COOPERATIVE RESEARCH REPORT

No. 34

REPORTS ON SURVEYS OF HERRING LARVAE IN THE NORTH SEA AND ADJACENT WATERS 1971 - 1972

https://doi.org/10.17895/ices.pub.8034

ISBN 978-87-7482-719-1

ISSN 2707-7144

International Council for the Exploration of the Sea

Charlottenlund Slot, 2920 Charlottenlund

Denmark

April 1973

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REPORT ON THE INTERNATIONAL SURVEYS OF HERRING LARVAE IN THE NORTH SEA AND ADJACENT WATERS 1971-1972

by

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1. Introduction

This Report describes the results of the 5th International Survey of Herring Larvae in the North Sea and Adjacent Waters. These surveys were started in 1967 (Saville, 1970; Boëtius and McKay, 1970; Wood, 1971; Zijlstra, 1972), initiated by a recommendation of the ICES Herring Committee in 1966 with the aim of describing changes in North Sea herring spawning stocks independently from catch per unit effort data. During autumn and winter 1971/72 five countries participated in this survey programme with the following research vessels: England: RV "Corella"; Federal Republic of Germany: RV "Anton Dohrn"; Netherlands: RV "Willem Beukelsz" and RV "Tridens"; Scotland: RV "Clupea" and RV "Explorer"; Sweden: RV "Thetis".

2. Material and Methods

The gear and its operation were in principle the same on all ships: a somewhat modified Gulf III sampler was towed in a double oblique haul, sampling the whole water column down to about 5 m above the sea floor. A detailed description of the gear in use was given by Saville (1970). Special problems with sampling gear and ancillary equipment as well as with gear and sample handling were discussed during a meeting of the Working Group on North Sea Herring Larval Surveys at IJmuiden in April 1971. The results were summarized in a report (Anon., 1971).

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Based on experiences from earlier surveys some revisions concerning the survey periods and areas were discussed at the 1971 meeting of the Working Group. This resulted in a reduction in the number of stations to be sampled in order to concentrate the effort on areas where herring larvae are to be expected, thus achieving a denser time coverage of the hatching periods in the various areas without unduly extending the total vessel time. A detailed programme of stations is found in the report of the Working Group. The survey periods are given in Table 1 (p.3), where the areas are listed according to the divisions made by the Working Group:

1) Shetland - Orkneys (north of 58°00'N)
2) Buchan (56° - 58 °N)
3) Whitby - Dogger (53° - 56°N)
4) Southern Bight - English Channel (south of 53°N)
5) Kattegat (Kobbergrund).

From the beginning of September 1971 to February 1972 a total of 1 554 stations were sampled. The results are shown in Figures 1-31 for areas, survey periods and size groups of larvae separately. The numbers of herring larvae below one square metre of sea surface are recorded for each station. For all areas, except the southern North Sea - English Channel, the size groups are as usual: < 10 mm, 10-15 mm and > 15 mm. For larvae of Downs herring, which hatch at greater body length, the Working Group decided to change the grouping slightly into: < 11 mm, 11-16 mm and > 16 mm. Yolk sac larvae were not taken into account. Charts with no or very few larvae have been omitted in this report. In cases of very few larvae in all size groups, only one chart with the total numbers of larvae per m^2 has been included, in order to present at least the area covered by the station grid.

In many cases it would have been very difficult to draw meaningful contour lines. Therefore, the larval abundance estimates are not, as they were in earlier survey reports, based on density contoured, planimetered charts. The very regular station grids make it possible to calculate the numbers of larvae within small areas, for which single stations are representative, and by adding them up, the total number of larvae was estimated for the area covered by the station grid.

Table 1. Surveys carried out during 1971/72.

Area	Period	Vessel	Country	Number of stations	
Shetland-Orkney	31 Aug - 2 Sep 1971	RV "Clupea"	Scotland	47	536
	3 Sep - 9 Sep 1971	RV "Corella"	England	94	
	16 Sep - 22 Sep 1971	RV "Explorer"	Scotland	114	
	18 Sep - 26 Sep 1971	RV "A. Dohrn"	Germany	91	
	23 Sep - 27 Sep 1971	RV "Explorer"	Scotland	70	
	1 Oct - 7 Oct 1971	RV "Explorer"	Scotland	120	
Buchan	30 Aug and 6 Sep - 8 Sep 1971	RV "Clupea"	Scotland	42	281
	10 Sep - 14 Sep 1971	RV "W.Beukelsz"	Netherlands	18	
	9 Sep - 16 Sep 1971	RV "Clupea"	Scotland	91	
	20 Sep - 30 Sep 1971	RV "Clupea"	Scotland	130	
Whitby-Dogger	7 Sep - 14 Sep 1971	RV "W.Beukelsz"	Netherlands	61	318
	14 Sep - 15 Sep 1971	RV "Clupea"	Scotland	11	
	15 Sep - 21 Sep 1971	RV "W.Beukelsz"	Netherlands	53	
	22 Sep - 23 Sep 1971	RV "Clupea"	Scotland	11	
	2 Oct - 7 Oct 1971	RV "Corella"	England	89	
	12 Oct - 20 Oct 1971	RV "Tridens"	Netherlands	93	
S.Bight-Channel	13 Dec - 22 Dec 1971	RV "Tridens"	Netherlands	95	365 (400)
	3 Jan - 26 Jan 1972 - (11 Feb 1972)	RV "W.Beukelsz"	Netherlands	127 (162)	
	4 Jan - 10 Jan 1971	RV "A.Dohrn"	Germany	56	
	18 Jan - 24 Jan 1971	RV "Corella"	England	87	
Kattegat	5 Oct - 20 Oct 1971	RV "Thetis"	Sweden	19	

3. Results

3.1 Shetlands - Orkneys

The Shetland-Orkneys area corresponds very closely to what was referred to as Northwestern North Sea in earlier reports, the southern boundary being shifted only 30' northwards. This area was sampled during three periods (31 Aug-9 Sep, 16-27 Sep, 1-7 Oct) by English, German and Scottish research vessels. Six cruises were made during these periods covering areas of different extension. As usual the western boundary

was 4°W. In early September only, an additional area west and north off Cape Wrath was covered by RV "Corella" in order to get an idea of the larval distribution west of 4°W and the exchange of larvae between Region VIa and IVa.

During the first coverage of the northwestern North Sea from 31 Aug - 9 Sep 1971 the area east of the Orkneys was worked by RV "Clupea", the area west and north of the Orkneys and southwest and northwest of the Shetlands by RV "Corella".

The distribution of herring larvae during this first period is shown separately for two different size groups in Figures 1 and 2. Larvae less than 10 mm in length were caught all around the Orkney Islands. The area of these small larvae was covered quite well by the station grid except for the part west of 4°W, where no complete delineation was to be expected. There is also some incompleteness in the coverage east of Scotland. Because of exceptionally high larval abundances in the area southeast of the Orkneys, stations which in earlier years had never given more than 10 larvae per square metre, and which had therefore been omitted in 1971 (i.e. at latitude 58°25'N), would have been very useful this year to delineate the patch of larvae. In addition some more stations east of 1°W would have been necessary for a complete coverage.

The patches of high concentrations southeast of the Orkney Islands showed up to 240 larvae per m^2, north of the Islands there were up to 760 larvae per m^2, and northwest of them up to 930 larvae per m^2.

Especially high numbers of larvae were found west and north of Cape Wrath (up to 1 160 larvae/m^2). Compared with the situation in 1970, the concentration of larvae west of 4°W was fairly separate from that east of this meridian, with only one station with 71 larvae/m^2 representing some connection.

Herring larvae from 10 - 15 mm in length (Figure 2) were found on either side of the Orkneys with main concentrations in the Pentland Firth (up to 80 larvae/m^2) and northeast of the Islands (up to 180 larvae/m^2). High numbers of larvae were also caught west off Cape Wrath (up to 187 larvae/m^2). In this size group (10 - 15 mm), patches of larvae east of 4°W were even more clearly separated from the patch west of that meridian.

No chart is given for the distribution of larvae more than 15 mm in length. In early September only a few larvae of that size were caught on single stations in the area west of the Orkneys, and large larvae were absent east of the Islands and the mainland.

During the second half of September three cruises were carried out in the northwestern North Sea, two by RV "Explorer" (16-22 Sep and 23-27 Sep) and one by RV "Anton Dohrn" (18-26 Sep). The Scottish cruises covered the area from 0° (1°) to 4°W and 58° to 59°30'N whereas the German ones operated slightly more to the north (58°30' - 60°N) and included an additional area northeast of the Shetland Islands (Figures 3-8).

As to the main concentrations of herring larvae, all three cruises resulted in generally similar pictures. But although the time periods were widely overlapping some differences between the cruises were obvious.

Small larvae (< 10 mm) were generally confined to areas west, north and northeast of the Orkney Islands, the northeastern patch extending progressively southward from the first to the third cruise.

West of the Orkneys the number of small larvae was not especially high(up to 20 larvae/m^2) during the first cruise, but increased very much during the survey period, so that on the last cruise the maximum density was 178 larvae/m^2. North of the Islands, on the other hand, more larvae were caught during the first and the last cruise than during the cruise in the middle of the survey period.

Herring larvae 10-15 mm in length were more widely distributed over the area with especially high abundance west of the Orkneys. In that area maximum frequencies increased during the period from 187 (first Scottish cruise) over 205 (German cruise) to 636 (second Scottish cruise) larvae/m^2. Obviously these high concentrations did not result from hatching in this area but from drift of larvae of the very productive areas off Cape Wrath.

In the second half of September large larvae (> 15 mm) were somewhat more numerous than during the first survey period. They were mainly confined to the areas west of the Orkneys, and within and east of the Moray Firth. However, the abundance of larvae north and northeast of the Orkneys increased during this survey period, so that during the third cruise a more general distribution was encountered.

The area of distribution for larger larvae was not covered completely. Besides the expected incompleteness to the west, the distribution was, even for small larvae, not delineated to the north in case of the Scottish cruise, and to the east in cases where the sampled area ended at 1°W.

At the beginning of October the northwestern North Sea was sampled for the third time by RV "Explorer" (1 to 7 Oct). Larvae less than 10 mm in length were very scarce at that time. The numbers of larvae only exceeded 10 per square metre on two stations east and west of the Orkney Islands and on one station in the northern part of the Moray Firth. Larger larvae, however, were more widely distributed with a main concentration east of the Orkneys (up to 245 larvae/m^2), 10-15 mm long, and 123 larvae/m^2, >15 mm long).

In the southern part of the area, within the Moray Firth and east of it, the larvae caught were nearly all large (>15 mm), similar to the situation in late September. As there were no smaller larvae caught in that particular area, the large larvae may have drifted from hatching places in the Buchan area (south of 58°N).

To summarize, large concentrations of larvae were located in the northwestern North Sea during the first half of September on either side of the Orkneys. Differing from earlier years, high numbers of larvae less than 10 mm were caught also east of the Orkneys (up to 240 larvae/m^2). Patches of larvae east of 4°W were almost separated from patches off Cape Wrath. In the second half of September larvae were scattered all over the area. The reduced station grid, which the Working Group had agreed on, did not cover the area of distribution of larvae, as was also the case in early September. Highest concentrations were located wes of the Orkneys. The significant increase in numbers of larger larvae up to values exceeding those of small larvae caught before, suggests an important transport of larvae from Region VIa into Region IVa, as also mentioned by Zijlstra (1971). At the end of September and the beginning of October, large larvae (>15 mm) appeared in the southern part of the Moray Firth and east of it, where no small larvae had been encountered before; a transport from areas south of 58°N may be the explanation.

3.2 Buchan Area

In the area between 56° and 58°N sampling was carried out from 30 August t 30 September 1971. During this period three surveys were made by research vessels from Scotland and the Netherlands (30 Aug and 6-8 Sep; 20-30 Sep).

Results from the first survey are shown in Figures 1-2. At the beginning of its cruise, on 30 August, the RV "Clupea" worked only five stations in the Buchan area, on which no larvae were caught. The vessel returned to the area for a more complete coverage from 6-8 September. At that

time, the maximum density of larvae was encountered on one of the five stations made on 30 August. The first results are, therefore, not comparable with results from the more complete coverage and were omitted in the charts. Thus a patch of recently hatched larvae (< 10 mm), confined to a small area off Buchan Ness, was not completely covered by the station grid. Densities exceeded 100 larvae/m^2 on three stations, the highest being 216 larvae per square metre. Larger larvae were very scarce, none of them being more than 15 mm in length.

The distribution of herring larvae in the Buchan area during 9-16 September is shown in Figures 15-16. Recently hatched larvae were less abundant at that time with a maximum number of 97 larvae per m^2 and were again confined to the northern part of the area, between 57°N and 58°N. Larger larvae (10-15 mm) have the same distribution pattern. The abundance of larvae of this size, however, had increased meantime to more than 50 larvae per square metre on several stations, the highest frequency being 129. Larvae of more than 15 mm in length were still insignificant.

The third survey of the Buchan area was carried out from 20 to 30 September. During this period a small area, extending roughly from 56° to 56°30'N and 1° to 2°W (Marrbank - Northeast Grounds) was sampled twice, 5 days apart, on a narrow station grid.

Sampling in the remaining area was distributed over the whole time period. In order to get a complete picture of larvae distribution in the Buchan area during late September, the data had to be combined. For this purpose the mean value for duplicate stations was taken. For presentation on a small-scale chart, numbers of larvae from the narrow station grid were combined by taking the mean numbers for those stations which were situated in an area for which one station is usually representative (mostly 10' latitude to 20' longitude).

The distribution of larvae at this time (late September) is shown in Figures 17-19. Larvae less than 10 mm had become scarce in that part of the area where they were numerous in the two previous surveys. A small patch of newly hatched larvae was encountered in the special area mentioned above. Hatching was still continuing during the survey period, as seen by a significant increase in numbers during the five days interval. Maximum density on a single station of the narrow grid was 69 larvae/m^2 on 23 September and 173 on 28 September. Maximum values calculated for a normal station area were 34 and 92 respectively. No larvae less than 10 mm were caught in this special area on 23 September, but many larvae, 10-15 mm, were recorded five days later

(up to 54 larvae/m^2 on a single station of the narrow grid). However, larvae more than 15 mm in length were not yet present in this small area; they were confined to and spread over the northern part of the Buchan area, whereas larvae of medium size (10-15 mm) were now located in the northern and southern parts but with the main concentrations confined to the area near the Scottish coast. However, another patch of larvae of this size (10-15 mm) was encountered at the eastern boundary of the sampled area with a density of up to 98 larvae/m^2. The presence of this patch has also been indicated by catch of small larvae at two stations. It was presumably not completely covered by the station grid.

To summarize, two or most likely three small spawning areas were detected in the Buchan area during the survey period. One was situated near the Scottish coast off Buchan Ness - this was sampled after maximum hatching had taken place; a second on Marrbank/Northeast Grounds which was encountered at the beginning of the hatching phase during the period of increasing numbers of small larvae; and a third between 57° and 58°N, part of which was presumably situated outside the sampled area, east of 0° - this patch was probably also sampled at the beginning of the hatching phase.

3.3 "Whitby - Dogger" Area

In the report of the Working Group of North Sea Herring Larval Surveys the area between latitudes 53° and 56°N was referred to as "Whitby - Dogger". Four surveys were carried out during September and October 1971 by research vessels from England, Netherlands and Scotland (Table 1, Figures 15-25).

During the first survey from 7-15 September herring larvae were located along the English northeast coast, with main concentrations in the Longstone area. The maximum density in that area was 147 larvae/m^2 for larvae less than 10 mm, and 31 larvae/m^2 for larvae 10-15 mm. Moreover, a few larvae were caught in the Whitby area, up to 13 larvae/m^2 of all sizes (Figures 15-16). Larvae larger than 15 mm were not present in the central North Sea during the first half of September.

Distributions of herring larvae during the second half of September are shown in Figures 17-18. Again no larvae larger than 15 mm were present. In the Longstone area where the other size groups were somewhat less abundant than before, the highest density was 115 larvae/m^2, less than 10 mm long, and 16 larvae/m^2, 10-15 mm long, and increasing in numbers in the Whitby-Dogger-Flamborough area. Newly hatched larvae were mor

or less restricted to the Whitby area with one rich station (124 larvae/m^2). During this survey the area of larvae distribution was not completely covered by the station grid.

A third survey was completed by RV "Corella" from 2-7 October. The distribution of larvae is shown in Figures 20-22. In the Longstone area recently hatched larvae (< 10 mm) were less abundant compared with the earlier cruises and up to 38 larvae/m^2 were found. In the Whitby area, however, the numbers of small larvae had increased further, up to a maximum of 198 larvae/m^2. A third patch, already indicated during the late September survey by 11 larvae/m^2, was encountered east of the river Humber, near the "Outer Dowsing" (53°40'N 00°50'E) with a maximum of 101 larvae/m^2. This patch was not completely covered by the station grid, as was also the case for another presumably small patch (up to 29 larvae/m^2) near the "Inner Well Bank Riff" (53° 55'N 2°E).

In early October larger larvae had increased in abundance in the whole area, up to a maximum frequency of 70 for 10-15 mm larvae off Flamborough Head and up to 24 larvae/m^2 larger than 15 mm on the same station. The distribution of the larger larvae extended some 50 miles from the English coast between latitudes 53°30' and 54°35'N. However, the station grid did not completely cover the area of distribution to the south. Larvae of 10-15 mm were encountered in lower densities (up to 16 larvae/m^2) off Northumberland and in the Longstone area. Altogether, the distribution pattern during 2-7 October was very much the same as in 1970 (Zijlstra, 1972).

The last survey of the western central North Sea was completed by RV "Tridens" during 12-20 October (Figures 23-25). Recently hatched larvae were encountered at generally the same places as before but in very insignificant numbers. Densities exceeded 10 larvae/m^2 for the area near the outer Dowsing only. Larger larvae were at this time even more scattered than before and were caught in somewhat smaller numbers.

To summarize, larval production started in the Longstone area between latitudes 53° and 56°N, where highest densities were encountered during the first survey (7-13 September). Production decreased there during the whole period of larval surveys and was almost completed at the time of the last cruise (12-20 Oct). The most important spawning ground was in Whitby area, where the highest number of recently hatched larvae were caught from 15-23 September. Two other, presumably smaller hatching places, which were not completely covered by the station grid, were located off the river Humber and near the Inner Well Bank Riff (south

of Dogger). The abundance of larger larvae increased during September and early October. They were dispersed more or less over the whole area sampled, with main concentrations around Flamborough Head.

3.4 Southern Bight - English Channel

Extensive surveys were carried out in the southern North Sea and eastern English Channel during December 1971 and January 1972 by research vessels from England, Germany, and the Netherlands. A very complete station grid in the areas south of 52°N between 4°E and 2°W was worked by RV "Tridens" from 13-20 December 1971. As may be seen from Figures 26-27 herring larvae were very scarce in that region. No larvae longer than 15 mm were present at all. The maximum number of larvae of other sizes was $7{,}6/m^2$, caught in the Straits of Dover.

Another extensive sampling in the Downs area was carried out during the first half of January 1972 by research vessels from the Netherlands and the Federal Republic of Germany. RV "Anton Dohrn" covered the area south of 52°30'N between 4 and 10 January whereas RV "W. Beukelsz" worked an area extending more to the north (up to 53°45'N) during 3 January to 11 February 1972. However, the largest part of the area was covered during 3 to 13 January. Only north of 52°N was sampling carried out with several interruptions until 11 February. This cruise is, therefore, largely comparable with the German one and both were combined in Figures 28-29, showing solid symbols for the stations worked in January and open symbols for those in February.

During the first half of January larvae were still scarce and scattered throughout the area. Densities were in many cases less than one larvae/m^2 and never exceeded five larvae/m^2 of all sizes.

The last survey of the area south of 52°30'N was completed by the English research vessel during 18 to 24 January 1972. Figure 30 shows the number of herring larvae of all sizes which obviously were very insignificant.

It seems noteworthy that some few recently hatched larvae were still encountered in early February north and west off Texel (Figure 29).

3.5 Kattegat (Kobbergrund)

In this area only one survey was made by the Swedish RV "Thetis" from 5 to 20 October 1971 (Figure 31). Larvae were taken mainly in the southern part of the area. Numbers were very low and the size of the larvae always less than 10 mm with one exception only (near the Danish

coast). In previous years concentrations of mainly recently hatched larvae were encountered during the second half of October along the Swedish coast between approximately 57°30' and 56°30'N, extending some 30 miles from the coast. In 1971 this area was not so densely covered and was sampled somewhat earlier, so that hatching might have taken place later on. However, spawning was probably poor, as already in 1970 (Zijlstra, 1972).

4. Quantitative Estimates

Considerable changes in the distribution of herring larvae and in the size of the herring spawning stocks in the North Sea are becoming obvious, when the results for the 1971/72 season are compared with earlier years. Some relative figures for the size of the spawning stocks in 1971/72 may be derived from Table 2 (p.12), giving the estimates of larval abundance for the three different size categories by spawning area and survey period. Difficulties in obtaining meaningful larval abundance estimates for the northwestern North Sea have already been discussed by Wood (1971) and Zijlstra (1972). As it is not yet possible to include the whole spawning area off Cape Wrath and off Lewis (Hebrides)into the survey programme, the Working Group on North Sea Herring Larval Surveys agreed on the 4°W as the western boundary of the area to be sampled. Occasionally surveys should be made in the area west of 4°W in order to get some information about the exchange of larvae between Region VIa and Region IVa.

Results from the 1970 and 1971 surveys suggest a more or less continuous distribution of recently hatched herring larvae in the later part of the season and a considerable transport of larvae from Region VIa into Region IVa. Nevertheless, larval abundance estimates were given for the area off Cape Wrath and the remaining parts of the northwestern North Sea separately, as was done by Wood (1971) and Zijlstra (1972), in order to get some rough figures for between-years comparisons.

The area off Cape Wrath has been sampled to a greater extent in the last two years. Recently hatched larvae were more abundant in early September 1971 (913×10^9) than in late September 1970 (386×10^9). The opposite was the case for larger larvae: 197×10^9 larvae in 1971 and $1\,132 \times 10^9$ larvae in 1970. These differences may be explained by the difference in time; in 1971 hatching was not as complete at the time of sampling as in 1970.

Table 2. Estimates of larval abundance.

Area	Period	Abundance of larvae x 10^{-9}			Total
		< 10 mm	10-15 mm	> 15 mm	
Cape Wrath (Region VIa)	3 Sep - 9 Sep 1971	913	195	2	1110
Shetland-Orkneys (Region IVa)	31 Aug - 9 Sep 1971	1400	380	3	1783
	16 Sep - 27 Sep 1971	160	541	109	810
	1 Oct - 7 Oct 1971	26	516	348	890
Buchan	6 Sep - 8 Oct 1971	208	1	0	209
	9 Sep - 16 Sep 1971	105	173	3	281
	20 Sep - 30 Sep 1971	78	155	66	299
Whitby-Dogger	7 Sep - 15 Sep 1971	108	14	0	103
	15 Sep - 23 Sep 1971	148	99	0	247
	2 Oct - 7 Oct 1971	374	184	56	614
	12 Oct - 20 Oct 1971	47	150	54	251
		< 11 mm	11-16 mm	> 16 mm	Total
S.Bight-Channel	13 Dec - 22 Dec 1971	6,4	3,2	0	9,6
	3 Jan - 26 Jan 1972	3,1	4,8	0,1	8,0
	18 Jan - 24 Jan 1972	0	1,4	1,3	2,7

Larval abundance estimates in the Shetland-Orkneys area are given in Table 2 (p.12) for the three different survey periods. The beginning of larval production was missed by these survey periods, as the highest numbers of herring larvae were encountered during the first cruise in early September. During the second period three cruises were carried out, each covering a somewhat different area and time period. The abundance estimates were based on mean values for areas sampled two or three times, supplemented by values derived for parts of the area sampled only once during the period.

Since the cruise of RV "Anton Dohrn" in the middle of the survey period was preceded and followed by cruises of RV "Explorer", some comparison of total abundance figures seems feasible. However, as there were differences in area, the comparison had to be restricted to an area sampled on all three cruises. The calculated numbers of herring larvae in this restricted area are given in Table 3 below for different size groups, based on sampling by RV "Explorer" (mean of both cruises) and RV "Anton Dohrn".

Table 3. Between ships comparison.

Size group	Calculated numbers of herring larvae x 10^{-9}			Total
	<10 mm	10-15 mm	>15 mm	
"Explorer"	129	559	39	727
"A. Dohrn"	171	478	58	707
Mean	150	519	48	717
Deviation from mean	14 %	8 %	21 %	1,4 %

The comparison between the vessels showed good agreement of the values for the total number of larvae. The deviation from the total mean, only 1,4 %, is not statistically significant (χ^2 - test). The deviation is somewhat higher for separate size groups, possible due to limitation in the comparability of length measurements by different persons.

