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Report on the International Surveys of Herring Larvae in
the North Sea and adjacent waters in 1969/70

by

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The international herring larval surveys which were started in 1967 were continued during the autumn and winter of 1969/70 with a total of six countries participating. The countries and their respective research vessels were England - RVs "Corella" and "Clione", Germany - RV "Anton Dohrn", Netherlands - RVs "Tridens" and "Willem Beukelsz", Norway - RV "G.O.Sars", Sweden - RV "Thetis", and Scotland - RVs "Scotia" and "Clupea". Details of the sampling gear used, its operation and the survey areas have already been described in earlier reports by SAVILLE (1970) and BOËTIUS and MCKAY (1970). The areas which were surveyed during 1969/70 were similar to those which were covered in the previous two years and included the north-western and western-central North Sea between latitudes $53^{\circ}30'N$ and $61^{\circ}12'N$, the Jutland Bank, the Kattegat from $56^{\circ}08'N$ to $57^{\circ}52'N$ and the southern North Sea and eastern Channel between $49^{\circ}30'N$ and $53^{\circ}30'N$. The first survey began on the 3 September 1969 and the last was completed on the 15 January 1970.

The results of all the surveys have been presented here, as in earlier years, as the estimated numbers of herring larvae beneath one square metre of surface at each of the stations worked. They are shown in three size groups, less than 10 mm, from 10-15 mm and greater than 15 mm. Where more than one haul was made at any particular station position only the highest number of herring larvae caught in any single haul has been plotted on the accompanying charts. In order to show clearly both the total area of herring larval distribution, and also the centres of density, on these charts only contours at levels of 1 and 25 larvae per square metre have been drawn. However, for the calculation of the larval abundance estimates, which are discussed in the concluding section of this report, only large-scale charts of either $\frac{1}{1\ 000\ 000}$ or $\frac{1}{1\ 250\ 000}$ have been used, and these were contoured and planimetered at appropriate levels of density.

North-Western North Sea

Sampling was carried out in the north-western North Sea between the 4-16 September 1969 by English and Scottish research vessels working both to the east and west of the Orkney and Shetland Islands and also off the northeast coast of Scotland. The distributions of herring larvae in this region during this period are shown separately for the three size groups in Figures 1-3. It will be seen that at this time high densities of recently hatched herring larvae, less than 10 mm in length, were confined to the area situated within an arc from southwest to northeast of Orkney, with densities exceeding 100 larvae per square metre at a number of positions, the highest being 351 per square metre to the north of Orkney. The distribution of herring larvae larger than 10 mm was somewhat more extensive with small numbers also occurring at the stations worked on the western side of Shetland and round to the northeast of the islands. Some larger larvae were also found to the east of Orkney and in the Moray Firth off Clythness. The highest densities encountered for the larger larvae were 226 per square metre for those between 10-15 mm in length and 36 per square metre for those larger than 15 mm, both found at positions to the southwest of Orkney. The contours for all three size groups of herring larvae were not completely closed along the western side of the survey area during the period 4-16 September 1969 and the full extent of the larval concentration to the west of Orkney and Shetland at this time could not be determined. Numbers of herring larvae of all sizes were insignificant elsewhere in this region.

Part of the northwestern region was resampled from 18 September - 4 October 1969 by English, Scottish and German research vessels but on this survey stations were confined to the east of the Orkney and Shetland Islands and the Scottish mainland. The distributions of herring larvae during this period are shown in Figures 4-6. The stations which were worked to the east of Orkney by the RV "Anton Dohrn" on 21-22 September were very close together. Owing to the nature of the distribution of these stations and the fact that they were worked in an area covered systematically by the RV "Scotia" survey, they have not been used in the final calculation of total larval abundance given in the concluding section of this report. It was, however, ascertained that their exclusion would not significant-

ly affect the larval estimates arrived at for this period. During this second survey fairly low densities of recently hatched herring larvae were found to the east of both Orkney and Shetland, the maximum density at any station being only 61 larvae per square metre. Larger herring larvae were confined to the same localities, and densities were also low, the maximum number being 29 per square metre for larvae between 10-15 mm in length and 14 per square metre for larvae larger than 15 mm.

To summarise, in the northwestern North Sea during the first half of September 1969 major concentrations of herring larvae were only located in the area to the west of the Orkney and Shetland Islands. During the second half of September, up to and including 4 October 1969, less dense concentrations were found to the east of both Orkney and Shetland. No significant concentrations of herring larvae were located elsewhere, but, because no sampling was carried out to the west of Orkney and Shetland during the second period, it is an open question whether the main centre of herring larval distribution was still situated there, as was the case in both 1967 and 1968. However herring larvae appeared to be abundant a few miles to the northwest of Fair-Isle during the night of 4-5 October when vertical distribution sampling was carried out there by RV "Corella". Unfortunately it was impossible to convert the numbers caught in these hauls to numbers beneath one square metre of surface.

It would seem to be of considerable importance to sample the area to the west of Orkney, during any future herring larval surveys carried out in the northwestern North Sea in late September and October. It must be of some concern that during the autumn of 1969 the overall extent of the area in which herring larvae were found to the east of the Orkney and Shetland Islands again showed a reduction for the second year in succession.

Central North Sea

During the period 3-25 September 1969 a very good coverage of the western part of the central North Sea was obtained by Dutch, German and Scottish research vessels working between latitudes $53^{\circ}30'N$ and the northern boundary of the region (i.e. $57^{\circ}30'N$), the

area off the Scottish east coast being particularly well covered by both German and Scottish vessels. The distributions of herring larvae in this region during the period are shown for the three size groups in Figures 7-9. Between 9-11 September small numbers of recently hatched herring larvae were found to the east of Whitby at four stations but the highest density at that time was only 14 larvae per square metre for those less than 10 mm in length and four per square metre for larvae between 10-15 mm. Over the remainder of the very large area which was surveyed between 3-25 September 1969 herring larvae were almost completely absent from the catches although a few odd individuals were caught off the Scottish coast, mainly to the east of Aberdeen Bank, where the highest density for all sizes of larvae was only four per square metre.

A second extensive survey was completed by Dutch and English research vessels in the western part of the central North Sea between latitudes $53^{\circ}30'N$ and $56^{\circ}00'N$ during the period 6-14 October 1969. The larval distributions at this time are shown in Figures 10-12. Small numbers of herring larvae less than 10 mm in length were found in two localities; at a maximum density of 19 larvae per square metre off Scarborough and eight larvae per square metre in the vicinity of the Outer Dowsing Light Vessel. Herring larvae larger than 10 mm were however caught in far greater numbers, up to 69 per square metre for larvae from 10-15 mm in length off Flamborough Head and 20 per square metre for larvae larger than 15 mm near the Outer Dowsing. These larger herring larvae were distributed over a wide area extending some 60 miles from the English coastline between approximately latitudes $53^{\circ}30'N$ and $54^{\circ}40'N$. The contours along the southern edge of the survey area however were not completely closed. A very small, low density, patch of herring larvae mainly from 10-15 mm in length was also located between 11-13 October off the Northumberland coast to the south of the Longstone area, but the highest density was only four larvae per square metre for all sizes combined.

To summarise, the only substantial concentrations of herring larvae in the western part of the central North Sea in the autumn of 1969 were found during September-October in the Whitby-Flamborough-Dowsing area. It seems ominous that there was apparently a complete

absence of herring larval production in the N.E. Bank area, however, and that only very minor concentrations were found in the vicinity of Aberdeen Bank and the Longstone. It must be added that catches of ripe herring (in maturity stage VI) were still being landed by English vessels fishing the Longstone grounds as late as 9 October 1969, so that hatching of herring larvae must still have occurred after the last survey ended. In addition the very small numbers of herring larvae, mainly from 10-15 mm in length, which were found around the western and southwestern edges of the Dogger Bank in October may have been derived from spawning which took place in that area.

The Jutland Bank and Kobbergrund area

Sampling in the northeastern North Sea and Skagerak was carried out by research vessels of Norway and Sweden between 16-28 October 1969. Norway surveyed the Jutland Bank on 16-17 October and the Kobbergrund area from 20-23 October. Sweden also surveyed the Kobbergrund area at this time, i.e. 20-28 October with all but four stations being completed between 20-24 October. Sampling was again carried out by Norway with both the Juday and Clarke-Bumpus nets while Sweden used a Gulf III. Most of the herring larvae caught during these surveys were less than 10 mm in length. The Clarke-Bumpus net usually gave higher numbers of larvae per square metre of surface than the Juday net and in the accompanying charts only the highest number of larvae caught by either gear at any station has been plotted. There seemed generally to be good agreement between the numbers of herring larvae caught beneath one square metre of surface by the Clarke-Bumpus and Gulf III samplers.

The results of the Norwegian and Swedish surveys during October 1969 are given in Figures 13 and 14. As in 1967 and 1968 no herring larvae were found over Jutland Bank but in the Kobbergrund area herring larvae less than 10 mm in length were taken at several stations in numbers exceeding 25 larvae per square metre, the highest being 48 per square metre. Small numbers of herring larvae were present over a considerable part of the Kattegat but unfortunately because of the spacing of the southernmost stations it was impossible to contour the distribution accurately.

To summarise, there were again no catches of herring larvae over the Jutland Bank in the autumn of 1969 for the third year in succession, but it would seem that herring larval production in the Kattegat was of approximately the same magnitude as in the previous two years.

Southern North Sea and Eastern Channel

Although it was not originally specified that the spawning grounds of the Downs stock should be included in the international larval surveys, the results of surveys of these grounds carried out by research vessels of the Netherlands have been made available for inclusion in the previous reports for 1967 and 1968. During the winter of 1969/70 there was a much better coverage of the Downs spawning areas than for a number of years and it has been possible to include all the results in this report.

Research vessels of the Netherlands carried out two extensive surveys, the first in December 1969 and the second in January 1970. In addition a survey was made by England during early January 1970 covering both the southern North Sea and Eastern Channel, while a survey by Germany in the same month extended over parts of the southern and central North Sea.

The distributions of the herring larvae caught during the first survey which was carried out by the RV "Tridens" from 8-9 December 1969 are shown in Figures 15 and 16. A number of additional stations were worked, and a few of the earlier ones resampled, between 19-23 December, and these showed the presence of small numbers of larvae at three stations in the Sandettie area where they had been absent on the previous survey. During the whole of the period 8-23 December small numbers of recently hatched herring larvae less than 10 mm in length were located in three general areas:-

- 1) in the Bay of the Seine, with concentrations of up to six larvae per square metre;
- 2) off Point d'Ailly with concentrations of up to 11 larvae per square metre;
- 3) in the Sandettie area where the density was only one larva per square metre.

Very small numbers of herring larvae between 10-15 mm in length were also caught in these localities but nowhere did they exceed six larvae per square metre and only a single larva larger than 15 mm was caught during the whole of the December survey.

The second survey made between 3-6 January 1970 by RV "Clione" produced small numbers of herring larvae at approximately half of the stations worked. Herring larvae less than 10 mm in length were scattered throughout the Southern Bight and Eastern Channel but at no point did their density exceed 5 per square metre. The picture was very similar for those larvae between 10-15 mm in length and these had a maximum density of only 8 larvae per square metre. Again, as during the December survey, only a single larva larger than 15 mm was caught.

The third and most productive survey was made between 5-15 January 1970 by the RV "Willem Beukelsz". The distributions of these larvae are shown in Figures 17 and 18. Herring larvae less than 10 mm in length were found not only in the Sandettie area, at densities of up to 25 larvae per square metre, but also in the Channel off Point d'Ailly where the maximum density was 22 larvae per square metre, and in the Bay of the Seine where up to 75 larvae per square metre were obtained. Even higher concentrations occurred amongst the larvae from 10-15 mm in length at several of the stations in the Channel, the highest of all being one of 200 per square metre some 25 miles NW of Point d'Ailly. The full extent of the herring larval concentrations both at Sandettie and in the Bay of the Seine could not be determined because most of the contours remained open in these two areas. During the whole of this survey no herring larvae larger than 15 mm were caught. Sampling which was done during the same period by the RV "Anton Dohrn" in the northern part of this survey area and also in the central North Sea produced only a single larva.

Thus, for the first time in a number of years appreciable herring larval production occurred during the winter of 1969/70 in the Eastern Channel, the densest concentrations being found during January 1970 in the Bay of the Seine and off Point d'Ailly. Herring larval production of some importance also took place in the Sandettie area during the same period.

Discussion

One of the chief objectives of the international herring larval surveys is to obtain estimates from year to year of the changes which are taking place in the size of each of the major spawning stocks. In Table 1 larval abundance estimates are given for the three size groups of herring larvae separately by either area or stock, together with the total for all sizes.

The data from the area west of Orkney and Shetland presented something of a problem. A small number of stations were worked by RV "Scotia" during the first half of September 1969 to the west of longitude 4° West in ICES Region VIa and at these stations high densities, particularly of recently hatched herring larvae, were obtained. There are good reasons for not including these herring larvae in production estimates with those found closer to Orkney in ICES Region IVa. The autumn spawning ground off Cape Wrath has been known for many years (e.g. CLARK 1933) and the herring which spawn there may be associated more closely with the Hebrides autumn spawners (see WOOD 1968a) than with those of the northwestern North Sea. In Table 1 the abundance estimates for herring larvae surveyed in ICES Region VIa during the period 4-16 September 1969 have therefore been shown separately. The total abundance estimate for these larvae of 281.7×10^9 is very considerable and it must be noted that because of the very small number of stations worked in that area the overall distribution picture cannot be deduced. The figure given is therefore probably a very considerable underestimate of the total production of herring larvae off Cape Wrath in the first half of September 1969.

The herring larval estimates for the northwestern North Sea are shown in Table 1 for two periods 4-16 September, and 18 September - 4 October 1969. Included in these is a figure of 3.1×10^9 for herring larvae found in the traditional Buchan area off the Scottish east coast (mainly near to Aberdeen Bank) in ICES Region IVb. The total abundance estimate of 757.8×10^9 herring larvae for the period 4-16 September 1969 is almost identical to that of 762.1×10^9 given by SAVILLE (1970) for the Buchan stock during the period 6-24 September 1967. The figure of 180.2×10^9 herring larvae for the period 18 September - 4 October 1969 is considerably less than that of

888.8×10^9 for the period 25 September - 13 October 1967 but as was pointed out earlier in this report no stations were worked to the west of Orkney or Shetland during this period in 1969 while the major part of the 1967 abundance estimate was derived from a number of stations with very high densities to the southwest of Orkney. The production figures for the Buchan stock in 1968 (BOËTIUS and McKAY, 1970) were somewhat lower than those in both 1967 and 1969, but the timing of the surveys in 1968 was slightly different and the coverage, particularly during the first half of September, not so extensive.

It thus seems reasonable to conclude from these larval abundance estimates that there has been no appreciable change in the overall size of the spawning population in the northwestern North Sea during the years 1967-1969. There has however been a marked change in the distribution of herring larvae in this area during these years. In 1967 significant numbers of herring larvae were found over a considerable area to the east of both Orkney and Shetland and off the Scottish east coast, in addition to the main concentrations further to the west. In 1969, however, production in the northwestern North Sea was very largely confined to the area west of the Orkney and Shetland Islands.

For the Bank stock larval estimates are given in Table 1 for the two periods 3-25 September and 6-14 October 1969. As stated earlier the September survey was very extensive and covered the whole of the western part of the central North Sea. It is probable however that this survey was timed too early to cover herring larval production on all the spawning grounds in this region as HEMPEL and SCHNACK (1968) deduced that the major hatching of herring larvae on the N.E. Bank in 1967 began on 22 September, and this area was surveyed by RV "Anton Dohrn" in 1969 between 12-19 September. A small patch of recently hatched herring larvae was sampled off Whitby by RV "Tridens" between 9-11 September and together with the few odd larvae caught elsewhere gave a total abundance estimate for the Bank stock in the period 3-25 September 1969 of only 11.4×10^9 herring larvae. The figure of 184.8×10^9 herring larvae during the period 6-14 October 1969 composed almost entirely of larvae caught in the Whitby/Flamborough/Dowsing area is of the same order of

magnitude as that for the survey carried out in the same area by RV "Ernest Holt" between 17-21 October 1968. During the second survey period in 1969 the N.E.Bank was again surveyed, this time by RV "Tridens", but no herring larvae were caught there. Herring larval production in the Bank stock in both 1968 and 1969 seems to have been almost entirely confined to the Whitby/Flamborough/Dowsing area and the abundance estimates for these years are very much lower than those which were obtained in 1967. In 1967 there was considerable production in the vicinity of the N.E.Bank while none has been in evidence there in either of the two succeeding years. The figure given by SAVILLE (1970) of 400.5×10^9 for the Bank stock during the period 6-24 September 1967 was however for larvae caught in the main off Whitby and it is therefore perhaps roughly comparable with the figure of 184.8×10^9 herring larvae for the period 6-14 October 1969. It would thus appear that during the three years 1967-1969 production of herring larvae has virtually ceased over the N.E.Bank, has been considerably reduced in the Whitby area and been at an extremely low level in the Dogger/Well Bank area.

