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Planning Group for Herring Surveys

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PGHERS 2003 - EXECUTIVE SUMMARY

1. **TERMS OF REFERENCE** According to C. Res. 2002/2G02 the **Planning Group for Herring Surveys** [PGHERS] (Chair: P.G. Fernandes, UK) met in Aberdeen, UK, from 21 -24 January 2003 to:

   a) combine the 2002 survey data to provide indices of abundance for the population within the area;

   b) consider a re-allocation of effort by participating countries in the acoustic survey of the North Sea and adjacent waters in 2003;

   c) co-ordinate 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 2003;

   d) evaluate the outcome of a maturity staging workshop with a view to harmonising the determination of maturity in herring and sprat;

   e) evaluate investigations on the effect of time of day on the allocation of herring to acoustic data;

   f) develop protocols and criteria to ensure standardization of all sampling tools and survey gears.

2. **REVIEW OF LARVAE SURVEYS IN 2002/2003** At the time of writing two of the seven surveys in the North Sea remained to be carried out in January 2003. Results will be ready for the Herring Assessment Working Group (HAWG) meeting in March 2003. Estimates from Western Baltic larvae survey in the Greifswalder Bodden area are given from 1992-2002.

3. **CO-ORDINATION OF LARVAE SURVEYS FOR 2003/2004** In the 2003 period, the Netherlands and Germany will undertake 6 larvae surveys in the North Sea from 1 September 2003 to 31 January 2004. The herring larvae survey in the Greifswalder Bodden (Baltic Sea) will be conducted from 22 April to 27 June using the FRV *Clupea*.

4. **REVIEW OF LARVAE SURVEY RESULTS IN RELATION TO GRAVEL EXTRACTION** As a result of a request at the 2002 ICES ASC, maps of the distribution of early stage herring larvae were compiled from the last 5 years of the larvae survey in the central and southern North Sea. These serve as an indication of herring spawning grounds which may be sensitive to gravel extraction.

5. **NORTH SEA ACOUSTIC SURVEYS IN 2002** Six acoustic surveys were carried out during late June and July 2002 covering the North Sea and west of Scotland. The provisional total combined estimate of North Sea spawning stock biomass (SSB) is 2.9 million t, an increase from 2.4 million t in 2001. The survey shows exceptional numbers of 2-ring herring (the 1998 year-class) and indicates that the 2000 year class may also be strong. The estimate of Western Baltic spring spawning herring SSB is 255,000 t, an increase since 2001 (77,000 t). The west of Scotland SSB estimate is 548,000 t (up from 327,500 t). The surveys are reported individually in Appendix II.

6. **WESTERN BALTIC ACOUSTIC SURVEY IN 2002** A joint German-Danish acoustic survey was carried out with R/V *Solea* from 14 to 25 October in the Western Baltic. The total number of herring was 6,000 million (down from last years 9,800 million) and the total for sprat 6,700 million (down from last years 8,700 million). A full survey report is given in Appendix III.

7. **SURVEY OVERLAP BETWEEN FRV *SCOTIA* AND FRV *G.O. SARS*.** A provisional analysis of acoustic data from an extended area overlap between these vessels indicated large differences between the two vessels, due primarily to the large temporal difference. A schedule for a more comprehensive analysis of the data was drawn up to be presented next year in order to determine the effect of different scrutiny procedures.

8. **SPRAT.** Data on sprat were only available from RV *Walther Herwig III*, RV *Tridens* and RV *Dana*. The total sprat biomass estimated was 241,000 t in the North Sea (up from 200,000 t in 2001) and 10,000 t in the Kattegat (up from 8,000 t in 2001). The distribution pattern demonstrates that the southern border was still not reached.

9. **CO-ORDINATION OF ACOUSTIC SURVEYS IN 2003** Six acoustic surveys will be carried out in the North Sea and west of Scotland in 2003 between 23 June and 21 July. Participants are referred to Figure 8 for indications of survey boundaries. *Scotia* and *Tridens* will survey an overlapping area to the south of Shetland. *Scotia* and *G.O. Sars* will survey an overlapping area to the east of Shetland. A survey of the western Baltic and southern part of Kattegat, will be carried out by *Solea* from 29 September to 20 October.

10. **FUTURE PLANNING OF ACOUSTIC SURVEYS IN THE NORTH SEA** An analysis of the spatial variability in the distribution of herring was conducted in relation to the requirements of the assessment to determine which areas were most sensitive to the precision of the survey. These areas were plotted using a variety of metrics. Predicted changes in survey variance with changes in track intensity were also made. The results were used to determine which areas would be more appropriate for any future redesigns. The group considered the benefits and drawbacks of implementing a variety of new design options. It was concluded that closer integration of methods and cross-boundary experience was required before any radical changes could be made. In the forthcoming year minor modifications to the design were planned and a number of studies were identified to investigate this further.

11. **ACOUSTIC SURVEY MANUAL REVISION** A review was made of the current acoustic survey manual in response to TOR (f). Modifications were made to the existing manual and an update is provided in Appendix IV as version 3.1. A fuller revision will take place next year.

12. **MATURITY DETERMINATION.** Ambiguities in the use of scales for the determination of herring maturity were resolved. The acoustic survey manual has been updated to include a full description of the original 8 point scale and conversion tables for deviations from this scale. A maturity staging workshop was not possible in 2002. Instead digital photographs of herring were collected and these were examined. Procedures for the acquisition of good quality photographs are described in detail to encourage all participants to collect more examples for further examination.

13. **SPRAT OTOLITH EXCHANGE.** A sprat otolith exchange was completed in 2002. In general, there was a reasonable agreement between the age determinations. There is nonetheless potential for improvement and action should be taken to achieve a greater precision within institutes and between the various participants.

14. **THE EFFECT OF TIME OF DAY ON THE ACOUSTIC DETECTION OF HERRING**. Further studies of the diurnal vertical migration (DVM) behaviour in North Sea were presented. Although there may be bias associated with herring DVM it is likely to be small. Furthermore any reduction in this bias by elimination of early and late survey hours may have seriously adverse consequences on the precision of the surveys. Future studies should therefore assess the balance between these two sources of uncertainty.

15. **RECOMMENDATIONS - 2004 MEETING.** PGHERS should meet, at Flødevigen, Norway, from 26 to 30 January 2004 (chair to be announced) to:

    a) combine the 2003 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 2004;

    c) review and update the PGHERS manual for acoustic surveys to address standardization 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.

16. **OTHER RECOMMENDATIONS:**

- Larvae surveys in the North Sea should have an expanded area coverage in the 2004/05 period.

- Nations participating in the acoustic surveys should make strong efforts to exchange staff between surveys. This is essential prior to any re-evaluation of survey effort allocation where scientists may survey unfamiliar areas, to ensure that consistent scrutinising and evaluation methods are applied.

- Acoustic survey data from 1991 onwards should be archived into the HERSUR database if this is to continue.

- A review should be made of existing documentation on practical aspects of larvae survey methods, including data collection and analysis.

- Despite recommendations from this group over the past two years, efforts are not being made to cover the whole Subdivision IIIa during the October survey on Baltic spring spawning herring. If there is a need for this survey to deliver an index to the HAWG, that group must endorse these recommendations.

- Biological samples from the surveys should be examined more closely to investigate maturity in 1 winter ring fish.

- Photographs of herring maturity stages should be obtained during the 2003 acoustic surveys. These will be examined at the next PGHERS meeting.

1 TERMS OF REFERENCE

According to C. Res. 2002/2G02 the **Planning Group for Herring Surveys** [PGHERS] (Chair: P.G. Fernandes, UK) met in Aberdeen, UK, from 21 -24 January 2003 to:

a) combine the 2002 survey data to provide indices of abundance for the population within the area;

b) consider a re-allocation of effort by participating countries in the acoustic survey of the North Sea and adjacent waters in 2003;

c) co-ordinate 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 2003;

d) evaluate the outcome of a maturity staging workshop with a view to harmonising the determination of maturity in herring and sprat;

e) evaluate investigations on the effect of time of day on the allocation of herring to acoustic data;

f) develop protocols and criteria to ensure standardization of all sampling tools and survey gears.

PGHERS will report by 7 February 2003 for the attention of the Resource Management and Living Resources Committees, and to HAWG.

2 PARTICIPANTS

Bram Couperus	The Netherlands
Paul Fernandes (Chair)	UK (Scotland)
Eberhard Götze	Germany
Soenke Jansen	Germany
Dave Reid	UK (Scotland)
John Simmonds	UK (Scotland)
Else Torstensen	Norway
Christopher Zimmermann	Germany

Contact details for each participant are given in Appendix I.

3 HERRING LARVAE SURVEYS

3.1 Review of Larvae Surveys in 2002/2003

3.1.1 North Sea larvae survey

At the time of writing it was not possible to give a full review of the larvae surveys, because the larvae surveys were not completed yet. Two surveys in the southern North Sea remained to be carried out in January 2003.

In the reporting period only the Netherlands and Germany participated in the larvae surveys. A total of seven units and time periods will be covered in the North Sea during the 2002/2003 period. They are given in the following table:

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

* these periods remain in the reporting period 2002

The information necessary for the calculation of larvae abundance estimates although not yet complete, will be ready for the Herring Assessment Working Group (HAWG) meeting in March 2003.

3.1.2 Review of Western Baltic larvae survey

The most important spawning ground of spring-spawning herring of the western Baltic Sea is the Greifswalder Bodden in German coastal waters. The Greifswalder Bodden has an area of 510.2 km^2 and a mean depth of 5.8 m and belongs to ICES Subdivision 24. The German effort to monitor the herring larvae started in 1977 with the aim of delivering an index of year class strength for this stock, which migrates in Subdivisions 22-24 and Division IIIa. Since then the sampling and calculation method has been kept constant. Each year up to 10 cruises are carried out during the whole spawning season. Currently the FRV *Clupea* typically samples 35 standard stations from March/April to June during daylight. Samples are taken with a bongo net (diameter: 600 mm; mesh size of both nets: 0.315 mm, since 1996 Hydro-Bios bongo nets with a mesh size of 0.335 mm have been used) using double oblique tows at a speed of 3 knots. For each cruise the number of larvae per length-class is estimated for the total area according to Müller & Klenz (1994). To estimate the year class strength, the number of larvae with a mean total length >= 30 mm (related to the number of age group 0 of the herring stock in Subdivisions 22-24 and Division IIIa) were calculated, taking growth and mortality rates of the larvae cohorts into consideration (Klenz 2002).

The estimated numbers of larvae for the period 1992 to 2002 are summarised in Table 1. Compared to the previous two years of relatively low estimates, the 2002 estimate of the larvae index (number of larvae which will grow up to the total length of greater than 30 mm) was back to the very high levels estimated in 1998 and 1999.

3.2 Co-ordination of Larvae Surveys for 2003/2004

In 2003/2004 period only The Netherlands and Germany will participate in the larvae surveys in the North Sea. To date the cruise plans of the institutes involved are not fixed and of tentative nature only. A preliminary survey schedule for the 2003 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, including hydrographic data, should be sent, in the standard format, to IfM Kiel for inclusion into the IHLS database. IfM Kiel will report the summarised results and the updated series of MLAI-values to the HAWG.

The current larvae surveys are restricted in area coverage (see for example Section 3.3 below). The last time an expanded area coverage was implemented was in the 2000/2001 sampling period (ICES 2001b) with the inclusion of additional effort from Norway. The last time a complete area coverage was carried out was in 1989 when surveys were carried out by Denmark, England, Scotland, the Netherlands and Germany. The current spawning stock biomass is at its highest level since 1968 and is twice as high as it was in 1998. PGHERS recommends that with such high stock levels the area covered by the larvae survey should be expanded once again in 2004/5 to validate the restricted area coverage. Requests for Norwegian ship time should be made at the earliest opportunity.

The German herring larvae survey in the Greifswalder Bodden (Baltic Sea) will be conducted from 22 April to 27 June using FRV *Clupea*.

PGHERS recommends that larvae survey methods and reporting procedures be reviewed in the light of TOR (f). A larvae survey manual should be prepared ahead of the next PGHERS meeting in 2004.

3.3 Review of larvae survey results in relation to gravel extraction

At the 2002 ICES Annual Science Conference a request was made to PGHERS to supply maps of the distribution of early stage herring larvae from the larvae surveys. These would be used to give an indication of the location of herring spawning sites which may be sensitive to plans for gravel extraction in the area. It should be stressed however, that the surveys are deliberately restricted subset of the whole area where larvae are likely to occur. Furthermore, the distribution of larvae is not a direct indication of herring spawning sites as larvae move and drift with water movements (e.g tide and residual currents) and the surveys are conducted some time after spawning. Permission for any gravel extraction should be conditional on more specific direct observational studies of the actual substrate during the spawning season. The distribution of larvae less than 10 mm from the last 5 years (1996-2001) are plotted in Figure 1 (central North Sea) and Figure 2 (southern North Sea).

4 ACOUSTIC SURVEYS

4.1 Review of acoustic surveys in 2002

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 53°30'N in the North Sea and north of 56°N to the west of Scotland to a northern limit of 62°N. The eastern edge of the survey area was bounded by the Norwegian, Danish and German coasts, and to the west by the shelf edge at approximately 200 m depth. The areas covered and dates of surveys are shown in Figure 3. The surveys are reported individually in Appendices IIa-f. Data were combined to produce a global estimate. Estimates of numbers-at-age, maturity stage and mean weights-at-age were calculated as weighted means of individual survey estimates by ICES statistical rectangle. The weighting applied was proportional to the survey track for each vessel that covered each statistical rectangle.

Provisional estimates of the three stocks surveyed are shown in Tables 2a-c by stock for North Sea autumn spawning herring, Western Baltic spring spawning herring, and west of Scotland (VIa_{north}) herring respectively. The distribution of adult herring is given in Figure 4 and that of juvenile herring in Figure 5. A full report of the finalised estimates, including distribution maps, will be prepared for the Herring Assessment Working Group and later produced as an ICES paper. The estimates of North Sea spawning stock biomass (SSB) and number of adults are 2.9 million t and 17,200 million herring respectively, an increase from 2.4 million t and 15,000 million fish in 2001. The current estimate is the largest in the acoustic survey time-series. The North Sea survey is consistent with previous years, giving a total adult mortality of about 0.39 over the last 3 years, which is similar to the estimates from the assessment (0.45). 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 (ICES 2001a). The acoustic survey in 2003 indicates that the abundances of these year classes are similar and about six times that of the preceding (1997) year class.

The estimates of Western Baltic spring spawning herring SSB and number of adults are 255,000 t and 2,874 million respectively, an increase in SSB since 2001 from 77,000 t; this is typical of the survey estimates of this stock which have shown fluctuations with a general increasing trend.

The west of Scotland survey estimates of SSB and number of adults are 548,000 t and 2.9 million respectively, and indicate that the 1995 year class is large as previously indicated. The 1998 year class is the largest seen during the survey time-series.

4.1.2 Western Baltic

A joint German-Danish acoustic survey was carried out with R/V *Solea* from 14 to 25 October 2002 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 Subdivisions 21, 22, 23 and 24. Due to technical problems with the winch on board of the research vessel, the survey started with a delay of more than two weeks. Since the survey time has to be shortened the Kattegat (Subdivision 21) could not be covered in 2002. As in previous years, the survey was carried out during the night. An EK500 echosounder and BI500 Bergen Integrator software were used to collect acoustic data. The cruise track covered a length of 666 nautical miles. 37 trawl hauls were carried out and from each haul sub-samples were taken to determine length, weight and age of fish. In general the catch composition was dominated by herring and to a lower extent by sprat. The total herring stock was estimated to be 6,000 million fish or about 195,200 t in Subdivisions 22-24. The abundance estimates were dominated by young herring. The estimated total sprat stock was 6,700 million fish or 58,100 t. A survey report is given in Appendix III.

4.2 Survey overlap between FRV *Scotia* and FRV *G.O. Sars*

In order to address question of standardisation and quality control for the acoustic surveys (TOR f) overlap areas have been included within the survey design. Analyses of abundance estimates between two or more countries in experimental overlapping survey areas have indicated some inconsistencies (ICES 2001b). An additional extended overlap was therefore carried out in 2002 with the objective of establishing the cause of these inconsistencies. The overlap area consisted of four ICES rectangles adjacent to the east coast of the Shetland Isles (Figure 3 and Figure 6).

Scotia surveyed the overlap area from 05/07/02 to 13/07/02; G.O. Sars surveyed from 16/07/02 to 18/07/02. It is strongly suspected that the large difference in timing resulted in the large differences observed (Figure 6). The mean acoustic density (NASC in $m^2.nmi^{-2}$) was 623 for FRV *Scotia* and 222 for FRV *G.O.Sars*. It is clear that these data cannot be used together to estimate the biomass in the area. Nonetheless, the exercise does provide data which will serve to study differences in scrutinising trends between operators in the two surveys. A more comprehensive analysis of scrutiny procedures was not possible at the meeting because: a) the full suite of scrutinising tools were not available (e.g. BI500 post processing system); and b) tools for writing to the common data exchange format (HAC) had only recently (21/01/2003) become available. The data will therefore be analysed by the respective institutes over the coming year.

It was agreed that an additional overlap should be carried out in the 2003 survey and that the data from both the 2002 and the 2003 surveys should be analysed in advance of the next PGHERS meeting. The following schedule was agreed upon to assist in the preparation of the analyses.

- IMR to send *G.O.Sars* multifrequency data (38, 120 and 200 kHz) from the 2002 overlaps to FRS by end March 2003. IMR to include information on equivalent beam angle, default S_v transducer gain, calibrated S_v transducer gain (for each frequency) and sound velocity used on the survey.

- FRS to send *Scotia* 38 kHz data from the 2002 overlaps in the HAC data exchange format to IMR by end March 2003. To include information on equivalent beam angle, default S_v transducer gain, calibrated S_v transducer gain (for each frequency) and sound velocity used on the survey.

- IMR to analyse Scotia's 2002 overlap data by end July 2003, submit results to FRS (P Fernandes).

- FRS to analyse G.O.Sars 2002 overlap data by end July 2003, submit results to FRS (P Fernandes).

- IMR to send *G.O.Sars* multifrequency data (120 and 200 kHz) from the 2003 overlaps to FRS by end July 2003.

- FRS to send *Scotia* 38 kHz data from the 2003 overlaps in the HAC data exchange format to IMR by end July 2003.

- IMR to analyse Scotia's 2003 overlap data by end August 2003, submit results to FRS (P Fernandes).

- FRS to analyse G.O.Sars 2003 overlap data by mid September 2003, submit results to FRS (P Fernandes).

4.3 Sprat

Data on sprat were available from RV *Walther Herwig III*, RV *Tridens* and RV *Dana*. No sprat were reported by RV *Scotia* and RV *G.O.Sars* in the northern areas. The distribution of sprat by numbers in millions and biomass in the North Sea is shown in Figure 7. The distribution pattern during the surveys 2002 demonstrates that the southern border was still not reached.

In Div. IIIa, sprat were present in the Kattegat, but none were found in the Skagerrak. This was a similar situation as in 2001. The bulk of abundance and biomass was found in the German Bight . The 2001-year class contributed with 74% of the biomass in eastern part, while the 2000-year class made up about 60% in the west. The total sprat biomass estimated was 241,000 t in the North Sea (Table 3) and 10,000 t in the Kattegat. In Kattegat, the total biomass in 2001 was 8,000 t.

4.4 Co-ordination of acoustic surveys in 2003

4.4.1 North Sea

Acoustic surveys in the North Sea and west of Scotland in 2003 will be carried out in the periods and areas given in the following Table and Figure 8.

Vessel	Period	Area
Charter west Scotland	01 July – 19 July	56°- 60°N, 3° - 6° W
G.O. Sars	01 July – 21 July	56°30'- 62° N, 2° - 6° E
Scotia	27 June – 21 July	58°- 62° N, 2/4° W - 2° E
Tridens	23 June – 18 July	54°30 – 58° N, west of 3° E
Walther Herwig III	25 June – 19 July	52° - 57° N, east England / 3° E
Dana	27 June – 10 July	North of 57° N, east of 6° E

The results from the national acoustic surveys in June-July 2003 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). A new spreadsheet to assist in the submission of data will be distributed by John Simmonds by 31 May 2003; this should be used by all participants. Data for both sprat and herring should be with the co-ordinators by **30 November 2003**.

4.4.2 Western Baltic

In the Western Baltic and the Kattegat, the following survey will be carried out in 2003.

Vessel	Period	Area
Solea	29 September – 20 October	Subdivision 21 to 24

5 FUTURE PLANNING OF ACOUSTIC SURVEYS IN THE NORTH SEA AND ADJACENT WATERS

5.1 Analysis of spatial variability in the acoustic surveys for herring in the North Sea

5.1.1 Introduction

Term of reference b) requested that PGHERS considered a re-allocation of effort by participating countries in the acoustic survey of the North Sea and adjacent waters in 2003. In response to this request PGHERS investigated:

- the spatial variability of the estimates of herring at age over the time-series 1989-2002;
- the influence on the assessment and projections of the variability in the estimates of different age classes of herring.

From these two studies the influence of the precision of each age class estimate was determined and used as a weighting factor for the spatial distribution of variance at age. This provided a single (multi-year) distribution of spatial variability in the survey, weighted in relation to the requirements of the assessment (described below). The results were used to define three classes of ICES statistical rectangle to be surveyed at different intensities.

5.1.2 Methods

The spatial variability by year class and maturity stage (for 2 & 3 winter ring) was estimated through the relative abundance of each age between years.

$$V_{as} = Var_{over-y}(A_{ays} / \sum_{s} A_{ays})$$

where:

V_{as} = variance at age a in statistical rectangle s

A_{ays}=abundance at age a in year y in statistical rectangle s

Var_{over-y} = variance over years

To study the influence of estimates at age in the assessment the relative importance and therefore the weighting factors at age were estimated through bootstrap assessments of multiple realisations of the acoustic survey by age. Four terminal years were selected (1998 to 2001 inclusive). The methods used for the assessments were those documented in the SGEHAP study group report (ICES 2001c) and short-term deterministic projections as carried out in the EU project EVARES (Simmonds *in prep.*).

Three criteria were selected for investigation of the influence of age groups on the assessment, the variability in terminal $F_{2\text{-}6}$, terminal SSB and the adult TAC following the EU Norway exploitation agreement. To carry out this investigation the influence of each age group was investigated in subsets (1, 2, 3&4, 5&6&7, 8&9+). For a single measure of influence on the assessment, the variance of multiple ages was assumed to be allocated equally among these ages. The reason for this procedure is that there is some correlation in errors between ages. The age groupings were chosen because of the correlation between ages and the similarity in spatial pattern of the variability.

A single age dependant function is required. Equal weight was allocated to the 'state of the stock' (both terminal F and SSB) and on the TAC. The influence by age was thus defined as:-

$$W_a = 0.25Var_a(F)/\overline{Var(F)} + 0.25Var_a(SSB)/\overline{Var(SSB)} + 0.5Var_a(TAC)/\overline{Var(TAC)}$$

W_a = weighting factor at age

$Var_a(X)$ = Variance of the factor X (F or SSB or TAC) due to age a in the survey.

These values are available for each age class but do not take into account the maturity split available in the spatial data. For simplicity the proportion of W_a allocated to immature and mature herring (2I & 2M and 3I & 3M) was in proportion to the abundance in each category. The overall influence of spatial variance (V_s) was then computed as:

$$V_s = V_{as}.W_a$$

5.1.3 Results

The spatial variability is described by the relative spatial distribution of variance V_{as} (Figure 9).

The sensitivity of assessment and projections due to age a in the survey (Var_a) for the assessment parameters F, SSB and projected TAC is given in Table 4. The combined weighting factor at age W_a is also shown in Table 4.

Combining the factors W_a (Table 4) and the spatial variance by age (Figure 9) provides a spatial distribution of survey weighting (Figure 10). A classed version of this can be seen in Figure 11. Three classes were defined: those with the smallest values contributing 5% of total variance; those contributing the next 30%; and those giving the top 65% of the variance. The effort could be allocated to these in a number of ways; options for the coming year have been considered in the design for 2003 (see section 5.2 below). Table 5 indicates the predicted change in survey variance with changes in track intensity for constant survey effort.

5.2 Considerations for the re-allocation of survey effort

Effort allocation in the international herring acoustic survey has been, to date, based on historic and national considerations rather than the most optimal application of survey effort to increase accuracy and precision. An analysis of the geographical and temporal distribution of variance was carried out at this meeting (see section 5.1 above). This indicated that, from first principles a reallocation of effort, particularly into the Shetland area would have potential benefits.

This discussion is based on the use of the survey for herring stock estimation, redesign implications may be different while the survey continues to be used to provide a sprat stock estimate.

Redesigning the survey would have a number of potential impacts and implications, both positive and negative.

Positive impacts and implications:

- The redesign would make the most efficient use of ship time, allocating highest effort to areas of high abundance/variance;

- The resultant stock estimate should have a lower variance;

- As part of the process it would be necessary to maintain a high level of standardisation in survey practice and methodology, which is a desirable target in itself;

- Following from this, there should also be reduced impact of vessel/operator variability on the survey;

- In the case of a fully integrated survey, the outcome would be more robust to the loss of a single vessel contribution. At present, if a vessel drops out of the survey, for whatever reason, it will often mean an entire area is missed out, or surveyed by a replacement team unfamiliar with the area. This happened as a result of the omission of the Danish survey in 1999 (ICES 2000).

Negative impacts and implications:

- The survey would require more precise planning and co-ordination. A fully interlaced design will need vessels to be available at the same time in similar areas;

- In-survey co-ordination would need to be much better. For instance, in an interlaced transect design it would be important that alternate transects were occupied as close together in time as possible;

- As vessels and teams may have to cover areas and stock situations with which they were unfamiliar, there will be scope for mistakes in data interpretation e.g. scrutiny and location of trawl hauls;

- Existing commitments to other sampling programmes may be compromised.

In the light of this, PGHERS considered a range of options:

1. Retain the existing design with small adjustments;

2. Continue and expand the number of survey overlap areas for experimental purposes – i.e. to harmonise scrutiny and integration procedures;

3. Continue and expand the number of survey overlap areas for use in producing real stock estimates from combined data;

4. Retain the general pattern as per 2002, but with changes in effort stratification. Surveys in areas with high historical abundance/variance would have more effort applied in those areas. As a result the overall area covered by some individual surveys may be reduced and this would compensated by increases in the areas covered by other surveys. This in turn would lead to a reduction of effort in the lower abundance/variance areas.

5. Full scale redesign of surveys. The survey would be designed as a single operation, based on abundance and variance distributions. Vessels survey areas would be allocated according to need, without reference to historically surveyed areas. This type of design is used in a variety of other ICES co-ordinated surveys e.g. Atlanto-Scandian herring acoustic surveys, triennial mackerel egg surveys or IBTS.

5.3 Implementation of re-allocated effort

PGHERS felt that currently the level of standardisation between institutes was not sufficient for full integration (option 5 above). Essentially this is due to fact that the pattern of spatial aggregation of herring differs substantially between the different survey areas. For instance, in the Norwegian area, the bulk of the herring are found in very small surface schools, while in the Shetland area (where the bulk of the stock is found) the schools tend to be larger and distributed near the bottom. This leads to differences in choice of trawling locations, in interpretation of trawling results and interpretation of echograms (scrutiny). While this is not a problem when the same team surveys the same area every year, it may raise problems when a team surveys an unfamiliar area.

In consideration of the above, PGHERS agreed a number of steps could be taken immediately towards the eventual aim of full integration.

1. Increase the number of areas of overlap between surveys. The data collected in these overlaps could then be analysed by the two teams separately AND together, and methods harmonised.

2. Take advantage of the fact that two of the surveys are carried out by FRS, Scotland (Orkney/Shetland and VIa(N)). The area covered by the charter vessel on the west coast (VIa(N)) could be extended eastwards to the western side of the Orkney/Shetland archipeligo, where a high intensity survey design using interlaced transects with FRV *Scotia* could be used to cover the areas of high abundance/variance.

3. Examine the utility and value of the sprat survey in the southern North Sea. In the last two years the German survey area has been extended southwards in an attempt to encompass the full distribution of sprat in the North Sea. In 2002 the survey was extended further south than before, however, sprat were found on the southernmost transect, implying more stock to the south. It was proposed that in 2003 this survey be extended to provide a coverage of the entire area of the southern North Sea down to 52°N. Decisions on the exact and extent of the utility of the sprat survey could then be taken.

6 PROTOCOLS AND CRITERIA TO ENSURE STANDARDIZATION OF SAMPLING METHODS

In response to TOR (f) PGHERS examined the latest "Manual for herring acoustic surveys in ICES divisions III, IV and VIa". PGHERS has revised this manual annually and is, therefore, consistently assessing its protocols to ensure standardisation of sampling methods. A review was made of the current acoustic survey manual (version 3, ICES 2002) and the following revisions were applied:

1. The maturity key conversion table was modified to reflect the actual numbering system used by the Netherlands.
2. An expanded section describing the 8 point maturity scale was added.
3. The acoustic survey data submission tables were modified to include biomass and numbers totals; and to include an example of the mean length by age and area table.

The new manual is attached as version 3.1 in Appendix IV. In the light of ICES new concerns, however, it was felt that a major revision of the manual should be prepared for the next PGHERS meeting. This is particularly timely in the light of recent changes in some of the instrumentation used. The new Simrad EK60 echosounder is now available and is being used by some participants. The manual had hitherto been based on operation of the previous SIMRAD EK500 echosounder and PGHERS should consider implications of using the new system. There are also a variety of different software packages being used by participants: Sonardata Echoview (UK); the Bergen Integrator (Norway); Simrad's BI500 (Germany & the Netherlands); and the new EK60 software may also be used soon.

The revision of the manual at next years meeting should be part of a review cycle of methods which should consider items such as scrutiny, ageing, determination of maturity and the manual. All of these items have been considered in recent years to good effect. A proposal which should be considered would be to undertake one of these items each year as follows, for example: 2003, manual revision; 2004, scrutiny workshop; 2005, maturity staging 2006, otolith exchange.

7 MEASUREMENT OF BIOLOGICAL PARAMETERS

7.1 Maturity determination

Different scales, used for the determination of maturity stages of herring by the different partners of the survey, have repeatedly lead to some confusion. At the December 2001 meeting PGHERS decided that a preliminary set of photographic images of herring gonads should be collected during the 2002 survey to be discussed between the participants. These images were presented by Emma Hatfield and Else Torstensen. This presentation led to a discussion on the different maturity scales that are presently being used. The current use of maturity scales is as follows:

Denmark:	8-point scale
Germany:	4-point scale
Netherlands:	4-point scale
Norway:	8-point scale
Scotland:	8-point scale

Details of the description for the single stages can be found in the latest Manual for Herring Acoustic Surveys In ICES Divisions III, IV and VIa (version 3.1, Appendix IV to this report, Table 9 for females and Table 10 for males). PGHERS decided to complete the collection of images of different maturity stages by asking all participant countries to contribute high-quality, high resolution images following the photographic procedures described in Section 7.2 (below). It would be particularly important to obtain images of stages II and III (on the 8 point scale), including examples that are difficult to stage. The overall aim is to arrive at an agreed description of stages following an examination of photographs at the next PGHERS meeting.

7.2 Photography for the demonstration of maturity stages

Procedures for the acquisition of herring maturity stage photographs have been developed for a variety of EU projects. The methods are described here to assist PGHERS members in obtaining an image of the whole fish and the details of its gonads to help in determining the different maturity stages. They should demonstrate both 'typical' example images of the different stages for demonstration purposes and images of fish on the border between stages for discussion.

7.2.1 Photographic hardware

Camera: The digital camera used should be able to produce images of a resolution of 3 megapixels or more. It should be equipped with a macro setting, the possibility to operate in aperture priority mode and allow white balance adjustment.

Copy stand: A copy-stand is essential to ensure the stability of the camera and consistency of the image composition. A set-up known to work is shown in Figure 12. A sturdy copy stand with a column of about 70 cm or more and a baseboard of 40x40 cm or more will be suitable. For reasons of compactness and simplicity the lamps can be attached on the baseboard via arms but to avoid potential problems with internal vibration, another fixture for the lights should be used.

Lighting: The light should be sufficiently strong to ensure a shutter speed of $1/125^{th}$ of a second or less at an aperture of f5.6 or smaller (i.e. larger aperture-numbers). External flash is preferred over halogen light, which again is preferred over tungsten light. It is best to avoid a fluorescent light source as this has an light output which oscillates at a frequency which may be out of step with the shutter speed. Built-in camera flash should also be avoided because this produces glare. Four lights of 100W each at a distance of 50 cm from the fish have proven to be sufficient. These should be directed at an angle of about 45° to baseboard to minimise glare. Surrounding the copy stand with white cardboard or styrofoam lightens the shadows and produces softer lighting.

Background: The background for the photos should be a medium-tone. Dark-blue mm-graduations on paper of size A3 as used for construction drawings is suitable. Apart from the mm-graduations, an additional scale should be included in the picture to determine sizes. To allow the true reproduction of colours of the images on a screen or in print, a Kodak Pantone card should be included in the picture. Subsequent reproductions of the picture can be adjusted by this standard.

Set-up: To eliminate vibration when working on a vessel, the whole set-up should be dampened against the frequencies of 10-100 Hz that predominate on most ships and are worst with regard to photography. This can be achieved by placing the whole copy stand on a closed cell foam base (e.g. karrimat). For some lower frequencies it might be advisable to detach the lamps from the baseboard if they induce any resonance vibration.

7.2.2 Photographic procedures

- A label identifying the fish should be included to verify age and other particulars.

- For images of the whole fish, a moderate telephoto lens or the equivalent zoom setting should be used in order to minimise perspective distortion. The equivalent of 75 - 150 mm in 135-photography is appropriate (see Figure 13).

- For the close-ups of the gonads it may be necessary to switch to a wide-angle setting of the zoom lens, as this would render a slightly greater depth-of-field at a given aperture at the cost of some image perspective distortion (see Figure 14).

- An aperture of f5.6 or smaller (i.e. larger numbers) should be used to obtain sufficient depth-of-field. It may be necessary to switch the camera into a macro mode if the distance between object and camera is lower than a certain value.

- The white balance feature of the camera should be used to account for the colour of the lighting you are using.

- The auto exposure feature in ‘average’ or ‘evaluative’ mode should be used for test photos. If these prove satisfactory, these settings can be used. If the images prove to be too bright/dark then they should be corrected accordingly ensuring that larger apertures (i.e. smaller numbers) than f5.6 are not used (decreasing depth of field). Shutter speeds slower than 1/125th second should not be used.

- Several shots of each subject, should be taken, bracketing the exposure settings and focus.

- After the exposure, the images should be checked immediately on a computer screen at the full resolution and not on the tiny LCD of the camera.

- The images should be saved as a jpeg-file with the lowest possible compression (largest size).

- *These procedures should be* ***tried and tested*** *under as realistic circumstances as possible with real fish before embarking on a dedicated sampling exercise!*

7.3 Maturity patterns in Skagerrak-Kattegat 2000 to 2002

A working document on changes of maturity in herring caught in the Danish survey in the Skagerrak and Kattegat was presented to the PGHERS (WD Stæhr 2003). For the combined survey report, all spring and autumn spawners of age 4+ have been considered to be mature, whilst the maturities of younger fish were determined from samples taken during the annual surveys. Results of recent analyses indicate an increasing fraction of immature fish at older age, with up to 83% and 50% immature autumn spawning herring at age 4 winter ring and 5 winter ring respectively. However, these fractions are based on a very small sample size (e.g. 2 fish at age 5 winter ring in 2002) and the mean weights-at-age do not indicate reduced growth for these older fish. Additionally, any consideration of including immature old fish had negligible influence on the biomass estimate for the survey area and the assessment of both autumn and spring spawners. PGHERS felt that the issue of maturity in older fish in this region should be studied in future surveys.

7.4 Sprat otolith exchange

A sprat otolith exchange was organised from December 2001 to May 2002. Age readers from seven institutes took part in the exercise. The readers were experienced age readers and the majority were familiar with ageing sprat otoliths, either from the North Sea or adjacent areas. Participating institutes were:

SOAEFD Marine Laboratory, Aberdeen, Scotland
Department of Agriculture and Rural Development, Belfast, N.Ireland
Department of Fisheries Research, Charlottenlund, Denmark
Institut für Seefischerei, Hamburg, Germany,
Institute of Marine Research, Lysekil, Sweden,
Institute of Marine Research, Flødevigen, Norway,
RIVO, Ijmuiden, The Netherlands.

A total of 270 pairs of sprat otoliths were available from RV *Solea*, RV *Tridens* and RV *Michael Sars* (Table 6). All otoliths were mounted in synthetic resin in black plastic trays. The age determination criteria were a) 1 January the date of birth and b) annual growth consists of one hyaline and one opaque ring. Precision estimates and comparison of individual readers were made using the Excel worksheet "AGE COMPARISONS.XLS" Ver. 1.0 (Eltink *et al.* 2000). A basic concept for this worksheet is to compare individual age estimates with the modal age of each pair of otoliths. The modal age is the age for which most of the readers have a preference and the average age is the arithmetic mean of all the age readings of each otolith.

The mean ages by length given by the individual readers are shown in Figure 15 and the overall agreement between readers was 85% (Table 7). The ageing was consistent between readers for only 26 pairs of the otoliths. The individual age reading results and modal ages had >85% agreement in 171 pairs of otoliths, >80% in 225 pairs of otoliths. One reader had an over all agreement of less than 20%. There were significant differences between readers and between the modal age and estimated age among four of the readers.

In general, there was a reasonable agreement between the age determinations (Figure 15). One of the readers had a 17% agreement with the modal age and an extremely low agreement of modal age 1 and 2. The data from the individual readings shows that sprat <10.5 cm were aged 1 yr older then by the others. The CV´s on modal age 1 were in general high for most of the readers.

There are indications of difficulties in interpretation of the edge that seems to be a usual problem in age reading of fish sampled in a period of fast growth. The period for deposition of winter-rings vs. growth zones in otoliths in young and older sprat from the North Sea area is not documented. The results indicate that there is potential for improvement and action should be taken to achieve a greater precision within institutes and between the various participants. A review of the criteria used for ageing sprat and further validation of the formation of winter rings and allocation to year classes is recommended. This implies that there is a need to gain understanding of the spawning and recruitment processes, focusing on autumn spawning in sprat.

8 INVESTIGATION OF THE EFFECT OF TIME OF DAY ON THE DETECTION OF HERRING DURING THE NORTH SEA ACOUSTIC SURVEY

There are many examples of herring dispersing and rising into surface waters at night. This behaviour makes them either unavailable to the acoustic apparatus used in the co-ordinated acoustic survey or difficult to distinguish acoustically from other scatterers. To mitigate for this, some of the acoustic surveys suspend operations at night. However, the amount of time and the start and end points varies amongst participants. The surveys in the Orkney-Shetland area and the west of Scotland (carried out by Scotland) are suspended from 22:00 to 02:00 GMT; the Dutch suspend the survey from 21:00 to 04:00; and the Germans from 20:00 to 04:00. The Danes do not suspend acoustic surveying but do restrict trawling to the pelagic zone from 21:00 to 03:00; whilst the Norwegians survey 24 hours a day. PGHERS has examined data from past acoustic surveys to investigate the influence of time of day on the abundance estimation of herring.

In a previous study, Fernandes et al. (2001) examined the Diurnal Vertical Migration behaviour by fitting a model to image analysis data of fish school size and number. This work has been expanded to incorporate loess smoother fits to the NASC data by time. The fit of the model to the data was significantly different from a straight line indicating that the measurement of NASC is not independent of the time of day (Figure 16). Elimination of successive hourly bins from the early hours of the morning and later hours of the night gradually reduces this deviation (from a straight line fit), until it is no longer significant. The latter point occurs by elimination of between 3 and 5 hours worth of data.

Studies of the temporal NASC dependence in the Norwegian area (Figure 17) indicate that there may be quite a marked increase in measured NASC in the late morning. This is similar to results from the previous year and merits further investigation.

During the 2002 *Walter Herwig* III acoustic survey, a transect of 20 n.mi length was sampled during daytime and again in the dark. Daytime concentrations consisted mostly of large herring schools in midwater or near the bottom. At about 2000 UTC (sunset was at approx. 20:20) vertical migration started and by 2200 UTC all the herring were scattered as single targets or in small schools in the upper layers. The discrimination of such echo-traces from other scatterers (such as plankton) and or noise is difficult. This can be demonstrated by the comparison of the mean NASCs over the total track from observations from night and day when the threshold level is changed. Although it is assumed that similar targets are present at day and night, the different spatial distributions of these objects results in changes in their acoustic density (NASC). In the daylight echogram the plankton can be removed by increasing the threshold. In the other case more and more of the fish echo will be clipped when the threshold level is increased. The threshold filtering of plankton noise is not possible for scattered night concentrations.

PGHERS considered that although there may be bias associated with herring DVM it is likely to be small. Furthermore any reduction by elimination of survey hours may have seriously adverse consequences on the precision of the surveys. More studies are therefore required to assess the balance between the bias associated with the DVM and the imprecision associated with fewer hours for surveying.

9 RECOMMENDATIONS

The Planning Group for Herring Surveys recommends that:

- The Planning Group for Herring Surveys should meet, at Flødevigen, Norway, from 26 to 30 January 2003 (chair to be announced) to:

a) combine the 2003 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 2004;

c) review and update the PGHERS manual for acoustic surveys to address standardization 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.

Justification

Terms 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 practises and or equipment.

Term of reference d)

At the 2002 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 2002 PGHERS meeting. The results of these overlap analyses will be presented at the 2003 PGHERS meeting after which further consideration can be given to a more integrated survey design involving more survey overlaps.

Term of reference e)

The HERSUR database was built with the idea of providing a common and internationally accessible archive of data from the International Herring Acoustic Survey. The database was built and maintained under the EC funded projects HERSUR I and II. With the termination of that project questions remain as to the future of the database: at the very least, the maintenance of the database should be considered; and at best, further development may take place to produce a global estimation system. PGHERS will review the status of the HERSUR database at the time of meeting in 2003 and make recommendations as to how it may be utilised or developed according to perceived needs.

Additional recommendations

- The larvae surveys in the North Sea should have an expanded area coverage in the 2004/05 period. Requests for ship time should be made at the earliest opportunity.

- PGHERS recommends that nations participating in the acoustic surveys should make strong efforts to exchange staff between surveys. This is essential prior to any re-evaluation of survey effort allocation where scientists may survey unfamiliar areas, to ensure that consistent scrutinising and evaluation methods are applied.

- PGHERS recommends that acoustic survey data from 1991 onwards be archived into the HERSUR database if this is to continue.

- PGHERS recommends that a review be made of existing documentation on practical aspects of larvae survey methods, including data collection and analysis.

- PGHERS recommends that all survey reports and manuals (for larvae and acoustic surveys) relevant to the group be posted on the "clupea.net" website. Furthermore, possibilities should be explored to use "clupea.net" as a portal site to access historic acoustic survey data from the North Sea, which is stored on the HERSUR database.

- PGHERS notes that despite recommendations from this group over the past two years, efforts are not being made to cover the whole Subdivision IIIa during the October survey on Baltic spring spawning herring. If there is a need for this survey to deliver an index to the HAWG, that group must endorse these recommendations.

- PGHERS recommends that biological samples from the surveys be examined more closely to investigate maturity in 1 winter ring fish.

- PGHERS recommends that photographs of herring maturity stages be obtained during the 2003 acoustic surveys. These will be examined at the next PGHERS meeting.

10 REFERENCES

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Table 1 Results of the German herring larvae surveys in the Greifswalder Bodden and adjacent waters in the western Baltic, 1992-2002. S = Total survival rate; S1 = Survival rate of the youngest larvae. N 30 = estimated number of herring larvae which will grow up to the total length of TL >= 30 mm

Year	Total number of herring larvae [number/m^2]	Mean number of herring larvae per Station [(Nm$^{-2)}$]	Number of N30-larvea in the total area [millions]	Mean survival rate per day (S/S1) [%]	Mean growth rate [mm day^{-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	2553	92 / 96	0,63
1999	195 163	34,30	1945	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	2051	94 / 94	0,48

Table 2a Combined acoustic survey estimates of numbers (millions), biomass (thousands of tonnes), percentage mature (assuming 100% 4wr and older) mean weight and mean length for North Sea autumn spawning herring summer 2002.

North Sea	Numbers	Biomass	Maturity	weight(g)	length (cm)
0	7428.8	41.0	0.00	6	9.3
1	23054.9	1031.9	0.06	45	18.1
2	4875.1	673.0	0.86	138	24.7
3	8220.6	1421.0	0.97	172	26.4
4	1390.0	270.8	1.00	194	27.4
5	794.6	178.6	1.00	224	28.6
6	1031.2	254.7	1.00	247	29.4
7	244.4	63.8	1.00	261	29.9
8	121.0	33.8	1.00	280	30.6
9+	149.5	37.2	1.00	249	29.2
Immature	30075.6	1058.2			
Mature	17234.5	2947.5			
Total	47310.1	4005.7			

Table 2b Combined acoustic survey estimates of numbers (millions), biomass (thousands of tonnes), percentage mature (assuming 100% 4wr and older) mean weight and mean length for the Western Baltic spring spawning herring summer 2002.

Baltic	Numbers	Biomass	Maturity	weight(g)	length (cm)
0	22.4	0.2	0.00		
1	3346.2	138.5	0.05	41	18.4
2	1576.6	107.8	0.56	68	21.4
3	1392.8	126.9	0.82	91.1	23.4
4	524.3	55.9	1.00	106.6	24.5
5	87.5	12.8	1.00	145.8	26.8
6	39.5	7.4	1.00	186.5	28.3
7	17.8	3.5	1.00	198.7	28.3
8.00	5.9	1.2	1.00	200.8	29.2
9+	11.2	2.0	1.00	174.2	28.7
Immature	4149.8	200.6			
Mature	2874.5	255.5			
Total	7024.3	456.0			

Table 2c Combined acoustic survey estimates of numbers (millions), biomass (thousands of tonnes), percentage mature (assuming 100% 4wr and older) mean weight and mean length for the West of Scotland (VIaN) autumn spawning herring summer 2002.

West Scot	Numbers	Biomass	Maturity	weight(g)	length (cm)
0	0.0	0.0	0.00		
1	424.7	26.2	0.00	62	19.0
2	436.0	66.7	0.92	153	25.4
3	1436.9	255.0	1.00	177	26.6
4	199.8	39.6	1.00	198	27.6
5	161.7	34.3	1.00	212	28.2
6	424.3	91.4	1.00	215	28.3
7	152.3	34.3	1.00	225	28.7
8.00	67.5	16.4	1.00	243	29.4
9+	59.5	15.4	1.00	259	30.0
Immature	459.9	30.6			
Mature	2903.0	548.8			
Total	3362.9	579.4			

Table 3 Estimates of sprat in the North Sea from the 2002 acoustic survey. Total number (millions), total biomass (thousands of tonnes) and Spawning Stock Biomass (SSB, thousands of tonnes).

Year	**Total Number**	**Total biomass**	**SSB**
2001	21.300	202	157
2002	21.900	241	165

Table 4 The relative variance for each age group in the assessment parameters F and SSB and projected TAC from bootstrapped assessments and projects by ages 1, 2, 3&4, 5&6&7, 8&9+.

Age (wr)	F2-6	SSB	TAC	W
1	0.36	0.53	1.36	0.90
2	1.04	1.46	1.31	1.28
3 or 4	2.11	2.18	1.07	1.60
5,6 or 7	1.03	0.61	0.63	0.72
8 or 9+	0.47	0.23	0.63	0.49

Table 5 Predicted change in survey variance with changes in track intensity for constant survey effort.

Area	Relative track intensity			
high	1	4	4	6.5
medium	1	2	3	2
low	1	1	1	1
Area	Variance			
high	0.65	0.28	0.34	0.21
medium	0.3	0.26	0.21	0.31
low	0.05	0.09	0.10	0.10
Total	**1**	**0.63**	**0.65**	**0.62**

Table 6 Sprat otoliths provided from herring acoustic surveys in the North Sea June/July 2001.

Survey	Pairs of otoliths	Length range (cm)	Mean length
RV Sole	95	8.5-13.5	11.0
RV Tridens	75	10.5-13.5	11.9
RV Michael Sars	100	9.0-12.5	10.1

Table 7 Agreement (%) with length and modal age among the readers.

	Modal age			
Length	1	2	3	Total
8.5	90 %			88 %
9.0	90 %			88 %
9.5	89 %			87 %
10.0	89 %			86 %
10.5	84 %	86 %		84 %
11.0	77 %	85 %		79 %
11.5	78 %	91 %		86 %
12.0	80 %	82 %	75 %	81 %
12.5		86 %		86 %
13.0		88 %	90 %	89 %
13.5		83 %	86 %	84 %
Sum	85 %	85 %	87 %	85 %
Pair of Otoliths	166	86	12	264

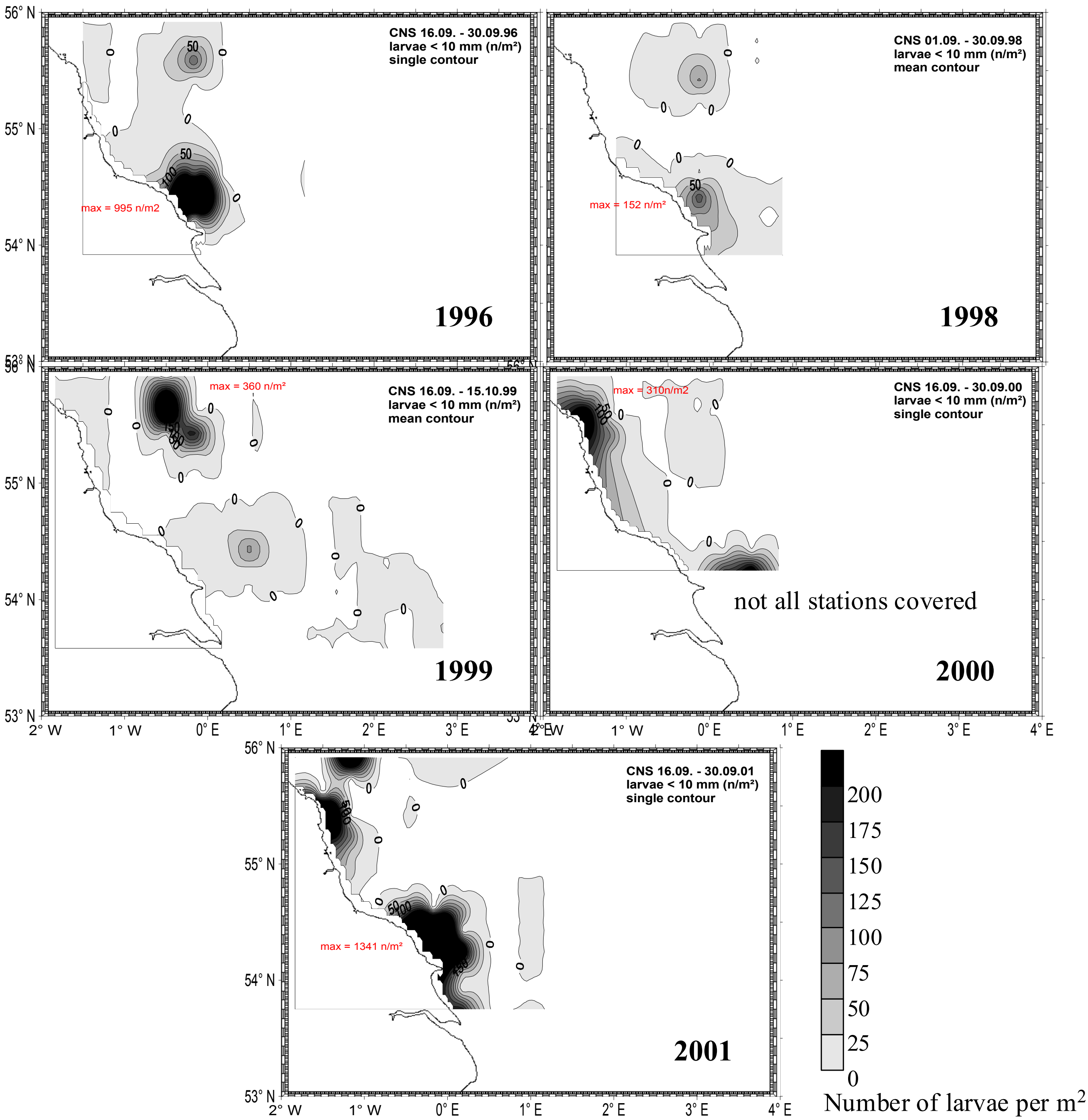

Figure 1 Distribution of larvae < 10 mm (n/m²) obtained from the International larvae survey for herring from 1996 – 2001 in the central North Sea.

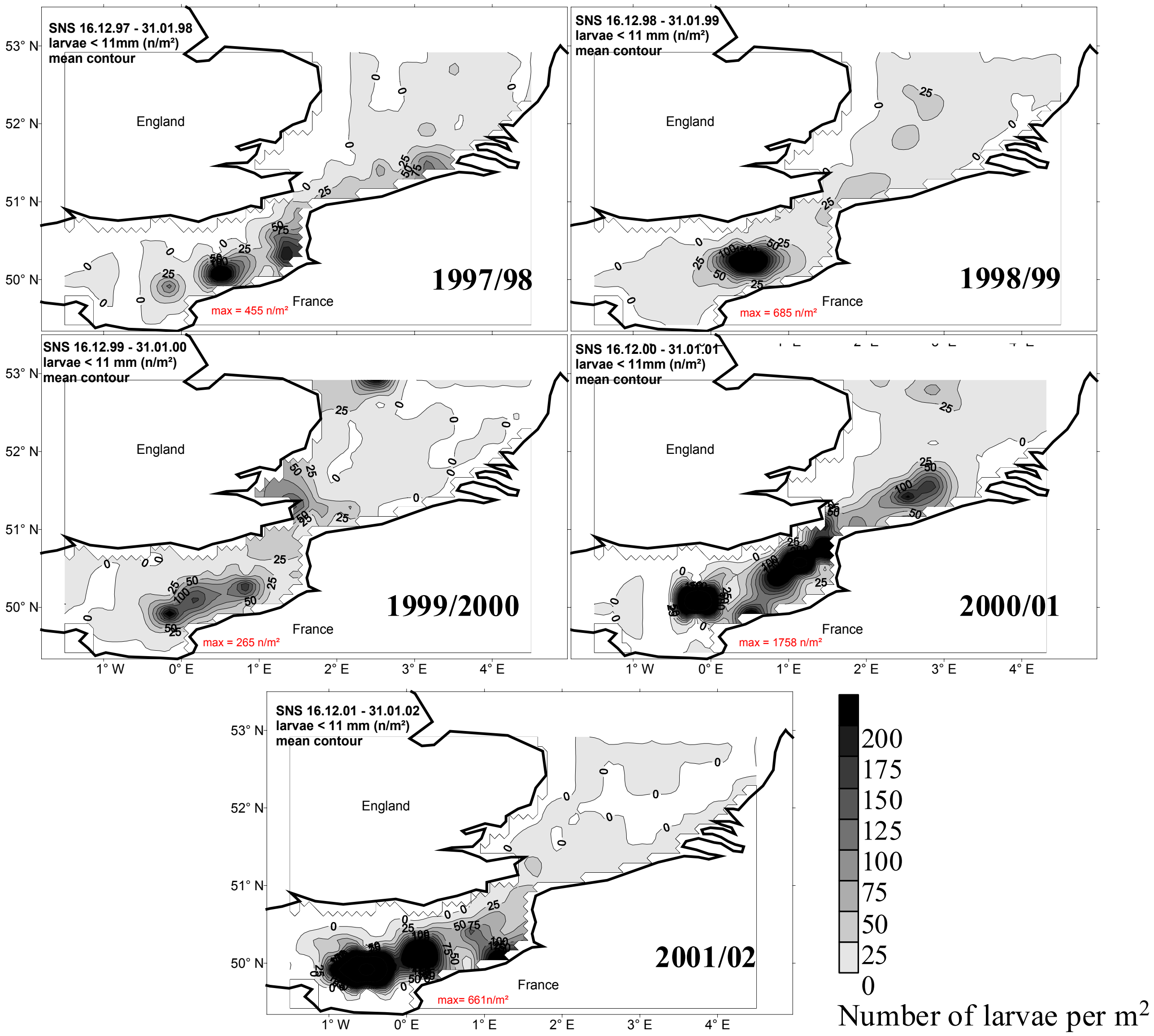

Figure 2 Distribution of larvae < 10 mm (n/m²) obtained from the International larvae survey for herring from 1996 – 2001 in the southern North Sea

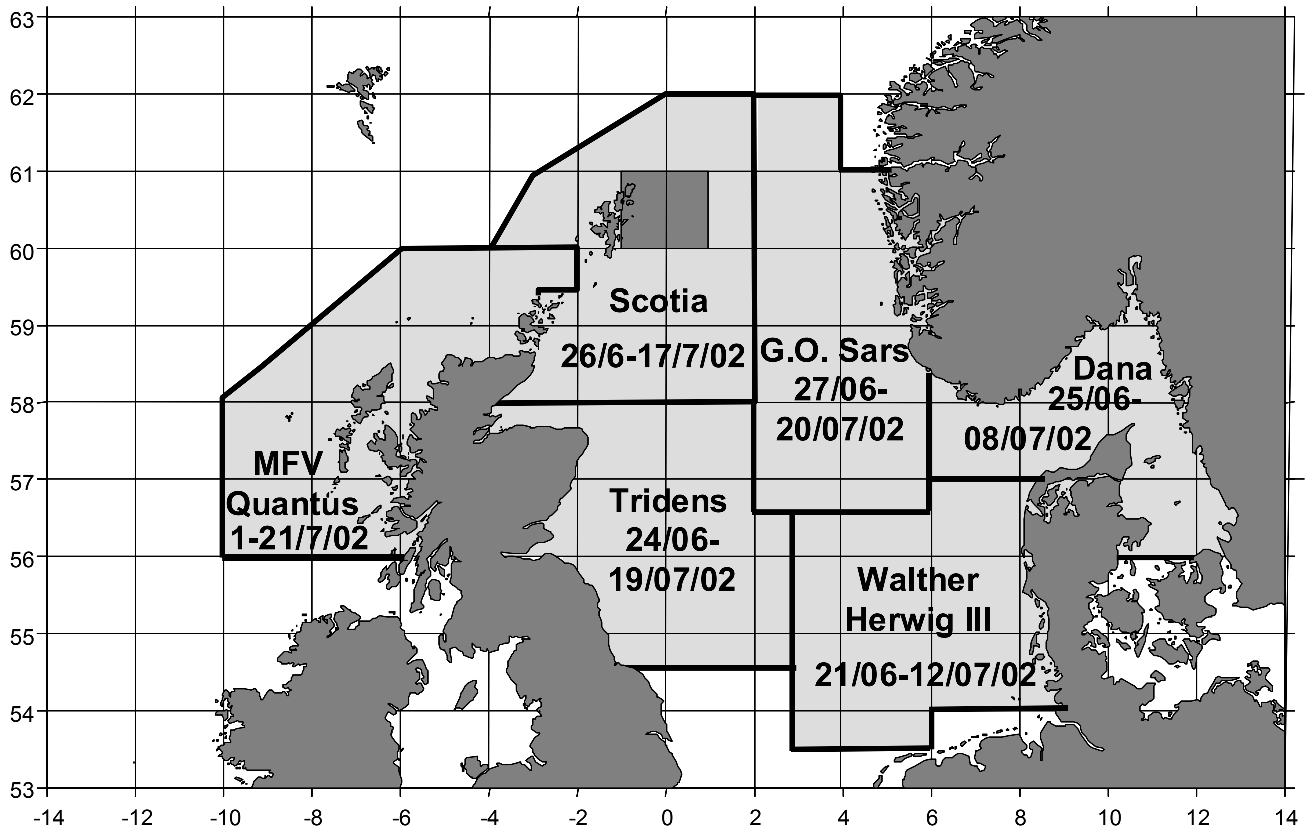

Figure 3 Survey area layouts and dates for all participating vessels in the 2002 acoustic survey of the North Sea and adjacent areas. Shaded areas indicate areas of overlap.

