ICES Living Resources Committee
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Report of the
Planning Group for Herring Surveys (PGHERS)

27–30 January 2004
Flødevigen, Norway

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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Executive Summary

1. **Terms of Reference** According to C. Res. 2003/2G05 the **Planning Group for Herring Surveys** [PGHERS] (Chair: B. Couperus, Netherlands) will meet in Flødevigen, Norway, from 27–23 January 2004 to:

    a) combine the 2003 survey data to provide indices of abundance for the population within the area;

    b) coordinate the timing, area allocation and methodologies for acoustic and larvae surveys for herring and sprat in the North Sea, Division VIa and IIIa and Western Baltic in 2004;

    c) review and update the PGHERS manual for acoustic surveys to address standardisation of all sampling tools and survey gears;

    d) evaluate the results of the investigations of survey overlaps between vessels in the North Sea acoustic survey;

    e) assess the status and future of the HERSUR database;

    f) examine digital photographs of herring maturity stages in order to harmonise their definitions.

2. **Review of larvae surveys in 2003/2004.** At the time of writing two of the seven surveys in the North Sea remained to be carried out in January 2004. Results will be ready for the Herring Assessment Working Group (HAWG) meeting in March 2004. The utility of the surveys was examined by the group and in light of historic and recent studies, the survey was found to be vital to the assessment of North Sea herring. The group also reviewed the use of a larvae index for Western Baltic Spring Spawning herring. This index uses a novel technique of larvae production at 30mm length as recruitment index. The group supported this work, but suggested a closer analysis prior to incorporation into the assessment.

3. **Co-ordination of larvae surveys for 2004/2005.** In the 2004/2005 period, the Netherlands and Germany will undertake 7 larvae surveys in the North Sea from 1 September 2004 to 31 January 2005. The Baltic Sea Fisheries Institute will continue to conduct the larvae survey in the Greifswalder Bodden in 2004.

4. **North Sea acoustic surveys in 2003.** Six acoustic surveys were carried out during late June and July 2003 covering the North Sea and west of Scotland. The provisional total combined estimate of North Sea spawning stock biomass (SSB) is 3.1 million t, an increase from 2.9 million t in 2002. The survey shows high numbers of 2-ring and 4-ring herring (the 2000 and 1998 year classes) confirming last year's expectation that the 2000 year class would be strong. The estimate of Western Baltic spring spawning herring SSB is 106,000 t, a decrease since 2002 (255,000 t). The west of Scotland herring SSB estimate is 739,000 t (up from 548,000 t). The surveys are reported individually in Appendix II.

5. **Western Baltic acoustic survey in 2003.** A joint German-Danish acoustic survey was carried out with R/V Solea from 30 September to 18 October in the Western Baltic. The total number of herring was 5,400 million (down from last years 6,000 million) and the total for sprat 16,000 million (down from last years 6,700 million). A full survey report is given in Appendix III.

6. **Survey overlap between FRV Scotia, FRV G.O. Sars and Tridens.** A provisional analysis was made of acoustic and trawl catch data from an extended area overlap between these vessels. Comparisons were made between length, age compositions and total abundance. The results for Scotia and Tridens demonstrate a good agreement, while the differences between Scotia and Sarsen may be a cause for concern. The group discussed possible reasons for the discrepancies and concluded that differences in timing, sampling strategy and in the interpretation of echograms would be the most likely causes. To solve these problems, it is proposed to conduct another survey overlap in 2004 (between the Norwegian and two other vessels, see below) and an echogram scrutiny workshop in early 2005.

7. **Manuals for acoustic and herring larvae surveys.** The manual for herring acoustic surveys in ICES Divisions III, IV, and VIA has been reviewed and updated according to TOR (c) The new version 3.2 is provided in appendix IV. A completely new manual (version 1.0) has been prepared for the International Herring larvae Survey.

8. **Harmonisation of herring maturity definitions.** A series of photographs of different herring maturity stages have been examined. It was agreed to make an exchange series of photographs covering the whole spectrum of maturity stages. The results of this exchange will be assessed at the PGHERS in 2005.

9. **Status and future of the HERSUR database.** The participants agreed to upload acoustic data no later than 30 April. During 2004 a meta-database, holding national aggregated data with survey results will be set up by Denmark. This new database will be used to develop further an automated system for delivering output for the combined survey report to the HAWG.

10. **Sprat.** Data on sprat were only available from RV Walther Herwig III, RV Tridens and RV Dana. The total sprat biomass estimated was 270,000 t in the North Sea (up from 241,000 t in 2001) and 13,000 t in the Kattegat (up from 10,000 t in 2002). The southern summer distribution limit of sprat in the North Sea was still not reached, in spite of the extension of the survey area to 52ºN.

11. **Co-ordination of acoustic surveys in 2004.** Six acoustic surveys will be carried out in the North Sea and west of Scotland in 2004 between 28 June and 30 July. Participants are referred to Figure 4 for indications of survey boundaries. Scotia and Tridens will survey an overlapping area to the east of Scotland. Scotia and Johan Hjort will survey an overlapping area to the east of Shetland. Dana, Walther Herwig III and Johan Hjort will survey an overlapping area off north west Denmark. A survey of the western Baltic and southern part of Kattegat, will be carried out by a German research vessel from 29 September to 19 October.

Recommendations – 2005 Meeting.

2G05 PGHERS will meet at the Institute for Marine Research Bergen, Norway, from 24 to 28 January 2005 (chair: B. Couperus, The Netherlands) to:

a) combine the 2004 survey data to provide indices of abundance for the population within the area;
b) co-ordinate the timing, area and effort allocation and methodologies for acoustic and larvae surveys for herring and sprat in the North Sea, Division VIa and IIIa and Western Baltic in 2005;
c) review and update the PGHERS manual for acoustic surveys to address standardization of all sampling tools and survey gears;
d) review the results of an exchange exercise on herring maturity staging, and comment on the implications of the conclusions of the sprat age reading exchange and workshop for the acoustic surveys;
e) evaluate the results of the investigations of survey overlaps between vessels in the North Sea acoustic survey;
f) to conduct an echogram scrutiny workshop aiming at further harmonisation of scrutiny procedures.

PGHERS will report by 7 February 2005 for the attention of the Resource Management and Living Resources Committees, and 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:	Term of reference a) and b) Surveys for herring are currently carried out by five different countries, covering the whole of the North Sea, Western Baltic and the west coast of Scotland. Effective co-ordination and quality control for these surveys is essential and while data combination can be managed by mail, a meeting is required to ensure that the larvae database is being used correctly and that the acoustic surveys are being carried out and analysed on a consistent basis. Term of reference c) The issue of standardisation of procedures and survey protocols is becoming increasingly important in the light of concerns of the quality assurance of data which are used for the assessment of commercial fish stocks. ICES is particularly concerned about the issue with regard to survey data as a result of adverse experiences in North America in recent years. Fortunately, PGHERS has always attempted to document their procedures through the production of a manual for the surveys conducted. This manual has been reviewed periodically from time to time on an *ad hoc* basis. In the light of current concerns, PGHERS agreed that a more comprehensive review of the manual

	should take place in 2003. Participants are expected to examine the manual and be prepared to discuss any alterations due to changes in working practices and or equipment. Term of reference d) At the 2003 PGHERS meeting a major redesign of the acoustic survey was considered to improve the efficiency of the combined acoustic survey. It was decided that before any major changes could be implemented, a closer examination of operating procedures by participants unfamiliar with new surveying territories should be carried out. This should be achieved by close comparative scrutiny of data from overlapping areas surveyed by one or more participant countries. The scrutiny of data requires an additional program of work as agreed at the 2003 PGHERS meeting. The results of these overlap analyses will be presented at the 2004 PGHERS meeting after which further consideration can be given to a more integrated survey design involving more survey overlaps.
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 ACFM with information required for responding to requests for advice/information from NEAFC and EC DGXIV.
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 Organisations	None
Cost Share	ICES 100%

1 Terms of reference

According to C. Res. 2003/G505 the **Planning Group for Herring Surveys** [PGHERS] (Chair: B. Couperus, The Netherlands) will meet in Flødevigen, Norway from 27–30 January 2004 to:

a) combine the 2003 survey data to provide indices of abundance for the population within the area;
b) coordinate the timing, area allocation and methodologies for acoustic and larvae surveys for herring and sprat in the North Sea, Division VIa and IIIa and Western Baltic in 2004;
c) review and update the PGHERS manual for acoustic surveys to address standardisation of all sampling tools and survey gears;
d) evaluate the results of the investigations of survey overlaps between vessels in the North Sea acoustic survey;
e) assess the status and future of the HERSUR database;
f) examine digital photographs of herring maturity stages in order to harmonise their definitions.

PGHERS will report by 6 February 2004 for the attention of the Living Resources and the Resource Management Committees.

2 Participants

Bram Couperus (Chair)	The Netherlands	
Phil Copland	UK	Non-member
Mark Dickey Collas	The Netherlands	
Peter Faber (part-time)	Denmark	
Eberhard Götze	Germany	
Knut Hansen (part-time)	Norway	Non-member
Teunis Jansen (part-time)	Denmark	
Birgitt Klenz	Germany	
Bo Lundgren	Denmark	
Ciaran O'Connell	Ireland	Non-member
John Simmonds	UK	Non-member
Else Torstensen	Norway	
Norbert Rohlf	Germany	
Christopher Zimmermann	Germany	

Full contact details for each participant are given in Appendix I.

3 Herring larvae surveys

3.1 Review of larvae surveys 2003/2004

3.1.1 Review of the North Sea larvae survey

In the reporting period the Netherlands and Germany participated in the larvae surveys. In total seven units and time periods out of ten were covered in the North Sea. They are listed below.

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

The recent herring larvae sampling period was finished just prior to the PGHERS 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 of the larvae survey results. Distribution maps of larval abundance from an individual survey in September (Orkney/Shetlands) and October (Central North Sea) are shown in the Figures 1 and 2. However, as in previous years, the information necessary for the larvae abundance index calculation will be ready for the Herring Assessment Working Group (HAWG) meeting in March 2004.

3.1.2 Role of larvae surveys within an assessment context

The larvae surveys have long been accepted as a reliable indicator of SSB of North Sea herring (Cushing and Bridger, 1966; Hempel and Schnack, 1971; Postuma and Zijlstra, 1974; ICES 2003), and have been carried out since the beginning of the last century (Redeke and van Breemen, 1907; Wallace, 1924). The decline of southern North Sea herring was clearly shown by surveys of larvae and these survey results were used to raise the alarm bells, when the CPUE assessment technique failed to show the decline in the stock (Figure 3; ICES 1965; Burd, 1985). Some stocks of fish around the world are successfully managed using only ichthyoplankton surveys and harvest control rules (GLOBEC, 2001; Jacobson pers com).

Since the development of ICA assessments tuned by surveys, the larval herring index has been incorporated into the North Sea herring assessment (Nichols, 2001; HAWG 2003). Recent investigations of the utility of surveys in the North Sea herring assessment showed that the larval survey was a valuable and necessary contribution to the assessment (Evares project, 2003). In a scenario testing analysis, of all the indices examined the removal of MLAI, at F_{pa} or $F_{status\ quo}$, would have the greatest influence over the estimation of TAC advice the following year. The MLAI index acts in balance with the IBTS and acoustic surveys with independent year effects to give a robust assessment (Evares project, 2003). The larvae surveys are already carried out at a low level and decreasing the effort and/or removing the survey would have serious consequences on the advice (Evares project, 2003). A recent publication showed that the variance in the assessment from the larval survey was comparable with the IBTS 1 ringers and acoustic estimate of 2 ringers (Simmonds 2003).

To quote the EU Evares project:

> *"In conclusion the analysis of variance and correlation indicates that the MLAI provides a good SSB index, the acoustic survey provides good information from 1–8wr and the IBTS 1st Quarter from 0 and 1wr."*

In addition to the above arguments, under the current survey programme on North Sea herring, the larvae survey is the only way to analyse the longer term trends of the component parts of the stock (McQuinn, 1997) and gain an estimate of the reproductive output of the stock (Chambers and Trippel, 1997). This has relevance with regard to the management of components of the stock of North Sea herring (HAWG 2003). They are also potentially the best field estimates for mapping changes in the time of spawning and variability in spawning location (e.g., Dickey-Collas *et al*., 2001).

The herring larvae survey is internationally coordinated and provides a time series used in the assessment of North Sea herring. Recent research has shown that the larvae survey and the MLAI that it produces, is a crucial part of this assessment. The larvae survey now also delivers information on plaice egg production in the southern North Sea. Therefore it should be considered for priority 1 funding under the EU data collection directive.

3.1.3 Review of the Western Baltic larvae survey

Background

The results of the time series of larvae surveys in the Greifswalder Bodden were presented to the planning group (Appendix VI: Klenz, 2004). The survey results are used to deliver the N30 index, which is a projection of numbers of larvae per season at 30mm length. With the change in the bottom trawl survey in subdivision 22–24 (from herring gear to demersal gear in 2002), the time series of larvae surveys has been proposed as an alternative and robust index for herring recruitment in the area. This follows on from the work of Brielmann (1981; 1989), who suggested that the development of the N30 index would produce a useful index of herring recruitment in this stock of spring spawning herring. The Greifswalder Bodden is thought to be the major spawning site for western Baltic spring spawning herring in 22–24 and IIIa. This was further developed by Müller and Klenz to incorporate cohort analysis and tracking.

The index has been proposed as to tune the assessment in 2002 and 2003, at the stock assessment working group (HAWG 2002; 2003). The series was criticised over a range of issues, from the presence of an outlier in 1998, to the highly innovative methods and to the lack of analysis into the utility and sensitivity of the series. No assessment of a major herring stock uses the results of a larvae survey as a recruitment index; they are generally used as indicators of spawning biomass.

The series of surveys of larval herring in the Greifswalder Bodden was begun in 1977, and the current data set began in 1992. The series from 1992 to 2003 shows strong correlations between the N30 index derived from the larvae surveys and the abundance of recruits in the acoustic survey of subdivisions 22–24 Klenz (2004). The old bottom trawl series using herring gear, which ended in 2001, also showed a significant correlation with 0 group abundance in subdivision 24. There is a highly significant correlation with the N30 and the estimate of 0 group abundance in the current stock assessment.

Novelty of this method and specificity to the western Baltic

It has long been recognised that the abundance of herring larvae in the North Sea determined by the annual larvae survey, shows strong correspondence with the total spawning biomass of the North Sea herring stock (ICES 1965; Cushing, and Bridger, 1966; Hempel and Schnack, 1971; Postuma and Zijlstra, 1974). These surveys are temporally coarser than the Greifswalder Bodden surveys and cover a much greater area. There is little correspondence between the interannual variation in larval abundance at hatching and recruitment strength for that year in the North Sea (Nash and Dickey-Collas, in press). The North Sea index only uses newly hatched larvae whereas the Greifswalder Bodden survey uses all larvae caught.

The much higher average age at metamorphosis for North Sea herring (6 months for North Sea and 6–8 weeks for western Baltic herring; Heath *et al*., 1997) means that a longer period of exposure to environmental processes exists in the North Sea. The factors that determine year class strength in the North Sea have been found to occur at the latest stages of larval development, as shown by the strong relationship between the MIK net surveys and 0 group abundance estimates (Nash and Dickey-Collas in press) and the MIK net index has proved its utility as a recruitment index through the bootstrapping study of Simmonds (2003). In terms of timing relative to metamorphosis, these MIK net surveys are not dissimilar from the Greifswalder Bodden surveys.

Where the N30 method is very different though, is that it is a projection from the cohorts of caught larvae from the weekly surveys forward to 30mm, using estimates of recent growth and mortality as the projected values. That is, is assumes that the recent past will reflect the recent future. Considering the oceanographic stability of the region and the relatively low cumulative mortality experienced by the larvae (as estimates from the decline in cohorts; Lough *et al*., 1985), this assumption may be valid over such a short time period of 3 weeks.

The planning group felt that the investigators in the current study should give greater acknowledgement to the novelty of their work and the fact that this approach is highly innovative and uses a time series of larvae surveys in a revolutionary way.

Testing the suitability of the N30 series as a tuning index

However, before the survey is included in the assessment, further investigations are required. The fact that there are strongly significant correlations does not mean that the index will automatically perform well within an assessment or projection framework. The large variability in the N30 estimates could suggest that strong correlative relationships may not translate into strong power within the ICA model (Simmonds pers comm.). The utility of the series needs to be tested and compared to the other tuning indices used in the current assessment. This requires ichthyoplankton investigators and assessment biologists to collaborate and investigate the performance of the series within ICA. It is proposed that a short investigation be carried out prior to the assessment working group meeting in March.

There is a need to explain in terms of processes and biology why the correlations vary in terms of Subdivisions 22 and 24 and between acoustic and bottom trawl (old time series) surveys. Correlates cannot be blindly used without understanding the underlying biological and ecological processes (Borja *et al*, 1998; Planque and Fox, 1998; O'Brien *et al*., 2000; ICES SGPRISM, 2002). Care should be taken with regards to the assumption of linearity between life history stages and within the method of spatial surveys.

Klenz (2004) explained the source of the outlier in 1998, and commented that there are methods being determined to score the potential impact of outliers. Such outliers are relativity common in all survey series, and many investigators remove them prior to analysis (Marshall *et al* 2000). Removal is usually done on purely subjective criteria. The group welcomed the quantitative approach being used by Oeberst and Klenz to score outliers and looked forward to their results and further development of the method.

Biomass index

The planning group also felt that the investigators should consider the use of the Greifswalder Bodden larvae surveys as an index of spawning biomass or reproductive potential, using traditional methods such as a larval abundance index or larval production index. Whilst the recruitment index N30, shows a significant correlation with the incoming year class, it would be very interesting and potentially very useful to determine whether a larval based biomass estimate would also be of use, and thus increase the utility of the survey series.

SSB in correlation analysis

The group also felt that the correlation analysis should be extended to the VPA and estimates of SSB derived from the German/Danish October acoustic survey. It would be highly informative to determine whether SSB or egg production is correlated with the N30 series or the abundance of 0 group fish in the VPA or acoustic survey. The power of the relationships could also be examined in a similar way to Mukhina *et al* (2003) and thus again show the utility of the survey to the assessment and population dynamics of western Baltic herring.

Conclusion
The planning group welcomed this study and recognised the potential of the survey as a fishery independent tuning series for the assessment of the western Baltic herring. It felt that the series needed a little more explanation and its potential use within an ICA assessment should be investigated. As mentioned by many previous authors and ICES SGPRISM (2002), correlative analysis should only be used if the underlying processes are understood; this is probably the case in the N30 investigation.

The planning group expressed concern about the loss of survey data prior to 1992, and encourages the investigators to search and collate any data from the surveys between 1977 and 1991 which may be found in old reports and grey literature.

3.2 Co-ordination of larvae surveys for 2004/2005

One of the objectives for the 2003/04 period was a complete coverage of all sampling areas and periods in the North Sea. To achieve this aim the announced additional effort of Norway was essential, but due to a lack in Norwegian ship time, a complete coverage was not possible. Therefore the plan was changed to schedule the survey in the 2004/05 period. Norway cannot provide ship time for the 2004/2005 period either, but offers to send 4 staff on a foreign vessel and to evaluate the survey, if any other nation can offer ship time. The involved institutes will look for a solution which gives the possibility to include Norway in the next period.

At present only the participation of The Netherlands and Germany is confirmed in the 2004/05 period. A preliminary survey schedule for the 2004 period is presented in the following table:

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

Survey results should be sent, in the standard format, to Norbert Rohlf, IfM-Geomar in Kiel for inclusion into the IHLS database. IfM-Geomar will report the summarised results and the updated series of MLAI-values to the HAWG.

4 Acoustic surveys

4.1 Review of acoustic surveys in 2003

4.1.1 North Sea and west of Scotland acoustic survey

Six 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 to a northern limit of 62°N. The eastern edge of the survey area was bounded by the Norwegian and Danish, Swedish and German coasts and to the west by the shelf edge between 200 and 400 m depth. See following table and Figure 4.

Vessel	Period	Area
FV Enterprise (charter)	01 July – 21 July	56°- 60°N, 3° - 7° W
R.V Sarsen	1 – 22 July	56°30’- 61° N, 2° - 6° E
Scotia	27 June – 20 July	58°- 62° N, 4° W - 2° E
Tridens	23 June – 18 July	54°30 – 58° N, west of 3° E
Walther Herwig III	26 June – 13 July	52° - 57° N, east England / 3° E
Dana	27 June – 10 July	North Sea, Skagerrak northof 57°NS and 56° N, Kattegat east of 6° E

The surveys are reported individually in Appendix IIA-F. 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 estimates of North Sea autumn spawning herring are consistent with previous years at 3.1 million tonnes and 18,400 million herring. The survey also shows two exceptional year classes of herring (the 1998 and 2000 year classes) in the North Sea, which is consistent with the observation of exceptionally large year classes observed in the MIK and IBTS surveys. The estimates of Western Baltic spring spawning herring SSB are 106,000 tonnes and 823,000 herring and show a substantial decrease compared with the previous year. This part of the survey, which deals with the spring spawners, produces a rather noisy signal but the indications are of a stock that is slightly higher than during the period 1996 to 2000. The West of Scotland survey estimates of 739,000 tonnes and 4,000 million herring and shows the high 1995 year class again this year. The 1998 year class (4 ring) is now confirmed as a large one. Indications are that the 2000 year class is also good. Total adult mortality shows low mortality again (0.1) but the mean mortality over the last 4 years has been around 0.3: this is consistent with the 2003 assessment that the stock is lightly exploited. A report is provided for ICES herring Assessment Working Group (ICES WD 2004).

4.1.2 Western Baltic

A joint German-Danish acoustic survey was carried out with R/V *Solea* from 30 September to 18 October 2003 in the Western Baltic. This survey is traditionally co-ordinated within the framework of Baltic International Acoustic Survey. It was planned to cover the whole Sub-divisions 21, 22, 23 and 24. Due to bad weather conditions in sub-division 21, the Kattegat, was covered only partially. As in previous years, the survey was carried out during the night. An EK500 echosounder and BI500 Bergen Integrator software were used to collect and process acoustic data. The cruise track covered 864 nautical miles. In all 50 trawl hauls were carried out and from each haul sub-samples were taken to determine length, weight and age of fish. The total Western Baltic spring spawning herring stock was estimated to be 5,400 million fish or about 155,800 t in Sub-divisions 22–24. This is comparable to the last year's result. Young herring dominated the abundance estimates. The estimated total sprat stock was 16,070 million fish or 78,000 t. The sprat numbers are nearly three times the 2002 abundance with a dominating 0-group. A survey report is provided in Appendix III.

4.2 Survey overlap areas

There were 3 areas of survey overlap in 2003 which are given by ICES statistical rectangle:

Area A:	Scotia and Sarsen	49E9, 49F0, 50E9 and 50F0
Area B:	Tridens II and Scotia	47E8, 47E9, 48E8 and 48E9
Area D:	Tridens II and Sarsen	43F2 and 44F2

The locations of these areas are given in Figure 4. Comparisons were made between length and age compositions and total abundance.

Cumulative length distributions for areas A and B are given by rectangle and vessel in Figures 5 and 6. Length distributions are derived from combining only those hauls within the statistical rectangle. Cumulative distributions of maturity/age for areas A and B are given by rectangle and vessel in Figures 7 and 8. Age distributions are obtained by aggregating haul data at length and age as carried out on the survey. There are differences in the results for these areas which may be due to sampling and temporal differences. We found that the vessel differences are smaller than the area differences. This suggests that the sampling is reasonable.

The ratio of numbers and biomass of herring estimated by the national surveys are given in Table 1 for the three overlap areas A, B and D. The best match is obtained between Scotia and Tridens. In this case the timing of the overlap was very good as Tridens surveyed the area during two days while Scotia surveyed a larger area over a four day period which included these two days. The timing differed between Sarsens and both Scotia and Tridens by more than 7 days. These results are rather imprecise and confidence intervals would include unity in all cases. However, the differences here may be a cause for concern and a further echogram scrutinising workshop is planned (see recommendations).

4.3 Sprat

Data on sprat were available from RV *Walther Herwig III*, RV *Tridens* and RV *Dana*. No sprat was reported by RV *Scotia* and RV *Sarsen* in the northern areas. The distribution of sprat by numbers in millions and biomass in the North Sea is shown in Figure 9. The distribution pattern during the 2003 surveys suggests that the southern boundary may not have been reached. However, this may have been due to the unusual hydrographic conditions observed during the survey (Appendix IIF).

In Div. IIIa, sprat was only encountered in the south eastern Kattegat. This was a similar situation as in the previous two years. In the North Sea the highest concentrations of abundance and biomass were estimated in the German Bight and off East Anglia. The total sprat biomass estimated was 270,000 tonnes in the North Sea (Table 2). In the Kattegat area the estimated abundance was 983 million with a total biomass of 13,000 tonnes.

4.4 Co-ordination of acoustic surveys in 2004

4.4.1 North Sea

Following the reviews of the 2003 surveys and the extensive plans for a re-allocation of survey effort in the near future (see Sec 5 of 2003 PGHERS report), the group considered it necessary to conduct the survey with an intermediate structure for a second year rather than starting with interlaced transects. Firstly, the group felt that scrutiny procedures have still not been harmonized between partners to a level that an interlaced transect survey could easily be implemented. An echogram scrutiny workshop in conjunction with next year's PGHERS meeting aims to resolve this problem. Secondly, as the southern distribution boundary for sprat may not have been reached and hydrographical conditions appeared to be unusual in 2003 (Section 4.3 and Appendix IIf), the wide distribution of sprat should be confirmed in a second survey extending southwards to 52°N. The survey structure for 2004 will therefore be unchanged as compared to 2003: Survey effort will be high in areas with high variability and/or herring abundance and lower in all other areas, overlapping areas (surveyed by different vessels ideally at the same time) will be slightly different than in 2003 (see Figure 10).

Acoustic surveys in the North Sea and west of Scotland in 2004 will be carried out in the periods and areas given in the following Table and Figure 10.

Vessel	Period	Area
Charter west Scotland	02 July – 20 July	56°- 60°N, 3° - 6° W
Johan Hjort	08 July – 30 July	56°- 62° N, 2° - 6° E
Scotia	01 July – 22 July	58°30 - 62° N, 2/4° W - 2° E
Tridens	28 June – 23 July	54°30 – 58° N, west of 3° E
Walther Herwig III	28 June – 19 July	52° - 57° N, east of Engl./ 3° E / 6° E
Dana	29 June – 12 July	Kattegat and North of 57° N, east of 6° E

Overlapping areas will be surveyed by (A) RV Scotia and RV Johan Hjort (mid of July, with lower priority than last year), (B) RV Scotia and RV Tridens (2–4 July), (C) the charter vessel and RV Scotia (at dates to be defined), and (D) RV Johan Hjort, RV Dana and RV Walther Herwig III (10–12 July, high priority).

The results from the national acoustic surveys in June-July 2004 will be collected and the result of the entire survey will be combined prior to the next PGHERS. Survey results for sprat should be sent to Else Torstensen (Norway). Survey results for herring should be sent to John Simmonds, U.K. (Scotland) in the format specified in the manual for the International Acoustic Survey in the North Sea and west of Scotland (Appendix IV). Data for both sprat and herring should be with the coordinators by **30 November 2004**. The group agreed that if one or more parties deliver their *validated* data later than 15 December 2004, the most delayed institute will be given the responsibility for producing the combined survey data and report in 2005.

4.4.2 Western Baltic

In the Western Baltic and the Kattegat, the following German-Danish acoustic survey will be carried out in 2004.

Vessel	Period	Area
Solea	29 September – 19 October	Subdivision 21 to 24

4.5 Hydrographic data

Eberhard Götze (BFA Fi, Hamburg) gave a presentation on an initial study on the correlation between water temperature and relative distribution of herring and sprat in the southern North Sea (Rückert *et al*, 2003). This study was conducted in cooperation with the Institute of Hydrobiology/Hamburg University and the IFM/Geomar Kiel. CTD data were compared with echograms and species composition from trawl hauls. Preliminary results suggest that, in the southern North Sea, herring prefer intermediate water temperatures, while sprat is mainly found in warmer water. No clupeids were found in coldest Winter Water in the NW of the area surveyed.

While the study is clearly preliminary, results appear to be promising and show concordance between the hydrographic conditions and the distribution of clupeids. Hydrographic data collected during the survey may therefore help to determine areas of interest for effort distribution. These areas could then be surveyed with a higher intensity, while the transect spacing in areas of lower interest could be reduced *ad hoc*.

As all participants in the herring acoustic survey collect hydrographical data as a routine, a quasi-synoptic data set matching the hydro acoustic data temporally and spatially is already available. In order to facilitate further analysis, the group recommends that the data is collected and combined in a similar way as the biological and hydroacoustic data and presented in the report (e.g as a number of temperature contour plots for the combined area). To facilitate the collection, BFA Fi (Eberhard Götze) agreed to collate validated CTD profiles in a standard format (details will be sent to partners prior to the survey in 2004), to transfer them into Ocean Data View (a freeware program widely used in the oceanography community, available for different platforms at http://www.awi-bremerhaven.de/geo/odv), and to produce a small set of standard outputs for the report. ODV contains a database, and combined and raw data will be available to all partners in the future.

5 Review and update of the PGHERS manuals

5.1 PGHERS manual for herring acoustic surveys

It was agreed by the group that the acoustic survey manual should be updated where necessary on an annual basis. However, due to the number of participants and the range of scientific echosounders currently employed in national survey programmes it was decided that a single approach could not be adopted for this year. The most commonly used echosounders across participants are the Simrad EK500 and the EK60 (ER60) units. Currently the manual focuses on instrument settings for the EK500, it was proposed that in the future the manual be updated to include settings for the EK60.

In terms of survey design an alteration of this section will be considered at the 2005 PGHERS meeting after the ICES led survey design workshop findings are taken into consideration (workshop due in June 2004, Aberdeen).

Data exchange practices are to be reviewed and updated where necessary. Spread sheet and database refinements are to be made to facilitate the ease of data transfer. This was highlighted as a dynamic process in light of the planned interlacing of survey tracks and output data.

5.2 IHLS manual

A draft version 1.0 of the manual for the International Herring Larvae Surveys was prepared by Norbert Rohlf (Appendix V).

6 Measurement of biological parameters

Dutch, Irish and Norwegian series of photographs of different herring maturity stages were presented and discussed. It was agreed to make an exchange series of photographs covering the whole spectrum of maturity stages (8 point scale). Photographs of gonads in transitions stages will be of greatest importance in this series. Good quality photos from the Irish, Scottish and the Dutch series, along with information of the national readings, are to be sent to Else Torstensen by 15 May 2004. The exchange series of photographs will be prepared and sent on CD to all participating laboratories by the end of May for maturity determination. The results have to be returned before 15 June 2004.

7 Status and future of the HERSUR database

Peter Faber of DIFRES Hirtshals presented the current state of the HERSUR database (http://ff07.dfu.min.dk/hersur). This database was developed in Hirtshals within the framework of the EU-funded projects “Herrings Surveys in the North Sea and West of Scotland” I and II, and is online since 2001. It is supposed to hold all primary acoustic and trawl data from the North Sea Herring Acoustic Survey (including West of Scotland and Kattegat/Skagerrak) and to provide primary outputs (tables and figures).

As per end of January 2004, the database holds information as given in table 3. While partial information is available for Denmark and Germany from 1992 and 1994 onwards, respectively, Scottish data were delivered for both surveys (North Sea and West Coast) for 1999 and 2000 only, the Netherlands have only submitted incomplete data for 2000, and no data is available from Norway. Therefore, not a single year with complete data from all survey participants is currently stored in the HERSUR-database.

The database has not been developed further over the last year. There are serious restrictions on the work to be allocated for further development since the EU funding ended, as Denmark has not incorporated this work in the EU funded national sampling program. Major developments therefore cannot be conducted. However, DIFRES agreed to resolve some minor inconsistencies and problems with the data definitions and data input (e.g., inconsistent description of file structure between XML and ASCII/IBTS format; errors in parameter lists – the latter should be obtainable from users; possibility for deletion of erroneous data sets) in the near future without additional financial requirements.

DIFRES proposed to move the HERSUR database in the course of this year and to include it in the FISHFRAME (ex BALTCOM) database to ease further development. Teunis Jansen of DIFRES Charlottenlund presented this database which holds international commercial catch and discard data and primary sampling data for the Baltic (on the individual fish level). At a later stage, the responsibility for FISHFRAME should be handed over to ICES, and ICES is currently exploring possibilities to use (an adapted) system for handling commercial catch for all of its assessment working groups.
The move to FISHFRAME would have some technical and long-term advantages, however, the financial constraints for significant developments cannot be solved if DIFRES fails to utilise EU funding or if no other source for funds is available. There was concern that an immediate move of the HERSUR database to a new one could delay the completion of the data basis significantly. It would therefore be preferable to first enter all missing data into the "old" database before moving to a new one.

The group discussed the various options for future developments. It recognised that with the current method of estimation of population indices, it would not be possible to use the HERSUR database to derive standard outputs to be delivered to HAWG. There is no common procedure available to raise primary acoustic and biological data to derive total figures for the whole survey. Use of the HERSUR database as it currently stands requires implementation of flexible combination of biological and acoustic data that matches current national procedures. In spite of this, the storage of primary data is considered to be important by PGHERS.

The group agreed to follow a two-track approach:

1) Survey participants are encouraged to submit all basic data to the HERSUR database, starting with year 2000 (as this is the year for which most data is already available). Bo Lundgren (DIFRES Hirtshals) will take the lead to check which data is submitted and which is still missing, will contact those responsible for missing data and report back to the group. Complete, consistency-checked data for 2000 should be uploaded no later than 30 April 2004. Peter Faber will spend some work to solve minor problems mentioned above, which should ease the data upload. Once most of the data for all years is uploaded, the database can be incorporated into FISHFRAME.
2) A meta-database holding national aggregated data with survey results will be set up by Teunis Jansen (DIFRES), based on the consistency-checked data available from John Simmonds (MarLab). This database is used to develop further an automated system for delivering the outputs needed for the combined survey report and HAWG, using parts of the routines already developed within the HERSUR database. Simmonds and Jansen will meet in March to discuss the needed routines in detail and to pass on 2002–2003 data to allow development of the database. The aim is to deliver data for the 2004 survey to this database instead of using a spreadsheet system.

At a later stage, the missing link between primary acoustic and biological data and national meta-data (numbers by age and rectangle, mean weights) should be developed, following the harmonisation of national raising procedures in the course of the restructuring of the acoustic survey (see last year's report and Sec. 4) and the incorporation of the HERSUR database into FISHFRAME.

8 Recommendations

The Planning Group for Herring Surveys recommends that:

PGHERS will meet at the Institute for Marine Research Bergen, Norway, from 24 to 28 January 2005 (Chair: B. Couperus, The Netherlands) to:

a) combine the 2004 survey data to provide indices of abundance for the population within the area;
b) co-ordinate the timing, area and effort allocation and methodologies for acoustic and larvae surveys for herring and sprat in the North Sea, Division VIa and IIIa and Western Baltic in 2005;
c) review and update the PGHERS manual for acoustic surveys to address standardization of all sampling tools and survey gears;
d) review the results of an exchange exercise on herring maturity staging, and comment on the implications of the conclusions of the sprat age reading exchange and workshop for the acoustic surveys;
e) evaluate the results of the investigations of survey overlaps between vessels in the North Sea acoustic survey;
f) to conduct an echogram scrutiny workshop aiming at further harmonisation of scrutiny procedures.

PGHERS will report by 7 February 2005 for the attention of the Resource Management and Living Resources Committees, and to HAWG.

Justification

Term of reference a) and b)

Surveys for herring are currently carried out by five different countries, covering the whole of the North Sea, Western Baltic and the west coast of Scotland. Effective co-ordination and quality control for these surveys is essential and while data combination can be managed by mail, a meeting is required to ensure that the larvae database is being used correctly and that the acoustic surveys are being carried out and analysed on a consistent basis.

Term of reference c)

The issue of standardisation of procedures and survey protocols is becoming increasingly important in the light of concerns of the quality assurance of data which are used for the assessment of commercial fish stocks. ICES is particularly concerned about the issue with regard to survey data as a result of adverse experiences in North America in recent years. Fortunately, PGHERS has always attempted to document their procedures through the production of a manual for the surveys conducted. This manual has been reviewed periodically from time to time on an *ad hoc* basis. In the light of current concerns, PGHERS agreed that a more comprehensive review of the manual should take place in 2003. Participants are expected to examine the manual and be prepared to discuss any alterations due to changes in working practices and or equipment.

Term of reference d)

At the 2003 PGHERS meeting a major redesign of the acoustic survey was considered to improve the efficiency of the combined acoustic survey. It was decided that before any major changes could be implemented, a closer examination of operating procedures by participants unfamiliar with new surveying territories should be carried out. This should be achieved by close comparative scrutiny of data from overlapping areas surveyed by one or more participant countries. The scrutiny of data requires an additional program of work as agreed at the 2003 PGHERS meeting. The results of these overlap analyses will be presented at the 2004 PGHERS meeting after which further consideration can be given to a more integrated survey design involving more survey overlaps.

Additional recommendations

PGHERS recommends:

from Section 3 Herring larvae surveys

- that before the N30 is used in the assessment of western Baltic herring, the index should be tested within the ICA assessment framework to determine if the index can make a contribution to the assessment. In addition the development of the quality indicators should be encouraged to ensure that the index is robust and defendable.
- that attempts should be made to elongate the N30 time series to prior to 1992, by the investigation of old reports and grey literature.
- that the western Baltic herring larval surveys should be used to construct a biomass index as well.
- that the North Sea herring larvae survey should be considered for priority 1 EU funding, as it is international, covers more than 1 species and is incorporated into the stock assessment.
- that Norway should be encouraged to join the North Sea herring larvae survey in period 2005.

from Section 4 Acoustic Surveys

- to collect hydrographic data taken during the survey, to combine these in a similar way as biological and hydroacoustic data and to present primary outputs within the report. Hydrographic data taken during the 2004 survey should – in a format to be specified and validated – be sent to Eberhard Götze, BFA Fi Hamburg, not later than 1 November 2004. Data from the 2003 survey is welcome at any time.

from Section 7 HERSUR database

- to participants of the herring acoustic survey to provide all missing national data to the HERSUR database, starting with survey year 2000. Data for the latter year should be uploaded no later than 30 April 2004.
- to develop a meta-database within the DIFRES-based FISHFRAME database containing national aggregated data at least for 2002 and 2003, and to develop tools for the further aggregation of data and the production of standard outputs according to the spreadsheet system currently in use.

- to incorporate the HERSUR database into FISHFRAME once all historic data is entered and validated, provided DIFRES will be able to allocate resources for future maintenance and development of the database. This work should ideally be financially supported within the framework of the EU sampling directive.

Other Recommendations

- to conduct an exchange for herring maturity determination in May/June 2004 on the basis of photographs.
- to organise an Echogram Scrutiny Workshop in conjunction with the next PGHERS meeting in January 2005. The datasets to be used have yet to be decided on, but the set will include acoustic data from the 2002–2004 overlapping areas. Else Torstensen will be responsible for the planning of the WS.
- to Norway to ensure that BI-system can read Echoview recorded files for the Scrutiny Workshop (2002 datafile example provided).

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Table 1. Ratio of the estimated numbers and biomass by rectangle and for totals for the overlap areas A, B and C.

A: SCOTIA / SARSEN

Stat Rect	*Numbers*	*Biomass*
49E9	5.26	5.66
49F0	1.07	1.28
50E9	68.59	77.15
50F0	199.81	220.42
Total	4.82234	5.545047

B: SCOTIA / TRIDENS II

Stat Rect	*Numbers*	*Biomass*
47E8	0.75	0.87
47E9	1.37	1.44
48E8	1.66	2.19
48E9	0.61	0.67
Total	1.093985	1.258566

D: TRIDENS II / SARSEN

Stat Rect	*Numbers*	*Biomass*
43F2	10.4496	14.23843
44F2	0	0
Total	4.250553	5.542084

Table 2. Estimates of sprat in the North Sea from the acoustic surveys, 2001–2003. Total number (million), total biomass (thousands of tonnes) and Spawning Stock Biomass (SSB, thousands of tonnes).

Year	**Total Number (million)**	**Total biomass (1000 tonnes)**	**SSB (1000 tonnes)**
2001	21 300	202	157
2002	21 900	241	165
2003	29 828	269	160

Table 3. Data available (number of data sets) at the HERSUR database (http://ff07.dfu.min.dk) as per end of January 2004.

SA: Acoustic records; fishery data: HH: detailed haul information HE: additional haul information, HL: length frequency data; SMALK: sex/maturity/age/length keys

Nation	Year	Cruise	SA	HH	HE	HL	SMALK
DEN	1992	DAN7	12066	45	45	70	
	1993	DAN6	32997	36	36	447	556
	1994	DAN7	14007	43	43	357	
	1995	DAN7	6698				
	1996	DAN10	11835	36	36	545	1843
	1997	DAN10	9659	37	37	2646	1610
	1998	DAN8	11831	53	53	3257	1743
	2000	DAN6	5922				
	2001	DAN6	6192				
	2002	DAN5		31	31	2006	1397
GFR	1994	WH149	1276				365
	1995	WH162	2205	44	44	2568	1433
	1996	SO392	1029				
	1997	WH186		78	78	5955	2802
	1998	WH1996	1791	43	43	1289	1596
	1999	SO444	650	10	10	371	
	2000	WH218	1822	39	39	2278	2734
	2001	SO478	1625	31	31	787	
	2002	WH240	1752	37	37	1470	2905
	2003	WH253	1992	27	27	1152	2275
NED	2000	TRI6	3688	22	22		
SCO	1999	CSO1	976	38	38	339	1556
	1999	SCO11	1101	39	39		1988
	2000	CSO4	1039	50	50	562	2391
	2000	SCO10	975	45	45	593	2194

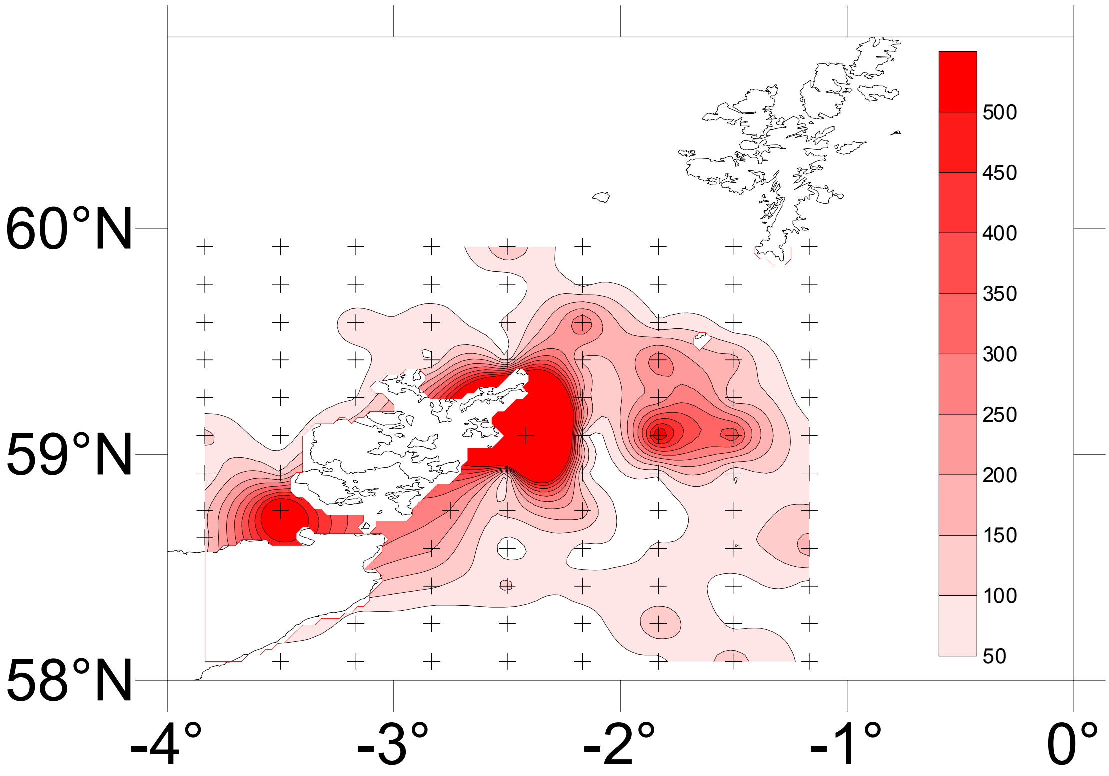

Figure 1. Orkney/Shetland, 16.09. – 30.09.03. Larvae abundance < 10 mm TL (n/m²)).

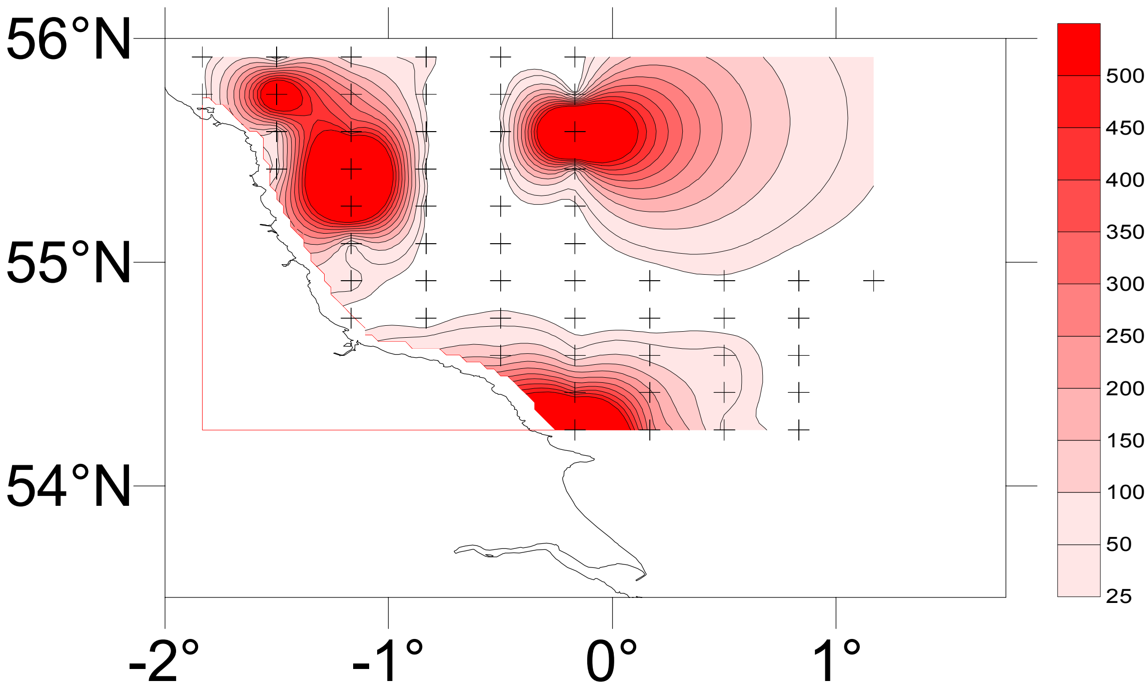

Figure 2. Central North Sea, 01.10.–15.10.03. Larvae abundance < 10 mm TL (n/m²).

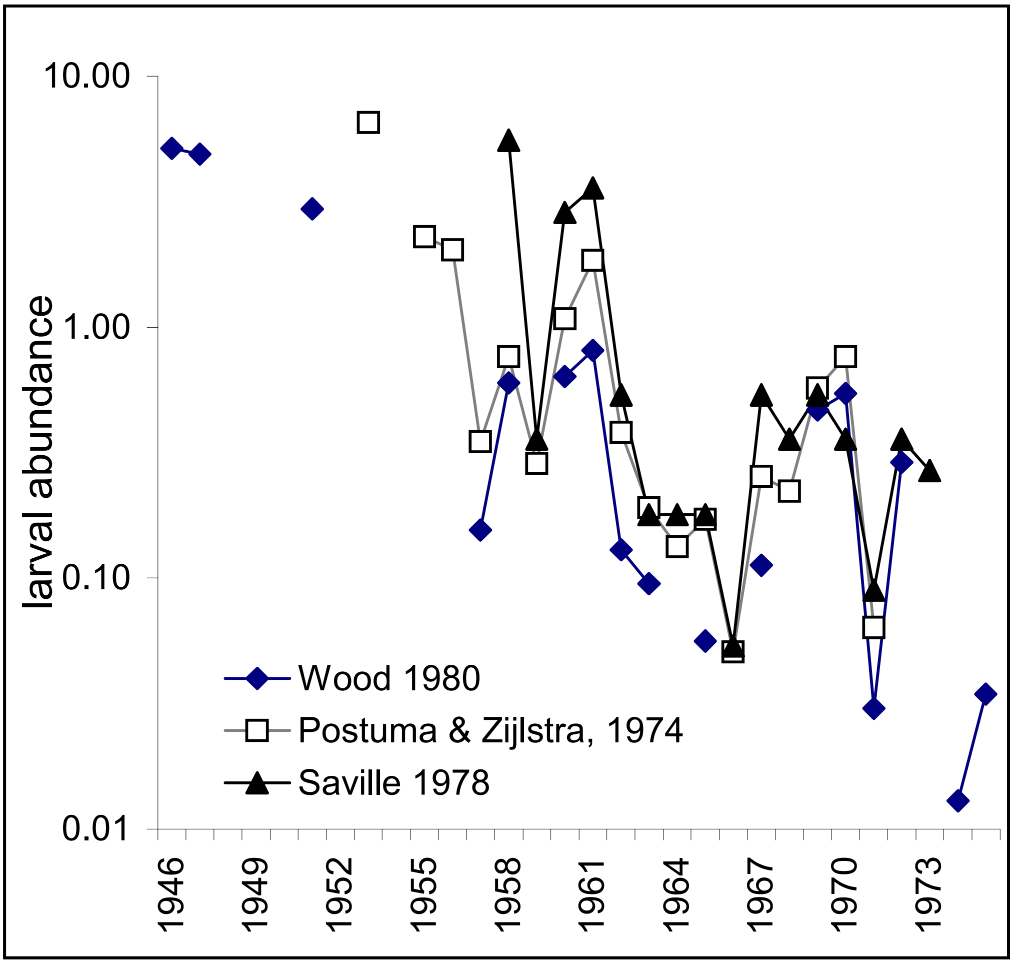

Figure 3. Decline in larval abundance in the southern North Sea from the 1940 to 1972, as charted by three studies.

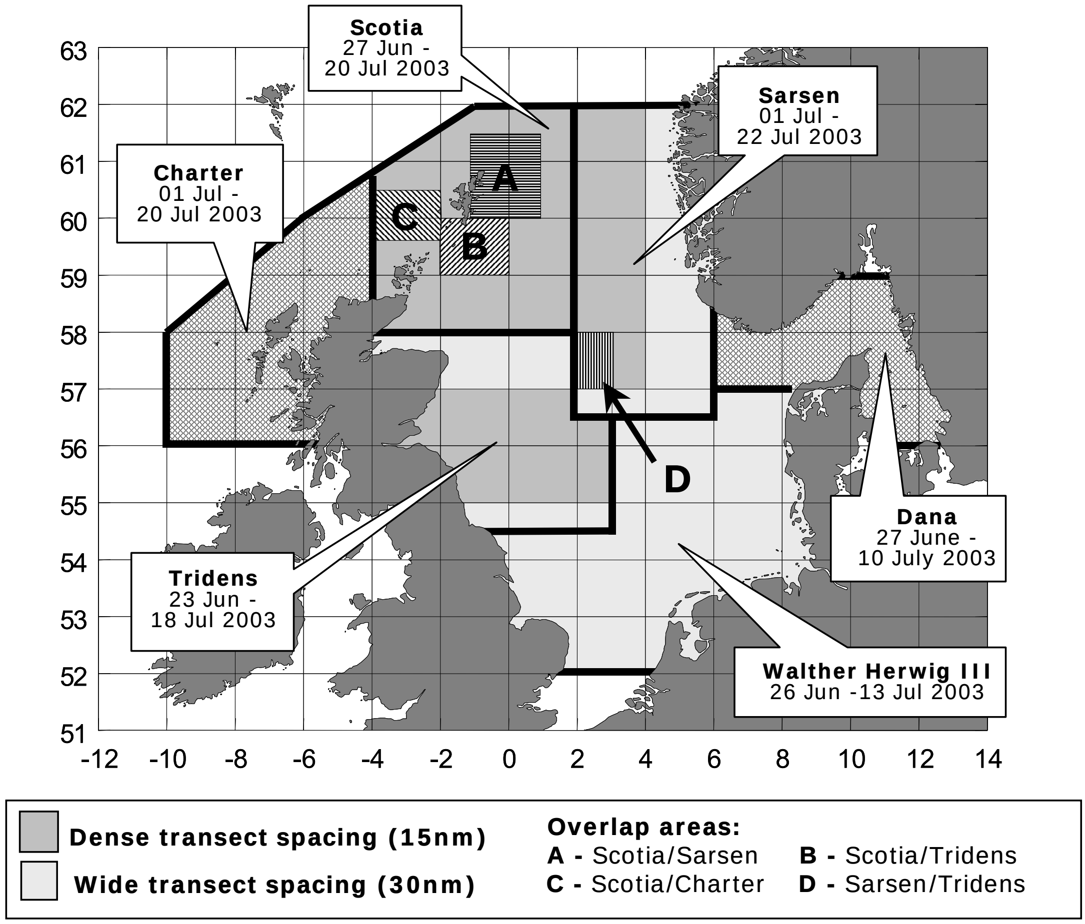

Figure 4. Survey area layouts and dates for all participating vessel in the 2003 acoustic survey of the North Sea and adjacent area's. Area's A- B indicate areas of overlap.

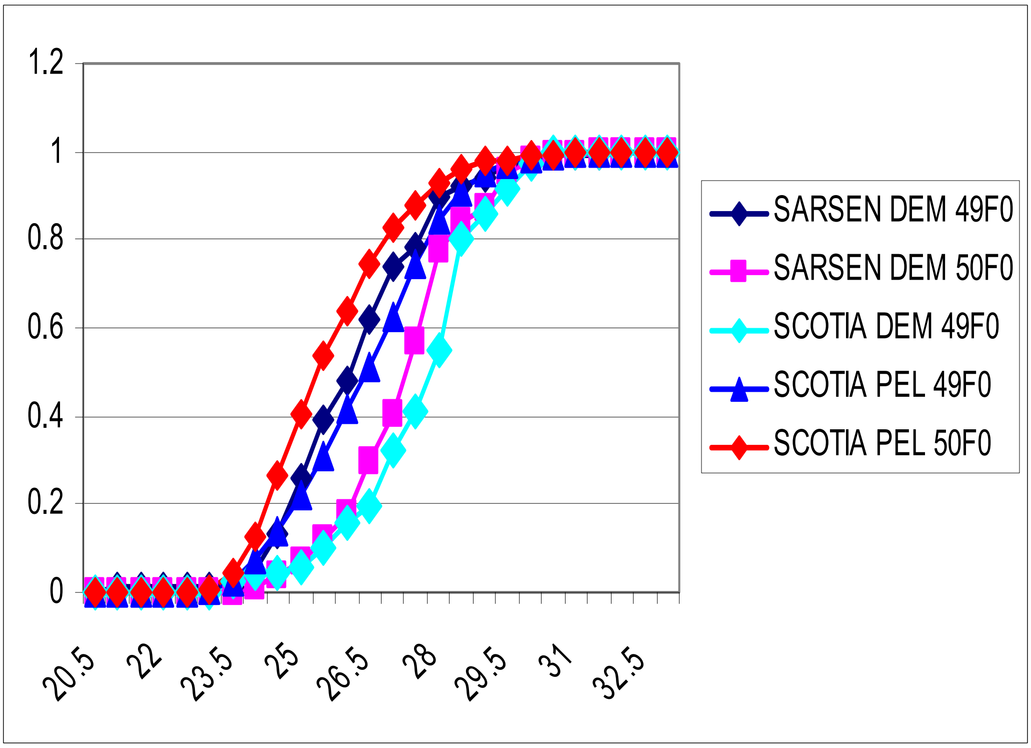

Figure 5. Comparison of estimated herring length in overlap area A expressed as a cumulative distribution. Length are given by area and gear for SCOTIA as only demersal gear length frequency is available for SARSEN. North Sea hydro acoustic survey, 2003.

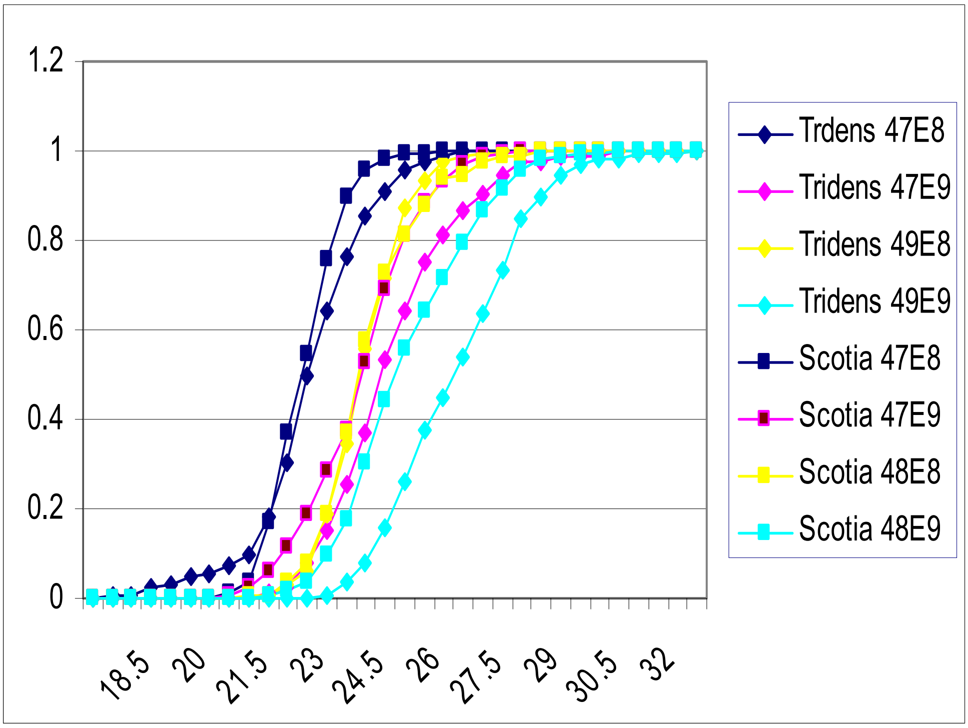

Figure 6. Comparison of estimated herring length in overlap area B expressed as a cumulative distribution. North Sea hydro acoustic survey, 2003.

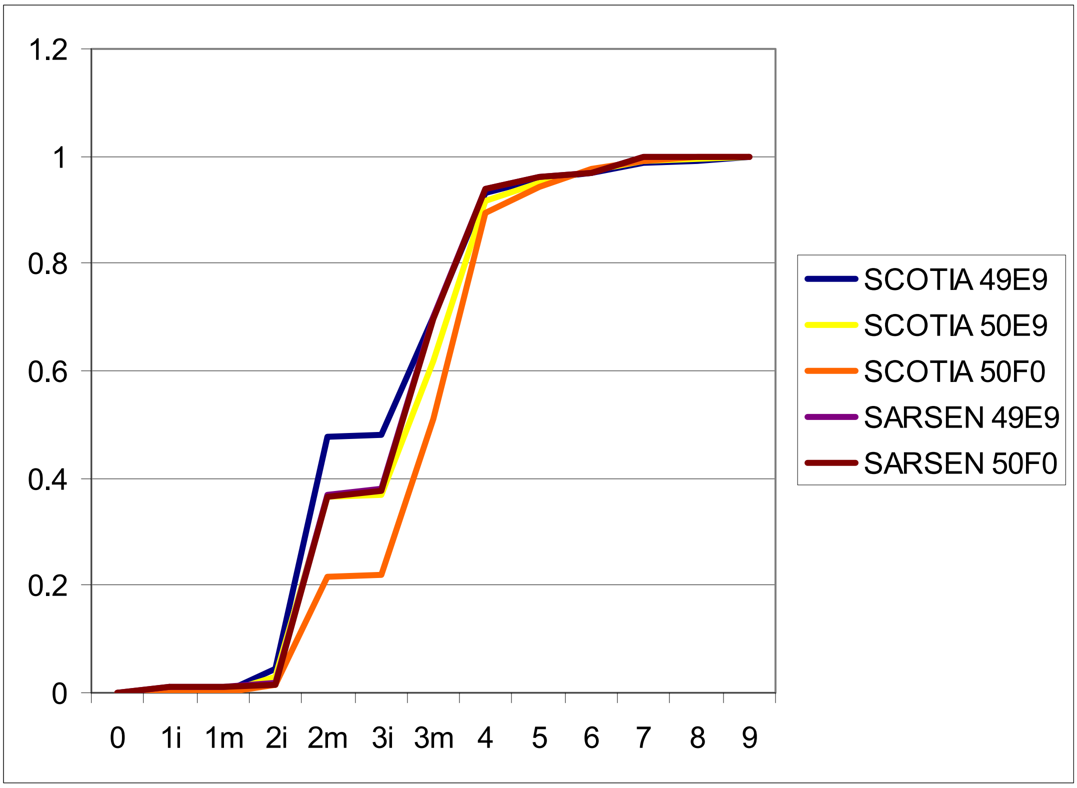

Figure 7. Comparison of estimated herring age and maturity in overlap area A expressed as a cumulative distribution. North Sea hydro acoustic survey, 2003.

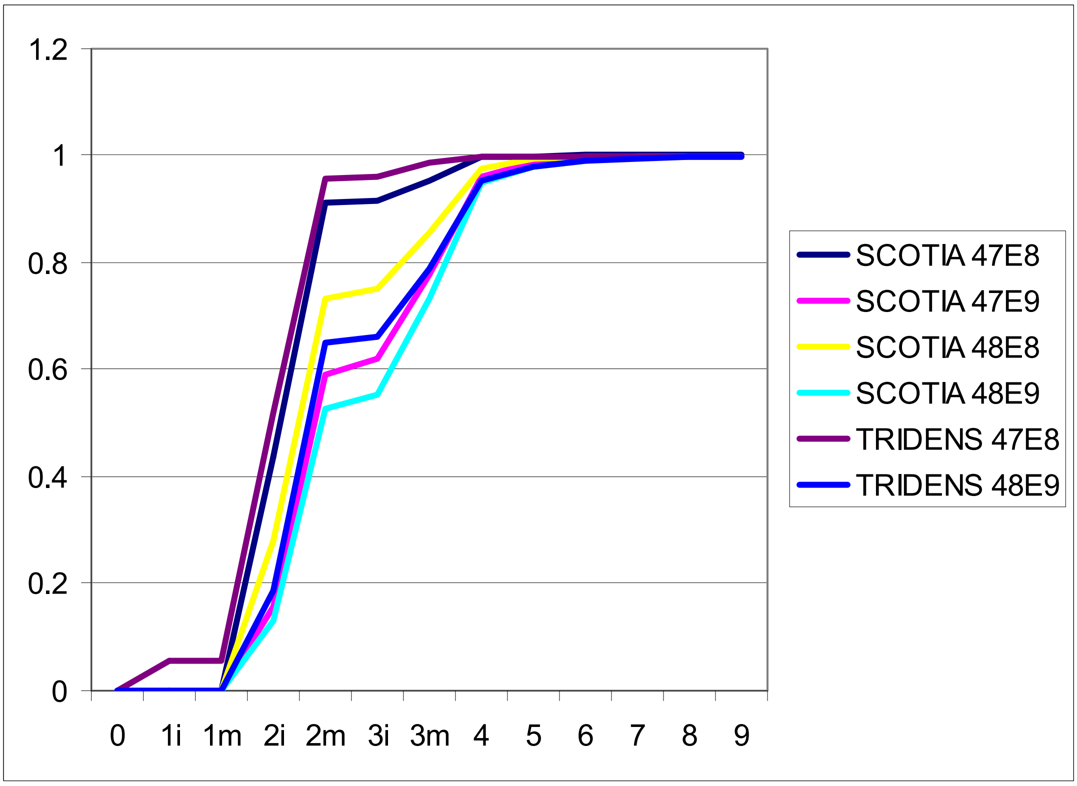

Figure 8. Comparison of estimated herring age and maturity in overlap area B expressed as a cumulative distribution. North Sea hydro acoustic survey, 2003.

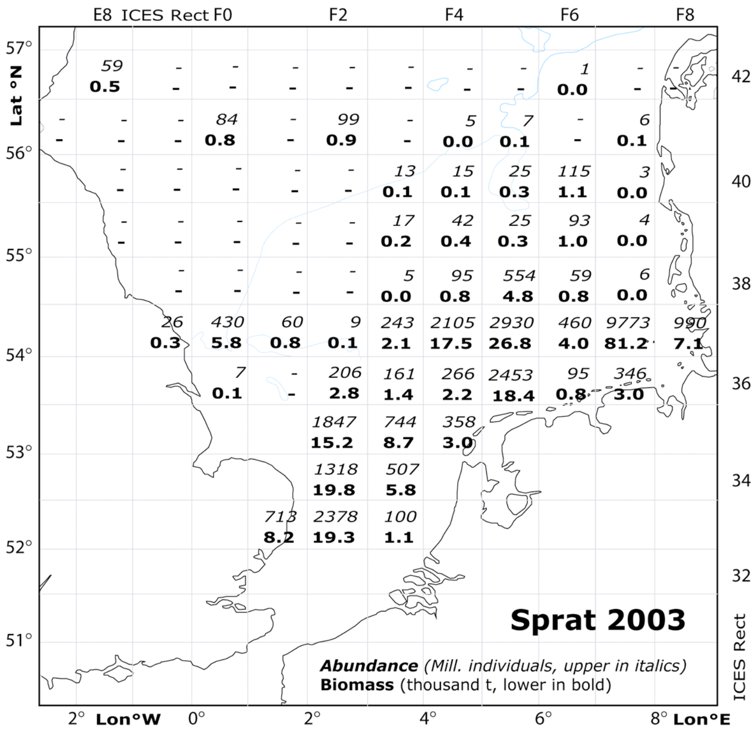

Figure 9. Abundance (millions upper value in italics) and biomass (thousand tonnes, lower value in bold) of sprat per statistical rectangle.

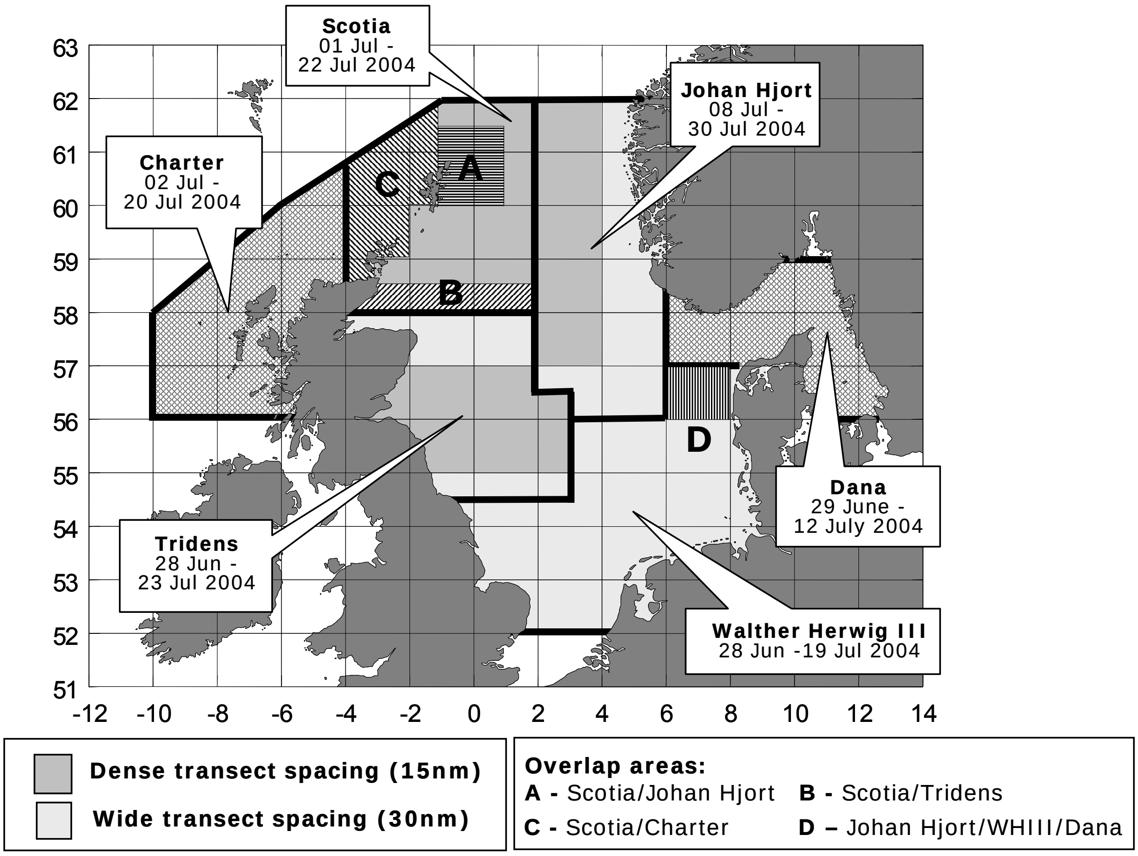

Figure 10. Survey layouts and dates for all participating vessels in the 2004 acoustic survey of the North sea and adjacent areas. Shaded indicate areas of stratifications as indicated in the legend. Areas A – D indicate areas of overlap as defined in the legend.

Appendix I: Participant contact details

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Appendix II: 2003 Acoustic Survey Reports

Appendix IIA: West of Scotland

Survey report for MFV *Enterprise*
1–20 July 2003
Dave Reid, 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 1–20 July 2003. The survey was conducted on the chartered fishing vessel MFV *Enterprise*. 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 co-ordinated 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 2004.

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

Dave Reid	Cruise Leader
Emma Hatfield	
Doug Beare	(1–12 July)
Eric Armstrong	
Finlay Burns	
Colin Millar	(12–20 July)
Claire Embling	Visitor (U. of St Andrews)

2.2 Narrative

Loading of the vessel and installation of container and equipment was carried out on the 30 June and was completed successfully. The vessel left Fraserburgh at 1400 on the 1 July and proceeded to Loch Eriboll for a calibration carried out overnight. Survey work began at Cape Wrath on the morning of the 2nd. The survey continued in generally good weather until 12th July when the vessel steamed to Ullapool for half landing and crew change. A second calibration was carried out in Loch Broom on the 12th prior to landing. The survey continued from the 13th in good weather, until the 18th, and covered the full survey area up to 60^{o}N 4^{o}W. The vessel then rendezvoused with FRV *Scotia* at 0400h on the morning of the 19th July to carry out a vessel intercalibration, in the area between 4 and 3^{o} 20'W. This was successfully completed by the afternoon. Two further hauls were then carried out in this area for comparison purposes. A final calibration was carried out at Scapa Flow on the morning of the 20th. The vessel then steamed to Fraserburgh for offloading of personnel at 18:30 on the 20th. Equipment and gear was offloaded on Monday the 21st. No time was lost due to weather or mechanical breakdown. One net was seriously damaged during a fishing operation on Barra Head Bank.

2.3 Survey design

The survey design (Figure1) was selected to cover the area in three levels of sampling intensity based on herring densities found in 1991–2001. Areas with highest intensity sampling had a transect spacing of 3.75 nautical miles, areas with medium 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 60.5° N, and the shelf break in the west and the Scottish coast or the 2° W line in the east.

2.4 Calibration

Three good calibrations were carried out, at the beginning (2 July) in Loch Erribol, in the middle (12 July) in Loch Broom, and at the end of the survey (20 July) in Scapa Flow. All calibrations were carried out in ideal conditions, and the constants for the 38 kHz integrating frequency agreed well (Table 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 EK500 38 kHz sounder echo-integrator, the system settings are given in Table 1. Further data analysis was carried out using SonarData Echoview and Marine Laboratory Analysis systems. Data from the echo integrator were summed over quarter hour periods (2.5 n.mi. at 10 knots). The survey was generally restricted to hours of daylight between 0300h and 2300h UTC, although on occasion where time permitted the survey was started later, at 0400h to allow for herring to complete their downward vertical migration. A total of 2462 nautical miles of track were recorded. Echo integrator data was collected from 10 metres below the surface (transducer at 5.5 m depth) to 0.5 m above the seabed. Data were archived as EchoView files (*.ek5) and stored on CDR.

2.6 Biological data - fishing trawls

45 trawl hauls (Figure 1 and Tables 2 and 3) were carried out opportunistically during the survey on the denser echo traces. All trawls were carried out using a PT160 pelagic trawl with a 20 mm cod end liner. A scanning netsonde was mounted on the headline. Each haul was sampled for length, age, maturity and weight of individual herring. Up to 350 fish were measured at 0.5 cm intervals from each haul. Otoliths were collected with 2 per 0.5 cm class below 22 cm, 5 per 0.5 cm class from 20 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 Hydrographic data

No hydrographic data were collected

2.8 Data analysis

EDSUs were defined by 15 minute intervals which assuming a survey speed of 10 knots represented 2.5 n.mi. per EDSU. The data were divided into four categories: “herring traces”, “probably herring traces”, “possibly herring traces” which were identified with enough uncertainty as to not be included in the estimate and “herring in a mixture”. 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 seven strata based on length distributions and geographic criteria. The seven regions (Figure 3) were:

I. North Minch
II. South Minch
III. Barra Head
IV. Shelf Break South
V. West Hebrides
VI. Shelf Break North
VII. North of Scotland

Trawling in the Minch area was again very difficult except in the most northerly and southerly parts. The length frequencies are presented in Table 4. The overall age length key is presented in Table 5.

3. RESULTS

3.1 Acoustic data

The geographical distribution of the NASC values assigned to herring are presented in Figure IIA.2. The bulk of the herring were found along and inshore of the shelf break. The main areas of concentration were between 56° 30’ and 57°N, around 58°N, around 58° 45’N, and around 59° 30’N. There were also some good marks recorded at Barra Head, the Butt of Lewis and Cape Wrath. Unusually, there were no major concentrations NW of Lewis at Gallan Head as in previous surveys. No herring were detected in the main part of the Minch

3.2 Biological data

A total of 45 trawl hauls were carried out, the results of these are shown in Tables IIA.2 and IIA.3. 34 hauls contained sufficient herring to define the 7 survey sub areas (Figure IIA.3). Herring was present in 37 hauls and there was a good coverage of herring trawl hauls across the area. All major concentrations were well characterised biologically from these trawls. Other hauls were mostly dominated by young gadoids (mostly blue whiting) or mackerel, or were unsuccessful.

The weight of herring at length was determined by weighing fish from each trawl haul that contained more than 50 fish. Lengths were recorded by 0.5 cm intervals to the nearest 0.5 cm below. The resulting weight-length relationship for herring was:

$$W = 0.004942.L^{-3.1785} \text{ g} \quad \text{L measured in cm}$$

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

3.3 Biomass estimates

The total biomass estimates for the survey were:

Definitely herring	671,160 tonnes	84%
Probably herring	115,950 tonnes	15%
Herring in mixture	11,500 tonnes	1%
Total herring	**889,200 tonnes**	
Spawning stock biomass	745,070 tonnes	96%
Immature	31,360 tonnes	4%

Total abundance (numbers of fish) were:

Total herring	5,231 million	
Spawning stock numbers	3918 million	89%
Immature numbers	466 million	11%

A breakdown of the estimates by age class is given in Table 6. The survey included all of ICES sub-division VIa (N) plus some of the area between 3° and 4°W in sub-division IV. The estimates given here are for VIa (N) alone.

