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REPORT ON THE INTERNATIONAL SURVEYS OF HERRING LARVAE IN THE NORTH SEA, 1967 AND 1968

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REPORT ON THE INTERNATIONAL SURVEYS OF HERRING LARVAE IN THE NORTH SEA IN 1967

by

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Introduction

A Special Meeting of the Herring Committee of ICES was held in 1966 to consider the effects on the North Sea herring stocks of the large increase in fishing effort following the entry of the Norwegian purse-seine fleet into this fishery in 1964. One of the recommendations of this meeting was that the countries concerned in the North Sea herring fisheries should collaborate in an attempt to get better measures of larval abundance in the North Sea as a guide to the relative size of the stocks and of changes in them.

A small group of experts was set up to implement this recommendation, consisting of A. C. Burd (England), J. J. Zijlstra (Netherlands), G. Hempel (Germany), S. Haraldsvik (Norway), K. Popp Madsen (Denmark), and A. Saville (Scotland), Convenor. This Group decided that an attempt should be made, starting in 1967, to sample all of the known spawning areas of autumn-spawning herring in the northern and central North Sea and in the Skagerak at the time of the peak of hatching in each area and agreed on a sub-division of the area to be sampled between the six countries. The coordination of the programmes of the different countries was carried out by the Convenor of the Group.

Methods

The total area to be sampled can be divided into two regions, the western North Sea from 53°30'N to the Shetlands and, in the eastern North Sea, Jutland Bank and West Bank, the Skagerak and the Kobbergrund area. In the western North Sea the Netherlands sampled the area from 53°30'N to 55°N including the spawning areas of the Dogger Bank, Well Bank and the Whitby area; Germany the area from 55°N to 57°30'N including the North-East Bank, the Longstone area, Montrose-Aberdeen- and Turbot Banks; Scotland the area from 57°30'N to 59°30'N including the Moray Firth, Clyth-

ness and the grounds around Orkney and Fair Isle while England sampled the area to the north of Fair Isle and on both sides of the Shetlands. In the eastern area Denmark and Norway each sampled Jutland Bank, the Skagerak and the Kattegat to 56°20'N at rather different times.

England, Scotland and Germany were asked to sample the areas allocated to them in September while the Netherlands, Norway and Denmark were asked to sample their areas between mid-September and mid-October. In practice, much of the area was sampled twice during the course of the surveys. The station spacing varied somewhat from one area to another but generally speaking stations were about 10 miles apart or less.

In an attempt to get as much uniformity of sampling as possible all countries were asked to use oblique hauls from bottom to surface with a Gulf III high speed sampler, towed at 5 knots. It was also agreed that the sampler should be fitted with a flowmeter and that the speed of shooting and hauling should be so adjusted as to ensure that sampling was conducted for an equal interval of time in each successive 10 metre depth stratum. In practice - as must inevitably happen in a programme with many countries and a wide variety of ships involved - there was some divergence in sampling technique.

As agreed, the results of the surveys were recorded as the numbers of larvae below 1 square metre of surface at each station in the three size groups, < 10 mm, 10-15 mm and > 15 mm. It is on material collected in 1967 that this report has been prepared.

North-Western and Central North Sea

This area was sampled by English, Scottish, German and Dutch research vessels in the period 6-24 September and a fairly satisfactory coverage of the distribution of herring larvae within the known spawning areas of the Buchan and Bank stocks was attained. The distribution of larvae less than 10 mm long in this area, in the period 6-24 September, is shown in Figure 1 (p.10).

It will be seen that at this time high densities of recently hatched larvae were located in only two regions - in the Whitby-Flamborough area (statistical rectangles D7 and D8), where there was

a small area of larvae exceeding 250 per square metre close to the English coast, and to the west of Orkney where concentrations also exceeded 250 per square metre. The 250 per square metre contour in the latter area was open to the west so that the full extent of this concentration could not be determined. In the Dogger-Well Bank area larvae of this size group were completely absent, and they were extremely scarce on the Buchan spawning grounds, where the only larvae of this size group found was a small patch close to the Aberdeenshire coast. To the east of Orkney and at Clythness off the north coast of the Moray Firth where larvae of this size have, in recent years, been plentiful they were also scarce. Somewhat larger numbers occurred in an area of considerable extent to the north-west of Fair Isle, extending northwards to the west of Shetland. There was also an area of moderate size to the east of Shetland at a density exceeding 10 per square metre, with a small patch of 50 per square metre, both of which were open to the east.

At the time of this survey, larvae of 10-15 mm (Fig.2, p.11) were largely confined to the north-western North Sea, there being only one small patch at a level of 1 per square metre, in the central North Sea, to the east of Whitby. North of this, larvae of 10-15 mm, although more plentiful than recently hatched larvae, were scarce in comparison with previous years. The highest density of this size group was an area exceeding 250 per square metre found to the west of Orkney and enclosed by a considerably larger area at concentrations of 50 per square metre, covering all of the area sampled to the west of Orkney. In the "Buchan" area the highest concentration of this size group was 10 per square metre in three small areas enclosing only one station each to the south and east of Aberdeen and a rather larger area extending from east of Montrose to east of the Forth.

As might be expected at the time of this survey, larvae greater than 15 mm long (Fig.3) were confined to the area of the Scottish coasts and were nowhere found at high densities. The highest concentration of this size group was again found west of Orkney at levels of 10 per square metre with an indication of perhaps greater numbers along the Scottish north coast further to the west. There were small concentrations to the east of Orkney, off the southern shore of the Moray Firth, and on Aberdeen Bank. No larvae of this size group were taken in the central North Sea on this survey.

Part of this area was resampled in the period 25 September to 13 October. The coverage was less satisfactory than on the first survey but it did serve to confirm and extend the conclusions drawn from the first one. The Dutch survey at this time covered the spawning grounds in the Dogger-Well Bank area and again emphasised the scarcity of recently hatched larvae in this region in 1967 (Fig. 4). No sampling of the Whitby-Flamborough area was done at this time but some German sampling in the area of the North-East Bank showed a small region with concentrations of 250 recently hatched larvae per square metre in this area. In the area sampled by Scotland, larvae less than 10 mm were again virtually absent from the Buchan area proper but there was a small area of low density of these larvae off Clythness and a band at concentrations of 1000 per square metre extending along the north coast of Scotland.

Larvae of 10-15 mm were again scarce within the sampled area on this survey (Fig. 5). The only concentration of note was a small one of 250 per square metre west of the Pentland Firth enclosed by an area with a density of 50 per square metre, extending over the whole of the area west of Orkney to the western limit of sampling. Small patches of these larvae at densities of 10 per square metre were located east of Clythness, east of Aberdeen, to the south-east of the North-East Bank and on the western edge of the Dogger.

Larvae larger than 15 mm (Fig. 6) were rather more plentiful. Although they were virtually absent from the North-East Bank area, there was a considerable patch of them at this time on the western edge of the Dogger, with one station having more than 50 per square metre. Larvae of this size were again fairly plentiful around Orkney and there was another patch of 10 per square metre to the east of Clythness.

The Jutland Bank - Kobbergrund Area

This area was also sampled on two occasions - in the period 12-14 October by the Danes and in the period 20-25 October by the Norwegians. On both surveys no larvae were taken outside the Kattegat and very few larvae were found on either survey at a greater size than 10 mm long so that only the distributions of larvae less than 10 mm have been shown for this area in Figures 7 and 8 (p.16 and 17).

The data from these two surveys are also rather more difficult to compare quantitatively. The Danish one was done exclusively by Gulf III and so is comparable with the sampling in the western area by other countries. On the Norwegian survey, samples were taken by Gulf III and by a Juday net hauled vertically from 200 metres to the surface at each station. No larvae at all were taken by the Gulf III sampler, although considerable numbers were caught at a few stations with the Juday net. The reason for the failure of the Gulf III to catch herring larvae in this case is not clear but in view of this it has been necessary to convert the Juday catches to numbers below 1 square metre and to plot these as the numbers found on the second survey of this area. There is probably no serious error in using these figures for comparison with Gulf III catches for the smallest size category but the absence of larger larvae at the time of the Norwegian survey may be an artefact caused by evasion of this slow-moving net.

When the first survey of this area was carried out (Fig. 7) the highest concentration found was an area enclosing only one station of 10 per square metre. All the larvae taken in this survey were very small and it would appear likely that it coincided with the start of hatching in this region. On the Norwegian survey of the area, larvae would appear to have been more abundant (Fig. 8) with an area of 250 per square metre at the eastern edge of the sampled area and a considerably larger area of 10 per square metre whose eastern limit was again not defined by the station grid.

Discussion

One of the major objectives of these surveys was to obtain estimates of the relative sizes of the spawning concentrations in the different areas and of the changes in them with time. One of the problems in doing this is to decide what size of larvae gives the best index of the size of the spawning concentration. Basically this should be best given by the smallest size group as with these any problem of differential survival between stocks, or between years within a stock, is minimised. However, this size group is open to other objections on the grounds of the short time the larvae stay in this size group and the limited spatial extent of the major concentrations. This can result in estimates of their abundance

being liable to large variations due to the timing and spacing of sampling grids. Estimates based on larger larvae however can be biased if, as in this case, the spawning times of the stocks are different, so that for one stock the estimate is based on larvae, accumulating from spawning, extending over a considerable part of the hatching period while, for another, the samples contain only larvae hatched near the beginning of the hatching period. Thus in the case of the first survey of the central and north-western North Sea it seems obvious from the size distributions of the larvae caught that in the spawning area of the Buchan stock we were sampling an accumulation of larvae hatched over a considerable time period while in the area of the Bank stock hatching had been in progress for only a comparatively short time.

Three estimates are given in Table 1 (p.8) of larval abundance for each stock based on larvae less than 10 mm long, on larvae up to 15 mm long and on the total larval population on each survey that was done on them. For the reasons given above it would appear on balance that the estimate based on larvae less than 10 mm probably gives the best estimate of the relative sizes of the spawning stocks. Of the two surveys done in the western North Sea the first one is certainly the most reliable for the Bank stock in so far as it gives the most complete coverage of the area whilst in the second one the main centre of larval abundance on the first survey was not sampled at all. For the Buchan stock the second survey gave a greater abundance of larvae despite the fact that the coverage of the area was much less satisfactory. This would suggest that the first survey was too early to sample the peak of hatching of larvae for that stock.

Despite the uncertainties attaching to the interpretation of these data some conclusions can be drawn. The autumn-spawning stock of the Kobbergrund area would seem in 1967 to have been considerably smaller than either the Bank or Buchan stocks (perhaps about $^{1}/_{6}$th-$^{1}/_{10}$th of the size of these stocks). It is more difficult to decide, on the basis of this material, on the relative sizes of the Banks and Buchan stocks. In view of the uncertainties inherent in such material, the best estimate that can be made is that in 1967 they were of about the same size.