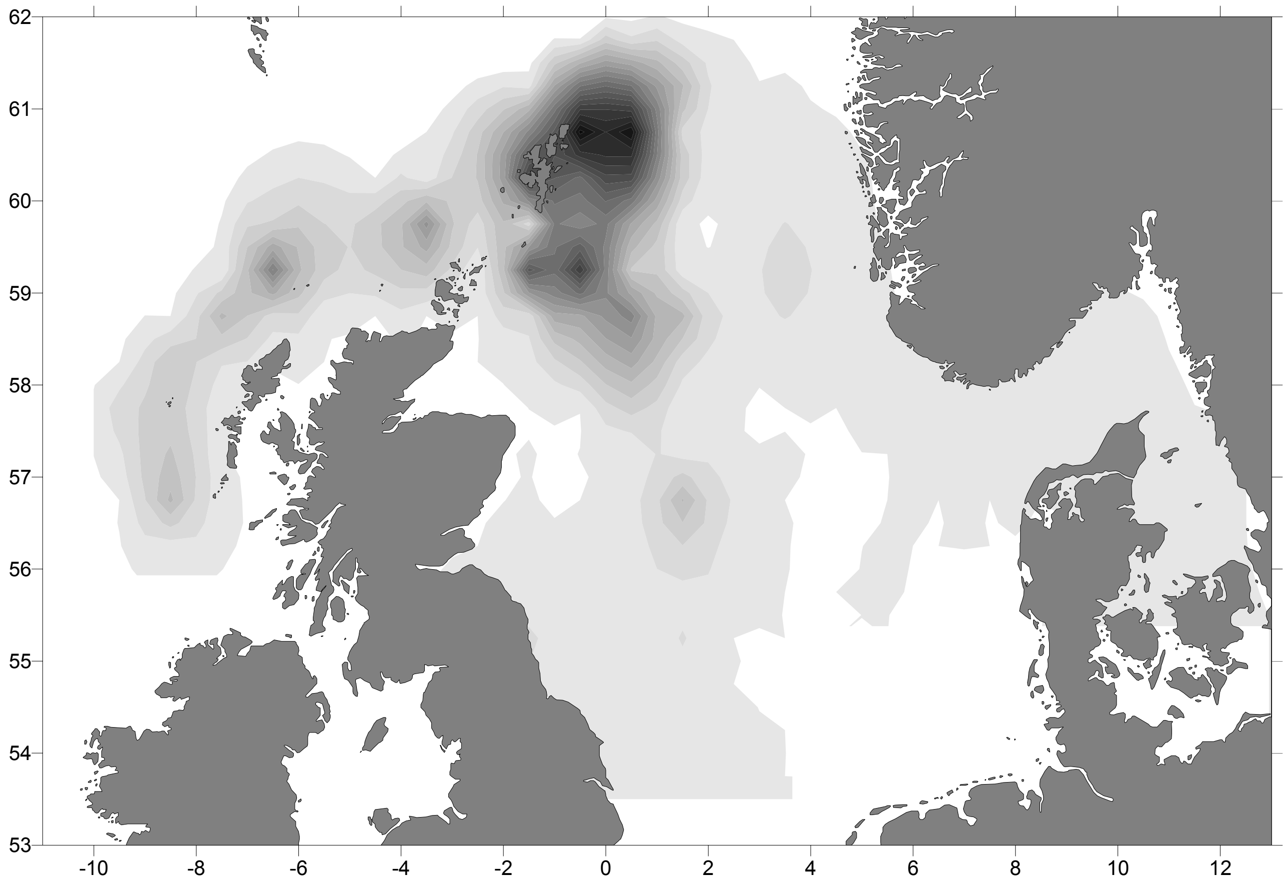

Figure 4 Map of the North Sea and adjacent waters showing the distribution of adult autumn spawning herring as estimated from the 2002 international herring acoustic survey.

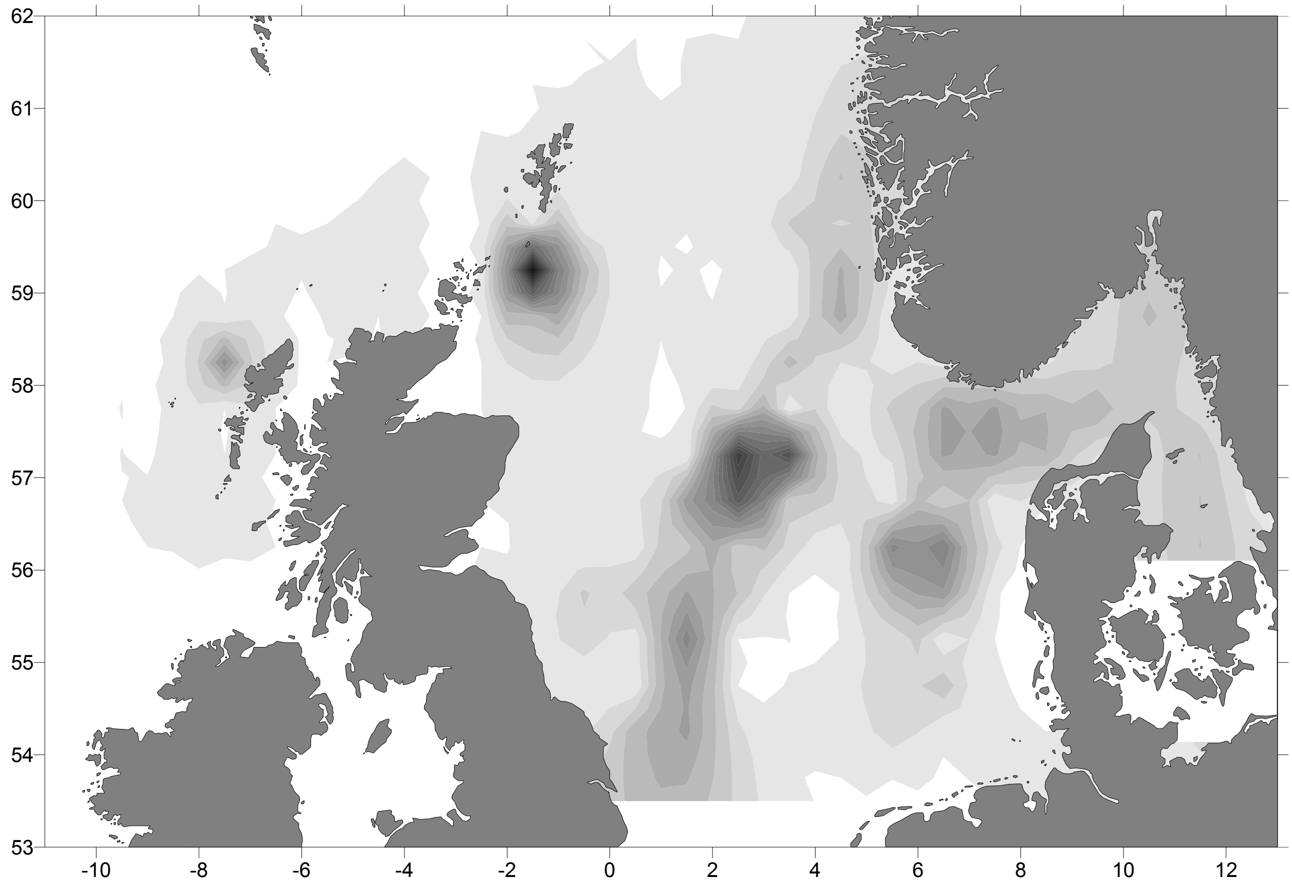

Figure 5 Map of the North Sea and adjacent waters showing the distribution of immature autumn spawning herring as estimated from the 2002 international herring acoustic survey.

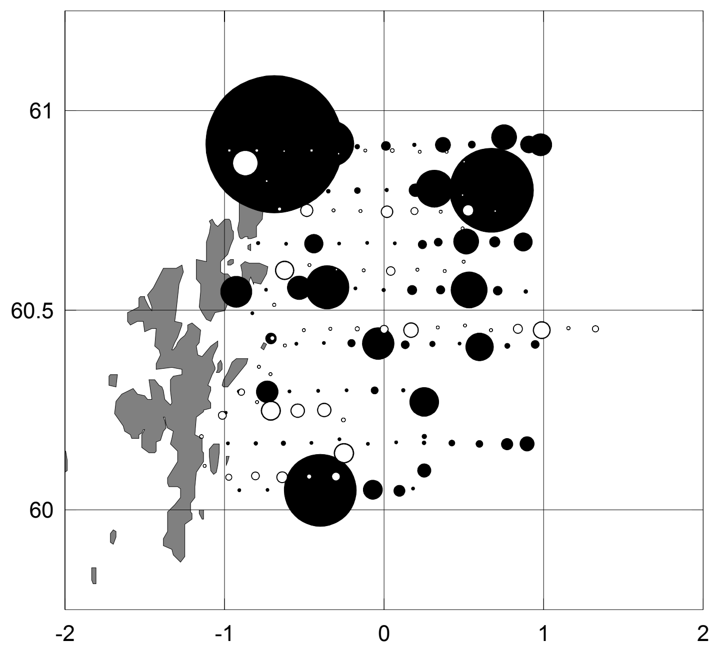

Figure 6 Map of the Shetland Isles showing plot of acoustic density (circle area proportional to NASC in $m^2.nmi^{-2}$) obtained during the overlap as surveyed by FRV *Scotia* (black solid circles) and FRV *G.O.Sars* (white circles).

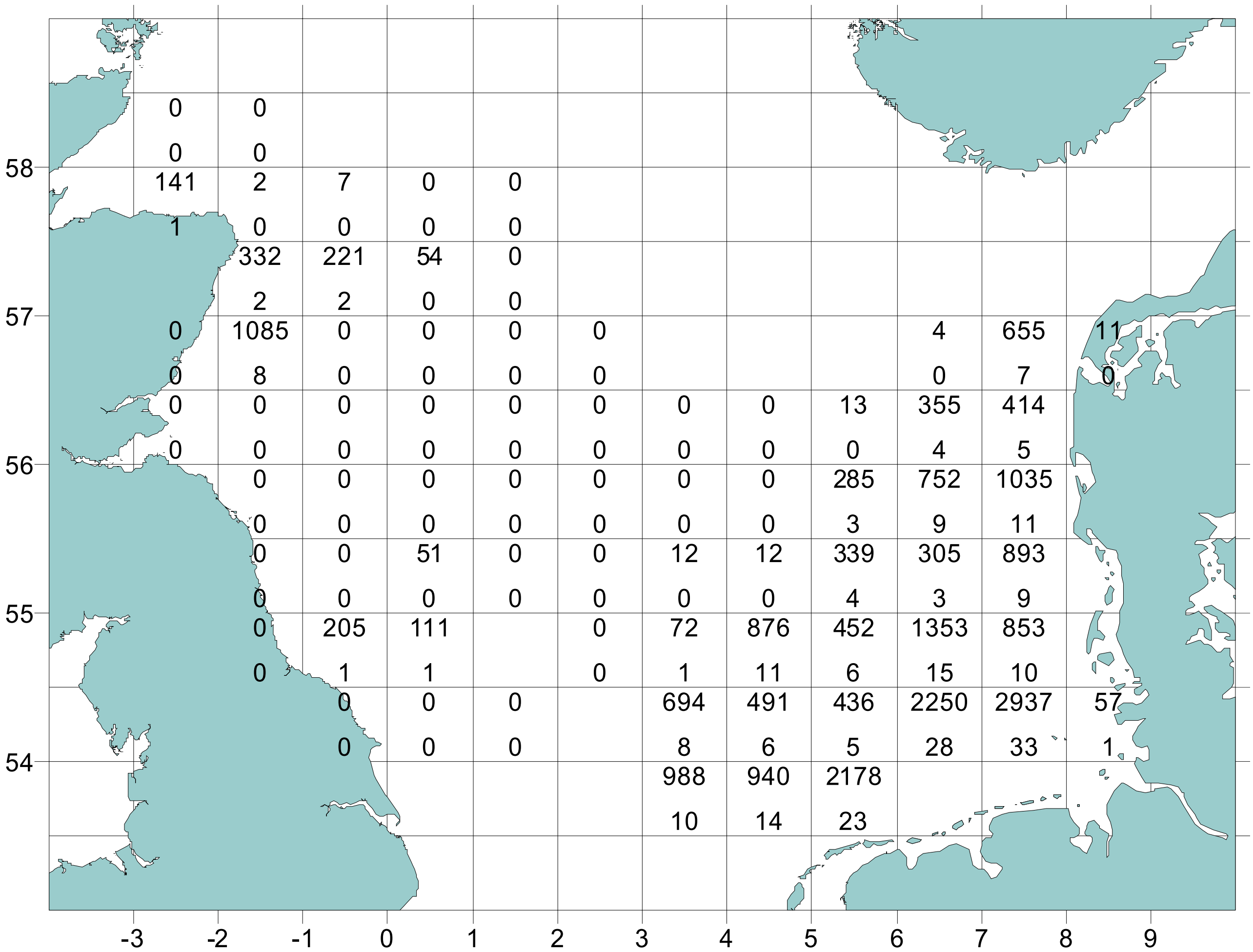

Figure 7 Map showing estimated numbers of sprat in millions (figure in upper half of each rectangle) and biomass in thousands of tonnes (lower half) by ICES rectangle. Combined results from the July 2002 North Sea hydro acoustic survey, using data from RV *Walther Herwig III*, RV *Tridens* and RV *Dana*.

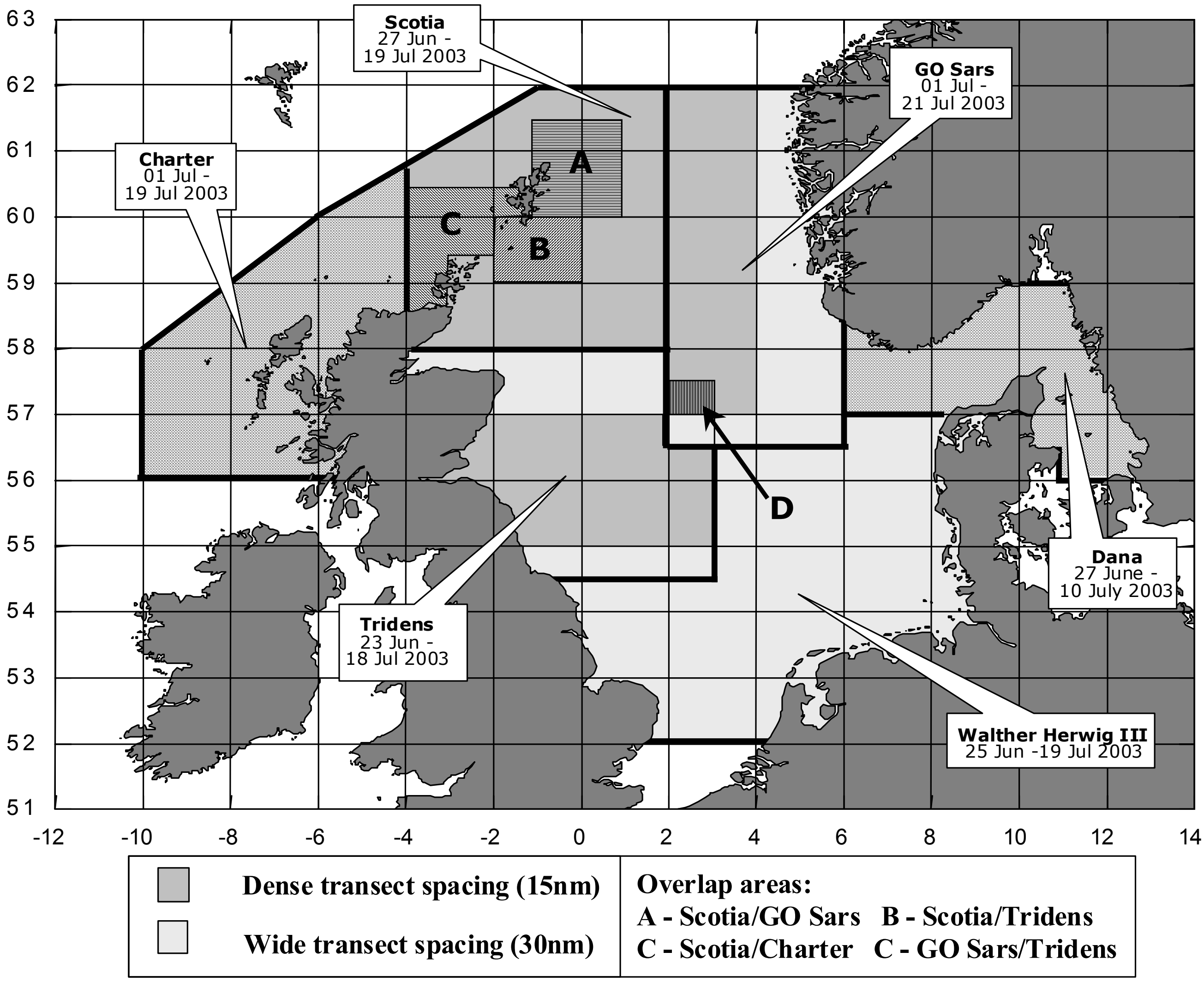

Figure 8 Survey area layouts and dates for all participating vessels in the 2003 acoustic survey of the North Sea and adjacent areas. Shaded areas indicate areas of stratification as indicated in the legend. Striped areas indicate areas of overlap as defined in the legend. Hatched areas indicate areas largely unchanged.

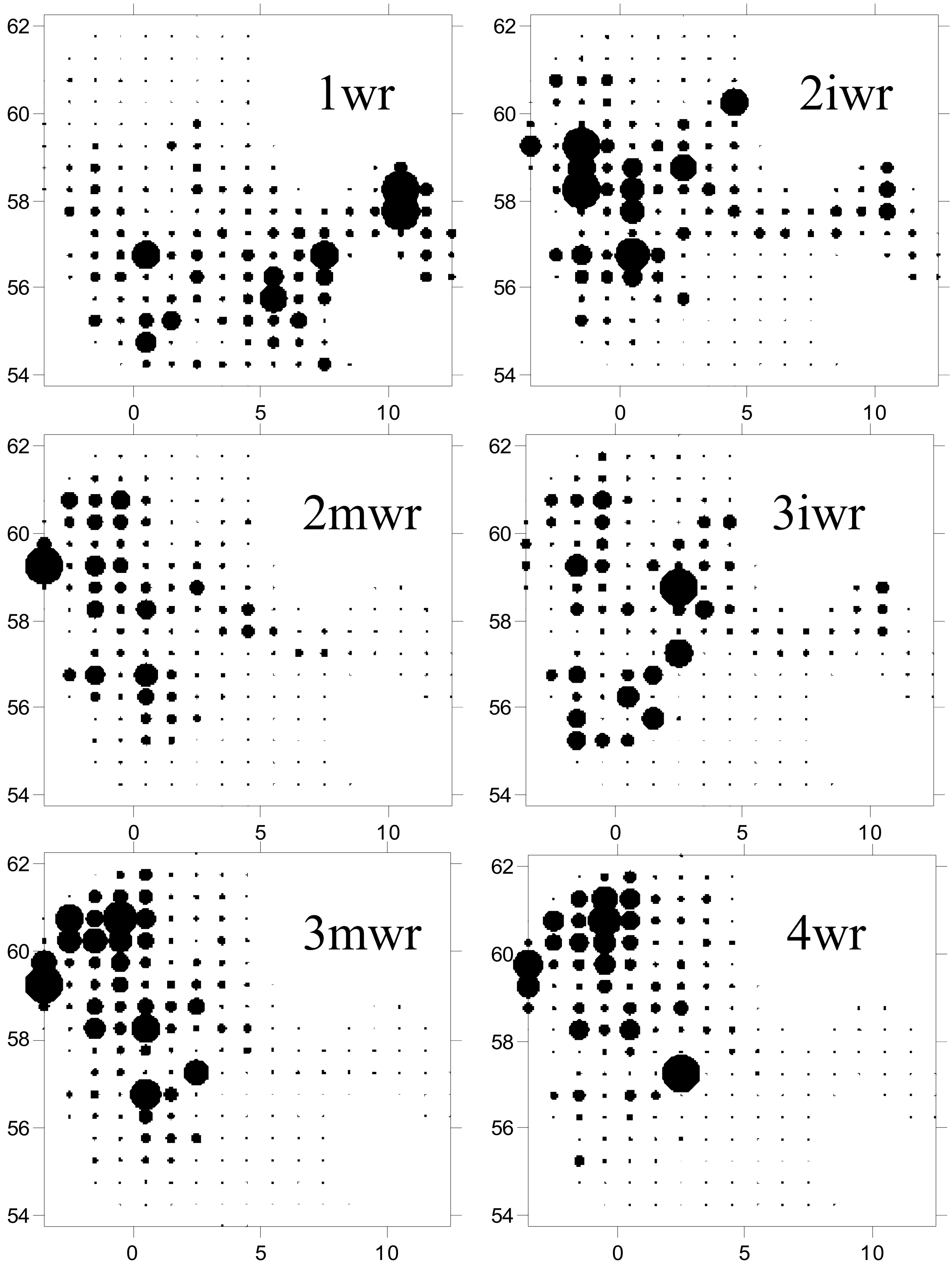

Figure 9a The relative variance at age from acoustic survey data at age and maturity stage from 1989 to 2002 inclusive ages 1 to 4.

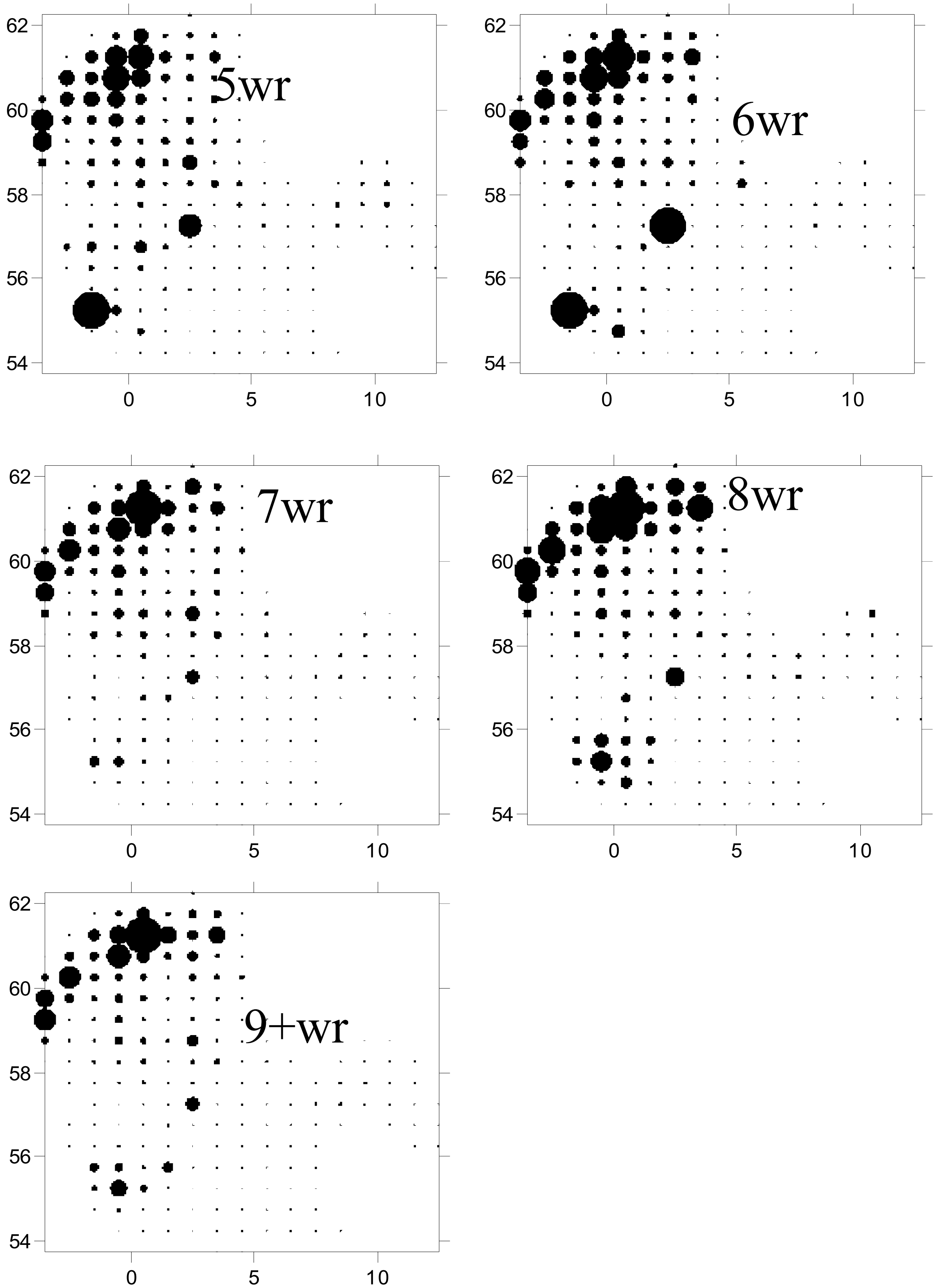

Figure 9b The relative variance at age from acoustic survey data at age and maturity stage from 1989 to 2002 inclusive ages 5 to 9+.

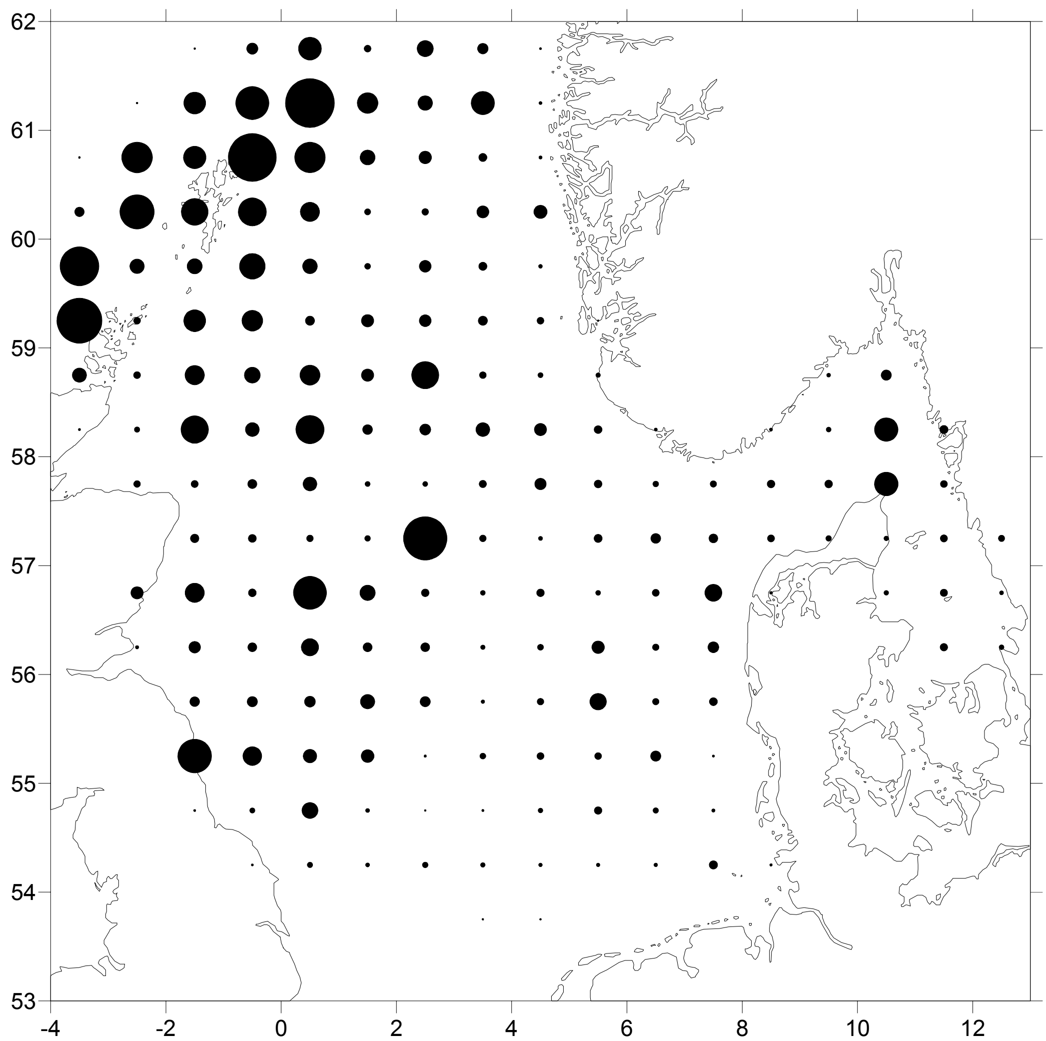

Figure 10 Assessment and projection weighted survey variance for acoustic survey

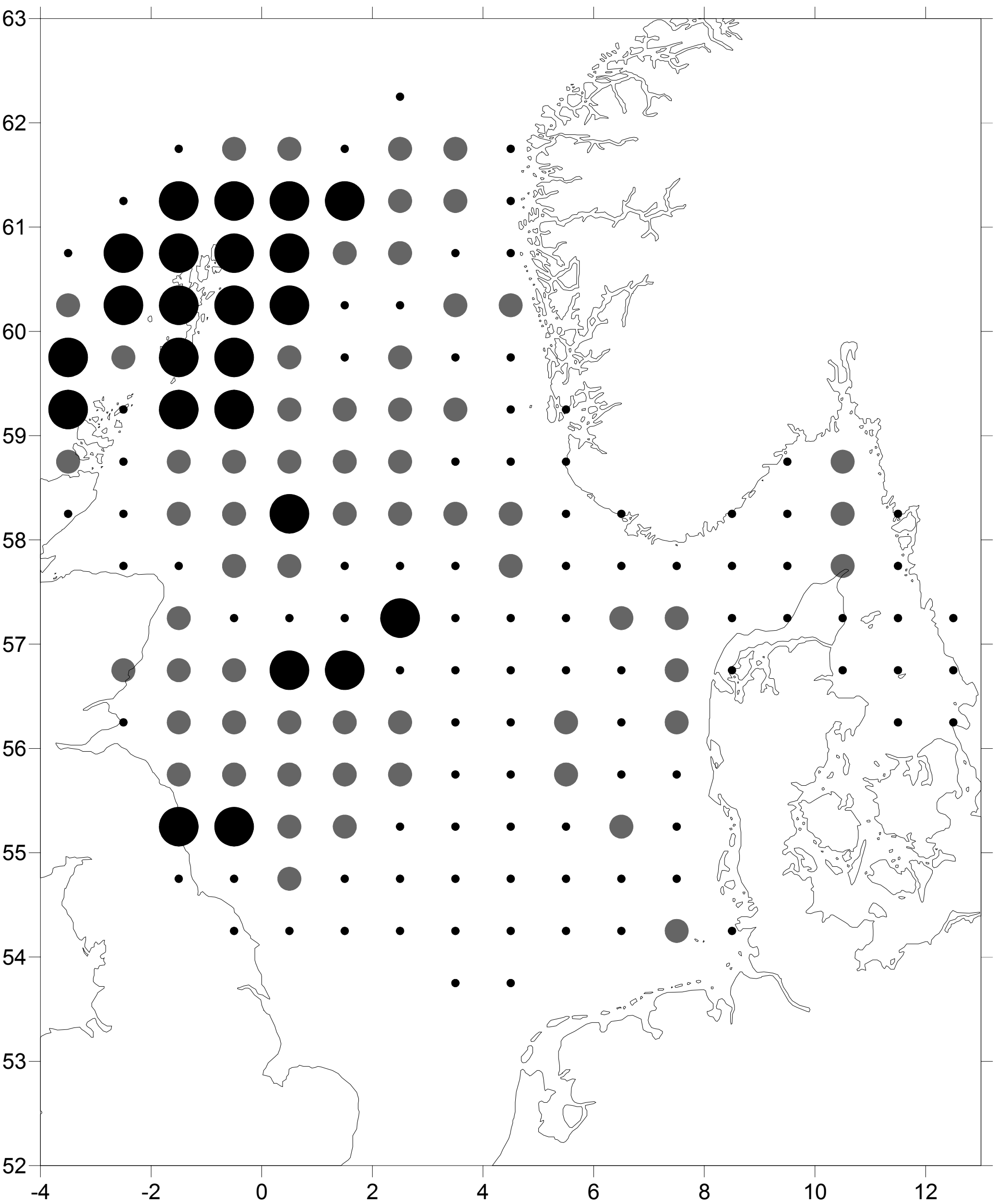

Figure 11 Classed assessment and projection weighted survey variance for acoustic survey The three classes are defined, as those with the smallest values contributing 5% of total variance (points), those contributing the next 30% (grey dots), and those giving the top 65% of the variance (big black dots).

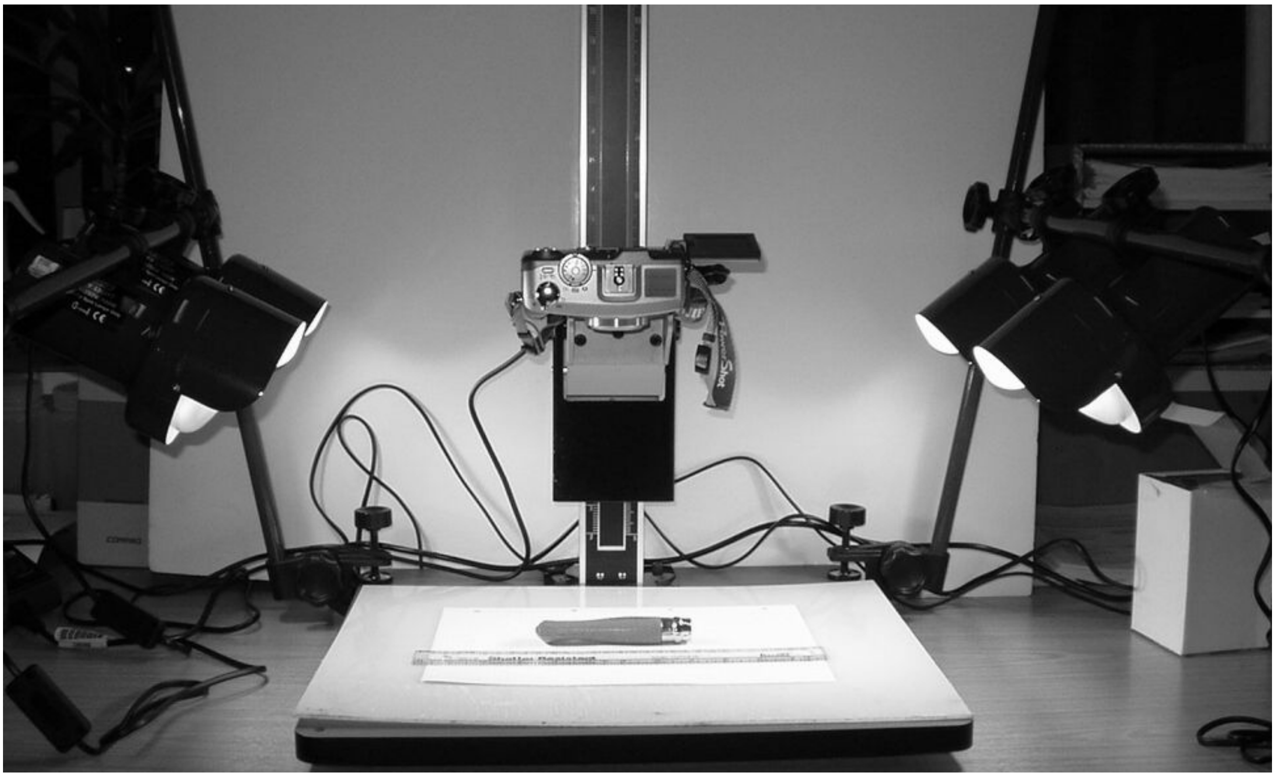

Figure 12 Set-up with copy stand, 4pcs 100W tungsten lights and Canon Powershot G2

Figure 13 Whole fish to show the relative size of the gonad (zoom at moderate telephoto setting)

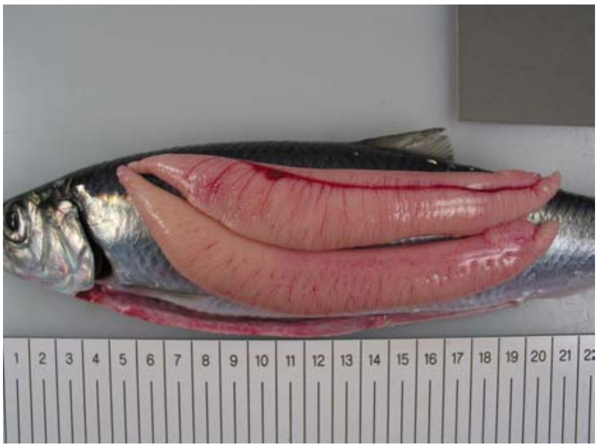

Figure 14 Gonad close-up (zoom at wide angle setting)

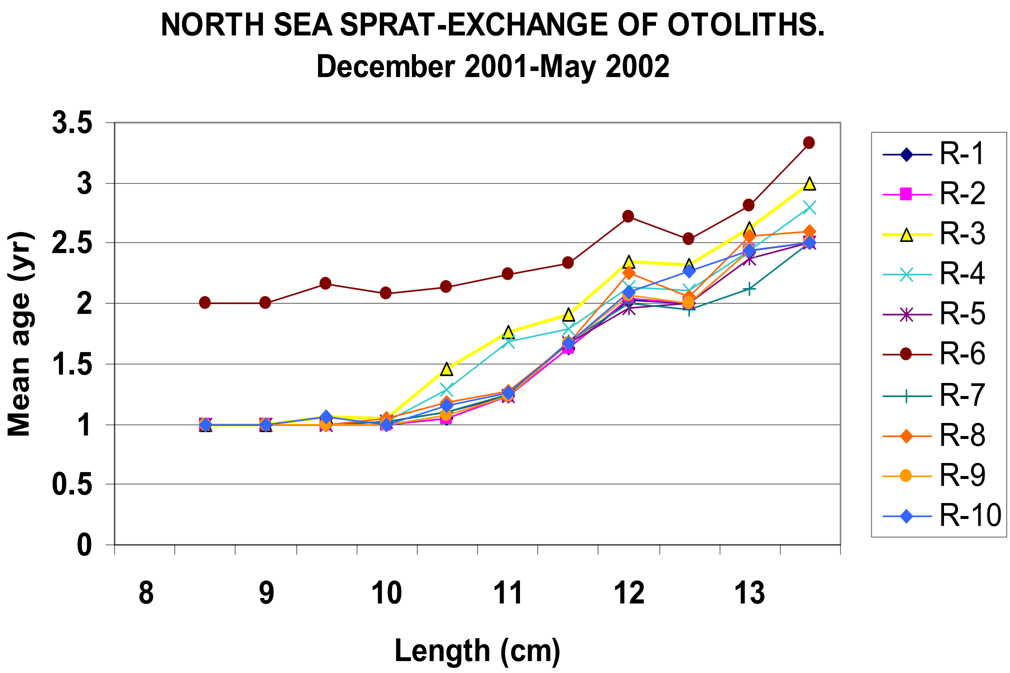

Figure 15 The mean ages by length given by the individual readers during the sprat otolith exchange programme.

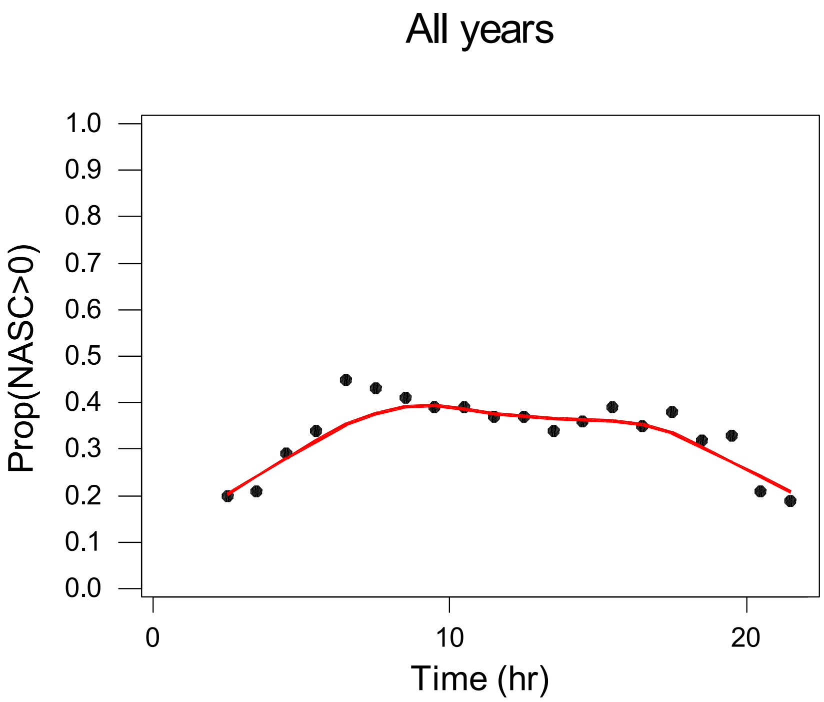

Figure 16 Bin averaged proportion of NASC >0 (arithmetic mean by hour of the day, black dots) with LOESS smoother fit (red line). Mean values of NASC attributed to herring for the Orkney-Shetland herring acoustic surveys 1991 and 1993-1997.

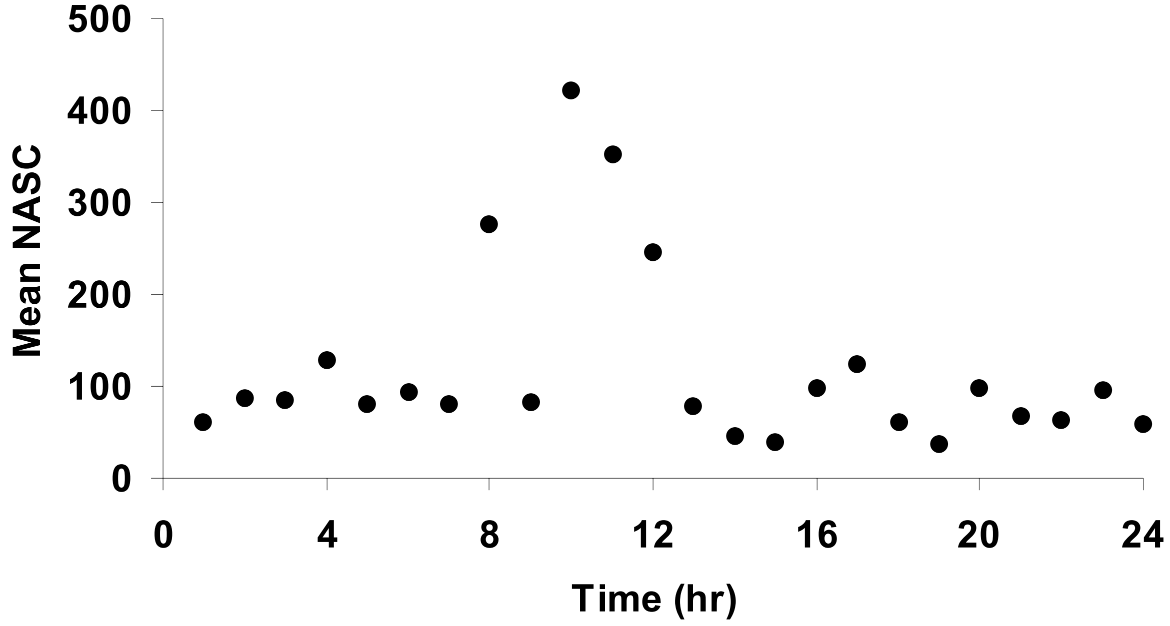

Figure 17 Bin averaged (arithmetic mean by hour of the day) NASCs against time from the 2002 Norwegian acoustic survey.

APPENDIX I

PARTICIPANT CONTACT DETAILS

Paul Fernandes (Chair and host),
Fisheries Research Services,
Marine Laboratory Aberdeen,
P.O.Box 101 Victoria Road,
Aberdeen AB11 9DB
Tel: +44 1224 295403
Fax: +44 1224 295511
Email: fernandespg@marlab.ac.uk

Bram Couperus,
Netherlands Institute for Fisheries Research (RIVO),
P.O. Box 68,
1970 AB IJmuiden,
The Netherlands.
Tel: +31 255 564763
Fax: +31 255 564644
Email: bram@rivo.dlo.nl

Eberhard Götze,
Institut fuer Fischereitechnik (IFH),
Bundesforschungsanstalt fuer Fischerei,
Palmaille 9,
D - 22767 Hamburg,
Germany.
Tel: +49 40 38905 202
Fax: +49 40 38905 264
Email: goetze.ifh@bfa-fisch.de

Soenke Jansen,
Institut fuer Seefischerei (ISH),
Bundesforschungsanstalt fuer Fischerei,,
Palmaille 9,
22767 Hamburg,
Germany.
Tel: +49 40 38905-166
Fax: +49 40 38905-263
Email: jansen.ish@bfa-fisch.de

Dave Reid,
Fisheries Research Services,
Marine Laboratory Aberdeen,
P.O.Box 101 Victoria Road,
Aberdeen AB11 9DB
Tel: +44 1224 295363
Fax: +44 1224 295511
Email: reiddg@marlab.ac.uk

John Simmonds,
Fisheries Research Services,
Marine Laboratory Aberdeen,
P.O.Box 101 Victoria Road,
Aberdeen AB11 9DB
Tel: +44 1224 295366
Fax: +44 1224 295511
Email: simmondsej@marlab.ac.uk

Else Torstensen,
Institute of Marine Research,
Flødevigen Research Station,
N-4817 His,
Norway.
Tel: +47 37059 000
Fax: +47 37059 001
Email: else.torstensen@imr.no

Christopher Zimmermann,
Institut fuer Seefischerei (ISH),
Bundesforschungsanstalt fuer Fischerei,
Palmaille 9,
D - 22767 Hamburg,
Germany.
Tel: +49 40 38905 266
Fax: +49 40 38905 263
Email: zimmermann.ish@bfa-fisch.de

APPENDIX II: 2002 ACOUSTIC SURVEY REPORTS

APPENDIX IIA WEST OF SCOTLAND

Survey report for MFV *Quantus*

1 –21 July 2002
Paul Fernandes, 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 1st to the 21st July 2002. The survey was conducted on the chartered fishing vessel MFV *Quantus*. 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 2003.

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 & METHODS

2.1 Personnel

Paul Fernandes	Cruise Leader
Phil Copland	
Melanie Harding	
Finlay Burns	
Craig Davis	(1-12 July)
Kevin Peach	(12-21 July)

2.2 Narrative

All gear was transported to Peterhead on 28 June and installation was complete by the morning of 1 July. Scientific staff joined the vessel at 11:00 on 1 July and it departed at 13:00. A small meeting was held with all scientists, and crew taking a navigational watch, to explain the objectives of the survey and to describe general operating procedures. The vessel then proceeded to Loch Eriboll where calibration of the three transducers was carried out starting at 05:00 on 2 July. The survey commenced in the North Minch at 19:00 on 2 July. Zig-zag transects at a spacing of 15 n.mi. were adopted in the Minch. On reaching the southern limit of the Minch, transects progressed northwards along lines of latitude, at spacings of 15, 7.5 or 3.75 nautical miles (n.mi.). Transect spacing was based on the results of previous surveys and transects were placed relative to ICES rectangles. Transects extended as far as the shelf edge (250 m contour) to the west, and as far as safely possible to the east, on approaching the coast. A half landing took place on 12 July in Ullapool for the exchange of personnel (K. Peach for F. Burns). The 38 kHz transducer was calibrated in Loch Broom prior to landing. The vessel resumed surveying at 18:00 on 13 July. North of the Hebrides, transects extended from the shelf edge to longitude 2° West, progressing northwards as far as 60° 04' North. The survey was completed on 20 July at 20:15. A second calibration was carried out at 08:00 in Scapa $\mathbf{F}_{low}$ on 21 July. The vessel returned to Peterhead on the evening of 21 July. Scientists and gear were unloaded the following morning and returned to Aberdeen.

2.3 Survey design

The survey design (Figure IIA.1) 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 (21 July) in Scapa $\mathbf{F}_{low}$. All calibrations were carried out in ideal conditions, and the constants for the 38 kHz integrating frequency agreed to within 0.02 dB (Table IIA.1). All procedures were according to those defined in the survey manual.

2.5 Acoustic data collection

The survey was carried out using a Simrad EK500 38 kHz sounder echo-integrator, the system settings are given in Table IIA.1. Further data analysis was carried out using SonarData Echoview and Marine Laboratory Analysis systems. Data from the echo integrator were summed over quarter hour periods (2.5 n.mi. at 10 knots). The survey was generally restricted to hours of daylight between 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 2245 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

49 trawl hauls (Figure IIA.1 & Tables IIA.2 & IIA.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 & 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 nine strata based on length distributions and geographic criteria. The nine regions (Figure IIA.3) were:

I. Barra Head

II. Inshore South

III. Offshore South

IV. Gallan Head and the Minch

V. North Hebrides

VI. Inshore North

VII. Offshore North

VIII. Inshore Oceanic North

IX. Oceanic North

Trawling in the Minch area was extremely difficult due to the topography, the presence of fixed gear and the unfortuante coincidence of a moving oil rig during the survey. This made it impossible to obtain further samples, however, very few echotraces thought to be herring were detected in the Minch. The length frequencies are presented in Table IIA.4. The overall age length key is presented in Table IIA.5.

3. RESULTS

3.1 Acoustic data

The geographical distribution of the NASC values assigned to herring are presented in Figure IIA.2. There was a fairly even distribution of herring detected throughout the area athough most was located just inshore of the shelf break. The main areas of concentration were along the shelf break in the southern and middle sections; NW of Lewis at Gallan Head; and Northwest of the Orkney Islands. Unusually for this survey, virtually no herring were detected off Barra Head. Very little if any herring were detected in the Minch

3.2 Biological data

A total of 49 trawl hauls were carried out, the results of these are shown in Tables IIA.2 & IIA.3. 37 hauls contained sufficient herring to define the 9 survey sub areas (Figure IIA.3). Herring was present in 39 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 (such Norway pout and blue whiting), or were unsuccessful.

The weight of herring at length was determined by weighing fish from each trawl haul which 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:

$$W = 0.0045.L^{-3.205} \text{ g} \quad \text{L measured in cm}$$

Samples of fish were aged in the laboratory by counting winter rings. These were then used to compile an age length key (Table IIA.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	529,300 tonnes	68%
Probably herring	233,100 tonnes	30%
Herring in mixture	14,010 tonnes	2%
Total herring	**776,410 tonnes**	
Spawning stock biomass	745,070 tonnes	96%
Immature	31,360 tonnes	4%

Total abundance (numbers of fish) were:

Total herring	4,383 million	
Spawning stock numbers	3918 million	89%
Immature numbers	466 million	11%

A breakdown of the estimates by age class is given in Table IIA.6. The survey included all of ICES Subdivision VIa(N) plus the area between 2° and 4°W in Subdivision IV. The estimates for VIa(N) alone as estimated from the combined survey estimates are :

Total VIaN herring 579,400 tonnes

VIaN SSB	548,800 tonnes	95%
VIaN Immature	30,600 tonnes	5%

4. DISCUSSION

The stock estimate for VIa(N) is up substantially by approximately 64% from 2001 (from 353,700 to 579,400 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 68% (327,500 to 548,800 tonnes) from 2001 to 2002. Examination of the abundance and biomass distribution (Figure IIA.4) shows that large amounts of herring were detected east of 4°W. It is likely, therefore, that there is some mixing of IV and VIaN fish as the 4° line does not represent a significant border between the two distributions. The abundance by year class is consistent with previous years and also with results from the adjacent North Sea area. The 1998 year class is again very strong and there are indication that the 1999 and 2000 year classes are also good.

Unlike previous years (e.g. 2001) the main concentrations were not found at Barra Head. However, in keeping with previous years there were substantial concentrations off the west coast of Lewis and along the shelf edge North and west of Lewis (Figure IIA.2). However, as in recent years the fish are distributed quite widely throughout the area.

