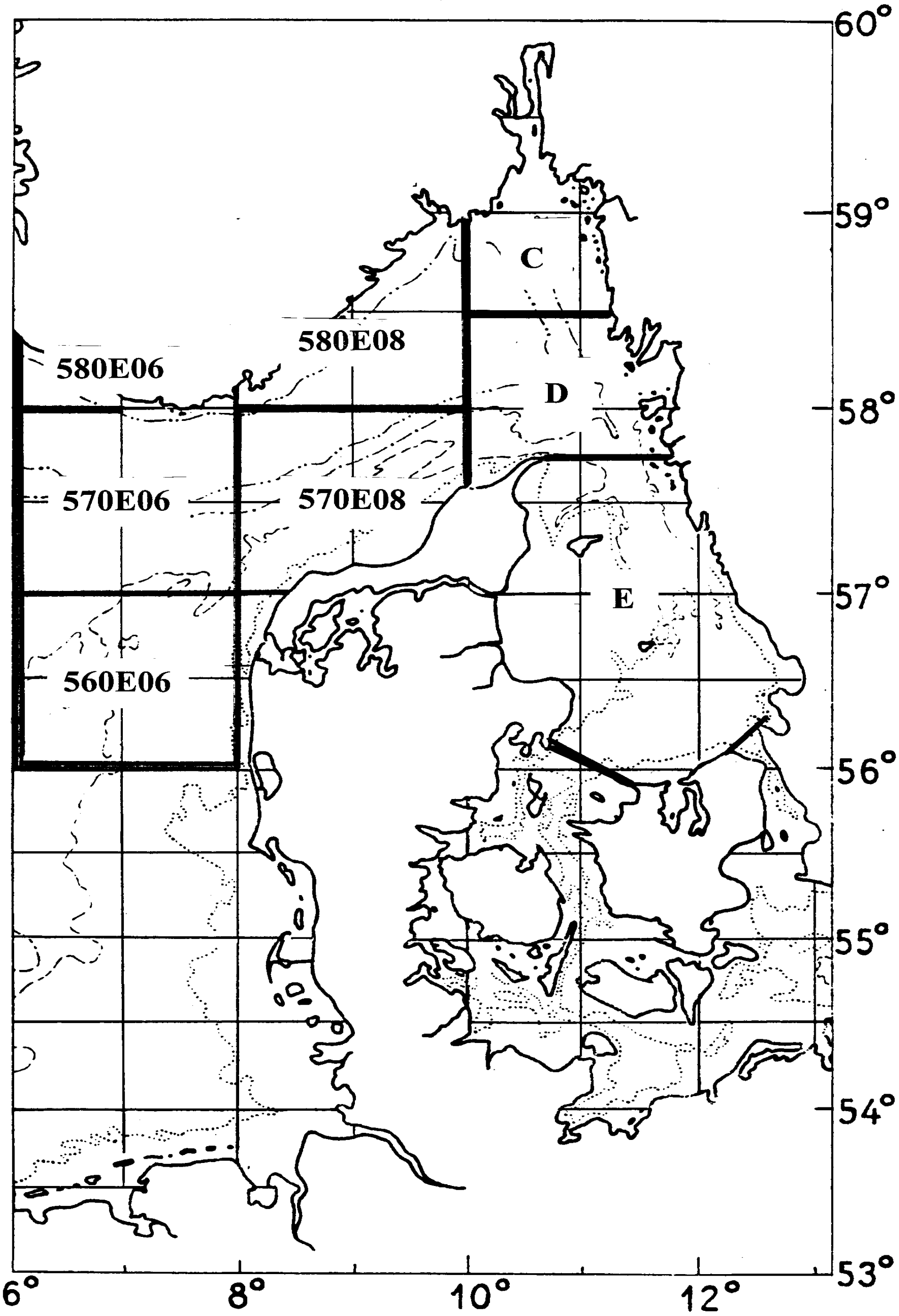


Figure 1. Map showing the survey area for the Danish acoustic survey with RV "Dana" in July 2010. The map shows the subareas (strata) used in the abundance estimation.

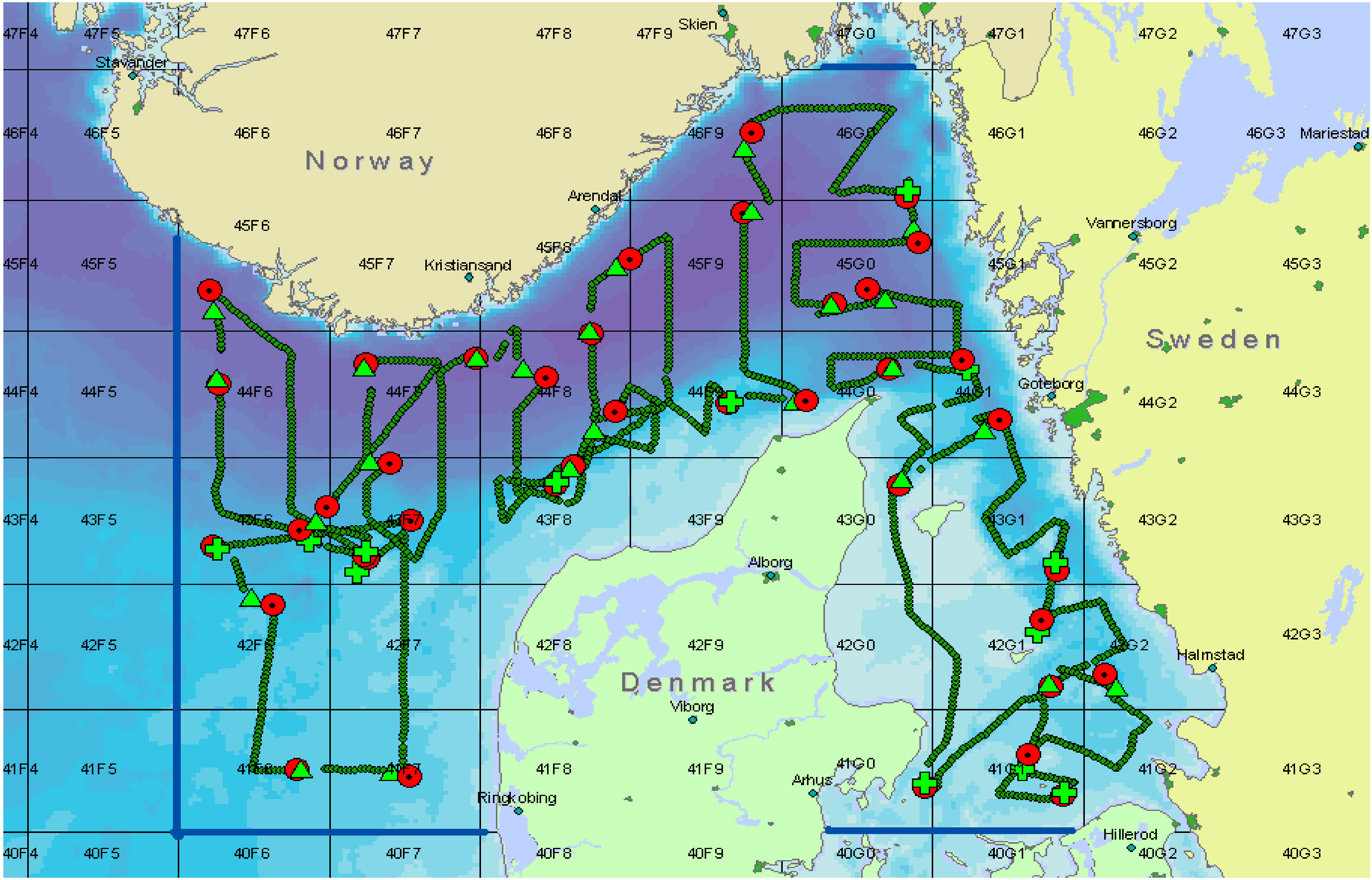


Figure 2. Map showing cruise track and trawl stations during the Danish acoustic survey with RV "Dana" in July 2010.

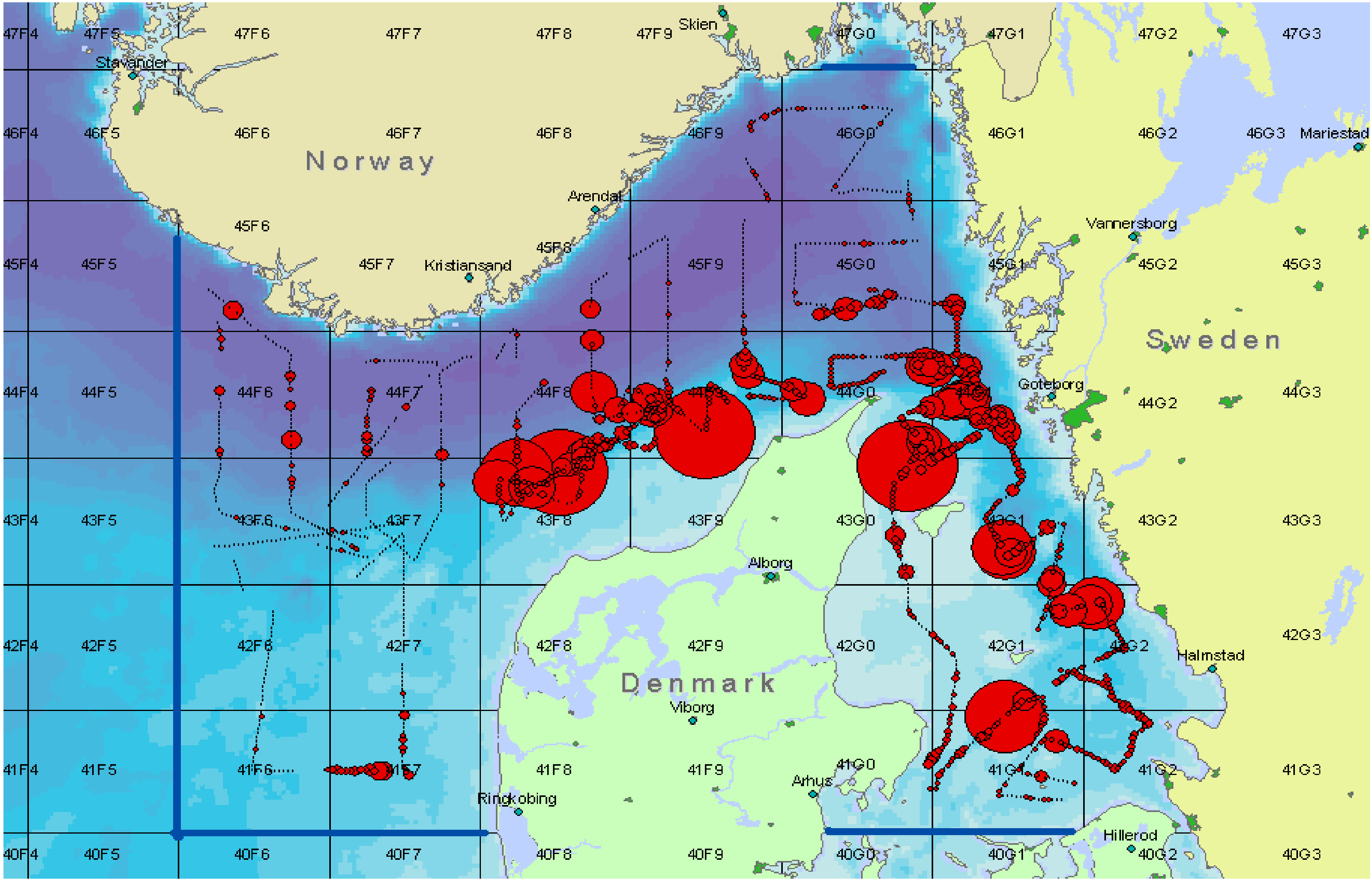


Figure 3. Relative herring density (in numbers per nm²) along the track of the July 2010 Danish acoustic survey in the eastern North Sea, Skagerrak and Kattegat. Red circles indicate relative density of herring per ESDU.

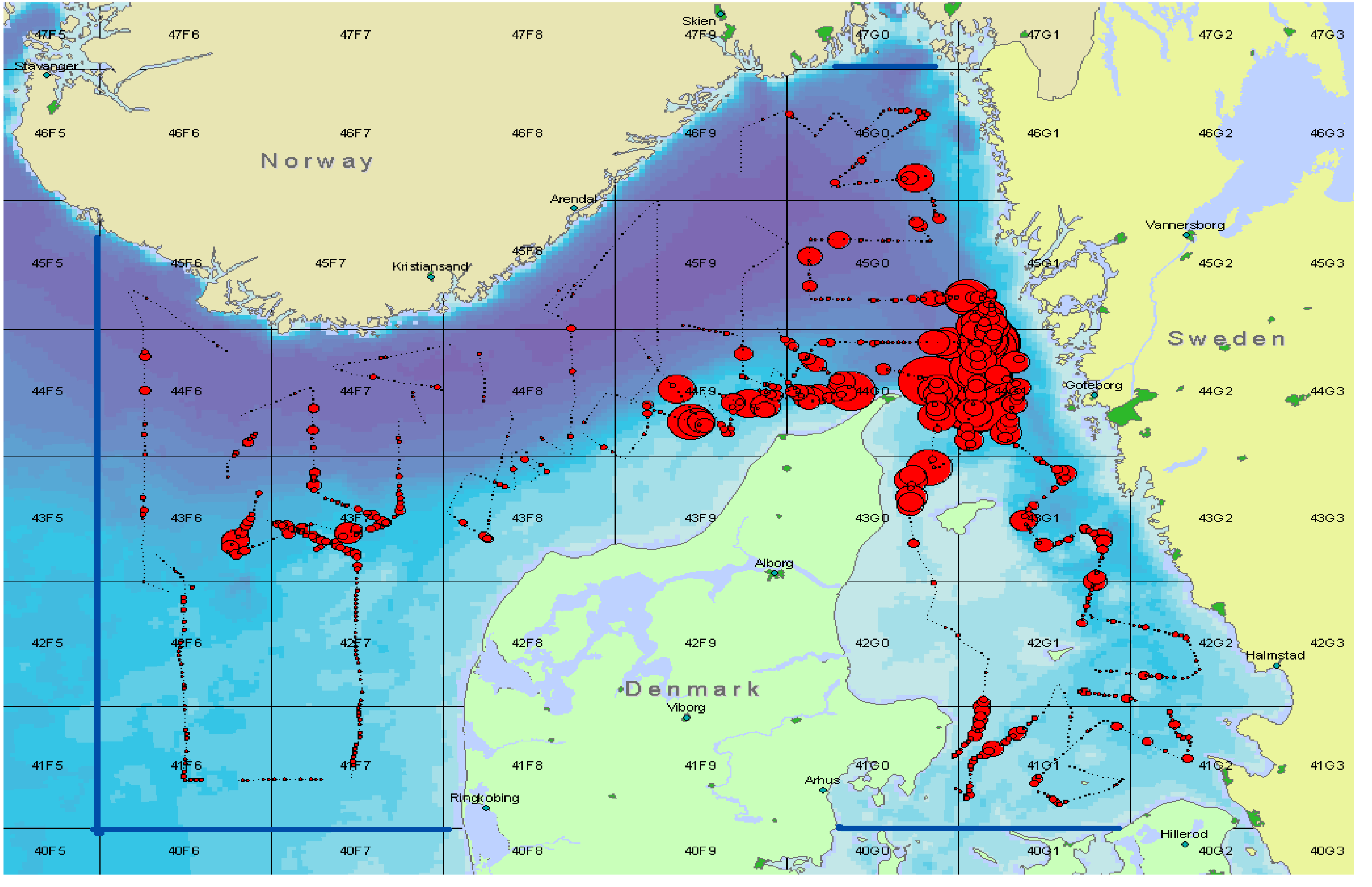


Figure 4. Relative herring density (in numbers per nm²) along the track of the June-July 2009 Danish acoustic survey in the eastern North Sea, Skagerrak and Kattegat. Red circles indicate relative density of herring per ESDU.

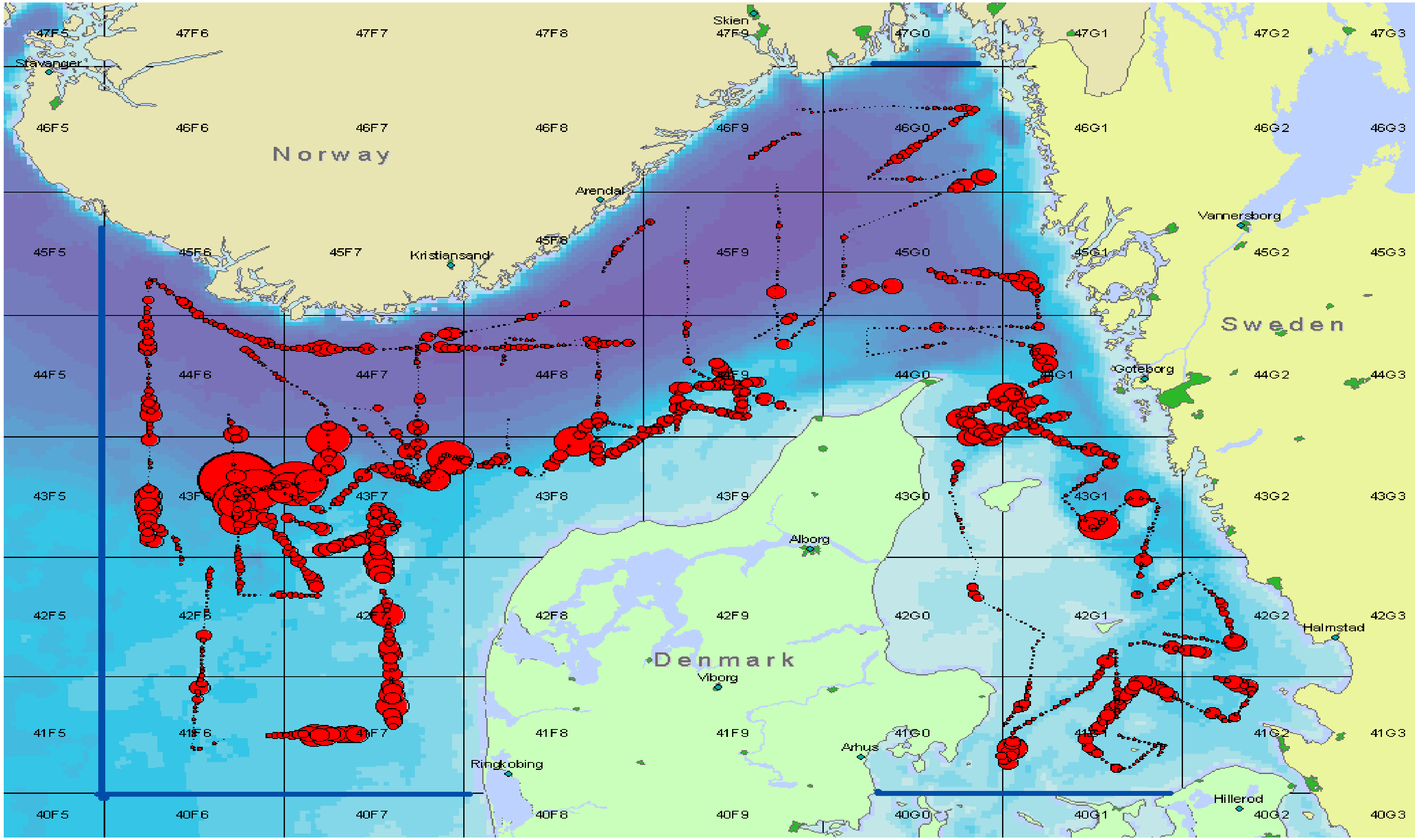


Figure 5. Relative herring density (in numbers per nm²) along the track of the June-July 2008 Danish acoustic survey in the eastern North Sea, Skagerrak and Kattegat. Red circles indicate relative density of herring per ESDU.

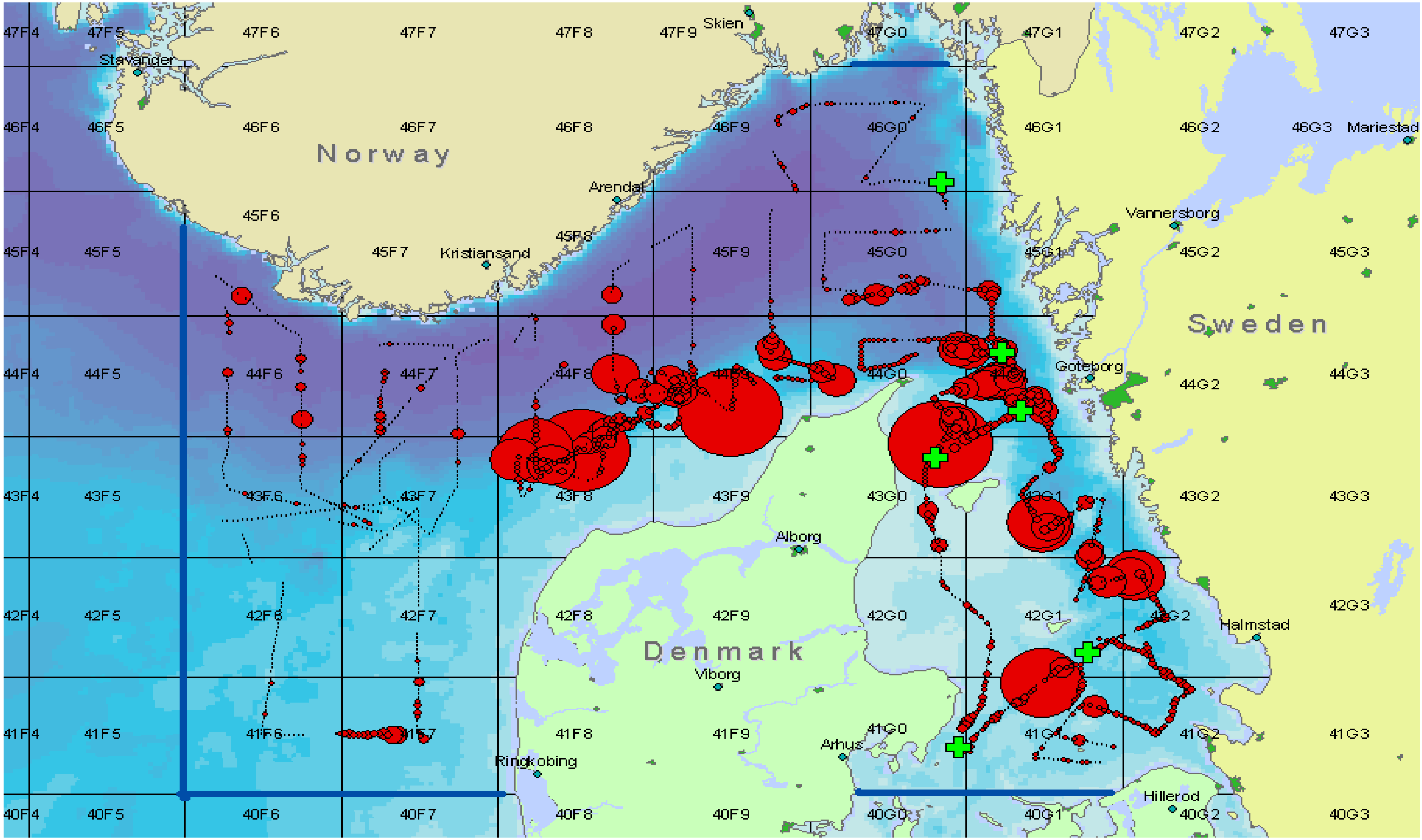


Figure 6. Stations with herring infected with Ichthyophonus (green crosses) and relative herring density (in numbers per nm²) along the track of the July 2010 Danish acoustic survey in the eastern North Sea, Skagerrak and Kattegat. Red circles indicate relative density of herring per ESDU.

Table 1. Simrad EK60 and analysis settings used during the Acoustic Herring Survey with RV "Dana" Cruise July 2010.

Transceiver Menu	
Frequency	38 kHz
Sound speed	1508 m.s^{-1}
Max. Power	2000 W
Equivalent two-way beam angle	-20.5 dB
Transducer Sv gain	25.40 dB
3 dB Beamwidth	6.9°
Calibration details	
TS of sphere	-33.6 dB
Range to sphere in calibration	9.56 m
Measured NASC value for calibration	19300 m^2/nmi^2
Calibration factor for NASCs	1.00
Absorption coeff	6.063 dB/km
Log Menu	
Distance	1,0 n.mi. using GPS-speed
Operation Menu	
Ping interval	1 s external trig
Analysis settings	
Bottom margin (backstep)	1.0 m
Integration start (absolute) depth	7 - 9 m
Range of thresholds used	-70 dB

Table 2 Survey statistics for the Danish acoustic survey with RV "Dana" in July 2010.

Stratum	Area, Nm*2	ESDU	Hauls	Mean Sa	Mean TS
560E06	3980	109	6	3.03E-06	6.47E-05
570E06	3600	369	10	1.10E-06	5.02E-05
570E08	3406	279	8	7.70E-06	3.58E-05
580E06	209	16	1	3.09E-06	3.59E-06
580E08	1822	90	5	5.35E-07	1.22E-05
C	988	64	4	3.63E-07	2.49E-05
D	1837	167	8	2.46E-06	1.86E-05
E	5228	413	10	5.05E-06	1.83E-05

Table 3. Trawl haul details for the Danish acoustic survey with RV "Dana" in July 2010.

Date dd-mm-yy	Haul no.	Time UTC	ICES Square	Position Latitude	Longitude	Trawl Direction deg.	Wire length m	Trawl type	Cath depth m	Mean depth m	Total catch kg	Main Species	Trawling speed Kn	Trawling duratin min,	Wind speed m/s	Sea state
06-07-10	160	10:38	43F6	57.08.474 N	006.16.129 E	132	350	Expo	Bottom	63	33	Hake, Gunard	3.5	60	9.6	4
06-07-10	172	13:36	42F6	56.56.838N	006.29.708 E	112	270	Fotö	20	46	140	Large medusa	4	60	11.9	4
06-07-10	229	20:57	41F6	56.15.301 N	006.49.615 E	90	360	Fotö	Surface	35	800	Mackerel, Herring	4.2	60	7	4
07-07-10	248	00:20	41F7	56.124.652 N	007.25.416 E	108	350	Fotö	Surface	28	2920	Herring	3.7	60	5.8	4
07-07-10	329	10:45	43F7	57.02.970 N	007.11.786 E	34	210	Expo	Bottom	33	212	Large medusa	3.3	60	12.5	4
07-07-10	345	14:02	43F6	57.10.499 N	006.52.268 E	327	200	Expo	Bottom	65	116	Haddock, Herring	3	60	10.3	4
07-07-10	400	21:05	44F6	57.48.705 N	006.16.198 E	4	380	Fotö	Surface	314	1116	Herring	4.4	61	9.6	4
07-07-10	413	23:49	45F6	58.04.495 N	006.14.795 E	354	320	Fotö	Surface	330	540	Krill, Herring, Mackerel	4.4	61	8.7	4
08-07-10	500	10:37	43F7	57.07.959 N	007.15.214 E	0	260	Expo	Bottom	60	62	Cod, Haddock	2.8	60	5.3	4
08-07-10	515	13:34	43F6	57.15.002 N	006.55.508 E	33		Expo	12	82	9	Gunard, Large medusa	3.8	59	4.7	4
08-07-10	578	21:04	44F7	57.51.383 N	007.14.430 E	169	310	Fotö	Surface	418	460	Herring, Mackerel	4.7	60	4.8	3
09-07-10	600	00:22	43F7	57.29.222 N	007.16.749 E	94	300	Fotö	Surface	207	530	Mackerel	4.5	60	5.3	3
09-07-10	688	10:46	44F8	57.53.653 N	007.59.361 E	96	310	Fotö	Surface	487	200	Herring, Large medusa	3.9	60	5.8	3
09-07-10	709	14:11	44F8	57.50.952 N	008.17.611 E	110	350	Fotö	Surface	492	310	Herring, Mackerel	4.1	60	2.7	3
09-07-10	760	21:00	43F8	57.27,717 N	008.36.207 E	237	330	Fotö	Surface	52	4722	Herring	4.2	50	9.2	3
10-07-10	874	10:45	43F8	57.24.255 N	008.31.060 E	56	260	Expo	Bottom	37	440	Haddock	3.6	60	4.1	2
10-07-10	887	13:20	44F8	57:36,563 N	008.45.822 E	48	350	Fotö	Surface	91	72	Mackerel, Large medusa	4.6	60	4.9	3
10-07-10	945	21:06	45F8	57.59.836 N	008.44.315 E	1	340	Fotö	Surface	563	240	Large medusa, Krill, Mackerel	3.8	60	3.5	2
11-07-10	963	00:18	45F9	58.14.565 N	008.54.833 E	55	350	Fotö	Surface	403	205	Mackerel, Lumpsuker, Krill	4.4	60	3	2
11-07-10	1043	10:38	44F9	57.43.193 N	009.40.633 E	62	235	Expo	Bottom	37	1100	Herring, Large medusa	2.8	60	0.7	2
11-07-10	1057	13:23	44G0	57.43.300 N	010.05.800 E	87		Fotö	10	41	10000	Herring	4	24	6	2
11-07-10	1113	21:12	45F9	58.27.712 N	009.48.513 E	59	320	Fotö	Surface	524	522	Herring, Mackerel, Medusa	3.9	60	7.5	2
12-07-10	1131	00:20	46F9	58.42.080 N	009.45.675 E	26	320	Fotö	Surface	350	230	Krill	4.3	60	10.1	2
12-07-10	1209	10:39	46G0	58.32.156 N	010.50.607 E	1	400	Expo	Bottom	82	1100	Krill	2.5	58	1.4	2
12-07-10	1223	13:47	45G0	58.23.639 N	010.53.114 E	166	310	Fotö	Surface	124	65	Large medusa	4.1	60	4.5	2
12-07-10	1276	21:00	45G0	58.08.842 N	010.20.500 E	229	350	Fotö	Surface	137	250	Mackerel, Herring	4.3	60	5.4	3
13-07-10	1295	00:18	45G0	58.07.153 N	010.41.869 E	300	330	Fotö	Surface	223	500	Krill, Herring, Mackerel	4.1	60	8	3
13-07-10	1379	10:35	44G0	57.51.276 N	010.44.746 E	81	330	Fotö	Surface	110	245	Large medusa, Herring	4.2	60	8.3	3
13-07-10	1395	13:38	44G1	57.50.826 N	011.14.438 E	325	345	Expo	Bottom	60	100	Haddock, Medusa, Herring	3.2	60	5.3	3
13-07-10	1448	21:00	43G0	57.25.016 N	010.48.201 E	66	320	Fotö	Surface	41	645	Herring	4.3	60	9.6	3
14-07-10	1468	00:39	44G1	57.36.566 N	011.21.273 E	53	330	Fotö	Surface	86	280	Krill	4.7	62	6.9	3
14-07-10	1551	10:35	43G1	57.05.205 N	011.49.537 E	5	270	Expo	Bottom	53	57	Large medusa	3.4	61	6.5	3
14-07-10	1576	14:21	42G1	56.48.525 N	011.42.142 E	21	200	Expo	Bottom	47	330	Herring, Medusa, Sprat	3.2	61	8	3
14-07-10	1625	20:54	42G1	56.36.242 N	011.47.053 E	45	320	Fotö	Surface	38	195	Large medusa	4.3	60	10	3
15-07-10	1642	00:04	42G2	56.35.248 N	012.13.792 E	320	310	Fotö	Surface	49	190	Large medusa	4.8	58	11.6	3
15-07-10	1728	10:25	41G1	56.09.440 N	011.53.217 E	45	170	Expo	Bottom	27	78	Large medusa	3.3	61	5.9	3
15-07-10	1743	13:09	41G1	56.15.376 N	011.36.177 E	24	170	Expo	Bottom	30	107	Large medusa, Herring	3.7	60	8.8	3
15-07-10	1800	20:11	41G0	56.11.83 N	010.57.66 E	10	155	Expo	Bottom	20	97	Large medusa	3.6	60	4.9	3

Table 4. Catch composition in trawl hauls for the Danish acoustic survey with RV Dana in June-July 210.

		Station	**160**	**172**	**229**	**248**	**329**	**345**	**400**	**413**	**500**	**515**	**578**	**600**	**688**
		ICES sq.	**43F6**	**42F6**	**41F6**	**41F7**	**43F7**	**43F6**	**44F6**	**45F6**	**43F7**	**43F6**	**44F7**	**43F7**	**44F7**
		Gear	**Expo**	**Fotö**	**Fotö**	**Fotö**	**Expo**	**Expo**	**Fotö**	**Fotö**	**Expo**	**Fotö**	**Fotö**	**Fotö**	**Fotö**
		Fishing depth	**Bottom**	**20**	**Surface**	**Surface**	**Bottom**	**Bottom**	**Surface**	**Surface**	**Bottom**	**12**	**Surface**	**Surface**	**Surface**
		Total depth	**67**	**46**	**35**	**28**	**33**	**65**	**314**	**330**	**60**	**82**	**418**	**207**	**487**
		Day/Night	**D**	**D**	**N**	**N**	**D**	**D**	**N**	**N**	**D**	**D**	**N**	**N**	**D**
		Total catch	**33**	**140**	**800**	**2,920**	**212**	**116**	**1,116**	**540**	**62**	**9**	**460**	**530**	**200**
Herring	***Clupea harengus***				245.269	1531.091	0.064	26.972	819.748	117.2			269.397	38.872	88.8
Large Medusa	***Medusa, spp***		0.84	127.486	77.023	4.325	176.134	4.262	34.383	32.668	18.8	3.942	21.988	16.351	62.949
Krill	***Euphausidae spp.***								8.552	201.325			2.192	20.832	
Mackerel	***Scomber scombrus***		0.264	2.768	391.91	257.7			238.013	97.7		1.07	161.034	415.011	31.199
Sprat	***Sprattus sprattus***					1051.32									
Haddock	***Melanogrammus aeglefinus***		16	0.77			0.052	38.156		0.008	6.092	0.008			0.022
Lumpsucker	***Cyclopterus lumpus***			5.84			0.46	1.114	9.94	9.2			2.56	20.3	15.9
Gurnard	***Trigala spp.***		3.73	3.068	83.299	10.71	12.2				2.952	4.208			
Pearlside	***Mauorolicus muelleri***								0.481	75.161			0.217	1.799	
Cod	***Gadus Morhua***		0.32				14.2	20			27.4				
Horse mackere	***Trachurus trachurus***				2.5	64.2									
Whiting	***Merlangius merlangus***		0.622	0.068		0.116	0.434	0.79		0.006	1.574				0.1
Invertebrates	***Invertebrates***		0.9					10.44							
Hake	***Merluccius merluccius***		4.97				5.4	2.256							
Norway pout	***Trisopterus esmarki***							0.074		0.258					
Garfish	***Belone belone***								4.688	0.184			2.536		1.03
Common weav	***Trachinus draco***					0.246							0.076		
Greater sandee	***Hyperoplus lanceolatus***					0.02	0.17				0.042				
Dab	***Limanda limanda***		2.62			0.1	0.864	1.01			1.374				
Plaice	***Pleuronectes platessa***		0.356			0.172	1.112	3.84			1.122				
Blue whiting	***Micromesistius poutassou***													13.1	
Saithe	***Pollachius virens***						0.158			3.344	0.104				
Long rough dal	***Hippoglosides plattessoides***		0.39								0.084				
Picked Dogfish	***Squalus acanthias***							2.584		2.946					
Squids	***Cephalopoda sp***							0.478	0.196		1.242				
Pollack	***Pollachius pollachius***														
	Trachipterus arctius													3.734	
Halibut	***Hippoglossus hippoglossus***							3.6							
Lemon sole	***Microstomus kitt***						0.74	0.338			1.258				
Brill	***Scophthalmus rhombe***		2.014												
Norway lobster	***Nephrops norvegicus***														
Anchovy	***Engraulis encrasicolus***														
Flounder	***Platichthys flesus***														
	Allionymus lyra														
Sandeel	***Ammodytes marinus***						0.012								
Gray sole	***Glyptocephalus cynoglossus***														
Snake blenny	***Lumpenus lampretaeformis***														

Table 4. continued.

	Station	709	760	874	887	945	963	1043	1057	1113	1131	1209	1223	1276
	ICES sq.	44F8	43F8	43F8	44F8	45F8	45F8	44F9	44G0	45F9	46F9	46G0	45G0	45G0
	Gear	Fotö	Fotö	Expo	Fotö	Fotö	Fotö	Expo	Fotö	Fotö	Fotö	Expo	Fotö	Fotö
	Fishing depth	Surface	Surface	Bottom	Surface	Surface	Surface	Bottom	10	Surface	Surface	Bottom	Surface	Surface
	Total depth	492	52	39	80	563	403	35	41	576	416	89	120	137
	Day/Night	D	N	D	D	N	N	D	D	N	N	D	D	N
	Total catch	310	4,722	440	72	240	205	1,100	10,019	522	230	1,110	65	250
Herring	*Clupea harengus*	169.613	4581.359		0.198	0.128	0.212	641.764	9730	187.102		10.972	8.28	45.338
Large Medusa	*Medusa, spp*	38.149	71.659	50.067	29.3	81.726	31.249	383.143	270	3.843	2.906		55.9	1.97
Krill	*Euphausidae spp.*					65.663	33.613			144.113	175.44	1064.02		40.733
Mackerel	*Scomber scombrus*	80.351	68.1		36.374	56.407	86.7		16.5	151.524	22.422	0.918		143.2
Sprat	*Sprattus sprattus*							0.958						
Haddock	*Melanogrammus aeglefinus*	0.006		272.517	0.008			2.124				0.284	0.02	
Lumpsucker	*Cyclopterus lumpus*	16.9			3.47	33.4	41.5	0.926	2	35.4	18.1			17.7
Gurnard	*Trigala spp.*			10.542				3.988						
Pearlside	*Mauorolicus muelleri*					1.536	4.313				9.714	0.096		0.043
Cod	*Gadus Morhua*			65.8				0.396				0.512		
Horse mackere	*Trachurus trachurus*		0.292					2.13				0.168		0.19
Whiting	*Merlangius merlangus*	0.026		15.854	0.086		0.585	27.257				2.624	0.094	0.012
Invertebrates	*Invertebrates*											9.635		
Hake	*Merluccius merluccius*							24.4						
Norway pout	*Trisopterus esmarki*											20.062		
Garfish	*Belone belone*	4.956			2.618	1.048	2.034				1.268		0.24	0.814
Common weav	*Trachinus draco*					0.096		0.218						
Greater sandee	*Hyperoplus lanceolatus*			22.072										
Dab	*Limanda limanda*			0.32				4.292						
Plaice	*Pleuronectes platessa*		0.59	1.446				3.564						
Blue whiting	*Micromesistius poutassou*													
Saithe	*Pollachius virens*			0.348			4.7							
Long rough dal	*Hippoglosides plattessoides*							0.532				0.629		
Picked Dogfish	*Squalus acanthias*													
Squids	*Cephalopoda sp*			1.054				0.317			0.15			
Pollack	*Pollachius pollachius*							3.77						
	Trachipterus arctius													
Halibut	*Hippoglossus hippoglossus*													
Lemon sole	*Microstomus kitt*							0.29						
Brill	*Scophthalmus rhombe*													
Norway lobster	*Nephrops norvegicus*											0.056		
Anchovy	*Engraulis encrasicolus*													
Flounder	*Platichthys flesus*													
	Allionymus lyra									0.018				
Sandeel	*Ammodytes marinus*													
Gray sole	*Glyptocephalus cynoglossus*													
Snake blenny	*Lumpenus lampretaeformis*											0.0023		

Table 4. continued.

	Station	1295	1379	1395	1448	1468	1551	1576	1625	1642	1728	1743	1800
	ICES sq.	45G0	44G0	44G1	43G0	44G1	43G1	42G1	42G1	42G2	41G1	41G1	41G0
	Gear	Fotö	Fotö	Expo	Fotö	Fotö	Expo	Expo	Fotö	Fotö	Expo	Expo	Expo
	Fishing depth	Surface	Surface	Bottom	Surface	Surface	Bottom	Bottom	Surface	Surface	Bottom	Bottom	Surface
	Total depth	242	92	60	41	86	53	47	38	49	27	30	20
	Day/Night	N	D	D	N	N	D	D	N	N	D	D	N
	Total catch	500	245	100	645	280	57	330	195	190	78	107	97
Herring	*Clupea harengus*	47.809	37.919	17.73	516.357	12.9	0.734	163.059	21.768	0.296	3.292	51	8.165
Large Medusa	*Medusa, spp*	25.912	195.699	27.349	99.482		50.4	89.854	154.434	185.354	44.5	30.5	76.662
Krill	*Euphausidae spp.*	341.087				264.99							
Mackerel	*Scomber scombrus*	27.468	9.392		7.13	2.108			9.29		2.186		0.454
Sprat	*Sprattus sprattus*				0.257		0.098	73.681	5.304	1.562	7.41	5.894	9.925
Haddock	*Melanogrammus aeglefinus*		0.034	25.695			0.26		0.01	0.058			
Lumpsucker	*Cyclopterus lumpus*	17.7	1.426				1.716	3.346	0.36	0.808	0.042		0.964
Gurnard	*Trigala spp.*			0.264						0.038	0.188	0.056	0.046
Pearlside	*Mauorolicus muelleri*	37.61											
Cod	*Gadus Morhua*			0.74							0.086		
Horse mackere	*Trachurus trachurus*				0.19								
Whiting	*Merlangius merlangus*		0.146	11.583		0.002	2.586	0.05	0.424	0.53	1.398	1.476	0.01
Invertebrates	*Invertebrates*			1.99			0.286				11.7	14.1	0.482
Hake	*Merluccius merluccius*			0.342									
Norway pout	*Trisopterus esmarki*			9.022			0.074						
Garfish	*Belone belone*	2.414	0.384		4.206								
Common weav	*Trachinus draco*				17.379		0.372		3.41	1.102	1.02	0.476	0.146
Greater sandee	*Hyperoplus lanceolatus*												
Dab	*Limanda limanda*						0.288				4.002	3.386	
Plaice	*Pleuronectes platessa*			0.08							1.896		0.146
Blue whiting	*Micromesistius poutassou*												
Saithe	*Pollachius virens*												
Long rough dal	*Hippoglosides plattessoides*			3.994			0.031					0.046	
Picked Dogfish	*Squalus acanthias*												
Squids	*Cephalopoda sp*			0.748									
Pollack	*Pollachius pollachius*												
	Trachipterus arctius												
Halibut	*Hippoglossus hippoglossus*												
Lemon sole	*Microstomus kitt*			0.218									
Brill	*Scophthalmus rhombe*												
Norway lobster	*Nephrops norvegicus*			0.202			0.134				0.048		
Anchovy	*Engraulis encrasicolus*									0.252			
Flounder	*Platichthys flesus*										0.11		
	Allionymus lyra			0.076									
Sandeel	*Ammodytes marinus*												
Gray sole	*Glyptocephalus cynoglossus*							0.01					
Snake blenny	*Lumpenus lampretaeformis*												

Table 5. Measured length distribution of herring by haul for the Danish acoustic survey with RV "Dana" in June-July 2010.

Station	229	248		345	400	413	578	600	688	709	760	1043	1057	1113	1209	1223	1276	1295	1379	1395	1448	1468	1551	1576	1625	1642	1743	1800
ICES sq.	41F6	41F7		43F6	44F6	45F6	44F7	43F7	44F7	44F8	43F8	44F9	44G0	45F9	46G0	45G0	45G0	45G0	44G0	44G1	43G0	44G1	43G1	42G1	42G1	42G2	41G1	41G0
Gear	Fotö	Fotö		Expo	Fotö	Fotö	Fotö	Fotö	Fotö	Fotö	Fotö	Expo	Fotö	Fotö	Expo	Fotö	Fotö	Fotö	Fotö	Expo	Fotö	Fotö	Expo	Expo	Fotö	Fotö	Expo	Expo
Fishing depth	Surface	Surface		Bottom	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Bottom	10	Surface	Bottom	Surface	Surface	Surface	Surface	Bottom	Surface	Surface	Bottom	Bottom	Surface	Surface	Bottom	Surface
Total depth	35	28		65	314	330	418	207	487	492	52	35	41	576	89	120	137	242	92	60	41	86	53	47	38	49	30	20
Day/Night	N	N		D	N	N	N	N	D	D	N	D	D	N	D	D	N	N	D	D	N	N	D	D	N	N	D	N
Total catch,kg	800	2,920		116	1,116	540	460	530	200	310	4,700	1,100	10,019	522	1,110	65	250	500	245	100	645	280	57	330	195	190	107	97
Total catch Herring,kg		1487.151	43.94	26.972	819.748	117.2	269,397	38,872	88.8	169,613	4,581,359	641,764	9730	187,102	10,972	8.28	45,388	47,809	37,919	17.73	516,357	12.9	0.734	163,059	21,768	0.296	51.00	8,165
Sample Herring,kg	31	1.992	16.532	26.972	61.546	41.304	38.978	38,872	54,782	53,218	36,924	43.791	32,063	68,161	10,972	8.28	45,388	47,809	37,919	17.73	28.85	12.9	0.734	36,294	21,768	0.296	26,680	8,165
Length in cm								.																				
5.5																												
6																												
6.5																												
7																												
7.5																												
8		60																										
8.5		122																										
9		85																		12								
9.5		78																		7								
10		59																		8								
10.5		23																		4								
11		5																										
11.5																												
12															1								1					
12.5			2												2													
13			2												2													
13.5			68												8					1					3			2
14			132												14					1	3		1		12			1
14.5			76												17					2	10				36			2
15			40												24					16	4		4		28			
15.5			13												25					16	7		7		29			
16	2		61									1			28					18	8		8	1	23			3
16.5	7		67												29					35	8	4	3	3	9			11
17	29		77												19					36	18	1		4	7			39
17.5	140		46				1					1			17					29	48	4	1	34	4		3	58
18	262		22	8		1			2			4			13			1		36	123	4	1	149	16		29	46
18.5	186		3	52		5	1	4	1	3	7	37	12		3			1		31	204	7	1	213	41		62	13
19	43		2	113	1	7	1	9	5	15	26	125	34		2		1			25	123	7		213	64		47	3
19.5	11			96		8	7	19	1	27	54	215	99		4		1	6	6	20	39	15		61	33		53	2
20	1		1	71	4	41	7	28	10	64	99	172	141	25	6			7	8	11	18	7		30	29		65	4
20.5			1	48	15	11	31	55	11	71	124	81	94	14	4		9	18	11	15	4	10		25	44	1	77	6
21			2	22	14	45	38	62	21	98	102	30	68	17	11	12	9	43	29	28	9	19	1	18	33		61	4
21.5				17	13	28	42	54	23	86	47	13	23	15	18	19	26	68	37	10		25	1	2	19	1	37	
22				2	10	35	62	26	34	57	24	2	3	18	12	10	38	72	49	10		26		2	11		16	2
22.5				1	14		43	27	29	64	8		2	18	11	15	47	75	73	11		11			10	1	9	1
23					17	22	33	11	39	39	1			25	2	16	39	55	55	9		8			7		8	
23.5					27	35	38	6	50	25				30	2	8	54	43	39	4		6			5			
24			1		25	33	27	5	46	18				34	1	5	40	24	24	1		6			3	1		
24.5					28	31	22	4	40	10				21	1	3	19	14	18			4			2			
25					38	12	5	8	21	4				37			21	17	4	2		2			3			
25.5				1	42	14	7	4	26	3				26		1	13	12	9			1						
26				1	36	5	11	7	30	3				29	2		20	7	10	1		2						
26.5					38	13	6	4	16	2				30		1	17	14	7									
27					24	5	7	10	11	2				24			21	6	4			4						
27.5					24	6		5	12					24			3	4	7									
28					23	5	1	12	6	1				20		2	3	3	4									
28.5					12	3		12	11					20			3	5	2									
29					19	3		7	10					13			6	2	2			1						
29.5					3	1	1	3	1	1				8			2	2	2									
30					8	1								4			2	2										
30.5					4			3						5														
31						2		3	2					1			1											
31.5					2									2				1										
32					1			1	1					2														
32.5					2									1														
Total no.	681	432	616	432	444	372	391	389	459	593	492	681	476	463	278	92	395	502	400	399	626	174	28	755	471	4	467	197
Mean Length	18.06020558	9.049769	15.44156	19.6169	25.32883	22.86962	22.59207	23.929	23.96623	21.55818	20.49187	19.69383	20.12395	24.90065	17.40468	22.55978	23.86329	22.87749	22.96875	17.82331	18.33546	21.33621	16.07143	18.76159	18.54883	22.125	20.00321	17.74365

Table 6. Abundance, mean weight, mean length and biomass by age group and subarea for North Sea autumn spawning herring in the Danish acoustic survey with RV "Dana" in June-July 2010.

Numbers in mill												
	WR											
Strata	0	1i	1m	2i	2m	3i	3m	4i	4m	5	6	7
580E06	0	5.150866	0.012367	0.165169	0.042472	0.082123	0.014282	0.022247	0.014832	0	0	0
570E06	0	18.96277	0.045529	4.888424	1.257023	0.55836	0.097106	0.418063	0.278708	0.143378	0	0.114731
580E08	0	6.718286	0.01613	1.617231	0.415859	0.600958	0.104514	0.394745	0.263163	0.16652	0	0
570E07	0	1219.405	2.927743	4.738073	1.218362	0.992676	0.172639	0.011754	0.007836	0.039464	0	0.005211
C	0.260738	3.021327	0.007254	0.404774	0.104085	0.094562	0.016446	0.123667	0.082445	0	0	0
D	0.062474	202.3751	0.485894	5.861047	1.507126	1.450402	0.252244	0.012092	0.008062	0.007773	0	0
E	49.68213	958.7771	7.690725	2.371008	6.322687	0.85614	1.28421	0	0	0	0	0
560E06	205.3609	2.885927	0	0.000637	0.000637	0	0	0	0	0	0	0

Biomass in ton												
	WR											
Strata	0	1i	1m	2i	2m	3i	3m	4i	4m	5	6	7
580E06	0	387.4968	0.930364	13.21356	3.397772	10.78967	1.876464	2.936641	1.957761	0	0	0
570E06	0	1480.509	3.554643	609.9164	156.8356	67.71749	11.77696	68.25208	45.50139	21.50677	0	22.70551
580E08	0	544.6681	1.307726	196.6299	50.56199	70.81552	12.31574	49.63512	33.09008	23.14625	0	0
570E07	0	85130.38	204.3947	365.7641	94.05362	95.07096	16.53408	1.966097	1.310731	6.985128	0	0.99009
C	4.780114	133.8417	0.321349	57.02042	14.66239	13.35458	2.322537	19.86015	13.2401	0	0	0
D	0.753882	12833.15	30.81188	412.3452	106.0316	95.3839	16.58851	1.706658	1.137772	0.930599	0	0
E	1067.091	42125.63	337.9061	150.5085	401.356	75.91762	113.8764	0	0	0	0	0
560E06	977.7124	126.7792	0	0.076122	0.076122	0	0	0	0	0	0	0

Mean length in cm												
	WR											
Strata	0	1i	1m	2i	2m	3i	3m	4i	4m	5	6	7
580E06	0.00	20.51	20.51	21.50	21.50	25.27	25.27	26.00	26.00	0.00	0.00	0.00
570E06	0.00	20.85	20.85	24.22	24.22	25.18	25.18	27.07	27.07	27.00	0.00	28.80
580E08	0.00	20.94	20.94	23.75	23.75	24.31	24.31	25.53	25.53	26.00	0.00	0.00
570E07	0.00	20.14	20.14	20.59	20.59	22.60	22.60	27.32	27.32	28.00	0.00	29.00
C	14.76	17.69	17.69	24.90	24.90	25.59	25.59	26.62	26.62	0.00	0.00	0.00
D	12.17	19.90	19.90	20.73	20.73	20.78	20.78	25.91	25.91	24.49	0.00	0.00
E	14.83	18.35	18.35	19.91	19.91	22.32	22.32	0.00	0.00	0.00	0.00	0.00
560E06	9.05	18.09	0.00	24.00	24.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Mean weight in g												
	WR											
Strata	0	1i	1m	2i	2m	3i	3m	4i	4m	5	6	7
580E06	0.00	75.23	75.23	80.00	80.00	131.38	131.38	132.00	132.00	0.00	0.00	0.00
570E06	0.00	78.07	78.07	124.77	124.77	121.28	121.28	163.26	163.26	150.00	0.00	197.90
580E08	0.00	81.07	81.07	121.58	121.58	117.84	117.84	125.74	125.74	139.00	0.00	0.00
570E07	0.00	69.81	69.81	77.20	77.20	95.77	95.77	167.28	167.28	177.00	0.00	190.00
C	18.33	44.30	44.30	140.87	140.87	141.23	141.23	160.59	160.59	0.00	0.00	0.00
D	12.07	63.41	63.41	70.35	70.35	65.76	65.76	141.13	141.13	119.71	0.00	0.00
E	21.48	43.94	43.94	63.48	63.48	88.67	88.67	0.00	0.00	0.00	0.00	0.00
560E06	4.76	43.93	0.00	119.50	119.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 7. Abundance, mean weight, mean length and biomass by age group and subarea for Baltic Sea spring-spawning herring in the Danish acoustic survey with RV "Dana" in June-July 2010.

Numbers in mill																	
	WR																
Strata	0	1i	1m	2i	2m	3i	3m	4i	4m	5	6	7	8	9	10	11	12
580E06	0	0.509398	0.132066	0.409668	3.174931	0.070435	2.829132	0	1.332058	0.582138	0.32444	0.037079	0	0	0	0	0
570E06	0	2.087684	0.541251	1.681124	13.02871	0.543288	21.82207	0	8.572289	4.510022	2.235875	0.748243	0.385288	0.487195	0.244976	0.012684	0.09729
580E08	0	0.303158	0.078597	1.34457	10.42042	0.455828	18.30907	0	6.750455	3.592728	1.620802	1.557212	0.696305	0.384448	0	0	0
570E07	0	88.67	22.98852	6.353667	49.24092	0.476805	19.15165	0	0.286793	0.096791	0.055151	0.022986	0	0.010422	0	0	0
C	0	0.116317	0.030156	0.46707	3.61979	0.129042	5.183201	0	1.53883	1.050715	0.453805	0.461956	0.235397	0.146857	0	0	0
D	0	36.48444	9.45893	10.55839	81.82754	0.371845	14.93577	0	1.596527	0.375543	0.10216	0.065546	0.027841	0.009079	0.002009	0	0
E	0.663616	535.9844	75.22588	74.42143	232.7146	12.84707	46.57062	0.513266	6.929091	3.490358	0.565281	0.388632	0.120652	0	0	0	0
560E06	0	1.815998	0	0	0.013141	0	0.002329	0	0	0	0	0	0	0	0	0	0
Biomass in ton																	
	WR																
Strata	0	1i	1m	2i	2m	3i	3m	4i	4m	5	6	7	8	9	10	11	12
580E06	0	34.6862	8.992717	41.05721	318.1934	7.9395	318.9032	0	166.168	76.98684	47.90596	7.082089	0	0	0	0	0
570E06	0	152.8902	39.63821	181.2831	1404.944	66.84431	2684.913	0	1197.035	706.6239	382.398	146.0194	76.69178	102.0709	57.24676	2.803227	22.96032
580E08	0	25.81362	6.692419	148.8771	1153.797	54.99694	2209.044	0	995.6512	638.6234	306.2614	305.8332	152.4415	73.88241	0	0	0
570E07	0	5922.267	1535.402	508.8477	3943.57	38.42007	1543.206	0	39.17301	15.32901	7.787387	4.876478	0	2.006235	0	0	0
C	0	9.955801	2.581134	46.53303	360.631	15.84929	636.6133	0	244.3243	177.1588	91.66349	94.44846	51.21064	26.75315	0	0	0
D	0	2400.846	622.4414	704.7792	5462.039	26.79713	1076.352	0	129.2742	37.21327	15.64447	11.02159	5.837035	1.804326	0.331532	0	0
E	12.43979	23929.14	3358.476	4048.366	12659.18	759.7844	2754.218	36.19847	488.6794	224.6285	65.74027	42.06864	16.64998	0	0	0	0
560E06	0	62.66036	0	0	0.874701	0	0.220459	0	0	0	0	0	0	0	0	0	0
Mean length in cm																	
	WR																
Strata	0	1i	1m	2i	2m	3i	3m	4i	4m	5	6	7	8	9	10	11	12
580E06	0.00	19.98	19.98	22.87	22.87	24.45	24.45	0.00	25.53	25.78	26.60	31.00	0.00	0.00	0.00	0.00	0.00
570E06	0.00	20.30	20.30	23.19	23.19	24.92	24.92	0.00	26.25	27.24	27.77	29.12	29.62	30.08	31.11	31.00	32.50
580E08	0.00	21.35	21.35	23.39	23.39	24.65	24.65	0.00	26.42	28.12	28.55	28.90	29.99	28.54	0.00	0.00	0.00
570E07	0.00	19.91	19.91	21.11	21.11	21.57	21.57	0.00	25.62	26.96	26.14	29.47	0.00	29.00	0.00	0.00	0.00
C	0.00	21.27	21.27	22.59	22.59	24.57	24.57	0.00	26.58	27.58	28.78	28.62	29.80	27.99	0.00	0.00	0.00
D	0.00	19.91	19.91	20.54	20.54	21.11	21.11	0.00	21.85	23.82	26.66	27.60	29.75	28.82	29.50	0.00	0.00
E	13.87	18.22	18.22	19.69	19.69	20.54	20.54	21.77	21.77	21.37	24.20	24.24	26.50	0.00	0.00	0.00	0.00
560E06	0.00	16.72	0.00	0.00	20.44	0.00	24.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mean weight in g																	
	WR																
Strata	0	1i	1m	2i	2m	3i	3m	4i	4m	5	6	7	8	9	10	11	12
580E06	0.00	68.09	68.09	100.22	100.22	112.72	112.72	0.00	124.75	132.25	147.66	191.00	0.00	0.00	0.00	0.00	0.00
570E06	0.00	73.23	73.23	107.83	107.83	123.04	123.04	0.00	139.64	156.68	171.03	195.15	199.05	209.51	233.68	221.00	236.00
580E08	0.00	85.15	85.15	110.72	110.72	120.65	120.65	0.00	147.49	177.75	188.96	196.40	218.93	192.18	0.00	0.00	0.00
570E07	0.00	66.79	66.79	80.09	80.09	80.58	80.58	0.00	136.59	158.37	141.20	212.15	0.00	192.50	0.00	0.00	0.00
C	0.00	85.59	85.59	99.63	99.63	122.82	122.82	0.00	158.77	168.61	201.99	204.45	217.55	182.17	0.00	0.00	0.00
D	0.00	65.80	65.80	66.75	66.75	72.07	72.07	0.00	80.97	99.09	153.14	168.15	209.66	198.73	165.00	0.00	0.00
E	18.75	44.65	44.65	54.40	54.40	59.14	59.14	70.53	70.53	64.36	116.30	108.25	138.00	0.00	0.00	0.00	0.00
560E06	0.00	34.50	0.00	0.00	66.56	0.00	94.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 8. Age distribution in estimate of autumn spawners during the Danish acoustic survey with RV "Dana" in June-July from 2006 to 2010 given as number per age and strata in mill. and % of total abundance given by age and strata.

Autumn spawners in 2006

Number in millions

Strata	WR 0	1	2	3	4	5	6	7	Totalt
580E06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
570E06	0.00	313.22	77.82	1.31	0.00	0.00	0.00	0.00	392.36
580E08	0.00	72.47	5.61	0.00	0.00	0.28	0.00	0.00	78.36
570E08	30.99	425.10	40.41	2.00	0.00	0.00	0.00	0.00	498.50
C	0.00	125.25	21.23	0.00	0.00	0.32	0.00	0.00	146.79
D	0.00	265.61	13.04	1.53	0.00	0.00	0.00	0.00	280.17
E	6.57	107.84	17.39	1.23	0.00	0.00	1.09	0.00	134.12
560E06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
All stratas	37.56	1309.49	175.49	6.07	0.00	0.60	1.09	0.00	1530.29

Age distribution in % of total abundance

Strata	WR 0	1	2	3	4	5	6	7
580E06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
570E06	0.00	79.83	19.83	0.33	0.00	0.00	0.00	0.00
580E08	0.00	92.48	7.16	0.00	0.00	0.36	0.00	0.00
570E08	6.22	85.28	8.11	0.40	0.00	0.00	0.00	0.00
C	0.00	85.32	14.46	0.00	0.00	0.22	0.00	0.00
D	0.00	94.80	4.65	0.55	0.00	0.00	0.00	0.00
E	4.90	80.41	12.97	0.92	0.00	0.00	0.81	0.00
560E06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
All stratas	2.45	85.57	11.47	0.40	0.00	0.04	0.07	0.00

Autumn spawners in 2007

Number in millions

Strata	WR 0	1	2	3	4	5	6	7	Totalt
580E06	0.00	4.28	0.78	0.00	0.00	0.00	0.00	0.00	5.05
570E06	0.00	121.40	56.69	5.73	0.08	0.00	0.00	0.00	183.90
580E08	0.00	59.15	26.53	0.00	0.00	0.00	0.00	0.00	85.68
570E08	0.00	753.58	118.42	0.00	0.00	0.00	0.00	0.00	872.00
C	0.00	75.63	7.93	0.00	0.00	0.00	0.00	0.00	83.56
D	0.00	1365.50	109.44	5.59	0.00	0.00	0.00	0.00	1480.53
E	0.00	1542.98	46.92	7.76	0.00	0.00	0.00	0.00	1597.67
560E06	0.00	134.85	0.00	0.00	0.00	0.00	0.00	0.00	134.85
All stratas	0.00	4057.35	366.72	19.08	0.08	0.00	0.00	0.00	4443.24

Age distribution in % of total abundance

Strata	WR 0	1	2	3	4	5	6	7
580E06	0.00	84.62	15.38	0.00	0.00	0.00	0.00	0.00
570E06	0.00	66.01	30.83	3.12	0.04	0.00	0.00	0.00
580E08	0.00	69.03	30.97	0.00	0.00	0.00	0.00	0.00
570E08	0.00	86.42	13.58	0.00	0.00	0.00	0.00	0.00
C	0.00	90.51	9.49	0.00	0.00	0.00	0.00	0.00
D	0.00	92.23	7.39	0.38	0.00	0.00	0.00	0.00
E	0.00	96.58	2.94	0.49	0.00	0.00	0.00	0.00
560E06	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00
All stratas	0.00	91.32	8.25	0.43	0.00	0.00	0.00	0.00

Autumn spawners in 2008

Numbers in millions

Strata	WR 0	1	2	3	4	5	6	7	Totalt
580E06	0.00	5.76	5.27	1.14	0.00	0.00	0.00	0.00	12.17
570E06	0.00	233.35	44.02	10.12	1.83	0.97	1.17	0.00	291.45
580E08	0.00	14.77	0.80	0.95	0.00	0.00	0.00	0.00	16.52
570E08	0.00	30.46	35.50	15.28	12.23	0.00	0.00	0.00	93.47
C	0.00	17.00	1.81	0.29	0.00	0.00	0.00	0.00	19.09
D	11.88	61.84	12.28	3.66	1.16	0.71	0.00	0.00	91.51
E	2347.35	13.79	1.01	3.67	0.00	0.00	0.00	0.00	2365.82
560E06	1556.12	26.99	0.00	0.00	0.00	0.00	0.00	0.00	1583.12
All stratas	3915.35	403.95	100.68	35.11	15.21	1.68	1.17	0.00	4473.15

Age distribution in % of total abundance

Strata	WR 0	1	2	3	4	5	6	7
580E06	0.00	47.34	43.32	9.35	0.00	0.00	0.00	0.00
570E06	0.00	80.06	15.10	3.47	0.63	0.33	0.40	0.00
580E08	0.00	89.39	4.83	5.77	0.00	0.00	0.00	0.00
570E08	0.00	32.59	37.98	16.35	13.08	0.00	0.00	0.00
C	0.00	89.02	9.46	1.52	0.00	0.00	0.00	0.00
D	12.98	67.58	13.41	3.99	1.27	0.77	0.00	0.00
E	99.22	0.58	0.04	0.16	0.00	0.00	0.00	0.00
560E06	98.29	1.71	0.00	0.00	0.00	0.00	0.00	0.00
All stratas	87.53	9.03	2.25	0.78	0.34	0.04	0.03	0.00

Autumn sawners in 2009

Numbers in millions

	WR 0	1	2	3	4	5	6	7	Total
580E06	0.00	0.69	0.09	0.02	0.00	0.00	0.00	0.00	0.81
570E06	31.06	171.89	42.79	7.42	0.00	0.00	0.00	0.00	253.16
580E08	0.00	9.70	4.14	0.27	0.53	0.26	0.05	0.00	14.95
570E08	108.09	747.46	8.76	0.31	0.68	0.27	0.06	0.00	865.63
C	260.15	0.59	0.06	0.00	0.00	0.00	0.00	0.00	260.80
D	3864.97	482.56	3.47	0.16	0.85	0.37	0.00	0.00	4352.38
E	3409.91	277.26	0.30	0.00	0.00	0.00	0.00	0.00	3687.48
560E06	138.33	103.89	1.80	0.00	0.00	0.00	0.00	0.00	244.03
All Strata	7812.52	1794.04	61.42	8.18	2.07	0.91	0.10	0.00	9679.24

Age distribution in % of total abundance

	WR 0	1	2	3	4	5	6	7
580E06	0.00	85.88	11.60	2.53	0.00	0.00	0.00	0.00
570E06	12.27	67.90	16.90	2.93	0.00	0.00	0.00	0.00
580E08	0.00	64.85	27.70	1.84	3.55	1.75	0.31	0.00
570E08	12.49	86.35	1.01	0.04	0.08	0.03	0.01	0.00
C	99.75	0.23	0.02	0.00	0.00	0.00	0.00	0.00
D	88.80	11.09	0.08	0.00	0.02	0.01	0.00	0.00
E	92.47	7.52	0.01	0.00	0.00	0.00	0.00	0.00
560E06	56.69	42.57	0.74	0.00	0.00	0.00	0.00	0.00
All Strata	80.71	18.53	0.63	0.08	0.02	0.01	0.00	0.00

Autumn sawners in 2010

Numbers in millions

	WR 0	1	2	3	4	5	6	7	Total
580E06	0.00	5.16	0.21	0.10	0.04	0.00	0.00	0.00	5.50
570E06	0.00	19.01	6.15	0.66	0.70	0.14	0.00	0.11	26.76
580E08	0.00	6.73	2.03	0.71	0.66	0.17	0.00	0.00	10.30
570E08	0.00	1222.33	5.96	1.17	0.02	0.04	0.00	0.01	1229.52
C	0.26	3.03	0.51	0.11	0.21	0.00	0.00	0.00	4.12
D	0.06	202.86	7.37	1.70	0.02	0.01	0.00	0.00	212.02
E	49.68	966.47	8.69	2.14	0.00	0.00	0.00	0.00	1026.98
560E06	205.36	2.89	0.00	0.00	0.00	0.00	0.00	0.00	208.25
All Strata	255.37	2428.48	30.91	6.58	1.64	0.36	0.00	0.12	2723.45

Age distribution in % of total abundance

	WR 0	1	2	3	4	5	6	7
580E06	0.00	93.80	3.77	1.75	0.67	0.00	0.00	0.00
570E06	0.00	71.02	22.96	2.45	2.60	0.54	0.00	0.43
580E08	0.00	65.40	19.74	6.85	6.39	1.62	0.00	0.00
570E08	0.00	99.42	0.48	0.09	0.00	0.00	0.00	0.00
C	6.34	73.59	12.37	2.70	5.01	0.00	0.00	0.00
D	0.03	95.68	3.48	0.80	0.01	0.00	0.00	0.00
E	4.84	94.11	0.85	0.21	0.00	0.00	0.00	0.00
560E06	98.61	1.39	0.00	0.00	0.00	0.00	0.00	0.00
All Strata	9.38	89.17	1.14	0.24	0.06	0.01	0.00	0.00

Table 9. Age distribution in estimate of spring spawners during the Danish acoustic survey with RV "Dana" in June-July from 2006 to 2010 given as number per age and strata.

Spring spawners in 2007															
Numbers in millions															
	WR														
Strata	0	1	2	3	4	5	6	7	8	9	10	11	12	13	Total
580E06	0	0.59	10.71	6.52	6.76	1.13	0.91	0.10	0.10	0	0	0	0	0	26.82
570E06	0	38.76	240.73	133.30	63.70	22.19	4.99	3.71	0.88	0	0	0	0	0	508.26
580E08	0	18.16	104.65	52.34	32.00	11.00	2.02	0.26	1.24	0.47	0	0	0	0	222.14
570E08	0	523.57	651.64	295.67	141.30	52.41	12.08	3.48	4.91	2.66	0	0	0	0	1687.73
C	0	500.81	329.72	87.72	27.43	6.10	1.21	0	1.40	0	0	0	0	0	954.39
D	0	531.74	612.87	161.57	51.80	10.31	0	0	1.76	0	0	0	0	0	1370.05
E	0	2138.61	1676.06	193.05	129.39	42.04	11.33	18.17	1.37	0	0	0	0	0	4210.02
560E06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
All stratas	0	3752.24	3626.38	930.17	452.37	145.18	32.54	25.73	11.66	3.14	0	0	0	0	8979.40
													Total 4-13 WR		670.61
													Total 0-3 WR		8308.79
Spring spawners in 2008															
Numbers in millions															
	WR														
Strata	0	1	2	3	4	5	6	7	8	9	10	11	12	13	total
580E06	0	4.75	22.36	11.44	4.64	1.63	0.23	0	0	0	0	0	0	0	45.06
570E06	0	2263.75	377.97	116.59	51.42	23.77	13.53	5.64	2.24	0.17	0.14	0	0	0	2855.22
580E08	0	49.79	59.90	36.90	7.15	5.02	1.89	1.00	0.48	0.13	0.00	0	0	0	162.26
570E08	0	701.72	228.78	147.20	71.33	46.00	41.03	15.91	6.89	5.64	0.00	0	0	0	1264.51
C	0	108.72	96.90	26.02	7.22	5.07	0.58	0.34	0	0	0.34	0	0	0	245.18
D	1.38	124.71	151.89	59.98	20.05	11.58	3.96	1.21	0	0	0.29	0	0	0	375.05
E	23.86	216.22	125.10	41.38	11.35	6.16	3.85	0.45	0.68	0.36	0	0	0	0	429.43
560E06	81.17	1903.13	5.62	0	0	0	0	0	0	0	0	0	0	0	1989.92
All stratas	106.42	5372.77	1068.54	439.52	173.17	99.23	65.08	24.55	10.28	6.31	0.77	0	0	0	7366.64
													Total 4-13 WR		379.39
													Total 0-3 WR		6987.25
Spring spawners in 2009															
Number in millions															
	WR														
Strata	0	1	2	3	4	5	6	7	8	9	10	11	12	13	total
580E06	0	0.18	0.85	0.44	0.32	0.19	0.02	0	0	0.01	0	0	0	0	2.01
570E06	0	60.72	136.57	138.97	116.99	51.61	44.13	15.51	11.38	1.72	2.16	1.16	0	1.52	582.44
580E08	0	0.00	17.81	9.09	7.78	3.76	2.29	0.71	0.16	0.24	0.05	0	0	0	41.88
570E08	0	87.86	59.76	19.24	13.05	6.39	3.68	1.12	0.21	0.28	0.07	0	0	0	191.66
C	0	0.00	2.61	1.01	0.64	0.09	0.03	0.03	0.03	0	0	0	0	0	4.43
D	0	1.12	66.37	22.03	14.97	5.02	3.51	1.26	0.23	0.39	0.12	0	0	0	115.03
E	0.94	155.35	27.00	5.35	1.99	0.68	0.65	0	0	0	0	0	0	0	191.95
560E06	0	194.39	1.80	0.72	0	0	0	0	0	0	0	0	0	0	196.91
All stratas	0.94	499.62	312.76	196.86	155.73	67.73	54.30	18.63	12.01	2.64	2.40	1.16	0	1.52	1326.32
													Total 4-13 WR		316.13
													Total 0-3 WR		1010.19
Spring spawners in 2010															
Number in millions															
	WR														
Strata	0	1	2	3	4	5	6	7	8	9	10	11	12	13	total
580E06	0	0.64	3.58	2.90	1.33	0.58	0.32	0.04	0	0	0	0	0	0	9.40
570E06	0	2.63	14.71	22.37	8.57	4.51	2.24	0.75	0.39	0.49	0.24	0.01	0.10	0	57.00
580E08	0	0.38	11.76	18.76	6.75	3.59	1.62	1.56	0.70	0.38	0	0	0	0	45.51
570E08	0	111.66	55.59	19.63	0.29	0.10	0.06	0.02	0	0.01	0	0	0	0	187.35
C	0	0.15	4.09	5.31	1.54	1.05	0.45	0.46	0.24	0.15	0	0	0	0	13.43
D	0	45.94	92.39	15.31	1.60	0.38	0.10	0.07	0.03	0.01	0	0	0	0	155.82
E	0.66	611.21	307.14	59.42	7.44	3.49	0.57	0.39	0.12	0.00	0	0	0	0	990.43
560E06	0	1.82	0.01	0	0	0	0	0	0	0	0	0	0	0	1.83
All stratas	0.66	774.43	489.28	143.70	27.52	13.70	5.36	3.28	1.47	1.04	0.25	0.01	0.10	0	1460.78
													Total 4-13 WR		52.72
													Total 0-3 WR		1408.06

Table 10. Abundance, mean weight, mean length and biomass by age group and subarea for sprat in the Danish acoustic survey with RV "Dana" in June-July 2010.

Abundance i mill.										
	WR									
Strata	0	1i	1m	2i	2m	3	4	5	6	7
580E06	0	0	0	0	0	0	0	0	0	0
570E06	0	0	0	0	0	0	0	0	0	0
580E08	0	0	0	0	0	0	0	0	0	0
570E07	0	0.022407	0.005244	0.083495	0.068222	0.097868	0.082392	0.046466	0.012117	0.001399
C	0	0	0	0	0	0	0	0	0	0
D	0	0	0	0	0	0	0	0	0	0
E	2.719978	677.4839	158.5601	189.069	154.4832	195.6962	121.3697	46.7424	9.216227	2.95871
560E06	0	1244.624	291.295	2.940072	2.402254	2.671163	0	0	0	0

Biomass in ton										
	WR									
Strata	0	1i	1m	2i	2m	3	4	5	6	7
580E06	0	0	0	0	0	0	0	0	0	0
570E06	0	0	0	0	0	0	0	0	0	0
580E08	0	0	0	0	0	0	0	0	0	0
570E07	0	0.282109	0.066026	1.254102	1.024693	1.687511	1.637918	0.917959	0.230694	0.018183
C	0	0	0	0	0	0	0	0	0	0
D	0	0	0	0	0	0	0	0	0	0
E	5.439956	5855.911	1370.532	2714.518	2217.96	3115.75	2221.821	859.8532	162.7388	38.46322
560E06	0	8978.537	2101.36	35.28086	28.82705	34.72512	0	0	0	0

Mean length in cm										
	WR									
Strata	0	1i	1m	2i	2m	3	4	5	6	7
580E06	0	0	0	0	0	0	0	0	0	0
570E06	0	0	0	0	0	0	0	0	0	0
580E08	0	0	0	0	0	0	0	0	0	0
570E07	0	12.22514	12.22514	13.09758	13.09758	13.74368	14.4808	14.74646	14.95671	13.5
C	0	0	0	0	0	0	0	0	0	0
D	0	0	0	0	0	0	0	0	0	0
E	6.75	10.70682	10.70682	12.87331	12.87331	13.28303	13.9409	14.32156	14.49511	13.5
560E06	0	9.596522	9.596522	11.75	11.75	12	0	0	0	0

Mean weight in g										
	WR									
Strata	0	1i	1m	2i	2m	3	4	5	6	7
580E06	0	0	0	0	0	0	0	0	0	0
570E06	0	0	0	0	0	0	0	0	0	0
580E08	0	0	0	0	0	0	0	0	0	0
570E07	0	12.59035	12.59035	15.02002	15.02002	17.24268	19.87946	19.7557	19.0389	13
C	0	0	0	0	0	0	0	0	0	0
D	0	0	0	0	0	0	0	0	0	0
E	2	8.643616	8.643616	14.35729	14.35729	15.92136	18.30623	18.39557	17.65786	13
560E06	0	7.213855	7.213855	12	12	13	0	0	0	0

Annex 5C: Norway

ICES coordinated acoustic survey on Herring and Sprat in the North Sea

RV "Johan Hjort", 3 July – 2 August 2010

Else Torstensen, Institute of Marine Research, Flødevigen, N-4817 His, Norway

Cecilie Kvamme, Institute of Marine Research, PO Box 1870 Nordnes, N-5817 Bergen, Norway

else.torstensen@imr.no

cecilie.kvamme@imr.no

1. INTRODUCTION

In 2010, the Norwegian Institute of Marine Research (IMR) carried out the Norwegian part of the ICES coordinated herring and sprat acoustic survey for the North Sea and adjacent areas. This acoustic survey (HERAS) is planned and coordinated by the Working Group for International Pelagic Surveys (WGIPS 2010). Six countries cooperate in surveying the North Sea and Div. IIIa for an acoustic abundance estimation of herring and sprat. The Norwegian herring acoustic area was defined as the area between 56°30′ and 62°N and between 2° and 6°E. This year, the survey was a multipurpose survey, covering HERAS, saithe acoustic, IBTS 3Q, a hydrographical standard transect (Utsira-Start Point), sampling for pollution (both in seawater and fish) as well as process studies for the project "Early life-history dynamics of North Sea Fishes". Data from the HERAS part of the survey will be combined with the HERAS surveys of the other countries to provide a combined age disaggregated abundance index for use in the assessment carried out by the ICES Herring Assessment Working Group (HAWG) to be held in March 2011.

Objectives for the HERAS part of the survey with RV "Johan Hjort" were:

a) To conduct an acoustic survey to estimate the abundance and distribution of herring and sprat in the north-eastern part of the North Sea, between 57°00′and 62° N, and between 2° and 5° E.

b) To obtain biological samples. Herring were sampled for data on length, weight, age, sex, maturity, mesenteric fat, vertebrae count and infection by Ichthyphonus.

