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**REPORTS ON SURVEYS OF HERRING LARVAE
IN THE NORTH SEA AND ADJACENT WATERS,
1972–1973**

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REPORT ON THE INTERNATIONAL SURVEYS OF HERRING LARVAE
IN THE NORTH SEA AND ADJACENT WATERS IN 1972/73

by

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Introduction

This report gives the results of the sixth international survey of herring larvae in the North Sea and adjacent waters. These surveys were started in 1967, following a recommendation of the ICES Herring Committee in 1966. They are intended to provide measures of changes in the herring spawning stocks which are independent of catch per unit effort data.

Results of previous surveys are published in Saville (1970), Boëtius & McKay (1970), Wood (1971), Zijlstra (1972) and Schnack (1973).

Material and Methods

During the autumn and winter of 1972/73, seven countries participated in the surveys with the following research vessels: Denmark: RV "Dana"; England: RV "Cirolana" and RV "Corella"; Federal Republic of Germany: RV "Anton Dohrn"; Iceland: RV "Arne Fridrikson"; Netherlands: RV "Willem Beukelsz" and RV "Tridens"; Scotland: RV "Clupea"; and Sweden: RV "Thetis". The timing of each survey in each area is given in Table 1.

On all ships, sampling was carried out using a modified Gulf III sampler towed in a double oblique haul, sampling the whole water column down to 5 metres above the bottom. A more detailed description of the gear and sampling technique is given by Saville (1970).

The reduction in the number of stations sampled, and a resultant concentration of sampling effort in areas where herring larvae are expected to occur, which was introduced in 1971/72, was again followed in the 1972/73 surveys (Anon 1971). The survey periods are given in Table 1,

in which the total surveyed area is broken down into sub-areas as proposed by the Working Group on North Sea Herring Larval Surveys, viz:

- 1) Shetland-Orkney (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 September 1972 to January 1973 a total of 1 233 stations was sampled. The results, recorded as numbers below one square metre of sea surface at each station, are shown in Figures 1-28 for separate areas, survey periods and size groups of larvae.

For all areas, except the Southern Bight-English Channel, the size groups are, as in previous reports, <10mm, 10-15mm and >15mm long. For larvae of the Downs stock, which hatch at a greater length, the size groups were changed in the 1971/72 survey to <11mm, 11-16mm and >16mm, and this grouping has again been used in this report. Yolk sac larvae were omitted in calculating larval abundances (Anon 1971). Charts of surveys on which no or very few larvae of a size group were caught have been omitted from this report.

Abundance estimates were calculated from larger scale charts than those given here - approximately 1/1 000 000 to 1/2 000 000. On these charts contour lines were drawn at levels of 1, 5, 25, 100, 500, 1 000 and 2 000 larvae per square metre and subsequently planimetered. The area between two contour levels was multiplied by the mean of these contour levels to estimate the abundance of larvae. The area within the highest contour level was multiplied by the mean of that level and the highest observed station value.

In previous reports on these surveys there has been considerable diversity in the way that the abundance estimates have been calculated and reported. For example, the 1967 and 1968 abundances were calculated

by multiplying the area between contour levels by the value of the lower contour level, the 1971 abundances by multiplying each station value by an area appropriate to that station, whilst in the other years the area between contour levels was multiplied by the mean of the station values between the contours. Similarly there have been some differences in the areas, and in the size groupings, for which abundance estimates were reported. This has resulted in it being difficult or impossible to make realistic comparisons of year to year changes in larval abundance over the period covered by these surveys. To correct for this all the past survey data for the Shetland-Orkney, Buchan and Whitby-Dogger areas have been recalculated, as described above for the 1972 data, and the resulting estimates are given in Table 2.

Results - Distributions

Shetland-Orkney

The Shetland-Orkney area was sampled during three periods, 6-11 September, 12-21 September and 22-27 September by Danish, English, Icelandic and Scottish research vessels. Five cruises were carried out during these periods, covering areas of different extent, and the data from these were combined into three surveys to give the optimum coverage of the area.

During the first survey the sampling was fairly complete, the main omission being the area to the east of the Scottish mainland (Figs. 1-2). The major concentrations of larvae less than 10mm long were located between Orkney and Fair Isle, and at the western entrance to the Pentland Firth. In the Orkney-Fair Isle patch densities up to 1 780 per m^2 were obtained. On this survey larvae 10-15mm long showed a rather similar distribution to that of the smaller size group but were much less abundant.

On the second survey (12-21 September) coverage was again good with all the recommended areas, except those to the north and east of Shetland, being sampled (Figs. 3-5). Larvae of all size groups were caught with the main concentrations of the smallest category being taken in the

Orkney-Fair Isle area and to the west of Orkney. In the former area densities of up to $2\ 384/m^2$ were obtained while in the patch to the west of Orkney the maximum density was $2\ 669/m^2$. Larvae of 10-15mm again showed a rather similar distribution to that of the smaller size group but at much lower levels of abundance. The most striking difference between the distribution of these two size groups was the relatively high abundance of larger larvae in B15 which might suggest a drift southwards into the Moray Firth from the areas of high density of smaller larvae to the east of Orkney. Larvae greater than 15mm long on this survey were taken only in small numbers at isolated stations, apart from a band extending south-east from Clythness to Kinnaird Head.

On the third survey (22-27 September) coverage of the area was less satisfactory, sampling being restricted to the east of Orkney and the outer Moray Firth (Figs. 6-8). Larvae of all size groups were present with the main concentrations of small larvae, at lower densities than on the previous survey, being found in the Orkney-Fair Isle area and to the east of Orkney. On this survey larvae 10-15mm long were more abundant than the smaller size group, with levels of more than $100/m^2$ covering an extensive area to the east of Orkney, and their distribution extended further to the south-east of Orkney. Larvae more than 15mm long at this time were taken in two patches; one east of the Pentland Firth and Clythness, and a second extending from Orkney to south of $58^\circ N$ and eastwards to the prime meridian.

Buchan

The Buchan area was surveyed three times during the period 30 August-5 October. The first survey (30 August-1 September) was of limited extent and only the smallest size group of larvae was obtained in a patch with a maximum density of $300/m^2$ off Rattray Head (Fig. 1).

On the second survey (13-20 September) coverage was more extensive with all the recommended stations being sampled. Larvae in the <10mm size group were caught in an area very similar to that of the previous survey but at much lower densities. On this survey a small patch of larvae, 10-15mm long, was found somewhat to the south and east of the patch of small larvae (Figs. 3-4).

Most of the recommended stations were again sampled on the third survey (26 September-5 October) and larvae of all size groups were collected. Small larvae were taken at only one station, off Buchanness at a density of $8/m^2$. A patch of 10-15mm larvae occupied a similar area and at similar densities to those found on the preceding survey. Larvae >15mm long were taken in small numbers at several stations over Aberdeen Bank (Figs. 6-8).

Whitby-Dogger

The Whitby-Dogger area was surveyed four times in September-October. On the first survey (5-13 September) all the recommended stations were sampled and larvae in the <10mm and 10-15mm categories were obtained (Figs. 9-10). Larvae in the smaller size group were taken off the Longstone area at densities of up to $413/m^2$ and, in a larger area at lower densities, off the Humber. Larvae in the 10-15mm size group were caught, in the same two areas, at lower densities.

The second survey (19-27 September) again gave good coverage of the area. Small larvae were still present in the Longstone area, but in lower concentrations. There was also a patch of small larvae, with a maximum density of $85/m^2$, in the Whitby-Flamborough Head area. Larvae in the 10-15mm size group were more abundant than in the preceding survey, and were taken in two areas coinciding with those of the small larvae (Figs. 11-12).

The third survey (30 September-6 October) covered all of the recommended area and larvae of all size groups were collected (Figs. 13-15). Larvae of the smallest size group were taken in the same two areas as on

the preceding survey; in the Longstone area at lower densities, and in the Whitby area at rather higher ones with a maximum concentration of $192/m^2$. On this survey, larvae 10-15mm long were more abundant than the smaller size category but the locations of the main centres of density were very similar, being only slightly displaced to the south-east. Small numbers of larvae >15mm long were taken in a narrow band extending south-eastwards from the Whitby area to $53^{\circ}30'N$.

On the last survey of this area all of the recommended stations were sampled and all size groups were again present. Larvae less than 10mm long were taken only in two small patches at low densities, one in the Whitby area and another off the entrance to the Humber. Larvae in the 10-15mm size group were also taken in the same two vicinities, but with a rather more extensive distribution, at very low densities. Larvae >15mm long were taken in a narrow band extending south-eastwards from the Whitby area to $53^{\circ}30'N$.

Southern Bight-English Channel

In December 1972 and January 1973 four surveys of this area were carried out with good coverage of the area on all surveys.

On the first survey (11-21 December) no larvae >16mm were caught and numbers in the smaller size groups were generally low. The maximum density of larvae <11mm, $29/m^2$, was found in the western Channel, off Le Havre, with small patches at lower densities off Point d'Ailly and in the Sandettie area (Figs. 19-20).

On the second survey (2-11 January) small larvae were much more widespread, although densities were still low, with one patch extending from the Bay of the Seine to east of Point d'Ailly, while another was situated in the Sandettie area. In neither patch did the densities exceed $16/m^2$. Larvae in the 11-16mm category were also taken over a considerable area in the survey extending from the Bay of the Seine to Sandettie (Figs. 21-22).

Small larvae were caught over much of the surveyed area during the third survey (9-13 January) with a maximum density of $33/m^2$ off Point d'Ailly and of $9/m^2$ in the Sandettie area. On this survey larvae in the 11-16mm size group were less widespread than on the preceding one, but were taken in concentrations of up to $26/m^2$ off Point d'Ailly and in lower concentrations in the Bay of the Seine and at Sandettie. Larvae $>16mm$ were taken only at low concentrations at a few stations in the Bay of the Seine and at the eastern entrance to the Channel (Figs. 23-25).

On the fourth survey (29-30 January) all size groups of larvae were again caught but numbers of small larvae were extremely low with only one station of $3/m^2$ and three stations of $1/m^2$. Larvae in the 11-16mm size group were, however, more numerous on this survey, being found in an area covering most of the southern part of the Channel and with a second patch at densities of up to $12/m^2$ in the Sandettie area. Larvae $>16mm$ long were also dispersed, at the time of this survey, over a very similar area with a maximum concentration of $7/m^2$ off the Belgian coast (Figs. 26-28).

Kobbergrund

Two surveys of this area were carried out in October 1972 without catching any significant numbers of herring larvae. On both surveys larvae were caught at only nine stations and at no station did the density exceed $1/m^2$.

Quantitative Estimates

The major aim of these surveys is to monitor changes in larval production as a measure of spawning stock sizes. In Table 3, estimates of larval abundance are given for 1972/73 for the three size groups of herring larvae, separately by area and survey period.

These results, as in previous years since these surveys began, again show clearly the dominance of the spawning stock in the Shetland-Orkney area in the total herring population of the North Sea.

To show more clearly the changes in larval abundance within areas over the period covered by these surveys the estimates of larval abundance taken from Table 2 for previous years, and from Table 3 for 1972 are broken down into 15 day periods in Table 4. When a survey extended across two of these periods the estimates are given on the dividing line between them.

In the Shetland-Orkney area the interpretation of these data with regard to changes in larval production in area IVa from year to year is rendered more difficult by the rather different time periods of the surveys between years. It would seem clear, however, that both in respect of the smallest and the intermediate size categories of larvae, the 1972 surveys gave higher larval abundances than in any previous year since these surveys were inaugurated. In the latter half of September 1972, numbers of the smallest size category were particularly high both on the complete survey of the area, and on the partial one carried out somewhat later, in which only the area to the east of Orkney was sampled. Wood (1971) and Zijlstra (1972) both commented on the possibility of larval abundance in this area being over-estimated because of transport of larvae into the area from spawning in VIa. In relation to the 1972 surveys it is of interest that on both of these surveys the abundance of the smallest size category of larvae, which one would not expect to have been transported far from the spawning area, was high, and that there were major concentrations of this size group to the east of Orkney which would demand transport over a considerable distance. On the basis of this evidence it would seem that there was, in 1972, a considerable recovery in the size of the spawning stock in the Shetland-Orkney area from the low levels of 1968-70.

The results given in Table 4 for the Buchan area show that in 1972 production of the smallest size category of larvae was appreciably lower than in 1971, although still high in comparison with the 1967-70 period.

For larvae in the 10-15mm size category the abundance estimates were low compared with those of 1971 and not very different from those of the years prior to 1971. This could suggest either a very low survival rate of the larvae hatched in the Buchan area in 1972, or alternatively a lesser transport of larvae into this area from the Shetland-Orkney area.

In the Central North Sea the estimates of abundance of both the less than 10mm larvae and of total larvae would suggest that larval production was appreciably lower than in 1971 and indeed perhaps somewhat lower than in any previous year except 1969, both in the Longstone-NE Bank area, and in the Whitby area. As in other years of these international surveys there was again no evidence of any spawning in the Dogger-Well Bank area.

In the Southern Bight-English Channel area comparison of larval abundance over the entire period of these international surveys is made more difficult by the fact that in 1967/68 and 1968/69 this area was not included in the reports and by the change in the size-groupings used in this area subsequent to 1970/71. However, Wood (1971) gives some estimates of total larval abundance in 1967/68 and 1968/69 from English surveys in this area, and these have been utilised in Table 4. The figures for total larval abundance should therefore be comparable throughout. The data given in Table 4 show that in 1972/73 both early larval abundance and total larval abundance was appreciably higher in this area than in 1971/72. The abundance of larvae of all size groups, however, was much lower than in 1970/71 and probably somewhat lower than in 1969/70, although higher than in 1967/68 and 1968/69.

Discussion

In the Report of the Working Group on North Sea Herring Larval Surveys (Anon 1971) it was stated that: "such data as were available strongly suggested that the production of larvae approximated to a normal curve with little variation in the timing of the mode". The Group went on to

suggest that under these circumstances better estimates of total larval production would be obtained if three surveys could be done in each area during the production period as this would define exactly the normal curve. In the 1972/73 surveys at least three surveys were done in each of the major areas of larval production. Examination of the results of these surveys, for larvae in the smallest size category, would not suggest, however, that the production cycle can be defined by a normal curve, except possibly in the Shetland-Orkney area. In this area, if the production curve is normal, the results from earlier surveys would suggest that there is considerable variability in the timing of its mode. It may well be that, in practice, in each discrete spawning area the production cycle is normal. But in the wider stock distributional areas considered in these surveys one is dealing with a number of discrete spawning sites - for example, in the Central North Sea with North-East Bank, Flamborough Head, Whitby, and Dogger - each of which has rather different timing of larval production. Under these circumstances even three or four surveys cannot measure with any great precision the production of larvae in these large areas containing a number of spawning areas each with its own spawning time and year to year variation in larval production.

It may be, therefore, that without a major increase in sampling intensity these surveys cannot provide other than rather gross estimates of year to year variations in spawning stock sizes within areas. This, however, is not intended to belittle their importance in the current situation, when major changes are taking place in stock sizes over very short periods and estimates of variations in them, dependent on measures of fishing effort, are facing major difficulties. The data given in Table 4, for example, would suggest a major recovery of the spawning stock in the Shetland-Orkney area in 1971 and particularly in 1972 from the very low levels it attained in 1968-70. This is all the more convincing in 1972 because of the major increase in abundance of the smallest category

of larvae to the east of Orkney which is unlikely to have been derived by transport from spawning in area VIa. Similarly in the Buchan area, over the period of these surveys, there would appear to have been an incontrovertible increase in spawning in 1971, and to a lesser extent in 1972, compared with the very low levels attained in this area in 1967-70.

In the Whitby-Dogger and Southern Bight-English Channel areas the picture is less optimistic. In the former area there would appear to have been no significant change in larval production over the period of these surveys, apart from the extremely low level attained in 1969. In the Southern Bight-English Channel area the larval production figures were certainly very much higher in 1972/73 than in 1971/72 but are still low even by comparison with the moderate ones of 1970/71.

In the Kobbergrund area spawning was negligible and it seems clear that the autumn spawning stock in this area has shown a continuous decline since 1970 and is now at a very low level.

