Living Resources Committee

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REPORT OF THE

PLANNING GROUP FOR HERRING SURVEYS

Bergen, Norway
12–16 January 1998

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1 TERMS OF REFERENCE

In accordance with C.Res.1997/2:32, the Planning Group for Herring Surveys (Co-Chairmen: E. Torstensen, Norway and K.-J. Stæhr, Denmark) met in Bergen, Norway from 12–14 January 1998 to:

a) coordinate the timing, area allocation and methodologies for acoustic and larval surveys for herring in the North Sea, Division VIa and IIIa and the Western Baltic;

b) combine the survey data to provide estimates of abundance for the population within the area;

c) hold a Workshop on acoustic echogram examination procedures;

d) assess the results of studies on the separation of west coast and North Sea herring stocks within the acoustic survey time series; the examination of the pre-1991 surveys for possible under-estimation due to signal saturation in the electronics; the inter ship-calibration and the study of variability of trawl performance between participants;

e) review the results of the above studies and then report on the applicability of further study on the herring survey time series.

2 PARTICIPANTS

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Bram Couperus	The Netherlands
Paul Fernandes	UK (Scotland)
Eberhard Götze	Germany
Cornelius Hammer	Germany
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Dave Reid	UK (Scotland)
Dietrich Schnack	Germany
John Simmonds	UK (Scotland)
Karl-Johan Stæhr (Co-chairman)	Denmark
Reidar Toresen	Norway
Else Torstensen (Co-chairman)	Norway
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3 HERRING LARVAL SURVEY

3.1 Review of Larvae Surveys

Due to a substantial decline in ship time and sampling effort allocated to the herring larvae surveys in recent years, a study was requested on the effects on the estimates of larvae abundance and production derived from these surveys. A first step of the analysis discussed at last years meeting considered the effect of a reduction in the number of sub-areas to be sampled and the required frequency of intermediate complete surveys. The main result was that it would be prudent to concentrate effort on a few target areas rather than attempting to cover all spawning areas of the North Sea, but that complete coverage would nevertheless be required, to observe long term trends in the relative importance of different spawning areas and in z/k values. For the further analysis the following tasks had been defined:

1) The effect of survey timing on larvae abundance indices and production estimates should be examined in more detail from the historical database, to confirm or disprove the indications so far available.

2) Reliability and changes of the z/k values should be studied as the LPE is especially sensitive to this parameter. A standard procedure to estimate z/k should be defined and the existing data series revised accordingly.

An intermediate status report of the requested analysis was presented during the present meeting, concentrating on the LPE index (Appendix A). From the discussion the following conclusions can be drawn:

1) The z/k values include some substantial degree of random variation; in addition some area specific trends are indicated, the time scales of which are, however, difficult to identify within the given variability, the restricted extent of the time series and the data gaps included.

2) As the LPE values are critically dependent on z/k values, some averaging over years is required to remove random variation as far as possible, but smoothing should be restricted to allow for actual trends to be transfered into the LPE values.

3) The regressions of LPE on SSB so far obtained for complete coverage as compared to different subsets of sampling units, defined by time and area, do not indicate a reduction in the precision of stock size estimates, when the index is generally based on a sampling scheme of the kind presently achieved. The analysis is, however, yet incomplete and results could have been largely effected by methodical problems related to the exclusion of too many sampling units by too narrow criteria for sufficiently complete sampling within these units.

4) The analysis should be completed, including a comparison of the performance of LPE, LAI and MLAI under restricted sampling effort conditions. For the time being, the MLAI should be used for assessment purpose.

3.2 Coordination of Larvae Surveys

3.2.1 Surveys planned for 1998/99

Germany	16–30 September 1998	Orkney/Shetland
Netherland	14–24 September 1998	Buchan
Netherland	14–18 December 1998	Southern North Sea
Germany	*01–15 January 1999	Southern North Sea
Netherland	*15–31 January 1999	Southern North Sea

* = preliminary

Optimal complete coverage for calculating LAI and LPE, as defined in the previous Planning Group report (Anon. 1997), should be attempted every three years, starting from 1999/2000 or as soon as possible. A total of about 90 days survey time would be required, which is about a doubling of the effort presently allocated.

3.2.2 Data processing

The herring larvae database has been transferred to IfM Kiel (Germany). Updating and reporting on yearly results is planned to be done at Kiel from 1998 onwards. A backup of the data bank and of the calculation routines should be kept at Aberdeen for the next two years.

A backup of the data bank updated until early 1997 will be kept in Aberdeen.

4 ACOUSTIC SURVEYS

4.1 Review of Acoustic Surveys in 1997

Herring

4.1.1 Acoustic surveys North Sea and west of Scotland in 1997

In 1997 the coordinated survey comprised six individual surveys covering the North Sea and the West of Scotland (Table 1). The methods employed were in accordance with the recommendations in Anon (1994). Individual survey results were collated in Aberdeen and presented in a short report to ACFM in October 1997 (Appendix B) and a full survey analysis and report will be made available for the Herring Assessment Working Group. The results of the Danish survey was presented (Appendix C) and will be included in the full survey report.

Table 1 Dates and locations of acoustic surveys in the 1997 co-ordinated herring acoustic survey.

Scotia	16 June–3 July	North of 56°30'N west of 3°W
Dana	2–12 July	North of 57° east of 6°E
GO Sars	28 June–18 July	North of 57° east of 1°W with reduced effort east of 3°E
Scotia	8–28 July	North of 58° 30' between 4°W and 2°E
Tridens	30 June–18 July	South of 59°N west of 2°E
W Herwig	23 June–16 July	South of 57°N east of 2°E reduced effort between 2°–6°E

4.1.2 Western Baltic

A joint German-Danish acoustic survey was carried out with R/V "Solea" from September 12 to October 2 1997. The survey covered the Sub-divisions 22, 23, 24 and the southern part of the Kattegat. All investigations were performed at night as in previous years.

The acoustic equipment used was an echosounder EK500 connected to the Bergen-Integrator BI500. The transducer 38-26 was installed in a towed body. The towed body had a lateral distance of about 30 m from the ship to decrease the influence of escape reactions of fish.

The cruise track was 1035 nm long and 48 trawl hauls were carried out to identify the targets. From each haul samples were taken for the determination of length, weight and age. After the haul the hydrographic condition was investigated by a CTD-probe.

The S_a values for each stratum were converted into fish numbers using the TS-length regressions:
Clupeids: TS = 20 log L (cm) - 71.2
Gadoids: TS = 20 log L (cm) - 67.5

The estimation of abundance is presented in Table 4.1.2. Cruise track and haul positions are given in Figure 4.1.2.

The abundance of herring was similar to the year before with a slight increase of about 15% in all Sub-divisions. However, sprat numbers in all subdivisions increased by more than a factor of two approaching the long-term mean in this areas.

4.1.3 Other surveys in the area

In connection with the environmental impact monitoring carried out during the construction of a fixed link across the Sound, western Baltic spring spawning herring migrating through the area have been monitored in both autumn and spring.

The aim of the environmental impact monitoring was to examine if the construction would disturb the migration pattern. With reference to the monitoring carried out on herring migration in the period before the initiation of the construction work (the base-line investigations) (Nielsen, J.R. 1996), the herring has been monitored in the autumn and in the spring. The purpose of the monitoring surveys were to examine whether the herring are migrating from the feeding grounds to the Sound in autumn in the same proportion as during the baseline investigations, and migrate south in the spring for the spawning grounds in the western Baltic.

The environmental impact monitoring has shown a higher biomass in the estimates from the surveys in the 1996/97 migration period and the 1997/98 migration period compared to the 1995/96 migration period (see Appendix D). This higher biomass seems to be due to an income of a strong 1994 year class of Western Baltic herring.

This strong 1994 year can be followed in the 1996/97 migration through the Sound as 2–3 year-old herring, in the fishery at the spawning ground in 1997 as 3 year-old herring, and in the Sound in November 1997 as 3–4 year-old herring in the 1997/98 migration period.

Sprat

4.1.4 Sprat

Data on sprat were provided by *Tridens* and *Walther Herwig III*; *G.O. Sars*, *Scotia* and *Dana* found only single specimens of sprat (Figure 4.1.4). The squares 45E9, 45E8, 45F0, 46F1, 46F0, 46E9 and 46E8 were covered by both ships. No sprat were caught in the 46-squares. From this it is assumed that the northern extension of the sprat stock in the area was reached during the surveys.

In the regular survey area of the "Walther Herwig III" off the Jutland coast, less than 600 t sprat were estimated. Due to the short time series of investigations, it can not be decided whether this is due to low stock size or to insufficient coverage of the distribution area.

The coverage in 1997 was smaller than usual as vessel time was used for intercalibration exercises. After termination of the "Walther Herwig III" survey, significant amounts of fish were detected close to the Wadden Sea area in the German Bight. These concentrations could not be sampled due to the lack of time. It is reasonable to assume that herring and/or sprat have formed these concentrations. The southern areas will be included in future surveys.

During the analysis, problems with the age reading of sprat otoliths occurred and otoliths collected on "Walther Herwig III" were sent to Norway and Sweden for re-reading. It was found that the German reader systematically estimated the age by one year higher than the Norwegian and Swedish readers.

Samples for ageing were not taken during the Tridens survey owing to lack of manpower and insufficient experience in sampling sprat.

It was suggested and agreed to use the Norwegian-type trays for storage of the otoliths in future as a standard storage device for sprat otoliths.

Another problem identified was the determination of the maturity stages of sprat. It was felt by the group that a mini-workshop of about two days should be held in early September 1998 in Arendal with Danish, Dutch, German, Norwegian and Swedish participants for improvement of the age reading and maturity staging. Travel funds shall be applied for from the European Fish Ageing Network (EFAN).

During the 1998-survey each participant should collect and freeze a sample of about 5 kg sprat of various sizes and bring these to Arendal for macroscopic examination of maturity stages. An exchange of sprat otoliths from the 1998-survey will be performed as soon as possible after the surveys.

4.2 Coordination of 1998 Acoustic Surveys

In 1998 the acoustic surveys in the North Sea and west of Scotland will be carried out according to the periods and areas given in the following table:

Vessel	Period	Area
Charter	July	North of 56°30'N, west of 3°W
Dana	29 June–16 July	North of 56°30'N, east of 4°E
G.O. Sars	27 June–20 July	North of 57°N, east of 1°W with reduced effort east of 3°E
Scotia	10–27 July	North of 59°N, between 4°W and 2°E
Tridens	29 June–17 July	South of 59°N, west of 2°E
W Herwig III	22 June–13 July	South of 57°N, east of 2°E reduced effort between 2°-4°E

In the western Baltic the following survey will be carried out:

Solea	2–20 October	ICES Sub-divisions 21 South, 22, 23 and 24

Intercalibration should take place between as many research vessels as possible. For a detailed description of intercalibration see Section 7.

The individual results from the national acoustics surveys in June-July 1998 will be collected and the total result of the survey will be presented to the Herring assessment working group. Survey results for sprat shall be send to Else Torstensen, Norway and survey results on herring shall be send to John Simmonds, Scotland. Data has to be send before 15. November 1998.

5 ACOUSTIC SURVEY METHODOLOGY STUDIES

5.1 Separation of North Sea and VIa North Herring

Since 1995 the abundance of herring in the area 30Nm either side of 4°W has increased considerably. The location of this line used to separate the stock has become increasingly critical.

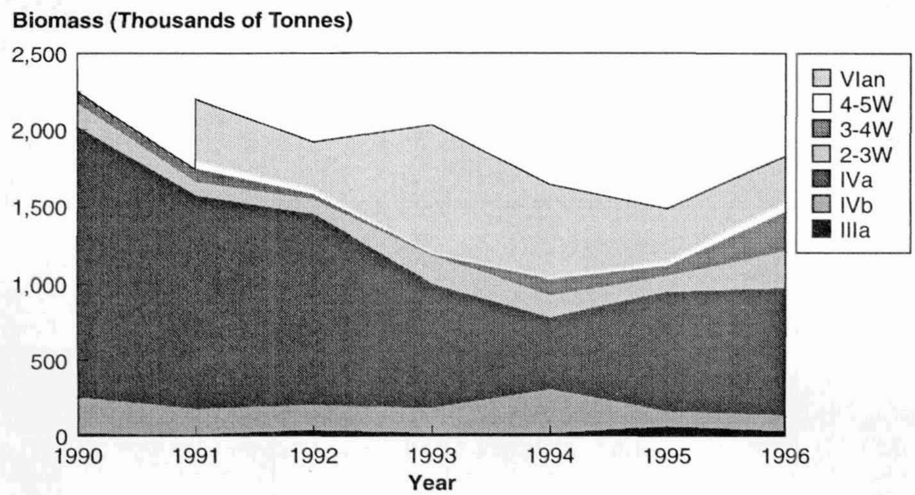

Figure 1 Index of total biomass of mature autumn spawning herring in the North Sea and West of Scotland from acoustic surveys.

A study of the herring data which had been collected from research vessel trawl hauls during June and July has been carried out by John Simmonds. The study was presented at the Planning Group.

5.1.1 Materials and methods

A total of 224 trawls with a catch of more than 50 herring have been carried out in the Orkney Shetland and West of Scotland surveys from 1993 to 1997 inclusive. Eighteen of these are from the area between 3W to 5W. The data collected from each haul provide information on age proportion, length distribution, length at age, and proportion mature at age. The location of the trawl, the number caught and sampled, as well as a total of 82 biological parameter values were available for use in estimating the separation:

Proportion at length 15–37cm in 0.5cm intervals
Proportion at age 1 to 9+
Cumulative proportion at age 1 to 1–8
Overall mean length,
Variance of length
Mean length at age 1 to 9+
Growth parameters; α, L_∞ , α_{33} (coefficient with L_∞ = 33cm)
Year

A series of neural networks were constructed and trained to recognise data sets from west of 5W and east of 3W as two separate categories (0 and 1), West Coast and North Sea. The remaining haul data from 3W to 4W was then presented to the trained networks to establish in which area these are most likely to belong. Later in the analysis the 18 unknown hauls were examined, and it was found that none of these has significant numbers of 1 year herring. So all hauls with more than 50% 1 year herring were removed from the training sets. This reduced the total number of hauls from 224 to 205 hauls.

The following network node constructions were used:

All hauls			
All data	82 input	20 hidden	1 output node
Hauls <50% 1 year			
Growth	16 input	16 hidden	1 output node
Age Structure	9 input	9 hidden	1 output node

To test the recognition of the network method 10% of the hauls were removed from the training sets and the networks retrained. These hauls were then presented to the new networks and the success of recognition used as a check of network performance.

5.1.2 Results

The results are preliminary and further work is required.

The All data network was capable of separating the training data, and on a scale of 0 to 1 no west coast hauls had values greater than 0.3 and no North Sea hauls had values less than 0.75.

For the test sets 10% of hauls were removed before training. Successful recognition was at 85% for age structure and 90% for growth.

The all data network has rather peculiar weightings for the parameters, and therefore, it was decided that the large network might be focusing on rather obscure differences between the data sets. Therefore, the reduced data sets and networks, growth and age structure were selected for further development.

The preliminary results suggest that there is considerable mixing to the North of Scotland and that the group of hauls may be rather independent of eight the West Coast or the North Sea. However further work is required.

5.2 Inter-Calibration

It was recommended by ICES that the acoustic survey participants should utilise as many opportunities as possible for inter-calibration during the 1997 surveys. In order to minimise the effect of spatial and temporal variability of herring abundance, the exercises were intended to be inter-ship calibrations, with the vessels running the same course at the same time. Since such an arrangement required some extra time for cruising, which inevitably reduced the coverage of the sampling area to some extent it was important to plan this efficiently. It was decided that pairwise inter-calibrations would be more efficient than trying to organise all vessels to be together at the same time, and it was judged to be acceptable to carry out up to two inter-calibrations per vessel.

The first inter-calibration was carried out at about 57 40N by 0E by *G.O. Sars* and *Walther Herwig III* on the morning of 1 July. Due to severe weather *Tridens* was unable to reach this location in time, and could not participate as planned. The inter-calibration was carried out throughout the entire survey day, during which no fishing took place.

The second calibration carried out between *Walther Herwig III* and *Dana* after the completion of the first inter-calibration. During 2 July *Walther Herwig III* sailed eastward and contacted and *Dana*. The inter-calibration was carried out in the morning of 3 July at a position 57 45'N and 06 00'E about 30Nm south west of the Norwegian coast.

The third inter-calibration was carried out between *G.O. Sars* and *Scotia* on 16 July at about 60 45N 30W. There was no need for a fourth inter-calibration because *Scotia* carried out both Scottish surveys using the same equipment for both cruises.

5.2.1 Procedure for the inter-calibration of echosounders during the North Sea herring survey

The vessels were positioned with one in front and the other 0.5 Nm behind at 500 m on the stern quarter. The speed during the Inter-calibration was 10 Knots. The period of integration depended on the extent of the fish aggregations and the needs of other parts of the survey.

The vessels took up their relative positions and started sailing at the agreed speed and course. When the vessels where in a stable formation the, the leading vessel gave a start signal and started logging. The other vessels start logging after steaming 0.5 Nm. A synchronising signal was given by the leading vessel every 5 Nm at which time both vessels record their geographic position and annotated their echograms accordingly. The leading vessel was changed approximately half way through each inter-calibration ensuring that any bias that might be due to a lead vessel was examined during the procedure.

A sampling interval of 1 Nm was used for integration. The integration was started at 10 m below water surface and the Sa-values were stored by 20 metre depth layers area so that 8 surface channels could be registered on one echogram and provide one bottom following layer and one total layer. Threshold for the echogram was set to -80 dB for both calibrations involving *G.O. Sars*. The threshold was set to -70 dB for *Walther Herwig III* and the minimum level possible for *Dana* during their inter-calibration. Other than these requirements the normal survey settings were used for all other parameters.

Three pairwise inter-calibrations were carried out, a summary of the data collected are given in the text table below.

Vessels	Date and time	Distance	Comparison	Cruise Track Figure
G.O. Sars *Walther Herwig*	1/7/97 0900-2000utc	90Nm	Whole water column	Figure 5.2.1
Dana *Walther Herwig*	3/7/97 0815-1300utc	31Nm	Whole water column	Figure 5.2.4
G.O. Sars *Scotia*	16/7/97 0900-1500utc	45Nm	Whole water column	Figure 5.2.7

General

G.O. Sars / Walther Herwig

The area chosen was about 40Nm east of Fraserbrough: a short south east transect was followed by two transects south west and then north east, the particular direction was chosen specifically to minimise the effects of the weather. The inter-calibration was carried out mostly on a few scattered schools close to the seabed, these were particularly dense during the section of the track in the south west of the area. In addition, there was a consistent plankton trace in the upper part of the water column. During this inter-calibration the weather was very poor, and *G.O. Sars* with a keel appeared to be largely unaffected by the aeration. However, *Walther Herwig III* showed some evidence of missing transmissions which are correctly excluded from the data processing by the EK system, but some signal loss may have affected the information in the echosounder records.

Walther Herwig III / Dana

The area chosen was about 30Nm south west from Lista on the Norwegian coast. *Dana* was in front for the first part of the track, travelling NNE. *Walther Herwig III* led during the second half travelling first west and then southwest. The water depth was between 125 to 150m. The fish concentrations were made up mostly of small schools on the seabed and a midwater plankton layer. The weather was good with no sign of any signal loss due to aeration.

G.O. Sars / Scotia

The inter-calibration was carried out with a layer of small herring schools mixed with a very small proportion of gadoids close to the seabed. The herring contributed about 70% of the biomass, and a plankton layer near the sea surface provided the remainder of the integral. Four zig-zag transects were carried out to the north east of Shetland, *G.O. Sars* led for the first two transects and *Scotia* for the second two. The distributions were quite even, and most of the variation between the two vessels was due to the differences in density of schools detected by the two vessels which followed tracks at about 200 m apart from each other.

Data Processing

For the *G.O. Sars*, *Scotia* and *Walther Herwig III* inter-calibrations there was no difference in the equipment and settings, the results could be compared directly. In the case of *Dana* and *Walther Herwig III* the equipment was different and there is some doubt about the exact alignment of the equivalent threshold levels between these echosounder systems. It is thought that *Dana* has a threshold of -65dB rel 1 volt, and the *Walther Herwig III* data was reworked in the BI 500 at this threshold. At the original level of -70dB a small but significant intercept was observed in this inter-calibration, however, this disappeared when the data was reworked with the increased threshold for *Walther Herwig III*. The sequence of data values were plotted as two time series and the alignment of the sequences checked (Figures 5.2.2, 5.2.5 and 5.2.8). Output data values on the turns and exchange of leadership were removed if necessary and the sequences selected. The sequences were plotted as XY scatter plots and a linear regression used to define a relationship (Figures 5.2.3, 5.2.6 and 5.2.9). To obtain a regression relationship each data set was regressed on the other using a simple least squares regression, the final regression was selected as the mean of these two lines (solid line). The CV for this factor was calculated as the sum of the intervals for the two regressions, summed using the route mean square. The interval for the intercept was estimated in the same way. In addition the factor assuming zero intercept was calculated from the data series means.

5.2.2 Results from inter-calibrations from North Sea acoustic surveys

The inter-calibration data details are shown in following figures.

Vessels	Sequence plot	Scatter Plot
G.O. Sars / Walther Herwig	Figure 5.2.2	Figure 5.2.3
Dana / Walther Herwig	Figure 5.2.5	Figure 5.2.6
G.O. Sars / Scotia	Figure 5.2.8	Figure 5.2.9

The results of the inter-calibration are given in summary the following text table.

Vessels	Ratio	CV	Intercept	Approx. Limits
G.O. Sars / Walther Herwig	0.76	0.04	-13.4	±50
Dana / Walther Herwig	0.88	0.12	0.6	±200
G.O. Sars / Scotia	0.98	0.04	0.8	±360

5.2.3 Conclusions

In all cases the differences between the slope from the regression and the slope estimated with zero intercept were negligibly different. In two cases they were effectively identical. *G.O. Sars* and *Scotia* were found to have the same performance. The ratio from the calibration from *Dana* and *Walther Herwig III* was not significantly different from unity but did indicate slightly lower sensitivity *Walther Herwig III*. The calibration between *G.O. Sars* and *Walther Herwig III* gave a ratio factor of 0.76 however, the accuracy of this factor and how it should be applied is currently uncertain. During this inter-calibration the weather was poor and there was some evidence of loss of signal from *Walther Herwig*, not seen on *G.O. Sars* which has a keel system for the transducer. The weather was the worst encountered during the whole survey, thus the effect was at its greatest. These data requires further investigation to establish if the apparent reduction from *Walther Herwig III* is weather dependant.

5.3 An Analysis of Trawl Variability in the 1995 Herring Acoustic Survey

The objective of this study was to examine the spatial variability in length and age and to assess to what extent the observed variability may be affected by obtaining trawl samples from different vessels. Trawl data from the 1995 co-ordinated herring acoustic survey were taken from Denmark, Norway, the Netherlands, Germany, Scotland (North Sea and west Atlantic) and the Republic of Ireland. Only those trawls which contained herring were considered, giving a total of 152 trawls.

The mean length of fish from each trawl was calculated and a variogram was plotted. The variogram was fitted with a linear model; this is an indication of the presence of a trend. This trend is obvious in the kriged map of mean length: small fish occur in the south east of the North Sea and larger fish occur towards the north west of the North Sea towards the Orkney and Shetland Isles. The test statistic of the Kolmogorov Smirnov test (D_{max}) was calculated for all pairs of trawls for which there were 30 or more fish (a total of 6555 tests). Values of D_{max} were averaged within distance classes to produce a plot of mean D_{max} against distance (a KS-ogram). The spatial continuity in length is reflected in the KS-ogram: trawls close together have more similar length distributions than those further away. Notably, the KS-ogram for trawl pairs within individual surveys was very similar to the KS-ogram for pairs between surveys. This indicates that any spatial variability in length is likely to be due to natural variability at a location rather than any variability derived from the sampling technique.

The greatest differences in D_{max} occur in areas where length changes occur across short distances such as the region between the German and Dutch surveys and that between Danish and Norwegian surveys. These regions should be trawled more extensively if large numbers of fish are observed during the survey so that the mean length can be determined with greater precision.

Age proportions have a structured spatial distribution only for the youngest ages (linear variograms). Older ages are distributed almost randomly; distribution by length is evidently the determining factor.

5.4 Examination of Pre-1991 Surveys for Signal Saturation in the Electronics

This work has been postponed due to lack of resources, the data will be examined during 1998 and 1999 for preparation for the acoustic survey database being developed under EU project HERSUR. The study will be carried out during this period.

6 WORKSHOP ON SCRUTINISING OF ECHOGRAMS

A vital step in the analysis of an acoustic survey is the visual scrutiny of the echogram and the allocation of the echointegral values to particular species. This process is essentially subjective and is usually carried out by trained and experienced scientists who have been responsible for the survey itself. The workshop was designed to examine the consistency of the mechanism of echogram scrutinisation.

To this end, the members of the planning group supplied echograms each of one days duration from five different surveys, Scotia, Tridens, G.O. Sars and Walther Herwig in the North Sea, and Christina S in ICES area VIa(N). These were supported with trawl data. Six scrutiny groups were set up, representing the originators of the data. Each group was then required to scrutinise all five surveys to a common format. For the purpose of the workshop the groups identified only herring from the echograms and worked on the basis of five nautical mile samples. The analysis was carried out using digital data presented on the Bergen Integrator (BI500). NB. One echogram (Christina S) was only available on paper and was analysed on a 2.5 nautical mile basis. Output data from the exercise were in the form of S_A values by 5 mile samples and produced by all six groups including the originators.

Preliminary analysis of the individual team and survey results are presented in Tables 6.1 to 6.3. It should be borne in mind that the teams in the exercise were usually unfamiliar with the surveys they had to analyse and also usually with the precise method of analysis on the BI500. In general there was remarkable agreement between the analyses by the different teams. Three of the surveys had CV values of 10% or less. In the case of the Tridens survey, the bulk of the biomass was concentrated in dense schools which were believed by the originators to contain about 10% herring. One team chose to assign these as 100% herring and this largely accounts for the high CV. This specifically highlights the need for developments in species classification and identification methodology.

A full report of the scrutiny workshop will be presented to the Echo Trace Classification Study Group (SGETC) in A Coruña, Spain in April 1998.

