CM 1981/H:5
Pelagic Fish Committee

REPORT OF THE PLANNING GROUP ON ICES-COORDINATED HERRING AND SPRAT ACOUSTIC SURVEYS

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Summary

This report summarises the results of a meeting held at Aberdeen, UK from 25 - 27 February 1981. Recommendations are made to use standard metal spheres for calibration and to report results with reference to the same target strength values.

The 1980 herring survey showed significant inter-ship variation which could not be totally accounted for. In view of the additional doubt about target strength, the results are of little use for assessment purposes. Plans for the 1981 survey in July - August are described and recommendations are made for increased trawling to identify echotraces, for standardisation for the procedure for partitioning the echo volume into its component species and for determining the variance of the estimates obtained.

An evaluation is given of the 1980 coordinated sprat survey and results for each country participating are expressed with reference to a target strength of -29dB/kg. Plans for future sprat surveys are listed.

Résumé

Ce rapport présente un résumé des résultats d'une séame qui a eu lieu à Aberdeen au Royaume-Uni du 25 jusqu'au 27 février, 1981. On recommande l'emploi des sphères métalliques calibrees pour l'étalonnage et pour que les résultats soient rapportés par comparaison avec les mêmes valeurs de réflection du cible. L'enquête par ultra-sons sur les harengs, fait en 1980 a montré des variations significatives entre les différentes navires qu'on n'a pas pu expliquer entièrement. En consideration de l'incertitude additionelle à l'égard des valeurs de réflection du cible, les résultats aeront peu utiles à des fins d'évaluation. On décrit le programme pour l'étude de 1981 en juillet - août et on recommande un redoublement du chalutage pour l'identification des enregistrements, pour l'unification de la méthode, pour la séparation de l'écho intégral en ses éléments constituants et pour déterminer le désaccord entre les estimations obtenues.

On présente une évaluation de l'enquête co-ordonnée de 1980 sur les sprats et on exprime les résultats pour chaque pays participant par comparison avec une valeur de réflection du cible de -29dB/kg. On fait une liste des plans pour les enquêtes futures sur les sprats.

1. Terms of Reference and Participants

At its 1980 meeting, the Council passed a resolution (C. Res. 1980/2:24) that 'in view of the need to prepare stock size estimates from acoustic surveys of sprat/herring in the North Sea, coordinated surveys for sprat should be carried out in January - February and autumn 1981 and a coordinated survey for herring in July - August 1981. A meeting of biologists and acoustic experts should take place in Aberdeen for 3 days in early 1981 (Convener: Dr R S Bailey) to:

(i) evaluate the methodology and results of the surveys carried out in previous years;

(ii) plan and coordinate the three 1981 surveys. Reports on them should be submitted to the 1981 Statutory Meeting by Dr R S Bailey (herring) and Dr P O Johnson (sprat).'

In accordance with this resolution, a meeting was held at the Marine Laboratory, Aberdeen, UK from 25 - 27 February 1981. The following participated:-

R S Bailey (Chairman)	UK
A Corten	The Netherlands
N Diner	France
H Dornheim	Federal Republic of Germany
J I Edwards	UK
K G Foote	Norway
G Freytag	Federal Republic of Germany
S A Iversen	Norway
P O Johnson	UK
D MacLennan	UK
J Masse	France
A Maucorps	France
B J Robinson	UK
E J Simmonds	UK

2. Acoustic Methods

2.1. Calibration of Acoustic Equipment

Comparison of acoustic survey results by different vessels can be facilitated by adoption of a common calibration method. Review of current practice and requirements for accuracy suggest the advantage of calibration against a solid metal sphere. Suitable spheres will be provided by the Institute of Marine Research in Norway before the summer 1981 surveys.

These spheres will be calibrated with a 38 kHz $\pm$ 100 Hz centre frequency, a 0.6 ms $\pm$ 24 μs transmit pulse length and a 3 kHz $\pm$ 100 Hz system bandwidth. Acoustic surveys should therefore be conducted with these equipment parameters. If required this type of target can be recalibrated for use with different equipment.

2.2. Target Strength Values of Herring and Sprat

The only data currently available on the target strength of herring are from Nakken and Olsen (1977), Edwards (1979) and K G Foote (unpublished data). From these data the best estimate of the target strength of a 27 cm, 170 g herring is -31 dB/kg. There is evidence that the back-scattering cross-section of individuals has a quadratic length dependence (target strength proportional to 20 $\log_{10} L_{(cm)}$). It is suggested that this relationship be combined with the length-weight regression found at the time of the survey in order to determine the target strength for individuals of a different length and weight. This estimate of target strength is for free swimming fish at the surface. It is possible that a lower value may be appropriate for a survey in order to take into account possible reductions in target strength due to depth changes or disturbance of the fish by survey vessels.

