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Report of the Planning Group of International Pelagic Surveys (PGIPS)

20–23 January 2009

Aberdeen, Scotland, UK

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CIEM
Conseil International pour l'Exploration de la Mer

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Executive summary

The Planning Group of International Pelagic Surveys (PGIPS, formerly PGHERS) has met at Fisheries Research Services Aberdeen/UK Scotland from 20–23 January 2009 under the Chair Norbert Rohlf (vTI-SF Hamburg, Germany) to coordinate acoustic and larvae surveys in the North Sea, the Malin Shelf and the Western Baltic; to combine recent survey results for assessment purposes and to elucidate parameters influencing these calculations. The group was made up of 12 participants from six different countries.

Review of larvae surveys in 2008/2009: Six survey métiers were covered in the North Sea. The herring larvae sampling period was still in progress at the time of PGIPS 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 2009. The same is evident for Larvae Surveys from the Baltic.

Results from larvae survey in the Irish Sea indicate for 2008 a similar distribution pattern to previous years, with highest abundance of herring larvae to the east and north of the Isle of Man. The point estimate of production in the northeastern Irish Sea was below the time-series average.

North Sea, West of Scotland and Malin Shelf summer acoustic surveys in 2008: Eight acoustic surveys were carried out during late June and July 2008 covering the North Sea, West of Scotland and the Malin Shelf area. The estimate of North Sea autumn spawning herring spawning stock is at 1.8 million tonnes. This is slightly higher than the previous year (1.2 million tonnes).

The West of Scotland estimates of SSB are 788 000 tonnes. This is the second highest estimate in the time-series. The survey did not detect many immature fish this year. The 1998 year class is now almost completely depleted, but there were a significant number of the 2000 year class still in the population.

For the first time, a synoptic survey of what is currently considered the Malin Shelf population of herring was carried out. This provided an estimate comprising four stocks to the west of the British Isles: the West of Scotland herring stock in Division VIaN; the Clyde stock; the stock in Division VIaS and VIIb, c and the Irish Sea stock. The Malin Shelf estimate of SSB was 826 000 tonnes and is largely dominated by the west of Scotland estimate.

The estimates of Western Baltic spring-spawning herring SSB were 283 000 tonnes, which is slightly lower than last year's estimate. The stock is dominated by 1 and 2 ring fish.

Sprat: In most recent years, there is a downward trend in North Sea sprat. In 2008, the total biomass was estimates to 270 000 tonnes, which is a reduction by 25% when compared to last year. The majority of the stock consists of mature fish. The sprat stock is dominated by 1- and 2-year old fish representing more than 95% of the biomass.

In Division IIIa, sprat was abundant in the Kattegat only. No sprat was observed in the Skagerrak area. The biomass has significantly decreased to 12 000 tonnes.

Western Baltic acoustic surveys in 2008: A joint German-Danish acoustic survey was carried out with RV "Solea" in the Western Baltic in October 2008. The estimate of Western Baltic spring-spawning herring is about 124 000 tonnes in Subdivisions 22–24 and is dominated by young herring as in former years. The present overall estimates are low both in terms of abundance and biomass, when compared to the long-term mean. The estimated total sprat stock is around 60 000 tonnes and indications are found for a weak upcoming year class.

1 Opening of the meeting

The Planning Group of International Pelagic Surveys met in Aberdeen, UK Scotland, from 20–23 January 2009 to:

a) combine the 2008 survey data to provide indices of abundance for the population of herring and sprat within the area, using the FishFrame Acoustics database;

b) coordinate the timing, area and effort allocation and methodologies for acoustic and larvae surveys for herring and sprat in the North Sea, the Malin Shelf and the Western Baltic in 2009;

c) examine the interpretation of echograms between the participants of the 2008 acoustic surveys to ensure quality control and proper exchange of experience;

d) review histological studies to determine the accuracy of herring maturity reading;

e) report on individual systems for the estimation of fish abundance from individual survey data and examine the potential of a common tool.

PGIPS will report by 7 March 2009 for the attention of SCICOM and the HAWG.

2 Adoption of the agenda

The agenda was presented and adopted by PGIPS on the very first day. Participants contact details are listed in Annex 1, the agenda is given in Annex 2.

The following persons attended PGIPS:

Name	Function	Country
Norbert Rohlf	Chair	Germany
Paul Fernandes	Host	UK
Cindy van Damme	common member	Netherlands
Eberhard Götze	common member	Germany
Emma Hatfield	common member	UK
Phil Copland	common member	UK
Karl-Johan Staehr	common member	Denmark
Eric Armstrong	common member	UK
Cecilie Kvamme	common member	NOR
Ciaran O'Donnell	common member	Ireland
Pieter-Jan Schön	common member	UK
Sascha Fässler	Invited by chair	UK

3 Herring larvae surveys

3.1 Review of larvae surveys in 2008

3.1.1 Western Baltic

The survey, conducted by the German Institute for Baltic Sea Fisheries, Rostock, and its predecessor since 1977, delivers a unique high-resolution dataset on the herring larvae ecology in the Western Baltic, both temporally (weekly sampling over most of the spawning season) and spatially (35 standard station over a small area considered to be the main spawning area of this stock). The recruitment index derived from the survey is based on the number of larvae passing a certain length (20 mm) between two sampling events and thus not dependent of the identification of cohorts. Calculation procedures have been reviewed and re-established in recent years and the recalculated index for the time-series 1991–2007 was used by HAWG in 2008.

The Rügen herring larvae survey (RHLS) has been continued in 2008. The survey results will be presented to HAWG 2009.

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 periods covered during the 2008/2009 herring larvae surveys:

Area / Period	1–15 September	16–30 September	1–15 October
Orkney / Shetland	Germany	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 PGIPS 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 2009.

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 are carried on 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} were assumed based on estimates made in 1993–1997.

The results for 2008 indicate a similar distribution pattern to previous years, with highest abundance of herring larvae to the east and north of the Isle of Man (Figure 3.1.3.1). In common with more recent years, some larvae have been found off the Irish Coast after no significant indication of spawning in this area for a number of years (Mourne grounds). The point estimate of production in the northeastern Irish Sea for 2008 (1.68 x 1012 larvae) was 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 for the Area South of 62° N (HAWG).

The 2009 survey is scheduled to take place from 7–20 November.

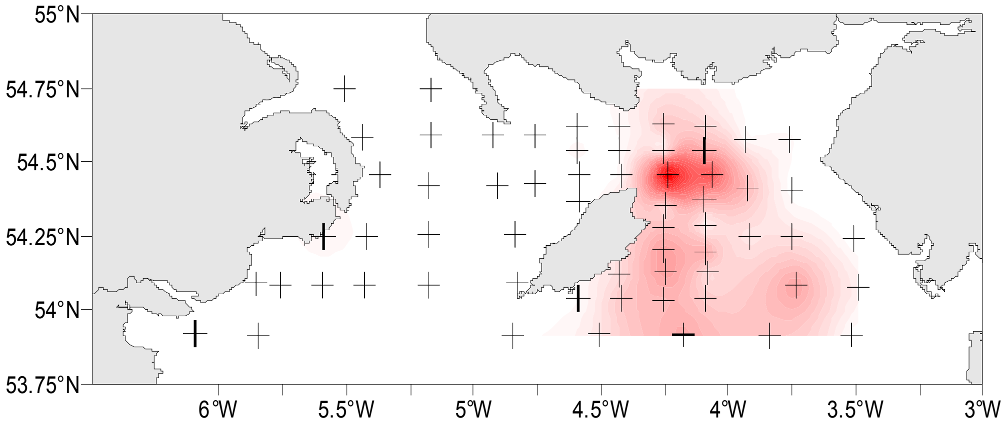

Figure 3.1.3.1. Estimates of larval herring abundance in the Northern Irish Sea in 2008. Crosses indicate sampling stations where no herring larvae were caught. Areas of shading is proportional to larva abundance (maximum = 71 per m^2).

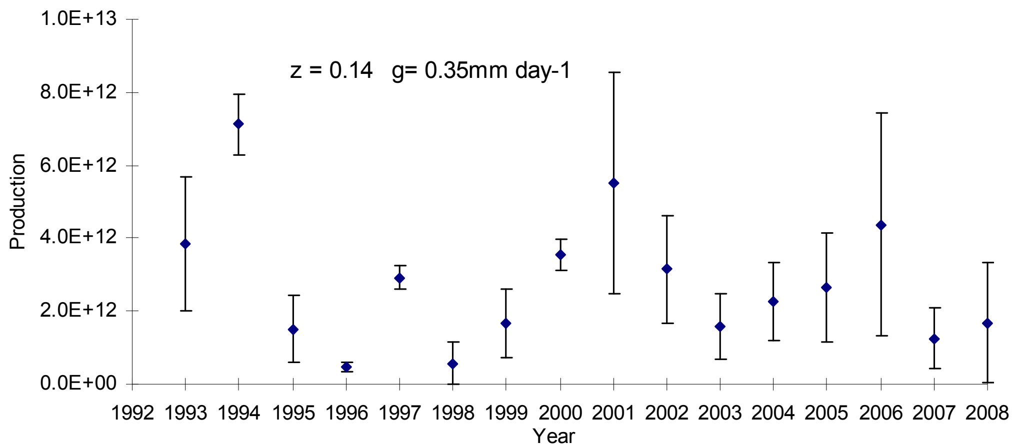

Figure 3.1.3.2. Estimates of larval herring production in the NE Irish Sea from 1993 to 2007. Error bars denote 1 standard error (calculated from coefficients of variation of the estimates of abundance, but not including uncertainty in growth or mortality).

3.2 Coordination of larvae surveys in 2008

At present only the participation of the Netherlands and Germany is confirmed in the 2009/2010 period. Because of the ships time schedule, 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 periods for the 2009/2010 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 Workshop on the Identification of Clupeid Larvae (WKIDCL)

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 easily be mixed up, effective quality control and proper larvae identification is essential to the survey results.

Thus PGIPS had recommended a workshop on the identification of ichthyoplankton, especially clupeid larvae, to take place in Hamburg, Germany, from 1–3 September 2009 with the following terms of reference:

a) review available information on the identification of clupeid fish larvae, under special consideration of larvae's appearance with ongoing development

b) identify sources of misidentification of clupeid larvae

c) establish an agreed identification key for participants in clupeid larvae surveys, e.g. for the IHLS in the North Sea, the Irish Sea, the IBTS (MIK index), the Rügen HLS and the Norwegian Spring-spawning herring larvae surveys.

However, actually only a very few persons have announced their interest in such a workshop. There is a critical mass of participants needed; otherwise it doesn't make sense to organize the WS. To get a better idea on the possible number of persons, all national laboratories are encouraged to name participants as soon as possible.

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 estimate of North Sea autumn spawning herring spawning stock is slightly higher than the previous year, at 1.8 million tonnes and 9 514 million herring. The survey continues to show the particularly strong 2000 year class of herring. Growth of this 2000 year class seems still to be slower than average: individuals of this year class were of a smaller mean length and mean weight than the younger 2001 year class.

The estimates of Western Baltic spring-spawning herring SSB were 283 000 tonnes and 2 299 million herring, which is slightly lower than last year's estimate. The stock is dominated by 1 and 2 ring fish.

The West of Scotland estimates of SSB are 788 000 tonnes and 3 770 million herring. This is the second highest estimate in the time-series. Once again the survey did not detect many immature fish this year. The 1998 year-class is now almost completely depleted, but there were a significant number of the 2000 year class still in the population. To ensure that the west of Scotland results were consistent with the existing time-series, they were derived from squares above 56°N only.

For the first time, a synoptic survey of what is currently considered the Malin Shelf population of herring was carried out, with participating vessels from Scotland (FV *Chris Andra*), Northern Ireland (RV *Corystes*) and Ireland (RV *Celtic Explorer*). The three vessel survey was an extension of the existing west of Scotland time-series to cover ICES divisions VIaS and VIIb (*C. Explorer*) and the Clyde and North Channel (*Corystes*). The Irish survey was a move away from the traditional spawning stock survey in early quarter one into summer and represents the first of a new time-series as part of the Malin shelf stock survey.

Transect interlacing was incorporated into the coordinated survey design in the boundary regions of VIaN and VIaS and in the southern area of VIaN in the approaches to the Northern Channel. In the latter area all three vessels allocated survey effort. However, in real terms the temporal progression of the survey meant that statistical rectangles in boundary areas were surveyed with a time-lag of up to 5 days. The surveys were combined in the same manner as those 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.

This provided an estimate comprising four stocks to the west of the British Isles: the West of Scotland herring stock in Division VIaN; the Clyde stock; the stock in Division VIaS and VIIb, c and the Irish Sea stock. The Malin Shelf estimate of SSB was 826 000 tonnes and 4 007 million fish and is largely dominated by the west of Scotland estimate.

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 2008, with mean weights and mean lengths by age ring.

AGE (RING)	NUMBERS	BIOMASS	MATURITY	WEIGHT(G)	LENGTH (CM)
0	6,870	60	0.00	8.7	10.5
1	3,714	232	0.05	62.4	19.2
2	2,853	403	0.86	141.4	25.0
3	1,709	307	0.98	179.7	26.8
4	1,485	272	0.99	183.3	27.0
5	809	157	1.00	194.4	27.5
6	712	164	1.00	229.9	28.7
7	1,749	380	1.00	217.4	28.4
8	185	50	1.00	267.9	29.7
9+	270	76	1.00	282.3	30.2
Immature	10,841	317		29.2	13.8
Mature	9,514	1,784		187.5	27.0
Total	20,355	2,100	0.47	103.2	20.0

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 2008, with mean weights, mean length and fraction mature by age ring.

AGE (RING)	NUMBERS	BIOMASS	MATURITY	WEIGHT(G)	LENGTH (CM)
0	112	0.7	0.00	6.3	9.6
1	5,852	284	0.05	48.6	18.2
2	1,160	101	0.43	87.0	22.0
3	843	102	0.81	120.8	24.4
4	333	47	0.93	141.4	25.6
5	274	45	1.00	165.5	26.9
6	176	31	1.00	175.6	27.5
7	45	9	1.00	208.5	28.8
8+	44	9	1.00	196.7	28.3
Immature	6,540	346		52.9	18.5
Mature	2,299	283		123.2	24.2
Total	8,839	629	1.00	71.2	20.0

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 2008, with mean weights, mean lengths and fraction mature by age ring.

Age (ring)	Numbers	Biomass	Maturity	weight(g)	Length (cm)
0					
1	48	3	0.00	54.6	18.2
2	233	40	0.98	172.1	26.3
3	912	174	1.00	191.3	27.2
4	669	139	1.00	208.3	28.0
5	340	73	1.00	214.3	28.2
6	272	58	1.00	213.9	28.2
7	721	159	1.00	220.6	28.5
8	366	82	1.00	224.2	28.6
9+	264	63	1.00	238.5	29.2
Immature	53	3		61.2	18.7
Mature	3,770	788		209.0	28.0
Total	3,824	791	0.99	207.0	27.9

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 2008, with mean weights, mean lengths and fraction mature by age ring.

Age (ring)	Numbers	Biomass	Maturity	weight(g)	Length (cm)
0					
1	425	27	0.01	63.4	19.5
2	377	56	0.76	147.5	25.1
3	1,000	189	1.00	188.7	27.1
4	718	149	1.00	207.0	27.9
5	362	77	1.00	213.6	28.2
6	286	61	1.00	214.9	28.1
7	721	159	1.00	220.6	28.5
8	366	82	1.00	224.2	28.6
9+	264	63	1.00	238.5	29.2
Immature	510	36		70.6	20.1
Mature	4,007	826		206.2	27.8
Total	4,517	862	0.89	190.9	27.0

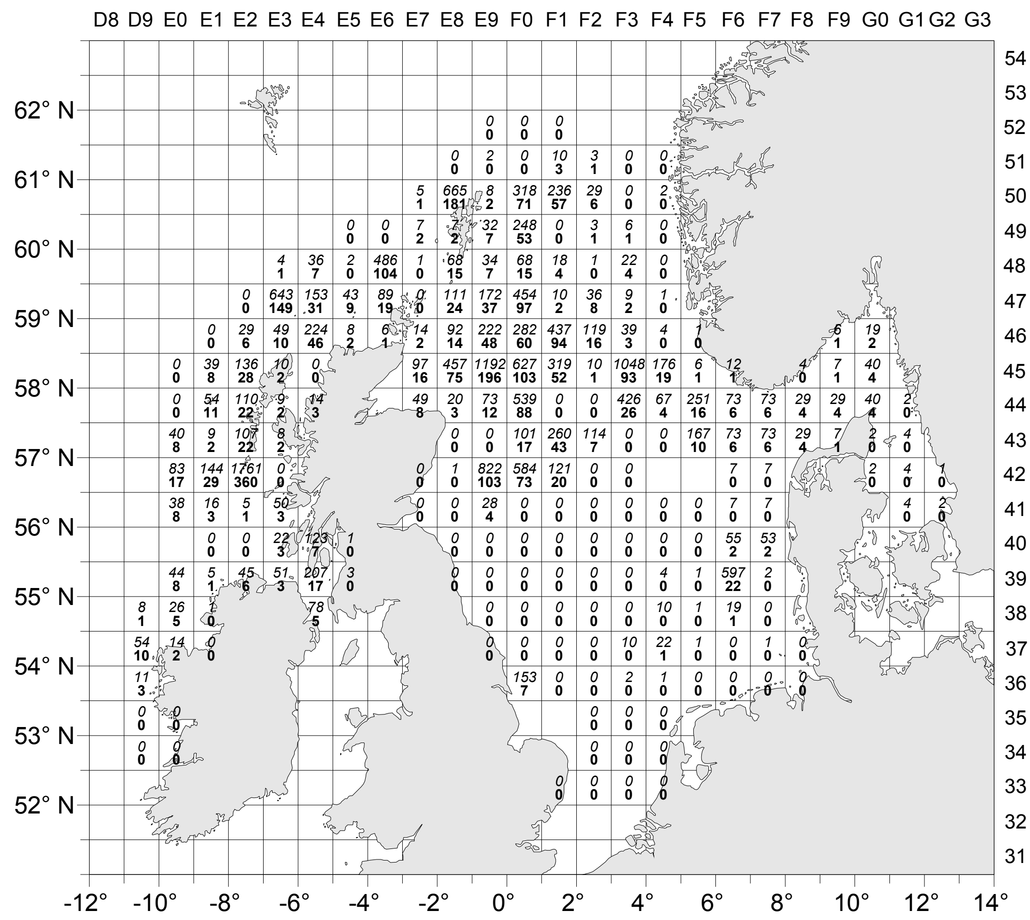

Figure 4.1.1.1. Abundance of autumn spawning herring (winter ring 1–9+) from the combined acoustic survey in June–July 2008. Numbers (millions, upper figure) and biomass (thousands of tonnes, lower figure). Blank rectangles are not surveyed.

4.1.2 Western Baltic acoustic survey

A joint German-Danish acoustic survey was carried out with RV "Solea" during 2 to 21 October 2008 in the Western Baltic. This survey is traditionally coordinated within the framework of the Baltic International Acoustic Survey to support ICES Herring Assessment Working Group for the Area South of 62°N (HAWG) and Baltic Fisheries Assessment Working Group (WGBFAS) with an index value for the stock size of herring and sprat in the Western Baltic area. 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 1,366 nautical miles long and is representative for an area of 14 026 nautical square miles. The ICES Subdivisions 21, 22, 23, and 24 were covered during the autumn survey. To identify the target species and determine the length and weight of fish, 53 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 probe.

The Western Baltic spring-spawning herring stock was estimated to be 3.5 x 10^9 fish or about 124 x 10^3 tonnes in Subdivisions 22–24. This numbers were dominated by young herring as in former years. Compared to the long-term mean the present overall estimates are low in numbers and in biomass. The estimated total sprat stock was 6.1 x 10^9 fish or 59.7 x 10^3 tonnes. The low estimate of sprat in total numbers indicates a weak upcoming year class. A detailed survey report is provided in Annex 5H.

4.2 Sprat in the North Sea and Division IIIa

Sprat data were available from RV *Solea*, RV *Tridens* and RV *Dana*. RV *Scotia* and RV *Johan Hjort* observed no sprat in the northern North Sea. In the acoustic surveys 2008 sprat concentrate more in the central and southern parts of the North Sea, with highest abundances and biomass in a wide area between 2° and 4° E and below 55° 30′ N. The survey area was again limited down to 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.

In most recent years, there is a downward trend in North Sea sprat (Table 4.2.2). The total abundance in 2008 was estimated to 25 125 million individuals and the biomass 270 kt (Table 4.2.1), which is a reduction by 25% in terms of biomass when compared to last year (ICES 2008). The majority of the stock consists of mature sprat. The sprat stock is dominated by 1- and 2-year old fish representing more than 95% 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 the Kattegat only (ICES squares 41G1-G2, 42G0-G2, 43G0-G1 and 44G1). No sprat was observed in the Skagerrak area (43F8-F9, 44F8-F9). The abundance was estimated to 775 million individuals (Table 4.2.3), a significant reduction compared to 6 318 million sprat in 2007. The biomass was estimated to 12 000 tonnes. Most sprat were two-year old fish, and half of them were immature.

Table 4.2.1. Sprat in the North Sea: Abundance, biomass, mean weight and mean length by age and maturity from summer 2008 North Sea acoustic survey.

Age	Abundance (million)	Biomass (1000 t)	mean weight (g)	mean length (cm)
1i	5,272	39	7.4	9.6
1m	11,893	122	10.2	10.7
2i	464	4	8.9	10.3
2m	6,946	97	14.0	12.1
3i	0.8	0.0	17.8	13.1
3m	525	8.2	15.7	12.6
4i	3	0.1	18.4	13.5
4m	20	0.3	16.8	12.9
immature	5,740	43	7.5	9.7
mature	19,384	227	11.7	11.3
grand total	25,124	270	10.8	10.9

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 5 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
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 by the means of FishFrame.**

Table 4.2.3. Sprat in Division IIIa: Abundance, biomass, mean weight and length by age and maturity from summer 2008 North Sea acoustic survey.

Age	Abundance (Million)	Biomass (1000 t)	Mean Weight (g)	Mean length (cm)
1i	20.1	0.2	8.5	10.4
1m	2.9	0.0	8.5	10.4
2i	226.3	3.1	13.9	11.8
2m	231.5	3.2	13.9	11.8
3i	27.7	0.5	19.4	13.5
3m	102.3	2.0	19.4	13.5
4i	16.5	0.3	20.1	13.8
4m	84.3	1.7	20.1	13.8
5	55.7	1.2	21.1	14.1
6	4.7	0.1	22.5	14.4
immature	290.7	4.2	14.4	12.0
mature	481.4	8.2	17.0	12.8
total	775.1	12.4	16.0	12.5

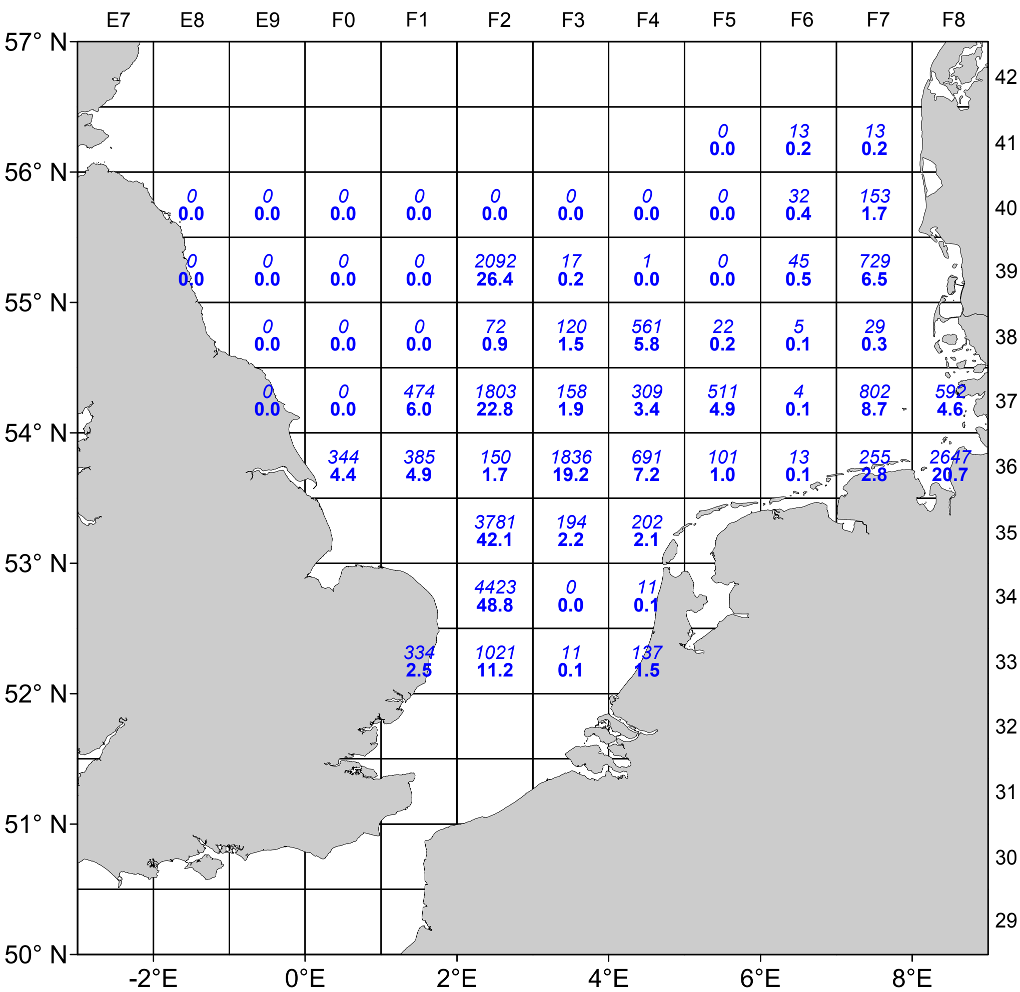

Figure 4.2.1. North Sea Sprat. Abundance (upper figure, in millions) and biomass (lower figure, in 1000 t) per statistical rectangle as obtained by the acoustic survey 2008.

4.3 Coordination of acoustic surveys in 2009

4.3.1 North Sea, West of Scotland and Malin Shelf

In 2004 the group reallocated the survey effort. In 2005, survey transects were interlaced for those vessels for which a good agreement of scrutiny procedures was demonstrated, and where fishing and interpretation of trawl haul information were comparable. In that year, the group considered that interlacing survey transects would benefit the overall quality of the survey, but has also foreseen that this demands a well harmonized and high level of coordination. The group is still convinced that interlacing is an advantage in survey design and quality. The interlacing has not caused any problems in the survey itself, but the close cooperation needed whereas analysing the national surveys was often hampered by practical aspects like rectangles without biological sampling, time constraints because of long steaming distances etc. Consequently, PGIPS decided to set up a survey design drawing more on the years prior to the interlacing. When FishFrame stage 1 and 2 are fully operational and supported by the national data suppliers, the national analysing tools become obsolete and a new attempt for a coordinated interlaced survey design in the North Sea would make sense.

Participants in 2009 should exchange tentative cruise tracks prior to the survey for further coordination. **Plans should be sent to Bram Couperus, IJmuiden, not later**

than 30 May 2009; he will then contact individual cruise leaders if amendments are required.

Additionally, vessels should be in daily radio contact during the cruise at **1730** hrs **UTC** 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 permit the coordinator to adapt other nations cruise tracks and to avoid gaps. Because of the long distances between the vessels while surveying, some participants have difficulties to listen to the radio communication. Thus e-mails with cruise track and trawl information should be exchange every second day. **Paul Fernandes and Bram Couperus have agreed to act as coordinators during the 2009 survey. They can be reached by e-mail or phone between June 25 and 1 July, and will initiate the radio communication from 1 July onwards**.

Acoustic surveys in the North Sea, West of Scotland and the Malin Shelf in 2009 will be carried out in the periods and areas given in Table 4.3.1.1 and Figure 4.3.1.1.

Table 4.3.1.1. Time periods, areas and rectangles to be covered in the 2009 acoustic surveys.

VESSEL	PERIOD	AREA	RECTANGLES
Celtic Explorer (IRE)	03 July – 22 July	52°30′-56°N ,12°-6°W	34D9-E0, 35D8-E0, 36D8-E0, 37D9-E1, 38D9-E1, 39E0-F3
Charter west Sco (SCO)	27 June – 16 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)	25 June – 19 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
Scotia (SCO)	28 June – 16 July	58°30′-62°N, 4°W-2°E	46E6-F1, 47E6-F1, 48E6-F1, 49E6-F1, 50E7-F1, 51E8-F1, 52E9-F1
Tridens (NED) PBVO	29 June – 24 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) DBFH	26 June – 15 July	52°-56°N, Eng to Den/Ger coasts	33F1-F4, 34F2-F4, 35F2-F4, 36F0-F7, 37F2-F8, 38F2-F7, 39F2-F7, 40F6-F7
Dana (DEN) OXBH	30 June –14 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
Corystes (NIR)	06 July–12 July	Clyde/North Channel	40E3-40E5, 39E3-E5, 38E4

Borders of survey areas between the west of Scotland charter vessel and RV "Scotia" can be moved if required. An overlap will also occur between RV "Celtic Explorer" and RV "Corystes" at least in Rectangle 39E3

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 2009 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.

The North Sea sprat stock should continue to be surveyed properly. This requires that the southern boundary of the survey area be kept at 52°N.

For the Malin Shelf, a subgroup should be established during PGIPS meetings to coordinate planning, effort allocation and logistics. As for the North Sea, a survey coordinator can be appointed by the participants in the Malin Shelf surveys to maintain contact between vessels at sea; communicate and coordinate planning of cruise tracks, transect interlacing areas, temporal progression and survey effort in the planning phase and communicate plans to PGIPS Chair.

A two day post cruise meeting can be established soon after the survey to compile and collate combined survey data and upload to FishFrame, evaluate survey data and discuss issues arising from the survey and conclude on recommendations to improve survey precision.

The results from the national acoustic surveys in June-July 2009 will be collated and the result of the entire survey will be combined at the next PGIPS. Individual or combined survey results for sprat and herring should be uploaded to FishFrame North-Sea module (FFN) no later than **20 December 2009**. This deadline should also permit the members of the group to prepare as much of their contributions to the final report as possible prior to the meeting and free up time for plenary discussions and data quality control. Participants should also be prepared to additionally deliver their remaining raw data to the stage 1 module. The upload procedures for FishFrame stage 1 (biological) data should be reviewed for software bugs and fixes by DTU-Aqua.

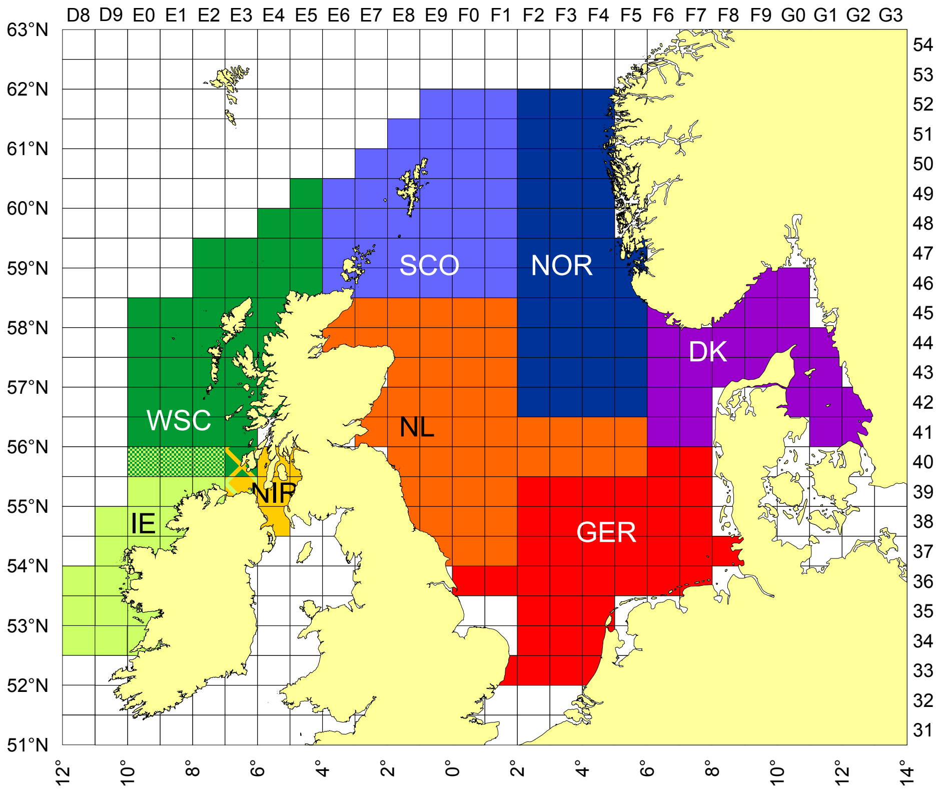

Figure 4.3.1.1. Survey area layouts for all participating vessel in the 2009 acoustic survey of the North Sea and adjacent areas. (NIR = Corystes; IE = Celtic Explorer; WSC = West of Scotland charter; SCO = Scotia; NOR = Johan Hjort; DK = Dana; NL = Tridens; GER = Solea).

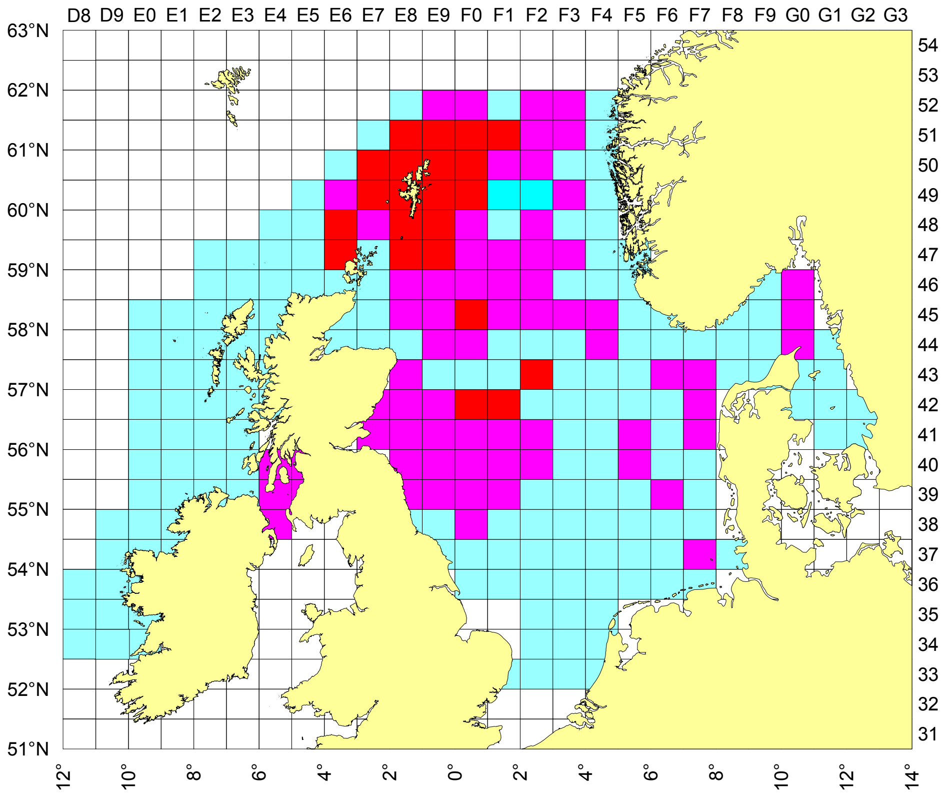

Figure 4.3.1.2. Survey effort in the 2009 acoustic survey of the North Sea and adjacent areas. (Red = 7.5 nautical miles spacing; Magenta 15 n. mi.; Cyan = 30 n. mi.).

4.4 Hydrographic data

Datasets on temperature and salinity obtained during summer acoustic surveys are available for the period 2000–2005 (OceanDataView format), but only Scotland, the Netherlands and Germany reported such datasets in 2006. No hydrographical data are accessible from the most recent survey periods. These missing datasets should be delivered as soon as possible to update the database (preferably as ASCII-format, could be sent for further processing to Eberhard.goetze@vti.bund.de).

It is recommended also for future surveys, that hydrographic data should be collected and stored into the FishFrame database as an additional table to allow fast and easy access for all users. It is of special advantage that the hydrographic data are synchronous with the acoustic measurements.

The main aim of the database is to permit studies searching for possible linkages between the hydrographic environment and the distribution of fish. An appropriate analysis is only practicable if a sufficient amount of data records is present.

5 Review and update of PGIPS manuals

PGIPS hasn't found the time to review the acoustic manual during the meeting. The group agreed in an update after the meeting by correspondence. Group members' responsibilities for specific chapters have been identified. PGIPS Chair will start a general review and distribute parts of the manual for revision to the specific editors in due course.

This year no modifications had to be included in the herring larvae surveys manual.

6 FishFrame

6.1 History and objectives

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 survey. 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 has been finished. In 2007 PGHERS began using FishFrame as the groups' standard calculation procedure.

6.2 FishFrame Outlook

Under the "Studies for carrying out the common fisheries policy: Open call for tenders No MARE/2008/10. Lot 1." a proposal has been 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 are the coordinator, 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. If funded, the project will start on 1 April and last for 18 months.

The project will establish a Regional Data Warehouse to hold all relevant data from the commercial fisheries and scientific surveys (both trawl surveys and acoustic surveys). All data are uploaded as raw (sampling data) or very low aggregated data (landing statistics, effort statistics, acoustic and VMS data). The data warehouse can be implemented in the Baltic region, North Sea and Skagerrak region, North east Atlantic region and the Mediterranean and Black Sea region. The warehouse is based on the further development of the existing Regional Data Warehouse called FishFrame Version 5.0 which is launched in 2008. Version 4.3 of FishFrame is already used in the Baltic region and in the North Sea region. The system main modules handles data upload, validation, quality assurance, version control, download, processing (raising and extrapolation) and presentation. The presentations include dynamic analytical outputs and a long list of standard outputs relevant to most groups working with fish stock management, assessment and regional planning and coordination of sampling schemes for fisheries data. Access to the data are managed by a tight role based system allowing differentiated access to data and functionalities. An international steering group representing most user groups and all regions will be established. This group will be responsible for further development beyond the end of the project. The warehouse is programmed in open source and is the property of the users.

In terms of the acoustic survey component the objectives of the project fall under Work package 2 as follows:

1) To transfer and update the functionality from FishFrame version 4.3 to version 5.0 (data upload, data delete, data validation and data status)
2) To complete the data processing procedures by development of the raising and extrapolation procedures which take data from the level of scrutinized NASCs and trawl catches to total stock estimates
3) To design and program relevant reports (general and expert group specific)

A meeting will be held early in the project in order to review the functionality in FishFrame version 4.3 in relation to acoustic survey data. The review will be done in the light of how similar modules have been implemented in version 5.0 for commercial fisheries data. A joint decision will be made on how to implement the basic features such as: Upload, validation, status, download, delete and basic presentation of data. Similarly a requirement specification that describes the new modules will be written in cooperation between the representatives from different regions and surveys. The new modules primarily handle the data processing for raising and extrapolating data from the level of scrutinized NASCs and trawl catches to national stock estimates. The processes will be accessed through a feature rich GUI wizard giving the user flexibility in stratification and choice of methodology. The choices will be logged, so that any estimation done in FishFrame is fully documented and replicable. The list of new features includes a range of outputs in the form of diagrams, maps and text-reports designed to match the needs from expert groups. Other outputs are dynamic pivot based tables, maps and diagrams that will be made available for online extrapolation and analysis. Each output will be designed according to the template available in FishFrame version 5.0. The template gives all information needed in order for the programmers to program the report and include it in the Report Library.

The deliverables associated with this work package are:

1) Document with a specification of requirements approved by representatives from a range of acoustic surveys.
2) Exchange format reviewed and approved by representatives from a range of acoustic surveys.
3) Modules developed, tested and documented for: upload, validation, status, download, delete and basic presentation of data from acoustic surveys.
4) Modules developed, tested and documented for; complete data processing of acoustic data in FishFrame from upload in exchange format to final stock estimates.
5) Outputs in the form of diagrams, maps and text-reports designed to match the need from expert groups.
6) Dynamic pivot based tables, maps and diagrams for online data mining analysis.

6.3 Requirements from national calculation to be implemented in further developments of FishFrame

PGIPS was asked under TOR (e) to consider the individual requirements of the participants of the various acoustic surveys in order to contribute to Deliverable 1 (see above, Chap. 6.2).

6.3.1 German procedure of acoustic estimates calculation

The principle steps for acoustic estimations of fish abundance in the German survey are as follows:

1) Physical measurement of NASC or sv in spatial elements
2) Segmentation of regions
3) Allocation of NASC regions (shoals) to target species or species groups
4) Definition of stratum
5) Estimation of conversion factors
6) Estimation of fish density and abundance

The acoustic measurements are comparable to all other participants in summer acoustic survey. Depending of the Vessel an EK500 or EK60 is used. An adaptation to other specific operating conditions is not problematic

All investigations are done during daytime and the species of interest (herring and sprat) are concentrated in good specifiable shoals and can be easily separated from other fish concentrations and plankton. But it exist no trusted procedure to discriminate herring shoals from sprat. Generally sprats forms smaller and diffuse shoals than herring, but in many cases sprat was found also in large herring-like “pillars” and it is most likely that both species occur in mixed schools. Therefore all adequate concentrations are treated as “clupeids” and the biological composition of species is taken from the fishing samples in the stratum. In cases where more trawls were made in one rectangle, these are weighted by the amount of catch for this specific rectangle.

Basically ICES statistical squares are used as strata but also combination of such rectangles can be applied.

The estimation of the conversion factor follows the rules for mixed layers (Chapter 6.2 in the manual). The basic principle is the definition of the scattering cross section of a “mean” fish and the estimation of the total amount of the fish mixture. The specific algorithm can easily be changed to any agreed data handling procedure.

6.3.2 Norwegian procedure of acoustic estimates calculation

The Norwegian national procedure is comparable with the German routines, but includes splitting for different herring stock. For estimation of abundance and biomass, total herring estimate are split per square into North Sea Autumn Spawners and Western Baltic Spring Spawners. The mean weights and mean lengths used are the same for the two stocks as they are not split on an individual bases. Estimates are reported by ICES square

6.3.3 Irish methodology estimating the acoustic abundance of herring

All survey data are partitioned and scrutinised using Echoview Version 4. Specific NASC data are export as PRC NASCs using an established Echoview template per EDSU (1 nm). These data are screened, by plotting to assure that all NASC data are geographically correct and ‘on track’.

Stratification is determined by full ICES statistical rectangle and haul allocations are based on ‘nearest neighbour’ or by combining hauls of similar length distribution in the localized area after visual inspection. Hauls in the same rectangle are equally weighted.

The abundance and biomass estimate for herring is generated using an R-script following the principles required for age stratified abundance as outlined in the PGIPS manual for acoustic surveys.

The R-Script outputs biomass at age, abundance-at-age, abundance at maturity and biomass at maturity by defined strata (ICES statistical rectangle) based on the acoustic and the biological data collected during the survey

6.3.4 Scottish MILAP work flow

Assume PRC NASCs in raw data per EDSU and located at centre point of EDSU.

Check EDSU's for positional errors and ensure that any periods of non surveying have been removed from dataset.

1) Perform K-S test on length frequency data from all hauls with significant numbers of herring (e.g. n > 30); set appropriate threshold of KS statistic to identify groups of trawl haul length frequency distributions that are similar enough to be combined in the group.

2) Relate KS groupings to haul locations on survey area map to ensure that groupings are spatially consistent. Adjust group membership to meet spatial constraints.

3) Determine areas surveyed which correspond to KS groupings. Define geographical limits of areas and name them

4) Allocate hauls to named areas with aid of KS test results

5) Hauls can be weighted by the total catch or can be equally weighted.

The following can be species-specific.

6) Specify length measurement method i.e. cm below etc

7) Input length weight relationship on basis of either :

- value for whole survey area
- individual hauls
- alternative allocation method

8) Input TS to length (& depth in future) relationship per species

9) Calculate Mean length, mean weight and TS per individual and kg

- per haul (Report)
- per area (Report)
- for survey (Report)

10) Calculate length frequency per haul as fraction (Report)

11) Calculate age and maturity by fraction.

- per haul (Report)
- per area (Report)
- for survey (Report)

12) Specify rectangle size for analysis and output.

13) Calculate abundance per rectangle

14) Calculate biomass per rectangle

15) Report abundance and biomass per area and for survey

16) Report age/maturity structure per area and for survey

6.3.5 Danish methodology estimating the acoustic abundance of herring

6.3.5.1 Danish requirements to FishFrame

Most of the abundances in the Danish survey area, Skagerrak and Kattegat, are in mixed layers without specific concentrations that can be applied directly to herring/sprat or Clupeid. Therefore the new estimation system must be prepared for handling situations where NASC are appointed to fish and where the energy has to be split because of the mean TS in the area based on the total catch composition in the trawl hauls. The number of "mean fish" hereafter has to be raised to species and length groups by the catch composition in the trawl hauls appointed for the specific strata.

FishFrame shall have the possibility to work on ICES rectangles and/or combinations of ICES rectangles (strata). It shall be possible to allocate the trawl hauls to each stratum free by the user and not only automatically the nearest hauls. Furthermore it shall be possible to get the results either by single ICES rectangles or by combinations of ICES rectangles as strata. Finally the calculation unit in FishFrame shall be able to deal with split between stocks based on single fish information. This means that number of herrings per length group shall first be split between stocks before stock specific keys are used for length-age and age mean-weight.

6.3.5.2 Danish calculation routines for fish samples and acoustic estimates

Based on the valid number of trawl hauls in a stratum a mean haul per stratum is calculated as a weighted mean over all hauls in the specific stratum (normalized to 60 minutes haul duration). Based on species and length combinations mean TS per stratum are calculated.

From each haul in a given stratum 10 herring per half cm length groups are taken for single fish analysis of maturity, weight, age and race. Based on all single fish analysis per haul and strata keys are estimated for:

- Length / race
- Length / age per race
- Length / weight per race
- Age / maturity per race

The work flow for the acoustic estimates is as follows:

1) EK 60: Raw data per NM, down to 300–500 m, Threshold -70 db
2) EchoView: Missing bottoms are fixed by introducing a new bottom line
3) Special software: Transformation of raw data to Sv/ NM in 1 m layer in intervals of 3dB. Stop by 500 m or 1 m above the bottom.
4) Special software: Combination of 1 m layer to sv/NM/standard Layer. Standard layers: 3–6, 6–10, 10–20, 20–30, 30–50, 50–100 and 100–150m. Treshold for Sv standard -53 dB
5) EchoAnn: Sv are judged per NM for each layer
6) EchoAnn: Calculation of Sa per NM2 per Log
7) Special software: mean Sa per stratum
8) Special software: By use of mean TS per stratum are number of "mean" fish calculated by stratum
9) Special software: By species and length distribution in "mean haul per stratum are number per length for each species in the stratum calculated

10) Excel: By the length/race, length/age, length/weight and age/maturity keys are total number and weight per age group and maturity for each strata.

6.3.6 Netherlands steps for acoustic abundance estimation of herring

1) Survey settings are accessible in an easy format outside the analysis code so the operator of the analysis cannot alter the code itself.

2) BI data and/or echoview datafiles are imported and can be merged when needed.

3) Data preparation

Acoustics

- Probability factor extracted from species name
- Aggregation level of the analysis is set to layer and/or interval
- Zero values included for target species for sampled areas with no fish

Trawl samples

- Minimum fish length to take into account for full analysis (mesh size dependent): 6cm
- Minimum amount of fish in a sample to be called representative for the school: 20. This means that hauls containing less than 20 specimens are not used for mean length (sigma) calculations.
- Maximum depth: 200m
- If maturity is missing how should it be determined: length-based, aged-based or assumptive? → IMARES uses assumption:
  - Herring: If length <12 then the fish is immature
  - Sprat: If length <8 then the fish is immature
  - If # rings ≥ 2 then the fish is mature
- If age is missing how should it be determined: length-based or assumptive? → IMARES uses assumption:
  - Herring: If length <12 then # rings = 0
  - Sprat: If length <8 then # rings = 0

4) Data check

Overview of activities per day? How many miles, trawl hauls and CTD stations? Very informative.

Acoustics

- Have all rectangles been assigned to a stratum?
- Finding outliers: NASC freq. distributions made by day and sorted list of NASC values
- Any GPS outliers or errors? We look for double counting of positions by 'hanging or stalling of the GPS, look for odd positions by displaying on a map.
- Any outliers or gaps in interval numbering caused by EK60? Double interval numbers could cause data loss.
- Which percentage of acoustic values do we lose by bad positioning?

Trawl samples

- Minimum, maximum values for length, length increment (!)

- Tables various combinations of different biological results. For example, how are females and males distributed over the catches? Age distribution? Etc.
- Do we have weight, age and maturity for all length classes? Where do we have gaps?
- Which percentage of fish samples cannot be used because biological parameters are partially lacking?

5) Strata will be assigned manually using

- cumulative LF distributions which are presented all together to reveal groupings;
- Mean length per haul which are plotted on a map also to reveal groupings;

Data check

- Do we find the same species in the trawl hauls and in the acoustic files for each stratum and ices rectangle?

6) Split nasc values of assigned groups into species (e.g. 'clupeids' are split into 'herring' and 'sprat' according to the TS distribution in the catch. Example:

7) NASC's converted into numbers based on existing TS relation. As mentioned earlier IMARES uses the modelled length frequency distribution. Mean sigma is not only calculated for each stratum but also for the whole area in case trawl information is missing in a certain stratum.

If we compare old and new systems we should be able to compare the results on a specific aggregation level such as ICES rectangle. We could compare NASC, sigma, millions and tonnage per rectangle.

Other assumptions which are used by IMARES:

- Each fish has a measured weight but is also given an estimated weight based on LW-relationship found in the survey. Method currently used at IMARES: LW-relationship. This to smooth length groups with small numbers.

TS relation is applied in accordance to the acoustic manual.

6.4 Requirements from the recent experience with FishFrame

Besides the fact that FishFrame performed successfully during the 2009 meeting, there are some remarks and suggestions left which occurred during this year's FishFrame exercise. Required and helpful tools for the next FishFrame version would be:

- Implement estimates of precision and cost efficiency.
- Needs to determine unsampled rectangles.
- Implement an easy to access status report for released data.
- For rectangles outside a boundary zone of probably 200m depth contour, no interpolation should take place.
- Permit a tool to save and restore settings for global estimate calculations.
- Develop a tool to detect zero abundance rectangles and to separate these from those which are unsampled.

7 Modelling depth-dependent target strength of herring

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 will 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 permits 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. Distributions of unknown model parameters (tilt angle distribution, swimbladder volume at the sea surface, and precision of the mean TS estimate) were estimated in a Bayesian framework by fitting backscatter models to mean TS data of herring at depth. Posterior distributions of model parameters were then used with the error propagation properties of the Bayesian framework to simulate backscattering by herring, while quantifying the precision of the TS estimate. Using these methods together with mean TS data for North Sea herring at depth (Edwards *et al*., 1984) and the Kirchhoff Ray Mode backscatter model (Clay and Horne, 1994), abundance and biomass of North Sea herring were calculated for the area covered by Scotland in 2007. The resulting total abundance was 23% higher than the one estimated using the conventional depth-independent TS-L relationship (ICES, 2008). Correspondingly, total biomass calculated using the Bayesian model was higher by 57% than the official estimate (ICES, 2008). 95% confidence intervals were also available from these models.

In order to use a depth-based TS model to analyse acoustic data it must be emphasized to collect Nautical Area Scattering Coefficients (NASCs) stratified by depth. Participating countries should therefore 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). Since all participating nations have now the required processing power and software readily available it would just be a matter of storing depth and species based Proportion Region to Cell (PRC) NASCs. A specific request should be made to the FishFrame consortium to allow for storage of these data in stage I datasets. There is still some work to be done in relation to determining final components of the Bayesian model. Specifically, there is a need to identify a particular back-scattering model and to collect relevant in situ TS data of North Sea herring. 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.

In order to work out a preliminary estimate, it was suggested that all nations should forward their respective acoustic and biological data for 2008 to Sascha Fässler (FRS, Aberdeen). Participants should forward the edsu-based PRC-NASC for North Sea herring (or clupeids/fish, where appropriate) broken down in 5m depth-intervals and all their biological data (length–frequency and age-length keys).

A potential switch over to the new method applying the depth-dependent Bayesian TS model into the North Sea herring assessment would require a parallel data collection for over one generation of fish ages (approx. 5 years). At the same time other sources of error (e.g. acoustic extinction, dead zone, or multiple scatter) could also be considered.

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Annex 1: List of participants

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Annex 2: Agenda

Agenda for ICES PGIPS, Aberdeen, 20–23 January 2009

Tuesday 22.01.08, 09:00

- Start of meeting
- Status on data availability
- Review of individual larvae surveys 2008
- Coordination of larvae surveys 2009 (ToR b)
- Workshop on the identification of clupeid larvae (WKIDCL)

14:00

- Work allocation to review and update PGIPS 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 2008 and echogram interpretation exercise (ToR c)

Wednesday 23.01.08, 09:00

- More individual acoustic surveys and echograms
- Status and future of FishFrame
- Report of SGHERWAY

14:00

- Joint estimate of the NS acoustic survey for herring and sprat (ToR a)
- Coordination of the acoustic survey in 2009 (ToR b)

Thursday 24.01.0, 09:00

- Presentation by Sascha Fässler on "Depth based modelling target strength"
- Presentation by Karl-Johan on "Splitting Procedures"
- Individual systems for the estimation of fish abundance and the potential of a common tool (ToR e)

14:00

- Collation of material for the final report
- Recommendations

Friday, 25.01.08, 09:00

- Review of combined report
- Review of final report
- Election of next Chair

13:00

- End of meeting

Annex 3: PGIPS terms of reference for the next meeting

The Planning Group of International Pelagic Surveys unanimously recommends that Karl-Johan Stæhr, Danmark, should be invited to Chair PGIPS from 1 January 2010.

The Planning Group for International Pelagic Surveys [PGIPS] (proposed Chair: Karl-Johan Stæhr*, Danmark) will meet at the Marine Institute, Galway, 19–22 January 2010 to:

a) combine the 2009 survey data to provide indices of abundance for the population of herring and sprat within the area, using the FishFrame-Acoustics database;

b) coordinate the timing, area and effort allocation and methodologies for acoustic and larvae surveys for herring and sprat in the North Sea, the Malin Shelf and the Western Baltic in 2010;

c) examine the interpretation of echograms between the participants of the 2009 acoustic surveys to ensure quality control and proper exchange of experience;

d) review the progress of FishFrame development in stage 1 and 2;

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.

PGIPS will report by XXX March 2010 for the attention of the SCICOM as well as to HAWG.

Supporting Information

Priority	The International Acoustic and Larvae surveys provide essential data for the assessment of pelagic stocks in and around the North Sea (Divisions IV, VIa, IIIa, and Western Baltic).

Scientific Justification and relation to Action Plan:	The work of this Expert Group referes to items 1.2.1, 1.2.2, 1.13 (Strategy plan ICES) 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 although 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 instituts. Exchange of experience is one of the vital interest of the PG to permit all involved participants a comparable background information and to reduces the risk of loss in informaton because of changing personnel. Term of reference d) FishFrame is the standard software for index calculation and data archiving used by PGIPS. Stage I and II should become fully available with version 5.0, thus a meeting is required to familiarise all participants with further developments and new tools offered by the next version. 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 affects 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 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 6 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). HAWG to see this report
Linkages to other Organizations:	None
Cost Share:	ICES 100%

Annex 4: Recommendations

Note that the recommendations below are sorted so that recommendation 1 to 6 is addressed to parties outside the PGIPS and recommendation 7 to 11 is addressed to the expert group members. Bold text refers to specific action required by PGIPS members.

RECOMMENDATION	FOR FOLLOW UP BY:
1. PGIPS recommends that consideration be given to incorporating depth into new target strength models for North Sea herring. An immediate aspect is the importance of inclusion of depth stratified acoustic data in FishFrame stage 1.	Expert Group members and WGFAST
2. PGIPS recommends that for the time being the Malin shelf combined synoptic surveys be continued. If appropriate, a post-cruise meeting to resolve initial problems could be organized by participating members in the Malin Shelf surveys.	SCICOM
3. PGIPS recommends that the EU commision provide funding to facilitate a transfer of the SIMFAMI database to an open access format	EU commision
4. PGIPS recommends that participants should follow the development of the calibration study group set up by WGFAST.	Expert Group members, PGNAPES, WGACEGG
5. PGIPS recommends that in the 2009 North Sea acoustic surveys, all participants take a student from Aberdeen University to make measurements of the accuracy of maturity staging in herring.	Expert group members and Aberdeen university
6. PGIPS recommends that all participants should upload stage 1 data. The input and upload procedures as well as the manual for stage 1 should be reviewed by DTU-Aqua. Participants should be aware that for the inclusion of stage 2 the upload of stage 1 data are essential.	Expert group members and DTU-Aqua
7. PGIPS 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
8. For the 2010 meeting, PGIPS recommends that all **participants should bring echograms** for interpretation transparancy.	Expert group members
9. **All participants in the 2009 North Sea herring acoustic survey should upload their survey estimates to the Fishframe database by 20 December 2009 for stage 3.**	Expert group members
10. PGIPS 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
11. To determine possible shifts in spawning PGIPS recommends that all areas in the herring larvae surveys should be covered.	Expert group members

Annex 5: 2008 Individual Acoustic Survey Reports

ANNEX 5A: West of Scotland

Survey report for MFV *Chris Andra*

27 June – 16 July 2008

Eric Armstrong, FRS Marine Laboratory, Aberdeen

1. INTRODUCTION

An acoustic survey for herring was carried out by the Marine Laboratory on the west coast of Scotland (ICES Div VIa(N)) from the 27 June to 16 July 2008. The survey was conducted on the chartered fishing vessel MFV *Chris Andra*. 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 2009.

This survey has been carried out every year, at this time, by the Marine Laboratory since 1992. With the exception of 1997 the survey has always been conducted using chartered commercial fishing vessels.

2. SURVEY DESCRIPTION and METHODS

2.1 Personnel

Eric Armstrong	Cruise Leader
Craig Davis	
Michael Stewart	
Melanie Harding	
Morag Campbell	

2.2 Narrative

Loading of the vessel and installation of a wet lab container and equipment was carried out on the 26 June. The vessel left Fraserburgh at 0830 on the 27 June and proceeded to Loch Eriboll for a calibration. Survey work began at Cape Wrath at 0800hrs on the morning of the 28 June. The survey continued in generally good weather until 6 July when the vessel steamed to Loch Broom where a second calibration was carried out on the morning of the 7th prior to landing in Ullapool for a crew change. The survey continued from the 8th covering the full survey area up to 60^{o}N 4^{o}W, finishing at 2130 on the 14. On the 15th a set of transects were conducted east of 4° for comparison with Scotia. This was successfully completed by 1200 on the 15th. The vessel then steamed to Fraserburgh for off loading of personnel and equipment on the morning of the 16th. No time was lost because of weather or mechanical breakdown.

2.3 Survey design

The survey design (Figure 5A.1) was selected to cover the area in two levels of sampling intensity based on herring densities found in previous years. 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. 250m depth and the Scottish coast or the 4° W line in the east. A single track was executed between 55° 30' N and 56°N for comparison with the survey conducted in Irish waters. Two transects were executed east of 4°West for comparison with the survey conducted by FRV "Scotia"

2.4 Calibration

Two good calibrations were carried out, at the beginning (28 June) in Loch Erribol and in the middle (7 July) in Loch Broom. All calibrations were carried out in ideal conditions, and the constants for the 38 kHz integrating frequency agreed with each other (Table 5A.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 5A.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 nautical mile at 10 knots). The survey was generally restricted to hours of daylight between 0300h and 2300h UTC. A total of 2384 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

24 trawl hauls (Figure 5A.1 and Tables 5A.2 – 5A.3) 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 461 fish were measured at 0.5 cm intervals from each haul. Otoliths were collected with 1 per 0.5 cm class below 23 cm, 3 per 0.5 cm class from 23 to 27 cm and 10 per 0.5 cm class for 27.5 cm and above. Fish weights were collected at sea for all fish aged. An eight stage maturity scale was used. Immature fish were defined as stages 1 and 2.

2.7 Data analysis

EDSUs were defined by 15 minute intervals which represented 2.5 nautical mile 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 15'.

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 three strata based on length distributions and geographic criteria. The three regions (Figure 5A.4) were:

I. Greater part of Survey

II. Haul 3

III. Haul 22

Trawling in the Inner Minch area was again very difficult, except in the most northerly and southerly parts, because of seabed conditions likely to cause net damage. The length frequencies are presented in Table 5A.4. The overall age length key is presented in Table 5A.5.

3. RESULTS

3.1 Acoustic data

The geographical distribution of the NASC values assigned to herring are presented in Figure 5A.2. Large quantities of herring were detected to the south and north of the area in the middle of the shelf. The main areas of concentration were north of 59° along the shelf and around 58° 00'N and two large schools recorded south and west of Barra Head.

3.2 Biological data

A total of 24 trawl hauls were carried out. Table 5A.2 gives the positions and characteristics of these trawl hauls and Table 5A.3 gives their species composition. 15 hauls contained sufficient herring to define the 3 survey subareas (Figure 5A.4). Herring were present in 15 hauls and there was a good coverage of herring trawl hauls across the area with the exception of the Minch. With the exception of the two large schools in the Inner Minch, all major concentrations were adequately characterized from these trawls. One haul was dominated by boar fish (haul 7), two with mainly mackerel (hauls 1 and 5), and four hauls which caught nothing (hauls 2, 9, 17 and 18).

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

$$W = 0.004893.L^{3.182} \qquad \text{L measured in cm}$$

Samples of fish were aged in the laboratory by counting winter rings. These were then used to compile an age length key (Table 5A.5) to determine the proportion at age for each length class.

3.3 Biomass estimates

The results for ICES Subdivision VIa(N) were:

Definitely herring	222,295 tonnes	28%
Probably herring	569,193 tonnes	72%
Total herring biomass	**791,488 tonnes**	
Total herring numbers	3,824 million	
Spawning stock biomass	788,200 tonnes	99.58%
Immature	3,288 tonnes	0.42%

A breakdown of the estimates by age class is given in Table 5A.6. The survey included all of ICES Subdivision VIa(N).

4. DISCUSSION

The stock estimate for VIa(N) has increased by approximately 160% from 2007 (from 299,025 tonnes to 791,488 tonnes), almost returning to the levels seen in 2003 (889,200 tonnes). In 2007 very few fish below 20cm or above 31cm were seen giving a weight/Length relationship that had a shallower gradient than in previous years, The catches this year gave a wider spread (15 to 35 cm) resulting in a more representative.

Almost half of the estimate(45%) was due to two large marks seen west of Barra Head aggregating around seabed features, making it impossible to fish without risking damage to the fishing gear (Figure 5A.6).

The abundance by year class is consistent with previous years and also with results from the adjacent North Sea area. There were a significant number of 3 and 7 ring fish seen on the survey (24% by number and 22% by weight for 3 ring, 19% by number and 20% by weight for 7 ring).

The distributions were broadly similar to previous years, with the bulk of the fish, south and west of Barra Head and all along the shelf edge north of St Kilda. Two large marks were seen west of Barra Head this year, accounting for almost half (45%) of the total biomass.

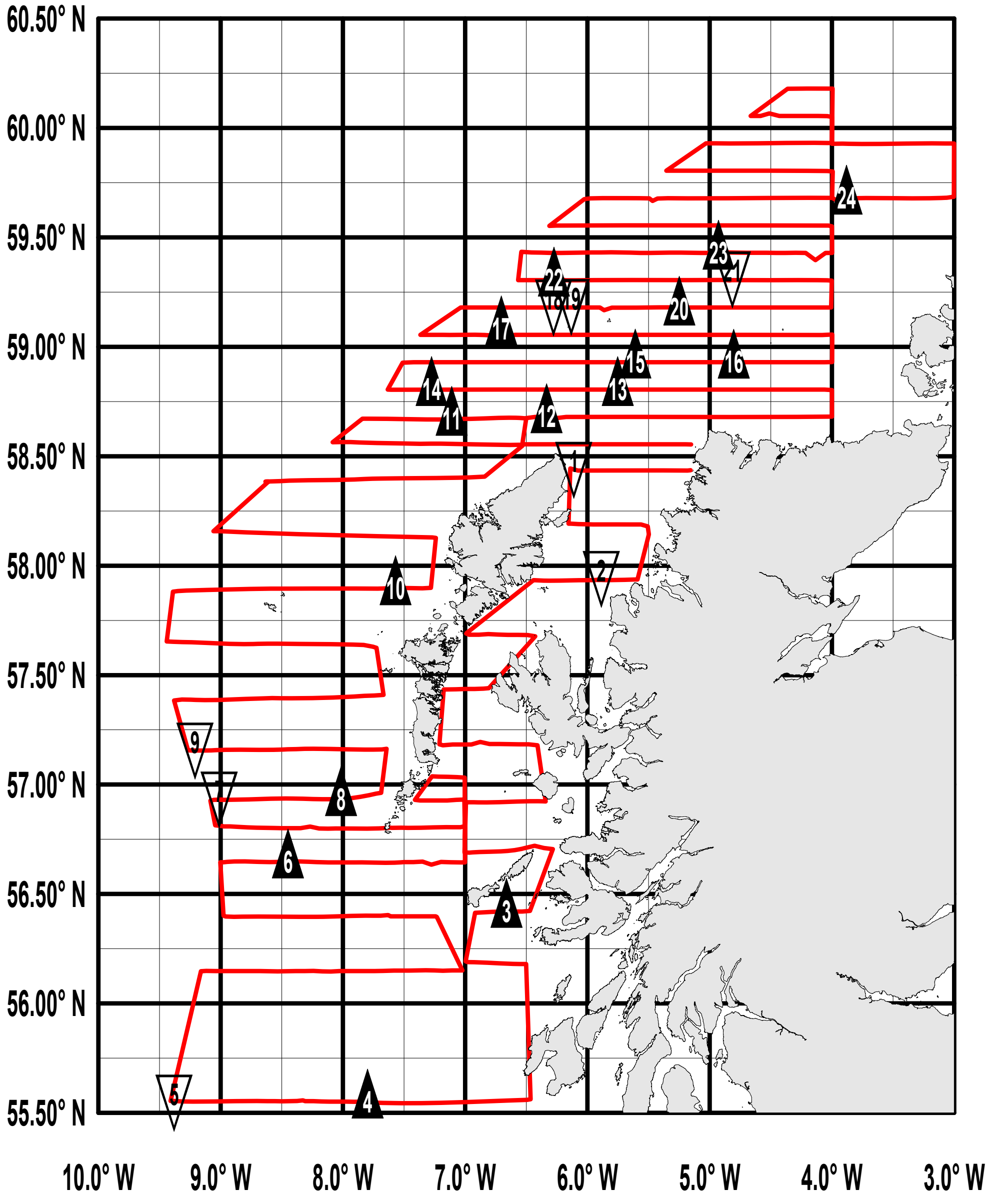


Figure 5A.1. Map of the west of Scotland showing cruise track and positions of fishing trawls during the July 2008 west coast acoustic survey on MFV *Chris Andra*. Filled triangles indicate trawls in which significant numbers of herring were caught, whilst open triangles indicate trawls with few or no herring. Haul 2 was shot on a large midwater mark, which caught no fish, but lots of larval herring were caught in the meshes of the net.

