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C.M. 1980/H:3
Pelagic Fish Committee

FINAL REPORT ON THE ICES-COORDINATED ACOUSTIC SURVEY
OF HERRING STOCKS IN 1979

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SUMMARY

The Herring Acoustic Survey Planning Group met in Aberdeen, U.K., from 22-24 January 1980:

- (a) to analyse the methodology and results of the 1979 survey and prepare a final report; and
- (b) to make plans for the survey in 1980.

Acoustic Techniques

It is not possible to compare the herring target strength values used by each vessel in 1979 because of differences in acoustic techniques. Recommendations are made for a standard calibration procedure, for the use of a towed body transducer housing and on the method for intercalibration experiments. Until improved target strength measurements are available, a value of -34dB/kg should be used as the standard for comparison.

Two methods of allocating 'acoustic biomass' to species were advocated:

- (i) using the proportion of each species in trawl hauls at appropriate depths;
- (ii) using trawl hauls to identify echotrace characteristics and classifying each shoal recorded.

The subjective nature of trace classification and the quantitative validity of trawl hauls were questioned and, since no consensus was reached on the most appropriate procedure, it was recommended that both be used in 1980.

Results

Echointegrator estimates of herring biomass are given for the central and northern North Sea, but not for area VIa. In the central North Sea, two independent estimates of 16000 and 11900t in July and August respectively were very much lower than that estimated from larval surveys (58000t). Possible reasons for the discrepancy are discussed. In the northern North Sea the estimates ranged from 30000 to 175000t depending on the method of analysis.

Age compositions of herring sampled are tabulated.

Plans for future surveys

Vessels intending to participate in the survey of the Orkney-Shetland area in 1980 were allocated areas of operation. The survey will extend from 25 June - 2 August.

The results are to be analysed on board preparatory to a meeting in Lerwick on 26 July. A report on the survey to be written by R S Bailey will be submitted to the 1980 Statutory meeting.

For 1981 it is recommended that the survey should be once again confined to the Orkney-Shetland area but that the survey period should extend from mid-July to the middle of August to facilitate a survey of the spawning areas.

RESUME

Le Groupe de Planification de la campagne d'inventaire acoustique sur le hareng s'est réuni à Aberdeen, Royaume-Uni, du 22 au 24 janvier 1980:

- (a) pour analyser la méthodologie et les résultats de la campagne 79 et préparer un rapport final;
- (b) pour préparer les plans de la campagne de 1980.

Techniques acoustiques

Il est impossible de comparer les valeurs des index de réflexion du hareng utilisé par chaque navire en 1979 en raison de la disparité des techniques acoustiques. Des recommandations ont été faites en vue de l'établissement d'une procédure standard de calibration, de l'emploi d'un transducteur abrité dans un corps remorqué et au sujet de la méthodologie des expériences d'intercalibration.

Dans l'attente des mesures d'indice de réflexion amélioré, une valeur de -34dB/kg devraient être utilisées comme moyen de comparaison.

Deux méthodes pour l'allocation de la 'biomasse acoustique' aux espèces furent préconisées en utilisant:

- 1° la proportion de chaque espèce présente dans les traicts de chalut exécutée dans les sondes appropriées;
- 2° les traicts de chaluts pour identifier les caractéristiques des enregistrements et en classifiant chaque banc enregistré.

La nature subjective de la classification des enregistrements et la valeur quantitative des traicts de chalut furent mises en doute et comme aucun consensus ne fut atteint sur la procédure la plus appropriée, il a été recommandé que chaque technique soit utilisée en 1980.

Des estimations par échointégration de la biomasse de harengs furent établies pour la Mer du Nord centrale et septentrionale, mais non pour la division VI a. En Mer du Nord centrale, les deux estimations indépendantes de 16 000 et 11 900 t obtenues respectivement pour les mois de juillet et août étaient très en-dessous de celles résultantes des campagnes d'inventaire de larve (58 000 t). On discute donc des causes possibles de ces différences. En Mer du Nord septentrionale, les estimations fluctuaient de 30 000 à 175 000 t en fonction de la méthode d'analyse.

On trouvera dans les tableaux joints les compositions en âge des harengs échantillonnés.

Projets pour les prochaines campagnes

Les navires devant participer à la campagne qui se déroulera du 25 juin au 2 août dans la zone Orcades-Shetlands en 1980, se voient allouer des secteurs d'opération. Les résultats devront être analysés sur le champ en vue de la préparation d'une réunion à Lerwick le 27 juillet.

R.S. BAILEY rédigera un rapport de la campagne et le présentera à la réunion statutaire de 1980.

Pour 1981, il est recommandé que la campagne soit une fois encore confinée à la zone Orcades-Shetlands, mais que la période couverte soit étendue de la mi-juillet à la mi-août afin de rendre possible la surveillance des frayères.

1 TERMS OF REFERENCE AND PARTICIPANTS

Following an ICES recommendation at the 1979 Statutory Meeting (C. Res. 1979/2:26), a meeting of the Herring Acoustic Survey Planning Group was held at the Marine Laboratory, Aberdeen, UK, from 22-24 January 1980.