4. DISCUSSION

The stock estimate for VIa (N) is up substantially by approximately 53% from 2002 (from 579,400 to 889,200 tonnes). Given the known difficulties of quantifying young fish on this survey, the SSB estimate is likely to give a better index of change. This is also up significantly, by 36% (548,800 to 745,070 tonnes) from 2002 to 2003. The abundance by year class is consistent with previous years and also with results from the adjacent North Sea area. The 1998 year class was still quite strong and there were also a very large number of 4 ring fish seen on the survey (32% by number and 36% by weight).

The distributions were broadly similar to previous years, with the bulk of the fish being found right along the shelf break. The regular hot spot of smaller fish at Barra Head was seen again this year, although it was not seen in 2002.

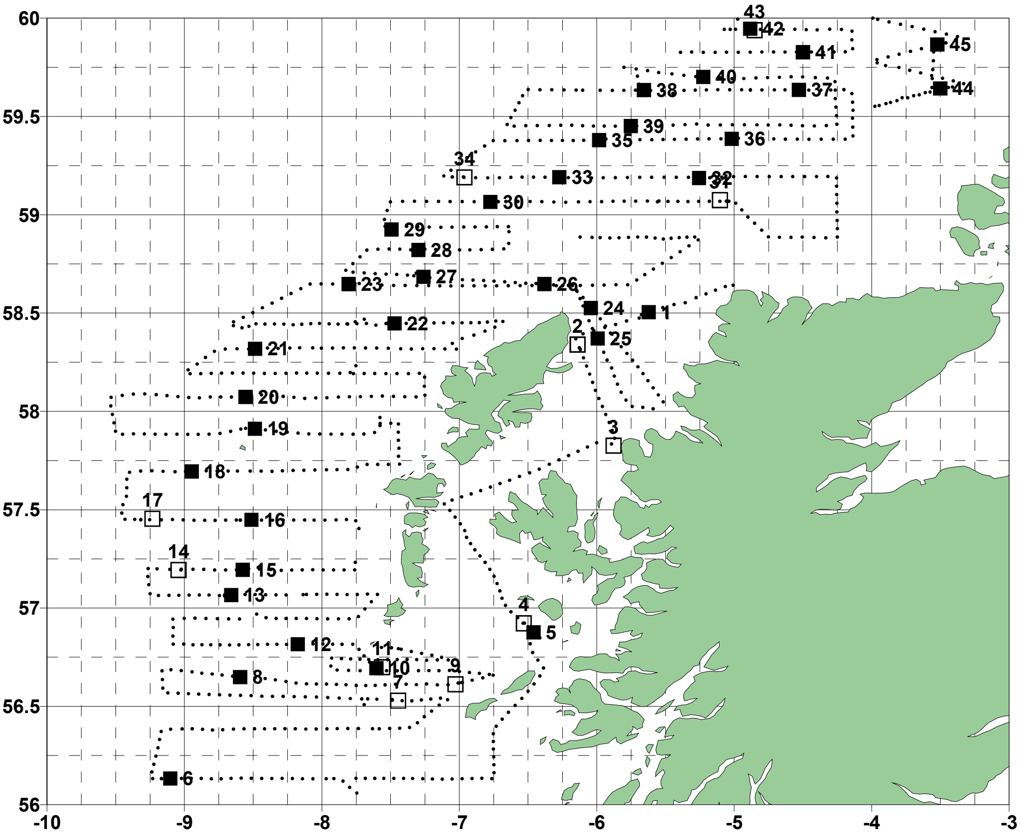

Figure 1. Map of the west of Scotland showing cruise track and positions of fishing trawls undertaken during the July 2003 west coast acoustic survey on MFV *Enterprise*. Filled triangles indicate trawls in which significant numbers of herring were caught, whilst open triangles indicate trawls with few or no herring.

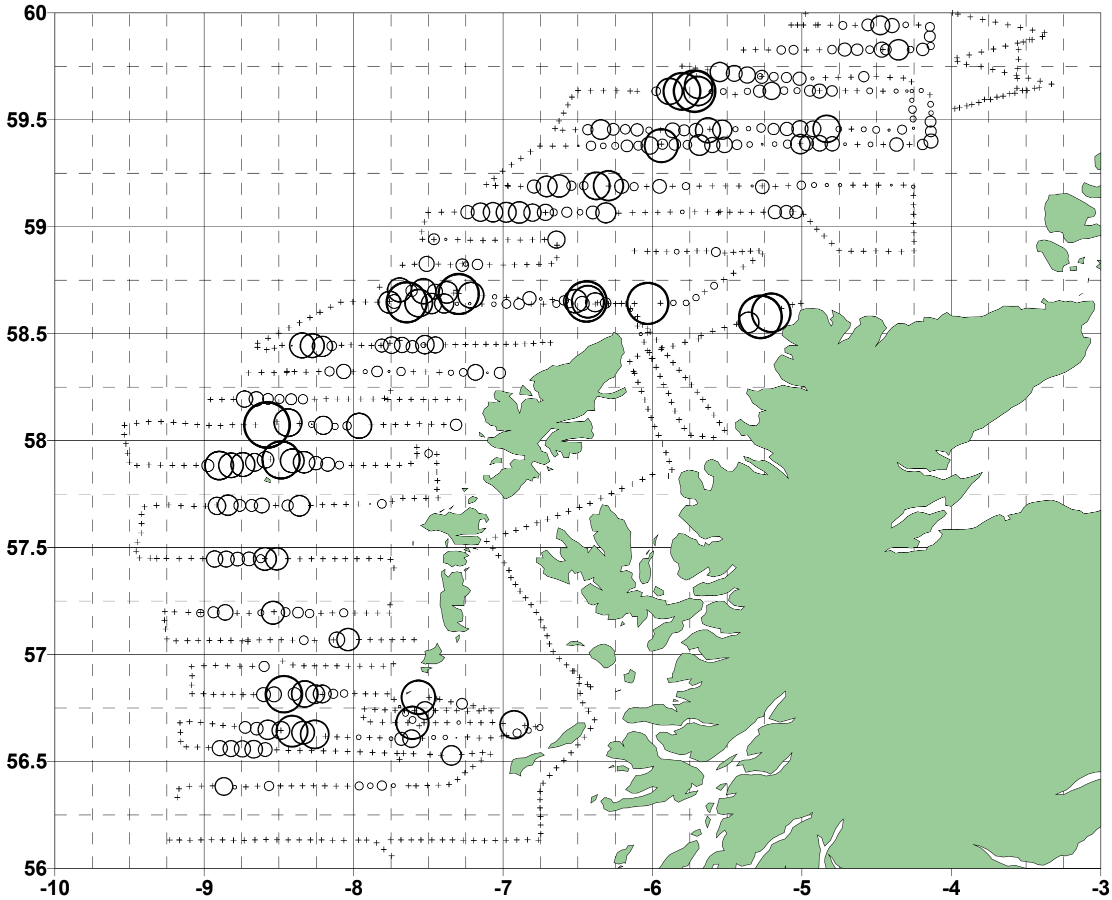

Figure 2. Post plot showing the distribution of "definitely" herring NASC values (on a proportional square root scale relative to the largest value of 3889) obtained during the July 2003 west coast acoustic survey on MFV *Enterprise*.

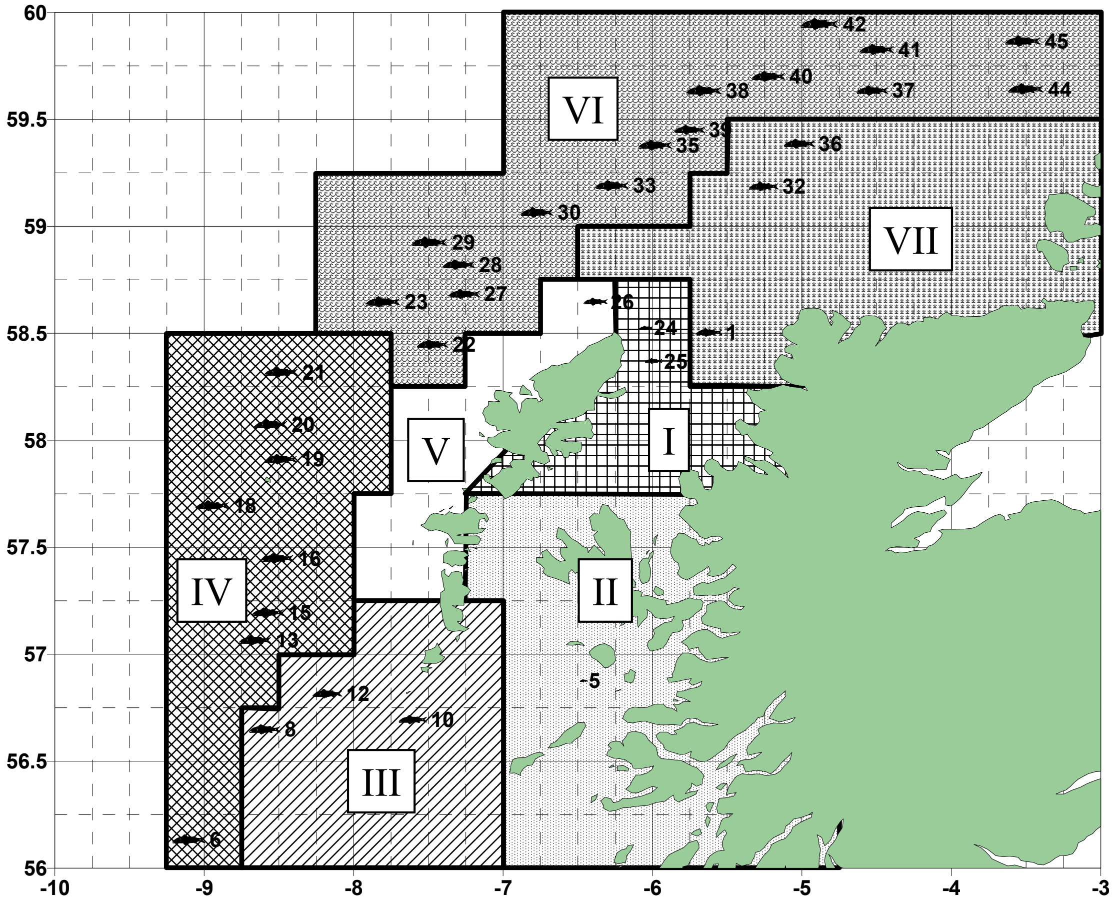

Figure 3. Post plot showing the mean length of herring caught in the trawl hauls carried out during the July 2003 west coast acoustic survey on MFV *Enterprise*. The plot also shows the area strata (indicated by shaded areas with roman numerals I-VII) used for combining data from the trawl hauls.

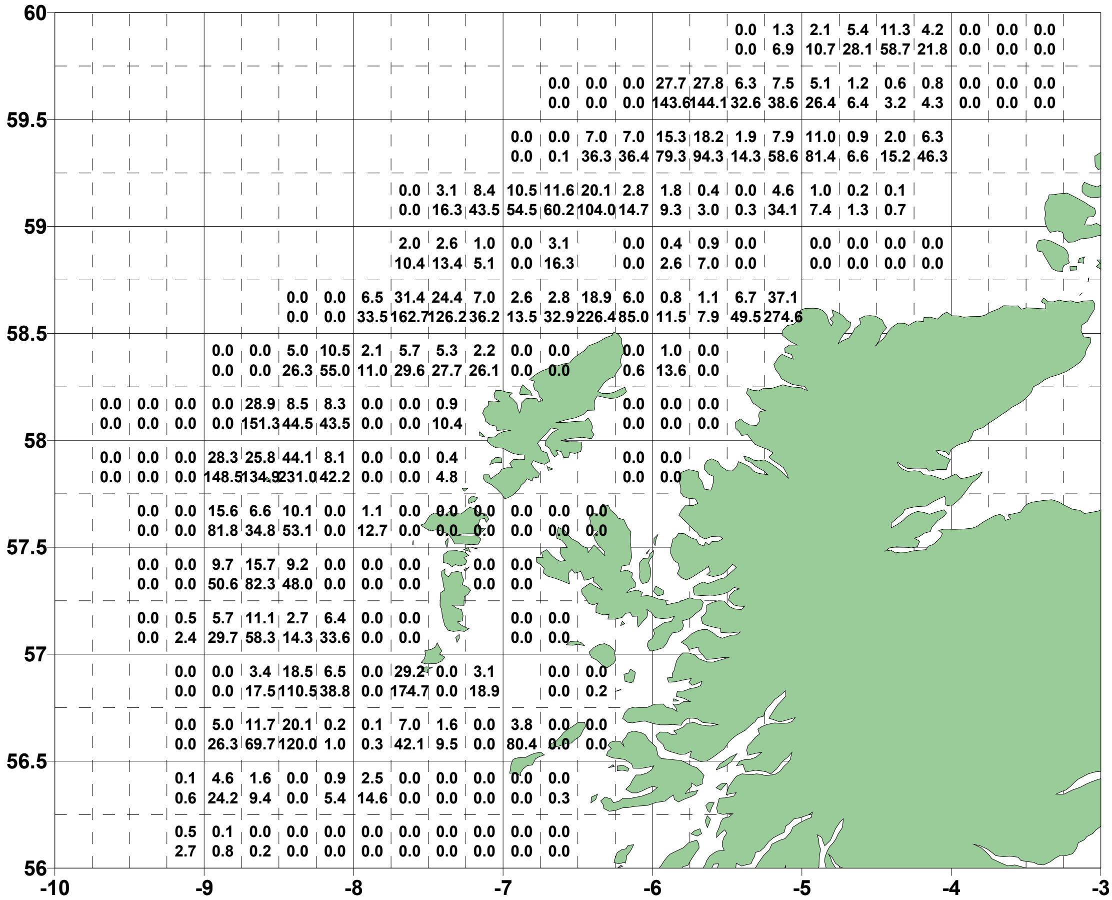

Figure 4. Post plot showing the herring numbers in millions (bottom) and biomass in thousands of tonnes (top) by quarter ICES rectangle obtained during the July 2003 west coast acoustic survey on MFV *Enterprise*.

Table 1. Simrad EK500 and analysis settings used on the July 2003west coast of Scotland herring acoustic survey on MFV *Enterprise*. Calibrations a) Loch Erribol 2 July; b) Loch Broom 12 July; c) Scapa Flow 20 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	1494 $m.s^{-1}$
Max. Power	2000 W
Equivalent two-way beam angle	-20.6 dB
Default Transducer Sv gain	26.5 dB
3 dB Beam width	7.1°
Calibration details	
TS of sphere	-42.36 dB
Range to sphere in calibration	9.8[a], 9.7[b], 9.9[c]
Measured NASC value for calibration	3195[a], 3030[b], 3061[c]
Calibration factor for NASCs	0.88[a], 0.81[b], 0.80[c]
Calibration constant for MILAP (optional)*	1..03 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 2. Details of the fishing trawls taken during the West Coast acoustic survey, July 20032; Trawl depth = depth (m) of headrope; Gear type P=pelagic; Duration of trawl (minutes); Total catch (number); Use H=used to qualify herring acoustic data, s= used to qualify sprat acoustic data (blank if neither).

Haul	Date	Latitude	Longitude	Time	Water Depth	Trawl depth	Gear type	Dura-tion	Use	Baskets
1	2/7	58° 30	5° 40 W	14:30	130	120	P	38	H	12
2	2/7	58° 20	6° 08 W	18:00	45	40	P	23		6
3	2/7	57° 49	5° 53 W	23:00	75	65	P	23		??
4	3/7	56° 55	6° 32 W	11:00	80	70	P	26		??
5	3/7	56° 52	6° 27 W	12:40	85	75	P	33	H	0.25
6	4/7	56° 08	9° 06 W	07:30	185	175	P	30	H	12
7	4/7	56° 32	7° 27 W	20:15	190	175	P	24		10
8	5/7	56° 39	8° 35 W	10:15	170	160	P	20	H	13
9	5/7	56° 37	7° 01 W	16:40	75	65	P	20		0
10	5/7	56° 41	7° 36 W	22:00	100	90	P	30	H	02
11	6/7	56° 42	7° 34 W	12:00	170	155	P	16		0
12	6/7	56° 49	8° 10 W	15:45	120	110	P	15	H	10
13	7/7	57° 04	8° 40 W	09:30	130	120	P	26	H	125
14	7/7	57° 12	9° 02 W	14:30	135	120	P	30		0
15	7/7	57° 12	8° 33 W	17:30	120	115	P	30	H	23
16	8/7	57° 27	8° 31 W	05:30	155	140	P	23	H	62
17	8/7	57° 27	9° 14 W	09:30	175	150	P	25		0
18	8/7	57° 42	8° 57 W	14:30	140	130	P	20	H	78
19	9/7	57° 55	8° 29 W	05:45	110	100	P	5	H	125
20	9/7	58° 05	8° 33 W	14:45	135	120	P	45	H	62
21	10/7	58° 19	8° 29 W	08:30	155	140	P	26	H	6
22	10/7	58° 27	7° 28 W	19:15	105	90	P	10	H	4
23	11/7	58° 39	7° 48 W	08:30	165	150	P	31	H	23
24	12/7	58° 32	6° 03 W	02:30	85	75	P	15	H	7
25	13/7	58° 22	6° 00 W	11:45	95	85	P	30	H	0.5
26	13/7	58° 39	6° 23 W	16:00	100	90	P	20	H	93
27	13/7	58° 41	7° 15 W	21:15	95	80	P	10	H	23
28	14/7	58° 49	7° 18 W	06:30	110	100	P	20	H	20
29	14/7	58° 55	7° 29 W	13:00	170	160	P	30	H	1
30	14/7	59° 04	6° 46 W	18:00	150	140	P	11	H	62
31	15/7	59° 04	5° 06 W	04:15	65	30	P	10		0
32	15/7	59° 11	5° 15 W	13:30	100	90	P	20	H	31
33	15/7	59° 11	6° 16 W	17:20	115	105	P	8	H	46
34	15/7	59° 11	6° 58 W	20:45	215	205	P	15		12
35	16/7	59° 23	5° 59 W	06:45	125	115	P	8	H	12
36	16/7	59° 23	5° 01 W	10:45	135	125	P	5	H	80
37	16/7	59° 38	4° 49 W	18:00	130	119	P	23	H	12

Table 2A.2. (cont) Details of the fishing trawls taken during the West Coast acoustic survey, July 2003; Trawl depth = depth (m) of headrope; Gear type P=pelagic; Duration of trawl (minutes); Total catch (number); Use H=used to qualify herring acoustic data, s= used to qualify sprat acoustic data (blank if neither).

Haul	Date	Latitude	Longitude	Time	Water depth	Trawl depth	Gear type	Dura-Tion	Use	Baskets
38	16/7	59° 38	5° 39 W	21:30	115	85	P	3	H	62
39	17/7	59° 27	5° 40 W	09:45	110	100	P	30	H	3
40	17/7	59° 42	5° 13 W	19:45	140	128	P	12	H	16
41	18/7	59° 60	4° 30 W	05:15	125	115	P	12	H	16
42	18/7	59° 57	4° 53 W	10:30	175	160	P	10	H	0.5
43	18/7	59° 57	4° 51 W	11:45	160	148	P	17		2
44	19/7	59° 38	3° 53 W	14:15	140	135	P	12	H	62
45	19/7	59° 52	3° 31 W	17:00	140	135	P	13	H	31

Table 3 Catch composition by trawl haul on the west coast herring acoustic survey. MFV *Enterprise* (1 - 20 July 2002).

	Haul	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Herring	*Clupea harengus*	1556	786	0	93	6	212	527	2155	0	5	0	5043	23183	2	4140	11904	1
Sprat	*Spratus spratus*	7	0	0	0	406	0	0	0	0	0	0	0	0	0	0	0	0
Mackerel	*Scomber scombrus*	76	0	0	0	0	26	14	229	13	0	0	60	0	1	0	155	0
Horse Mackerel	*Trachurus trachurus*	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0
European sandeel	*Ammodytes marinus*	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0
Smooth sandeel	*Gymnammodytes semisquamatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Greater sandeel	*Hyperoplus lanceolatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haddock	*Melanogrammus aegelfinus*	20	0	0	0	0	113	17	25	0	0	0	0	6	0	0	0	1
Whiting	*Merlangius merlangius*	100	0	0	0	0	0	18	15	0	0	0	0	0	0	0	0	0
Saithe	*Pollachius virens*	0	0	0	0	0	31	1	0	0	0	0	0	0	0	0	0	0
Norway pout	*Trisopterus esmarrki*	696	0	0	0	0	0	6	1	3	0	0	0	0	0	0	0	0
Blue whiting	*Micromesistius poutassou*	1040	0	0	0	0	4743	3007	120	0	05	0	60	2690	1	0	217	0
	Argentinia sphyraena	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Argentinia silus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lemon sole	*Microstomus kit*	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Grey gurnard	*Eutrigla gurnardus*	16	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
Red gurnard	*Chelidonichthys kumu*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Hake	*Merluccius merluccius*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spotted dogfish	*Scyliorhinus spp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blue mouth	*Helicolenus dactylopterus*	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0
	Ommastrephidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Squid	*Loligo forbesi*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3 (cont.) Catch composition by trawl haul on the west coast herring acoustic survey. MFV *Enterprise* (1–20 July 2002).

	Haul	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**
Herring	*Clupea harengus*	13533	23313	10726	969	6105	2918	120	130	40232	4290	11594	367	11656	0	7301	7291	0
Sprat	*Spratus spratus*	0	0	0	0	0	0	1180	201	0	0	0	0	0	0	0	0	0
Mackerel	*Scomber scombrus*	156	0	202	3	0	0	1920	66	0	0	248	0	0	0	610	0	0
Horse Mackerel	*Trachurus trachurus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
European sandeel	*Ammodytes marinus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Smooth sandeel	*Gymnammodytes semisquamatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Greater sandeel	*Hyperoplus lanceolatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haddock	*Melanogrammus aegelfinus*	0	0	0	0	0	3	17	14	0	0	0	0	0	0	0	0	0
Whiting	*Merlangius merlangius*	0	0	0	0	0	0	6	47	0	0	0	0	0	0	0	0	0
Saithe	*Pollachius virens*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Norway pout	*Trisopterus esmarrki*	0	0	0	0	0	0	0	84	0	0	0	0	0	0	0	0	0
Blue whiting	*Micromesistius poutassou*	0	0	0	60	0	2530	0	7	0	0	0	0	0	0	0	0	5952
	Argentinia sphyraena	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Argentinia silus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lemon sole	*Microstomus kit*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grey gurnard	*Eutrigla gurnardus*	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0
Red gurnard	*Chelidonichthys kumu*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hake	*Merluccius merluccius*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spotted dogfish	*Scyliorhinus spp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blue mouth	*Helicolenus dactylopterus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Ommastrephidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Squid	*Loligo forbesi*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3 (cont.) Catch composition by trawl haul on the west coast herring acoustic survey. MFV *Enterprise* (1 - 20 July 2002).

	Haul	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**
Herring	*Clupea harengus*	2146	19778	2340	10579	5782	2928	2797	56	0	9759	4118
Sprat	*Spratus spratus*	0	0	0	0	0	0	0	0	0	0	0
Mackerel	*Scomber scombrus*	90	0	0	0	186	0	0	0	2	0	124
Horse Mackerel	*Trachurus trachurus*	0	0	0	0	0	0	0	0	0	0	0
European sandeel	*Ammodytes marinus*	0	0	0	0	0	0	0	0	0	0	0
Smooth sandeel	*Gymnammodytes semisquamatus*	0	0	0	0	0	0	0	0	0	0	0
Greater sandeel	*Hyperoplus lanceolatus*	0	0	0	0	0	0	0	0	0	0	0
Haddock	*Melanogrammus aegelfinus*	0	0	0	0	0	0	0	0	0	0	0
Whiting	*Merlangius merlangius*	0	0	0	0	0	0	0	0	0	0	0
Saithe	*Pollachius virens*	0	0	0	0	0	0	0	0	0	5	0
Norway pout	*Trisopterus esmarrki*	0	0	0	0	5	0	0	0	0	0	0
Blue whiting	*Micromesistius poutassou*	0	0	0	0	0	0	0	0	6820	0	3255
	Argentinia sphyraena	0	0	0	0	0	0	0	0	0	0	0
	Argentinia silus	0	0	0	0	0	0	0	0	0	0	0
Lemon sole	*Microstomus kit*	0	0	0	0	0	0	0	0	0	0	0
Grey gurnard	*Eutrigla gurnardus*	0	0	0	0	0	0	0	0	0	0	0
Red gurnard	*Chelidonichthys kumu*	0	0	0	0	0	0	0	0	0	0	0
Hake	*Merluccius merluccius*	0	0	0	0	0	0	0	0	0	0	0
Spotted dogfish	*Scyliorhinus spp.*	0	0	0	0	0	0	0	0	0	0	0
Blue mouth	*Helicolenus dactylopterus*	0	0	0	0	0	0	0	0	0	0	0
	Ommastrephidae	0	0	0	0	0	0	0	0	0	0	0
Squid	*Loligo forbesi*	0	0	0	0	0	0	0	0	0	0	0

Table 4**.** Herring length frequency proportion by trawl haul by sub- area for west coast acoustic survey MFV *Enterprise* (1–20 July 2002). Length in cm, weight in g, TS=target strength in dB.

	I			II		III				IV				
L (cm)	24	25	mean	5	mean	8	10	12	mean	6	13	15	16	18
16		0.8	0.4											
16.5	0.8	0.8	0.8	16.7	16.7									
17	3.3	6.2	4.8	16.7	16.7									
17.5	7.5	14.7	11.1	50.0	50.0									
18	10.8	14.0	12.4											
18.5	16.7	11.6	14.1	16.7	16.7			0.1	0.0					
19	13.3	9.3	11.3											
19.5	22.5	5.4	14.0											
20	6.7	4.7	5.7											
20.5	10.0	0.8	5.4											
21	3.3	4.7	4.0											
21.5	1.7	3.1	2.4											
22	0.8	2.3	1.6											
22.5		2.3	1.2											
23		3.9	1.9					0.2	0.1					
23.5		3.1	1.6			0.3		1.1	0.5					
24	0.8	3.9	2.4			3.5	20.0	3.0	8.8					
24.5	0.8	2.3	1.6			0.3	20.0	6.6	9.0			0.4	0.3	
25		0.8	0.4			7.6	20.0	15.7	14.4	0.9	1.6	1.3	0.8	
25.5		1.6	0.8			9.8		18.9	9.6	2.8	2.4	6.5	0.8	1.2
26		2.3	1.2			17.6	20.0	23.2	20.3	6.1	10.8	11.3	8.9	1.7
26.5	0.8	1.6	1.2			13.6		13.9	9.2	10.8	18.4	16.1	17.7	5.5
27						19.5		10.0	9.9	22.2	29.7	28.7	26.8	14.7
27.5						13.0		5.2	6.1	17.5	18.1	21.7	19.5	22.5
28						9.0		1.6	3.5	17.5	12.1	8.7	12.2	25.6
28.5						4.4		0.2	1.5	14.6	5.2	3.5	9.1	17.0
29						0.8	20.0		6.9	4.7	1.8	1.3	2.6	9.5
29.5						0.3			0.1	1.9		0.4	1.0	1.7
30					0.3				0.1	0.9			0.3	0.3
30.5														0.3
31														
31.5														
32														
32.5														
33														
33.5														
34														
34.5														
35														
35.5														
Number	120	129		6	19101	2155	5	5048		212	23815	4140	11904	13533
length	19.7	20.4	20.0	17.9	17.9	27.1	26.2	26.3	26.5	28.0	27.6	27.5	27.7	28.3
weight	66	76	71	48	48	178	162	162	167	197	187	185	191	204
TS/ind	-45.3	-45.0	-45.1	-46.1	-46.1	-42.5	-42.8	-42.8	-42.7	-42.3	-42.4	-42.4	-42.3	-42.2
TS/kg	-33.5	-33.7	-33.6	-32.9	-32.9	-35.0	-34.9	-34.9	-34.9	-35.2	-35.1	-35.1	-35.1	-35.3

Table 4. (cont.) length frequency proportion by trawl haul by sub- area for west coast acoustic survey MFV *Enterprise* (1–20 July 2002). Length in cm, weight in g, TS=target strength in dB.

	IV (cont)				V		VI							
L (cm)	19	20	22	mean	26	mean	21	23	27	28	29	30	33	35
16														
16.5														
17														
17.5					0.4	0.4								
18					3.7	3.7								
18.5					7.2	7.2								
19					13.4	13.4								
19.5					19.3	19.3								
20					16.0	16.0								
20.5					8.5	8.5								
21					7.7	7.7								
21.5					3.1	3.1								
22					1.5	1.5								
22.5					0.7	0.7								
23					1.4	1.4			0.3					0.2
23.5					3.0	3.0							0.1	0.4
24			0.3	0.0	3.8	3.8			0.8	0.3		0.1	0.3	0.2
24.5			1.3	0.3	2.5	2.5			1.4	0.3		0.1	0.2	1.1
25	0.3		3.6	1.1	3.0	3.0		0.1	4.0	1.6		2.4	1.6	2.4
25.5	1.1	2.6	8.2	3.2	1.8	1.8		0.1	6.7	2.7		2.9	2.2	3.1
26	6.7	4.9	17.0	8.4	1.2	1.2	2.2	1.2	15.5	10.4		13.7	5.7	7.2
26.5	19.6	16.8	20.7	15.7	0.8	0.8	5.9	3.3	22.2	19.3	2.2	14.5	16.7	11.5
27	28.4	22.8	24.6	24.7	0.3	0.3	12.7	15.7	23.8	26.5	8.4	22.9	22.7	21.6
27.5	20.1	21.7	12.8	19.2	0.3	0.3	18.9	19.2	13.9	20.9	15.0	17.6	22.1	17.2
28	18.0	17.6	8.5	15.0	0.2	0.2	22.9	28.4	6.4	11.2	21.8	10.5	14.2	17.2
28.5	4.6	8.7	2.6	8.2	0.1	0.1	20.4	17.4	2.7	5.1	20.7	7.6	6.0	7.4
29	1.1	3.5		3.1			13.9	10.7	1.4	1.1	17.2	6.3	4.4	5.0
29.5		1.4		0.8			2.5	2.9	0.8	0.5	8.7	0.8	2.2	3.0
30	0.3		0.3	0.3			0.6	0.9			3.0	0.4	0.8	1.5
30.5				0.0				0.2		0.3	1.6	0.1	0.1	0.6
31					0.0	0.0					0.5		0.3	0.4
31.5											0.8			
32													0.2	0.2
32.5														
33														
33.5														
34													0.1	
34.5														
35														
35.5														
Number	23316	10726	610		40231		969	2920	4294	11594	367	11658	7291	541
length	27.7	27.8	27.2	27.7	21.2	21.2	28.4	28.4	27.2	27.5	28.9	27.7	27.8	27.9
weight	190	194	179	191	84	84	207	207	180	187	217	190	191	194
TS/ind	-42.4	-42.3	-42.5	-42.3	-44.6	-44.6	-42.1	-42.1	-42.5	-42.4	-42.0	-42.4	-42.3	-42.3
TS/kg	-35.1	-35.2	-35.0	-35.1	-33.9	-33.9	-35.3	-35.3	-35.1	-35.1	-35.4	-35.1	-35.1	-35.2

Table 4. (cont.). Length frequency proportion by trawl haul by sub- area for west coast acoustic survey MFV *Enterprise* (1 - 20 July 2002). Length in cm, weight in g, TS=target strength in dB.

	VI(cont)										VII		
L (cm)	36	37	38	39	40	41	42	44	45	mean	32	1	mean
16													
16.5													
17												0.4	0.2
17.5												0.1	0.1
18												0.3	0.1
18.5													
19												0.3	0.1
19.5												0.6	0.3
20												0.3	0.1
20.5												0.3	0.1
21													
21.5											0.5	0.3	0.4
22											3.7	2.6	3.1
22.5								0.7	0.3	0.1	5.7	4.4	5.0
23	1.6	0.5						0.9	1.3	0.3	13.8	12.3	13.1
23.5	2.1	1.5		0.8		0.8		1.0	1.5	0.5	16.2	14.1	15.2
24	5.3	5.3		2.1	0.1	1.5		3.3	1.7	1.2	18.8	19.0	18.9
24.5	11.5	7.9		4.8	0.4	2.9		2.6	2.2	2.1	10.9	11.3	11.1
25	19.9	13.7		9.4	0.5	6.7		4.7	2.4	4.1	10.3	9.5	9.9
25.5	15.0	14.0	1.5	11.8	1.9	11.3		5.3	4.1	4.9	6.3	3.3	4.8
26	19.2	15.4	4.1	17.7	9.4	14.5		7.4	5.5	8.8	6.5	6.7	6.6
26.5	9.5	12.8	14.9	21.4	14.3	15.3		9.9	8.6	11.9	3.1	5.7	4.4
27	9.9	15.4	24.0	16.4	29.1	19.2		13.8	13.4	17.4	1.5	2.8	2.2
27.5	2.5	6.3	21.4	9.9	21.2	10.9	8.9	9.6	12.1	14.6	1.1	2.6	1.9
28	2.5	5.0	17.0	4.0	14.0	7.8	10.7	11.2	12.6	12.8	0.6	1.8	1.2
28.5	0.5	1.0	8.2	1.1	5.8	2.3	12.5	8.3	9.9	8.1	0.4	0.8	0.6
29	0.2	0.9	4.1	0.5	1.5	1.9	14.3	8.2	7.9	5.8	0.1	0.4	0.3
29.5	0.1	0.2	1.9		0.3	2.5	17.9	5.5	4.5	3.2	0.1		0.0
30	0.1	0.1	1.5		0.7	0.5	10.7	3.1	4.2	1.7	0.1	0.3	0.2
30.5	0.1	0.1	0.5		0.2	0.6	7.1	1.8	2.8	0.9	0.1		0.1
31			0.4		0.4	0.8	3.6	1.8	2.1	0.6			
31.5			0.2		0.3	0.4	10.7	0.3	1.6	0.8			
32			0.2			0.3	1.8	0.2	0.7	0.2			
32.5						0.1	1.8	0.2	0.2	0.1			
33			0.1					0.1	0.2	0.0			
33.5								0.2	0.2	0.0			
34								0.1		0.0			
34.5													
35													
35.5													
Number	23316	10726	10581	5784	2928	2797	56	9528	4120		7300	1556	
length	27.7	27.8	28.0	26.8	27.7	27.2	30.0	27.8	28.1	27.8	24.7	24.9	24.8
weight	190	194	197	171	191	181	245	195	202	193	133	137	135
TS/ind	-42.4	-42.3	-42.3	-42.6	-42.3	-42.5	-41.7	-42.3	-42.2	-42.3	-43.3	-43.3	-43.3
TS/kg	-35.1	-35.2	-35.2	-35.0	-35.1	-35.1	-35.6	-35.2	-35.3	-35.2	-34.6	-34.6	-34.6

Table 5. Age/maturity-length key for herring (numbers of fish sampled MFV *Enterprise* (1 - 20 July 2002))

	Number at age / maturity										
Length (cm)	1	2I	2M	3I	3M	4	5	6	7	8	9+	Grand Total
16.0	1											1
16.5	1											1
17.0	4											4
17.5	4											4
18.0	4											4
18.5	2											2
19.0	4											4
19.5	4											4
20.0	7											7
20.5	3											3
21.0	7											7
21.5	8	3										11
22.0		10	2									12
22.5	2	8	5			1						16
23.0	1	10	12		1							24
23.5		15	16	1	3							35
24.0		11	31	1	3	2						48
24.5		6	33	1	9							49
25.0		5	41		12	1				1		60
25.5		5	26		26	8	1					66
26.0		4	37	1	107	75	2					226
26.5		3	21		101	99	2	2	1		1	230
27.0			9		55	125	6	2	2			199
27.5			2		44	117	15	6	12	5	2	203
28.0					33	104	15	20	43	12	2	229
28.5					19	74	23	12	59	19	12	218
29.0			1		16	38	16	20	57	15	14	177
29.5					11	36	7	10	32	12	13	121
30.0			1		3	20	11	4	23	11	17	90
30.5			1		2	9	3	4	14	8	7	48
31.0					3	5	2	9	12	4	5	40
31.5						1	4		14	8	9	36
32.0					1	2	2	2	6	4	4	21
32.5							1			2	3	6
33.0									1		2	3
33.5						1	1		1		2	5
34.0											1	1
34.5												
35.0												
35.5											1	1
Grand Total	52	80	238	4	449	718	111	91	277	101	95	2216

Table 6. Mean length, mean weight, biomass (thousands of tonnes) and numbers (millions) breakdown by age and maturity obtained during the MFV *Enterprise* 2003 herring acoustic survey.

Total area						
Age (ring)	Mean Length (cm)	Mean Weight (g)	Number×10^6	%	Biomass×10^3 T	%
1A	19.13	64.54	471	9	30.39	3
2I	23.57	122.31	263	5	32.21	4
2M	24.81	143.24	810	15	115.98	13
3I	24.45	136.59	3	0	0.36	0
3M	26.53	176.13	1014	19	178.60	20
4A	27.19	190.13	1685	32	320.32	36
5A	27.79	203.67	210	4	42.68	5
6A	28.16	212.22	146	3	30.91	3
7A	28.32	215.87	407	8	87.80	10
8A	28.55	221.54	135	3	29.92	3
9+	38.71	226.06	89	2	20.04	2
Mean	25.98	169.99				
Total			5231	100	889.20	100
Immature			466	14	31.36	7
Mature			3918	86	745.07	96

Appendix IIB: Denmark

Acoustic Herring Survey report for RV "DANA"

27 June 2003 – 10 July 2003

Bo Lundgren[1], Lotte Worsøe Clausen[2], Torben Filt Jensen[3]
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[3]Dept. of IT and Technical Support, Hirtshals, Denmark

1. INTRODUCTION

Since 1991 the Danish institute for Fisheries Research (DIFRES) has participated in the ICES co-ordinated herring acoustic survey of the North Sea and adjacent waters with the responsibility for the surveying the Skagerrak and Kattegat area.

The actual 2003-survey with R/V DANA, covering the Skagerrak and Kattegat, was conducted in the period 30 June to 10 July 2003, while some tests carried out 27June and calibration was done during 28–29. June

2. SURVEY

2.1 Personnel

During calibration 28–29/6–2003	
Bo Lundgren (cruise leader)	HFI
Torben Filt Jensen (assisting cruise leader)	ITT
Lotte A. Worsøe Clausen	HFI
Mogens R. Sørensen	ITT
Thyge Dyrnesli	ITT
Bo Tegen Nielsen	ITT
During acoustic monitoring 30/6–10/7–2002	
Bo Lundgren (cruise leader)	HFI
Lotte A. Worsøe Clausen (assisting cruise leader)	HFI
Torben Filt Jensen (assisting cruise leader)	ITT
Uffe Nielsen	HFI
Lise Sindahl	HFI
Tommy Henriksen	HFI
Mette Sørup	HFI
Rasmus F. Jensen	HFI
Bo Tegen Nielsen	ITT

HFI = Dept for Marine Fisheries, DIFRES, Denmark
ITT = Dept. of IT and Technical Support, DIFRES, Denmark

2.2 Narrative

R/V Dana left Hirtshals on 27 June 2003 at 12.30 for the calibration site in the Gullmar Fjord in Sweden. Some tests of new equipment were to be carried out underway. After about 1 hour's sailing a seawater cooler supply pipe broke, which made it necessary to back to harbour for repair. A new departure was made at 18.30 after which detailed functional tests were carried out underway across Kattegat until about 06.00 the next morning. Some tests of the echosounder equipment and some preparations for the calibration next day were carried out as well. A problem with a leaky connector in a 38 kHz transducer paravane was found and corrected. The problem showed up only when paravane was in the water.

R/V Dana was back in harbour on 30 June 2003 at 06.00 for exchange of scientific personnel and left again at 12.00 on June 30 with a westerly course to start the survey. The survey work (acoustic integration) started at 20.00 on the position 57º 53´ N 06º 56´ E in the western part of the Skagerrak. Totally the survey covered about 1600 nautical miles mainly using the 38 kHz paravane transducer running at depths of 4 – 6 m depending on the sea state and sailing direction relative to the waves.

The survey ended in Hirtshals on 10 July 2003 at 11.00 hour.

2.3 Survey design

The survey was carried out in the Skagerrak, east of 6° E, and Kattegat (Figure IIB.1). The area is split into 7 sub-areas (Figure IIB.2). The survey was started in the northwest corner of the survey area. In principal the survey design were planned with north-south survey tracks with a spacing of 10–15 NM in the area west of 10°E. Due to the fixed time periods for fishing this structure could not be kept. This gave a non-standard survey track in the western part of Skagerrak. Along the Swedish coast the transects were made east west with a spacing of 10 NM. In Kattegat the survey track were made in a zigzag way due to depth curves and ship traffic.

2.4 Calibration

Both the Simrad EY 500 38 kHz and EY500 120 kHz echosounders were calibrated with standard copper spheres (60 and 30.5 mm, respectively) at Bornö, Sweden 28–29 June 2003. See Table IIB.1.

2.5 Acoustic data collection

Acoustic data was sampled using mainly the SimradEY500 38 kHz echosounder with the transducer in a towed body (Type ES 38). The towed body runs running at approx. 3 m depth in good weather and down to about 6 -7 m as needed when breaking waves occur. The speed of the vessel during acoustic sampling was 8 – 10 knots. Acoustic data was collected all 24 hours. The sampling unit was 1 NM. Raw data is collected and stored. For the survey purpose raw data is pre-integrated into 1m meter samples for each ping and stored as files on harddisk for each 1 nm interval. Integration is conducted from 3 m to usually max 300 m below the transducer. During trawl hauls the towed body is taken aboard and the echosounder run on the hull transducer. The data collected during the hauls has not been included in the integration data. Some 120 kHz data were also collected during trawl hauls.

2.6 Biological data - fishing trawls

Trawl hauls were carried out during the survey for species identification. Pelagic hauls (Figure IIB.3) were carried out using a FOTÖ trawl (16 mm in the codend) while demersal hauls (Figure IIB.3) were carried out using an EXPO trawl (16 mm in the codend). Trawling was carried out in the time intervals 1000 to 1600h and 2000 to 0400h UTC (Table **IIB.**2). The trawling strategy was made in a way that all dept areas was covered with in each geographical strata (see Figure **IIB**.2). In the deeper areas mid water hauls were made to identify until which depth herring will be found. 1hour hauls were used as a standard during the survey.

The fish caught were sorted in to species, length distribution and weight for each species were recorded. The fish were measured to nearest 0.5 cm total length below and the weight to nearest 0.1g wet weight. In each trawl haul 10 herring per 0.5 cm length class were sampled for determination of age, race (North Sea autumn spawners or Baltic Sea spring spawmers) and maturity. Micro-structure formed during the larval period were used for the discrimination of herring race. Maturity was determined according to an 8-stage scale as also used by Scotland (see Survey Manual App IV.

2.7 Hydrographic data

CTD profiles with a Seabird 911 were made immediately before or after each trawl haul. Salinity and temperature were measured continuously during the cruise at an intake at about 5 m depth. Data is stored together with position and weather data in the vessel's general information system The distribution of CTD stations is shown in Figure IIB.4.

2.8 Data analysis

Scrutiny of the acoustic data is done for each mile, using special judging software, mostly deleting layers and/or intervals with interference from wave- or ship wake-bubbles or rarely bottom-integration. In areas with heavy abundance of jellyfish or zooplankton, usually krill, manually adjustable thresholds were applied separately to each layer to suppress background echoes

For each sub area the mean back scattering 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 is assumed to be in proportion to the contribution of the given species in the trawl hauls. Therefore, the relative density of a given species is estimated by subarea using the species composition in the trawl hauls. The nearest trawl hauls are allocated to subareas with uniform depth strata. The length-race and length-age distributions for herring are assumed to be in accordance with the length-race and length-age distributions in the allocated trawl hauls.

Length-weight relationships by race for the herring were made based on the single fish sampled in each haul and frozen for later for micro-structure analysis of the otolith after the cruise.

3. RESULTS and DISCUSSION

3.1 Acoustic data

The total number of acoustic sample units at 1 NM used in the stock size calculation is about 1300. Herring and sprat was not observed in mid-water trawl hauls at depths below 150 meters. Therefore, layers below 150 meter were excluded from the estimation.

3.2 Biological data

33 hauls were conducted (15 surface hauls, 3 mid water hauls and 14 bottom hauls (Figure IIB.2 and Tables IIB2 and IIB.3.). The total catch was 14,297 kg with a mean catch at 447 kg. Herring was present in 26 of the hauls and was the dominant catch in the fishery with a total catch at 3,534 kg. No herring was present in hauls below 150 m depths. Blue whiting, whiting, saithe, Norway pout, haddock and mackerel were the most common among the remaining species with a total catch at 1,177 kg, 743 kg, 599 kg, 525 kg, 341 kg and 175 kg respectively. They were mainly taken in the bottom and pelagic hauls, while mackerel and garfish were taken in surface hauls. Jellyfish and krill were sometimes present in high quantities in the catches totally almost 5 tonnes and 1,5 tonnes respectively. In the southern Kattegat totally 240 kg of sprat was taken.

Based on the single fish sampled in each haul for micro-structure analysis of the otolith the maturity by age key was made for both North Sea herring and Western Baltic herring as given in the text table below. In accordance with the survey manual both North Sea autumn spawners and Baltic spring-spawners at maturity state 3 and up have been considered as mature. The following constants have been used to split he catch.

North Sea autumn spawners:

WR	0im	1im	2im	2ma	3im	3ma	4	5
%	100	100	94	6	91	9	100	100

Western Baltic spring spawners:

WR	0im	1im	1ma	2im	2ma	3im	3ma	4	5	6	7	8	9+
%	100	100	0	99	1	96	4	100	100	100	100	100	100

The total catch during the survey was about 14.3 tons of which about one third was jellyfish with a mean catch of 450 kg. For herring the total catch was 3.5 tons which is clearly lower than previous years.

3.3 Biomass estimates

The total herring biomass estimate for the survey is 264,000 tonnes of which 51% or 141,000 tonnes is North Sea autumn spawning herring and 49 % or 122,000 tonnes is Western Baltic spring spawning herring.

The age composition and mean weight per age and mean length per age for the two herring stock components in the survey area are given in Table IIB.5

Stratum overview Acoustic Herring Survey R/V Dana Cruise 04/03 July 2003

Stratum Nr	Stratum ID	Stratum Nm^2	Number of logs	Nr hauls in stratum	Nr hauls allocated from neighbour strata	Total hauls used
3	580E06	209	35	1	0	1
4	570E06	3600	320	6	5	11
5	580E08	1822	108	7	2	9
6	570E08	3406	186	5	9	14
7	C	988	65	2	2	4
8	D	1837	255	7	2	9
9	E	5228	296	4	2	6

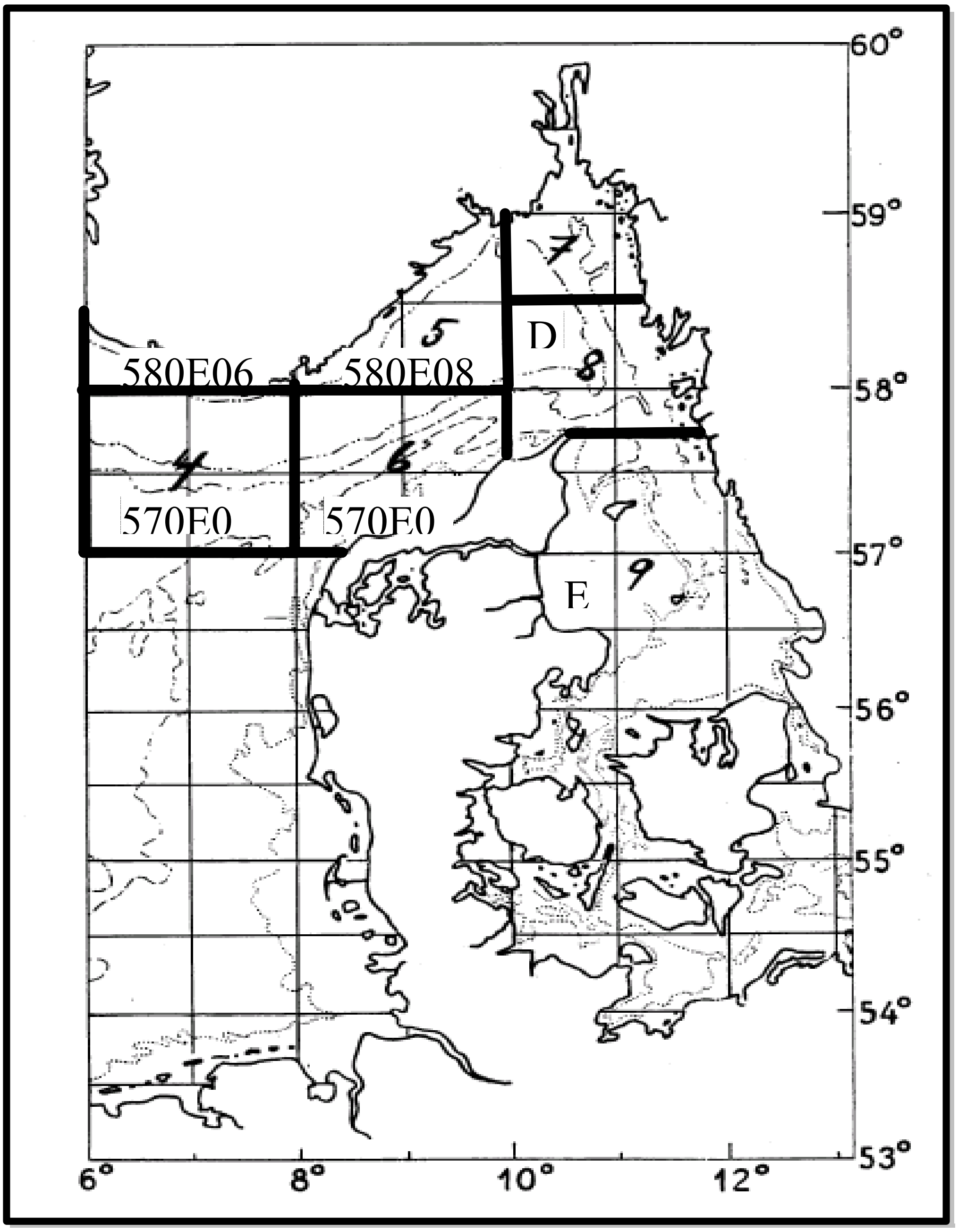

Figure IIB.1. Map of the eastern North Sea, Skagerrak and Kattegat showing the sub areas used in the estimation during the July Danish acoustic survey of R/V Dana 2003.

Cruise track and stations during the Acoustic Herring Survey R/V Dana Cruise 04/03 July 2003

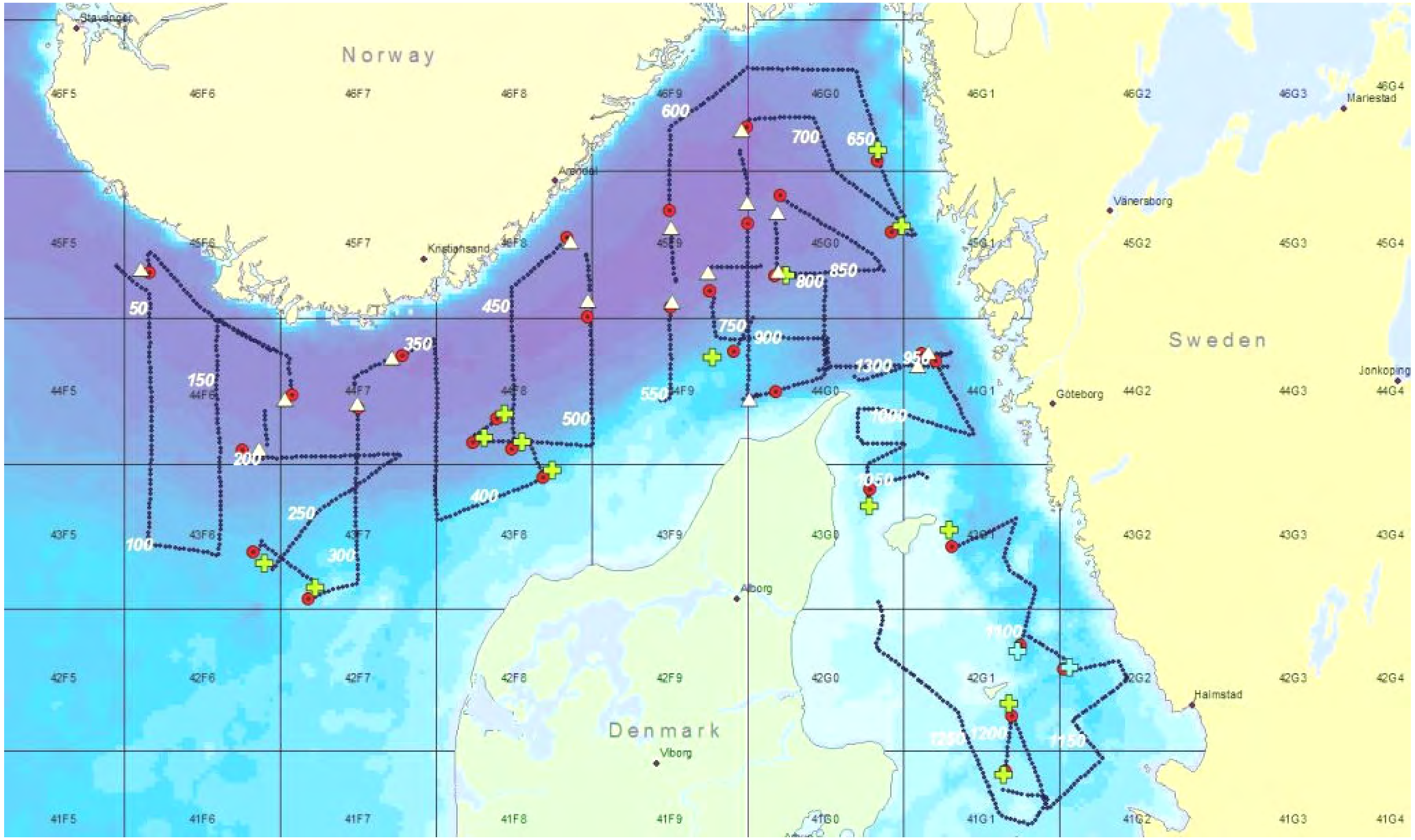

Figure IIB.2. Map of the eastern North Sea, Skagerrak and Kattegat showing cruise track, the location of CTD

stations ● and the location of trawl hauls during the July 2003 Danish acoustic survey (Fotö hauls ▲ are pelagic and Expo hauls ╬ are demersal, White numbers cumulative sailed distance along the track in nm).

Bathymetry from:
The MAST project DYNOCS MAST II contract No MAS2-CT94–0088

Density in numbers of herring during the Acoustic Herring Survey R/V Dana Cruise July 2003

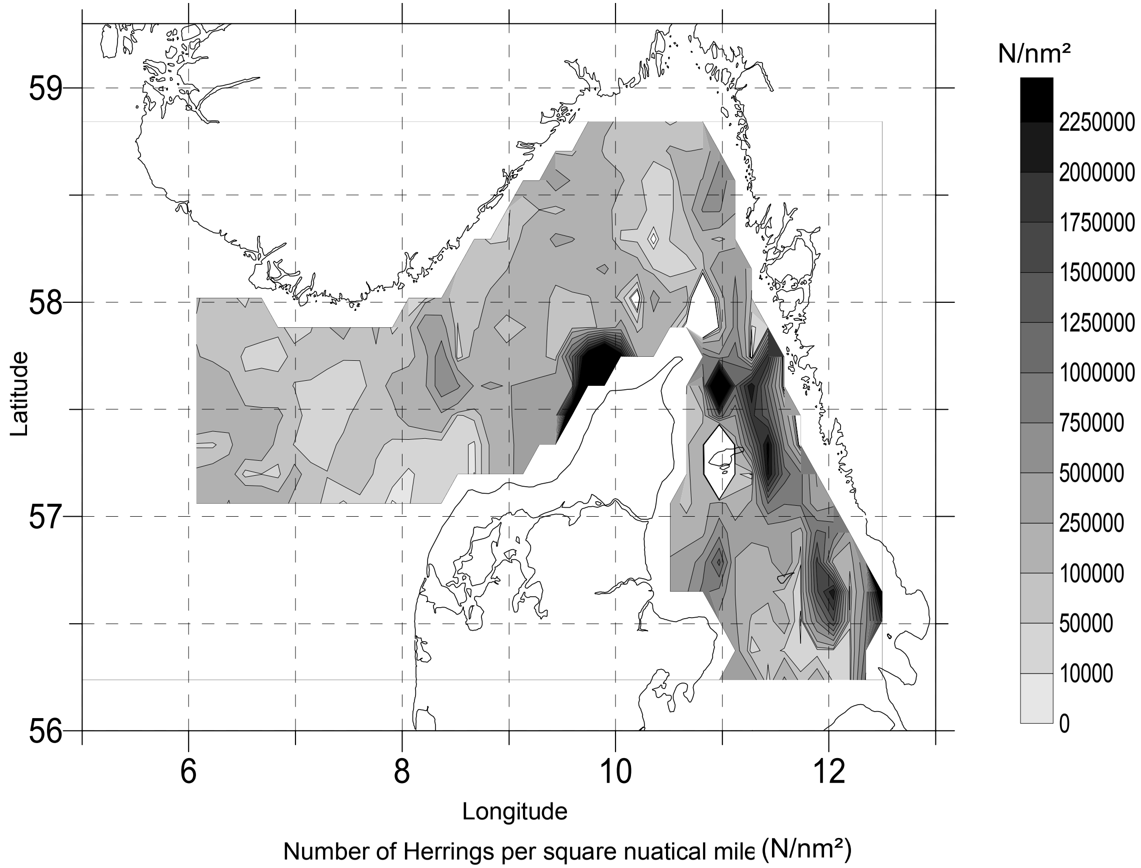

Figure IIB.3.a Contoured density (N/nm²) of herring from the July 2003 Danish acoustic survey in the eastern North Sea, Skagerrak and Kattegat.

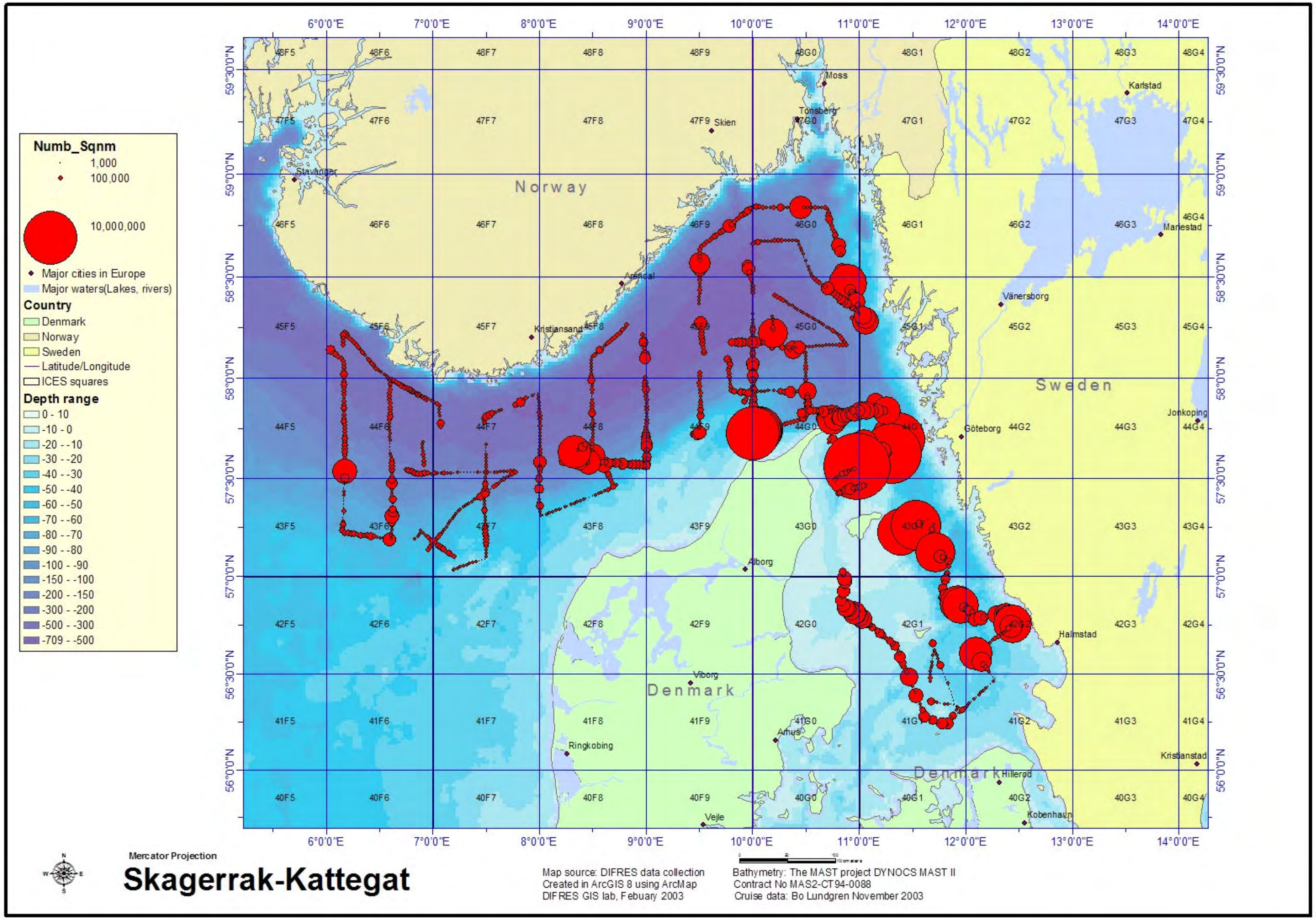

Figure IIB.3.b Herring density (in numbers per nm²) along the track of the July 2003 Danish acoustic survey in the eastern North Sea, Skagerrak and Kattegat.

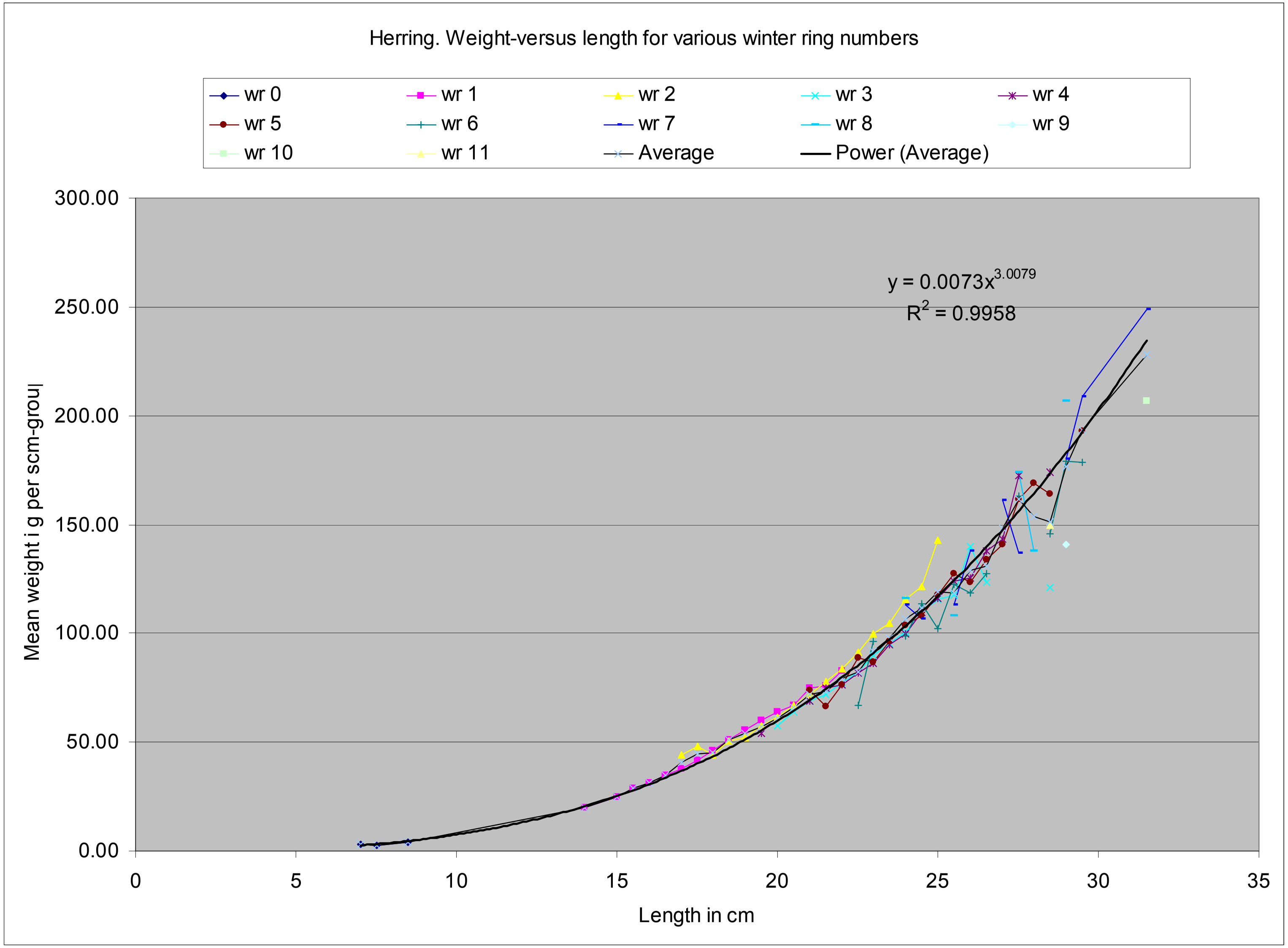

Figure IIB.4.a Length weight relationship by winter ring numbers for herring from the July 2003 Danish acoustic survey.

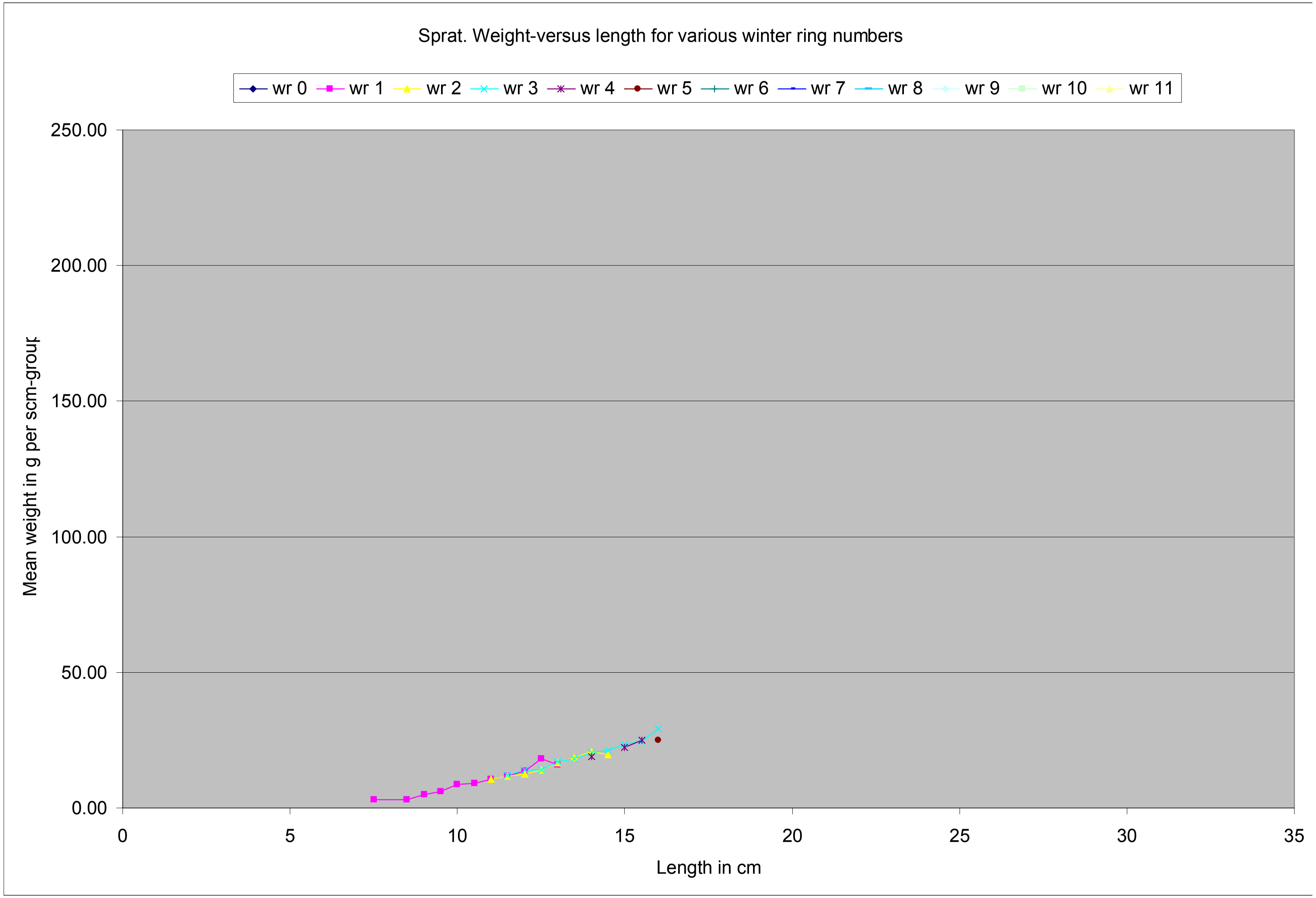

Figure IIB.4.b Length weight relationship by winter ring numbers for sprat from the July 2003 Danish acoustic survey.

Table IIB.1. Simrad EY500 and analysis settings used during the Acoustic Herring Survey R/V Dana Cruise July 2003.

Transceiver Menu	
Frequency	38 kHz
Sound speed	1498 m.s^{-1}
Max. Power	2000 W
Equivalent two-way beam angle	-20.5 dB
Default Transducer Sv gain	25.13 dB
3 dB Beamwidth	6.6°
Calibration details	
TS of sphere	-33.6 dB
Range to sphere in calibration	8.20
Measured NASC value for calibration	26500
Calibration factor for NASCs	0.844
Log Menu	
Distance	1,0 n.mi. using GPS-speed
Operation Menu	
Ping interval	1 s external trig
Analysis settings	
Bottom margin (backstep)	1.0 m
Integration start (absolute) depth	9 m
Range of thresholds used	-70 dB

Table IIB.2. Trawl hauls during the Acoustic Herring Survey R/V Dana Cruise July 2003.

Haul no.	Date dd-mm-yyyy	UTC Time	Sun time	ICES Square	Latitude N	Longitude E	Trawl	Catch depth m	Mean Bottdepth M	Total catch Kg	Main Species	Trawling speed Kn	Trawling duration min,	Wind speed m/s	Sea state
36	30–06–2003	23:23:00	23:47	45F5	58 11.18	06 06.23	FOTÖ	Surface	317	232.866	Blue Whiting, Herring	4.6	60	11	4
190	01–07–2003	21:33:00	22:01	44F7	57 41.6	06 55.1	FOTÖ	Surface	332	325	Herring, Mackerel, Blue Whiting	3.8	60	10	4
204	02–07–2003	00:26:00	00:53	44F7	57 32.93	06 46.32	FOTÖ	145	203	104.332	Saithe, Blue Whiting	3.3	60	8	3
280	02–07–2003	10:33:00	11:00	43F6	57 11.5	06 49.8	EXPO	Bottom	65	93	Haddock, Cod, Whiting	3.5	60	8	3
303	02–07–2003	14:14:00	14:42	43F7	57 01.9	07 10.9	EXPO	Bottom	33	113	Gurnard, Dab	3	60	8	2
354	02–07–2003	21:24:00	21:54	44F7	57 45.9	07 29.7	FOTÖ	Surface	416	300	Krill, Blue Whiting, Herring, Jellyfish	3.6	60	3	1
368	03–07–2003	00:25:00	00:55	44F7	57 52.6	07 47.5	FOTÖ	Surface	510	252	Krill, Herring, Jellyfish	3.6	60	6	2
445	03–07–2003	10:21:00	10:56	43F8	57 27.3	08 41.0	EXPO	Bottom	37	390	Jellyfish, Whiting, juvenile whiting, haddock, Norway pout	3.1	60	5	2
456	03–07–2003	13:17:00	13:51	44F8	57 33.3	08 28:8	EXPO	Bottom	101	695	Norway pout, Haddock, Saithe	3.3	60	9	2
510	03–07–2003	21:31:00	22:06	45F8	58 13.4	08 57.0	FOTÖ	Surface	412	362	Herring, Mackerel, Jellyfish	3.5	60	10	4
525	04–07–2003	00:18:00	00:53	45F8	58 00.3	08 58.5	FOTÖ	Surface	594	272	Herring, Krill, Jellyfish	3.7	60	11	3
585	04–07–2003	10:32:00	11:05	44F8	57 34.5	08 14.3	EXPO	Bottom	173	597	Blue Whiting, Saithe, Herring	2.6	60	6	2
600	04–07–2003	13:59:00	14:32	44F8	57 39.4	08 23.2	EXPO	Bottom	213	233	Blue Whiting, Shrimp, Haddock	2.9	60	4	2
658	04–07–2003	21:25:00	22:03	45F9	58 06.8	09 32.7	FOTÖ	Surface	483	123.247	Herring, Mackerel, Blue Whiting	3.7	60	3	1
675	05–07–2003	00:17:00	00:55	45F9	58 21.7	09 30.6	FOTÖ	Surface	619	174.533	Herring, Jellyfish, Krill, Garfish	3.8	60	3	0
752	05–07–2003	10:25:00	11:08	46G0	58 31.6	10 50.5	EXPO	Bottom	87	1542	Norway pout, Jellyfish, Saithe, Herring	2.9	60	4	0
770	05–07–2003	14:08:00	14:51	45G0	58 17.0	10 55.7	EXPO	Bottom	113	474	Krill, Norway pout, Saithe	3.1	60	2	1
826	05–07–2003	21:28:00	22:07	46F9	58 34.6	09 57.0	FOTÖ	Surface	471	232	Krill, Herring, Jellyfish	3.5	60	4	1
840	06–07–2003	00:18:00	00:58	45G0	58 19.6	09 59.9	FOTÖ	Surface	473	164.846	Krill, Herring, Jellyfish, Garfish	3.6	60	1	0
925	06–07–2003	10:26:00	11:07	45G0	58 08.6	10 10.6	EXPO	Bottom	195	488	Saithe, Blue Whiting, Shrimp	3.2	60	5	1
940	06–07–2003	13:54:00	14:34	45G0	58 24.5	10 12.2	FOTÖ	150	460	105	Lumpsucker, Saithe, Jellyfish, Krill	3.3	60	3	0
990	06–07–2003	21:22:00	22:02	45G0	58 10.2	10 06.1	FOTÖ	Surface	239	132	Krill, Herring, Jellyfish, Garfish	3.5	60	1	0
1005	07–07–2003	00:19:00	00:58	45F9	58 05.7	09 45.12	FOTÖ	Surface	417	252	Krill, Herring, Jellyfish, Garfish	3.8	60	0	0
1080	07–07–2003	10:23:00	11:03	44G0	57 44.7	10 09.6	FOTÖ	23	82.5	20	Jellyfish, old fish from trawl	3.2	60	14	6
1105	07–07–2003	13:58:00	14:37	44F9	57 53.1	09 53.2	EXPO	Bottom	59	210	Herring, juvenile whiting, haddock, Norway pout	2.9	60	13	5
1167	07–07–2003	21:19:00	22:03	44G1	57 53.3	11 16.9	FOTÖ	Surface	75	410	Herring, Jellyfish	3.3	44	12.5	5
1183	08–07–2003	00:17:00	01:01	44G1	57 50.7	11 06.0	FOTÖ	Surface	50	752	Herring	3.6	60	12	5
1265	08–07–2003	10:18:00	11:01	43G0	57 24.8	10 46.9	EXPO	Bottom	38	281	Herring, Bullrout	3.5	60	3	1
1293	08–07–2003	14:22:00	15:07	43G1	57 13.0	11 18.5	EXPO	Bottom	29	1612	Herring, juvenile whiting, sprat	3.2	60	5	1
1342	08–07–2003	21:19:00	22:05	42G1	56 54.4	11 46.4	EXPO	Surface	51		JELLYFISH; trawl emptied	3.4	30	9	3
1360	09–07–2003	00:16:00	01:04	42G2	56 47.5	12 01.7	EXPO	Surface	40	2320	JELLYFISH, herring	3	60	3	2
1445	09–07–2003	10:17:00	11:03	42G1	56 37.1	11 41.5	EXPO	Bottom	31	410	Sprat, Herring, Whiting	3.3	60	10	4
1462	09–07–2003	13:30:00	14:16	41G1	56 22.1	11 37.1	EXPO	Bottom	26	646	Herring, Jellyfish, Whiting, Sprat	2.8	60	9	4

Table IIB.3. Trawl haul species composition in kg during the Acoustic Herring Survey R/V Dana Cruise July 2003.