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Table 1. Surveys carried out in 1972/73

Country	Area	Period	Number of stations sampled
England	Shetland-Orkney	1-5/9/1972	69
Scotland	"	6-19/9/1972	49
Denmark	"	12-25/9/1972	79
Scotland	"	19-26/9/1972	52
Iceland	"	12-28/9/1972	18
			267
Scotland	Euchan	30/8-1/9/1972	30
Scotland	"	6-19/9/1972	58
Denmark	"	25-27/9/1972	17
Scotland	"	19-26/9/1972	52
			157
Netherlands	Whitby-Dogger	5-13/9/1972	87
Netherlands	"	19-27/9/1972	81
England	"	30/9-6/10/1972	97
Netherlands	"	17-26/10/1972	115
			380
Netherlands	Southern Bight-English Channel	11-21/12/1972	121
Netherlands	"	2-11/1/1973	89
Germany	"	9-13/1/1973	62
England	"	29-30/1/1973	80
			352
Denmark	Skagerak-Kattegat	4-6/10/1973	45
Sweden	Kattegat	Oct 1972	32
			77

Table 2. Recalculated abundance indices for previous surveys

Area	Period	Abundance of herring larvae x 10 ⁻⁹			
		< 10mm	10-15mm	> 15mm	Total
1967 Surveys (Sæviile 1970)					
Shetland-Orkney	8-22/9/1967	586	1 135	204	1 925
"	25/9-6/10/1967	1 122	539	257	1 918
Buchan	11-24/9/1967	1	115	80	196
"	25/9-13/10/1967	0	7	36	43
Whitby-Dogger	3-8/9/1967	1 003	17	0	1 020
"	10-13/10/1967	194	48	91	333
1968 Surveys (Boëtius & McKay 1970)					
Shetland-Orkney	2-14/9/1968	222	270	32	524
"	19/9-3/10/1968	32	121	91	244
Buchan	2-14/9/1968	0	1	0	1
Whitby-Dogger	3-5/9/1968	141	62	1	204
"	15-23/10/1968	133	12	28	173
1969 Surveys (Wood 1971)					
Shetland-Orkney	4-16/9/1972	492	489	132	1 413
"	18/9-4/10/1968	92	102	53	247*
Buchan	3-25/9/1972	0	1	0	1
Whitby-Dogger	9-11/9/1972	9	4	0	13
"	6-14/10/1972	19	181	44	244
1970 Surveys (Zijlstra 1972)					
Shetland-Orkney	11-29/9/1970	389	1 165	236	1 790
"	30/9-11/10/1970	71	650	333	1 054
Buchan	20/8-11/9/1970	2	2	0	4
"	8-29/9/1970	9	1	0	10
"	29/9-13/10/1970	1	5	2	8
Whitby-Dogger	26/8-11/9/1970	199	0	0	199
"	8-16/9/1970	554	31	0	585
"	6-12/10/1970	171	268	106	545
1971 Surveys (Schnack 1973)					
Shetland-Orkney	31/8-9/9/1971	1 742	148	0	1 890
"	16-27/9/1971	361	994	250	1 605
"	1-7/10/1971	31	656	490	1 177
Buchan	6-8/9/1971	214	0	0	214
"	9-16/9/1971	138	206	0	344
"	20-30/9/1971	76	166	83	325
Whitby-Dogger	7-15/9/1971	124	17	0	141
"	15-23/9/1971	184	118	0	302
"	2-7/10/1971	357	205	74	636
"	12-20/10/1971	45	165	57	267

*Survey incomplete

Table 3. Estimates of larval abundance in 1972

Area	Period	Abundance of herring larvae x 10 ⁻⁹			
		<10mm	10-15mm	>15mm	Total
Shetland-Orkney	6-11/9/1972	1 437	255	0	1 692
"	12-21/9/1972	6 177	1 510	10	7 697
"	22-27/9/1972	795	1 282	50	2 127*
Buchan	30/8-1/9/1972	70	0	0	70
"	13-20/9/1972	5	7	4	16
"	26/9-5/10/1972	1	7	11	19
Whitby-Dogger	3-13/9/1972	159	25	0	184
"	19-27/9/1972	105	145	0	250
"	30/9-6/10/1972	160	400	8	568
"	17-26/10/1972	23	27	53	103
		<11mm	11-16mm	>16mm	Total
Southern Bight-English Channel	11-21/12/1972	17	12	0	29
"	2-11/1/1973	34	41	0	75
"	9-13/1/1973	46	51	1	98
"	29-30/1/1973	1	28	38	67

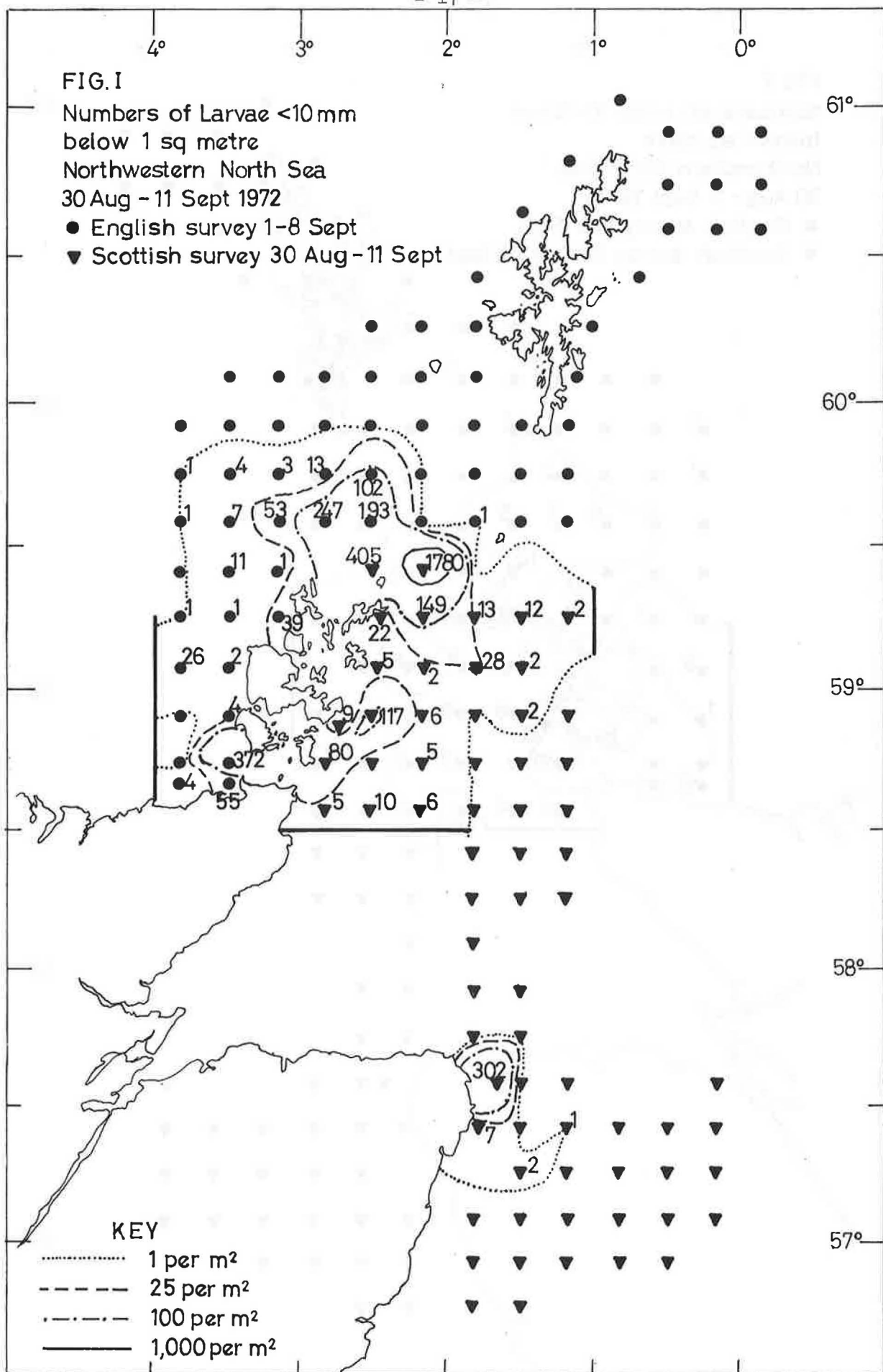
*Survey incomplete

Table 4. Estimated abundances of larvae in different areas by 15 day periods in the years 1967-72.

Abundance of herring larvae x 10 ⁻⁹																		
Date	1967			1968			1969			1970			1971			1972		
	<10 mm	10-15 mm	Total	<10 mm	10-15 mm	Total	<10 mm	10-15 mm	Total	<10 mm	10-15 mm	Total	<10 mm	10-15 mm	Total	<10 mm	10-15 mm	Total
<u>SHEPHERD-ORKNEY</u>																		
1-15/9				222	270	524	493	489	1 413				1 742	148	1 890	1 437	255	1 692
16-30/9	586	1 135	1 925							389	1 165	1 790						
				32	121	244	92	102	247	-	-	-	361	994	1 605	6 177	1 510	7 697
																795	1 282	2 127*
1-15/10	1 122	539	1 918	-	-	-	-	-	-	71	650	1 054	31	656	1 177	-	-	-
<u>BUCHAN</u>																		
1-15/9				-	1	1	-			2	2	4	214	-	214	70	-	70
16-30/9	1	115	196	-	-	-	-	1	1									
				-	-	-	-	-	-	9	1	10	138	206	344	5	8	17
1-15/10	-	7	43	-	-	-	-	-	-	1	5	8	76	166	325	1	7	19
<u>WHITBY-DOGGER</u>																		
1-15/9	1 003	17	1 020	141	62	204	9	4	13	199	-	199	124	17	141	159	25	184
16-30/9	-	-	-	-	-	-	-	-	-	554	31	585						
				-	-	-	-	-	-				184	118	302	105	145	250
1-15/10	194	48	333				19	181	244	171	268	545	357	205	636	160	400	568
16-30/10	-	-	-	133	12	173	-	-	-	-	-	-	45	165	267	23	27	103
<u>SOUTHERN BIGHT-ENGLISH CHANNEL</u>																		
Date	1967/68			1968/69			1969/70			1970/71			1971/72			1972/73		
	<10 mm	10-15 mm	Total	<10 mm	10-15 mm	Total	<10 mm	10-15 mm	Total	<10 mm	10-15 mm	Total	<11	11-16 mm	Total	<11 mm	11-16 mm	Total
8-23/12	?	?	(37 5	?	?	20	13	12	25	(23 70	(38 137	(61 211	6	3	10	17	12	29
2-15/1	?	?	50				(17 73	(22 186	(39 259	2	99	134				(34 46	(41 51	(75 98
				?	?	10				-	88	149	3	5	8			
16-30/1	?	?	10							-	25	74	-	1	3	1	28	67

* Survey incomplete.

- English survey 1-8 Sept
- ▼ Scottish survey 30 Aug - 11 Sept



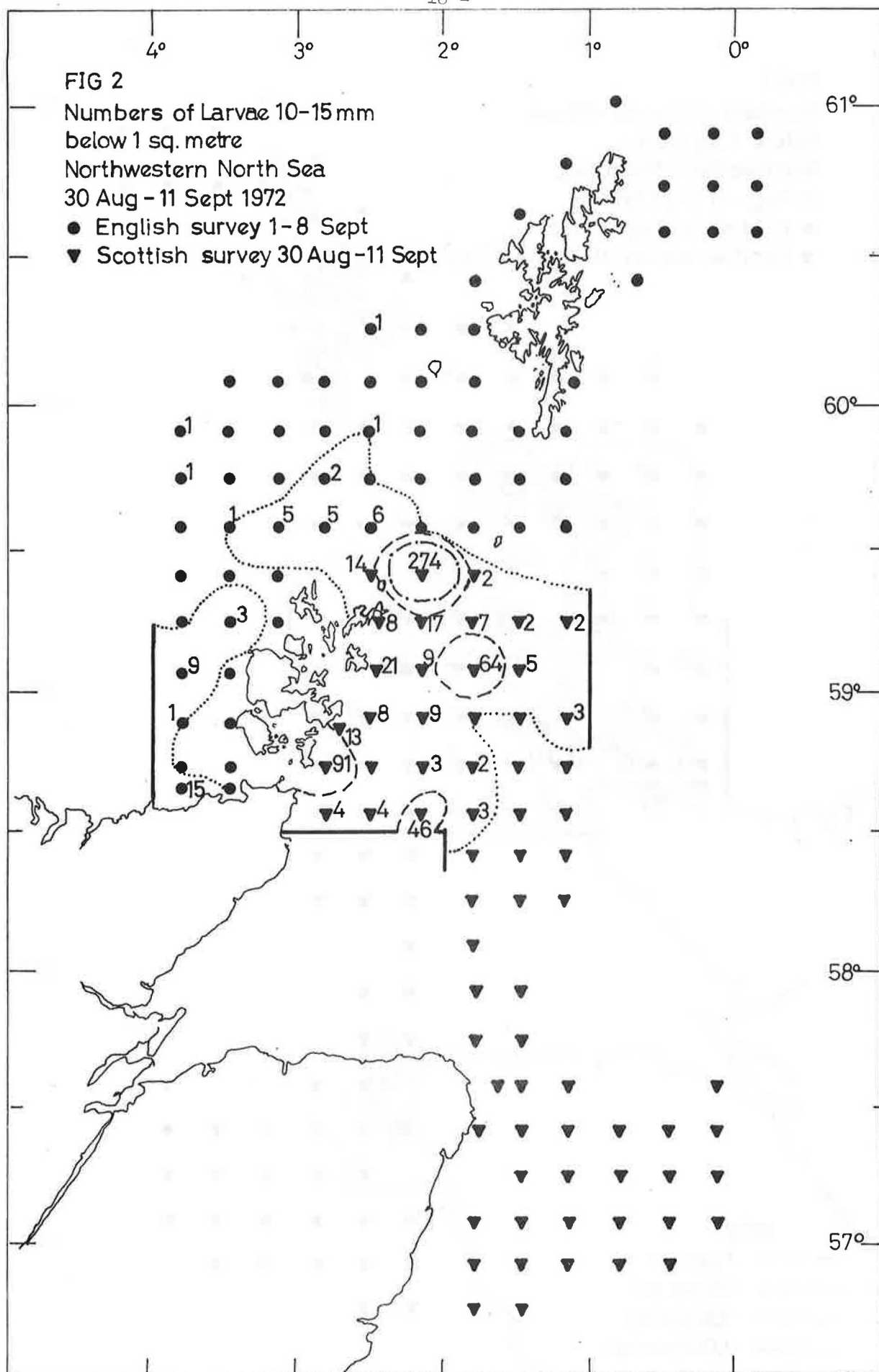
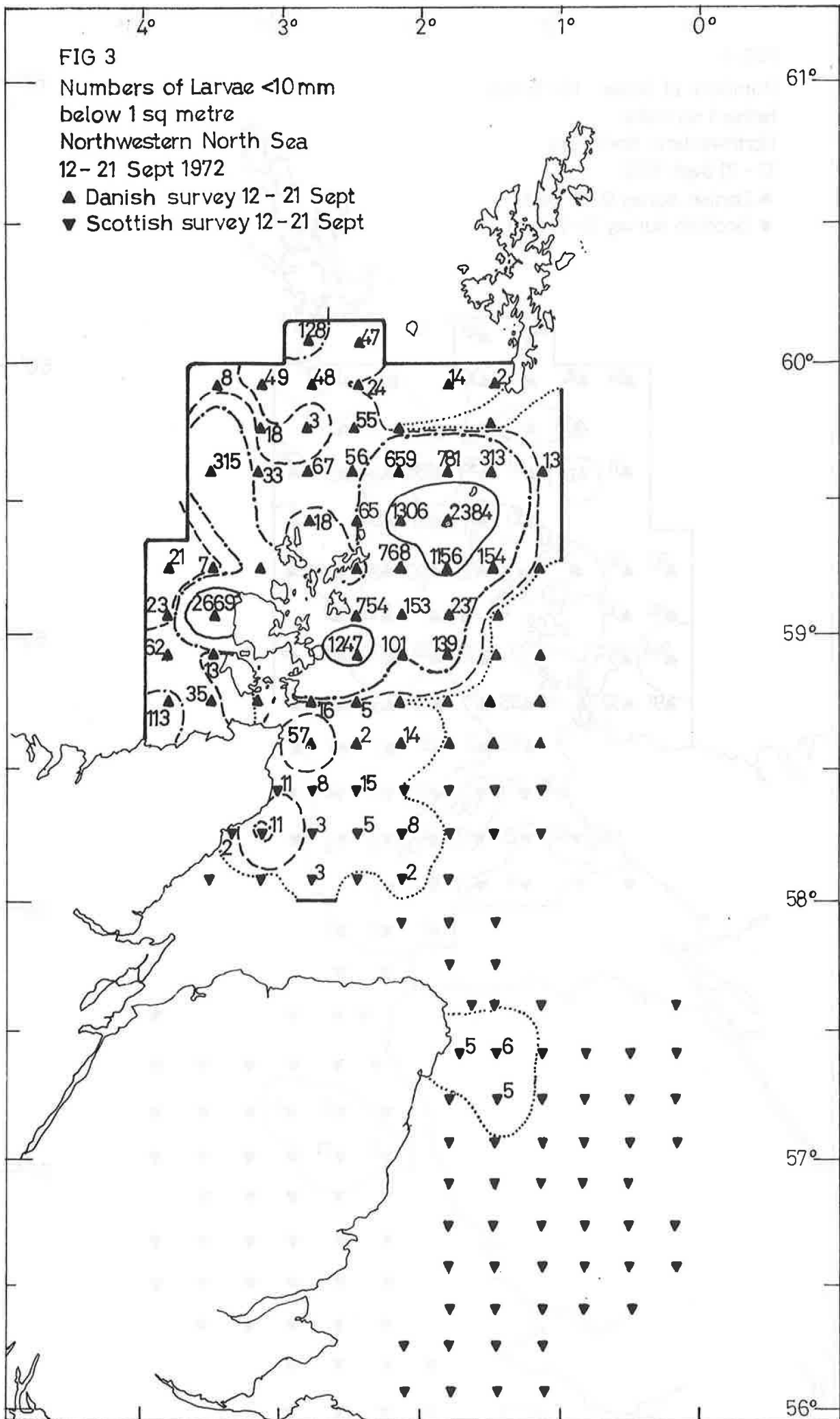
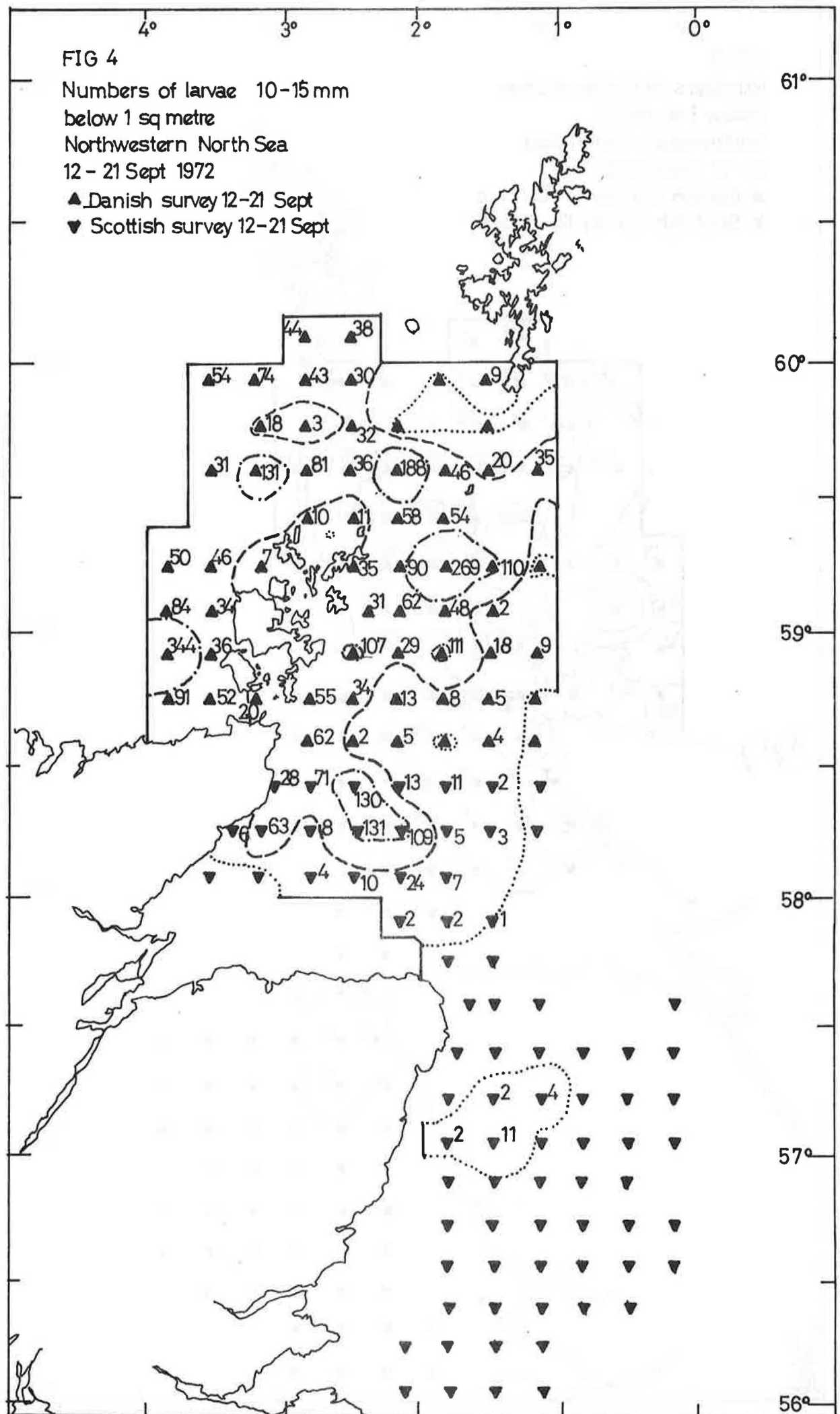


