This report not to be cited without prior reference to the Council*

International Council for the
Exploration of the Sea

CM1982/H:4
Pelagic Fish Committee

REPORT OF THE 1982 PLANNING GROUP ON ICES-COORDINATED HERRING AND SPRAT ACOUSTIC SURVEYS

* General Secretary
ICES
Palaegade 2-4
DK-1261
Copenhagen K
Denmark

SUMMARY

A meeting of the Planning Group on ICES-coordinated herring and sprat acoustic surveys was held at Aberdeen in March 1982. New length-dependent values of target strength for herring were recommended while that for sprat remains the same. Recommendations for calibration techniques were made.

The results of the 1981 herring survey were evaluated and it was concluded that a decrease in biomass had occurred from 212 000 tonnes in 1980 to 110 000 tonnes in 1981 in the Orkney-Shetland area. Samples of herring indicated an increase in the proportion of old fish.

Plans for the 1982 herring survey were made, stress being laid on the need to obtain estimates of the variance of biomass estimates.

Herring surveys in the southern North Sea and English channel in winter showed considerable potential for making biomass estimates.

The 1982 sprat acoustic survey showed a low biomass of sprat in the North Sea (166 000 tonnes) which were concentrated in the southwestern North Sea.

RESUME

Le groupe de planification des campagnes coordonnées CIEM concernant l'évaluation acoustique du hareng et du sprat s'est réuni à Aberdeen en Mars 1982.

Un nouvel index de réflexion, fonction de la longueur, a été utilisé pour le hareng tandis que pour le sprat il est resté inchange. Des recommandations furent émises au sujet des techniques de calibration.

L'analyse des résultats de la campagne '81 a permis de conclure à une diminution de la biomasse de 212 000 tonnes en 1980 à 110 000 tonnes en 1981 dans le secteur Orcades - Shetlands. L'échantillonnage du hareng a traduit l'augmentation relative de poissons âgés.

Les plans de la campagne 1982 sur le hareng furent élaborés en insistant sur la nécessité d'obtenir des estimations de la variance des évaluations de biomasse. Les campagnes hivernales exécutées sur le hareng dans le sud de la mer du nord et en manche ont révélé des possibilités considérables pour la réalisation d'estimation de biomasse par méthode acoustique.

La campagne acoustique de 1982 sur sprat a révélé une biomasse faible en mer du nord (166 000 tonnes) concentrée dans la partie méridionale.

1 TERMS OF REFERENCE AND PARTICIPATION

In accordance with ICES resolution 1981/2:22, a meeting of the Planning Group on ICES-coordinated herring and sprat acoustic surveys was convened by R S Bailey at the Marine Laboratory, Aberdeen, UK, from 2-5 March 1982. The terms of reference of the meeting were

1 to evaluate the results of the 1981 herring survey;

2 to analyse and evaluate the results of the 1982 sprat survey, and to report on it to the relevant assessment working group and to the Statutory Meeting;

3 to coordinate plans for the 1982 herring acoustic survey.

In addition, with the consent of participants, acoustic surveys carried out in the winter of 1981/82 in the southern North Sea and English Channel were considered.

The following participated in the meeting:-

A Aglen	Norway
R S Bailey	UK (Convener)
A C Burd	UK
A Corten	The Netherlands
J I Edwards	UK
G Eltink	The Netherlands
S Iversen	Norway
D MacLennan	UK
J Massé	France
A Maucorps	France
B J Robinson	UK
E J Simmonds	UK
Ø Ulltang	Norway
R J Wood	UK

2 ACOUSTIC METHODS

2.1 Fish Target Strength

(a) Herring

(i) Nakken and Olsen (1977) gave the following equation for the maximum dorsal aspect target strength (TS) for herring at 38 kHz,

$$TS_{max} = 13.6 \log_{10} L - 56.8 \text{ (dB per fish)}$$

where L is the fish length in cm and the equation is a regression line calculated from data obtained from stunned tethered fish. Nakken and Olsen say that the mean TS appropriate to live free fish should be 6 dB less to take account of the tilt angle distribution reported by Beltestad (1974). Thus we have:-

$$TS_{mean} = 13.6 \log_{10} L - 62.8 \text{ (dB per fish)}$$

The above results have been converted to dB per kg using Marine Laboratory (unpublished) weight length data for NW North Sea herring in the month of July. We obtain the following table:-

L (cm)	Weight (g)	TS_{max} (dB per kg)	TS_{mean} (dB per kg)
9	7	-22.3	-28.3
23	107	-28.6	-34.6
30	252	-30.9	-36.9

(ii) Edwards and Armstrong (1981) have reported experiments on caged swimming fish. For 21-25 cm fish at 17.5 m depth, they report TS = -33.8 dB per kg. This result should be compared with the TS_{mean} data quoted above, not the TS_{max}.