TABLE 1

Stock	Survey	Abundance of Larvae		
		< 10 mm	≤ 15 mm	Total
Buchan	6/9-24/9/67	243.6 x 10^9	682.6 x 10^9	762.1 x 10^9
	25/9-13/10/67	600.4 x 10^9	794.2 x 10^9	888.8 x 10^9
Bank	6/9-24/9/67	395.0 x 10^9	399.8 x 10^9	400.5 x 10^9
	25/9-13/10/67	154.3 x 10^9	167.1 x 10^9	205.8 x 10^9
Kobbergrund	12-14/10/67	2.8 x 10^9	2.8 x 10^9	2.8 x 10^9
	20-25/10/67	59.5 x 10^9	59.5 x 10^9	59.5 x 10^9

To use these surveys to get some measure of the variations in the sizes of these stocks in recent years is in most cases rendered difficult by the lack of comparable data for previous years. For the Buchan stock, where there is a series of comparable data extending back to 1951, this question has been fully discussed by Saville (1968) where it is shown that the 1967 figures of larval abundance suggest a sharp drop in the size of the Buchan spawning stock in 1966 and again in 1967.

For the Bank stock only available data on larval abundance in earlier years are those given by Zijlstra (1966). These are not strictly comparable to any of the estimates given in Table 1 on two grounds. Firstly the data in Zijlstra (1966) are derived from surveys only of the Dogger-Well Bank area while those in Table 1 also include larvae from the Whitby and North-East Bank areas. As can be seen from Figures 1-6, the latter areas provided most of the larvae taken in 1967. Secondly, the figures given by Zijlstra are for larvae "below 11 mm in length", and so are not strictly comparable with any of the size groups used here, although the discrepancy between less than 10 mm and below 11 mm must have added comparatively little to the 1967 figures for this area. However, the figures from the two sources are compared in Table 2.

TABLE 2

Stock	Year					
	1960	1961	1962	1964	1965	1967
Bank	137 x 10^9	85 x 10^9	62 x 10^9	52 x 10^9	275 x 10^9	395 x 10^9

Without doubt, the abundance of larvae and so presumably the size of the spawning stock in the Dogger-Well Bank area was very much lower in 1967 than in the other years sampled in 1960's. What cannot be decided on these data is whether the abundance of larvae in the central North Sea, and so the size of the Bank spawning stock, has also been reduced. This would seem likely, but it is possible that the reduction of spawning in the Dogger-Well Bank area has resulted from a shift in the major centre of spawning of this stock to the Whitby-North East Bank area.

For the Kobbergrund herring no comparable data are available of larval abundance in previous years. It is worthy of note however that, as in 1967, no evidence was found of spawning on the Jutland and West Banks in 1966 (Haraldsvik, 1967) or in 1965 (Postuma, 1966).

Plans have been made to repeat these surveys in 1968. It is only by the accumulation of similar data over a number of years that their full value can be utilised.

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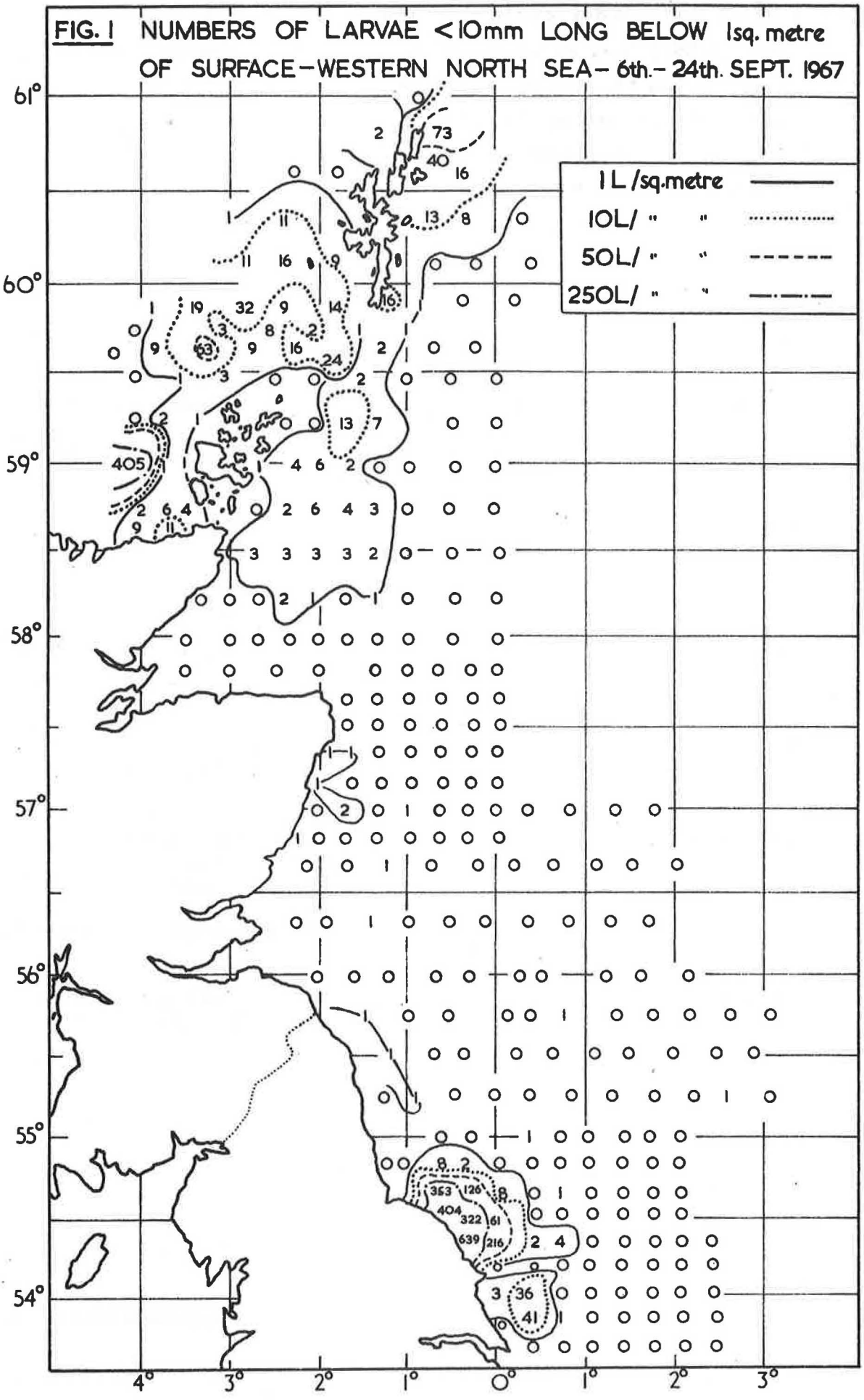


FIG. 1 NUMBERS OF LARVAE <10mm LONG BELOW 1sq. metre
OF SURFACE-WESTERN NORTH SEA- 6th.- 24th. SEPT. 1967
1 L /sq.metre
10L/ " "
50L/ " "
250L/ " "
61°
60°
59°
58°
57°
56°
55°
54°
4°
3°
2°
1°
0°
1°
2°
3°