2. SURVEY DESCRIPTION AND METHODS

2.1 Personnel

First part:

Else Torstensen	(Cruise leader, 3–20 July)
Irene Huse	(Scientist, 3–20 July)
Bjørn Vidar Svendsen	(Technician – pelagic fish, 3–7 July)
Anne-Liv Johnsen	(Technician – pelagic fish, 7 – 20 July)
Jan de Lange	(Technician – pelagic fish, 3 – 20 July)
Arne Storaker	(Technician – bottomfish, 3 – 20 July)
Guri Nesje	(Chemistry, 3–20 July)

Kjell Westrheim	(Chemistry, 3–20 July)
Bjarte Kvinge	(Acoustic operator, 3 – 20 July)
Terje Haugland	(Acoustic operator, 3 – 20 July)
Anne Lene Brungot	(Guest, Norwegian Radiation Protection Authority, 3–20 July)
Oxana Blinova	(Guest, IAEA, 3 – 20 July)
Hilde M.M. Karlsen	(Guest, master student, IMR, 3 – 20 July)

Second part:

Cecilie Kvamme	(Cruise leader, 21 July – 2 August)
Inger Henriksen	(Technician – pelagic fish, 21 July – 2 August)
Knut Hansen	(Technician – pelagic fish, 21 July – 2 August)
Anne Sæverud	(Technician – bottomfish, 21 July – 2 August)
Ole Oskar Arnøy	(Technician – bottomfish, 21 July – 2 August)
Grethe Tveit	(Chemsitry, 21 July – 2 August)
Sonnich Meier	(Scientist, 21 July – 2 August)
Richard Nash	(Scientist, 21 July – 2 August)
Jan Erik Nygaard	(Acoustic operator, 21 July – 2 August)
Andreas Nieuwejaar	(Acoustic operator, 21 July – 2 August)
Justin Gwynn	(Guest, Norwegian Radiation Protection Authority, 3–20 July)

2.2 Narrative

RV "Johan Hjort" left Bergen at 1600 UTC 3 July 2010 and set the course southeast. Because of oil leakage, the survey was started the day after, on 4 July. We started the acoustic survey in the southeastern part (43F7) at 2305 UTC 8 July in the position 57°5'N 7°8'E. The vessel then continued with east-west transects from south to north. The survey finished 1 August at 1658 UTC in position 60°46'N 04°26.5'E and the vessel proceeded to Bergen where "Johan Hjort" docked late in the evening. Figure 1 gives the cruise track and distribution of trawl haul stations. In general the weather in the first part of the survey was bad, with wind up to storm. In the second part of the survey the weather conditions were good.

The present report gives the results from the survey area covered by the Norwegian survey.

Samples of 25 herring from 4 stations (2 in the southern part, and 2 in the northern part) were frozen for later analysis at the Norwegian National Institute of Nutrition and Seafood Research (NIFES).

2.3 Survey design

The survey was mostly carried out in systematically parallel east-west transects progressing northwards from N57° to N62°, only disrupted by some IBTS and sediment stations. The Norwegian part of the survey should also have covered the ICES squares 42F2-F5 (WGIPS 2010). However, due to the technical problems with the vessel and the weather, these squares were not covered.

2.4 Calibration

Calibration of the echosounders was performed. An area suitable for calibration was found in Rosfjord, west of Lindesnes (58˚ 04'148'' N og 07˚ 00'185'' E. The calibration followed standard procedures, 6 July 2010. The main settings for the 38 kHz transceiver are given in Table 1.

2.5 Acoustic data collection

The acoustic survey on-board RV "Johan Hjort" was carried out using a SIMRAD ER60 38 kHz sounder and an ES38B SK transducer mounted on the drop keel. Acoustic data were collected 24 hours per day. Additional data were collected at 18, 120 and 200 kHz (ES120–7 transducer). These data were used to present the frequency responses as guidance in the scrutiny of the acoustic data for species allocations. The mean volume backscattering values (S_V) were integrated pr nm intervals from 9–13 m (depending on weather conditions and the use of keel) below the surface to 0.5 m above the seabed. The speed of the vessel during the acoustic sampling was about 10–11 knots. The acoustic data were archived on an external hard drive. The acoustic recordings were scrutinized twice per day using the new Post Processing System LSSS (ver. 1.2.2; *Large Scale Survey System*, Korneliussen *et al*., 2006).

2.6 Biological data - fishing trawl hauls

Trawling was carried out for supporting the species identification of acoustic scatters and for biological sampling. For pelagic trawling a salmon trawl, an Aakra trawl or a Harstad trawl was used, and the hauls were monitored by a SCANMAR TE40-2 (PL; narrow-beam) and depth sensor D1200. For bottom trawling mainly a GOV trawl with rock-hopper gear was used.

The catches were sampled for species composition by number and weights. Individual biological samples (length, weight, age and maturity) of the most important species were taken according to the IMR fish sampling manual (Mjanger *et al*., 2008). Herring were examined for sex, maturity (8 point scale), fat, stomach content, vertebrae count and macroscopic evidence of *Ichthyophonus* infection. Otoliths were taken for age determination (number of winter rings).

2.7 Hydrographic data

A CTD station was taken at each trawl station. The Utsira-Start point standard transect was also covered in this survey.

2.8 Acoustic data analysis

Data from the post-processing LSSS (sA) were averaged per 1 nm. The acoustic data were allocated to the following categories: herring, saithe, demersal fish, pelagic fish and plankton. To calculate integrator conversion factors, the target strengths of the target species herring and sprat were estimated using the following TS-length relationship:

$$TS = 20\log_{10}L - 71.2 \text{ dB}$$

Herring were separated from other recordings by using catch information and characteristics of the recordings (e.g. frequency response – Korneliussen *et al*., 2006). The abundance estimation (Toresen *et al*., 1998) was made by ICES rectangles and summed up for the whole area.

North Sea autumn spawners and Western Baltic spring spawners (WBSS) are mixed during summer in the area covered by RV "Johan Hjort" (east of 2°E). No system for workable stock discrimination on individual herring during the survey is available. The proportions of Baltic spring spawners and North Sea autumn spawners by age were calculated by applying the formula

WBSS= ((56.5-VS (sample))/(56.5–55.8)) (p. 29, HAWG 1999)

WBSS is the proportion of WBSS and VS(sample) is the mean vertebrae count of the sample. All samples were worked up on board. The length-at-age and weight-at-age were assumed to be the same in the two stocks. The measured proportions of mature fish were applied equally to calculate the maturing part of each age group in both stocks.

3 Results and discussion

The survey track, trawl hauls and CTD stations are presented in Figure 1.

3.1 Acoustic data

3.1.1 Herring

The distribution of sA-values assigned to herring, are presented as mean values (from 1 n.mi intervals) per ICES square in Figure 2. Herring were scattered distributed in the area in general low densities, with most herring in the southwestern part. The highest mean sA recorded by ICES rectangle was 318 (47F2) followed by sAs of 156 in 45F3 and 116 in 46F3. Pelagic trawling was based on both random positions regularly chosen for trawling at the surface, i.e. not based on echo registration (44%), and trawling on acoustic registrations (56%). In the "Norwegian area" herring tend to keep close to the surface and may thus be underestimated. Most of the schools were small and occurred scattered throughout the area, either close to the surface or near bottom. Few "classical" herring schools were observed this year, neither near bottom nor higher up in the water column.

In total, Norway pout dominated the catches (Table 3: 32% of total catch weight), occurring in 42 of the 97 trawl haul catches. This contributed to some level of confusion in allocation to species, i.e. herring or Norway pout, as they can be very similar also in frequency response (Fässler *et al.*, 2007). Herring and mackerel were the second and third most occurring species, contributing with 15 and 11% of the total catch weight, respectively.

3.1.2 Sprat

No sprat was observed by RV "Johan Hjort". This is the same situation as has been seen the last years.

3.2 Biological data

A total of 99 valid trawl hauls were carried out, of which 60 (37 PT and 23 BT) were taken in the "Norwegian herring" area (Figure 1, Table 2). In general 30 min hauls were made. Catch composition per haul is given in Table 3. Herring were present in 16 hauls of sample size >20 herring in the "herring" area (PT: 9, BT: 7), the length distributions of the herring samples used in the acoustic herring estimate are presented in Table 4. The herring samples were grouped according to length and age distribution, as well as proportions of WBSS by age. The areas covered by the different groups of herring samples are shown i Figure 3. A total of 2217 herring were length measured and 1018 aged (winter rings in otoliths). No herring was observed to be infected by Ichthyophonus.

3.3 Abundance and Biomass estimates

3.3.1 Herring

The geographical distribution of the sA-values assigned to herring, are presented in Figure 2. It was generally low amounts of herring, but the highest values were encountered in the more southwestern central part of the “herring” area, between 57.5 and 59.5 °N. Total number of herring was 1632 million (nearly 4 times the 2010 estimate) of which 66% was North Sea Autumn Spawners (NSAS).

Total biomass of **NSAS** was estimated to 162 000 tonnes and the spawning-stock biomass as 136 800 tonnes (84%). These estimates are much higher than the respective biomasses from the Norwegian area last year: 32 100 t and 27 600 t, respectively, but this is probably partly a result of the reduced coverage in 2009. Compared with the 2008 estimates, the 2010 total biomass estimate was reduced by 32%, whereas the spawning-stock biomass estimate was increased by 44%. The proportions of mature 2- and 3-ringers by numbers were estimated at 72 and 100%, respectively, thus lower than the proportions estimated in 2009 (100%) and a bit higher than in 2008 (54 and 99%). Of the estimated numbers of 1-ringers, 3% was classified as maturing (2009: 4%, 2008: 7%). The 2-ringers dominated the North Sea autumn spawners in numbers, making 28%, whereas 24% of the biomass. In biomass, the 3-ringers dominated with its 28%.

The total biomass of **WBSS** was 72 300 tonnes, an increase since last year (58 300 tonnes). This must however also be seen in the light of the reduced coverage of the Norwegian 2009 survey.

Few good acoustic marks of herring schools were observed and the majority of the trawling positions were regularly chosen for trawling at surface, i.e. not based on echo registration. Due to the tendency of staying near the surface during daytime, herring may have been underestimated.

Table 5 gives the mean length, mean weight, total numbers (millions) and biomass (thousands of tonnes) by age and maturity stage for the North Sea autumn spawners and the Western Baltic spring spawners in the Norwegian target area in July 2010.

3.4 Hydrography

A total of 131 CTD stations were sampled (Figure 1).

The hydrographical data are part of a general monitoring program of IMR/ICES, and will be analysed and published separately.

4. References

Fässler, S.M.M., Santos, R., García-Núñez, N. and Fernandes, P.G. 2007. Multifrequency backscattering properties of Atlantic herring (*Clupea harengus*) and Norway pout (*Trisopterus esmarkii*). Canadian Journal of Fisheries and Aquatic Sciences 64: 362–374.

HAWG 1999. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES HQ, 15–24 March 1999. ICES CM 1999/ACFM:12.

Korneliussen, R.J., Ona, E., Eliassen, I.K., Heggelund, Y., Patel, R., Godø, O.R., Giertsen, C., Patel, D., Nornes, E.H., Bekkvik, T., Knudsen, H.P., and Lien, G. 2006. The Large Scale Survey System-LSSS, a new post-processing system for multi-frequency echo sounder data. ICES WGFAST Report 2006.

Mjanger, H., Hestenes, K., Svendsen, B.V., de Lange Wenneck, T. 2008. Manual for sampling of fish and crustaceans. Ver. 3.16. Institute of Marine Research.

Toresen, R., Gjøsæter, H., and de Barros, P. 1998. The acoustic method as used in the abundance estimation of capelin (*Mallotus villosus* Müller) and herring (*Clupea harengus* Linné) in the Barents Sea. Fisheries Research 34: 27–37.

ICES. 2010. Report of the Working Group for International Pelagic Surveys (WGIPS). Galway, Ireland, 19–22 January 2010. ICES CM 2010/SSGESST:03.

Table 1. RV "Johan Hjort", survey 2010207. International acoustic survey on herring in the North Sea, 3 July – 2 August 2010. Simrad ER60 and analysis settings used.

Transceiver Menu	**38 kHz**
Absorption coefficient	9.3 dB/km
Pulse length	1.024 ms
Bandwidth	2.43 kHz
Max power	2000 W
Two-way beam angle	-20.6 dB
3 dB Beam width (deg) - along ship	6.94°
3 dB Beam width (deg) - athwart ship	6.87°
Calibration details	
TS of sphere	-33.6
Range to sphere in calibration	22.0 m
Transducer gain	26.93
Sa correction	-0.63
Log/Navigation Menu	
Speed	Serial from ship's GPS
Operation Menu	
Ping interval	1 s

Table 2. RV "Johan Hjort", survey 2010207, 3 July – 2 August 2010. Trawl stations in the North Sea. PT = Pelagic Trawl, BT = Bottom Trawl. H: herring sample (≥ 20 herring), h: herring present (< 20 ind.). Gear code: 3191 / 3194 = GOV trawl with single / double sweeps, 3270 = Campelen shrimp trawl with rock-hopper gear, 3513 / 3514 = Harstad trawl without / with large floats, 3533 = Aakra trawl with large floats, 3547 = salmon trawl. Quality: 1 = random position at surface, 2 = trawling on acoustic registration, 5 = the trawl has not been fishing properly due to technical problems.

Date	Trawl haul no	Quality	Gear code	Lat	Long	ICES sq	Time (UTC)	Water depth (m)	Trawl depth, max (m)	Duration (min)	Herring
20100700	BT238		3194	59.27	3.21	47 F3	1912	147	149	86	
20100700	BT239		3194	59.26	3.22	47 F3	0648	147	148	45	
20100700	BT240		3194	59.27	3.16	47 F3	0838	143	143	8	
20100700	BT241	1	3270	57.71	5.90	44 F5	0008	143	147	36	
20100700	BT242	1	3270	57.62	6.01	43 F6	0139	145	147	33	
20100700	BT243	1	3191	57.13	6.29	43 F6	0222	63	67	31	H
20100700	BT244	1	3191	57.17	5.85	43 F5	0446	50	53	30	
20100700	PT245	2	3547	57.18	5.47	43 F5	0720	58	267	19	
20100700	BT246	1	3191	57.25	4.08	43 F4	1236	62	62	31	H
20100700	PT247	2	3547	57.17	3.78	43 F3	1437	62	63	12	
20100700	PT248	2	3547	57.16	3.73	43 F3	1601	61	43	60	
20100700	BT249	1	3191	57.25	3.48	43 F3	1929	61	62	31	
20100700	PT250	2	3547	57.16	2.73	43 F2	2303	72	0	30	H
20100700	BT251	1	3191	57.28	2.54	43 F2	0109	82	83	30	H
20100700	BT252	1	3191	57.33	0.91	43 F0	0906	94	95	19	h
20100700	BT253	1	3191	57.60	0.80	44 F0	1134	105	109	31	H
20100700	BT254	1	3191	57.56	1.15	44 F1	1357	91	93	31	
20100700	BT255	1	3191	57.36	1.68	43 F1	1707	95	95	30	
20100700	PT256	2	3547	57.41	1.92	43 F1	1903	90	35	28	
20100700	PT257	1	3547	57.41	2.71	43 F2	2225	72	0	30	H
20100700	PT258	1	3547	57.42	3.26	43 F3	0055	62	0	49	
20100700	PT259	1	3547	57.42	4.07	43 F4	0417	71	0	32	
20100700	BT260	2	3191	57.55	6.20	44 F6	1521	125	136	19	
20100700	PT261	2	3547	57.67	5.30	44 F5	2201	107	0	30	H
20100700	PT262	2	3547	57.68	4.64	44 F4	0131	85	0	31	h
20100700	BT263	1	3191	57.75	4.56	44 F4	0306	85	87	23	h
20100700	BT264	1	3191	57.67	3.57	44 F3	0801	63	64	29	H
20100700	PT265	2	3547	57.66	2.94	44 F2	1114	64	35	45	
20100700	BT266	1	3191	57.67	2.14	44 F2	1503	84	85	30	H
20100700	PT267	2	3547	57.82	2.07	44 F2	1745	87	0	22	
20100700	PT268	2	3547	57.87	2.07	44 F2	1924	86	56	25	
20100700	PT269	1	3547	57.92	2.76	44 F2	2324	62	0	41	h
20100700	PT270	1	3547	57.92	3.41	44 F3	0229	76	0	30	
20100700	BT271	1	3191	57.93	5.46	44 F5	1145	168	169	24	
20100700	BT272	5	3191	57.94	5.84	44 F5	1502	260	271	32	
20100700	BT273	5	3191	57.93	5.93	44 F5	1647	274	278	31	
20100700	BT274	5	3191	58.09	5.88	45 F5	1924	319	321	15	
20100700	PT275	2	3547	58.17	4.56	45 F4	2210	181	0	30	H
20100700	PT276	2	3547	58.17	3.88	45 F3	0112	110	0	30	
20100700	BT277	1	3191	58.11	3.64	45 F3	0258	83	92	27	h
20100700	PT278	2	3547	58.17	3.24	45 F3	0527	77	0	30	h
20100700	PT279	2	3547	58.19	3.10	45 F3	0642	73	42	30	
20100700	BT280	1	3191	58.20	2.69	45 F2	0916	70	70	30	
20100700	BT281	1	3191	58.37	4.12	45 F4	2144	191	191	32	
20100700	PT282	2	3547	58.43	4.20	45 F4	0009	291	0	31	H
20100700	PT283	2	3547	58.44	5.04	45 F5	0441	301	0	30	H
20100700	BT284	1	3191	58.40	1.09	45 F1	0312	138	138	30	H
20100700	BT285	1	3191	58.38	0.66	45 F0	0614	148	149	25	H
20100700	BT286	1	3191	58.75	0.74	46 F0	0918	138	139	30	H
20100700	BT287	1	3191	58.77	1.10	46 F1	1134	109	111	31	H
20100700	BT288	1	3191	58.80	2.54	46 F2	1720	113	115	30	H
20100700	PT289	1	3547	58.89	3.19	46 F3	2125	115	0	30	H
20100700	BT290	1	3191	58.87	3.28	46 F3	2256	116	135	31	

Table 2. RV "Johan Hjort", survey 2010207, 3 July – 2 August 2010. Ctd.

Date	Trawl haul no	Quality	Gear code	Lat	Long	ICES sq	Time (UTC)	Water depth (m)	Trawl depth, max (m)	Duration (min)	Herring
20100700	PT291	2	3547	58.93	3.89	46 F3	0211	277	0	30	
20100700	BT292	1	3191	59.30	3.21	47 F3	1439	146	148	31	
20100700	BT293	1	3191	59.28	2.53	47 F2	1853	129	130	30	
20100700	PT294	2	3533	59.28	2.17	47 F2	2132	124	0	30	H
20100700	BT295	1	3191	59.30	1.63	47 F1	0050	115	116	30	
20100700	BT296	1	3191	59.28	0.54	47 F0	0617	132	135	30	H
20100700	BT297	1	3191	59.29	-0.38	47 E9	1029	139	139	30	
20100700	PT298	1	3533	59.48	4.57	47 F4	2116	267	0	27	h
20100700	PT299	2	3514	59.47	3.87	47 F3	0020	274	0	32	
20100700	PT300	1	3513	59.47	2.88	47 F2	0437	121	99	18	
20100700	PT301	2	3513	59.48	2.24	47 F2	0826	126	103	36	h
20100700	BT302	1	3191	59.76	1.97	48 F1	1209	116	116	32	H
20100700	BT303	1	3191	59.77	2.50	48 F2	1445	119	121	30	H
20100700	BT304	1	3191	59.74	3.16	48 F3	1747	143	143	30	h
20100700	PT305	2	3514	59.97	3.82	48 F3	0021	287	15	33	
20100700	PT306	2	3533	59.97	2.11	48 F2	0644	104	0	34	
20100700	BT307	1	3191	59.83	0.48	48 F0	1239	131	133	36	h
20100700	BT308	1	3191	59.75	-0.42	48 E9	1618	133	136	31	H
20100700	BT309	1	3191	60.00	-0.46	49 E9	1851	131	137	29	H
20100700	BT310	1	3191	60.23	1.41	49 F1	0337	122	122	30	h
20100700	BT311	1	3191	60.20	2.62	49 F2	0837	104	105	27	h
20100700	BT312	1	3191	60.22	3.11	49 F3	1127	129	142	31	
20100700	PT313	2	3513	60.22	3.73	49 F3	1449	296	168	28	
20100700	PT314	2	3514	60.45	3.85	49 F3	2053	298	0	31	h
20100700	PT315	2	3514	60.45	2.97	49 F2	0055	111	10	31	H
20100700	BT316	1	3191	60.78	1.28	50 F1	0844	143	146	29	
20100700	BT317	1	3191	60.72	2.56	50 F2	1329	120	120	30	H
20100700	BT318	1	3191	60.61	3.05	50 F3	1607	160	160	30	h
20100700	PT319	1	3514	60.91	3.82	50 F3	2151	343	10	31	h
20100700	PT320	1	3514	60.91	2.95	50 F2	0147	251	10	31	h
20100700	BT321	2	3191	60.97	1.99	50 F1	0622	131	131	30	
20100700	PT322	1	3513	61.16	2.53	51 F2	1014	261	30	31	
20100700	BT323	1	3191	61.31	2.10	51 F2	1919	231	250	19	
20100700	PT324	1	3514	61.40	2.29	51 F2	2127	317	0	31	h
20100700	BT325	1	3191	61.25	1.28	51 F1	0705	152	157	30	
20100700	BT326	1	3191	61.14	0.99	51 F0	0937	157	157	30	
20100700	BT327	1	3191	60.97	1.28	50 F1	1150	147	150	31	
20100700	BT328	1	3191	61.14	1.02	51 F1	1518	154	159	30	
20100700	BT329	1	3191	61.15	0.98	51 F0	1647	157	158	30	
20100700	BT330	1	3191	61.15	0.99	51 F0	1837	158	158	30	
20100700	PT331	1	3513	61.21	0.45	51 F0	2346	166	152	18	h
20100700	PT332	1	3513	61.20	-0.32	51 E9	0333	160	150	28	
20100700	BT333	1	3191	61.20	-0.26	51 E9	0456	158	164	30	
20100700	PT334	1	3513	61.16	0.46	51 F0	0916	159	0	25	h
20100700	BT335	1	3191	61.08	0.46	51 F0	1040	155	156	30	h
20100700	BT336	1	3191	60.81	0.48	50 F0	1336	142	142	30	h
20100700	PT337	1	3513	60.74	0.48	50 F0	1458	145	130	18	h
20100700	PT338	1	3513	60.48	0.51	49 F0	1728	135	123	21	
20100700	BT339	1	3191	60.47	0.53	49 F0	1830	132	142	30	h
20100700	PT340	1	3513	60.70	-0.31	50 E9	2226	129	112	23	
20100700	BT341	5	3191	60.70	-0.30	50 E9	1711	112	132	29	
20100700	PT342	1	3513	61.66	1.98	52 F1	0305	356	0	30	h
20100700	PT343	1	3513	61.59	4.16	52 F4	1058	269	25	30	h

Table 3. RV "Johan Hjort" 3 July – 2 August 2010. Catch composition in the trawl hauls (kg).

Species	Trawl haul no	**BT241**	**BT242**	**BT243**	**BT244**	**PT245**	**BT246**	**PT248**	**BT249**	**PT250**	**BT251**	**BT252**	**BT253**	**BT254**	**BT255**	**PT256**	**PT257**
	Serial no	24304	24305	24306	24307	24308	24309	24311	24312	24313	24314	24315	24316	24317	24318	24319	24320
	ICES area	44 F5	43 F6	43 F3	43 F5	43 F5	43 F4	43 F3	43 F3	43 F2	43 F2	43 F0	44 F0	44 F1	43 F1	43 F1	43 F2
	Total catch (kg)	617.95	506.26	130.56	70.46	6.41	277.05	24.14	296.21	60.27	83.24	1063.35	370.10	552.89	287.79	3.31	37.90
Herring	*Clupea harengus*			2.57			2.30			16.89		**940.00**	13.10	**366.00**	0.66		**23.72**
Mackerel	*Scomber scombrus*						0.21		0.26	27.40		2.15		2.41		**2.21**	7.92
Horse Mackerel	*Trachurus trachurus*									0.61							
Blue whithing	*Micromesistius poutassou*	5.26															
Saithe	*Pollachius virens*	**352.66**	**195.27**			0.09	0.14								1.92		
Cod	*Gadus morhua*	8.01	11.09	19.44	9.24				0.86		0.43	2.25	2.91	2.42	6.32		
Haddock	*Melanogrammus aeglefinus*	1.17	0.80	16.60	1.63	0.03		0.02	0.39		12.50	48.15	45.60	105.96	63.48		
Whiting	*Merlangius merlangus*			1.40	5.76						6.30	4.05	4.17		7.70		
Ling	*Molva molva*	1.78	2.66										0.26				
Pollack	*Pollachius pollachius*	1.26															
Hake	*Merluccius merluccius*	10.36	20.14	8.00	7.59		2.16					10.05	**123.23**	1.26			
Norway pout	*Trisopterus esmarkii*	**210.60**	**207.00**								0.20	13.20	**166.60**		**150.00**		
Poor cod	*Trisopterus minutus*	7.77	2.78										1.20				
Silvery pout	*Gadiculus argenteus*																
Dab	*Limanda limanda*			**36.73**	**17.75**		**156.56**		**250.60**		**40.04**			3.84	0.65		
Long rough dab	*Hippoglossoides platessoides*	1.35	1.28	13.76	1.91		11.44		6.45		3.20	4.25	2.00	1.90	7.50		
Lemon sole	*Microstomus kitt*				0.66		4.44		12.35		6.90	27.35	4.90	15.20	17.90		
Megrim	*Lepidorhombus whiffiagonis*																
Grey gurnards	*Eutrigla gurnardus*			3.96	10.81	0.79	80.48	5.12	5.70		1.51	2.30	2.90	2.28	4.25		
Tub gurnard	*Chelidonichthys lucernus*																
Argentine	*Argentina sphyraena*	4.03	1.20											3.18	1.80		
Greater argentine	*Argentina silus*											2.40	1.50				
Lumpsucker	*Cyclopterus lumpus*							2.00									
Medusae	*Hydroida*				2.10	5.50		17.00		15.08	7.30					1.10	6.01
Invertebrates		2.64		0.29	0.01	0.01	0.06			0.29	1.32	4.05		17.04	1.47		0.25
Other bonefish		11.08	64.06	19.00	13.01		7.26		8.10			3.15	1.67	31.40	21.73		
Sharks and rays				8.82			12.00		11.50		3.55		0.07		2.43		

Table 3. RV "Johan Hjort" 3 July – 2 August 2010. Ctd.

Species	Trawl haul no	PT258	PT259	BT260	PT261	PT262	BT263	BT264	PT265	BT266	PT267	PT268	PT269	PT270	BT271	PT275	PT276
	Serial no	24321	24322	24323	24324	24325	24326	24327	24328	24329	24330	24331	24332	24333	24334	24338	24339
	ICES area	43 F3	43 F4	44 F6	44 F5	44 F4	44 F4	44 F3	44 F2	44 F2	44 F2	44 F2	44 F2	44 F3	44 F5	45 F4	45 F3
	Total catch (kg)	41.60	3.40	114.44	48.42	17.10	101.30	120.10	9.00	213.88	21.51	40.45	74.15	8.31	166.26	162.19	59.38
Herring	*Clupea harengus*			0.54	2.89	0.14	0.10	12.82		17.20			0.56			16.82	
Mackerel	*Scomber scombrus*	**36.50**	**2.17**	1.21	43.83	15.99	0.28				20.85	**34.23**	**67.57**	**3.83**		**117.59**	**54.97**
Horse Mackerel	*Trachurus trachurus*				0.60												
Blue whithing	*Micromesistius poutassou*																
Saithe	*Pollachius virens*			11.07			0.95					0.01			42.42		
Cod	*Gadus morhua*			4.10			14.38	1.35		1.71					7.79		
Haddock	*Melanogrammus aeglefinus*			2.08			**55.56**	**72.84**	0.003	**88.90**		0.01			5.04		
Whiting	*Merlangius merlangus*			1.19			4.37	3.53	0.004	13.02			0.01		14.50		
Ling	*Molva molva*			1.73			0.91										
Pollack	*Pollachius pollachius*																
Hake	*Merluccius merluccius*			4.53			9.74	1.83							5.10		
Norway pout	*Trisopterus esmarkii*			**80.38**						6.56					**89.20**		
Poor cod	*Trisopterus minutus*														0.46		
Silvery pout	*Gadiculus argenteus*														0.04		
Dab	*Limanda limanda*						1.12	5.64		50.50					0.40		
Long rough dab	*Hippoglossoides platessoides*			2.27			1.41	0.13		4.35					0.36		
Lemon sole	*Microstomus kitt*			2.98			1.65	2.14		15.40							
Megrim	*Lepidorhombus whiffiagonis*																
Grey gurnards	*Eutrigla gurnardus*			0.28			4.36	5.82	0.44	2.69	0.66	0.88					
Tub gurnard	*Chelidonichthys lucernus*																
Argentine	*Argentina sphyraena*						0.07										
Greater argentine	*Argentina silus*														0.15		
Lumpsucker	*Cyclopterus lumpus*		0.44														
Medusae	*Hydroida*	5.10	0.80		0.77	0.88			**8.56**			5.33	5.68	1.97		2.56	4.15
Invertebrates				1.56		0.09	0.01	1.24		0.46			0.32	0.16		25.23	0.27
Other bonefish				0.07	0.33		6.42	12.79		11.62			0.02	2.36	0.46		
Sharks and rays				0.48						1.47					0.34		

Table 3. RV "Johan Hjort" 3 July - 2 August 2010. Ctd.

Species	Trawl haul no	**BT277**	**PT278**	**PT279**	**BT280**	**BT281**	**PT282**	**PT283**	**BT284**	**BT285**	**BT286**	**BT287**	**BT288**	**PT289**	**BT290**	**PT291**	**BT292**
	Serial no	24340	24341	24342	24343	24344	24345	24346	24347	24348	24349	24350	24351	24352	24353	24354	24355
	ICES area	45 F3	45 F3	45 F3	45 F2	45 F4	45 F4	45 F5	45 F1	45 F0	46 F0	46 F1	46 F2	46 F3	46 F3	46 F3	47 F3
	Total catch (kg)	258.85	2.44	12.83	138.30	162.79	130.81	165.61	490.94	129.05	635.55	1137.26	219.45	79.65	176.51	0.35	70.88
Herring	*Clupea harengus*	0.08	0.10		0.07		8.18	8.46	32.80	13.36	81.29	**508.00**	**95.42**	**34.58**			0.24
Mackerel	*Scomber scombrus*			**11.04**			**78.01**	**155.32**						**44.61**		**0.35**	3.06
Horse Mackerel	*Trachurus trachurus*						0.26										
Blue whithing	*Micromesistius poutassou*					6.48	1.29		0.08								
Saithe	*Pollachius virens*	2.40			0.44	**41.96**					4.83				11.09		3.09
Cod	*Gadus morhua*	32.81			17.02	22.26			11.01	2.52	18.21		0.67		11.89		0.15
Haddock	*Melanogrammus aeglefinus*	**173.49**			**89.10**	3.14	0.01		22.48	12.84	41.80	132.40	59.23		**70.76**		
Whiting	*Merlangius merlangus*	10.17	0.00	0.00	10.33		0.02	0.01	21.45	10.42	22.45	38.60	9.71		3.50		0.88
Ling	*Molva molva*					6.44							3.03				
Pollack	*Pollachius pollachius*																
Hake	*Merluccius merluccius*	7.46			2.88				3.81	2.90			17.23		2.84		**43.07**
Norway pout	*Trisopterus esmarkii*					**56.20**		0.23	**391.10**	**77.01**	**466.50**	**436.70**	25.93		**60.80**		13.66
Poor cod	*Trisopterus minutus*					3.97			0.11	0.09							
Silvery pout	*Gadiculus argenteus*					1.20				4.11							
Dab	*Limanda limanda*	1.60											0.52		1.46		
Long rough dab	*Hippoglossoides platessoides*	3.08			4.40	0.38			0.19	0.95		0.26	1.38				
Lemon sole	*Microstomus kitt*	7.22			1.75	0.26			0.35	0.35		10.95	0.73		0.55		
Megrim	*Lepidorhombus whiffiagonis*																0.92
Grey gurnards	*Eutrigla gurnardus*	4.42		1.79	4.93	1.50						3.96	0.72				2.25
Tub gurnard	*Chelidonichthys lucernus*																
Argentine	*Argentina sphyraena*	0.05							0.11	1.32			0.72				0.18
Greater argentine	*Argentina silus*					3.42											
Lumpsucker	*Cyclopterus lumpus*		0.33											0.02			
Medusae	*Hydroida*		**1.50**				43.05							0.44			
Invertebrates			0.15		0.13	0.44			2.60	2.35	0.47	0.60	0.22		11.20		2.00
Other bonefish		13.05	0.36		5.80	0.15		1.59	4.85	0.87		5.79	3.25		2.43		1.19
Sharks and rays		3.04			1.46	15.01							0.71				0.22

Table 3. RV "Johan Hjort" 3 July - 2 August 2010. Ctd.

Species	Trawl haul no	BT293	PT294	BT295	BT296	BT297	PT298	PT299	PT300	PT301	BT302	BT303	BT304	PT305	PT306	BT307	BT308
	Serial no	24356	24357	24358	24359	24360	24361	24362	24363	24364	24365	24366	24367	24368	24369	24370	24371
	ICES area	47 F2	47 F2	47 F1	47 F0	47 E9	47 F4	47 F3	47 F2	47 F2	48 F1	48 F2	48 F3	48 F3	48 F2	48 F0	48 E9
	Total catch (kg)	401.38	289.14	75.53	440.43	1003.57	336.58	82.36	12.21	5.92	341.69	303.79	245.91	107.65	0.63	168.04	577.65
Herring	*Clupea harengus*		115.72		14.14	0.20	0.31			0.85	69.60	**163.00**	0.75			0.70	27.23
Mackerel	*Scomber scombrus*	0.34	172.22	0.08	0.73	0.32	**291.33**	**22.17**		**3.00**	**112.41**	43.14	**110.82**	**28.87**			0.45
Horse Mackerel	*Trachurus trachurus*						17.31	4.89			0.45			**20.89**			0.31
Blue whithing	*Micromesistius poutassou*							0.70						2.12			
Saithe	*Pollachius virens*	70.31		1.28	3.72	26.22						24.01	34.91				2.58
Cod	*Gadus morhua*	26.94		15.41	13.91	30.46					9.73	28.64	4.86			4.88	51.01
Haddock	*Melanogrammus aeglefinus*	23.38		**24.03**	6.64	23.62		0.00		1.50	87.88	1.19		0.01		18.09	46.57
Whiting	*Merlangius merlangus*	21.28		3.85	16.60	77.33					3.40	8.30	13.61			1.88	40.48
Ling	*Molva molva*											1.06					
Pollack	*Pollachius pollachius*																
Hake	*Merluccius merluccius*	9.92		12.80	9.48						33.82	3.82	17.81			4.93	2.53
Norway pout	*Trisopterus esmarkii*	**235.34**		6.92	**372.00**	**838.10**			**11.70**			20.46	34.49	0.16		**131.53**	**377.26**
Poor cod	*Trisopterus minutus*				0.01											0.66	2.88
Silvery pout	*Gadiculus argenteus*															0.01	
Dab	*Limanda limanda*			0.35							0.57						0.04
Long rough dab	*Hippoglossoides platessoides*	1.00		2.31	0.63	1.88					0.04	0.31	2.86			0.40	12.04
Lemon sole	*Microstomus kitt*	0.78		1.14							0.38	0.98	0.23			0.30	3.50
Megrim	*Lepidorhombus whiffiagonis*	0.20		0.08	0.67	1.32						3.32				2.11	6.40
Grey gurnards	*Eutrigla gurnardus*	1.38		1.97	0.39						0.73	1.67	24.73		**0.53**	0.07	0.65
Tub gurnard	*Chelidonichthys lucernus*	1.42			0.55						0.41						
Argentine	*Argentina sphyraena*	5.90			0.51												
Greater argentine	*Argentina silus*			1.35		0.88					1.27	0.04	0.40			0.36	0.67
Lumpsucker	*Cyclopterus lumpus*						5.35							1.65			
Medusae	*Hydroida*		1.20				20.00	4.60	0.51	0.58				9.49	0.10		
Invertebrates				0.69	0.18			**50.00**					0.45	**44.35**		0.70	0.11
Other bonefish		3.21		3.31	0.27	3.26		0.00			21.02	3.85		0.11	0.00	1.01	2.97
Sharks and rays							2.29									0.43	

Table 3. RV "Johan Hjort" 3 July - 2 August 2010. Ctd.

Species	Trawl haul no	**BT309**	**BT310**	**BT311**	**BT312**	**PT313**	**PT314**	**PT315**	**BT316**	**BT317**	**BT318**	**PT319**	**PT320**	**BT321**	**PT322**	**BT323**	**PT324**
	Serial no	24372	24373	24374	24375	24376	24377	24378	24379	24380	24381	24382	24383	24384	24385	24386	24387
	ICES area	49 E9	49 F1	49 F2	49 F3	49 F3	49 F3	49 F2	50 F1	50 F2	50 F3	50 F3	50 F2	50 F1	51 F2	51 F2	51 F2
	Total catch (kg)	332.82	200.30	105.31	82.32	97.21	57.81	77.80	333.51	64.85	143.17	177.77	232.39	35.76	7.78	94.33	125.21
Herring	*Clupea harengus*	13.66	0.23	0.05			1.80	13.28		5.57	0.32	0.23	0.29				1.96
Mackerel	*Scomber scombrus*	1.63		0.59	1.21		**48.20**	**57.95**		4.60	0.76	**118.15**	6.68				**95.97**
Horse Mackerel	*Trachurus trachurus*						5.71	0.26				4.10	10.46		**7.78**	1.26	6.20
Blue whithing	*Micromesistius poutassou*											0.09	5.38			12.13	
Saithe	*Pollachius virens*		2.81	3.31	**39.50**			0.09	30.24	**13.85**	26.49			6.30		15.49	
Cod	*Gadus morhua*	35.80	16.90	12.52	12.55				5.43	9.19	3.45			4.80			
Haddock	*Melanogrammus aeglefinus*	77.68	20.23	**46.02**	5.89				5.28	**16.65**	0.02			1.58			
Whiting	*Merlangius merlangus*	39.82	17.81	6.54	0.60				13.51	0.71	0.77			0.73			
Ling	*Molva molva*	3.44							13.08								
Pollack	*Pollachius pollachius*									2.95							
Hake	*Merluccius merluccius*	16.51	1.11	29.43	13.64			2.22	23.46	0.03	10.67			3.41		15.99	
Norway pout	*Trisopterus esmarkii*	**130.31**	**129.01**	0.37					**222.75**	0.002	**90.97**			**17.82**		1.04	
Poor cod	*Trisopterus minutus*	0.16	0.43								0.25			0.15		0.22	
Silvery pout	*Gadiculus argenteus*	0.10							0.40							**37.90**	
Dab	*Limanda limanda*	0.77	0.11	0.39						1.61							
Long rough dab	*Hippoglossoides platessoides*	3.68	4.21	0.14					3.95	1.25	0.47			0.07		0.33	
Lemon sole	*Microstomus kitt*			1.76	0.63					0.17	0.52			0.40			
Megrim	*Lepidorhombus whiffiagonis*	2.18		0.16	0.22				2.61								
Grey gurnards	*Eutrigla gurnardus*	2.82	1.31	1.81	3.66		0.28		1.92	1.11	8.48	0.46				0.17	
Tub gurnard	*Chelidonichthys lucernus*	0.46															
Argentine	*Argentina sphyraena*	2.12			0.33				0.67	1.04							
Greater argentine	*Argentina silus*		0.47	2.25												7.06	
Lumpsucker	*Cyclopterus lumpus*						0.26										0.52
Medusae	*Hydroida*					**29.36**	1.57	4.00				51.00		0.51			
Invertebrates		0.01	0.27	0.01	2.03	0.70			0.27	0.07		3.00	**200.00**				
Other bonefish		1.68	3.52		0.93	67.15			9.96	6.07	0.02	0.75	9.58			0.18	20.56
Sharks and rays		0.02	1.90		1.16											2.59	

Table 3. RV "Johan Hjort" 3 July - 2 August 2010. Ctd.

Species	Trawl haul no	**BT325**	**BT328**	**BT329**	**BT330**	**PT331**	**PT332**	**BT333**	**PT334**	**BT335**	**BT336**	**PT337**	**PT338**	**BT339**	**PT340**	**BT341**	**PT342**	**PT343**
	Serial no	24388	24391	24392	24393	24394	24395	24396	24397	24398	24399	24400	24401	24402	24403	24404	24405	24406
	ICES area	51 F1	51 F1	51 F0	51 F0	51 F0	51 E9	51 E9	51 F0	51 F0	50 F0	50 F0	49 F0	49 F0	50 E9	50 E9	52 F1	52 F4
	Total catch (kg)	436.58	3.28	5.26	30.20	11.24	0.76	319.61	3.16	84.45	94.00	0.46	3.15	305.31	7.10	50.68	4.43	19.40
Herring	*Clupea harengus*					1.10			**1.23**	0.24	0.27	**0.21**		5.00			0.27	0.17
Mackerel	*Scomber scombrus*	0.55				**2.76**		0.24	0.83	1.91	0.19	**0.26**	**3.15**				0.30	0.65
Horse Mackerel	*Trachurus trachurus*							47.99						0.28		0.32		1.37
Blue whithing	*Micromesistius poutassou*	5.95						**119.13**		0.02								
Saithe	*Pollachius virens*	40.62						16.19		9.77	14.25			14.87				
Cod	*Gadus morhua*	10.45			**26.88**			6.03		6.55	9.47			24.61		11.26		
Haddock	*Melanogrammus aeglefinus*	8.46	**3.28**	**5.26**	3.32			1.90		13.98	13.78			52.13		**23.93**		
Whiting	*Merlangius merlangus*	2.91						1.89		0.60				10.64				0.01
Ling	*Molva molva*	40.85						8.50			14.39			7.83				
Pollack	*Pollachius pollachius*																	
Hake	*Merluccius merluccius*	32.14				**2.47**		52.02		10.55	**19.15**			0.29	**6.61**	4.56		
Norway pout	*Trisopterus esmarkii*	**224.40**				1.66		42.75		**30.99**	9.92			**133.84**				
Poor cod	*Trisopterus minutus*	0.92						1.88			0.77			1.06				
Silvery pout	*Gadiculus argenteus*	0.86						0.11										
Dab	*Limanda limanda*										0.06			0.93				
Long rough dab	*Hippoglossoides platessoides*	1.87						0.97		0.09	0.11			1.67				
Lemon sole	*Microstomus kitt*	0.09						0.29			0.39			0.54		0.86		
Megrim	*Lepidorhombus whiffiagonis*	8.28						12.27		4.96	6.37			5.20				
Grey gurnards	*Eutrigla gurnardus*	2.96				0.32	**0.76**	2.37	0.60	1.27	2.42			2.85	0.49	0.31	0.75	
Tub gurnard	*Chelidonichthys lucernus*															0.14		
Argentine	*Argentina sphyraena*									2.22	1.17				0.01			
Greater argentine	*Argentina silus*	3.73						0.62						2.24		2.05		
Lumpsucker	*Cyclopterus lumpus*					**2.95**			0.51									
Medusae	*Hydroida*																0.27	**17.20**
Invertebrates		48.87					0.002	0.09			0.11			33.32	0.00	0.35	**1.29**	
Other bonefish		2.67						2.15						8.02		2.10	**1.56**	
Sharks and rays								2.25		1.34	1.21					4.80		

Table 4. RV "Johan Hjort" 3 July – 2 August 2010. Herring length (cm) distribution in trawl hauls. The numbers define the group of herrings samples used for the areas defined in Figure 3. The herring samples were grouped according to length and age distribution, as well as proportion of WBSS by age.

	1	2					3			4		5	6		7
Trawl station	BT243	BT246	PT250	PT257	BT264	BT266	PT275	PT282	PT283	BT288	PT289	PT294	BT302	BT303	PT315
Ices square	43 F6	43 F4	43 F2	43 F2	44 F3	44 F2	45 F4	45 F4	45 F5	46 F2	46 F3	47 F2	48 F1	48 F2	49 F2
Length (cm)															
16.0	1														
16.5		1													
17.0					1										
17.5															
18.0	1	1			2										
18.5	7	1			2										
19.0	12	3	3		4	2			1						
19.5	7		3		3	13			2						
20.0	5	3	7	3	18	10	1		2	1					
20.5	6	5	12	13	20	13						4			
21.0	3	9	12	15	29	12		1	1	1		1		1	
21.5		2	7	30	8	18	1		2	3		2			
22.0		3	5	7	7	12	4	1		5	1	2			
22.5		3	4	12	4	8	5	1		4	1	2	1		
23.0			2	7	1	3	1	1	2	2	2				
23.5			2	3		6	2		9	19	1	4			
24.0			1	1			3		1	6		1			
24.5			1	4		1	2		16	15	4	1	1		
25.0		1	1	2		1	8	9	8	8	7	9	3		
25.5			2	2	1	1	6	7	5	4	7	4	1	1	
26.0	1	1	3	1			5	2	8	13	8	7	6	1	
26.5							9	2	2	3	7	5	5	2	
27.0			1				4	4	2	6	10	3	3	1	2
27.5			2				8	3	3	3	3	4	11		4
28.0							8	6	3	4	7	11	5	14	1
28.5							8	3		2	7	11	20	14	4
29.0							10	4			7	9	12	17	1
29.5							3	2			9	11	18	21	6
30.0							3	2			4	3	7	13	4
30.5							5	1			2	4	6	5	4
31.0							1	2			3	1	1	6	8
31.5							2			1	6	1		1	6
32.0							2							3	7
32.5											1				2
33.0															4
33.5											1				
34.0											1				1
34.5															1
35.0											1				
Grand total	43	33	68	100	100	100	101	51	67	100	100	100	100	100	55
Mean length	19.5	20.9	21.8	21.9	20.7	21.3	26.9	26.8	24.5	24.7	27.7	26.9	28.3	29.1	30.6
Mean weight	59.7	69.6	84.5	80.4	69.1	78.0	166.5	160.4	126.3	133.0	175.3	169.4	191.5	216.9	238.5

Table 5. RV "Johan Hjort" 3 July – 2 August 2010. Herring mean length, mean weight, numbers (millions) and biomass (thousands of tonnes) by age and maturity stages in the herring stocks in the Norwegian survey area.

			North Sea Autumn Spawners				Western Baltic Spring Spawners			
Age	L_{mean}	W_{mean}	No (mill)	%	Biom (10^3)	%	No (mill)	%	Biom (10^3)	%
1I	20.7	72.6	203.9	18.9	16.5	10.2	208.8	37.6	13.5	18.6
1M	21.8	88.8	5.6	0.5	0.5	0.3	3.3	0.6	0.2	0.3
2I	23.3	99.8	86.6	8.0	8.7	5.4	7.6	1.4	0.7	1.0
2M	25.2	136.5	218.7	20.3	29.9	18.4	14.1	2.5	1.9	2.7
3I	25.5	138.6	-	-	-	-	29.6	5.3	4.1	5.7
3M	27.0	162.1	272.6	25.3	45.2	27.9	79.7	14.3	11.9	16.4
4I	26.6	157.8	-	-	-	-	13.4	2.4	2.1	2.9
4M	27.7	171.1	59.0	5.5	10.8	6.7	73.4	13.2	11.8	16.4
5I	-	-	-	-	-	-	-	-	-	-
5M	29.2	202.3	59.4	5.5	12.8	7.9	50.8	9.2	9.5	13.1
6I	-	-	-	-	-	-	-	-	-	-
6M	29.2	209.4	18.5	1.7	3.9	2.4	18.3	3.3	3.8	5.2
7I	-	-	-	-	-	-	-	-	-	-
7M	30.0	221.3	17.1	1.6	3.8	2.4	25.0	4.5	5.5	7.6
8I	-	-	-	-	-	-	-	-	-	-
8M	29.8	219.3	85.4	7.9	18.6	11.5	20.7	3.7	4.6	6.4
9+	29.7	230.6	49.4	4.6	11.2	6.9	10.6	1.9	2.7	3.7
Total	25.5	143.6	1076.1	100.0	162.0	100.0	555.4	100.0	72.3	100.0
Immature	21.6	82.9	290.5	27.0	25.2	15.5	259.4	46.7	20.4	28.2
Mature	27.5	174.5	785.6	73.0	136.8	84.5	296.0	53.3	51.9	71.8

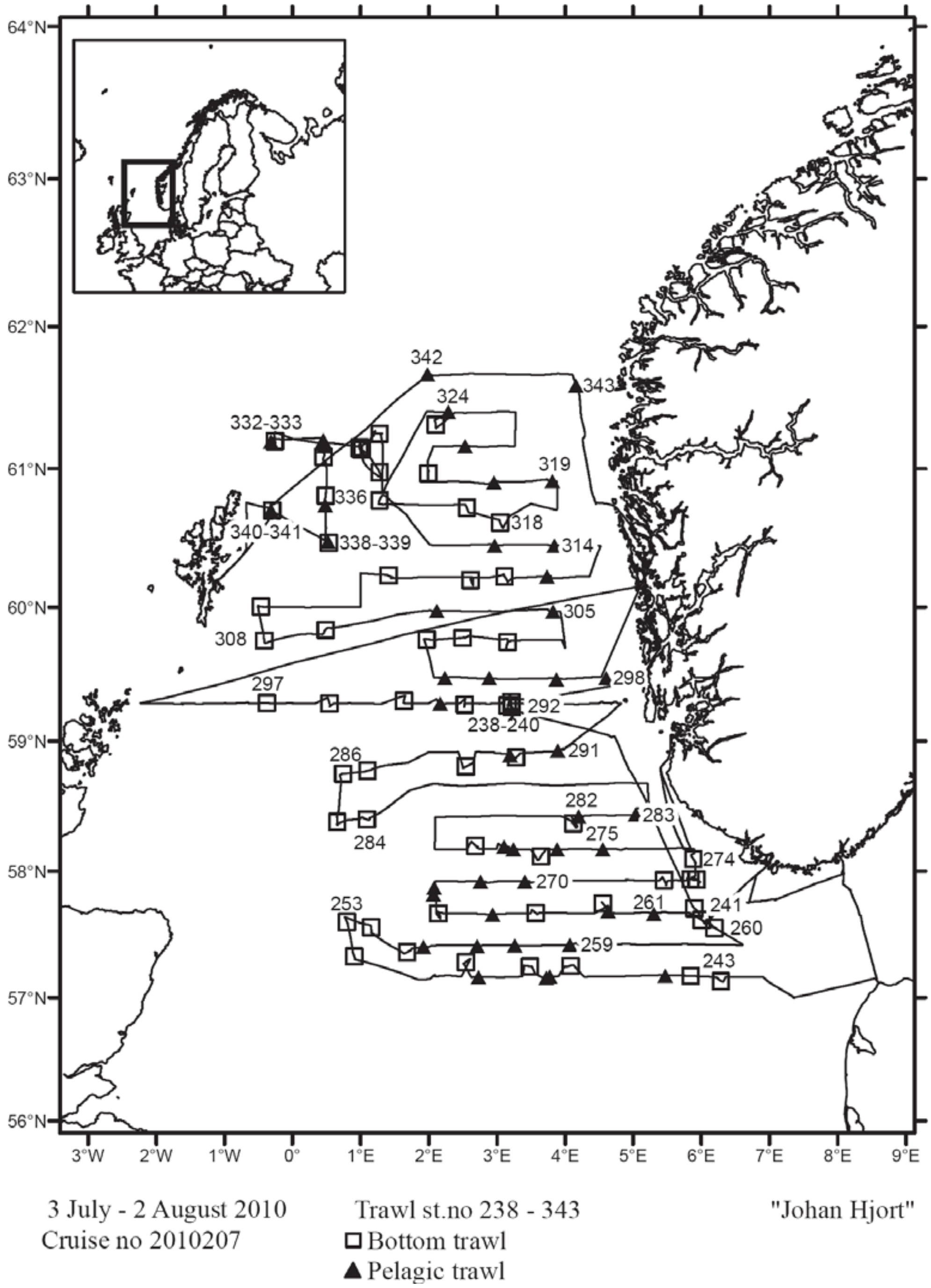


Figure 1. RV "Johan Hjort" 3 July – 2 August 2010. Cruise track and fishing trawl hauls. CTD stations were taken at least at each trawl haul.

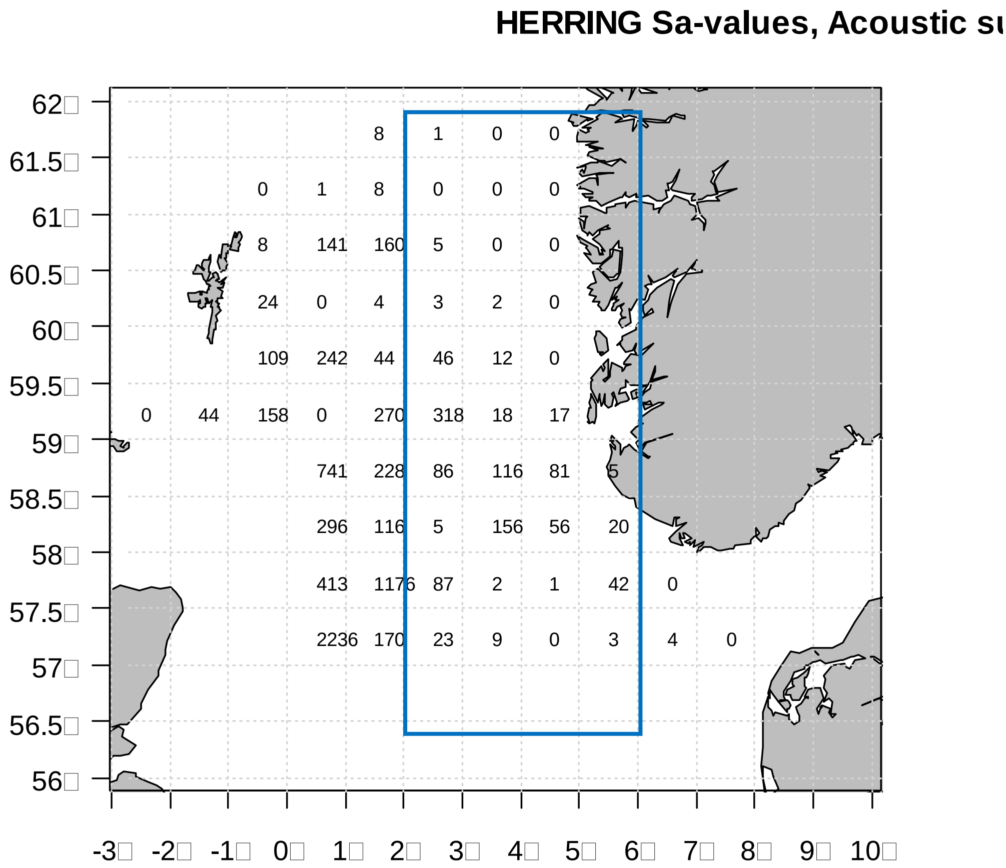


Figure 2. RV "Johan Hjort" 3 July – 2 August 2010. Mean values per ICES square of sA (NASC) values attributed to herring per 1 n.mi. along the cruise track. The "Norwegian herring area" is marked. The rest of the survey area was covered for other tasks, like e.g. the IBTS Q3 survey.

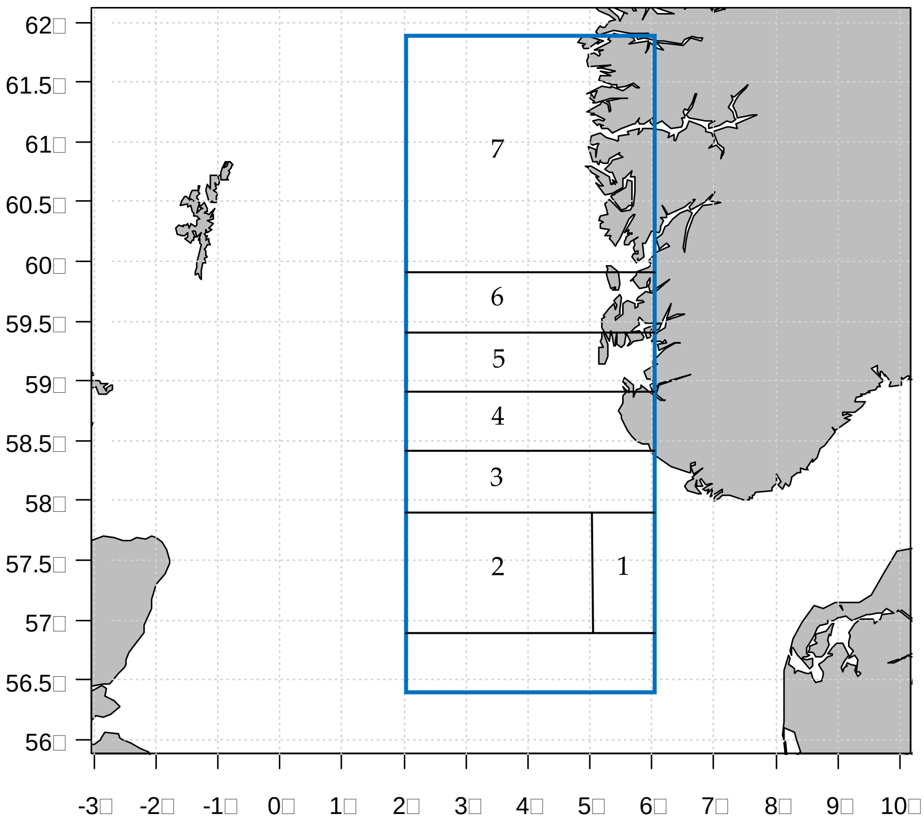


Figure 3. RV "Johan Hjort" 3 July – 2 August 2010. Map showing the areas where the herring sample groups in Table 4 were used. The southernmost part of the "Norwegian herring area" was not covered.

ANNEX 5D: Scotland (East)

Survey report for RV Scotia

28 June – 18 July 2010

P. J. Copland, FRS Marine Lab Aberdeen.

1. INTRODUCTION

Background

An acoustic survey for herring was carried out by FRS Marine Laboratory around the Orkney Shetland peninsula in the northern North Sea (ICES Div IV) from the 28 June to 18 July 2010 on the FRV *Scotia*. The main objective of the survey was to provide an abundance estimate for herring in this area and to map the distribution of this species.

The survey was carried out as a part of the ICES coordinated herring acoustic survey of the North Sea and adjacent waters. The data from this survey were combined with other surveys in the North Sea to provide an age disaggregated abundance index for use in the assessment process. The assessment will be carried out by the ICES Herring Assessment Working Group (HAWG) to be held in March 2011. This survey is part of a continuous series carried out by the Marine Laboratory annually since 1984.

Objectives

1) To conduct an acoustic survey to estimate the abundance and distribution of herring in the north western North Sea and north of Scotland between 58º 30'N - 62°N and 4ºW to 2ºE, excluding Faroese waters.
2) To obtain biological samples for echosounder trace identification using a pelagic trawl.
3) To obtain samples of herring for biological analysis, including age, length, weight, sex, maturity, ichthyophonus infection and fat content.
4) To obtain hydrographic data for comparison with the horizontal and vertical distribution of herring.
5) To obtain plankton samples to map the distribution and abundance of zooplankton.
6) To obtain information on seabed habitats using grab sampling and drop frame TV.
7) Obtain biological samples and digital images for the herring maturity workshop being held in Copenhagen during 2011

2. SURVEY DESCRIPTION AND METHODS

2.1 Personnel

Phil Copland	(In Charge)
Jim Hunter	Oceanographic Technician
Mike Robertson	Benthic Biologist
Stephen Keltz	Fisheries Biologist
Owen Goudie	Fisheries Biologist
Fiona McIntyre	Fisheries Biologist

John Dunn	Oceanographic Technician (Part 1)
Bruce McIver	Analyst Developer (Part 1)
Karen Webb (JNCC)	Benthic Biologist (Part 1)
Darius Kaminski	Analyst Developer (Part 2)
Chris Watt	Data Modeller (Part 2)
Laura Cornick (JNCC)	Benthic Biologist (Part 2)

2.1.1 Narrative

All gear was loaded in Aberdeen between 24 and 27 June. Scotia did not depart until 1800 on 28 June after a delay to allow for the repair of the vessels air conditioning system. A short meeting was held with all scientists to explain the objectives of the survey, to describe general operating procedures and discuss risk assessments for tasks. A deployment of the PT160 pelagic trawl with multicodend sampler was conducted en route to Scapa Flow to familiarise staff with the handling of the equipment.

Calibration of the hull mounted transducers took place in Scapa Flow between 0630 and 1400 on 29 June. Scotia then made her way to east of the Pentland Firth to the first survey transect beginning the survey at 1545. Transects extended as far east as 2° 00E, and as far as safely possible to the west, on approaching the coast. Fish traces were abundant in the area and fishing operations were carried out very successfully up to the half landing with 15 out of the 18 hauls conducted catching significant quantities of herring. There was also some Norway Pout in some catches in the Southern transects. The loss of a complete top panel of the net on the 30th did not restrict fishing operations but precluded the use of the multisampler until repairs could be effected to the extension panel that attaches it to the net body. After close inspection, concerns as to the strength of the remaining nets meant that the sampler was not deployed for the remainder of the cruise. A second incident where part of the bottom panel was damaged occurred on the 3 July. The Scotia crew repaired the damage to the second net using parts salvaged from the first.

From 1600 on the 4 July a strong southerly gale reduced the survey speed to 8 knots and restricted fishing operations until the morning of the 5 July. Where weather conditions and depth allowed, the period 2300 – 0300 each day was used for grab sampling and TV drop frame deployments to establish sediment type and fauna.

A 24 hour half landing took place on 7 – 8 July in Lerwick in accordance with the rest provision for the Working Time Directive and to allow for the exchange of personnel; (John Dunn, Bruce McIver and Karen Webb left and Chris Watt, Dariusz Kaminski and Laura Cornick joined the vessel). Spare netting material and a Day grab were also delivered from Aberdeen. Due to a major hydraulic leak Scotia was delayed in sailing until 1730 on the 8th and resumed surveying South East of Sumburgh at 2030.

Surveying continued around the North and down the West side of the area but few fish marks were seen. It was noted that the fish became much more difficult to catch and often the marks would either be very mobile or flatten themselves to the bottom making capture very difficult. A drifter buoy was deployed on 14 July at 60 50N, 02 29W.

Gale force winds on the 15th and 16th reduced survey speed and precluded fishing activities. Some survey time was lost dodging the worst of the weather on the 15th.

The survey was completed on 17 July at 0915. A second calibration was carried out in Scapa Flow on 17 July. The strong winds made the calibration difficult and the data will not be used for the survey. Scotia returned to Aberdeen docking at 0800 on the morning of 18 July.

2.2 Survey design

The survey track (Figure IID.1) was selected to cover the area with three levels of sampling intensity based on agreed boundaries to the East, West and South, and the limits of herring densities found in previous years to the North and Northwest. A transect spacing of 15 nautical miles was used in most parts of the area. On the basis of the stock distribution observed in previous surveys, additional short transects were carried out at 7.5 n.mi. spacing in the extreme South East corner of the survey area . On the administrative boundaries of 2°E the ends of the tracks were positioned at twice the track spacing from the area boundary, giving equal track length in any rectangle within the area: the between-track data were then included in the data analysis. Transects at the shelf break were continued to the limits of the 300 m contour and the transect ends omitted from the analysis. Transects at the coast were continued as close inshore as practical, those which were on average less than half a transect spacing from the coast were excluded from the analysis, those at a greater distance were included in the analysis. The origin of the survey grid was selected randomly within a sampling interval, the track was then laid out with systematic spacing from the random origin. Where a 7.5nm transect spacing was used the same random origin was used (as a proportion of the inter-transect space).

2.3 Calibration

Two calibrations were carried out of the EK60 echosounder system used during the survey: one at the beginning of the survey on 29 June and one at the end of the survey on 17 July, both in Scapa Flow. Standard sphere calibrations were carried out using 38.1mm diameter tungsten carbide sphere for 18, 38, 120 and 200 kHz. Unfortunately the second calibration was carried out in strong wind and tidal conditions. Vessel stability was very poor even with a stern anchor deployed and the results have not been included. The calibration settings and results for 38 kHz as used in the survey are given in Table IID.1.

2.4 Acoustic data collection

The acoustic survey on FRV *Scotia* was carried out using a Simrad EK60 multifrequency echosounder with all four transducers (18, 38, 120 and 200 kHz) mounted on the drop keel. For most of the survey the keel was kept at 3m extension, placing the transducer at 8.5 m depth. Data was archived for further data analysis which was carried out using Sonardata Echoview software and Marine Lab Analysis (MILAP) systems during and after the cruise. Data were collected from 0200 to 2200 GMT. A total of 910 EDSU and approximately 2000 n.mi. of acoustic survey track were included in the analysis.

2.5 Biological data - fishing trawls

A total of 28 trawl hauls (positions shown in Figure IID.1) were carried out during the survey on the denser echotraces. 19 hauls generated catches of more than 30 herring. The fishing gear used throughout the survey was the PT160 pelagic trawl augmented at the start of the survey by the addition of a three codend version of the same trawl. Each haul was monitored using a Simrad FS903 scanning netsonde. The catch from each haul was sampled, and a length frequency obtained. Additional biological information was collected for fish which were otolithed within each sample, whole weight, gutted weight, liver weight, gonad weight, sex, maturity stage, stomach contents and macroscopic evidence of icthyophonus infection. Otoliths were collected according to three length strata, two per 0.5 cm class below 22 cm, five per 0.5 cm class from 22.5 - 27.5 cm and ten per 0.5 cm class for 28.0 cm and above. The maturity scale used in data collection was the Scottish 8 point scale.

2.6 Hydrographic data

Surface temperature and salinity were collected throughout the survey using the ships thermosalinograph. At each trawl station, salinity and temperature were taken with a Seabird 19plus Conductivity, Temperature, Depth (CTD) recorder, mounted in an OCEAN sampler. 150 individual depth stratified plankton samples, as filtered by a 200 micron net, were also collected. A total of 30 deployments of the OCEAN sampler vehicle were made to provide one set of samples in each statistical rectangle that was surveyed.

2.6.1 Habitat Sampling

Habitat mapping and sediment sampling was carried out on 21 stations with 21 camera tows and 56 valid grab deployments. 427 digital stills photographs were recorded during the camera tows.

2.7 Data analysis

Data from the echo integrator were averaged over quarter hour **E**quivalent **D**istance **S**ampling **U**nits (EDSU of approximately 2.5 n.mi. at 10 knots). Echo integrator data were collected from 12 m below the surface (transducer at 8.5 m depth) to 0.5 m above the seabed, for most of the survey. The multifrequency thresholding method described in earlier reports was used to isolate echotraces of fish schools (with swimbladders) from other targets. These fish schools were then detected using the Shapes algorithm contained in Echoview and finally identified according to the four categories defined below by trawling and examination of school shape, echo intensity and the dB difference at 18, 38, 120 and 200 kHz:

1) Definitely herring traces,
2) Probably herring traces
3) Possible herring traces
4) Surface Herring

“Definitely herring” echotraces were identified on the basis of captures of herring from the fishing trawls which had sampled the echotraces directly, and/or as echotraces which had the typical characteristics of "definite" herring traces (very high intensity, narrow, inverted tear-shaped echotraces, either directly on the bottom or in midwater, with a dB difference profile typical of fish with swimbladders).

“Probably herring” were attributed to medium sized or small echotraces which had the physical and acoustic characteristics of "definite" herring traces, but had not been directly fished on.

“Possibly herring” were attributed to echotraces which had some characteristics of herring schools but were not typical due either to the location or depth, and/or because they were present in areas where only other fish had been caught and their dB difference profile was atypical of herring schools.

"Surface Herring" were attributed to echotraces encountered near the surface which had the dB difference profile of "definite" herring traces. These could not be fished on due to the limitations of the fishing gear.

"Possibly Herring" are not included in the analysis.

To calculate integrator conversion factors the target strengths for herring was estimated using the TS/length relationship recommended by the acoustic survey planning group (Anon, 1992):

$$\text{Herring TS} = 20\log_{10}L - 71.2 \text{ dB per individual}$$

The weight of herring at length was determined by weighing individual fish from each trawl haul. Lengths were recorded by 0.5 cm intervals to the nearest 0.5 cm below.

Data were allocated to quarter statistical rectangles by their midpoint location. An analysis was carried out in the national calculation programme (MILAP) at quarter rectangle resolution. Estimates of density were obtained as the arithmetic mean of all values weighted by the distance covered in the EDSU to accommodate the shorter EDSUs. Biological information was used in the post-stratified method based on a Kolmogorov Smirnov test (see MacLennan and Simmonds 2005 pg 341).

3. RESULTS

3.1 Acoustic data

The distribution of NASC values along the cruise track is shown in Figure IID.2. The distribution of fish differed little from 2009, with most herring schools being detected in the South East of the survey area. Few traces were detected at the Northern extremes of the survey area. Apart from isolated traces west of the Scalloway Deeps and North and West of Orkney little was detected West of Shetland. There were very also few inshore traces to the East of Shetland which had been a feature in previous years. Some herring schools were of the typical tall pillar shape, but many were observed as smaller schools very close to the seabed. Only 1 individual NASC value was significantly larger than last year's maximum, 30,000 compared to 10,000 $m^2.nmi^2$. However, there were many more values in the 5,000 to 10,000 $m^2.nmi^{-2}$.range.

3.2 Biological data

Fishing was generally successful and 28 trawl hauls were carried out (Figure IID.1). 5 hauls contained less than 30 herring and 4 contained none. The positions, dates and time of all hauls are given in Table IID.2. 6395 herring were measured for length frequency data, and a total of 1705 herring were further sampled for weight, sex, maturity and otoliths. Almost 17.5 tonnes of fish were caught during the survey of which more than 17 tonnes was herring. (Note that only the sampled catch was weighed. The total catch was estimated). The 19 hauls with significant numbers of herring were used to define four survey subareas according to the output from the Kolmogorov Smirnov test. Some of these areas are more fragmented geographically than has been the case in the past. (Figure IID.3). An additional analysis was carried out using only 2 survey subareas as shown in Figure IID.3a. Data from this analysis is included in Table 11D.4., and a comparison of results is shown in table IID.7:

4 area analysis

I/ SOU	Area in South East bounded by 1° - 2° W and 58° 30′- 58°45′ N. Mean length 24.83cm
II/MID	Central area encompassing East of Orkney to 59° 30′N and the extreme South East of the survey area. Mean length 25.74cm
III/RST	Central area to West of Orkney and Shetland to 60° 30′N. Mean length 28.11cm
IV/NRT	Northern area to North of Fair Isle. Mean length 29.93cm

2 area analysis

I/ SOU	Area in South East bounded by 1° - 2° W and 58° 30′- 58°45′ N. Mean length 24.83cm
II/REM	Remainder of survey area excluding I/ SOU. Mean length 27.86cm

Table IID.3 shows the total catch by species. The length frequency distributions, mean lengths, weights and target strengths for each haul and for each subarea are shown in Table IID.4. The spatial distribution of mean length is shown in Figure IID.3. Four age length keys, one per area, were constructed. The stratified weight at length data were used to define a single weight-length relationship for herring for the survey area, which was:

$$W = 0.0018\ L^{3.4799}$$

where:

W = weight (g)

L = length (cm to greater 0.5 cm)

The proportions of 2, 3 and 4 ring herring that were mature were estimated at 30.9, 90.4 and 100% respectively.

Biomass and Abundance estimates

The total biomass estimates for the survey were:

Total herring	2,919,823 tonnes	
Spawning stock biomass	2,603,757 tonnes	89.2%
Immature	316,066 tonnes	10.8%

The numbers and biomass of fish by quarter ICES statistical rectangle are shown in Figures IID.4 (a and b). A total estimate of 13,997 million herring or 2.919 million tonnes was calculated for the survey area. 2.60 million tonnes of these were mature. Table IID.6 shows the estimated herring numbers, mean lengths, weights, biomass, and proportion mature at age and year class.

In addition to herring, a variety of other fish species were caught, although examination of the catch by species (Table IID.3) shows that, aside from herring, the numbers caught were very small. The dominant species other than herring were Norway pout.

3.3 Ichthyophonus Infection

Only one of the 1705 fish examined for macroscopic evidence of ichthyophonus was found to be infected.

Multisampler codend.

The multisampler was not deployed after the 30th June when the top panel of the net was completely destroyed during a haul. The haul had no significant catch of fish and it was thought that the netting might have parted due to either the netsonde hanging up or a weakness in the netting. It was fortunate that the multisampler itself was not lost as damage extended to the extension piece of the sampler. Close examination of the remaining nets showed that many of the panels were in poor condition due to the age of the material and it was decided not to risk deploying the sampler. It is proposed that there will be a rolling replacement all of the PT160 trawls over the next two years.

Table IID.1. Simrad EK60 and analysis settings and calibration results from the Scotia herring acoustic survey 28 June - 18 July 2010.

Transceiver Parameters	
Frequency	38 kHz
Sound speed	1493 $m.s^{-1}$
Max. Power	2000 W
Equivalent two-way beam angle	-20.9 dB
Default Transducer Sv gain	23.99 dB
3 dB Beamwidth	7.1°
Calibration details	
	29 June 2010
TS of sphere	-42.40 dB
Range to sphere in calibration	11.79 m
Measured NASC value for calibration	2284
Calibrated Sv gain	23.38
Calibration constant for MILAP (optional)	1.1005 at -35 dB
EDSU	
Echoview integration cell size	15 minutes (approx 2.5 n.mi. at 10 knots)
Operation	
Ping interval	1 s at 250 m range
	2.5 at 500 m range
Analysis settings	
Bottom margin (backstep)	0.5 m
Integration start (absolute) depth	12 m
Range of thresholds used	-70 dB on 38 -170 on combined blurred 38,120,200

Table IID.2. Details of the fishing trawls taken during the Scotia herring acoustic survey, 28 June - 18 July 2010: No. = trawl number; Trawl depth = depth (m) of headrope; Gear type PT160 = pelagic trawl + MS = multisampler; Duration of trawl (minutes); Use H =used to qualify herring acoustic data (blank if not); Total catch in kg. (Estimated on deck if not sampled)

Haul No.	Date	Time (utc)	Position Mid Point	Water depth	Trawl Depth	Gear	Duration	Use	Weight
202	29/06/2010	2011	58°36.51 N, 2°1.82W	90	80	PT 160 + MS	38		2.7
203	30/06/2010	0634	58°31.81 N, 1°1W	116	102	PT 160	31	H	750
204	30/06/2010	1119	58°33.22 N, 0°14.08W	130	110	PT 160	23	H	24.2
205	30/06/2010	1815	58°33.69 N, 0°49.59E	146	110	PT 160	34	H	1800
206	01/07/2010	0437	58°40.89 N, 0°15.01W	127	124	PT 160	36	H	1800
207	01/07/2010	1202	58°48.37 N, 0°1.51E	142	110	PT 160	22		8.3
208	01/07/2010	1415	58°48.74 N, 0°15.89E	120	116	PT 160	35	H	300
209	02/07/2010	0623	58°36.29 N, 1°27.6E	118	88	PT 160	41	H	1050
210	02/07/2010	1101	58°55.88 N, 0°43.34E	131	110	PT 160	23	H	2400
211	03/07/2010	0723	59°6.68 N, 1°41W	98	71	PT 160	16	H	3600
212	03/07/2010	1400	59°3.31 N, 0°29.09W	140	116	PT 160	51		0
213	03/07/2010	1729	59°3.15 N, 0°17.17W	138	111	PT 160	26	H	300
214	03/07/2010	2051	59°3.44 N, 0°21.3E	120–135	109	PT 160	27	H	180
215	04/07/2010	0537	59°3.23 N, 0°47.62E	136	106	PT 160	13	H	1050
216	04/07/2010	1208	59°11.6 N, 0°20.19W	136	119	PT 160	43	H	1800
217	05/07/2010	1830	59°25.82 N, 0°2.41E	135	115	PT 160	37	H	1200
218	06/07/2010	0520	59°21.36 N, 1°12.14W	110	95	PT 160	52	H	40
219	06/07/2010	1549	59°36.53 N, 1°36.61W	92	68	PT 160	40		0
220	09/07/2010	0428	59°36.64 N, 0°2.6E	130	106	PT 160	37	H	240
221	09/07/2010	1844	59°51.57 N, 0°12.84E	147	115	PT 160	22	H	360
222	10/07/2010	0623	60°6.53 N, 0°52.83W	113	90	PT 160	38		0
223	10/07/2010	1016	60°6.58 N, 0°6.56W	138	104	PT 160	49		1.3
224	11/07/2010	0414	60°21.78 N, 0°20.37E	141	118	PT 160	33	H	107
225	12/07/2010	1749	61°6.46 N, 0°8.33W	146	110	PT 160	60		1.3
226	13/07/2010	1258	61°21.44 N, 0°19.78W	180	157	PT 160	33		11.5
227	14/07/2010	1220	60°36.66 N, 1°56.6W	105–124	100	PT 160	52		0.7
228	15/07/2010	1547	60°6.26 N, 2°17.45W	98	80	PT 160	45	H	450
229	16/07/2010	0825	59°51.4 N, 3°31.95W	127	113	PT 160	23	H	17.6

Table IID.3. Total catch by species for trawl hauls from the Scotia acoustic survey 28 June - 18 July 2010. Estimated total catch is given in kg and numbers by individual species.

Haul No	Est catch (Kgs)	Herring	Sprat	Mackerel	Horse Mackerel	Saithe	Blue Whiting	Haddock	Whiting	Grey gurnard	Hake	N.Pout
		Clupea harengus	Sprattus Sprattus	Scomber scombrus	Trachurus trachurus	Pollachius virens	M. Poutassou	Melanogrammus aeglefinus	Merlangius merlangus	Eutrigla gurnardus	Merluccius merluccius	Trisopterus esmarki
202	2.7	0	106	0	0	0	0	2	0	0	0	0
203	750	5768	0	0	0	0	0	0	0	0	0	0
204	24.0	138	0	4	0	0	0	0	0	0	0	0
205	1800	7032	0	0	0	0	0	0	0	0	0	1904
206	1800	9420	0	0	0	0	0	0	0	0	0	0
207	8.3	10	0	3	0	0	0	0	1	0	0	176
208	300	1569	0	9	0	0	0	0	0	0	0	0
209	1050	6028	0	0	0	0	0	0	11	0	0	1019
210	2400	12833	0	0	0	0	0	0	0	0	0	2084
211	3600	25076	0	0	0	0	0	0	0	0	0	0
212	0	0	0	0	0	0	0	0	0	0	0	0
213	300	30	0	1	0	0	0	0	1	0	0	10350
214	180	896	0	0	0	0	0	0	0	0	0	0
215	1050	6820	0	0	0	0	0	0	0	0	0	0
216	1800	9281	0	0	0	0	0	0	0	0	0	0
217	1200	5748	0	0	0	0	0	0	0	0	0	0
218	40	220	0	0	0	0	0	0	0	2	0	0
219	0	0	0	0	0	0	0	0	0	0	0	0
220	240	964	0	0	0	0	0	8	0	0	0	0
221	360	1572	0	0	0	0	0	0	0	0	0	0
222	0	0	0	0	0	0	0	0	0	0	0	0
223	1.3	5	0	0	0	0	0	0	1	0	0	0
224	107	432	0	0	0	0	0	0	0	0	0	0
225	1.3	0	0	0	0	0	0	0	0	2	1	0
226	11.5	11	0	20	0	0	0	0	0	0	0	0
227	0.7	3	0	0	0	0	0	0	0	0	0	0
228	450	2303	0	0	0	0	0	0	0	0	0	0
229	17.6	67	0	11	0	0	0	0	0	0	0	0
Totals	17495	96226	106	48	0	0	0	10	14	4	1	15533

Table IID.4. Herring length frequency percentage for individual trawl hauls by subarea (Figure IID.3) for the *Scotia* acoustic survey (28 June - 18 July 2010) length in cm and weight in g.