There is very little information on the target strength of sprat. The only published data are those of Nakken and Olsen (1977) for sprats of length 7 to 18 cm, which indicate a value of -29 dB/kg. In the absence of data for smaller sprat it is recommended that a single value of -29 dB/kg be used for this survey.

It is anticipated that further experimental data on the target strength of live herring and sprat will be available by the time the reports on the 1981 herring and sprat surveys have to be prepared, and it may then be appropriate to adopt different target strengths as the reference levels for these species.

2.3. Research in Progress

2.3.1. Calibration of Acoustic Survey Equipment

Work is in progress in Aberdeen and Bergen on the predictability and stability of solid reference targets and on suitable target suspension systems for use at sea. A facility has been constructed at Aberdeen for accurate measurements of transducer equivalent beam angles.

2.3.2. Fish Target Strength

Aberdeen

Target strength data on caged herring of length 19 - 28 cm await analysis. Further cage experiments with herring of different size groups and sprats are planned for 1981.

Lowestoft

In situ target strength data on sprat of mean lengths 7 cm and 12½ cm await analysis. Further in situ experiments on herring and sprats are planned. Attempts will also be made to measure the in situ target strength of sprats whilst the ship is steaming, thereby investigating any change in target strength due to avoidance of the vessel by the fish.

Norway

Target strength measurements on caged and stunned 27 cm herring are under analysis.

3. Herring Surveys

3.1. Evaluation of 1980 survey

A report on the 1980 acoustic survey in the Orkney - Shetland region was presented to the 1980 Statutory Meeting (Bailey et al., 1980). In this report, the tentative conclusion was that the total biomass of herring in the Orkney - Shetland area was not likely to have been higher than 150 - 200 000 tonnes, on the assumption of a target strength of -34 dB/kg. In Section 2.2, some justification is given to indicate that the target strength of herring measured under artificial conditions may be higher than -34 dB/kg. If the suggested new value of -31 dB/kg is used to interpret the 1980 survey, then the estimate of herring biomass would need to be halved to 75 - 100 000 tonnes.

3.1.1. Sources of Error in the 1980 Estimate

The area to the south of Shetland and around Orkney was surveyed independently by all four ships participating in 1980. Comparable results obtained by three of the ships showed that estimates of herring biomass for each statistical rectangle surveyed were extremely variable. For the rectangles shown in Figure 1 the results for each ship are given in Table I.

The methods of echotrace analysis for each ship are described in the report to the 1980 Statutory Meeting (Bailey et al., 1980), but for convenience they are stated briefly below.

G O SARS

Integrator values in eight depth channels were allocated to four categories (herring, bottom fish (ie less than 20 m from the sea bed), other fish and plankton) by two different methods. In the first herring traces were distinguished by a combination of their appearance and the results of trawl hauls. In the second, the densities of herring and bottom fish combined (identified by their echotrace appearance) were subdivided into their components solely on the composition of trawl catches in the appropriate area. In both cases, densities of herring were calculated using length dependent and length independent target strength values, but only the latter are reported here for comparison with results from other ships. The values using both methods of trace allocation are given in Table I.

THALASSA

An estimate of total fish biomass was made for each statistical rectangle assuming that all fish species have a TS of -34 dB/kg. Trawling by THALASSA provided insufficient evidence to allocate the estimates to species, and this was done using trawl haul data from the other ships and by examination of the echotraces. In addition to the estimates reported by Bailey et al. (1980), estimates have since been made based only on the results of trawl haul data, first using pelagic trawl hauls only, and second using both pelagic and bottom trawl haul data. The three estimates are given in Table I.

EXPLORER

The proportion of echo integrator readings attributable to herring was estimated in two ways. In the first, the contribution of distinct plume traces was calculated and the entire value allocated to herring. Second, other fish traces within 30 m of the sea bed were allocated from the mean percentage of herring in pelagic trawl hauls in the respective statistical rectangle. The estimates of herring biomass thus consisted of two components, that in plume traces and that in more dispersed traces.

The values obtained by EXPLORER were consistently higher than those obtained by the other vessels. To investigate this further, data were examined on the integrated values allocated to 'all fish'. The results for THALASSA and EXPLORER are given in Table II.

Possible reasons for the apparent differences between ships are:

(i) differences in calibration procedure;
(ii) different integrator threshold settings (which are dictated by ambient noise levels);
(iii) different times at which the vessels surveyed the same rectangle; and
(iv) differences in the techniques used to partition the contribution of different species.

It was not possible to decide which factor or factors were the most significant, but the key point is the observation that the calculations for EXPLORER and THALASSA surveying the same area were significantly different, by more than a factor of 2 in the case of total fish biomass, and by a larger factor after species partitioning had been done.