The total abundance estimate of herring larvae in the Kobbegrund area for the period 16-28 October 1969 is 29.2×10^9 . This figure is obviously an underestimate and perhaps a considerable one, for the main larval concentration was only partially covered by the survey and there were indications that herring larvae were widely distributed to the south of the main survey area. Despite this the abundance estimate is more than double the figure of 11.5×10^9 for 1968 (BOËTIUS and MCKAY 1970) although considerably lower than the estimate of 59.5×10^9 in 1967 (SAVILLE 1970).

Because of the incomplete coverage of the larval distribution in the Kattegat it would be unwise to draw any conclusions from the above estimates.

The results of the surveys carried out over the spawning grounds of the Downs stock during December 1969 and January 1970 are perhaps the most interesting of those covered by this report. Abundance estimates are given in Table 1 for Downs herring larvae in separate periods. A total of 25.0×10^9 herring larvae was obtained from the first survey, which was carried out between 8-23 December

1969, and this figure may be compared with that of 5.3×10^9 given by SAVILLE (1970) for the period 11-20 December 1967, and an English estimate of 36.8×10^9 for a survey carried out between 8-18 December 1967, during which the main larval patch off Beachy Head was covered more extensively. BOËTIUS and McKAY (1970) did not include an estimate for Downs larvae surveyed between 9-17 December 1968 but the figure would appear to be of the order of 20.0×10^9 , and therefore fairly similar to that of December 1969.

Two abundance estimates are given for the surveys carried out during January 1970, the first being 39.0×10^9 for the period 3-6 January and the second 259.0×10^9 for the period 5-15 January. The latter figure is relatively large and as has been pointed out is an underestimate of total abundance because only a part of two of the main concentrations were covered by the survey grid.

Some recent English abundance estimates (mainly derived from plaice egg and larval surveys) are available for Downs herring larvae during the early part of the year. These are as follows:-

<u>Survey Period</u>	<u>Total Abundance of Larvae</u>
2-10 January 1968	49.8×10^9
23-31 January 1968	10.0×10^9
9-20 February 1968	17.5×10^9
18-23 January 1969	10.0×10^9

It is clear that the estimate of 259.0×10^9 herring larvae for the period 5-15 January 1970 is exceptionally high, and in fact no comparable abundance has been obtained from English surveys in the Downs spawning area since a figure of 609×10^9 for the period 2-7 January 1952.

The only conclusion that can be drawn from the high abundance estimate for January 1970 is that the size of the Downs spawning stock during the 1969/70 season, particularly in the Eastern Channel, was much larger than for a number of years. It might appear unwise to base this conclusion on only one abundance estimate, but BURD and HOLFORD (1968) have commented that although herring larval production in the Downs stock reached an extremely low level in the mid 1950's,

there was, after a period of only light fishing effort, a significant recovery in larval production by the 1967/68 spawning season. WOOD (1968b) moreover found a marked increase in the abundance of 0-group herring of the previous (1966/67) year class thought to have been derived from the spawning grounds of the Downs stock, and WOOD and PARNELL (1970) have recently reported that a significant proportion of the recruit herring of the 1966/67 year class caught during the English driftnet fishery off North Shields in 1969 were almost certainly members of the Downs stock. It will be interesting during the next series of surveys to observe whether the recovery of the Downs stock shows signs of continuing.

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Table 1

Area or Stock	Survey	Abundance of herring larvae x 10 ⁹			
		< 10 mm	10-15 mm	> 15 mm	Total
Cape Wrath (Region VIa)	4-16 Sep. 1969	161.8	113.3	6.6	281.7
North-Western North Sea (Region IVa)	4-16 Sep. 1969	348.1	327.6	82.1	757.8
	18 Sep.-4 Oct. 1969	74.9	65.3	40.0	180.2
Bank	3-25 Sep. 1969	8.4	2.9	0.1	11.4
	6-14 Oct. 1969	12.7	138.6	33.5	184.8
Kobbergrund	16-28 Oct. 1969	28.1	1.1	-	29.2
Downs	8-23 Dec. 1969	13.0	12.0	-	25.0
	3-6 Jan. 1970	16.7	22.3	-	39.0
	5-15 Jan. 1970	73.1	185.9	-	259.0

KEY TO FIGURES 1 - 18.

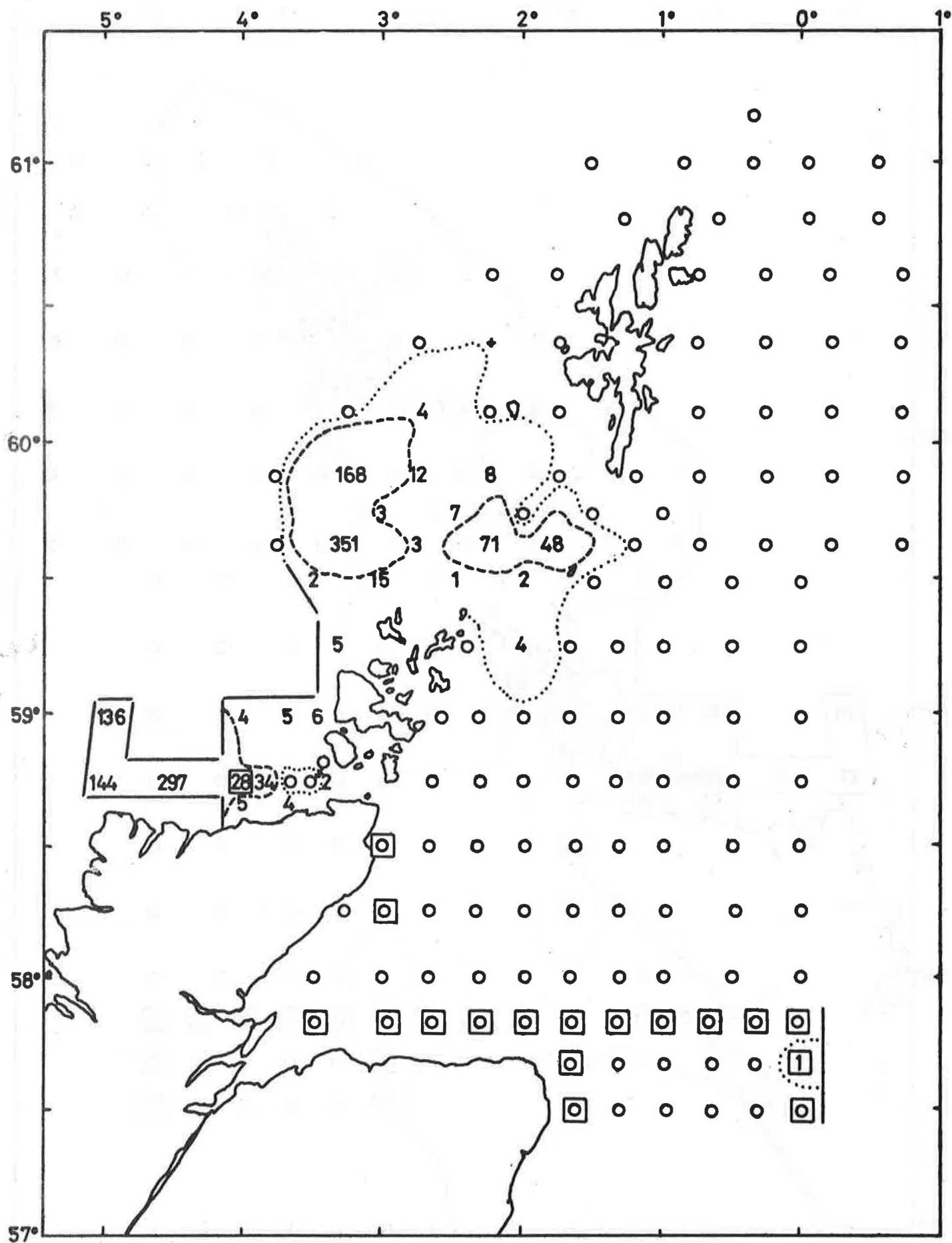
♦ Less than 0.5 herring larvae beneath one square metre of surface.

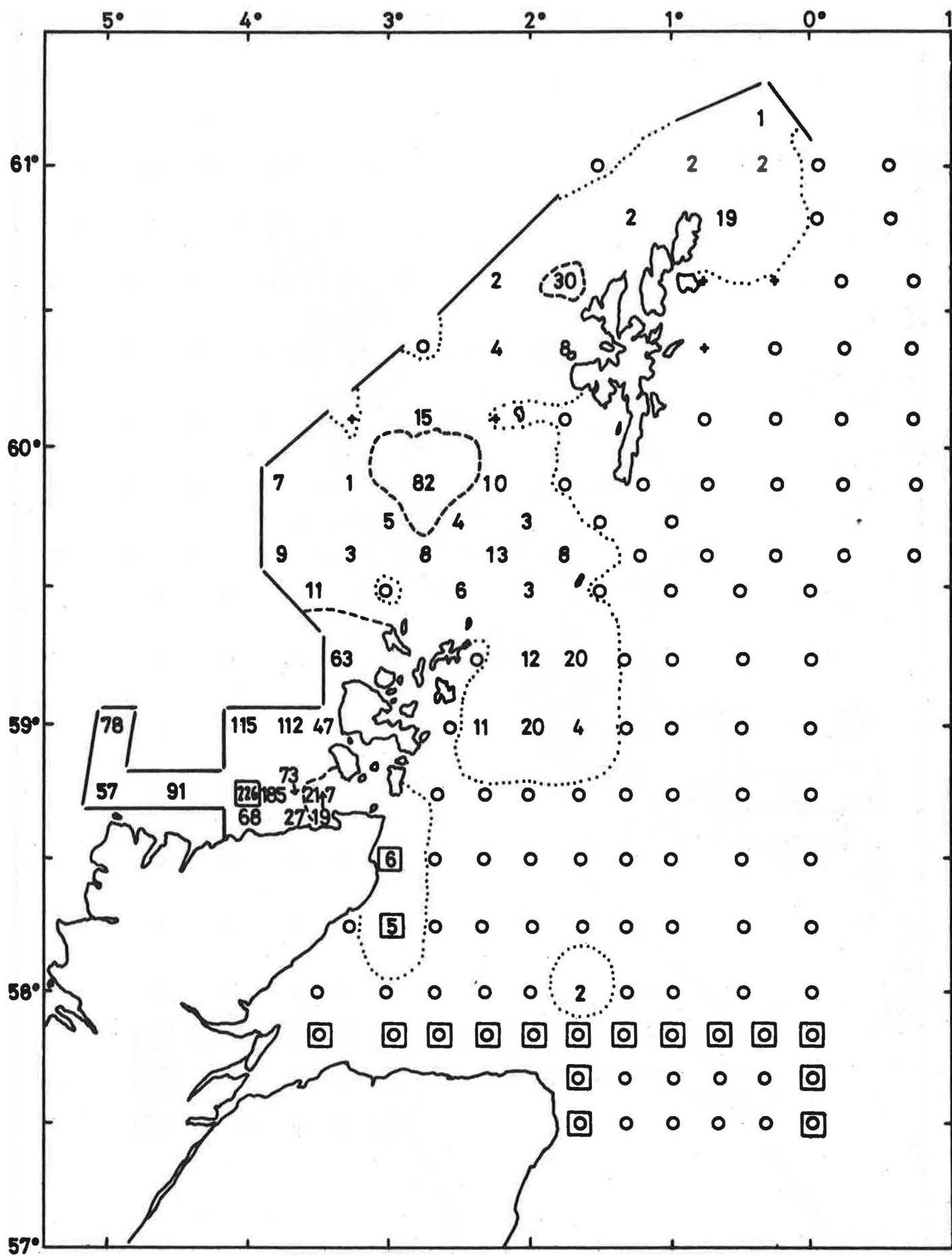
□ Station worked twice during survey period.

↙²⁰ Number of larvae indicated caught at position marked by point of arrow.

..... 1 herring larva beneath one square metre of surface.

----- 25 herring larvae beneath one square metre of surface.





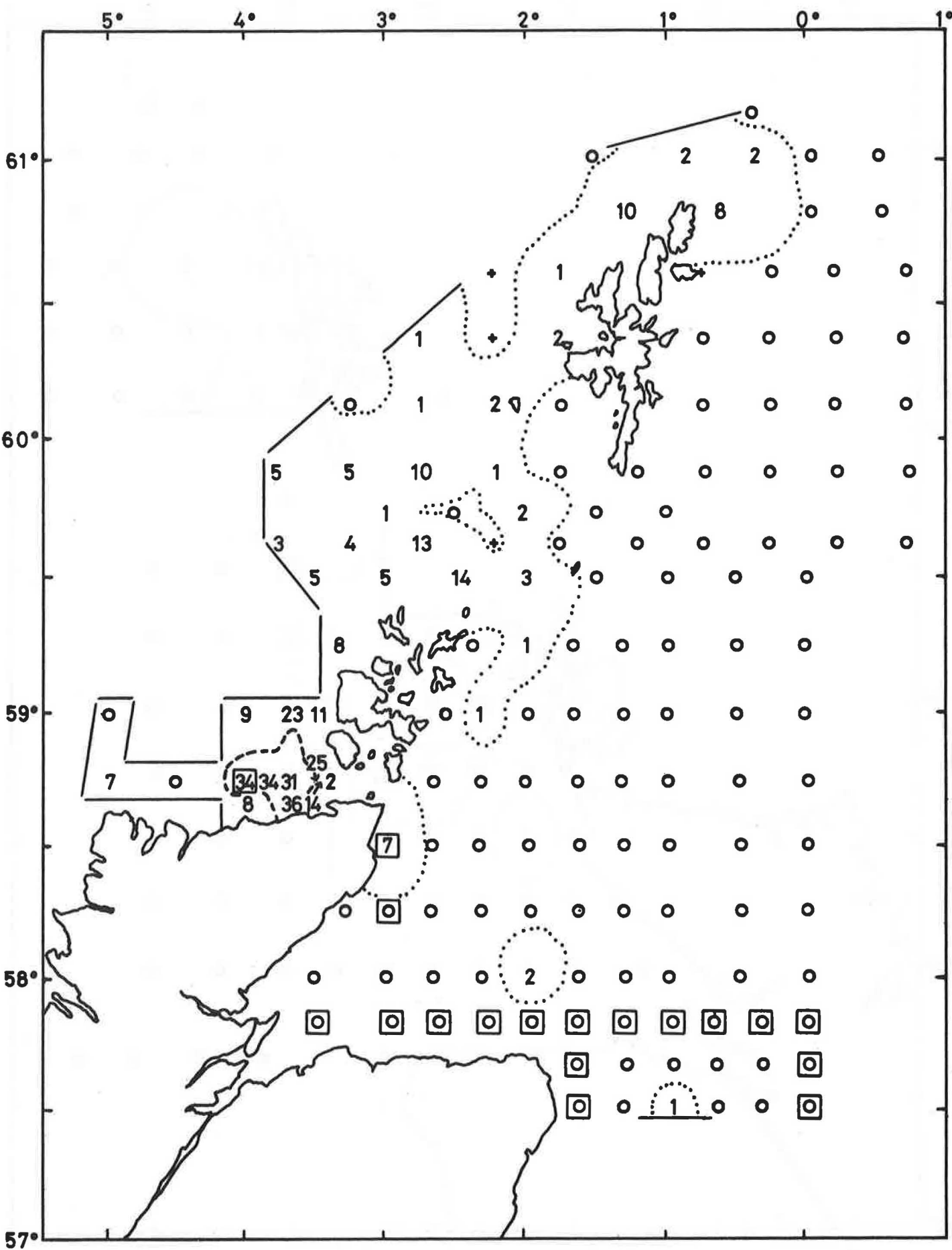


Figure 3 Numbers of herring larvae > 15 mm long beneath 1 square metre of surface. North-western North Sea. 4-16 September 1969.