For the northwestern North Sea, larval abundance estimates resulted in values of the same order of magnitude as in 1970 and were relatively high, when compared with the first three seasons of the international surveys (1967-1969). Considering only small larvae as an

index for spawning stock size, Zijlstra (1972) mentioned that there was no clear indication of a recovery of the northern North Sea herring stock since its decline in 1966 (Anon., 1970) up to 1970. However, he pointed out a re-appearance of small concentrations of larvae in the Buchan area.

In 1971 appreciable concentrations of herring larvae were found in the area east of the Orkneys, where they had become scarce in the last seasons, and three patches of larvae were encountered in the Buchan area, resulting in some considerable abundance values (Table 2). These results seem to give some indication of a recovery in the northwestern North Sea herring stock. It will be of special interest during the next series of surveys to observe whether this recovery is confirmed.

The most complete coverage of the hatching period in 1971 was made in the Whitby - Dogger area. Abundance estimates for herring larvae in that area are available for four periods (Table 2).

It is obvious from Table 2 that larvae were fairly abundant in 1971 compared with 1967-69. However, the especially high value for 1970 was not reached. As already stated in Section 3.3, the distribution of larvae was very similar to that in 1970. Again no recovery of the old Dogger patch was indicated. A fairly strong patch of larvae in the Longstone area, which was observed in 1970 for the first time, appeared in 1971.

A very considerable difference between 1971 and the two previous years will be noticed, when comparing abundance estimates for the Downs area. During three surveys periods extremely low numbers of larvae were caught in the Southern Bight and eastern English Channel in 1971 (Table 2). The recovery of the Downs stock since 1969 was not continued or stabilized, but the abundance fell back to almost zero.

No larval abundance estimates were available for the Kattegat (Kobbergrund) because of the incomplete coverage of the area. However, it seems likely that the old Kattegat spawning stock has almost disappeared. In 1971 the area was populated with Danish local herring, originally spawning in the fjords or very near to the coast (Ackefors, pers.comm.).

5. Summary

In the northwestern North Sea the highest densities of herring larvae were encountered west of the Orkneys and off Cape Wrath. A more or less continuous distribution of recently hatched larvae east and west of 4°W in the later periods of the season, and a transport of larvae from Region VIa to Region IVa is most likely.

East of the Orkneys herring larvae re-appeared in appreciable concentrations, and for the first time since 1967 patches of high larval density appeared in the Buchan area.

The distribution of herring larvae in the Whitby - Dogger area was very much the same as in 1970. Abundance estimates resulted in somewhat lower values than in 1970 but was still fairly high compared with the years 1967-1969.

The recovery of the Downs spawning stock was not continued in 1971/72. Abundance estimates of larvae were as low as in 1968/69.

No abundance estimates for the Kattegat (Kobbergrund) were available for 1971.

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Figure 1.

Numbers of larvae < 10 mm below 1 m^2

Northwestern North Sea incl. Buchan Area.

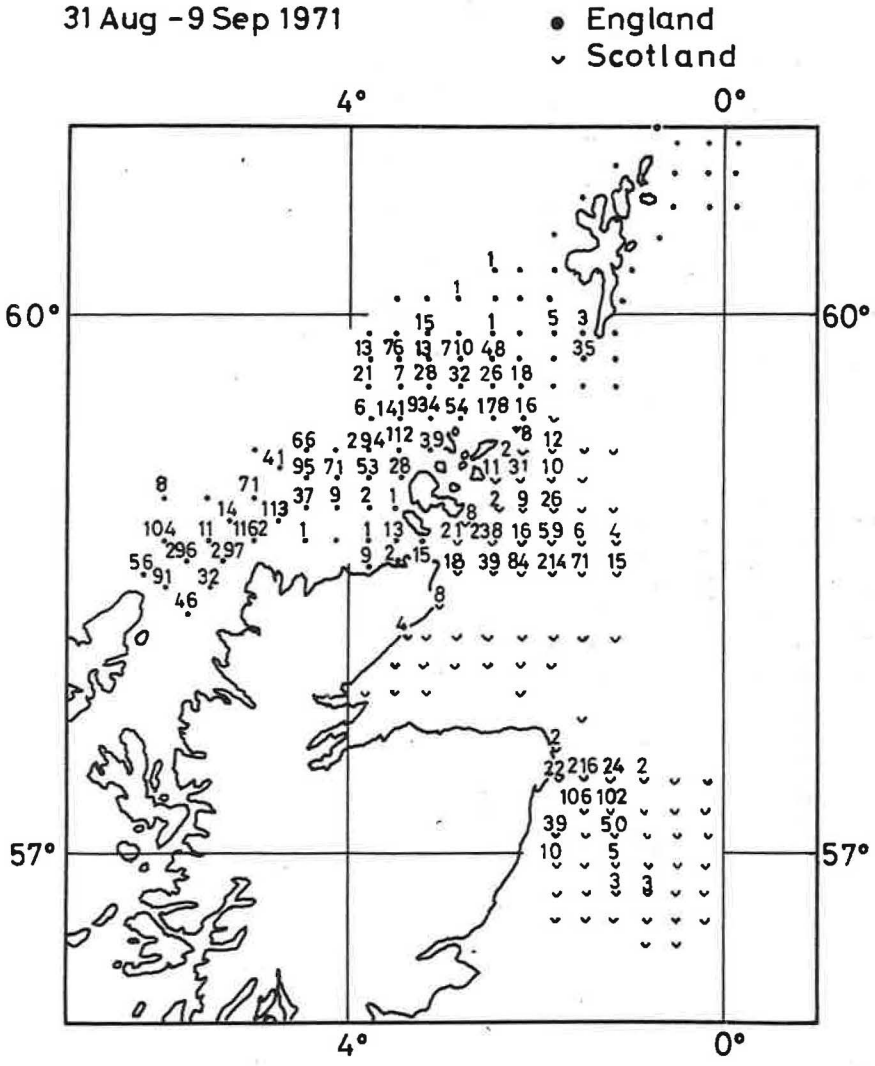


Figure 2.

Numbers of larvae 10-15 mm below 1 m^2

Northwestern North Sea incl. Buchan Area.

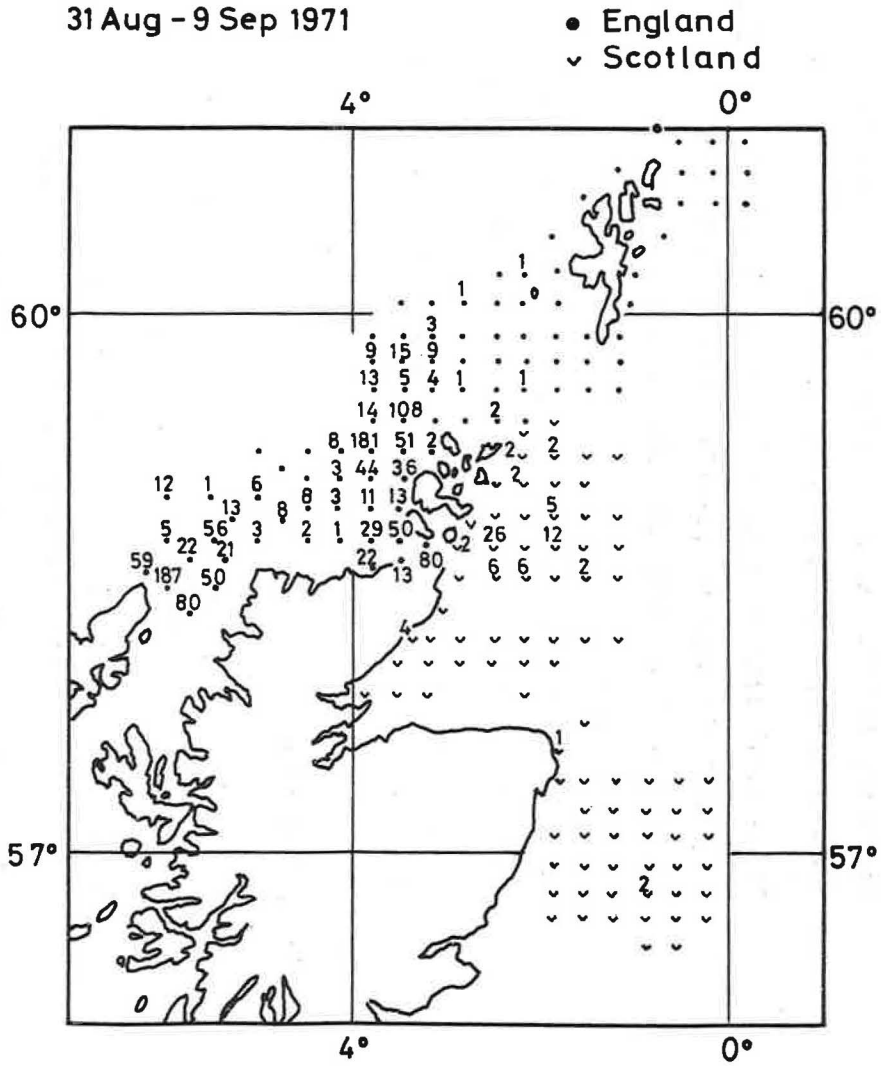


Figure 3.

Numbers of larvae < 10 mm below 1 m^2

Northwestern North Sea.

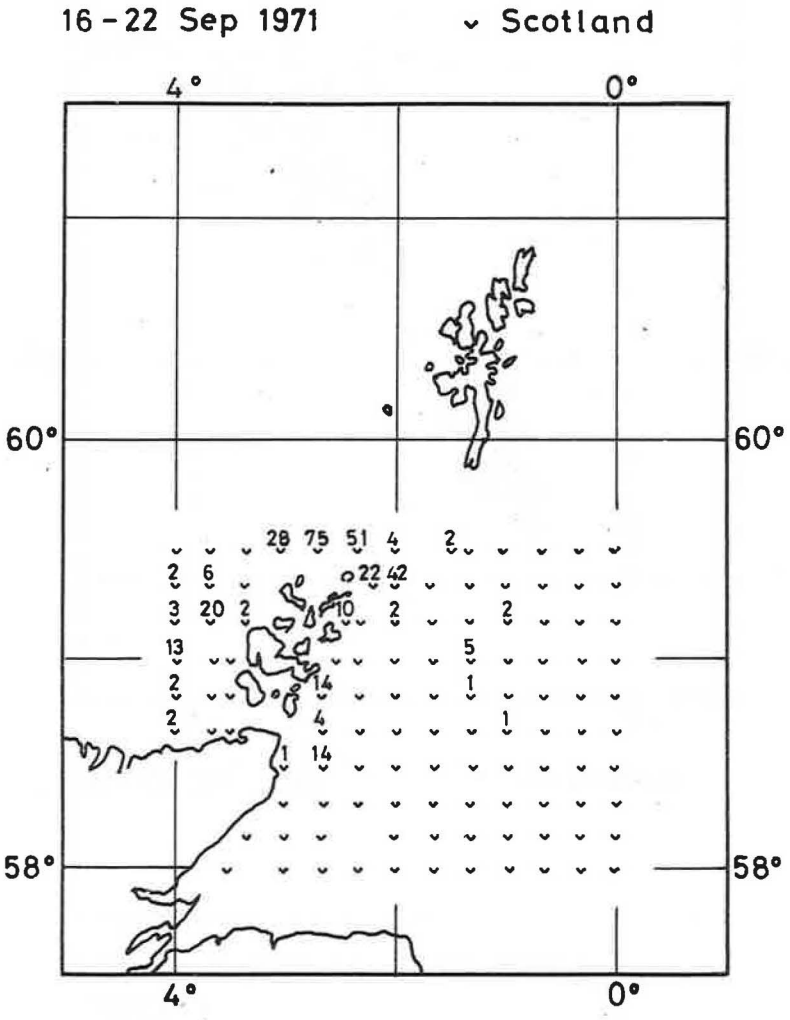


Figure 4.

Numbers of larvae 10-15 mm below 1 m^2

Northwestern North Sea.

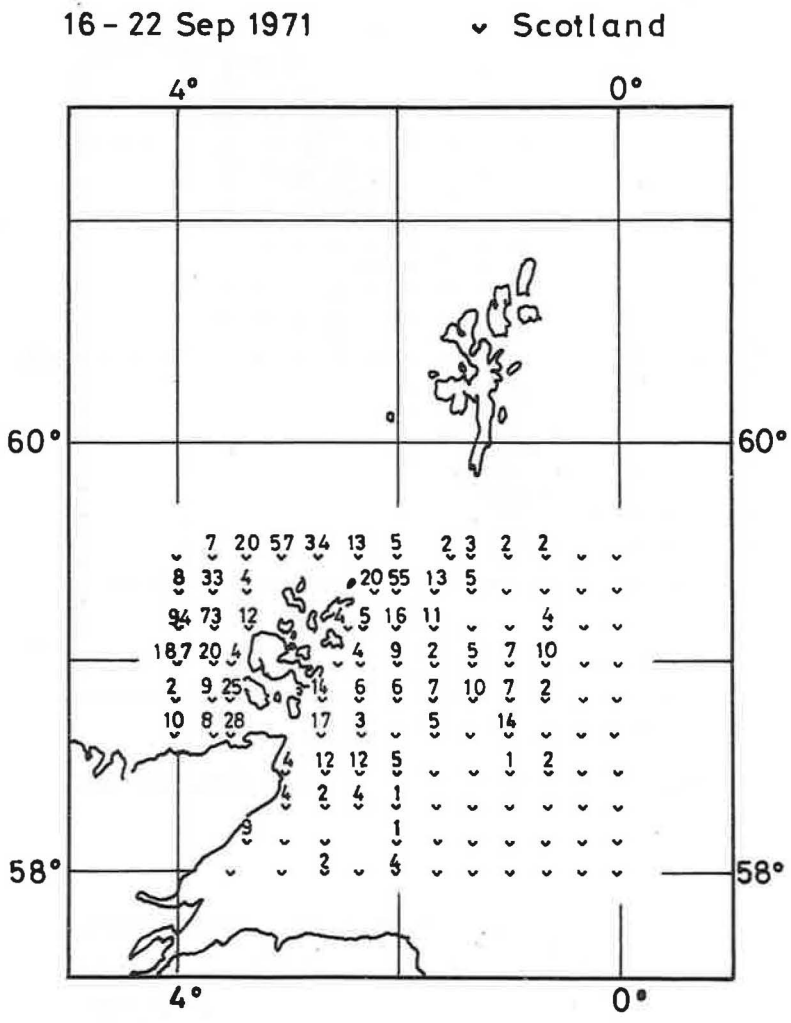


Figure 5.

Numbers of larvae > 15 mm below 1 m^2

Northwestern North Sea.

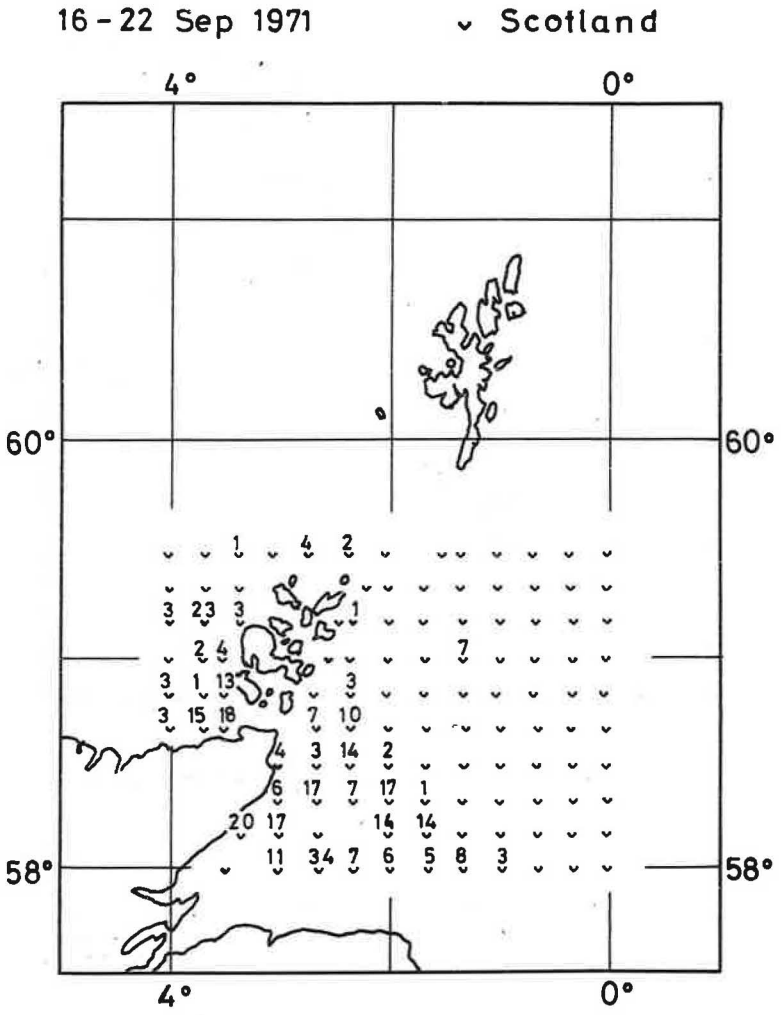


Figure 6.

Numbers of larvae < 10 mm below 1 m^2

Northwestern North Sea.

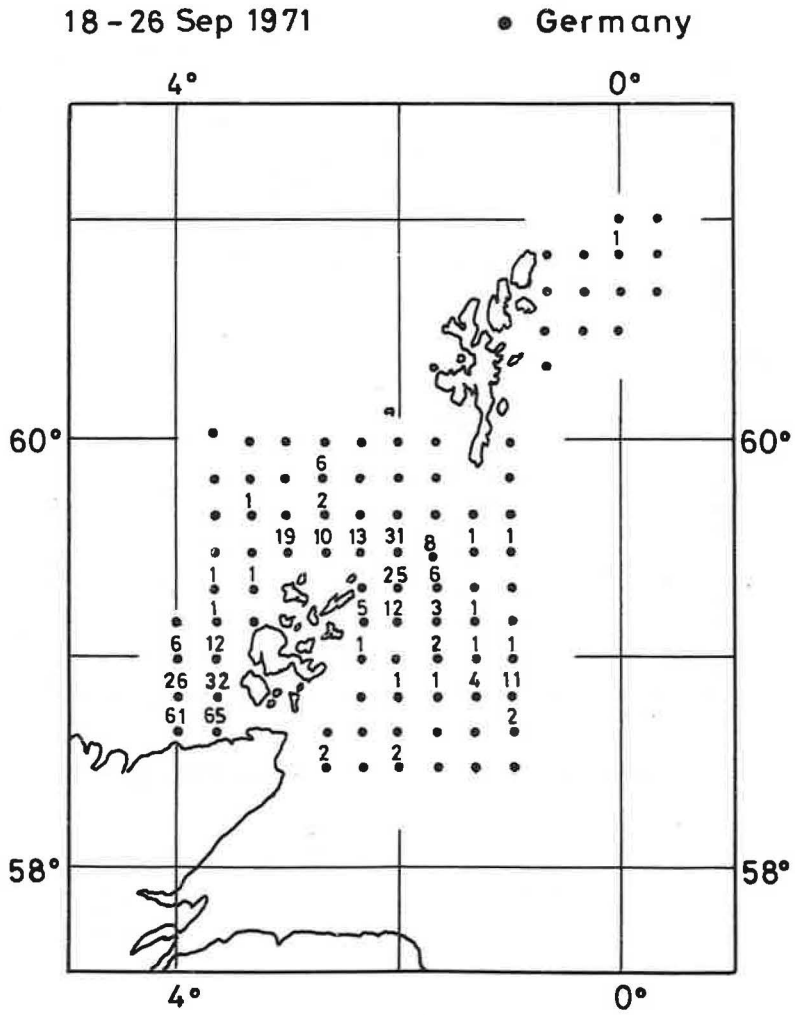


Figure 7.
Numbers of larvae 10-15 mm below 1 m^2
Northwestern North Sea.

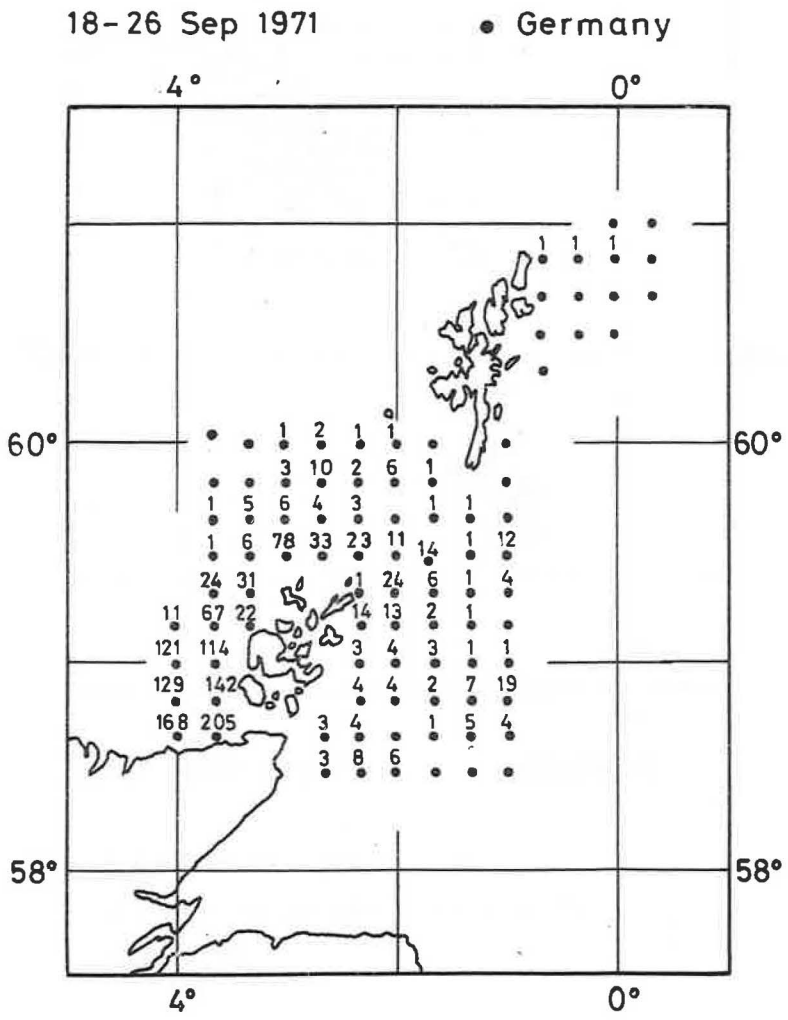


Figure 8.
Numbers of larvae > 15 mm below 1 m^2
Northwestern North Sea.

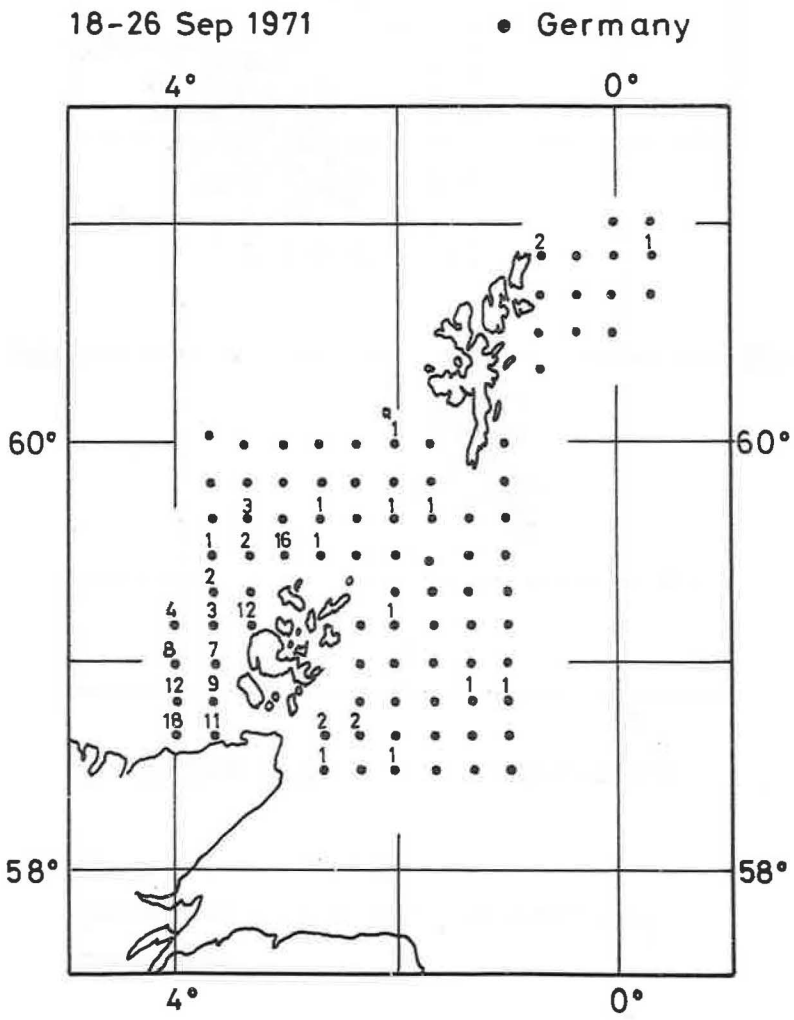


Figure 9.