(iii) Olsen (1980; 1981) has described observations on the reaction of herring to a survey vessel. The integrated signal from a transducer positioned below a shoal always decreased as the survey vessel passed, by as much as 10 dB depending on the shoal depth and the fish length.

(b) Sprat

B J Robinson reported a preliminary result of -27 dB per kg for 8.5 cm fish from in situ measurements. The analysis work is not complete, and this preliminary result must be regarded as tentative.

(c) Conclusions

(i) Herring

The only comparison which could be made from the limited available data was between the two results quoted above for 23 cm fish. These results are in good agreement, and the Planning Group therefore recommends that the mean value (-34.2 dB per kg) should be taken for the TS of 23 cm fish. The length dependence of the TS remains problematical. Beltestad's tilt angle distribution was for fish of mean length 13 cm and the length dependence of this distribution is unknown. In the absence of any better information, the TS length dependence has been calculated on the assumption that the acoustic cross section is proportional to the square of fish length. It is therefore recommended that herring survey data should be interpreted using the reference TS values shown in the following table:-

L (cm)	Weight (g)	TS (dB per fish)	TS (dB per kg)
19	59	-45.6	-33.3
21	81	-44.7	-33.8
23	106	-43.9	-34.2
25	138	-43.2	-34.6
27	175	-42.5	-34.9
29	218	-41.9	-35.3
31	268	-41.3	-35.6
33	326	-40.8	-35.9
35	393	-40.3	-36.2

(ii) Sprat

There is very little information on the target strength of sprat although it is expected that new experimental results will be published within the next year. In the meantime, there is no reason to change the previously adopted reference TS value of -29 dB per kg independent of length. It is recommended that this value should continue to be applied when interpreting the results of sprat surveys.

(iii) General

New experimental data on the target strength of live herring and sprat may become available before the reports on the 1982 surveys are complete. In the event of new evidence arising which would significantly alter the above conclusions, it may be necessary to change the common reference TS value for the 1982 reports and this would be arranged by correspondence.

2.2 Calibration

Recent work on the acoustic properties of metal spheres has shown that spheres made from electrical grade copper and tungsten carbide ball bearings are both suitable for the calibration of echo-sounders within 0.1 dB precision. Spheres made from other materials such as brass and stainless steel are not recommended for this purpose. It was noted that different sizes of sphere would be required depending upon whether the transducer was hull mounted or in a towed body.

It is recommended that echo-sounders used on acoustic surveys should be calibrated against standard copper or tungsten carbide targets. Advice on the target size, source of supply and the standard target strength to be used may be obtained from K G Foote (Fisheries Institute, Bergen) or D N MacLennan (Marine Laboratory, Aberdeen).

The standard target strength will be given for a 38 kHz $\pm$ 100 Hz centre frequency, a 1 ms $\pm$ 24 μs transmit pulse length and a 3 kHz $\pm$ 100 Hz system bandwidth. It is recommended that, to facilitate the comparison of results, the coordinated herring and sprat surveys should be conducted with these equipment parameters.

3 THE 1981 HERRING ACOUSTIC SURVEY OF THE ORKNEY-SHETLAND AREA

The results of the 1981 survey were described in the report to the 1981 Statutory Meeting (CM1981/H:50). To summarise, herring shoals giving characteristic plume traces on the echo-sounder were located in the area south of Shetland in July and early August. The shoals did not completely disperse at night and the herring caught were mostly large and at advanced maturity stages (IV-V in July, with mainly V and some spents in August). Biomass estimates of herring during this period

were obtained by identifying the traces by trawling and then classifying the echo-sounder traces into those of herring and other species.

Following a re-evaluation of data on the target strength of herring, the Planning Group adopted the new length-dependent relationship given in section 2.1(c). The herring biomass estimates for 1981 given in CM1981/H:50 converted to the new target strength values are given in Table 3.1.

Comparing repeat surveys by "G O Sars", there was evidence of a southerly movement during the second half of July. By early August, the biomass estimated on the "Tridens" survey was lower than in July. On the survey by "Scotia" during August, no characteristic plume traces of herring were found in the Orkney-Shetland area. Trawling through extensive echo-traces close to the sea-bed, however, gave catches consisting of a variable mixture of 0-group Norway pout, whiting, mackerel and spent herring, the first of these predominating in most hauls. Using the composition of trawl catches to allocate the total biomass attributable to these traces to species, the estimated biomass of herring was close to the more direct estimates obtained in July.

A possible interpretation of this change in the schooling behaviour of the herring during August is provided by detailed surveys of the spawning areas off Whitby along the northeast English coast. There, the spawning schools disperse within about three days of spawning, and are subsequently not easily detectable on the echo-sounder. In the Orkney-Shetland area in 1981 the disappearance of characteristic herring schools coincided with the period when spawning occurred.