The terms of reference, as set out in the ICES recommendation, were:

- (a) to analyse the methodology and results of the 1979 survey and prepare a final report;
- (b) to make plans for the survey in 1980.

The following participated:

A Aglen	Norway
R S Bailey (Convener)	UK
A Corten	The Netherlands
N Diner	France
H Dornheim	Fed Rep of Germany
J I Edwards	UK
A Maucorps	France
D W McKay	UK
R Mitson	UK
E J Simmonds	UK
P A M Stewart	UK
J Wood	UK
O J Østvedt	Norway

For a full account of the survey, reference may be made to the preliminary report presented at the 1979 Statutory Meeting (CM 1979/H:44). The purpose of the present report is to evaluate the methodology and results, in particular to assess whether they can be used to provide an acceptable stock biomass estimate. Plans for the 1980 survey and recommendations for 1981 are also included.

2 METHODOLOGY

2.1 Acoustic Techniques

2.1.1 The Scottish estimates of herring biomass reported in the Preliminary report employed a target strength of -34dB/kg . Owing to the lack of adequate calibration of the acoustic

equipment, it is not possible to calculate the target strength values corresponding to the conversion factors applied in the French and Norwegian stock estimates. The stock estimates, therefore, cannot all be referred to the same value of target strength.

- 2.1.2 It was agreed that for the 1980 joint survey all participants should use a calibration procedure involving a standard target, in addition to the customary calibration procedures used. A ping-pong ball should be used, in addition to any other standard targets. To assist in standardising the calibration procedures the representatives of the Marine Laboratory, Aberdeen, agreed to write and circulate a detailed description of their calibration procedure.
- 2.1.3 To standardise the calculation of stock estimates it was agreed that all participants should base their estimates on the same values of target strength. A number of experiments show that target strength depends on three main factors: species, fish size and fish behaviour. Because of the difficulties involved in quantifying these factors, it was agreed to use a target strength value of -34dB/kg as a reference until improved estimates become available. Since more reliable estimates of fish target strength are urgently required, it was recommended that new estimates be obtained by all possible means.
- 2.1.4 To simplify calibration and to improve operating efficiency during bad weather it was agreed that, wherever possible, towed bodies should be used to house transducers.
- 2.1.5 It was agreed that inter-calibration is useful, but should only be carried out if suitable echotraces are found, ie an evenly distributed trace of moderate density in a well defined area. Inter-calibration should be organised during the joint survey when conditions are favourable. Inter-calibration should not be carried out on plankton traces, and should not be a substitute for the independent calibration of each vessel's system. It was not found possible to define the minimum duration of an inter-calibration exercise needed to produce a reliable calibration. It was considered that this could be as short as three hours for an evenly distributed population and as long as 60 hours for a sparse, randomly distributed population.
- 2.1.6 Since herring are often found very close to the surface and bottom, it is recommended that further research should be carried out into the evaluation of fish targets near these boundaries.

Investigation of the use of upwards-looking transducers to survey stocks near the surface should be continued.

Allocation of integrator readings

One of the most crucial points of an acoustic survey is the proper allocation of integrator values to the various fish species occurring in the area. Two different methods were used during the 1979 survey, and it was impossible on the information available to judge which of these methods had yielded the most accurate results.

All vessels using echointegrators during the survey measured the total deflection (or readings) of the integrator over a certain length of cruise track, and then used the results of one or more trawl hauls in the area to allocate the integrator values to different species of fish. In addition to this method, the THALASSA used another approach in which the individual schools on the echo recording were inspected and tentatively classified as herring or other species. The deflection caused by individual herring schools was then measured and summed over each unit of distance. Trawl hauls were made from time to time to provide a check on the identity of the schools.

A lengthy discussion was devoted to the relative merits and disadvantages of both systems. In the first method, the species composition in the trawl catches is assumed to reflect the actual proportions of the various species in the total echo volume (after compensation for differences in target strength). It was pointed out that this is not necessarily true; trawl catches may in fact give a very biased picture of the actual species composition recorded on the echo sounder. A fast-swimming species like herring is often more difficult to catch in a trawl than, for instance, whiting; in this case the proportion of herring in the trawl catch will give an underestimate of its actual abundance in relation to the other species. The catchability of herring also depends on the time of the day and the current and thus the amount of bias will vary between hauls. Another factor is the considerable between-haul variance in trawl catches. Especially during daytime, the species composition of the catch will show large variations between hauls, which are caused by the trawl either meeting a herring school, or a school of another species. At night these differences will be less pronounced as the schools will break up and the fish will be distributed more evenly.

Apart from the presence of several species of fish in an area problems may be experienced if there are plankton scattering layers. Where the plankton layers are separated in depth from the fish it is possible to exclude plankton from the biomass estimates by appropriate setting of the counting channels. Where plankton and fish are intermixed it is essential that some estimate of the contribution of plankton be made. Such an estimate of the plankton contribution may be made from adjacent areas where fish are not present or in the same area when the distributions of fish and plankton are separated by depth.