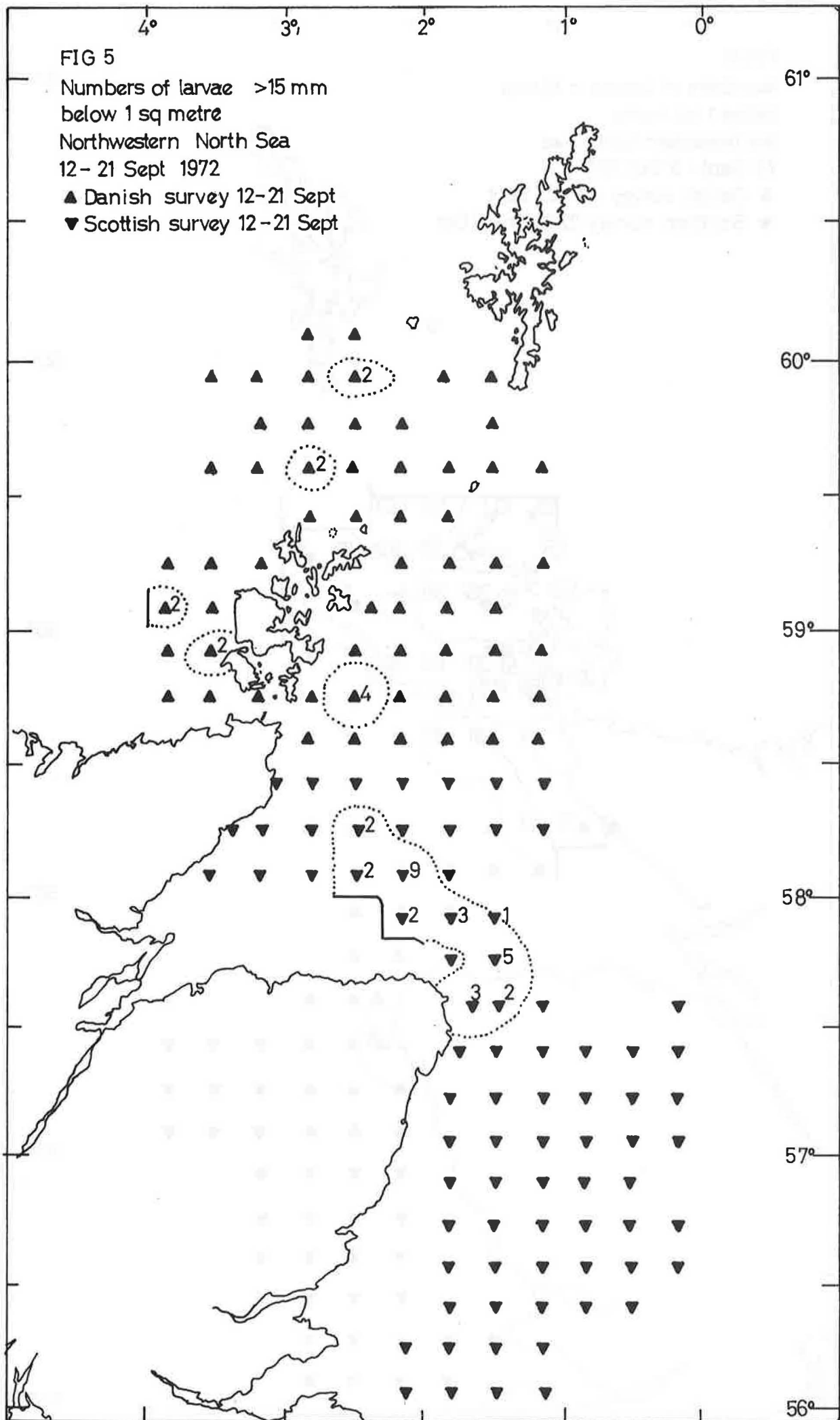
FIG 3

Numbers of Larvae <10 mm
below 1 sq metre
Northwestern North Sea
12 - 21 Sept 1972

- ▲ Danish survey 12 - 21 Sept
- ▼ Scottish survey 12 - 21 Sept







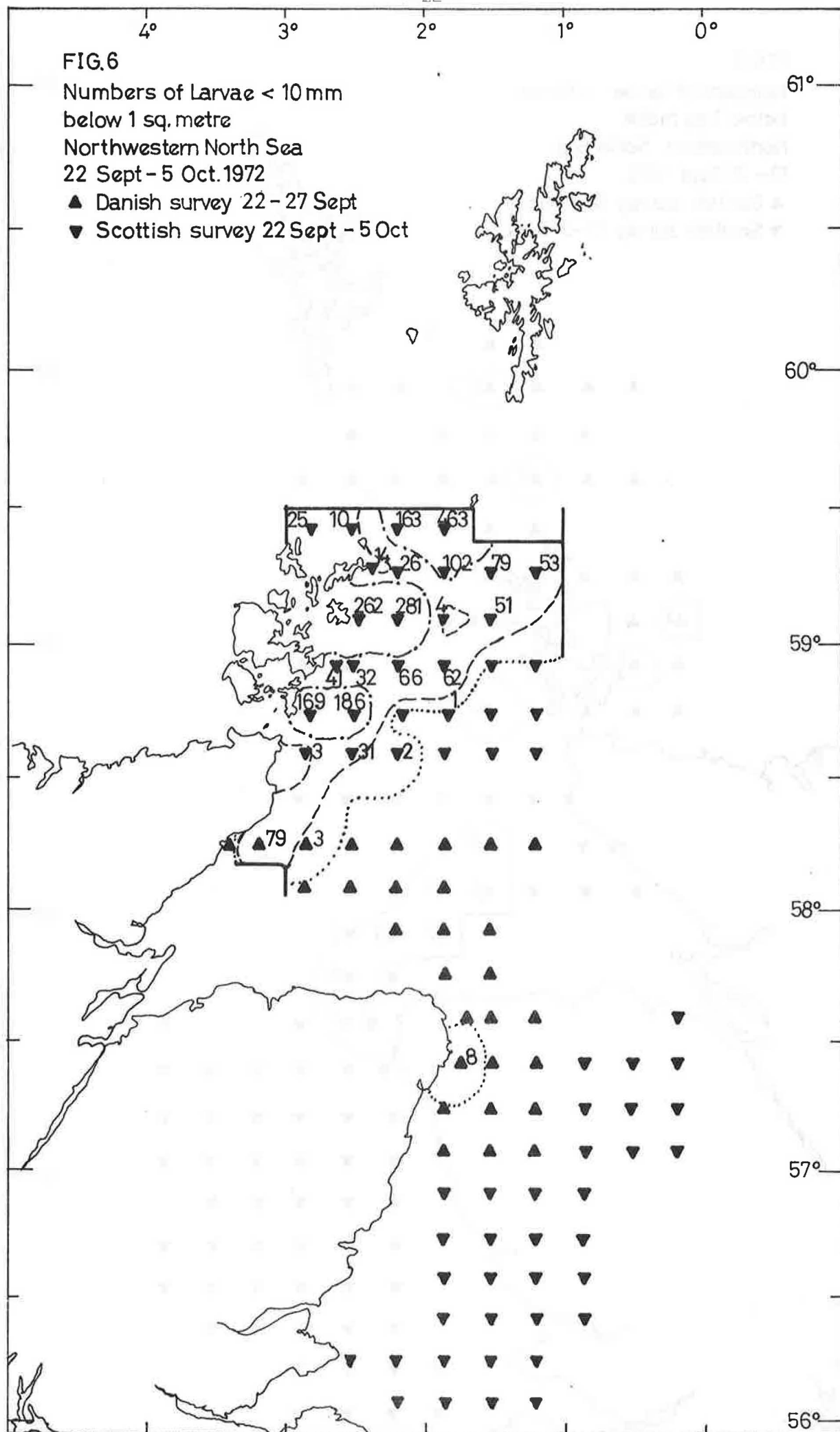


FIG 7

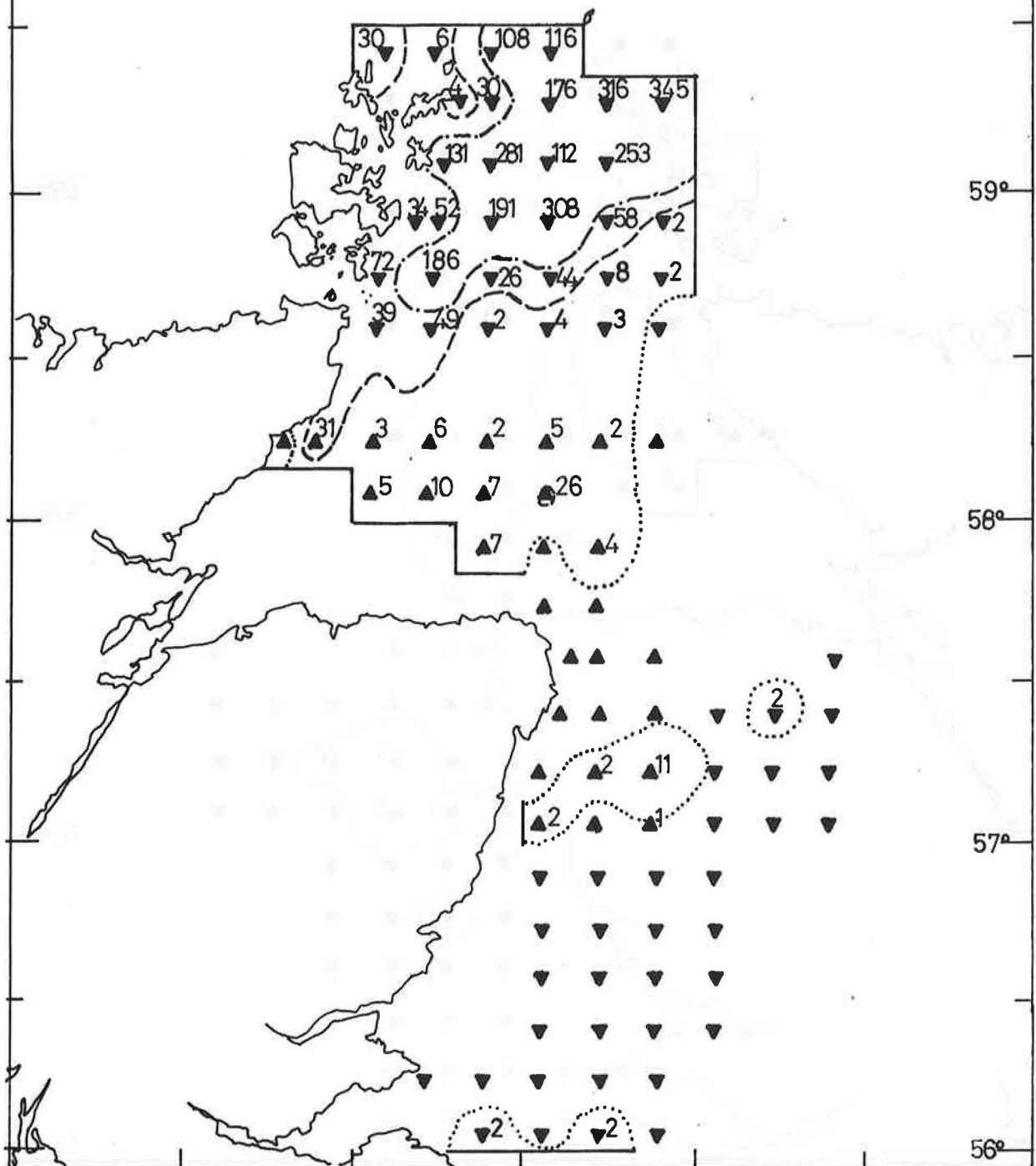
Numbers of larvae 10-15 mm
below 1 sq metre