It is also noted that uncertainty in the average target strength value to be applied could amount to a factor of 2 in an estimate of the absolute herring biomass based on the 1980 results. The combined uncertainty from the several sources of error listed above is therefore large, to the extent that an absolute estimate of herring biomass based on the 1980 acoustic survey will be of little

use for stock management purposes. On the other hand, the results will be of use for comparison with the results of surveys in future years; that is to say the confidence in relative stock changes indicated by comparable surveys in successive years is rather more optimistic.

3.2. Plans for the 1981 Survey

As in 1980 the Planning Group agreed that the 1981 survey should be confined to the Orkney - Shetland area.

3.2.1. Availability of Ships

Country	Vessel	Cruise period (port - port)
France	THALASSA(*)	17 July - 6 August
The Netherlands	TRIDENS	27 July - 8 August
Norway	G O SARS	13 - 29 July
UK (Scotland)	SCOTIA	12 August - 1 September

*The participation of THALASSA is subject to refit and re-equipment after the fire which destroyed her bridge. The Planning Group would like to stress the importance of the participation of another French vessel in the event of THALASSA not being available.

3.2.2. Survey Area

The area to be surveyed has been divided into eastern and western parts. The proposed allocation of each vessel to these areas is given in the text table below. Dates given are approximate and correspond to presence in the area.

	Western Area	Eastern Area
G O SARS	14 - 27 July	
THALASSA	21 July .....2 August	
TRIDENS		29 July - 6 August
SCOTIA	12 August - ..... 1 September	

THALASSA is expected to begin her survey in the western area where parallel tracks will be carried out with G O SARS (see 3.3). After completion of this, THALASSA will proceed to the eastern area for her main survey and will operate with TRIDENS in the same way as with G O SARS. The area surveyed by SCOTIA during the early part of the spawning season will be defined mainly in relation to the distribution of small herring larvae over the past 10 years. Alterations to these plans may be made in the light of information from commercial fishermen. Even if herring concentrations are reported, however, other areas should not be neglected because they may contain a significant proportion of the total herring biomass at a lower density.

3.2.3. Communications

Prior to and during the survey, information from commercial fishermen should be sent to R S Bailey who will pass it to research vessels working in the survey area. Vessels planning to work together should establish contact at 2000 hours GMT on 2056 kHz.

When leaving the survey area or as soon as possible after completion of the survey, vessels should give locations of major concentrations, ship tracks and other relevant information to R S Bailey who will report to the ICES Statutory Meeting.

3.3. Special Requirements for the 1981 Survey

3.3.1. Increased Trawling using Appropriate Gears

The accuracy of the survey depends entirely on the ability of participants to identify the various shoals they come across. In the area and period under investigation, herring shoals seem to be moving so fast that it requires specialised gear and considerable experience to catch them. This difficulty in the surveys has perhaps been underrated so far. Ships participating in the survey should either be capable of catching herring with a reasonable degree of efficiency themselves, or else acquire the assistance of other vessels. For the 1981 survey, it is proposed that TRIDENS works in the near vicinity of THALASSA and fishes on any major echotraces that the latter ship is unable to identify.

As a general guide ships should make at least four trawl hauls per day in areas where fish shoals are abundant.

3.3.2. Standard Procedure for Partitioning Total Echo Volume into Fish and Plankton

The echoes from plankton layers are often similar in amplitude to those from individual fish. It is not possible, therefore, to sift out fish traces from the plankton by setting a certain threshold level on the echo integrator. The only basis on which fish can be distinguished from plankton is the appearance of the echotraces, fish usually occurring in discrete shoals, and plankton in extended scattering layers. Thus, only the stepwise increments of the integrator values are considered as representing fish. Obviously, this classification is to some extent subjective, and care should be taken that operators on different ships use the same criteria for distinguishing between plankton and fish. This could be achieved by having each ship work side by side with another vessel for a period of at least 12 hours. During this exercise both ships should make sure firstly that their instruments measure the same echo integral at different depth intervals, and secondly that they both ascribe the same proportion of the echo integral to fish species.

3.3.3. Splitting Fish Echo Integral by Species

Even with an increase in the number of trawl hauls, it will not be possible to obtain a positive identification of each individual echotrace, and some arbitrary classification will have to be done for the unidentified traces. This classification will be based on a comparison of the trace with other positively identified traces in the same area during the same survey or from previous surveys. It is essential that people on different ships making this classification use the same judgement. It is therefore essential that these people have an opportunity to meet during the survey or immediately afterwards, in order to compare their recordings and to make sure they have used the same criteria for classification of shoals to species.

