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Pelagic Fish Committee

1994 ICES COORDINATED ACOUSTIC SURVEY OF ICES DIVISIONS IVa, IVb, VIa AND VIIb

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SUMMARY

Six surveys were carried out during late June and July covering most of the continental shelf North of 54°N in the North Sea and Ireland to the west of Scotland to a northern limit of 62°N. The eastern edge of the survey area is bounded by the Norwegian and Danish coasts, and to the west by the shelf edge between 200 and 400 m depth. The surveys are reported individually, and a combined report has been prepared from the data from all six surveys.

SURVEY REPORT FOR RV *GO SARS* 2-21 JULY 1994

Narrative

The survey started in Bergen on 2 July 1994. A short call was made in Haugesund in the afternoon on 14 July and a calibration of the echo sounder was done in a nearby fjord in the evening. A call was also made in Lerwick, Shetland on the evening of 15 July. The survey was finished in Bergen on 21 July. Weather conditions were good during the whole survey period.

The survey started in the south by doing systematic parallel transects, 15 Nm apart in an east-west direction. In the southern and northern part of the survey area the investigations were carried out westwards to the Scottish coast.

Survey Effort

Figure A1 shows the cruise track with fishing stations and the hydrographic profiles. Altogether 3,500 nm were surveyed and the total number of trawl hauls were 90 (87 pelagic and three demersal). The number of CTD stations where temperature, salinity, density and fluorescence were recorded was 145.

Methods

The catches were sampled for species composition, by weight and numbers. Biological samples, ie length and weight compositions were taken of all species. Otoliths were taken from herring and mackerel for age determination. Herring were also examined for fat content and maturity stage in the whole area, and vertebral counts for the separation of autumn spawning herring and Baltic spring spawners in the area to the east of 03°00'E.

The acoustic instruments applied for abundance estimation were a SIMRAD EK500 echo sounder and the Bergen Echo Integrator system (BEI). The setting of the instruments were as follows:

Absorption coefficient	10 dB/km
Pulse length	Medium
Bandwidth	Wide
Max power	4,000 W
Angle sensitivity	21.9
2-way beam angle	-21.0 dB
Sv transducer gain	25.2 dB
TS transducer gain	25.2 dB
3 dB beamwidth	7.1 deg
Alongship offset	-0.23 deg
Athw ship offset	0.13 deg
Transducer	ES38B

A summary of the results from the calibration of the acoustic instruments is given in Table A1.

The S_A-values were divided between the following categories on the basis of trawl catches and characteristics on the echo recording paper.

- Herring
- Mackerel
- Sandeel
- Plankton
- Demersal fish
- Others

The following target strength (TS) function was applied to convert S_A-values of herring to number of fish:

$$TS = 20 \log L - 71.2 \text{ dB} \qquad (1)$$

or in the form

$$C_F = 1.05 \cdot 10^6 \cdot L^{-2} \tag{2}$$

where L is the total length. The following formula was programmed into Excel (4.0) spreadsheet to calculate the number of fish in length groups (1/2 cm) in ICES statistical squares.

$$N_i = A \ . \ S_A \ . \ \frac{P_i}{\sum_{i=1}^{n} \frac{P_i}{C_\Phi}} \tag{3}$$

where N_i = number of fish in length group i
A = area in Nm^2
S_A = mean integrator value in the area
Pi = proportion of fish in length group i in samples from the area
C_{Fi} = fish conversion factor (equ 2) applying the length of fish in length group i

The number per length group were then divided in age groups according to the observed age distribution per length group observed in the samples representing the square. The number in each length categories and age group were then summed and the total number of fish obtained. The proportions of Baltic spring spawners and North Sea autumn spawners within each square were calculated by applying the mean vertebral counts per age group in the samples representing the square, and calculating the proportion of the stocks as described by the HAWG in its reports. To calculate the maturing part of the two stocks in each length group, the observed maturity stage for North Sea autumn spawners was applied for this stock while the maturity ogive as presented by last years HAWG was applied for the Baltic spring spawners.

The biomass of fish was calculated applying observed mean weights per age group multiplied by number of fish in the same groups.

Results

Hydrography

The horizontal distributions of temperature at 5 m, 50 m and at bottom in the surveyed area are shown in Figure A2a-c. The surface water is characterised by summer heating with temperatures ranging from 12-14°C. A 50 m depth, the overall level of the temperature is significantly lower showing that the thermocline is found in the upper layers of the water column.

Distribution and Abundance of Fish

Herring

The horizontal distribution of herring is shown in Figure A3. In the southeastern part of the survey area, small North Sea autumn spawners predominated (1-ringers) while along the Norwegian coast, older and mature Baltic spring spawners mixed with the younger autumn spawners. In the whole area the herring were distributed in the upper

30 metres of the water column. The registrations were very scattered and real herring schools were only recorded in a limited area in the central parts of the North Sea.

The mean weights at age applied for biomass estimation are shown in Table A2. The total estimated number of herring by age and length is shown in Table A3.

Ichthyophonus

All herring sampled during the survey were examined for ichthyophonus. Table A4 shows a record of the stations in which herring were examined. The number of herring investigated and the number of infected fish in each station are given, and in addition, the length, maturity stage, vertebral counts and age of the infected fish are also presented.

SURVEY REPORT FOR RV *TRIDENS* 20-28 JUNE 1994

The survey covered the western North Sea between 55°30 and 58°30'N and west of 2°E. Cruise track and position of trawl stations are shown in Figure B1. The survey was prematurely ended on 27 June, due to a serious accident on board. Research vessels from Norway and Scotland were requested to try and complete the abandoned Dutch transects north of 58°15'N.

Survey Methods

The normal Simrad EK500 system, in combination with a 38 kHz hull mounted transducer was used throughout the survey. Echo traces were identified by visual inspection or by trial fishing with a 2,000 mesh pelagic trawl (Table B2). Survey methods were taken from the Report of the Planning Group for Herring Surveys (ICES CM 1994/H:3).

The equipment was calibrated twice during the survey, with the ship floating in a calm sea. On both occasions, the measured TS-value of the standard copper sphere was 1.0 dB lower than the actual value (Table B1). The instrument settings were left unchanged, but the SA-values recorded during the survey were corrected by a factor of 1.26 to compensate for this difference.

Ship's speed was between 12-13 knots, and the survey was run continuously during day and night.

Observations

Herring schools were mainly found close to the coast between 56°00 and 57°30'N. Several Dutch freezer trawlers were fishing for herring in this area. These vessels were attracted by the high quality of the herring, rather than by their abundance. The herring was concentrated in a few large schools, which made it difficult to obtain a precise acoustic estimate. A large proportion of the acoustic estimate is derived from one school, estimated at 600 tonnes, which was found at the inshore border of the sampling area just south of Aberdeen.

In the open central North Sea, about 50 miles offshore, some dense surface schools were encountered, which could not be sampled by trawl. It was assumed that these schools consisted of herring, with the same length composition as the inshore schools.

In the coastal waters off Peterhead (57°40'N), an extensive area of dense bottom marks was found. Plans to trawl for these marks the following day had to be cancelled, due to the abortion of the cruise. Reports from the Norwegian research vessel suggested that the traces represented Norway Pout, whereas Scottish observations suggested that they were herring. It was decided to classify the traces as non-herring, although some doubt remains.

Data Analysis

Length distributions (Table B3) from trawl samples were grouped into three strata, as shown in Figure B2. The length distribution of haul 5 was given double weight, to account for the high acoustic biomass in its vicinity. Strata mean age/maturity distributions are in Table B4 and mean weights in Table B5.

Because of the limited amount of trawl samples, no acoustic estimates could be made of other species in the area, including sprat.

Ichthyophonus

Of the 250 herring investigated for Ichthyophonus, not a single specimen appeared to be infected with the disease (Table B6).

SURVEY REPORT FOR FRV *SCOTIA* IN THE NORTHERN NORTH SEA 6-26 JULY 1994

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Methods

The acoustic survey on FRV *Scotia* was carried out using a Simrad EK500 38 kHz sounder echo-integrator. Further data analysis was carried out using Simrad BI500 and Marine Laboratory analysis software. The survey track (Fig. C1) was selected to cover the area in one level of sampling intensity based on the limits of herring densities found in previous years. A transect spacing of 15 nautical miles was used in most parts of the area with the exception of a section west of Shetland. On the administrative boundaries of 2°E and 4°W the ends of the tracks were positioned at 1/2 the actual track spacing from the area boundary, giving equal track length in any rectangle within the area. This allowed the between-track data to be included in the data analysis. Transects at the coast and shelf break were continued to the limits of the stock and the transect ends omitted from the analysis. Having selected the origin of the survey grid randomly the track was then laid out using a 15 Nm interval systematic spacing from the origin. Where a 7.5 Nm spacing was employed the same random origin was used.

Trawl hauls (positions shown in Fig. C1) were carried out during the survey on the denser echo traces. Each haul was sampled for length, age, maturity and weight of individual herring. Up to 350 fish were measured at 0.5 cm intervals from each haul. Otoliths were collected with two per 0.5 cm class below 24 cm, and 10 per 0.5 cm class for 24 cm and above. The same fish were sampled for sex, maturity and macroscopic evidence of Ichthyophonus infection. Fish weights were collected at sea from a random sample of 50 fish per haul.

Data from the echo integrator were summed over quarter hour periods (2.5 Nm at 10 knots). Echo integrator data was collected from 9 m below the surface (transducer at 5 m depth) to 1 m above the seabed. The data were divided into five categories, by visual inspection of the echo-sounder paper record and the integrator cumulative output; "herring traces", "probably herring traces" and "probably not herring traces" all below 50 m, shallow herring schools and shallow schools probably not herring both from above 50 m. For the 1994 survey 74% of the stock by weight was attributable to the "herring traces", 17% to the "probably herring traces" and 8% to the shallow herring schools. The third category which gave 24% of total fish was attributable to Norway pout, whiting, mackerel, horse mackerel and haddock respectively in order of importance. Most of these species were either easily recognizable from the echo-sounder record or did not appear to occupy the same area as the herring. The final category of surface schools not allocated to herring constituted 4% of the total fish biomass. Generally herring were found in waters where the seabed was deeper than 100 m. Superficially similar small schools were found close to the seabed over "hard ground" in shallower water of 70 to 90 m depth. Fishing on these traces however consistently gave considerable numbers of Norway pout through the meshes of the trawl. The area to the east of Orkney between 1°W and 1°E contained large numbers of small Norway pout.

Two calibrations were carried out during the survey. Agreement between these was better than 0.05 dB. To calculate integrator conversion factors the target strength of herring was estimated using the TS/length relationship recommended by the acoustic survey planning group (Anon, 1982):

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

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

$$W = 1.776\ 10^{-3}\ L^{3.495} \text{ g (L measured in cm)}$$

Survey Results

A total of 34 trawl hauls were carried out (Fig. C1), the results of these are shown in Table C1. Nineteen hauls with significant numbers of herring were used to define three survey sub areas (Fig. C2). The mean length keys, mean lengths, weights and target strengths for each haul and for each sub area are shown in Table C2. 2,567 otoliths were taken to establish the three age length keys. The numbers and weights of fish by ICES statistical rectangle are shown in Figure C3. A total estimate of 3,254 million herring or 740,000 tonnes was calculated for the survey area. 716,000 tonnes of these were mature. Herring were found mostly in water with the seabed deeper than 100 m, with traces being found in waters with depths of up to 250 m. The survey was continued to 400 m depth for most of the western and northern edge between 0° and 4°W. Herring were generally found in similar water depths to those observed in 1993 although the distributions were denser to the west of Shetland but less dense to the east. There was an absence of large schools in the north of the area. Table C3 shows the numbers mean lengths, weights and biomass of herring by sub area by age class.

In addition to the 3,254 million herring, approximately 909 million other fish were observed in mid water. Examination of the catch by species (Table C1) illustrates the difficulty of allocating this figure between species and therefore this has not been attempted. The dominant part must be considered to be Norway pout. The proportions of mature 2-ring and 3-ring herring were estimated at 97% and 100% respectively. This is a much larger proportion for mature fish than those found in 1993.

SURVEY REPORT FOR RV *LOUGH FOYLE*
11-27 JULY 1994

Methods

The survey was carried out in the north east Atlantic Ocean off the north and west coasts of Ireland, from the Isle of Islay, to Dingle Bay. The cruise track (Fig. D1), proceeding west from Islay, consisted of 35 systematic parallel transects, of variable length (15-90 nmiles) spaced apart under two levels of stratification based on ICES statistical rectangles: 15 and 7.5 nmiles, resulting in two and four transects per rectangle. This stratification was designed with the aid of information obtained from the Irish fishing industry which was consistent in its identification of the principal fishing grounds in July. The limits to the survey were also decided on the basis of fishermens' advice; the fish were said not to occur beyond the 200 m contour. Inshore, the transects run to the limit of the 20 m contour. The start point of the survey was randomised within a 1/4 degree of latitude, with a 2.5 nmile buffer on each side (ie 1-10 nmile start point).

Acoustic data was collected with a Simrad "EK500" scientific echo-sounder interfaced to personal computer running version 4.5 b of Simrad's "EP500" software. The transducer utilised was a Simrad ES-38D (38 kHz) mounted in a towed body. The equipment was calibrated using a tungsten carbide standard target (Foote *et al.*, 1987) immediately prior to the survey. Data from the echo-integrator were summed over 15 minute periods (log intervals, simulated to 2.5 nmiles at 10 knots). In accordance with the other co-ordinated surveys, the data obtained between 1100 hrs and 0300 hours was not used for integration. It was assumed that the herring off the west coast would behave in a similar manner to those in adjacent areas, ie at night the schools will disperse and rise to shallower depths.

Fishing was carried out with a 24 x 16 m rectangular pelagic trawl. Fish samples were broken into species composition by weights. Measurements of lengths were taken, and in the case of herring, length stratified samples were taken for maturity, age (otolith extraction), weight, and vertebral counts. Appropriate raising factors were calculated to provide true relative length frequency compositions. The trawl data were supplemented with data from a commercial sample taken during the survey dates. This was apportioned to all herring marks.

The S_A values from each log interval were partitioned by inspection of the echogram into the following categories: 1) definitely herring; 2) probably herring; 3) possibly herring; and 4) herring in a mixture. Allocated integrator counts (SA values) from these categories were used to estimate herring numbers according to the method of Dalen and Nakken (1983). The acoustic backscattering cross sections for herring and sprat were obtained using the TS/length relationship recommended by the acoustic survey planning group (Anon, 1994):

$$\text{Herring TS} = 20 \log L - 71.2 \text{ dB per individual } (L = \text{length in cm})$$

Herring biomass was calculated from numbers using the length weight relationship determined from the trawl samples taken during the cruise:

$$\text{Herring weight (grams)} = 0.0029 * L^{3.367439} \ (L = \text{length in cm})$$

The analysis produced density values of numbers and biomass per nautical mile squared for each log interval. Density values from the four categories were summed as follows to produce three estimates: definitely herring (categories 1 + 4); probably herring (1 + 4 + 2); possibly herring (1 + 4 + 2 + 3).

Results

A total of 762 data samples were taken, of which 78 had at least one of the four categories assigned to them (and consequently a total of 684 zero values). There were 15 samples allocated to category one "definitely herring"; 23 to "probably herring"; 38 to "possibly herring" and 12 to herring contained in a mixture. A total of 26 trawl hauls were taken. Of these, none contained sufficient herring to which to attribute the observed herring traces. A commercial sample was obtained from the Netherlands Institute for Fisheries Research (RIVO). This single sample was used to obtain density estimates for all categories.

The total biomass estimates for the survey area were:

Definitely herring	300,174 tonnes	Minimum estimate
Probably herring	353,722 tonnes	Most likely estimate
Possibly herring	383,327 tonnes	Maximum estimate

The breakdown of probable biomass by ICES statistical rectangle is given in Figure D2. The principal deficiency of this survey was the lack of biological "ground-truth" data. Of the 26 hauls taken only one had more than 7% herring and 10 hauls caught absolutely nothing. This had the obvious consequence not allowing age and maturity compositions to be obtained. The herring found close to Dingle Bay form part of the species mixes and were almost entirely juvenile herring. The rest of the stock was assumed to have the length composition of the one commercial haul taken during the time of the survey (by a Dutch fishing vessel). No comments can therefore be made as to the size and therefore age distribution of the stock. In future, steps should be taken to ensure that fishing on herring marks is more successful.

In most cases the herring schools were found pelagically, making capture very difficult. However, the marks identified as "Definitely herring" were extremely characteristic, and those identified as “Probably herring” were reasonably characteristic. The most likley estimate of 353,722 tonnes is, therefore, the best estimate for the stock size from this survey.

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SURVEY REPORT FOR MFV *KINGS CROSS* IN ICES AREA Via(N) 9-29 JULY 1994

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Methods

The acoustic survey on the charter vessel MFV *Kings Cross* (9-29 July 1994) was carried out using a Simrad EK500 38 kHz sounder echo-integrator. Further data analysis was carried out using Simrad BI500 and Marine Laboratory Analysis systems. The survey track (Fig. E1) was selected to cover the area in two levels of sampling intensity based on herring densities found in 1991-93. Areas with high intensity sampling had a transect spacing of 7.5 nautical miles and lower intensity areas a transect spacing of 15 nautical miles. The track layout was systematic, with a random start point. The ends of the tracks were positioned at 1/2 the actual track spacing from the area boundary, giving equal track length in any rectangle within each intensity area. Where appropriate the between-track data could then be included in the data analysis. Between track data were abandoned at the westward end of all transects, and on the eastward ends between 56°45' and 58°00'N, along the coast of the Outer Hebrides.

Forty-one trawl hauls (Table E1) were carried out during the survey on the denser echo traces. Each haul was sampled for length, age, maturity and weight of individual herring. Up to 350 fish were measured at 0.5 cm intervals from each haul. Otoliths were collected with two per 0.5 cm class below 22 cm, five per 0.5 cm class from 20 to 27 cm and 10 per 0.5 cm class for 27.5 cm and above. Fish weights were collected at sea from a random sample of 50 fish per haul.

Data from the echo integrator were summed over quarter hour periods (2.5 Nm at 10 knots). Echo integrator data was collected from 9 m below the surface (transducer at 5 m depth) to 1 m above the seabed. The data were divided into five categories, by visual inspection of the echo-sounder paper record and the integrator cumulative output; "herring traces", "probably herring traces", "probably not herring traces", and two species mixture categories. In the north part of the survey area (north of 58°15'N), a number of the hauls contained mixtures of herring with other species, predominantly Norway pout. Two distinct size classes of pout were caught, small fish (around 6 cm) and large fish (around 16 cm). It was not possible to separate herring schools from pout schools on the echogram, so two species mix categories were defined. Category 4 was for mixtures containing herring with large pout. Category 5 was for mixtures containing herring with small pout. In both cases the split between herring and pout was based in the proportions of each species in the trawl hauls. In the case of the herring mixed with small pout (category 5) this proportion is probably unreliable as the pout were small enough to escape from the net, however, no other data were available on which to base the partition. Herring were also found in two hauls mixed with sprat and mackerel respectively. For the 1994 survey the total estimated stock was 600,430 tonnes. The spawning stock biomass (mature herring only) was 533,740 tonnes. 57.3% of the stock by number was attributable to the "herring traces" and 31.2% to the "probably herring traces". 3.4% of the herring was attributable to mixtures with large pout, 7.9% to mixtures with small pout, 0.17% with sprat and 0.03% with mackerel. Fish schools scored in category 3 (probably not herring) were identified from the echogram and trawling exercises, and were probably mostly pout, and other small gadoids. If all these traces were scored as herring they would total 353,000 tonnes, adding 59% to the stock and giving a maximum stock size of 953,430 tonnes. As in previous years, in general, herring were found in waters where the seabed was deeper than 100 m, however, herring were also caught in reasonable quantities in shallower waters (hauls 23, 24, 32, 34 and 38). As in 1993 Norway pout were found throughout the survey area, and in all depth ranges. In some cases marks could be attributed reliably to pout or herring based on trawl hauls (hauls 8, 17, 26 and 26), and on differences between the marks. Pout marks usually had lower integrator values for a given size of school and were generally considered as being closely in contact with the seabed, while herring schools were more pelagic. Unlike 1993, there were a number of marks where no partition could be made based on the echogram, and where the trawl hauls contained mixed pout and herring. In these cases the proportions from the trawl hauls were used to partition the integral as described above.

Two calibrations were carried out during the survey. To calculate integrator conversion factors the target strength of herring was estimated using the TS/length relationship recommended by the acoustic survey planning group (Anon, 1982) for clupeoids:

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

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

$$W = 0.0032267\ L^{3.304} \text{ g L measured in cm}$$

Survey Results

A total of 41 trawl hauls were carried out, the results of these are shown in Table E1. Twenty-two hauls contained more than 100 herring and these hauls were used to define five survey subareas (Fig. E2). The subareas were defined as:

I. Minch
II. Barra Head
III. South west Hebrides
IV. Shelf break (NW of Lewis)
V. North VIa(N)

The mean length keys, mean lengths, weights and target strengths for each haul and for each subarea are shown in Table E2. 2,289 otoliths were taken to establish the five age length keys. The numbers and weights of fish by quarter statistical rectangle are shown in Figure E3. A total estimate of 3,216.9 million herring or 600,430 tonnes was calculated for the survey area. 533,740 tonnes of these were mature. Herring were found mostly in water with the seabed deeper than 110 m, with traces being found in waters with depths of up to 250 m. The survey was continued over the shelf break for most of the western edge of the survey area. Herring were generally found in similar water depths to 1990. Table E3 shows the numbers and weights of herring by subarea by age class.