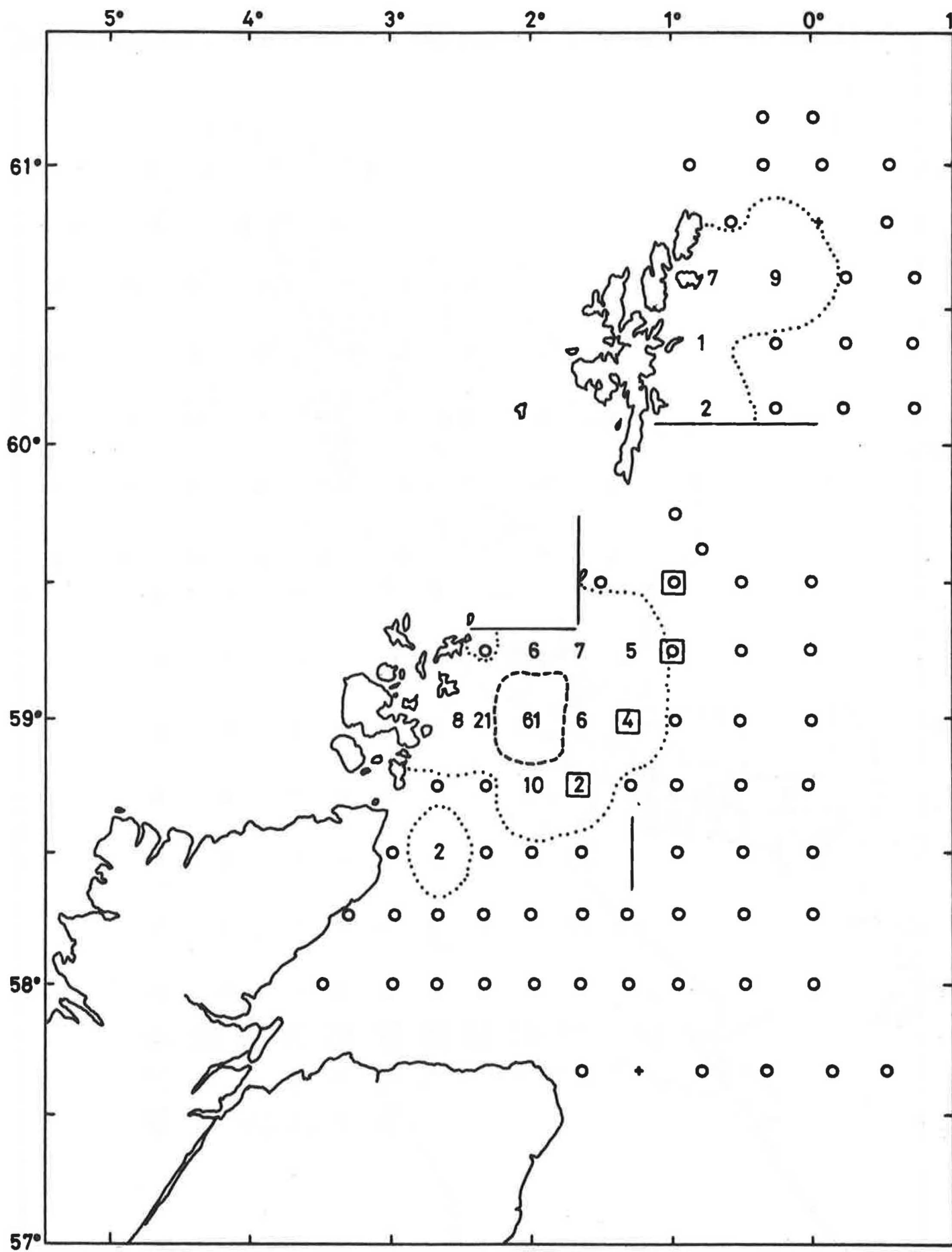


Figure 4 Numbers of herring larvae <10 mm long beneath 1 square metre of surface. North-western North Sea. 18 September - 4 October 1969.

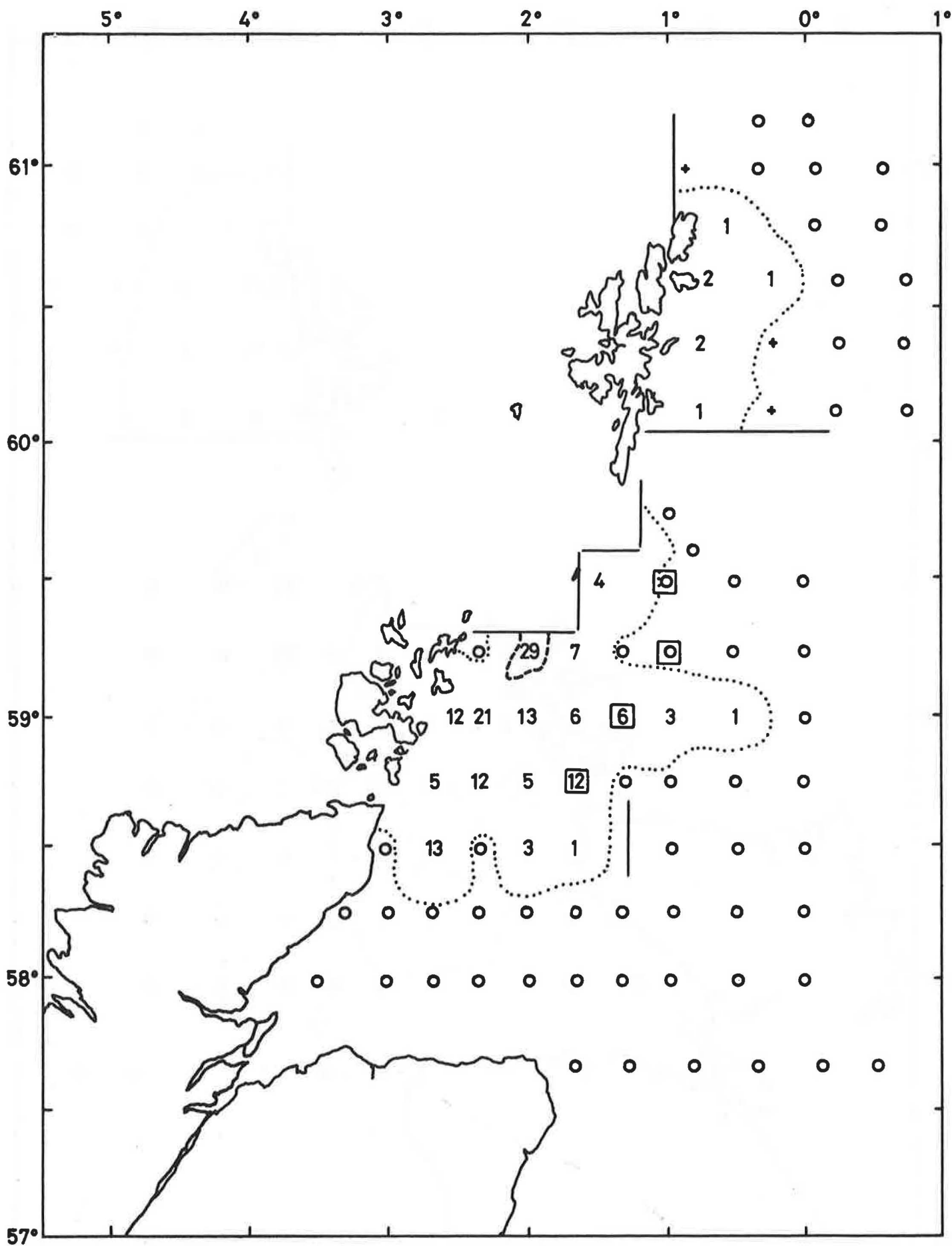


Figure 5 Numbers of herring larvae 10-15 mm long beneath
1 square metre of surface.
North-western North Sea. 18 September -
4 October 1969.

Figure 6 Numbers of herring larvae > 15 mm long beneath
1 square metre of surface.
North-western North Sea. 18 September -
4 October 1969.

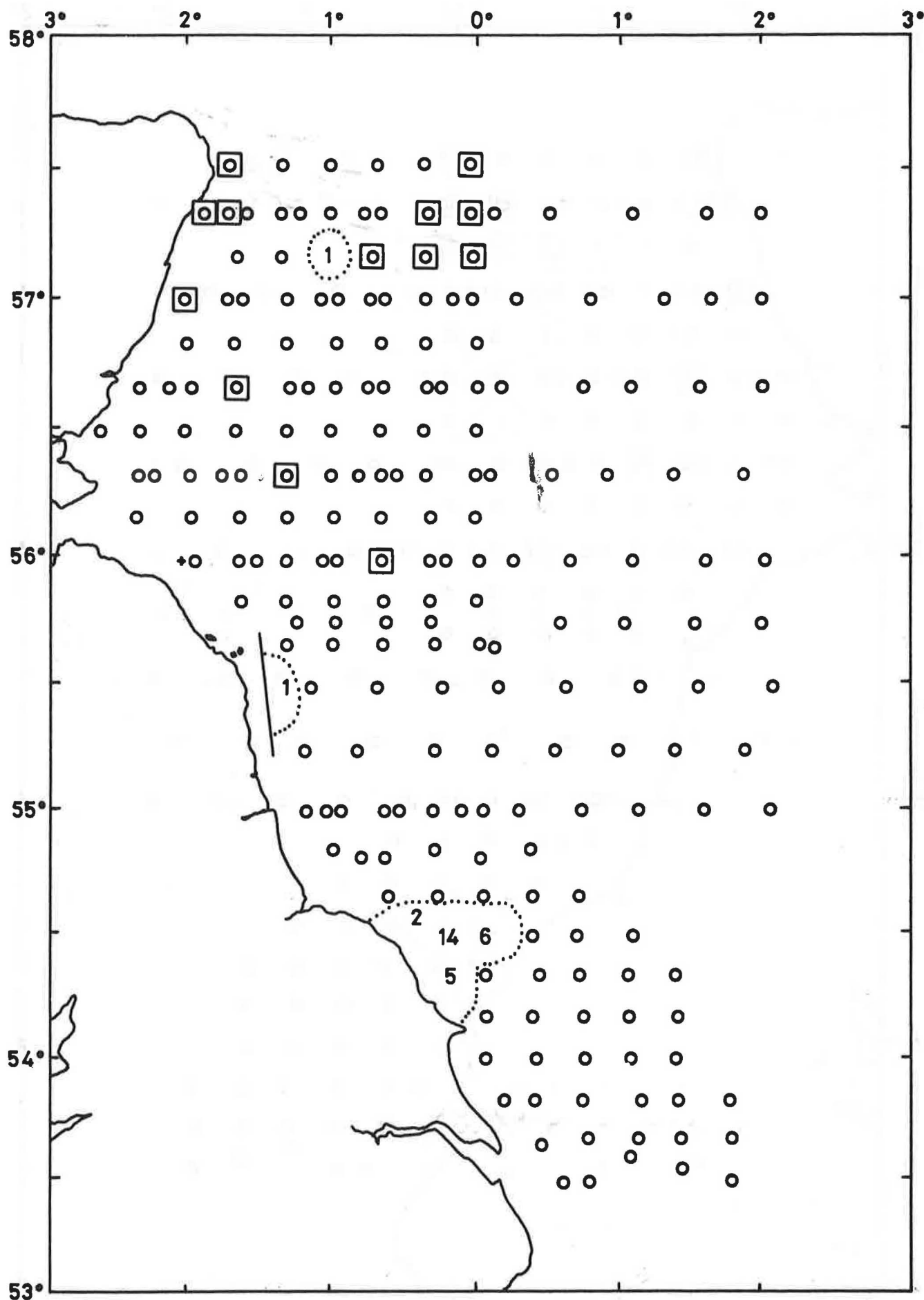


Figure 7 Numbers of herring larvae < 10 mm long beneath
1 square metre of surface.
Western central North Sea. 3-25 September 1969.

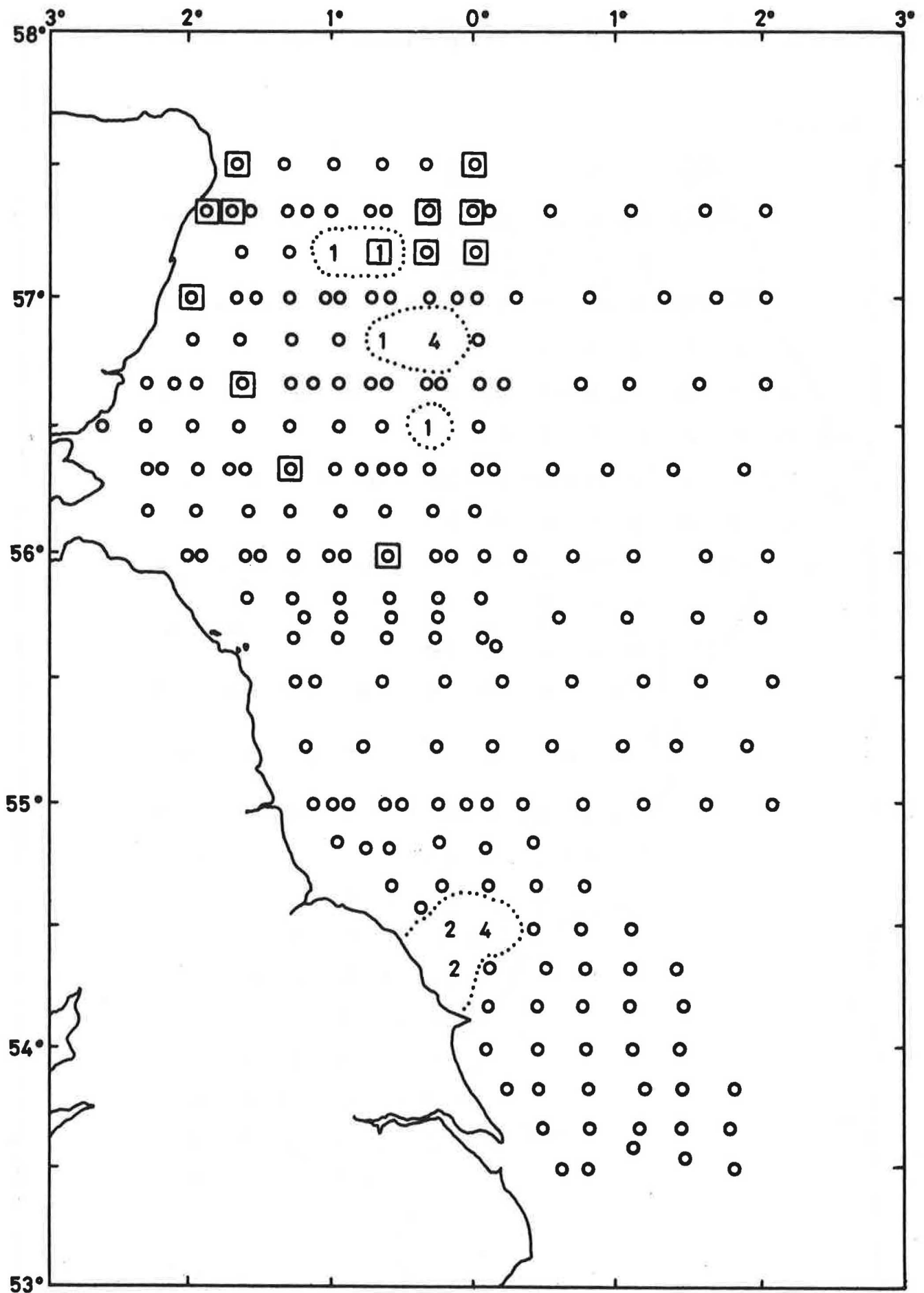


Figure 8 Numbers of herring larvae 10-15 mm long beneath 1 square metre of surface. Western central North Sea. 3-25 September 1969.