Numbers of larvae < 10 mm below 1 m^2

Northwestern North Sea.

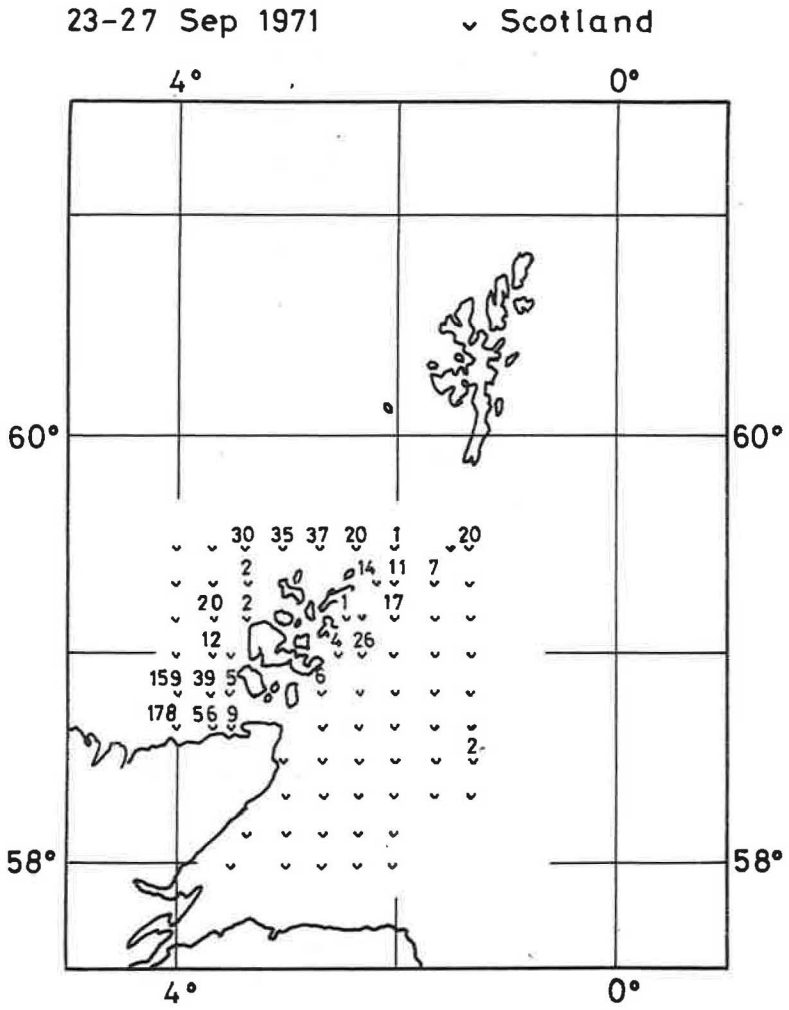


Figure 10.

Numbers of larvae 10-15 mm below 1 m^2

Northwestern North Sea

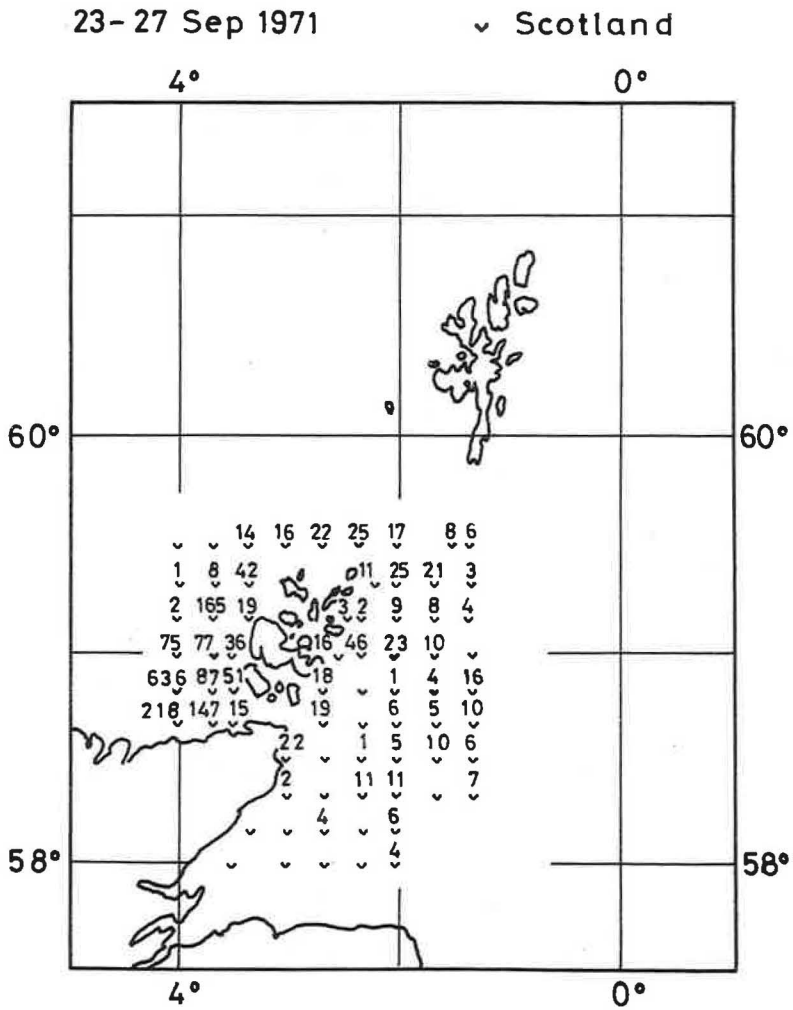


Figure 11.

Numbers of larvae > 15 mm below 1 m^2

Northwestern North Sea.

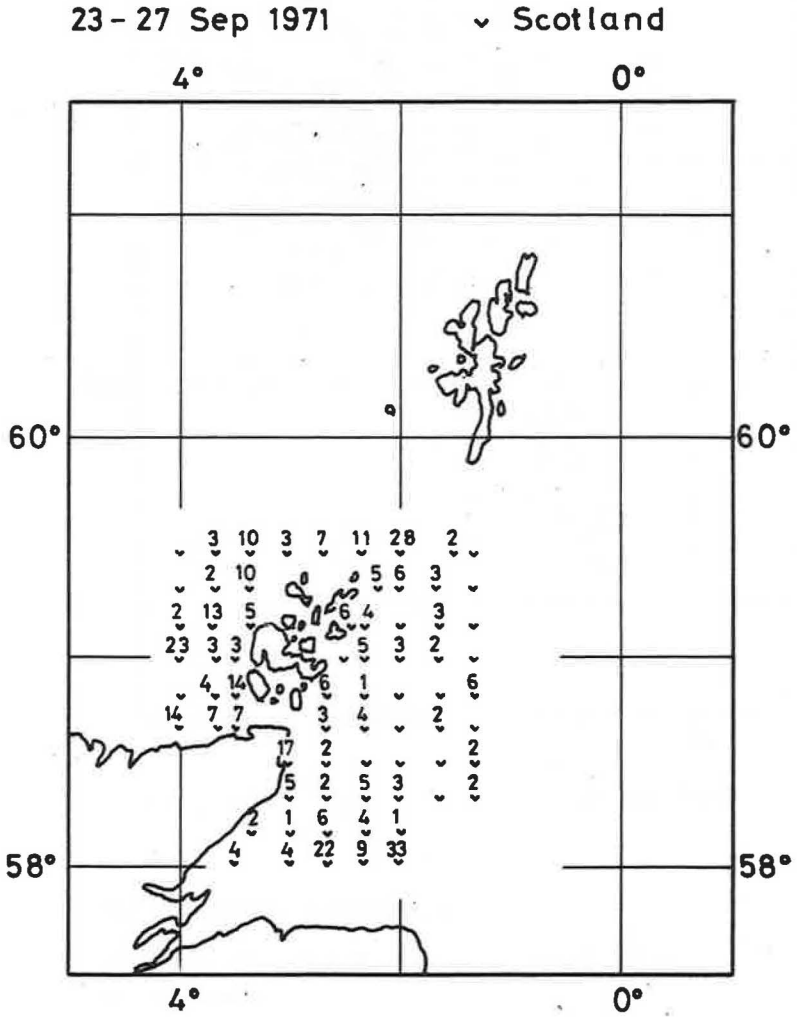


Figure 12.

Numbers of larvae < 10 mm below 1 m^2

Northwestern North Sea.

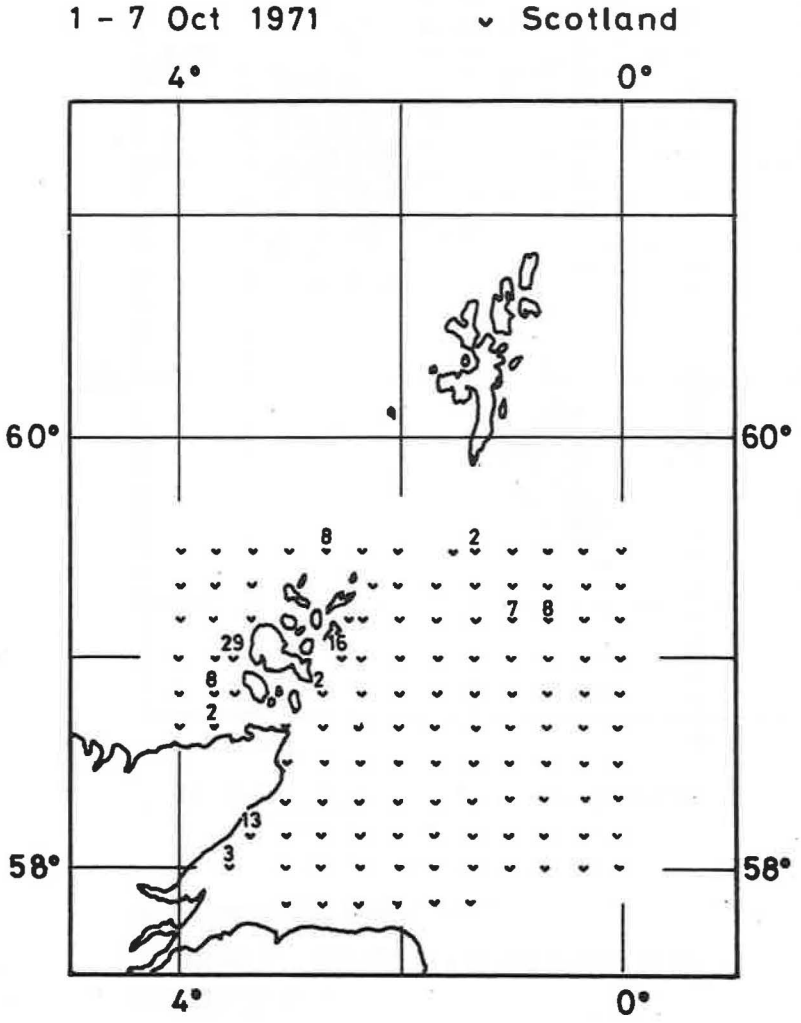


Figure 13.

Numbers of larvae 10-15 mm below 1 m^2

Northwestern North Sea.

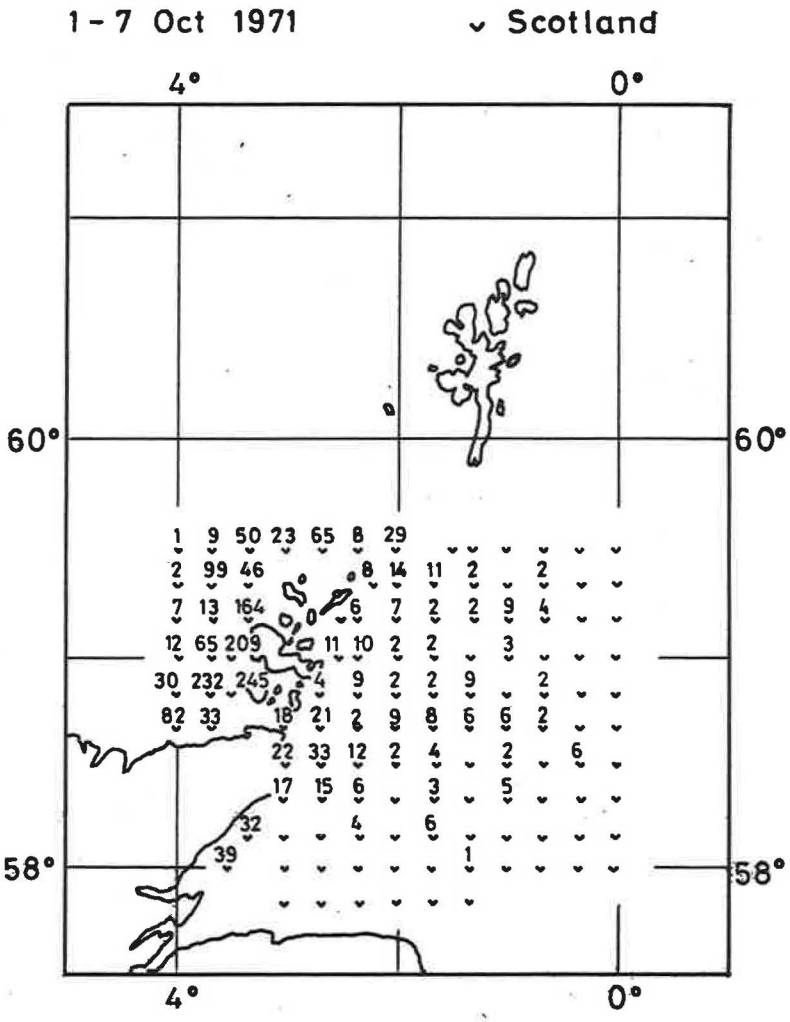


Figure 14.

Numbers of larvae > 15 mm below 1 m^2

Northwestern North Sea.

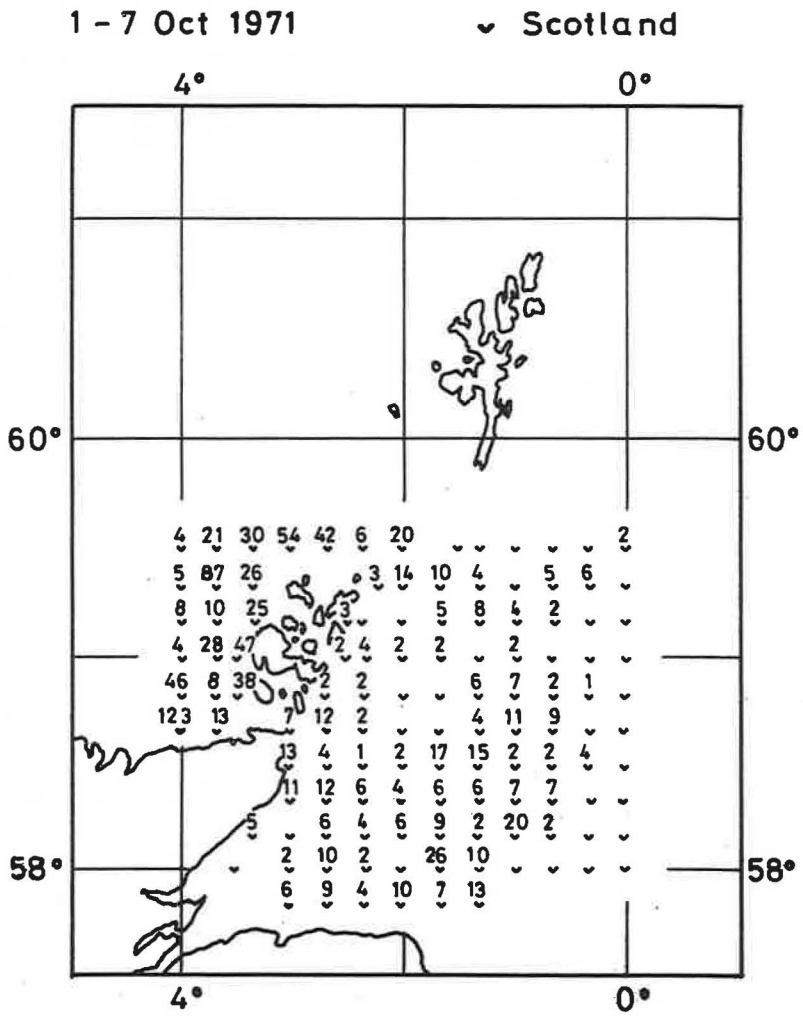


Figure 15.

Numbers of larvae < 10 mm below 1 m^2

Western central North Sea.

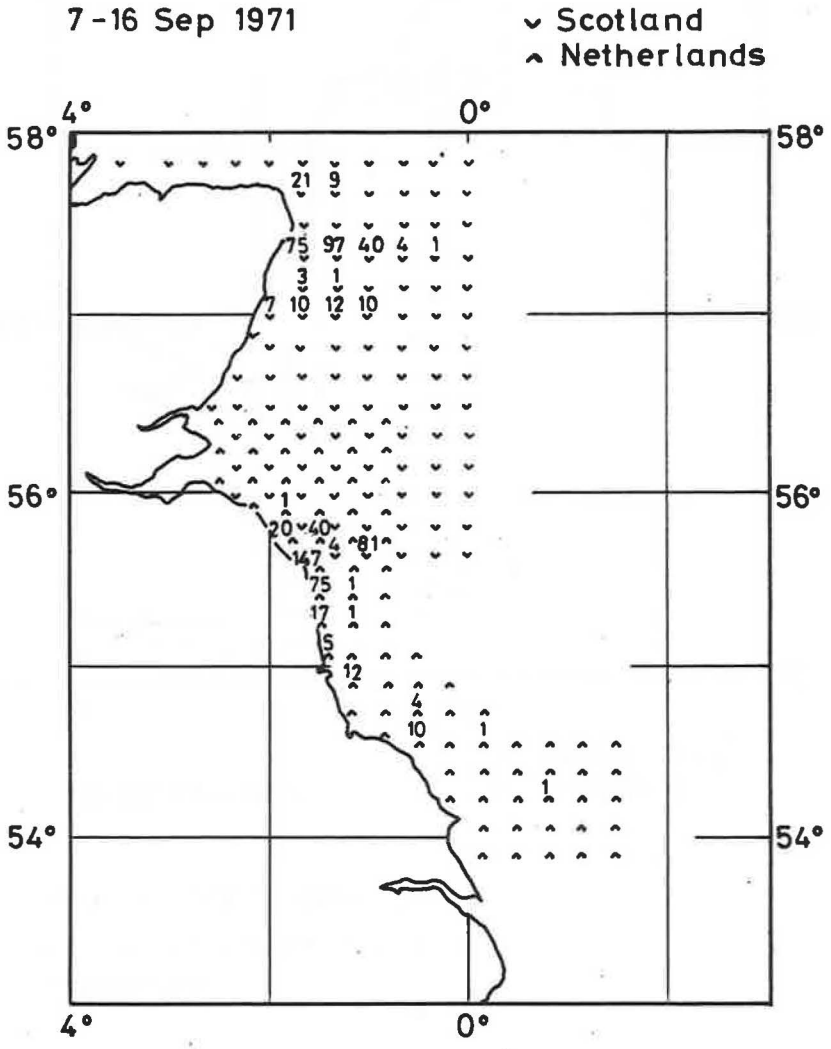


Figure 16.

Numbers of larvae 10-15 mm below 1 m^2

Western central North Sea.

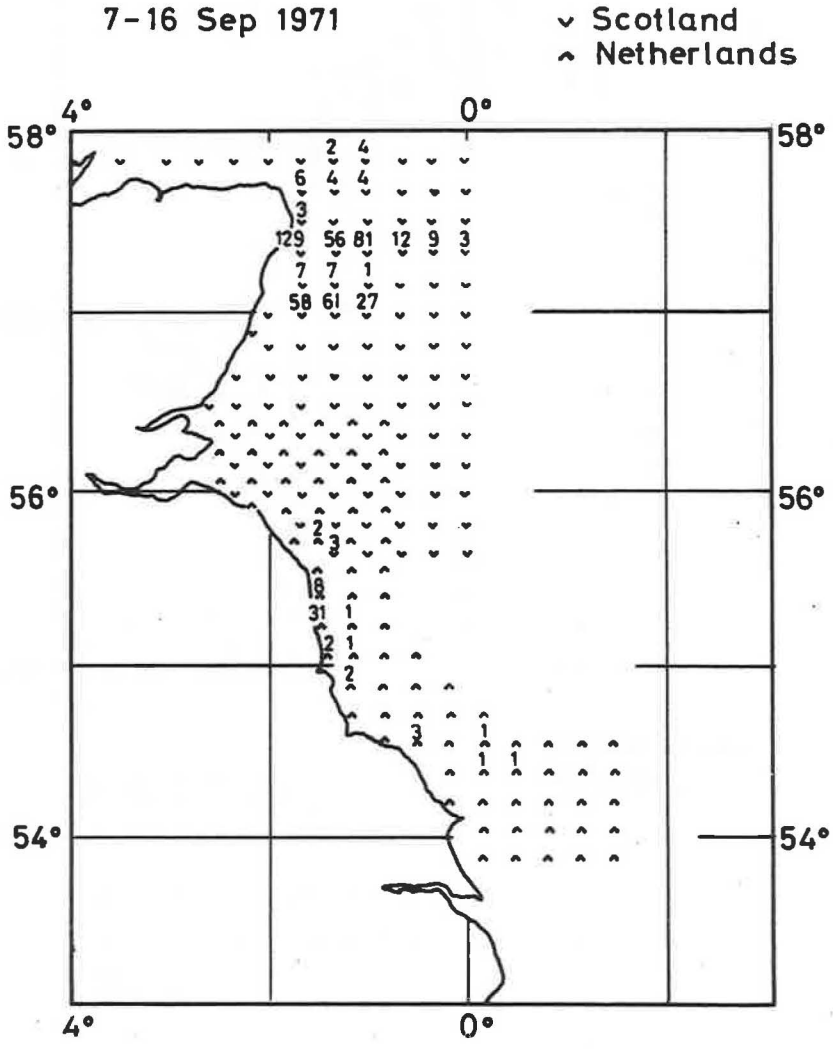


Figure 17.

Numbers of larvae <10 mm below 1 m^2

Western central North Sea.

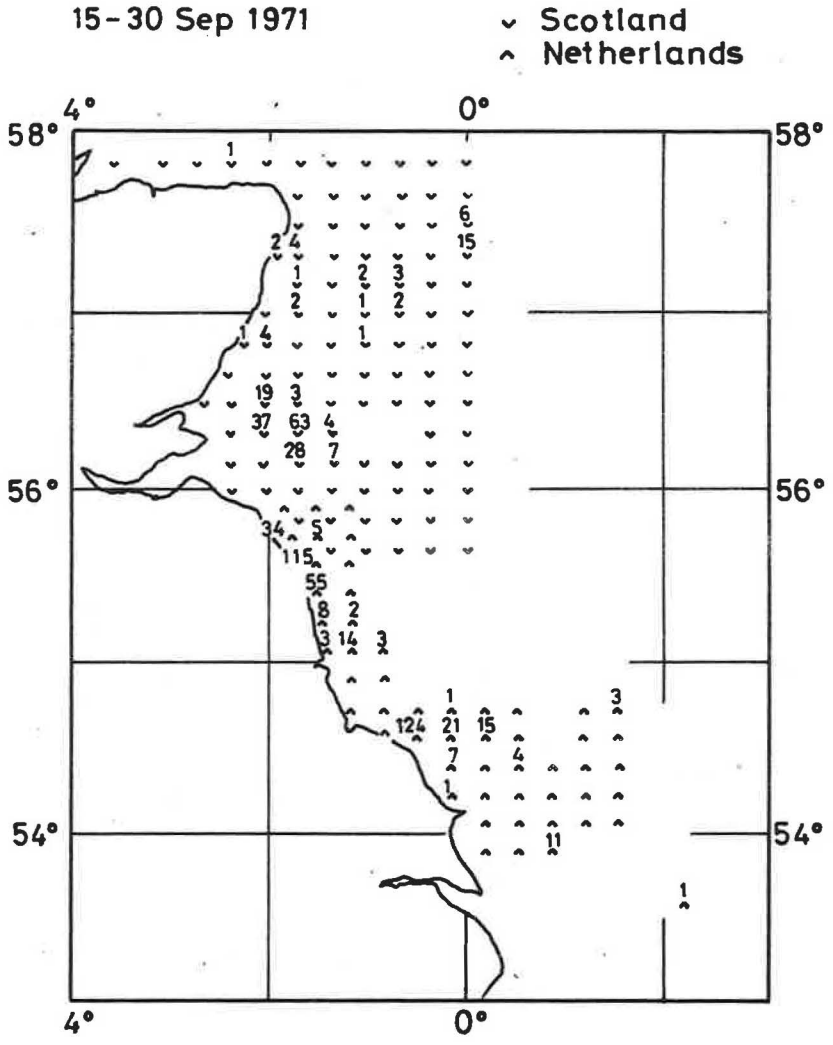


Figure 18.

Numbers of larvae 10-15 mm below 1 m^2

Western central North Sea.