3.3.4. Estimates of Variance on the Acoustic Estimate

The variance of the acoustic estimate will depend on the patchiness of the shoal distribution and on the density of the survey grid. An impression of the variance obtained with a 10 mile grid could be obtained by having two ships work such a grid simultaneously in the same area. Such an experiment could be done very well by THALASSA and TRIDENS, since these two ships are supposed to work in each other's vicinity. By shifting one vessel's grid 5 miles relative to the other one, the ships could work close together and still arrive at two independent estimates of acoustic biomass.

3.3.5. Day Versus Night Surveys

There is a general impression that herring shoals disperse during the night, and are difficult to distinguish from plankton at that time. In order to avoid a possible underestimation of herring abundance at this time of day, it is recommended that this problem be investigated by making repeat transects during light and darkness.

3.4. Biological Data

Length and maturity compositions of herring caught during the 1980 survey were tabulated in the report submitted to the 1980 Statutory Meeting. Age compositions, not available at that time, are summarised in Table III, which gives, for each ship participating, the percentage age composition excluding spring spawners (identified from maturity or otolith characteristics), the total weight of catch from which the samples were taken, and the number of otoliths on which the figures are based. Samples from THALASSA were excluded because of the small size of the catches which did not permit the calculation of a representative age composition.

All the surveys show the predominance of the 1976 year-class (3-ringers).

4. Sprat Surveys

4.1. Evaluation of the 1980 Survey

The first ICES-coordinated sprat survey in the North Sea was carried out in January 1980 by vessels from Norway, England and Scotland. The results, submitted in a report to the 1980 Statutory Meeting (Johnson, 1980), indicated that there had been a pronounced change in the winter distribution of sprats compared with previous years, most of the sprat population occurring in the eastern half of the central North Sea surveyed by the Norwegian research vessel.

At the 1980 Statutory Meeting some criticism was expressed about the difference between target strength values used by the participants to arrive at sprat biomass estimates. These estimates, together with recalculated estimates standardised to a target strength of -29 dB/kg, as advocated in Section 2.2 of this report, are tabulated below:

Survey	Area	Target Strength Value		Biomass estimates ($t \times 10^3$)	
				Reported value	Standardised to -29 dB/kg
Norway	Entire North Sea	1-group	-33 dB/kg*	660.1	300
		≥2-group	-36 dB/kg*	349.9	80
England	N E English Coast	all ages	-29 dB/kg	6.2	6.2
Scotland	Scottish & N E English coast	all ages	-34 dB/kg	20.5	7.0

*Norwegian values based on a length-dependent target strength relationship:

$$TS = 20 \log \ell - 75 \text{ dB}$$

or

$$TS/kg = -10 \log \ell - 25 \text{ dB}$$

where ℓ is length of fish in cm.

These equations are modifications of those given by Aglen & Iversen (1980).

An intercalibration carried out between the English and Norwegian vessels was not entirely satisfactory because it was in an area where sprats were at low density. Nevertheless, the limited results obtained indicate that the two systems were yielding comparable results (Johnson, 1980). As the surveys did not cover the same areas, no further comparison of the results is possible. The planning group therefore confined their discussion to a review of methods used in each country and to an evaluation of the possible sources of error in the estimates with a view to identifying areas in which improved techniques are required. Uncertainty in the target strength of sprats is dealt with in Section 2.2. and is not considered further here. The time allocated to the meeting was unfortunately insufficient to evaluate the results of the autumn sprat recruitment surveys.

4.1.1. Review of Methods

The acoustic apparatus employed by each country, together with calibration techniques, target strength values used, and fish sampling gear employed are given in Table IV.

4.1.2. Identification of Echotraces

Identification of the species composition of the echotraces on the sprat surveys is normally carried out by mid-water trawl sampling during the survey. Supplementary information has sometimes been obtained from the catches of commercial fishing vessels when these were operating within the survey area. In areas where the target species is not predominant the species composition has to be determined from the relative proportion of each species by weight in the trawl samples. Mid-water trawl catches, however, can be biassed in terms of both species and length composition. This is particularly so for small fish, such as 0-group sprats (< 7 cm), the majority of which can escape through the main meshes of the trawls used, but whose presence is shown by those entering the fine mesh cod-end, and by those often found hanging on the larger meshes after hauling. Biasses can also be due to the depth at which the trawl is towed, particularly where vertical stratification by species and/or size within a species is found. The speed at which the net is towed may also influence the size of fish caught.

Smaller planktonic organisms, such as larval fish or euphausiids may also pass relatively unrepresented through the trawl meshes, and these may contribute towards acoustic back-scatter as background 'biological noise'. When discrete pelagic shoals of fish are present, these may be separated from this source of noise by using the integrator analogue output on which shoals register as clearly defined 'steps' in the record. This has not generally posed a problem on the winter sprat surveys except on occasions in the eastern North Sea during November.