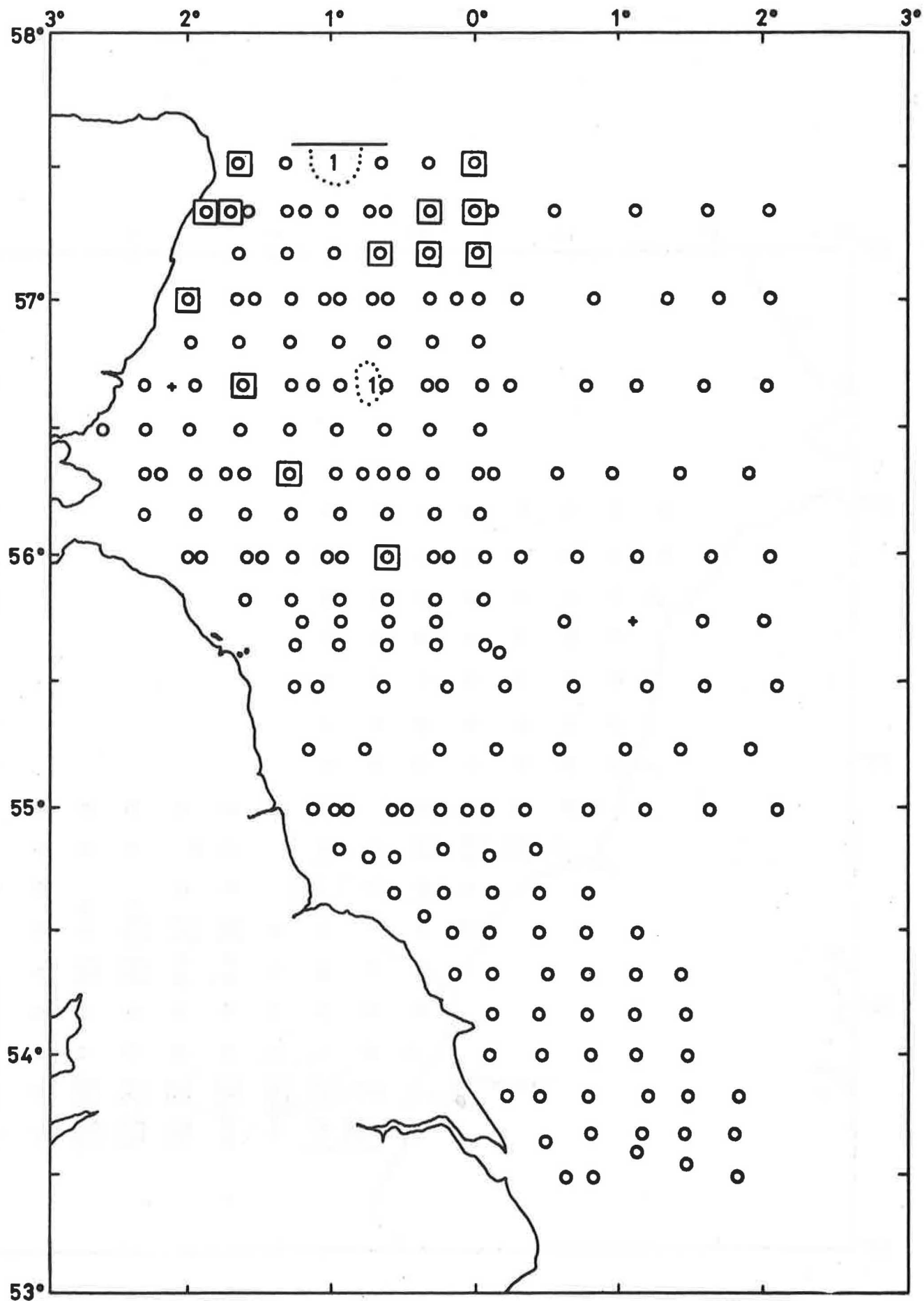


Figure 9 Numbers of herring larvae > 15 mm long beneath
1 square metre of surface.
Western central North Sea. 3-25 September 1969.

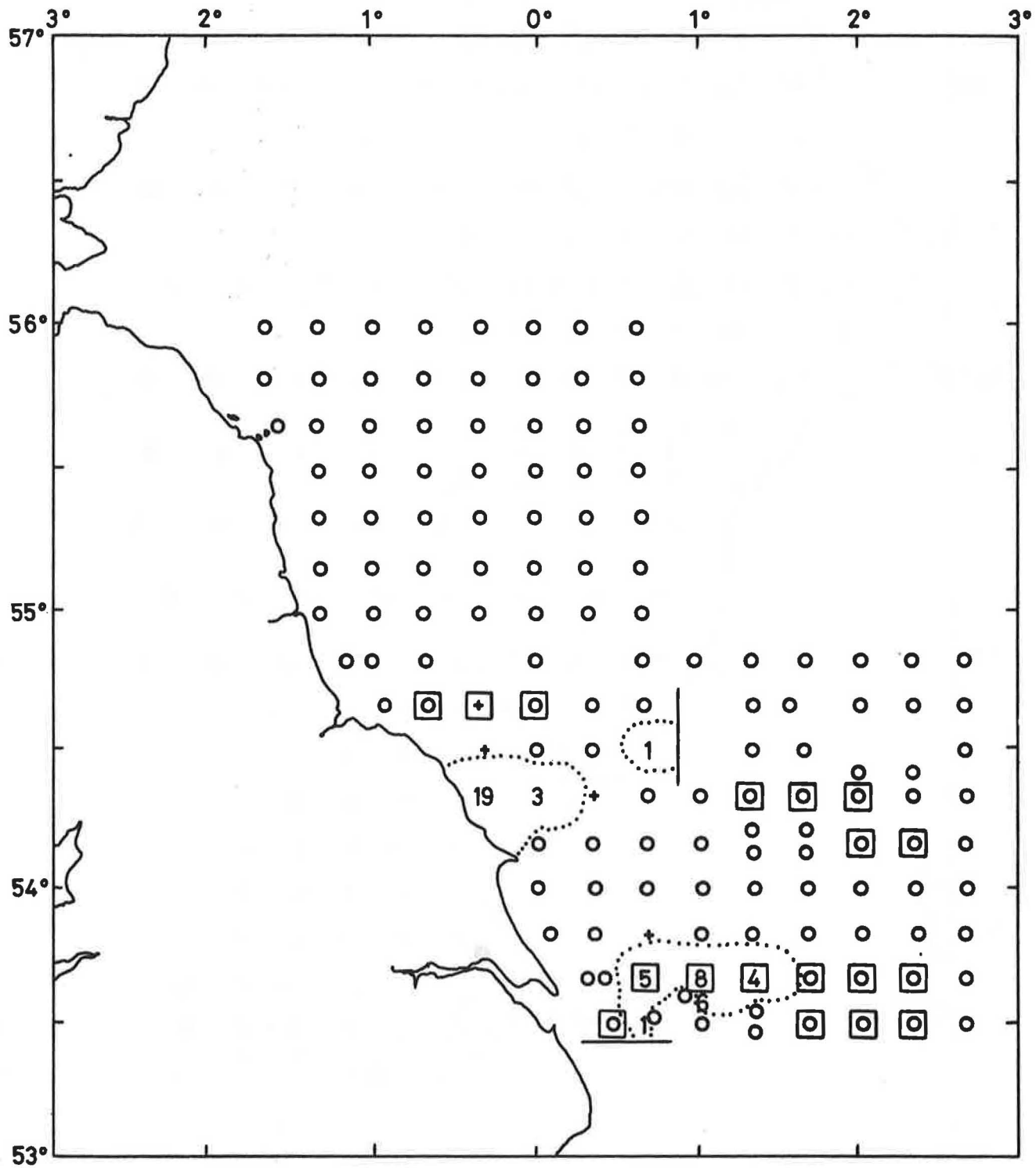
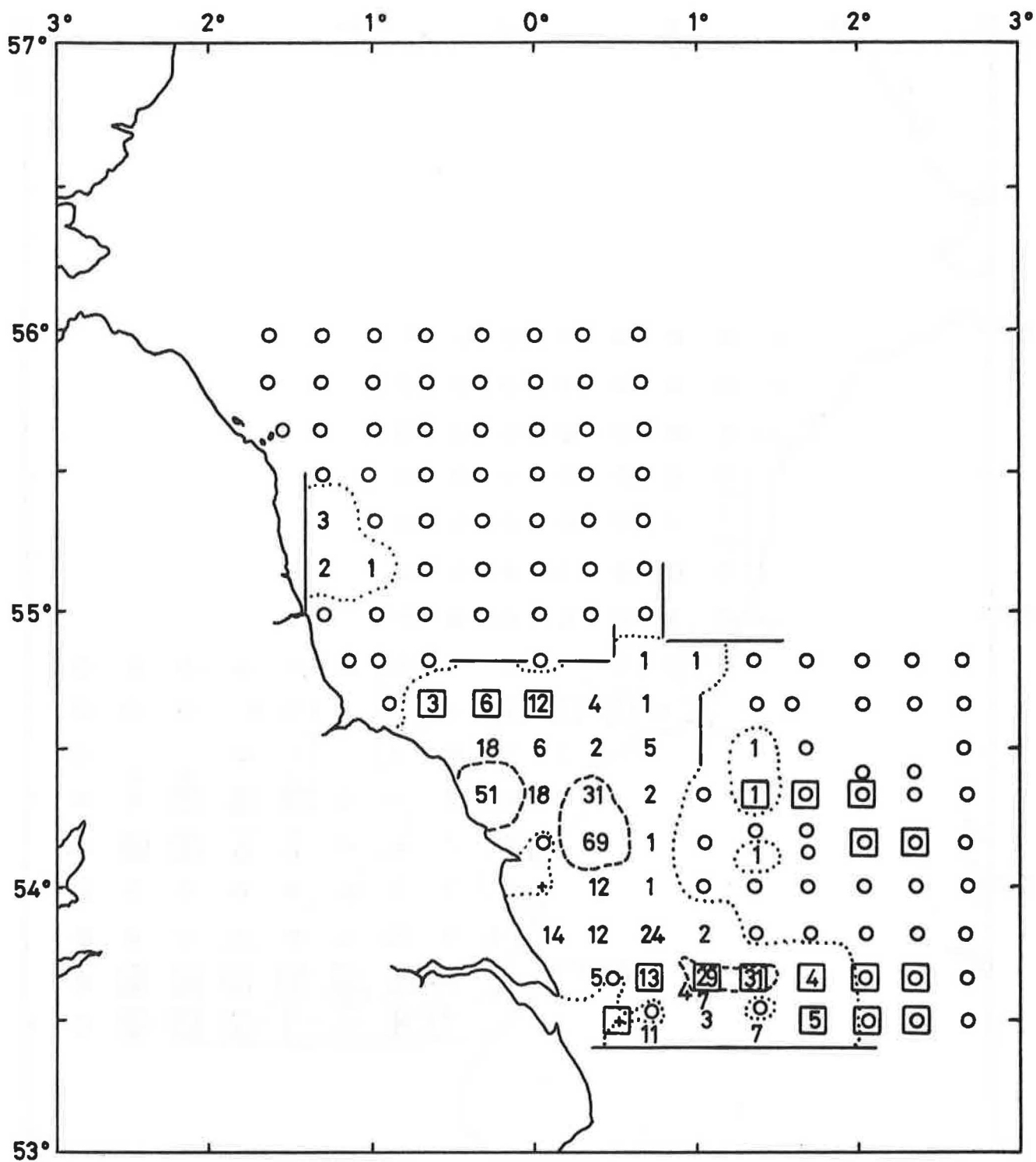


Figure 10 Numbers of herring larvae < 10 mm long beneath
1 square metre of surface.
Western central North Sea. 6-14 October 1969.



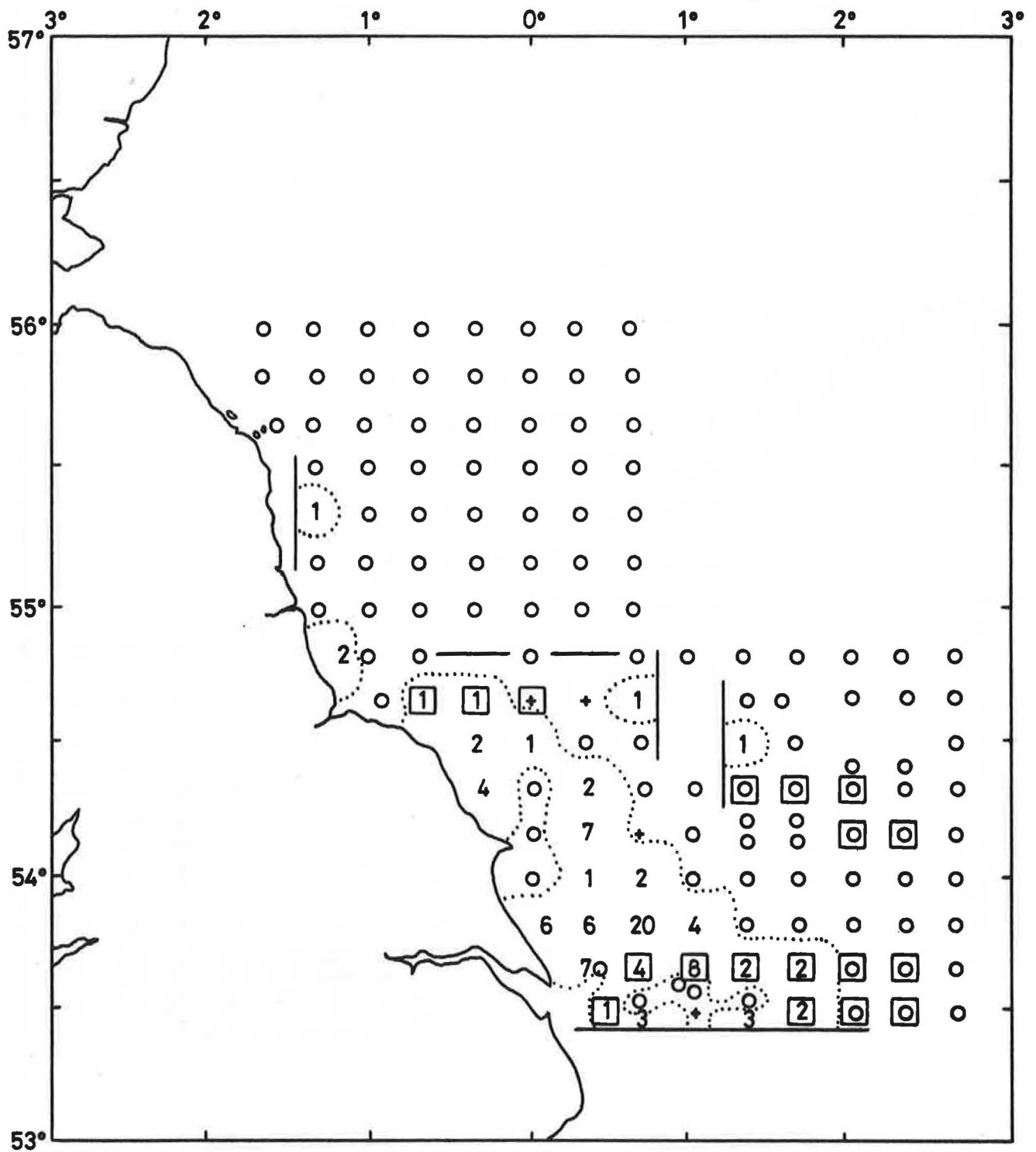


Figure 12 Numbers of herring larvae >15 mm long beneath 1 square metre of surface. Western central North Sea. 6-14 October 1969.