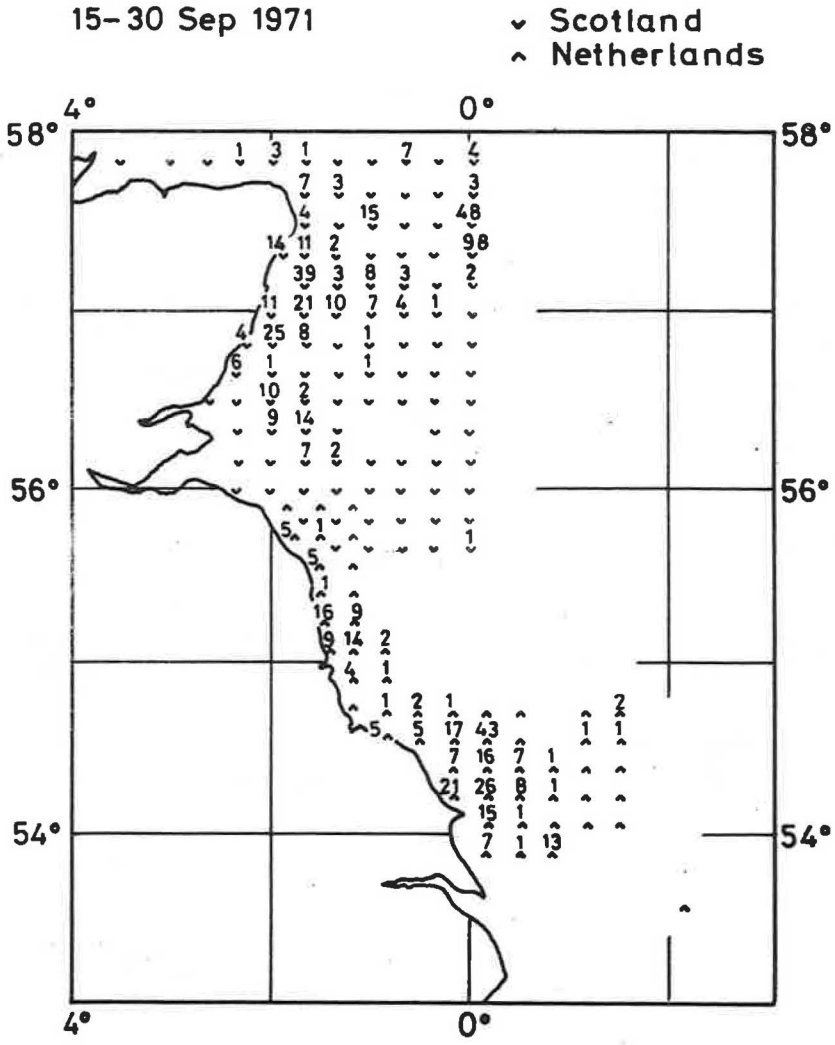


Figure 19.

Numbers of larvae > 15 mm below 1 m^2

Western central North Sea.

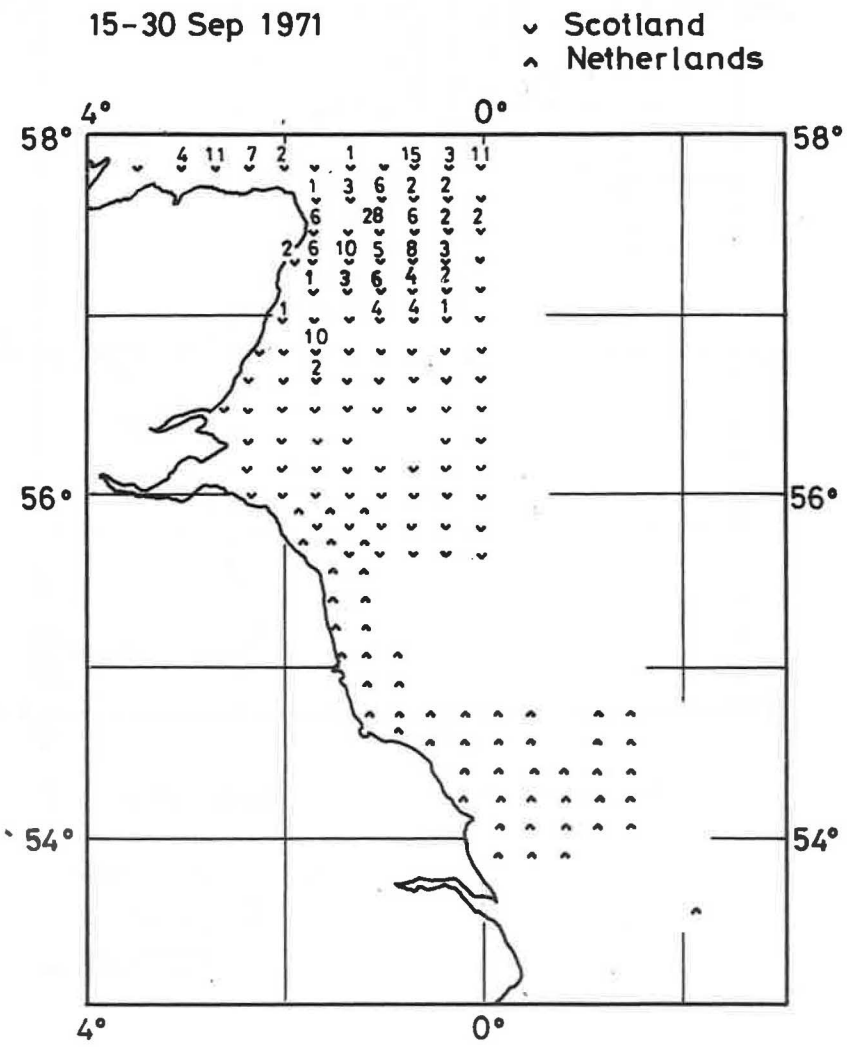


Figure 20.

Numbers of larvae < 10 mm below 1 m^2

Western central North Sea.

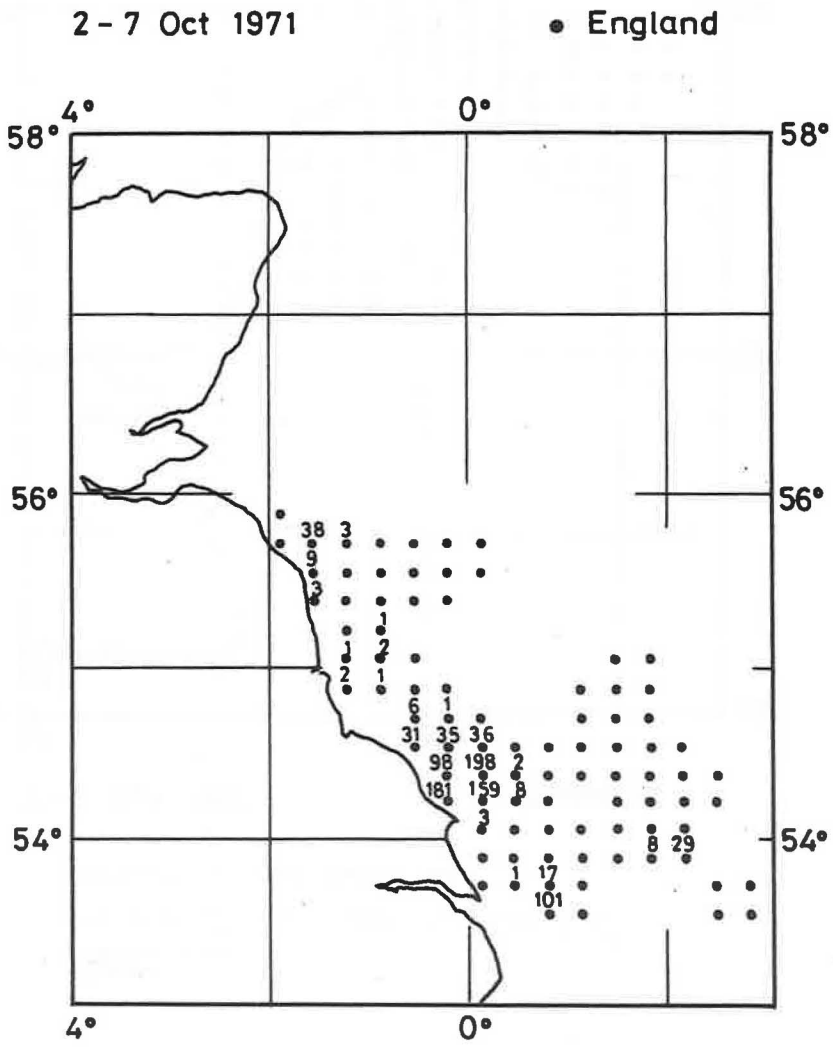


Figure 21.

Numbers of larvae 10-15 mm below 1 m^2

Western central North Sea.

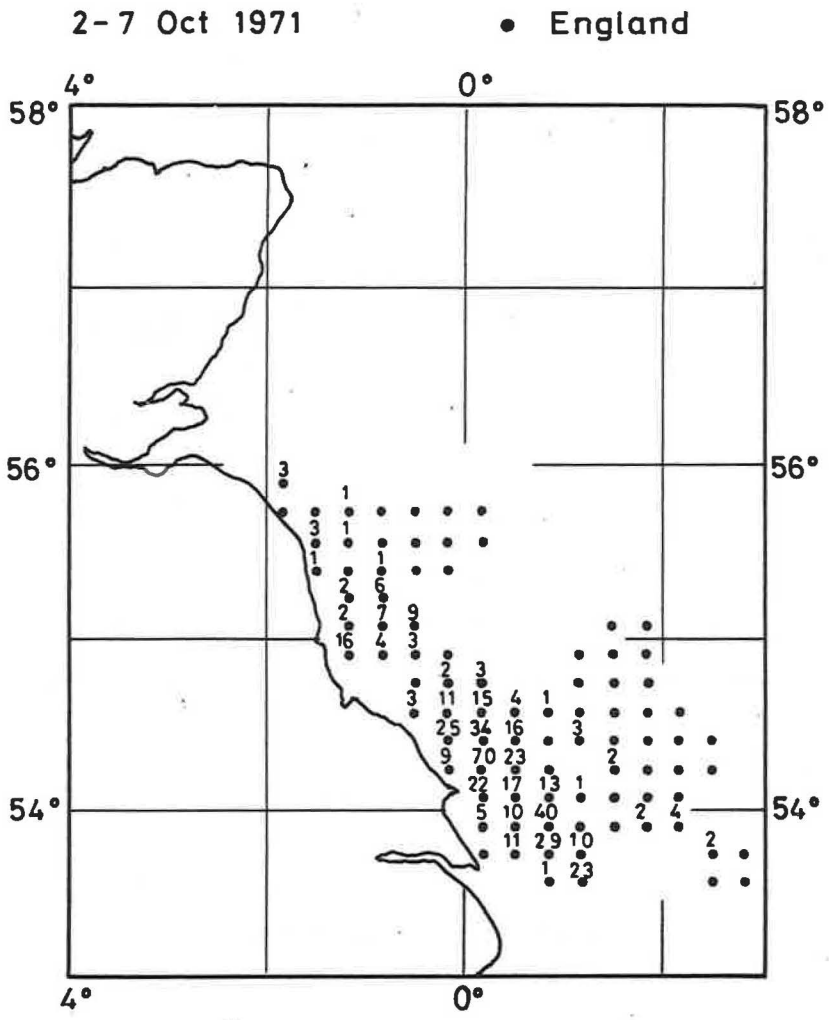


Figure 22.

Numbers of larvae >15 mm below 1 m^2

Western central North Sea.

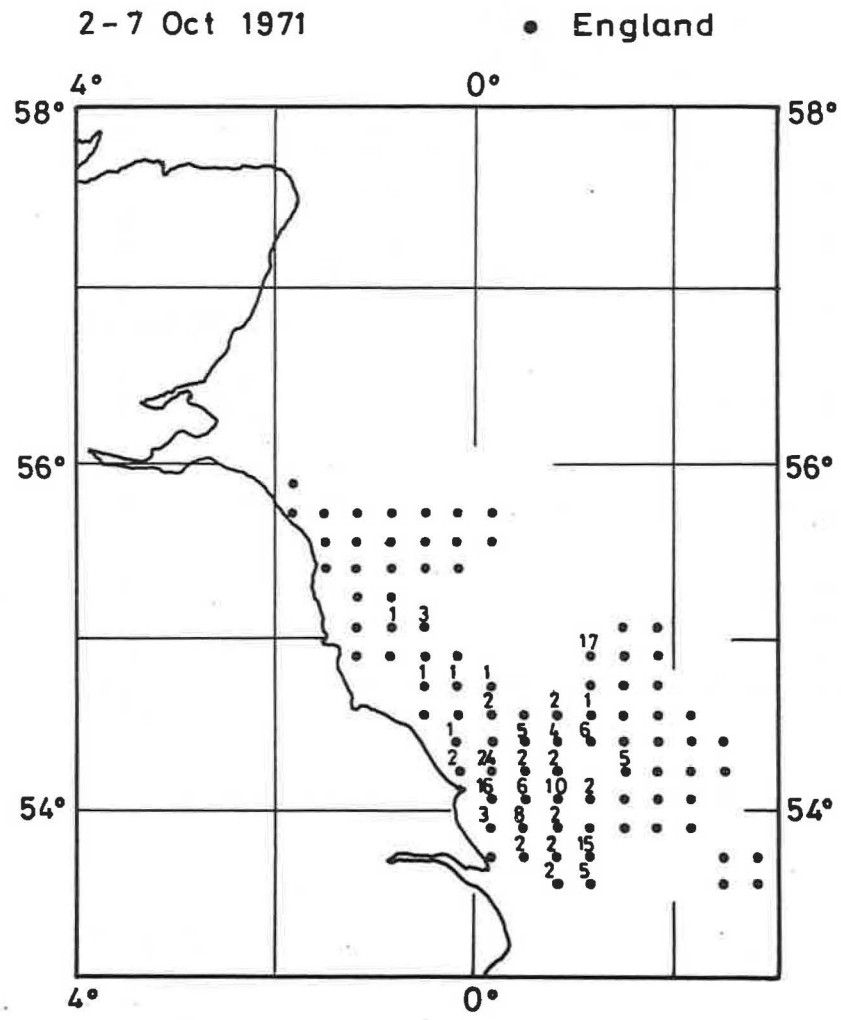


Figure 23.

Numbers of larvae <10 mm below 1 m^2

Western central North Sea.

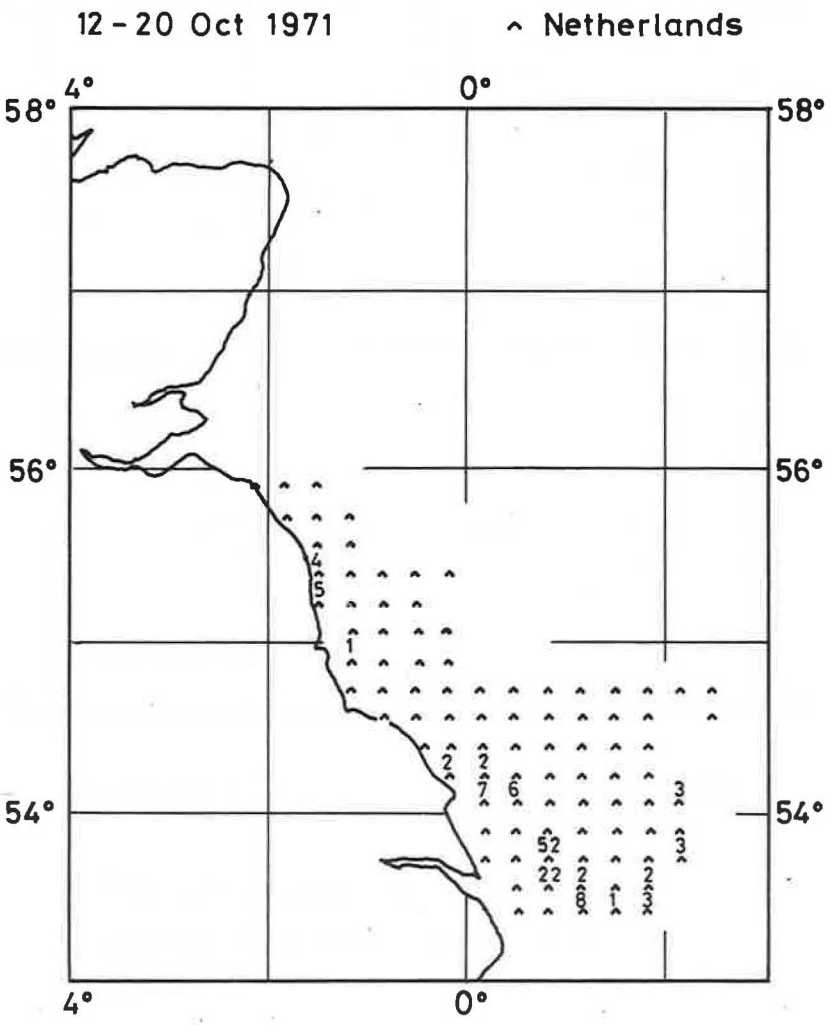


Figure 24.

Numbers of larvae 10-15 mm below 1 m^2

Western central North Sea.

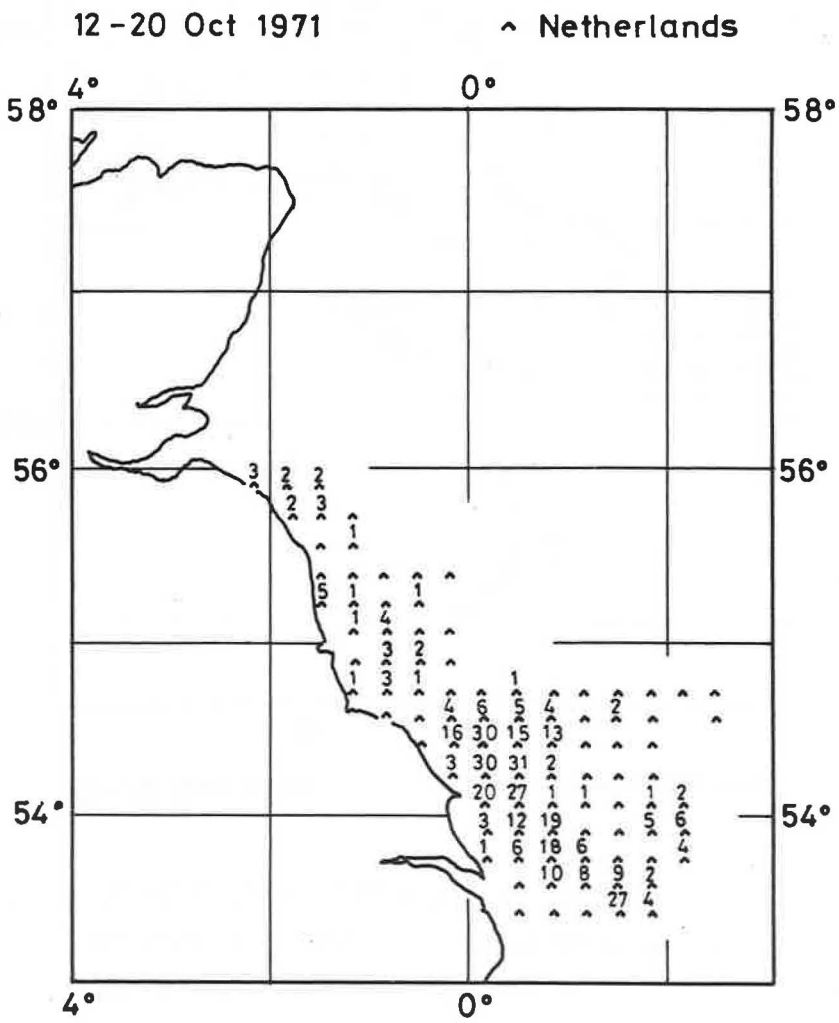


Figure 25.

Numbers of larvae > 15 mm below 1 m^2

Western central North Sea.

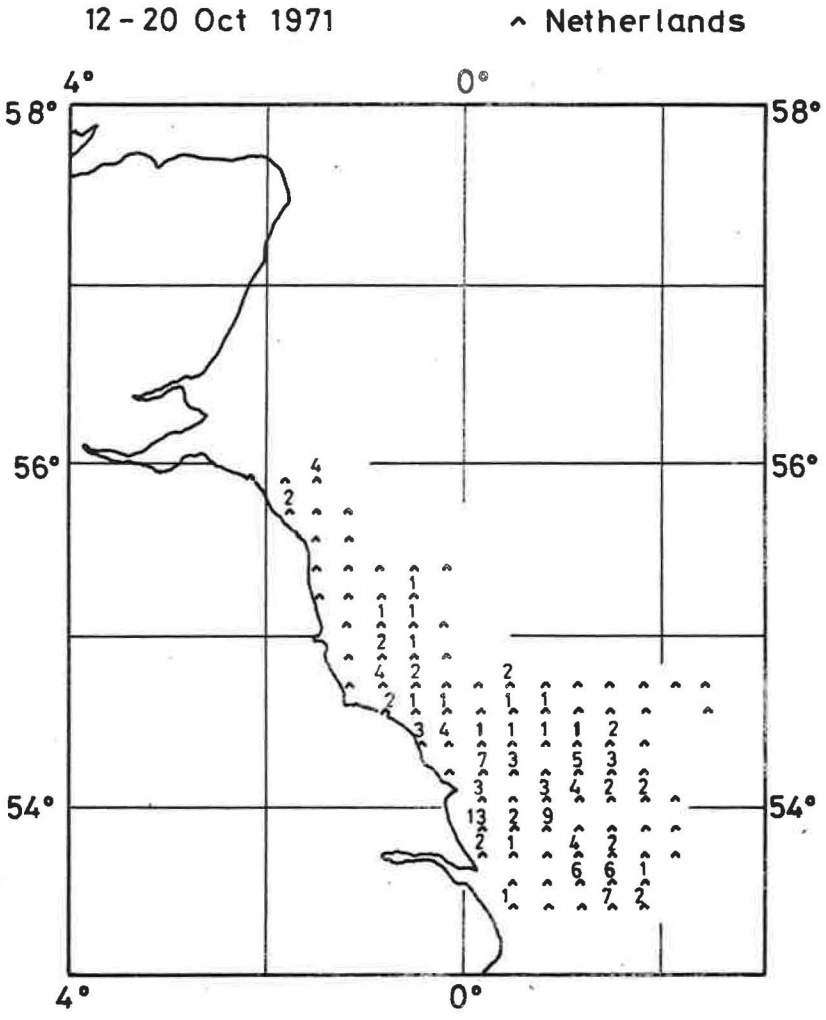


Figure 26.

Numbers of larvae < 11 mm below 1 m^2

Southern North Sea - English Channel.

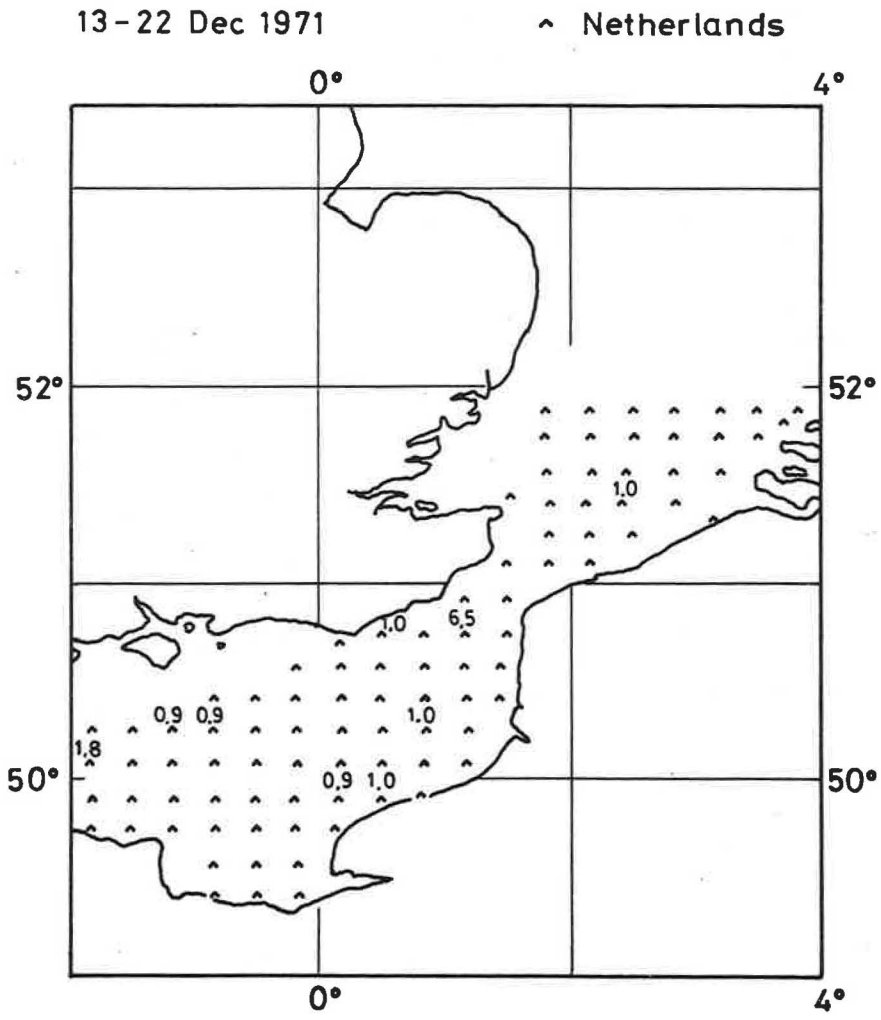


Figure 27.