A suggestion that an Isaac-Kidd mid-water trawl might be used to provide samples of the smallest fish, particularly 0-group sprat was considered, but there would still be the problem of determining whether this gear provided a representative estimate of the relative proportions of small and large sprat, since it may not catch larger fish efficiently. Despite these reservations about the representativeness of all trawling methods, it was generally agreed that increased sampling using conventional small mesh and Isaac-Kidd mid-water trawls to identify and partition species would be desirable. The use of chartered fishing vessels as a back-up to the research vessel effort would be one way of achieving this. Furthermore, to ensure uniformity of methods, intership calibrations should be carried out by integrating over the same track in areas of sprat concentrations.

4.1.3. Survey design

The total potential survey area between 51°30 - 59°30'N covers some 120 000 square nautical miles. Three research vessels are currently available, and typically 21 days survey time have been allocated for the Scottish and Norwegian ships, and 15

days for the English survey. In practice, with loss of time due to weather, fishing, calibrations etc, the effective ship days become reduced, the combined total amounting to about 48 days for the three vessels. The average effective survey speed is reduced to around $7\frac{1}{2}$ knots which results in approximately 180 nautical miles of survey track per day. The combined total survey track for all three vessels thus amounts to 8,460 nautical miles, which is equivalent to 14 square nautical miles for each nautical mile of track. This total track length would be roughly equivalent to a uniform grid of east - west legs spaced at 15 nautical mile intervals, to provide coast to coast cover over the whole area. In practice, the area is not surveyed uniformly owing to the patchy nature of the fish distribution and this could have an important effect on the sampling error of the surveys. It was agreed that a more even division of the total area between survey vessels would reduce errors from this source.

Two methods have been used to estimate total biomass from the survey tracks. These are:-

(1) Density contouring and raising by areas within density intervals.
(2) Raising by overall average densities within small sub-areas.

In general the two methods yield comparable results.

A problem has arisen on some surveys as a result of lack of accessibility for the research vessels into very shallow water areas where on occasion large sprat concentrations may develop. This situation usually arises in parts of the inner Moray Firth, Firth of Forth, Wash and Thames Estuary.

4.2. The 1981 Sprat Survey

The results of the 1981 survey, which took place in January, were not available at the meeting. It was therefore agreed that the results, worked up using a provisional target strength of -29 dB/kg for each 15 x 30 nautical mile rectangle, should be submitted to the ICES coordinator (Dr P O Johnson, Fisheries Laboratory, Lowestoft) by 15 April 1981 to enable him to compile a report for the 1981 Herring Assessment Working Group and the 1981 Statutory Meeting later in the year.

4.3. Future Surveys

It was agreed that the winter surveys should be continued using a provisional target strength of -29 dB/kg until a better estimate becomes available, both from work in progress and experiments planned. This procedure would at least provide a relative measure of changes in stock abundance from year to year.

4.3.1. Plans for 1981/82 Surveys

Below are listed the surveys planned for the remainder of 1981 and the early part of 1982.

SCOTLAND
November 1981

Integrator and fishing recruitment survey for 0-group sprat off the east coast of Scotland and north-east coast of England.

January 1982

Integrator and fishing survey for sprat covering waters between the Moray Firth and Flamborough Head offshore to about 0° (ICES coordinated for North Sea sprat stock assessment).

NORWAY
November - December 1981

Sprat and herring integrator and fishing survey, probably Norwegian coast - Skagerak.

January 1982

Integrator and fishing survey for sprat within the North Sea concentrating on the eastern half of the Central North Sea, between 53°30' - 57°30'N. (ICES coordinated.)

ENGLAND
December 1981

An integrator and fishing survey for sprat nominally allocated to the North Sea but which may now be diverted to examine the western Channel stock situation in the Lyme Bay region.

January 1982

A further ICES coordinated survey for the North Sea covering the area south from Flamborough Head to North Foreland (54° N - 51°31'N).

SIMRAD QD integrators should be available for use on the Norwegian and English surveys, and for the latter a new ceramic transducer unit should be introduced.

5. References

Aglen, A. & Iversen, S.A.	1980	Distribution and abundance of sprat in the North Sea in winter 1979/80 determined by acoustic methods. ICES CM 1980/H:41, mimeo
Bailey, R.S., Aglen, A., Corten, A., Diner, N & Simmonds, J.	1980	Report on the ICES-coordinated acoustic survey of herring stocks in 1980. ICES CM 1980/H:24, pp 4, mimeo
Edwards, J.I.	1979	A preliminary investigation of the target strength of herring. ICES CM 1980/B:19, pp 9, mimeo
Johnson, P.O.	1980	Report on echo-integrator surveys for sprat undertaken in the North Sea during the 1979-80 winter season. ICES CM 1980/H:6, pp 9, mimeo
Nakken, O. & Olsen, K.	1977	Target strength measurements of fish. Rapp. p.-V. Reun. Cons. perm. int. Explor. Mer., 170 : 52 - 69.