Region	I/SOU			II/MID			
	%			%			
Length (cm)	203	204	209	211	215	218	Mean
19.0							
19.5							
20.0		0.72					0.00
20.5	0.87		1.14				0.18
21.0	7.00		1.90				0.30
21.5	11.60		1.90	0.23			0.45
22.0	11.37		1.90	1.17	1.60		1.35
22.5	8.10		0.57	3.04	1.37		2.32
23.0	6.35		2.66	5.62	2.28		4.51
23.5	3.94	2.90	2.47	11.94	8.68	0.45	9.77
24.0	6.12	1.45	4.94	13.11	12.79	1.36	11.66
24.5	3.07	5.07	7.79	10.77	9.82	4.55	10.08
25.0	4.16	10.87	11.41	12.41	11.42	10.00	12.06
25.5	3.94	15.22	10.08	11.24	12.10	18.64	11.27
26.0	3.73	11.59	7.79	11.71	7.08	16.36	10.29
26.5	6.57	10.87	8.56	6.56	7.08	15.00	7.03
27.0	5.25	10.87	10.08	3.75	4.34	9.09	4.91
27.5	5.03	10.14	9.51	3.75	9.13	11.82	5.68
28.0	4.16	10.87	9.13	3.51	4.34	8.18	4.60
28.5	3.73	5.07	4.75	0.47	4.34	2.27	1.55
29.0	3.28	1.45	2.09	0.70	1.83	1.82	0.98
29.5	0.87	0.72	0.95		0.91		0.77
30.0	0.23	0.72	0.19		0.46	0.45	0.11
30.5	0.43	0.72	0.19		0.46		0.11
31.0	0.23						
31.5		0.72					0.00
32.0							
32.5							
33.0							
33.5							
Number	**457**	**138**	**526**	**427**	**438**	**220**	
mean length	**24.83**	**25.92**	**25.34**	**24.49**	**25.06**	**25.84**	**25.74**
mean weight	**134.51**	**167.83**	**167.34**	**143.56**	**153.97**	**164.41**	**148.15**

Table IID.4 continued. Herring length frequency percentage for individual trawl hauls by subarea (Figure IID.3) for the *Scotia* acoustic survey (28 June - 18 July 2010) length in cm and weight in g.

REGION				III/RST					
	206	208	210	213	214	216	217	228	MEAN
LENGTH (CM)									
19.0									
19.5						0.31			0.07
20.0									
20.5		0.21							0.01
21.0				6.67					0.00
21.5				16.67					0.01
22.0		0.41	0.87	33.33					0.29
22.5		0.21	0.58	10.00	0.23	0.31			0.28
23.0		1.03	5.80	3.33	0.45	0.31			1.89
23.5	0.31	0.62	4.06		1.58		0.23		1.39
24.0	1.23	4.95	4.64		2.48	1.23			2.20
24.5	0.92	5.77	8.70	6.67	4.74	0.92	0.46	1.29	3.52
25.0	4.60	7.63	6.09	6.67	8.13	1.23	1.62	4.52	4.09
25.5	6.44	8.87	6.09		5.87	3.38	6.26	9.03	5.85
26.0	7.98	7.22	4.06	3.33	9.03	6.46	7.42	15.81	6.79
26.5	11.04	7.84	6.67		7.00	12.31	11.37	14.19	9.99
27.0	14.72	10.93	5.80		6.55	15.38	7.66	16.13	10.93
27.5	18.10	9.90	9.28	3.33	11.51	17.23	11.60	11.94	13.53
28.0	12.88	10.31	12.75	3.33	14.45	18.77	16.71	7.74	14.31
28.5	12.58	7.42	8.70		11.96	13.23	12.06	8.06	11.01
29.0	5.21	7.01	8.99	6.67	7.22	5.23	12.53	5.16	7.47
29.5	3.07	4.33	2.61		5.42	1.85	5.57	3.23	3.10
30.0	0.31	4.12	2.90		0.90	1.85	3.94	2.26	2.20
30.5	0.31	0.62	0.58		1.58		1.39	0.65	0.53
31.0	0.31	0.41	0.58		0.23		0.70		0.36
31.5		0.21	0.29		0.23		0.23		0.12
32.0					0.45		0.23		0.05
32.5									
33.0									
33.5									
34.0									
Number	**326**	**485**	**345**	**30**	**443**	**325**	**431**	**310**	
mean length	**27.24**	**26.89**	**26.61**	**23.28**	**27.13**	**27.37**	**27.74**	**27.05**	**28.11**
mean weight	**191.10**	**191.20**	**184.64**	**121.67**	**201.04**	**193.97**	**208.72**	**195.42**	**200.53**

Table IID.4 continued. Herring length frequency percentage for individual trawl hauls by subarea (Figure IID.3) for the *Scotia* acoustic survey (28 June - 18 July 2010) length in cm and weight in g. Details of the 2 area analysis are included.

REGION			IV NRT				2 AREA ANALYSIS	I/ SOU	II/ REM
	205	220	221	224	229	MEAN		203	
Length (cm)									
19.0									
19.5									
20.0									0.06
20.5								0.87	0.06
21.0								7.00	0.12
21.5								11.60	0.49
22.0								11.37	1.19
22.5								8.10	0.90
23.0								6.35	2.51
23.5								3.94	2.08
24.0								6.12	2.25
24.5	0.28				1.49	0.19		3.07	2.93
25.0		0.40			4.48	0.01		4.16	4.84
25.5	0.28		0.80	0.23	2.99	0.27		3.94	6.29
26.0	0.83	0.40	1.34	0.69	2.99	0.75		3.73	5.88
26.5	0.83	1.60	8.02	0.46	1.49	0.86		6.57	6.41
27.0	1.93	8.80	4.28	6.71	2.99	3.05		5.25	7.13
27.5	3.87	7.60	11.50	9.03	5.97	4.62		5.03	8.36
28.0	5.25	14.40	17.91	9.95	13.43	6.66		4.16	9.40
28.5	8.01	16.80	17.38	12.96	13.43	10.42		3.73	10.01
29.0	11.05	20.00	13.64	14.12	19.40	12.73		3.28	8.58
29.5	22.93	13.60	9.36	15.05	13.43	20.84		0.87	8.46
30.0	15.47	8.00	7.22	9.72	4.48	14.08		0.23	4.97
30.5	13.26	3.60	3.74	9.03	7.46	11.58		0.43	3.31
31.0	10.50	2.40	2.41	5.32	4.48	8.54		0.23	1.99
31.5	3.59	2.00	1.34	4.63		3.35			1.14
32.0	1.38	0.40	0.53	0.69	1.49	1.39			0.34
32.5	0.55		0.27	0.69		0.55			0.25
33.0			0.27	0.46		0.06			0.04
33.5						0.04			0.01
34.0				0.23		0.01			0.01
Number	**362**	**250**	**374**	**432**	**67**				
mean length	**29.07**	**28.73**	**28.50**	**28.63**	**28.53**	**29.93**		**24.83**	**27.86**
mean weight	**250.22**	**236.88**	**228.96**	**248.03**	**230.45**	**247.58**		**134.51**	**196.72**

Table IID.5 FRV Scotia 28 June - 18 July 2010. Numbers of herring otolithed at length and at age, for all hauls. Lengths in cm measured to the nearest 0.5 cm below, ages in winter rings (wr).

	AGE CLASS											
LENGTH	1I	2I	2M	3I	3M	4M	5M	6M	7M	8M	9+	GRAND TOTAL
20	2											2
20.5	4											4
21	3	2										5
21.5	5	2										7
22	8	2										10
22.5	15	13										28
23	5	22		1								28
23.5		37	1	1								39
24	1	34	2	1	1							39
24.5		49	2	1	2							54
25		32	13	12	4							61
25.5		31	18	14	8	1						72
26		19	21	4	31	1	1					77
26.5		5	18	9	44	6						82
27			6	1	61	13		4				85
27.5			9		53	14	5	6	1		3	91
28			5	1	62	27	11	24	11	7	27	175
28.5			7		32	34	11	26	16	15	24	165
29				1	16	41	14	33	13	9	30	157
29.5					7	46	19	17	12	18	20	139
30					5	31	19	23	8	20	16	122
30.5					1	12	17	9	10	18	31	98
31						3	13	9	4	15	23	67
31.5							7	6	1	5	29	48
32								2	3	6	10	21
32.5						1		2	1	2	11	17
33								1		1	4	6
33.5								1				1
34							1				2	3
34.5								1				1
36.5											1	1
Grand Total	**43**	**248**	**102**	**46**	**327**	**230**	**118**	**164**	**80**	**116**	**231**	**1705**

Table IID.6. Mean length, mean weight, biomass (thousands of tonnes) and numbers (millions) breakdown by age (winter rings) and maturity obtained during the Scotia 28 June - 18 July 2010 herring acoustic survey. I= immature; M=mature; A=All. (2009 results for comparison)

Year	Age	Mean Length (cm)	Mean Weight (gm)	Numbers (10^6)	Biomass (Kt)
2008	1A	22.30	96.12	134	12.9
2007	2I	24.45	131.44	1930	253.6
2007	2M	26.27	168.01	863	145.1
2006	3I	25.58	152.77	324	49.5
2006	3M	27.38	193.17	3059	591.0
2005	4	28.90	232.41	2195	510.2
2004	5	29.50	249.19	1115	277.9
2003	6	29.01	235.44	1250	294.3
2002	7	29.13	238.52	640	152.6
2001	8	29.74	256.02	965	247.1
2000	9+	29.64	253.54	1521	385.7
2009	6339	1513	Total	13997	2919.8
	6143	1484	**SSB**	**11609**	**2603.8**
	195	29	**Immature**	**2388**	**316.1**

Table IID.7. Comparison of analysis using 2 sub survey and 4 sub survey areas in MILAP. As shown in Figure IID.3a.

		4 Area Analysis	2 Area Analysis	
Year	Age	Numbers (10^6)	Numbers (10^6)	% Difference (2 Area / 4 Area)
2008	1A	134	308	229
2007	2I	1930	3852	200
2007	2M	863	1384	160
2006	3I	324	589	182
2006	3M	3059	3560	116
2005	4M	2195	1658	76
2004	5	1115	667	60
2003	6	1250	924	74
2002	7	640	486	76
2001	8	965	595	62
2000	9+	1521	1069	70
	Total	13997	15092	108
	SSB	11609	10343	89
	Immature	2388	4749	199

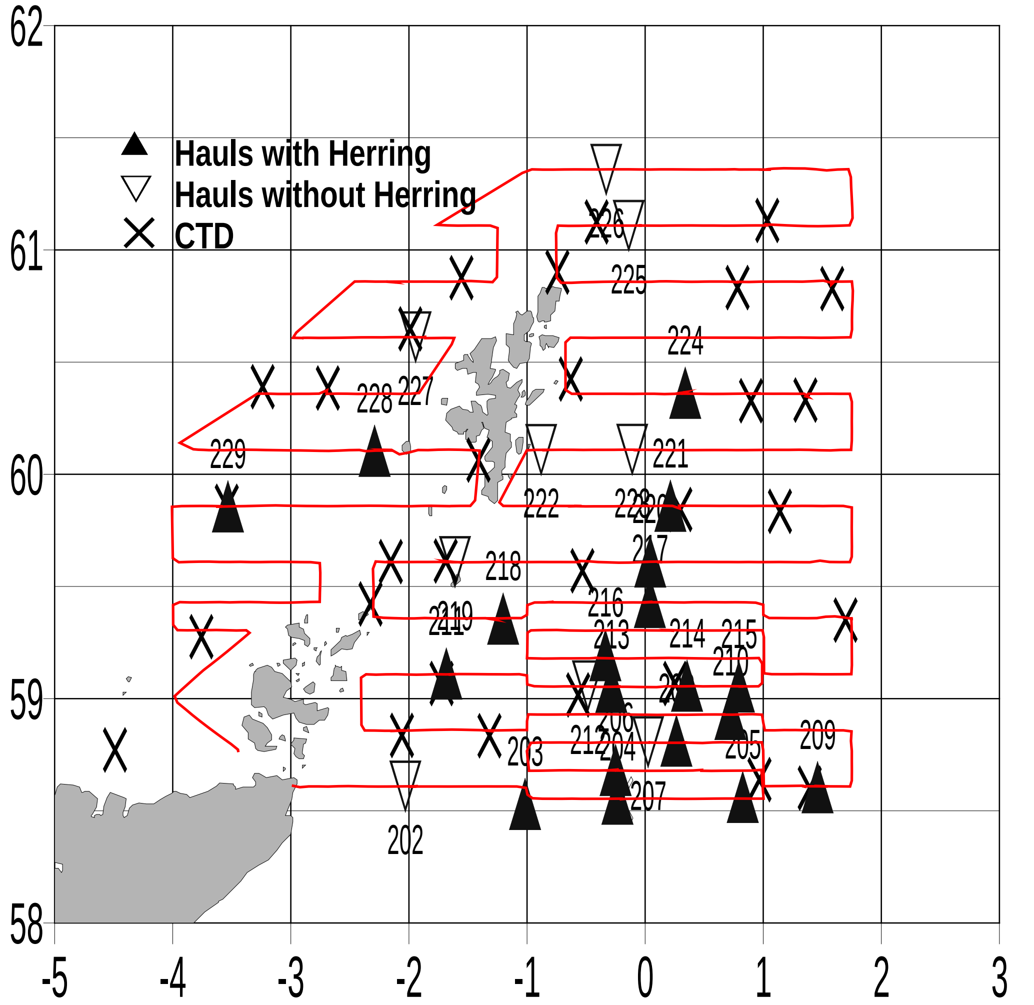


Figure IID.1. Map of the North Sea showing the cruise track (solid line) of FRV Scotia for the acoustic survey 28 June - 18 July 2010 indicating the location of trawl and CTD stations (symbols defined in legend).

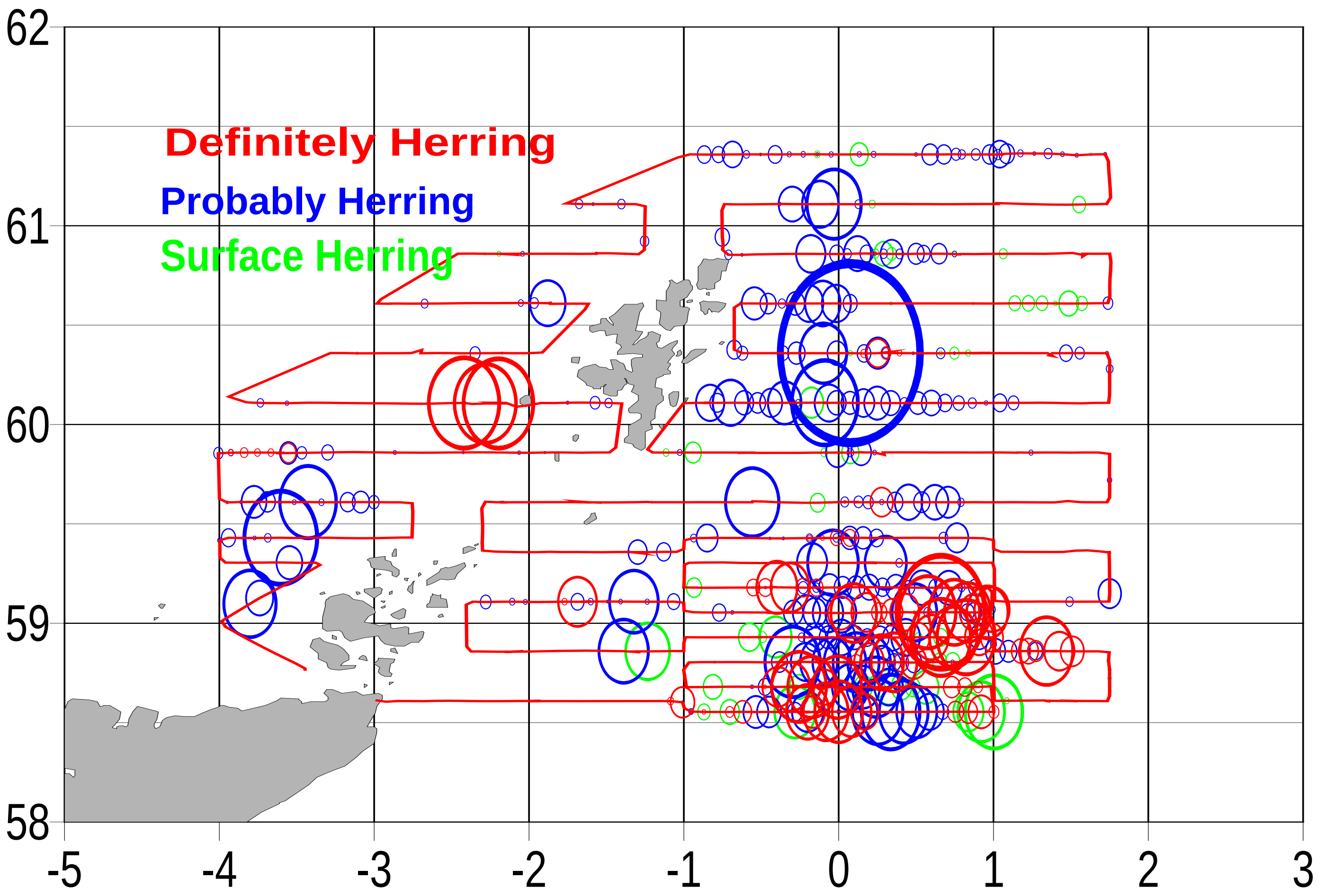


Figure IID.2. Map of the North Sea showing the distribution of NASC values attributed to herring from the herring acoustic survey on FRV SCOTIA for 28 June – 16 July 2009. Circle area scaled to NASC values at 15,000 per 0.5 inch dia. (Max value 30,000).

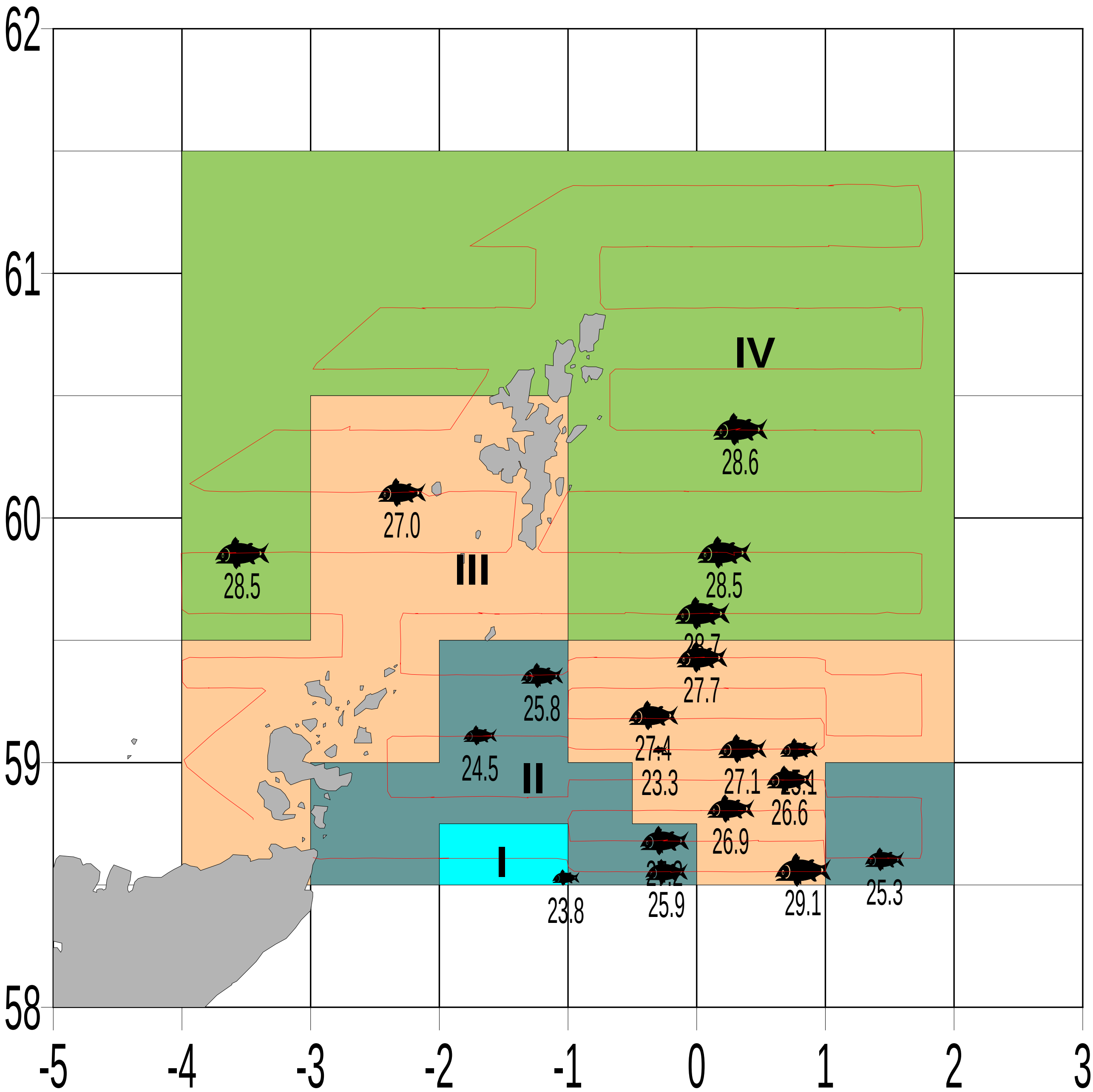


Figure IID.3. Map of the North Sea showing the mean length of all herring caught from pelagic trawls on FRV SCOTIA for 29 June - 18 July 2010. Trawl station numbers are given in Figure IID.1 and details in Tables IID.1 and IID.2. The four analysis areas are shaded and numbered with roman numerals (I-IV) and the length distributions, mean lengths and weights are given by area in Table IID.4.

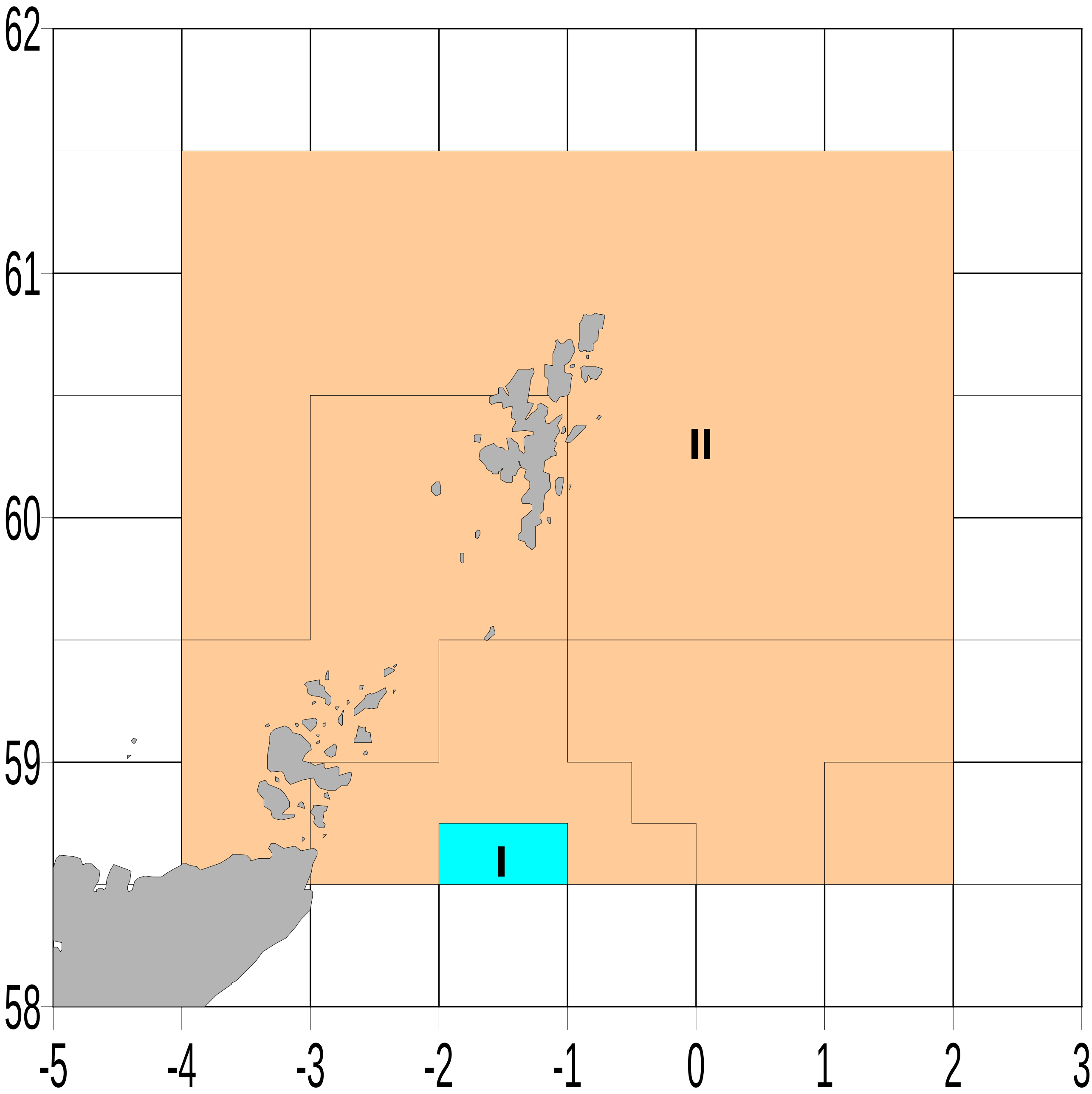


Figure IID.3a. Map of the North Sea showing reduced number of analysis areas. The two analysis areas are shaded and numbered with roman numerals (I-II) and the length distributions, mean lengths and weights are given by area in Table IID.4.

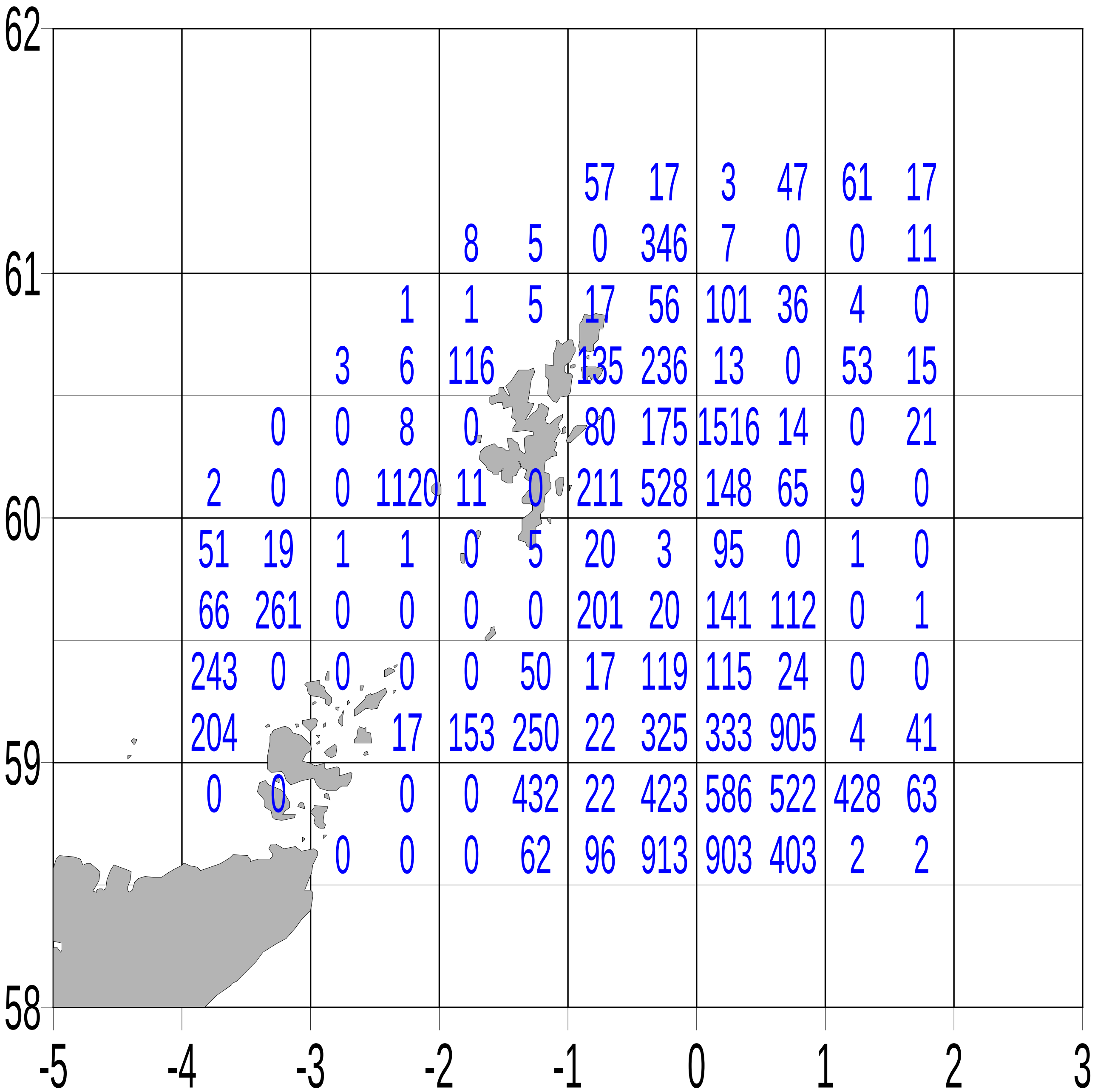


Figure IID.4a. Map of the North Sea showing the estimated numbers, in millions, by quarter statistical rectangle from the herring acoustic survey on FRV SCOTIA for 28 June – 18 July 2010 using 4 survey subareas.

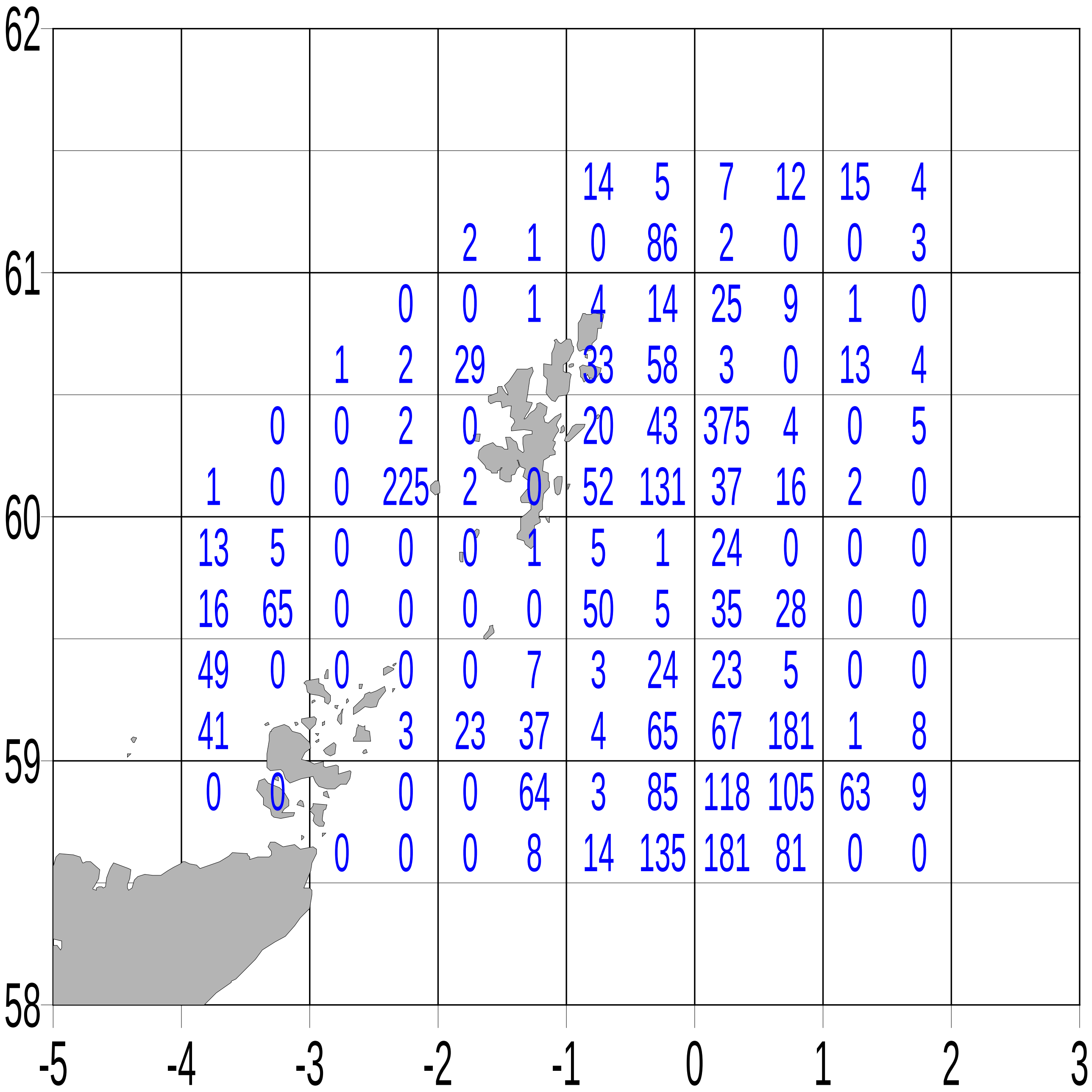


Figure IID.4b. Map of the North Sea showing the estimated biomass, in thousands of tonnes, by quarter statistical rectangle from the herring acoustic survey on FRV SCOTIA for 28 June - 18July 2010 using 4 survey subareas.

ANNEX 5E: The Netherlands

North Sea hydro acoustic herring survey report for RV "TRIDENS"

28 June - 23 July 2010

Authors: S.M.M. Fässler and A.S. Couperus

1. Introduction

The Dutch Institute for Marine Resources & Ecosystem Studies (IMARES) has been participating in the international North Sea hydro acoustic survey for herring since 1991. Participants in this survey are Scotland, Norway, Germany, Denmark, The Netherlands and Ireland. The survey is part of the EU data collection framework and is coordinated by the Working Group for International Pelagic Surveys (WGIPS, formerly PGIPS/PGHERS). The aim of this survey is to provide an abundance estimate of the whole North Sea herring population. This estimate is used as a tuning index by the ICES Herring Assessment Working Group (HAWG) in its assessment of the population size. In this report the results are presented of the survey in the central North Sea, carried out by the Dutch vessel RV "Tridens".

Cruise plan

The survey was split into two periods of 2 weeks. The executed cruise track and hydrographical positions are presented in Figures 1a and 1b. The actual surveyed transects may differ from the planned transects.

2. Methods

2.1 Scientific Staff

Imares staff	Wk 26	Wk 27	Wk 28	Wk 29
Bram Couperus (cruise leader 1st half)	x	x		
Sascha Fässler (cruise leader 2nd half)	x	x	x	x
Kees Bakker (technician)	x	x		
Hendrik-Jan Westerink (fish lab)	x	x		
Martijn de Jongh (ICT)	x	x		
Dirk Burggraaf (technician)			x	x
Silja Tribuhl (acoustics, fish lab)			x	x
Marcel de Vries (fish lab)			x	x
Daniel van Denderen (student)	x	x		

2.2 Narrative

After departure on Monday 28 June from the port of Scheveningen, Tridens steamed north in the direction of Scapa Flow. On 29 June at 56°25N-0°35E a test haul was carried out. Due to the extremely good weather conditions, it was decided to try to calibrate at sea. The calibration was carried out close to the starting point of the survey (58°23N-2°44W) in the afternoon of 29 June and the morning of 30 June. The actual survey started 8:51 UTC on the 30th of June 2010. During the remaining days up till the weekend stop in Peterhead, 6 hauls were carried out. A lot of small schools at the surface were seen in the area. Unfortunately, on two occasions the crew claimed that it was not possible to fish on the recordings due to technical problems (once because of a not working netsonde and once because the vessel had only on engine available). Hence important information on school composition was lost. The survey was interrupted at 57°50N – 1°40W at 11:05 UTC for the stop at Peterhead. Departure from Peterhead was delayed by one hour in the morning of 5 July on instruction of the harbour authorities. The survey continued according to the planned transects till Thursday 8 July at 56°50N – 1°50E. Arrival in Scheveningen the next morning at 6:00 UTC.

Departure from Scheveningen on Monday 12 July was delayed by 6 hours due to technical problems concerning navigation lights of the ship. After these problems were solved, Tridens steamed up northwest to the start point of transect line 6 (56°20N-2°27W). The survey was started the following day, Tuesday 13 July at 16:20 UTC. During week 28 no hauls were carried out as major fish aggregations were absent on the echosounder records. The weather situation turned to the worse towards the end of the week and gale force winds (8 or even 9) were experienced. While there were fish seen at that time, no trawls could be done due to the bad weather conditions. Also, 2 CTD stations had to be abandoned for bad weather reasons. On Friday morning 16 July at 7:42 UTC, it was noted that the network connection to the acoustic room was lost. An investigation identified the cable socket in the network hub in the ships computer room to be faulty - most probably caused by increased movement during bad weather. To solve the problem, the cable was rewired to a connector and provisionally connected to the acoustic room. The fault caused that the echosounder data had no GPS position signal for over 4 hours. The lost position data were interpolated during data analysis. Additionally, a security steal cable going to the towed body was found to be cut apart due to increased grinding on the towed body itself during heavy winds. The survey was stopped on Friday 16 July at 15:45 UTC, after the end of transect 7 (55°05N-1°33W) was reached and Tridens steamed to Newcastle-upon-Tyne for the week end break.

Departure from Newcastle was on Monday morning, 19 July at 6:00 UTC. The survey continued on the same day at 9:50 UTC at the start of an additional transect (55º35N-1º18W), which was added at latitude 55°35N between 1°18W and 1°50E. This was done in an attempt to collect biological/hydrographic information in rectangles where no trawling/CTD could be performed due to the bad weather in the previous week. As enough time was available, this did not affect the original coverage. The remaining transects were covered as planned until Thursday 22 July at 54°20N-0°8.8W. ETA in Scheveningen was on Friday 23 July at 5:00 UTC.

2.3 Survey design

The actual survey was carried out from 30 June to 22 July 2009, covering an area east of Scotland from latitude 54°20 to 58°20 North and from longitude 3° West (off the Scottish/English coast) to 6° East between 55°30 and 56°30. Following the survey design since 2005, an adapted survey design was applied, partly based on the herring distribution from previous years. As a result, parallel transects along latitudinal lines were used with spacing between the lines set at 15 or 30, depending on the expected distributions. Acoustic data from transects running north–south close to the shore (that is parallel to the depth isolines) were excluded from the dataset. The actual cruise track, trawl - and hydrographical station positions is presented in Figure 1.

2.4 Calibration of acoustic equipment

The calibration of the main (31010) and spare (30501) 38 kHz transducers mounted in the towed body was executed at sea in very calm conditions in the Morray Firth. Conditions allowed for an optimal and good calibration. Also, calibration of the 200 kHz transducer gave no problems, resulting in a RMS of 0.24. This was unusual, since calibration of the 200 kHz transducer in previous years usually gave worse results.

2.5 Acoustic data collection

Data collection

A Simrad 38 kHz split-beam transducer was operated in a towed body (type “Shark”) 6–7 m under the water surface. The settings of the EK60 are listed in Table 1. Acoustic data were collected with a Simrad EK60 scientific echosounder and logged with Sonardata Echoview software in 1 nautical mile intervals. The EK60 received the vessel speed from the ship’s GPS. An average survey speed of 10.0 knots was used.

All echoes were recorded with a threshold of -80dB up to a depth of 150 meters below the transducer. A ping rate of 0.6 sec was used during the entire survey. This ping rate has proven most suitable at the depths of 50 - 150 m observed in most of the area covered.

NOTE: As in previous years, there were substantial sinusoid noise bands on the 200 kHz data caused by vessel noise. These noise bands mask recordings at 200 kHz up to depths of about 50 m and present significant problems for multi-frequency data analysis. At present, the noise bands are so severe, that the 200 kHz data CANNOT be used! A solution to this problem would be the use of an acoustic drop keel (currently unavailable on “Tridens”).

2.6 Biological data collection

Fishing

The acoustic recordings were verified by fishing with a 2000 mesh pelagic trawl with 20 mm meshes in the codend. Fishing was carried out to identify species-composition of major recordings observed on the echosounder and to obtain biological samples of herring and sprat. In general, after it was decided to make a tow with a pelagic trawl, the vessel turned and fished back on its track line. If the recordings showed schools, a Simrad SD570 60kHz sonar was used to be able to track schools that were swimming away from the track line. In all hauls the footrope was very close to the ground with vertical net openings varying from 10 to 20 m (specifications are listed in the PGHERS manual).

A Furuno FS20/25 trawl sonar (vertical and horizontal scan direction) was used to monitor catch performance.

Biological samples

For all fish:

- Total species weight of the catch
- 150 to 250 specimens for individual length measurement. Depending of the catch weight, a subsample technique is used, based on weights.

Stratified samples of 5 fish per length class were taken from the 150–250 herring and sprat. The following parameters are sampled from these fish:

- Age of herring and sprat, by means of otolith reading
- Gender
- Maturity stage

2.7 Hydrographical data

Hydrographical data were collected at 48 stations, all at fixed locations (Figure 1b). A Seabird CTD device, type SBE 9plus in combination with a corresponding water sampler 9plus in combination with a corresponding Seabird SBE 32C carousel water sampler was used in this survey. It had been successfully calibrated in advance by the manufacturer. Conductivity, temperature and depth were measured.

2.8 Data handling, analysis and presentation

Data analysis

The echograms were scrutinized with Sonar data Echoview software.

For each ICES rectangle, species composition and length distribution were determined as the un-weighted mean of all trawl results for this rectangle. From these distributions the mean acoustic backscattering cross-section "sigma" (σ_{bs}) was calculated according to the target strength-length relationships (TS) recommended by the ICES Planning Group for Herring Surveys.

The qualitative breakdown of sprat and herring marks in "definitely", "probably" and "possibly" serves merely as a relative indication of certainty within the subjective process of integral partitioning ("scrutinising"). For the analysis "definitely–" and "possibly herring/sprat" integrator counts were summed to obtain a "best herring/sprat" estimate.

Then the numbers of herring and sprat per ICES rectangle were calculated by dividing the NASC within each rectangle by the overall σ_{bs} in the corresponding rectangle.

The biological samples used for stock structure and biomass calculations were grouped in 2 strata for herring and 1 stratum for sprat, based on similar length frequency distribution in the area (Figure 2). The numbers per year/maturity class were calculated, based on the age/length key for each stratum. For each separate stratum the mean weight per year/maturity class was then calculated.

3. Results

3.1 Acoustic data results

Largest herring concentrations were found in the north-eastern part of the Dutch survey area (Figure 3a). Sprat was found in the western Moray Firth and in the southern part of the survey area (rectangle with highest concentration: 37F1; Figure 3b). There were considerable aggregations of Norway pout observed in the north-east part of the survey area (Figure 3c). Marks observed in rectangle 45F1, which has been dominated by herring in previous years, were found to consist exclusively of Norway pout.

3.2 Trawl data results

In all, 15 trawl hauls were conducted. Herring was found in 10 hauls of which 6 samples of more than 20 herring were taken. Sprat was found in 4 hauls. The trawl list is presented in Table 2a, the catch weights per haul and species are presented in Table 2b and the length frequency proportions are presented in Table 2c. Norway pout was observed in trawls again after they appeared in 2009 for the first time since about 10 years. The biological samples contained a total of 467 herring and 157 sprat that were collected and used for length, age and maturity keys**.**

3.3 Stock estimates

The stock biomass estimate of herring found in the "Tridens" survey area:

Immature	98.6 thousand tonnes
Spawning stock	270.3 thousand tonnes

The stock biomass estimate of sprat found in the Tridens survey area:

Immature	1.9 thousand tonnes
Spawning stock	77.1 thousand tonnes

Figure 4 shows the estimated numbers and biomass of herring by ICES rectangle in the area surveyed by RV "Tridens". Table 3 summarizes stock estimates per stratum and Tables 4 and 5 summarize the sub stock estimates for herring and sprat.

Table 1. Simrad EK60 calibration settings used on the June 2010 North Sea hydro acoustic survey for herring, RV "Tridens".

```
#  Calibration  Version   2.1.0.12
#
#  Date:  29-6-2010
#
#  Comments:
#    Moray Firth 290610 38kHz 2nd
#
#  Reference Target:
#    TS                  -33.60 dB       Min. Distance         10.70 m
#    TS Deviation           5.0 dB       Max. Distance         14.80 m
#
#  Transducer:  ES38B  Serial No.   31010
#    Frequency            38000 Hz       Beamtype               Split
#    Gain                 24.15 dB       Two Way Beam Angle   -20.5 dB
#    Athw. Angle Sens.       21.90       Along. Angle Sens.      21.90
#    Athw. Beam Angle     7.15 deg       Along. Beam Angle    6.99 deg
#    Athw. Offset Angle   0.02 deg       Along. Offset Angle -0.10 deg
#    SaCorrection         -0.63 dB       Depth                 0.00  m
#
#  Transceiver:  GPT  38 kHz 009072017a3b 1-1 ES38B
#    Pulse Duration       1.024 ms       Sample Interval     0.192   m
#    Power                 2000  W       Receiver Bandwidth   2.43 kHz
#
#  Sounder Type:
#    EK60 Version  2.2.0
#
#  TS Detection:
#    Min. Value           -50.0 dB       Min. Spacing           100 %
#    Max. Beam Comp.        6.0 dB       Min. Echolength         80 %
#    Max. Phase Dev.           8.0       Max. Echolength        180 %
#
#  Environment:
#    Absorption Coeff.   9.5 dB/km       Sound Velocity     1498.7 m/s
#
#  Beam Model results:
#    Transducer Gain    = 24.70 dB       SaCorrection       = -0.63 dB
#    Athw. Beam Angle   = 6.91 deg       Along. Beam Angle  = 6.87 deg
#    Athw. Offset Angle = 0.03 deg       Along. Offset Angle=-0.05 deg
#
#  Data deviation from beam model:
#    RMS =    0.17 dB
#    Max =    0.50 dB  No. =   155  Athw. =  2.6 deg  Along =  3.1 deg
#    Min =   -0.68 dB  No. =    60  Athw. = -3.0 deg  Along =  3.1 deg
#
#  Data deviation from polynomial model:
#    RMS =    0.14 dB
#    Max =    0.42 dB  No. =   121  Athw. = -0.4 deg  Along =  4.7 deg
#    Min =   -0.63 dB  No. =    60  Athw. = -3.0 deg  Along =  3.1 deg
```

Table 2a. Details of the trawl hauls taken. "Tridens", North Sea acoustic survey 2010.

haul	day	month	year	hour	minute	haul duration	lat	lon	depth	geardepth	wind direction	wind force	gear
1	30	6	2010	14	40	63	58.23	-1	94	15	359	1	pelagic trawl
2	30	6	2010	20	10	20	58.23	-0.09	128.9	na	359	4	pelagic trawl
3	1	7	2010	9	10	29	58.23	1.15	140	na	90	9	pelagic trawl
4	1	7	2010	12	14	33	58.23	1.38	96	na	90	9	pelagic trawl
5	2	7	2010	18	55	62	58.08	-2.48	36.5	na	90	2	pelagic trawl
6	3	7	2010	6	30	17	57.53	-2.49	82	na	90	2	pelagic trawl
7	5	7	2010	11	31	25	57.49	-0.49	97.5	10	158	2	pelagic trawl
8	5	7	2010	15	13	74	57.49	-0.08	93	na	158	2	pelagic trawl
9	5	7	2010	7	56	74	57.19	1.4	86	na	135	3	pelagic trawl
10	6	7	2010	15	39	83	57.19	0.35	84	10	203	4	pelagic trawl
11	19	7	2010	11	25	12	55.35	-1.04	104.9	103	113	1	pelagic trawl
12	19	7	2010	16	49	88	55.35	0.13	5	50	225	1	pelagic trawl
13	20	7	2010	14	40	128	55.2	-0.06	72.5	6	113		pelagic trawl
14	21	7	2010	7	56	81	54.49	0.15	79.59	52	270	1	pelagic trawl
15	21	7	2010	18	52	76	54.2	1.46	49.7	93	135	1	pelagic trawl

Table 2b. Trawl catches. "Tridens", North Sea acoustic survey 2010 in kg.

haul no	herring	N. pout	other gadoids	mackerel	sprat	others
1				35.4		
2	1875.078	106.742	2.1	12.8		
3	24.19	99.91	23.541	0.46		
4	0.1	1296.498	3.801	8.701		2.4
5				1.4		
6			4.8		386.755	
7	6037.199	1.7	3.4	3.1		0.7
8	34.8	817.804	36	10.32		3.1
9	4033.5		0.7	40		5
10	727.936	184.242	4.3	1654.564		39.738
11			0.37	11.9	573.847	
12		20.7	0.58	10.1		
13	0.184			29.6		
14	1		46.22	496.1	6.6	60.048
15	0.036			0.21	1441.8	64.852

Table 2c. Length frequency proportions of herring by haul. "Tridens", North Sea acoustic survey 2010.

length/haul-no proportion %	2	3	7	8	9	10
16	0	0	0	0	0	0
16.5	0	0	0	0	0	0
17	0	0.78125	0	0	0	0
17.5	0	0	0	0	0	0
18	0	0	0	0	0	0
18.5	0	0	0.970874	1.37931	0	0
19	0	0.78125	0.970874	1.37931	0	0
19.5	0	0.78125	1.941748	0	0.409836	0
20	0	0	4.854369	3.448276	2.459016	1.265823
20.5	0	0	15.53398	2.758621	2.868852	0
21	0.526316	0	15.53398	9.655172	2.459016	3.797468
21.5	0	0.78125	21.84466	17.93103	2.04918	4.43038
22	0.526316	0	10.19417	9.655172	4.098361	7.594937
22.5	0	0	8.252427	4.827586	5.737705	6.329114
23	0	0	2.427184	1.37931	5.327869	6.329114
23.5	3.684211	0	2.912621	4.137931	5.327869	5.696203
24	4.736842	0	2.912621	1.37931	6.967213	8.227848
24.5	6.842105	0	2.427184	4.137931	11.06557	13.29114
25	12.10526	2.34375	2.912621	2.068966	14.34426	6.962025
25.5	15.78947	2.34375	3.398058	10.34483	9.836066	8.860759
26	10	3.90625	1.456311	3.448276	10.2459	4.43038
26.5	7.894737	6.25	0.485437	5.517241	3.688525	3.164557
27	10	6.25	0.970874	4.137931	5.327869	5.063291
27.5	12.63158	10.9375	0	2.758621	4.098361	5.063291
28	4.736842	11.71875	0	3.448276	0.819672	2.531646
28.5	3.684211	10.9375	0	2.758621	1.639344	3.164557
29	5.263158	16.40625	0	1.37931	1.229508	0.632911
29.5	1.052632	11.71875	0	1.37931	0	1.898734
30	0	7.03125	0	0.689655	0	0.632911
30.5	0	1.5625	0	0	0	0.632911
31	0	3.125	0	0	0	0
31.5	0	1.5625	0	0	0	0
32	0	0.78125	0	0	0	0
32.5	0	0	0	0	0	0
33	0	0	0	0	0	0
33.5	0.526316	0	0	0	0	0
34	0	0	0	0	0	0
34.5	0	0	0	0	0	0
35	0	0	0	0	0	0
no in sample	190	128	206	145	244	158

Table 3. Age/maturity-length keys for herring –Stratum A - D. "Tridens", North Sea acoustic survey 2010.

			Stratum A				
Age	Year	Mean Length (cm)	Mean weight (g)	Number (millions)	%	Biomass (1000 tons)	%
0I	2009im			0	0.0	0.000	0.0
0M	2009ad			0	0.0	0.000	0.0
1I	2008im	21.6	82.7	229	11.5	18.926	6.4
1M	2008ad	22.5	94.0	7	0.3	0.628	0.2
2I	2007im	24.1	110.1	193	9.7	21.227	7.2
2M	2007ad	25.3	139.5	690	34.6	96.266	32.4
3I	2006im	26.4	145.3	69	3.5	10.063	3.4
3M	2006ad	26.8	159.0	388	19.5	61.641	20.8
4I	2005im	29.0	165.0	10	0.5	1.612	0.5
4M	2005ad	28.7	212.0	164	8.2	34.710	11.7
5I	2004im	28.5	182.5	21	1.0	3.810	1.3
5M	2004ad	30.4	240.4	35	1.8	8.407	2.8
6M	2003	28.9	196.0	57	2.8	11.090	3.7
7M	2002	30.0	222.8	27	1.4	6.095	2.1
8M	2001	29.4	233.0	59	2.9	13.658	4.6
9M	2000	28.8	197.2	40	2.0	7.934	2.7
10M	1999			0	0.0	0.000	0.0
11M	1998	28.5	175.0	5	0.2	0.806	0.3
12+	<1998			0	0.0	0.000	0.0
Mean		27.2	170.3				
Total				1992	100.0	296.873	100.0
Immature				522	26.2	55.638	18.7
Mature				1470	73.8	241.234	81.3

			Stratum B				
Age	Year	Mean Length (cm)	Mean weight (g)	Number (millions)	%	Biomass (1000 tons)	%
0I	2009im			0	0.0	0.000	0.0
0M	2009ad			0	0.0	0.000	0.0
1I	2008im	21.1	79.4	403	57.2	32.029	44.4
1M	2008ad	24.9	135.3	10	1.4	1.298	1.8
2I	2007im	22.4	95.3	96	13.7	9.169	12.7
2M	2007ad	25.5	146.2	82	11.7	12.017	16.7
3I	2006im	24.9	125.2	14	2.0	1.798	2.5
3M	2006ad	26.2	146.7	67	9.4	9.758	13.5
4I	2005im			0	0.0	0.000	0.0
4M	2005ad	28.1	188.2	18	2.6	3.404	4.7
5I	2004im			0	0.0	0.000	0.0
5M	2004ad	28.4	161.8	4	0.6	0.655	0.9
6M	2003	27.9	172.9	6	0.8	0.980	1.4
7M	2002	28.0	205.0	2	0.3	0.498	0.7
8M	2001			0	0.0	0.000	0.0
9M	2000	28.0	186.0	2	0.3	0.452	0.6
10M	1999			0	0.0	0.000	0.0
11M	1998			0	0.0	0.000	0.0
12+	<1998			0	0.0	0.000	0.0
Mean		26.0	149.3				
Total				705	100.0	72.060	100.0
Immature				514	72.9	42.996	59.7
Mature				191	27.1	29.064	40.3

Table 4. Mean length, mean weight, biomass (thousands of tonnes) and numbers (millions) herring breakdown by age and maturity obtained during the July 2010 North Sea hydro acoustic survey, FRV "Tridens".

		Total area (all strata summarized)			
Age	Year	Number (millions)	%	Biomass (1000 tons)	%
0I	2009im	0	0.0	0.000	0.0
0M	2009ad	0	0.0	0.000	0.0
1I	2008im	632	23.4	50.955	13.8
1M	2008ad	16	0.6	1.926	0.5
2I	2007im	289	10.7	30.396	8.2
2M	2007ad	772	28.6	108.284	29.4
3I	2006im	84	3.1	11.861	3.2
3M	2006ad	454	16.8	71.399	19.4
4I	2005im	10	0.4	1.612	0.4
4M	2005ad	182	6.7	38.114	10.3
5I	2004im	21	0.8	3.810	1.0
5M	2004ad	39	1.4	9.062	2.5
6M	2003	62	2.3	12.070	3.3
7M	2002	30	1.1	6.593	1.8
8M	2001	59	2.2	13.658	3.7
9M	2000	43	1.6	8.386	2.3
10M	1999	0	0.0	0.000	0.0
11M	1998	5	0.2	0.806	0.2
12+	<1998	0	0.0	0.000	0.0
Total		2697	100.0	368.932	100.0
Immature		1035	38.4	98.634	26.7
Mature		1662	61.6	270.298	73.3

Table 5. Mean length, mean weight, biomass (thousands of tonnes) and numbers (millions) sprat breakdown by age and maturity obtained during the June-July 2010 North Sea hydro acoustic survey for herring, FRV "Tridens".

		Total area (all strata summarized)			
Age	Year	Number (millions)	%	Biomass (1000 tons)	%
0I	2009im	177	2.9	1.465	1.9
0M	2009ad	1876	31.2	21.084	26.7
1I	2008im	41	0.7	0.450	0.6
1M	2008ad	3312	55.2	46.300	58.6
2I	2007im	0	0.0	0.000	0.0
2M	2007ad	404	6.7	6.812	8.6
3I	2006im	0	0.0	0.000	0.0
3M	2006ad	194	3.2	2.869	3.6
4I	2005im	0	0.0	0.000	0.0
4M	2005ad	0	0.0	0.000	0.0
5I	2004im	0	0.0	0.000	0.0
5M	2004ad	0	0.0	0.000	0.0
6M	2003	0	0.0	0.000	0.0
7M	2002	0	0.0	0.000	0.0
8M	2001	0	0.0	0.000	0.0
9M	2000	0	0.0	0.000	0.0
10M	1999	0	0.0	0.000	0.0
11M	1998	0	0.0	0.000	0.0
12+	<1998	0	0.0	0.000	0.0
Total		6004	100.0	78.980	100.0
Immature		218	3.6	1.915	2.4
Mature		5786	96.4	77.065	97.6

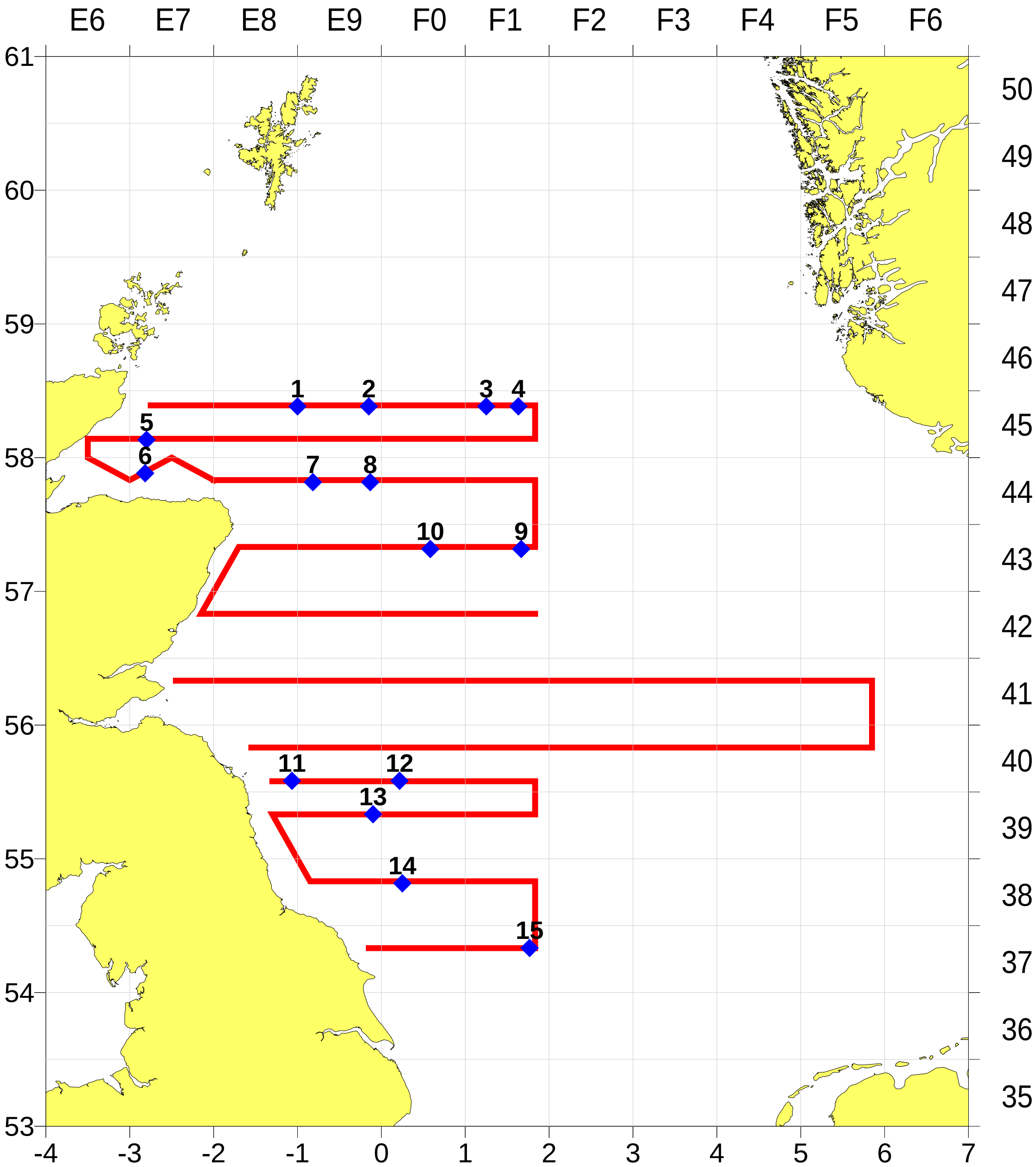


Figure 1a. Map of executed cruise track and positions of trawl stations (blue diamonds with numbers) during the June-July 2010 North Sea herring hydro acoustic survey on RV "Tridens".

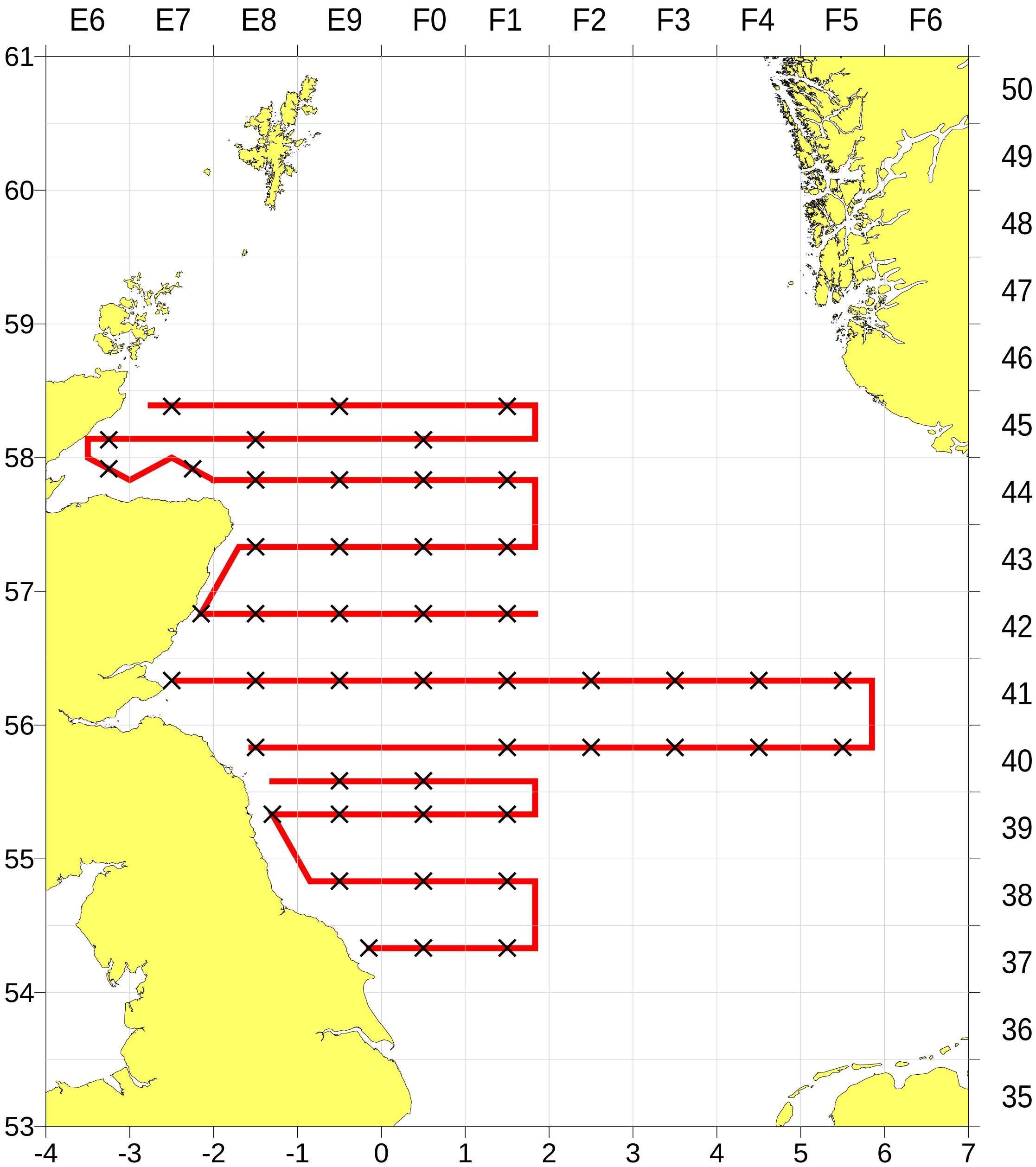


Figure 1b. Map of hydrographical stations (crosses) during the June-July 2010 North Sea herring hydro acoustic survey on RV "Tridens".

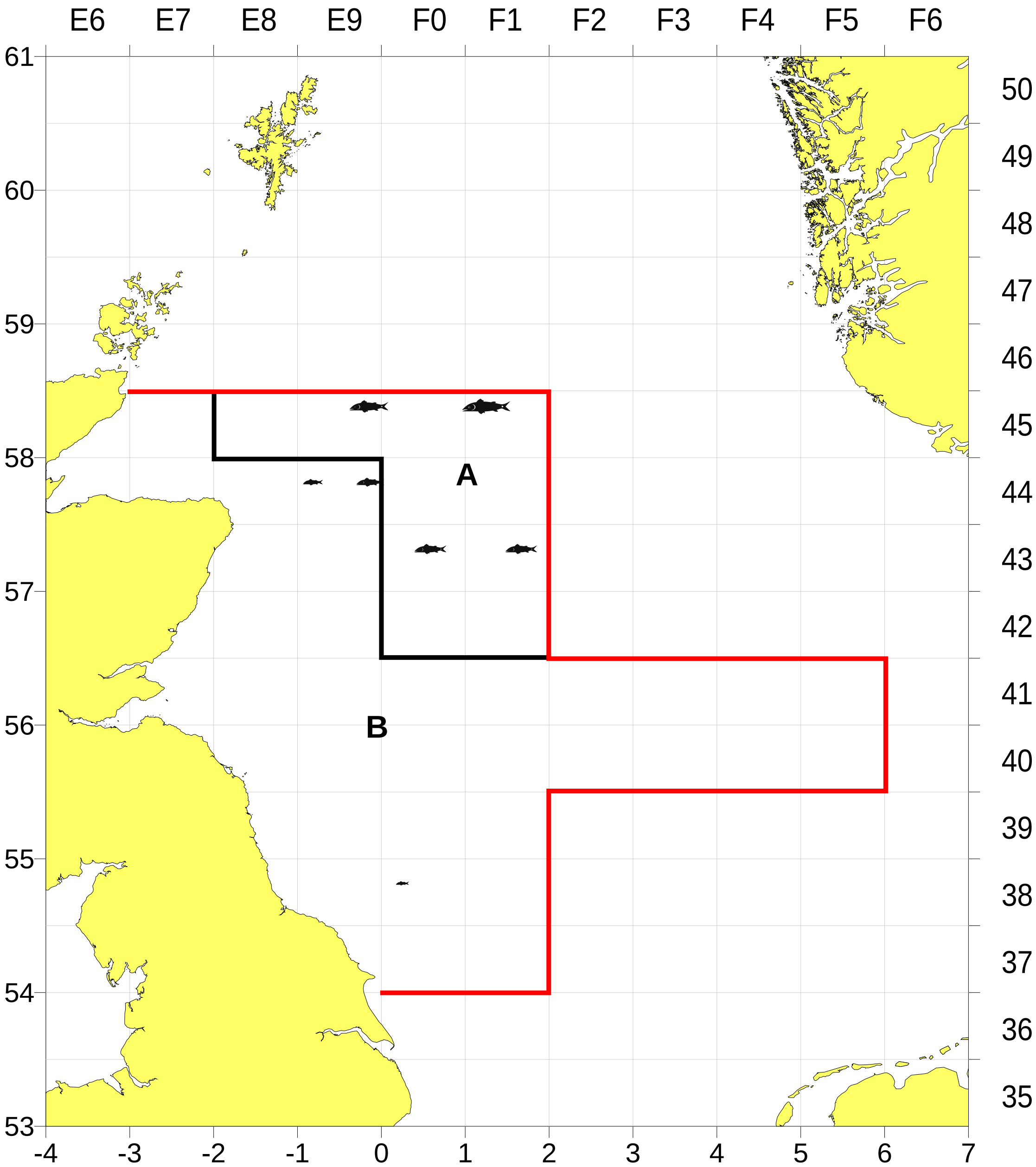


Figure 2. Geographical strata used to pool mean weights and relative mean lengths of herring in order to raise NASC's by rectangle to numbers and biomass during the June-July 2010 North Sea hydro acoustic survey for herring by RV "Tridens". Size of fish symbols represent relative mean lengths of herring caught in the respective hauls. Note that the haul in rectangle 38F0 is shown for indicative purposes only. It only contained 5 herring and was therefore not included in the analysis.

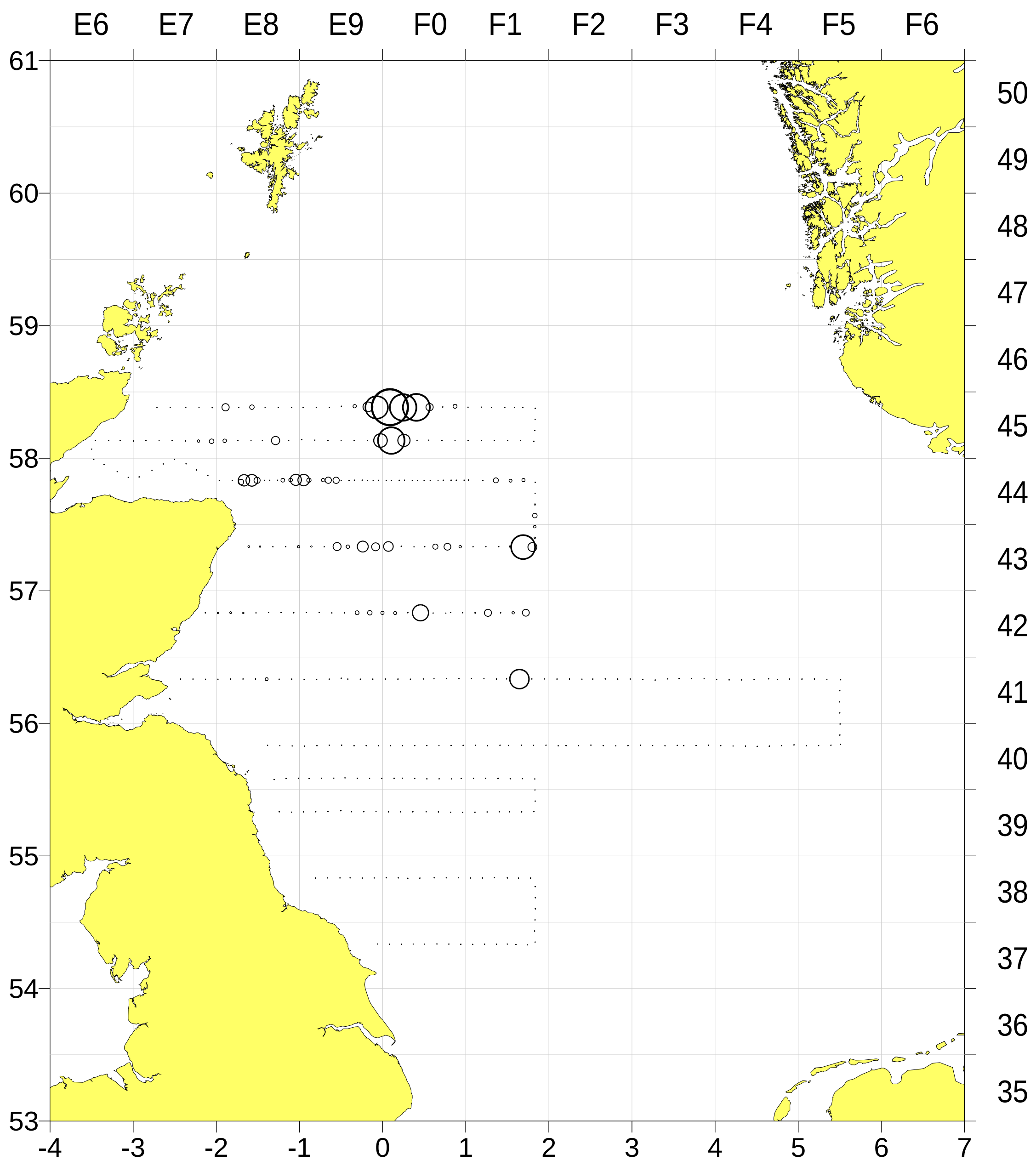


Figure 3a. Post plot showing the distribution of total herring NASC's of 5 nm intervals (on a proportional square root scale relative to the largest value of 3474.25) obtained during the June-July 2010 North Sea herring hydro acoustic survey on RV "Tridens".

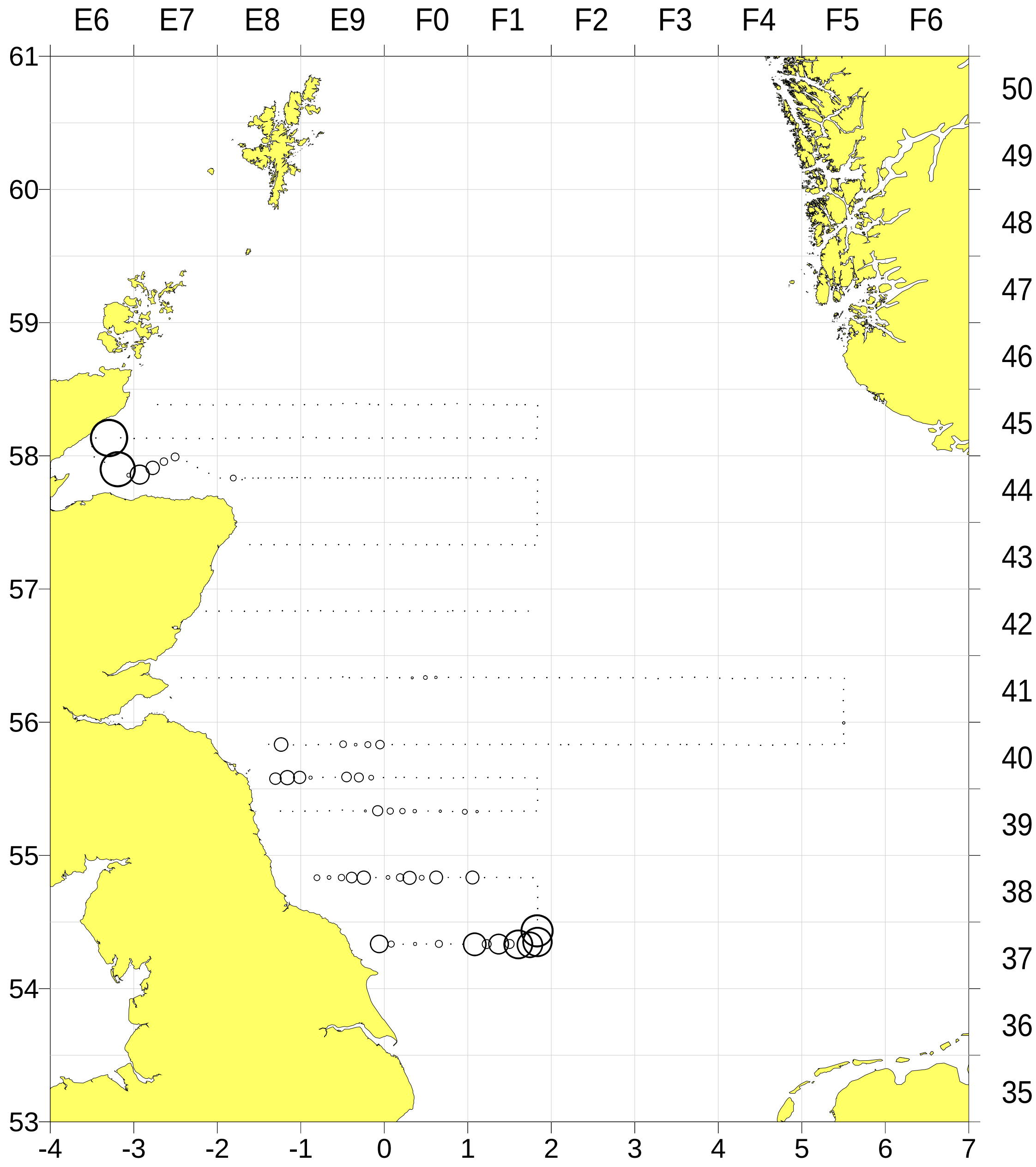


Figure 3b. Post plot showing the distribution of total sprat NASC's by 5 nm intervals (on a proportional square root scale relative to the largest value of 931.8). Obtained during the June-July 2009 North Sea herring hydro acoustic survey on RV "Tridens".