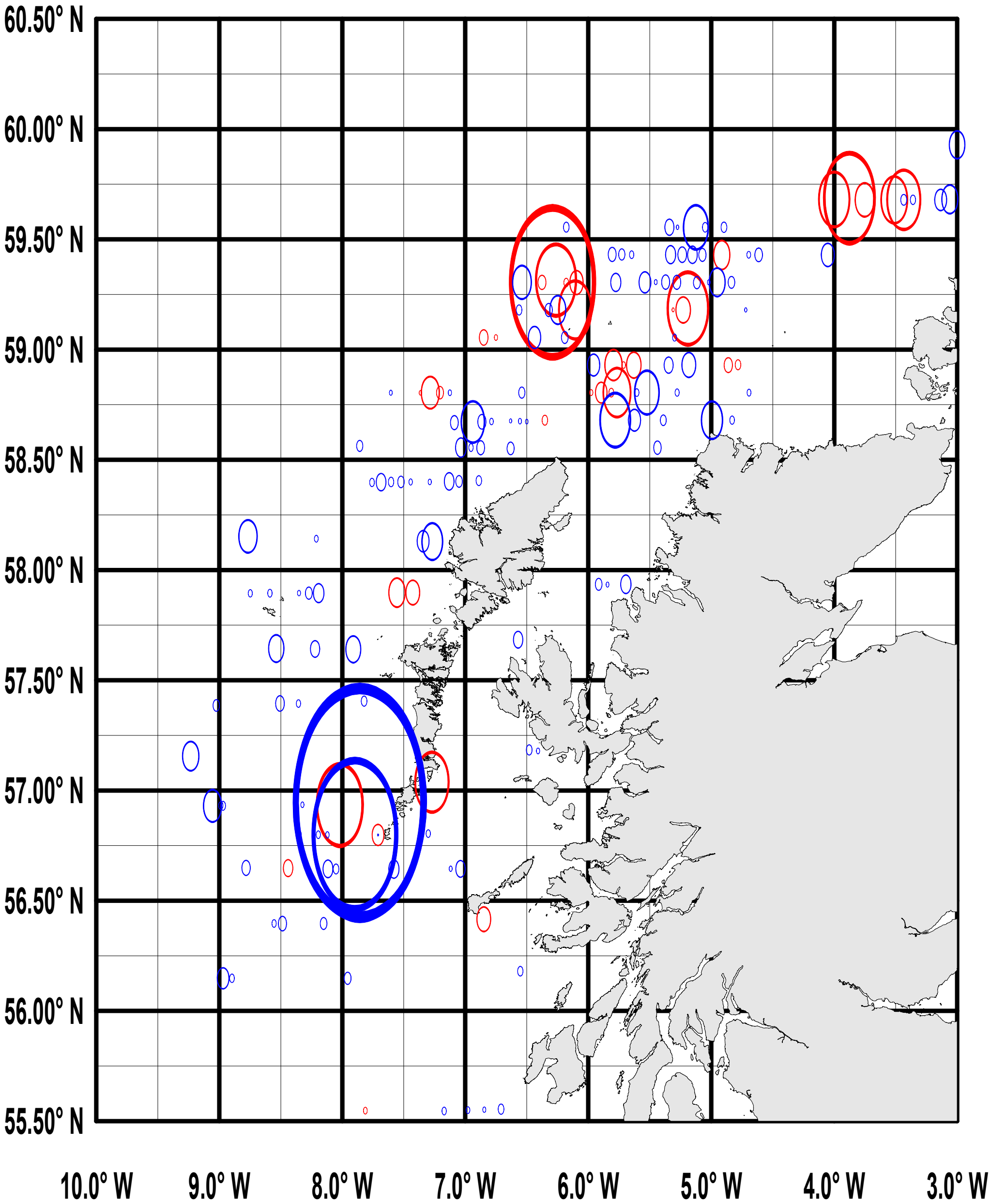


Figure 5A.2. Map of the west of Scotland with a post plot showing the distribution of herring NASC values (on a proportional square root scale relative to a value of 7500) obtained during the July 2008 west coast acoustic survey on MFV *Chris Andra*.

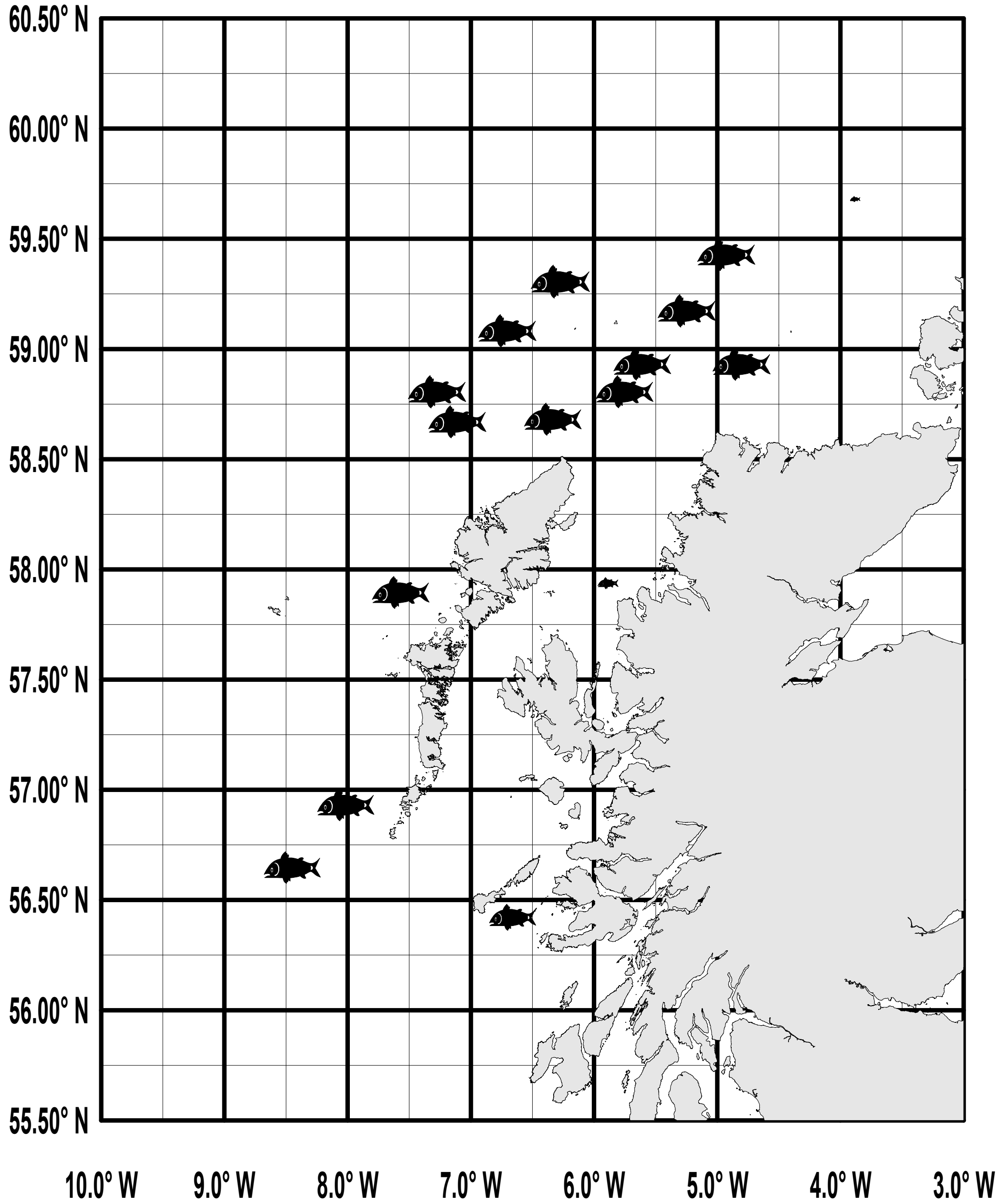


Figure 5A.3. Map of the west of Scotland with a post plot showing the mean length of herring caught in the trawl hauls carried out during the July 2008 west coast acoustic survey on MFV *Chris Andra.*

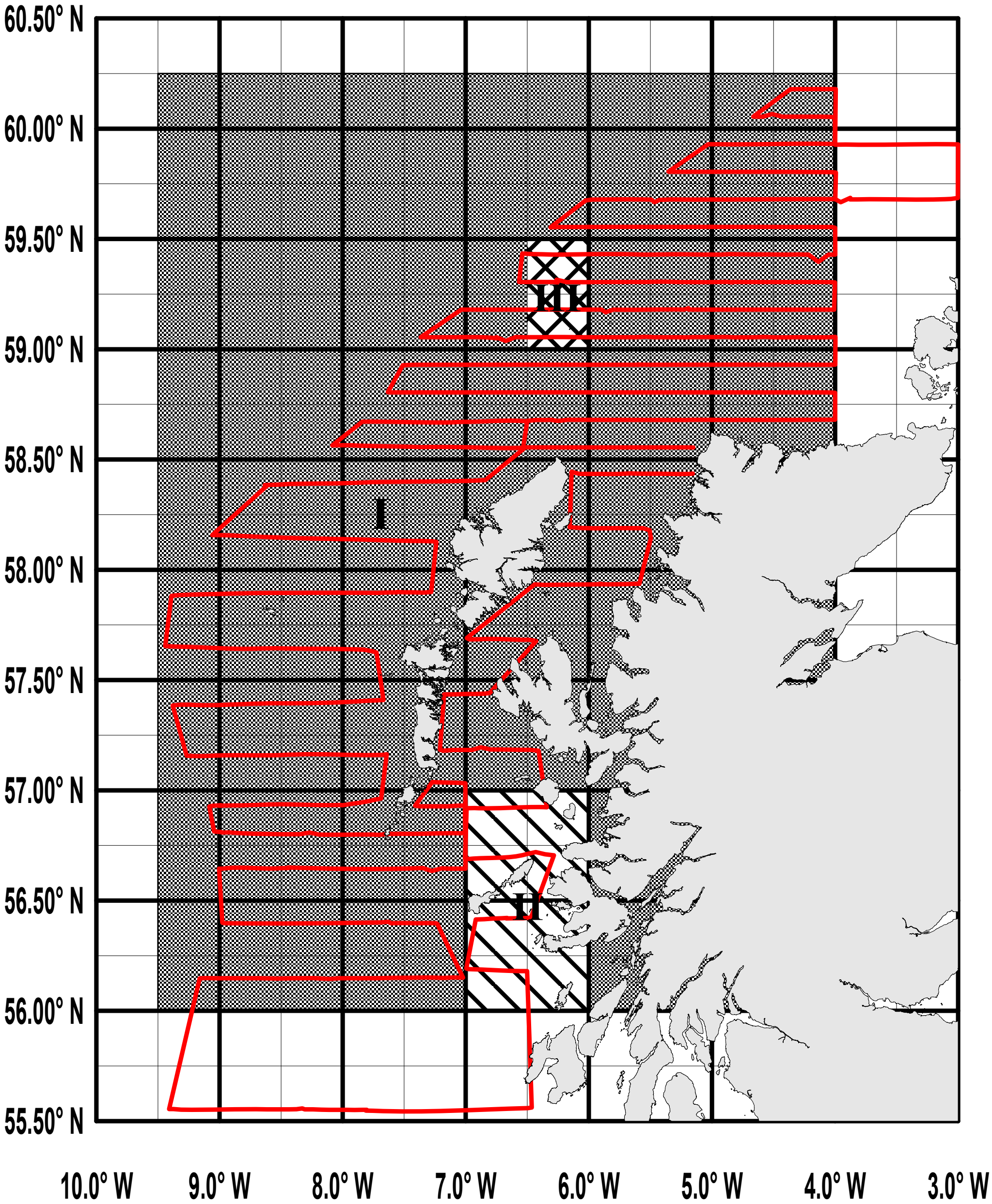


Figure 5A.4. Map of the west of Scotland showing the area strata (indicated by shaded areas with roman numerals I-III used for combining data from the trawl hauls.

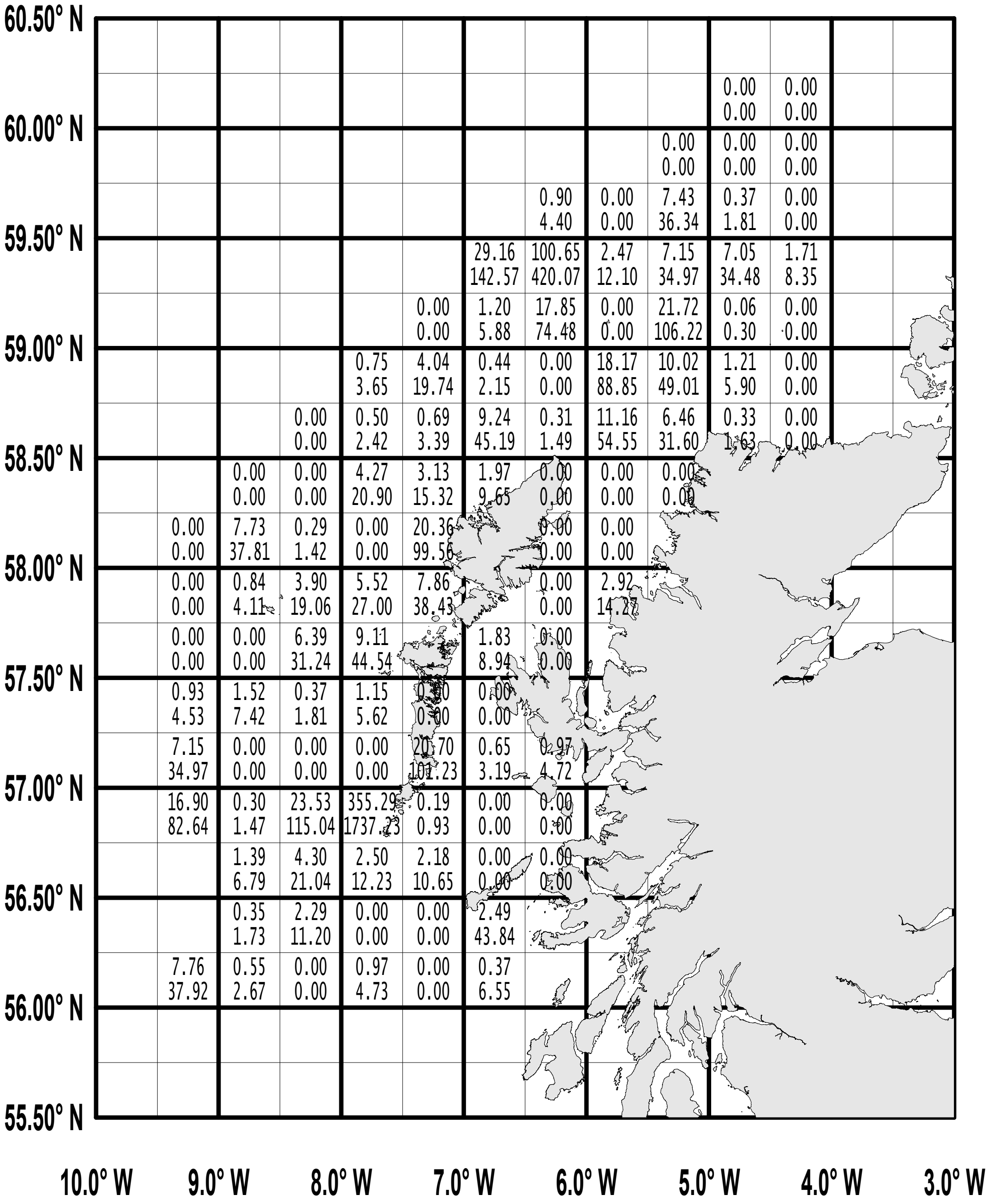
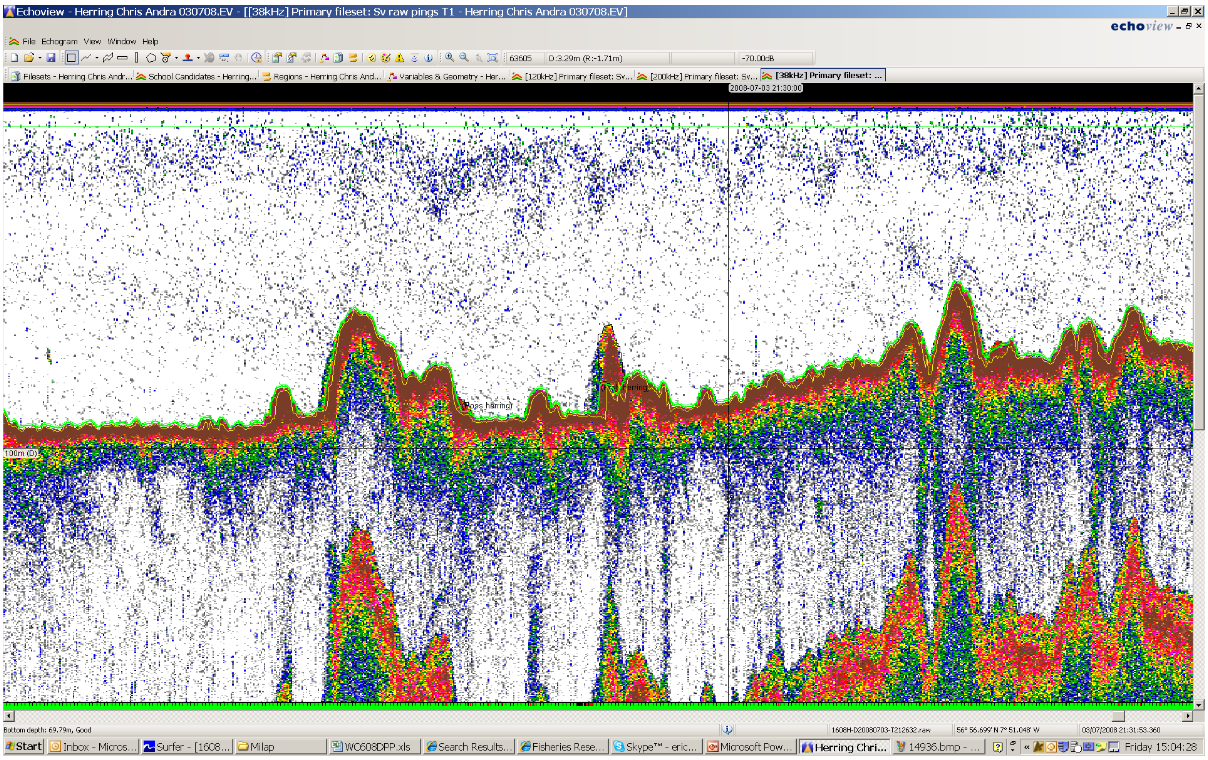


Figure 5A.5. Map of the west of Scotland with a plot showing the herring numbers in millions (bottom) and biomass in thousands of tonnes (top) by quarter ICES rectangle obtained during the July 2008 west coast acoustic survey on MFV *Chris Andra*.



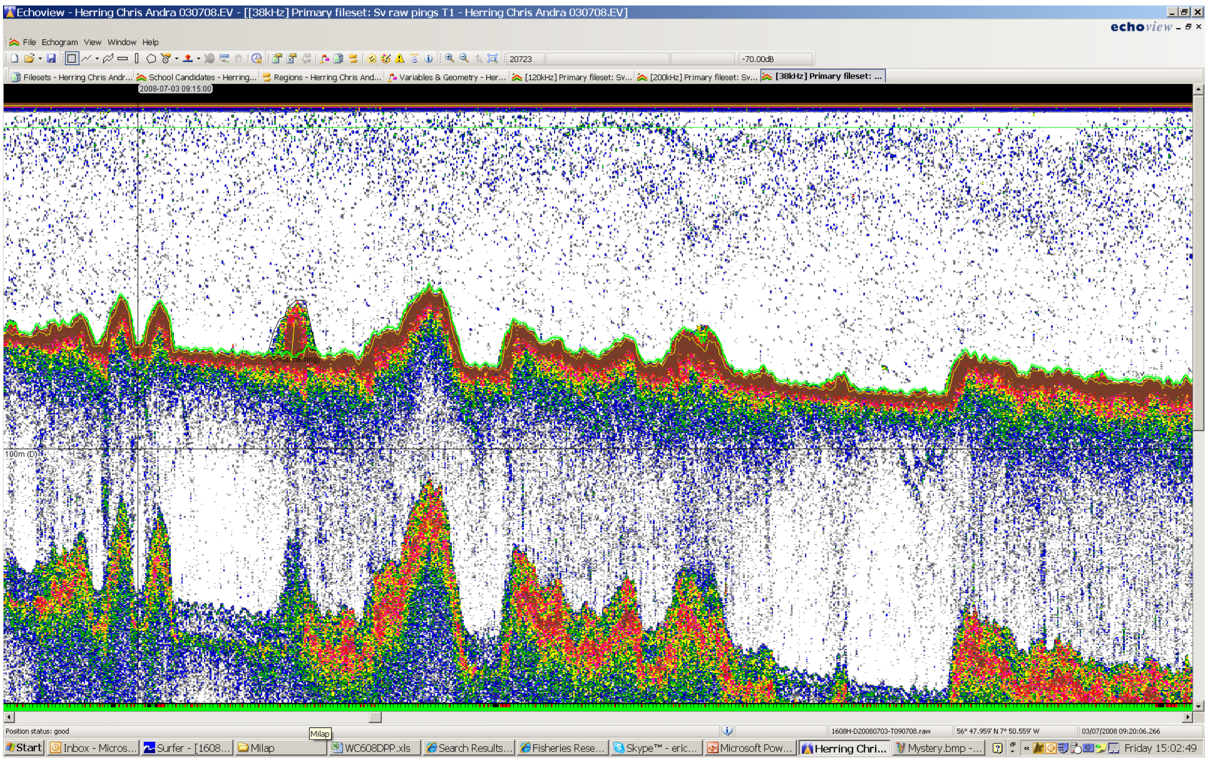


Figure 5A.6. Echograms of two schools assigned to "probably herring" seen west of Barra Head at around a depth of 75m. The top school realized a NASC value of 35539, the bottom school 14936. As can be seen from the echograms the schools are aggregated tightly to areas of rough seabed, making it unfeasible to attempt a trawl.

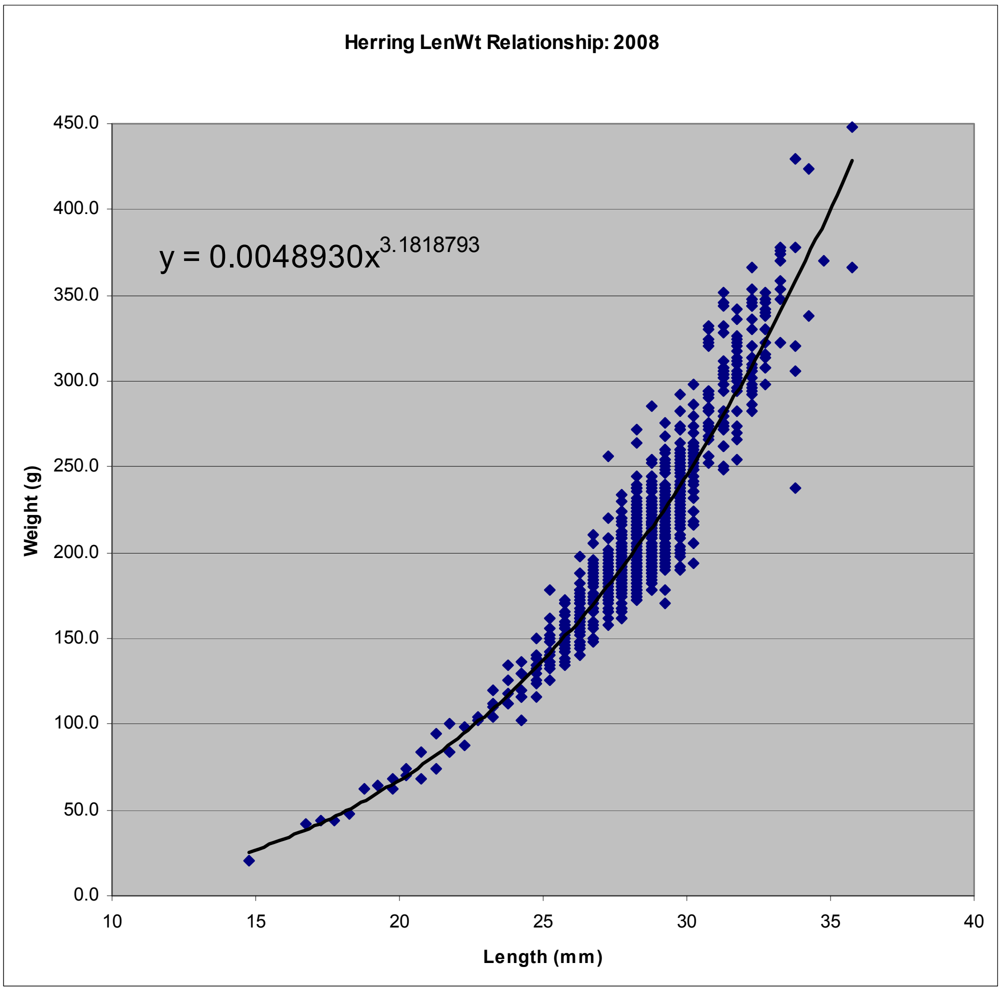


Figure5A.7. Length Weight relationships for 2008.

Table 5A.1. Simrad EK60 and analysis settings used on the July 2008 west coast of Scotland herring acoustic survey on MFV *Chris Andra*. Calibrations a) Loch Erribol 28 June; and b) Loch Broom 7 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	Not available, see above.
Max. Power	2000 W
Equivalent two-way beam angle	-20.6 dB
Default Transducer Sv gain	22.47 dB
3 dB Beamwidth	7.1°
CALIBRATION DETAILS	
TS of sphere	-42.4 dB
Range to sphere in calibration	9.34m, 9.75m.
Measured NASC value for calibration	3480a, 3175b.
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 5A.2. Details of the fishing trawls taken during the West Coast acoustic survey, July 2008; 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	Water Depth	Trawl Depth	Gear Type	Duration	Use	Baskets
1	28/6	58° 26.16 ' N	6° 06.68 ' W	11 : 18	50	42	PT160	37		30
2	28/6	57° 56.26 ' N	5° 53.19 ' W	18 : 47	50	42	PT160	27		0
3	30/6	56° 25.30 ' N	6° 39.69 ' W	03 : 46	95	87	PT160	44		2
4	30/6	55° 33.04 ' N	7° 47.87 ' W	18 : 58	70	62	PT160	36		10
5	1/7	55° 32.67 ' N	9° 22.88 ' W	06 : 58	202	194	PT160	37	H	1.5
6	2/7	56° 38.85 ' N	8° 26.96 ' W	11 : 11	125	117	PT160	31		24
7	3/7	56° 55.75 ' N	9° 00.72 ' W	15 : 00	135	127	PT160	60	H	30
8	3/7	56° 55.92 ' N	8° 00.92 ' W	19 : 58	128	120	PT160	27		12
9	4/7	57° 09.19 ' N	9° 12.56 ' W	07 : 58	170	162	PT160	36	H	0
10	5/7	57° 53.73 ' N	7° 34.15 ' W	11 : 16	95	87	PT160	30	H	0
11	6/7	58° 40.18 ' N	7° 06.59 ' W	18 : 03	95	87	PT160	32	H	20
12	9/7	58° 40.89 ' N	6° 20.05 ' W	02 : 58	115	107	PT160	46	H	3.5
13	9/7	58° 48.36 ' N	5° 45.12 ' W	18 : 15	91	83	PT160	45	H	4
14	10/7	58° 48.36 ' N	7° 16.46 ' W	04 : 47	107	99	PT160	35	H	60
15	10/7	58° 55.92 ' N	5° 36.50 ' W	14 : 04	99	91	PT160	31	H	35
16	10/7	58° 55.86 ' N	4° 48.18 ' W	17 : 59	60	52	PT160	35	H	0
17	11/7	59° 04.96 ' N	6° 42.26 ' W	10 : 48	144	136	PT160	27		18
18	11/7	59° 10.67 ' N	6° 16.61 ' W	18 : 17	110	102	PT160	34		0
19	11/7	59° 10.82 ' N	6° 07.91 ' W	20 : 16	115	107	PT160	31	H	0
20	12/7	59° 10.40 ' N	5° 14.87 ' W	04 : 47	96	88	PT160	22		6
21	12/7	59° 18.35 ' N	4° 48.85 ' W	13 : 30	106	98	PT160	25		11.75
22	12/7	59° 18.36 ' N	6° 16.41 ' W	19 : 19	163	155	PT160	17	H	15
23	13/7	59° 25.72 ' N	4° 55.63 ' W	07 : 20	133	125	PT160	10	H	45
24	15/7	59° 40.82 ' N	3° 52.81 ' W	10 : 22	118	110	PT160	27		44

Table 5A.3. Catch composition by trawl haul on the west coast herring acoustic survey. MFV *Chris Andra* (27 June – 16 July 2008).

SPECIES	HAUL NO	1	2	3	4	5	6	7	8	9	10	11	12
Herring	*Clupea harengus*			305	2235		4392		2262		5025	2860	506
Sprat	*Sprattus sprattus*			5									
Mackerel	*Scomber scombrus*	4830			368	151		252					2
Haddock	*Melanogrammus aeglefinus*												
Whiting	*Merlangius merlangus*			43									
Cod	*Gadus morhua*												
Norway Pout	*Trisopterus esmarki*			524									
Poor Cod	*Trisopterus minutus*												
Blue Whiting	*Micromesistius poutassou*					1							
Lesser Argentine	*Argentina sphyraena*					2							
Lemon Sole	*Microstomus kitt*					1							
Grey Gurnard	*Eutrigla gurnardus*					1							
Hake	*Merluccius merluccius*					1							
Boar Fish	*Capros aper*							9290					
Horse Mackerel (Scad)	*Trachurus trachurus*			3		1							
Blue-mouth	*Helicolenus dactylopterus*					2							
Spurdog	*Squalus acanthias*			1									
Shads	*Alosa*			1									
Species	HAUL NO	13	14	15	16	17	18	19	20	21	22	23	24
Herring	Clupea harengus	606	8370	5636	571	1410			834	9	1960	6728	5071
Sprat	*Sprattus sprattus*												
Mackerel	*Scomber scombrus*		300		6828	72			174	9			
Haddock	*Melanogrammus aeglefinus*	6				36			24	570			
Whiting	*Merlangius merlangus*									480			
Cod	*Gadus morhua*									1			
Norway Pout	*Trisopterus esmarki*					153							
Poor Cod	*Trisopterus minutus*					81							
Blue Whiting	*Micromesistius poutassou*					2250							

SPECIES	HAUL NO	1	2	3	4	5	6	7	8	9	10	11	12
Lesser Argentine	*Argentina sphyraena*					99				1			
Lemon Sole	*Microstomus kitt*												
Grey Gurnard	*Eutrigla gurnardus*					9				10			
Hake	*Merluccius merluccius*									3			
Boar Fish	*Capros aper*												
Horse Mackerel (Scad)	*Trachurus trachurus*					18							
Blue-mouth	*Helicolenus dactylopterus*												
Spurdog	*Squalus acanthias*												
Shads	*Alosa*												

Table 5A.4. Herring length frequency proportion by trawl haul by subarea for west coast acoustic survey MFV Chris Andra (27 June – 16 July 2008). Length in cm, weight in g, TS=target strength in dB.

	I								
L(CM)	6	8	10	11	12	13	14	15	16
24.0	0.01								
24.5	0.01		0.00		0.01	0.00			
25.0	0.03	0.01				0.00	0.00		0.01
25.5	0.08	0.03	0.01	0.00	0.02	0.00		0.01	0.02
26.0	0.13	0.11	0.02	0.01	0.02	0.02	0.00	0.02	0.05
26.5	0.13	0.14	0.10	0.02	0.09	0.09	0.02	0.09	0.04
27.0	0.19	0.21	0.21	0.08	0.13	0.20	0.06	0.18	0.10
27.5	0.18	0.24	0.26	0.17	0.22	0.20	0.11	0.26	0.11
28.0	0.15	0.18	0.27	0.35	0.26	0.21	0.32	0.24	0.21
28.5	0.05	0.06	0.10	0.24	0.15	0.16	0.28	0.13	0.26
29.0	0.03	0.02	0.02	0.11	0.08	0.08	0.16	0.06	0.15
29.5	0.01	0.01	0.00	0.02	0.02	0.02	0.04	0.01	0.04
30.0				0.00		0.00	0.00	0.00	0.02
30.5						0.00		0.00	
31.0						0.00			
31.5									
32.0									
32.5									
33.0									
33.5									
34.0									
34.5									
35.0									
35.5									
Number	4392	2262	5025	2860	506	606	8370	5618	571
mean length	27.46	27.70	28.00	28.56	28.21	28.22	28.70	28.15	28.49
mean weight	185.94	190.93	197.24	210.00	202.15	202.50	213.47	200.86	209.00
TS/individual	-42.42	-42.35	-42.25	-42.08	-42.19	-42.18	-42.04	-42.21	-42.10
TS/kilogramme	-35.11	-35.15	-35.20	-35.31	-35.25	-35.25	-35.33	-35.23	-35.30

Table 5A.4. (cont.)

	I				II		III	
L(CM)	17	20	23	MEAN	3	MEAN	22	MEAN
14.5					0.00	0.00		
15.0								
15.5								
16.0								
16.5					0.02	0.02		
17.0					0.13	0.13		
17.5					0.14	0.14		
18.0					0.24	0.24		
18.5					0.21	0.21		
19.0					0.12	0.12		
19.5					0.05	0.05		
20.0					0.03	0.03		
20.5					0.01	0.01		
21.0					0.01	0.01		
21.5					0.01	0.01		
22.0					0.01	0.01		
22.5					0.01	0.01		
23.0					0.00	0.00		
23.5					0.01	0.01		
24.0				0.00	0.00	0.00		
24.5			0.00	0.00				
25.0				0.01				
25.5			0.00	0.02				
26.0		0.01	0.02	0.03				
26.5	0.01	0.01	0.06	0.07				
27.0	0.06	0.10	0.10	0.13			0.02	0.02
27.5	0.15	0.15	0.16	0.18			0.04	0.04
28.0	0.26	0.27	0.26	0.26			0.14	0.14
28.5	0.24	0.23	0.19	0.17			0.22	0.22
29.0	0.19	0.14	0.12	0.09			0.23	0.23
29.5	0.03	0.06	0.03	0.02			0.11	0.11
30.0	0.02	0.02	0.01	0.01			0.05	0.05
30.5	0.01	0.00	0.00	0.00			0.03	0.03
31.0	0.03	0.00	0.01	0.00			0.06	0.06
31.5		0.01	0.01	0.00			0.05	0.05
32.0		0.00	0.00	0.00			0.04	0.04
32.5			0.00	0.00			0.01	0.01
33.0			0.01	0.00			0.01	0.01
33.5		0.00		0.00				
34.0			0.00	0.00				
34.5								

Table 5A.4. (cont.)

			I			II		III
L(CM)	17	20	23	MEAN	3	MEAN	22	MEAN
35.0								
35.5			0.00	0.00				
Number	1410	834	6728		305		1960	
mean length	28.85	28.76	28.58	28.30	18.85	18.85	29.72	29.72
mean weight	217.17	215.13	211.50	204.39	56.79	56.79	239.45	239.45
TS/individual	-41.99	-42.02	-42.07	-42.16	-45.67	-45.67	-41.73	-41.73
TS/kilogramme	-35.36	-35.35	-35.32	-35.27	-33.22	-33.22	-35.52	-35.52

Table 5A.5. Age/maturity-length key for herring (numbers of fish sampled MFV *Chris Andra* (27 June – 16 July 2008).

Length	0	1I	2I	2M	3	4	5	6	7	8	9+	Grand Total
14.5		1										1
15												
15.5												
16												
16.5		1										1
17		1										1
17.5		1										1
18		1										1
18.5		1										1
19		1										1
19.5		2										2
20		2										2
20.5		1	1									2
21		1	1									2
21.5			2									2
22		1	1									2
22.5			2									2
23			3	1								4
23.5			1	4								5
24			2	4	1							7
24.5			2	8	1							11
25				9	4							13
25.5				18	6		1					25
26				19	15	1	1					36
26.5				9	23	5			1			38
27				3	27	6	5	1	1	2		45
27.5				9	55	29	8	9	18	9	5	142
28				3	26	32	13	15	30	16	6	141
28.5					8	28	20	13	43	15	12	139
29					6	22	18	16	38	17	17	134
29.5					4	10	12	9	23	16	15	89
30					1	4	11	3	10	4	8	41
30.5								1	7	9	8	25
31								1	12	9	11	33
31.5					1	1	1		7	6	9	25
32								1	6	4	13	24
32.5								2	1	3	8	14
33									2	3	3	8
33.5										4	1	5
34										1	1	2
34.5											1	1
35.5										1	1	2
Grand Total		14	15	87	178	138	90	71	199	119	119	1030

Table 5A.6. Mean length, mean weight, biomass (thousands of tonnes) and numbers (millions) breakdown by age and maturity obtained during the MFV *Chris Andra* 2008 herring acoustic survey.

Total Area						
Age (ring)	Mean Length (cm)	Mean Weight (g)	Numbers x10^6	%	Biomassx10^3 T	%
1	18.16	54.61	48	1.25	3	0.33
2I	21.49	93.11	6	0.15	1	0.09
2M	26.17	169.85	227	5.93	39	4.97
3I				0.00	0	0.00
3M	27.32	193.53	912	23.85	174	22.04
4	28.21	213.65	669	17.49	139	17.61
5	28.44	219.08	340	8.89	73	9.20
6	28.37	217.33	272	7.12	58	7.36
7	28.89	230.85	721	18.85	159	20.09
8	29.14	237.54	366	9.57	82	10.36
9+	29.88	257.02	264	6.90	63	7.95
Mean	27.88	212.66				
Total			3823.98	100	791.488	100
Immature			53.57	1.40	3.288	0.42
Mature			3770.42	98.60	788.200	99.58

ANNEX 5B: Denmark

Acoustic Herring Survey report for RV "DANA"

26 June2008 – 10 July 2008

Karl Johan Stæhr, DTU-Aqua, National Institute of Aquatic Resources

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 2007-survey with RV "DANA", covering the Skagerrak and Kattegat, was conducted in the period 29 June 29 to 10 July 2008, whereas calibration was done during 26 June to 29 June 29 2008.

2. SURVEY DESCRIPTION and METHODS

2.1 Personnel

During calibration 26/6 – 29/6 2008

Karl-Johan Stæhr (cruise leader)
Torben Filt Jensen(assisting cruise leader)
Bo Lundgren
Thyge Dyrnesli
Bo Tegen Nielsen
Frederik Mathisen

During acoustic monitoring 29/6 – 10/7 2008

Karl-Johan Stæhr (cruise leader)
Bo Lundgren (assisting cruise leader)
Torben Filt Jensen
Lise Sindahl
Helle Rasmussen
Susanne Hansen
Nina Fuglsang
Thyge Dyrnesli

2.2 Narrative

The survey of RV "Dana" was planned to start on the 26 June at 12.00 hours to go to Bornö in the Gullmar Fjord, Sweden for calibration of acoustic equipment. As a result of a breakdown on the aft side-thruster the departure had to be postponed until 17.00 hours. The vessel was anchored at Bornö in the Gullmar Fjord, Sweden at midnight the 26 June and the calibration was initiated in the morning of the 27 June. The calibration was conducted until the morning of the 29 June.

The 29 June at noon the scientific crew was exchanged outside the harbour of Skagen. After the short break, RV "Dana" steamed towards the northwesterly corner of the survey area in Skagerrak. The acoustic integration was initiated on the 29 June at 19.30 UTC at 57º53 N, 08º58E.

The western Skagerrak area was covered during June 29 – July 4, eastern Skagerrak during July 5 – 7 and Kattegat during July 7 – 10. The acoustic integration was ended at 57º25 N, 10º45 E at 06.00 UTC.

At the 3 July two crew members had to be changed at Hirtshals and the cruise line for the survey had to be modified from the optimal to make this exchange at Hirtshals possible.

In the morning of the10 July a new towed body was tested in Kattegat north of Læsø. RV "Dana" arrived at Hirthals at 15.00 UTC on the 10 July.

Totally the survey covered about 1950 nautical miles mainly using data from the 38 kHz paravane transducer running at depths of 3–5 m depending on the sea state and sailing direction relative to the waves. Simultaneously data from the 120 kHz and 18 kHz echosounders using the hull-mounted transducers were also recorded. The quality of the latter data are strongly dependent on the weather conditions, but this year the weather was calm, so no data had to be excluded because of 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 in the Skagerrak, east of 6° E and north of 56° N (Figure 5B.1). The area surveyed by Dana 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. As a result of limited periods and places for fishing (late morning, early afternoon and immediately before and after midnight; 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 parts of 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 Gullmar Fjord, Sweden during 27–29 June 2008. The calibration was performed according to the procedures established for EK60 at three frequencies (18, 38 and 120 kHz). This was the second calibration of the year, the previous one before a cruise to the Norwegian Sea in May. The calibration of the paravane split-beam transducer at 38 kHz was done with a 60 mm copper sphere. Calibration of the three hull-mounted split-beam transducers at 18, 38 and 120 kHz were carried out with 63mm, 60 mm and 23 mm copper spheres, respectively. The results were similar to the previous calibration earlier in the year, 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 5B.1.

The hull-mounted 38kHz transducer showed that two of the four segments had a lower sensitivity that the normal. The transducer is installed in 1985 and it is requested to be changed at the next docking of the vessel. Data from this transducer was not used for integration during this survey.

The 38 kHz on the new towed body was calibrated for the first time.

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, but has not been directly used for the survey estimate but as an aid when distinguishing between fish and plankton. Acoustic data were recorded as raw data on hard disk all 24 hours a day, also during fishing operations, but data recorded during fishing periods (usually two daytime hauls and two night-time hauls (the latter immediately before and after local midnight)) have not been used for the biomass estimate. The sampling unit (ESDU) was one nautical mile (nm). During trawl hauls the towed body is taken aboard and the EK60 38 kHz echosounderrun on the hull transducer.

2.6 Biological data – fishing trawls

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), whereas 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 2200 to 0300 UTC, usually two day-hauls (mostly demersal) and two night-hauls (mostly surface or midwater). The strategy was to cover most depth zones within each geographical stratum. In the deeper areas midwater-hauls were made to help identify the largest depth at which herring would be expected. 1 hour hauls were used as a standard during the survey, but sometimes shortened if the catch indicators indicated very large catches.

The fish caught were sorted into species groups and length groups within each species. Number of individuals and weight for each length group for each species was recorded with emphasis on pelagic species. 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. In each trawl haul 10 (if available) herring per 0.5 cm length class were sampled for determination of age, race (North Sea autumn spawners or Baltic Sea spring spawners) and maturity. Fourier Shape Analyses calibrated to Microstructure formed in the otolith during the larval period was used for the discrimination of herring race (see Appendix VI, Application of otolith shape as a stock identification method in mixed Atlantic Herring (*Clupea harengus* L) stocks in the North Sea and Western Baltic). 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. The distribution of CTD stations is similar to the distribution of the trawl hauls and shown in Figure 5B.2. 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.

2.8 Data analysis

For the judging process rawdata are pre-integrated into 1 m meter samples for each ping. These samples 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.

Scrutiny of the acoustic data are done for a fixed set of layers (3–6 m, 6– 10, 10–20 etc.) for each mile, using special judging software. It allows deleting layers and/or intervals with interference from wave– or ship wake-bubbles or rarely with bottom-integration. In areas with heavy abundance of jellyfish or zooplankton, usually krill, manually adjustable thresholds is applied separately to each layer to suppress background echoes

For each subarea (56E06 – 58E08, C – E in Figure1) the mean backscattering cross section was estimated for herring, sprat, gadoids and mackerel based on the TS-relationships given in the Manual for Herring Acoustic Surveys in ICES Division III, IV, and IVa (ICES 2000):

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 = 20 log L – 84.9 dB

where L is the total length in cm. The number of fish per species in the survey area 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 near-by 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 the 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 single fish sampled in each haul and frozen for later for race analysis of the otolith 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 1619. The distribution of ESDU on strata's is given in Table 5B.2. Table 5B.2 also shows the mean Sa and mean TS per strata used in the abundance estimation. The used strata's are shown in Figure 5B.1 and the cruise track for the survey are shown in Figure 5B.2.

Herring and sprat was not observed in midwater trawl hauls at depths below 150 meters. Therefore, layers below 150 meter were excluded from the estimation.

The relative herring density in numbers per nm^2 along the cruise track is shown in Figure 5B.3. The distribution of herring was in 2008 distributed further west (west of 8° E) than in 2006 and 2007 and the large concentrations in Kattegat and along the Danish coast in Skagerrak are not as pronounced as in 2007 (see Figure 5B.4)

3.2 Biological data

During the survey in 2008 37 hauls were conducted, 27 surface hauls and 10 bottom hauls. The geographical distribution of hauls is shown in Figure 5B.2 and details on the hauls and catch are given in Table 5B.3 and 5B.4.

The total catch for the survey was 29.4 tons .Herring was present in 34 hauls with a total catch of 18.4 tons. The total catch of herring was dominated by one haul with 13.4 tons of herring In 2008 as in 2007 herring was fished best during daytime in surface hauls. Length distributions of herring per hauls are given in Table 5B.5.

Sprat was present in the hauls in Kattegat (stratum F) and in stratum 560E6 where they contributed to the catch with 1% and 0.5%, respectively. For the total survey area herring, mackerel and sprat contributed to the total catch by 64%, 24% and 0.1%, respectively.

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

North Sea autumn spawners:

Skagerrak

WR	0	1I	1M	2I	2M	3I	3M	4I	4M	5	6
%	1	1	0	0,66	0,34	0,79	0,21	088	0,12	1	1

Kattegat

WR	0	1I	1M	2I	2M	3I	3M
%	1	1	0	1	0	0,57	0,43

Baltic Sea spring spawners:

Skagerrak

WR	0	1I	1M	2I	2M	3I	3M	4I	4M	5	6	7	8	9	10
%	1	0.93	0.07	0.55	0.45	0.36	0.64	0.15	0.85	1	1	1	1	1	1

Kattegat

WR	0	1I	1M	2I	2M	3I	3M	4I	4M	5	6	7	8	9
%	1	0.93	0.07	0.74	0.26	0.35	0.65	0.03	0.97	1	1	1	1	1

3.3 Biomass estimates

The total herring biomass estimate for the Danish acoustic survey with RV "Dana" in June-July 2008 is 530,975 tonnes, of which 15.2% or 80,470 tonnes is North Sea autumn spawning herring and 84.8% or 450,505 tonnes is Baltic Sea spring-spawning herring.

For the total number of herring the survey results is 11,840 mill., of which 37.8% are North Sea autumn spawners and 62.2% 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 Tables 5B.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
Autumn spawners	Abundance in mill.	1530	4443	4473
	Biomass in tons	98786	315176	80469
Spring spawners	Abundance in mill.	6407	8847	7367
	Biomass in tons	471850	614048	450505

From 2006 to 2007 there was an increase in the abundance of autumn spawners of 190% and of the biomass of 219%. The age structure in the abundance for 2006 and 2007 was similar with 86% and 91% of the total abundance as 1 WR for the two years respectively (see Table 5B.7). This corresponds to an overall increase of the abundance of autumn spawners in the survey area.

From 2007 to 2008 the abundance of autumn spawners increased by 0.7%, whereas the biomass decreased by 74%. As it can be seen from Table 5B.7 this contradictory development between abundance and biomass is the result of a dramatic change in age composition from 2007 to 2008. In 2007 1 WR contributed with 91% of the abundance of autumn spawners whereas the 0 WR contributes with 88% of the abundance in 2008. (Table 5B.7).

The decline in biomass of autumn spawners in for the Danish acoustic survey with RV "Dana" in June-July 2008 from the survey in 2007 is therefore due to a change of age structure of the abundance in the survey area. This may also be the background for the change in the overall distribution pattern seen in 2008 (Figure 5B.3 and 5B.4)

For the spring spawners no larger changes in the age structure over the years from 2006 to 2007 can be seen.

4 Tables and Figures

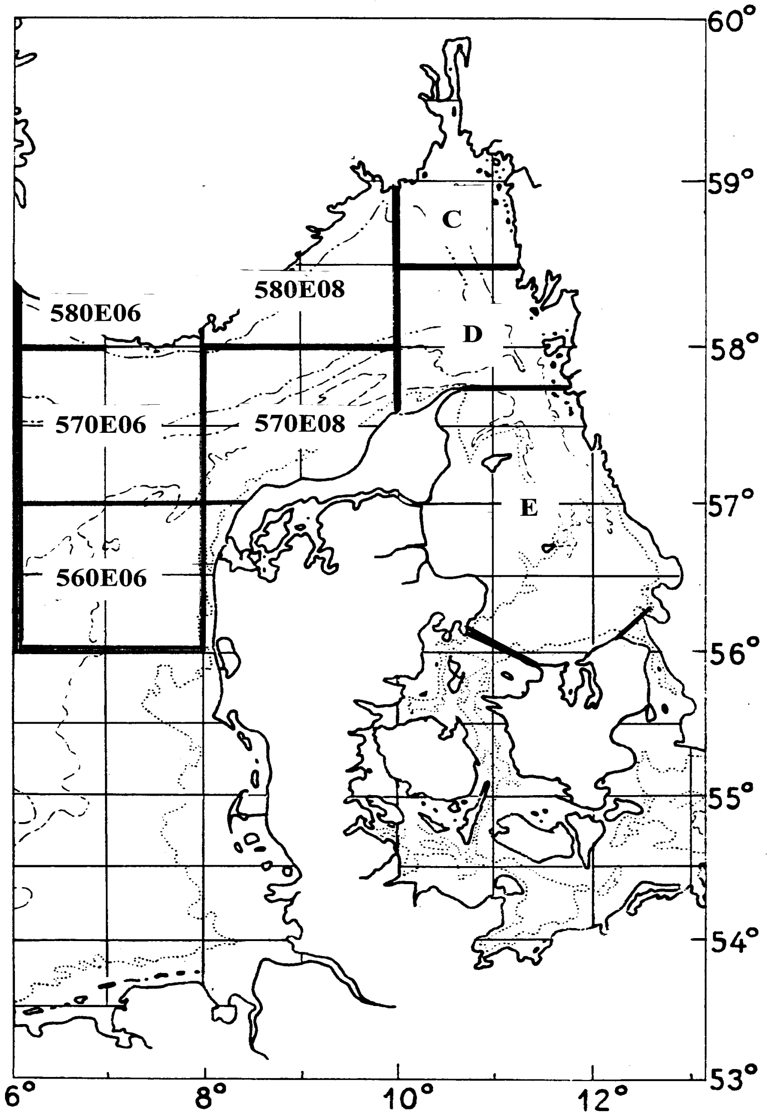


Figure 5B.1. Map showing the survey area for the Danish acoustic survey with RV "Dana" in June-July 2008. The map demonstrates the subareas used in the abundance estimation.

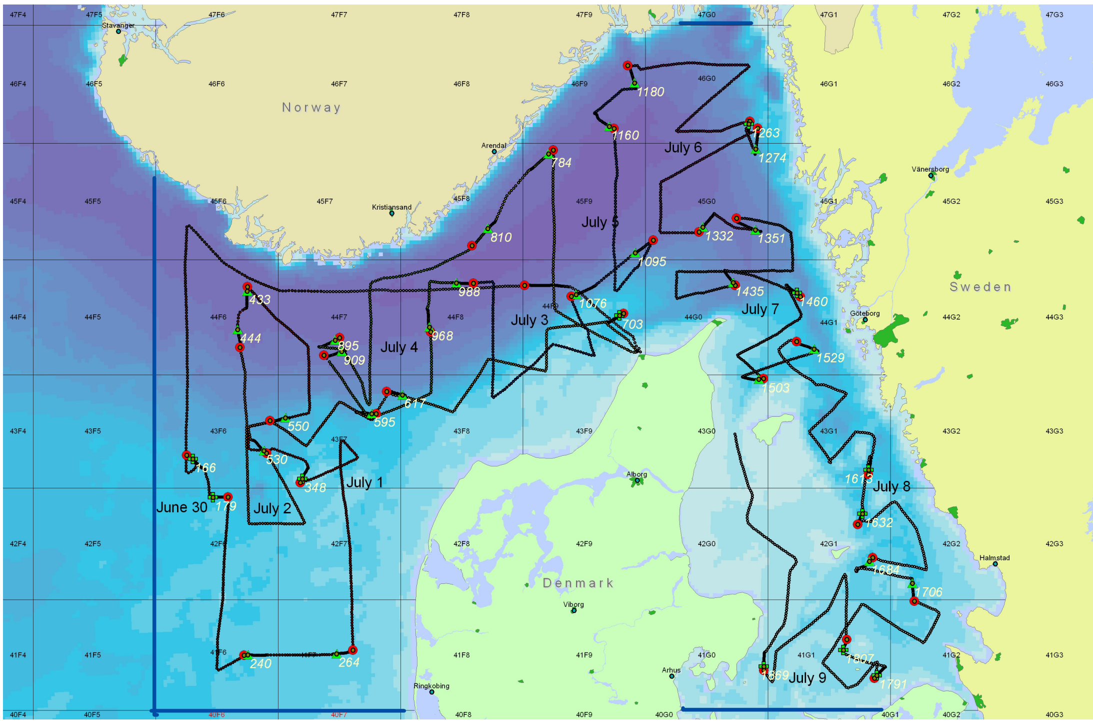


Figure 5B.2. Map showing cruise track and trawl stations during the Danish acoustic survey with RV "Dana" in June-July 2008.

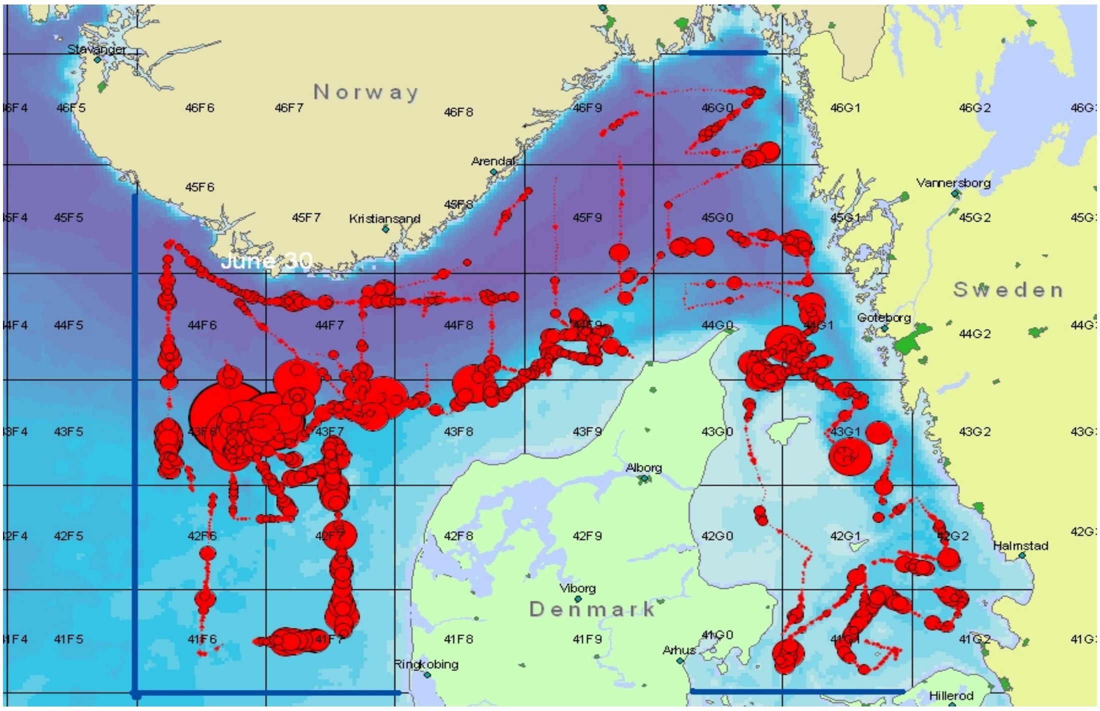


Figure 5B.3. Relative herring density (in numbers per nm²) along the track of the June-July 2008 Danish acoustic survey in the eastern North Sea, Skagerrak and Kattegat. Red circles indicate relative density of herring per ESDU.

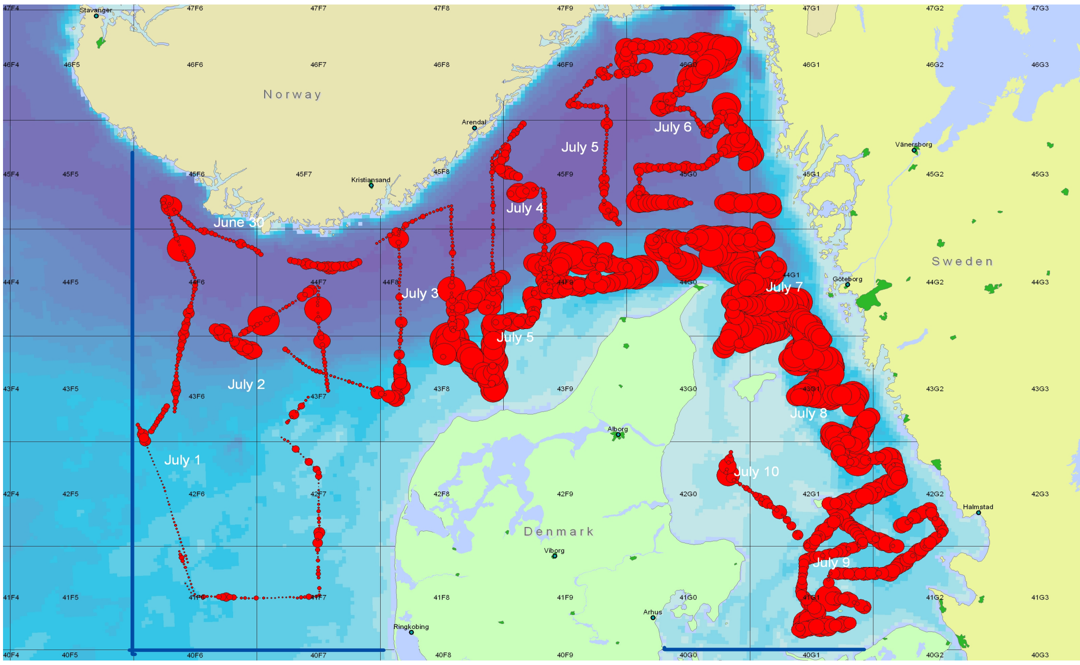


Figure 5B.4. Relative herring density (in numbers per nm²) along the track of the June-July 2007 Danish acoustic survey in the eastern North Sea, Skagerrak and Kattegat. Red circles indicate relative density of herring per ESDU.

Table 5B.1. Simrad EK60 and analysis settings used during the Acoustic Herring Survey with RV "Dana" Cruise July 2008.

Transceiver Menu	
Frequency	38 kHz
Sound speed	1488 m.s-1
Max. Power	2000 W
Equivalent two-way beam angle	-20.5 dB
Default Transducer Sv gain	24.85 dB
3 dB Beamwidth	6.9°
Calibration details	
TS of sphere	-33.6 dB
Range to sphere in calibration	8,70 m
Measured NASC value for calibration	25900 m2/nmi2
Calibration factor for NASCs	1.00
Absorption coeff	6,086 dB/km
Log Menu	
Distance	1,0 n.mi. using GPS-speed
Operation Menu	
Ping interval	1 s
Analysis settings	
Bottom margin (backstep)	1.0 m
Integration start (absolute) depth	7 - 9 m
Range of thresholds used	-70 dB

Table 5B.2. Survey statistic for the Danish acoustic survey with RV "Dana" in June-July 2008.

Stratum ID	area (nm^2)	Number of Logs	Number of Hauls	Mean SA	Mean TS
560E06	3980	141	3	5,14E-06	1,17E-05
570E06	3600	426	8	8,24E-06	2.05E-05
570E08	3406	287	5	1.07E-05	3.56E-05
580E06	209	21	1	3,78E-06	2,22E-05
580E08	1822	99	5	1,31E-06	2,33E-05
C	988	74	3	3,62E-05	1,73E-05
D	1837	163	7	3,37E-05	2,42E-05
E	5228	408	10	3,75E-05	1,22E-05

Table 5B.3. Trawl haul details for the Danish acoustic survey with RV "Dana" in June-July 2008.

Date dd-mm-yy	Haul no.	Time UTC	ICES Square	Position Latitude	Longitude	Trawl Direction deg.	Trawl type	Cath depth m	Mean depth m	Total catch kg	Main Species	Trawling speed Kn	Trawling duratin min,	Wind speed m/s
30-06-08	166	10:43	43F6	57.07.715 N	006.18.182 E	132	Expo	Bottom	60	35	Cod	2.9	61	9
30-06-08	179	13:18	42F6	56.57.497 N	006.28.173 E	94	Expo	Bottom	53	283	Cod	3	60	7
30-06-08	240	20:50	41F6	56.15.090 N	006.45.237 E	89	Fotö	Surface	37	860	Herring, Mackerel	4.5	60	6
01-07-08	264	00:22	41F7	56.15.431 N	007.28.673 E	81	Fotö	Surface	30	280	Herring	4.2	60	5
01-07-08	348	10:46	43F7	57.02.423 N	007.11.859 E	29	Expo	Bottom	33	91	Mackerel	3.1	60	6
07-07-08	433	22:16	44F6	57.51.88 N	006.44.751 E	184	Fotö	Surface	345	380	Mackerel, Herring	4.4	59	6
02-07-08	444	00:21	44F6	57.41.842 N	006.40.226 E	168	Fotö	Surface	240	550	Herring	4.4	60	7
02-07-08	530	10:45	43F6	57.09.875 N	006.52.963 E	296	Fotö	Surface	65	2774	Mackerel	4.2	60	9
02-07-08	550	14:06	43F6	57.18.657 N	007.03.516 E	260	Fotö	Surface	77	13500	Herring	4.5	60	10
02-07-08	595	21:02	43F7	57.19.733 N	007.45.913 E	276	Fotö	Surface	71	77	Mackerel	4.7	60	10
02-07-08	617	00:17	43F7	57.24.715 N	008.00.937 E	285	Fotö	Surface	133	817	Mackerel	4.5	60	10
03-07-08	703	10:48	44F9	57.45.478 N	009.47.229 E	131	Expo	Bottom	37	135	Whiting	3.1	60	10
03-07-08	784	21:10	45F9	58.27.241 N	009.12.542 E	226	Fotö	Surface	419	245	Mackerel, Herring	4.6	60	10
04-07-08	810	00:44	45F8	58.08.110 N	008.42.791 E	220	Fotö	Surface	455	696	Mackerel, Herring	4.4	60	9
04-07-08	895	10:50	44F7	57.39.079 N	007.28.011 E	248	Fotö	Surface	302	172	Herring	4.1	60	9
04-07-08	909	13:21	44F7	57.36.074 N	007.31.109 E	255	Fotö	Surface	279	856	Herring	4.5	60	9
04-07-08	968	21:12	44F8	57.42.451 N	008.14.106 E	358	Fotö	Surface	471	823	Mackerel, Herring	4.4	60	4
05-07-08	988	00:18	44F8	57.54.003 N	008.27.312 E	88	Fotö	Surface	526	632	Mackerel, Herring	4.1	60	5
05-07-08	1076	10:36	44F9	57.50.950 N	009.26.039 E	65	Fotö	Surface	95	27	Large medusa	4	60	1
05-07-08	1095	13:18	45G0	58.01.810 N	009.55.023 E	55	Fotö	Surface	155	23	Large medusa	4.3	60	6
05-07-08	1160	21:10	46F9	58.34.252 N	009.42.277 E	338	Fotö	Surface	527	702	Herring, Mackerel	3.9	60	9
06-07-08	1180	00:23	46F9	58.45.350 N	009.54.584 E	343	Fotö	Surface	256	410	Mackerel, Herring	4.2	60	9
06-07-08	1263	11:19	46G0	58.34.866 N	010.50.620 E	185	Expo	Bottom	86	268	Krill, Norway pout	2.7	60	9
06-07-08	1274	13:45	46G0	58.28.532 N	010.53.980 E	9	Fotö	Surface	71	210	Herring, picked dogfish	3.5	60	12
06-07-08	1332	21:11	45G0	58.08.452 N	010.28.008 E	38	Fotö	Surface	259	993	Herring	4.6	60	4
07-07-08	1351	00:18	45G0	58.07.775 N	010.53.765 E	290	Fotö	Surface	219	909	Mackerel, Herring	4.3	60	5
07-07-08	1435	10:44	44G0	57.54.087 E	010.42.894 E	323	Fotö	Surface	156	37	Herring	3.8	60	6
07-07-08	1460/1436	14:57	44G1	57.51.420 N	011.14.146 E	315	Expo	Bottom	59	69	Large meduse, Norway pout	2.9	60	8
07-07-08	1503	20:53	43G0	57.28.829 N	010.55.507 E	60	Fotö	Surface	33	623	Herring	3.7	60	6
08-07-08	1529	00:41	44G1	57.36.737 N	011.22.506 E	288	Fotö	Surface	43	564	Mackerel, Herring	4.3	60	10
08-07-08	1613	10:47	43G1	57.04.811 N	011.49.283 E	0	Expo	Bottom	53	100	Herring, Large medusa	3.2	60	4
08-07-08	1632	13:56	42G1	56.53.101 N	011.46.226 E	202	Expo	Bottom	44	182	Large medusa, Herring	2.9	60	3
08-07-08	1684	20:46	42G1	56.40.418 N	011.49.570 E	224	Fotö	Surface	38	119	Large medusa	4.2	60	3
09-07-08	1706	00:05	42G2	56.34.462 N	012.10.695 E	177	Fotö	Surface	41	87	Large medusa, Mackerel	4.2	60	8
09-07-08	1791	10:33	41G1	56.09.517 N	011.53.391 E	46	Expo	Bottom	26	65	Large medusa	3.2	60	5
09-07-08	1807	13:12	41G1	56.16.386 N	011.36.879 E	26	Expo	Bottom	30	123	Dab, Large medusa	2.9	60	3
09-07-08	1869	20:57	41G0	56.11.954 N	010.58.017 E	5	Expo	Surface	20	644	Large Medusa	3.9	60	5

Table 5B.4. Catch composition in trawl hauls for the Danish acoustic survey with RV "Dana" in June-July 2008.

	Station	166	179	240	264	348	433	444	530	550	595	617	703
	ICES sq.	43F6	42F6	41F6	41F7	43F7	44F6	44F6	43F6	43F6	43F7	43F7	44F9
	Gear	Expo	Expo	Fotö	Fotö	Expo	Fotö	Fotö	Fotö	Fotö	Fotö	Fotö	Expo
	Fishing depth	Bottom	Bottom	Surface	Surface	Bottom	Surface	Surface	Surface	Surface	Surface	Surface	Bottom
	Total depth	60	53	37	30	33	345	240	65	77	71	133	37
	Day/Night	D	D	N	N	D	N	N	D	D	N	N	D
	Total catch	35	283	860	280	91	380	550	2,774	13,500	77	817	135
Herring	*Clupea harengus*			505.127	161.457		107.8	372.215	200.28	13440.04	2.694	154.62	0.194
Mackerel	*Scomber scombrus*		0.182	314.234	69.704	34.625	146.6	105.685	2558.017	59.956	57.6	624.692	1.326
Large Medusa	*Medusa, spp*		107.446	10.882	10.789	21.43	11.084	51.353	14.91		12.3	26.838	
Pearlside	*Mauorolicus muelleri*						83.977	3.361					
Krill	*Euphausidae spp.*						14.93	2.951					
Lumpsucker	*Cyclopterus lumpus*			0.058				0.424			1.184	1.832	
Cod	*Gadus Morhua*	18.7	155.4			1.982							7.9
Whiting	*Merlangius merlangus*	0.26	0.516		0.182	0.196		0.029			0.012	0.002	80.3
Garfish	*Belone belone*			0.718	0.43		15.23	5.022	0.37		1.112	1.112	
Norway pout	*Trisopterus esmarki*										0.006		
Dab	*Limanda limanda*	1.714	0.968		0.168	5.426							15.6
Picked Dogfish	*Squalus acanthias*												
Gurnard	*Trigala spp.*	1.444	1.764	14.546	10.579	24.4			0.412		0.898	0.082	2.934
Horse mackere	*Trachurus trachurus*			11.283	19.4			0.318					3.382
Sprat	*Sprattus sprattus*				6.703								
Saithe	*Pollachius virens*		0.136									6.9	
Invertebrates	*Inv*	3.03			0.072								0.336
Common weav	*Trachinus draco*												
Haddock	*Melanogrammus aeglefinus*	2.742	4.09									0.006	8.385
Long rough dal	*Hippoglosides plattessoides*												
Hake	*Merluccius merluccius*	3.878											5.758
Plaice	*Pleuronectes platessa*	0.748			0.44	2.124							8.855
Anglerfish	*Lophiuspiscatorius*		9.7										
	Salmon solar							5.308					
Twaite shad	*Alosa fallax*			3.152									
Blue whiting	*Micromesistius poutassou*						0.378	3.098					
	Pandalus borealis												
	Cephalopoda sp	0.372	0.71		0.043	0.038					0.708	0.915	
Greater sandee	*Hyperoplus lanceolatus*	0.034	1.826			0.028							
Lemon sole	*Microstomus kitt*	0.944	0.262			0.524							
Flounder	*Platichthys flesus*												
Snake blenny	*Lumpenus lampretaeformis*												
	Myoxocephalus scorpius												
Pollack	*Pollachius pollachius*												
	Lampetra fluviatilis							0.238					
Norway lobster	*Nephrops norvegicus*												
	Trisopterus minutus												
	Phalis gunnellus												
	Ammodytes marinus				0.019								
Pipefish	*Entelurus aequoreus*							0.006	0.011				
	Buglossidium luteum				0.014								

Table 5B.4. continued.