Taking into account the differences in coverage, the biomass estimates on the different surveys in 1981 show relatively little variability. This suggests that the random error in the estimates is relatively low, although the lack of a target strength estimate valid under survey conditions casts doubt on the absolute level of the estimates. Since the target strength values used are based on fish in experimental situations, no allowance has been made for reaction to the survey vessel by avoidance or diving. The biomass estimates are therefore more likely to be too low than too high. Other reasons for inaccuracy in the biomass estimates may be that the survey area does not contain the entire spawning population, or that a proportion of the herring are close to the sea surface or sea-bed and hence outside the insonified depths.

The results of the 1981 survey are compared with those of previous years in Table 3.2. Since the coverage on different surveys was different, the biomass estimates are given for a set of six statistical rectangles in the south Shetland area which was covered on most surveys (Fig. 3.1), and which contained a major part of the total population on most surveys. Comparison with 1979 is not possible because the only reasonably complete survey in that year was done without adequate acoustic calibration. The only complete survey in July 1980 indicated a biomass of 174 000 t in the six rectangles compared with estimates of 110 000 t by "G O Sars" in July and 61 000 t by "Scotia" in August 1981.

Comparison of estimates for the whole Orkney-Shetland area indicate a decrease from 212 000 t in July 1980 to 110 000 t in July 1981. The latter estimate excludes the concentration of recruits recorded in the northern part of the Moray Firth in August (57 000 t).

The length compositions of herring sampled during the 1981 surveys were given in CM1981/H:50. Age compositions are given for each area in Table 3.3. In the area south of Shetland there is a close correspondence between the samples from the three survey vessels. The predominant age groups were 7-ringers (1973 year class) and 4-ringers (1976 year class), with somewhat smaller numbers of the intervening year classes. Compared with 1980, there was thus an increase in the proportion of fish older than 3-ringers. To the west of 4°W, the 1976 and 1977 year classes predominated. The only concentration of 2-ring recruits (1978 year class) was found close inshore in the Moray Firth.

The acoustic surveys in the years 1979-1981 were carried out over the period late-June to late-August, with most surveys during the period 7-28 July (Fig. 3.2). During July herring shoals have been located with little difficulty, mainly in the area around south Shetland. In August, characteristic herring traces have been difficult to find. From the larval surveys carried out in this area, it is clear that the peak spawning season is in mid-August. The exact locations of the spawning grounds are not known and it is therefore possible that a substantial proportion of the population spawns in inshore areas which are difficult to survey with a large vessel. From the results of surveys to date, July would therefore seem to be the most appropriate month to carry out surveys in future.

4 PLANS FOR THE 1982 HERRING SURVEY

4.1 Availability of Ships

At the time of the meeting countries intending to participate gave the following information:-

Country	Vessel	Cruise period (port-port)
France	Thalassa*	4-27 August
The Netherlands	Tridens	5-16 July
Norway	G O Sars	8-18 July
UK (Scotland)	Scotia	4-24 July

* There is still some uncertainty about the participation of "Thalassa" which may be required for another project. The Planning Group would like to stress the importance of her participation because she is the only vessel planned to carry out a survey in August.

4.2 Survey Area

It is proposed that the first vessel in the area ("Scotia") should carry out a brief survey of the large area shown in Figure 3.1 to establish the main areas of herring concentrations. The area subsequently to be surveyed by all ships participating in July is shown as the smaller area in Figure 3.1. This is a reduction in the area to be covered compared with 1980, the object being to concentrate the effort in those squares which normally contain the major part of the herring biomass around the Orkneys and Shetlands in July. Concentration of the survey effort in this restricted area within a limited time period will also provide what can be considered as replicate estimates of the herring biomass by each ship taking part.

The area in which "Thalassa" should work will be defined from information collected during the July surveys and from information available from commercial fishing vessels operating around the Shetlands. This information should be passed to R S Bailey.

4.3 Communication

The vessels working together should establish contact at 1000 hrs GMT on 2056 kHz to pass information which might improve the effectiveness of the survey. Arrangements should also be made to ensure that the intercalibration described in section 4.4 is carried out.

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

4.4 Special Requirements

General instructions given in the previous report (CM1981/H:5) for the 1981 survey should be taken into consideration, but the group wishes to underline the following objectives:-

a) Estimates of variance on the acoustic estimate

Since the beginning of the acoustic surveys in the Orkney/Shetland area no proper attempt has been made to estimate the variance of the herring biomass estimates. As three vessels will be working in the same area during the period 9 to 14 July, the 1982 survey provides the opportunity to make estimates of the variance of the biomass estimates. When the preliminary survey has been made, contact should be established and a single statistical rectangle chosen on the basis of herring concentration. The two vessels with echo-integrators should then carry out two intensive surveys of this rectangle on a five-mile grid over a two day period to provide four independent estimates of the herring biomass.

b) Diurnal variations

Night and day migrations and dispersion/concentration should be further investigated to define the behaviour of the herring in the area at that time and the consequence it might have on the biomass estimates.