Haul type (**s**urface, **p**elagic, **b**ottom)		**s**	**s**	**p**	**b**	**b**	**s**	**S**	**b**	**b**	**s**	**s**	**b**	**B**	**s**	**s**	**b**	**b**	**s**
Fishing depth		Surface	Surface	145	Bottom	Bottom	Surface	Surface	Bottom	Bottom	Surface	Surface	Bottom	Bottom	Surface	Surface	Bottom	Bottom	Surface
Strata		3	4	4	4	4	4	4	6	6	5	5	6	6	5	5	7	8	5
Haul		36	190	204	280	303	354	368	445	456	510	525	585	600	658	675	752	770	826
Trawl catch, kg		232.9	325	104.3	92.9	113	300	252	390	695	362	272	597	233	123.2	174.5	1542	474	232
Vahl's eelpout	*Lycodes vahli*												0.1						
Anchovy	*Engraulis encrasicolus*						0.1												
Squid	*Loligo spp.*				0.7				0.2										
Blue whiting	***Micromesistius poutassou***	71.3	3.8	32.4			99.5	4.4			1.9	3.3	555.5	157.5	5.4	0.8		1.3	
Sprat	***Sprattus sprattus***																		
Common weaver	*Trachinus draco*							0.1								0.1			
Dragonet	*Calllionymus spp.*																		
Poor cod	*Trisopterus minutus*																		
Catfish	*Anarhichas lupus*				7.5														
Fourbeard rockling	*Enchelyopus cimbrius*													0.8					
Horse mackerel	***Trachurus trachurus***								0.8										
Long rough dab	*Hippoglosides plattessoides*				0.3	0.1				1.6				1.7			0.2		
Garfish	***Belone belone***	13.9	7.6				2.8	1.0			5.1	3.7			1.7	10.8			3.2
Whiting	***Merlangius merlangus***	0.2	0.2		8.2		0.3	0.8	34.2	29.3		0.3	0.1		0.7	0.3	36.7	1.0	0.5
Invertebrates		93.0	26.0			59.2	63.8	62.9	326.2	1.3	103.8	50.9		8.5	69.2	60.0	518.7		
Dab	*Limanda limanda*				2.4	15.0			5.6										
Norway lobster	*Nephrops norvegicus*													0.2			0.3	0.2	
Gurnard	*Trigala spp.*				0.4	38.2			0.4										
Haddock	***Melanogrammus aeglefinus***				51.3				7.1	188.0			0.5	22.1	0.1		4.7	11.9	0.2
Hake	***Merluccius merluccius***			0.8					0.4	1.0			5.4	2.0			2.7	0.3	
Salmon	*Salmo salar*																		
Pearlside	***Maurolicus muelleri***	0.2	0.3					0.1											
Ling	*Molva molva*																0.5		
Snake blenny	*Lumpenus lampretaeformis*																		
Krill	*Euphausidae spp.*	0.7	0.5				100.0	98.9			120.0	50.9				49.0	518.7	281.8	153.3
Pollack	*Pollachius pollachius*																0.5		
Mackerel	***Scomber scombrus***	23.0	15.8				2.8	7.5	0.6		37.7	10.2	0.3		11.8				12.4
Picked dogfish	***Squalus acanthias***							2.5						0.3					
Plaice	*Pleuronectes platessa*					0.1			0.5										
Lemon sole	*Microstomus kitt*								6.5	5.2							2.4	0.2	
Pilchard, sardine	*Sardina pilchardus*																		
Saithe	***Pollachius virens***			70.3						184.0			22.1				97.8	79.7	
Herring	***Clupea harengus***	30.5	270.9				19.7	71.1		8.3	90.7	150.1	9.6	0.1	34.4	52.8	166.4	16.5	60.0
Gray sole	*Glyptocephalus cynoglossus*																		
Hagfish	*Myxine glutinosa*													0.1					
Flounder	*Platichthys flesus*																		
Norway pout	***Trisopterus esmarki***				2.6				5.0	255.4			1.8	4.8			183.2	56.4	
Lumpsucker	***Cyclopterus lumpus***			0.9			11.1	2.5			2.8	2.1	0.9	3.6		0.8			2.6
Lesser silver smelt	***Argentina sphyraena ****													0.2					
Edible crab	*Cancer pagurus*																		
Starry ray	*Raja radiata*																		
Sandeels	***Ammodytes spp.***								0.1										
Greater sandell	*Hyperoplus lanceolatus*				0.2	0.3			1.8										
Cod	***Gadus Morhua***				19.5				0.3	20.9				4.1			8.7	24.4	
Spiny stone-crab	*Lithodes maia*																		
Shrimp	*Pandalus spp., Crangon spp.*													26.9					
Bullrout	*Myoxocephalus scorpius*																		
		232.9	325.1	104.3	92.9	113.0	300.0	252.0	389.7	695.0	362.0	271.5	596.4	233.0	123.2	174.5	1541.5	473.6	232.0

Table IIB.3. Trawl haul species composition in kg during the Acoustic Herring Survey R/V Dana Cruise July 2003 (continued).

Haul type (**s**urface, **p**elagic, **b**ottom)		**s**	**b**	**P**	**s**	**s**	**p**	**B**	**s**	**s**	**b**	**b**		**s**	**b**	**b**
Fishing depth		Surface	Bottom	150	Surface	Surface	23	Bottom	Surface	Surface	Bottom	Bottom	Surface	Surface	Bottom	Bottom
Strata		5	8	8	8	5	9	6	9	9	9	9		9	9	9
Haul		840	925	940	990	1005	1080	1105	1167	1183	1265	1293	1342	1360	1445	1462
Trawl catch, kg		164.8	488	105	132	252		210	410	752	281	1612		2320	410	646
Vahl's eelpout	*Lycodes vahli*		1.9													
Anchovy	*Engraulis encrasicolus*															
Squid	*Loligo spp.*															
Blue whiting	***Micromesistius poutassou***		234.8			5.6										
Sprat	***Sprattus sprattus***										0.0	106.1		0.2	123.4	10.5
Common weaver	*Trachinus draco*	0.1									0.2	3.0		0.5	0.2	
Dragonet	*Calllionymus spp.*															
Poor cod	*Trisopterus minutus*															
Catfish	*Anarhichas lupus*															
Fourbeard rockling	*Enchelyopus cimbrius*															
Horse mackerel	***Trachurus trachurus***									0.5						
Long rough dab	*Hippoglosides plattessoides*							0.9								0.2
Garfish	***Belone belone***	15.0		1.0	3.4	6.1			3.1	7.0						0.2
Whiting	***Merlangius merlangus***	0.2				0.3		17.2	0.1		6.1	500.1			38.5	67.7
Invertebrates		47.0		40.0	29.4	51.0	10.0	10.5	225.4	29.9	158.0	44.8		2207.4	195.8	420.6
Dab	*Limanda limanda*							0.2			21.9	3.0			2.8	11.9
Norway lobster	*Nephrops norvegicus*		0.2					0.2								
Gurnard	*Trigala spp.*													0.1	0.1	0.2
Haddock	***Melanogrammus aeglefinus***	0.0	54.1			0.0		1.3			0.1				0.1	
Hake	***Merluccius merluccius***		0.4					0.5	0.8					1.6		
Salmon	*Salmo salar*															
Pearlside	***Maurolicus muelleri***															
Ling	*Molva molva*															
Snake blenny	*Lumpenus lampretaeformis*															
krill	*Euphausidae spp.*	47.0		39.5	29.4	56.0										
Pollack	*Pollachius pollachius*															
Mackerel	***Scomber scombrus***	2.0		0.5	18.4	16.3			5.4	9.2		0.3		1.0		0.5
Picked dogfish	***Squalus acanthias***															
Plaice	*Pleuronectes platessa*							0.5			0.3				0.8	2.1
Lemon sole	*Microstomus kitt*														0.6	
Pilchard, sardine	*Sardina pilchardus*															
Saithe	***Pollachius virens***	10.1	126.5	8.8												
Herring	***Clupea harengus***	39.6	0.7		37.5	116.7		173.0	173.2	696.4	84.5	946.9		109.2	45.2	130.0
Gray sole	*Glyptocephalus cynoglossus*		0.6													
Hagfish	*Myxine glutinosa*															
Flounder	*Platichthys flesus*										0.2					
Norway pout	***Trisopterus esmarki***		9.8					5.7			0.7					
Lumpsucker	***Cyclopterus lumpus***	3.2	1.7	15.2	13.8				1.6	9.6	1.4	7.8			1.6	1.1
Lesser silver smelt	***Argentina sphyraena ****															
Edible crab	*Cancer pagurus*															
Starry ray	*Raja radiata*															
Sandeels	***Ammodytes spp.***														0.1	
Greater sandell	*Hyperoplus lanceolatus*															
Cod	***Gadus Morhua***		0.1					0.1							0.8	0.9
Spiny stone-crab	*Lithodes maia*															
Shrimp	*Pandalus spp., Crangon spp.*		57.4													
Bullrout	*Myoxocephalus scorpius*										7.7					
		164.2	488.0	105.0	132.0	252.0	10.0	210.0	409.7	752.7	281.0	1612.0	0.0	2320.0	409.9	646.0

Table IIB.3. Trawl haul species composition in kg during the Acoustic Herring Survey R/V Dana Cruise July 2003 (continued).

Haul type (**s**urface, **p**elagic, **b**ottom) **Fishing depth** **Strata**		Total survey	Mean survey	Max survey	Min survey
			32		
Haul					
Trawl catch, kg		14297.7	446.80	2320.0	92.9
Vahl's eelpout	*Lycodes vahli*	2.0	0.06	1.9	0.1
Anchovy	*Engraulis encrasicolus*	0.1	0.00	0.1	0.1
Squid	*Loligo spp.*	0.8	0.03	0.7	0.2
Blue whiting	***Micromesistius poutassou***	1177.5	36.80	555.5	0.8
Sprat	***Sprattus sprattus***	240.3	7.51	123.4	0.0
Common weaver	*Trachinus draco*	4.1	0.13	3.0	0.1
Dragonet	*Calllionymus spp.*	0.0	0.00	0.0	0.0
Poor cod	*Trisopterus minutus*	0.0	0.00	0.0	0.0
Catfish	*Anarhichas lupus*	7.5	0.23	7.5	7.5
Fourbeard rockling	*Enchelyopus cimbrius*	0.8	0.02	0.8	0.8
Horse mackerel	***Trachurus trachurus***	1.3	0.04	0.8	0.5
Long rough dab	*Hippoglosides plattessoides*	4.9	0.15	1.7	0.1
Garfish	***Belone belone***	85.6	2.67	15.0	0.2
Whiting	***Merlangius merlangus***	743.0	23.22	500.1	0.1
Invertebrates		4913.6	153.55	2207.4	1.3
Dab	*Limanda limanda*	62.8	1.96	21.9	0.2
Norway lobster	*Nephrops norvegicus*	1.0	0.03	0.3	0.2
Gurnard	*Trigala spp.*	39.3	1.23	38.2	0.1
Haddock	***Melanogrammus aeglefinus***	341.6	10.67	188.0	0.0
Hake	***Merluccius merluccius***	15.8	0.49	5.4	0.3
Salmon	*Salmo salar*	0.0	0.00	0.0	0.0
Pearlside	***Maurolicus muelleri***	0.6	0.02	0.3	0.1
Ling	*Molva molva*	0.5	0.01	0.5	0.5
Snake blenny	*Lumpenus lampretaeformis*	0.0	0.00	0.0	0.0
krill	*Euphausidae spp.*	1545.9	48.31	518.7	0.5
Pollack	*Pollachius pollachius*	0.5	0.01	0.5	0.5
Mackerel	***Scomber scombrus***	175.8	5.49	37.7	0.3
Picked dogfish	***Squalus acanthias***	2.8	0.09	2.5	0.3
Plaice	*Pleuronectes platessa*	4.4	0.14	2.1	0.1
Lemon sole	*Microstomus kitt*	14.9	0.46	6.5	0.2
Pilchard, sardine	*Sardina pilchardus*	0.0	0.00	0.0	0.0
Saithe	***Pollachius virens***	599.3	18.73	184.0	8.8
Herring	***Clupea harengus***	3533.9	110.44	946.9	0.1
Gray sole	*Glyptocephalus cynoglossus*	0.6	0.02	0.6	0.6
Hagfish	*Myxine glutinosa*	0.1	0.00	0.1	0.1
Flounder	*Platichthys flesus*	0.2	0.01	0.2	0.2
Norway pout	***Trisopterus esmarki***	525.5	16.42	255.4	0.7
Lumpsucker	***Cyclopterus lumpus***	84.4	2.64	15.2	0.8
Lesser silver smelt	***Argentina sphyraena ****	0.2	0.01	0.2	0.2
Edible crab	*Cancer pagurus*	0.0	0.00	0.0	0.0
Starry ray	*Raja radiata*	0.0	0.00	0.0	0.0
Sandeels	***Ammodytes spp.***	0.2	0.01	0.1	0.1
Greater sandell	*Hyperoplus lanceolatus*	2.3	0.07	1.8	0.2
Cod	***Gadus Morhua***	79.8	2.49	24.4	0.1
Spiny stone-crab	*Lithodes maia*	0.0	0.00	0.0	0.0
Shrimp	*Pandalus spp., Crangon spp.*	84.3	2.63	57.4	26.9
Bullrout	*Myoxocephalus scorpius*	7.7	0.24	7.7	7.7

Table IIB.4.a Trawl length frequency composition by stratum and trawl station for the Acoustic Herring Survey R/V Dana Cruise July 2003.

	Herring Strata/Station numbers																										Herring Total
	570E06			570E08				580E06	580E08						C	D					E						
Length cm	190	354	368	456	585	600	1105	36	510	525	658	675	826	1005	752	770	840	925	990	1167	1183	1265	1293	1360	1445	1462	
7.5																						1					1
8																						2					2
9																						1					1
12.5																						1					1
14																									2		2
15																							7		14	6	27
15.5																						5	27	1		17	50
16																				5	25	39	63	33	62	86	313
16.5		1					5	2						2					1	45	69	84	126	89	106	95	625
17	3	2	1	1			12	3	2	3			1		3		1		3	60	96	83	87	86	53	48	548
17.5	5	1		1	2		35	2	6	7	3	3	3	1	15	2	6		4	62	60	27	29	27	17	7	325
18	11	1	5	4	6		45		10	11	7	2	6	1	27	3	9	1	8	35	27	4	14	5	6		248
18.5	16	3		3	12		59	5	41	24	20	8	21	9	33	3	17		19	22	5	3		4	1		328
19	35	16		1	12		44	5	65	24	24	8	23	10	35	4	19	2	37	5	2	2	1		3	1	378
19.5	93	13		6	16		23	22	60	34	23	9	23	18	21	2	12		25	6	1	3		1	1		412
20	73	17	42	9	21		21	30	47	31	26	13	19	13	20	3	26		19	9		2		5	4	4	454
20.5	60	12	28	4	12		2	40	27	49	20	25	29	22	22	1	28		21	2				2	1		407
21	40	10	28	2	13	1	1	30	23	38	14	35	25	14	23	6	21		18	2	1						345
21.5	25	12	16	5	3			19	14	17	16	28	25	18	18	6	30		13								265
22	24	10	14	1	4			24	21	21	15	29	25	20	19	5	26		10								268
22.5	22	9	23	1	2			20	14	14	8	30	33	25	16	6	29		11								263
23	16	7	12	1	6			6	10	11	10	25	32	20	14	3	21		3								197
23.5	7	4	14		8			15	5	12	9	25	23	23	6	10	12		5	1							179
24	7	8	9	3	2			22	6	6	14	16	16	23	2	6	9		6								155
24.5	13	5	6		5			17	3	7	7	9	10	13	1	3	3		7	1							110
25	2	6	2	3	5			17	2	4	9	3	9	8	1		2		1								74
25.5	4	1	3	1	2			10	1	4	9	4	3	9			2		5								58
26	5	3	1		2			13	2	4	6	2	3	4			1										46
26.5	4	2	1					4		1	2		2	6			2										24
27	1		2					10		3	3	2	2	2			3	1	4								33
27.5					1			6		1	2	3		5													18
28									1	1	2			1	1	1			1								8
28.5	1		1					2			1	2															7
29			2		1			2						1		0											6
29.5	1							1		1																	3
31.5								2																			2
33.5			27																								27
34			35																								35
34.5			35																								35
Grand Total	468	143	307	46	135	1	247	329	360	328	250	281	333	268	277	64	279	4	221	255	286	257	354	253	270	264	6280

Table IIB.4.b Raised catch numbers and weights of herring by trawl station for the Acoustic Herring Survey R/V Dana Cruise July 2003.

Station	36	190	354	368	456	510	525	585	600	658	675	752	770	826	840	925	990	1005	1105	1167	1183	1265	1293	1360	1445	1462	Total
Raised Catch Numbers	329	3683	250	836	123	1375	2018	135	2	413	637	2574	182	754	529	11	498	1263	3282	3894	17736	2271	27306	3231	1414	4028	78775
Raised Catch Weight in kg	30.53	270.89	19.67	71.13	8.31	90.66	150.07	9.59	0.10	34.40	52.80	166.43	16.50	59.96	39.60	0.68	37.50	116.71	173.01	173.21	696.43	84.46	946.91	109.20	45.18	130.02	3533.93

Table IIB.5a Numbers of herring by age, maturity, stock and sub area for the Acoustic Herring Survey R/V Dana Cruise July 2003.

	North Sea Autumn spawners. Abundance (Millions)......												
Stratum	0	1i	1m	2i	2m	3i	3m	4	5	6	7	8	9+
580E06	0.00	3.02	0.00	1.03	0.06	0.16	0.02	0.11	0.00	0.00	0.00	0.00	0.00
570E06	0.00	85.68	0.00	25.08	1.57	1.96	0.20	0.61	0.00	0.00	0.00	0.00	0.00
580E08	0.00	92.64	0.00	17.41	1.09	1.63	0.16	1.07	0.15	0.00	0.00	0.00	0.00
570E08	0.00	212.75	0.00	46.25	2.89	3.65	0.37	1.10	0.21	0.00	0.00	0.00	0.00
C	0.000	43.883	0.000	8.643	0.540	0.818	0.082	0.173	0.219	0.000	0.000	0.000	0.000
D	0.000	231.355	0.000	21.809	1.363	1.901	0.190	1.419	0.393	0.000	0.000	0.000	0.000
E	2.830	2774.691	0.000	7.131	0.446	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

	Baltic Sea Spring spawners Abundance (Millions)												
Stratum	0	1i	1m	2i	2m	3i	3m	4	5	6	7	8	9+
580E06	0.00	0.12	0.00	4.81	0.01	2.38	0.09	3.22	1.28	0.27	0.26	0.13	0.02
570E06	0.00	3.25	0.00	89.84	0.27	30.92	1.15	27.02	10.03	1.92	1.08	0.83	0.08
580E08	0.00	3.83	0.00	68.75	0.21	36.14	1.35	34.08	11.92	1.62	1.19	0.56	0.06
570E08	0.00	8.43	0.00	163.14	0.49	60.69	2.26	51.52	19.44	3.32	1.40	1.41	0.09
C	0.000	1.751	0.000	36.055	0.109	22.800	0.849	14.991	4.796	0.610	0.258	0.115	0.000
D	0.000	13.439	0.000	79.791	0.240	44.211	1.646	41.405	14.429	1.526	1.497	0.595	0.000
E	0.000	1011.919	0.000	108.439	0.327	14.005	0.521	2.151	0.836	0.046	0.092	0.000	0.000

Table IIB.5b Mean weight of herring by age, maturity, stock and subarea for the Acoustic Herring Survey R/V Dana Cruise July 2003.

	North Sea Autumn spawners. Mean weights (g)												
Stratum	**0**	**1i**	**1m**	**2i**	**2m**	**3i**	**3m**	**4**	**5**	**6**	**7**	**8**	**9+**
580E06	0.000	55.583		68.714	68.714	107.335	107.335	128.883	0.000	0.000	0.000	0.000	0.000
570E06	0.000	53.791		66.404	66.404	89.704	89.704	124.239	0.000	0.000	0.000	0.000	0.000
580E08	0.000	51.728		65.835	65.835	97.373	97.373	135.491	164.524	0.000	0.000	0.000	0.000
570E08	0.000	51.827		65.530	65.530	91.206	91.206	123.141	164.524	0.000	0.000	0.000	0.000
C	0.000	50.290		67.853	67.853	89.187	89.187	116.997	164.524	0.000	0.000	0.000	0.000
D	0.000	45.079		64.508	64.508	93.533	93.533	137.427	164.524	0.000	0.000	0.000	0.000
E	5.203	35.190		51.249	51.249	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

	Baltic Sea Spring spawners Mean weights (g)												
Stratum	**0**	**1i**	**1m**	**2i**	**2m**	**3i**	**3m**	**4**	**5**	**6**	**7**	**8**	**9+**
580E06		52.515		71.763	71.763	90.922	90.922	115.886	122.997	139.150	181.966	155.350	173.520
570E06		51.911		69.634	69.634	86.277	86.277	107.472	113.275	134.237	159.534	154.647	173.520
580E08		50.679		72.279	72.279	88.368	88.368	111.861	120.911	118.564	137.568	136.193	173.520
570E08		50.064		69.809	69.809	87.136	87.136	106.567	114.671	128.225	133.744	148.168	173.520
C		49.425		74.234	74.234	88.536	88.536	97.867	110.349	101.536	111.361	106.131	0.000
D		41.943		72.521	72.521	88.524	88.524	112.351	122.798	111.579	133.879	135.596	0.000
E	0.000	35.158		55.920	55.920	66.936	66.936	100.661	100.252	110.102	110.102	0.000	0.000

Table IIB.5b Mean weight of herring by age, maturity, stock and subarea for the Acoustic Herring Survey R/V Dana Cruise July 2003.

	North Sea Autumn spawners. Mean lengths (cm)												
Stratum	0	1i	1m	2i	2m	3i	3m	4	5	6	7	8	9+
580E06	0.00	19.46		20.89	20.89	24.06	24.06	25.78	0.00	0.00	0.00	0.00	0.00
570E06	0.00	19.27		20.66	20.66	22.65	22.65	25.47	0.00	0.00	0.00	0.00	0.00
580E08	0.00	19.02		20.57	20.57	23.33	23.33	26.21	28.00	0.00	0.00	0.00	0.00
570E08	0.00	19.03		20.56	20.56	22.80	22.80	25.40	28.00	0.00	0.00	0.00	0.00
C	0.00	18.84		20.77	20.77	22.75	22.75	24.97	28.00	0.00	0.00	0.00	0.00
D	0.00	18.14		20.41	20.41	23.07	23.07	26.33	28.00	0.00	0.00	0.00	0.00
E	8.61	16.74		19.00	19.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	Baltic Sea Spring spawners Mean lengths (cm)												
Stratum	0	1i	1m	2i	2m	3i	3m	4	5	6	7	8	9+
580E06		19.05		21.20	21.20	22.92	22.92	24.83	25.33	26.34	28.69	27.36	28.50
570E06		19.03		21.00	21.00	22.52	22.52	24.21	24.63	25.99	27.41	27.29	28.50
580E08		18.89		21.24	21.24	22.72	22.72	24.50	25.15	24.97	26.29	26.18	28.50
570E08		18.80		21.01	21.01	22.60	22.60	24.14	24.72	25.61	25.97	26.90	28.50
C		18.74		21.43	21.43	22.75	22.75	23.51	24.38	23.79	24.57	24.19	0.00
D		17.71		21.26	21.26	22.74	22.74	24.53	25.27	24.48	26.08	26.12	0.00
E	0.00	16.73		19.53	19.53	20.69	20.69	23.73	23.69	24.50	24.50	0.00	0.00

Appendix IIC: NORWAY

Acoustic Survey for Herring and Sprat in the North Sea

RV "SARSEN", 1 – 22 July 2003
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1 INTRODUCTION

The report presents the results from the Norwegian coverage of the International Herring Acoustic Survey for 2003. Five countries cooperate to survey the North Sea and the Skagerrak for an acoustic abundance estimation of herring and sprat. The surveys are planned in the Planning Group for Herring Surveys (ICES 2003), a sub group under the ICES Herring Assessment Working Group for the Area South of 62^{o}N. The data from this survey will be combined with the other surveys to provide a combined age-structured abundance index for use in the assessment made by the ICES Herring Assessment Working Group (HAWG) in March 2004.

Objectives: To estimate the abundance of herring and sprat in the area between latitudes 56º30'N and 62º00'N and 02º00'-06°00'E. Map the general hydrographical regime and monitor the standard profiles Oksøy - Hanstholm, Hanstholm - Aberdeen, Utsira - Start Point and Feie - Shetland.

2. SURVEY DESCRIPTION AND METHODS

2.1 Personnel

Else Torstensen	(Cruise leader)
Bjarte Kvinge	(Acoustic expert)
Karen Gjertsen	(Fish.lab)
Eilert Hermansen (1 – 11 July)	(Fish.lab)
Anne-Liv Johnsen	(Fish.lab)
Bente Lundin (11–22 July)	(Fish lab)
Sigmund Myklevoll (1–11 July)	(Fish.lab)
Georg Skaret	(Acoustic technician)
Bjørn Vidar Svendsen	(Fish.lab)

No exchange of staff with "Scotia" was made this year.

2.2 Narrative

RV "Sarsen" (re-named, former RV"G.O.Sars") sailed at 1400 UTC on 1 July 2003. The vessel made passage to Uggedalseide/Tysnes to calibrate the acoustic instruments. The conditions appeared to be unfavourable for calibration as there were too much fish/jellyfish in the sea. The vessel continued south and anchored in Rosfjord, N 58°03'96"E 7°00'4'' at 1440 UTC on 2 July to do the calibration of the sounders. At 2130 UTC RV "Sarsen" left the fjord following a successful calibration and commenced the survey at 0240 UTC 3 July at 58^{o} 3'N and 8^{o}5' E, the first hydrographical station (CTD623) on the Oksøy – Hanstholm transect.

The survey continued with transects from south to north. In general, the weather conditions were good. Early in the survey there were a couple of days with rough weather and lots of noises on the transducer, even with the drop keel in use.

A call was made in Egersund on 2 July, in Aberdeen on 7 July, in Stavanger on 11 July and in Lerwick, Shetland on 20 July. The survey finished in Bergen on 22 July 2003 at 1800 hrs UTC. During the survey, about 3.500 n.mi. were sailed, 75 trawl hauls and 145 CTD stations were taken. Figure 1 gives the cruise track and locations of trawl hauls and Figure 2 the locations of CTD-stations.

2.3 Survey design

The survey was carried out in systematic parallel transects in the east-west direction with a dense transect spacing between 2º and 4º E and a wider spacing between 4º and 6º E progressing from south to north. In order to plan the parallel transects in between the hydrographic transect, wide spacing transects were carried out in the south eastern area (44F4, 44F5, 45F4, 45F5, 46F4 and 46F5). Dense spacing (13–15 nm) was used in the overlapping area east of Shetland.

2.4 Calibration

The acoustic sounders, SIMRAD EK500 38 were controlled and calibrated on 2 July, before the start of the survey. A standard sphere calibration was carried out (Foote *et al*. 1983). For calibration of the 38kHz sounder a 60 mm copper sphere (CU60), Ts -33,7 dB, was used. Agreement between means of the calibrations this year and value from last year on the same systems, was better than 0.1 dB. The main settings for the 38 kHz are given in Table 1.

2.5 Acoustic data collection

Acoustic data were collected 24 hours per day using a SIMRAD EK500 38 kHz echo sounder with an ES38B SK transducer mounted on the drop keel. Additional data was collected at 120 kHz ((ES120–7 transducer) but was not used in the present analysis. Echo integrator data was collected from 10 m below the surface (transducer at 5–7.5 m depth, depending on weather conditions and the keel in use) to 1 m above the seabed. The speed of the vessel during the acoustic sampling was 10–11 knots. The acoustic data were archived to tape. The acoustic recordings were scrutinized twice per day using the IMR BEI/SIMRAD BI500 Scientific Post Processing System (The Bergen Echo Integrator) (Foote *et al*. 1991). Paper records were kept for acoustic data at 38 kHz.

2.6 Biological data - fishing trawls

Trawling was carried out for supporting the species identifications of acoustic scatters and for biological sampling. "Åkra" trawl (16 x 20 m) was used for pelagic trawling and a Campelen 1800 equipped with a Rock hopper gear for bottom trawling. The pelagic trawl had a 11 mm cod end liner. The bottom trawl hauls were monitored using Simrad TS150 scanning net-sonde and the pelagic trawl hauls monitored by Scanmar TE40, and depth sensor D1200.

Biological samples (length, weight) were taken of the most important species according to the IMR fish-sampling manual (Fotland *et.al.* 2002). Herring samples (up to 150 fish) were taken randomly from the catches. Target species were also examined for age, sex, maturity (8 point scale), fat, stomach contents and vertebral counts (east of 2°00'E). Herring was examined for macroscopic evidence of *Ichthyophonus* infection.

2.7 Hydrographic data

CTD stations for temperature, salinity and density measures, were taken regularly in addition to the four standard hydrographical profiles, Oksøy-Hanstholm, Hanstholm-Aberdeen, Utsira - Start Point and Feie – Shetland.

2.8 Data analysis

Echogram scrutiny was made per 5 n.mi. NASC values were allocated to the following categories: herring, sprat, pelagic fish, demersal fish, plankton and other. To calculate integrator conversion factors the target strength of clupeids in the mixture were estimated using the following TS/length relationship:

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

Herring were separated from other recordings by using catch information and characteristics of the recordings. 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 "Sarsen". No system for workable stock discrimination on individual herring during the survey is available. The proportion of Baltic spring spawners and North Sea autumn spawners by age was 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

3.1 Hydrography

The horizontal distributions of temperature at 5m, 50m and at bottom in the surveyed area are shown in Figure 3a-c, based on data from 145 CTD stations. The surface water (5 m depth) in the North Sea temperatures ranged from 13–14° C in the west to 15–18° C along the Norwegian west coast. These were in general 1–2°C higher than measured at the same time in 2002 (Torstensen, 2002). Off the west coast the temperatures at 5 m depth were 2–3°C higher than last year. At 50 m depth the temperature along the south western Norwegian coast was 2–3°C lower than in 2002. At the bottom the temperature regime was about the same as last year, with higher temperatures in west (up to 10–12°C) and in south east (up to 10–14°C) than in the central area (7–8°C).

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

3.2 Acoustic data

3.2. 1 Herring

Figure 4 presents the geographical distribution of the NASC values assigned to herring by 5-n.mi along the cruise track. More herring schools were observed than in the last years and single schools were observed scattered distributed over the area, often close to the surface. Trawling targeting some of the larger single schools failed, as we were not able to detect them again. Highest mean densities were measured in the ICES rectangles 44F5, 46F2 and 42F2. Random trawling positions were regularly chosen for trawling at the surface; i.e., not based on echo registration. In the "Norwegian" area herring tends to keep close to the surface during daytime and may thus be under-estimated.

3.2.2 Sprat

No sprat was observed in the target area of the Norwegian survey.

3.3 Biological data

The total number of valid trawl hauls taken during the survey was 75, 63 pelagic and 12 bottom trawl hauls (see Figure 1, Table 2), of which 9 (4 pelagic and 5 bottom hauls) were taken in the overlapping area east of Shetland. Of the pelagic hauls, 4 were mid water hauls and 59 were performed with large buoys for fishing at the surface. In general 30 min hauls were made. Catch composition per haul is given in Table 3. Herring was present in 45 hauls of which 28 had sample size >20 herring. The length distributions of herring are presented in Table 4. A total of 2.750 fish were measured and 1.575 fish were aged (otoliths). Few herring was observed with *Ichthyophonus* infection. In the Shetland area, however, infected fish was found in three out of 4 herring samples (BT503, BT506 and BT508) with 3–7 % of the fish infected.

3.4 Abundance and Biomass estimates

3.4.1 Herring

The main areas of concentration were the southwestern corner of the surveyed area and off the southwestern Norwegian coast (Figure 4). High densities were also recorded in the ICES rectangles 47E8-E9 and 49E9, 50E9-F0. These rectangles are not included in the Norwegian estimate but were part of a calibration exercise. While few or no schools of herring have been observed during the last surveys, large and smaller herring schools were recorded this year. The majority of the trawling positions were, however, regularly chosen with trawling at surface every 20–30 nautical miles; i.e., not based on echo registration. Due to the behaviour of keeping close to the surface during daytime, herring may have been under-estimated.

Total number of herring was 4,786 million of which 63% was North Sea Autumn Spawners (NSAS) and 37% Western Baltic Spring Spawners (WBSS). Total stock biomass of NSAS was estimated to 278,000 tonnes and the spawning stock biomass as 156,000 tonnes of which the 2-ringers (the 2000 year class) made 44% and 35% respectively. The 1998-year class (4-ringers) made 9% of the number and 17% of the biomass. The total biomass of WBSS was 158,000 tonnes.

Table 6 gives the mean length, mean weight, 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 2003.

3.4.1 Overlap area

The estimated herring abundance (mill) by rectangle in the overlapping area, was as follows:

ICES Rect.	Number (mill)
49E9	102.68
49F0	334.13
50E9	6.89
50F0	3.94

No herring was caught in pelagic hauls, only in the bottom trawl hauls.

4. References

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Table IIC.1. Simrad EK500 and analysis settings used on the SARSEN2003008 herring acoustic survey.

Transceiver 1 Menu (38 kHz)	
Absorption coefficient	10 dB.km^{-1}
Pulse length	Medium
Bandwidth	Wide
Max. Power	2000 W
Equivalent two-way beam angle	-21.0 dB
Default Transducer S_v gain	26.95 dB
TS-svingerfølsomhet	27.10 dB
3 dB Beamwidth	6.9/6.8 deg
Alongship offset	-0.10 deg
Althw.Ship Offset	0.03 deg
Calibration details	
TS of sphere	-33.54 dB (cupper 60 mm diameter)
Range to sphere in calibration	39.0
Selected NASC (sA) value for calibration	1573
Log Menu	
Mode NM+	
Operation Menu	
Ping interval	0.0 (all ranges)
Display	
TVG	20 log R
Integration line	1000
TS colour min.	-70 dB
Sv colour min.	-60 dB
Printer	
TS colour min.	-60 dB
Sv colour min	-70 dB

Table IIC.1. Cont.

Transceiver 1 Menu (120 kHz)	
Absorption coefficient	38 dB.km^{-1}
Pulse length	Long
Bandwidth	Narrow
Max. Power	1000 W
Equivalent two-way beam angle	-20.8 dB
Default Transducer S_v gain	26.10 dB
TS transducer gain	25.90 dB
3 dB Beamwidth	7.8/7.3 deg
Alongship offset	-0.19 deg
Althw.Ship Offset	0.33 deg
Calibration details	
TS of sphere	-39.57 dB (tungsten 38.1 (mm?) diameter)
Range to sphere in calibration	40.38
Selected NASC (sA) value for calibration	351
Log Menu	
GPS	
Operation Menu	
Ping interval	0.0 (all ranges)

Table IIC.2. RV “Sarsen” 1–22 July 2003. Details of trawl stations during the acoustic survey on herring and sprat in the North Sea.

Trawl haul no	Date	Lat	Lon	Time UTC	Water depth (m)	Trawl depth (m)	Duration min
BT440	03.jul	57°33'	8°22' E	0845	120	120	8
PT441	03.jul	57°00'	7°47' E	1510	41	0	29
PT442	03.jul	57°00'	6°40' E	2029	58	0	29
PT443	04.jul	57°00'	5°59' E	0009	52	0	30
PT444	04.jul	57°00'	5°19' E	0327	56	0	32
PT445	04.jul	57°00'	4°07' E	0845	64	0	30
PT446	04.jul	57°00'	2°55' E	1423	70	0	30
PT447	04.jul	56°55'	2°00' E	1934	92	0	25
PT448	05.jul	56°52'	3°28' E	0238	65	0	30
PT449	05.jul	56°51'	4°29' E	0757	62	0	31
PT450	05.jul	56°49'	5°48' E	1353	56	0	30
PT451	05.jul	56°41'	5°00' E	1930	64	0	28
PT452	05.jul	56°41'	3°59' E	2356	53	0	31
PT453	06.jul	56°41'	2°44' E	0506	71	0	30
PT454	06.jul	56°48'	1°53' E	0907	92	0	30
BT455	06.jul	57°00'	1°05' E	1457	90	90	30
PT456	08.jul	57°13'	0°42' E	0346	87	0	30
PT457	08.jul	57°14'	1°47' E	0753	96	0	35
PT458	08.jul	57°15'	2°32' E	1130	81	0	31
BT459	08.jul	57°15'	3°25' E	1538	63	63	30
PT460	08.jul	57°15'	5°02' E	2117	62	0	29
PT461	09.jul	57°23'	5°56' E	0148	78	0	30
PT462	09.jul	57°36'	5°55' E	0436	145	10	34
PT463	09.jul	57°32'	3°17' E	1653	66	0	31
PT464	09.jul	57°32'	2°05' E	2127	83	0	30
PT465	10.jul	57°44'	2°21' E	0222	80	0	30
PT466	10.jul	57°44'	3°42' E	0737	67	0	30
PT467	10.jul	57°59'	3°16' E	1235	88	48	30
PT468	10.jul	58°00'	2°05' E	1741	84	0	29
PT469	10.jul	58°14'	2°51' E	2202	72	0	29
PT470	11.jul	58°14'	3°34' E	0052	105	0	29
PT471	11.jul	58°15'	4°39' E	0450	288	0	31
PT472	12.jul	58°15'	5°01' E	1630	308	0	37
PT473	12.jul	58°25'	5°41' E	2220	308	0	30
PT474	13.jul	58°43'	5°05' E	0224	220	0	30
PT475	13.jul	58°43'	4°43' E	0432	222	0	33
BT476	13.jul	58°28'	2°46' E	1348	101	101	33
BT477	13.jul	58°41'	2°05 E	1830	99	99	33
PT478	13.jul	58°42'	3°19' E	2327	107	0	28
PT479	14.jul	58°49'	4°00' E	0252	281	0	30
PT480	14.jul	58°54'	2°53 E	0819	124	45	30
BT481	14.jul	58°54'	2°24' E	1107	115	115	34
PT482	14.jul	58°06'	3°40 E	1945	260	0	31
PT483	14.jul	59°05'	4°45' E	2356	264	0	36
PT484	15.jul	59°17'	2°10' E	1355	124	0	30
BT485	15.jul	59°17'	1°33' E	1654	112	112	31
PT486	15.jul	59°17'	0°32' W	0051	139	0	31
PT487	16.jul	59°17'	0°32' E	0051	139	0	31
PT488	16.jul	59°32'	2°08' E	1958	122	0	31
PT489	16.jul	59°32'	3°04' E	2346	129	0	34
PT490	16.jul	59°32'	3°24' E	0153	203	20	30

Table IIC.2. Cont.

Trawl haul no	Date	Lat	Lon	Time UTC	Water depth (m)	Trawl depth (m)	Duration min
PT491	16.jul	59°39'	4°40' E	757	264	0	32
PT492	17.jul	59°42'	3°12' E	1334	153	0	30
PT493	17.jul	59°53'	2°24' E	1914	100	0	28
PT494	17.jul	59°54'	3°03' E	2157	127	0	33
PT495	18.jul	59°54'	3°54' E	0100	283	0	30
PT496	18.jul	59°53'	4°28' E	0344	281	0	30
PT497	18.jul	60°06'	4°11' E	0829	293	0	29
PT498	18.jul	60°06'	2°32' E	1436	106	0	30
PT499	18.jul	60°18'	3°02' E	2051	119	0	28
PT500	18.jul	60°18'	3°50' E	2358	294	0	30
PT501	19.jul	60°25'	4°39' E	0355	372	0	30
PT502	19.jul	60°34'	3°26' E	0916	302	0	30
BT503	19.jul	60°33'	0°53' E	1845	140	140	28
PT504	19.jul	60°33'	0°11' E	2256	106	0	29
PT505	20.jul	60°33'	0°27' E	0027	118	16	29
BT506	20.jul	60°20'	0°48' E	0713	161	161	22
PT507	20.jul	60°12'	0°26' E	2122	121	0	28
BT508	21.jul	60°42'	0°34' E	0214	142	142	32
PT509	21.jul	60°58'	0°39' E	0437	139	0	30
BT510	21.jul	60°58'	0°05' E	0700	145	145	31
BT511	21.jul	60°53'	0°46' W	1210	98	98	30
PT512	21.jul	60°44'	2°13' E	2339	123	0	29
PT513	22.jul	60°44'	3°12' E	0412	291	0	30
PT514	22.jul	60°44'	4°07' E	0918	316	0	28

Table IIC.3. RV "Sarsen" 1 - 22 July 2003. Catch compositions in the trawl hauls (kg).

Trawl station		**440**	**441**	**442**	**443**	**444**	**445**	**446**	**447**	**448**	**449**	**450**	**451**	**452**	**453**	**454**	**455**	**456**	**457**	**458**	**459**	**460**
Total catch (kg)		**151.77**	**7.43**	**82.90**	**11.91**	**5.27**	**500.00**	**0.09**	**3.00**	**3.71**	**12.89**	**52.69**	**51.66**	**0.62**	**6.68**	**3.21**	**576.77**	**17.40**	**0.38**	**33.56**	**212.35**	**30.29**
Herring	Clupea harengus	0.17					486.34									0.08	468.10	17.36	0.34		12.35	
Sprat	Sprattus sprattus																					
Pilchard	Sardina pilchardus																					
Anchovy	Engraulis encrasicolus																					
Mackerel	Scombrus scombrus		1.64	12.44	6.71		12.55			1.25	0.17					0.65				32.54		24.22
Horse mackerel	Tracurus tracurus																					
Norway pout	Trisopterus esmarkii	5.10																				
Haddock	Melanogrammus aeglefinus	2.42	5.38	0.01							0.13						58.60		0.00	0.00	60.19	
Whiting	Merlangius merlangus		0.16	0.07	0.06	0.01					0.02	0.03	0.02				20.60	0.01	0.03	0.01	11.84	0.00
Blue-whiting	Micromesistius poutassou	101.10																				
Saithe	Pollachius virens	37.00																				
Hake	Merluccius merluccius	1.45																				
Pollack	Pollachius pollachius																					
Torsk	Brosme brosme																					
Cod	Gadus morhua																					
Poor cod	Trisopterus minutus																					
Ling	Molva molva																					
Argentine	Argentina sphyraena																					
Sandeels	Ammodytidae spp				0.01																	
Gurnard	Trigla spp		0.26	0.38	1.14	0.26	1.11	0.09		0.36	1.18	2.66	0.27	0.11		0.29	3.80				3.24	2.82
Dab	Limanda limanda																12.60				97.02	
Plaice	Pleuronectes platessa																					
Witch	Glyptocephalus cynoglossus																					
Lomre	Microstomus kitt																1.53				1.74	
Long rough dab	Hippoglossoides platessoides	1.76															10.62				25.97	
Wolffish	Anarhichas lupus																					
Lumpsucker	Cyclopterus lumpus									2.10	1.39		1.38		1.68	2.19				1.01		
Monkfish	Lophius piscatorius																					
Norway haddock	Sebastes marinus																					
Pigghå	Squalus acantias	1.76																				
Jellyfish				70.00	4.00	5.00			3.00		10.00	50.00	50.00	0.50	5.00							3.00
Other		1.02												0.01			0.92	0.03				0.25

Table IIC.3. Cont.

Trawl station Total catch (kg)		461 2010.94	462 10.72	463 4500.00	464 258.79	465 23.62	466 1.98	467 114.26	468 3.04	469 32.44	470 33.67	471 8.01	472 125.70	473 97.42	474 6.69	475 16.12	476 103.76	477 718.67	478 81.19	479 43.15	480 0.00	481 151.17
Herring	Clupea harengus	6.71	0.41	4500.00	5.47					0.79	11.04	1.03	74.44	30.64	1.46	0.23	32.40	569.20	19.68	33.16		62.36
Sprat	Sprattus sprattus																					
Pilchard	Sardina pilchardus																					
Anchovy	Engraulis encrasicolus																					
Mackerel	Scombrus scombrus	3.76	0.27		2.85	23.62	0.23	1.00		2.64	17.08	3.60	33.64	3.96	4.16	10.66			55.70	8.52		
Horse mackerel	Tracurus tracurus				0.42						0.28						0.38		3.46	1.42		
Norway pout	Trisopterus esmarkii																	8.30				47.30
Haddock	Melanogrammus aeglefinus	0.00				0.00	0.00	42.88	0.01	0.00				0.02		0.01	36.40	71.90				24.00
Whiting	Merlangius merlangus	0.02	0.03		0.05	0.01	0.01	46.05	0.01	0.71	0.05	0.00	0.11	0.00	0.01	0.04	14.56	26.00		0.04		4.60
Blue-whiting	Micromesistius poutassou													17.80								
Saithe	Pollachius virens											1.48	3.04				4.62	23.36				3.30
Hake	Merluccius merluccius																					
Pollack	Pollachius pollachius																					
Torsk	Brosme brosme																					
Cod	Gadus morhua																1.94					
Poor cod	Trisopterus minutus																					
Ling	Molva molva																		1.30			
Argentine	Argentina sphyraena																					
Sandeels	Ammodytidae spp																					
Gurnard	Trigla spp	0.45						4.33		0.62							2.27	1.19	0.05			
Dab	Limanda limanda																2.36	13.86				0.21
Plaice	Pleuronectes platessa																					
Witch	Glyptocephalus cynoglossus																					
Lemon dab	Microstomus kitt																					0.55
Long rough dab	Hippoglossoides platessoides																1.71	4.12				7.15
Wolffish	Anarhichas lupus																					
Lumpsucker	Cyclopterus lumpus						0.74			2.67	0.23	1.89	0.84									
Monkfish	Lophius piscatorius																					
Norway haddock	Sebastes marinus																					
Pigghå																						
Jellyfish		2000.00	10.00		250.00		1.00	20.00	3.00	25.00	5.00		10.00	45.00		5.00	4.00					
Other					0.01		0.00		0.02	0.01			3.63		1.07	0.19	3.12	0.74	1.00			1.70

Table IIC.3. Cont.

Trawl station		482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502
Total catch (kg)		**58.84**	**100.64**	**229.97**	**1.69**	**71.81**	**51.70**	**10.44**	**49.14**	**104.15**	**17.65**	**37.27**	**2.22**	**58.36**	**215.20**	**7.43**	**2.44**	**5.69**	**40.22**	**60.46**	**430.58**	**31.04**
Herring	Clupea harengus	7.33	72.18	182.48		2.11	33.58		6.12	95.40	0.99		0.19	13.99	167.72	0.94	0.34		0.96	10.72	18.00	0.64
Sprat	Sprattus sprattus																					
Pilchard	Sardina pilchardus																					
Anchovy	Engraulis encrasicolus																					
Mackerel	Scombrus scombrus	27.46	1.85	22.48		0.58	17.62	0.23	35.40	8.70	4.02	32.20		41.86	39.62	4.19		0.12	37.78	2.92	379.50	28.56
Horse mackerel	Tracurus tracurus					0.12			2.62							0.28			0.37		0.07	0.90
Norway pout	Trisopterus esmarkii					0.16																
Haddock	Melanogrammus aeglefinus	0.01				50.80							0.01									
Whiting	Merlangius merlangus	0.04	0.26			0.71		0.07			0.01		0.02			0.03	0.02				0.01	
Blue-whiting	Micromesistius poutassou		8.57																	14.92		
Saithe	Pollachius virens		7.68			7.34									6.62			4.90		16.40		
Hake	Merluccius merluccius																					
Pollack	Pollachius pollachius																					
Torsk	Brosme brosme																					
Cod	Gadus morhua					2.36																
Poor cod	Trisopterus minutus																					
Ling	Molva molva																					
Argentine	Argentina sphyraena																					
Sandeels	Ammodytidae spp																					
Gurnard	Trigla spp					0.64		0.08											0.43			0.44
Dab	Limanda limanda					1.04																
Plaice	Pleuronectes platessa					1.26																
Witch	Glyptocephalus cynoglossus																					
Lemon dab	Microstomus kitt					0.39																
Long rough dab	Hippoglossoides platessoides					2.70																
Wolffish	Anarhichas lupus																					
Lumpsucker	Cyclopterus lumpus	4.00			1.10						2.58						1.08		0.65			
Monkfish	Lophius piscatorius																					
Norway haddock	Sebastes marinus																					
Pigghå																						
Jellyfish		20.00	5.00	25.00	0.50		0.50	10.00	5.00		10.00	5.00	2.00	2.50		2.00	1.00	0.50		5.00	33.00	0.50
Other		0.01	5.11	0.01	0.09	1.61		0.06		0.05	0.04	0.07	0.01	0.01	1.24			0.17	0.04	10.50		

Table IIC.3. Cont.

Trawl station		**503**	**504**	**505**	**506**	**507**	**508**	**509**	**510**	**511**	**512**	**513**	**514**
Total catch (kg)		**199.92**	**0.34**	**6.17**	**218.25**	**3.01**	**267.78**	**3.69**	**74.71**	**87.08**	**97.41**	**1.11**	**6.23**
Herring	Clupea harengus	10.41			41.76		43.32		0.83				
Sprat	Sprattus sprattus												
Pilchard	Sardina pilchardus												
Anchovy	Engraulis encrasicolus												
Mackerel	Scombrus scombrus			5.63		2.90		2.50	0.10		96.40	1.10	6.22
Horse mackerel	Tracurus tracurus	0.79	0.33		0.60				1.09	0.22	1.00		
Norway pout	Trisopterus esmarkii	108.50			79.43		112.80		20.20				
Haddock	Melanogrammus aeglefinus	9.75			3.29		42.20		10.66	6.24			
Whiting	Merlangius merlangus	15.14			28.98		38.20	0.01	0.73			0.00	
Blue-whiting	Micromesistius poutassou				5.94								
Saithe	Pollachius virens	17.36			11.38		2.26		2.04	5.36			
Hake	Merluccius merluccius	4.13			0.08		1.80						
Pollack	Pollachius pollachius												
Torsk	Brosme brosme												
Cod	Gadus morhua								19.74	21.20			
Poor cod	Trisopterus minutus												
Ling	Molva molva								5.28				
Argentine	Argentina sphyraena												
Sandeels	Ammodytidae spp		0.00										
Gurnard	Trigla spp	1.89				0.08	1.61	0.11	0.90	2.29			
Dab	Limanda limanda	0.69							0.16				
Plaice	Pleuronectes platessa												
Witch	Glyptocephalus cynoglossus				0.67								
Lemon dab	Microstomus kitt	0.81					1.80		0.05	3.63			
Long rough dab	Hippoglossoides platessoides	24.83			28.04		9.33		3.63	0.46			
Wolffish	Anarhichas lupus								2.00				
Lumpsucker	Cyclopterus lumpus							0.80					
Monkfish	Lophius piscatorius												
Norway haddock	Sebastes marinus												
Pigghå													
Jellyfish				0.50				0.18					
Other		5.61	0.01	0.04	18.09	0.04	14.46	0.09	7.32	47.68	0.01	0.02	0.01

Table IIC.4. RV “Sarsen” 1–22 July 2003. Herring length (cm) distribution in trawl hauls where sample size>20 herring.

Trawl st	445	455	456	459	461	463	464	470	472	473	476	477	478	479
ICES rect	43F4	43F2	43F0	43F3	43F5	44F3	44F2	45F3	45F5	45F5	45F2	46F2	46F3	46F3
15.0														
15.5														
16.0										1				
16.5	5	1		6	3									
17.0	4	1	2	10	6			1						
17.5	12		1	21	8	5	2			1				
18.0	22		1	29	21	16	2			3	2			
18.5	24	4	8	19	31	20	10	1		1	1			
19.0	16	3	15	9	22	25	7	3	2	3	7			
19.5	9	13	15	3	10	10	7	5	3	5	5			2
20.0	6	9	29	3	7	2	10	6	7	4	7			4
20.5	1	13	17		6	10	10	2	13	18	7			6
21.0	1	21	7		2	6	9	5	9	16	7	1	2	10
21.5		17	1		4	5	8	3	14	18	5		2	9
22.0		16	3				6	9	8	11	14	2	5	8
22.5		11	1		1	1	5	3	4	5	7	1	5	8
23.0		12					4	7	6	3	9	7	10	4
23.5		15			1			6	5	4	8	5	7	2
24.0		4						6	7	2	7	6	7	8
24.5		2			1				4		3	7	9	6
25.0		3						10	4	2	3	17	14	8
25.5		2						5	3		2	13	11	6
26.0		1						7	4			12	6	6
26.5		2						5	2		5	13	9	4
27.0								6	1			8	5	2
27.5								4	2	1		4	2	2
28.0								1	2	2	1	3	3	2
28.5								2				1	1	
29.0								1					2	1
29.5														1
30.0														
30.5														
31.0														
31.5														
32.0														
32.5														1
33.0														
33.5														
34.0														
34.5														
35.0														
35.5														
36.0														
Total N	100	150	100	100	123	100	80	98	100	100	100	100	100	100
mean W(g)	0.051	0.091	0.063	0.050	0.055	0.059	0.068	0.113	0.101	0.085	0.092	0.145	0.136	0.119
mean L(cm)	18.7	22.1	20.1	18.2	19.1	19.4	20.6	23.8	22.8	21.6	22.4	25.6	25.0	23.8

Table IIC.4. Cont.

Trawl st	481	482	483	484	486	487	489	490	494	495	500	501	503	506	508
ICES rect	46F2	47F3	47F4	47F4	47F1	47E9	48F3	48F3	48F3	48F3	49F3	49F4	50F0	49F0	50F0
15.0															
15.5															
16.0															
16.5															
17.0															
17.5															
18.0															
18.5															
19.0			1												
19.5												1			
20.0				2								1			
20.5	1			2	1						1	1			
21.0			5	3								3		1	
21.5	1		5	12	1							10			
22.0	2		20	15	5	1				1		17			
22.5	3		9	12	1					2	2	6			
23.0	4		13	13	2	2		2		4	2	13			
23.5	2	1	3	8	6	3	1	1		4	1	6			
24.0	3	6	14	8	3	7		2	2	10	4	11	1	4	1
24.5	3	1	5	11		17	3	5	5	11	1	6	2	8	4
25.0	7	4	11	6	1	29	2	2	13	8	2	7	4	13	2
25.5	5	5	3	1		15	4	8	13	12	7	6	4	13	7
26.0	8	4	6	2	1	8	1	4	8	10	8	3	5	9	6
26.5	12	7	2	4		8	5	18	6	12	8	3	6	14	18
27.0	14	5				5	4	10	13	12	4	1	4	12	18
27.5	11	3	2			4	2	5	4	7	4	2	7	4	27
28.0	12	8	1	1		1	5	17	12	6	8	3	7	12	35
28.5	7	1					2	6	1				4	2	9
29.0	3	2				1	3	8	5	1	2		3	2	4
29.5	2	3					1	7	1		4		5	3	11
30.0							1	3	1		1		2	1	4
30.5								1			1			1	2
31.0							1		1		1				
31.5								1							1
32.0														1	
32.5											1				1
33.0															
33.5															
34.0															
34.5															
35.0															
35.5															
36.0											1				
Total	100	50	100	100	21	101	35	100	85	100	63	100	54	100	150
mean W(g)	0.167	0.147	0.111	0.110	0.100	0.138	0.175	0.196	0.165	0.155	0.17	0.112	0.1929	0.168	0.204
mean L(cm)	26.5	26.8	23.7	23.4	23.3	25.5	27.3	27.5	26.8	25.9	26.9	23.7	27.5	26.7	27.8

Table IIC. 5. RV “Sarsen” 1–22 July 2003. Number of otoliths collected by age and length and maturity stages (number of fish sampled) in the Norwegian target area.

Length	1		2		3		4	5	6	7	8	9+	Total
cm	im	mat	im	mat	im	mat	mat	mat	mat	mat	mat	mat	
16,0	1												1
16,5	3												3
17,0	8												8
17,5	19		2										21
18,0	38		5										43
18,5	44		8										52
19,0	44		18										62
19,5	32		19	1									52
20,0	26	1	24	4									55
20,5	17	1	44	5									67
21,0	10	1	34	16									61
21,5	8		38	17	1	1							65
22,0	1	1	50	34	2								88
22,5	1	1	22	22	3	2	1						52
23,0			28	36	2	6	1	1					74
23,5			14	23	3	7	4	1					52
24,0			15	36	8	17	8	1					85
24,5			3	30		17	7	3					60
25,0			6	50	4	25	17	2					104
25,5			1	42	2	19	26	3					93
26,0				19	2	23	25	8	1				78
26,5				22		27	37	15	1	1			103
27,0				4		22	33	10	3	1			73
27,5				2	1	16	19	10	2	3			53
28,0				1		19	33	15	8	3	2		81
28,5						4	10	4	1		1		20
29,0						1	13	5	5	3	1		28
29,5						2	9	1	1	6	4		23
30,0						1	4	1		1		1	8
30,5									1	1	2		4
31,0								1					1
31,5							1						1
32,0													0
32,5									1			1	2
36,0										1			1
Total	252	5	331	364	28	209	248	81	24	20	10	2	1574

Table IIC.6. Mean length, mean weight, numbers (millions) and biomass (thousands of tonnes) by age and maturity stage for herring in the Norwegian target area. RV "Sarsen", 1–22 July 2003.

Age	L_{mean}	W_{mean}	North Sea Autumn Spawners				Western Baltic Spring Spawners			
			No (mill)	%	Biom.(10^3 t)	%	No (mill)	%	Biom(10^3 t)	%
1I	19,2	52,62	1030	34,3	54	19,5	788	44,3	41	26,0
1M	21,5	89,63	2	0,1	0	0,1	6	0,3	1	0,3
2I	21,7	75,35	852	28,3	64	23,1	340	19,1	26	16,1
2M	23,7	113,10	476	15,8	54	19,4	205	11,5	23	14,5
3I	24,1	116,24	25	0,8	3	1,1	48	2,7	6	3,5
3M	25,8	145,84	178	5,9	26	9,4	141	7,9	20	12,8
4	26,7	164,50	280	9,3	46	16,6	162	9,1	27	16,7
5	27,2	173,40	112	3,7	19	7,0	63	3,6	11	6,9
6	28,2	189,84	18	0,6	3	1,2	13	0,7	2	1,5
7	29,3	213,22	24	0,8	5	1,8	12	0,7	3	1,7
8	29,4	227,21	7	0,2	2	0,6	1	0,1	0	0,1
9+	31,5	230,68	3	0,1	1	0,3	0	0,0	0	0,0
Total	23,4	92,30	3007	100,0	278	100	1780	100	160	100
Immature	20,8	63,61	1907	63,4	121	43,7	1177	66,1	73	45,5
Mature	25,5	142,04	1100	36,6	156	56,3	603	33,9	87	54,5

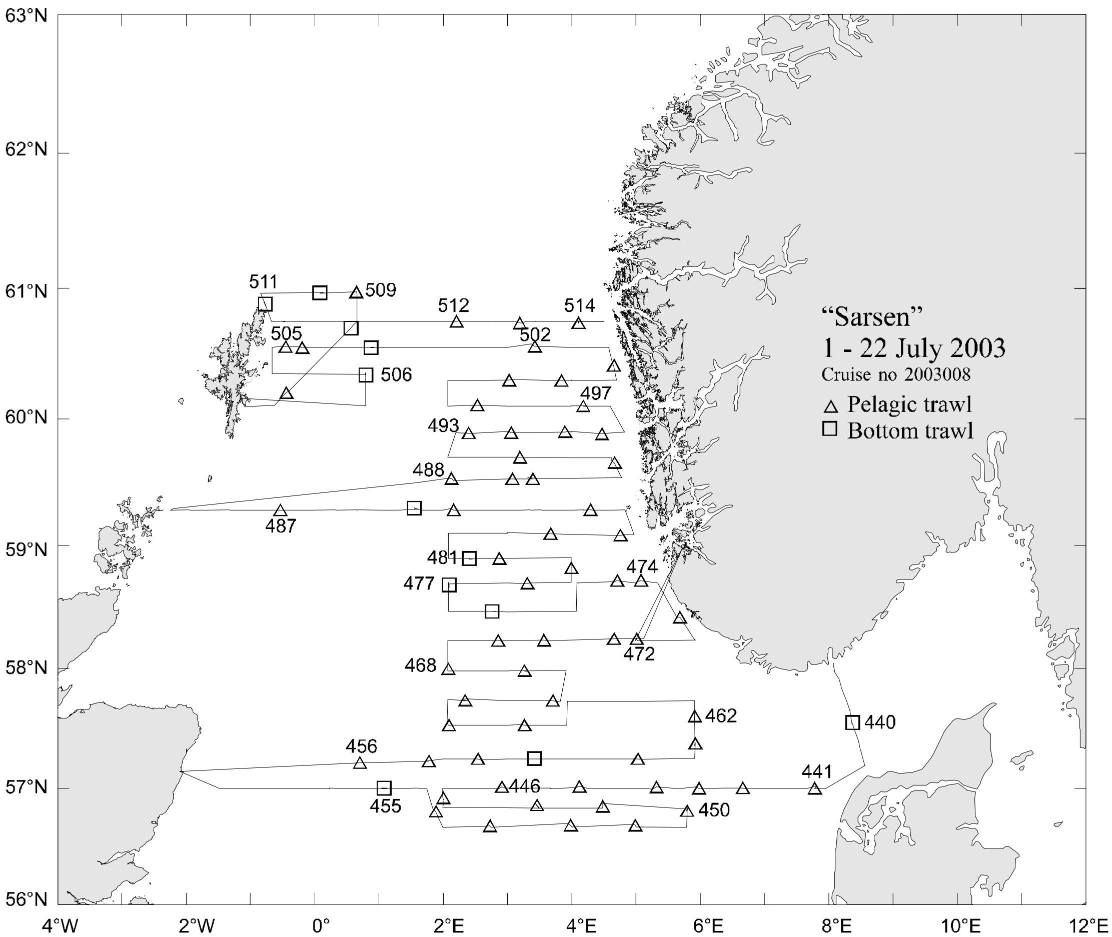


Figure IIC.1. Cruise track and fishing trawls undertaken during the acoustic survey on RV "Sarsen", 1–22 July 2003.

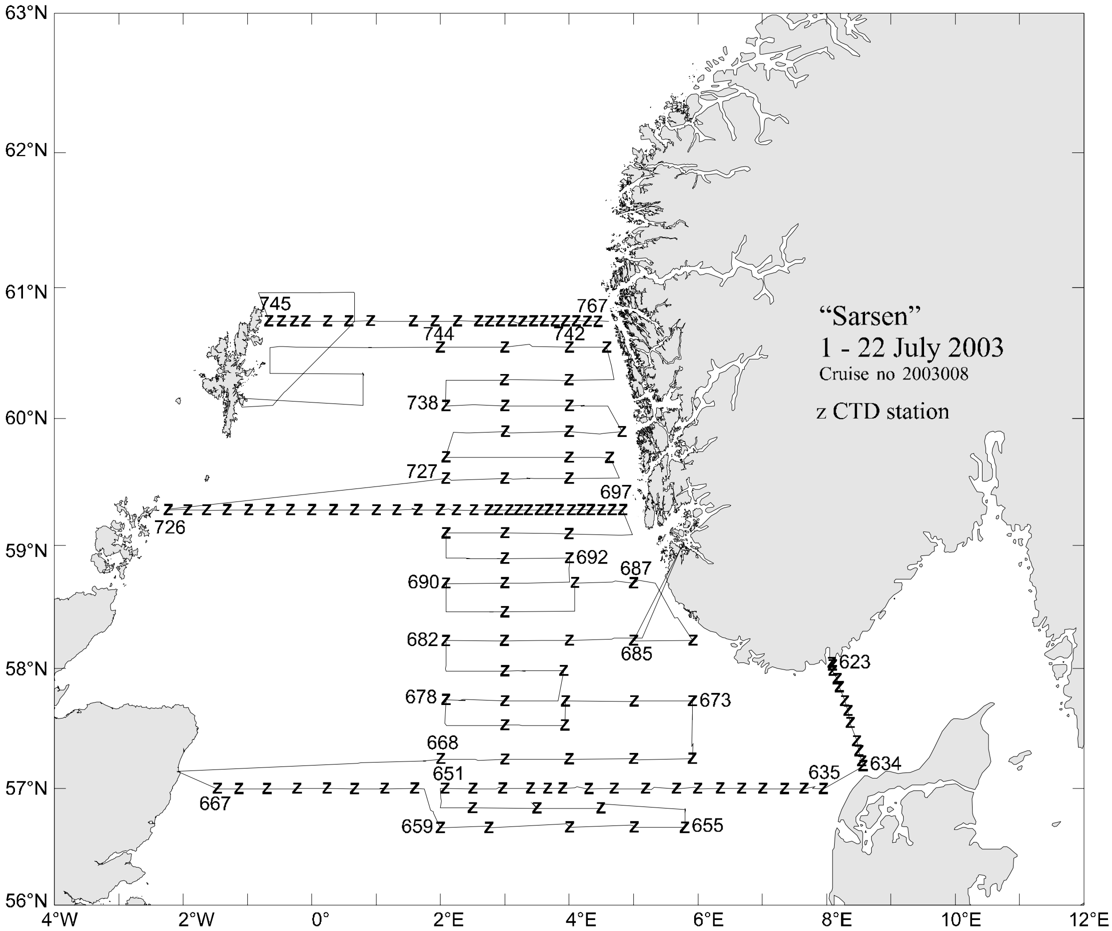


Figure IIC.2. Cruise track and CTD-stations undertaken during the acoustic survey on RV "Sarsen", 1–22 July 2003.

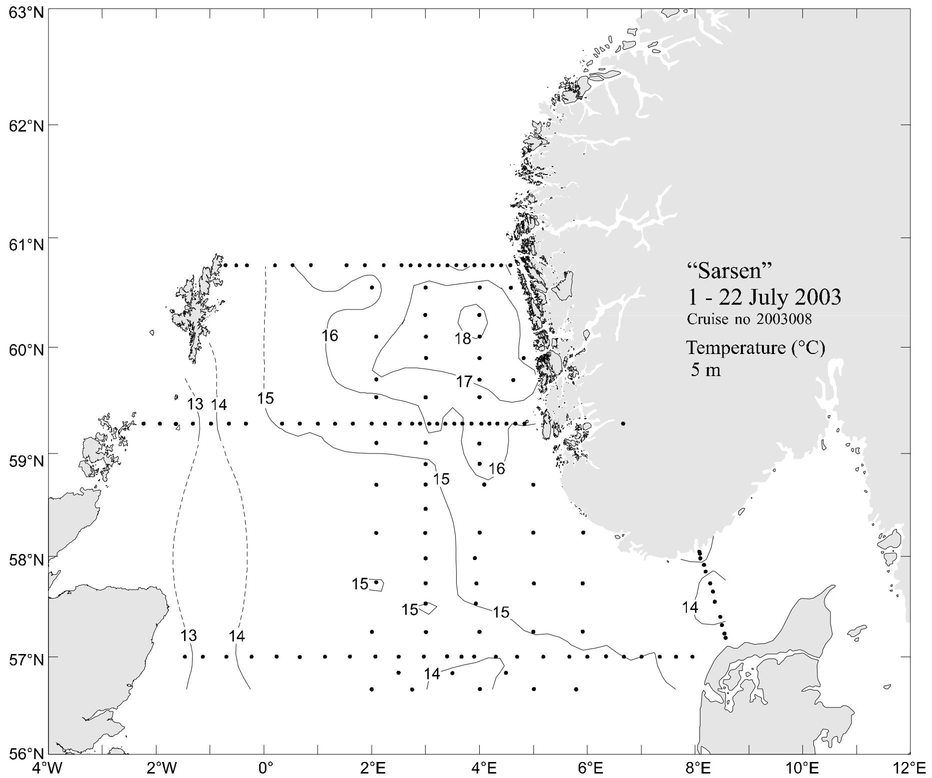


Figure IIC.3a. The horizontal distribution of temperature at 5 m. RV "Sarsen", 1–22 July 2003.

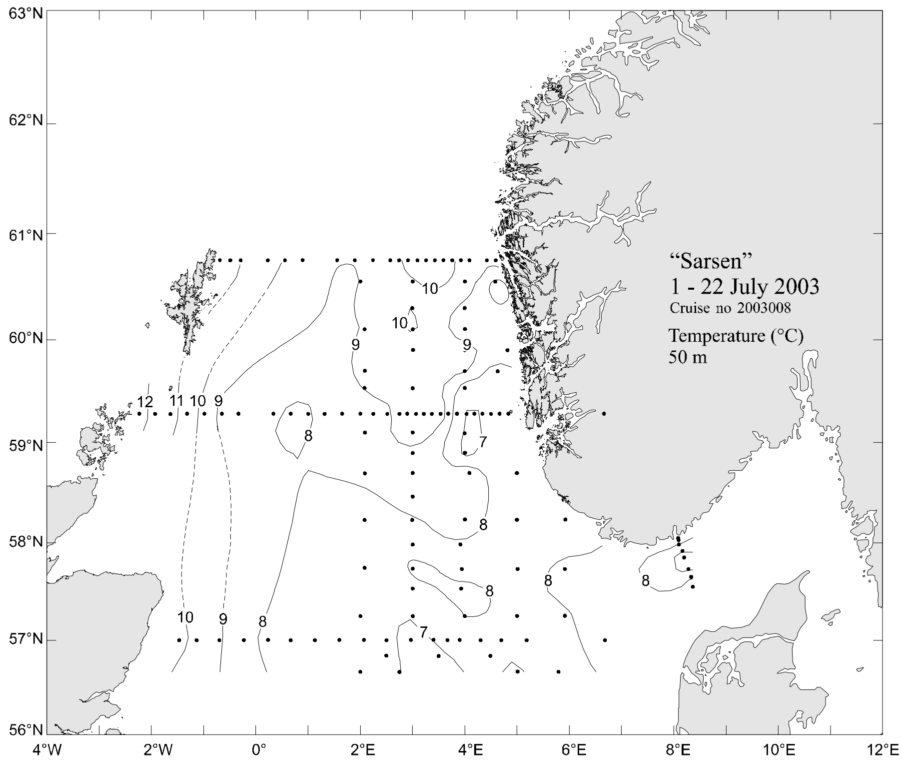


Figure IIC.3b. The horizontal distribution of temperature at 50m. RV "Sarsen", 1–22 July 2003.

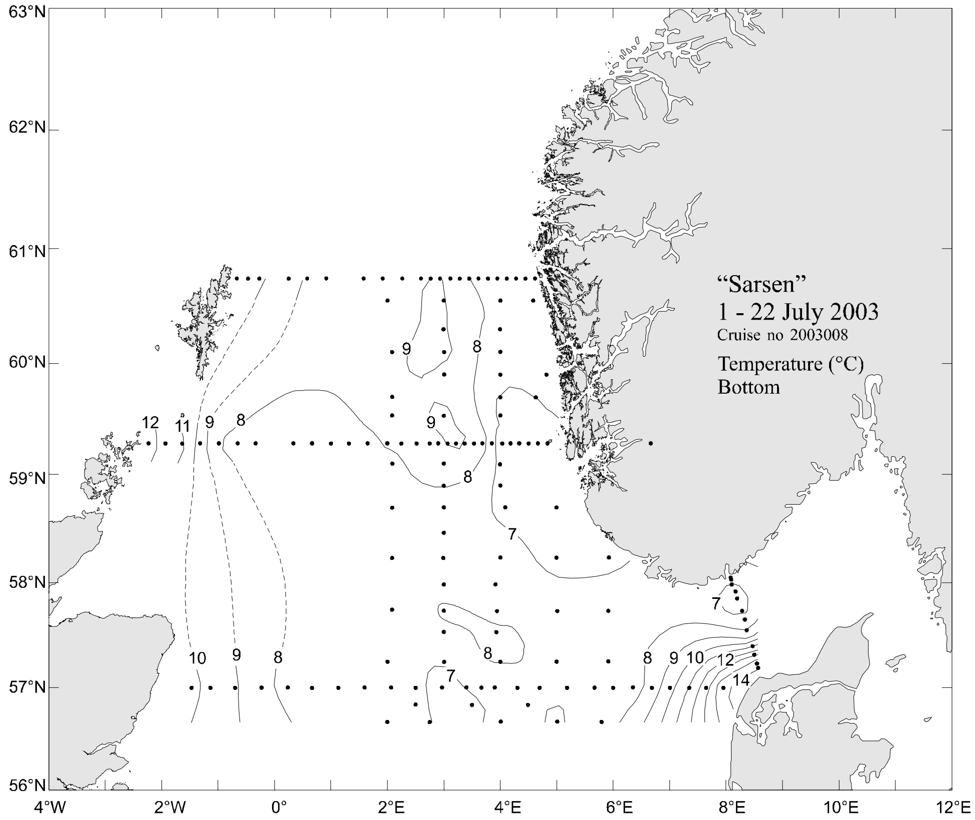


Figure IIC.3c.The horizontal distribution of temperature at bottom. RV "Sarsen", 1–22 July 2003.