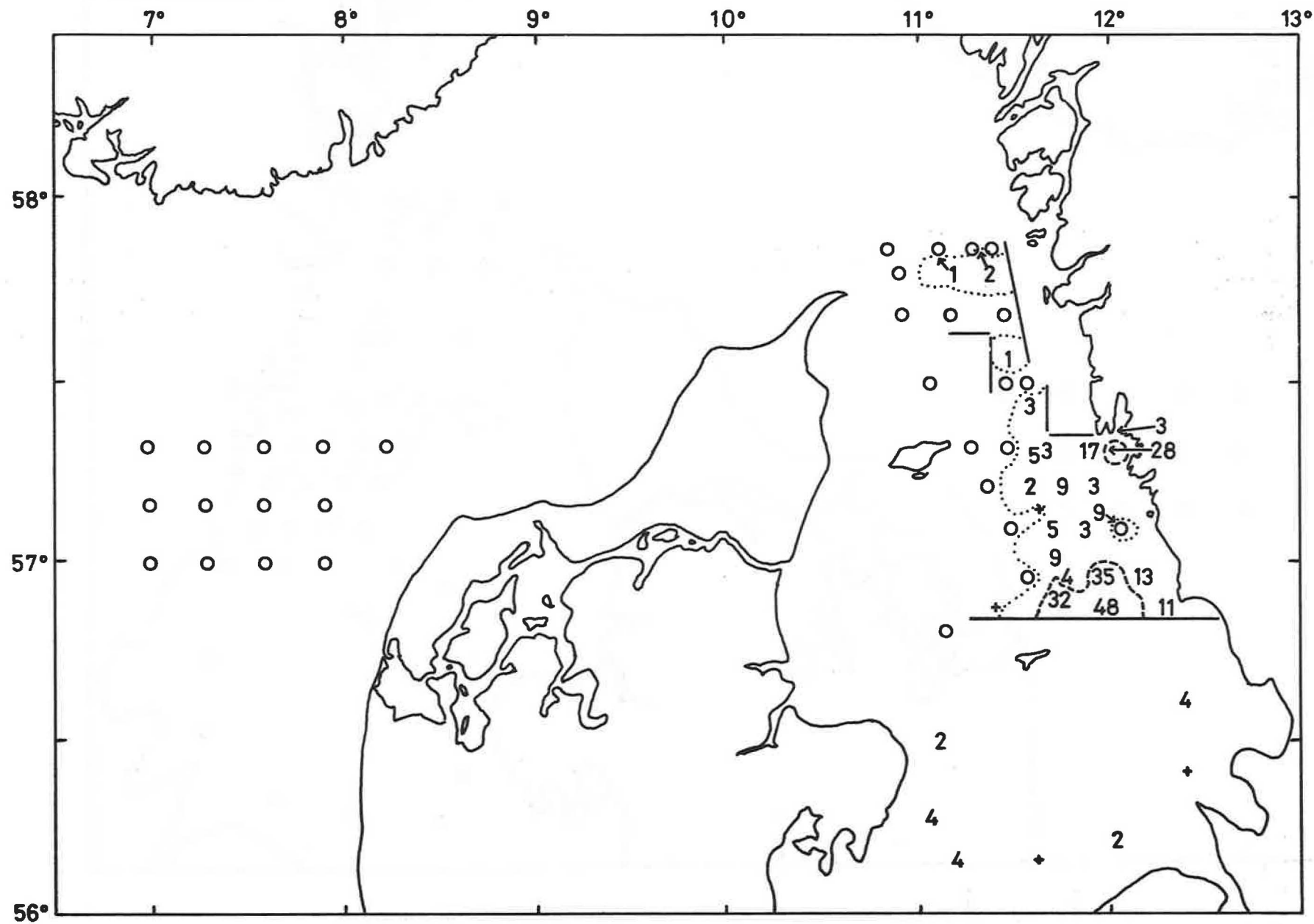


Figure 13 Numbers of herring larvae < 10 mm long beneath
1 square metre of surface.
Jutland Bank and Kobbergrund area.
16-28 October 1969.

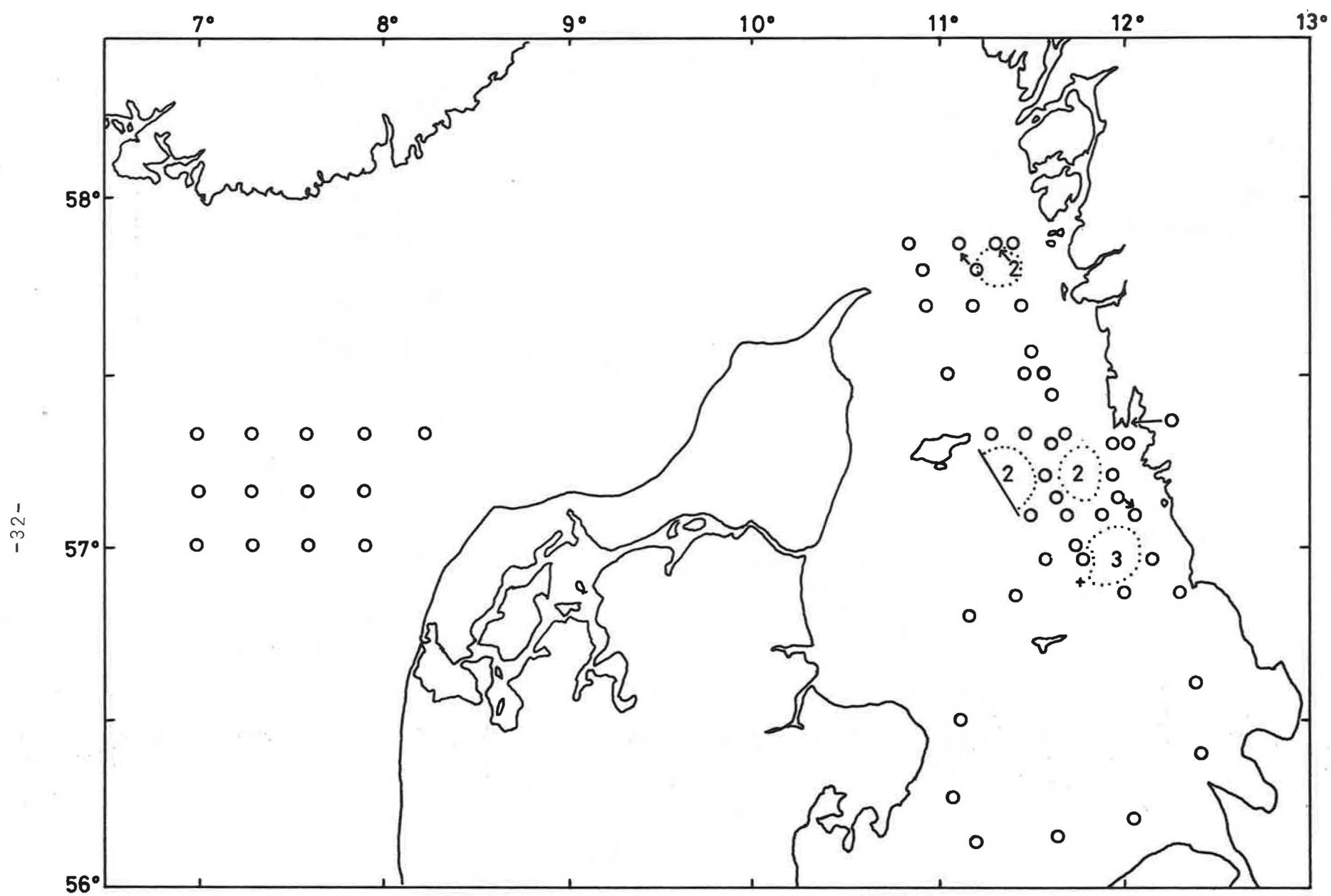


Figure 14 Numbers of herring larvae 10-15 mm long beneath
1 square metre of surface.
Jutland Bank and Kobbeggrund area.
16-28 October 1969.

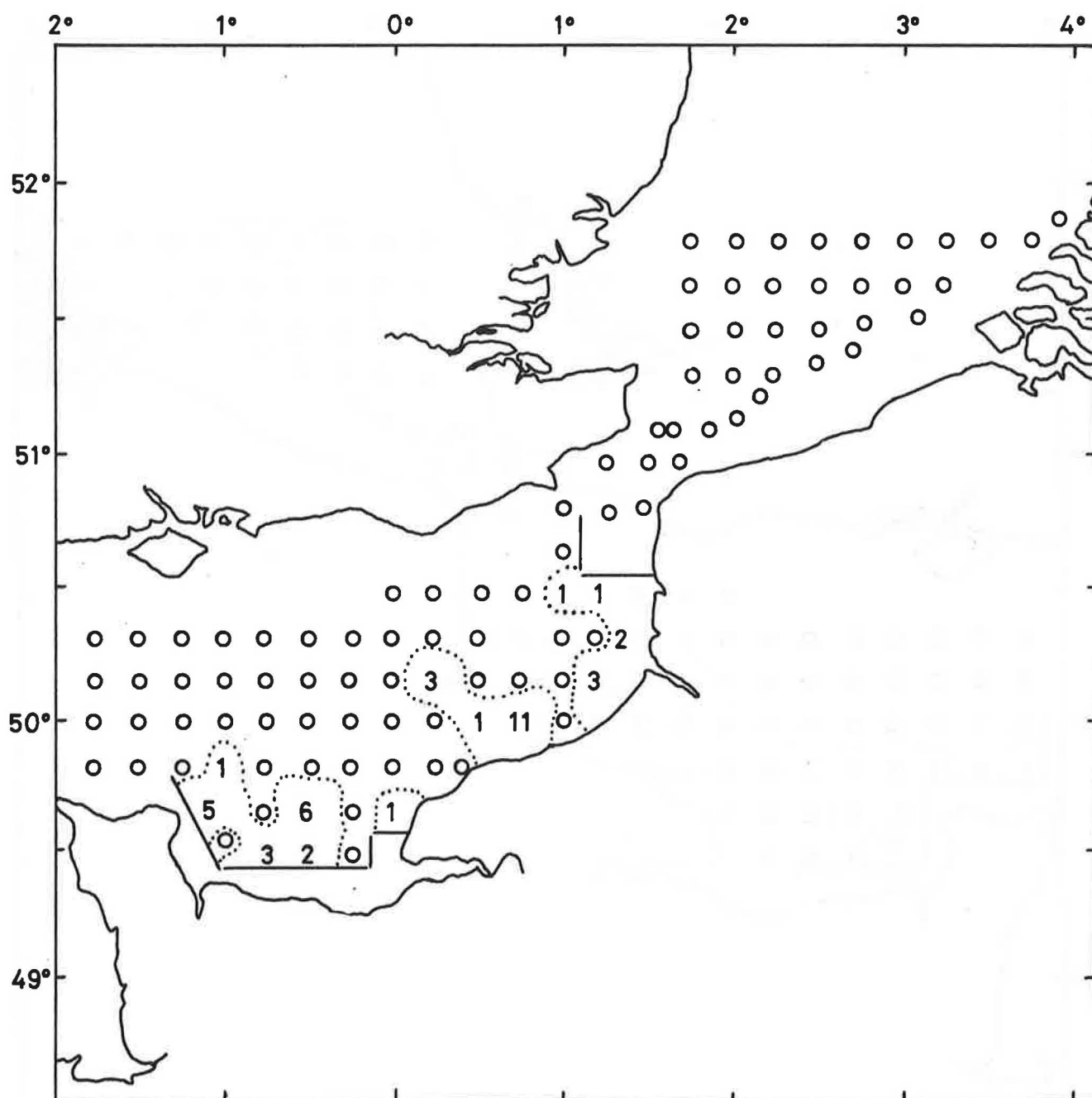


Figure 16 Numbers of herring larvae 10-15 mm long beneath
1 square metre of surface.
Southern North and Eastern Channel.
8-19 December 1969.

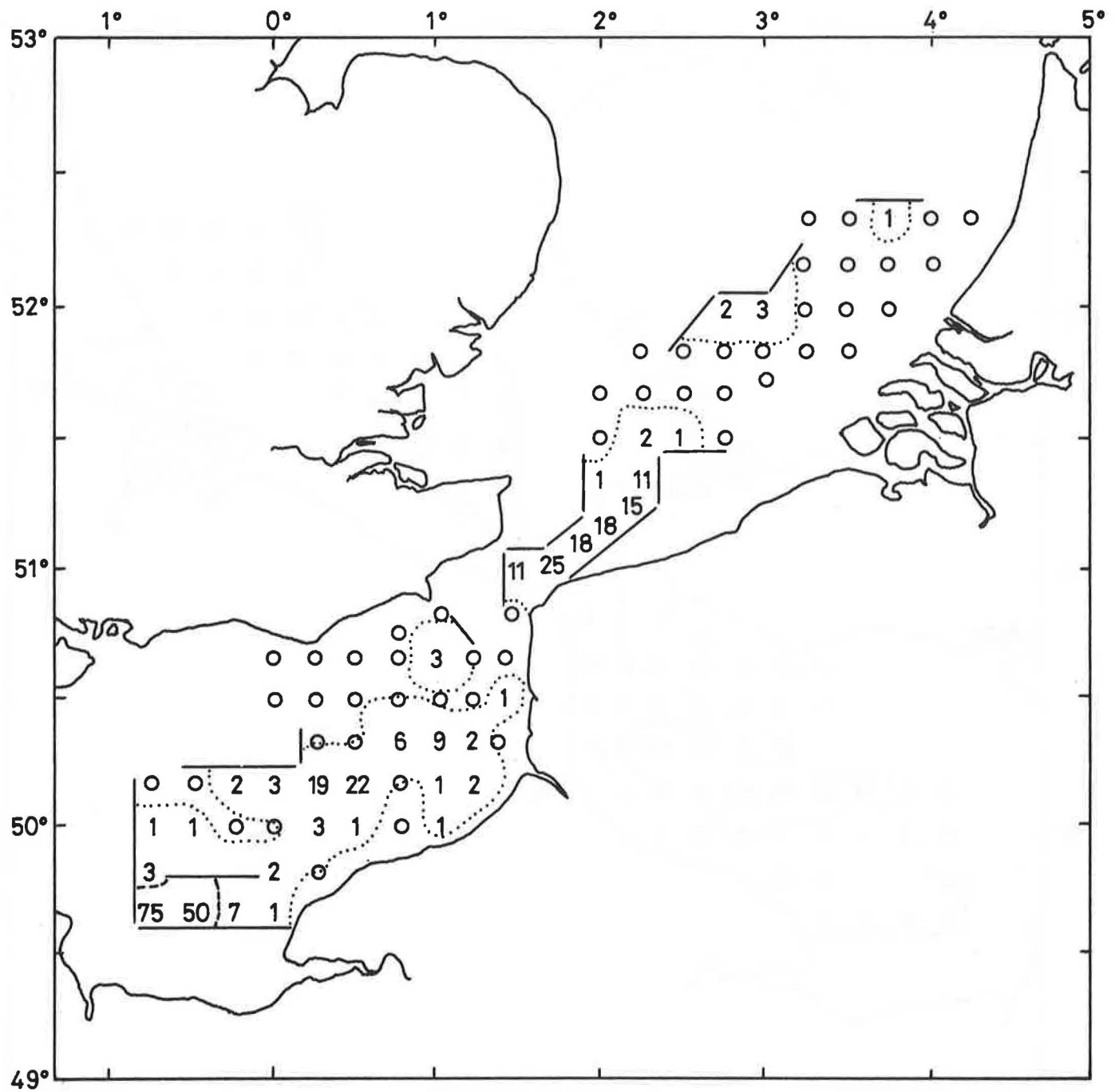


Figure 17 Numbers of herring larvae < 10 mm long beneath 1 square metre of surface. Southern North Sea and Eastern Channel. 5-15 January 1970.

Figure 18 Numbers of herring larvae 10-15 mm long beneath
1 square metre of surface.
Southern North Sea and Eastern Channel.
5-15 January 1970.

Estimation of the abundance of Atlanto-Scandian herring larvae
based on the results of sampling on the spawning grounds in 1969

by

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Studies on the spawning efficiency and collection of larvae of the Atlanto-Scandian herring in the area of the Norwegian and Faroe shelf waters were carried out from two vessels, the R/V "Akademik Knipovich" and the "Fridtjof Nansen". The investigations of this problem was carried out in accordance with the methods generally accepted in PINRO (YUDANOV 1962, 1963).

A summary of all the material collected during the investigations of the main spawning areas of herring on the West Scandinavian Shelf and around the Faroes, is presented in Table 1.

The location of the stations sampled during these investigations on each survey of the spawning areas are shown in Figures 1-6.

Norwegian shelf

The first spawners with running gonads appeared on the Sklinna Bank on 28 February and on 12 March, and sampling of the Norwegian shallow waters was started in the area of the Buagrunden, Frøya, Halten and Sklinna Banks. Ichthyoplankton nets were used by short tows at 4-5 depths from the Halten Bank to the south up to 62°N and then from the Sklinna Bank to the Griptarene Bank. Up to the 30 March no herring larvae were caught in any of the samples taken at the 34 stations in the area under investigation (Figure 1).

The first herring larvae were caught on 31 March on the Griptarene Bank. Therefore, during the next 7 days a smaller area was resampled. This area was situated between the Buagrunden and Frøya Banks. Thirtyfour stations were carried out. Herring larvae were caught on only 6 stations out of 15 in the northern part of

the Griptarene area and on 8 stations out of 15 in the southern part of the Frøya Bank area. On 4 stations in the area of the Buagrunden Bank no herring larvae were taken. In 42 samples out of 149, 956 herring larvae were found. Of this number, 677 larvae were collected on the Griptarene Bank and 279 on the Frøya Bank. Most of the larvae had yolk sacs and were from 6 to 12 mm long, 9 mm being the modal length.