The total stock is dominated by 3 and 7 ring fish. The bulk of the 1 ring fish (99%) were found in subarea I (Minch). In 1993 very few 1 ringers were seen in the Minch, although it was dominated by 2 ring fish. This may mean that 1 ringers were present in the Minch in 1993 but not caught in the trawls. Alternatively, there may be a larger number present there this year and that a good recruitment can be expected next year. Two ring fish were relatively most abundant in subareas II (Barra Head) - 35.5%, and V (North VIa(N)) - 48.5%. In 1993 subarea V (North VIa(N)) was also dominated by 2 ring fish, in 1992 this subarea was dominated by 1 and 2 ring fish. Subarea III (south west Hebrides), representing 51.6% of the total stock by weight, was dominated by 7 ring fish (20.3%), In 1993 the dominant age class was 6 ring fish. As in 1993 subarea III (south west Hebrides) contained similar numbers in most of the other main age classes, in 1993, 3-5 ringers and in 1994 3-6 ringers. In 1992 a similar structure was identified with similar numbers in all age classes between 2 and 5. There may be evidence of a stronger year class of 3 ring fish (c 608 million fish - 19%), although this will have to be confirmed in 1995. This should be compared to the 16% 3 ring fish in 1993 and 11.3% in 1992. Fishing appeared to be successful and trace identification was straight forward with the exception of some areas in the north containing mixed schools of herring and pout.

The stock estimate shows a substantial decrease from 1993 (893,600 to 600,430 tonnes). However, there are reasons to believe that the 1993 estimate was a substantial overestimate (1993 ICES coordinated acoustic survey of ICES Divisions IVa, IVb and VIa -CM 1994/H:22, and the Report of the Planning Group for Herring Survey CM 1994/H:3). The stock estimate in 1992 was 428,600 tonnes. One of the reasons postulated for the high estimate in 1993 was that the VIa(N) stock is more contagiously distributed than in IVa. The HSPG report (1993) recommended that greater survey intensity was used in the areas of high fish density in 1994, particularly in the area south of the Hebrides. This was accomplished, resulting in an estimate closer to the 1992 figure and in closer agreement with the estimates of the Herring Assessment Working Group.

SURVEY REPORT RV *DANA*
10-26 JULY 1994

Methods

The echo integration survey covered the North Sea east of 5°E between 57° and 59°N. Acoustic data were collected by a 38 kHz Simrad ES 400 echosounder using a hull mounted transducer. The echointegration data were stored by the echo analysis system ECHOANN (Degnbol *et al.*, 1990). The hydroacoustic equipment was calibrated in the beginning of the survey at Bornö, Gullmarnfjord, Sweden. Settings and calibration data are given in Table F1. Figure F1 shows the survey track and operation area. Table F2 gives the total area, number of Nm, number of trawl stations used, and mean Sa by area. Ship's speed during the survey was about 10 knots.

Pelagic sampling was carried out mainly as pelagic trawling with a Fotö trawl (16 mm in the cod-end), but also an Expo trawl (16 mm cod-end) was used on the bottom. The trawl hauls were carried out mainly during night (1600-0600). Each haul was sampled for species, length, age, and weight. Fish were measured to the nearest 0.5 cm and weighed to the nearest 0.1 g. Otoliths and samples for vertebral counting from herring were taken from 10 individuals per 0.5 cm class above 10 cm.

Target strength for each length group was estimated by:

Herring	TS = 20 log L - 71.2
Sprat	TS = 20 log L - 71.2
Gadoids	TS = 20 log L - 67.5
Mackerel	TS = 20 log L - 84.9
Horse mackerel	TS = 20 log L - 67.5

Results

A total of 44 trawl hauls were carried out (Fig. F2), the results are given in Table F3. The estimated numbers and mean weight per age group of herring are given in Table F4 for the areas shown in Figure F3.

COMBINED SURVEY REPORT

Figure G1 shows survey area for each vessel. The results for the six surveys have been combined. Procedures and TS values are the same as for the 1992 surveys (CM 1994/ H:22). The stock estimates have been calculated by age and maturity stage for 30'N-S by 1°E-W statistical rectangles for the survey area north of 56°N to the west of Scotland and west of 6°E. To the east of this area only age dis-aggregation has been applied and for VIa and VIIb south only total abundance data is available. The combined data have given estimates of immature and mature (spawning) herring for ICES area VIa north, IVa and IVb separately. The region east of 6°E is presented separately and the data have been split between North Sea and Baltic stocks. Where the survey areas for individual vessels overlap the mean estimates by age and maturity stage for each overlapping rectangle have been used. Stock estimates are shown in Table G1 for areas VIa north, IVa south, IVa and IVb separately, for area IVab combined and for the area east of 6°E for autumn spawning herring. Stock estimates are shown in Table G2 for areas IVa and IVb separately and for area IVab combined and for the area east of 6°E for Baltic herring. Tables G3 and G4 give the mean weights used to convert numbers to biomass. Figure G2 shows the distribution of abundance (numbers and biomass) of all 1-ring and older herring for all areas surveyed. Figure G3 shows the distribution split by age of 1-ring, 2-ring and 3-ring and older herring, omitting data from VIa south and VIIb where the age split is unavailable and also omitting "0" group estimates in all areas. Figures G4 and G5 show the density distribution of numbers and biomass of all 1-ring and older herring as contour plots.

Ichthyophonus Infection

Figure G6 shows the prevalence found in samples which were taken during all the surveys and inspected for infection. Rectangles with 0 indicate the presence of trawl hauls with zero incidence of the disease. The samples have been combined using linear interpolation for unsampled squares. These were assumed to be the mean proportions of surrounding squares with samples (equal weight to each square). As can be seen only a very small number of samples in the northern North Sea showed any infection at all. In this study the Baltic spring spawning herring are included with the North Sea autumn spawning fish west of 6°E as there was no information on the proportions of infected fish from each population. East of 6°E there is no information on infection rates. A total of 45 million fish were estimated as infected, all in ICES area IVa. This is 0.25% of the total population surveyed or 0.8% of the herring found in ICES area IVa. The numbers of fish infected are insufficient to obtain an age breakdown. The table below gives the number of infected fish at age for those infected herring with known ages:

Ring	1	2	3	4	5	6	7	8	9+	Total
No infected	0	1	1	3	0	5	2	6	4	22

These figures do not indicate any substantial spread of infection to younger fish and support to some extent that the infection is now in even older fish than previous years, however, with such small numbers the age spread must be regarded as unreliable.

The prevalence of ichthyophonus at 0.8% compares with 3.6% in 1993 and 5% in 1992. These results show much lower prevalence of infection than in previous years, suggesting the influence of the disease on the population is declining substantially.

Table A1: Calibration Sheet EK-500 - RV *GO Sars*

Date:	13 July 1994	Location:	Førdepolden
Sphere type:	CU 60	Target strength:	-33,6
Sea temp: (at sphere depth)	12.9°C	Sound speed: (mean transducer to sphere)	1,498 ms
Responsible/personnel: Reidar Toresen, Ronald Pedersen, Egil Øvretveit			

Parameter	Old setting	New setting
Transceiver/frequency	1/38 kHz	1/38 kHz
Transducer depth (must be 0.0 m during calibration)	5.00 m	5.00 m
Absorption coefficient	10 dB/km	10 dB/km
Pulse length	Medium	Medium
Band width	Wide	Wide
Maximum power	4,000 W	4,000 W
Angle sensitivity	21.9	21.9
2 way beam angle	-21.0 dB	-21.0 dB
SV transducer gain	24.8 dB	25.2 dB
TS transducer gain	24.8 dB	25.2 dB
3 dB beamwidth	7.1°	7.1°
Alongship offset	-0.23°	-0.23°
Athwardship offset	0.13°	0.13°
Range to sphere during integration (ref sound speed setting)		19.1
Theoretical SA		6,493
Measured SA after cal		6,504
Comments:		

Table A2: Weight at age in ICES stat squares for age groups and maturity stages - RV *GO Sars*

43F1										
1	2I	2M	3I	3M	4	5	6	7	8	9+
0.00	160.00	200.90	146.70	229.40	215.60	229.50	266.00	273.30	284.00	286.70
43F2										
1	2I	2M	3I	3M	4	5	6	7	8	9+
0.00	160.00	200.90	146.70	229.40	215.60	229.50	266.00	273.30	284.00	286.70
43F5										
1	2I	2M	3I	3M	4	5	6	7	8	9+
49.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
43F6										
1	2I	2M	3I	3M	4	5	6	7	8	9+
49.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
44F6										
1	2I	2M	3I	3M	4	5	6	7	8	9+
84.50	112.80	147.40	116.70	158.30	181.90	156.60	283.70	0.00	0.00	0.00
44F5										
1	2I	2M	3I	3M	4	5	6	7	8	9+
83.90	92.10	138.30	102.70	152.70	136.10	153.40	205.20	263.00	0.00	0.00
44F4										
1	2I	2M	3I	3M	4	5	6	7	8	9+
0.00	160.00	200.90	146.70	229.40	215.60	229.50	266.00	273.30	284.00	286.70
44F2										
1	2I	2M	3I	3M	4	5	6	7	8	9+
0.00	160.00	200.90	146.70	229.40	215.60	229.50	266.00	273.30	284.00	286.70
44F1										
1	2I	2M	3I	3M	4	5	6	7	8	9+
0.00	160.00	200.90	146.70	229.40	215.60	229.50	266.00	273.30	284.00	286.70
45F1										
1	2I	2M	3I	3M	4	5	6	7	8	9+
0.00	160.00	200.90	146.70	229.40	215.60	229.50	266.00	273.30	284.00	286.70
45F4										
1	2I	2M	3I	3M	4	5	6	7	8	9+
0.00	160.00	200.90	146.70	229.40	215.60	229.50	266.00	273.30	284.00	286.70
45F5										
1	2I	2M	3I	3M	4	5	6	7	8	9+
80.00	92.80	0.00	96.00	108.30	96.70	135.00	0.00	140.00	0.00	286.70
46F2										
1	2I	2M	3I	3M	4	5	6	7	8	9+
0.00	140.50	167.50	145.60	175.30	180.20	191.50	230.40	0.00	214.00	0.00
46F3										
1	2I	2M	3I	3M	4	5	6	7	8	9+
0.00	140.50	167.50	145.60	175.30	180.20	191.50	230.40	0.00	214.00	0.00
46F4										
1	2I	2M	3I	3M	4	5	6	7	8	9+
77.80	115.00	142.70	106.60	141.70	128.10	133.60	0.00	110.00	160.00	0.00
47F4										
1	2I	2M	3I	3M	4	5	6	7	8	9+
67.10	121.00	138.20	122.00	122.00	139.00	156.00	151.00	0.00	0.00	0.00

47F3										
1	2I	2M	3I	3M	4	5	6	7	8	9+
67.10	121.00	138.20	122.00	122.00	139.00	156.00	151.00	0.00	0.00	0.00
48F3										
1	2I	2M	3I	3M	4	5	6	7	8	9+
57.40	119.60	155.80	120.80	139.60	147.80	158.70	171.80	213.60	162.00	0.00
48F4										
1	2I	2M	3I	3M	4	5	6	7	8	9+
57.40	119.60	155.80	120.80	139.60	147.80	158.70	171.80	213.60	162.00	0.00
49F4										
1	2I	2M	3I	3M	4	5	6	7	8	9+
57.40	119.60	155.80	120.80	139.60	147.80	158.70	171.80	213.60	162.00	0.00
50F4										
1	2I	2M	3I	3M	4	5	6	7	8	9+
57.40	119.60	155.80	120.80	139.60	147.80	158.70	171.80	213.60	162.00	0.00
50F0										
1	2I	2M	3I	3M	4	5	6	7	8	9+
0.00	0.00	208.60	0.00	243.10	253.90	288.60	303.60	263.00	308.20	312.00
50E9										
1	2I	2M	3I	3M	4	5	6	7	8	9+
0.00	183.00	208.60	0.00	243.10	253.90	288.60	306.60	263.00	308.20	312.00

Table A3: Estimated number and biomass of herring divided on age groups and length groups - RV *GO Sars*

Length (cm)	Age groups									N (mill)	W (ton E-3)
	1	2	3	4	5	6	7	8	9+		
15.0											
15.5											
16.0											
16.5	14.66									14.66	0.57
17.0	15.81									15.45	0.63
17.5	75.02									74.48	3.08
18.0	326.73									325.65	14.86
18.5	110.11									107.78	5.23
19.0	159.52									156.83	8.18
19.5	29.31									27.78	1.37
20.0	44.39									42.95	2.77
20.5	36.61	4.12								38.93	2.49
21.0	8.55	5.15	2.05							14.69	1.11
21.5	13.42	11.32	8.00		1.03					33.59	2.62
22.0	7.10	30.05	8.63	3.32	0.80					49.73	4.23
22.5	6.82	28.94	22.90	5.71	2.70					66.35	6.33
23.0	4.97	42.02	31.55	8.80	2.29	0.80				90.07	8.66
23.5		48.02	14.13	2.40	1.26					63.84	6.67
24.0		29.99	37.82	3.21	3.54		0.63			74.66	8.30
24.5		31.99	19.36	2.64	3.57	1.38	0.00			55.35	6.78
25.0		30.90	16.46	4.37	1.38	1.16	0.00			49.78	6.58
25.5		37.71	16.08	10.54	1.60	0.58	2.63			68.12	10.20
26.0		69.15	15.92	6.14	2.46	2.64	10.90	0.58		102.47	16.91
26.5		14.05	22.74	6.45	4.41	2.35	0.00	0.63		45.41	7.14
27.0		70.84	43.85	9.10	1.49	3.09	0.00	0.00		124.50	23.44
27.5		17.51	27.15	25.31	0.80	22.18	0.58	0.97		91.35	19.45
28.0		33.54	44.59	52.34	23.20	24.02	0.58	0.00		172.77	35.88
28.5		22.72	26.60	56.17	26.87	22.13	2.08	0.97		152.79	33.58
29.0			22.71	33.83	44.39	23.61	20.64	0.00		141.02	31.78
29.5			2.01	15.82	22.30	13.29	0.00	11.29		61.59	16.06
30.0			34.07	2.08	4.66	46.77	13.43	21.68	10.32	121.40	32.10
30.5			10.32	12.67	1.62	3.05	0.00	2.08	1.04	24.17	6.66
31.0			12.40	2.01	3.12	11.36	2.19	25.76	2.08	45.04	14.13
31.5				3.11	1.04	11.36	10.32	4.15	10.32	31.99	10.53
32.0					10.32	0.00	10.32	1.04	12.40	30.96	10.06
32.5					0.58	0.00	1.04	2.08	1.04	0.40	
33.0						1.04	1.04		1.04	0.00	
33.5						1.49				1.49	0.47
34.0											
34.5											
35.0				1.49		0.97				2.46	0.65
35.0											
36.0											
Total number	853.01	528.02	439.35	267.50	165.41	193.25	76.37	71.22	30.96	2625.09	359.49

Table A4: Record of observations of ichthyophonus in herring - RV *GO Sars*

Station	Invest-igated	Infected	Length	Maturity	Vertebrae	Age	
334	10	0					
335	77	0					
336	1	0					
343	2	0					
347	100	0					
351	15	0					
353	6	1	23.5	2			
359	4	0					
360	101	0					
361	100	0					
362	100	0					
366	100	0					
368	100	0					
373	100	0					
374	100	0					
375	100	2	26	8	57	2	
			25	3	7		
376	100	0					
379	7	0					
380	17	0					
381	11	0					
382	100	1	30.5	8	58	4	
400	100	0					
401	3	0					
402	6	0					
408	25	0					
412	2	0					
413	21	0					
414	55	3	no observations				
415	2	0					
416	1	0					
417	1	0					
418	0	0					
419	1	0					
420	0	0					
421	3	0					
422	1	0					
423	34	0					
425	21	16	32	8	57	6	
			31.5	8	56	6	

Station	Invest-igated	Infected	Length	Maturity	Vertebrae	Age	
			30.5	3	58	7	
			33	3	56	9	
			32	4	57	9	
			32.5	4	56	11	
			32	4	57	8	
			32	4	56	8	
			32.5	4	57	8	
			31	3	57	8	
			32	8	58	9	
			32.5	3	57	7	
			32.5	3	57	4	Probably Norwegian spring spawner
			34	8	58	4	Probably Norwegian spring spawner
			32.5	4	57	8	
			33		56	8	

Table B1: Calibration report EK500, *Tridens* 20-28 June 1994

38 kHz trandsucer			
Date and time:	26 June 1994 0530-0900 UTC	Position:	Open sea (floating) 57.35°N 01°160W
Bottom depth:	80 m	Wind:	1-3 BF
Water temperature:		Wave height:	0.2 m

Transceiver menu before calibration			
Pule length:	Medium	Bandwidth:	Wide
Maximum power:	4,000 W	Angle sensitivity:	22.1
Two-way beam angle:	-20.6 dB	Sv transducer gain:	25.6 dB
TS transducer gain:	25.6 dB	3 dB beam width:	7.1
Alongship offset:	0	Athw ship offset:	0
Ping interval:	0.6	Transmitter power:	Normal

Standard target: copper sphere, -33.6 dB
Target depth: 20.80 m
TS value measured: -34.6
(actual TS value standard target) - (TS measured) = 1.0 dB
Correction factor for SA-values measured = 10 exp (1.0/10) = 1.26

Table B2: Trawl station list, *Tridens* 20-28 June 1994. Trawl catches in kg

Haul	Date	Time UTC	Latitude	Longitude	Depth (m)	Duration min	Herring	N pout	Other gadoids	Mackerel	Sprat	Others	Remarks
1	21 06	1810	55.50	00.42E	80	40	1	0	2	1	1	23	traces missed
2	22 06	1315	56.05	0202W	63	35	931	0	30	0	15	1	
3	23 06	0855	56.35	00.54E	81	15	0	110	0	0	0	0	
4	23 06	1455	56.35	00.55W	68	25	0	0	1820	0	0	2	
5	23 06	1925	56.48	01.53W	79	15	7000	0	6	0	0	0	
6	24 06	1405	57.04	01.24W	1161	30	217	0	17	0	0	60	sandeel
7	25 06	1205	57.16	01.35W	78	10	334	1	8	0	1	0	
8	27 06	0630	58.05	01.11W	102	45	5468	0	14	0	0	0	

Table B3: Length distributions herring *Tridens* 20-28 June 1994

Length	Haul 2	Haul 5	Haul 6	Haul 7	Haul 8
15.0	0.00	0.00	0.00	0.00	0.00
15.5	0.19	0.00	0.00	0.00	0.00
16.0	0.00	0.00	0.00	0.00	0.00
16.5	0.19	0.00	0.00	0.00	0.00
17.0	1.69	0.00	0.00	0.00	0.00
17.5	5.25	0.00	0.00	0.00	0.00
18.0	9.01	0.00	0.00	0.00	0.00
18.5	11.26	0.00	0.00	0.00	0.00
19.0	10.51	0.00	0.00	0.00	0.00
19.5	7.50	1.25	0.00	0.00	0.00
20.0	6.75	0.63	0.00	0.00	0.00
20.5	5.44	1.25	1.65	0.00	0.00
21.0	4.50	0.63	0.83	0.65	0.00
21.5	4.88	2.50	1.65	0.00	0.00
22.0	3.38	1.88	4.13	0.00	0.71
22.5	3.19	5.63	4.96	5.19	0.00
23.0	4.50	15.00	4.13	2.60	1.42
23.5	6.94	11.25	8.26	16.23	3.55
24.0	6.19	16.88	7.44	20.78	7.80
24.5	4.88	13.13	9.92	12.99	16.31
25.0	2.06	9.38	11.57	10.39	9.93
25.5	1.50	10.00	13.22	12.99	23.40
26.0	0.19	5.63	9.09	7.79	7.09
26.5	0.00	3.75	9.92	4.55	11.35
27.0	0.00	0.00	3.31	4.55	9.93
27.5	0.00	1.25	4.96	0.00	4.96
28.0	0.00	0.00	1.65	0.65	1.42
28.5	0.00	0.00	0.83	0.00	1.42
29.0	0.00	0.00	0.83	0.00	0.71
29.5	0.00	0.00	0.83	0.00	0.00
30.0	0.00	0.00	0.00	0.00	0.00
30.5	0.00	0.00	0.83	0.00	0.00
31.0	0.00	0.00	0.00	0.00	0.00
31.5	0.00	0.00	0.00	0.00	0.00
32.0	0.00	0.00	0.00	0.00	0.00
32.5	0.00	0.00	0.00	0.00	0.00
33.0	0.00	0.00	0.00	0.00	0.00
Mean length	20.65	24.03	24.95	24.64	25.54
TS mean length	-44.80	-43.50	-43.17	-43.28	-42.97
Mean weight	82.5	127.0	138.0	129.5	137.0

Table B4: Age/maturity composition by stratum *Tridens* 20-28 June 1994

Stratum	Autumn spawners												Spr sp all ages	Totals
	1	2I	2M	3I	3M	4	5	6	7	8	9	9+		
A	0.000	0.047	0.773	0.000	0.087	0.000	0.085	0.007	0.000	0.000	0.000	0.000	0.000	1.000
B	0.037	0.177	0.615	0.019	0.052	0.048	0.045	0.006	0.001	0.001	0.000	0.000	0.000	1.000
C	0.647	0.143	0.148	0.000	0.062	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000

Table B5: Mean weight by age and maturity *Tridens* 20-28 June 1994

Stratum	Autumn spawners												Spr sp all ages
	1	2I	2M	3I	3M	4	5	6	7	8	9	9+	
A		95.0	133.3		147.3		166.5	222.0					
B	72.8	106.2	130.5	136.0	154.9	155.5	175.1	250.0	202.0	186.0			
C	59.3	104.6	131.6		136.0								

Table B6: Ichthyophonus infection *Tridens* 20-28 June 1994. Numbers of fish investigated