5 HERRING SURVEYS IN THE SOUTHERN NORTH SEA AND EASTERN CHANNEL

Two acoustic surveys were carried out in these areas during the period November-December 1981. In all cases below, biomass estimates are quoted with reference to a target strength of -34.6 dB/kg equivalent to herring of 25 cm which was the modal length in samples taken during the surveys.

The first survey was made by "Thalassa" from 5-15 November. This was concentrated mainly in five separate small areas where the best echo detections were observed. These were in the areas North Hinder, East Dyck, Bullock Bank, Bassurelle and off Le Tréport.

At the North Hinder herring were in maturity stages IV and V and were ideal for echo-integration because they were distributed in midwater and were not too densely concentrated. Very similar biomass estimates were obtained from both day and night surveys in this area. In the other areas herring were in maturity stages V and VI. They tended to be in compact shoals by day but well scattered during the hours of darkness. Biomass estimates from surveys conducted during daytime were generally quite different from those made from surveys at night. In all areas herring formed a high proportion of the fish taken in sample trawl huals and there was thus no problem of allocating biomass to species. The maximum biomass estimate from this survey was 64 000 t.

The second survey was carried out by "Clione" from 2-15 December. Herring were everywhere found to be very scattered, only two small shoals being seen during the whole survey. The scattered fish were somewhat more concentrated in four areas - Hinder/Sandettie, Vergoyer, off Dieppe and off Cap d'Antifer. Sample trawl catches consisted predominantly of recently spent herring. The total biomass estimate from this survey was 53 000 t.

An areas of diffuse midwater echo-trace was located off the Dutch coast from approximately IJmuiden southwards during the January-February 1982 sprat acoustic survey conducted by "Corella". This trace was identified by fishing as being composed almost entirely of herring - mostly spents with an admixture of immatures. The estimate of herring biomass on this survey was 144 000 t of adult herring and a further 10 000 t of immature herring.

The surveys described above are the first ones to have been carried out for herring in the Southern Bight and Eastern Channel. They have demonstrated:-

1 That successful acoustic surveys can be made of pre-spawning and spawning concentrations of herring in this area in November-December.

2 That spent herring concentrations can be surveyed acoustically in January-February.

3 That herring are so predominant in the area during winter at the present time that biomass allocation to species does not present a problem.

6 THE 1982 SPRAT ACOUSTIC SURVEY

The North Sea from 57°30'N to 51°00'N was surveyed by "Explorer" from 11 to 29 January, "Corella" from 25 January-9 Februray and "Johan Hjort" from 6 to 23 January. Each vessel surveyed a section of the North Sea as indicated in Figure 6.1, with the equipment and settings specified in Table 6.1. The sprat biomass was calculated from echo-integration readings by examining the echo-sounder traces and apportioning the biomass according to the weight of fish caught in relevant trawl hauls. Isaac Kidd samples were taken to aid in the identification of small fish in traces.

The results of the survey will be presented to the 1982 Statutory Meeting in a joint report to be compiled by the convener of the survey - Dr P O Johnson. A total of 166 000 t* of sprat was estimated based on a target strength of -29 dB per kg.

The concentration of sprats which were observed in the Silver Pit, off Sunderland and off Montrose in previous winters were not detected during the 1982 survey. Furthermore, concentrations recorded in the Dogger Bank area in November 1981 were not found. Sprats older than 1-group were only found in the Buchan Deep, in the Wash, Thames estuary and in the southern North Sea. No major concentrations of herring were located, except off the Dutch coast from IJmuiden southwards. Trawl hauls made off the northeast coast of England and Scotland also revealed significant proportions of 1-group herring. Although the over-all biomass estimate for these herring is small, the proportion of herring in the trawl hauls by weight was 30% in both the Firth of Forth and the outer Moray Firth (Buchan Deeps).

The most striking feature of the 1982 sprat survey is the very low densities recorded throughout the North Sea, with the exception of the Wash and Thames estuary which account for 30% of the total sprat biomass observed. The accuracy with which these two concentrations could be estimated obviously has a significant effect on the total estimate.

Results from the young fish survey in February 1982 indicate that there may have been a small sprat population south of 54°00'N and east of 6°30'E, an area not covered by this survey. However, it was not felt that the population in this area would significantly affect the estimate.

* Revised estimate based on re-analysis of data for the Wash and Thames estuary (cf 230 000 t in "Report of Working Group for Norway pout, sandeel and sprat fisheries in the North Sea and adjacent waters", CM1982/ASSESS:6).