	Station	784	810	895	909	968	988	1076	1095	1160	1180	1263	1274
	ICES sq.	45F9	45F8	44F7	44F7	44F8	44F8	44F9	45G0	46F9	46F9	46G0	45G0
	Gear	Fotö	Fotö	Fotö	Fotö	Fotö	Fotö	Fotö	Fotö	Fotö	Fotö	Expo	Fotö
	Fishing depth	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Bottom	Surface
	Total depth	419	455	302	279	471	526	95	155	527	256	86	71
	Day/Night	N	N	D	D	N	N	D	D	N	N	D	D
	Total catch	245	696	172	856	823	632	27	23	702	410	268	210
Herring	*Clupea harengus*	73.075	252.208	142.6	760.581	293.469	142.785	1.194	1.804	365.286	64.466	4.084	89.22
Mackerel	*Scomber scombrus*	110.178	341.881		13.954	318.776	314.284	0.142	0.38	158.731	251.832		14.444
Large Medusa	*Medusa, spp*	30.958	75.55	11.965	63.954	113.493	40.566	22.215	14.895	29.472	25.299	54.019	44.504
Pearlside	*Mauorolicus muelleri*	1.674				49.518	92.699			89.957	57.077		
Krill	*Euphausidae spp.*	12.084				9.169	24.675			25.679	1.813	97.513	
Lumpsucker	*Cyclopterus lumpus*	9.7	7.974	17.4	16.4	36.8	12.5	1.988	3.418	18	6.51		0.132
Cod	*Gadus Morhua*											1.55	
Whiting	*Merlangius merlangus*	0.044	0.087	0.026	0.086	0.013	0.026	0.022	0.04		0.072	2.908	
Garfish	*Belone belone*	7.195	18.3	0.296	0.24	1.764	4.432		1.156	2.102	0.33		
Norway pout	*Trisopterus esmarki*											79.507	
Dab	*Limanda limanda*												
Picked Dogfish	*Squalus acanthias*											1.012	61.7
Gurnard	*Trigala spp.*							0.93	1.016				
Horse mackere	*Trachurus trachurus*												
Sprat	*Sprattus sprattus*												
Saithe	*Pollachius virens*				0.76					12.4	2.6	1.376	
Invertebrates	*Inv*											10.99	
Common weav	*Trachinus draco*							0.05					
Haddock	*Melanogrammus aeglefinus*			0.004	0.025		0.032					0.706	
Long rough dal	*Hippoglosides plattessoides*											11.299	
Hake	*Merluccius merluccius*											0.36	
Plaice	*Pleuronectes platessa*											0.068	
Anglerfish	*Lophiuspiscatorius*												
	Salmon solar												
Twaite shad	*Alosa fallax*											0.614	
Blue whiting	*Micromesistius poutassou*												
	Pandalus borealis												
	Cephalopoda sp	0.092											
Greater sandee	*Hyperoplus lanceolatus*												
Lemon sole	*Microstomus kitt*												
Flounder	*Platichthys flesus*												
Snake blenny	*Lumpenus lampretaeformis*											0.929	
	Myoxocephalus scorpius												
Pollack	*Pollachius pollachius*									0.374			
	Lampetra fluviatilis												
Norway lobster	*Nephrops norvegicus*												
	Trisopterus minutus												
	Phalis qunnellus												
	Ammodytes marinus												
Pipefish	*Entelurus aequoreus*												
	Buglossidium luteum												

	Station	1332	1351	1435	1460/1436	1503	1529	1613	1632	1684	1706	1791	1807	1869	
	ICES sq.	45G0	45G0	44G0	44G1	43G0	43G1	43G1	42G1	42G1	42G2	41G1	41G1	41G0	
	Gear	Fotö	Fotö	Fotö	Expo	Fotö	Fotö	Expo	Expo	Fotö	Fotö	Expo	Expo	Expo	
	Fishing depth	Surface	Surface	Surface	Bottom	Surface	Surface	Bottom	Bottom	Surface	Surface	Bottom	Bottom	Surface	
	Total depth	259	219	156	59	33	43	53	52	38	41	26	30	20	Total
	Day/Night	N	N	D	D	N	N	D	D	N	N	D	D	N	Catch
	Total catch	993	909	37	69	623	564	100	182	119	87	65	123	644	29357.24
Herring	*Clupea harengus*	438.547	244.288	20.796	8.369	513.122	148.162	39.1	33.092	4.644	14.8	5.922	7.084	29.264	18642.39
Mackerel	*Scomber scombrus*	128.797	642.236	2.2		14.49	357.221	1.97	0.61	11.242	19.106	7.075		2.34	6684.51
Large Medusa	*Medusa, spp*	116.288	19.058	13.94	28.077	79.475	43.794	28.725	110.957	92.522	48.246	38.021	40.141	601.703	2054.869
Pearlside	*Mauorolicus muelleri*	227.18						0.06							605.503
Krill	*Euphausidae spp.*	29.447													218.261
Lumpsucker	*Cyclopterus lumpus*	24.7	0.15		3.63	0.152		15.9	10.1			2.094	4.038	1.738	196.822
Cod	*Gadus Morhua*				0.497			1.744	0.622						188.395
Whiting	*Merlangius merlangus*	0.041	0.067	0.01	7.809	3.691		5.372	13.916	0.234	0.916	0.688	1.277	0.052	118.894
Garfish	*Belone belone*	23.3	2.644			5.304	6.29			5.274	1.644				104.265
Norway pout	*Trisopterus esmarki*				13.017										92.53
Dab	*Limanda limanda*							0.669	8.701	0.034		3.992	51.415	0.028	88.715
Picked Dogfish	*Squalus acanthias*														62.712
Gurnard	*Trigala spp.*			0.188				0.13			0.096	0.836			60.255
Horse mackere	*Trachurus trachurus*		0.556				1.846								36.785
Sprat	*Sprattus sprattus*					2.731		0.028	0.354	1.036	0.458	1.056	11.815	8.53	32.711
Saithe	*Pollachius virens*	4.7												0.124	28.996
Invertebrates	*Inv*				0.262			1.833	0.88			1.564	3.77		22.737
Common weav	*Trachinus draco*					2.731	6.6878			4.014	1.734	3.136	0.397	0.168	18.9178
Haddock	*Melanogrammus aeglefinus*				1.587			0.044	0.456			0.002			18.079
Long rough dal	*Hippoglosides plattessoides*				2.188			0.544	1.701				0.591		16.323
Hake	*Merluccius merluccius*				2.434	0.802		0.299							13.531
Plaice	*Pleuronectes platessa*							0.532	0.51						13.277
Anglerfish	*Lophiuspiscatorius*														9.7
	Salmon solar											0.396			5.704
Twaite shad	*Alosa fallax*				0.972										4.738
Blue whiting	*Micromesistius poutassou*														3.476
	Pandalus borealis							2.974							2.974
	Cephalopoda sp					0.043						0.01			2.931
Greater sandee	*Hyperoplus lanceolatus*											0.19	0.101		2.179
Lemon sole	*Microstomus kitt*				0.152								0.13		2.012
Flounder	*Platichthys flesus*												1.346		1.346
Snake blenny	*Lumpenus lampretaeformis*														0.929
	Myoxocephalus scorpius												0.833		0.833
Pollack	*Pollachius pollachius*														0.374
	Lampetra fluviatilis														0.238
Norway lobster	*Nephrops norvegicus*							0.014	0.1						0.114
	Trisopterus minutus							0.068							0.068
	Phalis qunnellus												0.06		0.06
	Ammodytes marinus											0.018		0.02	0.057
Pipefish	*Entelurus aequoreus*														0.017
	Buglossidium luteum														0.014

Table 5B.4. Measured length distribution of herring by haul for the Danish acoustic survey with RV "Dana" in June-July 2008.

Station	240	264	433	444	530	550	595	617	703	784	810	895	909	968	988	1076
ICES sq.	41F6	41F7	44F6	44F6	43F6	43F6	43F7	43F7	44F9	45F9	45F8	44F7	44F7	44F8	44F8	44F9
Gear	Fotö	Fotö	Fotö	Fotö	Fotö	Fotö	Fotö	Fotö	Expo	Fotö	Fotö	Fotö	Fotö	Fotö	Fotö	Fotö
Fishing depth	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Bottom	Surface	Surface	Surface	Surface	Surface	Surface	Surface
Total depth	37	30	345	240	65	77	71	133	37	419	455	302	279	471	526	95
Day/Night	N	N	N	N	D	D	N	N	D	N	N	D	D	N	N	D
Total catch,kg	860	280	433	550	2,774	13,500	77	817	135	245	696	172	856	823	632	27
Total catch Herrin	505.127	161.457	107.8	372.215	200.28	13440.04	2.694	154.62	0.194	73.075	252.208	142.6	760.581	293.469	142.785	1.194
Sample Herring,k	36.156	9.647	58.32	56.825	19.814	40.35	2.694	19.46	0.194	30.64	48.076	60.847	63.094	56.674	54.382	1.194
Length in cm																
5.5																
6																
6.5																
7																
7.5		12														
8		71														
8.5		217														
9		185														
9.5		152														
10		96														
10.5		35														
11		7														
11.5		2														
12																
12.5																
13																
13.5																
14		1														
14.5		2														
15		11					1									
15.5	3	27						1								
16	29	38			7		1	16		1				1	5	
16.5	164	41	1		39	25	9	81				3	6	1	7	
17	284	31	3		92	53	11	109				3	5	1	8	
17.5	166	6	4		113	59	16	76		1		4	2	3	13	
18	136	4	1	3	71	80		44		1		7	3	2	12	
18.5	79	2	1		48	53	3	31			2	8	2	1	5	
19	26	1	1	1	16	48		12			1	4	6	3	4	
19.5	12		1	2	13	51	1	3		3		10	4	6	7	
20	2		4	2	12	57		1		12	16	11	12	11	14	
20.5			2	1	6	50		4		20	8	19	10	8	14	
21	1	1	16	2	8	56		5		26	30	13	15	16	20	2
21.5			31	6		26	3	7		41	36	7	33	14	25	2
22	1		15	11		19	2	5		46	55	16	34	20	44	2
22.5			69	27		13	1	3	2	29	53	27	37	13	48	2
23			71	31		9	1			28	48	39	41	20	56	1
23.5			79	40		8	2	1		26	39	38	55	27	44	1
24			50	45		5	1			26	37	40	53	21	43	1
24.5			39	40		2		1		6	35	31	30	20	31	2
25			25	32		2		1		7	23	20	25	26	27	
25.5			23	40		4		2		13	15	31	18	19	23	
26			19	40	1			1		10	27	34	37	34	13	
26.5			16	48		1				4	10	47	32	26	15	
27			6	32		1				6	10	28	25	31	20	
27.5			8	20		2				4	5	28	23	25	12	
28			3	9				1		1	2	7	10	12	11	
28.5			8	10				1		1	1	13	13	21	3	
29				4							1	2	2	7		
29.5				3						1		2	1	10		
30			1					1				3	1	9	1	
30.5						1						1	1	1	1	
31								1				1		2		
31.5														3		
32								1								
32.5													1			
Total no.	903	942	497	449	426	625	52	409	2	313	454	497	537	414	526	13
Mean Length	17.35326689	10.33015	23.57545	24.92984	17.78756	19.4216	18.20192	17.7934		22.71086	23.25551	24.14185	23.88641	24.86473	22.97909	22.57692

Station	1095	1160	1180	1263	1274	1332	1351	1435	1460/1436	1503	1529	1613	1632	1684	1706	1807	1869
ICES sq.	45G0	46F9	46F9	46G0	45G0	45G0	45G0	44G0	44G1	43G0	43G1	43G1	42G1	42G1	42G2	41G1	41G0
Gear	Fotö	Fotö	Fotö	Expo	Fotö	Fotö	Fotö	Fotö	Expo	Fotö	Fotö	Expo	Expo	Fotö	Fotö	Expo	Expo
Fishing depth	Surface	Surface	Surface	Bottom	Surface	Surface	Surface	Surface	Bottom	Surface	Surface	Bottom	Bottom	Surface	Surface	Bottom	Surface
Total depth		527	256	86	71	259	219	156	59	33	43	53	52	38	41	30	20
Day/Night	D	N	N	D	D	N	N	D	D	N	N	D	D	N	N	D	N
Total catch,kg	22,709	702	410	268	210	993	909	37	69	623	564	100	182	119	87	123	644
Total catch Herrin	10804	365.286	64.466	4.084	89.22	438.547	244.288	20.796	8.369	513.122	148.162	39.1	33.092	4.644	14.8	7.084	29.264
Sample Herring,k	1.804	43.125	24.959	4.084	35.305	60.1	50.01	20.796	2.24	9,226	29.272	29.028	5.204	4.644	14.8	2.108	29.264
Length in cm																	
5.5																	
6				52													
6.5				26						1			1				
7										2			4				
7.5										3			21				
8										4			65				
8.5										7			75				
9									8	8			88				
9.5									4	7			102				
10									8	27			68				
10.5									8	47			63				
11									14	112			34				
11.5									11	212			8				
12									10	147							
12.5									7	49			1				
13										12							
13.5										1							
14																	
14.5										1							
15													1				
15.5										2			2				
16										2						1	
16.5	1					1		1		2							1
17	4						4	1			3	1		1			18
17.5	4		1	1		1				3	2		1	5		3	60
18			1		1	1	5			7	13	2	1	4		4	112
18.5			4			1	3	1	1	1	17	28	4	22	2	2	138
19			4		1		6	2		6	65	93	12	30	2	4	92
19.5			5	1	16		15	1		4	109	108	2	9	3	1	48
20	1		15	4	49	7	35	1	4	3	108	65	1	8	4	3	47
20.5		10	30	6	93	7	40	6	5	1	65	57	5	6	3	4	32
21	1	22	39	11	102	35	74	18	8		32	53	6	4	1	3	30
21.5	4	35	65	6	82	64	109	32	1		21	37		1	5	2	18
22		62	42	5	47	90	86	30	2	1	8	19	2	2	3	3	11
22.5		80	41	5	34	121	92	37	1		5	7			1	1	4
23	1	70	16	4	18	106	59	28		1	1	5			2	2	
23.5		56	21	1	11	67	28	26			3	5		1	4	1	
24	1	31	5	1	3	39	12	10			2	1			2		
24.5	2	18	2	1	1	21	10	11			2	1			4		
25		11	2	1	2	10	5	6			4				4		
25.5	1	10		1	1	9	2	5							4		
26	1	10	1			9	2	3							14		
26.5			1			8	1	1							16		
27		5				6									9		
27.5		2	2		1	2									14		
28								2							8		
28.5		2				4		1							3		
29																	
29.5															1		
30	1																
30.5						2											
31																	
31.5																	
32																	
32.5																	
Total no.	22	424	297	126	462	611	588	223	92	673	460	482	567	93	109	34	611
Mean Length	20.86364	22.95165	21.7138	12.04762	21.23701	22.82815	21.77211	22.60987	13.25	11.70505	19.97826	20.0778	9.95679	19.19355	25.09174	19.97059	20.8789

Table 5B.5. 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 2008.

Numbers in millions															
	WR														
Strata	0	1i	1m	2i	2m	3i	3m	4i	4m	5	6	7	8	9	10
580E06	0	5.759368	0	3.480536	1.78999	0.893362	0.243644	0	0	0	0	0	0	0	0
570E06	0	233.3463	0	29.0668	14.94864	7.953745	2.169203	1.598667	0.228381	0.97172	1.166064	0	0	0	0
580E08	0	14.77055	0	0.527494	0.271282	0.74947	0.204401	0	0	0	0	0	0	0	0
570E08	0	30.46026	0	23.4449	12.05738	12.00792	3.274887	10.69737	1.528195	0	0	0	0	0	0
C	0	16.99621	0	1.192675	0.613376	0.22778	0.062122	0	0	0	0	0	0	0	0
D	11.87653	61.8407	0	8.106213	4.16891	2.872055	0.783288	1.013811	0.14483	0.706254	0	0	0	0	0
E	2347.35	13.78818	0	1.011825	0	2.096488	1.572366	0	0	0	0	0	0	0	0
560E06	1556.124	26.99296	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean weigth in gram															
	WR														
Strata	0	1i	1m	2i	2m	3i	3m	4i	4m	5	6	7	8	9	10
580E06	0.0	93.4	93.4	105.1	105.1	103.0	103.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
570E06	0.0	70.4	70.4	104.2	104.2	115.7	115.7	120.9	120.9	119.0	136.0	0.0	0.0	0.0	0.0
580E08	0.0	95.6	95.6	122.6	122.6	126.5	126.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
570E08	0.0	75.7	75.7	142.9	142.9	186.9	186.9	104.5	104.5	0.0	0.0	0.0	0.0	0.0	0.0
C	0.0	85.6	85.6	87.8	87.8	120.0	120.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D	8.5	89.6	89.6	99.6	99.6	99.2	99.2	108.5	108.5	120.0	0.0	0.0	0.0	0.0	0.0
E	10.7	47.8	47.8	74.1	74.1	76.8	76.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
560E06	4.7	38.6	38.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mean length in cm															
	WR														
Strata	0	1i	1m	2i	2m	3i	3m	4i	4m	5	6	7	8	9	10
580E06	0.0	22.4	22.4	23.6	23.6	23.5	23.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
570E06	0.0	20.3	20.3	23.0	23.0	24.5	24.5	25.5	25.5	25.5	25.5	0.0	0.0	0.0	0.0
580E08	0.0	22.6	22.6	24.5	24.5	25.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
570E08	0.0	20.8	20.8	24.9	24.9	27.2	27.2	24.2	24.2	0.0	0.0	0.0	0.0	0.0	0.0
C	0.0	21.9	21.9	22.7	22.7	24.0	24.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D	10.8	22.2	22.2	23.2	23.2	23.3	23.3	24.2	24.2	24.0	0.0	0.0	0.0	0.0	0.0
E	11.2	18.3	18.3	21.3	21.3	21.6	21.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
560E06	9.1	17.0	17.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Biomass in tonn															
	WR														
Strata	0	1i	1m	2i	2m	3i	3m	4i	4m	5	6	7	8	9	10
580E06	0	537.8728	0	365.7019	188.0753	92.01627	25.09535	0	0	0	0	0	0	0	0
570E06	0	16425.11	0	3028.174	1557.346	920.2199	250.9691	193.3559	27.62228	115.6347	158.5848	0	0	0	0
580E08	0	1411.56	0	64.66284	33.25517	94.82227	25.86062	0	0	0	0	0	0	0	0
570E08	0	2305.293	0	3350.354	1723.039	2243.757	611.9339	1117.478	159.6397	0	0	0	0	0	0
C	0	1454.537	0	104.7758	53.88471	27.33358	7.454613	0	0	0	0	0	0	0	0
D	100.3812	5542.808	0	807.4947	415.283	284.7674	77.66383	109.9927	15.71324	84.75048	0	0	0	0	0
E	25029.34	658.7248	0	74.97878	0	161.0291	120.7718	0	0	0	0	0	0	0	0
560E06	7268.57	1042.235	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 5B.6. Abundance, mean weight, mean length and biomass by age group and subarea for Baltic Sea spring-spawning herring in the Danish acoustic survey 2008.

Numbers in millions

	WR													
Strata	0	1i	1m	2i	2m	3i	3m	4i	4m	5	6	7	8	9	10
580E06	0	4.397147	0.350271	12.29409	10.07069	4.13648	7.307781	0.684736	3.959558	1.626579	0.23028	0	0	0	0
570E06	0	2096.724	167.0221	207.7732	170.1972	42.14208	74.45101	7.581251	43.83941	23.76703	13.53144	5.641147	2.240824	0.168337	0.142474
580E08	0	46.11512	3.673466	32.92637	26.9716	13.33691	23.56187	1.054662	6.098695	5.018811	1.894965	0.9969	0.476556	0.132367	0
570E08	0	649.948	51.77395	125.7643	103.0197	53.20398	93.9937	10.51712	60.81637	46.00456	41.0344	15.90546	6.888062	5.642334	0
C	0	100.6947	8.021198	53.26785	43.6343	9.40576	16.61684	1.06412	6.15339	5.06947	0.579803	0.339799	0	0	0.337388
D	1.378056	115.5073	9.201148	83.49441	68.39436	21.68065	38.30249	2.956288	17.09506	11.58314	3.955683	1.210712	0	0	0.28923
E	23.86369	201.6199	14.60006	92.09093	33.01373	14.34586	27.03642	0.391481	10.96147	6.158667	3.854107	0.451898	0.678876	0.362604	0
560E06	81.1742	1903.126	0	3.749727	1.874864	0	0	0	0	0	0	0	0	0	0

Mean weigth in gram

	WR													
Strata	0	1i	1m	2i	2m	3i	3m	4i	4m	5	6	7	8	9	10
580E06	0.0	72.7	72.7	100.4	100.4	119.5	119.5	129.6	129.6	165.5	210.5	0.0	0.0	0.0	0.0
570E06	0.0	53.7	53.7	84.9	84.9	102.9	102.9	121.4	121.4	158.3	152.5	180.6	245.2	156.0	240.0
580E08	0.0	84.7	84.7	95.7	95.7	101.2	101.2	127.2	127.2	135.0	146.2	158.6	136.4	152.6	0.0
570E08	0.0	45.1	45.1	101.7	101.7	123.9	123.9	147.5	147.5	162.3	189.5	196.1	212.0	187.6	0.0
C	0.0	71.0	71.0	78.3	78.3	85.3	85.3	95.2	95.2	96.5	101.5	118.0	0.0	0.0	166.0
D	10.0	75.0	75.0	86.6	86.6	92.6	92.6	108.0	108.0	110.6	129.0	202.9	0.0	0.0	166.0
E	11.4	47.7	47.7	58.9	58.9	71.0	71.0	100.1	100.1	117.6	113.6	126.7	120.4	195.0	0.0
560E06	4.8	37.1	37.1	67.3	67.3	0.0	0.0	0.0	0.0	0.0	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
580E06	0.0	20.5	20.5	23.2	23.2	24.8	24.8	25.6	25.6	27.6	29.3	0.0	0.0	0.0	0.0
570E06	0.0	18.6	18.6	21.7	21.7	23.5	23.5	24.7	24.7	26.7	26.9	28.2	30.5	28.0	31.0
580E08	0.0	21.7	21.7	22.7	22.7	23.6	23.6	25.3	25.3	25.7	26.6	27.2	26.8	28.0	0.0
570E08	0.0	17.7	17.7	23.1	23.1	24.7	24.7	26.2	26.2	26.9	28.3	29.0	29.3	28.8	0.0
C	0.0	20.7	20.7	21.6	21.6	22.4	22.4	22.8	22.8	23.8	24.0	26.0	0.0	0.0	27.5
D	11.4	21.1	21.1	22.2	22.2	23.1	23.1	23.6	23.6	24.5	25.5	29.1	0.0	0.0	27.5
E	11.1	18.4	18.4	20.1	20.1	21.4	21.4	22.9	22.9	24.2	24.1	25.5	24.5	28.0	0.0
560E06	9.2	17.2	17.2	21.3	21.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Biomass in tonn

	WR													
Strata	0	1i	1m	2i	2m	3i	3m	4i	4m	5	6	7	8	9	10
580E06	0	319.6322	25.46146	1234.027	1010.852	494.4562	873.5393	88.72068	513.037	269.1477	48.47392	0	0	0	0
570E06	0	112562	8966.532	17634.12	14444.97	4336.11	7660.462	920.1134	5320.656	3763.432	2063.524	1018.82	549.4884	26.26052	34.19376
580E08	0	3907.468	311.2635	3149.804	2580.158	1349.672	2384.42	134.1329	775.638	677.7815	277.1181	158.1033	65.02055	20.20512	0
570E08	0	29311.16	2334.886	12789.06	10476.15	6592.466	11646.69	1551.449	8971.425	7466.087	7777.444	3119.028	1460.558	1058.691	0
C	0	7148.282	569.4222	4172.858	3418.192	802.616	1417.955	101.2967	585.7592	489.4134	58.85002	40.09628	0	0	56.00635
D	13.84893	8660.597	689.8911	7234.437	5926.081	2006.749	3545.257	319.1429	1845.478	1281.003	510.4807	245.6675	0	0	48.01224
E	272.7827	9619.892	696.6129	5424.951	1944.794	1018.319	1919.139	39.19094	1097.346	724.0486	437.7261	57.23668	81.733	70.70778	0
560E06	387.3042	70623.54	0	252.4148	126.2074	0	0	0	0	0	0	0	0	0	0

Table 5B.7. Age distribution in estimate of autumn spawners during the Danish acoustic survey from 2006 to 2008 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

	WR										
Strata	0	1	2	3	4	5	6	7	8	9	Totalt
580E06	0	0	0	0	0	0	0	0	0	0	0
570E06	0	313.2245	77.82016	1.310689	0	0	0	0	0	0	392.3554
580E08	0	72.47082	5.607853	0	0	0.280924	0	0	0	0	78.3596
570E08	30.98883	425.0991	40.40881	2.000434	0	0	0	0	0	0	498.4972
C	0	125.2478	21.22575	0	0	0.317077	0	0	0	0	146.7906
D	0	265.6062	13.03738	1.528584	0	0	0	0	0	0	280.1722
E	6.566309	107.84	17.38965	1.233393	0	0	1.086413	0	0	0	134.1158
560E06	0	0	0	0	0	0	0	0	0	0	0
All stratas	37.55514	1309.488	175.4896	6.073101	0	0.598001	1.086413	0	0	0	1530.291

Age distribution in % of total abundance

	WR									
Strata	0	1	2	3	4	5	6	7	8	9
580E06	0.00	0.00	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	0.00	0.00
580E08	0.00	92.48	7.16	0.00	0.00	0.36	0.00	0.00	0.00	0.00
570E08	6.22	85.28	8.11	0.40	0.00	0.00	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	0.00	0.00
D	0.00	94.80	4.65	0.55	0.00	0.00	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	0.00	0.00
560E06	0.00	0.00	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	0.00	0.00

Autumn spawners in 2007

Number in millions

	WR										
Strata	0	1	2	3	4	5	6	7	8	9	Totalt
580E06	0	4.275523	0.777364	0	0	0	0	0	0	0	5.052887
570E06	0	121.3957	56.68901	5.730107	0.081208	0	0	0	0	0	183.896
580E08	0	59.14779	26.5337	0	0	0	0	0	0	0	85.68149
570E08	0	753.575	118.4236	0	0	0	0	0	0	0	871.9986
C	0	75.62764	7.928773	0	0	0	0	0	0	0	83.55641
D	0	1365.499	109.4435	5.590177	0	0	0	0	0	0	1480.533
E	0	1542.982	46.9248	7.764333	0	0	0	0	0	0	1597.671
560E06	0	134.8495	0	0	0	0	0	0	0	0	134.8495
All stratas	0	4057.353	366.7207	19.08462	0.081208	0	0	0	0	0	4443.239

Age distribution in % of total abundance

	WR									
Strata	0	1	2	3	4	5	6	7	8	9
580E06	0.00	84.62	15.38	0.00	0.00	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	0.00	0.00
580E08	0.00	69.03	30.97	0.00	0.00	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	0.00	0.00
C	0.00	90.51	9.49	0.00	0.00	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	0.00	0.00
E	0.00	96.58	2.94	0.49	0.00	0.00	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	0.00	0.00
All stratas	0.00	91.32	8.25	0.43	0.00	0.00	0.00	0.00	0.00	0.00

Autumn spawners in 2008

Numbers in millions

	WR										
Strata	0	1	2	3	4	5	6	7	8	9	Totalt
580E06	0	5.759368	5.270526	1.137006	0	0	0	0	0	0	12.1669
570E06	0	233.3463	44.01544	10.12295	1.827048	0.97172	1.166064	0	0	0	291.4496
580E08	0	14.77055	0.798776	0.95387	0	0	0	0	0	0	16.5232
570E08	0	30.46026	35.50228	15.28281	12.22556	0	0	0	0	0	93.47091
C	0	16.99621	1.806051	0.289902	0	0	0	0	0	0	19.09216
D	11.87653	61.8407	12.27512	3.655343	1.158641	0.706254	0	0	0	0	91.51258
E	2347.35	13.78818	1.011825	3.668854	0	0	0	0	0	0	2365.818
560E06	1556.124	26.99296	0	0	0	0	0	0	0	0	1583.117
All stratas	3915.35	403.9546	100.68	35.11073	15.21125	1.677974	1.166064	0	0	0	4473.151

Age distribution in % of total abundance

	WR									
Strata	0	1	2	3	4	5	6	7	8	9
580E06	0.00	47.34	43.32	9.35	0.00	0.00	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	0.00	0.00
580E08	0.00	89.39	4.83	5.77	0.00	0.00	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	0.00	0.00
C	0.00	89.02	9.46	1.52	0.00	0.00	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	0.00	0.00
E	99.22	0.58	0.04	0.16	0.00	0.00	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	0.00	0.00
All stratas	87.53	9.03	2.25	0.78	0.34	0.04	0.03	0.00	0.00	0.00

ANNEX 5C: Norway

Survey report for RV *Johan Hjort*

8–31 July 2008

Else Torstensen and Cecilie Kvamme, IMR Flødevigen and Bergen, Norway

1. INTRODUCTION

In 2008, the Norwegian Institute of Marine Research carried out a combined survey in the North Sea from 8 to 31 July. The survey was a joint survey combining the ICES coordinated herring acoustic survey for the North Sea and adjacent areas (ICES 2008), the third quarter IBTS and the IMR saithe acoustic survey.

The herring acoustic survey is planned and coordinated by the Planning Group for Herring Surveys (PGHERS 2008). 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. Data from the present survey will be combined with the other surveys 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 2009.

Objectives for the combined survey with RV "Johan Hjort" were:

a) To conduct an acoustic survey to estimate the abundance and distribution of herring and sprat in the northeastern part of the North Sea, between 56°30′and 62° N, and between 2° and 6° E.

b) To conduct an acoustic survey to estimate the abundance and distribution of saithe in the northern North Sea, between 57° and 62° N, and 1° W and 7° E.

c) To obtain biological samples (length, weight) of defined fish species; for target species length, weight, age, sex, and maturity data were sampled and, in herring, also vertebrae count and infection by Ichthyophonus were recorded.

d) To map the general hydrographical regime and monitor the standard profiles: Oksøy – Hanstholm, Hanstholm – Aberdeen, Utsira – Start Point and Fedje – Shetland.

e) To collect data on zooplankton and phytoplankton along the transects Utsira – Start Point and Hanstholm – Aberdeen.

2. SURVEY DESCRIPTION AND METHODS

2.1 Personnel

Else Torstensen	(Cruise leader, 8 – 24 July)
Espen Johnsen	(Cruise leader, 24 – 31 July)
Cecilie Kvamme	(Scientist, 16 – 31 July)
Øyvind Torgersen	(Acoustic expert, 8 – 31 July)
Bjarte Kvinge	(Acoustic operator, 8 – 16 July)
Jan Erik Nygaard	(Acoustic operator, 16 – 31 July)
Anne-Liv Johnsen	(Technician – pelagic fish, 8 – 16 July)
Bjørn Vidar Svendsen	(Technician – pelagic fish, 8 – 16 July)
Inger Henriksen	(Technician – pelagic fish, 16 – 31 July)

Knut Hansen	(Technician – pelagic fish, 16 – 31 July)
Arne Storaker	(Technician – demersal fish, 8 – 16 July)
Harald Larsen	(Technician – demersal fish, 8 – 16 July)
Ole Oscar Arnøy	(Technician – demersal fish, 16 – 31 July)
Tor-Ivar Halland	(Technician – demersal fish, 16 – 31 July)
Julio Erices	(Technician – ctd and plankton, 8 – 31 July)
Karen Gjertsen	(Technician – ctd and plankton, 08 – 31 July)
Guri Nesje	(Technician – chemistry, 8 – 16 July)
Kjell Westrheim	(Technician – chemistry, 8 – 16 July)
Hildegunn Strømsnes	(Technician – chemistry, 16 – 31 July)
Sonnich Meier	(Scientist – chemistry, 16 – 31 July)
Franz Uiblein	(Scientist – fish taxonomy, 8 – 16 July)

Dr Tara Marshall, University of Aberdeen, was visiting scientist onboard (16–31 July), doing fat measurements of herring.

2.2 Narrative

The survey plan was to start off 1 July. Because of technical problems, the departure was postponed and RV "Johan Hjort" left Bergen at 2210 UTC 8 July 2008 and set the course south. Because of the reduction in available ship time, original plans had to be reduced. We started by bottom trawling in the stony area near the Egersund Bank to collect fish for chemical analyses of demersal fish (cod, haddock, saithe). The vessel then continued with east-west transects from south to north, starting out with the first CTD–station on the Hanstholm – Aberdeen transect. The hydrographic transect Oksøy – Hanstholm and the western part of the Hanstholm – Aberdeen transect were not sampled in order to manage the acoustic coverage of herring according to the PGHERS plan and the acoustics of saithe. On the 15 July, we stopped the survey at N58°46′ and E5°18′ and called Stavanger at 1500 UTC for change of crew. "Johan Hjort" sailed again in the afternoon of the 16 July at 1410 UTC and recommenced the survey at 1830 UTC. We started the Utsira – Start Point hydrographical transect west of Utsira (N59°17′ E4°50′) on the 18 July. The transect was finalized in the west July 21 (0112 UTC). The realization of the transect suffered by very bad weather (storm and gale), and on some CTD stations plankton sampling could not be carried out, neither could trawling be performed. We returned eastwards to continue the E-W transects between 2º E and the Norwegian west coast. A call was made in Lerwick, Shetland July 23 for change of cruise leader and a break. "Johan Hjort" left the next day (1500 UTC) and continued the survey in the northern area. The survey finished 30 July at 1845 UTC in position 60°45′N and 04°37′E and the vessel proceeded to Bergen where "Johan Hjort" docked late in the night. Figure 5C.1 gives the cruise track and distribution of trawl haul stations, Figure 5C.2 gives the distribution of CTD and plankton-stations and Figure 5C.3 demonstrates the grab (boxcore) stations. In general the weather conditions were good, but we had some bad days midway in the survey with wind condition up in storm.

The present report gives the results from the Norwegian PGHERS target area (ICES 2008).

2.3 Survey design

The first part of the survey was carried out in systematically parallel east-west transects progressing northwards from N57° to N62°. According to the original plan, we should cover the ICES rectangles 42F2-F5, but had to drop these as a result of time constraint. This was communicated to the other participating parties and the Netherlands managed to cover the two most western rectangles. The three most northern rectangles, 52F2-F4, were not covered. In principle, 15 nm and 30 nm were used as distance between the tracks according to the coordinated plan (ICES 2008).

2.4 Calibration

Calibration of the echosounders was not performed. The sounders on board "Johan Hjort" have turned out to be stable and the settings used were from calibration made in April 21 2008, in the Lyngdal area (Børøy Bight). The main settings for the 38 kHz transceiver are given in Table 5C.1.

2.5 Acoustic data collection

The acoustic survey onboard 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 (Sv) were integrated pr nm intervals from 9–13m (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 9 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 an Aakra trawl was used. GOV trawl, as standard for the IBTS surveys and equipped with Balmoral Kite floats, was used for bottom trawling. The bottom-trawl hauls were monitored using SCANMAR TE40 (wide beam) and distance/depth sensor (A4693), whereas SCANMAR TE40-2 (PL) (narrow-beam) and depth sensor D1200 were used to monitor pelagic trawl hauls.

The catches were sampled for species composition by number and weights. Individual biological samples (length, weight) of the most important species were taken according to the IMR fish sampling manual (Mjanger *et al*., 2007). Herring were examined for sex, maturity (8 point scale), fat, stomach content, vertebrae count (east of 2°E) and macroscopic evidence of *Ichthyophonus* infection. Otoliths were taken for age determination (number of winter rings).

Eight herring samples from the area east of 2º E were sampled and frozen for otolith microstructure studies to be carried out by the DTU Aqua, Denmark.

2.7 Hydrographic data

CTD stations were taken at each trawl station in addition to the standard hydrographical profiles Hanstholm – Aberdeen, Utsira – Start Point and Fedje – Shetland. The part of the Hanstholm – Aberdeen transect west of 2°E, was not covered as a result of time constraint.

2.8 Acoustic data analysis

Data from the post-processing LSSS (sA) were averaged per 5 nm. The acoustic data were allocated to the following categories: herring, saithe, demersal fish, blue whiting, pelagic fish and plankton/ myctophidae. To calculate integrator conversion factors the target strengths of the target species herring and sprat, were estimated using the following TS-length relationship:

$$TS = 20\log10L - 71.2 \text{ dB}$$

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)) (ICES 1999). 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 showing the trawl hauls and the CTD, plankton and grab stations are presented in Figure 5C.1 and 5C.2, respectively.

3.1 Acoustic data herring

The distribution of the sA-values assigned to herring, are presented as mean values per 5 n.mi intervals in Figure 5C.3. Herring were distributed in the entire surveyed area, but in general in low densities. The highest mean sA recorded by ICES rectangle was 873 (45F3) followed by sAs of 291 in 45F4 and 195 in 44F5. Pelagic trawling was mainly based on random positions regularly chosen for trawling at the surface, i.e. not based on echo registration. In the "Norwegian" area herring tend to keep close to the surface and may thus be underestimated. More herring schools were observed than in the last years. Most of them were small and occurred scattered throughout the area, either close to the surface or near bottom, but also bigger, more "classical" herring schools were observed this year, near bottom and higher up in the water column.

3.2 Acoustic data Sprat

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

3.3 Biological data

A total of 78 valid trawl hauls were carried out, of which 58 (39 PT and 19 BT) were taken in the "herring" area (Figure 5C.1, Table 5C.2). In general 30 min hauls were made. Catch composition per haul is given in Table 5C.3. Herring were present in 27 hauls of sample size >20 herring. The length distributions of herring are presented in Table 5C.4. A total of 2 504 herring were length measured and 1 326 were aged (winter rings in otoliths). A small number of herring infected by *Ichthyophonus* was observed (<10 herring).

3.4 Abundance and Biomass estimates

The abundance and biomass estimates presented, are confined to the Norwegian target area between 57° and 61.5°N, 2° and 6°E. The geographical distribution of the sA-values assigned to herring, are presented in Figure 5C.3. The highest values were encountered in the central area, between 57°30′N and 58°30′N. Total number of herring was 4.161 million, of which 69% was North Sea Autumn Spawners (NSAS). Total biomass of NSAS was estimated to 239,000 tonnes and the spawning-stock biomass as 95,000 tonnes. These estimates are higher than the respective biomasses from the Norwegian area last year: 175 000 t and 93 000 t. The proportions of mature 2- and 3-ringers by numbers were estimated at 54% and 99%, respectively, higher than the proportions estimated in 2007, 44 and 78%, respectively. Of the estimated numbers of 1-ringers 7% was classified as maturing (2007: 1%). The 1-ringers dominated the North Sea autumn spawners, making 75% in numbers and 60% in biomass.

The total biomass of WBSS was 173,000 tonnes, a large increase since last year.

Few good acoustic marks of herring schools were observed and the majority of the trawling positions were, however, 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 5C.6 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 2008.

3.5 Hydrography

A total of 133 CTD stations were sampled (Figure 5C.2). The horizontal distribution of temperature and salinity at 5 m, 50 m and at seabed, are shown in Figures 5C.4a-c and 5C.5a-c, respectively. The temperature at surface (5 m depth) ranged from 12–15°C in the west to 14–19°C in the east, with the general highest temperature in the northeastern area. At 50 m depth, the highest temperatures were in the west, 10–12° in the Shetland area.

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

4. References

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5. Tables and Figures

Table 5C.1. RV "Johan Hjort", survey 2008207. International acoustic survey on herring in the North Sea, 8–31 July 2008. Simrad ER60 and analysis settings used.

Transceiver Menu	38 kHz
Absorption coefficient	10.2 dB/km
Pulse length	1.024 ms
Bandwidth	2.43 kHz
Max power	2000 W
Two-way beam angle	-22.6 dB
3 dB Beam width	6.24/6.78
Calibration details	
TS of sphere	-33.68
Range to sphere in calibration	15-21.00 m
Transducer gain	26.67
Sa correction	-0.58
Log/Navigation Menu	
Speed	Serial from ship's GPS
Operation Menu	
Ping interval	0.0 - 1.0 sec
Display/Printer Menu	
Integration line	n/a
TS colour min.	-70
Sv colour min.	-34 dB

Table 5C.2. RV "Johan Hjort", survey 2008207, 8–31 July 2008. Details of total trawl stations in the North Sea. PT = Pelagic Trawl, BT = Bottom Trawl. H: herring sample, h: herring, but no biological sample. * = Bottom trawl hauls, but not valid as IBTS hauls.

Date	Trawl haul no	Lat	Long	ICES Area	Time (UTC)	Water depth	Trawl depth	Duration	Herring	Total Catch
						(m)	(m)	min		(kg)
09/07/2008	BT241*	57.708	5.898	44 F5	1912	141	142	13	Not valid	280
09/07/2008	BT242*	57.622	6.008	44 F6	2055	143	143	15	h	82
11/07/2008	PT243	57.013	3.548	43 F3	1	63	0	28	h	107
11/07/2008	PT244	57.002	2.923	43 F2	336	68	0	34	h	10
11/07/2008	PT245	57.473	5.403	43 F5	2130	83	0	29	H	196
12/07/2008	PT246	57.525	6.100	44 F6	106	95	0	21	H	648
12/07/2008	BT247*	57.570	6.190	44 F6	253	143	143	30		301
12/07/2008	BT248*	57.723	5.670	44 F5	648	133	133	19	Not valid	0
12/07/2008	BT249	57.737	4.057	44 F4	1325	77	75	25		24
12/07/2008	BT250	57.740	3.883	44 F3	1511	70	70	24		123
12/07/2008	PT251	57.770	2.082	44 F2	2219	87	0	30		67
13/07/2008	PT252	57.970	2.332	44 F2	107	74	0	30	h	190
13/07/2008	BT253	57.972	3.523	44 F3	607	89	88	30	h	79
13/07/2008	PT254	57.980	4.402	44 F4	1007	102	0	28		11
13/07/2008	BT255	57.960	5.417	44 F5	1450	178	179	31		197
13/07/2008	PT256	58.250	5.365	45 F5	2159	314	0	30	H	245
14/07/2008	PT257	58.243	4.945	45 F4	36	303	0	32	H	76
14/07/2008	BT258	58.238	3.455	45 F3	646	101	102	32	h	126
14/07/2008	BT259*	58.243	3.440	45 F3	826	102	102	55	h	182
14/07/2008	PT260	58.253	3.338	45 F3	1120	98	70	26		21
14/07/2008	PT261	58.258	2.325	45 F2	1541	76	0	30		125
14/07/2008	PT262	58.452	2.100	45 F2	1831	86	0	30		144
14/07/2008	PT263	58.505	2.690	46 F2	2204	101	0	30		119
15/07/2008	PT264	58.522	3.327	46 F3	49	109	0	31	H	1200
15/07/2008	PT265	58.527	4.520	46 F4	532	274	0	29	H	1200
16/07/2008	PT266	58.780	5.088	46 F5	1833	209	0	30	H	316
16/07/2008	PT267	58.777	4.477	46 F4	2233	239	0	34	H	120
17/07/2008	BT268	58.647	3.640	46 F3	439	171	180	30	h	213
17/07/2008	BT269	58.768	2.523	46 F2	1057	109	110	42	H	235
17/07/2008	BT270*	58.780	2.268	46 F2	1416	106	106	24	H	171
17/07/2008	PT271	58.938	2.118	46 F2	1708	110	0	30		17
17/07/2008	BT272	59.035	3.138	47 F3	2223	155	152	30		104
18/07/2008	PT273	59.047	3.863	47 F3	225	275	0	31	H	136
18/07/2008	PT274	59.043	4.818	47 F4	708	244	0	30	H	41
18/07/2008	PT275	59.245	4.842	47 F4	929	191	0	30	h	17
18/07/2008	PT276	59.293	3.880	47 F3	2323	276	0	30	H	168
19/07/2008	PT277	59.293	3.288	47 F3	418	154	0	30	H	244
19/07/2008	BT278	59.302	2.762	47 F2	911	116	118	31		242
19/07/2008	PT279	59.283	2.362	47 F2	1508	127	125	45	h	16
19/07/2008	PT280	59.290	2.188	47 F2	1739	124	0	30		18
19/07/2008	BT281	59.318	1.405	47 F1	2217	102	108	30		204
21/07/2008	BT282	59.733	4.067	48 F0	1311	124	126	29	H	184
21/07/2008	BT283	59.688	1.337	48 F1	1649	113	113	14		59
21/07/2008	PT284	59.595	2.117	48 F2	2021	118	0	31	H	55
22/07/2008	BT285	59.625	2.763	48 F2	23	120	120	29		84
22/07/2008	PT286	59.593	2.977	48 F2	236	118	0	30	H	42
22/07/2008	BT287	59.568	3.260	48 F3	451	161	161	30		128
22/07/2008	PT288	59.597	3.773	48 F3	746	266	0	31	H	197
22/07/2008	PT289	59.623	4.875	48 F4	1227	197	0	30	h	1
22/07/2008	PT290	59.790	4.103	48 F4	1752	275	0	34	H	21
22/07/2008	PT291	59.793	3.400	48 F3	2107	245	0	33	H	2000
23/07/2008	PT292	59.787	2.432	48 F2	118	120	0	30	h	67
23/07/2008	BT293	60.068	1.108	49 F1	651	123	123	31	H	249
23/07/2008	BT294	60.227	0.568	49 F0	1000	150	150	24	h	384
24/07/2008	BT295*	60.048	-0.283	49 E9	1849	129	135	31	h / Not valid	160

Table 5C.2. continued.

Date	Trawl haul no	Lat	Long	ICES Area	Time (UTC)	Water depth	Trawl depth	Duration	Herring	Total Catch
						(m)	(m)	min		(kg)
25/07/2008	BT296	60.177	2.630	49 F2	528	103	108	31	h	58
25/07/2008	BT297	60.100	3.167	49 F3	844	158	158	31	h	164
25/07/2008	PT298	60.343	4.447	49 F4	1743	277	0	33	H	99
25/07/2008	PT299	60.337	3.652	49 F3	2112	300	0	30	H	168
26/07/2008	PT300	60.348	2.453	49 F2	138	93	0	30	h	12
26/07/2008	PT301	60.560	2.313	50 F2	607	119	0	34	h	21
26/07/2008	BT302	60.625	2.570	50 F2	830	110	117	30		23
26/07/2008	BT303	60.590	3.027	50 F3	1155	143	156	31	h	263
26/07/2008	PT304	60.562	3.703	50 F3	1541	300	0	30	h	297
26/07/2008	PT305	60.923	0.703	50 F4	2058	360	0	30	h	633
27/07/2008	PT306	61.272	3.262	51 F3	326	379	0	30	h	633
27/07/2008	BT307	61.280	2.037	51 F2	916	143	143	21		128
27/07/2008	BT308	60.932	1.263	50 F1	1359	145	150	30		375
27/07/2008	BT309*	60.947	1.288	50 F3	1622	145	148	30		473
27/07/2008	BT310	61.253	1.277	51 F1	1932	152	152	30	h	1065
27/07/2008	BT311*	61.263	1.317	51 F1	2246	151	151	32		540
28/07/2008	BT312	61.685	1.455	52 F1	339	187	188	30	h	346
28/07/2008	BT313	61.687	0.512	52 F0	818	209	209	30	h	161
28/07/2008	BT314	61.675	-0.307	52 E9	1203	210	210	31		309
28/07/2008	BT315	61.233	-0.247	51 E9	1624	163	163	29	H	190
28/07/2008	BT316	61.230	0.495	51 F0	2005	169	169	31	h	170
29/07/2008	BT317	60.467	-0.187	49 E9	335	111	111	29	H	323
29/07/2008	BT318	59.723	-0.415	48 E9	928	135	137	27	H	161
29/07/2008	BT319	60.713	-0.255	50 E9	1803	94	100	30	H	168
29/07/2008	BT320	60.772	0.535	50 F0	2244	144	144	30	h	247
30/07/2008	PT321	60.753	2.658	50 F2	737	123	0	33		23

Table 5C.3. RV "Johan Hjort" 8–31 July 2008. Catch compositions in the trawl hauls (kg) taken.

	Trawl haul	BT241	BT242	PT243	PT244	PT245	PT246	BT247	BT249	BT250	PT251	PT252	BT253	PT254	BT255	PT256	PT257	BT258	BT259
	Serie no	24401	24402	24403	24404	24405	24406	24407	24409	24410	24411	24412	24413	24414	24415	24416	24417	24418	24419
	ICES SQ	44 F5	44 F6	43 F3	43 F2	43 F5	44 F6	44 F6	44 F4	44 F3	44 F2	44 F2	44 F3	44 F4	44 F5	45 F5	45 F4	45 F3	45 F3
Species	Total Catch	280.409	81.806	107.119	9.619	195.896	648.376	300.96	23.565	122.862	66.796	190.453	79.02	11.465	197.145	245.005	75.539	133.639	182.421
Herring	Clupea harengus		0.266	0.100	0.104	8.070	620.000					0.140	0.115			53.950	25.790	0.358	1.859
Mackerel	Scomber scombrus		0.659	86.660	2.605	124.070	0.676			0.089	26.700	57.130				4.866	3.067		0.439
Horse Mackerel	Trachurus trachurus																		
Blue whithing	Micromesistius poutassou		0.464												42.600	33.450	15.347		
Saith	Pollachius virens	24.605						220.012							57.835	3.890	2.415	13.750	0.945
Cod	Gadus morhua	4.794	1.048					15.047	1.140	46.412			13.915		16.620			29.709	39.610
Haddock	Melanogrammus aeglefinus							1.755	7.521	34.070	0.008	0.008	25.545		1.892			46.970	64.475
Whiting	Merlangius merlangus			0.004		3.400				21.500		0.001	3.350					2.050	3.910
Ling	Molva molva	4.330						2.975							0.712				
Pollack	Pollachius pollachius							5.230											
Hake	merluccius merluccius	1.185	2.256					17.430		9.560			11.240		29.115			22.780	13.420
Norway pout	Trisopterus esmarki	244.000	49.290					15.650							22.200	0.049			
Poor cod	Trisopterus minutus	1.077	5.900					5.140											
Silvery pout	Gadiculus argenteus														0.314				
Tusk	Brosme brosme																		
Angler fish	Lophius piscatorius			2.204				4.025		1.500								2.630	6.090
Spotted catfish	Anarhicas minor	0.109																	
Wolf fish	A.lupus		0.644					0.548											3.455
Lemon sole	Microstomus kitt		0.402					5.080	2.375	1.300			7.350					1.010	9.915
Long rough dab	Hippoglossoides platessoides		0.080					6.550		0.166			2.532		0.624			0.584	1.650
Witch	Glyptocephalus cynoglossus		0.468					1.300					0.408		0.730			0.418	0.518
Plaice	Pleuronectes platessa								0.382	1.030			0.673					1.090	2.945
Dab	Limanda limanda								3.899	2.140			7.735					3.425	4.840
Common sole	Solea solea																		
Atlantic halibut	Hippoglossus hippoglossus									2.085									
Megrim	Lepidorhombus whiffiagonis																		
Lumpsucker	Cyclopterus lumpus		0.427			4.385	14.900					8.030			0.857	6.430			
Garpike	Belone belone																		
Cuckoo ray	R.naevus																		
Thorny skate	Raja radiata		0.971						0.534				1.046					2.815	5.905
Thornback ray	R.clavata																		
Common skate	R.batis																		
Spiny dogfish	Squalus acanthias											0.945							
Dogfish	Scyliorhinus caniculus																		
Snake pipefish	Entelurus aequerius				0.010						0.010								
Argentine	Argentina sphyraena												0.091		21.105			3.165	13.665
Gurnard	Trigla gurnardus			1.091		1.516			3.920	3.010		0.719	3.032		0.176			2.850	7.160
Norway lobster	Nephrops norvegicus		0.084					0.173							1.815				
Other		0.309	18.847	17.060	6.900	54.455	12.800	0.047	3.794	0.000	40.078	123.480	1.988	11.465	0.550	142.370	28.920	0.035	1.620

Table 5C.3. RV "Johan Hjort" 8–31 July 2008. Continued.

Species	Trawl haul	PT260	PT261	PT262	PT263	PT264	PT265	PT266	PT267	BT268	BT269	BT270*	PT271	BT272	PT273	PT274	PT275	PT276	PT277
	Serie no	24420	24421	24422	24423	24424	24425	24426	24427	24428	24429	24430	24431	24432	24433	24434	24435	24436	24437
	ICES SQ	45 F3	45 F2	45 F2	46 F2	46 F3	46 F4	46 F5	46 F4	46 F3	46 F2	46 F2	46 F2	47 F3	47 F3	47 F4	47 F4	47 F3	47 F3
	Total Catch	20.855	124.971	144.009	118.705	1200	1200	315.9	119.733	212.7	235.171	167.336	17.171	103.707	135.71	41.314	17.291	168.433	243.545
Herring	Clupea harengus					1134.650	1150.000	215.000	30.000	0.722	10.500	11.226			100.690	13.981	0.718	32.500	222.000
Mackerel	Scomber scombrus		4.431	52.455	51.330	65.350	50.000	57.900	23.770	3.938	3.417	102.890	0.931		4.317	0.925	0.698	14.113	13.696
Horse Mackerel	Trachurus trachurus								0.628										0.455
Blue whithing	Micromesistius poutassou								47.735	11.665								89.105	
Saith	Pollachius virens									158.170	1.569			42.890	26.840			28.575	
Cod	Gadus morhua									1.790	6.350	4.070	0.002	14.900					
Haddock	Melanogrammus aeglefinus									0.487	147.483	20.520		2.021					
Whiting	Merlangius merlangus	0.003			0.002					0.246	37.380	6.560		1.146	0.003	0.010			
Ling	Molva molva									4.410									
Pollack	Pollachius pollachius									3.822									
Hake	merluccius merluccius									3.829	14.080			1.460					
Norway pout	Trisopterus esmarki									12.660	0.227			23.570					
Poor cod	Trisopterus minutus									0.784				0.850					
Silvery pout	Gadiculus argenteus																		
Tusk	Brosme brosme																		
Angler fish	Lophius piscatorius									3.735				10.640					
Spotted catfish	Anarhicas minor																		
Wolf fish	A.lupus																		
Lemon sole	Microstomus kitt									0.594	2.367	5.708		1.697					
Long rough dab	Hippoglossoides platessoides									5.451	1.322	7.740		2.340					
Witch	Glyptocephalus cynoglossus																		
Plaice	Pleuronectes platessa											1.540							
Dab	Limanda limanda													0.065					
Common sole	Solea solea																		
Atlantic halibut	Hippoglossus hippoglossus										3.788								
Megrim	Lepidorhombus whiffiagonis																		
Lumpsucker	Cyclopterus lumpus	2.661	2.980	1.180									0.018		3.820		0.275	4.140	
Garpike	Belone belone															0.330			0.394
Cuckoo ray	R.naevus																		
Thorny skate	Raja radiata									0.000		0.377							
Thornback ray	R.clavata																		
Common skate	R.batis																		
Spiny dogfish	Squalus acanthias		56.600	39.240	0.686														
Dogfish	Scyliorhinus caniculus																		
Snake pipefish	Entelurus aequerius																		
Argentine	Argentina sphyraena													1.840					
Gurnard	Trigla gurnardus	0.190	0.960	1.134	0.587					0.000	6.460	6.280		0.273					
Norway lobster	Nephrops norvegicus																		
Other		18.001	60.000	50.000	66.100	0.000	0.000	43.000	17.600	0.397	0.228	0.425	16.220	0.015	0.040	26.068	15.600	0.000	7.000

Trawl haul	BT278	PT279	PT280	BT281	BT282	BT283	PT284	BT285	PT286	BT287	PT288	PT289	PT290	PT291	PT292	BT293	BT294	BT295
Serie no	24438	24439	24440	24441	24442	24443	24444	24445	24446	24447	24448	24449	24450	24451	24452	24453	24454	24455
ICES SQ	47 F2	47 F2	47 F2	47 F1	48 F0	48 F1	48 F2	48 F2	48 F2	48 F3	48 F3	48 F4	48 F4	48 F3	48 F2	49 F1	49 F0	49 E9
Total Catch	236.609	15.55	17.956	203.646	184.104	59.191	55.45	83.858	41.815	127.908	196.51	1.003	21.43	2000	66.773	248.901	384.418	159.734
Clupea harengus		0.177			26.240		27.810		6.815		185.810	0.841	10.238	225.297	0.863	7.444	4.585	2.045
Scomber scombrus		0.621			1.912	0.349			35.000		6.180	0.149	4.887	1766.932	64.640		3.018	0.809
Trachurus trachurus							0.640						1.245	7.771	1.270	0.339	0.884	0.315
Micromesistius poutassou																		
Pollachius virens	10.310			16.300	1.850			10.740		75.570						12.610	37.985	1.640
Gadus morhua	21.877			5.655	3.430	0.715		19.400		4.809						24.530	85.033	36.830
Melanogrammus aeglefinus	139.930	3.025		153.185	23.575	44.710		21.720								13.405	26.140	42.380
Merlangius merlangus	1.353	0.003	0.003	12.965	9.325			2.335		5.240		0.013				17.240	12.735	4.512
Molva molva	5.035			0.367		1.314		2.305										3.487
Pollachius pollachius																		
merluccius merluccius	51.335			1.845	2.535			4.940		11.070						10.055	10.220	9.440
Trisopterus esmarki	0.660			0.252	108.390	0.051		3.480		28.090						145.050	189.590	38.560
Trisopterus minutus										0.081						0.300	0.098	
Gadiculus argenteus																	0.492	
Brosme brosme																		
Lophius piscatorius								5.510		1.382							1.158	3.138
Anarhicas minor																		
A.lupus						2.686												
Microstomus kitt	1.140			2.555		0.962		1.080								0.301	0.398	
Hippoglossoides platessoides	0.165			0.243	3.340	0.258		2.740								10.520	7.530	9.845
Glyptocephalus cynoglossus						0.615												
Pleuronectes platessa	1.588				0.767	0.251												
Limanda limanda	0.326			2.915		1.340											0.198	
Solea solea								0.703									0.269	
Hippoglossus hippoglossus				2.520														
Lepidorhombus whiffiagonis						0.418				0.329						1.752	2.530	4.450
Cyclopterus lumpus		7.670	0.960															
Belone belone																		
R.naevus																		
Raja radiata						0.381		1.990		0.274						0.466		
R.clavata																		
R.batis																		
Squalus acanthias																		
Scyliorhinus caniculus																		0.483
Entelurus aequerius																		
Argentina sphyraena				1.834				4.100									0.247	
Trigla gurnardus	2.890	1.044	0.213	3.010	0.675	1.455		2.815		0.300						3.945	1.308	1.300
Nephrops norvegicus										0.165								
	0.000	3.010	16.780	0.000	2.065	3.686	27.000	0.000	0.000	0.598	4.520	0.000	5.060	0.000	0.000	0.944	0.000	0.500

Table 5C.3. RV "Johan Hjort" 8–31 July 2008. Continued.

	Trawl haul	BT296	BT297	PT298	PT299	PT300	PT301	BT302	BT303	PT304	PT305	PT306	BT307	BT308	BT309*	BT310*	BT311	BT312	BT313
	Serie no	24456	24457	24458	24459	24460	24461	24462	24463	24464	24465	24466	24467	24468	24469	24470	24471	24472	24473
	ICES SQ	49 F2	49 F3	49 F4	49 F3	49 F2	50 F2	50 F2	50 F3	50 F3	50 F4	51 F3	51 F2	50 F1	50 F3	51 F1	51 F1	52 F1	52 F0
Species	Total Catch	58.285	163.723	98.928	167.63	12.283	20.628	22.833	263.02	297.273	632.898	633.442	128.306	374.63	473.273	1064.62	539.614	345.713	161.406
Herring	Clupea harengus	0.853	1.581	34.290	18.110	0.555	0.177		0.489	1.953	0.710	5.146				3.072		0.333	0.393
Mackerel	Scomber scombrus	0.751	0.572	26.820	102.350	9.849	2.080	0.668	1.129	288.380	623.520	592.480	0.983		0.792	0.210			
Horse Mackerel	Trachurus trachurus				4.400		0.356		0.396	2.367	6.875	35.510	66.395	1.210	0.533	0.327			
Blue whithing	Micromesistius poutassou								0.307						0.212	5.030		40.400	25.730
Saith	Pollachius virens	8.640	99.760		19.290				47.890				23.555	12.329	32.722	914.520	500.000	150.000	58.650
Cod	Gadus morhua	3.211	3.275					0.220	7.085					23.530	17.271	16.970	6.280	2.995	8.010
Haddock	Melanogrammus aeglefinus	12.209	0.136					6.413	0.030				0.670	13.596	19.461	8.902	8.334	2.370	0.807
Whiting	Merlangius merlangus	1.575	0.718	0.009			0.009	0.555	6.025				1.525	8.350	24.190	8.525			
Ling	Molva molva	5.495							0.525					6.510		8.665		27.810	8.795
Pollack	Pollachius pollachius								4.935							7.450	25.000		
Hake	merluccius merluccius	2.220	2.000					1.592	7.815				1.545	59.850	66.120	36.065		5.340	44.255
Norway pout	Trisopterus esmarki	0.048	44.700						166.945				29.240	232.600	280.000	40.000		16.205	3.400
Poor cod	Trisopterus minutus								0.064									1.176	
Silvery pout	Gadiculus argenteus																	79.760	2.100
Tusk	Brosme brosme													1.150					3.110
Angler fish	Lophius piscatorius	7.885	3.030					1.577	3.710									7.290	
Spotted catfish	Anarhicas minor																		
Wolf fish	A.lupus							4.058											
Lemon sole	Microstomus kitt	1.004	1.230						2.105				0.176			0.174		0.414	0.218
Long rough dab	Hippoglossoides platessoides	0.293	1.480					0.621	7.100				0.093	10.100	20.900	1.720			
Witch	Glyptocephalus cynoglossus															0.160			0.226
Plaice	Pleuronectes platessa																		
Dab	Limanda limanda	0.906						2.218							1.580				
Common sole	Solea solea																		
Atlantic halibut	Hippoglossus hippoglossus																		
Megrim	Lepidorhombus whiffiagonis		1.121						2.455				0.269		0.490	5.700		5.325	
Lumpsucker	Cyclopterus lumpus			1.206	3.408	1.149	1.482			1.362	0.278								
Garpike	Belone belone																	1.135	
Cuckoo ray	R.naevus																		
Thorny skate	Raja radiata	0.997						0.459							0.592	0.614			
Thornback ray	R.clavata																		
Common skate	R.batis																		
Spiny dogfish	Squalus acanthias																		
Dogfish	Scyliorhinus caniculus															0.708			1.062
Snake pipefish	Entelurus aequerius			0.003															
Argentine	Argentina sphyraena		0.077						0.208				0.610	1.900					
Gurnard	Trigla gurnardus	6.718	3.940			0.730	0.384	3.152	3.425	0.372			3.245	3.505	5.720	5.440		0.640	0.700
Norway lobster	Nephrops norvegicus																		
Other		5.480	0.103	36.600	20.072	0.000	16.140	1.300	0.382	2.839	1.515	0.306	0.000	0.000	2.690	0.365	0.000	4.520	3.950

	Trawl haul	BT314	BT315	BT316	BT317	BT318	BT319	BT320	PT321
	Serie no	24474	24475	24476	24477	24478	24479	24480	24481
	ICES SQ	52 E9	51 E9	51 F0	49 E9	48 E9	50 E9	50 F0	50 F2
Species	Total Catch	309.413	190.242	170.34	322.67	160.9	168.089	246.98	23.103
Herring	Clupea harengus		21.986	4.304	29.100	73.000	10.822	1.700	
Mackerel	Scomber scombrus	0.352			0.387	7.365			21.100
Horse Mackerel	Trachurus trachurus		1.745	0.212	0.296				
Blue whithing	Micromesistius poutassou	45.600	34.140	27.875					
Saith	Pollachius virens	112.985	57.595	50.640		1.045		56.600	
Cod	Gadus morhua	6.115	7.445	18.310	36.720	0.745	25.690	47.920	
Haddock	Melanogrammus aeglefinus	6.523	6.475	8.110	96.975	18.410	48.450	37.540	
Whiting	Merlangius merlangus		1.115		5.730	9.250	1.300	10.955	0.003
Ling	Molva molva	28.220		4.230			4.485	2.310	
Pollack	Pollachius pollachius							39.450	
Hake	merluccius merluccius	5.745	12.645	25.820	110.885	5.955	26.760	6.335	
Norway pout	Trisopterus esmarki	30.800	19.860	8.095	2.603	29.800	0.602	21.800	
Poor cod	Trisopterus minutus			0.099	1.536		4.340		
Silvery pout	Gadiculus argenteus	14.560		0.995					
Tusk	Brosme brosme	2.655							
Angler fish	Lophius piscatorius	10.450	13.790		3.532	2.555			
Spotted catfish	Anarhicas minor								
Wolf fish	A.lupus								
Lemon sole	Microstomus kitt		0.627	0.287	3.410	4.080	1.064	0.525	
Long rough dab	Hippoglossoides platessoides	0.020	0.400	4.020	0.533	5.155	0.238	4.900	
Witch	Glyptocephalus cynoglossus			0.608					
Plaice	Pleuronectes platessa				6.685		5.690	0.420	
Dab	Limanda limanda				0.813		1.357		
Common sole	Solea solea								
Atlantic halibut	Hippoglossus hippoglossus				4.645				
Megrim	Lepidorhombus whiffiagonis	6.348	7.470	6.075	2.175			8.150	
Lumpsucker	Cyclopterus lumpus								
Garpike	Belone belone								
Cuckoo ray	R.naevus		1.160		1.401			2.775	
Thorny skate	Raja radiata								
Thornback ray	R.clavata			2.264					
Common skate	R.batis	2.800							
Spiny dogfish	Squalus acanthias								
Dogfish	Scyliorhinus caniculus			3.410		1.935	11.715		
Snake pipefish	Entelurus aequerius								
Argentine	Argentina sphyraena					0.640		3.300	
Gurnard	Trigla gurnardus	10.040	1.040	3.115	9.195	0.965	6.786	1.980	
Norway lobster	Nephrops norvegicus							0.320	
Other		26.200	2.749	1.871	6.049	0.000	18.790	0.000	2.000

Table 5C.4. RV "Johan Hjort" 8–31 July 2008. Norwegian Acoustic area, F2-F6. Herring length (cm) distribution in trawl hauls where sample size>20 herring.

Trawl st ICES Sq	PT245 43 F5	PT246 44 F6	PT256 45 F5	PT257 45 F4	PT264 46F3	PT265 46F4	PT266 46F5	PT267 46 F4	BT269 46 F2	BT270 46 F2	PT273 47 F3	PT274 47 F4	PT276 47 F3	PT277 47F3
16.0														
16.5	2													
17.0	16				1									
17.5	20	3	1	2	5	2			2					
18.0	17	3			6	5			1			1		
18.5	14	9	1	2	8	3	4	1						
19.0	15	11	1	3	22	9	4	3	1					
19.5	5	14	1	2	17	3	1		1					
20.0	6	12		1	12	4	5	2				1		
20.5	1	16		1	11	5	4	3	1					
21.0	2	10		2	11	7	1	1	2					
21.5	1	5	2	1	6	3	2	1	1					
22.0	1	6		3	1	5	2	4	2					
22.5		5	3	4		3	6	2		1	1			
23.0		1	7	9		2	8	4		3		2		
23.5		4	10	7		2	5	10	2	2	1	8	3	
24.0			11	8		3	5	2		1	2	8		
24.5			19	19		2	11	16	1	4	3	18	6	
25.0		1	13	11		8	9	21	1	7	4	16	12	3
25.5			7	4		6	6	7	1	4	8	5	6	1
26.0			11	6		7	10	5	2	12	12	11	11	3
26.5			5	5		8	4	2	1	6	7	8	12	4
27.0			2	3		1	3	3	2	4	11	4	10	9
27.5			5	3		6	5	6	12	12	13	9	14	9
28.0				1			3	4	6	7	7	2	8	10
28.5			1	2		3	1	1	8	3	11	3	6	20
29.0						1		1			2	2	4	11
29.5				1		1		1	6	1	7		4	10
30.0									2	2	1		3	8
30.5						1					3			6
31.0									1		4			3
31.5									1		3	1		1
32.0														2
32.5														
33.0														
33.5														
34.0														
34.5														
35.0														
35.5									1				1	
36.0														
36.5														
37.0														
37.5														
Grand Total	100	100	100	100	100	100	99	100	58	69	100	99	100	100
MeanL (cm)	18.5	20.5	24.8	24.3	19.8	23.3	24.1	24.8	26.7	26.6	27.6	25.7	27.1	28.8
Mean w (gr)	48.4	73.6	121.8	120.6	68.9	115.2	120.2	122.4	178.7	162.7	185.4	140.2	169.8	210.8

Table 5C.4: Continued.