Square		Autumn spawners												Spr sp all ages	Totals
		1	2I	2M	3I	3M	4	5	6	7	8	9	9+		
45E8	Neg	0	3	36	0	6	0	4	1	0	0	0	0	0	50
	Pos	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48E8	Neg	2	19	58	1	7	5	5	1	1	1	0	0	0	100
	Pos	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42E8	Neg	4	3	33	2	2	3	3	0	0	0	0	0	0	50
	Pos	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41E7	Neg	31	8	9	0	2	0	0	0	0	0	0	0	0	50
	Pos	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table C1: Catch composition by trawl haul *Scotia* 6-20 July 1994

Haul no	Position		Depth (m)	Herring	Whiting	Haddock	Pout	Mackerel	Horse mackerel	Gurnard	Sprat	
	Latitude	Longitude										
227	58°05.00'N	01°27.35'W	90	288	1		3				40	
228	58°20.37'N	01°10.73'W	94	6220			660					
229	58°35.00'N	02°22.68'W	68	11045								
230	58°35.40'N	01°39.50'W	110	8075		25	50	25				
231	58°34.89'N	00°11.24'E	150									"0" group pout
232	58°51.30'N	00°5.28'W	132									"0" group pout
233	58°49.13'N	00°24.05'W	135	214	1	2	26					
234	58°49.85'N	01°30.22'W	119	1082	244	166	110	5		2	165	10 mix fish
235	59°05.00'N	00°17.00'W	140									"0" group pout
236	59°34.95'N	01°27.81'W	95	13	2	1	2	82				
237	59°35.00'N	00°20.38'W	130	1149	54	345	798	24				6 cod; 3 lemon sole; 3 argentines
238	59°41.75'N	00°45.56'E	120		4	1	4					"0" group pout; 1 cod
239	60°08.18'N	00°48.66'W	110				1					
240	60°04.90'N	00°16.68'W	126									Foul haul
241	60°33.70'N	00°39.36'W	110	14725	150		10875					
242	60°32.94'N	00°41.24'E	144									Foul haul
243	60°55.26'N	00°03.40'W	150	6951	17		33					
244	61°20.03'N	00°45.60'W	20/150	1284				198	6			
245	61°19.80'N	00°46.60'W	176	576								
246	61°05.00'N	00°56.00'W	146	413				21		1		
247	60°54.80'N	01°45.20'W	135	537				160	2			
248	60°52.33'N	00°59.56'W	102		260	49		18				
249	60°48.00'N	02°17.60'W	135	7				4				
250	60°40.00'N	02°09.00'W										Missed mark

Haul no	Position		Depth (m)	Herring	Whiting	Haddock	Pout	Mackerel	Horse mackerel	Gurnard	Sprat	
	Latitude	Longitude										
251	60°36.80'N	01°31.34'W	85	272	45	3		20				
252	60°32.95'N	02°10.52'W	150	637			12	1				
253	60°24.88'N	01°44.59'W	88	2528								
254	60°18.40'N	02°16.00'W	120	6500								
255	60°07.86'N	01°35.18'W	95									Missed mark
256	60°03.00'N	02°09.00'W	98					24				
257	60°03.10'N	02°34.00'W	100	1306								
258	59°55.41'N	02°44.09'W	90	2				18				"0" group pout
259	59°48.00'N	03°30.00'W	110				12	1				"0" group pout
260	59°35.90'N	03°45.50'W	110	1320	144			9				
261	59°07.00'N	03°37.00'W	70									Missed mark
262	61°35.00'N	00°22.50'W	250									Maurilicus

Table C2: Herring length frequency by trawl haul by subarea *Scotia* 6-26 July 1994

Length	227	229	mean	228	230	234	mean	233	237	241	243	244	245	246	247	251	252	253	254	257	260	mean
16.0	1.7		0.9																			
16.5	4.9		2.4	0.2			0.1															
17.0	15.3		7.6																			
17.5	15.3	0.5	7.9			0.8	0.3															
18.0	12.5	3.5	8.0	0.3	0.6	4.3	1.7															
18.5	6.6	11.6	9.1		0.3	5.7	2.0															
19.0	3.8	20.8	12.3		0.3	8.7	3.0															
19.5	2.1	21.8	12.0		1.5	7.0	2.9															
20.0	0.3	17.2	8.8		1.2	5.3	2.2															
20.5	1.0	9.4	5.2	0.2	0.9	4.7	1.9													0.2		0.0
21.0	0.3	8.1	4.2		1.2	2.6	1.3															
21.5	0.7	2.2	1.4		4.3	3.0	2.4											0.3				0.0
22.0	1.4	2.4	1.9	0.3	4.3	3.5	2.7											0.3				0.0
22.5	5.6	1.1	3.3	0.3	6.2	3.5	3.3													0.6		0.0
23.0	4.9	0.5	2.7	0.3	9.9	5.9	5.4													0.8		0.1
23.5	4.2	0.5	2.4	2.3	14.2	7.5	8.0													1.5		0.1
24.0	6.3	0.3	3.3	5.5	16.1	9.6	10.4	0.5	0.3								0.2			4.6	0.2	0.4
24.5	4.5		2.3	7.7	13.3	5.5	8.9	1.4		0.2						0.4	0.2	0.6	0.3	5.2	1.3	0.7
25.0	4.5		2.3	10.3	10.8	6.1	9.1	0.5		1.2						0.7	1.3	0.9	1.8	10.1	1.3	1.3
25.5	3.1		1.6	10.3	6.2	5.2	7.2	1.9	1.0	2.9		0.2				2.6	1.4	2.8	3.1	7.5	2.2	1.8
26.0	1.0		0.5	10.0	4.3	4.3	6.2	4.7	2.1	5.9	1.0			0.2	0.6	7.7	0.9	6.3	3.7	7.8	2.9	3.1
26.5				10.5	1.9	3.1	5.2	5.1	4.7	8.0	3.1	0.5		1.2	0.7	10.3	1.7	8.2	8.0	8.0	2.6	4.4
27.0				12.7	1.2	1.9	5.3	4.2	8.6	13.2	4.6	2.8		1.2	1.1	14.3	3.8	18.0	15.4	7.0	5.5	7.1
27.5				9.8	0.9	0.9	3.9	12.1	7.8	11.4	7.4	4.0		0.7	3.7	14.7	6.9	17.1	13.2	5.1	6.4	7.9
28.0				8.5		0.2	2.9	8.9	11.2	11.5	8.4	3.0		3.4	4.1	14.0	11.1	15.5	16.3	5.2	8.3	8.6
28.5				4.8		0.2	1.7	8.9	5.5	8.0	6.0	4.0		2.9	4.5	9.9	8.0	8.9	11.4	4.7	7.8	6.5
29.0				2.7		0.2	1.0	7.9	9.1	8.1	7.9	5.8		3.1	6.7	5.5	6.6	7.6	9.2	3.4	8.3	6.4
29.5				1.9		0.2	0.7	6.1	6.5	3.9	6.7	4.4	0.7	5.6	7.8	4.0	8.0	4.4	4.3	1.8	7.1	5.1
30.0				0.2			0.1	4.7	7.6	3.9	6.9	6.8	2.1	6.8	8.4	2.2	8.0	1.6	4.0	2.6	6.9	5.2
30.5				0.5			0.2	6.5	7.8	5.6	9.4	8.2	3.1	8.2	9.5	4.0	8.2	0.9	1.8	3.7	8.0	6.1

Length	227	229	mean	228	230	234	mean	233	237	241	243	244	245	246	247	251	252	253	254	257	260	mean
31.0				0.3			0.1	9.3	9.7	5.1	13.2	11.0	6.6	13.6	8.4	4.0	7.5	0.6	2.2	4.9	7.3	7.4
31.5				0.5			0.2	8.4	7.6	3.4	10.5	9.1	9.7	12.1	10.1	3.3	6.6	3.2	1.2	3.8	4.4	6.7
32.0								4.7	7.3	3.4	7.7	11.7	18.8	14.3	9.3	1.1	6.0	1.6	1.8	4.6	4.5	6.9
32.5								2.3	1.6	2.5	4.6	9.8	19.8	10.2	10.6	0.4	5.3	0.9	0.9	3.2	5.5	5.5
33.0								0.9	0.8	1.2	1.7	8.9	16.3	8.0	7.1	0.4	4.6		0.6	1.8	5.3	4.1
33.5								0.9	0.5	0.5	0.5	5.8	11.8	5.3	3.9		2.8		0.6	1.1	2.6	2.6
34.0											0.5	1.9	6.9	1.2	2.2		0.8			0.5	0.9	1.1
34.5									0.3			1.2	2.1	1.2	0.7	0.4	0.2			0.2	0.4	0.5
35.0												0.5	1.4	0.2	0.6						0.5	0.2
35.5												0.5	0.7							0.2		0.1
36.0														0.2								0.0
36.5																						
37.0																						
37.5														0.2								0.0
Number caught	288	11045		6220	8075	1082		214	1149	14725	6951	1284	576	413	537	272	637	2528	6500	1306	1321	
Mean length (cm)	20.4	20.2	20.3	26.8	24.3	22.8	24.6	29.5	29.8	29.0	30.3	31.5	33.0	31.7	31.3	28.5	30.3	28.3	28.6	28.2	30.1	30.0
Mean weight (g)	74	66	70	178	125	106	136	250	256	233	273	311	361	317	304	220	272	213	221	216	267	265
TS/ind (dB)	-44.9	-45.1	-45.0	-42.6	-43.5	-44.0	-43.3	-41.8	-41.7	-41.9	-41.5	-41.2	-40.8	-41.2	-41.3	-42.1	-41.6	-42.2	-42.1	-42.2	-41.6	-41.6
TS/kg (dB)	-33.6	-33.3	-33.4	-35.1	-34.5	-34.2	-34.7	-35.7	-35.8	-35.6	-35.9	-36.1	-36.4	-36.2	-36.1	-35.5	-35.9	-35.4	-35.5	-35.5	-35.9	-35.9

Table C3: Herring numbers and biomass by age, maturity and subarea *Scotia* 6-26 July 1994

Age/Maturity	Numbers (*10^6)	Mean length (cm)	Mean weight (g)	Biomass (tonnes 10^-3)
Area I				
1A	193.67	18.79	56.29	10.90
2I	28.57	22.29	100.10	2.86
2M	24.93	24.30	133.63	3.33
3I	0.56	25.00	146.32	0.08
3M	1.84	24.43	135.97	0.25
4A	0.43	26.00	167.37	0.07
5A	0.00			0.00
6A	0.00			0.00
7A	0.00			0.00
8A	0.00			0.00
9+	0.00			0.00
Total	250.01	19.81	69.99	17.50
Area II				
1A	95.52	19.68	65.79	6.28
2I	32.03	22.38	100.99	3.23
2M	368.25	24.81	144.38	53.17
3I	1.38	21.50	87.34	0.12
3M	38.27	27.05	193.90	7.42
4A	25.03	27.60	206.34	5.16
5A	4.42	29.62	262.44	1.16
6A	1.21	29.54	259.99	0.31
7A	1.01	30.71	297.63	0.30
8A	0.30	31.50	323.55	0.10
9+	0.00			0.00
Total	567.43	24.14	136.17	77.27
Area III				
1A	1.37	21.51	87.66	0.12
2I	1.96	24.22	131.37	0.26
2M	764.64	27.05	193.04	147.60
3I	0.00			0.00
3M	505.47	28.74	237.79	120.20
4A	169.12	29.86	271.79	45.97
5A	175.41	31.10	311.21	54.59
6A	210.80	31.33	319.13	67.27
7A	304.35	31.79	335.52	102.12
8A	186.81	32.05	345.70	64.58
9+	116.52	32.74	372.00	43.35
Total	2436.46	29.49	265.11	645.93
Total				
1A	290.56	19.70	66.75	17.31
2I	62.56	23.34	117.09	6.35
2M	1157.83	26.99	191.76	204.10
3I	1.94	22.50	104.36	0.20
3M	545.58	28.72	237.45	127.87
4A	194.58	29.85	271.55	51.20
5A	179.84	31.10	311.21	55.75
6A	212.01	31.33	319.13	67.59
7A	305.35	31.79	335.52	102.42
8A	187.11	32.05	345.70	64.68
9+	116.52	32.74	372.00	43.35
Total	3253.90	28.75	250.12	740.70

Table E1: Catch composition by trawl haul *Kings Cross* 9-29 July 1994

Haul number	Position		Depth (m)	Numbers caught								Others
	Latitude (°N)	Longitude (°W)		Herring	Whiting	Haddock	Pout	Mackerel	Horse mackerel	Blue whiting	Sprat	
1	58 23.00	5 42.00	100		5		101	2				126 sandeels
2	57 26.82	7 04.59	100	147	10	1	4				6828	1 gurnard 9 hake 2 skate
3	57 14.34	6 37.09	70	6	14	3	3				171	
4	57 12.48	6 33.85	60								10651	
5	57 50.70	7 25.77	120	609								
6	56 06.60	8 33.44	120	4				120				1 gurnard
8	56 13.40	7 31.33	125	13	45		1310	1				1 hake
9	56 13.55	7 18.38	87	6	234	34	120	83				3 gurnard 9 flatfish 2 argentines
10	56 27.59	8 05.78	140	28726								
11	56 35.23	8 44.60	133	23252								
12	56 42.64	8 26.18	130	307				3			11	
13	56 40.95	7 34.96	120	26925								
14	56 50.88	8 17.66	130	13400				40				
15	56 57.63	9 00.30	130									280 boarfish 1 dragonet
16	56 57.86	8 15.27	120	26176								
17	57 06.25	7 54.80	100		1		992					
18	57 06.17	8 20.27	130	9631								
19	57 33.68	8 54.93	150	1396	6		12540	915				
20	57 50.39	9 16.19	180	4868	18		736		54			
21	57 50.30	8 55.30	138	3584	14		14					
22	58 04.70	8 20.48	135	322	4			1141				16 Sebastes viviparous
23	56 37.37	7 41.42	65	11311								
24	58 25.23	6 01.93	90	2520	20	54	8	2			2520	6 spurdog
25	58 22.58	6 52.54	50	23	2		18	476				1 ling 1 angler fish
26	58 20.15	7 34.26	75				540					15 saithe 2 angler fish
27	58 20.19	8 13.18	210	5180			74	60	234	34		7 poor cod

Haul number	Position		Depth (m)	Numbers caught								Others
	Latitude (°N)	Longitude (°W)		Herring	Whiting	Haddock	Pout	Mackerel	Horse mackerel	Blue whiting	Sprat	
29	58 36.23	7 01.58	90	40			880	203				1 gurnard 2 anglers
30	58 36.61	6 37.30	90	22	2		640	57				
31	58 35.97	5 43.87	135	12058	30	30	90				330	40 spurdog 30 argentines
32	58 43.90	5 37.70	85	177	19	105	1791					2 anglers 1 spurdog
33	58 56.96	4 14.35	60		23	2	66					25 sandeels
34	58 58.09	5 38.22	95	927			1210	4				
36	59 05.65	6 59.98	190	313	9		1544	4	9	52		5 argentine 2 poorcod 1 cod 3 hake
37	59 06.24	5 42.88	65									1151 sandeels
38	59 13.22	5 16.73	92	217			3008					
40	59 29.00	6 25.02								1		300 pearlsides
41	59 22.44	4 03.99	110	405	1	17	487	7				12 gurnard

Table E2: Herring length frequency by trawl haul by sub area. *Kings Cross* 9-29 July 1994 mean length - cm, mean weight - g, target strength - dB)

Haul No	Area I			Area II				Area III										
	2	24	Mean	5	10	23	Mean	11	12	13	14	16	18	19	20	21	22	mean
15.5	1.6		0.8															
16.0	3.1		1.6															
16.5	16.3	0.6	8.4															
17.0	16.3	2.8	9.6															
17.5	27.9	4.5	16.2															
18.0	14.0	10.7	12.3														0.6	0.1
18.5	10.1	11.3	10.7															
19.5	8.5	7.9	8.2															
19.0	2.3	10.7	6.5	0.4			0.1											
19.5		7.9	4.0														0.6	0.1
20.0		4.5	2.3															
20.5		4.0	2.0	0.4			0.1											
21.0		3.4	1.7	0.4			0.1											
21.5		2.8	1.4	0.4			0.1											
22.0		5.1	2.5															
22.5		6.8	3.4	0.4		0.3	0.2											
23.0		3.4	1.7	0.7			0.2											
23.5		6.2	3.1	1.1	1.2	1.0	1.1										0.6	0.1
24.0		2.3	1.1	3.5	3.1	1.0	2.5	0.4		2.5	0.3			0.5				0.4
24.5		2.3	1.1	6.7	8.2	1.6	5.5	0.4		2.8	0.6	0.4						0.4
25.0		1.1	0.6	7.8	11.0	7.3	8.7	0.4		3.2	0.9	1.4	0.4					0.6
25.5		0.6	0.3	11.0	10.2	9.8	10.3	0.4		7.8	2.4	3.9					1.6	1.6
26.0				13.1	8.6	12.1	11.3	0.8	0.7	4.6	2.1	5.7	5.7	1.0		0.8	4.7	2.6
26.5				12.8	7.4	13.7	11.3	4.7	1.0	7.1	11.9	17.8	16.0	2.4	1.4	1.2	6.2	7.0
27.0		1.1	0.6	8.2	7.4	14.3	10.0	7.1	2.9	9.9	14.3	16.4	18.6	9.3	4.3	4.0	16.5	10.3
27.5		27.5		10.6	9.4	15.9	12.0	20.1	17.9	16.0	19.7	16.4	24.0	21.1	11.2	5.5	23.3	17.5
28.0		28.0	28.0	8.2	12.2	16.2	12.2	21.3	27.0	17.0	27.8	20.3	22.4	25.0	26.6	11.1	22.7	22.1
28.5		28.5	28.5	6.0	11.4	6.7	8.0	22.0	31.6	19.5	16.1	16.0	10.3	28.9	25.2	15.1	11.8	19.6
29.0		29.0	29.0	5.3	7.1		4.1	16.1	15.6	7.1	3.6	1.4	2.3	10.3	17.6	13.1	4.7	9.2
29.5		29.5	29.5	2.8	2.4	0.3	1.8	5.9	2.9	1.4	0.3	0.4	0.4	0.5	6.1	7.1	2.5	2.8

Haul No	Area I			Area II				Area III										
	2	24	Mean	5	10	23	Mean	11	12	13	14	16	18	19	20	21	22	mean
30.0		30.0	30.0	0.4	0.4		0.2	0.4	0.3	0.7	0.7			0.5	3.6	8.7	3.7	1.8
30.5		30.5	30.5					30.5	30.5	0.4	0.4	0.4	0.4	0.5	1.8	12.3	0.6	1.6
31.0		31.0	31.0					31.0	31.0						1.1	10.7	10.7	1.2
31.5		31.5	31.5					31.5	31.5						0.7	5.9	5.9	0.7
32.0		32.0	32.0					32.0	32.0							2.0	2.0	0.2
32.5		32.5	32.5					32.5	32.5					32.5		1.4	1.4	0.1
33.0		33.0	33.0					33.0	33.0					33.0	0.4	0.8	0.8	0.1
33.5		33.5	33.5					33.5	33.5					33.5		0.4	0.4	0.4
34.0		34.0	34.0					34.0	34.0					34.0				
34.5		34.5	34.5					34.5	34.5					34.5				
Number	129	177		282	28726	11311		23252	307	26925	13400	26176	9631	1396	4868	3534	322	¬
mean lgt	18.0	21.0	19.5	27.4	27.7	27.8	27.6	29.1	29.2	28.3	28.5	28.3	28.4	29.0	29.5	30.4	28.6	28.9
mean wt	46	80	63	185	191	191	189	221	225	205	208	203	205	220	232	259	211	219
TS/ind	-46.1	-44.7	-45.3	-42.4	-42.3	-42.3	-42.4	-41.9	-41.9	-42.1	-42.1	-42.2	-42.1	-41.9	-41.8	-41.5	-42.1	-42.0
TS/kg	-32.7	-33.7	-33.3	-33.3	-35.1	-35.1	-35.1	-35.4	-35.4	-35.3	-35.3	-35.2	-35.2	-35.4	-35.5	-35.7	-35.3	-35.4

Table E2 (continued)

Haul No	Area IV			Area V					
	27	36	mean	31	32	34	38	41	mean
15.5									
16.0									
16.5									
17.0									
17.5									
18.0									
18.5				0.3					0.1
19.5				0.3					0.1
19.0				0.3					0.1
19.5				0.3					0.1
20.0						0.3			0.1
20.5				0.3					0.1
21.0				0.5					0.1
21.5				0.5		0.3			0.2
22.0				0.8					0.2
22.5				1.9		0.3			0.4
23.0				3.6	0.6	2.4	0.5	1.7	1.7
23.5				9.0	0.6	4.2	2.3	4.0	4.0
24.0				12.6	4.5	8.3	1.8	5.4	6.5
24.5				13.4	5.6	8.6	2.8	15.6	9.2
25.0				9.9	9.0	8.0	4.1	15.1	9.2
25.5		0.3	0.2	9.6	17.5	9.2	9.7	15.1	12.2
26.0		0.6	0.3	12.6	19.8	12.2	7.4	12.6	12.9
26.5		0.3	0.2	7.9	12.4	12.7	7.8	11.1	10.4
27.0	0.4	0.6	0.5	5.5	17.5	13.7	6.5	8.1	10.3
27.5	0.8	0.3	0.5	3.6	4.5	7.1	10.1	5.2	6.1
28.0	5.0	0.6	2.8	2.7	4.5	3.9	5.1	2.5	3.7
28.5	5.8	3.2	4.5	1.6	1.1	2.7	6.5	1.5	2.7
29.0	5.8	2.2	4.0	1.1	1.1	2.7	5.5	0.7	2.2
29.5	7.7	3.5	5.6	0.5		1.2	4.6	0.7	1.4
30.0	12.0	5.8	8.9		0.6	0.3	4.6	0.2	1.1
30.5	22.4	13.7	18.1	0.8			7.4	0.2	1.7
31.0	14.7	21.4	18.0			0.9	2.8		0.7
31.5	13.1	19.2	16.1	0.3			5.5	0.2	1.2
32.0	8.9	14.4	11.6		0.6	0.3	1.8		0.5
32.5	2.3	9.3	5.8			0.3	0.9		0.2
33.0	1.2	2.6	1.9			0.3	1.4		0.3
33.5		1.6	0.8				0.9		0.2
34.0		0.3	0.2						
34.5									
Number	5180	313		12058	177	927	217	405	
mean lgt	31.4	32.1	31.7	26.2	27.1	27.1	28.9	26.7	27.2
mean wt	287	307	297	159	177	177	222	168	180
TS/ind	-41.3	-41.1	-41.2	-42.8	-42.5	-42.5	-42.0	-42.7	-42.5
TS/kg	-35.8	-35.9	-35.9	-34.8	-35.0	-35.0	-35.4	-34.9	-35.1