During the second investigation of the Norwegian Shelf, carried out from the 8 to 15 April, the area of the Frøya, Halten, Sklinna and Traena Banks was explored. On the Frøya Bank herring larvae were present only at one station out of three. At this station 15 samples were taken and only one of them contained herring larvae. This sample however contained 92 herring larvae from 6 to 9 mm long, most of them being 8 mm long. The average length of the larvae collected on 8 April (8.19 mm) was 0.75 mm less than the average length (8.94 mm) of those collected on 1 April (224 specimens). This indicates a drift of larvae from the area of the bank and that spawning was continuing there. On 8-10 April herring larvae were caught on the Halten Bank at 9 stations out of 16. In 27 samples out of 85 there were 661 larvae. These were 6 to 11 mm long, most of them being 9 mm long and their average length was 8.74 mm. On 11-13 April on the Sklinna Bank herring larvae were caught at 7 stations out of 11 and 15 samples out of 69. They totalled 106 specimens and were from 6 to 15 mm long, most of them being 9 and 11 mm, with an average length of 9.99 mm. Specimens 10 to 15 mm long, most of them being 11 mm long, amounted to 55% of the total number. This fact corroborates the idea of larvae drifting from the areas of the Griptarene and Frøya Banks. In the area of the Traena Bank, out of 35 stations 7 showed no larvae (Figure 2).

In addition to the general investigation of the shelf, diurnal stations were carried out on the 7, 10 and 12 April, the vessel being moored in the area of the Frøya, Halten and Sklinna Banks. These stations were done to determine the direction and speed of larval drift and also the depth distribution of the larvae. Sampling was carried out every two hours. The greatest number of herring larvae was collected on the diurnal station on the Sklinna Bank. There they were taken in 65 samples out of 78 and amounted to 797

specimens. These were from 6 to 14 mm long, most of them being 9 and 12 mm long; their average length was 10.92 mm. There is no doubt that the second peak of the size-frequency, i.e. the 12 mm one, was the result of transport of larvae from the banks to the south and can be considered as indicative of their survival when they began to feed on small plankton, as large larvae of 10 to 14 mm in length made up 59.2% of the total number. While only 182 larvae were registered in 33 samples out of 144 taken on the Frøya and Halten Banks, 142 of these, 5 to 12 mm in length, were registered on the Frøya Bank, with the greatest number of these being 8-9 mm long, at an average length of 9.17 mm (Figure 3). Special attention should be given to the results obtained at the diurnal station on the Sklinna Bank. There, herring larvae were collected from 1 p.m. on 12 April to 1 p.m. on the next day. The results are presented in Table 2 and give the time of collection of the larvae and their distribution at five depths, from the surface to 130 m, in day- and night-time.

The data presented indicate that larvae are caught in greater numbers when it is dark, i.e. from dusk to dawn, than when it is light, particularly than in the morning. It should be noted that in the dark the bulk of larvae was caught at the surface and also in the near-bottom layer at a depth of 100 to 130 m, whereas in the morning and afternoon they were distributed evenly in the upper and intermediate layers. Both in daylight and in darkness the size composition was different depending on the depth at which they were caught, their average length being less as the depth increased. One should also note the comparison drawn between the size frequencies of larvae in 1968 and 1969. This comparison shows that in 1969 spawning of herring on the Sklinna Bank took place somewhat later than in 1968 (Figure 3).

The efficiency of spawning of herring in 1969 and also the size composition of the herring larvae for each bank and for the whole of the shelf were estimated from the results of these investigations of the main spawning areas. (Table 3).

Comparison of the average number of larvae per sample for the last five years indicates that the production of herring larvae in

the main spawning areas of the Norwegian Shelf in these years was poor, and that the abundance in 1967-1969 was extremely poor.

Lofoten shelf

The investigation of the Lofoten shallow waters by means of plankton nets was carried out twice: from 15 to 23 April by the R/V "Akademik Knipovich" and from 28 April to 2 May by the R/V "Fridtjof Nansen". During the first investigation of the whole Lofoten shallow waters from the Røst Bank to the Malangen Bank at 32 stations out of 134, no herring larvae were caught. None were caught, either, at 24 stations, where 109 samples were taken, along the northwestern coast of Norway up to the North Cape.

Five days later, during the second investigation of the same area which was carried out at 15 stations, where 72 samples were taken, herring larvae were only found in four samples. These were taken at two stations in the area of the Røst and Vesterålen Banks. Judging from the length of the larvae, 14 to 18 mm long with a mean of 16.2 mm, they had nothing to do with spawning in this area, and most of them were probably transported with the current from the area to the south of the Sklinna Bank. The result of these two surveys of the shallow waters indicates that no mass spawning took place in the entire area.

Faroe shelf

In 1969, as in the previous 5 years the investigation of spawning grounds in the area of the Faroes was carried out beyond the 50 m isobath. Three surveys were done: from 25 March to 1 April, from 9 April to 14 April, and from 19 April to 25 April. The station positions were the same in every survey. In every case the collection of larvae was carried out at four depths from the surface to a depth of 150 m.

During the first survey (150 samples taken at 35 stations) herring larvae were not caught at all. During the second and the third survey herring larvae were only found in two samples taken at two stations. All these four larvae had yolk sacs. At four diurnal

stations which were worked on 2, 6, 17 and 18 April in the southeast, south, west and north of the shelf, no herring larvae were registered in any of the 105 samples.

Data available from the biological analysis of ten samples (each containing 100 specimens) from the commercial catches of herring taken during March and the first decade of April, make it possible to draw some conclusions as to the development and the time of mass spawning of herring on the Faroe shelf. According to the gonad indices, post-spawning specimens made up 18% of the samples in the first decade of March, 56% in the second decade of March, and 87% in the last decade of March and in the first decade of April. Judging from these data we can say that mass spawning of herring on the Faroe shelf took place during the second and third decade of March, the time of spawning being about the same as in previous years.

Thus, it must be assumed that the unsatisfactory results of larval sampling in the Faroe shallow waters in 1969 are a consequence of unfavourable conditions for egg development and of their nearly complete extinction before hatching. Therefore, the abundance of the 1969 year class in this area is likely to be extremely poor. The same can be said about the abundance of this year class for all the main spawning areas of Atlanto-Scandian herring in 1969.

References

- | | | |
|---------------|------|---|
| YUDANOV, I.G. | 1962 | "Investigations concerning spawning grounds of the Atlanto-Scandian herring." Trudy PINRO, vol. 14. |
| YUDANOV, I.G. | 1963 | "Spawning efficiency and yield estimation of Atlanto-Scandian herring in 1961." Voprosy ikhtiologii, t.3, vol. 3(23). |

TABLE 1. Data collected during investigations of the main spawning areas of
Norwegian spring-spawning herring in 1969

Research Vessel	Date	Stations		Samples		Number of herring caught
		Total	Containing larvae	Total	Containing larvae	
			<u>The Norwegian shelf</u>			
"Akademik Knipovich"	12.3 - 30.3	34	-	152	-	-
	31.3 - 6.4	34	14	149	42	956
	8.4 - 15.4	39	17	183	43	859
	7.4 - 12.4	3 ^x)	3	241	102	979
"Fridtjof Nansen"	26.4 - 29.4	23	8	98	14	29
Total	12.3 - 29.4	133	42	823	201	2 794
			<u>The Lofoten shelf</u>			
"Akademik Knipovich"	18.4 - 23.4	54	-	243	-	-
	19.4 - 21.4	2 ^x)	-	28	-	-
"Fridtjof Nansen"	29.4 - 2.5	15	2	72	4	4
Total	18.4 - 2.5	71	2	343	4	4
			<u>The Faroe shelf</u>			
"Fridtjof Nansen"	26.3 - 1.4	35	-	150	-	-
	9.4 - 14.4	31	2	132	2	2
	19.4 - 23.4	32	2	151	2	2
	1.4 - 18.4	4 ^x)	-	105	-	-
Total	26.3 - 23.4	104	4	538	4	4

x) Diurnal stations

TABLE 2. The results of herring larvae collection at the diurnal station on Sklinna Bank depending on the time of the day (A), and the depth at which the larvae were collected during darkness (B) and in daylight (C).

Time and depth of larvae collection	Length of larvae in mm									Number of larvae caught		Average length in mm
	6	7	8	9	10	11	12	13	14	Total	%	
	A. depending on the time of the day											
8-12	-	3	23	17	3	-	4	-	-	50	6.3	8.77
13-16	1	7	40	26	18	35	8	1	-	136	17.1	9.48
17-20	-	1	14	10	31	67	41	12	2	178	22.4	10.90
21-24	-	3	10	17	32	52	58	11	-	183	22.8	10.89
01-04	-	4	30	64	11	32	14	5	-	160	20.1	9.67
05-08	-	2	17	36	6	18	11	-	-	90	11.3	9.65
Total	1	20	134	170	101	204	136	29	2	797	100.0	10.18
%	0.1	2.5	16.8	21.7	12.7	25.6	17.1	3.6	0.2	100.0	-	-
	B. during darkness from 8 p.m. to 6 a.m., by depth of larvae collection (m)											
Surface	-	-	2	6	24	42	69	13	2	158	36.5	11.31
25	-	-	3	4	12	18	13	4	-	54	12.5	10.89
50	-	-	3	6	5	6	7	3	-	30	6.9	10.57
75	-	-	2	10	4	7	7	1	-	31	7.2	10.32
100	-	3	17	45	6	5	1	2	-	79	18.2	9.19
130	-	7	25	30	4	8	5	2	-	81	18.7	9.05
Total	-	10	52	101	55	86	102	25	2	433	100.0	10.37
%	-	2.3	12.0	23.3	12.7	19.9	23.6	5.8	0.4	100.0	-	-
	C. during daylight, from 8 a.m. to 4 p.m., by depth of larvae collection (m)											
Surface	-	-	-	-	-	70	1	-	-	71	19.5	12.53
25	-	-	5	8	15	32	13	-	-	73	20.0	10.55
50	-	2	8	6	4	8	9	1	-	38	10.5	10.03
75	-	2	28	30	20	6	6	2	-	94	25.8	9.28
100	-	4	35	22	5	1	5	1	-	73	20.1	8.71
130	1	2	6	3	2	1	-	-	-	15	4.1	8.40
Total	1	10	82	69	46	118	34	4	-	364	100.0	9.85
%	0.3	2.8	22.4	19.0	12.7	32.4	9.3	1.1	-	100.0	-	-

Length of larvae mm	III-IV Buagrunden- Griptarene		V. Frøya			VI-VII Halten Sklinna	VI-VIII Halten Vesterålen	Total			Total number
	1-5.4	26.4	31.3-6.4	8.4	26-27.4	8-13.4	27-28.4	31.3-6.4	8-15.4	26-28.4	
					I. Number of specimens						
5	2	-	-	-	-	-	-	2	-	-	2
6	30	-	-	1	-	7	-	30	8	-	38
7	107	-	18	8	-	67	-	125	75	-	200
8	209	-	69	55	-	205	-	278	260	-	538
9	214	-	138	28	-	318	-	352	346	-	698
10	113	-	51	-	-	123	-	164	123	-	287
5-10	675	-	276	92	-	720	-	951	812	-	1 763
11	2	-	3	-	1	23	1	5	23	2	30
12	-	-	-	-	5	17	2	-	17	7	24
13	-	-	-	-	2	3	1	-	3	3	6
14	-	-	-	-	2	3	3	-	3	5	8
15	-	-	-	-	4	1	1	-	1	5	6
11-15	2	-	3	-	14	47	8	5	47	22	74
16	-	-	-	-	1	-	1	-	-	2	2
17	-	-	-	-	2	-	-	-	-	2	2
18	-	-	-	-	2	-	1	-	-	3	3
16-18	-	-	-	-	5	-	2	-	-	7	7
Total	677	-	279	92	19	767	10	956	859	29	1 844
Average length, mm	8.46	-	8.86	8.19	14.26	8.76	13.90	8.58	8.84	14.19	8.78
No. of samples	92	17	57	15	32	168	62	149	183	111	443
Samples containing larvae	24	-	18	1	7	45	7	42	46	14	102
Date of mass spawning	2-9.3	-	27.2-7.3	3-10.2	3-10.3	2-9.3	3-10.3	27.2-7.3	3-10.3	3-10.3	27.2-10.3
Date of larvae hatching	20-27.3	-	17-24.3	21-28.3	21-28.3	20-27.3	21-28.3	17-24.3	21-28.3	21-28.3	17-28.3
					II. Average number of herring larvae per sample ^{x)}						
1969	7/28	-	5/15	6/92	1/3	5/17	1/1	7/24	5/19	1/2	4/18
1968	2/6	-	5/6	1/5	-	1/5	7/17	2/30	3/10	-	2/13
1967	13/21	13/32	2/9	1/2	1/2	1/5	-	5/15	3/19	1/2	4/15
1966	16/23	16/23	28/119	4/8	-	2/11	-	23/58	6/16	2/13	12/43
1965	1/2	1/1	112/196	4/28	4/28	2/8	-	53/106	3/19	4/28	24/104

x) The numerator is the average number of larvae registered in all samples taken in the area of spawning. The denominator is the average number of larvae in samples containing herring larvae.

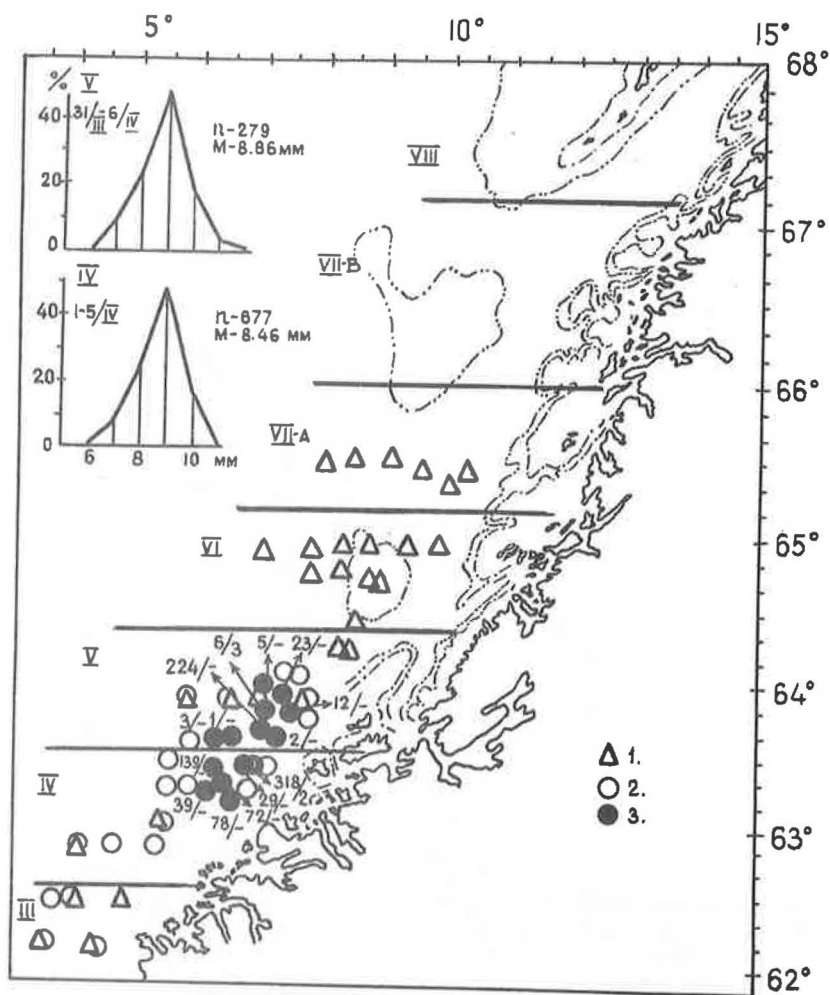


Figure 1. Distribution of stations, and distribution and size of herring larvae during the investigations on the Norwegian Shelf from 12 March to 6 April.

Symbol 1 - from 12 March to 30 March.

Symbols 2 and 3 - from 31 March to 6 April.

Symbol 2 - stations where no larvae were caught.

Symbol 3 - stations where larvae were caught.

Figures placed near the station positions show the number of larvae collected (the numerator shows the number of larvae up to 10 mm in length; the denominator shows the number of larvae more than 10 mm long).