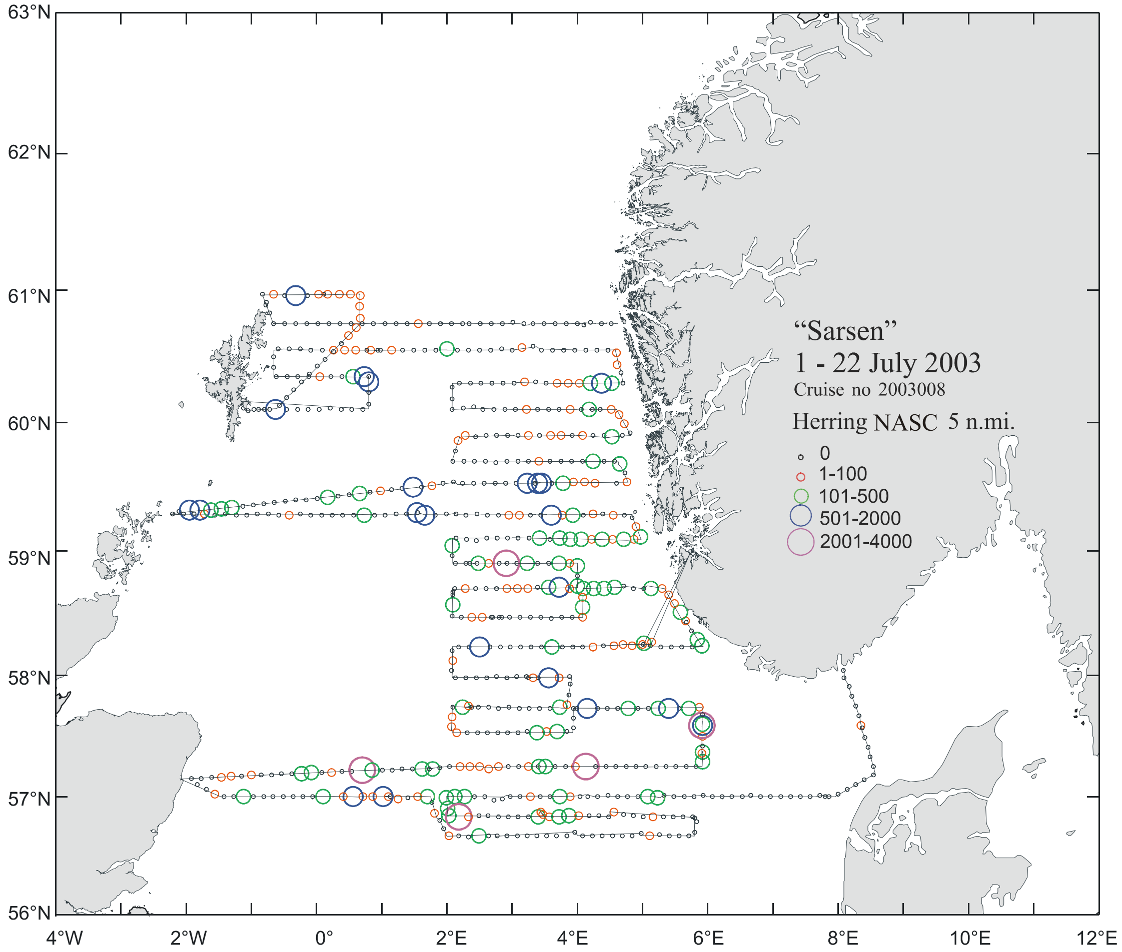


Figure IIC.4. Mean NASC -values attributed to herring per 5 n.mi. during the acoustic survey on RV "Sarsen", 1–22 July 2003.

Appendix IID: Survey report for RV Scotia

27 June -20 July 2003

E. J. Simmonds, FRS Marine Lab Aberdeen.

1. INTRODUCTION

Background

This survey was developed from 1979 to 1983 and has been carried out annually since 1984 to provide estimates of adult herring in the Orkney Shetland area. The survey is designed to provide indices of abundance at age for herring.

Objectives

- To conduct an acoustic survey to estimate the abundance and distribution of herring in the north western North Sea and north of Scotland between 58–61·45'N and 4·W to 2·E, Faroese waters.
- To Obtain echosounder trace identification using pelagic trawl and demersal trawl.
- To obtain samples of herring for biological analysis, including age, length, weight, sex, maturity and ichthyophonus infection
- To obtain samples of herring for genetic analysis for HERGEN.
- To obtain photographic records for fish maturity analysis.
- To obtain hydrographic data for comparison with the horizontal and vertical distribution of herring.
- To obtain plankton samples for acoustic identification work.

2. Survey Description and Methods

2.1 Staff

John Simmonds	Cruise Leader
Iain Penney	Fish Lab Technician 2nd half
Robert Watret	Fish Lab Technician 1st half
Phil Copland	Acoustic Technician
Marco Kienzle	Fisheries Biologist
Michael Stewart	Acoustic Technician 1st half
Owen Goudie	Fish Lab Technician
Angus Mair	Phd Student
Jose Xavier	BAS student
Norma Garcia-Nunez	MSc Student pt 1st half
Juan Zwalinowski	Phd Student pt 2nd half

2.2 Narrative

Scotia sailed at 1200 UTC on 27 June 2001 and made passage and anchored in Scapa Flow to calibrate the acoustic instruments on all scientific sounders. At 0730 Scotia left Scapa Flow and commenced survey at 1015 UTC at 59° 03' N 2° 37' W. The survey was carried out on east west transects on a 15n.mi. spacing progressing northwards between 2E, the Scottish mainland, and the Orkney and Shetland Islands from 0200 to 2200 UTC. The cruise track is given in Figure IID1. This section was chosen to be carried out first to coincide with FRV Tridens which also surveyed part of this area during these days After five transects were carried out Scotia steamed south overnight and surveyed the area between 58° N and 59° N, returning north to carry on the survey to the easy of Shetland. Additional short transects were added into the survey in areas of expected higher herring abundance to the east of Shetland. Scotia broke off the survey at 2200 on 9 July FRV Scotia at 60° 41'N 1°30'E) and docked in Lerwick at 0700 UTC on 10 July for a mid cruise break. Scotia sailed again at 0700 UTC on 11 July and recommenced the survey at 60° 48'N 0° 44'W at 1245 BST. FRV Scotia continued the survey north to 61° 33'N and then progressed southwards to the west of Shetland carrying out 7.5 n.mi spaced transects west of Shetland. Scotia carried out an inter-ship comparison with FV Enterprise on 19 July in an area between 59° 30'N 4° 00'W and 60° 00'N 3° 20'W. FV Enterprise was carrying out an acoustic survey for herring to the west of Scotland..

Scotia finished the survey at 0400 UTC on 20 July.(58° 43'N 3° 25'W). FRV Scotia then proceeded to Scappa Flow to carry out a second calibration of the acoustic instruments. FRV Scotia departed Scappa Flow following successful calibration of acoustic instruments at 1600 UTC and sailed to Aberdeen and docked at 0530 UTC on 21 July 2003.

2.3 Survey design

The survey track (Fig 1) was selected to cover the area in two 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 north west. A transect spacing of 15 nautical miles was used in most parts of the area with the exception areas both east and west of Shetland where short additional transects were carried out at 7.5 n.mi. spacing. On the administrative boundaries of 2°E and 4°W 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 was then included in the data analysis. Transects at shelf break were continued to the limits of the stock and the transect ends omitted from the analysis. Transects at the coast were continued as close inshore as practical, those on average less than half a transect spacing from the coast were excluded from the analysis, those at greater distance were included in the analysis. The origin of the survey grid was selected randomly within a 15 n.mi. interval the track was then laid out with systematic spacing from the random origin. Where the 7.5 n.mi. transect spacing was used the same random origin was used.

2.4 Calibration

Two calibrations were carried out in Scappa Flow on the transducer systems used during the survey one at the beginning of the survey on the night of 27/28 June and one at the end of the survey on 20 July. Standard sphere calibrations were carried using 38.1mm diameter tungsten carbide sphere for 18, 38 and 120kHz. A 36.4mm sphere was used for 200kHz. For the 38kHz agreement between this years calibration and the previous year was better than 0.2 dB. Agreement between the calibrations was better than 0.1dB. The calibration settings and results for 38kHz are given in Table IID1.

2.5 Acoustic data collection

The acoustic survey on FRV *Scotia* was carried out using a Simrad EK500 38 kHz sounder echo-integrator with transducer mounted on the drop keel. For most of the survey the keel was kept at 1m extension placing the transducer at 7m depth. Only during bad weather was the keel lowered to 3m extension with the transducer at 9m depth. Additional data was collected at 18 120 and 200kHz. Data was archived for further data analysis carried out using Echoview software and Marine Lab Analysis systems. Only data from 38,120 and 200kHx systems were used in the analysis. Data was collected from 0200 to 2200 UTC. Paper records were kept for acoustic data at 38. A total of 2,784 n.mi. were surveyed and included in the analysis.

2.6 Biological data - fishing trawls

Pelagic trawl hauls (positions shown in Fig 1) were carried out during the survey on the denser echo traces. The pelagic fishing gear used throughout the survey was PT160. The haul was monitored using Simrad FS903 scanning netsonde and computer recordings of the hauls were archived to PC using screen capture software. 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 0.5cm class from 21–25.5cm 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.

Demersal trawls were carried out at 20 of the pelagic trawl locations immediately following the pelagic trawls on a reverse track. The trawl used throughout was the BT101 Monk trawl. In all but 2 demersal hauls all species were counted and measured, sub-samples were taken on two hauls.

2.7 Hydrographic data

Surface temperature and salinity was collected throughout the survey. CTD stations were taken at each night location (2200hrs) and mini-logger recordings of temperature were taken at each haul location.

2.8 Data analysis

Data from the echo integrator were averaged over quarter hour periods (2.5 n.mi. at 10 knots). Echo integrator data was collected from 11 m below the surface (transducer at 7 m depth) to 0.5 m above the seabed, for most of the survey. The data were divided into seven categories, by visual inspection of the echo-sounder paper record and the integrator cumulative output:

1) “herring traces”,
2) “probably herring traces” and
3) “probably not herring traces” all below 50 m
4) shallow herring schools above 50 m,
5) shallow schools not herring above 50m,
6) mixture including herring blue whiting, and mackerel
7) mixture including herring and mackerel

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

$$TS = 20\log_{10}L - 71.2 \text{ dB per individual for herring}$$
$$TS = 20\log_{10}L - 67.5 \text{ dB per individual for all gadoids}$$
$$TS = 20\log_{10}L - 84.9 \text{ dB per individual for mackerel}$$

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

To process the data for extraction of schools the variable computation method available in Echo View was used. The method used in 2001 was used again this year. Previously when processing by hand (2000 and before) a small ‘background’ value for scattered fish was removed from integrator layers with many fish schools. It was noted that fish schools appear consistently on 38,120 and 200kHz echograms while other features such as plankton may be strong on some frequencies and week on others. The processing was:

Sv_{used} = Sv38*[Sv_{38}+ Sv_{120}+Sv_{200} ** Blur>-170dB]

Where Blur is a convolution matrix:

$$\begin{bmatrix} 1 & 2 & 1 \\ 2 & 1 & 2 \\ 1 & 2 & 1 \end{bmatrix}$$

The Blur convolution filter is chosen as a suitable smoothing function as previous experiences suggests it is well suited to the types of amplitude distributions expected from echoes from fish aggregations. It provides a smoother spatial filter for filling in values in a school than either a centered weighted or uniform averaging filters.

Data are allocated to quarter statistical rectangles by their mid point location, the estimate of density is obtained as the arithmetic mean of all values weighted by duration of the run to accommodate the small number of short ESDUs.

Biological information in post stratified method based on kolmogerof Smirnov test (see MacLennan and Simmonds 1992). The length frequency data is given in Table IID4.

The mixed species categories were apportioned using the catches in the local area. For the gadoid mixtures hauls 245 and 257 were used individually to give numbers by species. For mackerel herring mixture to the west of Shetland catches from hauls 287, 288 and 289 were combined. These mixtures contribute less than 2% to the total estimate of herring.

3. RESULTS

3.1 Acoustic data

The distribution of NASC values along the cruise track is shown in Figure IID2. The herring are distributed more evenly in 2002 than in 2001 the largest single 2.5n.mi. ESDU contributes only 4% of the population estimate from FRV Scotia.

3.2 Biological data

A total of 40 pelagic trawl hauls were carried out (Fig 1), the locations, dates and time of these are shown in Table IID2. All 40 hauls had significant numbers of herring were used to define eight herring survey sub areas (Fig 3). Table IID3 shows the total catch by species. The mean length keys, mean lengths, weights and target strengths for each haul and for each sub area are shown in Table IID4. The spatial distribution of mean length is shown in Figure IID3. A total of 3,294 otoliths were taken to establish eight age length keys, one per area, the total number of otoliths taken by length and age is given in Table IID6. There is again evidence of only very small amounts of icthyophonus in the population. This was similar to last year. Only 6 herring from 3,294 herring sampled were found to show macroscopic evidence of infection. From these numbers its not possible to infer age or size of the infected fish. The stratified weight at length data was used to define the weight-length relationship for herring, which was:

$$W = 2.024\ 10^{-3}\ L^{3.465}\ g\ (L\ \text{measured in cm})$$

The proportions of mature 2 ring and 3 ring herring were initially estimated at 47% and 83% respectively. This is a very different proportion for both 2 ring and 3 ring mature to those found in 2001 and 2002 (2wr 88% 3wr 96%). The differences were investigated. The herring found in the North West (analysis areas I, II, III, VII and VIII in Figure IID3) are similar to those found throughout the area in 2001 and 2002. Those found in the South East (analysis areas IV, V and VI) are different. The proportions mature can be seen in Figure IID4 for the three years and for the two sections of the area in 2003. The mean length of 2 and 3wr herring in the different stages of maturity was also investigated (Figure IID5). Immature herring at 2 and 3wr are a similar size in the three years and the two parts of the area in 2003. Mature herring at 2wr are larger than immature herring and similar among years but may be smaller in the South East. Mature 3wr herring are a similar size in all years though larger 3wr herring are found in the North West. The abundance of immature 2wr herring is relatively greater in 2003 than previous years leading to a smaller less mature population in the area. On average 2wr herring are 1.3cm smaller in 2003 than in 2001 or 2003. In addition the maturity ogive is to be slightly higher in 2003 by about 0.4cm (Figure IID6). Further investigation of the maturity ogive suggested that there may be some difference in interpretation of maturity stage. The maturity staging was investigated further. The weight of gonads by maturity stage were compared for the last 3 years. Cumulative distributions of gonad weight are shown in Figure IID6 for 2001, 2 and 3 at stage 2 and 3. 2003 is shown as having both the heaviest immature gonads and the lightest mature ones. This suggests delayed development but also the possibility that some maturing gonad might have been classed as immature. The results from 2001 and 2 suggest a number of weight and fish length criteria.

no mature gonads weighed more than 3 g
the 50% mature point occurred at gonad weight of 1.0 g
the 50% mature point occurred at fish length of 23.0 cm

These criteria developed from earlier years were compared in the NW and SE parts of the area through the maturity ogive. The outcome is shown in Figure IID7. The NW part of the area is relatively unaffected by the change in method. However, the SE area is rather sensitive to the choice The high gonad weights seen in data from 2003 were thought to be potentially incorrect and it was decided to use the value of 1g derived from 2001/2 data. This results in fractions mature of 0.65 and 0.93% respectively.

Thus there is a suggestion that the 2000 year class has grown more slowly and is maturing later than earlier year classes. In contrast, the 1999 year class has grown at the same rate and mean weights are higher those from the 1997 and 1998 year classes. The change in fraction mature is due primarily to a shift in overall growth.

3.3 Biomass and Abundance estimates

The numbers and biomass of fish by quarter ICES statistical rectangle are shown in Figure IID7 A total estimate of 16,210 million herring or 2,504 thousand tonnes was calculated for the survey area. 2,275 thousand tonnes of these were mature. Herring were found mostly in water with the seabed deeper than 100 m, with traces being found in waters with depths of up to 200 m. The survey was continued to 250 m depth for most of the western edge between 0E and 4EW. Herring were generally found in similar water depths and location to 2001 however, the distributions were slightly more northerly with more herring found east of Shetland. The proportion of 4 ring herring was much higher than last year, rising from 16% of the total 2+ biomass in 2001 to 35% in 2002, this year class now dominates the adult population. The incoming 2000 year class contributes 24% but as only 60% by weight is mature this will be an important year class. The fish traces were continuous in character similar to previous years mixed in size but in most case quite separate from other species. Table IID6 shows the estimated herring numbers mean lengths weights and biomass and proportion mature at age 2 and 3 ring by age class.

In addition to the 2,504 thousand tonnes of herring, approximately 400 thousand tonnes of other fish species were observed in mid water in similar depths and conditions. Examination of the catch by species (Table IID1) shows that the numbers of fish species other than herring caught in pelagic hauls were very small and very variable indicating the difficulty of allocating this component among these species so this has not been attempted. The dominant species other than herring must be considered to be blue whiting, mackerel with some Norway pout. For the second time no cod were caught as by-catch in any of the pelagic hauls. Though some were caught in demersal hauls, the survey indicates that the overall biomass is similar to last year with 4 and 2 ring herring dominating.

3.4 Ichthyophonus Infection

Only 6 out of 3,294 fish examined for macroscopic evidence of ichthyophonus infection were found to contain this.

Table IID1. Simrad EK500 38 kHz system and analysis settings used on the Scotia herring acoustic survey 27/6–20/7/2003.

Transceiver Menu	
Frequency	38 kHz
Sound speed	1490 m.s^{-1}
Max. Power	2000 W
Equivalent two-way beam angle	-21.0 dB
Default Transducer Sv gain	26.67dB
3 dB Beamwidth	7.1°
Calibration details	
TS of sphere	-42.36 dB
Range to sphere in calibration	9.94
Measured NASC value for calibration	3150
Calibration factor for NASCs	0.934
Calibration constant for MILAP (optional)	0.93 at -35 dB
Log Menu	
Simulated	2.5 n.mi. at 10 knots
Operation Menu	
Ping interval	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
Range of thresholds used	-70 dB on 38 -170 on combined blurred 38,120,200

Table IID2. Details of the fishing trawls taken during the Scotia herring acoustic survey, 27/6–20/7/2003: No. = trawl number; Trawl depth = depth (m) of headrope *if net is on bottom; Gear type P=pelagic, D=demersal, O=other; Duration of trawl (minutes); Total catch in kg Use: h=used to qualify herring acoustic data, s= used to qualify sprat acoustic data (blank if neither).

No	Date	Postion	time (UTC)	Water Depth	Trawl Depth	Gear Type	Duration (min)		Total Kg
267	28/6	59 03.31N 001 57.14W	1332	76	66*	P	46	h	120
268	/	foul haul							
269	29/6	59 03.15N 000 11.13W	0319	132	122*	P	132	h	900
270	29/6	59 03.11N 000 04.82W	0500	144	134*	P	144	h	600
271	29/6	59 04.79N 000 08.02W	0630	142	140*	B	142		300
272	29/6	59 18.19N 000 29.57E	1851	132	122*	P	132	h	750
273	29/6	59 17.96N 000 30.74E	2040	130	128*	B	130		120
274	30/6	59 18.05N 000 34.70W	0522	126	116*	P	126	h	60
275	30/6	59 17.85N 001 30.65W	0903	99	89*	P	99	h	1500
276	30/6	59 17.74N 001 30.54W	1113	120	118*	B	120		300
277	1/7	59 33.07N 001 11.12W	0439	105	95*	P	105	h	180
278	1/7	59 33.18N 001 15.60W	0604	115	113*	B	115		240
279	1/7	59 33.03N 000 03.91W	1023	138	128*	P	138	h	1800
280	1/7	59 32.87N 000 08.12W	1213	140	138*	B	140		160
281	2/7	59 48.47N 000 06.21W	0528	130	120*	P	130	h	750
282	2/7	59 48.47N 000 49.78W	0922	127	117*	P	127	h	750
283	2/7	59 47.87N 000 46.84W	1057	127	125*	B	127		136
284	2/7	59 54.90N 000 41.08W	1459	125	115*	P	125	h	2400
285	3/7	58 47.85N 000 00.61E	0937	140	130*	P	140	h	750
286	3/7	58 48.00N 000 09.56E	1202	135	133*	B	135		170
287	3/7	58 47.81N 000 52.20W	1557	125	115*	P	125	h	300
288	4/7	58 03.36N 000 15.92W	1211	125	115*	P	125	h	2400
289	5/7	58 19.03N 000 18.13E	0606	145	135*	P	145	h	900
290	5/7	58 18.52N 000 18.51E	0754	145	143*	B	145		165
291	6/7	58 32.95N 000 22.01W	1000	115	105*	P	115	h	150
292	6/7	58 33.37N 000 16.23W	1156	120	118*	B	120		124
293	6/7	58 33.14N 000 41.42E	1551	150	148*	B	150		139
294	7/7	60 03.11N 000 19.49W	1044	115	105*	P	115	h	3600
295	7/7	60 10.97N 000 33.58E	1944	145	135*	P	145	h	450
296	7/7	60 10.90N 000 34.98E	2048	130	128*	B	130		60
297	8/7	60 23.81N 000 44.87E	0426	146	136*	P	146	h	1200
298	8/7	60 18.02N 000 05.53E	1350	155	145*	P	155	h	930
299	9/7	60 32.83N 000 07.38E	0615	125	115*	P	125	h	360
300	9/7	60 32.84N 000 10.51E	0800	127	125*	B	127		75
301	9/7	60 41.03N 000 41.61W	1240	98	88*	P	98	h	600
302	9/7	60 40.99N 000 32.14W	1416	125	115*	P	125	h	2400
303	9/7	60 40.94N 000 35.43W	1555	125	123*	B	125		60
304	11/7	60 47.96N 000 32.52W	1247	111	101*	P	111	h	1050
305	12/7	61 17.98N 000 09.85W	1207	167	157*	P	167	h	300
306	12/7	61 18.27N 000 12.97W	1344	167	165*	B	167		105
307	12/7	61 18.05N 000 49.65E	1838	162	152*	P	162	h	3000
308	12/7	61 18.02N 000 42.18E	1914	162	160*	B	162		420
309	13/7	61 32.95N 001 11.46E	0535	184	174*	P	184	h	1020
310	13/7	61 32.89N 000 32.88E	0919	195	185*	P	195	h	2100
311	13/7	61 32.88N 000 46.88W	1509	202	200*	B	202		510
312	13/7	61 32.82N 000 47.44W	1701	202	192*	P	202	h	450
313	14/7	60 48.82N 002 03.63W	0821	122	112*	P	122	h	195
314	15/7	60 26.04N 002 02.26W	0552	109	99*	P	109	h	1200
315	15/7	60 26.15N 001 54.77W	0730	120	118*	B	120		70
316	15/7	60 17.94N 003 34.32W	1528	130	128*	B	130		60
317	15/7	60 17.95N 003 39.15W	1728	130	120*	P	130	h	450
318	16/7	60 11.33N 002 20.71W	0657	120	110*	P	120	h	1800
319	16/7	60 10.99N 002 14.20W	0838	120	118*	B	120		105
320	16/7	60 02.87N 003 30.51W	1503	135	125*	P	135	h	2700
321	16/7	60 03.11N 003 35.15W	1659	135	133*	B	135		480
322	17/7	60 03.01N 004 32.57W	0400	130	120*	P	130	h	600
323	17/7	59 48.11N 001 41.49W	0833	115	105*	P	115	h	1200
324	17/7	59 55.00N 003 38.95W	1920	146	136*	P	146	h	900
325	17/7	59 55.03N 003 43.50W	2035	145	143*	B	145		60
326	18/7	59 40.85N 003 25.78W	0600	145	135*	P	145	h	300
327	18/7	59 33.04N 003 51.84W	0953	164	154*	P	164	h	300
328	18/7	59 32.82N 003 55.20W	1152	150	148*	B	150		60

Table IID2. (cont.) Total catch in number by species for trawl hauls from the Scotia acoustic survey 27/6 – 20/7/2003. Estimated total catch is given in kg.

Haul No	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290
Est catch (Kgs)	120	FOUL	900	600	300	750	120	60	1500	300	180	240	1800	160	750	750	136	2400	750	170	300	2400	900	165
Herring	1336		6615	4740	240	4913	51	497	14300	31	1578	16	12120	357	4250	5975	1	19361	5767	257	3120	30480	6900	96
Mackerel			75				1	1	300	5		6		9			2							2
Sprat																								
Cod							1			6		3		5			4			1				2
Saithe					172		26			4		8		22	12		6			16				53
Blue Whiting										3							1							1
Norway Pout					308	12	404			288		690		985			78			1348				504
Poor Cod										20		5					4							
Gadiculus														3						3				1
Greater Argentine										5		5												
Lesser Argentine										18		63		1			5			1				
Haddock	4				270		69	11		375		467		35			252			147				86
Whiting					53	12	64	1		637		301		61			63			60	20			43
Hake										7		1		1			1							
Ling														1			2							
Scad										3							7							
Lythe																								
Cuckoo ray														1										
Starry ray														1										
4 Beard Rockling																								
C.Lyra										3														
Imperial Scaldfish										2														
Angler	4									5														
Norway haddock																	22							
Bluemouth																								
Greater Forkbeard																								
L.Spotted Dogfish												1					1							
Grey Gurnard								35		184		33					9							
Red Gurnard																								
Megrim																								
Plaice										47		23												
Lemon Sole										47		46		2										
Witch					2																			
Common Dab					2					198		30		1			5			1				
Long Rough Dab					17		16			9		8					2			7				12
Nephrops							57																	1
Ommastrephids																	2							1
Pandalus																								9
unidentified																								
Sample (kg)	30		60	30	290	60		60	30	180	30	240	60	160	60	30	136	45	60	30	30	30	50	165

Table IID3(cont) Total catch in number by species for trawl hauls from the Scotia acoustic survey 27/6 – 20/7/2003. Estimated total catch is given in kg

Haul No	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314
Est catch (Kgs)	150	124	139	3600	450	60	1200	930	360	75	600	2400	60	1050	300	105	3000	420	1020	2100	510	450	195	1200
Herring	1520	156	408	20480	2550	71	5984	4665	2034		11175	15200	78	4725	1203	21	11167	24	3477	7644	18	1548	456	4660
Mackerel		1	7						6						9	4		2					356	60
Sprat																								
Cod						2										1		2						
Saithe		2	9			4		15		16			2			28		459	36		38	6		
Blue Whiting						20				33						119		8			8952			
Norway Pout		201	271			147				684			258			476		300			20			
Poor Cod		3	1							11			6			5					4			
Gadiculus																					86			
Greater Argentine						2										4					99			
Lesser Argentine		1				2				3			10			3					6			
Haddock		218	88			24				65			79			46		30			15		1	
Whiting	10	66	18			51				22			83			10		15						
Hake						3				2						3		1			4			
Ling										1						3		1			2			
Scad						1				53			18		6	107		74			76			
Lythe																								
Cuckoo ray																								
Starry ray																								
4 Beard Rockling						1																		
C.Lyra																								
Imperial Scaldfish																								
Angler						1																		
Norway haddock										1														
Bluemouth																								
Greater Forkbeard																								
L.Spotted Dogfish													1											
Grey Gurnard						1				4			1			10		2			1			
Red Gurnard																								
Megrim						7				1			3			2		10			6			
Plaice										1			1											
Lemon Sole						1				1			21			1		6			1			
Witch						4										1								
Common Dab		7	2										3											
Long Rough Dab		16	1			11				8			4			2		2						
Nephrops						17				1														
Ommastrephids			1																					
Pandalus			59																					
unidentified																								
Sample (kg)	30	124	139	90	75	60	90	60	60	75	60	60	60	90	90	105	90	420	90	75	510	75	195	120

Table IID3 (cont.) Total catch in number by species for trawl hauls from the Scotia acoustic survey 27/6 – 20/7/2003. Estimated total catch is given in kg

Haul No	315	316	317	318	319	320	321	322	323	324	325	326
Est catch (Kgs)	70	60	450	1800	105	2700	480	600	1200	900	60	300
Herring	29		2125	9720	65	14040	18	3940	8400	4860	96	1500
Mackerel	10			1170	1	135	1		680	90	5	285
Sprat												
Cod		4			4		3					
Saithe		27			1		38					
Blue Whiting		205					1657			195	269	
Norway Pout		237			4		44				82	
Poor Cod	1	11			9		7				9	
Gadiculus												
Greater Argentine		7										
Lesser Argentine	21	8			3		10				7	
Haddock	137	15			226		42				22	
Whiting	62				20		10				11	
Hake	6						2					
Ling		1					5					
Scad	21	18			25		13				5	
Lythe							87					
Cuckoo ray												
Starry ray												
4 Beard Rockling												
C.Lyra												
Imperial Scaldfish												
Angler												
Norway haddock		61										
Bluemouth		7									1	
Greater Forkbeard												
L.Spotted Dogfish	4	1			4		1				1	
Grey Gurnard	21	5			1		2				2	
Red Gurnard							1					
Megrim	19						3					
Plaice	17	4			1							
Lemon Sole	43	1			12		1				42	
Witch												
Common Dab	73	1										
Long Rough Dab	7											
Nephrops												
Ommastrephids												
Pandalus												
unidentified												
Sample (kg)	70	60	60	60	105	60	480	30	30	60	60	60

Table IID4. Herring length frequency proportion for individual trawl hauls by sub-area (Figure IID3) for the *Scotia* acoustic survey (27/6 – 20/7/2003) length in cm, weight in g, calculated target strength in dB per individual using TS=-71.2+20log(L).

Haul/ length	305	307	309	310	312	313	314	317	327	Mean I	281	295	297	304	Mean II
21.0															
21.5															
22.0												0.2			0.1
22.5							0.2		0.4	0.1		0.2		0.2	0.1
23.0						0.3	0.2		0.4	0.1			0.2	0.2	0.1
23.5						0.3	0.4		1.5	0.2	0.3	1.2	1.6	0.2	0.8
24.0						2.0	0.6		0.8	0.4	1.8	5.9	3.3	2.0	3.2
24.5	0.8					1.7	1.5		1.5	0.6	5.9	7.8	5.6	2.0	5.3
25.0	0.3	0.3				0.9	1.7		1.9	0.6	6.2	8.2	6.2	5.4	6.5
25.5	1.9	0.6	0.7			0.9	1.5		2.3	0.9	5.3	8.7	8.9	8.6	7.9
26.0	5.8	0.3	0.3			0.9	2.1	0.7	3.8	1.5	8.2	10.6	11.4	8.9	9.8
26.5	8.0	2.4	0.7	1.5	0.4	0.9	4.3	2.5	5.7	2.9	9.1	8.5	10.0	11.1	9.7
27.0	11.6	8.7	2.0	4.4	1.2	2.6	6.4	11.0	13.6	6.8	11.2	10.8	12.0	9.6	10.9
27.5	19.7	12.5	0.3	2.6	2.7	4.6	10.9	19.4	15.5	9.8	16.5	11.8	12.2	9.9	12.6
28.0	12.5	12.8	6.7	10.3	13.6	4.8	9.0	20.5	16.2	11.8	15.6	10.8	10.0	12.6	12.3
28.5	14.7	14.9	10.1	14.3	16.3	12.5	8.8	19.1	18.9	14.4	9.7	6.8	6.7	6.4	7.4
29.0	12.2	13.4	16.8	14.3	17.1	11.7	10.7	12.0	7.5	12.9	5.6	5.6	5.1	6.9	5.8
29.5	6.6	10.7	13.4	16.8	16.7	16.2	8.2	6.0	6.4	11.2	1.8	0.9	2.2	4.2	2.3
30.0	1.7	2.7	14.8	10.6	12.0	16.0	11.6	2.8	1.5	8.2	0.9	1.4	1.8	5.7	2.4
30.5	1.9	6.3	10.1	11.4	8.5	13.1	5.4	3.5	1.1	6.8	0.9	0.5	1.6	3.2	1.5
31.0	1.1	5.7	7.7	2.9	5.8	6.0	7.5	1.8	0.4	4.3	1.2		0.4	1.0	0.7
31.5	0.6	1.8	5.0	6.2	1.9	1.7	5.8	0.7	0.4	2.7			0.2	1.0	0.3
32.0	0.3	4.2	7.0	3.3	1.6	2.3	1.3			2.2			0.2	0.5	0.2
32.5		0.6	1.3		1.2	0.9	0.4		0.4	0.5			0.2		0.1
33.0		0.6	1.3	0.4	0.4		0.9			0.4				0.2	0.1
33.5			0.3	0.7	0.4		0.2			0.2					
34.0	0.3	0.9	1.3	0.4	0.4					0.4					
34.5		0.3					0.2			0.1					
35.0		0.3								0.0					
Number	361	335	298	273	258	351	466	283	265		340	425	449	405	
mean length	28.4	29.4	30.3	29.9	29.8	29.6	29.3	28.8	28.2	29.3	27.6	27.1	27.4	27.9	27.5
mean weight	222	251	279	265	263	258	248	231	216	248	202	189	196	210	199
TS/individual	-42.1	-41.8	-41.6	-41.7	-41.7	-41.7	-41.9	-42.0	-42.2	-41.8	-42.4	-42.5	-42.4	-42.3	-42.4
TS/kilogramme	-35.6	-35.8	-36.0	-35.9	-35.9	-35.9	-35.8	-35.7	-35.5	-35.8	-35.4	-35.3	-35.4	-35.5	-35.4

Table IID4 (cont.). Herring length frequency proportion for individual trawl hauls by sub-area (Figure IID3) for the *Scotia* acoustic survey (27/6 – 20/7/2003) length in cm, weight in g, calculated target strength in dB per individual using TS=-71.2+20log(L).

Haul	294	298	299	301	302	318	326	Mean III	269	270	272	279	282	284	285	289	323	Mean IV
20.0																		
20.5									0.2				0.4					0.1
21.0							0.3	0.0								1.2		0.1
21.5							0.7	0.1	0.2	0.4			1.7	0.3	0.7	1.2		0.5
22.0	0.2	0.3					0.3	0.1	0.5	2.1			2.1	1.7	1.5	2.0	0.5	1.1
22.5	0.4			0.4		1.9	2.0	0.7	2.5	8.9	1.5	0.5	4.6	2.5	2.2	3.8	1.0	3.0
23.0	2.9	1.0	0.6	2.0	0.5	8.3	5.0	2.9	7.9	8.4	4.3	0.7	7.1	10.7	5.6	5.8	3.3	6.0
23.5	3.5	4.2	3.8	4.7	6.3	9.9	4.0	5.2	10.9	10.5	7.6	2.7	13.8	8.8	9.8	5.8	11.0	9.0
24.0	7.8	5.1	8.3	6.3	10.8	6.5	9.0	7.7	16.1	19.0	15.8	6.9	18.8	15.7	13.4	11.0	21.4	15.4
24.5	8.4	6.8	13.6	9.4	15.3	8.0	8.3	10.0	21.3	19.4	15.3	9.2	18.4	17.1	18.2	13.0	17.6	16.6
25.0	11.3	9.6	13.9	8.7	13.4	10.2	8.0	10.7	16.6	13.1	13.0	9.2	15.5	11.6	15.0	17.4	12.4	13.7
25.5	10.7	8.7	13.3	8.3	12.1	9.0	10.7	10.4	10.0	8.0	9.2	10.4	8.4	6.6	12.8	13.3	11.9	10.1
26.0	8.8	11.3	10.6	6.9	11.1	5.6	5.7	8.6	6.6	5.1	7.6	9.7	2.5	7.7	9.3	9.9	9.0	7.5
26.5	12.1	10.6	10.6	11.2	8.2	4.9	7.7	9.3	3.9	3.4	9.7	9.7	2.5	9.4	6.3	5.8	1.9	5.8
27.0	11.3	9.6	8.3	9.6	8.7	11.4	8.3	9.6	1.6	0.8	6.6	12.9	2.5	3.3	2.0	6.1	5.2	4.6
27.5	10.4	12.9	5.0	8.9	5.8	4.6	4.3	7.4	1.1	0.8	4.8	10.1	0.8	2.2	1.3	2.3	1.9	2.8
28.0	4.7	8.4	5.0	7.4	1.6	0.9	6.3	4.9	0.2		2.0	8.2	0.4	1.4	0.9	0.6	1.0	1.6
28.5	2.9	5.1	2.9	6.3	2.9	2.8	4.3	3.9	0.5		1.5	5.2	0.4	0.6	0.9	0.9	1.4	1.3
29.0	2.9	1.9	1.8	3.8	1.1	2.8	2.7	2.4			0.3	2.0			0.2			0.3
29.5	0.8	1.9	0.3	4.0	0.5	2.2	2.0	1.7			0.5	1.5		0.6				0.3
30.0	0.2	0.3	1.2	0.9	1.1	2.2	3.0	1.3				0.2					0.5	0.1
30.5	0.4	1.0	0.3	0.7	0.8	2.5	1.7	1.0				0.7						0.1
31.0	0.2	0.3	0.3			3.4	2.0	0.9			0.3	0.2						0.1
31.5			0.3			0.9	2.3	0.5										
32.0		0.6		0.4		0.9	1.0	0.4										
32.5		0.3				0.9		0.2										
33.0						0.3	0.3	0.1										
33.5																		
Number	512	311	339	447	380	324	300		441	237	393	404	239	363	461	345	210	
mean length	26.5	26.9	26.4	26.9	26.1	26.6	26.8	26.6	25.1	24.8	25.7	26.8	24.8	25.2	25.3	25.4	25.4	25.4
mean weight	175	185	172	184	167	181	185	179	144	138	158	182	139	148	148	150	150	151
TS/ind	-42.7	-42.6	-42.8	-42.6	-42.8	-42.7	-42.6	-42.7	-43.2	-43.3	-43.0	-42.6	-43.3	-43.1	-43.1	-43.1	-43.1	-43.1
TS/kilog	-35.2	-35.3	-35.1	-35.3	-35.1	-35.2	-35.3	-35.2	-34.8	-34.7	-35.0	-35.2	-34.7	-34.8	-34.8	-34.9	-34.9	-34.9

Table IID4 (cont.) Herring length frequency proportion for individual trawl hauls by sub-area (Figure IID3) for the *Scotia* acoustic survey (27/6 – 20/7/2003) length in cm, weight in g, calculated target strength in dB per individual using TS=-71.2+20log(L).

Haul /length	274	275	277	287	288	291	Mean V	267	Mean VI	322	Mean VII	320	324	Mean VII
17.5								0.6	0.6					
18.0								0.3	0.3					
18.5								0.9	0.9					
19.0								0.6	0.6					
19.5								0.6	0.6					
20.0					0.5		0.1	1.5	1.5					
20.5	1.4	1.0	0.4	1.0	1.6		0.9	1.8	1.8					
21.0	4.0	2.4	0.8	2.9	6.0	1.6	3.0	13.2	13.2	2.0	2.0			
21.5	8.9	13.3		10.9	11.3	4.9	8.2	17.4	17.4					
22.0	10.7	20.3	4.9	19.9	17.3	10.5	13.9	25.7	25.7	9.6	9.6			
22.5	11.7	17.5	7.2	17.0	19.4	15.8	14.8	16.2	16.2	17.8	17.8		0.3	0.2
23.0	10.7	21.0	16.7	16.0	13.9	20.7	16.5	10.8	10.8	21.8	21.8	1.0	0.6	0.8
23.5	7.8	14.0	23.6	7.4	10.8	14.1	12.9	6.6	6.6	19.3	19.3	1.0	0.3	0.6
24.0	12.3	6.3	19.8	12.2	8.1	14.1	12.1	2.1	2.1	12.7	12.7	2.6	4.0	3.3
24.5	10.9	2.4	14.1	5.8	7.1	7.6	8.0	0.6	0.6	8.6	8.6	4.2	7.1	5.6
25.0	6.8	1.0	4.6	2.6	2.9	4.9	3.8	0.9	0.9	5.6	5.6	7.4	8.0	7.7
25.5	4.2	0.3	3.4	2.6	0.8	3.6	2.5	0.3	0.3	1.0	1.0	6.4	5.9	6.1
26.0	4.2	0.3	2.7	0.6		0.7	1.4					6.4	8.3	7.4
26.5	2.6		0.4	1.0		1.3	0.9			0.5	0.5	11.2	9.9	10.5
27.0	2.4		1.1	0.3	0.3		0.7			1.0	1.0	16.0	16.4	16.2
27.5	1.0						0.2					14.4	12.0	13.2
28.0	0.4						0.1					5.1	9.3	7.2
28.5			0.4				0.1					7.1	7.4	7.2
29.0												4.2	1.5	2.9
29.5												4.5	2.2	3.3
30.0												2.2	1.9	2.0
30.5												2.6	1.9	2.2
31.0												1.9	0.9	1.4
31.5												0.6	1.5	1.1
32.0												0.3	0.3	0.3
32.5												1.0	0.3	0.6
Number	497	286	263	312	381	304		334		197		312	324	
mean length	24.0	23.1	24.3	23.4	23.2	23.8	23.6	22.5	22.5	23.8	23.8	27.6	27.4	27.5
mean weight	126	109	128	114	110	120	118	99	99	120	120	204	197	200
TS/individual	-43.6	-43.9	-43.5	-43.8	-43.9	-43.7	-43.7	-44.1	-44.1	-43.7	-43.7	-42.4	-42.4	-42.4
TS/kilogramme	-34.6	-34.3	-34.6	-34.4	-34.3	-34.5	-34.4	-34.1	-34.1	-34.5	-34.5	-35.4	-35.4	-35.4

Table IID 5 FRV Scotia 27/6–20/7/2003 Numbers of herring otolithed at length and at age, lengths in mm measured to the nearest 0.5cm below, ages in winter rings (wr). Of the 3294 otoliths taken 1 was unreadable.

Len	1	2I	2m	3i	3m	4	5	6	7	8	9+	Grand Total
175	1											1
180	1											1
185	1											1
190	1											1
195	1											1
200	1	1										2
205		7										7
210		9	1									10
215		13										13
220		18	1									19
225		21	4									25
230		49	24	3								76
235		47	54	4	1							106
240		38	83	12	4	6						143
245		20	117	10	10	7						164
250		16	119	10	17	15	2					179
255		4	95	9	35	33	2	1				179
260		1	61	4	58	45	2	1				172
265		1	32	1	83	55	11					183
270			12	1	79	83	7					182
275			15	1	114	159	15	6	1			311
280			4		82	153	19	8	12	1		279
285			5		41	178	12	12	12	2	2	264
290					37	115	14	26	11	5		208
295					14	91	27	26	19	2	3	182
300					6	58	15	25	32	7	2	145
305					2	25	12	27	52	12	8	138
310					1	9	11	14	50	9	13	107
315					3	10	3	8	23	11	17	75
320						1	5	4	27	12	13	62
325						2		2	7	2	12	25
330							2		4	1	8	15
335						1		1		3		5
340							1		1		8	10
345											2	2
350									1			1
Grand Total	6	245	628	55	587	1045	160	161	252	67	88	3294

Table IID6. Mean length, mean weight, biomass (thousands of tonnes) and numbers (millions) breakdown by age and maturity obtained during the Scotia 27 June to 20 July 2002 herring acoustic survey.

Age/Maturity	Number (millions)	Mean Weight (g)	Mean Length(cm)	Biomass (thousands of tonnes)
1A	49	61	19.0	3.0
2I	4258	111	22.8	474.4
2M	3825	145	24.6	555.1
3I	468	144	24.6	67.7
3M	2301	198	27.0	455.1
4A	3738	215	27.6	804.4
5A	454	238	28.5	108.3
6A	373	269	29.6	100.5
7A	539	292	30.3	157.3
8A	136	300	30.5	40.9
9+	162	330	31.4	53.3
Total	16304	173	25.7	2819.9

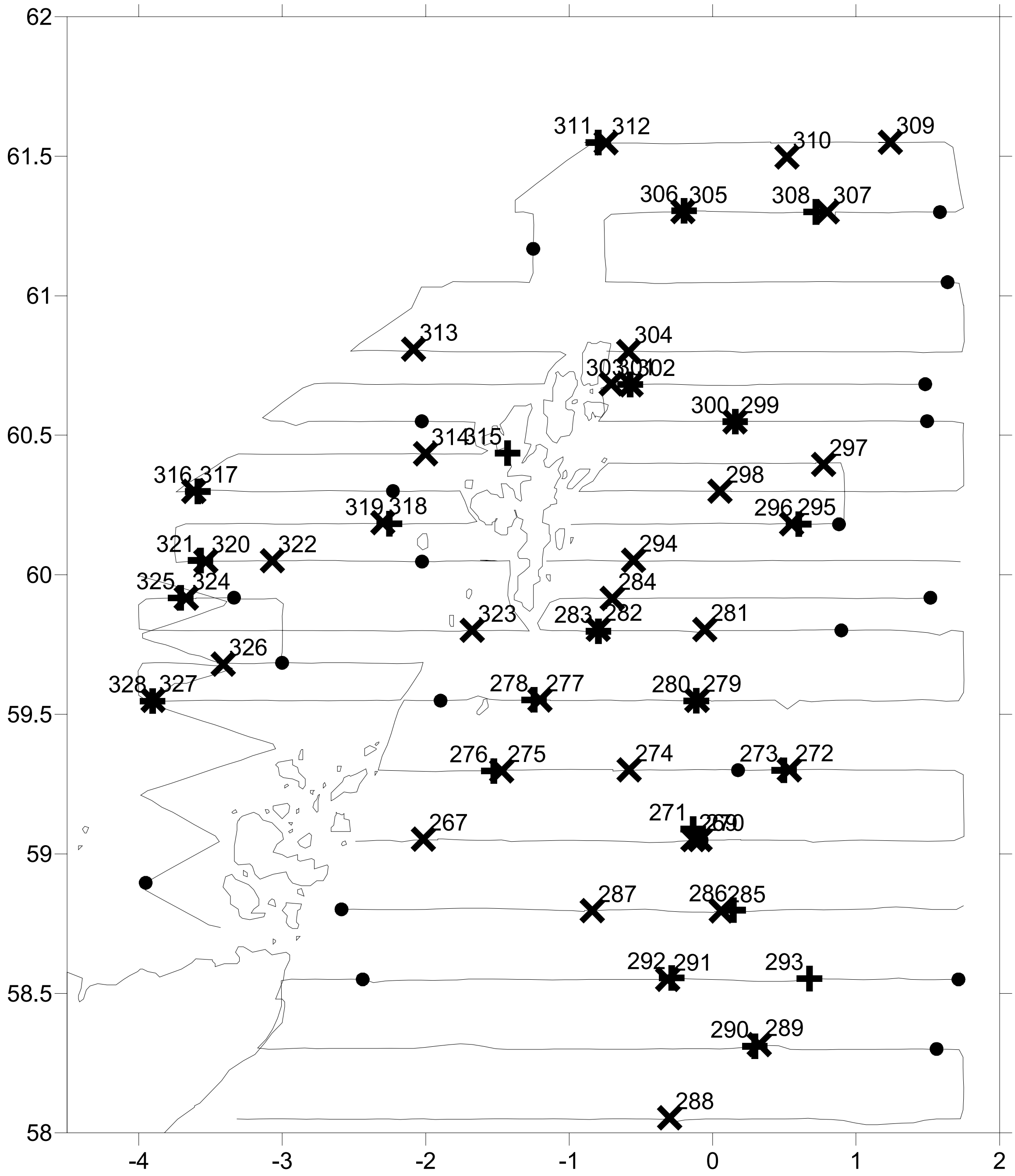


Figure IID1. Cruise track FRV SCOTIA for 27 June-20 July 2003 pelagic trawl stations. Demersal trawl stations (+) CTD stations (●).

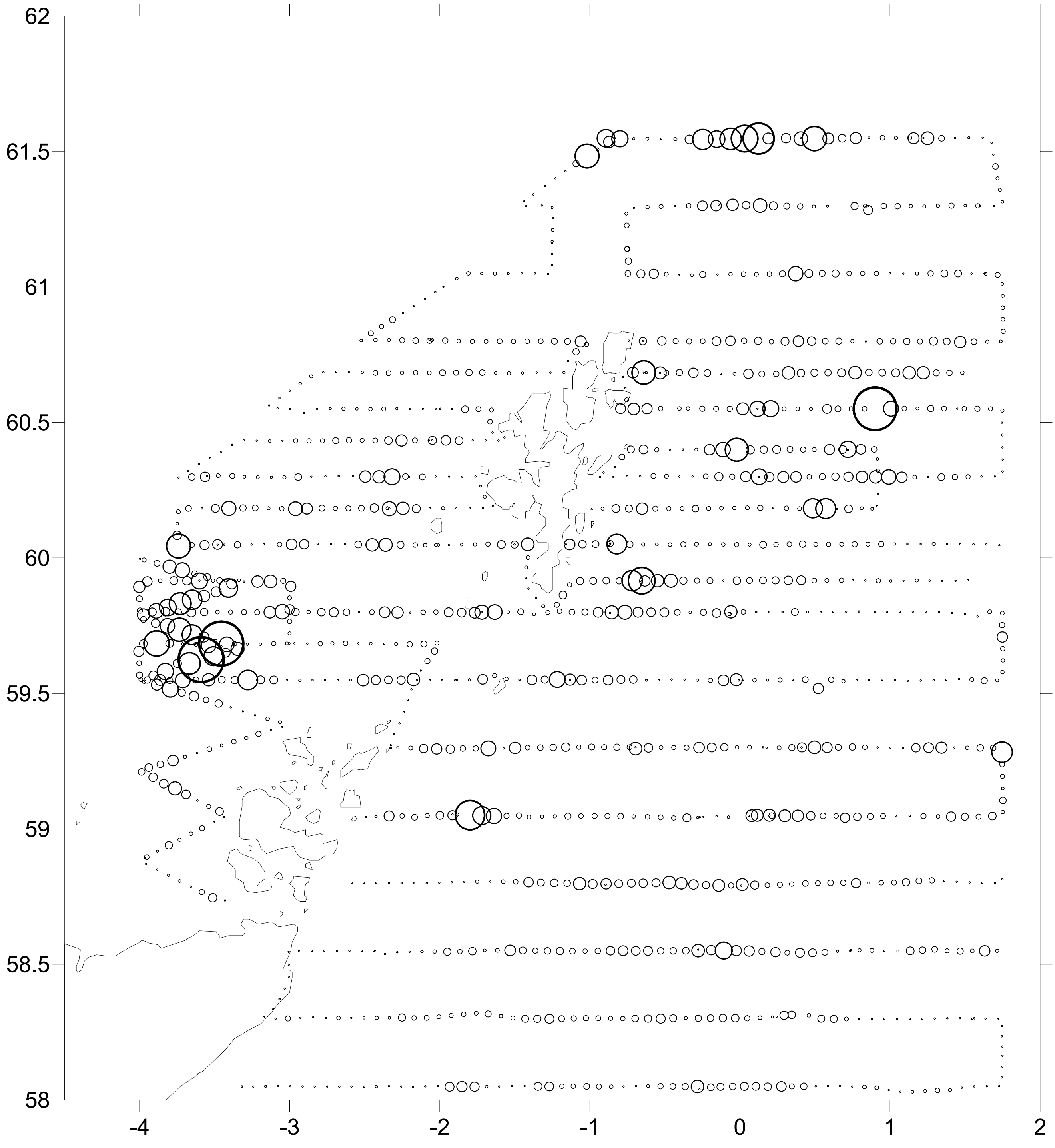


Figure IID2. Post plot of NASC values attributed to herring from FRV SCOTIA for 27 June-20 July 2003 Zig-zag track between 59 30 and 60N 4 and 3W was for inter-calibration and not used in the survey estimate.

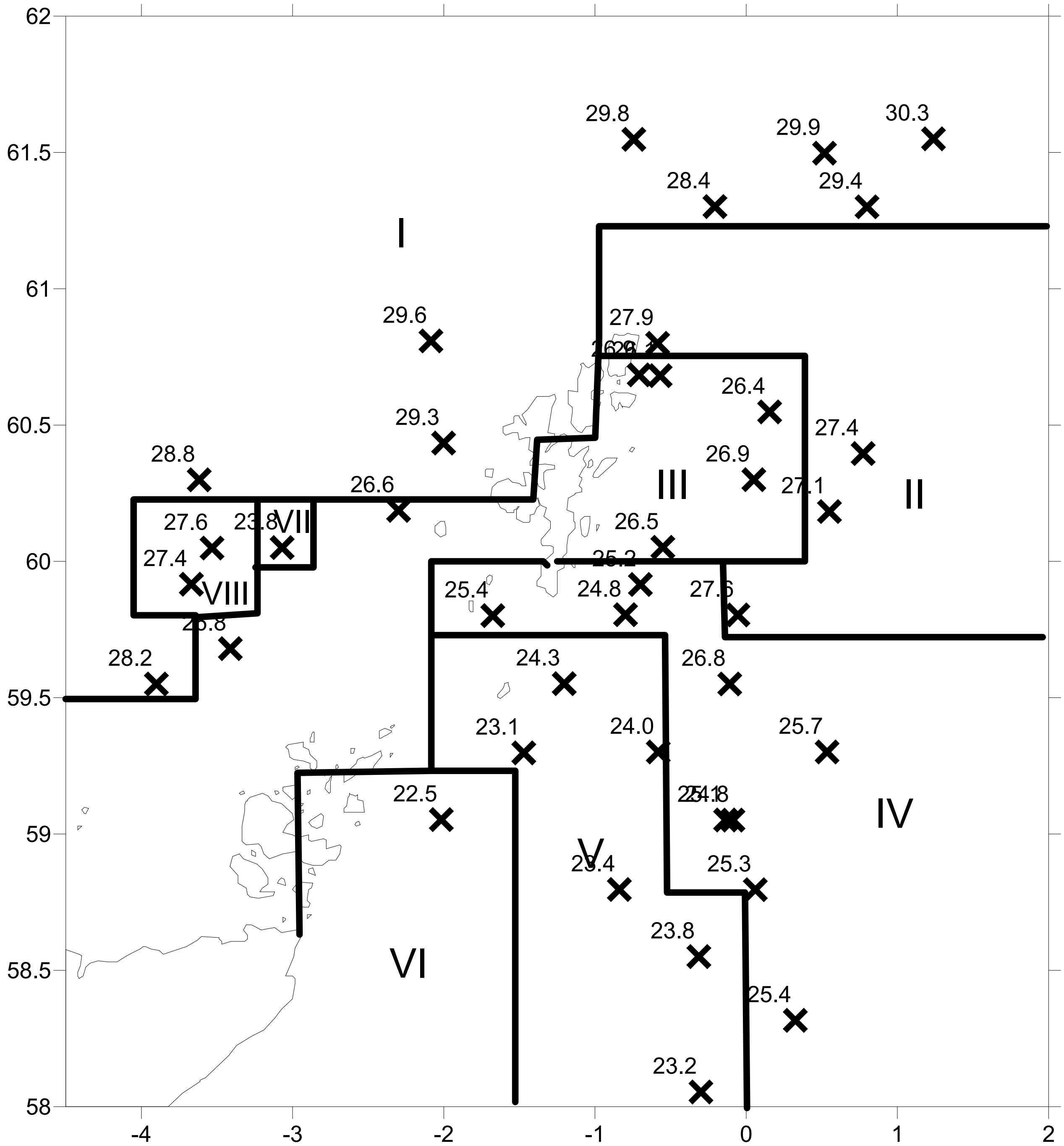


Figure IID3. Mean Length of herring from pelagic trawl catches, FRV SCOTIA for 27 June-20 July 2003 trawl station numbers are given in Figure IID1 and details in Tables 1 and 2. The eight analysis areas are shown in roman numerals and the length distributions, mean lengths, weights and target strengths are given by haul and area in Table IID4.

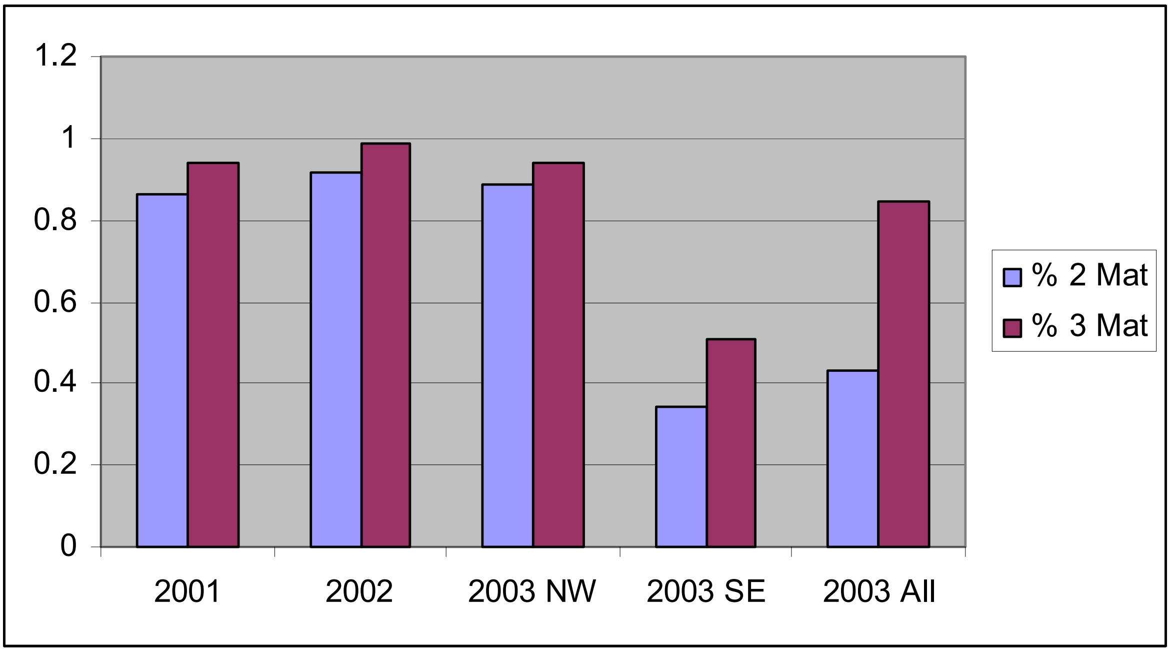


Figure IID4. Percentage of 2wr herring mature in the Scotia surveys in 2001 to 2003. Showing that the North western area contained herring of a similar proportion mature in 2003 as the whole area in 2001 and 2002. There are a large number of herring in the south western part of the area that are less mature.

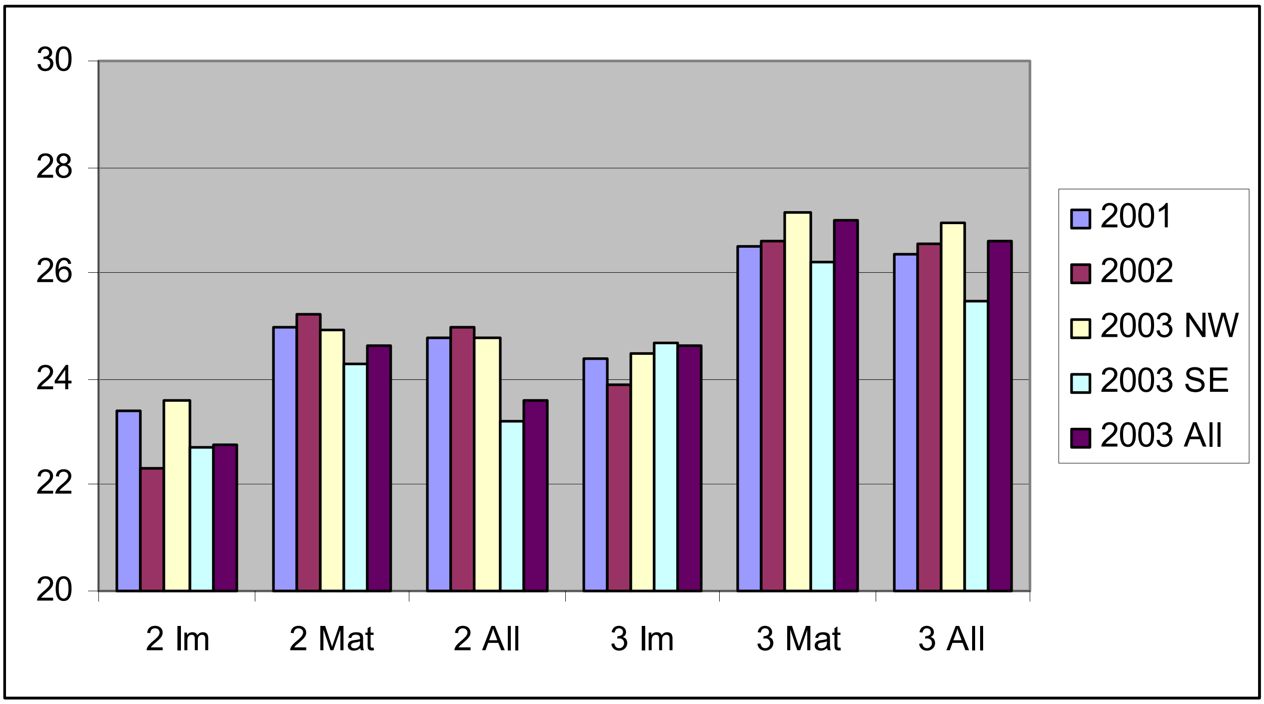


Figure IID5. Comparison of growth and maturity in 2001 to 2003. Mature and immature herring are similar sizes in all three years and all parts of the area. There is a higher proportion of 2 ring herring that are smaller and less mature than in previous years.

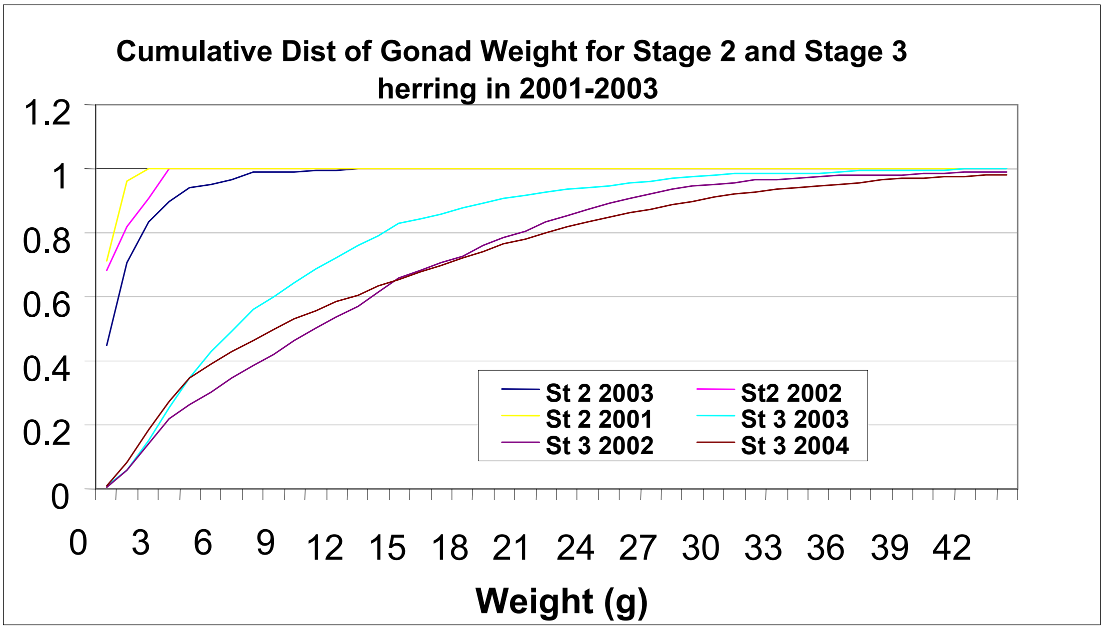


Figure IID6. Cumulative distribution of Gonad weight at stage 2 and stage 3 for the last three years 2001–2003.

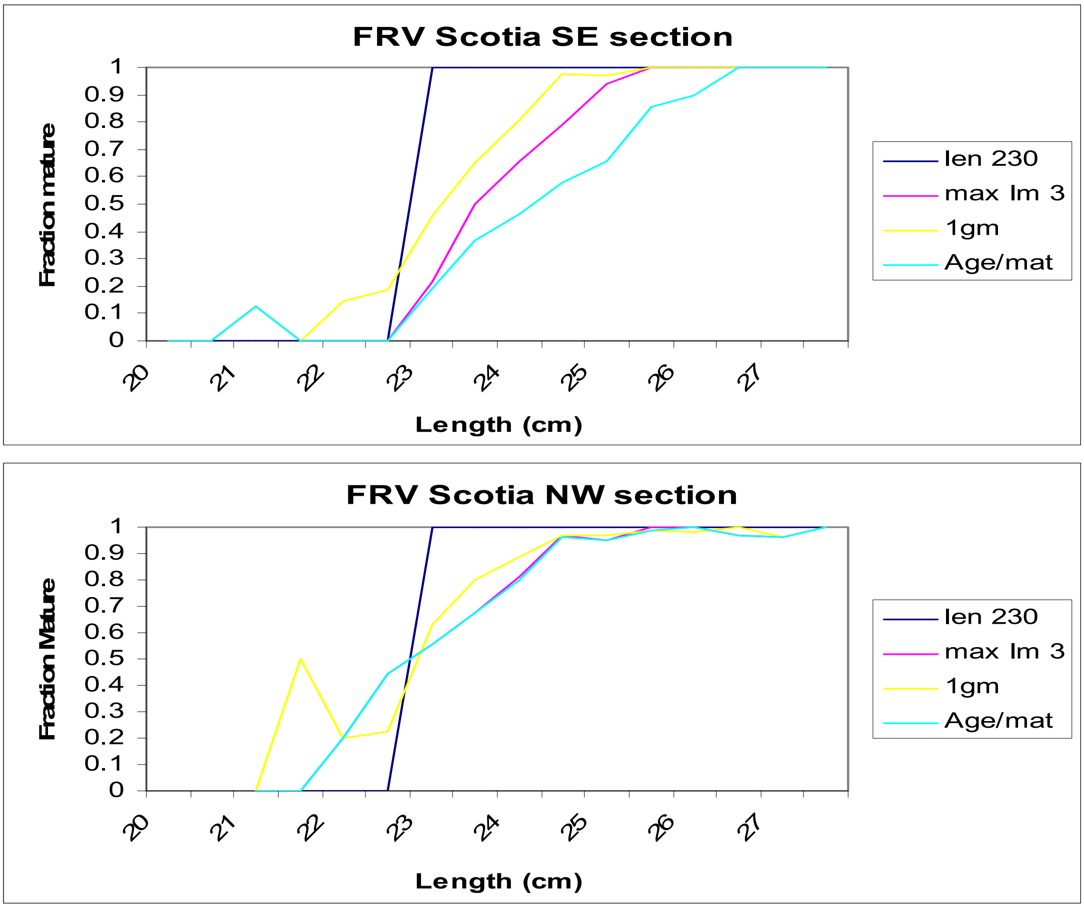


Figure IID7**.** Maturity at length Ogives for the FRV Scotia survey separated in to SE (areas VI,VI and VI) and NW (areas I, II, III, VII and VIII) showing maturity at length for the original data (Age/Mat), knife edge at gonad weight of 1gm (1gm), Maximum immature gonad of 3g (max im 3) and knife edge at 23 cm (len 230). The NW area is relatively insensitive to these choices. Maturity in the SE area. Of the length independent measures 1gm knife edge gives the best results.

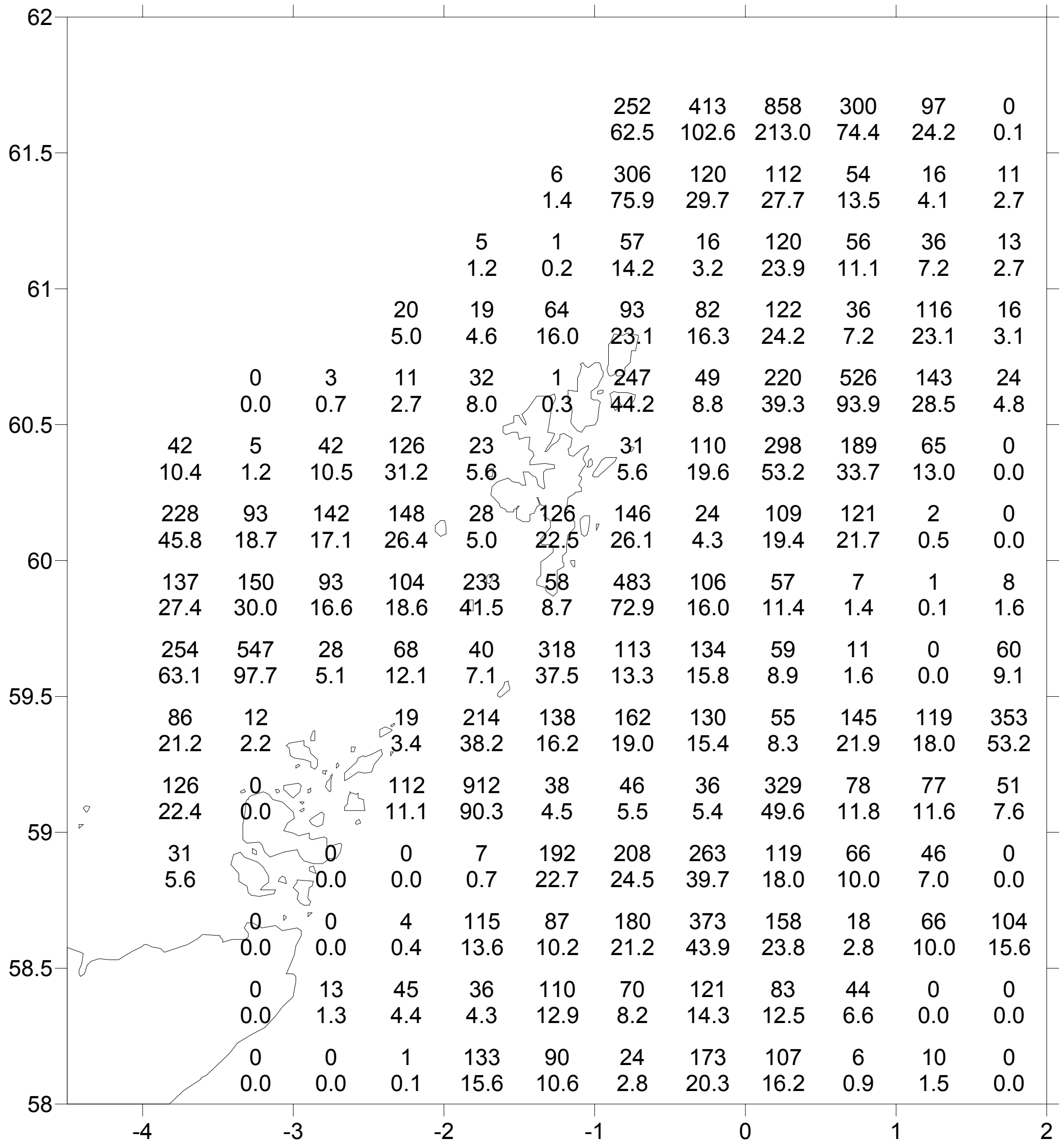


Figure IID8**.** Estimated numbers (millions) and biomass (thousands of tonnes) by quarter statistical rectangle FRV SCOTIA for 27 June-20 July 2003 (numbers upper and biomass lower values.

Appendix IIE: Netherlands

Survey report for FRV "Tridens"

23 June – 18 July 2003

1. INTRODUCTION

The Netherlands Institute for Fisheries Research (RIVO) participates in the international North Sea hydro acoustic survey for herring since 1991. The survey is part of the EU data collection framework. 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) to determine the population size. In this report the results are presented of the survey in the central North Sea, carried out by FRV "Tridens".

2. METHODS

2.1 Scientific Staff

Sytse Ybema
Bram Couperus (cruise leader 2nd two weeks)
Mario Stoker (2nd two weeks)
Kees Bakker (cruiseleader 1st two weeks)
Marcel de Vries (2nd two weeks)
Kees Camphuysen (Ornithologist)
Steve Geelhoed (Ornithologist; 1st two weeks)
Marcel Laks (Ornithologist; 2nd two weeks)
Reinold Pasterkamp (guest scientist from De Vrije Universiteit, Amsterdam)

2.2 Narrative

On Monday 23 June Tridens left the port of IJmuiden and headed towards Scapa Flow. On its way the equipment for the calibration was prepared. Arrival at Scapa Flow was Tuesday at 23.00 Dutch time. Next morning a colleague from the Marine Laboratory Aberdeen was picked up at Scapa Flow. The calibration started (see paragraph "Calibration").

On Thursday 26 June the survey started at the western end of the 57.45 transect (Moray Firth). There was some trouble logging the data with the BI500, so that of the first 30 nautical miles only raw EK60 data were collected. These data are not included in this analysis. Next day the 57.15 transect was finished. The weekend was spent in Aberdeen.

In the night from Sunday to Monday, Tridens set course for Shetland in order to sample 4 ICES squares with double intensity together with FRV Scotia. After having surveyed this area, Tridens headed on 2 July for ICES square 41F2, to survey from there in southern direction. Thursday evening the survey was interrupted and course was set to IJmuiden.

On Monday morning 7 June the port was left at 11.30 local time. On 8 July the 56.55 transect was picked up slightly more to the west than planned because a derrick barge ship operated in the area. The rest of the trip developed without difficulties with a cruise break in Newcastle during the weekend. On Thursday 17 July the survey was terminated and course was set to IJmuiden.

2.3 Survey design

The survey was carried out from 2 June to 19 July 2003, covering an area east of Scotland from latitude 54°30 to 57°30 North and from longitude 3° West (or the Scottish/English coast) to 3° East. An adapted survey design was applied, partly based on the herring distribution from previous years. Parallel transects along latitudinal lines were used with spacing between the lines set at 15 or 30 nm depending on the expected distributions. South of Shetland an area between 59º N and 60º N and between 0º W and 2º W was surveyed at the same time together with FRV Scotia. (Figure IIE.1). Acoustic data from transects running north-south close to the shore (that is parallel to the depth isolines) were excluded from the dataset.

2.4 Calibration

Four calibrations were executed:

1. 38 kHz in the towed body.
2. 200 kHz in the towed body, 1.024 puls duration: poor results.

3. 38 kHz hull mounted: very poor results (probably defect hardware).
4. 200 kHz towed body 0.256 ms – poor results.

Three of four calibrations were unsuccessful. Fortunately the most important transducer, the 38 kHz in the towed body performed all right. The 200 kHz is only used as a help for species recognition during the survey. The poor performance of the 200 kHz transducer in the towed body and the 38 kHz in the hull mounted is presently under investigation.

2.5 Acoustic 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 IIE.1. Acoustic data were collected with a Simrad EK60 scientific echo sounder. The data were logged with the Simrad BI500 integrator software under X Windows, simulated under Windows 2000. The EK60 received the vessel speed (approximately 10–12 knots) from the ship's GPS. A ping rate of 0.6 s was used. This ping rate has proven most suitable at depths of 50 - 150 m as they occur in most of the area.
The data were logged in 1 nm intervals. In total SA values of 1805 intervals have been collected.

2.6 Biological data

The acoustic recordings were verified by fishing with a 2000 mesh pelagic trawl with 20 mm meshes in the cod-end. Fishing was carried out when there was doubt about the species composition of recordings observed on the echo sounder 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 60 kHz sonar was used to be able to hunt schools that were swimming away from the track line. In haul 11 four large floating buoys were attached to the headline of the trawl to keep the net as high as possible at the surface and to enlarge the vertical opening (25–30 m). In most other hauls the bottom rope was very close to the ground with vertical net openings varying from 10 to 20 m.