Table E3: Herring numbers and biomass by age, maturity and area. *Kings Cross* 9-29 July 1994

Category	Number x 10^{-6}	Mean length (cm)	Mean weight (g)	Biomass (tonnes $x10^{-3}$)
Area I (Minch)				
1 ring	488.02	18.14	51.79	25.27
2 ring immature	36.63	23.00	109.85	4.02
2 ring mature	49.15	23.55	119.03	5.85
3 ring immature	0.00			0.00
3 ring mature	9.56	25.53	155.72	1.49
4	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00
9+	0.00	0.00	0.00	0.00
Total	583.36	19.03	62.80	36.64
Area II (Barra Head)				
1 ring	1.97	20.86	80.27	0.16
2 ring immature	127.18	25.71	157.33	20.01
2 ring mature	41.55	25.65	156.32	6.51
3 ring immature	11.94	27.36	192.49	2.30
3 ring mature	86.57	27.00	184.09	15.94
4	50.46	28.08	209.30	10.56
5	44.06	28.22	212.39	9.36
6	43.95	28.37	216.39	9.51
7	45.05	28.76	225.94	10.18
8	17.42	28.95	230.90	4.02
9+	5.00	29.47	244.44	1.22
Total	475.13	27.14	188.89	89.75
Area III (South West Hebrides)				
1 ring	1.76	19.00	59.62	0.10
2 ring immature	29.74	25.89	161.05	4.79
2 ring mature	22.63	26.41	172.31	3.90
3 ring immature	25.31	27.71	200.76	5.08
3 ring mature	286.30	27.47	194.95	55.81
4	203.88	28.57	221.23	45.10
5	245.90	28.48	218.86	53.82
6	182.82	28.80	227.33	41.56
7	287.49	28.94	230.96	66.40
8	91.64	29.73	252.78	23.17
9+	39.06	30.14	264.43	10.33
Total	1416.52	28.44	218.89	310.06

Category	Number x 10^{-6}	Mean length (cm)	Mean weight (g)	Biomass (tonnes x10^{-3})
Area IV (Shelf break)				
1 ring	0.00			0.00
2 ring immature	0.41	26.50	172.98	0.07
2 ring mature	0.41	26.50	172.98	0.07
3 ring immature	0.44	27.50	195.06	0.09
3 ring mature	13.94	29.82	255.45	3.56
4	13.18	29.72	252.18	3.32
5	8.10	30.35	270.71	2.19
6	30.49	31.02	290.14	8.85
7	55.74	31.15	294.01	16.39
8	54.06	31.62	308.13	16.66
9+	81.91	31.75	312.14	25.57
Total	258.69	31.23	296.75	76.77
Area V (North of Scotland)				
1 ring	2.41	20.57	77.32	0.19
2 ring immature	29.91	24.75	139.52	4.17
2 ring mature	204.45	25.57	155.02	31.69
3 ring immature	2.04	28.19	211.51	0.43
3 ring mature	171.62	27.09	186.67	32.04
4	18.10	28.07	209.63	3.79
5	8.70	30.01	261.26	2.27
6	10.87	29.13	236.28	2.57
7	18.56	30.49	275.43	5.11
8	10.62	31.03	290.07	3.08
9+	5.91	31.82	315.13	1.86
Total	483.22	26.68	180.49	87.22
Total Area				
1 ring	494.15	18.17	52.06	25.72
2 ring immature	223.88	25.16	147.70	33.07
2 ring mature	318.20	25.33	150.88	48.01
3 ring immature	39.74	27.63	198.76	7.90
3 ring mature	567.98	27.31	191.62	108.83
4	285.61	28.50	219.81	62.78
5	306.76	28.53	220.50	67.64
6	268.13	29.00	233.04	62.49
7	406.84	29.30	241.08	98.08
8	173.74	30.32	270.09	46.92
9+	131.88	31.19	295.58	33.98
Total	3216.91	26.50	186.65	600.43

Table F1: Settings and calibration of echo sounder at Bornö, Gullmarn, Sweden July 1994

Echo sounder	EK/ES 400, 38 kHz
Transducer	Simrad ceramic 38-29/25
SL + VR	132.500
10 LOG psi	-20.200
TVG	64.6
Sound velocity (m/s)	1498
Pulse length (s)	0.0010

Table F2: Danish acoustic survey July 1994. Survey statistics

Strata		Area NM**	No logs	Trawl haul	Mean Sa
I	580A04	912	122	1	3,55E-06
II	570A04	1,936	207	5	3,11E-06
III	580A06	209	36	2	3,21E-06
IV	570A06	3,516	682	11	5,10E-06
V	580A08	1,822	159	7	8,65E-06
VI	570A08	2,470	370	8	2,48E-06
VII	C	803	137	3	3,22E-06
VIII	D	1,630	325	6	2,04E-05

Table F3: Trawl stations from RV *Dana* July 1994

Date	Time UTC	Lat °N	Long °E	Haul no	ICES square	Trawl	Catch depth m	Total depth m	Total catch kg
11 07	21.33	57 26.2	07 55.7	3569	43F7	Fotö	Surface	140	3085
12 07	00.33	57 39.7	07 48.1	3585	44F7	Fotö	Surface	388	598
12 07	21.31	58 01.8	05 32.0	3778	44F5	Fotö	Surface	251	1824
13 07	00.07	57 50.6	05 16.7	3794	44F5	Fotö	Surface	95	174
13 07	17.42	57 17.9	05 29.0	3963	43F5	Expo	Bottom	58	uklar
13 07	18.41	57 17.4	05 30.7	3968	43F5	Expo	Bottom	56	657
13 07	21.35	57 20.2	05 28 3	3977	43F5	Fotö	Surface	70	445
14 07	00.36	57 36.9	05 58.7	4001	44F6	Fotö	Surface	143	1514
14 07	21.34	57 50.9	09 19.5	4202	44F9	Fotö	Surface	125	1258
15 07	00.25	58 00.1	08 58.6	4219	44F8	Fotö	Surface	555	2087
15 07	19.11	57 03.9	07 11.4	4393	43F7	Expo	Bottom	25	291
15 07	21.49	57 09.8	06 55.4	4406	43F6	Fotö	Surface	64	1600
16 07	00.17	57 13.7	06 33.7	4422	43F6	Fotö	Surface	66	372
16 07	17.33	57 43.4	06 39.1	4560	44F6	Fotö	95	300	89
16 07	21.29	57 51.5	06 41.2	4579	44F6	Fotö	Surface	330	3000
17 07	00.18	57 39.9	06 38.7	4592	44F6	Fotö	Surface	200	2075
17 07	18.37	57 08.5	07 44.0	4735	43F7	Expo	Bottom	45	756
17 07	21.47	57 20.9	07 45.2	4752	43F7	Fotö	Surface	71	124
18 07	00.21	57 35.4	07 41.7	4767	44F7	Fotö	Surface	284	1571
18 07	22.10	57 38.5	08 34.8	4899	44F8	Fotö	Surface	146	2316
19 07	00.26	57 48.9	08 25.0	4912	44F8	Fotö	Surface	490	2776
19 07	17.00	58 27.1	09 12.9	5064	45F9	Fotö	200	445	22
19 07	22.00	58 11.1	09 35.8	5091	45F9	Fotö	Surface	589	1716
20 07	00.25	58 01.5	09 51.6	5104	45F9	Fotö	Surface	130	1800
20 07	17.10	58 38.2	09 33.0	5234	46F9	Fotö	300	445	303
20 07	21.37	58 37.1	10 16.4	5266	46G0	Fotö	Surface	275	1026
21 07	00.13	58 40.6	10 31.6	5281	46G0	Fotö	Surface	128	3227
21 07	18.15	58 24.4	10 32.2	5392	46G0	Fotö	150	210	31
21 07	21.47	58 31.0	10 52.3	5413	46G0	Fotö	Surface	64	8000
22 07	16.48	57 37.7	10 49.9	5558	44G0	Expo	Bottom	25	2758
22 07	21.38	57 33.8	10 32.3	5588	44G1	Fotö	Surface	60	3942
23 07	00.53	57 18.4	11 36.8	5606	43G1	Fotö	Surface	60	2700
23 07	16.34	56 50.7	12 00.3	5743	42G1	Expo	Bottom	39	1349
23 07	21.41	56 39.1	12 11.7	5779	42G2	Fotö	Surface	43	680
24 07	00.32	56 33.8	11 54.6	5792	42G1	Expo	Surface	30	2124
24 07	13.59	56 14.6	12 19.0	5918	41G2	Expo	Bottom	29	684
24 07	17.43	56 07.1	11 43.1	5945	41G1	Expo	Bottom	21	110
25 07	04.23	56 25.9	11 05.3	6035	41G1	Expo	Bottom	19	976
25 07	16.55	57 48.1	10 24.0	6145	44G0	Expo	Bottom	80	1241
25 07	22.10	57 52.9	11 05.7	6179	44G1	Fotö	Surface	60	2018
26 07	00.50	58 02.3	10 48.5	6194	45G0	Fotö	Surface	210	1450
26 07	16.38	57 43.9	09 42.4	6318	44F9	Expo	Bottom	36	880
26 07	21.35	58 20.8	09 45.4	6357	45F9	Fotö	Surface	573	888
27 07	00.55	58 15.0	09 20.0	6378	45F9	Fotö	Surface	682	1435

Table F4. Proportions at age and weights at age from Danish survey July 1994

Area	Ring	Numbers									Weights									
	r 0	r 1	r 2	r 3	r 4	r 5	r 6	r 7	r 8	r 9	r 0	r 1	r 2	r 3	r 4	r 5	r 6	r 7	r 8	r 9
580A04																				
All herring	0.00	0.56	0.17	0.13	0.10	0.02	0.01	0.01	0.00	0.00	0	77	111	138	160	206	222	255	0	0
North Sea	0.00	0.69	0.16	0.10	0.04	0.01	0.00	0.00	0.00	0.00	0	77	118	156	184	219	0	0	0	0
Baltic Sea	0.00	0.00	0.23	0.27	0.34	0.06	0.08	0.03	0.00	0.00	0	0	91	112	147	195	222	255	0	0
570A04																				
All herring	0.01	0.34	0.30	0.16	0.11	0.04	0.02	0.01	0.00	0.00	4	78	139	155	172	209	236	246	335	0
North Sea	0.01	0.43	0.33	0.14	0.06	0.03	0.00	0.00	0.00	0.00	4	78	144	170	188	213	0	0	0	0
Baltic Sea	0.00	0.00	0.15	0.23	0.33	0.11	0.09	0.07	0.01	0.00	0	94	117	162	205	236	246	335	0	0
580A06																				
All herring	0.00	0.30	0.24	0.25	0.14	0.04	0.03	0.01	0.00	0.00	0	78	122	136	160	200	210	248	0	0
North Sea	0.00	0.42	0.28	0.21	0.08	0.02	0.00	0.00	0.00	0.00	0	78	127	151	178	215	0	0	0	0
Baltic Sea	0.00	0.00	0.14	0.36	0.31	0.08	0.09	0.02	0.00	0.00	0	0	95	115	150	189	211	248	0	0
570A06																				
All herring	0.00	0.52	0.23	0.12	0.05	0.04	0.02	0.01	0.00	0.00	6	74	126	137	176	177	213	217	0	0
North Sea	0.00	0.61	0.25	0.09	0.03	0.02	0.00	0.00	0.00	0.00	6	74	129	152	180	188	0	0	0	0
Baltic Sea	0.00	0.00	0.17	0.30	0.19	0.16	0.12	0.05	0.02	0.00	0	99	112	172	169	213	217	245	0	0
580A08																				
All herring	0.00	0.18	0.19	0.27	0.17	0.10	0.06	0.02	0.01	0.00	5	74	109	125	147	174	191	199	227	200
North Sea	0.00	0.61	0.32	0.07	0.00	0.00	0.00	0.00	0.00	0.00	5	74	123	174	0	0	0	0	0	0
Baltic Sea	0.00	0.00	0.14	0.35	0.24	0.14	0.09	0.03	0.01	0.00	0	95	122	147	174	191	199	227	200	0
570A08																				
All herring	0.00	0.56	0.17	0.12	0.09	0.02	0.01	0.01	0.00	0.00	7	72	109	130	137	180	184	162	227	0
North Sea	0.01	0.85	0.13	0.02	0.00	0.00	0.00	0.00	0.00	0.00	7	72	119	175	0	0	0	0	0	0
Baltic Sea	0.00	0.00	0.25	0.33	0.26	0.07	0.04	0.04	0.01	0.00	10	0	125	137	180	184	162	227	0	0

Area	Ring	Numbers									Weights									
	r 0	r 1	r 2	r 3	r 4	r 5	r 6	r 7	r 8	r 9	r 0	r 1	r 2	r 3	r 4	r 5	r 6	r 7	r 8	r 9
C																				
All herring	0.61	0.22	0.07	0.06	0.02	0.01	0.00	0.00	0.00	0.00	10	66	94	110	138	157	203	205	218	0
North Sea	0.69	0.25	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10	66	102	0	0	0	0	0	0	0
Baltic Sea	0.00	0.00	0.19	0.52	0.14	0.10	0.03	0.01	0.01	0.00	0	78	110	138	157	203	205	218	0	0
0.00																				
All herring	0.58	0.36	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	9	58	93	104	137	152	192	220	175	236
North Sea	0.61	0.37	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9	58	102	0	0	0	0	0	0	0
Baltic Sea	0.00	0.00	0.18	0.46	0.22	0.09	0.04	0.01	0.01	0.00	0	77	104	137	152	192	220	175	236	0

Table G1: Numbers (millions) and biomass (thousands of tonnes) of autumn spawning herring by ICES Area from the combined survey

Ring	Numbers (millions)						Biomass (thousands of tonnes)					
	VIa South	VIa North	IVa	IVb	IVab	East of 6°E	VIa South	VIa North	IVa	IVb	IVab	East of 6°E
0				395.43	395.43	2931.16						
1		494.15	436.26	388.05	824.32	2822.05		25.72	27.14	22.50	49.65	177.07
2I		223.88	163.06	357.46	520.52	395.94		33.07	17.91	41.14	59.06	28.76
2M		318.20	1313.49	985.32	2298.81	64.46		48.01	222.42	132.90	355.32	7.85
3I		39.74	25.05	48.91	73.96	62.36		7.90	3.31	6.88	10.19	7.92
3M		567.98	589.12	198.04	787.16	33.58		108.83	131.80	38.35	170.15	5.32
4		285.61	234.87	169.27	404.14	25.28		62.78	56.58	32.40	88.98	4.55
5		306.76	211.36	136.28	347.64	15.50		67.64	59.64	27.61	87.25	2.91
6		268.13	218.36	102.45	320.82	0.00		62.49	65.57	27.11	92.67	0.00
7		406.84	288.99	38.94	327.94	0.00		98.08	92.77	10.54	103.31	0.00
8		173.74	187.63	32.66	220.29	0.00		46.92	62.11	9.14	71.25	0.00
9		131.88	113.31	18.74	132.05	0.00		38.98	40.37	5.37	45.74	0.00
Immature		757.77	1019.81	794.42	1814.23	6211.51		66.69	48.37	70.53	118.89	217.28
Mature		2459.15	3157.14	1681.71	4838.86	138.81		533.74	731.25	283.42	1014.67	20.64
Total	1621.28	3216.91	4176.95	2476.13	6653.08	6350.32	353.77	600.43	779.62	353.95	1133.57	237.92

Table G2: Numbers (millions) and biomass (thousands of tonnes) of Baltic herring in ICES Areas IVa IVb and east of 6°E

	Numbers (millions)				Biomass (thousands of tonnes)			
Ring/Area	IVa	IVb	IVab	East of 6°E	IVa	IVb	IVab	East of 6°E
0								
1	3.15	0.00	3.15	0.00	0.25	0.00	0.25	0.00
2I	92.73	6.56	99.29	1319.66	9.32	0.62	9.94	110.81
2M	28.36	13.93	42.29		2.78	1.80	4.58	
3I	46.50	2.73	49.23	3134.69	5.39	0.32	5.71	339.85
3M	140.07	9.59	149.66		18.22	1.16	19.38	
4	134.54	15.90	150.44	1612.98	21.77	2.58	24.35	230.26
5	53.63	6.81	60.44	771.20	10.18	1.34	11.52	124.25
6	71.87	4.62	76.49	418.26	17.40	1.09	18.49	82.68
7	28.52	3.39	31.92	143.84	7.32	0.83	8.15	29.89
8	11.95	0.70	12.65	87.40	3.05	0.23	3.29	17.21
9	6.46	0.00	6.46	7.21	1.85	0.00	1.85	1.60
Immature	53.06	9.29	151.66		14.96	0.94	15.90	
Mature	475.40	54.94	530.34		82.57	9.04	91.61	
Total	64.23	64.23	682.00	7505.85	97.54	9.98	107.51	938.68

Table G3: Mean weights (g) by age and maturity for autumn spawning herring by ICES area from the combined survey

	VIa South	VIa North	IVa	IVb	IVab	East of 6°E
1		52.06	62.21	57.99	60.23	62.75
2I		147.70	109.86	115.09	113.46	72.63
2M		150.88	169.34	134.88	154.57	121.86
3I		198.76	132.16	140.69	137.80	127.08
3M		191.62	223.71	193.66	216.15	158.37
4		219.81	240.88	191.43	220.17	180.16
5		220.50	282.17	202.58	250.97	188.00
6		233.04	300.28	264.56	288.87	
7		241.08	321.00	270.74	315.03	
8		270.09	331.04	279.81	323.45	
9		295.58	356.25	286.70	346.38	
Immature		88.01	47.43	88.78	65.53	34.98
Mature		217.04	231.62	168.53	209.69	148.69
Total	218.20	186.65	186.65	142.94	170.38	37.47

Table G4: Weights (g) of Baltic herring by age in ICES areas IVa, IVb and east of 6°E

Ring/Area	IVa	IVb	IVab	East of 6°E
0				
1	80.00	0.00	80.00	0.00
2I	100.48	94.12	100.06	83.97
2M	97.94	129.21	108.24	
3I	116.00	117.00	116.06	108.41
3M	130.07	121.44	129.51	
4	161.84	162.00	161.86	142.76
5	189.72	197.24	190.57	161.11
6	242.14	235.66	241.75	197.67
7	256.60	246.00	255.47	207.79
8	255.66	335.00	260.06	196.89
9	286.70	0.00	286.70	222.38
Immature	282.03	100.84	104.84	
Mature	173.69	164.56	172.75	
Total	1518.57	155.35	157.64	125.06

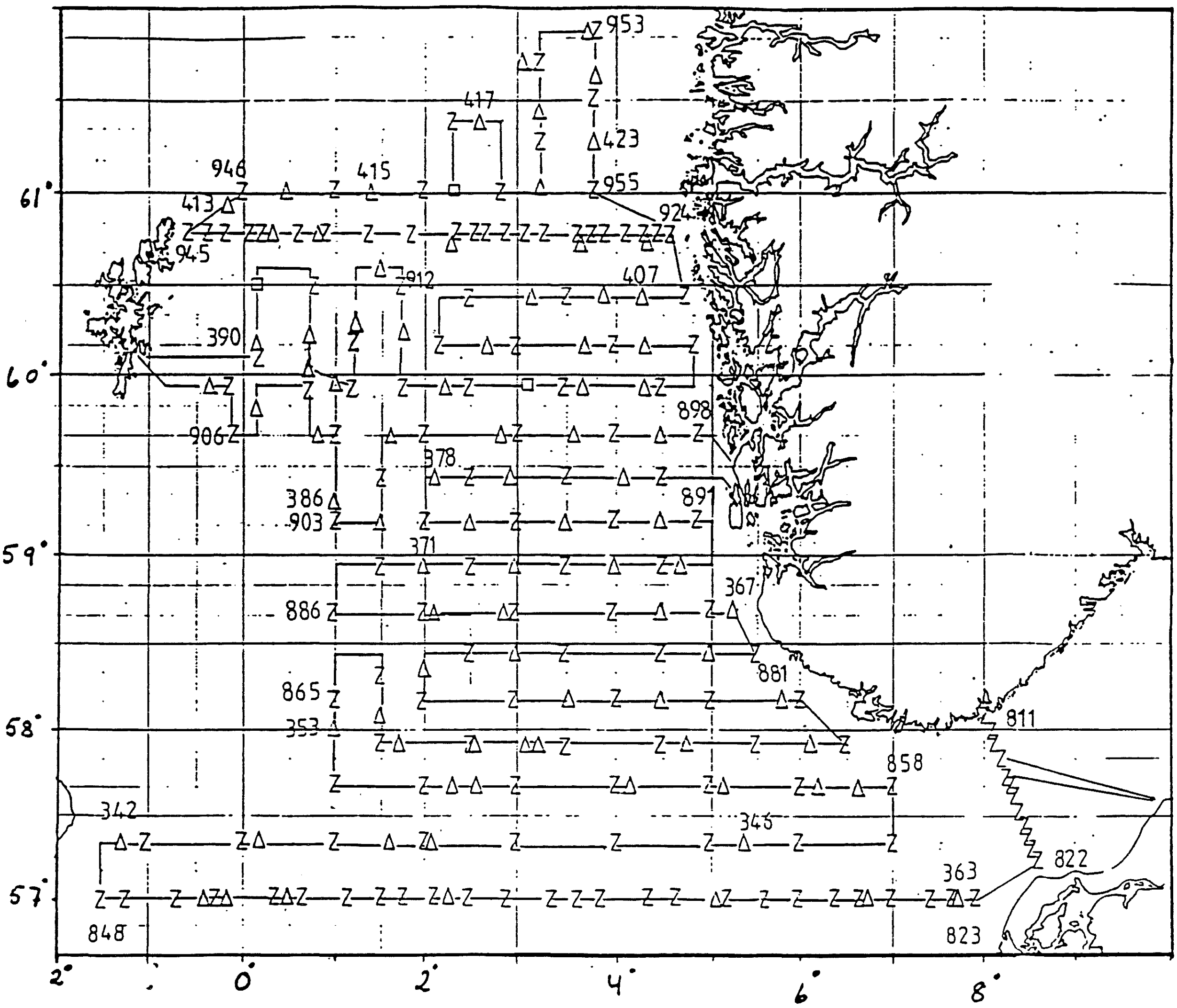


Figure A1. Cruise track with CTD (Z) stations and trawl stations (Δ) for RV *GO Sars*, 2-21 July 1994.