Table IIA.1. Simrad EK500 and analysis settings used on the July 2002 west coast of Scotland herring acoustic survey on MFV *Quantus*. Calibrations a) Loch Erribol 2 July; b) Loch Broom 12 July; c) Scapa $\mathbf{F}_{low}$ 21 July. *Milap factor based on a simrad factor of 1 because calibration setings 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 Beamwidth	7.1°
Calibration details	
TS of sphere	-42.36 dB
Range to sphere in calibration	9.4[a], 9.4[b], 9.4[c]
Measured NASC value for calibration	3241[a], 3210[b], 3183[c]
Calibration factor for NASCs	0.80[a], 0.82[b], 0.81[c]
Calibration constant for MILAP (optional)*	1.1 at -35 dB
Log Menu	
Integration performed in Echoview post processing based on 15 minute EDSUs	
Operation Menu	
Ping interval	1 s at 100 m range 1.5 s at 250 m range 2.5 at 500 m range
Analysis settings	
Bottom margin (backstep)	0.5 m
Integration start (absolute) depth	11 m
Sv gain threshold	-70 dB

Table IIA.2 Details of the fishing trawls taken during the West Coast acoustic survey, July 2002; 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 (UTC)	Water depth	Trawl depth	Gear Type	Duration	Use	Catch Number
01	2/7/02	58° 26.66	5° 30.38	21:53	100	90	P	24		29
02	3/7/02	57° 12.23	6° 49.26	18:20	100	32	P	24		13
03	4/7/02	56° 28.64	6° 36.15	6:31	45	15	P	21		1103
04	4/7/02	56° 4.09	7° 2.47	10:50	87	77	P	25		6094
05	4/7/02	56° 19.01	8° 40.61	19:57	131	119	P	31	h	460
06	5/7/02	56° 39.27	8° 34.57	16:55	120	118	P	37	h	2489
07	6/7/02	56° 46.88	8° 10.49	17:41	120	112	P	42	h	621
08	6/7/02	56° 46.96	8° 44.78	19:51	120	106	P	39	h	1558
09	7/7/02	56° 54.62	8° 46.31	5:11	120	110	P	48	h	248
10	7/7/02	56° 54.58	8° 20.61	8:17	130	106	P	48	h	5985
11	7/7/02	57° 1.99	8° 23.03	15:15	130	122	P	39	h	1882
12	7/7/02	57° 8.61	9° 14.91	19:58	216	23	P	37		8024
13	7/7/02	57° 9.32	9° 3.79	21:36	140	126	P	41		20
14	8/7/02	57° 19.22	8° 23.42	12:16	130	113	P	30	h	19201
15	8/7/02	57° 33.83	8° 54.44	18:40	150	125	P	41	h	2273
16	8/7/02	57° 33.9	8° 27.32	21:23	157	131	P	34	h	553
17	9/7/02	57° 48.93	8° 31.89	10:52	53	42	P	27		10
18	9/7/02	57° 48.23	8° 19.89	12:11	119	103	P	30	h	2077
19	9/7/02	58° 1.93	8° 18.42	20:38	137	110	P	44	h	946
20	10/7/02	58° 1.97	7° 17.41	6:23	97	46	P	52	h	2516
21	10/7/02	58° 9.36	8° 12.5	12:56	130	101	P	20	h	6720
22	10/7/02	58° 16.91	8° 16.71	19:20	137	132	P	24	h	3094
23	11/7/02	58° 16.88	7° 12.6	8:33	106	77	P	29	h	7878
24	11/7/02	58° 33.86	7° 41	17:14	137	127	P	26	h	1104
25	13/7/02	58° 46.95	5° 46.24	20:41	108	92	P	23	h	233
26	14/7/02	58° 46.75	7° 23.07	6:40	100	90	P	40	h	1910
27	14/7/02	58° 54.52	6° 49.67	11:54	160	134	P	36	h	2277
28	14/7/02	58° 54.99	6° 33.74	13:55	120	110	P	20	h	33811
29	15/7/02	58° 48.92	3° 45.84	4:57	92	81	P	31		100
30	15/7/02	58° 52.76	3° 30.03	7:18	73	15	P	48		807
31	15/7/02	59° 1.71	6° 50.17	20:7	157	151	P	37	h	1196
32	16/7/02	59° 9.46	6° 41.52	5:46	135	120	P	37	h	20459
33	16/7/02	59° 9.45	6° 11.24	8:52	87	74	P	34	h	29879
34	16/7/02	59° 16.89	4° 57.49	14:7	115	105	P	67	h	11727
35	16/7/02	59° 16.92	3° 51.15	19:23	134	123	P	25	h	1794
36	17/7/02	59° 24.35	3° 14.98	5:16	66	57	P	29		91
37	17/7/02	59° 24.39	3° 45.68	7:39	140	136	P	37	h	9424
38	17/7/02	59° 33.91	5° 58.48	20:25	124	115	P	89	h	1974
39	18/7/02	59° 33.97	5° 9.33	5:58	135	119	P	21	h	2084
40	18/7/02	59° 31.93	4° 42.09	8:24	121	100	P	29	h	6061
41	18/7/02	59° 31.96	3° 58.64	11:42	124	115	P	25	h	13014
42	18/7/02	59° 39.36	2° 20.97	20:46	79	70	P	27		0
43	19/7/02	59° 39.42	3° 30.52	5:25	140	126	P	25	h	814
44	19/7/02	59° 39.35	4° 40.09	9:43	100	80	P	36	h	2064
45	19/7/02	59° 46.92	3° 49.2	16:23	134	123	P	16	h	18083
46	19/7/02	59° 46.91	2° 40.71	20:40	71	55	P	25		0
47	20/7/02	59° 54.47	2° 20.17	5:12	99	89	P	20	h	96
48	20/7/02	59° 59.88	4° 0.51	11:32	126	62	P	79	h	12521
49	20/7/02	60° 3.83	2° 14.52	18:45	95	80	P	29	h	2712

Table IIA.3 Catch composition by trawl haul on the west coast herring acoustic survey. FRV *Quantus* (1 - 21 July 2002)

	Haul	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Herring	Clupea harengus	0	0	0	5	459	2436	527	1558	239	5850	1558	0	0	19101	2249	131	0
Sprat	*Spratus spratus*	7	0	888	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mackerel	*Scomber scombrus*	0	0	0	269	1	45	14	0	1	15	0	0	0	0	12	1	0
European sandeel	*Ammodytes marinus*	0	0	215	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	2
Greater sandeel	*Hyperoplus lanceolatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Haddock	*Melanogrammus aegelfinus*	2	0	0	2101	0	0	18	0	4	0	4	0	6	0	0	4	0
Whiting	*Merlangius merlangius*	5	9	0	3607	0	0	57	0	0	0	0	0	0	0	0	21	0
Saithe	*Pollachius virens*	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0
Norway pout	*Trisopterus esmarrki*	15	4	0	0	0	0	0	0	4	0	4	0	0	0	0	8	0
Blue whiting	*Micromesistius poutassou*	0	0	0	46	0	4	1	0	0	105	316	8024	12	0	12	388	0
	Argentinia sphyraena	0	0	0	28	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	1	0	0	0	0
Lemon sole	*Microstomus kit*	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0
Grey gurnard	*Eutrigla gurnardus*	0	0	0	18	0	0	3	0	0	15	0	0	0	100	0	0	7
Red gurnard	*Chelidonichthys kumu*	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Hake	*Merluccius merluccius*	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Spotted dogfish	*Scyliorhinus spp.*	0	0	0	2	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	4	0	0	0	0	0	0	0	0	0	0	0	0	0
Squid	*Loligo forbesi*	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0

Table IIA.3(cont.) Catch composition by trawl haul on the west coast herring acoustic survey. FRV *Quantus* (1 - 21 July 2002)

	Haul	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**
Herring	Clupea harengus	2072	899	2516	6702	2995	7603	861	43	1875	1346	33811	9	0	570	20439	29879	11452
Sprat	*Spratus spratus*	0	0	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0
Mackerel	*Scomber scombrus*	0	8	0	18	99	250	75	0	35	6	0	12	0	0	20	0	200
European sandeel	*Ammodytes marinus*	0	0	0	0	0	0	0	0	0	0	0	0	807	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	7	0	0	0	0	60	0	0	14	0	10	0	0	0	0	50
Whiting	*Merlangius merlangius*	5	0	0	0	0	0	6	0	0	8	0	2	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	72	190	0	32	0	67	0	0	0	0	0
Blue whiting	*Micromesistius poutassou*	0	32	0	0	0	0	21	0	0	867	0	0	0	626	0	0	25
	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	2	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	2	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 IIA.3(cont.) Catch composition by trawl haul on the west coast herring acoustic survey. FRV *Quantus* (1 - 21 July 2002)

	Haul	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**
Herring	Clupea harengus	1434	0	8574	1914	2049	6016	12600	0	812	2044	17959	0	96	12521	2712
Sprat	*Spratus spratus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mackerel	*Scomber scombrus*	278	0	275	6	10	15	189	0	2	0	82	0	0	0	0
European sandeel	*Ammodytes marinus*	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
Greater sandeel	*Hyperoplus lanceolatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haddock	*Melanogrammus aegelfinus*	8	0	0	6	10	15	38	0	0	5	0	0	0	0	0
Whiting	*Merlangius merlangius*	12	0	0	6	0	0	0	0	0	0	0	0	0	0	0
Saithe	*Pollachius virens*	0	0	0	6	0	0	0	0	0	5	0	0	0	0	0
Norway pout	*Trisopterus esmarrki*	52	91	175	0	5	0	187	0	0	0	0	0	0	0	0
Blue whiting	*Micromesistius poutassou*	10	0	375	36	0	0	0	0	0	0	0	0	0	0	0
	Argentinia sphyraena	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
Lemon sole	*Microstomus kit*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grey gurnard	*Eutrigla gurnardus*	0	0	25	0	10	15	0	0	0	10	42	0	0	0	0
Red gurnard	*Chelidonichthys kumu*	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
Spotted dogfish	*Scyliorhinus spp.*	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
	Ommastrephidae	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

Table IIA.4 Herring length frequency proportion by trawl haul by sub- area for west coast acoustic survey FRV *Quantus* (1 – 21 July 2002).

Length in cm, weight in g, TS=target strength in dB.

Area	I		II								III							IV			V	
L (cm)	7	mean	10	11	14	16	18	19	21	mean	5	6	8	9	15	22	mean	20	23	mean	25	mean
17					0.01	0.01																
17.5					0.06	0.03	0.04															
18	0.01	0.01			0.15	0.11	0.13															
18.5	0.01	0.01			0.16	0.12	0.14															
19	0.01	0.01			0.23	0.27	0.25															
19.5	0.01	0.01			0.17	0.17	0.17															
20	0.02	0.02			0.07	0.10	0.09		0.01													
20.5	0.01	0.01			0.04	0.05	0.05															
21					0.01	0.01	0.01	0.02	0.02													
21.5	0.01	0.01								0.01												
22	0.01	0.01						0.02	0.02	0.01												
22.5	0.01	0.01			0.01		0.01	0.05	0.05													
23	0.08	0.08			0.01	0.02	0.02	0.14	0.14	0.01	0.01		0.02	0.01	0.01							
23.5	0.11	0.11		0.01	0.01			0.02	0.03	0.03	0.16	0.16	0.03	0.03	0.01	0.02	0.02		0.01			
24	0.21	0.21	0.02		0.01		0.01	0.01	0.01		0.02	0.04	0.03	0.28	0.28	0.11	0.10	0.02	0.11	0.01	0.01	0.21
24.5	0.16	0.16	0.01	0.02	0.01	0.04	0.01		0.01	0.02			0.01	0.02	0.02	0.16	0.16	0.15	0.11	0.09	0.15	0.01
25	0.16	0.16	0.14	0.10	0.03	0.05	0.03	0.04	0.02	0.06	0.01	0.04	0.02		0.01	0.01	0.02	0.01	0.09	0.09	0.18	0.17
25.5	0.07	0.07	0.17	0.15	0.15	0.13	0.07	0.06	0.07	0.11	0.04	0.07	0.02	0.06	0.03	0.04				0.02	0.02	0.20
26	0.06	0.06	0.24	0.28	0.24	0.24	0.22	0.21	0.20	0.23	0.10	0.15	0.13	0.13	0.08	0.02	0.10				0.05	0.05
26.5	0.03	0.03	0.19	0.18	0.21	0.14	0.23	0.19	0.19	0.19	0.14	0.15	0.12	0.19	0.14	0.07	0.14					
27	0.02	0.02	0.10	0.09	0.19	0.12	0.17	0.22	0.21	0.16	0.19	0.15	0.19	0.19	0.25	0.14	0.19					
27.5	0.01	0.01	0.05	0.08	0.10	0.10	0.13	0.11	0.11	0.10	0.15	0.13	0.16	0.15	0.20	0.18	0.16					
28	0.01	0.01	0.05	0.06	0.05	0.14	0.09	0.10	0.09	0.08	0.17	0.14	0.20	0.17	0.16	0.24	0.18					
28.5			0.01	0.02	0.03	0.03	0.03	0.05	0.05	0.03	0.12	0.07	0.10	0.05	0.09	0.18	0.10					
29			0.01	0.01	0.01			0.02	0.04	0.01	0.06	0.05	0.05	0.03	0.04	0.10	0.05					
29.5											0.02	0.02	0.02	0.01	0.01	0.04	0.02					
30									0.01		0.01	0.01				0.01	0.01					
Number	527		5850	1558	19101	131	2072	899	6705		459	2436	1558	239	3349	2995		2516	7605		43	
length	24.7	24.7	26.7	26.8	27.0	27.0	27.2	27.3	27.3	27.0	27.9	27.5	27.9	27.6	27.8	28.4	27.8	19.9	20.2	20.1	24.4	24.4
weight	132.5	132.5	167.7	170.2	174.8	174.6	178.7	180.8	181.3	175.5	193.2	186.5	193.2	186.5	191.6	205.6	192.8	67.5	70.9	69.2	126.5	126.5
TS/ind	-43.3	-43.3	-42.7	-42.6	-42.6	-42.6	-42.5	-42.5	-42.5	-42.6	-42.3	-42.4	-42.3	-42.4	-42.3	-42.1	-42.3	-45.2	-45.1	-45.1	-43.5	-43.5
TS/kg	-34.6	-34.6	-34.9	-35.0	-35.0	-35.0	-35.0	-35.1	-35.1	-35.0	-35.2	-35.1	-35.2	-35.1	-35.1	-35.3	-35.2	-33.5	-33.6	-33.5	-34.5	-34.5

Table IIA.4(cont.) Herring length frequency by trawl haul by sub area. MFV *Quantus* (1 to 21 July 2002) mean length - cm, mean weight - g, target strength – dB.

Area	VI									VII					VIII					IX				
L (cm)	28	33	34	35	40	44	47	49	mean	24	26	27	31	mean	37	39	43	45	mean	32	38	41	48	mean
22.5																								
23																								
23.5																								
24	0.01	0.07				0.01																		
24.5	0.02	0.17	0.03	0.09	0.01	0.02	0.02	0.01	0.01															
25	0.21	0.2	0.03	0.07	0.26	0.1	0.15	0.03	0.01	0.01	0.06	0.03	0.05		0.01	0.01	0.02							
25.5	0.21	0.22	0.16	0.07	0.1	0.08	0.18	0.15	0.1	0.02	0.09	0.08	0.07	0.09	0.02	0.05	0.02	0.04		0.01				
26	0.18	0.17	0.24	0.14	0.26	0.21	0.06	0.32	0.2	0.17	0.18	0.2	0.2	0.19	0.11	0.16	0.1	0.04	0.1	0.06	0.03	0.04	0.01	0.04
26.5	0.1	0.11	0.13	0.07	0.21	0.27	0.04	0.16	0.14	0.16	0.22	0.23	0.17	0.2	0.17	0.25	0.1	0.05	0.14	0.13	0.1	0.1	0.04	0.09
27	0.03	0.05	0.06	0.05	0.25	0.17	0.03	0.11	0.09	0.18	0.18	0.28	0.18	0.2	0.15	0.23	0.18	0.12	0.17	0.14	0.12	0.15	0.11	0.13
27.5	0.01	0.01	0.02	0.03	0.06	0.08	0.03	0.05	0.04	0.14	0.11	0.09	0.12	0.12	0.09	0.13	0.12	0.13	0.12	0.16	0.14	0.15	0.18	0.16
28	0.01	0.01		0.02	0.06	0.04	0.01		0.02	0.09	0.12	0.06	0.1	0.09	0.08	0.1	0.11	0.13	0.11	0.19	0.18	0.15	0.2	0.18
28.5		0.01		0.01	0.02	0.02	0.02	0.01	0.01	0.08	0.09	0.02	0.03	0.06	0.05	0.05	0.05	0.07	0.05	0.12	0.11	0.12	0.11	0.11
29		0.01					0.01	0.01		0.03	0.02	0.02	0.02	0.02	0.05	0.02	0.06	0.08	0.05	0.07	0.1	0.12	0.12	0.1
29.5										0.01	0.02			0.01	0.04	0.01	0.02	0.07	0.03	0.06	0.06	0.05	0.08	0.06
30					0.01	0.01	0.01	0.01							0.06		0.04	0.1	0.05	0.02	0.05	0.06	0.04	0.04
30.5					0.01		0.01	0.01							0.04		0.04	0.06	0.03	0.02	0.02	0.02	0.06	0.03
31								0.01							0.02		0.01	0.05	0.02	0.02	0.03	0.02	0.02	0.02
31.5															0.01		0.02	0.03	0.02		0.01	0.01		0.01
32															0.01		0.03	0.03	0.02		0.02	0.01	0.01	0.01
32.5																	0.02	0.01	0.01		0.01			
33							0.01										0.02	0.01	0.01		0.02			
Number	33811	29879	11452	1434	6016	2044	96	2712		861	1875	1346	570		8574	225	812	17959		20439	1914	12600	12521	
length	25.8	25.9	26.1	25.7	27.1	26.9	25.8	26.6	26.3	27.4	27.6	27.2	27.2	27.3	27.9	27.5	28.5	29.1	28.3	28.4	28.9	28.6	28.9	28.7
weight	150.9	153.3	157.5	150.7	176.5	173.4	152.3	167.7	160.3	182.9	187.8	178.1	178.5	181.8	196.9	185.8	210.3	224.3	204.3	205.7	218.1	210.9	216.6	212.8
TS/ind	-43.0	-42.9	-42.9	-43.0	-42.5	-42.6	-43.0	-42.7	-42.8	-42.5	-42.4	-42.5	-42.5	-42.5	-42.3	-42.4	-42.1	-41.9	-42.2	-42.1	-42.0	-42.1	-42.0	-42.0
TS/kg	-34.8	-34.8	-34.8	-34.8	-35.0	-35.0	-34.8	-34.9	-34.9	-35.1	-35.1	-35.0	-35.0	-35.1	-35.2	-35.1	-35.3	-35.4	-35.3	-35.3	-35.4	-35.3	-35.4	-35.3

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

	Number-at-age / maturity											
Length (cm)	1	2I	2M	3I	3M	4	5	6	7	8	9+	Grand Total
17.0	4											4
17.5	12											12
18.0	16											16
18.5	16											16
19.0	16											16
19.5	18											18
20.0	32											32
20.5	22											22
21.0	5	2										7
21.5	7	4										11
22.0	5	9										14
22.5	2	14	7									23
23.0	1	17	26		2							46
23.5		12	52		1							65
24.0		14	71		5							90
24.5		7	89		13							109
25.0		4	90	2	74	2	1	1				174
25.5		3	69		149	1	1	1			1	225
26.0			29		208	9	2					248
26.5			21		214	10		2	1		1	249
27.0			13		154	33	12	18	5	1		236
27.5			5		93	33	18	61	12	2	2	226
28.0			6		31	18	21	93	30	12	6	217
28.5			1		28	18	26	60	25	17	9	184
29.0			3		10	6	15	43	30	19	11	137
29.5					3	5	5	22	18	6	15	74
30.0					3	3	10	36	7	9	11	79
30.5					1	1	5	24	9	11	6	57
31.0						4	4	15	11	6	10	50
31.5						1		8	8	5	8	30
32.0								5	7	7	10	29
32.5									3	7	7	17
33.0								1		5	14	20
33.5										1	2	3
34.0										1		1
35.5											1	1
36.0											1	1
Grand Total	156	86	482	2	989	144	120	390	166	109	115	2759

Table IIA.6 Mean length, mean weight, biomass (thousands of tonnes) and numbers (millions) breakdown by age and maturity obtained during the MFV *Quantus* 2002 herring acoustic survey.

Total area						
Age (ring)	Mean Length (cm)	Mean Weight (g)	Number×10^6	%	Biomass×10^3 T	%
1A	19.0	61.7	426	10	26.28	3
2I	23.8	124.9	39	1	4.93	1
2M	25.6	157.0	630	14	98.87	13
3I	25.0	144.9	1	0	0.14	0
3M	26.7	178.6	1970	45	351.91	45
4A	27.7	202.0	220	5	44.43	6
5A	28.3	214.3	220	5	47.09	6
6A	28.6	221.3	536	12	118.64	15
7A	29.0	232.3	181	4	42.13	5
8A	29.8	254.8	85	2	21.71	3
9+	30.4	270.5	75	2	20.29	3
Mean	26.3	177.1				
Total			4384	100	776.43	100
Immature			466	11	31.36	4
Mature			3918	89	745.07	96

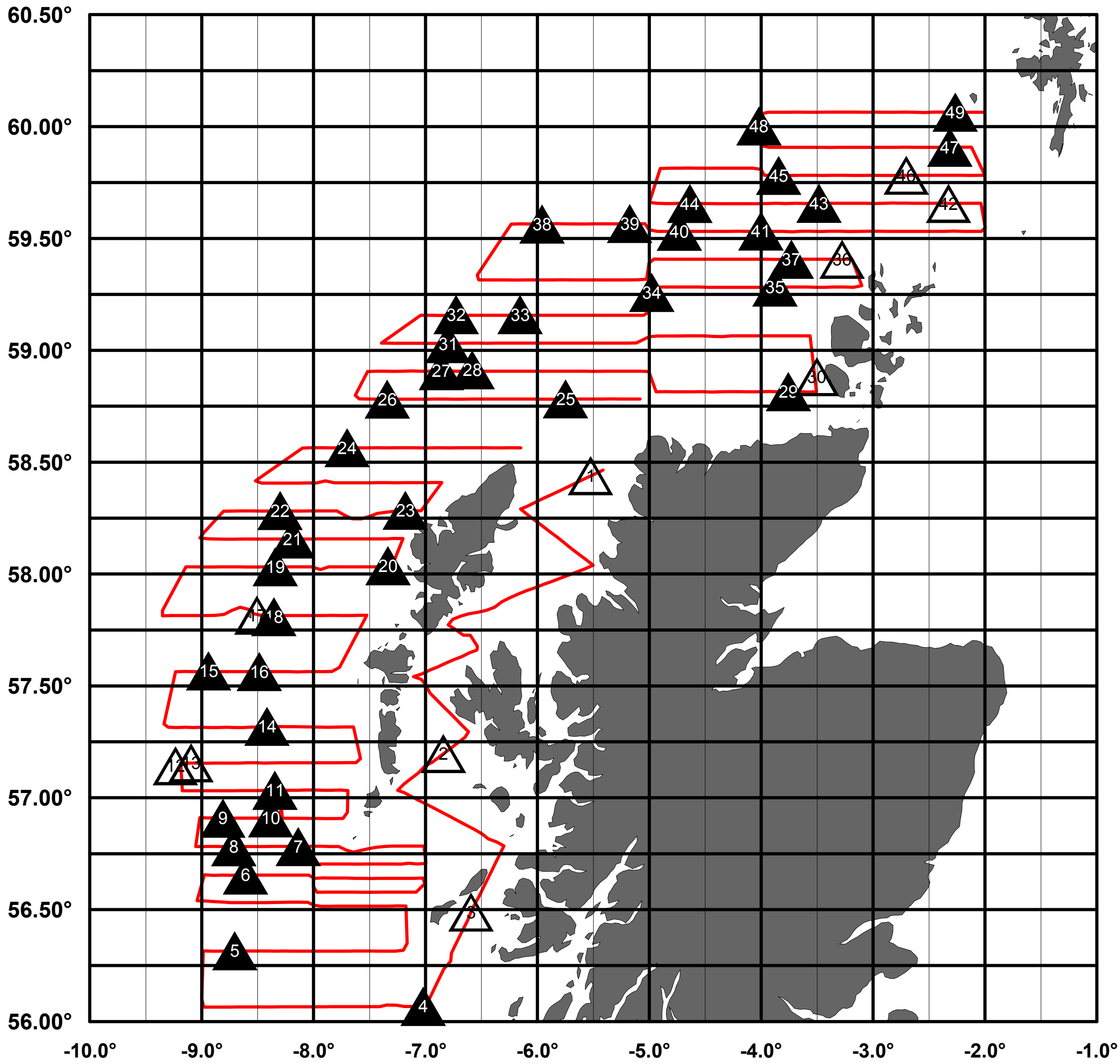

Figure IIA.1. Map of the west of Scotland showing cruise track and positions of fishing trawls undertaken during the July 2002 west coast acoustic survey on MFV *Quantus*. Filled triangles indicate trawls in which significant numbers of herring were caught, whilst open triangles indicate trawls with few or no herring.

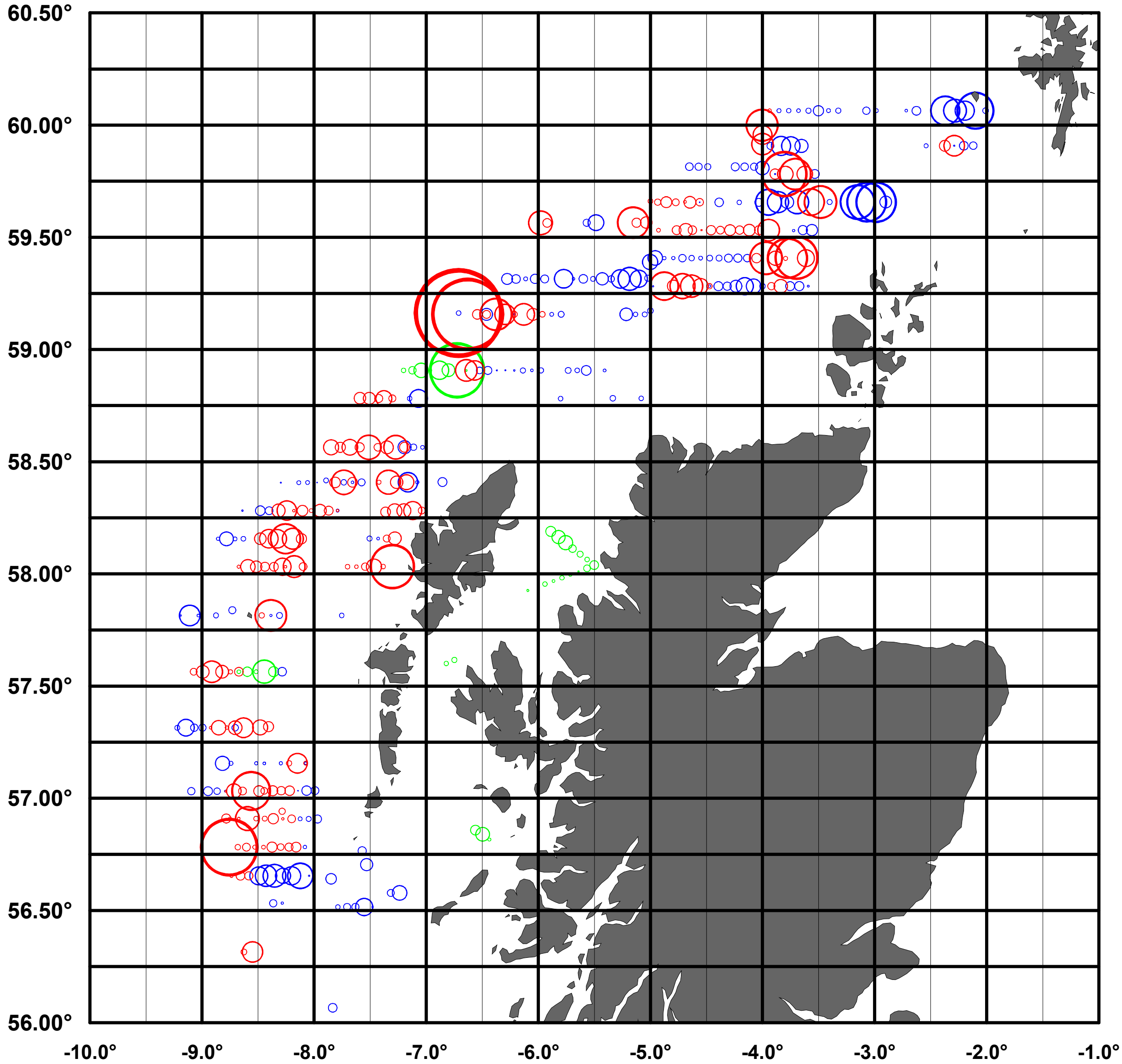

Figure IIA.2 Post plot showing the distribution of total herring NASC values (on a proportional square root scale relative to the largest value of 11,308) obtained during the July 2002 west coast acoustic survey on MFV *Quantus*. Circles are coloured to indicate definite herring traces (red), probably herring (blue), and herring in a mixture (green).

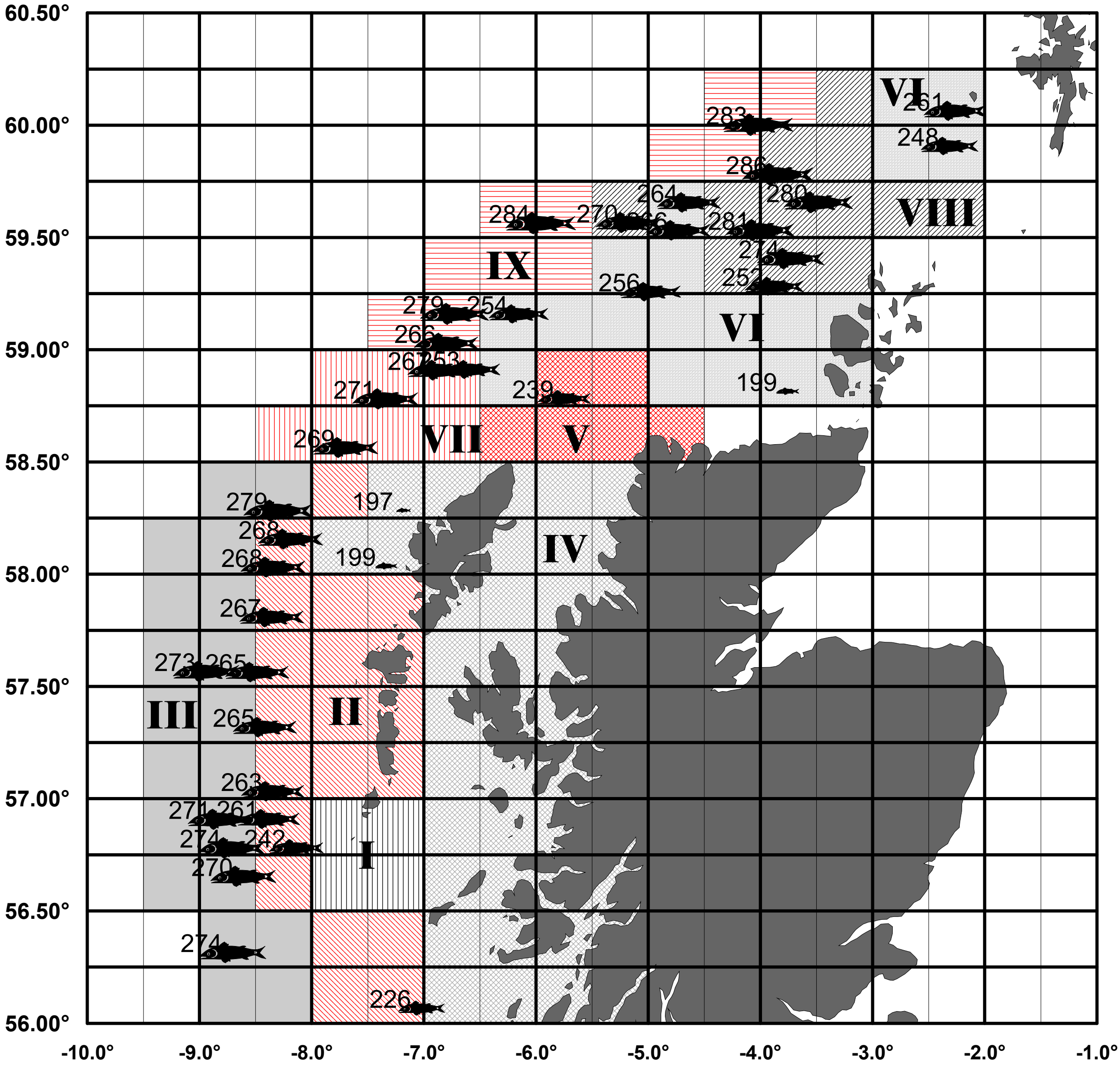

Figure IIA.3 Post plot showing the mean length of herring caught in the trawl hauls carried out during the July 2002 west coast acoustic survey on MFV *Quantus*. The plot also shows the area strata (indicated by shaded areas with roman numerals I-IX) used for combining data from the trawl hauls.

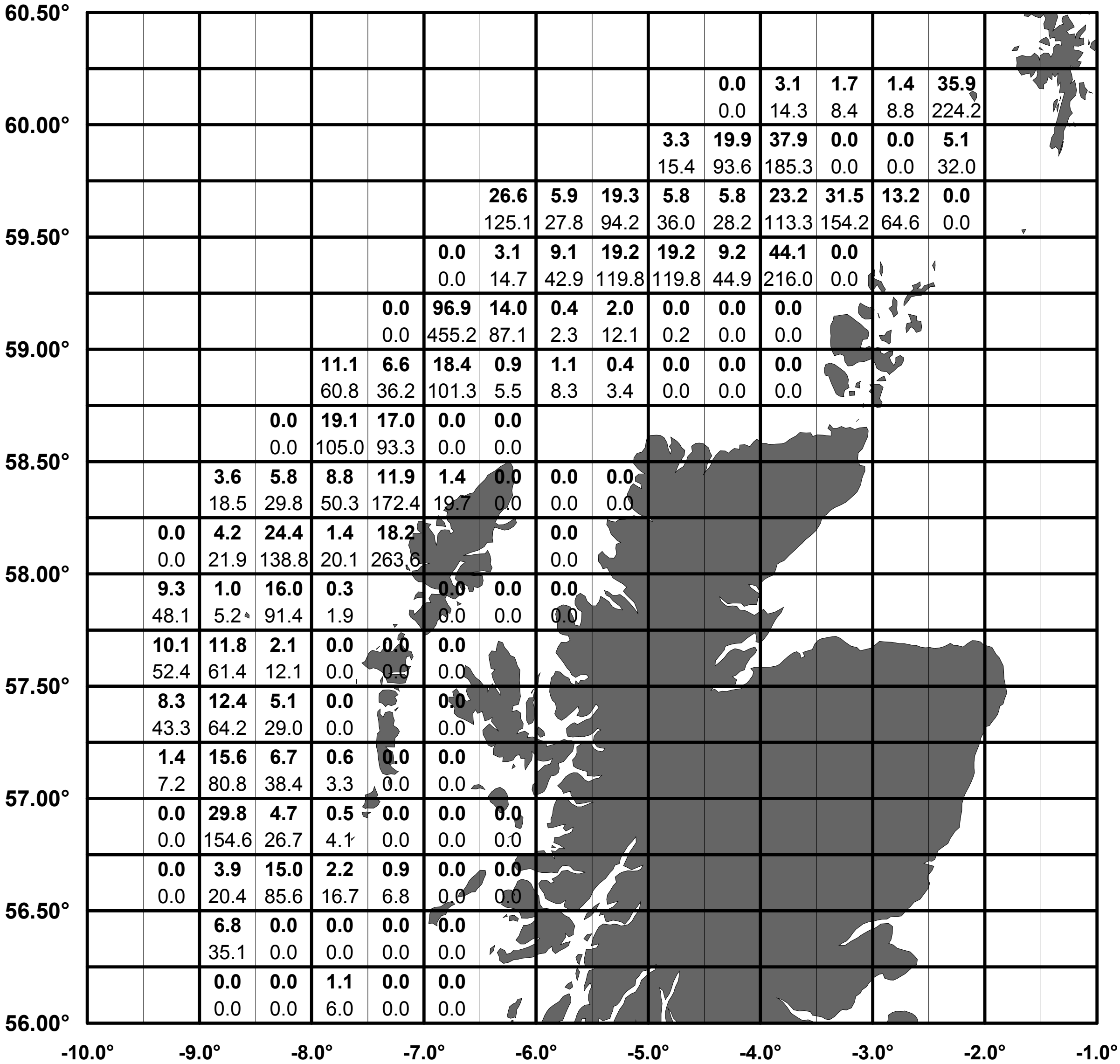

Figure IIA.4 Post plot showing the herring numbers in millions (bottom) and biomass in thousands of tonnes (top) by quarter ICES rectangle obtained during the July 2002 west coast acoustic survey on MFV *Quantus*.

APPENDIX IIB: DENMARK

Survey report for RV "DANA"

25th June 2002 – 8th July 2002

Karl-Johan Stæhr

Danish Institute for Fisheries Research. Dept for sea fishery, Hirtshals, Denmark

1. INTRODUCTION

Since 1991 the Danish institute for Fisheries research has participated in the ICES coordinated international hydro acoustic survey on herring in the North Sea, Skagerrak and Kattegat with the responsibility for the survey area in Skagerrak and Kattegat.

In 2002 the survey with R/V DANA has been covering the Skagerrak and Kattegat. The survey was conducted in the period June 25 to July 8 2002.

2. SURVEY

2.1 Personnel

During calibration 25-27/6-2002

Karl-Johan Stæhr (cruise leader), DIFRES
Bo Lundgren (ass. cruise leader), DIFRES
Torben Filt Jensen, DIFRES
Mogens R. Sørensen, DIFRES
Thyge Dyrnesli, DIFRES
Claus Halle, DIFRES

During acoustic monitoring 27/6-8/7-2002

Karl-Johan Stæhr (cruise leader), DIFRES
Torben Filt Jensen (ass. cruise leader), DIFRES
Niels Jørgen Phil (acoustic), DIFRES
Lise Sindahl (fish lab.), DIFRES
Uffe Nielsen (acoustic), DIFRES
Helle Rasmussen (fish lab.), DIFRES
Lotte A. Worsøe (fish lab.), DIFRES
Inge Holmberg (fish lab.), DIFRES
Ulrik Cold (fish lab.), DIFRES
Bo Tegen Nielsen (electronics), DIFRES

2.2 Narrative

Departure: Hirtshals 25 June 2002 at 1200 hour for calibration.

Visit to harbour 27 June 2002 for exchange of scientific personnel before start of acoustic monitoring.

Arrival: Hirtshals 8 July 2002 at 0600 hour.

2.3 Survey design

The survey was carried out in the Skagerrak, east of 6° E, and Kattegat (Figure IIB.1). The area was split into 7 subareas (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 could this structure not be kept. This gave a not standard like 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

The Simrad EY 50038 kHz echosounder were calibrate with a standard coper sphere calibration at Bornö, Sweden 25-27 June 2002. See Table **IIB.**1.

2.5 Acoustic data collection

Acoustic data was sampled using SimradEY500 28kHz echo sounder with the transducer at a towed body (Type ES 38-29). The towed body was running at aprox. 3 m depth. The speed of the vessel during acoustic sampling was 8 – 12 knots. Acoustic data were collected all 24 hours. The sampling unit was 1 NM. The data are store in 1m intervals for each 1 NM on tape. Integration is conducted from 3 – 300 m below the transducer.

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.**1). 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 analyzed. 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.

2.7 Hydrographic data

In connection to trawling CTD profiles were made with a Sea Bird . During the survey salinity and temperature were measured in 5 m depth. Distribution of CTD stations is shown in Figure IIB.4.

2.8 Data analysis

Scrutiny of the acoustic data was done for each mile.

For each sub area the mean back scattering cross section was estimated for herring, sprat, gadoids and mackerel by TS relationship 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 was assumed to be in proportion to the contribution of the given species in the trawl hauls. Therefore, the density of a given species was estimated by sub area using the species composition in the trawl hauls. The nearest trawl hauls were allocated to sub areas with uniform depth strata. The length-race and length-age distributions for herring were 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 for micro-structure analysis of the otolith.

3. RESULTS AND DISCUSSION

3.1 Acoustic data

The total number of acoustic sample units at 1 NM used in the stock size calculation was 1098.

Herring and sprat was not observed mid water trawl hauls at depths below 150 meters. Therefore, layers below 150 meter were excluded during the estimation.

3.2 Biological data

31 hauls were conducted (16 surface hauls, 3 mid water hauls and 12 bottom hauls (Figure IIB.3 and table **IIB.**2 and **IIB.**3). The total catch was 15,604 kg with a mean catch at 503 kg. Herring was present in 29 of the hauls and was the dominant catch in the fishery with a total catch at 78,300 kg No herring was present in hauls below 150 m depths. Whiting haddock and mackerel dominated the remaining species with a total catch at 1,255 kg, 1,094 kg and 1,042 kg respectively. Whiting and haddock were mainly taken in the bottom hauls, were as mackerel was taken in surface hauls. Jellyfish was also present in high quantities in the catches by totally 1,596 kg.

Keys for length-race, length-age per race and length-weight per race were made for each strata based on the single fish sampled in each haul for micro-structure analysis of the otolith.

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. For the North Sea autumn spawners all herring at maturity state 3 and up worth were taken as mature.

North Sea autumn spawners:

WR	0im	1im	2im	2ma	3im	3ma	4im	4ma	5im	5ma
%	100	100	88	12	90	10	83	17	50	50

For the Western Baltic spring spawners all herring of maturity state 2 and up worth were taken as mature.

Western Baltic spring spawners:

WR	0im	1im	1ma	2im	2ma	3im	3ma	4im	4ma	5ma	6	7	8	9	10	11
%	100	93	7	38	62	15	85	5	95	100	100	100	100	100	100	100

The total catch during the survey was 15,604 kg with a mean catch of 503 kg. This is at the same mean catch level as in 2001. For herring the mean catch in all hauls was 268 kg witch is at the same level as in 2001

For the surface hauls the mean catch was 559 kg witch is 88% of what was seen in 2001. These catches in 2001 were dominated by herring (table **IIB.**2).

For the bottom hauls the mean catch was 514 kg witch is 68 % of what was seen in 2001. These catches in 2002 were dominated by whiting where as the mean catch of haddock was 32% of what was seen in 2001.

3.3 Biomass estimates

The total biomass estimates for the survey:

North Sea atumn spawning herring	263,908 tonnes	41%
Western Baltic spring spawning herring	315,514 tonnes	59%
Total herring	**579,422 tonnes**	

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

The biomass of North Sea autumn spawning herring in the survey area was estimated to 263,908 tonNes. This is 3.25 times the biomass estimated in 2001 and 55% of the biomass estimated in 2000. Compared to 2001 and 2000 especially the 0 and 1 WR the biomass are much higher than in 2001. See text table below.

Biomass estimate per age for North Sea autumn spawning herring 1998 to 2002 in tonnes

	WR									
Year	0	1	2	3	4	5	6	7	8	Total
2002	11744,0	220366,0	18286,3	10268,8	2086,0	1157,1				263908,3
2001	1427,6	53022,2	20373,9	5118,0	844,3	275,0	101,1			81162,2
2000	5240,6	446190,5	19457,2	1082,7	982,9					472953,8
1998	4450,5	129264,4	19804,0	4484,0	265,8	85,1	73,4		498,1	161163,0

The biomass of the Western Baltic spring spawning herring in the survey area was estimated to 315,514 tones. This is 3.7 times the biomass estimated in 2001 and 92 % of the biomass estimated in 2000. Compared to 2001 all the year classes are higher in 2002, but especially the 1, 2, 3, 4 and 5 WR. Compared to 2000 the large year class can be seen again in 2002 shifted 2 winter rings up. See text table below.

Biomass estimate per age for Western Baltic spring spawning herring 1998 to 2002 in tonnes

	WR												
Year	0	1	2	3	4	5	6	7	8	9	10	11	Total
2002	158	71402,5	85123,5	91729,5	48377,1	10157,6	4500,1	1510,4	885,1			1669,9	315513,7
2001		3606,6	34159,2	31981,0	7796,0	5297,8	1838,7	278,7	159,9		45,5	34,3	85197,7
2000		64747,5	133347,6	69313,5	42998,9	25043,5	5839,7	1472,0					342762,7
1998		5587,6	115485,5	59395,7	20021,2	8579,8	3801,6	3119,6	3957,8	863,8	401,2		234800,9

The geographic distribution by number for both stocks are shown in Figure IIB.6.

The geographical distribution of the biomass given as % of the total estimated biomass per sub area is given for each stock component in the text tables below.

% of total biomass estimate per sub area for North Sea autumn spawning herring 1998 to 2002

	sub area						
Year	3	4	5	6	7	8	9
2002	0,8	33,1	6,7	19,9	5,5	7,0	27,0
2001		14,2	7,6	16,6	3,7	44,4	13,4
2000		28,7	1,1	32,1	1,1	9,2	27,7
1998		9,5	6,5	15,5	13,2	31,5	23,7

% af total biomass estimate per sub area for Western Baltic spring spawning herring 1998 to 2002

	sub area						
Year	3	4	5	6	7	8	9
2002	0,6	21,8	16,1	16,9	7,7	9,5	27,3
2001		16,8	12,8	12,6	6,0	24,4	27,5
2000		22,9	3,1	36,4	1,5	16,1	20,0
1998		6,5	17,3	6,8	24,3	24,2	20,9

It can be seen that the geographical distribution for both stock components are very variable in this survey area, Skagerrak and Kattegat.

Table IIB.1 Simrad EY500 and analysis settings used on the July 2002 herring acoustic survey.

Transceiver Menu	
Frequency	38 kHz
Absorption coefficient	0.008 $m.s^{-1}$
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	6.8°
Calibration details	
TS of sphere	-33.6 dB
Range to sphere in calibration	6.90
Measured NASC value for calibration	44200
Log Menu	
Simulated	1,0 n.mi. at 10 knots
Operation Menu	
Ping interval 0.0	1 s external trigger
Analysis settings	
Bottom margin (backstep)	1.0 m
Integration start (absolute) depth	9 m
Range of thresholds used	-70 dB

Table IIB.2 Trawl haul information from R/V Dana 25 June to 8 July 2002

Haul no.	Date	Position		Mean depth	Trawl depth	Trawl	Used in	Total catch
	0	N	E	m	m		calculation	kg
148	020628	57 52.68	006 09.47	546	290	Fotö		37
252	020629	56 58.64	006 52.17	38	Bottom	Expo	+	159
270	020629	57 12.47	006 48.42	65	Bottom	Expo	+	510
316	020629	57 50.40	006 37.00	346	Surface	Fotö	+	498
338	020630	58 06.56	006 11.91	343	Surface	Fotö	+	405
414	020630	57 46.37	007 30.06	440	150-165	Fotö	+	114
485	020630	57 25.70	007 07.90	121	Surface	Fotö	+	159
510	020701	57 30.01	007 30.66	208	Surface	Fotö	+	518
588	020701	57 27.66	008 40.75	39	Bottom	Expo	+	441
604	020701	57 33.44	008 29.00	102	Bottom	Expo	+	1128
647	020701	58 02.40	008 19.10	340	Surface	Fotö	+	422
670	020702	57 47.34	008 12.04	490	Surface	Fotö	+	440
798	020702	58 05.50	009 21.70	580	Surface	Fotö	+	388
819	020703	57 54.27	009 24.73	156	Surface	Fotö	+	290
891	020703	57 44.02	009 43.18	36	Bottom	Expo	+	1734
908	020703	57 58.18	009 51.32	98	Bottom	Expo	+	412
953	020703	58 34.00	009 41.80	560	Surface	Fotö	+	235
970	020704	58 44.12	010 03.78	295	Surface	Fotö	+	1188
1034	020704	58 32.35	010 50.65	85	Bottom	Expo	+	575
1057	020704	58 17.47	010 57.04	105	Bottom	Expo	+	350
1100	020704	58 10.30	010 07.30	250	Surface	Fotö	+	630
1120	020705	58 09.47	010 47.07	150	Surface	Fotö	+	440
1186	020705	57 55.57	010 48.65	160	57-101	Fotö	+	340
1198	020705	57 53.06	011 09.50	58	Bottom	Expo	+	256
2029	020705	57 27.00	010 50.70	39	Surface	Fotö	+	630
1265	020706	57 36.38	011 24.55	56	Surface	Fotö	+	888
1342	020706	56 50.09	011 43.67	43	Bottom	Expo	+	310
1363	020706	56 42.41	012 07.64	42	Bottom	Expo	+	136
1411	020706	56 37.30	011 51.70	31	Surface	Fotö	+	667
1435	020707	56 26.18	012 07.64	33	Surface	Fotö	+	1373
1511	020707	56 18.67	011 38.40	29	Bottom	Expo	+	230

Table IIB.3 Trawl haul species composition for R/V Dana 25 June to 8 July 2002

		148	252	270	316	338	414	485	510	588	604	647	670	798
Trawl catch, kg		37	159	510	498	405	114	130	478	438	1128	422	440	388
	Lycodes vahli													
Anchovy	*Engraulis encrasicolus*	0,1												
Squid	*Loligo spp.*		0,6											
Blue whiting	*Micromesistius poutassou*	1,6			0,2	16,9	100,8		17,4				38,1	
Sprat	*Sprattus sprattus*													
Greater weever	*Trachinus draco*									2,9				
Dragonet	*Calllionymus spp.*		0,1							0,8				
Poor cod	*Trisopterus minutus*										0,5			
Catfish	*Anarhicas lupus*			5,4							7,3			
	Rhinonemus cimbrius													
Horse mackerel	*Trachurus trachurus*		0,1							0,6		0,4		
Long rough dab	*Hippoglosides plattessoides*			6,3							84,9			
Garfish	*Belone belone*				2,1	0,5			0,5			0,4		0,4
Whiting	*Merlangius merlangus*		2,0	77,7						255,0	29,1			
Invertebrates		19,6	31,7	85,6		14,2	9,3	6,2	18,9	36,7	11,4	18,3	243,4	72,1
Dab	*Limanda limanda*		5,1	7,4						11,7	0,4			
Norway lobster	*Nephrops norvegicus*													
Gurnard	*Trigala spp.*		21,5					0,2		14,8				
Haddock	*Melanogrammus aeglefinus*		76,6	102,8							815,7			
Hake	*Merluccius merluccius*			3,9						0,5	5,3			
Salmon	*Salmo solar*											1,5		
Sheppy argentine	*Maurolicus muelleri*													
Ling	*Molva molva*													
	Lumpenus lampretaeformis										0,6			
krill														
Mackerel	*Scomber scombrus*	0,6		8,6	237,5			10,2	10,7	0,2		102,4	13,7	0,5
Picked dogfish	*Squalus acanthias*				0,7	0,8							0,8	
Plaice	*Pleuronectes platessa*			3,0						11,9				
Lemon sole	*Microstomus kitt*		4,0	0,4						24,0	5,7			
Pilchard	*Sardina pilchardus*							0,4		8,6				
Saithe	*Pollachius virens*	6,9	3,3							0,6	19,0			5,3
Herring	*Clupea harengus*	2,3	0,1	98,1	253,7	367,1	3,8	111,2	430,2	58,8		298,9	134,4	289,7
Witch	*Glyptocephalus cynoglossus*													
	Myxine glutinosa										0,5			
Flounder	*Platichthys flesus*													
Norway pout	*Trisopterus esmarki*						0,1				90,1			
Lumpsucker	*Cyclopterus lumpus*	5,5			4,3	5,5		1,8					9,5	20,0
Lesser silver smelt	*Argentina sphyraena* *													
Crab	*Cancer pagurus*									0,4				
Starry ray	*Raja radiata*			21,7						0,8	1,3			
Sandeels	*Ammodytes spp.*		1,4											
Greater sandell	*Hyperoplus lanceolatus*		0,6							7,2				
Cod	*Gadus Morhua*		11,7	88,5						2,4	56,6			
Spinous spider crab	*Maia squinado*													
Sculpin	*Myoxocephalus scorpius*													

Table IIB.3. Continued

Haul		819	891	908	953	970	1034	1057	1100	1120	1186	1198	2029	1265
Trawl catch, kg		290	1734	412	235	1188	568	274	630	440	340	256	630	888
	Lycodes vahli													
Anchovy	*Engraulis encrasicolus*													
Squid	*Loligo spp.*		3,0		0,1		0,6					0,6		
Blue whiting	*Micromesistius poutassou*	1,7								113,4	4,8			
Sprat	*Sprattus sprattus*												11,9	
Greater weever	*Trachinus draco*		2,3					0,1		0,3			4,8	0,5
Dragonet	*Callionymus spp.*		1,5									0,3		
Poor cod	*Trisopterus minutus*													
Catfish	*Anarhicas lupus*													
	Rhinonemus cimbrius			2,7			1,0					1,7		
Horse mackerel	*Trachurus trachurus*												4,5	
Long rough dab	*Hippoglosides plattessoides*		0,5	1,8			1,9	0,4				30,2		
Garfish	*Belone belone*	0,3			1,7	6,1			11,1	3,7			0,3	2,0
Whiting	*Merlangius merlangus*		130,8	39,6			442,6	64,2				127,1		
Invertebrates				7,7	163,7	26,8	51,2		100,8	28,3		18,6	29,6	333,1
Dab	*Limanda limanda*		144,0											0,9
Norway lobster	*Nephrops norvegicus*			0,1			1,5					1,3		
Gurnard	*Trigala spp.*		2,5									1,2		
Haddock	*Melanogrammus aeglefinus*			97,8			0,6					0,4		
Hake	*Merluccius merluccius*		0,4	2,5			2,9	0,4				13,3		
Salmon	*Salmo solar*													
Sheppy argentine	*Maurolicus muelleri*							0,4						
Ling	*Molva molva*			1,3										
	Lumpenus lampretaeformis						5,8							
krill		194,8						65,1			225,6			
Mackerel	*Scomber scombrus*	15,3			8,9	405,8			57,7	36,2	2,7	1,1	4,4	62,3
Picked dogfish	*Squalus acanthias*		2,4				1,0	0,1						
Plaice	*Pleuronectes platessa*		7,1				1,9	1,2				2,3		
Lemon sole	*Microstomus kitt*		4,3	0,4			0,3	0,4				2,6		
Pilchard	*Sardina pilchardus*													
Saithe	*Pollachius virens*			21,2			4,2	50,2			15,3	4,5		
Herring	*Clupea harengus*	75,8	1424,7	66,9	69,5	748,3	7,5	5,0	460,4	258,0	91,6	47,1	574,0	489,0
Witch	*Glyptocephalus cynoglossus*			0,3			0,5							
	Myxine glutinosa											0,1		
Flounder	*Platichthys flesus*													
Norway pout	*Trisopterus esmarki*	0,5		155,1			42,8	68,6				2,3		
Lumpsucker	*Cyclopterus lumpus*	1,5				0,9								
Lesser silver smelt	*Argentina sphyraena* *						0,1							
Crab	*Cancer pagurus*													
Starry ray	*Raja radiata*		1,3					2,3				0,6		
Sandeels	*Ammodytes spp.*													
Greater sandell	*Hyperoplus lanceolatus*												0,1	0,2
Cod	*Gadus Morhua*		8,6	14,6			1,4	14,0						
Spinous spider crab	*Maia squinado*							1,4				0,5		
Sculpin	*Myoxocephalus scorpius*													