FIG. 2 NUMBERS OF LARVAE 10–15 mm LONG BELOW 1 sq metre OF SURFACE
WESTERN N. SEA – SAMPLED 6–24/9/67

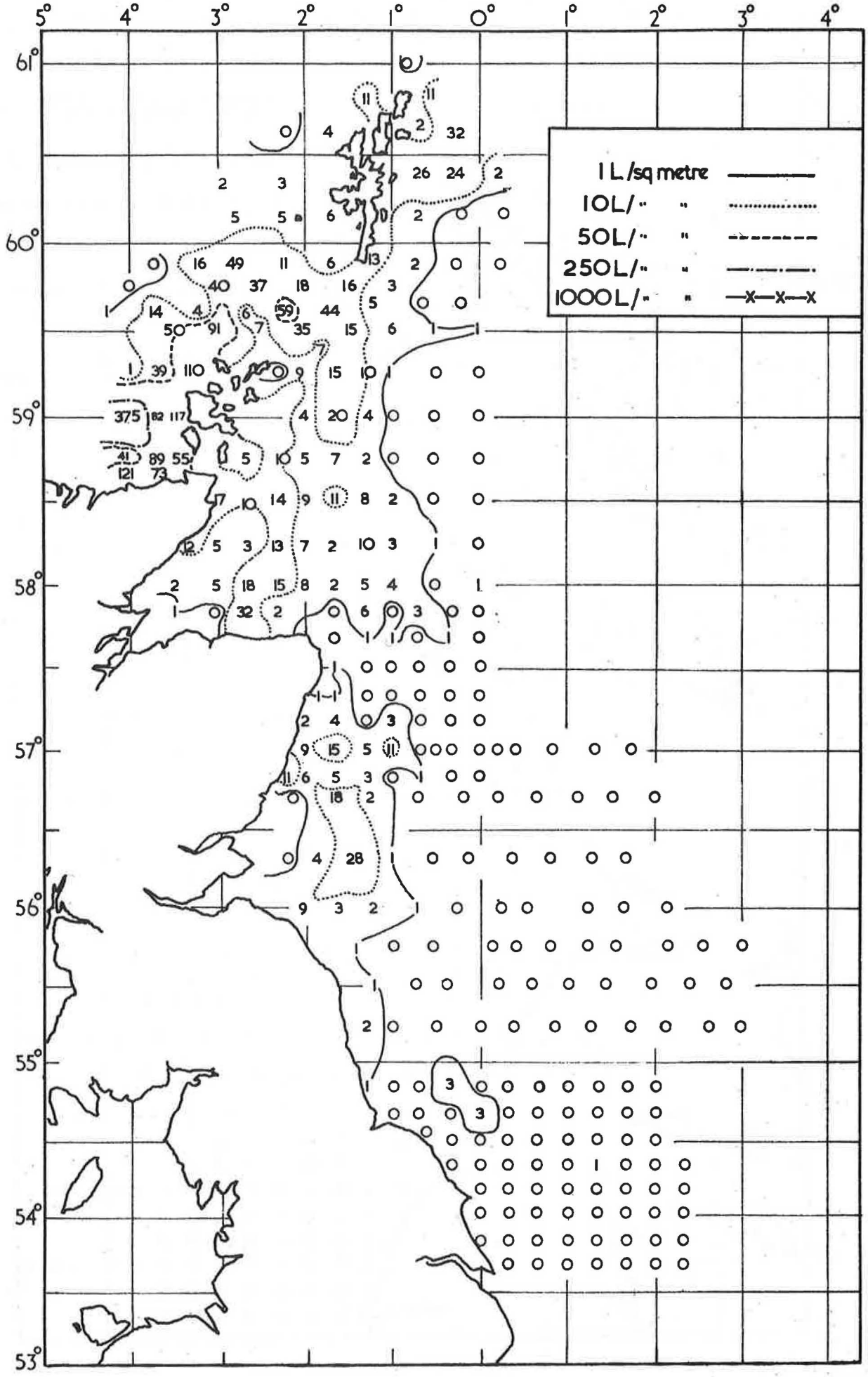


FIG 3 NUMBERS OF LARVAE >15 mm LONG BELOW 1 sq metre OF SURFACE — WESTERN NORTH SEA — 6th — 24th SEPT. 1967

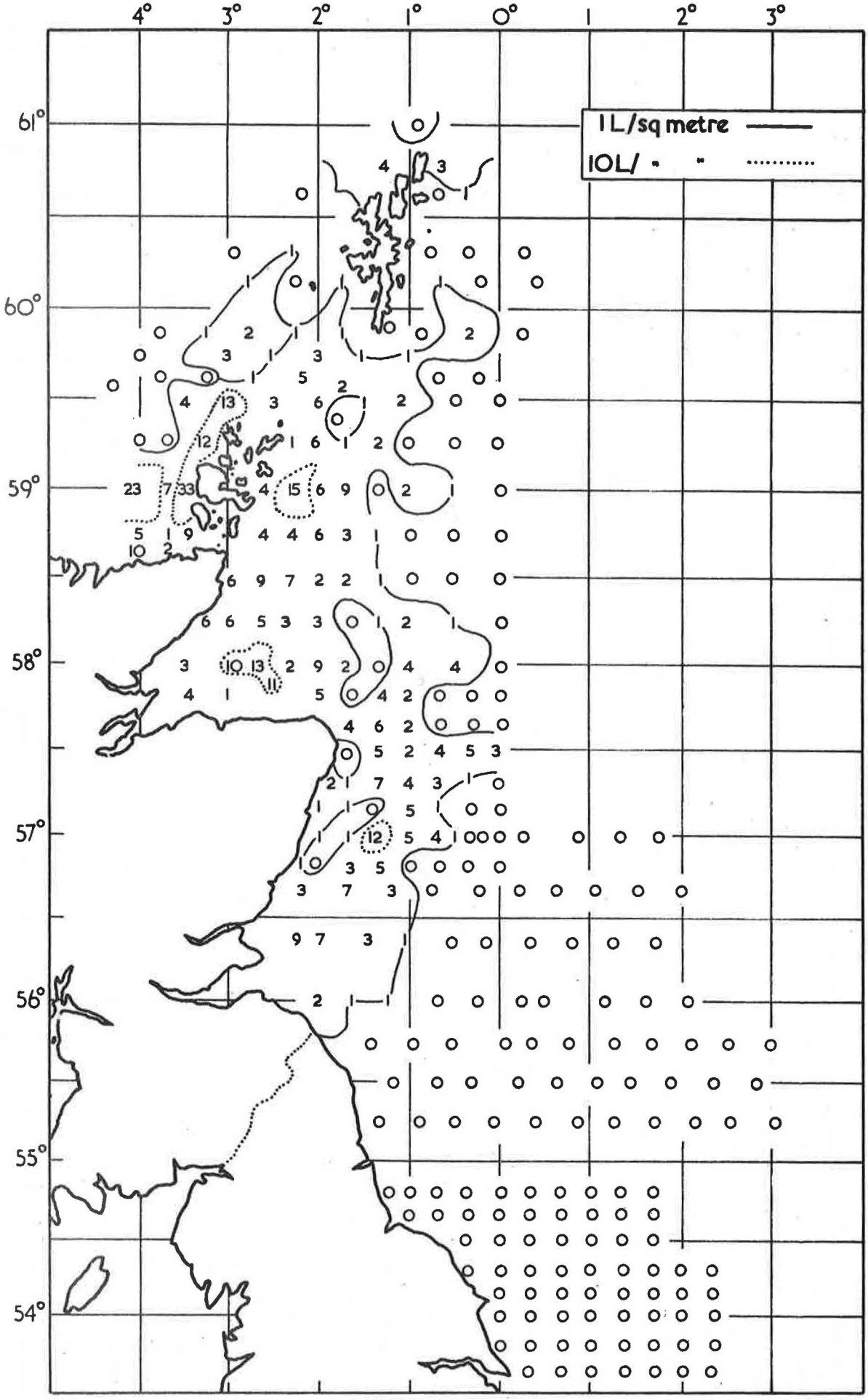


FIG. 4. NUMBERS OF LARVAE < 10mm LONG BELOW 1 sq. metre OF SURFACE.
WESTERN N SEA — SAMPLED 25/9 — 13/10/67

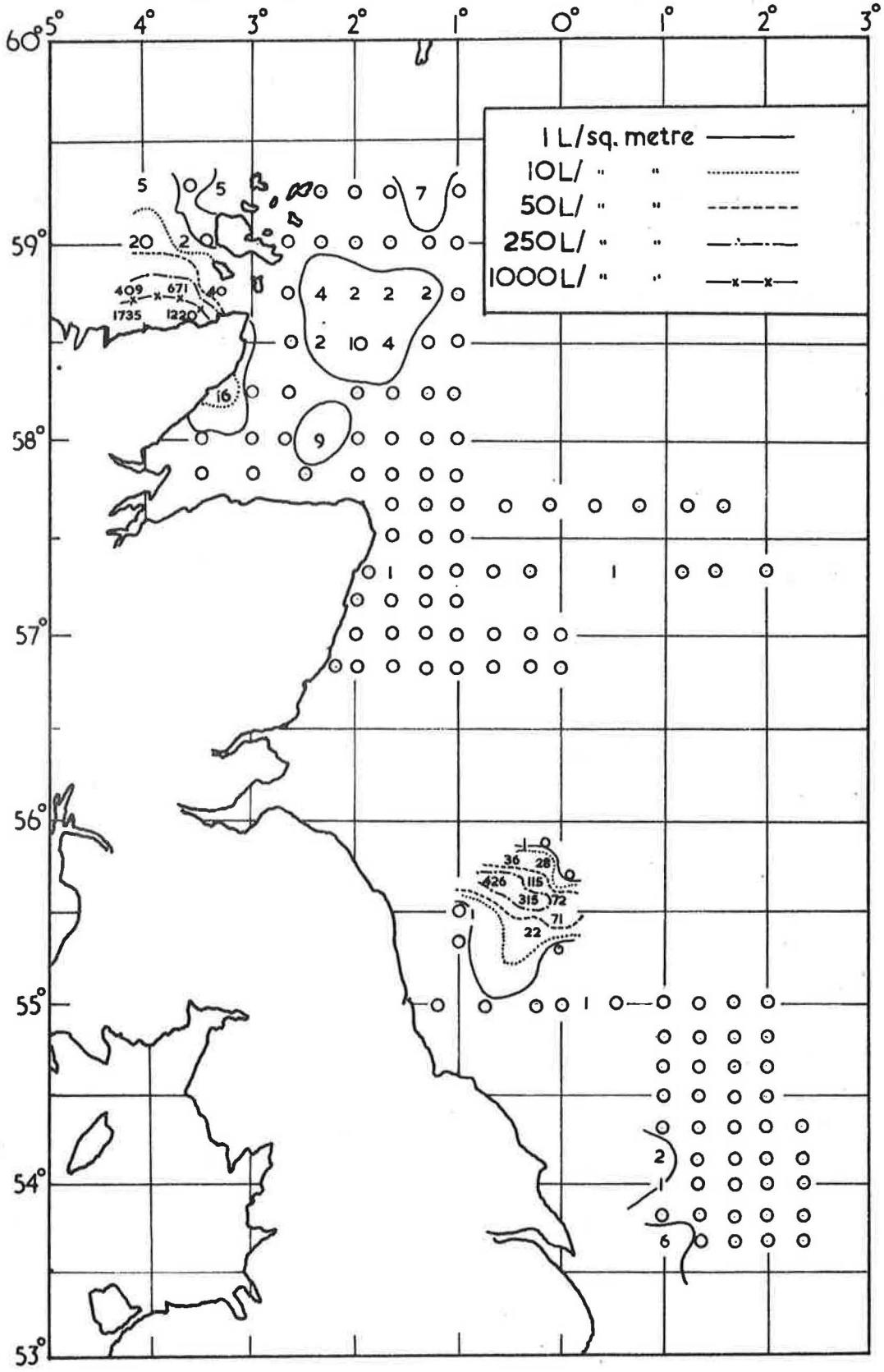