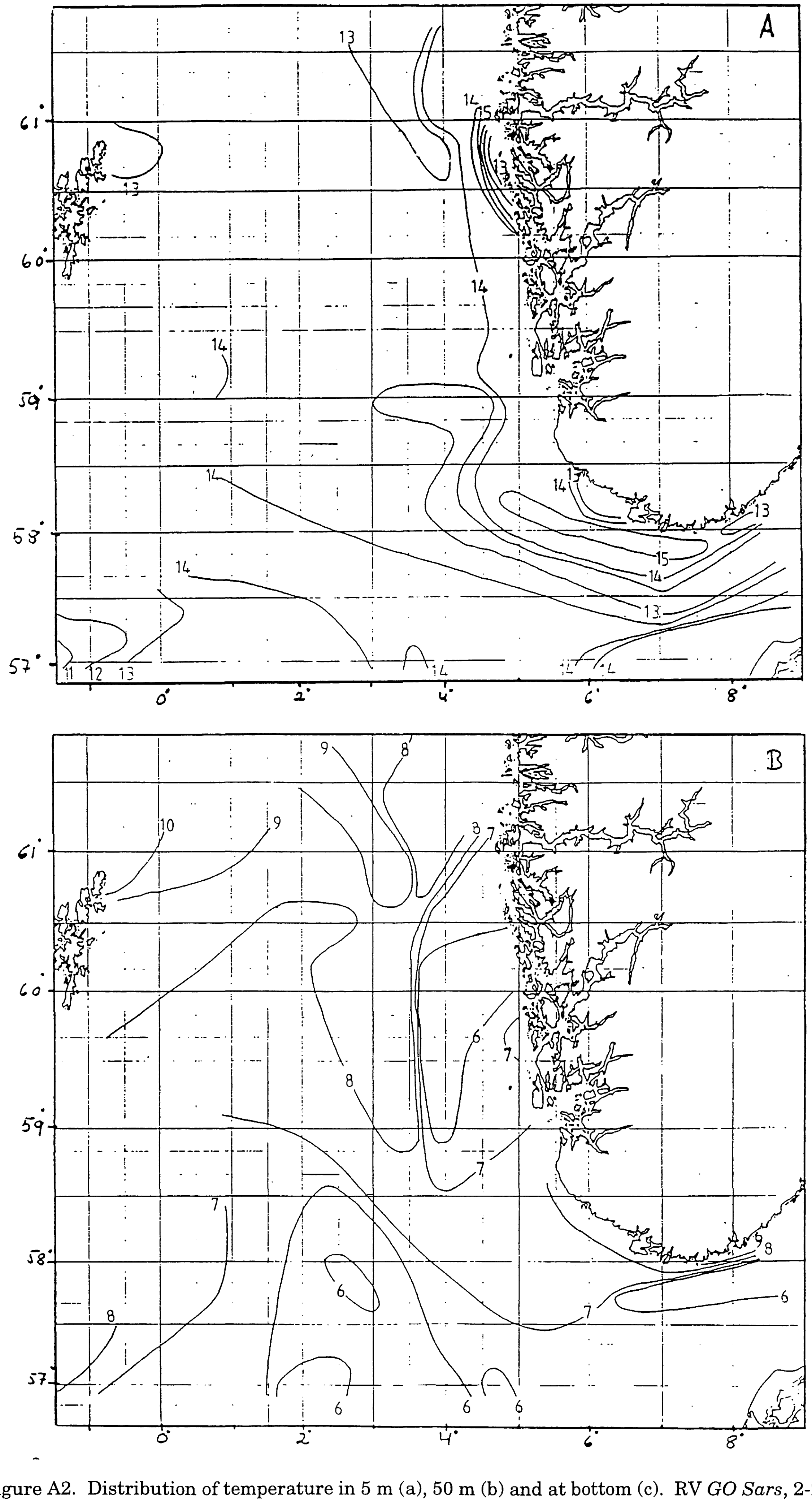


Figure A2. Distribution of temperature in 5 m (a), 50 m (b) and at bottom (c). RV *GO Sars*, 2-21 July 1994.

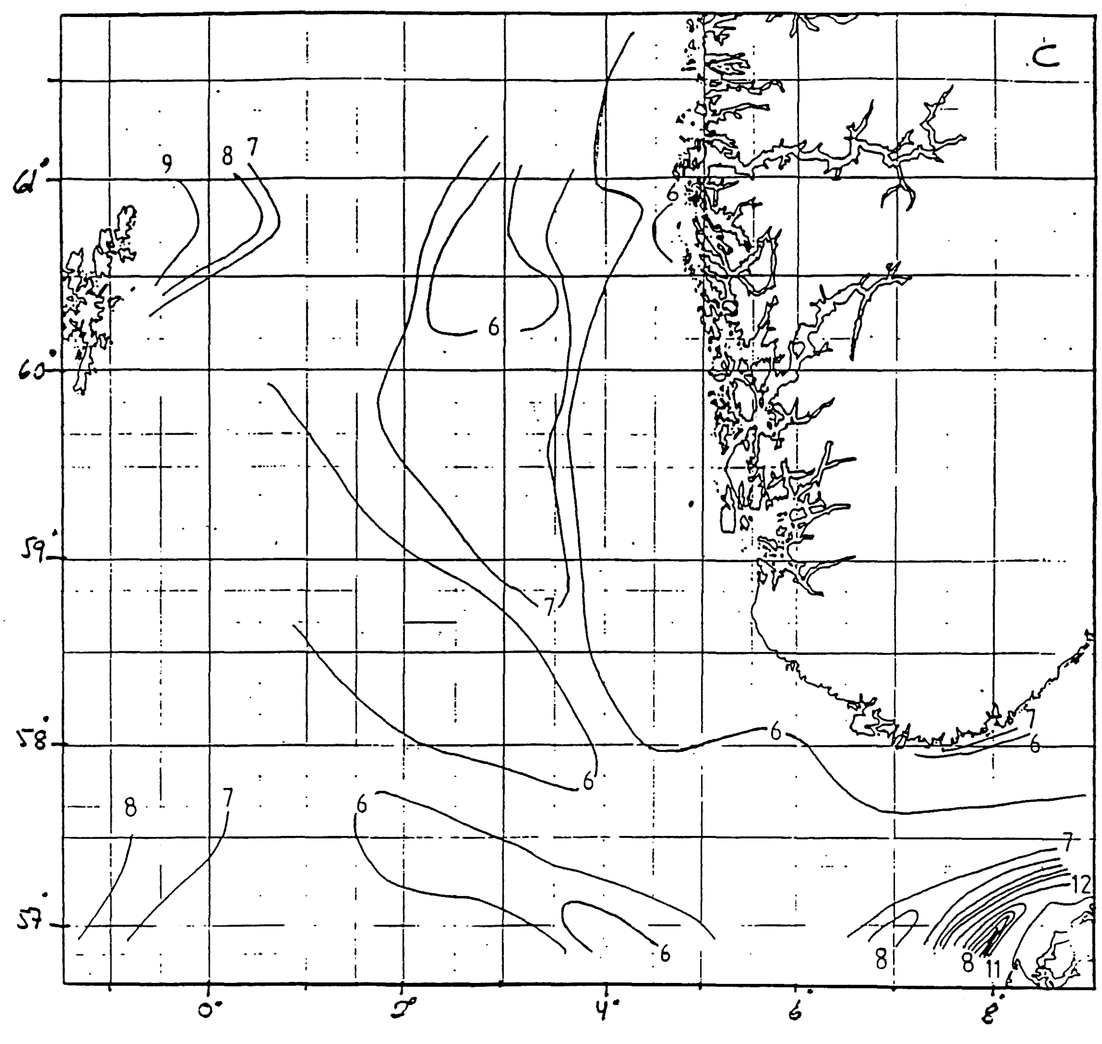


Figure A2 continued

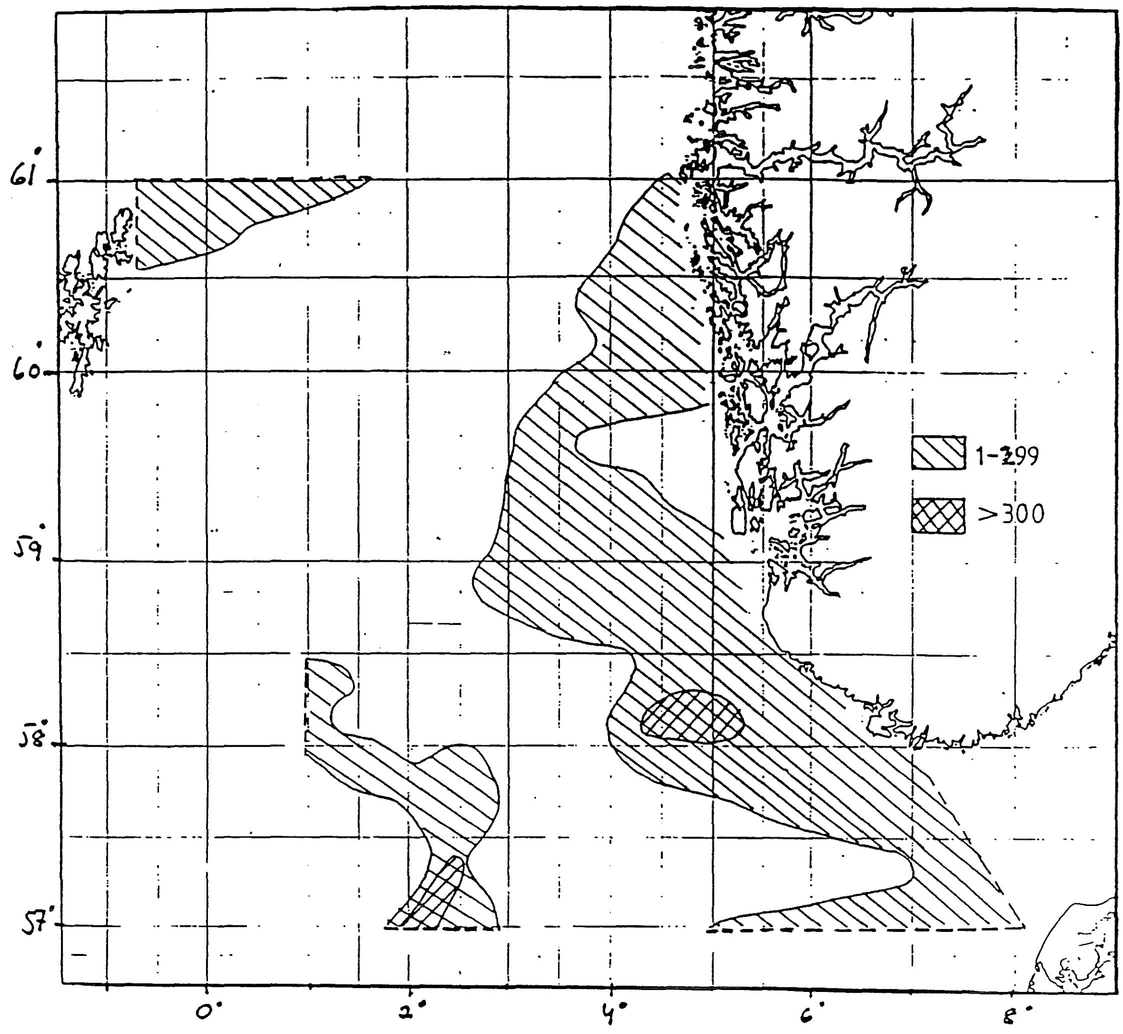


Figure A3. The horizontal distribution of herring. RV *GO Sars*, 2-21 July 1994.

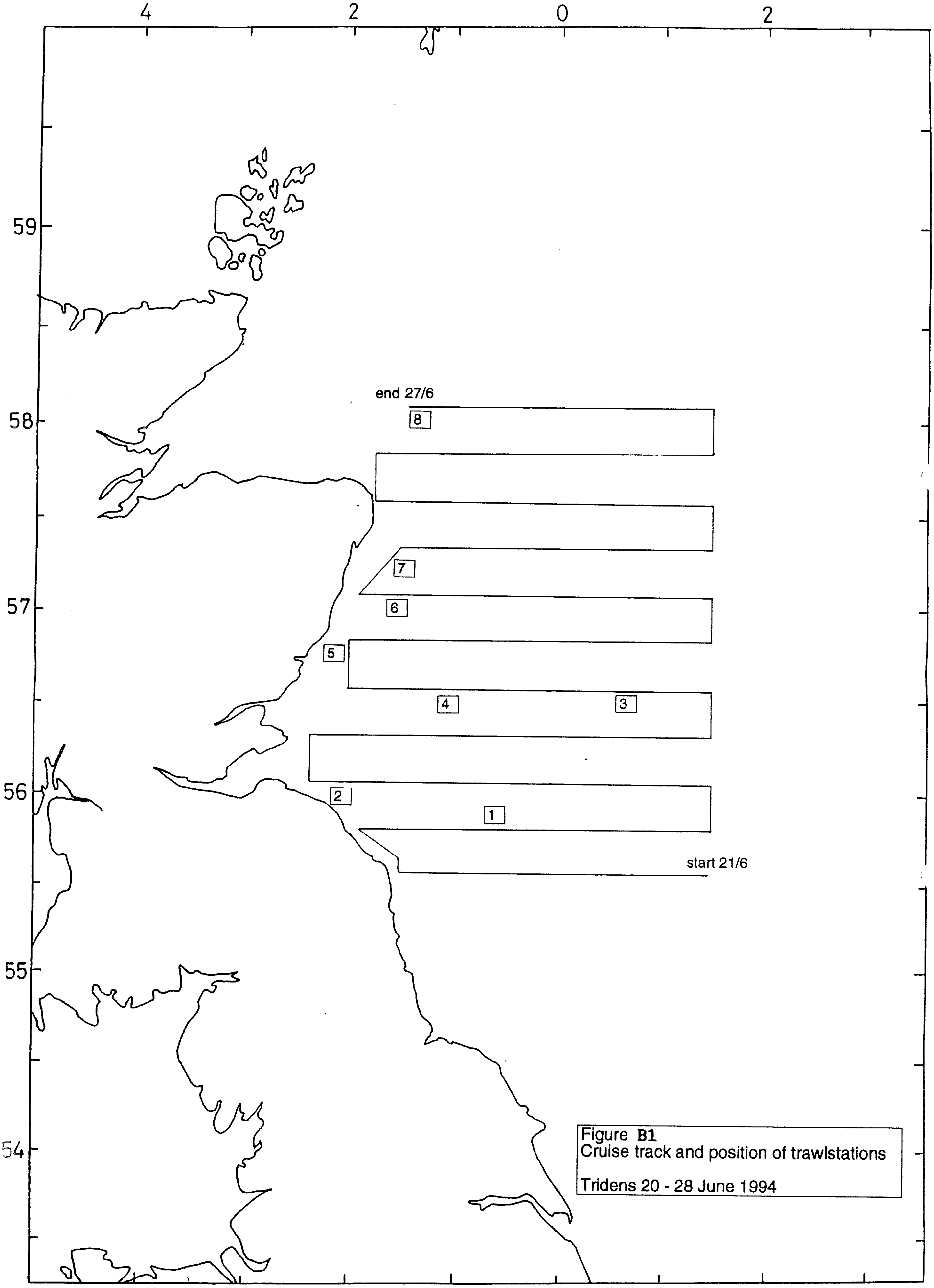


Figure **B1**
Cruise track and position of trawlstations

Tridens 20 - 28 June 1994

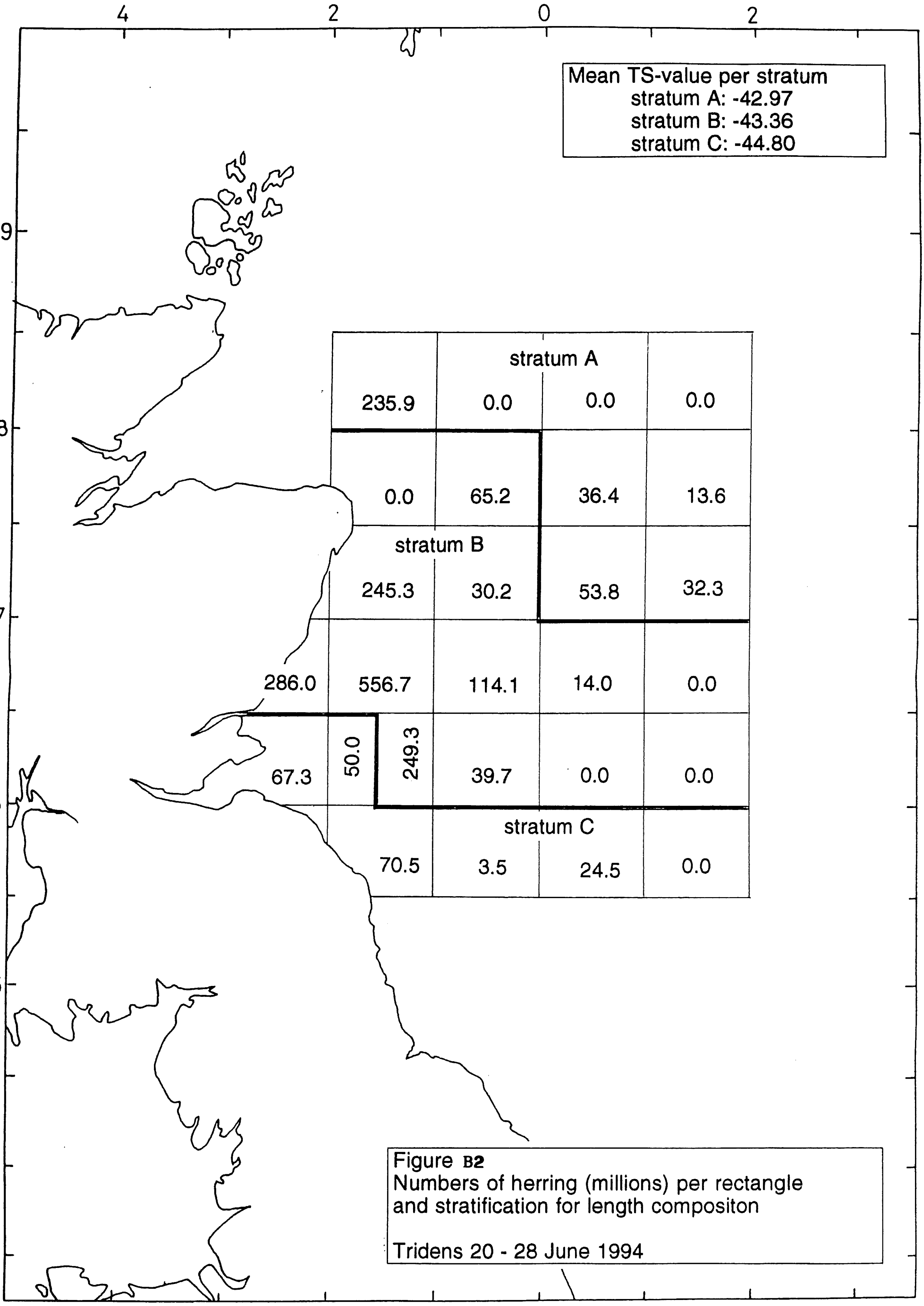


Figure B2
Numbers of herring (millions) per rectangle and stratification for length compositon

Tridens 20 - 28 June 1994

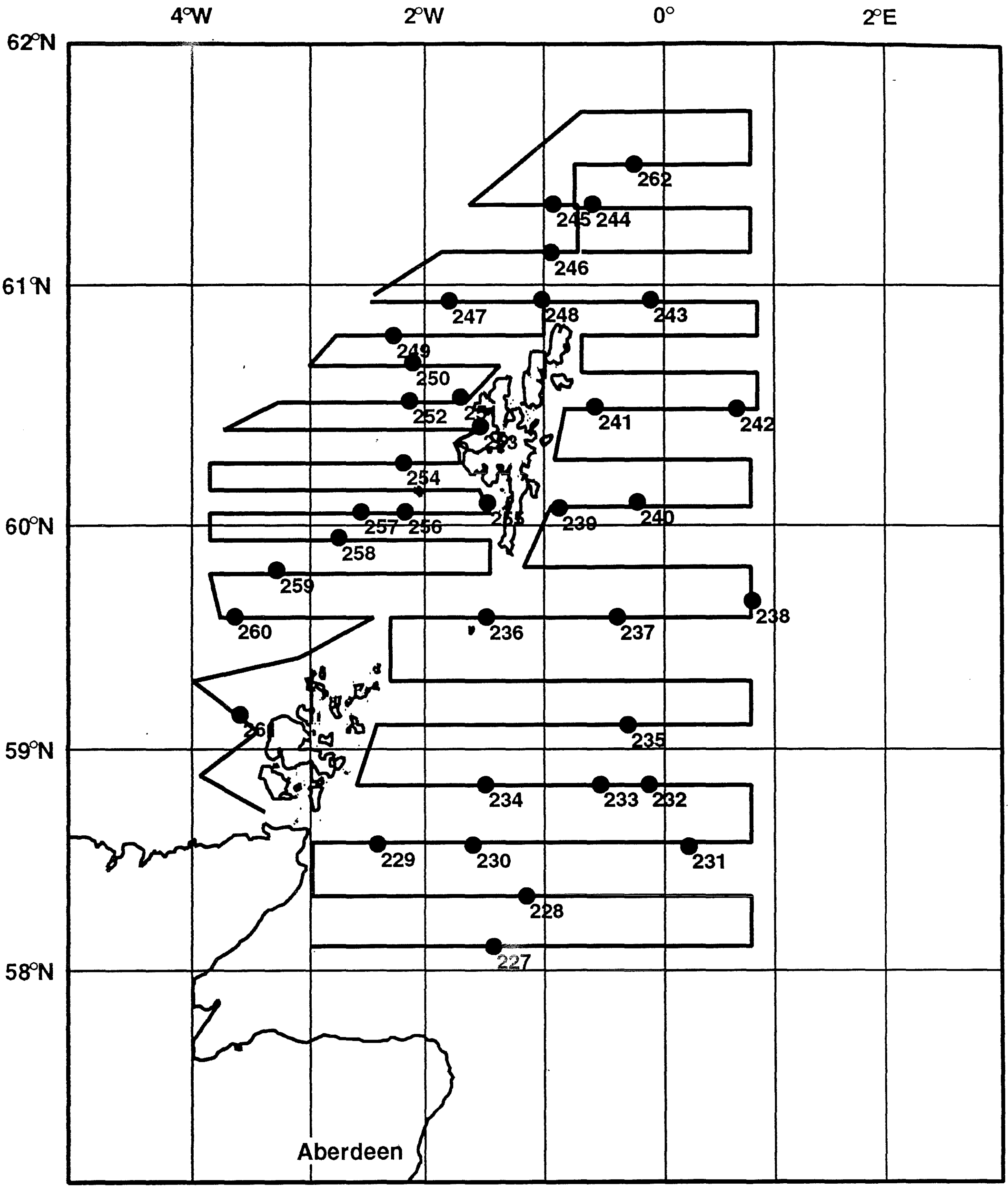


Figure C1. Cruise track and trawl haul positions. *Scotia*, 6-26 July 1994.