7 INTER-SHIP CALIBRATION

It was decided by the planning group to utilise as many opportunities as possible for intercalibration during the 1998 survey. In order to minimise the effect of spatial and temporal variability of herring abundance, the exercises are intended to be inter-ship calibration, with the vessels running the same course at the same time. The inter-ship calibration will be performed according to the procedure for the intercalibration of echo sounders during the North Sea herring survey given in the Planning Group Report for 1997 (Anon. 1997). Details of various ships communications are provided in Table 7.1.

The *Walther Herwig* and the *Tridens* will leave port 22 June 1998 and sail to their site for echo sounder calibration, presumably Kristiansand, Norway. After calibration they will sail to an area near Kristiansand for an echo sounder intercalibration on/about 24–25 June 1998. Details on timing and location will be arranged by radio contacts between the two vessels. Radio contact will be established during 22 June 1998.

The vessels *Tridens* and *G O Sars* will meet for echo sounder intercalibration in the over-lapping area (North of 57°N, South of 59°N, East of 1°W, West of 2°E) in the first week of July 1998. Details on timing and location will be arranged by radio contacts between the two vessels. Radio contact will be established 2 July at 9:00 UTC.

The vessels *Dana* and *G.O. Sars* will meet for an echo sounder intercalibration in the over-lapping area between the North Sea and Skagerrak on/about 29–30 June 1998. Details on timing and location will be arranged by radio contacts between the two vessels. Radio contact will be established 29 June at 18:00 UTC.

Further intercalibration will be attempted between *Walther Herwig* and *Dana* in the area around 57°N and 4°E (i.e. ICES square 42F3 and 42F4) in the first week of July 1998. Details on timing and location will be arranged by radio contacts between the two vessels. Radio contact will be established 1 July at 9:00 UTC.

A second intercalibration will be attempted between *Scotia* and the west coast charter. Details on timing and location will be arranged by radio contact between the two vessels.

Responsible for the intercalibration:

G.O. Sars: Reidar Toresen
Walther Herwig: Eberhard Götze
Tridens: Bram Couperus
Scotia: John Simmonds
West coast charter: Paul Fernandes
Dana: Jens Pedersen

The results for each intercalibration, together with the results of the acoustic survey, should be submitted to John Simmonds, Aberdeen, by no later than 15 November 1998. The results should be submitted in a spreadsheet in Microsoft Excel version 5.0 or later. The format for exchange of data should be Sa-values of 1 Nm sampling intervals and related log number, time and position information.

8 RECOMMENDATIONS

General

The Planning Group should meet in Hirtshals, Denmark from 2–4 February 1999 under the charmanship of K.-J. Stæhr, Denmark and E Torstensen, Norway to:

a) coordinate the timing, area allocation and methodologies for acoustic and larval surveys for herring in the North Sea, Division VIa and IIIa and the Western Baltic;

b) combine the survey data to provide estimates of abundance for the population within the area;

For acoustic surveys:

The Planning Group recommends the existing manual of the North Sea acoustic survey (ICES CM 1994/H:3) to be reviewed, taking into consideration recent developments in methodolgy and the results of the scrutiny workshop.

The Planning Group recommends that the echogram scrutiny workshop be repeated on a regular basis. To this end a further workshop should be held in 2000.

The Planning Group recommends that development of species recognition methods should be a priority.

For larvae surveys:

a) Yearly surveys should continue for the present time to focus on Southern North Sea as well as on the Orkney/Shetland and/or Buchan area. Complete coverage should take place every three years beginning in the year 2000. This will require participation by Germany, Netherlands and Norway. If possible other countries should be involved.

b) The analysis of the historical database on the effect of the reduced sampling effort, should be completed to provide an improved basis for a final decision on the index and the target sampling units to be used.

9 REFERENCES

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

Anon 1997. Report of the Planning Group for Herring Surveys. ICES CM 1997/H:5.

Nielsen, J.R. 1996. Acoustic monitoring of herring related to the establishment of a fixed link across the Sound between Copenhagen and Malmö. DFU-report no. 11-96, 1996. ISSN 1395-8216.

Table 4.1.2 Survey statistics- R/V "Solea" September 1997

subdiv	rect	area [nm²]	Sa [m²/nm²]	σ [cm²]	N total [mill]	N herring [mill]	N sprat [mill]
21	4156	985	70	3.53	195	168	13
21	4157	485	147	2.86	249	186	1
21	4256	987	141	2.97	469	339	0
21	4257	659	197	1.13	1151	315	2
21	total	3116			2064	1009	15
22	22A	1297	48	0.55	1123	81	408
22	22B	1694	69	2.54	460	352	1
22	22C	1086	102	3.31	335	227	29
22	22D	1102	288	2.18	1454	1056	373
22	total	5179			3372	1717	811
23	4057	195	2190	6.04	707	580	122
23	4157	56	445	3.80	66	64	2
23	total	251			772	644	123
24	3757	205	715	1.52	964	439	508
24	3857	853	196	2.04	818	448	331
24	3858	882	602	1.59	3340	1021	1919
24	3859	1036	568	1.37	4296	569	3665
24	3957	438	287	2.16	581	395	171
24	3958	780	629	1.22	4036	468	3319
24	3959	529	723	1.51	2537	27	2506
24	total	4723			16572	3367	12420

Table 6.1 Percentage deviations from the originators analysis.

	Team 1	Team 2	Team 3	Team 4	Team 5	Team 6
Christina S	0	2.25	-19.12	-7.31	-10.92	11.02
GO Sars	46.34	0	-0.35	-60.67	-18.24	33.96
Walther Herwig	-0.76	-7.26	-13.44	0	-2.35	-2.4
Tridens	86.04	667.29	-71.51	-32.71	0	71.80
Scotia	2.12	-8.33	-9.3	-4.8	-19.92	0

Table 6.2 Percentage deviations from the mean of all analyses.

	Team 1	Team 2	Team 3	Team 4	Team 5	Team 6
Christina S	4.18	6.52	-15.73	-3.43	-7.20	15.66
GO Sars	21.55	-16.94	-17.24	33.45	32.09	-11.27
Walther Herwig	3.77	-3.02	-9.49	4.57	2.11	2.05
Tridens	-15.49	248.52	-87.06	-69.43	-54.58	21.96
Scotia	7.62	-3.40	-4.42	10.44	-15.61	5.38

Table 6.3 Means, standard deviations and coefficients of variation for each survey and for the pooled data sets.

Survey	Mean	Standard Deviation	Coefficient of variation
Christina S	5975	606	0.10
GO Sars	6126	1442	0.24
Walther Herwig	13808	674	0.05
Tridens	14812	16874	1.14
Scotia	8938	792	0.09

Table 7.1
Communication information for research vessels participants in the North Sea herring survey.

Vessel	Telephone		Telefax		Telex	Radio call sign
	mobile	satellite	mobile	satellite		
G O Sars	Bridge: +47 94 55 68 11 Mess: +47 94 50 50 71 GSM: +47 91 19 33 83	+871 3257 15010 +871 3257 15011	+47 94 54 99 00	+871 3257 15012	+581 4257 15010 +581 3257 15014	LLZG
Scotia	+44 8 36 38 59 75	+871 144 0552 +872 144 0552	+44 8 36 38 59 75	+871 144 0561 +872 144 0561		GOWS
Walther Herwig				+871 112 3221	+581 112 3217 +581 4211 21550	DBFR
Tridens	+31 6 52 11 16 35			+871 130 0346	+581 4244 03310	PBVO
Dana	Bridge: +45 30 20 03 63 Scientist: +45 30 28 68 64	+871 161 0205		+871 161 0207	+581 161 0205	OXBH

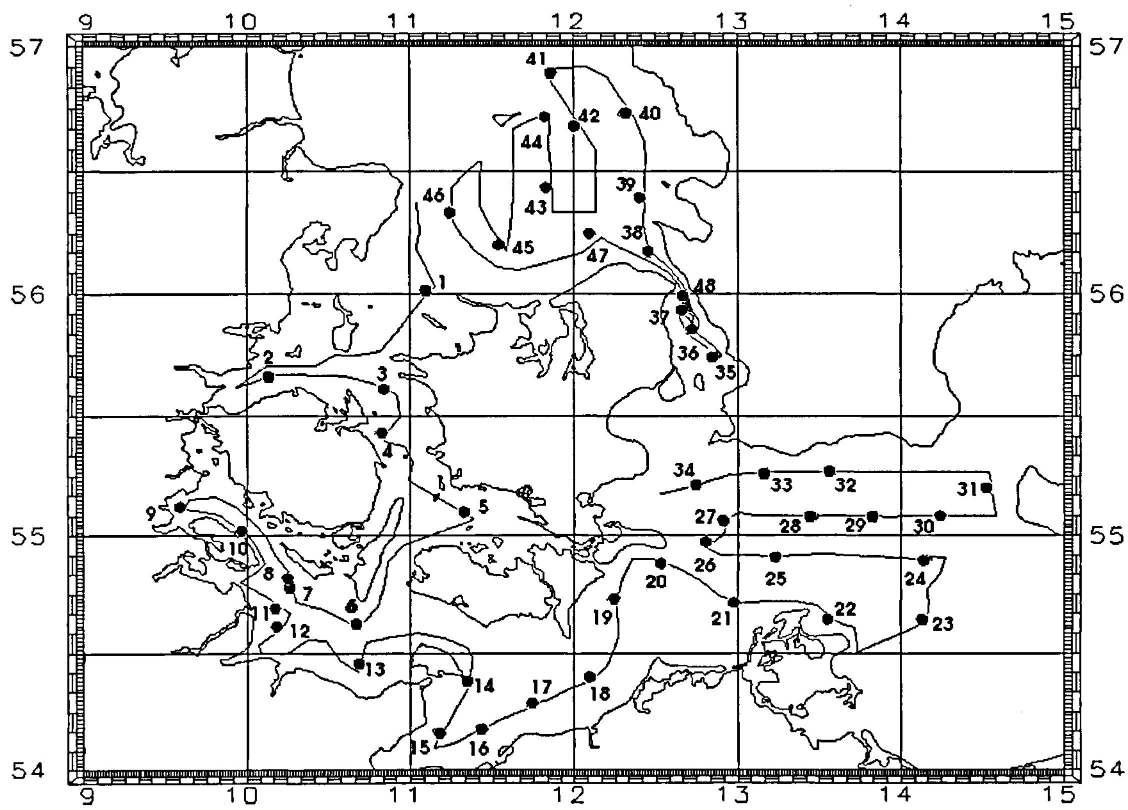

Figure 4.1.2 Cruise track and trawl stations – R/V "Solea" September 1997.

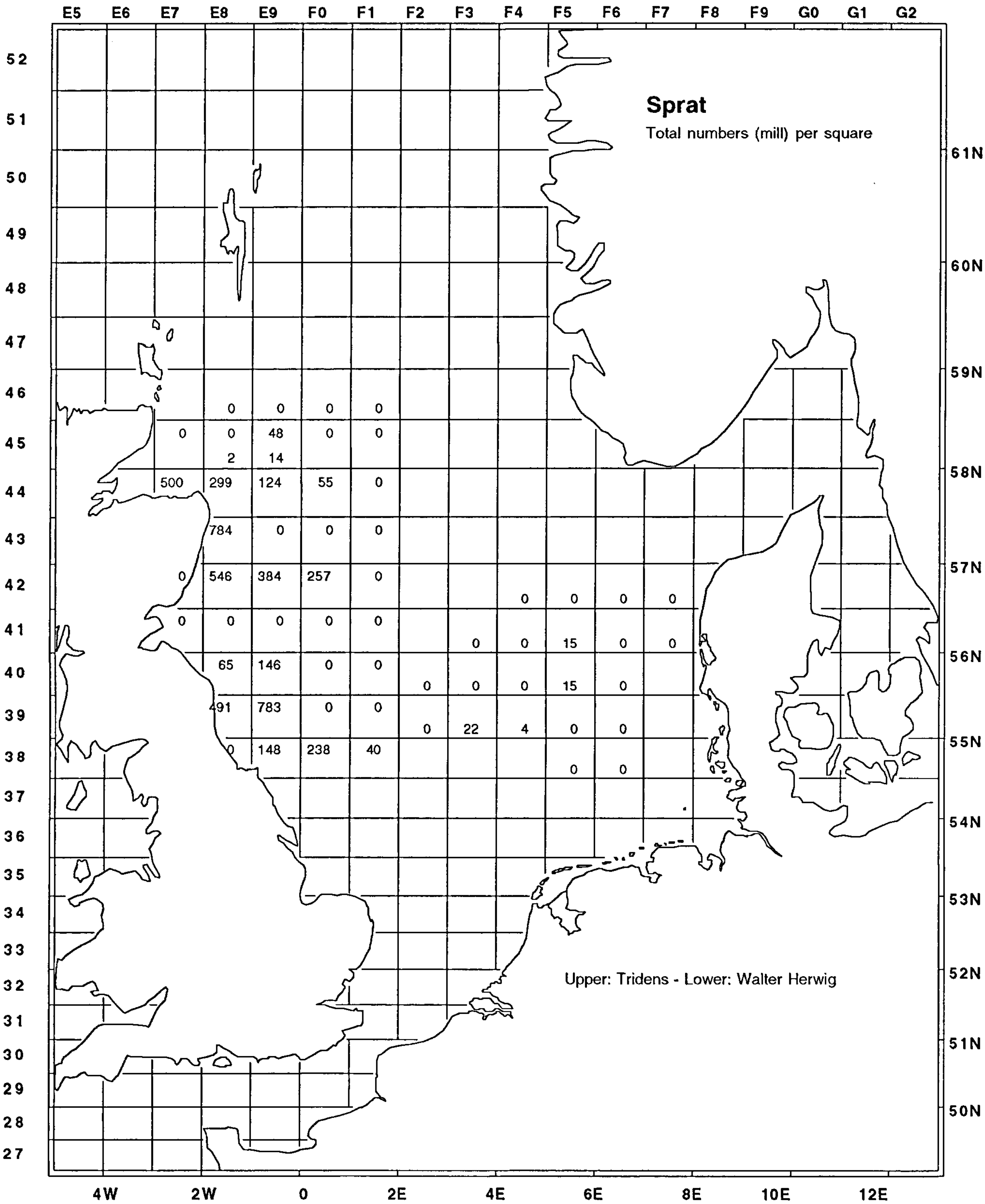

Figure 4.1.4 Sprat numbers (mill.) per square.

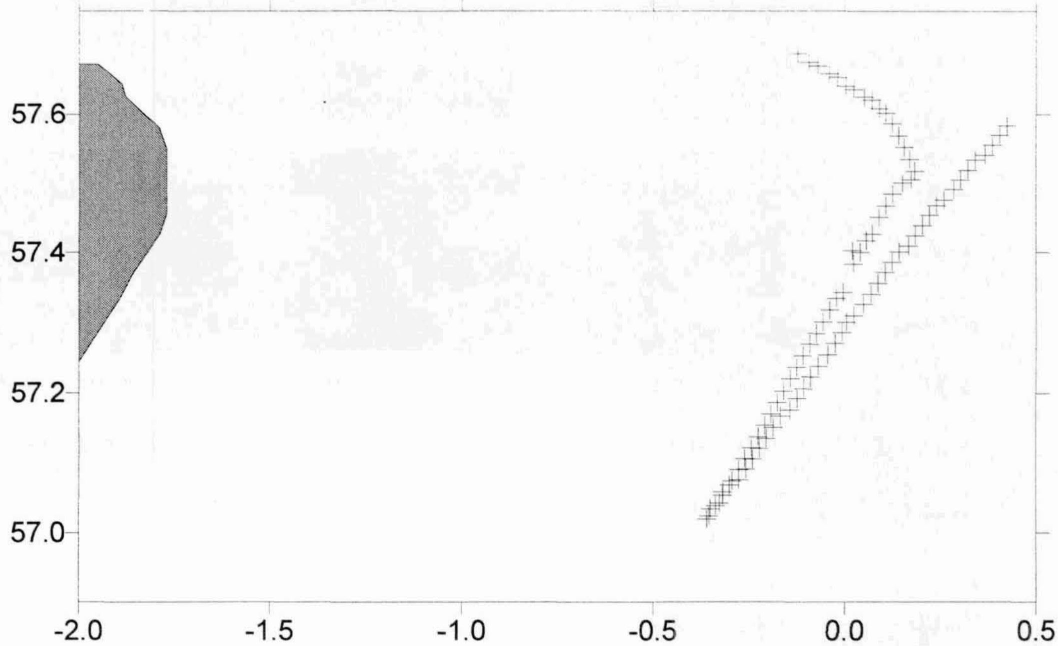

Figure 5.2.1 Inter-calibration Cruise Track *G.O. Sars* and *Walther Herwig III* 1 July 1997

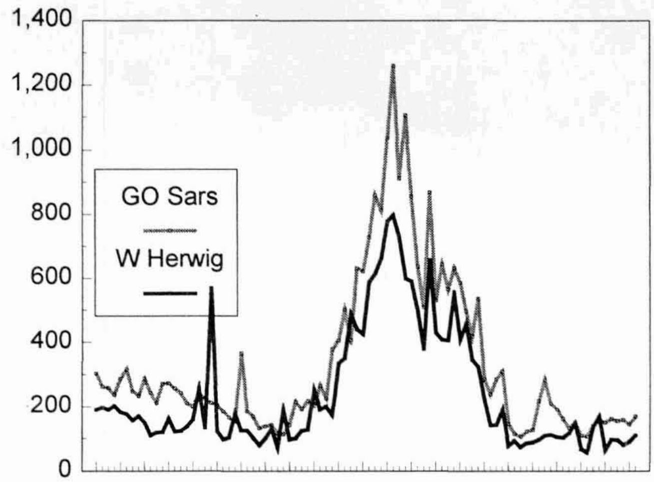

Figure 5.2.2 Sequence of echo integrator values (SA) for the whole water column for *G.O. Sars* and Walther *Herwig III* July 1997

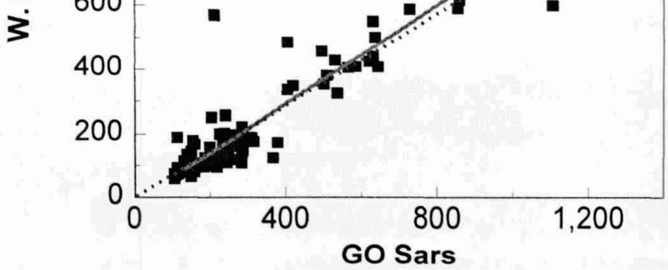

Figure 5.2.3 Scatter plot of SA values *G.O. Sars* W *Herwig III* July 1997

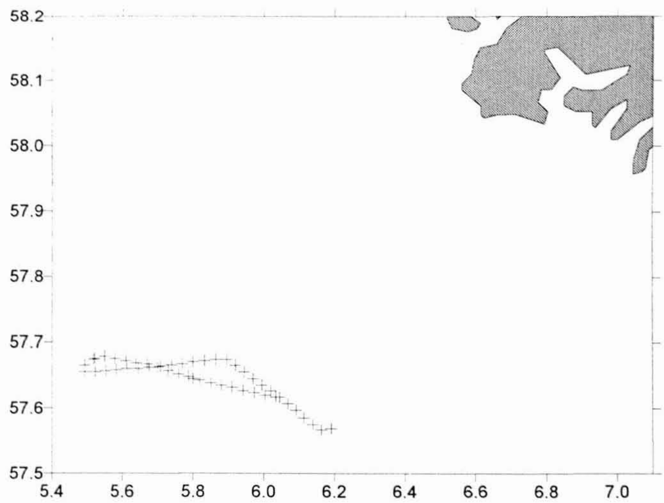

Figure 5.2.4 Cruise track for *Dana* - *Walther Herwig III* Inter-calibration 3 July 1997

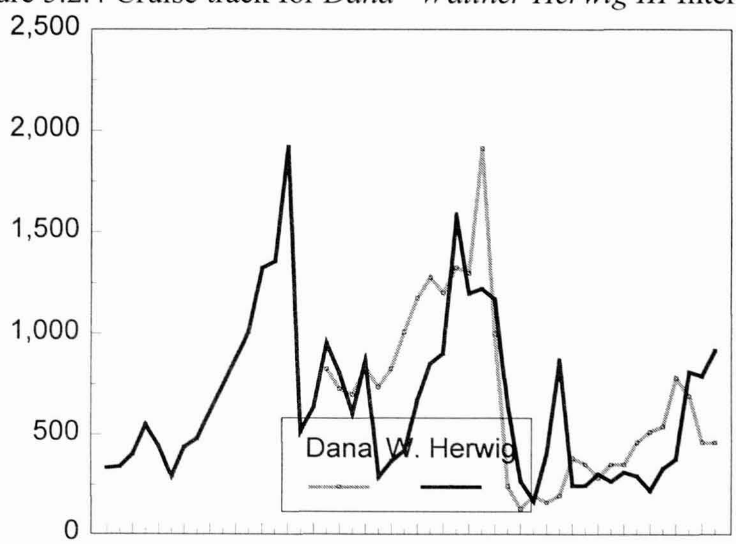

Figure 5.2.5 Sequence of echo integrator values (SA) for the whole water column for *Dana* and *Walther Herwig III* 3 July 1997

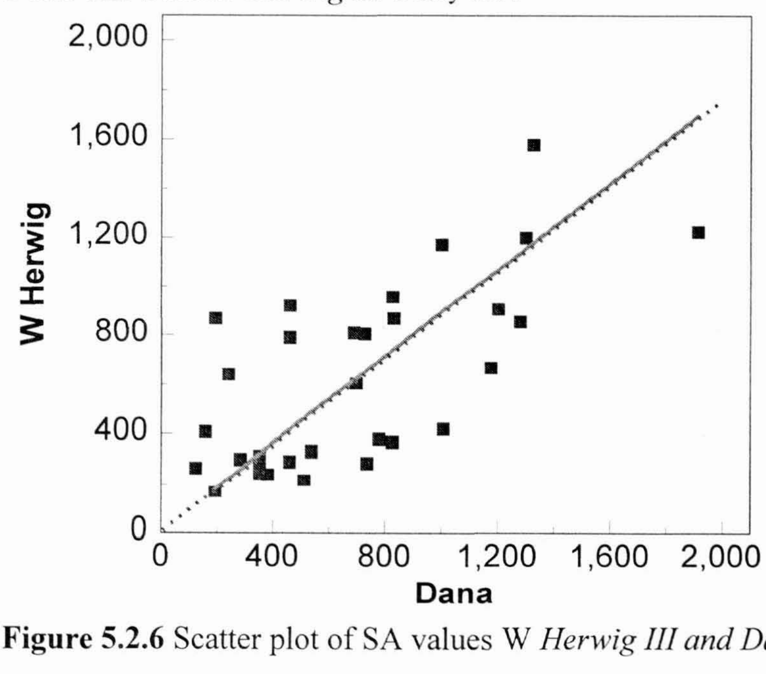

Figure 5.2.6 Scatter plot of SA values W *Herwig III and Dana 3* July 1997

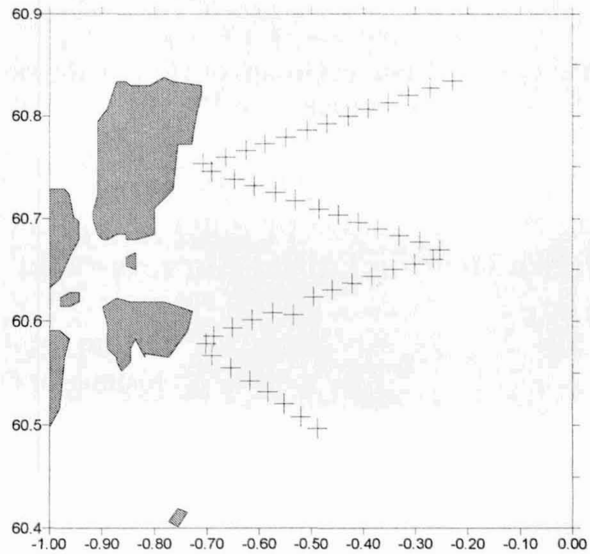

Figure 5.2.7 Cruise track for inter-calibration of *G.O. Sars* and *Scotia* July 1997

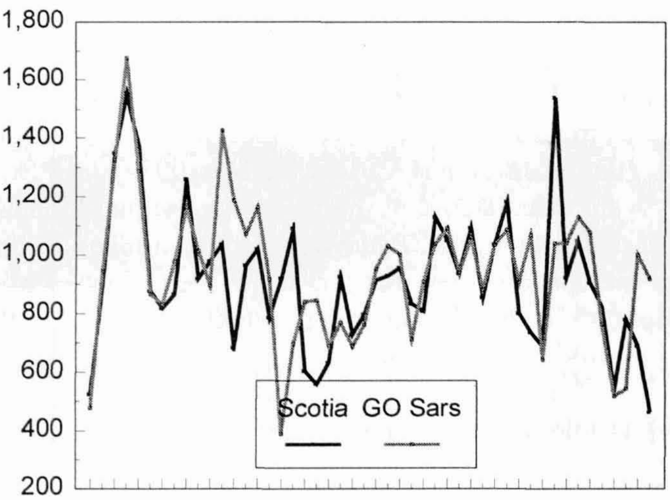

Figure 5.2.8 Sequence of echo integrator values (SA) for the whole water column for *G.O. Sars* and *Scotia* 16 July 1997

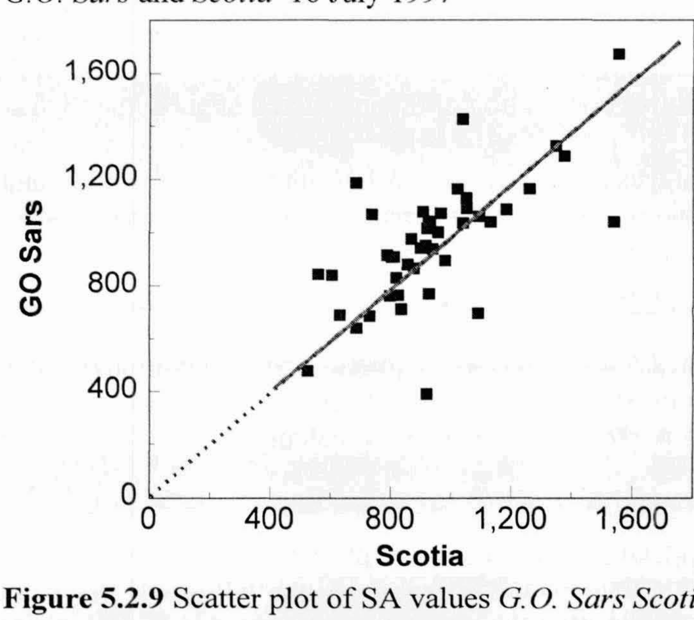

Figure 5.2.9 Scatter plot of SA values *G.O. Sars Scotia* July 1997

<u>**Appendix A**</u>

Working Document to the Planning Group for Herring Surveys
January 1998

Effects of reduced sampling effort on larval production estimates (LPE) from North Sea Herring Larvae Surveys.