FIG. 5 NUMBERS OF LARVAE 10–15mm LONG BELOW 1sq.metre OF SURFACE – WESTERN NORTH SEA – 25th SEPT. – 13th OCT. 1967

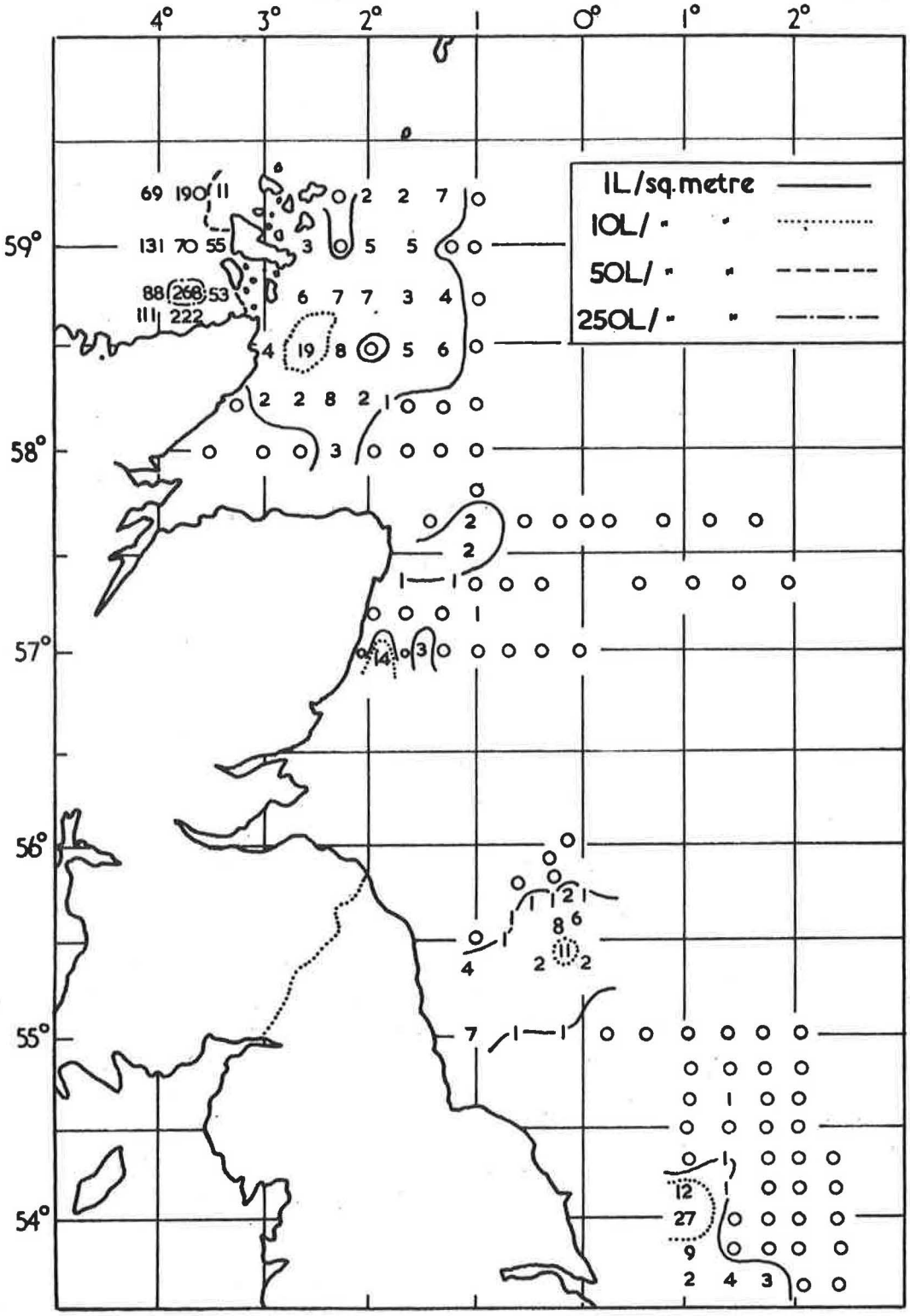


FIG 6 NUMBERS OF LARVAE > 15 mm LONG BELOW 1 sq. metre OF SURFACE
WESTERN N. SEA — SAMPLED 25/9 — 13/10/67

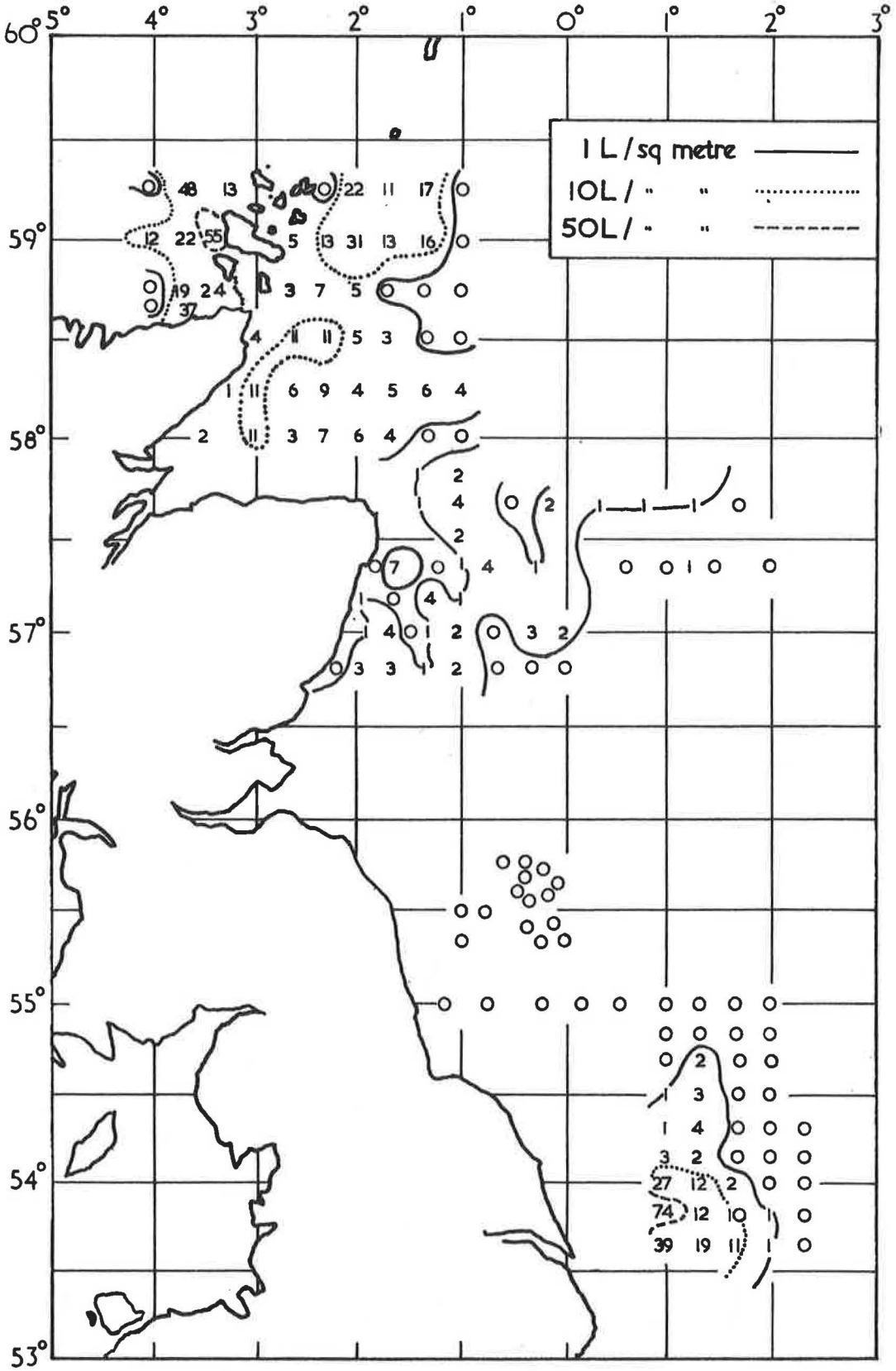


FIG 7 NUMBERS OF LARVAE <10mm LONG BELOW 1sq metre OF SURFACE-EASTERN NORTH SEA & SKAGERRAK — 12th-14th OCT. 1967

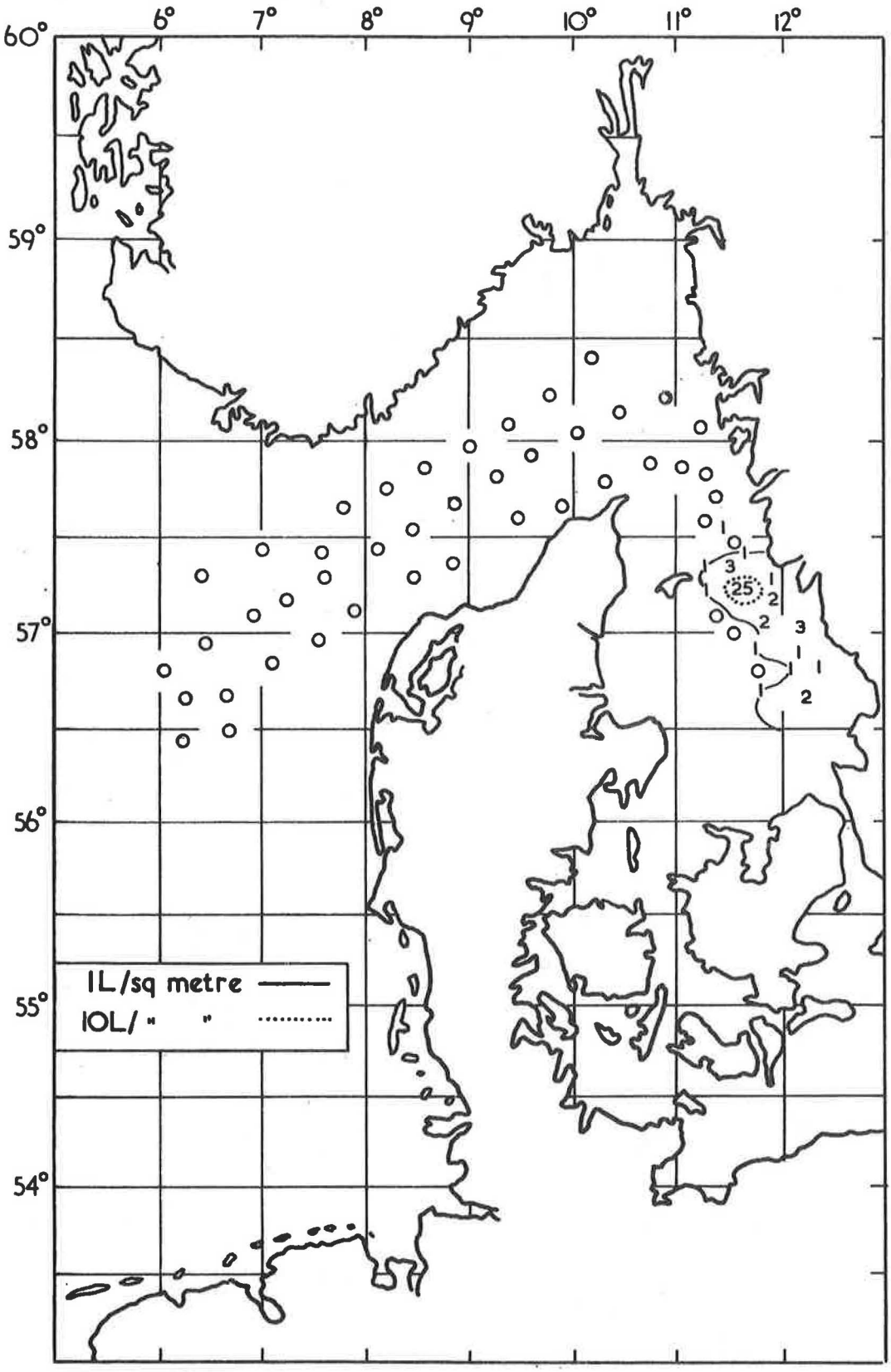
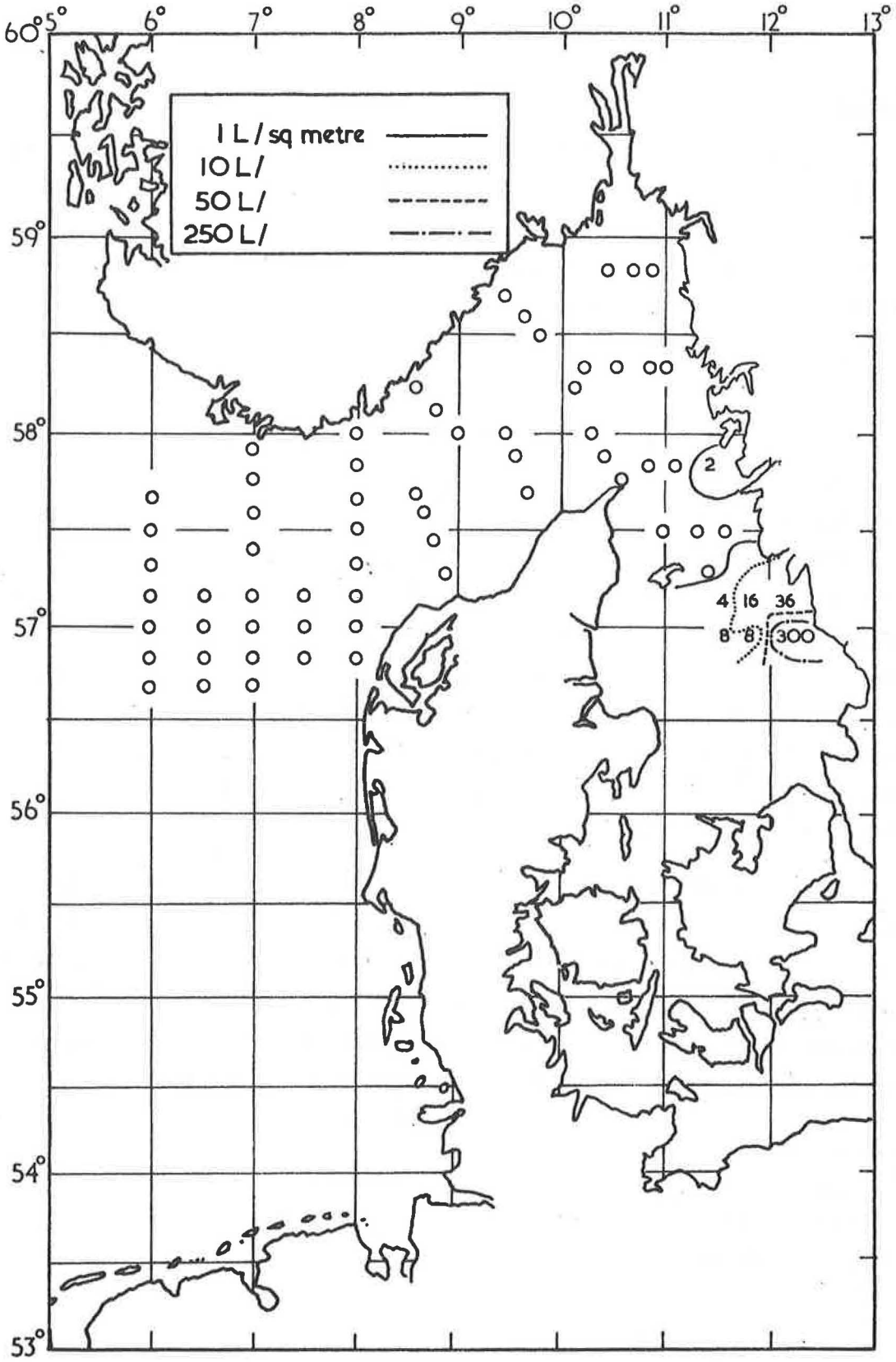