If more than one trawl haul is available, the problem arises whether to use each haul exclusively to allocate echotraces in its immediate vicinity, or to combine several trawl catches into one 'species-key' which is applied to integrator values over a larger area. The results of the THALASSA survey west of Shetland illustrate this problem. If the trawl hauls are applied individually to the neighbouring integrator values, the total amount of herring in the area is estimated at 62000 tonnes. If the hauls are combined before they are applied to the echo values, the amount of herring is reduced to 30000 tonnes. This is due to a large catch of whiting in an area of low echo density which has markedly influenced the raising factor for a larger area.

The school classification system may avoid the problems outlined above of using trawl catch compositions to allocate the biomass to species. However, in this case everything depends on the accuracy of school identification. Some participants expressed serious doubts as to the possibility of classifying echo traces by looking at the shape of them. The inherent danger in this approach is that an assumption has to be made that herring in a particular area will give a characteristic type of trace which can easily be recognised. While this might have been true during the July 1979 surveys in the northern North Sea, where only herring and whiting were caught in any quantity, it was the view of some participants that this approach would not have been valid in the central North Sea. There, a number of pelagic fish species are present during the summer months, eg herring, horse mackerel, sprat, mackerel and sometimes pilchard and anchovy. Some of these species frequently occur together in relatively small areas and can apparently give paper recordings which look very similar. On the other hand, it is known that when fishing skippers have worked in a certain area for some time they become fairly confident of their identification of traces. Although there is no scientific basis for this as yet, it was felt by some participants that the identification of traces to a reasonable degree of accuracy could be achieved provided that regular checks were carried out by fishing with the trawl. In areas where classification of individual schools is possible this system may give a greater degree of precision than the trawl catch proportion method, as the information from the echo sounder would be used to a fuller extent.

Both methods are to some extent complementary. The school classification system requires the presence of clearly defined fish schools, which are normally only available during daytime (and possibly only at certain phases of the tidal cycle). On the other hand, the trawl catch proportion method probably works best during the night, when the fish are distributed in scattering layers, and when the species composition of repeated trawl hauls may show the smallest variance.

A comparison between the two methods made by THALASSA during the 1979 survey yielded widely different results. While the application of the trawl catch proportion method resulted in an estimate of herring stock of 30000 or 62000 tonnes (depending on whether or not the trawl sets were combined), the school classification method gave an estimated herring stock of 174000 tonnes in the same area. Because of the discrepancy the group recommended that both methods of data analysis should be applied during the 1980 survey to get further comparisons.

3 EVALUATION OF RESULTS

Coverage by each ship during the acoustic survey has been described in detail in the preliminary report, and is summarised in Table 3.1. In Figure 3.1 a chart is given showing the total area covered by the survey, together with the positions of all trawl hauls, differentiating between those in which herring were present and absent. Herring were caught in 66 out of 117 hauls.

Acoustic estimates of herring biomass were made in each of the areas shown in Figure 3.2. The values obtained are summarised in Table 3.2.

An evaluation of the acoustic survey in each area is given below.

3.1 Area I - Central North Sea

JOHAN HJORT surveyed a patch of herring covering an area of approximately 3500km² off the English northeast coast from 10-13 July 1979, identified by the scouting vessel ANNA HILLINA as the main concentration in this area at the time. Herring were only clear of the sea bed and suitable for echo integration for about six hours each night during the hours of darkness. Trawl identification was made with both demersal and pelagic fishing gear within the survey area and an estimate of 16000t of herring was obtained using catch composition data to allocate the total acoustic biomass.

EXPLORER conducted a second survey from 17-27 August 1979. Herring were located within an area of about 2200km² between Hartlepool and Flamborough Head and in an area of 810km² in the Bayman's Hole area. Echo integration and demersal trawling were both carried out during the hours of daylight. Based on the proportion of herring to other species caught, an estimate of 11900t was obtained for herring.

Both the above estimates of herring biomass are very low in relation to the Herring Assessment Working Group estimate of spawning stock size in the Central North Sea at the present time based on herring larval surveys (58000t in 1978, CM 1979/H:6). It is important to identify the possible causes of these very considerable discrepancies.

- (a) Neither of the echointegrator surveys covered the entire area, and a significant part of the central North Sea spawning stock could have been distributed outside the survey areas. In July ANNA HILLINA certainly located herring-like traces further to the west. Local fishing boats reported concentrations of mature herring on the Seahouses Bank (just South of the Farne Islands) on 15 August.
- (b) The biomass estimate of 16000t obtained from the JOHAN HJORT survey in July is probably a considerable underestimate. This is possibly because of the method used in this instance to estimate a conversion factor to biomass which involved counting single fish. For this an assumption was made that all the fish were countable up to -9dB from the axis of the beam, but it is likely in fact that some of the fish within this area would have been missed.
- (c) At night a further factor leading to underestimation of biomass could be due to proximity of the fish to the vessel. Fish close to the ship may take avoiding action by swimming to the side, or by diving. In the first case a low density would be recorded. In the latter case a reduction in target strength would occur, and both these effects would cause underestimation.
- (d) The EXPLORER integrator survey during August was conducted mainly during daylight hours when a considerable part of the herring population would probably have been very close to the sea bed. Integration was not made on signals within 2 metres of the sea bed so it seems very likely that a considerable proportion of the herring present in the area would have been below the lower depth limit of integration.