Table IIB.3. Continued

Haul		1342	1363	1411	1435	1511	Total survey	Mean survey	Max survey	Min survey
Trawl catch, kg		323	136	667	1216	230	15604	503,4	1734	37
	Lycodes vahli						0	0,0	0	0
Anchovy	Engraulis encrasicolus						0,1	0,0	0,1	0,1
Squid	Loligo spp.						4,9	0,2	3	0,1
Blue whiting	Micromesistius poutassou						294,9	9,5	113,4	0,2
Sprat	Sprattus sprattus			31,7		45	88,6	2,9	45	11,9
Greater weever	Trachinus draco	0,2		0,7	0,9	1,8	14,5	0,5	4,8	0,1
Dragonet	Callionymus spp.						2,7	0,1	1,5	0,1
Poor cod	Trisopterus minutus						0,5	0,0	0,5	0,5
Catfish	Anarhicas lupus	1,9					14,6	0,5	7,3	1,9
	Rhinonemus cimbrius						5,4	0,2	2,7	1
Horse mackerel	Trachurus trachurus		0,1		0,6	0,6	6,9	0,2	4,5	0,1
Long rough dab	Hippoglosides plattessoides	1,7	1,5				129,2	4,2	84,9	0,4
Garfish	Belone belone				0,7		29,8	1,0	11,1	0,3
Whiting	Merlangius merlangus	6,3	29			52	1255,4	40,5	442,6	2
Invertebrates		8,5	19	142,2	79,6	19,3	1595,8	51,5	333,1	6,2
Dab	Limanda limanda	14,1	0,5			62,4	246,5	8,0	144	0,4
Norway lobster	Nephrops norvegicus						2,9	0,1	1,5	0,1
Gurnard	Trigala spp.	0,1	0,1			1,7	42,1	1,4	21,5	0,1
Haddock	Melanogrammus aeglefinus						1093,9	35,3	815,7	0,4
Hake	Merluccius merluccius						29,2	0,9	13,3	0,4
Salmon	Salmo solar						1,5	0,0	1,5	1,5
Sheppy argentine	Maurolicus muelleri						0,4	0,0	0,4	0,4
Ling	Molva molva						1,3	0,0	1,3	1,3
	Lumpenus lampretaeformis						6,4	0,2	5,8	0,6
krill							485,5	15,7	225,6	65,1
Mackerel	Scomber scombrus			16,1	48		1042,9	33,6	405,8	0,2
Picked dogfish	Squalus acanthias	0,2					6	0,2	2,4	0,1
Plaice	Pleuronectes platessa	2	4,7			8,3	42,4	1,4	11,9	1,2
Lemon sole	Microstomus kitt	3,2	0,2				45,5	1,5	24	0,2
Pilchard	Sardina pilchardus						9	0,3	8,6	0,4
Saithe	Pollachius virens	0,3					130,8	4,2	50,2	0,3
Herring	Clupea harengus	278,5	68,5	476,2	1085,9	24,8	8300	267,7	1424,7	0,1
Witch	Glyptocephalus cynoglossus						0,8	0,0	0,5	0,3
	Myxine glutinosa						0,6	0,0	0,5	0,1
Flounder	Platichthys flesus		0,5				0,5	0,0	0,5	0,5
Norway pout	Trisopterus esmarki	0,6					360,1	11,6	155,1	0,1
Lumpsucker	Cyclopterus lumpus	1,8				4,5	55,3	1,8	20	0,9
Lesser silver smelt	Argentina sphyraena *						0,1	0,0	0,1	0,1
Crab	Cancer pagurus						0,4	0,0	0,4	0,4
Starry ray	Raja radiata						28	0,9	21,7	0,6
Sandeels	Ammodytes spp.					2,6	4	0,1	2,6	1,4
Greater sandell	Hyperoplus lanceolatus	0,1				5,8	14	0,5	7,2	0,1
Cod	Gadus Morhua	2,7	10,5			1,4	212,4	6,9	88,5	1,4
Spinous spider crab	Maia squinado						1,9	0,1	1,4	0,5
Sculpin	Myoxocephalus scorpius	0,5					0,5	0,0	0,5	0,5

Table IIB.4. Trawl length frequency composition (by trawl number and strata) for R/V Dana 2002

Sub area	4	4	4	4	3	4	4	4	6	5	6	5	6	6	6	5	7	7	8	8	8	8	8	9	9	9	9	9	9	9
cm \haul	148	252	270	316	338	414	485	510	588	647	670	798	819	891	908	953	970	1034	1057	1100	1120	1186	1198	2029	1265	1342	1363	1411	1435	1511
7,5																								1						
8,0																								3	1					
8,5																								5	1	6	1			
9,0																			1				2	12	11	7		2		1
9,5										5	1								1				1	38	39	11	1	4		2
10,0										3	1								10				6	61	60	15	2	4		2
10,5																			28			1	5	82	21	23	5	4		3
11,0										1									21			5	2	113	14	9	2	6		1
11,5																			2			3	2	82	3	1		2		
12,0																						1	2	21	1					
12,5										1																				
13,0						2																	2	1						
13,5		1				2			5													5	8	4	1					
14,0						1			27					7							1	7	25	7	6	1		1		2
14,5									44	4				28					1		1	16	42	6	12		1	2		
15,0			11	3	1				62	4				59	2				1		7	6	59	9	15	1	1	2		
15,5			29	2					79	4				68	3				6		4	23	68	12	14	8	1	20	1	6
16,0	1		42	3	2			1	88	15				82	2				7		5	61	81	15	23	44	8	34	10	5
16,5			52	6	7				66	36				78	1	1	5	1	6		32	96	102	17	18	70	15	71	13	8
17,0	4		25	8	36	1			49	113				58	2	1	18		3		55	134	53	8	17	78	40	103	36	26
17,5	6		13	24	135			5	58	361	5		1	28	1	4	40	3	2		75	83	32	8	14	33	49	99	77	27
18,0	8		7	28	134	2		13	25	572	5		8	10	3	10	62	4			58	42	13	2	14	19	38	35	61	23
18,5	11	1	2	37	63	5	5	8	15	291	3		4	13	10	3	74	4			43	8	7	2	8	8	17	13	19	15
19,0	11		5	19	13	1	11	24	4	124	2		17	2	23	1	36	6			19	5	2	1	4	5	8	6	11	4
19,5	4		1	12	8		30	29		51	5		30	2	26	1	27	3			9	1	1		1	1	5	3	1	2
20,0	2		1	5	4	2	64	29		11	10	2	40	1	31	1	6	4			11	1	1		1	6	6	5		
20,5				7	2	1	61	26		11	12	1	32	1	26	7	10	6	2	3	11		1	1	3	5	4	11	7	2
21,0	2			12	7	1	49	30		15	19	3	31		27	13	20	14		1	16	2	1		2	7	12	17	7	3
21,5				41	6	4	24	48		18	54	8	28		17	22	18	21		3	28				2	2	10	8	7	1
22,0				42	7	6	18	23		11	57	14	25		19	32	24	11		6	20		3			3	4	1	1	1
22,5				27	3		18	22		22	79	15	22		8	42	27	8	1	11	17		2			4	2		1	
23,0				11	3		7	11		4	42	21	7		2	19	9	11		14	8		7							
23,5				19		1	15	12			37	18	13		2	18	9	5		8	8				2		1			
24,0	1			11		1	6	3			30	25	6		3	8	6	3	2	8	5				1					
24,5				11			11	14			32	19	2			9	8	6		22	4									
25,0				8			2	11			17	19	4			7	8			16	1				1	1				
25,5				2			1	15			15	20	3			5	3			26	2									
26,0								5			3	19	2			6	5	1		23	2				3	1				
26,5				1				13			2	14	1			2	2			27	2									
27,0				1				6			5	12	1			2	1			16	1									
27,5								4			0	6	1			2	1			14	1				1					
28,0								4			3	1	1					1		15										
28,5				1							2	3					1			9										
29,0												3								12										
29,5												2								6										
30,0																1				1										
30,5																				1										
31,0																				2										
31,5																														
32,0																														

Table IIB.5a Biomass of herring by age, stock and sub area for R/V Dana 25 June to 8 July 2002

Subarea	WR										Total biomass tonnes
	0im	1im	2im	2ma	3im	3ma	4im	4ma	5im	5ma	
	North Sea Autumn spawners										
3		1911,3	30,2	4,1	43,2	4,8					1993,6
4	2809,1	73871,1	5239,5	714,5	4105,3	456,1	187,6	38,4			87421,6
5	6,3	9000,7	2092,4	285,3	3450,9	383,4	1400,4	286,8	389,8	389,8	17685,7
6	160,2	47493,0	3838,5	523,4	468,5	52,1					52535,7
7	840,9	9993,0	2688,3	366,6	527,8	58,6					14475,3
8	496,1	15315,2	1202,6	164,0	646,2	71,8	143,4	29,4	188,8	188,8	18446,4
9	7431,4	62781,8	1000,3	136,4							71349,9
Total	11744,0	220366,0	16091,9	2194,4	9242,0	1026,9	1731,4	354,6	578,6	578,6	263908,3
%	4,5	83,5	6,1	0,8	3,5	0,4	0,7	0,1	0,2	0,2	100,0

Subarea	WR																Total biomass tonnes
	0im	1im	1ma	2im	2ma	3im	3ma	4 im	4ma	5ma	6	7	8	9	10	11	
	Western Baltic spring spawners																
3		249,7	18,8	275,2	449,0	119,5	677,0	9,7	184,3	44,5							2027,5
4		6467,8	486,8	8521,7	13903,9	4309,9	24422,7	406,7	7726,6	2376,3		247,4					68869,7
5		2947,3	221,8	4219,0	6883,7	2675,3	15160,3	522,9	9934,4	3806,5	2077,3	572,3				1669,9	50690,8
6		3765,1	283,4	3701,9	6039,9	3182,0	18031,4	802,5	15247,6	974,3	886,7	376,0	156,0				53446,8
7		1365,1	102,7	3897,9	6359,8	1170,4	6632,2	150,4	2856,8	1675,9							24211,3
8	158,0	1328,5	100,0	3388,4	5528,5	1650,9	9355,1	237,8	4519,1	1280,2	1536,2	314,8	729,1				30126,6
9		50280,7	3784,6	8342,8	13611,9	651,4	3691,3	288,9	5489,5								86141,1
Total	158,0	66404,3	4998,2	32346,9	52776,6	13759,4	77970,1	2418,9	45958,2	10157,6	4500,1	1510,4	885,1			1669,9	315513,7
%	0,1	21,0	1,6	10,3	16,7	4,4	24,7	0,8	14,6	3,2	1,4	0,5	0,3			0,5	100,0

Table IIB.5b Number of herring by age, stock and sub area for R/V Dana 25 June to 8 July 2002

Subarea	WR										Total number *1000000
	0im	1im	2im	2ma	3im	3ma	4im	4ma	5im	5ma	
	North Sea autumn spawners										
3		47,40	0,43	0,06	0,62	0,07					48,58
4	194,88	1744,91	67,18	9,16	49,98	5,55	2,11	0,43			2074,20
5	1,03	221,62	19,04	2,60	29,87	3,32	11,11	2,28	2,52	2,52	295,90
6	14,77	1027,70	29,91	4,08	5,76	0,64					1082,86
7	116,59	212,77	30,80	4,20	7,47	0,83					372,66
8	70,35	419,46	11,09	1,51	5,83	0,65	1,19	0,24	1,22	1,22	512,78
9	1113,35	2044,65	25,01	3,41	0,00	0,00					3186,41
total	1510,96	5718,51	183,46	25,02	99,53	11,06	14,41	2,95	3,74	3,74	7573,39
%	19,95	75,51	2,42	0,33	1,31	0,15	0,19	0,04	0,05	0,05	100,00

Subarea	WR																Total number *1000000
	0im	1im	1ma	2im	2ma	3im	3ma	4 im	4ma	5ma	6	7	8	9	10	11	
	Wester Baltic spring spawners																
3		6,48	0,49	3,99	6,51	1,55	8,81	0,11	2,01	0,42							30,37
4		184,74	13,91	123,69	201,81	51,60	292,37	4,07	77,34	19,86		1,74					971,13
5		69,55	5,23	57,20	93,32	28,92	163,89	4,25	80,80	26,10	13,69	3,53				10,43	556,92
6		112,41	8,46	53,92	87,98	38,26	216,82	8,05	153,03	6,10	5,89	2,12	0,80				693,86
7		34,89	2,63	50,97	83,16	15,35	86,96	1,72	32,66	14,85							323,18
8	22,41	43,24	3,25	48,33	78,85	18,62	105,50	1,88	35,75	7,40	8,22	1,57	3,76				378,77
9		1380,56	103,91	164,91	269,07	11,31	64,11	3,71	70,58	0,00							2068,17
total	22,41	1831,87	137,88	503,01	820,69	165,61	938,46	23,80	452,18	74,73	27,79	8,96	4,56			10,43	5022,39
%	0,45	36,47	2,75	10,02	16,34	3,30	18,69	0,47	9,00	1,49	0,55	0,18	0,09			0,21	100,00

Table IIB.5c Mean weight (g) by age, stock and sub area of herring for R/V Dana 25 June to 8 July 2002

Subarea	WR									
	0im	1im	2im	2ma	3im	3ma	4im	4ma	5im	5ma
	North Sea autumn spawners									
3		40,2	78,3	78,3	79,1	79,1				
4	14,4	42,3	78,0	78,0	82,1	82,1	89,0	89,0		
5	6,1	40,6	109,9	109,9	115,5	115,5	126,1	126,1	154,5	154,5
6	10,8	46,2	128,3	128,3	81,3	81,3				
7	7,2	47,0	87,3	87,3	70,7	70,7				
8	7,1	36,5	108,4	108,4	110,8	110,8	120,0	120,0	154,5	154,5
9	6,7	30,7	40,0	40,0						

Subarea	WR															
	0im	1im	1ma	2im	2ma	3im	3ma	4 im	4ma	5ma	6	7	8	9	10	11
	Western Baltic spring spawners															
3		38,5	38,5	69,0	69,0	76,9	76,9	91,8	91,8	104,8						
4		35,0	35,0	68,9	68,9	83,5	83,5	99,9	99,9	119,7		142,0				
5		42,4	42,4	73,8	73,8	92,5	92,5	122,9	122,9	145,9	151,8	162,0				160,1
6		33,5	33,5	68,7	68,7	83,2	83,2	99,6	99,6	159,7	150,6	177,6	194,0			
7		39,1	39,1	76,5	76,5	76,3	76,3	87,5	87,5	112,8						
8	7,0	30,7	30,7	70,1	70,1	88,7	88,7	126,4	126,4	172,9	186,9	201,0	194,0			
9		36,4	36,4	50,6	50,6	57,6	57,6	77,8	77,8							

Table IIB.5d Mean length (cm) by age, stock and sub area of herring for R/V Dana 25 June to 8 July 2002

Subarea	WR									
	0im	1im	2im	2ma	3im	3ma	4im	4ma	5im	5ma
	North Sea autumn spawners									
3		18,03	21,94	21,94	22,21	22,21				
4	13,28	18,09	22,23	22,23	22,95	22,95	24,50	24,50		
5	10,10	18,07	23,74	23,74	24,94	24,94	25,29	25,29	26,50	26,50
6	12,03	18,39	25,00	25,00	23,00	23,00				
7	10,58	18,55	22,93	22,93	21,89	21,89				
8	10,50	17,25	24,00	24,00	24,33	24,33	25,00	25,00	26,50	26,50
9	10,34	16,42	18,00	18,00						

Subarea	WR															
	0im	1im	1ma	2im	2ma	3im	3ma	4 im	4ma	5ma	6	7	8	9	10	11
	Western Baltic spring spawners															
3		17,88	17,88	21,67	21,67	22,68	22,68	24,10	24,10	25,95						
4		17,21	17,21	21,64	21,64	23,17	23,17	24,40	24,40	25,74		26,00				
5		18,48	18,48	22,10	22,10	23,73	23,73	25,63	25,63	27,45	27,28	27,00				28,71
6		16,91	16,91	21,75	21,75	23,23	23,23	24,18	24,18	27,66	27,29	27,60	29,00			
7		17,89	17,89	22,24	22,24	22,59	22,59	23,38	23,38	24,79						
8	10,87	16,46	16,46	21,70	21,70	23,29	23,29	25,85	25,85	28,19	28,82	28,50	29,00			
9		17,47	17,47	19,65	19,65	20,69	20,69	22,75	22,75							

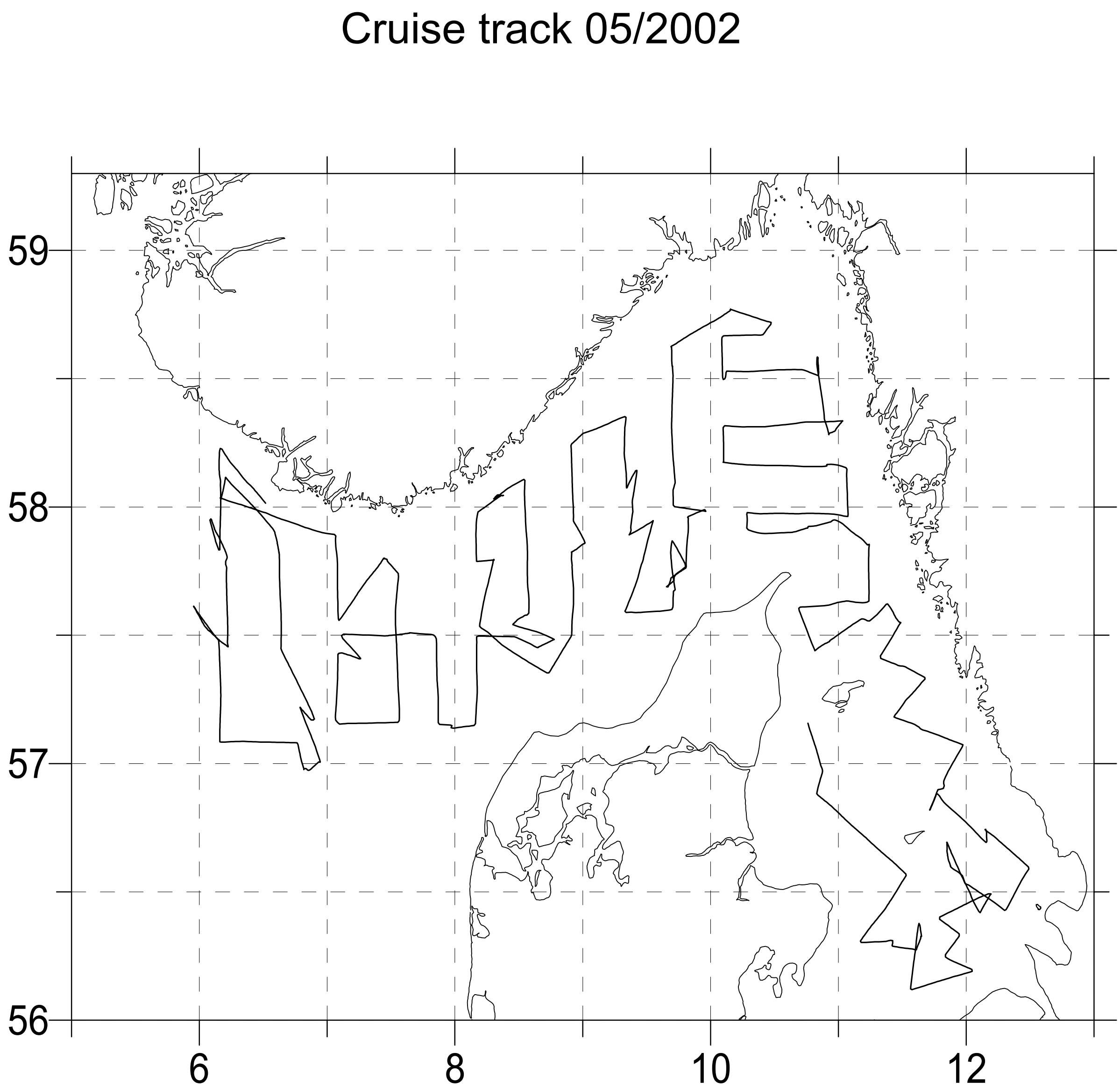

Figure IIB.1 Map of the eastern North Sea, Skagerrak and Kattegat showing the cruise tack of the FRV *Dana* during the July 2002 Danish acoustic survey.

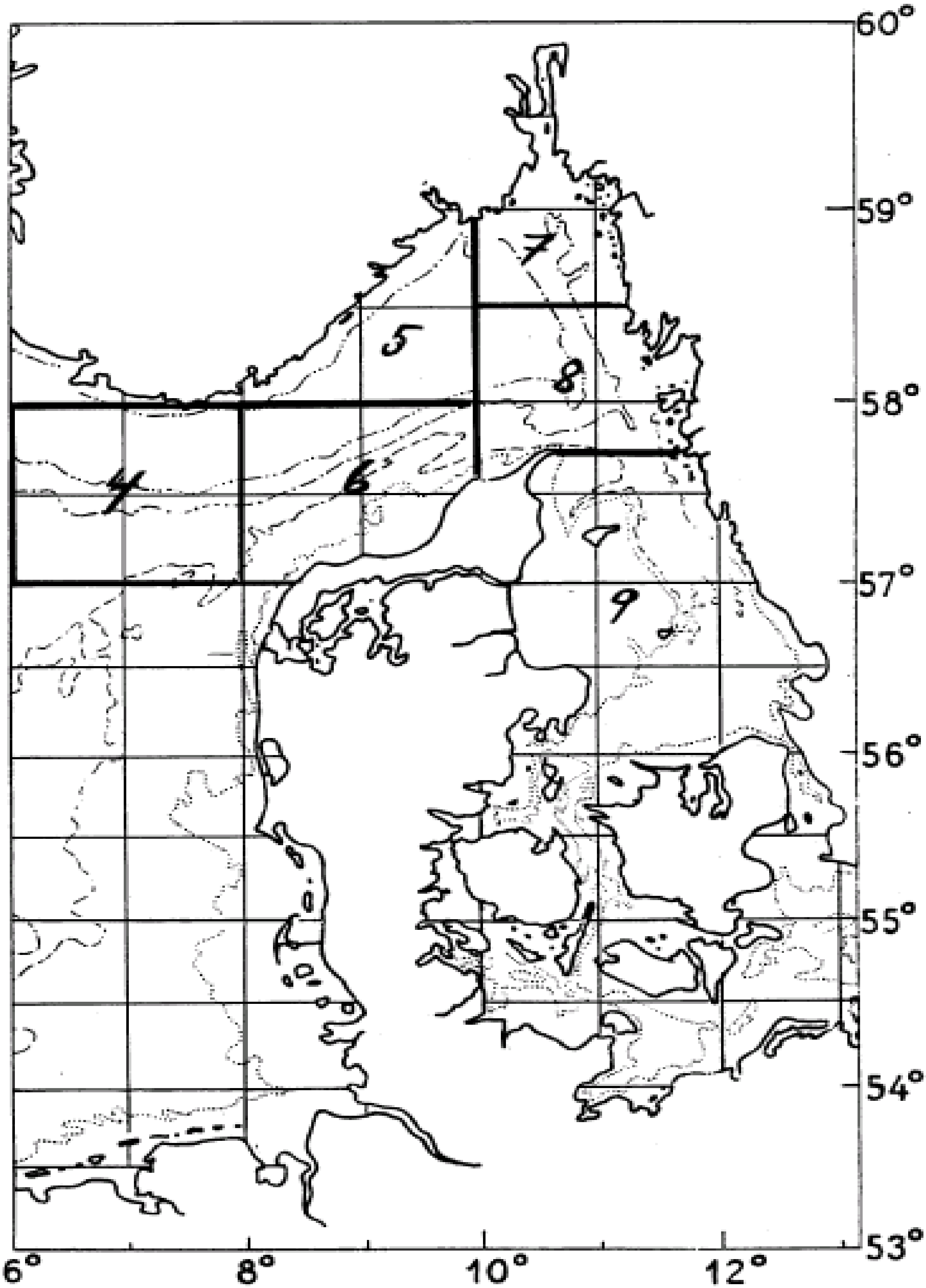

Figure IIB.2 Map of the eastern North Sea, Skagerrak and Kattegat showing the sub areas used in the estimation for R/V Dana 2002 during the July 2002 Danish acoustic survey.

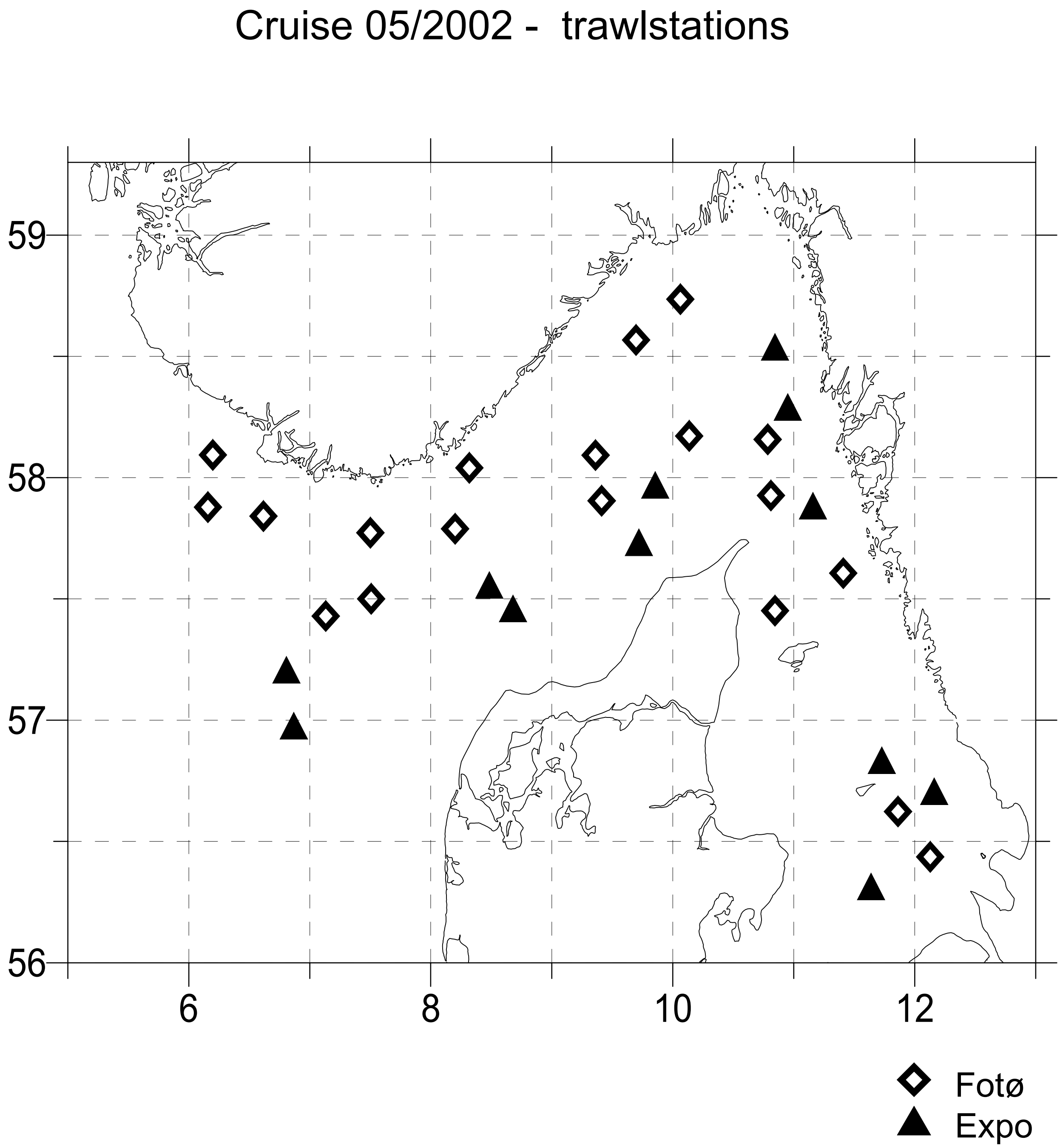

Figure IIB.3	Map of the eastern North Sea, Skagerrak and Kattegat showing the location of trawl hauls during the July 2002 Danish acoustic survey (Fotö hauls are pelagic and Expo hauls are demersal).

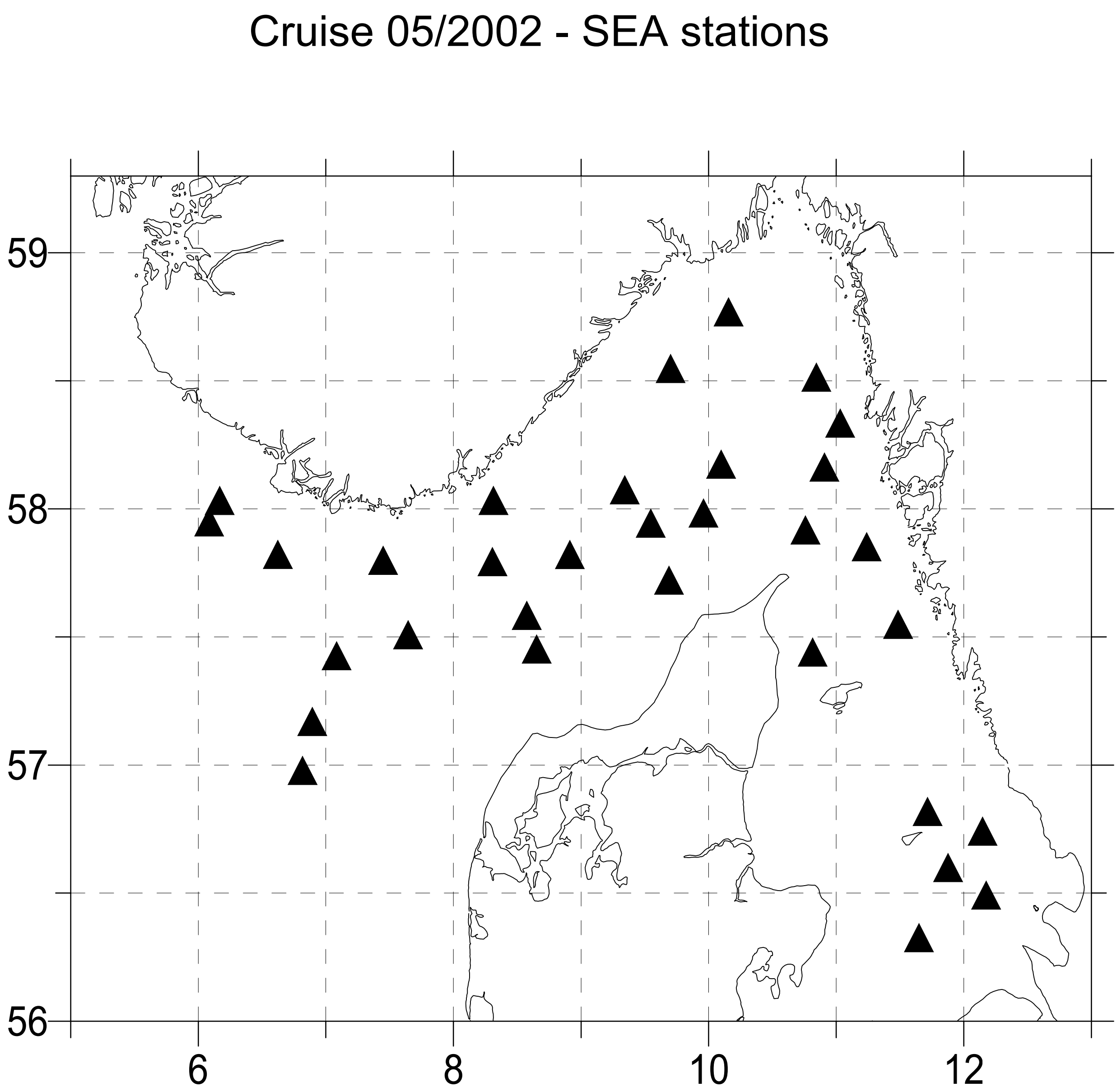

Figure IIB.4 Map of the eastern North Sea, Skagerrak and Kattegat showing the location of CTD stations during the July 2002 Danish acoustic survey.

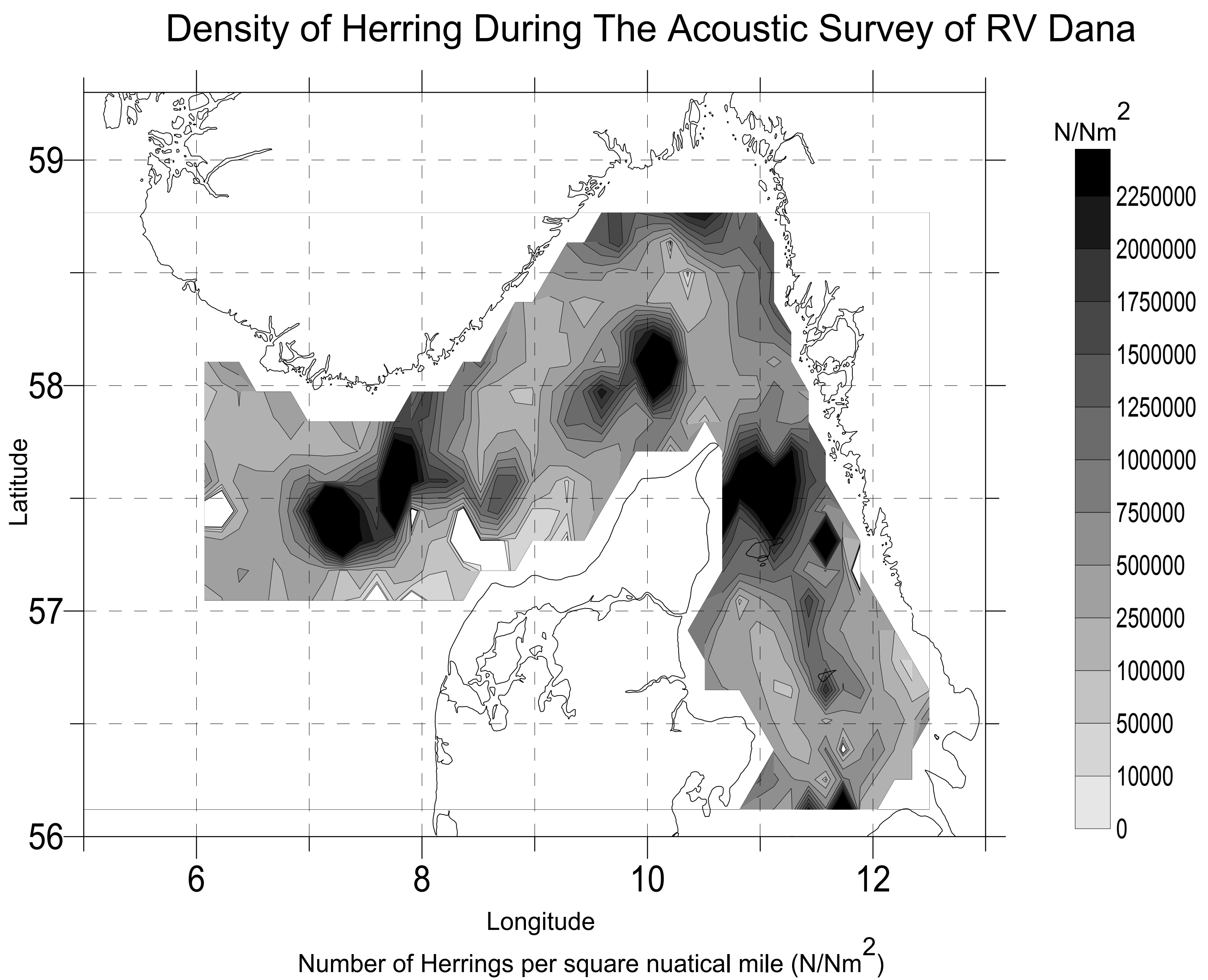

Figure IIB.5. Map of the eastern North Sea, Skagerrak and Kattegat showing contoured density of herring from the July 2002 Danish acoustic survey.

APPENDIX IIC: NORWAY

Acoustic Survey for North Sea Herring and Sprat

RV "G.O SARS" 27 June – 20 July 2002

Else Torstensen

Institute of Marine Research, Department of Coastal Zone
N-4817 His. Norway

else.torstensen@imr.no

1. INTRODUCTION

The report presents the results from the Norwegian coverage of the International Herring Acoustic Survey for 2002. 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 2002), a sub group under the ICES Herring Assessment Working Group for the Area South of 62^{o}N.

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)
Øyvind Torgersen	(Acoustic expert)
Valantine Anthonypillai	(Fish.lab)
Karen Gjertsen (11 – 20 July)	(Fish.lab)
Anne-Liv Johnsen	(Fish.lab)
Sigmund Myklevoll	(Fish.lab)
Henrik Myran (27 June – 11 July)	(Fish.lab)
Einar Osland	(Acoustic technician)
Bjørn Vidar Svendsen	(Fish.lab)

Exchange of staff with "Scotia":

Eric Armstrong, Marine Lab, Aberdeen, 4 - 17 July.

2.2 Narrative

RV "G.O. Sars" sailed at 1400 UTC on 27 June 2002. The vessel made passage to Uggedalseide/Tysnes and anchored at 1800 UTC to calibrate the acoustic instruments. The conditions appeared to be unfavourable for calibration and the vessel continued to the Førdesfjord, north of Haugesund. Entered at 0240 UTC without anchoring. Was positioned for a while and left the area at 0610 UTC. Again, the condition was not satisfactory for calibration as there were too much fish/jellyfish in the sea. On 28 June the vessel anchored in Rosfjord, 58° 04' N and 7° 00' E at 2040 UTC to calibrate the acoustic instruments on all scientific sounders. At 0500 UTC RV "G.O.Sars" left the fjord following a successful calibration of all scientific sounders and commenced the survey at 0920 UTC at 58^{o} 3' N and 8^{o} 5' E, the first CTD-station on the Oksøy – Hanstholm transect.

The survey continued with transects from south to north. The weather conditions were good except for the last two days. Due to rough weather and small acoustic registrations in the ICES rectangles 50F2 and 51F2, the rectangle 51F3 was not covered.

A call was made in Egersund on 28 June, in Aberdeen on 3 July, in Haugesund on 11 July and in Lerwick, Shetland on 17 July. The survey finished in Bergen on 20 July 2002 at 2015 hrs UTC. About 3.600 n.mi. were covered by the survey and 100 trawl hauls and 168 CTD stations were taken. Figure IIC.1 shows the cruise track and locations of trawl hauls and Figure IIC.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 distance of 13-17 n.mi. spacing progressing from south to north. Additional short transects were made in the overlapping area east of Shetland, with 7-8 n.mi. transects spacing. North of 60° 45' transects in a south – north direction were performed.

2.4 Calibration

The acoustic sounders, Simrad EK500 18, 38 and 120 kHz, were controlled and calibrated before the actual survey started. A standard sphere calibration was carried out. For calibration of the 38kHz sounder a 60 mm cupper 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.

2.5 Acoustic data collection

Acoustic data were collected 24 hours per day using a SIMRAD EK500 38 kHz echo sounder with an ES38B transducer mounted on the drop keel. Additional data were collected at 18 and 120 kHz but these were not used for the present assessment. 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 main settings of the acoustic instruments are given in Table IIC.1. 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. Herring were separated from other recordings by using catch information and characteristics of the recordings.

2.6 Biological data - fishing trawls

Trawling was carried out for supporting the species identifications of acoustic scatters and for biological sampling. The survey started with using a "Fotø"trawl (16 x 20 m) to be able to handle pelagic trawling close to bottom as well as near surface, and a Campelen 1800 equipped with a Rock hopper gear used for bottom trawling. Half-way through the survey the "Fotö"-trawl was damaged and replaced by an "Åkra"-trawl. 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. 2000). Target species were also examined for age, sex, maturity (8 point scale), fat, stomach contents and macroscopic evidence of *Ichthyophonus* infection. Off the south-west coast of Norway, North Sea autumn spawners (NSAS) and Western Baltic spring spawners (WBSS) mix during summer. No system for routine stock discrimination on individual herring during the survey, is available. East of 2°00'E vertebral counts were thus taken for stock separation.

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, in a Bergen Echo Integrator System (BEI). The NASC values were allocated to the following categories: herring, sprat, pelagic and 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:

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

The abundance estimation is made by ICES rectangles and summed up for the whole area. Toresen et al (1998) describes the acoustic method used for the abundance estimation in this survey.

North Sea autumn spawners and Western Baltic spring spawners (WBSS) are mixed during summer in the southern part of the area covered by RV ”GOSars”. No system for routinely stock discrimination on individual herring during the survey is available. The proportion of Baltic spring spawners and North Sea autumn spawners by age were calculated by applying the formula, WBSS= ((56,5-VS(sample))/(56.5-55.8)) (ICES 1999). All samples were worked up on board. Sampling procedures are described in Fotland et al.2000. 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 Acoustic data

3.1.1 Herring

The geographical distribution of the NASC values assigned to herring is presented by 5-n.mi. along the cruise track in Figure IIC.4. The main areas of concentration were the southwestern corner of the surveyed area and off the southwestern Norwegian coast 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 to keep close to the surface during daytime, herring may have been under-estimated.

3.1.2 Sprat

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

3.2 Biological data

The total number of valid trawl hauls was 99, 84 pelagic and 15 bottom trawl hauls (see Figure IIC.2, Table IIC.2). Of the pelagic hauls, 7 were mid water hauls, 6 hauls were taken close to the bottom and 71 were performed with large buoys for fishing in the surface. In general 30 min hauls were made. Catch composition per haul is given in Table IIC.3. Herring was present in 56 trawl hauls of which 41 had sample size >20 herring and the length distribution of herring in these hauls is given in Table IIC.4. A total of 3.678 fish were length measured and 2.047 fish were aged (otoliths). Number of otoliths collected by age and length and maturity stages (number of fish sampled) in the Norwegian target area, is given in Table IIC.5.

3.3 Abundance and Biomass estimates

3.3.1 Herring

Mean length, mean weight, numbers (millions) and biomass (thousands of tonnes) by age and maturity.

Total number of herring was 8,541 million of which 77% was North Sea Autumn Spawners. Total stock biomass of North Sea herring was estimated to 377,000 tonnes and the spawning stock biomass 88,000 tonnes. In the stock of the North Sea Autumn Spawners, the 1-ringers (2000 year class) made nearly 90% of the number and 75% of the biomass. Of the 1-ringers, 1% was maturing. The total biomass of western Baltic Spring Spawner was 143,000 tonnes and the maturing biomass 55,000 tonnes.

4. REFERENCES

Fotland, AA., Borge, A., Gjøsæter, H. and Mjanger, H. 2000. Manual for sampling of fish and shellfish. (In Norwegian). Ver. 3.14. Institute of Marine Research.

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Table IIC.1 Simrad EK500 and analysis settings used on the GOS2002009 herring acoustic survey.

Transceiver 1 Menu	
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	27.1 dB
3 dB Beamwidth	7.3/7.0 deg
Alongship offset	-0.05 deg
Althw.Ship Offset	-0.01 deg
Calibration details	
TS of sphere	-33.6 dB (cupper 60 mm diameter)
Range to sphere in calibration	23.3
Selected (sA) NASC value for calibration	4372
Log Menu	
GPS	
Operation Menu	
Ping interval	0.0 (all ranges)
Display / Printer Menu	
TVG	20 log R
Integration line	1000
TS colour min.	-50 dB
Sv colour min.	-70 dB

Table IIC.2 RV "GOSars" 27 June - 20 July 2002. 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
PT470	29.jun	57°56'	8°02' E	10:48	534	70	30
PT471	29.jun	57°23'	8°28' E	17:06	37	0	38
BT472	29.jun	57°11'	8°32' E	20:07	31	31	23
PT473	30.jun	57°00'	8°02' E	23:58	32	0	30
PT474	30.jun	57°00'	7°31' E	03:04	35	0	30
PT475	30.jun	57°00'	6°14' E	09:04	61	0	30
PT476	30.jun	57°00'	5°07' E	13:49	120	0	30
PT477	30.jun	57°00'	4°32' E	16:36	64	22	29
PT479	30.jun	57°00'	4°14' E	19:10	63	0	13
BT480	30.jun	57°00'	4°12' E	19:58	63	63	26
PT481	30.jun	57°00'	3°38' E	23:08	64	0	30
PT482	01.jul	57°00'	2°58' E	02:15	67	0	30
PT483	02.jul	56°48'	2°06' E	08:11	88	0	30
PT484	02.jul	56°48'	4°32' E	16:30	60	0	28
PT485	02.jul	56°46'	5°51' E	21:45	57	0	30
PT486	02.jul	56°40'	4°59' E	02:33	65	0	30
BT487	02.jul	56°35'	3°54' E	07:06	72	72	30
PT488	02.jul	56°37'	2°00' E	14:42	87	0	30
BT489	02.jul	56°54'	1°46' E	17:16	94	94	30
PT490	02.jul	57°00'	0°38' E	23:03	91	0	30
PT491	03.jul	57°00'	0°03' E	02:05	83	0	30
PT492	04.jul	57°10'	1°07' W	14:57	59	40	24
BT493	04.jul	57°11'	0°47' W	17:13	69	65	31
PT494	05.jul	57°13'	2°02' E	02:49	87	0	30
PT495	05.jul	57°13'	2°17' E	04:25	83	83	30
PT496	05.jul	57°13'	3°06' E	08:17	66	30	12
PT497	05.jul	57°12'	3°06' E	08:57	66	66	29
BT498	05.jul	57°13'	5°34' E	17:43	55	55	30
PT499	05.jul	57°27'	5°50' E	21:14	83	0	30
PT500	06.jul	57°27'	4°53' E	01:02	81	0	30
BT501	06.jul	57°27'	3°45' E	05:25	66	65	30
BT502	06.jul	57°27'	3°00 E	09:19	65	65	29
PT503	06.jul	57°27'	2°24' E	12:05	80	40	13
PT504	06.jul	57°27'	2°15' E	14:17	81	81	32
PT505	06.jul	57°41'	2°39' E	18:46	70	0	29
PT506	06.jul	57°41'	3°34 E	22:15	64	0	30
PT507	07.jul	57°40'	4°22' E	01:32	77	0	30
BT508	07.jul	57°41'	5°33' E	06:16	114	113	30
PT509	07.jul	57°55'	3°48 E	16:40	88	0	29
PT510	07.jul	57°55'	2°17' E	22:13	75	0	30
PT511	08.jul	58°09'	2°40 E	02:29	70	0	30
BT512	08.jul	58°09'	3°19' E	05:36	81	81	30
PT513	08.jul	58°09'	3°46' E	07:35	91	0	30
PT514	08.jul	58°11'	5°51' E	15:29	332	0	30
PT515	08.jul	58°24'	4°43' E	23:21	287	0	30
PT516	09.jul	58°23'	3°18' E	04:35	114	0	30
PT517	09.jul	58°23'	3°17' E	05:31	116	45	28
PT518	09.jul	58°36'	3°02' E	14:32	104	0	30
PT519	09.jul	58°36'	4°14' E	19:03	285	0	35

Table IIC.2. Cont.

Trawl haul no	Date	Lat	Lon	Time UTC	Water depth (m)	Trawl depth (m)	Duration min
PT520	09.jul	58°36'	5°02' E	22:14	251	0	30
PT521	10.jul	58°51'	5°16' E	02:24	116	0	30
PT522	10.jul	58°50'	4°38' E	05:11	238	0	30
PT523	10.jul	58°51'	4°08' E	07:44	287	30	30
PT524	10.jul	58°51'	3°58' E	09:47	279	0	30
PT525	10.jul	58°51'	2°58' E	14:10	120	0	30
BT526	10.jul	58°51'	2°28' E	16:33	115	115	31
PT527	10.jul	59°04'	2°43' E	21:29	127	0	30
PT528	11.jul	59°04'	3°21' E	00:18	171	0	30
PT529	11.jul	59°04'	3°02' E	04:16	264	0	30
PT530	11.jul	59°04'	5°00' E	06:58	247	0	31
PT531	12.jul	59°17'	4°19' E	17:12	266	0	31
PT532	12.jul	59°17'	3°38' E	20:55	246	0	30
PT533	13.jul	59°17'	2°58' E	00:22	116	0	30
PT534	13.jul	59°17'	2°18' E	03:35	128	122	30
BT535	13.jul	59°17'	0°39'W	15:08	128	124	31
PT536	13.jul	59°17'	1°36' W	19:14	94	82	12
PT537	14.jul	59°32'	2°12' E	11:18	124	0	31
PT538	14.jul	59°31'	3°16' E	15:13	154	0	30
BT539	14.jul	59°31'	3°25' E	16:35	206	206	32
PT540	14.jul	59°32'	4°46' E	22:22	239	0	30
PT541	15.jul	59°50'	4°53' E	01:28	235	0	30
PT542	15.jul	59°49'	4°19' E	03:51	283	0	31
PT543	15.jul	59°49'	3°25' E	07:29	253	0	29
PT544	15.jul	59°49'	3°18' E	08:46	220	220	25
PT545	15.jul	59°49'	2°18'E	12:58	112	0	30
PT546	15.jul	60°07'	3°02' E	18:43	121	0	31
PT547	15.jul	60°07'	4°02' E	22:33	293	0	30
PT548	16.jul	60°10'	4°53' E	01:53	221	0	30
PT549	16.jul	60°27'	4°33' E	05:01	315	0	31
PT550	16.jul	60°27'	3°28' E	09:06	307	0	30
PT551	16.jul	60°27'	2°15' E	13:26	112	0	30
PT552	16.jul	60°27'	0°50' E	18:45	136	135	30
PT553	16.jul	60°27'	0°1' W	23:38	93	0	31
PT554	17.jul	60°18'	0°46' W	02:18	94	0	30
BT555	17.jul	60°36'	0°38' W	19:57	133	133	35
PT556	17.jul	60°36'	0°11' E	23:02	136	0	30
PT557	18.jul	60°54'	0°27' E	02:57	123	0	30
PT558	18.jul	60°54'	0°13' W	05:26	164	0	29
BT559	18.jul	60°45'	0°22' W	11:24	135	135	29
PT560	18.jul	60°46'	2°15' E	20:52	327	0	36
PT561	19.jul	61°22'	2°17' E	01:36	302	0	30
PT562	19.jul	61°50'	2°31' E	06:03	391	0	44
PT563	19.jul	61°38'	2°46' E	08:44	390	0	30
PT564	19.jul	61°05'	2°46' E	12:46	281	0	29
PT565	19.jul	60°45'	3°09' E	18:09	254	0	30
PT566	19.jul	61°02'	3°17' E	23:03	358	0	30
PT567	20.jul	61°21'	3°45' E	06:44	366	0	33
PT568	20.jul	60°53'	3°46' E	10:14	340	0	30
PT569	20.jul	60°45'	4°08' E	14:44	320	0	30

Table IIC.3. RV "G.O.Sars" 27 June - 20 July 2002. Catch compositions in the trawl hauls (kg).

Trawl station		**470**	**471**	**472**	**473**	**474**	**475**	**476**	**477**	**478**	**479**	**480**	**481**	**482**	**483**	**484**	**485**	**486**	**487**	**488**	**489**	**490**
Total catch (kg)		**4.85**	**10.19**	**181.01**	**1.12**	**0.11**	**69.01**	**37.02**	**4.70**	**0.00**	**27.00**	**162.14**	**133.39**	**272.02**	**1.89**	**3.14**	**137.65**	**0.31**	**275.10**	**7.20**	**95.49**	**11.34**
Herring	Clupea harengus			1.82							27.00	26.08	121.64	217.66			103.84		174.00		59.40	2.00
Sprat	Sprattus sprattus			2.08																		
Pilchard	Sardina pilchardus		0.09				0.37															
Anchovy	Engraulis encrasicolus																					
Mackerel	Scombrus scombrus		0.97	0.62	1.09	0.10	68.30	37.02					10.97	46.84	1.89	2.42	33.10	0.31		6.28	0.88	6.73
Horse mackerel	Tracurus tracurus			8.28													0.46					
Norway pout	Trisopterus esmarkii																				5.15	
Haddock	Melanogrammus aeglefinus	0.00										7.60							5.20		23.33	0.06
Whiting	Merlangius merlangus	0.01	0.04	16.50	0.03	0.01						4.10	0.78			0.00					2.41	0.06
Blue-whiting	Micromesistius poutassou																					
Saithe	Pollachius virens																					
Hake	Merluccius merluccius			3.00																		
Pollack	Pollachius pollachius																					
Torsk	Brosme brosme																					
Cod	Gadus morhua			24.42															0.80			
Poor cod	Trisopterus minutus																					
Ling	Molva molva																					
Argentine	Argentina sphyraena																					
Sandeels	Ammodytidae spp			0.76																		0.01
Gurnard	Trigla spp		0.05				0.35									0.21	0.25		2.20		1.94	0.31
Dab	Limanda limanda			36.12								90.40							82.40		0.20	
Plaice	Pleuronectes platessa			64.80																		
Witch	Glyptocephalus cynoglossus																					
Lomre	Microstomus kitt			17.28															1.70			
Long rough dab	Hippoglossoides platessoides											31.20							8.80		2.18	
Wolffish	Anarhichas lupus											1.60										
Lumpsucker	Cyclopterus lumpus								2.71											0.92		
Monkfish	Lophius piscatorius																					
Norway haddock	Sebastes marinus																					
Jellyfish		4.84	9.04						1.00							0.50						2.18
Other				5.34					0.99			1.16		7.52								0.01

Table IIC.3. Cont

Trawl station		491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	510	511	512
Total catch (kg)		**22.14**	**26.05**	**240.34**	**27.82**	**130.85**	**0.13**	**35.72**	**518.60**	**179.40**	**140.23**	**349.96**	**262.89**	**363.00**	**0.25**	**12.75**	**315.00**	**128.42**	**409.40**	**19.37**	**22.55**	**73.83**
Herring	Clupea harengus	7.41				33.20		29.00				123.97	205.20	363.00			180.00			7.96	0.17	
Sprat	Sprattus sprattus																					
Pilchard	Sardina pilchardus																					
Anchovy	Engraulis encrasicolus																					
Mackerel	Scombrus scombrus	1.12			27.82			6.72		179.40	140.00	6.23				12.72	135.00	128.42		11.41	22.38	0.29
Horse mackerel	Tracurus tracurus																					
Norway pout	Trisopterus esmarkii	13.03		1.84		3.25													177.43			
Haddock	Melanogrammus aeglefinus	0.03	0.03	194.24		46.90			353.28			120.38	3.24						60.37			52.40
Whiting	Merlangius merlangus		0.01	13.56		8.00						34.64	10.44						1.44			3.55
Blue-whiting	Micromesistius poutassou																					
Saithe	Pollachius virens			7.44					84.96										107.38			5.55
Hake	Merluccius merluccius								17.76										12.01			
Pollack	Pollachius pollachius																		14.27			
Torsk	Brosme brosme																		11.82			
Cod	Gadus morhua			1.41					43.36													0.95
Poor cod	Trisopterus minutus																		0.13			
Ling	Molva molva								7.04													
Argentine	Argentina sphyraena																					
Sandeels	Ammodytidae spp		25.00																			
Gurnard	Trigla spp			3.00		1.90					0.23											2.34
Dab	Limanda limanda			2.04		20.90			11.48			48.21	12.38									7.51
Plaice	Pleuronectes platessa																					
Witch	Glyptocephalus cynoglossus																					
Lomre	Microstomus kitt			1.68								6.18							3.83			
Long rough dab	Hippoglossoides platessoides			3.16		16.70			0.72			10.35	31.46						3.50			1.24
Wolffish	Anarhichas lupus																		4.32			
Lumpsucker	Cyclopterus lumpus														0.25							
Monkfish	Lophius piscatorius																		9.40			
Norway haddock	Sebastes marinus																		3.44			
Jellyfish		0.55	1.00				0.04															
Other				11.97			0.09						0.18			0.04			0.05			

Table IIC.3. Cont.

Trawl station Total catch (kg)		513 22.52	514 150.43	515 169.21	516 7.74	517 5.16	518 3.92	519 221.77	520 145.84	521 52.94	522 49.81	523 15.01	524 60.74	525 4.76	526 131.18	527 36.17	528 49.41	529 0.00	530 84.92	531 5.73	532 200.00	533 20.49
Herring	Clupea harengus	22.22	55.55	1.41			0.13	0.15	4.61	2.72	0.28		47.00		5.99		32.02		20.00	4.70	200.00	1.37
Sprat	Sprattus sprattus																					
Pilchard	Sardina pilchardus																					
Anchovy	Engraulis encrasicolus																					
Mackerel	Scombrus scombrus		92.68	8.71			1.19	21.28	17.12	35.20	2.49		3.06			0.89	5.64		4.76	0.13		18.54
Horse mackerel	Tracurus tracurus																					
Norway pout	Trisopterus esmarkii														16.76							
Haddock	Melanogrammus aeglefinus			0.08		3.86		0.10			0.02	0.01	0.02		64.94	0.03	0.01		0.01	0.05		0.00
Whiting	Merlangius merlangus			0.02				0.09	0.11	0.02	0.03	0.01	0.00	0.01	2.87	0.12	0.04		0.03	0.07		0.58
Blue-whiting	Micromesistius poutassou			21.75					24.00								1.50					
Saithe	Pollachius virens			6.38								0.99			30.10							
Hake	Merluccius merluccius																					
Pollack	Pollachius pollachius																					
Torsk	Brosme brosme																					
Cod	Gadus morhua																					
Poor cod	Trisopterus minutus																					
Ling	Molva molva																					
Argentine	Argentina sphyraena																					
Sandeels	Ammodytidae spp																					
Gurnard	Trigla spp	0.30													0.95							
Dab	Limanda limanda														0.33							
Plaice	Pleuronectes platessa																					
Witch	Glyptocephalus cynoglossus																					
Lomre	Microstomus kitt														0.37							
Long rough dab	Hippoglossoides platessoides														6.54							
Wolffish	Anarhichas lupus																					
Lumpsucker	Cyclopterus lumpus			10.87				0.15					0.65						0.11	0.79		
Monkfish	Lophius piscatorius																					
Norway haddock	Sebastes marinus																					
Jellyfish			2.20	120.00	7.74	1.30	2.60	200.00	100.00	15.00	47.00	14.00	10.00	4.75		35.00	10.00		60.00			
Other															2.34	0.13	0.20					

Table IIC.3. Cont.