Numbers of larvae 11-16 mm below 1 m^2

Southern North Sea-English Channel.

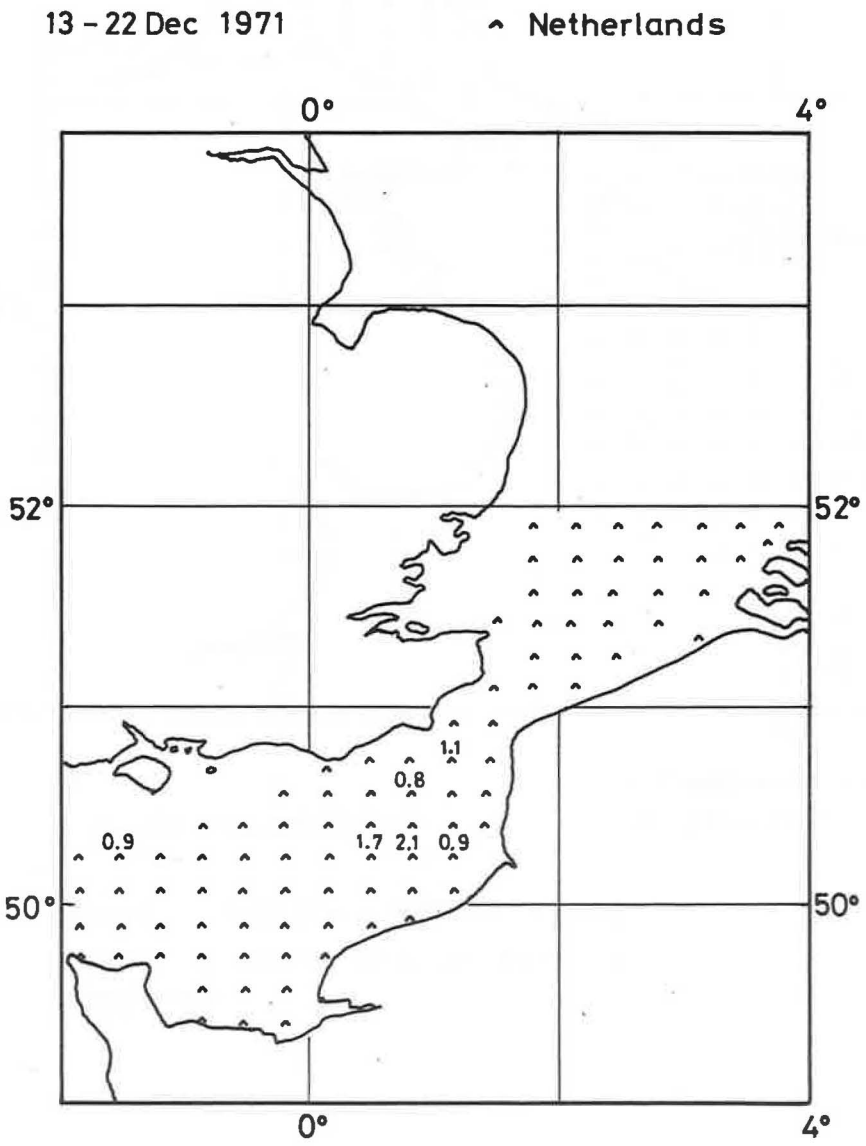


Figure 28.

Numbers of larvae <11 mm below 1 m^2

Southern North Sea - English Channal.

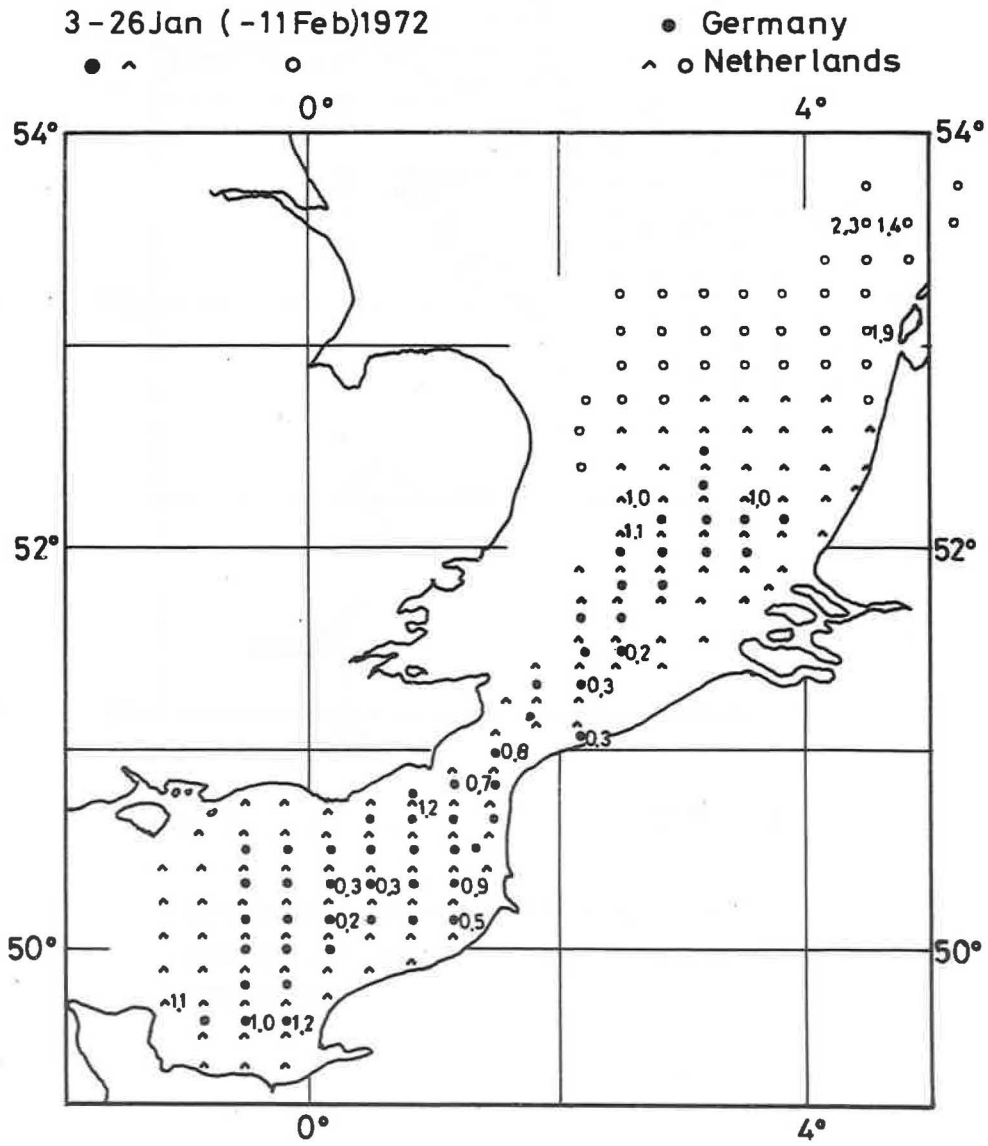


Figure 29.

Numbers of larvae 11-16 mm below 1 m^2

Southern North Sea - English Channel.

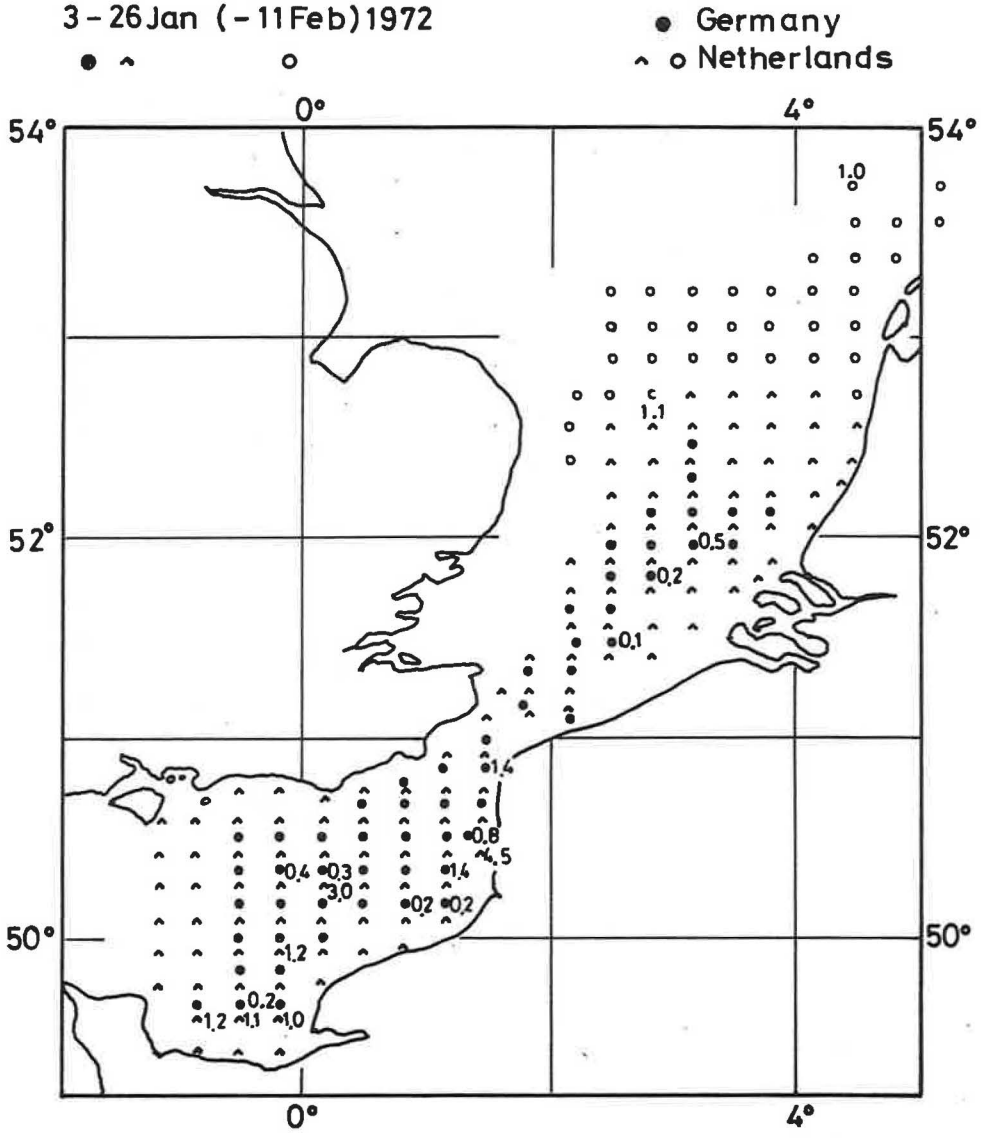
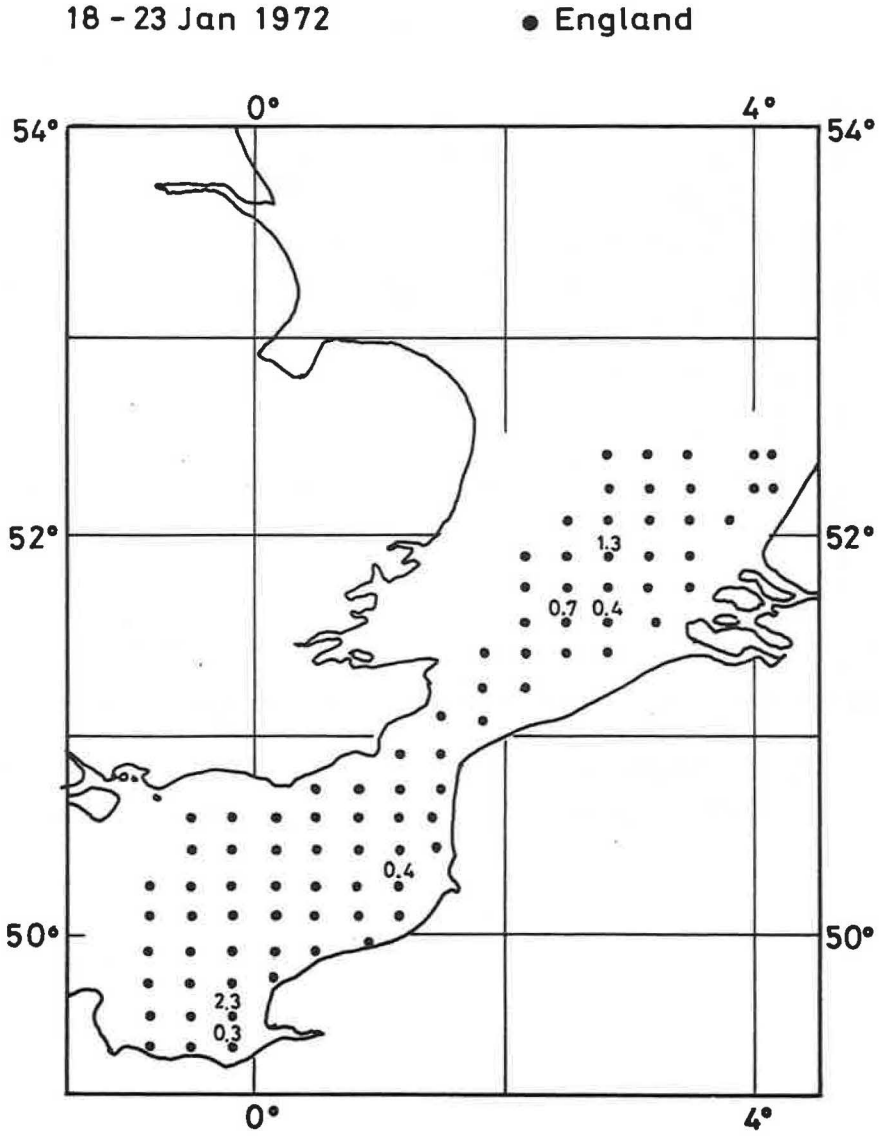


Figure 30.

Numbers of larvae of all sizes below 1 m^2

Southern North Sea - English Channel



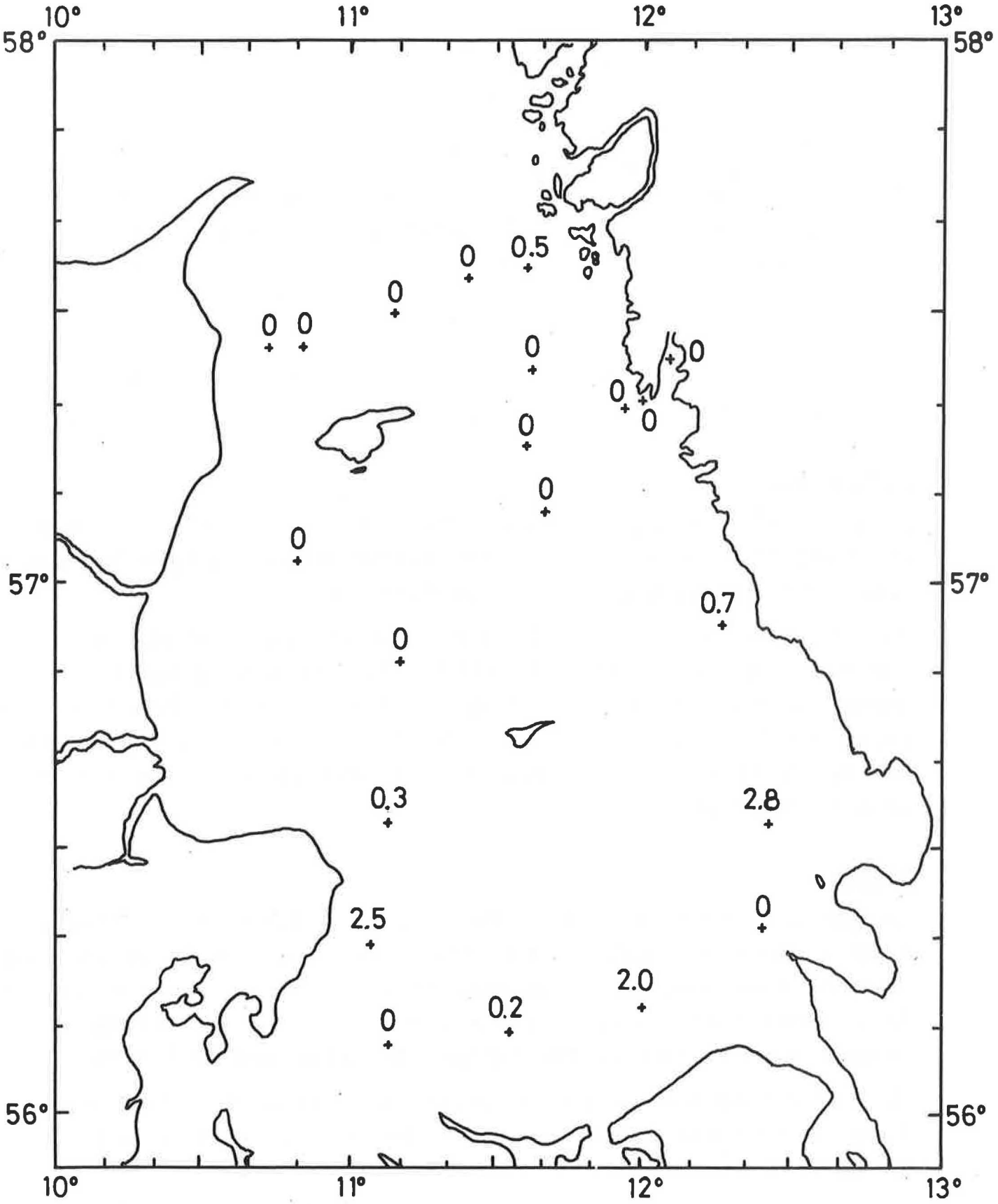


Figure 31. Numbers of larvae of all sizes below 1 m^2 - Kattegat.
5 Oct - 20 Oct 1971. (Sweden)

INVESTIGATIONS ON HERRING LARVAE BY SOVIET SCIENTISTS IN THE NORTH SEA IN 1971

by

E M Saplina*

In September and October the most abundant concentrations of herring larvae were observed along the English coast in the area of Spurn Head, as well as north of Flamborough Head between 54°35'N and 54°20'N. In the middle of September no herring larvae were observed between 55°20'N and 57°00'N.

The abundance of herring larvae of more than 9 mm in length was at the same level in September-October 1970 and 1971.

Introduction

Investigations of herring larvae were carried out in the central North Sea by Soviet scientists in 1971. Three ichthyoplankton samples were made, including plankton sampling and hydrographical investigations.

The first survey took place from 10 to 16 September and was conducted in the area between 56°55'N 53°35'N and 01°28'E 01°54'W. The second survey was carried out in the area between 55°05'N 55°30'N and 01°27'W 01°35'E from 24 to 30 September. The third survey took place from 14-23 October in the area between 55°35'N 53°21'N and 01°09'W 02°03'E. The hauls were made at a distance of 15 miles and more from the shore.

Methods

The gear used for the investigation was a High Speed Plankton Sampler which is a modification of the Gulf-3 sampling device. The sampler was fitted with a depth recording cable echo-sounder (IGEK) which controlled the submergence of the gear. Thus, samples could be obtained from any depth, even 2 m from the bottom. A flowmeter was also mounted in the sampler. The towing speed was 5 knots.

All sampled larvae were measured and counted just after capture. They were divided into three size groups, i.e. larvae less than 10 mm, larvae 10-15 mm and larvae of more than 15 mm in length.

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For each size group at every station the larval abundance under 1 m^2 surface was determined, and the area of investigation was divided into abundance levels (1, 10, 25, 50, 100 specimens per m^2) in order to obtain a summary abundance of larvae at the period of observation.

Material and Results

Figures 1 - 3 show the distribution of herring larvae on 10-16 September. In the northernmost part of the area, between 57°00' and 55°20'N no larvae were observed. It should be noted that in this part of the area stations were more scarce than in the southern part and this may have had an influence on the survey results. In the central part of the area fished, the abundance of larvae was insignificantly small. Maximum concentration in this region was 19 specimens per m^2 of the second size group (i.e. 10-15 mm). Great concentrations of larvae were observed only in the southernmost part of the survey area off Spurn Head, where the abundance value for larvae less than 10 mm in length reached 103 specimens per m^2. Larvae of more than 15 mm in length were not caught during the first survey.

The second survey - carried out from 24-30 September, showed a more abundant larvae population than during the first survey. Besides, the length frequency data (Figures 9 and 10) show that the larvae not sampled during the first survey were the most abundant. In the southern area this is attributed to the hatching of a new very strong generation. As for the central part of the area, the great abundance of larvae was due to the main concentrations being found within the 15 miles' zone during the time of the first survey. The subsequent drift had evidently taken them beyond that zone some time later.

The greatest concentrations of larvae less than 10 mm long were observed in the area of Spurn Head. A maximum number of 163 specimens per m^2 was found in this area. Small quantities belonging to this size group were also reported from Whitby. The larvae from the second size group had the widest distribution. Their abundance in the central and southern parts of the survey area reached 70-80 specimens per m^2. It should be noted that compared with the distribution of small larvae in the southern part by mid-September, the concentration of larvae 10-15 mm long had shifted towards the northeast by the end of September, crossing the latitude of 54°00'N, which is a conventional border between the central and southern parts of the survey areas. A similar shift was observed in the southern part of the area for larvae longer than 15 mm.

The northern border of the second survey was more to the south than in the first survey. In the samples taken from north of 55°20'N herring larvae were absent as before.

By the time of the third survey (14-23 October) the abundance of herring larvae had decreased sharply. The length frequency distribution shows (Figures 10 and 11) that the greatest abundance found was of larvae not sampled during the second survey, because they evidently appeared in the plankton after the survey was over. The only concentration of larvae less than 10 mm long was recorded from the area south of Spurn Head. The larvae of the second size group were most abundant in the area off Flamborough Head and to the southeast of Spurn Head. The greatest concentrations of the third size group were observed in the same area; they were much more widely distributed than during the first two surveys.

The general direction of displacement of larvae concentrations in October was evidently southeasterly. This was confirmed by a southeastern shift of the patches of maximum larval concentrations and by the fact that in the southern area much larger individuals (up to 26 mm) were caught than in the area north of 54°00'N.

Similar surveys were carried out in 1970 with the difference that the area south of 54°00'N was not sampled. The distributions of larvae in 1970 and 1971 coincide in the sense that no larvae were observed between 57°00'N and 55°20'N, and that considerable concentrations were reported from the area between 54°20'N and 54°35'N.

Table 1. Abundance of herring larvae in the central North Sea.

Year	Period of sampling	Number of larvae x 10^9 by size groups			Total number of larvae x 10^9
		< 10 mm	10-15 mm	> 15 mm	
1970	14-20 Sep	92.26	117.21	2.74	213.21
	10-15 Oct	26.05	117.97	54.26	198.28
1971	10-16 Sep	68.08	24.78	-	109.37
	24-30 Sep	116.96	198.00	38.93	353.89
	14-23 Oct	4.54	103.80	116.30	224.64

Table 1 above represents the quantitative distribution of larvae by the three size groups for 1970 and 1971. The abundance of larvae less than 10 mm long is underestimated to a great extent, because the 15 miles inshore zone was not fished. More reliable values are given for the abundance of larvae of more than 9 mm in length. There are also difficulties in comparing the 1970 and 1971 values, because the 1970 surveys covered a shorter period and a smaller area than the 1971 surveys. We have, therefore, compared the time interval and area common to the 1970 and 1971 surveys, and the mean daily number of larvae less than 9 mm long was calculated by the trapezium method for the period from 16 September to 12 October.

The indices presented in Table 2 below show that the abundance of herring larvae more than 9 mm long was at the same level in 1970 and 1971.

Table 2. Mean daily number of herring larvae of more than 9 mm length in 1970 and 1971.