Fish samples were divided into species by weight. Length measurements were taken to the 0.5 cm below for sprat, herring and sand eel and to the cm below for other species. For herring and sprat length stratified samples were taken for maturity, age (otolith extraction) and weight, five specimens per 0.5 cm class as a maximum.

2.7 Hydrographical data

Hydrographical data have been collected in 21 CTD stations, mostly at the end of a haul. The CTD-data are used for other studies.

2.8 Data analysis

The acoustic values (NASC's) from each log interval were assigned to the following categories: "definitely herring", "probably herring", "possibly herring", "definitely sprat", "probably sprat", "possibly sprat", "gadoids", "mackerel", and "sand eel". 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. The TS/length relationships used were those recommended by the ICES Planning Group for Herring Surveys (ICES 2000). The numbers of herring and sprat per ICES rectangle were calculated.

The biological samples were grouped in 6 strata for herring and 1 stratum for sprat, based on similar length distribution and geographical position (see Figure IIE.2). The numbers per year/maturity class were calculated, based on the age/length key for each stratum. For each separate stratum the mean weight per year/maturity class was then calculated.

3. RESULTS

3.1 Acoustic data

Figure 3 shows the acoustic values (NASC's) per five nautical mile interval along the track lines for herring.

3.2 Biological data

In all, 22 trawl hauls have been conducted (Figure IIE.1 and Table IIE.2a. Herring was found in 21 hauls of which 21 samples were taken. Sprat was found in 5 hauls of which 5 samples were taken (see also 2.8 Data analysis). In 20 hauls herring was the most abundant species in weight. In none of the hauls sprat was the most abundant species. In haul 11 the meshes were stuck with small sand eel indicating that this species would have been an abundant species in the catch if the mesh size had been smaller. The catch weights per haul and species are presented in table 2b. Length frequency proportions of herring are presented by haul in table 2c.

Table 3 shows the age/maturity length keys for herring (strata A-F) and sprat.

3.3 Biomass estimates

Table IIE.4 summarises numbers and biomass for stratum A-F for herring. Table IIE.5a and IIE.5b summarise numbers and biomass for the whole area for herring and sprat. The stock biomass estimate of herring is 1403.96 tonnes and for sprat 2.23 tonnes. Figure IIE.4 shows the estimated numbers and biomass of herring by ICES rectangle.

4. DISCUSSION

The coverage of the Dutch part of the 2003 hydro acoustic survey for herring in the North Sea is different from previous years. Therefore the results are not directly comparable. Nevertheless, some results and observations are striking:

Only 43% of the 2WR (year class 2000) is found mature. In the 2002 survey this percentage was 90%. If this is the case in the whole survey, it will certainly have an impact on the herring stock assessment.

In the 2002 survey a surprising high number (30%) of 1 ringers was found mature in the Dutch survey. Normally, this is less than 1%. This high number was not found during this year's survey.

Norway pout, a species that was very abundant in the survey hauls during the second half of the 1990s, was absent in the 2003 catches, confirming the decreasing trend of the last three years.

In general the herring was more equally distributed over the surveyed area than in previous years. The main concentrations of herring were found below 56º30N, in particular south and southeast of the Devil's holes, east of Farn Deep and Dogger Bank.

Table IIE.1. Simrad EK60 settings used on the June 2003 North Sea hydro acoustic survey for herring, FRV "Tridens".

Transceiver menu	
Absorption coefficient	9.4 dB/km
Pulse length	1.024 ms
Bandwidth	2.43 kHz
Max Power	2000 W
Two-way beam angle	-20.6 dB
3 dB Beam width	7.0 dg
Calibration details	
TS of sphere	-33.6 dB
Range to sphere in calibration	11.50 m
Transducer gain	25.57 dB
Calibration factor for NASC's	-
Log/Navigation Menu	
Speed	Serial from ship's GPS
Operation Menu	
Ping interval	0.6 s
Display/Printer Menu	
TVG	20 log R
Integration line	N/A
TS colour min.	-50 dB
Sv colour min.	-70 dB

Table IIE.2a. Details of the trawl hauls taken during the July 2003 North Sea hydro acoustic survey, FRV "Tridens".

Haul	Date	Position	ICES rectangle	Time UTC	Haul duration (s)	Depth (m)	Gear	Sample ID
1	27/06/2003	57 15N 01 48E	43F1	06:40	35	91	pelagic trawl	5400243
2	27/06/2003	57 15N 00 06E	43F0	14:02	58	80	pelagic trawl	5400244
3	30/06/2003	59 09N 01 50W	47E8	07:50	60	80	pelagic trawl	5400245
4	30/06/2003	59 10N 00 28W	47E9	12:32	23	140	pelagic trawl	5400246
5	01/07/2003	59 45N 01 19W	48E8	05:36	33	87	pelagic trawl	5400247
6	01/07/2003	59 51N 00 09W	48E9	11:07	26	142	pelagic trawl	5400248
7	01/07/2003	59 20N 00 44W	47E9	17:10	13	122	pelagic trawl	5400249
8	02/07/2003	59 25N 01 16W	47E8	07:35	15	100	pelagic trawl	5400250
9	03/07/2003	56 09N 02 10E	41F2	06:37	49	80	pelagic trawl	5400251
10	08/07/2003	56 54N 00 37E	42F0	09:26	16	89	pelagic trawl	5400252
11	08/07/2003	56 54N 01 21W	42E8	16:53	28	60	pelagic trawl	5400253
12	09/07/2003	56 39N 01 27E	42F1	06:20	35	91	pelagic trawl	5400254
13	09/07/2003	56 40N 00 19W	42E9	13:44	16	75	pelagic trawl	5400255
14	10/07/2003	56 23N 00 21E	41F0	12:33	16	88	pelagic trawl	5400256
15	10/07/2003	56 09N 00 35E	41F0	07:29	3	80	pelagic trawl	5400257
16	11/07/2003	56 09N 00 07W	41E9	13:53	9	85	pelagic trawl	5400258
17	14/07/2003	55 55N 00 37W	40E9	08:28	29	69	pelagic trawl	5400259
18	15/07/2003	55 40N 01 04E	40F1	06:17	18	95	pelagic trawl	5400260
19	16/07/2003	55 24N 00 50W	39E9	06:17	18	95	pelagic trawl	5400261
20	16/07/2003	55 09N 00 58E	39F0	18:26	14	73	pelagic trawl	5400262
21	17/07/2003	54 45N 00 04E	38F0	06:40	18	78	pelagic trawl	5400263
22	17/07/2003	54 44N 00 11E	38F0	08:51	18	68	pelagic trawl	5400264

Table IIE.2b. Trawl catches in kg. Tridens, North Sea acoustic survey 2003.

Haul	Herring	Haddock	Saithe	Whiting	Norway pout	Mackerel	Raitt's sand eel	Grey gurnard	Sprat
1	1158.73								
2	2325.13								
3	831.76								
4	1070.13	1.72	10.93	4.43					
5	1298.82								
6	1715.81				10.63				
7	871.71				2.15	23.31			
8	2871.89								
9	2244.99	0.57		0.48		63.58			
10	766.22					5.25			
11	0.78	0.91				1.65	4.01	0.34	1.23
12	7134.51	2.2		0.62		0.9		0.12	
13	1432.23	44.82		14.68		0.57		2.82	
14	10003.08	8.59		1.3		0.24		0.17	
15	618.9								
16	3012.33	0.73		1.42				19.83	
17	3286.68	80.92		26.8		66.65		15.43	38.48
18		34.57		1.53				1.95	
19	2.05	1.53	2.65	26.93				1	1.33
20	1515.57	5.48		14.86				1.45	0.16
21	1.32	69.77	0.85	147.26				0.8	0.15
22	14204.99	5.71		119.92		20.95		1.69	

Table IIE.2c. Length frequency proportions of herring by haul. Length in cm. Tridens, North Sea acoustic survey 2003.

	haul 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
length																					
6.00											1.71										
6.50											5.98										
7.00											20.51										
7.50											26.07										
8.00											29.06										
8.50											10.68										
9.00											5.56										
9.50											0.43										
10.00																					
10.50																					
11.00																					
11.50																					
12.00																					
12.50																					
13.00																					
13.50																					
14.00																					
14.50																					
15.00																					
15.50																					
16.00																					
16.50												0.30					0.51				
17.00			0.29										0.20					11.76	0.34		0.84
17.50	1.27		0.57						0.28			1.18	0.43	0.23			0.25		0.68		0.28
18.00	1.27		0.57						0.84	1.42		1.78	2.39	0.23	0.94		1.01	5.88	1.36		0.84
18.50	3.80	0.27	3.14						2.81	0.47		5.62	3.91	1.35	3.07	0.55	2.53		2.71	4.76	1.68
19.00	0.95	0.81	2.00						7.02	4.49		4.73	8.91	3.83	10.14	1.93	7.32		4.07	9.52	6.16
19.50	0.95	2.42	2.86						8.99	6.86		7.69	11.09	13.96	15.80	3.87	16.41	5.88	6.10	14.29	9.52
20.00	0.63	3.49	2.00						13.76	10.87		5.03	17.39	19.37	18.40	9.12	17.42	5.88	8.81	38.10	10.08
20.50	0.63	6.99	2.86						15.17	11.35		7.40	19.35	14.19	15.09	17.40	16.16		10.51	28.57	13.73
21.00	3.16	10.75	4.86	0.44					11.24	13.24		5.03	14.13	11.94	12.74	19.61	16.41		7.80	4.76	14.01
21.50	4.11	11.83	12.57	2.18	0.43			4.68	10.39	13.24		8.88	11.96	10.81	9.20	15.75	5.56		7.80		10.36
22.00	8.23	11.56	14.00	2.62	2.59			10.03	7.02	11.82		7.69	5.00	9.46	7.08	9.12	6.82		9.83		8.68
22.50	6.01	12.90	20.00	10.92	3.02			19.06	6.46	7.33		8.28	2.39	4.28	2.36	7.73	3.28		4.75		5.60
23.00	11.08	11.02	10.57	12.66	12.50	0.41	1.49	18.73	4.49	4.49		5.03	0.87	2.48	2.36	5.25	3.54		4.41		5.32
23.50	11.08	7.80	9.43	14.85	15.95	3.25	5.94	14.05	2.53	4.26		6.21	1.09	1.80	0.94	1.93	1.01		2.71		3.92
24.00	10.44	9.14	7.14	19.21	21.12	4.47	3.96	11.37	2.25	2.84		5.92	0.43	2.03	0.94	1.93	0.76		3.05		2.80
24.50	9.45	3.23	4.00	13.54	15.95	7.72	18.32	7.36	1.12	2.84		3.55	0.22	1.80	0.71	1.93	0.76		4.75		1.96
25.00	7.55	3.76	1.14	8.30	15.52	10.16	14.36	7.69	1.69	0.95		5.92	0.22	1.35		3.04	0.25	5.88	4.75		1.96
25.50	6.01	2.15	0.86	5.68	6.47	11.38	15.35	3.68	1.40	1.18		3.55		0.23	0.24			17.65	4.41		0.84
26.00	6.01	0.81	1.14	3.06	3.88	7.32	9.90	1.34	0.56	1.65		2.37		0.45		0.83		17.65	4.75		0.56
26.50	3.16	1.08		2.62	1.29	8.94	7.92	1.67	0.84			0.89						17.65	2.37		0.28
27.00	0.95			3.06	0.43	10.16	4.46		1.12	0.24		0.89		0.23					1.69		0.28
27.50	1.58			0.87	0.86	9.35	7.43			0.24		0.89							1.36		0.28
28.00	1.58					11.79	5.45					0.59							1.02		
28.50						4.47	0.99	0.33		0.24		0.59									
29.00						4.88	1.98											11.76			
29.50						2.44															
30.00						1.22															
30.50						0.41	2.48														
31.00						0.81															
31.50						0.41															
32.00																					
32.50						0.41															

Table IIE.3a. Age/maturity-length key for herring – Stratum A,B,C,D,E and F. Tridens, North Sea acoustic survey 2003.

Stratum	length class	0imm	1imm	1mat	2imm	2mat	3imm	3mat	4mat	5mat	6imm	6mat	7mat	8mat	9mat+
A	17		1												
A	17.5		1												
A	18		1												
A	18.5		5												
A	19		5												
A	19.5		4												
A	20		3												
A	20.5		3												
A	21				6										
A	21.5				10										
A	22				13	2									
A	22.5				15										
A	23				7	8									
A	23.5				4	10		1							
A	24				5	10									
A	24.5					14	1								
A	25					11		2							
A	25.5					13		1	1						
A	26					8		2	1						
A	26.5					2		1	3			1			
A	27					1									
A	27.5							1	1						
A	28.5								1						
Stratum	length class	0imm	1imm	1mat	2imm	2mat	3imm	3mat	4mat	5mat	6imm	6mat	7mat	8mat	9mat+
B	21				1										
B	21.5				3										
B	22				3										
B	22.5				3										
B	23				7										
B	23.5				5	7									
B	24				2	8		1							
B	24.5				3	6	1	1							
B	25					9		2							
B	25.5					9		1	1						
B	26					6		1	4						
B	26.5					6		3	2						
B	27					3		3	5						
B	27.5					1		4	4	1					
B	28					1		1	4	2					
B	28.5							3	3	1					
B	29								7				1		
B	29.5								2			2	1		
B	30								1			1			1
B	30.5								1			1			
B	31									1					1
B	31.5												1		
B	32.5													1	
Stratum	length class	0imm	1imm	1mat	2imm	2mat	3imm	3mat	4mat	5mat	6imm	6mat	7mat	8mat	9mat+
C	6.5	5													
C	7	5													
C	7.5	5													
C	8	5													
C	8.5	5													
C	9	5													
C	9.5	1													
Stratum	length class	0imm	1imm	1mat	2imm	2mat	3imm	3mat	4mat	5mat	6imm	6mat	7mat	8mat	9mat+
D	17		1												
D	17.5		12		1										
D	18		26		5										
D	18.5		28		12										
D	19		27		19										
D	19.5		23		25										
D	20		18		29										
D	20.5		9		37										
D	21		4		45										
D	21.5		3		46	2									
D	22				42	6	1								
D	22.5				26	23		1							
D	23				13	36									
D	23.5				4	43	1								
D	24				4	35		4	1						
D	24.5					35		8							
D	25					27		7	2						
D	25.5					16		4	7						
D	26					11		5	10						
D	26.5					1		2	11	1					
D	27							1	8	1		1			
D	27.5							1	3	3		1		1	
D	28								4	1		2			
D	28.5								1			1		1	

Table IIE.3a. Continued. Age/maturity-length key for herring – Stratum A,B,C,D,E and F. Tridens, North Sea acoustic survey 2003.

Stratum	length class	0imm	1imm	1mat	2imm	2mat	3imm	3mat	4mat	5mat	6imm	6mat	7mat	8mat	9mat+
E	18		1												
E	19.5		1												
E	20				1										
E	25											1			
E	25.5											2	1		
E	26									1		2			
E	26.5									1					
E	29														2
Stratum	length class	0imm	1imm	1mat	2imm	2mat	3imm	3mat	4mat	5mat	6imm	6mat	7mat	8mat	9mat+
F	17.5		3												
F	18		7												
F	18.5		7		4										
F	19		9		3										
F	19.5		9		4										
F	20		13		5										
F	20.5		6		10										
F	21		2		9										
F	21.5				9	1									
F	22				3	7									
F	22.5				4	6									
F	23					10									
F	23.5				1	9									
F	24					9		1							
F	24.5					10									
F	25					10		1							
F	25.5					5		1	1						
F	26					3			4						
F	26.5					2			1	2		1			
F	27							1	3	1		1			
F	27.5									2		2	1		
F	28								1	1			1		

Table IIE.3b. Age/maturity-length key for sprat - Total area. Tridens, North Sea acoustic survey 2003.

Length class	0 imm	1 imm	1 mat	2 imm	2 mat	3 mat
8.5		5		1		
9		4	6			
9.5		2	9			
10		1	10		1	
10.5		2	13	1	3	
11			20		3	
11.5			13		4	
12			5		3	3
12.5					10	3
13					9	1
13.5					9	2
14					5	1
14.5					1	1

Table IIE.4. Herring. Mean length, mean weight, biomass (thousands of tonnes) and numbers (millions) breakdown by age and maturity per stratum. Tridens, North Sea acoustic survey 2003.

Stratum A						
age	mean weight (g)	mean length (cm)	Numbers (millions)	Biomass (1000 tonnes)	Millions %	Tonnes %
0imm	0.00	0.00	0.00	0.00	0.00	0.00
0mat	0.00	0.00	0.00	0.00	0.00	0.00
1imm	58.79	19.29	62.19	3.66	5.68	3.20
1mat	0.00	0.00	0.00	0.00	0.00	0.00
2imm	93.41	22.48	505.59	47.23	46.14	41.28
2mat	118.40	24.09	479.25	56.74	43.73	49.60
3imm	121.27	24.50	6.05	0.73	0.55	0.64
3mat	133.75	24.88	30.26	4.05	2.76	3.54
4mat	160.82	26.53	11.08	1.78	1.01	1.56
5mat	0.00	0.00	0.00	0.00	0.00	0.00
6mat	152.30	26.50	1.42	0.22	0.13	0.19
7mat	0.00	0.00	0.00	0.00	0.00	0.00
8mat	0.00	0.00	0.00	0.00	0.00	0.00
9mat	0.00	0.00	0.00	0.00	0.00	0.00
Total			**1095.84**	**114.40**	**100.00**	**100.00**
Immature			**573.83**	**51.62**	**52.36**	**45.12**
Mature			**522.01**	**62.79**	**47.64**	**54.88**

Stratum B						
age	mean weight (g)	mean length (cm)	Numbers (millions)	Biomass (1000 tonnes)	Millions %	Tonnes %
0imm	0.00	0.00	0.00	0.00	0.00	0.00
0mat	0.00	0.00	0.00	0.00	0.00	0.00
1imm	0.00	0.00	0.00	0.00	0.00	0.00
1mat	0.00	0.00	0.00	0.00	0.00	0.00
2imm	104.17	23.24	177.46	18.49	18.86	13.61
2mat	134.65	25.07	433.83	58.42	46.11	43.02
3imm	123.56	24.50	10.99	1.36	1.17	1.00
3mat	156.60	26.29	121.34	19.00	12.89	13.99
4mat	186.46	27.48	155.00	28.90	16.47	21.28
5mat	199.59	28.11	23.43	4.68	2.49	3.44
6mat	265.25	30.05	8.90	2.36	0.95	1.74
7mat	253.35	29.74	5.84	1.48	0.62	1.09
8mat	280.00	32.50	1.39	0.39	0.15	0.29
9mat	262.67	30.50	2.78	0.73	0.30	0.54
Total			**940.95**	**135.79**	**100.00**	**100.00**
Immature			**188.46**	**19.84**	**20.03**	**14.61**
Mature			**752.50**	**115.95**	**79.97**	**85.39**

Table IIE.4. Herring Continued. Mean length, mean weight, biomass (thousands of tonnes) and numbers (millions) breakdown by age and maturity per stratum. Tridens, North Sea acoustic survey 2003.

Stratum C						
age	mean weight (g)	mean length (cm)	Numbers (millions)	Biomass (1000 tonnes)	Millions %	Tonnes %
0imm	2.81	7.66	1077.34	3.02	100.00	100.00
0mat	0.00	0.00	0.00	0.00	0.00	0.00
1imm	0.00	0.00	0.00	0.00	0.00	0.00
1mat	0.00	0.00	0.00	0.00	0.00	0.00
2imm	0.00	0.00	0.00	0.00	0.00	0.00
2mat	0.00	0.00	0.00	0.00	0.00	0.00
3imm	0.00	0.00	0.00	0.00	0.00	0.00
3mat	0.00	0.00	0.00	0.00	0.00	0.00
4mat	0.00	0.00	0.00	0.00	0.00	0.00
5mat	0.00	0.00	0.00	0.00	0.00	0.00
6mat	0.00	0.00	0.00	0.00	0.00	0.00
7mat	0.00	0.00	0.00	0.00	0.00	0.00
8mat	0.00	0.00	0.00	0.00	0.00	0.00
9mat	0.00	0.00	0.00	0.00	0.00	0.00
Total			**1077.34**	**3.02**	**100.00**	**100.00**
Immature			**1077.34**	**3.02**	**100.00**	**100.00**
Mature			**0.00**	**0.00**	**0.00**	**0.00**

Stratum D						
age	mean weight (g)	mean length (cm)	Numbers (millions)	Biomass (1000 tonnes)	Millions %	Tonnes %
0imm	0.00	0.00	0.00	0.00	0.00	0.00
0mat	0.00	0.00	0.00	0.00	0.00	0.00
1imm	60.59	19.61	1839.92	111.48	19.15	14.16
1mat	0.00	0.00	0.00	0.00	0.00	0.00
2imm	74.74	20.90	5588.80	417.72	58.17	53.06
2mat	112.90	23.60	1774.66	200.35	18.47	25.45
3imm	94.40	22.46	23.58	2.23	0.25	0.28
3mat	132.61	24.84	176.33	23.38	1.84	2.97
4mat	273.13	50.30	171.30	26.19	1.78	3.33
5mat	172.62	27.29	15.86	2.74	0.17	0.35
6mat	176.10	27.79	12.57	2.21	0.13	0.28
7mat	0.00	0.00	0.00	0.00	0.00	0.00
8mat	183.91	28.00	4.94	0.91	0.05	0.12
9mat	0.00	0.00	0.00	0.00	0.00	0.00
Total			**9607.95**	**787.21**	**100.00**	**100.00**
Immature			**7452.29**	**531.43**	**77.56**	**67.51**
Mature			**2155.66**	**255.78**	**22.44**	**32.49**

Table IIE.4. Herring Continued. Mean length, mean weight, biomass (thousands of tonnes) and numbers (millions) breakdown by age and maturity per stratum. Tridens, North Sea acoustic survey 2003.

Stratum E						
age	mean weight (g)	mean length (cm)	Numbers (millions)	Biomass (1000 tonnes)	Millions %	Tonnes %
0imm	0.00	0.00	0.00	0.00	0.00	0.00
0mat	0.00	0.00	0.00	0.00	0.00	0.00
1imm	37.00	17.88	49.00	1.81	23.53	7.86
1mat	0.00	0.00	0.00	0.00	0.00	0.00
2imm	64.00	20.00	12.25	0.78	5.88	3.40
2mat	0.00	0.00	0.00	0.00	0.00	0.00
3imm	0.00	0.00	0.00	0.00	0.00	0.00
3mat	0.00	0.00	0.00	0.00	0.00	0.00
4mat	0.00	0.00	0.00	0.00	0.00	0.00
5mat	127.83	26.38	49.00	6.26	23.53	27.17
6mat	133.07	25.60	61.25	8.15	29.41	35.35
7mat	129.33	25.50	12.25	1.58	5.88	6.87
8mat	0.00	0.00	0.00	0.00	0.00	0.00
9mat	182.00	29.00	24.50	4.46	11.76	19.34
Total			**208.25**	**23.05**	**100.00**	**100.00**
Immature			**61.25**	**2.60**	**29.41**	**11.26**
Mature			**147.00**	**20.46**	**70.59**	**88.74**

Stratum F						
age	mean weight (g)	mean length (cm)	Numbers (millions)	Biomass (1000 tonnes)	Millions %	Tonnes %
0imm	0.00	0.00	0.00	0.00	0.00	0.00
0mat	0.00	0.00	0.00	0.00	0.00	0.00
1imm	62.90	19.65	998.20	62.79	27.47	18.44
1mat	0.00	0.00	0.00	0.00	0.00	0.00
2imm	80.05	20.87	1365.52	109.31	37.58	32.10
2mat	125.57	23.47	1070.87	134.47	29.47	39.49
3imm	0.00	0.00	0.00	0.00	0.00	0.00
3mat	153.56	25.18	38.31	5.88	1.05	1.73
4mat	170.38	26.27	90.50	15.42	2.49	4.53
5mat	178.86	27.10	35.99	6.44	0.99	1.89
6mat	179.44	27.08	23.40	4.20	0.64	1.23
7mat	183.54	27.75	10.80	1.98	0.30	0.58
8mat	0.00	0.00	0.00	0.00	0.00	0.00
9mat	0.00	0.00	0.00	0.00	0.00	0.00
Total			**3633.58**	**340.48**	**100.00**	**100.00**
Immature			**2363.72**	**172.09**	**65.05**	**50.54**
Mature			**1269.86**	**168.39**	**34.95**	**49.46**

Table 5a. Herring. Mean length, mean weight, biomass (thousands of tonnes) and numbers (millions) breakdown by age and maturity. Tridens, North Sea acoustic survey 2003.

Year	age	Numbers (millions)	Biomass (1000 tonnes)	Numbers %	Biomass %	Mean weight (g)	Mean length (cm)
2002	0imm	1077.34	3.02	6.50	0.22	2.81	7.66
2002	0mat						
2001	1imm	2949.30	179.73	17.81	12.80	60.94	19.59
2001	1mat						
2000	2imm	7649.62	593.53	46.18	42.28	77.59	21.05
2000	2mat	3758.61	449.97	22.69	32.05	119.72	23.79
1999	3imm	40.63	4.32	0.25	0.31	106.29	23.31
1999	3mat	366.22	52.31	2.21	3.73	142.85	25.36
1998	4imm	427.87	72.29	2.58	5.15	169.84	26.73
1998	4mat	124.29	20.12	0.75	1.43	161.85	27.03
1997	5mat	107.53	17.14	0.65	1.22	159.37	26.56
1996	6mat	28.89	5.05	0.17	0.36	174.66	27.20
1995	7mat	6.33	1.30	0.04	0.09	205.01	28.99
1994	8mat	27.28	5.19	0.16	0.37	444.67	59.50
1993	9+mat	1077.34	3.02	6.50	0.22	2.81	7.66
Total		**16563.91**	**1403.96**	**100.0**	**100.0**		
Immature		**11716.89**	**780.60**	**70.74**	**55.60**		
Mature		**4847.02**	**623.36**	**29.26**	**44.40**		

Table 5b. Sprat. Mean length, mean weight, biomass (thousands of tonnes) and numbers (millions) breakdown by age and maturity. Tridens, North Sea acoustic survey 2003.

Year	age	Numbers (millions)	Biomass (1000 tonnes)	Numbers %	Biomass %	Mean weight (g)	Mean length (cm)
2002	0imm						
2002	0mat						
2001	1imm	31.22	0.18	12.87	8.20	5.87	9.35
2001	1mat	145.10	1.15	59.80	51.52	7.93	10.22
2000	2imm	2.76	0.02	1.14	0.92	7.48	10.08
2000	2mat	51.97	0.70	21.42	31.54	13.56	12.16
1999	3imm						
1999	3mat	11.57	0.17	4.77	7.81	15.09	12.64
1998	4mat						
1997	5mat						
1996	6mat						
1995	7mat						
1994	8mat						
1993	9mat						
Totaal		**242.63**	**2.23**	**100.00**	**100.00**		
Immature		**33.98**	**0.20**	**14.01**	**9.13**		
Mature		**208.65**	**2.03**	**85.99**	**90.87**		

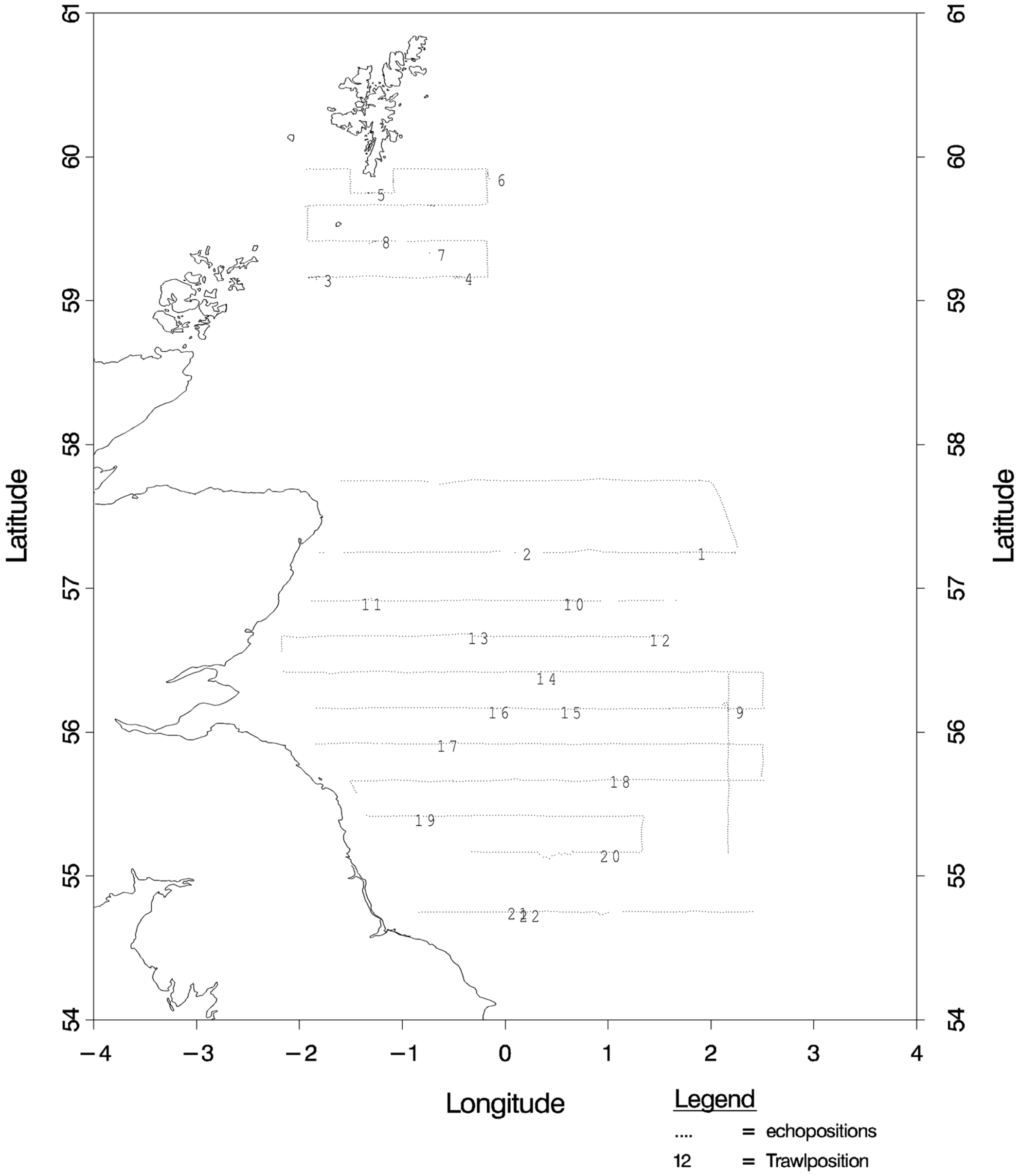


Figure IIE.1. Cruise track and positions of fishing trawls undertaken. Sprat was caught in haul 11,17,19,20 and 21. Tridens, North Sea acoustic survey 2003.

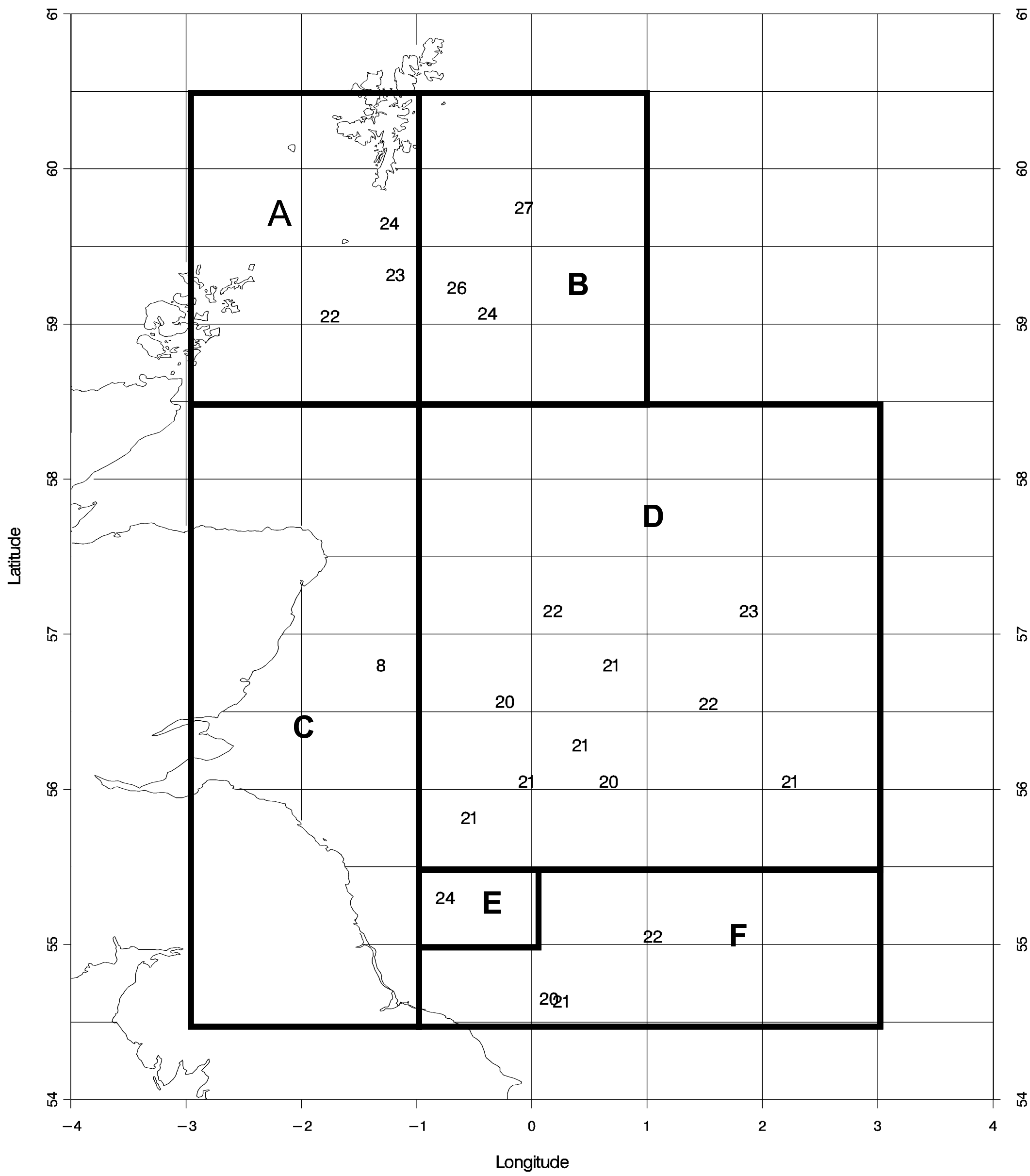


Figure IIE.2. Mean length of herring from pelagic trawl catches. Strata-areas A to F are indicated. Tridens, North Sea acoustic survey 2003.

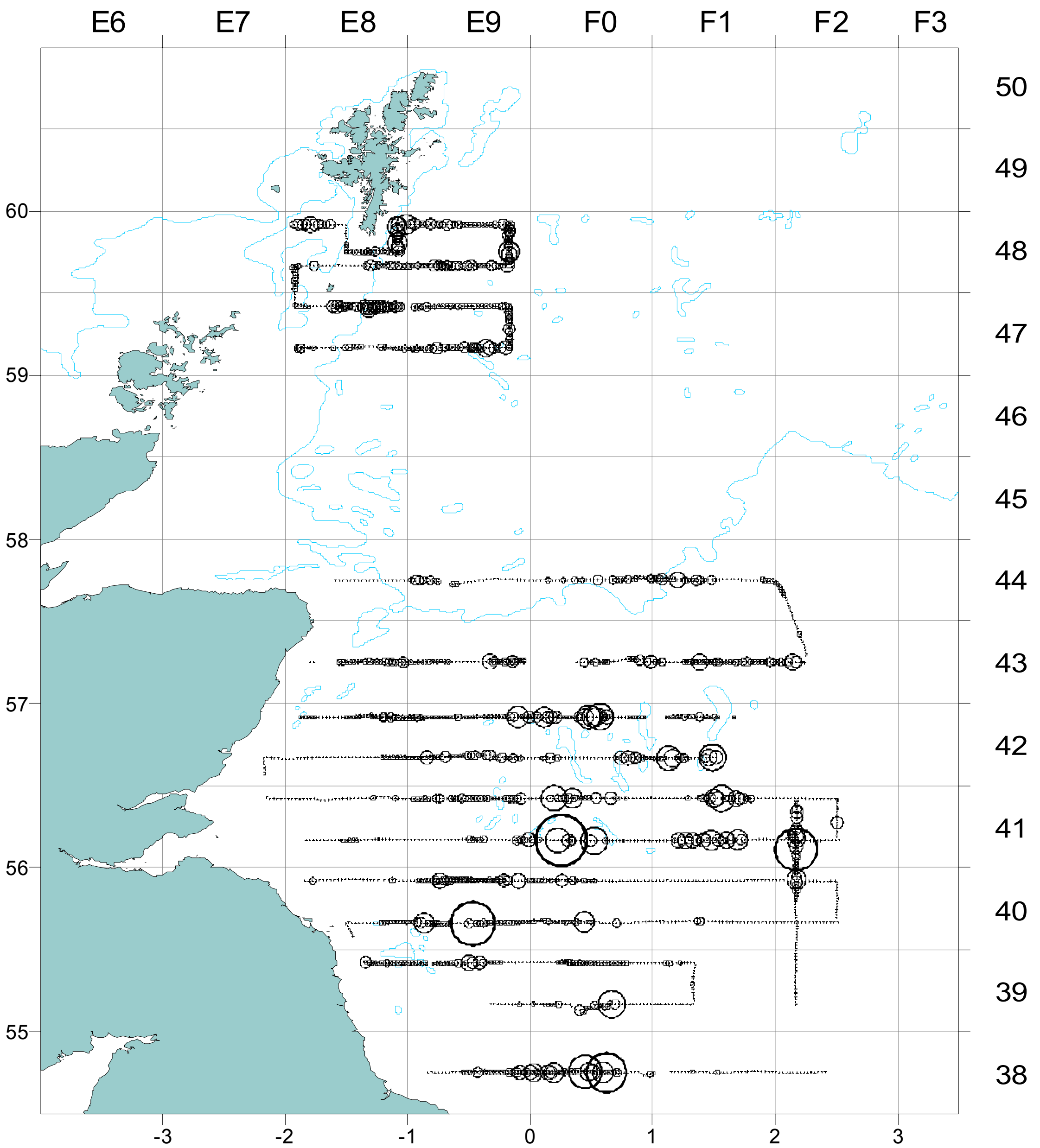


Figure IIE.3. Post plot showing the distribution of total herring NASC values (on a proportional square root scale relative to the largest value of 3601,4). Tridens, North Sea acoustic survey 2003.

Figure IIE.4. Estimated numbers of herring in millions (upper half square) and biomass in thousands of tonnes (lower half of square) by ICES rectangle. Tridens, North Sea acoustic survey 2003.

Appendix IIF: Germany

Survey report for FRV "Walther Herwig III" cruise 253

International Herring Acoustic Survey in the North Sea

26 Jun 2003 – 13 Jul 2003

Christopher Zimmermann, Soenke Jansen, Inst Sea Fisheries (ISH),
Eberhard Götze, Inst Fishery Technology Fish Quality (IFF), Hamburg

1. INTRODUCTION

Context: "Walther Herwig III" cruise 253 was conducted in the framework of the international hydroacoustic survey on pelagic fish in the North Sea, which is co-ordinated by the ICES Planning Group for Herring Surveys (PGHERS). Further contributors to the quasi-synoptic survey are the national fisheries research institutes of Scotland, Norway, Denmark and The Netherlands. The results are delivered to the ICES herring assessment working group. Since 1984 they represent the most important fishery independent data (i.e., biomass estimate) for the assessment of herring stocks in the area.

The working area for "Walther Herwig III" 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. This year, the survey area was significantly extended to the south (to 52°N) in an attempt to reach the southern distribution limit of sprat. Survey intensity therefore had to be reduced in most of the area.

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 specimens for a number of national and international projects (BFA Fi: Univ. Aberdeen/ISH and IFÖ; FTZ Büsum, IfM Kiel, Univ. Göttingen).

2. SURVEY DESCRIPTION and METHODS

2.1 Personnel

Dr C. Zimmermann	scientist in charge, fishery biology		ISH
E. Götze	hydroacoustics	IFF(T)	
M. Drenckow	hydroacoustics	IFF(T)	
Mrs G. Hemken	fishery biology	ISH	
S. Aster	fishery biology	ISH	
N. Geveke	fishery biology	ISH	
A. Hammrich	fishery biology	ISH	
N. Pinz	fishery biology	ISH	
Mrs C. Wördemann	fishery biology	ISH	
Dr I. Stürmer	guest researcher	Univ. Göttingen	to 04.07.03
H. Baumann	guest researcher	Univ. Hamburg	from 04.07.03

2.2 Narrative

FRV "Walther Herwig III" left the port of Bremerhaven on 26 June at noon, and calibrated the hydroacoustic equipment under favourable conditions in the morning of 27 June off Helgoland. Therefore, it was again not necessary to sail to Kristiansand. Recording of hydroacoustic measurements started immediately in the river Elbe estuary (Figure 1). The work off the Danish west coast could be completed with east-west-transects by 3 July. The northern part was surveyed with double intensity (15 n.mi. transect spacing) to account for the importance of that area for the calculation of juvenile herring abundance. The remaining area was surveyed with 30 n.mi. transect spacing. After exchanging the two guest researchers from Helgoland on 4 July, the work commenced with north-south transects off the Frisian coast and again East-West-transects south of the Dogger Bank to the English coast. While weather conditions promoted the survey in this year, a technical failure required a slight shortening of the scientific program at the last day. "Walther Herwig III" reached Bremerhaven at 13 July 2003 in the morning, having sailed 2569 n.mi.

2.3 Survey design

In contrast to previous years, the working area for the German vessel contributing to the survey was extended to the west and the south, aiming at defining a southern distribution limit of sprat in July. This would be a prerequisite for the development of a sprat biomass index in the near future using this acoustic survey. The survey area was confined to the southern and south-eastern 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 57°N (eastern part) and 54.5°N (western part) to the north, respectively.

Hydroacoustic measurements were conducted on east-west or north-south transects with 15 or 30 n.mi. intertransect distance (as done by other research vessels participating in the survey) on fixed longitudes (7.5 n.mi. distance to upper and lower limits of statistical rectangle). In general, each ICES statistical rectangle was surveyed with at least one transect, and with two transects where historically a high abundance or variability of abundance of juvenile herring had been detected. Fishing activities had to be kept at a minimum to account for the extension of the survey area.

2.4 Calibration

The hull mounted transducer ES38B (starboard blister) was calibrated at the start of the survey (June 26th and 27th) at open sea west of Helgoland. In spite of rather favourable conditions, the calibration procedure required 17 hrs. It was carried out with the PC program "Calibrate" (Bethke 2000) which gives equivalent results as the "Lobe" (Simrad) program and the methods described in the 'Manual for Herring Acoustic Surveys in ICES Divisions III, IV and VI' (ver. 3.1, ICES CM 2003/G:03, Appendix 4). Important parameters and settings are listed in Table 1. The difference to the last calibration on "Herwig" (conducted in the Western Baltic in early June 2003 under good conditions and recalculated for the North Sea environment) was found to be minimal and it was decided to take the new values.

2.5 Acoustic data collection

The acoustic investigations were performed during daylight (0400 to 2000 hrs UTC), using a Simrad EK500 echosounder with a standard frequency of 38 kHz. The echo telegrams were continuously recorded with the Bergen integrator BI500. The specific settings of the hydroacoustic equipment were used as described in the 'Manual for Herring Acoustic Surveys in ICES Divisions III, IV and VI' (ver. 3.1, ICES CM 2003/G:03, Appendix 4). Basic settings are documented in Table 1. The transducer ES38B was mounted on starbord in the vessel's hull. The vessel was running at a speed of 10–11 knots. During cruise 253, "Herwig" sailed 2569 n.mi. Of these, 1992 n.mi. could be used for acoustic data sampling.

2.6 Biological data - fishing trawls

For the identification of echo traces and further biological sampling, 27 trawl hauls were conducted either on specific large schools (after turning the ship) or, if small schools occurred frequently, continuing the survey track. On "Walther Herwig III", a small pelagic trawl (PSN205, approx. 13 m vertical opening, mesh size in the codend 10 mm) was used both in the midwater and close to the bottom. The net was equipped with a Krupp-Atlas net sonde. Standard tow periods were 30 mins; however, they varied between 4 and 75 mins depending on the indications of net filling.

From each trawl, the mass of the total catch and species composition (on subsamples, if needed) was determined. Length frequency distributions were produced for each species. Length-stratified samples (10 samples per half cm class per ICES stat rectangle) of herring and sprat were taken for the determination of maturity (using a 4 point scale), sex and individual body mass, and otoliths were removed for age reading (from 1151 herring, 968 sprat and 27 anchovies). If conditions did not allow conducting this work immediately after the haul, fish was frozen for further processing at the institute (additional 180 specimens taken in two stat. rectangles).

2.7 Hydrographic data

After each of the hauls and on additional hydrographic stations, vertical profiles of temperature, salinity and depth were recorded using a "Seabird 911- multiprobe" CTD-water sampler rosette (Figure 1). Water samples for calibration have been taken close to the bottom.

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 using a Bergen integrator BI500, 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 BI500.

As it was not possible to distinguish between herring and sprat within clupeid schools and to allocate the integrator readings to a single species. species composition was based on the trawl catch results (see above).

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 □was calculated according to the following target strength-length (TS) relationship:

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

The total number of fish (total N) in one rectangle was estimated to be the product of the mean area scattering cross section NASC and the rectangle area (or more precisely the area 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 which appeared in single clusters of some n.mi. extension. Echoes attributed to plankton were not considered to be problematic for the identification of fish schools.

The highest nautical area scattering coefficients (NASCs) have been found in the south and the south-east of the investigation area. Only 22% of all 1992 measured intervals contained clupeid schools. Approximately 50% of the total NASC was found in only 15 intervals, with the highest value south of Helgoland (56,144 $m^2 n.mi.^{-2}$) in a school with about 1 n.mi. extension. This is by far the highest value ever detected during the German part of the survey. Figure 2 gives the NASC distribution on 1 n.mi. EDSUs, divided into herring and sprat.

3.2 Biological data

27 hauls with the pelagic trawl PSN205 have been deployed. Due to time constraints caused by the extension of the survey area this year, 28 statistical rectangles out of 49 covered during the survey could not be sampled with trawl hauls (Figure 1 and Table 2) – 10 of these without or with only minimal NASCs. 17 rectangles have been sampled successfully (with more than 200 clupeids per hour trawling) and were used for raising unsampled rectangles. Total catch varied between 3.4 and 1694 kg.

Herring was mainly found in the north-eastern part of the area, but also on one spot off Flamborough Head (bottom water temperatures 10–14°C) sampled for the first time this year, while sprat was concentrated in warmer water close to the Frisian, English and Dutch coasts. Almost no fish could be observed in water colder than 10°C in the north-west. A summer southern distribution limit for sprat in the Channel could **not** be detected; the possible use of the summer acoustic survey for the calculation of a sprat biomass index will have to be discussed by PGHERS. As in last year, large mature anchovies occurred in the Elbe estuary.

24 species have been caught (mean 6 species per haul). Highest presence was recorded for grey gurnard (in 23 of 27 hauls), sprat and mackerel (21), herring (20) and whiting (19). The main share of the total catch of approx. 9 tons (573’000 specimens) could be attributed to sprat (44%, 436’500 ind) and herring (28%, 77'200 ind), followed by mackerel, horse mackerel and whiting (Table 3).

3.3 Biomass and abundance estimates

The total biomass estimates for the survey:

Total herring	**110,900 t**	(2002: 183,400 t)
Spawning stock biomass	49,900 t / 45 %	(2002: 57 t / 0.03 %)
Total sprat	**266,100 t**	(2002: 225,600 t tonnes)
Spawning stock biomass	158,500 t / 59 %	(2002: 151,800 t / 67 %)

The total abundance estimates for the survey:

Total herring	**4,100 mill.**	(2002: 8,400 mill.)
Spawning stock abundance	1,200 mill. / 31 %	(2002: 1 mill. / 0.01 %)

Total sprat	**29,600 mill.**	**(2002: 19,700 mill.)**
Spawning stock abundance	**14,700 mill. / 50 %**	**(2002: 12,700 mill. / 64 %)**

Note that these values are not directly comparable to last year's as the survey area has been significantly expanded. Herring abundance has halved, mainly due to the halved number of 1 wr fish. The age composition has slightly changed to previous years' results. However, the vast majority (>90%) of herring in this area still consists of 0- and 1-wr (Age 1 and 2). The fraction of mature herring has significantly increased. There is uncertainty about the quality of the maturity determination this year, and indications for a bias towards higher maturity. These values should therefore be treated with caution. Problems like this can only be solved by means of a maturity workshop.

Sprat biomass and abundance have been increased as compared to last year, reflecting mainly the expansion of the survey area.

Detailed information on abundance and biomass by statistical rectangle can be found in Figures 3 and 4; they are further split into age group and maturity in Tables 5 and 6 for herring, and in Table 7 for sprat.

3.4 Hydrographic data

The number of CTD stations has been doubled this year to promote an analysis of the influence of bottom water temperature on clupeid distribution. 92 vertical profiles have been recorded at stations spread over the whole area, with a maximum distance of about 30 n.mi. between any station. The water column was clearly stratified on most of the offshore stations; surface temperatures ranged between 12.7 and 18.0°C and bottom temperatures between 6.9 and 17.7°C (at 24–63 m water depth), see Figure 5.

Weather conditions have been favourable during this cruise: wind speed was above 13 $m\ s^{-1}$ (6 Bft.) only on 3 days. Surface water and air temperatures have been very similar.

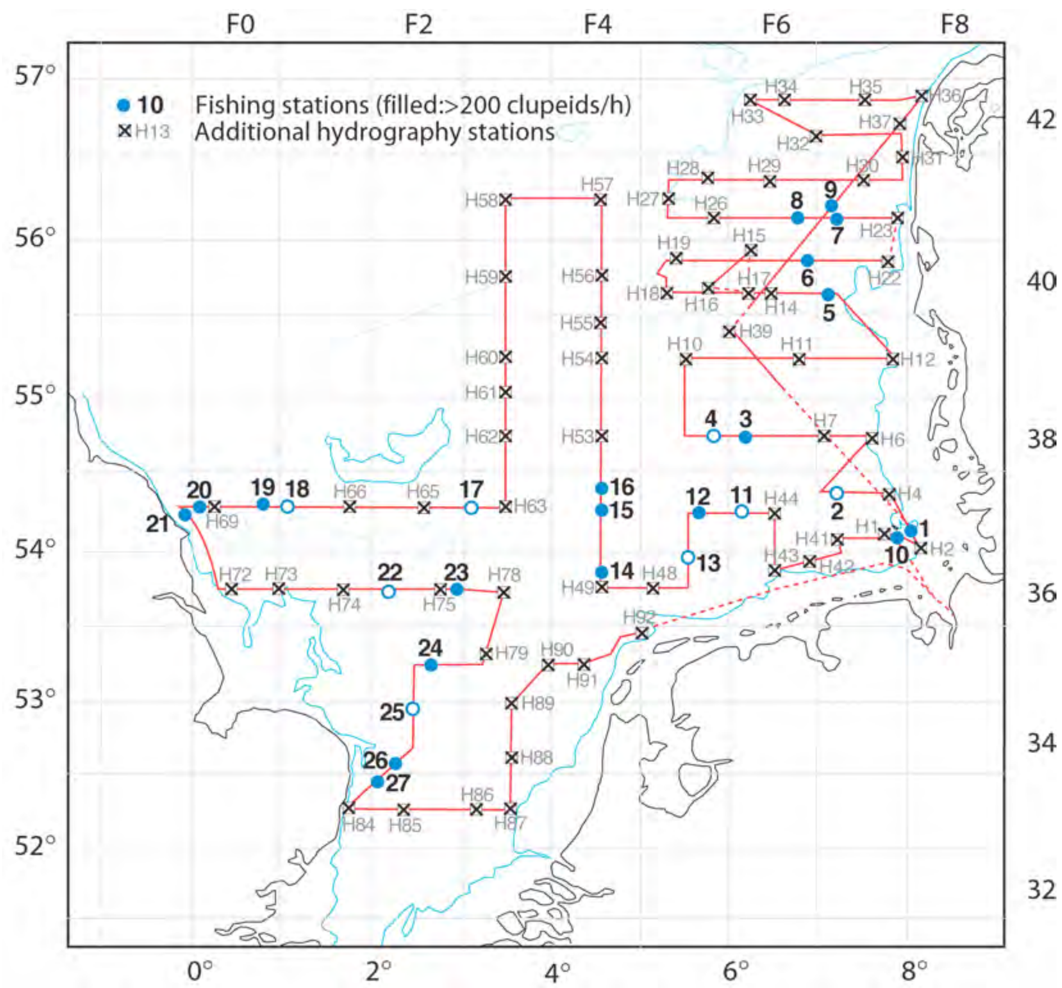
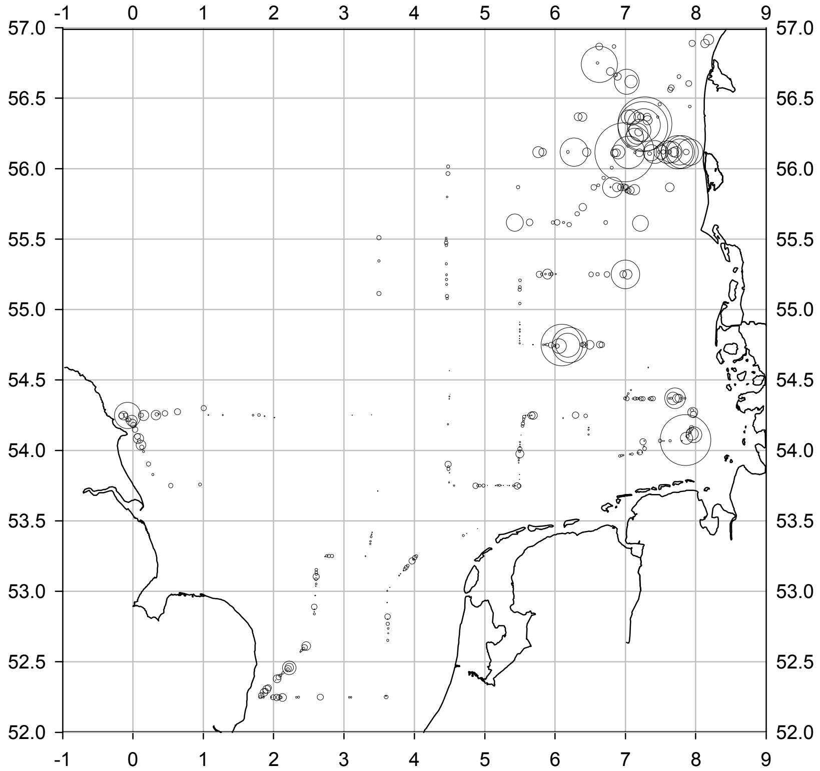


Figure 1. FRV "Walther Herwig III", cruise 253: International hydroacoustic survey on herring in the North Sea, 26 June 2003 -13 July 2003: Cruise track, fishing stations and hydrographic stations. 20 and 50 m depth contour drawn.



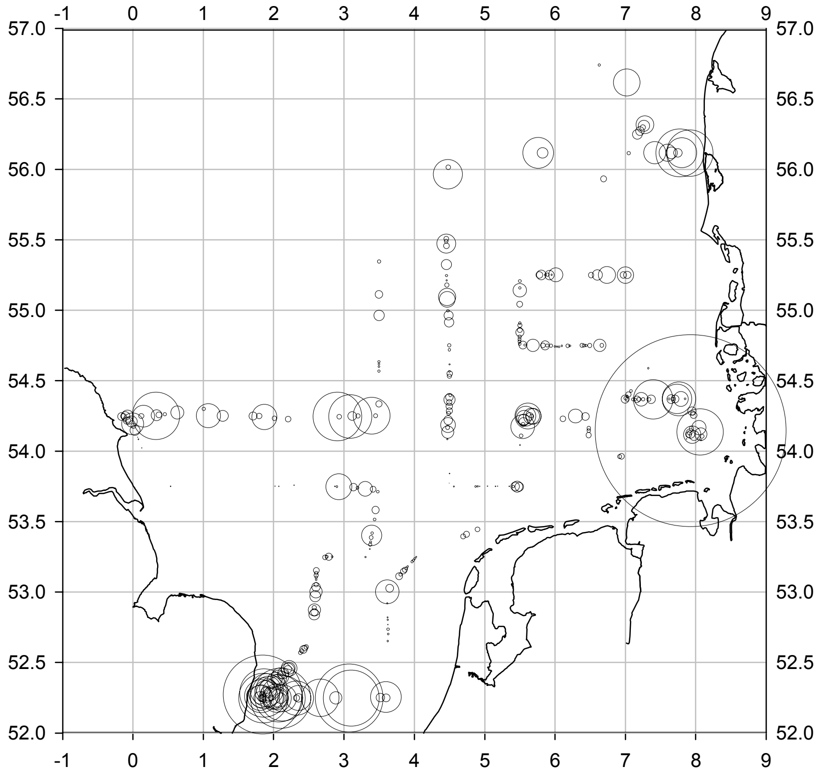


Figure 2. FRV "Walther Herwig III", cruise 253: International hydroacoustic survey on herring in the North Sea, 26 June 2003 -13 July 2003: Post plot showing the distribution of total NASC values (sum per n.mi.), attributed to **herring** (upper, on a proportional sq. root scale relative to the largest value of 5036 $m^2 n.mi.^{-2}$), and **sprat** (lower, largest value 52439 $m^2 n.mi.^{-2}$). Smallest dots indicate zero values.

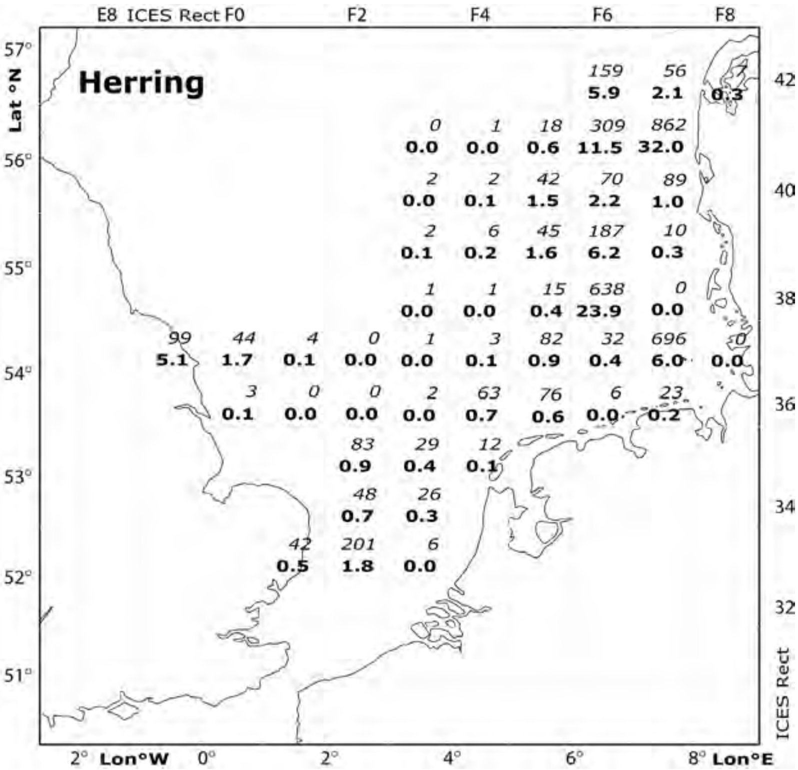


Figure 3. FRV "Walther Herwig III", cruise 253: International hydroacoustic survey on herring in the North Sea, 26 June 2003 -13 July 2003: Abundance (Mill. individuals, upper value in italics) and biomass (thousand t, lower value in bold) of **herring** per statistical rectangle.

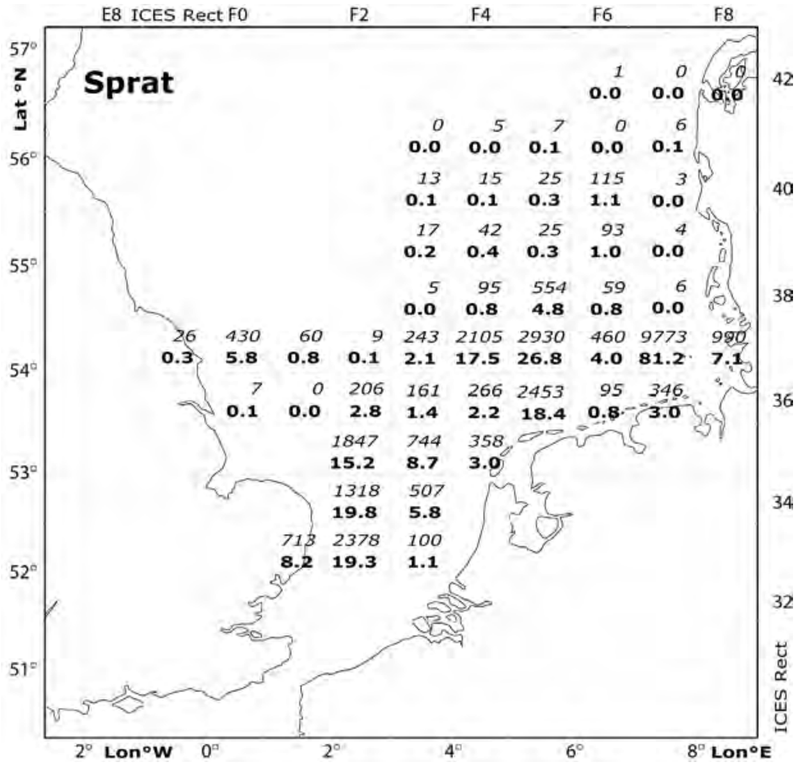


Figure 4. FRV "Walther Herwig III", cruise 253: International hydroacoustic survey on herring in the North Sea, 26 June 2003 -13 July 2003: Abundance (Mill. individuals, upper value in italics) and biomass (thousand t, lower value in bold) of **sprat** per statistical rectangle.

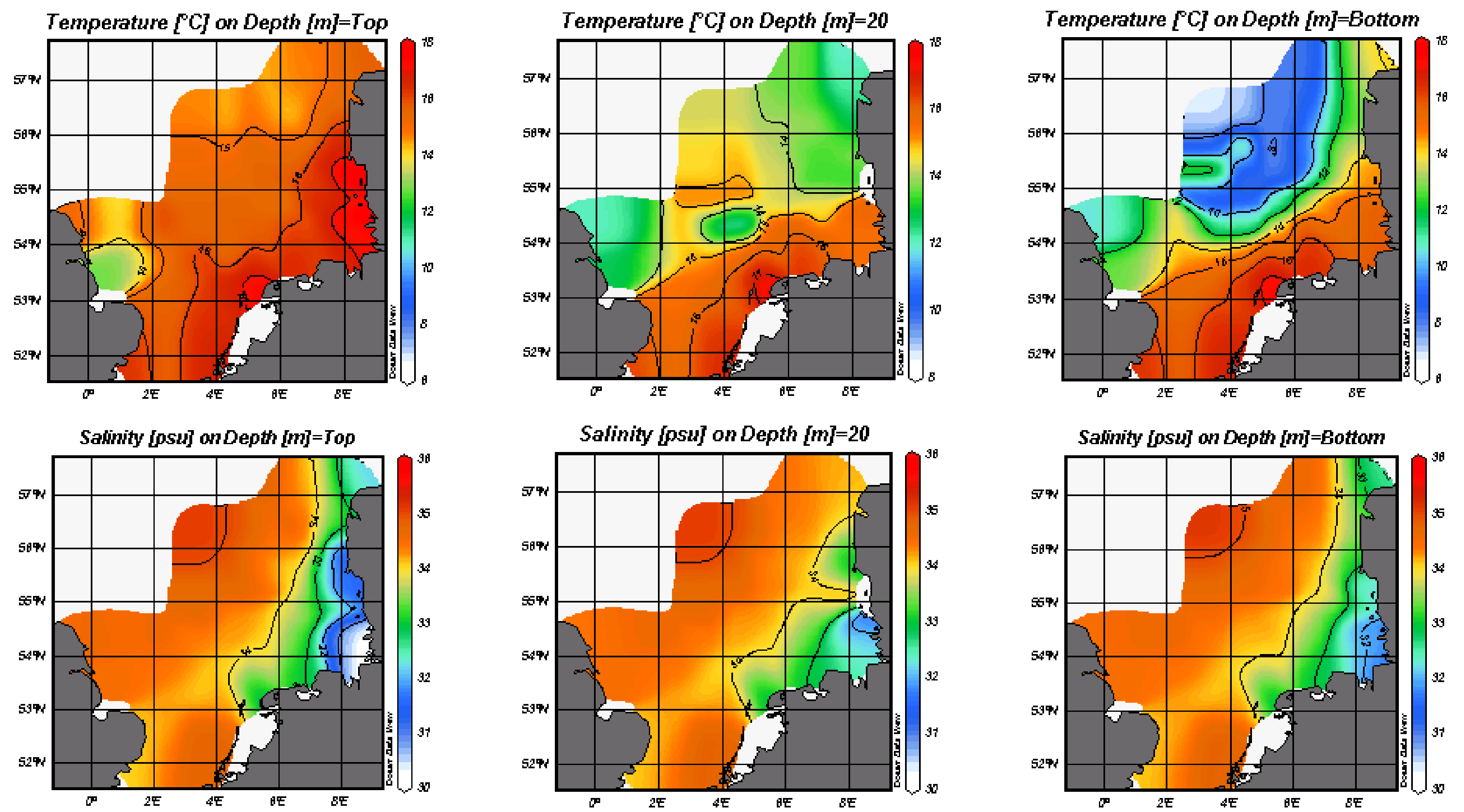


Figure 5. FRV “Walther Herwig III”, cruise 253: International hydroacoustic survey on herring in the North Sea, 26 June 2002 –13 July 2003: Temperature and salinity in different depth layers.

Table 1. FRV “Walther Herwig III”, cruise 253: International hydroacoustic survey on herring in the North Sea, 26 June 2003 -13 July 2003: Simrad EK500 and analysis settings used.

Transceiver Menu	
Frequency	38 kHz
Transducer	FL1 STB-Blister ES38B
Sound speed	1505 ms^{-1}
Max. Power	2000 W
Equivalent two-way beam angle	-20.4 dB
Default Transducer Sv gain	26.74 dB
Calibration details	
TS of sphere	-33.6 dB
Range to sphere in calibration	12.82 m
Measured NASC value for calibration	12767.2
Log Menu	
Speed	1 n.mi.
Operation Menu	
Ping interval	1 s at 50 m range
Analysis settings	
Bottom margin (backstep)	0.5 m
Integration start (absolute) depth	9.5 m
Range of thresholds used	-50 dB

Table 2. FRV "Walther Herwig III", cruise 253: International hydroacoustic survey on pelagic fish in the North Sea, 26 June- 13 July 2003: **Trawl station data**

Stat	**Haul**	**Rect**	**Dat**	**Time of day** (hhmm UTC)	**Trawl**	**ShotPosLat** (°°MM.MM)	**Shot PosLon** (°°MM.MM)	**Water Depth** (m)	**Catch Depth** (m)	**Catch** time (min)
452	1	37F8	20030627	823	PSN205	540684N	0080476E	25.5	20	30
454	2	37F7	20030627	1335	PSN205	542200N	0070597E	38.5	32.5	38
457	3	38F6	20030628	747	PSN205	544503N	0060494E	42.5	35.5	59
458	4	38F5	20030628	1055	PSN205	544501N	0054493E	43.5	37	62
462	5	40F7	20030630	1150	PSN205	553701N	0071829E	30	23	30
470	6	40F6	20030630	1608	PSN205	555251N	0065840E	36	29	60
473	7	41F7	20030701	638	PSN205	560706N	0072480E	28	24	60
474	8	41F6	20030701	923	PSN205	560705N	0065629E	37.5	30.5	61
487	9	41F7	20030703	1433	PSN205	561905N	0071650E	33	25	10
489	10	37F7	20030704	1510	PSN205	540436N	0075009E	43.5	36	4
494	11	37F6	20030705	1009	PSN205	541522N	0061856E	38	30	60
495	12	37F5	20030705	1354	PSN205	541495N	0054016E	40	33	46
496	13	36F5	20030705	1632	PSN205	535995N	0052994E	37	31.5	30
499	14	36F4	20030706	646	PSN205	534803N	0042982E	39.5	33	26
500	15	37F4	20030706	1009	PSN205	541511N	0042909E	49.5	43	60
501	16	37F4	20030706	1213	PSN205	542354N	0042996E	49	41.5	30
513	17	37F3	20030708	1023	PSN205	541492N	0030807E	46	37.5	30
516	18	37F1	20030709	635	PSN205	541551N	0010288E	51.5	43	30
517	19	37F0	20030709	840	PSN205	541757N	0004509E	54	44.5	68
519	20	37F0	20030709	1217	PSN205	541494N	0001344E	59.5	52.5	60
520	21	37E9	20030710	1457	PSN205	541446N	0001014W	52	46.5	75
524	22	36F2	20030710	1007	PSN205	534507N	0020516E	28	21.5	59
526	23	36F2	20030710	1429	PSN205	534488N	0025586E	42.5	34.5	46
529	24	35F2	20030711	633	PSN205	531490N	0024809E	32.5	24.5	30
530	25	34F2	20030711	911	PSN205	525894N	0023571E	37.5	30	60
531	26	34F2	20030711	1257	PSN205	523656N	0022758E	50.5	42.5	20
532	27	33F2	20030711	1501	PSN205	522717N	0021267E	41.5	34	28

Table 3. FRV “Walther Herwig III”, cruise 253: International hydroacoustic survey on herring in the North Sea, 26 June 2003 -13 July 2003: Species distribution per haul (catch in kg), relative composition of the clupeid catch, and total raised number of clupeids. Stations marked yellow were used for verification of echo traces.

Station																															
452					0.8					1.5	0.0						0.1		1.4	642.0		0.0			**645.9**	7		**0%**	114704	**100%**	114704
454						3.3				0.0									0.1						**3.4**	3					0
457	0.0		159.8			3.5								0.0					20.0	5.2			1.5		**190.1**	7	3867	**91%**	360	**9%**	2149
458						11.5								0.0					220.0	0.3			2.7		**234.6**	5		**0%**	18	**100%**	9
462			5.8			3.3				0.0		0.1		0.0						0.2					**9.5**	6	522	**96%**	19	**4%**	541
470			41.2			7.2				0.1		0.0		0.0					0.6	34.3	0.0				**83.4**	8	1671	**38%**	2726	**62%**	2199
473		0.0	88.2			12.6		0.5		34.1		0.1		0.0					1.7	34.8					**171.9**	9	2854	**58%**	2064	**42%**	2459
474			115.1			8.9				0.4									0.1						**124.5**	4	4142	**100%**		**0%**	2037
487			1691.0			2.9								0.0											**1693.9**	3	49186	**100%**		**0%**	147558
489			17.0											0.0					5.3	288.2					**310.5**	4	2439	**7%**	34242	**93%**	275108
494						0.6													398.2				378.5		**777.2**	3					0
495			14.7	0.3		1.1				0.0				0.1					2.6	364.9			41.5		**425.2**	8	1080	**3%**	38788	**97%**	26001
496			13.4			1.0				0.1									8.7	483.6			167.0		**673.8**	6	1462	**3%**	47439	**97%**	48901
499			0.8			0.1		0.0			0.1	0.2		0.0			1.5		1.3	4.3			0.9		**9.3**	10	126	**19%**	536	**81%**	764
500			0.2			1.2								12.9				1.7		15.0			0.1		**31.0**	6	9	**1%**	1601	**99%**	805
501			1.0			4.6								14.2	0.3					745.0					**765.1**	5	163	**0%**	102384	**100%**	102547
513						0.8				11.7				97.0					147.0						**256.5**	4					0
516				0.0		6.5		3.4								0.4			0.4						**10.7**	5					0
517			0.1	0.7		7.4		0.1						0.0						116.0					**124.2**	6	1	**0%**	7587	**100%**	3348
519			34.1			17.0							1.1	30.9					143.6	30.0					**256.6**	6	820	**27%**	2264	**73%**	1542
520			285.0	1.1		3.8	1.3		0.1			0.0	2.3	446.0						11.0			0.5	0.2	**751.4**	11	4448	**79%**	1165	**21%**	2245
524				0.6		2.8		30.4		11.8		1.0		0.2		1.3			3.9	0.0					**52.0**	9		**0%**	1	**100%**	1
526			0.1	0.0		0.2		0.7		0.1		0.2							9.4	81.0			11.8		**103.5**	9	1	**0%**	6244	**100%**	4073
529			17.1	0.9		0.1					0.1			0.6					5.6	218.9			0.1		**243.5**	8					0
530			0.1	0.1		0.1					0.1								46.7	0.6					**47.7**	6					0
531			28.8	0.0										0.1					8.6	630.2					**667.7**	5	1438	**4%**	39551	**96%**	61484
532			25.5	0.5						0.1	0.1			0.1					2.5	247.5					**276.3**	7	2947	**8%**	34794	**92%**	40437
Total	0.0	0.0	2538.9	4.3	0.8	100.4	1.3	35.0	0.1	59.7	0.4	1.7	3.4	602.1	0.3	1.7	1.6	1.7	1027.8	3953.3	0.0	0.0	604.7	0.2	**8939.4**	24	77176		436487		838909

Table 4a. FRV “Walther Herwig III”, cruise 253: International hydroacoustic survey on herring in the North Sea, 26 June 2003 -13 July 2003: **Herring** length frequency proportion (%) by trawl haul. Length in cm.

Stat.Rect.		38F6	40F7	40F6	41F7	41F6	41F7	37F7	37F5	36F5	36F4	37F4	37F4	37F0	37F0	37E9	36F2	35F2	34F2	34F2
Length (cm)	Total	457	462	470	473	474	487	489	495	496	499	500	501	517	519	520	526	529	530	531
3.75	0										0	11								
4.25	0										0	33								
4.75	0										0	11								
5.25	0										1									
5.75	0										3							1		
6.25	0										4									
6.75	0										11									
7.25	0										32		25					1		
7.75	0										23							4		
8.25	0									7	9							4		
8.75	1							5		3	5		25					5		
9.25	2							15	3	15	1							1		
9.75	2		0					19	3	5	1		25					5		
10.25	3		10					26	20	15	1							5		
10.75	3		36	2				21	26	29								9		
11.25	2		31	7				11	14	14								9		
11.75	1		11	6				3	17	5								11	33	4
12.25	0		0	4					6	7								18	33	7
12.75	1		0	0														15		25
13.25	0		0	0							1				0			3		31
13.75	0		0	0									25		1	1		2		10
14.25	0		0	3	1										9	0		2	33	
14.75	0		0	9	3						1				12	1				3
15.25	5		2	18	19	1	5					11			8	2		1		4
15.75	22	2	3	21	42	8	27				1	11			9	1				4
16.25	23	9	2	14	24	28	28		3		1	11			7	1		1		4
16.75	20	14	2	11	8	28	24		3		3				4	0		1		4
17.25	10	29		3	3	26	11		3		1	11			4	4				3
17.75	2	27		1	1	7	2				2				5	2				
18.25	1	16		0	0	1	1		3		1				6	6				1
18.75	1	4					1				1				8	15				
19.25	0	0													9	14				
19.75	0													100	8	14				
20.25	0														7	14				
20.75	0														1	7				
21.25	0														0	1				
21.75	0															0				
22.25	0														0	1				
22.75	0															1				
23.25	0															1				
23.75	0															2				
24.25	0															0	100			
24.75	0														0	3				
25.25	0															1				
25.75	0															1				
26.75	0															0				
27.75	0															0				
Total n ('000)	368.2	3.9	1.0	1.7	2.9	4.1	295.1	36.6	1.4	2.9	0.3	0.0	0.3	0.0	0.8	3.6	0.0	3.0	0.0	4.3

Table 4b. FRV "Walther Herwig III", cruise 253: International hydroacoustic survey on herring in the North Sea, 26 June 2003 -13 July 2003: **Sprat** length frequency proportion (%) by trawl haul. Length in cm.