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Introduction

Due to a substantial decline in ship time and sampling effort allocated to the Herring Larvae Surveys since the end of the 80's, it has been questioned, whether these surveys can still provide abundance and production indices (LAI and LPE) comparable to those of previous years and sufficiently reliable for the use as measure of stock size. Since 1992/3 a multiplicative model was used to fill in missing values (Patterson and Beveridge 1994, 1995a) and for the periods since 1994/95 no traditional indices were calculated, but the multiplicative model approach was used to analyse overall trends in the larval data series (Patterson and Beveridge 1995b, 1996; Patterson, Schnack & Robb 1997). This method assumes that larval production in each area and time unit defined for the traditional sampling schedule is a certain constant proportion of the total. In view of the urgent demand for reliable stock size estimates, the Herring Assessment Working Group requested to evaluate the validity of assumptions in the methods used and to define the minimum sampling effort required and possible survey strategies that could be achieved considering given restrictions in ship time.

A first analysis of the effect of using only few target areas for the abundance estimates was presented and discussed during the last years Planning Group meeting (Anon. 1997). This analysis was based on the historical larval herring data base and the reported abundance and production estimates for the individual spawning areas. In addition the residuals from the multiplicative model were inspected for trends in the relative contibution of the individual areas to the total spawning.

Based on this discussion it was suggested to develop an EU application for additional funding of these surveys to keep or improve the present level of sampling effort and plan for a yearly sampling of defined target areas, with a three years cycle for complete coverage of all traditional sampling areas. The analysis of the effect of reduced sampling effort was to be completed by including the effect of the timing of surveys and by testing the reliability and variability of the z/k values required for the larval production estimates. This analysis required a re-calculation of the indices for individual sampling units defined by standard time periods and areas. As the data bank had to be transfered to IfM Kiel this also required to re-establish the calculation routines and reviewing the utilized procedures.

The proposed analysis is not completed yet, due mainly to problems in the documentation of details of the calculation routines and some redundant, partly conflicting definitions given. The presented working document, thus, presents a short intermediate status report, and includes no final results.

Implementation of data bank and review of calculation procedures

The larval herring database has been transfered, can be utilized and will be updated at Rostock and Kiel. In order to produce from this data base yearly abundance and production estimates comparable to the previously reported results and to study the effects of restricting the surveys in area and time, it was necessary to identify the calculation procedures previously used in detail. The documentation included some problems, especially in the definition of the smallest area units, in the procedures of interpolation and combination of results. The values obtained for larval abundance index LAI and larval production estimate LPE are critically depending on some of these details.

The LAI is especially effected by interpolation methods used for filling gaps from unsampled stations. Re-calculations of index values according to the given documentation resulted in differences compared to the published data. The problem may be related to different area difinitions given for this index and perhaps inconsistancies in the interpolation procedures. It appeared necessary to define the standard procedure and re-calculate the data series. For this purpose and before testing the effects of different survey strategies on this index, it is attempted to introduce a geostatistical method for filling gaps from unsampled stations. This task is not yet completed.

From previous analysis of the data set (Anon 1990), it was expected that the LPE was better suited for reducing the number of surveys per subarea than the LAI depending only on the smallest size group of larvae. Thus, analysing the effect of the presently reduced sampling effort and testing for an optimum combination of sampling units, as defined by fortnight time periods and subareas, was started using the LPE index and included an inspection of the z/k-values (see below).

Funding for an improved sampling effort

The suggestion was, to develop a combined EU proposal for the acoustic and the herring larvae surveys. Within this programm, the larvae surveys should aim for a yearly coverage of specifically defined target sampling units, which can be done on the basis the effort presently allocated to these surveys, and for a complete coverage comparable to the earlier level of effort every three years. In the short time available for developing the proposal, it turned out that no additional partners could be identified, who were able to participate on a three years basis in this survey programm. The present and slightly increased level of sampling effort has now been ensured for two years by the approved EU contract, but attempts have to be made to allow for a three year cycle of complete coverage by including additional partners in the next funding proposal.

Reliability and changes in z/k-values

The size distribution of larvae from which the z/k-values are derived in the different subareas are depending not only on growth and mortality of the larvae but also on their drift from and to neighbouring areas and on the temporal variation in the the spawning activity. The size distribution data are in several cases obviously not adequate and the selection of useful data and size ranges to be used is to some extend a subjective one. Thus, these values can be expected to show some substantial random variability, but may also depend on actual differences in the environmental conditions. So far, the LPE calculation used an long-term average z/k-value for each subarea, which was updated each year by including the new available information as a single additional data point to the complete time series. Thus, the validity of the average is improved, but actual changes are not considered. **Figure 1** shows the yearly variation of z/k-values for the four traditional subareas considered in this survey programme. The coefficient of total variation, which is in the range of 30-40%, includes a high degree of random variation. Additional area specific trends are indicated, but it appears difficult to confirm these statistically and to identify the relevant time scales to be considered. The data set includes frequent gaps and is too small yet for a more rigorous time series analysis. It may be reasonable to use some kind of moving or running average, by which the variability will not be completely smoothed as in a general long term mean, but actual shifts in the z/k-values are still considered and will be transfered into the LPE calculation. The figure includes as an example (by solid line) the results of a procedure, where each new value is averaged in equal weight with the average value used in the previous year. The remaining variablity can further be reduced by giving less weight to the most recent year, but this will also reduce the inclusion of perhaps relevant trends into the LPE index.

Identification of minimum effort requirements

The first step in this analysis, discussed at the last years Planning Group meeting, was restricted to the given historical set of LAI and LPE values, which are available for the traditional subareas but not for the individual standard time periods separately. It was indicated that a reduction in effort and concentration on two target areas only, did not obviously decrease the precision of SSB estimates by these index values. To study the effect of sampling time as well, the LPE index was considered first as mentioned above. A new time series of LPE values was calculated, based on the given documentation for each sampling unit (area per standard time period) separately. For this pupose also z/k-values have been re-calculated for each unit as well. Regressions of LPE on SSB from VPA were calculated for values obtained from complete coverage, combining all sampling units, as compared to values from reduced sampling, combining differently compose subsets of sampling units. It was planned to compare the degree of explained variance (R5) and the inverse prediction error according to Neter et al. (1985) among the complete set and the different subsets of sampling units. In order to exclude the effect of incomplete sampling <u>within</u> individual units, the presently available comparison considered only those values derived from at least 90% complete sampling within the units.

The results of this comparison are summarized in **Figure 2.** R5 values (Rsq) and prediction errors are given relative to the value for complete coverage. The reduction in effort was done by the following scheme:

1) exclusion of all Central North Sea units, most gaps and uncomplete sampling was observed here;
2) testing all combinations of four to two Buchan and Orkney/Shetland units;
3) at the combination under 2) with lowest prediction, testing all combinations of 3 out of 4 time periods in the Southern North Sea area.

Though there is some variation in the results, no substantial differences become obvious. Some subset combinations even led to reduced prediction errors, but this is probably not statistically significant. This analysis contains the problem, that by the 90% completeness criteria too many subsamples were not considered where they should have been included, and the data sets look rather similar for different combinations of sampling units due to these gaps. A different approach is necessary with a lower comleteness criteria for the sampling within units and with a reasonable interpolation procedure for missing values. Where sampling is too incomplete the whole year has to be excluded from the comparison.

Conclusion

This analysis, as the previous one, did not indicate a reduction in the prediction capability of the LPE by the presently reduced sampling effort. The present results, however, may well have been largely effected by too many sampling units not being considered due to a too strong completeness criteria. The analysis has to be revised and to be extended to both indices. As regressions for indices based on reduced sampling schemes have not yet been sufficiently tested and approved, the multiplicative model approach, at present, appears to provide the most reasonble information from the larvae surveys for assement purpose. The sampling schedule should be kept for the time being as suggested in the last Planning Group report.

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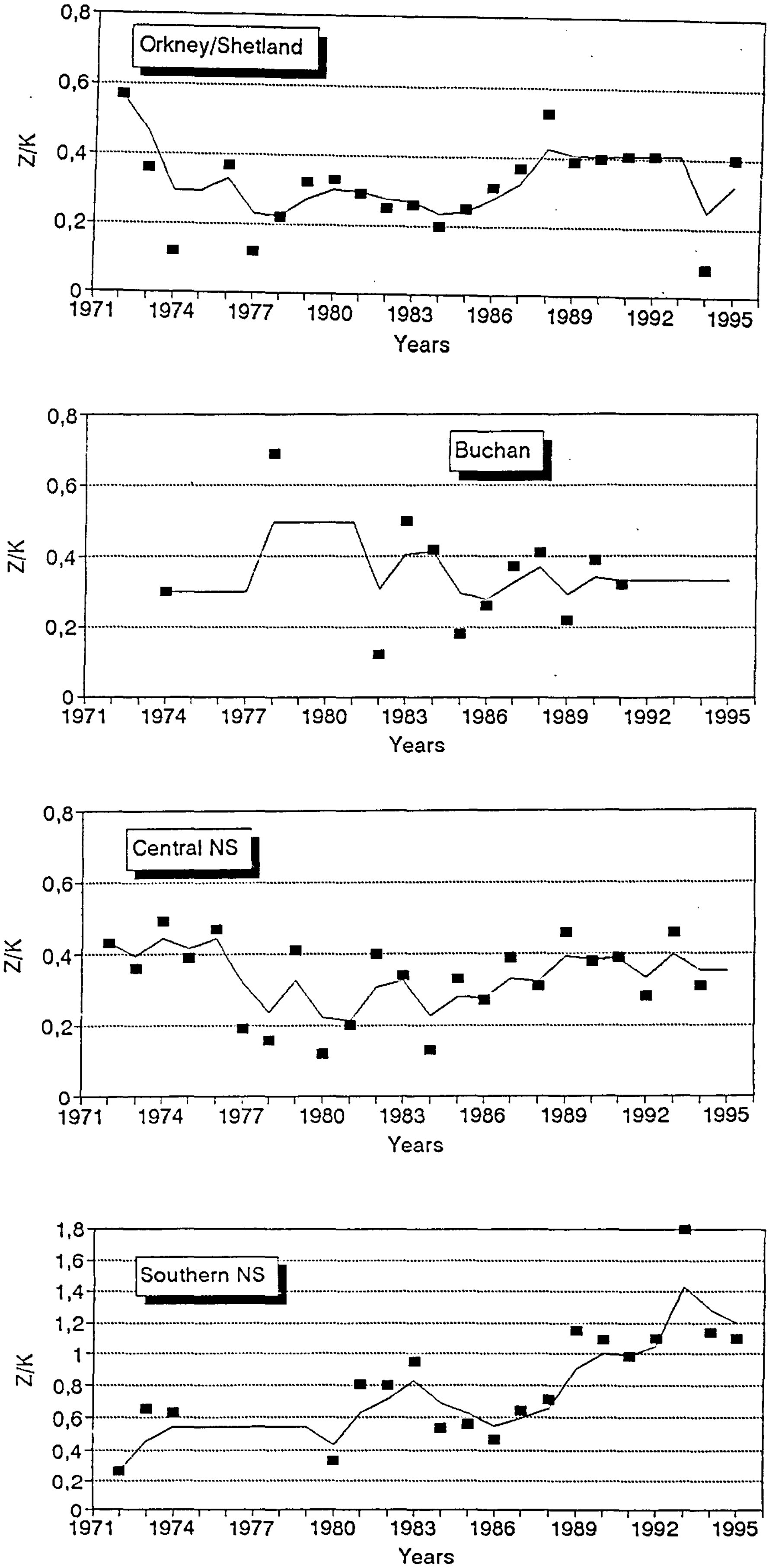

Figure 1: Time series of z/k values calculated for the four standard areas of the herring larvae survey programme. The solide lines indicate the progression of average values derived from combining as a new mean the most recent value with the previously used average in equal weight.

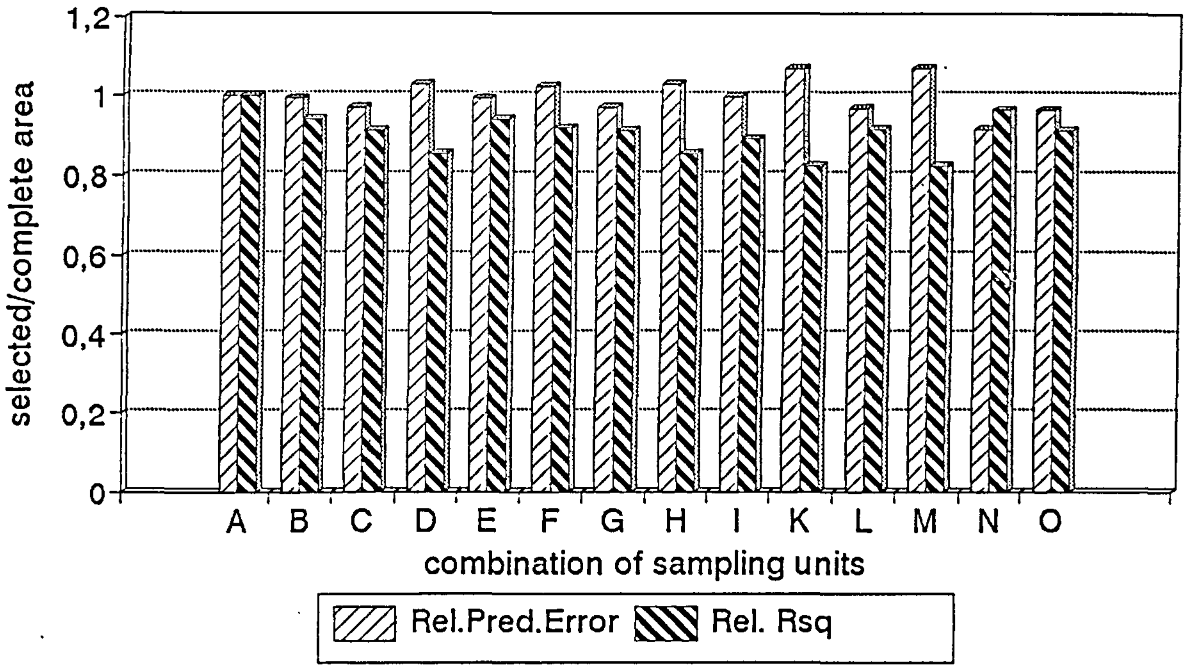

Figure 2: Changes in Explained Variance (Rsq) and invers Prediction Error for regressions of LPE on SSB obtained from different combinations of sampling units relative to complete coverage. The combination of sampling units are indicated by letters as follows, where numbers indicate the standard (fortnight) time periods considered:

A: Orkney/Shetland1,2 & Buchan1,2 & Central NS1-4 & Southern NS1-4
B: Orkney/Shetland1,2 & Buchan1,2 & Southern NS1-4
C: Orkney/Shetland2 & Buchan1,2 & Southern NS1-4
D: Orkney/Shetland1 & Buchan1,2 & Southern NS1-4
E: Orkney/Shetland1,2 & Buchan2 & Southern NS1-4
F: Orkney/Shetland1,2 & Buchan1 & Southern NS1-4
G: Orkney/Shetland2 & Buchan2 & Southern NS1-4
H: Orkney/Shetland1 & Buchan2 & Southern NS1-4
I: Orkney/Shetland2 & Buchan1 & Southern NS1-4
K: Orkney/Shetland1 & Buchan1 & Southern NS1-4
L: Orkney/Shetland2 & Buchan2 & Southern NS2,3,4
M: Orkney/Shetland2 & Buchan2 & Southern NS1,3,4
N: Orkney/Shetland2 & Buchan2 & Southern NS1,2,4
O: Orkney/Shetland2 & Buchan2 & Southern NS1,2,3

Appendix B

Preliminary Estimates from Acoustic Surveys of ICES areas IVa and IVb

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Martin Bailey, Marine Lab, Aberdeen, Scotland
Reidar Toresen, Inst Marine Research, Bergen, Norway
Bram Couperus RIVO, IJmuiden, Netherlands
Niels Hammer, ISF, Hamburg Germany

Surveys

Scotland	8 - 28 July	58 30 to 61 45 N, 4 W to 2 E
Norway	27 June - 18 July	57 to 62 N, 3W/1E to 5 E
Netherlands	1 - 16 July	54 30 to 59 N 4 W to 2 E
Germany	23 June - 16 July	54 to 57N 2E to 7E

The results for the four surveys have been combined to give preliminary estimates of North Sea autumn spawning herring by age class and spawning proportion at 2 and 3 ring. Procedures are the same as 1996 surveys (ICES CM 1997/H:11). The stock estimates have been worked out by age for 30 min by 1 degree stat squares for the North Sea. Where the survey areas for individual vessels overlap the mean estimates for each overlapping rectangle have been used. If effort in overlapping squares is different (2 or 4 transects per rectangle) weighting of the individual estimate has been applied accordingly. Stock estimates are shown in Table 1 for 1996 and 1997 North Sea autumn spawning herring (excluding Baltic Spring Spawning herring). Estimates of immature, mature and totals are included at the base of the table. It should be remembered that estimates of 1 group are not regarded as accurate, the changes in this cohort from 96-97 are not significant and the relative abundance of 1 group in 96 and 97 are not representative of yearclass strength.

The results must be regarded as preliminary as the Danish data has not yet been included because it has not been made available in time. However, although this means we are unable to provide estimates of North Sea herring in IIIa, it is unlikely to have a major impact on the overall estimates for the spawning stock as relatively little of the SSB is usually found in these waters. This data is likely to have an effect on the estimates of immature fish.

The preliminary indications from these surveys are that the stock is continuing to recover and that the 2 year old recruitment to spawning stock (this years) is very good and 3 year old recruitment (last years) is better than for a number of years. Numbers and biomass of spawning fish are therefore increasing from 7195 to 9799 million herring and from 1427 to 1742 thousand tonnes.

John Simmonds 8 October 1997

Table 1 Estimates of Autumn Spawning Herring for North Sea from acoustic surveys in 1996, 1997 in North Sea . (Numbers $*10^{-6}$ Biomass tonnes $*$ 10^{-3}).

	Numbers (millions)		Biomass (Thousand Tonnes)		Mean Wt (g)
Ring/year	1996	1997	1996	1997	1997
1	4798	7723	206	339	43.9
2i	1620	2113	143	200	94.7
2m	2576	3951	366	531	134.3
3i	65	163	9	23	141.8
3m	2724	2932	540	502	171.3
4	1074	1689	274	385	227.7
5	303	674	81	173	256.3
6	97	243	29	59	244.0
7	82	75	25	19	251.8
8	133	76	43	21	273.2
9+	206	158	69	52	329.3
Immature	6483	9999	358	562	51.4
Mature	**7195**	**9799**	**1427**	**1742**	177.7
Total	16380	20740	1792	2308	111.3

Appendix C

Working paper

Planning Group for Herring Surveys

Bergen, January 1998

Survey Report for *RV Dana*

2 July - 13 July 1997

Jens Pedersen, Danish Institute for Fisheries Research

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Introduction

In several years Denmark has participated in the international acoustic survey of herring in the North Sea, Skagerrak and Kattegat. In the past five years Denmark has covered the North Sea east of 5^{E}E, and between 57^{E}N and 59^{E}N, Skagerrak and Kattegat. The time effort of the Danish survey has decreased from 22 days in 1991 to 12 days in 1997.

Survey area

The survey was carried out in the North Sea east of 5^{E}E, and between 57^{E}N and 59^{E}N, Skagerrak and Kattegat (Fig. 1). The area was split up into 8 subareas (Fig. 2). The survey started in the west by doing parallel transects, 10-20 nautical miles apart in an north-south direction. In the easthern part of the survey area the transects were carried out westwards to the Swedish coast. The origin of the survey transect was selected "randomly". The track was then laid out with semi-systematic spacing.

Methods

Acoustic data was sampled using a Simrad EK400 and a Simrad EY500 38 kHz echo sounder with a towed body (type Es 38-29) and a hull mounted split-beam transducer (type Es 38), respectively. The towed body and the hull mounted transducer was 3.0 m and 6.0 m below the surface, respectively. The EK400 echo sounder operated in conjunction with a Simrad ES400 split-beam echo sounder and the ECHOANN analyzer system, with the EK400 sounder serving as the transmitter (Degnbol *et al.*, 1990). The pulse duration was 1 ms and the receiver bandwidth 1 kHz between -3 dB point during the survey. The integration data was stored by the ECHOANN analyzer system for each nautical mile for each 1.0 m depth interval. Speed of the ship during acoustic sampling was 9-12 knots.

The hydroacoustic equipment was calibrated using a standard copper sphere of 60 mm in diameter at Bornö, Gullmarn fjord, Sweden in May 1996 and October 1997. The two calibrations were consistent.

Trawl hauls (Fig. 3) were carried out during the survey for length, age, maturity and weight of individual herring. Pelagic trawling was carried out using a Fotö trawl (16 mm in cod-end), while benthic trawling was carried out using an Expo trawl (16 mm in cod-end). Trawling was carried out in the time interval 12.00-18.00 h and 23.00-05.00 h (Table I). In conjunction with each trawl haul CTD profiles of temperature, salinity, density and fluoresecence were collected.

The fish caught in each trawl haul was sorted and analysed for species, length, age and weight. The fish were measured to the nearest 0.5 cm total length and weighed to the nearest 0.1 g wet weight. In each haul 10 herring were sampled per 0.5 cm length class of herring for separation of North Sea autumn spawners and Baltic spring spawners, and for determination of age and maturity. Micro-structure formed during the herring's larval period is retained as the central part of the adult otoliths and used to discriminate between North Sea autumn spawners and Baltic spring spawners. A total of 3,932 otoliths of herring were sampled and examined.

The acoustic data were judged for each nautical mile. Herring and sprat was not observed on depths below 150 meters. Layers below 150 meters was therefore excluded during the acoustic judging. The contribution from plankton, air, bubbles, bottom echoes and noise were removed. When fish echoes were mixed with plankton echoes the contribution from plankton was estimated by comparing the integration values with values obtained at other close sampling positions with similar plankton recordings not containing fish. Significant contribution from air bubbles, bottom echoes and noise were removed by skipping those layers.

For each subarea the mean back-scattering cross section was estimated for herring, sprat, gadoids and mackerel by the TS-length relationship recommended by The Planning Group for Herring Surveys (Anon, 1994):

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

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

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

$$\text{mackerel TS} = 21.7 \log L - 84.9 \text{ dB}$$

where L is the total fish length in cm. The number of each fish species was assumed to be in proportion to their contribution in trawl hauls. The density of a particular fish species was therefore estimated by subarea using the contribution of the species in trawl hauls. The nearest trawl hauls was allocated to subareas with uniform depth strata. Allocation to length-age for each species was assumed to be in accordance with the length-age distribution in the allocated trawl hauls.

As the current maturity of North Sea autumn and Baltic spring spawning herring was below 10%. The spawning biomass of herring was estimated using the maturity key:

age 0 and 1: no mature individuals
age 2: 50% mature individuals
age 3: 85% mature individuals
age 4+: 100% mature individuals

Results

In 1997 the temperature of the water in the surface was characterized by summer heating with temperatures ranging from 16-21^{E}C, which was 2-3^{E}C higher than in 1995 and 1996. Below the thermocline at 20-25 meters depth the temperatures were ranging from 7-8^{E}C, which was in consistent with the previous years.

Approximately 1,600 nautical mile were surveyed (Fig. 1) and 37 trawl hauls were carried out (Table I and Fig. 3). The total catch was 21,723 kg with a mean catch of 587 kg. Approximately 55% of the catch was made up by herring as the total catch of herring was 12,019 kg and the mean catch of herring 353 kg. The catch of sprat was insignificant. The length frequency of herring for each trawl haul is given in figure 4.

A total of $5.7*10^9$ herring or 319,468 tonnes was estimated (Table II). The estimated spawning biomass of the North Sea autumn and the Baltic spring spawning herring was 195,924 and 123,543 tonnes, respectively (Table III). The biomass by age was calculated using the estimated number of fish by age (Table IV) and the mean weight by age calculated from the length-weight relationship given in Table V. Approximately 50% of the spawning biomass was found in subarea IV-VI (Table III).

Generally, the mean weight of herring by age was significant higher in subarea I-V than in subarea VI-IX (Table VI). Significant difference in length of herring between subareas was not found. However, herring caught within the 100 m line of depth show a tendency to be smaller than herring caught within the area of the 100-200 m lines of depth and above the 200 m line of depth (Fig. 5a-5c).

In the Skagerrak and Kattegat the estimated total stock of herring was 542,059 and 394,147 tonnes in 1995 and 1996, respectively (Simmonds et al., 1996). In 1997 the total herring stock was 319,468 tonnes (Table II), which was 41.1% and 18.9% lower than in 1995 and 1996, respectively. The spawning biomass decreased from 401,309 tonnes in 1995 to 166,202 tonnes in 1996 (Simmonds et al., 1996) and 128,325 tonnes in 1997 (Table III). The decrease in spawning biomass from 1995 to 1996 was higher for the Baltic spring spawners than for the North Sea autumn spawners (62% and 26%, respectively). However, the spawning biomass of the North Sea autumn spawners increased from 36,251 tonnes in 1996 to 52,062 tonnes in 1997, while the spawning biomass of the Baltic spring spawners decreased from 164,079 tonnes in 1996 to 76,263 tonnes in 1997. The total catch decreased from 1,050 kg in 1995 to 634 kg in 1996 and 587 kg in 1997 (Fig. 6), which also indicate a decrease in stock size as the effort was alike the three years.

Acknowledgements

I am grateful to Torben F. Jensen (The Danish Institute for Fisheries Research) for invaluable help with computer calculations.