FIG. 8. NUMBERS OF LARVAE < 10mm LONG BELOW 1 sq metre OF SURFACE
EASTERN N.SEA & SKAGERRAK SAMPLED 20–25/10/67



REPORT ON THE INTERNATIONAL SURVEYS OF HERRING LARVAE IN THE NORTH SEA IN 1968

by

J. Boëtius* and D. W. McKay**

Introduction

In 1966 a Special Meeting of the ICES Herring Committee recommended that the countries concerned in the North Sea herring fisheries should collaborate in attempts to get better measures of larval abundance in the North Sea as a guide to the relative size of the stocks and of the changes in them. This recommendation was first implemented in 1967 and the results are published by Saville in this volume. This report gives the results of a similar survey carried out in 1968.

In 1968 the countries participating in the survey were England, Scotland, Germany, Netherlands, Norway and Denmark. In the western North Sea the Netherlands and England sampled from 53°30'N to 55°N including the spawning grounds in the Dogger Bank, Well Bank and Whitby areas; Germany sampled from 54°20'N to 57°40'N including the North East Bank, the Long-stone area, Montrose, Aberdeen, and Turbot Banks and the area east of Orkney; Scotland sampled the area from 57°30'N to 59°30'N including the Moray Firth and Clythness, and the grounds around Orkney and Fair Isle, while England sampled the area north of Fair Isle and around Shetland. In the eastern area Denmark and Norway each sampled Jutland Bank, the Skagerak, and the Kattegat from 56°10'N to 58°50'N.

England and the Netherlands worked in the central North Sea in both September and October. The Scottish area was sampled in September and part of the area was resurveyed in the beginning of October. Germany sampled in the last half of September overlapping the Scottish survey and, at the same time England sampled around the Shetlands. Denmark and Norway both sampled the Skagerak-Kattegat area in October.

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The results of the surveys were recorded as numbers of larvae below 1 square metre of surface at each station in three size groups, < 10 mm, 10-15 mm, and > 15 mm. The sampling was done by various types of Gulf III high speed sampler except by Norway, which used the Juday net.

North-Western and Central North Sea

This area was sampled by English, Scottish, German and Dutch research vessels in the month of September and a fairly satisfactory coverage of the distribution of herring larvae within the known spawning areas in the north-western and central North Sea was obtained.

The distribution of larvae less than 10 mm long in the area, in September is shown in Figure 1 (p.23). It will be seen that at this time the only concentrations of recently hatched larvae were found in the Whitby-Flamborough area (statistical rectangles D8 and E8), where in a small area close to the English coast the numbers of larvae exceeded $25/m^2$, and in the north-western North Sea around the Orkneys and Shetlands where concentrations again exceeded $25/m^2$. In the latter area densities of this order were found in three fairly small patches:

1) to the west of Orkney

2) between Orkney and Fair Isle

3) in the area north-east of Shetland.

These patches of high density in the north-western North Sea were surrounded by fairly extensive areas of lower densities. In the Dogger-Well Bank area and on the spawning grounds off the east coast of Scotland larvae of this size were totally absent.

At the time of the surveys larvae of 10-15 mm (Fig.2, p.24) were largely confined to the north-western North Sea, but a small patch of larvae of this size in which the numbers exceeded $25/m^2$ was found east of Flamborough Head. To the west of Orkney, a patch of larvae 10-15 mm long with densities exceeding $100/m^2$ was found surrounded by an extensive area with densities of over $25/m^2$. To the

east of Orkney and in the Clythness area, a fairly extensive area of larvae of this size was located. In the Scottish east coast area larvae of 10-15 mm were extremely scarce with only two small patches at a level of $1/m^2$.

As might be expected in September, larvae greater than 15 mm (Fig.3, p. 25) were most abundant in the north-western North Sea but were nowhere found at high densities. The highest concentration of this size group was found in the Moray Firth area where densities exceeding $5/m^2$ were found. There was also a small patch of this size group in the area off Flamborough Head.

The Dogger-Well Bank area was resampled in October as was a small area in the Moray Firth and around Orkney. This was a far from satisfactory coverage of the spawning grounds but serves to amplify the picture gained on the September surveys. Larvae < 10 mm (Fig.4, p. 26) were again absent from the Dogger-Well Bank area but a small patch of larvae with densities exceeding $100/m^2$ was again located off Flamborough Head (statistical rectangles E6 and F6). Although the Orkney area was sampled to a limited extent, a patch of larvae with densities exceeding $100/m^2$ was found to the west of Orkney in the area west of 3°30'W. Since sampling did not extend sufficiently far to the west, its full extent was not determined.

10-15 mm larvae (Fig.5, p.27) were found in October to the west of Orkney where densities exceeded $25/m^2$ over much of the area surveyed. However, the survey was only of limited extent and the patch limits were not defined accurately. A fairly extensive area, with densities exceeding $5/m^2$ was located to the east of Orkney. In the Dogger-Well Bank region larvae of this size group were only found in a small patch with very low densities close to the English coast in the Flamborough Head area.

In October larvae > 15 mm (Fig.6, p. 28) were widespread around Orkney and in the Moray Firth area but only at low densities. In the Dogger-Well Bank area larvae of this size group were found only at a density of $1/m^2$ in an area off Flamborough Head (statistical rectangles E6, F6, F7, G6).

The Jutland Bank - Kobbergrund Area

This area was sampled in the second half of October both by Denmark and Norway. No larvae were taken outside the Kattegat by

either country and the majority of the larvae found were less than 10 mm. As mentioned above, the Norwegian data are based on hauls with a Juday net. These surveys located larvae of less than 10 mm (Fig.7, p. 29) in the Kobbergrund area but at fairly low densities. The survey also showed a scarcity of larger larvae (Fig.8, p.30). Only 3 small patches of 10-15 mm larvae at densities of $1/m^2$ were found.

Discussion

The major aim of these surveys was to obtain estimates of the relative sizes of spawning concentrations in the different areas and of the changes in them with time. In accordance with Saville (this volume) three estimates are given in Table 1, page 22, of larval abundance for each stock, based on larvae less than 10 mm long, on larvae up to 15 mm long, and on the total larval population, in each month of the surveys. Of the two months considered the September estimates are the most satisfactory in that the area was surveyed most completely in that month, and, as the September estimates are the larger, they probably give the better estimate of relative sizes of the stocks.

Despite the difficulties in interpretation of these data some conclusions can be drawn. The autumn-spawning stock in the Kobbergrund area would seem in 1968 to have been considerably smaller than the north-western North Sea stock (perhaps $1/10$th - $1/15$th of its size). On the basis of these data the north-western North Sea stock now seems to be larger than the central North Sea one (perhaps by a factor of 2-3). Comparison with the results of the 1967 survey would suggest that the north-western North Sea and Kobbergrund stocks have maintained the same relative size while the central North Sea stock has declined relative to them.

Comparison of the 1968 surveys with those of 1967 suggests that in both months, for all size groups, the estimates of larval abundance had decreased. The factor of this decrease is given in Table 2 (p.22) for each comparison.