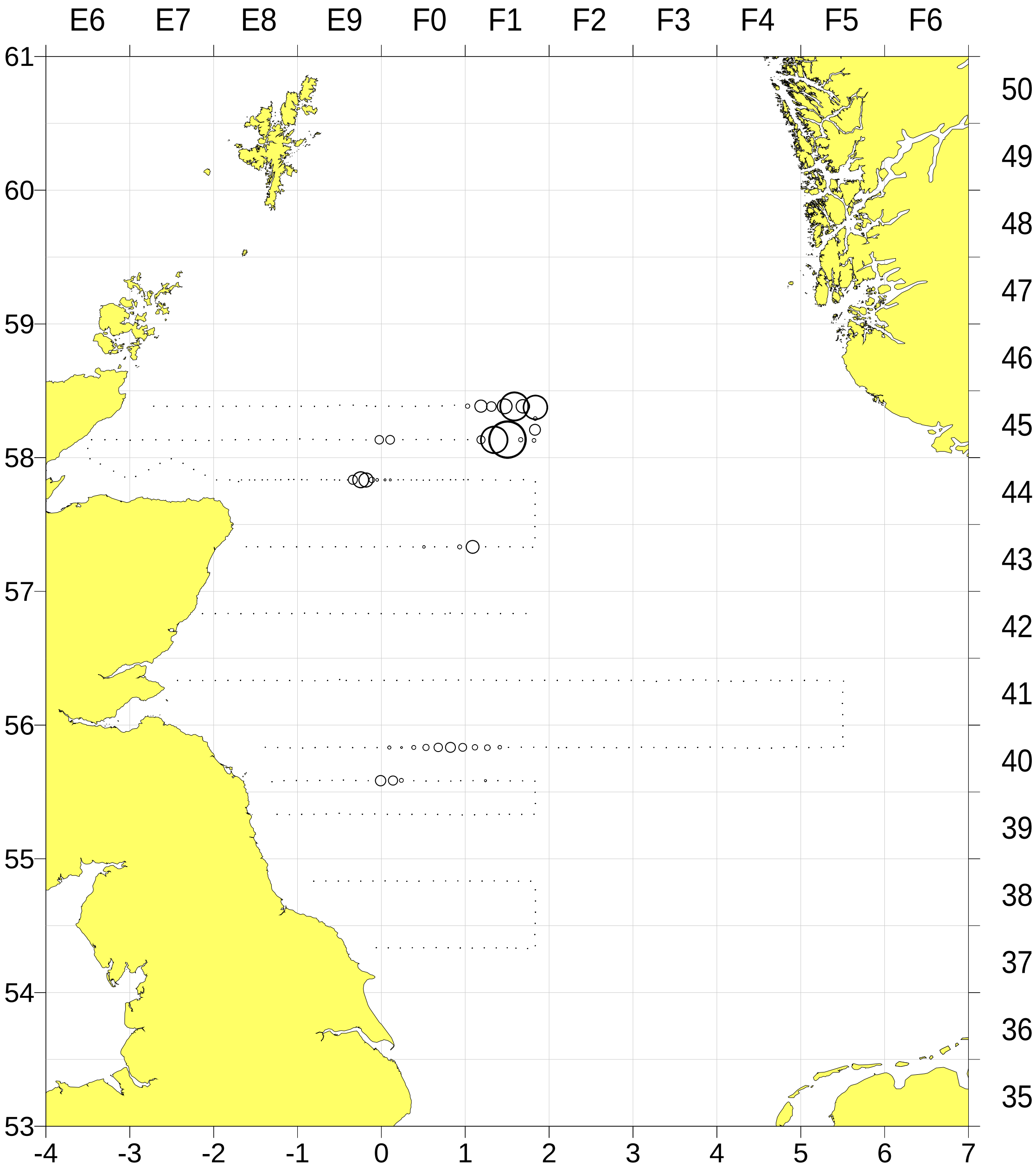


Figure 3c. Post plot showing the distribution of total Norway pout NASC's by 5 nm intervals (on a proportional square root scale relative to the largest value of 931.8). Obtained during the June-July 2009 North Sea herring hydro acoustic survey on RV "Tridens".

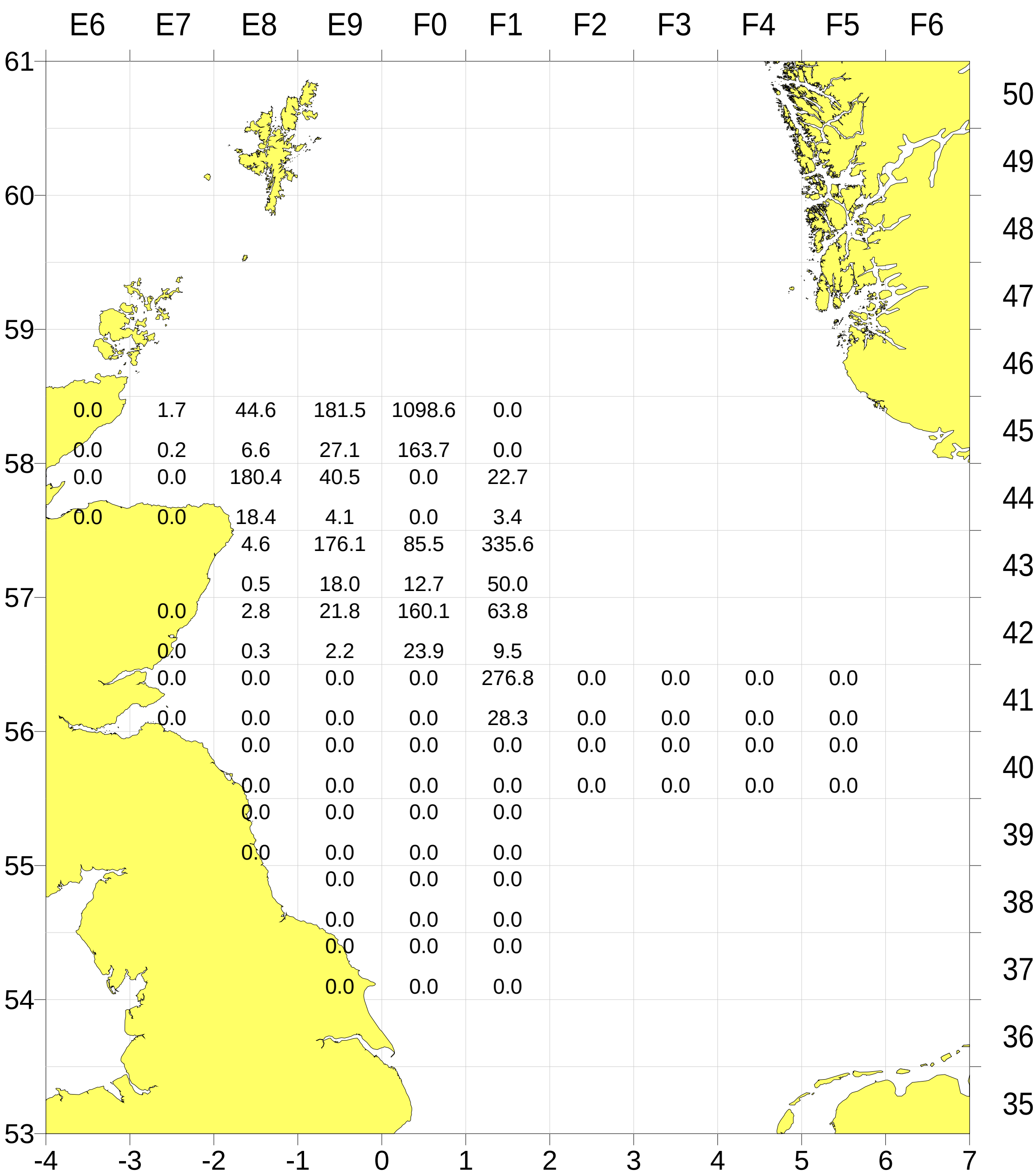


Figure 4. Estimated numbers of herring in millions (upper half square) and biomass in thousands of tonnes (lower half of square) by ICES rectangle. Results from the July 2010 North Sea hydro acoustic survey, RV "Tridens".

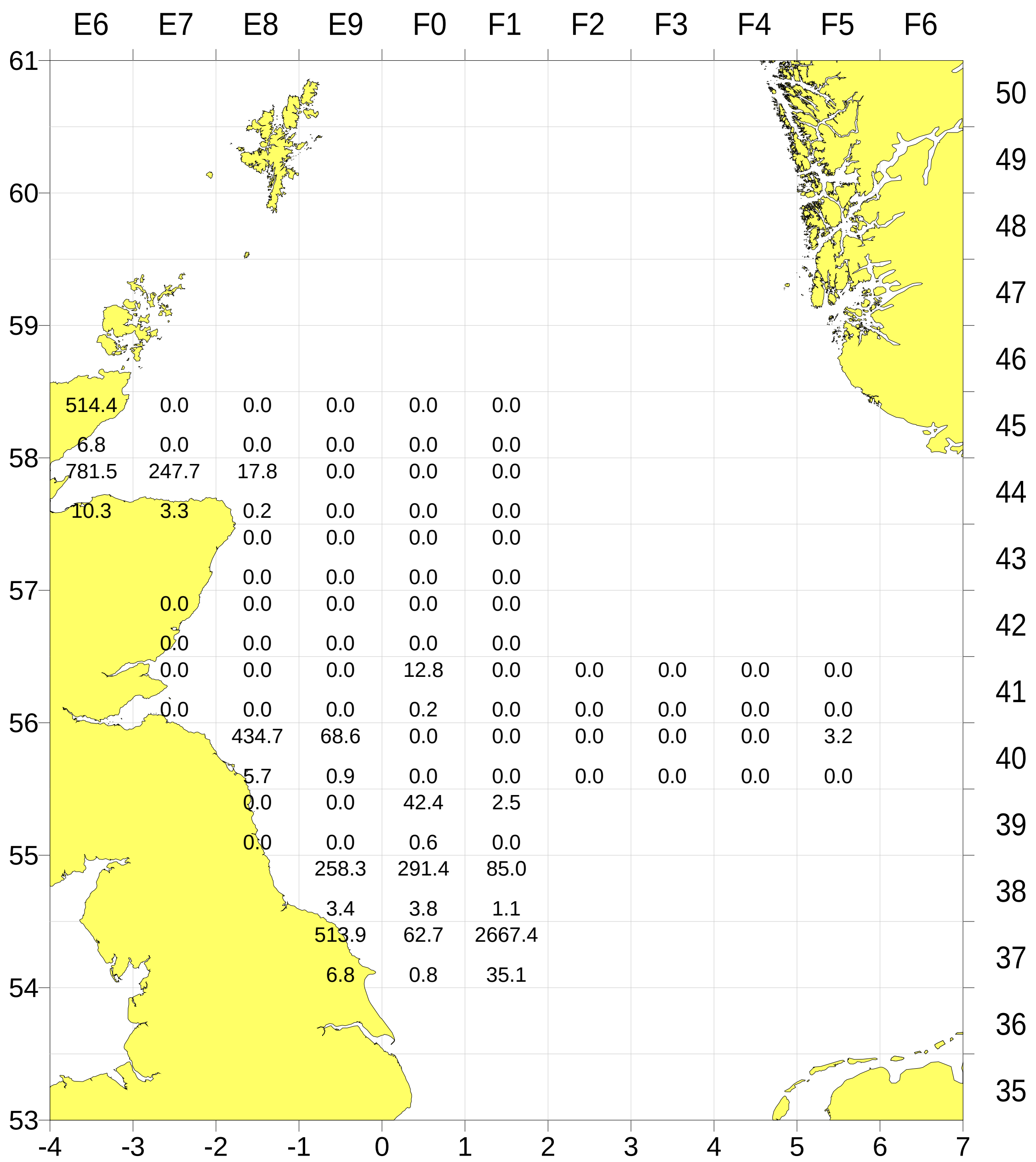


Figure 5. Estimated numbers of sprat in millions (upper half square) and biomass in thousands of tonnes (lower half of square) by ICES rectangle. Results from the July 2010 North Sea hydro acoustic survey, RV "Tridens".

ANNEX 5F: Germany

Survey report for FRV "Solea"

International Herring Acoustic Survey in the North Sea

25 June 2010 – 13 July 2010

Norbert Rohlf, Matthias Schaber and Eckhard Bethke

vTI-SF, Institute of Sea Fisheries, Hamburg

1 INTRODUCTION

Background: FRV "Solea" cruise 624 was conducted in the framework of the international hydroacoustic survey on pelagic fish in the North Sea, which is coordinated by the ICES Working Group for International Pelagic Surveys (WGIPS). Further contributors to the quasi-synoptic survey are the national fisheries research institutes of Scotland, Norway, Denmark, Ireland, Northern Ireland and The Netherlands. The results are delivered to the ICES herring assessment working group. Since 1984 they represent an important fishery-independent dataset (i.e. biomass estimate) for the assessment of herring stocks in the area.

The survey area for "Solea" was confined to the Southern and South-Eastern North Sea. This area is regarded as one of the main distribution areas for juvenile herring. Since 2001, PGHERS calculates a juvenile biomass index for the North Sea herring assessment, mainly based on the survey results from the SE North Sea and the Kattegat/Skagerrak area. During the last years, the survey area was significantly extended to the south (to about 52°N) in an attempt to reach the southern distribution limit of sprat, and this area was covered this year again. The survey effort is comparable to last year.

Objectives: Hydroacoustic recording of pelagic fish stocks for abundance and biomass estimation, biological sampling for the verification of echoes, calibration of the hydroacoustic equipment, hydrographic investigations, sampling of data and specimen.

2 SURVEY DESCRIPTION and METHODS

2.1 Personnel

Eckhard Bethke	Scientist in charge, acoustics	vTI-SF
Matthias Schaber	Acoustics	vTI-SF
Michael Sasse	Acoustics	vTI-SF
Norbert Rohlf	Biology	vTI-SF
Jörg Appel	Biology	vTI-SF
Linda Olmos-Pino	Biology	vTI-SF
Mayke Walhorn	Journalist	NDR

2.2 Narrative

FRV "Solea" left port of Cuxhaven on 25 June 2010. Calibration of the hydroacoustic equipment was conducted successful that day northwest of Helgoland Island. The survey transect started on 26 June. Supported by very good weather conditions the acoustic measurements and fishing activities could be conducted without any disturbances. Recordings were terminated in the afternoon of 12 July in the area of Helgoland. During the last two days of the cruise, NDR journalist Mayke Walhorn, embarking from Helgoland, jointed us to conduct a radio media production. FRV "Solea" reached her home port in the evening of 12 July, having sailed 2360 nautical miles.

2.3 Survey design

The working area for the German vessel contributing to the survey concentrated in the central and southern parts of the North Sea. The survey effort was comparable to last year. The southern survey limit was chosen in order to reach a southern distribution limit of sprat in July. The survey area was confined to the southern and central North Sea between 52°N and the 20 m depth contour off Frisia to the south, the 20 m depth line off the English coast to the west and off the German and Danish coast to the east, and 56°00′ N to the north, respectively.

Hydroacoustic measurements were conducted on east-west or north–south transects with 15 or 30 nautical miles distance (as done by other research vessels participating in the survey) on fixed latitudes. In general, each ICES statistical rectangle was surveyed with at least one transect, and with higher intensity where historically a high abundance or variability in abundance of juvenile herring or sprat had been detected.

2.4 Calibration

The calibration of the acoustic equipment was carried out at sea in the afternoon of 25 June 2010. Water depth was 16 - 22 m. According to current forecasts given by the German BSH, position 54° 12'N, 007° 47'E was estimated to have only neglectable currents for a given time windows of three hours. This period was sufficient for successful calibration of the 38 kHz transducer, but too short to calibrate the 120 kHz transducer as well. Calibration methods are described in the 'Manual for Herring Acoustic Surveys in ICES Divisions III, IV and VI' (ver. 3.1, ICES CM 2003/G:03, Appendix 4). Important parameters and settings are listed in Table 1.

2.5 Acoustic data collection

The acoustic investigations were performed during daylight (0400 to 1800 hrs UTC), using a Simrad EK60 echosounder with standard frequencies of 38 and 120 kHz. Echo telegrams were continuously recorded and evaluated using the EchoView 4 software package. The specific settings of the hydroacoustic equipment were used as described in the 'Manual for Herring Acoustic Surveys in ICES Divisions III, IV and VI' (ver. 3.1, ICES CM 2003/G:03, Appendix 4). Basic settings are documented in Table 1. The vessel was running at a speed of 10–11 knots. The cruise track (Figure 1) totally reached a length of 2360 nautical miles

2.6 Biological data - fishing trawls

For the identification of echotraces and further biological sampling, 41 trawl hauls were conducted either on specific large schools (after turning the ship) or, if small schools occurred frequently, on the survey track. On board RV Solea, a small pelagic trawl (PSN388, approx. 8 m vertical opening, and 10 mm mesh size in the codend) was used both in midwater trawls and close to the bottom. The net was equipped with Simrad trawl sonar FS20. Standard tow periods were 30 minutes; however, they varied between 6 and 60 minutes depending on the indication of net filling. 23 statistical rectangles had been sampled.

From each trawl, total catch weight and species composition (on subsamples, if necessary) were determined. Length frequency distributions were produced for each species. Length-stratified samples (10 samples per half cm class per ICES stat rectangle) of herring, sprat, anchovies and sardines were taken for maturity determination (4 point scale), sex and individual body mass. Fish were deep-frozen for later otolith removal and age determination.

2.7 Hydrographic data

Hydrographic data were sampled just prior or after fishing activities, or at least in distances of approximately 30 nautical miles (Figure 2). At each of these stations, vertical profiles of temperature, salinity and depth were recorded using a "Seabird SBE 19 plus-multiprobe" CTD. Water samples for calibration purposes were taken on every station.

2.8 Data analysis

The echo integration, i.e. the allocation of the nautical area backscattering cross section (NASC) to the species herring and sprat was done with the EchoView 4 software package, using information from trawl hauls usually targeting specific schools. Herring and sprat were exclusively found in characteristic "pillars". The NASC attributed to clupeids was estimated for each ESDU of 1 nautical mile. Contributions from air bubbles, bottom structures and scattering layers were manually removed from the echogram using the EchoView software. It is not possible to distinguish between herring and sprat within clupeid schools. To allocate the integrator readings to a single species, species composition was based on the trawl results.

For each rectangle the species composition and length distribution of herring and sprat were determined as the weighted mean of all trawl results in this rectangle. For rectangles without valid hauls a mean of the catch results of the neighbouring rectangles was used. From these distributions the mean cross section σ was calculated according to the following target strength-length (TS) relationship:

TS = 20 log L (cm) - 71.2 (ICES 1983/H:12)

The total number of fish (total N) in one rectangle was estimated to be the product of the mean area scattering cross section NASC and the rectangle area (or more precisely the area within a water depth of more than 20 m), divided by the corresponding mean cross section. This total number was divided into species and age/maturity classes according to the trawl catch results.

3. RESULTS and DISCUSSION

3.1 Acoustic data

The identification of the echotraces was carried out by trawls. Herring and sprat was found only in the presence of characteristic "poles" or small clouds. These indications were not homogeneously distributed over larger areas. Small regions with partially high NASC were followed again by nearly empty areas. Only 33% of all sampled miles had a NASC greater than one.

However, fish indications were spread out over large areas and had a relatively high intensity. This is consistent with the significantly higher catch results, compared to last years. High fish densities were found again in the vicinity of the island Helgoland. Another area of concentrations was located SE of Dogger Bank in the ICES rect. 36F4, 36F5, 37F4 and 37F5, where the density of fish was much higher than usual. These higher concentrations were already observed in this area in 2009. In contrast, the former concentrations in SW part of the survey area were missing. Figure 2 gives the NASC distribution on a basis of 5 nautical miles EDSUs for clupeids (herring and sprat combined).

3.2 Biological data

During the acoustic survey 40 rectangles were covered. Of those, 23 rectangles have been sampled with in total 41 trawl hauls by the PSN 388 (Figure 1 and Table 2). Valid results (> 200 clupeids h-1 trawling) were obtained for 22 rectangles. Those were used to raise unsampled rectangles. The majority of the unsampled rectangles had no or only minimal NASCs. Total catch varied between 1 and 9 207 kg (standardized to 30 minutes trawl duration).

Herring school have spread out in the area of investigation and catches were larger, but still most of the schools were found in the north-eastern parts of the surveyed area (in Danish waters and in the German bight). Most herring were immature 0- and 1-wr fish, but some adults were present. Sprat was more uniformly distributed, but most sprat were observed south of 55°N. Highest densities were found around Helgoland, southeast of Dogger-Bank and around Smith's Knoll. As in last year, the high sprat concentrations in the southwest were missing. There is some likelihood that summer southern distribution limit for sprat in the Channel was reached during the survey.

In total, 21 different species were caught during trawling (Table 3). Sprat showed the highest presence (in 37 trawls out of 41) and was the most abundant in terms of biomass (20.8 t, equal to 83% of the total catch weight). Sprat catches increased continuously during the last three years (2009: 14.6 t; 2008: 3.1 t). Also total catch of herring increased to 3.9 t in 2010 (2009: 1.0 t; 2008: 1.1 t). Herring were present in 34 hauls. Catches yielded larger quantities of mackerel *Scomber scombrus* and, to a much smaller extent, grey gurnard *Eutrigla gurnardus*. Other species occurred only on occasion and "exotic" species like pilchard *Sardina pilchardus* and anchovies *Engraulis encrasicolus* were nearly absent. This was may be linked to the relatively cold winter water temperatures in the North Sea in 2009/2010.

3.3 Biomass and abundance estimates

Herring total biomass: 399 766 t (2009: 41 538 t; 2008: 63 058 t)

Herring spawning-stock biomass: 6 346 t / 1.6% (2009: 0 t / 0%; 2008: 746 t / 1.2%)

Herring total abundance: 23 111 mill. (2009: 5 354 mill; 2008: 3 775 mill.)

Herring spawning stock abundance: 101 mill. / 0.44% (2009: 0 mill. / 0%; 2008: 8.2 mill. / 0.2%)

Sprat total biomass: 291 097 t (2009: 558 448 t; 2008: 263 700 t)

Sprat spawning-stock biomass: 289 580 t / 99% (2009: 437 248 t / 78%; 2008: 221 022 t / 84%)

Sprat total abundance: 28 840 mill. (2009: 66 002 mill.; 2008: 24 600 mill.)

Sprat spawning stock abundance 28 433 mill. / 99% (2009: 42 067 mill. / 64%; 2008: 18 900 mill. / 77%)

Compared to last year, herring abundance has increased by a factor of 5 and the biomass almost by 10. As in the last years, the vast majority of herring in the surveyed area had always been young 0- and 1-wr fish (Age 1 and 2). The amount of adult fish in 2010 is less than 2%.

Abundance and biomass of sprat has decreased when compared to 2009 and is in the some order of magnitude as in 2008. In most recent years, roughly 1/3 of the sprat were immature fish. This is in contrast to 2010, when almost all sprat are mature. Detailed information on abundance and biomass by statistical rectangle can be found in Figure 3 and 5. Mean length (cm) for herring and sprat per statistical rectangle is given in Figure 4 and 6, respectively.

3.4 Hydrographic data

In addition to the trawl hauls a dense net of hydrographic stations was conducted during the survey. Temperature and salinity profiles were measured on 63 stations with a maximum distance of approximately 30 nautical miles between stations. Sea surface temperature ranged from 12° to 21° C, with the typical increase towards the coastal area in the inner German Bight, where the maximum of 21° C was observed.

In the northern part relatively cold water below 8 °C was found in the bottom-water layers, with a thermocline between 10 and 20 m depth. Towards the South, these gradients dissolved more and more and water layers were well mixed. Only the somewhat warmer surface layer was persistent.

4 Tables and Figures

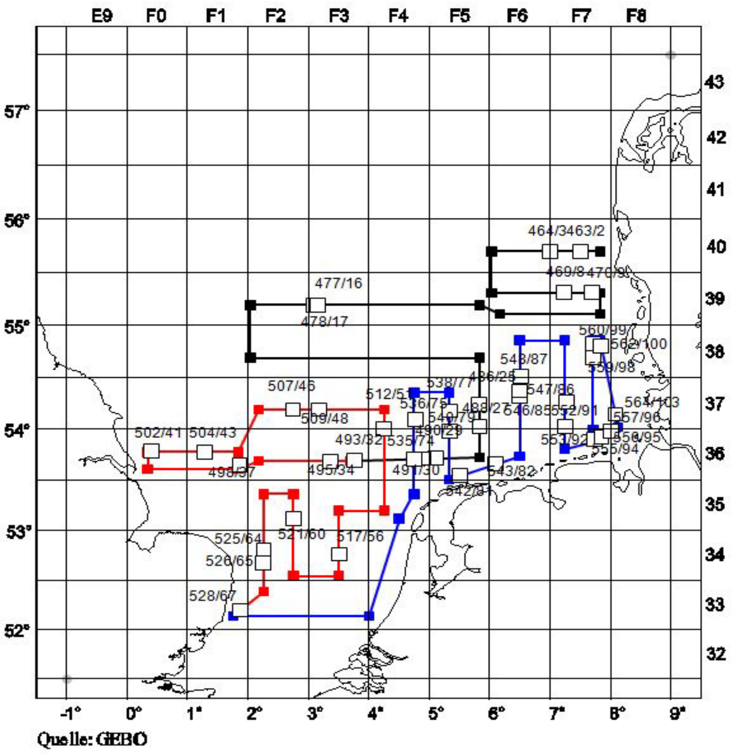


Figure 1a. FRV "Solea", cruise 624, herring acoustic survey: Cruise track and trawl stations (white squares).

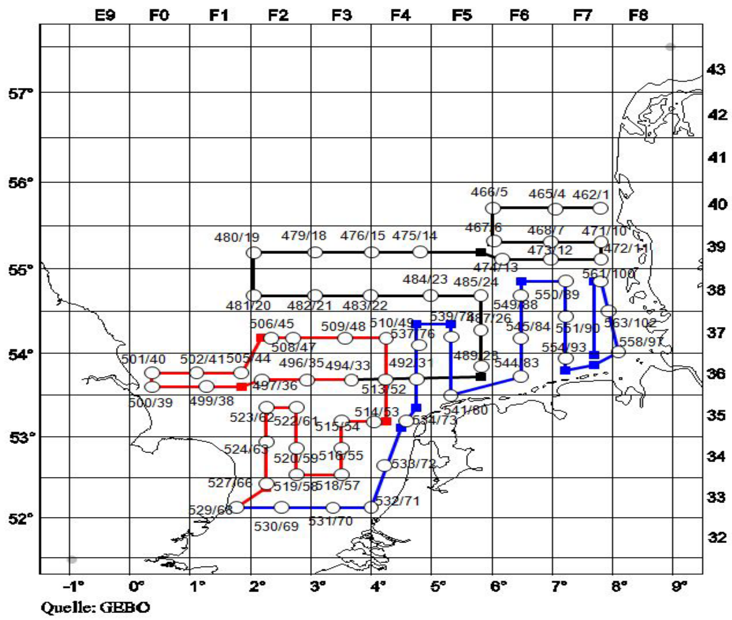


Figure 1b. FRV "Solea", cruise 624, herring acoustic survey: CTD profiles (white circles).

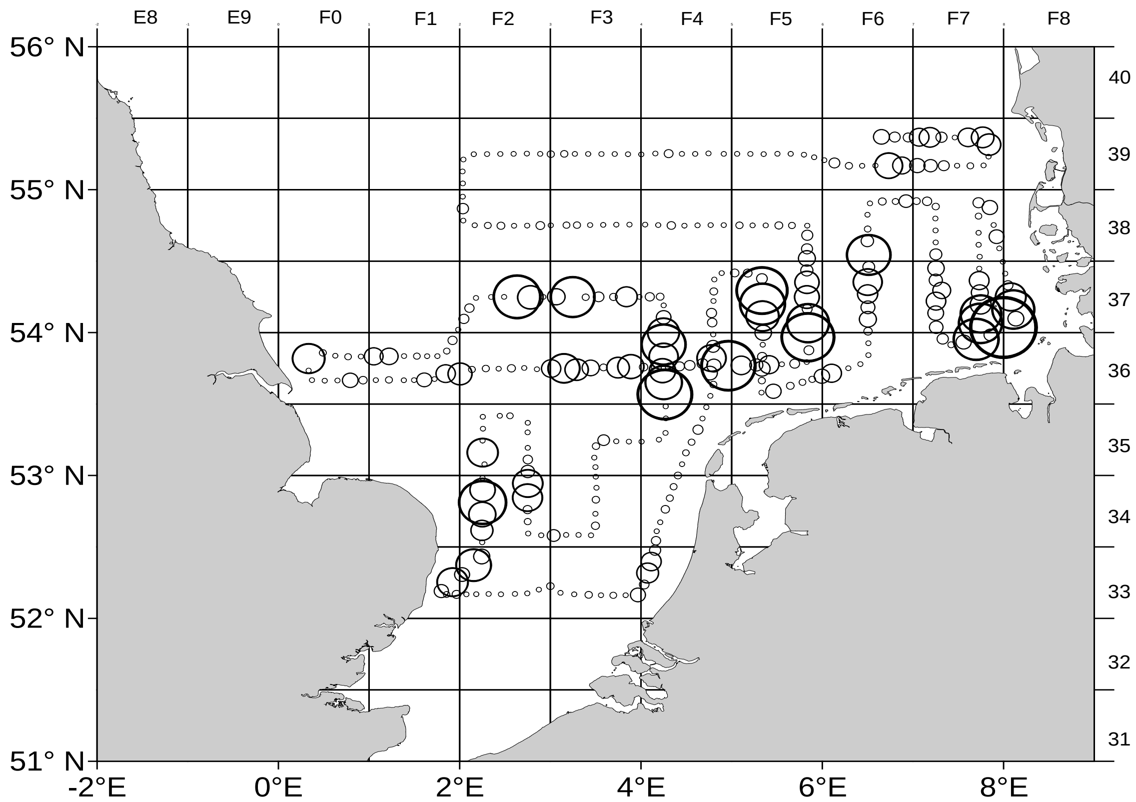


Figure 2. FRV "Solea", cruise 624: Distribution of total NASC values attributed to clupeoids (sum per 5 nautical miles, on a proportional square root scale relative to the largest value of 25 000 m² 5n.mi.-²). Smallest dots indicate zero values.

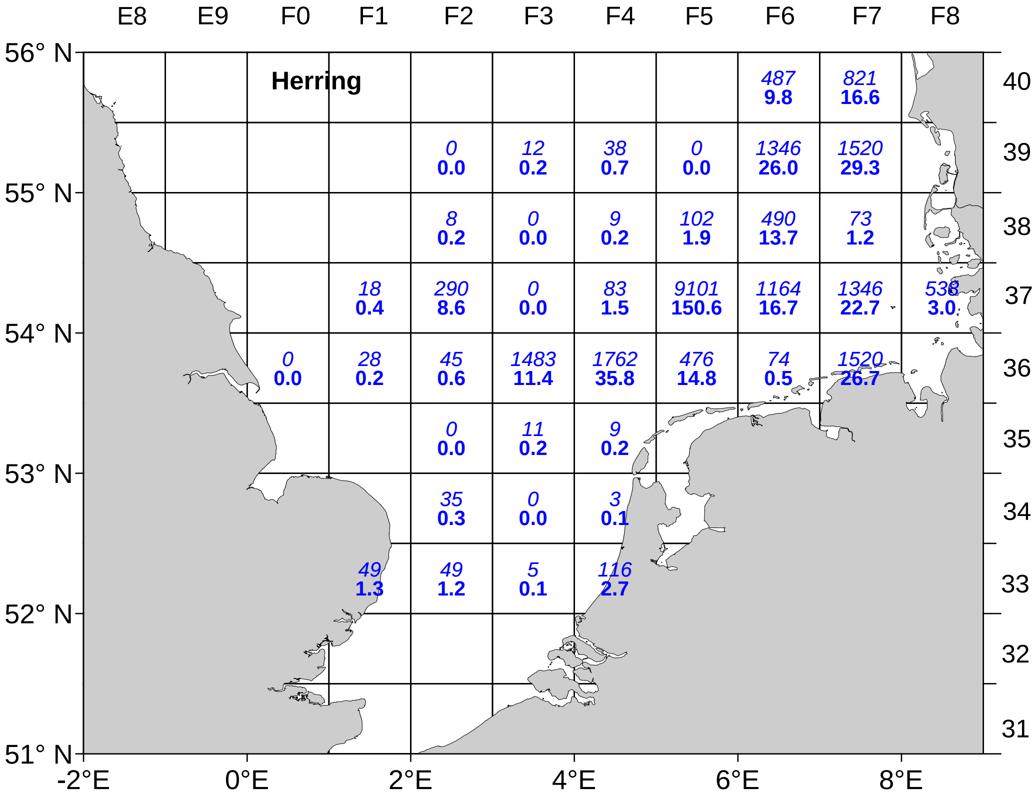


Figure 3. FRV "Solea", cruise 624: Abundance (Mill. individuals, upper value in italics) and biomass (thousand t, lower value in bold) of herring per statistical rectangle.

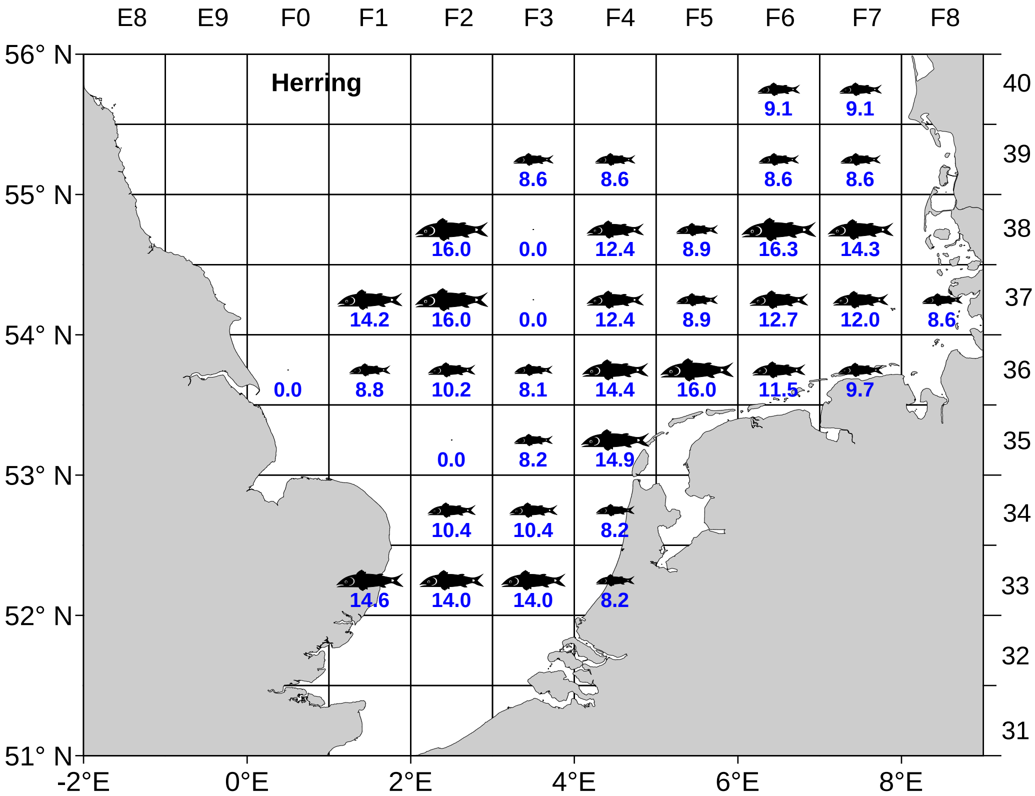


Figure 4. FRV "Solea", cruise 624: Mean length of herring (cm) per statistical rectangle as obtained from trawl catches.

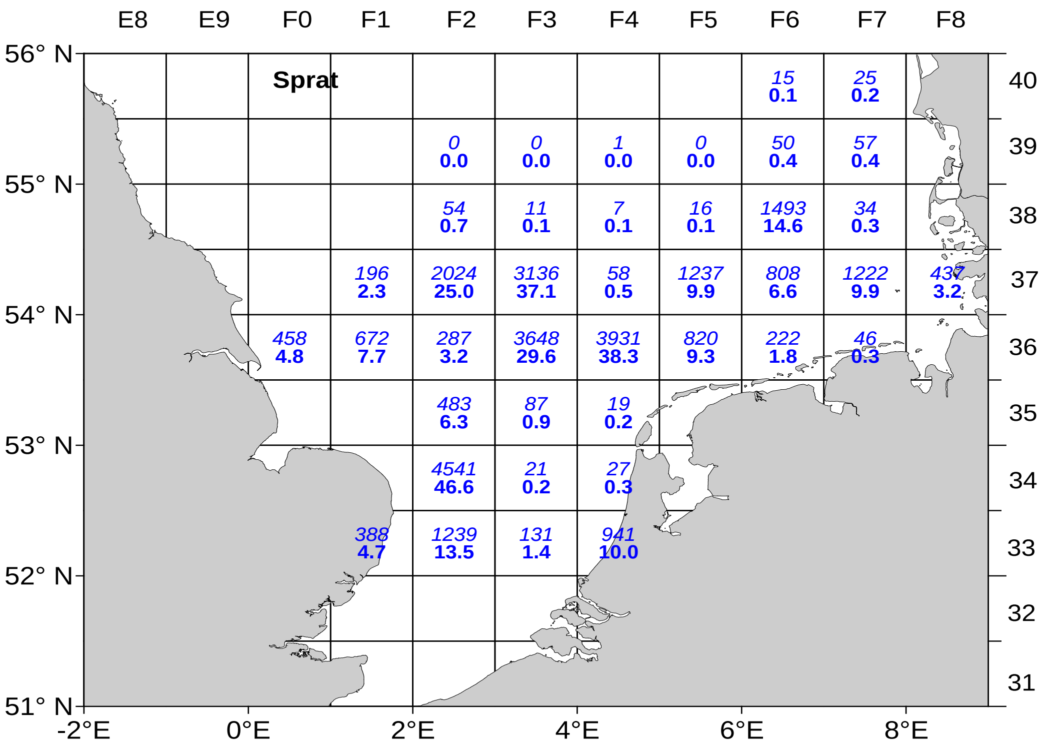


Figure 5. FRV "Solea", cruise 624: Abundance (Mill. individuals, upper value in italics) and biomass (thousand t, lower value in bold) of sprat per statistical rectangle.

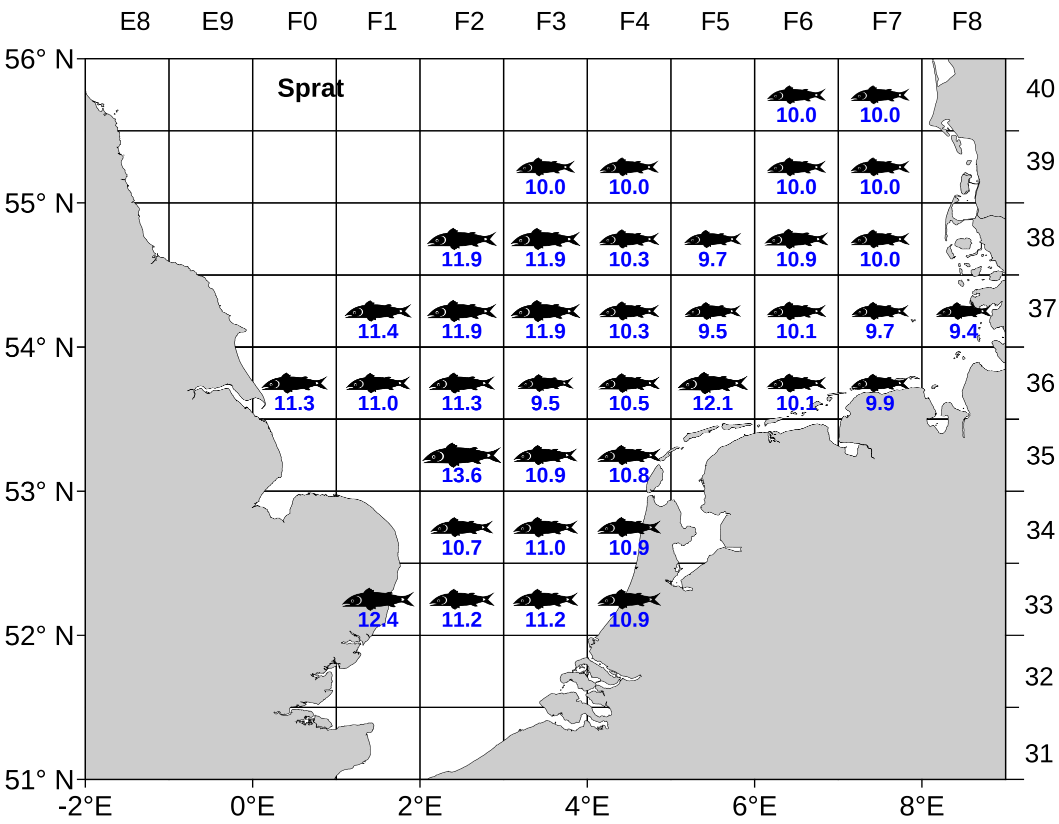


Figure 6. FRV "Solea", cruise 624: Mean length of sprat (cm) per statistical rectangle as obtained from trawl catches.

Table 1. FRV "Solea", cruise 624. Simrad EK60 calibration report.

Calibration Version 2.1.0.12

Date: 2009–06–25

Comments:

Northwest of Helgoland 54° 12.258' N, 007° 47.915' E

Reference Target:

TS	-33.60 dB	Min. Distance	16.00 m
TS Deviation	5.0 dB	Max. Distance	22.00 m

Transducer: ES38B Serial No. 30545

Frequency	38000 Hz	Beamtype	Split
Gain	26.50 dB	Two Way Beam Angle	-20.6 dB
Athw. Angle Sens.	21.70	Along. Angle Sens.	21.70
Athw. Beam Angle	7.10 deg	Along. Beam Angle	7.10 deg
Athw. Offset Angle	0.00 deg	Along. Offset Angle	0.00 deg
s_ACorrection	0.00 dB	Depth	0.00 m

Transceiver: GPT 38 kHz 009072056b06 3–1 ES38B

Pulse Duration	1.024 ms	Sample Interval	0.190 m
Power	2000 W	Receiver Bandwidth	2.43 kHz

Sounder Type:

EK60 Version 2.2.0

TS Detection:

Min. Value	-40.0 dB	Min. Spacing	100%
Max. Beam Comp.	6.0 dB	Min. Echolength	80%
Max. Phase Dev.	4.0	Max. Echolength	180%

Environment:

Absorption Coeff.	10.2 dB/km	Sound Velocity	1488.0 m/s

Beam Model results:

Transducer Gain =	26.22 dB	SaCorrection =	-0.51 dB
Athw. Beam Angle =	7.24 deg	Along. Beam Angle =	7.21 deg
Athw. Offset Angle=	-0.02 deg	Along. Offset Angle=	0.01 deg

Data deviation from beam model:

RMS =	0.21 dB		
Max = 0.56 dB	No. = 379	Athw. = 3.2 deg Along =	-4.0 deg
Min = -1.28 dB	No. = 83	Athw. = -5.0 deg Along =	-0.3 deg

Data deviation from polynomial model:

RMS =	0.16 dB		
Max = 0.47 dB	No. = 22	Athw. = -2.7 deg Along =	-3.8 deg
Min = -0.91 dB	No. = 228	Athw. = -0.8 deg Along =	-4.9 deg

Table 2. Trawl station data of FRV "Solea" during cruise 624 (25.06. – 13.07.10.).

Station	Haul	Rectangle	Date	Time (UTC)	Trawl type	Shot Pos Latitude	Shot Pos Longitude	Water depth (m)	Catch depth (m)	Catch time (min)
463	1	40F7	20100626	0613	PSN388	554489N	0072974E	22	10	30
464	2	40F7	20100626	0837	PSN388	554501N	0070091E	31	18	30
469	3	39F7	20100627	0504	PSN388	552204N	0071384E	28	11	30
470	4	39F7	20100627	0738	PSN388	552191N	0074337E	22	12	20
477	5	39F3	20100628	1152	PSN388	551497N	0030589E	29	21	30
478	6	39F3	20100628	1239	PSN388	551486N	0030826E	29	10	30
486	7	37F5	20100630	0609	PSN388	541894N	0054981E	39	30	20
488	8	37F5	20100630	0837	PSN388	540440N	0055043E	37	29	30
491	9	36F5	20100630	1516	PSN388	534602N	0045479E	36	28	30
490	10	36F4	20100630	1333	PSN388	534628N	0050749E	34	26	30
493	11	36F3	20100701	0620	PSN388	534528N	0034437E	37	29	30
495	12	36F3	20100701	0828	PSN388	534501N	0032295E	40	32	22
498	13	36F1	20100701	1504	PSN388	534085N	0015223E	58	37	19
502	14	36F0	20100702	0827	PSN388	535021N	0002252E	43	24	11
504	15	36F1	20100702	1205	PSN388	535000N	0011584E	33	22	31
507	16	37F2	20100703	0535	PSN388	541494N	0024338E	43	35	13
509	17	37F3	20100703	0759	PSN388	541491N	0031108E	43	35	15
512	18	37F4	20100703	1322	PSN388	540438N	0041486E	48	40	54
517	19	34F3	20100704	1007	PSN388	524908N	0033016E	30	20	30
521	20	35F2	20100705	0508	PSN388	530963N	0024498E	34	25	31
525	21	34F2	20100705	1307	PSN388	525127N	0021520E	43	29	32
526	22	34F2	20100705	1507	PSN388	524466N	0021514E	37	24	17
528	23	33F1	20100706	0510	PSN388	521333N	0015183E	30	18	20
535	24	36F4	20100707	1055	PSN388	534525N	0044560E	36	24	20
536	25	37F4	20100707	1358	PSN388	540908N	0044640E	45	28	60
557	26	37F5	20100710	1201	PSN388	540274N	0080166E	26	18	14
538	27	37F5	20100708	0513	PSN388	541513N	0052022E	41	34	8
540	28	36F5	20100708	0700	PSN388	540241N	0052060E	39	28	31
542	29	36F6	20100708	1105	PSN388	533598N	0053095E	25	17	30
543	30	37F6	20100708	1357	PSN388	534306N	0060693E	25	18	22
546	31	37F6	20100709	0505	PSN388	542191N	0063033E	37	30	30
547	32	38F6	20100709	0639	PSN388	542664N	0063043E	38	30	30
548	33	37F7	20100709	0826	PSN388	543385N	0063078E	38	31	27
552	34	37F7	20100710	0422	PSN388	541959N	0071632E	42	34	27
553	35	36F7	20100710	0632	PSN388	540586N	0071555E	36	26	30
555	36	36F7	20100710	1005	PSN388	535753N	0074520E	33	25	6
556	37	37F8	20100710	1045	PSN388	535908N	0075168E	35	25	30
559	38	38F7	20100711	1604	PSN388	544590N	0074345E	19	10	10
560	39	38F7	20100711	1726	PSN388	545185N	0074313E	19	13	15
562	40	38F7	20100712	0447	PSN388	545189N	0075099E	18	9	30
564	41	37F7	20100712	0906	PSN388	541209N	0080461E	27	20	15

Table 3. FRV "Solea", cruise 624. Species distribution per haul (catch in kg per 30 min.)

RECTANGLE	STATION	kg total	*AMMODYTES MARINUS*	*CALLIONYMUS LYRA*	*CLUPEA HARENGUS*	*CRYSTALLOGOBIUS*	*ECHIICHTHYS VIPERA*	*ENGRAULIS ENCRASICOLUS*	*EUTRIGLA GURNARDUS*	*GADUS MORHUA*	*HYPEROPLUS IMMACULATUS*	*HYPEROPLUS LANCEOLATUS*	*LIMANDA LIMANDA*	*LAMPETRA FLUVIATILIS*	*MERLANGIUS MERLANGUS*	*MERLUCCIUS MERLUCCIUS*	*PLEURONECTES PLATESSA*	*SALMO SALAR*	*SARDINA PILCHARDUS*	*SCOMBER SCOMBRUS*	*SPRATTUS SPRATTUS*	*TRACHURUS TRACHURUS*	*TRISOPTERUS LUSCUS*	Number of Species
40F7	463	386.4			79.7				1.0			0.0								5.1	301			5
40F7	464	197.6			181.2				3.1			0.1			0.0					9.1	4			6
39F7	469	89.1			63.9				0.6												25			3
39F7	470	364.2			140.0							0.1								11.7	213			4
39F3	477	3.0	0.0		0.0				2.4		0.5										0			5
39F3	478	1.0							0.3		0.6				0.0									3
37F5	486	894.8			39.5				0.2			0.1									855			4
37F5	488	409.7			19.8		0.5	0.0	1.4			0.1			0.5		0.2			0.2	380	7.1		10
36F5	490	414.0			56.3		0.0	0.0	1.1			0.0	0.3		0.9				0.0	1.2	354	0.4		11
36F4	491	730.1		0.0	3.7				0.2			0.1			0.2					1.0	725			7
36F3	493	79.3			0.5				0.2						0.0						79			4
36F3	495	447.4			0.4				0.2				0.1		1.5					0.3	445			6
36F1	498	512.3			0.1				0.2						0.0						512			4
36F0	502	56.2					2.4														54			2
36F1	504	195.8			0.1		0.2		0.5			4.5	0.1		0.1						190			7
37F2	507	1077.4			2.9				0.7			0.1	0.2		0.4						1073			6
37F3	509	42.8							2.6						0.1						40			3
37F4	512	50.4			13.0				0.1	3.8			0.0		0.2						33			6
34F3	517	0.8						0.1			0.2	0.1			0.0						0			5
35F2	521	79.5					0.0		0.4			1.0			0.1					14.9	63			6
34F2	525	157.1			0.1		0.0								0.0				0.1	34.5	122			6
34F2	526	599.2			0.0	0.0	0.9														598			4
33F1	528	916.5			1.1		0.1								0.2						915			4
36F4	535	572.3			30.7				0.8						0.7						540			4
37F4	536	13.6			13.0				0.5						0.0						0			4
37F5	538	1544.0			62.0				0.8						0.0		0.9				1480			5
37F5	540	30.2			0.1				0.3						0.0						30			4
36F5	542	2.0																		2.0				1
36F6	543	988.8			4.1															3.0	982			3
37F6	546	346.7			85.8				0.2			0.0					0.5				260			5
37F6	547	364.4			132.9				0.4				0.1			3.9					227			5
38F6	548	619.4			47.6																572			2
37F7	552	436.4			257.9				2.4						0.5					1.0	170	4.7		6
37F7	553	859.7			716.5				0.1				0.4		0.1						143	0.1		6
36F7	555	988.2			254.7				1.0				0.2							45.6	673	14.1		6
36F7	556	30.1			14.6				0.1						0.0						15			4
37F8	557	9207.3			1558															1.6	7648			3
38F7	559	37.1													0.0					35.1		2.0		3

Table 4. FRV "Solea", cruise 624. Herring length frequency (%) by trawl haul (length in cm).

	STAT:	463	464	469	470	477	486	488	490	491	493	495	498	504	507	512	525
	HAUL:	1	2	3	4	5	7	8	9	10	11	12	13	15	16	18	21
Length	Rect:	40 F7	40 F7	39 F7	39 F7	39 F3	37 F5	37 F5	36 F5	36 F4	36 F3	36 F3	36 F1	36 F1	37 F2	37 F4	34 F2
(cm)	Total																
5.25	0.3	0	0	0	0	0	0	0	0	0	1	14	0	0	0	0	0
5.75	0.5	0	0	0	0	0	0	0	0	0	0	6	0	0	0	1	0
6.25	0.5	0	0	0	0	0	1	0	0	0	2	4	0	0	0	0	0
6.75	0.9	0	0	0	0	0	0	1	0	0	4	8	0	0	0	0	0
7.25	0.8	0	0	0	0	0	1	2	0	0	14	0	13	0	0	2	0
7.75	5.6	6	0	0	17	0	3	5	0	0	24	18	13	0	0	11	0
8.25	15.3	20	0	1	50	100	5	3	0	0	32	16	38	33	0	32	0
8.75	19.5	33	0	17	25	0	4	1	0	0	19	16	19	0	0	36	0
9.25	20.2	24	0	29	4	0	5	1	0	0	2	6	19	0	0	14	0
9.75	17.8	11	0	30	1	0	11	1	0	0	1	2	0	0	0	1	0
10.25	9.7	2	0	17	0	0	14	1	0	0	1	0	0	0	0	0	75
10.75	2.3	2	0	3	0	0	8	1	0	1	0	0	0	0	0	0	0
11.25	1.1	0	0	0	0	0	5	1	0	0	0	0	0	0	0	0	0
11.75	1.0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
12.25	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12.75	0.0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
13.25	0.0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0
13.75	0.1	0	0	0	0	0	2	3	0	4	0	0	0	0	0	0	0
14.25	0.2	0	0	0	1	0	2	9	1	11	0	0	0	0	3	0	0
14.75	0.5	0	1	1	1	0	4	21	3	19	0	2	0	67	8	0	0
15.25	0.5	0	2	1	1	0	6	22	11	34	0	4	0	0	19	0	0
15.75	0.8	0	9	1	0	0	10	18	38	16	0	6	0	0	27	0	25
16.25	0.9	0	19	1	0	0	10	7	34	11	0	0	0	0	27	0	0
16.75	0.8	0	25	1	0	0	6	2	11	2	0	0	0	0	8	0	0
17.25	0.4	0	12	0	0	0	2	1	1	0	0	0	0	0	3	0	0
17.75	0.1	0	16	0	0	0	0	0	0	0	0	0	0	0	3	0	0
18.25	0.0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.75	0.0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19.25	0.0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19.75	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
20.25	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24.75	0.0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
total n	100	17014	231	347	15294	1	573	392	156	142	151	70	25	3	85	131	4
mean		9.0	17.0	9.7	8.5	8.3	12.3	14.2	16.0	15.1	8.0	8.4	8.3	12.6	16.0	8.6	11.6

Table 4a cont.: FRV „Solea", cruise 624. Herring length frequency (%) by trawl haul (length in cm).

STAT	526	528	535	536	538	540	543	546	547	548	552	553	555	556	557	560	562	564
HAUL	22	23	24	25	26	27	29	30	31	32	33	34	35	36	38	39	40	41
RECT	34 F2	33 F1	36 F4	37 F4	37 F5	37 F5	36 F6	37 F6	37 F6	38 F6	37 F7	37 F7	36 F7	36 F7	38 F7	38 F7	38 F7	37 F7
LENGTH	(CM)																	
5.25	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5.75	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.25	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.75	0	0	0	6	0	0	1	0	0	0	0	0	0	0	0	0	0	0
7.25	0	1	0	5	0	0	2	0	0	0	0	0	0	0	0	0	0	0
7.75	0	2	0	11	17	0	6	0	0	0	0	0	0	13	0	0	0	0
8.25	0	5	0	20	17	0	7	1	0	0	0	1	1	30	0	1	5	0
8.75	0	7	0	20	0	0	6	1	0	0	0	14	5	31	0	10	38	0
9.25	0	6	0	18	0	0	7	0	0	10	11	27	21	20	0	27	40	0
9.75	0	5	0	6	0	1	7	2	0	24	22	31	34	5	0	25	12	0
10.25	0	2	0	1	0	20	8	5	0	19	3	19	6	1	0	18	5	0
10.75	0	1	0	0	0	22	5	7	1	8	0	4	1	0	0	14	0	0
11.25	0	0	0	0	0	22	3	3	1	1	0	2	0	0	0	4	0	0
11.75	3	1	0	0	17	9	3	5	0	1	0	2	0	0	0	1	0	3
12.25	7	1	0	0	0	11	4	3	1	0	0	0	0	0	0	0	0	7
12.75	3	1	0	0	0	10	2	1	0	0	0	0	0	0	0	0	0	3
13.25	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13.75	10	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	10
14.25	10	1	0	0	0	1	1	0	0	1	2	0	0	0	0	0	0	10
14.75	33	1	0	0	0	1	4	2	1	1	0	0	2	0	0	0	0	33
15.25	13	5	2	0	0	1	4	2	4	4	11	0	12	0	0	0	0	13
15.75	10	17	13	1	33	0	10	11	14	11	17	0	10	0	3	0	0	10
16.25	7	15	36	1	17	0	8	20	24	11	23	0	6	0	16	0	0	7
16.75	0	17	31	1	0	1	9	20	33	4	9	0	3	0	43	0	0	0
17.25	3	10	14	0	0	1	4	15	20	1	0	0	0	0	31	0	0	3
17.75	0	1	3	0	0	0	0	2	1	0	0	0	0	0	6	0	0	0
18.25	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
18.75	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
total n	45	252	121	13688	6	124	539	128	89	421	322	43460	196	791	446	251	190	45
mean	14.6	14.1	16.5	8.6	12.6	11.5	12.2	15.0	16.3	12.1	13.7	9.7	11.5	8.6	16.9	9.8	9.1	14.6

Table 4b. FRV "Solea", cruise 624. Sprat length frequency (%) by trawl haul (length in cm).

	Stat:	463	464	469	470	477	486	488	490	491	493	495	498	502	504	507	509	512	517	521
	Haul:	1	2	3	4	5	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Length	Rect:	40F7	40F7	39F7	39F7	39F3	37F5	37F5	36F5	36F4	36F3	36F3	36F1	36F0	36F1	37F2	37F3	37F4	34F3	35F2
(cm)	Total																			
5.25	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7.25	0.1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
7.75	0.2	0	0	0	0	0	0	2	0	0	3	0	0	0	0	0	0	0	0	0
8.25	1.4	2	0	0	0	0	2	9	0	0	5	8	0	0	0	0	0	0	0	0
8.75	7.8	30	1	0	7	0	7	24	0	0	25	15	0	0	0	0	0	2	4	0
9.25	15.0	33	4	0	29	0	16	31	0	1	23	21	0	0	0	0	0	9	0	0
9.75	18.9	24	11	11	29	0	37	21	1	10	28	23	6	3	0	0	0	26	8	0
10.25	17.7	8	29	30	24	0	29	9	6	30	12	22	23	12	8	1	0	32	0	1
10.75	11.7	2	26	37	8	0	9	2	12	36	2	6	38	11	34	12	6	23	25	3
11.25	8.0	0	15	18	3	0	1	0	16	13	1	2	26	28	36	17	20	6	17	2
11.75	6.4	0	7	2	0	0	0	0	13	6	0	0	7	39	15	23	35	0	25	0
12.25	4.5	0	5	1	0	0	0	0	11	1	0	0	0	7	3	24	21	2	4	2
12.75	3.4	0	2	1	0	50	0	0	17	1	0	0	0	0	2	13	12	0	4	7
13.25	2.3	0	1	0	0	0	0	0	16	1	0	0	0	0	1	5	4	0	8	22
13.75	1.6	0	0	0	0	50	0	0	7	0	0	1	0	0	0	4	2	0	4	32
14.25	0.7	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	22
14.75	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
15.25	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
15.75	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
total n	100	259	258	174	411	2	452	286	269	276	252	290	332	592	345	595	420	174	24	325
Mean L		9.3	10.7	10.6	9.8	13.3	9.8	9.3	12.1	10.7	9.3	9.6	10.8	11.3	11.2	11.9	11.9	10.2	11.4	13.6

Stat:	517	521	525	526	528	535	536	538	540	543	546	547	548	552	553	555	556	557	562	564
Haul:	19	20	21	22	23	24	25	26	27	29	30	31	32	33	34	35	36	37	40	41
Rect:	34F3	35F2	34F2	34F2	33F1	36F4	37F4	37F5	37F5	36F6	37F6	37F6	38F6	37F7	37F7	36F7	36F7	37F8	38F7	37F7
Length																				
5.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7.75	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
8.25	0	0	0	4	0	0	0	4	0	0	2	0	0	1	0	0	0	5	0	0
8.75	4	0	0	37	0	6	0	24	2	1	14	2	0	2	1	1	0	17	1	12
9.25	0	0	0	34	0	7	0	39	2	14	16	9	1	5	10	16	18	32	13	49
9.75	8	0	0	13	0	17	0	20	14	29	24	15	7	25	33	42	54	31	34	36
10.25	0	1	0	6	0	31	0	10	48	32	23	29	22	41	44	29	24	14	37	2
10.75	25	3	7	3	4	17	0	1	28	17	14	26	27	21	10	11	4	2	11	1
11.25	17	2	9	2	3	12	0	0	4	4	3	14	30	3	2	1	0	0	3	0
11.75	25	0	12	0	11	3	100	1	0	2	1	4	10	1	0	0	0	0	0	0
12.25	4	2	20	0	35	3	0	0	1	0	0	0	4	1	0	0	0	0	0	0
12.75	4	7	22	0	34	2	0	0	0	1	1	0	1	0	0	0	0	0	0	0
13.25	8	22	18	0	11	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
13.75	4	32	9	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14.25	0	22	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14.75	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15.25	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
total n	24	325	431	522	356	603	1	1016	238	371	235	228	271	220	175	1145	166	643	326	452
Mean L	11.4	13.6	12.5	9.2	12.4	10.4	11.8	9.3	10.3	10.1	9.8	10.4	10.9	10.2	10.1	9.9	9.8	9.4	10.0	9.4

Table 5. FRV "Solea", cruise 624. Age/maturity-length key for herring (sampled numbers not raised to the abundance in the survey area).

WR	0	1	1	2	6	
Maturity	I	I	M	I	M	
Length (cm)						Sum
5.25	2					2
5.75	5					5
6.25	7					7
6.75	25					25
7.25	41					41
7.75	78					78
8.25	98					98
8.75	115					115
9.25	115					115
9.75	93					93
10.25	87					87
10.75	73					73
11.25	52					52
11.75	32					32
12.25	23	1				24
12.75	22	3				25
13.25		12				12
13.75		34				34
14.25		57				57
14.75	1	81				82
15.25		99				99
15.75		134				134
16.25	1	131				132
16.75		117		1		118
17.25		85		1		86
17.75		47				47
18.25		17				17
18.75		11	1			12
19.25		3				3
19.75		1	1			2
20.25		1				1
20.75						
21.25						
24.75					1	1
25.25						
total	870	834	2	2	1	1709

Table 6. FRV "Solea", cruise 624. Age/maturity-length key for sprat (sampled numbers not raised to the abundance in the survey area).

Age	1	1	2	3	
Maturity	I	M	M	M	
Length (cm)					Sum
5.25					
5.75					
6.25					
6.75					
7.25	4	1			5
7.75	11	9			20
8.25	5	56			61
8.75	1	109	1		111
9.25		136	3		139
9.75		153	10		163
10.25		151	22		173
10.75		134	68		202
11.25		93	78	1	172
11.75		29	94	2	125
12.25		7	113	2	122
12.75		4	88	2	94
13.25			70	4	74
13.75			54	3	57
14.25			18	4	22
14.75			6	6	12
15.25				4	4
15.75				1	1
total	21	882	625	29	1557

ANNEX 5G: Ireland (West)

Survey report for RV Celtic Explorer

18 June – 07 July 2010

Ciaran O'Donnell, Marine Institute, Galway, Ireland

1. INTRODUCTION

The northwest and west coast (ICES Divisions VIaS and VIIb, c) herring acoustic survey programme was first established in 1994. Prior to acoustic estimation, a larval survey programme was conducted from 1981–1986. In the early 1990s, the ICES herring working group (HAWG) identified the need for a dedicated herring acoustic survey in this area (Anon, 1994). From 1994 to 1996 surveys were carried out on this stock during summer feeding phase. In 1997 a two-survey spawning survey was established covering both autumn and winter components. In 2004, this was modified into single spawning stock survey was carried out early in quarter 1 which continued until 2007. In 2008, it was decided that this survey should be incorporated into the larger coordinated Malin shelf survey on recommendation from SGHERWAY and WGHAWG.

The summer 2010 survey represents the third in the new time series (est. in 2008). The Irish component was carried out concurrently with the West of Scotland (MarLab) and Irish Sea surveys (AFBI) and was coordinated through the ICES Working Group of International Pelagic Surveys (WGIPS). Combined survey data on herring distribution, abundance and age are used to provide a measure of the relative abundance of herring within the Malin shelf stock complex. Survey data on stock numbers-at-age are submitted to the ICES Herring Assessment Working Group (HAWG) and used in the annual stock assessment process.

The northwest and west coast (ICES Divisions VIaS and VIIb) herring stock is composed of 2 of spawning components, autumn and winter spawners. Spawning covers a large geographical area and extends over a 4-month period from late September through to late March (Molloy *et al.*, 2000). Traditionally fishing effort has been concentrated on spawning and prespawning aggregations. The autumn spawning component, which mostly occurs within VIIb and VIaS, feeds along the shelf break area to the west of the spawning grounds. The winter spawning component is found further north in VIaS. In VIaS, summer distribution extends from close inshore to the shelf break. Components of winter spawning fish are known to undertake northward feeding migration into VIaN before returning in winter to spawn along the Irish coast.

Objectives

The primary survey objectives of the survey are listed below:

- Carry out a predetermined survey cruise track based on the known summer herring distribution
- Collect biological samples from directed trawling on fish echotraces to determine age structure and maturity state of survey stock
- Determine an age stratified estimate of relative abundance and biomass of herring within the survey area (ICES Divisions VIIb and VIaS-N) using acoustic survey techniques

- Collect physical oceanography data as horizontal and vertical profiles from a deployed sensor array.
- Perform interlaced co-surveyed areas with other participant survey vessel(s)
- Collect detailed morphometric data on individual herring to contribute to stock discrimination studies for SGHERWAY
- Conduct a sighting survey of marine mammals and seabirds encountered during the survey (IWDG)

2. SURVEY DESCRIPTION AND METHODS

2.1 Personnel

Organisation	Name	Capacity
FSS	Ciaran O'Donnell	Acoustics (SIC)
FSS	Eugene Mullins	Acoustics
FSS	Susan Beattie	Acoustics
GMIT	John Boyd	Acoustics
FSS	Mairead O'Sullivan	Biologist (Deck Sci)
FSS	Nigel Griffen	Biologist
FSS	Robert Bunn	Biologist
FSS	Michael McAuliffe	Biologist
IWDG	Laura Kavanagh	Marine Mammal Obs.

2.2 Survey design

The survey focused on the northwest and west coast of Ireland (ICES Divisions VIaS and VIaN and VIIb) as shown in Figure 1. The survey track commenced in the south and worked progressively northwards.

To keep in line with existing survey methodology (MarLab West of Scotland survey) acoustic surveying was only undertaken between 04:00 and 00:00 (daylight hours).

A systematic parallel transect design was adopted with a randomized start point. Transects were positioned running perpendicular to the lines of bathymetry where possible. Offshore, transects extended to the 250m depth contour and inshore to approximately the 30m depth contour. Transect spacing was set at 5nmi (nautical miles) in the main body of the survey and at 15nmi where transects were interlaced with the other vessels.

In total, the survey accounted for 2,004nmi (nautical miles), with 1,884nmi suitable for acoustic integration. Survey design and methodology adheres to the methods laid out in the PGHERS acoustic survey manual.

2.3 Calibration

The ER60 was calibrated in Killary Harbour on the 19 June at the start of the survey. The results of the calibration are presented in Table 1. Prior to this the ER60 was last calibrated in March 2010 (O'Donnell *et al.*, 2010).

2.4 Acoustic data collection

Equipment settings for the acoustic equipment were determined before the start of the survey program and were based on established settings employed by FSS on previous surveys (O'Donnell *et al.*, 2004). Equipment settings of the *Celtic Explorer* acoustic array are shown in Table 1.

Acoustic data were collected using the Simrad ER60 scientific echosounder. A Simrad ES-38B (38 KHz) split-beam transducer is mounted within the vessels drop keel and lowered to the working depth of 3.3m below the vessels hull or 8.8m below the sea surface. Three additional operating frequencies were used during the survey (18, 120 and 200kHz) for trace recognition purposes, with the 38KHz data used solely to generate the abundance estimate.

Whilst 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). Cruising speed is maintained at a maximum of 10 Kts (knots) where possible. During fishing operations normal 2 engine operations were employed to provide sufficient power to tow the net.

Acoustic data were observed and recorded onto the hard-drive of the processing unit using the equipment settings from previous surveys (Table 1). The "RAW files" were logged via a continuous Ethernet connection as "EK5" files 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 an external HDD and copied to DVD. Sonar Data's Echoview® Echolog (Version 4.2) 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 were recorded for each transect within each survey strata. This log was used to monitor the time spent off track during fishing operations and hydrographic stations plus any other important observations.

2.5 Biological data - fishing trawls

A single pelagic midwater trawl with the dimensions of 19m in length (LOA) and 6m at the wing ends and a fishing circle of 330m was employed during the survey (Figure 11). Mesh size in the wings was 1.6m through to 2cm in the codend. The net was fished with a vertical mouth opening of approximately 8m, 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 and length and weight measurements were taken for 100 individuals in addition to a 300 fish length frequency sample. Age, length, weight, sex and maturity data were recorded for individual herring within a random 100 fish sample from each trawl haul with a further 100 random length and weight measurements were also taken in addition to a 300 fish length frequency sample. 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 echotraces 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.

2.6 Hydrographic data

Oceanographic stations were carried out during the survey at predetermined locations along the track. Data on temperature, depth and salinity were collected using a Seabird 911 sampler from 1m subsurface to full depth (with a 2m safety offset).

2.7 Data analysis

Echogram scrutinisation

Acoustic data were backed up every 24 hrs and scrutinised using Sonar data's Echoview® (V 4.2) post-processing software. Partitioning of data into the above categories 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" echotraces or traces were identified on the basis of captures of herring from the fishing trawls which had sampled the echotraces 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 proximity to the seabed).

2. "Probably herring" were attributed to smaller echotraces 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 which had been carried out on similar echotraces in similar water depths.

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

The "EK5" files were imported into Echoview for echo 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 following TS/length relationships used were those recommended by the acoustic survey planning group (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)

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)

The same categories were applied to other target pelagic species encountered during the survey. Selection criteria are based primarily upon the species composition of trawl samples as well as target strength (TS) information.

Abundance estimates

Total abundance, N_T, is given by $\sum_{m}^{Mark-types} N_{T,m}$, the sum over the total abundance by mark-types.

$$N_{T,m} = \sum_{s}^{strata} N_{m,s}$$

Suppressing the mark-type index, m, the stratum abundance is

$$N_s = area_s \sum_{l}^{transects} \bar{n}_{s,t} l_{s,t} \Big/ \sum_{j} l_{s,j}$$

, where l is the transect length and $\bar{n}$ is the transect mean abundance n.mi^{-2} which is given by

$$\sum_{j}^{track\cdot fragments} n_{s,t,j} d_{s,t,j} \Big/ l_{s,t}$$

, where d is the distance of the track fragment and $n_{s,t,j}$ is the mean abundance n.mi^{-2} for the jth track fragment.

Because hauls are assigned with their own stratification that will not necessarily coincide with the acoustic strata, the conversion of NASC into mean density is done at the track fragment level, usually a 1 n.mi segment, but these could be just for the schools themselves. The haul assigned, $h_{m,s,t,j}$, depends strongly on the mark-type (m) and since more than one school can be in a track fragment it needs to be specified. Since age and maturity length-keys are to be applied, the basic estimation is mean density by length bins. The $n_{s,t,j}$ is found by summing over the $n_{s,t,j}$.

$$n_{t,j,i} = \frac{NASC_{t,j}}{\bar{\sigma}_{h_{m,t,j}}} p_{i,h_{m,t,j}}$$

, where i indices length bins, p_i is the proportion of herring in the i^{th} length bin, and is given by $\sum_{spe}^{species} \sum_{i} p_{spe,i} 10^{(a+b\log 10(L_{spe,i}))/10}$

, where $p_{spe,i}$ applies over all species considered in the haul, $L_{spe,i}$ is the length to use for the i^{th} length bin and the data comes from the haul (of combination of hauls) assigned, $h_{m,t,j}$. For non-mix mark-types, the later simplifies to

$$\sum_{i} p_{herring,i} 10^{(073+20\log 10(L_{herring,i}))/10} .$$

For biomass, a mean weight is also applied to the $n_{t,j,i}$ using the estimated regression relationship, a L_i^b.

For abundance by age and maturity, the abundance by length bin, $n_{t,j,i}$, is averaged over track fragments and then transects to give a strata (and mark-type) mean. The age and maturity keys are applied to the results.

$V_s = area_s^2 s_s^2 W_s$, where $W_s = \sum_{l}^{transects} l^2_{s,t} \Big/ (\sum_{j} l_{s,j})^2$ and s^2 is the sample variance.

The variance for the total is the sum of strata variances.

The total biomass can be obtained directly from the track fragment mean biomass by

$B_T = \sum_{k}^{track\cdot fragment} \overline{n}_k w_k$, where w_k is a factor that takes into account the factors for transect

and strata averaging, i.e. $w_k = \frac{1n.mi}{l_{t_k}} \frac{l_{t_k}}{\sum_{t}^{stratum.s_k} l_{s_k,t}} area_{s_k} = \frac{1}{\sum_{t}^{stratum.s_k} l_{s_k,t}} area_{s_k}$

, where the 1 n.mi is the length of the track fragment. This ignores the mark-type since that is already accounted for in the $\overline{n}_k$. The $\overline{n}_k w_k$ is the biomass from a track fragment and they can then be used to map the biomass at a fine spatial scale.

Estimates are made for SSB, total abundance and biomass, abundance by age (ring counts), and abundance by age x length bins. A cv (based on strata standard error divided by the strata mean) is estimated for SSB, total abundance and biomass, and abundance by age.

3. RESULTS

Twenty five hauls were carried out during the survey of which 16 contained herring (Figure 2, Table 2). Over 2,170 lengths, 1,545 length/weight measurements were taken in addition to the 935 individual herring that were aged during the survey. A total of 763 photographs and 660 additional otiliths collected for the Irish component of the SGHERWAY stock identification project.

3.1 Herring biomass and abundance

A full breakdown of the survey stock structure is presented by strata, age, length, biomass, abundance and area in Tables 4, 5 and 6 and Figures 3 and 4.

Herring	Abund (mils)	Biomass (t)	% contribution
Total estimate			
Definitely	371	54,201	28.1
Mixture	998	118,175	61.2
Probably	199	20,603	10.7
Total estimate	**1,568**	**192,979**	100
Possibly	17	2,772	
Possible estimate	1,585	195,751	
SSB Estimate			
Definelty	366	53,738	31.6
Mixture	639	97,536	57.3
Probably	175	18,880	11.1
SSB estimate	**1180**	**170,154**	100

3.2 Herring distribution

A full breakdown of school categorization, number and biomass by strata is provided in Table 9.

Reference to ICES divisions is relevant only to the statistical rectangles covered during the survey which were grouped for presentation purposes and should not be taken to represent the division as a whole.

Within VIIb, herring were found distributed as thin mixed species layers in close proximity to the bottom interspersed with several high density regions (Figure 6a). Together these mixed species layers covered a wide geographical area and provided a significant contribution to the overall VIIb biomass. Herring were most frequently encountered in waters ranging from 100–140m. In previous years (2008–2009) herring were observed at the shelf edge as large easily identifiable high density schools on or close to the bottom. Such shelf edge schools (180-250m) contained herring mixed with large (>300g) mackerel in various spawning states. During this survey herring were distributed in mixed layers with juvenile blue whiting and mackerel ranging from 150-300g and were located further inshore. Numerous high density surface feeding schools of mackerel and boarfish were also present in this area (Figures 5 and 6d-e). Herring within VIIb represented some of the largest individuals encountered during the survey ranging from 24-34cm with a mode of 29cm (Table 3).

In the southern area of VIaS low density mixed layers containing herring were observed near the shelf break and further inshore near traditional inshore spawning areas. Catches were often mixed with mackerel and juvenile blue whiting in deeper waters and juvenile mackerel further inshore. Single low density herring registrations were observed north of the Killala spawning grounds as in previous surveys.

Further north, single high density herring schools dominated and were observed in clusters to the east and west of the 09ºW and the 08ºW lines of latitude close inshore (Figure 3). Combined these areas contributed significantly to the VIaS biomass.

The largest contribution to the overall biomass recorded during the survey was distributed within the southern area of VIaN. Herring biomass was found composed of both single high density herring schools of mature fish and as mixed species high density scattering layers observed over several miles (Figure 6a). Biomass was distributed mainly in waters of 80–180m between 56º-57ºN. Juvenile herring (1-group) were well represented in catches to the east of 07ºW and so are prominent in the overall survey biomass (Figure 2, Table 3).

3.3 Stock structure

Age analysis of biological samples showed herring within the survey area to be composed of age from 1–9 years (winter rings), as shown in Figure 4 and Table 4.

The total-stock biomass (TSB) broken down by ICES division represents 57% (110,900t) in VIaN, 25% in VIaS (49,000t) and the remaining 17% (33,200) in VIIb. Overall, the stock age profile is dominated by 2-ring (29%), 1-ring (17%) and 3-ring (11%). In terms of abundance total stock numbers (TSN) proportions are 2-ring (32%), 1-ring (34%) and 3-ring (9%) as shown in Tables 5 and 6, Figure 4.

Taken individually, the age structure within each division is noticeably different. A total of 11 herring hauls and 935 aged herring were used to determine the age structure for the survey stock (Figure 2, Table 3).

Within the southern area of VIaN ages ranged from 1–9 rings and the age structure was dominated by the high proportion of 1 and 2-ring fish of the 2008–2007 year classes which represented 29% and 20% of the total biomass and 51% and 21% of the abundance. The third highest ranked age component is 5-ring (2005 year-class) which accounted for 11% of biomass and 6% of abundance.

In VIaS, ages ranged from 1–8-rings and were dominated by a high very proportion of 2-ring fish representing 60% of the total biomass and 66% of the abundance for this division. Three and 4-ring fish ranked second and third respectively contributing a much smaller proportion of 16% and 10% to the biomass and 14% and 8% to the abundance.

The northern area of VIIb was found to contain herring ranging from 2–9-rings and contained the highest relative contribution of older fish overall. Dominant age classes were ranked as 4, 5 and 3-rings representing 17%, 16% and 15% of the biomass and 18%, 15%, 17% of the abundance.

Combined maturity analysis indicates that 12% of the TSB is considered immature with a corresponding 25% of the TSN. In terms of biomass the SSB is 170,154t with a corresponding SSN of 1,180 million individuals. Maturity staging showed individuals from stage 1–4 and 8, with stage 2 and stage 8 as the most frequently encountered (Figure 4).

Overall, VIaN was found to contain the largest proportion of immature herring representing 20% of the biomass and 38% of the abundance for this area (Tables 6 and 7). Within VIaS and VIIb, which contained comparable biomass, proportions of immature fish were similar representing 1% of the total.

3.4 Secondary species

Boarfish (*Capros aper*) were encountered from 100–250m in two areas of distribution in the (Figure 5). The main area of abundance was located in the south and was characterized by numerous high density, near-surface schools occurring over a wide geographical area (Figure 6e). This area also contained the bulk of boarfish biomass in 2009 but not in the high abundance observed during this survey. Boarfish schools were distinctive in shape, density and depth profile and so were readily identified during the analysis. In the southern area a total of 323 boarfish schools were identified out of a survey total of 343, accounting for 89% of the TSB for this area (Table 10).