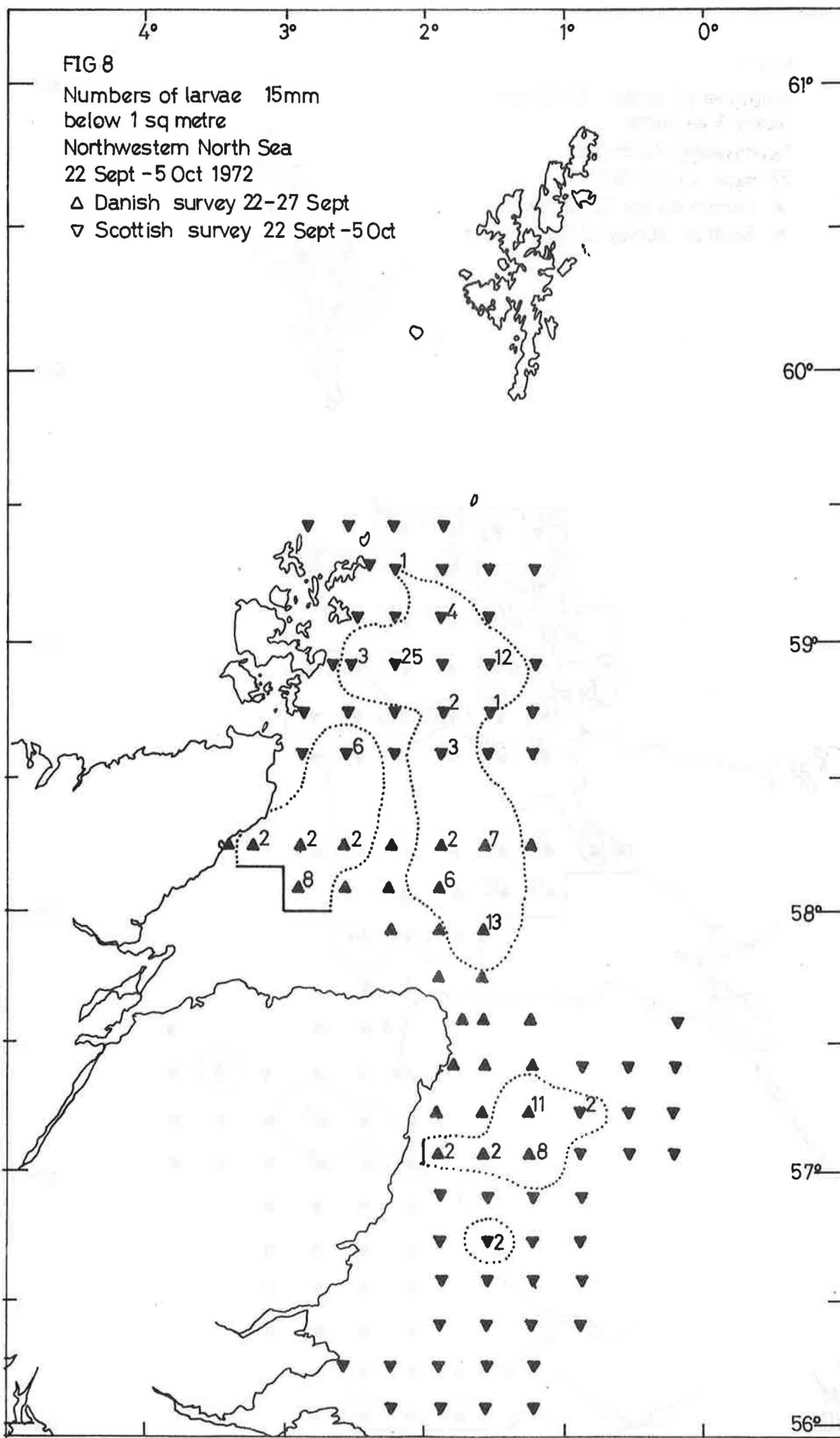
Northwestern North Sea

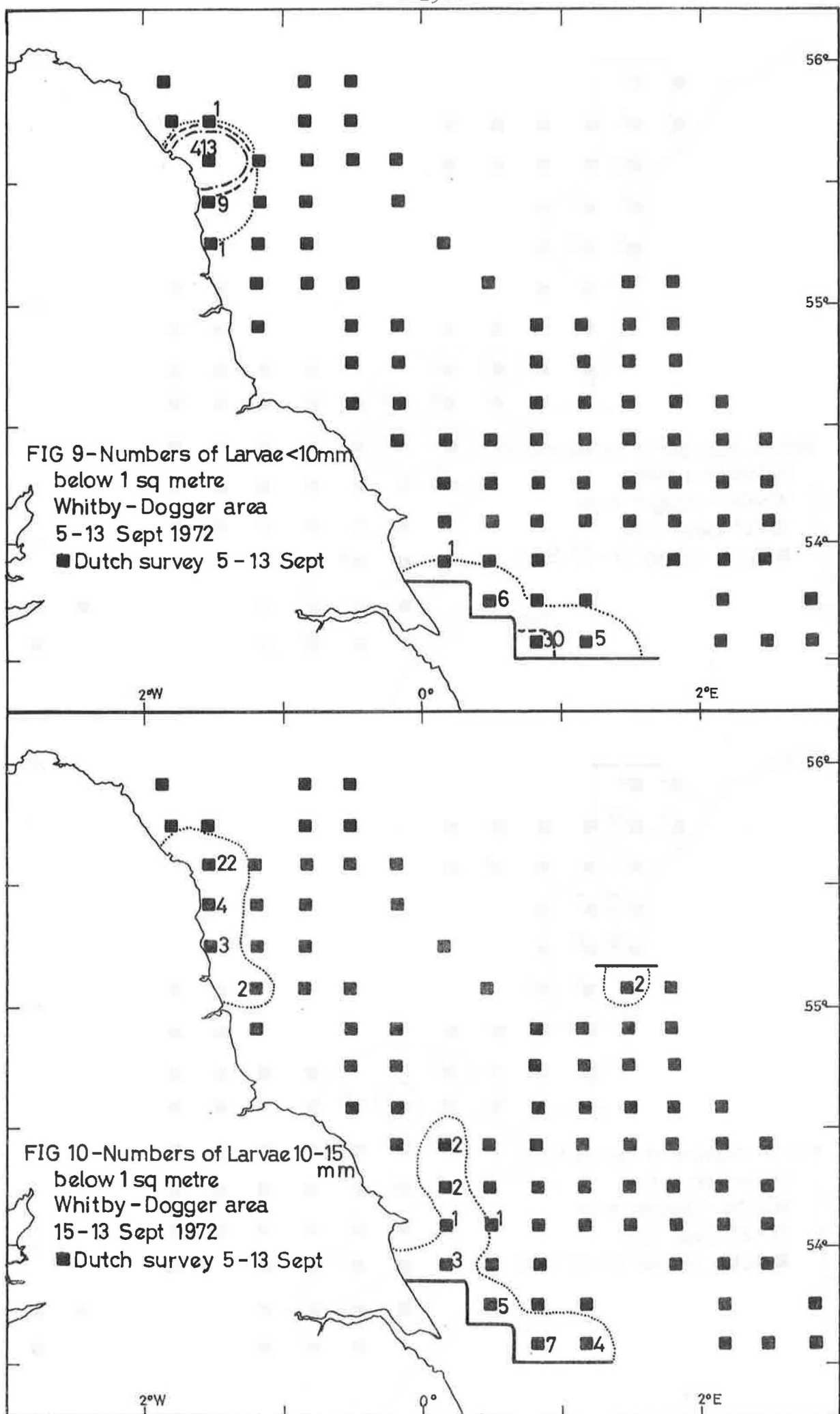
22 Sept - 5 Oct 1972

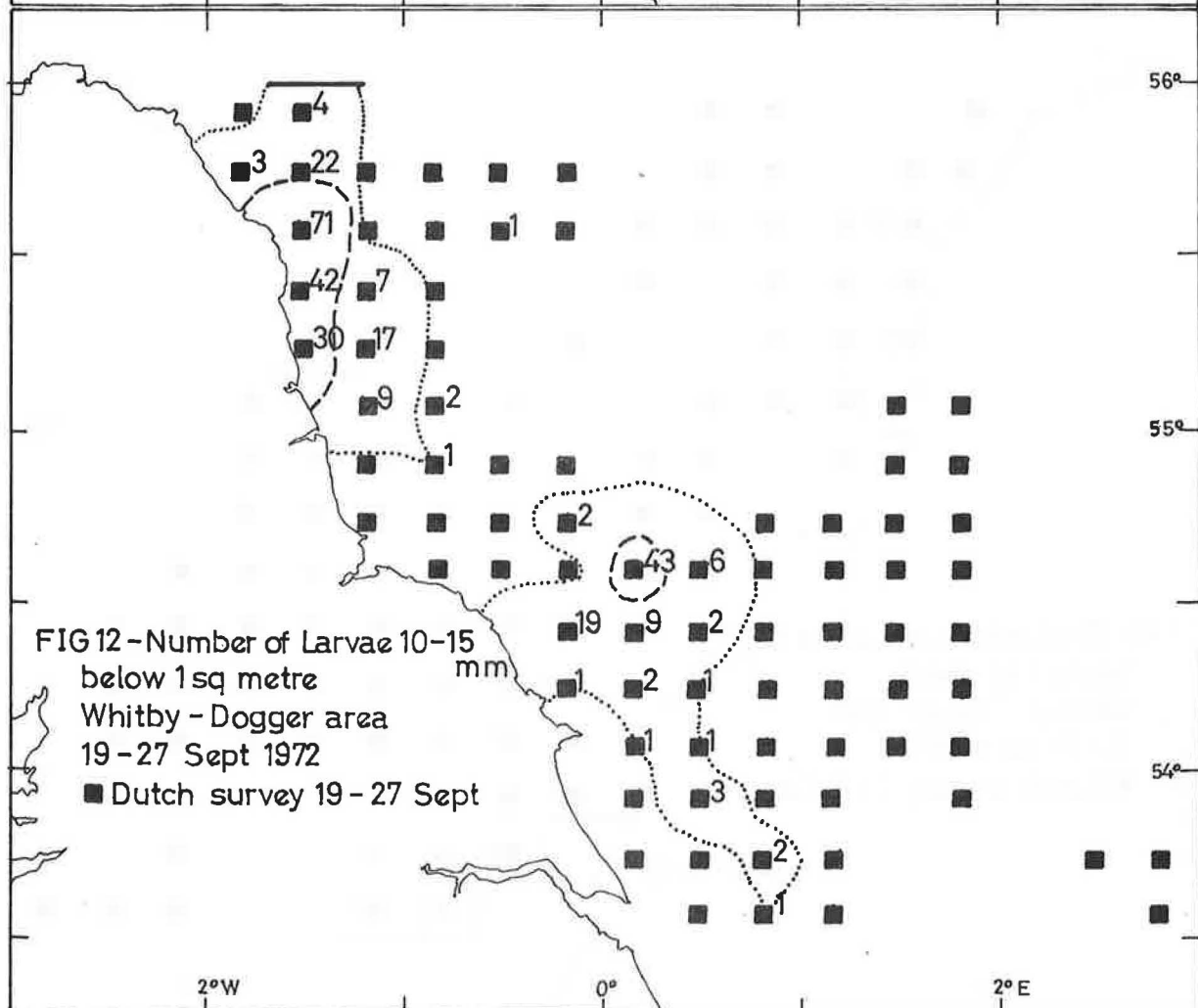
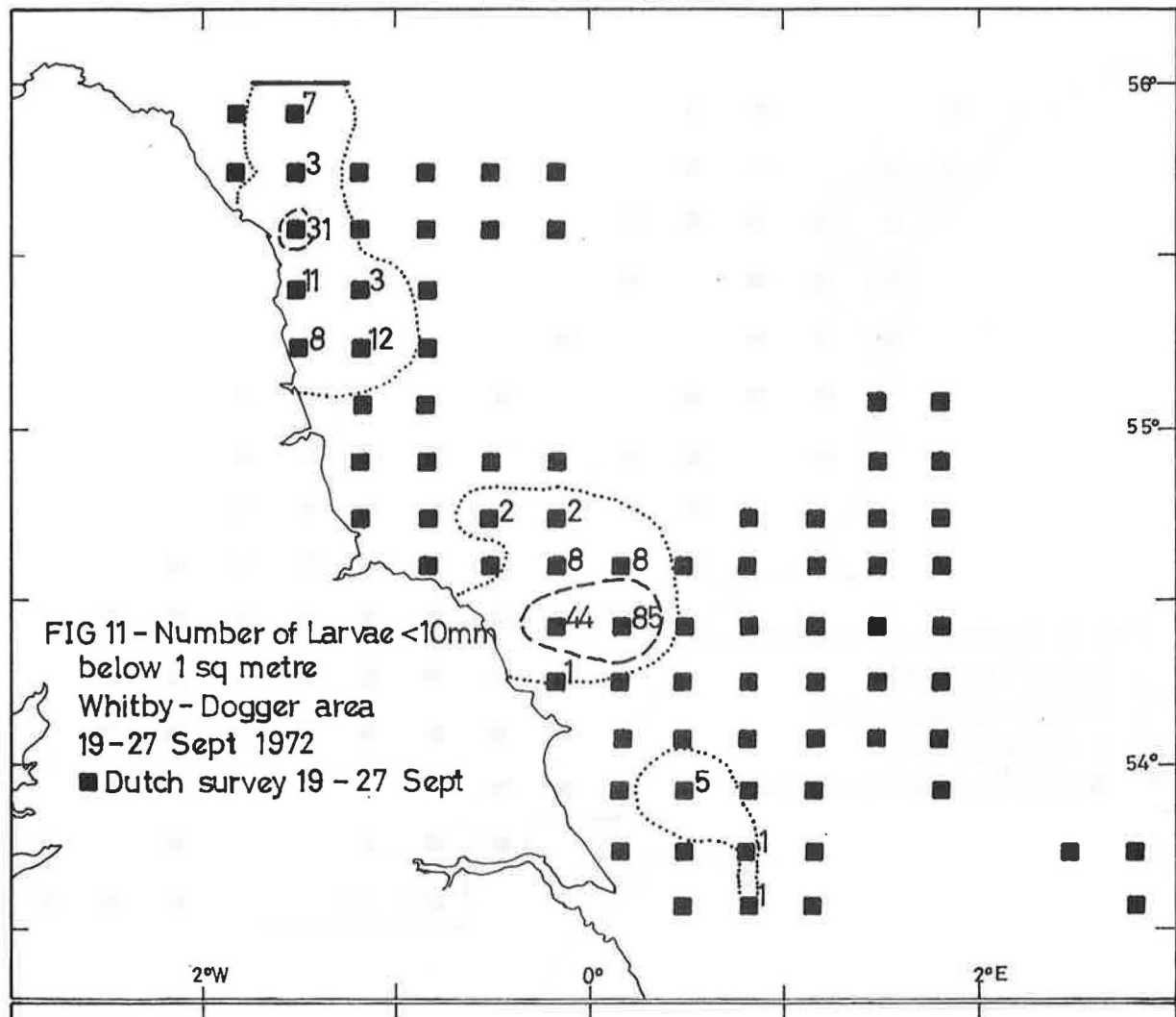
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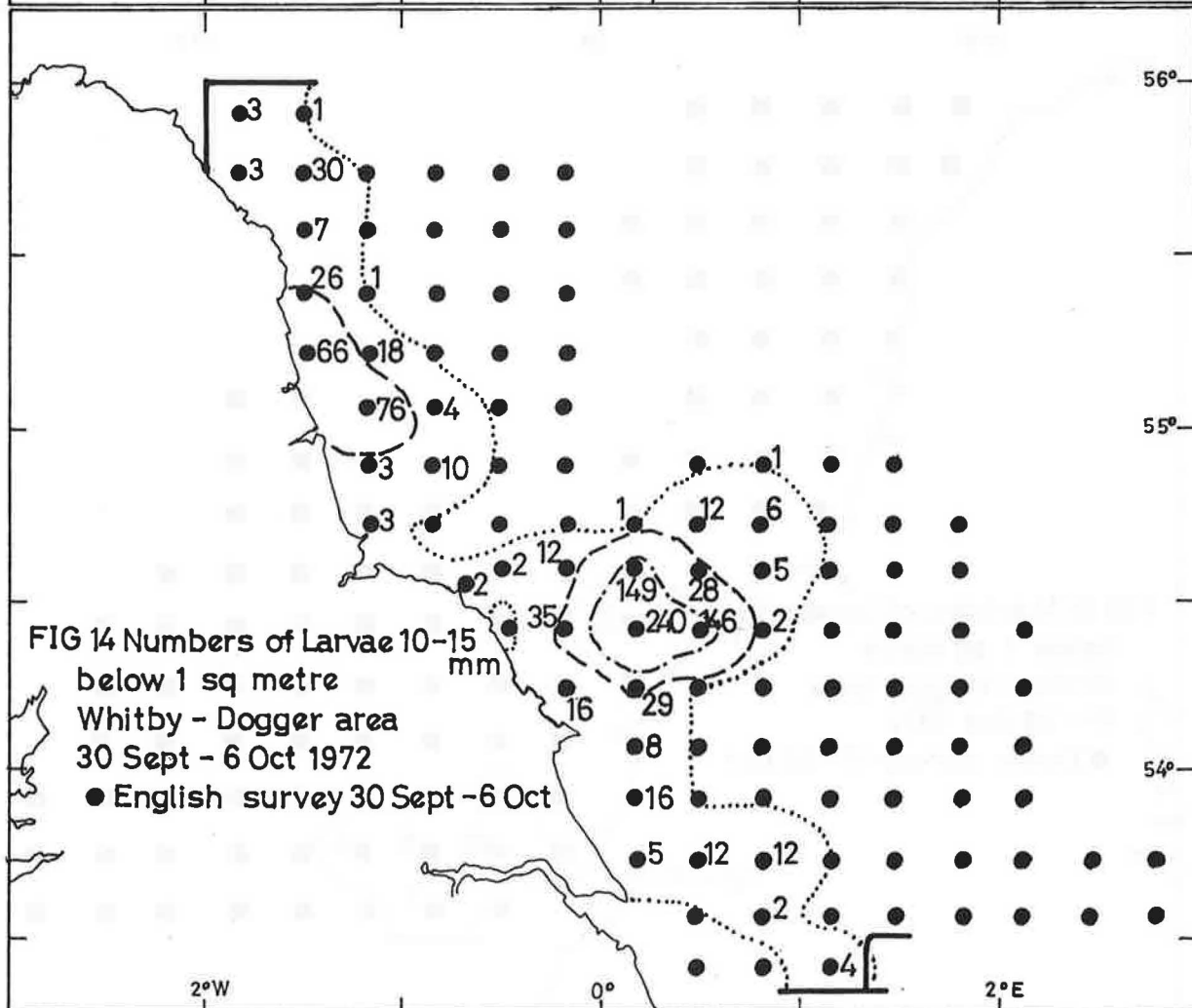
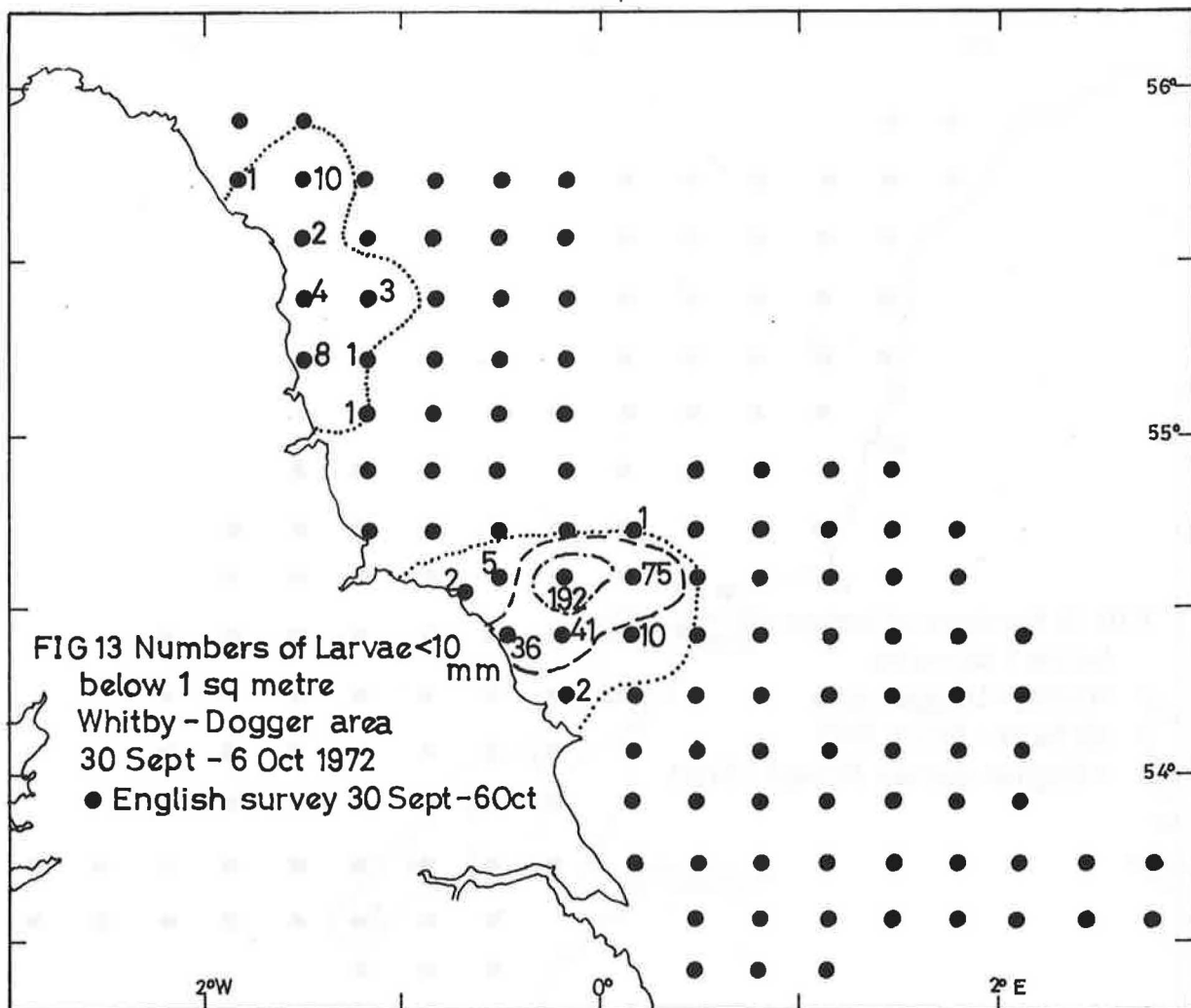
▼ Scottish survey 22 Sept - 6 Oct