Year	Period of observation	Areas	
		54°00'N 55°30'N	53°20'N 55°30'N
1970	16 Sep - 12 Oct	146.0×10^9	-
1971	16 Sep - 12 Oct	136.5×10^9	201.2×10^9
	13 Sep - 19 Oct	131.7×10^9	193.8×10^9

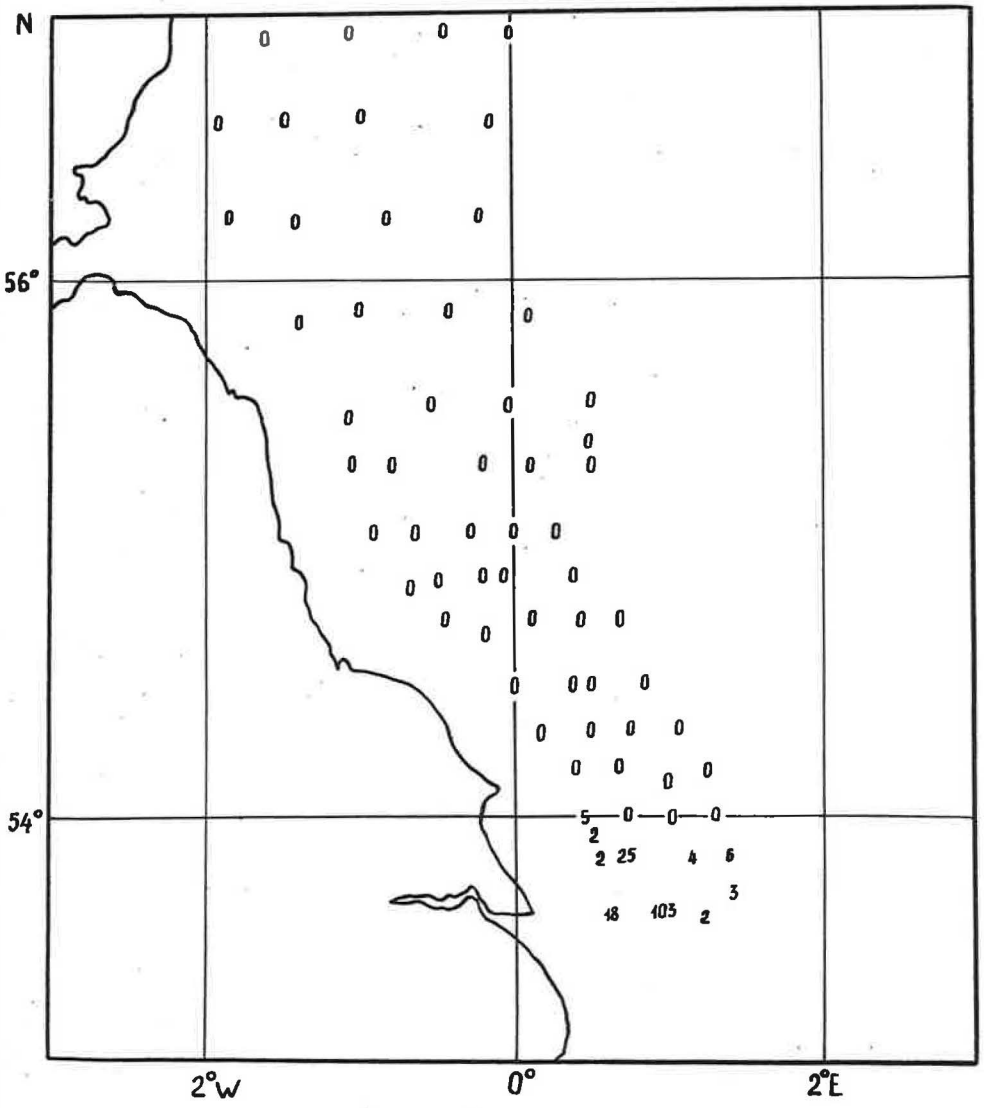

FIGURE 1. DISTRIBUTION OF HERRING LARVAE LESS THAN 10 MM IN LENGTH, 10-16 SEPTEMBER, 1971.

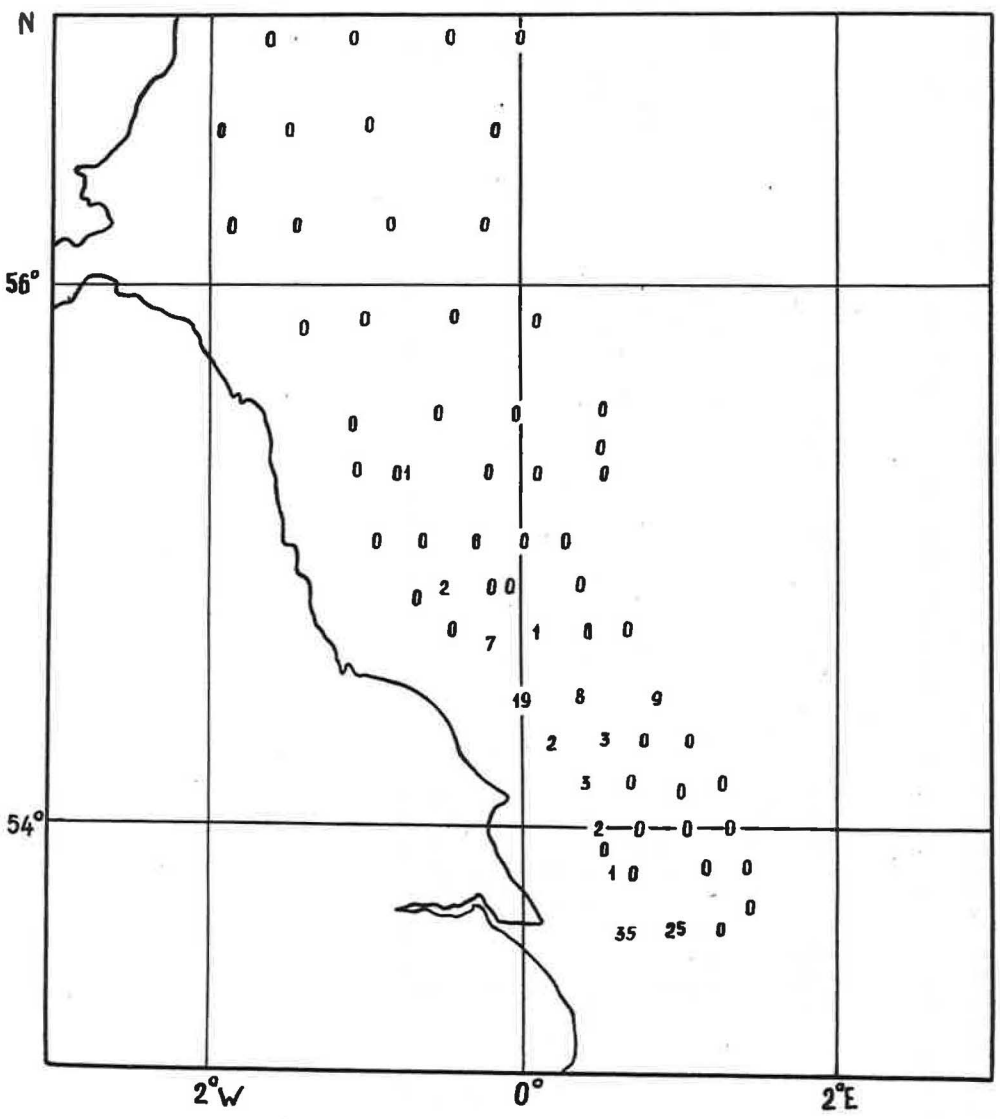

FIGURE 2. DISTRIBUTION OF HERRING LARVAE 10-15 MM IN LENGTH, 10-16 SEPTEMBER, 1971.

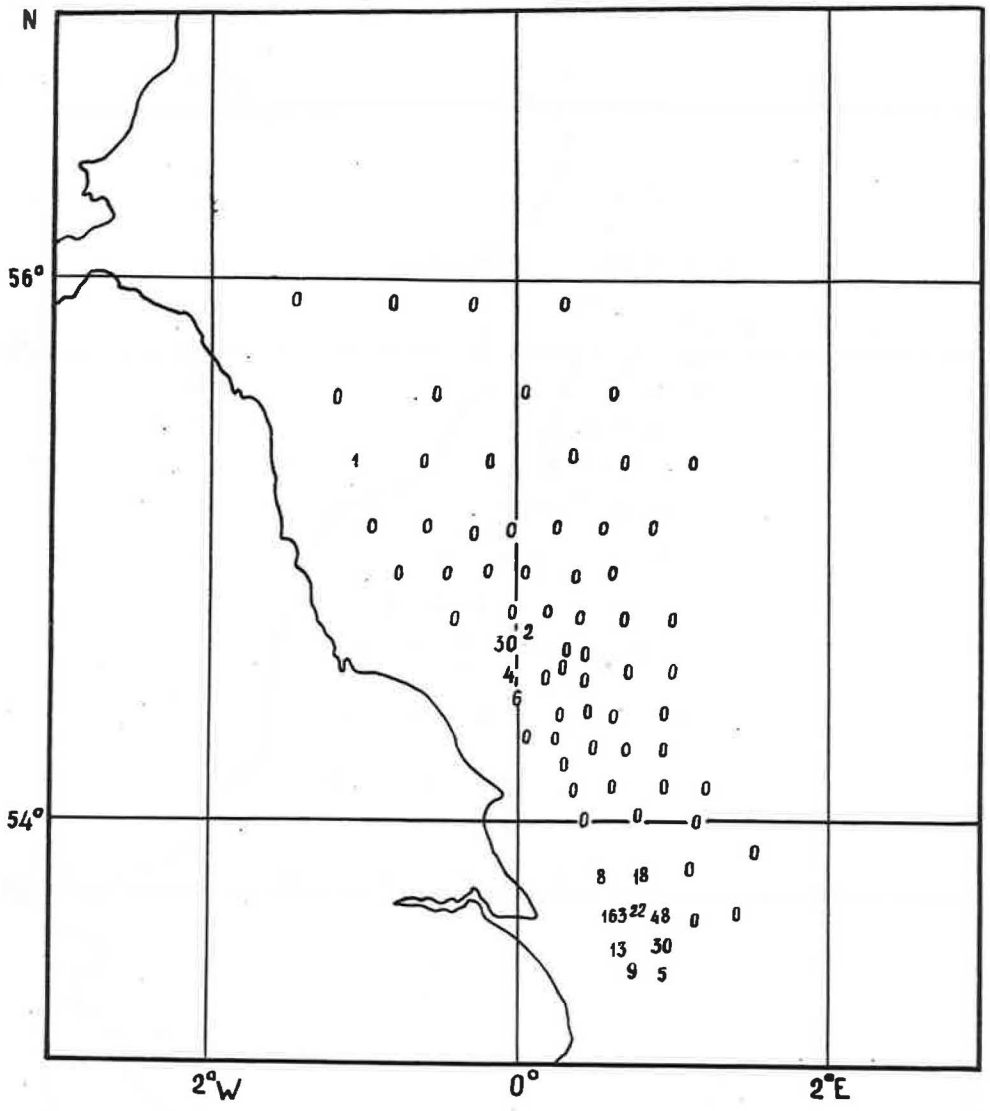

FIGURE 3. DISTRIBUTION OF HERRING LARVAE LESS THAN 10 MM IN LENGTH, 24-30 SEPTEMBER, 1971.

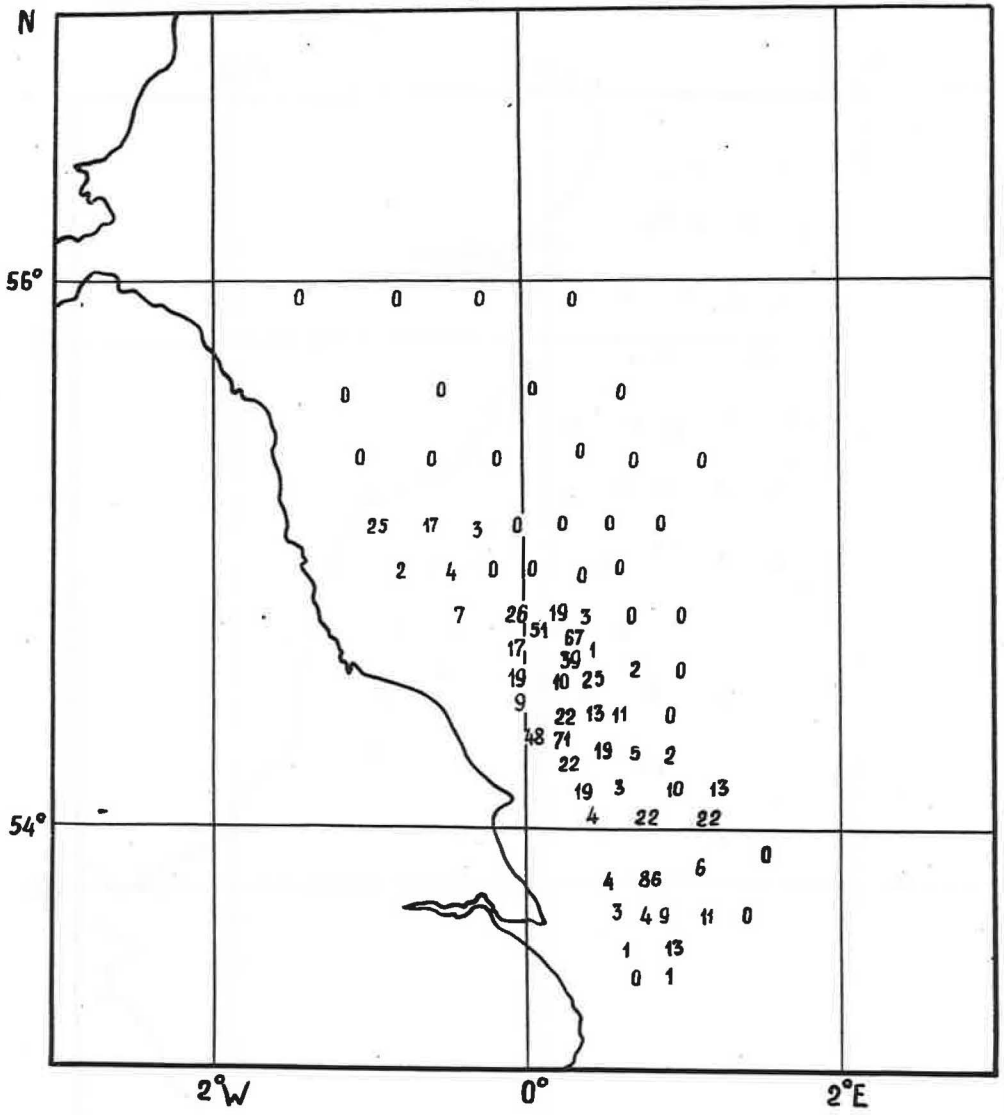

FIGURE 4. DISTRIBUTION OF HERRING LARVAE OF THE 10-15 MM SIZE GROUP, 24-30 SEPTEMBER, 1971.

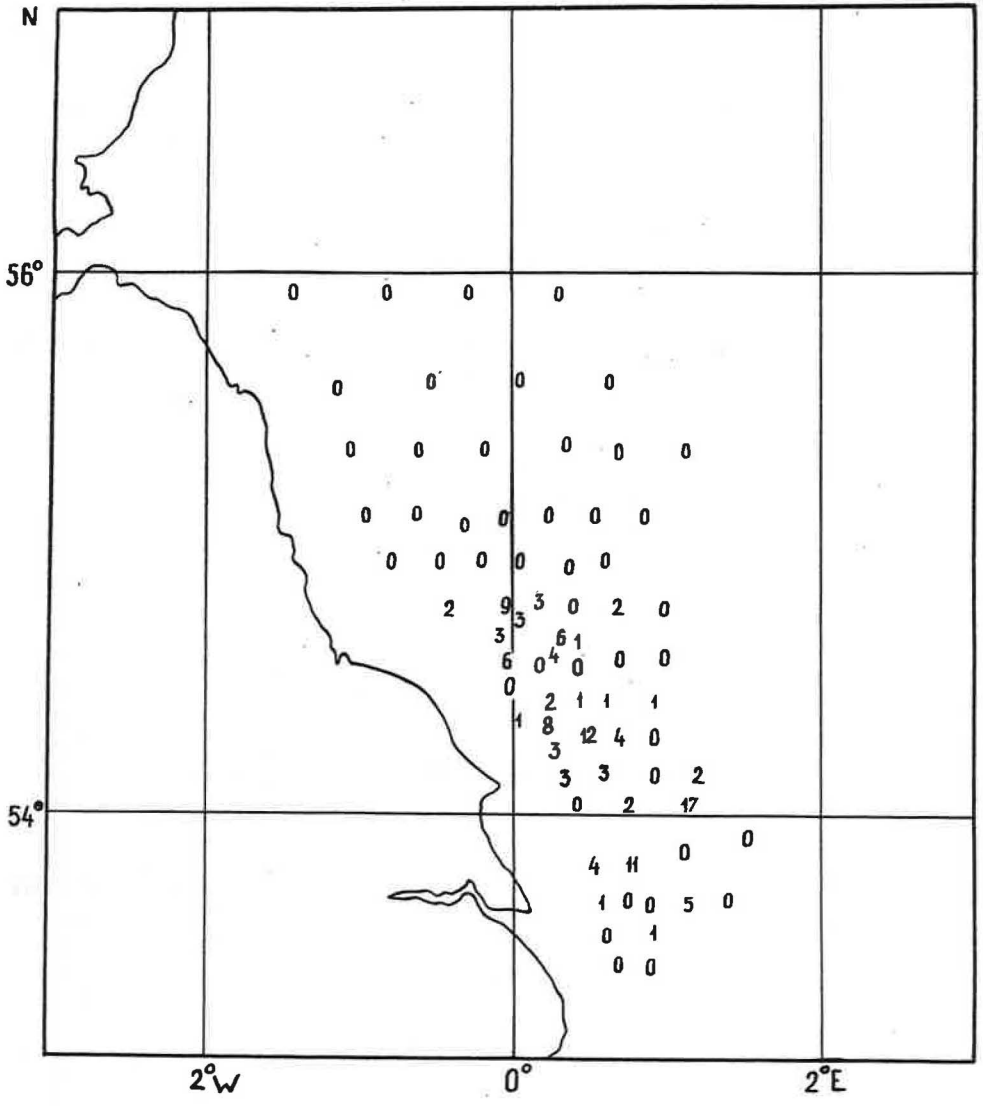

FIGURE 5. DISTRIBUTION OF HERRING LARVAE MORE THAN 15 MM IN LENGTH, 24-30 SEPTEMBER, 1971.

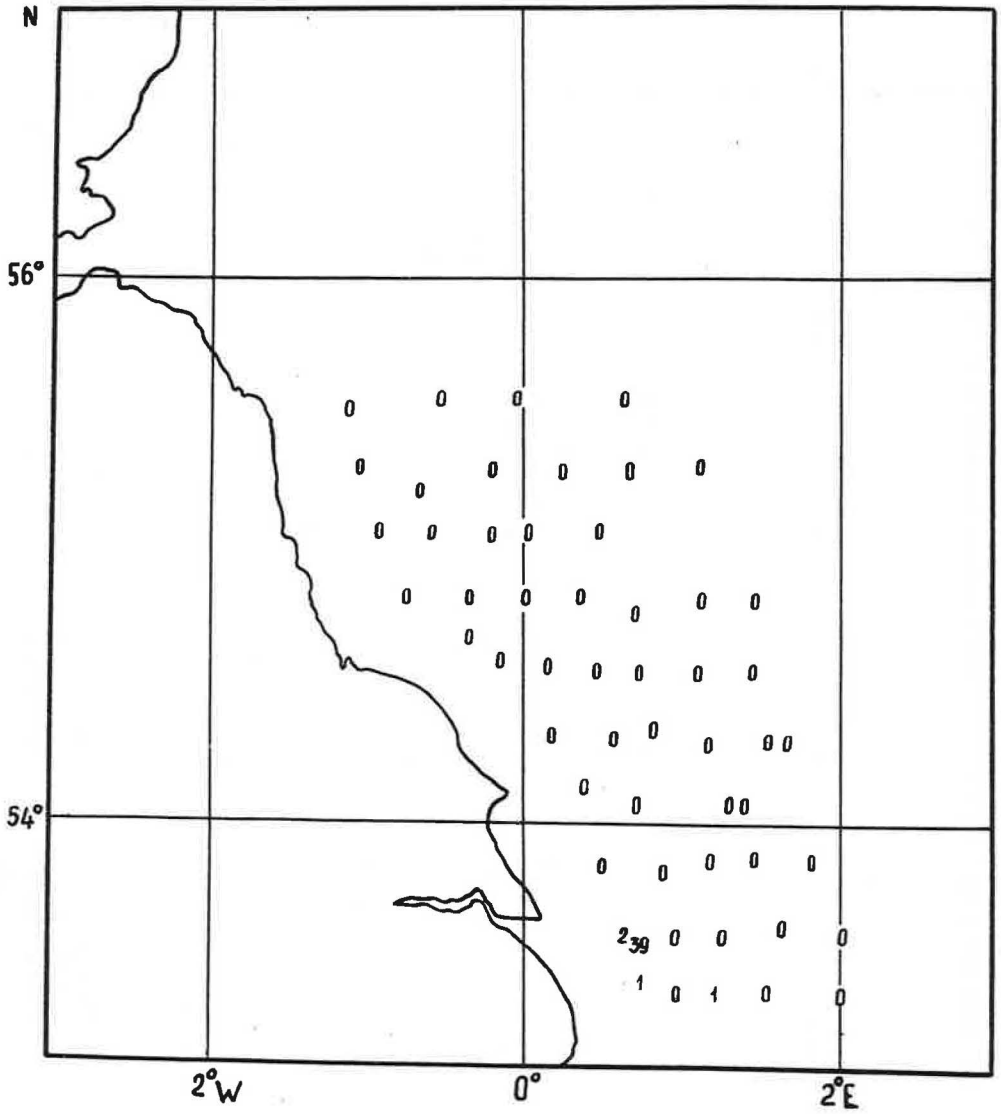

FIGURE 6. DISTRIBUTION OF HERRING LARVAE LESS THAN 10 MM IN LENGTH, 14-23 OCTOBER, 1971.