Stat.Rect.		37F8	38F6	38F5	40F7	40F6	41F7	37F7	37F5	36F5	36F4	37F4	37F4	37F0	37F0	37E9	36F2	36F2	35F2	34F2	34F2	33F2
Length (cm)	**Sum**	452	457	458	462	470	473	489	495	496	499	500	501	517	519	520	524	526	529	530	531	532
5.75	**0**																		0			
6.25	**0**																		1			
6.75	**0**										0								0			
7.25	**0**										1								0			
7.75	**0**	0								1	4								0			0
8.25	**1**	6								1	2	1	1						1			1
8.75	**11**	52						1		6	7	5	3						11			14
9.25	**18**	34	4					12	4	21	9	21	18			3			36			37
9.75	**22**	6	6		5	2		26	9	37	25	18	34			11			30	2		28
10.25	**20**	1	11		5	14		30	31	20	30	12	30	0	1	17		2	12	0	0	9
10.75	**9**	0	5		16	31		15	28	7	10	10	7	0	5	23		6	5	2	1	2
11.25	**5**		5		16	25	3	9	12	3	4	6	3	4	18	17		11	2	22	5	2
11.75	**2**		8		37	15	18	2	7	1	3	6	0	16	30	11		12	1	18	9	1
12.25	**2**		20	6	21	4	21	1	2	1	2	8	1	19	17	7	100	15	0	27	15	2
12.75	**4**		26	50		5	15	3	5	1	2	8	1	26	16	5		22	0	18	28	2
13.25	**3**		12	44		3	21	1	3	0	0	3	1	21	8	3		21		7	26	2
13.75	**1**		2			2	16					1		11	4	2		9		2	11	0
14.25	**0**		0			0	3					0		2	1			3		2	4	
14.75	**0**		0				1							1	0			0				
Total n ('000)	**1377.9**	229.4	0.4	0.0	0.0	2.7	2.1	513.6	50.6	94.9	1.2	1.6	204.8	5.8	2.3	0.9	0.0	8.1	66.2	0.0	118.7	74.6

Table 5. FRV “Walther Herwig III”, cruise 253: International hydroacoustic survey on herring in the North Sea, 26 June 2003 -13 July 2003: Age/maturity-length key for **herring** (absolute numbers (‘000) raised to the abundance in the survey area).

wr	0	1	1	2	2	3	4	5+	
Age	1	2	2	3	3	4	5	6+	
Length (cm)	**1 imm.**	**2 imm.**	**2 mat.**	**3 imm.**	**3 mat.**	**4 mat.**	**5 mat.**	**5+mat.**	Sum
5.25	522.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	522.9
5.75	3216.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3216.2
6.25	2614.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2614.6
6.75	8275.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8275.5
7.25	23264.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23264.6
7.75	20617.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20617.3
8.25	27787.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27787.9
8.75	75666.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	75666.0
9.25	162402.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	162402.0
9.75	202907.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	202907.4
10.25	272712.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	272712.8
10.75	280660.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	280660.0
11.25	175513.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	175513.8
11.75	95512.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	95512.9
12.25	64753.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	64753.0
12.75	52202.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	52202.9
13.25	28234.2	4929.2	0.0	0.0	0.0	0.0	0.0	0.0	33163.5
13.75	5730.8	5285.8	3362.3	0.0	0.0	0.0	0.0	0.0	14379.0
14.25	0.0	6716.2	4406.5	0.0	0.0	0.0	0.0	0.0	11122.7
14.75	0.0	18720.8	5476.3	0.0	0.0	0.0	0.0	0.0	24197.1
15.25	0.0	62036.1	44433.6	0.0	0.0	0.0	0.0	0.0	106469.7
15.75	0.0	215844.7	141696.4	1637.4	0.0	0.0	0.0	0.0	359178.5
16.25	0.0	292646.0	154096.5	1916.4	0.0	0.0	0.0	0.0	448658.9
16.75	0.0	201227.7	246933.1	0.0	0.0	0.0	0.0	0.0	448160.8
17.25	0.0	232802.9	210846.1	10755.8	12080.1	0.0	0.0	0.0	466485.0
17.75	0.0	134230.8	147614.2	27836.2	34175.6	0.0	0.0	0.0	343856.8
18.25	0.0	71315.9	126911.7	0.0	10566.9	0.0	0.0	0.0	208794.5
18.75	0.0	28168.0	35667.7	2136.6	5423.5	0.0	0.0	0.0	71395.8
19.25	0.0	3819.6	7496.5	3608.9	8708.0	0.0	0.0	0.0	23633.0
19.75	0.0	6427.6	9715.7	0.0	2399.6	0.0	0.0	0.0	18542.9
20.25	0.0	2089.1	3841.9	1752.8	9843.8	0.0	0.0	0.0	17527.5
20.75	0.0	0.0	62.6	62.6	8039.7	0.0	0.0	0.0	8164.9
21.25	0.0	0.0	335.4	0.0	908.2	0.0	0.0	0.0	1243.7
21.75	0.0	0.0	0.0	0.0	3.3	502.3	0.0	0.0	505.6
22.25	0.0	0.0	0.0	0.0	816.5	816.5	0.0	0.0	1633.0
22.75	0.0	0.0	0.0	0.0	5.0	1511.7	0.0	0.0	1516.7
23.25	0.0	0.0	0.0	0.0	807.5	166.4	1331.2	166.4	2471.5
23.75	0.0	0.0	0.0	0.0	505.6	505.6	1011.1	505.6	2527.9
24.25	0.0	0.0	0.0	0.0	1.3	36.9	3.9	3.9	46.1
24.75	0.0	0.0	0.0	0.0	112.8	416.8	1216.2	1520.2	3265.9
25.25	0.0	0.0	0.0	0.0	0.0	0.0	252.8	758.4	1011.1
25.75	0.0	0.0	0.0	0.0	0.0	0.0	101.1	910.0	1011.1
26.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	505.6	505.6
27.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	491.2	491.2
28.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum	1502595	1286261	1142896	49707	94397	3956	3916	4861	4088590

Table 6. FRV “Walther Herwig III”, cruise 253: International hydroacoustic survey on herring in the North Sea, 26 June 2003 -13 July 2003: Mean weight, biomass (tonnes) and numbers (millions) for **herring** by age and maturity per statistical rectangle. Note that for rectangles marked in orange/violet LFDs for the whole survey area have been used, as no catch information from neighbouring rectangles was available.

Herring

		E9		F0		F1		F2		F3		F4		F5		F6		F7		F8	
		W [t]	N [10^6]	W [t]	N [10^6]	W [t]	N [10^6]	W [t]	N [10^6]	W [t]	N [10^6]	W [t]	N [10^6]	W [t]	N [10^6]	W [t]	N [10^6]	W [t]	N [10^6]	W [t]	N [10^6]
42	total															**5'872.6**	**158.5**	**2'055.1**	**55.5**	**263.2**	**7.1**
	1i															0.9	0.1	0.3	0.0	0.0	0.0
	2i															2'857.9	79.4	1'003.5	27.9	128.9	3.6
	2m	no stations and		no stations and		no stations and		no stations and		no stations and		no stations and		no stations and		2'876.2	76.0	1'005.0	26.6	128.6	3.4
	3i	no echo-information		no echo-information		no echo-information		no echo-information		no echo-information		no echo-information		no echo-information		72.0	1.7	25.1	0.6	3.2	0.1
	3m															65.6	1.2	21.2	0.4	2.5	0.0
	4m															0.0	0.0	0.0	0.0	0.0	0.0
	5m															0.0	0.0	0.0	0.0	0.0	0.0
	6+															0.0	0.0	0.0	0.0	0.0	0.0
41	total									**0.0**	**0.0**	**16.8**	**0.6**	**637.1**	**17.5**	**11'537.1**	**308.7**	**32'007.4**	**862.2**		
	1i									0.0	0.0	1.9	0.2	7.3	0.9	0.0	0.0	0.0	0.0		
	2i									0.0	0.0	6.1	0.2	241.2	6.7	5'408.6	150.3	17'137.0	476.2		
	2m	no stations and		no stations and		no stations and		no stations and		0.0	0.0	7.5	0.2	335.6	8.9	5'472.6	144.6	13'677.3	361.4	no stations and	
	3i	no echo-information		no echo-information		no echo-information		no echo-information		0.0	0.0	0.2	0.0	10.0	0.2	292.3	6.9	407.1	9.6	no echo-information	
	3m									0.0	0.0	0.9	0.0	43.1	0.8	363.5	6.9	786.0	14.9		
	4m									0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
	5m									0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
	6+									0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
40	total									**48.3**	**1.8**	**56.8**	**2.1**	**1'508.1**	**42.3**	**2'209.7**	**70.3**	**1'010.9**	**88.8**		
	1i									5.5	0.7	6.4	0.8	25.5	3.0	109.1	13.1	666.0	79.7		
	2i									17.6	0.5	20.7	0.6	599.5	16.7	1'300.9	36.1	140.3	3.9		
	2m	no stations and		no stations and		no stations and		no stations and		21.4	0.6	25.2	0.7	772.6	20.4	799.6	21.1	164.1	4.3	no stations and	
	3i	no echo-information		no echo-information		no echo-information		no echo-information		0.7	0.0	0.8	0.0	22.0	0.5	0.0	0.0	40.6	1.0	no echo-information	
	3m									2.5	0.0	3.0	0.1	88.6	1.7	0.0	0.0	0.0	0.0		
	4m									0.2	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
	5m									0.2	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
	6+									0.3	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
39	total									**63.3**	**2.3**	**158.2**	**5.8**	**1'618.1**	**44.9**	**6'245.1**	**187.4**	**306.7**	**10.0**		
	1i									7.2	0.9	17.9	2.1	22.6	2.7	238.9	28.6	20.5	2.5		
	2i									23.0	0.6	57.6	1.6	626.8	17.4	2'370.6	65.9	113.6	3.2		
	2m	no stations and		no stations and		no stations and		no stations and		28.0	0.7	70.1	1.9	841.4	22.2	3'161.9	83.6	150.3	4.0	no stations and	
	3i	no echo-information		no echo-information		no echo-information		no echo-information		0.9	0.0	2.3	0.1	24.5	0.6	91.9	2.2	4.3	0.1	no echo-information	
	3m									3.3	0.1	8.3	0.2	102.7	2.0	381.8	7.3	17.9	0.3		
	4m									0.2	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
	5m									0.3	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
	5+									0.3	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
38	total									**16.8**	**0.6**	**6.1**	**0.5**	**447.4**	**15.1**	**23'893.3**	**638.1**	**3.7**	**0.3**		
	1i									1.9	0.2	3.6	0.4	35.7	4.3	22.0	2.6	2.5	0.3		
	2i									6.1	0.2	1.2	0.0	143.6	4.0	11'499.6	319.5	0.4	0.0		
	2m	no stations and		no stations and		no stations and		no stations and		7.5	0.2	1.1	0.0	226.9	6.0	10'314.1	272.5	0.6	0.0	no stations and	
	3i	no echo-information		no echo-information		no echo-information		no echo-information		0.2	0.0	0.0	0.0	7.1	0.2	917.2	21.7	0.0	0.0	no echo-information	
	3m									0.9	0.0	0.1	0.0	34.1	0.6	1'140.3	21.7	0.1	0.0		
	4m									0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
	5m									0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
	6+									0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		

Table 6. Continued: **herring**.

37	total	**5'148.2**	**98.7**	**1'714.1**	**43.8**	**135.9**	**3.5**	**0.2**	**0.0**	**7.9**	**0.6**	**53.9**	**3.4**	**948.8**	**81.6**	**373.8**	**32.3**	**5'956.4**	**696.1**	**0.0**	**0.0**
	1i	2.9	0.4	0.0	0.0	0.3	0.0	0.0	0.0	4.5	0.5	20.9	2.5	604.4	72.3	240.7	28.8	5'782.0	691.5	0.0	0.0
	2i	731.1	20.3	777.9	21.6	54.0	1.5	0.0	0.0	2.1	0.1	0.2	0.0	166.4	4.6	47.1	1.3	0.0	0.0	0.0	0.0
	2m	1'257.2	33.2	624.5	16.5	53.6	1.4	0.0	0.0	1.1	0.0	32.8	0.9	177.9	4.7	73.1	1.9	174.5	4.6	0.0	0.0
	3i	122.6	2.9	47.6	1.1	4.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.1	0.0	0.0	0.0	0.0
	3m	1'573.1	29.9	218.1	4.1	20.9	0.4	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	10.6	0.2	0.0	0.0	0.0	0.0
	4m	368.1	3.6	16.1	0.2	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5m	429.7	3.7	0.0	0.0	0.8	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	6+	663.5	4.7	29.9	0.2	1.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	total			**127.2**	**2.7**	**0.0**	**0.0**	**3.3**	**0.0**	**22.6**	**2.1**	**705.3**	**62.6**	**632.0**	**75.6**	**49.8**	**5.8**	**197.5**	**23.1**		
	1i			0.2	0.0	0.0	0.0	0.0	0.0	15.8	1.9	469.3	56.1	632.0	75.6	47.8	5.7	192.2	23.0		
	2i			27.7	0.8	0.0	0.0	0.0	0.0	4.2	0.1	160.9	4.5	0.0	0.0	1.0	0.0	2.9	0.1		
	2m	no stations and		36.1	1.0	0.0	0.0	0.0	0.0	2.4	0.1	75.2	2.0	0.0	0.0	1.0	0.0	2.5	0.1	no stations and	
	3i	no echo-information		4.9	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	no echo-information	
	3m			31.5	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0		
	4m			7.1	0.1	0.0	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
	5m			8.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
	6+			11.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
35	total							**871.5**	**82.6**	**439.3**	**29.4**	**108.7**	**12.4**								
	1i							639.1	76.4	189.1	22.6	102.7	12.3								
	2i							58.6	1.6	160.0	4.4	2.5	0.1								
	2m	no stations and		no stations and		no stations and		173.8	4.6	86.2	2.3	3.1	0.1	no stations and		no stations and		no stations and		no stations and	
	3i	no echo-information		no echo-information		no echo-information		0.0	0.0	1.1	0.0	0.1	0.0	no echo-information		no echo-information		no echo-information		no echo-information	
	3m							0.0	0.0	2.5	0.0	0.3	0.0								
	4m							0.0	0.0	0.1	0.0	0.0	0.0								
	5m							0.0	0.0	0.2	0.0	0.0	0.0								
	6+							0.0	0.0	0.2	0.0	0.0	0.0								
34	total							**748.6**	**47.9**	**336.7**	**25.5**										
	1i							300.6	35.9	177.6	21.2										
	2i							107.2	3.0	99.2	2.8										
	2m	no stations and		no stations and		no stations and		340.8	9.0	53.1	1.4	no stations and		no stations and		no stations and		no stations and		no stations and	
	3i	no echo-information		no echo-information		no echo-information		0.0	0.0	0.7	0.0	no echo-information		no echo-information		no echo-information		no echo-information		no echo-information	
	3m							0.0	0.0	1.7	0.0										
	4m							0.0	0.0	0.4	0.0										
	5m							0.0	0.0	3.6	0.0										
	6+							0.0	0.0	0.5	0.0										
33	total					**519.0**	**41.6**	**1'765.5**	**201.4**	**72.4**	**5.8**										
	1i					300.2	35.9	1'664.1	199.0	41.9	5.0										
	2i					132.5	3.7	0.0	0.0	18.5	0.5										
	2m	no stations and		no stations and		71.1	1.9	59.8	1.6	9.9	0.3	no stations and		no stations and		no stations and		no stations and		no stations and	
	3i	no echo-information		no echo-information		1.0	0.0	0.0	0.0	0.1	0.0	no echo-information		no echo-information		no echo-information		no echo-information		no echo-information	
	3m					2.6	0.1	41.5	0.8	0.4	0.0										
	4m					1.0	0.0	0.0	0.0	0.1	0.0										
	5m					9.2	0.1	0.0	0.0	1.3	0.0										
	6+					1.4	0.0	0.0	0.0	0.2	0.0										

Weight at age & maturity [g]	
1i	8.36
2i	35.99
2m	37.84
3i	42.31
3m	52.60
4m	101.27
5m	116.63
6+	140.71

Totals [t]: **Weight**	**110'946**	Totals [mio]: **Numbers**	**4'099**
1i	12'645.3	1i	1'509.76
2i	46'261.4	2i	1'285.36
2m	43'398.9	2m	1'146.74
3i	2'106.9	3i	49.80
3m	4'970.0	3m	94.49
4m	398.5	4m	3.93
5m	454.5	5m	3.90
6+	710.4	6+	5.05

biomass from validly sampled squa	89'206	80%
biomass from interpolated squares	21'715	20%

calculated with mean weigh per age&maturity-class

= interpolated square

= no haul info and too remote for interpolation. Calculated "against the rules" with whole survey mean LFD-data to avoid unpleasant

Table 7. FRV “Walther Herwig III”, cruise 253: International hydroacoustic survey on herring in the North Sea, 26 June 2003 -13 July 2003: Mean weight, biomass (tonnes) and numbers (millions) for sprat by age and maturity per statistical rectangle. Note that for rectangles marked in violet LFDs for the whole survey area have been used, as no catch information from neighbouring rectangles was available.

Sprat

		E9		F0		F1		F2		F3		F4		F5		F6		F7		F8	
		W [t]	N [10^6]	W [t]	N [10^6]	W [t]	N [10^6]	W [t]	N [10^6]	W [t]	N [10^6]	W [t]	N [10^6]	W [t]	N [10^6]	W [t]	N [10^6]	W [t]	N [10^6]	W [t]	N [10^6]
42	total															**15.2**	**1.1**	**5.4**	**0.4**	**0.7**	**0.0**
	1i															0.1	0.0	0.0	0.0	0.0	0.0
	1															2.1	0.2	0.7	0.1	0.1	0.0
	2i	no stations and		no stations and		no stations and		no stations and		no stations and		no stations and		no stations and		0.3	0.0	0.1	0.0	0.0	0.0
	2m	no echo-information		no echo-information		no echo-information		no echo-information		no echo-information		no echo-information		no echo-information		11.5	0.7	4.1	0.3	0.5	0.0
	3															1.2	0.1	0.4	0.0	0.1	0.0
	4															0.0	0.0	0.0	0.0	0.0	0.0
41	total									**0.0**	**0.0**	**41.3**	**4.5**	**70.7**	**6.9**	**0.0**	**0.0**	**76.2**	**6.0**		
	1i									0.0	0.0	12.9	1.8	8.0	1.1	0.0	0.0	0.0	0.0		
	1									0.0	0.0	17.7	2.0	35.3	4.0	0.0	0.0	22.1	2.5		
	2i	no stations and		no stations and		no stations and		no stations and		0.0	0.0	0.4	0.0	1.5	0.1	0.0	0.0	0.0	0.0	no stations and	
	2m	no echo-information		no echo-information		no echo-information		no echo-information		0.0	0.0	9.8	0.6	24.9	1.6	0.0	0.0	53.4	3.4	no echo-information	
	3									0.0	0.0	0.5	0.0	1.0	0.1	0.0	0.0	0.7	0.0		
	4									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
40	total									**118.6**	**12.9**	**139.5**	**15.2**	**256.2**	**25.0**	**1'079.9**	**114.7**	**33.7**	**3.2**		
	1i									36.9	5.2	43.4	6.1	29.1	4.1	86.3	12.1	2.4	0.3		
	1									50.9	5.7	59.9	6.8	127.8	14.4	796.8	90.0	18.1	2.0		
	2i	no stations and		no stations and		no stations and		no stations and		1.1	0.1	1.3	0.1	5.3	0.4	0.0	0.0	0.0	0.0	no stations and	
	2m	no echo-information		no echo-information		no echo-information		no echo-information		28.2	1.8	33.2	2.1	90.2	5.8	187.3	12.1	13.2	0.9	no echo-information	
	3									1.5	0.1	1.8	0.1	3.8	0.2	9.5	0.5	0.0	0.0		
	4									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
39	total									**155.4**	**16.9**	**388.6**	**42.3**	**260.3**	**24.8**	**975.6**	**92.8**	**46.2**	**4.4**		
	1i									48.3	6.8	120.9	17.0	27.9	3.9	104.4	14.7	4.9	0.7		
	1									66.7	7.5	166.8	18.8	119.9	13.5	449.5	50.8	21.3	2.4		
	2i	no stations and		no stations and		no stations and		no stations and		1.5	0.1	3.7	0.3	5.3	0.4	20.0	1.6	1.0	0.1	no stations and	
	2m	no echo-information		no echo-information		no echo-information		no echo-information		36.9	2.4	92.3	5.9	102.9	6.6	385.7	24.8	18.3	1.2	no echo-information	
	3									2.0	0.1	4.9	0.3	4.3	0.2	15.9	0.9	0.7	0.0		
	4									0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0		
38	total									**41.3**	**4.5**	**809.2**	**95.1**	**4'803.6**	**554.3**	**788.0**	**59.3**	**46.6**	**5.5**		
	1i									12.9	1.8	294.4	41.3	1'606.4	225.6	7.6	1.1	19.0	2.7		
	1									17.7	2.0	422.5	47.7	2'517.6	284.3	166.1	18.8	22.0	2.5		
	2i	no stations and		no stations and		no stations and		no stations and		0.4	0.0	6.2	0.5	42.5	3.4	0.0	0.0	0.4	0.0	no stations and	
	2m	no echo-information		no echo-information		no echo-information		no echo-information		9.8	0.6	84.3	5.4	625.0	40.3	605.4	39.0	5.2	0.3	no echo-information	
	3									0.5	0.0	1.7	0.1	12.2	0.7	8.8	0.5	0.1	0.0		
	4									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		

Table 7. Continued **sprat**.

37	total	**254.1**	**26.1**	**5'848.8**	**429.6**	**813.8**	**60.0**	**121.3**	**9.0**	**2'067.2**	**243.3**	**17'450.9**	**2'105.7**	**26'821.1**	**2'930.3**	**4'030.4**	**459.7**	**81'246.2**	**9'772.7**	**7'052.7**	**990.4**
	1i	4.5	0.6	102.7	14.4	12.0	1.7	2.4	0.3	782.7	109.9	6'803.6	955.5	4'807.8	675.2	1'243.3	174.6	37'121.6	5'213.2	7'052.7	990.4
	1	193.6	21.9	1'001.7	113.1	139.9	15.8	21.0	2.4	1'040.5	117.5	9'560.5	1'079.7	17'172.8	1'939.5	2'164.8	244.5	34'991.4	3'951.9	0.0	0.0
	2i	0.0	0.0	40.7	3.3	16.0	1.3	2.0	0.2	14.4	1.2	33.0	2.7	243.5	19.6	38.7	3.1	1'201.7	96.9	0.0	0.0
	2m	54.5	3.5	4'174.0	268.8	600.1	38.6	89.0	5.7	221.0	14.2	1'053.8	67.9	4'597.0	296.1	574.6	37.0	7'931.5	510.8	0.0	0.0
	3	1.5	0.1	529.8	30.0	45.4	2.6	6.9	0.4	8.5	0.5	0.0	0.0	0.0	0.0	9.0	0.5	0.0	0.0	0.0	0.0
	4	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	total			**98.8**	**7.4**	**0.0**	**0.0**	**2'798.9**	**206.0**	**1'358.7**	**160.9**	**2'205.0**	**266.1**	**18'423.4**	**2'452.8**	**829.6**	**95.1**	**3'013.8**	**346.1**		
	1i			1.8	0.3	0.0	0.0	69.5	9.8	551.5	77.5	913.7	128.3	15'413.5	2'164.6	264.2	37.1	959.0	134.7		
	1			18.5	2.1	0.0	0.0	423.6	47.8	646.2	73.0	1'115.1	125.9	1'707.0	192.8	442.3	50.0	1'621.7	183.2		
	2i	no stations and		2.1	0.2	0.0	0.0	0.0	0.0	8.8	0.7	29.6	2.4	710.1	57.3	7.7	0.6	27.7	2.2	no stations and	
	2m	no echo-information		71.1	4.6	0.0	0.0	2'298.9	148.1	145.8	9.4	146.6	9.4	592.8	38.2	113.6	7.3	399.3	25.7	no echo-information	
	3			5.2	0.3	0.0	0.0	6.9	0.4	6.3	0.4	0.0	0.0	0.0	0.0	1.8	0.1	6.0	0.3		
	4			0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
35	total							**15'161.6**	**1'847.2**	**8'659.9**	**743.6**	**2'956.4**	**358.0**								
	1i							6'521.4	915.8	1'377.4	193.4	1'291.7	181.4								
	1							7'724.3	872.4	1'704.6	192.5	1'423.4	160.8								
	2i	no stations and		no stations and		no stations and		0.0	0.0	97.0	7.8	17.4	1.4	no stations and		no stations and		no stations and		no stations and	
	2m	no echo-information		no echo-information		no echo-information		915.9	59.0	5'074.4	326.8	220.5	14.2	no echo-information		no echo-information		no echo-information		no echo-information	
	3							0.0	0.0	406.3	23.0	3.3	0.2								
	4							0.0	0.0	0.1	0.0	0.0	0.0								
34	total							**19'821.4**	**1'317.9**	**5'767.6**	**507.1**										
	1i							0.1	0.0	1'060.8	149.0										
	1							1'497.5	169.1	1'153.1	130.2										
	2i	no stations and		no stations and		no stations and		0.0	0.0	61.0	4.9	no stations and		no stations and		no stations and		no stations and		no stations and	
	2m	no echo-information		no echo-information		no echo-information		14'296.6	920.7	3'234.9	208.3	no echo-information		no echo-information		no echo-information		no echo-information		no echo-information	
	3							4'027.1	228.0	257.8	14.6										
	4							0.0	0.0	0.0	0.0										
33	total					**8'215.7**	**713.0**	**19'297.8**	**2'378.0**	**1'146.8**	**99.5**										
	1i					1'446.6	203.1	13'987.2	1'964.3	201.9	28.4										
	1					1'553.2	175.4	1'420.8	160.5	216.8	24.5										
	2i	no stations and		no stations and		88.3	7.1	251.7	20.3	12.3	1.0	no stations and		no stations and		no stations and		no stations and		no stations and	
	2m	no echo-information		no echo-information		4'750.0	305.9	3'467.3	223.3	663.0	42.7	no echo-information		no echo-information		no echo-information		no echo-information		no echo-information	
	3					377.6	21.4	170.7	9.7	52.7	3.0										
	4					0.0	0.0	0.0	0.0	0.0	0.0										

Weight at age &maturity [g]	
1i	7.12
1	8.85
2i	12.40
2m	15.53
3	17.66
4	20.00

Totals [t]: **Weight**	**266'121**	Totals [mio]: **Numbers**	**29'616**
1i	104'608.5	1i	14'669.75
1m	94'186.1	1	10'622.52
2i	2'999.7	2i	241.49
2m	58'316.9	2m	3'742.28
3	6'009.1	3	339.43
4	0.9	4	0.04

biomass from validly sampled squa	218'360	82%
biomass from interpolated squares	47'254	18%

calculated with mean weight per age&maturity-class

= interpolated square

= no haul info and too remote for interpolation. Calculated "against the rules" with whole survey mean LFD-data to avoid unpleasant gaps.

Appendix III: Western Baltic Acoustic Survey

Survey Report for RV "SOLEA"
30.09.-18.10.2003

Federal Research Centre for Fisheries, Germany
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1 INTRODUCTION

The main objective is to assess clupeoid resources in the Baltic Sea. The joint German/Danish survey in September/October is traditionally co-ordinated within the frame of the **Baltic International Acoustic Survey.** The reported acoustic survey is conducted every year to supply the ICES:

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

with an index value for the stock size of herring and sprat, respectively, in the Western Baltic area (Sub-divisions 22, 23 and 24).

2 METHODS

2.1 Personnel

M. Drenkow	Institute for Fishery Technology and Fish Quality, Hamburg
Dr T. Gröhsler	Institute for Baltic Sea Fisheries, Rostock, in charge
M. Koth	Institute for Baltic Sea Fisheries, Rostock
S.-E. Levinsky	DIFRES, Charlottenlund, Denmark
R. Oeberst	Institute for Baltic Sea Fisheries, Rostock

2.2 Narrative

The 514th cruise of RV 'Solea' represents the 16th subsequent survey and took place from 30th September to 18th October in 2003. RV "SOLEA" left the port of Rostock/Warnemünde on 30th October 2003. The joint German-Danish acoustic survey was intended to cover the whole Sub-divisions 21, 22, 23 and 24. Due to bad weather conditions only the southern part of the Kattegat area (Sub-division 21) could be covered in 2003. The survey ended on 18th October 2003 in Rostock/Marienehe.

2.3 Survey design

For all Sub-divisions the statistical rectangles were used as strata (ICES 2003). The area is limited by the 10 m depth line. The survey area in the Western Baltic Sea is characterised by a number of islands and sounds. Parallel transects would lead in consequence to an unsuitable coverage of the survey area. Therefore a zig-zag track was used to cover all depth strata regularly. The survey area was 10,892 n. mi^2. The cruise track (Figure 1) totally reached a length of 864 nautical miles.

2.4 Calibration

The transducer 38–26 was calibrated during the survey time in Rostock/seaport. The calibration procedure was carried out as described in the 'Manual for the Baltic International Acoustic Surveys (BIAS)' (ICES 2003).

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 echosounder EK500 on 38 kHz. The transducer 38–26 was installed in a towed body, which had a lateral distance of about 30 m to reduce escape reactions of fish. 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 echo signals was done by the Bergen integrator BI500. The mean volume back scattering values (Sv) were integrated over 1 nm intervals from 8 m below the surface to the bottom.

Contributions from air bubbles, bottom structures and scattering layers were removed from the echogram by using the BI500.

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 9–10 m was achieved. The trawling time lasted usually 30 minutes, but in dense concentrations the duration was reduced. From each haul sub-samples were taken to determine length and weight of fish. Samples of herring and sprat were frosted for further investigations in the lab (i.e., sex, maturity, age). After each trawl haul it was intended to investigate the hydrographic condition by a CTD-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 distribution 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:

Clupeoids	TS = 20 log L (cm) - 71.2	(ICES 1983)
Gadoids	TS = 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 were separated into herring and sprat according to the mean catch composition.

3 RESULTS

3.1 Biological data

In total 50 trawl hauls were carried out (9 hauls in Sub-division 21, 21 hauls in Sub-division 22, 3 hauls in Sub-division 23 and 17 hauls in Sub-division 24). 2175 herring and 806 sprat were frozen for further investigations in the lab.

The results of the catch composition by Sub-division are presented in Table 1–4. The contribution of anchovy and sprat in 2003 was remarkable higher then in 2002. The catch in the northern part of sub-division 22 and in the southern part of Sub-division 21 contained for the first time shad. On sea lamprey was caught in the Hohwachter bight (Sub-division 22).

The length distributions of herring and sprat of the years 2002 and 2003 are presented by Sub-division in Figures 2 and 3.

For herring the major differences can be seen in Sub-divisions 22 and 23 (Figure 2). In this area the one year old herring (16–20 cm = year class 2002) is occurring to a lesser degree compared to 2002. The 2002 year class is only dominating in Sub-division 21, which could not be surveyed last year. Remarkable higher proportions of older herring (> 20 cm) are found this year in the Sound (Sub-division 23). In the last two years the new incoming year class is dominating in Sub-division 22 and 24. The amount of older herring (> 20 cm) decreased compared to last year. The actual new incoming year class 2003 (<= 15 cm) is characterised by two maxima. Further analysis may show whether this two peaks are referring to different growth pattern or whether they are caused by spring and autumn spawned herring.

The length distributions of sprat in 2002 and 2003 show a different picture in all Sub-divisions (Figure 4). Compared to last year the contribution of older sprat (>10 cm) decreased both in Sub-division 22 and 24. In contrast to 2002 and beside the results in Sub-division 21 the new incoming year class is now dominating in Sub-divisions 22–24. Remarkable numbers of large sprat are occurring in 2003 in Sub-division 21 and 23.

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 Sub-division/rectangle are shown in Table 4.

The horizontal distribution of S_a values (Figure 4 and Table 4) was quite different compared to the results in previous years. Remarkably high values were now found in the Belt Sea (Sub-division 22). Very high concentrations were observed particularly in the Kiel Bay and in the Lille Belt. In the entire Arkona Sea (Sub-division 24) the S_a values reached only about 50% of the mean of the period 1991–2002. In the area of the Kattegat (Sub-division 21) and the Sound (Sub-division 23) the highest fish concentrations were detected in the southern parts as in former years.

3.3 Abundance estimates

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

The herring stock was estimated to be 6.13 x 10^9 fish or about 182.4 x 10^3 tonnes in Sub-divisions 21–24. For the included area of Sub-divisions 22–24 the number of herring was calculated to be 5.35 x 10^9 fish or about 155.8 x 10^3 tonnes. As in former years the abundance estimates were dominated by young herring. Adult herring, which was concentrated in former years only in the Sound, could be found the last two years in deeper areas of the Arkona Sea.

The estimated sprat stock was 16.12 x 10^9 fish or 78.8 x 10^3 tonnes in Sub-divisions 21–24. For the included area of Sub-divisions 22–24 the number of sprat was calculated to be 16.07 x 10^9 fish or 78.0 x 10^3 tonnes. As for herring, the abundance estimates of sprat were dominated by young sprat (Figure 3 and Table 9). The year class strength 2003 was estimated on a record high level.

4 DISCUSSION

Last year the Kattegat area (Sub-division 21) could not be surveyed at all because of a lack of survey time caused by technical problems with the research vessel. Therefore this years results are only compared to last year’s results in Sub-divisions 22, 23 and 24.

The total number of herring in Sub-divisions 22–24 decreased slightly by 10 % compared to the results in 2002. This overall small decrease is characterised by a strong decrease in numbers in Sub-divisions 22 (- 53 %), which was mostly compensated by higher numbers in Sub-division 23 (+ 43 %) and in Sub-division 24 (+ 13 %). The slight increase in Sub-division 24 was based either by decreased numbers of age groups 2–4 (2002: 32 % and 2003: 10 %) or by increased numbers of age-groups 0–1 (2002: 66 % and 2003: 87 %), which are on a high level in 2003. The smaller numbers of age groups 2–4 could be explained by a changed migration pattern compared to last year. A lower proportion of adult herring may have been migrated at the survey time from the Sound into the Arkona Sea on the way to the spring spawning areas around Rügen Island.

In 2002 the entire level in numbers is dominated by a high fraction of 0-group herring (Figure 2 and Table 5: 67 % in 2002 and 69 % in 2003). In the last two years the total abundance of young herring was about 2 times higher compared to the estimates of the last two years before. The year class 2002 and 2003 attained about the level of the big 1999 year class.

The total biomass reached only 80 % of the estimate in 2002 of 195.3 x 10^3 t.

The abundance of sprat in the Western Baltic increased and was now in Sub-divisions 22–24 estimated about 142 % higher than that of the last year. The years 2002 and 2001 abundance estimates were already about 3 times higher than in 2000, which represented the lowest level of the time series since 1991. The increase in numbers was mainly caused by the high 0-group estimate in Sub-division 22, which is about 13 times higher than in 2002 (2002: 0.8 x 10^9 fish and 2003: 11.0 x 10^9 fish). The actual high contribution of the age-group 0 in Sub-divisions 22–24 was 87 % in numbers and 61 % in biomass (2002: 60 % in numbers and 33 % in biomass).

4 REFERENCES

ICES 1983. Report of the Planning Group on ICES co-ordinated 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.

Table 1: Catch composition (kg/0.5 h) per haul No. in Sub-division 21

Haul No.	42	43	44	45	46	47	48	49	50	Total
Species/ICES Rectangle	41G2	41G1	41G1	41G1	41G2	42G1	42G1	42G2	41G2	
AGONUS CATAPHRACTUS		0,01								**0,01**
ALOSA FALLAX	0,20	0,01	1,18		0,78	10,82	0,17		0,32	**13,48**
APHIA MINUTA	+		+		+		+	0,01		**0,01**
CLUPEA HARENGUS	0,47	106,74	1,35	1236,71	2,78	2,40	0,06	337,71	9,13	**1697,35**
CYCLOPTERUS LUMPUS		0,94								**0,94**
ELEDONE			0,01							**0,01**
ENGRAULIS ENCRASICOLUS	0,22	0,57	39,32	19,83	19,88	138,26	4,14	0,49	12,34	**235,05**
GADUS MORHUA		0,69			+			4,20	0,01	**4,90**
LIMANDA LIMANDA		5,13			0,05	0,11		6,07	0,04	**11,40**
LOLIGO FORBESI			0,07		0,13	0,40	0,03	0,02		**0,65**
MERLANGIUS MERLANGUS		0,95	0,04		7,57	1,38	0,13	7,92	0,54	**18,53**
MULLUS SURMULETUS		0,01	0,11		0,22				0,07	**0,41**
MYOXOCEPHALUS SCORPIUS		0,15								**0,15**
NEPHROPS NORVEGICUS									0,10	**0,10**
PLEURONECTES PLATESSA								0,34		**0,34**
POMATOSCHISTUS MINUTUS					+	+				**+**
SCOMBER SCOMBRUS				2,09	0,11	0,57				**2,77**
SPRATTUS SPRATTUS		0,02	0,07	89,00	0,07	0,13	0,07	1,86	0,01	**91,23**
TRACHINUS DRACO		0,35	0,10		0,86	0,50	0,04	0,20	0,05	**2,10**
TRACHURUS TRACHURUS	0,01	0,16	0,65		0,10	1,71	+	0,02	0,02	**2,67**
TRIGLA LUCERNA								0,03		**0,03**
TRISOPTERUS MINUTUS								0,08	0,00	**0,08**
Total	**0,90**	**115,73**	**42,90**	**1347,63**	**32,55**	**156,28**	**4,64**	**358,95**	**22,63**	**2082,21**
Medusae	0,94	0,54	3,16		1,14		1,25	0,57	0,43	8,01

+' = < 0.01 Kg

Table 2: Catch composition (kg/0.5 h) per haul No. in Sub-division 22

Haul No.	18	19	20	21	22	23	24	25	26	27	28	29
Species/ICES Rectangle	37G1	37G1	37G1	37G1	38G1	38G0	37G0	38G0	38G0	38G0	39G0	39F9
ALOSA FALLAX												
APHIA MINUTA							+		0,01	+		
CLUPEA HARENGUS	4,92	4,79	13,12	21,03	1,35	2,54	5,47	2,52	5,02	6,21	0,79	6,39
CRANGON CRANGON												
CTENOLABRUS RUPESTRIS												
ENGRAULIS ENCRASICOLUS	0,39	8,16	0,47	0,77	0,51	8,12	4,75	12,57	1,12	52,36	36,88	0,68
GADUS MORHUA	0,01		11,88	0,03				0,94	0,47	0,01		
GASTEROSTEUS ACULEATUS	+	7,25	+			+	+	0,03	+	0,16	0,10	4,67
GOBIUS NIGER						0,01						0,01
LEANDER SQUILLA												
LIMANDA LIMANDA	0,09				0,12	1,54					0,21	
LOLIGO FORBESI						0,01						
MERLANGIUS MERLANGUS	0,81	0,40	0,15	0,58	0,94		0,21	2,12	0,31	0,01	0,01	0,08
MULLUS SURMULETUS		0,07				0,05	0,04		0,14			
PETROMYZON MARINUS							0,42					
POMATOSCHISTUS MINUTUS	+					+			+	+		
SCOMBER SCOMBRUS		2,90		0,36								
SPRATTUS SPRATTUS	3,59	47,62	0,09	92,65	75,76	12,30	7,28	1,70	56,92	2,55	12,02	101,59
SYNGNATHUS ROSTELLATUS												
TRACHINUS DRACO												
TRACHURUS TRACHURUS	1,40	17,05	2,89	0,47	0,12	1,00	10,83	288,54	1,00	0,62		0,30
TRISOPTERUS MINUTUS						+						
Total	**11,21**	**88,24**	**28,60**	**115,89**	**78,80**	**25,57**	**29,00**	**308,42**	**64,99**	**61,92**	**50,01**	**113,72**
Medusae	21,9	299,3	118,5	32,6	3,1	55,3	114,8	20,5	63,2	70,5	48,3	21,5

Haul No.	30	31	32	33	34	35	36	37	38	Total
Species/ICES Rectangle	39F9	40G0	40G0	41G0	40G0	39G0	39G0	39G1	38G1	
ALOSA FALLAX		0,05	0,03	0,13	0,49					**0,70**
APHIA MINUTA	0,02	0,01	0,03			+	+	0,03	+	**0,10**
CLUPEA HARENGUS	1,14	0,64	0,20	1,04	2,68	1,80	4,49	0,49	1,10	**87,73**
CRANGON CRANGON					+					**+**
CTENOLABRUS RUPESTRIS							+			**+**
ENGRAULIS ENCRASICOLUS	0,29	3,43	3,01	84,94	34,48	6,05	2,33	0,23	0,09	**261,63**
GADUS MORHUA	0,01	0,02	0,03				0,05	0,10	0,04	**13,59**
GASTEROSTEUS ACULEATUS	0,09	0,01						0,08	+	**12,39**
GOBIUS NIGER										**0,02**
LEANDER SQUILLA								+		**+**
LIMANDA LIMANDA			+		0,01	0,04			0,02	**2,03**
LOLIGO FORBESI		0,01	0,59			0,01	0,01	0,02	+	**0,65**
MERLANGIUS MERLANGUS	0,45	0,08	0,05	0,11	0,01	0,16	0,17	0,03	0,05	**6,73**
MULLUS SURMULETUS		0,01	0,02	0,00	0,01		0,03	0,02	0,03	**0,42**
PETROMYZON MARINUS										**0,42**
POMATOSCHISTUS MINUTUS			0,01			+	+	+	0,01	**0,02**
SCOMBER SCOMBRUS		0,03								**3,29**
SPRATTUS SPRATTUS	102,32	22,62	28,42	0,04	0,19	32,60	46,32	6,04	0,56	**653,18**
SYNGNATHUS ROSTELLATUS		+						+		**+**
TRACHINUS DRACO					0,24					**0,24**
TRACHURUS TRACHURUS	0,10	0,02	0,04	0,05	0,16	0,22	0,04	0,02	0,02	**324,89**
TRISOPTERUS MINUTUS			0,01							**0,01**
Total	**104,42**	**26,93**	**32,44**	**86,31**	**38,27**	**40,88**	**53,44**	**7,06**	**1,92**	**1368,04**
Medusae	19,8	2,6	2,2	3,8	2,4	3,9	1,3	2,1	20,2	927,8

+' = < 0.01 Kg

Table 3: Catch composition (kg/0.5 h) per haul No. in Sub-division 23

Haul No.	39	40	41	Total
Species/ICES Rectangle	**40G2**	**40G2**	**41G2**	
APHIA MINUTA			+	+
CLUPEA HARENGUS	1703,55	402,24	5,07	**2110,86**
ENGRAULIS ENCRASICOLUS	0,47	0,78	5,64	**6,89**
GADUS MORHUA	61,16	33,26	+	**94,42**
LIMANDA LIMANDA			0,02	**0,02**
MERLANGIUS MERLANGUS	3,09	12,11	0,16	**15,36**
SCOMBER SCOMBRUS			0,05	**0,05**
SPRATTUS SPRATTUS	29,30	42,00	0,03	**71,33**
TRACHINUS DRACO			0,01	**0,01**
TRACHURUS TRACHURUS			0,04	**0,04**
Total	**1797,57**	**490,39**	**11,02**	**2298,98**
Medusae		5,32	0,7	6,0

+' = < 0.01 Kg

Table 4: Catch composition (kg/0.5 h) per haul No. in Sub-division 24

Haul No.	1	2	3	4	5	6	7	8	9	10	11	12
Species/ICES Rectangle	**37G2**	**38G2**	**38G2**	**38G2**	**38G3**	**38G3**	**38G4**	**38G4**	**38G4**	**38G3**	**39G3**	**39G3**
AMMODYTES MARINUS	0,05											
ANGUILLA ANGUILLA								0,11				
CLUPEA HARENGUS	7,13	34,08	23,85	5,80	28,09	3,60	3,12	18,67	11,23	35,96	22,70	97,67
CRANGON CRANGON			+		0,02							
CYCLOPTERUS LUMPUS												0,26
ENGRAULIS ENCRASICOLUS	2,60	1,35	0,23	0,04	1,30	0,06	0,10	0,01	0,03	0,05		0,01
GADUS MORHUA	3,66			0,22	0,78	0,49	1,65	42,26		0,85	2,44	2,32
GASTEROSTEUS ACULEATUS		0,01			+	0,01	0,19		0,01	0,01		
GOBIUS NIGER	+	0,01										
HYPEROPLUS LANCEOLATUS					0,08							
LIMANDA LIMANDA	3,10	0,12			0,97							
MERLANGIUS MERLANGUS	0,75	1,14		0,37	4,81	1,46		0,75	0,55	0,26		3,42
MYOXOCEPHALUS SCORPIUS							+	+				
PLATICHTHYS FLESUS						0,43						
PLEURONECTES PLATESSA										0,19		
POMATOSCHISTUS MINUTUS	0,02	0,07	0,09		0,04	0,06	+	0,12	+			
POMATOSCHISTUS PICTUS		+										
SCOMBER SCOMBRUS	0,01											
SPRATTUS SPRATTUS	3,78	4,82	25,28	0,25	70,03	24,43	0,05	19,06	0,86	7,11	1,27	48,51
SYNGNATHUS ROSTELLATUS												+
TRACHURUS TRACHURUS	0,15	2,21		0,10							0,09	
Total	**21,25**	**43,81**	**49,45**	**6,78**	**106,12**	**30,54**	**5,11**	**80,98**	**12,68**	**44,43**	**26,50**	**152,19**
Medusae	21,0	19,7	16,0	233,1	41,8	87,5	25,1	6,8	82,4	22,8	71,5	3,7

Haul No.	13	14	15	16	17	Total
Species/ICES Rectangle	**39G4**	**39G4**	**39G3**	**39G3**	**39G2**	
AMMODYTES MARINUS						**0,05**
ANGUILLA ANGUILLA					0,03	**0,14**
CLUPEA HARENGUS	34,92	20,70	115,18	157,92	20,78	**641,40**
CRANGON CRANGON						**0,02**
CYCLOPTERUS LUMPUS						**0,26**
ENGRAULIS ENCRASICOLUS	0,05				0,02	**5,85**
GADUS MORHUA		0,77	9,02	11,30	1,53	**77,29**
GASTEROSTEUS ACULEATUS						**0,23**
GOBIUS NIGER						**0,01**
HYPEROPLUS LANCEOLATUS						**0,08**
LIMANDA LIMANDA						**4,19**
MERLANGIUS MERLANGUS		0,96	2,89	1,57	0,03	**18,96**
MYOXOCEPHALUS SCORPIUS						+
PLATICHTHYS FLESUS						**0,43**
PLEURONECTES PLATESSA				0,54		**0,73**
POMATOSCHISTUS MINUTUS		+		0,01	0,09	**0,50**
POMATOSCHISTUS PICTUS						+
SCOMBER SCOMBRUS						**0,01**
SPRATTUS SPRATTUS	70,19	11,54	85,09	2,40	0,52	**375,19**
SYNGNATHUS ROSTELLATUS						+
TRACHURUS TRACHURUS					+	**2,55**
Total	**105,16**	**33,97**	**212,18**	**173,74**	**23,00**	**1127,89**
Medusae	72,8	2,5	26,3	4,9	5,2	743,0

+' = < 0.01 Kg

Table 5 Survey statistics RV "Solea" September/October 2003

Sub-division	ICES Rectangle	Area (nm²)	Sa (m²/NM²)	Sigma (cm²)	N total (million)	Herring (%)	Sprat (%)	NHerring (million)	NSprat (million)
21	**41G1**	946,8	220,8	2,068	1010,88	59,37	4,02	600,16	40,65
21	**41G2**	432,3	39,9	1,154	149,49	19,98	0,10	29,86	0,14
21	**42G1**	884,2	62,5	1,678	329,25	0,65	0,51	2,13	1,69
21	**42G2**	606,8	86,1	3,555	146,96	97,34	1,99	143,05	2,93
	Total	**2870,1**			**1636,58**			**775,20**	**45,41**
22	**37G0**	209,9	570,2	0,901	1327,84	9,58	53,38	127,25	708,84
22	**37G1**	723,3	211,1	1,223	1248,37	29,77	44,91	371,67	560,65
22	**38G0**	735,3	466,8	0,988	3474,05	4,26	44,81	148,07	1556,56
22	**38G1**	173,2	724,6	0,828	1515,09	20,83	75,28	315,66	1140,51
22	**39F9**	159,3	1726,3	0,526	5224,51	1,58	94,28	82,50	4925,78
22	**39G0**	201,7	283,0	0,758	753,52	2,16	79,39	16,28	598,24
22	**39G1**	250,0	91,7	0,663	345,88	2,56	88,88	8,84	307,43
22	**40G0**	538,1	349,5	0,853	2205,03	2,07	62,62	45,67	1380,73
22	**41G0**	173,1	169,4	1,134	258,64	0,60	0,07	1,56	0,18
	Total	**3163,9**			**16352,93**			**1117,50**	**11178,92**
23	**40G2**	164,0	1938,7	4,357	729,80	78,54	19,89	573,16	145,14
23	**41G2**	72,3	517,4	1,001	373,54	23,19	0,38	86,62	1,41
	Total	**236,3**			**1103,34**			**659,78**	**146,55**
24	**37G2**	192,4	103,5	1,032	193,02	39,24	34,39	75,75	66,38
24	**38G2**	832,9	189,2	1,282	1229,69	61,72	33,31	758,93	409,66
24	**38G3**	865,7	517,9	1,126	3982,89	28,89	70,23	1150,72	2797,06
24	**38G4**	1034,8	134,0	1,434	966,64	43,54	32,70	420,84	316,08
24	**39G2**	406,1	138,9	2,103	268,19	82,16	17,25	220,34	46,27
24	**39G3**	765,0	256,1	1,944	1007,84	64,37	35,42	648,78	356,95
24	**39G4**	524,8	323,5	1,607	1056,50	28,47	71,50	300,75	755,41
	Total	**4621,7**			**8704,77**			**3576,11**	**4747,81**
22-24	**Total**	**8021,9**			**26161,04**			**5353,39**	**16073,28**
21-24	**Total**	**10892,0**			**27797,62**			**6128,59**	**16118,69**

Table 6 Estimated numbers (millions) of herring RV "Solea" Sept./Oct. 2003

Sub-division	Rectangle/ W-rings	0	1	2	3	4	5	6	7	8+	Total
21	41G1	233,95	349,55	16,34	0,33						600,17
21	41G2	21,64	7,80	0,38	0,01	0,03					29,86
21	42G1	0,79	1,23	0,10							2,12
21	42G2	0,06	125,55	17,14	0,29						143,04
	Total	256,44	484,13	33,96	0,63	0,03	0,00	0,00	0,00	0,00	775,19
22	37G0	111,02	15,92	0,11	0,16		0,05				127,26
22	37G1	280,47	78,06	6,42	5,04	1,37	0,32				371,68
22	38G0	142,02	5,76	0,29							148,07
22	38G1	305,04	10,62								315,66
22	39F9	82,10	0,40								82,50
22	39G0	16,09	0,20								16,29
22	39G1	8,81	0,03								8,84
22	40G0	45,44	0,23								45,67
22	41G0	1,44	0,10		0,02						1,56
	Total	992,43	111,32	6,82	5,22	1,37	0,37	0,00	0,00	0,00	1117,53
23	40G2	114,90	55,95	62,35	117,85	152,98	49,32	14,68	3,89	1,25	573,17
23	41G2	81,28	5,34								86,62
	Total	196,18	61,29	62,35	117,85	152,98	49,32	14,68	3,89	1,25	659,79
24	37G2	64,46	11,14	0,10	0,04						75,74
24	38G2	584,16	163,67	6,57	2,85	1,08	0,30	0,30			758,93
24	38G3	940,59	86,85	29,86	24,39	39,66	18,09	7,46	1,84	1,96	1150,70
24	38G4	280,05	32,8	27,65	22,88	28,25	14,97	7,76	1,85	4,64	420,83
24	39G2	128,51	56,06	10,94	8,79	9,30	4,34	1,50	0,18	0,71	220,33
24	39G3	357,35	163,95	38,84	34,07	31,83	12,21	7,09	1,17	2,26	648,77
24	39G4	157,51	93,65	17,27	13,67	11,82	3,71	2,37	0,45	0,30	300,75
	Total	2512,63	608,10	131,23	106,69	121,94	53,62	26,48	5,49	9,87	3576,05
22-24	Total	3701,24	780,71	200,40	229,76	276,29	103,31	41,16	9,38	11,12	5353,37
21-24	Total	3957,68	1264,84	234,36	230,39	276,32	103,31	41,16	9,38	11,12	6128,56

Table 7 Herring mean weight (g) per age group RV "Solea" Sept./Oct. 2003

Sub-division	Rectangle/ W-rings	0	1	2	3	4	5	6	7	8+	Total
21	41G1	14,15	41,89	58,87	66,27						31,55
21	41G2	11,21	39,52	62,16	66,27	161,00					19,43
21	42G1	16,91	44,41	50,77							34,46
21	42G2	26,29	47,23	62,38	66,27						49,07
	Total	13,91	43,24	60,65	66,27	161,00					34,32
22	37G0	10,56	33,45	76,83	76,83		76,83				13,59
22	37G1	9,07	34,56	61,78	71,38	88,24	76,83				16,53
22	38G0	10,08	32,35	46,50							11,01
22	38G1	9,63	30,33								10,32
22	39F9	5,94	30,42								6,06
22	39G0	10,26	28,76								10,48
22	39G1	10,89	17,00								10,91
22	40G0	9,42	23,85								9,49
22	41G0	13,22	28,13		109,00						15,58
	Total	9,35	33,83	61,37	71,69	88,24	76,83				12,52
23	40G2	10,83	37,85	100,50	112,82	147,25	163,04	181,66	192,28	176,64	99,67
23	41G2	10,45	30,66								11,70
	Total	10,67	37,22	100,50	112,82	147,25	163,04	181,66	192,28	176,64	88,12
24	37G2	7,45	26,63	43,62	38,40						10,34
24	38G2	7,88	28,24	52,45	60,57	95,73	90,98	97,78			13,05
24	38G3	6,56	31,86	62,48	93,04	124,92	145,46	145,56	138,59	162,50	19,39
24	38G4	7,64	28,79	65,92	88,67	112,24	155,99	151,44	135,57	175,58	34,89
24	39G2	11,99	30,84	62,35	92,71	106,31	123,97	116,35	146,50	137,04	29,92
24	39G3	9,76	32,07	62,84	90,79	102,51	127,70	114,75	118,58	157,21	31,46
24	39G4	10,91	32,58	62,27	88,17	95,81	118,73	112,52	92,00	116,89	29,81
	Total	8,02	30,70	62,76	89,85	111,63	140,46	133,88	129,75	164,22	23,39
22-24	Total	8,51	31,66	74,45	101,22	131,24	151,01	150,92	155,68	165,62	29,10
21-24	Total	8,86	36,09	72,45	101,12	131,24	151,01	150,92	155,68	165,62	29,76

Table 8 Herring total biomass (t) per age group RV "Solea" Sept./Oct. 2003

Sub-division	Rectangle/ W-rings	0	1	2	3	4	5	6	7	8+	Total
21	41G1	3310,4	14642,6	961,9	21,9						18936,8
21	41G2	242,6	308,3	23,6	0,7	4,8					580,0
21	42G1	13,4	54,6	5,1							73,1
21	42G2	1,6	5929,7	1069,2	19,2						7019,7
	Total	3568,0	20935,2	2059,8	41,8	4,8	0,0	0,0	0,0	0,0	26609,6
22	37G0	1172,4	532,5	8,5	12,3		3,8				1729,5
22	37G1	2543,9	2697,8	396,6	359,8	120,9	24,6				6143,6
22	38G0	1431,6	186,3	13,5							1631,4
22	38G1	2937,5	322,1								3259,6
22	39F9	487,7	12,2								499,9
22	39G0	165,1	5,8								170,9
22	39G1	95,9	0,5								96,4
22	40G0	428,0	5,5								433,5
22	41G0	19,0	2,8		2,2						24,0
	Total	9281,1	3765,5	418,6	374,3	120,9	28,4	0,0	0,0	0,0	13988,8
23	40G2	1244,4	2117,7	6266,2	13295,8	22526,3	8041,1	2666,8	748,0	220,8	57127,1
23	41G2	849,4	163,7								1013,1
	Total	2093,8	2281,4	6266,2	13295,8	22526,3	8041,1	2666,8	748,0	220,8	58140,2
24	37G2	480,2	296,7	4,4	1,5						782,8
24	38G2	4603,2	4622,0	344,6	172,6	103,4	27,3	29,3			9902,4
24	38G3	6170,3	2767,0	1865,7	2269,2	4954,3	2631,4	1085,9	255,0	318,5	22317,3
24	38G4	2139,6	943,7	1822,7	2028,8	3170,8	2335,2	1175,2	250,8	814,7	14681,5
24	39G2	1540,8	1728,9	682,1	814,9	988,7	538,0	174,5	26,4	97,3	6591,6
24	39G3	3487,7	5257,9	2440,7	3093,2	3262,9	1559,2	813,6	138,7	355,3	20409,2
24	39G4	1718,4	3051,1	1075,4	1205,3	1132,5	440,5	266,7	41,4	35,1	8966,4
	Total	20140,2	18667,3	8235,6	9585,5	13612,6	7531,6	3545,2	712,3	1620,9	83651,2
22-24	Total	31515,1	24714,2	14920,4	23255,6	36259,8	15601,1	6212,0	1460,3	1841,7	155780,2
21-24	Total	35083,1	45649,4	16980,2	23297,4	36264,6	15601,1	6212,0	1460,3	1841,7	182389,8

Table 9 Estimated numbers (millions) of sprat RV "Solea" Sept./Oct. 2003

Sub-division	Rectangle/ Age group	0	1	2	3	4	5	6	7	8+	Total
21	41G1	6,84	3,58	17,07	11,72	0,76	0,67				40,64
21	41G2	0,13			0,01						0,14
21	42G1		0,19	0,72	0,58	0,18	0,03				1,70
21	42G2	1,28	0,56	0,51	0,54	0,03	0,01				2,93
	Total	8,25	4,33	18,30	12,85	0,97	0,71	0,00	0,00	0,00	45,41
22	37G0	708,84									708,84
22	37G1	403,93	6,00	3,89	67,67	41,25	19,67	18,23			560,64
22	38G0	1523,59	0,94	2,89	20,85	5,01	1,88	1,41			1556,57
22	38G1	1140,51									1140,51
22	39F9	4925,78									4925,78
22	39G0	596,85	0,45	0,35	0,40	0,10		0,10			598,25
22	39G1	307,43									307,43
22	40G0	1370,03	1,53	0,00	1,53	7,65					1380,74
22	41G0	0,18									0,18
	Total	10977,14	8,92	7,13	90,45	54,01	21,55	19,74	0,00	0,00	11178,94
23	40G2	45,12	7,08	27,34	33,97	22,39	7,28	0,50	1,46		145,14
23	41G2	1,21	0,05	0,15							1,41
	Total	46,33	7,13	27,49	33,97	22,39	7,28	0,50	1,46	0,00	146,55
24	37G2	50,78	3,95	5,20	3,34	1,77	0,33	0,53	0,47		66,37
24	38G2	280,57	26,66	48,48	31,66	16,50	2,04	1,28	2,40	0,06	409,65
24	38G3	1919,95	390,09	281,73	154,20	42,49	1,90	1,62	5,10		2797,08
24	38G4	227,87	37,82	28,01	13,96	6,69	0,34	0,65	0,75		316,09
24	39G2	45,62	0,65								46,27
24	39G3	214,24	39,09	53,71	30,97	14,50	1,25	0,96	2,15	0,08	356,95
24	39G4	270,18	146,06	177,93	97,01	47,61	4,16	4,14	7,07	1,25	755,41
	Total	3009,21	644,32	595,06	331,14	129,56	10,02	9,18	17,94	1,39	4747,82
22-24	Total	14032,68	660,37	629,68	455,56	205,96	38,85	29,42	19,40	1,39	16073,31
21-24	Total	14040,93	664,70	647,98	468,41	206,93	39,56	29,42	19,40	1,39	16118,72

Table 10 Sprat mean weight (g) per age group RV "Solea" Sept./Oct. 2003

Sub-division	Rectangle/ Age group	0	1	2	3	4	5	6	7	8+	Total
21	41G1	5,51	18,37	20,62	20,38	23,43	22,00				17,89
21	41G2	7,86			25,80	25,80					9,14
21	42G1		17,74	21,00	21,35	27,44	21,53				21,43
21	42G2	7,04	15,80	19,95	19,25	23,15	22,58				13,43
	Total	5,78	18,01	20,62	20,38	24,17	21,99				17,71
22	37G0	3,43									3,43
22	37G1	3,97	18,26	16,20	19,30	21,13	22,94	23,43			8,62
22	38G0	3,61	18,26	15,22	16,76	18,59	23,15	21,70			3,91
22	38G1	3,99									3,99
22	39F9	2,65									2,65
22	39G0	3,65	14,29	13,00	18,79	18,79		18,79			3,68
22	39G1	3,83									3,83
22	40G0	3,82	17,74		17,74	17,74					3,93
22	41G0	4,78									4,78
	Total	3,25	17,97	15,65	18,69	20,41	22,96	23,28			3,56
23	40G2	4,57	17,22	20,22	23,05	24,70	25,31	29,11	27,99		16,93
23	41G2	3,23	15,50	15,50							4,99
	Total	4,54	17,21	20,19	23,05	24,70	25,31	29,11	27,99		16,82
24	37G2	3,11	12,20	15,33	16,47	17,51	19,77	20,90	19,52		6,01
24	38G2	3,52	13,87	15,60	15,87	15,90	19,81	19,54	17,78	21,20	7,30
24	38G3	4,03	11,50	13,50	13,71	15,49	19,02	18,80	16,72		6,78
24	38G4	4,31	10,4	14,61	14,84	16,67	19,56	20,88	18,51		6,76
24	39G2	3,59	6,00								3,62
24	39G3	3,78	12,90	15,18	15,34	16,30	19,32	19,03	17,21	21,20	8,18
24	39G4	4,23	12,52	14,91	15,22	16,83	19,23	19,54	17,61	21,20	10,87
	Total	3,98	11,85	14,31	14,59	16,21	19,35	19,53	17,42	21,20	7,54
22-24	Total	3,41	11,99	14,58	16,03	18,24	22,47	22,22	18,22	21,22	4,85
21-24	Total	3,42	12,03	14,75	16,15	18,26	22,45	22,22	18,22	21,22	4,89

Table 11 Sprat total biomass (t) per age group RV "Solea" Sept./Oct. 2003

Sub-division	Rectangle/ Age group	0	1	2	3	4	5	6	7	8+	Total
21	41G1	37,7	65,8	352,0	238,9	17,8	14,7				726,9
21	41G2	1,0			0,3						1,3
21	42G1	0,0	3,4	15,1	12,4	4,9	0,6				36,4
21	42G2	9,0	8,8	10,2	10,4	0,7	0,2				39,3
	Total	47,7	78,0	377,3	262,0	23,4	15,5	0,0	0,0	0,0	803,9
22	37G0	2431,3									2431,3
22	37G1	1603,6	109,6	63,0	1306,0	871,6	451,2	427,1			4832,1
22	38G0	5500,2	17,2	44,0	349,4	93,1	43,5	30,6			6078,0
22	38G1	4550,6									4550,6
22	39F9	13053,3									13053,3
22	39G0	2178,5	6,4	4,5	7,5	1,9		1,9			2200,7
22	39G1	1177,5									1177,5
22	40G0	5233,5	27,1		27,1	135,7					5423,4
22	41G0	0,9									0,9
	Total	35729,4	160,3	111,5	1690,0	1102,3	494,7	459,6	0,0	0,0	39747,8
23	40G2	206,2	121,9	552,8	783,0	553,0	184,3	14,6	40,9		2456,7
23	41G2	3,9	0,8	2,3							7,0
	Total	210,1	122,7	555,1	783,0	553,0	184,3	14,6	40,9	0,0	2463,7
24	37G2	157,9	48,2	79,7	55,0	31,0	6,5	11,1	9,2		398,6
24	38G2	987,6	369,8	756,3	502,4	262,4	40,4	25,0	42,7	1,3	2987,9
24	38G3	7737,4	4486,0	3803,4	2114,1	658,2	36,1	30,5	85,3		18951,0
24	38G4	982,1	391,4	409,2	207,2	111,5	6,7	13,6	13,9		2135,6
24	39G2	163,8	3,9								167,7
24	39G3	809,8	504,3	815,3	475,1	236,4	24,1	18,3	37,0	1,7	2922,0
24	39G4	1142,9	1828,7	2652,9	1476,5	801,3	80,0	80,9	124,5	26,5	8214,2
	Total	11981,5	7632,3	8516,8	4830,3	2100,8	193,8	179,4	312,6	29,5	35777,0
22-24	Total	47921,0	7915,3	9183,4	7303,3	3756,1	872,8	653,6	353,5	29,5	77988,5
21-24	Total	47968,7	7993,3	9560,7	7565,3	3779,5	888,3	653,6	353,5	29,5	78792,4

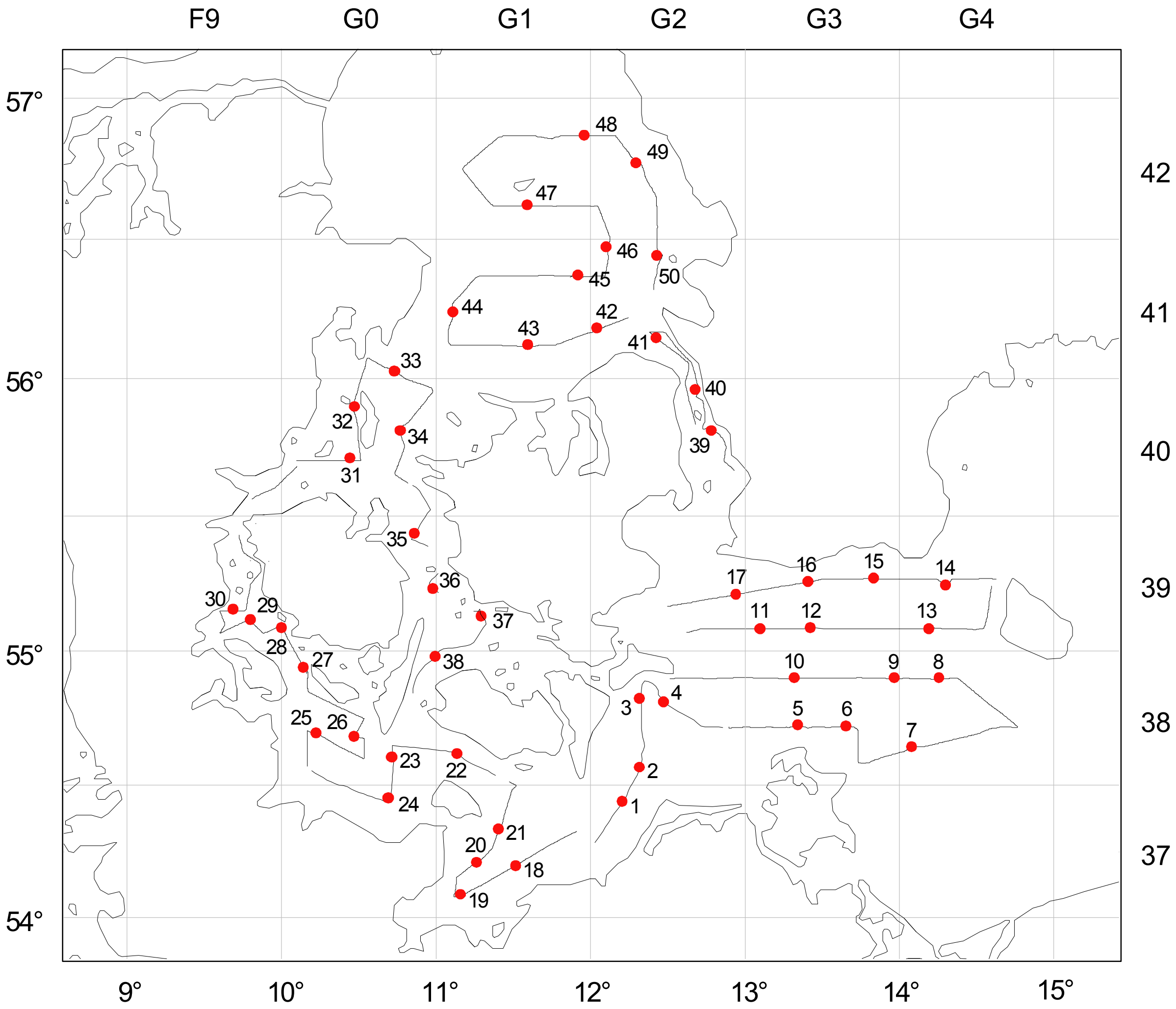

Figure 1. Cruise track and trawl positions for RV „SOLEA" in Sept./Oct. 2003.