TABLE 1

Stock	Survey	Abundance of Larvae		
		< 10 mm	< 15 mm	Total
Buchan	Sept.	162.2×10^9	390.9×10^9	455.2×10^9
	Oct.	28.9×10^9	101.8×10^9	127.8×10^9
Bank	Sept.	37.0×10^9	49.4×10^9	50.2×10^9
	Oct.	19.5×10^9	23.0×10^9	28.0×10^9
Kobbergrund	Oct.	9.2×10^9	11.5×10^9	11.5×10^9

TABLE 2

Stock	Month	Factor of Decrease from 1967 to 1968			Total
		<.10 mm	10-15 mm	> 15 mm	
Buchan	Sept.	1.5	1.9	5.1	1.7
	Oct.	20.8	2.7	3.7	7.0
Bank	Sept.	10.7	.4	.9	8.0
	Oct.	7.9	3.7	6.4	7.4
Kobbergrund	Sept.				
	Oct.	6.7	-	-	5.2

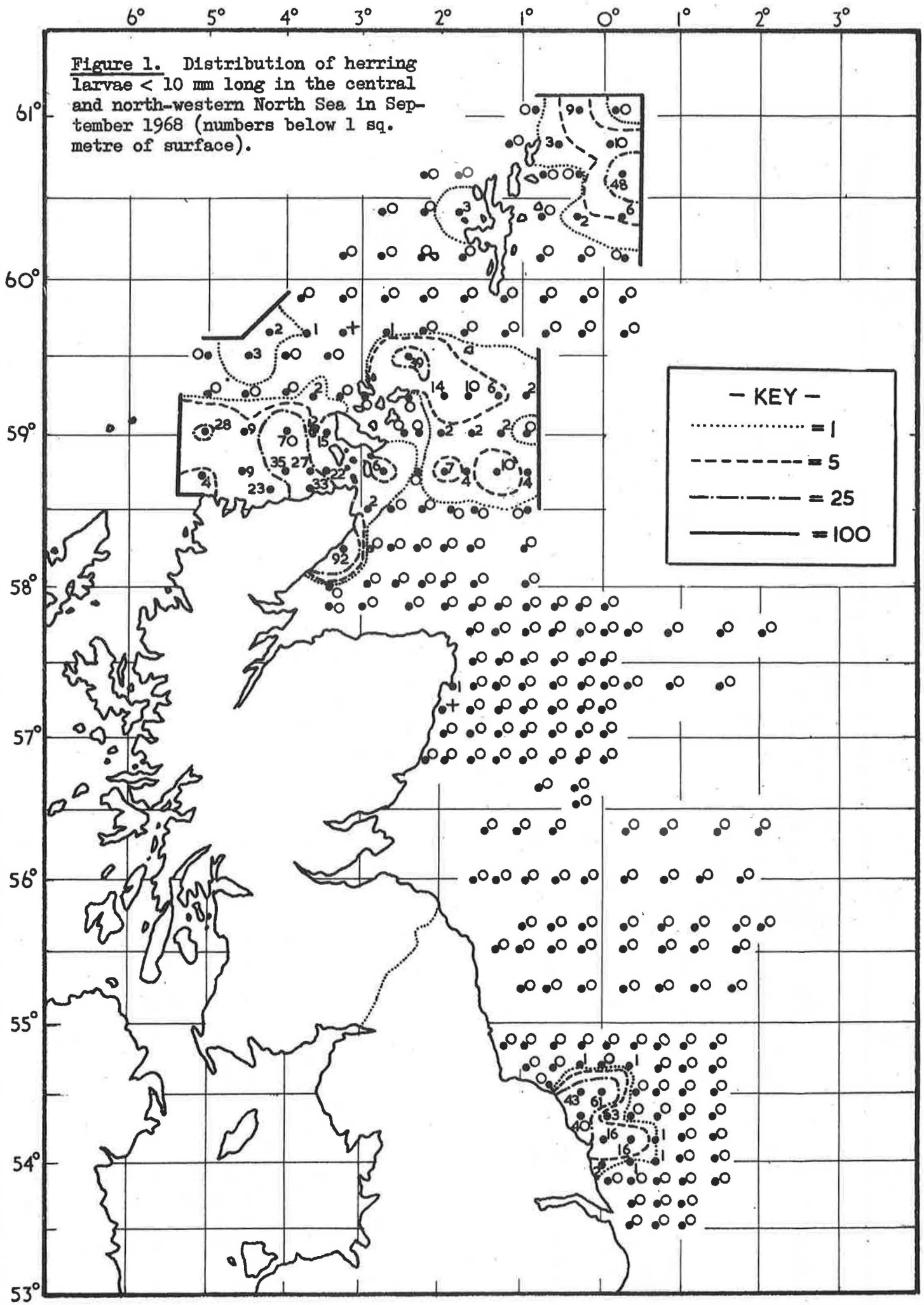

Figure 1. Distribution of herring larvae < 10 mm long in the central and north-western North Sea in September 1968 (numbers below 1 sq. metre of surface).

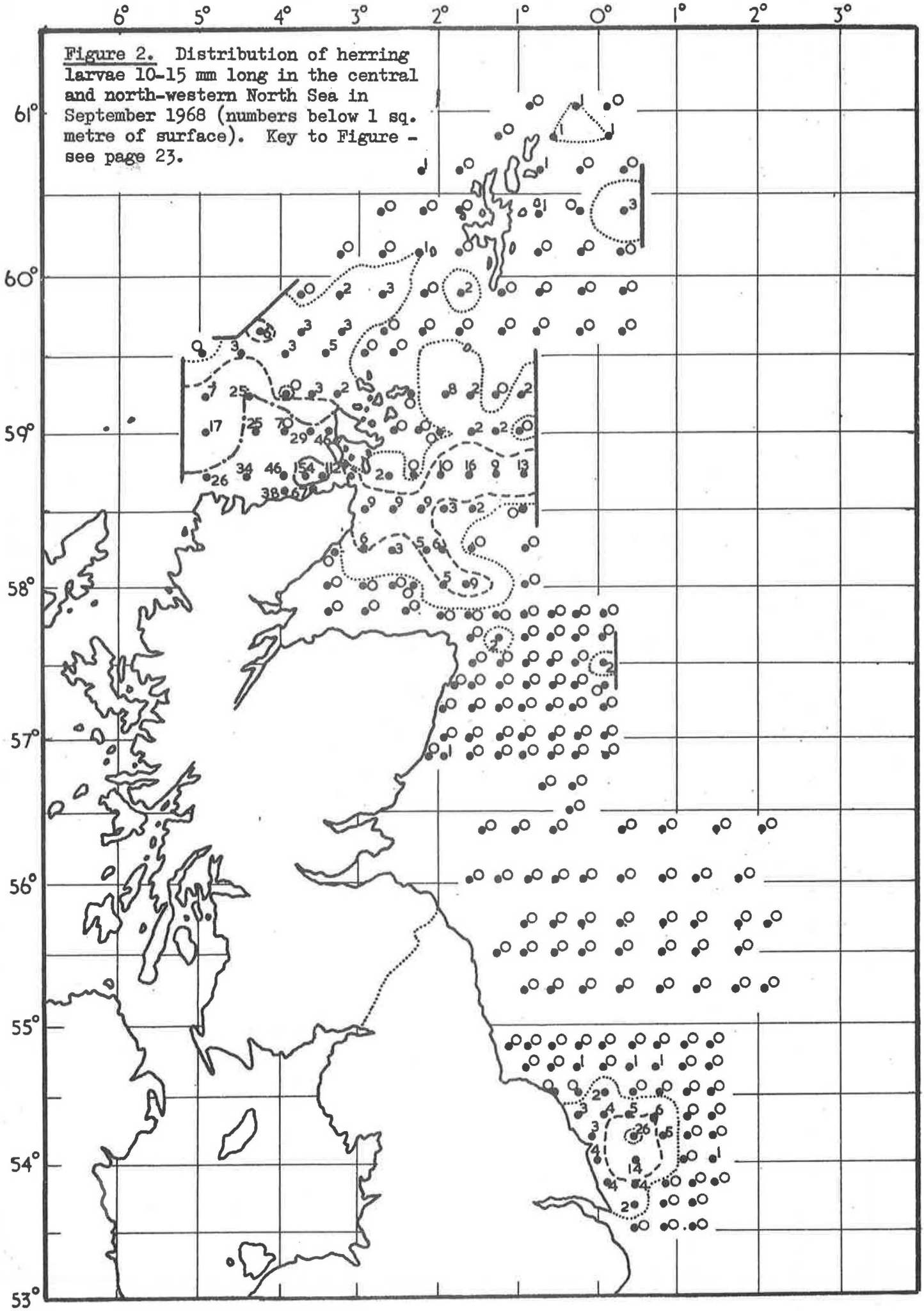

Figure 2. Distribution of herring larvae 10-15 mm long in the central and north-western North Sea in September 1968 (numbers below 1 sq. metre of surface). Key to Figure - see page 23.

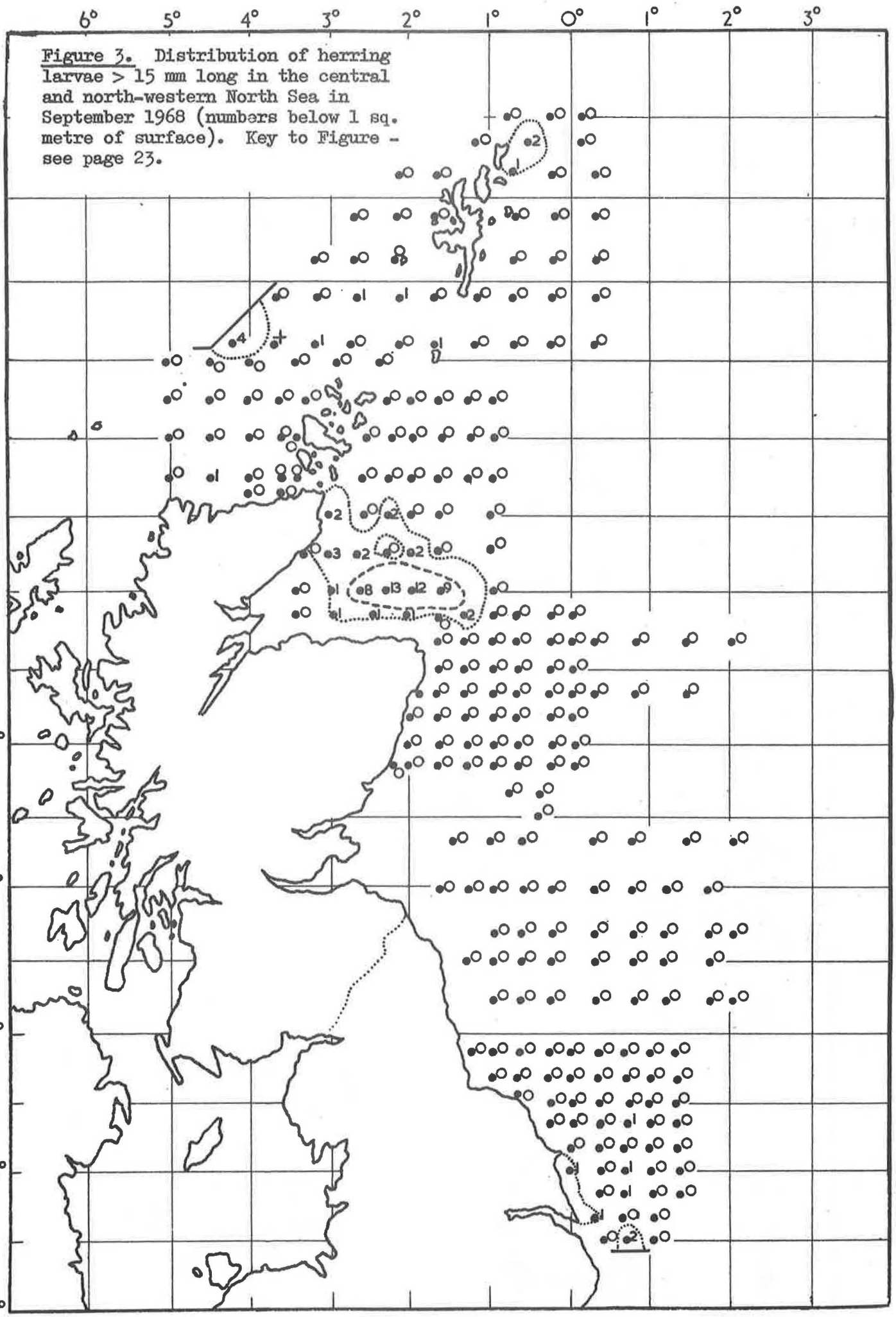

Figure 3. Distribution of herring larvae > 15 mm long in the central and north-western North Sea in September 1968 (numbers below 1 sq. metre of surface). Key to Figure - see page 23.