Trawl st ICES Sq	BT282 48 F0	PT284 48 F2	PT286 48 F2	PT288 48 F3	PT290 48 F4	PT291 48 F3	BT293 49 F1	PT298 49 F4	PT299 49 F3	BT315 51 E9	BT317 49 E9	BT318 48 E9	BT319 50 E9
16.0								1					
16.5													
17.0								1					
17.5								4					
18.0								7					
18.5								9					
19.0								16					
19.5								6					
20.0	1		1					6					
20.5								8					
21.0								2					
21.5													
22.0													
22.5													
23.0													
23.5				2				1					
24.0	1			3									
24.5				6	3			3	4				
25.0			1	24	7	1		5	18				
25.5	1	1	1	11	6	2		6	11				
26.0	3	2	3	16	10	2		4	10			1	
26.5	3	4		16	9	1		7	20		4	2	1
27.0	5	5	2	10	7	4		5	7		5	8	2
27.5	16	10	5	7	4	13		3	11		17	10	18
28.0	19	14	4	3	3	12	3	1	7		10	18	12
28.5	32	20	5	2	4	19	2	3	2		12	24	7
29.0	5	10	2		3	2					11	9	2
29.5	9	16	5		2	10	8	2	4		10	11	3
30.0	2	6	3		1	9	7		1		5	6	3
30.5	2	10	1		2	3	3			5	4	3	1
31.0		1	1			3	2			5	6	4	1
31.5		1	1				2		1	8	6	2	
32.0	1					1	1		3	20	4		
32.5									1	11	2		
33.0						2				9	1	2	
33.5					1					2	1		
34.0										3	1		
34.5													
35.0													
35.5											1		
36.0													
36.5													
37.0													
37.5													
Grand Total	100	100	35	100	62	84	28	100	100	63	100	100	50
Mean L (cm)	28.3	28.9	28.3	26.2	27.1	28.9	30.1	22.2	27.0	32.4	29.5	28.9	28.4
Mean w (gr)	203.9	228.0	194.7	146.1	165.1	210.6	265.9	101.3	158.1	349.0	248.3	221.6	216.4

Table 5C.5. RV "Johan Hjort" 8–31 July 2008. 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 Autmn Spawners				Western Baltic Spring Spawners			
Age	L_{mean}	W_{mean}	No (mill)	%	Biom (10^3)	%	No (mill)	%	Biom (10^3)	%
1I	19.4	64.1	2003	69.7	127	53.1	266	20.7	19	10.8
1M	22.4	100.1	153	5.3	15	6.4	12	1.0	1	0.7
2I	20.8	77.5	208	7.2	16	6.9	52	4.1	4	2.2
2M	24.5	137.2	247	8.6	34	14.3	40	3.1	5	3.1
3I	24.6	125.2	1	0.0	0	0.1	2	0.2	0	0.2
3M	25.3	139.5	102	3.5	15	6.2	410	31.8	57	32.8
4I	26.0	136.0	0	0.0	0	0.0	1	0.0	0	0.0
4M	26.2	156.5	43	1.5	7	2.9	166	12.9	26	14.9
5I	24.0	126.0	0	0.0	0	0.0	0	0.0	0	0.0
5M	27.3	177.6	38	1.3	7	3.0	177	13.8	31	18.0
6I	26.0	136.0	0	0.0	0	0.0	0	0.0	0	0.0
6M	27.8	186.5	44	1.5	9	3.9	113	8.8	20	11.6
7I	-	-	0	0.0	0	0.0	0	0.0	0	0.0
7M	29.1	232.5	23	0.8	5	2.2	20	1.6	5	2.7
8	27.5	187.0	7	0.2	2	0.6	20	1.5	3	2.0
9+	29.9	243.6	5	0.2	1	0.5	7	0.5	2	1.0
Total	22.0	98.9	2874	100.0	239	100.0	1287	100.0	173	100.0
Immature	19.6	65.6	2212	77.0	143	60.0	321	25.0	23	13.3
Mature	25.7	150.8	662	23.0	95	40.0	966	75.0	150	86.7

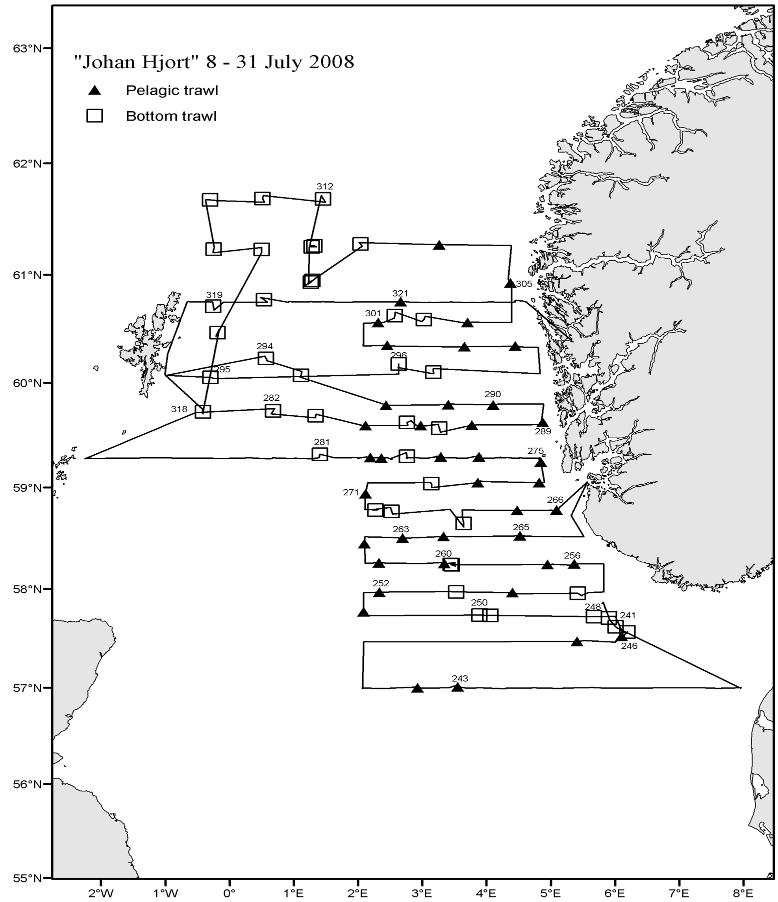

Figure 5C.1. RV "Johan Hjort" 8–31 July 2008. Cruise track and fishing trawl hauls undertaken during the survey.

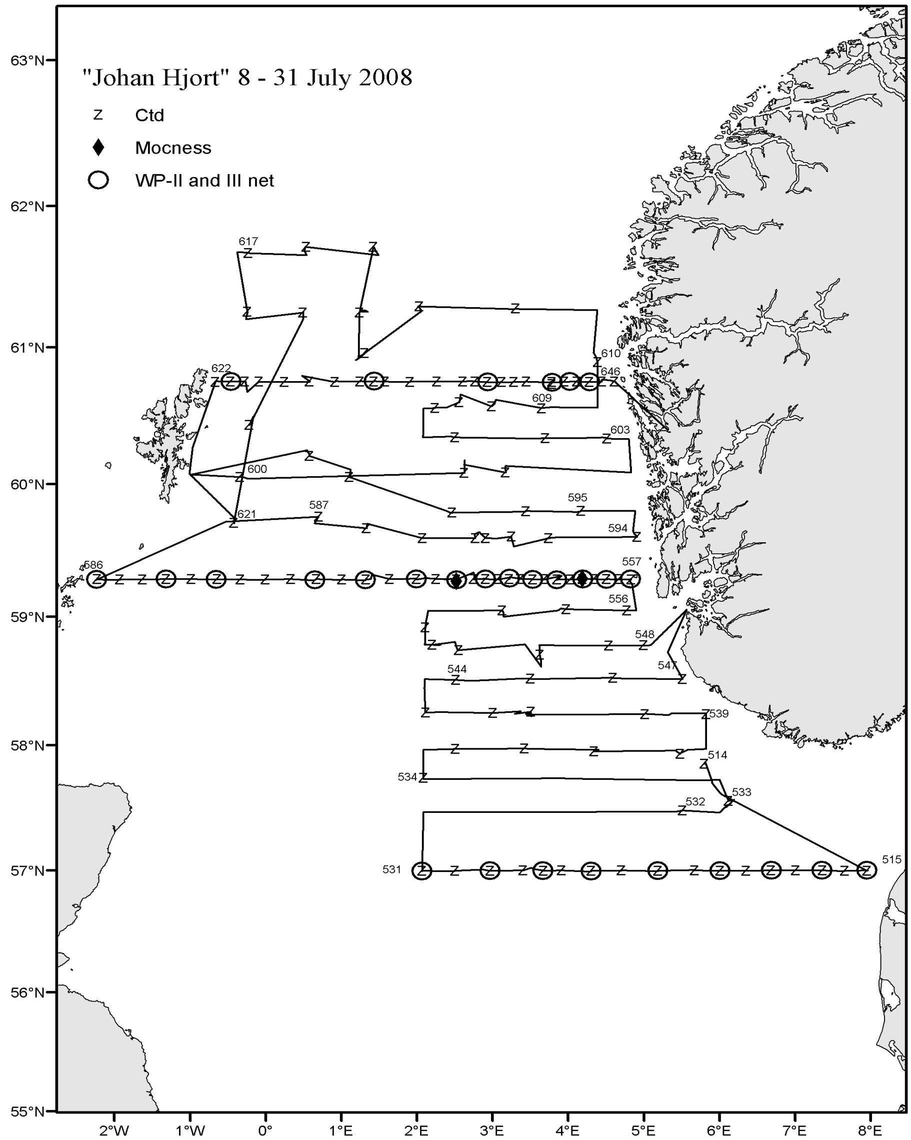

Figure 5C.2. RV "Johan Hjort" 8–31 July 2008. Cruise track, CTD and plankton- stations taken during the survey.

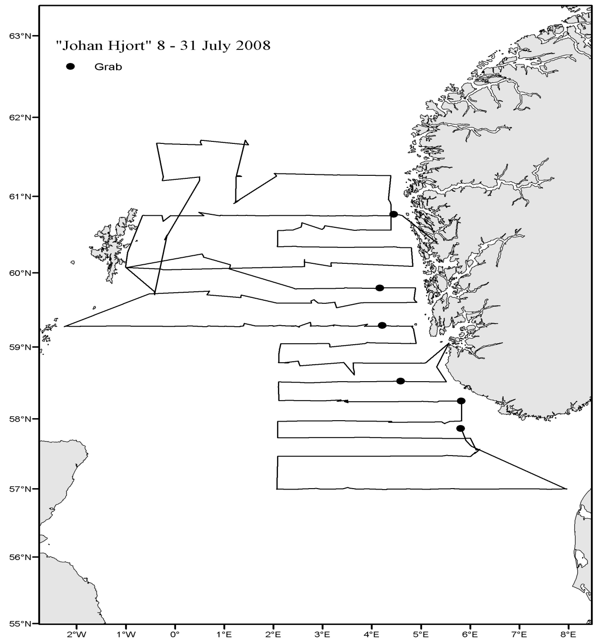

Figure 5C.3. RV "Johan Hjort" 8–31 July 2008. Distribution of grab (boxcore) stations.

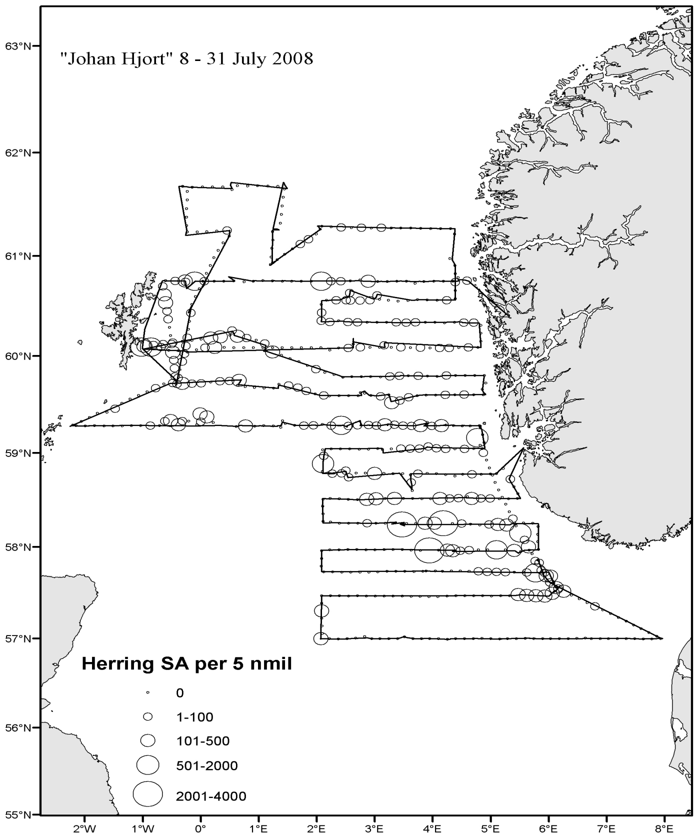

Figure 5C.4. RV "Johan Hjort" 8–31 July 2008. Distribution of sA (NASC) values attributed to herring per 5 nautical miles along the cruise track.

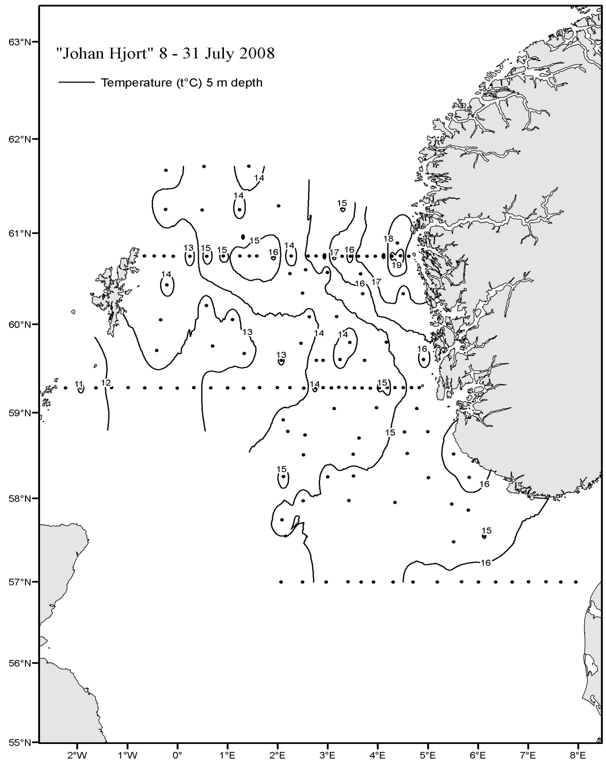

Figure 5C.4a. RV "Johan Hjort" 8–31 July 2008. The horizontal distribution of temperature at 5 m depth.

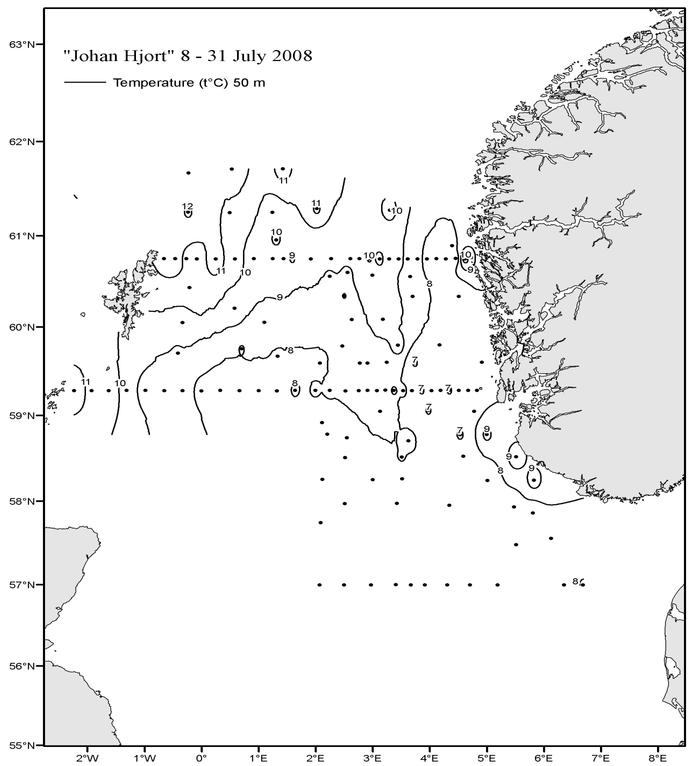

Figure 5C.4b. RV "Johan Hjort" 8–31 July 2008. The horizontal distribution of temperature at 50m depth.

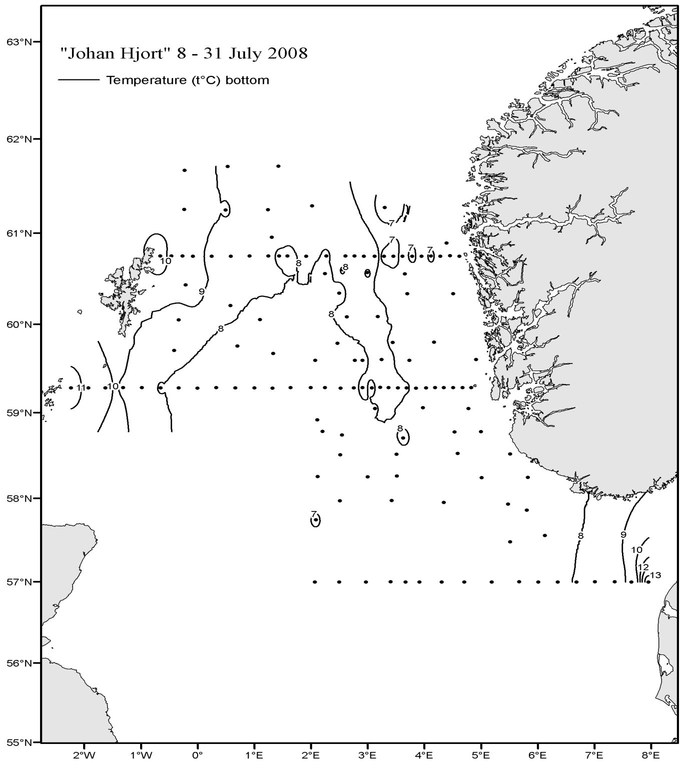

Figure 5C.4c. RV "Johan Hjort" 8–31 July 2008. The horizontal distribution of temperature at bottom.

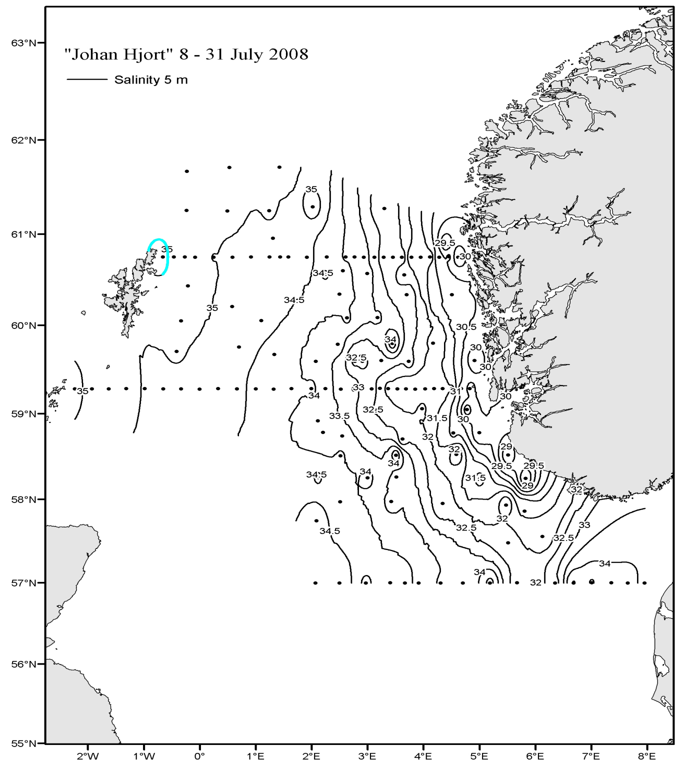

Figure 5C.5a. RV "Johan Hjort" 8–31 July 2008. The horizontal distribution of salinity at 5 m.

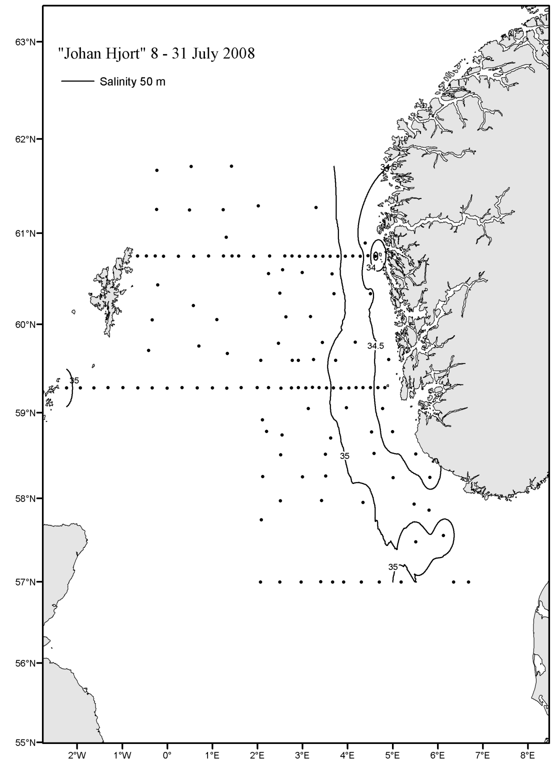

Figure 5C.5b. RV "Johan Hjort" 8–31 July 2008. The horizontal distribution of salinity at 50 m depth.

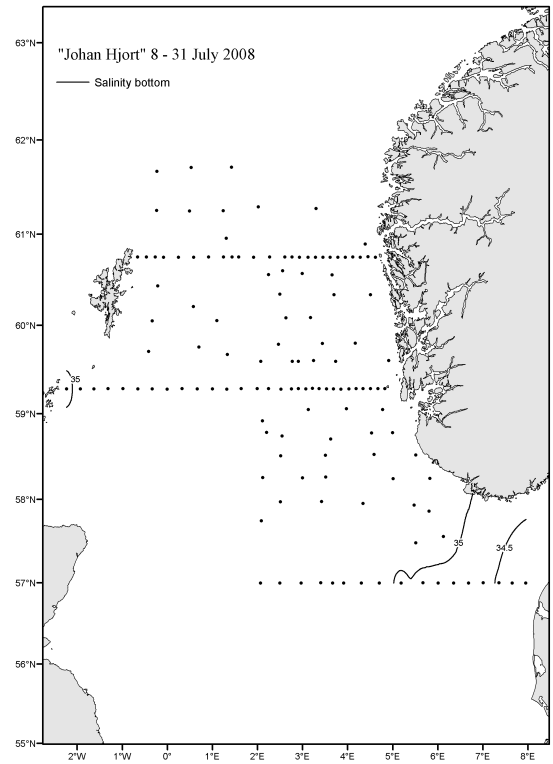

Figure 5C.5c. RV "Johan Hjort" 8–31 July 2008. The horizontal distribution of salinity at bottom.

ANNEX 5D: Scotland (East)

Survey report for RV *Scotia*

28 June – 18 July 2008

P. J. Copland, FRS Marine Lab Aberdeen.

1. INTRODUCTION

1.1 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 the 18 July 2008 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 2009. This survey has been carried out by the Marine Laboratory at this time every year since 1984.

1.2 Objectives

1) To conduct an acoustic survey to estimate the abundance and distribution of herring in the northwestern 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 in-situ target strength data on herring using the autonomous echosounder mounted in a drop frame.

2. SURVEY DESCRIPTION AND METHODS

2.1 Personnel

Phil Copland	(In Charge)
Paul Fernandes	Fisheries Biologist (Part 1)
Stephen Keltz	Fisheries Biologist
Rui Catarino	Fisheries Biologist
Andrzej Jaworski	Fisheries Biologist (Part 1)
Jim Hunter	Oceanographic Technician
Owen Goudie	Fisheries Biologist
Dave Lee	Engineer (Part 2)
Sascha Faessler	Student, FRS
Jenny Hochmuth	Student, Aberdeen University

2.2 Narrative

All gear was loaded in Aberdeen on 26 and 27 June. Scientific staff joined the vessel at 0800 BST on 28 June and it departed at 0915 on the same day. 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. The 4 hour training period for vessel crew was carried out en route to Scapa Flow. Deployments of the PT160 pelagic trawl with multicodend sampler and ARIES sampler were conducted, during this period, to familiarise staff with the handling of the equipment. Calibration of the hull mounted transducers took place in Scapa Flow between 2330 on 28 June and 0600 on 29 June. Calibration of the autonomous echosounder transducers continued until 1100 after which Scotia made her way to east of the Pentland Firth to the first survey transect. Transects extended as far east as 1° 45E, and as far as safely possible to the west, on approaching the coast.

On the afternoon of the 6 July, Scotia assisted by standing by and providing pumping equipment to a diver's cruise vessel which had asked for coast guard assistance in the vicinity of Sumburgh head. Scotia stood by for approximately 4 hours until released by the coast guard.

A half landing took place on 7 July in Lerwick in accordance with rest provision for the Working Time Directive and to allow for the exchange of personnel (P Fernandes and Andrzej Jaworski left and David Lee joined). The vessel resumed surveying at 1100 on 8 July. West of the Shetland Isles, transects extended from the coast to the shelf edge or longitude 4° west. The survey was completed on 17 July at around 0500. All four hull transducers were calibrated successfully in Scapa Flow between 0800 and 1400 on 17 July. Scotia returned to Aberdeen on the morning of 18 July.

2.3 Survey design

The survey track (Fig 5D.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. In the areas to the east of Shetland and in the extreme southeast corner, short additional transects were carried out at 7.5 nautical mile spacing. 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 the 7.5nm transect spacing was used the same random origin was used (as a proportion of the intertransect space).

2.4 Calibration

Two calibrations were carried out of the EK60 echosounder system used during the survey: one at the beginning of the survey on 28 and 29 June (overnight) in Scapa Flow and one at the end of the survey on 17 July in Scapa Flow. A calibration of the drop frame echosounder system was carried out only at the start of the cruise. Standard sphere calibrations were carried using 38.1mm diameter tungsten carbide sphere for 18, 38, 120 and 200 kHz. Agreement between the calibrations for 38 kHz was approximately 0.14 dB. The calibration settings and results for 38 kHz are given in Table 5D.1.

2.5 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. Data were collected from 0200 to 2200 GMT. A total of approx. 2100 nautical mile of acoustic survey track were included in the analysis.

2.6 Biological data – fishing trawls

A total of 29 trawl hauls (positions shown in Fig 5D.1) were carried out during the survey on the denser echotraces. The fishing gear used throughout the survey was the PT160 pelagic trawl augmented by the addition of a three codend multisampling trawl. Each haul was monitored using a Simrad FS903 scanning netsonde. The catch from each haul was sampled for length, age, maturity and weight of individual herring. In addition, weights of gonads and livers were also collected. Between 250 and 500 fish were measured at 0.5 cm intervals from each haul. Otoliths were collected with one per 0.5 cm class below 20.5 cm, three per 0.5 cm class from 21–25.5 cm and ten per 0.5 cm class for 26.0 cm and above. The same fish were sampled for whole weight, gonad weight, liver weight, sex, maturity, stomach contents and macroscopic evidence of Ichthyophonus infection. The maturity scale used in data collection was the Scottish 8 point scale.

2.7 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 ARIES sampler. Integrated whole water column plankton, as filtered by a 200 micrometre net, were also collected at each hydrographic station. A total of 34 deployments of the ARIES vehicle were taken to provide at least one set of samples in each statistical rectangle that was surveyed.

2.8 Data analysis

Data from the echo integrator were averaged over quarter hour Equivalent Distance Sampling Units (EDSU of approximately 2.5 nautical miles 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 five 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) Gadoids
5) Norway pout

“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 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.

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

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

$$\text{gadoid TS} = 20\log_{10}L - 67.5 \text{ dB per individual}$$

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 program (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 5D.2. The distribution of fish differed from 2007, with many herring schools being detected along the 0° line for the whole length of Shetland. Very little was detected at the northern extremes and little too was detected west of Shetland. Most schools in the western area were relatively small and isolated, as well as difficult to catch, although there was a concentration of larger schools seen west of Eysh’s Point. (60° 35N, 1° 63W). Some herring schools were of the typical tall pillar shape, but most were detected as small schools very close to the seabed. The NASC values did not differ significantly from the previous year with a few large values in the order of 7000 m^2.nautical mile^{-2} (in 2007 the maximum NASC was 5016 m^2.nautical mile^{-2}).

3.2 Biological data

Fishing was generally successful and 29 trawl hauls were carried out (Figure 5D.1). The positions, dates and time of these are given in Table 5D.2. In addition to length frequency data, a total of 1631 herring were sampled for weight, sex, maturity and otoliths. A subset of these was sampled for fat content. The 20 hauls with significant numbers of herring were used to define four survey subareas (Figure 5D.3):

I/ A: Area in South West bounded by 4° W — 1° E and 58° 30′— 59° N. Mean length 25.86cm

II/B: Central area encompassing Orkney and east of Shetland to 60° 45′N. Mean length 28.27cm

III/C: Eastern Area to North and east of Shetland. Mean length 29.35cm

IV/D: Northern area to North and West of Shetland. Mean length 30.30cm

Table 5D.3 demonstrates 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 5D.4. The spatial distribution of mean length is shown in Figure 5D.3. Two age length keys, one per area, were constructed. The stratified weight at length data were used to define the weight-length relationship for herring, which was:

$$W = 0.0018 L3.494$$

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 92, 99 and 99% respectively.

3.3 Biomass and Abundance estimates

The total biomass estimates for the survey were:

Total herring	922,190 tonnes	
Spawning stock biomass	914,070 tonnes	99.12%
Immature	8,110 tonnes	0.88%

The numbers and biomass of fish by quarter ICES statistical rectangle are shown in Figure 5D.4. A total estimate of 4,104 million herring or 922 thousand tonnes was calculated for the survey area. 914 thousand tonnes of these were mature. Herring were generally found in similar water depths and location to 2007. Significantly however there were fewer shoals detected in inshore waters around Orkney and Shetland. There also appeared to be fewer shoals east of the 0° line. Table 5D.6 demonstrates 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 5D.3) demonstrates that, aside from herring, the numbers caught were very small. The dominant species other than herring were mackerel, followed by Norway pout, haddock and whiting. No cod were caught as bycatch in any of the hauls.

3.4 Ichthyophonus Infection

Seven of the 1631 fish examined for macroscopic evidence of ichthyophonus were found to be infected. Unusually, these were all from a single haul. Haul 215 off the island of Fetlar (60° 35N, 0° 14E).

Multisampler

Although it collected valuable data on the majority of hauls, the multisampler exhibited a number of faults during the survey. The faults generally created uncertainty in whether the bars had been deployed successfully. Some work on the system will be required before it is used again.

3.5 Autonomous Echosounder

The autonomous echosounder system worked very reliably during the survey. 6 deployments were made with the system in locations where herring shoals had been identified by trawl sampling. The results of these deployments are the subject of a separate presentation at PGIPS.

4 Tables and Figures

Table 5D.1. Simrad EK60 and analysis settings and calibration results from the Scotia herring acoustic survey 28 June – 17 July 2008.

TRANSCEIVER PARAMETERS		
Frequency	38 kHz	
Sound speed	1500 m.s-1	
Max. Power	2000 W	
Equivalent two-way beam angle	-20.9 dB	
Default Transducer Sv gain	23.95 dB	
3 dB Beamwidth	7.1°	
CALIBRATION DETAILS		
	28 June 2008	17 July 2008
TS of sphere	-42.33 dB	-42.33
Range to sphere in calibration	12.148 m	12.388
Measured NASC value for calibration	2057	1985
Calibrated Sv gain	23.38	23.24
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 5D.2. Details of the fishing trawls taken during the Scotia herring acoustic survey, 28 June – 18 July 2008: 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.

Haul no	Date	Time (UTC)	Position Mid Point	Water depth	Trawl depth	Gear	Duration	Use	Weight
197 C1	29/6/2008	1718	58°35.27 N, 1°39.95W	123	114	PT160 + MS	24	h	360
197 C2	29/6/2008	1746	58°35.27 N, 1°39.95W	123	70	PT160 + MS	5	h	3.6
198 C1	30/6/2008	0433	58°32.55 N, 0°14.29W	133	119	PT160 + MS	20	h	1500
198 C2	30/6/2008	0454	58°32.55 N, 0°14.29W	133	110	PT160 + MS	7	h	90
199 C1	30/6/2008	1743	58°40.09 N, 0°49.39W	123	123	PT160 + MS	33		28
200 C1	01/07/2008	0731	58°43.71 N, 0°0.01E	115	101	PT160 + MS	12	h	300
201 C1	01/07/2008	1443	58°35.2 N, 1°5.75E	143	125	PT160 + MS	38		0.5
202 C1	02/07/2008	1243	58°50.32 N, 2°6.56W	85	53	PT160 + MS	18		30.7
202 C2	02/07/2008	1306	58°50.32 N, 2°6.56W	85	65	PT160 + MS	19		3
203 C1	03/07/2008	0445	59°28.57 N, 0°38.16W	123	112	PT160 + MS	55	h	99.4
204 C1	03/07/2008	1122	59°5.04 N, 0°5.07E	130	99	PT160 + MS	60	h	41.3
205 C1	04/07/2008	0944	59°20.18 N, 1°14.88W	108	90	PT160 + MS	22		1.5
205 C2	04/07/2008	1010	59°20.18 N, 1°14.88W	108	57	PT160 + MS	27		1.654
206 C1	04/07/2008	1709	59°29.65 N, 2°18.47W	84	71	PT160 + MS	33		7.35
207 C1	04/07/2008	23.56	59°35.23 N, 1°14.57W	106	86	PT160 + MS	22		60
208 C1	05/07/2008	0720	59°35.21 N, 0°3.32E	132	116	PT160 + MS	34	h	157.1
209 C1	05/07/2008	1418	59°36.94 N, 1°45.54E	123	100	PT160 + MS	28	h	53
210 C1	06/07/2008	0435	59°50.21 N, 0°2E	145	124	PT160 + MS	44		2
211	06/07/2008	1914	60°5.85 N, 0°0.49E	140	129	PT 160	34	h	360
212	08/07/2008	1613	60°4.77 N, 0°5.9E	159	136	PT 160	44	h	450
213	09/07/2008	1022	60°20.17 N, 0°5.75E	150	150	PT 160	7	h	1500
214 C1	10/07/2008	0705	60°47.57 N, 0°3.44W	145	145	PT160 + MS	14	h	25.6
215 C1	10/07/2008	1030	60°35.1 N, 0°13.58E	143	143	PT160 + MS	19	h	150
216 C1	10/07/2008	1651	60°35.17 N, 1°7.67E	140	140	PT160 + MS	15	h	2100
217 C1	11/07/2008	0331	60°45.42 N, 1°44.67E	128	128	PT160 + MS	31		11.35
218 C2	11/07/2008	1003	60°50.12 N, 0°17.66E	137	137	PT160 + MS	55	h	180
219 C1	11/07/2008	1417	60°54.98 N, 0°11.61W	162	162	PT160 + MS	26	h	316.6
220 C1	12/07/2008	1516	61°24.38 N, 1°6.31E	161	161	PT160 + MS	23	h	9.2
220 C3	12/07/2008	1550	61°24.38 N, 1°6.31E	161	161	PT160 + MS	9		86.5
221 C1	13/07/2008	0735	61°17.61 N, 1°5.94W	178	178	PT160 + MS	20	h	234.1
221 C3	13/07/2008	0758	61°17.61 N, 1°5.94W	178	178	PT160 + MS	12		64.4
222 C1	13/07/2008	1540	60°50.2 N, 1°28.21W	113	113	PT160 + MS	34	h	25.4
223 C1	14/07/2008	0458	60°35.17 N, 1°55.7W	100	100	PT160 + MS	28		1950
224	14/07/2008	0804	60°35.22 N, 1°55.85W	126	126	PT 160	24	h	2100
225	16/07/2008	1223	59°35.175 N, 3°46.885W	160	157	PT 160	16	h	750

Table 5D.3a. Total catch by species for trawl hauls from the Scotia acoustic survey 28 June – 18 July 2008. Estimated total catch is given in kg and numbers by individual species

Haul No	Est catch (Kgs)	Herring	Mackerel	Horse Mackerel	Saithe	Haddock	Whiting	Grey gurnard	Hake	N.Pout
		Clupea harengus	*Scomber scombrus*	*Trachurus trachurus*	*Pollachius virens*	*M. aeglefinus*	*Merlangius merlangus*	*Eutrigla gurnardus*	*Merluccius merluccius*	*Trisopterus esmarki*
197 C1	360	2536	8							8
197 C2	3.6	3	13							
198 C1	1500	8501								
198 C2	90	591								
199 C1	28		134							
200 C1	300	1675	5							
201 C1	0.5		1							
202 C1	30.7		1			123		111		
202 C2	3					8		23		
203 C1	99.4	517								2
204 C1	41.3	155	22							
205 C1	1.5		1			6		2		
205 C2	1.654							20		
206 C1	7.35		24							541
207 C1	60					6	7	10	40	16
208 C1	157.1	596	172			1				
209 C1	53	13	158			2		3		
210 C1	2	7	2						1	
211	360	1613								
212	450	1868								
213	1500	5897						21		
214	25.6	21			19	2				
215 C1	150	715	8							
216 C1	2100	8408								
217 C1	11.35	2	55							
218 C2	180	657								
219 C1	316.6	1109			2				1	
220 C1	9.2	33								
220 C3	86.5	12			1					
221 C1	234.1	165	799		1					
221 C2	64.4	15	223			1				
222 C1	25.4	41	26	23						
223 C1	1950									
224	2100	6947	205							
225	750	2909						20		

Table 5D.4a. Herring length frequency percentage for individual trawl hauls by subarea (Figure 5D.3) for the *Scotia* acoustic survey (28 June – 18 July 2008) length in cm, weight in g, calculated target strength in dB per individual using TS=-71.2+20log(L).

Region	I/A				II/B		
Length (cm)	197	mean	198	200	203	204	208
21.00		0.00		0.00			
21.50		0.00		0.00			
22.00		0.00		0.00			
22.50	0.01	0.01		0.00			
23.00	0.02	0.02		0.00			
23.50	0.03	0.03		0.01			
24.00	0.05	0.05	0.01	0.00			
24.50	0.14	0.14	0.00	0.01	0.00		
25.00	0.19	0.19	0.03	0.03	0.00		0.00
25.50	0.22	0.22	0.05	0.03	0.05	0.02	0.01
26.00	0.20	0.20	0.17	0.05	0.09	0.01	0.04
26.50	0.07	0.07	0.25	0.13	0.21	0.02	0.07
27.00	0.06	0.06	0.19	0.16	0.26	0.10	0.14
27.50	0.01	0.01	0.10	0.17	0.16	0.11	0.16
28.00	0.01	0.01	0.09	0.14	0.13	0.15	0.17
28.50	0.00	0.00	0.06	0.08	0.04	0.18	0.13
29.00	0.00	0.00	0.04	0.07	0.03	0.10	0.11
29.50	0.00	0.00	0.00	0.05	0.01	0.12	0.08
30.00	0.00	0.00	0.00	0.04	0.00	0.11	0.04
30.50	0.00	0.00	0.01	0.01	0.00	0.05	0.04
31.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
31.50	0.00	0.00	0.00	0.00	0.00	0.01	0.00
32.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
32.50	0.00	0.00	0.00	0.00	0.00	0.01	0.00
33.00	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
34.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Number	2539		9092	1675	517	155	596
mean length	25.86	25.86	27.36	28.01	27.59	29.05	28.59
mean weight	156.17	156.17	190.33	207.24	195.55	234.86	222.07
TS/individual	-42.94	-42.94	-42.45	-42.24	-42.38	-41.93	-42.07

Table 5D.4 continued: Herring length frequency percentage for individual trawl hauls by subarea (Figure 5D.3) for the *Scotia* acoustic survey (28 June – 18 July 2008) length in cm, weight in g, calculated target strength in dB per individual using TS=-71.2+20log(L).

REGION				II/B			
Length (cm)	211	212	213	215	225	mean	209
21.00						0.00	
21.50						0.00	
22.00						0.00	
22.50						0.00	
23.00						0.00	
23.50				0.00		0.00	
24.00		0.00		0.00		0.00	
24.50		0.00		0.01	0.00	0.00	
25.00	0.00	0.00		0.00	0.01	0.02	
25.50	0.01	0.00		0.02	0.02	0.03	
26.00	0.01	0.02	0.01	0.04	0.03	0.08	
26.50	0.04	0.07	0.04	0.10	0.03	0.13	
27.00	0.11	0.11	0.09	0.18	0.05	0.14	0.08
27.50	0.15	0.15	0.10	0.20	0.12	0.12	0.08
28.00	0.21	0.17	0.10	0.14	0.14	0.12	0.15
28.50	0.16	0.16	0.17	0.11	0.20	0.12	0.23
29.00	0.11	0.14	0.20	0.10	0.19	0.11	0.15
29.50	0.07	0.06	0.12	0.04	0.14	0.06	0.08
30.00	0.07	0.03	0.09	0.03	0.03	0.04	0.15
30.50	0.03	0.04	0.04	0.03	0.01	0.02	0.00
31.00	0.01	0.02	0.02	0.00	0.01	0.01	0.00
31.50	0.00	0.01	0.01	0.01	0.01	0.00	0.08
32.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00
32.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
33.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Number	1613	1868	5897	714	2913		13
mean length	28.75	28.73	29.15	28.30	28.90	28.27	29.35
mean weight	226.40	226.14	237.60	214.54	230.68	214.11	243.12
TS/individual	-42.02	-42.02	-41.90	-42.16	-41.97	-42.16	-41.84

Table 5D.4 continued: Herring length frequency percentage for individual trawl hauls by subarea (Figure 5D.3) for the *Scotia* acoustic survey (28 June – 18 July 2008) length in cm, weight in g, calculated target strength in dB per individual using TS=-71.2+20log(L).

REGION		III/C					
Length (cm)	214	216	218	219	mean	220	221
21.00					0.00		
21.50					0.00		
22.00					0.00		
22.50					0.00		
23.00					0.00		
23.50					0.00		
24.00					0.00		
24.50		0.00			0.00		
25.00		0.00			0.00		
25.50		0.00			0.00		
26.00		0.00		0.01	0.00		0.01
26.50	0.05	0.03	0.01	0.01	0.02		0.00
27.00	0.10	0.06	0.08	0.05	0.06		0.02
27.50	0.10	0.12	0.07	0.06	0.11	0.03	0.06
28.00	0.10	0.11	0.13	0.09	0.11	0.06	0.04
28.50	0.05	0.16	0.14	0.13	0.15	0.09	0.06
29.00	0.29	0.17	0.11	0.16	0.16	0.06	0.12
29.50	0.10	0.13	0.17	0.16	0.13	0.09	0.20
30.00	0.14	0.11	0.13	0.14	0.11	0.15	0.08
30.50	0.05	0.07	0.07	0.08	0.07	0.06	0.14
31.00	0.05	0.02	0.04	0.06	0.02	0.15	0.07
31.50	0.00	0.02	0.02	0.04	0.02	0.06	0.10
32.00	0.00	0.00	0.01	0.01	0.01	0.12	0.06
32.50	0.00	0.00	0.00	0.01	0.00	0.06	0.02
33.00	0.00	0.00	0.01	0.00	0.00	0.03	0.02
33.50	0.00	0.00	0.01	0.00	0.00	0.00	0.01
34.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
34.50	0.00	0.00	0.00	0.00	0.00	0.00	0.01
35.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00
Number	21	8408	658	1109		33	180
mean length	29.29	29.28	29.58	29.73	29.35	30.97	30.46
mean weight	241.48	241.21	250.68	254.74	243.30	295.09	277.92
TS/individual	-41.86	-41.86	-41.77	-41.73	-41.84	-41.37	-41.52

Table 5D.4 continued: Herring length frequency percentage for individual trawl hauls by subarea (Figure 5D.3) for the *Scotia* acoustic survey (28 June – 18 July 2008) length in cm, weight in g, calculated target strength in dB per individual using TS=-71.2+20log(L).

REGION	IV/D		
Length (cm)	222	224	mean
21.00			0.00
21.50			0.00
22.00			0.00
22.50			0.00
23.00			0.00
23.50			0.00
24.00			0.00
24.50			0.00
25.00			0.00
25.50			0.00
26.00	0.05	0.00	0.00
26.50	0.05	0.00	0.00
27.00	0.07	0.01	0.01
27.50	0.07	0.04	0.04
28.00	0.07	0.06	0.06
28.50	0.05	0.09	0.09
29.00	0.05	0.13	0.13
29.50	0.05	0.19	0.19
30.00	0.05	0.15	0.15
30.50	0.10	0.11	0.11
31.00	0.05	0.08	0.08
31.50	0.12	0.06	0.06
32.00	0.10	0.03	0.03
32.50	0.07	0.04	0.04
33.00	0.02	0.00	0.00
33.50	0.02	0.01	0.01
34.00	0.00	0.00	0.00
34.50	0.00	0.00	0.00
35.00	0.00	0.00	0.00
Number	41	6949	
mean length	30.26	30.29	30.30
mean weight	274.54	271.88	272.15
TS/individual	-41.56	-41.57	-41.56

Table 5D.5. FRV Scotia 28 June – 18 July 2008. Numbers of herring otoliths at length and at age, lengths in cm measured to the nearest 0.5 cm below, ages in winter rings (wr).

	Age Class												
Length(cm)	1I	2I	2M	3I	3M	4I	4M	5M	6M	7M	8M	9+	Total
21.0	1												1
22.5	3		1										4
23.0	2	3	1										6
23.5	2	5	1				1						9
24.0		4	2	1									7
24.5		4	8		1		1						14
25.0		5	13	2	2	1							23
25.5		2	23		4		6	1	1	2			39
26.0			22		5	1	11	7	1	3			50
26.5			16		14		15	12	2	2			61
27.0			10		17		18	6	4	14	1		70
27.5			6		23		19	6	3	27	2		86
28.0			6		40		21	6	13	39	4	2	131
28.5			2		28		12	20	16	38	6	7	129
29.0			1		21		19	8	28	34	5	13	129
29.5					9		9	14	32	24	5	16	109
30.0					3		10	6	30	34	7	15	105
30.5							8	2	11	43	5	14	83
31.0							3	5	7	11	15	17	58
31.5							1	1	11	11	16	18	58
32.0							1	1	4	10	8	12	36
32.5								1	3	2		11	17
33.0									2	1	3	4	10
33.5										3		5	8
34.0											1		1
34.5										2			2
35.0										1			1
Total	8	23	112	3	167	2	155	96	168	301	78	134	1247

Table 5D.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 2008 herring acoustic survey. I= immature; M=mature; A=All.

YEAR CLASS	AGE	MEAN LENGTH (CM)	MEAN WEIGHT (G)	NUMBERS (10^6)	BIOMASS (KT)
2006	1A	22.6	105.9	3	0.4
2005	2I	24.6	139	39	5.4
2005	2M	26.3	176	450	79.2
2004	3I	24.9	145	8	1.2
2004	3M	27.7	211	753	158.6
2003	4I	25.7	162	7	1.2
2003	4M	27.6	210	695	145.8
2002	5	27.9	218	376	82.1
2001	6	29.1	249	450	112.2
2000	7	28.8	242	895	216.6
1999	8	29.9	274	167	45.8
1998	9+	30.2	283	260	73.8
	Average	28.1	224.7		
			Total	4104	922
			Spawning Stock	4046	914
			Immature	58	8

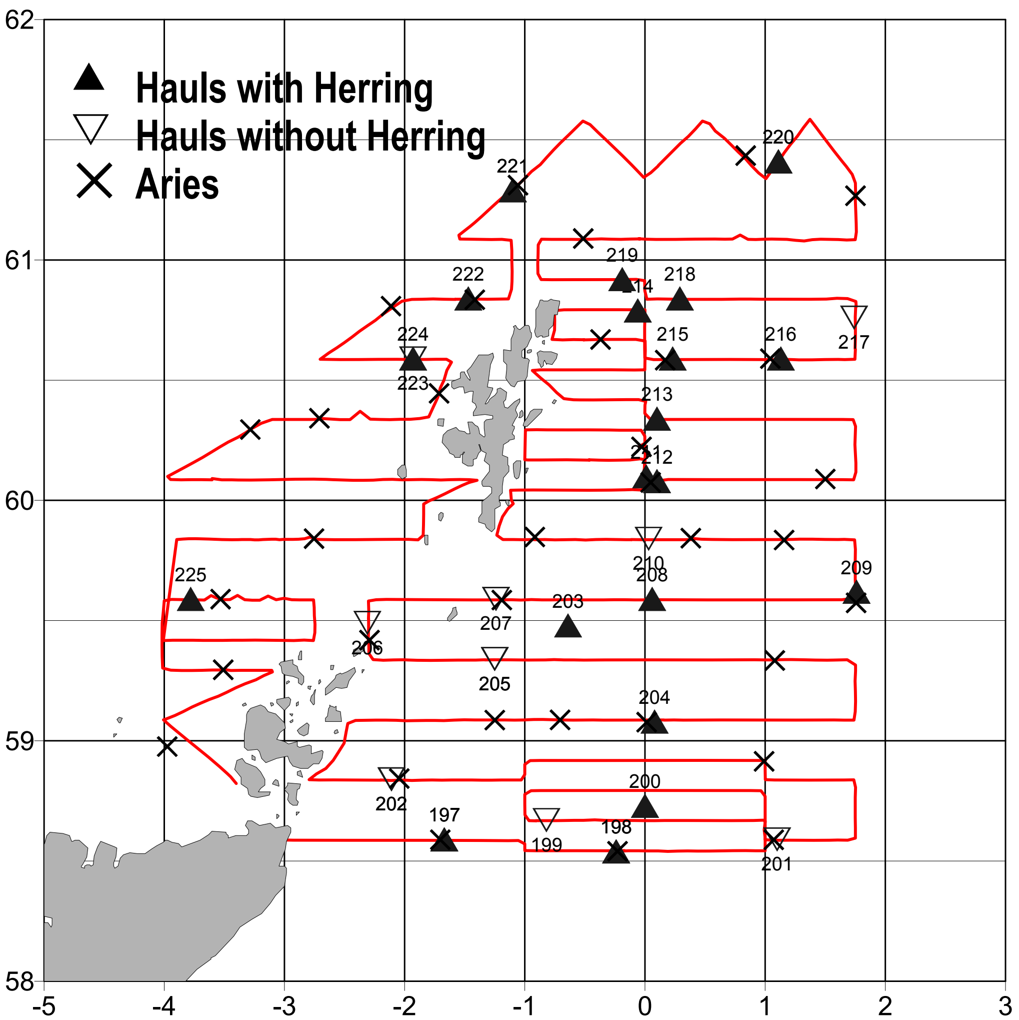

Figure 5D.1. Map of the North Sea showing the cruise track (solid lines) of FRV Scotia for the acoustic survey 28 June – 18 July 2008 indicating the location of trawl and CTD stations (symbols defined in legend).

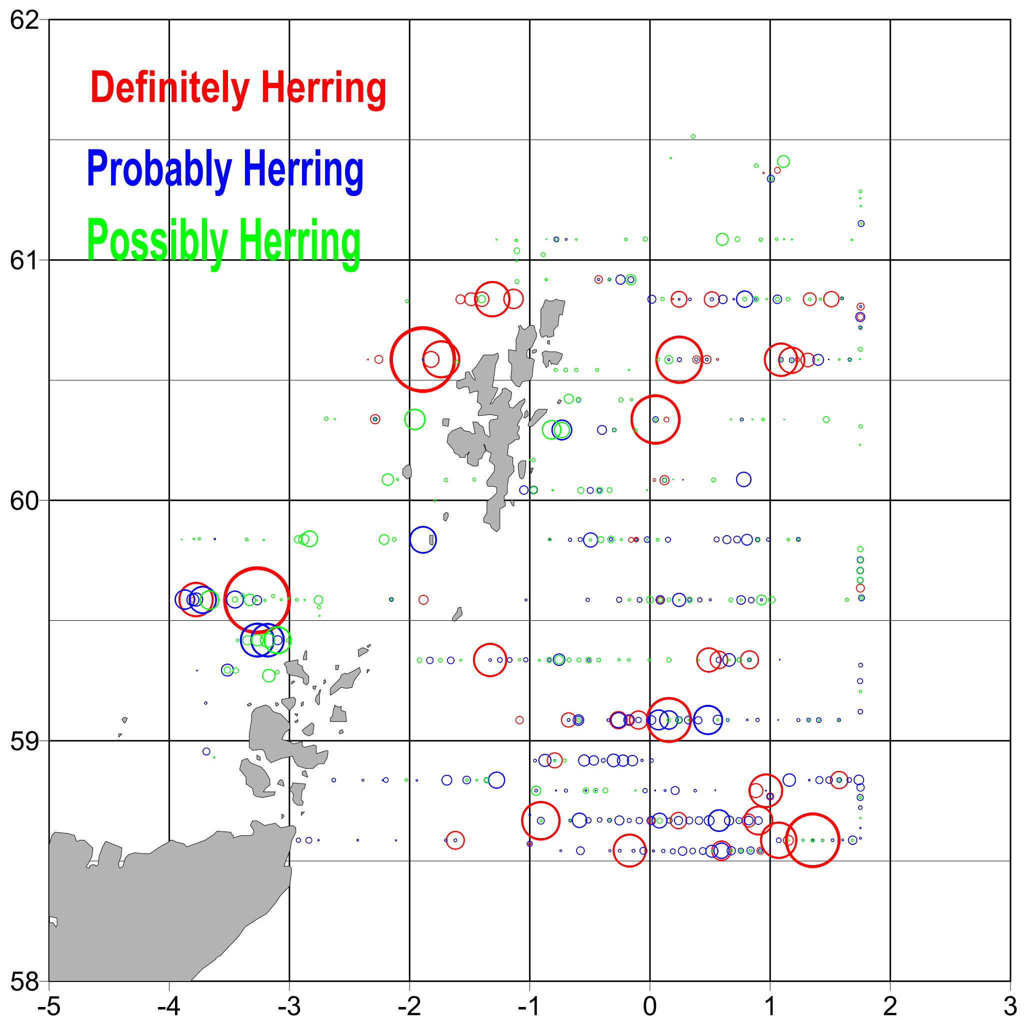

Figure 5D.2. Map of the North Sea showing the distribution of NASC values attributed to herring from the herring acoustic survey on FRV SCOTIA for 28 June – 18 July 2008. NASC values proportional to circle area (max = 7224).

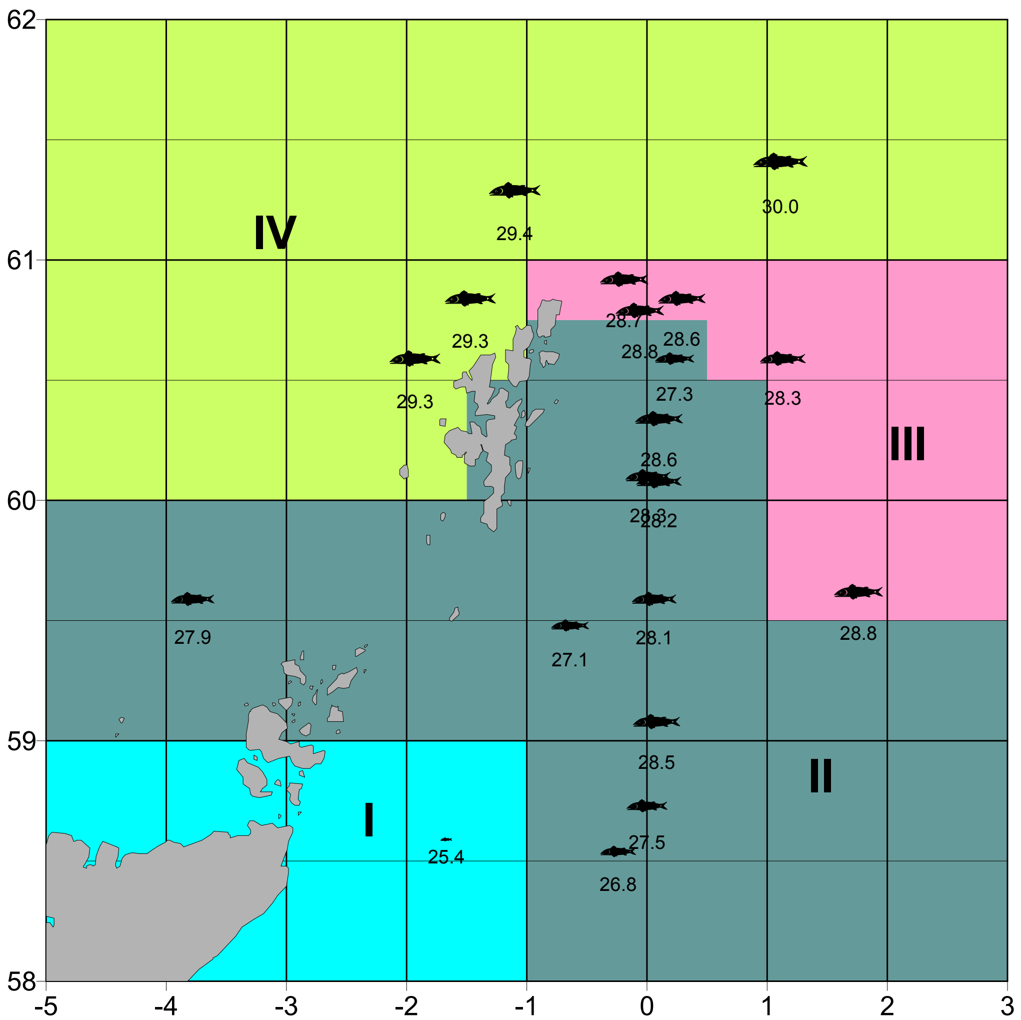

Figure 5D.3. Map of the North Sea showing the mean length of herring from pelagic trawl catches from FRV SCOTIA for 29 June – 18 July 2008 trawl station numbers are given in Figure 5D.1 and details in Tables 5D.1 and 5D.2. The four analysis areas are shaded and numbered with roman numerals (I–V) and the length distributions, mean lengths, weights and target strengths are given by area in Table 5D.4.

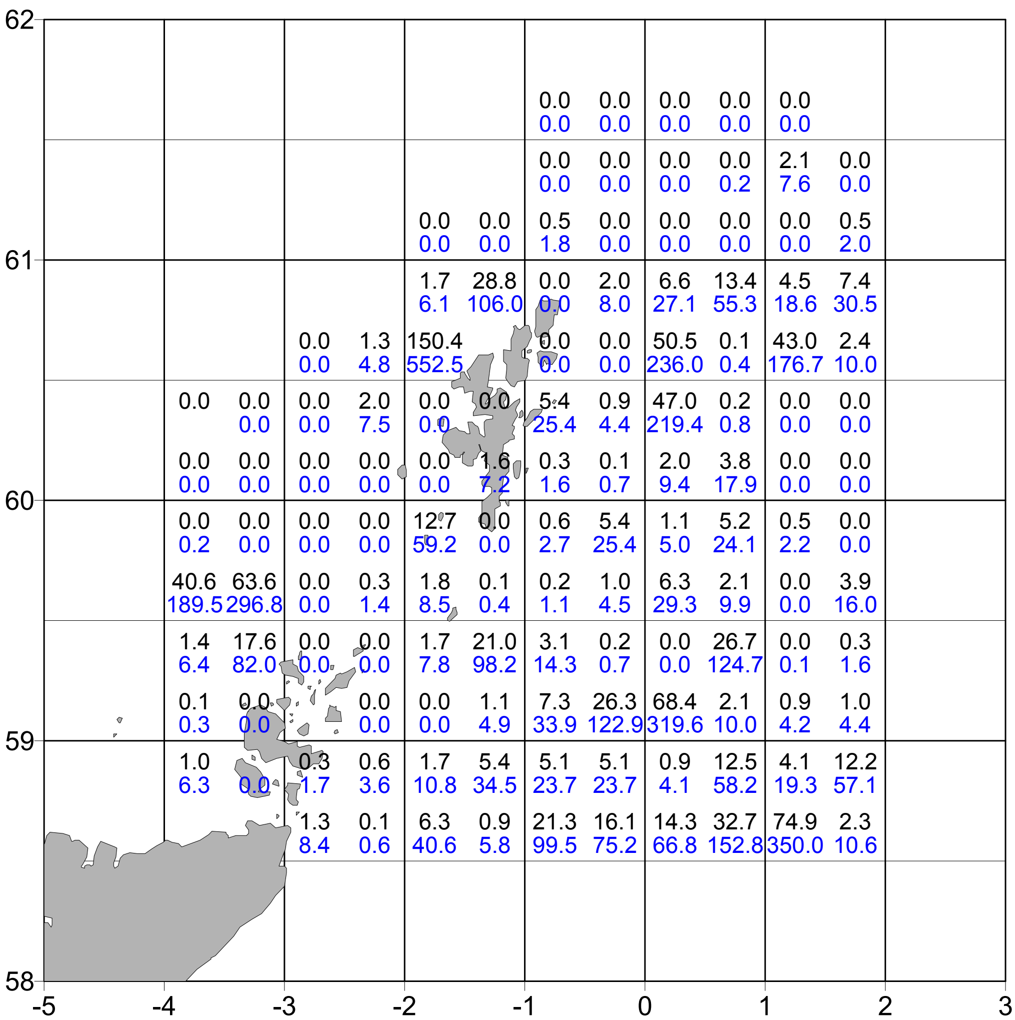

Figure 5D.4. Map of the North Sea showing the estimated numbers (millions in blue, lower figures) and biomass (thousands of tonnes in black upper figures) by quarter statistical rectangle from the herring acoustic survey on FRV SCOTIA for 28 June – 18 July 2008.

ANNEX 5E: The Netherlands

Survey report for RV *Tridens*

25 June – 20 July 2008

A.S. Couperus and S. Ybema, IMARES, IJmuiden

1. INTRODUCTION

The Netherlands Institute for Fisheries Research (RIVO) participates in the international North Sea hydro acoustic survey for herring since 1991. Participants in this survey are Scotland, Norway, Germany, Denmark and Netherlands. The survey is part of the EU data collection framework and is coordinated by the Planning Group for Herring Surveys (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 planned cruise track and hydrographical positions are presented in figures 5E.1 and 2. In order to avoid large time gaps between neighbouring transects covered by different participants, radio and e-mail contact between vessels was frequent. The actual surveyed transects therefore differ from the planned transects.

2. SURVEY DESCRIPTION and METHODS

2.1 Personnel

	Wk 26	Wk 27	Wk 28	Wk 29
Bram Couperus (cruise leader 1st half)	x	x		
Kees Bakker (cruise leader second half)	x	x	x	x
Sytse Ybema	x	x		
Bjarne Stage			x	x
Hendrik-Jan Westerink	x	x	x	x
Mohamed Ahmed Taleb	x	x		
Mohamed Belemlih (Khales)	x	x		
Alexander Ebbing		x	x	x
Erwin Winter			x	x
Lindsay McPherson (Univ. Aberdeen)		x	x	x

2.2 Narrative

On Monday 23/6 11:00, Dutch summertime Tridens steamed up to Loch Eriboll for the calibration. On its way the equipment for the calibration was prepared and two test hauls were conducted. Arrival at Loch Eriboll on Wednesday morning. The 38 and 200 kHz transducers were calibrated. The calibration process was hampered by wind en current, caused by the bad weather conditions (for more detailed information see paragraph "calibration". Nevertheless in the evening all transducer were calibrated. The survey started on 26 June at the western point of the 58°20N transect. The survey continued till Saturday morning 28 June 9:00 and was stopped at 57°46N.

During the short steaming trip to Aberdeen the towing cable was replaced, because it seemed to have a week point. On Monday morning 30 June the 57°46N transect was continued in eastern direction. The fourth transect (57°18N) was relatively empty. Hence for transect 5 there was some extra time for fishing. On 3 July Tridens sailed until 56°48N – 003°41N on the fifth transect. At 11:30 survey was interrupted for the weekend break in Scheveningen.

Tridens left the port of Scheveningen on Monday 7 July 10:30 for the second half of the survey. Arrival on 8 July 11:00 at the planned position. There was a delay because of some network problems.

The First haul was at 56°17 N – 0°39 W for small schools at the bottom (200 kg mackerel). During the remainder of this transect no fish was encountered. Some hauls were conducted, without any catch worth mentioning.

After the weekend in Newcastle, the survey was resumed on Monday 14 July 8:00. Finally some fish schools were spotted, but during shooting of the trawl, the portside trawl winch burned. As it turned out impossible to fish after this event, it was tried to get into contact with the German vessel for fish information, without success.

The survey was terminated at Wednesday 16 July at 54°20 N and 01°50E. Tridens sailed back to Scheveningen.

2.3 Survey design

The actual survey was carried out from 26 to 16July 2008, covering an area east of Scotland, from latitude 54°20 to 58°20 North and from longitude 2° 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. 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 with the depth isolines) were excluded from the dataset.

The actual cruise track, trawl – and hydrographical station positions is presented in Figure 5E.1.

2.4 Calibration of acoustic equipment

Five calibrations were executed at Loch EribollFive. The towed body's 200 kHz transducer and a spare 200 kHz transducer, the two 38 kHz transducers from the towed body and the hull mounted transducer were calibrated using the EK60 integrated calibration application.

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 5E.1. Acoustic data were collected with a Simrad EK60 scientific echo sounder and logged with Sonardata Echoview software in 1 nautical mile intervals. The EK60 received the vessel speed from the ship's GPS. A vessel 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 depths of 50 – 150 m at which depth herring occur in most of the area.

A 200 kHz transducer was used for species separation by acoustic means. The algorithms used for this extraction were developed within the EU project "SIMFAMI" and made it easier to distinguish non-swimbladdered fish like sandeel and mackerel from swimbladdered fish like herring and sprat. The algorithm itself is explained in the cruise report of 2005.

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 when there was doubt about the species composition of 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 control the catch.

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

Fat content

In some samples a Torry Fish Fatmeter (TFFM) made by Distell Inc. was used to measure the water content of the fillet, and converts this into the fat content using the strong inverse relationship between water and fat.

2.7 Hydrographical data

Hydrographical data have been collected in 43 stations, all at fixed locations (Figure 5E.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 Sonardata Echoview software.

In stratum E (Figure 5E.2) herring and sprat were observed in mixed concentration. In this stratum the assignment of NASC's was based on trawl catch distributions.

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 cross section "sigma" was calculated according to the target strength-length relationships (TS) recommended by the ICES Planning Group for Herring Surveys.

The breakdown of sprat and herring 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 in a rectangle by the overall sigma in the corresponding rectangle.

The biological samples, used for stock structure and biomass calculations were grouped in 5 strata for herring and 1 stratum for sprat, based on similar length frequency distribution in the area (Figure 5E.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.

All calculations were performed by SAS (SAS Institute) routines. Hydro acoustic – biological and hydrographical data are being stored in the HERSUR format.

3. Results

3.1 Acoustic data results

Apart from some isolated schools in the area, herring was only found in the two northern most transects (Figure 5E.3a and b). Apart from a single concentration (NASC 1384 in a 1 nautical mile interval in rectangle 37 F1, assigned to "probably sprat"), in the southern part of the survey area, only "possibly sprat" has been recorded.

3.2 Trawl data results

In all, 18 trawl hauls have been conducted. Herring was found in 8 hauls of which 6 samples of more than 20 herring were taken. Sprat was not found in any haul. The trawl list is presented in Table 5E.2a, the catch weights per haul and species are presented in Table 5E.2b and the length frequency proportions are presented in Table 5E.2c.

The biological samples contained total 374 herring which 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	42 thousand tonnes
Spawning stock	770 thousand tonnes

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

Immature	n.a.
Spawning stock	n.a.