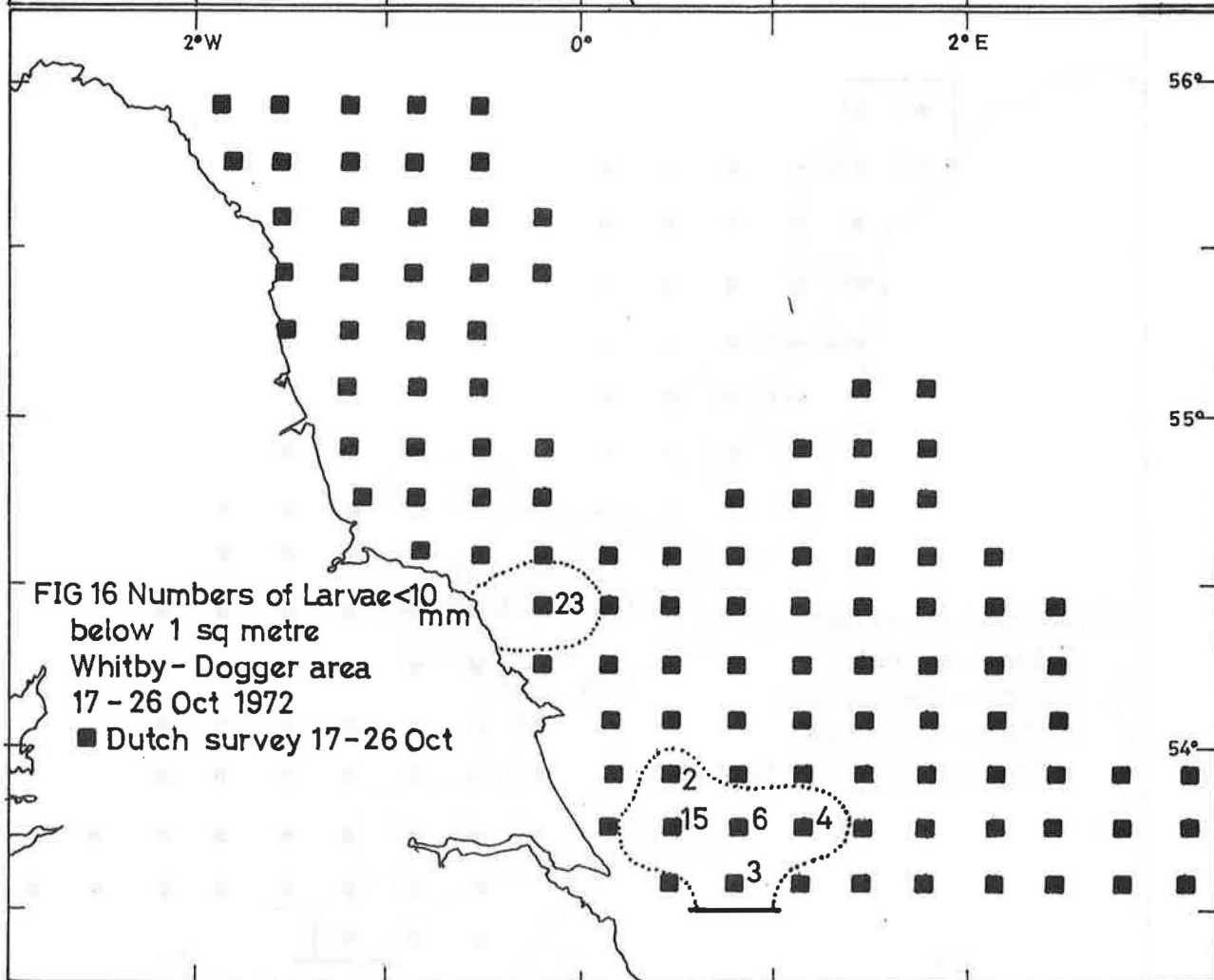
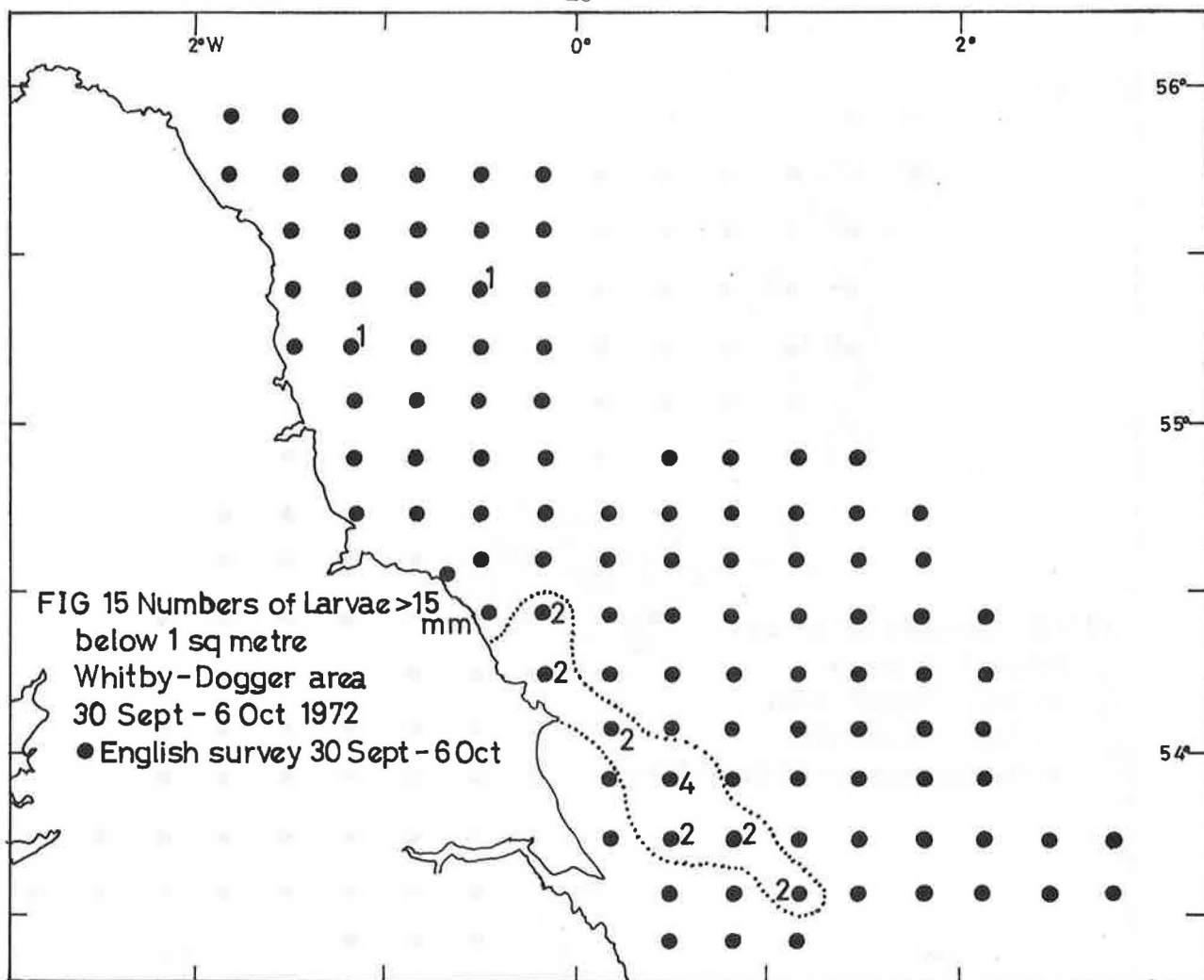


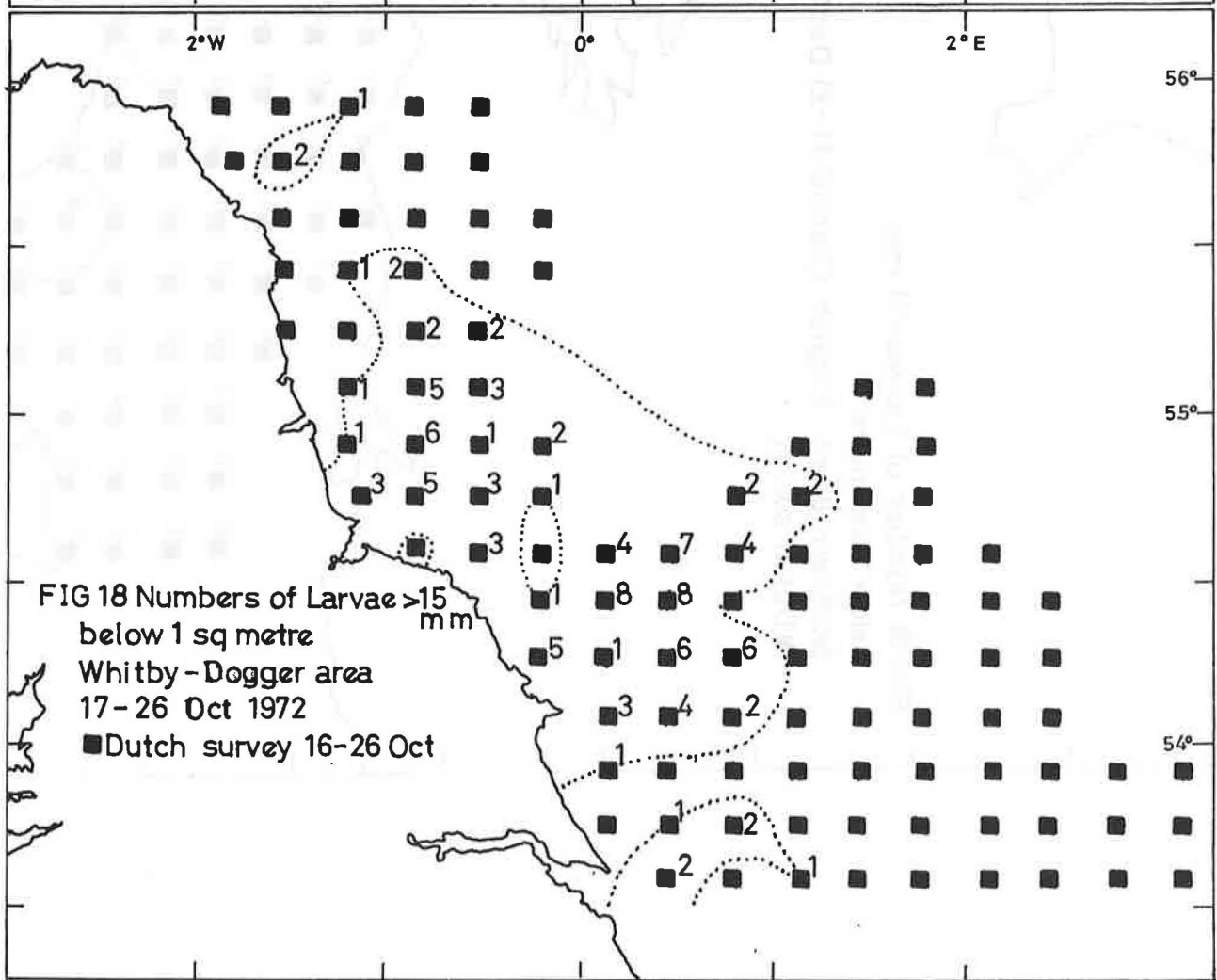
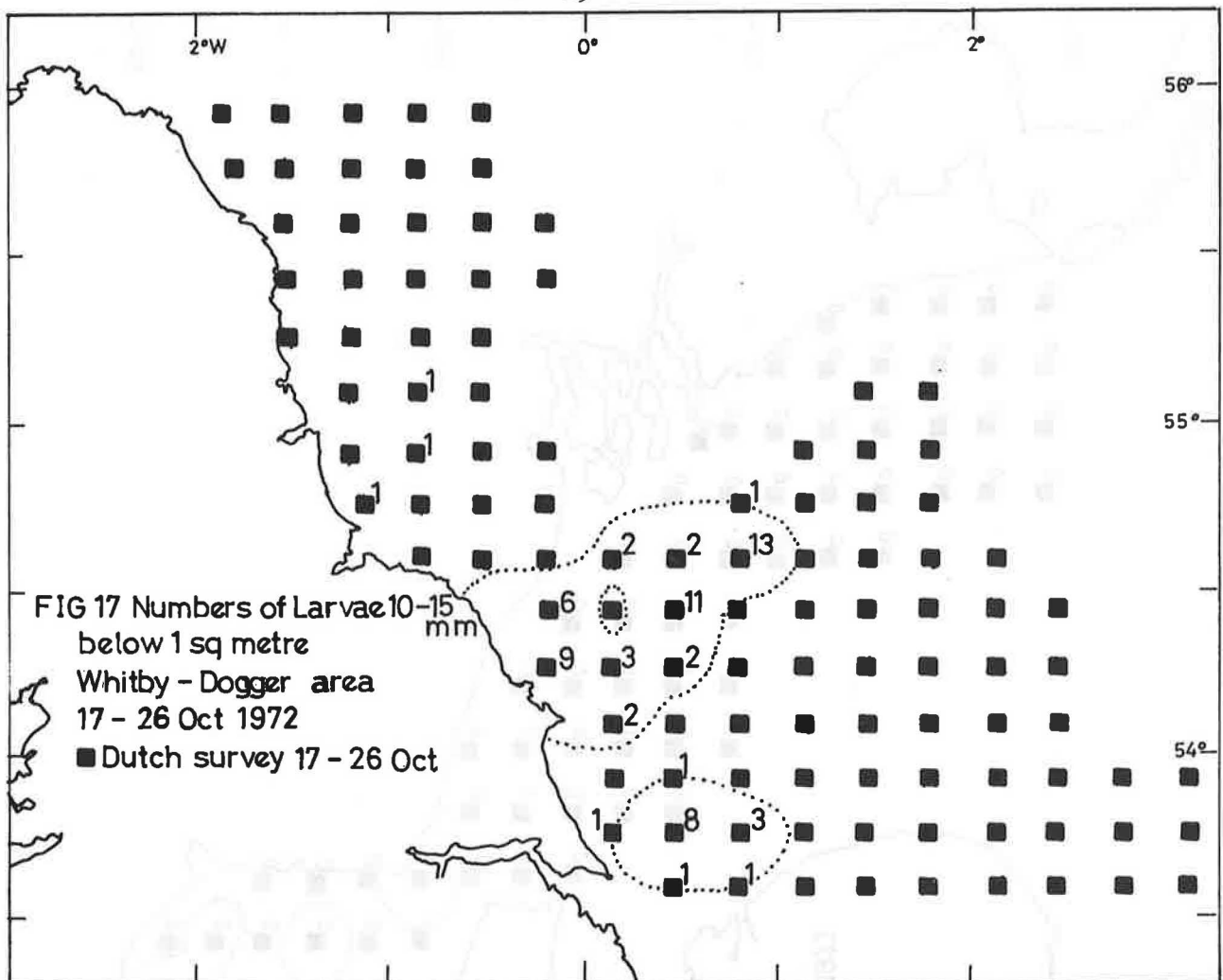