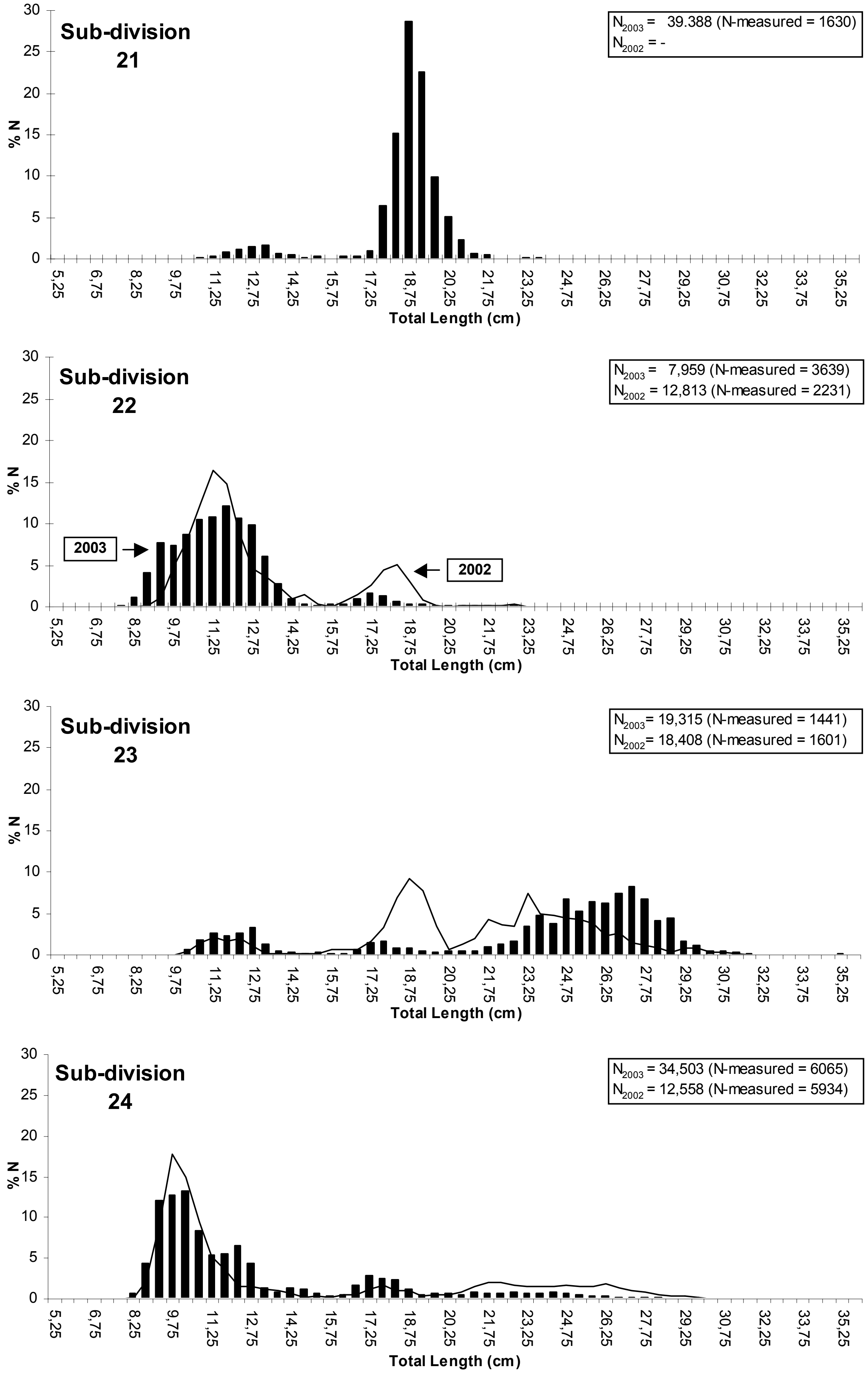

Figure 2 **Length distribution of herring in Sub-divisions 21, 22, 23 and 24 in 2002 (=line) and in 2003 (=bar)**

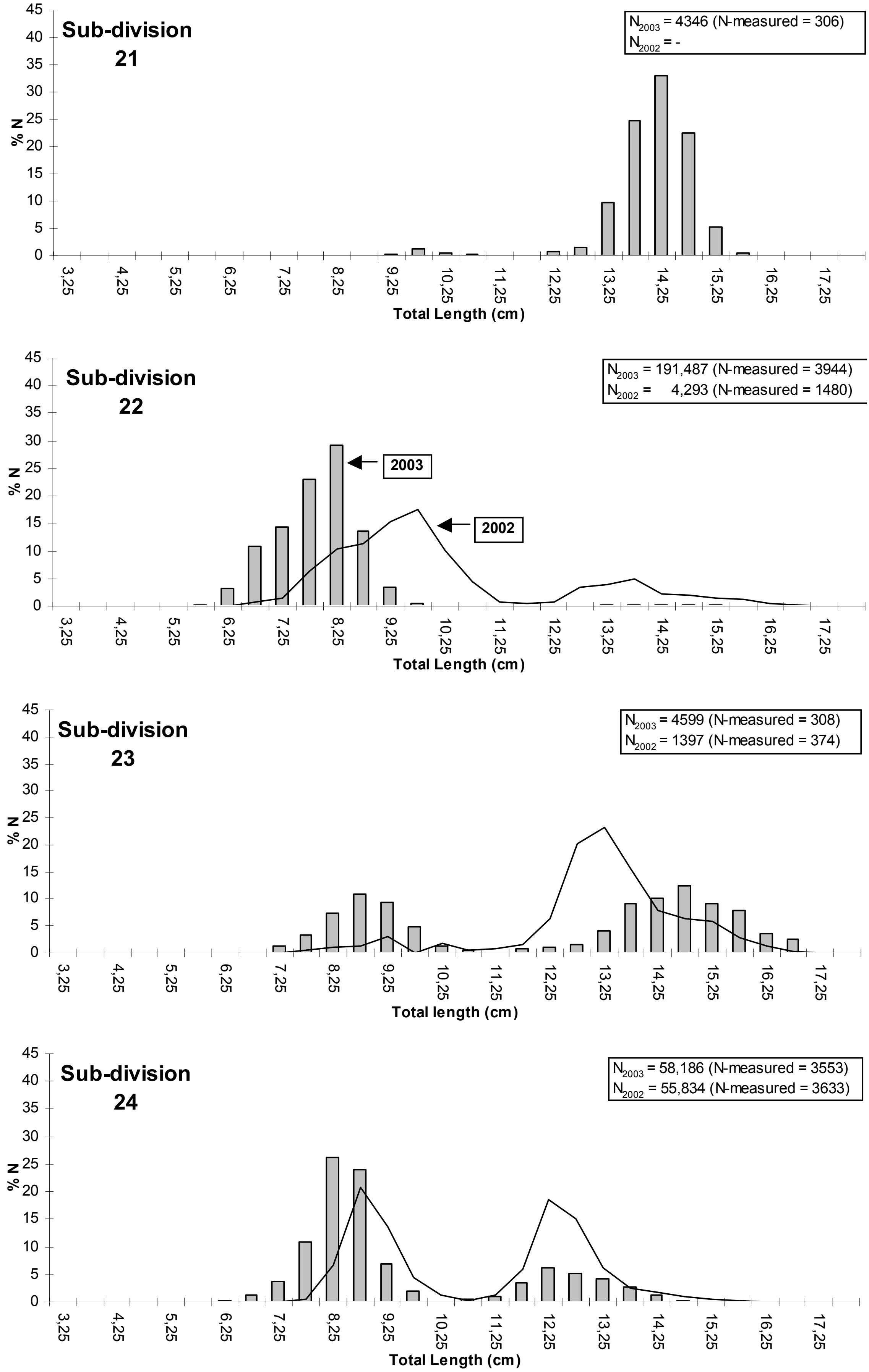

Figure 3 **Length distribution of sprat in Sub-divisions 21, 22, 23 and 24 in 2002 (=line) and in 2003 (=bar)**

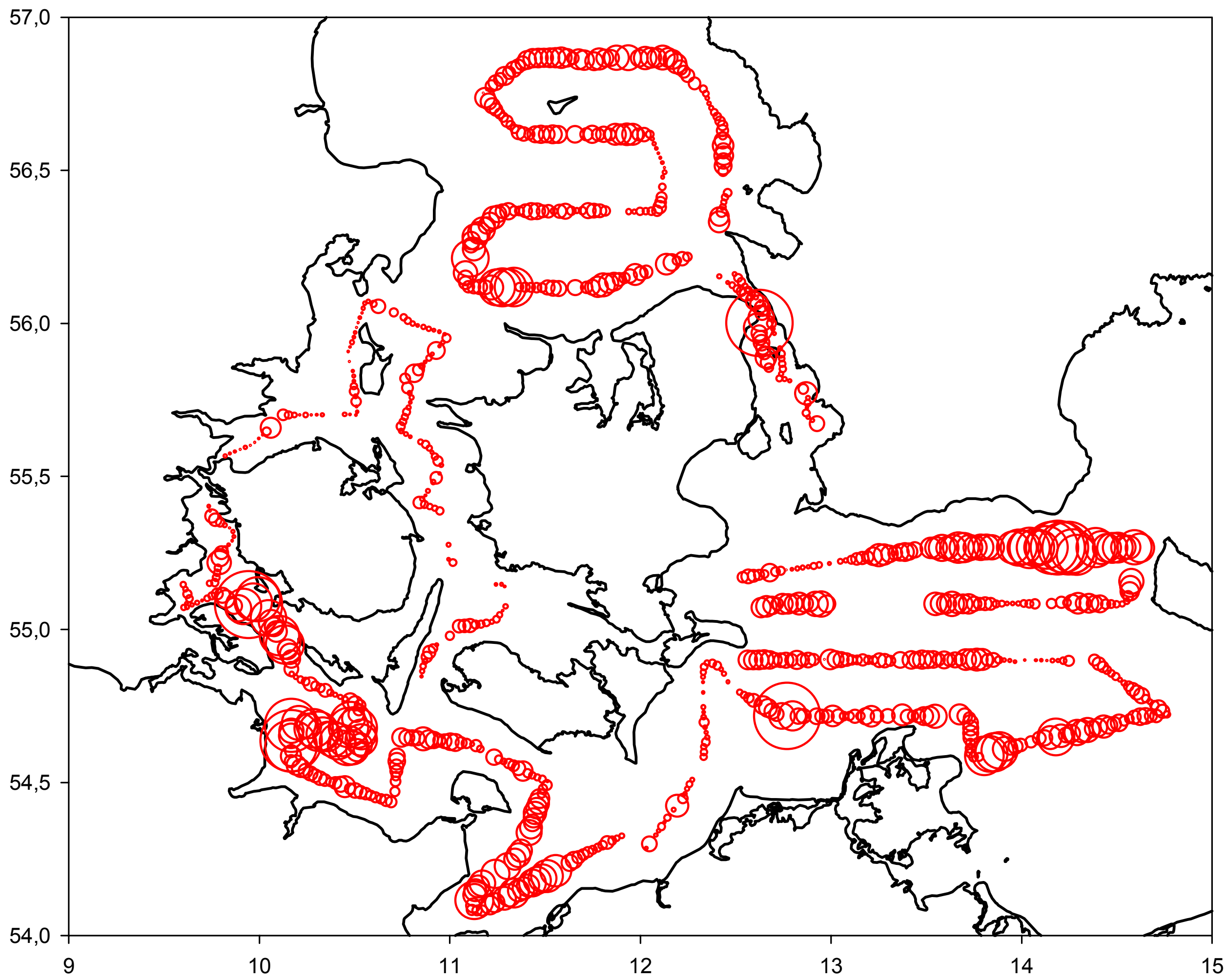

Figure 4. Distribution of S_a-values for RV "SOLEA" in Sept/Oct. 2003.

Appendix IV: Manual for Herring Acoustic Surveys in ICES Divisions III, IV and VIa

Version 3.2
January 2004

1 Transducer and calibration

The standard frequency used for the survey is 38 kHz. In order of preference, it is advisable to mount the transducer in a dropped keel, a towed body or on the hull of the vessel. Steps should be taken to ensure that the flight of the towed body is stable and level, this should ideally be achieved with the aid of a motion sensor.

Calibration of the transducer should be conducted at least once during the survey. Calibration procedures are described in the Simrad EK500 and EK60 manuals and by Foote *et al.* (1987). Ideally, the procedure as described in the Simrad manuals should be followed with certain exceptions (see below). Minimum target range for the calibration of a split beam 38 kHz echosounder is 10 metres, although greater distances are recommended (about 20 m), particularly with hull mounted transducers, where centering of the target below the transducer is facilitated if the target is suspended at a greater depth. An average integrated value for the sphere, taken when it is centrally located, should be taken as the measured NASC. The calculations should be then performed a number of times (two or three) in an iterative procedure such that the values of measured NASC and theoretical NASC should converge, as described in the Simrad manual. A choice is then made as to whether the S_v Transducer gain should be changed, rendering absolute **NASC's**, or alternatively, the S_v Transducer gain can be unaltered and a correction factor applied to the **NASC's**. Only one strategy should be applied during a cruise, such that for example, the latter option is to be employed when calibration is only possible after the cruise has started. If possible, the transducer should be calibrated both at the beginning and the end of the survey; with a mean correction factor applied to the data. If a new calibration differs by more than 0.4 dB, the system should be thoroughly inspected.

There are a number of parameters that require knowledge of the speed of sound in water. It is therefore recommended that appropriate apparatus be used to determine the temperature and salinity of the water so that sound speed can be calculated (see MacLennan and Simmonds 1992 for equations) and entered into the chosen echosounder.

It is evident that all versions of the EK500 up to and including version 5.* do not take account of the receiver delay in the calculation of target range (see Fernandes and Simmonds 1996). This is particularly important when calibrating at short range (10 m) as it can lead to a systematic underestimate of biomass of 3%. The correct range to the target should therefore be applied in calibration (see below). The equivalent two way beam angle (ψ) should also be corrected for sound speed according to Bodholt (1999).

Currently there is insufficient experience with the EK60 system to provide a complete list of variables that must be held constant to maintain comparable survey conditions. This will be developed over the next year. Presently operators are requested to identify the equivalent features to those listed for the EK500 and to ensure the settings for these are held constant.

There are a number of changes in system specification between EK500 and EK60. Some of these are expected to provide improvements for the user. For example the method for computing range to a target is expected to be an improvement, following a presentation at the FAST WG, 2003. However, concerns were raised about the possibility of range dependent effects in measuring target echoes during calibration where the target is held at a fixed range. The sampling rate of 4 samples per pulse length synchronised to the transmit time may give different echo integral results depending on the relative timing of samples and the echo. These problems have been found with very short pulse systems such as multibeam sounders (Simmonds *et al,*2000). This will be checked with Simrad before FAST WG in April, 2004.

A number of calibration parameters and results should be included as a minimum in the survey report. These are tabulated in Table 1. Some of these parameters are not included in the Simrad operator manuals and are defined as follows.

Table 1. Calibration report sheet.

Calibration report			
Frequency (kHz)			
Echosounder type			
Transducer serial no.			
Vessel			
Date			
Place			
Latitude			
Longitude			
Bottom depth (m)			
Temperature (°C)			
Salinity (ppt)			
Speed of sound (m.s-1)			
TS of sphere (dB)			
Pulse duration (s)			
Equivalent 2-way beam angle (dB)			
Receiver delay (s)*			
Default S_v transducer gain			

Iteration no.	1	2	3
Time			
Range to half peak amplitude (m)*			
Range to sphere (m)			
Theoretical NASC (m2.nmile-2)			
Measured NASC (m2.nmile-2)			

Calibated S_v transducer gain			
DeltaG = New gain - Old gain			
Correction factor for pre-calibration NASC's on EK			
Correction factor for pre-calibration S_v's			

Default TS transducer gain			
Iteration no.	1	2	3
Time			
Measured TS			
Calibrated TS gain			

Note:* Parameters may not be necessary when using the Simrad EK60 echosounder.

Receiver delay = $\mathbf{t_{del}}$ This is very specific to the echosounder bandwidth (due to the band pass filters), to the transducer bandwidth, and to a lesser extent to the standard target and the pulse duration which may affect the peak value. Target, bandwidth and pulse duration specific values for the Simrad EK400 are given in Foote *et al.* (1987, their Table 1). Values for the EK500 are not available, but Simrad recommend using 3 sample distances (10 cm) in wide bandwidth (3 kHz). This equates to a value of $\mathbf{t_{del}}$ of 0.00039 s at 38 kHz.

Range to half peak amplitude = $\mathbf{r_m}$ This is the measured range between the start of the transmit pulse and the point on the leading edge of the echo at which the amplitude has risen to half the peak value (m). This is usually determined from experience with the readings from an oscilloscope display. For example, for a 38.1 mm tungsten carbide standard target insonified at 38 kHz at a colour threshold setting of -70 dB (S_v colour min.), it is measured as from the top of the transmit pulse to the leading edge of the pink colour on the target sphere echo.

Range to sphere = $\mathbf{r_{sph}}$ may then be calculated from:

$$\mathbf{r_{sph} = r_m - ((c \times t_{del})/2)}$$

Correction factor for pre-calibration NASC's on EK500 = K = 1/(10^(DeltaG/5))

Where:

DeltaG = Calibrated S_v Transducer Gain – Default S_v Transducer gain

Correction factor for pre-calibration S_v's on EK = $10(\log_{10}(s_A$ correction factor))

2 Instrument settings during the survey (for the Simrad EK500).

For most settings the default values from the manufacturer may be used, or alternatively the operator can choose his own settings depending on the circumstances. It is recommended that each year the same settings be used for the printer in order to facilitate comparison of echograms.

There are a number of settings that are set during calibration that have a direct influence on the fundamental operation for echo-integration and target strength measurement and therefore affect logged data. Once set according to the particular transducer, these should **NOT** be changed during the survey. These important settings are listed in Table 2.

The minimum detection level on the bottom detection menu depends on the water depth and bottom type. At depths less than 100 m and hard bottoms, the threshold level may be set at –30 dB: this will enable the instrument to detect dense schools close to the bottom. At depths greater than 100 m or soft bottoms, the threshold has to be lowered (-60 dB), otherwise the upper layer of the bottom will be counted as fish as well.

In the operation menu it is recommended to use as short a regular ping interval as possible. It is not advisable to use a ping rate of 0.0 seconds (variable interval according to depth) as this brings about irregular sample (ping) numbers per equivalent distance sampling unit which may bias the analysis.

A bottom margin of the order of 0.5 m is recommended for the layer menus. In shallow areas (<100 m) this can be somewhat reduced.

The S_v minimum for echo integration and presentation of the echogram should be set at –70 dB. Increasing the S_v minimum will reduce the integration values if the herring occur in scattering layers or in loose aggregations. This setting is less important when the data is collected by a post processing package such as Simrad's BI500 or Sonardata's echoview software as the threshold can be determined in post processing.

Table 3 lists those settings which are important for target strength measurements. It should be noted however, that the transducer depth setting may affect the calibration if the range to target is read form the echo sounder.

In the future it is the intention of the users to provide a list of survey settings for other echosounder systems, namely the EK60. Users are asked to compile a list of variables over the coming year that must be held constant to maintain comparable survey conditions. The absorption coefficient on the EK60 can be set to 1 decimal place. Calculations using Temperature of 10.5 degrees, salinity of 34.5 ppt depth of 60m, ph 7.5 gives an absorption of 9.8dB/km at 38kHz (from Echoview calculator using Francois and Garrison (1982) formula).

3 Survey design

Transects are spaced at a maximum distance of 15 nautical miles. Two aspects should be considered in choosing the direction of the transects. Transects should preferably run perpendicular to the greatest gradients in fish density, which are often related to gradients in bottom topography and hydrography. This means that transects will normally run perpendicular to the coast. The second aspect considers the direction in which the fish are migrating. If there is evidence of rapid displacement of the fish throughout the area, it is advisable to run the transects parallel to the direction of the migration. This survey design will minimise the bias caused by migration. A detailed simulation study of the effects of motion on the survey design of North Sea herring is available in Rivoirard *et al*. (2000).

Ship's speed during the survey is typically 10–12 knots. At higher speeds, problems are encountered with engine noise or propeller cavitation. These problems, however, depend on the vessel. In rough weather, the ship's speed may be reduced in order to avoid problems with air bubbles under the ship, although this problem is alleviated by the use of a dropped keel.

If species identification depends on recognition of schools on the echogram (see section 4.3), the survey will have to be interrupted during periods in the 24 hour cycle when the schools disperse. This occurs during the hours of darkness, depending on the area. When schools disperse during darkness, some of the herring may rise to the surface and get above the transducer. During this time (23:00 – 03:00 around Shetland / Orkney for example) it is advisable to cease surveying. It is recommended – if time permits during the survey – to study the diurnal behaviour of fish schools, in order to determine at what time during the 24hr period the fish may not be available to the echosounder.

A review of survey design will be considered at the 2005 PGHERS meeting after the ICES led survey design workshop WKSDDA, findings are taken into consideration (workshop due in June 2004, Aberdeen).

Table 2. Important calibration and survey settings for the EK500, which should not be changed during the survey. Those marked * indicate settings that are specific to the transducer / transceiver.

/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/BANDWIDTH
/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/PULSE LENGTH
/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/MAX. POWER*
/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/2-WAY BEAM ANGLE*
/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/SV TRANSD. GAIN*
/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/TS TRANSD. GAIN*
/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/ABSORPTION COEF.*
/OPERATION MENU/TRANSMIT POWER
/BOTTOM DETECTION MENU/BOTTOM DETECTION-1 MENU/MINIMUM DEPTH
/BOTTOM DETECTION MENU/BOTTOM DETECTION-1 MENU/MAXIMUM DEPTH
/BOTTOM DETECTION MENU/BOTTOM DETECTION-1 MENU/MINIMUM LEVEL
/SOUND-VELOCITY MENU/PROFILE TYPE
/SOUND-VELOCITY MENU/VELOCITY MIN
/SOUND-VELOCITY MENU/ VELOCITY MAX

Table 3. Settings affecting tracking or locating objects within the beam for the EK500. Those marked * indicate settings that are specific to the transducer / transceiver.

/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/TRANSDUCER DEPTH
/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/ANGLE SENS.ALONG*
/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/ANGLE SENS.ATHW.*
/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/ALONGSHIP OFFSET*
/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/ATHW.SHIP OFFSET*
/TS DETECTION MENU/TS DETECTION-1 MENU/MIN. VALUE
/TS DETECTION MENU/TS DETECTION-1 MENU/MIN. ECHO LENGTH
/TS DETECTION MENU/TS DETECTION-1 MENU/MAX. ECHO LENGTH
/TS DETECTION MENU/TS DETECTION-1 MENU/MAX. GAIN COMP.
/TS DETECTION MENU/TS DETECTION-1 MENU/MAX. PHASE DEV.
/MOTION SENSOR MENU/HEAVE
/MOTION SENSOR MENU/ROLL
/MOTION SENSOR MENU/PITCH
/MOTION SENSOR MENU/TD-1 ATH. OFFSET
/MOTION SENSOR MENU/TD-1 ALO. OFFSET
/MOTION SENSOR MENU/TD-2 ATH. OFFSET
/MOTION SENSOR MENU/TD-2 ALO. OFFSET
/MOTION SENSOR MENU/TD-3 ATH. OFFSET
/MOTION SENSOR MENU/TD-3 ALO. OFFSET

4 Species allocation of acoustic records

Different methods of species allocation are being used in the various areas. The method used depends largely upon the schooling behaviour of the herring and sprat, and the mixing with other species. In the North Sea and Division VIa the species allocation is based mainly on the identification of individual schools on the echogram. In the Skagerrak-Kattegat and Baltic the identification is based on composition of trawl catches. Both methods are described in more detail below.

Only persons who are familiar with the area and the way fish aggregations of different species occur in the area should scrutinise the echo records. The way species aggregate either in schools or in layers, mixed or not mixed with other species is very different per (sub) area. Allocation of **NASC's** to species always needs support of trawl-information. However, one has to be aware that the catch composition is influenced by the fish behaviour in response to the net. It is therefore necessary to judge whether the catch-composition is a reflection of the real species composition and whether the allocated percentage of sprat/herring needs correction.

It is obvious that during the scrutinising process subjective decisions have to be made. However, joint sessions of scientists from participating countries who scrutinised each others data has shown that the deviation between the estimated quantities of herring are within the range of 10%, provided that trawl information of the recordings is available (Reid *et al.* 1998).

4.1 Using the EK500 printer output and/or post processing systems

Scrutiny of the echo recordings may be done by measuring the increment of the integrator line on the printed paper output of the echogram. This is a simple and efficient way of scrutinising if one deals with single species schools and if there are no problems with bottom integration. Post processing systems may then be used as backup. More generally, computer based post-processing systems such as the Simrad BI500 or Sonar data Echoview systems are currently being used for scrutinising. The printer output is mostly used as a visual backup.

It is recommended that one depth-range is used for the whole area in the printer output and on post-processing systems. This will ensure that similar echo traces from all parts of the survey area will have the same appearance and hence are visually more comparable.

Echoview post-processing system

The following section describes preliminary protocol for the use of Echoview for processing as used in FRS Marine Lab in Aberdeen. It is expected that this will develop further.

Start of analysis load template

Load template
C:\Program files\sonardata\echoview2\templates\NS2001template.ev

1) Make one day file set

Goto FILESET window
---Add one days file set to include 0200 to 2200

Save as using cruise and daily file name to d:\s1002\mainevfiles\ cruise_date.ev
(e.g., S1002_280602.ev)

2) Cruise track process

View ------- cruise track ------- primary fileset ----- SV Q1 telegram T1
Cruise track --------process
Just check to see if cruise track is in the correct place and OK
If not this might be due to freak start so add extra file at the beginning of file set
Or edit cruise processing
View evfile properties cruise track
Save

3) Assign line

First ensure that you open SV Q1 Telegrams T1----
Go to FILESET window Raw Variables section. Highlight SV Q1 Telegram T1
click Echogram-----this opens the file window on the screen and allows you to update the lines and save as detailed below.
Go Primary fileset SV Q1 Telegram T1 window
View ---- evfile properties ----- lines ----- bottom ----- new

Check ----- Existing line -----------------------select---------primary fileset sv Q1 telegrams T1
Check --------Overwrite existing line ----------select -------- bottom
OK

Save

4) Block out data not required

On the primary fileset SVQ1 telegrams T1
Use vertical band tool (5) --------- select region (mouse and keys) --------- define region (right mouse button over region) -------- trawl (bad data) --------- close

Sections to block out:

1) Period before 0200 (to check data start is correct as well)
2) All trawls start block at end of run before fishing (take start position here from echoview) end at point where track crosses start position on restarted survey
3) Any other periods not to be included because data in not to analysed; such as: extra stations, parts of track when ship is steaming or between transect sections not to be included
4) Period after 2200 (and to check data at end is included) Note: cntl right arrow steps screen to right as you drag with mouse

Save

Check to if all files are there (somehow! Check for Continuous Cruise track and or smooth echograms etc.) IF you find files missing—gaps in data or start too late or finish too early load these and go back to **3) ASSIGN LINE**

ALWAYS make sure all the data are in and 'bottom' assigned before next step.

Adding data or changing files at this point requires the following work to be redone.

4.2 Allocation to classified schools

In the western and northern part of the area covered by the survey, most of the herring occur in well-defined schools, often of a characteristic shape as pillar-shaped large dense schools or as layers of very small and dense school at the surface. In the northern and central part, schools of Norway pout and herring are difficult to distinguish from each other. In low density area's of the western area mixed layers and aggregation of small schools consisting of gadoids and herring may occur.

Sprat marks in the North Sea and VIa appear mostly as quite large, typical, pillar-shaped marks, usually slightly more diffuse than herring and usually in shallow water.

Use of trawl Information

The allocation of echo-traces to species is governed by the results of trawl hauls. In many cases these are considered together with observations from the netsonde and the echogram during the haul. In some cases it is not possible to assign schools (echo traces) to species directly e.g., where the haul contains a mixture of species and no clear differentiation can be made between the observed schools. In such situations the integral is assigned to a species mixture category according to the trawl results. This is defined as percentage by number or weight taking into account the correct conversion to scattering length (see section 6.2); post processing software is then used to apply weights and lengths. There are two main problems with using trawl data to define "acoustic" mixtures:

- Different species are known to have different catchabilities, so the exact proportions in the trawl are unlikely to be an exact sample of the true mixture. For instance herring are likely to be faster swimmers than Norway pout.
- Herring are often found in a mixture with "0" group pout, which are mostly lost through the meshes. This may also occur with other small gadoids. In this case the exact proportions are unavailable and the operator must make an informed guess.

Thresholding to filter out plankton

An advantage of using a post-processing system like the BI500 and EchoView, is the ability to change the threshold-value of the received echo's. By changing the threshold the non-target-species (plankton in particular) can be filtered out. The threshold used may differ, depending on a variety of conditions, including the water depth (more care should be taken at greater depth) and the particular size of fish. Examples of conditions where certain thresholds have been applied are described below; they should not be used without verification. At the beginning of the survey it is advisable to find the right thresholds by isolating schools and changing the threshold.

In stratified waters (mainly in the northern - and northeastern part of the survey area) there is often a layer of plankton in the upper 50 m. In this layer, very small, dense schools of herring may be found. Normally all the plankton is filtered out at –42 dB. The remaining **NASC's** may be assigned to herring if clear schools are still visible and, of course, trawl information indicates that herring are present. In the range of 30–60 m the same procedure may be used. Here **NASC's** are normally assigned to schools of fish after filtering out plankton by putting the threshold in the range of –48 to –51 dB. In the layer below 60 m a threshold of –54 to –60 dB may be applied. In the deeper parts of the area (>150m) a lower threshold than –60 dB may be applied. At these depths, often close to the bottom, herring schools are normally, larger and easier to recognise.

Use of other frequencies

The echosounder frequency routinely used in the North Sea echo survey is 38 kHz. However, data may be collected at 120 and 200 kHz. In some cases these can be used as an aid to identify marks to species. For instance, herring and mackerel may have different target strengths at different frequencies. Mackerel is believed to backscatter more strongly at 200 kHz than at 38 kHz, whilst for herring the reverse is the case. In the absence of good observations of such relationships, this approach should be used with caution.

To process the data for extraction of schools the variable computation method available in Echo View has been used at FRS Marine Lab. The method has been used in 2001–2003 and was developed under the EU program SIMFAMI. Previously when processing by hand (2000 and before) a small 'background' value for scattered fish was removed from integrator layers with many fish schools. It was noted that fish schools appear consistently on 38, 120 and 200kHz echograms while other features such as plankton may be strong on some frequencies and weak on others. The processing was

Sv_{used} = Sv38*[Sv_{38}+ Sv_{120}+Sv_{200} ** Blur>-170dB]

Where Blur is a convolution matrix

$$\begin{bmatrix} 1 & 2 & 1 \\ 2 & 1 & 2 \\ 1 & 2 & 1 \end{bmatrix}$$

The Blur convolution filter is chosen as a suitable smoothing function as previous experiences suggests it is well suited to the types of amplitude distributions expected from echoes from fish aggregations (Reid and Simmonds 1993). It provides a smoother spatial filter for filling in values in a school than either a centred weighted or uniform averaging filters.

Use of single target TS distribution data

The SIMRAD EK500 used with a split-beam transducer allows the collection of TS values for all single targets detected in the beam. A TS distribution can then be produced for each EDSU. In some situations there may be two species present in an area with substantially different TS values, and this could be used to determine the species allocation. Again, this data must be used with caution. There are doubts about the precision of the TS detection algorithm, particularly in older firmware releases. By definition, single targets are unlikely to be detected from fish in schools. As schools are often the main subject for herring acoustic surveys, such data may be unrepresentative. However, where the survey encounters diffuse mixtures, there may be value in such data.

Use of image analysis techniques

The Marine Laboratory Aberdeen has developed an image processing system for post processing of echograms. This can extract a range school descriptors; energetic, morphometric and positional, which can be used to define the characteristics of schools of a particular species. Such systems have also been developed elsewhere and one example is available with Sonardata’s Echoview post processing software. In general such systems can differentiate most observed schools to species, however, these are usually the schools which an experienced survey operator can also discriminate by more traditional methods. These systems are likely to become more invaluable in the future when they can be combined with multi-frequency data.

4.3 Allocation to mixed layers or mixed schools

Sometimes herring occur mixed with other species in aggregations of smaller schools. In this case, species allocation is based on the composition of trawl catches.

In the southern North Sea, Skagerrak, Kattegat and the Baltic, herring and sprat may occur in mixed schools. Those schools are separated from other fish using the standard scrutinising procedures (see above) and the allocation of the proportion of herring (spring and/or autumn spawners) and sprat is done afterwards on the basis of catch composition. Trawl catches within each stratum (or statistical rectangle) are combined to give an average species, stock, age and length composition of the clupeid fraction of the catch.

5 Biological sampling

5.1 Trawling

Species allocation of the acoustic records is impossible if no trawl information is available. The general rule is to make as many trawl hauls as possible, especially if echo traces are visible on the echosounder after a blank period. If surface schools are known to occur in the area it is often advisable to take occasional surface trawls even in the absence of any significant marks.

The principal objective is to obtain a sample from the school or the layer that appears as an echo trace on the sounder. The trawling gear used is of no importance as long as it is suitable to catch a sample of the target-school or layer. Some dimensions of the trawls used by the participants are given in Table 4.

Table 4**.** Characteristics of trawl gear used in the North Sea and Celtic Sea herring surveys. “Mesh sizes in all panels” are listed for panels from the mouth of the net to the cod end; the number of entries is not an indication of the number of panels as adjacent panels may have the same mesh size.

Country	Vessel	Power	Code	Name	Type	Panels	Headl	Groundr	Sweeps	Length	Circum	Mesh sizes in all panels						Codend	Heig ht	Spread (wings)
		kW			B/P	2/4	m	m	m	m	m	mm	mm	mm	mm	mm	mm	**mm**	m	m
DEN	DAN2																	**16**		
GFR	WAH3	2900	GOV	GOV	B	2	36.0	52.8	110.0	51.7	76.0	200	160	120	80	50			4	23
GFR	WAH3	2900	PS205	PSN205	P	4	50.4	55.4	99.5	84.3	205.0	400	200	160	80	50		**10**	15	28
GFR	SOL	588	AAL	Aalhopser	B	2	31.0	29.7	63.5	57.5	119.0	160	120	80	40				6	19
GFR	SOL	588	PS388	Krake	P	4	42.0	42.0	63.5	59.8	142.4	400	200	80				**10**	10	21
NED	TRI2	2940		2000 M Pel. Trawl	P	4	64.0	72.0	100.0	140.0	400	800	400	200	120	80		**20**	16	45
NOR	GOS	1700	3532	Akratral	P	4	72.0	72.0	160.0	130.0	486.4	3200	1620	400	200	100	38	**10**	33	
NOR	GOS	1700		[bottom trawl]	B															
SCO	SCO2	3000	PT160	Pel. Sampl. Trawl	P	4	38.0	38.0	70–115	87.0	256.0	800	600	400	200	100	38	**38**	12	32
IRE	CEX	3000	PMT	Pel. midwater trawl	P	4	58.0	58.0	55.0	40.0	330.0	3200	1600	400	200	100	50	**20**	15	45

During trawling it is important to take note of the traces on the echosounder and the netsonde in order to judge if the target-school entered the net or if some other traces "spoil" the sample. It is recommended that notes be made on the appearance and behaviour of fish in the net during every haul. If a target is missed during a haul, the catch composition should not be used for species allocation.

5.2 Biological sampling procedure

The fish sample obtained from the trawl catch are to be divided into species by weight and by number. Length measurements are taken to the 0.5 cm below for and herring (and to the whole cm below for other species). For herring and sprat either representative or length stratified samples are taken for maturity, age (otolith extraction) and weight.

Maturity should be determined according to the scales given in Tables 9 and 10, although reporting of the data varies according to participants (Table 8). The 8 point scale is based on Bowers and Holliday (1961).

6 Data analysis

This section describes the calculation of numbers and biomass by species from the echo-integrator data and trawl data. Most of this section is taken from Simmonds *et al.* 1992.

The symbols used in this section are defined in the text but for completeness they have been collated and are given below:

F_i	estimated area density of species i
K	equipment physical calibration factor
$<\sigma_i>$	mean acoustic cross-section of species i
E_i	partitioned echo-integral for species i
E_m	echo-integral of a species mixture
c_i	echo-integrator conversion factor for species i
TS	target strength
TS_n	target strength of one fish
TS_w	target strength of unit weight of fish
a_i, b_i	constants in the target strength to fish length formula
a_n, b_n	constants in formula relating TS_n to fish length
a_w, b_w	constants in formula relating TS_w to fish length
a_f, b_f	constants in the fish weight-length formula
L	fish length
W	weight
L_j	fish length at midpoint of size class j
f_{ij}	relative length frequency for size class j of species i
w_i	proportion of species i in trawl catches
A_k	area of the elementary statistical sampling rectangle k
Q	total biomass
Q_i	total biomass for species i

The objective is to estimate the density of targets from the observed echo-integrals. This may be done using the following equation from Foote *et al.* (1987):

$$F_i = \left(\frac{K}{<\sigma_i>}\right)E_i \qquad \textbf{(1)}$$

The subscript i refers to one species or category or target. K is a calibration factor, $<\sigma_i>$ is the mean acoustic cross-section of species i, E_i is the mean echo-integral after partitioning and F_i is the estimated area density of species i. The quantity is the number or weight of species i, depending on whether σ_i is the mean cross-section per fish or unit weight. $c_i = (K/<\sigma_i>)$ is the integrator conversion factor, which may be different for each species. Furthermore, c_i depends upon the size-distribution of the insonified target, and if this differs over the whole surveyed area, the calculated conversion factors must take the regional variation into account.

K is determined from the physical calibration of the equipment, which is described in section 1 above. K does not depend upon the species or biological parameters. Several calibrations may be performed during a survey. The measured values of K or the settings of the EK500 may be different but they should be within 10% of one another. If two successive measurements are very different the cause should be investigated since the equipment may be malfunctioning. Otherwise, K should be taken as the average of two measurements before and after the relevant part of the survey.

6.1 Conversion factors for a single species

The mean cross-section $<\sigma_i>$ should be derived from a function which describes the length-dependence of the target-strength, normally expressed in the form:

$$TS = a_i + b_i Log_{10}(L) \qquad \textbf{(2)}$$

Where a_i and b_i are constants for the i'th species, which by agreement with the other participants in the survey are given in Table 5.

Table 5. The recommended target strength relationships for herring surveys in the North Sea and adjacent waters.

	Target Strength Equation Coefficients	
Species	**b_i**	**a_i**
Herring	20	-71.2
Sprat	20	-71.2
Gadoids	20	-67.5
Mackerel	20	-84.9
horse mackerel	20	-71.2

The equivalent formula for the cross-section is:

$$\sigma_i = 4\pi 10^{\left(\left(a_i + b_i Log(L)\right)/10\right)} \qquad \textbf{(3)}$$

The mean cross-section is calculated as the σ average over the size distribution of the insonified fish. Thus L_j is the mid-point of the j'th size class and f_{ij} is the corresponding frequency as deduced from the fishing samples by the method described earlier. The echo-integrator conversion factor is $c_i = K/<\sigma_i>$. The calculation may be repeated for any species with a target strength function.

$$<\sigma_i> = 4\pi \sum_j f_{ij} 10^{\left(\left(a_i + b_i Log(L_j)\right)/10\right)} \qquad \textbf{(4)}$$

Note that it is the cross-section that is averaged, not the target-strength. The arithmetic average of the target-strengths gives a geometric mean, which is incorrect. The term “mean target-strength” may be encountered in the literature, but this is normally the target-strength equivalent to $<\sigma_i>$, calculated as $10\log_{10}(<\sigma_i>/4\pi)$. Some authors refer to TS as 10 $\log(\sigma_{bs})$ the definition of σ is different from σ_{bs} and should not be confused.

6.2 Conversion factors for mixed species layers or categories

Sometimes several species are found in mixed concentrations such that the marks on the echogram due to each species cannot be distinguished. From inspection of the echogram, the echo-integrals can be partitioned to provide data for the mixture as one category, but not for the individual species. However, further partitioning to species level is possible by reference to the composition of the trawl catches (Nakken and Dommasnes, 1975).

Suppose E_m is the echo-integral of the mixture, and w_i is the proportion of the i’th species, calculated from fishing data. It is necessary to know the target-strength or the acoustic cross-section, which may be determined in the same manner as for single species above. The fish density contributed by each species is proportional to w_i. Thus the partitioned fish densities are:

$$F_i = \frac{w_i K}{(\sum_i w_i <\sigma_i>)} E_m \qquad \textbf{(5)}$$

The w_i may be expressed as the proportional number or weight of each species, according to the units used for $<\sigma_i>$ and c_i. Consistent units must be used throughout the analysis, but the principles are the same whether it is the number of individuals or the total weight that is to be estimated.

6.3 Using weight-length relationships

The abundance is expressed either as the total weight or the number of fish in the stock. When considering the structure of the stock, it is convenient to work with the numbers at each age. However, an assessment of the commercial fishing opportunities would normally be expressed as the weight of stock yield. Consistent units must be used throughout the analysis. Thus if the abundance is required as a weight while the target-strength function is given for individual fish, the latter must be converted to compatible units. This may be done by reference to the weight-length relationship for the species in question.

For a fish of length L, the weight W is variable but the mean relationship is given by an equation of the form:

$$W = a_f L^{b_f} \qquad \textbf{(6)}$$

Where a_f and b_f are taken as constants for one species. However, a_f and b_f could be considered as variables varying differently with stock and time of year as well as species. Suppose the target-strength of one fish is given as:

$$TS_n = a_n + b_n \log_{10}(L) \qquad \textbf{(7)}$$

The corresponding function TS_w, the target-strength of unit weight of fish has the same form with different constants:

$$TS_w = a_w + b_w \log_{10}(L) \qquad \textbf{(8)}$$

The number of individuals in a unit weight of fish is (1/W), so the constant coefficients are related to the formulae:

$$b_w = b_n - 10b_f \qquad \textbf{(9)}$$

$$a_w = a_n - 10\log_{10}(a_f) \qquad \textbf{(10)}$$

6.4 Abundance estimation

So far the analysis has produced an estimate of the mean density of the insonified fish, for each part of the area surveyed, and for each species considered. The next step is to determine the total abundance in the surveyed area. The abundance is calculated independently for each species or category of target for which data have been obtained by partitioning the echo-integrals. The calculations are the same for each category:

$$Q_i = \sum_{k=1}^{n} A_k F_i \qquad \textbf{(11)}$$

The total biomass for all species is:

$$Q = \sum_{i} Q_i \qquad \textbf{(12)}$$

The F_i are the mean densities and A_k are the elements of the area that have been selected for spatial averaging. The may be calculated from the shape of an area or measured, depending upon the complexity of the area. The presence of land should be taken into account, possibly by measuring the proportions of land and sea.

7 Data exchange

Each individual country is responsible for working up its own survey data. However, the results need to be submitted to the Chair of PGHERS in a standard format for the coordinated survey results. In addition, the **NASC's** per sampling unit allocated to target species together with all trawl information should be entered in the international database for acoustic herring surveys in the North Sea (HERSUR-database).

7.1 Exchange of data for the combined survey result.

The standard spreadsheet template should be used to enter the results of the survey by ICES statistical rectangles on four data sheets: 1) the cruise sheet by ICES statistical rectangle (Table 6); and the proportions by age/maturity class sheet (Table 7a) mean weights at age/maturity sheet (Table 7b) and mean length sheet (Table 7c).

The cruise sheet consists of six columns of data with as many rows as required for the survey. There must be at least one entry for each rectangle covered but to allow more flexible strata to be accommodated, multiple entries for abundance belonging to different strata may be entered with the same rectangle reference. The abundance must sum to the total for the rectangle.

The six columns are:

1) The central (decimalised) latitude of the data or ICES rectangle;
2) Central (decimalised) longitude of the data or ICES rectangle;
3) The biological sub-area to which the ICES rectangle belongs;
4) The ICES statistical rectangle code for the rectangle
   (This may be calculated according to the first two columns);
5) Herring abundance in millions of fish;
6) Survey weight (in nautical miles of survey track per rectangle).

Part of an example data sheet is given in Table 6.

The proportions data (Table 7a) contains the proportion of Autumn spawners (North Sea and VIa north) and Spring spawners (Western Baltic) broken down according to strata (in rows) and age/maturity (in columns). There are currently 26 columns covering both spawning types. These proportions can be submitted as actual proportions or as total abundances. Ages of autumn spawning herring should be submitted as winter rings (where winter rings = age class – 1). Sprat and spring spawning herring ages are expressed as age class. Currently different maturity scales are in use, Table 8 provides the scales and their relationship. Tables 9 and 10 describe the maturity scales in detail according to Bowers and Holliday (1961). Data should be prepared according to the following age/maturity classes: 1 immature (maturity stage 1 or 2), 1 mature (maturity stage 3+), 2 immature, 2 mature, 3 immature, 3 mature, 4, 5, 6, 7, 8, 9+ (c.f. 1–8 scale in Tables 9 and 10).

The mean weights (Table 7b) at age/maturity by biological sub-area for North Sea autumn spawners and Baltic spring spawners.

The mean length (Table 7c) at age/maturity by biological sub-area for North Sea autumn spawners and Baltic spring spawners.

A cruise report should also be produced, and sent with the data file, following a standardised format. A description and an example of this format is given in the current report in Appendix IIA. Text should be provided under the headings given (sections 1–4). All Figures (1–4) and Tables (1–6) are required, although the exact format of Figure 3 (mean length post plot and area subdivisions) may vary for clarity (see for example Figure IIE.3).

7.2 Data exchange for the international acoustic database (HERSUR).

All acoustic data from the national surveys is to be entered in the international database for acoustic surveys in the North Sea (HERSUR) together with the biological data from trawling.

Acoustic data, consisting of the NASC value per sampling unit allocated to species, together with additional information on time, position and instrumentation shall be exchanged according to the format described in the HERSUR Exchange Format Specification (to be submitted March 2000). This specification also described how trawl information is to be submitted.

Data exchange will be performed through the Internet (ff07.dfu.min.dk/hersur) through XLM files described in the HERSUR Exchange Format Specification, refer to International Acoustic Survey Database Manual (Ver. 1.0), also HERSUR users manual (Faber, 2001).

8 References

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Table 6. An example of the excel worksheet used to submit survey data by ICES statistical rectangle - the 'cruise sheet' with data from four ICES statistical rectangles.

2003 Cruise sheet on ICES stat square scale.							
Ship name and country (in here):			TRIDENS	Netherlands		**FILL THIS!**	
VERSION 20.11.2003							
			Total Numbers (millions)			16558.204	**FILL THIS!**
			Total Biomass (thousands t)			1432.5295	**FILL THIS!**
					Stat	**Abund'ce**	**Survey**
		Latitude	**Longitude**	**Stratum**	**square**	**Millions**	**milage**
Origin:	**00A0**	54.75	-0.5	**F**	**38E9**	170.88	30.0
lat	**35.5**	54.75	0.5	**F**	**38F0**	3104.93	37.0
long	**-50**	54.75	1.5	**F**	**38F1**	0.00	35.0
		54.75	2.5	**F**	**38F2**	0.00	15.0
		55.25	-1.5	**C**	**39E8**	146.47	12.0
		55.25	-0.5	**E**	**39E9**	208.25	46.0
		55.25	0.5	**F**	**39F0**	357.77	69.0
		55.25	1.5	**F**	**39F1**	0.00	38.0
		55.25	2.5	**F**	**39F2**	0.00	21.0
		55.75	-1.5	**C**	**40E8**	40.78	51.0
		55.75	-0.5	**D**	**40E9**	1081.54	68.0
		55.75	0.5	**D**	**40F0**	192.62	68.0
		55.75	1.5	**D**	**40F1**	0.00	69.0
		55.75	2.5	**D**	**40F2**	164.78	79.0
		56.25	-2.5	**C**	**41E7**	0.00	6.0
		56.25	-1.5	**C**	**41E8**	0.00	61.0
		56.25	-0.5	**D**	**41E9**	157.76	68.0
		56.25	0.5	**D**	**41F0**	1844.79	67.0
		56.25	1.5	**D**	**41F1**	1228.26	68.0
		56.75	2.5	**D**	**41F2**	892.54	82.0
		56.75	-2.5	**C**	**42E7**	0.00	12.0

Table 7.

a) An example of the excel worksheet used to submit survey data broken down by age/sub area - the 'proportions sheet'

	North Sea Autumn spawners.								Western Baltic Spring Spawners >>>>>>>>>>>>>>>>>>>>>>					
		Abundance (Millions)......												
Sum	**Stratum**	**0**	**1i**	**1m**	**2i**	**2m**	**3i**	**3m**	**4**	**5**	**6**	**7**	**8**	**9+**
1	**A**	0.00	0.06	0.00	0.46	0.44	0.01	0.03	0.01	0.00	0.00	0.00	0.00	0.00
1	**B**	0.00	0.00	0.00	0.19	0.46	0.01	0.13	0.16	0.02	0.01	0.01	0.00	0.00
1	**C**	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	**D**	0.00	0.19	0.00	0.58	0.18	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00
1	**E**	0.00	0.24	0.00	0.06	0.00	0.00	0.00	0.00	0.24	0.29	0.06	0.00	0.12
1	**F**	0.00	0.27	0.00	0.38	0.29	0.00	0.01	0.02	0.01	0.01	0.00	0.00	0.00

b) An example of the excel worksheet used to submit survey data broken down by age/sub area - the 'mean weights sheet'

North Sea Autumn spawners.... Mean weight (grams).....												
0	**1i**	**1m**	**2i**	**2m**	**3i**	**3m**	**4**	**5**	**6**	**7**	**8**	**9+**
	57.3		90.7	127.0	110.0	144.4	160.0		166.0			
			98.7	138.1	126.0	167.3	199.8	190.8	269.0	264.0	280.0	267.0
2.8												
	53.3		75.6	118.9	90.0	132.7	156.3	165.7	163.6		194.0	
	37.0		64.0					125.0	134.8	134.0		182.0
	57.3		79.5	133.7		152.0	173.0	176.7	175.5	185.0		

c) An example of the excel worksheet used to submit survey data broken down by age/sub area - the 'mean lengths sheet'

North Sea Autumn spawners.... Mean length (cm).....												
0	**1i**	**1m**	**2i**	**2m**	**3i**	**3m**	**4**	**5**	**6**	**7**	**8**	**9+**
	19.29		22.48	24.09	24.50	24.88	26.53		26.50			
			23.24	25.07	24.50	26.29	27.48	28.11	30.05	29.74	32.50	30.50
7.68												
	19.61		20.90	23.60	22.46	24.84	26.19	27.29	27.79		28.00	
	17.88		20.00					26.38	25.55	25.50		29.00
	19.65		20.87	23.47		25.18	26.27	27.10	27.08	27.75		

Table 8. Maturity scales currently used by the participants in ICES coordinated acoustic surveys in ICES divisions III, IV and Va.

Reporting state	**8 point scale (Scotland, Norway, Denmark)**	**5 point scale (HERSUR)**	**4 point scale Netherlands***	**4 point scale (Germany)**
Immature	1. Virgin	1. Virgin	(**I**) Virgin	1. Virgin
	2. Small gonads			
Mature	3. Gonads half cavity	2. Maturing	(**M**). Maturing	2. Maturing
	4. Gonads long cavity			
	5. Gonads fill cavity			
	6. Ripe and running	3. Spawning	**(R)** Spawning	3. Spawning
	7. Spent	4. Spent	(**S**) Spent and Resting	4. Spent
	8. Recovering spents	5. Resting		

*Dutch Code (**I-M-R-S**) between brackets

Table 9. Maturity classification of female herring as used in the 2003 survey.

Netherlands and Germany	Norway	Scotland and Denmark*	Ireland
0= undefined	0= undecided / not checked		
1= virgin (**I**mmature) ovaries are thin, whitish, translucent and long ribbons; no sign of development; pointed end	1= immature (a) thread-like, thin, completely transperent and colourless; sex difficult to determine	1= Virgin herring gonads very small – threadlike; 2–3 mm broad; ovaries wine red	1= Virgin individuals: small sexual organs close under vertebral column Wine in colour, torpedo-shaped ovaries about 2–3 cm long and 0.66 mm thick
	2= immature (b) somewhat larger in volume; sex easier determined; still transparent with hint of colour	2= Virgin herring with small gonads the height of ovaries is about 3–8 mm; eggs not visible to the naked eye but can be seen with a magnifying glass; ovaries bright red colour	2= Maturing Virgins. Slightly larger than stage 1, still transparent.
2= maturing (**M**ature) ribbons are already larger, reddish colour; lightly ribbed and milky or development has clearly started, eggs are becoming larger; ovaries are more and more filling in the body cavity; eggs still cannot be extruded using moderate pressure	3= maturing (a) opaque but developed in volume; distinct veins; ovaries with yellow/white eggs in lamellae; can occupy half body cavity or more	3= maturing gonads occupy about half of the ventral cavity; breadth of the sexual organs is between 1 and 2 cm; eggs are small but can be distinguished with the naked eye; the ovaries are organs	3= Sexual Organs become more swollen, occupying about half of the ventral cavity
	4= maturing (b) gonads larger in volume; distinct veins; ovaries yellowish or white, can occupy 2/3 or more of the body cavity depending on fish condition; Eggs distinct, feel like grain, becoming transparent in the front part of the gonad	4= maturing gonads are almost as long as the body cavity; eggs larger than in 3, varying in size and opaque; ovaries orange or pale yellow in colour	4= Ovaries become more swollen, filling two thirds of ventral cavity, eggs not transparent.
	5= maturing (c) ovaries fill the entire body cavity; most eggs transparent	5= maturing gonads fill the body cavity; eggs are large and round; some are transparent; ovaries are yellowish; eggs do not flow	5= Sexual Organs filling ventral cavity, ovaries with some large transparent eggs
3= spawning (**R**unning) eggs are freely extruding or developed eggs are extruding using moderate pressure to the fish body	6= spawning running gonads when light pressure is applied	6= spawning ripe gonads; eggs transparent; eggs flow freely	6= Roe running – Spawning
4= spent (**S**pent) gonads are shrunken, drained, not translucent, reddish, lightly ribbed; residues of eggs; showing no development	7= spent gonads loose; some remaining eggs	7= spent gonads baggy and bloodshot; ovaries are empty or only contain a few residual eggs; body cavity may contain bloody fluid. At this stage there can be difficulty in deciding sex; if the gonads are spread out it is easier to view the leading edge – sharp for male and rounded for female	7= Spents, ovaries slack with residual eggs, baggy and bloodshot
*Dutch Code (**I-M-R-S**) between brackets	8= resting gonads small; eggs not visible; difficult to distinguish from stage 2–3	8= recovering ovaries are firm and larger than virgin herring in Stage 2. Eggs are not visible to the naked eye. The walls of the gonads are striated vertically and blood vessels are prominent. Gonads are wine-red in colour. (This stage passes into Stage 3)	8= Recovering spents, no eggs visible. Blood vessels showing.

* Denmark most often use to go directly from stage 7 to stage 3

Table 10. Maturity classification of male herring as used in the 2003 survey.

Netherlands & Germany	Norway	Scotland & Denmark*	Ireland
0= undefined	0= undecided / not checked		
1= virgin (**I**mmature) testes are long, very thin, translucent and transparent ribbons lying along an unbranched blood vessel; no sign of development; round end	1= immature (a) juvenile phase, gonads thread-like, thin, completely transperent and colourless; sex difficult to determine	1= Virgin herring gonads very small – threadlike; 2-3 mm broad; testes whitish or grey brown	1= Virgin individuals: small sexual organs close under vertebral column whitish or greyish brown in colour, knife shaped testes 2-3 cm long and 0.66 mm thick.
	2= immature (b) somewhat larger in volume; sex easier determined; still transparent with hint of colour	2= Virgin herring with small sexual organs height of testes is about 3-8 mm; testes a reddish grey colour	2= Maturing Virgins. Slightly larger than stage 1, still transparent colouration.
2= maturing (**M**) ribbons are already larger, reddish colour; smooth and transparent or development has clearly started, whitish/creamy colour of the gonades; gonads are more and more filling in the body cavity; sperm/milk still cannot be extruded using moderate pressure	3= maturing (a) opaque but developed in volume; distinct veins; testes white or with white spots, firm; can occupy half body cavity or more	3= maturing gonads occupy about half of the ventral cavity; breadth of the sexual organs is between 1 and 2 cm; testes reddish grey or greyish	3= Sexual Organs become more swollen, occupying about half of the ventral cavity
	4= maturing (b) gonads larger in volume; distinct veins; testes light grey or white; milt thick and slow-flowing	4= maturing gonads are almost as long as the body cavity; testes whitish	4= Gonads become more swollen, filling two thirds of ventral cavity, milt whitish
	5= maturing (c) testes are grey or white; The gonads are not yet running, however, a light pressure on the abdomen causes the milt to run	5= maturing gonads fill the body cavity; testes are milky white; sperm does not flow but can be extruded by pressure	5= Sexual Organs filling ventral cavity, milt is white in colour but not yet running
3= spawning (**R**unning) sperm/milk is flowing out or is extruded using moderate pressure to the fish body	6= spawning running gonads when light pressure is applied	6= spawning ripe gonads; testes white; sperm flow freely	6= milt running – Spawning
4= spent (**S**) gonads are shrunken, drained, transparent and reddish; residues of sperma/milk; showing no development	7= spent gonads loose; contain remaining milt	7= spent gonads baggy and bloodshot; testes may contain remains of sperm. The body cavity may contain bloody fluid. At this stage there can be difficulty in deciding sex; if the gonads are spread out it is easier to view the leading edge – sharp for male and rounded for female	7= Spents, testes slack, baggy and bloodshot
*Dutch Code (**I**-**M**-**R**-**S**) between brackets	8= resting gonads small; difficult to distinguish from stage 2-3	8= recovering testes are firm and larger than virgin herring in Stage 2. The walls of the gonads are striated laterally and blood vessels are prominent. Gonads are wine-red in colour. (This stage passes into Stage 3)	8= Recovering spents. Blood vessels showing.

* Denmark most often use to go directly from stage 7 to stage 3.

Appendix V: Manual for the International Larvae Surveys South of 62° North

MANUAL

Version 1.0 (draft)

28 January 2004

for

THE INTERNATIONAL HERRING LARVAE SURVEYS SOUTH OF 62° NORTH

1. Introduction

The ICES programme of international herring larval surveys in the North Sea and adjacent areas is in operation since 1967. The main purpose of this programme is to provide quantitative estimates of herring larval abundance, which are used as a relative index of changes of the herring spawning stock biomass in the assessment.

The larvae surveys are carried out in specific time periods and areas, following the autumn and winter spawning activity of herring from north to south. Catch data together with specific information like haul position, survey area etc. are reported to the ICES International Herring Larvae database annually. The database contains information about the surveys conducted since 1972.

This manual should describe most aspects of the methods used in the surveys. It should summarize the status-quo of the surveys and should form a basis for discussion which, if any, modifications in methodology and changes in survey design become necessary.

2. Sampling

2.1 Sampling strategy

The aim is to sample the major herring spawning grounds in the appropriate areas in an approximate 10 by 10 nautical miles grid. The station grid is based on the positions given in Anon. (1985). This grid should include every square that is known to contain herring larvae less than 10 mm. The areas should be sampled in the half month periods. Wherever possible, hauls should be done within the centre of the 10*10 nm rectangle.

In areas with high densities of small larvae (more than 1000 larvae per haul) extra samples should be taken within the specific 10 x10 nm grid.

If there is a shortage of time during the survey, the scientist in charge should give higher priority to stations which are presumed to represent areas with higher densities of larvae instead of areas with are believed to have lower densities.

2.2 Sampling locations

The herring larval abundance is surveyed in four different areas: the Orkney/Shetland area, the Buchan region, the Central North Sea and the Southern North Sea. The first two areas should be covered twice while the last both should be covered for three times. In total there are 10 sampling units which must be surveyed for a complete coverage of the herring spawning activity. The survey period and locations are given in Table 1. The positions of the stations for each specific sampling area are described in the Annex.

All other locations, e.g., IVa North and IVa South and VIIb, which were part of the surveys up to the 90s, are not sampled anymore since 1994. Also the forth sampling period in the Central North Sea (16.10. – 31.10.) is omitted from the surveys since 1999.

Table 2.2.1. Sampling locations and periods

Area / Period	**1–15 September**	**16–30 September**	**1–15 October**
Orkney / Shetland	yes	yes	no sampling required
Buchan	yes	yes	no sampling required
Central North Sea	yes	yes	yes
	16–31 December	**1–15 January**	**16–31 January**
Southern North Sea	yes	yes	yes

Sampling should preferably take place in the centre of the squares. In case stations have to be shifted it must be made sure that they are still in the required 10*10 nm rectangle.

Stations should be given a number which allocates them to a standard 30 x 30 nm rectangle. This is based on the ICES code for statistical rectangles (Anon. 1977) followed by a letter from a to i which allocates them to the respective 10 x 10 nm sampling grid within that rectangle. These station numbers are given in the tables of standard positions for each sampling unit in the Annex (Tables 6.1.1– 6.4.3)

Participants in the surveys should notify the Chair of the Working Group as soon as the allocation of vessel time to the herring larval surveys is known. Any necessary adjustments could then be considered and arranged at PGHERS.

3. Sampling Gear

3.1 Standard sampler

It is recommended that all participants should use a GULF III sampler or one of its modifications for the herring larval surveys.

The sampler should be fitted with a 300 µ mesh size net. Samplers should be equipped with depth recorder and two flow meters, one internal and one external. The internal flowmeter should be fitted in the middle of the noise cone. The external flowmeter should be mounted to the sampler in a way that the flowmeter is not object to sampler induced turbulence.

Hydrographic measurements can be obtained by a CTD mounted to the GULF III sampler.

3.2 Calibration

The theoretical volume of water accepted by a plankton sampler in free flow (i.e., without a filtering cone) can be expressed as the product of the area of the mouth opening and the distance towed. For flowmeter calibration, the sampler should be deployed well below the ships keel and towed for a known distance (e.g., 1 nm obtained from GPS) on a horizontal path at 5 knots through the water. This calibration must be reproduced also on a reciprocal course.

The nose cones of the different modification of GULF III samplers at present in use in the surveys are not designed in the same way. Thus each of these samplers has different inherent sampler efficiency and these results in different theoretical volumes accepted. The sampler efficiency was calculated from measurements done in a flume tank by measuring the actual volume accepted in free flow at the operational speed of 5 knots. An efficiency factor exists for each sampler type.

An additional factor that affects the volume filtered is clogging of plankton in the meshes. This factor can be calculated from the ratio of the inner and outer flowmeter.

3.3 Method of deployment

The standard towing speed is 5 knots through the water. Hauls should be “double oblique hauls” from the sea surface to within at least 5 metres of the seabed (irrespective of depth) and back to the surface. Whenever weather conditions are moderate, a distance of the sampler to the seabed within 3 metres is preferable. Shooting and hauling the gear should be continuous and the profile should be as uniform as possible. The time from the sampler going below the surface until it comes back should be measured and reported as haul duration. Samples can be taken working throughout the available 24 hour periods.

4. Treatment of samples

4.1 Washing the net

After hauling the sampler should be placed in an upright position on deck to ensure that no part of the sample is running out from the net basket back into the net. The net should be gently spoiled with sea water before removing the sampling bag. Washing with a too powerful jet can cause severe damage to the larvae.

4.2 Sample fixation

The standard fixative is a 4% buffered formaldehyde solution in water (fresh or distilled). This solution is approximately isotonic with seawater and should be used in preference to 4% formaldehyde in seawater. The sample should not come in contact with formaldehyde strength in excess of 4%; therefore water should be added to the sample first whenever higher concentrations are used to produce the 4% solution directly in the sample jar.

The 4% formaldehyde should be made up as follows: 1 part of 40% formaldehyde and 9 parts of water. An appropriate buffer of 7 – 8 is to be used (e.g., 2 gram borax added to 98 ml of 40% formaldehyde).

The plankton volume should not exceed 50% of the volume of the jar. If the sample contains more plankton, additional jars should be used for storage.

Fixation should take place immediately after retrieval of the sample from the tow net and before any sub sampling.

4.3 Stations with high records of small larvae

To ensure that stations with high densities of small larvae are recognize early enough to conduct additional sampling within that square, the samples should be checked directly after each haul. If the sample is believed to contain more than 1000 small larvae (<10 mm), three additional stations in that square are recommended. These stations should be placed around 2 miles from the centre of the 10x10 nm grid.

4.4 Sorting and measuring

Prior to sorting larvae must be exposed for at least 48 hours into the conservation fluid to ensure proper fixation. After sorting larvae should be stored again in a 4% formaldehyde-water solution to keep larvae shrinkage comparable.

It is advisable that all larvae are sorted and counted in all samples. However, if this is not possible sub sampling techniques may be used. The larvae tend to aggregate with plankton and other larvae, thus splitting the sample just in two halves is preferred instead of multiple splitting.

Whenever available, a sub sample of at least 200 larvae per station should be measured. All larvae should be measured as total length and to millimetre below (e.g., 10 mm size-group ranges from 10.00 to 10.99 mm).

Yolk-sac larvae should be included in the measurements. If yolk-sac larvae are detected in the samples, their number should be reported to aid in the localization of spawning grounds.

For identification of clupeid larvae Russell (1976) can be recommended. For species identification of herring and sprat, myotomes should be counted from a reasonable amount in all size groups in a sample.

5. Data Treatment

5.1 Data Sheet

For each station the minimum amount of information is the station and haul number, position, date and time (UTC), haul duration, flowmeter revolutions, bottom and sampler depth, water bottom temperature and ship's direction. For the whole cruise information on gear type and flowmeter calibration is needed. After finalization of larvae measurements information about the length distribution must be given for each specific station. An example for the data sheet is given in the Annex 6.5.

5.2 Calculations

The numbers of larvae per square metre at each station can be calculated as:

$$n/m^2 = \frac{larvae\ per\ sample\ (n) * bottom\ depth\ (m)}{volume\ filtered\ (m^3)}$$

The volume filtered is obtained from the formula:

$$Volume\ \ filtered \quad = \quad \frac{area\ of\ \ mouth\ opening\ (m^2)*efficieny\ \ factor*flowmeter\ revolutions}{flowmeter\ calibration\ constant}$$

5.3 Data exchange

The International Herring Larvae Database is held at the Leibniz Institute of Marine Sciences in Kiel, Germany. Excel Spreadsheets with the requested data should be sent to the Institute as soon as they are available. Reporting should be done not later than the third week in February to ensure that there is enough time for the necessary database update and the specific calculation procedures prior to the Meeting of the Herring Assessment Working Group (HAWG).

5.4 Database

The herring larval data is updated annually since 1972. The database contains the following information:

a) general heading information listing the area surveyed, the survey vessel, the flowmeter calibration in revolutions per metre, the type of gear and the survey dates

b) Location and sampling details, e.g., the date and position of the haul, the time (UTC) of the haul, the sampler and bottom depths, the hauls duration and the total number of larvae taken in the haul

c) the length distributions of the measured larvae

d) larvae abundance estimates for the relevant length classes at each station (n/m²)

5.5 Larvae Abundance Index

The calculation procedure for the larval abundance index (LAI) follows in principle the procedure described in the IHLS documentation (Anon. 1995).

Four spawning areas are distinguished and sampled separate. In order to define how complete the area and time units have been sampled, a coverage value is defined and expressed as percentage standard positions sampled within each unit:

$$Coverage_{Year,Unit} = \frac{sampled\ \ positions_{Year,Unit}}{standard\ \ positions\ in\ the\ area\ definition\ \ file_{Unit}} * 100$$

For each year and standard position the measured larvae are aggregated into the following three length frequency distribution groupings:

- 5mm ≤ larvae < 10 mm (< 11 mm for the Southern North Sea)
- 10 mm ≤ larvae ≤ 15 mm (11 mm ≤ larvae ≤ 16 mm for the SNS)
- 15mm ≤ larvae ≤ 24 mm (16 mm ≤ larvae ≤ 24 mm for the SNS)

Larvae numbers per square metre are calculated for each year and position by the formulae given below for three time periods separately. The differences in these formulae reflect changes in the information given for flowmeter calibrations:

a) 1972 – 1980

$$n/m^2_{Year,10x10\ rectangle} = grouped\ LFD * (\frac{Total\ n/m^2}{Total\ LFD * Efficieny\ Factor})$$

b) 1981 – 1982

$$Raising\ Factor = \frac{total\ n\ caught}{total\ LFD}$$

$$Calibration\ Factor = \frac{flowmeter\ calibration * bottom\ depth}{flowmeter\ revolutions * pi * \left(\frac{aperture}{2}\right)^2 * efficiency\ \ factor}$$

$$n/m^2_{Year,10*10\ rectangle} = grouped\ LFD * raising\ \ factor * calibration\ \ factor$$

c) from 1983 onwards

$$Raising\ Factor = \frac{total\ n\ caught}{total\ measured}$$

$$Calibration\ Factor = \frac{flowmeter\ calibration * bottom\ depth}{flowmeter\ revolutions * pi * \left(\frac{aperture}{2}\right)^2 * efficiency\ \ factor}$$

$$n/m^2_{Year,10*10\ rectangle} = grouped\ LFD * raising\ \ factor * calibration\ \ factor$$

In case of replicate sampling within a 10*10 nm rectangle and time period, the number of larvae obtained is averaged. If sampling was done within a three days interval, the number of larvae within this three days interval is average first. Afterwards the number of larvae for all observations at this station within the half month period is averaged.

The number of larvae per square metre at each station is used to calculate mean numbers of larvae per m² for each 10*20nm rectangle (consists of 9 stations in total). These values are raised by the sea surface corresponding to that rectangle, i.e.,

$$\overline{n/m^2_{\ Year,10\ *20\ rectangle}} = \frac{1}{n}\sum n/m^2_{\ Year,10\ *10\ rectangle}$$

$$LAI_{Year,10*20\ rectangle} = \overline{n/m^2_{\ Year,10*20\ rectangle}} * Area_{10*20\ rectangle}$$

These estimates are summed up to calculate larval abundance indices and related coefficients of variance (CVs) for each LAI unit and year, i.e.,

$$LAI_{Year,Unit} = \sum LAI_{Year,10*20\ rectangle}$$

$$CV(LAI_{Year,Unit}) = \frac{\sigma(LAI_{Year,Unit})}{\overline{LAI_{Year,Unit}}} * 100$$

where $\sigma(LAI_{Year,\ Unit})$ is the standard deviation and $\overline{LAI_{Year,Unit}}$ the mean Larval abundance index calculated per year and unit.

The methods used for the calculation of abundance indices are described in Rohlf *et al.* (1998) in detail.

References

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Gröger, J.; D. Schnack and N. Rohlf (2001): Optimisation of survey design and calculation procedure for the International Herring Larvae Survey in the North Sea. Arch. Fish. Mar. Res. 49 (2): 103–116.

Rohlf, N.; J. Gröger and D. Schnack (1998). Effects of calculation procedure and reduced sampling effort on abundance indices of herring larvae as measure of spawning stock size. ICES C.M. 1998/BB:04.

Russell, F.S. (1976): The Eggs and Planktonic Stages of British Marine Fishes. Academic Press, London.

6. Appendix

6.1 Surveys in the Orkney/Shetland area

Table 6.1.1 Positions in Orkney/Shetlands, 01.09. – 15.09. (Area code B1).

Latitude	Longitude	ICES-Code
59°55N	03°50W	48E6a
59°55N	03°30W	48E6b
59°55N	03°10W	48E6c
59°55N	02°50W	48E7a
59°55N	02°30W	48E7b
59°55N	02°10W	48E7c
59°55N	01°50W	48E8a
59°55N	01°30W	48E8b
59°55N	01°10W	48E8c
59°45N	03°50W	48E6d
59°45N	03°30W	48E6e
59°45N	03°10W	48E6f
59°45N	02°50W	48E7d
59°45N	02°30W	48E7e
59°45N	02°10W	48E7f
59°45N	01°50W	48E8d
59°45N	01°30W	48E8e
59°45N	01°10W	48E8f
59°35N	03°50W	48E6g
59°35N	03°30W	48E6h
59°35N	03°10W	48E6i
59°35N	02°50W	48E7g
59°35N	02°30W	48E7h
59°35N	02°10W	48E7i
59°35N	01°50W	48E8g
59°35N	01°30W	48E8h
59°35N	01°10W	48E8i
59°25N	03°50W	47E6a
59°25N	03°30W	47E6b
59°25N	03°10W	47E6c
59°25N	02°50W	47E7a
59°25N	02°30W	47E7b
59°25N	02°10W	47E7c
59°25N	01°50W	47E8a
59°25N	01°30W	47E8b
59°25N	01°10W	47E8c
59°15N	03°50W	47E6d
59°15N	03°30W	47E6e
59°15N	03°10W	47E6f
59°15N	02°30W	47E7e
59°15N	02°10W	47E7f
59°15N	01°50W	47E8d
59°15N	01°30W	47E8e
59°15N	01°10W	47E8f
59°05N	03°50W	47E6g
59°05N	03°30W	47E6h
59°05N	02°30W	47E7h
59°05N	02°10W	47E7i
59°05N	01°50W	47E8g

Latitude	Longitude	ICES-Code
59°05N	01°30W	47E8h
59°05N	01°10W	47E8i
58°55N	03°50W	46E6a
58°55N	03°30W	46E6b
58°55N	02°30W	46E7b
58°55N	02°10W	46E7c
58°55N	01°50W	46E8a
58°55N	01°30W	46E8b
58°55N	01°10W	46E8c
58°45N	03°50W	46E6d
58°45N	03°30W	46E6e
58°45N	02°50W	46E7d
58°45N	02°30W	46E7e
58°45N	02°10W	46E7f
58°45N	01°50W	46E8d
58°45N	01°30W	46E8e
58°45N	01°10W	46E8f
58°35N	03°50W	46E6g
58°35N	03°30W	46E6h
58°35N	03°10W	46E6i
58°35N	02°50W	46E7g
58°35N	02°30W	46E7h
58°35N	02°10W	46E7i
58°35N	01°50W	46E8g
58°35N	01°30W	46E8h
58°35N	01°10W	46E8i
58°25N	03°10W	45E6c
58°25N	02°50W	45E7a
58°25N	02°30W	45E7b
58°25N	02°10W	45E7c
58°25N	01°50W	45E8b
58°25N	01°30W	45E8b
58°25N	01°10W	45E8c
58°15N	03°10W	45E6f
58°15N	02°50W	45E7d
58°15N	02°30W	45E7e
58°15N	02°10W	45E7f
58°15N	01°50W	45E8d
58°15N	01°30W	45E8e
58°15N	01°10W	45E8f
58°05N	03°30W	45E6h
58°05N	03°10W	45E6i
58°05N	02°50W	45E7g
58°05N	02°30W	45E7h
58°05N	02°10W	45E7i
58°05N	01°50W	45E8g
58°05N	01°30W	45E8h
58°05N	01°10W	45E8i

Table 6.1.2. Positions in Orkney/Shetlands, 15.09. – 30.09. (Area code B2).

Latitude	Longitude	ICES-Code
59°55N	03°30W	48E6b
59°55N	03°10W	48E6c
59°55N	02°50W	48E7a
59°55N	02°30W	48E7b
59°55N	02°10W	48E7c
59°55N	01°50W	48E8a
59°55N	01°30W	48E8b
59°55N	01°10W	48E8c
59°45N	03°30W	48E6e
59°45N	03°10W	48E6f
59°45N	02°50W	48E7d
59°45N	02°30W	48E7e
59°45N	02°10W	48E7f
59°45N	01°50W	48E8d
59°45N	01°30W	48E8e
59°45N	01°10W	48E8f
59°35N	03°50W	48E6g
59°35N	03°30W	48E6h
59°35N	03°10W	48E6i
59°35N	02°50W	48E7g
59°35N	02°30W	48E7h
59°35N	02°10W	48E7i
59°35N	01°50W	48E8g
59°35N	01°30W	48E8h
59°35N	01°10W	48E8i
59°25N	03°50W	47E6a
59°25N	03°30W	47E6b
59°25N	03°10W	47E6c
59°25N	02°50W	47E7a
59°25N	02°30W	47E7b
59°25N	02°10W	47E7c
59°25N	01°50W	47E8a
59°25N	01°30W	47E8b
59°25N	01°10W	47E8c
59°15N	03°50W	47E6d
59°15N	03°30W	47E6e
59°15N	03°10W	47E6f
59°15N	02°30W	47E7e
59°15N	02°10W	47E7f
59°15N	01°50W	47E8d
59°15N	01°30W	47E8e
59°15N	01°10W	47E8f
59°05N	03°50W	47E6g
59°05N	03°30W	47E6h
59°05N	02°30W	47E7h
59°05N	02°10W	47E7i
59°05N	01°50W	47E8g

Latitude	Longitude	ICES-Code
59°05N	01°30W	47E8h
59°05N	01°10W	47E8i
58°55N	03°50W	46E6a
58°55N	03°30W	46E6b
58°55N	02°30W	46E7b
58°55N	02°10W	46E7c
58°55N	01°50W	46E8a
58°55N	01°30W	46E8b
58°55N	01°10W	46E8c
58°45N	03°50W	46E6d
58°45N	03°30W	46E6e
58°45N	02°50W	46E7d
58°45N	02°30W	46E7e
58°45N	02°10W	46E7f
58°45N	01°50W	46E8d
58°45N	01°30W	46E8e
58°45N	01°10W	46E8f
58°35N	03°50W	46E6g
58°35N	03°30W	46E6h
58°35N	03°10W	46E6i
58°35N	02°50W	46E7g
58°35N	02°30W	46E7h
58°35N	02°10W	46E7i
58°35N	01°50W	46E8g
58°35N	01°30W	46E8h
58°35N	01°10W	46E8i
58°25N	03°10W	45E6c
58°25N	02°50W	45E7a
58°25N	02°30W	45E7b
58°25N	02°10W	45E7c
58°25N	01°50W	45E8a
58°25N	01°30W	45E8b
58°25N	01°10W	45E8b
58°15N	03°10W	45E6f
58°15N	02°50W	45E7d
58°15N	02°30W	45E7e
58°15N	02°10W	45E7f
58°15N	01°50W	45E8d
58°15N	01°30W	45E8e
58°15N	01°10W	45E8f
58°05N	03°30W	45E6h
58°05N	03°10W	45E6i
58°05N	02°50W	45E7g
58°05N	02°30W	45E7h
58°05N	02°10W	45E7i
58°05N	01°50W	45E8g
58°05N	01°30W	45E8h
58°05N	01°10W	45E8i

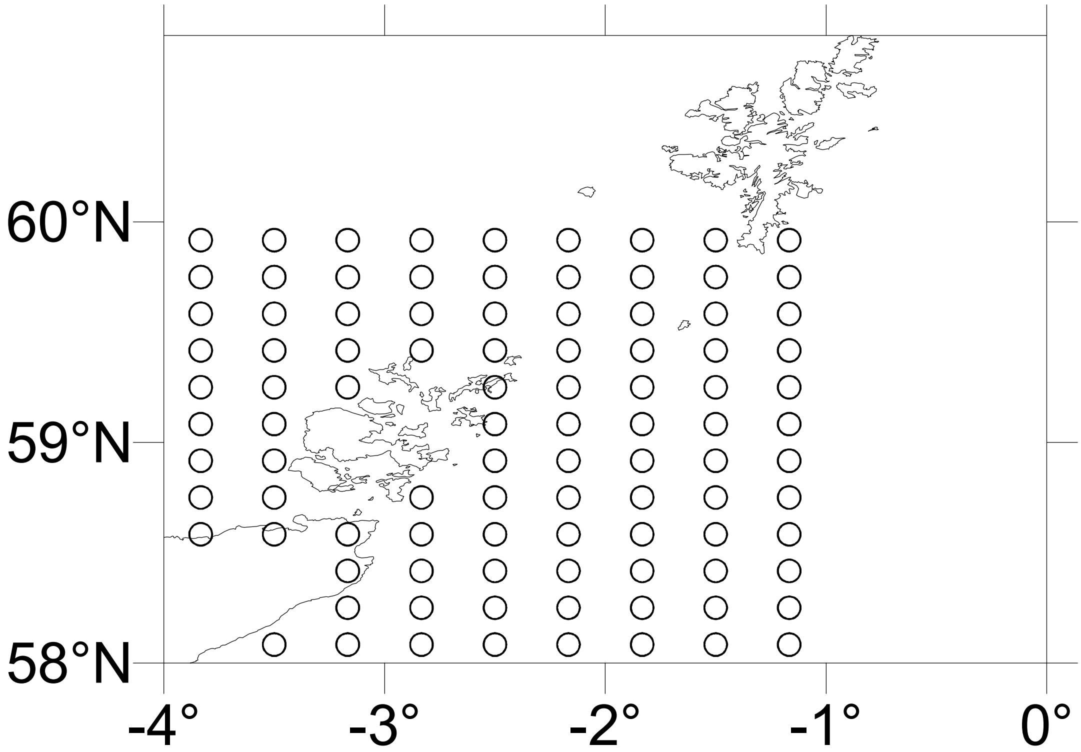

Figure 6.1.1 Station grid in Orkney/Shetlands, 01.09. – 15.09.