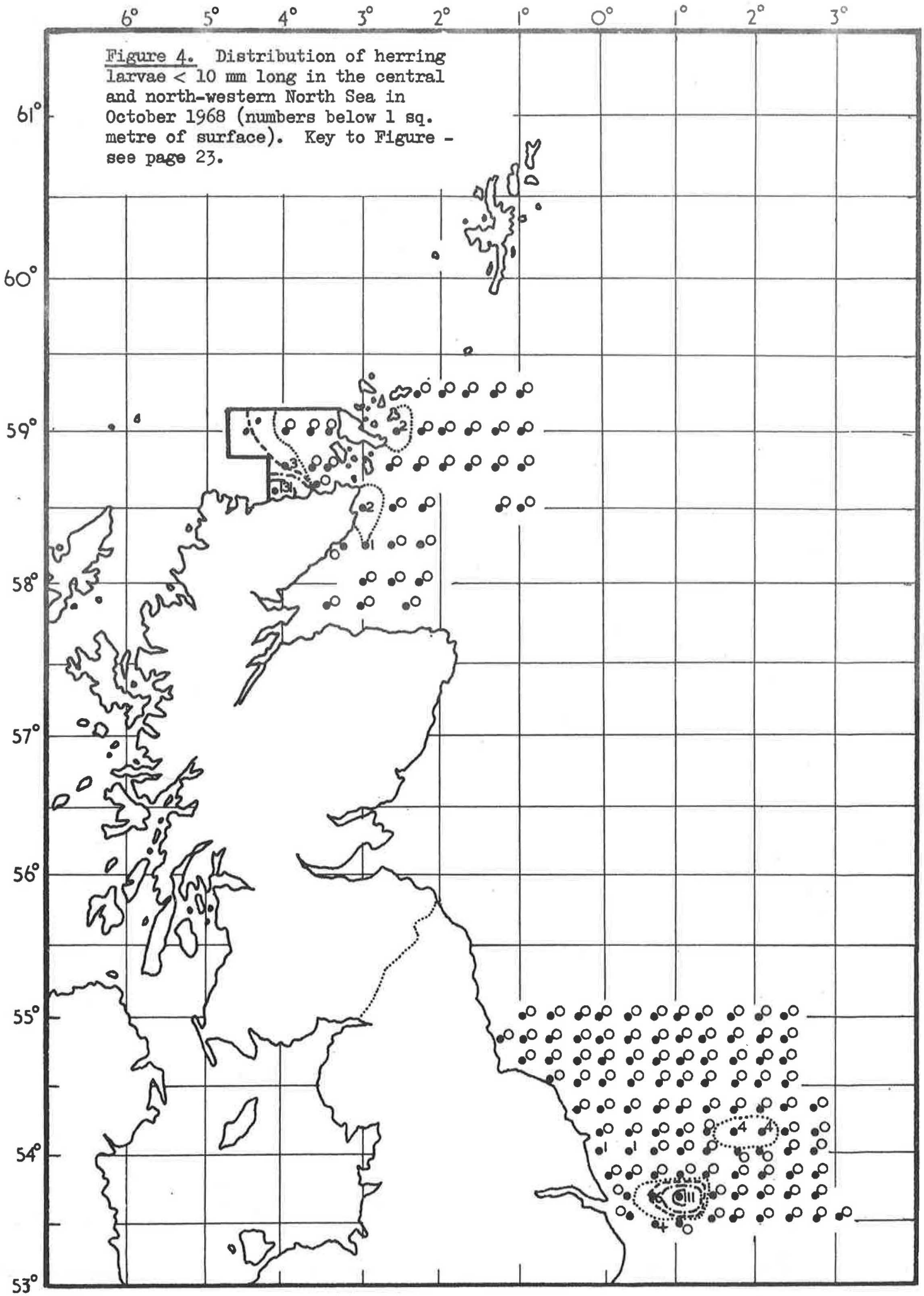

Figure 4. Distribution of herring larvae < 10 mm long in the central and north-western North Sea in October 1968 (numbers below 1 sq. metre of surface). Key to Figure - see page 23.

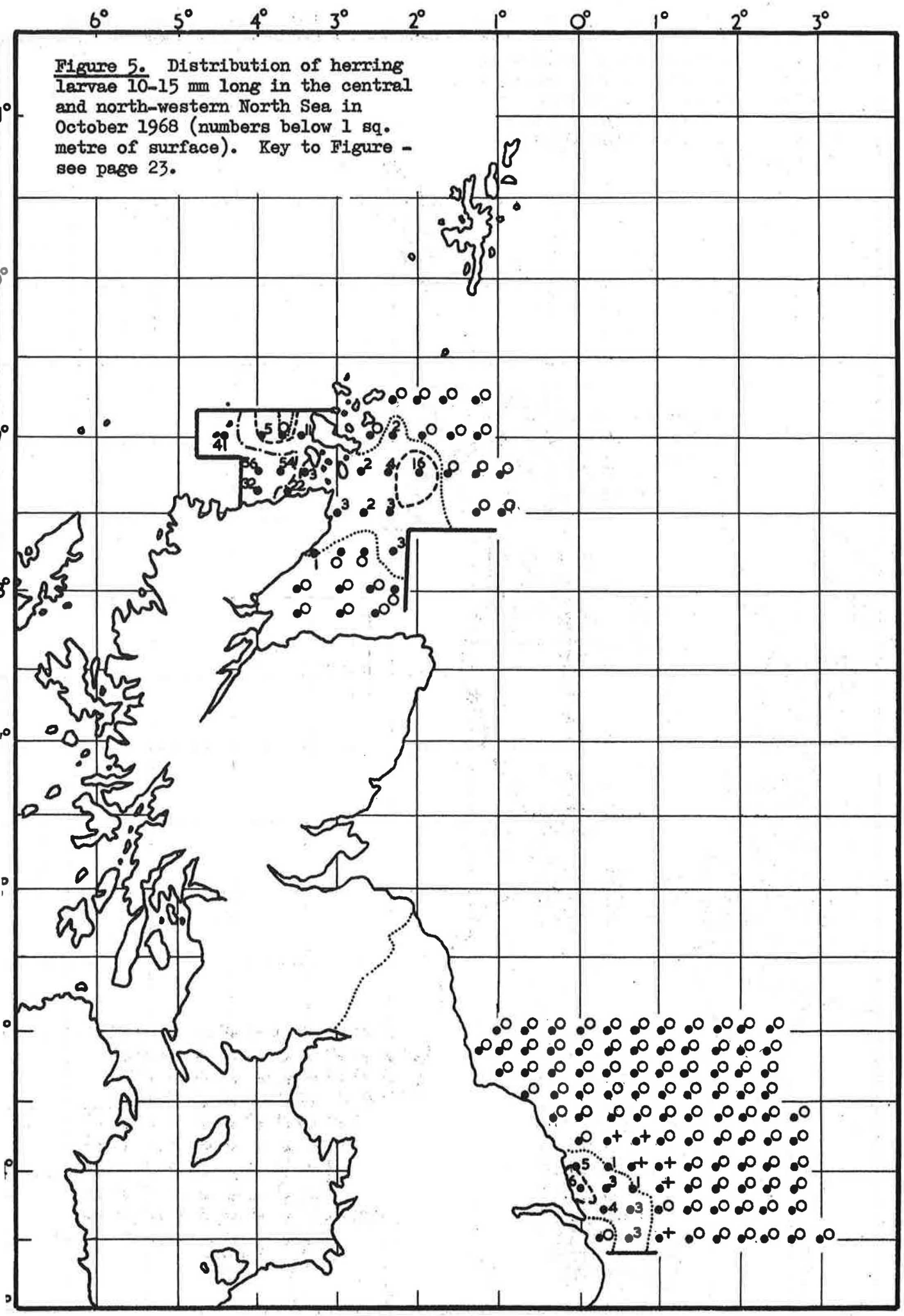

Figure 5. Distribution of herring larvae 10-15 mm long in the central and north-western North Sea in October 1968 (numbers below 1 sq. metre of surface). Key to Figure - see page 23.