Trawl station		534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549	550	551	552	553	554
Total catch (kg)		**15.00**	**212.05**	**185.71**	**1.34**	**5.75**	**563.14**	**180.10**	**148.20**	**66.51**	**56.01**	**598.04**	**0.30**	**10.03**	**363.16**	**172.31**	**30.50**	**11.72**	**5.96**	**687.06**	**1.65**	**2.54**
Herring	Clupea harengus		7.88	17.46		0.18	76.08	91.49	38.50	45.00	40.00	6.88			249.17	150.00		9.32		427.20		
Sprat	Sprattus sprattus																					
Pilchard	Sardina pilchardus																					
Anchovy	Engraulis encrasicolus																					
Mackerel	Scombrus scombrus			0.68	0.52	0.58		36.47	24.50	0.41	15.85	8.31		1.01	43.56	6.38	0.50	1.20	5.72		0.91	
Horse mackerel	Tracurus tracurus																					
Norway pout	Trisopterus esmarkii		132.53	81.84	0.05		127.60					54.82								48.70	0.01	
Haddock	Melanogrammus aeglefinus		41.85	40.62	0.30		0.20					5.14			0.07					12.70		
Whiting	Merlangius merlangus		13.76	32.55	0.00		13.68	0.01	0.20	0.00		8.08				0.01				8.30		
Blue-whiting	Micromesistius poutassou						315.20	1.19				322.49			2.52					6.30		
Saithe	Pollachius virens											159.02			9.00					178.40		
Hake	Merluccius merluccius						0.52					3.34										
Pollack	Pollachius pollachius																					
Torsk	Brosme brosme																					
Cod	Gadus morhua		4.64									0.87										
Poor cod	Trisopterus minutus																					
Ling	Molva molva																					
Argentine	Argentina sphyraena											13.29								0.96	0.01	
Sandeels	Ammodytidae spp																					
Gurnard	Trigla spp				0.12																	
Dab	Limanda limanda																					
Plaice	Pleuronectes platessa																					
Witch	Glyptocephalus cynoglossus						8.20															
Lomre	Microstomus kitt		2.59	0.80	0.19		2.34															
Long rough dab	Hippoglossoides platessoides		5.44				1.30															
Wolffish	Anarhichas lupus																					
Lumpsucker	Cyclopterus lumpus									1.06	0.16					0.51		1.20	0.24			
Monkfish	Lophius piscatorius									0.04												
Norway haddock	Sebastes marinus																					
Jellyfish		15.00				5.00		50.83	85.00	20.00			0.30	2.00	58.82	15.00	30.00					2.54
Other			3.38	11.76	0.16		18.02	0.10				15.80		7.03	0.02	0.41				4.50	0.72	

Table IIC.3. Contd

Trawl station		555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	567	568	569
Total catch (kg)		**872.43**	**29.96**	**3.56**	**1.00**	**384.03**	**15.06**	**52.45**	**7.15**	**19.57**	**4.65**	**1.02**	**35.25**	**27.08**	**11.31**	**61.58**	**27.08**	**11.31**	**61.58**
Herring	Clupea harengus	5.82	7.74	0.17		0.55							0.21	0.13	8.27	2.24	0.13	8.27	2.24
Sprat	Sprattus sprattus																		
Pilchard	Sardina pilchardus																		
Anchovy	Engraulis encrasicolus																		
Mackerel	Scombrus scombrus		22.01	3.39		0.94		48.94	2.15	14.52	4.57		25.34	6.95	3.03	59.30	6.95	3.03	59.30
Horse mackerel	Tracurus tracurus							2.20					0.59						
Norway pout	Trisopterus esmarkii	590.40				168.84													
Haddock	Melanogrammus aeglefinus	139.20			0.00	90.90		0.00			0.01					0.04			0.04
Whiting	Merlangius merlangus	108.60			0.00	61.56	0.06	0.00	0.01				0.01	0.01	0.01	0.00	0.01	0.01	0.00
Blue-whiting	Micromesistius poutassou												1.68						
Saithe	Pollachius virens					12.65		1.26					2.16						
Hake	Merluccius merluccius					14.04													
Pollack	Pollachius pollachius																		
Torsk	Brosme brosme																		
Cod	Gadus morhua					12.74													
Poor cod	Trisopterus minutus																		
Ling	Molva molva					10.54													
Argentine	Argentina sphyraena	2.25				4.28													
Sandeels	Ammodytidae spp																		
Gurnard	Trigla spp		0.21			1.85													
Dab	Limanda limanda	1.20																	
Plaice	Pleuronectes platessa																		
Witch	Glyptocephalus cynoglossus																		
Lomre	Microstomus kitt	9.60				1.78													
Long rough dab	Hippoglossoides platessoides	12.15				3.23													
Wolffish	Anarhichas lupus																		
Lumpsucker	Cyclopterus lumpus									0.04									
Monkfish	Lophius piscatorius										0.07	0.02							
Norway haddock	Sebastes marinus																		
Jellyfish					1.00		15.00		5.00	5.00		1.00	5.00	20.00			20.00		
Other		3.21				0.14		0.05					0.27						

Table IIC.4 RV "GOSars" 27 June-20 July 2002. Herring length (cm) distribution in trawl hauls where sample size>20 herring

Trawl st	479	480	481	482	485	487	489	495	497	501	502	503	506	510
ICES rect	43F4	43F4	43F3	43F2	42F5	42F3	42F1	43F2	43F3	43F3	43F2	43F2	44F3	44F2
13.0		1												
13.5	1	1			1									
14.0	3	4	1		1	6								
14.5	7	8	3	2	2	17					1			
15.0	24	37	23	2	4	36			11	2	4			
15.5	38	21	19	8	2	29			14	1	2	1		
16.0	11	11	26	23	7	6	3		21	10	4			
16.5	8	10	17	15	16	4	12		17	19	1			
17.0	5	2	7	20	28	1	13		14	21	6	1		
17.5	1	1	3	17	20		8	1	8	9	17	2	1	
18.0	2	4		5	10	1	11		3	7	20	4	4	
18.5				1	5		3	5	6	15	17	6	7	
19.0			1	1	3		2	8	4	11	11	10	18	1
19.5				3	1		5	14	1		5	6	24	3
20.0				1			8	28		4	4	13	22	7
20.5							6	25	1		5	8	10	25
21.0				1			6	13		1		18	10	25
21.5							4	4			3	15	4	12
22.0							3	2				6		15
22.5				1			2					4		4
23.0							3					4		2
23.5														1
24.0							3							2
24.5							2					2		2
25.0							3							
25.5							3							1
26.0														
26.5														
27.0														
27.5														
28.0														
28.5														
29.0														
29.5														
30.0														
30.5														
31.0														
31.5														
32.0														
32.5														
Total N	100	100	100	100	100	100	100	100	100	100	100	100	100	100
mean W(g)	28.6	27.5	26.9	35.7	34.0	24.3	62.4	65.9	31.4	39.7	46.3	66.5	61.6	75.7
mean L(cm)	15.8	15.7	16.1	17.1	17.2	15.4	19.7	20.4	16.8	17.2	18.4	20.7	20.0	21.5

Table IIC.4. Cont.

Trawl st	513	514	515	520	521	524	526	528	529	530	531	532	535	536
ICES rect	45F2	45F5	45F4	46F5	46F5	46F3	46F2	47F3	47F4	47F5	47F4	47F3	47E9	47E8
13.0														
13.5														
14.0														
14.5														
15.0														
15.5														
16.0					1									
16.5				2	1					1				
17.0		1		5	3									
17.5			3	4	7					1	1			
18.0		9	6	6	7		1			5	5			
18.5		14	7	10	3					25	2			
19.0		14	1	6	3				3	10	13			
19.5	2	15		6					2	10	15			
20.0	7	12		4		1	1		2	5	13			
20.5	15	11	1	3		2			8	3	11		1	
21.0	18	9		5	2	4			8	4	8			
21.5	19	5		4	2	5		1	5	14	3	1	2	
22.0	19	8		6	3	8	1	4	9	8	1	1	3	
22.5	5			4		5	1		6	4		2	2	
23.0	8	1		1		5	3	2	3	3	1	7	2	
23.5	5			2	1	7	3	2	6	1		1	3	1
24.0	2	1		1		14	7	3	1	1		6	2	4
24.5			1	1	2	16	11	6	4	2	1	6	4	1
25.0				2	1	10	7	5		2		5	2	8
25.5					1	7	5	6	9			5	2	10
26.0					1	4	4	3	4			6	1	11
26.5						4	2	17	8		1	8		17
27.0			1		1	3		5	7			9		18
27.5						1	1	12	7			8	1	12
28.0					1	2	1	16	4			13		12
28.5						2		5	2	1		14		2
29.0								5	1			3		3
29.5			1					4	1			2		
30.0								1				2		1
30.5														
31.0								2				1		
31.5														
32.0								1						
32.5														
Total N	100	100	21	72	40	100	48	100	100	100	75	100	25	100
mean W(g)	81.1	56.9		64.0	68.0	122.4	124.8	182.3	122.5	63.5	62.6	173.4	111.2	174.6
mean L(cm)	21.8	20.1	19.5	20.2	20.2	24.3	24.7	27.0	24.2	20.5	20.2	26.7	23.9	26.9

Table IIC.4. Contd.

Trawl st	539	540	541	542	543	547	548	550	552	555	556	568
ICES rect	48F2	48F4	48F4	48F4	48F3	49F4	49F4	49F3	49F0	50E9	50F0	50F3
13.0												
13.5												
14.0												
14.5												
15.0												
15.5												
16.0												
16.5												
17.0		1					1					
17.5		7	1			1	3					
18.0		18	1			1	13	2				
18.5		20	11			3	23	12				
19.0		16	12	5		6	17	5				
19.5		16	16	5		14	11	8				
20.0		8	16	3		11	9	8				
20.5		4	5	3	2	11	4	8				
21.0		4	10	10	1	12	6	2				
21.5		4	8	15	8	7	5	4				
22.0		4	5	12	10	8	4	8				3
22.5		2	7	4	8	1	3	4				1
23.0			6	12	12	3		8				3
23.5			2	10	9	5		2				5
24.0			1	7	11	3		10				4
24.5			1	5	4	3		1				8
25.0				3	13			5	1			8
25.5				2	3			3	1	1	3	8
26.0	1				3			2	2		3	5
26.5	2			4	2	2		1	12	6	9	3
27.0	5				6	2	1	2	25	2	9	4
27.5	16				2	2			19	7	6	
28.0	9				1	1		1	17	2	4	2
28.5	18		1		1	1		1	8	6	2	2
29.0	11				1	1			9	4	5	1
29.5	9				1	2		1	2		2	1
30.0	8							2	2			
30.5	7				1					1		
31.0	5								1			1
31.5	5								1			
32.0	1				1							
32.5	3											
Total N	100	104	103	100	100	100	100	100	100	29	43	59
mean W(g)	237.2	55.4	67.6	90.7	117.8	92.5	59.0	93.2	200.1	200.6	180.0	140.2
mean L(cm)	29.3	19.4	20.8	22.6	24.4	21.9	19.7	22.3	27.9	28.0	27.6	25.5

Table IIC.5 RV "GOSars" 27 June-20 July 2002. 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)	Imm	Mat	Imm	Mat	Imm	Mat	Tot	Tot	Tot	Tot	Tot	Tot	
13.0													
13.5													
14.0	1												1
14.5	3												3
15.0	16												16
15.5	12												12
16.0	19												19
16.5	20												20
17.0	22												22
17.5	36												36
18.0	52												52
18.5	85	3	1										89
19.0	105												105
19.5	104	1			1								106
20.0	105	1	2										108
20.5	112	2	3		2								119
21.0	110	2	8	2	3	1		1					127
21.5	77	2	23	2	7								111
22.0	54	5	28	10	6	5							108
22.5	19	1	10	5	7	6	3						51
23.0	13	2	15	12	11	4	3	1					61
23.5	1		12	8	10	15	3						49
24.0	2	4	8	13	3	23	8						61
24.5			6	19	4	34	6						69
25.0		1	4	15	3	21	9	1				1	55
25.5		1	1	16	1	15	11			1			46
26.0				15	1	11	5	1					33
26.5		2		12	1	20	14	2					51
27.0		2		7		19	12	1					41
27.5				8		17	10	3	1				39
28.0		1		5		17	13	6	4	2			48
28.5				3		13	11	4	2	1			34
29.0				2		3	1	5	3	2	1		17
29.5						1	4	2	3	4			14
30.0						2		5	2	1			10
30.5									3	1	1		5
31.0								1	5	2			8
31.5							1	1	1				3
32.0										1			1
32.5												1	1
33.0													
33.5							1						1
Total	968	30	121	154	60	227	115	34	24	15	2	2	1752

Table IIC.6 RV "GOSars" 27 June-20 July 2002. Mean length, mean weight, numbers (millions) and biomass (thousands of tonnes) by age and maturity.

Age	L_{mean}	W_{mean}	North Sea Autumn Spawner				Western Baltic Spring Spawners			
			No.mill	%	Biomass (10^3 t)	%	No.mill	%	Biomass (10^3 t)	%
1I	19,7	47,6	5734	87,7	273	72,3	1 346	67,3	64,1	44,7
1M	22,7	85,5	64	1,0	5	1,5	27	1,4	2,3	1,6
2I	22,4	84,6	148	2,3	13	3,3	188	9,4	15,9	11,1
2M	25,0	130,9	193	2,9	25	6,7	64	3,2	8,4	5,8
3I	22,9	89,8	44	0,7	4	1,0	89	4,4	8,0	5,6
3M	25,7	142,2	176	2,7	25	6,6	199	9,9	28,3	19,7
4	26,4	156,2	126	1,9	20	5,2	48	2,4	7,5	5,3
5	28,1	207,4	34	0,5	7	1,9	13	0,6	2,7	1,9
6	29,6	239,2	11	0,2	3	0,7	12	0,6	2,8	2,0
7	29,4	233,0	8	0,1	2	0,5	9	0,4	2,1	1,4
8	29,8	219,7	1	0,0	0	0,0	1	0,1	0,3	0,2
9+	28,8	358,0	3	0,0	1	0,3	3	0,2	1,1	0,8
Total	22,1	60,9	6 542	100	377	100	1 999	100	143	100
Immature			5 926		289		1 623		88	
Mature			615		88		376		55	

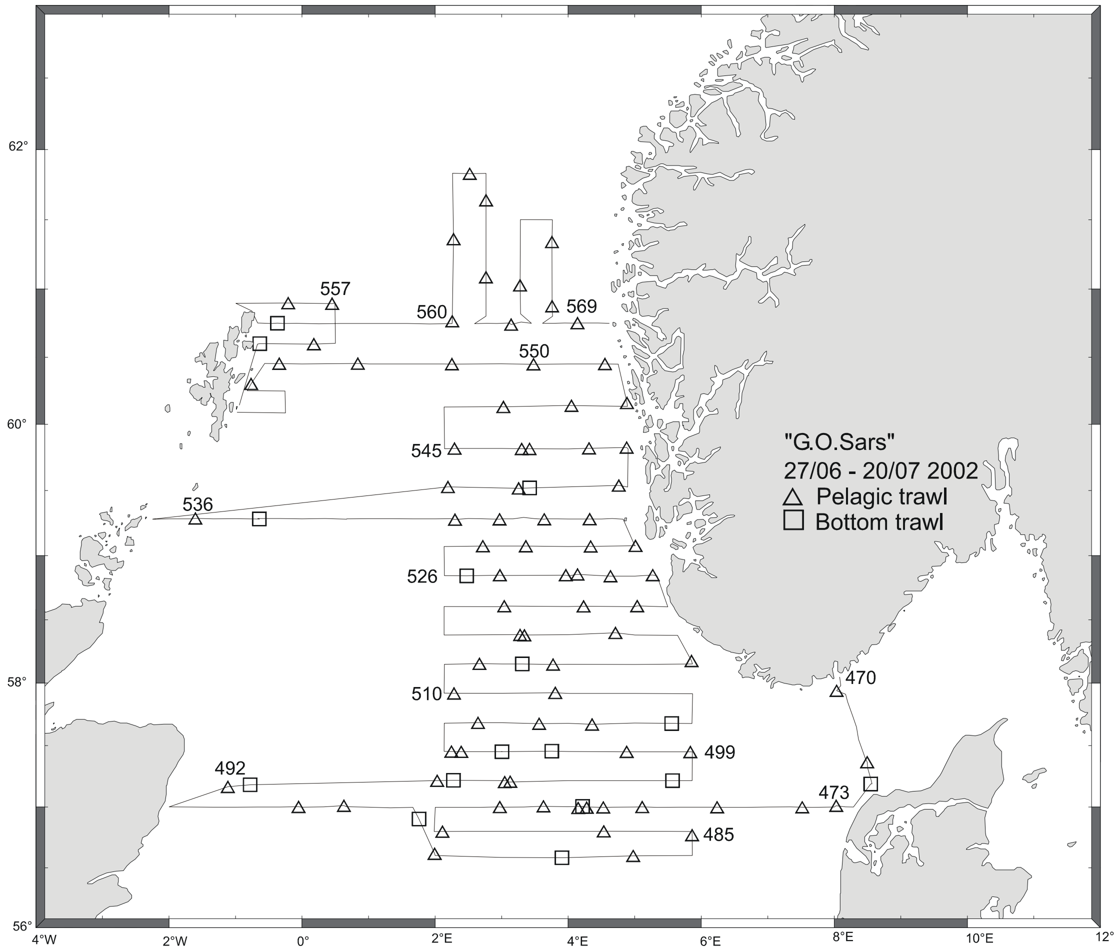

Figure IIC.1 Cruise track and fishing trawls undertaken during the acoustic survey on RV "G.O.Sars", 27 June-20 July 2002.

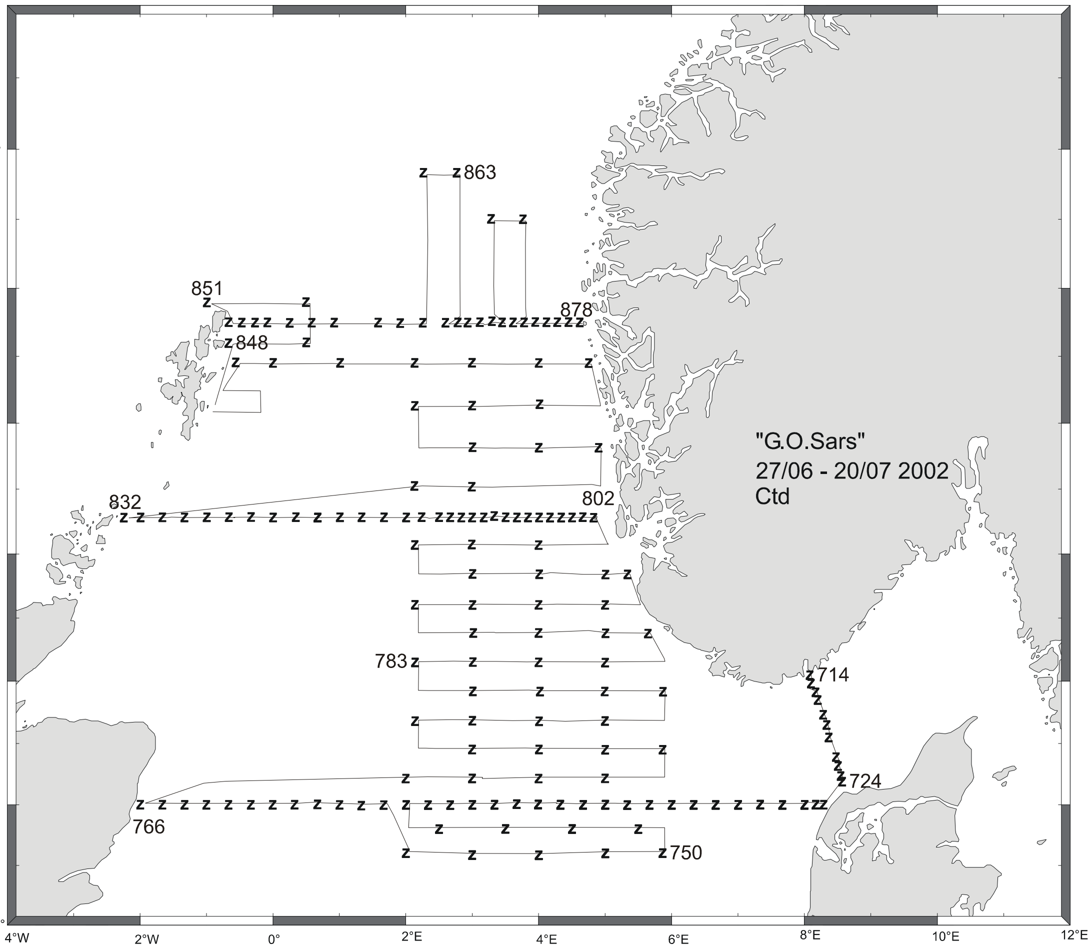

Figure IIC.2 Cruise track and CTD-stations undertaken during the acoustic survey on RV "G.O.Sars", 27 June-20 July 2002.

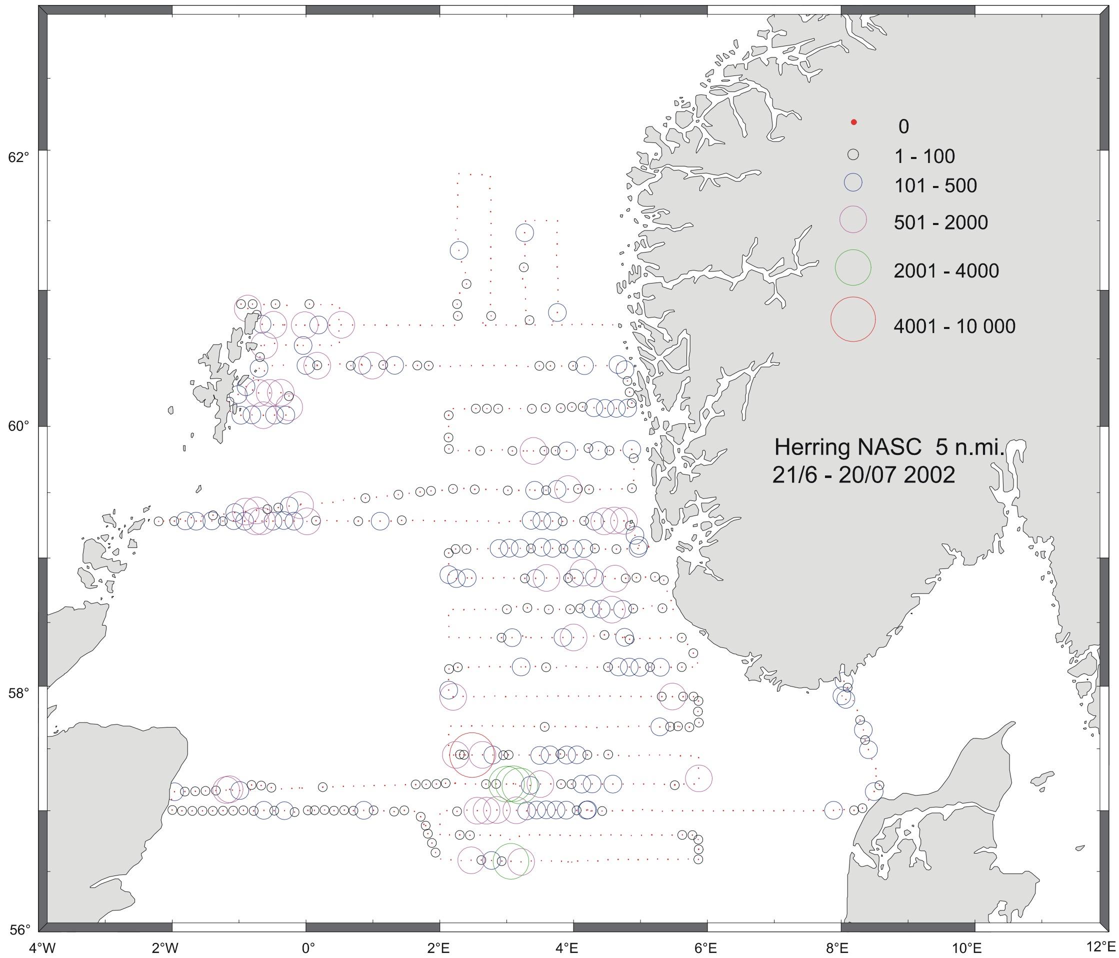

Figure IIC.3 Mean NASC -values attributed to herring per 5 n.mi. during the acoustic survey on RV "G.O.Sars", 27 June-20 July 2002.

APPENDIX IID: SCOTLAND (East)

Survey report for RV Scotia

27 June -17 July 2002

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

1. To conduct an acoustic survey to estimate the abundance and distribution of herring in the Northwestern North Sea and north of Scotland between 58-61·45'N and 4·W to 2·E, excluding Norwegian and Faroese waters.

2. To Obtain echosounder trace identification using pelagic trawl.

3. To obtain samples of herring for biological analysis, including age, length, weight, sex, maturity and ichthyophonus infection

4. To obtain samples of herring for genetic analysis.

5. To obtain photographic records for fish maturity analysis.

6. To obtain hydrographic data for comparison with the horizontal and vertical distribution of herring.

7. To obtain plankton samples for acoustic identification work.

2. SURVEY DESCRIPTION AND METHODS

2.1 Staff

John Simmonds	Cruise Leader
Sandy Robb	Fisheries Biologist
Emma Hatfield	Fisheries Biologist
Stuart Halewood	Acoustic Technician
Stephen Keltz	Fisheries Biologist
Rob Watret	Fish Lab Technician
Tony Greig	Ph.D. Student
Alicia Mosteiro Cabanelas	M.Sc. Student

2.2 Narrative

Scotia sailed at 1300 on 27 June 2002 and made passage towards Sinclair Bay (Wick) which provided shelter from the strong northwesterly wind to attempt a calibration. However, the tide was too strong and a calibration was not attempted. Scotia started the survey at 0200 GMT on 28 June and at 58° 10'N 3° 14'W and followed this latitude eastwards. East west transects were carried out at 15 n.mi spacing progressing northwards. After two transects were carried out Scotia broke off the survey at 2015 on 29 June and anchored in Scapa $\mathbf{F}_{low}$ to calibrate the acoustic instruments on 18, 38, 120 and 200kHz scientific sounders. At 0300 Scotia left Scapa $\mathbf{F}_{low}$ and commenced survey at 0600 BST at 58° 42' N 2° 52' 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 GMT. The cruise track is given in Figure IID.1. Additional short transects were added to the survey in areas of expected higher herring abundance to the east of Shetland. FRV Scotia ceased the survey at 2200GMT at 60^o 33'N 1^{o}32'E) and docked in Lerwick at 0730 on 8 July for a mid cruise break. Scotia sailed again at 0700 on 9 July and recommenced the survey at 60^o 40'N 0^o 47'W at 1145 BST. FRV Scotia continued the survey north to 61^o 40'N and then progressed southwards to the west of Shetland carrying out 7.5 n.mi spaced transects west of Shetland and finished the survey at 0600 BST on 15 July (60^o 03'N 1^o 10'W). FRV Scotia then proceeded to Sandwick Bay to carry out a second calibration of the acoustic instruments. FRV Scotia departed Sandwick Bay following successful calibration of acoustic instruments at 1400 GMT and sailed to Aberdeen and docked at 0530 GMT on 17 July 2002.

2.3 Survey design

The survey track (Fig IID.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 Northwest. 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^{o}E and 4^{o}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 the transducer systems used during the survey one near the beginning of the survey on the night of 29/30 June in Scappa $\mathbf{F}_{low}$ and one at the end of the survey on 16 July in Sandwick Bay. 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 0.1 dB. Agreement between the calibrations was better than 0.05dB. The calibration settings and results for 38kHz are given in Table IID.1.

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 which was 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 GMT. Paper records were kept for acoustic data at 38, 120 and 200kHz. A total of 2,445 n.mi. were surveyed and included in the analysis.

2.6 Biological data - fishing trawls

Trawl hauls (positions shown in Fig IID.1) were carried out during the survey on the denser echo traces. The 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.

2.7 Hydrographic data

Surface temperature and salinity was collected throughout the survey, except during the last 2 days due to equipment failure. 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 whiting, haddock, Norway pout and saithe
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 trawl haul which contained more than 200 herring. 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

[1 2 1

2 1 2

1 2 1]

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 centred 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 IID.4.

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 IID.2. The herring are distributed more evenly in 2002 than in 2001 the largest single 2.5n.mi. ESDU contributes only 5% of the population estimate from FRV Scotia.

3.2 Biological data

A total of 50 trawl hauls were carried out (Figure IID.1), the locations, dates and time of these are shown in Table IID.2. 40 hauls with significant numbers of herring were used to define four survey sub areas (Figure IID.3). Table IID.3 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 IID.4. The spatial distribution of mean length is shown in Figure IID.3. A total of 3,290 otoliths were taken to establish 4 age length keys, one per area, the total number of otoliths taken by length and age is given in Table IID.6. There is again evidence of only very small amounts of icthyophonus in the population. This was similar to last year. Only 5 herring from 3,290 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:

$$W = 2.875\ 10^{-3}\ L^{3.341}\ g \quad \text{(L measured in cm)}$$

The proportions of mature 2 ring and 3 ring herring were estimated at 92% and 99% respectively. This is a similar proportion for 2 ring mature to those found in 2001 The proportion of 3 ring mature was higher than usual.

3.3 Biomass and Abundance estimates

The numbers and biomass of fish by quarter ICES statistical rectangle are shown in Figure IID.4 A total estimate of 14,871 million herring or 2,604 thousand tonnes was calculated for the survey area. 2,480 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 and northern edge between 0°and 4°W. Herring were generally found in similar water depths and location to 2001 however, the distributions were slightly more easterly with more herring found east of Shetland. The proportion of 3 ring herring was much higher than last year, rising from 16% of the total 2+ biomass in 2001 to 48% in 2002, this year class now dominates the adult population. The fish traces were continuous in character similar to previous years mixed in size but in most case quite separate from other species. Table IID.6 shows the estimated herring numbers mean lengths weights and biomass and proportion mature at age 2 & 3 ring by age class.

In addition to the 2,604 thousand tonnes of herring, approximately 200 thousand tonnes of other fish species were observed in mid water in similar depths and conditions. Examination of the catch by species (Table IID.1) shows that the numbers of fish species other than herring caught 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 Norway pout with some haddock, mackerel and whiting. For the first time no cod were caught as by-catch in any of the hauls. The survey indicates that the overall biomass has increased substantially due mostly to the influx of 3 ring herring. The abundance of 3 ring herring in the Scotia survey is approximately four times that observed last year.

3.4 Ichthyophonus Infection

Only 6 out of 3,290 fish examined for macroscopic evidence of ichthyophonus infection were found to contain this.

Table IID.1. Simrad EK500 and analysis settings used on the Scotia herring acoustic survey 27/6-17/7/2002.

Transceiver Menu	
Frequency	38 kHz
Sound speed	1490 m.s^{-1}
Max. Power	2000 W
Equivalent two-way beam angle	-20.6 dB
Default Transducer Sv gain	26.6 dB
3 dB Beamwidth	7.1°
Calibration details	
TS of sphere	-42.36 dB
Range to sphere in calibration	9.85
Measured NASC value for calibration	3444
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	1.6 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 IID.2 Details of the fishing trawls taken during the Scotia herring acoustic survey, 27/6-17/702: 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	Position	Time (UTC)	Water depth	Trawl Depth*	Gear Type	Duration		Total (kg)
243	28/6/02	58 09.98N 000 29.30E	14:17	150	140*	P	28	h	1500
244	28/6/02	58 11.17N 001 27.55E	19:30	106	96*	P	30	h	450
245	29/6/02	58 25.06N 000 32.10E	05:56	150	140*	P	20	h	120
246	30/6/02	58 40.13N 001 02.22W	11:03	105	95*	P	22	h	1650
247	30/6/02	58 39.81N 000 01.32W	15:25	147	137*	P	30	h	1650
248	30/6/02	58 39.85N 000 36.89E	19:12	147	137*	P	23	h	600
249	1/7/02	58 54.69N 000 38.73E	07:19	135	125*	P	30	h	1200
250	1/7/02	58 54.79N 000 55.32W	13:52	127	117*	P	45	h	360
251	1/7/02	58 55.01N 001 49.30W	18:35	93	83*	P	15	h	180
252	2/7/02	59 09.91N 001 28.46W	06:47	105	95*	P	22	h	750
253	2/7/02	59 10.27N 000 46.44W	10:10	132	122*	P	34	h	300
254	2/7/02	59 10.00N 000 24.44W	12:40	142	132*	P	46		10
255	2/7/02	59 09.98N 000 01.72E	16:05	140	130*	P	15	h	1500
256	3/7/02	59 24.80N 001 29.20E	04:25	105	95*	P	35		1
257	3/7/02	59 25.51N 000 02.75W	10:45	131	121*	P	25	h	300
258	3/7/02	59 24.73N 000 21.08W	13:10	131	121*	P	17	h	1800
259	3/7/02	59 24.86N 001 09.93W	16:45	120	110*	P	17	h	4500
260	3/7/02	59 25.00N 002 11.78W	20:52	76	66*	P	17		10
261	4/7/02	59 39.39N 000 36.51W	08:18	136	126*	P	26	h	360
262	4/7/02	59 39.92N 001 00.78E	14:25	119	109*	P	35	h	142.5
263	4/7/02	59 40.00N 001 09.00E	17:40	114	104*	P	30		0.3
264	5/7/02	59 54.52N 000 13.56E	06:40	133	123*	P	45		30
265	5/7/02	59 57.99N 000 06.03W	10:22	139	129*	P	43	h	10
266	5/7/02	59 55.03N 001 12.12W	15:30	90	80*	P	3	h	25
267	5/7/02	60 02.95N 000 29.98W	19:07	135	125*	P	53		10
268	5/7/02	60 02.88N 000 25.18W	21:27	135	125*	P	28		25
269	6/7/02	60 02.79N 000 04.40E	04:55	162	152*	P	35	h	105
270	6/7/02	60 20.71N 000 32.22W	10:40	125	115*	P	35	h	240
271	6/7/02	60 09.83N 000 48.07E	18:45	153	143*	P	15	h	1500
272	7/7/02	60 24.49N 000 36.78E	07:22	127	117*	P	10	h	4500
273	7/7/02	60 30.98N 000 51.73W	13:12	119	109*	P	18	h	1350
274	7/7/02	60 33.16N 000 33.17W	15:35	135	125*	P	1	h	1500
275	9/7/02	60 39.65N 000 27.93W	12:07	138	128*	P	28	h	30
276	9/7/02	60 40.05N 000 15.57E	15:44	143	133*	P	9	h	1650
277	9/7/02	60 40.32N 000 55.97E	18:30	155	145*	P	7	h	900
278	10/7/02	60 55.18N 000 54.23E	05:43	146	136*	P	40	h	600
279	10/7/02	60 54.73N 000 12.96W	10:30	165	155*	P	24	h	90
280	10/7/02	60 48.19N 000 15.87E	16:48	145	135*	P	29	h	300
281	11/7/02	61 03.11N 000 39.28W	05:12	160	150*	P	42	h	105
282	11/7/02	61 09.78N 000 10.52W	09:41	154	144*	P	12	h	90
283	11/7/02	61 09.94N 001 00.72E	14:30	158	148*	P	6	h	1800
284	12/7/02	61 25.13N 000 04.17W	09:15	180	170*	P	23	h	45
285	12/7/02	61 09.79N 000 53.04W	19:09	156	146*	P	33	h	257
286	13/7/02	60 54.97N 001 24.33W	08:45	114	104*	P	29	h	120
287	13/7/02	60 52.15N 000 57.64W	11:50	105	95*	P	12	h	900
288	14/7/02	60 40.09N 001 36.30W	03:04	106	96*	P	28	h	600
289	14/7/02	60 33.23N 002 42.34W	10:40	130	120*	P	3	h	180
290	14/7/02	60 25.04N 002 05.87W	18:02	114	104*	P	11	h	1500
291	14/7/02	60 24.90N 001 44.94W	20:07	110	100*	P	15		0
292	15/7/02	60 18.06N 003 41.80W	08:37	145	135*	P	9		2

Table IID.3 Total catch by species for trawl hauls from the Scotia acoustic survey 27/6 – 17/7/2002. Estimated total catch is given in kg and numbers by individual species

Haul No	Est catch (kg)	Herring	Mackerel	Sprat	Blue Whiting	Norway Pout	Haddock	Whiting	Saithe	Spurdog	Lump-sucker	Pearl-sides
		Clupea herangus	Scomber Scomberous	Spratus Spratus	M. Poutassou	*Trisopterus esmarki*	*Melanogrammus aeglefinus*	Merlangius merlagus	*Pollachius virens*	*Squalus acanthias*	*Cyclopterus lumpus*	*Maurolicus muelleri*
243	1500	7975										
244	450	3540										
245	120	656				4	4	3	2			
246	1650	15431										
247	1650	12540										
248	600	3667						1	1			
249	1200	6773										
250	360	2272	1									
251	180	2586		24								
252	750	6900										
253	300	2900	1			3						
254	10	96	5								1	
255	1500	10620										
256	1	0					4					
257	300	1913					177	87		1		
258	1800	14736										
259	4500	39075										
260	10	0				10						
261	360	2630										
262	142.5	355							120			
263	0.3	0					1					
264	30	27					12					
265	10	65					3					1
266	25	171				5600						
267	10	0					12	7				
268	25	18					17	9				
269	105	755										
270	240	1245										
271	1500	9160										
272	4500	26820										
273	1350	8406										
274	1500	10025										
275	30	129										
276	1650	8305										
277	900	4700										
278	600	2773										
279	90	308										
280	300	1450										
281	105	406										
282	90	374										
283	1800	8740										
284	45	184							3			meshed
285	257	109			9	189	5	7				
286	120	669										
287	900	4150	540									
288	600	2873	220									
289	180	810	22									
290	1500	8067										
291	0	0							126	1	1	1
292	2	10										

Table IID.4a Herring length frequency proportion for individual trawl hauls by Subarea (Figure IID.3) for the *Scotia* acoustic survey (27/6 – 17/7/2002) length in cm, weight in g, calculated target strength in dB per individual using TS=-71.2+20log(L).

Haul / Length	276	277	278	279	280	281	282	283	284	285	286	287	289	290	292	mean
24.0																
24.5													0.2	0.2		0.0
25.0		0.2									0.2	0.7	0.2			0.1
25.5	0.9	0.2		0.3							3.3	3.1	0.5	1.7		0.7
26.0	2.6	5.5	3.4	1.3	0.2	2.2	0.5			2.3	6.9	6.5	1.5	5.8		2.6
26.5	5.7	13.6	8.7	4.2	5.5	9.1	1.6	1.8		3.9	12.4	10.1	7.2	9.7		6.2
27.0	10.6	18.9	17.1	9.1	12.9	15.0	3.7	4.8		5.8	17.5	16.9	12.8	14.0		10.6
27.5	17.2	17.9	15.1	15.6	14.9	15.8	9.6	6.6	1.1	7.4	15.3	15.9	13.6	12.8		11.9
28.0	16.8	17.0	19.0	13.3	16.1	18.0	12.8	10.1	2.2	11.7	14.6	14.9	12.1	13.8	20.0	14.2
28.5	13.2	11.5	13.7	13.0	15.6	12.3	13.4	11.0	8.2	11.3	8.1	12.8	11.9	10.1	10.0	11.7
29.0	13.5	6.6	11.1	12.7	12.6	11.6	15.0	8.7	9.8	12.8	6.7	7.7	11.9	8.1	50.0	13.2
29.5	7.7	3.8	6.5	10.7	7.8	5.4	11.2	12.8	9.8	12.1	5.0	3.4	6.9	6.0	10.0	7.9
30.0	6.0	1.9	1.7	7.1	5.5	4.7	10.7	11.4	18.5	10.1	3.6	3.6	7.7	6.4	10.0	7.3
30.5	4.0	1.7	1.4	4.9	3.4	2.5	8.0	11.2	15.2	9.7	2.2	1.7	4.9	3.5		5.0
31.0	1.3	0.6	0.7	3.6	2.1	2.2	6.4	9.2	15.8	4.7	1.9	1.4	2.2	3.7		3.7
31.5	0.2		1.0	2.6	1.1	0.5	3.5	5.5	8.7	5.4	1.4	0.2	3.0	1.9		2.3
32.0		0.2	0.5	0.6	1.6	0.5	1.6	2.5	5.4	1.2	0.2	0.2	2.2	1.0		1.2
32.5		0.2	0.2	0.3	0.2		0.8	2.7	2.7	0.8	0.2	0.5	1.0	0.6		0.7
33.0					0.2	0.2	0.5	0.9	1.6	0.4	0.2	0.2	0.2	0.2		0.3
33.5	0.2			0.3			0.3	0.5						0.2		0.1
34.0				0.3				0.2	1.1					0.2		0.1
34.5										0.4						0.0
35.0																
35.5																
36.0																
36.5																
37.0							0.3									0.0
Number	453	470	416	308	435	406	374	437	184	257	418	415	405	484	10	
Mean length (cm)	28.7	28.2	28.5	29.1	28.9	28.6	29.7	30.0	30.8	29.6	28.3	28.3	29.0	28.7	29.4	29.1
Mean wt (g)	216	202	210	226	221	213	240	250	272	238	205	205	224	216	232	225
TS/id	-42.0	-42.2	-42.1	-41.9	-42.0	-42.1	-41.7	-41.6	-41.4	-41.8	-42.2	-42.2	-41.9	-42.0	-41.8	-41.9
TS/kg	-35.4	-35.3	-35.3	-35.5	-35.4	-35.3	-35.6	-35.6	-35.8	-35.5	-35.3	-35.3	-35.4	-35.4	-35.5	-35.4

Table IID.4 continued Herring length frequency proportion for individual trawl hauls by subarea (Figure IID.3) for the *Scotia* acoustic survey (27/6 – 17/7/2002) length in cm, weight in g, calculated target strength in dB per individual using TS=-71.2+20log(L).

Haul /Len	243	244	245	247	248	249	250	255	257	258	261	262	264	265	266	268	269
21.0							0.4										
21.5	0.2		1.2				0.7		0.3								
22.0	0.9	0.5	1.8				1.2		1.2	0.2							
22.5	1.7	0.2	1.6	0.2	0.4		1.6	0.4	2.1	0.2							
23.0	3.4	0.7	3.5	0.4	0.2		2.6	0.4	4.5	0.2	0.4						
23.5	4.5	1.2	4.3	3.0	0.5		4.8	1.1	4.0	2.8	2.2				1.2		
24.0	10.7	1.7	11.0	9.8	2.0		11.6	3.2	12.4	5.2	4.6	0.6	1.3	3.1	7.6	1.7	0.7
24.5	13.5	6.1	11.4	13.0	4.9	1.4	13.2	7.2	12.5	8.3	8.9	1.4	4.6	6.2	9.4	4.1	5.8
25.0	16.1	12.9	17.3	19.8	10.0	5.7	17.3	14.5	15.7	16.4	17.7	6.2	11.8	10.8	17.0	11.6	15.6
25.5	13.6	13.4	14.8	17.4	11.5	7.9	16.0	17.7	13.2	16.6	18.4	14.1	17.6	18.5	25.1	28.9	16.1
26.0	12.7	17.5	13.8	17.4	15.8	15.9	16.2	17.5	13.6	18.9	19.7	17.7	20.3	23.1	19.3	23.1	16.9
26.5	8.6	15.1	8.3	8.9	16.0	16.5	7.0	15.6	7.1	14.5	14.4	16.3	17.0	20.0	8.8	19.8	17.8
27.0	8.3	14.7	5.9	6.0	16.2	21.3	3.3	13.0	7.1	10.7	8.9	16.6	13.7	10.8	7.6	9.1	12.6
27.5	2.7	8.3	3.0	2.6	10.4	11.0	2.8	5.8	3.0	2.9	3.1	9.6	6.5	6.2	2.9	0.8	8.2
28.0	1.3	3.9	1.2	0.4	6.9	11.2	0.9	2.1	1.9	1.8	1.3	8.5	3.9	1.5	0.6	0.8	4.1
28.5	0.5	2.4	0.6	0.9	3.5	4.1	0.2	0.9	1.0	0.8	0.2	3.4					1.5
29.0	0.8	0.8	0.2	0.2	1.3	3.7	0.2	0.6	0.2	0.2	0.2	2.5	2.0		0.6		0.2
29.5		0.5		0.2	0.5	0.4				0.3		1.4					0.6
30.0	0.3	0.2				0.4						0.8	1.3				
30.5						0.2						0.6					
31.0	0.2					0.2						0.3					
31.5																	
32.0																	
32.5																	
33.0																	
33.5																	
34.0																	
34.5																	
35.0																	
35.5																	
36.0																	
36.5																	
37.0																	
Samp No	638	590	492	570	550	508	568	531	574	614	548	355	153	65	171	121	539
Mean len (cm)	25.8	26.6	25.7	25.9	26.9	27.3	25.6	26.4	25.7	26.2	26.2	27.2	26.7	26.5	26.1	26.4	26.6
Mean wt(g)	151	168	148	153	173	182	147	163	149	159	158	179	169	164	156	161	168
TS/Id	-43.0	-42.7	-43.0	-42.9	-42.6	-42.5	-43.0	-42.8	-43.0	-42.8	-42.8	-42.5	-42.7	-42.7	-42.9	-42.8	-42.7
TS/kg	-34.7	-34.9	-34.7	-34.8	-35.0	-35.1	-34.7	-34.9	-34.7	-34.8	-34.8	-35.0	-34.9	-34.9	-34.8	-34.9	-34.9

Table IID.4 continued Herring length frequency proportion for individual trawl hauls by Subarea (Figure IID.3) for the *Scotia* acoustic survey (27/6 – 17/7/2002) length in cm, weight in g, calculated target strength in dB per individual using TS=-71.2+20log(L).

Haul / Len	270	271	272	273	274	275	288	mean	246	252	253	254	259	mean	251	mean
16.0															0.2	0.2
16.5															0.7	0.7
17.0															11.4	11.4
17.5															22.3	22.3
18.0															26.2	26.2
18.5															17.2	17.2
19.0															12.3	12.3
19.5										0.2				0.0	5.1	5.1
20.0															1.6	1.6
20.5										0.8				0.2		
21.0								0.0	1.8	6.4	0.3	1.0	0.8	2.1	0.7	0.7
21.5								0.1	5.1	15.1	3.3	4.2	4.2	6.4	0.7	0.7
22.0								0.2	10.0	19.7	8.1	5.2	11.9	11.0	0.7	0.7
22.5								0.3	9.8	13.7	9.8	7.3	10.6	10.2	0.2	0.2
23.0								0.7	13.8	11.2	13.1	8.3	10.0	11.3	0.2	0.2
23.5								1.2	12.6	6.8	10.9	11.5	8.8	10.1	0.5	0.5
24.0				0.2			0.2	3.6	14.1	7.7	16.9	21.9	13.2	14.7		
24.5	3.4		0.9	2.8	1.5		1.2	5.9	9.8	4.6	9.8	16.7	9.0	10.0		
25.0	5.1	1.7	3.8	10.9	2.2	0.8	5.1	11.1	11.2	6.0	12.2	14.6	12.3	11.3		
25.5	11.1	7.4	9.4	15.2	8.2	2.3	10.2	14.4	5.7	2.5	5.5	2.1	6.7	4.5		
26.0	9.0	13.3	18.3	21.6	13.2	3.9	15.1	16.4	3.9	3.5	6.0	1.0	6.7	4.2		
26.5	16.3	18.8	19.9	22.5	19.7	11.6	18.6	15.0	1.2	1.4	1.9	4.2	2.9	2.3		
27.0	16.7	22.3	15.9	11.8	17.7	15.5	19.5	12.7	0.8	0.4	0.9	1.0	1.7	1.0		
27.5	10.5	15.7	14.8	8.8	13.0	13.2	12.8	7.4	0.2		0.9		1.0	0.4		
28.0	9.9	10.9	6.5	3.0	10.5	15.5	6.7	4.8			0.3			0.1		
28.5	6.4	4.6	5.4	1.7	6.5	10.9	2.6	2.4				1.0	0.2	0.2		
29.0	5.1	1.7	2.7	1.3	3.0	7.0	2.6	1.5								
29.5	1.7	1.5	1.6		1.2	7.0	2.8	0.8								
30.0	2.6	0.9	0.4	0.2	1.7	8.5	0.9	0.8								
30.5	0.9	0.7	0.2		0.5	3.9	0.9	0.3								
31.0	0.9				0.2		0.2	0.1								
31.5		0.2	0.2		0.5			0.0								
32.0	0.2				0.2			0.0								
32.5	0.2	0.2					0.5	0.0								
33.0							0.2	0.0								
No	467	458	447	467	401	129	431		491	483	580	96	521		431	
Mean len (cm)	27.5	27.5	27.3	26.8	27.5	28.4	27.4	26.7	24.2	23.4	24.4	24.5	24.4	24.2	18.7	18.7
Mean wt (g)	188	187	182	170	187	209	184	169	121	109	126	127	126	122	52	52
TS/id	-42.4	-42.4	-42.5	-42.6	-42.4	-42.1	-42.4	-42.7	-43.5	-43.8	-43.4	-43.4	-43.4	-43.5	-45.8	-45.8
TS/kg	-35.1	-35.1	-35.1	-34.9	-35.1	-35.3	-35.1	-34.9	-34.4	-34.2	-34.4	-34.4	-34.4	-34.4	-32.9	-32.9

Table IID.5 FRV Scotia 27/6-17/7 02 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 3290 otoliths taken 13 were unreadable.

Len/Age wr	0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Grand Total
160		1											1
165		1											1
170		1											1
175		1											1
180		1											1
185		1											1
190		1											1
195		2											2
200		1											1
205			1										1
210		7	1										8
215		6	5										11
220		8	3	1									12
225		8	6	1									15
230		2	4	6	1	3							16
235			3	8		6							17
240		1		14	1	7							23
245				20		21	1	1					43
250			1	43		35	2						81
255				71		107	11		1				190
260				78		147	20	3	1				249
265				75		181	30	3	5				294
270				32		199	18	6	2	1			258
275				24		172	28	10	13	1	1		249
280				14		206	60	35	37	13	2		367
285				12		133	60	48	33	12	6		304
290				5		78	54	53	53	12	4	2	261
295				1		34	42	44	63	9	3	1	197
300				1		18	24	46	71	14	4	3	181
305				1		6	18	28	74	12	7	4	150
310						4	4	12	65	18	8	11	122
315							2	2	47	21	8	10	90
320								6	13	14	17	10	60
325							1	3	8	9	11	6	38
330								1	2	3	4	7	17
335										1		5	6
340									2	1		2	5
345											1		1
350													0
355													0
360													0
365													0
370												1	1
Grand Total	0	42	24	407	2	1357	375	301	490	141	76	62	3277

Table IID.6 Mean length, mean weight, biomass (thousands of tonnes) and numbers (millions) breakdown by age (winter rings) and maturity obtained during the Scotia 27 June to 17 July 2002 herring acoustic survey. I= immature; M=mature; A=All.