3.2 Area II - Orkney-Shetland

A detailed description of the surveys carried out in this area is given in CM 1979/H:44 together with the main characteristics of fish distribution, haul composition and behaviour of herring shoals.

The herring biomass calculated from the EXPLORER survey gave values of 2030 or 1490 tonnes, depending on the method used, in a restricted area south of Foula.

On THALASSA three different methods of analysis were used (see paragraph 2.2) all based on the same echointegration constant obtained from calibration on caged anchovy carried out in June 1979 and referred by calculation to herring of 26.5cm. The results obtained are given in Table 3.3. Apart from the evaluation given in Table 3 (column (c)), the other estimates obtained by EXPLORER and THALASSA seem very low compared with estimates of stock size made from the larval surveys (148000t in 1978, CM 1979/H:6). Several reasons appear to be responsible for these underestimates:

- (a) incomplete coverage: in the case of THALASSA, the entire area of herring distribution was not covered; areas of dense concentration were found on some occasions on the border of the area surveyed.

In the case of EXPLORER, too much time was spent to the east and north of Shetland whereas major spawning grounds in the vicinity of Orkney (corresponding to areas of high herring larvae concentration) were not surveyed at all.

- (b) inappropriate searching method: MOUSSE mainly directed her searching activity to very large shoals corresponding to commercial fishing targets, whereas herring were very often distributed in quite small shoals scattered over a wide area.
- (c) distribution of herring by day: herring can be very scattered by day on or very close to the bottom and may therefore not have been adequately recorded and integrated. In such instances acoustic survey alone can be completely misleading so far as distribution and biomass of fish are concerned.
- (d) threshold level: owing to an unidentified source of noise on THALASSA, the threshold required on the echointegrator was so high that a considerable number of echoes from fish scattered during night time were not integrated and this resulted in an underestimation of the total biomass. For instance, in the area southwest of Sumburgh Head which was surveyed by day and night the biomass obtained by night was approximately three times lower than that obtained by day. The use of a towed body may overcome this problem.

Whatever the method of analysis used, an additional source of error may have resulted from the lack of trawling either to define the precise area of herring distribution or the species ratio and echotrace identifications.

3.3

Area III - Division VIa

Owing to the low intensity of coverage in Division VIa, the Planning Group made no attempt to make herring biomass estimates. Echointegrator surveys were carried out in the Butt of Lewis area, the North Minch and south of St Kilda. In the two latter areas, echotraces were of complex composition and allocation of the biomass to species is not possible with any degree of confidence using the trawl haul data.

3.4

Vertical migration

The results of the surveys show that the diurnal migration of herring greatly affected the biomass estimates. By day the herring were often close to the sea bed while

at times during the night they may ascend to the surface above the transducer. It is essential therefore that on any future survey the diurnal behaviour of the herring in the area should be studied, in order to establish that echointegration is appropriate and, if so, the most suitable period of the day or night.

4

BIOLOGICAL DATA

The Planning Group recognised that the results of the survey provide a useful source of data on the biological composition of the spawning populations in 1979. They therefore tabulated age compositions for each haul for use by the Herring Assessment Working Group. Length compositions of herring caught in each trawl haul are tabulated in the preliminary report. Age data for each haul were pooled and in Table 4.1 age compositions weighted by the estimated number of herring in each haul are given for each main part of the area surveyed.

In the central North Sea it is clear that the 1974 year-class was still of considerable importance and the weakness of the 1975 year-class which recruited in 1978 is confirmed. In the Buchan area, the 1975 year-class predominated over the 1974 year-class. In the Orkney-Shetland area, age compositions varied locally, but overall the 1974 year-class predominated and the 1975 year-class was poor. In VIa two year old recruits (1976 year-class) predominated.

5

RECOMMENDATION FOR FUTURE SURVEYS

5.1

Plans for the 1980 Survey

Following the ICES recommendation, the Planning Group agreed that the 1980 survey should be confined to the Orkney-Shetland area, ie Area II in the 1979 survey slightly enlarged.

5.1.1

Availability of ships

<u>Country</u>	<u>Vessel</u>	<u>Overall cruise period</u>
France	THALASSA	11-31 July
The Netherlands	TRIDENS	7-19 July
Norway	G O SARS	21 July - 2 August
UK	SCOTIA	25 June - 15 July
UK	EXPLORER	9-29 July

In addition the UK vessel CORELLA is programmed to carry out a survey of the northeast coast of England in late August.