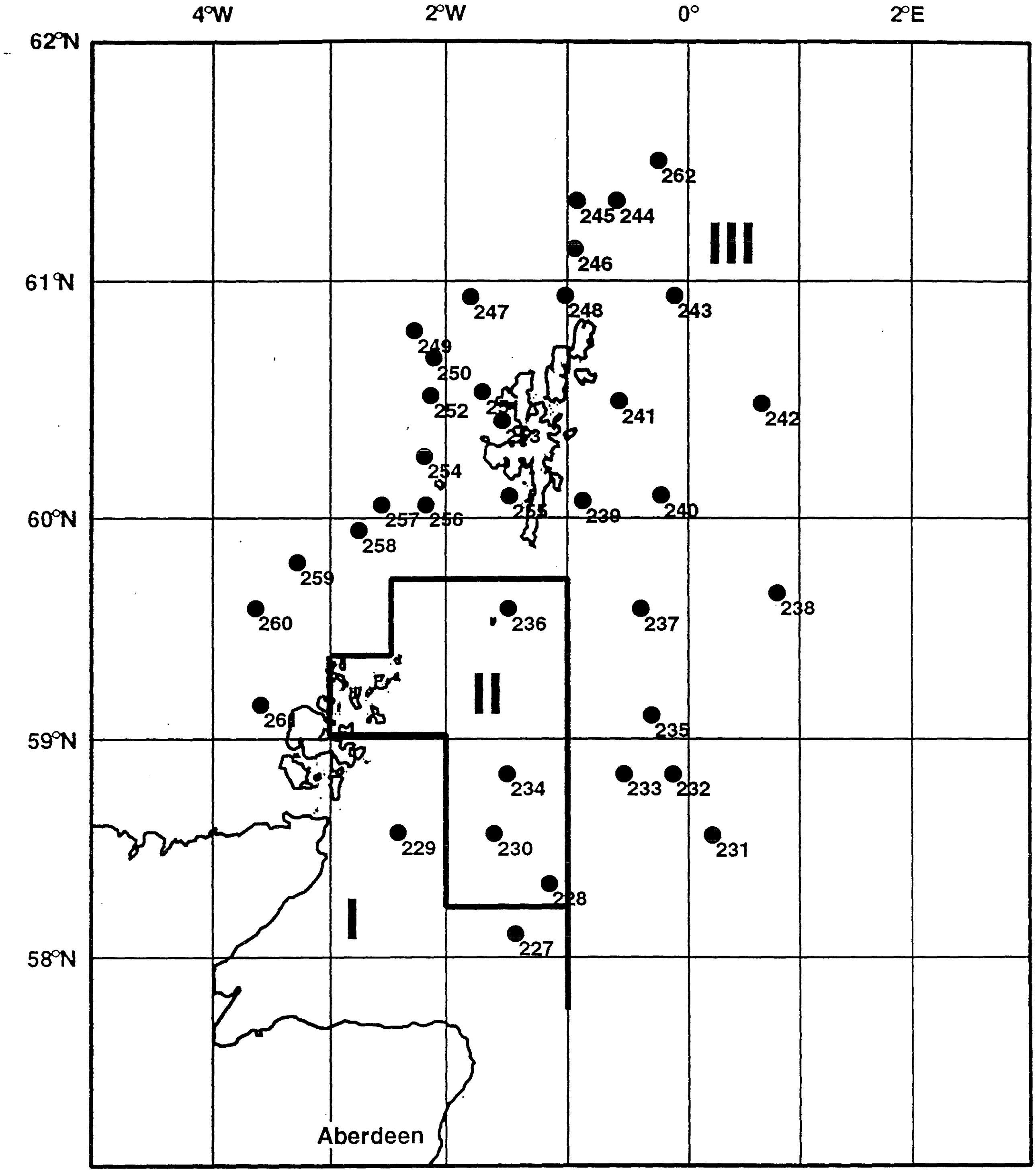


Figure C2. Haul positions and area subdivisions. *Scotia*, 6-26 July 1994.

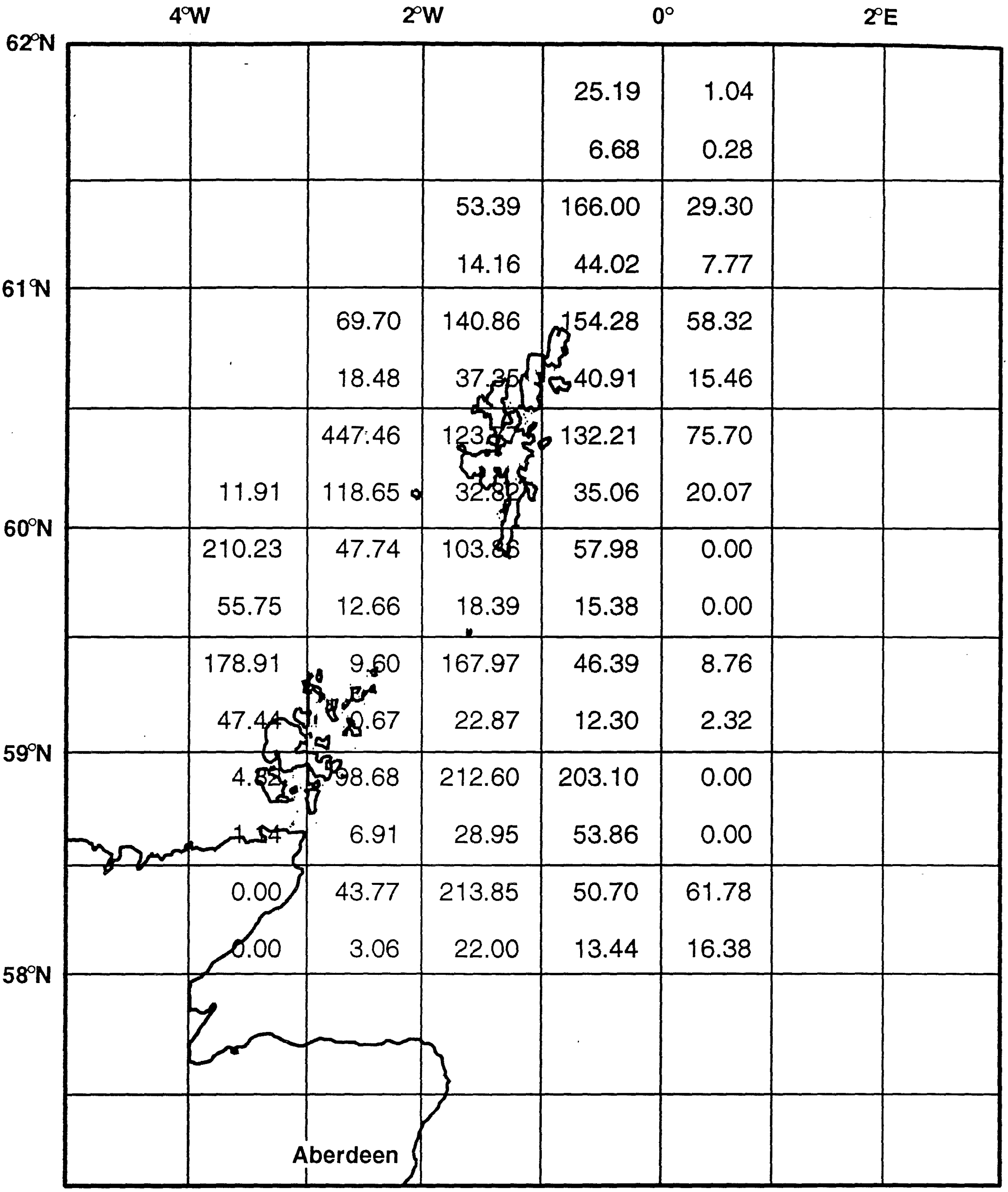


Figure C3. Herring numbers (millions) and herring biomass (thousand tonnes). *Scotia*, 6-26 July 1994.

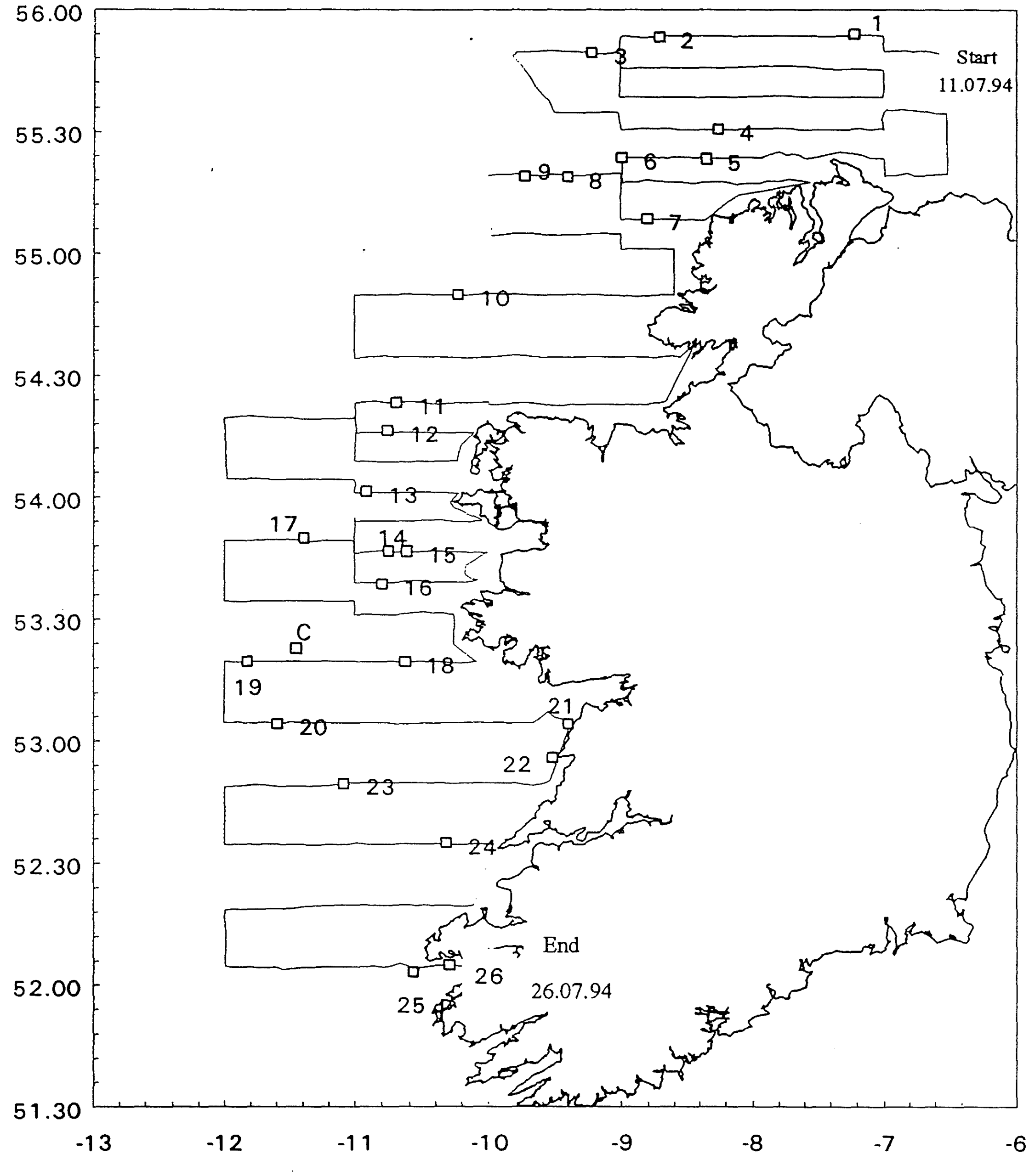


Figure D1. Map of the western approaches of the Atlantic Ocean, showing cruise track and positions of fishing trawls (C = commercial trawls). *Lough Foyle*, 11-26 July 1994.

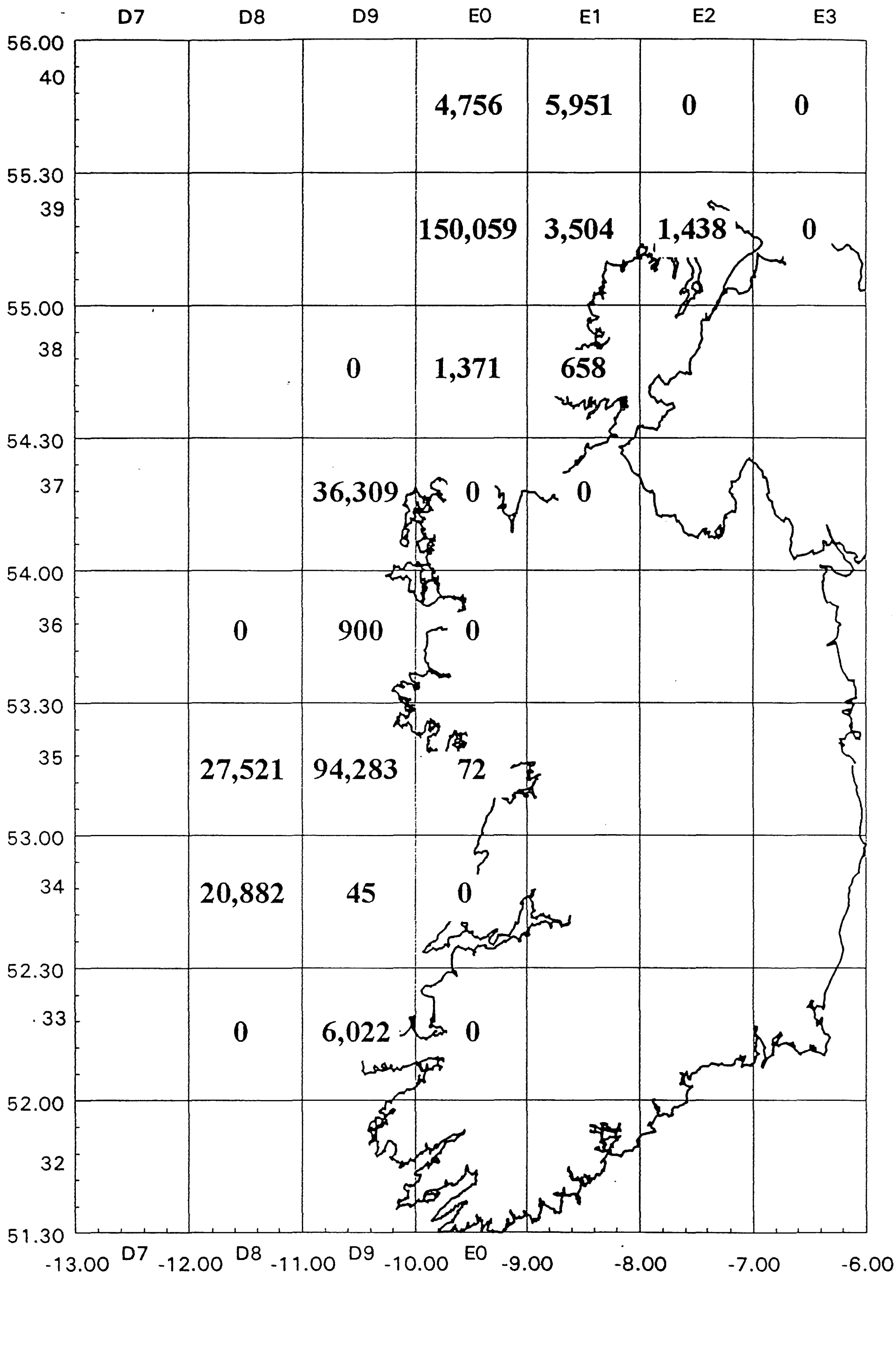


Figure D2. Estimates of probable herring biomass (tonnes) by ICES statistical rectangle. *Lough Foyle*, 11-26 July 1994.