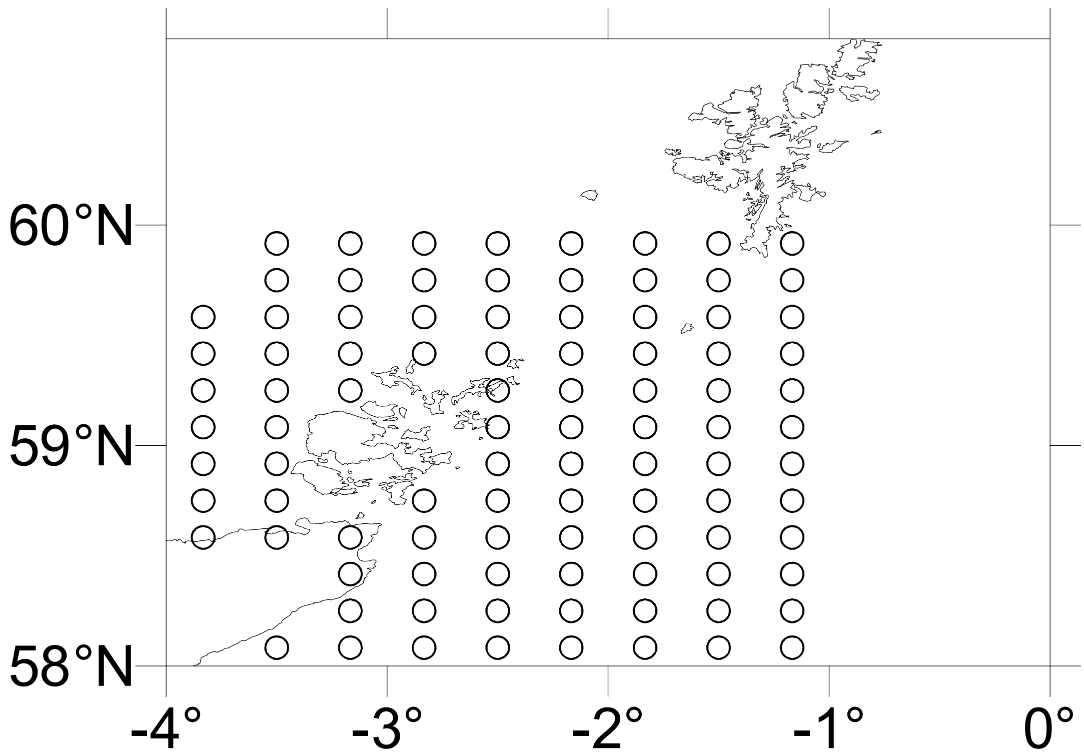

Figure6.1.2. Station grid in Orkney/Shetlands, 15.09. – 30.09.

6.2 Surveys in the Buchan area

Table 6.2.1 Positions in the Buchan-Area, 01.09. – 15.09. (Area code C1).

Latitude	Longitude	ICES-Code
57°55N	03°50W	44E6a
57°55N	03°30W	44E6b
57°55N	03°10W	44E6c
57°55N	02°50W	44E7a
57°55N	02°30W	44E7b
57°55N	02°10W	44E7c
57°55N	01°50W	44E8a
57°55N	01°30W	44E8b
57°55N	01°10W	44E8c
57°55N	00°50W	44E9a
57°45N	03°50W	44E6d
57°45N	03°30W	44E6e
57°45N	03°10W	44E6f
57°45N	02°50W	44E7d
57°45N	02°30W	44E7e
57°45N	02°10W	44E7f
57°45N	01°50W	44E8d
57°45N	01°30W	44E8e
57°45N	01°10W	44E8f
57°45N	00°50W	44E9d
57°35N	01°50W	44E8g
57°35N	01°30W	44E8h
57°35N	01°10W	44E8i
57°35N	00°50W	44E9g
57°25N	01°50W	43E8a
57°25N	01°30W	43E8b
57°25N	01°10W	43E8c
57°25N	00°50W	43E9a
57°25N	00°30W	43E9b
57°25N	00°10W	43E9c
57°15N	01°50W	43E8d
57°15N	01°30W	43E8e
57°15N	01°10W	43E8f
57°15N	00°50W	43E9d
57°15N	00°30W	43E9e
57°15N	00°10W	43E9f
57°05N	01°50W	43E8g
57°05N	01°30W	43E8h
57°05N	01°10W	43E8i

Latitude	Longitude	ICES-Code
57°05N	00°50W	43E9g
57°05N	00°30W	43E9h
57°05N	00°10W	43E9i
56°55N	02°10W	42E7c
56°55N	01°50W	42E8a
56°55N	01°30W	42E8b
56°55N	01°10W	42E8c
56°55N	00°50W	42E9a
56°55N	00°30W	42E9b
56°55N	00°10W	42E9c
56°45N	02°10W	42E7f
56°45N	01°50W	42E8d
56°45N	01°30W	42E8e
56°45N	01°10W	42E8f
56°45N	00°50W	42E9d
56°45N	00°30W	42E9e
56°45N	00°10W	42E9f
56°35N	02°10W	42E7i
56°35N	01°50W	42E8g
56°35N	01°30W	42E8h
56°35N	01°10W	42E8i
56°35N	00°50W	42E9g
56°35N	00°30W	42E9h
56°35N	00°10W	42E9i
56°25N	02°10W	41E7c
56°25N	01°50W	41E8a
56°25N	01°30W	41E8b
56°25N	01°10W	41E8c
56°25N	00°50W	41E9a
56°15N	02°30W	41E7e
56°15N	02°10W	41E7f
56°15N	01°50W	41E8d
56°15N	01°30W	41E8e
56°15N	01°10W	41E8f
56°15N	00°50W	41E9d
56°05N	02°10W	41E7i
56°05N	01°50W	41E8g
56°05N	01°30W	41E8h
56°05N	01°10W	41E8i
56°05N	00°50W	41E9g

Table 6.2.2. Positions in the Buchan-Area, 16.09. – 30.09. (Area code C2).

Latitude	Longitude	ICES-Code
57°55N	02°50W	44E7a
57°55N	02°30W	44E7b
57°55N	02°10W	44E7c
57°55N	01°50W	44E8a
57°55N	01°30W	44E8b
57°55N	01°10W	44E8c
57°55N	00°50W	44E9a
57°45N	02°50W	44E7d
57°45N	02°30W	44E7e
57°45N	02°10W	44E7f
57°45N	01°50W	44E8d
57°45N	01°30W	44E8e
57°45N	01°10W	44E8f
57°45N	00°50W	44E9d
57°35N	01°50W	44E8g
57°35N	01°30W	44E8h
57°35N	01°10W	44E8i
57°35N	00°50W	44E9g
57°25N	01°50W	43E8a
57°25N	01°30W	43E8b
57°25N	01°10W	43E8c
57°25N	00°50W	43E9a
57°25N	00°30W	43E9b
57°25N	00°10W	43E9c
57°15N	01°50W	43E8d
57°15N	01°30W	43E8e
57°15N	01°10W	43E8f
57°15N	00°50W	43E9d
57°15N	00°30W	43E9e
57°15N	00°10W	43E9f
57°05N	01°50W	43E8g
57°05N	01°30W	43E8h
57°05N	01°10W	43E8i
57°05N	00°50W	43E9g
57°05N	00°30W	43E9h
57°05N	00°10W	43E9i
56°55N	02°10W	42E7c

Latitude	Longitude	ICES-Code
56°55N	01°50W	42E8a
56°55N	01°30W	42E8b
56°55N	01°10W	42E8c
56°55N	00°50W	42E9a
56°55N	00°30W	42E9b
56°55N	00°10W	42E9c
56°45N	02°10W	42E7f
56°45N	01°50W	42E8d
56°45N	01°30W	42E8e
56°45N	01°10W	42E8f
56°45N	00°50W	42E9d
56°45N	00°30W	42E9e
56°45N	00°10W	42E9f
56°35N	02°10W	42E7i
56°35N	01°50W	42E8g
56°35N	01°30W	42E8h
56°35N	01°10W	42E8i
56°35N	00°50W	42E9g
56°35N	00°30W	42E9h
56°35N	00°10W	42E9i
56°25N	02°10W	41E7c
56°25N	01°50W	41E8a
56°25N	01°30W	41E8b
56°25N	01°10W	41E8c
56°25N	00°50W	41E9a
56°15N	02°30W	41E7e
56°15N	02°10W	41E7f
56°15N	01°50W	41E8d
56°15N	01°30W	41E8e
56°15N	01°10W	41E8f
56°15N	00°50W	41E9d
56°05N	02°10W	41E7i
56°05N	01°50W	41E8g
56°05N	01°30W	41E8h
56°05N	01°10W	41E8i
56°05N	00°50W	41E9g

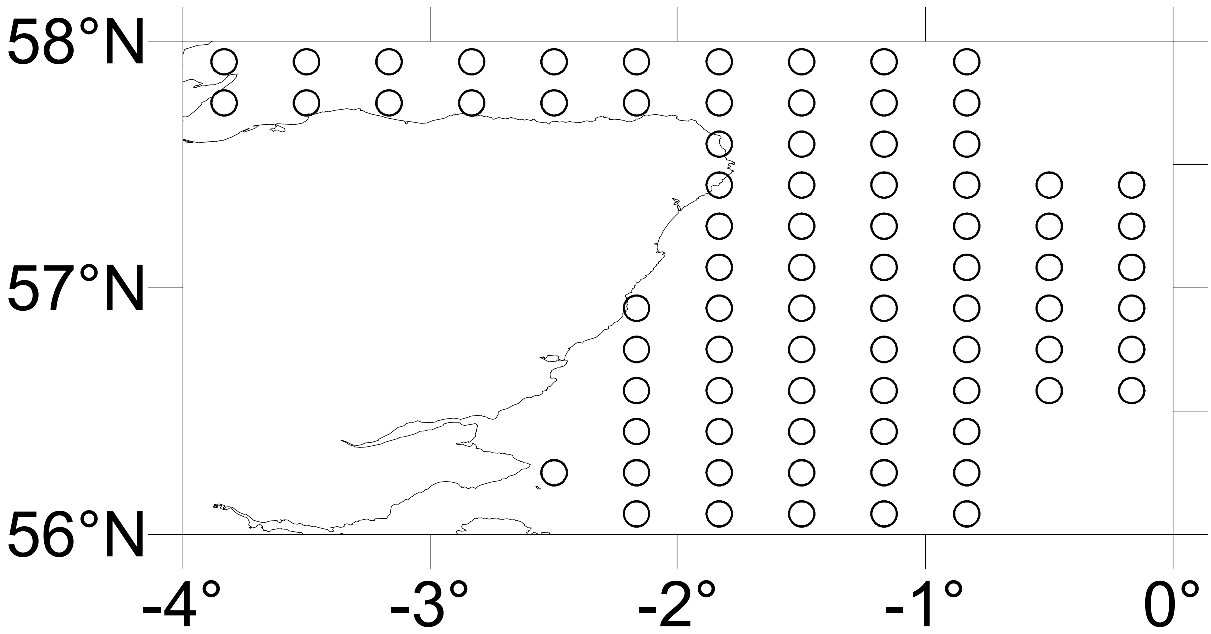

Figure 6.2.1. Station grid in the Buchan-Area, 01.09. – 15.09.

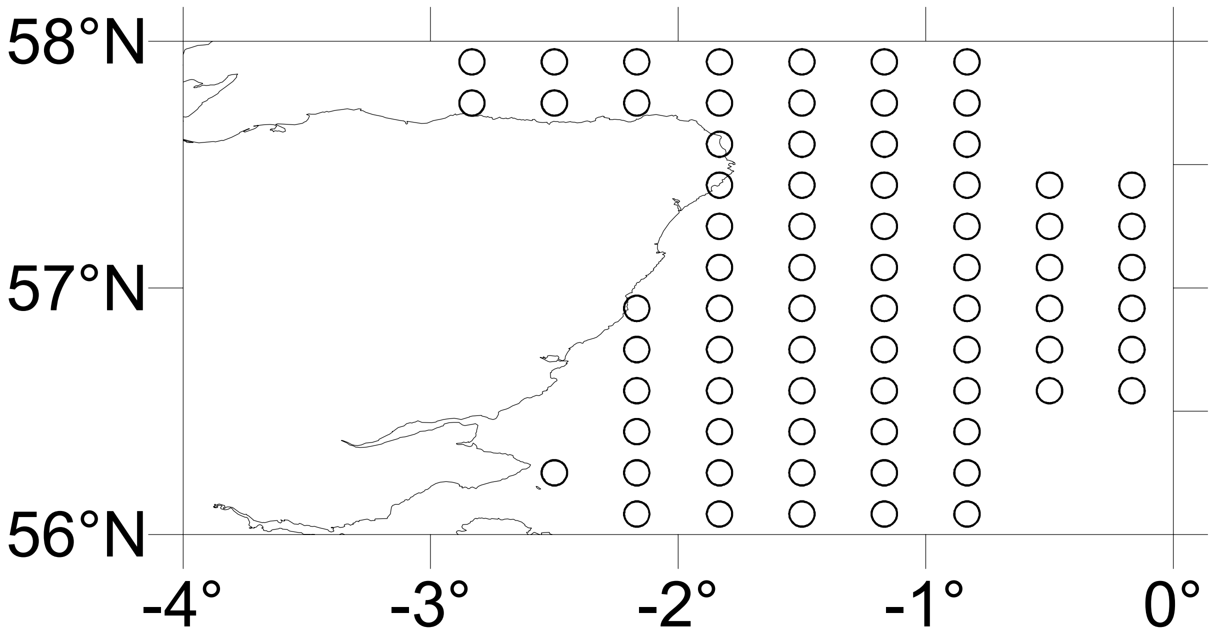

Figure 6.2.2. Station grid in the Buchan-Area, 15.09. – 30.09.

6.3 Surveys in the Central North Sea

Table 6.3.1. Positions in the Central North Sea, 01.09. – 15.09. (Area code D1).

Latitude	Longitude	ICES-Code
55°55N	01°50W	40E8a
55°55N	01°30W	40E8b
55°55N	01°10W	40E8c
55°55N	00°50W	40E9a
55°45N	01°50W	40E8d
55°45N	01°30W	40E8e
55°45N	01°10W	40E8f
55°45N	00°50W	40E9d
55°35N	01°30W	40E8h
55°35N	01°10W	40E8i
55°35N	00°50W	40E9g
55°35N	00°30W	40E9h
55°25N	01°30W	39E8b
55°25N	01°10W	39E8c
55°25N	00°50W	39E9a
55°15N	01°30W	39E8e
55°15N	01°10W	39E8f
55°15N	00°50W	39E9d
55°05N	01°10W	39E8i
55°05N	00°50W	39E9g
55°05N	00°30W	39E9h
54°55N	01°10W	38E8c
54°55N	00°50W	38E9a
54°55N	00°30W	38E9b
54°55N	00°10W	38E9c
54°45N	01°10W	38E8f
54°45N	00°50W	38E9d
54°45N	00°30W	38E9e
54°45N	00°10W	38E9f
54°45N	00°10E	38F0d
54°45N	00°30E	38F0e
54°45N	00°50E	38F0f
54°35N	00°50W	38E9g
54°35N	00°30W	38E9h
54°35N	00°10W	38E9i
54°35N	00°10E	38F0g
54°35N	00°30E	38F0h
54°35N	00°50E	38F0i
54°35N	01°10E	38F1g
54°25N	00°10W	37E9c
54°25N	00°10W	37F0a
54°25N	00°30W	37F0b
54°25N	00°50W	37F0c
54°25N	01°10W	37F1a
54°15N	00°10W	37E9f
54°15N	00°10E	37F0d
54°15N	00°30E	37F0e
54°15N	00°50E	37F0f
54°15N	01°10E	37F1d
54°05N	00°10E	37F0g
54°05N	00°30E	37F0h
54°05N	00°50E	37F0i
54°05N	01°10E	37F1g
53°55N	00°10E	36F0a
53°55N	00°30E	36F0b
53°55N	00°50E	36F0c
53°55N	01°10E	36F1a
53°45N	00°10E	36F0d
53°45N	00°30E	36F0e
53°45N	00°50E	36F0f
53°45N	01°10E	36F1d
53°35N	00°30E	36F0h
53°35N	00°50E	36F0i
53°35N	01°10E	36F1g

Table 6.3.2. Positions in the Central North Sea, 16.09. – 30.09. (Area code D2).

Latitude	Longitude	ICES-Code
55°55N	01°50W	40E8a
55°55N	01°30W	40E8b
55°55N	01°10W	40E8c
55°55N	00°50W	40E9a
55°45N	01°50W	40E8d
55°45N	01°30W	40E8e
55°45N	01°10W	40E8f
55°45N	00°50W	40E9d
55°35N	01°30W	40E8h
55°35N	01°10W	40E8i
55°35N	00°50W	40E9g
55°25N	01°30W	39E8b
55°25N	01°10W	39E8c
55°25N	00°50W	39E9a
55°15N	01°30W	39E8e
55°15N	01°10W	39E8f
55°15N	00°50W	39E9d
55°05N	01°10W	39E8i
55°05N	00°50W	39E9g
55°05N	00°30W	39E9h
54°55N	01°10W	38E8c
54°55N	00°50W	38E9a
54°55N	00°30W	38E9b
54°55N	00°10W	38E9c
54°45N	01°10W	38E8f
54°45N	00°50W	38E9d
54°45N	00°30W	38E9e
54°45N	00°10W	38E9f
54°45N	00°10E	38F0d
54°35N	00°50W	38E9g
54°35N	00°30W	38E9h
54°35N	00°10W	38E9i
54°35N	00°10E	38F0g
54°35N	00°30E	38F0h
54°35N	00°50E	38F0i
54°35N	01°10E	38F1g
54°25N	00°10W	37E9c
54°25N	00°10E	37F0a
54°25N	00°30E	37F0b
54°25N	00°50E	37F0c
54°25N	01°10E	37F1a
54°25N	01°30E	37F1b
54°15N	00°10W	37E9f
54°15N	00°10E	37F0d
54°15N	00°30E	37F0e
54°15N	00°50E	37F0f
54°15N	01°10E	37F1d
54°15N	01°30E	37F1e
54°05N	00°10E	37F0g
54°05N	00°30E	37F0h
54°05N	00°50E	37F0i
54°05N	01°10E	37F1g
54°05N	01°30E	37F1h
53°55N	00°10E	36F0a
53°55N	00°30E	36F0b
53°55N	00°50E	36F0c
53°55N	01°10E	36F1a
53°55N	01°30E	36F1b
53°45N	00°10E	36F0d
53°45N	00°30E	36F0e
53°45N	00°50E	36F0f
53°45N	01°10E	36F1d
53°45N	01°30E	36F1e
53°35N	00°30E	36F0h
53°35N	00°50E	36F0i
53°35N	01°10E	36F1g
53°35N	01°30E	36F1h

Table 6.3.3. Positions in the Central North Sea, 01.10. – 15.10. (Area code D3).

Latitude	Longitude	ICES-Code
55°55N	01°50W	40E8a
55°55N	01°30W	40E8b
55°55N	01°10W	40E8c
55°55N	00°50W	40E9a
55°55N	00°30W	40E9b
55°55N	00°10W	40E9c
55°45N	01°50W	40E8d
55°45N	01°30W	40E8e
55°45N	01°10W	40E8f
55°45N	00°50W	40E9d
55°45N	00°30W	40E9e
55°45N	00°10W	40E9f
55°35N	01°30W	40E8h
55°35N	01°10W	40E8i
55°35N	00°50W	40E9g
55°35N	00°30W	40E9h
55°35N	00°10W	40E9i
55°25N	01°30W	39E8b
55°25N	01°10W	39E8c
55°25N	00°50W	39E9a
55°25N	00°30W	39E9b
55°25N	00°10W	39E9c
55°15N	01°30W	39E8e
55°15N	01°10W	39E8f
55°15N	00°50W	39E9d
55°15N	00°30W	39E9e
55°15N	00°10W	39E9f
55°05N	01°10W	39E8i
55°05N	00°50W	39E9g
55°05N	00°30W	39E9h
55°05N	00°10W	39E9i
54°55N	01°10W	38E8c
54°55N	00°50W	38E9a
54°55N	00°30W	38E9b
54°55N	00°10W	38E9c
54°55N	00°10E	38F0a
54°55N	00°30E	38F0b
54°55N	00°50E	38F0c
54°55N	01°10E	38F1a
54°55N	01°30E	38F1b
54°55N	01°50E	38F1c
54°45N	01°10W	38E8f
54°45N	00°50W	38E9d
54°45N	00°30W	38E9e
54°45N	00°10W	38E9f
54°45N	00°10E	38F0d
54°45N	00°30E	38F0e
54°45N	00°50E	38F0f
54°45N	01°10E	38F1d
54°45N	01°30E	38F1e
54°45N	01°50E	38F1f
54°35N	00°30W	38E9h
54°35N	00°10W	38E9i
54°35N	00°10E	38F0g
54°35N	00°30E	38F0h
54°35N	00°50E	38F0i
54°35N	01°10E	38F1g
54°35N	01°30E	38F1h
54°35N	01°50E	38F1i
54°25N	00°10W	37E9c
54°25N	00°10E	37F0a
54°25N	00°30E	37F0b
54°25N	00°50E	37F0c
54°25N	01°10E	37F1a
54°25N	01°30E	37F1b
54°25N	01°50E	37F1c
54°25N	02°10E	37F2a
54°25N	02°30E	37F2b
54°15N	00°10W	37E9f
54°15N	00°10E	37F0d
54°15N	00°30E	37F0e
54°15N	00°50E	37F0f
54°15N	01°10E	37F1d
54°15N	01°30E	37F1e
54°15N	01°50E	37F1f
54°15N	02°10E	37F2d
54°15N	02°30E	37F2e
54°05N	00°10E	37F0g
54°05N	00°30E	37F0h
54°05N	00°50E	37F0h
54°05N	01°10E	37F1g
54°05N	01°30E	37F1h
54°05N	01°50E	37F1i
54°05N	02°10E	37F2g
54°05N	02°30E	37F2h
53°55N	00°10E	36F0a
53°55N	00°30E	36F0b
53°55N	00°50E	36F0c
53°55N	01°10E	36F1a
53°55N	01°30E	36F1b
53°55N	01°50E	36F1c
53°55N	02°10E	36F2a
53°55N	02°30E	36F2b
53°55N	02°50E	36F2c
53°45N	00°10E	36F0d
53°45N	00°30E	36F0e
53°45N	00°50E	36F0f
53°45N	01°10E	36F1d
53°45N	01°30E	36F1e
53°45N	01°50E	36F1f
53°45N	02°10E	36F2d
53°45N	02°30E	36F2e
53°45N	02°50E	36F2f
53°35N	00°30E	36F0h
53°35N	00°50E	36F0i
53°35N	01°10E	36F1g
53°35N	01°30E	36F1h
53°35N	01°50E	36F1i
53°35N	02°10E	36F2g
53°35N	02°30E	36F2h
53°35N	02°50E	36F2i

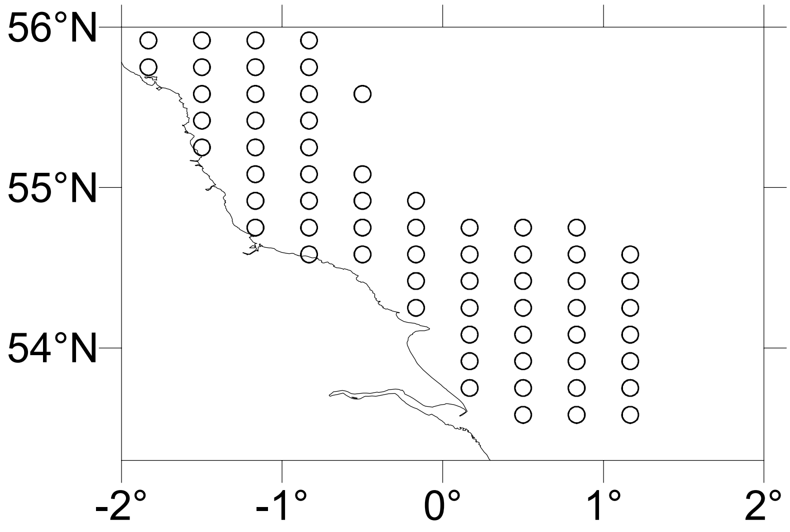

Figure 6.3.1. Station grid in the Central North Sea, 01.09. – 15.09.

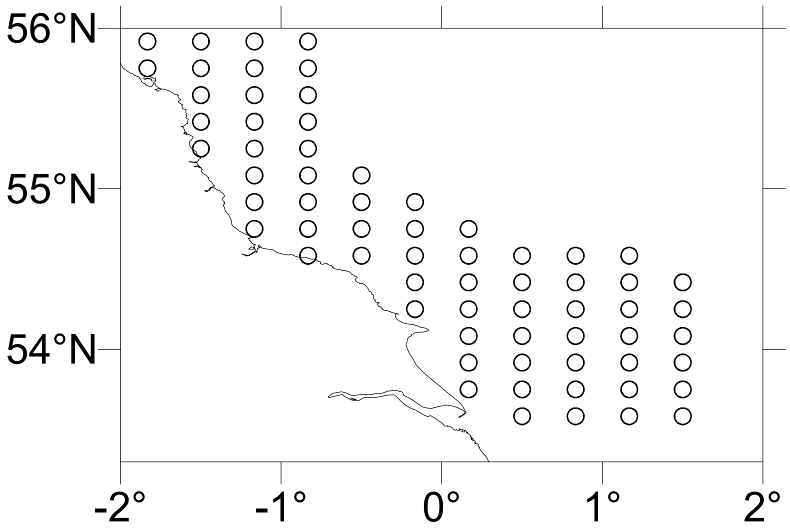

Figure 6.3.2. Station grid in the Central North Sea, 16.09 – 30.09.

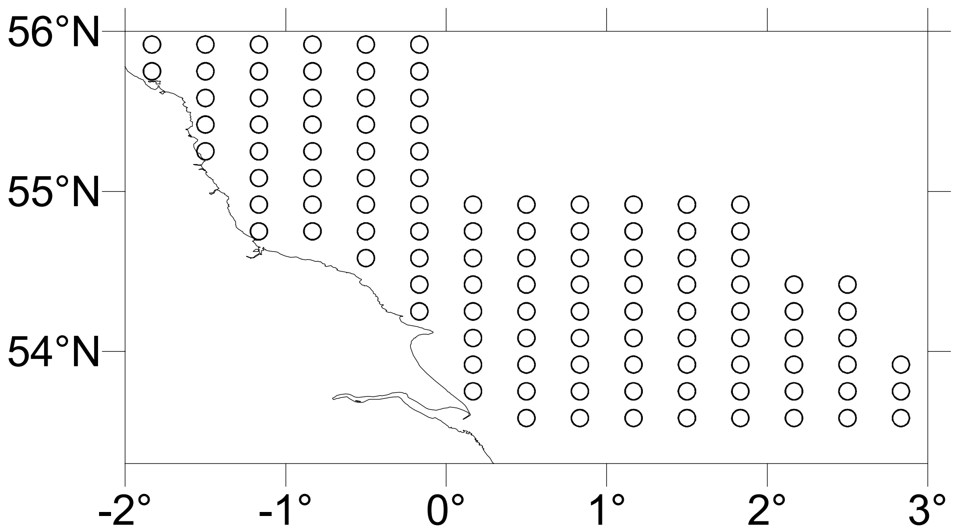

Figure 6.3.3. Station grid in the Central North Sea, 01.10. – 15.10.

6.4 Surveys in the Southern North Sea

Table 6.4.1. Positions in the Southern North Sea, 16.12. – 31.12. (Area code E1).

Latitude	Longitude	ICES-Code
51°55N	02°30E	33F2a
51°55N	02°50E	33F2b
51°55N	03°10E	33F2c
51°45N	02°10E	33F3a
51°45N	02°30E	33F3b
51°45N	02°50E	33F3c
51°45N	03°10E	33F4a
51°35N	01°50E	33F2d
51°35N	02°10E	33F2e
51°35N	02°30E	33F2f
51°35N	02°50E	33F3d
51°35N	03°10E	33F3e
51°25N	01°50E	33F3f
51°25N	02°10E	33F4d
51°25N	02°30E	33F2g
51°25N	02°50E	33F2h
51°15N	01°50E	33F2i
51°15N	02°10E	33F3g
51°05N	01°30E	33F3h
51°05N	01°50E	33F3i
50°55N	01°10E	32F2a
50°55N	01°30E	32F2b
50°45N	00°50E	32F2c
50°45N	01°10E	32F3a
50°45N	01°30E	32F3b
50°35N	00°10E	32F1f
50°35N	00°30E	32F2d
50°35N	00°50E	32F2e
50°35N	01°10E	32F2f

Latitude	Longitude	ICES-Code
50°35N	01°30E	32F3d
50°25N	00°10E	32F3e
50°25N	00°30E	32F1i
50°25N	00°50E	32F2g
50°25N	01°10E	32F2h
50°25N	01°30E	32F2i
50°15N	00°10W	32F3g
50°15N	00°10E	31F1c
50°15N	00°30E	31F2a
50°15N	00°50E	31F2b
50°15N	01°10E	31F2c
50°05N	00°30W	31F1f
50°05N	00°10W	31F2d
50°05N	00°10E	31F2e
50°05N	00°30E	31F1h
50°05N	00°50E	31F1i
50°05N	01°10E	30F1a
49°55N	00°30W	30F1b
49°55N	00°10W	30F0f
49°55N	00°10E	30F1d
49°55N	00°30E	30F1e
49°55N	00°50E	30F0h
49°45N	00°30W	30F0i
49°45N	00°10W	30F1g
49°45N	00°10E	30F1h
49°35N	00°30W	29F0a
49°35N	00°10W	29F0b
49°25N	00°30W	29F0c
49°25N	00°10W	29F1a

Table6.4.2. Positions in the Southern North Sea, 01.01. – 15.01. (Area code E2).

Latitude	Longitude	ICES-Code
52°25N	02°50E	33F2c
52°25N	03°10E	33F3a
52°25N	03°30E	33F3b
52°15N	02°30E	33F2e
52°15N	02°50E	33F2f
52°15N	03°10E	33F3d
52°15N	03°30E	33F3e
52°15N	03°50E	33F3f
52°15N	04°10E	33F4d
52°05N	02°30E	33F2h
52°05N	02°50E	33F2i
52°05N	03°10E	33F3g
52°05N	03°30E	33F3h
52°05N	03°50E	33F3i
51°55N	02°30E	32F2b
51°55N	02°50E	32F2c
51°55N	03°10E	32F3a
51°55N	03°30E	32F3b
51°45N	02°10E	32F2d
51°45N	02°30E	32F2e
51°45N	02°50E	32F2f
51°45N	03°10E	32F3d
51°45N	03°30E	32F3e
51°35N	01°50E	32F1i
51°35N	02°10E	32F2g
51°35N	02°30E	32F2h
51°35N	02°50E	32F2i
51°35N	03°10E	32F3g
51°25N	01°50E	31F1c
51°25N	02°10E	31F2a
51°25N	02°30E	31F2b
51°25N	02°50E	31F2c
51°15N	01°50E	31F1f
51°15N	02°10E	31F2d
51°15N	02°30E	31F2e
51°05N	01°30E	31F1h
51°05N	01°50E	31F1i
50°55N	01°10E	30F1a
50°55N	01°30E	30F1b
50°45N	00°50E	30F0f
50°45N	01°10E	30F1d
50°45N	01°30E	30F1e
50°35N	00°30E	30F0h
50°35N	00°50E	30F0i
50°35N	01°10E	30F1g
50°35N	01°30E	30F1h
50°25N	00°10E	29F0a
50°25N	00°30E	29F0b
50°25N	00°50E	29F0c
50°25N	01°10E	29F1a
50°25N	01°30E	29F1b
50°15N	00°10W	29E9f
50°15N	00°10E	29F0d
50°15N	00°30E	29F0e
50°15N	00°50E	29F0f
50°15N	01°10E	29F1d
50°05N	00°30W	29E9h
50°05N	00°10W	29E9i
50°05N	00°10E	29F0g
50°05N	00°30E	29F0h
50°05N	00°50E	29F0i
50°05N	01°10E	29F1g
49°55N	00°30W	28E9b
49°55N	00°10W	28E9c
49°55N	00°10E	28F0a
49°55N	00°30E	28F0b
49°55N	00°50E	28F0c
49°45N	00°30W	28E9e
49°45N	00°10W	28E9f
49°45N	00°10E	28F0d
49°35N	00°30W	28E9h
49°35N	00°10W	28E9i
49°25N	00°30W	27E9b
49°25N	00°10W	27E9c

Table 6.4.3. Positions in the Southern North Sea, 15.01. – 31.01. (Area code E3).

Latitude	Longitude	ICES-Code
52°25N	02°10E	33F2a
52°25N	02°30E	33F2b
52°25N	02°50E	33F2c
52°25N	03°10E	33F3a
52°25N	03°30E	33F3b
52°25N	03°50E	33F3c
52°25N	04°10E	33F4a
52°15N	02°10E	33F2d
52°15N	02°30E	33F2e
52°15N	02°50E	33F2f
52°15N	03°10E	33F3d
52°15N	03°30E	33F3e
52°15N	03°50E	33F3f
52°15N	04°10E	33F4d
52°05N	02°10E	33F2g
52°05N	02°30E	33F2h
52°05N	02°50E	33F2i
52°05N	03°10E	33F3g
52°05N	03°30E	33F3h
52°05N	03°50E	33F3i
51°55N	02°10E	32F2a
51°55N	02°30E	32F2b
51°55N	02°50E	32F2c
51°55N	03°10E	32F3a
51°55N	03°30E	32F3b
51°45N	01°50E	32F1f
51°45N	02°10E	32F2d
51°45N	02°30E	32F2e
51°45N	02°50E	32F2f
51°45N	03°10E	32F3d
51°45N	03°30E	32F3e
51°35N	01°50E	32F1i
51°35N	02°10E	32F2g
51°35N	02°30E	32F2h
51°35N	02°50E	32F2i
51°35N	03°10E	32F3g
51°25N	01°50E	31F1c
51°25N	02°10E	31F2a
51°25N	02°30E	31F2b
51°25N	02°50E	31F2c
51°15N	01°50E	31F1f
51°15N	02°10E	31F2d

Latitude	Longitude	ICES-Code
51°15N	02°30E	31F2e
51°05N	01°30E	31F1h
51°05N	01°50E	31F1i
50°55N	01°10E	30F1a
50°55N	01°30E	30F1b
50°45N	00°50E	30F0f
50°45N	01°10E	30F1d
50°45N	01°30E	30F1e
50°35N	00°30E	30F0h
50°35N	00°50E	30F0i
50°35N	01°10E	30F1g
50°35N	01°30E	30F1h
50°25N	00°10E	29F0a
50°25N	00°30E	29F0b
50°25N	00°50E	29F0c
50°25N	01°10E	29F1a
50°25N	01°30E	29F1b
50°15N	00°30W	29E9e
50°15N	00°10W	29E9f
50°15N	00°10E	29F0d
50°15N	00°30E	29F0e
50°15N	00°50E	29F0f
50°15N	01°10E	29F1d
50°05N	00°30W	29E9h
50°05N	00°10W	29E9i
50°05N	00°10E	29F0g
50°05N	00°30E	29F0h
50°05N	00°50E	29F0i
50°05N	01°10E	29F1g
49°55N	00°30W	28E9b
49°55N	00°10W	28E9c
49°55N	00°10E	28F0a
49°55N	00°30E	28F0b
49°55N	00°50E	28F0c
49°45N	00°30W	28E9e
49°45N	00°10W	28E9f
49°45N	00°10E	28F0d
49°35N	00°30W	28E9h
49°35N	00°10W	28E9i
49°35N	00°10E	28F0g
49°25N	00°30W	27E9b
49°25N	00°10W	27E9c

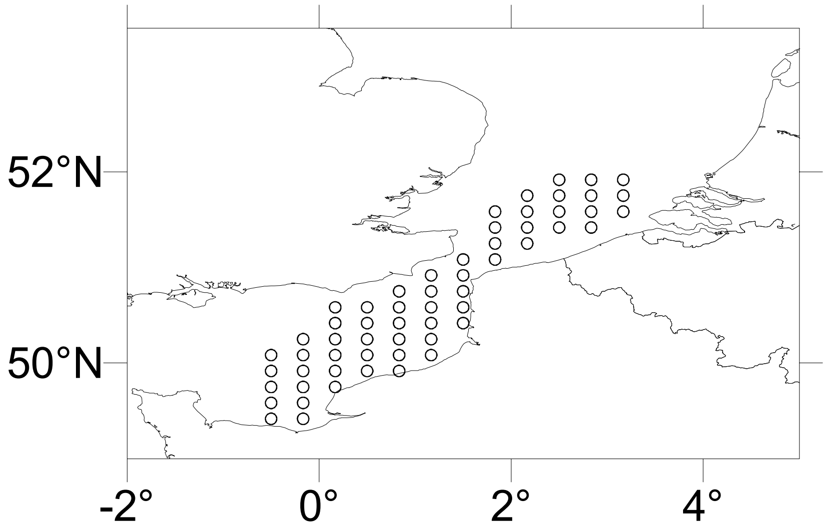

Figure 6.4.1. Station grid in the Southern North Sea, 16.12. – 31.12.

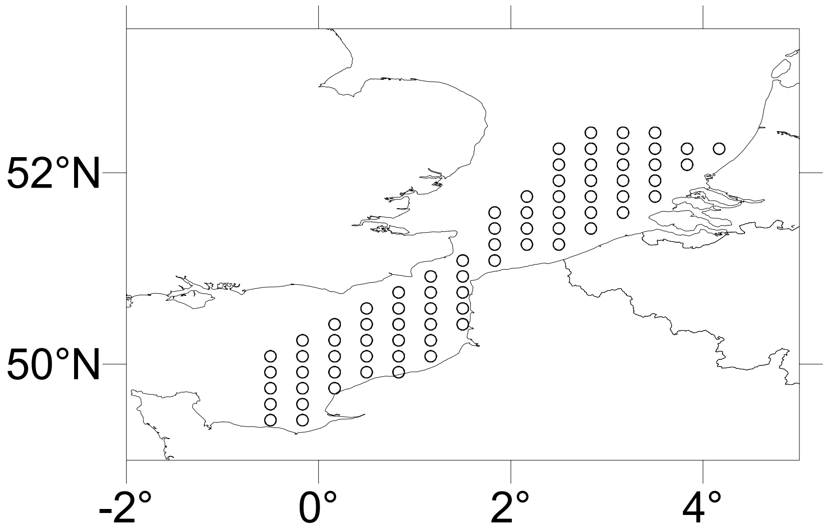

Figure 6.4.2. Station grid in the Southern North Sea, 01.01. – 15.01.

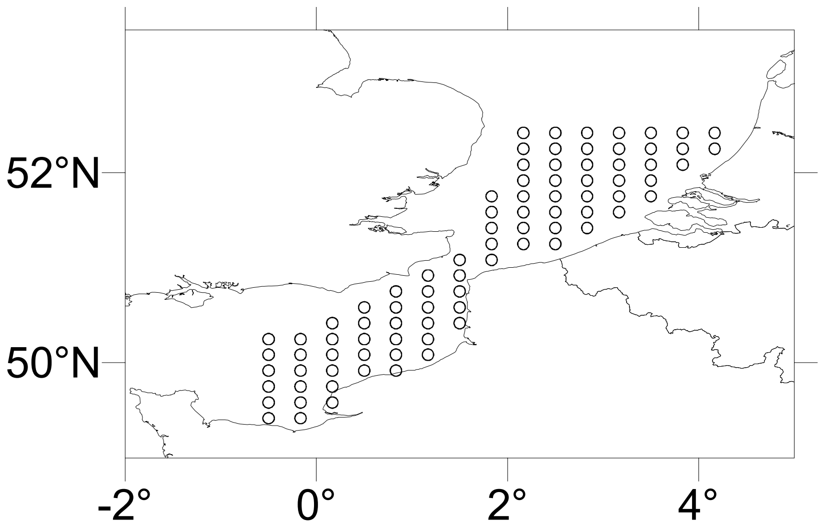

Figure 6.4.3.Stationgrid in the Southern North Sea, 16.01. – 31.01.

6.5 Data sheet

INPUT SHEET ICES LARVAE SURVEYS

Country	**Germany**
Area	**Or/Shet**
Year	**2002**
Vessel	**Alkor**
Start of survey	**16. Sep**
Sampling gear	**Nackthai**
End of survey	**06. Okt**
Aperture (mm)	**200**
Calibration (rev/m)	**41,688**
Sampler efficiency	**1,000**

Country	Gear	Aper	Cal	Eff	Stat number	Date	Latitude	Longitude	E/W	UTC	Flowmeter revol.	Sampler depth (m)	Bottom depth (m)	Bottom temp (°C)	Duration (min.sec.)	Ship Course
FRG_B2	Nackthai	200	41,688	1,00	1226	180902	5805	0110	W	1647	192290	103	106	10,6	2642	249
FRG_B2	Nackthai	200	41,688	1,00	1227	180902	5805	0130	W	1802	097240	073	076	12,6	1437	269
FRG_B2	Nackthai	200	41,688	1,00	1228	180902	5805	0150	W	1908	132358	086	089	12,6	1850	269
FRG_B2	Nackthai	200	41,688	1,00	1229	180902	5805	0210	W	2019	074597	064	067	13,3	1108	269

Haul			**Raised length distribution (per mm) of total larvae in sample**																	**Total caught**			Total larvae
number	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	>=24	Non yolk	yolk	Total	measured
001	0	0	0	0	1	4	15	23	23	21	6	4	8	5	4	0	0	0	0	0	_	_	114	110
002	0	0	0	1	0	5	30	40	37	23	13	7	5	2	3	1	2	0	0	0	_	_	170	165
003	0	2	8	8	1	2	5	15	30	29	14	7	3	0	1	0	1	0	0	0	_	_	127	120
004	0	0	0	0	1	0	0	0	1	3	11	5	6	4	4	8	1	0	0	0	_	_	45	44

Appendix VI: Working paper

ICES Planning Group for Herring Surveys (PGHERS)

The German Herring larvae Programme – A method for estimating a fishery independent recruitment index for the herring stock in the western Baltic Sea

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Abstract

The aim of this paper is the evaluation of the quality of the recruitment index N30 based on the German herring larvae surveys in the main spawning area of the western Baltic Sea spring spawning herring stock.

Index N30 presents an accurate estimate of the recruiting year class. It should be used with a high weight as tuning variable by the assessment of the stock biomass and for stock forecast.

Since the long-term series of the German bottom trawl survey using the herring bottom trawl HG 20/25 ended in 2001 it is necessary to continue both the other German fishery independent surveys, the herring larvae survey and the acoustic survey to obtain two independent estimates of the same year class.

Introduction

The spring spawning herring stock in the western Baltic Sea (ICES-Subdivisions 22–24 and Division IIIa) is important for the international fishery activities because of its feeding and spawning migration between the Isle of Bornholm and eastern parts of the North Sea. The stock is inside safe biological limits. The spawning stock biomass ranged from 1998 to 2000 between 125,000 t and 140,000 t and increased in 2002 to 178,000 t (ICES 2002a).

The main spawning area of this herring stock is situated in the Greifswalder Bodden (area: 510.2 km^2, volume: 2,960 * 10^6 m^3, mean depth: 5.8 m, greatest depth: 13.5 m) and adjacent waters off the coast of Mecklenburg / Vorpommern (Biester 1989). Here the eggs are deposited on water plants, the larvae hatch and grow up. Small spawning grounds can also be found in the coastal waters and the estuaries of the ICES-SD 22 (Weber 1971). The spawning places are given in Figure 1.

The Institute for Baltic Sea Fisheries Rostock (IOR) estimates fishery independent indices for this herring stock based on different methods as tuning variables for the stock assessment and for stock forecast. For the latter a weekly repeated larvae survey is carried out in the main spawning area during the spawning season. This “German Herring Larvae Programme” was started by Brielmann (1981, 1986, 1989) in 1977. The assumption of this programme was that the larvae stay in the main spawning area until they will reach the juvenile stage at total length of 30mm. Brielmann found that the abundance of larvae reaching the juvenile stage in the Greifswalder Bodden and Strelasund is a good indicator for the year class strength of the spring spawning herring in the western Baltic Sea. This index is called N30.

Unfortunately, the data up to 1991 estimated by Brielmann are not available any more. The series of comparable indices for the correlation with the number of recruits in AG 0 started in 1992. This paper evaluates the quality of the recruitment index N30 and discusses the usefulness of the estimates of herring larvae programme for the stock assessment.

Material and Methods

The herring larvae surveys take place every year from March/April to June/July in the main spawning area Greifswalder Bodden and Strelasund. Since 1977 the same sampling strategy, the same sampling method and the same station grid have been used. During max. 10 weekly cruises 35 standard stations are sampled in daylight with R/V Clupea. The station grid is given in Figure 2. Brielmann stratified the sampling area into 15 sub-areas because of the different distribution of spawning herring schools. Biological criteria like different conditions for the deposition of spawned eggs were taken into account too. And another historical reason for this programme was to study the importance of local spawning places within the main spawning area.

Double oblique hauls are carried out by 1 m steps using a Bongo-Net (net opening: 600 mm, mesh size: 0.335 mm) at a speed of 3 knots. The distance from the bottom amounts to 1 m. All plankton samples are fixed and preserved with buffered formaldehyde immediately after capture. In the lab the herring larvae are picked out from the samples, they are counted and the total length TL of every larva is measured to 1 mm below. It‘s a very high workload and so only the larvae of the outer net are taken into consideration because there were no differences between the number and length composition of the inner and the outer net.

From samples with a high abundance (more than 1,000 larvae per sample and net) only the larvae of 3 sub-samples (200 larvae per sub-sample) are measured. The sum is raised to the total number counted to get the length composition of the total catch.

The procedure of the quantitative larvae analysis, that means the notations for the calculations of the

- mean number of larvae per m^2 and station
- number of larvae per sub-area of the Greifswalder Bodden and Strelasund
- number per length-class and cruise
- growth in length per day
- instantaneous natural mortality rate
- time that is necessary for the last component of a cohort to reach the mean length of 30 mm
- number of larvae when the mean length of 30 mm of a cohort is reached
  and
- total number of larvae after metamorphosis (TL>=30 mm)

are presented in Müller and Klenz (1994) and Müller (2000).

The length frequency and the total number of larvae in the Greifswalder Bodden are estimated based on the 35 hauls per cruise.

From 1992 onwards the polymodal length composition of each cruise is split into a variable number of normally distributed components (cohorts) using the BHATTACHARYA and NORMSEP method. A cohort consists of larvae which hatched at the same time, i.e., in the same week. During the sampling season nearly every week a new cohort can be identified. For the separation procedures the FAO software package FISAT (Gayanilo *et al*. 1996) is used.

Figure 3 gives an example for a separation result.

For each detected cohort growth and mortality per day from one cruise to the next is assessed. Then, the data of all cohorts are combined to estimate the total number of herring larvae which potentially reach the juvenile stage at the total length of TL=30 mm. This index is called N30 and is used as index of the year class strength of the spring spawning herring stock in the western Baltic Sea (“Rügen herring”). Although N30 is given as number in million individuals it can only be taken as an index of the year class strength because not the total spawning ground is covered by the surveys (Figure 1).

Growth in length and mortality parameters are the basis for the estimation of the recruitment index N30. The detection and assignment of the different cohorts = hatching batches as well as the estimate of the mean daily growth are the critical points of the method because of an inherent element of subjectivity. Therefore a second independent technique to assess the daily growth in length, the microstructure analysis of Sagitta otoliths of herring larvae, was used to evaluate the estimates of the herring larvae programme. The studies were carried out with larvae material of the spawning seasons 1996 (Oeberst and Klenz 2003b) and 1997 (Oeberst and Klenz personal comm.).

And now the question is: How is the accuracy of the recruitment index N30? The fishery independent indices for AG 0 of the spring spawning herring stock in the western Baltic Sea based on the German herring larvae surveys [N30], on the German-Danish acoustic surveys in October [HA0] and on the German bottom trawl surveys in November used the herring bottom trawl HG 20/25 [BT0] were compared (Oeberst and Müller and Klenz 1996) (Oeberst and Klenz 2003a). Statistical analyses were carried out using Statgraphics Plus Version 5.0.

Results and Discussion

Growth and mortality parameters

In Table 1 an example is given to demonstrate the procedure for the calculation of the herring larvae index N30 on the basis of mean length and number. The survey of 2001 was chosen.

Both the independent estimates of mean daily growth using data of larvae surveys and of otolith microstructure for the spawning seasons 1996 and 1997 correspond well. They estimated comparable means of daily growth [mm per day] of the same larvae (see Oeberst and Klenz 2003b).

Theref ore:

The method for estimating the larvae index N 30 is a suitable estimator of the year class strength of the spring spawning herring stock in the western Baltic Sea since the basic data, the growth in length per day and the instantaneous natural mortality rate and survival rate of larvae, are unbiased.

Recruitment indices N30 for the period 1992 - 2003

Very different numbers of larvae were estimated (see Table 2).
The size of the recruitment index N30 depends rather on the survival rate of the youngest larvae (S1) and on the growth rate. If a great number of larvae has been hatched like in 1997 it is possible that high mortality rates cause a great loss of larvae (see the black painted cohort in Figure 3) because after yolk-sac absorption the right and enough zooplankton (selective feeding) must be available to the right time at the right place.

The recruitment index N30 for 2003 is at the same level as the index for 2002 (see Figure 4).

How it can be proved that N30 is a good index for the year class strength of the spring spawning herring stock in the western Baltic Sea, Kattegat and Skagerrak? Correlation analysis for the German fishery independent indices and the stock size of AG 0 estimated by VPA (ICES 2002a) for this herring stock was used to evaluate the quality of the different survey indices (see Table 3 and Table 4) (Oeberst and Klenz 2003a).

The estimates of the year class 1998 by N30 and BT0 / BT0 24 were biased and overestimated. The same station grid and the same analytical methods were used. However, the unfavourable salinity was probably the reason for a significant higher catchability of AG 0 and AG 1 herring by the bottom trawl survey due to concentrations of herring in deeper areas of the Arkona Sea and very close to the bottom.

The idea of the larvae programme is to cover the total spawning period by weekly surveys. This implies that low densities of hatching batches normally are observed during the last surveys, when spawning activities peter out. However, in 1998 large hatching batches occurred during the last 2 surveys (see Figure 5). For these larvae unbiased estimates of mean daily growth and mortality rates were not available. Therefore values of the period before were used and resulted in an overestimation of this year class.

For this reason N30 and BT0 / BT0 24 of year class 1998 were as estimators excluded from the studies (outliers).

Apparently the indices N30, HA0 and BT0 24 provide accurate estimates and give the same order of the year class. Therefore these indices should be used with a high weight as tuning variables by the assessment of the stock biomass.

The indices of the herring larvae survey and of the bottom trawl survey in 1998 give evidence of the possibility of biased estimates although the same survey design and the same methods of data analyses were used. If these biased estimates are used during further analyses like VPA, planning of surveys, etc. significant different results can be produced. However, the quality of different estimates can only be assessed if the basic data are available which is normally not possible during "Herring Assessment Working Group" meetings. Therefore, it seems necessary to develop and establish criteria of quality for the different surveys. These criteria should cover all parameters that can significantly influence the indices, e.g., "Does the herring larvae survey representatively cover the total spawning season?" The results of the quality check must be available if the indices are used. That means that the indices of the same survey type can be used with different weights.

Since the results of the bottom trawl surveys using the herring bottom trawl HG 20/25 will not be available in the future it is necessary to continue both the other German surveys, the larvae survey **and** the acoustic survey to get **two independent** estimates of the same year class.

Summary

- Results of the German herring larvae surveys are presented. Larval recruitment index N30 is shown for the period since 1992.

- Compared to 2002 N30 is at the same high level in 2003.

- **The estimates of the larvae index N30 based on the German Herring Larvae Programme are highly significant correlated with the number of recruits (number of AG 0 in the stock) estimated by the Herring Assessment Working Group.**

- N30 is a good index for the year class strength of the spring spawning herring stock in the western Baltic Sea (ICES-Subdivisions 22–24 and Division IIIa).

  A high estimate of index N30 presents a strong year class, a small index N30 presents a weak year class.

  The result of the German Herring Larvae Programme presents an accurate estimator of the year class and should be used with high weight as tuning variables by the assessment of the stock biomass.

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TABLES

Table 1. Procedure for the calculation of the herring larvae index N30.

Herring larvae survey 2001

For G and M grand mean used.
Bhattacharya (B) and NORMSEP (N) (FISAT) used for mean length and number.

Mean length (mm)

Mean date of cruise	Component 1.	2.	3.	4.	
24.04.01	8,44	10,94			N
01.05.01	8,60	11,02			N
08.05.01	7,95	9,20	12,00		N
15.05.01	7,07	10,13	12,85	16,57	N
22.05.01	7,17	9,05	12,09	15,29	N1
29.05.01	7,15	11,08	14,23	16,85	N
06.06.01	7,47	10,11	15,58	18,22	B1
12.06.01	7,44	13,04	19,20	23,95	B1
19.06.01	7,12	10,00	15,91	20,64	N
27.06.01	7,80	10,58	14,70	19,25	N

Number (millions)

Mean date of cruise	Component 1.	2.	3.	4.	Number at TL=30 mm	Date when TL=30 mm
24.04.01	8098,44	1196,84				
01.05.01	4384,89	118,17				
08.05.01	3638,79	2758,49	263,14			
15.05.01	2584,56	4397,10	960,60	82,71	5,435	09.06.01
22.05.01	5160,70	5915,23	2163,26	3297,29	167,137	18.06.01
29.05.01	7510,92	5119,97	3913,69	1738,54	120,905	22.06.01
06.06.01	424,98	3293,22	1108,38	401,98	36,905	28.06.01
12.06.01	1014,93	2904,61	1164,95	69,23	20,307	23.06.01
19.06.01	496,87	1141,81	989,45	262,59	39,374	06.07.01
27.06.01	82,69	147,89	269,49	136,62	15,455	17.07.01
Number	0,92	2,89	12,12			
Date when TL= 30 mm	08.08.01	02.08.01	26.07.01			
	Sum of larvae at 30 mm (N30)				**421,442**	**[N30 = 421,442 x 10^6 ind.]**
	Sum N1:				33397,77	

For each larvae cohort the number and the date when it is 30 mm on average are given.

Table 1 continued.

Growth per day (mm)

Delta t days	Component 1 to 2	2 to 3	3 to 4	Mean	Delta t needed for TL=30 mm
7	0,369			0,369	56,879
7	0,086	0,140		0,113	56,879
7	0,311	0,521	0,653	0,495	56,879
7	0,283	0,280	0,349	0,304	25,463
7	0,559	0,740	0,680	0,660	27,890
8	0,370	0,563	0,499	0,477	24,932
6	0,928	1,515	1,395	1,279	22,334
7	0,366	0,410	0,206	0,327	11,471
8	0,433	0,588	0,418	0,479	17,746
Mean	0,412	0,595	0,600	**0,527**	20,382
Delta t needed for TL=30 mm	42,090	36,819	29,008		

The growth per day and the time that the cohort needs to reach 30 mm is given.

Natural mortality rate M per day (mm)

Delta t	Component 1 to 2	2 to 3	3 to 4	Mean
7	0,604			0,604
7	0,066	-0,114		-0,024
7	-0,027	0,151	0,165	0,096
7	-0,118	0,101	-0,176	-0,064
7	0,001	0,059	0,031	0,030
8	0,103	0,191	0,284	0,193
6	-0,320	0,173	0,462	0,105
7	-0,017	0,154	0,213	0,117
8	0,151	0,180	0,247	0,193
Mean	0,049	0,112	0,175	0,107

Table 1 continued.

Survival rate S

Date	Component 1 to 2	2 to 3	3 to 4	Mean		
01.05.01	0,547			0,547		
08.05.01	0,936	1,121		1,029		
15.05.01	1,027	0,860	0,848	0,912		
22.05.01	1,126	0,904	1,193	1,074		
29.05.01	0,999	0,943	0,969	0,970		
06.06.01	0,902	0,826	0,752	0,827		
12.06.01	1,378	0,841	0,630	0,949		
19.06.01	1,017	0,857	0,808	0,894		
27.06.01	0,859	0,835	0,781	0,825		
Mean	0,977	0,898	0,854	**0,915**	Total	**Mean survival rate S**
				0,977	of N1	**Mean survival rate of youngest larvae S1**

Table 2. Results of the herring larvae surveys in the Greifswalder Bodden and Strelasund from 1992 to 2003.
S = total survival rate; S1 = survival rate of the youngest larvae.

Year	Number of herring larvae caught	Mean abundance [Nm^{-2}]	Recruitment index N30 (number of larvae) [millions]	Mean survival rate per day (total /of the first cohort) S / S1 [%]	Mean growth per day [$mm\ d^{-1}$]
1992	33 944	6,60	**18**	80 / 71	0,48
1993	81 433	14,35	**199**	79 / 75	0,53
1994	286 951	41,86	**788**	92 / 92	0,47
1995	235 600	31,68	**171**	90 / 64	0,53
1996	304 783	77,05	**31**	81 / 77	0,44
1997	157 978	26,16	**54**	76 / 73	0,43
1998	128 977	25,42	**2 553**	92 / 96	0,63
1999	195 163	34,30	**1 945**	91 / 95	0,59
2000	34 997	6,29	**151**	87 / 91	0,68
2001	89 091	16,49	**421**	92 / 98	0,53
2002	75 026	17,40	**2 051**	94 / 94	0,48
2003	74 283	14,60	**2 005**	97 / 100	0,51

Table 3. Notations of German Rügen herring indices.

HA0	Index of age group 0, German acoustic surveys in Subdivisions 22 – 24 in October (ICES 2002a)
HA022	Index of age group 0, German acoustic surveys in Subdivision 22 in October (BAD1)
HA024	Index of age group 0, German acoustic surveys in Subdivision 24 in October (BAD1)
N30	Index of age group 0, German herring larvae surveys in Greifswalder Bodden (Klenz 2003, ICES 2002a)
BT0	Index of age group 0, German standard bottom trawl survey in Subdivision 22 and 24 (ICES 2002a)
BT022	Index of age group 0, German bottom trawl survey in Subdivision 22 (ICES 2002a)
BT024	Index of age group 0, German bottom trawl survey in Subdivision 24 (ICES 2002a)

N30 in Mio individuals
HA in Mio individuals
BT in Mio based on catch per hour

Table 4. Correlation coefficients R between the different fishery independent stock indices of AG 0 Rügen herring and estimates of VPA using the period 1992–1997, 1999–2001.

R	HA0	HA022	HA024	BT0	BT022	BT024	VPA
N30	**0.65 ***	**0.74 ***	0.36	0.45	-0.25	**0.94 ****	**0.80 ****
HA0		0.97**	0.91**	0.13	-0.33	0.55*	0.84**
HA022			0.78**	0.17	-0.38	0.67*	0.85**
HA024				0.03	-0.17	0.24	0.68*
BT0					0.73*	0.66*	0.15
BT022						-0.03	-0.40
BT024							0.66*

* significant correlations with $p < 0.05$ ** significant correlations with $p < 0.01$.

FIGURES

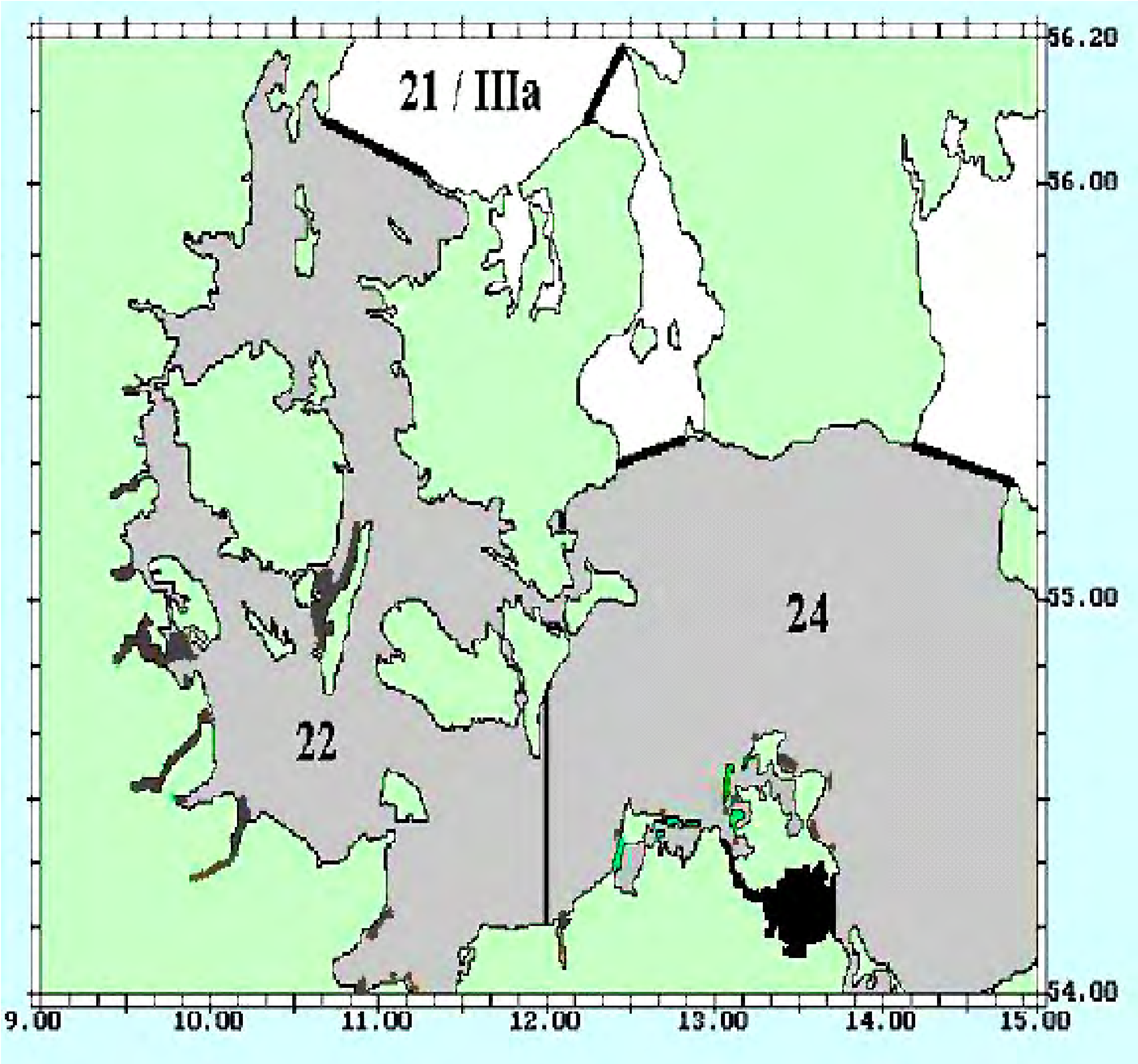

Figure 1. Main spawning ground and hatching area of larvae (black shading), little spawning places (dark grey shading) and area of distribution of AG 0 and 1 (light grey shading) of spring spawning herring in the western Baltic Sea.

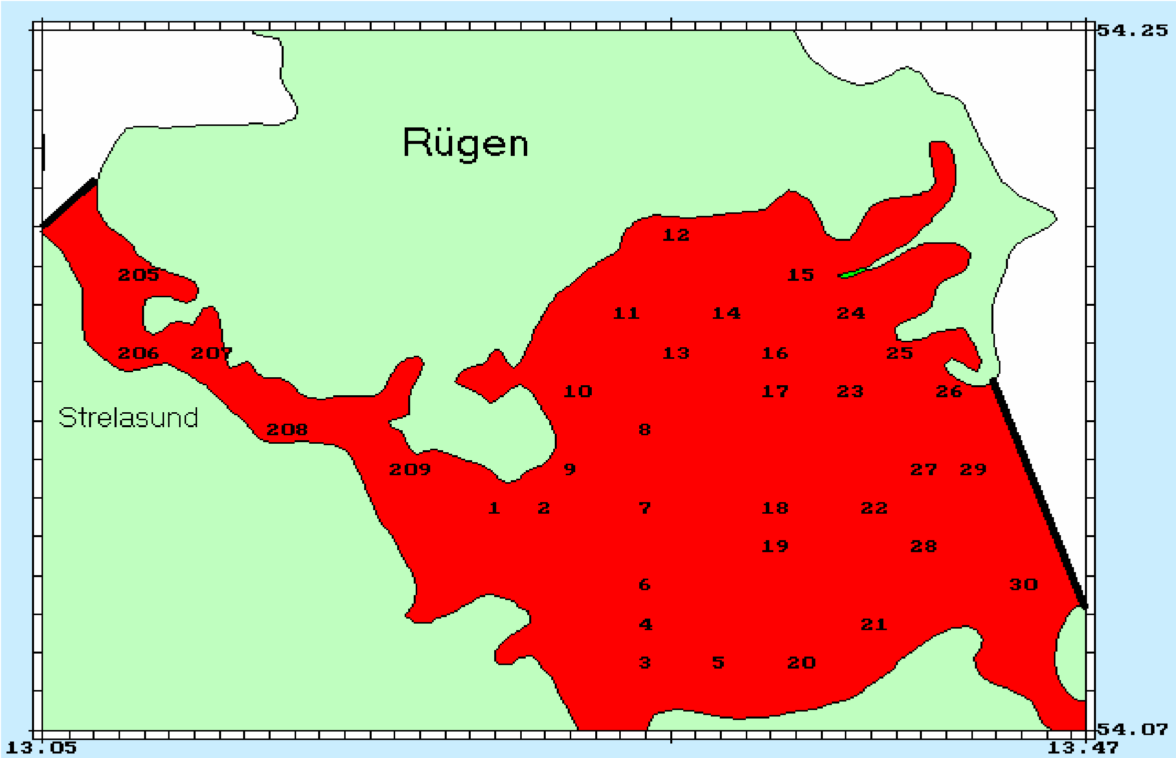

Figure 2. Standard station grid of herring larvae surveys: 30 stations in Greifswalder Bodden and 5 Stations in Strelasund.

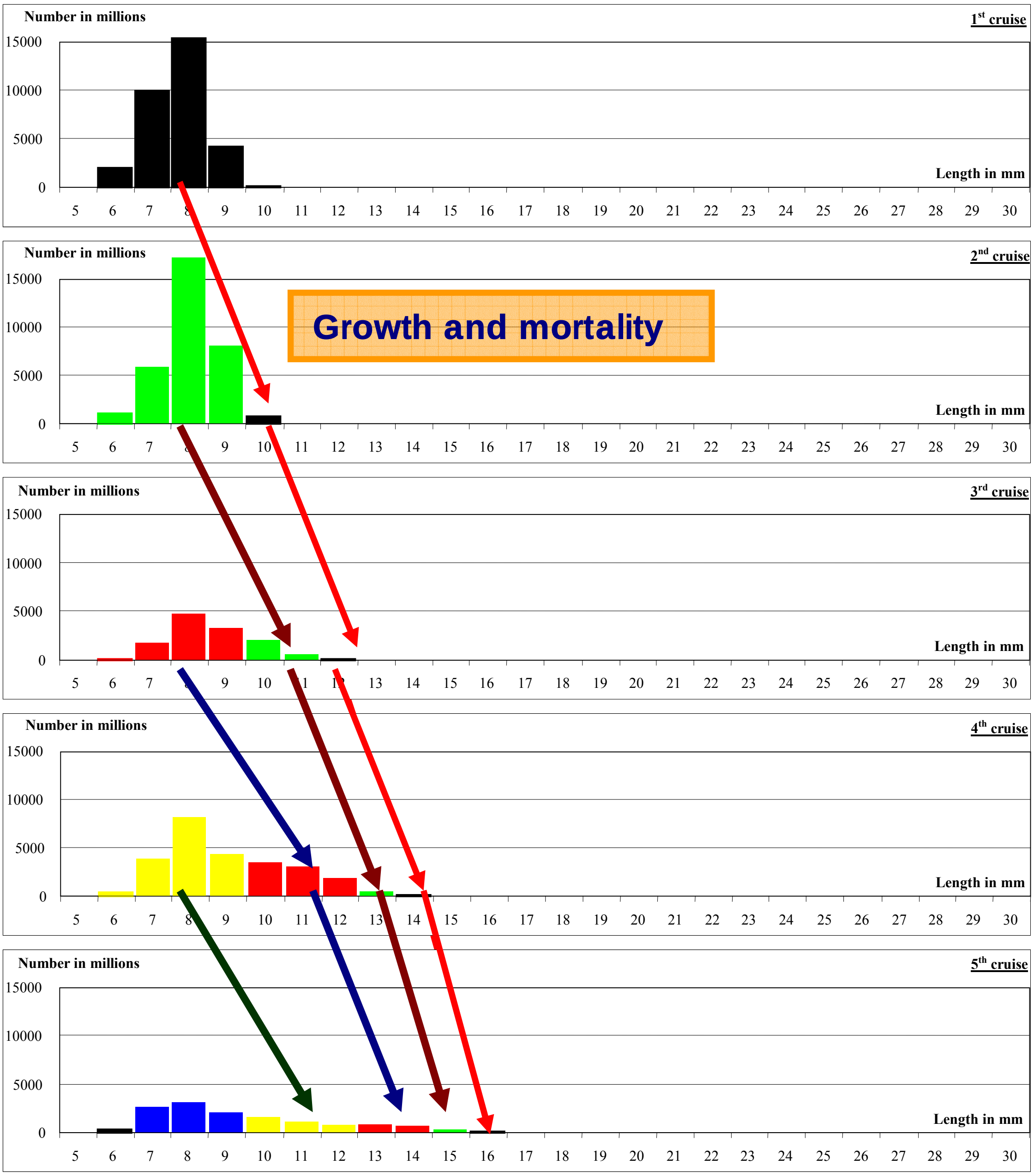

Figure 3. Separation of length distributions of consecutive surveys in 1997 into different hatching batches (=cohorts).

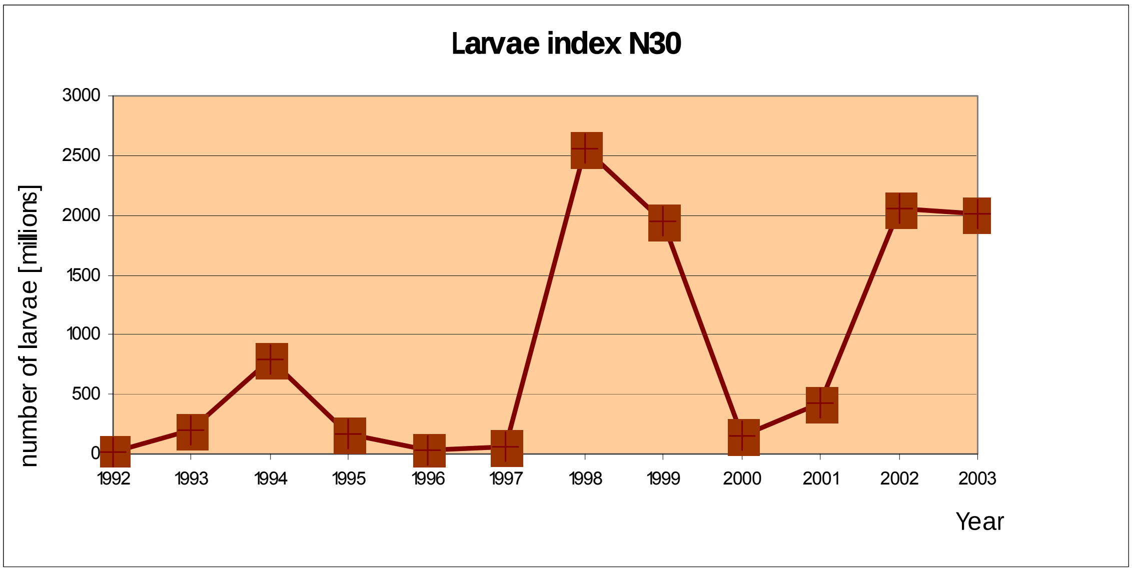

Figure 4. Recruitment indices N30 for the period 1992 – 2003.

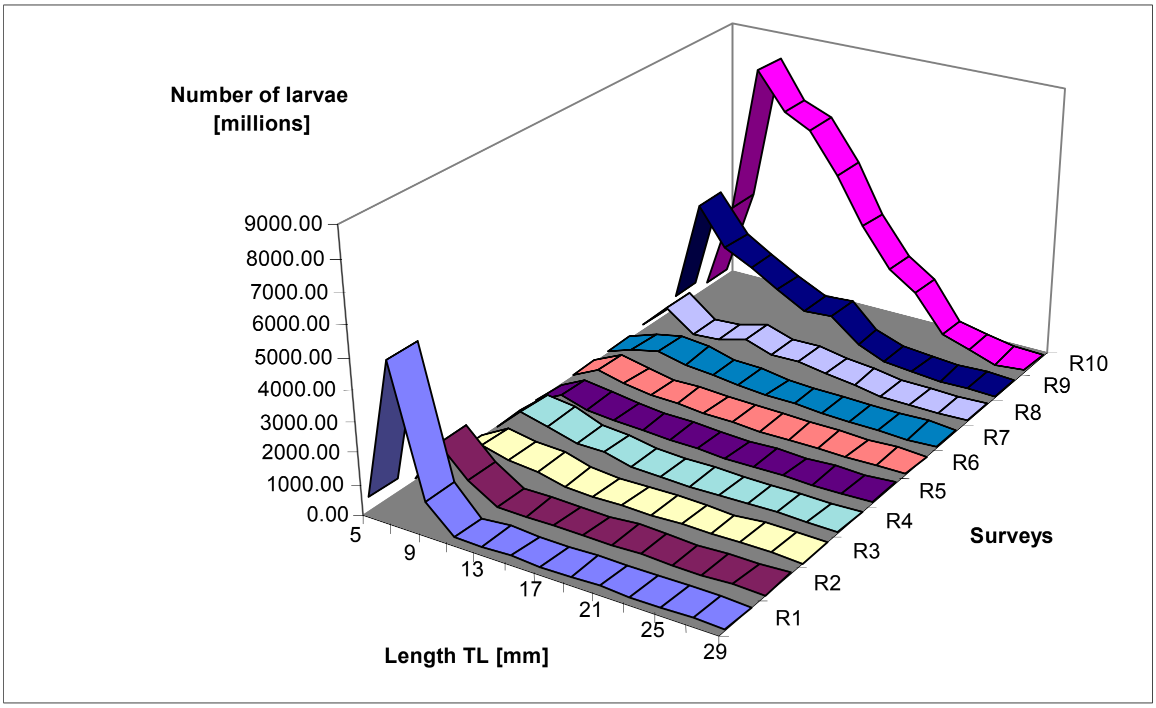

Figure 5. Length distribution of herring larvae by surveys in 1998 (R_i – number of survey).