5.1.2

Survey Area

The area to be surveyed is shown in Figure 5.1. To ensure an even coverage of the whole area, each vessel will be allocated to either the eastern or western parts of the area. A small area of overlap will be covered by all vessels participating.

Since location of herring by echosounder was not always easy in 1979, it was decided that the two subareas should also be covered by a bottom trawl survey, primarily to locate areas of concentration.

The proposed disposition of each vessel is given in the text table below. Dates given are approximate.

<u>Western Area</u>	<u>Eastern Area</u>
SCOTIA 25 June - 5 July (Preliminary coverage of entire area)	
SCOTIA 5-15 July	TRIDENS 7-19 July (including bottom trawl survey)
THALASSA 13-27 July	EXPLORER 9-19 July (including bottom trawl survey)
EXPLORER 20-27 July (including bottom trawl survey)	G O SARS 21-27 July 28 July-2 August (or areas of special interest)

At the beginning of the survey SCOTIA should survey the entire area using a grid spaced at 10 mile intervals to establish the location of major herring concentrations. Thereafter each vessel should carry out a more intensive acoustic and midwater trawling survey to localise areas of high herring abundance and to establish the behaviour of the herring and the composition of echotraces. It is essential that as many trawl hauls as possible be carried out covering both day and night distributions.

When areas of high herring abundance are located intensive echointegrator surveys should be carried out over a fine grid of transects in order to estimate the herring biomass in these areas to reduce the effects of random errors on the estimates. However, for the remaining areas of low abundance, an estimate of herring biomass should also be obtained by carrying out a more widely spaced grid. Each vessel should attempt to arrive at an estimate for the total herring stock in the whole area it is assigned to. If time permits each survey should be repeated.

Intercalibration experiments should be carried out whenever practicable, by ad hoc arrangement between the vessels concerned.

5.1.3

Communication and analysis of results

During the surveys, participants should keep in frequent contact. Where other arrangements have not been made, daily contact should be made at 2000 hrs GMT on 2056 kHz.

During the survey, track charts should be drawn up and echointegrator results analysed on a day to day basis. For further analysis of the results:

- (a) TRIDENS should pass her information to R S Bailey in Aberdeen at the end of her cruise on 19 July;
- (b) G O SARS, THALASSA and EXPLORER and the Convener should meet in Lerwick on 26 July to analyse the results of the echointegrator surveys.

A report in which biomass estimates are included will be written for presentation to the 1980 Statutory Meeting by R S BAILEY.

Description of the calibration techniques used in each country during the survey should be made available for the report.

5.2

Recommendations for 1981

As requests for research vessel time have to be submitted well in advance, consideration was given to the timing of the 1981 surveys. The suggestion was made that the timing of the surveys should be altered to coincide with the start of the spawning season in IVa, ie the first two weeks of August. The main points in favour of this change were:

- (a) Herring concentrations would be found on the spawning grounds which could be predicted from the larval survey data.
- (b) The areas of concentrations would be small and once located could be intensively and repeatedly surveyed.
- (c) Trace identification and therefore biomass allocation would present less of a problem.
- (d) The estimate of herring biomass obtained would be an estimate of spawning stock size and would therefore be more easily compared with estimates from the larval surveys.
- (e) Sampling would provide the age composition of the spawning stock.

It was, however, pointed out that such a change would cause a loss of continuity of data assuming that the 1980 surveys produced a biomass estimate for July.

The Planning Group therefore recommend that the surveys in 1981 should be designed such that:

- (a) estimates of herring biomass in July should be obtained;
- (b) that the feasibility of carrying out surveys during the spawning season should be assessed.

The surveys in 1981 should therefore begin in mid-July and extend until mid-August.

In view of the uncertainty in the optimum timing of acoustic surveys in 1981 it was felt that surveys should again be concentrated in the Orkney-Shetland area. Expansion of the survey area should only take place once the methodology of this type of survey had been agreed and tested.

TABLE 3.1 Areas and dates of coverage by each vessel on the 1979 survey

	Central North Sea IVb		Northern North Sea IVa	West of Scotland VIa
	Northeast England	Buchan	Orkney-Shetland	
ANNA HILLINA	4- 7 July	9-11 July	11-17 July	-
OLAV HJORT	10-13 July	-	13-16 July	-
MOUSSE	20 July	-	10-19 July	-
THALASSA	15 July	26 July	16-21 July and 24-25 July	22-23 July
SCOTIA	-	25-26 July	27-30 July	31 July-14 August
EXPLORER	17-27 August	-	7-16 August	-

TABLE 3.2 Echointegrator estimates of herring biomass in areas shown in Figure 3.2