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

4. Tables and Figures

Table 5E.1. Simrad EK60 calibration settings used on the June 2008 North Sea hydro acoustic survey for herring, RV "Tridens".

```
Calibration Version  2.1.0.11
#
# Date: 25/06/2008
#
# Comments:
#  Loch Eriboll calibration #2
#
# Reference Target:
#   TS                 -33.60 dB     Min. Distance      11.60 m
#   TS Deviation         5.0 dB      Max. Distance      15.10 m
#
#  Transducer:  ES38B  Serial No.   30501
#   Frequency          38000 Hz      Beamtype            Split
#   Gain               25.59 dB      Two Way Beam Angle   -20.6 dB
#   Athw. Angle Sens.       21.90    Along. Angle Sens.      21.90
#   Athw. Beam Angle     7.26 deg    Along. Beam Angle    7.12 deg
#   Athw. Offset Angle  -0.09 deg    Along. Offset Angle -0.01 deg
#   SaCorrection        -0.56 dB     Depth               0.00  m
#
#  Transceiver:  GPT  38 kHz 009072017a3b 1 ES38B
#   Pulse Duration      1.024 ms     Sample Interval     0.192   m
#   Power               2000  W      Receiver Bandwidth   2.43 kHz
#
#  Sounder Type:
#   EK60 Version  2.1.1
#
#  TS Detection:
#   Min. Value          -50.0 dB     Min. Spacing          100%
#   Max. Beam Comp.       6.0 dB     Min. Echolength        80%
#   Max. Phase Dev.       8.0        Max. Echolength       180%
#
#  Environment:
#   Absorption Coeff.   9.5 dB/km    Sound Velocity     1496.7 m/s
#
#  Beam Model results:
#   Transducer Gain    = 25.94 dB    SaCorrection       = -0.56 dB
#   Athw. Beam Angle   = 6.94 deg    Along. Beam Angle  = 6.99 deg
#   Athw. Offset Angle = 0.06 deg    Along. Offset Angle=-0.02 deg
#
#  Data deviation from beam model:
#   RMS =    0.28 dB
#   Max =    0.87 dB  No. =   112  Athw. = -3.7 deg  Along = -3.8 deg
#   Min =   -1.29 dB  No. =    26  Athw. = -0.3 deg  Along = -4.5 deg
#
#  Data deviation from polynomial model:
#   RMS =    0.20 dB
#   Max =    0.61 dB  No. =    30  Athw. = -0.8 deg  Along = -5.0 deg
#   Min =   -1.08 dB  No. =    26  Athw. = -0.3 deg  Along = -4.5 deg
```

Table 5E.2a. Details of the trawl hauls taken. "Tridens", North Sea acoustic survey 2008.

sample	haul	date	position	ICES	time GMT	haul_duration	depth	geardepth	gear
5400501	1	26/06/2008	58.20N 01.51W	45E8	07:53	64	95	60	pelagic trawl
5400502	2	26/06/2008	58.19N 00.56W	45E9	11:11	23	95	85	pelagic trawl
5400503	3	26/06/2008	58.19N 00.10E	45F0	18:13	33	139	110	pelagic trawl
5400504	4	27/06/2008	58.05N 01.17E	45F1	09:14	32	120	93	pelagic trawl
5400505	5	28/06/2008	57.46N 02.16W	44E7	04:17	17	122	102	pelagic trawl
5400506	6	30/06/2008	57.45N 01.37W	44E8	08:50	70	65	15	pelagic trawl
5400507	7	30/06/2008	57.46N 00.43W	44E9	12:48	84	117	85	pelagic trawl
5400508	8	30/06/2008	57.45N 00.20E	44F0	18:05	30	114	91	pelagic trawl
5400509	9	01/07/2008	57.18N 01.21E	43F1	09:21	39	93	70	pelagic trawl
5400510	10	01/07/2008	57.18N 00.13W	43E9	15:52	52	72	20	pelagic trawl
5400511	11	01/07/2008	57.18N 00.42W	43E9	18:20	67	73	14	pelagic trawl
5400512	12	02/07/2008	56.48N 00.24W	42E9	10:21	83	72	46	pelagic trawl
5400513	13	02/07/2008	56.48N 00.08E	42F0	13:50	24	68	52	pelagic trawl
5400514	14	02/07/2008	56.48N 00.43E	42F0	16:56	28	86	58	pelagic trawl
5400515	15	08/07/2008	56.17N 00.33W	41E9	17:28	42	67	44	pelagic trawl
5400516	16	11/07/2008	55.47N 01.00E	40F1	06:34	33	74	44	pelagic trawl
5400517	17	11/07/2008	55.48N 01.21W	40E8	18:43	115	78	22	pelagic trawl
5400518	18	14/07/2008	55.18N 00.46W	39E9	08:52	62	91	60	pelagic trawl

Table 5E.2b. Trawl catches. "Tridens", North Sea acoustic survey 2008 in kg.

sample	Snake pipefish	Grey gurnard	Haddock	Mackerel	Whiting	Herring	Norway pout	Lumpsucker	Dab	Raitts sandeel
5400501	0.01	2.0	2.1	1	0.3					
5400502	0.48	4.3	0.8	4406		4166				
5400503						4526				
5400504	2.74			925		1738				
5400505			0.4	2			7.0			
5400506	0.03		0.0	165	0.0			0.9		
5400507	0.67	1.0	0.4	46		660	47.9			
5400508				416		8946				
5400509		2.0	1.8	1	0.2					
5400510	0.48	3.9	1.2	446					0.1	
5400511	0.06	2.9	9.1	15						262
5400512	0.19	18.0	4.1	7	0.8	2				
5400513	0.06	12.8	3.2	263		1				
5400514	0.06	1.7		3		35				
5400515	0.28	6.4	8.7	186	0.5					
5400516		0.8								
5400517	0.06			22	0.0		0.0			
5400518	0.02	1.8	1.3		14.8			2.6		

Table 5E.2c. Length frequency proportions of herring by haul. "Tridens", North Sea acoustic survey 2008.

length	5400502	5400503	5400504	5400507	5400508	5400512	5400514	5400513
19			0.5				1.1	
19.5			0.5	0.4				
20			0.5		1.8	4.5	4.0	
20.5					2.4	4.5	3.4	13.3
21			0.5	1.8	3.0	18.2	2.3	
21.5				0.9	0.6	4.5	0.6	13.3
22					1.2	18.2	2.3	40.0
22.5					0.6	4.5	4.6	13.3
23			1.5	0.4	0.6	4.5	2.3	6.7
23.5			0.5	0.4			3.4	
24				1.3	3.0		6.3	6.7
24.5		0.5	1.0	3.1	3.0	13.6	8.0	
25	4.9		2.6	11.2	6.5	4.5	8.6	
25.5	16.2	6.2	7.2	20.6	10.7		11.4	6.7
26	17.6	5.2	15.9	27.8	17.8	13.6	11.4	
26.5	24.6	10.3	14.9	14.8	20.1	4.5	9.1	
27	22.5	12.9	21.0	12.6	11.8		6.9	
27.5	9.9	13.9	14.9	3.6	10.7	4.5	8.0	
28	2.1	13.4	7.2		4.1		4.0	
28.5	1.4	10.8	6.7	0.9	1.8		0.6	
29		10.8	3.6				1.7	
29.5	0.7	7.2			0.6			
30		4.6	1.0					
30.5		2.6						
31		1.0						
31.5								
32		0.5						
32.5								

Table 5E.3. Age/maturity-length keys for herring –Stratum A and B. "Tridens", North Sea acoustic survey 2008.

Stratum A							
Age	Year	Mean Length (cm)	Mean weight (g)	Number (millions)	%	Biomass (1000 tons)	%
0I	2007im			0	0.0	0.000	0.0
0M	2007ad			0	0.0	0.000	0.0
1I	2006im	20.8	79.0	109	2.8	8.572	1.4
1M	2006ad	22.3	97.1	8	0.2	0.752	0.1
2I	2005im	22.3	98.6	8	0.2	0.764	0.1
2M	2005ad	25.9	153.3	1055	27.6	161.683	25.8
3I	2004im			0	0.0	0.000	0.0
3M	2004ad	26.3	161.9	679	17.7	109.908	17.5
4I	2003im			0	0.0	0.000	0.0
4M	2003ad	26.4	157.3	674	17.6	105.957	16.9
5I	2002im			0	0.0	0.000	0.0
5M	2002ad	27.0	170.8	382	10.0	65.233	10.4
6M	2001	28.1	188.6	154	4.0	29.070	4.6
7M	2000	28.0	193.8	729	19.0	141.192	22.5
8M	1999	28.5	185.0	11	0.3	2.036	0.3
9M	1998	31.0	302.0	4	0.1	1.191	0.2
10M	1997			0	0.0	0.000	0.0
11M	1996			0	0.0	0.000	0.0
12+	<1996	25.5	0.0	16	0.4	0.000	0.0
Mean		26.0	149.0				
Total				3826	100.0	626.359	100.0
Immature				116	3.0	9.336	1.5
Mature				3710	97.0	617.023	98.5

Stratum B							
Age	Year	Mean Length (cm)	Mean weight (g)	Number (millions)	%	Biomass (1000 tons)	%
0I	2007im			0	0.0	0.000	0.0
0M	2007ad			0	0.0	0.000	0.0
1I	2006im	20.9	81.5	328	22.6	26.759	14.4
1M	2006ad	23.1	111.1	49	3.4	5.482	2.9
2I	2005im	21.4	87.8	72	4.9	6.292	3.4
2M	2005ad	24.7	137.3	666	45.8	91.375	49.1
3I	2004im			0	0.0	0.000	0.0
3M	2004ad	25.6	147.7	122	8.4	18.081	9.7
4I	2003im			0	0.0	0.000	0.0
4M	2003ad	26.2	162.4	43	3.0	7.014	3.8
5I	2002im			0	0.0	0.000	0.0
5M	2002ad	28.0	189.0	6	0.4	1.100	0.6
6M	2001	27.5	189.4	60	4.1	11.375	6.1
7M	2000	27.1	171.0	93	6.4	15.922	8.6
8M	1999			0	0.0	0.000	0.0
9M	1998			0	0.0	0.000	0.0
10M	1997			0	0.0	0.000	0.0
11M	1996			0	0.0	0.000	0.0
12+	<1996	27.5	173.0	15	1.0	2.631	1.4
Mean		25.2	145.0				
Total				1455	100.0	186.031	100.0
Immature				400	27.5	33.051	17.8
Mature				1055	72.5	152.980	82.2

Table 5E.4. Mean length, mean weight, biomass (thousands of tonnes) and numbers (millions) herring breakdown by age and maturity obtained during the July 2008 North Sea hydro acoustic survey for herring, FRV "Tridens".

Total area (all strata summarized)					
Age	Year	Number (millions)	%	Biomass (1000 tons)	%
0I	2007im	0	0.0	0.000	0.0
0M	2007ad	0	0.0	0.000	0.0
1I	2006im	437	8.3	35.331	4.3
1M	2006ad	57	1.1	6.234	0.8
2I	2005im	79	1.5	7.056	0.9
2M	2005ad	1721	32.6	253.059	31.1
3I	2004im	0	0.0	0.000	0.0
3M	2004ad	801	15.2	127.989	15.8
4I	2003im	0	0.0	0.000	0.0
4M	2003ad	717	13.6	112.971	13.9
5I	2002im	0	0.0	0.000	0.0
5M	2002ad	388	7.3	66.333	8.2
6M	2001	214	4.1	40.445	5.0
7M	2000	822	15.6	157.114	19.3
8M	1999	11	0.2	2.036	0.3
9M	1998	4	0.1	1.191	0.1
10M	1997	0	0.0	0.000	0.0
11M	1996	0	0.0	0.000	0.0
12+	<1996	31	0.6	2.631	0.3
Total		5281	100.0	812.390	100.0
Immature		516	9.8	42.387	5.2
Mature		4765	90.2	770.003	94.8

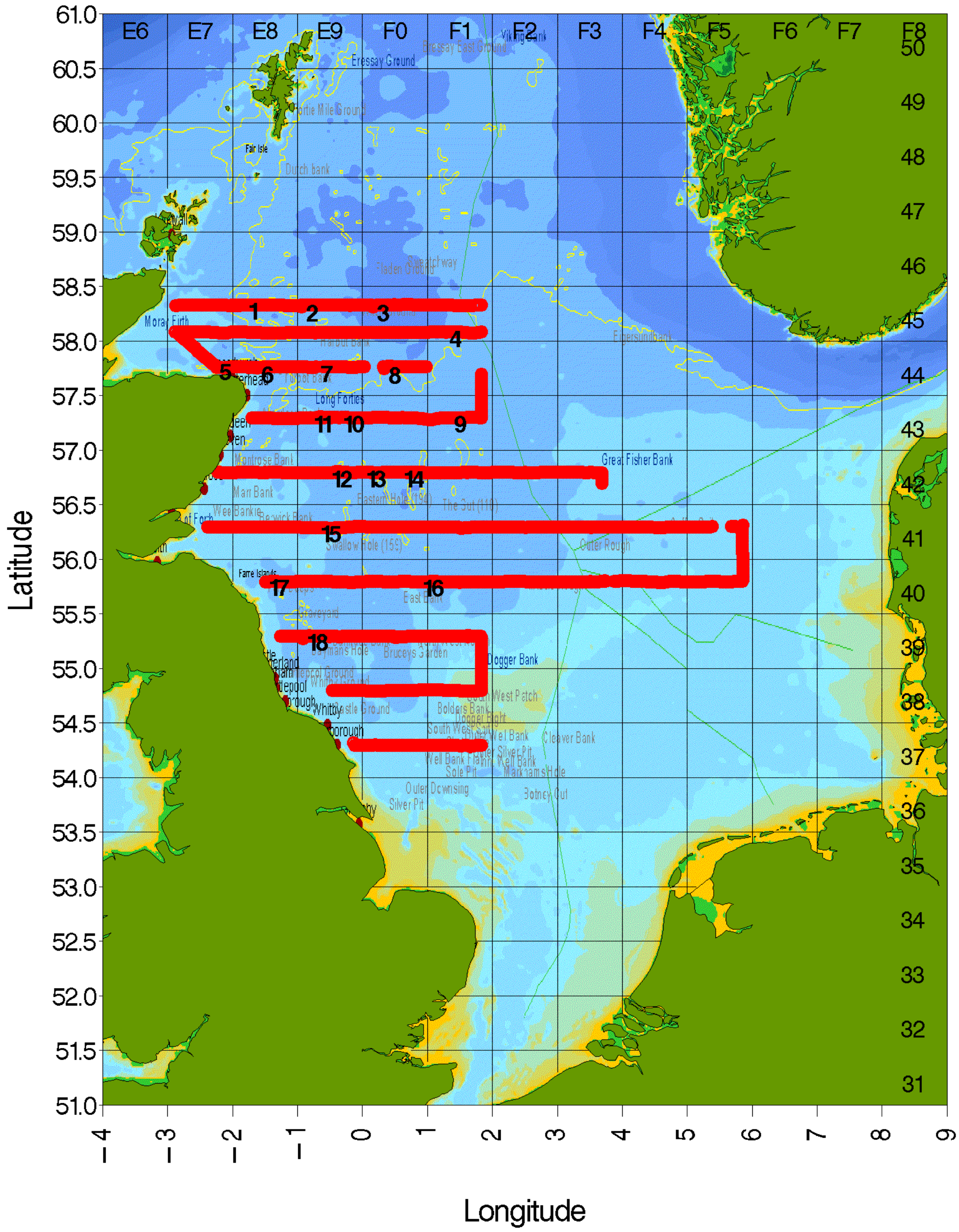

Figure 5E.1a. Map of executed cruise track and positions of trawl stations (open squares with numbers) and hydrographical stations (crosses) during the June-July 2008 North Sea herring hydro acoustic survey on RV "Tridens".

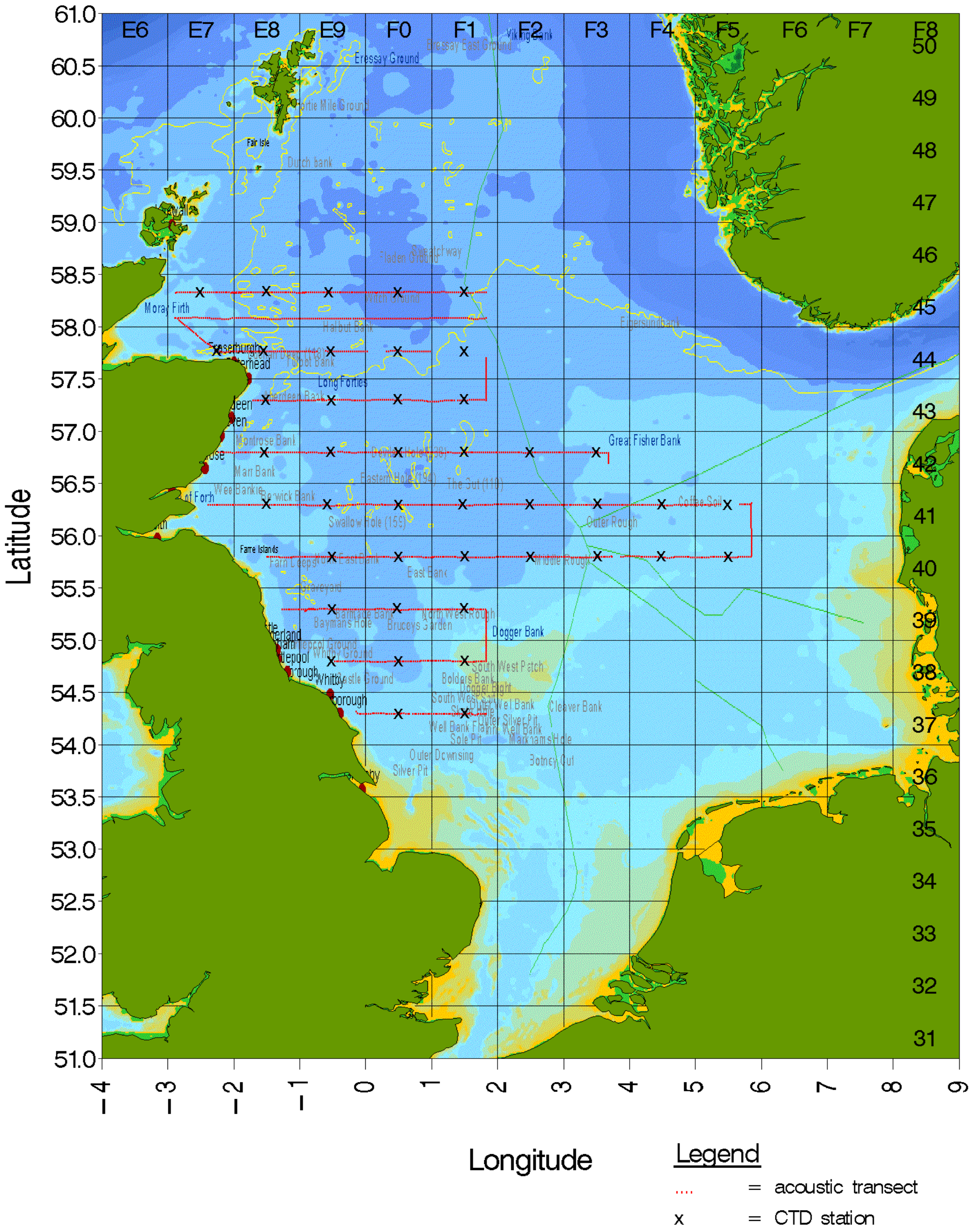

Figure 5E.1b. Map of hydrographical stations (crosses) during the June-July 2008 North Sea herring hydro acoustic survey on RV "Tridens".

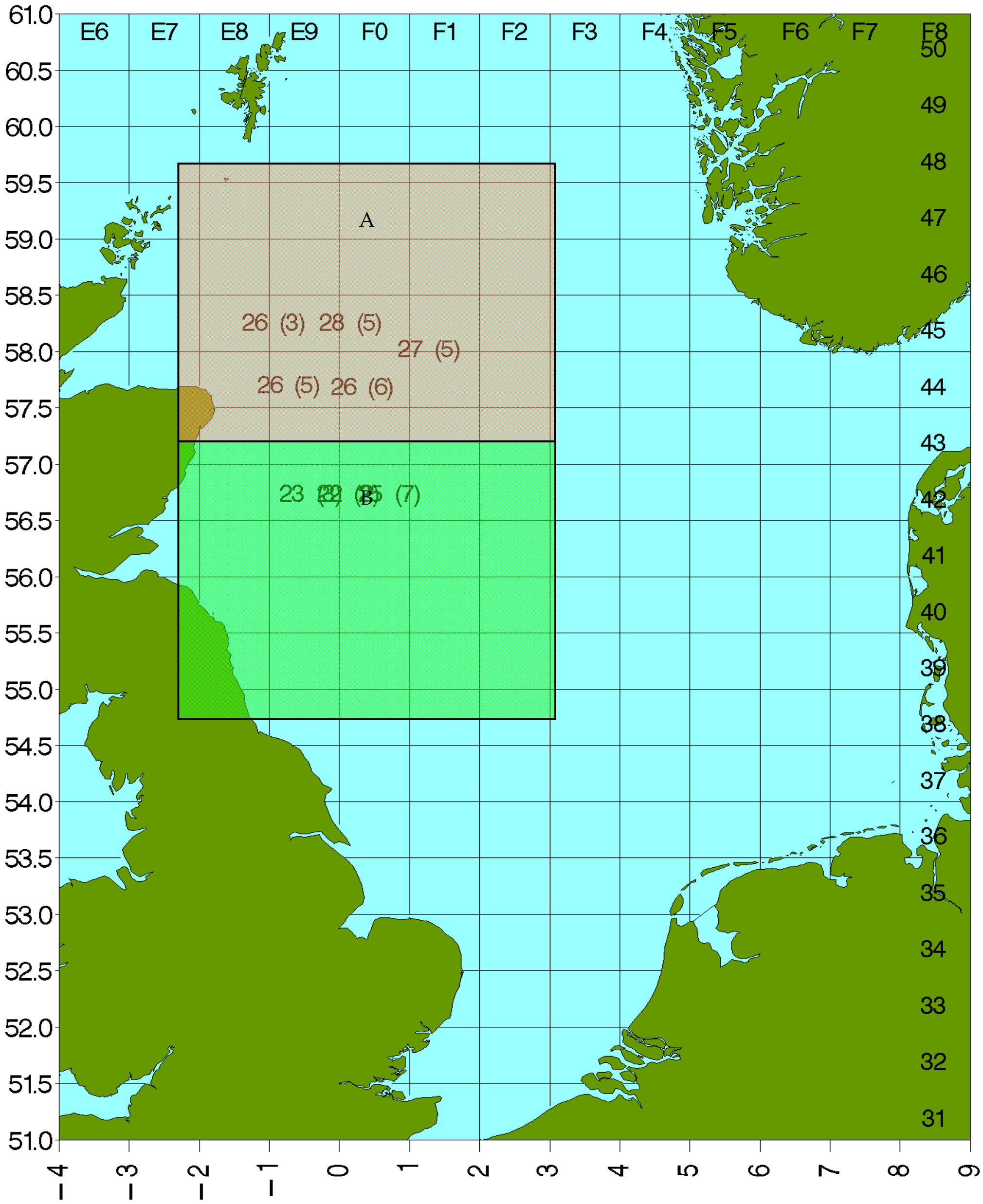

Figure 5E.2. Geographical strata used to pool mean weights and lengths of herring in order to raise NASC's by rectangle to numbers and biomass during the July 2008 North Sea hydro acoustic survey for herring by RV "Tridens". Numbers and numbers between brackets show mean lengths (cm) and standard deviations.

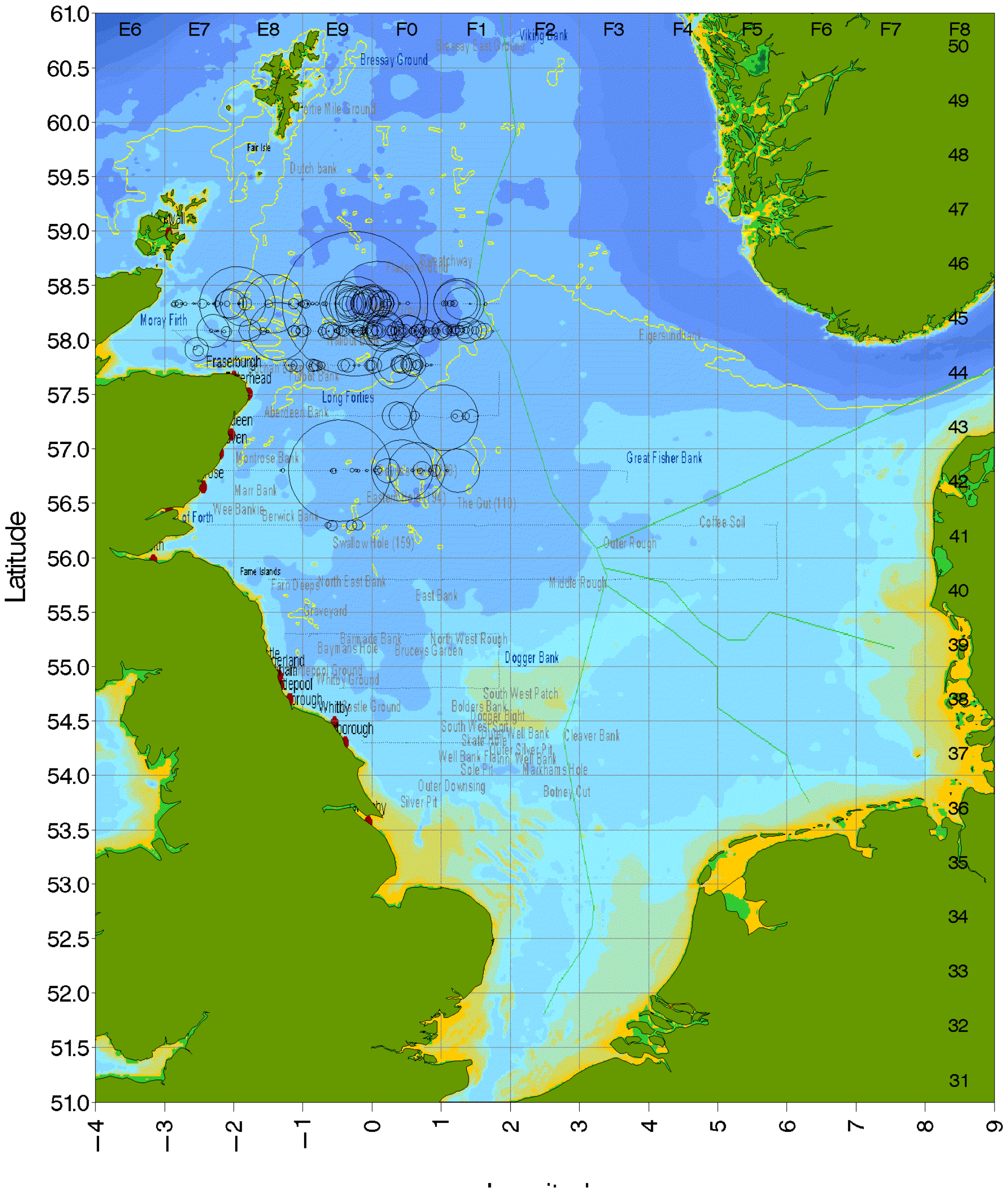

Figure 5E.3a. Post plot showing the distribution of total herring NASC's of 1 nm intervals (on a proportional square root scale relative to the largest value of 30821) obtained during the June-July 2008 North Sea herring hydro acoustic survey on RV "Tridens".

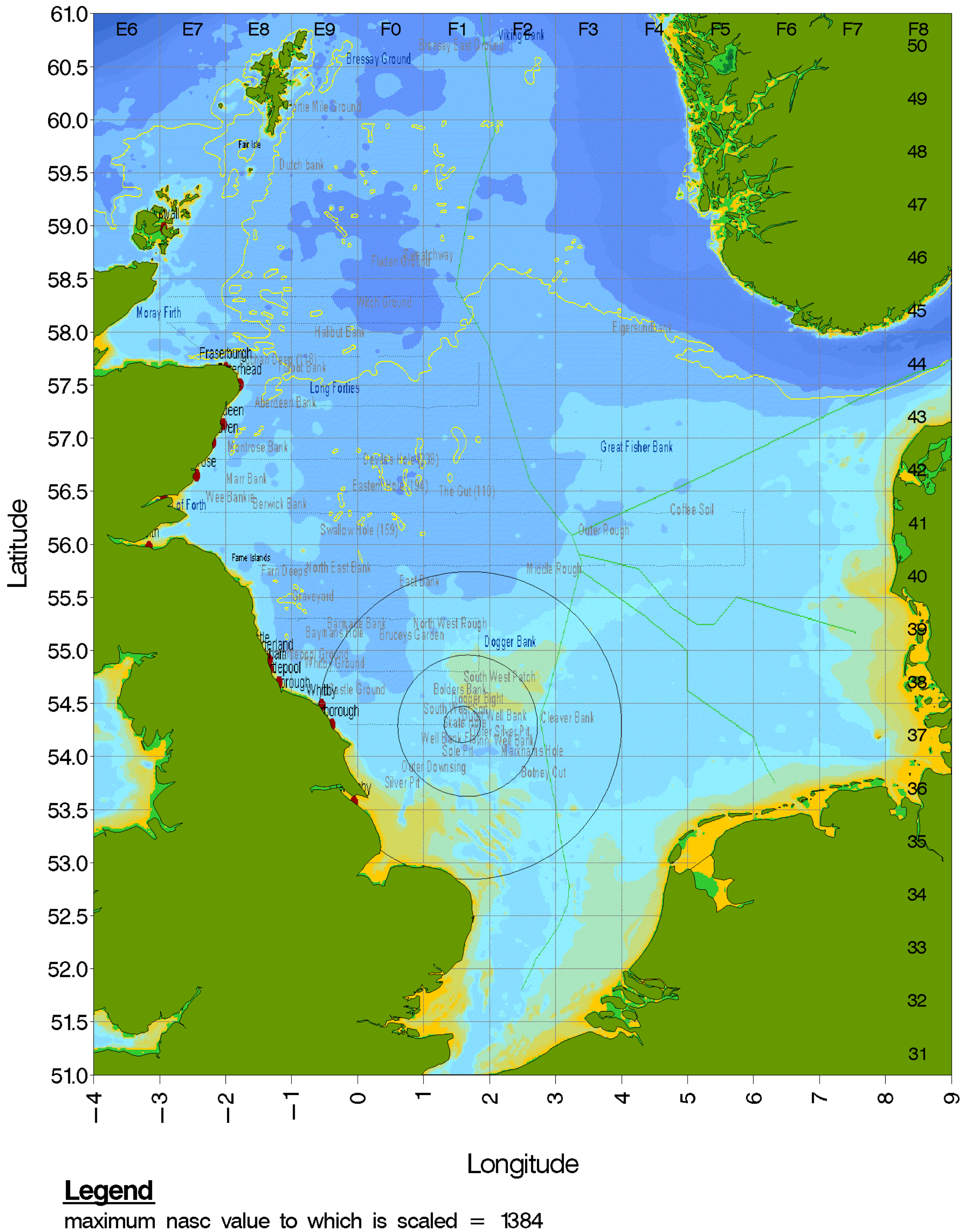

Figure 5E.3b. Post plot showing the only recorded clupeid concentration in the southern area (on a proportional square root scale relative to the largest value of 1384). Assigned to 'probably sprat' since trawl information was absent. Obtained during the June-July 2008 North Sea herring hydro acoustic survey on RV "Tridens".

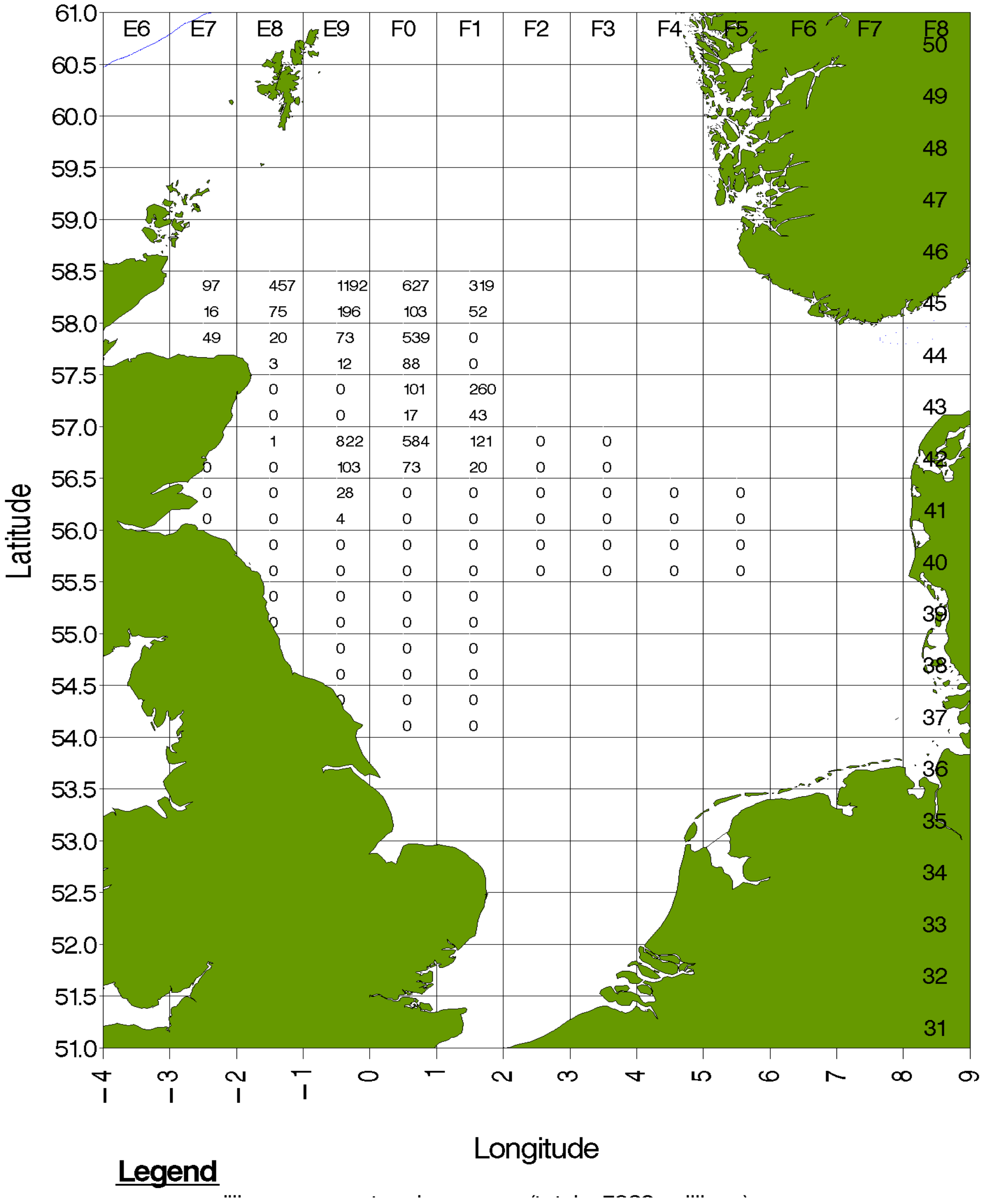

Figure 5E.4. Estimated numbers of herring in millions (upper half square) and biomass in thousands of tonnes (lower half of square) by ICES rectangle. Results from the July 2008 North Sea hydro acoustic survey, RV "Tridens".

ANNEX 5F: Germany

Survey report for FRV *Solea*

26 June – 16 July 2008

Norbert Rohlf, Eberhard Götze, Eckhard Bethke, vTI-SF, Hamburg, Germany

1. INTRODUCTION

Background: FRV "Solea" cruise 591 was conducted in the framework of the international hydroacoustic survey on pelagic fish in the North Sea, which is coordinated by the ICES Planning Group for International Pelagic Surveys (PGIPS). 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 working area for "Solea" was confined to the Southern and South-Eastern North Sea. This area is regarded to be 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

E. Bethke	Scientist in charge, acoustics	vTI-SF
M. Sasse	Acoustics	vTI-SF
N. Rohlf	Biologist	vTI-SF
G. Gentschow	Technician	vTI-SF
M. Wunderskirchner	Biologist	vTI-SF
O. Meyer-Klaeden	Biologist	vTI-SF
D. Gloe	Biologist	vTI-SF

2.2 Narrative

FRV "Solea" left port of Cuxhaven on 26 June, and tried to calibrate the hydroacoustic equipment eastwards of the island Helgoland. Strong winds and currents prolonged the calibration procedure and calibration results were regarded as preliminary but used for the acoustic measurements. Hydroacoustic measurements started the next day. Weather conditions were relatively unfavourable, but cleared up for some days during the survey along the British coastline. Here a second calibration exercise was conducted. These resulted in estimates highly comparable to last year and consequently these were used for data analyses. Recordings were terminated in the afternoon of 15 July in the area of Helgoland. FRV "Solea" reached her home port at the same evening, having sailed 2492 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 7.5, 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 planned at open sea close to the German island Helgoland at 54°11.467N, 007°57.846E. Because of bad weather conditions, strong wind and current, the measurements were assumed to be unreliable and therefore postponed to better conditions. However, the hydroacoustic measurements were carried out with the preliminary calibration results. A second calibration was carried out later at the English coastline (53° 51.561 N, 000° 19,276 E). On 4 July the 38 kHz transducer was calibrated successfully. Calibration methods are described in the 'Manual for Herring Acoustic Surveys in ICES Divisions III, IV and VI' (version 3.1, ICES CM 2003/G:03, Appendix 4). Important parameters and settings are listed in Table 5F.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 frequency of 38 kHz. Echo telegrams were continuously recorded and evaluated using the EchoView 3 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' (version 3.1, ICES CM 2003/G:03, Appendix 4). The vessel was running at a speed of 10–11 knots. The cruise track (Figure 5F.1) totally reached a length of 1867 nautical miles.

2.6 Biological data – fishing trawls

For the identification of echotraces and further biological sampling, 33 trawl hauls were conducted either on specific large schools (after turning the ship) or, if small schools occurred frequently, on the survey track. On "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 15 and 67 minutes depending on the indication of net filling. 17 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. Otoliths were removed for age readings.

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 5F.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 from the surface layer 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 3 software package, using information from trawl hauls usually targeting specific schools. Herring and sprat were exclusively found in characteristic "pillars". The NASC attributed to clupeoids 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:

$$TS = 20 \log L \text{ (cm)} - 71.2 \text{ (ICES 1983/H:12)}$$

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 with 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

As in previous years, clupeids were exclusively found in characteristic schools, appearing in single clusters of some nautical miles extension. Echoes attributed to plankton were not considered to be problematic for the identification of fish schools.

In the northern part of our area of investigation we found only few echo-indications of the target species. The low fish densities were also confirmed by the fishery results. High concentrations were found in the German Bight around the island Helgoland and in the northwest part of The Channel. However, the indications are not homogeneously distributed over larger areas. Small regions with partially high NASC were followed again by nearly empty areas. Only 27% of all sampled miles had a NASC greater than zero and half of the total NASC originates from 20 sampling intervals. Figure 5F.2 gives the NASC distribution on a basis of 5 nautical miles EDSUs for clupeids (herring and sprat combined).

3.2 Biological data

The pelagic trawl PSN388 has been deployed at 33 stations. 40 rectangles were covered during the acoustic survey, of which 17 have been sampled with trawl hauls (Figure 5F.1 and Table 5F.2). Valid results (> 200 clupeids h-1 trawling) were obtained for 12 rectangles. Those were used to raise unsampled rectangles. The majority of the unsampled rectangles had no or only minimal NASCs. Total catch varied between 0.1 and 926.5 kg (standardized to 30 minutes trawl duration).

Herring was relatively rare during the survey. Only very small quantities were located in the central parts of the investigation area. Larger herring schools were observed in rectangle 36F0 right in front of the British coastline, in rectangles in Danish waters and in the German bight. Spratt was much more uniformly distributed. The tendency to aggregate in the south was not so pronounced than in former years. There is some likelihood that summer southern distribution limit for sprat in the Channel was reached during the survey.

Trawling resulted in 15 different species. Spratt showed the highest presence (in 28 trawls out of 39) and was the most abundant in terms of biomass (3 100 kg, equal to 71% of the total catch weight). Total catch of herring was 1 100 kg. Herring were present in every second haul, but their total catch is reduced by 2/3 compared to last year. Species diversity is listed in Table 5F.3. Snake-pipefish (*Entelurus aequorius*) were present in 7 hauls only (compared to 20 in 2007). This species occurred in 20 hauls of the pelagic net. Catches yielded larger quantities of mackerel *Scomber scombrus* and grey gurnard *Eutriglia gurnardus*. All other species occurred only on occasion.

3.3 Biomass and abundance estimates

Herring total biomass: **63 058 t** (2007: 253 425 t; 2006: 83 200 t)

Herring spawning-stock biomass 746 t / 1.2% (2007: 49 213 t / 19.4%; 2006: 5 330 t / 6.4%)

Herring total abundance: **3 775 mill**. (2007: 28 670 mill; 2006: 5 454 mill.)

Herring spawning stock abundance 0.0082 mill. / 0.22% (2007: 0.374 mill. / 1.3%; 2006: 0.04 mill. / 0.01%)

Sprat total biomass: **263 700 t** (2007 : 319 200 t ; 2006: 420 300 t tonnes)

Sprat spawning stock biomass 221 022 t / 84% (2007: 208 460 t / 65%; 2006: 417 000 t / 99%)

Sprat total abundance: **24 600 mill.** (2007: 41 250 mill.; 2006: 41 300 mill.)

Compared to last year, herring abundance has decreased considerably, and the biomass has decreased by a factor of 4. The vast majority (>90%) of herring in this area still consists of 0- and 1-wr (Age 1 and 2).

The absolute number of sprat calculated from the 2008 survey is much lower compared to 2007 and 2006, and the sprat's total biomass has decreased by 20%. One quarter of sprat was immature. Detailed information on abundance and biomass by statistical rectangle can be found in Figure 5F.3 and 5F.5. Mean length (cm) for herring and sprat per statistical rectangle is given in Figure 5F.4 and 5F.6, respectively.

3.4 Hydrographic data

In addition to the trawl hauls a dense net of hydrographic stations was conducted during the survey. 61 vertical profiles were recorded, with a distance of approximately 30 nautical miles between stations. Surface temperature ranged between 12.8° C and 18.0° C, and the water temperature increased inshore the German Bight. The bottom temperature decreased in the northern area between 8 to 9°C. In this region we found a pronounced thermocline in water layers between 20 to 30 m depth, whereas in the southeastern parts of our survey area the water column was well mixed.

4 Tables and Figures

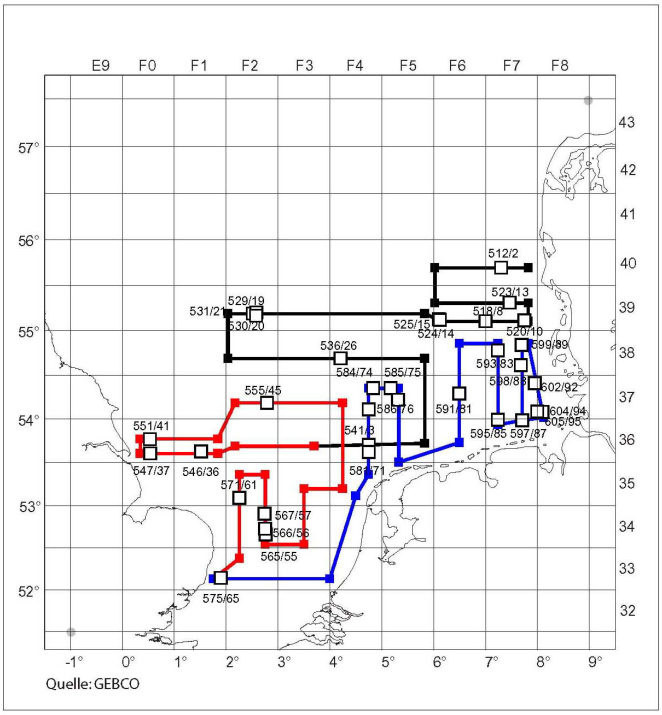

Figure 5F.1a. FRV "Solea", cruise 591, herring acoustic survey: Cruise track and fishing stations (white marks).

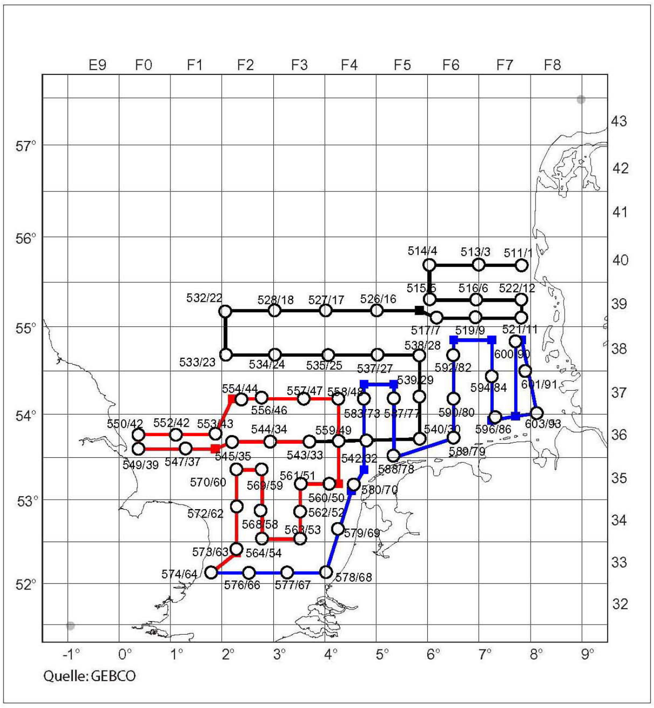

Figure 5F.1b. FRV "Solea", cruise 591, herring acoustic survey: CTD profiles (white circles).

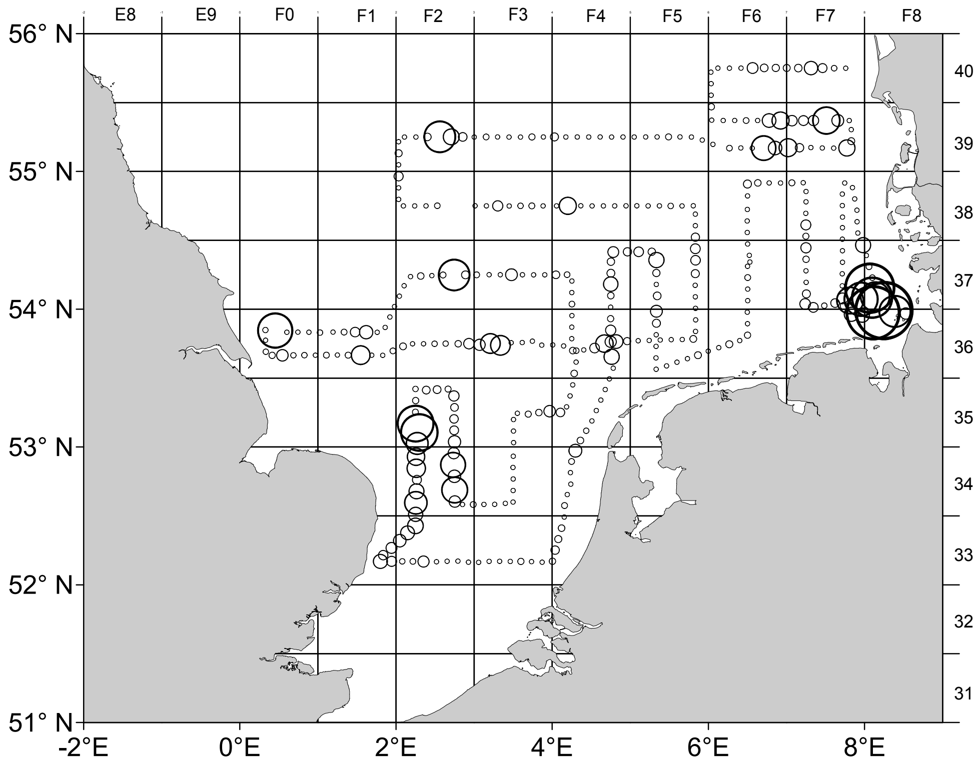

Figure 5F.2. FRV "Solea", cruise 591: Distribution of total NASC values attributed to clupeoids (sum per 5 nautical miles, on a proportional square root scale relative to the largest value of 6760 m²nautical mile⁻²). Smallest dots indicate zero values.

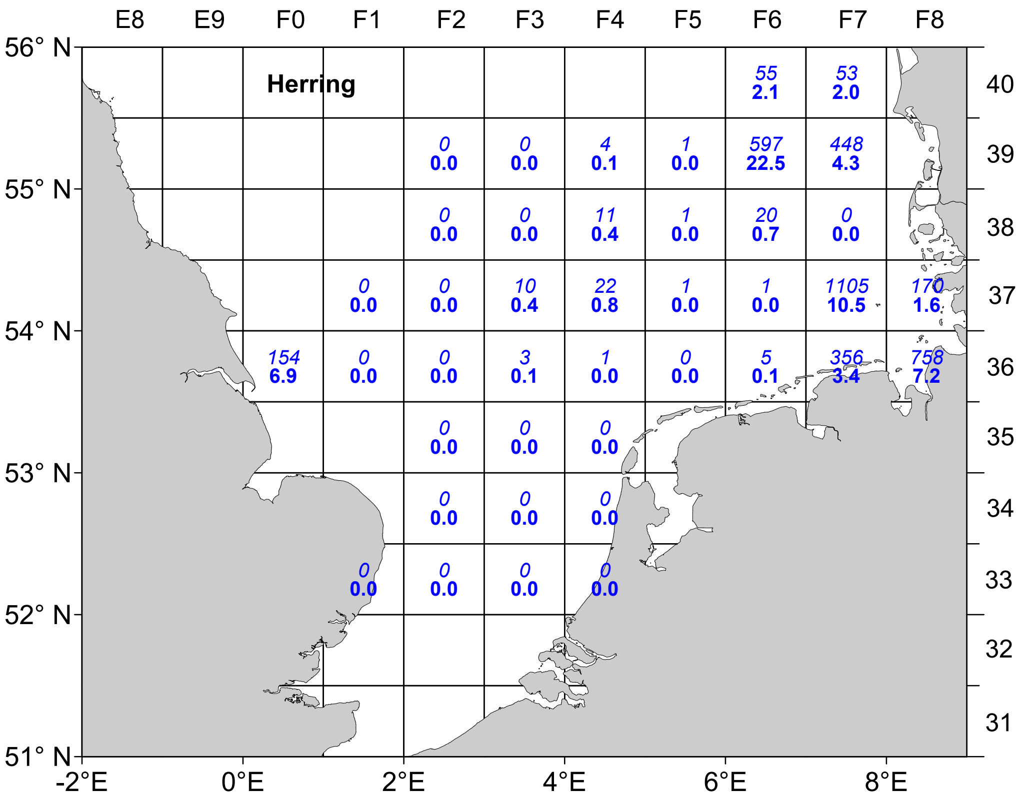

Figure 5F.3. FRV "Solea", cruise 591: Abundance (Mill. individuals, upper value in italics) and biomass (thousand t, lower value in bold) of herring per statistical rectangle.

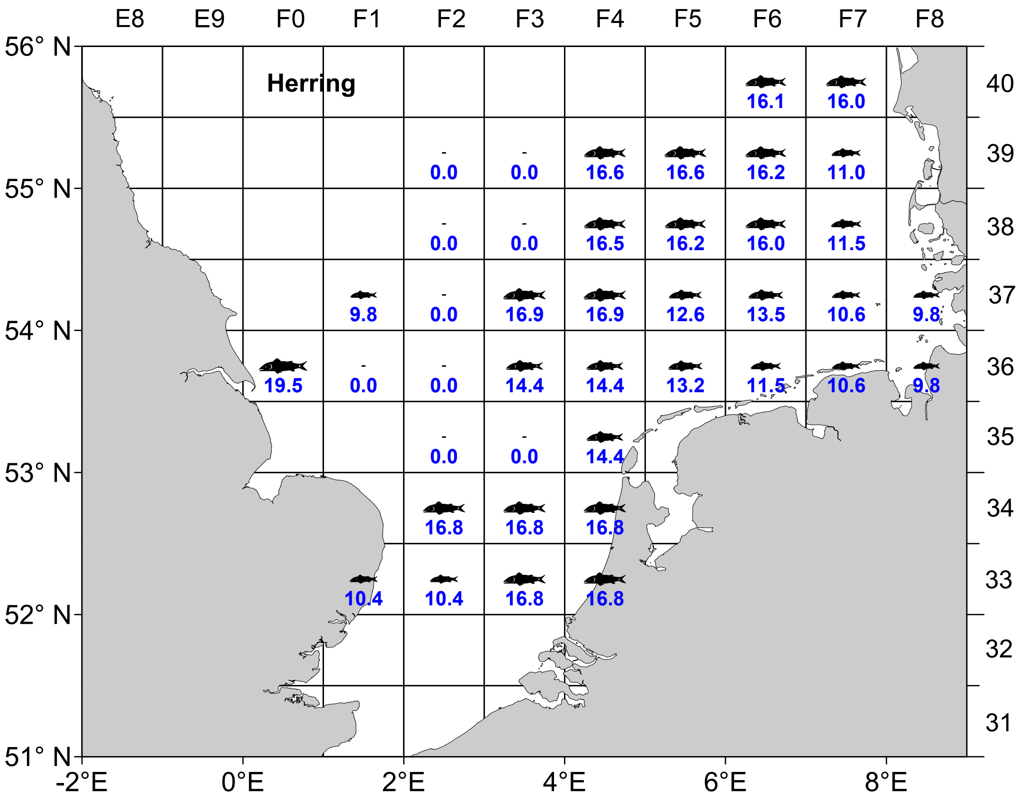

Figure 5F.4. FRV "Solea", cruise 591: Mean length of herring (cm) per statistical rectangle.

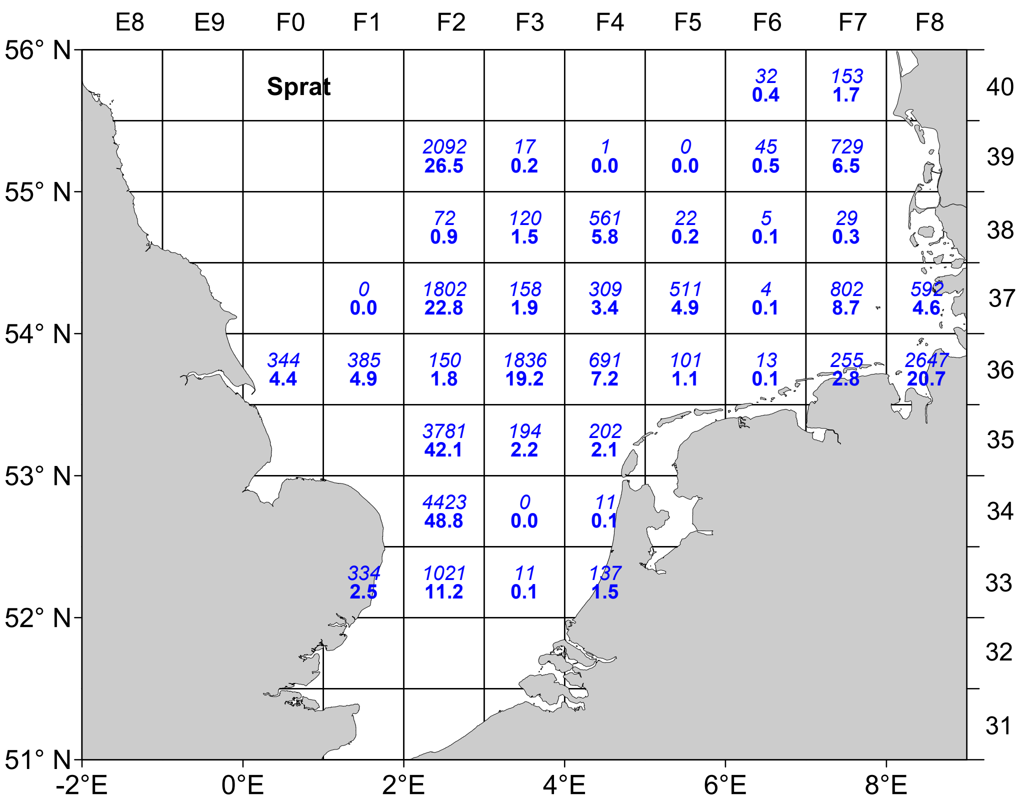

Figure 5F.5. FRV "Solea", cruise 591: Abundance (Mill. individuals, upper value in italics) and biomass (thousand t, lower value in bold) of sprat per statistical rectangle.

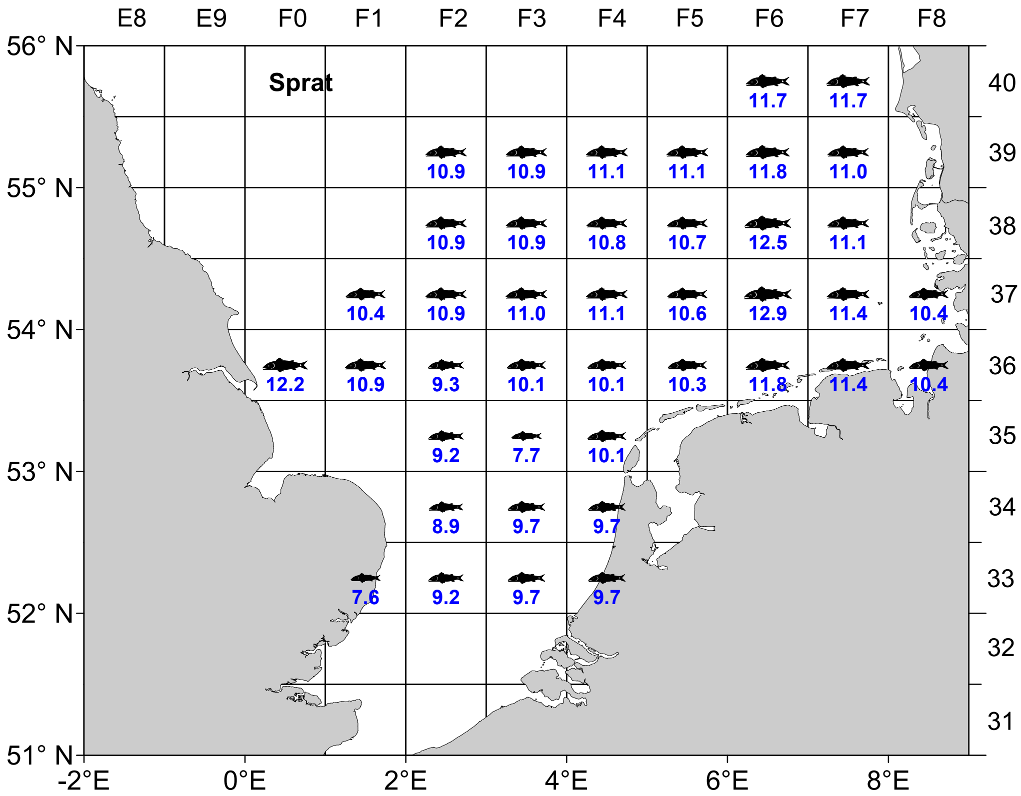

Figure 5F.6. FRV "Solea", cruise 591: Mean length of sprat (cm) per statistical rectangle.

Table 5F.1. FRV "Solea", cruise 591. Simrad EK60 calibration report.

Calibration Version 2.1.0.11
Date: 2008-07-04
Comments:
At position 53° 51.561 N, 000° 19,276 E, English coast, Wind force 4
Reference Target:
TS -33.60 dB Min. Distance 21.00 m
TS Deviation 6.0 dB Max. Distance 27.00 m
Transducer: ES38B Serial No. 30545
Frequency 38000 Hz Beamtype Split
Gain 25.45 dB Two Way Beam Angle -20.6 dB
Athw. Angle Sens. 21.90 Along. Angle Sens. 21.90
Athw. Beam Angle 6.48 deg Along. Beam Angle 7.12 deg
Athw. Offset Angle -0.33 deg Along. Offset Angle 0.24 deg
s_ACorrection -0.55 dB Depth 3.90 m
Transceiver: GPT 38 kHz 009072056b06 2 ES38B
Pulse Duration 1.024 ms Sample Interval 0.193 m
Power 2000 W Receiver Bandwidth 2.43 kHz
Sounder Type:
EK60 Version 2.1.1
TS Detection:
Min. Value -50.0 dB Min. Spacing 100%
Max. Beam Comp. 6.0 dB Min. Echolength 80%
Max. Phase Dev. 8.0 Max. Echolength 180%
Environment:
Absorption Coeff. 8.1 dB/km Sound Velocity 1505.5 m/s
Beam Model results:
Transducer Gain = 26.13 dB SaCorrection = -0.52 dB
Athw. Beam Angle = 6.98 deg Along. Beam Angle = 7.33 deg
Athw. Offset Angle= -0.22 deg Along. Offset Angle= -0.02 deg
Data deviation from beam model:
RMS = 0.49 dB
Max = 1.04 dB No. = 130 Athw. = -4.0 deg Along = -3.0 deg
Min = -3.48 dB No. = 123 Athw. = 3.2 deg Along = 1.1 deg
Data deviation from polynomial model:
RMS = 0.44 dB
Max = 1.39 dB No. = 125 Athw. = 3.9 deg Along = 1.0 deg
Min = -2.89 dB No. = 123 Athw. = 3.2 deg Along = 1.1 deg

Table 5F.2. Trawl station data of FRV "Solea" during cruise 591 (26. 6. – 16.7.08.).

STATION	HAUL	RECTANGLE	DATE	TIME	TRAWL	SHOT POS	SHOT POS	WATER	CATCH	CATCH
				(UTC)	type	Latitude	Longitude	depth (m)	depth (m)	time (min)
512	1	40F7	20080628	0620	PSN388	554505N	0071807E	25	10	30
518	2	39F6	20080629	0715	PSN388	551022N	0065954E	37	27	30
520	3	39F7	20080629	1103	PSN388	551029N	0074526E	21	9	30
523	4	39F7	20080629	1453	PSN388	552210N	0072928E	25	12	30
524	5	39F6	20080630	0505	PSN388	551141N	0060514E	47	33	30
525	6	39F6	20080630	0624	PSN388	551108N	0060705E	48	34	30
529	7	39F2	20080701	0619	PSN388	551521N	0023296E	34	19	15
530	8	39F2	20080701	0703	PSN388	551525N	0023493E	33	18	52
531	9	39F2	20080701	0831	PSN388	551427N	0023408E	34	19	67
536	10	38F4	20080702	0825	PSN388	544503N	0041283E	50	37	30
541	11	36F4	20080703	1057	PSN388	534577N	0044585E	38	21	30
546	12	36F1	20080704	0929	PSN388	534012N	0013216E	88	48	21
548	13	36F0	20080704	1338	PSN388	533993N	0003249E	25	5	30
551	14	36F0	20080705	0517	PSN388	535004N	0003092E	44	27	30
555	15	37F2	20080705	1612	PSN388	541494N	0024779E	47	30	32
565	16	34F2	20080708	1029	PSN388	524142N	0024535E	45	28	30
566	17	34F2	20080708	1208	PSN388	524568N	0024501E	46	26	30
567	18	34F2	20080708	1425	PSN388	525669N	0024420E	39	8	30
571	19	35F2	20080709	0824	PSN388	530809N	0021671E	47	26	24
575	20	33F1	20080709	1617	PSN388	521040N	0015387E	33	18	30
581	21	36F4	20080711	0433	PSN388	534178N	0044530E	34	21	31
582	22	37F4	20080711	0815	PSN388	541011N	0044514E	46	31	30
584	23	37F4	20080711	1105	PSN388	542501N	0045073E	45	25	30
585	24	37F5	20080711	1337	PSN388	542502N	0050999E	42	28	30
586	25	37F5	20080711	1527	PSN388	541766N	0052008E	43	30	30
591	26	37F6	20080712	1423	PSN388	542109N	0063021E	38	25	30
593	27	38F7	20080713	0746	PSN388	544979N	0071415E	28	14	30
595	28	37F7	20080713	1347	PSN388	540233N	0071525E	33	15	30
597	29	37F7	20080714	0422	PSN388	540347N	0074319E	39	18	30
598	30	38F7	20080714	0841	PSN388	544012N	0074254E	21	7	35
599	31	38F7	20080714	1118	PSN388	545403N	0074255E	21	8	30
602	32	37F7	20080714	1620	PSN388	542873N	0075745E	18	7	30
604	33	37F8	20080715	0454	PSN388	540976N	0080636E	22	9	30
605	34	37F8	20080715	0640	PSN388	540850N	0075918E	34	14	18

Table 5F.3. FRV "Solea", cruise 591. Species distribution per haul (catch in kg per 30 min.)

RECTANGLE	STATION	kg total	*BELONE BELONE*	*CALLIONYMUS LYRA*	*CLUPEA HARENGUS*	*DICENTRARCHUS LABRAX*	*ECHIICHTHYS VIPERA*	*ENGRAULIS ENCRASICOLUS*	*ENTELURUS AEQUOREUS*	*EUTRIGLA GURNARDUS*	*HYPEROPLUS LANCEOLATUS*	*LIMANDA LIMANDA*	*MERLANGIUS MERLANGUS*	*SCOMBER SCOMBRUS*	*SPRATTUS SPRATTUS*	*TRACHURUS TRACHURUS*	*TRIGLA LUCERNA*	Number of Species
40F7	512	76.0			26.3					0.5	0.1	0.5	0.0	16.3	32.4			7
39F6	518	104.9			101.3					0.4	0.0		0.0	0.2	3.0			6
39F7	520	53.8			0.0					0.5	0.1				53.2			4
39F7	523	174.0			75.6					0.0				2.4	95.9			4
39F6	524	3.2								3.1	0.0		0.0		0.0			4
39F6	525	32.8			25.0					6.6					1.2			3
39F2	530	0.2							0.0	0.2								2
39F2	531	0.1					0.0		0.0	0.0	0.0							4
38F4	536	2.4								2.4			0.0					2
36F4	541	207.7			1.4			0.0		1.5			0.0	16.1	188.5	0.1		7
36F1	546	13.6					0.1						0.0	0.3	13.1			4
36F0	548	133.0			0.2		1.0		1.1	0.1	0.9		0.0		129.7			7
36F0	551	272.9			264.0		3.0		0.0	0.1	1.0			4.9	0.1			7
37F2	555	0.8								0.8								1
34F2	565	71.0					0.6			0.1			1.2	1.0	68.1			5
34F2	566	227.4			0.0		0.4		0.0				0.2	0.2	226.6			6
34F2	567	2.7				0.3	0.1						0.0		2.2			4
35F2	571	141.6	0.2				6.6	0.0	0.0	1.1	5.5			0.8	126.5		0.8	9
33F1	575	27.6			0.0		0.3				0.1		0.0	2.6	24.5			6
36F4	581	140.7			0.0			0.0	0.0					1.0	139.6			5
37F4	582	139.5		0.0	26.5					0.1			0.9	2.4	109.6			6
37F4	584	1.7								0.4			0.0	0.8			0.5	4
37F5	585	295.2			1.2					0.6			0.0	0.9	292.5			5
37F5	586	222.7	0.2		1.4					0.2			0.1	7.4	213.4			6
37F6	591	22.1			5.5								0.1	4.5	12.1			4
38F7	593	0.2								0.2			0.0			0.0		3
37F7	595	373.9			93.2			0.8						0.3	279.6			4
37F7	597	497.3			312.2					0.1			0.0	3.2	181.8			5
38F7	598	2.3												2.3		0.0		2
38F7	599	1.0											0.0	1.0		0.0		3
37F7	602	26.8						1.8						16.8	5.3	2.9		4
37F8	604	196.2			69.8			0.1						2.4	123.9			4
37F8	605	926.5			117.6			0.2						0.4	808.2			4
total		4391.8	0.4	0.0	1121.2	0.3	12.2	2.9	1.1	19.2	7.7	0.5	2.6	88.2	3131.1	3.0	1.3	15
proportion (%)			0.0	0.0	25.5	0.0	0.3	0.1	0.0	0.4	0.2	0.0	0.1	2.0	71.3	0.1	0.0	
number of catches			2	1	19	1	9	7	7	21	9	1	19	23	25	5	2	
presence (%)			6.1	3.0	57.6	3.0	27.3	21.2	21.2	63.6	27.3	3.0	57.6	69.7	75.8	15.2	6.1	

Table 5F.4. FRV "Solea", cruise 591. Herring length frequency (%) by trawl haul (length in cm).

	Stat:	512	518	520	523	525	541	548	551	566	575	581	582	585	586	591	595	597	604	605
	Haul:	1	2	3	4	6	10	12	13	16	19	20	21	23	24	25	27	28	32	33
Length	Rect:	40F7	39F6	39F7	39F7	39F6	36F4	36F0	36F0	34F2	33F1	36F4	37F4	37F5	37F5	37F6	37F7	37F7	37F8	37F8
(cm)	Total																			
7.25	0.1	0	0	0	0	0	2	0	0	0	33	0	0	0	0	0	0	0	0	0
7.75	0.2	0	0	0	0	0	2	0	0	0	0	0	0	3	0	0	0	0	1	0
8.25	0.5	0	0	0	0	0	6	0	0	0	33	0	0	0	0	0	0	0	4	1
8.75	1.2	0	0	0	0	0	8	0	0	0	0	0	0	4	2	0	0	0	8	2
9.25	3.3	0	0	0	1	0	6	0	0	0	0	0	0	4	7	0	0	1	26	9
9.75	9.6	0	0	0	4	0	0	0	0	0	0	0	0	12	19	0	1	19	46	43
10.25	8.2	0	0	0	12	0	0	0	0	0	0	0	0	4	15	0	3	36	13	28
10.75	9.6	0	0	0	38	0	0	0	0	0	0	0	0	4	7	0	15	30	2	14
11.25	7.8	0	0	50	30	0	0	0	0	0	0	0	0	4	1	0	33	10	0	2
11.75	6.5	0	0	50	12	0	0	0	0	0	0	0	0	16	6	1	37	5	0	1
12.25	2.2	0	0	0	2	0	0	0	0	0	0	0	0	1	4	11	8	0	0	0
12.75	3.2	0	0	0	1	0	0	0	0	0	0	0	0	3	2	31	3	0	0	0
13.25	2.3	0	0	0	0	0	2	0	0	0	0	0	0	3	0	24	1	0	0	0
13.75	0.9	1	1	0	0	0	0	0	0	0	0	0	0	1	0	8	0	0	0	0
14.25	1.1	5	1	0	0	0	0	0	0	0	0	0	0	1	0	4	0	0	0	0
14.75	2.4	10	5	0	0	0	2	20	0	0	0	0	1	3	2	8	0	0	0	0
15.25	3.9	14	9	0	0	1	8	40	0	0	0	0	4	9	5	7	0	0	0	0
15.75	6.5	20	28	0	0	13	8	0	0	0	33	100	6	10	5	5	0	0	0	0
16.75	8.1	17	30	0	0	36	24	20	1	0	0	0	13	9	6	0	0	0	0	0
18.75	8.9	19	22	0	0	30	27	0	2	100	0	0	31	7	8	1	0	0	0	0
19.25	4.1	8	4	0	0	12	2	0	1	0	0	0	25	0	6	1	0	0	0	0
19.75	2.3	3	2	0	0	5	2	0	6	0	0	0	13	0	4	0	0	0	0	0
20.25	1.0	1	1	0	0	2	0	0	5	0	0	0	5	0	1	0	0	0	0	0
20.75	1.4	1	0	0	0	0	0	0	17	0	0	0	1	0	0	0	0	0	0	0
21.25	1.3	0	0	0	0	1	0	20	17	0	0	0	0	0	0	0	0	0	0	0
21.75	1.0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0
22.25	1.2	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0
22.75	0.7	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0
23.25	0.2	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
total n	2943	365	195	2	291	171	49	5	206	1	3	1	210	69	85	255	332	267	249	187
mean		16.0	16.1	11.5	11.0	16.6	14.3	16.2	19.5	16.8	10.4	15.8	16.9	12.7	12.6	13.5	11.5	10.5	9.5	10.0

Table 5F.4b. FRV "Solea", cruise 591. Sprat length frequency (%) by trawl haul (length in cm).