Age/Maturity	Number (millions)	Mean Length(cm)	Mean Weight (g)	Biomass (thousands of tonnes)
1A	903	21.9	95	85.8
2I	313	22.3	99	30.9
2M	3,495	25.2	149	522.2
3I	85	23.9	125	10.7
3M	6,966	26.6	178	1,237.4
4A	1,164	27.6	202	235.2
5A	663	28.8	230	152.8
6A	898	29.5	250	224.2
7A	206	30.0	263	54.3
8A	105	30.4	277	28.9
9+	72	31.4	305	22.0
Total	14,871	26.3	175	2,604.4

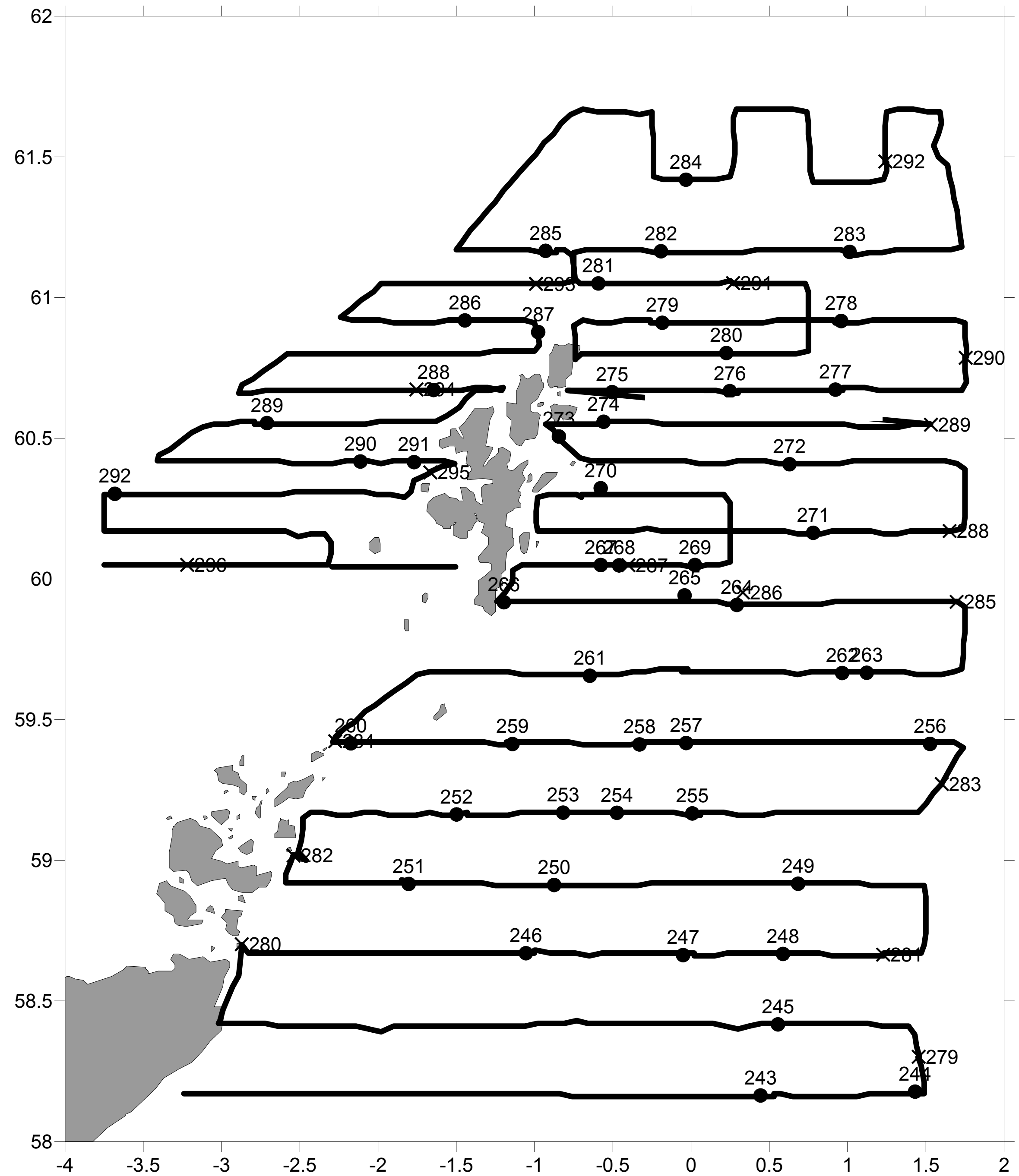

Figure IID.1 Cruise track FRV SCOTIA for 27 June-17 July 2002 trawl stations (•), CTD stations (X)

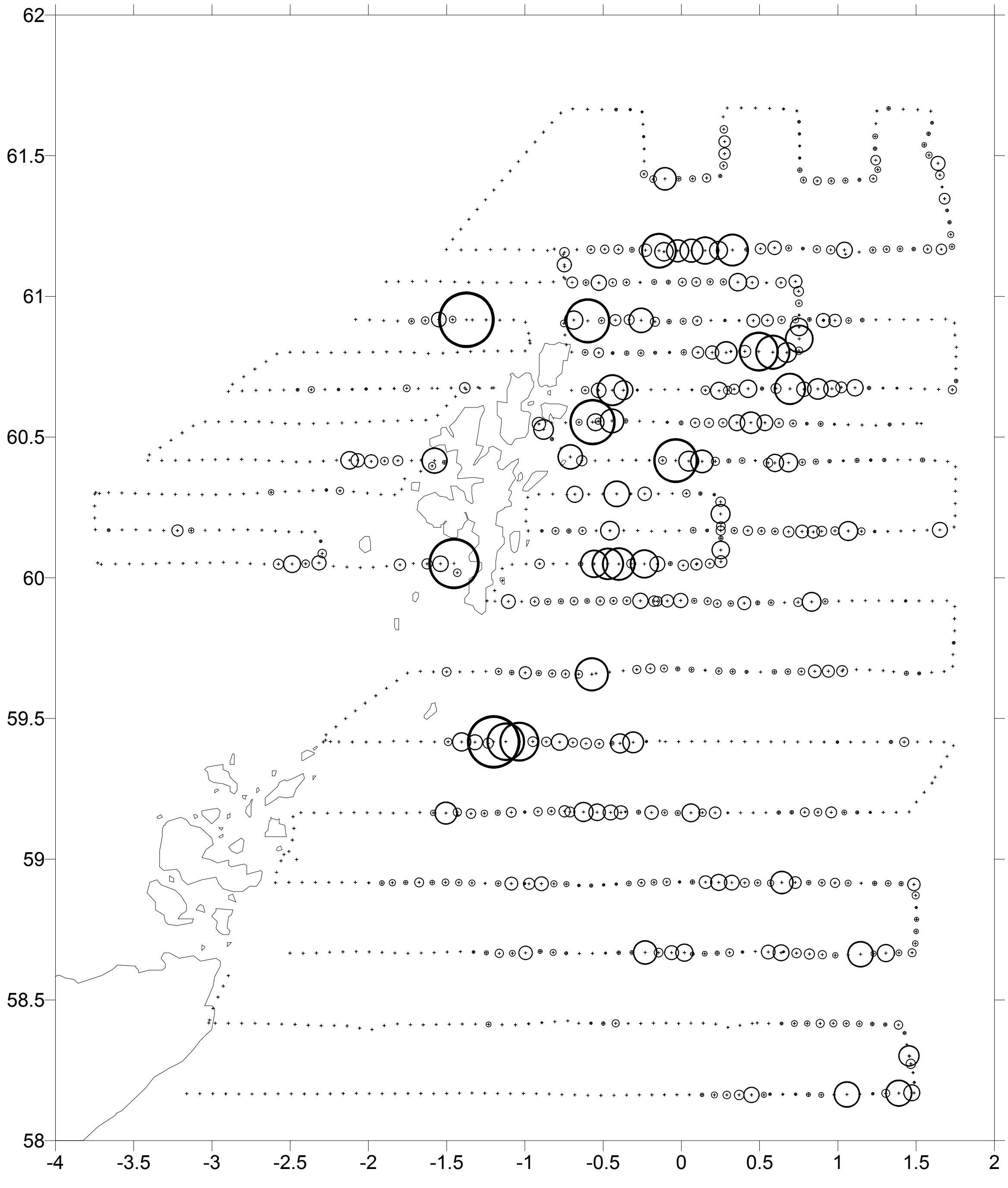

Figure IID.2 Post plot of NASC values attributed to herring from FRV SCOTIA for 27 June-17 July 2002

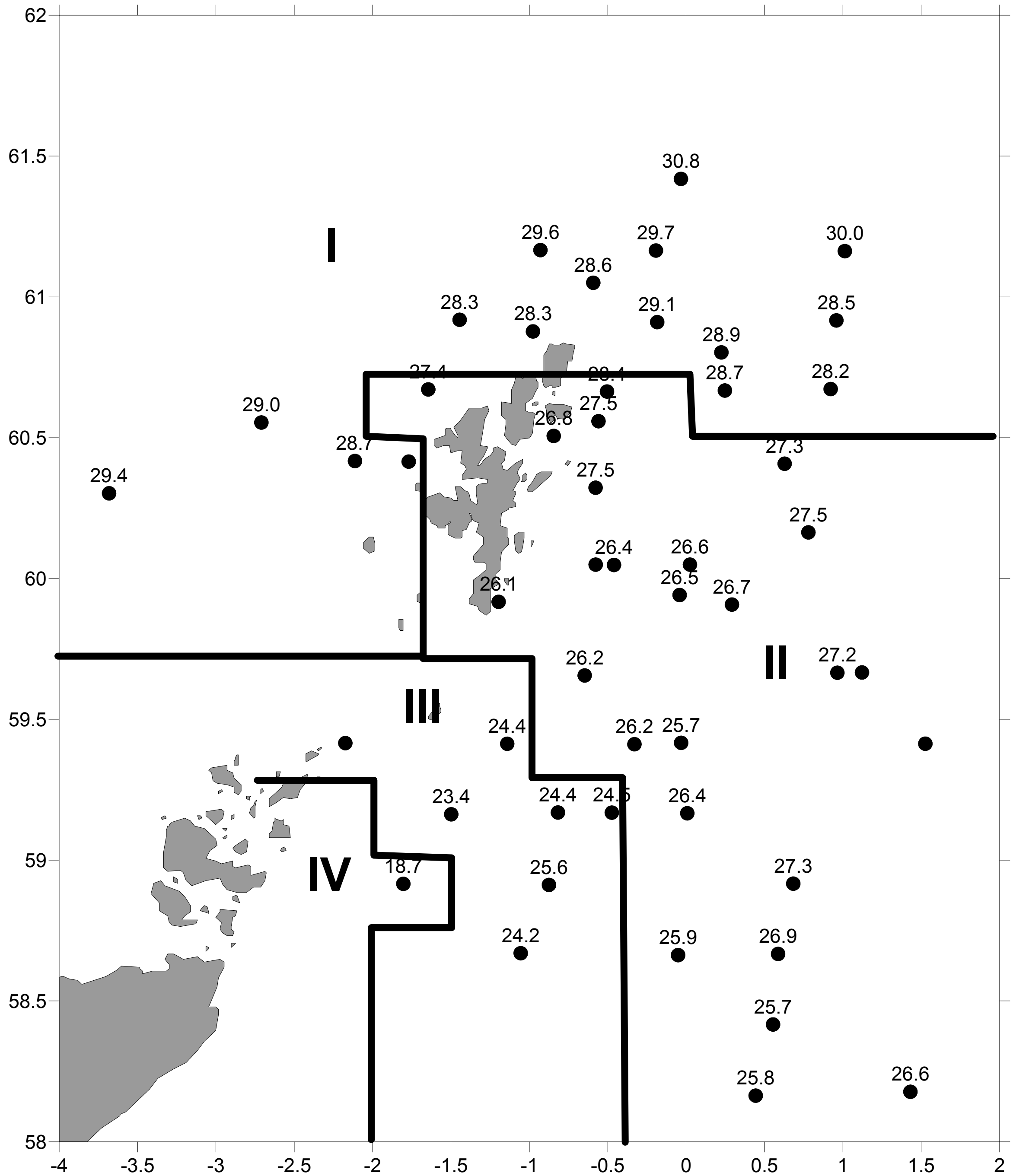

Figure IID.3 Mean Length of herring from pelagic trawl catches, FRV SCOTIA for 27 June-17 July 2002 trawl station numbers are given in Figure IID.1 and details in Tables IID.1 and IID.2. The four analysis areas are shown and the length distributions, mean lengths, weights and target strengths are given by area in Table IID.4.

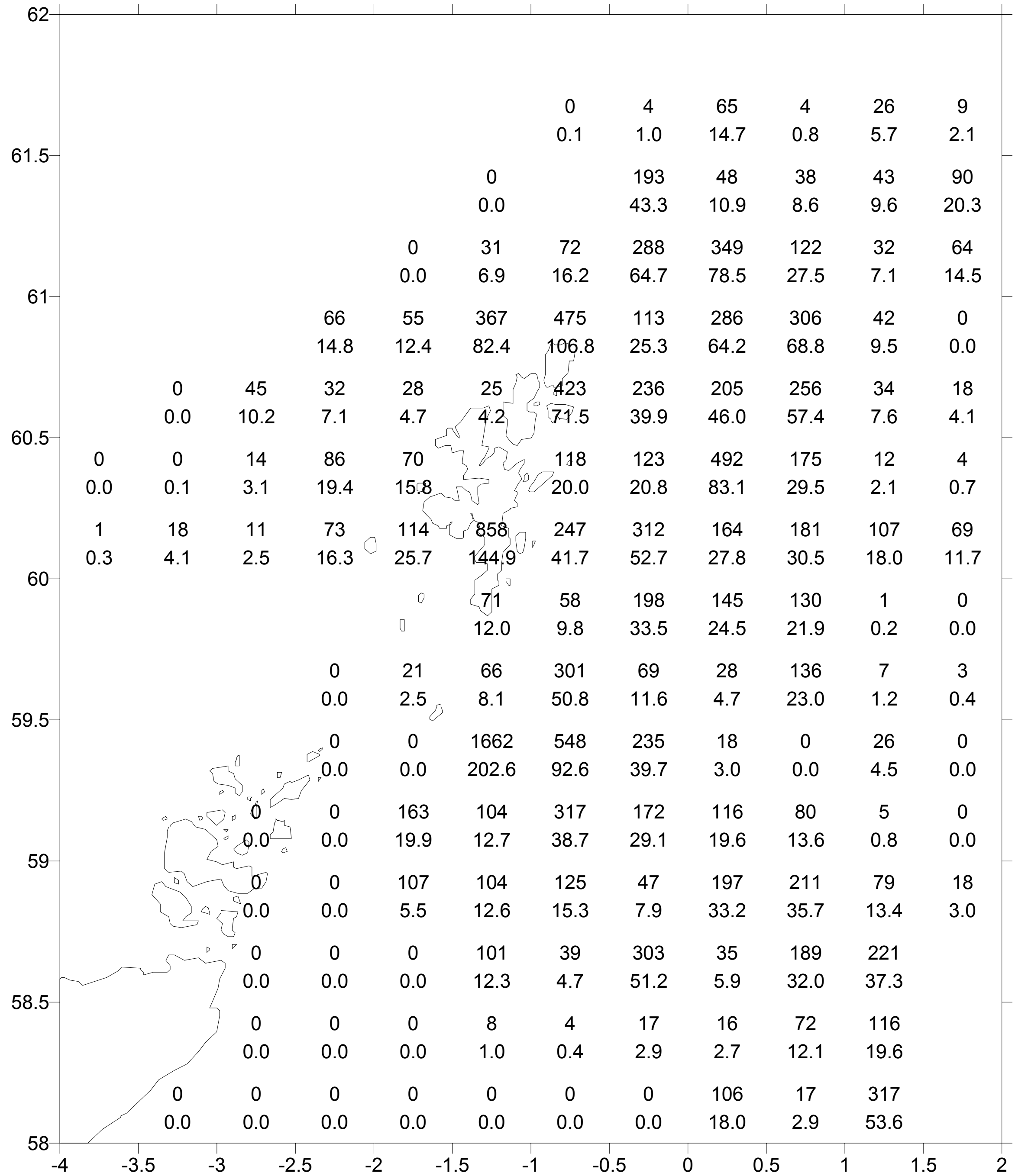

Figure IID.4 Estimated numbers (millions) and biomass (thousands of tonnes) by quarter statistical rectangle FRV SCOTIA for 27 June-17 July 2002

APPENDIX IIE: NETHERLANDS

Survey report for FRV "Tridens"

North Sea hydro acoustic survey

24 June – 19 July 2002

1. INTRODUCTION

The Netherlands Institute for Fisheries Research (RIVO) participates in the international North Sea hydro acoustic survey since 1991. 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 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

Bram Couperus (Cruiseleader)
Ronald Bol
Kees Bakker (1st two weeks)
Arie Kraayenoord (2nd two weeks)
Kees Camphuysen (Birdwatcher)
Martin Poot (Birdwatcher; 1st two weeks)
Jaap van der Meer (Birdwatcher; 2nd two weeks)

2.2 Narrative

"Tridens" left the port of IJmuiden on Monday 24 June heading for the scheduled calibration site at Scapa $\mathbf{F}_{low}$, Orkneys.

In the morning of 26 June "Tridens" anchored in Scapa $\mathbf{F}_{low}$ (exact position: 58°55.70 N - 003°01.98 W). Due two a strong northwestern wind it appeared not to be possible to calibrate the hull mounted and the towed body transducers. Since the forecast was not very promising, it was decided to run the survey on calibration settings of a calibration conducted on 3 June at Europort.

The survey started in the Moray Firth at 57°55 N. Soon after the start the net was shoot for schools at the bottom, which resulted in a severe damaged net and no catch. The rest of the day it was not possible to fish. Therefore it was decided to stop early in to avoid missing a lot of fish recordings. Also some repairs had to be conducted on the CTD sonde and the heel and pitch cable. During the first week the 57°40 was finished. The weekend of 29 and 30 June was spent in Aberdeen.

In the second week the 56°55 transect was finished. ICES rectangle 42F2 was also covered on the transect of 56°40. The eastern most rectangles south of 56°30 N were covered by running on transect in southern direction on the way to IJmuiden, where the weekend of 6/7 July was spent.

The survey was resumed on 8 July at the 56°40 N transect in western direction. Relative large concentrations of herring in the whole area and in particular southwest of the Devils Hole were encountered. In the Wee Bankie area transects were adjusted to collect additional data on Sandeel for the IMPRESS project. The weekend of 13/14 July was spent in Leith. Due to lack of time, during the last week, large parts of the scheduled transects south of 55°30 N were cancelled. On 18 July "Tridens" was homeward bound. Arrival on 19th of July in IJmuiden.

2.3 Survey design

The survey was carried out from 24 June to 19 July 2002, covering an area east of Scotland from latitude 54° to 58° North and from longitude 3° West (or the Scottish/English coast) to 3° East. A stratified survey design was applied, based on the herring distribution from previous years. Parallel transects along the lines of latitude were used with spacing between the lines set at 15 nm. From 55° southwards ICES rectangles were covered less extensively (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.

In the 2002 survey the transects at Wee Bankie were slightly altered to collect acoustic data for the another sampling program (IMPRESS).

2.4 Calibration

Due to the strong northwestern wind, the sphere was moving too much, which made positioning almost impossible. There was a lot of air in the first meters below the surface. Also many pieces of debris or weed were floating at the site. Since there was no expected improvement of the weatherconditions that day, it was decided to use the calibration settings of the last calibration (3 June, Europort, Europahaven; see table IIE.1). For that calibration, the program implemented in the EK60 was used.

2.5 Acoustic data collection

A Simrad 38 kHz splitbeam transducer was operated in a towed body (type “Shark”) 6-7 m under the water surface. Acoustic data were collected with a Simrad EK60 scientific echosounder. The data were logged with the Simrad BI500 integrator software runned under Windows X, simulated under Winows 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 proved the most suitable with depths (50 - 150 m) in most of the area.

The data were logged in 1 nm intervals. In total SA values from 2002 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 echosounder and to obtain biological samples of herring and sprat. In general, after it was decided to fish, the vessel turned and fished back on its trackline. If the recordings showed schools, a 60 kHz sonar was used to be able to hunt schools that were swimming away from the trackline. In haul 4, 8, and 9 four large floating buoys were attached to the upper rope 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 bottom with vertical netopenings varying from 10 to 20 m.

Fish samples were divided into species by weight. Measurements were taken to the 0.5 cm below for sprat, herring and sandeel 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 53 CTD stations spread over the survey area (Figure IIE.2). The CTD-data are used for other studies.

2.8 Data analysis

The SA values 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 “sandeel”. 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 (“scrutinizing”). 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.3). 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.

Due to technical problem and human errors, length frequency samples of sprat from haul 27 en 28 were not available. For the analysis, the length frequency distribution of haul 31 was used. Due to the same kind of problems, the sprat sample of haul 31 was not used: for this report sprat length stratified age and maturity samples from haul 3, 5, 19 en 27 have been analysed

3. RESULTS

3.1 Acoustic data

Figure IIE.4 shows the acoustic values (NASC's) per five nautical mile interval along the tracklines for herring.

3.2 Biological data

In all 31 trawl hauls have been conducted (figure IIE.1). Herring was found in 23 hauls of which 21 samples were taken. Sprat was found in 9 hauls of which 5 samples were taken (see also 2.8 *Data analysis*). In 16 hauls herring was the most abundant species in weight. Sprat was most abundant in none of the hauls. Whiting, haddock, mackerel and Norway pout dominated other trawls. In 6 hauls the meshes were stuck with small sandeel (5) or small a mixture of Norway pout and sandeel (1) indicating the these species would have been the mose abundant species in the catch if the meshesize would have been smaller. The catch weights per haul and species are presented in table IIE.2.

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

3.3 Biomass estimates

Table IIE.4a and IIE.4b summarize numbers and biomass for stratum A-F for herring. Table IIE.5a and IIE.5b summarize numbers and biomass for the whole area for herring and sprat. The spawning stock biomass estimate of herring is 488 000 tonnes and for sprat 15 000 tonnes. Figure IIE.5 shows the estimated numbers and biomass of herring by ICES rectangle.

4. DISCUSSION

The numbers in the area south of 58° N (and west of 3° E) are higher than in 2001 when it was highest in five years. The estimation of the spawning stock biomass is 237.000 ton. However, this figure also includes one-ringers. According to the maturity readings, about 30 % of the one ringers is mature. Normally this percentage is much lower and in the stock assessment, all 1 ringers are considered immature. If all 1 ringers are considered immature, the spawning stock is approximately 130.000 ton of which almost 50% is from the strong 98 year class. The high number of 1 ringers in the abundance estimate of all ages indicates a strong year class 2000, which is in line with the ICES larvae and MIK net surveys. The area covered by FRV "Tridens" is mainly important for immatures and for recruits (three ringers) in the herring spawning stock. The 2001-2002 situation is comparable with the years 87-89 when recruits from the strong 84, 85 and 86 year classes showed up in the area south of 58° N.

Compared to the late 90's the adult herring was less often mixed with Norway pout. Especially in the 1999 survey, when the abundance of herring was extremely low in the area south of 58° N, mixed aggregations of herring and Norway pout caused severe problems in the scrutinizing process. Like in 2000 and 2001, most herring was found in the area of the Devil's Holes. Compared to 2001 the herring concentrations were slightly more distributed in southerly direction.

Table IIE.1 Simrad EK60 settings used on the June 2002 North Sea hydro acoustic survey for herring, FRV "Tridens".

Transceiver menu	
Absorption coefficient	10.3 dB/km
Pulse length	1.024 ms
Bandwith	2.43 kHz
Max Power	2000 W
Two-way beam angle	-20.6 dB
3 dB Beamwidth	7.1 dg
Calibration details	
TS of sphere	-33.6 dB
Range to sphere in calibration	11.50 m
Transducer gain	25.63 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	1000
TS clour min.	-50 dB
Sv colour min.	-70 dB

Table IIE.2a Details of the fishing trawls taken during the July 2002 North Sea hydro acoustic survey, FRV "Tridens".

haul no	date	latitude(N)	longitude	E/W	time UTC	Geartype	depth meters	trawl depth	duration min.	Used (biol. Samples)
1	26-jun	57.55	2.42	W	15:35	pel. trawl	60	bottom	55	no samples
2	27-jun	57.55	0.43	E	13:00	pel. trawl	130	bottom	45	her
3	28-jun	57.55	0.05	W	12:45	pel. trawl	180	bottom	45	her & sprat
4	28-jun	57.4	0.46	W	17:01	pel. trawl	97	surface	28	no samples
5	1-jul	57.24	1.32	W	6:15	pel. trawl	63	bottom	45	her & sprat
6	1-jul	57.25	0.01	E	16:46	pel. trawl	91	bottom	19	her
7	1-jul	57.25	0.59	E	19:54	pel. trawl	95	bottom	36	her
8	2-jul	57.25	1.38	E	9:28	pel. trawl	86	surface	22	no samples
9	2-jul	57.2	1.49	W	12:25	pel. trawl	73	surface	19	no samples
10	2-jul	57.1	0.03	W	14:15	pel. trawl	74	bottom	15	no samples
11	3-jul	56.55	1.47	E	8:05	pel. trawl	92	bottom	27	her
12	3-jul	56.56	0.08	E	11:45	pel. trawl	85	bottom	45	her
13	3-jul	56.55	2.05	E	17:46	pel. trawl	70	bottom	44	her
14	4-jul	56.25	2.51	E	6:25	pel. trawl	80	bottom	55	her
15	9-jul	56.26	2.48	E	7:00	pel. trawl	85	bottom	45	her
16	9-jul	55.16	2.51	E	9:18	pel. trawl	90	bottom	32	her
17	9-jul	56.4	1.24	E	11:55	pel. trawl	86	bottom	20	her
18	9-jul	56.4	0.59	W	18:03	pel. trawl	68	midwater	35	no samples
19	10-jul	56.25	0.05	W	6:23	pel. trawl	75	bottom	17	her & sprat
20	10-jul	56.25	0.31	W	11:55	pel. trawl	72	sandeel	40	no samples
21	11-jul	56.25	1.14	E	6:02	pel. trawl	85	bottom	10	her
22	11-jul	56.1	1.11	E	9:35	pel. trawl	82	bottom	10	her
23	11-jul	56.1	0.29	W	16:05	pel. trawl	83	bottom	25	no samples
24	15-jul	56.1	1.01	W	12:02	pel. trawl	35	bottom	13	no samples
25	15-jul	56.1	1.54	W	6:46	pel. trawl	73	midwater	44	her
26	16-jul	55.55	0.43	E	14:45	pel. trawl	77	bottom	35	her
27	16-jul	55.55	0.26	W	7:05	pel. trawl	67	midwater	40	her & sprat
28	17-jul	55.55	2.19	E	15:04	pel. trawl	90	bottom	86	her
29	17-jul	55.35	0.09	E	11:04	pel. trawl	64	bottom	30	her
30	17-jul	55.28	0.5	W	18:05	pel. trawl	88	bottom	13	her
31	18-jul	54.54	1.1	W	6:55	pel. trawl	65	bottom	20	sprat

Table IIE.2b Trawl catches during the July 2002 North Sea hydro acoustic survey, FRV "Tridens".

haul	herring	N. pout	other gadoids	mackerel	Sprat	others	comments
1	0	0	0	0	0	0	
2	2000	11,3	3,6	0,5	0	0	
3	5,3	0	5,5	0,3	2,7	0	
4	0	0	0,02	0,98	0	0	surface haul; sandeel
5	27,5	64,2	0	33	0,93	0	sandeel
6	1200	0	2,205	0	0	0	
7	86	0,15	0,75	2,4	0	0	
8	0	0	0	14,3	0,6	0	surface haul; sandeel
9	0	0	0,613	44,4	0	0	surface haul; some sandeel
10	0	25,95	0	4,7	4,3	0	sandeel
11	14	0	19,3	10,32	0	0	
12	15000	0	0	50	0	0	
13	798,7	0	1,4	40,2	0	0	
14	1252	0	0,514	0,3	0	0	
15	36,8	0	0,5	9,5	0	0	
16	38	0	5,53	0	0	0	
17	5000	0	0	0	0	0	
18	0	0	0	0	0	0	midwater
19	256,4	0	0,12	0	2,4	0	
20	0	0	0	6,6	0	0	sandeel
21	2000	0	0,595	11,5	0	0	
22	315	0	0,62	0	0	0	
23	0	0	20,53	0,31	0	0	
24	0,016	0	0,01	0	0	0	sandeel
25	11,16	0	338,28	18	0,02	0	midwater
26	885	0	0	0	0	0	
27	2,9	0	13,48	8,48	0,067	0	midwater
28	1829	0	186	0	187,82	0	
29	30,6	0	0	0	0	0	
30	714,3	0	397,1	0	0	0	
31	0,065	0	97,6	0	0,995	0	

Table IIE.3a Age/maturity-length key for herring - Stratum A.

Tridens, North Sea acoustic survey 2002

Length	0		1		2		3		4	5	6	7	8	9+	Grand
(cm)	imm	mat	imm	mat	imm	mat	imm	mat	Total	Total	Total	Total	Total	Total	Total
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14,5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15,5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
16	0	0	6	0	0	0	0	0	0	0	0	0	0	0	6
16,5	0	0	10	0	0	0	0	0	0	0	0	0	0	0	10
17	0	0	10	0	0	0	0	0	0	0	0	0	0	0	10
17,5	0	0	10	0	0	0	0	0	0	0	0	0	0	0	10
18	0	0	10	0	0	0	0	0	0	0	0	0	0	0	10
18,5	0	0	10	0	0	0	0	0	0	0	0	0	0	0	10
19	0	0	10	0	0	0	0	0	0	0	0	0	0	0	10
19,5	0	0	10	0	0	0	0	0	0	0	0	0	0	0	10
20	0	0	8	1	0	0	0	0	0	0	0	0	0	0	9
20,5	0	0	5	2	0	0	0	0	0	0	0	0	0	0	7
21	0	0	4	1	0	0	0	0	0	0	0	0	0	0	5
21,5	0	0	3	1	1	1	0	0	0	0	0	0	0	0	6
22	0	0	0	5	0	1	0	0	0	0	0	0	0	0	6
22,5	0	0	0	2	0	4	0	0	0	0	0	0	0	0	6
23	0	0	0	1	0	4	0	0	0	0	0	0	0	0	5
23,5	0	0	0	0	0	5	0	0	0	0	0	0	0	0	5
24	0	0	0	0	0	5	0	0	0	0	0	0	0	0	5
24,5	0	0	0	0	0	4	0	0	0	0	0	0	0	0	4
25	0	0	0	0	0	2	0	2	1	0	0	0	0	0	5
25,5	0	0	0	0	0	3	0	1	1	0	0	0	0	0	5
26	0	0	0	0	0	2	0	0	1	0	0	0	0	0	3
26,5	0	0	0	0	0	3	0	1	0	0	0	0	0	0	4
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28,5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29,5	0	0	0	0	0	0	0	0	1	0	0	0	1	0	2
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grand Total	0	0	98	13	1	35	0	4	4	0	0	0	1	0	156

Table IIE.3b Age/maturity-length key for herring - Stratum B.

Tridens, North Sea acoustic survey 2002

Length	0		1		2		3		4	5	6	7	8	9+	Grand
(cm)	imm	mat	imm	mat	imm	mat	imm	mat	Total	Total	Total	Total	Total	Total	Total
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
19,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
20,5	0	0	3	0	0	0	0	0	0	0	0	0	0	0	3
21	0	0	10	2	0	1	0	0	0	0	0	0	0	0	13
21,5	0	0	4	7	0	0	0	0	0	0	0	0	0	0	11
22	0	0	1	7	0	2	0	0	0	0	0	0	0	0	10
22,5	0	0	0	6	0	5	0	0	0	0	0	0	0	0	11
23	0	0	0	2	0	6	0	3	0	0	0	0	0	0	11
23,5	0	0	0	0	0	10	0	4	1	0	0	0	0	0	15
24	0	0	0	0	0	4	0	10	1	0	0	0	0	0	15
24,5	0	0	0	0	0	6	0	9	0	0	0	0	0	0	15
25	0	0	0	0	0	4	0	11	0	0	0	0	0	0	15
25,5	0	0	0	0	0	5	0	8	2	0	0	0	0	0	15
26	0	0	0	0	0	1	0	12	1	1	0	0	0	0	15
26,5	0	0	0	0	0	3	0	7	3	1	0	1	0	0	15
27	0	0	0	0	0	0	0	10	3	2	0	0	0	0	15
27,5	0	0	0	0	0	1	0	9	2	2	0	0	0	0	14
28	0	0	0	0	0	0	0	4	3	1	1	0	0	0	9
28,5	0	0	0	0	0	0	0	0	3	0	0	0	0	0	3
29	0	0	0	0	0	0	0	0	1	0	1	1	0	0	3
29,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grand Total	0	0	20	24	0	48	0	87	20	7	2	2	0	0	210

Table IIE.3c Age/maturity-length key for herring - Stratum C.

Tridens, North Sea acoustic survey 2002

Length	0		1		2		3		4	5	6	7	8	9+	Grand
(cm)	imm	mat	imm	mat	imm	mat	imm	mat	Total	Total	Total	Total	Total	Total	Total
7	5	0	0	0	0	0	0	0	0	0	0	0	0	0	5
7,5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	5
8	5	0	0	0	0	0	0	0	0	0	0	0	0	0	5
8,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grand Total	15	0	0	0	0	0	0	0	0	0	0	0	0	0	15

Table IIE.3d Age/maturity-length key for herring - Stratum D.

Tridens, North Sea acoustic survey 2002

Length	0		1		2		3		4	5	6	7	8	9+	Grand
(cm)	imm	mat	imm	mat	imm	mat	imm	mat	Total	Total	Total	Total	Total	Total	Total
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
15,5	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
16	0	0	10	0	0	0	0	0	0	0	0	0	0	0	10
16,5	0	0	12	0	0	0	0	0	0	0	0	0	0	0	12
17	0	0	20	0	0	0	0	0	0	0	0	0	0	0	20
17,5	0	0	22	0	0	0	0	0	0	0	0	0	0	0	22
18	0	0	26	0	0	0	0	0	0	0	0	0	0	0	26
18,5	0	0	19	2	0	0	0	0	0	0	0	0	0	0	21
19	0	0	24	0	0	0	0	0	0	0	0	0	0	0	24
19,5	0	0	27	2	0	0	0	0	0	0	0	0	0	0	29
20	0	0	25	4	1	0	0	0	0	0	0	0	0	0	30
20,5	0	0	12	19	0	0	0	0	0	0	0	0	0	0	31
21	0	0	7	23	0	1	0	0	0	0	0	0	0	0	31
21,5	0	0	9	17	2	5	0	0	0	0	0	0	0	0	33
22	0	0	1	26	0	6	0	1	0	0	0	0	0	0	34
22,5	0	0	0	19	2	7	0	0	0	0	0	0	0	0	28
23	0	0	0	4	0	17	0	3	0	0	0	0	0	0	24
23,5	0	0	0	0	0	16	0	5	0	0	0	0	0	0	21
24	0	0	0	0	0	13	0	8	0	0	0	0	0	0	21
24,5	0	0	0	0	0	3	0	14	0	0	0	0	0	0	17
25	0	0	0	0	0	8	0	13	0	0	0	0	0	0	21
25,5	0	0	0	0	0	5	0	14	2	0	0	0	0	0	21
26	0	0	0	0	0	4	0	14	2	0	0	0	0	0	20
26,5	0	0	0	0	0	1	0	7	4	1	0	0	0	0	13
27	0	0	0	0	0	1	0	7	4	0	0	0	0	0	12
27,5	0	0	0	0	0	0	0	5	1	2	2	0	0	0	10
28	0	0	0	0	0	0	0	0	1	4	0	1	0	0	6
28,5	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grand Total	0	0	218	116	5	87	0	91	14	7	3	1	0	0	542

Table IIE.3e Age/maturity-length key for herring - Stratum E.

Tridens, North Sea acoustic survey 2002

Length	0		1		2		3		4	5	6	7	8	9+	Grand
(cm)	imm	mat	imm	mat	imm	mat	imm	mat	Total	Total	Total	Total	Total	Total	Total
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
17,5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
18	0	0	4	0	0	0	0	0	0	0	0	0	0	0	4
18,5	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
19	0	0	5	0	0	0	0	0	0	0	0	0	0	0	5
19,5	0	0	4	1	0	0	0	0	0	0	0	0	0	0	5
20	0	0	0	5	0	0	0	0	0	0	0	0	0	0	5
20,5	0	0	0	5	0	0	0	0	0	0	0	0	0	0	5
21	0	0	0	5	0	0	0	0	0	0	0	0	0	0	5
21,5	0	0	0	5	0	0	0	0	0	0	0	0	0	0	5
22	0	0	0	5	0	0	0	0	0	0	0	0	0	0	5
22,5	0	0	0	5	0	0	0	0	0	0	0	0	0	0	5
23	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
23,5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
24	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2
24,5	0	0	0	0	0	1	0	2	0	0	0	0	0	0	3
25	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
25,5	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26,5	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27,5	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grand Total	0	0	17	33	0	1	0	7	0	1	0	0	0	0	59

Table IIE.3f Age/maturity-length key for herring - Stratum F.

Tridens, North Sea acoustic survey 2002

Length	0		1		2		3		4	5	6	7	8	9+	Grand
(cm)	imm	mat	imm	mat	imm	mat	imm	mat	Total	Total	Total	Total	Total	Total	Total
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
15,5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
16	0	0	19	0	0	0	0	0	0	0	0	0	0	0	19
16,5	0	0	24	0	0	0	0	0	0	0	0	0	0	0	24
17	0	0	24	0	0	0	0	0	0	0	0	0	0	0	24
17,5	0	0	29	0	0	0	0	0	0	0	0	0	0	0	29
18	0	0	32	0	0	0	0	0	0	0	0	0	0	0	32
18,5	0	0	34	0	0	0	0	0	0	0	0	0	0	0	34
19	0	0	35	0	1	0	0	0	0	0	0	0	0	0	36
19,5	0	0	31	4	0	0	0	0	0	0	0	0	0	0	35
20	0	0	30	6	0	0	0	0	0	0	0	0	0	0	36
20,5	0	0	21	14	0	0	0	0	0	0	0	0	0	0	35
21	0	0	12	14	1	1	0	0	0	0	0	0	0	0	28
21,5	0	0	8	17	0	0	0	0	0	0	0	0	0	0	25
22	0	0	2	12	0	6	0	0	0	0	0	0	0	0	20
22,5	0	0	0	9	0	4	0	1	0	0	0	0	0	0	14
23	0	0	0	1	0	8	0	1	0	0	0	0	0	0	10
23,5	0	0	0	0	0	2	0	1	0	0	0	0	0	0	3
24	0	0	0	0	0	3	0	2	0	0	0	0	0	0	5
24,5	0	0	0	0	0	1	0	6	1	0	0	0	0	0	8
25	0	0	0	0	0	0	0	3	2	1	1	0	0	0	7
25,5	0	0	0	0	0	0	0	2	1	2	0	0	0	0	5
26	0	0	0	0	0	0	0	6	1	1	2	0	0	0	10
26,5	0	0	0	0	0	0	0	0	1	3	2	0	0	0	6
27	0	0	0	0	0	0	0	1	0	0	2	0	0	0	3
27,5	0	0	0	0	0	0	0	0	0	0	1	1	0	1	3
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28,5	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grand Total	0	0	304	77	2	25	0	23	6	7	9	1	0	1	455

Table IIE.3g Age/maturity-length key for sprat - Total area.

Tridens, North Sea acoustic survey 2002

Length (cm)	1		2		3		4		5	Grand
	imm	mat	imm	mat	imm	mat	imm	mat	Total	Total
7	2	0	0	0	0	0	0	0	0	2
7,5	1	0	0	0	0	0	0	0	0	1
8	3	1	7	0	0	0	0	0	0	11
8,5	2	6	10	0	0	0	0	0	0	18
9	0	5	3	10	0	0	0	0	0	18
9,5	0	5	0	13	0	0	0	0	0	18
10	0	2	0	15	0	0	0	0	0	17
10,5	0	0	0	15	0	1	0	0	0	16
11	0	0	0	10	0	2	0	0	0	12
11,5	0	0	0	1	0	3	0	0	0	4
12	0	0	0	1	0	4	0	0	0	5
12,5	0	0	0	0	0	4	0	1	0	5
13	0	0	0	0	0	2	0	3	0	5
13,5	0	0	0	0	0	1	0	4	0	5
14	0	0	0	0	0	3	0	2	0	5
Grand Total	8	19	20	65	0	20	0	11	1	144

Table IIE.4 Herring. Mean length, mean weight, biomass (thousands of tonnes) and numbers (millions) breakdown by age and maturity per stratum obtained during the July 2002 North Sea hydro acoustic survey for herring, FRV "Tridens".

Stratum A							
Age	Year	Mean Length (cm)	Mean weight (g)	Number (millions)	%	Biomass (1000 tons)	%
0I	2001im			0	0,0	0,000	0,0
0M	2001ad			0	0,0	0,000	0,0
1I	2000im	18,2	46,6	49	83,9	2,264	69,9
1M	2000ad	21,7	82,4	4	6,6	0,316	9,8
2I	1999im	21,5	82,0	0	0,7	0,032	1,0
2M	1999ad	23,7	116,5	4	7,8	0,524	16,2
3I	1998im			0	0,0	0,000	0,0
3M	1998ad	25,5	149,5	0	0,5	0,040	1,2
4A	1997	26,5	166,3	0	0,5	0,045	1,4
5A	1996			0	0,0	0,000	0,0
6A	1995			0	0,0	0,000	0,0
7A	1994			0	0,0	0,000	0,0
8A	1993	29,5	248,0	0	0,1	0,017	0,5
9+	<1993			0	0,0	0,000	0,0
Mean		23,8	127,3				
Total				58	100,0	3,238	100,0
Immature				49	84,6	2,297	70,9
Mature				9	15,4	0,941	29,1

Stratum B							
Age	Year	Mean Length (cm)	Mean weight (g)	Number (millions)	%	Biomass (1000 tons)	%
0I	2001im			0	0,0	0,000	0,0
0M	2001ad			0	0,0	0,000	0,0
1I	2000im	21,1	72,8	17	5,3	1,240	3,0
1M	2000ad	21,9	81,2	28	8,7	2,288	5,5
2I	1999im			0	0,0	0,000	0,0
2M	1999ad	24,5	124,6	76	23,6	9,496	22,7
3I	1998im			0	0,0	0,000	0,0
3M	1998ad	25,5	139,5	162	50,4	22,650	54,3
4A	1997	26,4	152,7	26	8,1	3,970	9,5
5A	1996	26,8	162,6	9	2,8	1,462	3,5
6A	1995	28,4	199,8	1	0,3	0,203	0,5
7A	1994	26,9	169,3	3	0,8	0,437	1,0
8A	1993			0	0,0	0,000	0,0
9+	<1993			0	0,0	0,000	0,0
Mean		25,2	137,8				
Total				322	100,0	41,745	100,0
Immature				17	5,3	1,240	3,0
Mature				305	94,7	40,505	97,0

Stratum C							
Age	Year	Mean Length (cm)	Mean weight (g)	Number (millions)	%	Biomass (1000 tons)	%
0I	2001im						
0M	2001ad						
1I	2000im						
1M	2000ad						
2I	1999im						
2M	1999ad						
3I	1998im						
3M	1998ad						
4A	1997						
5A	1996						
6A	1995						
7A	1994						
8A	1993						
9+	<1993						
Mean							
Total							
Immature							
Mature							

Stratum D							
Age	Year	Mean Length (cm)	Mean weight (g)	Number (millions)	%	Biomass (1000 tons)	%
0I	2001im			0	0,0	0,000	0,0
0M	2001ad			0	0,0	0,000	0,0
1I	2000im	18,8	51,2	725	45,7	37,108	29,3
1M	2000ad	21,3	76,8	378	23,8	28,992	22,9
2I	1999im	21,6	81,3	16	1,0	1,282	1,0
2M	1999ad	23,6	108,0	196	12,4	21,208	16,7
3I	1998im			0	0,0	0,000	0,0
3M	1998ad	25,3	135,4	226	14,3	30,661	24,2
4A	1997	26,5	154,4	32	2,0	4,878	3,8
5A	1996	27,4	179,1	10	0,6	1,810	1,4
6A	1995	27,7	175,9	4	0,3	0,715	0,6
7A	1994	28,0	165,0	1	0,1	0,167	0,1
8A	1993			0	0,0	0,000	0,0
9+	<1993			0	0,0	0,000	0,0
Mean		24,5	125,2				
Total				1588	100,0	126,823	100,0
Immature				741	46,7	38,390	30,3
Mature				847	53,3	88,433	69,7

Table IIE.4. (continued)

Stratum E							
Age	Year	Mean Length (cm)	Mean weight (g)	Number (millions)	%	Biomass (1000 tons)	%
0I	2001im			0	0,0	0,000	0,0
0M	2001ad			0	0,0	0,000	0,0
1I	2000im	18,9	51,9	49	17,2	2,548	11,5
1M	2000ad	21,1	78,9	218	76,8	17,230	77,8
2I	1999im			0	0,0	0,000	0,0
2M	1999ad	24,5	112,0	2	0,6	0,191	0,9
3I	1998im			0	0,0	0,000	0,0
3M	1998ad	24,9	127,1	12	4,2	1,517	6,9
4A	1997			0	0,0	0,000	0,0
5A	1996	27,5	190,0	3	1,2	0,648	2,9
6A	1995			0	0,0	0,000	0,0
7A	1994			0	0,0	0,000	0,0
8A	1993			0	0,0	0,000	0,0
9+	<1993			0	0,0	0,000	0,0
Mean		23,4	112,0				
Total				285	100,0	22,133	100,0
Immature				49	17,2	2,548	11,5
Mature				236	82,8	19,585	88,5

Stratum F							
Age	Year	Mean Length (cm)	Mean weight (g)	Number (millions)	%	Biomass (1000 tons)	%
0I	2001im			0	0,0	0,000	0,0
0M	2001ad			0	0,0	0,000	0,0
1I	2000im	18,8	52,8	3729	78,4	196,981	69,0
1M	2000ad	20,9	75,4	766	16,1	57,748	20,2
2I	1999im	19,8	58,8	24	0,5	1,403	0,5
2M	1999ad	22,5	97,1	100	2,1	9,755	3,4
3I	1998im			0	0,0	0,000	0,0
3M	1998ad	24,8	126,1	68	1,4	8,520	3,0
4A	1997	25,4	147,3	19	0,4	2,836	1,0
5A	1996	26,0	156,1	23	0,5	3,620	1,3
6A	1995	26,5	167,9	25	0,5	4,198	1,5
7A	1994	27,5	195,0	2	0,0	0,319	0,1
8A	1993			0	0,0	0,000	0,0
9+	<1993	27,5	151,0	2	0,0	0,247	0,1
Mean		24,0	122,8				
Total				4757	100,0	285,626	100,0
Immature				3753	78,9	198,384	69,5
Mature				1004	21,1	87,242	30,5

Table IIE.5a Herring. Mean length, mean weight, biomass (thousends of tonnes) and numbers (millions) breakdown by age and maturity obtained during the July 2002 North Sea hydro acoustic survey for herring, FRV "Tridens".

Total area (all strata summarized)					
Age	Year	Number (millions)	%	Biomass (1000 tons)	%
0I	2001im	3447	33,0	8,174	1,7
0M	2001ad	0	0,0	0,000	0,0
1I	2000im	4569	43,7	240,141	49,2
1M	2000ad	1394	13,3	106,573	21,9
2I	1999im	40	0,4	2,717	0,6
2M	1999ad	379	3,6	41,174	8,4
3I	1998im	0	0,0	0,000	0,0
3M	1998ad	469	4,5	63,388	13,0
4A	1997	77	0,7	11,729	2,4
5A	1996	46	0,4	7,539	1,5
6A	1995	30	0,3	5,117	1,0
7A	1994	5	0,0	0,923	0,2
8A	1993	0	0,0	0,017	0,0
9+	<1993	2	0,0	0,247	0,1
Total		10457	100,0	487,739	100,0
Immature		8056	77,0	251,033	51,5
Mature		2401	23,0	236,706	48,5

Table IIE.5b Sprat. Mean length, mean weight, biomass (thousands of tonnes) and numbers (millions) breakdown by age and maturity obtained during the July 2002 North Sea hydro acoustic survey for herring, FRV "Tridens".

Total area (all strata summarized)				
Age	Number (millions)	%	Biomass (1000 tons)	%
1I	80	3,6	0,264	1,7
1M	423	19,1	2,208	14,4
2I	363	16,4	1,623	10,6
2M	1113	50,3	7,562	49,3
3I	0	0,0	0,000	0,0
3M	139	6,3	1,918	12,5
4I	0	0,0	0,000	0,0
4M	90	4,1	1,713	11,2
5A	3	0,1	0,064	0,4
Total	2210	100,0	15,353	100,0
Immature	443	20,0	1,887	12,3
Mature	1767	80,0	13,465	87,7

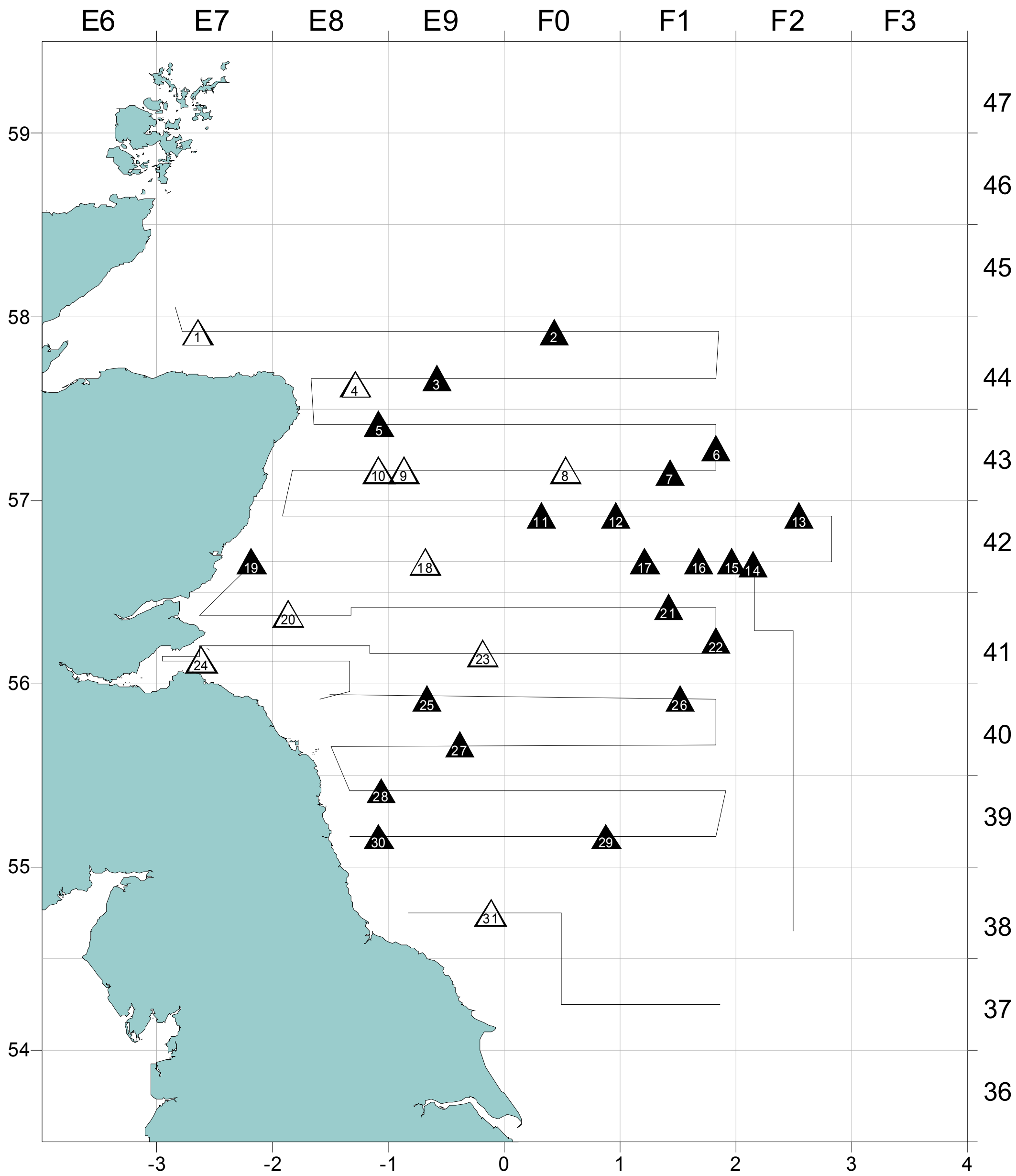

Figure IIE.1 Map of east of Scotland showing cruise track and positions of fishing trawls undertaken during the July 2002 North Sea hydro acoustic survey for herring by RV Tridens. Filled triangles indicate pelagic trawls in which herring were caught. Open triangles indicate trawls with no herring. Sprat was caught in haul 3, 5, 8, 19, 27, 28 and 31.

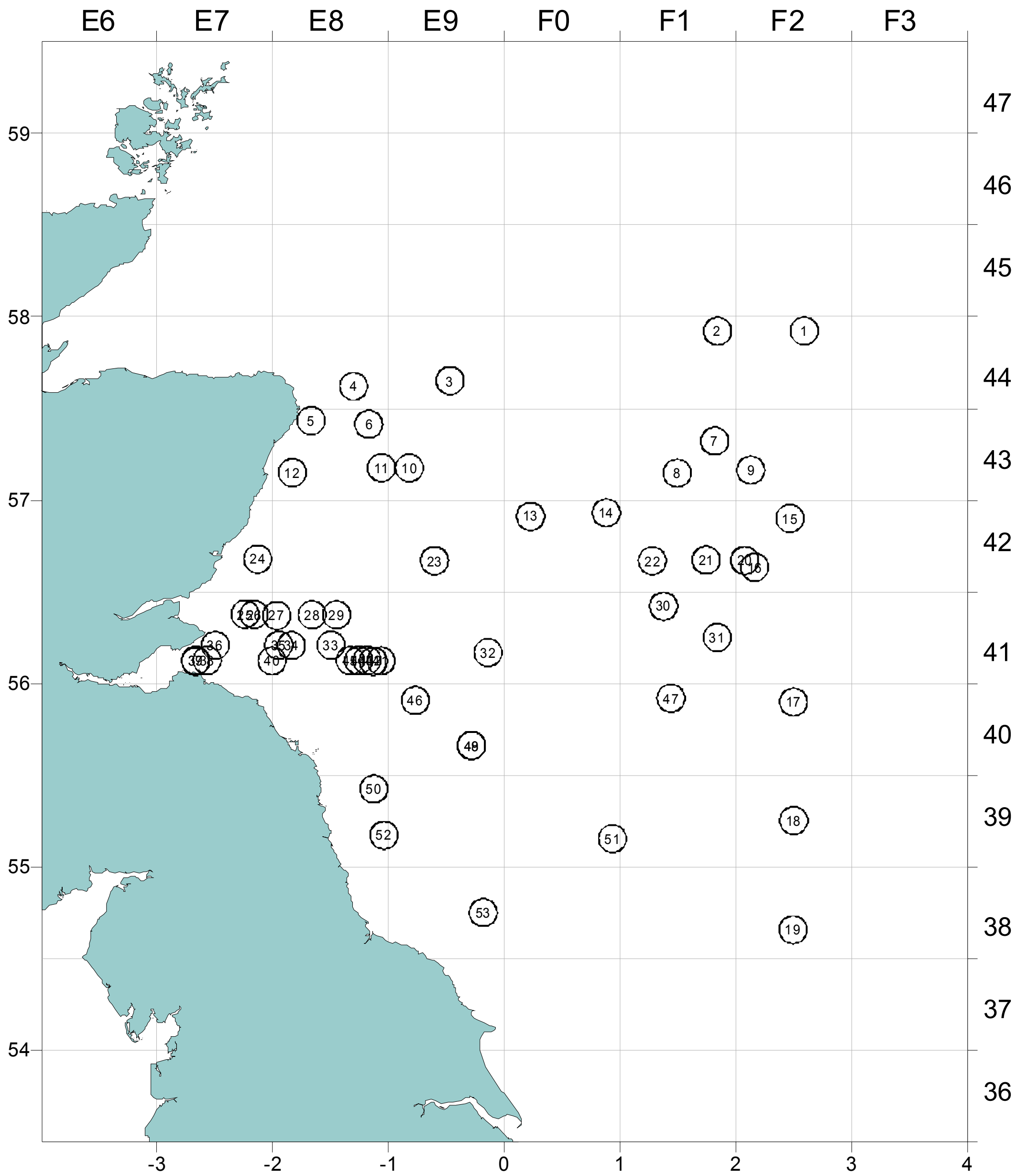

Figure IIE.2 Positions of CTD stations undertaken during the July 2002 North Sea hydro acoustic survey for herring by FRV "Tridens".

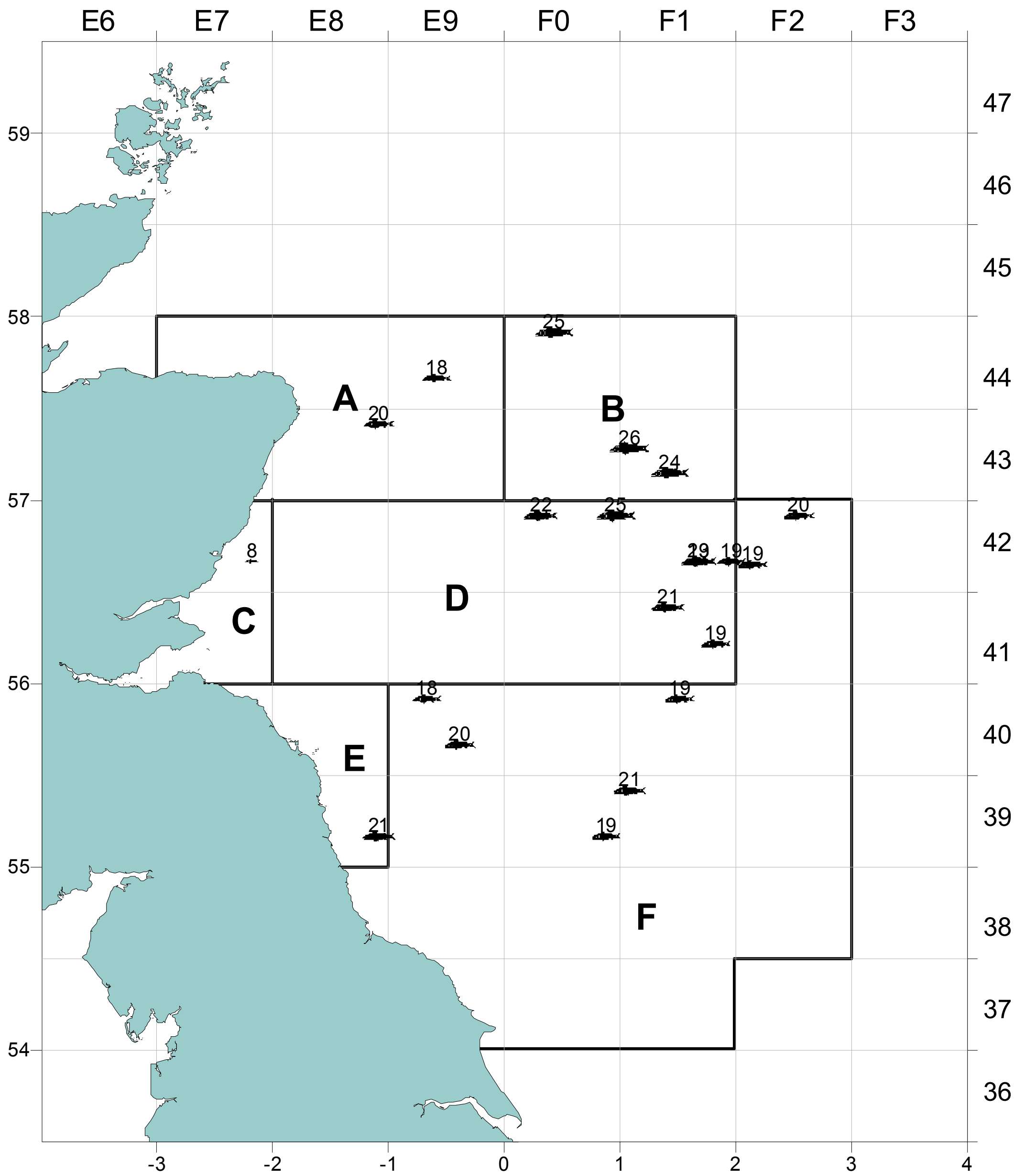

Figure IIE.3 Post plot of herring mean length from FRV "Tridens", observed during the July 2002 North Sea hydro acoustic survey for herring. Symbol size is proportional to the mean length from trawl hauls used to qualify the acoustic data. The number above the symbols indicates the mean length in cm. Strata-areas A to F are indicated.