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Table 1 Catch information by trawl haul during the acoustic survey of RV *Dana* in Skagerrak and Kattegat in the period 2–13 July 1997.

Date dd/mm/yy	Haul no	Time hour	ICES square	Trawl	Catch depth m	Mean depth m	Trawling Speed kn	Trawling time min	Total catch kg	Main species
020797	420	24.00	44F7	FOTÖ	surface	210	4.0	60	295	herring, mackerel, blue whiting
030797	563	16.50	44F6	FOTÖ	130-145	182	4.0	60	480	krill, pearlsides, saithe
030797	615	24.00	45F5	FOTÔ	surface	314	4.3	60	985	herring, mackerel, blue whiting
040797	627	02.58	45F5	FOTÖ	surface	301	3.3	60	400	herring, mackerel, blue whiting
040797	711	12.55	44F5	EXPO	bottom	137	3.4	60	953	Norway pout, saithe, cod
040797	730	16.02	44F5	EXPO	bottom	102	3.1	60	1398	Norway pout, cod, saithe
040797	788	23.34	43F6	FOTÖ	surface	70	4.1	60	170	mackerel, herring
050797	807	02.50	43F6	FOTÖ	surface	56	3.5	60	84	jellyfish, mackerel, lumpsucker, herring
050797	886	13.30	44F6	FOTÖ	235-250	295	3.4	60	55	krill, pearlsides, blue whiting
050797	902	16.20	43F7	FOTÖ	140-154	204	3.6	60	76	saithe, lumpsucker, herring
050797	953	00.05	43F7	FOTÖ	126-140	173	3.3	60	148	saithe, Norway pout, blue whiting
060797	965	02.30	43F7	FOTÖ	17-34	132	4.4	60	150	herring, mackerel
060797	1055	12.45	43F8	EXPO	bottom	28	3.2	40	150	herring, sandeel
060797	1073	15.50	43F8	EXPO	bottom	55		?	106	herring
060797	1137	23.47	44F8	FOTÖ	surface	435	3.8	60	400	herring, mackerel, lumpsucker, blue whiting
070797	1156	02.58	44F8	FOTÖ	surface	50	4.7	60	625	herring
070797	1234	13.08	45F9	FOTÖ	159-174	390	3.4	60	50	krill, blue whiting, mackerel, saithe
070797	1252	16.45	45F9	FOTÖ	290-305	600	3.3	60	40	roundnose grenadier, blue whiting
070797	1303	23.45	44F9	FOTÖ	surface	35	4.1	60	2730	herring
080797	1321	03.03	44F9	FOTÖ	surface	90	3.6	60	1530	herring
080797	1389	16.45	44G0	EXPO	bottom	146	3.1	60	1020	Norway pout, shrimps
080797	1462	23.48	46F9	FOTÖ	surface	486	3.9	60	387	herring, mackerel
090797	1479	02.44	46F9	FOTÖ	surface	440	2.1	60	254	herring, mackerel
090797	1559	13.10	46F9	FOTÖ	250-265	445	3.9	60	7	shrimps, blue whiting
090797	1577	16.00	46F9	FOTÖ	190-205	315	3.9	60	53	herring, blue whiting
090797	1632	23.45	46G0	FOTÖ	surface	105	4.0	60	1275	herring, mackerel
100797	1652	02.40	45G0	FOTÖ	surface	115	3.5	60	965	herring, mackerel
100797	1729	12.45	44F9	EXPO	bottom	150	4.0	60	1240	Norway pout, blue whiting, haddock
100797	1741	15.15	44G0	EXPO	bottom	80	4.2	60	795	herring, Norway pout
100797	1803	23.45	45G1	FOTÖ	surface	150	3.2	60	685	herring, mackerel, horse mackerel, krill
110797	1819	02.30	45G0	FOTÖ	surface	200	3.4	60	350	mackerel, herring
110797	1900	13.35	43G1	EXPO	bottom	28	3.0	60	1782	herring
110797	1913	15.10	43G1	EXPO	bottom	66	3.5	60	565	herring, jellyfish
110797	1977	23.36	43G1	FOTÖ	surface	55	3.7	60	500	herring, jellyfish
120797	1987	01.53	43G2	FOTÖ	surface	50	3.9	60	490	herring, jellyfish
120797	2077	12.34	41G2	GOV	bottom	32	3.4	60	180	cod
120797	2090	15.08	41G2	GOV	bottom	30	3.6	60	350	herring, cod, whiting
mean catch									587.1	
total				37					21723.0	

Table 2 The total biomass (tonnes) and number (*1,000,000) of herring calculated by Sub-area during the acoustic survey of RV *Dana* in the period 2–13 July 1997.

Subarea	Biomass tonnes	Number *1000000	% of biomass	% of number
I	11447.2	205.9	3.6	3.6
II	43110.7	705.6	13.5	12.4
III				
IV	88583.5	1274.7	27.7	22.4
V	12718.4	141.3	4.0	2.5
VI	55160.4	805.7	17.3	14.2
VII	10123.9	120.1	3.2	2.1
VIII	35995.9	417.0	11.3	7.3
IX	62328.2	2021.4	19.5	35.5
Total	319468.2	5691.7	100.0	100.0

Table 3 The calculated biomass (tonnes) of immature/mature North Sea autumn and Baltic spring spawners by Sub-area and age at the acoustic survey of RV *Dana* in the period 2–13 July 1997.

Subarea	Age													Total biomass
	0	1	2 Im	2 MAT	3 Im	3 MAT	4	5	6	7	8	9	10	tonnes
Northe Sea autumn spawners														
I		3706.6	1172.7	1172.7	233.7	1324.4	196.8	196.8	196.8					8200.5
II		14053.2	4138.6	4138.6	1116.5	6326.9								29773.8
III														0
IV		19732.4	11382.0	11382.0	1744.5	9885.5	496.1	496.1						55118.6
V		3413.6	824.4	824.4	53.1	301.0					116.2			5532.7
VI		23992.5	3172.3	3172.3	69.3	392.7								30799.1
VII	428.3	4278.1												4706.4
VIII		11620.7	2387.0	2387.0	89.2	505.4								16989.3
IX	1209.7	29660.2	4838.9	4838.9	544.4	3084.7				627.3				44804.1
tonnes	1638.0	110457.3	27915.9	27915.9	3850.7	21820.6	692.9	692.9	196.8	627.3	116.2	0.0	0.0	195924.5
% by age	0.8	56.4	14.2	14.2	2.0	11.1	0.4	0.4	0.1	0.3	0.1	0.0	0.0	100.0
Baltic spring spawners														
I		542.2			203.1	1150.8	811.7			269.5	269.5			3246.8
II		13337.0												13337.0
III														0.0
IV		1606.3	4785.5	4785.5	2389.4	13539.9	1606.3		4752.0					33464.9
V		165.3	1336.6	1336.6	251.1	1423.2	1006.0	503.0	503.0	330.5				6855.3
VI		4506.8	3532.4	3532.4	1538.4	8717.7	633.4	633.4	633.4	633.4	330.5			24691.8
VII			1934.1	1934.1	117.0	663.1	384.6	384.6						5417.5
VIII		627.2	3962.9	3962.9	1091.9	6187.6	1577.5	950.3				323.1	323.1	19006.5
IX		192.8	4188.3	4188.3	972.6	5511.4	1524.6	771.1	175.2					17524.3
tonnes	0.0	20977.6	19739.8	19739.8	6563.5	37193.7	7544.1	3242.4	6063.6	1233.4	600.0	323.1	323.1	123544.1
% by age	0.0	17.0	16.0	16.0	5.3	30.1	6.1	2.6	4.9	1.0	0.5	0.3	0.3	100.0

Table 4 The number (*1,000,000) of North Sea autumn and Baltic spring spawners by Sub-area and age during the acoustic survey of RV *Dana* in the period 2–13 July 1997.

Subarea	Age													Total number
	0	1	2 Im	2 MAT	3 Im	3 MAT	4	5	6	7	8	9	10	*1000000
Northe Sea autumn spawners														
I		71.2	22.6	22.6	4.5	25.5	3.8	3.8	3.8					157.8
II		253.3	74.6	74.6	20.1	114.1								536.7
III														0
IV		320.6	185.0	185.0	28.4	160.7	8.1	8.1						895.9
V		42.0	10.2	10.2	0.6	3.7					1.4			68.1
VI		433.6	57.4	57.4	1.2	7.1								556.7
VII	6.1	61.2												67.3
VIII		159.6	32.8	32.8	1.2	7.0								233.4
IX	47.3	1159.7	189.2	189.2	21.3	120.6				24.5				1751.8
number	53.4	2501.2	571.8	571.8	77.3	438.7	11.9	11.9	3.8	24.5	1.4	0.0	0.0	4267.7
% by age	1.3	58.6	13.4	13.4	1.8	10.3	0.3	0.3	0.1	0.6	0.0	0.0	0.0	100.0
Baltic spring spawners														
I		8.1			3.0	17.1	12.1			4.0	4.0			48.3
II		168.9												168.9
III														0.0
IV		18.2	54.2	54.2	27.1	153.3	18.2		53.8					379.0
V		1.7	13.6	13.6	2.6	14.5	10.2	5.1	5.1	3.4	3.4			73.2
VI		46.1	36.1	36.1	15.7	89.2	6.5	6.5	6.5	6.5				249.2
VII			18.9	18.9	1.1	6.5	3.7	3.7						52.8
VIII		6.1	38.3	38.3	10.6	59.8	15.3	9.2				3.1	3.1	183.8
IX		3.0	64.4	64.4	15.0	85.7	23.5	11.9	2.7					270.6
number	0.0	252.1	225.5	225.5	75.1	426.1	89.5	36.4	68.1	13.9	7.4	3.1	3.1	1425.8
% by age	0.0	17.7	15.8	15.8	5.3	29.9	6.3	2.6	4.8	1.0	0.5	0.2	0.2	100.0

Table 5 Statistical information of length-weight relationship of North Sea autumn and Baltic spring spawning herring in Skagerrak and Kattegat during the acoustic survey of RV *Dana* in the period 2–13 July 1997.

ANOVAR of linear regression

Source of variation	North Sea autumn spawning herring				Baltic spring spawning herring			
	df	SS	S^2	F	df	SS	S^2	F
Regression	1	111.159	111.159	9229.83	1	33.672	33.672	2709.03
Residual	442	5.323	0.012		280	3.480	0.012	
Total	443	116.483			281	37.152		

Linear regression

			S.E	t-value	95% confidence limits		R	number
					Lower	Upper		
North Sea herring	Slope	3.228	0.033	96.07	3.162	3.294	0.9543	444
	Intercept	0.0004	0.124	-63.03	0.0003	0.0005		
Baltic herring	Slope	3.054	0.059	52.05	2.938	3.169	0.9063	282
	Intercept	0.0007	0.223	-32.56	0.0005	0.0011		

Table 6 The calculated mean weight (g) of North Sea autumn and Baltic spring spawners by Sub-area and age during the acoustic survey of RV *Dana* in the period 2–13 July 1997.

Subarea	Age										
	0	1	2	3	4	5	6	7	8	9	10
Northe Sea autumn spawners											
I		58.0	124.0	124.0	101.0	126.0	159.0				
II		56.0	103.0	113.0	110.0	134.0	159.0				
III		57.0	109.0	116.0	101.0	126.0	159.0				
IV		55.0	100.0	113.0	110.0	134.0	159.0				
V		57.0	81.0	121.0					137.0		
VI		45.0	85.0	111.0							
VII	5.0	50.0	82.0	121.0					137.0		
VIII		50.0	74.0	68.0							
IX	5.0	37.0	56.0	53.0				133.0			
mean											
Baltic spring spawners											
I		45.0		136.0	119.0			215.0	88.0		
II		51.0	83.0	122.0	120.0		134.0	215.0	88.0		
III		45.0		136.0	119.0			215.0	88.0		
IV		51.0	83.0	115.0	120.0	83.0	134.0	215.0	88.0		
V		52.0	78.0	96.0	100.0	116.0	106.0	187.0	122.0	168.0	
VI		27.0	85.0	101.0	176.0	83.0	84.0	157.0			
VII		52.0	74.0	91.0	96.0	106.0	144.0		141.0	168.0	
VIII		49.0	74.0	83.0	88.0	103.0				168.0	198.0
IX		55.0	60.0	68.0	68.0	86.0	80.0				
mean											

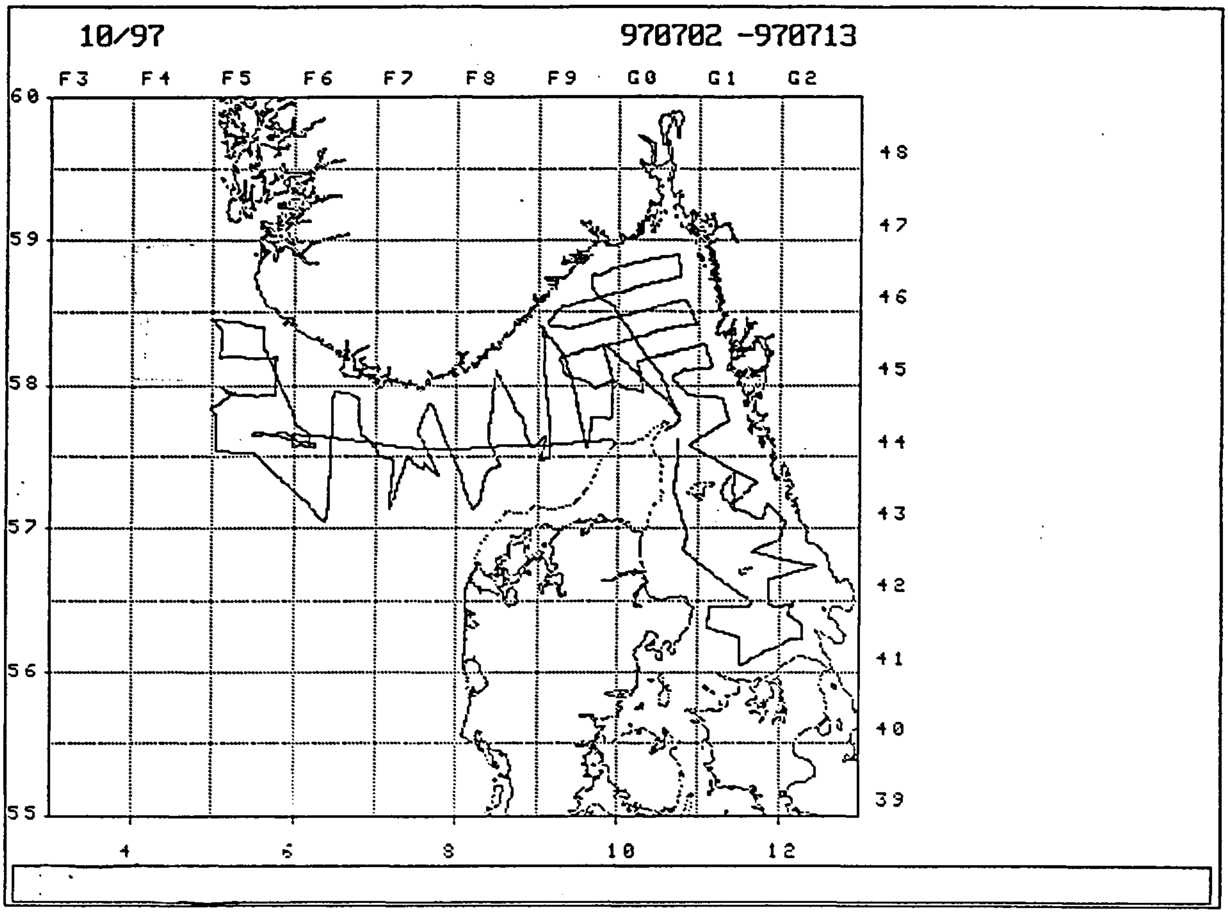


Figure 1 Cruise track during the acoustic survey of RV *Dana* in the period 2-13 July 1997.

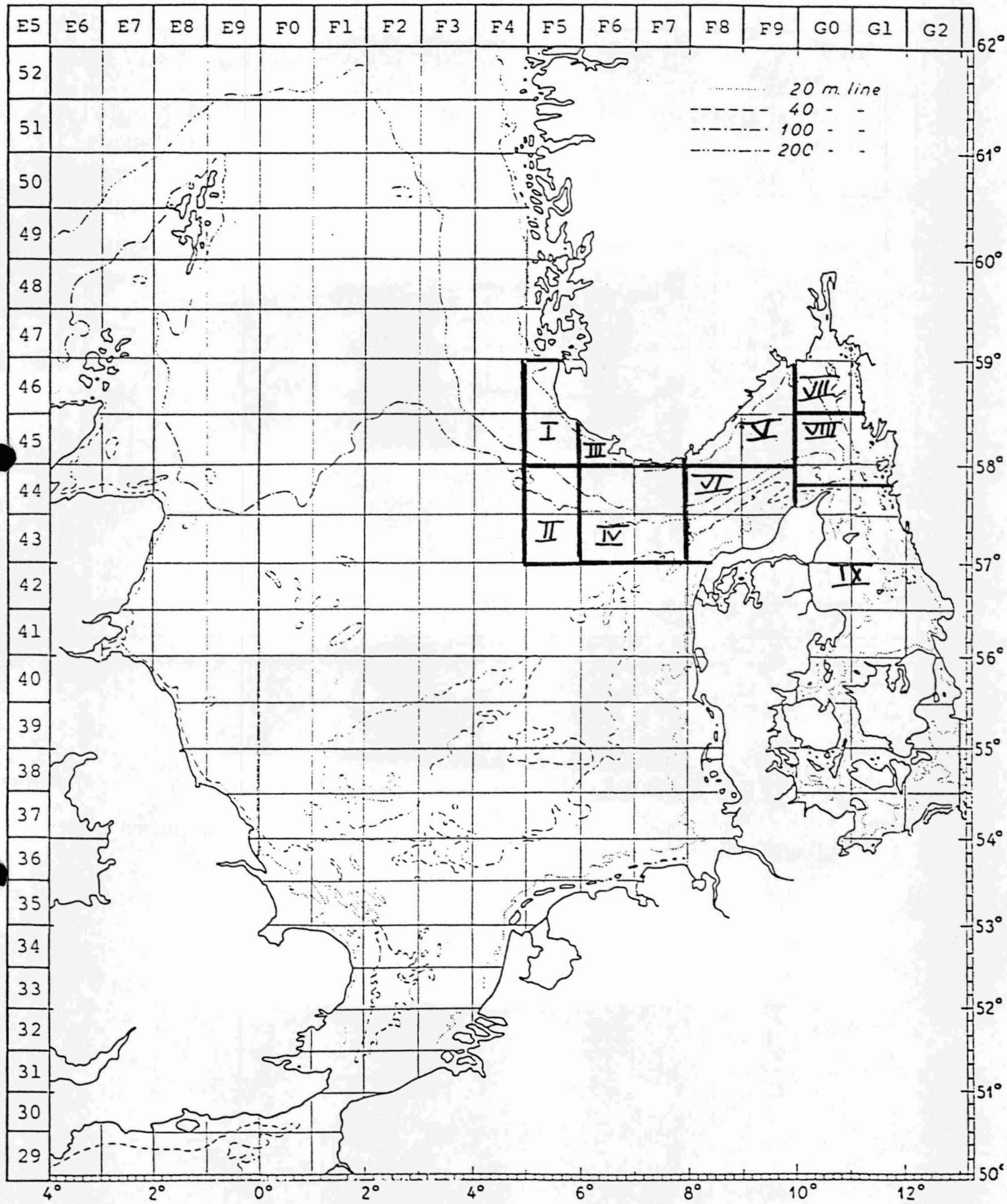


Figure 2 Subareas used during the acoustic survey of RV *Dana* in the period 2-13 July 1997.

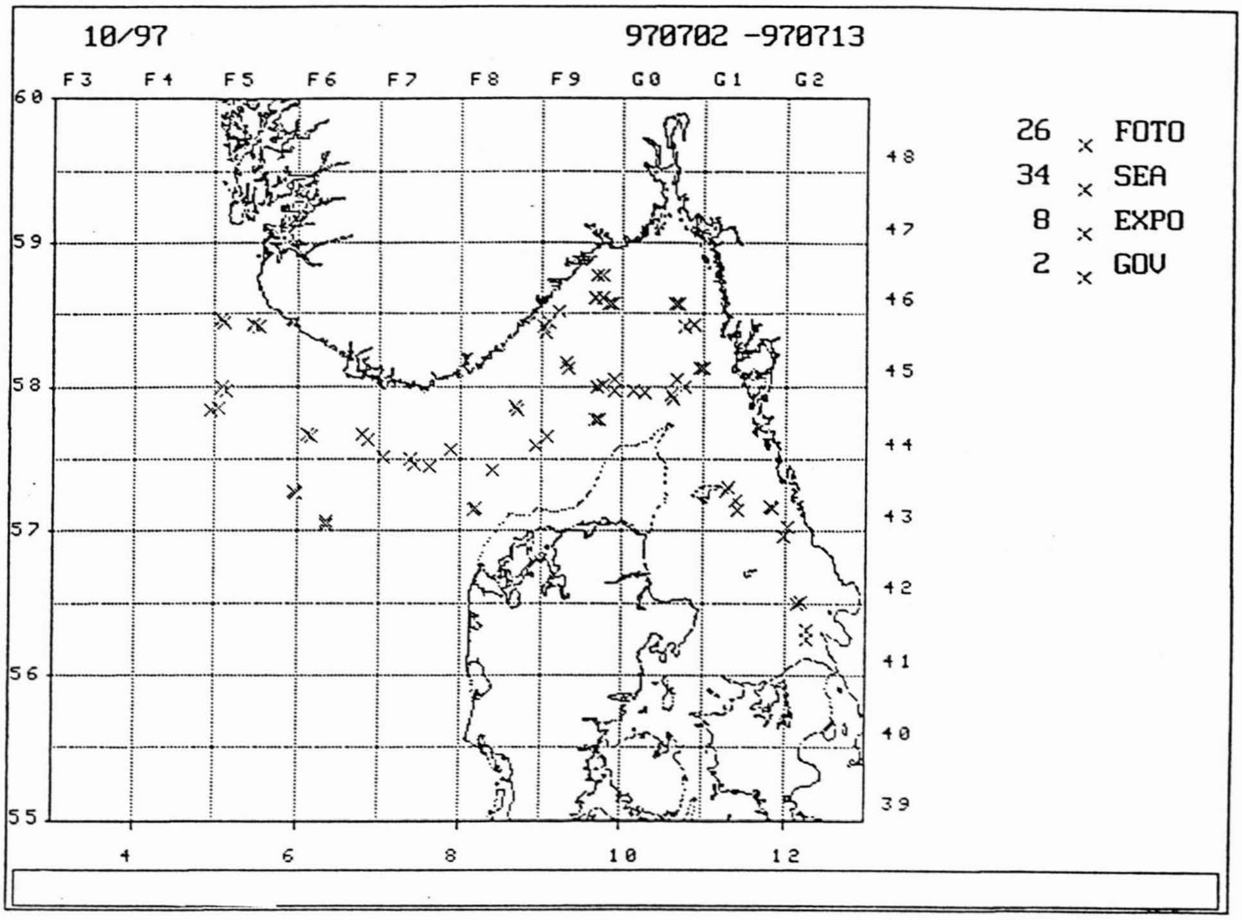
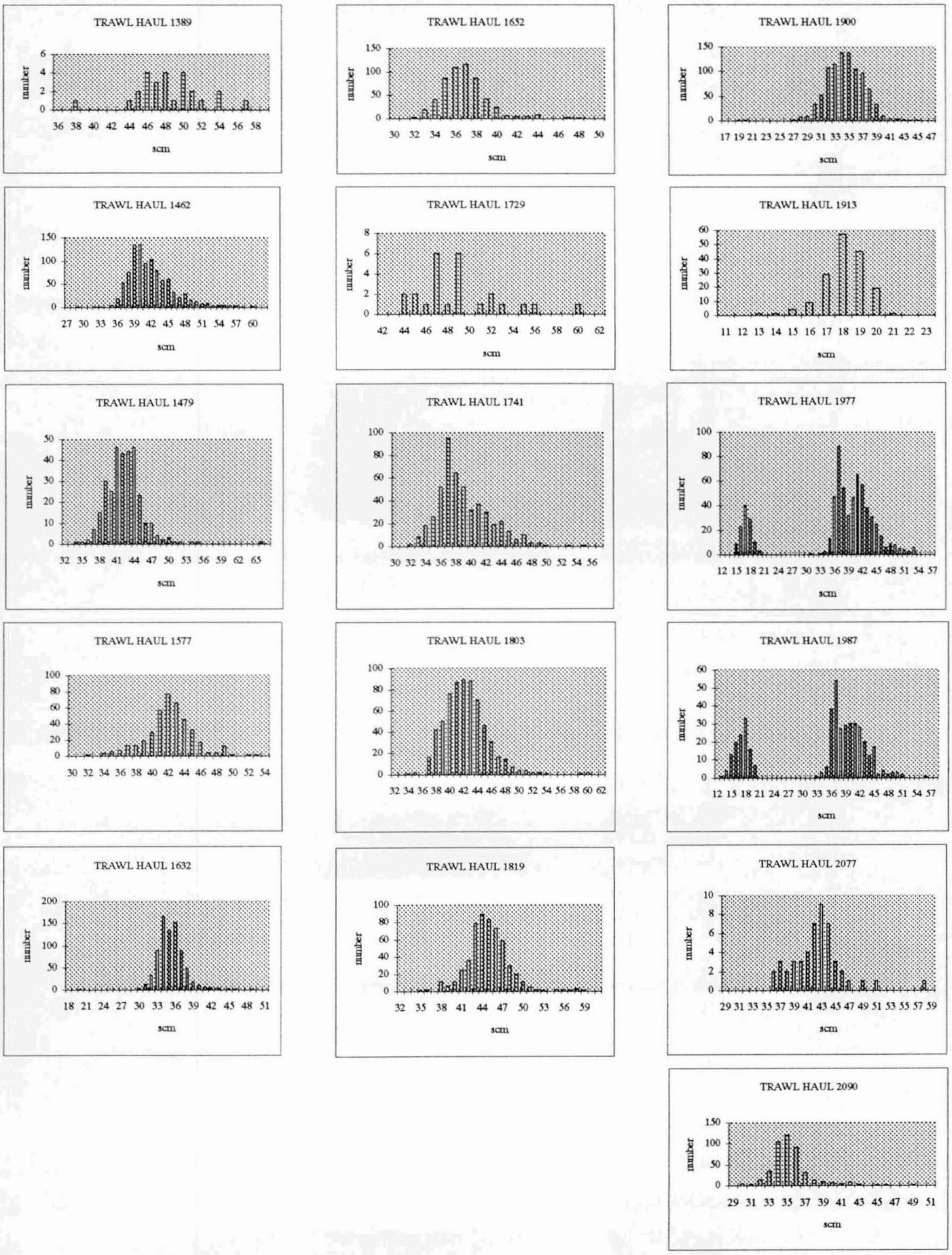


Figure 3 Trawl haul positions during the acoustic survey of RV *Dana* in the period 2-13 July 1997.