TABLE I Herring biomass in thousand tonnes based on TS of -34dB/kg, and dates of survey in each rectangle

Statistical Rectangle (see Fig. 1)	Herring biomass						Dates		
	G O SARS (a)	(b)	THALASSA (c)	(d)	(e)	EXPLORER (f)	G O SARS	THALASSA	EXPLORER
1	0.6	0.7	-	-	-	15.3	24-28 July	-	11-17, 23 and 28 July
2	3.6	3.3	2.6	4.0	3.8	9.4	24-28 July	24-25 July	11 and 17-28 July
3	10.0	5.9	5.6	14.5	3.7	25.4	27-29 July	17-18 and 21-24 July	
4	-	-	0.0	5.9	1.3	1.4	-	23 July	20-22 July
5	5.2	2.8	-	-	-	5.8	25 and 29-31 July	-	10-11, 15-18 & 23, 28 July
6	-	-	0.7	0.1	0.1	0.7	-	16 July	10, 15-18 and 24 July
7	-	-	0.2	0.6	0.1	2.2	-	19 July	19-21 July
8	-	-				0.6	-	20 July	20-21 July

(a) Herring component allocated from appearance of echotraces and results of trawl hauls.
(b) Fish traces allocated to herring and other species from trawl haul data.
(c) Value published in Bailey et al. (1980) based on subjective allocation of traces supported by results of trawl hauls.
(d) Based solely on results of pelagic trawl haul data.
(e) Based on results of pelagic and bottom trawl haul data.
(f) Based on subjective allocation of plume traces and allocation of other fish traces using trawl haul data.

TABLE 7 Herring biomass in thousand tonnes based on [illegible], and dates of survey in each rectangle

Statistical Rectangle (see Fig. 1)	Herring biomass						Dates		
	G O SARS		THALASSA			EXPLORER	G O SARS	THALASSA	EXPLORER
	(a)	(b)	(c)	(d)	(e)	(f)			
1	0.6	0.7	-	-	-	13.7	24-28 July	-	11-12, 23 and 29 July
2	3.6	3.3	2.6	0.4	3.8	9.4	26-28 July	29-31 July	11 and 17-28 July
3	10.0	9.8	5.6	14.5	3.7	23.4	27-29 July	17-19 and 23 July	21-24 July
4	-	-	0.0	2.9	2.3	1.1	-		20-21 July
5	5.2	2.8	-	-	-	5.8	25 and 29-31 July	-	10-11, 14-16, 23, 28 July
6	-	-	0.7	1.0	0.1	0.7	-	15 July	10, 13-18 and 20 July
7	-	-	0.2	0.6	0.1	0.2	-	19 July	19-21 July
8	-	-				0.6	-	20 July	20-21 July

(a) Herring component allocated from appearance of echotraces and results of trawl hauls.
(b) Fish traces allocated as herring and other species from trawl haul data.
(c) Value published in Bailey et al. (1980) based on subjective allocation of traces supported by results of trawl hauls.
(d) Based solely on results of pelagic trawl haul data.
(e) Based on results of pelagic and bottom trawl haul data.
(f) Based on subjective allocation of plume traces and allocation of other fish traces after trawl haul data.

TABLE II Estimated biomass of all fish in thousand tonnes based on TS of -34dB/kg for all species in rectangles shown in Figure 1

Statistical Rectangle	EXPLORER	THALASSA
1	-	-
2	38.2	11.5
3	58.2	25.8
4	11.0	12.1
5	-	-
6	8.8	3.4
7	9.0	4.9
8	2.8	

TABLE III Age composition of herring in samples taken during the 1980 acoustic survey

	PERCENTAGE										
Year Class Age (winter rings)	77 2	76 3	75 4	74 5	73 6	72 7	71 8	< 71 > 8	Number of otoliths	No of otoliths of spring spawners excluded	Catch (kg)
Tridens	7.77	44.88	11.31	8.48	24.73	1.06	1.06	0.71	283	11	43110
Explorer	28.37	32.42	13.20	7.00	15.27	1.98	1.01	0.75	255	24	500
Scotia	19.22	47.09	13.68	7.68	9.15	1.80	0.71	0.67	303	8	524
G O Sars	8.2	41.5	19.0	17.7	11.6	2.0	"	"	302	"	620