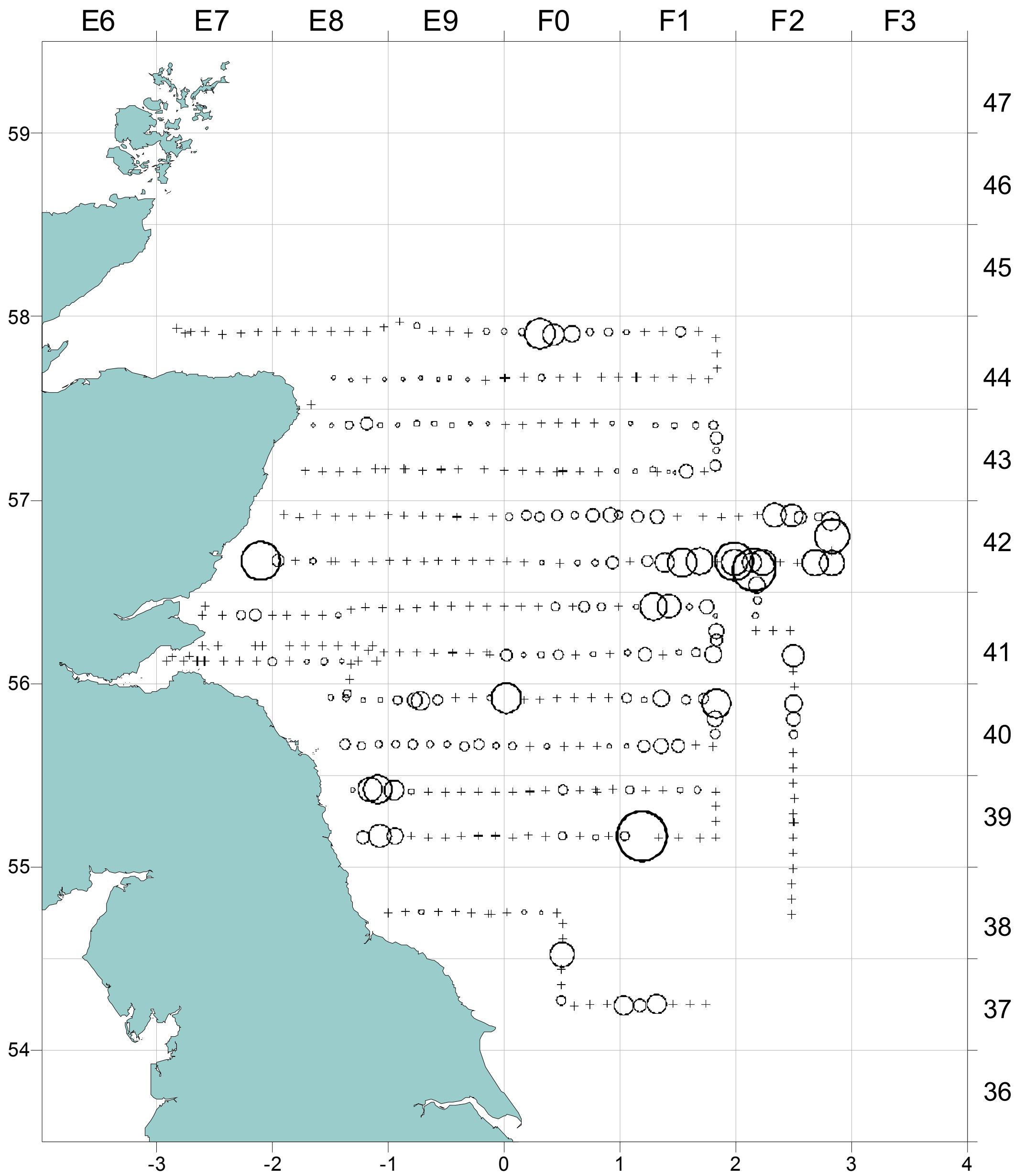

Figure IIE.4 Post plot showing the distribution of total herring NASC values (on a proportional square root scale relative to the largest value of 3601,4) obtained during the July 2002 North Sea herring hydro acoustic survey on FRV "Tridens". Crosses indicate zero values.

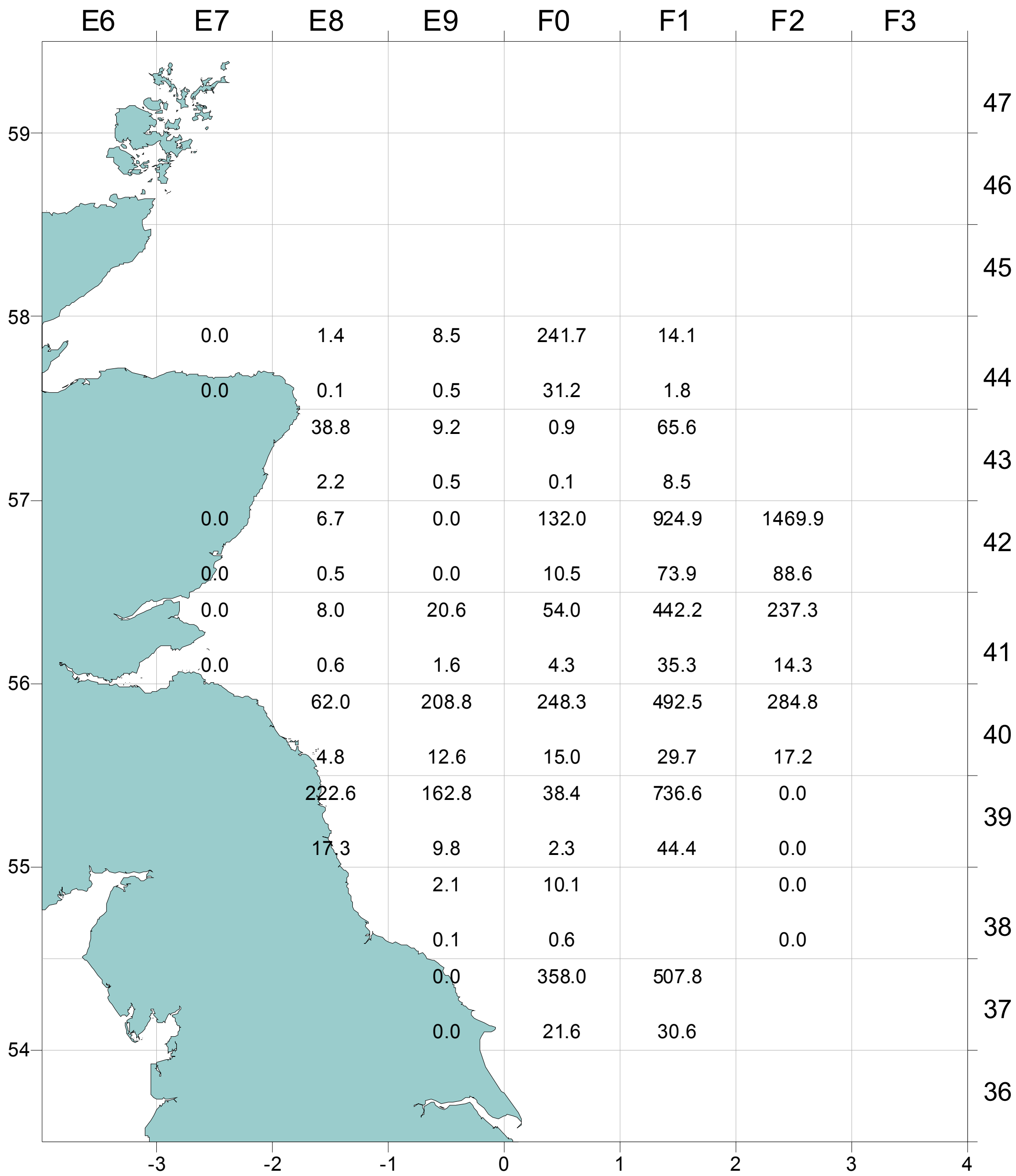

Figure IIE.5 Map showing estimated numbers of herring in millions (upper half square) and biomass in thousands of tonnes (lower half of square) by ICES rectangle. Results from the July 2002 North Sea hydro acoustic survey, FRV "Tridens".

APPENDIX IIF: GERMANY

Survey report for FRV "Walther Herwig III" cruise 240

International Herring Acoustic Survey in the North Sea

21 Jun 2002 – 12 Jul 2002

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

1. INTRODUCTION

Context: "Walther Herwig III" cruise 240 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 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.

Objectives: Hydroacoustic recording of pelagic fish stocks for abundance and biomass estimation, biological sampling for the verification of echoes, calibration of the hydroacoustic equipment, intercalibration with other vessels participating in the survey, hydrographic investigations.

2. SURVEY DESCRIPTION AND METHODS

2.1 Personnel

Dr. C. Zimmermann	scientist in charge, fishery biology, ISH		
Dr. E. Bethke	hydroacoustics	IFF(T)	
M. Sasse	hydroacoustics	IFF(T)	
Dr. I. Stürmer	guest researcher	Univ. Göttingen	to 26.06.02
Mrs. G. Gentschow	fishery biology	ISH	fro 29.06.02
G. Kurtz	fishery biology	ISH	fro 29.06.02
A. Baer	fishery biology	ISH	fro 29.06.02
H. Mayer	fishery biology	ISH	fro 29.06.02
Mrs. D. Seidler	fishery biology	ISH	fro 29.06.02
Dr. H. Kroos	takeone TV production Hamburg		29.06.-02.07.02
T. Reinecke	takeone TV production Hamburg		29.06.-02.07.02

2.2 Narrative

FRV "Walther Herwig III" left the port of Bremerhaven in the evening of June 21st, and calibrated the hydroacoustic equipment under favourable conditions in the morning of June 22nd off Helgoland. Therefore, it was not necessary to sail to Kristiansand. Until June 25th, the vessel surveyed areas with historically low density of clupeids, as fishing was not possible due to a failure of the fishing winch. "Walther Herwig III" returned to her home port for repair until June 29th and covered the remaining area with frequent sampling until July 11th. The planned intercalibration with the dutch FRV "Tridens" had to be postponed to next year as she was already behind schedule. "Walther Herwig III" reached Bremerhaven at 12th July 2002 at noon, having sailed 2840 nm.

2.3 Survey design

As in previous years, the working area for the German vessel contributing to the survey was confined to the south-eastern North Sea between 56.5°N and 54°N, and 3°E to the 20 m depth line off the Danish and German coasts. This year, the survey area was again extended southwards to a latitude of 53.5° N to cover three additional statistical rectangles (Figure IIF.1), while three statistical rectangles in the NW were covered by the Norwegian vessel.

Hydroacoustic measurements were conducted on east-west transects with 15 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 two transects. To account for the reduction of survey time due to the failure of the main fishing winch at the start of the survey, areas where only small amounts of clupeids have been detected during the last years' surveys (Northwestern part of the area) were surveyed with halved intensity on N-S transects. In these rectangles, no fishing could be conducted.

2.4 Calibration

The hull mounted transducer ES38B (starboard blister) was calibrated at the start of the survey (June 22th) under favourable conditions west of Helgoland. The calibration procedure was carried out with the programme "Calibrate" (Bethke 2000) which gives equivalent results as the "Lobe" (Simrad) programme and the methods described in the 'Manual for Herring Acoustic Surveys in ICES Divisions III, IV and VI' (ICES CM 2000/G:02, Appendix 6). Important parameters and settings are listed in Tab. IIF.1. The difference to the two last calibrations on "Herwig" (conducted for test purposes in the Western Baltic in early June 2002 under good conditions and recalculated for the North Sea environment) was found to be acceptable (ΔTS Gain: +0.12 dB, -0.24 dB; ΔS_v Gain: +0.53 dB, +0.09 dB) and it was decided to take the new values.

An intercalibration between the Dutch and the German research vessel participating in the survey was planned for 11 Jul 2002. Unfortunately, this exercise had to be postponed to next year as the Dutch research vessel couldn't reach the meeting point in time.

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' (ICES CM 2000/G:02, Appendix 6). Basic settings are documented in Table IIF.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 240, "Herwig" sailed 2840 n.mi. Of these, 2247 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, 37 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. 12 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 Scanmar net sonde. Standard tow periods were 30 mins; however, they varied between 7 and 81 mins depending on the indications of net filling.

From each trawl, the mass of the total catch and species composition (on subsamples, if needed) were determined. Length frequency distributions were produced for each species. Length-stratified samples (10 samples per half cm class per ICES stat rectangle) of herring 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 1274 herring, 1086 sprat and 36 anchovies). If conditions did not allow conducting this work immediately after the haul, fish was frozen for further processing at the institute (additional 300 specimens).

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 "Kieler Multisonde KMS113" CTD-water sampler rosette (Figure IIF.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. The identification of the echo records was made by means of aimed trawling. 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 s 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, 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 – in contrast to last year – 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 center of the investigation area. A maximum, however, was detected close to the northern limit (10'949 $m^2 n.mi.^{-2}$). Figure IIF.2 gives the NASC distribution on 1 n.mi. EDSUs.

3.2 Biological data

37 hauls with the pelagic trawl PSN205 have been deployed. Due to time constraints and the technical problems during the first part of the survey (see above), 10 statistical rectangles out of 32 covered during the survey could not be sampled with trawl hauls (Figure IIF.1 and Tab. IIF.2).

The distribution of fish species appeared to follow the pattern seen until 2000: largest abundances of herring have been found in the center of the survey area and those of sprat on the southern fringe. In this respect, last year's fish distribution seems to have been an exception. However, sprat was far more abundant in this year and was found in significant numbers even in the northern part of the area (Figure IIF.3).

Whiting, which dominated the inshore catches as 0-group last year, disappeared almost completely from the catch in this year. Mackerel was far more frequent this year (in terms of presence and biomass). This and the occurrence of large, mature anchovies could indicate an in$\mathbf{F}_{low}$ of warm Atlantic water into the southern North Sea.

20 species have been caught (mean 6 species per haul). Highest presence was recorded for sprat (in 34 of 37 hauls), herring and mackerel (33) and grey gurnard (32). The main share of the total catch of approx. 10 tons (607'000 specimens) could be attributed to sprat (50%, 444'200 ind) and herring (41%, 155'500 ind) (Tab. IIF.3).

Figure IIF.6 gives the total length frequency distribution for herring and sprat in comparison to the 2001 survey results. There are indications that the obviously strong 2000/2001 herring year class is now found as 1 ringers (2 year old fish), while the following 2001/2002 year class is less abundant.

3.3 Biomass and abundance estimates

The total biomass estimates for the survey:

Total herring	**183'400 t**	(2001: 216'600 t)
Spawning stock biomass	57 t / 0.03 %	(2001: 130 t / 0.06 %)
Total sprat	**225'600 t**	(2001: 121'800 tonnes)
Spawning stock biomass	151'800 t / 67 %	(2001: 77'100 tonnes/63 %)

The total abundance estimates for the survey:

Total herring	**8'400 mill.**	(2001: 15'900 mill.)
Spawning stock abundance	1 mill. / 0.01 %	(2001: 2 mill. / 0.01 %)
Total sprat	**19'700 mill.**	(2001: 14'600 mill.)
Spawning stock abundance	12'700 mill. / 64 %	(2001: 8'200 mill. / 56 %)

The age composition is very similar to previous years' results: the vast majority of herring in this area consists of 0- and 1-wr (Age 1 and 2), however, with a much higher share for 1-wr fish this year. The fraction of mature herring has slightly increased. The herring biomass was calculated to be 15% less than last year's value, while the abundance was almost halved.

In contrast to herring, the majority of sprat in the area was found to be mature. Biomass and abundance have been increased significantly as compared to last year. This, after the high reduction in last year, corroborates the perception that the sprat stock undergoes strong fluctuations.

Detailed information on abundance and biomass by statistical rectangle can be found in Figure IIF.4 and IIF.5, they are further split to age group and maturity in Tab. IIF.6 and IIF.7.

3.4 Hydrographic data

43 CTD vertical profiles have been recorded at stations spread over the whole area. The water column was clearly stratified on most of the offshore stations; surface temperatures ranged between 13.7 and 16.0°C and decreased by up to 5°C to the sea floor.

Weather conditions have been rather unusual during this cruise: out of 18 days at sea, wind speed was less than 6 Bft. only on 4 days. Heavy rainfalls led to extended freshwater lenses of up to 7 m thickness.

Table IIF.1 FRV "Walther Herwig III", cruise 240: International hydroacoustic survey on herring in the North Sea, 21 June – 12 July 2002: Simrad EK500 and analysis **settings** used.

Transceiver Menu	
Frequency	38 kHz
Transducer	FL1 STB-Blister ES38B
Sound speed	1500 $m.s^{-1}$
Max. Power	2000 W
Equivalent two-way beam angle	-20.3 dB
Default Transducer Sv gain	26.74 dB
Calibration details	
TS of sphere	-33.6 dB
Range to sphere in calibration	21.50 m
Measured NASC value for calibration	4470.1
Log Menu	
Speed	1 n.mi.
Operation Menu	
Ping interval	1 s at 50 m range
Analysis settings	
Bottom margin (backstep)	1 m
Integration start (absolute) depth	9 m
Range of thresholds used	-50 dB

Table IIF.2 FRV "Walther Herwig III", cruise 240: International hydroacoustic survey on herring in the North Sea, 21 June 2002 -12 July 2002: 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)
489	1	37F7	20020630	0648	PSN205	540706N	0070102E	36	27	30
491	2	37F6	20020630	0932	PSN205	540669N	0064158E	36	26	25
493	3	37F6	20020630	1354	PSN205	540540N	0060518E	35	26	30
495	4	37F5	20020630	1645	PSN205	540305N	0054195E	37	22	37
498	5	37F4	20020701	0644	PSN205	540717N	0042878E	48	36	30
500	6	37F4	20020701	1128	PSN205	542200N	0042201E	52	44	58
502	7	37F5	20020701	1450	PSN205	542191N	0050891E	46	37	35
504	8	37F6	20020702	0422	PSN205	541982N	0063436E	39	28	10
506	9	37F7	20020702	0927	PSN205	541807N	0071177E	42	32	44
508	10	37F8	20020702	1445	PSN205	540546N	0080294E	27	17	14
511	11	38F6	20020703	0857	PSN205	543710N	0061551E	42	32	29
513	12	38F5	20020703	1129	PSN205	543711N	0054365E	44	33	30
515	13	38F4	20020703	1436	PSN205	543708N	0045812E	47	33	20
517	14	38F4	20020703	1618	PSN205	543712N	0043537E	51	43	9
520	15	38F5	20020704	0922	PSN205	545199N	0054564E	43	34	60
522	16	38F6	20020704	1207	PSN205	545200N	0062116E	42	33	47
524	17	38F7	20020704	1517	PSN205	545182N	0070229E	28	16	30
527	18	39F7	20020705	0516	PSN205	550494N	0074479E	21	15	14
529	19	39F6	20020705	1210	PSN205	550893N	0061500E	48	40	75
531	20	39F6	20020705	1500	PSN205	552202N	0061657E	50	40	55
534	21	40F7	20020709	0650	PSN205	553396N	0072240E	35	24	16
536	22	40F6	20020706	0904	PSN205	553704N	0065782E	33	25	30
538	23	40F6	20020706	1215	PSN205	553918N	0061469E	45	36	7
540	24	40F6	20020706	1509	PSN205	555183N	0061639E	46	37	60
543	25	41F7	20020707	0719	PSN205	560700N	0073897E	31	21	30
545	26	41F6	20020707	1209	PSN205	560707N	0063060E	44	33	30
547	27	41F5	20020707	1449	PSN205	561293N	0055730E	49	40	7
549	28	41F5	20020708	0505	PSN205	562198N	0054696E	51	37	54
551	29	41F6	20020708	0833	PSN205	562151N	0062412E	44	35	60
553	30	41F7	20020708	1320	PSN205	562291N	0074306E	29	18	22
555	31	42F7	20020708	1521	PSN205	563180N	0075513E	26	17	27
558	32	42F6	20020708	0552	PSN205	563710N	0064700E	45	34	81
560	33	42F6	20020709	1238	PSN205	565183N	0065798E	37	27	10
562	34	42F7	20020709	1518	PSN205	565199N	0071913E	33	24	71
565	35	36F5	20020700	1243	PSN205	535928N	0053738E	37	28	30
567	36	36F4	20020710	1603	PSN205	534699N	0045904E	37	37	45
570	37	36F3	20020711	0715	PSN205	533669N	0033876E	40	31	60

Table IIF.3 FRV "Walther Herwig III", cruise 240: International hydroacoustic survey on herring in the North Sea, 21 June 2002 -12 July 2002: 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.

Stat	*Belone belone*	*Callionymus lyra*	***Clupea harengus***	*Engraulis encrasicolus*	*Eutrigla gurnardus*	*Hyperoplus lanceolatus*	*Limanda limanda*	*Melanogrammus aeglefinus*	*Merlangius merlangus*	*Merluccius merluccius*	*Microstomus kitt*	*Pleuronectes platessa*	*Salmo trutta*	*Sardina pilchardus*	*Scomber scombrus*	***Sprattus sprattus***	*Trachurus trachurus*	*Trigla lucerna*	*Trisopterus luscus*	**Total catch (kg)**	**No. of Species**	Herring (n in haul)	Herring (% of clupeid catch)	Sprat (n in haul)	Sprat (% of clupeid catch)	**Number of clupeids/30 min**
489	0.3		**67.5**	0.0	0.0	0.0									2.4	**634.8**				**705.0**	7	7350	**11%**	60965	**89%**	2907
491			**0.2**			1.5									134.0	**1.6**	11.5			**148.8**	5	2	**1%**	158	**99%**	32
493	0.2		**14.5**			0.2									138.0	**838.4**	2.7			**994.0**	6	512	**1%**	64112	**99%**	1950
495			**6.2**						0.1						17.6	**64.6**	3.4			**91.9**	5	196	**4%**	4875	**96%**	1655
498			**6.3**		0.7	0.1								0.1	6.9	**177.1**	1.2			**192.3**	7	262	**1%**	17818	**99%**	2821
500			**30.3**		0.3	0.1								0.1	0.1	**5.6**	16.5			**53.0**	7	889	**62%**	538	**38%**	808
502			**146.6**		1.5	0.2									5.6	**53.8**	3.5			**211.2**	6	4583	**51%**	4406	**49%**	1277
504	0.5		**1.7**		0.1	0.1							2.4		10.0	**218.6**	0.1			**233.4**	8	76	**0%**	16690	**100%**	2155
506		0.0	**93.8**		1.2	0.0	0.4					0.1			16.8	**142.6**	5.5			**260.3**	9	6701	**37%**	11384	**63%**	2084
508			**3.5**	4.1											10.8	**20.5**	0.1			**39.0**	5	540	**19%**	2376	**81%**	2242
511			**94.3**		0.7	0.2			0.1						18.4	**126.5**				**240.0**	6	3846	**27%**	10310	**73%**	1769
513			**133.9**		0.8				0.2						2.8	**96.7**	0.4			**234.7**	6	4201	**43%**	5640	**57%**	1258
515			**139.0**		2.4	0.1			0.0							**287.4**	0.6			**429.5**	6	4241	**15%**	23790	**85%**	1958
517			**17.5**		1.8										0.5	**81.8**	3.5			**105.1**	5	567	**5%**	10545	**95%**	3171
520			**44.6**		3.5										0.6	**50.9**		0.3		**99.8**	5	1398	**26%**	4036	**74%**	1633
522			**0.3**		2.0				0.1						15.0	**30.7**	1.7			**49.8**	6	10	**0%**	2450	**100%**	1482
524					0.5										0.2		0.2			**0.8**	3					0
527			**33.2**	0.2	0.4	0.0	0.2		0.0						0.3	**120.8**	2.7	0.3		**158.2**	10	4695	**27%**	12790	**73%**	3316
529	1.1		**13.3**		2.8	0.1			0.7				1.3		18.6	**337.2**				**375.0**	8	526	**1%**	47354	**99%**	3830
531			**53.5**		2.9	0.6			3.9	0.8	0.1			0.4	68.5	**69.3**	3.6			**203.7**	10	1891	**32%**	4006	**68%**	869
534			**11.8**		1.2	2.6	0.0								12.5	**36.0**				**64.1**	6	1408	**28%**	3645	**72%**	2364
536					39.6										6.1		1.5			**47.2**	3					0
538			**474.2**		7.2										0.9	**216.4**				**698.7**	4	19159	**56%**	15095	**44%**	1471
540			**198.4**		4.8			0.8	0.0			0.3			4.6	**285.0**				**493.9**	7	8965	**27%**	24835	**73%**	2053
543			**96.2**		4.3				0.0						13.4	**103.6**	0.1			**217.7**	6	6482	**43%**	8612	**57%**	2080
545			**263.3**		3.1				1.1							**43.2**	12.9			**323.5**	5	11786	**77%**	3513	**23%**	1419
547			**593.2**		1.7				0.0							**1.1**				**596.0**	4	17809	**100%**	75	**0%**	900
549			**1029.2**		13.5				0.5						2.8	**22.9**	2.9			**1071.7**	6	29277	**95%**	1419	**5%**	859
551			**10.8**		2.9	0.1		0.3	0.2						0.8	**1.0**	2.2			**18.2**	8	387	**87%**	59	**13%**	735
553			**1.8**		2.9	1.1	0.0								0.9	**0.0**				**6.8**	6	220	**99%**	3	**1%**	991
555			**23.9**		0.4	0.0									3.7	**16.5**				**44.4**	5	2582	**62%**	1611	**38%**	2830
558			**325.7**		6.8				0.1						0.3	**0.4**			0.0	**333.3**	6	11434	**100%**	22	**0%**	1031
560			**86.4**		0.1			0.4								**1.0**				**87.9**	4	2978	**98%**	57	**2%**	1036
562					1.7				0.0					0.1	6.3					**8.1**	4					0
565			**0.6**		0.4				0.3						38.7	**249.6**				**289.6**	5	17	**0%**	21717	**100%**	2251
567					0.1				5.9						144.1	**159.6**	0.4			**310.0**	5		**0%**	9462	**100%**	916
570	0.2		**8.9**	0.1					21.9						13.6	**411.5**	0.6			**456.8**	7	505	**1%**	49836	**99%**	3306
Total	2.3	0.0	**4024.6**	4.4	112.2	6.9	0.6	1.5	35.0	0.8	0.1	0.4	3.7	0.7	715.5	**4906.5**	77.7	0.6	0.0	**9893.6**	20	155495		444204		

Table IIF.4a. FRV "Walther Herwig III", cruise 240: International hydroacoustic survey on herring in the North Sea, 21 June 2002 -12 July 2002: **Herring** length frequency proportion (%) by trawl haul. Length in cm.

rectangle	36F3	36F5	37F4	37F4	37F5	37F5	37F6	37F6	37F6	37F7	37F7	37F8	38F4	38F4	38F5	38F5	38F6	38F6	39F6	39F6	39F7	40F6	40F6	40F7	41F5	41F5	41F6	41F6	41F7	41F7	42F6	42F6	42F7	
length/stat	**570**	**565**	**498**	**500**	**495**	**502**	**491**	**493**	**504**	**489**	**506**	**508**	**515**	**517**	**513**	**520**	**511**	**522**	**529**	**531**	**527**	**538**	**540**	**534**	**547**	**549**	**545**	**551**	**543**	**553**	**558**	**560**	**555**	**total**
7.75																							0											**0**
8.25			7									0																						**0**
8.75	8											6																						**0**
9.25				0								38									6			0									0	**0**
9.75	8									1	2	34							3		52		1	7						3		4	2	**2**
10.25	8									6	14	9							3		23		1	38						32		2	14	**2**
10.75										49	13	5									11		0	34			0		2	49			42	**3**
11.25										29	16	5									6		0	14			0		10	15			31	**2**
11.75	8								50	12	13	1					1				1		1	2			0		13	1			8	**1**
12.25	8							8		3	8	2		1			2				1					0	0		6					**1**
12.75	31		7								3	1		1			2				0	0							2					**0**
13.25					2				13		4			1			1					1	5			0	2	1	2				0	**1**
13.75								8			5			1	1		4		3	2		1	12	1	1	0	14	7	8		0	1	0	**2**
14.25					2			8			9				1	1	14	17	10	3		14	15		3	3	31	15	20		4	5	1	**8**
14.75	8		14	2		0					6			4	3	3	22		3	16		29	23	2	6	5	26	23	19		12	15	1	**14**
15.25			14	5	10	3		25			3		9	6	7	16	24	17	21	23		26	22	1	12	4	15	17	13		20	16	1	**15**
15.75			36	13	32	29		8	25		1		27	24	26	26	19	50	38	25		22	15	0	14	12	6	14	4		25	21	0	**16**
16.25		25	21	23	34	39		33	13		1		31	34	27	26	8	17	7	20		6	3		27	14	3	10	0		23	18		**14**
16.75	8	50		38	15	25		8			1		25	19	22	15	3		7	9		1	1		18	20	1	6			12	11		**9**
17.25	8			13	2	3					0		4	7	7	9				1		1			11	18	0	2			3	4		**5**
17.75	8	25		4		0					1		2	2	4	3			3						2	8		2			1	0		**1**
18.25						0							1	1	1	0	0								3	7		2				1		**1**
18.75				0											0										2	5		2						**1**
19.25					2								0		0										0	3		0						**0**
19.75																										2								**0**
20.25																									0									**0**
22.25							50																											**0**
24.25							50																											**0**
total n ('000) /60min	0.5	0.03	0.5	0.9	0.3	7.9	0.00	1.0	0.5	14.7	9.1	2.3	12.7	3.8	8.4	1.4	8.0	0.01	0.4	2.1	20.1	164.2	9.0	5.3	152.7	32.5	23.6	0.4	13.0	0.6	8.5	17.9	5.7	527.9

Table IIF.4b. FRV "Walther Herwig III", cruise 240: International hydroacoustic survey on herring in the North Sea, 21 June 2002 -12 July 2002: Sprat length frequency proportion (%) by trawl haul. Length in cm.

rectangle	36F3	36F4	36F5	37F4	37F4	37F5	37F5	37F6	37F6	37F6	37F7	37F7	37F8
length/stat	**570**	**567**	**565**	**498**	**500**	**495**	**502**	**491**	**493**	**504**	**489**	**506**	**508**
8.25						0							
8.75											0		2
9.25	1			1		2		4	0				8
9.75	17			4	2	4		13	3		5	1	22
10.25	47		0	29	15	12	6	25	14		18	1	27
10.75	28	0	8	45	26	16	22	20	32	1	36	3	20
11.25	6	2	42	17	19	3	26	23	25	4	32	24	10
11.75	1	3	37	1	15	6	17	12	11	21	6	47	11
12.25		13	11	1	15	12	16	3	8	42	2	17	1
12.75	0	24	2	1	7	25	7	1	6	26		5	
13.25		31	0		2	15	6		1	5		1	0
13.75		21		1	0	4	0		0	0			
14.25		4			0					0		0	
14.75		1											
15.25													
total n ('000) /60 min	49.8	12.6	43.4	35.6	0.6	7.9	7.6	0.4	128.2	100.1	121.9	15.5	10.2

rectangle	38F4	38F4	38F5	38F5	38F6	38F6	39F6	39F6	39F7	40F6	40F6	40F7
length/stat	**515**	**517**	**513**	**520**	**511**	**522**	**529**	**531**	**527**	**538**	**540**	**534**
8.25												
8.75												
9.25					0	1	0				0	
9.75				1	2	1	6		7		0	2
10.25	3	7	1	6	16	7	22	0	36		4	32
10.75	24	34	1	15	32	12	39	2	40	1	33	45
11.25	30	24	4	27	23	18	25	2	12	17	36	18
11.75	14	18	9	24	13	13	4	2	3	26	16	2
12.25	10	9	9	12	10	21	3	5	2	18	4	1
12.75	13	4	33	6	3	18	1	27	1	18	2	
13.25	4	3	33	6	1	7		40		15	2	0
13.75	3	1	11	3	0	2	0	17		3	1	0
14.25				1		0		4		1	1	
14.75								1		1		
15.25												
total n ('000) /60 min	71.4	70.3	11.3	4.0	21.3	3.1	37.9	4.4	54.8	129.4	24.8	13.7

rectangle	41F5	41F5	41F6	41F6	41F7	41F7	42F6	42F6	42F7	
length/stat	**547**	**549**	**545**	**551**	**543**	**553**	**558**	**560**	**555**	**total**
8.25										0.0
8.75										0.1
9.25										0.2
9.75									1	2.9
10.25			1	2		33			22	12.3
10.75	7		16	2	15	33			51	22.9
11.25	19		39	5	43	33			20	21.3
11.75	25	8	27	12	31				5	14.5
12.25	20	16	8	10	8				1	11.2
12.75	8	22	4	29	1		50	50	1	8.5
13.25	15	39	2	20	1			40	0	4.4
13.75	5	10	2	14			50			1.4
14.25		2	0	5	0					0.3
14.75		2		2				10		0.2
15.25	1									0.0
total n ('000) /60 min	0.6	1.6	7.0	0.1	17.2	0.01	0.02	0.3	3.6	1010.8

Table IIF.5 FRV "Walther Herwig III", cruise 240: International hydroacoustic survey on herring in the North Sea, 21 June 2002 -12 July 2002: Age/maturity-length key for herring (absolute numbers ('000) raised to the abundance in the survey area).

Age *winterrings* length (cm)	1 *0* **1 imm.**	2 *1* **2 imm.**	2 *1* **2 mat.**	3 *2* **3 imm.**	3 *2* **3 mat.**	4 *3* **4 mat.**	 **Sum**
5.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.75	225.7	0.0	0.0	0.0	0.0	0.0	225.7
8.25	695.8	0.0	0.0	0.0	0.0	0.0	695.8
8.75	1884.5	0.0	0.0	0.0	0.0	0.0	1884.5
9.25	32305.8	0.0	0.0	0.0	0.0	0.0	32305.8
9.75	265093.1	0.0	0.0	0.0	0.0	0.0	265093.1
10.25	444504.5	0.0	0.0	0.0	0.0	0.0	444504.5
10.75	827971.3	0.0	0.0	0.0	0.0	0.0	827971.3
11.25	573066.0	0.0	0.0	0.0	0.0	0.0	573066.0
11.75	222237.1	0.0	0.0	0.0	0.0	0.0	222237.1
12.25	62861.1	164.1	0.0	0.0	0.0	0.0	63025.2
12.75	28889.4	5065.4	0.0	0.0	0.0	0.0	33954.8
13.25	4978.1	56227.5	0.0	0.0	0.0	0.0	61205.6
13.75	6478.6	271175.6	0.0	0.0	0.0	0.0	277654.2
14.25	0.0	768968.9	0.0	0.0	0.0	0.0	768968.9
14.75	0.0	1002422.6	0.0	0.0	0.0	0.0	1002422.6
15.25	0.0	985395.0	0.0	0.0	0.0	0.0	985395.0
15.75	0.0	973700.2	0.0	0.0	0.0	0.0	973700.2
16.25	0.0	838539.4	0.0	0.0	0.0	0.0	838539.4
16.75	0.0	535430.7	0.0	0.0	0.0	0.0	535430.7
17.25	0.0	262421.6	0.0	0.0	0.0	0.0	262421.6
17.75	0.0	76478.0	0.0	0.0	0.0	0.0	76478.0
18.25	0.0	65906.1	0.0	0.0	0.0	0.0	65906.1
18.75	0.0	39811.0	0.0	0.0	0.0	0.0	39811.0
19.25	0.0	14148.7	0.0	0.0	0.0	0.0	14148.7
19.75	0.0	4937.9	548.7	0.0	0.0	0.0	5486.6
20.25	0.0	3788.6	0.0	0.0	0.0	0.0	3788.6
20.75	0.0	2.8	0.4	0.0	0.0	0.2	3.4
21.25	0.0	572.2	0.0	0.0	0.0	0.0	572.2
21.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.75	0.0	0.0	284.4	0.0	284.4	0.0	568.8
23.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26.25	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
Sum:	2471191.0	5905156.5	833.5	0.0	284.4	0.2	8377465.6

Table IIF.6 FRV "Walther Herwig III", cruise 240: International hydroacoustic survey on herring in the North Sea, 21 June 2002 -12 July 2002: Mean weight, biomass (tonnes) and numbers (millions) for **herring** by age and maturity per statistical rectangle.

Summary by rectangle = interpolated square

Herring

	Age (wr+1)	F3 W [t]	F3 N [10^6]	F4 W [t]	F4 N [10^6]	F5 W [t]	F5 N [10^6]	F6 W [t]	F6 N [10^6]	F7 W [t]	F7 N [10^6]	F8 W [t]	F8 N [10^6]
42	total							**8236.2**	**308.9**	**9518.9**	**1050.3**	**172**	**10.5**
	1i							114.6	13.5	8'672.4	1019.6	52.0	6.1
	2i							8'121.6	295.4	846.5	30.8	120.5	4.4
	2m	no stations and		no stations and		no stations and		0.0	0.0	0.0	0.0	0.0	0.0
	3i	no echo-information		no echo-information		no echo-information		0.0	0.0	0.0	0.0	0.0	0.0
	3m							0.0	0.0	0.0	0.0	0.0	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
	5+							0.0	0.0	0.0	0.0	0.0	0.0
41	total	**6'589**	**239.3**	**0**	**0.0**	**29'808**	**1083.9**	**32'634**	**1189.9**	**6'717**	**326.2**		
	1i	0.1	0.0	0.0	0.0	0.0	0.0	34.3	4.0	1'007.8	118.5		
	2i	6'557.1	238.5	0.0	0.0	29'787.6	1083.6	32'599.4	1185.9	5'709.6	207.7		
	2m	31.3	0.5	0.0	0.0	20.2	0.3	0.0	0.0	0.0	0.0	no stations and	
	3i	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	no echo-information	
	3m	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
	4m	0.0	0.0	0.0	0.0	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	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		
40	total	**0**	**0.0**	**32**	**1.2**	**16'258**	**592.9**	**23'197**	**845.1**	**3'708**	**399.9**		
	1i	0.0	0.0	0.0	0.0	19.8	2.3	15.6	1.8	3'264.7	383.8		
	2i	0.0	0.0	32.4	1.2	16'232.9	590.5	23'181.8	843.3	443.0	16.1		
	2m	0.0	0.0	0.0	0.0	5.8	0.1	0.0	0.0	0.0	0.0	no stations and	
	3i	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	no echo-information	
	3m	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
	4m	0.0	0.0	0.0	0.0	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	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		
39	total	**38**	**1.4**	**51**	**1.9**	**5'009**	**183.2**	**488**	**17.9**	**2'788**	**327.8**		
	1i	0.1	0.0	0.1	0.0	11.7	1.4	1.8	0.2	2'788.2	327.8		
	2i	37.9	1.4	51.3	1.9	4'997.0	181.8	486.6	17.7	0.0	0.0		
	2m	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	no stations and	
	3i	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	no echo-information	
	3m	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
	4m	0.0	0.0	0.0	0.0	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	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		
38	total	**206**	**7.5**	**2'780**	**101.1**	**7'955**	**289.4**	**11'440**	**435.7**	**1'484**	**117.6**		
	1i	0.5	0.1	0.0	0.0	0.0	0.0	240.9	28.3	783.4	92.1		
	2i	205.2	7.5	2'780.4	101.1	7'955.4	289.4	11'199.3	407.4	701.0	25.5		
	2m	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	no stations and	
	3i	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	no echo-information	
	3m	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
	4m	0.0	0.0	0.0	0.0	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	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		
37	total	**1'285**	**47.9**	**528**	**19.6**	**6'340**	**230.6**	**342**	**14.6**	**5'513**	**509.9**	**112.0**	**13.1**
	1i	14.6	1.7	4.7	0.6	0.0	0.0	26.3	3.1	3'809.7	447.9	110.9	13.0
	2i	1'270.7	46.2	523.7	19.0	6'339.9	230.6	315.7	11.5	1'703.6	62.0	1.1	0.0
	2m	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0
	3i	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0
	3m	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0
	4m	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0
	5m	0.0	0.0	0.0	0.0	0.0	0.0	0.0	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
36	total	**131**	**8**	**0**	**0.0**	**46**	**1.7**						
	1i	45.9	5.4	0.0	0.0	0.0	0.0						
	2i	84.7	3.1	0.0	0.0	45.5	1.7						
	2m	0.0	0.0	0.0	0.0	0.0	0.0	no stations and		no stations and		no stations and	
	3i	0.0	0.0	0.0	0.0	0.0	0.0	no echo-information		no echo-information		no echo-information	
	3m	0.0	0.0	0.0	0.0	0.0	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						
	5+	0.0	0.0	0.0	0.0	0.0	0.0						

Weight at age and maturity [g]	
1i	8.51
2i	27.49
2m	68.70
3i	
3m	95.00
4m	59.00
5m	---
5+	---

Totals [t]:		Totals [mio]:	
Weight	**183'409**	**Number:**	**8'377**
1i	21'020	1i	2'471
2i	162'331	2i	5'905
2m	57	2m	1
3i	0	3i	0
3m	0	3m	0
4m	0	4m	0
5m	0	5m	0
5+	0	5+	0

Table IIF.7. FRV "Walther Herwig III", cruise 240: International hydroacoustic survey on herring in the North Sea, 21 June 2002 -12 July 2002: Mean weight, biomass (tonnes) and numbers (millions) for **sprat** by age and maturity per statistical rectangle.

Summary by rectangle

= interpolated square

Sprat

	Age (wr+1)	F3 W [t]	F3 N [10^6]	F4 W [t]	F4 N [10^6]	F5 W [t]	F5 N [10^6]	F6 W [t]	F6 N [10^6]	F7 W [t]	F7 N [10^6]	F8 W [t]	F8 N [10^6]
42	total							**61**	**4.2**	**7061**	**655.3**	**121**	**10.9**
	1i							4.3	0.4	1538.9	150.8	33.1	3.2
	1m	no stations and		no stations and		no stations and		0.0	0.0	5329.9	491.6	71.2	6.6
	2i							0.0	0.0	0.0	0.0	3.3	0.2
	2m	no echo-information		no echo-information		no echo-information		56.6	3.8	191.8	12.9	12.4	0.8
	3m							0.0	0.0	0.0	0.0	0.5	0.0
	4							0.0	0.0	0.0	0.0	0.0	0.0
41	total	**0**	**0.0**	**0**	**0.0**	**180**	**13.0**	**3'986**	**355.5**	**4'516**	**414.4**		
	1i	0.0	0.0	0.0	0.0	0.0	0.0	194.1	19.0	438.5	43.0		
	1m	0.0	0.0	0.0	0.0	39.4	3.6	3'267.5	301.3	3'892.9	359.0	no stations and	
	2i	0.0	0.0	0.0	0.0	0.0	0.0	53.4	3.5	0.0	0.0		
	2m	0.0	0.0	0.0	0.0	132.4	8.9	470.7	31.6	184.4	12.4	no echo-information	
	3m	0.0	0.0	0.0	0.0	8.5	0.5	0.0	0.0	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		
40	total	**0**	**0.00**	**0**	**0.01**	**3'487**	**285.2**	**9'223**	**752.2**	**11'012**	**1'035.0**		
	1i	0.0	0.0	0.0	0.0	594.3	58.2	79.0	7.7	3'839.7	376.3		
	1m	0.0	0.0	0.0	0.0	1'372.0	126.5	5'280.7	487.0	7'059.2	651.0	no stations and	
	2i	0.0	0.0	0.0	0.0	113.2	7.4	0.0	0.0	0.0	0.0		
	2m	0.0	0.0	0.1	0.0	1'276.3	85.7	3'691.5	247.8	113.4	7.6	no echo-information	
	3m	0.0	0.0	0.0	0.0	130.9	7.3	171.7	9.6	0.0	0.0		
	4	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0		
39	total	**137**	**11.9**	**144**	**12.4**	**4'046**	**339.4**	**3'429**	**304.8**	**9'213**	**893.0**		
	1i	33.1	3.2	33.2	3.2	834.5	81.8	385.6	37.8	8'233.6	807.0		
	1m	67.9	6.3	68.5	6.3	1'733.9	159.9	2'508.1	231.3	811.0	74.8	no stations and	
	2i	3.5	0.2	3.8	0.3	120.2	7.8	0.0	0.0	70.7	4.6		
	2m	30.2	2.0	35.9	2.4	1'242.7	83.4	499.4	33.5	98.2	6.6	no echo-information	
	3m	2.1	0.1	2.7	0.2	114.7	6.4	36.3	2.0	0.0	0.0		
	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0		
38	total	**823**	**72.2**	**10'627**	**875.8**	**5'836**	**452.3**	**15'076**	**1'352.8**	**9'612**	**852.8**		
	1i	219.3	21.5	2'282.2	223.7	648.0	63.5	4'418.4	433.0	2'898.2	284.0		
	1m	411.9	38.0	3'858.7	355.9	1'713.0	158.0	8'343.5	769.5	4'763.6	439.3	no stations and	
	2i	20.7	1.3	924.5	60.4	65.6	4.3	0.0	0.0	235.5	15.4		
	2m	160.1	10.8	3'277.0	220.0	3'198.0	214.7	1'873.7	125.8	1'622.5	108.9	no echo-information	
	3m	11.3	0.6	284.4	15.8	211.8	11.8	439.9	24.5	92.2	5.1		
	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
37	total	**7'835**	**694.0**	**5'624**	**491.3**	**5'280**	**436.2**	**28'330**	**2'249.5**	**32'529**	**2'937.3**	**623**	**57.5**
	1i	2'494.8	244.5	89.5	8.8	958.6	93.9	71.5	7.0	4'003.5	392.4	453.2	44.4
	1m	3'688.6	340.2	4'439.0	409.4	2'213.4	204.1	13'764.6	1'269.5	25'134.8	2'318.1	73.2	6.7
	2i	204.3	13.3	0.0	0.0	19.0	1.2	0.0	0.0	0.0	0.0	90.2	5.9
	2m	1'333.9	89.6	1'062.6	71.3	1'799.8	120.8	14'493.4	973.1	3'317.7	222.7	6.6	0.4
	3m	113.7	6.3	33.0	1.8	288.9	16.1	0.0	0.0	72.8	4.1	0	0
	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
36	total	**10'161**	**987.6**	**13'672**	**939.6**	**22'986**	**2'177.9**						
	1i	9'890.3	969.3	1'593.2	156.2	20'581.5	2'017.2						
	1m	38.1	3.5	0.0	0.0	0.0	0.0	no stations and		no stations and		no stations and	
	2i	86.1	5.6	4'607.8	300.8	369.3	24.1						
	2m	83.8	5.6	5'826.9	391.2	2'035.0	136.6	no echo-information		no echo-information		no echo-information	
	3m	63.2	3.5	1'644.0	91.5	0.0	0.0						
	4	0.0	0.0	0.0	0.0	0.0	0.0						

Weight at age and maturity [g]	
1i	10.20
1m	10.84
2i	15.32
2m	14.89
3	17.97
4	

Totals [t]:		Totals [mio]:	
Weight	**225'629**	**Number:**	**19'664**
1i	66'844	1i	6'551
1m	99'945	1m	9'218
2i	6'991	2i	456
2m	48'127	2m	3'231
3	3'723	3	207
4	0	4	0

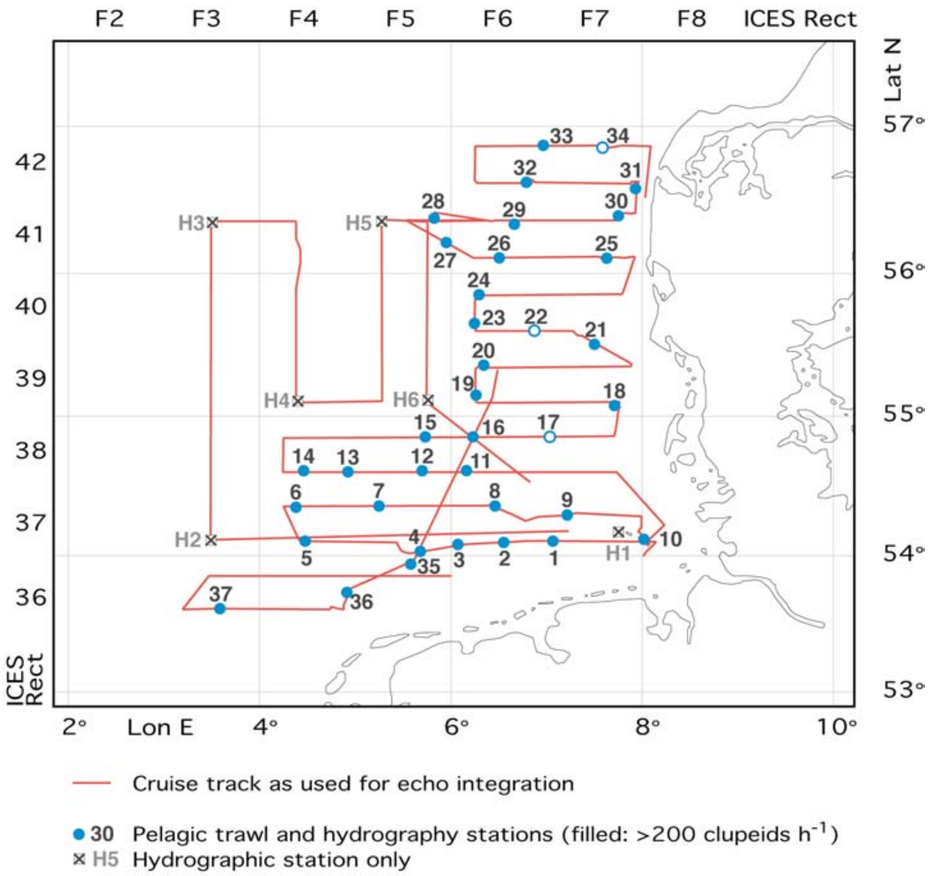

Figure IIF.1 FRV "Walther Herwig III", cruise 240: International hydroacoustic survey on herring in the North Sea, 21 June 2002 -12 July 2002: Cruise track, fishing stations and hydrographic stations.

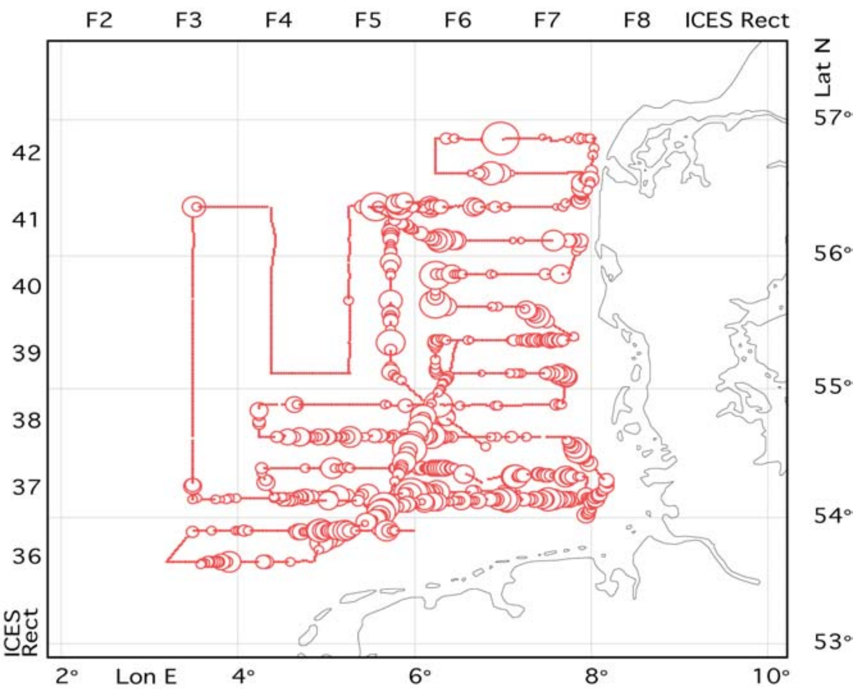

Figure IIF.2 FRV "Walther Herwig III", cruise 240: International hydroacoustic survey on herring in the North Sea, 21 June 2002 -12 July 2002: Post plot showing the distribution of total NASC values attributed to clupeids (sum per n.mi., on a proportional sq. root scale relative to the largest value of 10'949 $m^2 n.mi.^{-2}$). Smallest dots indicate zero values.

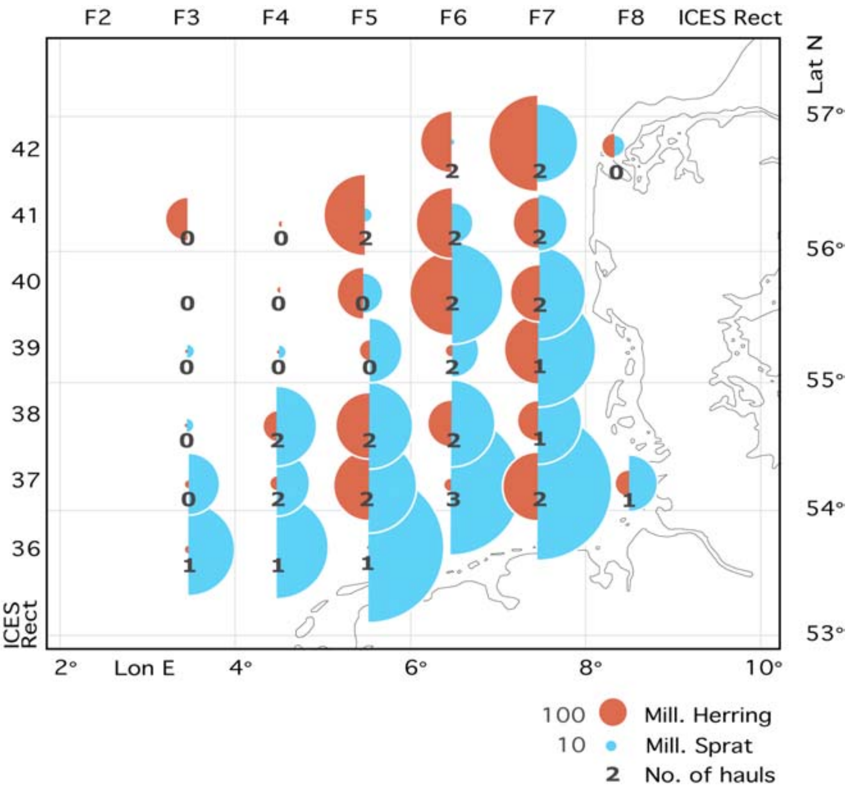

Figure IIF.**3** FRV "Walther Herwig III", cruise 240: International hydroacoustic survey on herring in the North Sea, 21 June 2002 -12 July 2002: Abundance of herring and sprat (circle diameter is proportional to abundance), relative proportion of herring and sprat, and number of hauls per statistical rectangle. Biological information for rectangle 41F3 was interpolated from neighbouring rectangles sampled by the Norwegian survey participants.

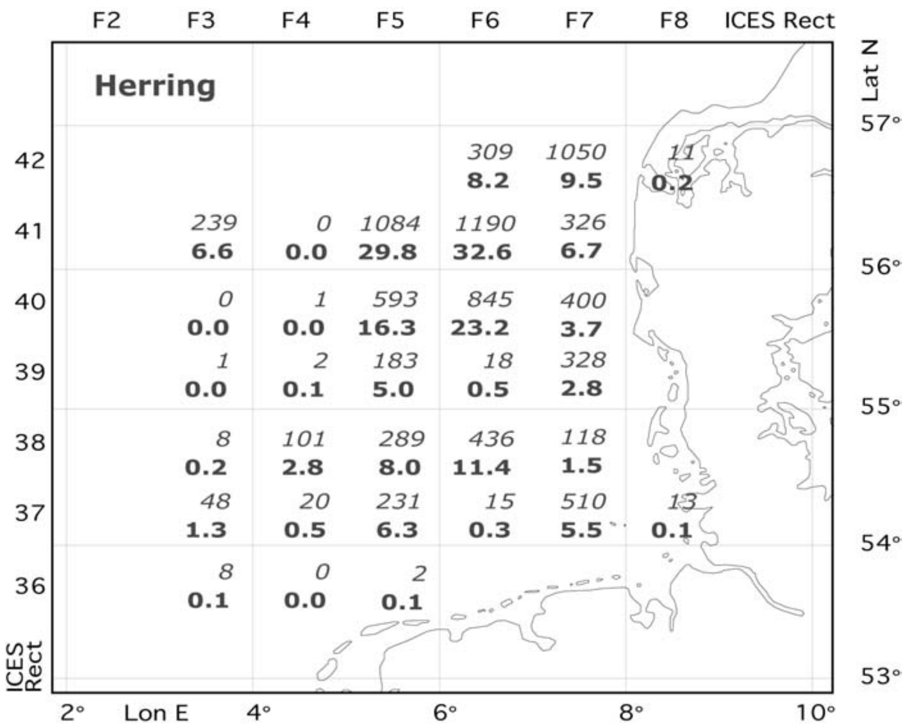

Figure IIF.**4** FRV "Walther Herwig III", cruise 240: International hydroacoustic survey on herring in the North Sea, 21 June 2002 -12 July 2002: Abundance (Mill. individuals, upper value in italics) and biomass (thousand t, lower value in bold) of herring per statistical rectangle. Biological information for rectangle 41F3 was interpolated from neighboring rectangles sampled by the Norwegian survey participants.