Area in Figure	Ship	Dates	Area	Herring biomass estimate (t)
A	JOHAN HJORT	10-13 July	NE England	16000
B	EXPLORER	12 August	Foula (Shetland)	1490- 2030
C	EXPLORER	19-22 August	NE England	11000
D	EXPLORER	24-25 August	Bayman's Hole	900
E	THALASSA	16-21 July	Noup Head	2700- 3000
F	THALASSA	19-21 July	SW Shetland	9600-95700
G	THALASSA	19 July	SE Shetland	2800-26800
H	THALASSA	24-25 July	SE Fair Isle	14800-49200
J	SCOTIA	26 July	Turbot Bank	1400

TABLE 3.3 Northern North Sea: Herring stock biomass (tonnes) calculated from THALASSA results

Zone	Number of trawl hauls	a	b	c
Noup Head	2	3000	3000	2700
West Shetland	3	40800	9600	95700
East Shetland	1	2800	2800	26800
SE Fair Isle	3	15600	14800	49200
TOTAL		<u>62200</u>	<u>30200</u>	<u>174400</u>

- (a): trawl catch proportion method: each trawl haul considered individually
 (b): trawl catch proportion method: trawl hauls combined for each area
 (c): direct identification of herring shoals on the echograms

TABLE 4.1 Estimated numbers of herring per age group caught in all trawl hauls combined, and percentage age composition of herring age 2 rings and over

Age (rings)	Year Class	<u>N E England</u>						<u>Buchan</u>		<u>Orkney/Shetland</u>		<u>VIa</u>	
		<u>July</u>		<u>August</u>		<u>July & August Combined</u>		<u>July</u>		<u>July</u>		<u>July-August</u>	
		<u>No</u>	<u>%</u>	<u>No</u>	<u>%</u>	<u>No</u>	<u>%</u>	<u>No</u>	<u>%</u>	<u>No</u>	<u>%</u>	<u>No</u>	<u>%</u>
1	1977	64		2645		2709		168		32079		3268	
2	1976	418	15.9	4613	48.3	5031	41.3	2442	22.1	19394	22.9	19095	60.4
3	1975	443	16.9	1075	11.3	1518	12.5	3983	36.1	9244	10.9	5878	18.6
4	1974	1217	46.4	2202	23.1	3419	28.1	1725	15.6	33535	39.5	3341	10.6
5	1973	226	8.6	459	4.8	685	5.6	1822	16.5	21736	25.6	3105	9.8
6	1972	125	4.8	167	1.7	292	2.4	435	3.9	704	0.8	109	0.3
7	1971	33	1.3	625	6.5	658	5.4	351	3.2	216	0.2	104	0.3
8	1970	162	6.2	207	2.2	369	3.0	289	2.6	10	+	-	-
9	1969	-	-	127	1.3	127	1.0	-	-	-		1	+
10	1968	-	-	26	0.3	26	0.2	-	-	-		-	-
11	1967	-	-	46	0.5	46	0.4	-	-	-		-	-
TOTAL		<u>2688</u>		<u>12192</u>		<u>14880</u>		<u>11215</u>		<u>116918</u>		<u>34901</u>	