The target strength of -29 dB/kg recommended in 1981 has been retained because of the lack of any further evidence, although it was felt that sprat target strength probably has a length dependence similar to that shown by herring. It was decided that any new evidence which may be available in June at the Bergen symposium should be assessed.

While the validity of the absolute estimate of sprat stock size in 1982 cannot be substantiated, the relative estimate produced by the 1982 survey is thought to be reasonably reliable. Few problems were encountered with weather, ships' logistics, or sampling by trawl. Furthermore, there were few problems in apportioning the total biomass observed to species.

An intercalibration between "Explorer" and "Corella" was carried out on 26 January in the area 54° 05'N-54° 15'N and 00° 20'E-0° 15'W and consisted of approximately six hours steaming in close company with "Corella" following "Explorer", approximately 1/4 mile astern on "Explorer's" port quarter. The intercalibration took place at 8 knots. The results of this intercalibration indicate a consistent difference between echo-integration readings of the two ships which could not be explained at the meeting. This will be considered in more detail in the report to the Statutory Meeting.

7 AUTUMN SPRAT SURVEYS - 1981

Acoustic surveys for sprats were carried out by Norwegian and Scottish research vessels in November 1981. The main objective on the survey by "Johan Hjort", which covered the Dogger Bank area, was to investigate the variability of repeated trawl hauls done in a scattering layer of the same type and density. Unfortunately, owing to bad weather, only three sets of data were obtained. There were fairly large quantities of sprats and also some herring in the area during the survey period. The distribution was very patchy. During day time sprats were often close to the bottom. For a period of one-two hours during the night the sprats rose from the bottom into depths suitable for echo-integration. This is the same behaviour as experienced in earlier surveys during November.

The survey by "Explorer" in the western part of the central North Sea was designed to provide an estimate of recruitment of 0-group sprats. Large parts of the area, however, contained a diffuse echo-trace from which fish traces could not easily be distinguished. Trawl hauls through this trace (International Young Gadoid Pelagic Trawl and Isaac-Kidd Midwater Trawl) contained sprats and 0- and 1-group herring in some areas, together with large numbers of herring larvae, the squid Alloteuthis and gobies. Allocation of the total estimated biomass between sprats, herring and other organisms was not possible. The results of both these surveys therefore indicate that November 1981 was not an appropriate time for sprat acoustic surveys in the North Sea.

REFERENCES

Beltestad, A.K.	1974	Feeding behaviour, vertical migration and schooling among 0-group herring (Clupea harengus L.) in relation to light intensity. Thesis, University of Bergen, 80pp (unpublished).
Edwards, J.I. and Armstrong, E.	1981	Measurement of the target strength of live herring and mackerel. ICES CM1981/B:26, pp5 (mimeo).
Nakken, O. and Olsen, K.	1977	Target strength measurements of fish. Rapp. P.-v. Réun. Cons. perm. int. Explor. Mer, 170: 52-69.
Olsen, K.	1980	Echo surveying and fish behaviour. Paper presented to Fish Reaction Working Group of ICES Fish Capture Committee, Reykjavik, May 1980, pp20 (mimeo).
Olsen, K.	1981	The significance of fish behaviour in the evaluation of hydro-acoustic survey data. ICES CM1981/B:22, pp25 (mimeo).

TABLE 3.1 Biomass estimates of herring in the Orkney-Shetland area July-August 1981, standardised to target strength values given in section 2.1(c).

Ship	Dates	No of Quarter Rectangles Surveyed	Herring Biomass (t)
G O Sars	15-20 July	62	110 000
G O Sars	26-28 July	21	74 000
Tridens	27 July-7 August	28	69 000
Scotia	12-31 August	65	118 000

TABLE 3.2 Biomass estimates of herring in six statistical rectangles around Shetland (see Fig. 3.1), standardised to target strengths given in section 2.1.

				Herring Biomass Estimates ($t \times 10^{-3}$)		
Year	Ship	Dates	No of Rectangles Surveyed	Plume traces	Diffuse traces near sea-bed	Total
1979	Thalassa	10-30 July	6	122.5	0	122.5*
	Explorer	7-16 August	6	2.3	?	2.3**
1980	Explorer	10-28 July	6	122.5	51.5	174.0
	Thalassa	15-25 July	2	) not available		11.6
	G O Sars	23-31 July	3	)		17.0
1981	G O Sars	14-26 July	6	110.0	0	110.0
	G O Sars	26-28 July	3.25	73.0	0	73.0
	Tridens	27 July-7 August	3.25	60.0	0	60.0
	Scotia	12-31 August	5.5	0	61.0	61.0

* Target strength uncertain owing to lack of adequate calibration

** Plume traces only

TABLE 3.3 Percentage age compositions of herring in samples taken during the 1981 acoustic survey.