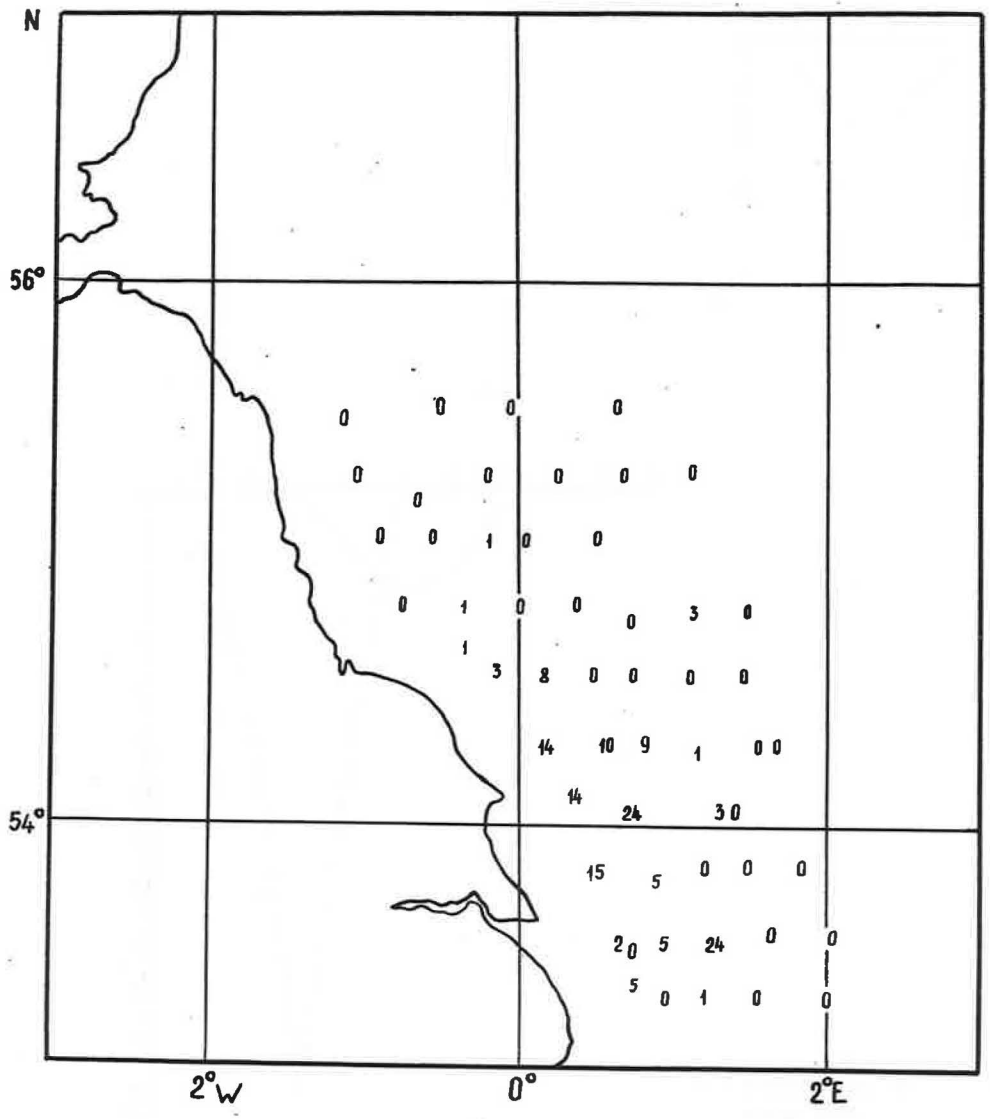

FIGURE 7. DISTRIBUTION OF HERRING LARVAE 10-15 MM IN LENGTH, 14-23 OCTOBER, 1971

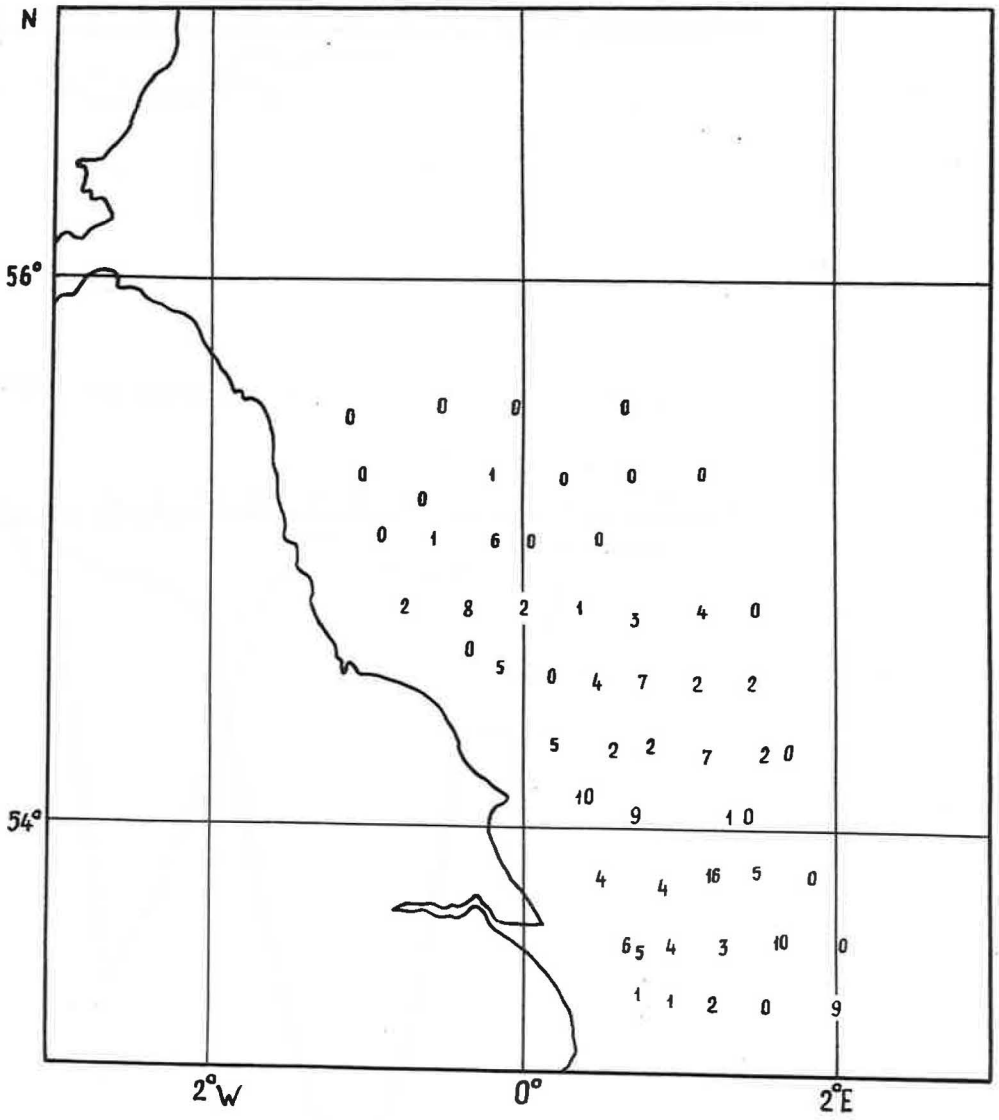

FIGURE 8. DISTRIBUTION OF HERRING LARVAE MORE THAN 15 MM IN LENGTH, 14-23 OCTOBER 1971.

LEGENDS TO FIGURES 9-11

N - AVERAGE NO. OF HERRING LARVAE IN THE AREA OF DISTRIBUTION (in: INDIVIDUALS PER M^2)

l - LENGTH OF HERRING LARVAE (IN MM)

I - NORTHERN PART OF SURVEY AREA

II - SOUTHERN PART OF SURVEY AREA

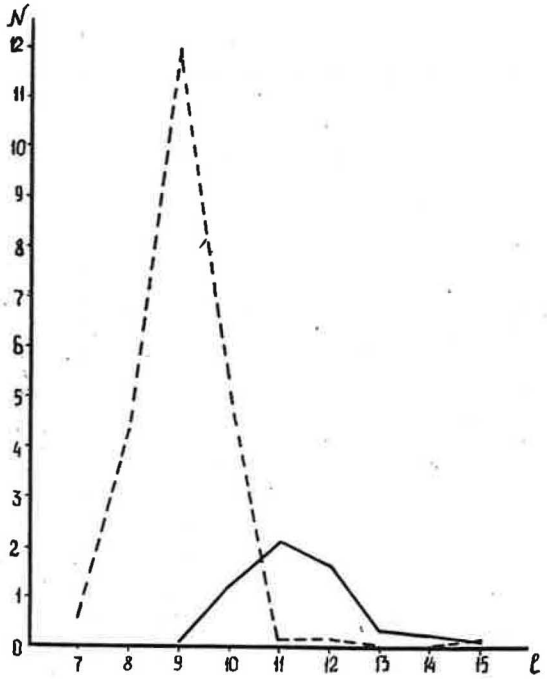

FIGURE 9. DISTRIBUTION OF HERRING LARVAE BY SIZE GROUPS, 10-16 SEPTEMBER, 1971.

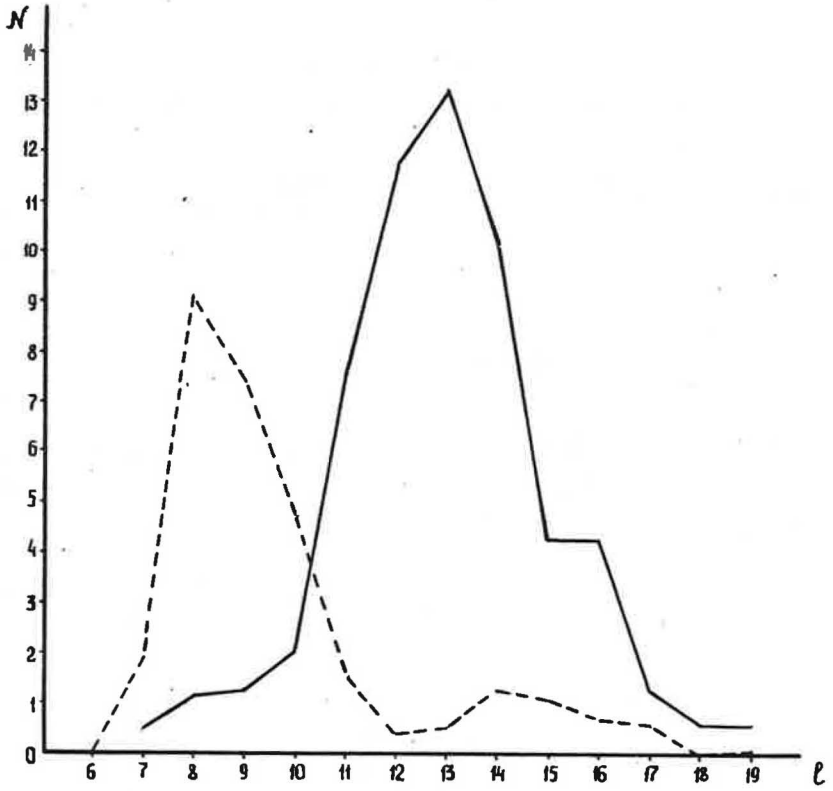

FIGURE 10. DISTRIBUTION OF HERRING LARVAE BY SIZE GROUPS, 24-30 SEPT., 1971.

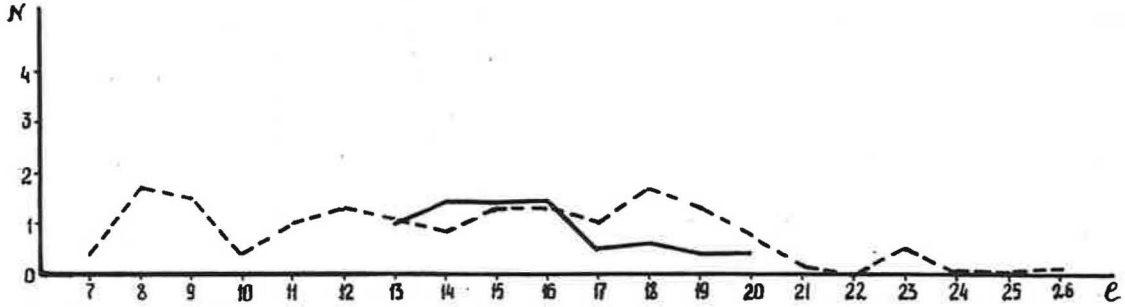

FIGURE 11. DISTRIBUTION OF HERRING LARVAE BY SIZE GROUPS, 14-23 OCTOBER, 1971.

HERRING LARVAE TO THE WEST OF SCOTLAND IN THE AUTUMN OF 1971

by

R J Wood*

Introduction

The first extensive survey of herring larvae over the autumn-spawning grounds to the west of Scotland was carried out by the English research vessel "Clione" in October 1965 (Wood, 1968). Considerable numbers of herring larvae were caught over an area of approximately 18 200 square miles extending from Donegal Bay to beyond the Butt of Lewis and Cape Wrath (see Figures 1 and 5), and the total number of herring larvae in the survey area during the period 16-25 October 1965 was estimated to be 1 759 x 10^9. When allowance was made for a difference both in fecundity and in the size of the adult spawners in the two areas, it was concluded that the size of the total autumn-spawning herring population to the west of Scotland in 1965 was probably of the same order as that of the Downs stock in the North Sea during the years 1946-51.

Acting on a request from the Liaison Committee of ICES the North Sea Herring Assessment Working Group met in December 1969 to consider the state of the herring stocks around Ireland and northwest of Scotland (Anon., 1971). In addition to noting the above comparison the Working Group compared the estimated abundance of larvae to the west of Scotland in the autumn of 1965 with the abundance estimates for larvae in the central and northern North Sea in the two periods 1957-60 and 1961-64, and concluded that a stock size to the west of Scotland of between 960 000 and 620 000 tons was indicated. However, further estimates by the Working Group based on catch-fishing mortality estimates gave a much lower stock size, between 460 000 and 330 000 tons, although in this case, as most of the data used referred to the Minch herring, the magnitude of the stock component spawning off Donegal could have been underestimated. It was pointed out that none of the estimates was very precise. The Working Group Report recommended that, in order to be able to use abundance estimates of larvae for future stock assessment in this area, regular sampling for herring larvae should be initiated.

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As no further surveys for herring larvae had, however, been carried out in the area west of Scotland following the 1965 RV "Clione" survey, it was decided to repeat the October survey in 1971, using RV "Cirolana". In addit in 1971, after completion of the Lowestoft Laboratory's share in the ICES coordinated surveys over the spawning grounds adjacent to the Orkney and Shetland Islands, RV "Corella" surveyed the early September production of herring larvae off the Butt of Lewis and Cape Wrath.

Material and Methods

The RV "Corella" survey, comprising a grid of 24 stations, was carried out during 8 and 9 September 1971 over an area lying north of the Butt of Lewis and Cape Wrath. The gear used was a standard English 20 inch (50.8 cm) high speed sampler fitted with an 8 inch (20.4 cm) nose cone and 60 meshes per in (23.6 per cm) nylon filter. The same sampler was used on the second survey, which was carried out by RV "Cirolana" in October 1971. With only a few minor exceptions the station positions for this survey were identical with those worked in 1965 and the period of sampling was virtually the same, being 16-24 October (16-25 October in 1965). It was most unfortunate that mechanical troubles reduced the duration of the cruise, thus leaving insufficient time to work the stations through the Minches or the full grid off Cape Wrath In spite of this, a total of 83 stations was completed during the October 1971 survey, which adequately covered the area from Donegal Bay to north of the Butt of Lewis, along the western side of the Outer Hebrides.

From the samples at each station on both surveys the herring larvae were picked out and identified. All were then measured and examined for the presence of yolk sacs unless the numbers were very large, in which case only sub-samples were completely examined. The total number of herring larvae at each station was afterwards converted to the number beneath one square metre of surface, and for the October survey the area was then contoured and planimetered in exactly the same way as when the 1965 survey was worked up (Wood, 1968). The total number of herring larvae for the survey was then calculated

Results and Conclusions

The results of the first survey, made during 8 and 9 September 1971, are presented in Figure 2. A high-density patch of almost entirely recently hatched herring larvae was found extending from the western edge of the survey grid off the Butt of Lewis, across the North Minch and northeastwards beyond the Cape Wrath. This patch was almost completely separate from the high-density patch just west of Orkney which had been surveyed during the preceding 2 days (Schnack, this volume). The small size of the herring

larvae off the Butt of Lewis and Cape Wrath, plus the fact that a considerable proportion still had yolk sacs, indicated that at this time the larvae were still in close proximity to their hatching areas. At one station a few miles north of Cape Wrath the very high number of 2 689 herring larvae was found beneath one square metre of surface, and of this total 1 527 had yolk sacs.

The survey during 8 and 9 September 1971 did not completely cover the whole area of possible distribution of herring larvae off the Butt of Lewis. However, in view of the results of an earlier survey carried out between 30 August and 5 September 1965, and reproduced here as Figure 3, it seems likely that the greater part of the area of distribution was covered. The estimated total number of herring larvae from the area surveyed during 8 and 9 September was extremely high and of the order of $2\ 000 \times 10^9$. However, as approximately half of this figure is related to yolk-sac stages of larvae the number of $1\ 110 \times 10^9$ for the residue is more comparable, and this approximates to an estimate of $1\ 517 \times 10^9$ herring larvae derived from a block of 14 stations worked off Cape Wrath during 23 and 24 September 1970 by RV "Scotia" (Zijlstra, 1972).

A matter of some importance arises from this in connection with the North Sea international surveys of herring larvae. It is quite probable that many of the larvae which originate from the Butt of Lewis - Cape Wrath area in early September are carried eastwards where they would later be included in the estimates of abundance for northern North Sea herring larvae.

The results of the second survey to the west of Scotland and northwest of Ireland, carried out in October 1971, are presented in Figures 4 and 6; for comparison, those from October 1965 are reproduced in Figures 5 and 7. The pattern of distribution of the herring larvae in both years can be seen to have been very similar, the chief difference being the occurrence of recently hatched herring larvae at several stations along the western extremity of the grid off the northwest Irish coast in 1971, where few, if any, herring larvae were caught in 1965. This, however, could well be due to the fact that these particular stations were worked a few days later in 1971 than in 1965. The abundance estimates for total herring larvae in the area south of latitude 56°N, which includes the Donegal Bay and Tory Island spawning grounds, are almost identical in both years, being 516×10^9 in 1971 and 484×10^9 in 1965 (see Table 1, p. 46).

An exact comparison between the abundance estimates northwards of latitude 56°N in both years unfortunately cannot be made in the same way, as the area off Cape Wrath was not completely covered by the survey in October 1971, nor were the stations worked through the Minches. The Minches did not, however, constitute an important area of distribution in October 1965, and those

stations which were not covered by the survey in 1971 contributed only 80 x 10^9 herring larvae towards the total abundance estimate of 1 275 x 10^9 for the whole of the surveyed area northwards of latitude 56°N in October 1965. Because of the poor coverage of the area off Cape Wrath in October 1971, the total number of herring larvae was probably somewhat underestimated. The best comparison that can be made for the area northwards of latitude 56°N, excluding the Minches, is between a total abundance estimate of herring larvae in October 1971 of 909 x 10^9 and of 1 195 x 10^9 in October 1965. It must therefore be concluded that the total numbers of herring larvae which were distributed to the west of Scotland and northwest of Ireland during the month of October in both 1971 and 1965 were very much the same and thus the size of the adult spawning population from which these larvae originated must have been fairly similar in both years. The importance of the various spawning areas also appeared to be unchanged. The grounds off the northwest Irish coast contributed roughly one-third of the total estimated number of herring larvae both in October 1971 and 1965, and the most important concentration of larvae was situated to the west and north of the islands of Harris and Lewis in the Outer Hebrides.

The apparent magnitude of the hatching of herring larvae off the Butt of Lewis and Cape Wrath in early September is a striking feature of the recent investigations (see footnote). Few larvae in the October survey were of a size sufficiently large to have been derived from this spawning (see Figure 8), so that the estimates of abundance for October herring larvae are probably related very largely to hatchings in late September and early October. It was on these later larvae that the original estimate of stock size to the west of Scotland and northwest of Ireland was based (Wood, 1968), although it now seems probable that this estimate was somewhat over-optimistic. A recent re-appraisal of the abundance estimates of Downs herring larvae has shown that the total abundances during the period 1946-51 were in fact approximately twice as large as the "minimum estimates" which were used in the original calculations and which had been published by Bridger (1961). However, if the abundance estimates for herring larvae to the northwest of Scotland in early September are considered in conjunction with both the October estimates, a stock size is now indicated which is very similar to that of the Downs stock during the period 1946-51, i.e. approximately 700 000 tons (Anon., 1971).

Footnote: Since this paper was presented at the 1972 Annual Meeting of ICES the data for the latest survey have become available. They indicate at least 3 000 x 10^9 herring larvae in this area during the period 5 to 8 September 1972.

Summary

1. Two surveys of the abundance and distribution of autumn-spawned herring larvae to the west of Scotland were carried out by English research vessels during the autumn of 1971.

2. The first survey, by RV "Corella" during 8 and 9 September, revealed a dense patch of newly hatched herring larvae extending from off the Butt of Lewis to northeastwards of Cape Wrath. The total number of herring larvae in the area surveyed at that time was estimated to be approximately 2 000 x 10^9, of which roughly half were in the yolk-sac stage.

3. The second survey, by RV "Cirolana" between 16 and 24 October, covered the area from Donegal Bay to north of the Butt of Lewis and Cape Wrath. The total number of herring larvae in the area surveyed was estimated to be 1 425 x 10^9.

4. This estimate was reasonably similar to the estimated number of herring larvae in approximately the same area and during the same period of October 1965, and it was concluded that the spawning stock size related to these later larvae was probably similar in the two years.

5. It was also concluded that, as very few of the early September larvae appeared to have been included in the October abundance estimates, a total spawning stock size for the whole area to the west of Scotland and northwest of Ireland of approximetaly 700 000 tons was indicated.

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Table 1. Abundance estimates of herring larvae in October to the west of Scotland, x 10^{-9}.

Year	North of lat.56°N (excluding Minches)	South of lat.56°N	Minch area	Whole area (excluding Minches)	Whole area (including Minches)
1965	1 195	484	80	1 679	1 759
1971	909	516	-	1 425	-

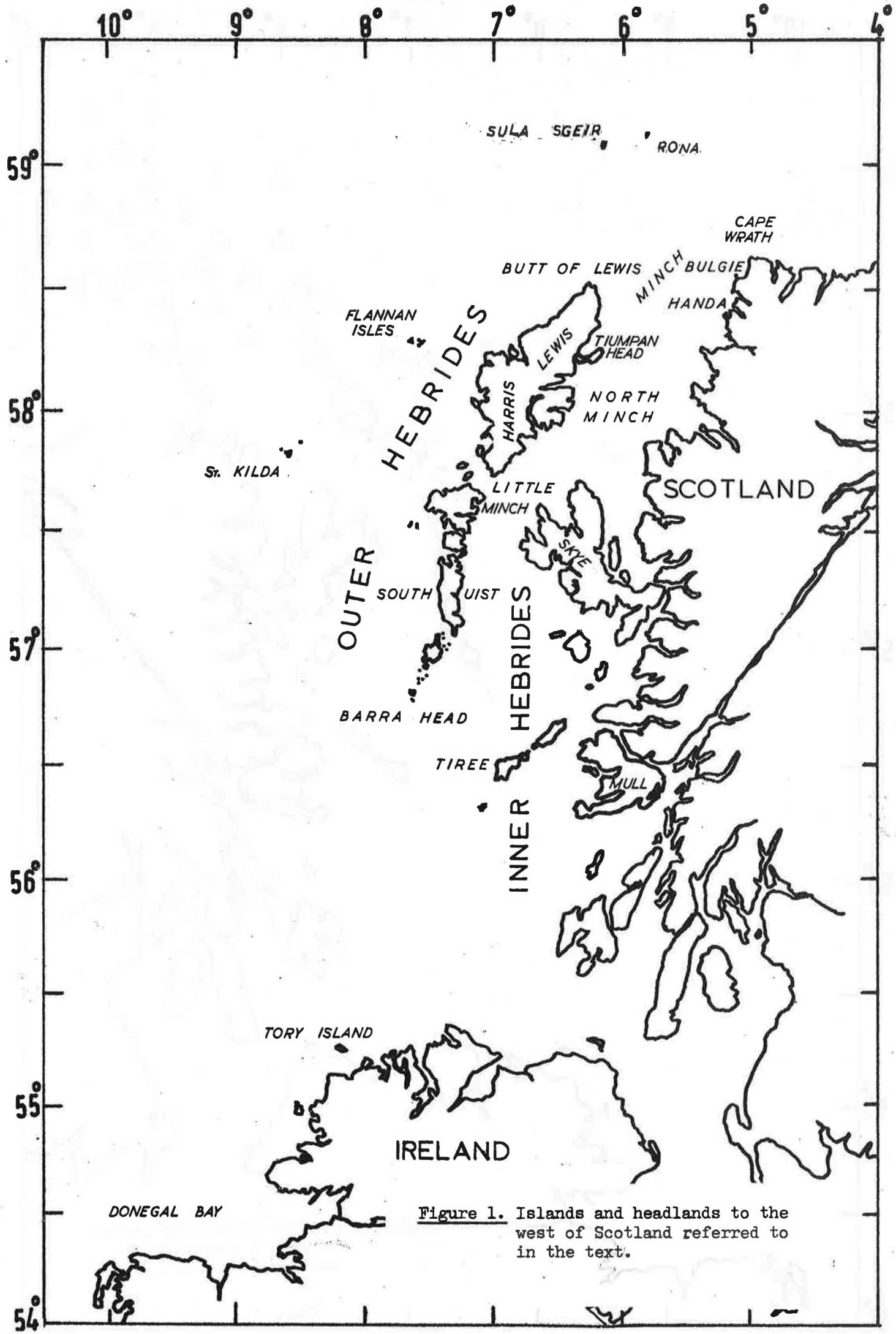

Figure 1. Islands and headlands to the west of Scotland referred to in the text.

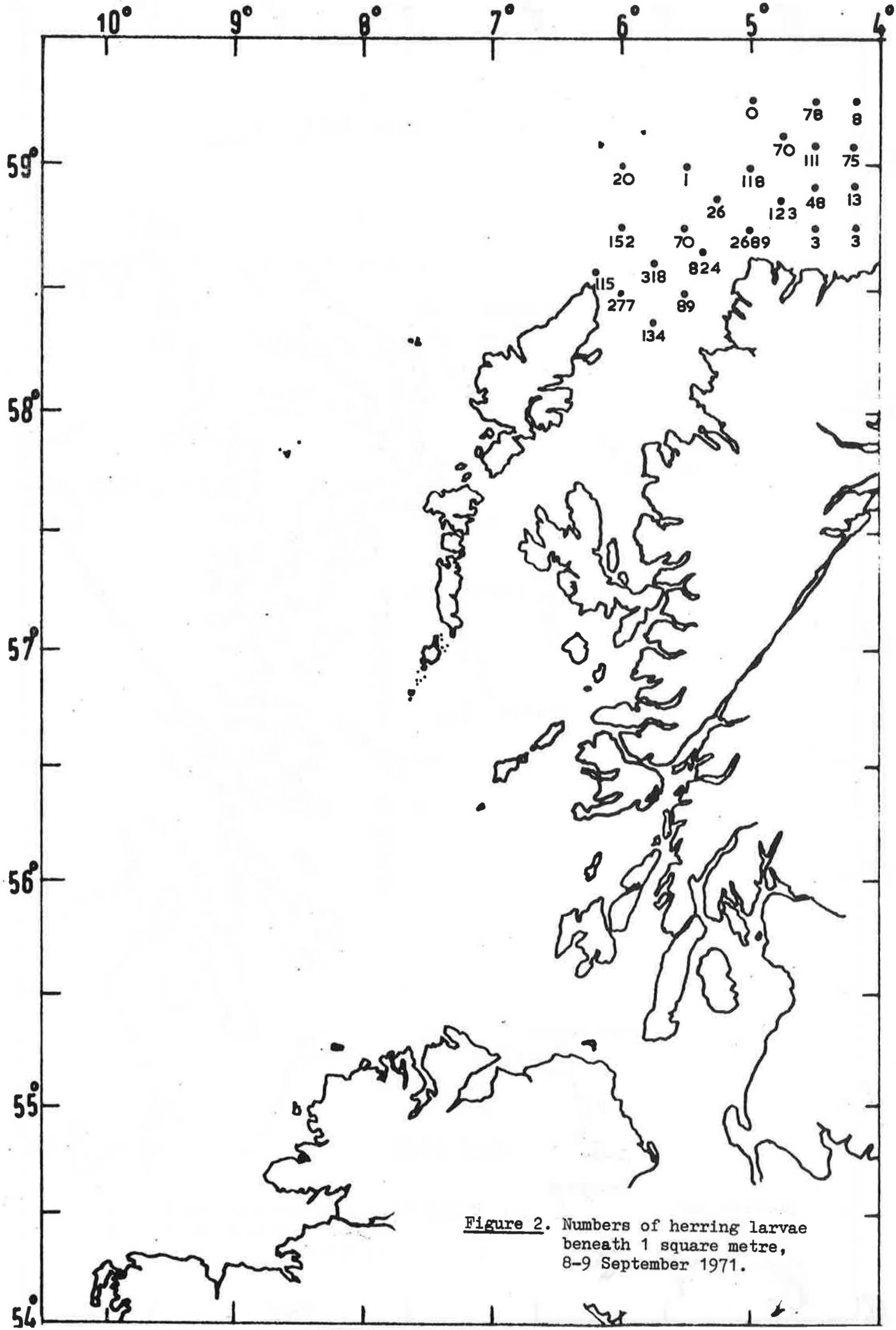

Figure 2. Numbers of herring larvae beneath 1 square metre, 8-9 September 1971.