Figure 4 The length frequency of herring for each trawl haul during the acoustic survey of RV *Dana* in the period 2–13 July 1997.



(continued)

Figure 4 (continued) The length frequency of herring for each trawl haul during the acoustic survey of RV *Dana* in the period 2–13 July 1997.

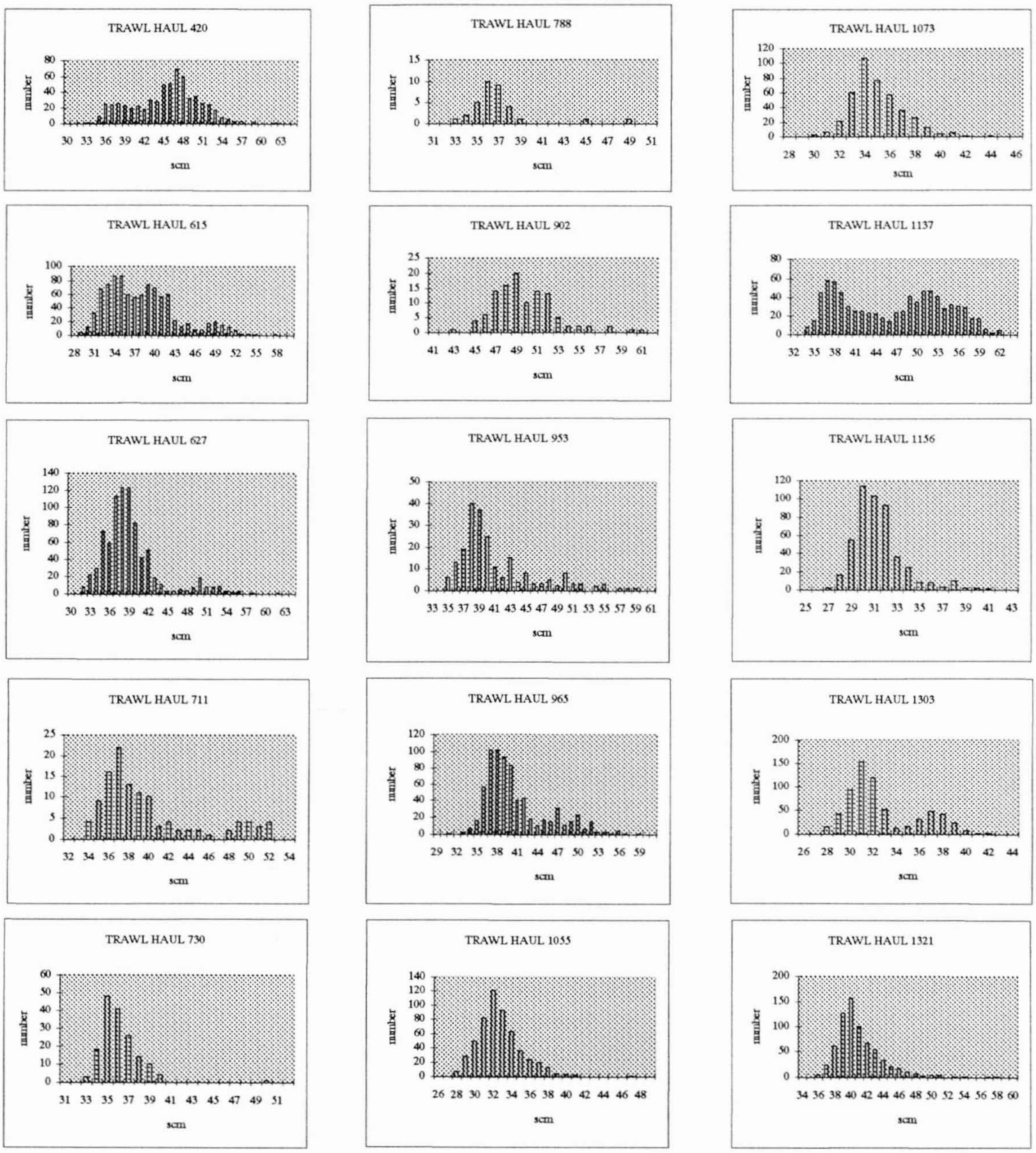


Figure 5 The length of herring caught within the 100 m, 100–200 m and > 200 m line of depth during the acoustic survey of RV *Dana* in the period 2–13 July 1997.

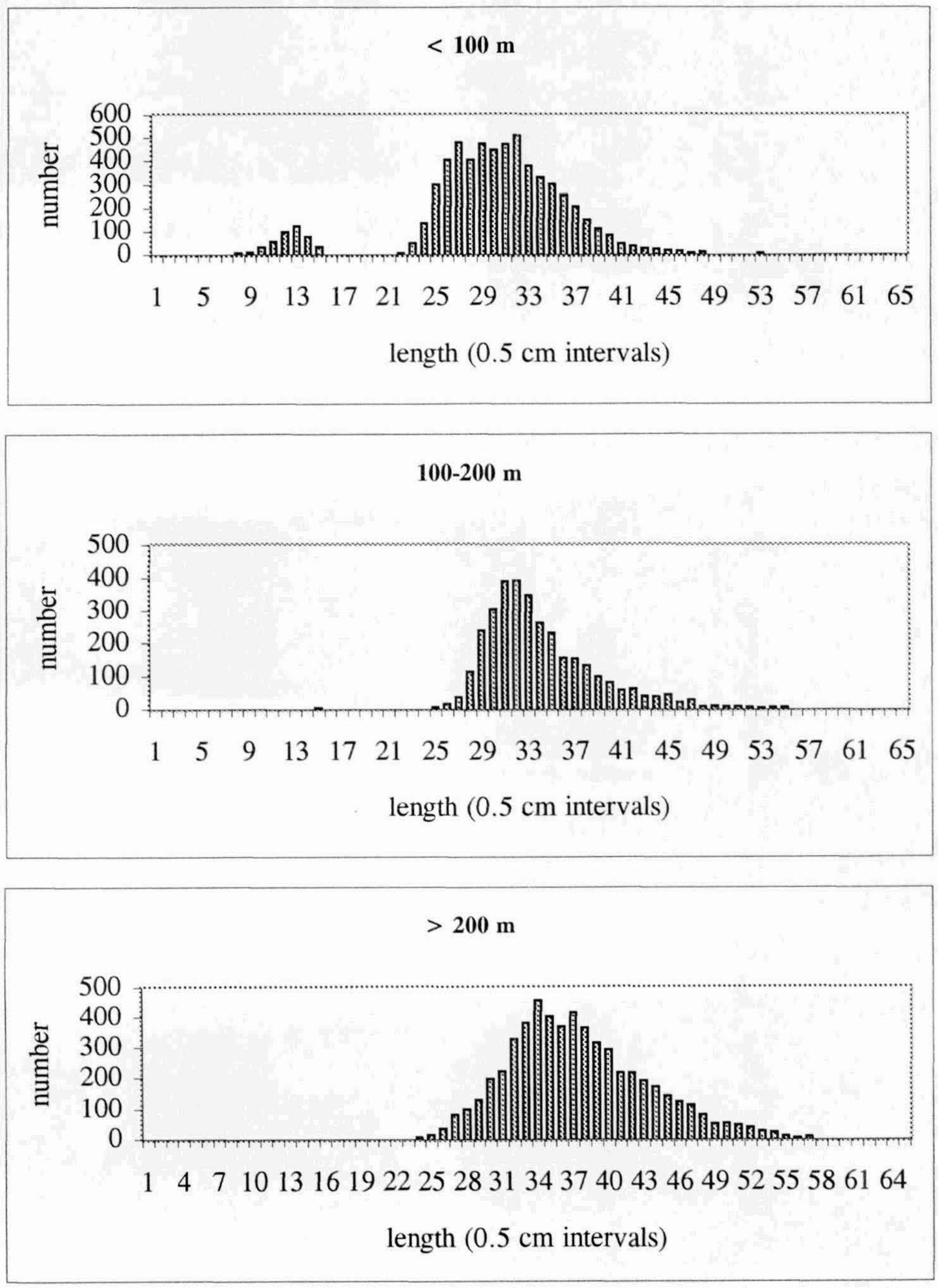
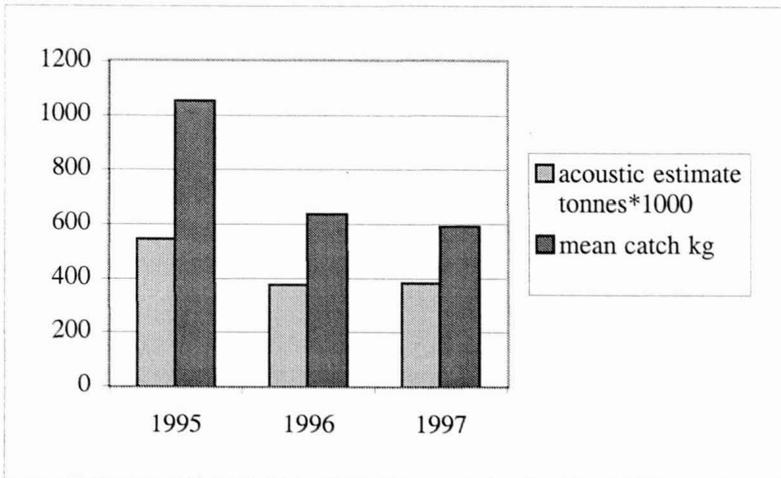


Figure 6 The mean catch and the acoustic estimate of herring during the acoustic surveys of RV *Dana* in the period 1995–1997.



Appendix D

Working paper
Planning Group for Herring Surveys
Bergen January 1998
Study Group on the Stock Structure
of Baltic Springspawning Herring
Lysekil January 1998

Summary of the Environmental Impact Monitoring on Herring in the Sound Autumn 1995 to Autumn 1997

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Introduction

Objectives

The objectives of environmental impact monitoring of herring in the Sound are to follow the herring stocks in the Sound to examine if changes in behaviour occur as a result of construction activities in connection with the establishment of a fixed link across the Sound between Copenhagen and Malmö.

The environmental impact monitoring program will follow the herring stock in the Sound during the migration period to investigate whether or not plumes of suspended material from the construction work disturb the migration pattern of the Western Baltic Herring Stock (Rügen Herring Stock).

The migration of herring will be monitored several times during the migration season to ensure that the herring will come into the Sound at the beginning of the migration in the autumn and leave the Sound for the spawning grounds in the early spring.

Background

The Sound is a transition area for several migrating fish stocks such as herring, garfish, lumpsucker, mackerel and to some extent cod. Also, some smaller, local stock components of cod, flatfish, herring and several other fish are found here.

Of these stocks, herring is the dominant one. Results from early tagging experiments (Beister 1979; Otterlind 1984) showed that the Sound is a major overwintering area and an important migration route for the western Baltic (Rügen) herring stock. The western Baltic herring stock is of high importance for the fishery in Skagerrak/Kattegat and the Baltic Sea with catches of around 200,000 tonnes per year during the most recent years (Degnbol 1996).

The most important feeding grounds for the western Baltic Herring stock are situated in Skagerrak-Kattegat and the North Sea area where the 2 year old and older herring are located during summer. In the late summer (July/August), they migrate southwards through Kattegat. During the period August to March the herring are found in high concentrations in the Sound and spawning takes place at Rügen and surrounding areas in the western Baltic April-May after spawning the herring migrate back to the Skagerrak-Kattegat area.

In connection with the construction of the fixed link across the Sound, fine -grained sediment will be suspended in the water. Several investigations have shown that fish may avoid plumes of suspended material. At the planning phase of the fixed link across the sound no data was available which described thresholds for avoidance reactions to plumes of suspended sediment of limestone and glacial till for herring during a migration situation. However, laboratory experiments investigated threshold values for avoidance by sensitive pelagic species as herring from other types of suspended sediment, showed threshold values at 9-12 mg/l for sediment with median particle diameter of 6.2 Fm (Johnston & Wildish 1981). Demersal fish such as cod, flatfish and eel seem to be able to tolerate somewhat higher concentrations of suspended material.

Related to the construction of the fixed link across the Sound a number of environmental criteria, among others with respect to herring in the Sound, shall be respected and obeyed . Related to migration routes and distribution of herring in the Sound the Danish environmental authorities (Miljø- og Energiministeriet, Trafikministeriet, Januar 1995) and Swedish authorities (Vattendomstolen, July 1995) have set the following criteria:

The situation must not arise that sediment plumes simultaneously prevent the passage of herrings through both the Drogden Channel and Flinterenden when moving south to their spawning grounds in the Baltic Sea and when moving north to their fouraging grounds in the Skagerrak and Kattegat.

This criterion together with criteria on other aspects of nature and environment also ensure the migration of eel, garfish, mackerel and lumpfish.

Monitoring programme and methods.

Based on the knowledge on the migration pattern for the Western Baltic Herring Stock obtained during the Base-line studies, autumn 1993 to spring 1995 (Nielsen, J.R. 1996), a program for an environmental impact monitoring of herring in the Sound has been set up.

The base line studies showed that the herring migrate into the Sound in the early autumn, (September-October) from the feeding grounds in Skagerrak-Kattegat. Large concentrations of herring stay in the Sound throughout the winter, then migrate south for the spawning grounds in the spring. During the base-line studies, this migration south occurred primarily before March-April.

To monitor if the construction work in the Sound will disturb this migration pattern a program has been set up to monitor that the herring arriving in the Sound during the autumn occur in numbers comparable with those found during the base-line studies and that they leave the Sound in the spring to migrate south.

A programme with two monitoring surveys in the autumn, one in September-October and one in November (in 1995 only the survey in September-October has been conducted) and with two surveys in the spring, one in March and one in April, was agreed upon by the constructor and the environmental authorities in Denmark and Sweden.

Materials and methods

The monitoring surveys were conducted as hydro-acoustic surveys and biological sampling was performed with scientific, multi-panel gill nets equipped with a broad spectre of mesh sizes.

Study and survey area: The study area covers both Danish and Swedish waters in the Sound from Helsingør in the north to Drogden in the south. The study area has been divided into 13 subareas in order to describe small scale geographical variations within the larger area (Fig. 1). Each subarea is approximately 2.5 NM wide in the north-south-going direction. The area sizes of the different strata in nautical square miles (NM**2) are given in Fig. 1.

Hydro acoustic echo integration: Sampling of echo integration data has been performed with a mobile, scientific SIMRAD EY-200 38 kHz single beam echosounder system mounted in R/V HAVFISKEN, DFU, during all acoustic surveys. From the research vessel integration was carried out with a towed body (paravane) mounted transducer (swinger) typically towed in a depth of ca. 2 m below sea surface. This operation distance is as near the surface as possible taking physical turbulence from currents and wind into account. The upper 3 m layer from the transducer placement can not be integrated using echo sounder methods in general, i.e. integration has not been performed in the 0-5 m depth layer in the whole study area. The operating frequency on all surveys was 38 kHz, and basic settings of high power, 1 ms pulse duration, and 1 kHz receiver bandwidth were

used. The echosounder systems are calibrated using the standard copper sphere technique (Foote et al. 1986; Degnbol et al. 1990).
The echo integration systems were connected to GPS navigation units from which synchronous position data were sampled. Sampling of acoustic integration data was performed during night. The standard acoustic survey transects divided into way points and way point positions are shown in Tab. 8. These transects cover each strata with a constant zig-zag-pattern on both Danish and Swedish side of the Sound. The specific way point sequence during each acoustic integration survey, i.e. the actual integration cruise route for R/V HAVFISKEN on each integration night and survey depended of wind and current direction. Cruise speed was typically 3-6 knots dependent of wind and current. Acoustic integration data were analysed with the Echo-Ann analyser system (Degnbol et al. 1990) and hereby the acoustic data were judged for approximately each 0.4-0.5 nautical mile. The contributions from plankton, air bubbles (including wind induced up welling of surface layers and propeller noise from passing vessels), bottom echoes and (other) noise were removed during the judging procedure. Bottom detection on dense fish schools / aggregations (typically herring) were compensated during judging. When fish echoes were mixed with plankton echoes the contribution from plankton was estimated by comparing the integration values with values obtained on other close sampling positions with similar isolated plankton recordings not containing fish.

For each subarea mean target strength (mean TS) was estimated for each species or category of species and each species length group by using TS - length relations for the most important fish species occurring in the Sound by fish biomass. The target strength is species and size dependent, and TS is mainly determined by factors as target swimbladder size, target swimbladder directivity (tilt angles), target fat content and target behaviour. The following empirical estimated TS algorithms were used (Anon. 1992 (4)):

Herring:	TS = 20 log L - 71.2	(Anon. 1983).
Gadoids:	TS = 20 log L - 67.5	(Anon. 1984).

An overall mean TS for each subarea was then estimated. The TS contributions from each species and species length group were weighted in the proportion of their respective occurrences in the gill net catches during the parallel (in time and space) performed biological sampling based on gill net fishery. The mean area back scattering strength (Sa) for each subarea was estimated. The total number of each fish species and fish species length group in each subarea was then estimated by calculating the values of mean Sa divided by mean TS. The number of each fish species and fish species length group was then assumed to be in proportion with their contribution to total catch in the gill net fishery. Allocation to length and age group for each species was assumed to be in accordance with the length and age distribution for each species in the gill net catches. Allocation of fishing stations was based on a spatial and temporal representative and covering fishery related to the acoustic integration activities.
Biological sampling: Fishing surveys were performed with experimental (scientific) gill nets (Tab. 9). Each setting comprise 7-9 nets (panels) with mesh sizes 19.5 mm, 21.0 mm, 26.0 mm, 27.0 mm, 28.0 mm, 29.0 mm, 34.0 mm, 46.0 mm, 55.0 mm and 60.0 mm. Usually fishing was performed with standard sets of 8 nets (panels) with mesh size 19.5, 21, 26, 27, 28, 29, 34 and 55 mm, respectively. The used gill nets were approximately 30-40 m long and 5 m high (deep). Technical measures of the used gill nets during surveys are given in Tab. 9.. Dependent of time, weather and water currents the fishing stations were stratified to cover both demersal and pelagic water layers and all geographical strata during each survey on both Danish and Swedish side of the Sound. Both demersal and pelagic gill net settings were carried out related to judgment of highest probability of catching the fish representatively. Fishery was mainly performed during night synchronous with acoustic integration. Fishing were performed from R/V HAVKATTEN , DFU.

Catch were for each mesh size on all settings during all fishing surveys sorted and determined to fish species. Standard sampling included length measurements (total length) of all caught fish by species per mesh size, and total weight (in grams) of catch by species per mesh size, and thus, also resulting recording of total catch weight by species pooled for all mesh sizes on each fishing station. Clupeoids (herring and sprat) were length estimated to semi-centimetre (scm) below and all other species to centimetre (cm) below.

Results.

To date eight surveys have been conducted in the environmental impact monitoring programme (Table 1.). For the migration period 1995/96, one in the autumn 1995 and two in the spring 1996, for the migration period 1996/97, two in the autumn 1996 and two in the spring 1997 and for the migration period 1997/98, one in the autumn 1997.

The biomass in tonnes per NM**2 and abundance in mill. per NM**2 for each survey are given in Table 2 and Table 3. The results for each survey are given for the 2.5 NM subareas used during the base line studies (see Figure 1). Mean length and mean weight per stratum for each survey are given in Table 4 and 5.

Biomass in tonnes per NM**2 for surveys conducted in the autumn, September, October and November, both during the base-line studies and the environmental impact monitoring are given in Table 6. Biomass in tonnes per NM**2 for surveys conducted in the spring March and April both during the base-line studies and the environmental impact monitoring are given in Table 7.

Discussion

The same migration pattern as seen during the base-line studies has been recognised in the environmental impact monitoring with the herring migrating into the Sound in large numbers in the autumn and migrating out south in the early spring.

This migration south seems to be influenced by hydrographic parameters. In spring 1996, the winter was very cold with ice conditions until March and this seems to have delayed migration south. This is also reflected in the figures for German landings per month at the spawning site of Greifswalder Bodden (Figure 2).
In the migration period 1996/97 and 1997/98 the highest biomass for both the base-line studies and the environmental impact monitoring were estimated (Table 6 and 7). Both for the spring and autumn survey higher abundance were estimated. At the same time the mean length and the mean weight in the stock showed a decrease compared to the migration period 1995/96 (Table 4 and 5).

The change in abundance for the migration period 1996/97 did not seem to have influenced on the landings at the spawning site of Greifswalder Bodden (Figure 2) as the herring seem to have arrived at the spawning site at the same time and in the same amount as in previous years giving the bases for a normal fishery pattern in the area.

A comparison of the length distribution in the estimated biomass from surveys carried out during the same time in the migration period 1995/96 and the migration period 1996/97, (October 1995/October 1996, March 1996/March 1997 and April 1996/April 1997), showed a higher abundance of smaller herring in the 1996/97 migration period than in the 1995/96 migration period (Figure 3 to 5).

During the Base-line studies, migration period 1994/95, young immature herring i.e. 1- and 2-group were present in Oct.-Dec., with a mean length of 22-24 cm. Vertebral counting showed that these immature herring could have been North Sea herring at the southern boarder of the distribution area. These small herring were concentrated in the most northern part of the Sound and only in 4. Quarter.

The smaller herring seen in 1996/97, especially in March and April, seem to be dominated by the size groups around 24-25 cm corresponding to the 3-year age group (Nielsen, J.R. 1996).

The 2-year old herring from the Western Baltic Stock are described to enter the migration pattern known for the older herring of this stock. This means that this component will arrive in the Sound in the following autumn during the south migration as nearly 3 years old herring.

The observed high abundance of young herring (3 years) in autumn 1996 and spring 1997 correspond with the observed higher abundance 0-rings found in the larval surveys at Greifswalder Bodden in 1994 compered to the previous 5 years (ICES CM 1997/ASSESS:8).
The fishery at the spawning site also showed highest proportion of 3-year old herring in the spring 1997 for the period 1993 to 1997 (Gröhsler, T. ,IOR, pers.com.). These 3-year old herring did arrive in the later part of the spawning period due to the age composition in the catch at the spawning place (Gröhsler, T. ,IOR, pers.com.).

A comparison of the length distribution in the estimated biomass from surveys carried out during the autumn in the migration period 1995/96, the migration period 1996/97, and the migration period 1997/98 (October 1995, november 1996 and November 1997), showed that this higher abundance of smaller herring in the 1996/97 migration period compered to the 1995/96 migration period continued in the 1997/97 migration period (Figure 6).

In November 1997 the length distribution seem to be dominated by the size group around 26.5 to 28.5 cm corresponding to the 4 year age group due to the age length key found during the 1994/95 migration period (Nielsen, J.R. 1996).

Conclusion:

The higher biomass in the estimates from the surveys in the 1996/97 migration period and the 1997/97 migration period compared to the 1995/96 migration period seem to be due to an income of a strong 1994 year class of Western Baltic herring.

This strong 1994 year can be followed in the 1996/97 migration through out the Sound as 2-3 year-old herring, in the fishery at the spawning ground in 1997 as 3 year-old herring and in the Sound in November 1997 as 3-4 year-old herring in the 1997/98 migration period.

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Table 1. Environmental Impact Monitoring

Month	September	October	November	December	January	February	March	April
Surveys 1995/1996		S-09-95					S-03-96	S-04-96
Period		9-13/10					18-22/3	10-14/4
Acoustic integration		*					*	*
Biological sampling		*					*	
Individ. analysis of herr.		*					*	
Hydrographich sampling		*					*	*
Surveys 1996/1997		S-10-96	S-11-96				S-03-97	S-04-97
Period		30/9-6/10	11-17/11				03-09-03	05-10-04
Acoustic integration		*	*				*	*
Biological sampling		*	*				*	*
Individ. analysis of herr.		*	*				*	(*)
Hydrographich sampling		*	*				*	*
Surveys 1997/1998			S-11-97					
Period			11-15/11					
Acoustic integration			*					
Biological sampling			*					
Individ. analysis of herr.			*					
Hydrographich sampling			*					

Table 2. Environmental Impact Monitoring

BIOMASSE IN TONNES PER NM2**

Data from November are preliminary

YEAR	95		96						97			
MONTH	October		March	April		October	November		March	April		November
SURVEY	S-09-95		S-03-96	S-04-96		S-10-96	S-11-96		S-03-97	S-04-97		S-11-97
STRATA												
G01	283.31		329.58	210.42		213.85	2533.85		176.95	376.16		1480.47
G02	259.47		174.96	40.20		1025.62	893.82		299.17	554.53		1371.48
G03	591.09		246.35	137.52		275.56	1109.42		524.01	668.24		1757.33
G04	334.07		344.50	163.54		1704.43	1538.58		363.79	299.31		1036.54
G05	343.42		181.38	102.80		621.42	819.06		291.40	213.86		851.46
G06	148.88		127.82	165.38		895.21	771.73		755.56	262.98		550.90
G07	119.88		136.66	22.47		1396.25	416.61		263.99	253.76		613.35
G08	405.43		74.82	77.30		773.22	297.43		0.00	96.08		485.52
G09	166.71		85.18	45.07		499.06	249.61		0.00	70.42		378.91
G10	60.09		46.75	28.51		30.72	151.99		0.00	20.26		288.17
G11	58.27		28.98	10.98		19.70	10.89		0.00	2.08		3.79
G12	3.26		2.19	1.21		3.71	5.75		0.95	0.79		
Mean	231.16		148.26	83.78		621.56	733.23		222.99	234.87		801.63
Min	3.26		2.19	1.21		3.71	5.75		0.00	0.79		3.79
Max	591.09		344.50	210.42		1704.43	2533.85		755.56	668.24		1757.33
Total Tonns	60417.47		36329.08	20304.09		187596.58	162172.70		61498.63	58863.57		180666.10

Table 3. Environmental Impact Monitoring

ABUNDANCE: IN MILL PER NM2**

Data from November are preliminary

YEAR	95		96						97			
MONTH	October		March	April		October	November		March	April		November
SURVEY	S-09-95		S-03-96	S-04-96		S-10-96	S-11-96		S-03-97	S-04-97		S-11-97
STRATA												
G01	1.77		1.97	1.26		1.61	18.70		1.19	2.53		12.58
G02	1.72		1.03	0.24		7.87	7.35		2.01	3.73		11.65
G03	2.99		1.45	0.81		1.79	8.39		3.45	4.40		12.05
G04	1.75		1.97	0.93		9.47	10.30		2.48	2.04		7.03
G05	1.89		1.01	0.57		4.08	4.40		2.40	1.76		5.23
G06	0.70		0.87	1.13		4.99	4.14		5.45	1.90		3.48
G07	0.74		1.00	0.16		8.66	2.44		1.90	1.83		4.15
G08	2.66		0.41	0.43		4.67	1.65		0.00	0.82		2.93
G09	0.91		0.49	0.26		2.99	1.45		0.00	0.65		2.19
G10	0.34		0.27	0.17		0.17	0.79		0.00	0.19		1.67
G11	0.33		0.18	0.07		0.11	0.05		0.00	0.02		0.02
G12	0.02		0.01	0.01		0.02	0.03		0.01	0.01		
Mean	1.32		0.89	0.50		3.87	4.97		1.57	1.66		5.73
Min	0.02		0.01	0.01		0.02	0.03		0.00	0.01		0.02
Max	2.99		1.97	1.26		9.47	18.70		5.45	4.40		12.58
Total no.	344.83		221.82	122.91		1156.42	1052.06		438.44	422.13		1239.60

Table 4. Environmental Impact Monitoring

Mean length per stratum in cm.