Year Class	1979	1978	1977	1976	1975	1974	1973	>1973	Number of otoliths (autumn spawners)	Number of otoliths of spring spawners excluded
Winter Rings	1	2	3	4	5	6	7	>7		
Tridens (East of 4°W)	-	0.7	8.0	29.3	14.7	11.3	32.0	0.7	145	5
G O Sars (East of 4°W)	0.7	1.0	3.9	28.8	12.0	12.2	38.5	2.9	410	23
G O Sars (West of 4°W)	-	13.3	47.1	26.9	3.7	0.9	8.1	-	323	6
Scotia (East of 4°W Shetland)	-	2.5	7.6	32.7	11.2	8.2	36.3	1.5	474*	-
Scotia (Moray Firth)	1.0	79.2	10.5	6.3	1.7	0.3	1.0	-	889*	-

* Including spring spawners

TABLE 6.1

	EXPLORER Scotland	CORELLA England	JOHAN HJORT Norway
Echo-Sounder	EK 38A (Simrad)	KH MS 44	EK 38A (Simrad)
Echo-Integrator	Aberdeen Digital echo-integrator	QM (Simrad)	QD (Simrad)
Frequency	38 kHz	29.3 kHz	38 kHz
Transducer	Ceramic (in towed body)	Magneto-strictive (in towed body)	Ceramic (hull mounted)
Method of Calibration	Tungsten carbide sphere	Triangulation	Copper sphere
Calibration Constant	25 tonnes/km^2 per count/TX	6.4 tonnes/km^2 per volt per n m	1 mm reading = 0.115 tonnes/n mile^2 (20 dB gain on integrator)
Units of Integration	15 mins (every 2.5 nautical miles at 10 knots)	Volts per n m	mm per nautical mile
Survey Speed	Approx 10 knots	Approx 8 knots	10 knots
Integration Limits	7 m from surface to 3 m above sea-bed	5.5-6 m from surface to within 1-2 m of bottom	8 m from surface to within 0.5 m of bottom
Trawl	International Young Gadoid (10 mm codend)	800 mesh Engels (10 mm codend cover)	"HARSTAD" pelagic trawl (10 mm codend cover)
Towing Speed	2.5-5 knots		
Plankton Sampler	Isaac Kidd	Isaac Kidd from Cirolana 2/82	None
Towing Speed	2 knots		