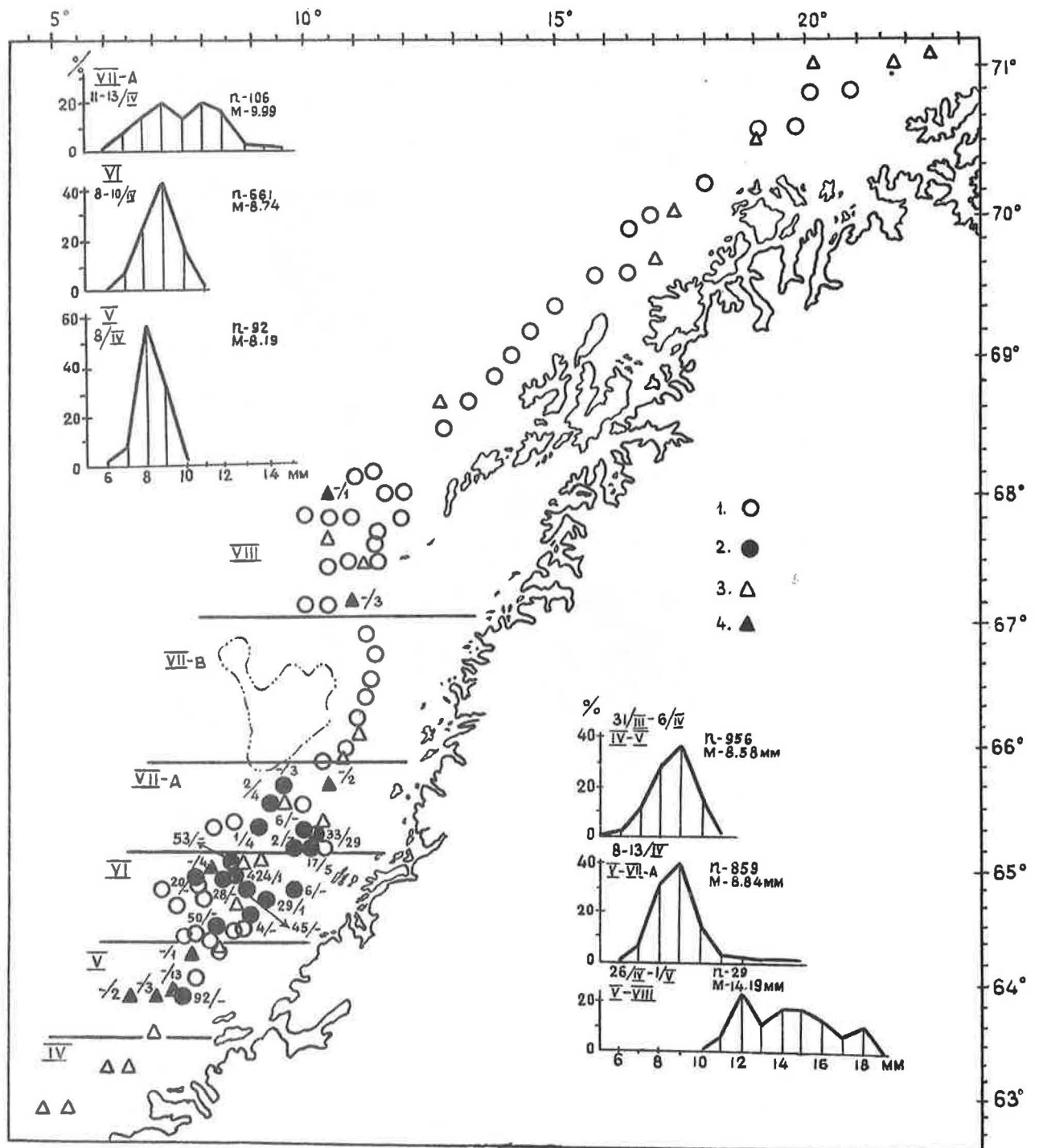


Figure 2. Distribution of stations, and distribution and size of herring larvae during the second investigation on the Norwegian Shelf from 8 to 23 April (1-2) and from 26 April to 1 May (3-4):

- 1 and 3 stations where no larvae were caught.
- 2 and 4 stations where larvae were caught.

Figures at the station positions show the number of larvae collected. The numerator shows the number of larvae up to 10 mm long; the denominator shows the number of larvae more than 10 mm long.

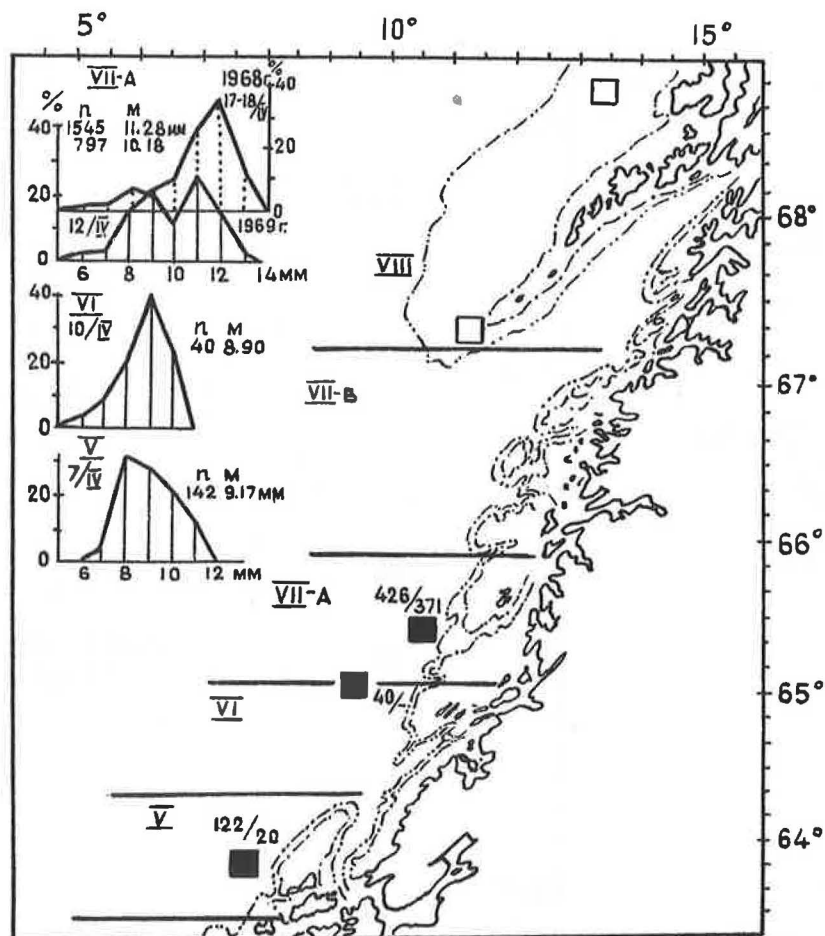


Figure 3.

Results of the collection of herring larvae on diurnal stations carried out on the Norwegian Shelf from 7 to 19 April.

- Stations sampled on 7-12 April, where larvae were caught.
- Stations sampled on 15-19 April, where no larvae were caught.

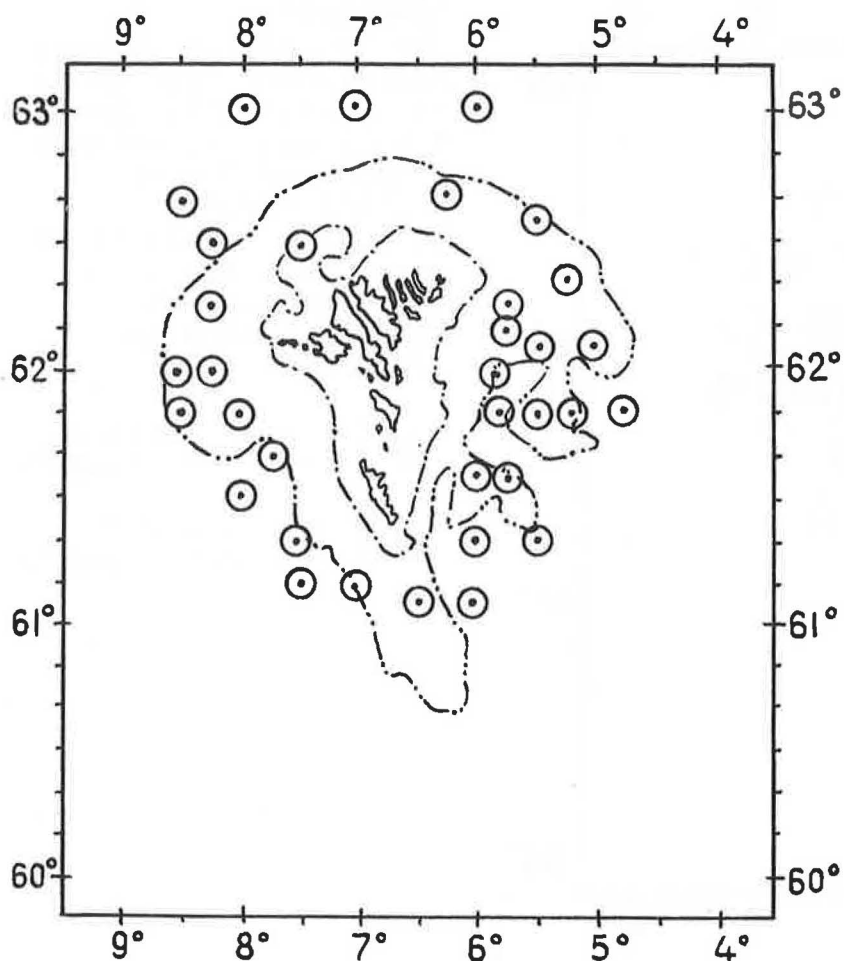


Figure 4.

The 1st larvae survey, carried out from 26 March to 1 April, 1969.

- Stations where no larvae were caught.
- Stations where larvae were caught.

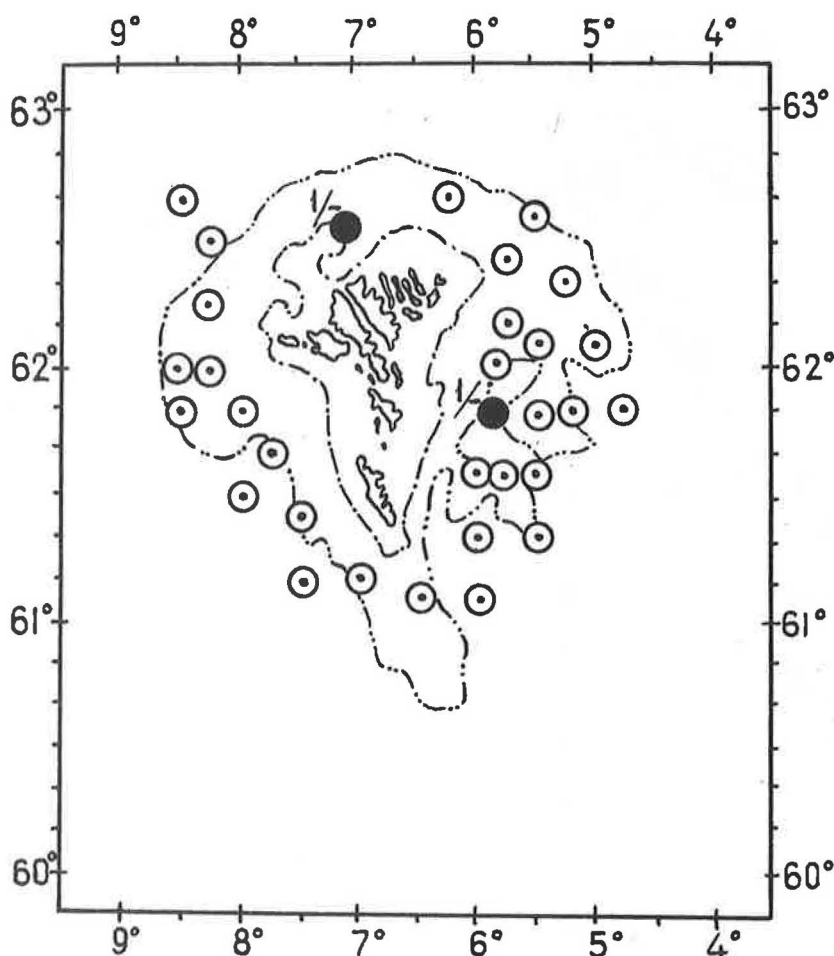


Figure 5.

The 2nd larvae survey carried out on 9 to 14 April, 1969. Larvae 8 mm long collected at $61^{\circ}50'N$ $5^{\circ}50'W$ on 11 April. Larvae 10 mm long collected at $62^{\circ}35'N$ $7^{\circ}19'W$ on 18 April.

- Stations where larvae were caught.
- Stations where no larvae were caught.

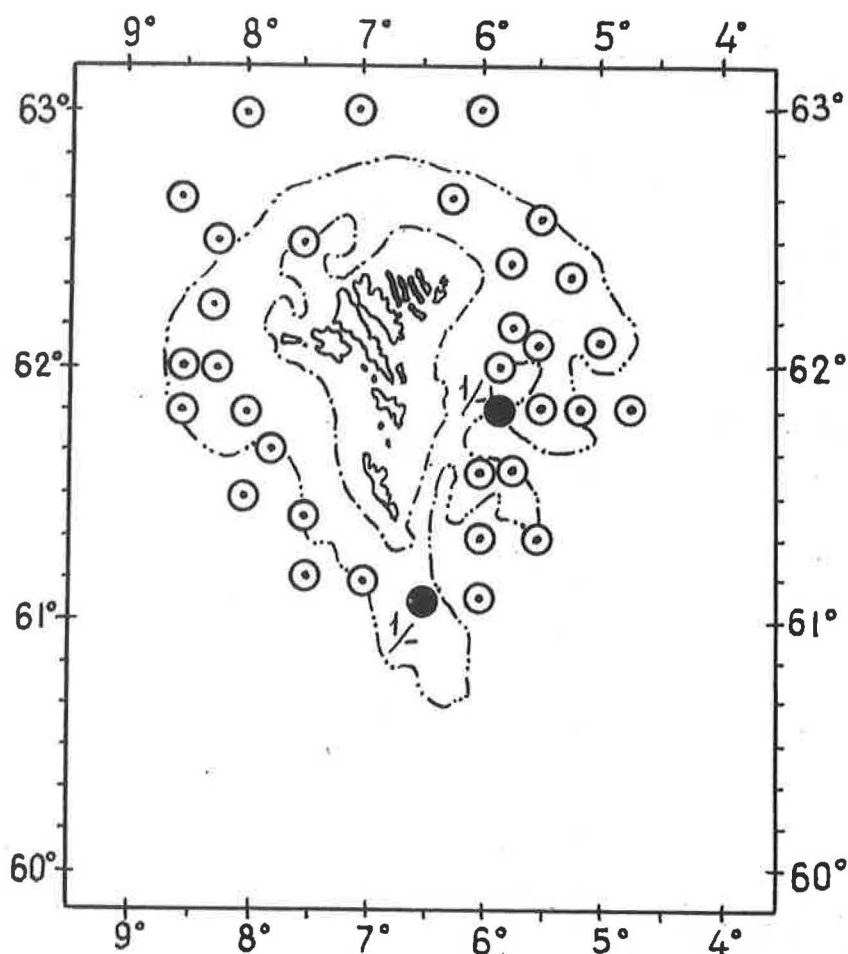


Figure 6.

The 3rd larvae survey, carried out from 19 to 23 April, 1969. Larvae 7 mm long, collected at a depth of 0 m at $61^{\circ}05'N$ $6^{\circ}30'W$ on 20 April. Larvae 10 mm long collected at a depth of 50 m at $61^{\circ}50'N$ $5^{\circ}50'W$ on 22 April.

- Stations where no larvae were caught.
- Stations where larvae were caught.

10 to 15 mm and over 15 mm.

The results for each station have been expressed as the number of herring larvae below 1 square metre of the surface.

Results

In 1968 herring larvae were recorded at 13 stations located on three fishing grounds: Aberdeen Bank, Long Forties and Flamborough Head. In addition larvae were also caught at station 526 (Figure 1).

During the 1968 investigation the highest number of herring larvae was obtained at station 526, (Table 1), where 20 individuals/ m^2 were taken. The length of larvae caught in this region ranged from 7 to 23 mm.

On the Aberdeen Bank, Long Forties and Flamborough Head areas the larvae were considerably less numerous but their length was markedly greater than that of the specimens caught at station 526.

It can be concluded from the size of the larvae that in the area of Aberdeen, the Long Forties and Flamborough Head fishing grounds the herring spawned earlier than in the more northern areas (station 526), because the larger larvae there must have had more time to develop.