Overall 1,486 individual length measurements and 452 length/weight measurements were recorded from 6 hauls (Table 2). Length ranged from 10–17.5cm with a corresponding weight range of 28–121g. Mean length was 13.5cm and mean weight 54g.

Boarfish	Abund (mils)	Biomass (t)	% contribution
Total estimate			
Definitely	5,243	99,000	100
Mixture	-	-	0
Probably	-	-	0
Total estimate	5,243	99,000	100

Mackerel

Mackerel were the most commonly observed species on the survey and were found in 88% of hauls. Mackerel were distributed over the entire survey area as single species schools and as mixed species scattering layers. On shelf schools were composed of mixed size classes and tended towards smaller individuals (<25cm). Areas of very high abundance containing surface feeding schools were observed from 53º30–54º30N often occurring over several nautical miles (Figure 6d). Further offshore at the shelf break, larger spawning fish were encountered mainly as mixed species schools.

In total 1,209 individual lengths and 1,147 length/weight measurements were recorded for mackerel from 21 hauls. Length ranged from 21–41cm with a corresponding weight range of 111–549g. Mean length was 25.6cm and mean weight 146g.

3.5 Oceanography

A total 41 CTD casts were made during the survey (Figure 7). All data were compiled to produce horizontal plots of temperature and salinity at the following depths; 5m, 20m, 40m and 60m subsurface (Figures 8–11).

Comparing data from 2009 and 2010 both temperature and salinity are broadly similar. However, the widest range of data points was observed in 2010, where cooler and fresher waters are more visible (Figure 12). That said coastal waters to the west of Ireland appear more saline than last year and this may be due among others to the degree of influence of the Irish Shelf Front. The front is present year-round in this highly dynamic region and acts as a boundary region between coastal and oceanic waters further offshore. Largely defined by the 35.3 isohaline the frontal boundary is located around 11ºW and varies seasonally (McMahon *et al.*, 1995). The conditions observed during the survey would indicate the stronger influence of oceanic waters in coastal areas as compared to previous years.

Herring were actively feeding closer to the bottom in shallower waters as compared to previous years where more surface feeding was encountered. Herring distribution overlapped with cooler more saline waters. Conditions at the shelf edge appeared slightly warmer than those recorded on shelf and this may have influenced the distribution of herring. Normally prominent high density shelf edge schools in the south were found closer to shore than in previous years and spread thinly over a wide geographical area.

The prominence of the Islay Front is again evident in 2010 with influence noticeable to a depth of 60m plus (Figure 11).

3.6 Marine mammal and seabird survey

Marine mammals

Eighty five hours of survey time were logged, with 60 hours (70.6%) at Beaufort Sea state three or less, 19 hours (22.4%) at sea state four and 6 hours (7%) at sea state five or higher.

Fifteen sightings were recorded, of at least four cetacean species and one species of elasmobranch totalling one hundred and twelve individual animals (Figure 15). Six sightings, totalling nineteen animals were made outside logged hours.

Identified cetacean species included common dolphin (*Delphinus delphis*), bottlenose dolphin (*Tursiops truncatus*), white-beaked dolphin (*Lagenorhynchus albirostris*) and minke whale (*Balaenoptera acutorostrata*) as shown in Table 12.

The identified species of elasmobranch was the basking shark (*Cetorhinus maximus*); a large male (7m+) was taken as bycatch at the surface during trawling, outside logged hours (Figure 16). The animal was released alive but unfortunately injured although every effort was made to release the animal unharmed. A sample of the sharks mucous was taken for future genetic analysis.

One group of dolphins and one whale sighted together, outside logged hours, could not be identified as they were observed too briefly in rough conditions (Beaufort Sea state 6+ and heavy swells).

Common dolphins were the most commonly encountered and abundant species recorded during the survey. Minke whale was the only species of whale encountered.

Environmental conditions

Environmental data were collected at 394 stations. Beaufort Sea state was recorded at ≤ 3 at 70.3% of the environmental stations and at ≥ 4 at 29.7% of the stations. Visibility of ≤ 5km was recorded at 1.3% of the stations, 6 – 10km at 15% of the stations, 11 – 15km at 92% of the stations, and at 16 – 20km+ at 71.5% of the stations. No swell was recorded at 41.1% of the stations, a light swell of 0 – 1m was recorded at 49.5%, a moderate swell of 1 – 2m at 5.6% and a heavy swell of 2m+ at 3.8% of the stations. No precipitation was recorded at 98% of the stations, with rainfall recorded at 2% of the stations.

Five and a half survey days were lost due to bad weather (sea state 6+, heavy swell of 2m+ and low visibility ≤ 500m) and one half day was lost while the ship anchored at Killary for calibration of equipment.

Seabird activity

Daily species lists were made of all bird species observed on and around the survey vessel. Fifteen species of bird were observed during the survey (Figure 17).

Barn swallow (*Hirundo rustica),* Collared dove (*Streptopelia decaocto),* Fulmar (*Fulmarus glacialis),* Gannet (*Morus bassanus),* Great black backed gull (*Larus marinus),* Great skua (*Stercirarius skua),* Guillemot (*Uria aalge),* Herring gull (*Larus argentatus),* Kittiwake (*Rissa tridactyla),* Lesser black backed gull (*Larus fuscus graellsii),* Manx shearwater (*Puffinus puffinus),* Puffin (*Fratercula arctica*), Razorbill (*Alca torda*), Shag (*Phalacrocorax aristotelis*), Storm petrel (*Hydrobates pelagicus).*

4. DISCUSSION AND CONCLUSIONS

4.1 Discussion

Overall, the survey can be considered a success with all components of the work program completed as planned. A total of 163nmi was dropped from the original survey design. Of this 93nmi occurred in the northern channel, an area that was to be co-surveyed with the RV *Corystes*. However, due to the significant time-lag between vessels (9 days) effort was reallocated further north. The remaining 70nmi of track was dropped in the northern extreme due to time allowances caused by poor weather and trawl gear damage.

Within divisions VIaS and VIIb detected biomass increased by 4% from 2008–2009 and by 77% from 2009–2010 for comparable area coverage, timing and transect spacing. The estimate of abundance should be considered as robust due to the high level of ground coverage and trawling achieved in areas of high herring abundance especially regarding mixed species layers. The survey derived age profile closely resembles that observed from commercial sampling and has successfully tracked the progress of the strong 2008 year-class. That said the VIIb the estimate may be an underestimate, though not considered large, due to uncertainties in whether the stock was fully contained within the southern limit.

In 2010 area coverage increased by approximately 5,000nmi^2 (to 14,600nmi^2) from previous years due to extension into VIaN. Over 57% of the TSB for the survey was located within VIaN in an area co-surveyed with the Scottish vessel. Both vessels showed good temporal and spatial alignment and trawling was undertaken to ensure a high degree of precision and area coverage. At the time of writing the results from the Scottish survey were not available for comparison.

Herring distribution was generally observed as numerous low/medium/high density registrations carpeted over a wide geographical area. The presence of cooler, more saline water on self may have influenced distribution over a wider area than normally observed. This carpeting effect when combined with high transect resolution would increase survey precision by increasing the 'hit' rate and reduced number of zero data points per ESDU. Overall, the level of precision of the estimate is considered good as reflected by the CV estimate of 25% which slightly lower than previous years.

4.2 Conclusions

Acoustically derived estimates of abundance are used as a relative index of abundance or 'snapshot' of the stock present within the survey area at the time of surveying. Variations between successive estimates are not uncommon and where possible sources of variation such as timing, area coverage and transect spacing are fixed. That said numerous biotic and abiotic factors no doubt heavily influence the distribution and feeding behaviour of herring.

Although significantly larger than previous estimates the survey findings can be considered robust due to high levels of sampling, high resolution coverage and duel-vessel coverage in areas of highest abundance.

References/Bibliography

Anon. (1994). Report of the planning group for herring surveys. *ICES C.M. 1994/H:3.*

Anon. (2002) Underwater noise of research vessels. Review and recommendations. 2002. *ICES No. 209.*

Anon (2003) Report of the Planning Group for Herring Surveys, *ICES CM 2003/G:03*, Aberdeen, UK.

Dalen, J., and Nakken, O. (1983) "On the application of the echo integration method" *ICES CM 1983/B:19.*

Foote, K.G. (1987). Fish target strengths for use in echo integrator surveys. *J. Acoust. Soc. Am.* 82: 981–987.

Foote, K.G., Knudsen, H.P., Vestnes, G., MacLennan, D.N. and Simmonds, E.J. (1987). Calibration of acoustic instruments for fish density estimation: a practical guide. *Int. Coun. Explor. Sea. Coop. Res. Rep.* 144: 57 pp.

Landry J, McQuinn IH (1988) Guide d'identification microscopique et macroscopique des stades de maturité sexuelle du hereng de l'Atlantique (*Clupes harengus harengus* L.). *Rapp. Tech. Can. Sci. Halieut. Aquat. 1655.*

McMahon, T., Raine, R., Titov, O and Boychuk, S. (1995). Some oceanographic features of northeastern Atlantic waters west of Ireland. *ICES Journal Marine Science. 52: 221–232.*

Molloy, J., Kelly, C., and Mullins E. (2000). Herring in VIaS and VIIb,c. A review of biological information. Report on findings of a workshop between scientists and fishermen. Killybegs Fishermen's Organization.

O'Donnell, C., Griffin, K., Mullins, E., Egan, A., Smith, T. and Bunn. (2004), R. Northwest Herring Acoustic Survey Cruise Report, 2004.

O'Donnell, C., Saunders, R., Lynch, D., Mullins, E., Lyons, K., Wragg, O., Smith, T., Hoare, D., and Blaszokowski, M. (2008) Northwest Herring Acoustic Survey Cruise Report, 2008.

O'Donnell, C., Mullins, E, Johnston, G., Saunders, R., Beattie, S., McCann, K., Lyons, K., Brkic, Z and O'Leary, L. (2009) Blue whiting acoustic survey cruise report, 2009.

O'Donnell, C., Mullins, E, Johnston, G., Saunders, R., Lyons, K., Beattie, S., McCann, K. and Jorgan Pihl, N. (2010) Blue whiting acoustic survey cruise report, 2010.

Table 1. Survey settings and calibration report (38kHz) for the Simrad ER60 echosounder. North-west herring survey, June 2010.

Echo Sounder System Calibration

Vessel :	R/V Celtic Explorer	Date :	19/06/2010
Echo sounder :	ER60 PC	Locality :	Killary Harbour
Type of Sphere : WC-38,1	TS_{Sphere}: -33.50 dB (Corrected for soundvelocity or t,S)	Depth(Sea floor) :	32 m

Calibration Version 2.1.0.11

Comments:
19.06.10

Reference Target:

TS	-33.50 dB	Min. Distance	15.00 m
TS Deviation	5 dB	Max. Distance	25.00 m

Transducer: ES38B Serial No. 30227

Frequency	38000 Hz	Beamtype	Split
Gain	25.84 dB	Two Way Beam Angle	-20.6 dB
Athw. Angle Sens.	21.90	Along. Angle Sens.	21.90
Athw. Beam Angle	7.04 deg	Along. Beam Angle	6.99 deg
Athw. Offset Angle	- 0.03 deg	Along. Offset Angl	-0.07 deg
SaCorrection	-0.69 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 2.2.0

TS Detection:

Min. Value	-50.0 dB	Min. Spacing	100 %
Max. Beam Comp.	6.0 dB	Min. Echolength	80 %
Max. Phase Dev.	8.0	Max. Echolength	180 %

Environment:

Absorption Coeff.	9.3 dB/km	Sound Velocity	1502.4 m/s

Beam Model results:

Transducer Gain =	25.94 dB	SaCorrection =	-0.63 dB
Athw. Beam Angle =	6.68 deg	Along. Beam Angle =	6.77 deg
Athw. Offset Angle =	-0.11 deg	Along. Offset Angle=	-0.08 deg

Data deviation from beam model:
RMS = 0.23 dB
Max = 0.51 dB No. = 53 Athw. = -2.9 deg Along = -2.8 deg
Min = -0.83 dB No. = 302 Athw. = -4.0 deg Along = 2.6 deg

Data deviation from polynomial model:
RMS = 0.20 dB
Max = 0.74 dB No. = 113 Athw. = -4.6 deg Along = 1.2 deg
Min = -0.77 dB No. = 302 Athw. = -4.0 deg Along = 2.6 deg

Comments :
Flat calm conditions
Wind Force : 8 kn. **Wind Direction :** S (180 degrees)
Raw Data File: \\Expfileclstr\ER-60_Data\NWHAS_2010\RAW ER60 Files\Calibration\NWHAS_Mar_2010-D20070328-T135915.raw
Calibration File: \\Expfileclstr\ER-60_Data\ER-60\Calibrations_2010\NWHAS 2010\38 KHZ

Calibration : Ciaran O'Donnell

Table 2. Catch composition and position of hauls undertaken by the RV *Celtic Explorer*. Northwest herring survey, June 2010.

No.	Date	Lat. N	Lon. W	Time	Bottom (m)	Target (m)	Bulk Catch (Kg)	Herring %	Mackerel %	Scad %	Boarfish %	Others^ %
1	19.06.10	53 32.27	010 59.55	20:58	135	80	15.0		16.0		0.6	83.4
2	20.06.10	53 32.50	011 53.59	06:10	280	65	2000.0		1.0	1.0	97.9	0.1
3	20.06.10	53 37.49	010 45.52	12:40	115	0	80.0	12.6				87.4
4	20.06.10	53 42.44	010 56.43	19:43	154	134	1500.0		3.6	0.1	92.0	4.3
5	21.06.10	53 47.44	010 52.57	09:25	158	10	1800.0	2.4	7.4			91.2
6	22.06.10	54 02.28	011 07.95	10:45	226	3	400.0		1.8			98.2
7	22.06.10	54 12.39	010 41.92	20:42	181	0	168.0	2.2	42.2			55.6
8*	23.06.10	54 26.59	008 46.86	18:25	62	0	0.0					
9	24.06.10	54 32.34	010 28.23	07:44	138	0	181.5	1.8	21.0			77.2
10*	24.06.10	54 32.11	009 02.61	16:30	70	60	12.0		100.0			
11	25.06.10	54 42.19	010 18.36	10:15	116	0	200.0	0.2	11.8		87.0	1.0
12	25.06.10	54 42.20	009 14.20	15:45	93	0	200.0	7.9	27.6			64.5
13	26.06.10	54 52.09	010 07.77	06:35	118	10	1000.0		12.4		87.4	0.2
14	26.06.10	54 52.20	009 02.11	12:10	72	0	1.4	6.5	56.7			36.8
15	26.06.10	54 57.17	008 59.64	17:00	75	8	6000.0	97.7	2.3			
16	27.06.10	55 06.84	008 47.00	12:20	83	0	8.7	10.8	85.0			4.2
17	27.06.10	55 06.98	009 48.33	19:55	113	0	63.0		73.1		26.0	0.9
18	28.06.10	55 14.52	008 04.24	10:30	45	0	3000.0	44.1	55.9			
19	29.06.10	55 21.70	007 55.01	09:55	61	0	1200.0	99.4	0.5			
20	30.06.10	55.31.88	007.46.43	11:05	60	0	2.0	3.3	23.9			72.8
21	01.07.10	56.01.98	007.45.75	20:07	135	0	56.5	79.8	16.1			5.1
22	02.07.10	56.17.11	006.47.28	10:15	69	66	185.0	53.8	20.3			25.9
23	02.07.10	56 16.39	007 30.87	15:34	138	5	750.0	6.8	9.9			83.3
24	03.07.10	56 31.92	008 11.18	12:05	161	0	500.0	98.8				1.2
25*	03.07.10	56 31.91	007 40.65	16:35	173	0	0.0					

*** Indicates target schools not represented in the catch. ^ Includes non target demersal species and other taxa.**

Table 3. Length frequency of herring hauls used in the analysis. Northwest herring survey, June 2010.

Haul #	3	5	7	9	15	18	19	21	22	23	24
Division	VIIb	VIIb	VIIb	VIIb*	VIaS	VIaS	VIaS	VIaN	VIaN	VIaN	VIaN
Length (cm)											
16									2		
16.5									3		
17									5		
17.5									14		
18									23		
18.5									29	1	
19								2	15	3	
19.5						2		3	7	8	
20						5		10	1	23	
20.5					1	6		11		19	
21						13	1	14		11	
21.5						9	3	12		5	
22					2	14	9	9		7	
22.5					7	12	13	9		2	
23					14	9	9	7		3	
23.5					11	9	21	5		7	1
24	3				27	6	15	5		5	1
24.5	4				8	6	10	7		2	1
25	1	4			8	4	8	1			
25.5	7				7	3	4	1			
26	8			6	7	2	1	1		1	1
26.5	8			6	1	1	1				1
27	15			6	1	1	1				5
27.5	8	8		28	1		1				11
28	11	4	6	22	2		1			1	12
28.5	7	8	12	11							16
29	11	36	24	17						1	19
29.5	4	20	18	6						1	17
30	11	16	24								9
30.5		4									3
31			6								1
31.5	1										
32											
32.5											
33			6								
33.5	3										
34			6								
34.5											

* Haul located in VIaS border but age profile more similar to VIIb

Table 4. Herring length-at-age (winter rings) as abundance (millions) and biomass (000's tonnes). Northwest herring survey, June 2010.

Length	Age (Rings)											Abundance	Biomass	Mn wt
(cm)	0	1	2	3	4	5	6	7	8	9	10	(millions)	000's t	(g)
16		5.8										5.84	0.21	36.2
16.5		8.8										8.76	0.35	39.7
17		16										16.06	0.7	43.4
17.5		42										42.33	2	47.3
18		69										68.61	3.53	51.5
18.5		89										89.01	4.97	55.9
19		56										55.52	3.36	60.5
19.5		45										45.2	2.96	65.4
20		68	5.3									73.19	5.17	70.6
20.5		65	2.7									67.68	5.14	76
21		33	27									60.13	4.91	81.7
21.5		16	31									47	4.12	87.7
22		6.4	50									56.2	5.28	94
22.5		4.8	58	1.6								64.41	6.47	100.5
23		1.1	68	2.3								70.98	7.62	107.4
23.5			81	2.6								83.86	9.61	114.6
24			93	21								114.69	14	122
24.5			47	15								61.19	7.95	129.8
25			21	7	7							34.86	4.81	138
25.5			12	11	8.9							31.84	4.66	146.4
26			7.4	13	9.2	7.4						36.74	5.7	155.3
26.5				7.3	8.2	3.6				0.9		19.97	3.28	164.4
27				9.8	22	2	2					35.33	6.15	173.9
27.5				13	23	19		3.9				59.58	10.95	183.8
28				21	13	17	7.6	3.8				62.87	12.2	194.1
28.5				7.9	6.6	13	18	7.9	2.7			56.69	11.6	204.7
29				1.2	2.5	22	28	12	9.8	6.2		82.42	17.78	215.7
29.5					2.7	14	15	14	11	4		59.39	13.49	227.1
30					4.6	3.5	5.7	15	8	3.5		40.06	9.57	238.9
30.5						1.3	5.3	1.3	1.3			9.36	2.35	251.1
31										2.9		2.9	0.77	263.7
31.5							1.2					1.16	0.32	276.7
32												0.0	0.0	0.0
32.5												0.0	0.0	0.0
33							0.4					0.35	0.11	318.4
33.5									2.3			2.31	0.77	333.2
34									0.4			0.35	0.12	348.4
SSN		152	496	133	106	102	84	57	35	15		**1179.14**		
SSB		12	55	21	19	21	18	13	8.2	3.2			**170.1**	
Mn wt (g)		63	111	158	179	201	218	220	234	228				
Mn L (cm)		19	23	26	27	29	29	29	30	30				

Table 5. Herring biomass (000's tonnes) at age (winter rings) by strata and ICES division.

Strata	0	1	2	3	4	5	6	7	8	9	10	Total
D9 36	0	0	0.9	2.2	2.8	2	1.8	1.3	1.3	0.4	0	12.7
D8 36	0	0	0.4	1	1.4	1.9	2	1.5	1.1	0.4	0	9.8
D8 37	0	0	0	0	0	0	0	0	0	0	0	0
D9 37	0	0	0	0.4	0.5	0.6	0.6	0.4	0.3	0.2	0	3
E0 37	0	0.1	2.9	1.2	0.9	0.7	0.4	0.2	0.1	0	0	6.5
E1 37	0	0	0.8	0.2	0.1	0	0	0	0	0	0	1.2
E1 38	0	0	0.3	0.1	0	0	0	0	0	0	0	0.5
E0 38	0	0.2	10	3.1	1.8	1	0.3	0.2	0.1	0	0	16.7
D9 38	0	0	0	1.1	1.2	1.4	0.8	0.5	0.2	0.1	0	5.3
E0 39	0	0	0.5	0.1	0.1	0	0	0	0	0	0	0.8
E1 39	0	0.6	6.7	1.6	0.9	0.3	0	0	0	0	0	10.1
E2 39	0	0.3	6.4	1.1	0.6	0.2	0	0	0	0	0	8.5
E3 40	0	0	0.9	0.2	0.1	0	0	0	0	0	0	1.2
E2 40	0	0.2	4.1	0.7	0.4	0.1	0	0	0	0	0	5.4
E1 40	0	0	0.3	0	0	0	0	0	0	0	0	0.4
E0 40	0	0	0	0	0	0	0	0	0	0	0	0
E0 41	0	0	0	0	0	0	0	0	0	0	0	0
E1 41	0	5	9.7	2	1.6	2.1	2	1.5	0.9	0.5	0	25.2
E2 41	0	9.5	10	1	0.3	0.3	0.2	0.2	0.1	0.1	0	21.7
E3 41	0	15.2	0	0	0	0	0	0	0	0	0	15.2
E2 42	0	2	1.5	2.3	2.8	4.4	4.4	3.1	1.8	1	0	23.2
E1 42	0	0	0.6	2.8	3.6	5.5	5.6	3.9	2.3	1.3	0	25.6
Total	0	33.1	56.0	21.0	19.2	20.7	18.2	12.7	8.3	4.0	0.0	193.0
TSB %	0	17.1	29.0	10.9	9.9	10.7	9.4	6.6	4.3	2.1	0.0	100.0
VIaN	0.0	28.6	19.7	7.3	7.5	11.1	11.0	7.8	4.6	2.6	0.0	100.0
VIaS	0.0	2.7	59.7	16.4	10.4	6.1	2.2	1.4	0.6	0.2	0.0	100.0
VIIb	0.0	0.3	15.1	15.1	17.2	15.7	14.5	10.2	8.4	3.0	0.0	100.0

Table 6. Herring abundance (millions) at age (winter rings), by strata and ICES division.

Strata	0	1	2	3	4	5	6	7	8	9	10	Total
D9 36	0.0	0.0	6.7	13.2	15.8	10.4	8.0	5.8	4.8	1.6	0.0	66.3
D8 36	0.0	0.0	2.9	5.9	7.8	9.1	9.1	6.6	4.7	1.9	0.0	47.9
D8 37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D9 37	0.0	0.0	0.1	2.0	2.5	3.1	2.7	1.8	1.3	0.8	0.0	14.3
E0 37	0.0	0.8	24.2	8.0	5.5	3.9	1.7	1.0	0.4	0.2	0.0	45.8
E1 37	0.0	0.2	6.7	1.6	0.7	0.3	0.0	0.0	0.0	0.0	0.0	9.6
E1 38	0.0	0.1	2.8	0.7	0.3	0.1	0.0	0.0	0.0	0.0	0.0	4.0
E0 38	0.0	2.7	84.0	21.4	11.4	5.6	1.6	1.0	0.3	0.2	0.0	128.3
D9 38	0.0	0.0	0.3	5.8	6.7	7.1	3.8	2.3	1.0	0.5	0.0	27.5
E0 39	0.0	0.1	4.2	1.0	0.5	0.2	0.0	0.0	0.0	0.0	0.0	6.0
E1 39	0.0	7.1	58.3	11.5	5.5	1.9	0.2	0.1	0.0	0.0	0.0	84.7
E2 39	0.0	3.0	56.5	8.0	3.6	0.9	0.1	0.1	0.0	0.0	0.0	72.2
E3 40	0.0	0.4	8.0	1.1	0.5	0.1	0.0	0.0	0.0	0.0	0.0	10.2
E2 40	0.0	1.9	35.8	5.1	2.3	0.6	0.1	0.1	0.0	0.0	0.0	45.8
E1 40	0.0	0.1	2.3	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	3.0
E0 40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E0 41	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E1 41	0.0	65.3	94.0	13.0	8.9	10.3	9.4	6.5	3.9	2.0	0.0	213.1
E2 41	0.0	129.8	98.5	7.5	1.8	1.6	1.1	0.7	0.5	0.2	0.0	241.8
E3 41	0.0	281.8	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	282.1
E2 42	0.0	31.1	13.6	12.4	14.8	21.2	20.3	13.8	8.2	4.3	0.0	139.6
E1 42	0.0	0.4	5.0	15.0	18.7	26.7	25.7	17.5	10.3	5.5	0.0	124.8
Total	0.0	524.8	504.3	133.3	107.4	103.0	83.7	57.6	35.3	17.5	0.0	1566.8
TSN %	0.0	33.5	32.2	8.5	6.9	6.6	5.3	3.7	2.3	1.1	0.0	100.0
Cv (%)	NA	67	25.6	25	30	35.3	40.2	40	40.5	40.7	NA	NA
VIaN	0.0	50.8	21.1	4.8	4.4	6.0	5.6	3.9	2.3	1.2	0.0	100.0
VIaS	0.0	4.1	66.1	14.4	8.1	4.3	1.5	1.0	0.3	0.2	0.0	100.0
VIIb	0.0	0.5	22.1	16.6	17.6	14.6	11.7	8.3	6.1	2.5	0.0	100.0

Table 7. Herring biomass (000's tonnes) at maturity by strata and ICES division.

Strata	Imm	Mature	Spent	Total
D9 36	0.1	12.6	0	12.7
D8 36	0	9.7	0	9.8
D8 37	0	0	0	0
D9 37	0	3	0	3
E0 37	0.1	6.5	0	6.5
E1 37	0	1.2	0	1.2
E1 38	0	0.5	0	0.5
E0 38	0.1	16.6	0	16.7
D9 38	0.1	5.2	0	5.3
E0 39	0	0.8	0	0.8
E1 39	0.2	9.9	0	10.1
E2 39	0.1	8.5	0	8.5
E3 40	0	1.2	0	1.2
E2 40	0	5.4	0	5.4
E1 40	0	0.4	0	0.4
E0 40	0	0	0	0
E0 41	0	0	0	0
E1 41	1.9	23.3	0	25.2
E2 41	4.2	17.4	0	21.7
E3 41	14.4	0.8	0	15.2
E2 42	1.4	21.8	0	23.2
E1 42	0.2	25.4	0	25.6
Total	22.8	170.2	0.0	193.0
TSB %	11.8	88.2	0.0	100.0
VIaN	19.9	80.1	0.0	100.0
VIaS	1.0	99.0	0.0	100.0
VIIb	0.6	99.4	0.0	100.0

Table 8. Herring abundance (millions) at maturity by strata and ICES division.

Strata	Imm	Mature	Spent	Total
D9 36	0.4	66.0	0.0	66.3
D8 36	0.3	47.6	0.0	47.9
D8 37	0.0	0.0	0.0	0.0
D9 37	0.2	14.1	0.0	14.3
E0 37	0.4	45.3	0.0	45.8
E1 37	0.1	9.5	0.0	9.6
E1 38	0.0	4.0	0.0	4.0
E0 38	1.0	127.3	0.0	128.3
D9 38	0.5	27.0	0.0	27.5
E0 39	0.0	6.0	0.0	6.0
E1 39	2.2	82.4	0.0	84.7
E2 39	0.6	71.6	0.0	72.2
E3 40	0.1	10.2	0.0	10.2
E2 40	0.4	45.4	0.0	45.8
E1 40	0.0	3.0	0.0	3.0
E0 40	0.0	0.0	0.0	0.0
E0 41	0.0	0.0	0.0	0.0
E1 41	25.3	187.8	0.0	213.1
E2 41	61.5	180.3	0.0	241.8
E3 41	270.6	11.5	0.0	282.1
E2 42	22.4	117.1	0.0	139.6
E1 42	1.0	123.7	0.0	124.8
Total	387.0	1179.8	0.0	1566.8
TSN %	24.7	75.3	0.0	100.0
VIaN	38.0	62.0	0.0	100.0
VIaS	1.3	98.7	0.0	100.0
VIIb	0.7	99.3	0.0	100.0

Table 9. Herring biomass and abundance by survey strata. Northwest herring survey, June 2010.

Category Stratum	No. transects	No. schools	Def schools	Mix schools	Prob schools	% zeros	Def Biomass	Mix Biomass	Prob Biomass	Biomass (000's t)	SSB (000's t)	Abundance millions
D9 36	6	12	0	11	1	67	0	12.4	0.3	12.7	12.6	66.3
D8 36	6	21	0	21	0	67	0	9.8	0	9.8	9.7	47.9
D8 37	2	0	0	0	0	100	0	0	0	0	0	0.0
D9 37	6	24	1	20	3	17	0	2.5	0.5	3	3	14.3
E0 37	2	27	1	21	5	0	0.1	5.7	0.7	6.5	6.5	45.8
E1 37	2	7	1	6	0	0	0.2	1	0	1.2	1.2	9.6
E1 38	6	6	1	0	5	50	0.3	0	0.2	0.5	0.5	4.0
E0 38	6	46	5	30	11	17	8.4	7.1	1.2	16.8	16.6	128.3
D9 38	6	27	8	19	0	33	0.3	5	0	5.3	5.2	27.5
E0 39	6	5	2	2	1	67	0.5	0.1	0.1	0.8	0.8	6.0
E1 39	6	19	15	1	3	33	9.8	0.1	0.3	10.1	9.9	84.7
E2 39	3	18	12	4	2	0	6.9	1.4	0.1	8.5	8.5	72.2
E3 40	2	6	0	0	6	50	0	0	1.2	1.2	1.2	10.2
E2 40	2	6	4	0	2	50	5.1	0	0.4	5.4	5.4	45.8
E1 40	2	2	0	0	2	50	0	0	0.4	0.4	0.4	3.0
E0 40	2	0	0	0	0	100	0	0	0	0	0	0.0
E0 41	2	0	0	0	0	100	0	0	0	0	0	0.0
E1 41	2	12	0	10	2	0	0	9.9	15.3	25.2	23.3	213.1
E2 41	2	25	0	25	0	0	0	21.7	0	21.7	17.4	241.8
E3 41	2	6	0	6	0	50	0	15.2	0	15.2	0.8	282.1
E2 42	2	10	0	10	0	50	0	23.2	0	23.2	21.8	139.6
E1 42	2	43	17	26	0	0	22.5	3	0	25.6	25.4	124.8
Total	77	322	67	212	43	42	54.2	118.2	20.6	193	170.2	1566.8
Cv (%)	-	-	-	-	-	-	-	-	-	24.4	24.7	28.8

Table 10. Boarfish biomass and abundance by survey strata. Northwest herring survey, June 2010.

Category Stratum	No. transects	No. schools	Def schools	Mix schools	Prob schools	% zeros	Def Biomass	Mix Biomass	Prob Biomass	Biomass (000's t)	Abundance millions
D9 36	6	65	65	0	0	0	16.3	0	0	16.3	898.9
D8 36	6	149	149	0	0	0	46.4	0	0	46.4	2476.4
D8 37	2	17	17	0	0	50	7.6	0	0	7.6	421.1
D9 37	6	92	92	0	0	17	18.1	0	0	18.1	919.9
E0 37	2	0	0	0	0	100	0	0	0	0	0.0
E1 37	2	0	0	0	0	100	0	0	0	0	0.0
E1 38	6	0	0	0	0	100	0	0	0	0	0.0
E0 38	6	0	0	0	0	100	0	0	0	0	0.0
D9 38	6	0	0	0	0	100	0	0	0	0	0.0
E0 39	6	0	0	0	0	100	0	0	0	0	0.0
E1 39	6	0	0	0	0	100	0	0	0	0	0.0
E2 39	3	0	0	0	0	100	0	0	0	0	0.0
E3 40	2	0	0	0	0	100	0	0	0	0	0.0
E2 40	2	0	0	0	0	50	0	0	0	0	0.0
E1 40	2	10	10	0	0	50	1.4	0	0	1.4	68.5
E0 40	2	0	0	0	0	100	0	0	0	0	0.0
E0 41	2	0	0	0	0	100	0	0	0	0	0.0
E1 41	2	0	0	0	0	100	0	0	0	0	0.0
E2 41	2	0	0	0	0	100	0	0	0	0	0.0
E3 41	2	0	0	0	0	100	0	0	0	0	0.0
E2 42	2	0	0	0	0	100	0	0	0	0	0.0
E1 42	2	10	10	0	0	50	9.2	0	0	9.2	458.4
Total	77	343	343	0	0	70	99	0	0	99	5243.2
Cv (%)	-	-	-	-	-	-	-	-	-	16	16

Table 11. Historical survey time series. Abundance (millions), TSB and SSB (tonnes), age in winter rings. Northwest herring survey, June 2010.

Winter rings	2008^	2009^	2010^	2010*
0	-	-	-	-
1	6.1	416.4	16.5	524.8
2	75.9	81.3	292.8	504.3
3	64.7	11.4	85.2	133.3
4	38.4	15.1	63.2	107.4
5	22.3	7.7	43.2	103.0
6	26.2	7.1	27.3	83.7
7	9.1	7.5	19.0	57.6
8	5.0	0.4	12.5	35.3
9	3.7	0.9	5.5	17.5
10+	-	-	-	-
TSN (mil)	251.4	547.7	565.2	1,566.9
TSB (t)	44,611	46,460	82,100	192,979
SSB (t)	43,006	20,906	81,400	170,154
CV	34.2	32.2	-	24.7

^ Survey coverage: VIaS & VIIb

* Survey coverage: VIaS, VIaN & VIIb

Table 12. Sightings, counts and group size ranges for cetaceans sighted during the survey.

Species	No. of Sightings	No. of Individuals	Range of Group Size
Common dolphin	7	70	4 – 20
Bottlenose dolphin	1	20	20
White-beaked dolphin	2	15	7 – 8
Minke whale	2	2	1
Basking shark	1	1	1
Unidentified dolphin	1	3	3
Unidentified whale	1	1	1

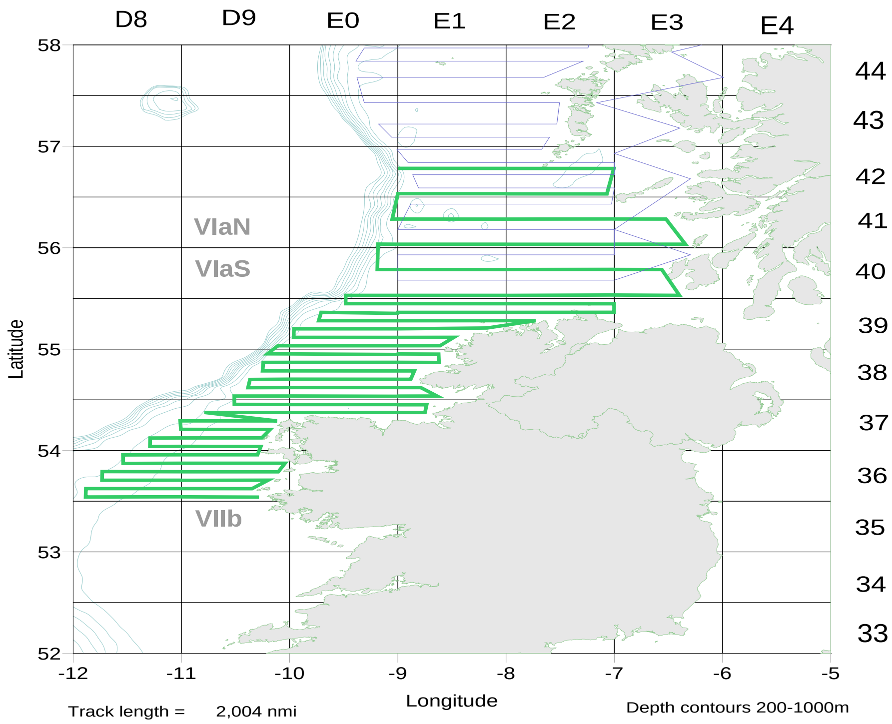


Figure 1. RV "Celtic Explorer" cruise track (green) showing interlacing transects with the Scottish vessel (blue). Northwest herring survey, June 2010.

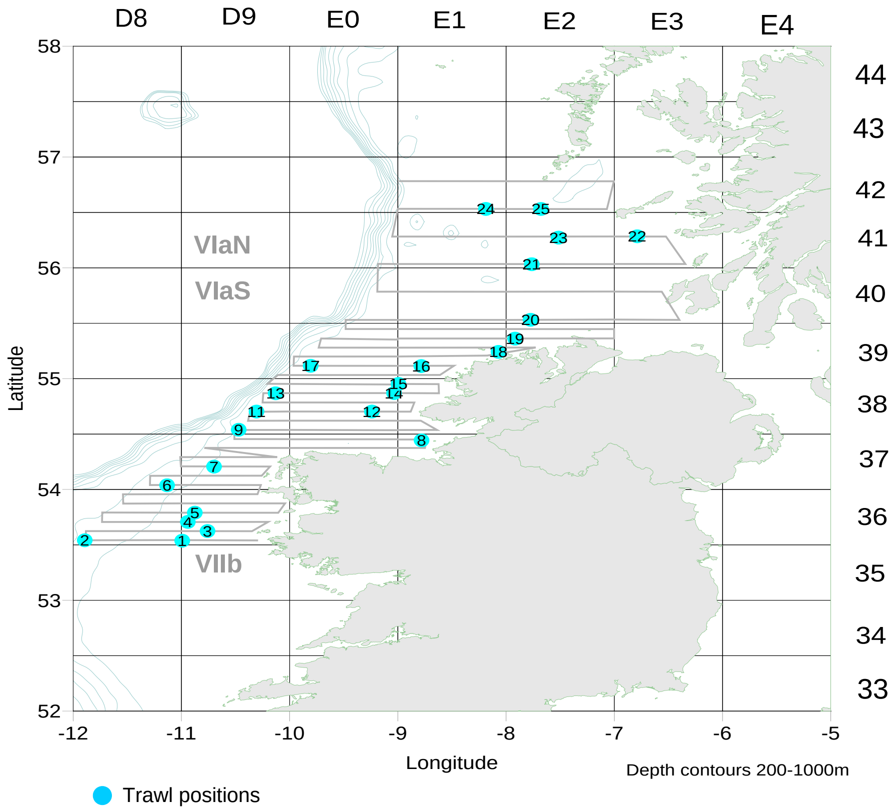


Figure 2. RV "Celtic Explorer" trawl stations. Northwest herring survey, June 2010.

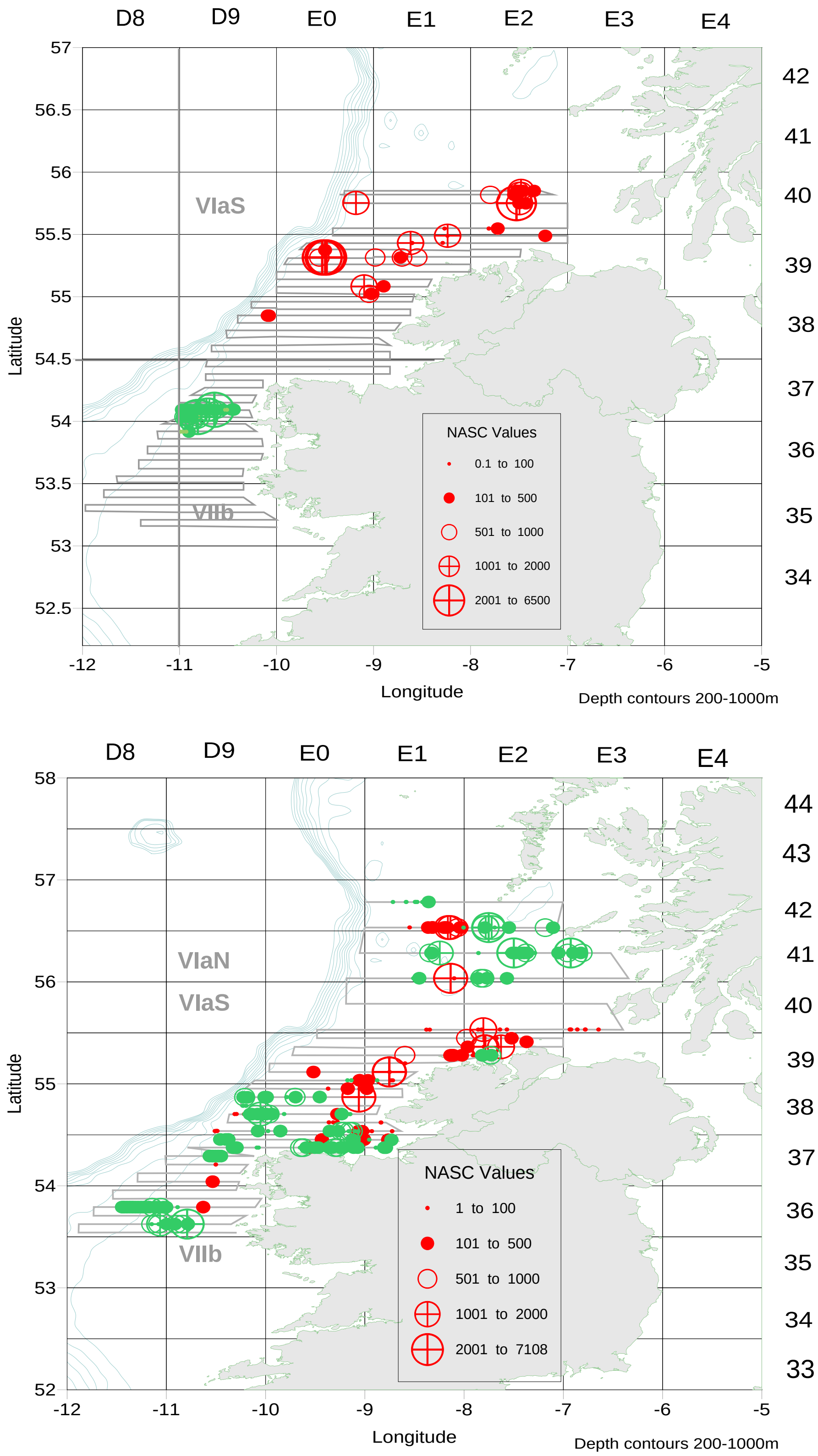


Figure 3. NASC plot of herring distribution. Top panel 2009 survey, bottom panel 2010 survey. Circle size proportional to NASC value. Red circles represent single herring schools, green circles represent herring occurring in mixed schools.

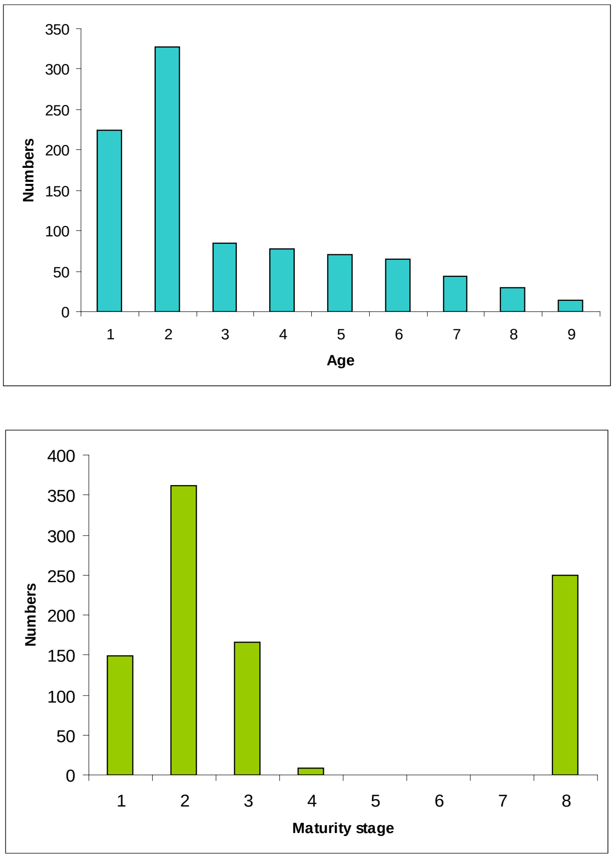


Figure 4. Percentage composition of herring samples at age (top panel) and maturity (bottom panel). Northwest herring survey, June 2010.

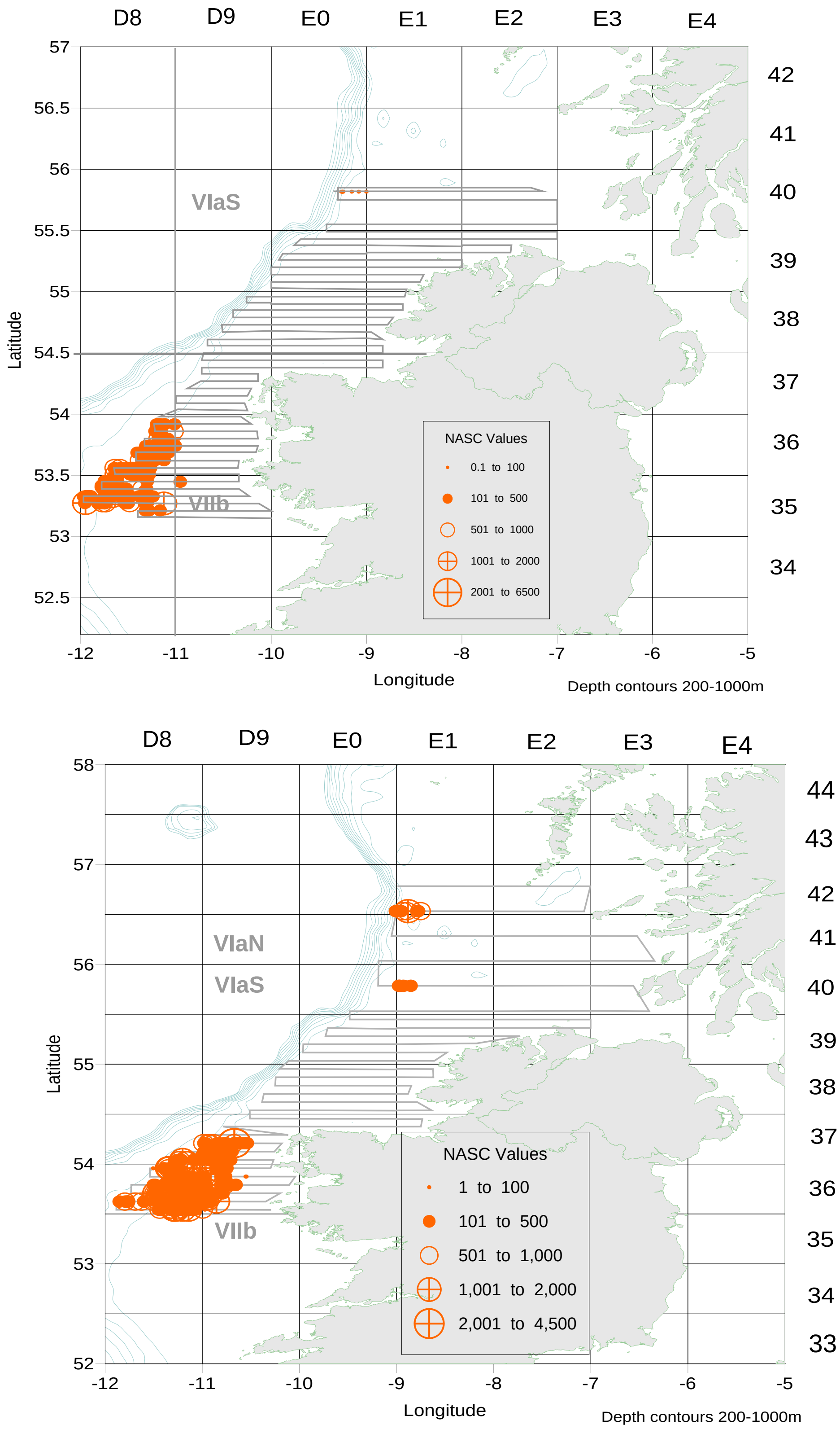
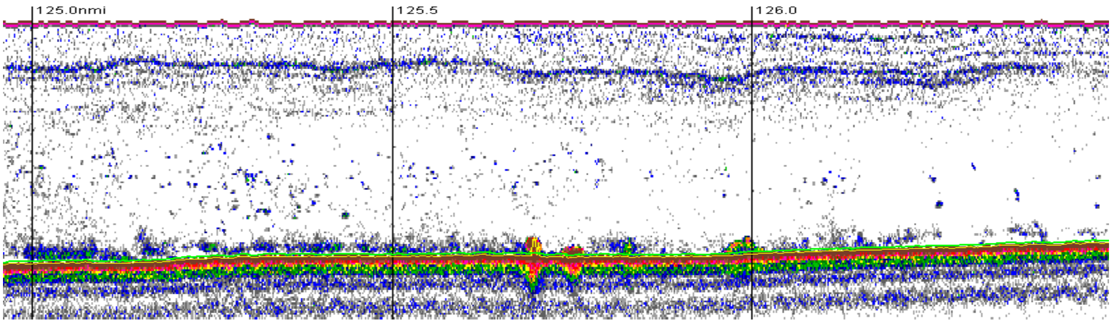
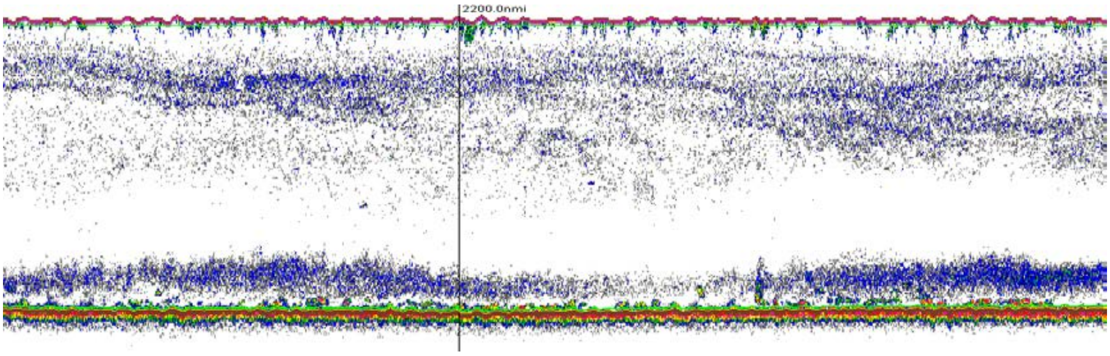


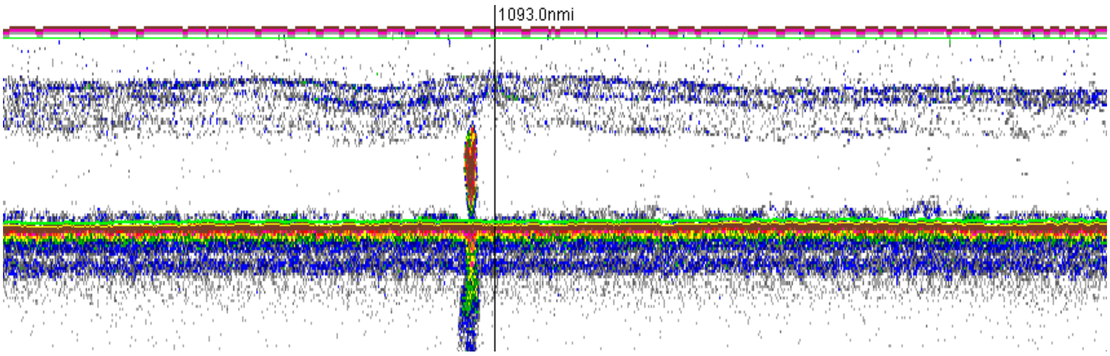
Figure 5. NASC plot of boarfish (*Capros aper*) distribution. Top panel 2009 survey, bottom panel 2010 survey. Circle size proportional to NASC value.



a). *Scattering layer containing herring recorded prior to Haul 03 at 12:40 This type of scattering layer was typical of those encountered between 53º30N-54ºN in area VIIb. Bottom depth is 115m with targets extending from 0–10m off the bottom.*

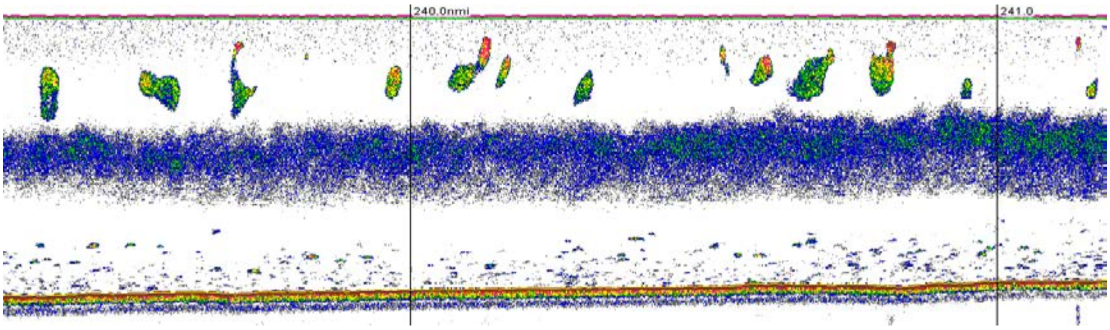


b). *Bottom scattering layer containing herring recorded prior to Haul 24 at 12:05 which extended for over 9nmi. This type of scattering layer was typical of those encountered between 55º-56ºN in the areas to the NW of the Stanton Banks. Bottom depth is 161m with targets extending from 0–8m off the bottom.*

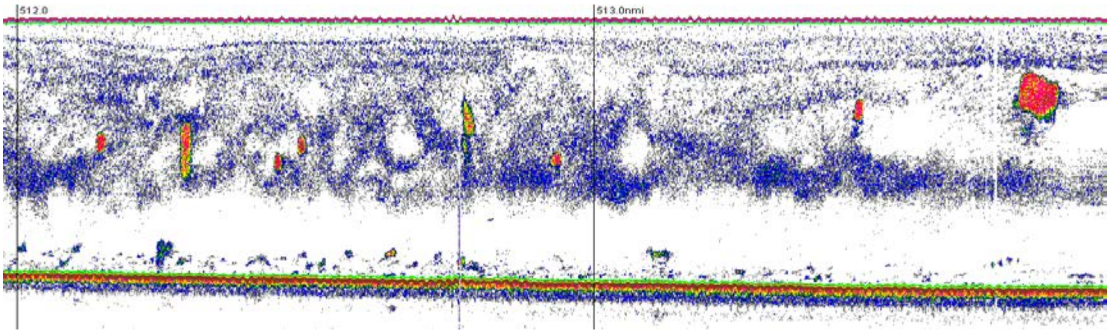


c). *High density herring school recorded prior to Haul 014 at 12:10. Bottom depth is 72m with school extending from 0–40m off the bottom.*

Figures 6a-d. Echotraces recorded prior to directed trawls. Northwest herring survey, June 2010. Note: vertical bands on echograms represent 1nmi (nautical mile) intervals.



d). *High-density surface mackerel schools encountered on shelf (90–150m depth between 53º30N and 54ºN. Bottom depth is 110m with targets occurring 10–25m from the surface.*



e). *Very high-density schools of boarfish in surface waters, typical of those encountered along the shelf slopes from 53.30–54.30ºN. Recorded during Haul 07 where actual target marks were located close to the bottom. Bottom depth is 180m with targets occurring 30–80m from the surface.*

Figures 6a-d. continued.

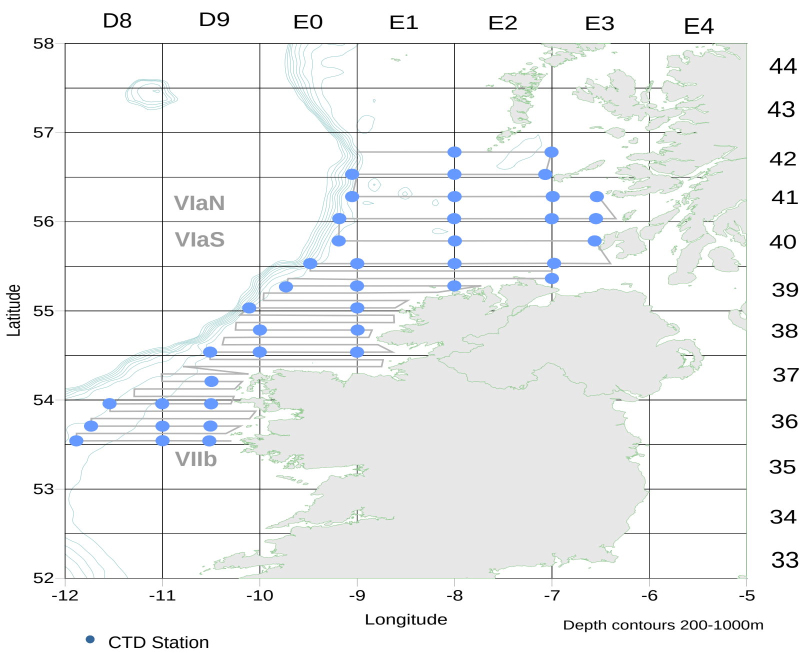


Figure 7. Location of CTD casts. Northwest herring survey, June 2010.

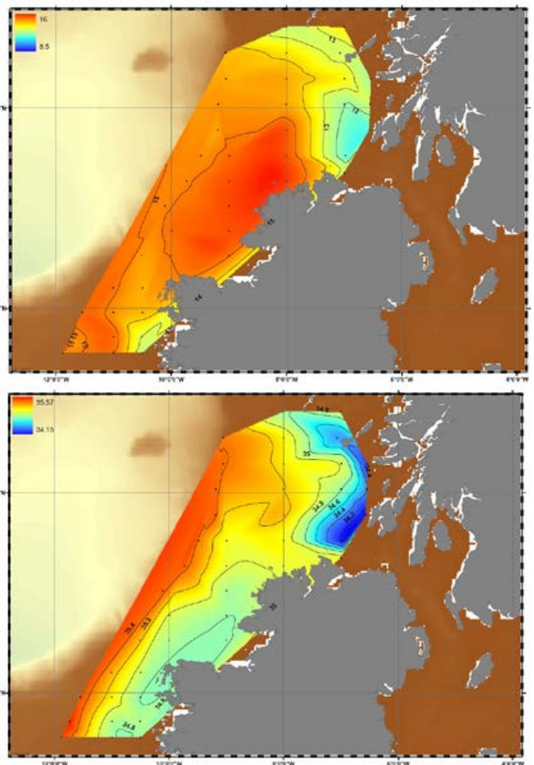


Figure 8. Horizontal temperature (left panel) and salinity (right panel) at 5m subsurface as derived from vertical CTD cast data. Northwest herring survey, June 2010.

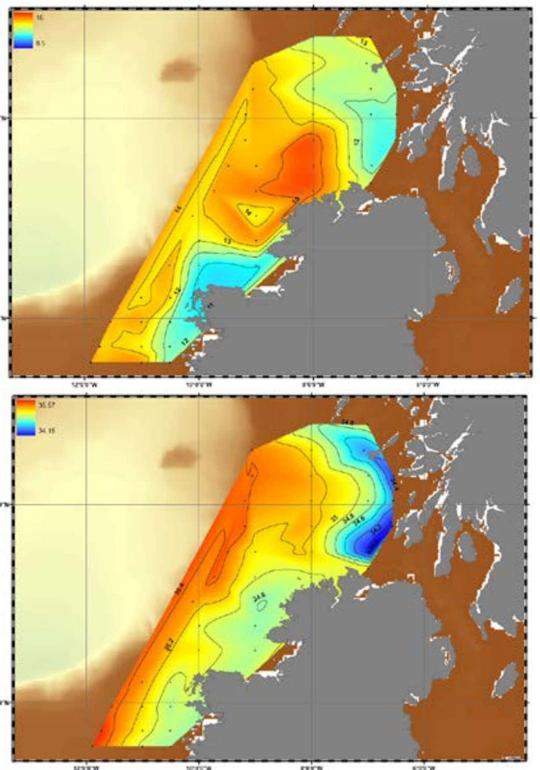


Figure 9. Horizontal temperature (left panel) and salinity (right panel) at 20m subsurface as derived from vertical CTD cast data. Northwest herring survey, June 2010.

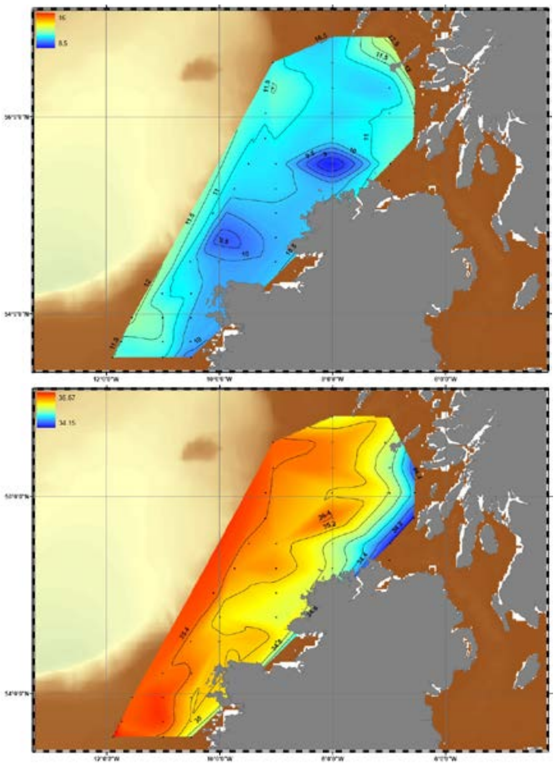


Figure 10. Horizontal temperature (left panel) and salinity (right panel) at 40m subsurface as derived from vertical CTD cast data. Northwest herring survey, June 2010.

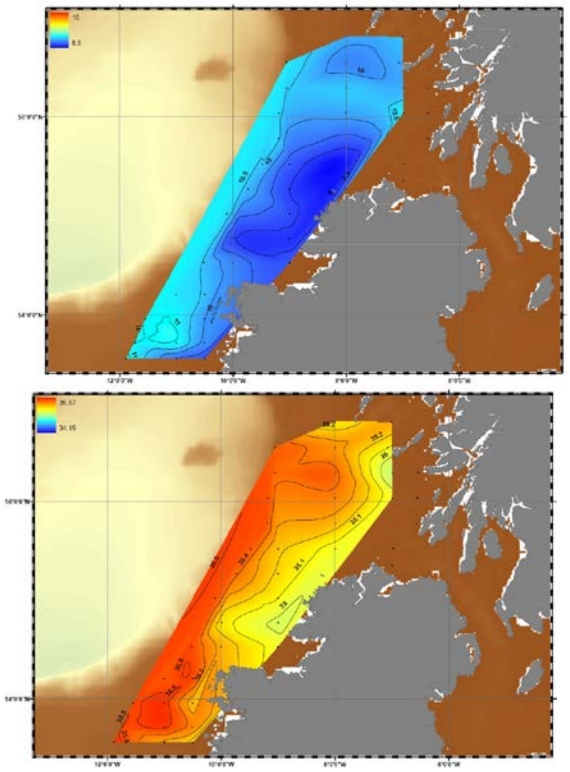


Figure 11. Horizontal distribution of temperature (top) and salinity (bottom) at 60m depth. 100 m depth contour shaded. Northwest herring survey, June 2010.

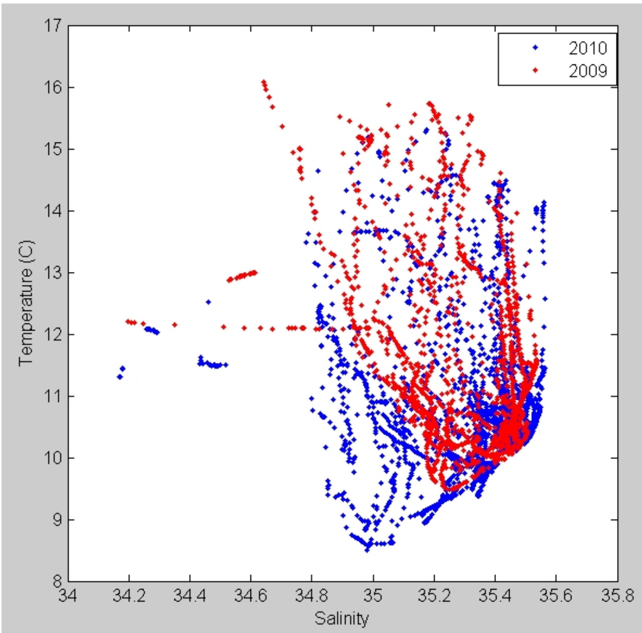


Figure 12. Comparative plot of temperature and salinity from individual vertical CTD casts taken during the 2009 and 2010 surveys. Northwest herring survey, June 2010.

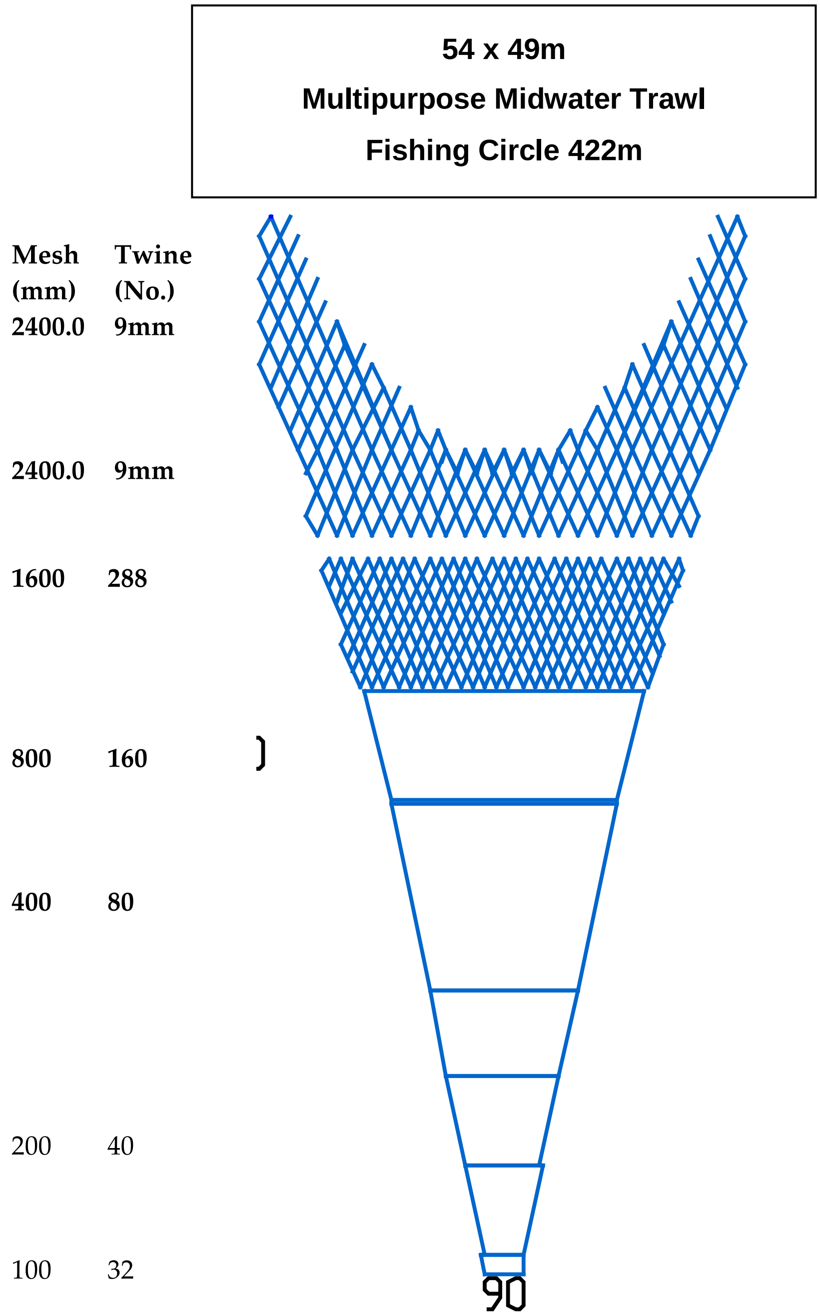


Figure 13. "Celtic Explorer" multi-purpose midwater trawl employed during the Northwest herring acoustic survey, June 2010.

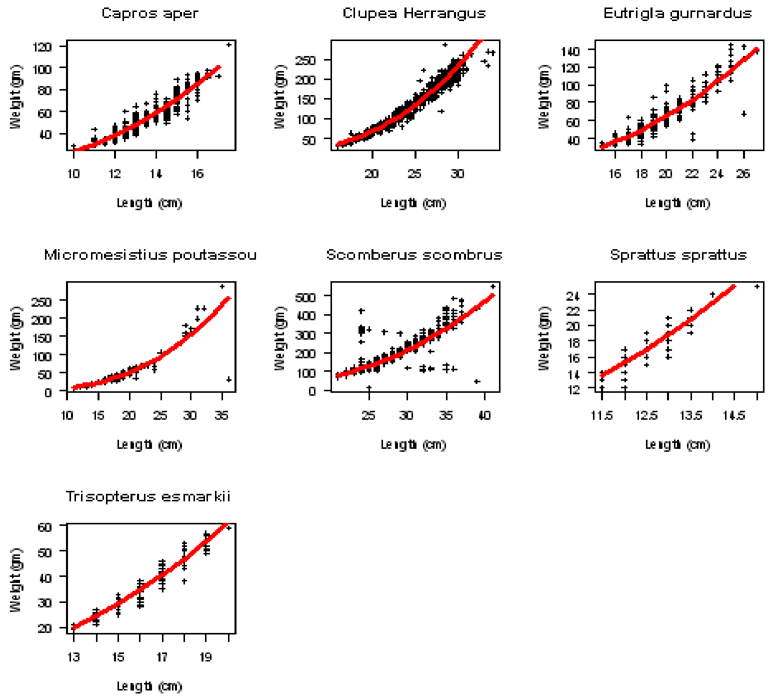


Figure 14. Length weight plots of major trawl component species used during the analysis. Northwest herring acoustic survey, June 2010.

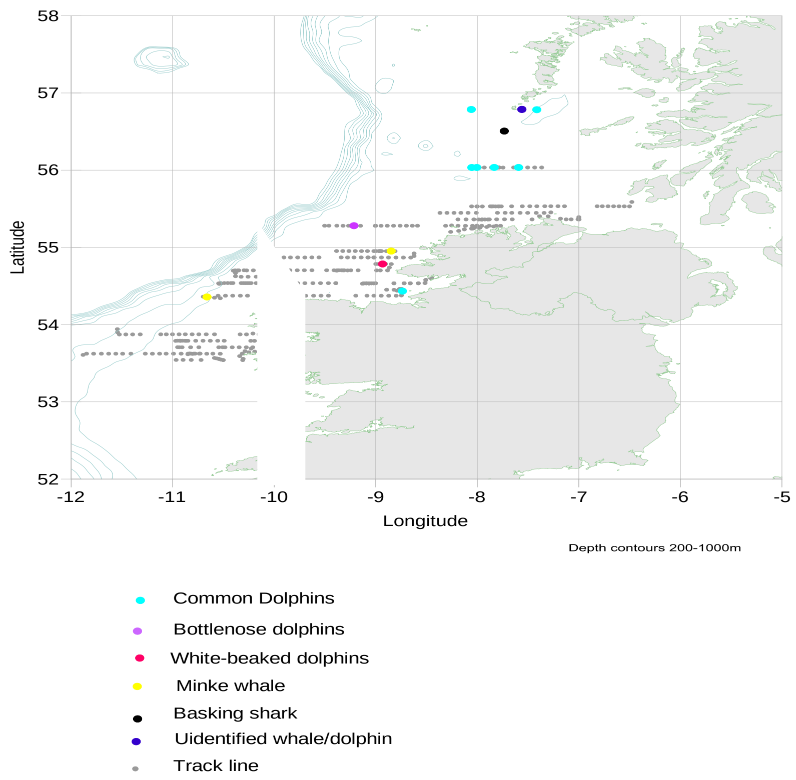


Figure 15. Distribution of ceatcean and shark species recorded during the survey.

Figure 16. Basking shark (*Cetorhinus maximus*), large male of 7m+ in length and ~3–4t in weight taken as bycatch to the southwest of Barra Head during Haul 24.

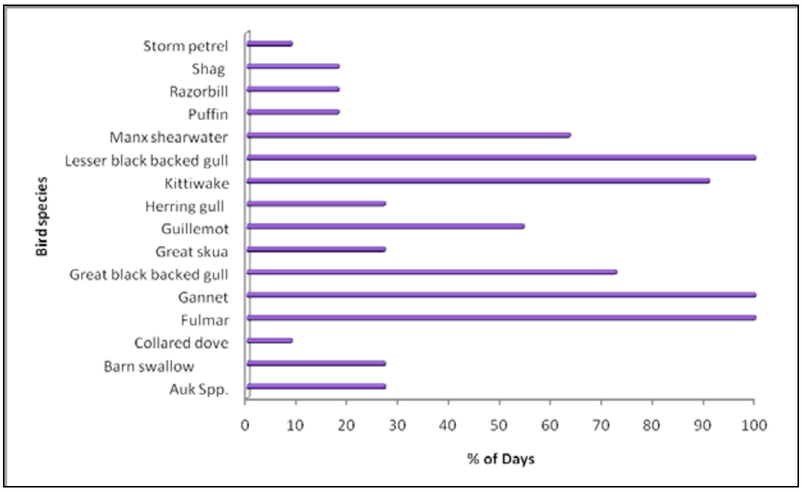


Figure 17. Percentage of days on which bird species were recorded, during 11 days of active surveying.

ANNEX 5H: German/Danish (Western Baltic)

Survey report for FRV "SOLEA"

Baltic International Acoustic Survey

4 – 22 October 2010

Tomas Gröhsler[1], Matthias Schaber[2]

Johann Heinrich von Thünen-Institute

[1] Institute of Baltic Sea Fisheries, Rostock, Germany (vTI-SF)

[2] Institute of Sea Fisheries, Hamburg, Germany (vTI-OSF)

1 INTRODUCTION

Background: FRV "SOLEA" cruise 628 was conducted within the framework of the Baltic International Acoustic Survey (BIAS), which is coordinated within the scope of ICES. The joint Danish/German survey is carried out annually in autumn. Results of the acoustic survey are delivered to the ICES to provide the Herring Assessment Working Group for the Area South of 62°N (HAWG) and the Baltic Fisheries Assessment Working Group (BFAS) with an index value for the stock size of herring and sprat in the Western Baltic/Kattegat area (Subdivisions 21, 22, 23 and 24).

Objectives: Hydroacoustic recording of pelagic fish stocks for abundance and biomass estimation, biological sampling for the verification of echoes, calibration of the hydroacoustic equipment, hydrographic investigations, sampling of data and specimen.

2 SURVEY DESCRIPTION and METHODS

2.1 Personnel

Tomas Gröhsler	Scientist in charge (6–11 Oct 2010), biology	vTI-OSF
Matthias Schaber	Scientist in charge (4–6 and 11–22 Oct 2010), acoustics	vTI-SF
Uwe Böttcher	Acoustics, hydrography	vTI-OSF
Tom Jankiewicz	Biology	vTI-OSF
Mario Koth	Biology	vTI-OSF
Svend-Erik Levinsky	Biology	DTU Aqua
Ben Stefanowitsch	Biology	vTI-OSF
Michael Drenckow	Technician (4–6 Oct 2010)	vTI-SF

2.2 Narrative

The 628th cruise of FRV "SOLEA" represents the 23nd subsequent survey. FRV "SOLEA" left the port of Rostock/Marienehe on 4 October 2010. The acoustic survey covered the southern part of Subdivision 21 and the whole area of Subdivisions 22, 23 and 24. The northern part of Subdivision 21 could not be covered because of unfavourable weather conditions. The survey ended on 22 October 2010 in Rostock/Marienehe.

2.3 Survey design

The ICES statistical rectangles were used as strata for all Subdivisions (ICES 2003). The area was limited by the 10 m depth line. The survey area in the Western Baltic Sea is characterized by a number of islands and sounds. Parallel transects would lead in consequence to an unsuitable coverage of the survey area. Therefore a zig-zag track was used to cover all depth strata regularly. The survey area was 13 206 nmi². The cruise track (Figure 1) totally reached a length of 1 242nmi.

2.4 Calibration

The hull mounted transducer was calibrated in the daytime on 5 October 2010 in the eastern area of the Mecklenburg Bight a water depth of around 20 m. The calibration procedure was carried out as described in the 'Manual for the Baltic International Acoustic Surveys (BIAS)' (ICES 2010). During neat weather conditions it was possible to calibrate both the 38 kHz and 120 kHz transducer. Calibration results each fulfilled the required accuracy.

2.5 Acoustic data collection

Acoustic investigations were performed during night-time. The main pelagic species of interest were herring and sprat. The acoustic equipment used was an echosounder EK60 on 38 kHz (120 kHz). Specific settings of the hydroacoustic equipment were used as described in the 'Manual for the Baltic International Acoustic Surveys (BIAS)' (ICES 2010). Echo integration, i.e. the allocation of the area backscattering strength (NASC) to species was accomplished using the post-processing software EchoView 4.90. Mean volume backscattering values (sv) were integrated over 1 nmi intervals from 8 m below the surface to the bottom. In areas with large interferences in surface layers, integration start-depth was shifted downwards to depths sometimes exceeding 10 m. Interferences from air bubbles, bottom structures and scattering layers were removed from the echogram

2.6 Biological data - fishing trawls

Trawl operations were conducted with a pelagic gear 'PSN388' in the midwater as well as near the bottom. Mesh size in the codend was 10 mm. The intention was to carry out at least two hauls per ICES statistical rectangle. Trawling depth and net opening were controlled by a netsonde. Trawl depth was chosen in accordance with the 'characteristic indications' on the echogram. Normally, a vertical net opening of about 8–10 m was achieved. The trawling time lasted 30 minutes. From each haul subsamples were taken to determine length and weight of fish. Samples of herring and sprat were frozen for additional investigations (e.g. determining sex, maturity, age).

2.7 Hydrographic data

Hydrographic data were sampled just after fishing activities. At each of these stations, vertical profiles of temperature, salinity, oxygen concentration and depth were recorded using a "Seabird SBE 19 plus-multiprobe" CTD. Water samples for calibration purposes were taken on several stations. Additional CTD casts were conducted in the Femern Belt leading to an overall of 61 CTD stations.