	Stat:	512	518	520	523	524	525	541	548	546	551	565	566
	Haul:	1	2	3	4	5	6	10	11	12	13	15	16
Length	Rect:	40F7	39F6	39F7	39F7	39F6	39F6	36F4	36F1	36F0	36F0	34F2	34F2
(cm)	Total												
1.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.25	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.75	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.25	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.75	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.25	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.75	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.25	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.75	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.25	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.75	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.25	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.75	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
8.25	1.4	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.0	0.0	0.0	0.6
8.75	3.1	0.0	0.0	0.0	0.0	0.0	0.0	12.3	0.0	0.0	0.0	0.0	18.2
9.25	6.2	0.0	0.0	0.0	0.7	0.0	0.0	36.5	1.4	0.0	0.0	0.4	34.5
9.75	8.8	1.0	0.0	0.4	1.3	100.0	6.5	32.2	5.7	0.0	0.0	6.8	26.5
10.25	11.9	1.5	0.0	5.6	15.8	0.0	9.3	11.7	13.9	0.0	0.0	32.8	13.0
10.75	19.2	11.8	1.1	37.8	38.5	0.0	29.9	3.1	37.9	1.3	0.0	37.4	4.7
11.25	18.4	30.0	7.1	43.8	33.9	0.0	34.6	1.2	24.3	1.9	0.0	15.8	1.7
11.75	11.6	25.6	32.8	11.6	8.9	0.0	11.2	0.0	12.5	34.8	0.0	3.4	0.6
12.25	6.4	18.7	33.3	0.8	1.0	0.0	4.7	0.0	3.6	42.6	0.0	1.5	0.3
12.75	3.7	7.9	20.2	0.0	0.0	0.0	0.9	0.0	0.4	16.1	66.7	1.1	0.0
13.25	1.9	3.0	4.9	0.0	0.0	0.0	0.9	0.0	0.4	2.6	33.3	0.8	0.0
13.75	0.6	0.5	0.5	0.0	0.0	0.0	1.9	0.0	0.0	0.6	0.0	0.0	0.0
14.25	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
total n	6315	203	183	251	304	1	107	326	280	155	3	265	362
mean		11.7	12.2	11.1	10.9	9.8	11.1	9.5	10.9	12.2	12.9	10.7	9.5

Table 5F.4b. Sprat length frequency (%) by trawl haul (length in cm), continued.

	567	571	575	581	582	585	586	591	595	597	602	604	605
Length	17	18	19	20	21	23	24	25	27	28	31	32	33
(cm)	34F2	35F2	33F1	36F4	37F4	37F5	37F5	37F6	37F7	37F7	37F7	37F8	37F8
1.75	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.25	3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.75	11.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.25	19.9	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.75	47.6	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.25	14.1	7.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.75	1.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.25	1.0	1.2	4.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.75	0.5	0.3	20.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.25	0.0	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.75	0.0	0.0	1.7	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	4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.75	0.0	4.9	17.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8.25	0.0	7.8	16.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0
8.75	0.0	8.1	15.4	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	3.5	0.0
9.25	0.0	4.9	7.0	0.3	0.5	1.6	7.3	0.0	0.0	1.0	0.0	15.5	5.5
9.75	0.0	2.9	4.3	2.1	4.0	10.8	23.3	0.0	0.0	6.0	0.0	19.9	20.7
10.25	0.0	3.8	1.7	6.8	12.6	21.6	26.2	0.0	0.9	20.3	2.9	20.2	26.9
10.75	0.0	18.5	0.3	17.5	29.4	36.2	21.9	0.0	4.0	27.6	16.0	22.4	28.5
11.25	0.0	18.8	0.0	24.7	30.9	24.1	10.8	0.4	24.8	27.6	41.3	15.5	13.3
11.75	0.0	6.6	0.0	23.6	17.3	3.5	7.9	4.7	40.6	10.6	28.2	2.5	4.5
12.25	0.0	2.9	0.0	13.7	3.8	1.9	0.9	19.6	18.3	6.0	7.3	0.0	0.0
12.75	0.0	1.7	0.0	6.8	1.3	0.0	0.9	36.2	5.6	1.0	2.9	0.0	0.6
13.25	0.0	0.9	0.0	3.4	0.3	0.3	0.0	26.0	4.6	0.0	1.5	0.0	0.0
13.75	0.0	0.0	0.0	0.3	0.0	0.0	0.0	12.3	1.2	0.0	0.0	0.0	0.0
14.25	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0
total n	191	346	299	292	398	315	343	235	323	301	206	317	309
mean	3.6	9.2	7.6	11.5	11.1	10.7	10.4	12.9	11.8	10.9	11.4	10.2	10.5

Table 5F.5. FRV "Solea", cruise 591. Age/maturity-length key for herring (sampled numbers not raised to the abundance in the survey area).

WR	0	1	1	2	2	3	
Maturity	i	i	m	i	m	m	
Length (cm)							Sum
7.25	1						1
7.75	5						5
8.25	13						13
8.75	20						20
9.25	26						26
9.75	40						40
10.25	38						38
10.75	38						38
11.25	27						27
11.75	34						34
12.25	31						31
12.75	25						25
13.25	13	2					15
13.75	10	5					15
14.25	3	22					25
14.75		38					38
15.25		58					58
15.75		56					56
16.25		54					54
16.75		57					57
17.25		41					41
17.75		43		1			44
18.25	1	28					29
18.75		15					15
19.25		11		1			12
19.75		10					10
20.25		8		2			10
20.75		7		3			10
21.25		2	1	3			6
21.75		1	3	2	1		7
22.25					2	1	3
22.75					1		1
23.25					1	1	2
total	325	458	4	12	5	2	806

Table 5F.6. FRV "Solea", cruise 591. Age/maturity-length key for sprat (sampled numbers not raised to the abundance in the survey area).

Age	1	1	2	2	3	4	
Maturity	i	m	i	m	m	m	
Length (cm)							Sum
7.25	1						1
7.75	5						5
8.25	18	3					21
8.75	30	23					53
9.25	29	45		1			75
9.75	58	40	6	6			110
10.25	41	56	4	15	2		118
10.75	23	70	4	25			122
11.25	9	72		34	3		118
11.75		70		53	4	1	128
12.25		32		64	10	2	108
12.75		9		64	7		80
13.25		2		47	5		54
13.75		1		10	7	2	20
14.25				1	3		4
total	214	423	14	320	41	5	1017

ANNEX 5G: Ireland

Survey report for RV *Celtic Explorer*

19 June – 8 July 2008

Ciaran O'Donnell, Marine Institute, Galway, Ireland

1. INTRODUCTION

The northwest and west coast (ICES Divisions VIaS and VIIb, c) herring acoustic survey program was first established in 1994. A larval survey programme was initially carried out between 1981 and 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 aggregation program was established covering both autumn and winter stock components. In 2004, a single spawning stock survey was carried out early in quarter 1 and continued until 2007, whereupon it was decided that this survey should be incorporated into the larger coordinated Malin shelf survey.

This survey will be the first in a new time-series and a step away from the traditional spawning stock surveys. The Irish survey will be carried out concurrently with the West of Scotland (MarLab) and Irish Sea surveys (AFBI) and will be coordinated through the ICES Planning Group of Herring Acoustic Surveys (PGHERS). Combined survey data on herring distribution, abundance and age will be 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, c) herring stock is composed of 2 of spawning components (autumn and winter spawners), covering a large geographical area and having a protracted spawning season, which 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. In VIaS, fishing begins in late November and continues until late March (winter spawners). Further south in VIIb, peak fishing takes place from October to December (autumn spawners). The protracted spawning period of herring and the overlap between the two spawning stocks in this area (October to February) is highly dynamic with variations between annual spawning events of up to 3 weeks.

Up to 40 vessels commonly participate in the fishery, many of which are based in the Co. Donegal port of Killybegs. The fleet is made up of 20 RSW (Refrigerated Seawater) vessels of 40–70m in length; 20 polyvalent trawlers 10 of which are vessels of 22–40m and 10 of less than 25m.

Objectives

The primary survey objectives of the *Explorer* are listed below:

- Carry out a predetermined survey cruise track based on the known summer herring distribution
- Work in collaboration with the fishing industry, using a scoping survey, to determine the extent and distribution of summer feeding aggregations of herring within the survey confines

- 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, c and VIaS) using acoustic survey techniques
- Collect physical oceanography data via a deployed sensor array.

The primary survey objectives of the commercial scouting survey are listed below:

- Actively search for herring aggregations and mixed herring schools within the survey area working from South to North (ICES Divisions VIIb, c and VIaS).
- Work in collaboration with the Celtic Explorer to determine the extent and distribution of summer feeding aggregations of herring within the survey confines
- Relay information on herring distribution to the Celtic Explorer
- Collect biological samples of herring and species of interest from trawl samples

2. SURVEY DESCRIPTION AND METHODS

2.1 Personnel

Name	Role
RV Celtic Explorer	
Ciaran O'Donnell (SIC)	Acoustics
Eugene Mullins	Acoustics
Deirdre Lynch	Acoustics
Ryan Saunders	Acoustics
Turloch Smith	Biologist
Deirdre Hoare	Biologist
Oral Hanniffy	Biologist
Marcin Blaszkowski	Biologist
FV Eternal Dawn	
Micheal Mc Aullife (SIC)	Biologist
Francis Mc Daid	Biologist

2.2 Survey design

The survey was focused on the northwest and west coast of Ireland (ICES Divisions VIaS and VIIb, c) as shown in Figure 5G.1. The survey track commenced off the west coast of Ireland at the southeastern extension and worked in continuity from south to north.

To keep in line with existing survey methodology (MarLab West of Scotland survey) acoustic surveying was only undertaken between 04:00 and 23:00 (daylight hours).

The commercial survey focused effort in the ICES areas VIIb and VIaS offshore from known autumn and winter spawning grounds where the fishery is focused in quarters 4 and 1. The vessels also covered the grounds extending to the shelf break and northwards to the 56ºN. The commercial vessels worked 24hrs over the 10 day charter period.

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 120 to 200m depth contours depending on area, and inshore to approximately the 30m depth contour. Transect spacing was set at 4 and 7.5nmi (nautical miles). As this is the first of a new survey time-series it was deemed important to cover the grounds as intensively as possible to highlight any potential areas of distribution or dense aggregations.

In total, the survey accounted for 2,418nmi, with 2,140nmi of data available for acoustic integration. Survey design and methodology adheres to the methods laid out in the PGHERS acoustic survey manual.

The commercial survey used a random sonar based search pattern to cover the area shown in Figure 5G.1. The search pattern consisted of vessels being separated by up to 3nmi with sonar ranges set up to 2000m.

In the north/south aspect of the survey transects were interlaced along the 55º33N with the FV *Chris Andra* taking this transect to interlace with the RV *Celtic Explorer*. In the east/west aspect a transect running from 06–07ºW along the 55º29N was taken up by the RV *Corystes*.

2.3 Calibration

The ER60 was calibrated in Killary Harbour on the 20 June in near ideal conditions. The results of the calibration are presented in Table 5G.1. The ER60 was last calibrated in October 2007 (O'Donnell *et al.*, 2007). Overall, drift within the system can be regarded as minor between successive calibrations to date.

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 5G.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 200 kHz) 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 5G.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 5G.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 Commercial scouting survey

The commercial survey was carried out over a 10 day period from June 20–30. The vessels mobilized in Ros a Mhil, Co. Galway and worked in a northerly direction in line with the Explorer. Temporal progression between the Explorer and the commercial pair averaged 2 days overall.

The FV *Atlantic Quest* and FV *Eternal Dawn* are owner operated polyvalent vessels with a long track record in the herring fishery in this area. A picture of the vessels and general specifications are provided in Figure 5G.12.

Non-quantifiable acoustic data from the Simrad ES60 were recorded from both vessels using HDD USB external hard drives installed on board. These data will be used as a means of visual comparison of mark types observed between vessels.

Biological data from trawl catches were collected using the same sampling methodology applied on board the Explorer.

2.8 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 for 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 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

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

where l is the transect length and $\overline{n}$ 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 $n_{s,t,j}$.

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

, 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

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

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

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

Thirty seven hauls were carried out over the course of the survey (Figure 5G.2, Table 5G.2a). Of this 21 contained herring. Herring represented the second most frequently encountered species after mackerel. Some hauls yielded no catch but were targeted on specific surface marks most likely to be herring but that had evaded the net. This was most notable on marks within 10 m of the surface. Over 4,300 length measurements were taken and 1,087 individual herring were aged during the survey.

Mackerel were the most commonly observed species on the survey and were found in 26 out of 37 hauls throughout the survey area in both inshore and shelf break areas. Over 2,000 individual length measurements were taken and the mean length for mackerel encountered during the survey was 25.16 cm relating to a mean weight of 137 g. Length range was 19–39 cm overall. Juvenile mackerel were found as mixed surface schools with herring in the northern area of the survey, whereas mature spawning and prespawning individuals were mainly taken in deeper waters towards the shelf edge (> 100 m).

Horse mackerel were the third most frequently encountered pelagic species with a distribution towards the shelf margins in waters in excess of 100 m. Length ranged between 20–38 cm, with a mean length and weight of 29.6 cm and 237 g respectively.

3.1 Herring biomass and abundance

A full breakdown of the survey stock structure is presented by distribution, age, length, biomass, abundance and area in Tables 5G.4, 5 and 6 and Figures 5G.2 and 4a.

HERRING	MILLIONS	BIOMASS (T)	% CONTRIBUTION
Total estimate			
Definitely	71.0	11,593	26.0
Mixture	189.0	31,888	71.5
Probably	7.0	1130	2.5
Total estimate	**267**	**44,611**	**100**
Possibly	6.0	1,044	
Possible estimate	273	45,655	
SSB Estimate			
Definilty	65.0	11,016	25.6
Probably	7.0	1,101	2.6
Mixture	180.0	30,889	71.8
SSB estimate	**252**	**43,006**	**100**

3.2 Herring distribution

A full breakdown of school type, number and biomass by strata is provided in Table 5G.9.

In the southern area of Division VIIb the (52º30N to 53º30N) no single or mixed herring marks were identified from trawling or during data scrutinization. This was surprising considering this area supports a small autumn fishery on spawning grounds in and around Galway Bay, namely from Oranmore to Rinville and from Spiddal to Ros An Mhil.

In the northern area of VIIb (53º30N to 54º15N) herring were observed as large mixed schools with mature mackerel and occurred mainly in waters of over 150m depth, no mixed schools were observed in shallower inshore waters. In the northern extreme of VIIb in rectangle D837, single schools of herring were observed from deeper waters eastwards towards autumn spawning grounds located from Downpatrick Head to Lenadoon. Overall, this rectangle contributed the highest overall herring biomass observed during the survey relating to 44 definitely herring and 32 mixed herring schools which contributed 25% to the total SSB. Westward transect extension was continued where marks were observed close to the original transect endpoint until no more fish were observed. This adaptive surveying method was applied as and when required throughout the survey.

The southern area of VIaS in rectangle D938 was found to contain the greatest distribution of single herring marks totalling 107, composed of low density schools and contributing 11% to the total SSB. Herring distribution was categorized as being well spread from 50–150m depth, with the latter deeper waters containing the greatest biomass.

Herring in the northern area of VIIb, as in the southern area of VIaS, were found in proximity to autumn spawning grounds. In both the above areas herring marks were observed as small single “chips” occurring from 5–15m off the seabed and often over a large area. No surface schools were observed.

The northern area of VIaS (55ºN to 56ºN) can be regarded as a cross over point. Herring schools in this area from 6º– 9ºW showed a marked difference to those observed further south in both school structure and behaviour (Figure 5G.4 b and c). Herring in this area were observed as large high density single and mixed schools and fewer low density marks. In general, larger schools were observed higher in the water column than those in the south. The greatest biomass was yielded from mixed schools (with juvenile mackerel) located in proximity to winter spawning grounds along the north coast.

Overall the northern area of VIaS along the north coast contributed over 46% to the total SSB estimate and contained the only juvenile herring recorded during the survey.

No juvenile herring were observed west of 9ºW in VIIb or in VIaS. To the east of 9ºW along the north coast, in division VIaS, juvenile herring accounted for 3.6% of the total recorded biomass.

3.3 Stock structure

Age analysis of biological samples showed herring within the survey area to be composed of age from 1–10 years (winter rings), as shown in Figure 5G.4a. The stock within the survey area is dominated by 2 winter ring fish, which make up 24.8% by weight of the total biomass and over 31% by numbers (Tables 5G.4, 5G.5 and Figure 5G.4). The second most abundant age class observed was the 3 winter ring fish which represented 23.9% by weight and 24.3% by numbers of the total biomass. The 4, 5 and 6 winter ring herring make up the remaining total biomass, representing 40.1% by weight and 33.2% by numbers. Age structure analysis indicates the bulk of the survey stock is bolstered by the younger 2–3 winter rings herring and not by older individuals.

Maturity analysis indicates the bulk of the survey stock to be mature, 96.4% by weight and 94.2% by numbers. Stage 8, spent/recovering was the most commonly encountered maturity stage representing 48% of the total (based on Landry and McQuinn 1988; ICES 2003). Over 29% were classified as Stage 3 ripening. The remaining stages were made up as juveniles (5.7%) and developing virgins (16.3%).

One winter ring herring accounted for 2.6% by weight and 4.6% by numbers of the total biomass and were found exclusively along the north coast in Division VIaS between 7–9ºW. The presence of 1 winter ring fish has also been picked up in commercial catches in quarter 1 in this area.

3.4 Commercial scouting survey

A total of 10 trawls were carried out over the 10 day survey (Figure 5G.2, Table 5G.2b). All trawls were carried out at the surface with the headline between 4–7m subsurface and with a typical vertical net opening of 25m. Of the trawls carried out 80% were blind tows in areas of known summer distribution and were carried out with no visible marks observed on the vessels echosounders. Two directed trawls were carried out using a combination of high frequency sonar for tracking on marks initially observed on the vessel echosounders (Figure 5G.12).

The commercial vessels were instructed to carry out blind tows in surface waters to assess the level of non quantified biomass. Information from the skippers revealed that multiple marks were often visible on the high frequency sonar and herring were present but none were actually recorded on the vessels echosounder. This would indicate a degree of vessel avoidance. However, it should be noted that the mark types observed along the north coast, where the commercial vessels concentrated effort, were of greater biomass and tended to school between 5–20m subsurface than those observed in more southern locales. More southern mark types were observed as deeper and less dense marks occurring 5–15m off the bottom and no surface schooling was observed (Figure 5G.5b).

Comparing the age structure of herring taken from the Celtic Explorer and the commercial vessels (Figure 5G.4a-b) show that the Celtic Explorer caught a wider range of age classes over 31 trawls than the commercial vessel (n=10). This may in some way be attributed to the larger amount of trawling undertaken by the Explorer and also that 80% commercial tows were often undertaken as blind surface tow (Table 5G.2b). The age structure of the commercial trawl samples show that 2-winter ring fish dominated catches. Older year-classes, of 3 and 4 winter ring fish were not well represented as compared to the Explorer catches. Comparative maturity work was not undertaken because of inconsistencies in maturity sampling. However, the maturity state from the Explorer samples is robust.

3.5 Oceanography

In total 31 vertical CTD casts were undertaken during the survey (Figure 5G.6). Two stations were lost due to poor weather and one due mechanical failure. All data were compiled to produce horizontal plots of temperature and salinity at the following depths; 5m subsurface, 20m, 40m and 60m (Figures 5G.7–10 respectively).

Horizontally compiled data indicate oceanographic conditions typical for the time of year with a moderate thermocline stratifying surface waters. In deeper waters (Figure 5G.10) the West Irish Shelf Front is visible through the tightening of the isohalines off Mayo and provides a good indication of the position of this front.

The Islay Front in the northern survey area is the most noticeable feature in surface waters north of Malin Head (Figure 5G.8). This is a well-documented front that separates Atlantic water from the Irish Sea.

4. DISCUSSION AND CONCLUSIONS

4.1 Discussion

Overall, the survey was a success with only small time losses due to poor weather. Survey aims were achieved as planned.

Of the 606 schools identified during the survey 55% were categorized as 'definitely' herring while only 9% were given to 'probably' herring and fewer still to 'possibly' herring. The remaining 36% represented herring occurring in mixed schools. The large proportion of 'mixed' schools contributing to the total biomass (over 71%) can be attributed to the abundance of mackerel in the area. In the northern area on the shelf, juvenile mackerel were mixed with herring in surface waters with over a wide area. In deeper waters (>100 m) in the southern area herring were encountered mixed with pre and post-spawning mackerel.

Comparing herring catches in the northern area taken from blind surface tows by the commercial pair and those of the Explorer it appears that most of the herring encountered occurred in surface waters (5–20 m subsurface). Discounting the effects of vessel avoidance which would no doubt have an effect on fish detection, the acoustic integration takes place from 10m subsurface to 0.5 m from the seabed. So any herring occurring from 0–10m would not be available to the equipment. Although every effort was made to have the transducers positioned as shallow as possible this was a trade-off between data quality and detection due to poor weather conditions. As a result combining both the effects of vessel avoidance and nearfield acoustic range an unknown proportion of the herring biomass within the survey area was unaccounted for, a phenomenon which is not new to the field of fisheries acoustics.

Observations of behavioural differences between northern and southern areas were notably different. In the southern area, herring were found to be distributed over a larger area in lower density and at greater depths, making for a more accurate estimation of observed biomass. Schools observed in the northern area were often found as mixed assemblages with juvenile mackerel in surface water as higher density schools.

As part of agreements made at the Planning Group for Herring Surveys (PGHERS) meeting in 2008 transects were interlaced between vessels surveying the Malin Shelf Stock Complex. It is recommended for future surveys that the time-lag between vessels observed in 2008 (2 days RV *C. Explorer* and FV *C. Andra* and 6 days RV *C. Explorer* and RV *Corystes*) be reduced where possible to ensure continuity across the survey.

4.2 Conclusions

Although a large percentage of the biomass in the area at the time of surveying was recorded an undetermined proportion of the total biomass was unavailable to the acoustic equipment. As a result the estimate of abundance, although an accurate representation, should consider this smaller but nonetheless important unaccounted biomass. Once the survey has an established and recognized time-series it is hoped that variations in the year on year estimates will be able to estimate this element of the biomass during the assessment process.

The bulk of the recorded biomass was observed in the northern area of the survey, which contains the spawning grounds of winter spawning component. The distribution of herring in this area extended from inshore around the spawning areas northwards to the northern limit of the survey. This is in line with current knowledge of herring summer feeding movements and information from the fleet. A consideration that should be taken into account by the west of Scotland survey which covers this area from 56°N to 58.30°N using mainly low intensity (15 nautical mile spaced) transect as compared to the 4nmi transect spacing used by the Explorer.

The use of a summer survey program as a means to accurately estimate the relative abundance of herring biomass within divisions VIIb, c and VIaS cannot be determined from this first survey. However, what is important to note is that both autumn and winter spawning components of the stock were observed within the survey confines. Distribution patterns in the northern area clearly indicate herring distribution extending northwards outside the scope of the survey area, this is in line with existing information on summer distribution and information from the fleet. It is hoped once established that the combined Malin shelf survey will provide the most accurate estimate of abundance for this trans-boundary stock.

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Table 5G.1. Survey settings and calibration report (38KHz) for the Simrad ER60 echosounder. Northwest herring survey, June 2008.

Vessel : R/V Celtic Explorer		Date : 20/06/2008
Echo sounder : ER60 PC		Locality : Killary Harbour
Type of Sphere : CU-60	TS_{Sphere}: -33.50 dB (Corrected for soundvelocity or t,S)	Depth(Sea floor) : 30 m

Calibration Version 2.1.0.11

Comments:
Killary Harbour, Flat Calm @ 08:30am

Reference Target:

TS	-33.50 dB	Min. Distance	10.00 m
TS Deviation	10.0 dB	Max. Distance	25.00 m

Transducer: ES38B Serial No. 30227

Frequency	38000 Hz	Beamtype	Split
Gain	25.83 dB	Two Way Beam Angle	-20.6 dB
Athw. Angle Sens.	21.90	Along. Angle Sens.	21.90
Athw. Beam Angle	6.94 deg	Along. Beam Angle	6.80 deg
Athw. Offset Angle	-0.03 deg	Along. Offset Angl	0.02 deg
SaCorrection	-0.67 dB	Depth	8.80 m

Transceiver: GPT 38 kHz 009072033933 2 ES38B

Pulse Duration	1.024 ms	Sample Interval	0.193 m
Power	2000 W	Receiver Bandwidth	2.43 kHz

Sounder Type:
EK60 Version 2.1.1

TS Detection:

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

Environment:

Absorption Coeff.	8.9 dB/km	Sound Velocity	1507.9 m/s

Beam Model results:

Transducer Gain =	25.73 dB	SaCorrection =	-0.73 dB
Athw. Beam Angle =	7.05 deg	Along. Beam Angle =	6.96 deg
Athw. Offset Angle =	-0.01 deg	Along. Offset Angle=	-0.07 deg

Data deviation from beam model:
RMS = 0.11 dB
Max = 0.39 dB No. = 154 Athw. = -2.7 deg Along = -3.2 deg
Min = -0.37 dB No. = 63 Athw. = -3.4 deg Along = 3.6 deg

Data deviation from polynomial model:
RMS = 0.06 dB
Max = 0.21 dB No. = 65 Athw. = -2.5 deg Along = 3.9 deg
Min = -0.21 dB No. = 219 Athw. = 1.8 deg Along = 4.5 deg

Comments :
Flat Calm, good overall conditions
Wind Force : 7 kn. **Wind Direction :** NW
Raw Data File: F:\Northwest Herring 2008\Calibration files\NWHAS_08-D20080620-T084011.raw
Calibration File: H:\ER-60\Calibrations 2008\38Khz Killary 20.06.08

Calibration: Ciaran O'Donnell

Table 5G.2a. Catch composition and position of hauls undertaken by the RV *Celtic Explorer*. Northwest herring survey, June 2008

No.	Date	Lat. N	Lon. W	Time	Bottom (m)	Target (m)	Bulk Catch (Kg)	Herring %	Mackerel %	Scad %	Sprat %	Others* %
1	20.06.08	52 34.35	10 24.07	22:45	94	74	3		95.0			5.0
2	21.06.08	52 42.09	10 34.32	09:51	112	70	0					
3	21.06.08	52 49.47	10 05.18	18:42	96	60	1					100.0
4	21.06.08	52 49.34	10 15.35	20:45	104	50	1					100.0
5	22.06.08	52 56.58	10 32.40	15:45	104	95	1					100.0
6	23.06.08	53 11.61	10 30.85	11:16	96	80	0					
7	24.06.08	53 45.70	10 58.18	07:15	155	15	29	2.9	34.2	2.6		40.3
8	25.06.08	53 59.05	10 45.60	05:00	150	50	450		8.2	0.3		97.5
9	25.06.08	54 02.82	10 51.03	09:20	194	10	12		14.0			86.0
10	26.06.08	54 15.00	10 31.85	06:37	150	5	7	49.8	19.7	7.9		22.6
11	26.06.08	54 14.98	10 39.59	09:47	180	65	600		17.5	2.1		80.4
12	26.06.08	54 20.99	09 07.65	19:34	46	0	167	0.9	98.5			0.6
13	27.06.08	54 25.23	09 32.90	04:44	73	55	236	31.1	68.9			
14	27.06.08	54 29.05	10 03.46	11:02	105	25	94	87.4	12.1			0.5
15	27.06.08	54 33.08	09 40.97	22:00	95	10	30	74.5	23.1			2.4
16	28.06.08	54 41.12	09 36.82	15:00	97	15	39	46.0	52.8			1.2
17	28.06.07	54 41.13	09 44.10	17:17	99	0	23		99.4			0.6
18	29.06.08	54 52.96	09 51.33	13:03	106	0	36	12.6	83.0	0.7		3.7
19	30.06.08	55 02.04	09 57.19	06:19	107	0	102	11.0	1.2	0.6		87.2
20	30.06.08	55 01.16	09 11.52	10:25	80	5	6.7	73.2	26.8			
21	30.06.08	55 05.29	09 42.75	20:10	120	40	29		1.5			98.5
22	01.07.08	55 09.11	08 30.99	10:42	47	0	426	10.9	88.9			0.2
23	01.07.08	55 17.43	09 48.75	20:04	188	50	0*					
24	02.07.08	55 21.20	07 58.00	13:00	59	40	800	55.8	44.2			0.1
25	03.07.08	55 25.42	07 50.94	08:22	60	0	199	63.0	37.0			
26	03.07.08	55 25.40	06 48.21	13:15	67	40	16	18.0	82.0			
27	04.07.08	55 29.40	07 56.42	05:06	73	20	900	76.4	23.6			
28	04.07.08	55 29.36	08 27.28	09:50	91	10	35		100.0			
29	04.07.08	55 37.16	07 48.66	17:09	75	35	32	2.5	97.5			
30	05.07.08	55 41.07	08 51.51	11:05	102	0	270			99.7		0.3
31	05.07.08	55 44.85	08 3.92	16:46	100	80	0*					
32	05.07.08	55 44.88	07 02.28	21:40	52	35	0*					
33	06.07.08	55 48.71	07 59.63	11:05	128	4	3	11		50		39
34	06.07.08	55 52.67	08 09.66	19:15	171	15	42	45.4		21.3		33.3
35	07.07.08	55 56.71	07 16.18	10:25	81	0	69	5	59			36
36	07.07.08	55 56.67	07 52.68	14:05	165	0	119	23.4	22.4	0.6		53.6
37	07.07.08	55 56.54	07 48.34	15:10	156	0	302	18.5	0.36	78.9		2.24

Note: "Others" was used to represent fish and non-fish species occurring in the catch. * Indicates target mark not caught.

Table 5G.2b. Catch composition and position of hauls undertaken by the FV *Atlantic Quest* and FV *Eternal Dawn*. Northwest herring survey, June 2008.

No.	Date	Lat. N	Lon. W	Time	Bottom (m)	Target (m)	Bulk Catch (Kg)	Herring %	Mackerel %	Scad %	Sprat %	Others* %
1	23.06.08	54 56.02	9 36.22	19:50	96	Blind tow	486	0.5	91.4			8.1
2	24.06.08	54 52.30	8 44.75	06:50	66	Blind tow	3500		100.0			
3	24.06.08	55 12.64	9 47.09	15:46	118	Blind tow	233	19.0	80.8			0.2
4	25.06.08	55 11.46	8 19.27	09:36	50	Blind tow	10000	69.0	31.0			
5	26.06.08	55 30.40	6 49.79	10:00	56	Blind tow	70	88.4	2.4			9.2
6	27.06.08	55 50.30	6 54.01	09:10	44	Blind tow	190	24.6	71.6			3.8
7	27.06.08	55 49.37	7 36.69	13:55	109	Blind tow	116		100.0			
8	27.06.08	55 49.43	8 47.55	20:22	122	Blind tow	3500		100.0			
9	28.06.08	55 41.67	7 24.95	10:16	56	DT	8000	80.3	16.7			
10	28.06.08	55 25.99	7 47.81	16:43	47	DT	5000	96.4	3.6			

Note: "Others" was used to represent fish and non-fish species occurring in the catch. * Indicates target mark not caught.

Table 5G.3. Length frequency (%) of herring hauls used for calculating 'definitely' and 'probably' abundance. Northwest herring survey, June 2008.

Haul # Length	14	16	18	20	22	27	29	34	19	24	Totals
19.5											**0**
20										1	**1**
20.5								2		1	**3**
21							25			1	**26**
21.5						1					**1**
22						1		1			**2**
22.5						2	12			1	**15**
23						4				3	**7**
23.5						10	12			6	**28**
24						12	38			13	**63**
24.5					2	18	12			17	**49**
25					6	16				22	**44**
25.5					9	14		1	2	6	**32**
26	1	2			12	8		4	3	13	**43**
26.5	4	15	4		27	6		4	8	7	**75**
27	11	26	8	20	24	5		16	28	6	**144**
27.5	15	17	17	20	11	2		10	13		**105**
28	22	22	29	30	5	1		12	20	1	**142**
28.5	27	11	21	20	2			12	17		**110**
29	12	4	12	10	2			17	2		**59**
29.5	5	3	4					10	5		**27**
30	3	1	4					13	2		**23**
30.5											
31											
Totals	**100**	**101**	**99**	**100**	**100**	**100**	**99**	**102**	**100**	**98**	**999**

Table 5G.4. Herring length-at-age (winter rings) as abundance (millions) and biomass (000's tonnes). Northwest herring survey, June 2008.

Length (cm)	Age (Rings) 0	1	2	3	4	5	6	7	8	9	10	Abundance (millions)	Biomass 000's t	Mn wt (g)
19		0.02										0.02		65.2
19.5		0.49										0.49	0.03	70.3
20		0.98	0.14									1.12	0.08	75.5
20.5		4.63										4.63	0.38	81.1
21		0.93										0.93	0.08	86.9
21.5		0.84	0.17									1.01	0.09	92.9
22		1.6	1.96									3.56	0.35	99.2
22.5		0.97	2.91	0.14								4.01	0.42	105.8
23		0.44	9.74									10.18	1.15	112.7
23.5		0.65	16.2	1.32								18.12	2.17	119.9
24			14.6	2.6								17.19	2.19	127.4
24.5		0.29	13.9	3.68	0.29							18.13	2.45	135.1
25		0.18	5.51	3.86	0.56							10.12	1.45	143.2
25.5			6.81	5.87	1.13		0.2					14.01	2.12	151.5
26			4.34	11.1	0.84	0.15						16.4	2.63	160.2
26.5		0.26	4.67	17.7	5.42	0.75						28.83	4.88	169.2
27			0.89	8.43	4.43	0.3	0.14		0.14			14.33	2.56	178.5
27.5			0.65	7.39	8.27	3.05	2.62	0.22	0.22			22.43	4.22	188.2
28			0.27	2.34	9.33	5.7	3.63	0.51	0.27		0.27	22.32	4.42	198.2
28.5				0.43	6.47	4.74	7.32	3.01	1.3	0.43		23.7	4.94	208.5
29			0.66		1.29	6.45	9.05	3.88	1.29	1.29	1.29	25.19	5.52	219.2
29.5						0.9	1.62	0.72	1.08	0.36		4.69	1.08	230.2
30							1.36	0.68	0.68			2.72	0.66	241.6
30.5														
31							2.72					2.72	0.72	265.5
SSN		6.08	75.9	64.7	38.4	22.3	26.2	9.12	5.04	2.1	1.57	**251.39**		
SSB		0.62	10.3	10.7	7.28	4.59	5.57	1.99	1.11	0.46	0.34		**43.0**	
Mn wt (g)		93	133	165	189	205	216	216	218	219	216			
Mn L (cm)		21.7	24.6	26.4	27.7	28.6	29.1	29.1	29.2	29.2	29.1			

Table 5G.5. Total biomass (000's tonnes) of herring at age (winter rings), by strata as derived from acoustic estimate of abundance. Northwest herring survey, June 2008.

Strata	0	1	2	3	4	5	6	7	8	9	10	Total
D834	0	0	0	0	0	0	0	0	0	0	0	**0**
D934	0	0	0	0	0	0	0	0	0	0	0	**0**
D935	0	0	0	0	0	0	0	0	0	0	0	**0**
D835	0	0	0	0	0	0	0	0	0	0	0	**0**
D836	0	0	0	0.1	0.6	0.6	0.7	0.2	0.1	0.1	0.1	**2.4**
D837	0	0	0.3	1.3	2.1	1.9	3.5	1.1	0.5	0.2	0.2	**11.1**
D937	0	0	0.2	0.9	0.7	0.3	0.3	0.1	0	0	0	**2.6**
E038	0	0	0.1	0.1	0	0	0	0	0	0	0	**0.2**
D938	0	0	0.4	1.8	1.3	0.5	0.5	0.1	0.1	0	0	**4.8**
D939	0	0	0.1	0.5	0.4	0.2	0.1	0	0	0	0	**1.4**
E039	0	0.1	2.4	2.1	0.5	0.1	0.1	0	0	0	0	**5.3**
E139	0	0.3	3.8	1.6	0.3	0	0	0	0	0	0	**6**
E239	0	0.1	0.4	0.1	0	0	0	0	0	0	0	**0.6**
E040	0	0.1	1.8	1.8	1.2	0.8	1	0.4	0.3	0.1	0	**7.5**
E140	0	0.5	1.6	0.3	0.1	0	0.1	0	0	0	0	**2.6**
E240	0	0	0	0	0	0	0	0	0	0	0	**0**
D838	0	0	0	0	0	0	0	0	0	0	0	**0**
Total	**0**	**1.10**	**11.10**	**10.70**	**7.20**	**4.50**	**6.20**	**2.00**	**1.10**	**0.50**	**0.30**	**44.60**
%	**0**	**2.60**	**24.80**	**23.90**	**16.10**	**10.10**	**13.90**	**4.40**	**2.40**	**1.00**	**0.80**	**100.00**

Table 5G.6. Herring abundance (millions) at age (winter rings), by strata as derived from acoustic estimate of abundance. Northwest herring survey, June 2008.

Strata	0	1	2	3	4	5	6	7	8	9	10	Total
D934	0	0	0	0	0	0	0	0	0	0	0	**0**
E034	0	0	0	0	0	0	0	0	0	0	0	**0**
E035	0	0	0	0	0	0	0	0	0	0	0	**0**
D935	0	0	0	0	0	0	0	0	0	0	0	**0**
D936	0	0	0.14	0.46	2.79	2.68	3.13	1.15	0.44	0.26	0.24	**11.3**
D937	0	0.05	1.77	7.24	10.49	9.30	15.44	4.91	2.33	1.06	0.92	**53.5**
E037	0	0.02	1.14	5.18	3.82	1.62	1.43	0.35	0.24	0.07	0.06	**13.9**
E138	0	0.01	0.39	0.73	0.22	0.05	0.04	0.01	0.01	0.00	0.00	**1.4**
E038	0	0.05	2.35	10.42	6.98	2.78	2.44	0.59	0.41	0.11	0.09	**26.2**
E039	0	0.02	0.77	2.96	1.99	0.79	0.69	0.16	0.11	0.03	0.03	**7.5**
E139	0	1.03	17.38	13.38	3.13	0.56	0.40	0.08	0.06	0.01	0.01	**36.0**
E239	0	3.51	29.21	10.62	1.64	0.22	0.20	0.03	0.02	0.01	0.01	**45.5**
E339	0	0.61	3.50	0.63	0.09	0.05	0.08	0.03	0.01	0.01	0.01	**5.0**
E140	0	1.55	13.46	11.14	6.38	3.76	4.55	1.63	1.29	0.49	0.18	**44.4**
E240	0	5.35	13.04	2.06	0.46	0.23	0.28	0.10	0.07	0.03	0.01	**21.6**
E340	0	0.09	0.18	0.01	0	0	0	0	0	0	0	**0.3**
D938	0	0	0.01	0.03	0.03	0.02	0.02	0.00	0.00	0.00	0.00	**0.1**
Total	**0**	**12.28**	**83.33**	**64.85**	**38.02**	**22.04**	**28.67**	**9.03**	**4.99**	**2.07**	**1.55**	**266.845**
%	**0**	**4.60**	**31.23**	**24.30**	**14.25**	**8.26**	**10.74**	**3.39**	**1.87**	**0.78**	**0.58**	**100**

Table 5G.7. Herring biomass (000's tonnes) at maturity by strata. Northwest herring survey, June 2008.

Strat	Imm	Mature	Total
D934	0	0	0
E034	0	0	0
E035	0	0	0
D935	0	0	0
D936	0	2.4	2.4
D937	0	11.1	11.1
E037	0	2.6	2.6
E138	0	0.2	0.2
E038	0	4.8	4.8
E039	0	1.4	1.4
E139	0.2	5.1	5.3
E239	0.5	5.5	6
E339	0.1	0.6	0.6
E140	0.2	7.3	7.5
E240	0.5	2	2.6
E340	0	0	0
D938	0	0	0
Total	**1.6**	**43**	**44.6**
%	**3.6**	**96.4**	**100**

Table 5G.8. Herring abundance (millions) at maturity by strata. Northwest herring survey, June 2008.

Strat	Imm	Mature	Total
D934	0	0	0
E034	0	0	0
E035	0	0	0
D935	0	0	0
D936	0	11.29	11.29
D937	0	53.51	53.51
E037	0	13.92	13.92
E138	0.01	1.43	1.441
E038	0	26.21	26.21
E039	0.01	7.54	7.541
E139	1.93	34.12	36.05
E239	5.00	40.45	45.45
E339	0.68	4.32	5.00
E140	1.90	42.51	44.41
E240	5.68	15.94	21.62
E340	0.10	0.19	0.29
D938	0	0.11	0.11
Total	**15.3**	**251.55**	**266.85**
%	**5.73**	**94.27**	**100**

Table 5G.9. Herring biomass and abundance by survey strata. Northwest herring survey, June 2008.

Category Stratum	No. transects	No. schools	Def schools	Mix schools	Prob schools	% zeros	Def Biomass	Mix Biomass	Prob Biomass	Biomass (t)	SSB (t)	Abundance millions
D934	4	0	0	0	0	100	0	0	0	0	0	0
E034	3	0	0	0	0	100	0	0	0	0	0	0
E035	1	0	0	0	0	100	0	0	0	0	0	0
D935	2	0	0	0	0	100	0	0	0	0	0	0
D936	7	35	0	35	0	71	0	2.4	0	2.4	2.4	11.29
D937	7	76	44	32	0	57	0.9	10.2	0	11.1	11.1	53.51
E037	3	91	76	15	0	0	1.8	0.8	0	2.6	2.6	13.92
E138	7	8	0	0	8	57	0	0	0.2	0.2	0.2	1.44
E038	7	131	107	5	19	0	4.2	0.5	0.1	4.8	4.8	26.21
E039	7	67	43	8	16	29	0.6	0.4	0.4	1.4	1.4	7.54
E139	8	62	25	37	0	25	1	4.3	0	5.3	5.1	36.05
E239	4	32	0	32	0	50	0	6	0	6	5.5	45.45
E339	1	4	0	4	0	0	0	0.6	0	0.6	0.6	5.00
E140	7	55	17	33	5	14	1.3	5.9	0.3	7.5	7.3	44.41
E240	6	36	17	18	1	17	1.7	0.8	0	2.6	2	21.62
E340	6	3	3	0	0	83	0	0	0	0	0	0.29
D938	2	6	0	0	6	0	0	0	0	0	0	0.11
Total	82	606	332	219	55	44	11.6	31.9	1.1	44.6	43	266.85
Cv (%)										33.4	34.2	33.9

Table 5G.10. Historical spawning stock survey time-series. Abundance (millions), TSB and SSB (000's tonnes). Age in winter rings. Northwest herring survey, June 2008.

Winter rings	1999	2000	2001	2002	2003	2004	2005	2006	2007
0	-	-	5	19.36	-	0.09	1.28	-	-
1	18.99	10.71	22.69	51.65	10.28	-	7.83	1.6	0.3
2	104.77	60.88	52.33	102.93	26.26	3.9	56.91	6.9	3.5
3	32.53	48.96	6.41	48.15	30.02	62.35	93.51	86.7	59.8
4	11.34	25.57	6.47	10.87	11.08	54.93	109.87	57.5	21.9
5	1.65	9.43	2.63	9.17	2.94	80.07	100.8	27.9	11.7
6	0.94	2.35	1.94	5.54	0.64	47.14	56.54	16	6.35
7	0.3	1.28	0.12	3.95	0.94	13.81	21.16	4.8	1.86
8	0.17	0.43	0.24	1.68	0.3	11.77	24.64	4.8	-
9+	0.11	0.75	0.07	2.06	0.14	-	12.74	1.3	-
Abundance (millions)	170.8	160.36	97.9	111.33	82.6	274.06	485.29	202.9	105.41
Total Biomass (t)	23,762	21,048	11,062	8,867	10,300	41,700	71,253	27,770	14,222

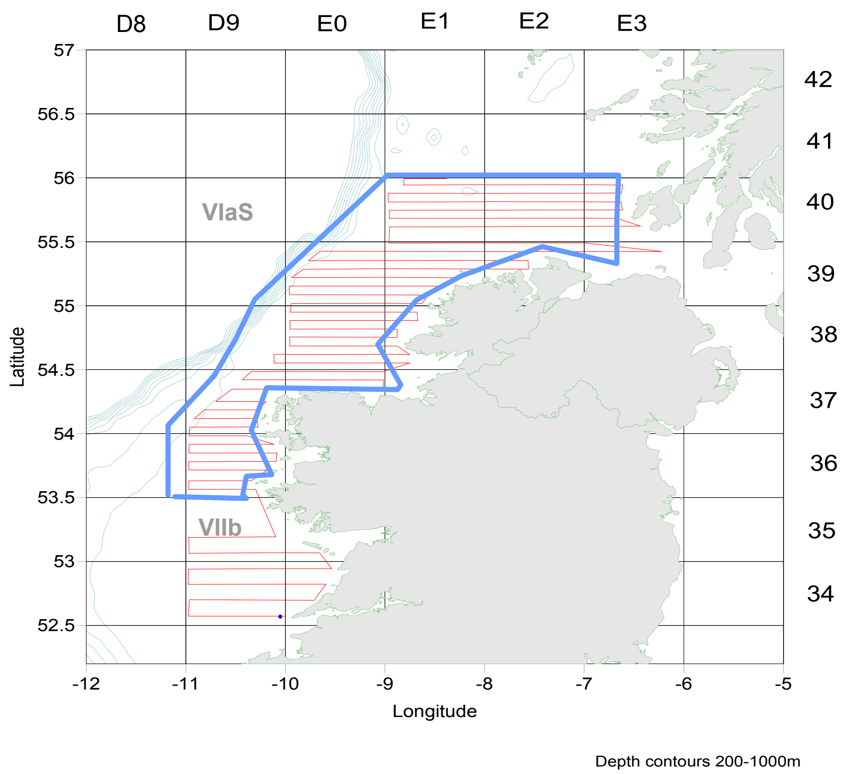


Figure 5G.1. RV "Celtic Explorer" cruise track (red line) and the extent of the commercial scouting survey (blue line). Northwest herring survey, June 2008.

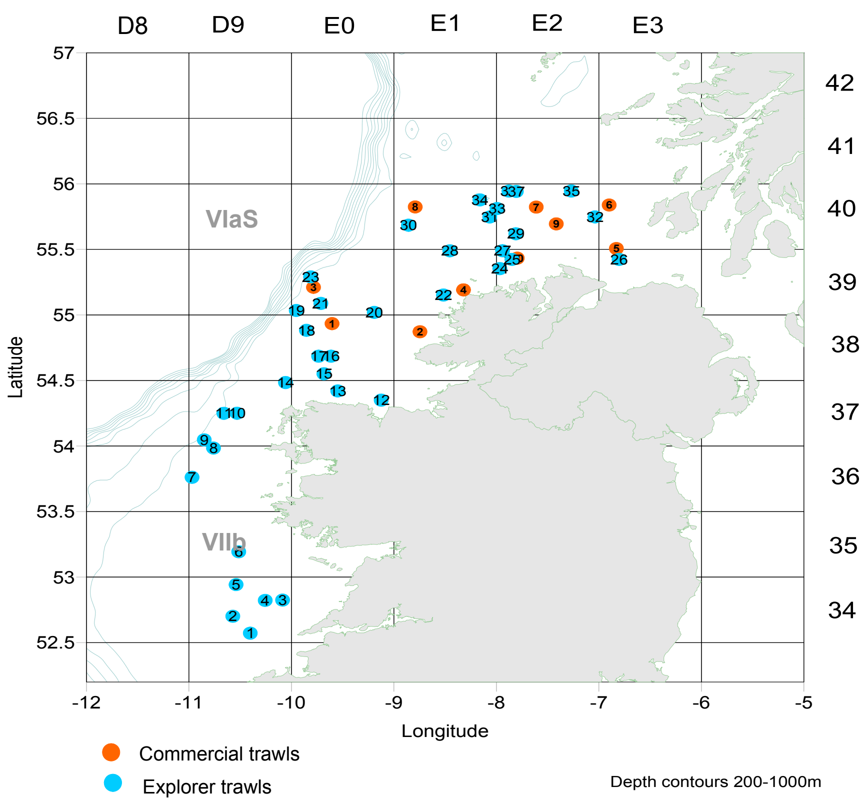


Figure 5G.2. RV "Celtic Explorer" cruise trawl stations and those carried out by the commercial vessels Northwest herring survey, June 2008.

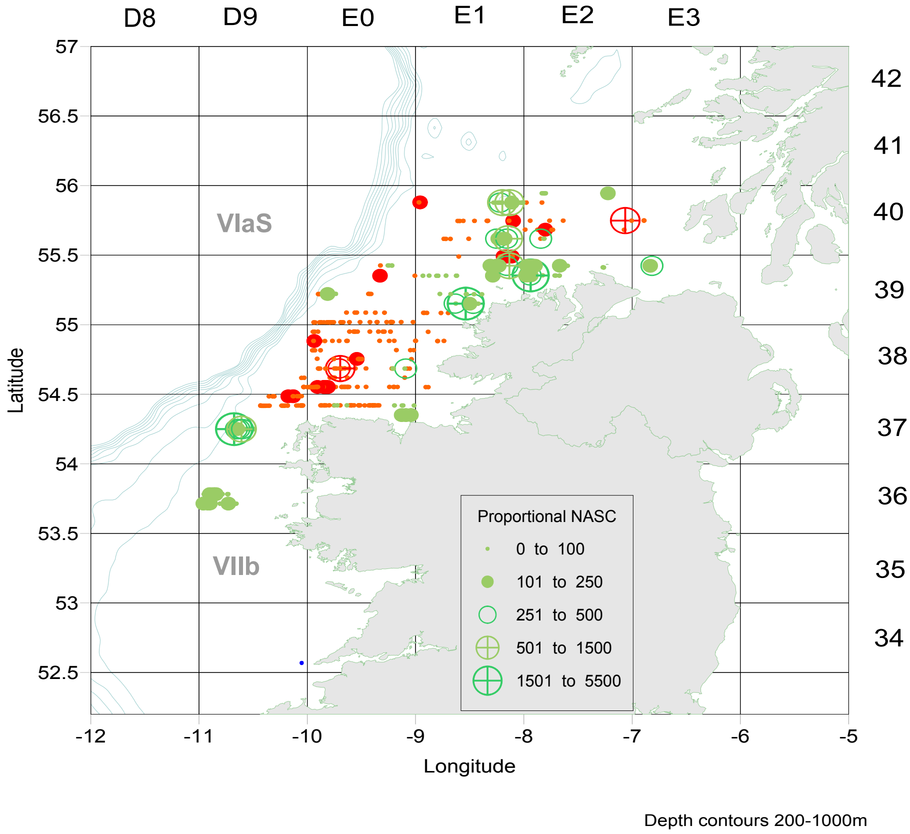


Figure 5G.3. NASC distribution plot of herring occurrence, red circles represent single herring marks, green circles represent herring occurring in mixed schools. Circle size relative to NASC value. Northwest herring survey, June 2008.

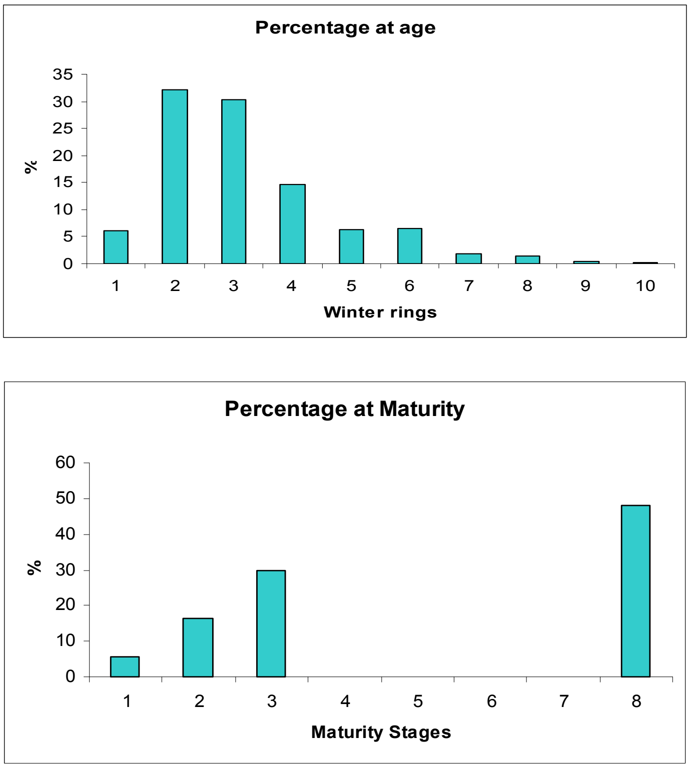


Figure 5G.4a. Percentage composition of age (top panel) and maturity (bottom panel) of "Celtic Explorer" herring samples within the survey area. Northwest herring survey, June 2008.

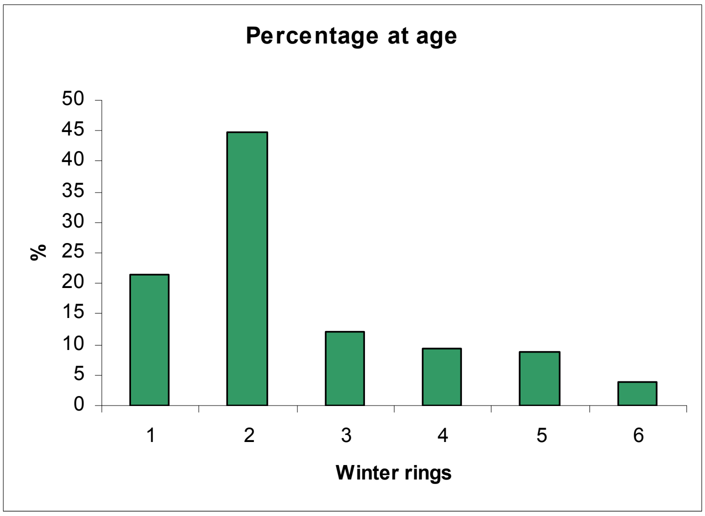
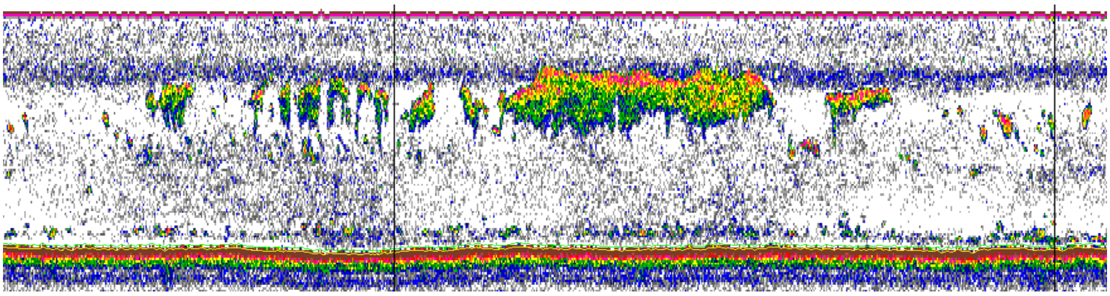
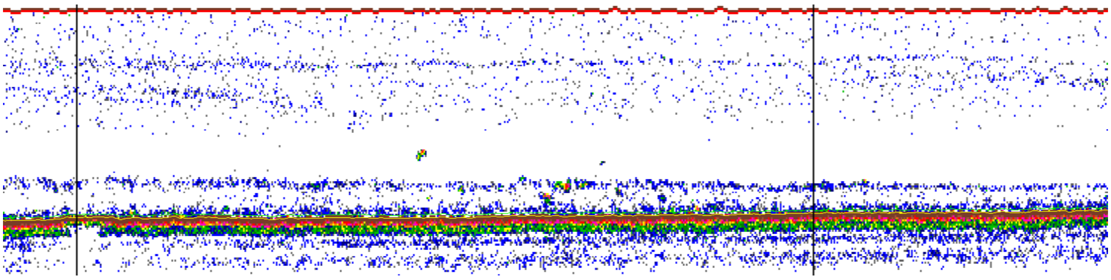


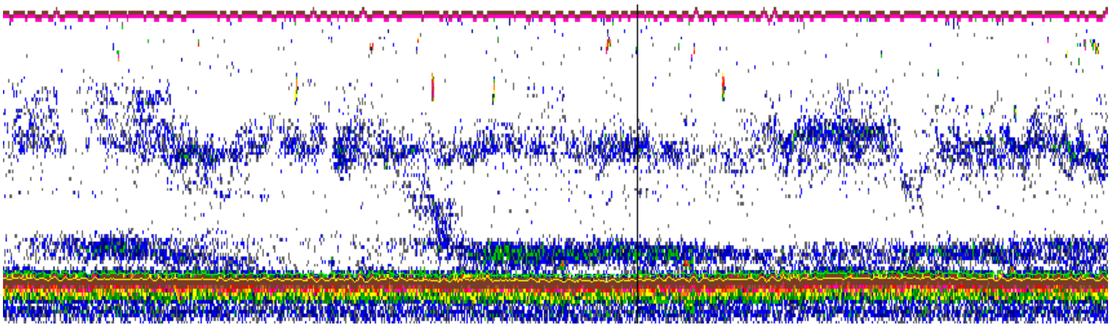
Figure 5G.4b. Percentage composition of age of commercial survey herring samples within the survey area. Northwest herring survey, June 2008. Note: Percentage maturity data are not shown due to error in sampling method.



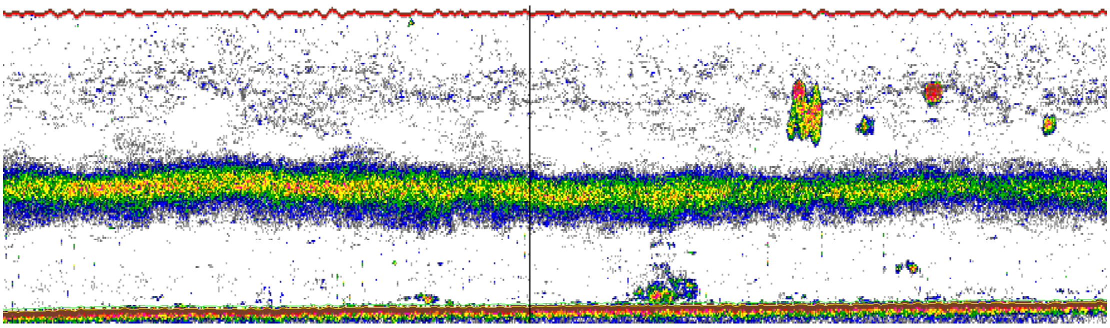
a). High-density schools of mixed 0-group demersal and pelagic species recorded prior to Haul 04 at 20:45 on Transect 3 (52°49N and 10°15W). Vertical bands on echogram represent 1nmi (nautical mile) intervals. Bottom depth is 100m with targets occurring at 30m subsurface.



b). Low-density schools of herring typical of those encountered between 54-55ºN. Echogram recorded prior to Haul 14 on Transect 22. Vertical bands on echogram represent 1nmi (nautical mile) intervals. Bottom depth is 105m with targets occurring 10–30m off the bottom



c). High-density schools of herring typical of those encountered along the north coast. Recorded prior to Haul 27 on Transect 37. Vertical bands on echogram represent 1nmi (nautical mile) intervals. Bottom depth is 73m with targets occurring 10–25m from the surface.



d). High-density schools of borefish typical of those encountered along the shelf slopes from 54–56ºN. Recorded prior to Haul 11 on Transect 19. Vertical bands on echogram represent 1nmi (nautical mile) intervals. Bottom depth is 73m with targets occurring 20m from the surface.

Figures 5G.a-d. Echotraces recorded prior to directed trawls. Northwest herring survey, June 2008.

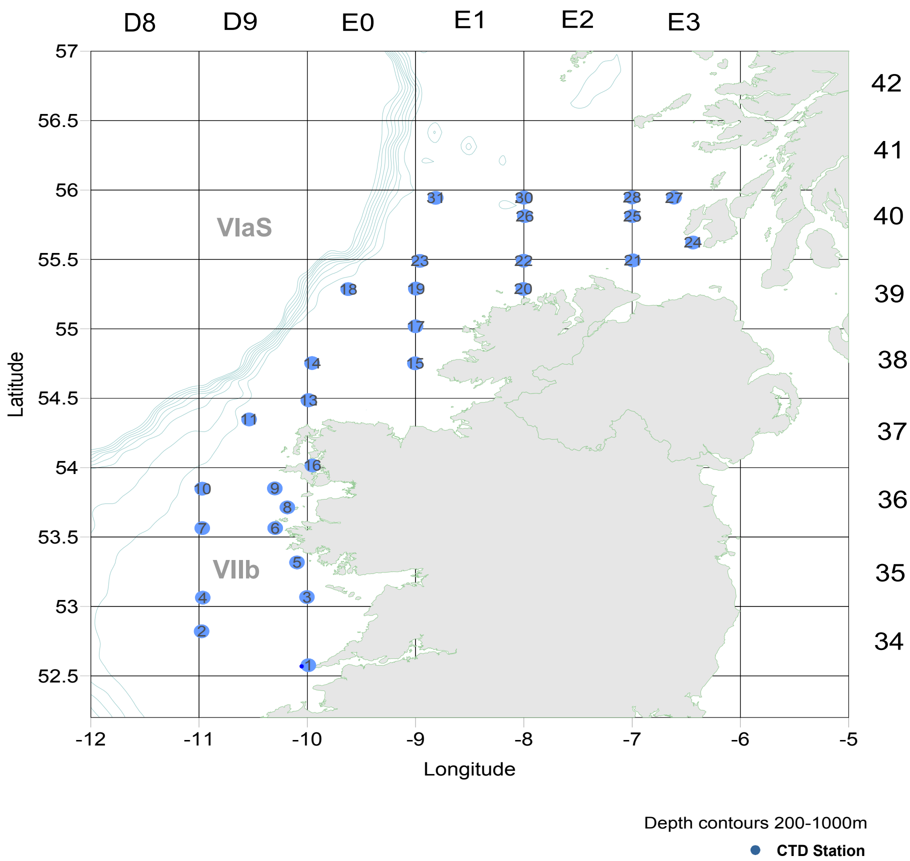


Figure 5G.6. Oceanography stations taken as CTD casts. Blue points represent stations taken to a maximum depth of 1000m, purple points indicate full depth stations, green points stations dropped due to poor weather. Northwest herring survey, June 2008.

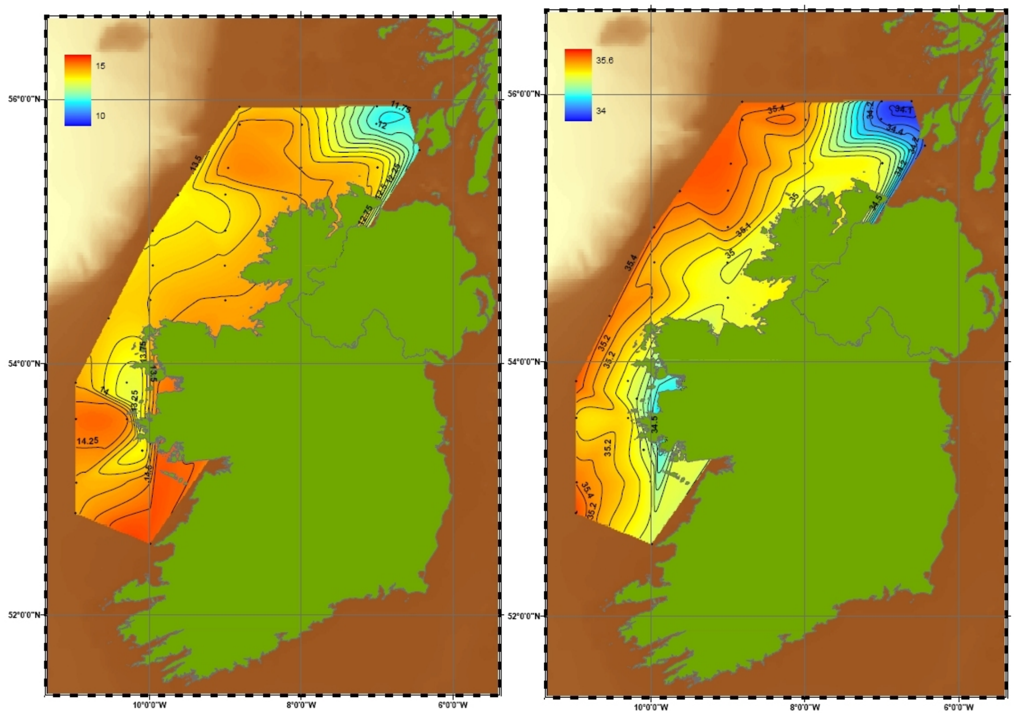


Figure 5G.7. Horizontal temperature (left panel) and salinity (right panel) at 5m subsurface as derived from vertical CTD cast data. Northwest herring survey, June 2008.

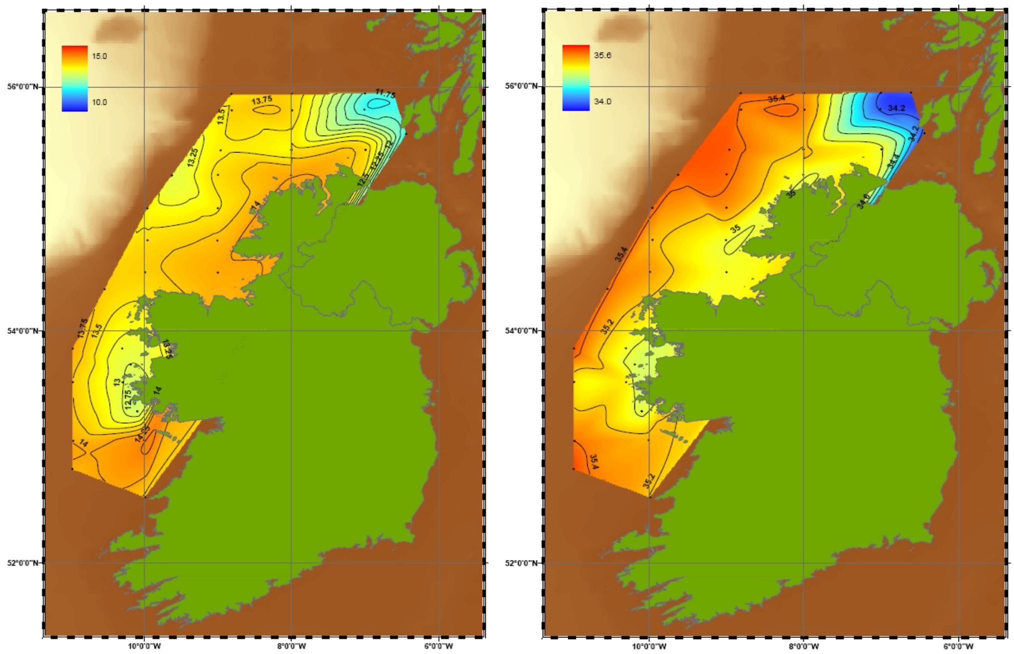


Figure 5G.8. Horizontal temperature (left panel) and salinity (right panel) at 20m subsurface as derived from vertical CTD cast data. Northwest herring survey, June 2008.