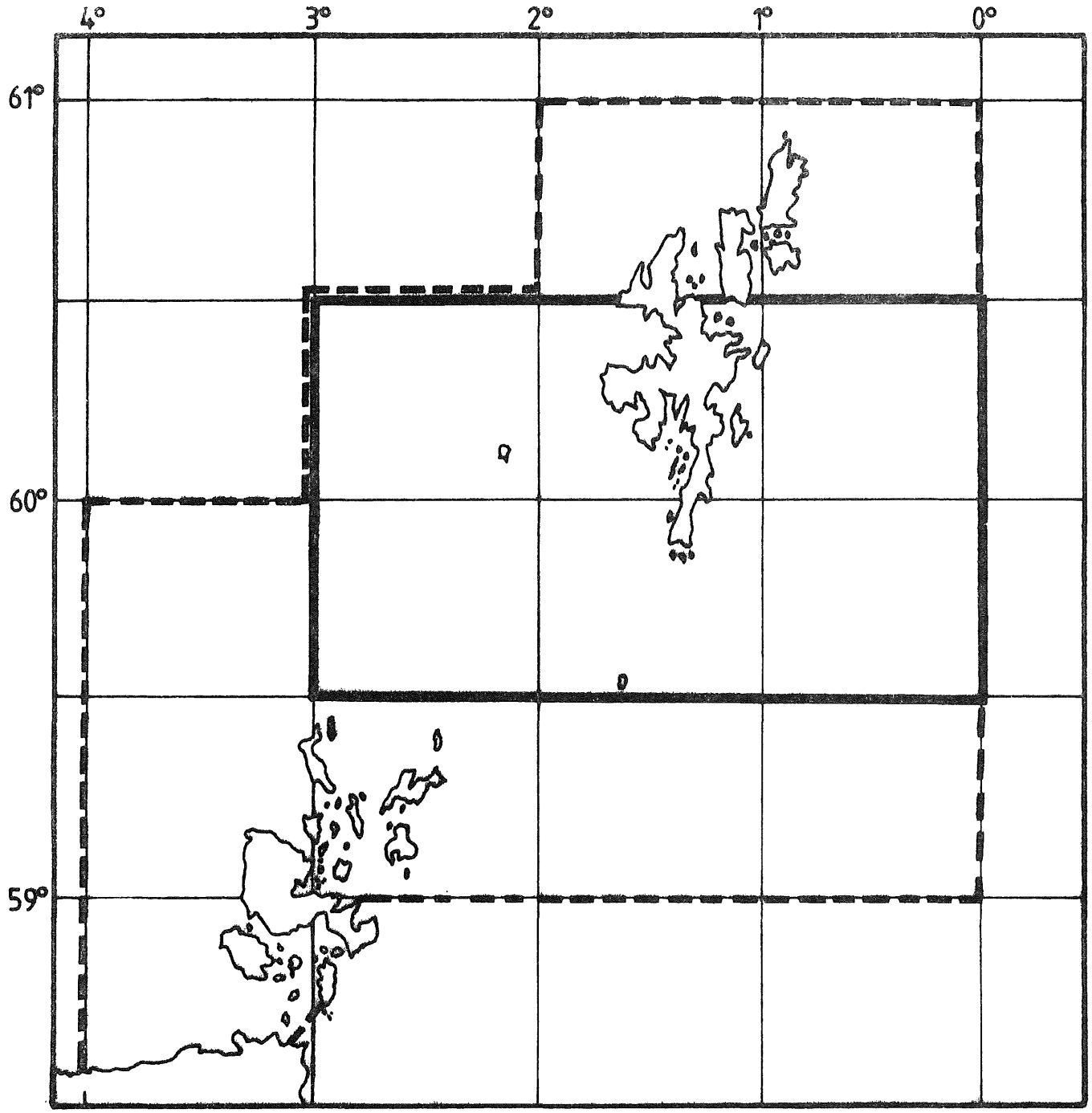

Figure 3.1 Statistical rectangles used for comparison of biomass estimates

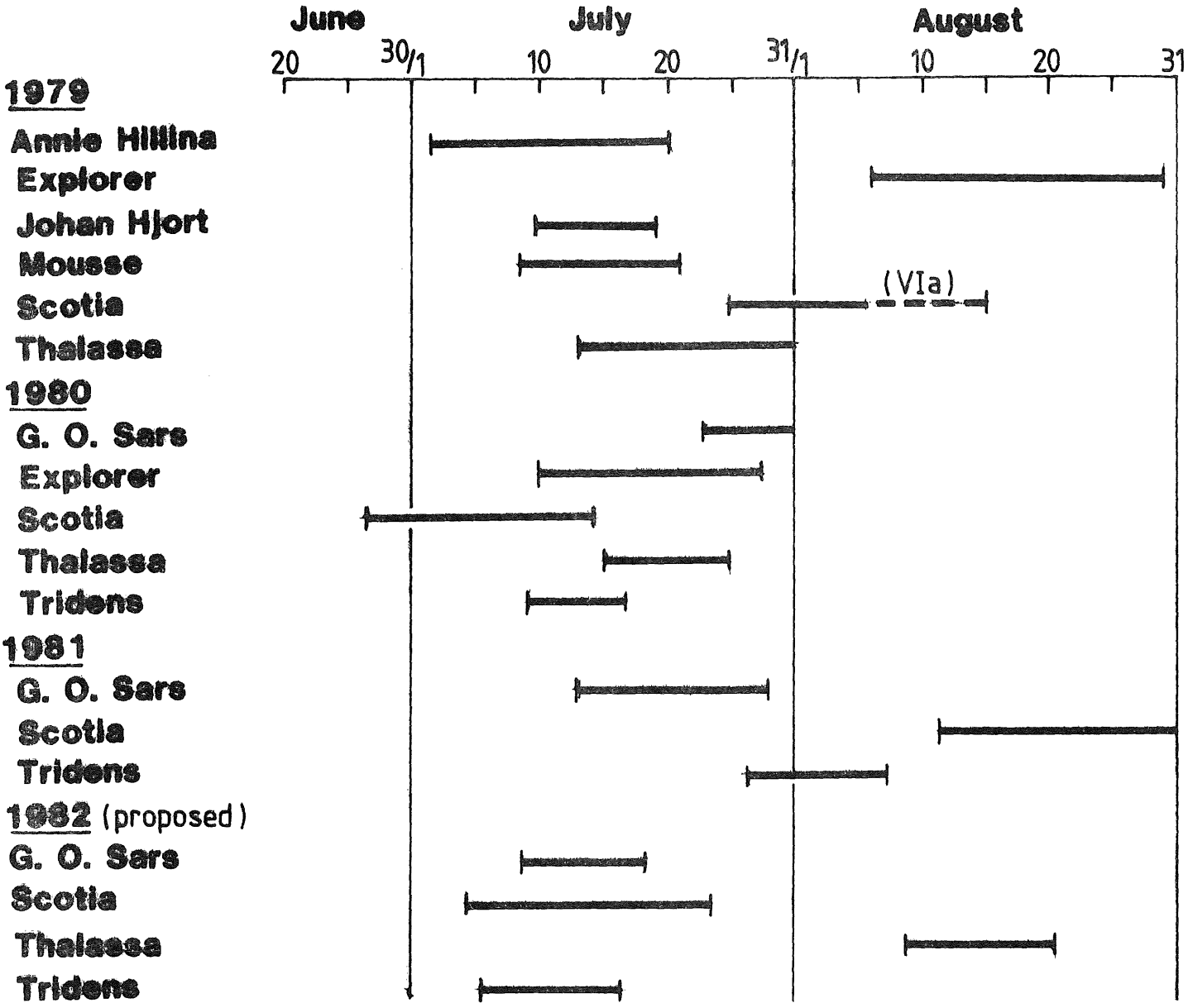

Figure 3.2 Diagram showing timing of herring