2.8 Data analysis

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

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

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

In accordance with the guidelines in the 'Manual for the Baltic International Acoustic Surveys (BIAS)' (ICES 2010) the further calculation was performed in the following way:

Fish species considered:
Clupea harengus
Crystallogobius linearis
Engraulis encrasicolus
Gadus morhua
Gasterosteus aculeatus
Merlangius merlangus
Sprattus sprattus
Trachurus trachurus

Exclusion of trawl hauls with low catch level:

Haul No.	Rectangle	Subdivision (SD)
44	41G1	21
47	41G1	21
50	42G1	21
55	42G2	21

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

Rectangle/SD to be filled	with Haul No.	of Rectangle/SD
43G2/21	53 & 54	43G1/21
40F9/22	32, 33, 35	40G0/22
40G1/22	32, 33, 35	40G0/22
39G2/23	13, 20	39G2/24
37G4/24	5, 8, 9	38G4/24

3 RESULTS and DISCUSSION

3.1 Acoustic data

The survey statistics concerning the survey area, the mean S_A, the mean scattering cross section σ, the estimated total number of fish, the percentages of herring and sprat per Subdivision/rectangle are shown in Table 5.

As in the previous year the horizontal distribution of the mean values showed the usual main pattern (Figure 4). The highest S_A values were found in Subdivision 23, followed by second highest backscatter values in the Arkona Sea (Subdivision 24) and generally low fish concentrations in the Belt Sea (Subdivision 22) and in the Kattegat (Subdivision 21). However, the hydroacoustic measurements in 2010 showed higher fish densities as compared to the long-term minimum values of 2009 in subdivisions 22–24. A new minimum level was recorded in subdivision 21. Overall S_A values were in most cases above the long-term mean. Additionally, in SD 23 both higher S_A values and fish densities could be recorded. Especially around the island of Ven, typical dense aggregations of large herring known from former years (before 2008) were present. Above-average fish densities were also observed in the Kiel Bight.

3.2 Biological data

In total 57 trawl hauls were carried out:

Subdivision	No. of Hauls
21	14
22	19
23	4
24	20

1654 herring and 691 sprat were frozen for further investigations (e.g. determining sex, maturity, age).

Results of the catch composition by Subdivision are presented in Tables 1–4. Overall mean catches by Subdivision were higher than the very low catch rates in the preceding years. The highest concentrations of adult herring were found - as in the years before - in the Sound (Subdivision 23). The overall mean catch of herring in Subdivision 23 was above last year's record low level. The distribution area of sardine (*Sardina pilchardus*) and Greater weever (*Trachinus draco*) further decreased in 2010. These species formerly occurred as far southeast as the Arkona Sea in 2008. Later in 2009 their distribution reached southward only to the Belt Sea. In 2010 the southern distribution boundary was marked by the Kattegat area.

The length distributions of herring and sprat of the years 2009 and 2010 are presented by Subdivision in Figures 2 and 3. Compared to results from 2009, herring length distributions by Subdivision show the following:

- juvenile herring (<15 cm) again dominate in Subdivision 21, 22 and 24. However, the length distribution is only in 2010 characterized by two maxima.
- Contribution of older and larger herring slightly increased in 2010. However, in Subdivision 23, which was mostly dominated by older herring before 2009, the contribution of this fraction is still on a low level.
- The length distributions of sprat in 2009 and 2010 (Figure 3) show that:
- Subdivision 21 is now dominated by the new incoming year class (<10 cm). Last year's larger part of older sprat disappeared in 2010.
- Subdivision 22 consisted in both years mostly of the new incoming year class.
- Subdivision 23 in 2010 contained – beside older sprat –also a larger fraction of the new incoming year class.

- Subdivision 24 is in both years characterized by the new incoming year class, whereas older sprat is of minor importance. The growth maximum within the new incoming year class is in 2010 smaller than in 2009.

3.3 Biomass and abundance estimates

The total abundance of herring and sprat is presented in Table 5. The estimated numbers of herring and sprat by age group and Subdivision/rectangle are given in Table 6 and Table 9. The corresponding mean weights by age group and Subdivision/rectangle are shown in Table 7 and Table 10. The estimates of herring and sprat biomass by age group and Subdivision/rectangle are summarized in Table 8 and Table 11.

The herring stock in Subdivisions 21–24 was estimated to be 7.2 x 10^9 fish or about 208.9 x 10^3 tonnes. For the included area of Subdivisions 22–24 the number of herring was calculated to be 6.6 x 10^9 fish or about 200.8 x 10^3 tonnes. The abundance estimate was dominated by young herring as in former years (Figure 2 and Table 6). However, total abundance and biomass estimates increased significantly compared to the record low values from 2009.

The estimated sprat stock in Subdivisions 21–24 was 24.4 x 10^9 fish or 109.9 x 10^3 tonnes. For the included area of Subdivisions 22–24 the number of sprat was calculated to be 24.2 x 10^9 fish or 108.64 x 10^3 tonnes. The present high estimates of sprat in numbers and biomass are caused by a strong new year class (Figure 3 and Table 9), which is about 5 times higher than in 2009.

3.4 Hydrography

Figure 5 displays the horizontal distribution of temperature, salinity and oxygen concentration at the surface and on the seabed. Surface temperature ranged from 13°C in SD24 (Arkona Basin) to 12–12.5°C in SD22 (Belt Sea) and 10–11°C in SD21 (Kattegat). Salinity in surface layers increased from 8 PSU in SD24 to ca. 14 PSU in SD22 and reached 20 PSU in SD21. In the Kattegat (SD21), a distinct halocline was measured in 10–14 m depth. In Kiel Bught and Mecklenburg Bight (SD22), halocline depth was at 15–20 m. In the Arkona Sea (SD24) the vertical salinity gradient was not as pronounced. A weak halocline there was only measured in the southern part (Figure 6). In the Belt Sea (SD22), oxygen concentrations in layers deeper than 22–25 m on several stations decreased below 1 ml/l. In the Sound (SD23), comparatively low oxygen levels also indicate oxygen depletion.

3.5 Discussion

Compared to last year's results, the present estimates of herring show a more pronounced increase in biomass than in abundance:

	Difference compared to 2009	
Area	**Numbers (%)**	**Biomass (%)**
Subdivisions 22–24	+88	+147
Subdivisions 21–24	+77	+132

Abundance and biomass estimates dramatically increased in all age groups; the highest increase of more than 200% was recorded in the age groups 3–8+. When comparing the development of these cohorts in 2009/2010 they all show negative values. The increase in 2010 is mainly caused by the results from SD 24 (Table 6). The overall large increase of older herring is in contrast to the results of the length distributions given in Figure 2. In 2010, most areas, except SD 23, were mainly dominated by younger herring below 20 cm. Herring of this length classes originating in Western Baltic areas should have most likely an age of 3 years and younger. The pronounced high numbers and biomass of older, small herring in SD 24 could be explained by an increased immigration from slow growing central Baltic herring from easterly adjacent areas (SD 25–27, 28.2, 29 and 32) in 2010.

In order to supply HAWG with an unbiased index for this 2010 survey (standard area: excl. 43G1, 43G2 of SD 21 and 37G3, 37G4 of SD 24), a method to quantify and correspondingly subtract the central Baltic herring fraction from the 2010 calculations (for SD24) will be looked for until the next meeting of HAWG in March 2011.

The abundance of sprat, which

- decreased significantly in 2007 compared to the high level in 2006 (2007/2006: Subdivisions 21–24: -68%; Subdivisions 22–24: -70%)
- continued this downward trend in 2008 (2008/2007: Subdivisions 21–24: -30%; Subdivisions 22–24: -25%),
- showed rather stable status in 2009 (2009/2008: Subdivisions 21–24: +1.3%; Subdivisions 22–24: +0.1%),

now increased significantly in 2010 (2010/2009: Subdivisions 21–24: +401% and Subdivisions 22–24: 403%).

This drastic overall increase in 2010 compared to 2009 is characterized by higher abundance estimates in all areas (Subdivision 21: +82%, Subdivision 22: +726%, Subdivision 23: +93% and Subdivision 24: +57%). The increase in all areas is further related to the dominance of the new incoming year class (2010/2009 in Subdivision 21: +586%, in Subdivision 22: +836%, in Subdivision 23: +2.459% and in Subdivision 24: +186%). The contribution of the new year class abundance Subdivisions 21–24, as well as, in Subdivisions 22–24 was 83% in 2006, 10% in 2007, about 52% in 2008, 72% in 2009 and 88% in 2010. The contribution of the 0-group to the total biomass was 2010 about 1.5 times higher than 2009 (in Subdivisions 21–24, as well as, in Subdivisions 22–24: 2010: 48% and 50%, 2009 ca. 42%).

4 References

ICES. 1983. Report of the Planning Group on ICES co-ordinated herring and sprat acoustic surveys. ICES CM 1983/H:12.

ICES. 2010. Report of the Baltic International Fish Survey Working Group. ICES CM 2010/SSGEST:07, Addendum 2.

Foote, K.G., Aglen, A., and Nakken, O. 1986. Measurement of fish target strength with a split-beam echosounder. J.Acoust.Soc.Am. 80(2): 612–621.

Tables and Figures

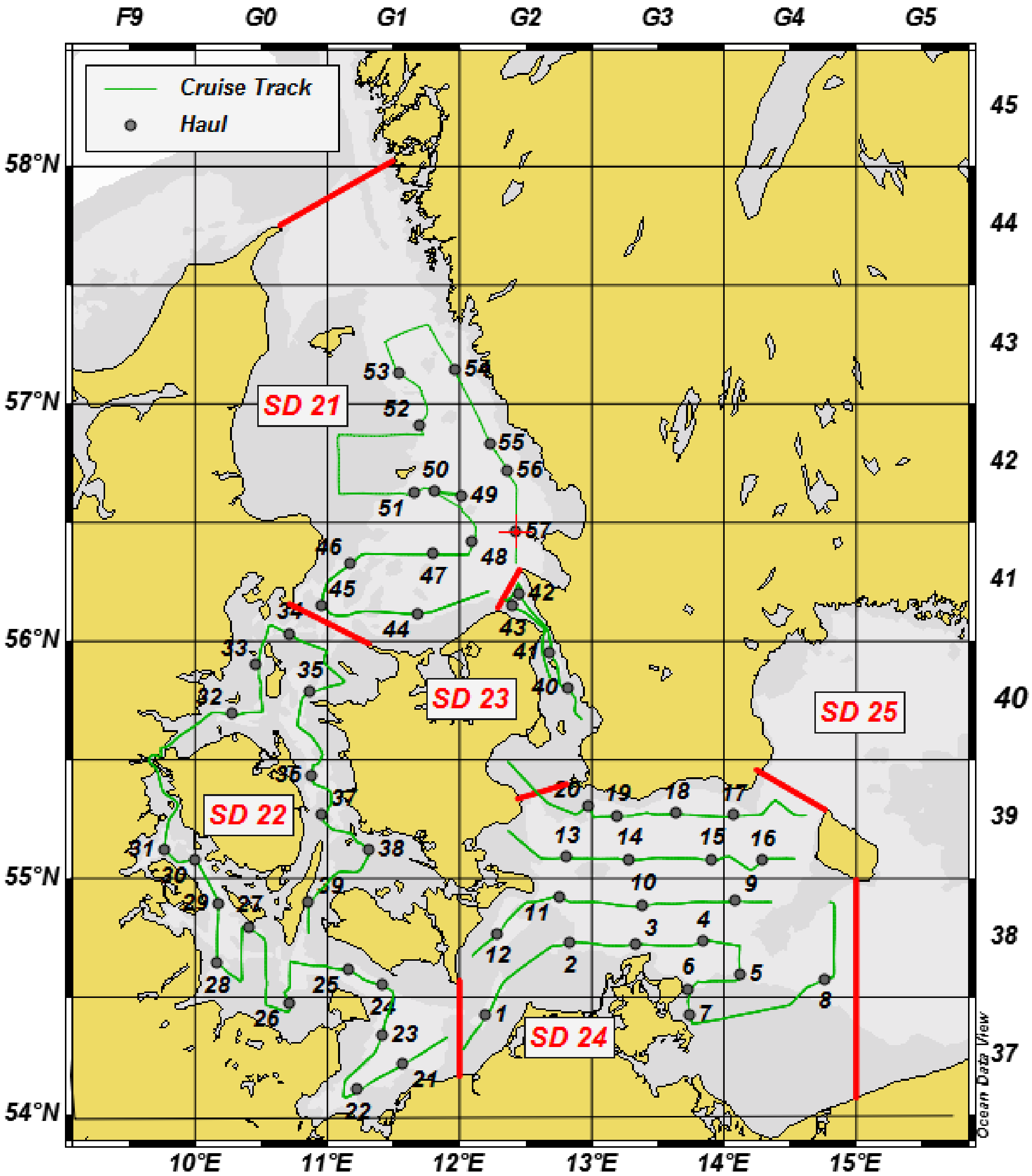


Figure 1. Cruise track and trawl positions of FRV "SOLEA" 628 in October 2010.

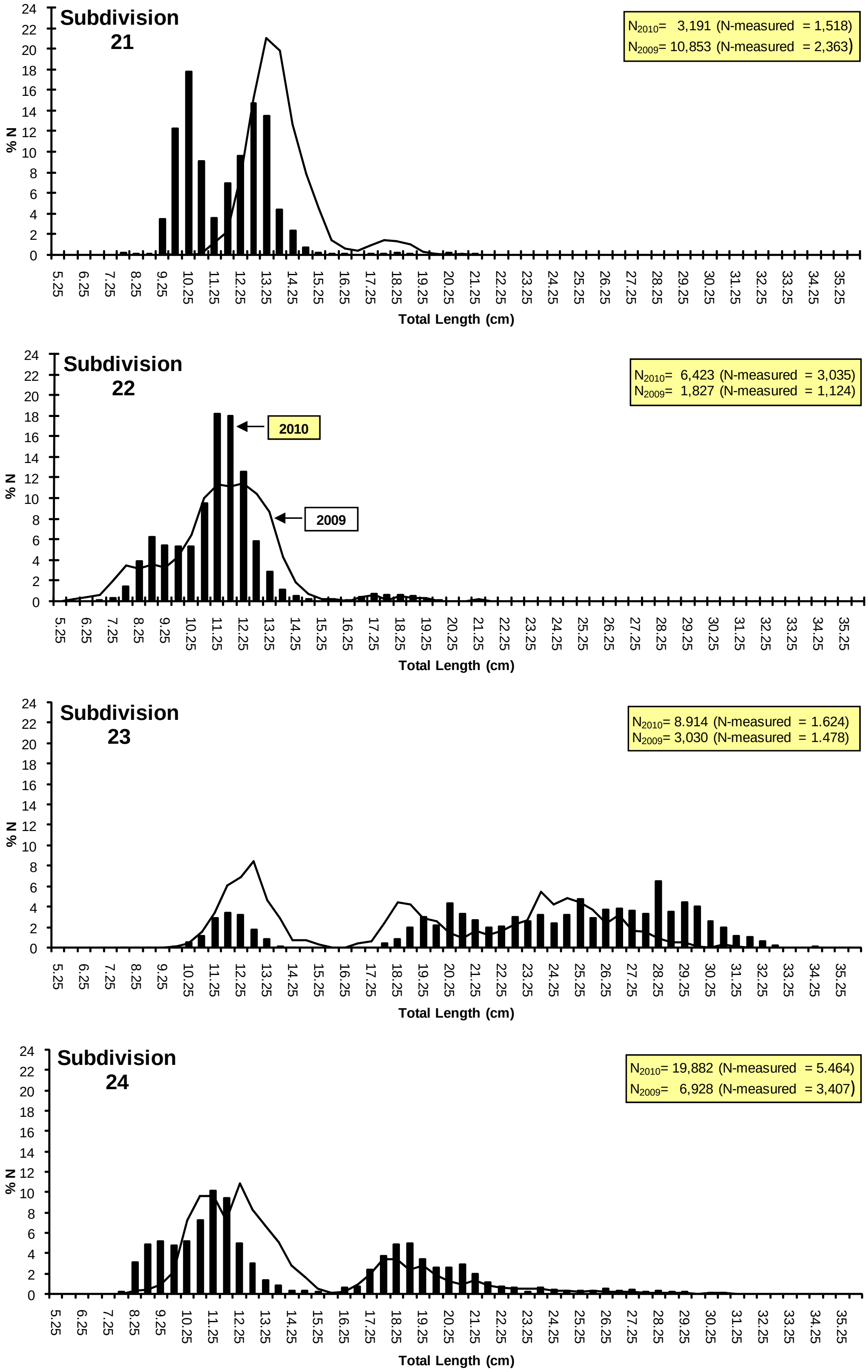


Figure 2. Length distribution of herring in Subdivisions 21, 22, 23 and 24 in 2009 (=line) and in 2010 (=bar).

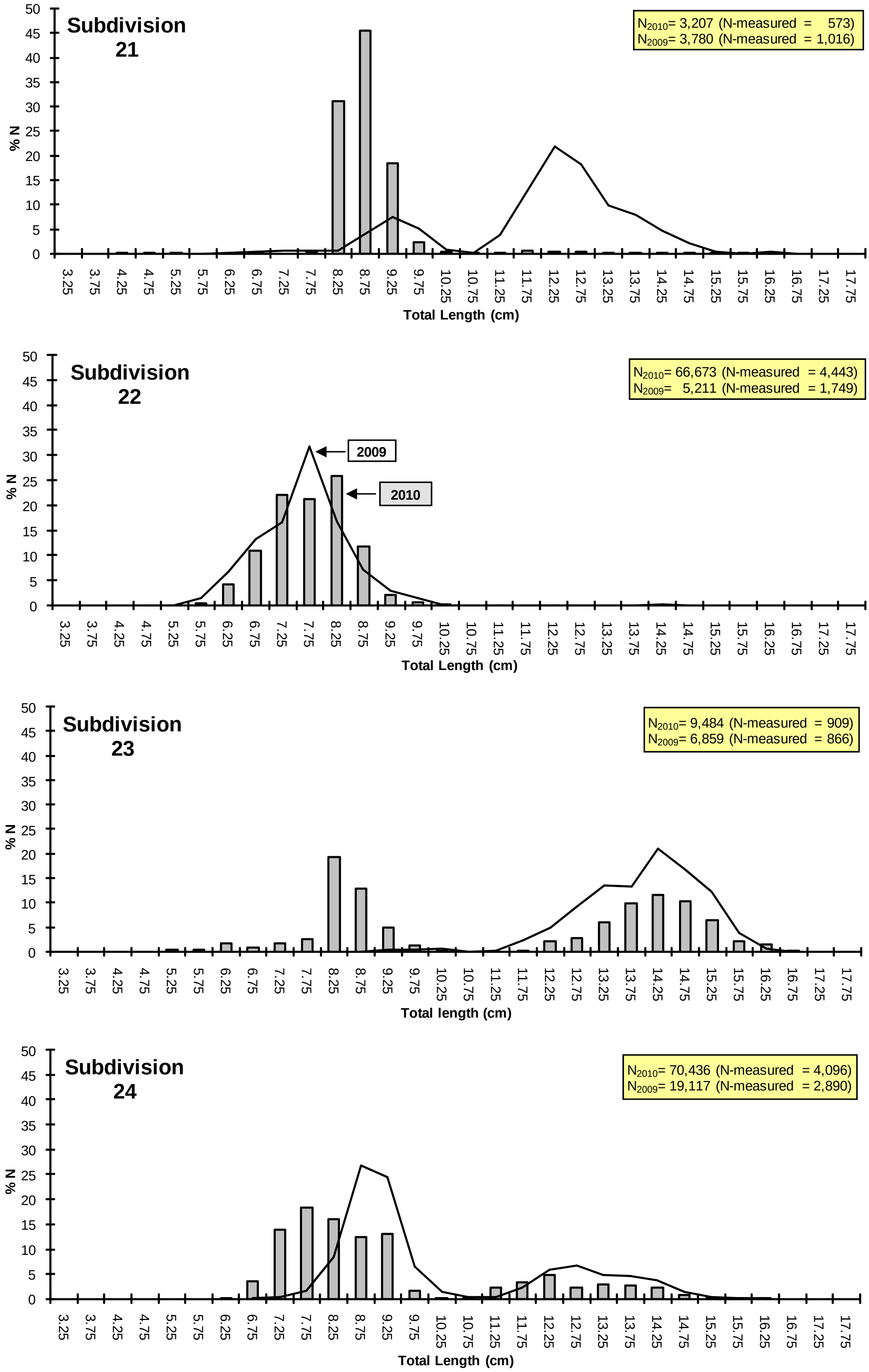


Figure 3. Length distribution of sprat in Subdivisions 21, 22, 23 and 24 in 2009 (=line) and in 2010 (=bar).

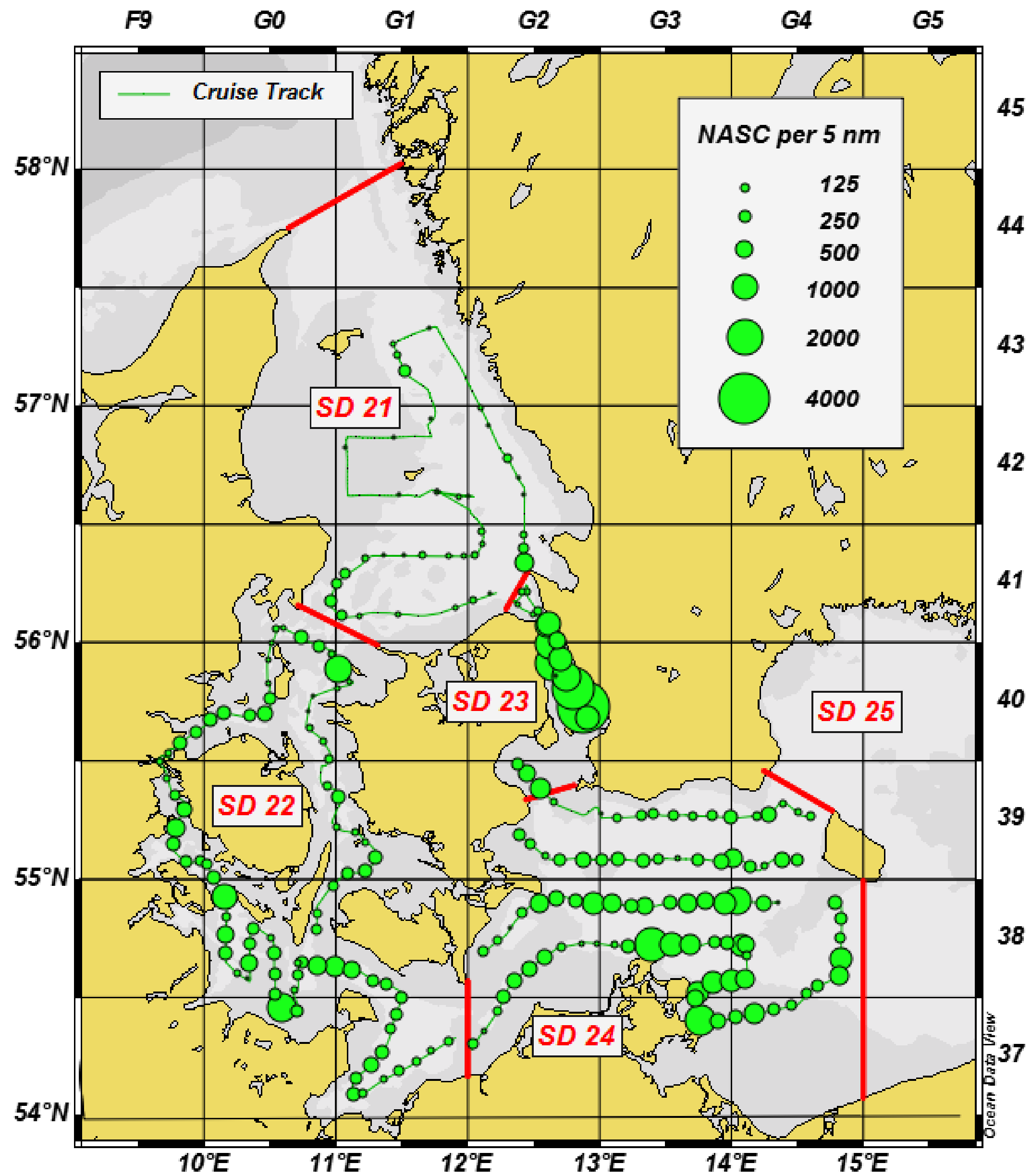


Figure 4. Distribution of sA-values obtained during the acoustic survey of FRV "SOLEA" 628 in October 2010.

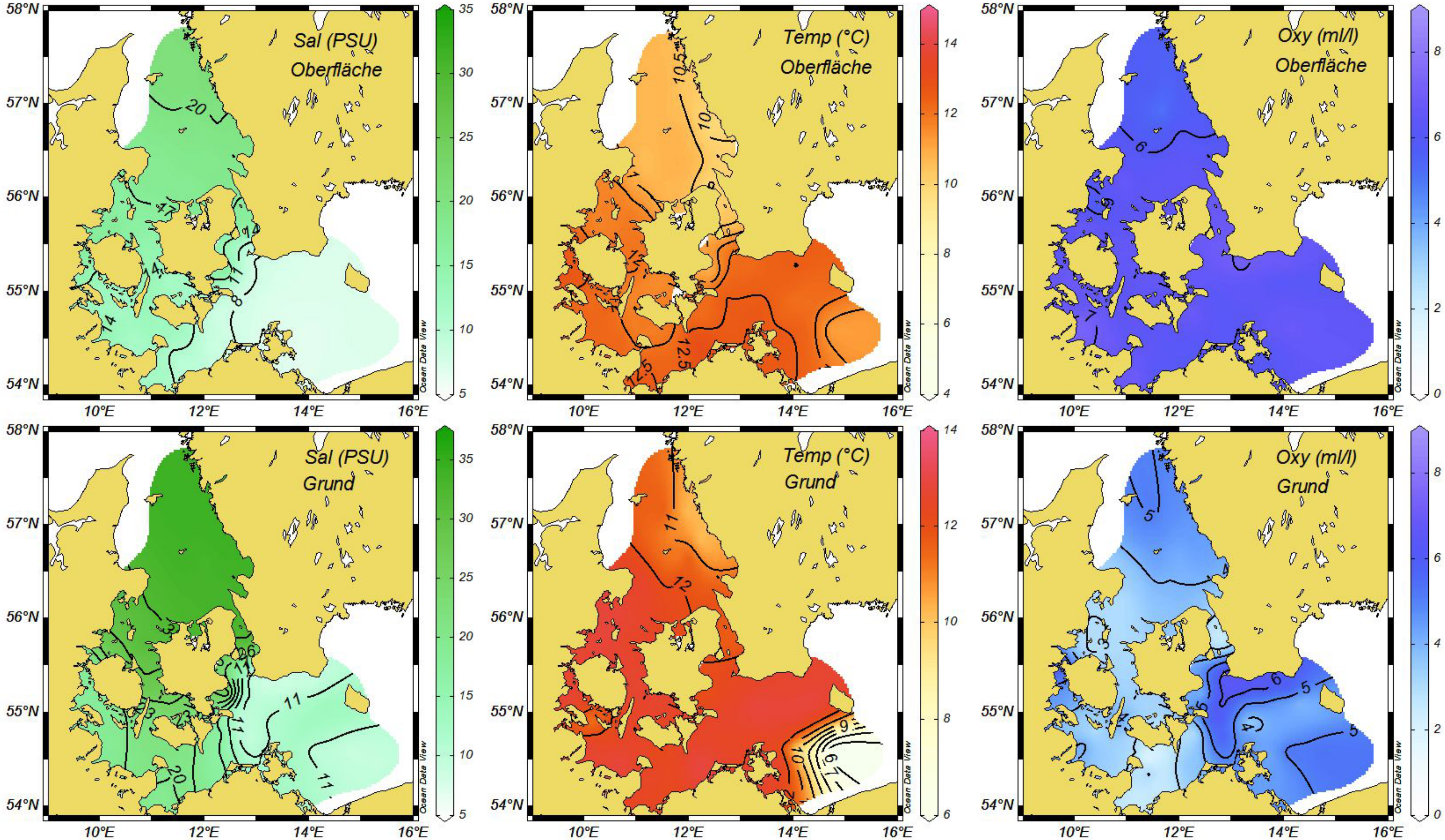


Figure 5. Salinity (Sal), temperature (Temp) and Oxygen concentration (Oxy) at the surface and on over the seabed during FRV "SOLEA" 628 in October 2010.

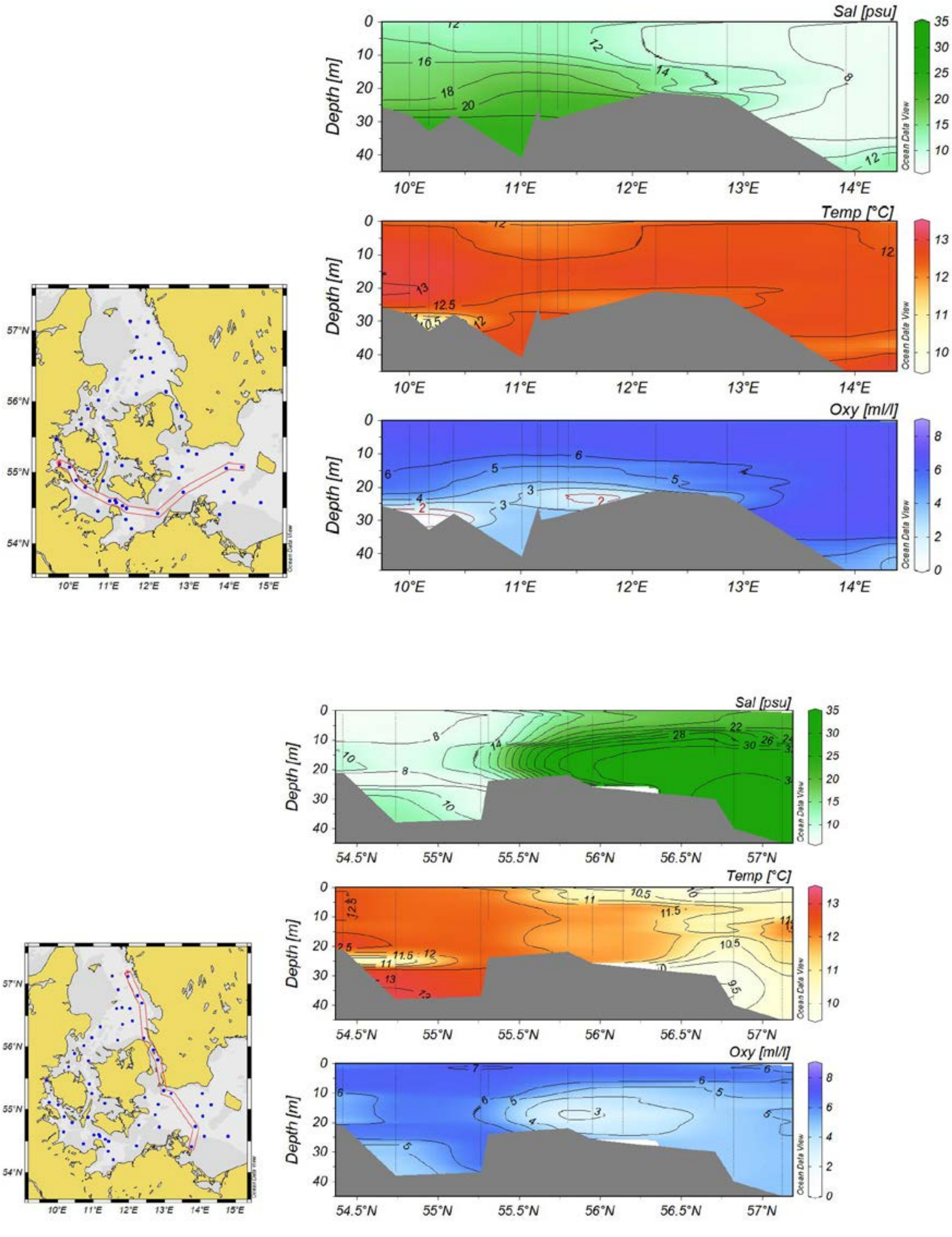


Figure 6. Vertical distribution of salinity, temperature and oxygen concentration on transects from the Little Belt to the Bornholmsgat (upper panel) and from Kattegat to Sassnitz Trench (lower panel) during FRV "SOLEA" 628 in October 2010.

Table 1. Catch composition (kg/0.5 h) by trawl haul in Subdivision 21 (FRV "SOLEA" in 2010).

Haul No.	44	45	46	47	48	49	50	51	52
Species/ICES Rectangle	41G1	41G0	41G1	41G1	41G2	42G2	42G1	42G1	42G1
CARCINUS									
CLUPEA HARENGUS	0.44	9.27	6.40	0.30	0.83	1.53	0.11	2.31	1.53
CRYSTALLOGOBIUS LINEARIS	+	0.01	0.29	+	+		0.01	+	0.03
CTENOLABRUS RUPESTRIS	+								
ENGRAULIS ENCRASICOLUS	1.71	9.10	9.65	4.86	5.59	0.21	2.98	0.09	
EUTRIGLA GURNARDUS	+								+
GASTEROSTEUS ACULEATUS		0.02	0.01	+	+	+		+	
LIMANDA LIMANDA	0.02			0.05					
LOLIGO FORBESI	0.02	0.17	0.12	0.11	0.06	+	0.17	0.05	0.11
MERLANGIUS MERLANGUS	0.01	0.03	0.12	0.29	0.01	0.06	0.15	0.04	0.05
MERLUCCIUS MERLUCCIUS				+				+	+
MULLUS SURMULETUS			0.01						
MYSIDACEA									0.01
POMATOSCHISTUS MINUTUS			+						+
SARDINA PILCHARDUS		0.01			0.01				
SCOMBER SCOMBRUS		0.19	0.11			0.41	0.05		
SEPIOLA									0.01
SOLEA VULGARIS									
SPRATTUS SPRATTUS	0.12	11.63	2.02		0.01	0.22		0.04	0.26
SQUALUS ACANTHIAS									3.14
TRACHINUS DRACO	0.38		0.11	0.22	0.23	0.04	0.35	1.05	1.09
TRACHURUS TRACHURUS	0.19	0.22	0.12	0.09	0.05	0.08	0.19	0.11	0.01
Total	**2.89**	**30.65**	**18.96**	**5.92**	**6.79**	**2.55**	**4.01**	**3.69**	**6.24**
Medusae	2.27	2.97	4.06	4.80	2.81	4.27	0.27	2.80	1.15

Haul No.	53	54	55	56	57	Total
Species/ICES Rectangle	43G1	43G1	42G2	42G2	41G2	
CARCINUS		0.02				**0.02**
CLUPEA HARENGUS	1.22	0.06	0.57	6.54	0.38	**31.49**
CRYSTALLOGOBIUS LINEARIS	+	0.01	+	+	+	**0.35**
CTENOLABRUS RUPESTRIS						**+**
ENGRAULIS ENCRASICOLUS	0.02		0.01	0.31	0.72	**35.25**
EUTRIGLA GURNARDUS					+	**+**
GASTEROSTEUS ACULEATUS			+			**0.03**
LIMANDA LIMANDA						**0.07**
LOLIGO FORBESI	0.03	0.03	0.04	0.11	0.24	**1.26**
MERLANGIUS MERLANGUS	0.03		0.06	0.03	0.04	**0.92**
MERLUCCIUS MERLUCCIUS			0.01	+		**0.01**
MULLUS SURMULETUS						**0.01**
MYSIDACEA						**0.01**
POMATOSCHISTUS MINUTUS		+	+			**+**
SARDINA PILCHARDUS			0.01			**0.03**
SCOMBER SCOMBRUS					0.12	**0.88**
SEPIOLA		0.04	0.02	+	0.02	**0.09**
SOLEA VULGARIS			+			**+**
SPRATTUS SPRATTUS			0.02	0.01	0.03	**14.36**
SQUALUS ACANTHIAS		9.10				**12.24**
TRACHINUS DRACO	0.12		0.47	0.21	0.25	**4.52**
TRACHURUS TRACHURUS	0.04	+	0.02		0.02	**1.14**
Total	**1.46**	**9.26**	**1.23**	**7.21**	**1.82**	**102.68**
Medusae	2.90	1.05	1.63	4.12	1.83	**36.94**

+ = < 0,01 kg

Table 2. Catch composition (kg/0.5 h) by trawl haul in Subdivision 22 (FRV "SOLEA" in 2010).

Haul No.	21	22	23	24	25	26	27	28	29	30	31
Species/ICES Rectangle	**37G1**	**37G1**	**37G1**	**38G1**	**38G1**	**37G0**	**38G0**	**38G0**	**38G0**	**39G0**	**39F9**
AGONUS CATAPHRACTUS				0.02							
APHIA MINUTA			+				+				
BELONE BELONE						0.04			0.04		
CLUPEA HARENGUS	4.53	1.93	13.63	17.70	6.65	0.54	0.84	5.46	0.34	1.00	0.40
CRANGON CRANGON											
CRYSTALLOGOBIUS LINEARIS								+	+		+
CYCLOPTERUS LUMPUS						0.18					
ENGRAULIS ENCRASICOLUS	0.06	0.34	0.08	0.04	+	4.14	0.19	2.14	0.35	0.05	0.83
GADUS MORHUA				0.02	0.02	4.71	0.01				
GASTEROSTEUS ACULEATUS		1.49	0.29	1.42	0.26	0.11	0.16	0.17	0.39	0.01	0.30
GOBIUS NIGER					+						0.01
HYPEROPLUS LANCEOLATUS		0.01									
LIMANDA LIMANDA			0.63	0.25	0.38		0.15	0.24	0.06		0.20
LOLIGO FORBESI											
MERLANGIUS MERLANGUS	0.04	0.09	0.14	0.05	0.03	0.23	0.02	0.11	0.01	+	0.05
MULLUS SURMULETUS											
MYOXOCEPHALUS SCORPIUS					0.01						
PLATICHTHYS FLESUS											
POMATOSCHISTUS MINUTUS		0.01						+			
SCOMBER SCOMBRUS											
SEPIOLA											
SPRATTUS SPRATTUS	24.02	7.84	3.95	13.82	4.56	8.50	5.56	11.08	1.45	2.81	10.71
SYNGNATHUS ROSTELLATUS					+						
SYNGNATHUS TYPHLE											+
TRACHURUS TRACHURUS	0.10	0.05	0.02	0.02		6.64	+	0.35	0.03	0.04	0.04
Total	**28.75**	**11.76**	**18.74**	**33.34**	**11.91**	**25.09**	**6.93**	**19.55**	**2.67**	**3.91**	**12.54**
Medusae	8.5	22.4	18.4	8.2	4.3	18.5	6.3	10.8	4.6	7.8	3.7

Haul No.	32	33	34	35	36	37	38	39	Total
Species/ICES Rectangle	**40G0**	**40G0**	**41G0**	**40G0**	**39G0**	**39G0**	**39G1**	**38G0**	
AGONUS CATAPHRACTUS	+								**0.02**
APHIA MINUTA									**+**
BELONE BELONE									**0.08**
CLUPEA HARENGUS	0.15	0.05	0.13	1.53	0.43	1.59	0.16	0.48	**57.54**
CRANGON CRANGON		+		+			+		**+**
CRYSTALLOGOBIUS LINEARIS	+	+	+	0.01	+	+	0.02	0.01	**0.04**
CYCLOPTERUS LUMPUS						0.24			**0.42**
ENGRAULIS ENCRASICOLUS	0.40	0.36	0.71	0.05	0.56	0.43	0.01	0.06	**10.80**
GADUS MORHUA	0.03	0.12			0.03	0.02		0.00	**4.96**
GASTEROSTEUS ACULEATUS	6.30	0.66	+	0.08	1.38	0.45	3.08	0.58	**17.13**
GOBIUS NIGER		+					0.02		**0.03**
HYPEROPLUS LANCEOLATUS									**0.01**
LIMANDA LIMANDA						0.05	0.21	0.30	**2.47**
LOLIGO FORBESI		0.03	0.01	0.02	0.02	+	0.06	0.01	**0.15**
MERLANGIUS MERLANGUS	0.28	0.03	0.06	0.26		0.07	0.05	0.08	**1.60**
MULLUS SURMULETUS				0.01					**0.01**
MYOXOCEPHALUS SCORPIUS									**0.01**
PLATICHTHYS FLESUS	0.11								**0.11**
POMATOSCHISTUS MINUTUS	+	+		+	+	+	0.02	0.00	**0.03**
SCOMBER SCOMBRUS	0.05								**0.05**
SEPIOLA							+		**+**
SPRATTUS SPRATTUS	20.04	8.47	0.48	39.58	0.89	17.19	16.73	1.20	**198.88**
SYNGNATHUS ROSTELLATUS									**+**
SYNGNATHUS TYPHLE									**+**
TRACHURUS TRACHURUS	0.01	0.02	0.11	0.17		0.06	0.09	0.11	**7.86**
Total	**27.37**	**9.74**	**1.50**	**41.71**	**3.31**	**20.10**	**20.45**	**2.83**	**302.20**
Medusae	4.6	2.4	2.2	4.3	3.3	1.6	0.5	7.5	**139.9**

+ = < 0,01 kg

Table 3. Catch composition (kg/0.5 h) by trawl haul in Subdivision 23 (FRV "SOLEA" in 2010).

Haul No.	**40**	**41**	**42**	**43**	**Total**
Species/ICES Rectangle	**40G2**	**40G2**	**41G2**	**41G2**	
CLUPEA HARENGUS	625.89	374.34	4.03	6.68	**1010.94**
CRYSTALLOGOBIUS LINEARIS			+	0.04	**0.04**
ENGRAULIS ENCRASICOLUS				0.01	**0.01**
EUTRIGLA GURNARDUS			+		**+**
GADUS MORHUA	29.16	7.03			**36.19**
GASTEROSTEUS ACULEATUS			+	+	**+**
LEANDER				+	**+**
LIMANDA LIMANDA			0.06	0.06	**0.12**
LOLIGO FORBESI			0.01	0.05	**0.06**
MERLANGIUS MERLANGUS	0.83	0.21	0.06	0.02	**1.12**
POMATOSCHISTUS MINUTUS		+		+	**+**
SPRATTUS SPRATTUS	98.64	1.18	1.40	16.48	**117.70**
SEPIOLA			+		**+**
TRACHINUS DRACO			+	0.08	**0.08**
TRACHURUS TRACHURUS	0.01	0.03	0.01	0.01	**0.06**
Total	**754.53**	**382.79**	**5.57**	**23.43**	**1166.32**
Medusae	1.6	2.3	3.6	2.6	**10.0**

+ = < 0,01 kg

Table 4. Catch composition (kg/0.5 h) by trawl haul in Subdivision 24 (FRV "SOLEA" in 2010).

Haul No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Species/ICES Rectangle	**37G2**	**38G2**	**38G3**	**38G3**	**38G4**	**38G3**	**37G3**	**38G4**	**38G4**	**38G3**	**38G2**
ANGUILLA ANGUILLA						0.18					
APHIA MINUTA											
BELONE BELONE									0.01		
CLUPEA HARENGUS	1.38	5.22	7.34	33.50	5.42	68.23	14.94	40.60	122.90	15.4	4.82
CRANGON CRANGON		+					+				+
ENGRAULIS ENCRASICOLUS	0.09	0.06	0.02	0.02					+	0.04	+
GADUS MORHUA		3.95	3.09		3.85	20.40	16.63	1.36	6.71	0.72	
GASTEROSTEUS ACULEATUS	0.20	0.49	0.06	0.10	0.03	0.49	0.14	0.10	0.25	0.05	0.13
GOBIUS NIGER			+								
LEANDER	0.00										
LIMANDA LIMANDA						0.02					
LIPARIS LIPARIS											
MERLANGIUS MERLANGUS	0.02	0.01	16.13	4.05		83.10	39.12	0.97	14.63		
MYSIDACEA											
OSMERUS EPERLANUS	+	+		0.02	+	1.07	0.57		0.05		
PERCA FLUVIATILIS						0.01					
PLATICHTHYS FLESUS			0.35			+	1.19	0.60	0.38	0.45	
PLEURONECTES PLATESSA											
POMATOSCHISTUS MINUTUS		0.01	0.13	0.05		0.14	0.12		+	0.01	+
SCOMBER SCOMBRUS						0.41					
SPRATTUS SPRATTUS	0.22	4.97	23.80	7.05	12.86	52.01	14.65	158.88	17.98	6.09	17.21
STIZOSTEDION LUCIOPERCA							0.19				
SYNGNATHUS ROSTELLATUS											
TRACHURUS TRACHURUS	0.14	0.08	+	0.01			0.02		0.08		0.01
Total	**2.05**	**14.79**	**50.92**	**44.80**	**22.16**	**226.06**	**87.57**	**202.51**	**162.99**	**22.76**	**22.17**
Medusae	4.2	4.9	0.4	6.7	3.5	1.2	2.6	0.6	9.1	1.0	3.0

Haul No.	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**Total**
Species/ICES Rectangle	**38G2**	**39G2**	**39G3**	**39G3**	**39G4**	**39G4**	**39G3**	**39G3**	**39G2**	
ANGUILLA ANGUILLA										**0.18**
APHIA MINUTA			+							**+**
BELONE BELONE	0.01		0.03		0.04					**0.09**
CLUPEA HARENGUS	8.05	5.22	32.66	36.70	68.96	9.82	7.3	15.53	5.38	**509.37**
CRANGON CRANGON			+				+	+		**+**
ENGRAULIS ENCRASICOLUS	0.01	0.02	0.02	0.01		0.07		+		**0.36**
GADUS MORHUA	0.01		3.01	3.11	6.20	19.93	9.00	2.15	9.55	**109.67**
GASTEROSTEUS ACULEATUS	0.58	0.12	0.02	+						**2.76**
GOBIUS NIGER										**+**
LEANDER										**+**
LIMANDA LIMANDA										**0.02**
LIPARIS LIPARIS	+									**+**
MERLANGIUS MERLANGUS			0.30	2.44	14.30	+				**175.07**
MYSIDACEA						+				**+**
OSMERUS EPERLANUS										**1.71**
PERCA FLUVIATILIS										**0.01**
PLATICHTHYS FLESUS										**2.97**
PLEURONECTES PLATESSA			0.24							**0.24**
POMATOSCHISTUS MINUTUS	+	0.10	0.24	0.01		0.08	0.04	0.05	0.01	**0.99**
SCOMBER SCOMBRUS					0.55					**0.96**
SPRATTUS SPRATTUS	0.90	5.99	17.70	24.43	14.90	3	6.3	7.86	2.18	**398.98**
STIZOSTEDION LUCIOPERCA										**0.19**
SYNGNATHUS ROSTELLATUS					+					**+**
TRACHURUS TRACHURUS	0.01	+	0.07	0.01			+	0.01		**0.44**
Total	**9.57**	**11.45**	**54.29**	**66.71**	**104.95**	**32.90**	**22.64**	**25.60**	**17.12**	**1204.01**
Medusae	1.2	1.8	1.1	2.0	3.3	2.5	1.8	5.2	2.1	**58.2**

+ = < 0,01 kg

Table 5. Survey statistics by area (FRV "SOLEA" October 2010).

Sub-division	ICES Rectangle	Area (nm²)	Sa (m²/NM²)	Sigma (cm²)	N total (million)	Herring (%)	Sprat (%)	NHerring (million)	NSprat (million)
21	41G0	108.1	247.2	0.844	316.62	22.54	45.89	71.36	145.29
21	41G1	946.8	65.5	0.747	830.05	17.99	9.82	149.33	81.49
21	41G2	432.3	93.0	1.200	335.08	15.32	0.80	51.35	2.69
21	42G1	884.2	22.8	1.150	175.34	56.19	3.79	98.52	6.65
21	42G2	606.8	42.0	1.594	159.84	76.23	3.21	121.84	5.14
21	43G1	699.0	43.4	0.840	360.96	31.32	0.00	113.05	0.00
21	43G2	107.0	6.3	0.840	8.02	31.32	0.00	2.51	0.00
21	Total	3,784.2			2,185.91			607.96	241.26
22	37G0	209.9	727.2	0.798	1,912.89	1.44	65.75	27.62	1,257.77
22	37G1	723.3	281.3	0.723	2,814.60	20.05	64.43	564.35	1,813.38
22	38G0	735.3	346.8	0.531	4,801.53	6.76	67.09	324.55	3,221.53
22	38G1	173.2	547.9	0.727	1,305.31	22.55	64.80	294.39	845.87
22	39F9	159.3	319.3	0.457	1,112.43	1.18	92.33	13.18	1,027.05
22	39G0	201.7	151.6	0.543	562.84	7.82	61.75	44.02	347.58
22	39G1	250.0	224.2	0.491	1,141.55	0.11	63.81	1.31	728.43
22	40F9	51.3	244.1	0.541	231.41	0.72	77.20	1.67	178.66
22	40G0	538.1	241.8	0.541	2,404.48	0.72	77.20	17.34	1,856.37
22	40G1	174.5	250.2	0.541	806.84	0.72	77.20	5.82	622.91
22	41G0	173.1	137.8	0.898	265.69	6.04	43.40	16.04	115.30
22	Total	3,389.7			17,359.57			1,310.29	12,014.85
23	39G2	130.9	536.2	1.22	575.19	35.36	61.41	203.36	353.21
23	40G2	164.0	2,321.9	5.094	747.49	69.13	30.08	516.71	224.86
23	41G2	72.3	360.9	0.934	279.39	34.77	60.05	97.15	167.79
23	Total	367.2			1,602.07			817.22	745.86
24	37G2	192.4	121.0	0.763	305.08	16.62	16.62	50.70	50.70
24	37G3	167.7	882.6	1.356	1,091.76	5.83	89.04	63.60	972.11
24	37G4	875.1	365.2	1.720	1,858.32	21.31	76.38	396.10	1,419.41
24	38G2	832.9	366.7	0.791	3,861.39	29.92	51.51	1,155.21	1,989.07
24	38G3	865.7	654.4	1.270	4,462.00	24.01	73.03	1,071.31	3,258.79
24	38G4	1,034.8	516.9	1.720	3,110.25	21.31	76.38	662.94	2,375.64
24	39G2	406.1	162.0	1.220	539.13	35.36	61.41	190.61	331.06
24	39G3	765.0	258.6	1.405	1,407.81	40.62	58.85	571.82	828.49
24	39G4	524.8	268.1	2.817	499.50	61.19	35.91	305.65	179.37
24	Total	5,664.5			17,135.24			4,467.94	11,404.64
22-24	Total	9,421.4			36,096.88			6,595.45	24,165.35
21-24	Total	13,205.6			38,282.79			7,203.41	24,406.61

Table 6. Numbers (millions) of herring by age and area (RV "SOLEA" October 2010).

Sub-division	Rectangle/ W-rings	0	1	2	3	4	5	6	7	8+	Total
21	41G0	71.35	0.02								71.37
21	41G1	149.23	0.10								149.33
21	41G2	50.87	0.48								51.35
21	42G1	94.64	3.88								98.52
21	42G2	114.88	6.75	0.21							121.84
21	43G1	94.32	14.02	3.43		1.28					113.05
21	43G2	2.10	0.31	0.08		0.03					2.52
21	Total	577.39	25.56	3.72	0.00	1.31	0.00	0.00	0.00	0.00	607.98
22	37G0	26.23	0.74	0.04	0.35	0.12	0.08	0.04	0.04	0.00	27.64
22	37G1	536.25	12.26	1.07	6.07	2.66	2.72	1.01	2.14	0.16	564.34
22	38G0	315.91	4.64	0.05	3.24	0.38	0.11	0.16	0.05	0.00	324.54
22	38G1	275.78	8.98	0.53	4.19	2.37	1.44	0.30	0.64	0.15	294.38
22	39F9	13.18									13.18
22	39G0	44.01	0.01								44.02
22	39G1	1.31									1.31
22	40F9	1.66	0.01								1.67
22	40G0	17.21	0.06			0.03				0.01	17.31
22	40G1	5.77	0.02			0.01					5.80
22	41G0	16.04									16.04
22	Total	1,253.35	26.72	1.69	13.85	5.57	4.35	1.51	2.87	0.32	1,310.23
23	39G2	189.46	4.61	1.63	3.68	2.52	0.54	0.25	0.55	0.13	203.37
23	40G2	11.81	85.66	127.78	104.5	58.69	65	39.34	14.01	9.92	516.71
23	41G2	95.69	1.32		0.14						97.15
23	Total	296.96	91.59	129.41	108.32	61.21	65.54	39.59	14.56	10.05	817.23
24	37G2	20.52	12.79	2.05	7.62	5.01	1.61	0.21	0.88		50.69
24	37G3	33.00	5.37	3.49	7.43	7.02	4.08	1.56	1.21	0.45	63.61
24	37G4	84.18	67.74	53.45	75.19	58.59	23.63	9.15	18.19	5.99	396.11
24	38G2	1,071.59	32.94	6.17	21.60	14.38	5.38	0.68	2.29	0.19	1,155.22
24	38G3	512.08	174.10	67.56	134.45	100.78	43.38	11.13	24.18	3.65	1,071.31
24	38G4	140.90	113.37	89.46	125.85	98.07	39.54	15.32	30.44	10.00	662.95
24	39G2	177.59	4.33	1.53	3.45	2.36	0.51	0.23	0.51	0.12	190.63
24	39G3	452.23	40.38	14.12	29.52	19.44	8.79	2.46	4.43	0.43	571.80
24	39G4	155.12	28.31	26.58	38.22	29.23	12.61	5.17	8.08	2.33	305.65
24	Total	2,647.21	479.33	264.41	443.33	334.88	139.53	45.91	90.21	23.16	4,467.97
22-24	Total	4,197.52	597.64	395.51	565.50	401.66	209.42	87.01	107.64	33.53	6,595.43
21-24	Total	4,774.91	623.20	399.23	565.50	402.97	209.42	87.01	107.64	33.53	7,203.41

Table 7. Mean weight (g) of herring by age and area (RV "SOLEA" October 2010).

Sub-division	Rectangle/ W-rings	0	1	2	3	4	5	6	7	8+	Total
21	41G0	7.03	16.93								7.03
21	41G1	9.31	16.93								9.32
21	41G2	12.00	17.26								12.05
21	42G1	13.27	28.27								13.86
21	42G2	12.91	34.83	51.83							14.19
21	43G1	15.24	40.75	56.58		186.00					21.60
21	43G2	15.24	40.75	56.58		186.00					21.60
21	Total	11.62	36.74	56.32		186.00					13.33
22	37G0	8.00	29.73	33.24	30.48	30.77	33.24	28.43	33.24		9.12
22	37G1	8.79	33.21	37.12	33.49	35.46	36.81	41.82	41.61	43.83	10.10
22	38G0	7.47	27.07	33.24	50.76	30.05	33.24	28.43	33.24		8.24
22	38G1	9.67	31.82	36.02	32.25	36.28	35.92	28.43	37.90	43.83	11.16
22	39F9	5.27									5.27
22	39G0	6.45	16.29								6.45
22	39G1	7.27									7.27
22	40F9	7.31	42.41	39.21	39.21	43.17	39.21		39.21		7.58
22	40G0	7.31	42.41	39.21	39.21	43.17	39.21		39.21	43.83	7.58
22	40G1	7.31	42.41	39.21	39.21	43.17	39.21		39.21		7.58
22	41G0	7.47									7.47
22	Total	8.47	31.60	36.57	37.08	35.39	36.37	37.28	40.52	43.83	9.60
23	39G2	8.21	33.74	48.93	42.42	58.10	48.74	57.06	79.29	78.37	10.76
23	40G2	10.18	55.47	112.10	135.27	167.22	199.20	203.36	221.26	205.42	133.99
23	41G2	9.44	33.78		26.89						9.79
23	Total	8.68	54.06	111.30	131.98	162.73	197.96	202.44	215.90	203.77	88.56
24	37G2	10.20	33.92	37.82	33.95	36.83	38.75	39.42	40.25		25.05
24	37G3	5.26	37.32	57.62	82.11	111.93	124.36	133.33	94.20	138.11	44.99
24	37G4	9.47	37.45	57.66	60.69	62.65	66.73	79.99	77.65	121.76	48.21
24	38G2	7.01	33.24	41.56	33.49	37.20	38.79	43.18	42.01	53.12	9.06
24	38G3	5.70	36.10	51.96	46.04	49.25	54.74	65.54	50.24	81.24	26.59
24	38G4	9.47	37.45	57.66	60.69	62.65	66.73	79.99	77.65	121.58	48.21
24	39G2	8.21	33.74	48.93	42.42	58.10	48.74	57.06	79.29	79.30	10.76
24	39G3	9.09	35.70	49.08	39.55	41.75	42.91	50.64	45.99	58.25	15.66
24	39G4	9.76	39.98	58.59	67.69	66.42	63.66	78.94	66.89	78.35	34.89
24	Total	7.57	36.54	55.26	53.87	57.25	61.44	75.76	66.75	109.28	25.92
22-24	Total	7.91	39.01	73.52	68.42	73.02	103.65	132.73	86.22	136.98	30.44
21-24	Total	8.36	38.91	73.36	68.42	73.39	103.65	132.73	86.22	136.98	29.00

Table 8. Total biomass (t) of herring by age and area (RV "SOLEA" October 2010).

Sub-division	Rectangle/ W-rings	0	1	2	3	4	5	6	7	8+	Total
21	41G0	501.6	0.3								501.9
21	41G1	1,389.3	1.7								1,391.0
21	41G2	610.4	8.3								618.7
21	42G1	1,255.9	109.7								1,365.6
21	42G2	1,483.1	235.1	10.9							1,729.1
21	43G1	1,437.4	571.3	194.1		238.1					2,440.9
21	43G2	32.0	12.6	4.5		5.6					54.7
21	Total	6,709.7	939.0	209.5	0.0	243.7	0.0	0.0	0.0	0.0	8,101.9
22	37G0	209.8	22.0	1.3	10.7	3.7	2.7	1.1	1.3		252.6
22	37G1	4,713.6	407.2	39.7	203.3	94.3	100.1	42.2	89.0	7.0	5,696.4
22	38G0	2,359.8	125.6	1.7	164.5	11.4	3.7	4.5	1.7		2,672.9
22	38G1	2,666.8	285.7	19.1	135.1	86.0	51.7	8.5	24.3	6.6	3,283.8
22	39F9	69.5									69.5
22	39G0	283.9	0.2								284.1
22	39G1	9.5									9.5
22	40F9	12.1	0.4								12.5
22	40G0	125.8	2.5			1.3				0.4	130.0
22	40G1	42.2	0.8			0.4					43.4
22	41G0	119.8	0.0								119.8
22	Total	10,612.8	844.4	61.8	513.60	197.1	158.2	56.30	116.30	14.0	12,574.5
23	39G2	1,555.5	155.5	79.8	156.10	146.4	26.3	14.30	43.60	10.2	2,187.7
23	40G2	120.2	4,751.6	14,324.1	14,135.7	9,814.1	12,948.0	8,000.2	3,099.9	2,037.7	69,231.5
23	41G2	903.3	44.6		3.8						951.7
23	Total	2,579.0	4,951.7	14,403.9	14,295.6	9,960.5	12,974.3	8,014.5	3,143.5	2,047.9	72,370.9
24	37G2	209.3	433.8	77.5	258.7	184.5	62.4	8.3	35.4		1,269.9
24	37G3	173.6	200.4	201.1	610.1	785.7	507.4	208.0	114.0	62.2	2,862.5
24	37G4	797.2	2,536.9	3,081.9	4,563.3	3,670.7	1,576.8	731.9	1,412.5	729.3	19,100.5
24	38G2	7,511.8	1,094.9	256.4	723.4	534.9	208.7	29.4	96.2	10.1	10,465.8
24	38G3	2,918.9	6,285.0	3,510.4	6,190.1	4,963.4	2,374.6	729.5	1,214.8	296.6	28,483.3
24	38G4	1,334.3	4,245.7	5,158.3	7,637.8	6,144.1	2,638.5	1,225.4	2,363.7	1,215.7	31,963.5
24	39G2	1,458.0	146.1	74.9	146.3	137.1	24.9	13.1	40.4	9.5	2,050.3
24	39G3	4,110.8	1,441.6	693.0	1,167.5	811.6	377.2	124.6	203.7	25.0	8,955.0
24	39G4	1,514.0	1,131.8	1,557.3	2,587.1	1,941.5	802.8	408.1	540.5	182.5	10,665.6
24	Total	20,027.9	17,516.2	14,610.8	23,884.3	19,173.5	8,573.3	3,478.3	6,021.2	2,530.9	115,816.4
22-24	Total	33,219.7	23,312.3	29,076.5	38,693.5	29,331.1	21,705.8	11,549.1	9,281.0	4,592.8	200,761.8
21-24	Total	39,929.4	24,251.3	29,286.0	38,693.5	29,574.8	21,705.8	11,549.1	9,281.0	4,592.8	208,863.7

Table 9. Numbers (millions) of sprat by age and area (FRV "SOLEA" October 2010).

Sub-division	Rectangle/ Age group	0	1	2	3	4	5	6	7	8+	Total
21	41G0	144.62	0.67								145.29
21	41G1	75.91	3.76	1.30	0.41	0.11					81.49
21	41G2	2.02		0.22	0.22	0.11	0.11				2.68
21	42G1	1.29	2.75	1.52	0.77	0.29	0.03				6.65
21	42G2		1.40	1.64	0.68	0.99	0.43				5.14
21	43G1										0.00
21	43G2										0.00
21	Total	223.84	8.58	4.68	2.08	1.50	0.57	0.00	0.00	0.00	241.25
22	37G0	1,236.18	15.29	4.50	1.80						1,257.77
22	37G1	1,807.59	4.58	0.61	0.61						1,813.39
22	38G0	3,214.38	2.98	2.98	1.19						3,221.53
22	38G1	845.87									845.87
22	39F9	1,027.05									1,027.05
22	39G0	347.58									347.58
22	39G1	728.43									728.43
22	40F9	178.66									178.66
22	40G0	1,856.37									1,856.37
22	40G1	622.91									622.91
22	41G0	115.30									115.30
22	Total	11,980.32	22.85	8.09	3.60	0.00	0.00	0.00	0.00	0.00	12,014.86
23	39G2	347.49	3.67	1.49	0.39	0.17					353.21
23	40G2	0.00	16.30	57.85	63.60	58.57	19.36	8.22	0.00	0.96	224.86
23	41G2	166.87	0.77	0.08	0.04		0.04				167.80
23	Total	514.36	20.74	59.42	64.03	58.74	19.40	8.22	0.00	0.96	745.87
24	37G2	47.07	2.89	0.69	0.04						50.69
24	37G3	951.16	10.25	8.05	1.71	0.95					972.12
24	37G4	748.31	355.32	213.41	70.15	30.99	0.41	0.81			1,419.40
24	38G2	1,966.33	13.72	6.96	1.40	0.66					1,989.07
24	38G3	2,768.45	317.88	120.36	38.84	12.18	0.36	0.72			3,258.79
24	38G4	1,252.44	594.70	357.19	117.41	51.87	0.68	1.36			2,375.65
24	39G2	325.71	3.44	1.39	0.36	0.16					331.06
24	39G3	598.49	88.96	81.57	40.01	18.27	0.77	0.41			828.48
24	39G4	46.14	48.41	49.91	23.67	10.84	0.13	0.27			179.37
24	Total	8,704.10	1,435.57	839.53	293.59	125.92	2.35	3.57	0.00	0.00	11,404.63
22-24	Total	21,198.78	1,479.16	907.04	361.22	184.66	21.75	11.79	0.00	0.96	24,165.36
21-24	Total	21,422.62	1,487.74	911.72	363.30	186.16	22.32	11.79	0.00	0.96	24,406.61

Table 10. Mean weight (g) of sprat by age and area (FRV "SOLEA" October 2010).

Sub-division	Rectangle/ Age group	0	1	2	3	4	5	6	7	8+	Total
21	41G0	4.20	12.33								4.24
21	41G1	4.80	13.51	15.78	17.51	18.80					5.46
21	41G2	4.16		20.83	20.83	20.83	20.83				8.33
21	42G1	4.91	13.52	16.87	18.32	19.02	20.83				13.44
21	42G2		15.55	18.13	18.71	22.84	22.53				18.78
21	43G1										
21	43G2										
21	Total	4.41	13.76	17.18	18.56	21.67	22.11				5.26
22	37G0	2.89	11.55	12.87	12.67						3.04
22	37G1	3.32	14.30	12.67	12.67						3.36
22	38G0	2.51	12.87	12.87	12.67						2.53
22	38G1	2.85									2.85
22	39F9	2.00									2.00
22	39G0	3.02									3.02
22	39G1	3.35									3.35
22	40F9	3.17									3.17
22	40G0	3.17									3.17
22	40G1	3.17									3.17
22	41G0	3.99									3.99
22	Total	2.88	12.28	12.86	12.67						2.91
23	39G2	4.19	10.34	12.03	16.08	17.69					4.31
23	40G2	0.00	14.46	17.99	20.78	21.41	23.58	23.55		24.60	20.13
23	41G2	4.50	12.67	13.56	13.56		13.56				4.54
23	Total	4.29	13.66	17.83	20.74	21.40	23.56	23.55		24.60	9.13
24	37G2	3.25	10.72	10.59	12.05						3.78
24	37G3	2.74	11.00	13.86	15.00	15.55					2.95
24	37G4	4.30	11.14	13.66	16.16	16.47	20.82	20.82			8.29
24	38G2	3.83	10.91	13.48	13.90	15.20					3.92
24	38G3	3.33	11.11	12.74	16.14	16.62	20.82	20.82			4.65
24	38G4	4.30	11.14	13.66	16.16	16.47	20.82	20.82			8.29
24	39G2	4.19	10.34	12.03	16.08	17.69					4.31
24	39G3	4.51	11.33	14.58	17.02	17.40	21.68	20.82			7.15
24	39G4	4.64	11.86	14.69	16.53	16.96	20.82	20.82			11.73
24	Total	3.72	11.16	13.67	16.29	16.65	21.11	20.82			5.87
22-24	Total	3.26	11.22	13.94	17.04	18.16	23.29	22.72		24.60	4.49
21-24	Total	3.27	11.23	13.96	17.05	18.19	23.26	22.72		24.60	4.50

Table 11. Total biomass (t) of sprat by age and area (FRV "SOLEA" October 2010).

Sub-division	Rectangle/ Age group	0	1	2	3	4	5	6	7	8+	Total
21	41G0	607.4	8.3								615.7
21	41G1	364.4	50.8	20.5	7.2	2.1					445.0
21	41G2	8.4		4.6	4.6	2.3	2.3				22.2
21	42G1	6.3	37.2	25.6	14.1	5.5	0.6				89.3
21	42G2		21.8	29.7	12.7	22.6	9.7				96.5
21	43G1										
21	43G2										
21	Total	986.5	118.1	80.4	38.6	32.5	12.6	0.0	0.0	0.0	1,268.7
22	37G0	3,572.6	176.6	57.9	22.8						3,829.9
22	37G1	6,001.2	65.5	7.7	7.7						6,082.1
22	38G0	8,068.1	38.4	38.4	15.1						8,160.0
22	38G1	2,410.7									2,410.7
22	39F9	2,054.1									2,054.1
22	39G0	1,049.7									1,049.7
22	39G1	2,440.2									2,440.2
22	40F9	566.4									566.4
22	40G0	5,884.7									5,884.7
22	40G1	1,974.6									1,974.6
22	41G0	460.0									460.0
22	Total	34,482.3	280.5	104.0	45.6	0.0	0.0	0.0	0.0	0.0	34,912.4
23	39G2	1,456.0	37.9	17.9	6.3	3.0					1,521.1
23	40G2	0.0	235.7	1,040.7	1,321.6	1,254.0	456.5	193.6		23.6	4,525.7
23	41G2	750.9	9.8	1.1			0.5				762.3
23	Total	2,206.9	283.4	1,059.7	1,327.9	1,257.0	457.0	193.6	0.0	23.6	6,809.1
24	37G2	153.0	31.0	7.3	0.5						191.8
24	37G3	2,606.2	112.8	111.6	25.6	14.8					2,871.0
24	37G4	3,217.7	3,958.3	2,915.2	1,133.6	510.4	8.5	16.9			11,760.6
24	38G2	7,531.0	149.7	93.8	19.5	10.0					7,804.0
24	38G3	9,218.9	3,531.6	1,533.4	626.9	202.4	7.5	15.0			15,135.7
24	38G4	5,385.5	6,625.0	4,879.2	1,897.3	854.3	14.2	28.3			19,683.8
24	39G2	1,364.7	35.6	16.7	5.8	2.8					1,425.6
24	39G3	2,699.2	1,007.9	1,189.3	681.0	317.9	16.7	8.5			5,920.5
24	39G4	214.1	574.1	733.2	391.3	183.8	2.7	5.6			2,104.8
24	Total	32,390.3	16,026.0	11,479.7	4,781.5	2,096.4	49.6	74.3	0.0	0.0	66,897.8
22-24	Total	69,079.5	16,589.9	12,643.4	6,155.0	3,353.4	506.6	267.9	0.0	23.6	108,619.3
21-24	Total	70,066.0	16,708.0	12,723.8	6,193.6	3,385.9	519.2	267.9	0.0	23.6	109,888.0

ANNEX 5I: Ireland (Celtic Sea)

Celtic Sea Herring Acoustic Survey Cruise Report 2009

Acoustic calibration at Bere Island

Ryan Saunders[1],Ciaran O'Donnell[1], Andrew Campbell[1], Deirdre Lynch[1], Kieran Lyons[2] and Dave Wall[3]

[1]The Marine Institute, Fisheries Science Services,

Rinville, Oranmore, Co. Galway.

[2]The Marine Institute, Ocean Science Services

Irish Whale and Dolphin Group (IWDG)

Introduction

In the southwest of Ireland and the Celtic Sea (ICES Divisions VIIaS, g and 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 small number of purpose built Refrigerated seawater vessels (RSW). The stock is composed of both autumn and winter spawning components and the fishery targets prespawning and spawning aggregations. The Irish commercial fishery has historically taken place within 1–20 nmi (nautical miles) of the coast and focused on aggregated schools within the spawning cycle. In recent years the larger RSW vessels have actively targeted off-shore 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 shore including many bays and inlets. 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.

The stock structure and discrimination of herring in this area has been investigated recently. Hatfield *et al*. (2007) has demonstrated 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 VII j 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 represents the 18th in the overall acoustic series or the fourth in the modified time series.

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 by detailed hydrographic and marine mammal and seabird work programs first initiated during this survey in 2004.

Material and methods

Scientific Personnel

FSS	Ryan Saunders	Acoustics (SIC)
FSS	Deirdre Lynch	Acoustics
FSS	Andrew Campbell	Acoustics
FSS	Turloch Smith	Acoustics
FSS	Michael McAuliffe	Biologist
FSS	Tobi Rapp	Biologist
FSS	Kieran Mc Cann	Biologist (Deck Sci)
FSS	Clementine Harma	Biologist
IWDG	Dave Wall	Marine Mammal Obs.
SWFB	John O' Regan	Fisheries Observer

Survey Plan

Survey objectives

The primary survey objectives are listed below:

- Carry out a predetermined 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
- Collect ancillary information on secondary pelagic species such as sprat and pilchard to determine biomass and abundance within the survey area
- Collect physical oceanography data as horizontal and vertical profiles from a deployed sensor array.
- Survey by visual observations marine mammals and seabird abundance and distribution during the survey

Area of operation

The autumn 2009 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 and VIIg. The survey started in the north and worked in a southerly direction to facilitate temporal progression of spawning within stock components.

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; 2005a; 2005b; 2006; 2007; 2008). The broad scale survey was composed of 10 strata and formed an integral component of the overall survey. Broad scale outer lying areas form an important transit area for herring migrating to and from inshore spawning areas and from offshore summer feeding grounds. The second component of the survey focused exclusively on known spawning areas and was made up of 6 strata.

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 65nmi (nautical miles). Transects 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 maximize geographical coverage within these confined areas.

Transect start points within each stratum are randomized each year using a random number generator within established baseline stratum bounds.

In total the combined survey accounted for 3,190 nm, with around 2,700 nm of integrateable acoustic transect data collected.

Equipment and system details and specifications

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 FSS 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 ER60 scientific echosounder. The Simrad ES-38B (38 KHz) split-beam transducer is mounted within the vessel's drop keel and lowered to the working depth of 3.3m below the vessel's hull or 8.8m below the sea surface. Three other operating frequencies were used during the survey (18, 120 and 200Khz) for trace recognition purposes, with the 38Khz data used solely to generate the abundance estimate.

Whilst 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.

Calibration of acoustic equipment

A calibration of the ER60 was carried out behind Bere Island on the 25 October. The calibration report for the 38 kHz transducer is included in Annex 1. The calibration was conducted in 30 m of water during the evening and night-time. Night-time calibrations are considered to be robust, particularly when extra data points are collected for the beam model and S_a correction calculations. Over 350 data points were collected at each frequency, so the potential impact of DVM organisms distorting the calibration is highly unlikely. Indeed, the calibration experiment gave good results for the 38 kHz transducer. However, the ER60 was not updated using the 2009 calibration experiment results. The ER60 was last calibrated in Irish coastal waters 7 months prior to the survey start (O'Donnell *et al.*, 2009) and these settings remain the same.

Survey protocols

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 as "EK5" files 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 were 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.

Echogram scrutinisation

Acoustic data were 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" echotraces or traces were identified on the basis of captures of herring from the fishing trawls which had sampled the echotraces 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 echotraces 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 echotraces in similar water depths.

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

The "EK5" 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 were those recommended by the acoustic survey planning group (Anon, 1994) and were as follows:

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)

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)

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 codend. 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 on-board. The appropriate raising factors were calculated and applied to provide length frequency compositions for the bulk of each haul.

Decisions to fish on particular echotraces 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.

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 Seabird 911 sampler at 1m subsurface and 3m above the seabed. Coverage was broken down into 4 main hydrographic transects with CTD casts undertaken on selected transects in each of the target strata. Hydrographic stations were equally spread at 6–10nmi spacing on each transect where possible (Figure 9).

Marine mammal and seabird observations

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, windspeed and wind direction. For each sighting the following data were recorded: time, location, species, distance, Bereing 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.

Analysis methods

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) = 0.00648* $L^{3.351}$ (L = length in cm)

Mackerel weight (grams) = 0.01118* $L^{3.032}$ (L = length in cm)

Sprat weight (grams) = 0.02404* $L^{3.192}$ (L = length in cm)

Abundance estimate

Total abundance, N_T, is given by $\sum_{m}^{Mark-types} N_{T,m}$, the sum over the total abundance by mark-types.

$$N_{T,m} = \sum_{s}^{strata} N_{m,s}$$

Suppressing the mark-type index, m, the stratum abundance is

$$N_s = area_s \sum_{l}^{transects} \bar{n}_{s,t} l_{s,t} \Big/ \sum_{j} l_{s,j}$$

,where l is the transect length and $\bar{n}$ is the transect mean abundance n.mi^{-2} which is given by

$$\sum_{j}^{track\cdot fragments} n_{s,t,j} d_{s,t,j} \Big/ l_{s,t}$$

, where d is the distance of the track fragment and $n_{s,t,j}$ is the mean abundance n.mi^{-2} for the jth track fragment.

Hauls are assigned with their own stratification that may not necessarily coincide with the acoustic strata, the conversion of NASC into mean density is done at the track fragment level, usually a 1 n.mi segment. The haul assigned, $h_{m,s,t,j}$, depends strongly on the mark-type (m) and since more than one school can be in a track fragment it needs to be specified. Since age and maturity length-keys are to be applied, the basic estimation is mean density by length bins. The $n_{s,t,j}$ is found by summing over the $n_{s,t,j}$.

$$n_{t,j,i} = \frac{NASC_{t,j}}{\bar{\sigma}_{h_{m,t,j}}} p_{i,h_{m,t,j}}$$

, where i indices length bins, p_i is the proportion of herring in the i^{th} length bin, and is given by $\sum_{spe}^{species} \sum_i p_{spe,i} 10^{(a+b\log10(L_{spe,i}))/10}$

, where $p_{spe,i}$ applies over all species considered in the haul, $L_{spe,i}$ is the length to use for the i^{th} length bin and the data comes from the haul (of combination of hauls) assigned, $h_{m,t,j}$. For non-mix mark-types, the later simplifies to

$$\sum_i p_{herring,i} 10^{(073+20\log10(L_{herring,i}))/10}.$$

For biomass, a mean weight is also applied to the $n_{t,j,i}$ using the estimated regression relationship, a L_i^b.

For abundance by age and maturity, the abundance by length bin, $n_{t,j,i}$, is averaged over track fragments and then transects to give a strata (and mark-type) mean. The age and maturity keys are applied to the results.

$V_s = area_s^2 s_s^2 W_s$, where $W_s = \sum_l^{transects} l^2_{s,t} \Big/ (\sum_j l_{s,j})^2$ and s^2 is the sample variance.

The variance for the total is the sum of strata variances.

The total biomass can be obtained directly from the track fragment mean biomass by

$B_T = \sum_k^{track\cdot fragment} \bar{n}_k w_k$, where w_k is a factor that takes into account the factors for transect

and strata averaging, i.e. $w_k = \frac{1n.mi}{l_{t_k}} \frac{l_{t_k}}{\sum_t^{stratum.s_k} l_{s_k,t}} area_{s_k} = \frac{1}{\sum_t^{stratum.s_k} l_{s_k,t}} area_{s_k}$

, where the 1 n.mi is the length of the track fragment. This ignores the mark-type since that is already accounted for in the $\bar{n}_k$. The $\bar{n}_k w_k$ is the biomass from a track fragment and they can then be used to map the biomass at a fine spatial scale.

Estimates are made for SSB, total abundance and biomass, abundance by age (ring counts), and abundance by age x length bins. A cv (based on strata standard error divided by the strata mean) is estimated for SSB, total abundance and biomass, and abundance by age.

Results

Celtic Sea herring stock

Herring biomass and abundance

Herring	Millions	Biomass (t)	% contribution
Total estimate			
Definitely	828	91.764	77,1
Mixture	220	14.000	11,8
Probably	99	13.319	11,2
Total estimate	1147	119.083	100
SSB Estimate			
Definitely	512	75.071	82,6
Probably	78	11.594	12,7
Mixture	46	4.272	4,7
SSB estimate	636	90.937	100

Estimates of herring biomass and abundance detected during the survey are summarized above. These estimates were derived from 644 echotraces that were identified with the aid of 30 directed net hauls (Figure 2). Of the total number of echotraces attributed to herring, approximately 44% were in the 'Definitely herring' category, 47% were classed as 'Mixed herring' and 9% occurred in the 'Probably herring' category (Table 11).