Figure E1

Survey Track: Kings Cross 9 - 29 July 1994

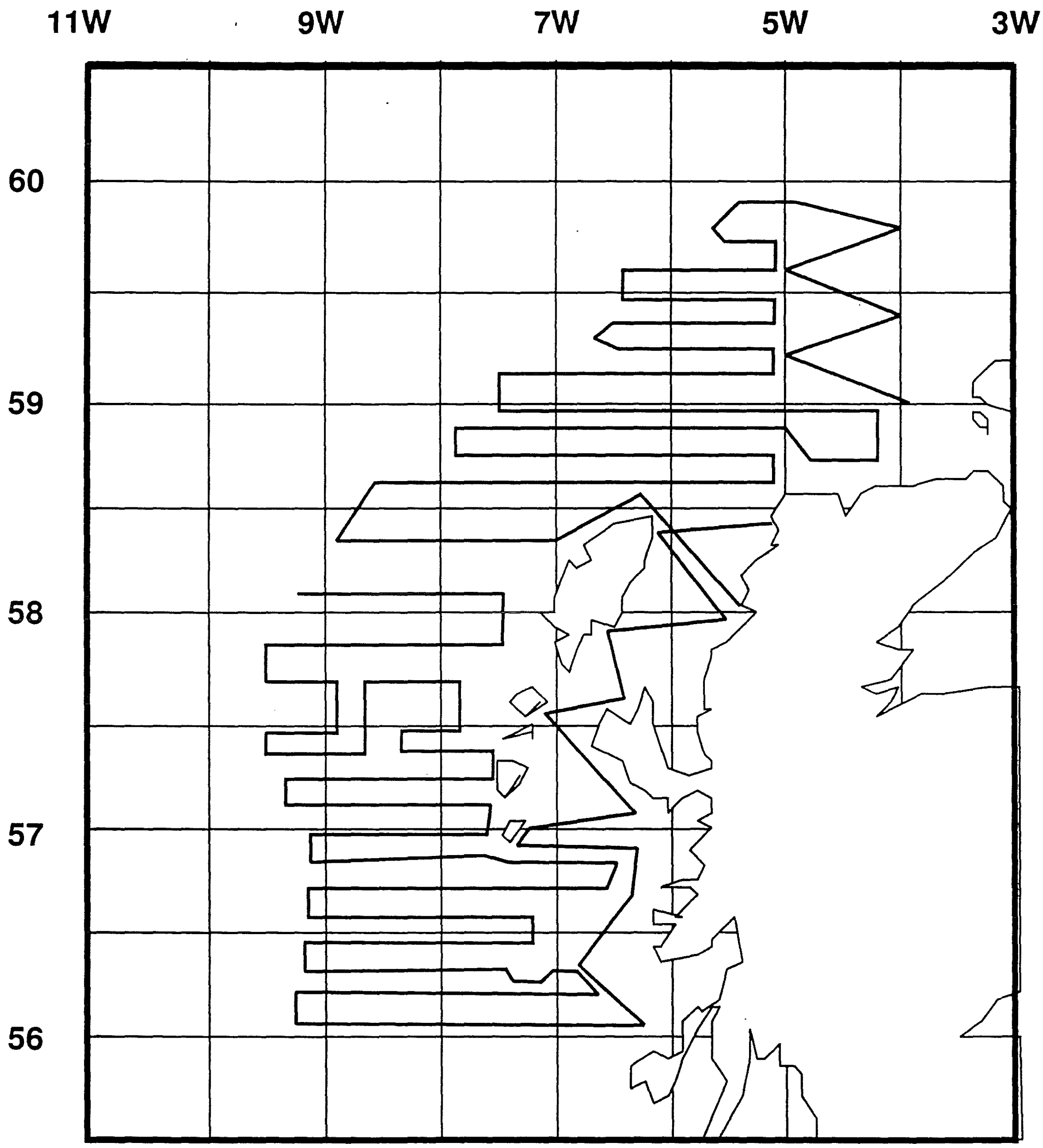


Figure E2

Haul positions and Area Sub-divisions

Kings Cross 9 - 29 July 1994

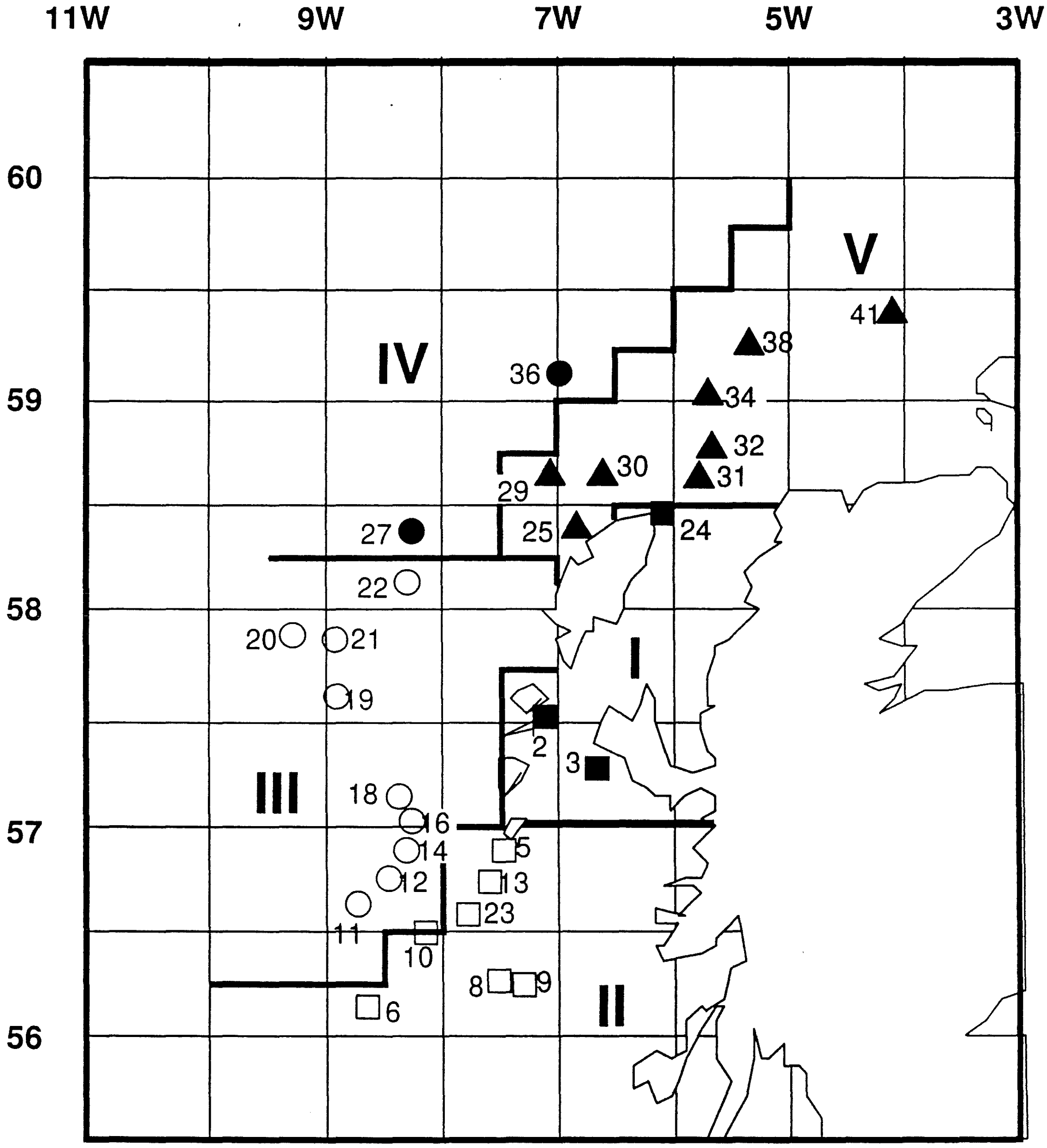
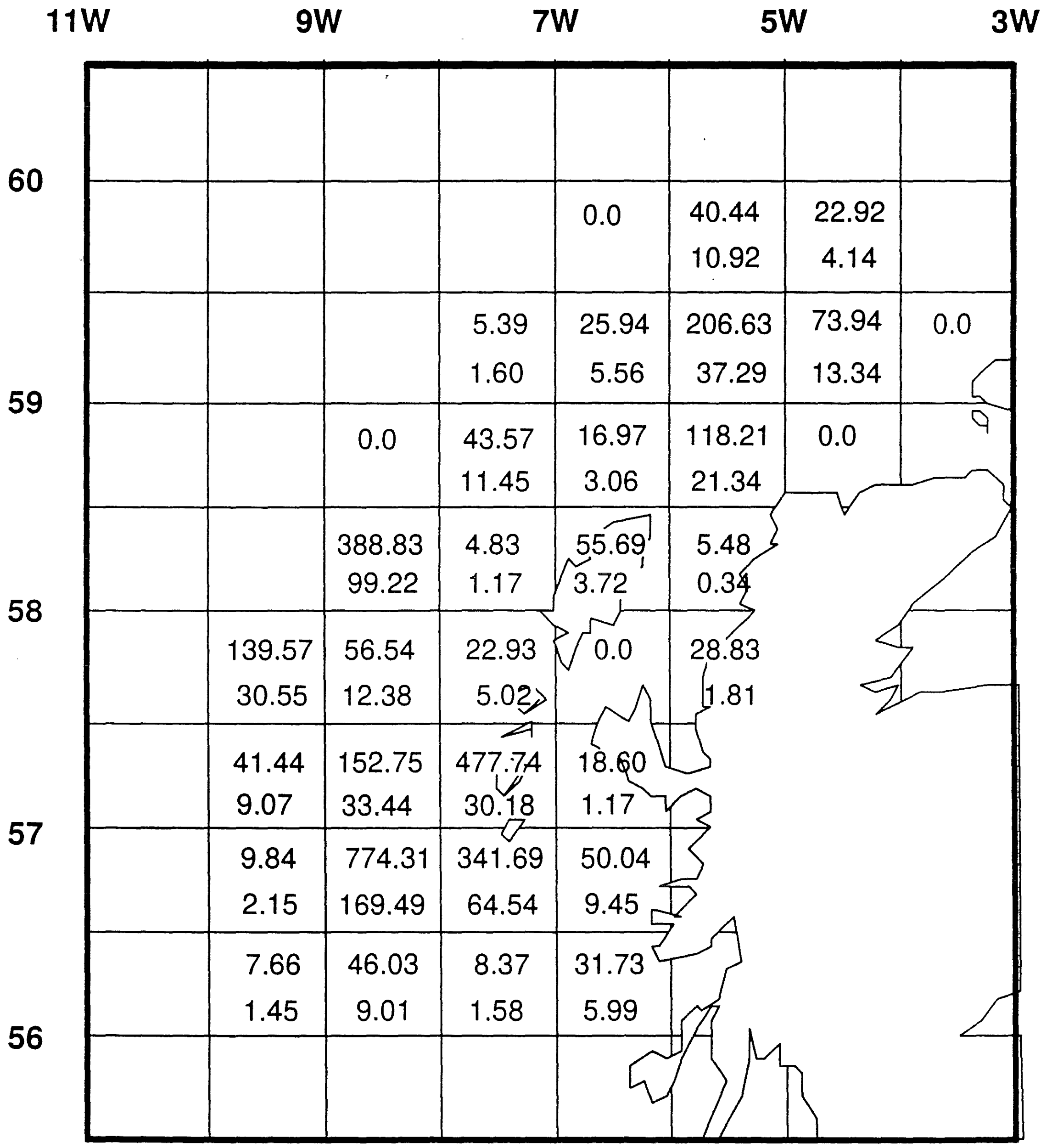


Figure E3

Herring numbers (millions) - top

Herring Biomass (thousand tonnes) - bottom

Kings Cross 9 - 29 July 1994



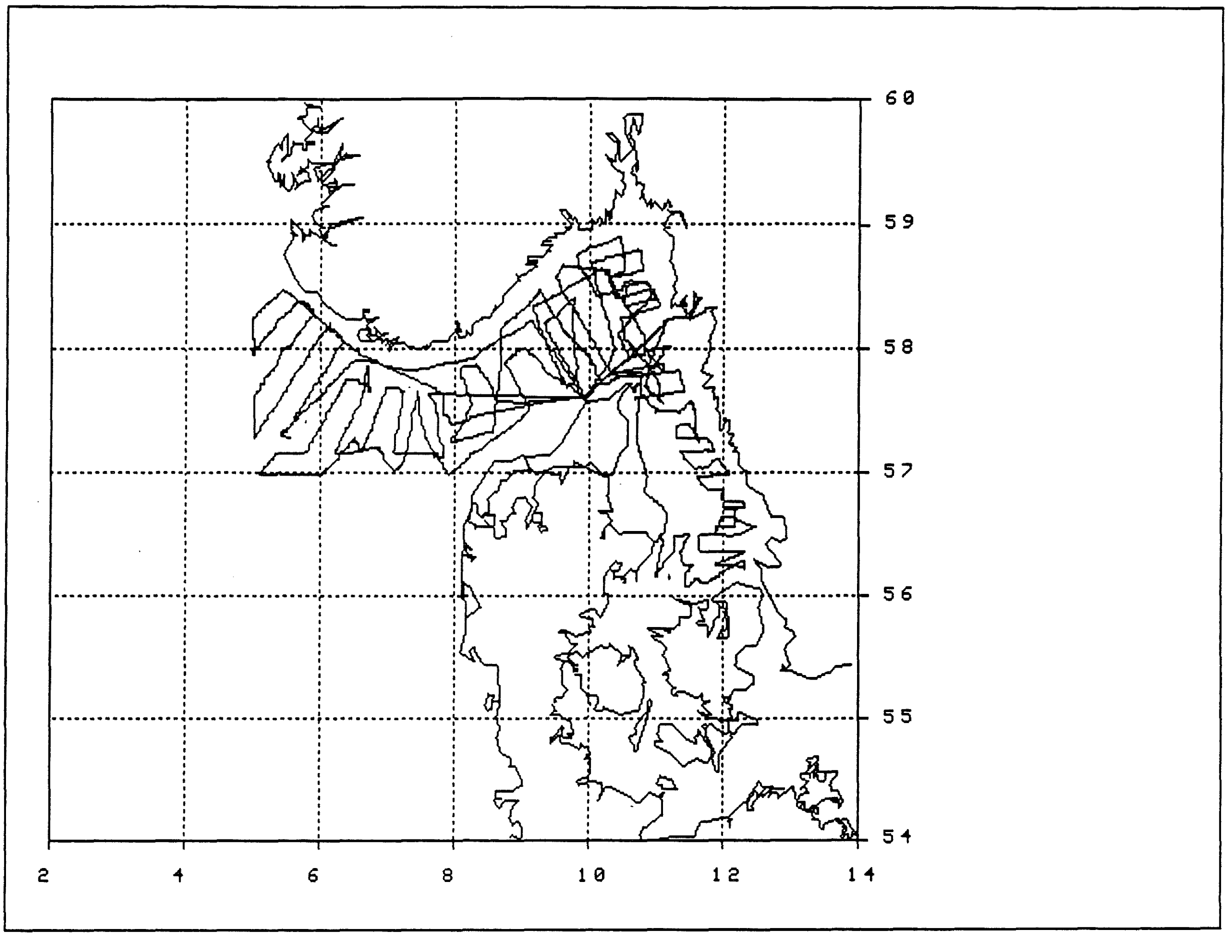


Figure F1. Cruise track R/V *Dana* 7-27 July 1994

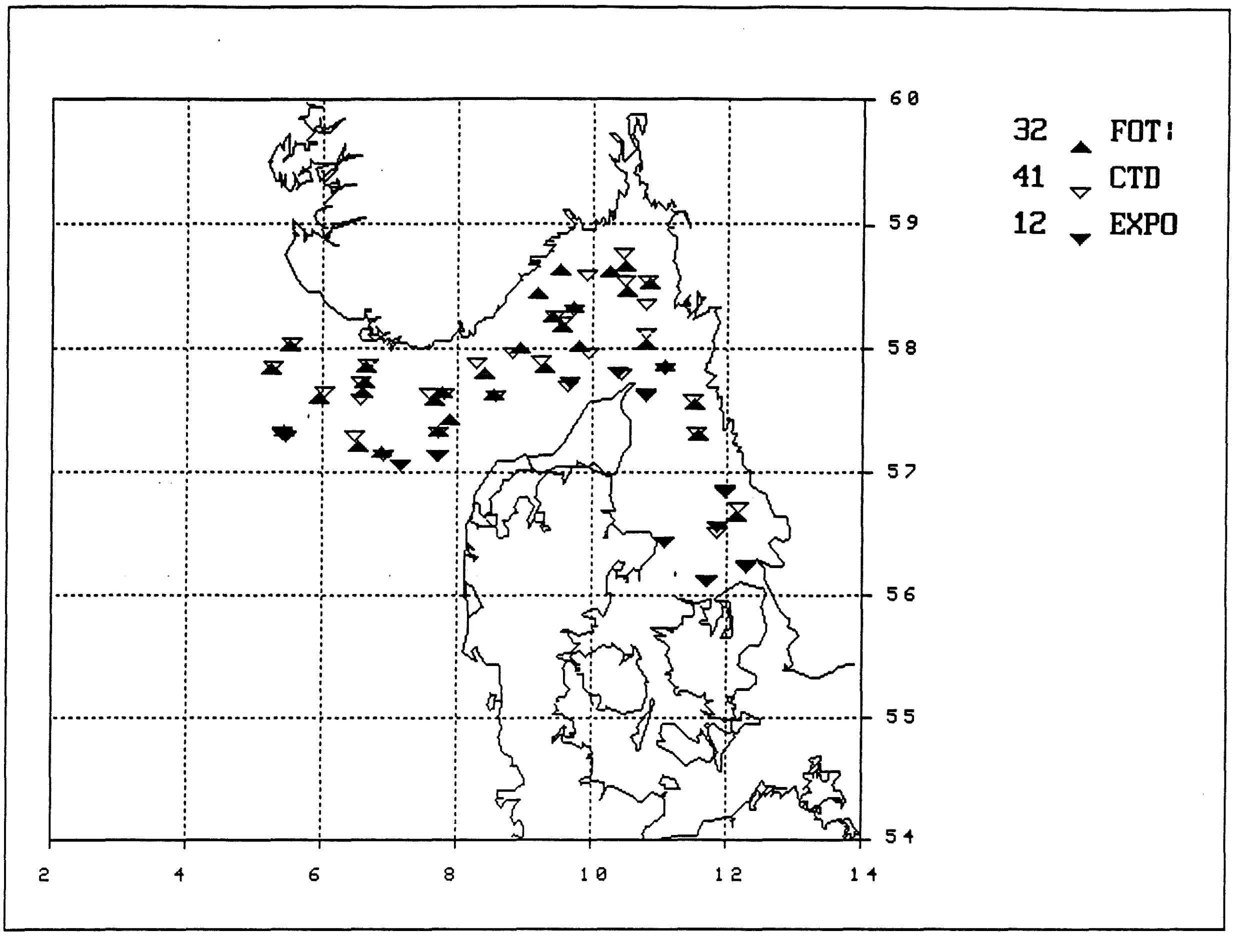


Figure F2. Trawl haul positions R/V *Dana* 7-27 July 1994

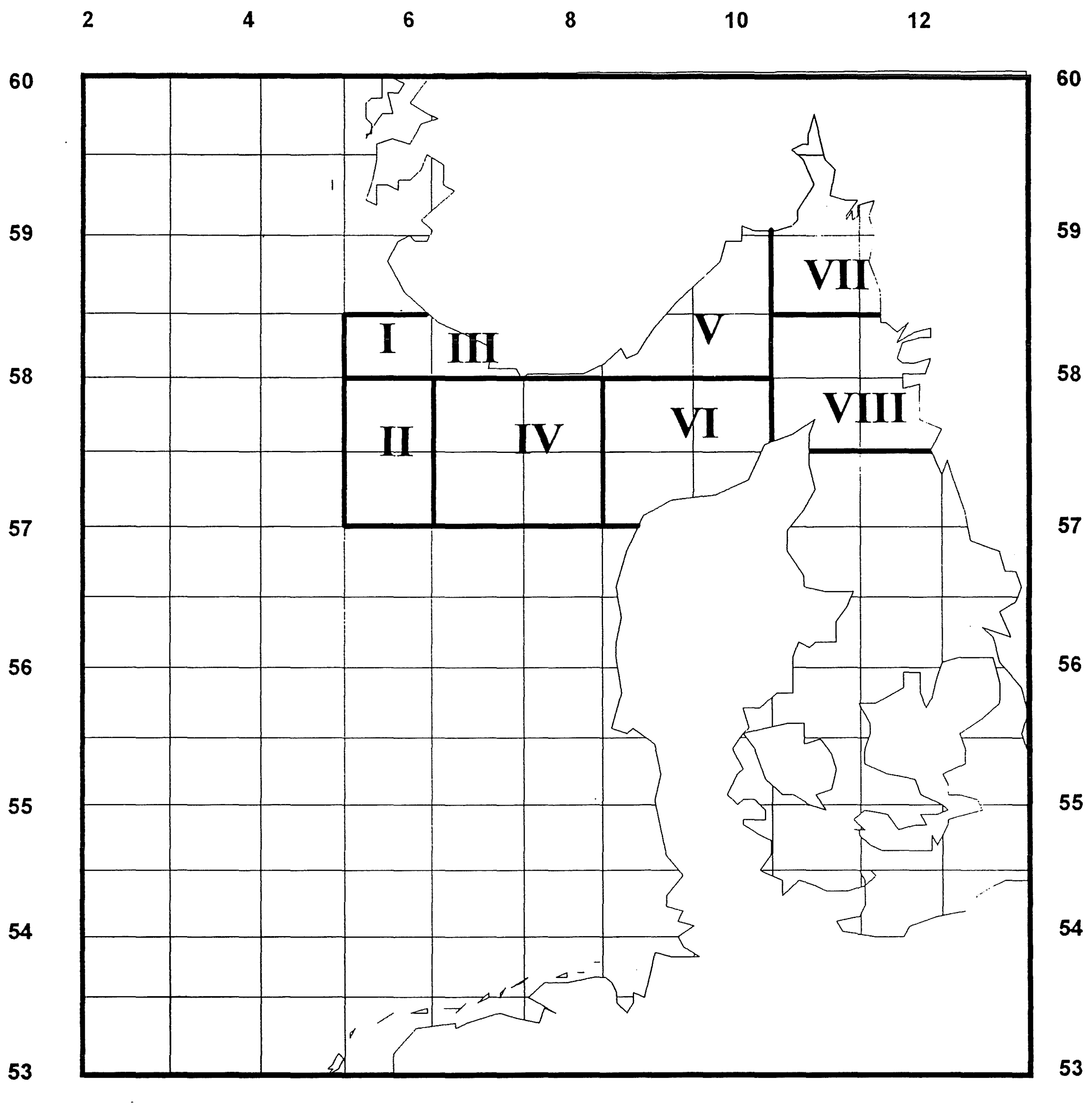


Figure F3. Area sub-divisions. *Dana*, 10-26 July 1994.