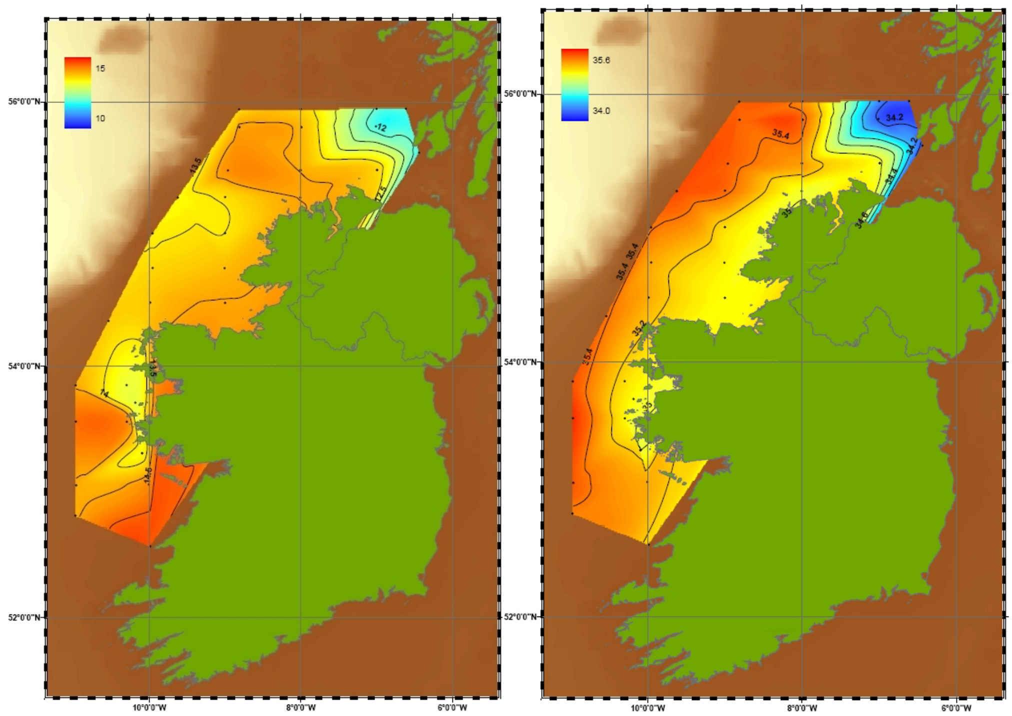


Figure 5G.9. Horizontal distribution of temperature (top) and salinity (bottom) at 40m subsurface as derived from vertical CTD cast data. Northwest herring survey, June 2008.

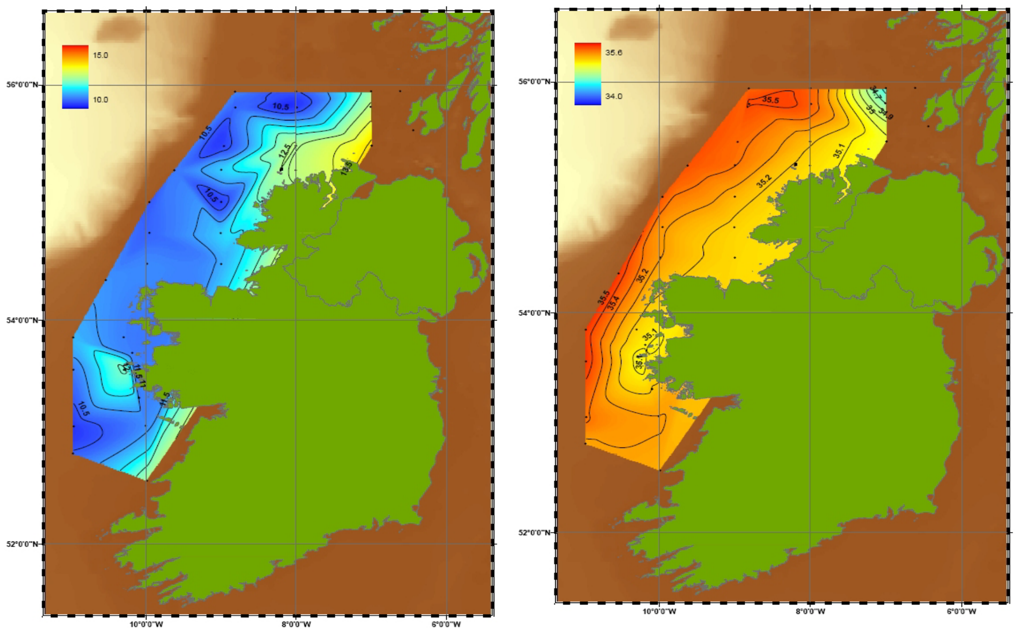


Figure 5G.10. Horizontal distribution of temperature (top) and salinity (bottom) at 60m depth. 100 m depth contour shaded. Northwest herring survey, June 2008.

ANNEX 5H: German/Danish Western Baltic Autumn Survey

Survey report for RV *Solea*

2 – 21 October 2008

Eberhard Götze, vTI-SF Hamburg, Tomas Gröhsler, vTI-OSF Rostock, Germany

1. INTRODUCTION

The joint German/Danish survey is part of the Baltic International Acoustic Survey, which is coordinated within the scope of ICES and has the main objective to annually assess the clupeoid resources of herring and sprat in the Baltic Sea in autumn. The reported acoustic survey is conducted every year to supply ICES Herring Assessment Working Group for the Area South of 62°N (HAWG) and Baltic Fisheries Assessment Working Group (WGBFAS) with an index value for the stock size of herring and sprat, respectively, in the Western Baltic area (Kattegat/Subdivisions 21 and Subdivisions 22, 23 and 24).

2 METHODS

2.1 Personnel

PARTICIPANTS/CALIBRATION OF ACOUSTIC EQUIPMENT/02.–04.10.2008:	
M. Drenckow	Institute of Sea Fisheries, Hamburg
D. Gloe	Institute of Baltic Sea Fisheries, Rostock
E. Götze	Institute of Sea Fisheries, Hamburg, Cr. Leader
Participants/Acoustic survey/04.– 21.10.2008:	
E. Götze	Institute of Sea Fisheries, Hamburg, Cr. Leader
D. Gloe	Institute of Baltic Sea Fisheries, Rostock
Dr T. Gröhsler	Institute of Baltic Sea Fisheries, Rostock
S. Hagemann	Institute of Baltic Sea Fisheries, Rostock
M. Koth	Institute of Baltic Sea Fisheries, Rostock
S.-E. Levinsky	DTU Aqua, Charlottenlund, Denmark

2.2 Narrative

The 595th cruise of RV "SOLEA"' represents the 21st subsequent survey. RV "SOLEA" left the port of Rostock/Marienehe on 2 October 2008. The joint German-Danish acoustic survey covered the area of Subdivisions 21, 22, 23 and 24. The survey ended on 21 October 2008 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 zigzag track was used to cover all depth strata regularly. The survey area was 14,026 nautical mile^2. The cruise track (Figure 5H.1) totally reached a length of 1,366 nautical miles.

2.4 Calibration

The hull mounted transducer ES38B was calibrated on 3 October 2008 north of the Isle of Ruegen at a water depth of 21 m. The calibration procedure was carried out as described in the 'Manual for the Baltic International Acoustic Surveys (BIAS)' (ICES

2003). Because of strong wind conditions the measurements were difficult. It was nevertheless, possible to calibrate the 38 kHz transducer twice at different depths of the calibration sphere. The difference between the two measurements was below 0.1 dB, which corresponds to the mandatory accuracy. A calibration of the 120 kHz channel was not feasible at the existing weather conditions.

2.5 Acoustic data collection

The acoustic investigations were performed during night-time. The main pelagic species of interest were herring and sprat. The acoustic equipment was an echo-sounder EK60 on 38 kHz (120 kHz). The specific settings of the hydroacoustic equipment were used as described in the 'Manual for the Baltic International Acoustic Surveys (BIAS)' (ICES 2003). The post-processing of the stored echosignals was done by EchoView 4.20. The mean volume backscattering values (s_v) were integrated over 1 nautical mile intervals from 8 m below the surface to the bottom. Contributions from air bubbles, bottom structures and scattering layers were removed from the echogram.

2.6 Biological data – fishing stations

Trawling was done with the pelagic gear 'PSN388' in the midwater as well as near the bottom. The mesh size in the codend was 10 mm. The intention was to carry out at least two hauls per ICES statistical rectangle. The trawling depth and the net opening were controlled by a netsonde. The trawl depth was chosen in accordance to the 'characteristic indications' by the echogram. Normally a net opening of about 8–10 m was achieved. The trawling time lasted usually 30 minutes, but in dense concentrations the duration was reduced. From each haul subsamples were taken to determine length and weight of fish. Samples of herring and sprat were frosted for additional investigations (e.g. determining sex, maturity, age). The hydrographic condition was investigated after each trawl haul by a CTD-O_2 probe.

2.7 Data analysis

The pelagic target species sprat and herring are usually distributed in mixed layers in combination with other species so that the integrator readings cannot be allocated to a single species. Therefore the species composition was based on the trawl catch results. 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 σ was calculated according to the following target strength-length (TS) relation:

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

The total number of fish (total N) in one rectangle was estimated as the product of the mean area scattering cross section (s_A) 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 2003) the further calculation was performed in the following way:

Fish species considered:	
CLUPEA HARENGUS	
CRYSTALLOGOBIUS LINEARIS	
ENGRAULIS ENCRASICOLUS	
GADUS MORHUA	
GASTEROSTEUS ACULEATUS	
MERLANGIUS MERLANGUS	
POMATOSCHISTUS MINUTUS	
SPRATTUS SPRATTUS	
Exclusion of trawl hauls with low catch level:	
Haul No. 1 (38G0/SD 22)	
Haul No. 51 (41G1/SD 21)	
Usage of neighboring trawl information for rectangles, which only contains acoustic investigations:	
41G0 (SD 21) filled with Haul No. 52	(SD 21/41G1)
43G2 (SD 21) filled with Haul No. 45 and 49	(SD 21/43G1)
40F9 (SD 22) filled with Haul No. 5, 7, 8	(SD 22/40G0)
40G1 (SD 22) filled with Haul No. 5, 7, 8	(SD 22/40G0)
39G2 (SD 23) filled with Haul No. 31 and 38	(SD 24/39G2)
37G4 (SD 24) filled with Haul No. 24 and Haul No. 23, 25, 26, 27	(SD 24/37G3) (SD 24/38G4)

3. RESULTS

3.1 Biological data

In total 53 trawl hauls were carried out:

Subdivision	21	22	23	24
No. of Hauls	11	18	4	20

1,684 herring and 821 sprat were frozen for further investigations (determination of e.g. sex, maturity, age).

The results of the catch composition by Subdivision are presented in Tables 5H.1–4. The mean catch by Subdivision was in all areas very low and it even reached a record low level in Subdivision 22 and 24. The highest concentrations of adult herring were found – as in the years before – in the Sound (Subdivision 23). It should be noted that anchovies (*Sardina pilchardus*), which had in former years the most southern distribution area in the Belt Sea, were this year also caught in the Arkona Sea (Subdivision 24).

The length distributions of herring and sprat of the years 2007 and 2008 are presented by Subdivision in Figures 5H.2 and 3. The herring length distributions by Subdivision are characterized in the following way:

- Subdivision 21 is now dominated by young herring (< 15 cm), whereas older fish was the major contribution last year.
- Subdivision 22 is in both years characterized by young herring. The growth seems to be better in 2008.
- Subdivision 23, which usually has a higher contribution of older herring, contains a higher fraction of the largest fish (> 25 cm) in 2008.

- Subdivision 24 has similar results in both years. The widest ranges of length distributions of herring start with 7 cm and end with more than 30 cm.

The length distributions of sprat in 2007 and 2008 give different results in all areas (Figure 5H.3). The contribution of the new incoming year-class (< 10 cm) increased in Subdivision 21, 22 and 24 compared to 2007. As in the years before the fraction of the new incoming year-class is almost negligible in Subdivision 23. Subdivision 23 contains mainly older sprat (> 10 cm). The fraction of the largest sprat (> 13 cm) in this area is in 2008 higher than in 2007.

3.2 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 5H.5.

The horizontal distribution of the NASC showed the usual pattern. The highest NASC values were found in Subdivision 23 as in former years. But these high values were only observed in a small area in the southern part of the Sound. The usual high concentrations around the Island of Ven were missing this year completely. The average NASC in Subdivision 23 was therefore very low. An average fish density was observed in the Arkona Sea (Subdivision 24). Compared to the last years the main fish concentrations were found in the northeast. The fish density is usually very low in all northern parts of Subdivision 22 but this year low NASC values we also found in the southern part of this area. Low densities were especially observed in the Mecklenburg Bay and Kiel Bay. This trend has also been observed in last year, but this year even lower densities were measured. The fish density in the Kattegat (Subdivision 21) has been poor in all years. Compared to 2007 the density significantly increased in the northern part.

3.3 Abundance estimates

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

The herring stock in Subdivisions 21–24 was estimated to be 4.6 x 10^9 fish or about 147.0 x 10^3 tonnes. For the included area of Subdivisions 22–24 the number of herring was calculated to be 3.5 x 10^9 fish or about 123.6 x 10^3 tonnes. The abundance estimate was dominated by young herring as in former years (Figure 5H.2 and Table 5H.6). However, compared to the results of the years 1993–2007 the present overall estimates are low in numbers and in biomass.

The estimated sprat stock in Subdivisions 21–24 was 6.1 x 10^9 fish or 59.7 x 10^3 tonnes. For the included area of Subdivisions 22–24 the number of sprat was calculated to be 5.9 x 10^9 fish or 58.8 x 10^3 tonnes. The present record low estimates of sprat in numbers and biomass (Figure 5H.3 and Table 5H.9) are caused by a comparatively weak upcoming year class and diminishing importance of the last strong 2006 year class.

4 DISCUSSION

Compared to last year's results, the present estimate of **herring** decreased in numbers but at the same time increased in biomass:

	Difference compared to 2007	
Area	Numbers (%)	Biomass (%)
Subdivision 22–24	-14	+8
Subdivision 21–24	-1	+8

The smaller numbers were mainly caused by a larger decrease in Subdivisions 22 and 23 (SD 21: +96%; SD 22: -25%; SD 23: -40% and SD 24: -5%).

The increase in biomass is caused by an increase:

- in numbers and biomass in Subdivision 21, mainly caused by larger numbers in the northern most distribution area of the ICES rectangles 43G1 and 44G1 (Table 5H.6) and
- of the fraction of older herring in numbers (3–7 winter ringer) in the eastern part of Subdivision 24 (Arkona Sea) in the ICES rectangles 37G4, 38G4 and 39G4 (Table 5H.6) .

The present herring biomass is nevertheless the second lowest recorded estimate in the whole time-series since 1993.

The overall decreasing numbers, which are resulting at the same time in some increase in biomass, could have been caused by following overlapping effects:

- lower recruitment during the last years, which is bringing down the stock size,
- different migration/distribution pattern, where a larger part of the adult Western Baltic herring stock, which is normally overwintering in Subdivision 23 (The Sound) to a larger extend already left this area during the survey time and entered Subdivision 24,
- occurrence of increased numbers of Central Baltic herring in Subdivision 24. Herring from the Central Baltic stock is characterized by lower mean weights-at-age.

As in the years before the age-groups 0-1 are in numbers the main contributor in Subdivisions 22–24 (2008: 70%, 2007: 81% and 2006: 77%). The age groups 2–4 constitute in numbers 19% in 2008 (2007: 10% and 2006: 15%). The present contribution of the age-group 0 in Subdivisions 22–24 is 60% in numbers and 19% in biomass (2007: 68% in numbers and 22% in biomass, 2006: 64% in numbers and 17% in biomass).

The abundance of **sprat,** which already 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%). This year lower abundance estimates occurred in all areas except of Subdivision 22, which showed increased numbers mainly caused by higher 0 age-group estimates (6 times higher than in 2007). The present estimate in numbers is still influenced by the strong 2006 year-class, but this year-class is not dominating as in the year before.

The overall smaller numbers in 2008 are mostly caused by a comparatively weak new year-class 2008. The contribution of the new year class was in Subdivisions 21–24 and 22–24 in 2006: 83%, in 2007: 10% and in 2008: ca. 24%. This year's contribution of 0-group abundance was nevertheless in all areas higher than in 2007 (2008/2007: Subdivision 21: 7.9 times higher, Subdivision 22: 6.0 times lower, Subdivision 23: 2.2 times higher and Subdivision 24: 3.5 times higher). The present fraction of the age-group 0 in biomass was at the same level as in 2007 and reached in the last two years 4% in Subdivisions 21–24 and 5% in Subdivisions 22–24.

5 REFERENCES

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

ICES. 2003. Report of the Baltic International Fish Survey Working Group. ICES CM 2003/G:05 Ref.: D, H.: Annex 3.

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.

6 TABLES AND FIGURES

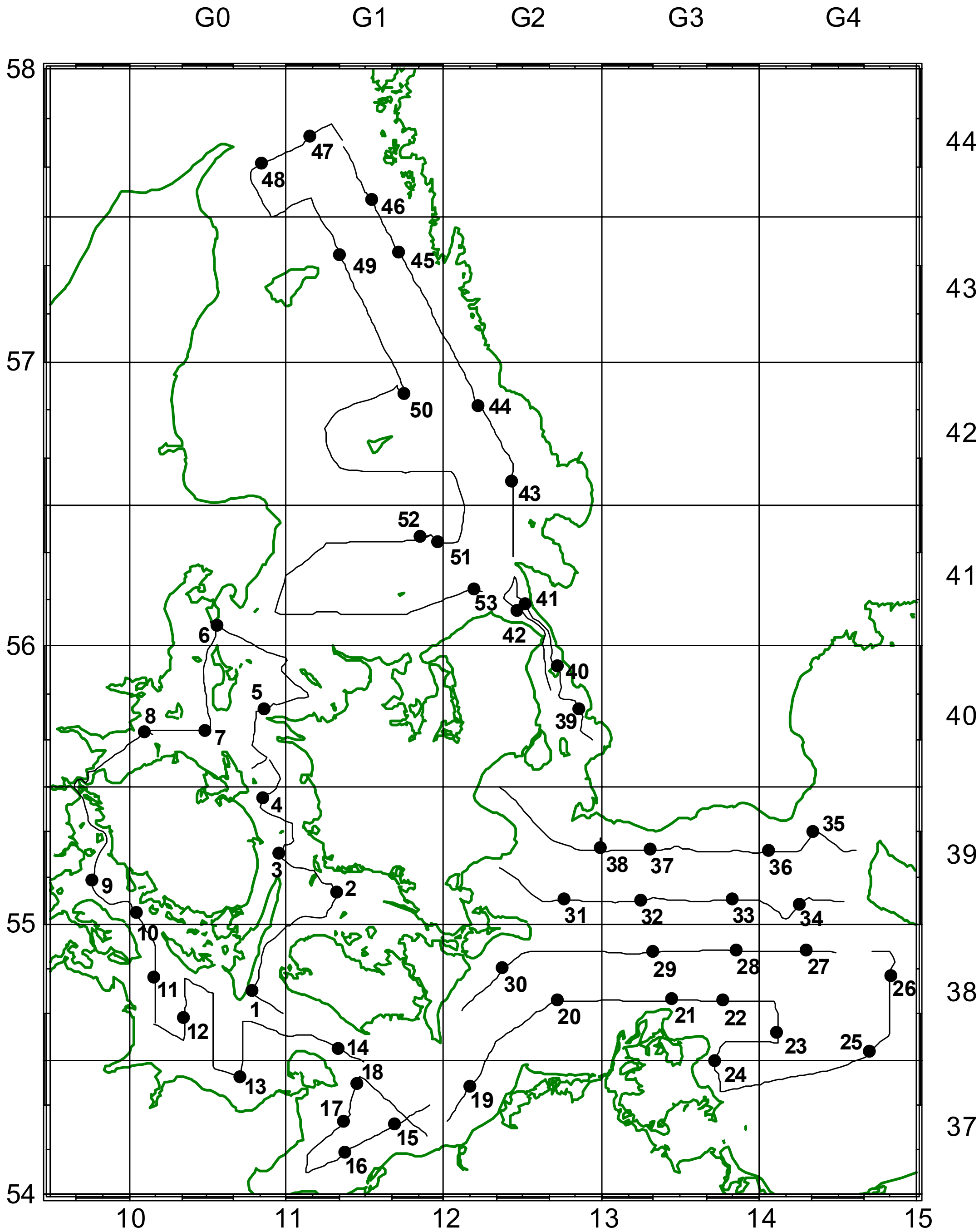


Figure 5H.1. Cruise track and trawl positions of the acoustic survey with RV "SOLEA" in October 2008

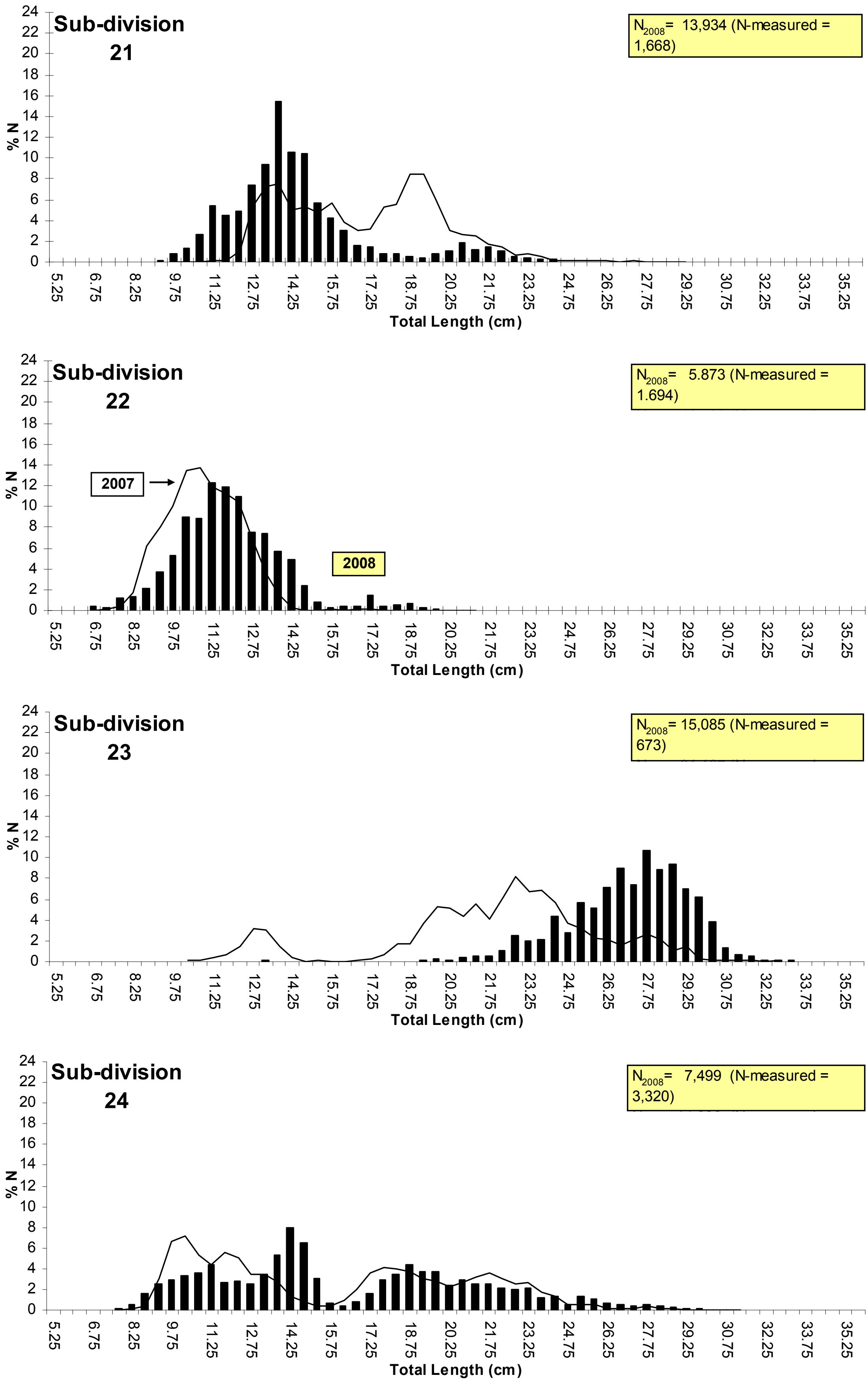


Figure 5H.2. Length distribution of herring in Subdivisions 21, 22, 23 and 24 in 2007 (=line) and in 2008 (=bar)

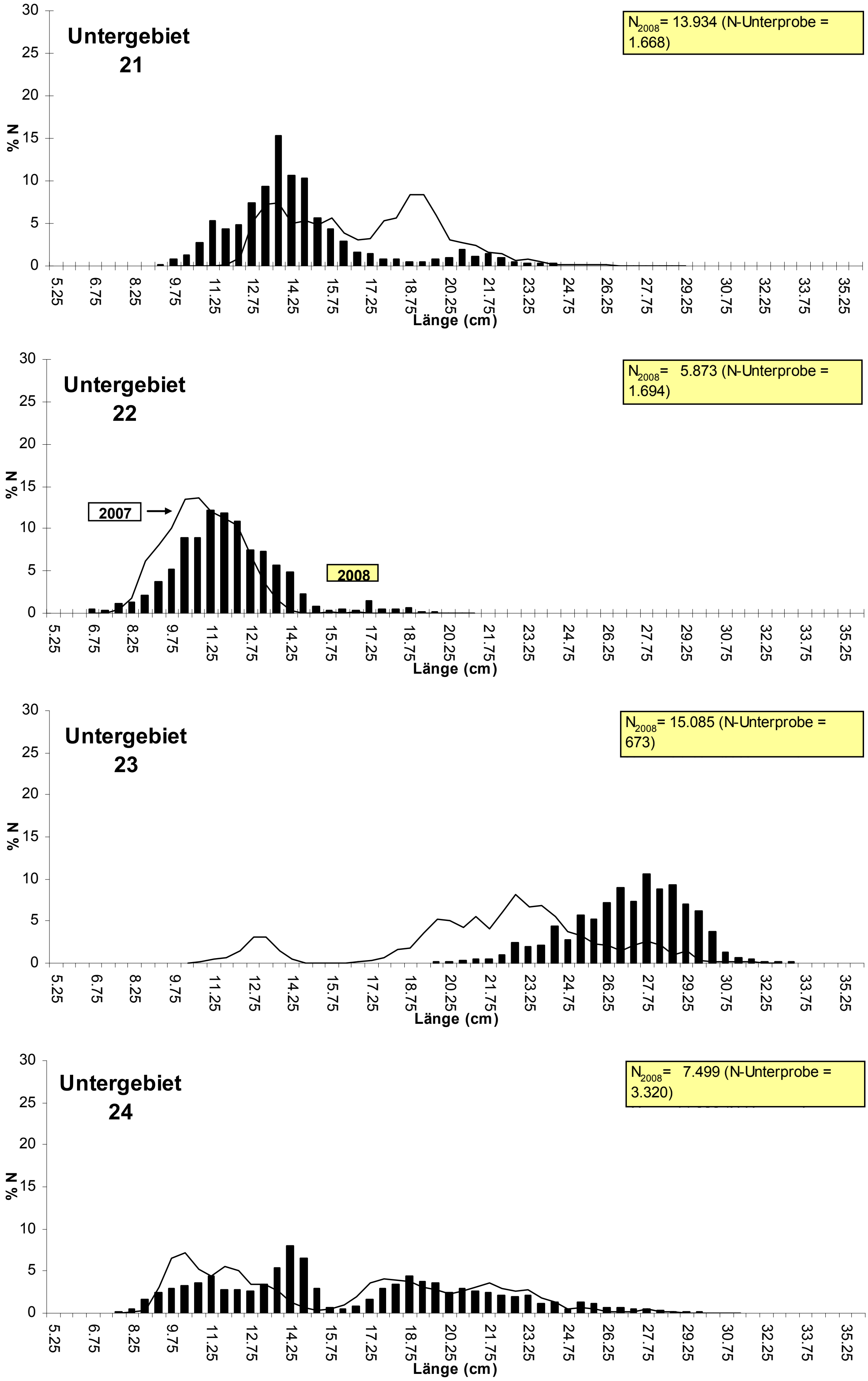


Figure 5H.3. Length distribution of sprat in Subdivisions 21, 22, 23 and 24 in 2007 (=line) and in 2008 (=bar)

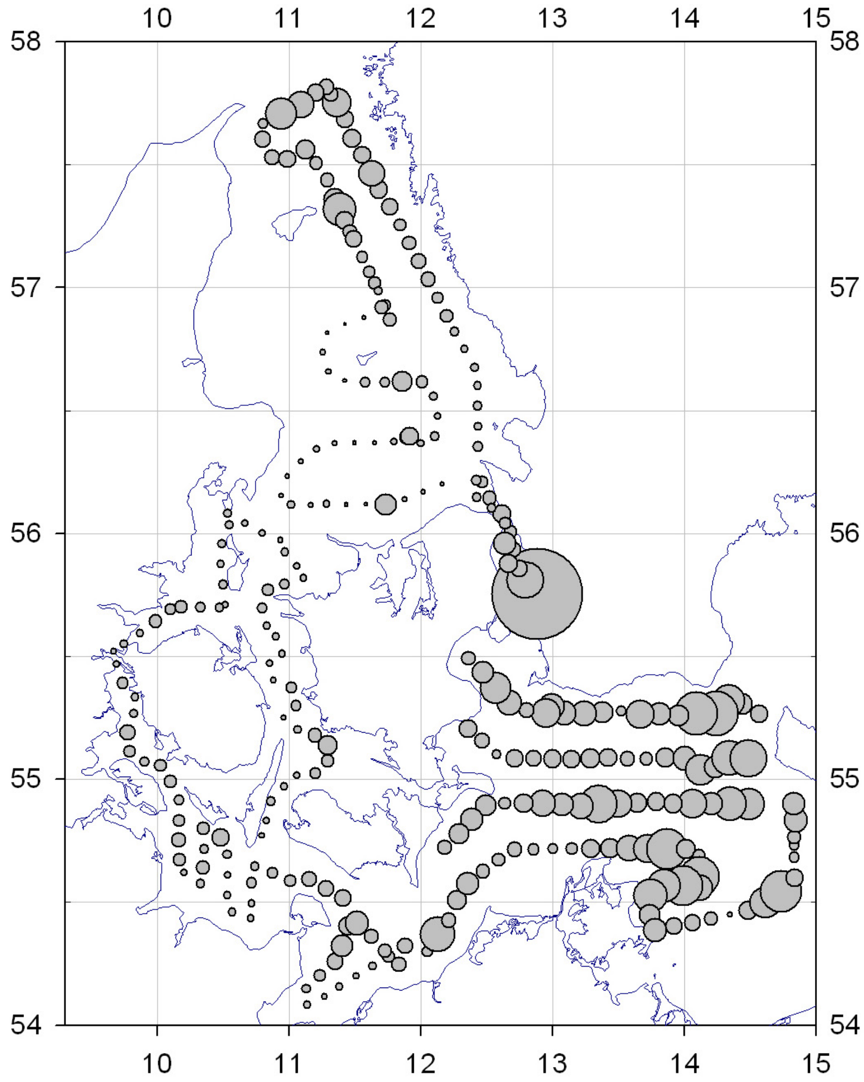


Figure 5H.4. Distribution of SA-values obtained during the acoustic survey of RV "SOLEA" in October 2008

Table 5H.1. Catch composition (kg/0.5 h) by trawl haul in Subdivision 21. (+) indicates catches of less than 0.01 kg (RV "SOLEA". October 2008).

HAUL NO.	43	44	45	46	47	48	49	50	51	52	53	TOTAL
Species/ICES Rectangle	42G2	42G2	43G1	44G1	44G1	44G0	43G1	42G1	41G1	41G1	41G2	
APHIA MINUTA					+			+				+
BELONE BELONE			0.04		0.23							0.27
CALLIONYMUS LYRA						+						+
CARCINUS				0.01	0.02	0.06	0.04					0.13
CLUPEA HARENGUS	0.51	0.20	1.50	30.06	144.62	0.23	33.24	18.14	0.01	67.44	1.36	297.31
CRYSTALLOGOBIUS LINEARIS		+	0.01	+		+						0.01
ELEDONE		0.01	0.02		+	+						0.03
ENGRAULIS ENCRASICOLUS	0.06	2.39	0.25	0.33	0.71	1.92	9.76	22.77	0.26	5.44	0.61	44.50
EUTRIGLA GURNARDUS						+						+
GASTEROSTEUS ACULEATUS											+	+
LIMANDA LIMANDA										0.08	0.03	0.11
LOLIGO FORBESI	0.02	0.32	0.79	0.15	0.27	0.59	0.37	0.11	0.08	0.06	+	2.76
MERLANGIUS MERLANGUS	0.07	0.01	0.13	0.03	0.02	0.03	0.08	0.10	0.01	0.03	0.05	0.56
MULLUS SURMULETUS					0.01							0.01
MYSIDACEA		+						10.69				10.69
POMATOSCHISTUS MINUTUS			+			0.01						0.01
SARDINA PILCHARDUS	0.04					0.42			0.01	0.02	0.03	0.52
SCOMBER SCOMBRUS		0.19			1.60			1.89		0.26		3.94
SPRATTUS SPRATTUS	0.04		+		0.09	0.63			0.05	1.80	0.52	3.13
SYNGNATHUS ROSTELLATUS						+						+
SYNGNATHUS TYPHLE	+											+
TRACHINUS DRACO	0.07	0.22		0.05		0.02		0.41	1.02	2.11	0.07	3.97
TRACHURUS TRACHURUS		0.01	0.03	0.06	0.07	0.01	0.06	0.59	0.01	0.01	+	0.85
TRISOPTERUS ESMARKI			+					0.01				0.01
Total	0.81	3.35	2.77	30.69	147.64	3.92	43.55	54.71	1.45	77.25	2.67	368.81
Medusae	4.12	1.60	2.51	0.77	0.30	4.28	1.67	3.59	2.34	3.05	6.78	31.01

Table 5H.2a. Catch composition (kg/0.5 h) by trawl haul in Subdivision 22 (RV "SOLEA" October 2008).

HAUL NO.	1	2	3	4	5	6	7	8	9	10
Species/ICES Rectangle	38G0	39G1	39G0	39G0	40G0	41G0	40G0	40G0	39F9	39G0
CLUPEA HARENGUS	0.02	0.21	0.10	0.11	1.74		1.16	0.13	0.37	0.06
CRANGON CRANGON		+	+		+					
CRYSTALLOGOBIUS LINEARIS		0.03	+		0.01					+
CTENOLABRUS RUPESTRIS		0.02	0.02		0.05	0.01				
CYCLOPTERUS LUMPUS			0.14			0.17				
ENGRAULIS ENCRASICOLUS	0.05	0.03	0.35	0.23	0.27	0.14	1.07	0.34	0.06	0.04
EUTRIGLA GURNARDUS					0.01					
GADUS MORHUA		+	0.06	0.02	+		0.11			
GASTEROSTEUS ACULEATUS		0.06	0.01	0.01	0.02		+		0.08	0.30
GOBIUS NIGER		0.07	+	+	+		+		0.05	0.01
GOBIUSCULUS FLAVESCENS		+								
LIMANDA LIMANDA	0.11	0.15	0.35	0.04	0.32	0.43	0.12	0.33	0.06	0.07
LOLIGO FORBESI	+	0.01	0.02	+	0.03	0.12	0.10	0.04		+
MERLANGIUS MERLANGUS		0.05	0.04	+	0.08	0.02	0.06		0.12	0.04
MULLUS SURMULETUS			0.03	0.03	0.02		0.01			0.03
PLEURONECTES PLATESSA						0.22	1.48			
POMATOSCHISTUS MINUTUS		0.14	0.02	+	0.11	+	+		0.03	+
SOLEA VULGARIS		0.03								
SPRATTUS SPRATTUS	0.00	1.58	0.36	0.09	2.77		8.66	2.49	3.50	1.21
SYNGNATHUS ROSTELLATUS		+	+	+		+	+	+	+	+
SYNGNATHUS TYPHLE		+								
TRACHINUS DRACO			0.05	0.06	0.63	0.12				
TRACHURUS TRACHURUS		+	0.05	0.08	0.06	0.02	0.15	+		
TRISOPTERUS ESMARKI			+							
ZOARCES VIVIPARUS		+								
Total	0.18	2.38	1.60	0.67	6.12	1.25	12.92	3.33	4.27	1.76
Medusae	2.0	3.1	8.6	26.3	5.3	6.2	8.3	2.4	5.2	2.4

Table 5H.2b. Catch composition (kg/0.5 h) by trawl haul in Subdivision 22.

HAUL NO.	10	11	12	13	14	15	16	17	18	TOTAL
Species/ICES Rectangle	39G0	38G0	38G0	37G0	38G1	37G1	37G1	37G1	37G1	
CLUPEA HARENGUS	0.06	0.12	3.44	0.38	17.08	1.31	1.50	26.17	10.93	64.83
CRANGON CRANGON										+
CRYSTALLOGOBIUS LINEARIS	+	+		+	+			+	+	0.04
CTENOLABRUS RUPESTRIS										0.10
CYCLOPTERUS LUMPUS				0.24				0.12		0.67
ENGRAULIS ENCRASICOLUS	0.04	0.32	0.09	0.30	0.14	0.06	0.02	0.06	0.21	3.78
EUTRIGLA GURNARDUS										0.01
GADUS MORHUA		+	5.62			+	0.01			5.82
GASTEROSTEUS ACULEATUS	0.30	0.10	0.18	0.07	0.09	0.46	0.09	0.29	0.54	2.30
GOBIUS NIGER	0.01			+	0.01				0.01	0.15
GOBIUSCULUS FLAVESCENS										+
LIMANDA LIMANDA	0.07	0.05	0.03	0.18	1.06			0.03	1.29	4.62
LOLIGO FORBESI	+				+					0.32
MERLANGIUS MERLANGUS	0.04	0.05	0.42	0.35	0.16	+	0.17	0.67	0.14	2.37
MULLUS SURMULETUS	0.03		0.02							0.14
PLEURONECTES PLATESSA										1.70
POMATOSCHISTUS MINUTUS	+			+	0.07	0.01	+	0.04	0.27	0.69
SOLEA VULGARIS										0.03
SPRATTUS SPRATTUS	1.21	1.28	2.70	0.36	0.03	0.17	0.22	1.05	0.04	26.51
SYNGNATHUS ROSTELLATUS	+	+								+
SYNGNATHUS TYPHLE										+
TRACHINUS DRACO			0.08						0.05	0.99
TRACHURUS TRACHURUS		0.04	0.03	0.01		0.02	0.11	0.19	0.02	0.78
TRISOPTERUS ESMARKI			+							+
ZOARCES VIVIPARUS										+
Total	1.76	1.96	12.61	1.89	18.64	2.03	2.12	28.62	13.50	115.85
Medusae	2.4	3.1	15.0	7.0	2.6	10.1	2.6	1.0	4.9	116.1

Table 5H.3. Catch composition (kg/0.5 h) by trawl haul in Subdivision 23.

HAUL NO.	39	40	41	42	TOTAL
Species/ICES Rectangle	40G2	40G2	41G2	41G2	
CLUPEA HARENGUS	2460.48	1.75	0.46	0.03	2462.72
CRYSTALLOGOBIUS LINEARIS			+	+	+
ENGRAULIS ENCRASICOLUS		0.01			0.01
EUTRIGLA GURNARDUS		+			+
GADUS MORHUA	32.55	2.27			34.82
GASTEROSTEUS ACULEATUS			+		+
LIMANDA LIMANDA		0.11			0.11
LOLIGO FORBESI			+		+
MELANOGRAMMUS AEGLEFINUS		0.81			0.81
MERLANGIUS MERLANGUS	0.97	1.30	0.01	0.01	2.29
PLATICHTHYS FLESUS			0.57	0.26	0.83
SPRATTUS SPRATTUS	20.32	1.68	0.03	0.01	22.04
TRACHINUS DRACO	0.10		0.03		0.13
TRACHURUS TRACHURUS	0.13	0.05	0.03	0.01	0.22
Total	2514.55	7.98	1.13	0.32	2523.98
Medusae	0.2	5.3	3.0	1.6	10.0

Table 5H.4a. Catch composition (kg/0.5 h) by trawl haul in Subdivision 24 (RV "SOLEA" October 2008).

HAUL NO.	19	20	21	22	23	24	25	26	27	28	29
Species/ICES Rectangle	37G2	38G2	38G3	38G3	38G4	37G3	38G4	38G4	38G4	38G3	38G3
AMMODYTES											
CLUPEA HARENGUS	15.85	1.00	2.59	7.76	2.57	1.88	0.67	41.30	8.72	6.1	0.3
CRANGON CRANGON			+					+		+	
CRYSTALLOGOBIUS LINEARIS	+										
ENGRAULIS ENCRASICOLUS	0.05	0.65	0.06						0.04	0.12	0.03
GADUS MORHUA			0.68	2.59		3.26		0.06	2.36		
GASTEROSTEUS ACULEATUS	0.09	0.04	0.15	0.02		0.17				+	0.05
LIMANDA LIMANDA	0.01	0.14		+							
MELANOGRAMMUS AEGLEFINUS	0.15		1.09	16.57		4.49				7.19	
OSMERUS EPERLANUS						0.10					
POMATOSCHISTUS MINUTUS	0.01	+	0.01	0.03		+		0.02		+	
SARDINA PILCHARDUS	0.01										
SCOMBER SCOMBRUS							0.88			1.77	0.78
SPRATTUS SPRATTUS	1.52	0.47	6.68	26.75	2.37	0.94	8.59	12.97	0.43	10.92	2.2
SYNGNATHUS ROSTELLATUS											
TRACHINUS DRACO	0.04										
TRACHURUS TRACHURUS	0.06	0.01	0.01	0.05							0.01
Total	17.79	2.31	11.27	53.77	4.94	10.84	10.14	54.35	11.55	26.10	3.37
Medusae	5.1	37.5	17.4	4.6	48.4	27.6	72.5	7.2	63.8	24.5	51.5

Table 5H.4b. Catch composition (kg/0.5 h) by trawl haul in Subdivision 24 (RV "SOLEA" October 2008).

HAUL NO.	30	31	32	33	34	35	36	37	38	TOTAL
Species/ICES Rectangle	38G2	39G2	39G3	39G3	39G4	39G4	39G4	39G3	39G2	
AMMODYTES									+	0.00
CLUPEA HARENGUS	4.27	6.34	2.71	2.02	5.04	61.18	65.93	8.72	26.57	271.52
CRANGON CRANGON		+	+							0.00
CRYSTALLOGOBIUS LINEARIS									+	0.00
ENGRAULIS ENCRASICOLUS		0.09	0.04	0.04				0.01		1.13
GADUS MORHUA		0.01	0.02	0.52	+	1.98		+		11.48
GASTEROSTEUS ACULEATUS	8.30						+			8.82
LIMANDA LIMANDA										0.15
MELANOGRAMMUS AEGLEFINUS	0.06	0.02	0.05	1.64	1.03	0.33		0.02		32.64
OSMERUS EPERLANUS										0.10
POMATOSCHISTUS MINUTUS	0.02	0.02	0.01	+	+	0.01	+	0.03	+	0.16
SARDINA PILCHARDUS										0.01
SCOMBER SCOMBRUS										3.43
SPRATTUS SPRATTUS	3.31	0.20	1.79	32.82	20.38	24.13	15.78	5.90	2.82	180.97
SYNGNATHUS ROSTELLATUS						+				0.00
TRACHINUS DRACO										0.04
TRACHURUS TRACHURUS	0.02	0.14	0.04	0.01				0.03	0.03	0.41
Total	15.98	6.82	4.66	37.05	26.45	87.63	81.71	14.71	29.42	510.86
Medusae	7.2	79.4	7.7	12.1	4.0	3.3	6.2	7.0	4.0	490.7

Table 5H.5. Survey statistics by area (RV "Solea", October 2008).

SUB-division	ICES Rectangle	AREA (nm²)	SA (m²/NM²)	SIGMA (cm²)	N TOTAL (million)	HERRING (%)	SPRAT (%)	NHERRING (million)	NSPRAT (million)
21	41G0	108.1	12.1	3.075	4.25	60.42	6.08	2.57	0.26
21	41G1	946.8	34.1	3.075	105.00	60.42	6.08	63.44	6.38
21	41G2	432.3	13.2	1.238	46.10	41.64	27.88	19.19	12.85
21	42G1	884.2	35.8	1.730	182.95	36.87	0.00	67.45	0.00
21	42G2	606.8	25.6	1.315	118.15	32.23	4.23	38.08	4.99
21	43G1	699.0	152.0	1.385	767.28	67.09	0.26	514.78	2.03
21	43G2	107.0	100.2	1.385	77.43	67.09	0.26	51.95	0.20
21	44G0	239.9	165.8	0.988	402.46	5.99	32.03	24.11	128.91
21	44G1	580.5	146.8	2.387	357.03	96.39	0.02	344.15	0.07
	Total	**4,604.6**			**2,060.65**			**1,125.72**	**155.69**
22	37G0	209.9	18.1	1.142	33.28	17.35	25.11	5.77	8.36
22	37G1	723.3	84.2	0.964	631.73	54.68	7.57	345.42	47.82
22	38G0	735.3	49.8	0.796	459.76	20.11	60.83	92.46	279.65
22	38G1	173.2	96.2	1.313	126.92	89.43	0.23	113.50	0.29
22	39F9	159.3	51.8	0.516	160.03	4.44	87.92	7.10	140.70
22	39G0	201.7	21.4	0.771	55.99	2.41	39.53	1.35	22.14
22	39G1	250.0	57.6	0.465	309.44	3.53	43.95	10.91	135.99
22	40F9	51.3	26.6	1.049	13.01	8.81	69.62	1.15	9.06
22	40G0	538.1	27.1	1.049	139.02	8.81	69.62	12.25	96.78
22	40G1	174.5	20.3	1.049	33.77	8.81	69.62	2.97	23.51
22	41G0	173.1	13.2	1.093	20.91	0.00	0.00	0.00	0.00
	Total	**3,389.7**			**1,983.86**			**592.88**	**764.30**
23	39G2	130.9	333.4	1.947	224.10	80.84	14.74	181.17	33.03
23	40G2	164.0	806.1	4.785	276.27	61.07	26.00	168.72	71.82
23	41G2	72.3	58.1	0.992	42.35	32.82	7.63	13.90	3.23
	Total	**367.2**			**542.72**			**363.79**	**108.08**
24	37G2	192.4	292.6	1.256	448.30	79.79	15.03	357.69	67.36
24	37G3	167.7	208.0	2.421	144.08	12.50	54.89	18.01	79.09
24	37G4	875.1	172.6	2.461	613.82	29.83	62.29	183.08	382.37
24	38G2	832.9	153.5	0.733	1,743.40	18.49	25.78	322.32	449.43
24	38G3	865.7	321.4	1.555	1,788.90	8.38	85.11	149.92	1,522.61
24	38G4	1,034.8	391.5	2.483	1,631.87	34.16	64.14	557.41	1,046.75
24	39G2	406.1	198.6	1.947	414.13	80.84	14.74	334.80	61.04
24	39G3	765.0	174.3	1.833	727.47	23.25	72.48	169.13	527.25
24	39G4	524.8	545.9	2.170	1,320.24	30.75	68.84	406.02	908.90
	Total	**5,664.5**			**8,832.21**			**2,498.38**	**5,044.80**
22-24	**Total**	**9,421.4**			**11,358.79**			**3,455.05**	**5,917.18**
21-24	**Total**	**14,026.0**			**13,419.44**			**4,580.77**	**6,072.87**

Table 5H.6. Numbers (millions) of herring by age and area (RV "Solea", October 2008).

Sub-division	Rectangle/ W-rings	0	1	2	3	4	5	6	7	8+	Total
21	41G0	0.10	2.25	0.21	0.02						2.58
21	41G1	2.36	55.44	5.16	0.48						63.44
21	41G2	18.93	0.26								19.19
21	42G1	66.94	0.51								67.45
21	42G2	36.17	1.90								38.07
21	43G1	510.90	3.88								514.78
21	43G2	51.55	0.39								51.94
21	44G0	24.11									24.11
21	44G1	285.83	49.23	7.63	1.46						344.15
	Total	**996.89**	**113.86**	**13.00**	**1.96**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**1,125.71**
22	37G0	5.77									5.77
22	37G1	323.02	21.48	0.34	0.29	0.29					345.42
22	38G0	90.46	2.00								92.46
22	38G1	111.74	1.72	0.04							113.50
22	39F9	7.10									7.10
22	39G0	1.01	0.06	0.28							1.35
22	39G1	10.91									10.91
22	40F9	1.00	0.13	0.01							1.14
22	40G0	10.73	1.39	0.09	0.02	0.02					12.25
22	40G1	2.61	0.34	0.02							2.97
22	41G0										0.00
	Total	**564.35**	**27.12**	**0.78**	**0.31**	**0.31**	**0.00**	**0.00**	**0.00**	**0.00**	**592.87**
23	39G2	148.58	9.77	5.68	4.29	3.12	4.18	3.71	1.32	0.51	181.16
23	40G2	39.06	41.46	17.65	25.49	16.45	17.47	7.65	0.48	3.01	168.72
23	41G2	11.34	2.28	0.22	0.06						13.90
	Total	**198.98**	**53.51**	**23.55**	**29.84**	**19.57**	**21.65**	**11.36**	**1.80**	**3.52**	**363.78**
24	37G2	343.66	8.20	2.68	1.64	0.41	0.66	0.08	0.36		357.69
24	37G3	8.61	1.40	1.13	1.77	2.06	1.75	0.84	0.31	0.13	18.00
24	37G4	34.91	24.77	24.78	28.53	23.58	24.07	13.83	6.01	2.60	183.08
24	38G2	288.19	20.93	6.13	3.19	0.37	1.97	0.96	0.57	0.02	322.33
24	38G3	87.26	14.64	9.06	12.22	9.18	8.76	5.92	1.90	0.99	149.93
24	38G4	66.20	83.44	85.54	94.89	73.83	78.10	46.13	20.44	8.86	557.43
24	39G2	274.59	18.06	10.49	7.93	5.77	7.72	6.86	2.44	0.94	334.80
24	39G3	77.07	35.21	19.66	11.08	6.09	8.69	7.17	3.27	0.89	169.13
24	39G4	125.65	71.36	50.20	47.40	34.34	38.77	23.14	11.43	3.73	406.02
	Total	**1,306.14**	**278.01**	**209.67**	**208.65**	**155.63**	**170.49**	**104.93**	**46.73**	**18.16**	**2,498.41**
22-24	**Total**	**2,069.47**	**358.64**	**234.00**	**238.80**	**175.51**	**192.14**	**116.29**	**48.53**	**21.68**	**3,455.06**
21-24	**Total**	**3,066.36**	**472.50**	**247.00**	**240.76**	**175.51**	**192.14**	**116.29**	**48.53**	**21.68**	**4,580.77**

Table 5H.7. Mean weight (g) of herring by age and area (RV "Solea", October 2008).

Sub-division	Rectangle/ W-rings	0	1	2	3	4	5	6	7	8+	Total
21	41G0	19.37	64.92	85.05	100.04						65.13
21	41G1	19.37	64.92	85.05	100.04						65.13
21	41G2	11.92	41.18								12.31
21	42G1	17.97	50.87								18.22
21	42G2	13.57	60.55								15.92
21	43G1	12.04	49.86								12.32
21	43G2	12.04	49.86								12.32
21	44G0	10.50									10.50
21	44G1	19.40	66.98	94.19	109.72						28.25
	Total	**14.58**	**65.06**	**90.42**	**107.24**						**20.72**
22	37G0	9.78									9.78
22	37G1	9.17	36.27	44.33	36.86	36.86					10.93
22	38G0	6.18	34.44								6.79
22	38G1	10.46	33.30	44.33							10.82
22	39F9	5.15									5.15
22	39G0	6.99	54.50	95.70							27.45
22	39G1	6.95									6.95
22	40F9	10.53	39.31	66.19	36.86	36.86					14.28
22	40G0	10.53	39.31	66.19	36.86	36.86					14.28
22	40G1	10.53	39.31	66.19	36.86	36.86					14.28
22	41G0										0.00
	Total	**8.89**	**36.20**	**66.28**	**36.86**	**36.86**					**10.24**
23	39G2	14.58	40.22	50.67	75.08	95.77	92.81	83.27	82.44	75.03	23.80
23	40G2	15.24	50.58	101.77	143.47	169.80	194.13	195.95	234.10	219.32	98.40
23	41G2	15.48	39.99	42.50	46.50						20.06
	Total	**14.76**	**48.24**	**88.89**	**133.45**	**158.00**	**174.57**	**159.15**	**122.89**	**198.41**	**58.26**
24	37G2	10.20	33.02	36.48	31.50	31.79	44.15	54.29	43.24		11.15
24	37G3	7.78	42.69	63.07	81.99	84.34	82.57	66.66	71.85	72.86	41.61
24	37G4	9.75	42.77	57.81	80.07	85.20	94.97	81.50	85.31	83.86	61.56
24	38G2	8.69	37.02	39.03	37.09	45.43	38.35	43.52	40.11	43.90	11.77
24	38G3	10.80	40.54	53.02	84.44	94.86	91.18	75.48	84.33	73.12	35.99
24	38G4	11.74	42.78	57.27	79.79	85.38	97.11	83.59	86.90	85.18	66.54
24	39G2	14.58	40.22	50.67	75.08	95.77	92.81	83.27	82.44	74.76	23.80
24	39G3	15.31	39.54	48.43	58.73	73.38	63.70	52.38	53.05	61.39	34.17
24	39G4	15.65	40.49	53.28	76.72	87.49	82.91	73.01	83.19	81.91	50.07
	Total	**11.70**	**40.78**	**54.27**	**77.09**	**86.04**	**90.34**	**77.85**	**82.08**	**81.83**	**38.57**
22-24	**Total**	**11.23**	**41.54**	**57.79**	**84.08**	**93.98**	**99.83**	**85.79**	**83.59**	**100.76**	**35.78**
21-24	**Total**	**12.32**	**47.21**	**59.51**	**84.27**	**93.98**	**99.83**	**85.79**	**83.59**	**100.76**	**32.08**

Table 5H.8. Total biomass (t) of herring by age and area (RV "Solea", October 2008).

SUB-	RECTANGLE/										
division	W-rings	0	1	2	3	4	5	6	7	8+	Total
21	41G0	1.9	146.1	17.9	2.0						167.9
21	41G1	45.7	3,599.2	438.9	48.0						4,131.8
21	41G2	225.6	10.7								236.3
21	42G1	1,202.9	25.9								1,228.8
21	42G2	490.8	115.0								605.8
21	43G1	6,151.2	193.5								6,344.7
21	43G2	620.7	19.4								640.1
21	44G0	253.2									253.2
21	44G1	5,545.1	3,297.4	718.7	160.2						9,721.4
21	Total	14,537.1	7,407.2	1,175.5	210.2	0.0	0.0	0.0	0.0	0.0	23,330.0
22	37G0	56.4									56.4
22	37G1	2,962.1	779.1	15.1	10.7	10.7					3,777.7
22	38G0	559.0	68.9								627.9
22	38G1	1,168.8	57.3	1.8							1,227.9
22	39F9	36.6									36.6
22	39G0	7.1	3.3	26.8							37.2
22	39G1	75.8									75.8
22	40F9	10.5	5.1	0.7							16.3
22	40G0	113.0	54.6	6.0	0.7	0.7					175.0
22	40G1	27.5	13.4	1.3							42.2
22	41G0										0.0
	Total	5,016.8	981.7	51.7	11.40	11.4	0.0	0.00	0.00	0.0	6,073.0
23	39G2	2,166.3	392.9	287.8	322.10	298.8	387.9	308.90	108.80	38.2	4,311.7
23	40G2	595.3	2,097.0	1,796.2	3,657.1	2,793.2	3,391.5	1,499.0	112.4	660.2	16,601.9
23	41G2	175.5	91.2	9.3	2.8	0.0	0.0	0.0	0.0	0.0	278.8
	Total	2,937.1	2,581.1	2,093.3	3,982.0	3,092.0	3,779.4	1,807.9	221.2	698.4	21,192.4
24	37G2	3,505.3	270.8	97.8	51.7	13.0	29.1	4.3	15.6	0.0	3,987.6
24	37G3	67.0	59.8	71.3	145.1	173.7	144.5	56.0	22.3	9.5	749.2
24	37G4	340.4	1,059.4	1,432.5	2,284.4	2,009.0	2,285.9	1,127.1	512.7	218.0	11,269.4
24	38G2	2,504.4	774.8	239.3	118.3	16.8	75.5	41.8	22.9	0.9	3,794.7
24	38G3	942.4	593.5	480.4	1,031.9	870.8	798.7	446.8	160.2	72.4	5,397.1
24	38G4	777.2	3,569.6	4,898.9	7,571.3	6,303.6	7,584.3	3,856.0	1,776.2	754.8	37,091.9
24	39G2	4,003.5	726.4	531.5	595.4	552.6	716.5	571.2	201.2	70.3	7,968.6
24	39G3	1,179.9	1,392.2	952.1	650.7	446.9	553.6	375.6	173.5	54.6	5,779.1
24	39G4	1,966.4	2,889.4	2,674.7	3,636.5	3,004.4	3,214.4	1,689.5	950.9	305.5	20,331.7
	Total	15,286.5	11,335.9	11,378.5	16,085.3	13,390.8	15,402.5	8,168.3	3,835.5	1,486.0	96,369.3
22-24	Total	23,240.4	14,898.7	13,523.5	20,078.7	16,494.2	19,181.9	9,976.2	4,056.7	2,184.4	123,634.7
21-24	Total	37,777.5	22,305.9	14,699.0	20,288.9	16,494.2	19,181.9	9,976.2	4,056.7	2,184.4	146,964.7

Table 5H.9. Numbers (millions) of sprat by age and area (RV "Solea", October 2008).

SUB-division	RECTANGLE/ Age group	0	1	2	3	4	5	6	7	8+	Total
21	41G0		0.02	0.18	0.03	0.02					0.25
21	41G1		0.57	4.46	0.72	0.57	0.06				6.38
21	41G2	11.60	0.65	0.51	0.05	0.04					12.85
21	42G1										0.00
21	42G2	4.77	0.11	0.11							4.99
21	43G1	2.03									2.03
21	43G2	0.20									0.20
21	44G0	125.14	1.70	1.99	0.09						128.92
21	44G1			0.03	0.03						0.06
21	Total	143.74	3.05	7.28	0.92	0.63	0.06	0.00	0.00	0.00	155.68
22	37G0	6.84	0.11	0.88	0.20	0.20	0.12				8.35
22	37G1	42.38	1.15	2.91	0.44	0.48	0.17		0.27		47.80
22	38G0	261.67	2.68	9.85	2.07	2.32	1.05				279.64
22	38G1	0.24	0.04	0.01							0.29
22	39F9	140.70									140.70
22	39G0	20.12	0.01	0.86	0.41	0.54	0.19				22.13
22	39G1	135.99									135.99
22	40F9	5.07	0.60	2.27	0.43	0.48	0.22				9.07
22	40G0	54.15	6.38	24.21	4.60	5.10	2.35				96.79
22	40G1	13.15	1.55	5.88	1.12	1.24	0.57				23.51
22	41G0										0.00
	Total	680.31	12.52	46.87	9.27	10.36	4.67	0.00	0.27	0.00	764.27
23	39G2	20.28	1.86	6.11	3.10	1.14	0.41	0.06	0.06		33.02
23	40G2	0.28	3.63	28.15	23.88	10.63	4.89	0.35			71.81
23	41G2	2.69	0.08	0.30	0.16						3.23
	Total	23.25	5.57	34.56	27.14	11.77	5.30	0.41	0.06	0.00	108.06
24	37G2	58.85	3.43	3.16	1.08	0.50	0.27	0.04	0.04		67.37
24	37G3	75.54	1.67	1.23	0.32	0.25	0.08				79.09
24	37G4	220.78	33.34	71.61	32.93	17.46	5.40	0.43	0.43		382.38
24	38G2	443.69	1.99	2.19	0.83	0.60	0.14				449.44
24	38G3	663.29	222.77	374.64	154.34	79.52	24.81	1.62	1.62		1,522.61
24	38G4	505.54	108.56	240.96	111.63	58.93	18.21	1.46	1.46		1,046.75
24	39G2	37.47	3.45	11.30	5.73	2.11	0.75	0.11	0.11		61.03
24	39G3	147.01	30.88	186.87	97.92	41.26	16.34	3.49	3.49		527.26
24	39G4	229.72	73.86	325.68	177.69	71.02	24.19	3.37	3.37		908.90
	Total	2,381.89	479.95	1,217.64	582.47	271.65	90.19	10.52	10.52	0.00	5,044.83
22-24	Total	3,085.45	498.04	1,299.07	618.88	293.78	100.16	10.93	10.85	0.00	5,917.16
21-24	Total	3,229.19	501.09	1,306.35	619.80	294.41	100.22	10.93	10.85	0.00	6,072.84

Table 5H.10. Mean weight (g) of sprat by age and area (RV "Solea", October 2008).

Sub-division	Rectangle/ Age group	0	1	2	3	4	5	6	7	8+	Total
21	41G0		13.70	16.48	18.37	20.70	19.85				16.85
21	41G1		13.70	16.48	18.37	20.70	19.85				16.85
21	41G2	6.49	10.56	14.26	18.25	18.94					7.10
21	42G1										0.00
21	42G2	7.00	8.04	8.04							7.05
21	43G1	4.17									4.17
21	43G2	4.17									4.17
21	44G0	4.84	10.64	11.11	13.58						5.02
21	44G1		19.85	29.14	25.74	19.85	19.85				26.62
21	Total	5.03	11.15	14.79	18.15	20.63	19.85				5.76
22	37G0	4.37	13.04	15.26	16.59	17.12	16.42				6.41
22	37G1	4.87	12.24	13.41	16.61	17.48	16.93		21.00		5.94
22	38G0	3.48	12.59	14.79	16.24	17.39	16.19				4.22
22	38G1	6.73	8.13	8.13							6.98
22	39F9	2.52									2.52
22	39G0	3.61	14.91	16.64	17.73	17.91	17.37				4.85
22	39G1	4.39									4.39
22	40F9	4.42	12.80	14.74	16.26	17.21	16.15				9.08
22	40G0	4.42	12.80	14.74	16.26	17.21	16.15				9.08
22	40G1	4.42	12.80	14.74	16.26	17.21	16.15				9.08
22	41G0										
	Total	3.66	12.68	14.71	16.34	17.30	16.27		21.00		4.91
23	39G2	4.40	13.94	16.28	16.78	16.04	16.83	18.39	18.39		8.91
23	40G2	5.50	15.63	18.47	19.87	22.57	22.33	25.44			19.65
23	41G2	5.50	16.49	16.49	16.49						7.33
	Total	4.54	15.06	18.06	19.50	21.94	21.91	24.39	18.39		15.99
24	37G2	4.25	12.58	15.38	17.39	15.73	17.38	18.39	18.39		5.56
24	37G3	4.10	12.44	14.05	14.99	14.73	14.79				4.52
24	37G4	5.14	13.50	15.65	16.37	16.28	16.54	18.39	18.39		9.50
24	38G2	4.29	12.27	14.69	15.49	15.29	15.49				4.42
24	38G3	4.45	13.50	15.33	16.02	15.35	15.62	18.39	18.39		10.40
24	38G4	5.66	13.56	15.67	16.38	16.30	16.56	18.39	18.39		10.75
24	39G2	4.40	13.94	16.28	16.78	16.04	16.83	18.39	18.39		8.91
24	39G3	4.83	14.07	16.81	17.07	17.28	17.88	18.39	18.39		13.45
24	39G4	4.88	13.87	16.48	16.96	16.72	17.48	18.39	18.39		13.49
	Total	4.79	13.59	15.96	16.58	16.27	16.79	18.39	18.39		10.57
22-24	Total	4.54	13.59	15.97	16.71	16.54	17.03	18.61	18.45		9.94
21-24	Total	4.56	13.57	15.96	16.71	16.54	17.04	18.61	18.45		9.83

Table 5H.11. Total biomass (t) of sprat by age and area (RV "Solea", October 2008).

SUB-division	RECTANGLE/ Age group	0	1	2	3	4	5	6	7	8+	Total
21	41G0		0.3	3.0	0.6	0.4					4.3
21	41G1		7.8	73.5	13.2	11.8	1.2				107.5
21	41G2	75.3	6.9	7.3	0.9	0.8					91.2
21	42G1										0.0
21	42G2	33.4	0.9	0.9							35.2
21	43G1	8.5									8.5
21	43G2	0.8									0.8
21	44G0	605.7	18.1	22.1	1.2						647.1
21	44G1			0.9	0.8						1.7
21	Total	723.7	34.0	107.7	16.7	13.0	1.2	0.0	0.0	0.0	896.3
22	37G0	29.9	1.4	13.4	3.3	3.4	2.0				53.4
22	37G1	206.4	14.1	39.0	7.3	8.4	2.9		5.7		283.8
22	38G0	910.6	33.7	145.7	33.6	40.3	17.0				1,180.9
22	38G1	1.6	0.3	0.1							2.0
22	39F9	354.6									354.6
22	39G0	72.6	0.1	14.3	7.3	9.7	3.3				107.3
22	39G1	597.0									597.0
22	40F9	22.4	7.7	33.5	7.0	8.3	3.6				82.5
22	40G0	239.3	81.7	356.9	74.8	87.8	38.0				878.5
22	40G1	58.1	19.8	86.7	18.2	21.3	9.2				213.3
22	41G0										0.0
	Total	2,492.5	158.8	689.6	151.5	179.2	76.0	0.0	5.7	0.0	3,753.3
23	39G2	89.2	25.9	99.5	52.0	18.3	6.9	1.1	1.1		294.0
23	40G2	1.5	56.7	519.9	474.5	239.9	109.2	8.9			1,410.6
23	41G2	14.8	1.3	4.9	2.6						23.6
	Total	105.5	83.9	624.3	529.1	258.2	116.1	10.0	1.1	0.0	1,728.2
24	37G2	250.1	43.1	48.6	18.8	7.9	4.7	0.7	0.7		374.6
24	37G3	309.7	20.8	17.3	4.8	3.7	1.2				357.5
24	37G4	1,134.8	450.1	1,120.7	539.1	284.2	89.3	7.9	7.9		3,634.0
24	38G2	1,903.4	24.4	32.2	12.9	9.2	2.2				1,984.3
24	38G3	2,951.6	3,007.4	5,743.2	2,472.5	1,220.6	387.5	29.8	29.8		15,842.4
24	38G4	2,861.4	1,472.1	3,775.8	1,828.5	960.6	301.6	26.8	26.8		11,253.6
24	39G2	164.9	48.1	184.0	96.1	33.8	12.6	2.0	2.0		543.5
24	39G3	710.1	434.5	3,141.3	1,671.5	713.0	292.2	64.2	64.2		7,091.0
24	39G4	1,121.0	1,024.4	5,367.2	3,013.6	1,187.5	422.8	62.0	62.0		12,260.5
	Total	11,407.0	6,524.9	19,430.3	9,657.8	4,420.5	1,514.1	193.4	193.4	0.0	53,341.4
22-24	Total	14,005.0	6,767.6	20,744.2	10,338.4	4,857.9	1,706.2	203.4	200.2	0.0	58,822.9
21-24	Total	14,728.7	6,801.6	20,851.9	10,355.1	4,870.9	1,707.4	203.4	200.2	0.0	59,719.2

ANNEX 5I: Northern Ireland (Clyde, North Channel)

Survey report for RV "Corystes"

7–11 July 2008

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 survey is an increase in survey effort and the first of a new time-series that covers the Clyde and North Channel, as 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

Pieter-Jan Schön (SIC)
Peter McCorriston
Ian McCausland
Enda O'Callaghan
John Peel

2.2 Narrative

The vessel departed Belfast at 2200 on 6 July and started the survey off the north coast at 0415 on the 7 July. Sea conditions were good throughout the survey, except during the first day of transecting off the north coast. The survey was completed at 0300 on the 11 July.

2.3 Survey design

The survey design of systematic, parallel transects covers approximately 540 nm (Figure 5I.1). Transect spacing is 4 nm in the Clyde and decreased 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 9 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 7 trawl hauls were carried out. Table 5I.2 gives the positions, catch composition and mean length by species for these trawl hauls. Only 3 hauls contained sufficient herring to be used in the analysis. 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 and sampling information from the RV "Celtic Explorer" was used in the analysis.

The resulting weight-length relationship for herring was calculated from the sampling information as $W = 0.00290*L^{3.389}$ (length measured in cm). The age length key (Table 5I.3) used in the analysis indicate that the population is composed of young, immature fish (age 1–2).

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, to the north of Galloway and in Port Logan Bay.

3.3 Biomass estimates

The estimated biomass and number of herring and sprat by subrectangle are given in Table 5I.4. Only young herring was found in the area and the total number estimate comprises of 86% age 1, 13% age 2 and 1% age 3.

4 DISCUSSION

The stock estimate in the survey area (Clyde/North Channel) was estimated to be 33,440 t or 503 x 10^6 individuals. The majority of the fish were below 20 cm and the major contribution of ages to the total estimates is from age's 1–2 fish. These fish were also mostly immature. From this year's data 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 the Firth of Clyde, around the Isle of Arran, to the north of Galloway and in Port Logan Bay.