A control investigation made at station 526 (15 hauls made by the fry net) showed relatively high variation (from 12.6 to 30 individuals per 1 m^2 surface).

In May and June 1969, 37 hauls were made with the Hensen net. Herring larvae were found in the area of the Celtic shelf at stations 582, 584, 587, 588 and 591 and at stations 563 and 578 in the North Sea (Figure 2). The greatest abundance of herring larvae, 31 individuals per 1 m^2 , was found at stations 584 and 587 (18 larvae per 1 m^2). At the other stations the numbers varied from 1 to 3 individuals under 1 m^2 of surface.

In autumn 1969 (October) 40 hauls were made with the HAI sampler

Some observations on quantitative occurrence and distribution
of herring larvae in the North Sea and on the
Celtic shelf in 1968 and 1969

by

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Time and area of sampling

In 1968 and 1969 investigations on the occurrence and distribution of herring larvae in the North Sea, and on the Celtic Shelf, were carried out together with plankton investigations.

In September-October 1968 samples were taken at 29 stations in the North Sea (Figure 1). In May-June 1969 (Figure 2) plankton was sampled at 37 stations and in October 1969 at 40 stations (Figure 3). The autumn period was the main period of observation because this is the most important time for herring reproduction and larval development. Larvae caught in spring are regarded as complementary material.

Method of investigations

In 1968 the herring larvae were sampled by a ring-trawl with a mouth opening of 2.1 m. At each station two or three vertical hauls were made with this net.

In 1969, the samples were taken by oblique hauls from surface to bottom with a HAI high-speed sampler towed at a speed of 5 knots. This type of sampler was introduced in order to standardise the sampling methods used by five socialist countries by special agreement.

Additional larval material was obtained from zooplankton samples taken by a Hensen net.

The herring larvae were counted after having been sorted out from the plankton samples and identified under a microscope. The larvae were measured and divided into 3 size groups; below 10 mm,

and the Hensen net. Herring larvae were caught at four stations only: 597, 598, 600 and 616 (Figure 3). Only one of these (598) gave a relatively high number of larvae (95 specimens per 1 m² by the Hensen net and 29 specimens by the HAI sampler). It should be noted that of all the hauls made by the Hensen net, only those at station 598 gave positive results with respect to herring larvae.

In these hauls in the autumn of 1969, larvae 10-15 mm in length were most abundant (Table 2).

Conclusions

1. During autumn (spawning time) herring larvae were only caught sporadically both in 1968 and 1969 at a few stations.
2. The numbers of larvae caught in 1968 and 1969 did not differ much.
3. The investigations conducted since 1963 allow one to conclude that, in the areas where Polish investigations have been made, the quantity of herring larvae has steadily decreased, being lowest in 1969.
4. In the spring of 1968, herring larvae were more abundant over the Celtic shelf than in the areas investigated in the North Sea.

TABLE 1. Numbers of herring larvae found in 1968 and 1969
in the area of the North Sea and on the Celtic shelf.

Station number	Date	Depth	Number of larvae under 1 m ² of the surface		
			Ringtrawl	Hensen	HAI
526	22.9.1968	85	20	-	-
527	23.9.1968	76	x	-	-
528	24.9.1968	86	x	-	-
529	24.9.1968	80	x	-	-
530	25.9.1968	85	x	-	-
533	25.9.1968	90	x	-	-
536	26.9.1968	72	x	-	-
538	1.10.1968	64	x	-	-
539	1.10.1968	74	x	-	-
540	2.10.1968	56	x	-	-
541	2.10.1968	52	1.3	-	-
542	2.10.1968	70	x	-	-
543	3.10.1968	72	x	-	-
546	3.10.1968	96	x	-	-
563	13.5.1969	74	-	3	-
572	15.5.1969	90	-	1	-
578	16.5.1969	48	-	2	-
582	4.6.1969	72	-	1	-
584	5.6.1969	116	-	29	-
587	6.6.1969	98	-	18	-
588	6.6.1969	104	-	1	-
591	6.6.1969	85	-	2	-
597	9.10.1969	67	-	0	8
598	9.10.1969	50	-	95	29
600	10.10.1969	66	-	0	2
616	14.10.1969	70	-	0	0.5

x = less than 1 individual under 1 m² of the sea surface.

- = no catches were made.

0 = larvae were missing.

TABLE 2

Numbers of herring larvae caught in 1969 and grouped according to size under 1 m² of the surface

Length groups (mm)	Spring									Autumn				
	stations									stations				
	563	572	578	582	584	587	588	591	Total	597	598	600	616	Total
10	-	-	-	-	12	-	-	2	14	-	1	-	-	1
10 - 15	1	-	1	1	8	12	-	-	22	4	49	3	-	56
15	2	1	2	-	11	6	1	-	23	4	16	1	1	22
Total number	3	1	3	1	31	18	1	2	59	8	66	4	1	79

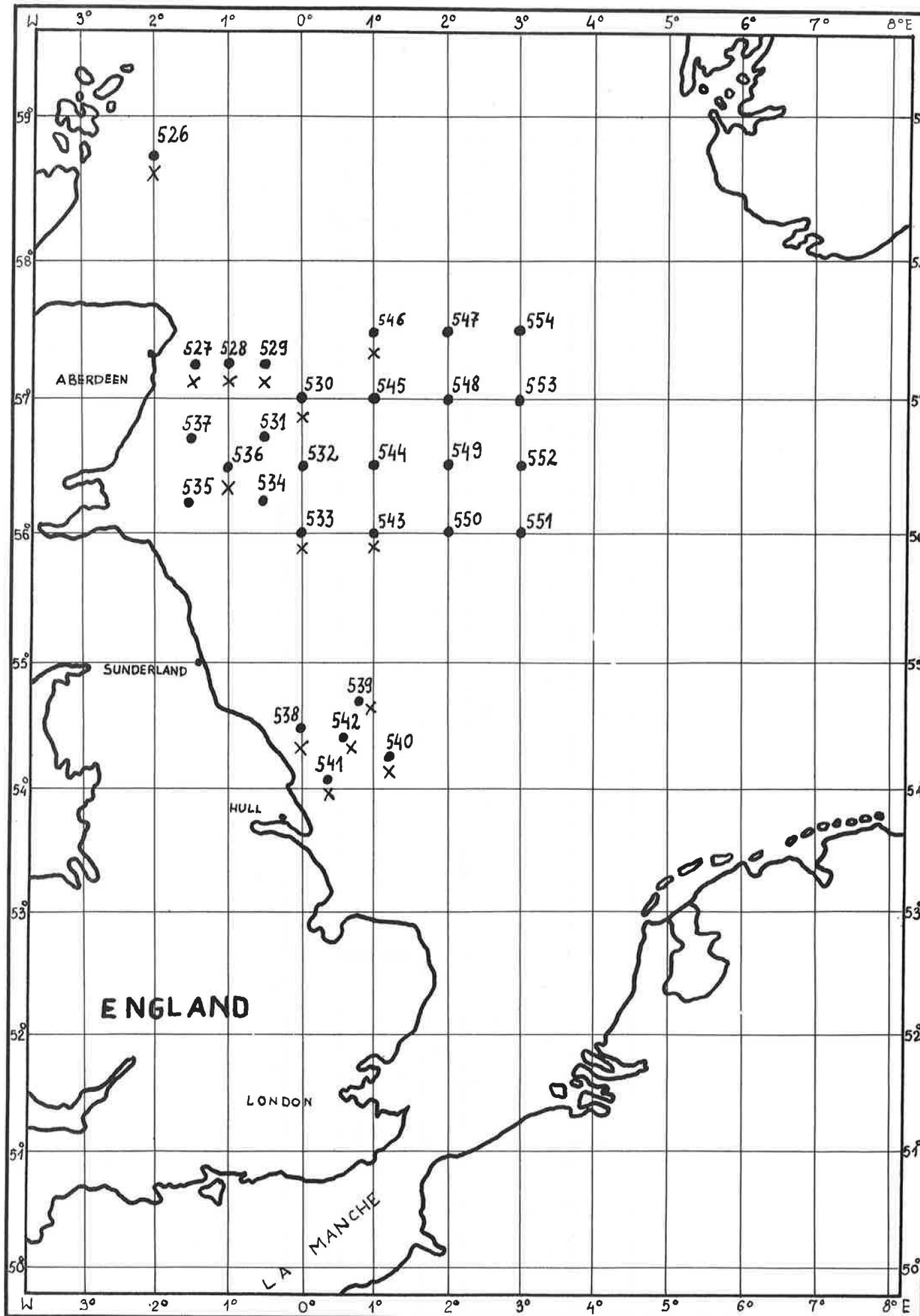


Figure 1. Map of stations where observations were made in October 1968.

x = larvae present.

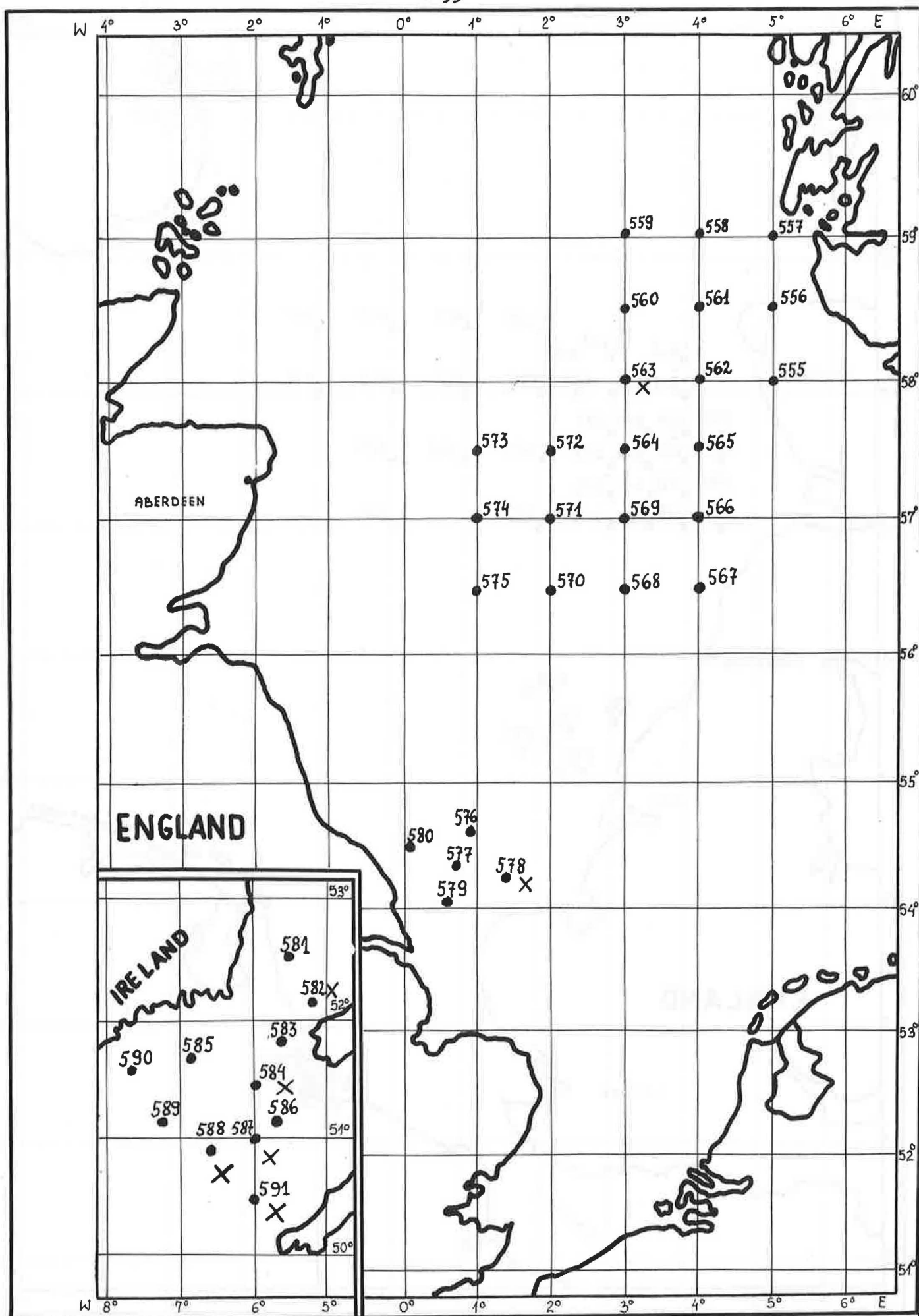


Figure 2. Map of stations where observations were made in May - June 1969.

x = larvae present.

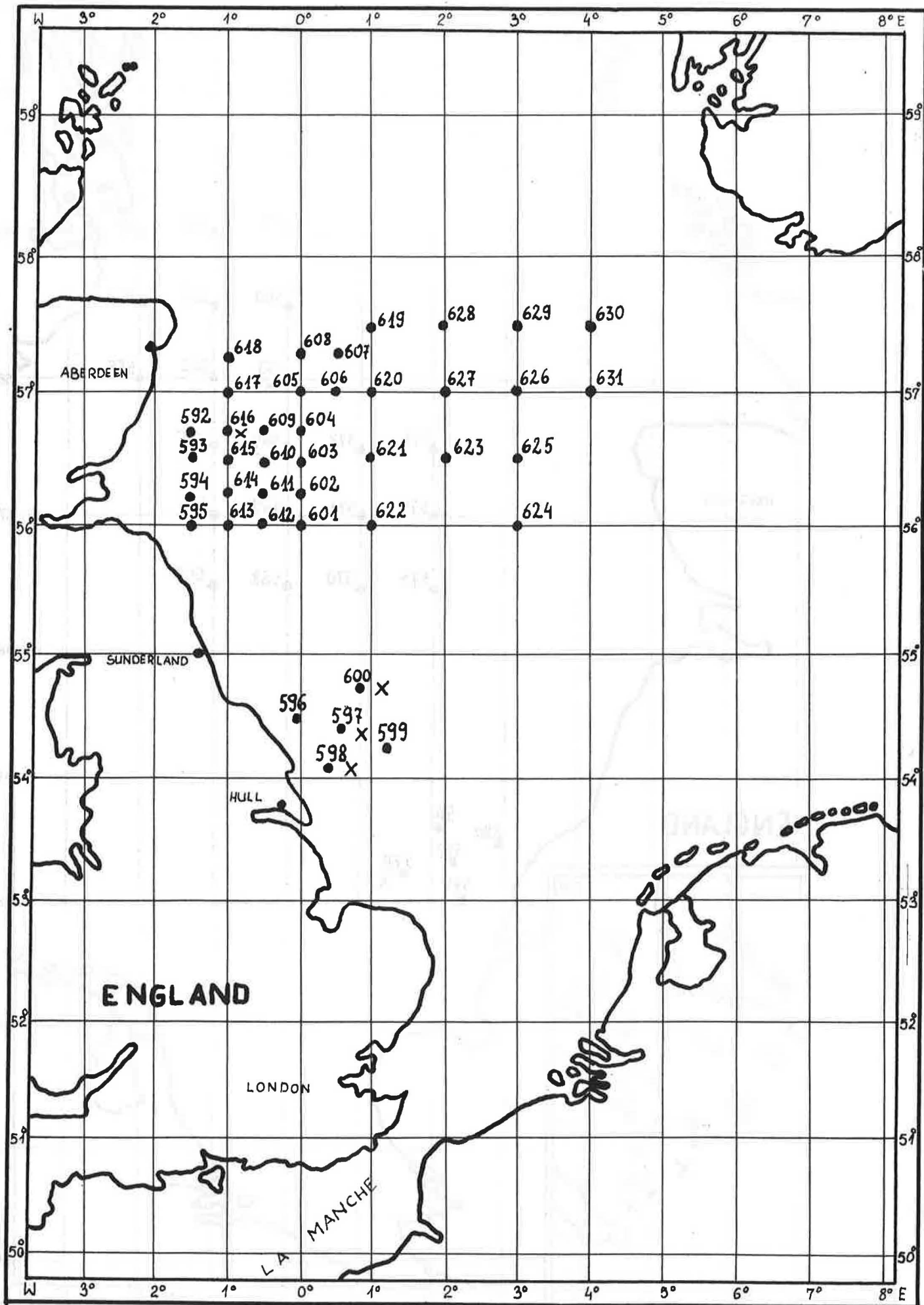


Figure 3. Map of stations where observations were made in October 1969.

x = larvae present.