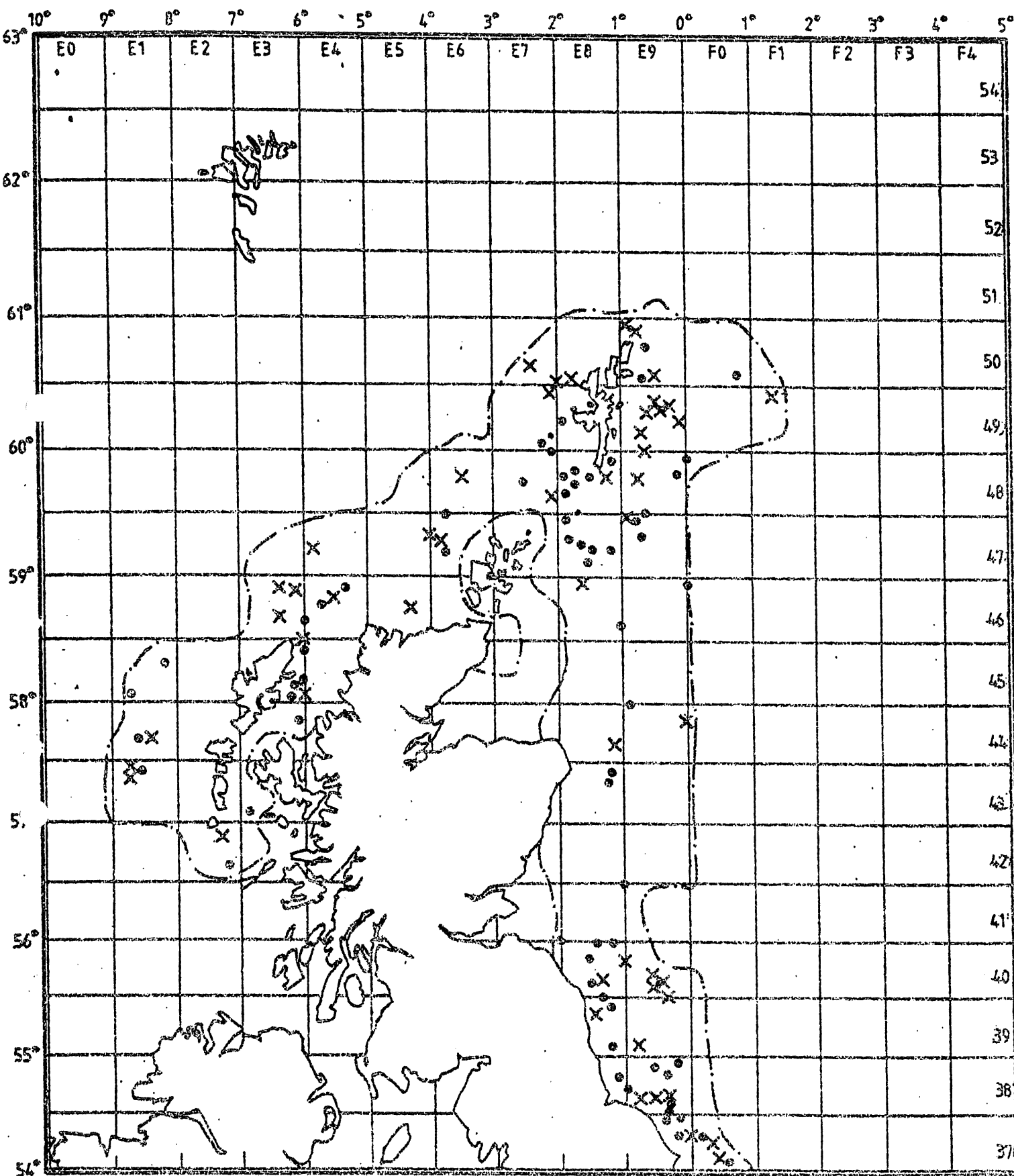


Fig 3.1 Chart showing area covered by 1979 acoustic survey and position of trawl hauls
 ● = herring caught x = no herring caught