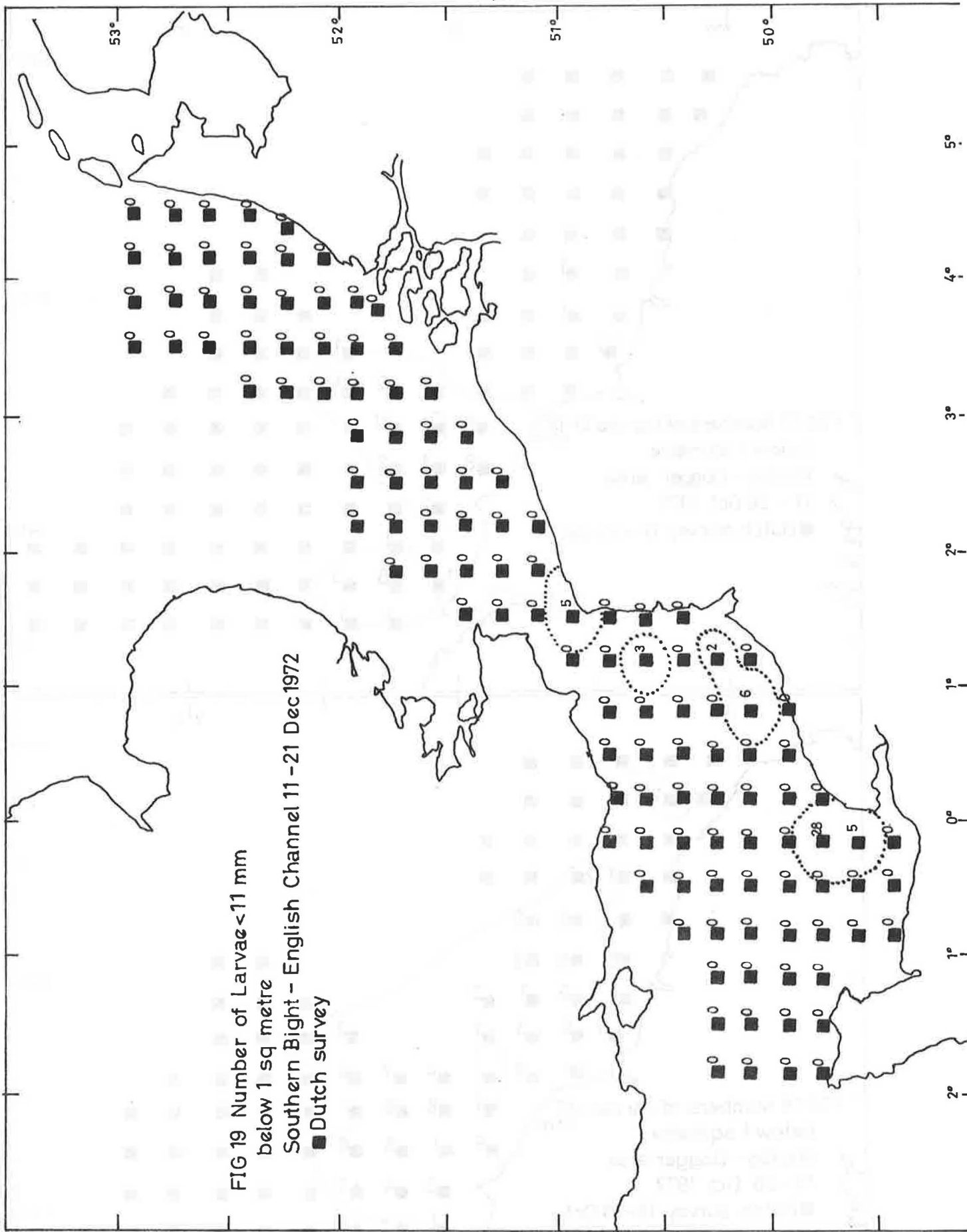
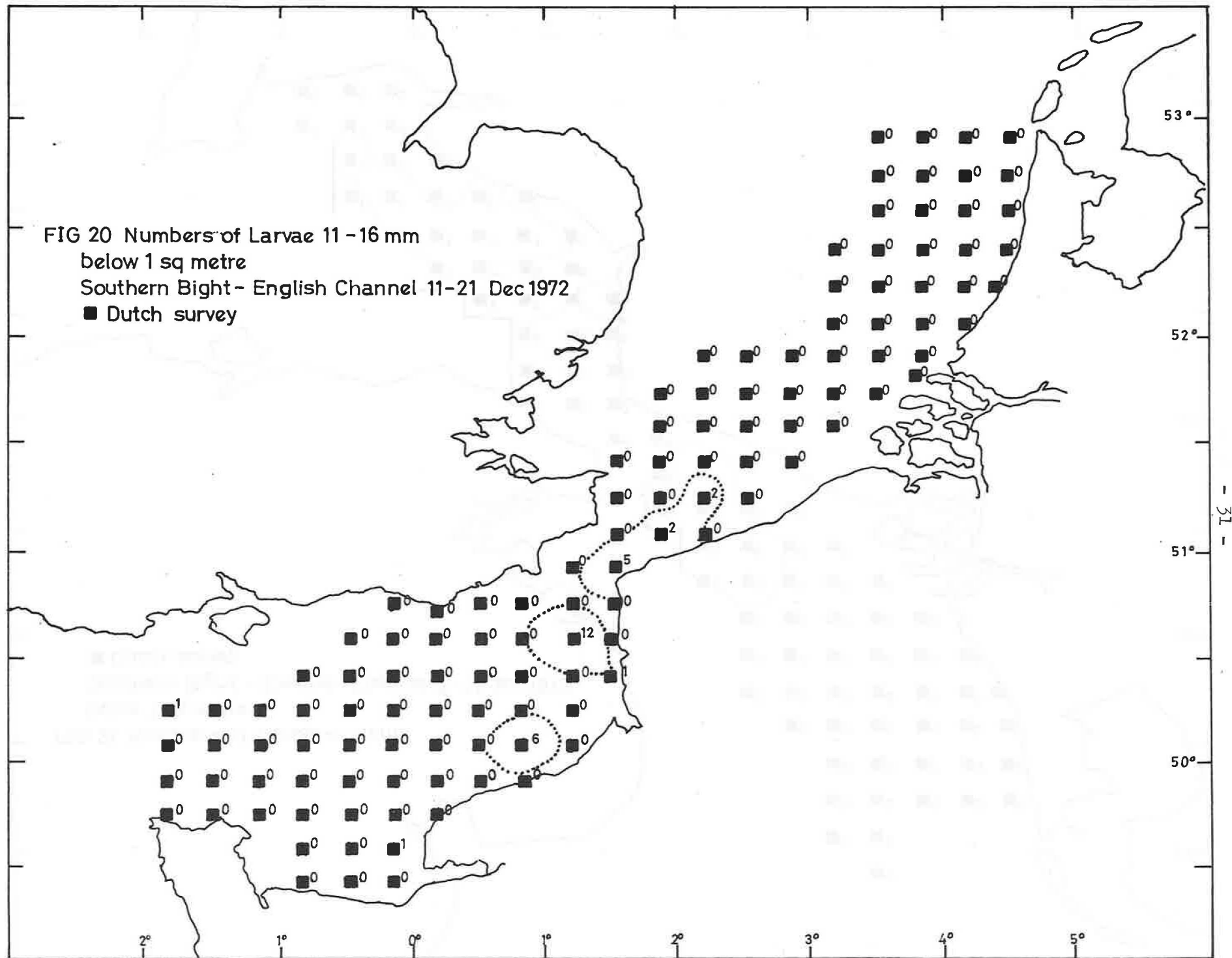


FIG 20 Numbers of Larvae 11-16 mm
below 1 sq metre
Southern Bight- English Channel 11-21 Dec 1972
■ Dutch survey



[illegible]

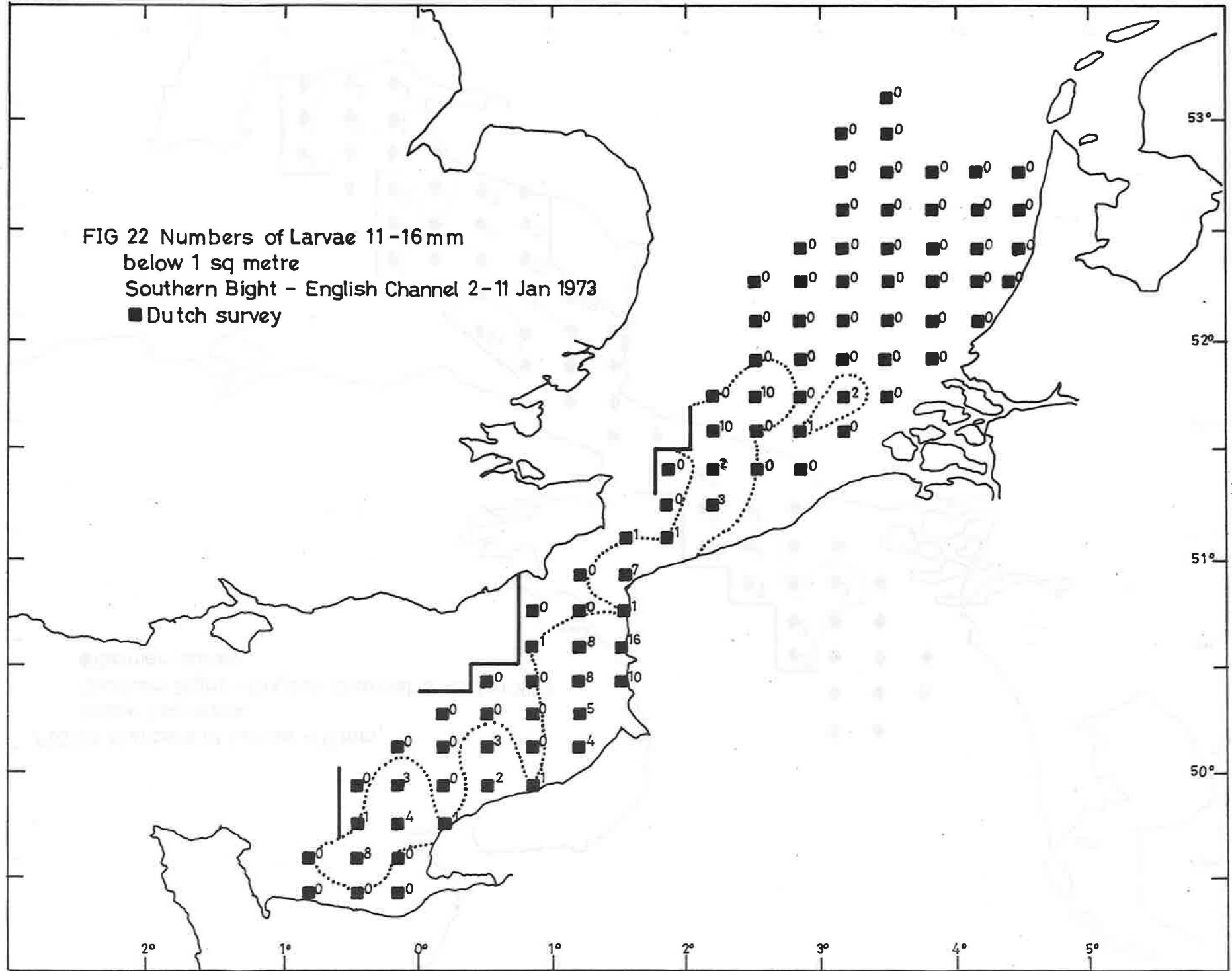
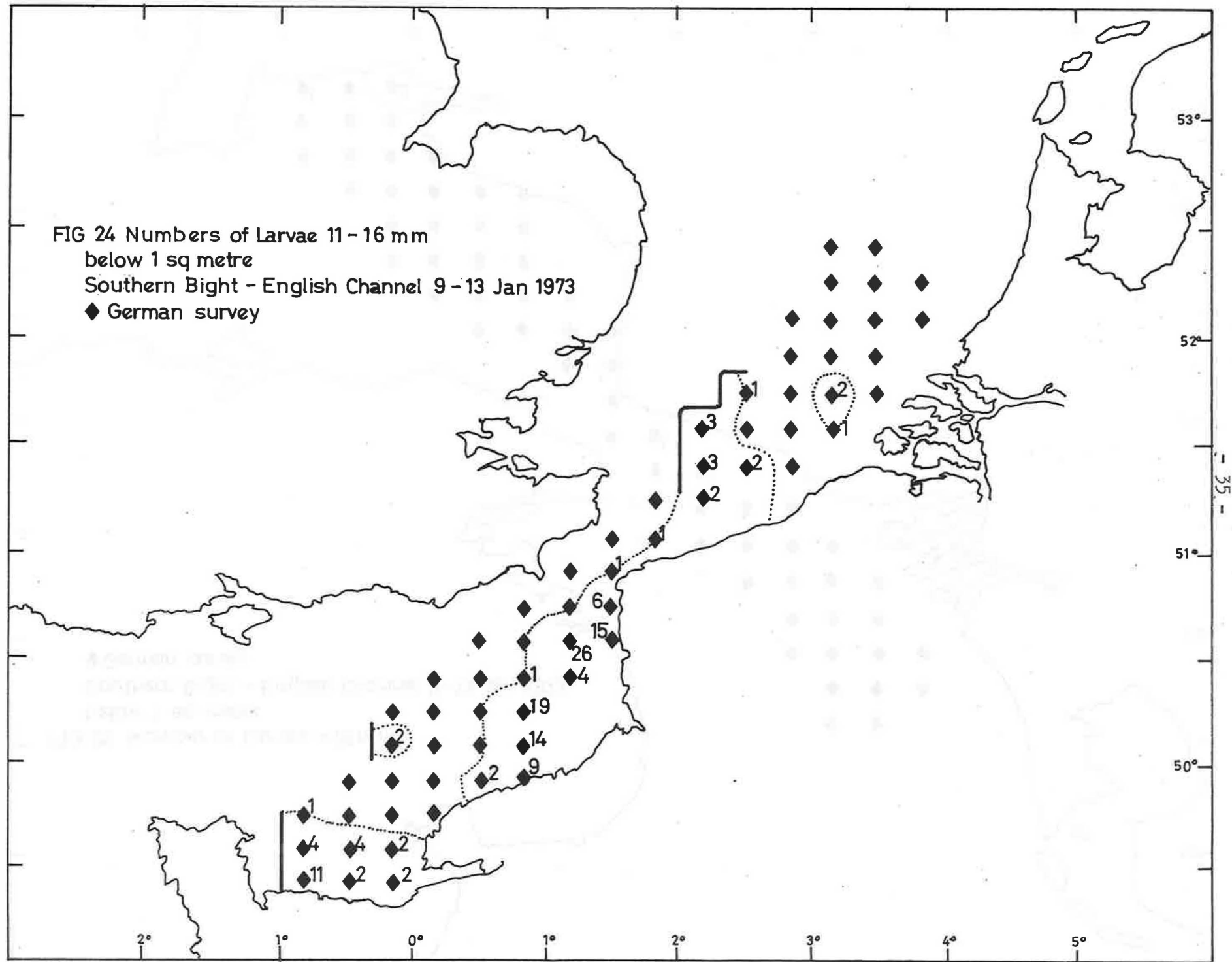
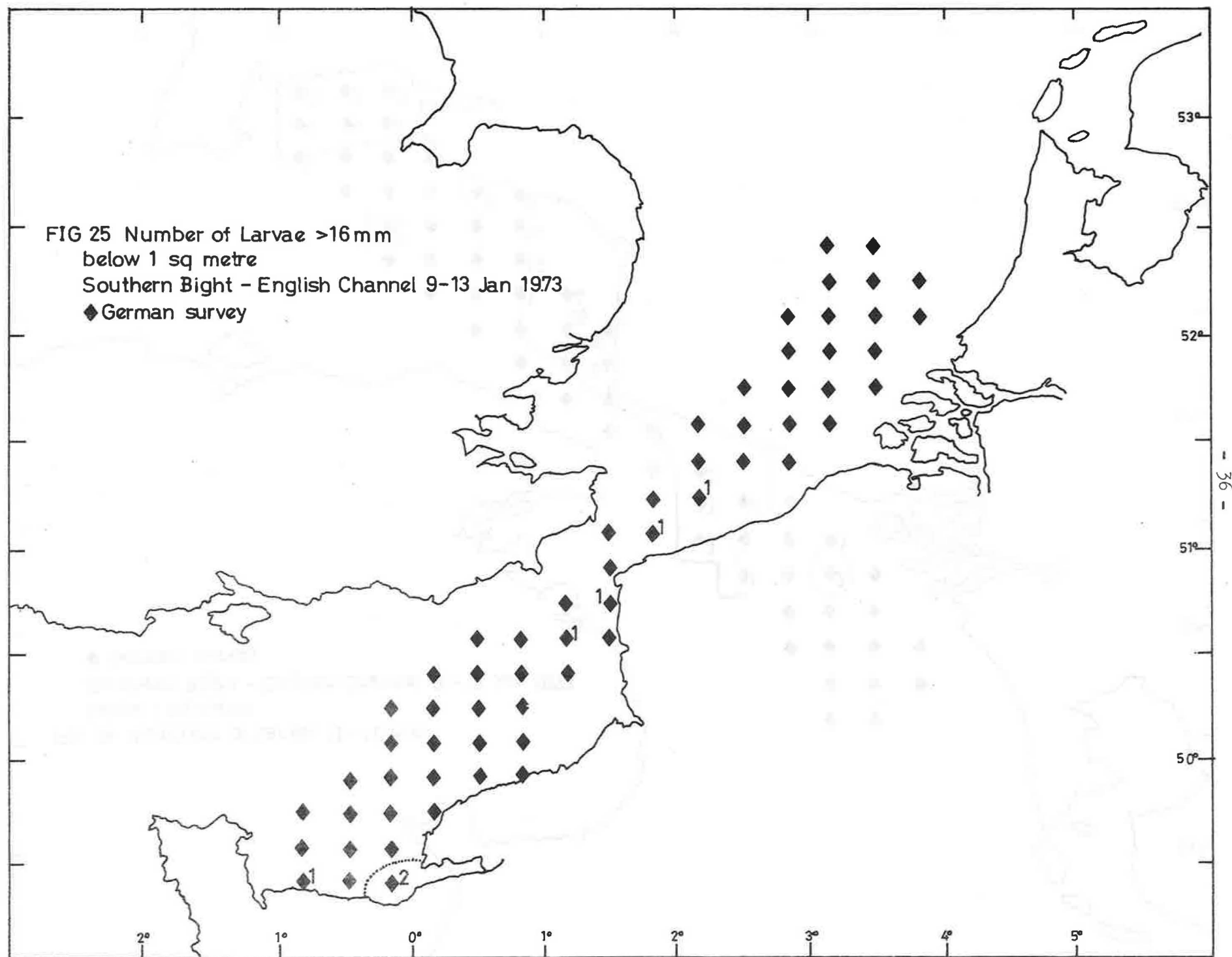
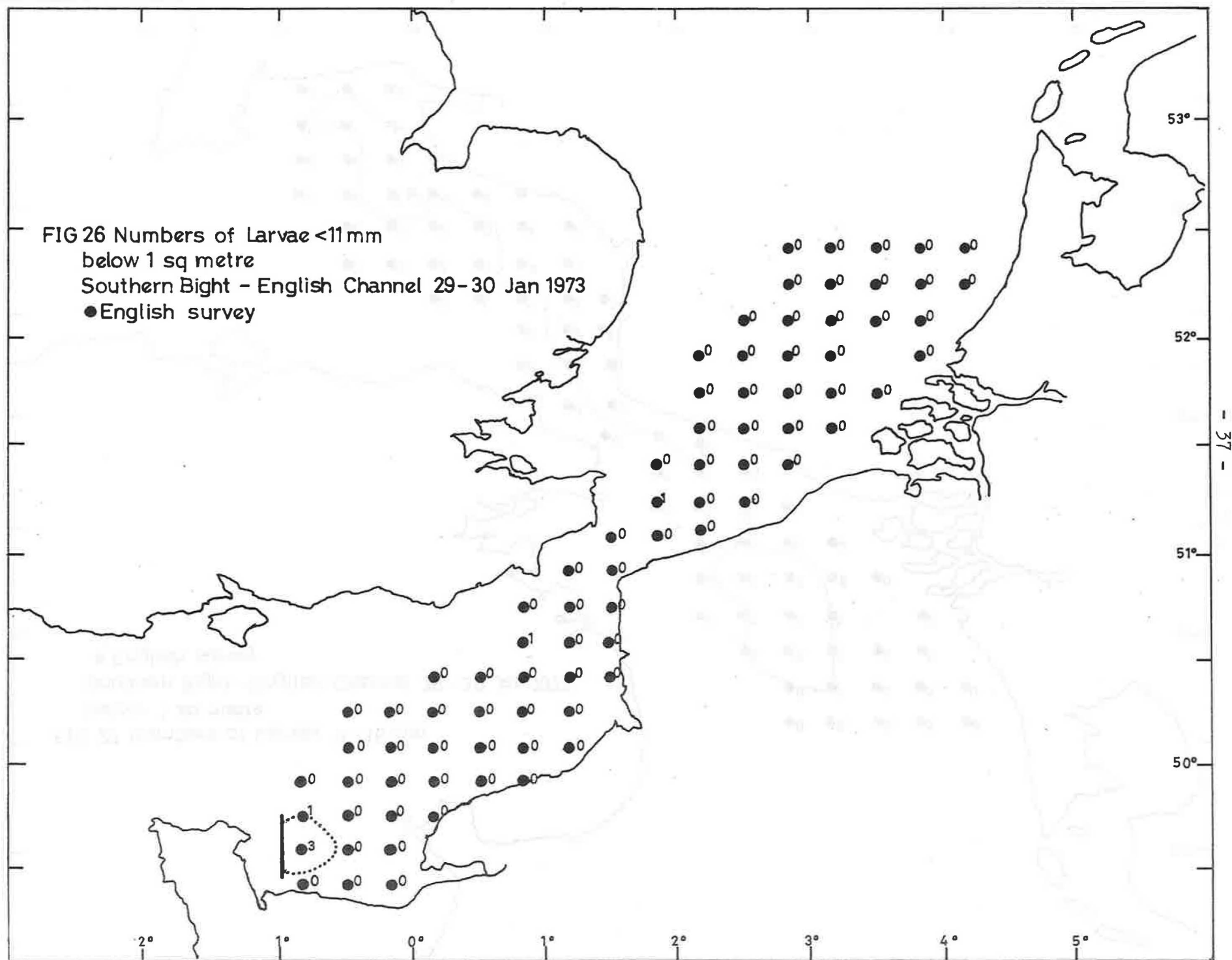