acoustic surveys in 1979 – 81 and proposed surveys in 1982

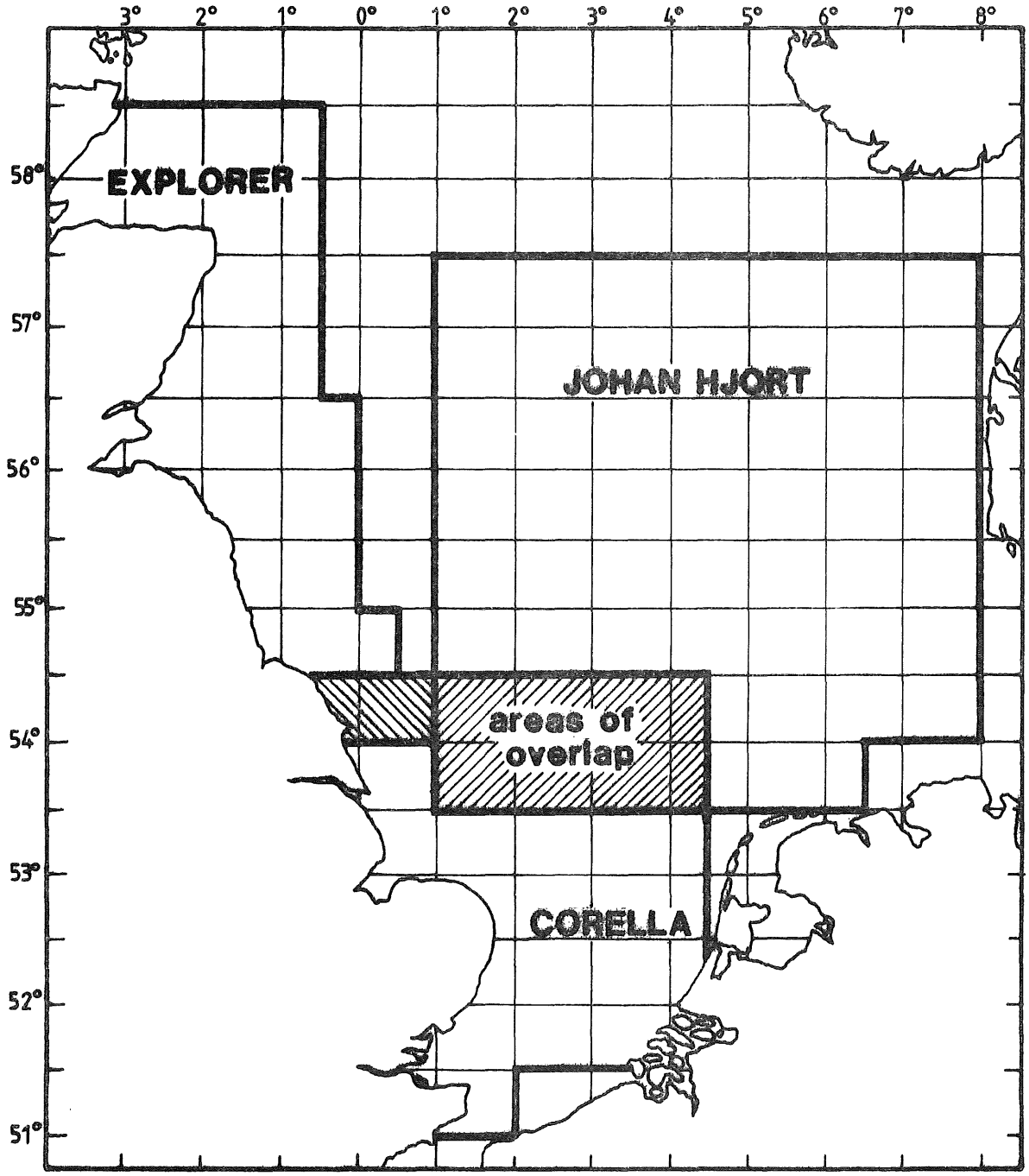

Figure 6.1 Areas surveyed by vessels participating in sprat acoustic survey, January – February 1982