Data from November are preliminary

YEAR	95		96						97			
Month	October		March	April		October	November		March	April		November
SURVEY	S-09-95		S-03-96	S-04-96		S-10-96	S-11-96		S-03-97	S-04-97		S-11-97
STRATA												
G01	26.2		28.0	28.0		24.9	26.1		26.7	26.7		24.9
G02	25.8		28.3	28.3		24.7	25.2		26.5	26.5		24.9
G03	28.3		28.3	28.3		26.3	25.9		26.7	26.7		26.8
G04	27.9		28.4	28.4		27.2	25.9		26.2	26.2		26.2
G05	27.4		28.7	28.7		25.6	27.9		24.8	24.8		27.1
G06	28.9		26.6	26.6		27.0	27.9		25.8	25.8		26.9
G07	26.3		25.8	25.8		26.0	27.0		25.8	25.8		26.3
G08	26.1		28.7	28.7		26.5	27.8		0.0	24.9		27.4
G09	28.0		28.3	28.3		26.5	27.4		0.0	24.2		27.8
G10	27.4		28.0	28.0		27.0	28.4		0.0	24.2		27.8
G11	27.4		27.2	27.2		27.3	29.5		0.0	24.2		27.8
G12	25.8		27.2	27.2		27.3	29.5		24.2	24.2		
Mean	27.2		27.7	27.8		26.3	26.5		25.9	25.9		25.9

Table 5. Environmental Impact Monitoring

Mean weight per stratum in gram.

Data from November are preliminary

YEAR	95		96						97			
MONTH	October		March	April		October	November		March	April		November
SURVEY	S-09-95		S-03-96	S-04-96		S-10-96	S-11-96		S-03-97	S-04-97		S-11-97
STRATA												
G01	160.1		167.6	167.6		132.8	150.1		148.4	148.4		117.7
G02	151.3		170.4	170.4		130.3	134.7		148.5	148.5		117.7
G03	197.4		170.3	170.3		154.3	146.5		151.9	151.9		145.8
G04	191.3		175.1	175.1		180.1	156.7		146.7	146.7		147.5
G05	182.0		179.1	179.1		152.3	195.2		121.5	121.5		162.7
G06	211.4		146.9	146.9		179.4	195.2		138.6	138.6		158.4
G07	161.5		136.4	136.4		161.2	178.8		138.6	138.6		147.7
G08	152.2		181.0	181.0		165.4	190.8		0.0	117.0		165.8
G09	183.7		173.6	173.6		166.8	182.4		0.0	108.5		173.0
G10	175.1		170.1	170.1		176.0	204.3		0.0	108.5		172.5
G11	174.9		157.0	157.0		181.1	226.1		0.0	108.5		172.4
G12	146.6		157.0	157.0		181.1	226.1		108.5	108.5		
Mean	175.2		163.8	165.2		162.2	165		140.3	139.4		145.8

Table 6. Base-line and Environmental Impact Monitoring
Autumn

BIOMASSE IN TONNES PER NM2**

Data from November are preliminary

YEAR	93				94			95		96			97
MONTH	September	October	November		October	November		October		October	November		November
SURVEY	S-09-93	S-10-93	S-11-93		S-10-94	S-11-94		S-09-95		S-10-96	S-11-96		S-11-97
STRATA													
G01	557.74	324.20			312.89	49.73		283.31		213.85	2533.85		1480.466
G02	737.93	453.03	506.01		487.41	78.85		259.47		1025.62	893.82		1371.481
G03	651.81	551.39	490.77		632.76	64.06		591.09		275.56	1109.42		1757.334
G04	726.00	448.47	256.90		591.81	244.56		334.07		1704.43	1538.58		1036.539
G05	407.88	453.94	179.74		410.60	315.75		343.42		621.42	819.06		851.4644
G06	568.71	412.26	176.89		424.05	381.70		148.88		895.21	771.73		550.9043
G07	541.65	265.61	266.47		292.39	286.52		119.88		1396.25	416.61		613.3522
G08	398.25	398.70	62.93		390.79	437.33		405.43		773.22	297.43		485.5226
G09	433.94	420.30	415.38		578.28	226.47		166.71		499.06	249.61		378.9054
G10	414.59	188.62	297.97		151.39	403.55		60.09		30.72	151.99		288.1669
G11	194.96	319.68	257.64		57.68	72.88		58.27		19.70	10.89		3.79451
G12	157.34	34.68	35.09		1.34	4.43		3.26		3.71	5.75		
Mean	482.56	355.91	267.8		333.31	197.59		231.16		621.56	733.23		801.6301
Min	157.34	34.68	35.09		1.34	2.87		3.26		3.71	5.75		3.79451
Max	737.93	551.39	506.1		632.76	437.33		591.09		1704.43	2533.85		1757.334
Total Tonns	130,241.01	96,741.95	69,504.27		99,723.53	67,146.45		60,417.47		187,596.58	162,172.70		180666.1

Table 7. Base-line and Environmental Impact Monitoring
Spring
BIOMASSE IN TONNES PER NM2**

YEAR	94			95			96			97	
MONTH	March	April		March	April		March	April		March	April
SURVEY	S-03-94	S-04-94		S-03-95	S-04-95		S-03-96	S-04-96		S-03-97	S-04-97
STRATA											
G01		16.34		219.43	32.00		329.58	210.42		176.95	376.16
G02	93.59	40.60		104.57	37.45		174.96	40.20		299.17	554.53
G03	142.17	77.28		157.63	70.25		246.35	137.52		524.01	668.24
G04	101.90	40.74		229.97	50.33		344.50	163.54		363.79	299.31
G05	81.60	20.89		82.20	41.26		181.38	102.80		291.40	213.86
G06	91.95	26.03		34.85	83.82		127.82	165.38		755.56	262.98
G07	114.54	12.38		60.86	143.87		136.66	22.47		263.99	253.76
G08		8.14		30.33	27.86		74.82	77.30		0.00	96.08
G09		4.05		29.23	31.21		85.18	45.07		0.00	70.42
G10		4.52		31.87	20.79		46.75	28.51		0.00	20.26
G11		3.31		49.59	8.53		28.98	10.98		0.00	2.08
G12		1.38		4.03	4.55		2.19	1.21		0.95	0.79
Mean	104.29	21.31		86.21	45.99		148.26	83.78		222.99	234.87
Min	81.60	1.38		4.03	4.55		2.19	1.21		0.00	0.79
Max	142.17	77.28		229.97	143.87		344.50	210.42		755.56	668.24
Total Tonns	15,291.28	5,342.55		19,673.69	14,651.56		36,329.08	20,304.09		61,498.63	58,863.57

Strata	Area NM**2
G1	8
G2	17
G3	20
G4	18
G5	24
G6	27
G7	40
G8	28
G9	29
G10	25
G11	19
G12	16
G13	8

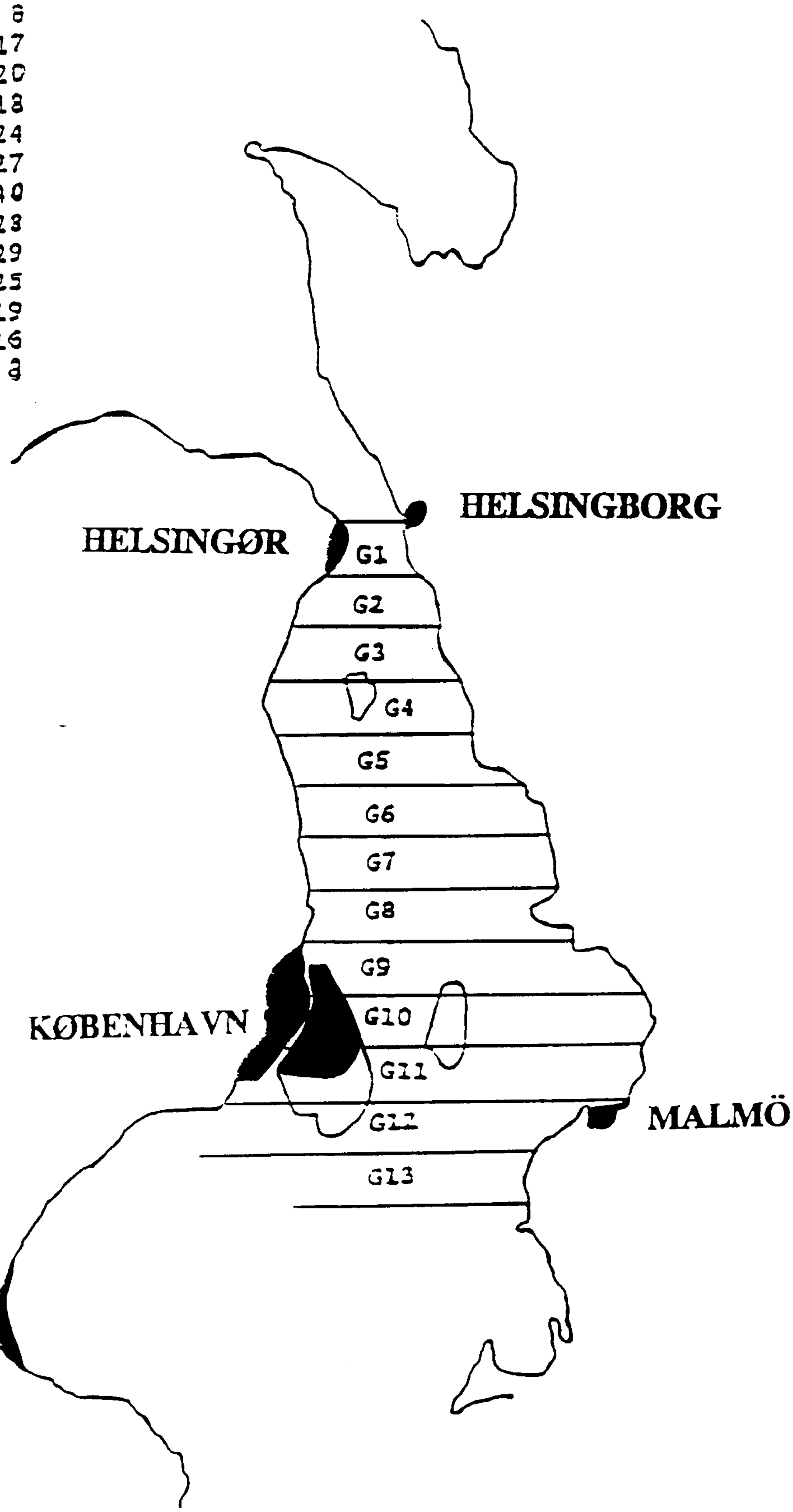

Figure 1. Survey area divided by stratum in the Sound. Area size in nautical square miles (NM**2) is given for each strata.

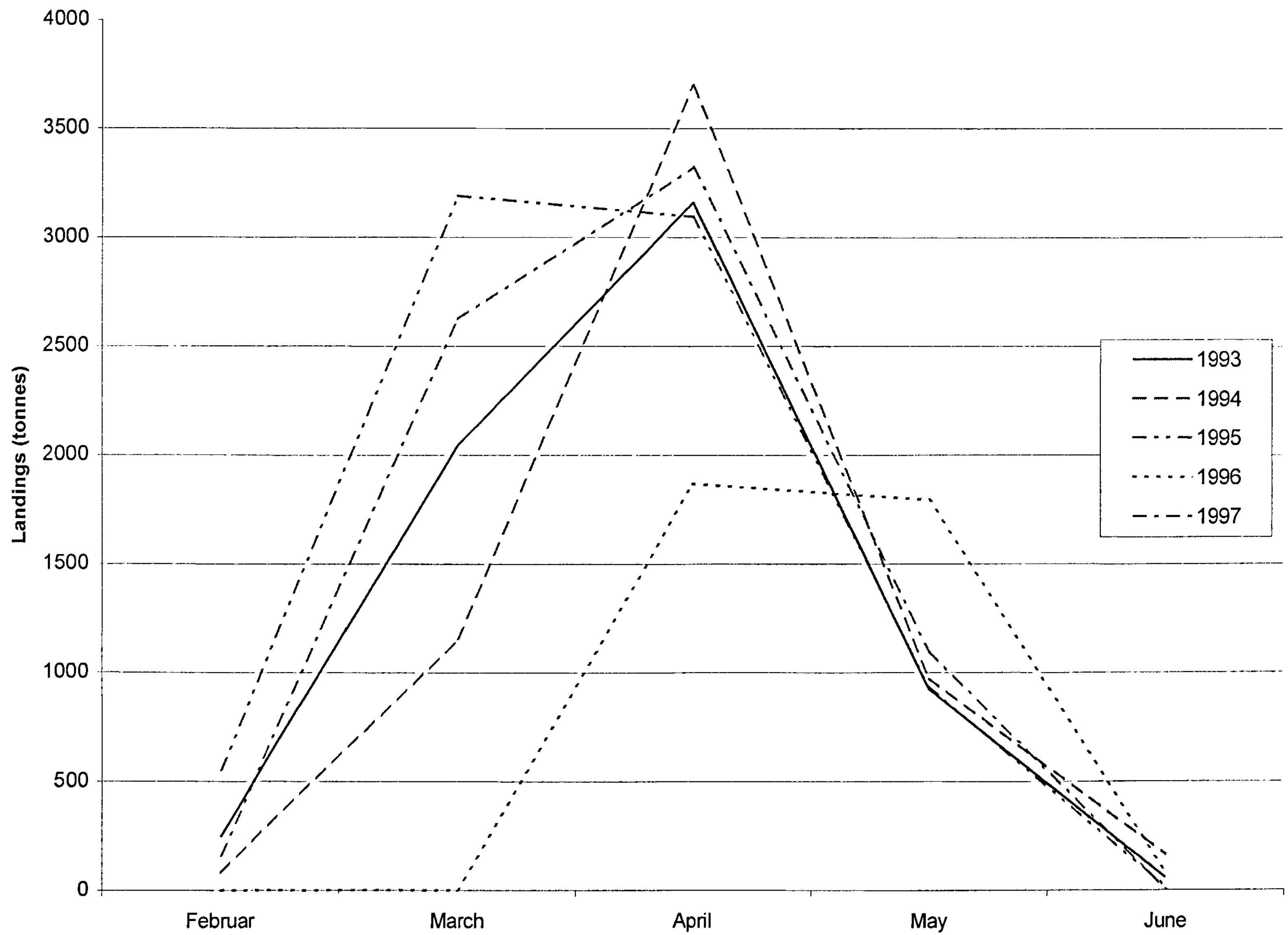

Figure 2. German herring landings (tonnes) at the spawning site of Greifswalder Bodden

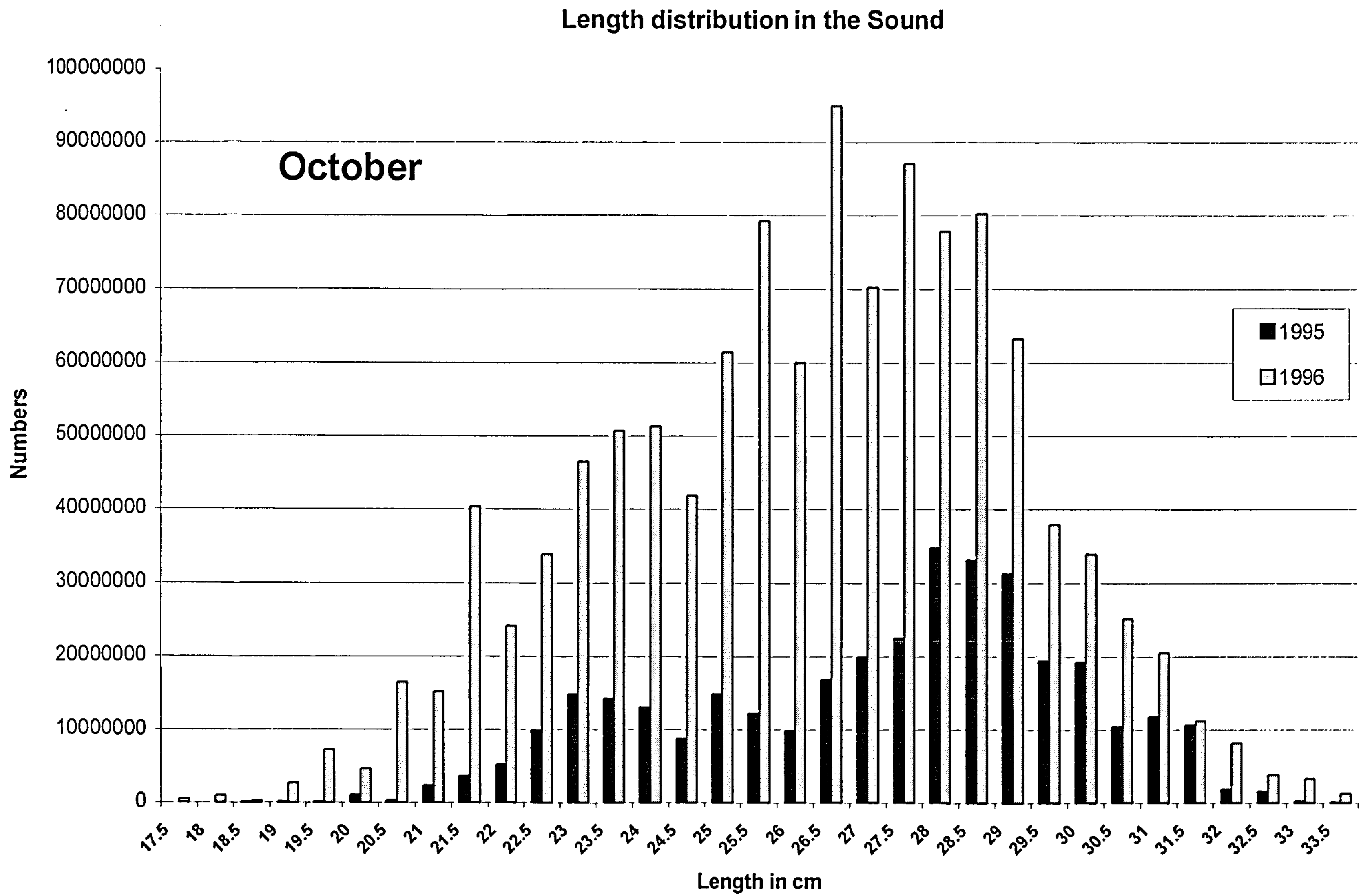

Figure 3. Length distribution in the Sound October 1995 and October 1996

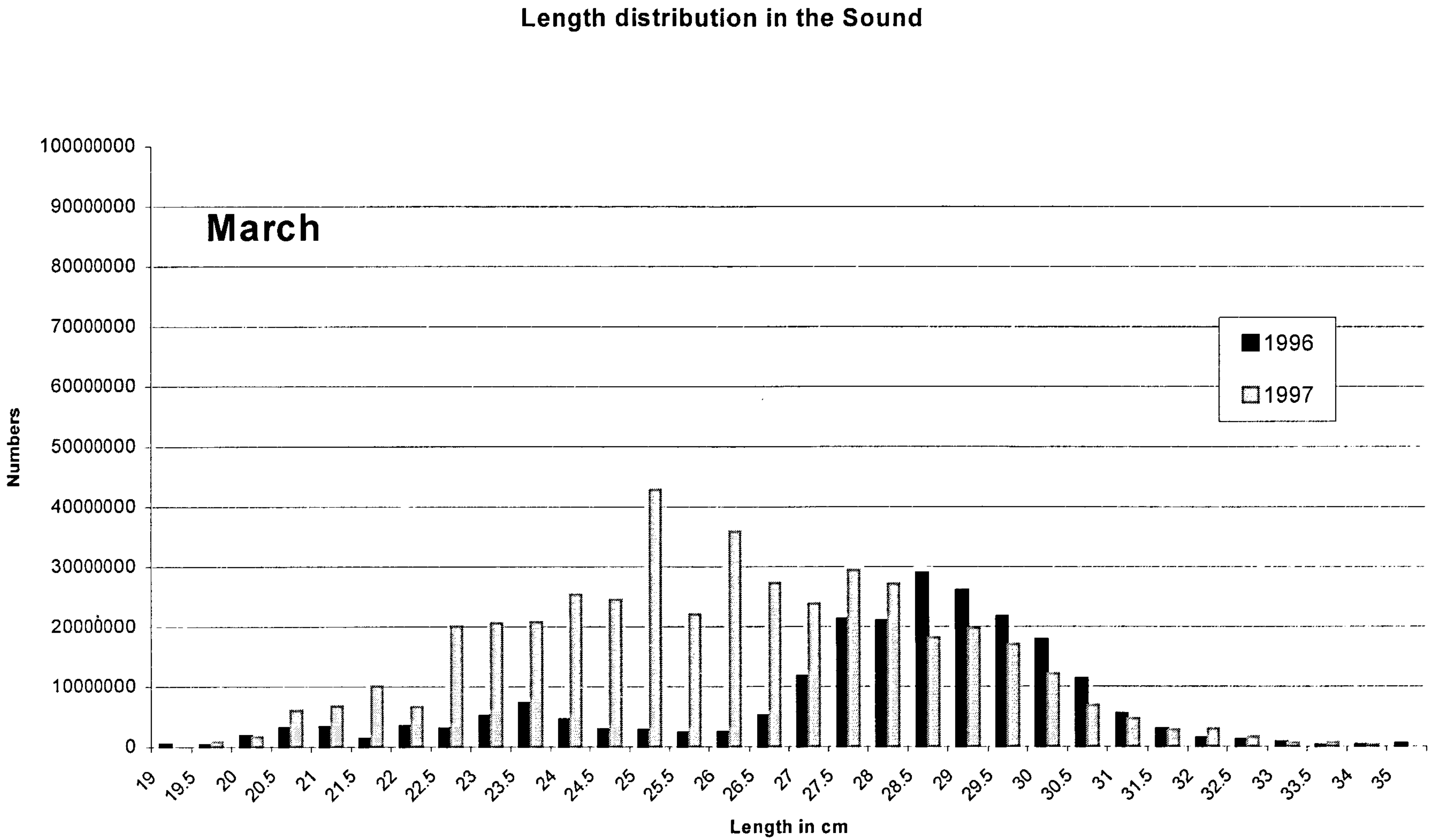

Figure 4. Length distribution in the Sound March 1996 and March 1997.