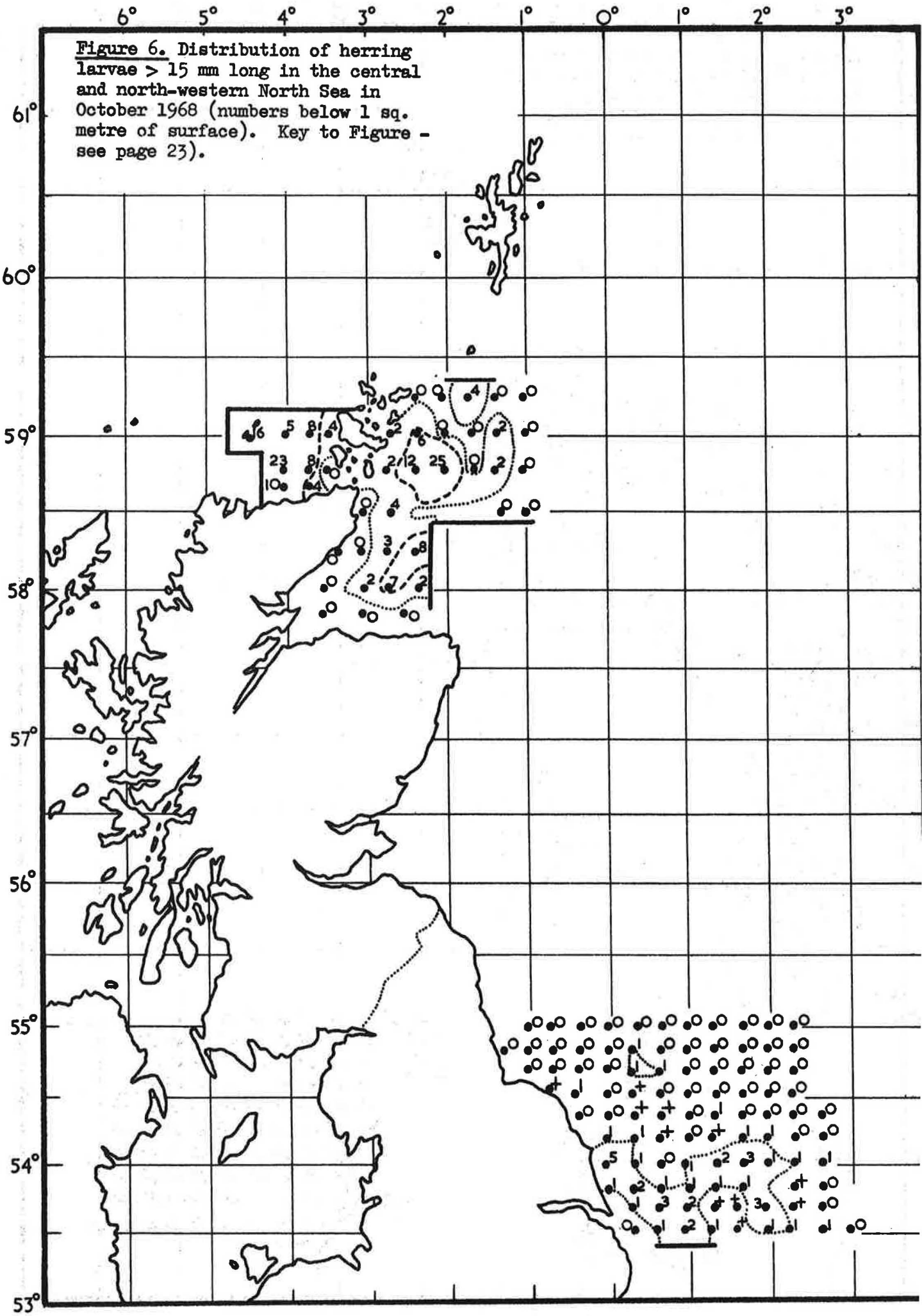

Figure 6. Distribution of herring larvae > 15 mm long in the central and north-western North Sea in October 1968 (numbers below 1 sq. metre of surface). Key to Figure - see page 23).

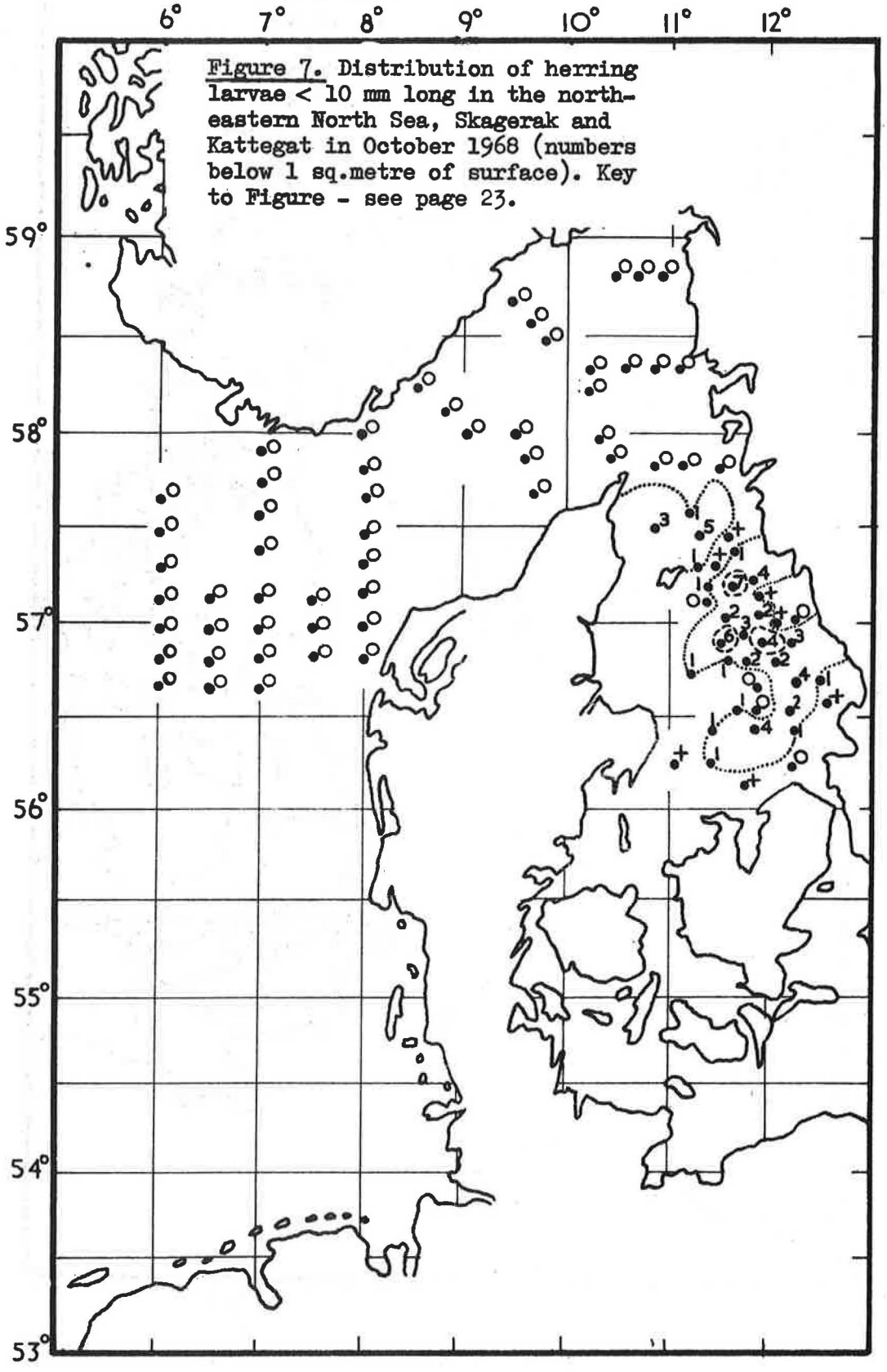

Figure 7. Distribution of herring larvae < 10 mm long in the north-eastern North Sea, Skagerak and Kattegat in October 1968 (numbers below 1 sq.metre of surface). Key to Figure - see page 23.

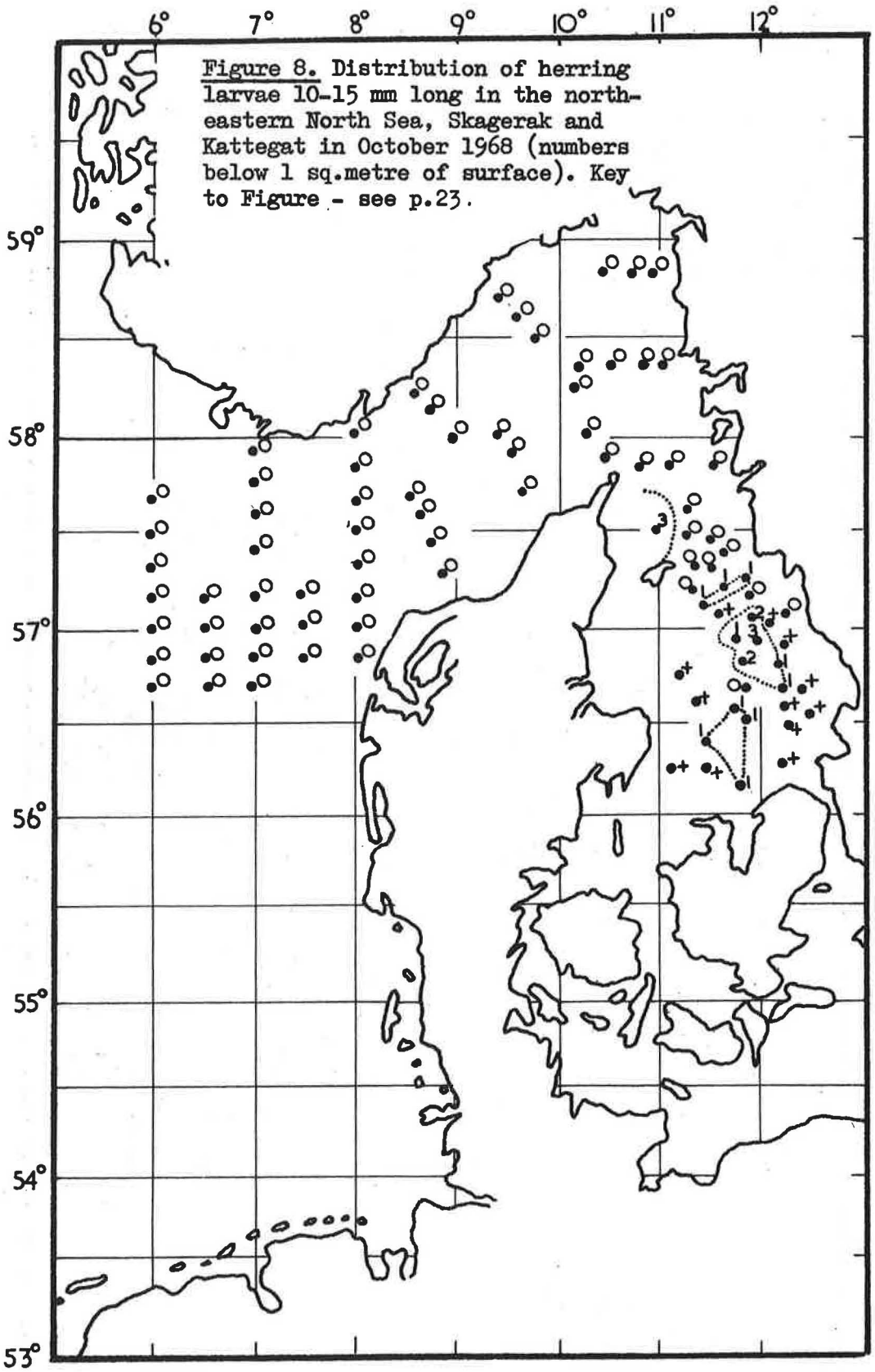

Figure 8. Distribution of herring larvae 10-15 mm long in the north-eastern North Sea, Skagerak and Kattegat in October 1968 (numbers below 1 sq.metre of surface). Key to Figure - see p.23.