TABLE XV Acoustic and trawling equipment and methods used on sprat surveys, and target strength values employed in calculation of sprat biomass

Acoustic methods

Country	Method of Transducer Calibration	Transducer Type	Transducer Mounting	Frequency
Norway	Hydrophone *Stainless steel sphere 130mm dia.	Ceramic	Ship Hull	38 kHz
Scotland	Table Tennis Ball	Ceramic/Magneto-Strictive	Towed Body	38 kHz
England	*Table Tennis Ball	Magneto-Strictive	Towed Body	30 kHz

(*First used in 1980)
(†Absolute reciprocity calibrations were also made at RDW Crystal Portland)

Target Strength Values used in calculations of sprat biomass on earlier surveys

Scotland - 34dB/kg

England - 29dB/kg

Norway-Length-dependent range of values (Aglen, personal communication)
7cm -33dB/kg; 12.5cm -36dB/kg

Fish Sampling Gear

	Trawl Type	Cod-end Mesh	Towing Speed (knots)	Gape (Metres)
Norway	'Harstad' Pelagic Trawl	10mm liner	3-4	13-15
Scotland	International Young Gadoid Trawl	10mm cod-end	3-4	9-10
England	800 mesh Engel Trawl	10mm liner	3-4	9-10

Units of Integration

Norway - per nautical mile

England - per nautical mile

Scotland - per 2.5n miles (every 15 minutes at 10kts survey speed)