The overall herring biomass and abundance estimates were approximately 119,000 t (CV 22.7%) and 1147 million individuals (CV 23.1%), respectively. The overall SSB observed during the survey was almost 91, 000 t (CV 24%), comprising an abundance of this component in the order of 636 million individuals. These estimates of abundance and biomass constitute the highest detected in the region during the c. 10 year acoustic survey time-series. However, the total SSB estimate is similar to that observed in 2008. The majority of herring biomass detected throughout the survey occurred in discrete schools that were classified as 'Definitely herring' according to targeted net hauls (77% and 83% for TSB and SSB, respectively). However, a substantial proportion of herring TSB occurred in mixed species assemblages (c. 12%), and the 'Probably herring' category comprised around 12% of both the TSB and SSB estimates. Estimates from these categories are still considered to be robust due to the high frequency of net sampling conducted throughout the survey region.

Herring stock abundance and biomass estimates are further broken down by age, maturity status, size and strata in Tables 6–10. The length frequency data used to calculate herring target strength for the TSB and SSB estimates are presented in Table 4, and herring school counts by category and strata are presented in Table 11. In general, the majority of herring biomass and abundance occurred in 4 strata (strata 8, 9, 10 and 12), with stratum 12 and stratum 9 contributing the greatest proportions to the TSB and SSB estimates. Of the 19 strata surveyed, 12 contained no herring. Herring within the 3 winter-ring group had the highest biomass (c. 32,000 t; Table 6), although the 0 and 1 winter-ring group comprised the greatest abundance (239 million and 381 million individuals, respectively; Table 7). Around 24% of the total herring biomass detect during the survey was derived from the juvenile component of the population

(Table 8). This contrasts markedly with the 2008 survey where the juvenile proportion represented just 3% of the TSB.

Herring distribution

A total of 30 trawl hauls were carried out during the survey (Figure 2), with 23 hauls containing herring and 11 hauls containing >50% herring by weight of bulk catch (Table 3). In general, large and dense herring schools were predominantly distributed close inshore around a single spawning ground in the Tramore Bay region (stratum 12: Figure 3). Relatively large herring schools were also detected in more offshore regions to the north of the Rigs and towards the most southeasterly sector of the survey grid. Most herring schools were detected between 7–8 ºW, although several occurred in the region to the north of Fastnet Island and a few were situated around c. 10 nm southwest of Ballycotton.

The majority of discrete herring schools detected throughout the survey were positioned in close proximity to the seabed, or occurred as dense 'towers' protruding from the seabed. Mixed species assemblages that often contained around 20% herring (usually as intense 'chips') were also distributed in regions close the bottom. Only a few herring schools were distributed between the surface and midwater depth. No herring were found in the southwest region of the survey area, except for a relatively small proportion observed in Dingle Bay. Overall, our observations accord well with reports from the commercial fishing fleet operating in the region in that substantial catches of herring were obtained by the fleet in regions around Fastnet, Mine Head and in proximity to Tramore Bay.

Herring stock composition

A total of 1,012 herring were aged during the survey. Also, over 5,120 herring were measured and approximately 2,740 length-weight measurements were obtained (Tables 3, 4 and 5). Herring age samples predominantly ranged from 1–5 winter-rings (Tables 6 and 7). The dominant age groups in terms of biomass were the 3 and 1 winter-ring fish that accounted for around 27% of the total TSB per group (32,000 t and 31,000 t, respectively). The 5 winter-ring group was also relatively strong comprising about 18% of the TSB (c. 22,000 t). Accordingly, these 3 cohorts were strong in terms of numerical abundance (3-group= 124.6 million, CV 24.6%; 1-group= 381.4 million, CV 41.5%; 5-goup= 124.6 million, CV 26.3%). The population also contained a relatively high abundance of small herring (mean length: 15.4 cm) within the 0 winter-ring group (239.5 million, CV 47.2%) that comprised approximately 21% of the TSN, but just 5.4% of the TSB. The majority of the 0-group was distributed in the offshore sector of the survey grid (stratum 9), with relatively few present as far inshore as the spawning bays. Herring maturity, as determined from trawl samples, showed the majority of the stock to be either in a prespawning state or immature. No spawning individuals and no spent fish were encountered during the survey (Tables 8 and 9).

The whole mature component of the herring stock (stages 3 to 9) sampled during the survey was in a prespawning state and was predominantly comprised of stage 4 individuals (70% of the mature component). This is similar to that observed in 2008 and 2007.

Secondary pelagic species

During the scrutinisation process, acoustic data were categorized for secondary and tertiary target species (see section 2.4.2) based on information from trawl data. Sprat and Mackerel (*Scomber scrombrus*) were encountered regularly during the survey.

Mackerel occurred in several of the nets, but generally only in small proportions. Of the 30 net hauls deployed, only 3 contained proportions of mackerel >40% by weight of bulk catch (Table 3). Mackerel catches were dominated by juveniles. The amount of single mackerel schools observed was low (Figure 6), with the majority occurring as mixed schools. There were generally fewer observations of mackerel on this survey than during the survey conducted in 2008. Due to insufficient net haul data on mackerel, the scrutinisation of the species cannot be considered robust and no biomass was determined for mackerel.

The distribution and abundance of horse mackerel (*Trachurus trachurus*) schools in the southwest area were notably scare during the 2008 survey compared to the 2007, and as a result no biomass estimates were determined. The results of this survey are similar to those in 2008; there was very little horse mackerel present throughout the survey area. Also, there were no boarfish present during the 2009 survey, unlike in 2008.

Sprat abundance and biomass

Sprat	Millions	Biomass (t)	% contribution
Total estimate			
Definitely	497	4.530	27,9
Mixture	921	11.699	72,1
Probably	0	0	0,0
Total estimate	1418	16.229	100

Sprat was encountered regularly in most areas and was present in relatively high proportions in many of the net hauls (Table 3). Sprat was often difficult to differentiate from herring acoustically, so frequent net hauls were deployed on almost every target of significant size and intensity. In general, most of the sprat was distributed around midwater column depth and was at times highly mobile and difficult to catch, particularly during the daytime. These observations were also reported by the commercial fishing fleet operating in the same areas during the survey. Our net data also showed that sprat frequently occurred in mixed assemblages, often co-occurring with juvenile herring of a similar body size (Table 3). However, there was sufficient net haul data obtained at an adequate spatial resolution to enable a fairly robust categorization of the species abundance and biomass (summarized above). The total biomass estimate for sprat was 16, 229 t (CV 31%) and the total numerical abundance was 1418 million individuals (CV 29%).

Sprat distribution is presented in Figure 4 for the “Definitely” and “Probably Sprat” category but does not include the “Sprat in a mix” which accounted for the majority of the total biomass detected (72%). Abundance and biomass by stratum are presented in Table 13. In general, more sprat was detected on the survey than during the 2008 survey. The species was widely distributed throughout the survey region with dense schools situated in proximity to Dingle Bay, the area southeast of Ballycotton, and the most southeasterly region of the survey grid. Several mixed schools comprising sprat were detected inside Dingle Bay. The size distribution of sprat was small, ranging between 7–15 cm in length and 2–28 g in weight. The mean length was 11 cm (SD 1.6) and the mean weight was 12 g (SD 5.7).

Oceanography

A total of 53 hydrographic stations were carried out during the survey. Surface plots of temperature and salinity are presented for the 5, 20, 40 and the >60 m depth profiles in Figures 5–8. In general, the Celtic Sea area was warmer and more saline than in 2008. Temperature in the surface layers (above 5 m) was around 14–15 °C with surface salinity ranging between 34.8–35.0 ppt. Surface waters around the main spawning bays and south coast regions were generally fresher than the offshore sectors (Figure 5 and Figure 9). However, there was no influx of cold and saline water around the Waterford coastal region similar to that detected in 2008 and 2007. The water column below 5 m was relatively well mixed in the eastern sector of the Celtic Sea and along the south coast regions (14–15 °C, c. 38.8 ppt), but well stratified further offshore and towards the west (<11 °C and >35.0 ppt below 5 m). This is in contrast to 2008 where the eastern regions were more notably stratified and the coastal waters were generally colder. The impact of this on the underlying circulation pattern in the region is not clear from the data.

Marine mammal and seabird observations

Environmental data were collected at 462 stations. Sea state was ≤ 3 at 52.6% of environmental stations and ≤ 4 at 80.3% of stations. Visibility was >5km at 90% of stations, 1–5km at 15.6% of stations and <1km at 3.5% of stations. Swell of 2m+ was recorded at 4.1% of stations. Rainfall was recorded at 7.8% of stations and fog was recorded at 10.6% of stations. Two half-days and two full days of survey effort were lost due to due to bad weather (gales or dense fog). One day of survey effort was lost when the vessel went to anchor at Lawrence's Cove, Bere Island to conduct calibration of acoustic survey equipment.

Marine mammal sightings

91.1 hours of survey time were logged with 46.6% (42.47 hrs) of this at Beaufort Sea state three or less; 73% (66.47 hrs) at Beaufort Sea state four or less and 88.6% (80.61hrs) at Beaufort Sea state five or less. 74 sightings of four cetacean species, totalling 1,011 individuals were recorded (Figures 10 and 11).

Identified cetacean species were fin whale (*Balaenoptera physalus*), minke whale (*Balaenoptera acutorostrata*), Risso's dolphin (*Grampus griseus*) and common dolphin (*Delphinus delphis*). All sightings of unidentified dolphins were thought to be common dolphins, while all sightings of unidentified whale blows were thought to be of fin whales but were classed as fin/blue/sei according to the IWDG's cetacean sightings database classification scheme (IWDG 2009).

Common dolphins were the most commonly encountered and abundant species recorded during the survey (Table 14). Minke whales were the most commonly encountered and abundant whale species.

Identified small-toothed cetacean species were common dolphin (*Delphinus delphis*) and harbour porpoise (*Phocoena phocoena*). The distribution of dolphins and porpoise is similar to that recorded in previous years.

Most of the recorded minke whale and fin whale activity took place around Dingle Bay and Southeast of Ram Head. It is thought that the whales were feeding on sprat, mackerel and young herring at both these locations. These observed distributions match those reported on the 2008 survey closely.

Seabird sightings

Daily species lists were made of all seabird species seen around the survey vessel. 17 seabird species were recorded during the survey (table 3): puffin (*Fratercula arctica*); guillemot (*Uria aalge*); razorbill (*Alca torda*); gannet (*Morus bassanus*); fulmar (*Fulmarus glacialis*); great shearwater (*Puffinus gravis*), manx shearwater (*Puffinus puffinus*); sooty shearwater (*Puffinus griseus*); kittiwake (*Rissa tridactyla*); lesser black backed gull (*Larus fuscus*); great black-backed gull (*Larus marinus*); herring gull (*Larus argentatus*); great skua (*Stercorarius skua*); parasitic skua (*Stercorarius parasiticus*); storm petrel (*Hydrobates pelagicus*); common scoter (*Melanitta nigra*) and shag (*Phalacrocorax aristotelis*).

Discussion and Conclusions

Discussion

The aims and objectives of the survey were carried out as planned. Weather conditions were favourable throughout the survey and all strata were sampled effectively. Extensive net sampling was conducted on almost every significant acoustic target detected, regardless of subjective mark-type classification. Furthermore, net sampling was conducted on medium-intensity layers (often containing high-intensity 'chips') that were detected continuously for >8 nm. We can therefore hold a high degree of confidence in the echotrace scrutinization for herring, and the overall results are highly robust in the context of the acoustic survey. Only 6 of the scheduled 59 CTD cast were lost due to poor weather, and the acoustic calibration was performed in favourable conditions at Bere Island.

The 2009 estimate of herring biomass is around 28, 000 t greater than that observed during the 2008 survey. The estimate is also the highest observed in the Celtic Sea area during the c. 10 year acoustic survey time-series. The results presented here corroborate the high biomass observed during the 2008 survey (c. 91, 000 t), and suggest that there has been an increase in herring stocks in the Celtic Sea over the last few years. For example, this is the fourth consecutive year that the acoustic estimate has increased substantially (2005–2009). Throughout the species distributional range in the Northeast Atlantic, herring stocks are generally considered to be in a state of decline with little signs of recovery in recent years. Our acoustic estimates suggest that the Celtic Sea herring stock might be countering this trend and that there is a tendency towards a recovery in the overall stock, with several strong year classes now present.

Further indication of a possible recovery in the Celtic Sea herring is that it is now becoming increasingly possible to track herring cohorts through time, and there appears to be a general tendency towards older fish becoming more prominent within the population. For example, the strong 3 and 5 winter-ring cohorts (2005 and 2003 year classes, respectively) detected during previous surveys also appears strong in the 2009 survey, indicating positive recruitment. Strong year classes were also spawned in 2007 and 2008 and are now becoming evident in the population as the abundant 1-winter-ring and 0-winter-ring groups. These preliminary trends in stock recovery are particularly interesting considering that herring are thought to be on the southern-most margins of its distributional limit in the Celtic Sea. However, herring distribution of abundance and population dynamics are highly variable in space and time, and further data are required to substantiate preliminary trends in stock recovery, and to address any potential causal mechanisms.

The distribution of herring was different from that observed in previous surveys in that the majority of herring biomass was not widely distributed and occurred predominantly within one spawning area around Tramore Bay. Our observations of herring distribution matched those of the commercial fishing fleet in the region during the survey. Furthermore, the fishing fleet similarly considered there to be an unusually high amount of herring present in the area. Communications with the fishing fleet were aided greatly by the presence of an on-board observer representing the Irish South and West Fish Producers Organisation. Throughout the survey, all herring assemblages were detected well within the confines of the survey boundaries. There were no instances of large herring schools occurring on the fringes of the survey grid. Furthermore, all the major herring cohorts were picked up in the biological samples collected on the survey. It is therefore becoming increasing apparent that the Celtic Sea Herring Acoustic Survey design is rigorous, particularly in the southwest region that constitutes the main survey sector. However, further attention should be placed on the SE corner of the grid. Historical information shows that herring are present in the Smalls area (Burd and Bracken, 1965) and future surveys should investigate this area. Standardised survey grid and fixed sampling times are essential prerequisites for quantifying interannual variations in herring abundance and population dynamics.

The presence of herring on the main autumn spawning grounds can extend for up to 3 months and overlaps with the arrival of the smaller winter spawning component. During this time biomass on the spawning grounds is replenished by several waves of migration. The survey is designed to contain the stock within its boundaries. As a result the 2009 biomass is likely to contain an un-quantified proportion of winter spawning component. As no survey is currently undertaken on winter stock component, it is impossible to determine the contribution of each component between years.

The hydrographic conditions encountered during this year's survey show the Celtic Sea to be warmer and less fresh than in 2008 and 2007. Overall, the trend in mean annual temperature in the Celtic Sea is increasing. A preliminary look at sea surface temperature in October across years (1998–2008) shows no correlation between cooler years and increased biomass. Herring are known to use temperature as one of the cues for the onset of spawning migrations. However, there are likely to be a number of complex physical and biological factors controlling such behaviour and temperature alone cannot be used to model herring abundance accurately.

Conclusions

- A high quantity of herring was observed in the Celtic Sea area during the 2009 acoustic survey. The TSB, TSN and SSB was 119,083 t (CV 22.7%), 1147 million individuals (CV 23.1%) and 90, 937 t (CV 24%), respectively. The TSB is the highest observed to date.
- Standardized survey design and fixed sampling times are enabling herring cohorts to be tracked. The herring population was sampled effectively during the survey and there is some evidence of successful recruitment of the 2007 and 2005 year-classes.
- The largest herring schools were predominantly distributed inshore around the Tramore Bay spawning area. However, almost all mature fish were in a prespawning state (stage 4 and 5) and there were no spent individuals.
- The most widely encountered secondary species was sprat, comprising a biomass of approximately 16, 229 t (CV 31%) and a total numerical abundance of around 1418 million individuals (CV 29%).

Acknowledgements

We would like to thank Dennis Rowan (Captain) and the crew of the Celtic Explorer for their help and professionalism during the survey. We also thank John O' Regan for his expert advice on fishing operations and for liaising with the commercial fishing fleet, Clementine Harma and Michael McAullife for their meticulous quality control of biological data, and the S&SW Fisheries Organisation for providing regular information on fishing gear locations in the survey region.

References\Bibliography

Anon. (1994). Report of the planning group for herring surveys. *ICES C.M. 1994/H:3.*

Anon (2002) Underwater noise of research vessels. Review and recommendations. 2002. ICES No. 209.

Brophy, D., and B. S. Danilowicz. 2002. Tracing populations of Atlantic herring (*Clupea harengus* L.) in the Irish and Celtic seas using otolith microstructure. ICES Journal of Marine Science, 59:1305–1313.

Burd, A. C., and J. Bracken. 1965. Studies on the Dunmore East Herring Stock. 1. A population assessment. J.Cons.Perm. Int. Explor. Mer, 29: 277–301.

Dalen, J. and Nakken, O. (1983) "On the application of the echo integration method" ICES CM 1983/B:19.

Foote, K.G. (1987). Fish target strengths for use in echo integrator surveys. *J. Acoust. Soc. Am.* 82: 981–987.

Foote, K.G., Knudsen, H.P., Vestnes, G., MacLennan, D.N. and Simmonds, E.J. (1987). Calibration of acoustic instruments for fish density estimation: a practical guide. *Int. Coun. Explor. Sea. Coop. Res. Rep.* 144: 57 pp.

Grainger, R. J. (1978). A study of herring stocks west of Ireland and their oceanographic conditions. Oceanography. Galway, University College Galway: 262.

Hatfield, E.M.C, Zuur, A.F., Boyd, J., Campbell, N., Chubb, J., Collins, C.M., Coughlan, J., Cross, M., Cross, T.F., Cunningham, C.O., Geffen, A.J., MacKenzie, K. ,Nash, R.D.M., Jansen, S., Kay, S., Kelly, C.J, O'Leary, D. B., Schlickeisen, J., Schon, P.-J., Watts, P. C; and Zimmermann, C. 2007. The scientific implications of the EU Project WESTHER (Q5RS - 2002 – 01056) to the assessment and management of the herring stocks to the west of the British Isles. ICESCM 2007/L:11.

ICES. 1994. Report of the Study Group on Herring Assessment and Biology in the Irish Sea and Adjacent Waters. ICES CM 1994/H :5. 67pp.

IWDG (2004b) Cetacean Distribution and Relative Abundance Survey during North-west Herring Acoustic Survey 2004. http://www.iwdg.ie/downloads/CEHerringAcousticSurvey2004.PDF

Molloy, J., E. Barnwall, and J. Morrison. 1993. Herring Tagging Experiments around Ireland, 1991. Fishery Leaflet, 154: 7pp.

Molloy, J. (1968). "Herring investigations on the southwest coast of Ireland 1967." ICES CM 1968/H:14: 10 pp.

O'Donnell, C., Griffin, K., Lynch D., Ullgren J., Goddijn L., Wall D., and Mackey M. (2004). Celtic Sea Herring Acoustic Survey Cruise Report, 2004.

O'Donnell, C. Doonan I., and Lynch D. (2005a) Celtic Sea Herring Acoustic Survey Cruise Report, FV Regina Ponti 2005.

O'Donnell, C. Doonan I., Lynch D., Dransfeld, L., and Wall D. (2005b) Celtic Sea Herring Acoustic Survey Cruise Report, RV Celtic explorer 2005.

O'Donnell, C., Doonan, I., Lynch, D., Egan, A., Boyd, J., Wall, D. and Ulgren, J (2006) Celtic Sea Herring Acoustic Survey Cruise Report, 2006.

O'Donnell, C., Egan, A., Lynch, D., Dransfeld, L., Boyd, J., Lyons, K. and Wall, D (2007) Celtic Sea Herring Acoustic Survey Cruise Report, 2007.

O'Donnell, C., Mullins E., Johnston, G., Lyons, K., Bethke, E., Holst, G. and Wall, D. (2008) Blue whiting Acoustic Survey Cruise Report, 2008.

O'Donnell, C., Saunders, R.A., Lynch, D., Lyons, K. and Wall, D (2008) Celtic Sea Herring Acoustic Survey Cruise Report, 2008.

Wall D., O'Brien J., Meade J., and Allen B.M. (2006). Summer distribution and relative abundance of cetaceans off the west coast of Ireland. Biology and Environment: Proceedings of the Royal Irish Academy, 106B (2), 135 - 142.

Tables and Figures

Table 1. Survey Strata details. Celtic Sea herring acoustic survey, October 2009.

STRATA	STRATA	SURVEY	TRANSECT	TOTAL	ACTIVE	TRANSECT	TOTAL TRANSECT	STRATA
no.	name	type	type	transects	transects	spacing	distance (nmi)	area (nmi2)
1 (a,b)	SW Shannon	Broad scale	Parallel	26	14	4	192	727
2	Inside Shannon	Broad scale	Zigzag	7	7	\	41	39
3	Dingle	Broad scale	Zigzag	9	9	\	69	99
4 (a,b)	SW corner	Broad scale	Parallel	15	8	4	179	548
5	Kenmare	Broad scale	Zigzag	7	7	\	43	61
6	Bantry	Broad scale	Zigzag	8	7	\	35	34
7	Dunmanus	Broad scale	Zigzag	7	7	\	26	9
8	Mizen area	Broad scale	Parallel	27	14	4	310	770
9	Offshore CS	Broad scale	Parallel	63	32	2	1002	1932
10 (a,b,c,d,e)	Inshore CS	Broad scale	Parallel	61	34	2	631	1106
11	Baginbun	Spawning grid	Parallel	17	9	1	67	29
12	Tramore	Spawning grid	Parallel	31	16	1	110	85
13	Waterford Hbr	Broad scale	Zigzag	4	4	\	11	4
14	Ballycotton	Spawning grid	Parallel	32	16	1	115	104
15	Daunt	Spawning grid	Parallel	25	13	1	80	69
16	Stags	Spawning grid	Parallel	9	5	1	97	16
17	Dingle_S	Spawning grid	Parallel	11	6	1	24	9
18	Dingle_N	Spawning grid	Parallel	11	6	1	22	7
19	Kerry Head	Spawning grid	Parallel	23	12	1	136	61
			Total	**393**	**226**		**3190**	**5705.98**

Table 2. Settings for the Simrad ER60 echosounder, employed during the Celtic Sea herring acoustic survey, October 2009.

Echo sounder:		Simrad ER 60
Frequency:		38 kHz
Transducer:		ES 38B- Serial
Absorption Coefficient:		0.067 dB/Km (manual)
Pulse length:		1.024 m/s
Bandwidth:		2.43 KHz
Transmitting Power:		2000 W (Max)
Angle Sensitivity:		13.9 dB
2- way beam angle:		-20.60°
Gain:		25,71
SA Correction:		-0,63
3 dB Beam W	Alongship:	6.97°
	Athwartship:	7.00°
Max Range:		500m

Note: Calibration report available (38KHz) in Appendix.

Table 3. Catch table from directed net hauls during the Celtic Sea herring acoustic survey, October 2009.

No.	Date	Lat. N	Lon. W	Time	Bottom (m)	Target (m)	Bulk Catch (Kg)	Herring %	Mackerel %	Scad %	Sprat %	Pilchard %	Others%*
1	09-Oct	52,36.415	10,15.50	11:06	95	85	17.71	0.0	1.3	12.7	83.2	0.0	2.8
2	10-Oct	51,58.743	10,29.493	6:21	73	10	21.94	0.0	27.8	0.7	68.4	0.0	3.1
3	10-Oct	52,05.455	10,18.249	10:23	35	25	200	0.3	40.2	0.0	59.5	0.0	0.0
4	11-Oct	51,34.11	10,28.209	9:47	102	22	156.42	0.0	28.9	23.3	0.0	0.0	47.8
5	11-Oct	51,30.227	10,24.073	13:52	105	55	31.87	0.0	98.0	1.0	0.0	0.0	1.0
6	12-Oct	51,19.889	10,00.623	2:25	103	17	182.82	0.0	0.0	100.0	0.0	0.0	0.0
7	12-Oct	51,18.873	9,28.687	14:56	80	75	145.44	91.7	3.2	0.1	0.6	0.0	4.4
8	13-Oct	51,19.72	8,26.805	10:35	90	60	0	0.0	0.0	0.0	0.0	0.0	0.0
9	13-Oct	51,5.951	8,26.69	13:53	n/a	n/a	1200	99.3	0.5	0.0	0.1	0.0	0.2
10	14-Oct	51,24.094	8,4.645	12:14	84	79	127.43	32.7	14.3	14.6	29.4	0.0	9.0
11	14-Oct	51,11.720	7,58.576	18:30	100	50	26.58	2.9	5.3	4.5	82.4	0.0	4.9
12	14-Oct	51,17.967	7,58.441	21:33	90	84	86.132	99.8	0	0.00	0.00	0.00	0.2
13	15-Oct	51,26.099	7,55.086	1:05	82	12	2000	65.8	34.2	0.0	0.0	0.0	0.1
14	15-Oct	51'2.201	7'45.505	12:33	96	91	36.626	30.1	0.0	0.0	65.9	0.0	4.0
15	15-Oct	51'16.936	7'39.098	22:50	87	17	56.147	88.1	1.2	0.0	0.8	0.0	10.0
16	16-Oct	51'20.822	7'29.697	11:57	82	76	250	15.2	15.3	0.0	68.6	0.0	0.9
17	16-Oct	51'8.464	7'29.661	14:19	91	86	2500	92.6	5.2	2.1	0.0	0.0	0.2
18	17-Oct	51'05.041	7'223.244	0:42	90	82	2000	99.6	0.0	0.0	0.0	0.0	0.4
19	17-Oct	51'32.597	7'16.359	7:55	76	66	31.634	0.0	99.6	0.0	0.0	0.0	0.3
20	17-Oct	51'22.161	7'9.893	16:06	82	74	250	39.4	16.5	0.1	34.1	0.0	9.8
21	18-Oct	51'23.849	6'50.374	10:54	83	61	240	1.8	2.7	0.0	94.7	0.0	0.9
22	19-Oct	52'2.0384	7'8.189	18:31	50	25	2500	96.5	3.2	0.0	0.0	0.3	0.0
23	20-Oct	52'3.758	7'14.873	11:50	37	26	2000	95.6	1.8	0.0	0.0	2.6	0.0
24	20-Oct	52'6.820	7'18.023	14:12	23	3	5000	99.7	0.1	0.1	0.0	0.1	0.1
25	20-Oct	51'52.947	7'15.974	18:31	67	52	121.065	1.5	11.8	0.0	55.2	0.0	31.5
26	21-Oct	51'48.758	7'28.258	10:20	67	52	292.14	22.6	33.0	5.4	38.4	0.0	0.7
27	21-Oct	51'49.625	7'34.283	18:43	65	33	104.68	1.3	17.8	0.0	66.9	0.0	14.0
28	22-Oct	51'36.368	7'48.675	5:42	85	35	5000	96.7	3.3	0.0	0.0	0.0	0.0
29	22-Oct	51'50.170	7'43.250	14:09	46	30	37.125	16.99	14.55	0.04	68.15	0.04	0.2
30	23-Oct	51'29.327	8'11.388	9;26	84	42	107.819	0.04	13.62	64.81	21.33	0	0.2

Table 4. Length-frequency (%) of herring hauls used for calculating 'definitely' and 'probably' abundance categories. Celtic Sea herring acoustic survey, October 2009.

Length (cm)	7	9	12	13	15	17	18	22	23	24	28
15							13				
15.5			1				23				
16							26				
16.5							23				
17							9				
17.5							4				
18							2				
18.5											
19		1		7							2
19.5		2		6						2	2
20		4		15						2	4
20.5		6		15	1	3			1	2	11
21		7		19	1	5			1	6	7
21.5		17		16	2	2		2	1	5	12
22	1	13		11	2	5		1	2	9	22
22.5	2	8		7	3	6		1	5	7	10
23	2	5		3	3	3		2	2	3	8
23.5	2	5	1		3	4		2	2	2	2
24	4	4			6	3		3	2	1	1
24.5	7	6	3	1	4	9		5	4	3	3
25	11	6	5		11	12		9	12	6	4
25.5	14	6	11		16	18		18	12	9	3
26	14	3	22		22	16		22	15	13	3
26.5	16	5	26		13	8		22	19	15	3
27	14	2	18		9	2		3	10	8	2
27.5	8		8		2	2		6	9	5	
28	4		4		2	1		3	1	1	1
28.5			1					1	1		
29	1					1			1	1	
Total	100	100	100	100	100	100	100	100	100	100	100

Table 5. Herring Age length key from combined trawl samples. Celtic Sea herring acoustic survey, October 2009.

Length class (cm)	0	1	2	3	4	5	6	7	8	9	Total
12.5	5										5
13	13										13
13.5	15										15
14	30										30
14.5	50										50
15	97										97
15.5	72										72
16	64										64
16.5	18										18
17	9										9
17.5	3										3
18	1	1									2
18.5	1	4									5
19	1	5									6
19.5		11									11
20		10									10
20.5		24									24
21		30									30
21.5		19	1								20
22		28	3								31
22.5		22	3								25
23		14	10								24
23.5		2	5								7
24			13	3							16
24.5			12	5							17
25			14	34	2	1					51
25.5			9	49	4	5					67
26			4	52	20	23	1		1		101
26.5				38	15	36	1				90
27				9	7	29	5	1			51
27.5				2	5	17	2	2	1		29
28				1	2	6	2		3	1	15
28.5				1	1	1			1		4
Total	379	170	74	194	56	118	11	3	6	1	1012
%	37.45	16.80	7.31	19.17	5.53	11.66	1.09	0.30	0.59	0.10	

Table 6. 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 2009.

Strata	0	1	2	3	4	5	6	7	8	9	Total
1	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0
8	0.1	0.6	2.7	7.7	2.4	5.8	0.7	0.2	0.4	0.1	20.6
9	5.9	14.7	3.4	6.2	1.6	3.2	0.3	0.1	0.2	0	35.4
10	0.5	10.7	3.2	4.9	1.4	2.9	0.3	0.1	0.2	0	24
11	0	0	0	0	0	0	0	0	0	0	0
12	0	4.4	3.8	12.5	4	9	0.8	0.3	0.5	0.1	35.5
13	0	0	0	0	0	0	0	0	0	0	0
14	0	0.5	0.3	0.8	0.2	0.5	0	0	0	0	2.4
15	0	0.4	0.1	0.1	0	0	0	0	0	0	0.6
16	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0.1	0.2	0.1	0.1	0	0	0	0	0.5
19	0	0	0	0	0	0	0	0	0	0	0
Total	6.5	31.2	13.6	32.2	9.7	21.7	2.1	0.7	1.3	0.2	119.1
%	5.4	26.2	11.4	27	8.1	18.2	1.8	0.6	1.1	0.1	100

Table 7. Herring abundance (millions) at age (winter rings), by strata as derived from acoustic estimate of abundance. Celtic Sea herring acoustic survey, October 2009.

Strata	0	1	2	3	4	5	6	7	8	9	Total
1	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0
8	3.15	5.77	21.15	49.94	14.20	33.30	3.60	1.11	1.80	0.33	134.36
9	220.04	188.14	29.02	40.62	9.59	18.62	1.59	0.37	0.88	0.14	509.00
10	14.69	126.81	27.71	31.96	8.10	16.98	1.55	0.43	0.88	0.13	229.23
11	0	0	0	0	0	0	0	0	0	0	0
12	0	50.53	30.49	80.55	23.78	51.73	4.60	1.62	2.59	0.26	246.13
13	0	0	0	0	0	0	0	0	0	0	0
14	1.48	5.61	2.40	5.06	1.39	2.99	0.27	0.09	0.15	0.01	19.46
15	0.02	4.39	0.78	0.53	0.11	0.21	0.02	0.00	0.01	0.00	6.06
16	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0
18	0.08	0.14	0.50	1.18	0.34	0.79	0.09	0.03	0.04	0.01	3.18
19	0	0	0	0	0	0	0	0	0	0	0
Total	239.45	381.39	112.04	209.85	57.49	124.63	11.71	3.65	6.35	0.88	1147.42
%	20.87	33.24	9.76	18.29	5.01	10.86	1.02	0.32	0.55	0.08	100.00
Cv (%)	47.20	41.50	25.40	24.60	25.40	26.30	28.00	28.80	26.40	29.50	23.10

Table 8. Herring biomass (000's tonnes) at maturity by strata. Totals do not account for the "possibly" herring classification. Celtic Sea herring acoustic survey, October 2009.

Strata	Immature	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	0	0
6	0	0	0	0
7	0	0	0	0
8	0.3	20.3	0	20.6
9	16.6	18.9	0	35.4
10	7.7	16.3	0	24
11	0	0	0	0
12	2.9	32.6	0	35.5
13	0	0	0	0
14	0.4	2.1	0	2.4
15	0.3	0.3	0	0.6
16	0	0	0	0
17	0	0	0	0
18	0	0.5	0	0.5
19	0	0	0	0
Total	28.1	90.9	0	119.1
%	23.6	76.4	0	100

Table 9. Herring abundance (millions) at maturity by strata. Totals do not account for the possibly herring classification. Celtic Sea herring acoustic survey, October 2009.

Strata	Immature	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	0	0
6	0	0	0	0
7	0	0	0	0
8	5.75	128.61	0	134.36
9	360.40	148.61	0	509.00
10	102.68	126.55	0	229.23
11	0	0	0	0
12	34.06	212.07	0	246.13
13	0	0	0	0
14	5.31	14.15	0	19.46
15	3.07	2.99	0	6.06
16	0	0	0	0
17	0	0	0	0
18	0.14	3.05	0	3.18
19	0	0	0	0
Total	511.40	636.02	0	1147.42
%	44.57	55.43	0	100.00

Table 10. Herring length-at-age (winter rings) as abundance (millions) and biomass (000's tonnes). Celtic Sea herring acoustic survey, October 2009.

Length (cm)	0	1	2	3	4	5	6	7	8	9	Abund. (mill)	Bio. (000 t)	Mn wt (g)
8,5	0,53										0,53		3,90
9	0,53										0,53		4,70
9,5	0,53										0,53		5,60
10	1,06										1,06	0,01	6,70
10,5	1,06										1,06	0,01	7,80
11	2,64										2,64	0,02	9,10
11,5	5,29										5,29	0,06	10,60
12	10,28										10,28	0,13	12,20
12,5	4,15										4,15	0,06	13,90
13	7,95										7,95	0,13	15,80
13,5	5,84										5,84	0,10	17,90
14	10,81										10,81	0,22	20,20
14,5	21,99										21,99	0,50	22,70
15	29,72										29,72	0,75	25,40
15,5	44,33										44,33	1,25	28,30
16	39,87										39,87	1,25	31,40
16,5	31,02										31,02	1,08	34,80
17	12,83										12,83	0,49	38,40
17,5	5,66										5,66	0,24	42,30
18	0,93	1,87									2,80	0,13	46,50
18,5	0,13	0,54									0,67	0,03	50,90
19	2,31	11,50									13,80	0,77	55,60
19,5		17,34									17,34	1,05	60,60
20		35,94									35,94	2,37	65,90
20,5		51,59									51,59	3,69	71,50
21		55,76									55,76	4,32	77,50
21,5		61,86	3,26								65,12	5,46	83,80
22		72,23	7,76								79,99	7,24	90,50
22,5		48,43	6,60								55,03	5,36	97,50
23		19,52	13,96								33,47	3,51	104,90
23,5		4,81	12,00								16,81	1,89	112,60
24			13,39	3,10							16,49	1,99	120,80
24,5			24,07	10,03							34,10	4,41	129,40
25			17,47	42,37	2,48	1,27					63,59	8,80	138,40
25,5			9,93	54,16	4,45	5,56					74,09	10,95	147,80
26			3,60	46,29	17,80	20,49	0,90		0,90		89,97	14,19	157,70
26,5				38,97	15,42	36,94	1,02				92,34	15,52	168,00
27				9,94	7,74	32,14	5,54	1,13			56,49	10,10	178,80
27,5				2,52	6,28	21,41	2,52	2,52	1,24		36,50	6,94	190,10
28				0,87	1,74	5,22	1,74		2,61	0,87	13,06	2,64	201,90
28,5				0,79	0,79	0,79			0,79		3,16	0,68	214,10
29				0,80	0,80	0,80			0,80		3,21	0,73	226,90
TSN (mill)	0,38	121,88	99,21	209,85	57,49	124,63	11,71	3,65	6,35	0,87	636,02		
TSB (000 t)	0,02	10,73	12,42	32,18	9,68	21,66	2,13	0,68	1,26	0,18		90,94	
Mn wt (g)	27,10	81,80	121,60	153,30	168,30	173,80	182,10	186,60	198,00	201,90			
Mn length (cm)	15,40	21,50	24,20	26,00	26,70	27,00	27,40	27,60	28,10	28,20			

Table 11. Herring biomass and abundance by survey strata. Celtic Sea herring acoustic survey, October 2009.

Stratum	No. transects	No. schools	Def schools	Mixed schools	Prob. Schools	Zero transects (%)	Def. biomass	Mixed biomass	Prob. biomass	Biomass (000 t)	SSB (000 t)	Abundance (millions)
1	14	0	0	0	0	100	0	0	0	0	0	0
2	6	0	0	0	0	100	0	0	0	0	0	0
3	9	0	0	0	0	100	0	0	0	0	0	0
4	8	0	0	0	0	100	0	0	0	0	0	0
5	7	0	0	0	0	100	0	0	0	0	0	0
6	7	0	0	0	0	100	0	0	0	0	0	0
7	5	0	0	0	0	100	0	0	0	0	0	0
8	14	39	35	0	4	86	19.8	0	0.8	20.6	20.3	134.4
9	32	325	97	194	34	38	20	13.3	2.2	35.4	18.9	509.0
10	35	94	34	52	8	83	16.1	0.4	7.5	24.0	16.3	229.2
11	9	0	0	0	0	100	0	0	0	0.0	0.0	0.0
12	17	117	116	0	1	53	35.4	0	0	35.5	32.6	246.1
13	4	0	0	0	0	100	0	0	0	0.0	0.0	0.0
14	17	63	1	58	4	65	0.5	0.2	1.7	2.4	2.1	19.5
15	11	3	0	0	3	91	0	0	0.6	0.6	0.3	6.1
16	5	0	0	0	0	100	0	0	0	0.0	0.0	0.0
17	6	0	0	0	0	100	0	0	0	0.0	0.0	0.0
18	6	3	0	0	3	83	0	0	0.5	0.5	0.5	3.2
19	12	0	0	0	0	100	0	0	0	0.0	0.0	0.0
Total	224	644	283	304	57	80	91.8	14	13.3	119.1	90.9	1147.4
Cv (%)	-	-	-	-	-	-	-	-	-	22.7	24.0	23.1

Table 12. Celtic Sea and VIIj Herring acoustic survey time series. Abundance (millions), TSB and SSB (000's tonnes). Age in winter rings.

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
0	202	3	-	0	-	25	40	0	24	-	2	-	1	2	0
1	25	164	-	30	-	102	28	42	13	-	65	21	106	63	122
2	157	795	-	186	-	112	187	185	62	-	137	211	70	295	99
3	38	262	-	133	-	13	213	151	60	-	28	48	220	111	210
4	34	53	-	165	-	2	42	30	17	-	54	14	31	162	57
5	5	43	-	87	-	1	47	7	5	-	22	11	9	27	125
6	3	1	-	25	-	0	33	7	1	-	5	1	13	6	12
7	1	15	-	24	-	0	24	3	0	-	1	-	4	5	4
8	2	0	-	4	-	0	15	0	0	-	0	-	1	-	6
9	2	2	-	2	-	0	52	0	0	-	0	-	0	-	1
Abundance	469	1338	-	656	-	256	681	423	183	-	312	305	454	671	636
SSB	36	151	-	100	-	20	95	41	20	-	33	36	46	93	91
CV	53	26	-	36	-	100	88	49	34	-	48	35	25	20	24

Table 13. Sprat biomass and abundance by survey strata. Celtic Sea herring acoustic survey, October 2009.

Stratum	No. transects	No. schools	Def schools	Mixed schools	Prob. Schools	Zero transects (%)	Def. biomass	Mixed biomass	Prob. Biomass	Biomass (000 t)	Abundance (mill)
1	14	37	26	11	0	79	0.7	2.5	0	3.2	248.543
2	6	0	0	0	0	100	0	0	0	0	0
3	9	80	0	80	0	11	0	6.4	0	6.4	571.7
4	8	3	0	3	0	88	0	0.3	0	0.3	47.609
5	7	0	0	0	0	100	0	0	0	0	0.0
6	7	0	0	0	0	100	0	0	0	0	0
7	5	0	0	0	0	100	0	0	0	0	0
8	14	0	0	0	0	100	0	0	0	0	0.0
9	32	76	76	0	0	91	3.8	0	0	3.8	364.7
10	35	43	0	43	0	91	0	2.5	0	2.5	185.237
11	9	0	0	0	0	100	0	0	0	0	0
12	17	0	0	0	0	100	0	0	0	0	0
13	4	0	0	0	0	100	0	0	0	0	0
14	17	0	0	0	0	100	0	0	0	0	0
15	11	0	0	0	0	100	0	0	0	0	0
16	5	0	0	0	0	100	0	0	0	0	0
17	6	0	0	0	0	100	0	0	0	0	0
18	6	0	0	0	0	100	0	0	0	0	0
19	12	0	0	0	0	100	0	0	0	0	0
Total	224	239	102	137	0	92	4.5	11.7	0	16.2	1417.9
Cv (%)	-	-	-	-	-	-	-	-	-	30.6	28.8

Table 14. Sightings, counts and group size ranges for cetaceans sighted during current survey. Celtic Sea herring acoustic survey, October 2009.

Species	No. Sightings	No. Individuals	Range of Group Size	Juveniles/ Calves
Common dolphin	40	814	2–150	8
Risso's dolphin	2	5	1–4	-
Fin whale	4	7	1–2	
Minke whale	13	14	1–2	-
Unidentified dolphin	10	157	1–50	-
Unidentified whale (blow)	5	14	1–10	-

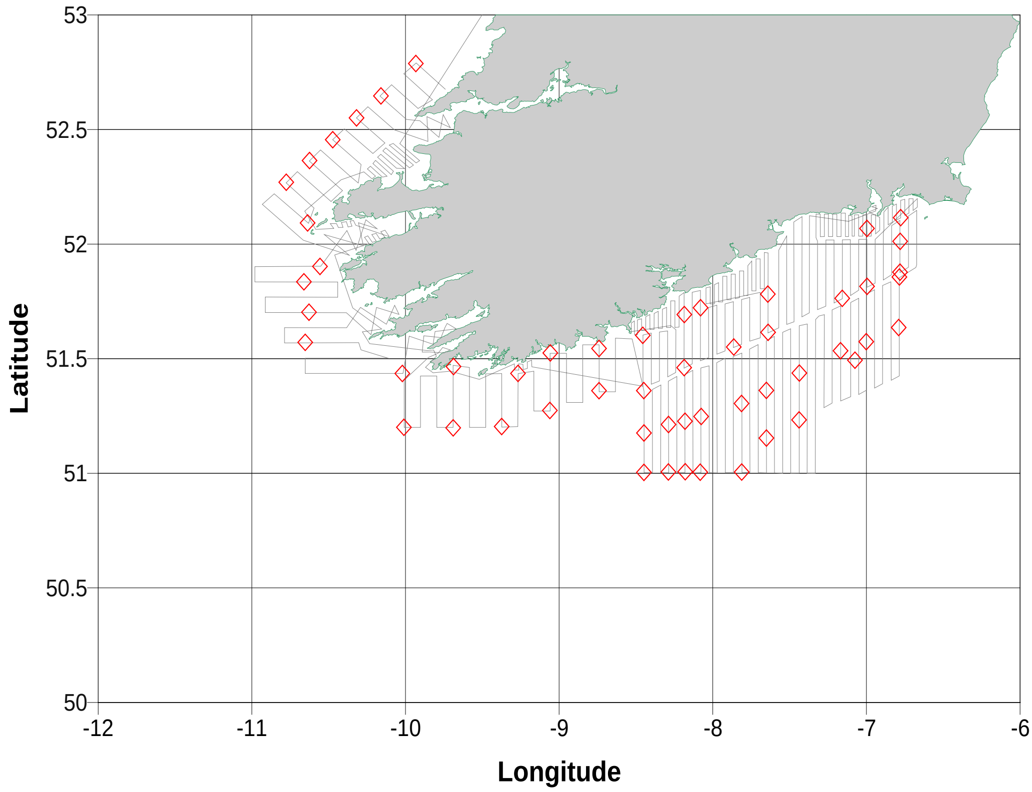


Figure 1. Cruise track (grey line) and CTD positions during the Celtic Sea herring acoustic survey, October 2009.

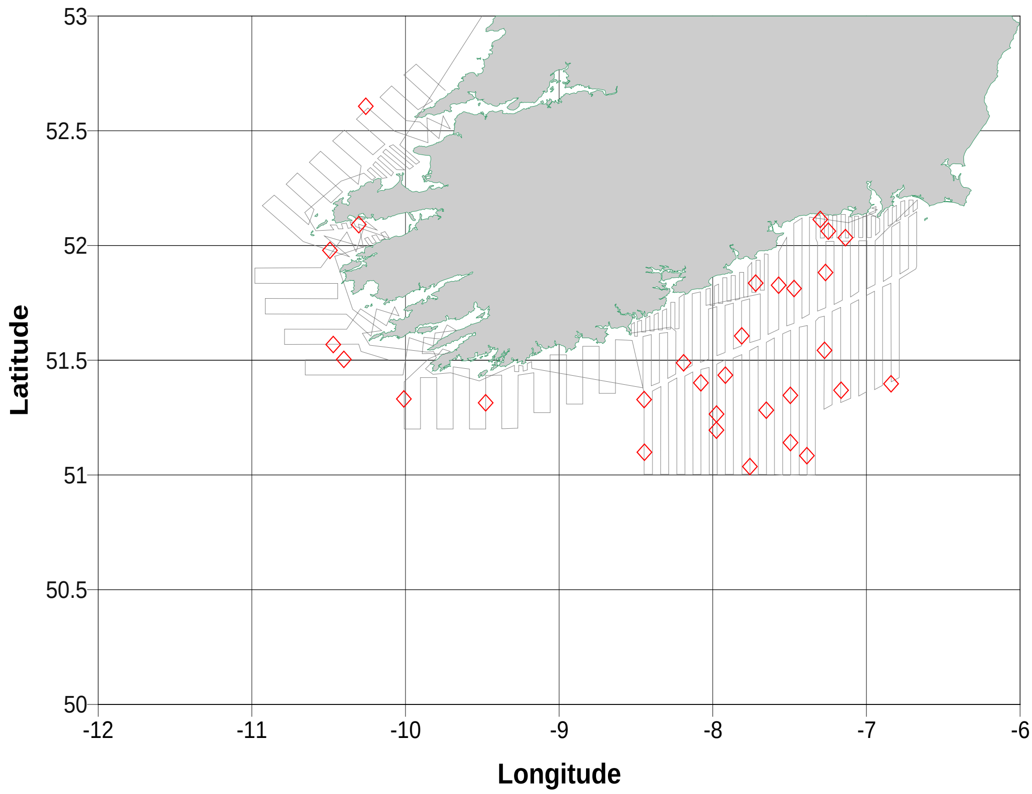


Figure 2. Haul positions. Celtic Sea herring acoustic survey, October 2009.

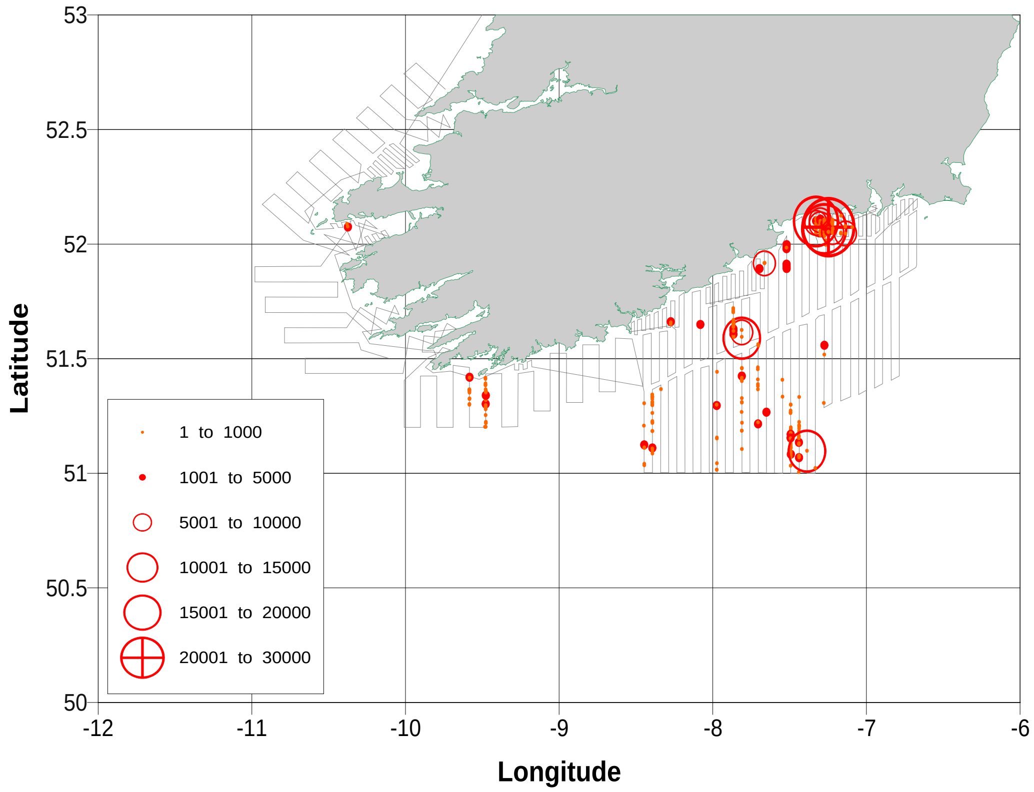


Figure 3. Weighted herring NASC (Nautical area scattering coefficient) plot showing the distribution of "definitely" and "probably" categories. Celtic Sea herring acoustic survey, October 2009.

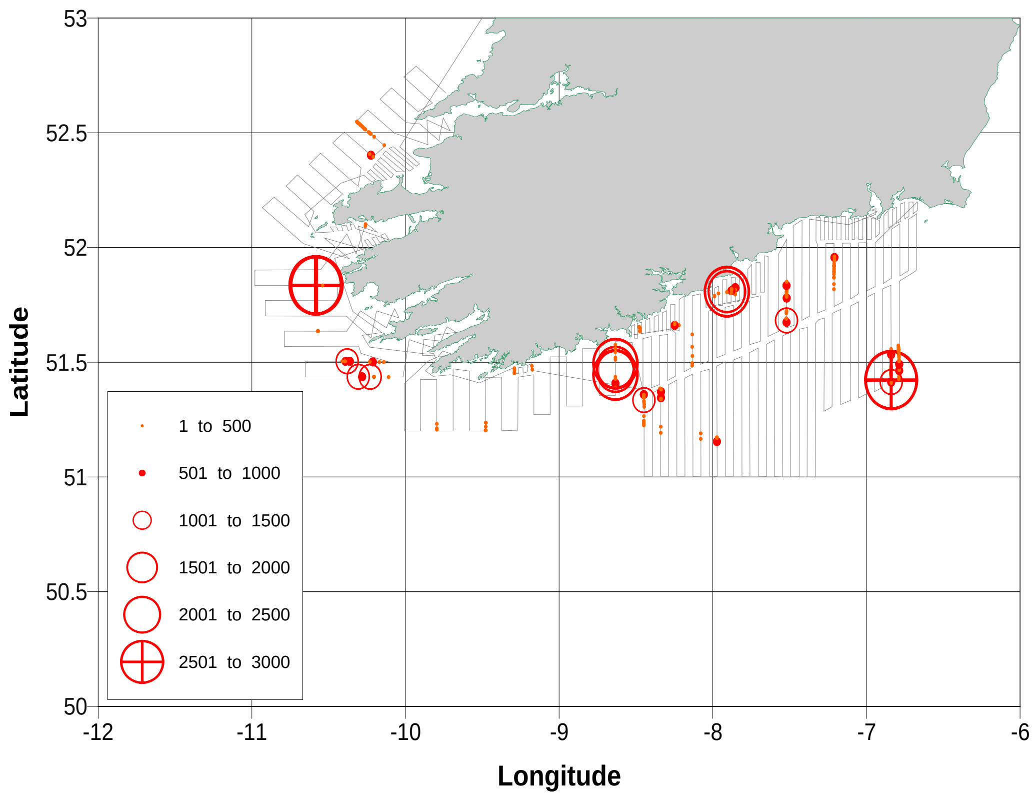


Figure 4. Weighted Sprat NASC (Nautical area scattering coefficient) plot showing the distribution of "definitely" and "probably" categories. Celtic Sea herring acoustic survey, October 2009.

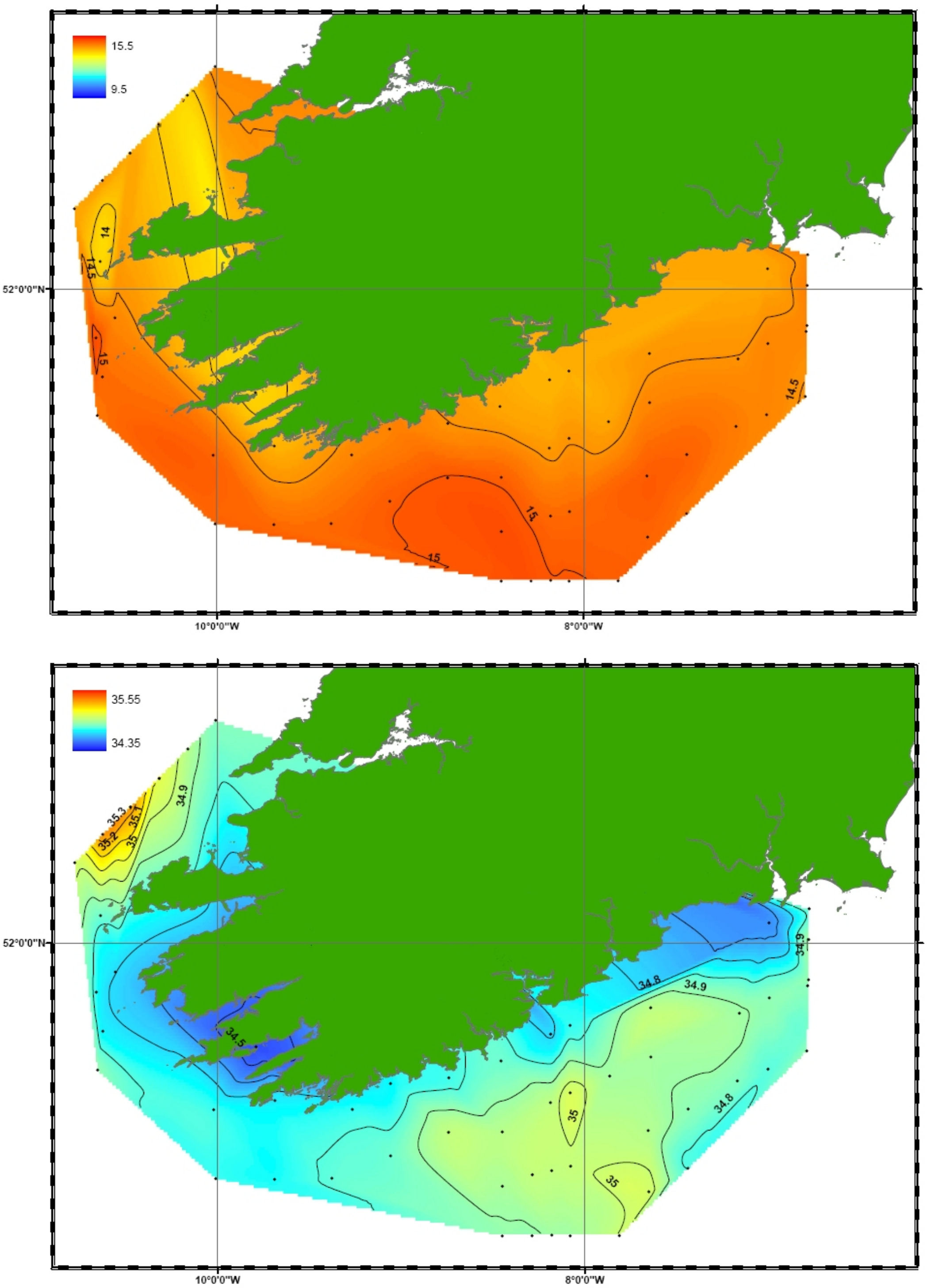


Figure 5. Surface plots of temperature (above) and salinity (below) at 5 m from combined CTD cast data. Celtic Sea herring acoustic survey, October 2009.

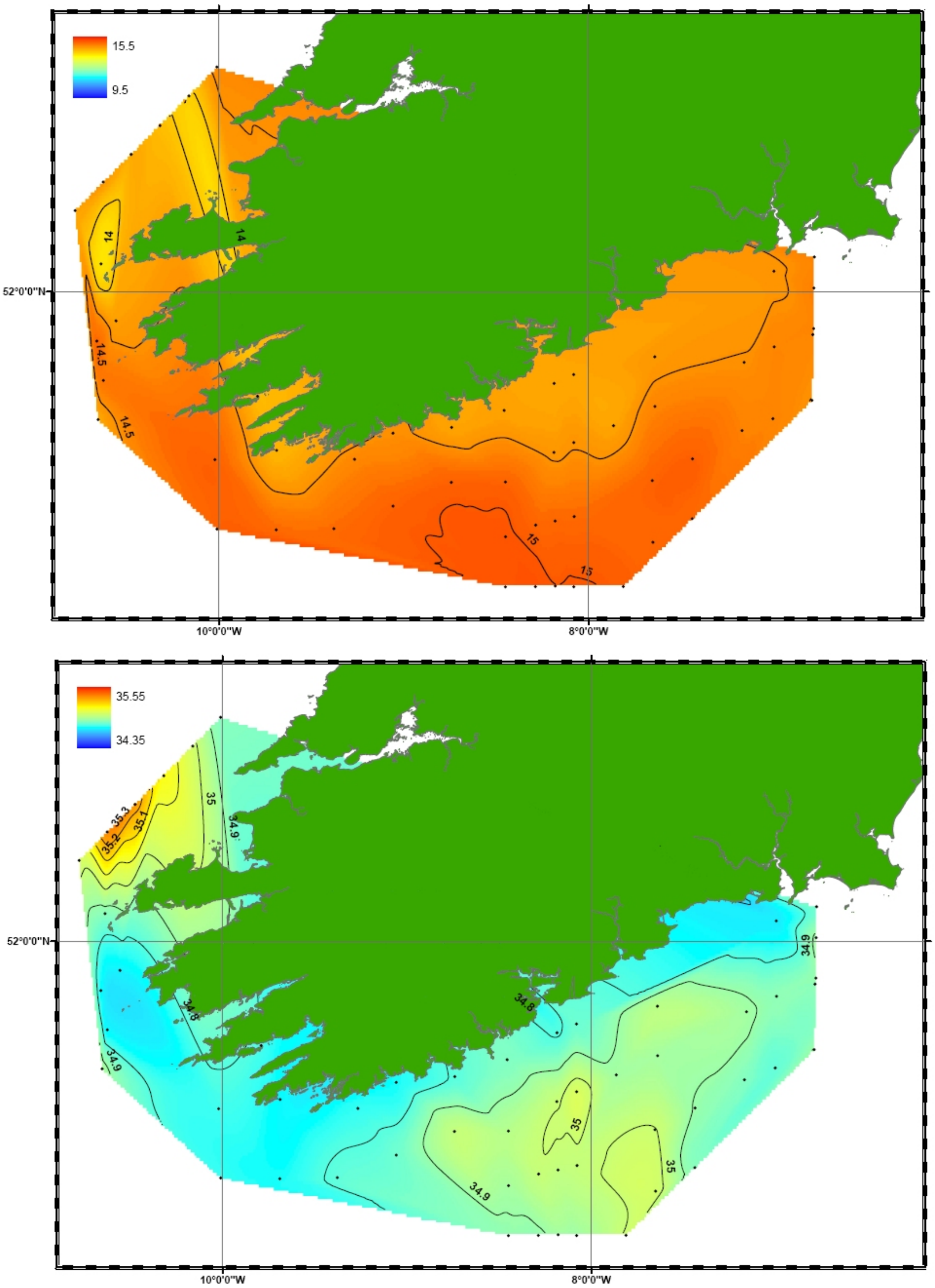


Figure 6. Surface plots of temperature (above) and salinity (below) at 20 m from combined CTD cast data. Celtic Sea herring acoustic survey, October 2009.

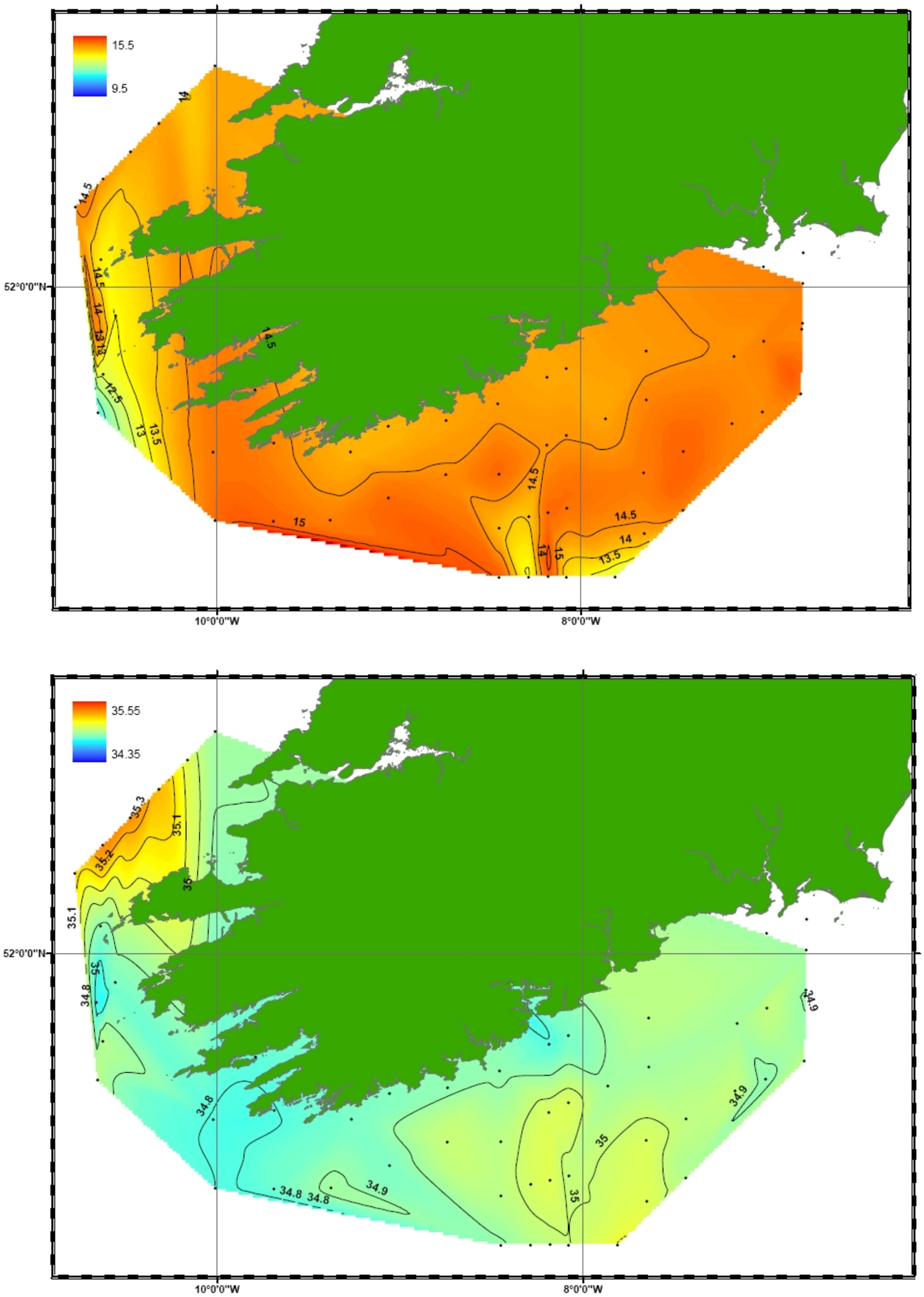
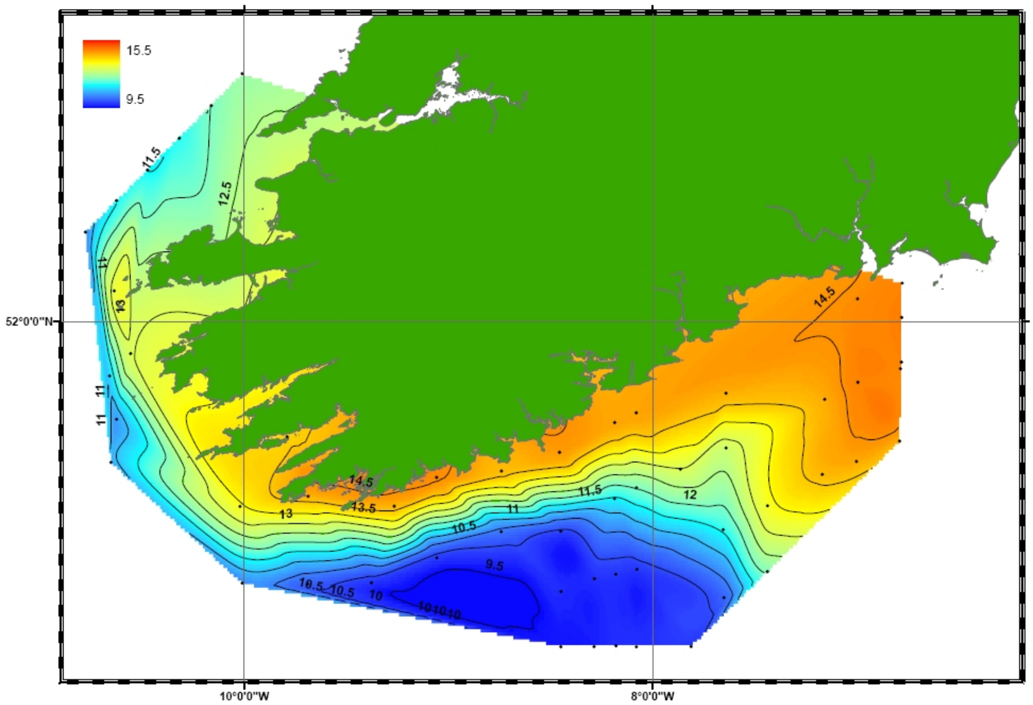


Figure 7. Surface plots of temperature (above) and salinity (below) at 40m from combined CTD cast data. Celtic Sea herring acoustic survey, October 2009.



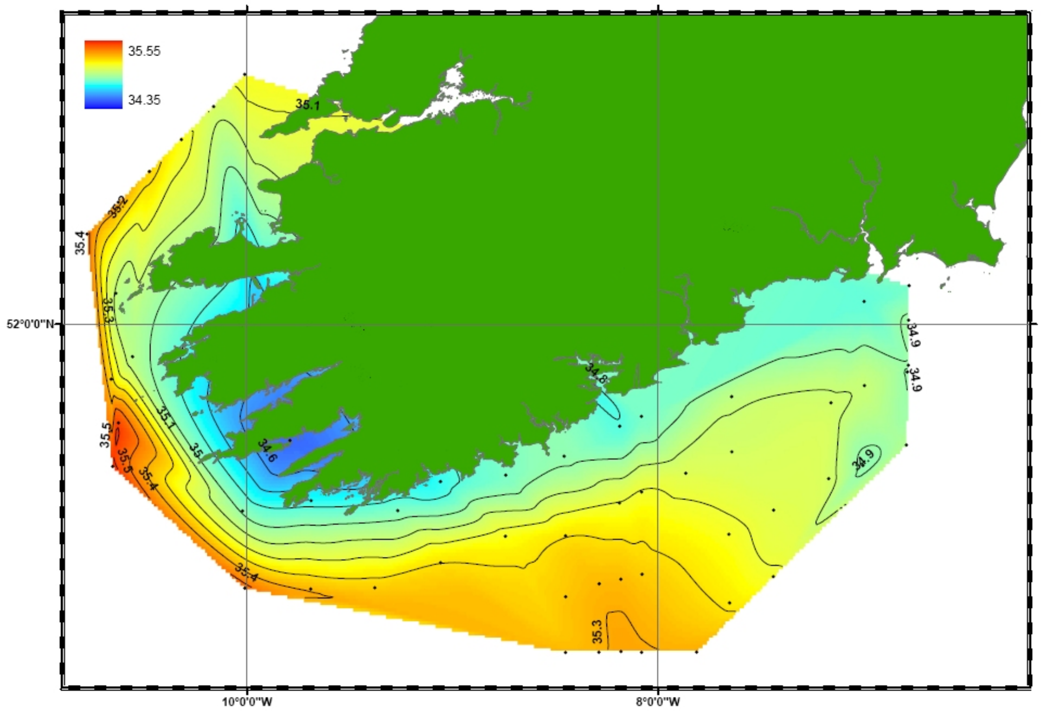


Figure 8. Surface plots of temperature (above) and salinity (below) at >60 m from combined CTD cast data. Celtic Sea herring acoustic survey, October 2009.

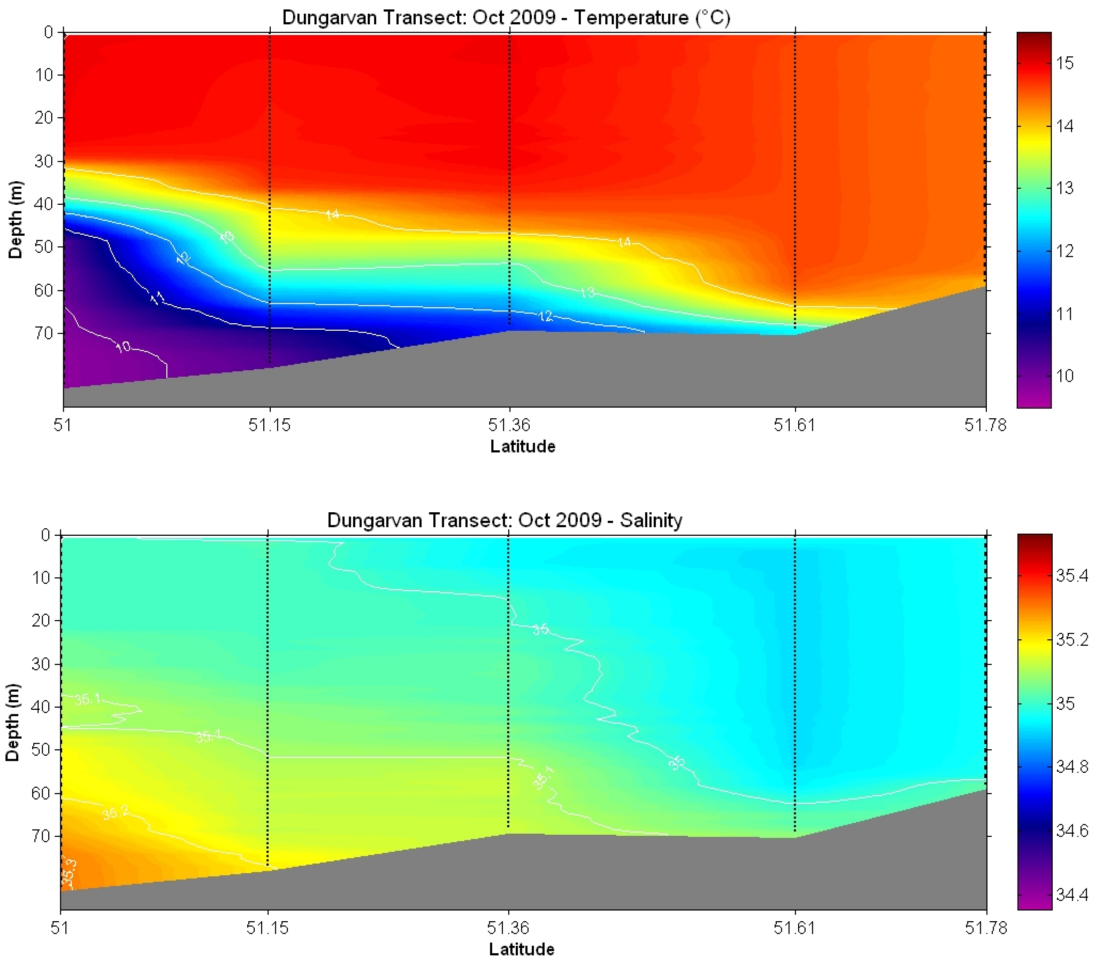


Figure 9. Vertical distribution of temperature (above) and salinity (below) along the Dungarvan transect. Celtic Sea herring acoustic survey, October 2009.

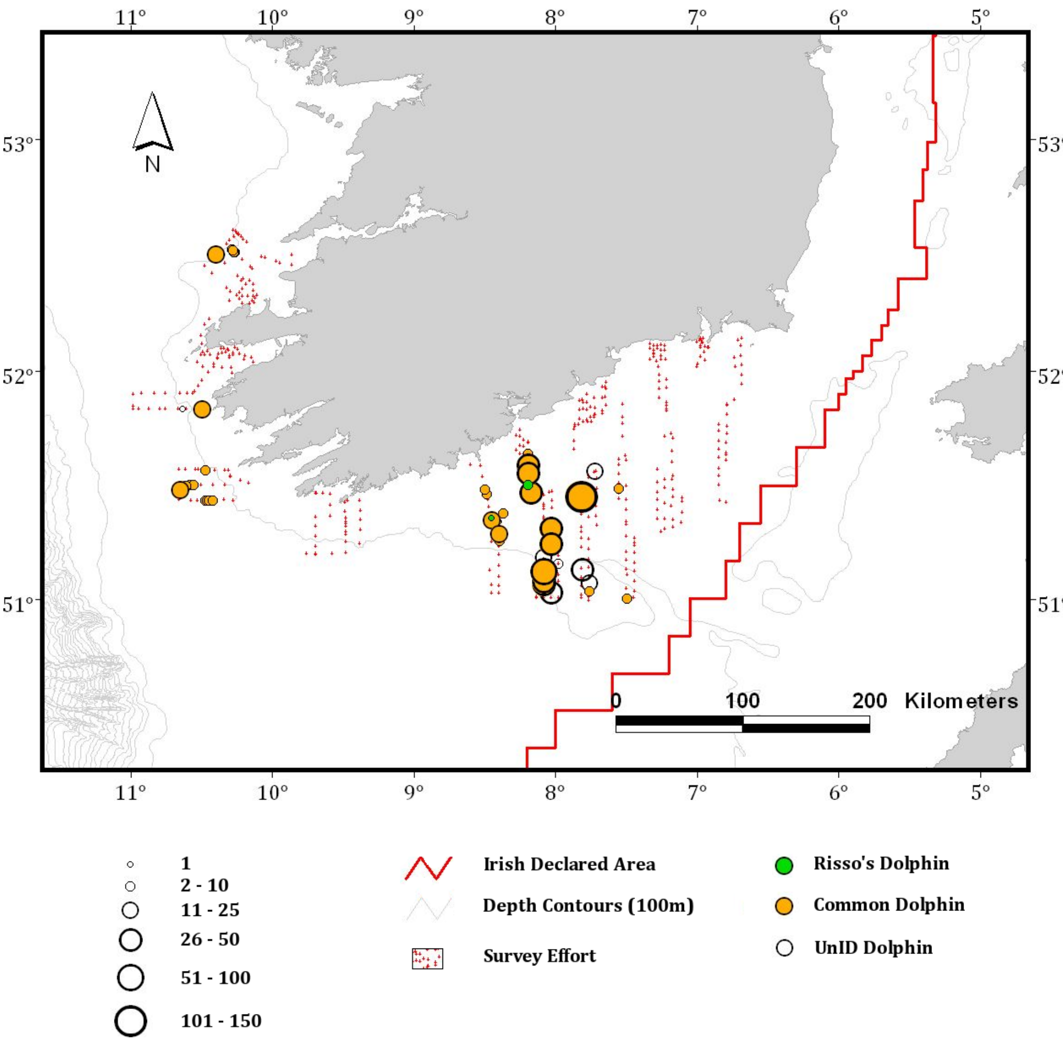


Figure 10. Distribution of dolphin and seal sightings. Celtic Sea herring acoustic survey, October 2009.

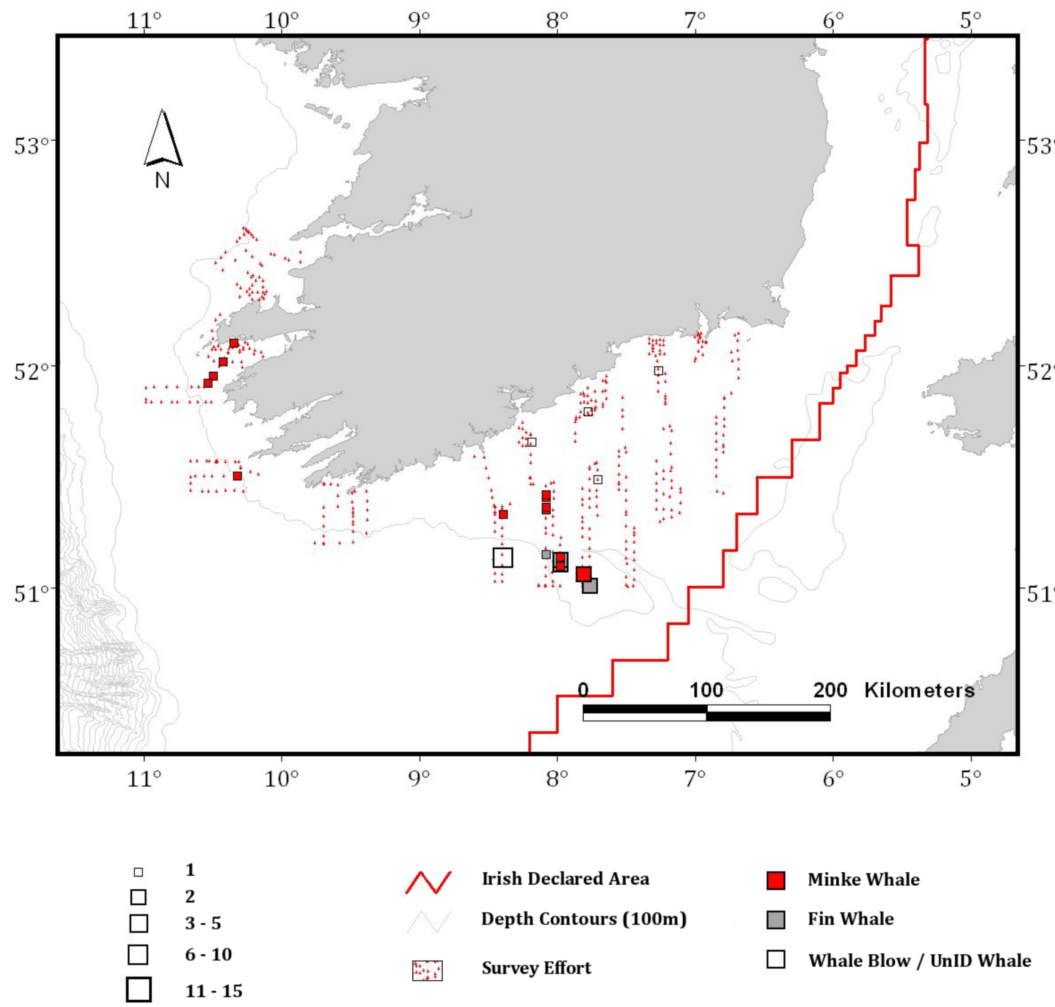


Figure 11. Distribution of whale sightings. Celtic Sea herring acoustic survey, October 2009.