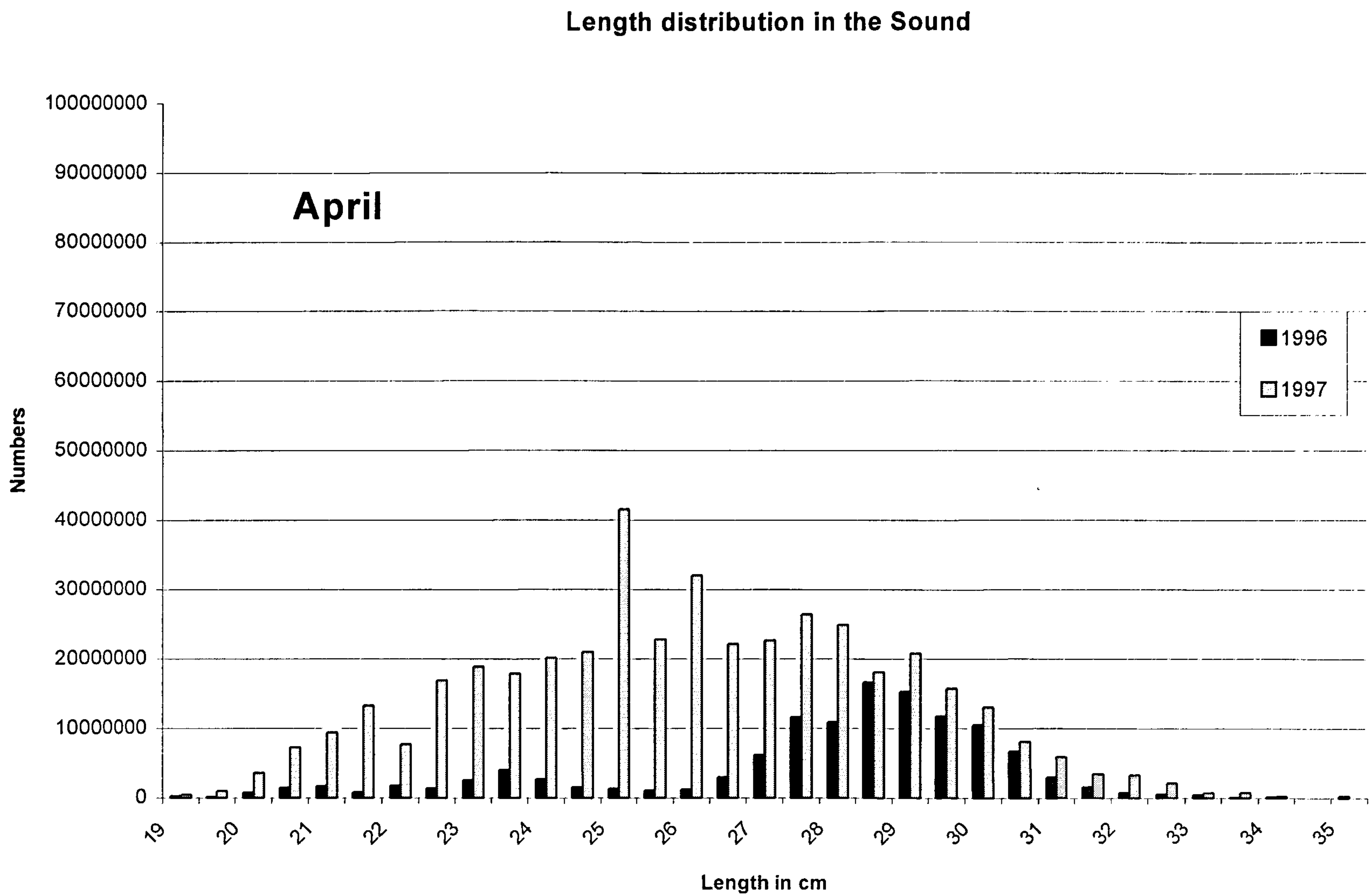

Figure 5. Length distribution in the Sound April 1996 and April 1997

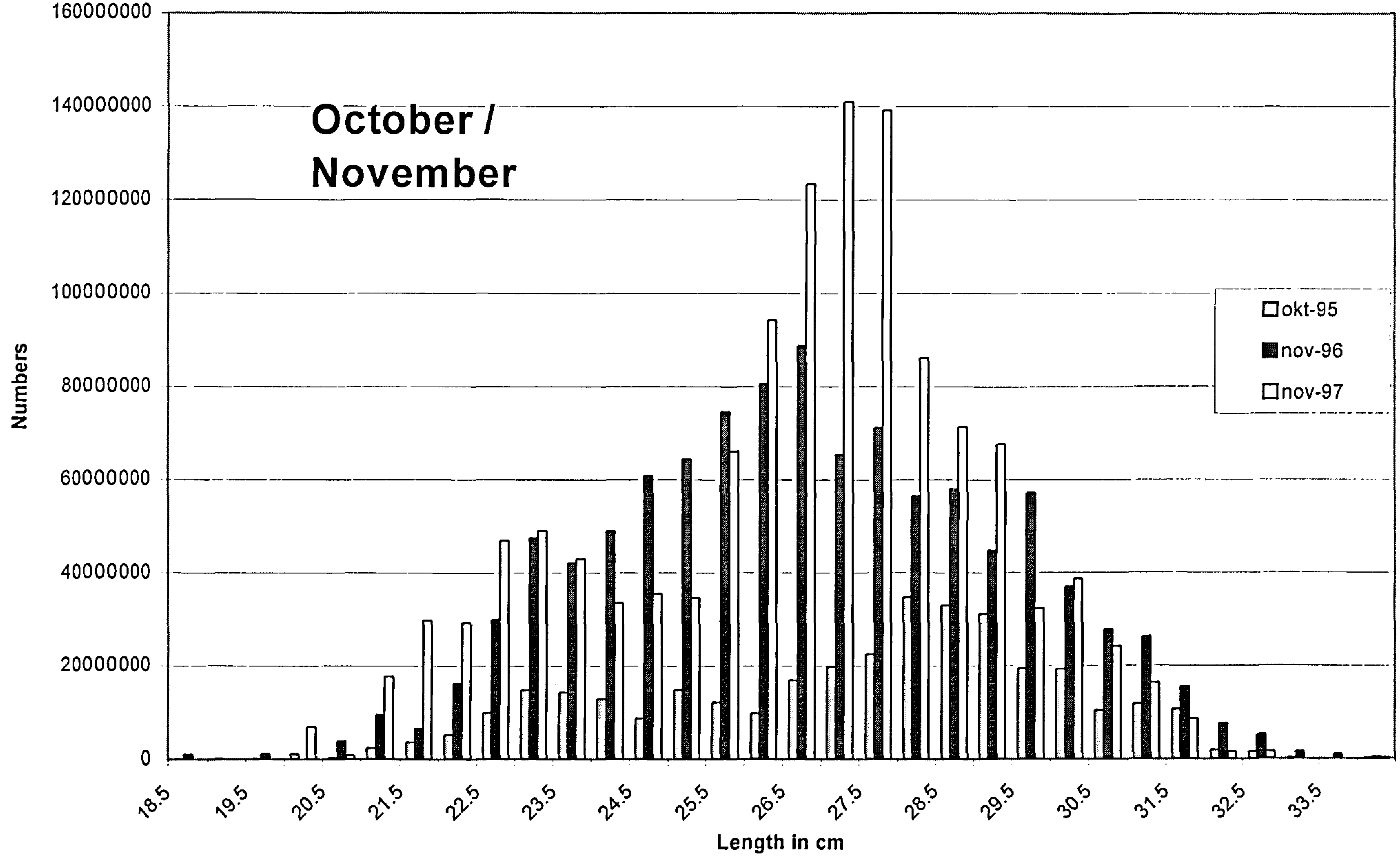

Figure 6. Length distribution in the Sound October 1995, November 1996 and November 1997

Appendix E

Herring Survey Planning Group Working Document, Bergen January 1998
P.G.Fernandes, Marine Lab., Aberdeen

An analysis of trawl variability in the 1995 herring acoustic survey.

Introduction

Acoustic surveys in the North Sea have been co-ordinated by the International Council for the Exploration of the Sea (ICES) since 1984. Currently the following countries participate in the co-ordinated survey: Scotland, Denmark, Germany, Norway, The Netherlands and Sweden. The survey is planned by the ICES Herring Survey Planning Group (HSPG) which meets once a year to discuss cruise plans and improvements to the co-ordinated survey. One of the recommendations arising from the 1997 HSPG was to undertake a study of the length frequency and age proportions of trawl hauls by different vessels in similar areas during the 1995 survey. The objective of the study was to examine the spatial variability in length and age, and to assess to what extent the observed variability may have been affected by obtaining trawl samples from different vessels.

Methods and Materials

Trawl data were taken from the 1995 co-ordinated herring acoustic survey from Denmark, Norway, the Netherlands, Germany, Scotland (East and West) and Ireland. The following information was supplied for each trawl in which herring was caught: Country; Ship; Gear type; Bot/Pel; Haul No.; Year; Month; Day; Date; Time shot; Duration; Longitude; Latitude; Water depth; fishing depth; Validity; Total catch; Length frequency; Pool code; Age proportions for North Sea fish; Age proportions for Baltic Sea fish; Mean weight at age for North Sea fish; Mean weight at age for Baltic Sea fish. Data from a total of 152 trawls were submitted.

The Kolmogorov-Smirnov (KS) test is often used to assess the goodness of fit of one cumulative frequency distribution to another (Zar 1984). The recommended procedure for stratifying an acoustic survey into areas of equal target strength is based on differences in length frequency distributions as determined by the KS test (MacLennan and Simmonds 1992). In the present study the KS test was performed on all combinations of the trawl data amounting to a total of 11,476 tests. The distance between each trawl for each KS test was also calculated. The test statistics (Dmax's) were binned into distance lags and plotted against distance: the resulting figure may be termed a KS-ogram.

Results and Discussion

The mean length of herring in each trawl was plotted as a post plot (Figure 1). A trend is evident from this plot that is confirmed by the calculation of the variogram of mean length (Figure 2). A linear model was fitted and used to krige the map of mean length (Figure 3). There is a clear trend in mean length in the North Sea: small individuals occur in the south-eastern part of the North Sea and larger ones in the north-western end. Medium sized fish occur in the middle and close to the coasts of mainland Britain and Norway.

The KS-ogram for the full dataset is given in Figure 4, this uses all 11476 tests between all trawls. The shape of this figure is what might be expected from a spatially continuous variable such as length; at short distances the maximum difference between cumulative distributions is small (trawls are similar), whilst at large distances the difference in length distributions is greater. The dip in the KS-ogram at about 550 nmiles is probably due to the similarity of trawls with medium sized fish which can be caught large distances apart (e.g. between the west coast of Scotland and cost of Norway). The trend is more marked when one considers only those trawls for which there are a minimum number of lengths. A sample size of 30 was chosen as a minimum resulting in a total of 6555 tests. The resulting figure showed even greater similarity at short distances (Figure 5). The remaining analyses were conducted on this "significant" dataset.

To establish to what extent the observed variability in length distribution may have been affected by obtaining trawl samples from different vessels the KS-ograms from within surveys were compared to those between surveys. The inter survey KS-ogram (Inter-ship KS-ogram Figure 6) and the intra-survey KS-ogram (Intra-ship KS-ogram Figure 7) were similar over the same ranges and both showed a similar pattern to the full dataset KS-ogram. This can be interpreted as follows: trawl variability within a survey is as variable as that between surveys and therefore any variability is probably driven by actual variability in length distribution at a spatial location rather than that caused by different ship sampling.

When considering individual survey KS-ograms (Figure 8), it is evident that there are differences in spatial continuity in length distributions between surveys. Norway has the most variable length distributions and this is certainly reflective of the large area covered by this survey. The Netherlands and Denmark have continuity at short distances and less at longer distances implying that these surveys occur in areas of a trend in length distributions. Germany has an erratic KS-ogram probably due to a medium to long range variable spatial length distribution; at short distances the continuity is quite good. The Scottish east survey has less variability than most over most of its range, whilst the Scottish west survey has a more variable spatial length distribution. There may be some anisotropies in these datasets which may account for the different shapes, although these have not been examined.

An analysis of those trawls from different surveys that fall within 30 nmiles of each other was also conducted. The locations of these trawls are given in Figure 9. Statistics from these trawls are given in Table 1. The KS statistic from these data indicate that most combinations produce reasonably similar length distributions and this is reflected in the proximity of their mean lengths. This leads to the assumption that the KS statistic and the absolute difference in mean length may be related: this is indeed the case (Figure 10). However, one would expect this relationship to occur only for those distributions which are symmetrical (i.e. normal or combinations of normal), because the mean length in these cases would be an acceptable measure of central tendency and therefore a good summary statistic.

The largest KS value in Table 1 refers to the combinations of trawl 20 from the Netherlands and trawls 750 and 751 from Germany. These two combinations produced a KS result of 1 and a mean length difference of 11 cm. This large difference is however, unlikely to be due to trawl performance error but in the highly variable spatial distribution of length in this area (approx. 55°N, 2°E). At this location the map of mean length shows the biggest rate of change relative to distance (Figure 3). It is therefore an area where differences in trawls can be great regardless of trawling method. Similarly high KS values occurred between Denmark and Norway at about 57°30'N, 6°E. This also coincides with an area of change in mean length.

It is therefore important that in areas of the greatest change, trawls be representative and perhaps more numerous, to establish the length distribution with more certainty. In these locations time variability may actually play a significant role although this has not been considered here. It may be prudent to consider altering the borders of surveys such that they do not coincide with borders of length change; in the latter case it might be better for the Germans and Dutch to overlap more.

Age proportions are related to length up to a certain point. Obviously young fish are small, but after age 2 in herring the lengths at age overlap considerably. It is therefore not surprising to find that for young fish a strong trend exists in their spatial distribution; evident in the variogram (Figure 11a). However, older fish have less structured spatial distributions and the variograms are subsequently unstructured - in many cases almost random (Figure 11b). This is further evidence that herring are distributed according to length beyond a certain age. The interpolation of age at location is therefore heavily dependant on an age length key. It is therefore imperative to obtain reasonable samples from a regular as possible a grid in order that a good age-length key be determined over the whole area. The procedure put forward by Guiblin and Rivoirard (Guiblin and Rivoirard 1996) would seem to be appropriate to deal with the distribution of ages.

Conclusions

1. The spatial continuity of mean length is rather good as has been shown before for the individual Shetland Orkney survey. A linear variogram indicates a trend in mean length from small individuals in the south-east to larger ones in the north-west, although small individuals also occur close to mainland coasts.
2. The spatial continuity is reflected in the KS-ogram which shows that trawls close together have more similar length distributions than those further away.
3. The greatest differences in the KS statistic occur in areas where the length changes in short distances and these borders should be taken into account when deciding on survey borders and overlaps.
4. Age proportions have a structured spatial distribution only for the youngest ages. Older ages are distributed almost randomly - distribution by length is evidently the determining factor.

References

Guiblin, P. and Rivoirard, J. (1996)."Spatial distribution of length and age for Orkney Shetland herring." *ICES CM 1996/D:14 Ref. H*, 20 pp. (mimeo).

MacLennan, D.N. and Simmonds, E.J. (1992). *Fisheries acoustics.* Chapman & Hall, London. 325 pp.

Zar, J.H. (1984). *Biostatistical analysis.* Prentice-Hall, New Jersey. 718 pp.

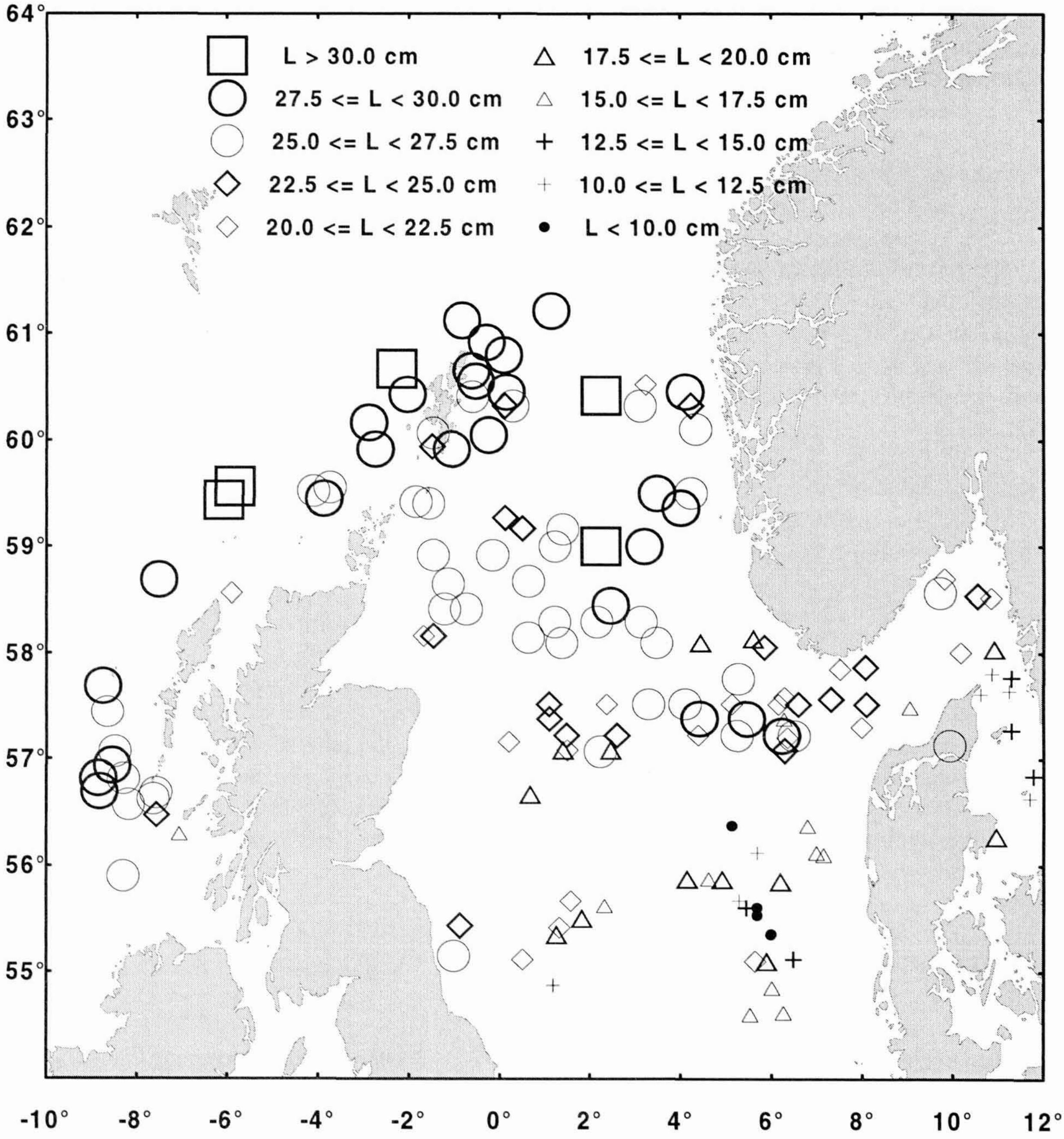

Figure 1 Post plot of mean length of herring taken in trawls during the 1995 acoustic survey.

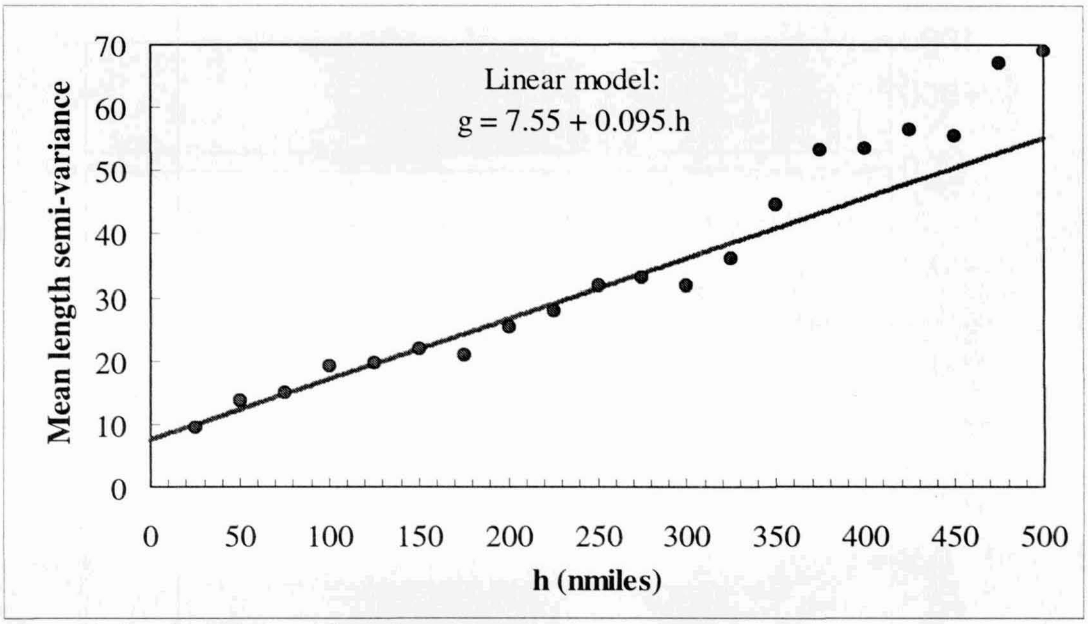

Figure 2 Variogram of mean length.

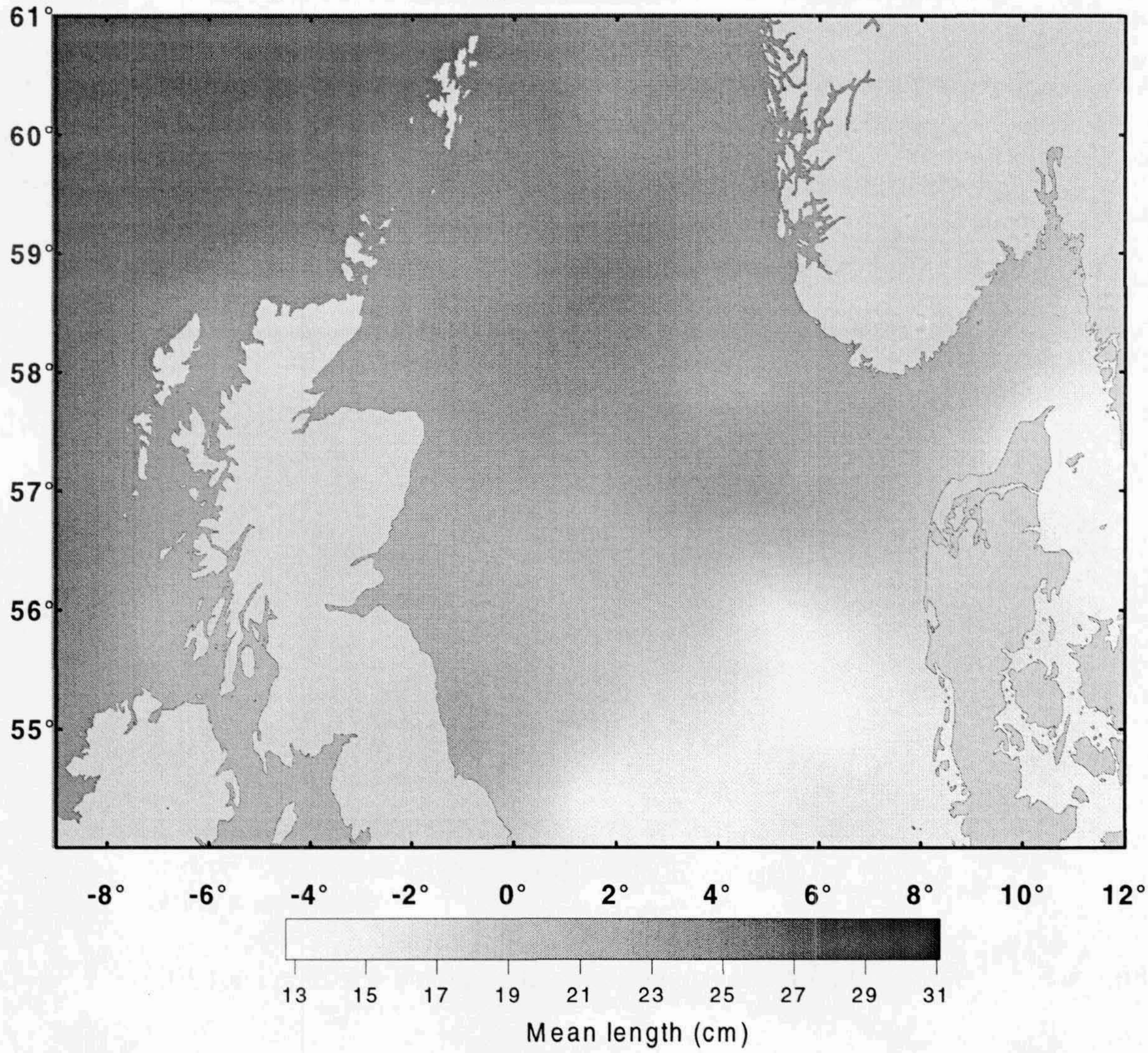

Figure 3 Kriged image of mean length.

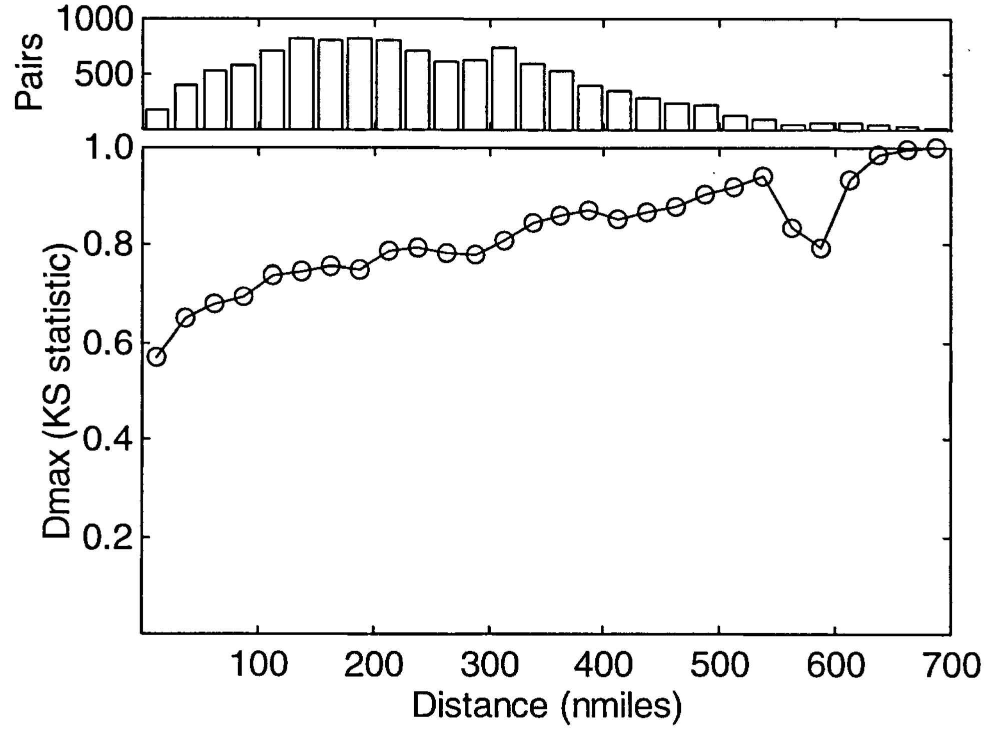

Figure 4 KS-ogram for all trawl data.