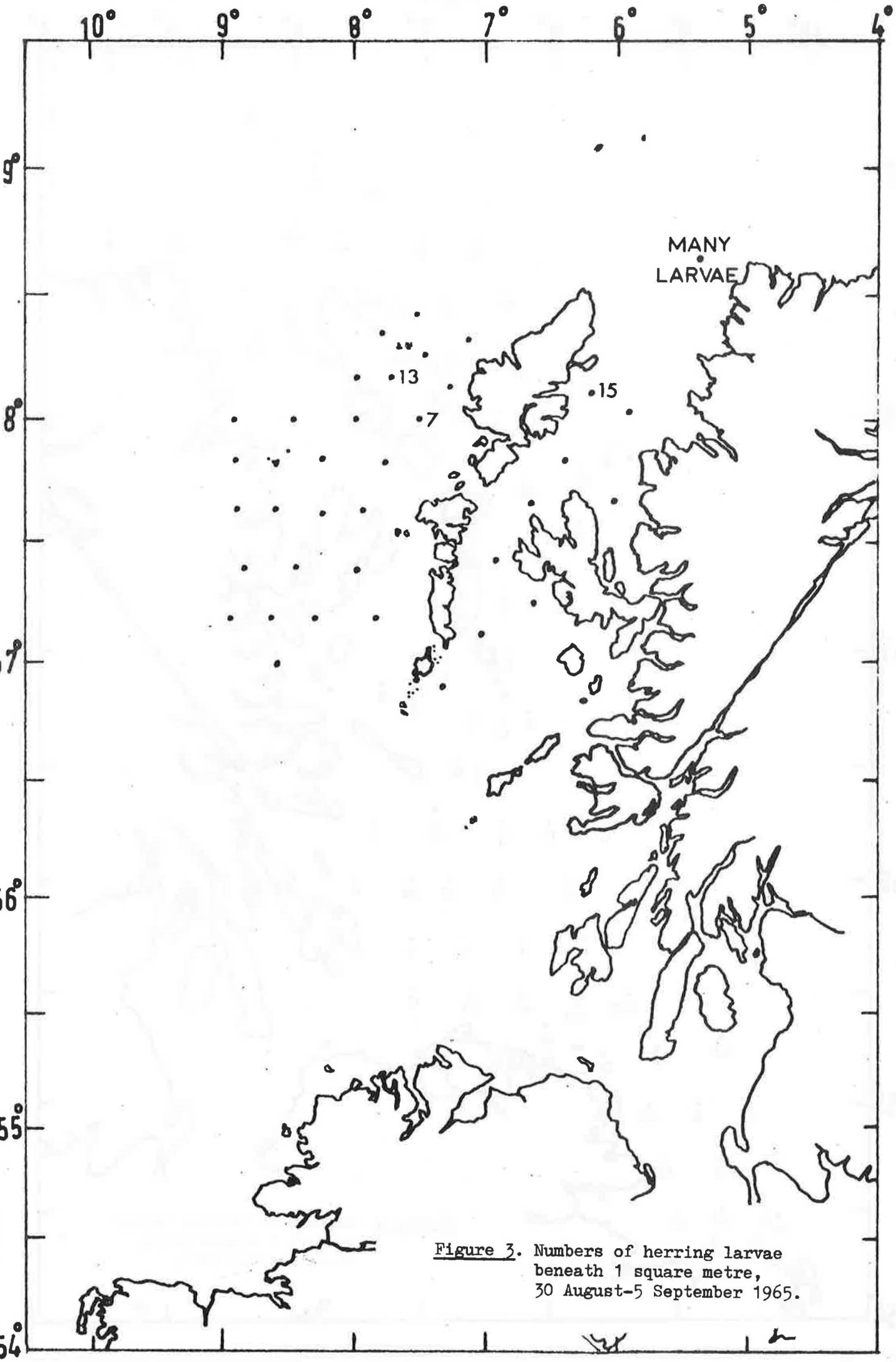

Figure 3. Numbers of herring larvae beneath 1 square metre, 30 August-5 September 1965.

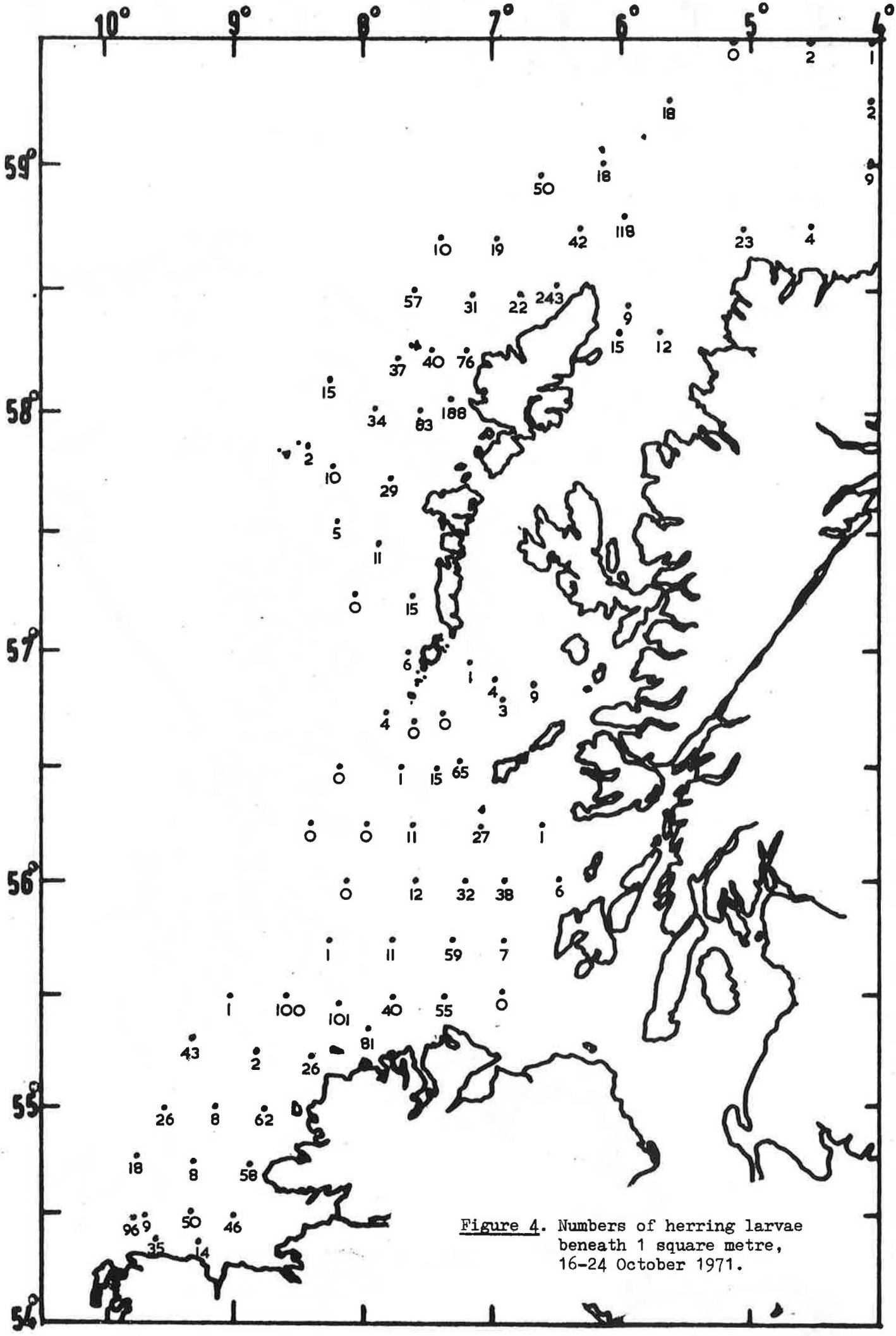

Figure 4. Numbers of herring larvae beneath 1 square metre, 16-24 October 1971.

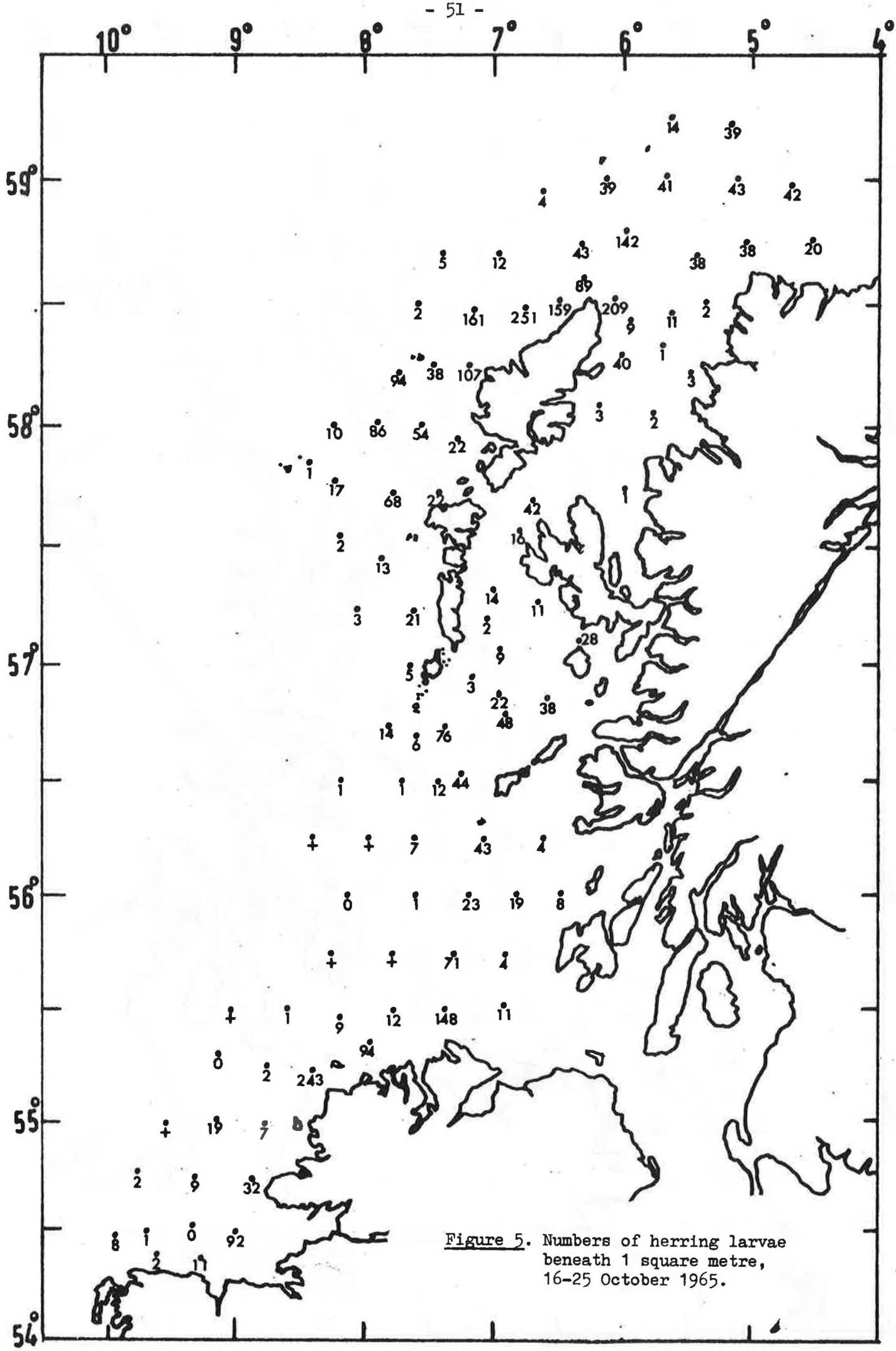

Figure 5. Numbers of herring larvae beneath 1 square metre, 16-25 October 1965.

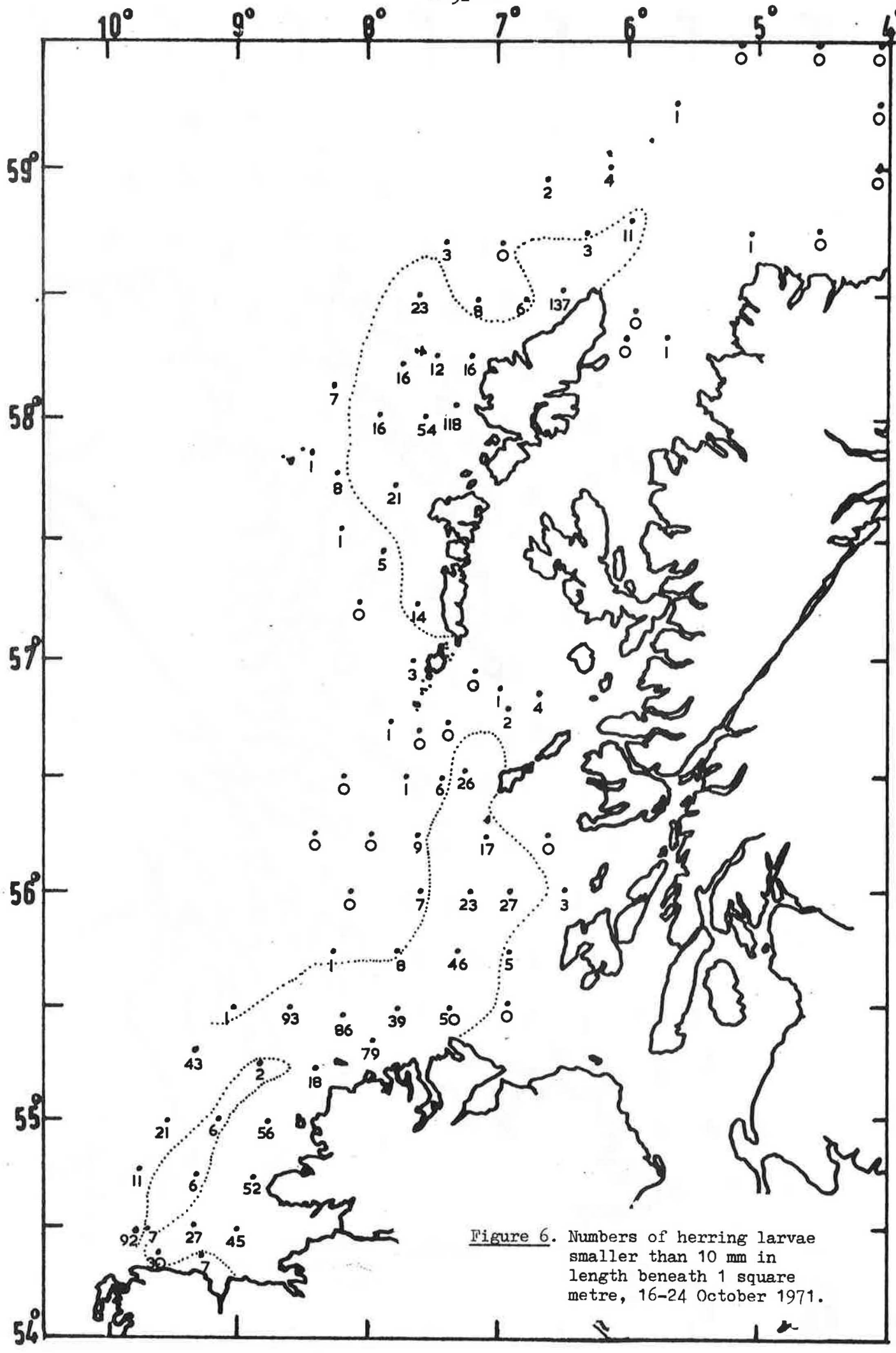

Figure 6. Numbers of herring larvae smaller than 10 mm in length beneath 1 square metre, 16-24 October 1971.

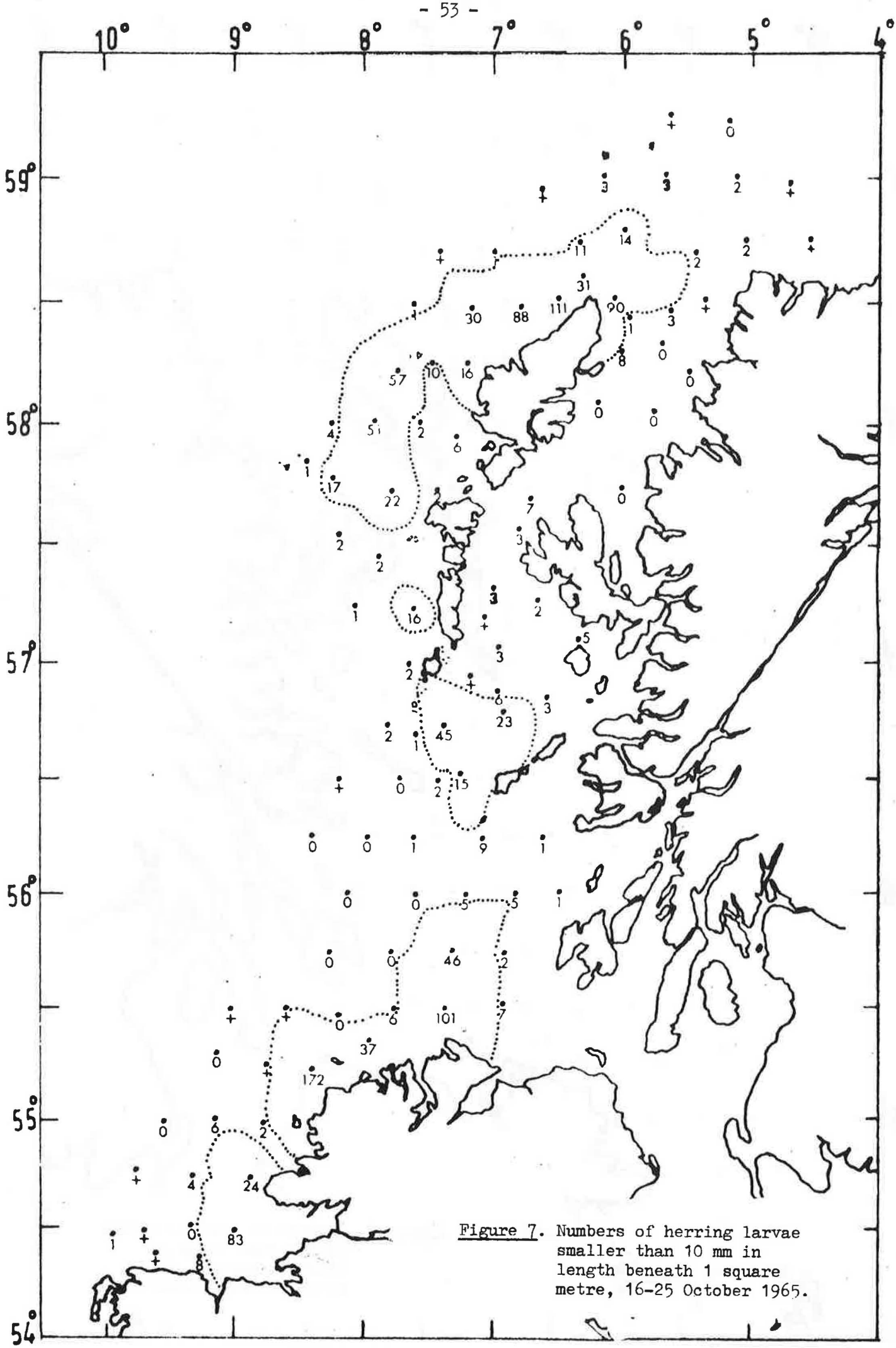

Figure 7. Numbers of herring larvae smaller than 10 mm in length beneath 1 square metre, 16-25 October 1965.

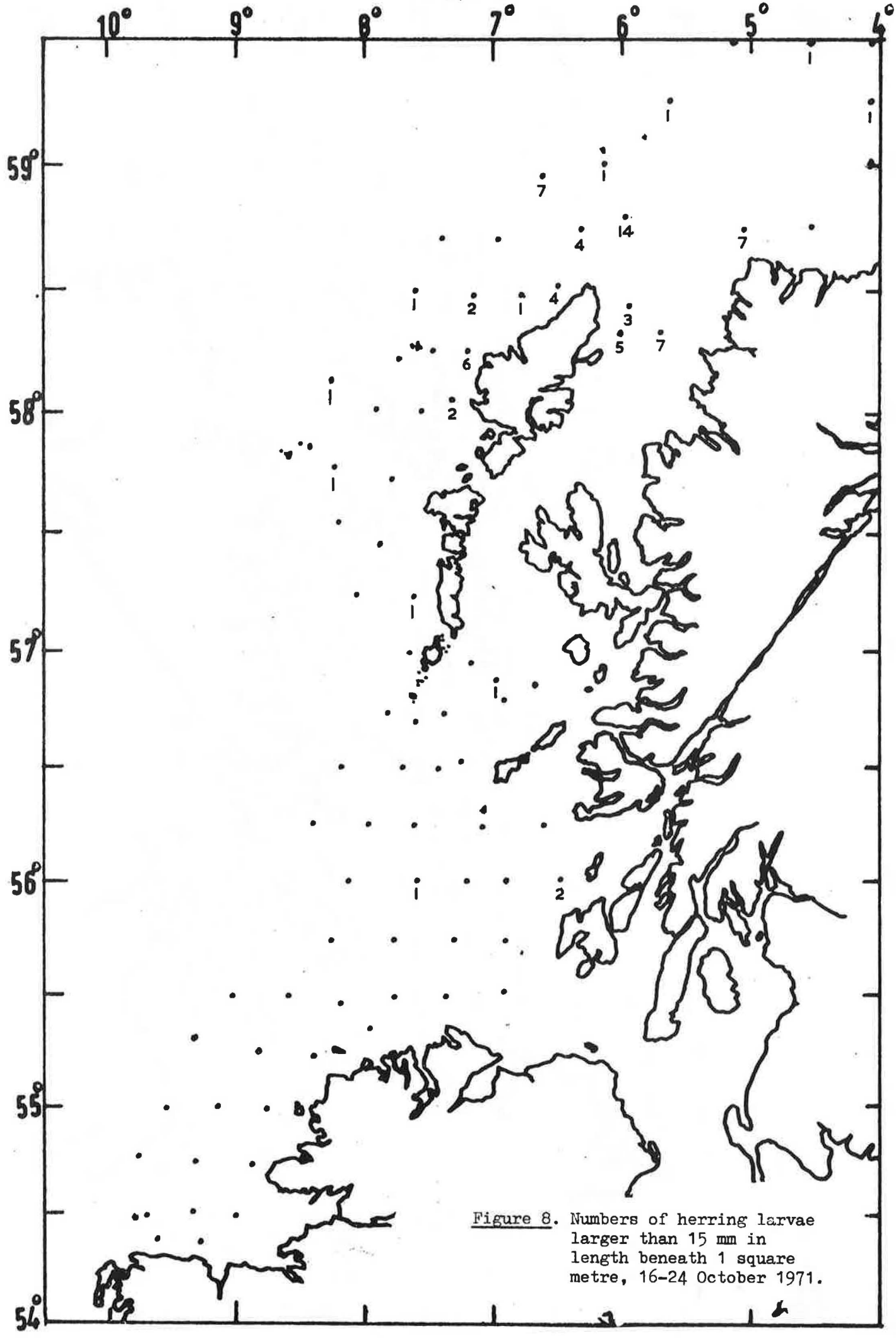

Figure 8. Numbers of herring larvae larger than 15 mm in length beneath 1 square metre, 16-24 October 1971.