October 2009																
	9	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**26**
Auk Species (all)			x		x		x	x		x	x	x			x	
Fulmar	x	x	x	x	x	x	x	x	x	x		x	x	x		
Gannet	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Great Black-backed Gull		x	x	x	x	x	x			x	x	x		x	x	x
Great Shearwater	x	x	x													
Great Skua	x	x	x	x	x	x	x	x	x	x		x	x	x	x	
Guillemot	x			x	x		x		x	x		x	x	x	x	x
Herring Gull	x	x	x		x			x			x	x		x		x
Kittiwake	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Lesser Black-backed Gull	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
Manx Shearwater	x															x
Parasitic Skua						x	x		x							
Puffin									x							
Razorbill	x	x				x			x					x		
Scoter (common)	x	x									x					
Shag		x								x	x	x		x	x	x
Sooty Shearwater	x	x	x	x		x							x			
Storm-petrel	x	x	x			x										

Figure 12. Percentage of days on which 15 bird species were recorded. Celtic Sea herring acoustic survey, October 2009.

HERRING MIDWATER TRAWL

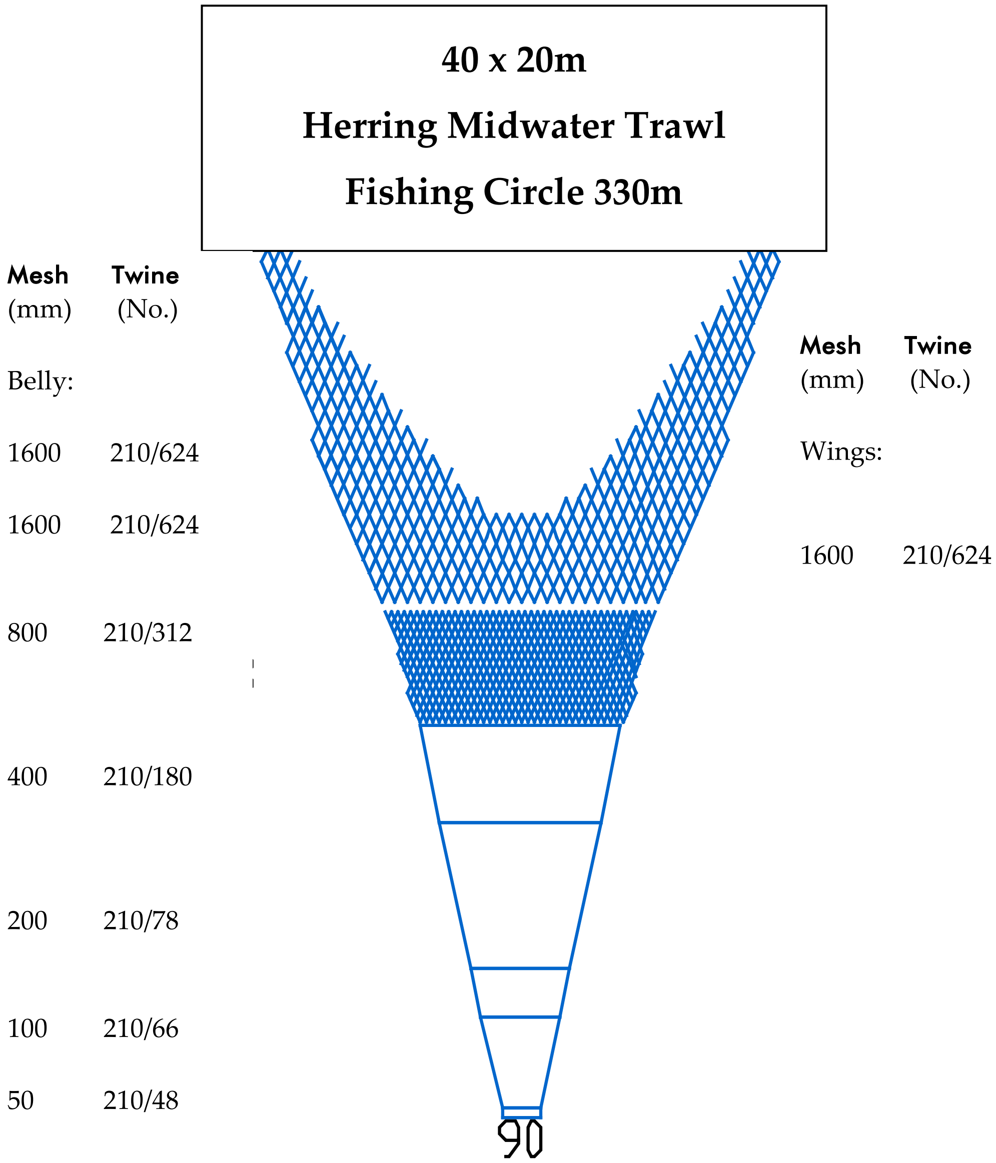


Figure 13. Single herring midwater trawlnet plan and layout. Celtic Sea herring acoustic survey, October 2009.

Note: All mesh sizes given in half meshes, schematic does not show 32m brailer.

Calibration report

Table 1. Calibration result of the Simrad ER60 ES38B (38 KHz) split-beam transducer.

Vessel : R/V Celtic Explorer		Date : 25-10-2009	
Echo sounder : ER60 PC		Locality : Bere Island	
Type of Sphere : WC-38,1	TS_{Sphere}: -33.50 dB (Corrected for soundvelocity or t,S)	Depth(Sea floor) : 30 m	

Calibration Version 2.1.0.12

Comments:

Reference Target:

TS	-33.50 dB	Min. Distance	15.00 m
TS Deviation	5 dB	Max. Distance	20.00 m

Transducer: ES38B Serial No. 30227

Frequency	38000 Hz	Beamtype	Split
Gain	25.71	Two Way Beam Angle	-20.6 dB
Athw. Angle Sens.	21.90	Along. Angle Sens.	21.90
Athw. Beam Angle	7.01 deg	Along. Beam Angle	6.97 deg
Athw. Offset Angle	0.02 deg	Along. Offset Angl	-0.06 deg
SaCorrection	-0.63 dB	Depth	8.8 m

Transceiver: GPT 38 kHz 009072033933 1 ES38B

Pulse Duration	1.024 ms	Sample Interval	0.191 m
Power	2000 W	Receiver Bandwidth	2.43 kHz

Sounder Type:
ER60 Version 2.2.0

TS Detection:

Min. Value	-50.0 dB	Min. Spacing	100 %
Max. Beam Comp.	6.0 dB	Min. Echolength	80 %
Max. Phase Dev.	8.0	Max. Echolength	180 %

Environment:

Absorption Coeff.	8.9 dB/km	Sound Velocity	1506.3 m/s

Beam Model results:

Transducer Gain =	25.85 dB	SaCorrection =	-0.63 dB
Athw. Beam Angle =	6.94 deg	Along. Beam Angle =	6.90 deg
Athw. Offset Angle =	-0.03 deg	Along. Offset Angle=	-0.06 deg

Data deviation from beam model:
RMS = 0.2 dB
Max = 1.30 dB No. = 274 Athw. = -2.7 deg Along = -1.9 deg
Min = -1.18 dB No. = 319 Athw. = 1.2 deg Along = -4.8 deg

Data deviation from polynomial model:
RMS = 0.18dB
Max = 1.11 dB No. = 247 Athw. = -2.7deg Along = -1.9 deg
Min = -0.96 dB No. = 319 Athw. = 1.2 deg Along = -4.8 deg

Comments :
Flat calm conditions
Wind Force : 15 kn. **Wind Direction :** SW
Raw Data File: \\Expfileclstr\ER-60_Data\CSHAS_2009\RAW ER60 Files\Calibration\CE0917_calibration_38
Calibration File: \\Expfileclstr\ER-60_Data\ER-60\Calibrations

Responsible : Ryan Saunders

ANNEX 5J: Northern Ireland (Clyde, North Channel)

Survey report for RV Corystes

6 –10 July 2009 and 27 August-13 September 2009,

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

1. INTRODUCTION

The WESTHER project recommended that the survey effort along the Malin shelf area (including ICES Divisions VIaN, VIaS, VIIb,c, Clyde and Irish Sea) should be increased or diverted to a combined survey on non-spawning herring. The utility of such a survey in a combined assessment of the three currently assessed stocks (VIaN, VIaS and VIIaN) was identified as necessary to move towards an integrated management plan for the area.

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 primarily the additional survey effort to the routine Irish Sea survey in autumn, which is an increase in survey effort and the second of a new time series that covers the Clyde and North Channel. The survey forms part of synoptic summer surveys on the Malin shelf. Concurrent surveys are conducted by Ireland (ICES Div VIaS, VIIb,c) and Scotland (ICES Div VIaN).

2. SURVEY DESCRIPTION and METHODS

2.1 Personnel

Steven Beggs (SIC)
Peter McCorriston
Ian McCausland
Enda O'Callaghan
John Peel

2.2 Narrative

The vessel departed Belfast at 2200 on the 5 July and started the survey off the north coast at 0300 on the 7 July after a day of calibration. Sea conditions were good throughout the survey, except during the first day of transecting off the north coast. The survey was completed at 1745 on 10 July.

2.3 Survey design

The survey design of systematic, parallel transects covers approximately 635 nm (Figure 5I.1), which is substantially more than the 540 nm in 2008. Transect spacing is 4 nm in the Clyde and increased to 7.5 nm off the north coast and channel, in accordance with perceived herring abundance. Data collected on connecting transects were not included in the estimates. The area to the west of the Isle of Arran was surveyed using a zigzag pattern to maximize coverage considering proximity to the coast. Survey design and methodology adheres to the methods laid out in the PGHERS acoustic survey manual.

2.4 Calibration

The hull mounted transducer ES38B was calibrated on the 6 July off Brodick on the east coast of Isle of Arran in the Clyde. 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 5I.1.

2.5 Acoustic data collection

Similar to the other surveys on the Malin shelf, acoustic data were only collected during daylight hours (0400–2300). 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 5I.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 (ICES rectangle) 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

In total 9 trawl hauls were carried out. Table 5I.2 gives the positions, catch composition and mean length by species for these trawl hauls. Six hauls contained herring to be used in the analysis, but only 3 hauls contained large numbers/proportions of herring. The length frequency distributions of these hauls are illustrated in Figure 5I.2. All distributions are unimodal and indicate relatively small herring of similar size within the sampling area. It was not possible to get a sample of herring off the north coast.

The resulting weight-length relationship for herring was calculated from the sampling information as $W = 0.00638*L^{3.062}$ (length measured in cm). The age length key (Table 5I.3) used in the analysis indicate that the population is composed of juveniles and young, immature fish (age 1).

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 5I.3. The highest abundance of herring was around the Isle of Aran and further south towards the North Channel.

3.3 Biomass estimates

The estimated biomass and number of herring and sprat by subrectangle are given in Table 5I.4. Only 0-gp and 1-gp herring were found in the area and the total number estimate comprises of 99% age 0 and 1% age 1.

4 DISCUSSION

The stock estimate in the survey area (Clyde/North Channel) was estimated to be 24,256 t or 5.9 x 10^9 individuals. The majority of the fish were below 10 cm and the major contribution of ages to the total estimates is from ages 0 fish. No mature fish were found in any of the hauls. Similar to the perception from last year's survey, the surveyed area appears to be a juvenile nursery area rather than an adult feeding ground, but this perception might change with subsequent survey information.

The herring were fairly widely distributed within mixed schools at low abundance, with a few distinct high abundance areas. The largest herring aggregations were found in to the south of the Isle of Arran.

TABLES AND FIGURES

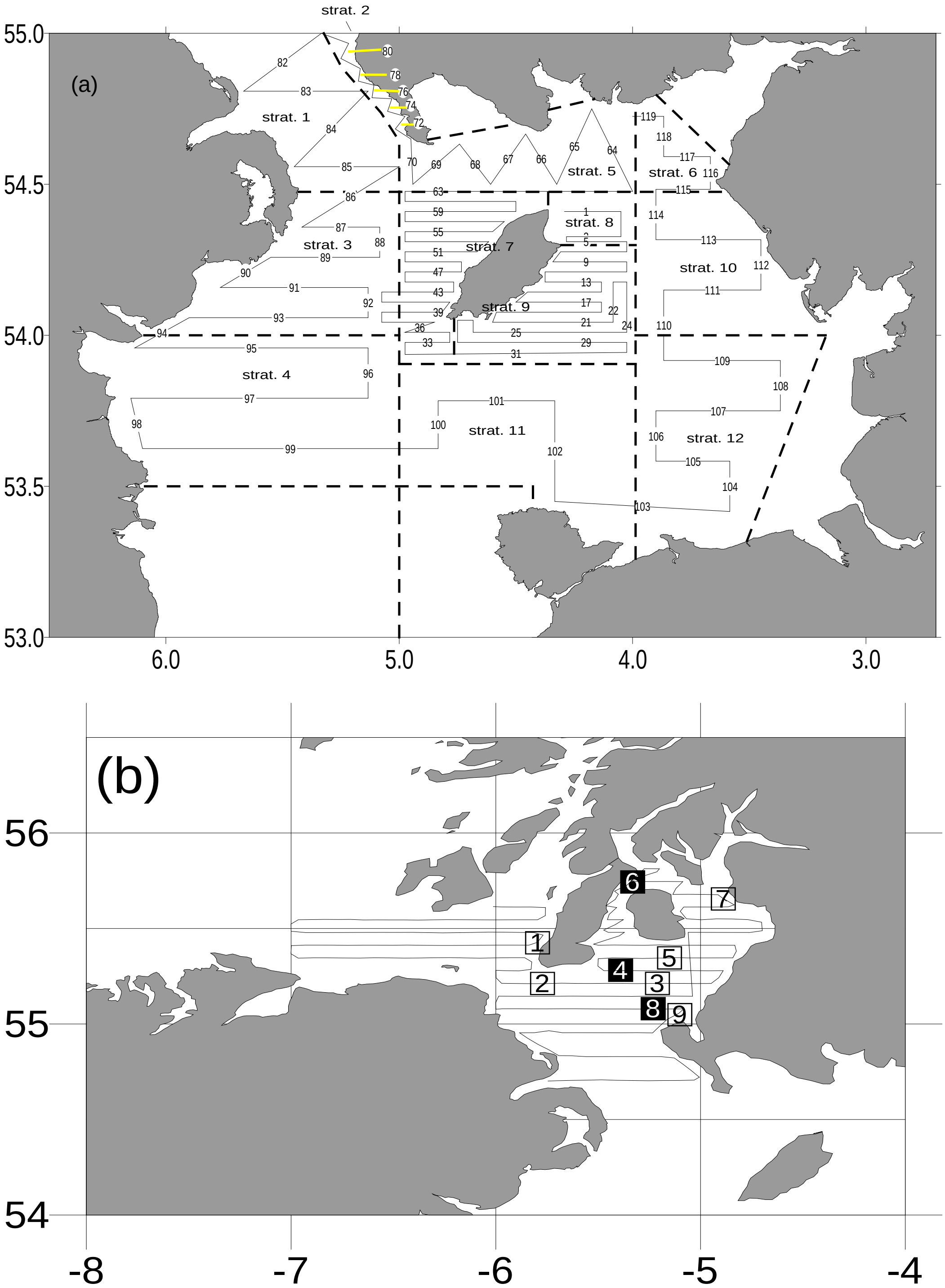


Figure 5I.1. Acoustic survey tracks of the Irish Sea, Clyde and North Channel surveys. (a) Survey grid of the main autumn herring acoustic survey in the Irish Sea in 2009. (b) Cruise track and trawl positions during the July 2009 Clyde and North Channel acoustic survey on RV "Corystes". Filled squares indicate trawls in which significant numbers of herring were caught or trawls with a high proportion of herring, while open squares indicate trawls with few or no herring.

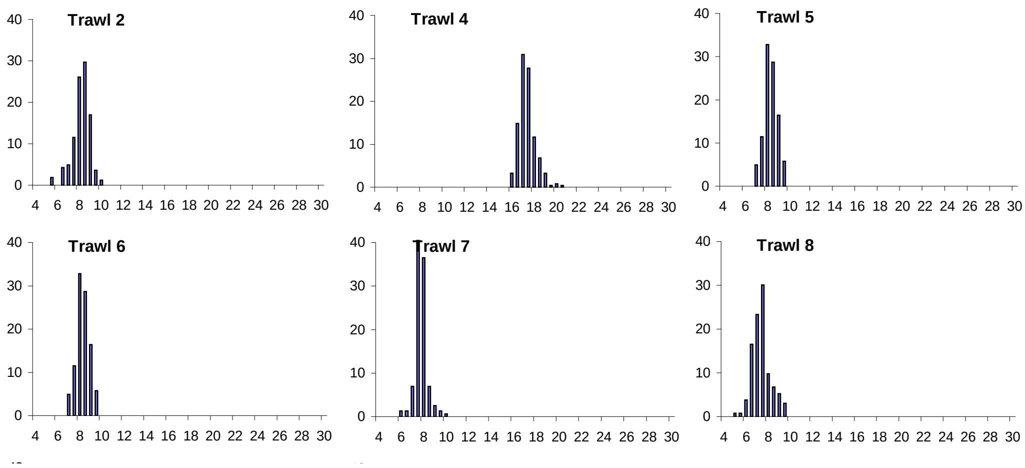


Figure 5I.2. Percentage length compositions of herring in each trawl sample in the July 2009 Clyde and North Channel acoustic survey on RV "Corystes".

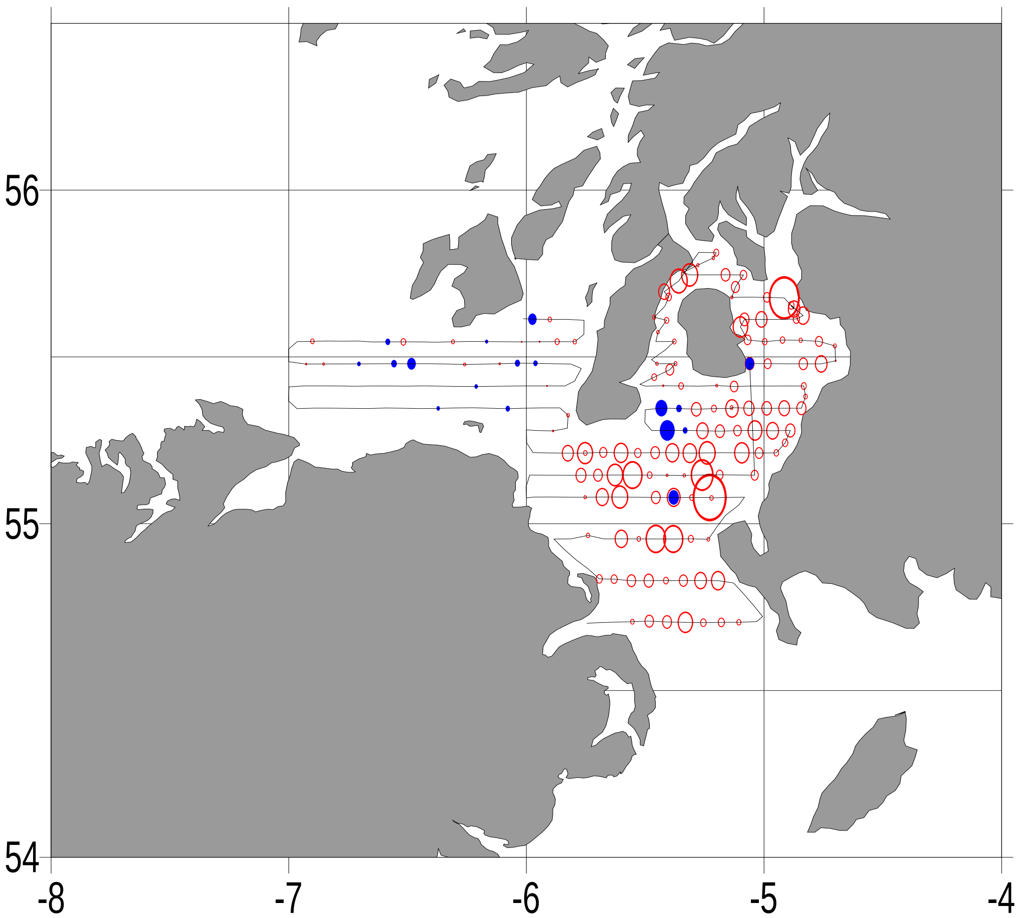


Figure 5I.3. Map of the Clyde and North Channel with a post plot showing the distribution of NASC values (size of elipses is proportional to square root of the NASC value per 15-minute interval) obtained during the July 2009 acoustic survey on RV "Corystes". (a) Solid circles are for herring NASC values (maximum value was 960) and (b) open circles are for clupeoid mix NASC, which include juvenile herring and sprat (maximum value was 5250).

Table 5I.1. Simrad EK60 and analysis settings used on the July 2009 Clyde and North Channel herring acoustic survey on RV "Corystes".

TRANSCEIVER MENU	
Frequency	38 kHz
Sound speed	1508 m.s^{-1}
Max. Power	2000 W
Equivalent two-way beam angle	-20.6 dB
Default Transducer Sv gain	24.84 dB
3 dB Beam width	6.9°
Calibration details	
TS of sphere	-33.6 dB
Range to sphere in calibration	12.5 m
Log Menu	
Integration performed in Echoview post-processing based on 15 minute EDSUs	
Operation Menu	
Ping interval	0.75 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 5I.2. Catch composition and position of hauls undertaken by the RV "*Corystes*" during the Clyde/North Channel survey, July 2009.

		Shooting details				Total fish	Percentage composition of fish by weight							Mean length (cm)		Invertebrate catch (kg)
Tow	Date	Time	Lat	Long	Depth (m)	Catch (kg)	Sprat	Herring	Mackerel	Scad	Anchovy	Whiting	Other fish	Sprat	Herring	
1	07/07	1406	55 25.5	6 47.8	25	0	98.3	0.0	0.1	0.1	0.1	0.1	1.2	4.5		0.0
2	08/07	0620	55 12.7	4 46.3	38	52	1.1	3.3	91.9	0.0	0.0	6.0	1.0	9.2	8.4	0.0
3	08/07	1020	55 12.8	5 12.6	19	35	0	0.0	0.2	0.0	0.0	0.0	0.0		18.0	0.0
4	08/07	1500	55 16.9	4 23.4	38	280	0	0.0	100.0	0.0	0.0	0.0	0.0		17.6	0.0
5	08/07	1906	55 20.8	5 9.1	25	47	75.5	0.03	24.4	0.0	0.0	0.1	0.0	8.4	8.5	0.0
6	09/07	0716	55 44.6	5 19.9	39	40	13.4	99.99	86.6	0.0	0.0	0.0	0.0	8.8	8.0	0.0
7	09/07	1222	55 39.3	4 53.3	24	49		75.6	24.4	0.0	0.0	0.0	0.0	6.0	7.2	0.0
8	10/07	0652	55 4.8	5 13.9	32	46		35.8	62.9	0.0	0.0	1.3	0.0	8.1	7.6	0.0
9	10/07	0756	55 2.9	5 6.1	40	248	6.8	96.9	0.0	0.0	0.0	0.0	0.0	12.0		0.0

Table 5I.3. Age-length key for herring from which otoliths were removed at sea during the July 2009 Clyde/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	TOTAL
5	2				2
6	4				4
7	8				8
8	8				8
9	7				7
10	1				1
11					
12		1			1
13					
14					
15					
16		4			4
17		6			6
18		8			8
19		5			5
20		3			3
21					
TOTAL	30	27			57

Table 5I.4. Acoustic survey estimates of biomass ('000t) and numbers ('000) of herring and sprat by survey stratum from the AFBI acoustic surveys in July 2008.

STRATUM	NO. SPRAT	BIOMASS SPRAT	NO. HER	BIOMASS HER
40E5C	349564	579	77517	212
40E4D	33509	170	379389	1439
40E4C	662	4	103753	466
40E4B	0	0	0	0
40E3D	1416	1	21911	98
40E3C	544	3	85183	382
39E5A	433347	1873	104731	482
39E4D	1909537	8252	607317	2796
39E4C	9601	56	1504335	6750
39E4B	503310	2175	163882	1598
39E4A	18	0	2755	12
39E3B	55	0	25509	748
39E3A	38	0	7688	101
38E4D	19459	89	74919	250
38E4C	86857	397	334402	1118
38E4B	503098	2299	1936929	6476
38E4A	103052	471	396752	1327
Total	3954067	16368	5826969	24256

Annex 6: The 2010 ICES Coordinated Acoustic Survey in the Skagerrak and Kattegat, the North Sea, West of Scotland and the Malin Shelf area

Eric Armstrong[1], Phil Copland[1], Cindy van Damme[2], Sascha Fässler[2], Cecilie Kvamme[4], Ciaran O'Donnel[5], Norbert Rohlf[3], Matthias Schaber [3], Pieter-Jan Schön[6] and Karl Johan Staehr[7].

[1] Marine Scotland Marine Laboratory, Aberdeen, Scotland, UK
[2] Wageningen-IMARES, IJmuiden, The Netherlands
[3] vTI, Institute of Sea Fisheries, Hamburg, Germany
[4] Institute of Marine Research, Bergen, Norway
[5] Marine Institute, Galway, Ireland
[6] Department of Agriculture and Rural Development, Belfast, Northern Ireland, UK
[7] DTU-Aqua, Charlottenlund, Denmark

Abstract

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 reported individually in the report of the ICES Working Group for International Pelagic Surveys (WGIPS): the global estimate of herring from all of 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 about 15% higher compared to the previous year, at 3.0 million tonnes and 14 231 million herring. The strong 2000 year-class of herring is now incorporated in the 9+ group. The 2008 year-class seems to be strong and persistent in this year's estimate.

The estimates of Western Baltic spring-spawning herring SSB were 101 000 tonnes and 981 million herring, which is lower than last year's estimate. The stock is dominated by 1 and 2 ring fish, however this year's estimated abundance of 1 and 2 ringers is considerably less than previous years, dating back to 2002.

The West of Scotland estimates of SSB are 253 000 tonnes and 1 319 million herring. This was lower than the estimate from the previous year. The survey detected a strong 2009 year-class that dominates the estimate of immature fish. The strong 2007 year-class observed in the previous year showed up in the estimate again this year. To ensure that the west of Scotland results were consistent with the time series, they were derived from squares above 56°N only.

This is the third year of the synoptic survey, covering what is currently considered the Malin Shelf population of herring. This provided an estimate comprising four herring stocks to the west of the British Isles: the West of Scotland in Division VIaN; the Clyde; Divisions VIaS and VIIb, c; and the Irish Sea. The SSB estimate was 303 000 tonnes and 1 616 million fish and is largely dominated by the West of Scotland estimate. Compared to the previous year, when no 0-group fish were detected, a strong year class of 0-group fish, dominating the numbers and biomass of immature fish of the Malin Shelf population, was observed this year.

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 and Danish, Swedish and German coastline and to the west by the shelf edge between 200 and 400 m depth. The surveys are reported individually in appendices 2A-I of the report of the planning group for international pelagic surveys. The vessels, areas and dates of cruises are given in Table 6.1 and in Figure 6.1.

Table 6.1. Vessels, areas and cruise dates during the 2010 herring acoustic surveys.

Vessel	Period	Area	Rectangles
Celtic Explorer (IR)	18 Jun – 07 July	53°-56°N ,12°-7°W	35D8-D9, 36D8-D9, 37D9-E1, 38D9-E1, 39E0-E2, 40E0-E2
Charter west Sco (SCO)	28 June – 17 July	55°30′-60°30′N, 4°-10°W	41E0-E3, 42E0-E3, 43E0-E3, 44E0-E3, 45E0-E4, 46E2-E5, 47E2-E5, 48E4-E5, 49E5
Johan Hjort (NOR)	3 July – 2 August	57°-62°N, 2°-5°E	43F2-F5, 44F2-F5, 45F2-F5, 46F2-F4, 47F2-F4, 48F2-F4, 49F2-F4, 50F2-F4, 51F2-F4, 52F2-F4
Scotia (SCO)	28 June –18 July	58°30′-62°N, 4°W-2°E	46E6-F1, 47E6-F1, 48E6-F1, 49E6-F1, 50E7-F1, 51E6-F1
Tridens (NED)	28 June – 23 July	54°– 58°30′N, 4° W–2°/ 6°E	37E9-F1, 38E8-F1, 39E8-F1, 40E8-F5, 41E7-F5, 42E7-F2, 43E7-F1, 44E6-F1, 45E6-F1
Solea (GER) DBFH	25 June – 13 July	52°-56°N, Eng to Den/Ger coasts	33F1-F4, 34F2-F4, 35F2-F4, 36F0-F7, 37F2-F8, 38F2-F7, 39F2-F7, 40F6-F7
Dana (DEN) OXBH	03 July– 23 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

The 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 (VIa north) herring and Malin Shelf stocks (VI and VII).

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 2010

The estimate of North Sea autumn spawning herring spawning stock is about 15% higher compared to the previous year, at 3.0 million tonnes and 14 231 million herring (Table 6.2). The strong 2000 year class of herring is now incorporated in the 9+ group. The abundance of the 2006 year class (age 3 this year) is consistent with a strong estimate of fish at age 2 last year, indicating that the 2007 estimate of age 0 fish was more precise than previously assumed. The current estimate also confirms a healthy 2008 year class already observed in the previous year.

The estimates of Western Baltic spring-spawning herring SSB are 101 000 tonnes and 981 million herring (Table 6.3), which are both lower than last years' estimates. The stock is once again dominated by 1 and 2 ring fish. Abundances of 1 and 2 ringers are however considerably less than those of previous years since 2002.

The West of Scotland estimates of SSB are 253 000 tonnes and 1 319 million herring (Table 6.4). This is about half as much as last year's estimate. The abundance is again dominated by immature fish, mainly due to the 2009 year-class observed for the first time this year. The abundance by year class is consistent with previous years and also with results from the adjacent North Sea area.

The synoptic survey covering what is currently considered the Malin Shelf population of herring was running for the second year. The provided estimate comprises four stocks to the west of the British Isles: the West of Scotland herring stock in Division VIaN (identified in Fishframe as her-vian); the Clyde stock (her-clyd); the stock in Division VIaS and VIIb,c (her-irlw) and the Irish Sea stock (her-nirs). 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 Malin Shelf estimate of SSB was 303 000 tonnes and 1 616 million fish (Table 6.5). This is largely dominated by the west of Scotland estimate. Most of the total stock estimate comprises immature fish, mainly due to the large 2009 year-class.

The area covered during the individual acoustic surveys is given in Figure 6.1. The spatial distributions of the abundance (numbers and biomass) of autumn spawning herring are shown in Figure 6.2. The distribution of numbers by age is shown in Figure 6.3 for 1 ring, 2 ring 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 6.4. The spatial distribution of mature and immature autumn spawning herring is shown in Figures 6.5 and 6.6 respectively. The spatial distributions of the abundance (numbers and biomass) of Western Baltic spring-spawning herring are shown in Figure 6.7. The distribution of numbers by age is shown in Figure 6.8 for 1 ring, 2 ring and 3+ ring. 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 6.9. The spatial distribution of mature and immature Western Baltic spring-spawning herring is shown in Figures 6.10 and 6.11 respectively.

The distribution of adult herring in the North Sea is still concentrated in the areas close to the Fladen grounds, but seems to stretch out towards the north, east of the Shetland Islands.

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 6.6 – 6.8, illustrated in Figures 6.12 -6.14 respectively. In each of them, a 3 year running mean is included to show the general trend more clearly.

Tables and Figures

Table 6.2. Total numbers (millions) and biomass (thousands of tonnes) of North Sea autumn spawning herring in the area surveyed in the acoustic surveys July 2010, with mean weights and mean lengths by age ring.

AGE (RING)	NUMBERS	BIOMASS	MATURITY	WEIGHT(G)	LENGTH (CM)
0	12,226	69	0.00	5.7	9.4
1	14,577	560	0.01	38.4	16.9
2	4,237	583	0.45	137.7	24.9
3	4,216	772	0.90	183.1	27.1
4	2,453	562	1.00	229.2	28.9
5	1,246	305	0.98	244.9	29.4
6	1,332	311	1.00	233.1	29.0
7	688	163	1.00	237.4	29.2
8	1,110	280	1.00	251.9	29.7
9+	1,619	407	1.00	251.2	29.6
Immature	29,473	985		33.4	14.5
Mature	14,231	3027		212.7	28.2
Total	43,705	4011	0.33	91.8	19.0

Table 6.3. Total numbers (millions) and biomass (thousands of tonnes) of Western Baltic spring-spawning herring in the area surveyed in the acoustic surveys July 2010, with mean weights, mean length and fraction mature by age ring.

AGE (RING)	NUMBERS	BIOMASS	MATURITY	WEIGHT(G)	LENGTH (CM)
0					
1	999	53	0.11	52.7	18.9
2	511	34	0.80	65.8	20.4
3	254	28	0.82	111.4	23.8
4	115	17	0.88	150.9	26.5
5	65	11	1.00	175.6	27.9
6	24	5	1.00	198.0	28.8
7	28	6	1.00	215.9	29.9
8+	34	8	1.00	234.8	30.2
Immature	1,049	60		57.6	19.4
Mature	981	101		103.4	22.9
Total	2,030	162	0.48	79.8	21.1

Table 6.4. Total numbers (millions) and biomass (thousands of tonnes) of autumn spawning West of Scotland herring in the area surveyed in the acoustic surveys July 2010, with mean weights, mean lengths and fraction mature by age ring.

AGE (RING)	NUMBERS	BIOMASS	MATURITY	WEIGHT(G)	LENGTH (CM)
0	1,559	2	0.00	1.6	5.9
1	425	25	0.00	60.0	18.8
2	489	60	0.50	124.6	24.0
3	398	73	0.97	185.1	27.4
4	150	29	0.98	198.7	28.0
5	143	30	1.00	212.1	28.6
6	95	20	1.00	214.2	28.9
7	63	13	1.00	210.2	28.6
8	48	10	1.00	218.2	29.0
9+	188	40	1.00	214.9	28.7
Immature	2,242	53		23.6	10.3
Mature	1,319	253		191.8	27.7
Total	3,561	307		86.2	16.7

Table 6.5. Total numbers (millions) and biomass (thousands of tonnes) of Malin Shelf herring in the area surveyed in the acoustic surveys July 2010, with mean weights, mean lengths and fraction mature by age ring.

AGE (RING)	NUMBERS	BIOMASS	MATURITY	WEIGHT(G)	LENGTH (CM)
0	3,707	6	0.00	1.6	5.9
1	659	35	0.00	53.9	18.0
2	793	96	0.41	121.6	23.8
3	462	83	0.96	179.8	27.2
4	202	38	0.98	191.1	27.8
5	185	38	1.00	206.6	28.5
6	120	25	1.00	212.8	28.9
7	83	17	1.00	209.7	28.8
8	65	14	1.00	218.8	29.3
9+	192	41	1.00	214.9	28.8
Immature	4,856	93		19.2	9.3
Mature	1,616	303		187.5	27.5
Total	6,473	397		61.3	13.8

Table 6.6. Estimates of North Sea autumn spawners (millions) at age from acoustic surveys, 1986–2010. 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 2010 estimates are from summer survey 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

Table 6.7. Numbers at age (millions) of Western Baltic Spring-spawning herring at age (rings) from acoustic surveys 1992 to 2010. 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

Table 6.8. Numbers at age (millions) and SSB of West of Scotland Autumn Spawning herring at age (rings) from acoustic surveys 1993 to 2010. 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

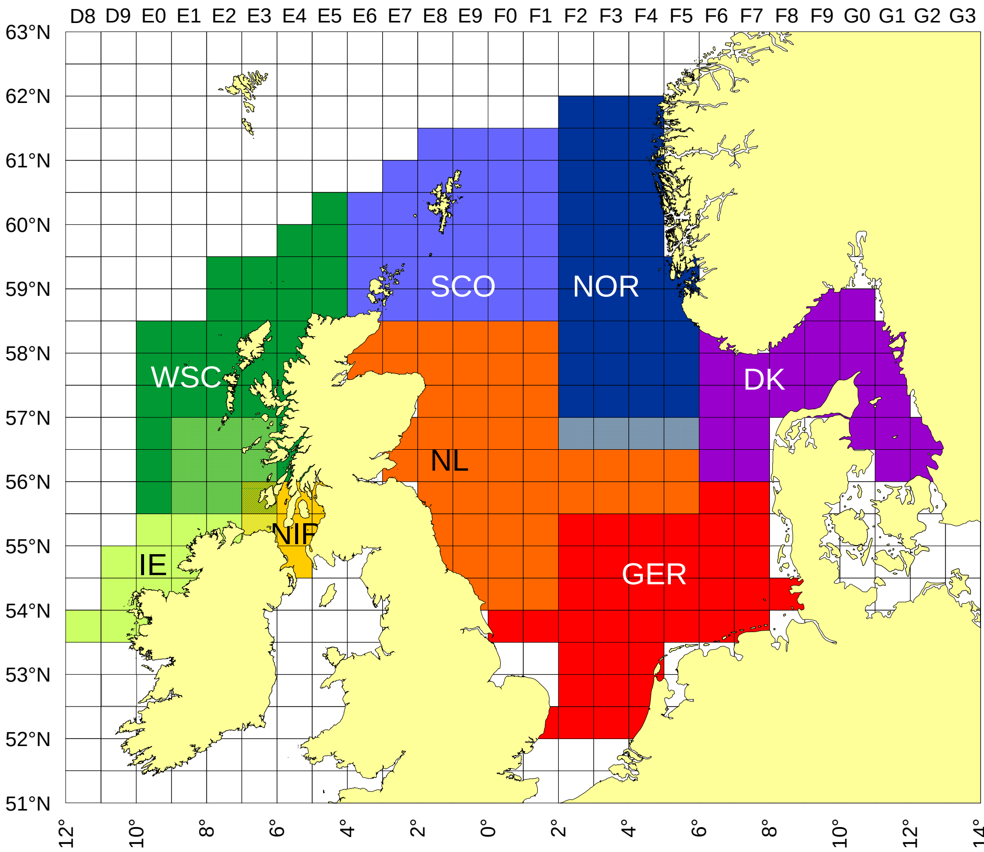


Figure 6.1. Survey area coverage in the pelagic acoustic surveys in 2010, by rectangle and nation (IR = Celtic Explorer; NIR = Corystes; WSC = West of Scotland charter vessel; SCO = Scotia; NOR = Johan Hjort; DK = Dana; NL = Tridens; GER = Solea). Multi-coloured rectangles indicate overlapping coverage by two or more nations (e.g. 40E1–40E3). Rectangles 42F2–42F5 were interpolated from surrounding ones.

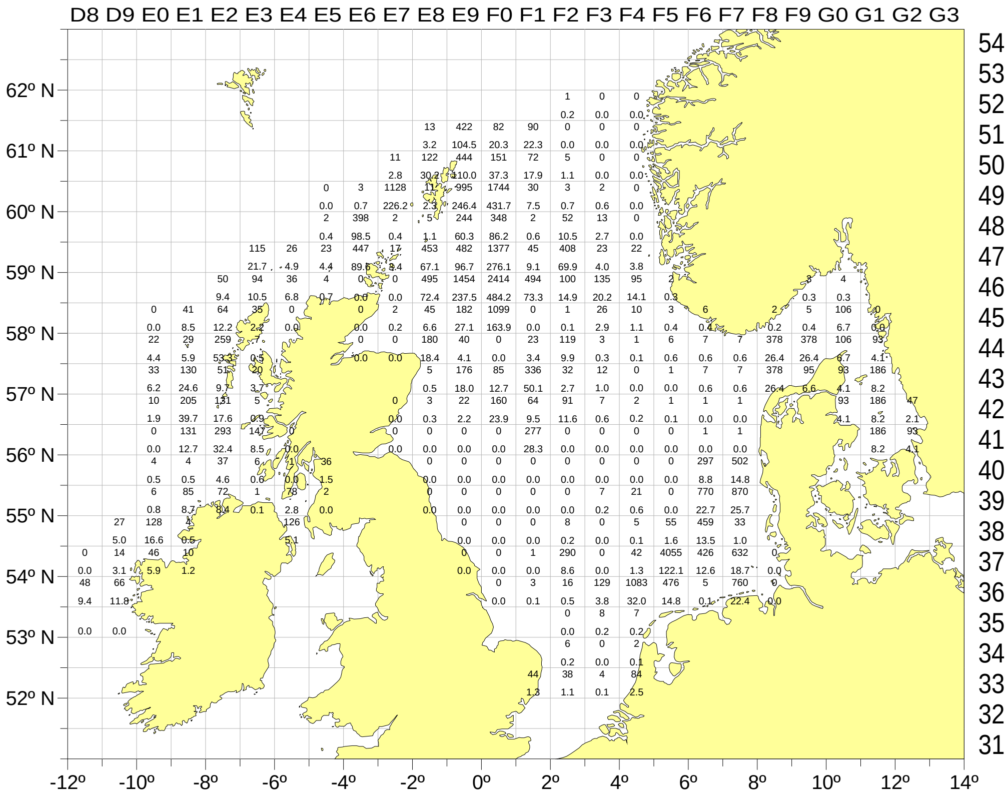


Figure 6.2. Abundance of autumn spawning herring (winter ring 1–9+) from the combined acoustic survey in June-July 2010. Numbers (millions, upper figure) and biomass (thousands of tonnes, lower figure). Blank rectangles are not surveyed.

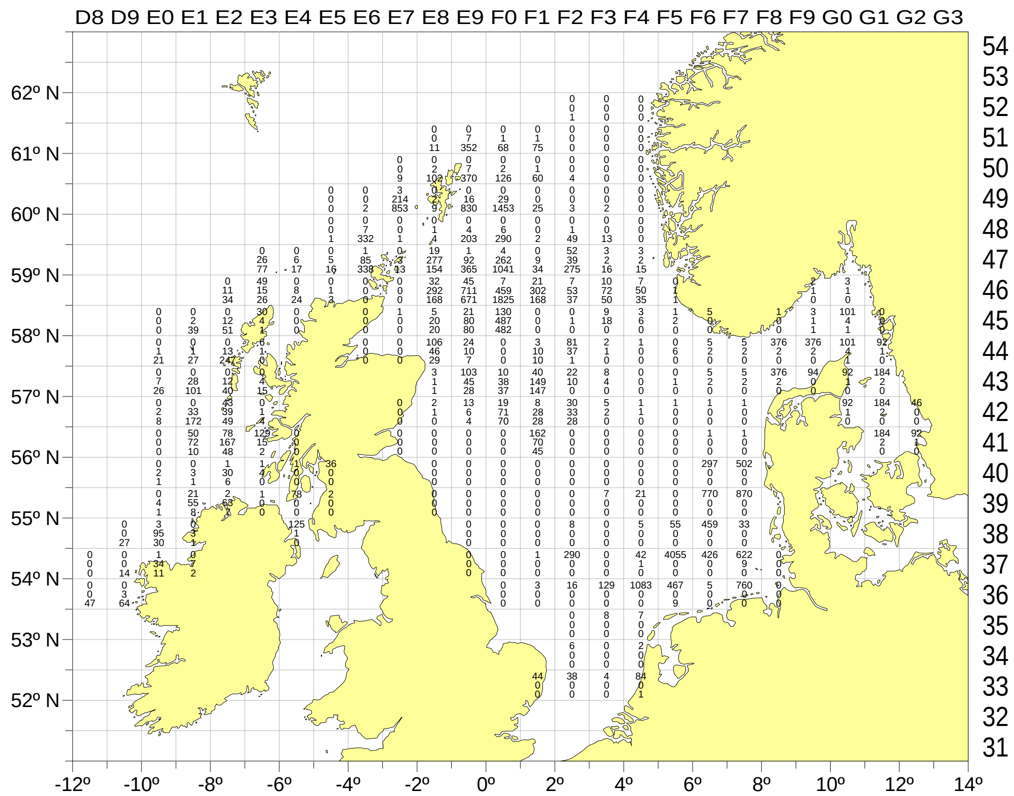


Figure 6.3. Numbers (millions) of autumn spawning herring from combined acoustic survey June – July 2010. 1 winter ring (upper figure), 2 ring (centre figure), 3+ (lower figure). Blank rectangles are not surveyed.

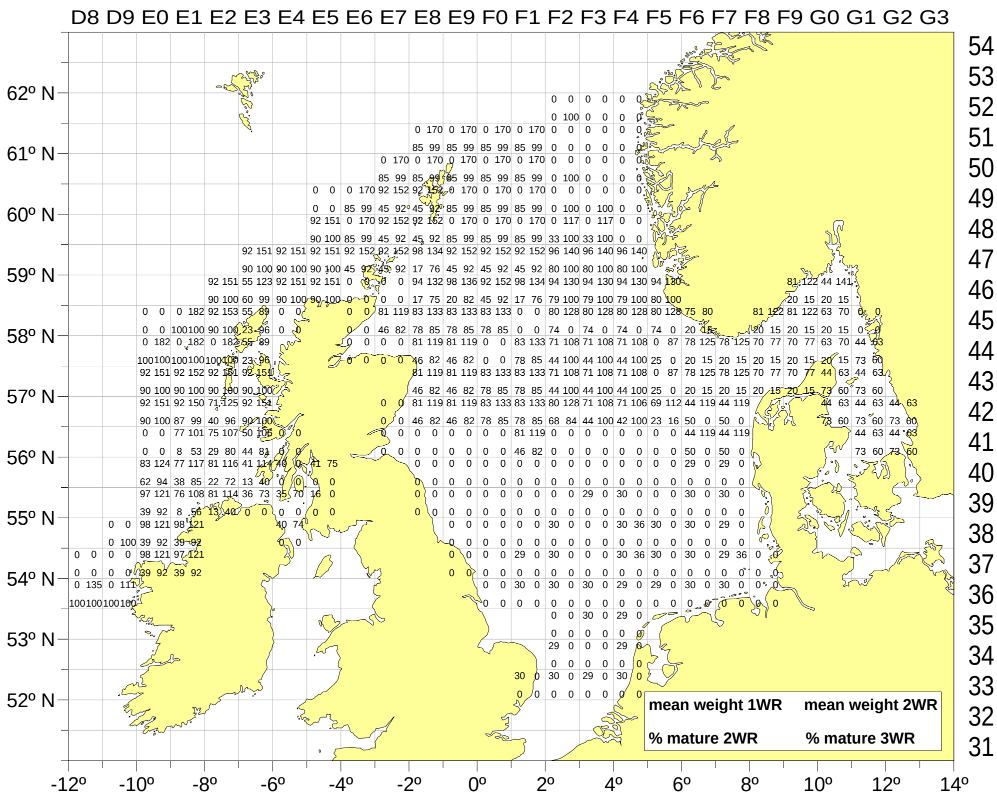


Figure 6.4. Mean weight and maturity of autumn spawning herring from combined acoustic survey June – July 2010. Four values per ICES rectangle, percentage mature of 2 ring (lower left) and 3 ring fish (lower right), mean weights (grammes) of 1 ring (upper left) and 2 ring fish (upper right), 0 indicates surveyed with zero abundance, blank indicates an unsurveyed rectangle.

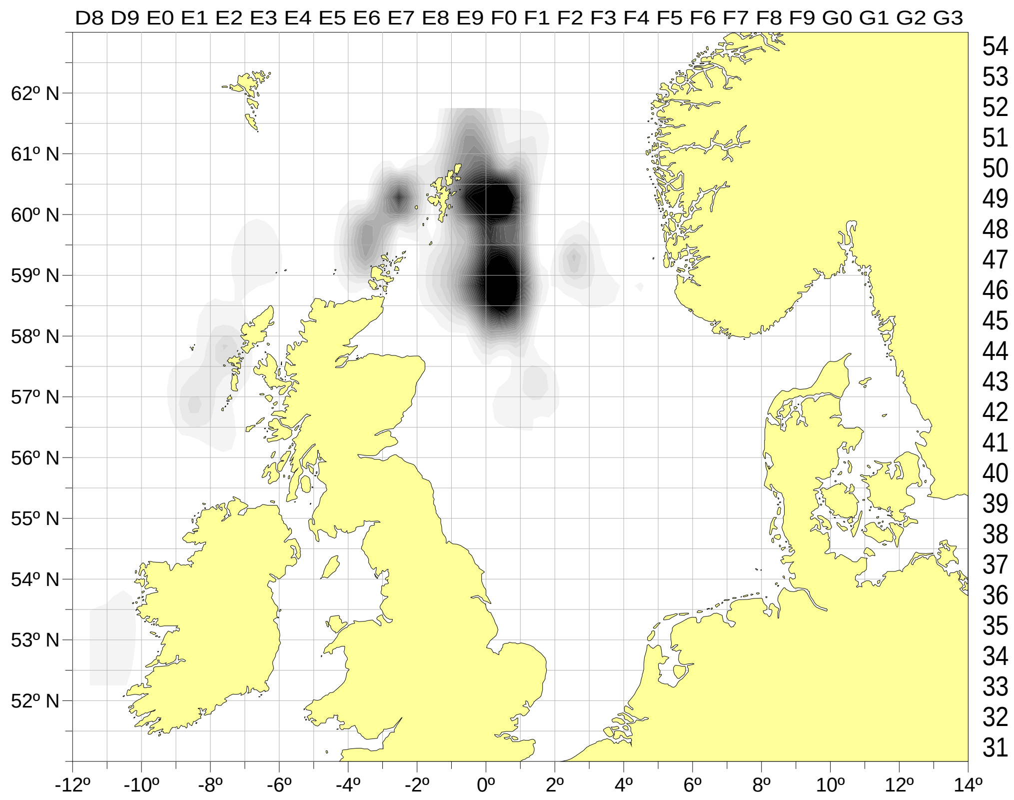


Figure 6.5. Biomass of mature autumn spawning herring from the combined acoustic survey in June – July 2010 (maximum value = 220 000).

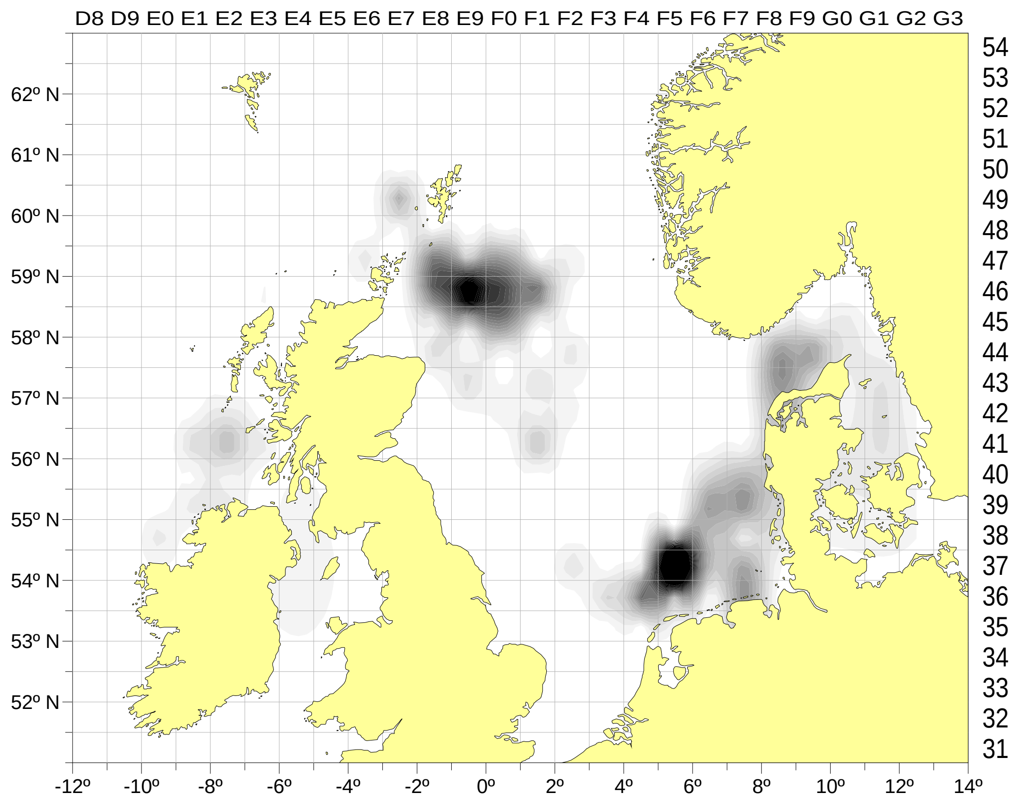


Figure 6.6. Biomass of immature autumn spawning herring from the combined acoustic survey in June – July 2010 (maximum value = 57 500).

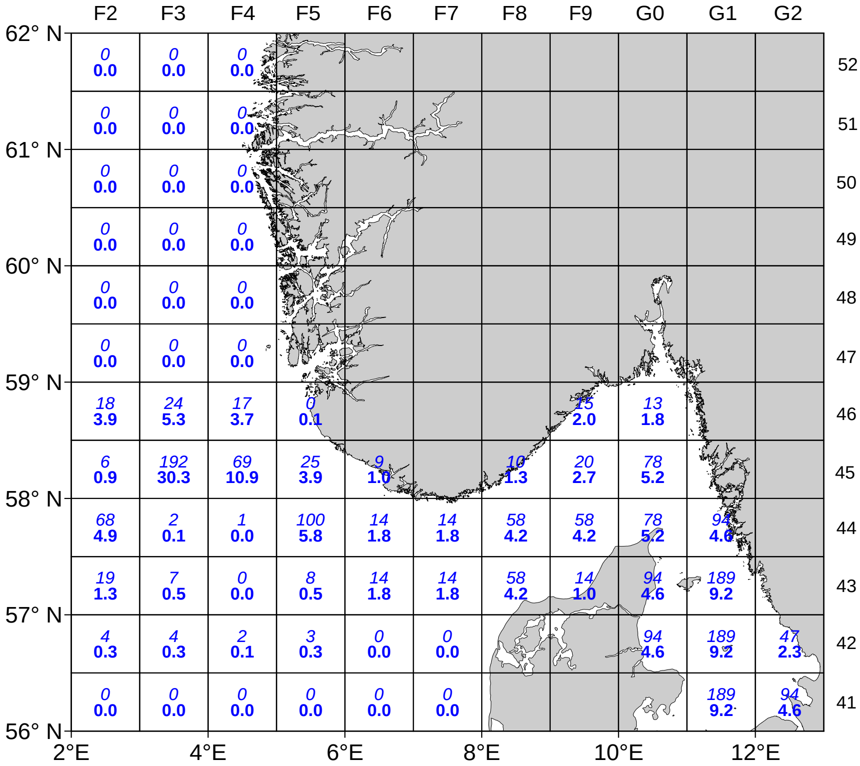


Figure 6.7. Abundance of western Baltic spring-spawning herring 1–9+ from combined acoustic survey July 2010. Numbers (millions, upper figure) and biomass (thousands of tonnes, lower figure).

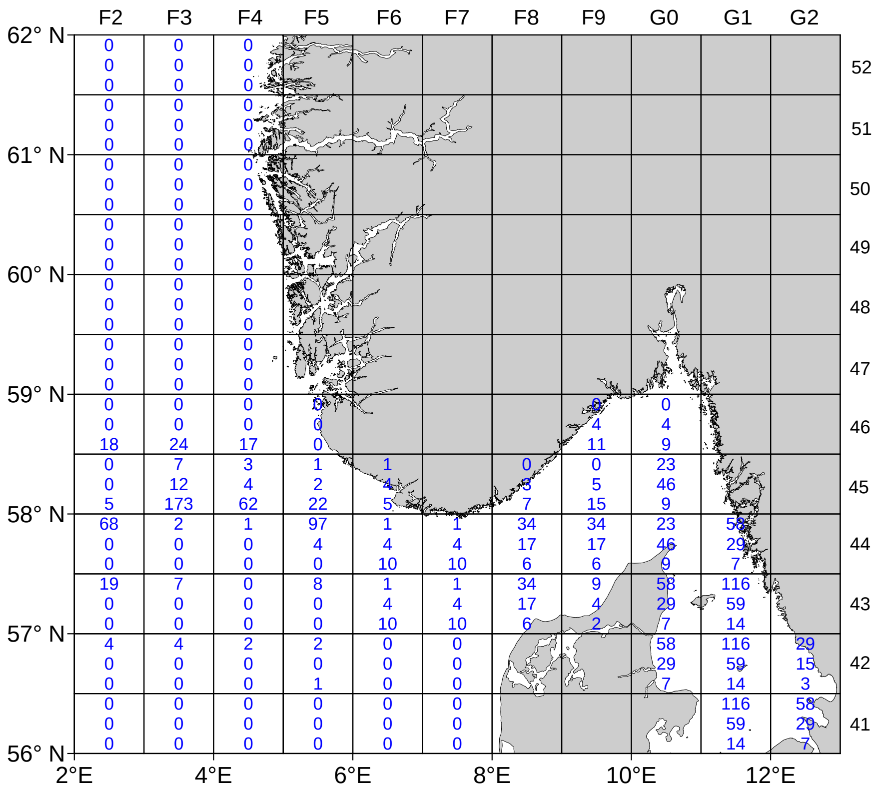


Figure 6.8. Numbers (millions) of western Baltic spring-spawning herring from combined acoustic survey June – July 2010. 1 ring (upper figure), 2 ring (centre figure), 3+ (lower figure).

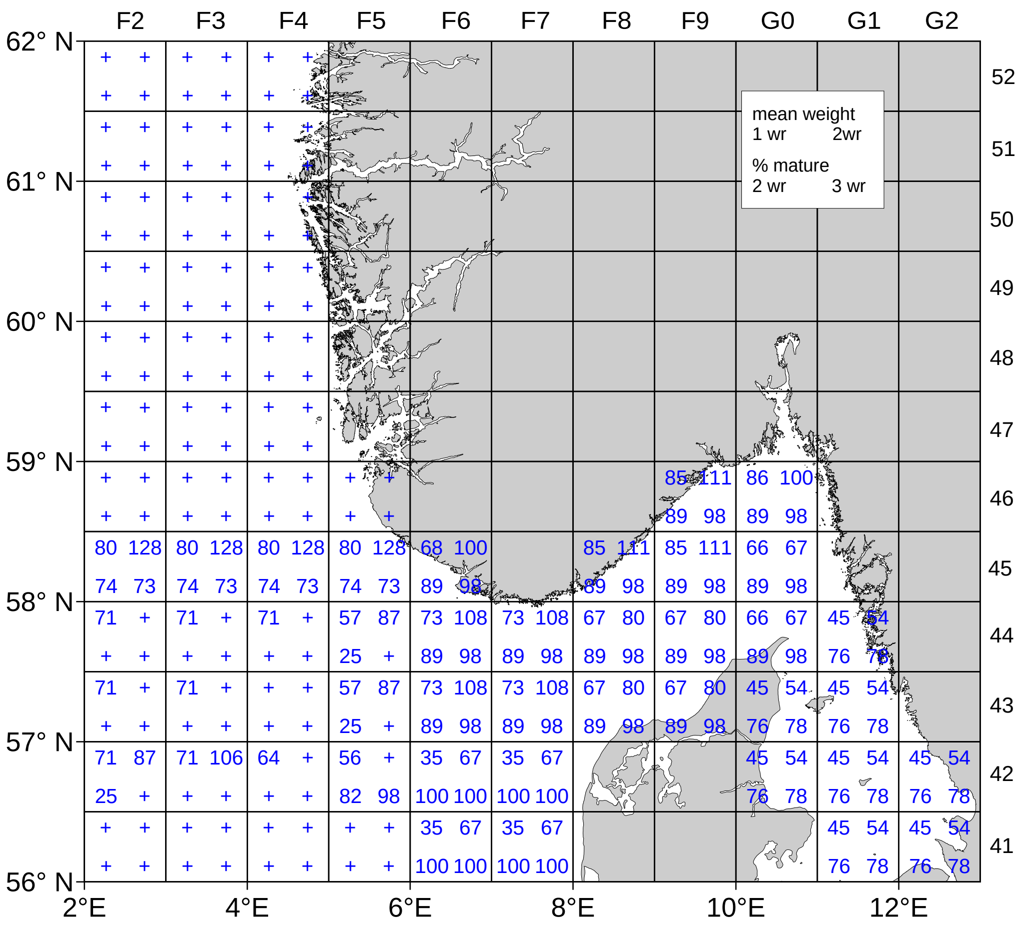


Figure 6.9. Mean weight and maturity of western Baltic spring-spawning herring from combined acoustic survey June – July 2010. Four values per ICES rectangle, percentage mature of 2 ring (lower left) and 3 ring fish (lower right), mean weights in grams of 1 ring (upper left) and 2 ring fish (upper right), + indicates surveyed with zero abundance, a blank indicates an unsurveyed rectangle.

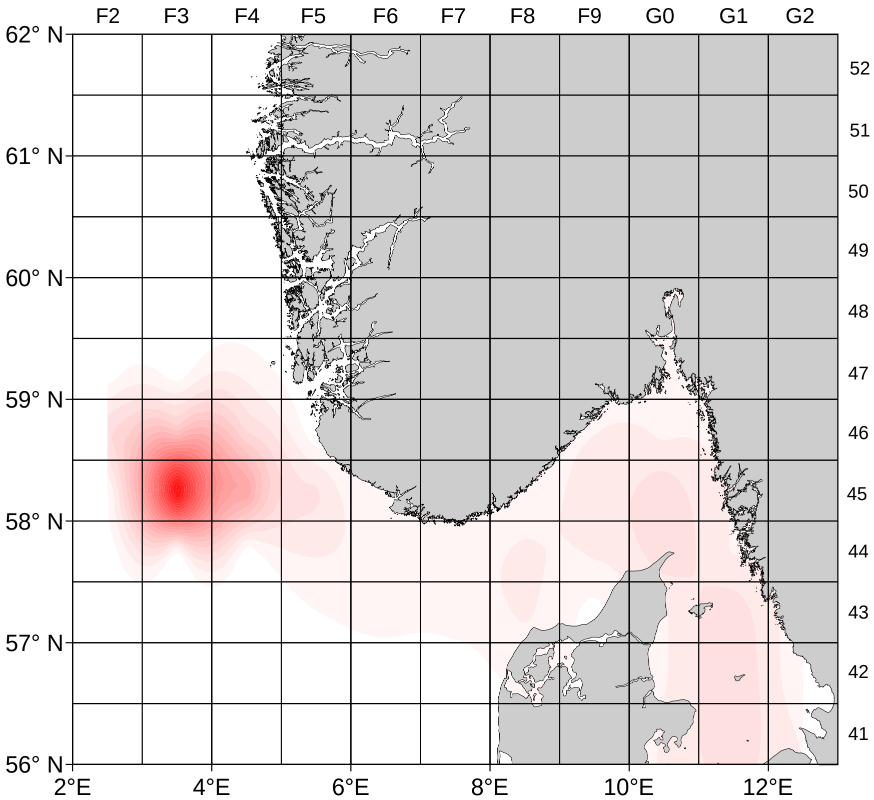


Figure 6.10. Biomass of mature western Baltic spring-spawning herring from combined acoustic survey in June – July 2010 (maximum = 24 000).

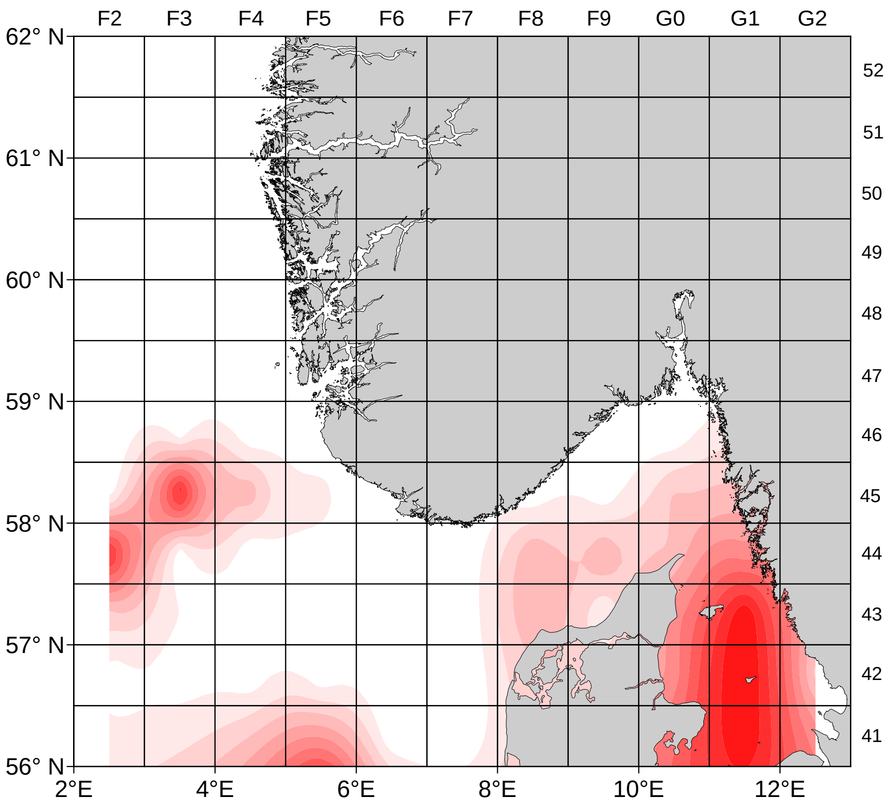


Figure 6.11. Biomass of immature western Baltic spring-spawning herring from combined acoustic survey in June – July 2010 (maximum = 5 500).

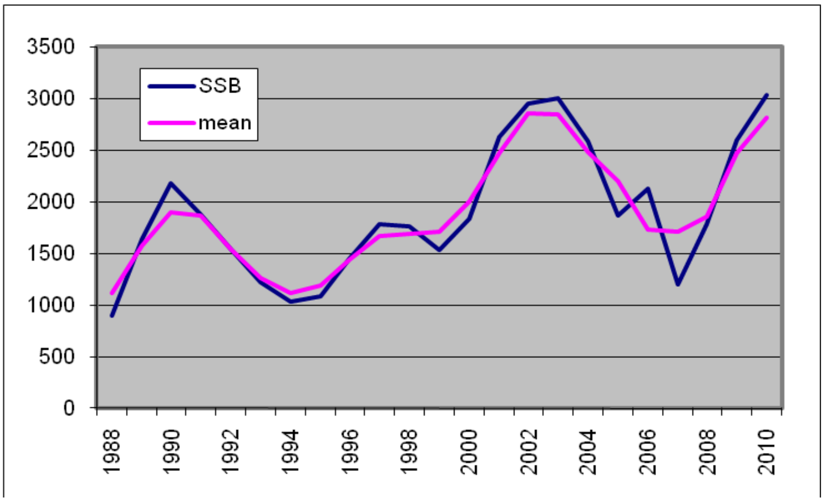


Figure 6.12. Time series of SSB of North Sea autumn spawning herring with three year running mean.

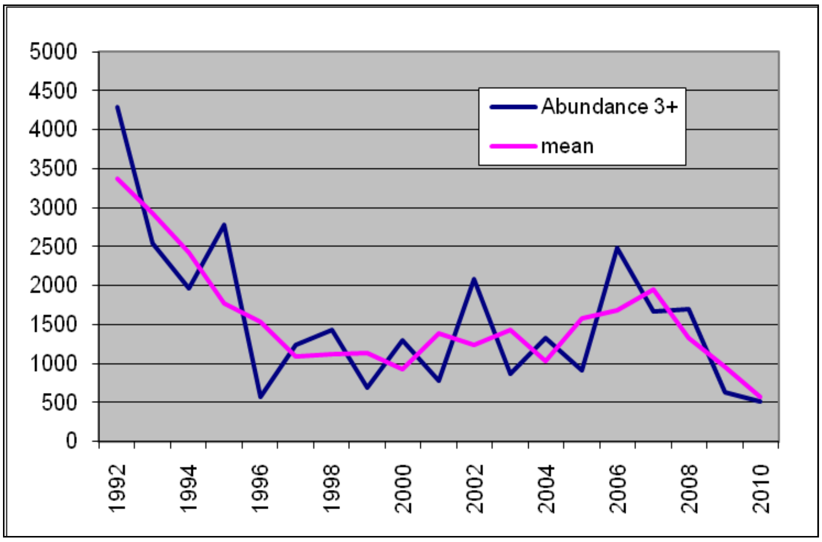


Figure 6.13. Time series of 3+ abundance of Western Baltic spring-spawning herring with three year running mean.

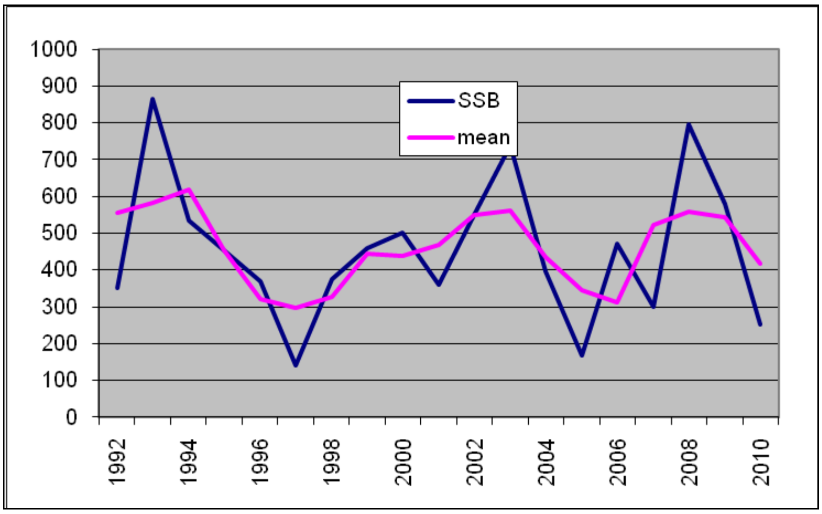


Figure 6.14. Time series of SSB of West of Scotland herring with three year running mean.

Annex 7: Working Documents to WGIPS

Proposal for a combined west of Scotland and North Sea herring acoustic survey

Paul Fernandes

Marine Scotland Science

Summary

- Due to financial constraints, Marine Scotland Science is no longer in a position to charter a commercial vessel to carry out the west of Scotland herring acoustic survey.
- This paper describes how a modified survey, traditionally carried out in the northern North Sea by Scotia, may be expanded to encompass both the North Sea and parts of the west of Scotland. This is contingent on the Republic of Ireland surveying those parts of the west of Scotland in ICES Division VIaN that remain. Agreement to this effect has been reached.
- Initial inspection indicates that there will be a loss of precision of the North Sea acoustic survey from a Relative Standard Error which on average has been just under 10% to one which is approximately 14%. Measures to improve this may yet be investigated. The precision of the west of Scotland survey should remain unaffected provided the Irish conduct a survey of similar duration to that proposed here.

Introduction

Marine Scotland Science (MSS) has traditionally undertaken two acoustic surveys each year to estimate the abundance and distribution of the two herring stocks around Scotland: the North Sea herring stock (ICES Division IV) and the west of Scotland herring stock (ICES Subdivision VIaN). Both of these are used to tune catch-at-age mathematical models at ICES assessment working groups. In the case of the west of Scotland survey, the data are the only tuning data for the catch-at-age model and have a time series going back to 1991. In recent years surveys have also been carried out by Northern Ireland and the Republic of Ireland to try to estimate the quantities of the various stock complexes which occur in ICES Division VI. In the case of the North Sea survey, the data are combined with data from several other nations to form the most important tuning index for the assessment of the stock.

Up until and including 2010, MSS have chartered a commercial vessel to carry out the west of Scotland acoustic survey and used the RV Scotia to conduct the North Sea survey. This was because it was essential that both surveys were carried out at the same time to minimize any problems associated with movement of fish between the two adjacent areas. From 2011, MSS will no longer have a charter budget for this survey. This note describes how the two surveys can be combined into one on the RV Scotia. It is predicated on the agreement that the Republic of Ireland survey, until now restricted to ICES Subdivision VIaS, is extended into VIaN as far as 58°30’N (west of the Hebrides and the Minches). The Irish have only recently (2007) reinstated their acoustic surveys in ICES Division VIaS.

New survey design

The North Sea survey typically lasts 21 days and has a track length of around 2500 nautical miles. In the case of an acoustic survey, the track length is relevant because it represents the sample size (data are collected continuously along the track). The proposed survey design for 2011 is given in Figure 1: this design would use 2826 nautical miles of track and require 21 days. The redistribution of effort has an effect on the amount of survey effort directed at each of the components: the new design has a track length in the North Sea of 2272 nautical miles (cf. 2400 n.mi. in 2010). The design can be modified to include elements of stratification in the light of further work into precision and in consultation with international colleagues

Effect on precision

The average precision of the North Sea herring acoustic survey from 1999 to 2005 was 9.4% (Woillez *et al.,* 2009). The new design differs from previous ones in that the transect spacing has had to be reduced in order to cover the larger area: this means that the stratification, which is used to improve the precision of the survey, will be lost. Without doing some extensive simulations, it is not known what effect the loss of stratification will have on the precision of the survey. However, assuming that precision is proportional to $n^{-0.5}$ (where n = sample size = track length) then we can estimate the likely change in precision of the survey from examination of the precision from previous surveys. The relationship between precision (expressed as the relative standard error – RSE) and sample size (track length in nautical miles) is given in Figure 2, with trajectories for each year calculated according to the relationship RSE = $b.n^{-0.5}$ where b is a year-specific constant. Extrapolating to the mean of these yearly trajectories and assuming a target precision of 15%, a minimum of 1073 samples would be required; extrapolating to the least precise trajectory (from the year 2000) a target precision of 15% would require a minimum of 1903 nautical miles. The estimated precision of the new survey in the North Sea based on a track length of 2272 nautical miles would be at least 13.7% (from the worst case, 2000, trajectory), at best 7.7% (from the best case, 2003 trajectory), and probably 10.3% (from the average trajectory). However, given that these precision estimates were based on data with stratification and that the new design does not have stratification (yet), it is more likely that the current design would be closer to the lower precision figure of 13.7%. As indicated above, this may be improved by considering elements of stratification. Nonetheless, this would seem to indicate, that on first inspection at least, the new design encompassing both areas should satisfy the minimum requirements for the precision of the North Sea survey (RSE<15%).

The effect on the west coast is unknown but the new design does have approximately half of the effort of that in 2009 and 2010. However, in the area's concerned (north of 58°30'N) there was little herring detected in 2010 and so reducing the effort would not have a drastic effect on survey precision. Furthermore, the small loss in precision is likely to be far outweighed by the increase in effort (and hence improved precision) which should be afforded by the proposed Irish survey designs based on a similar duration (20 days).

Reference

Woillez, M., Rivoirard, J., and Fernandes, P.G. 2009. Evaluating the uncertainty of abundance estimates from acoustic surveys using geostatistical conditional simulations. *ICES Journal of Marine Science,* **66**: 1377–1383.

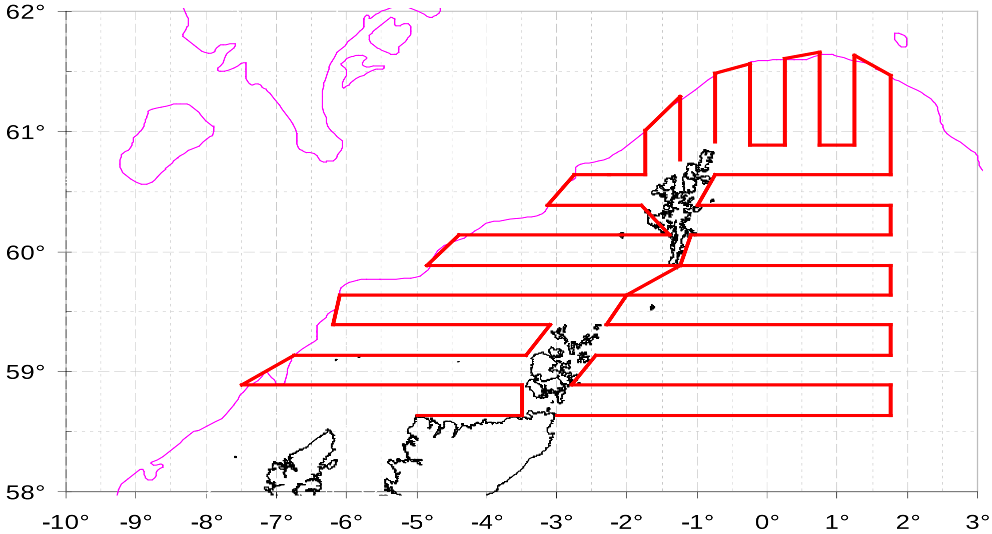


Figure 1. Map of the North of Scotland showing the cruise track design (red lines) for the 2011 North of Scotland pelagic survey.

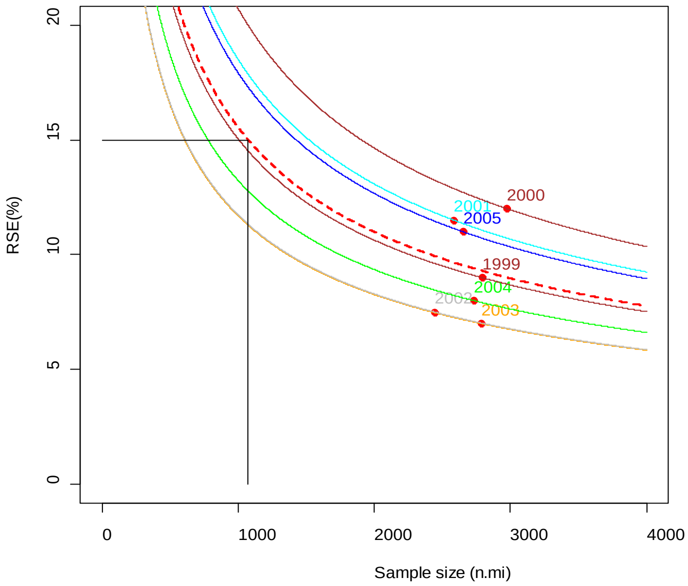


Figure 2. Relationship between sample size (acoustic track length in nautical miles) and the estimated precision (RSE) from (Woillez *et al.*, 2009): red dots represent the data from each year (1999 – 2005); coloured lines represent extrapolated values based on the assumed relationship RSE = b.n$^{-0.5}$. The red dotted line is the average of the yearly relationships. The black lines indicate the intersection of RSE=15% and n=1073 with the average relationship.