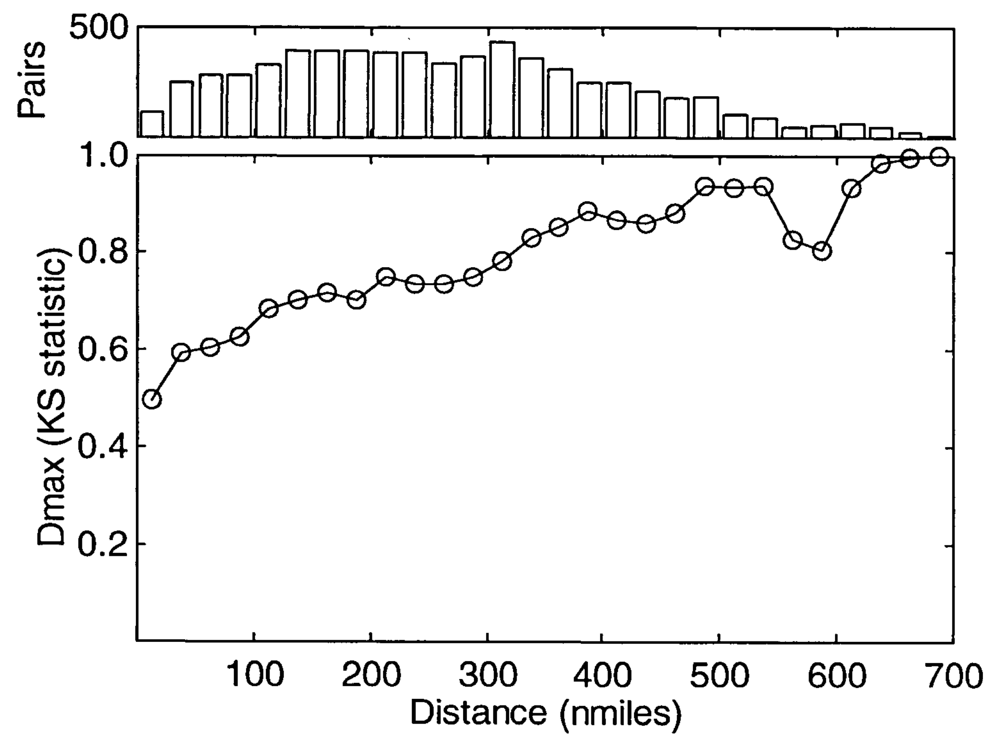

Figure 5 KS-ogram for data from trawls with a sample size of at least 30.

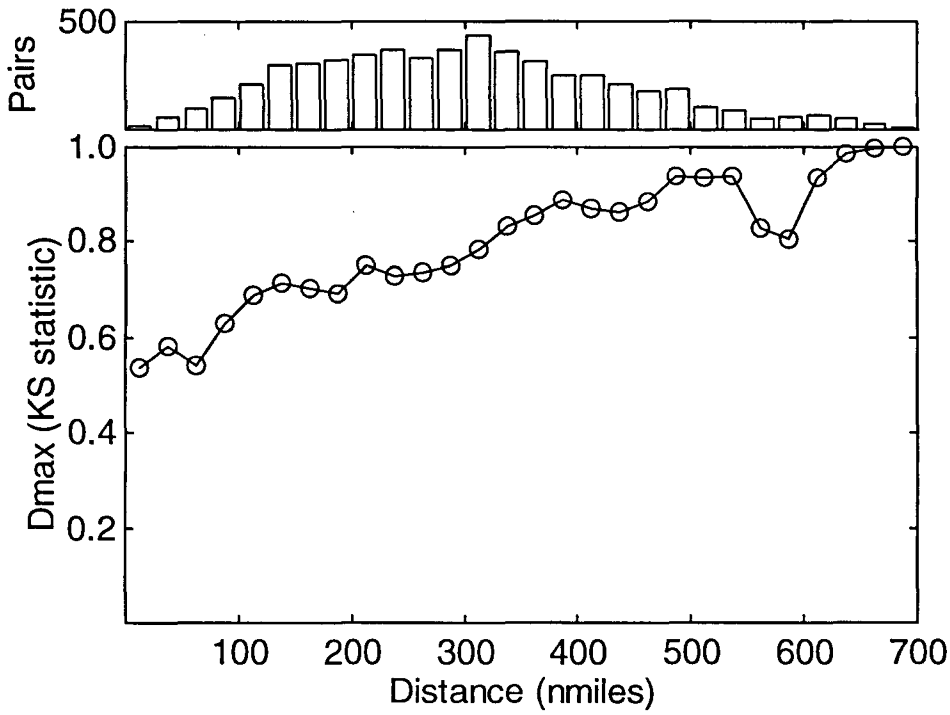

Figure 6 KS-ogram for data from trawls of different vessels (inter-ship comparison, n=5496).

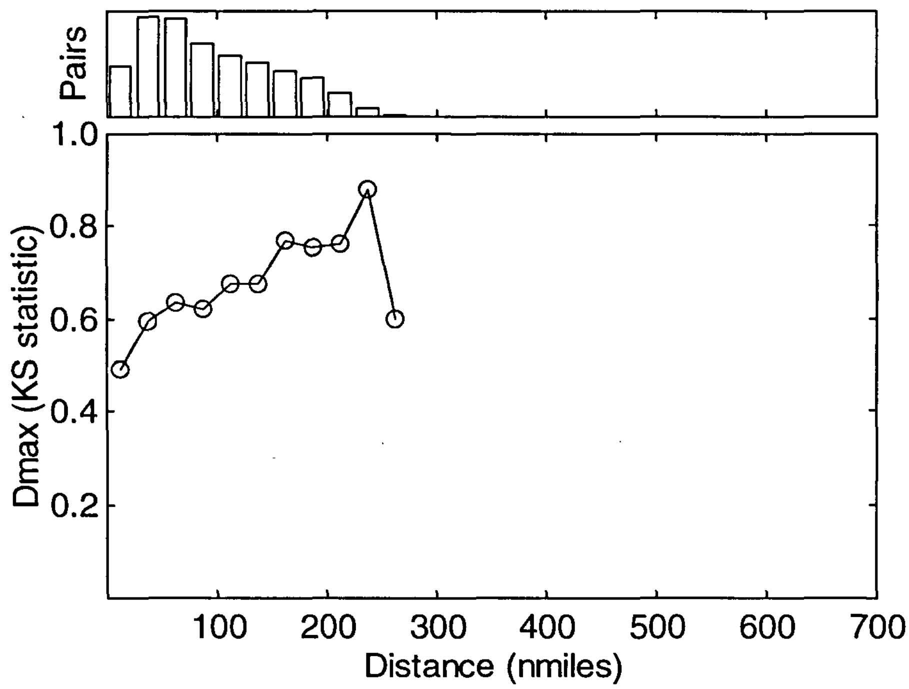

Figure 7 KS-ogram for data from trawls of the same vessels (intra-ship comparison, n=1059).

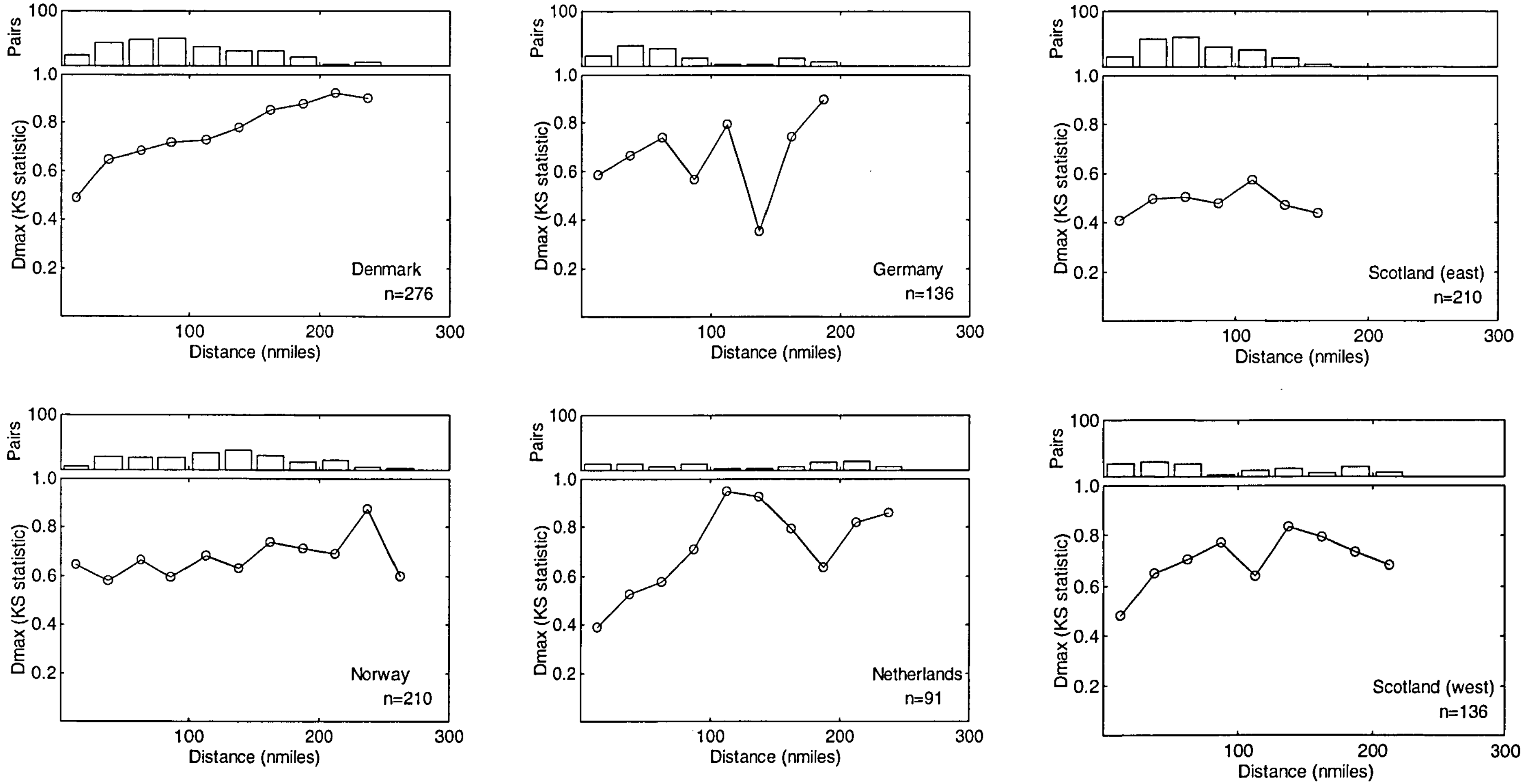

Figure 8. Individual survey KS-ograms

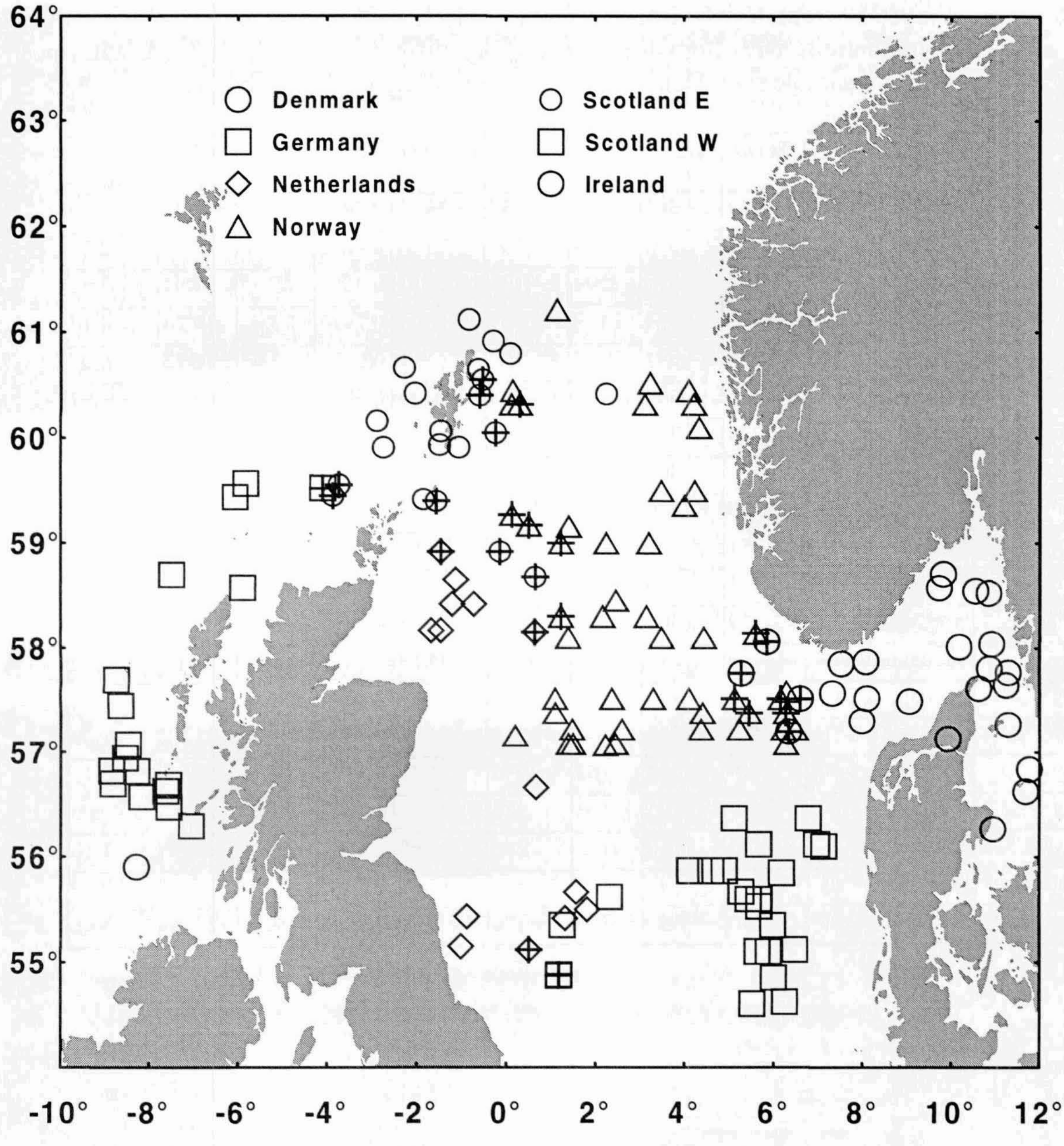

Figure 9 Location of trawls from the 1995 acoustic survey with trawls analysed for the KS test within 30 nmiles of each other crossed.

Table 1 Statistics from trawls from different vessels within 30 nmiles of each other. Trawl combinations with high KS values (very different) are highlighted. ML=mean length (cm), n=sample size, Delta ML = absolute difference in mean length.

Country #1	Country #2	Trawl #1	Trawl #2	n1	n2	Distance (nmiles)	KS	ML #1	ML #2	Delta ML
Denmark	Norway	5017	364	3594	57	23.42	0.7406	25.56	19.24	6.32
Denmark	Norway	5017	395	3594	100	25.14	0.3283	25.56	27.77	2.21
Denmark	Norway	5017	399	3594	121	14.51	0.4045	25.56	21.94	3.62
Denmark	Norway	5039	364	8168	57	10.17	0.7472	23.41	19.24	4.17
Denmark	Norway	5208	394	10115	102	11.90	0.9028	23.69	16.73	6.97
Denmark	Norway	5208	400	10115	33	14.18	0.5007	23.69	22.12	1.57
Denmark	Norway	5229	394	1159	102	11.77	0.895	20.44	16.73	3.72
Denmark	Norway	5229	400	1159	33	21.85	0.5304	20.44	22.12	1.68
Germany	Netherlands	750	20	167	18725	29.16	1	10.06	20.93	10.87
Germany	Netherlands	751	20	214	18725	29.09	1	10.06	20.93	10.87
Netherlands	Scotland (east)	1	219	24254	24075	29.79	0.3416	25.88	25.01	0.86
Netherlands	Norway	9	406	12745	100	19.43	0.3095	26.32	25.86	0.47
Norway	Scotland (east)	416	212	100	7448	24.63	0.1338	26.67	27.11	0.44
Norway	Scotland (east)	426	213	100	1215	23.55	0.4033	24.84	25.91	1.08
Norway	Scotland (east)	427	213	42	1215	21.90	0.3629	24.82	25.91	1.09
Norway	Scotland (east)	449	224	103	215	21.43	0.5583	26.64	28.75	2.12
Norway	Scotland (east)	449	225	103	383	27.71	0.1827	26.64	26.62	0.02
Norway	Scotland (east)	449	226	103	248	29.68	0.3131	26.64	27.82	1.18
Scotland (east)	Scotland (west)	245	43	4814	8816	11.10	0.3052	26.99	26.00	0.99
Scotland (east)	Scotland (west)	246	43	32750	8816	8.40	0.7164	29.47	26.00	3.48

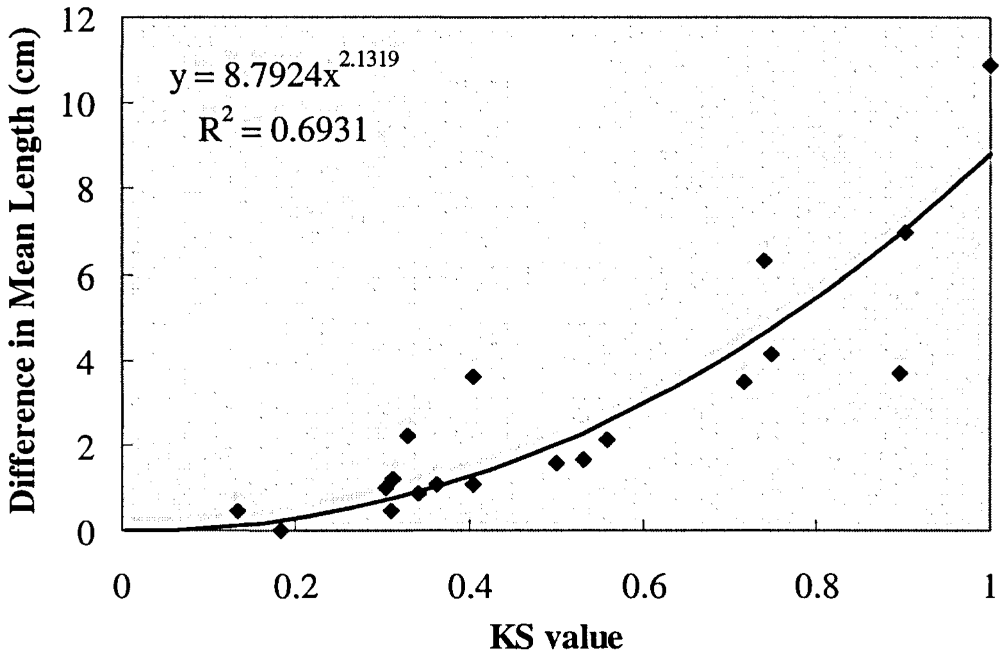

Figure 10 The relationship between the KS statistic and the difference in mean length for trawls from different vessels within 30 nmiles of each other

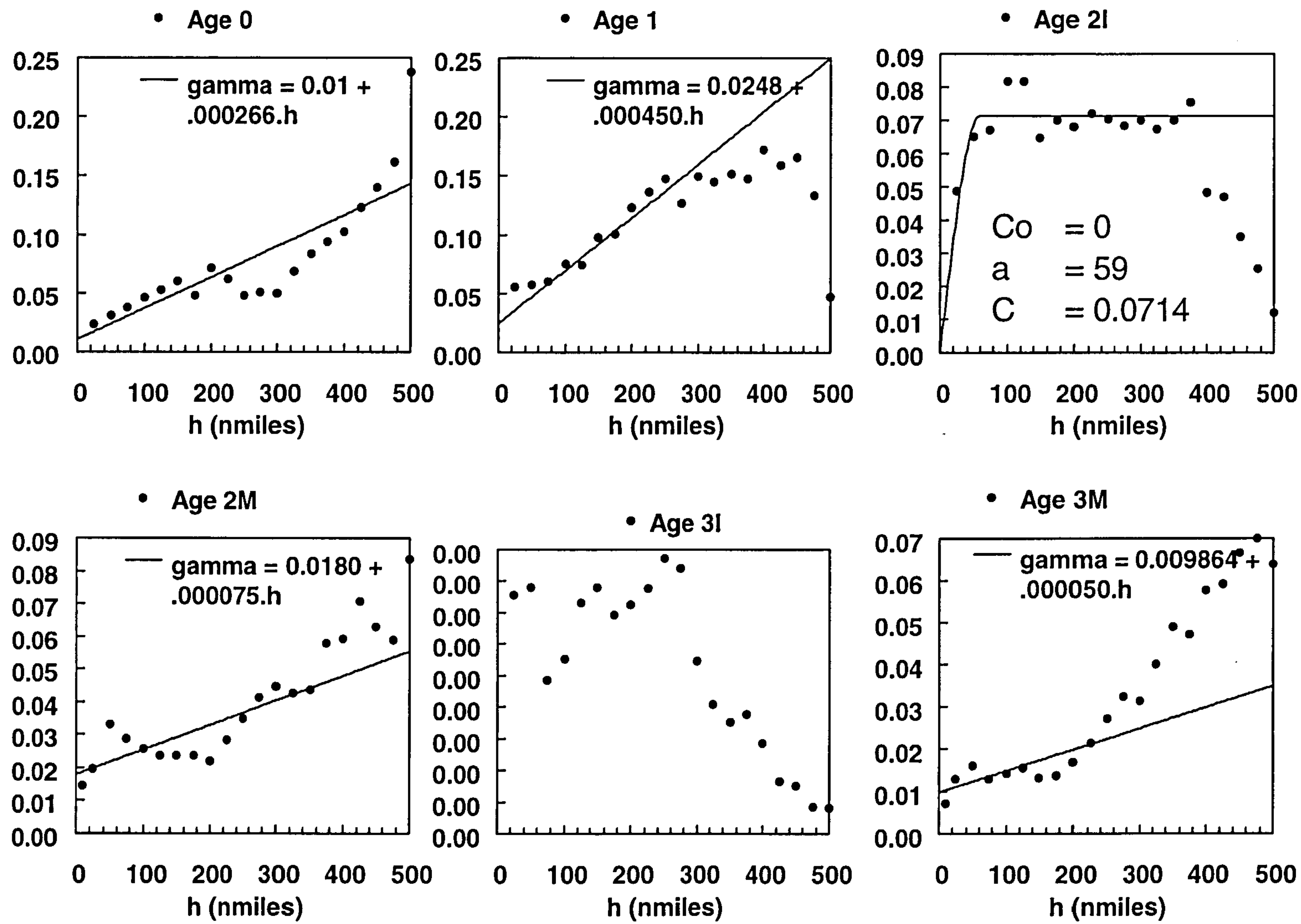

Figure 11a Variograms for age proportions 0-3M for the North Sea herring acoustic survey 1995.

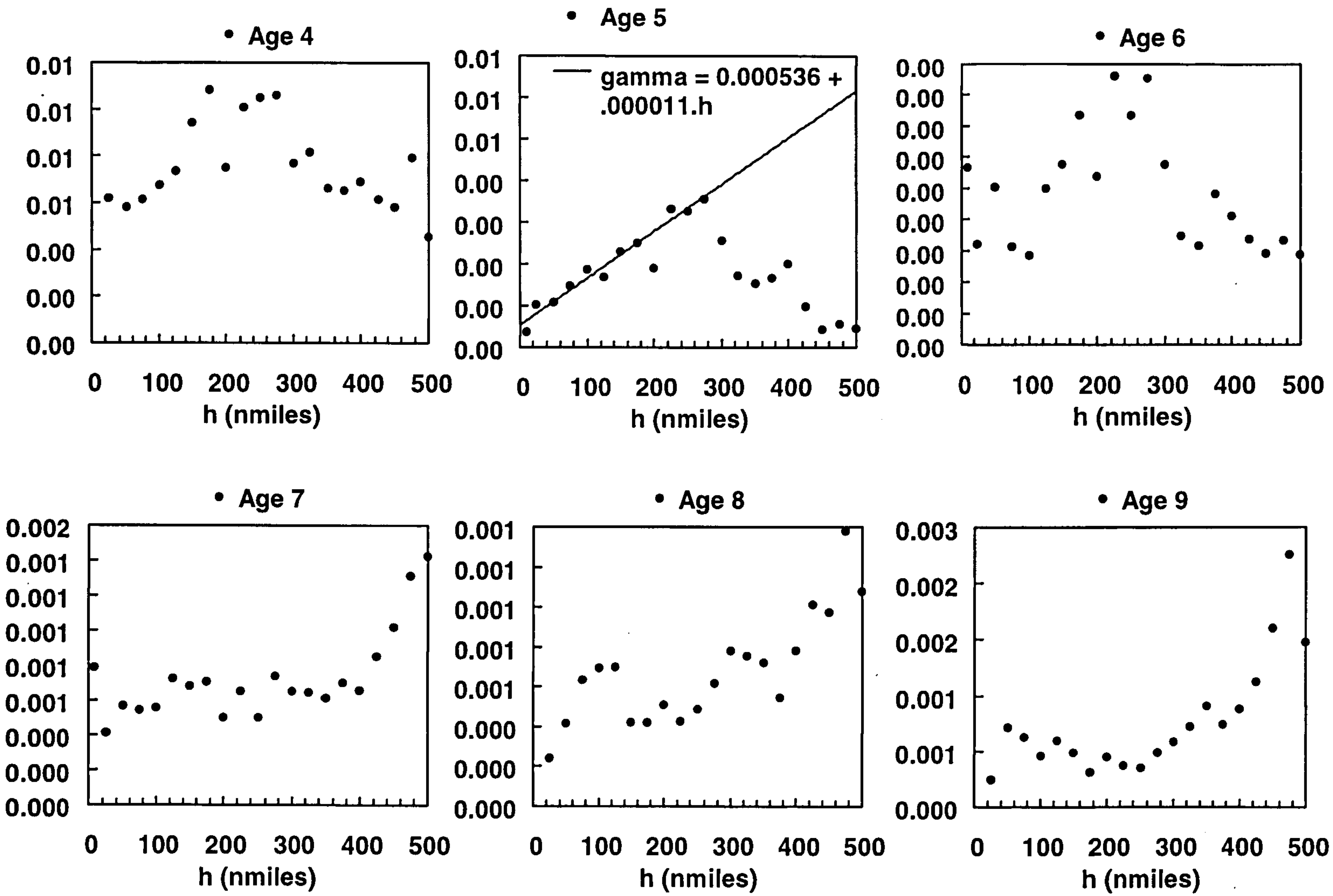

Figure 11b Variograms for age proportions 4-9+ for the North Sea herring acoustic survey 1995

Appendix F

PLANNING GROUP FOR HERRING SURVEY - BERGEN 12–16 JANUARY 1998

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