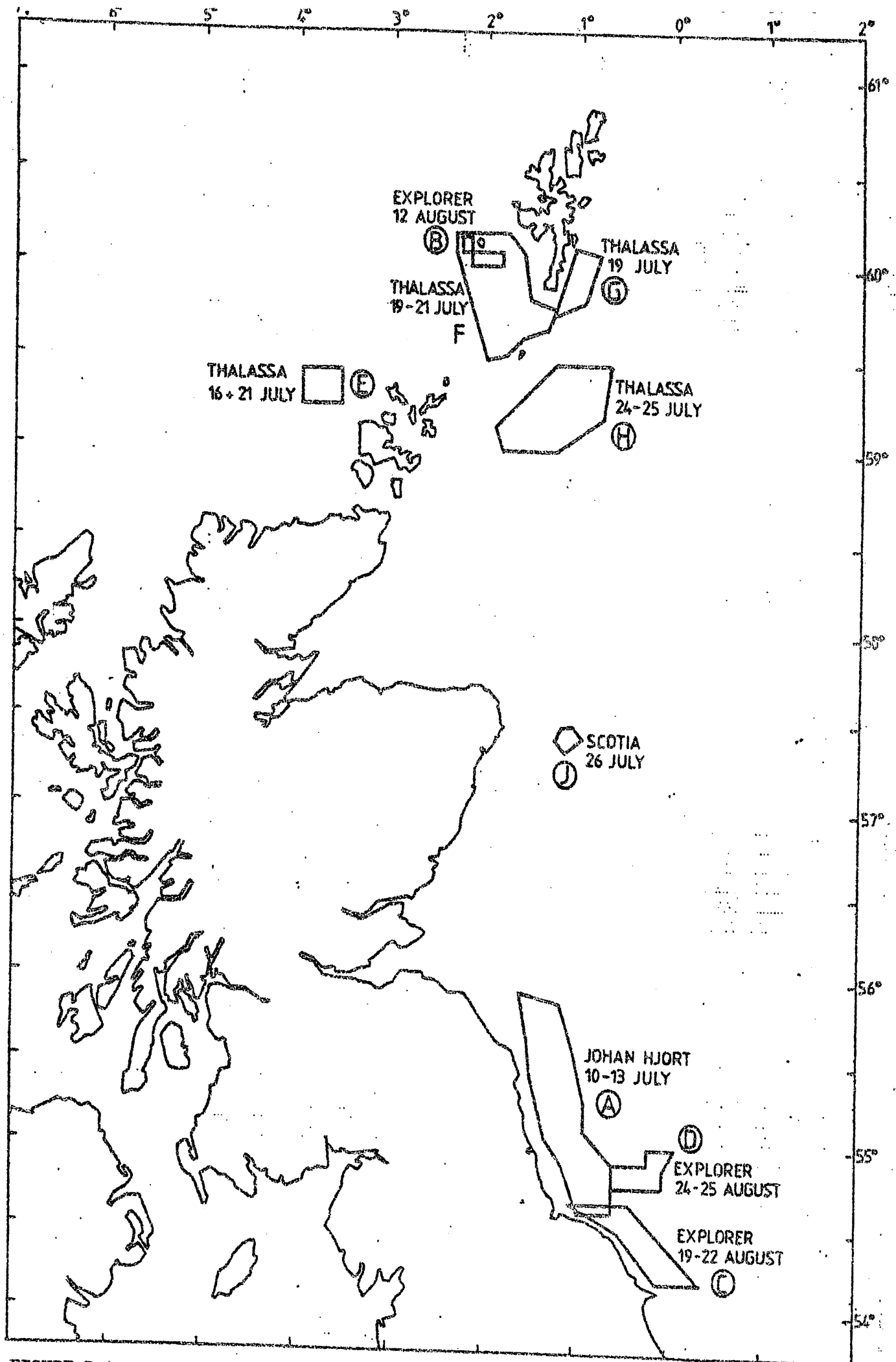


FIGURE 3.2 Chart showing approximate areas of intensive echointegrator surveys. Letters encircled refer to areas listed in Table 3.2.

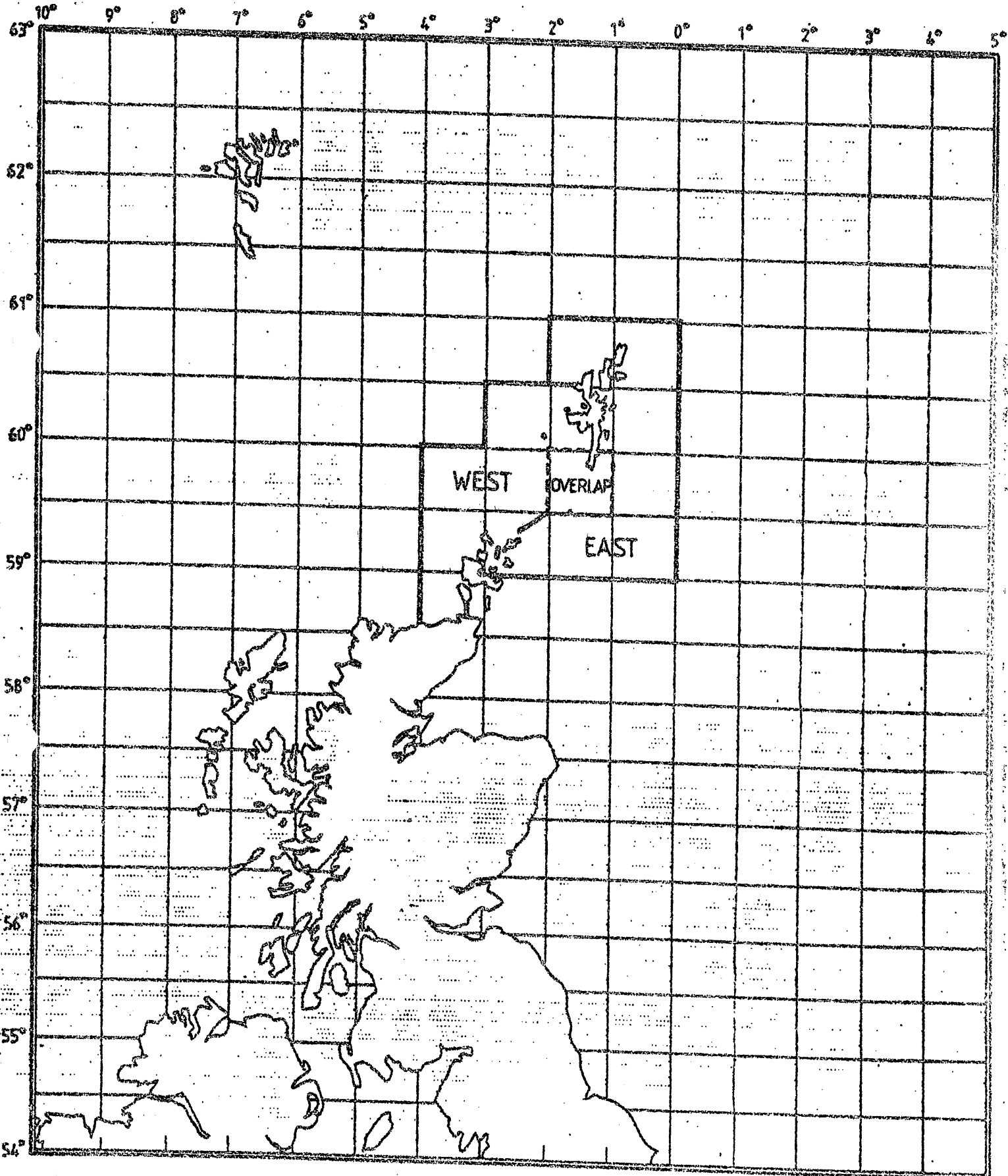


FIGURE 5.1 Survey area in 1980 showing division into east and west areas and area of overlap.