FIG 24 Numbers of Larvae 11 - 16 mm
below 1 sq metre
Southern Bight - English Channel 9 - 13 Jan 1973
◆ German survey







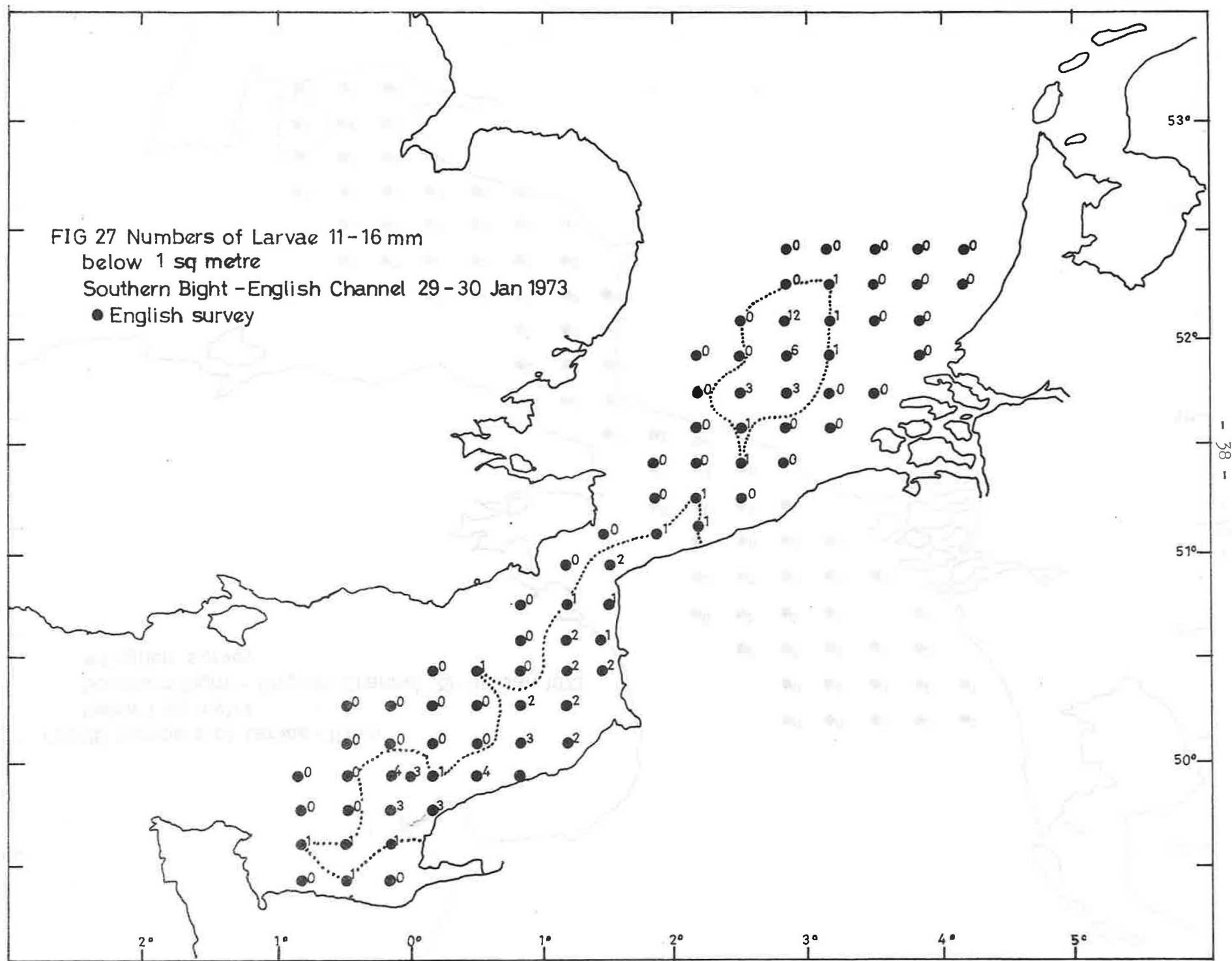
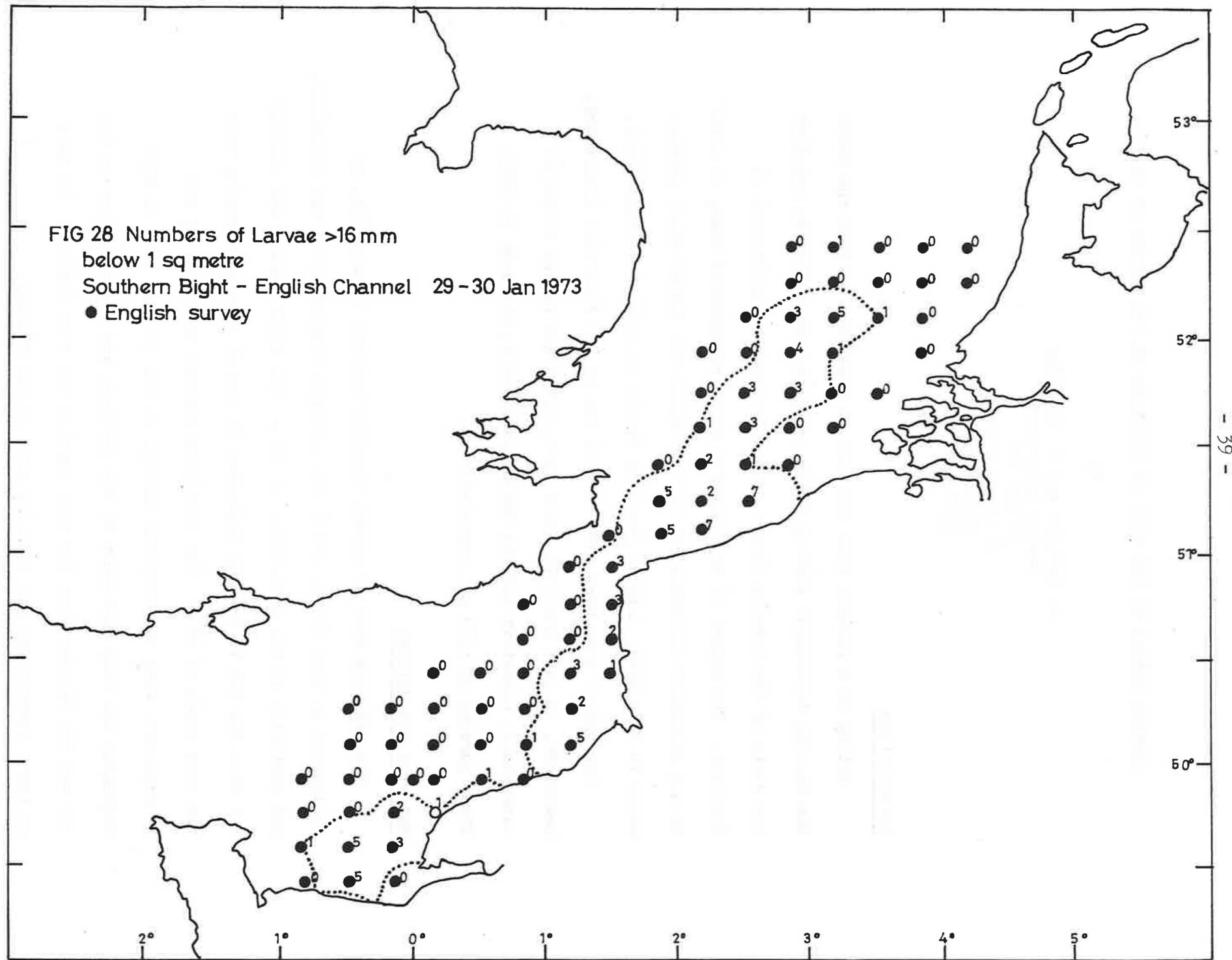


FIG 28 Numbers of Larvae >16 mm
below 1 sq metre
Southern Bight - English Channel 29 - 30 Jan 1973
● English survey



HERRING LARVAE TO THE WEST OF SCOTLAND IN THE AUTUMN OF 1972

by

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Introduction

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 north-west of Scotland. The report of this working group recommended that, in order to use abundance estimates of herring larvae for future stock assessments in this area, regular sampling should be initiated (Anon 1971).

Surveys of this area were carried out by the Fisheries Laboratory, Lowestoft, in 1965 and 1971 (Wood 1971, 1973) and by the Fisheries Laboratory, Lowestoft and the Marine Laboratory, Aberdeen in 1972. These surveys in 1972 are reported here.

Material and Methods

The spawning area of autumn spawning herring in area VIa, as delineated by Wood (1971, 1973) was surveyed completely on two occasions, and partially on two occasions, in 1972. The first survey was carried out from the 5th to the 8th September by the RV Corella covering only the area north of 58°N. The remaining surveys were done by the RV Explorer, with two complete surveys in the periods 15th to 22nd September and 22nd September to 4th October, and a partial one on the 5th and 6th October when the area sampled was very limited. On none of these surveys was any sampling done in the Minches.

Samples were taken and analysed in the same ways as in the North Sea larval surveys (Saville 1970). Densities of larvae, in numbers beneath one square metre of surface, were plotted and planimetered and total abundances estimated as described by Saville and McKay (this volume) for the North Sea surveys in 1972.

Results

The results of the first survey, carried out in the period 5-8 September 1972, are given in Figs 1 and 2. A high density patch, almost entirely of recently hatched larvae, was located north of Cape Wrath, with a secondary patch of much lower density north and west of the Butt of Lewis. These patches were almost completely separated from those found west and north of Orkney during the North Sea larval surveys (Saville and McKay this volume). The estimated number of larvae <10 mm long was very high at $7\,690 \times 10^9$. The number of larvae in the 10-15 mm length range was low at 660×10^9 indicating that hatching had started fairly recently (Table 1).

The numbers of larvae caught in the second survey (15-22 September) are shown in Figs 3-5. A patch of high density of recently hatched larvae was located west of South Uist with a second patch of much lower density north of Cape Wrath; there was again a clear demarcation between the patches of small larvae west and east of the 4°W boundary between areas VIa and IVa. The estimated number of <10 mm larvae during this survey was $1\,350 \times 10^9$. Older larvae, 10-15 mm long and >15 mm long, were generally distributed at lower densities from Barra Head northwards along the western side of the Outer Hebrides and north of the Butt of Lewis and Cape Wrath, with the major concentration in the latter area where numbers up to 405 per square metre were found. The estimated total number of larvae in the surveyed area in the 10-15 mm

and >15 mm length ranges were $1\,370 \times 10^9$ and 90×10^9 respectively (Table 1).

The results of the third survey carried out from 22 September to 4 October are shown in Figs 6-8. Three major patches of larvae <10 mm long were found; the most important one was to the north and west of the Butt of Lewis, while subsidiary ones were located north of Cape Wrath and west of North and South Uist. The estimated number of the smallest size category of larvae was high at $2\,410 \times 10^9$. Older larvae were again widely distributed from Barra Head north to Cape Wrath, with the major concentration north of Cape Wrath extending eastwards to the boundary of the survey area and west of South Uist. The estimated numbers of larvae in the 10-15 mm and >15 mm length ranges were $2\,140 \times 10^9$ and 81×10^9 respectively (Table 1).

The fourth survey, during 5 and 6 October, was of too limited extent to give meaningful abundance estimates. This survey, however, did indicate that there were still considerable numbers of recently hatched larvae in the area with a maximum density of 1 014 per square metre (Fig 9).

In neither of the two complete surveys was any substantial concentration of larvae located to the north-west of Ireland and, from the results of the surveys in previous years reported by Wood, it seems likely that this was due to the 1972 surveys of this area being too early. This in turn would suggest that the timing of hatching in the northern and southern spawning areas within VIa may differ by as much as a month.

Discussion

It is difficult to compare directly the abundance estimates from the 1972 surveys with those of 1971 and 1965 reported by Wood as the timing of the surveys is different, as is the method of calculating

larval abundance. Wood (1971, 1973), when calculating larval abundance, multiplied the area between contours by the value of the lower one, whereas in this paper the area has been multiplied by the mean value of the boundary contours. Estimates from Wood's surveys, recalculated to make them comparable with those of 1972, are given in Table 2. From these data it would appear that the abundance of larvae in early September was considerably higher in the northern part of VIa in 1972 than in the same period and area in 1971. No comparison can, unfortunately, be made of the abundances between 1972 and the earlier years, over the area as a whole, as the timing of complete surveys was quite different.

Because of the apparent difference in the timing of larval hatching in the two major spawning areas, to the north-west of Ireland and to the west and north of the Outer Hebrides, it is doubtful if any of the surveys yet carried out have been sufficiently extensive in time to give an adequate measure of larval production on which to base an estimate of the size of the spawning stock in VIa. The North Sea Herring Assessment Working Group using Wood's survey in 1965 produced estimates of the size of the spawning stock in the range 620 000 - 960 000 tonnes (Anon 1971). Wood (1973), basing his estimate on that of the North Sea Herring Assessment Working Group from a Downs - VIa comparison of larval abundance, suggested that the spawning stock in VIa in 1971 was, as in 1965, of the order of 700 000 tonnes.

These estimates of the size of the spawning stock in VIa are in serious conflict with those derived from virtual population analysis (Saville and Morrison 1973) on two counts: (a) that they suggest a spawning stock very considerably larger than those estimated from virtual population analysis and (b) they suggest little change in the size of the stock between 1965 and 1971 whereas the VPA would suggest

it had increased by about 50% between these two years. The explanation of the latter discrepancy probably lies in a change in the fecundity/weight relationship in the VIa stock. In the earlier period the relationship was $F = -4\ 267 + 412.65W$, in the latter one $F = -3\ 556 + 307.10W$ (Baxter unpublished information). No explanation for this change in the fecundity/weight relationship can yet be given. In the light of these discrepancies it seemed important to re-examine these estimates of stock sizes in VIa from larval abundances.