5 TABLES AND FIGURES

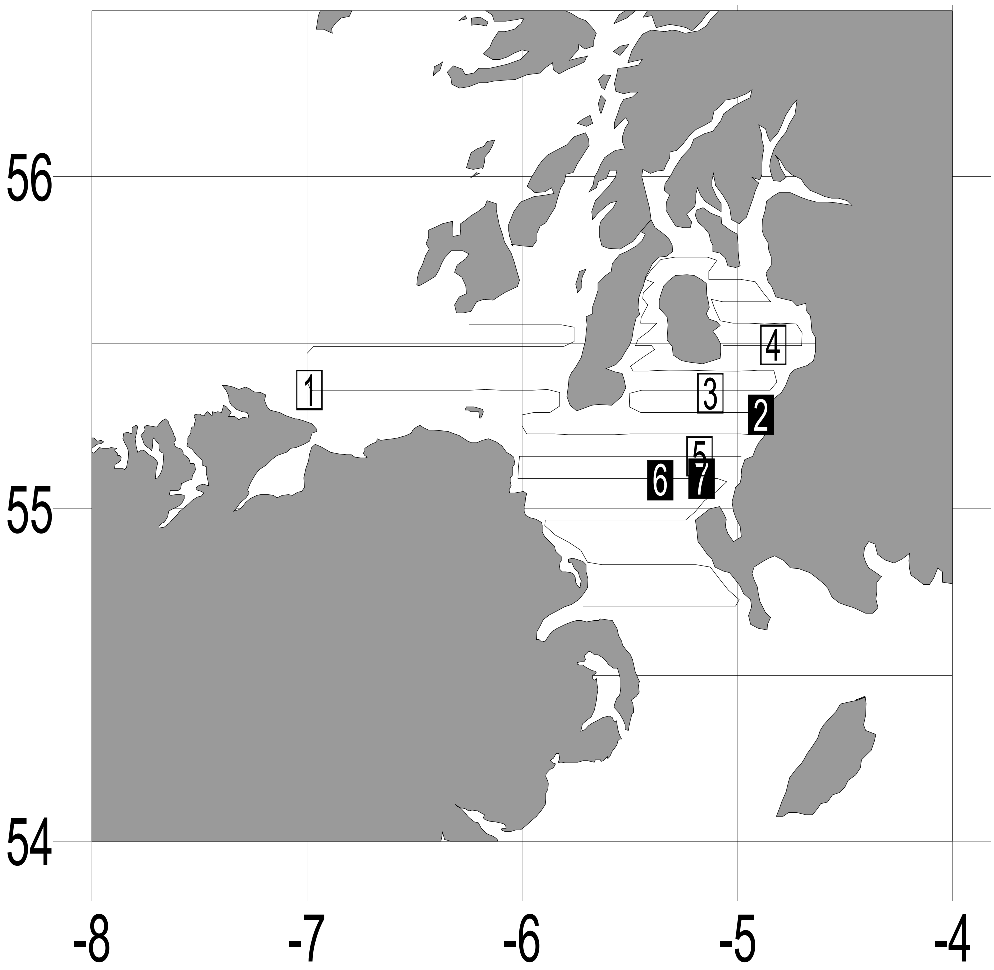


Figure 5I.1. Cruise track and trawl positions during the July 2008 Clyde and North Channel acoustic survey on RV "Corystes". Filled squares indicate trawls in which significant numbers of herring were caught, whereas open squares indicate trawls with few or no herring.

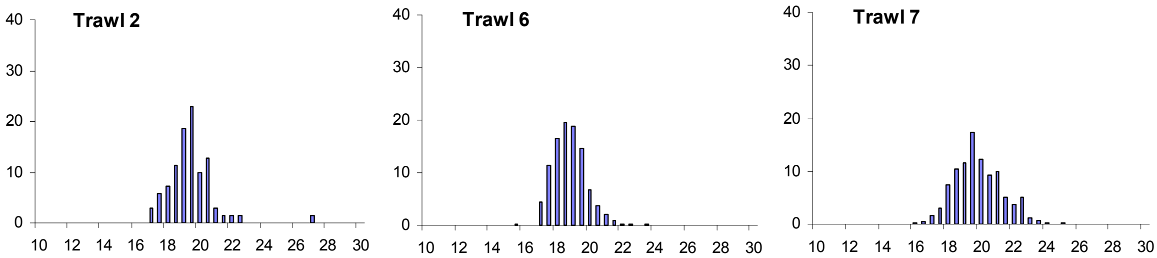


Figure 5I.2. Percentage length compositions of herring in each trawl sample in the July 2008 Clyde and North Channel acoustic survey on RV "Corystes".

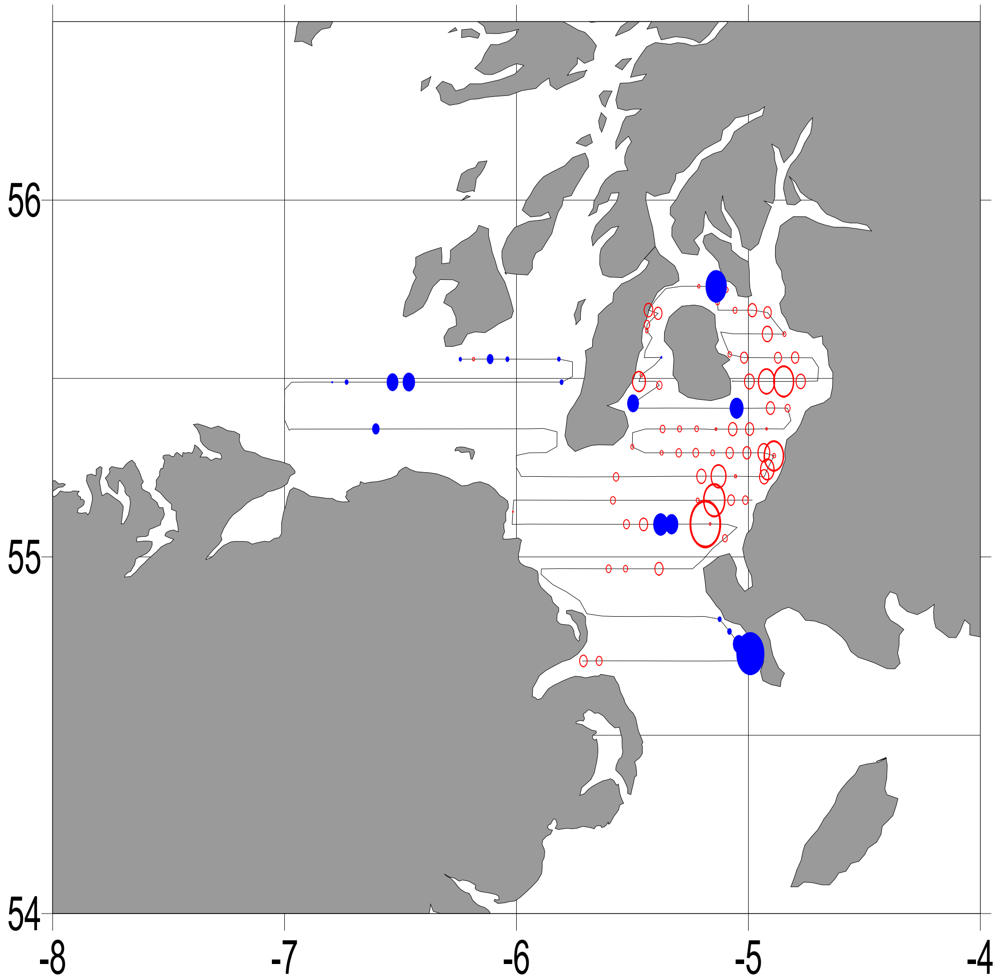


Figure 5I.3. Map of the Clyde and North Channel with a post plot showing the distribution of NASC values (size of ellipses is proportional to square root of the NASC value per 15-minute interval) obtained during the July 2008 acoustic survey on RV "Corystes". (a) Solid circles are for herring NASC values (maximum value was 3720) and (b) open circles are for clupeoid mix NASC, which include juvenile herring and sprat (maximum value was 4770).

Table 5I.1. Simrad EK60 and analysis settings used on the July 2008 Clyde and North Channel herring acoustic survey on RV "Corystes".

Transceiver Menu	
Frequency	38 kHz
Sound speed	1050 m.s^{-1}
Max. Power	2000 W
Equivalent two-way beam angle	-20.6 dB
Default Transducer Sv gain	24.96 dB
3 dB Beam width	6.9°
Calibration details	
TS of sphere	-33.5 dB
Range to sphere in calibration	12.25 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 2008.

		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	Euphausiids
1	07/07	1255	55 21.5	6 59.3	41	188	0.0	0.0	100.00	0.00	0.00	0.00	0.00			
2	08/07	0440	55 17.1	4 53.4	30	138	48.1	3.3	48.6	0.00	0.00	0.04	0.00	12.5	19.7	
3	08/07	1019	55 20.9	5 7.5	56	129	100	0.0	0.00	0.00	0.00	0.00	0.00	10.1		
4	09/07	1955	55 29.6	4 49.9	64	27	100	0.0	0.00	0.00	0.00	0.00	0.00	4.9		1068.3
5	10/07	0454	55 9.5	5 10.5	45	381	98.8	0.03	0.6	0.00	0.00	0.33	0.22	9.8	17.6	
6	10/07	1158	55 5.3	5 21.5	49	1332	0.0	99.99	0.01	0.00	0.00	0.00	0.00		19.0	
7	10/07	1355	55 5.5	5 10.0	28	3999	6.8	85.3	7.83	0.00	0.00	0.00	0.00	11.7	20.1	

Table 5I.3. Age-length key for herring from which otoliths were removed at sea during the July 2008 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
10					
11					
12					
13					
14		1			1
15		1			1
16		3			3
17		11			11
18		19			19
19		21			21
20		28			28
21		15	2		17
22		2	13		15
23			7		7
24			2		2
25			1		1
26					0
TOTAL		101	25		126

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	251662	1845	918	56
40E4D	77260	566	401	24
40E4C	8191	60	3498	319
40E4B	7064	52	119214	7111
40E3D	18594	136	26009	2377
39E5C	23410	172	85	5
39E5A	675132	4950	2463	149
39E4D	656514	5066	175933	11012
39E4C	67519	495	246	15
39E4B	453626	1618	35209	2101
39E4A	0	0	2051	188
39E3D	0	0	0	0
39E3B	0	0	25855	2365
39E3A	0	0	33786	3090
38E4D	0	0	76683	4574
38E4C	97384	714	355	21
38E4B	89738	658	327	20
38E4A	52439	384	191	12
Total	2478533	16717	503226	33436

Annex 6: The 2008 ICES Coordinated Acoustic Survey in the Skagerrak and Kattegat, the North Sea, West of Scotland and the Malin Shelf area

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Abstract

Eight 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 Planning Group for International Pelagic Surveys: 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 slightly higher than the previous year, at 1.8 million tonnes and 9 14 million herring. The survey continues to show the particularly strong 2000 year class of herring. Growth of this 2000 year class seems still to be slower than average: individuals of this year class were of a smaller mean length and mean weight than the younger 2001 year class.

The estimates of Western Baltic spring-spawning herring SSB were 283 000 tonnes and 2 299 million herring, which is slightly lower than last year's estimate. The stock is dominated by 1 and 2 ring fish.

The West of Scotland estimates of SSB are 788 000 tonnes and 3 770 million herring. This is the second highest estimate in the time-series. Once again the survey did not detect many immature fish this year. The 1998 year class is now almost completely depleted, but there were a significant number of the 2000 year class still in the population. To ensure that the west of Scotland results were consistent with the time-series, they were derived from squares above 56°N only.

For the first time, a synoptic survey of what is currently considered the Malin Shelf population of herring was carried out. This provided an estimate comprising four stocks to the west of the British Isles: the West of Scotland herring stock in Division VIaN; the Clyde stock; the stock in Division VIaS and VIIb, c and the Irish Sea stock. The Malin Shelf estimate of SSB was 826 000 tonnes and 4 007 million fish and is largely dominated by the west of Scotland estimate.

Introduction

Eight 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 2008 herring acoustic surveys.

VESSEL	PERIOD	AREA	RECTANGLES
Corystes (NIR)	05 July – 11 July	Clyde/ North Channel	40E3-E5, 39E4-E5,38E4
Celtic Explorer (IR)	28 June – 14 July	52°30'-56°N ,12°-6°W	34D9-E0, 35D9-E0, 36D9-E0, 37D9-E1, 38D9-E1, 39E0-E3, 40E1-E3
Charter west Sco (SCO)	30 June – 19 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)	01 July – 31 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
Scotia (SCO)	28 June – 18 July	58°30'-62°N, 4°W-2°E	46E6-F1, 47E6-F1, 48E6-F1, 49E6-F1, 50E7-F1, 51E8-F1, 52E9-F1
Tridens (NED)	23 June – 18 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) DBFH	26 June – 16 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	26 June –07 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 2008

The estimate of North Sea autumn spawning herring spawning stock is higher than the previous year, at 1.8 million tonnes and 9 514 million herring (Table 6.2). The survey indicates that the strong 2000 year class of herring still persists in the population. The abundance of the 2006 year class (age 1 this year) is now lower than the number of fish at age 1 last year, indicating that last years' estimate of age 0 fish was, as suspected, somewhat imprecise. Growth of the 2000 year class seems still to be slower than average, with individuals of this year class having a lower mean size and mean weight of those fish which are one year younger (the 2001 year class).

The estimates of Western Baltic spring-spawning herring SSB are 283 030 tonnes and 2 299 million herring (Table 6.3), which is slightly lower than years' estimate, although total-stock biomass is similar. The stock is once again dominated by 1 and 2 ring fish.

The West of Scotland estimates of SSB are 788 000 tonnes and 3 770 million herring (Table 6.4). This is considerably more than last year's estimate, and close to the highest estimate in the time-series. The abundance by year class is consistent with previous years and also with results from the adjacent North Sea area. The 2000 year class is still very large.

For the first time, a synoptic survey of what is currently considered the Malin Shelf population of herring was carried out. This provided an estimate comprising 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 VIIbc (her-irlw) and the Irish Sea stock (her-nirs). These 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 826 000 tonnes and 4 007 million fish (Table 6.5). This is largely dominated by the west of Scotland estimate.

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.

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.

References

ICES. 2008. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 2008/ACOM:02.

ICES. 2008. Report of the Planning Group for Herring Surveys. ICES CM 2008/LRC:01.

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 2008, with mean weights and mean lengths by age ring.

Age (ring)	Numbers	Biomass	Maturity	weight(g)	Length (cm)
0	6,870	60	0.00	8.7	10.5
1	3,714	232	0.05	62.4	19.2
2	2,853	403	0.86	141.4	25.0
3	1,709	307	0.98	179.7	26.8
4	1,485	272	0.99	183.3	27.0
5	809	157	1.00	194.4	27.5
6	712	164	1.00	229.9	28.7
7	1,749	380	1.00	217.4	28.4
8	185	50	1.00	267.9	29.7
9+	270	76	1.00	282.3	30.2
Immature	10,841	317		29.2	13.8
Mature	9,514	1,784		187.5	27.0
Total	20,355	2,100	0.47	103.2	20.0

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 2008, with mean weights, mean length and fraction mature by age ring.

Age (ring)	Numbers	Biomass	Maturity	weight(g)	Length (cm)
0	112	0.7	0.00	6.3	9.6
1	5,852	284	0.05	48.6	18.2
2	1,160	101	0.43	87.0	22.0
3	843	102	0.81	120.8	24.4
4	333	47	0.93	141.4	25.6
5	274	45	1.00	165.5	26.9
6	176	31	1.00	175.6	27.5
7	45	9	1.00	208.5	28.8
8+	44	9	1.00	196.7	28.3
Immature	6,540	346		52.9	18.5
Mature	2,299	283		123.2	24.2
Total	8,839	629	1.00	71.2	20.0

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 2008, with mean weights, mean lengths and fraction mature by age ring.

Age (ring)	Numbers	Biomass	Maturity	weight(g)	Length (cm)
0					
1	48	3	0.00	54.6	18.2
2	233	40	0.98	172.1	26.3
3	912	174	1.00	191.3	27.2
4	669	139	1.00	208.3	28.0
5	340	73	1.00	214.3	28.2
6	272	58	1.00	213.9	28.2
7	721	159	1.00	220.6	28.5
8	366	82	1.00	224.2	28.6
9+	264	63	1.00	238.5	29.2
Immature	53	3		61.2	18.7
Mature	3,770	788		209.0	28.0
Total	3,824	791	0.99	207.0	27.9

Table 6.5. Total numbers (millions) and biomass (thousands of tonnes) of Malin Shelf herring in the area surveyed in the acoustic surveys July 2008, with mean weights, mean lengths and fraction mature by age ring.

Age (ring)	Numbers	Biomass	Maturity	weight(g)	Length (cm)
0					
1	425	27	0.01	63.4	19.5
2	377	56	0.76	147.5	25.1
3	1,000	189	1.00	188.7	27.1
4	718	149	1.00	207.0	27.9
5	362	77	1.00	213.6	28.2
6	286	61	1.00	214.9	28.1
7	721	159	1.00	220.6	28.5
8	366	82	1.00	224.2	28.6
9+	264	63	1.00	238.5	29.2
Immature	510	36		70.6	20.1
Mature	4,007	826		206.2	27.8
Total	4,517	862	0.89	190.9	27.0

Table 6.6. Estimates of North Sea autumn spawners (millions) at age from acoustic surveys, 1985–2008. For 1985–1986 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 2008 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)
1985	726	2,789	1,433	323	113	41	17	23	19	5,484	697
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

Table 6.7. Numbers at age (millions) of Western Baltic Spring-spawning herring at age (rings) from acoustic surveys 1990 to 2008. 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
1990	135	1,497	549	319	110	24	10	5	2,680	1,017
1991		1,864	1,927	866	350	88	72	10	5,177	3,313
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

Table 6.8. Numbers at age (millions) and SSB of West of Scotland Autumn Spawning herring at age (rings) from acoustic surveys 1991 to 2008. 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:
1991	338	295	328	368	488	176	99	90	58	452
1992	74	503	211	258	415	240	106	57	64	352
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

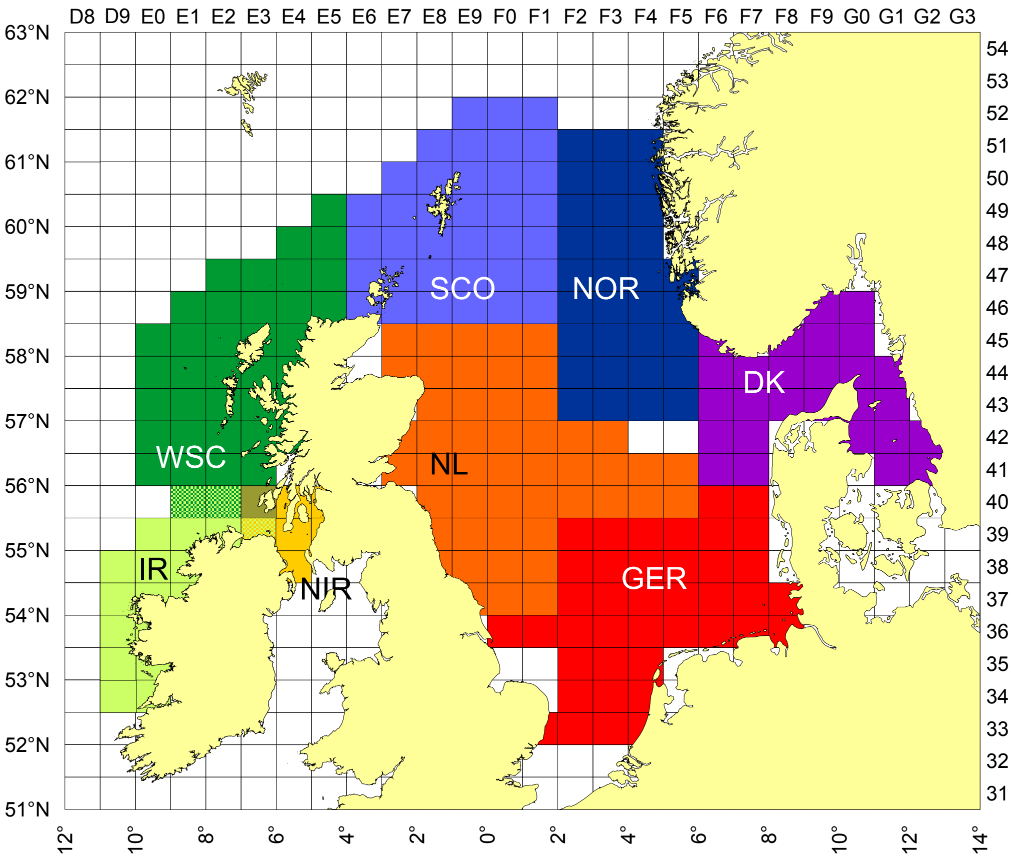

Figure 6.1: Survey area coverage in the pelagic acoustic surveys in 2008, by rectangle and nation (IR = Celtic Explorer; NIR = Corystes; WSC = West of Scotland charter vessel; SCO = Scotia; NOR = Johan Hjort; DK = Dana; NL = Tridens; GER = Solea). Multi-coloured rectangles indicate overlapping coverage by two or more nations (e.g. 40E1-40E3).

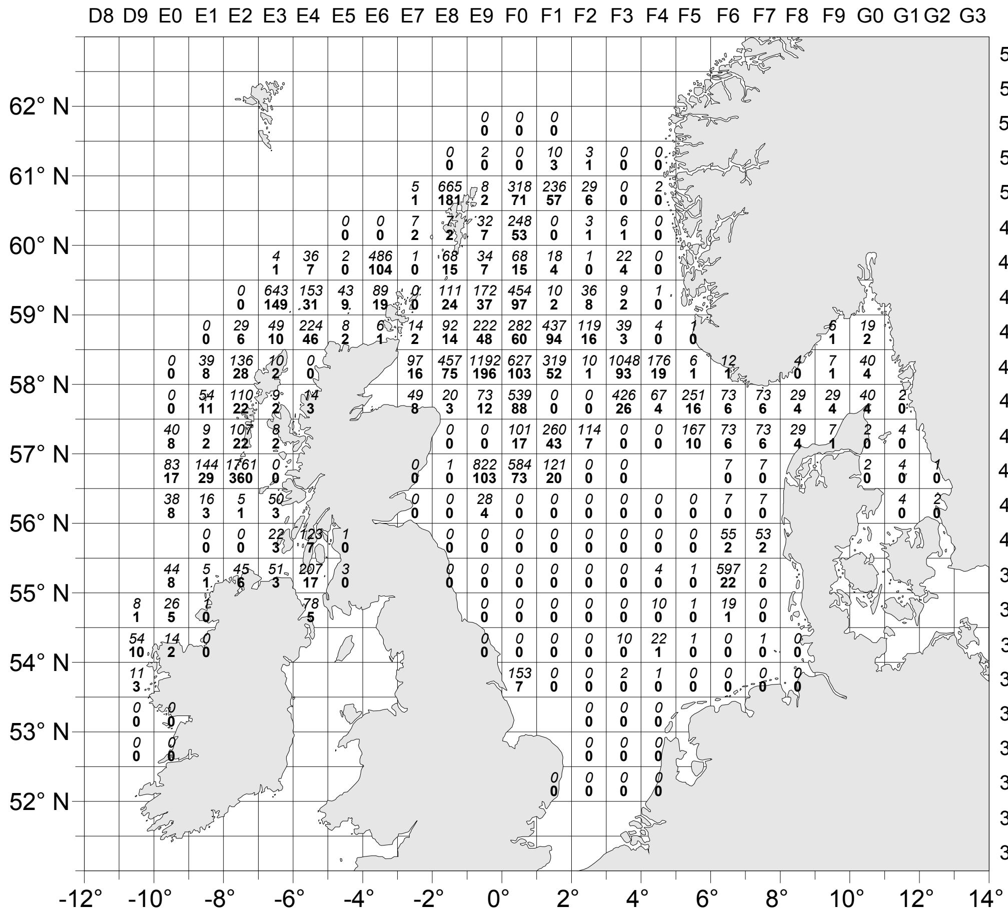

Figure 6.2. Abundance of autumn spawning herring (winter ring 1–9+) from the combined acoustic survey in June-July 2008. Numbers (millions, upper figure) and biomass (thousands of tonnes, lower figure). Blank rectangles are not surveyed.

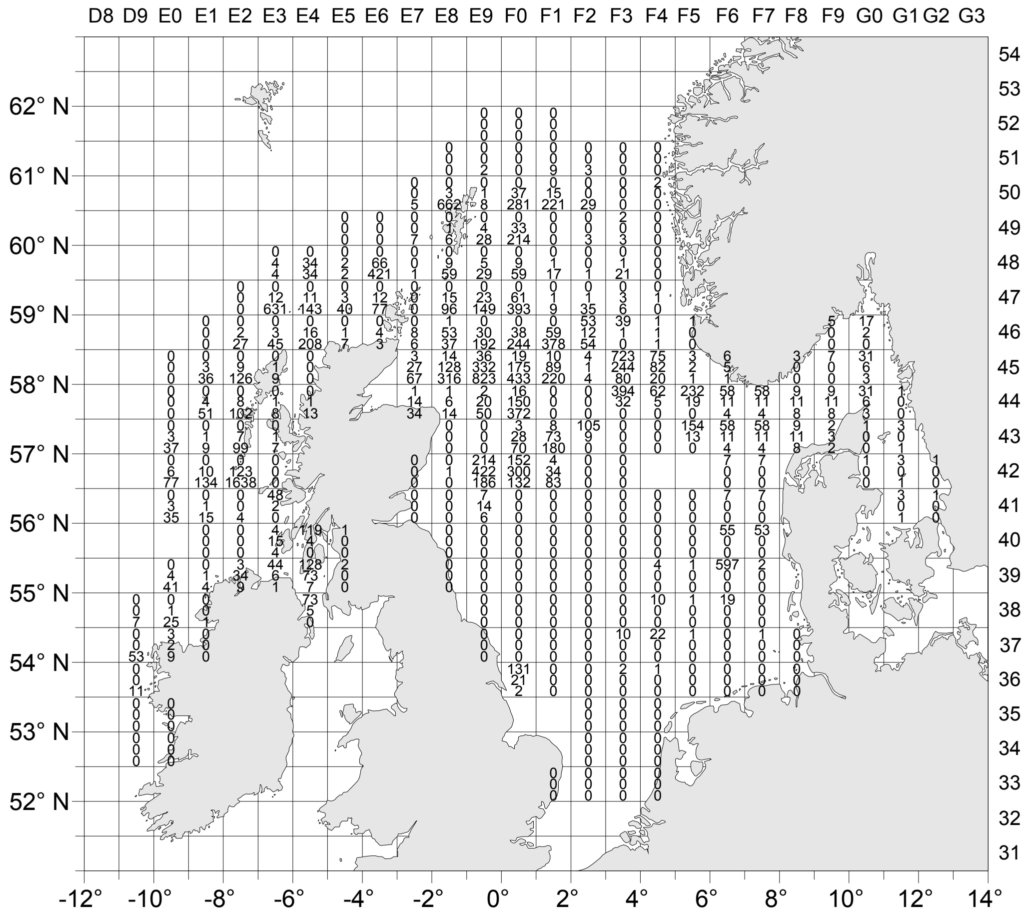

Figure 6.3. Numbers (millions) of autumn spawning herring from combined acoustic survey June – July 2008. 1 winter ring (upper figure), 2 ring (centre figure), 3+ (lower figure). Blank rectangles are not surveyed.

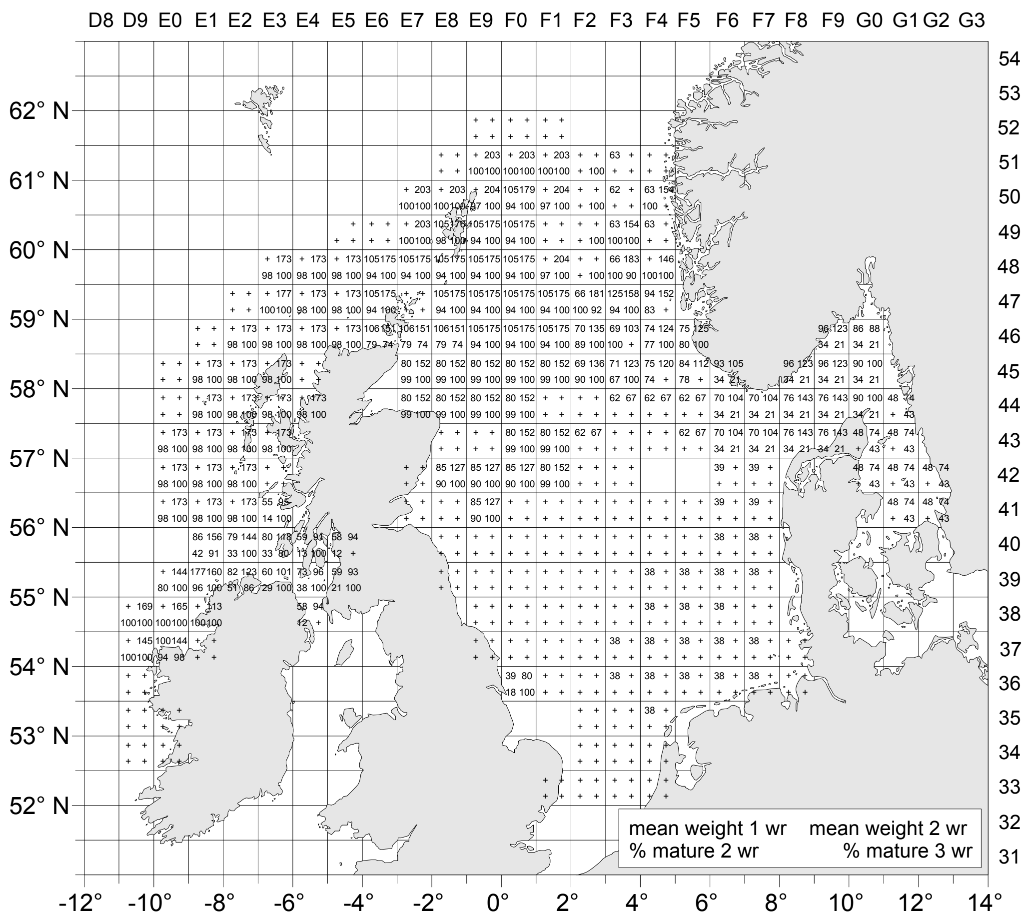

Figure 6.4. Mean weight and maturity of autumn spawning herring from combined acoustic survey June – July 2008. Four values per ICES rectangle, percentage mature of 2 ring (lower left) and 3 ring fish (lower right), mean weights (grams) of 1 ring (upper left) and 2 ring fish (upper right), + indicates surveyed with zero abundance, blank indicates an unsurveyed rectangle.

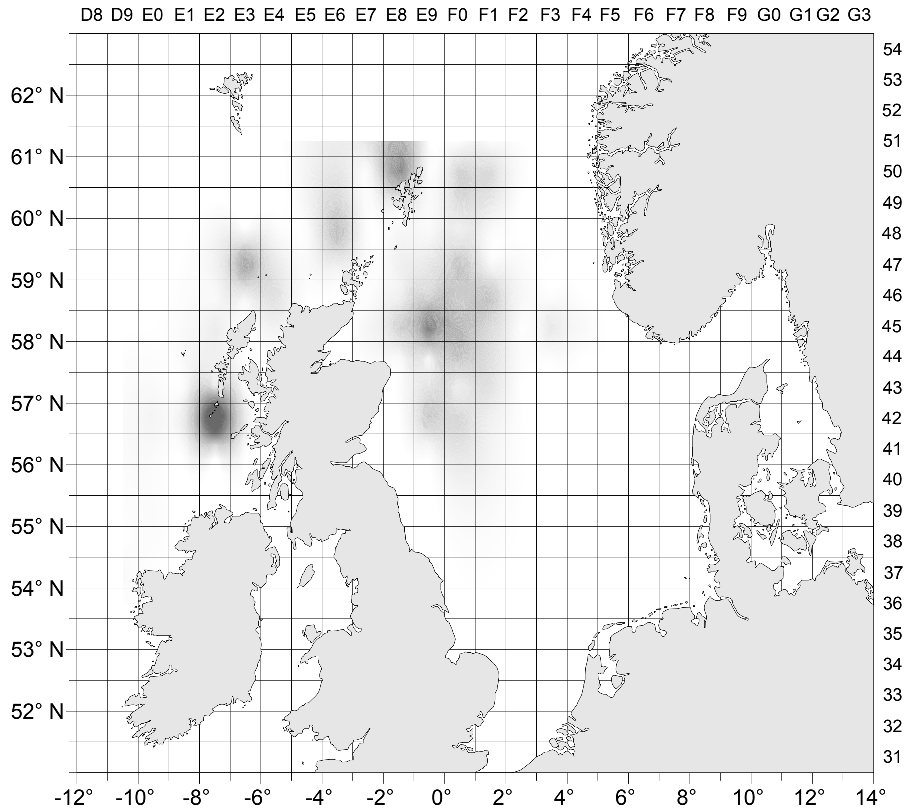

Figure 6.5. Biomass of mature autumn spawning herring from the combined acoustic survey in June – July 2008 (maximum value = 200 000).

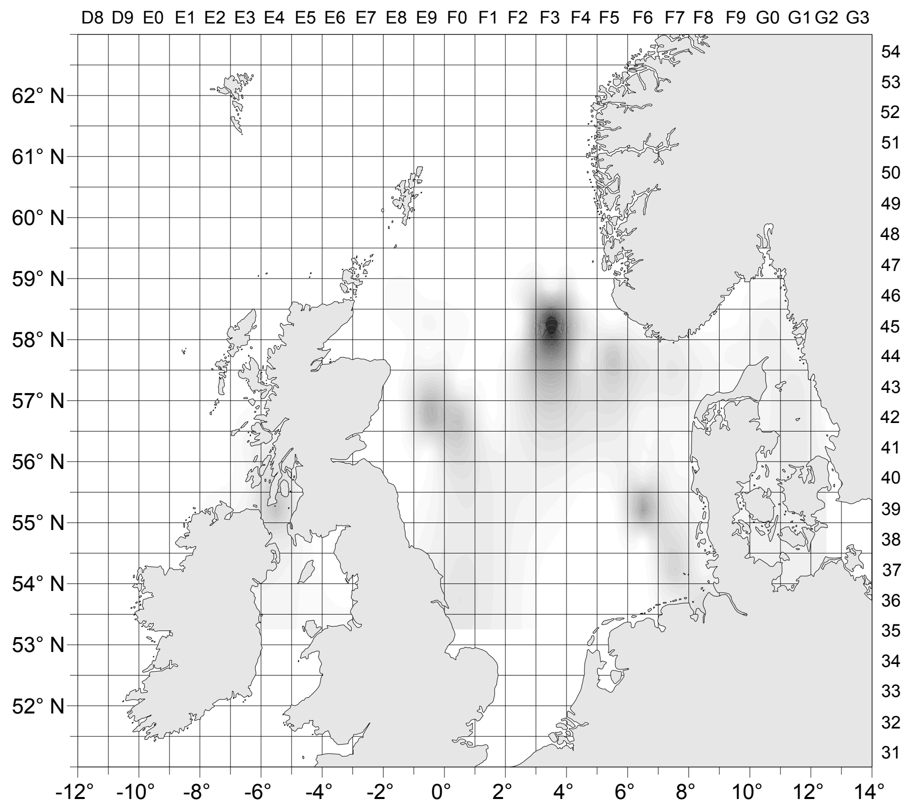

Figure 6.6. Biomass of immature autumn spawning herring from the combined acoustic survey in June – July 2008 (maximum value = 56 000).

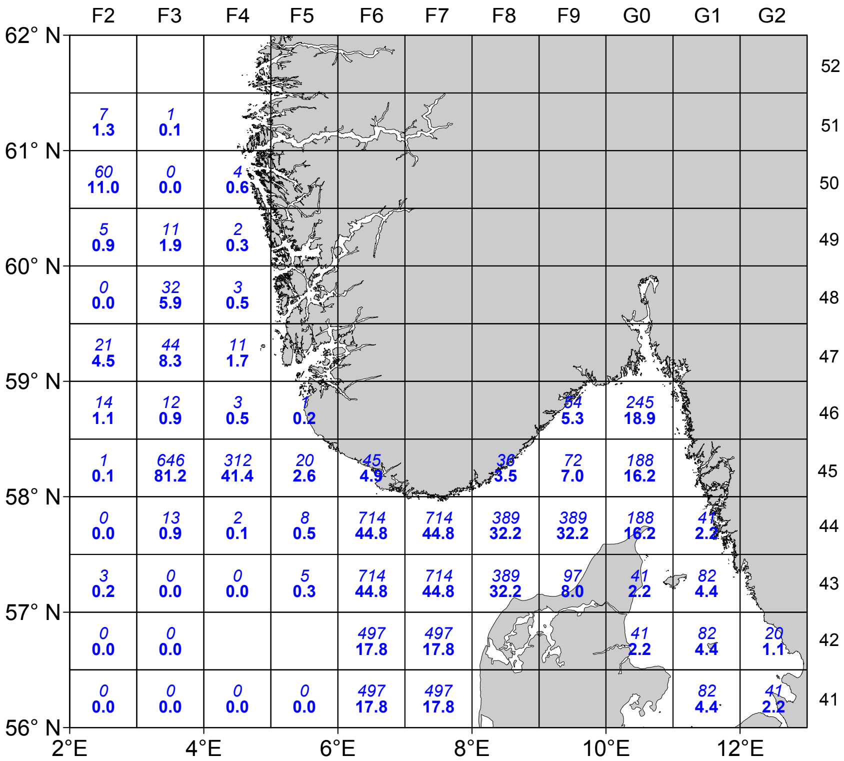

Figure 6.7. Abundance of western Baltic spring-spawning herring 1–9+ from combined acoustic survey July 2008. Numbers (millions, upper figure) and biomass (thousands of tonnes, lower figure).

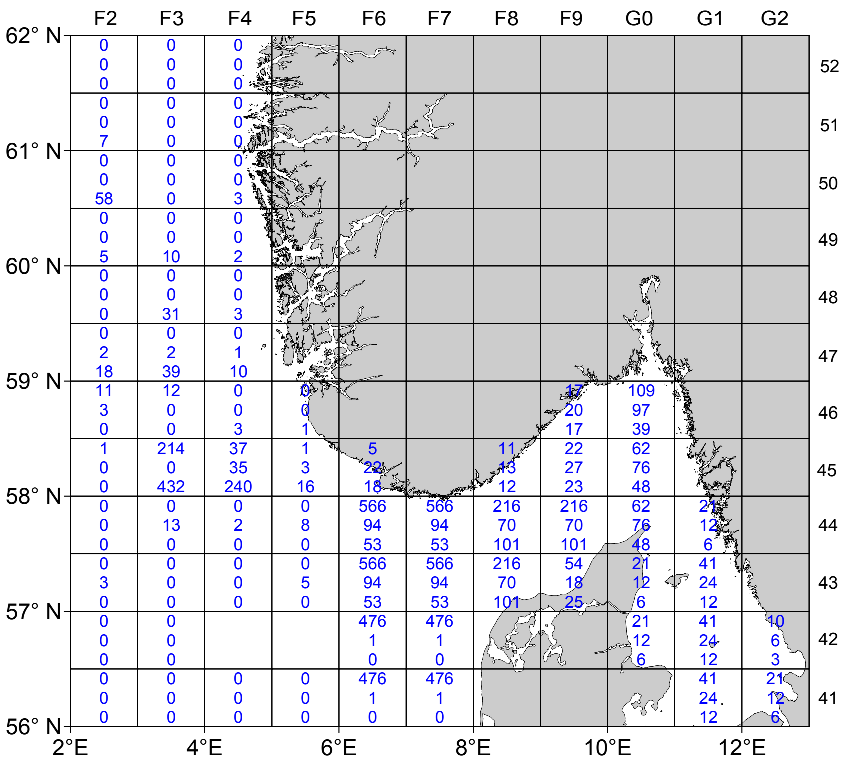

Figure 6.8. Numbers (millions) of western Baltic spring-spawning herring from combined acoustic survey June – July 2008. 1 ring (upper figure), 2 ring (centre figure), 3+ (lower figure).

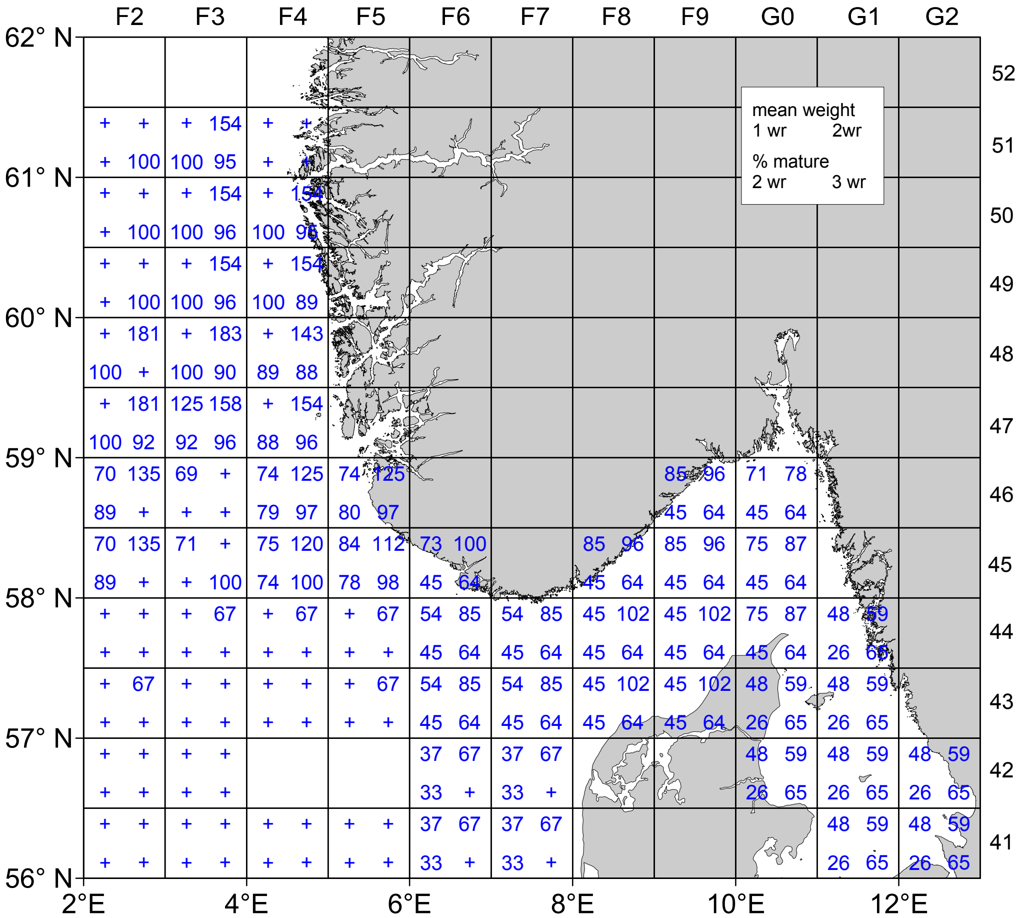

Figure 6.9. Mean weight and maturity of western Baltic spring-spawning herring from combined acoustic survey June – July 2008. Four values per ICES rectangle, percentage mature of 2 ring (lower left) and 3 ring fish (lower right), mean weights gram of 1 ring (upper left) and 2 ring fish (upper right), + indicates surveyed with zero abundance, blank indicates an unsurveyed rectangle.

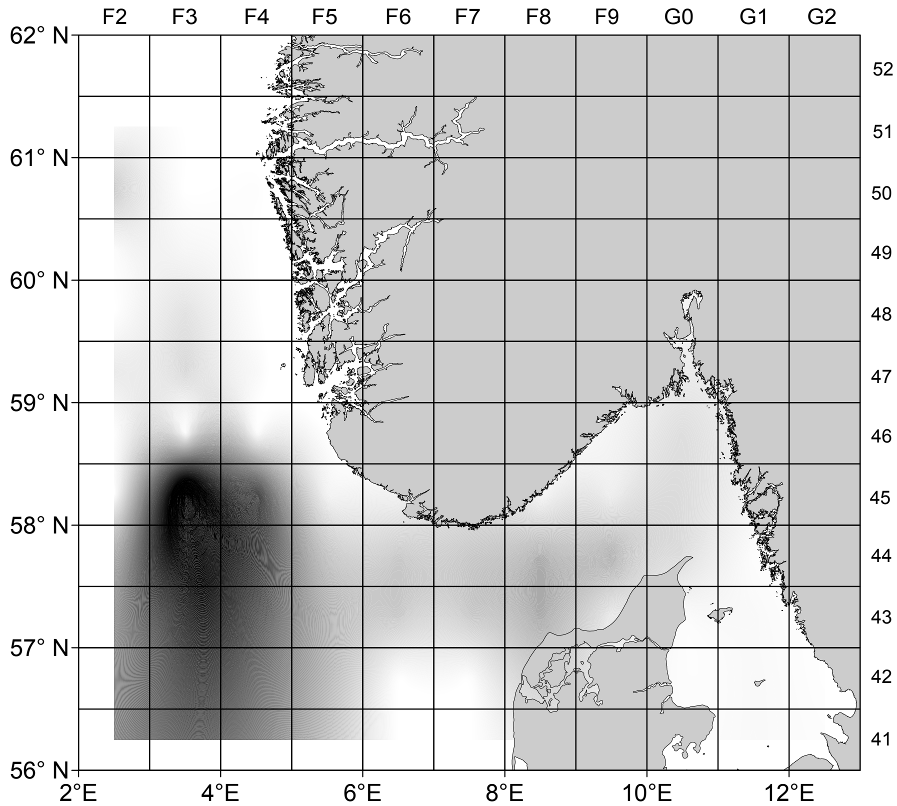

Figure 6.10. Biomass of mature western Baltic spring-spawning herring from combined acoustic survey in June – July 2008 (maximum = 70 000).

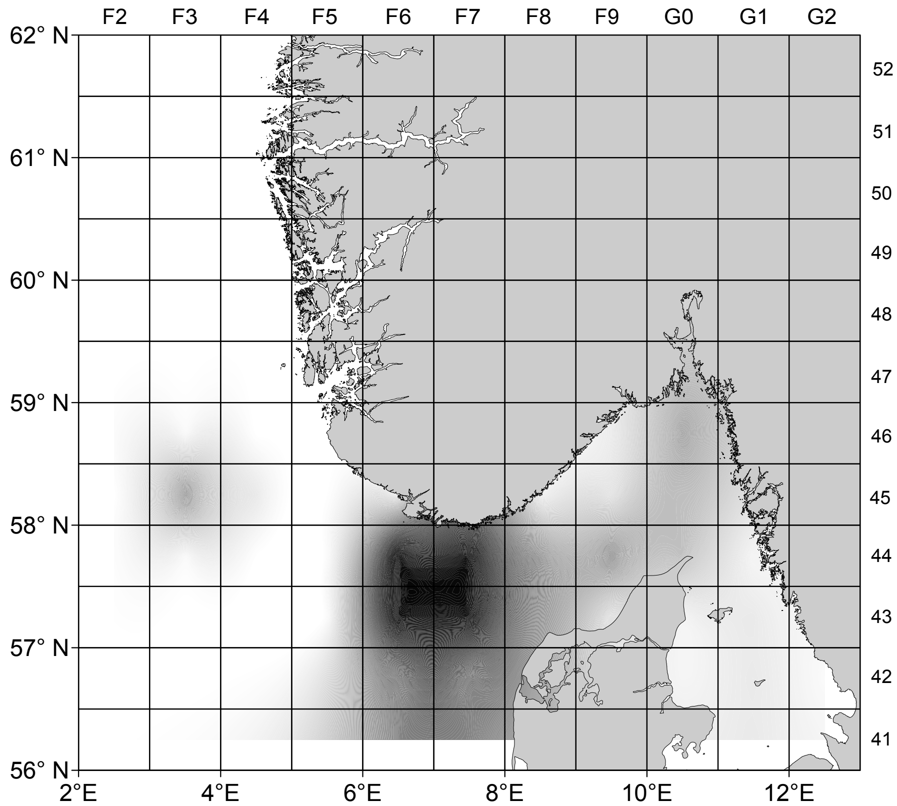

Figure 6.11. Biomass of immature western Baltic spring-spawning herring from combined acoustic survey in June – July 2008 (maximum = 36 000).

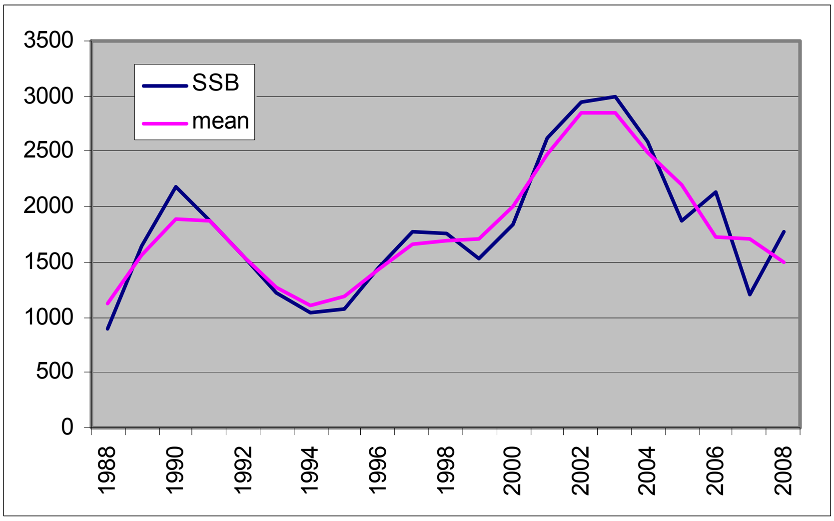

Figure 6.12. Time series of SSB of North Sea autumn spawning herring with three year running mean.

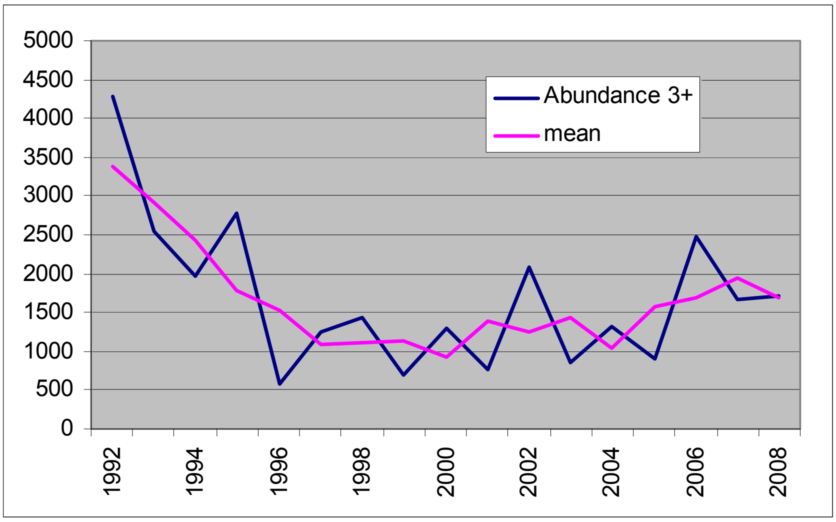

Figure 6.13. Time series of 3+ abundance of Western Baltic spring-spawning herring with three year running mean.

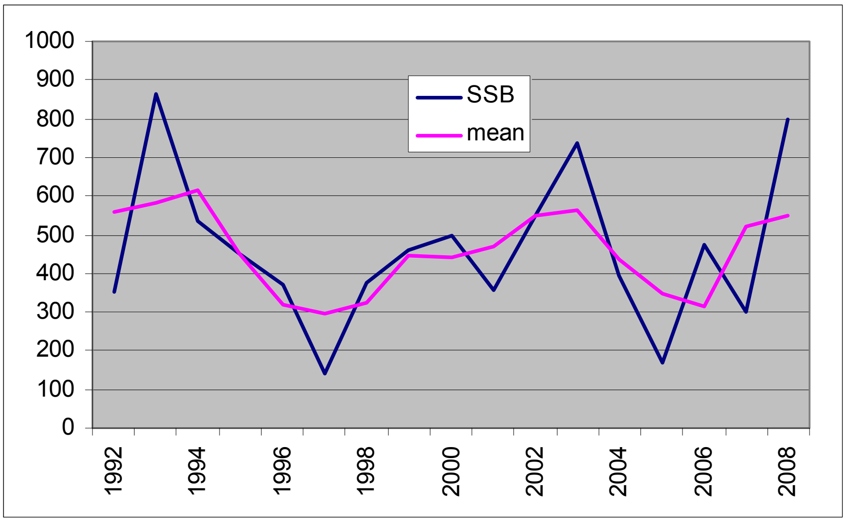

Figure 6.14. Time series of SSB of West of Scotland herring with three year running mean.

Annex 7: Working Documents to PGIPS

Application of otolith shape as a stock identification method in mixed Atlantic herring (Clupea harengus L) stocks in the North Sea and western Baltic.

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ABSTRACT

The origin and reproductive interactions of sympatric, spatially separated spawning components of Atlantic herring (*Clupea harengus*) have received long-standing interest. For stock assessment and/or management purposes, the herring populations in the North Sea and adjacent areas are split into stocks with different spawning times (winter, spring and autumn). Otolith shape analysis has been used to discriminate between populations for a variety of species and for herring this approach has had increasing success with development of imaging techniques and statistical methods. Here we use otolith morphological traits (otolith shape and larval otolith microstructure) to discriminate between different populations of Atlantic herring (*Clupea harengus*) collected during summer acoustic survey in ICES areas IVaE and IIIa. The otolith shape was found to clearly discriminate between different stocks. The overall success on a subset of randomly selected individuals was 88%, and may, when calibrated by otolith microstructure, be a robust tool for stock separation.

INTRODUCTION

Atlantic herring (*Clupea harengus* L) population dynamics are complex and different stocks often display variation in life-history traits and spawning times (Jennings and Beverton, 1991; McQuinn, 1997a) as well as genetic structuring (e.g. Bekkevold *et al.*, 2005; Mariani *et al.*, 2005). Herring commonly perform extensive seasonal migrations between spawning, feeding, and wintering areas (see e.g. Slotte, 1998) and different stock components often mix on feeding and wintering grounds (Rosenberg and Palmén, 1981; Wheeler and Winters, 1984; Husebø *et al.*, 2005; Ruzzante *et al.*, 2006). Thus herring spawning components uphold significant levels of reproductive isolation, possibly affected by selective differences among spawning and/or larval habitats.

Otolith shapes often vary geographically within a species and otolith shape analysis has been used to discriminate between stocks for a variety of species (Castonguay *et al.*, 1991, Cardinale *et al.*, 2004, Friedland and Reddin 1994, Begg and Brown 2000, Gauldie and Jones 2000, DeVries *et al.*, 2002). For herring this approach has had increasing success with development of image analysis technique and statistical methods. In an early study comparing different herring populations based on both meristic and otolith characters, Messieh (1972) used a combination of comparisons of otolith characters like length, angles between lines joining rostrum, postrostrum and pararostrum (figure 7.1) (Messieh, 1972) to discriminate between herring populations with different spawning times. A further development of this approach was made by Turan (2000) using a truss network system on otolith shape to successfully discriminate between herring stocks in the North-East Atlantic (Turan, 2000).

Using Fourier Series Shape Analysis on Alaskan herring and Northwest Atlantic herring, Bird *et al.* (1986) showed that otolith shape reflects differences in race, however, also differences between year-classes of the same race (Bird *et al.*, 1986). Using the same analysis Groth *et al.* 1988 report a strong variation in otolith shape between Western Baltic herring with identical spawning time but different ages. Additionally they conclude that as the difference in otolith shape between spring and autumn spawning Western Baltic herring is minor, the separation of these stocks based on otolith shape may be difficult (Groth *et al.*, 1988).

The Fourier Series Shape Analysis makes use of Fourier shape descriptors (harmonics) generated by taking a Fourier expansion of radius vectors drawn from the centroid as a function of the angle (Bird *et al.*, 1986). Another variation of the Fourier shape analysis method is the Elliptical Fourier Analysis, which generates harmonics by calculating *x*,y coordinates as a function of a third variable (*t*) and thus is not constrained by the overall curvature of the otolith as the Fourier Series Shape Analysis, where the each radius only is allowed to intersect the perimeter once (Tracey *et al.*, 2006). This permits the Elliptical Fourier Analysis to compare very complex shapes like herring otoliths where the elongated rostrum very likely would cause a radius vector from the centroid to cross the perimeter more than once.

In the present study, we apply the Elliptical Fourier Analysis of otolith shape to identify herring from different stocks at the individual level. We assess the accuracy of the method to separate herring stocks, by analysing to what extent otolith shape classification of otoliths from individuals collected during the herring acoustic survey in Div. IIIa and adjacent areas during summer 2008 corresponds to the individuals' respective hatch type as determined by otolith microstructure.

MATERIAL AND METHODS

Following age determination the otoliths were digitized using a Leica™ 350 F digital camera connected to a dissection microscope (Leica MZ6) and stored in an image database.

The otolith shape was found using the ImagePro™ 5.0 image-analysis package for Windows™. The otolith contour was automatically measured using the AOI tool in ImagePro, following the steepest light-dark gradient on the picture and reported as (x;y) coordinates.

The variable length of the series of x-y outline coordinates was transformed into 512 equally angular spaced coordinates as input to an Elliptic Fourier Transformation.

The contour coordinates (x;y) are represented by the complex Fourier descriptors Ai,Bi,Ci,Di, where the zero order (i=0) represents the size factor.

$$x;y=\sum_{1}^{i}(A_i\times\cos(i\times\theta)+B_i\times\sin(i\times\theta));\sum_{1}^{i}(C_i\times\cos(i\times\theta)+D_i\times\sin(i\times\theta))$$

Increasing i adds successively finer details to the contour line, and with the applied resolution the first 60 complex Fourier descriptors are capable of reconstructing all details of the otolith contour line (see figure 7.1 panels A-E).

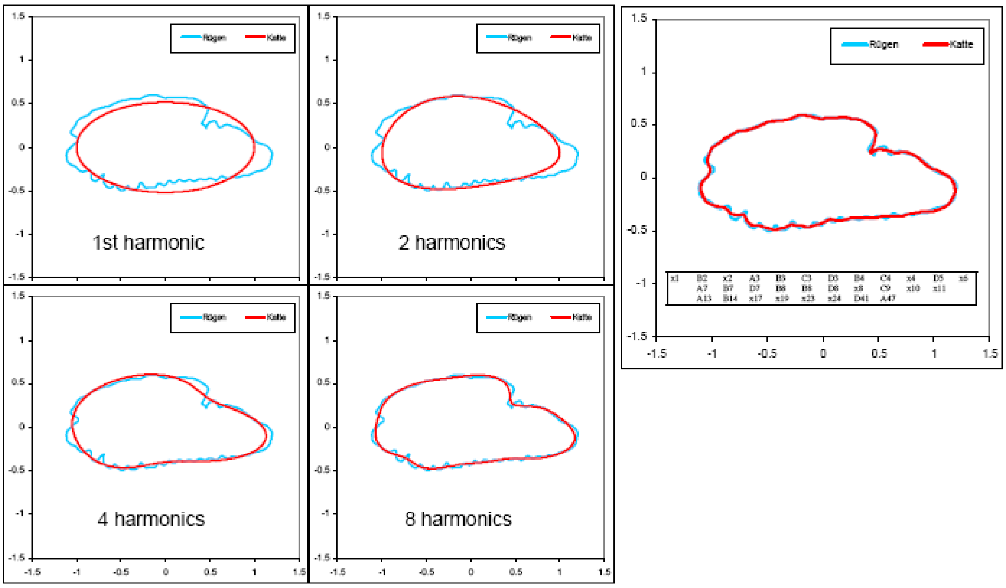

Figure 7.1. Initially 60 harmonics are applied to describe the shape of the otolith. Only a subset of the harmonic components is needed to discriminate among the herring populations (upper right panel 29 components).

In a Visual Basic macro routine data were transferred from imaging software to EXCEL. Elliptic Fourier Transformation was set to report 60 complex descriptors equalling in all 240 variables, with location, size, and angle set to be invariants.

The amplitude of each descriptor was determined as the square root of the sum of squares of the individual components: $X_i = \sqrt{A_i^2 + B_i^2 + C_i^2 + D_i^2}$

From earlier analyses it has been found that the information in the higher order Fourier Harmonics have no relationship with individual population related differences, also the correlation between right and left otolith higher order harmonics is not significant. Therefore the harmonics' order was restricted to < 22 in the following classification analyses.

The variables X_i, A_i, B_i, C_i, *and* D_i, *(i<22)* and their log transformed counterparts were applied in combination with herring individual metrics, length, weight, age, and maturity as well as habitat parameters depth, longitude and latitude, in a stepwise linear discriminant analysis (PROC STEPDISC; SAS™ v8) to reduce parameter space to a selection of around 10–20 components that all had a high influence on the discrimination power. This subset was then further tested in different versions of discriminant analysis (DA): linear, quadratic and non linear all with cross validation (PROC DISCRIM; SAS™ v8) to achieve a robust function for individual affiliation to hatch type that at the same time would exhibit the lowest bias in proportions at age assigned to hatch type.

The best DA was found by cross validated classification of known hatch type individuals from in a subset of randomly selected herring with otolith microstructure identification (1456 individuals covering all surveyed squares). A non linear method with a nearest neighbour classification rule (k=2) gave among the lowest cross-validated error rates and the most unbiased proportions by age group. This rule however had a relatively large unassigned proportion that was classified according to estimator rule c (see below).

Cross tabulation of proportional correct and incorrect categorized shapes into spawning populations as defined by the assigned hatch month type by analysis of the otolith microstructure gave an overall evaluation of the discrimination success.

When assigning hatch type (either to spring or autumn/winter type) in the material, several estimator rules were applied:

a) By microscope inspection of otolith microstructure (calibration of the shape assigned hatch type)

b) By Discriminate Analysis using fish metrics and otolith morphology

c) When the Discriminate Analysis failed to assign hatch type due to duality (one of each type among the two nearest neighbours), the individuals were assigned to a hatch type using a random number assignment within the age dependent probability distribution on hatch month types known from the microscope inspection.

RESULTS

The differences in otolith shape between the hatch types were expressed as scores of the first five canonical variates (Figure 7.2). The 0-group clearly separated out from the remaining age groups by having a different shape, however, still allowing a hatch type separation (Figure 7.2), indicating that the otolith shape is defined at a very early stage in life.

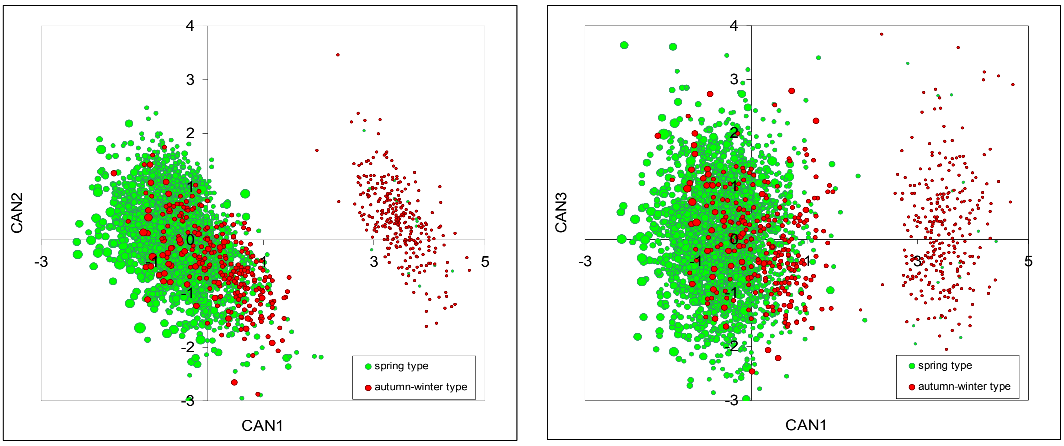

Figure 7.2. Individual assignment to hatch type using nearest neighbour criterion in the Discriminant Analysis, illustrated as Canonical variate 2 respectively 3 vs. Canonical variate 1 (a few outliers are excluded). The symbol size indicates the age of the individual herring from age 0 to age 10, note the separation of age-0 group along the CAN1 axis.

The fish metric – otolith shape parameters were found to clearly discriminate between different hatch types. When tested on the known hatch type from otolith micro structure (estimator type a), 82% of the individuals could be assigned to either spring- or autumn/winter hatch type (using estimator rule b. Table 7.1). Out of this group 93% and 90% were classified to correct hatch type respectively. Of the 18% remaining individuals with no hatch type classification, 88% and 34% respectively were assigned correctly using the random procedure based on prior proportions by age (estimator rule c. Table 7.1). Overall correct hatch type assignment is then estimated to be around 88% using the fish metric – otolith shape parameters in DA with nearest (k=2) neighbour classification, with spring type otoliths having 92% and autumn/winter type otoliths 71% correct classification. It should be noted, however, that the majority of the individuals in the total survey was of spring type and autumn type spawners only made up 18% of the total. This may affect the accuracy of the method differently for the two hatch types.

Table 7.1. Proportions of correct assigned hatch month type by analysis of fish metric – otolith shape. Numbers in brackets gives the total number of individuals subjected to otolith microstructure analysis.

	Estimator rule b)		Estimator rule c)	
hatch type	spring	aut/winter	spring	aut/winter
correctly assigned	93%	90%	88%	34%
Total number	(n=934)	(n=179)	(n=160)	(n=79)

Of the total sampled 4600 individuals it was possible to assign a hatch type applying one of the 3 classification rules (a, b, c as described in the material and methods) to 3297 individuals (72%). Only a negligible amount of individuals had to be assigned by method c (8% of the total assigned individuals, Table 7.2).

Table 7.2. Number of individuals assigned by each classification rule by age.

Age	Estimator Type a	b	c	Not assigned	Total
0	149	169	9	18	345
1	530	683	143	319	1675
2	280	338	73	160	851
3	171	227	34	94	526
4	77	106	11	46	240
5	57	89	4	29	179
6	46	45	1	21	113
7	6	27	1	7	41
8	5	7		6	18
9	3	4		2	9
10	2				2
No otolith available				601	601
Total	1326	1695	276	1303	4600

DISCUSSION

Our results show clear discrimination between stocks of herring with different spawning time and different genetic background, for all age groups, which defines the otolith shape as a solid stock classifier in herring. This is supported by several studies, e.g. Burke *et al*., 2008, that demonstrated a high degree of accuracy when applying otolith shape to classify juvenile and adult herring to separate stocks in the Irish Sea.

Shape analysis has a potential to providing a fast and reliable stock discrimination in Atlantic herring highly applicable in fisheries where several stocks mix as is the case in Division IIIa and adjacent areas. The method is less time-consuming than analysing individual otolith microstructure, and can when combined with the otolith microstructure analysis as calibration, provide an effective tool for identification of herring population structure.

The factors that influence shape are as yet not fully understood. A number of studies on stock discrimination have evaluated the relative importance of genetics/environmental conditions on otolith shape (e.g. Cardinale *et al*. 2004). In previous studies a genetic pattern across spawning populations in the North Sea and the Western Baltic has been identified (Bekkevold *et al*., 2005, Bekkevold *et al*., 2007) corresponding to the identified otolith shape pattern demonstrated in this study. We performed some preliminary analyses of potential covariation of the observed morphological differences with the previously identified genetic differentiation, and/or ecological differences among populations. Partial Mantel tests using estimates of genetic differentiation, otolith shape differences and a series of ecological and environmental factors (geographic distance, spawning time, salinity and temperature on spawning site) showed a significant positive relationship (r=0.3*) between genetic and morphological differentiation, however, when controlling for geographical distance, the relationship between genetic and morphological differentiation disappeared (r=-0.33NS). Thus, the differences in otolith shape found even within local herring stocks in an area where there is no significant difference in the genetics analysed, persist to be significant.

The shape analysis as a stock discrimination tool presented here shows potential to estimating stock proportions in the mixed-stock fishery on herring in area IIIa and adjacent areas. The results correspond well with those from other studies evaluating otolith shape analysis as a stock separating method and additionally with studies using other stock separation methods on the herring stocks in the area (Hatfield *et al.*, 200?, Bekkevold *et al.*, 2007, Clausen *et al.*, 2007). Morphological variation may be due to either purely ecological (e.g. environmental) variability or reflect genetic differences evolved by genetic drift or adaptive (heritable) divergence. A direct demonstration of heritability of morphological differences require setting up experimental crosses, however, preliminary studies indicate that morphological variation is at least in part affected by genetic origin, though it appears that the variation in otolith morphology is greater than that observed in neutral genetic markers.

Stock affiliation is expressed in the otolith shape and gives a high resolution separation independent of age, however, the development of otolith shape through all life stages (ages) need to be calibrated applying samples of herring with validated origin in order to apply the method independently of calibration samples of either otolith microstructure or other stock ID parameters.

It was assumed that individual shape change is a gradual accretion process that may alter otolith appearance according to fish growth conditions and environment within some genetically set boundaries (Simoneau *et al.*, 2000, Cardinale *et al.*, 2004). Therefore canonical scores should be tested for correlation between herring size and individual age to infer if steps should be taken to reduce influence of these metrics.