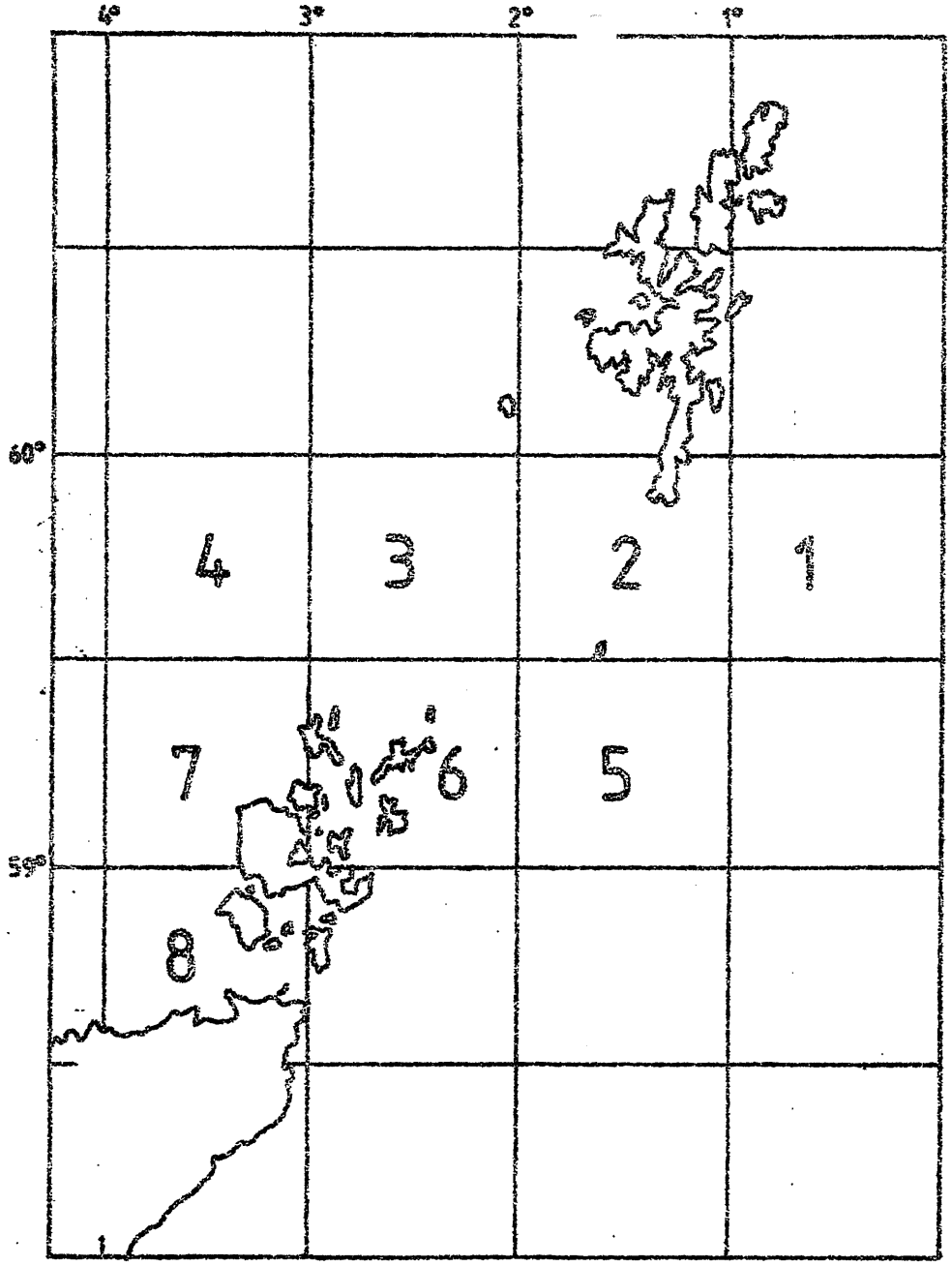

Figure 1 Statistical rectangle numbers referred to in Tables I and II

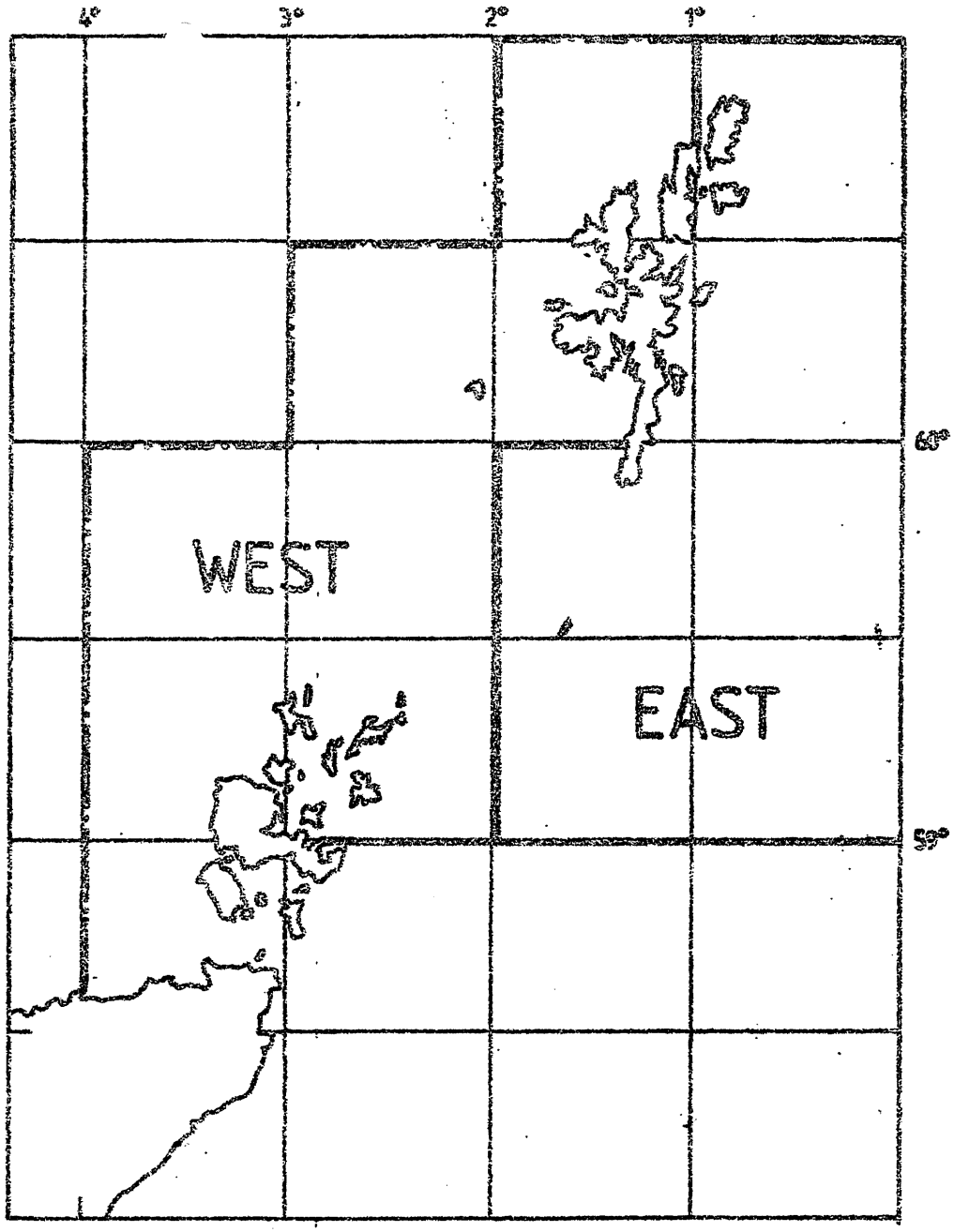

Figure 2 Survey area in 1981 showing division into east and west areas