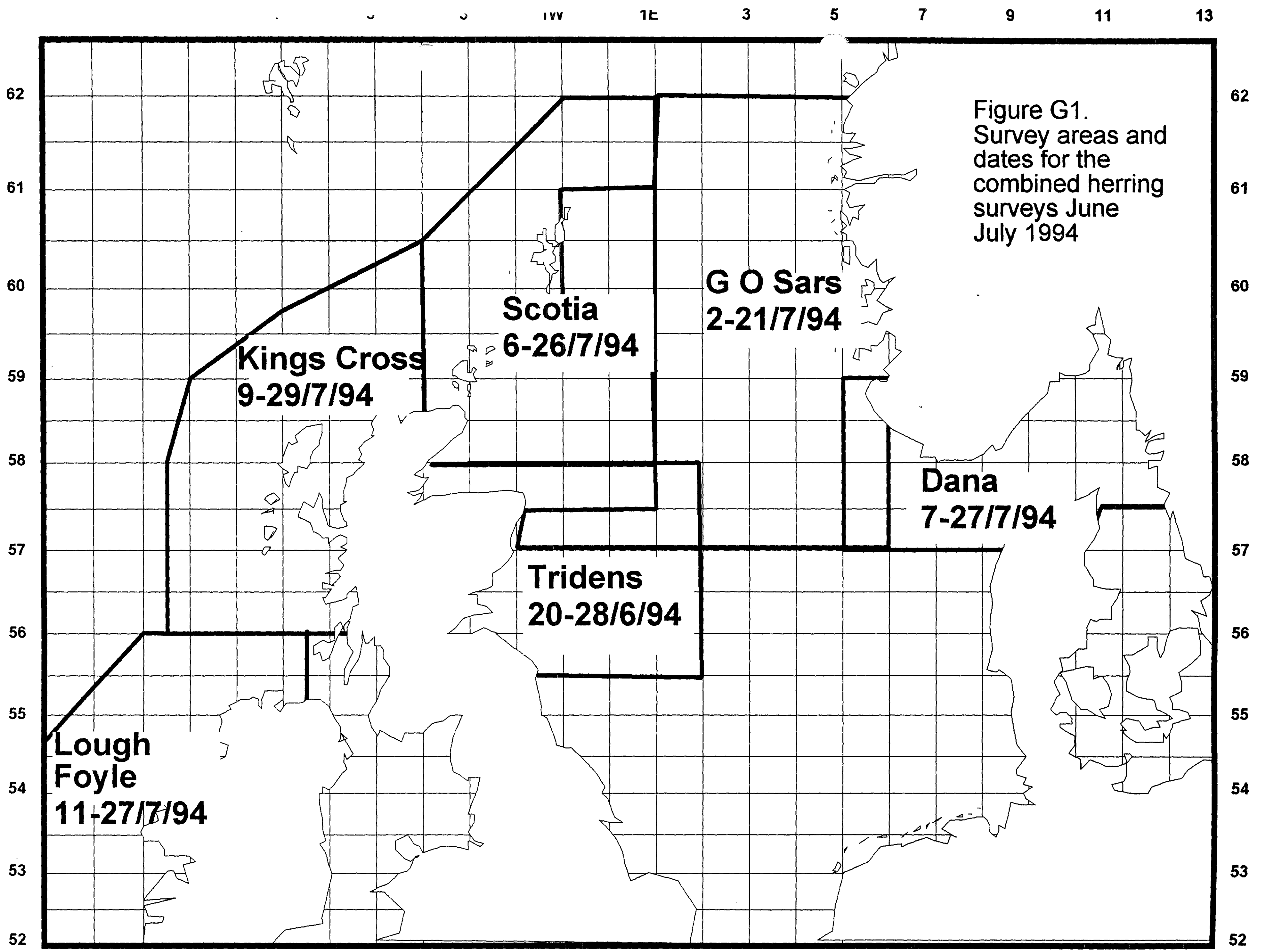


Figure G1.
Survey areas and dates for the combined herring surveys June July 1994

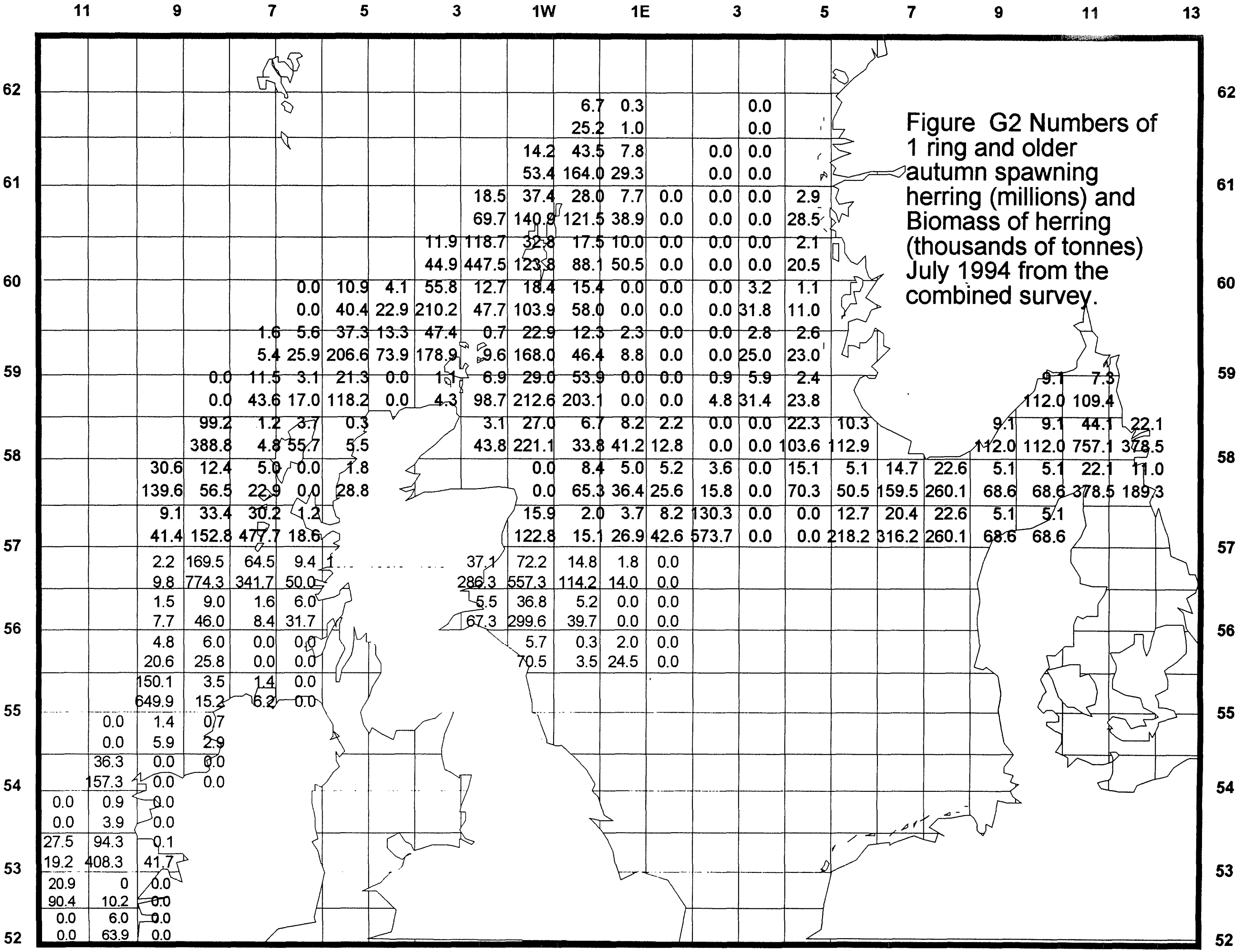


Figure G2 Numbers of 1 ring and older autumn spawning herring (millions) and Biomass of herring (thousands of tonnes) July 1994 from the combined survey.

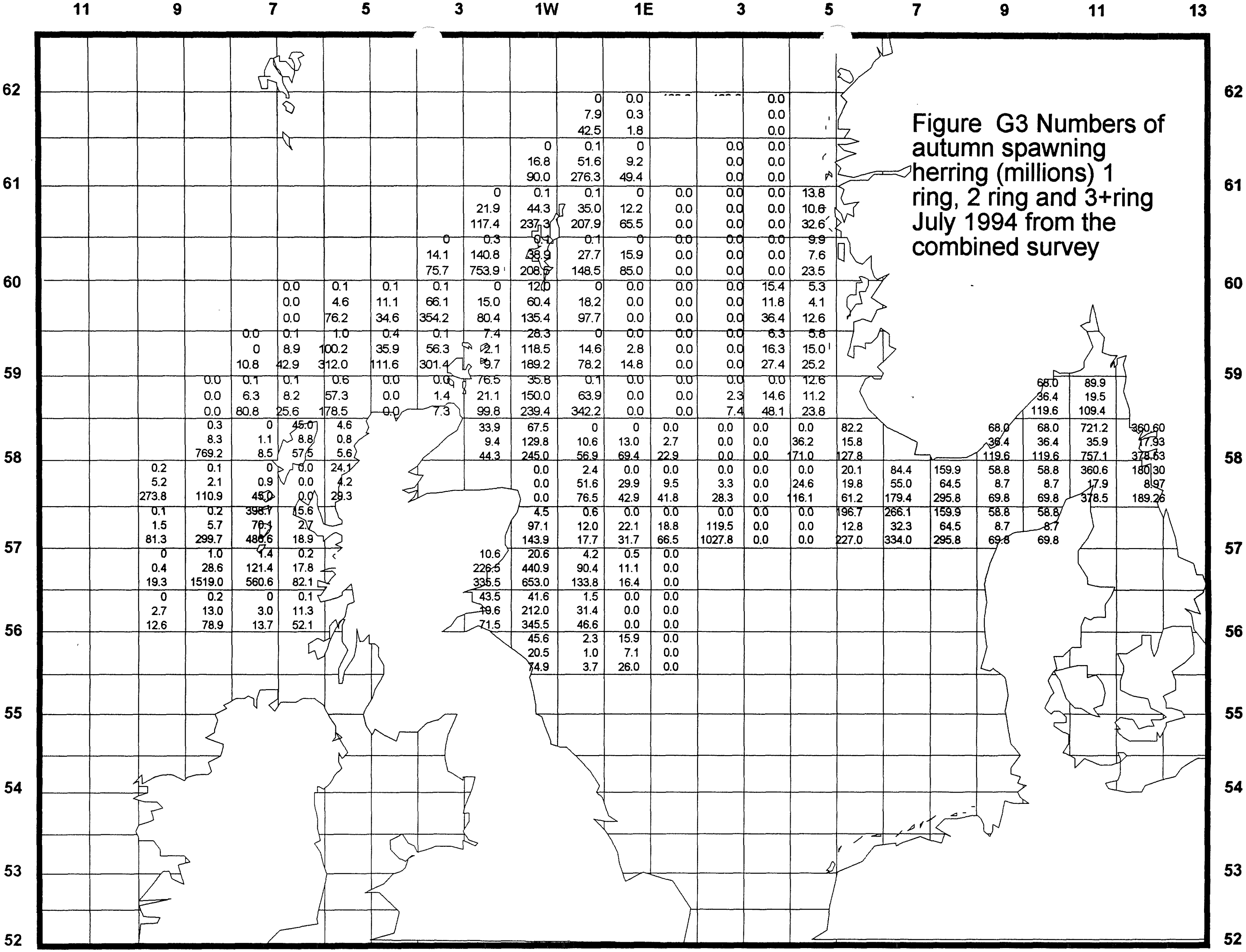
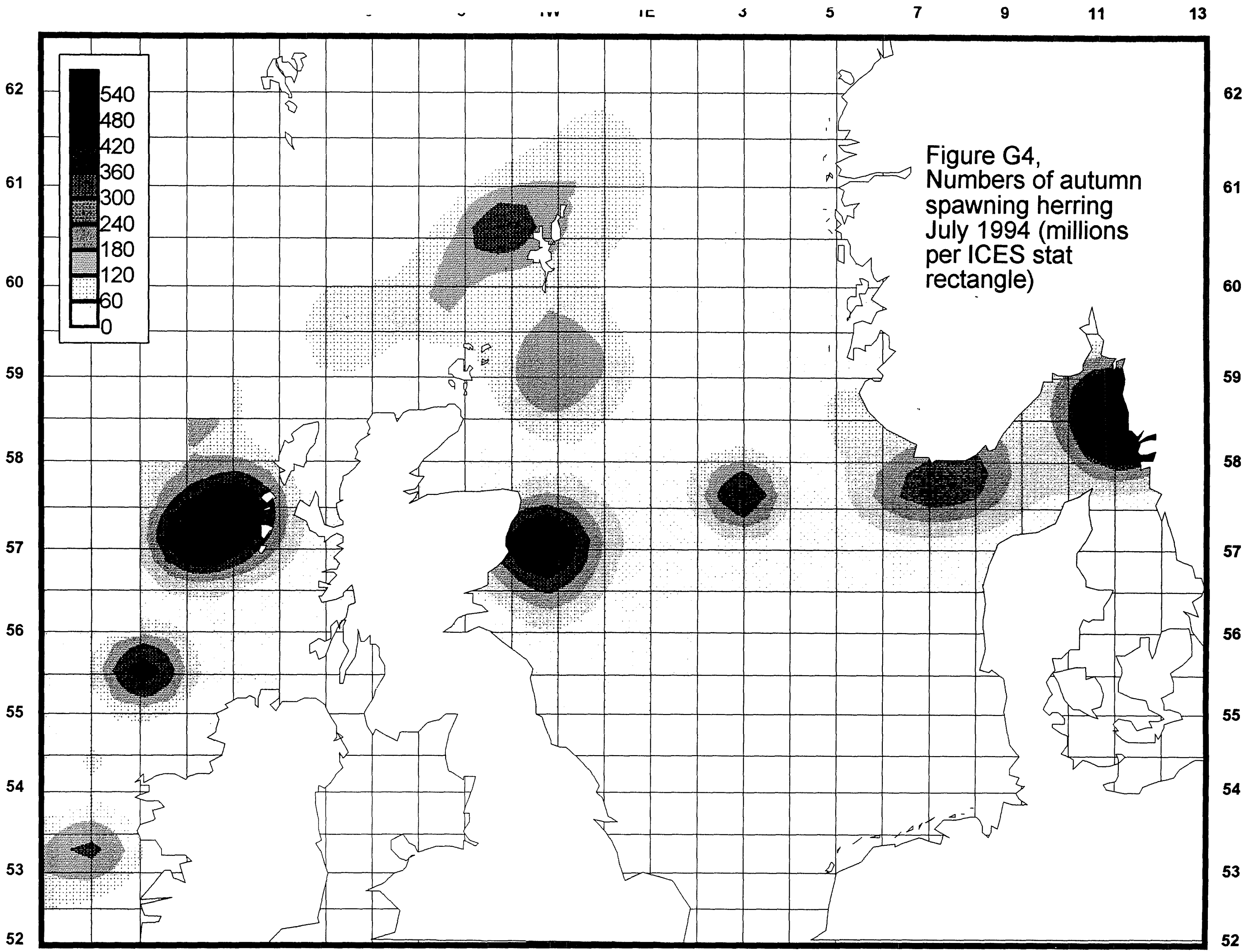


Figure G3 Numbers of autumn spawning herring (millions) 1 ring, 2 ring and 3+ring July 1994 from the combined survey


540
480
420
360
300
240
180
120
60
0
Figure G4,
Numbers of autumn
spawning herring
July 1994 (millions
per ICES stat
rectangle)
5
7
9
11
13
62
61
60
59
58
57
56
55
54
53
52

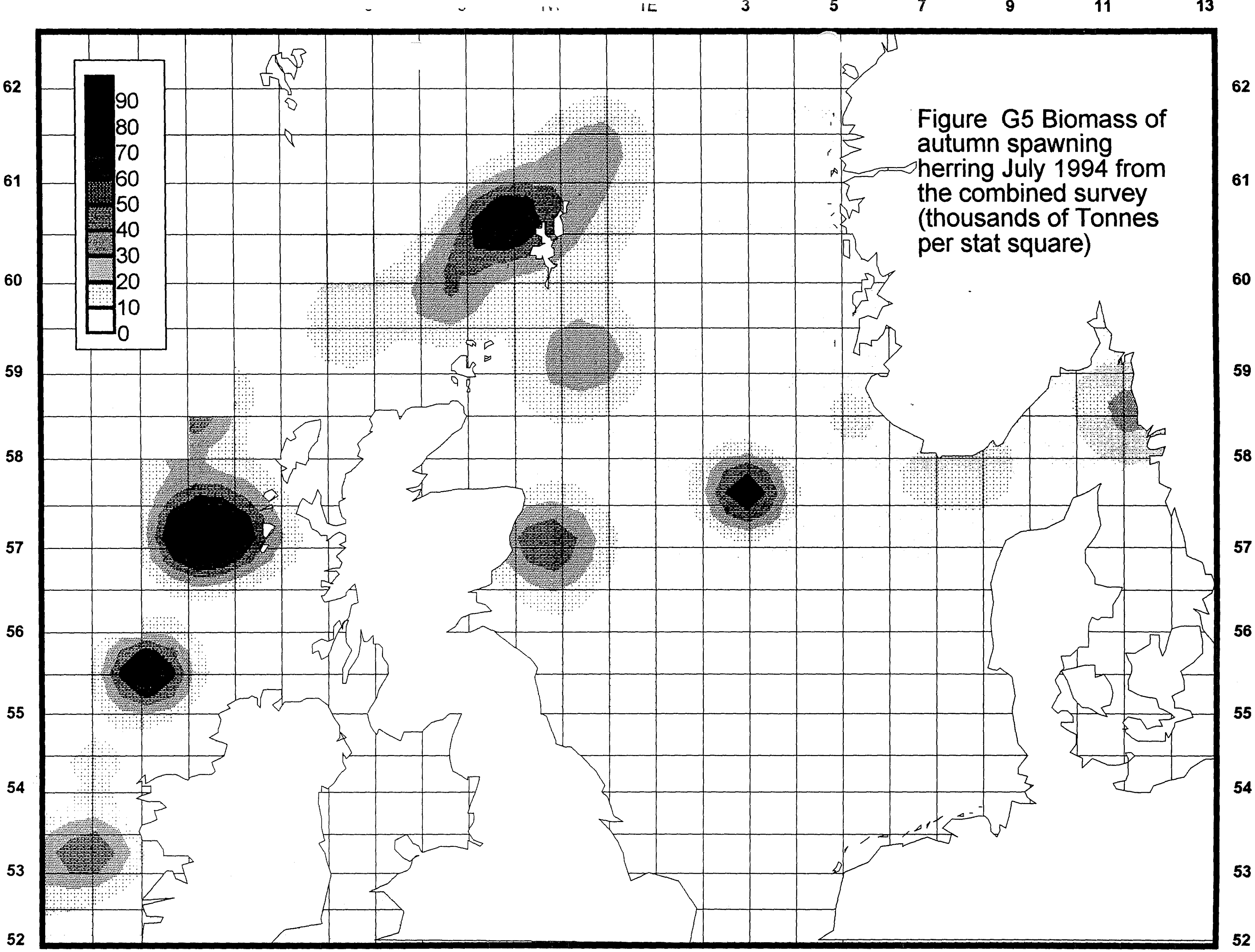


Figure G5 Biomass of autumn spawning herring July 1994 from the combined survey (thousands of Tonnes per stat square)

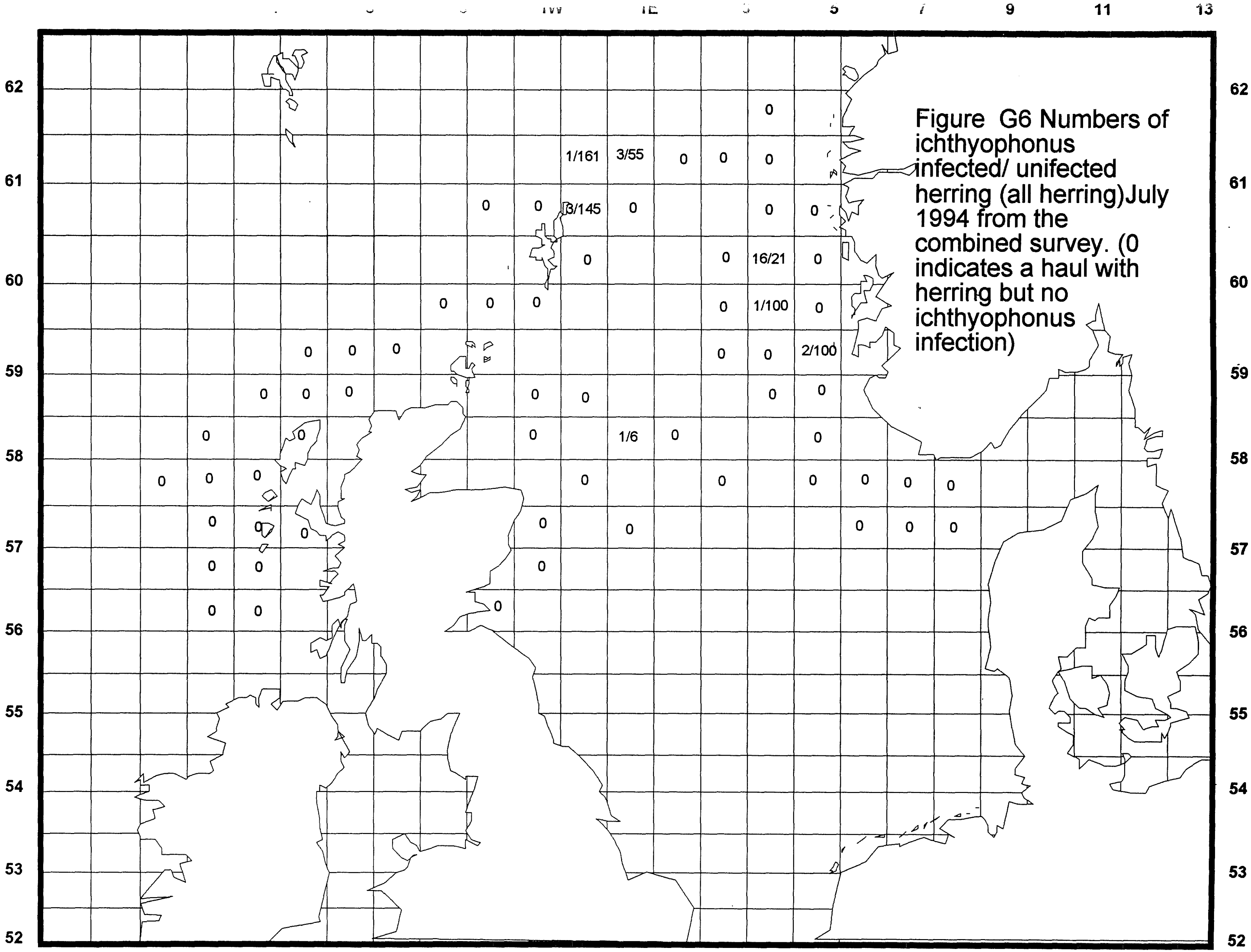


Figure G6 Numbers of ichthyophonus infected/ unifected herring (all herring)July 1994 from the combined survey. (0 indicates a haul with herring but no ichthyophonus infection)