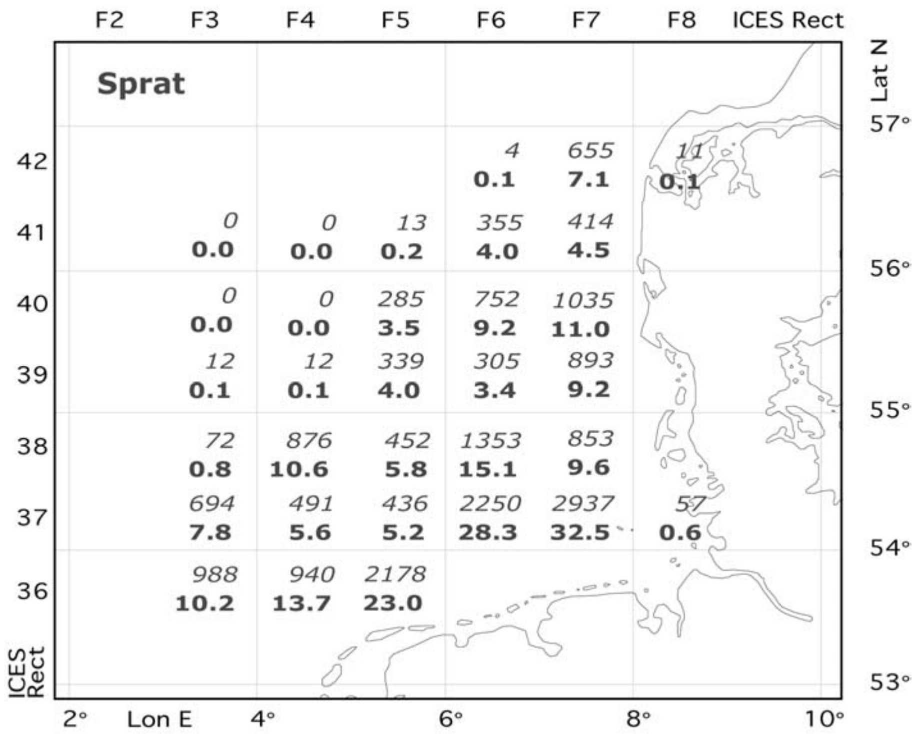

Figure IIF.5. FRV "Walther Herwig III", cruise 240: International hydroacoustic survey on herring in the North Sea, 21 June 2002 -12 July 2002: Abundance (Mill. individuals, upper value in italics) and biomass (thousand t, lower value in bold) of sprat per statistical rectangle. Biological information for rectangle 41F3 was interpolated from neighbouring rectangles sampled by the Norwegian survey participants.

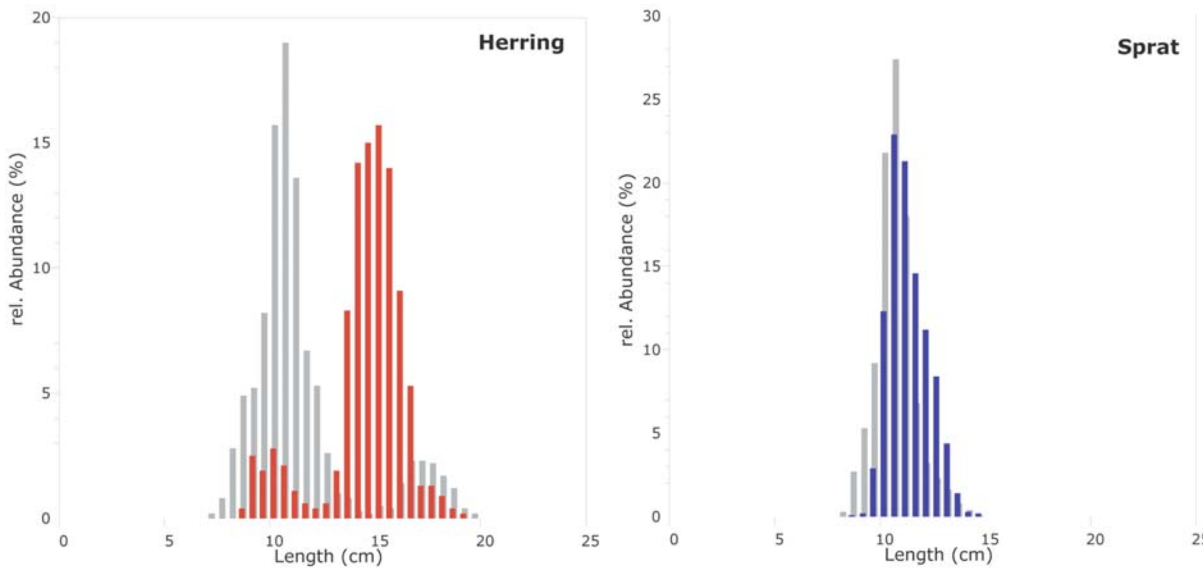

Figure IIF.6 FRV "Walther Herwig III", cruise 240: International hydroacoustic survey on herring in the North Sea, 21 June 2002 -12 July 2002: Relative length frequency distribution of herring (left panel) and sprat (right). Grey bars in the background represent last year's LF's (cruise So478, 2001).

APPENDIX III: WESTERN BALTIC ACOUSTIC SURVEY

Survey Report for RV "SOLEA"

14 – 25 October 2002

Federal Research Centre for Fisheries, Germany
Eberhard Götze [1] & Tomas Gröhsler [2]
[1] Inst. for Fishery Technology and Fish Quality, Hamburg, [2] Inst. for Baltic Sea Fisheries Rostock

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

'Baltic Fisheries Assessment Working Group (WGBFAS)'

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

2 METHODS

2.1 Personnel

E. Götze	Inst. for Fishery Technology and Fish Quality, Hamburg, in charge
Dr. T. Gröhsler	Institute for Baltic Sea Fisheries Rostock
U. Nielsen	DIFRES, Charlottenlund, Denmark
R. Oeberst	Institute for Baltic Sea Fisheries Rostock
G. Ulrich	Institute for Baltic Sea Fisheries Rostock

2.2 Narrative

The 498th cruise of RV 'Solea' represents the 15th subsequent survey and took place from 14th to 25th October in 2002. Due to technical problems with the winch on board of the research vessel, the survey started with a delay of more than two weeks. RV "SOLEA" left the port of Rostock/Warnemünde on 14th October 2002. The joint German-Danish acoustic survey was intended to cover the whole Subdivisions 21, 22, 23 and 24. Since the survey time has to be shortened the Kattegat area (Subdivision 21) could not be covered in 2002. The survey ended on 25th October 2002 in Kiel.

2.3 Survey design

For all Subdivisions the statistical rectangles were used as strata (ICES CM 2001/H:02 Ref.D: Annex 2). 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 7,900 NM^2. The cruise track (Figure 1) reached in total a length of 666 nautical miles.

2.4 Calibration

The transducer 38-26 was calibrated during the survey in Rostock/seaport. The calibration procedure was carried out as described in the 'Manual for the Baltic International Acoustic Surveys (BIAS)' (Annex 2 in the 'Report of the Baltic International Fish Survey Working Group', ICES CM 2001/H:02 Ref.D).

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)' (Annex 2 in the 'Report of the Baltic International Fish Survey Working Group', ICES CM 2001/H:02). The postprocessing of the stored echosignals 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 8-10 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 it is impossible to allocate the integrator readings 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) relationships:

Clupeoids	$TS = 20 \log L (cm) - 71.2$	(ICES 1983/H:12)
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 (Sa) 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 37 trawl hauls were carried out (16 hauls in Subdivision 22, 3 hauls in Subdivision 23 and 18 hauls in Subdivision 24). 1274 herring and 588 sprat were frosted for further investigations in the lab.

The results of the catch composition by Subdivision are presented in Tables 1-3. As in former years the catch composition was dominated by herring and to a lower extend by sprat.

The length distributions of herring and sprat of the years 2001 and 2002 are presented by Subdivision in Figures 2 and 3.

3.2 Acoustic data

The survey statistics concerning the survey area, the mean Sa, the mean scattering cross section σ, the estimated total number of fish, the percentages of herring and sprat per Subdivision/rectangle are shown in Table 4.

The horizontal distribution of Sa values (Figure 4 and Table 4) was similar to the years before. High fish concentrations were found in the Sound (Subdivision 23), in the Arkona Basin (Subdivision 24) and in the southern part of Subdivision 22. In the Belt Sea (northern part of Subdivision 22) the fish density was as low as in former years.

3.3 Abundance estimates

The total abundance of herring and sprat are presented in Table 4. The estimated number of herring and sprat by age group and Subdivision/rectangle are given in Table 5 and Table 8. The corresponding mean weights by age group and Subdivision/rectangle are shown in Table 6 and Table 9. The estimates of herring and sprat biomass by age group and Subdivision/rectangle are summarised in Table 7 and Table 10. It should be noted that the results in the Sound cannot be compared to last years results as this area could not be covered in 2001.

The herring stock was estimated to be 6.0 x 10^9 fish or about 195.2 x 10^3 tonnes in Subdivisions 22-24. The abundance estimates were dominated by young herring. Adult herring, which was concentrated in former years only in the Sound, could this year also be found in the deeper areas of the Arkona sea.

The estimated sprat stock was 6.7 x 10^9 fish or 58.1 x 10^3 tonnes in Subdivisions 22-24.

As for herring, the abundance estimates of sprat were dominated by young fish (Figure 3 and Table 8). The contribution of the age-groups 0 and 1 was 86% in numbers and 74% in biomass.

4 DISCUSSION

Caused by technical problems with the research vessel the Kattegat area could not be monitored this year. Last year the Sound (Subdivision 23) could not be surveyed due to the missing Swedish permission. Therefore last years results are only comparable with this years results of Subdivisions 22 and 24.

The total number of herring increased slightly by 24% compared to 2001. The present level is dominated by a high fraction of 0-group herring (Figure 2 and Table 5). The abundance of young herring was about 2 times higher compared to estimates of the last two years. The 2002 year class attained about the level of the big 1999 year class. Caused by the high fraction of young herring the total biomass reached only 84% of the estimated biomass in 2001.

The relatively high fraction of adult fish in the Arkona sea could be explained by the late survey time. Some adult herring could have been already migrated from the Sound into the Arkona sea on the way to the spring spawning areas around Rügen island.

The abundance of sprat in the Western Baltic was slightly lower than that of the last year. The last two years abundance estimates were about 3 times higher than in 2000. In 2000 the sprat abundance was on the lowest level for the last ten years. It should be noted that the whole time-series of the sprat abundance estimates is characterised by strong fluctuations from year to year.

5 REFERENCES

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

ICES 2001. Report of the Baltic International Fish Survey Working Group. ICES CM 2001/H:02 Ref.: D.

Foote, K.G., Aglen, A. & 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 22

Species/Haul No.	1	2	3	4	5	6	7	29	30	31
APHIA MINUTA									0,08	+
BELONE BELONE		0,04		0,11	0,05					
CLUPEA HARENGUS	0,36	0,29	16,23	6,44	10,34	130,76	22,24	4,26	3,59	1,04
CRANGON									+	
CTENOLABRUS RUPESTRIS										
ENGRAULIS ENCRASICOLUS				0,01	+			0,02	0,03	0,05
EUTRIGLA GURNARDUS				0,01						
GADUS MORHUA		0,65		7,02	2,12		2,41			
GASTEROSTEUS ACULEATUS			0,02	0,05	0,02	0,03	0,01	0,02	0,01	0,01
GOBIUS NIGER									+	
HYPEROPLUS LANCEOLATUS										0,01
LIMANDA LIMANDA		0,23	0,13	0,53	0,07			0,15	+	
LOLIGO									+	
MERLANGIUS MERLANGUS	0,19		+	0,02	+	0,75	0,31		+	
MYOXOCEPHALUS SCORPIUS										
POMATOSCHISTUS MINUTUS		+		0,01	+			+		
SOLEA VULGARIS		0,02								
SPINACHIA SPINACHIA										
SPRATTUS SPRATTUS	0,28	0,03	0,20	0,44	12,34	12,76	4,41	0,04	2,26	
TRACHURUS TRACHURUS	0,04		+	+	0,14	0,95	0,08		0,01	0,01
Total	**0,87**	**1,26**	**16,58**	**14,64**	**25,08**	**145,25**	**29,46**	**4,49**	**5,98**	**1,12**
Medusae	50,00	103,45	73,70	28,70	5,28	103,97	186,51	21,10	5,40	12,50

Species/Haul No.	32	33	34	35	36	37	Total
APHIA MINUTA	0,17	+	+				**0,25**
BELONE BELONE							**0,20**
CLUPEA HARENGUS		0,01	0,11	0,04	0,09	0,03	**195,83**
CRANGON							**+**
CTENOLABRUS RUPESTRIS			0,01				**0,01**
ENGRAULIS ENCRASICOLUS	0,31	+	+				**0,42**
EUTRIGLA GURNARDUS							**0,01**
GADUS MORHUA		0,11		13,02			**25,33**
GASTEROSTEUS ACULEATUS		0,19	0,31	0,03	0,37	0,14	**1,21**
GOBIUS NIGER	+		+	0,01	+		**0,01**
HYPEROPLUS LANCEOLATUS							**0,01**
LIMANDA LIMANDA	0,24	0,07		0,01		0,33	**1,76**
LOLIGO	0,34	0,02					**0,36**
MERLANGIUS MERLANGUS			0,01	0,11		0,01	**1,40**
MYOXOCEPHALUS SCORPIUS			0,06				**0,06**
POMATOSCHISTUS MINUTUS				+			**0,01**
SOLEA VULGARIS				0,02			**0,04**
SPINACHIA SPINACHIA	+						**+**
SPRATTUS SPRATTUS	+	0,17	1,02	0,69	0,74	0,02	**35,40**
TRACHURUS TRACHURUS	0,01			+			**1,24**
Total	**1,07**	**0,57**	**1,52**	**13,93**	**1,20**	**0,53**	**263,55**
Medusae	1,90	96,77	22,10	85,50	29,00		**825,87**

+ = < 0.01 kg

Table 2: Catch composition (kg/0.5 h) per haul No. in Sub-division 23

Species/Haul No.	26	27	28	Total
ANGUILLA ANGUILLA			0,68	**0,68**
CLUPEA HARENGUS	777,58	494,28	19,00	**1290,86**
ENGRAULIS ENCRASICOLUS			0,07	**0,07**
GADUS MORHUA	36,90	4,77	1,11	**42,78**
LIMANDA LIMANDA			0,02	**0,02**
LOLIGO			0,32	**0,32**
MELANOGRAMMUS AEGLEFINUS	0,86	0,92		**1,78**
MERLANGIUS MERLANGUS	39,04	11,73	49,30	**100,07**
MERLUCCIUS MERLUCCIUS		0,21		**0,21**
MULLUS SURMULETUS			0,03	**0,03**
SOLEA VULGARIS	0,45			**0,45**
SPRATTUS SPRATTUS	0,16	8,18	14,34	**22,68**
TRACHINUS DRACO		0,04		**0,04**
TRACHURUS TRACHURUS			0,04	**0,04**
Total	**854,99**	**520,13**	**84,91**	**1460,03**

Table 3: Catch composition (kg/0.5 h) per haul No. in Sub-division 24

Species/Haul No.	8	9	10	11	12	13	14	15	16	17
ANGUILLA ANGUILLA					1,11			0,19	1,86	
BELONE BELONE				0,09		0,10				0,10
CLUPEA HARENGUS	11,25	40,44	37,11	99,40	42,97	68,75	1,52	9,36	8,57	10,00
ENGRAULIS ENCRASICOLUS	0,05			0,02	0,01				0,05	0,01
GADUS MORHUA	7,06	7,90	0,24	1,09	0,99	0,44		4,51	1,83	2,07
GASTEROSTEUS ACULEATUS	0,06			0,01	0,02	0,04 +				
LIMANDA LIMANDA	1,77									
MERLANGIUS MERLANGUS	26,23	0,15	0,03	0,03	3,14	0,30		1,26	3,96	
OSMERUS EPERLANUS						0,07				
PLATICHTHYS FLESUS							0,19			
PLEURONECTES PLATESSA								0,22		
POMATOSCHISTUS MINUTUS				0,03	0,50	0,01 +			0,08	0,19
SALMO TRUTTA		0,22								
SOLEA VULGARIS	0,02									
SPRATTUS SPRATTUS	7,05	2,68	0,22	0,07	1,62	9,75	0,68	79,39	200,82	5,39
TRACHURUS TRACHURUS				0,03	0,04				0,10	0,02
Total	**53,49**	**51,39**	**37,60**	**100,77**	**50,40**	**79,46**	**2,39**	**94,93**	**217,27**	**17,78**
Medusae	2,55	9,29	150,00	13,07	11,06	34,13	6,35	31,93	37,70	17,49

Species/Haul No.	18	19	20	21	22	23	24	25	Total
ANGUILLA ANGUILLA				0,10					**3,26**
BELONE BELONE				0,05			0,17		**0,51**
CLUPEA HARENGUS	1,26	13,41	8,57	4,77	23,84	5,05	11,43	4,29	**401,99**
ENGRAULIS ENCRASICOLUS			0,01	0,01					**0,16**
GADUS MORHUA		4,74	1,22	2,87			0,44	0,20	**35,60**
GASTEROSTEUS ACULEATUS									**0,13**
LIMANDA LIMANDA									**1,77**
MERLANGIUS MERLANGUS	0,47	0,20	0,37	0,46				0,01	**36,61**
OSMERUS EPERLANUS									**0,07**
PLATICHTHYS FLESUS									**0,19**
PLEURONECTES PLATESSA									**0,22**
POMATOSCHISTUS MINUTUS	0,06		+						**0,87**
SALMO TRUTTA									**0,22**
SOLEA VULGARIS									**0,02**
SPRATTUS SPRATTUS	0,17	34,14	31,50	91,35	25,36	18,89	2,99	0,02	**512,09**
TRACHURUS TRACHURUS				0,06		0,03			**0,28**
Total	**1,96**	**52,49**	**41,67**	**99,67**	**49,20**	**23,97**	**15,03**	**4,52**	**993,99**
Medusae	19,90	28,59	12,00	8,88	53,73	87,00	17,90	43,60	**573,16**

Table 4 Survey statistics RV "Solea" October 2002

Sub-division	ICES Rectangle	Area (nm²)	Sa (m²/NM²)	Sigma (cm²)	N total (million)	Herring (%)	Sprat (%)	NHerring (million)	NSprat (million)
22	**37G0**	209,9	122,6	1,303	197,45	85,92	10,67	169,66	21,07
22	**37G1**	723,3	390,5	1,619	1744,21	63,67	35,71	1110,53	622,78
22	**38G0**	735,3	132,0	1,303	744,72	85,92	10,67	639,89	79,45
22	**38G1**	173,2	240,5	1,279	325,76	87,77	6,26	285,91	20,39
22	**39F9**	159,3	70,4	0,675	166,21	1,89	64,31	3,14	106,89
22	**39G0**	201,7	41,2	0,932	89,18	47,59	2,47	42,44	2,20
22	**39G1**	250,0	89,2	0,780	285,75	32,39	42,43	92,56	121,23
22	**40F9**	51,3	18,0	0,368	25,07	1,02	28,67	0,26	7,19
22	**40G0**	538,1	42,7	0,368	623,83	1,02	28,67	6,36	178,82
	Total	3042,1			4202,2			2350,75	1160,02
23	**40G2**	164,0	1295,1	4,639	457,81	95,92	2,59	439,14	11,84
23	**41G2**	72,3	452,1	4,525	72,23	29,09	44,18	21,01	31,91
	Total	236,3			530,04			460,15	43,75
24	**37G2**	192,4	148,0	2,468	115,37	20,07	67,31	23,16	77,66
24	**38G2**	832,9	184,9	2,188	703,69	76,40	19,74	537,60	138,88
24	**38G3**	865,7	616,1	2,466	2163,02	41,83	48,01	904,76	1038,44
24	**38G4**	1034,8	351,9	1,046	3481,63	31,13	67,72	1083,68	2357,84
24	**39G2**	406,1	186,2	2,739	276,09	58,35	11,89	161,10	32,82
24	**39G3**	765,0	266,4	1,831	1112,99	26,29	73,70	292,60	820,22
24	**39G4**	524,8	343,9	1,580	1142,04	13,67	86,30	156,16	985,56
	Total	4621,7			8994,83			3159,06	5451,42
22-24	**Total**	7900,1			13727,05			5969,96	6655,19

Table 5 Estimated numbers (millions) of herring RV "Solea" October 2002

Sub-division	Rectangle/ Age group	0	1	2	3	4	5	6	7	8+	Total
22	**37G0**	166,43	3,15	0,06	0,02						169,66
22	**37G1**	819,65	238,85	20,79	19,35	10,41		1,49			1110,54
22	**38G0**	627,71	11,87	0,23	0,08						639,89
22	**38G1**	278,96	6,95								285,91
22	**39F9**	3,14	0,00								3,14
22	**39G0**	42,20	0,24								42,44
22	**39G1**	91,25	1,31								92,56
22	**40F9**	0,24	0,02								0,26
22	**40G0**	5,96	0,40								6,36
	Total	2035,54	262,79	21,08	19,45	10,41	0,00	1,49	0,00	0,00	2350,76
23	**40G2**	39,51	164,11	123,70	75,79	26,04	5,30	2,38	1,83	0,47	439,13
23	**41G2**	9,43	9,47	1,12	0,59	0,28	0,07	0,03	0,02	0,01	21,02
	Total	48,94	173,58	124,82	76,38	26,32	5,37	2,41	1,85	0,48	460,15
24	**37G2**	12,76	3,40	2,98	2,84	0,90	0,21	0,05		0,02	23,16
24	**38G2**	350,75	19,09	32,38	73,15	46,08	10,11	3,45	0,22	2,38	537,61
24	**38G3**	236,57	60,08	101,46	270,07	187,83	29,24	10,90	0,60	8,00	904,75
24	**38G4**	989,66	22,81	25,50	31,31	11,34	2,13	0,63		0,31	1083,69
24	**39G2**	64,49	2,66	16,62	36,75	28,78	7,60	2,76		1,44	161,10
24	**39G3**	181,14	29,14	25,13	34,58	17,08	3,94	1,13		0,47	292,61
24	**39G4**	64,63	37,38	22,31	21,07	8,06	1,97	0,56		0,18	156,16
	Total	1900,00	174,56	226,38	469,77	300,07	55,20	19,48	0,82	12,80	3159,08
22-24	**Total**	3984,48	610,93	372,28	565,60	336,80	60,57	23,38	2,67	13,28	5969,99

Table 6 Herring mean weight (g) per age group RV "Solea" October 2002

Sub-division	Rectangle/ Age group	0	1	2	3	4	5	6	7	8+	Total
22	**37G0**	9,39	32,49	56,60	56,60						9,84
22	**37G1**	9,34	37,27	60,73	65,14	73,73		94,00			18,00
22	**38G0**	9,39	32,49	56,60	56,60						9,84
22	**38G1**	9,84	35,78								10,47
22	**39F9**	12,85									12,83
22	**39G0**	12,48	35,23								12,61
22	**39G1**	9,86	32,42								10,18
22	**40F9**	8,90	35,23								10,77
22	**40G0**	8,90	35,23								10,55
	Total	9,52	36,93	60,67	65,10	73,73		94,03			13,84
23	**40G2**	10,70	47,98	80,59	109,06	139,20	185,83	179,20	193,81	197,82	72,91
23	**41G2**	10,04	38,04	67,34	114,96	161,25	173,81	173,10	194,51	197,82	31,71
	Total	10,57	47,44	80,47	109,11	139,44	185,68	179,13	193,84	197,92	71,02
24	**37G2**	6,71	36,01	61,67	67,59	72,06	59,64	75,89		43,10	28,75
24	**38G2**	6,39	35,38	70,23	100,30	120,31	150,47	148,24	233,95	163,67	38,22
24	**38G3**	7,48	33,91	74,12	104,79	121,20	144,52	147,80	230,94	139,31	76,80
24	**38G4**	7,26	35,54	63,28	77,34	92,70	73,32	82,76		100,48	12,29
24	**39G2**	8,34	34,01	73,33	102,27	123,57	151,55	154,51		141,61	67,93
24	**39G3**	8,69	33,08	64,48	86,02	101,94	113,51	109,58		118,71	32,47
24	**39G4**	9,25	34,09	60,32	71,93	81,47	64,64	70,14		83,74	35,68
	Total	7,36	34,23	69,69	98,98	117,90	138,44	142,08	231,83	141,47	41,16
22-24	**Total**	8,50	39,14	72,79	99,19	118,22	142,63	142,84	205,51	143,51	32,71

Table 7 Herring total biomass (t) per age group RV "Solea" October 2002

Sub-division	Rectangle/ Age group	0	1	2	3	4	5	6	7	8+	Total
22	37G0	1562,8	102,3	3,4	1,1						1669,6
22	37G1	7655,5	8901,9	1262,6	1260,5	767,5		140,1			19988,1
22	38G0	5894,2	385,7	13,0	4,5						6297,4
22	38G1	2745,0	248,7								2993,7
22	39F9	40,3									40,3
22	39G0	526,7	8,5								535,2
22	39G1	899,7	42,5								942,2
22	40F9	2,1	0,7								2,8
22	40G0	53,0	14,1								67,1
	Total	19379,3	9704,4	1279,0	1266,1	767,5	0,0	140,1	0,0	0,0	32536,4
23	40G2	422,8	7874,0	9969,0	8265,7	3624,8	984,9	426,5	354,7	93,0	32015,4
23	41G2	94,7	360,2	75,4	67,8	45,2	12,2	5,2	3,9	2,0	666,6
	Total	517,5	8234,2	10044,4	8333,5	3670,0	997,1	431,7	358,6	95,0	32682,0
24	37G2	85,6	122,4	183,8	192,0	64,9	12,5	3,8		0,9	665,9
24	38G2	2241,3	675,4	2274,0	7336,9	5543,9	1521,3	511,4	51,5	389,5	20545,2
24	38G3	1769,5	2037,3	7520,2	28300,6	22765,0	4225,8	1611,0	138,6	1114,5	69482,5
24	38G4	7184,9	810,7	1613,6	2421,5	1051,2	156,2	52,1		31,1	13321,3
24	39G2	537,8	90,5	1218,7	3758,4	3556,3	1151,8	426,4		203,9	10943,8
24	39G3	1574,1	964,0	1620,4	2974,6	1741,1	447,2	123,8		55,8	9501,0
24	39G4	597,8	1274,3	1345,7	1515,6	656,6	127,3	39,3		15,1	5571,7
	Total	13991,0	5974,6	15776,4	46499,6	35379,0	7642,1	2767,8	190,1	1810,8	130031,4
22-24	Total	33887,8	23913,2	27099,8	56099,2	39816,5	8639,2	3339,6	548,7	1905,8	195249,8

Table 8 Estimated numbers (millions) of sprat RV "Solea" October 2002

Sub-division	Rectangle/ Age group	0	1	2	3	4	5	6	7	8+	Total
22	37G0	11,77	5,84	1,37	0,32	0,88	0,88				21,06
22	37G1	345,42	168,07	53,26	27,80	16,24	9,76	2,23			622,78
22	38G0	44,39	22,04	5,18	1,22	3,31	3,31				79,45
22	38G1	13,27	5,54	1,14	0,26	0,14	0,03				20,38
22	39F9	105,85	0,97	0,06							106,88
22	39G0	2,20									2,20
22	39G1	120,69	0,44	0,08	0,03						121,24
22	40F9	7,18									7,18
22	40G0	178,71	0,11								178,82
	Total	829,48	203,01	61,09	29,63	20,57	13,98	2,23	0,00	0,00	1159,99
23	40G2	4,26	1,21	1,67	3,02	1,12	0,41	0,15			11,84
23	41G2		14,41	5,60	10,93	0,43	0,53	0,01			31,91
	Total	4,26	15,62	7,27	13,95	1,55	0,94	0,16	0,00	0,00	43,75
24	37G2	73,45	2,74	0,44	0,49	0,20	0,22	0,11		0,01	77,66
24	38G2	94,52	27,56	4,37	6,72	2,35	2,17	0,85	0,01	0,34	138,89
24	38G3	579,03	348,19	32,29	49,56	9,28	15,53	1,00	0,03	3,51	1038,42
24	38G4	2075,53	177,27	29,90	36,25	15,90	11,30	10,23	0,18	1,28	2357,84
24	39G2	14,54	15,08	1,40	1,05	0,27	0,26	0,22			32,82
24	39G3	51,85	502,10	79,29	91,64	37,60	35,44	18,50	0,81	2,99	820,22
24	39G4	291,19	460,79	73,35	77,11	31,29	31,56	17,94	0,36	1,97	985,56
	Total	3180,11	1533,73	221,04	262,82	96,89	96,48	48,85	1,39	10,10	5451,41
22-24	Total	4013,85	1752,36	289,40	306,40	119,01	111,40	51,24	1,39	10,10	6655,15

Table 9 Sprat mean weight (g) per age group RV "Solea" October 2002

Sub-division	Rectangle/ Age group	0	1	2	3	4	5	6	7	8+	Total
22	**37G0**	6,26	14,82	24,15	14,33	28,67	28,67				11,79
22	**37G1**	5,54	17,00	19,46	22,38	22,32	24,94	26,28			11,39
22	**38G0**	6,26	14,82	24,15	14,33	28,67	28,67				11,79
22	**38G1**	6,97	15,77	18,17	18,57	19,98	20,53				10,25
22	**39F9**	4,86	12,85	18,52							4,94
22	**39G0**	4,64									4,64
22	**39G1**	4,66	16,06	16,82	16,82						4,71
22	**40F9**	3,51	9,22								3,51
22	**40G0**	3,51	9,22								3,51
	Total	4,94	16,64	19,93	21,92	23,60	26,04	26,28			8,84
23	**40G2**	4,97	16,02	18,39	19,20	22,76	20,98	23,39			14,10
23	**41G2**		15,30	16,14	16,36	19,83	17,95	21,95			15,92
	Total	4,98	15,36	16,66	16,97	21,94	19,26	23,13			15,42
24	**37G2**	4,76	11,99	14,99	16,13	16,41	15,61	16,55		17,93	5,22
24	**38G2**	4,82	13,38	15,23	16,62	16,73	16,35	16,55	19,38	17,93	7,90
24	**38G3**	4,28	13,20	14,12	16,55	17,72	16,44	16,97	19,38	17,93	8,52
24	**38G4**	4,83	12,26	15,44	16,56	17,17	16,91	16,76	19,38	17,93	5,90
24	**39G2**	5,28	12,48	13,78	14,22	16,23	15,31	16,55			9,48
24	**39G3**	4,94	13,40	15,18	16,37	17,15	16,47	16,65	19,38	17,93	13,77
24	**39G4**	4,78	13,30	15,09	16,10	16,91	16,13	16,69	19,38	17,93	11,41
	Total	4,73	13,18	15,02	16,35	17,12	16,40	16,69	19,38	17,93	8,65
22-24	**Total**	4,77	13,60	16,10	16,92	18,30	17,63	17,13	19,42	17,93	8,72

Table 10 Sprat total biomass (t) per age group RV "Solea" October 2002

Sub-division	Rectangle/ Age group	0	1	2	3	4	5	6	7	8+	Total
22	**37G0**	73,7	86,5	33,1	4,6	25,2	25,2				248,3
22	**37G1**	1913,6	2857,2	1036,4	622,2	362,5	243,4	58,6			7093,9
22	**38G0**	277,9	326,6	125,1	17,5	94,9	94,9				936,9
22	**38G1**	92,5	87,4	20,7	4,8	2,8	0,6				208,8
22	**39F9**	514,4	12,5	1,1							528,0
22	**39G0**	10,2									10,2
22	**39G1**	562,4	7,1	1,3	0,5						571,3
22	**40F9**	25,2									25,2
22	**40G0**	627,3	1,0								628,3
	Total	4097,2	3378,3	1217,7	649,6	485,4	364,1	58,6	0,0	0,0	10250,9
23	**40G2**	21,2	19,4	30,7	58,0	25,5	8,6	3,5			166,9
23	**41G2**		220,5	90,4	178,8	8,5	9,5	0,2			507,9
	Total	21,2	239,9	121,1	236,8	34,0	18,1	3,7	0,0	0,0	674,8
24	**37G2**	349,6	32,9	6,6	7,9	3,3	3,4	1,8		0,2	405,7
24	**38G2**	455,6	368,8	66,6	111,7	39,3	35,5	14,1	0,2	6,1	1097,9
24	**38G3**	2478,2	4596,1	455,9	820,2	164,4	255,3	17,0	0,6	62,9	8850,6
24	**38G4**	10024,8	2173,3	461,7	600,3	273,0	191,1	171,5	3,5	23,0	13922,2
24	**39G2**	76,8	188,2	19,3	14,9	4,4	4,0	3,6			311,2
24	**39G3**	256,1	6728,1	1203,6	1500,1	644,8	583,7	308,0	15,7	53,6	11293,7
24	**39G4**	1391,9	6128,5	1106,9	1241,5	529,1	509,1	299,4	7,0	35,3	11248,7
	Total	15033,0	20215,9	3320,6	4296,6	1658,3	1582,1	815,4	27,0	181,1	47130,0
22-24	**Total**	19151,4	23834,1	4659,4	5183,0	2177,7	1964,3	877,7	27,0	181,1	58055,7

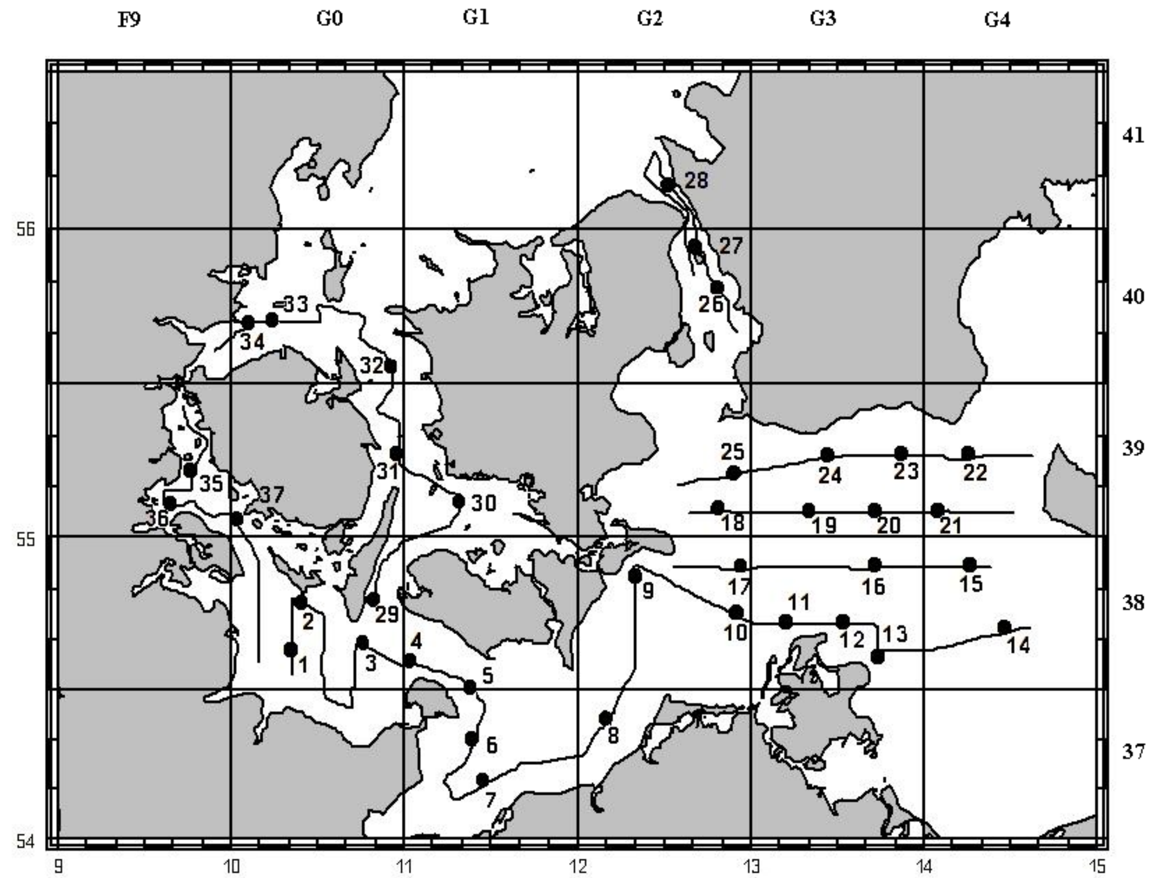

Figure 1 Cruise track and trawl positions for RV „SOLEA" in October 2002

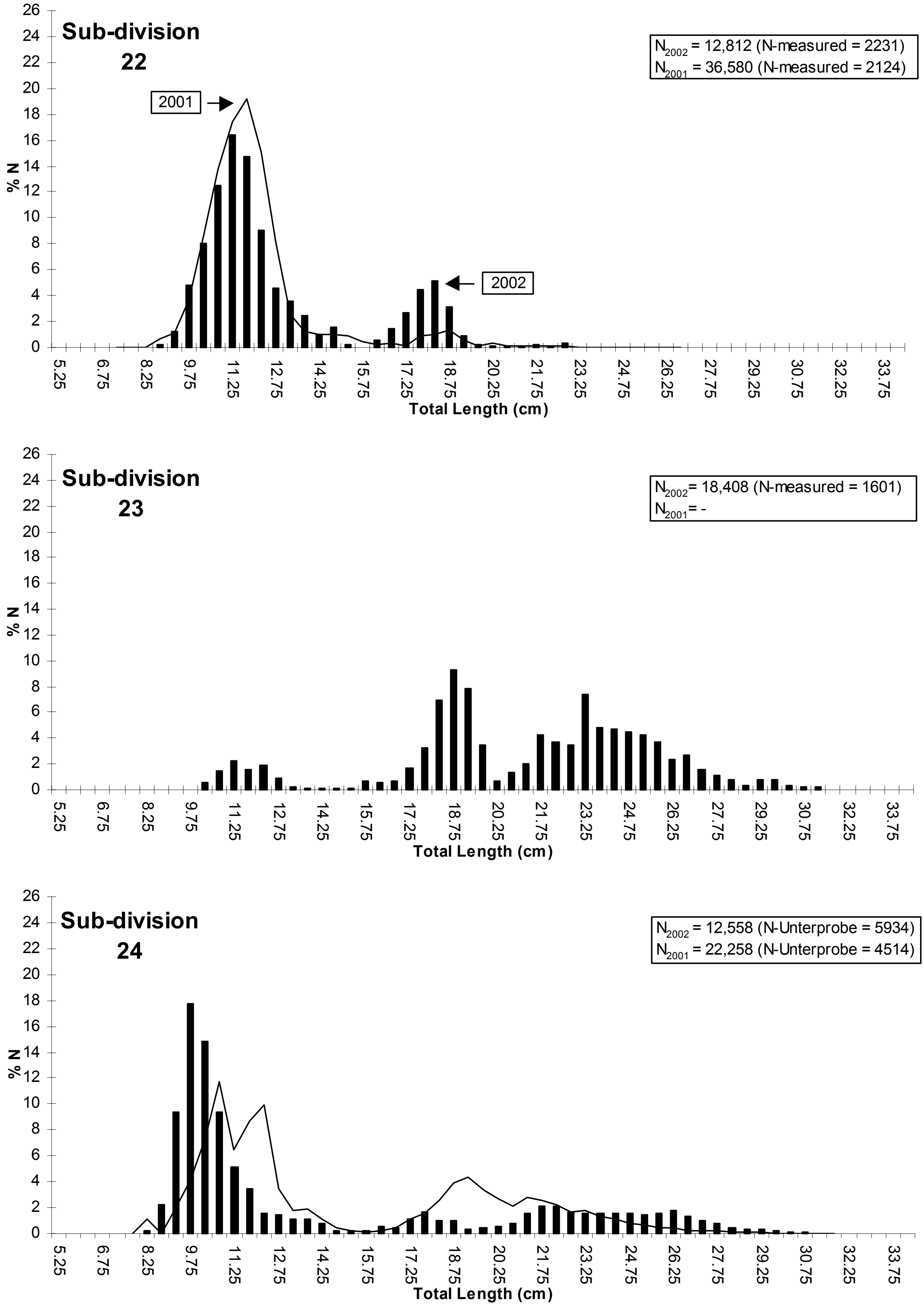

Figure 2 Length distribution of herring in Subdivisions 22, 23 and 24 in 2001 (=line) and in 2002 (=bar)

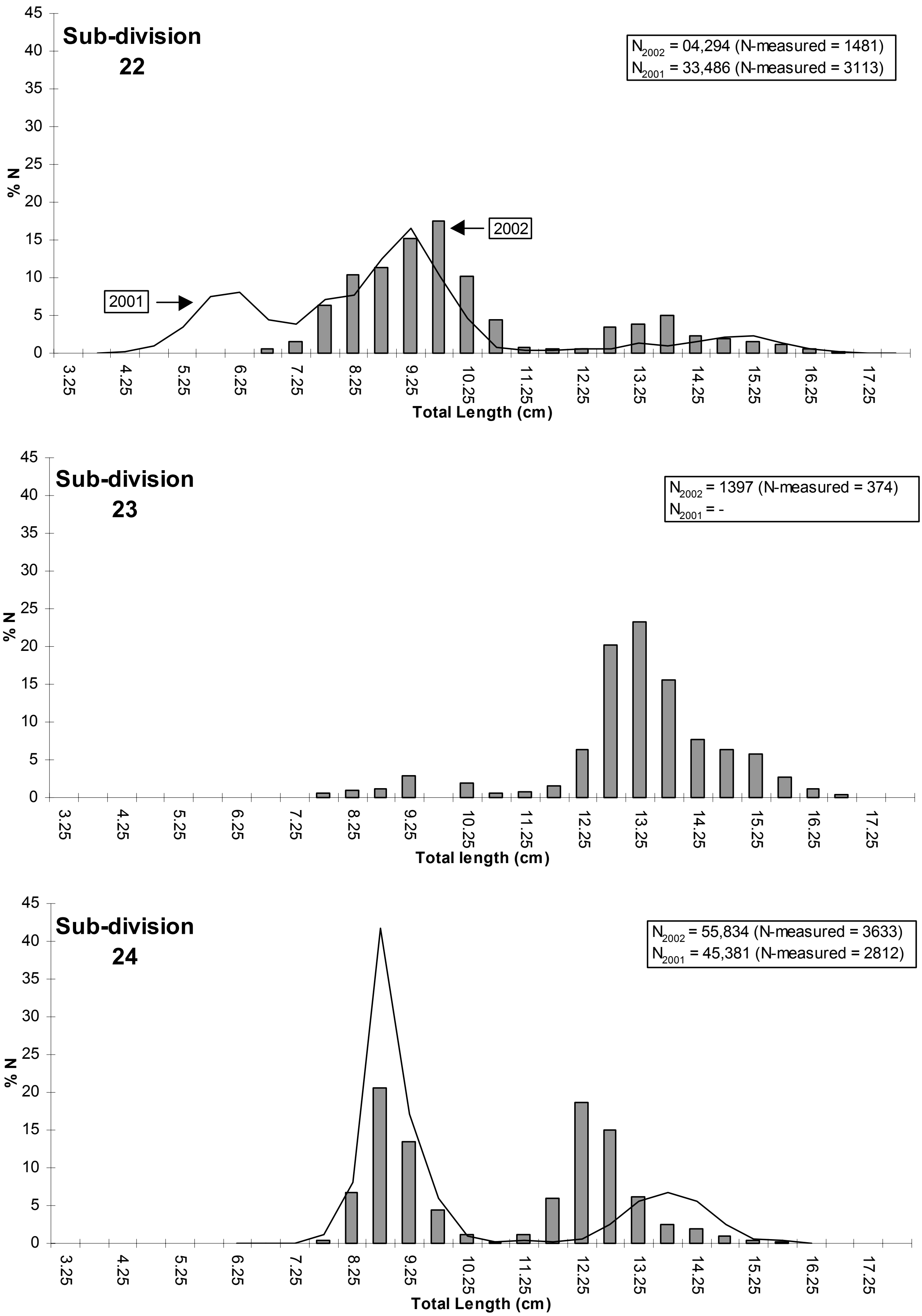

Figure 3 Length distribution of sprat in Subdivisions 22, 23 and 24 in 2001 (=line) and in 2002 (=bar)

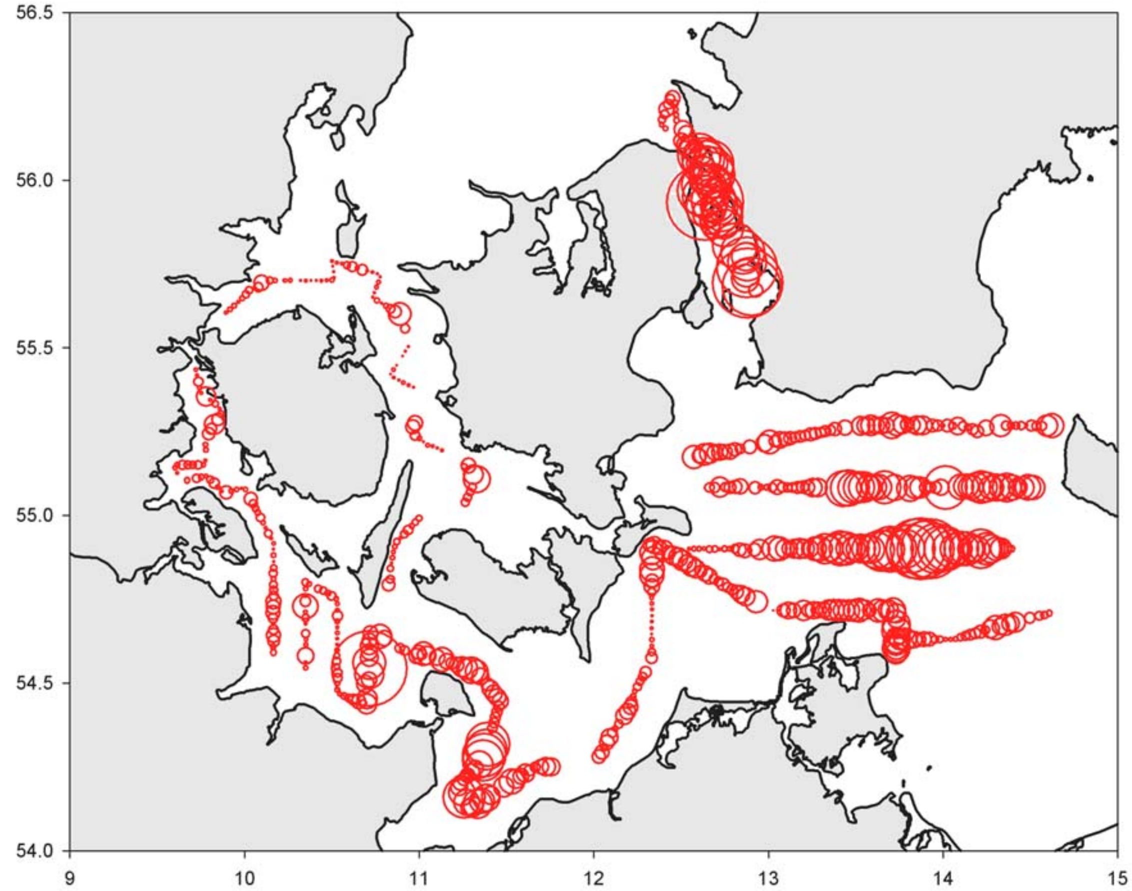

Figure 4 Distribution of NASC values for RV "SOLEA" in October 2002

APPENDIX IV

MANUAL FOR HERRING ACOUSTIC SURVEYS IN ICES DIVISIONS III, IV AND VIa

Version 3.1

February 2003

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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 manual and Foote *et al.* (1987). Ideally, the procedure as described in the Simrad manual 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 which 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 & Simmonds 1992 for equations) and entered into the EK500.

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 & 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).

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 manual and are defined as follows.

Table 1 Calibration report sheet

Calibration report	
Frequency (kHz)	
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)			

Calibrated 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			

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.

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*. (in press).

Ship's speed during the survey is typically 10-12 knots. At higher speeds, problems are encountered with engine noise or propellor 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.

Table 2 Important calibration and survey settings, 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. 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 Sonardata 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.

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.

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 herring survey. “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	Height	Spread
		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	36.0	36.0	70.0	87.0	256.0	800	600	400	200	100	38	**20**	14	20

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:

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

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.

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

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:

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

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 chairman 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 two data sheets: 1) the cruise sheet by ICES statistical rectangle (Table 6); and the proportions by age class sheet (Table 7).

The cruise sheet consists of six columns of data with as many rows as there are statistical rectangles sampled in the survey. The six columns are: the central (decimalised) latitude of the ICES rectangle; central (decimalised) longitude of the ICES rectangle; the biological Subarea to which the ICES rectangle belongs; the ICES statistical rectangle code (calculated according to the first two columns); herring abundance in millions of fish; and the survey weight (in nautical miles of survey track per rectangle). Part of an example data sheet is given in Table 6.

The proportions data contains the proportion of North Sea autumn spawners and Baltic spring spawners broken down according to biological subareas (in rows) and age/maturity (in columns). These proportions can be submitted as actual proportions or as total abundances. It also contains the mean weights-at-age/maturity by biological Subarea for North Sea autumn spawners and Baltic spring spawners. Ages of autumn spawning herring should be submitted as winter ring (where winter ring = age class – 1). Sprat and spring spawning herring ages are expressed as age class. An example of this data sheet is given in Table 7.

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 t 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).

A cruise report should be produced 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 (www.dfu.min.dk/hersur) through XLM files described in the HERSUR Exchange Format Specification. A users guide to the Internet site and upload procedure will be submitted in March 2000.

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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.

Lat long stat square: For location enter either central location in latitude and longitude (and decimal) or enter alpha numeric code for statistical rectangle

Stratum: Enter biological strata as alpha numeric code of your choice - see proportions page e.g. A, B, etc.

Abundance: Enter number of herring (millions) for the location. If estimates are for part of stat rects just give the estmate for the area you use and a series of entries that sum to the total for your estimate of the abundance for the stat square. If abundance is for multiple stat rectangles please aportion between rectangles in any proportion you prefer and ensure total is consistent.

Total Num/Biomas: Enter total number and total biomass as a cross check this is an important check and must be filled in

Survey mileage: Enter the aproximate number of miles of survey (acoustic data) track used to estimate the abundance – i.e. Two transects = 60 n.mi. Survey mileage is only used to weight multiple surveys in same area and approximate values are adequate.

yyyy Cruise sheet on ICES stat square scale.

Ship name and country (in here):

VERSION 22.08.2002

Total Numbers (millions)	
Total Biomass (thousands t)	

		Lat.	**Long.**	**Stratum**	**Statistical Rectangle**	**Abundance Millions**	**Survey mileage**
Origin:	**00A0**	59.75	2.5	**A**	**48F2**	15.00	30
lat	**35.5**	59.75	3.5	**A**	**48F3**	9.35	60
long	**-50**	59.25	2.5	**B**	**47F2**	2.65	30
		59.25	3.5	**B**	**47F3**	12.33	60
					-71F0		
					-71F0		
					-71F0		
					-71F0		
					-71F0		
					-71F0		
					-71F0		
					-71F0		
					-71F0		
					-71F0		
					-71F0		
					-71F0		
					-71F0		
					-71F0		

Table 7 An example of the excel worksheet used to submit survey data broken down by age/sub area - the 'proportions sheet'

	North Sea Autumn spawners. Abundance (Millions)......									**Mean weights and lengths in over here >>>>>> Weights - column AC, lengths in column BC**				
Sum	**Stratum**	**0**	**1i**	**1m**	**2i**	**2m**	**3i**	**3m**	**4**	**5**	**6**	**7**	**8**	**9+**
77.000	**A**	0.000	0.000	24.987	0.555	51.281	0.000	0.177	0.000	0.000	0.000	0.000	0.000	0.000
48.300	**B**	0.000	0.000	0.000	0.000	47.620	0.000	0.680	0.000	0.000	0.000	0.000	0.000	0.000
109.600	**C**	0.000	0.000	8.921	0.000	100.679	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
217.500	**D**	0.000	0.000	0.000	0.000	214.048	0.000	3.452	0.000	0.000	0.000	0.000	0.000	0.000
0.801	**E**	0.000	0.000	0.303	0.004	0.490	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000
494.200	**F**	0.000	0.000	191.716	4.260	298.224	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

North Sea Autumn spawners.... Mean weight (grams).....												
0	**1i**	**1m**	**2i**	**2m**	**3i**	**3m**	**4**	**5**	**6**	**7**	**8**	**9+**
0.000	6.375	6.375	27.750	35.826		70.429	120.667	181.000	0.000	0.000	0.000	0.000
0.000	6.375	6.375	27.750	35.826		70.429	120.667	181.000	0.000	0.000	0.000	0.000
0.000	6.375	6.375	27.750	35.826		70.429	120.667	181.000	0.000	0.000	0.000	0.000
0.000	6.375	6.375	27.750	35.826		70.429	120.667	181.000	0.000	0.000	0.000	0.000
0.000	6.375	6.375	27.750	35.826		70.429	120.667	181.000	0.000	0.000	0.000	0.000
0.000	6.375	6.375	27.750	35.826		70.429	120.667	181.000	0.000	0.000	0.000	0.000

North Sea Autumn spawners.... Mean length (cm).....												
0	**1i**	**1m**	**2i**	**2m**	**3i**	**3m**	**4**	**5**	**6**	**7**	**8**	**9+**
	19.6		23.2	24.2		25.6	26.7	26.3	27.8	27.5	27.0	26.5
			24.9	25.2	25.0	26.3	27.1	27.5	27.7	27.9	28.3	28.7
			24.5	25.8	25.0	26.6	27.4	27.8	27.9	28.2	28.5	28.5
	19.0		23.3	24.0		25.0		28.0	27.5	28.0		
	21.0		22.0	23.9		25.8						
	20.9		24.0	25.1		26.2	27.6	28.1	28.6	28.6		31.0

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	2. Virgin	1. Virgin
	2. Small gonads			
Mature	3. Gonads half cavity	2. Maturing	4. Maturing	2. Maturing
	4. Gonads long cavity			
	5. Gonads fill cavity			
	6. Ripe & running	3. Spawning	6. Spawning	3. Spawning
	7. Spent	4. Spent	8. Spent & Recovering	4. Spent
	8. Recovering spents	5. Resting		

Table 9 Maturity classification of female herring as used in the 2002 survey.

Netherlands & Germany	Norway	Scotland & Denmark
0= undefined	0= undecided / not checked	
1= virgin 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
	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 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
	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
	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 $\mathbf{F}_{low}$
3= spawning 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 $\mathbf{F}_{low}$ freely
4= spent 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
	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)

Table 10 Maturity classification of male herring as used in the 2002 survey.

<table>
<tr><th>Netherlands & Germany</th><th>Norway</th><th>Scotland & Denmark</th></tr>
<tr><td>0= undefined</td><td>0= undecided / not checked</td><td></td></tr>
<tr><td rowspan="2">1= virgin
testes are long, very thin, translucent and transparent ribbons lying along an unbranched blood vessel; no sign of development; round end</td><td>1= immature (a)
thread-like, thin, completely transperent and colourless; sex difficult to determine</td><td>1= Virgin herring
gonads very small – threadlike; 2-3 mm broad; testes whitish or grey brown</td></tr>
<tr><td>2= immature (b)
somewhat larger in volume; sex easier determined; still transparent with hint of colour</td><td>2= Virgin herring with small sexual organs
height of testes is about 3-8 mm; testes a reddish grey colour</td></tr>
<tr><td rowspan="3">2= maturing
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</td><td>3= maturing (a)
opaque but developed in volume; distinct veins; ovaries with yellow/white eggs in lamellae; can occupy half body cavity or more</td><td>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</td></tr>
<tr><td>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</td><td>4= maturing
gonads are almost as long as the body cavity; testes whitish</td></tr>
<tr><td>5= maturing (c)
ovaries fill the entire body cavity; most eggs transparent</td><td>5= maturing
gonads fill the body cavity; testes are milky white; sperm does not $\mathbf{F}_{low}$ but can be extruded by pressure</td></tr>
<tr><td>3= spawning
sperm/milk is Flowing out or is extruded using moderate pressure to the fish body</td><td>6= spawning
running gonads when light pressure is applied</td><td>6= spawning
ripe gonads; testes white; sperm $\mathbf{F}_{low}$ freely</td></tr>
<tr><td rowspan="2">4= spent
gonads are shrunken, drained, transparent and reddish; residues of sperma/milk; showing no development</td><td>7= spent
gonads loose; some remaining egs</td><td>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</td></tr>
<tr><td>8= resting
gonads small; eggs not visible; difficult to distinguish from stage 2-3</td><td>8= recovering
ovaries and 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)</td></tr>
</table>