In Anon (1971) estimates of stock sizes are given in the Downs and Central/Northern North Sea areas together with estimates of the larval numbers in the same areas and time periods. These data need considerable revision as some of the data on which the estimates are based have been modified in subsequent North Sea Herring Assessment Working Group reports, and because the estimates of stock sizes were calculated with an assumed M of 0.2 whilst all recent herring assessments have assumed an M of 0.1. The adjusted values of stock size and larval abundance for these North Sea areas are given below.

Area	Period	Catch (m tonnes)	F	M	Stock size (m tonnes)	Larval numbers
Downs	1946-51	182 700	0.4	0.1	580 473	$824 \times 10^{9^{1)}}$
Northern/Central North Sea	1957-60	490 000	0.49	0.1	896 318	$3\ 585 \times 10^{9^{2)}}$
Northern/Central North Sea	1961-64	570 000	0.53	0.1	952 393	$5\ 745 \times 10^{9^{2)}}$

1)
All sizes of larvae

2)
Larvae <10 mm

Using the catch in numbers in Anon (1972) for the areas and time periods given above, and the mean weights per age group in the appropriate months and areas from the same paper one can calculate the mean weights of spawners in these areas and time periods. Using Baxter's (1959) fecundity-weight relationships one can then calculate the mean fecundities and the egg production per tonne of stock. Similarly these parameters can be calculated for VIa from the age compositions of stock given by Saville and Morrison (1973), Scottish weight per age data, and the fecundity-weight relationship given earlier for VIa. These parameters are given below.

Stock	Mean fecundity	Fecundity per tonne
Downs 1947-51	43 064	107 x 10 ⁶
Northern/Central North Sea 1957-60	82 193	195 x 10 ⁶
" " " " 1961-64	82 193	195 x 10 ⁶
VIa 1965	90 643	197 x 10 ⁶
VIa 1971	64 006	146 x 10 ⁶

Using these data the size of the spawning stock in VIa in 1965 and 1972 can be estimated by comparison with the larval production and spawning potential of the stock in each of the three North Sea area/time periods from the relationship

$$S_{VIa} = \frac{S_{N.S} \times F_{N.S} \times L_{VIa}}{F_{VIa} \times L_{N.S}}$$

where S = spawning stock size in metric tonnes, F = fecundity per metric tonne, L = larval abundance, and the subscripts VIa and N.S. refer to areas. From this relationship, and using for VIa the numbers of larvae

from the October surveys in 1965 and 1971, one gets the 3 estimates given below of the spawning stock in VIa in each of the years. For comparison, estimates are given of the biomass of the spawning stock in each of these years, derived from the virtual population analysis of Saville and Morrison (1973) by calculating the number of survivors of the stock at 1 January to the time of spawning, and multiplying by the mean weight per age group at spawning.

Year	Period/Area comparison	Estimated spawning stock size in VIa from larval abundance (m tonnes)	Estimated spawning stock size in VIa from VPA (m tonnes)
1965	Downs 1947-51	818 000	231 700
1965	Central/Northern N. Sea 1957-60	227 500	
1965	Central/Northern N. Sea 1961-64	150 800	
1971	Downs 1947-51	1 020 700	330 200
1971	Central/Northern N. Sea 1957-60	371 000	
1971	Central/Northern N. Sea 1961-64	220 500	

The estimates from virtual population analysis and those from the comparison of larval abundance in VIa and in the Northern/Central North Sea is as close as could be expected from the nature of the data; the estimates from the Downs comparison are very much higher than the VPA ones. Several factors could be responsible for making the estimate based on the Downs comparison less valid. It may be significant that this comparison is based on larvae of all size groups and not only on the smallest size group as in the Central/Northern estimates. Such a

comparison would not be valid if larval mortality rates in the Downs area and in VIa are appreciably different. They may be so; the eggs of Downs spawners are known to be considerably larger than those of the stocks spawning in September-October and this is thought to give them a greater capacity for survival (Blaxter and Hempel 1963). The fact that the Downs estimates are based on all size categories of larvae would also seriously affect their validity if the speeds of drift of larvae out of the surveyed areas were very different, although at this stage it is not possible to predict whether this would be likely to reduce or increase the disparity.

A third factor which affects the validity of all the estimates from larval abundances is that they are based on a single estimate of larval abundance from each area which is made at or near the assumed mode of larval production. This is justified only on the assumption that the larval production curve in the two areas compared are the same apart from differences in the height of the mode. Too little is known of the shape of the larval production curve in any of the areas considered to make this a safe assumption; it is particularly dubious in area VIa where the rather limited data suggests that there may be two distinct spawning areas with quite different times of maximum larval production. It is hoped that more extensive sampling in this area in 1974 will provide better data for measuring larval production, as an index of spawning stock size.

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- | | | |
|--------------------------------|------|--|
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Table 1. Estimated abundances of herring larvae on each survey in VIa in 1972.

Date	Survey Area	No of Larvae x 10 ⁹			Total
		< 10 mm	10-15 mm	>15 mm	
5.9 - 8.9.72	N of 58°N	7 691	669	0	8 360
15.9 - 22.9.72	55°N - 59°N	1 355	1 379	90	2 824
22.9 - 4.10.72	55°N - 59°N	2 419	2 143	81	464

Table 2. Estimated abundances of herring larvae on each survey in VIa in 1965 and 1971 (after Wood 1971, 1973).

Date of Survey	Larval Abundance Estimates (x 10 ⁻⁹)	
	< 10 mm	Total
16.10 - 25.10.65	919	2 137
8.9 - 9.9.71*	?	3 267**
16.10 - 24.10.71	996	1 977

* Incomplete survey.

** Approximately half in yolk-sac stage.

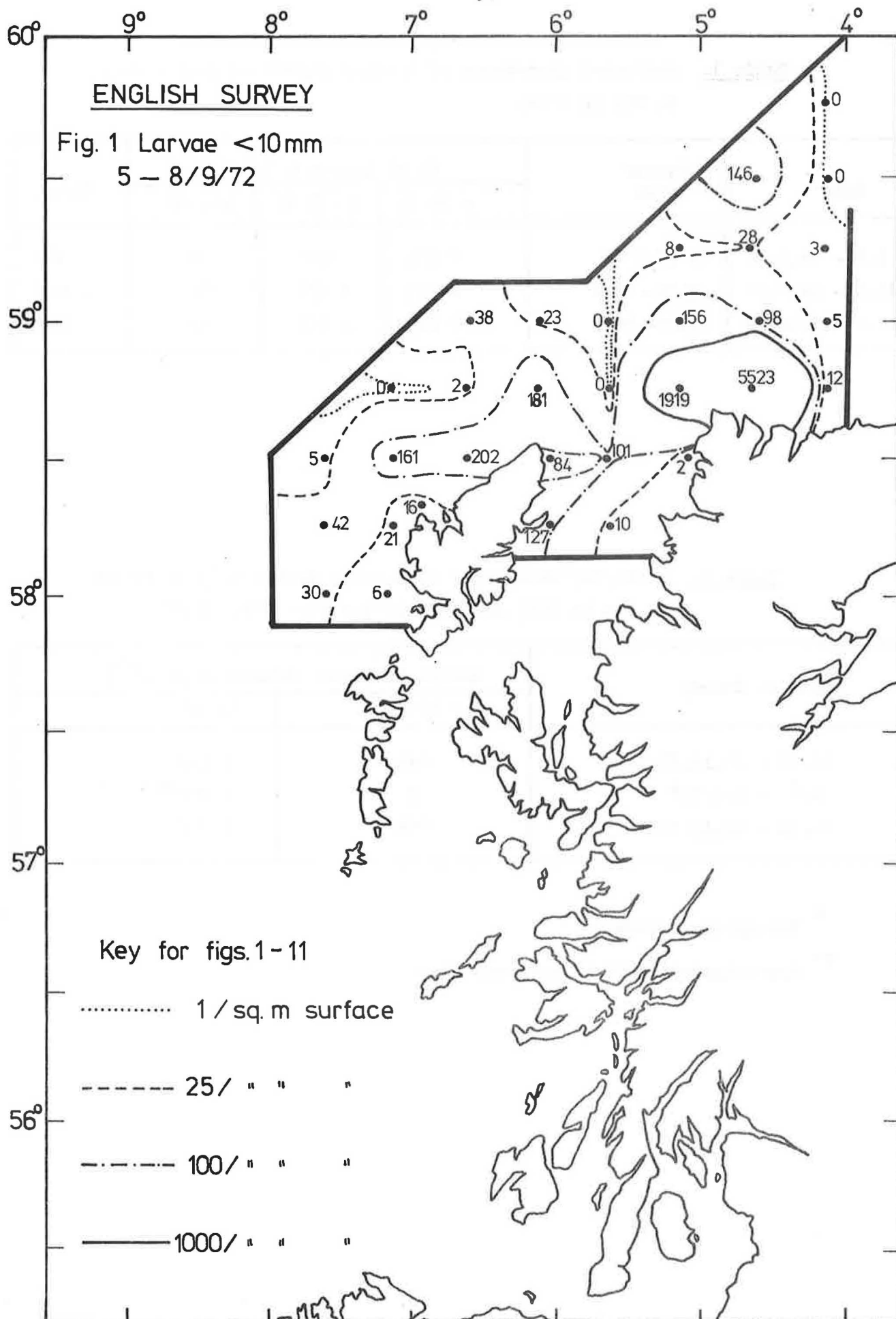


Figure 1. Numbers of larvae <10 mm below 1 sq metre, 5-8 Sep 1972.

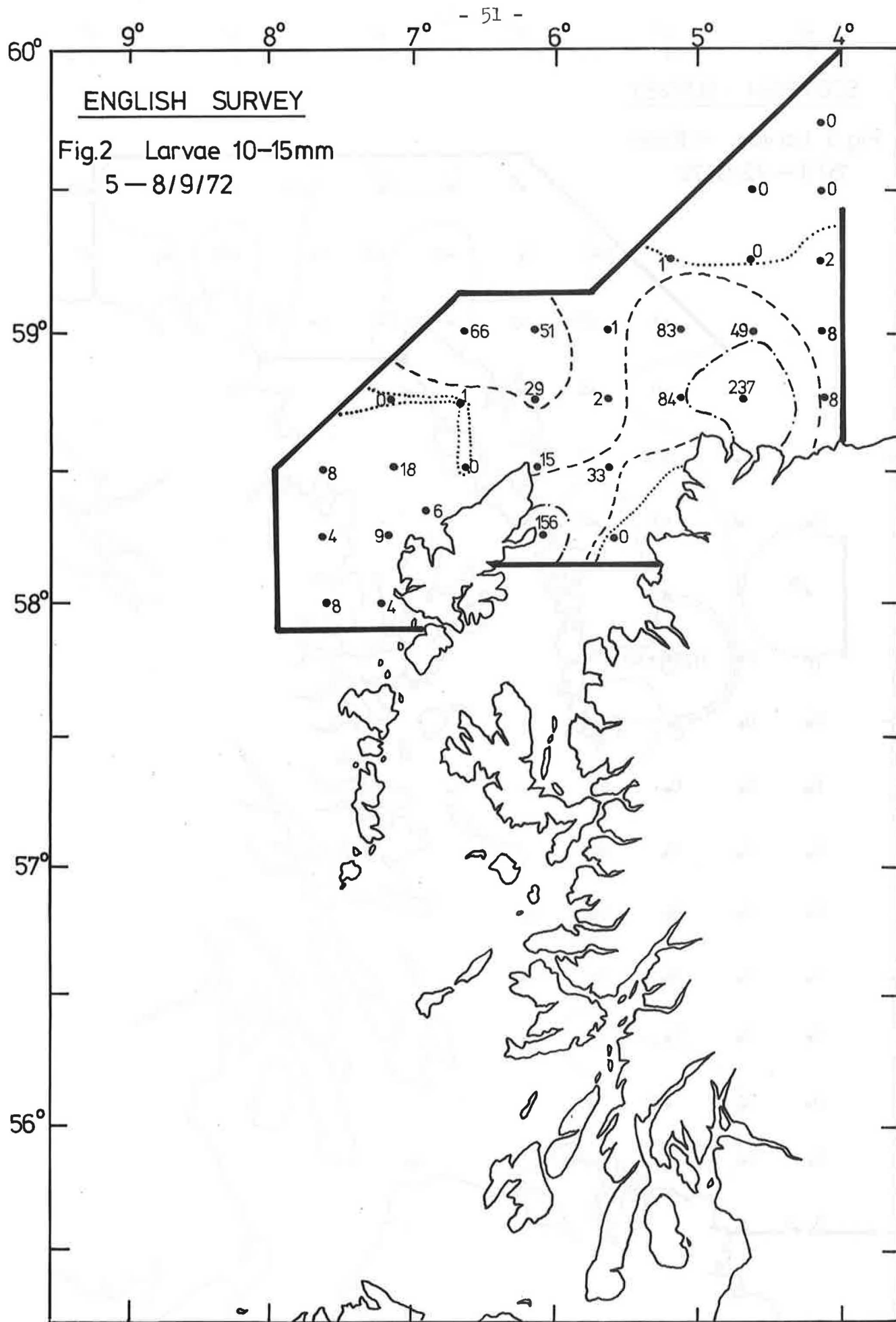


Figure 2. Numbers of larvae 10-15 mm below 1 sq metre, 5-8 Sep 1972.

Fig. 3 Larvae <10mm
15/9—22/9/72

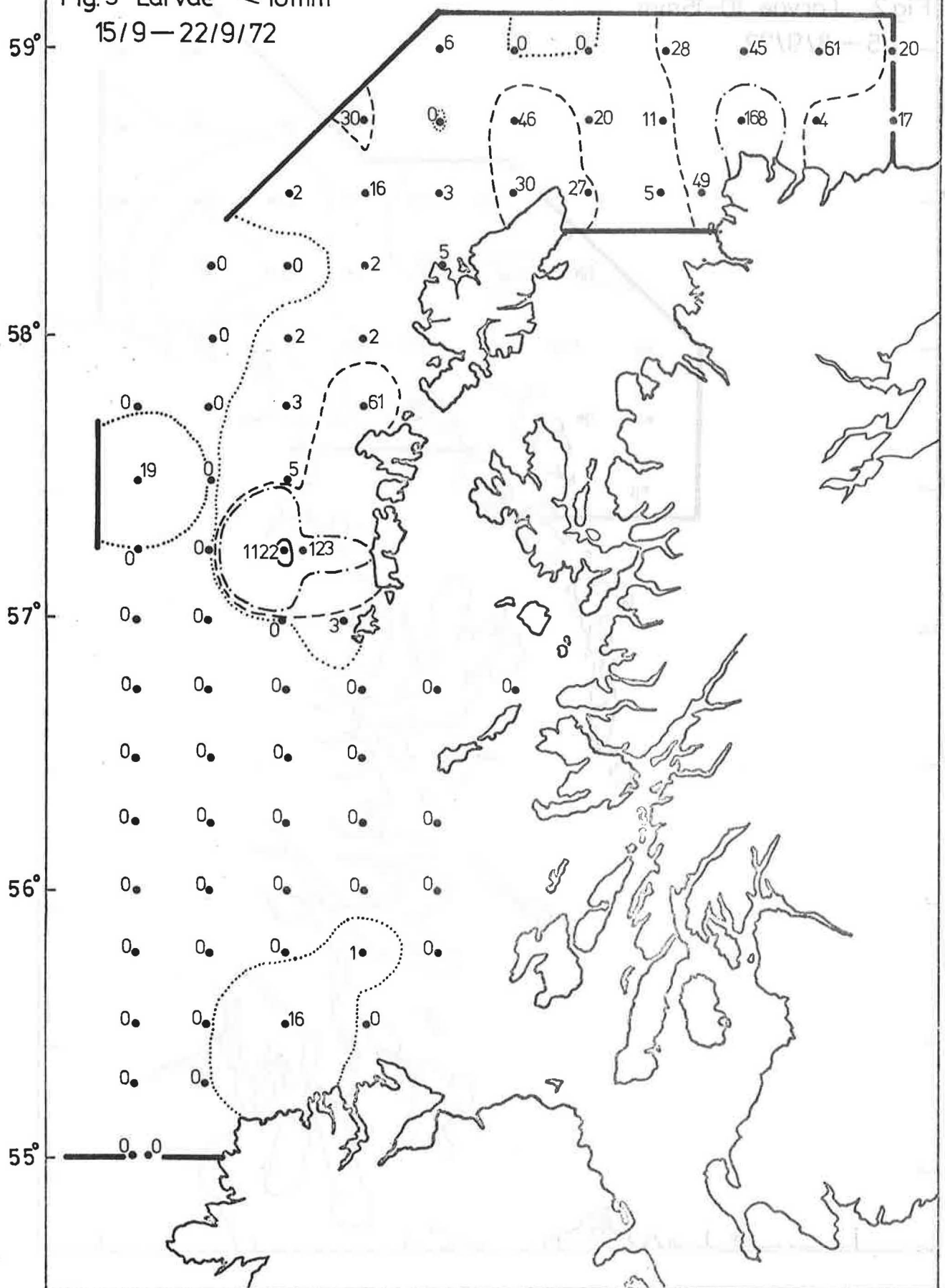


Figure 3. Numbers of larvae <10 mm below 1 sq metre, 15-22 Sep 1972.

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Figure 5. Numbers of larvae >15 mm below 1 sq metre, 15-22 Sep 1972.

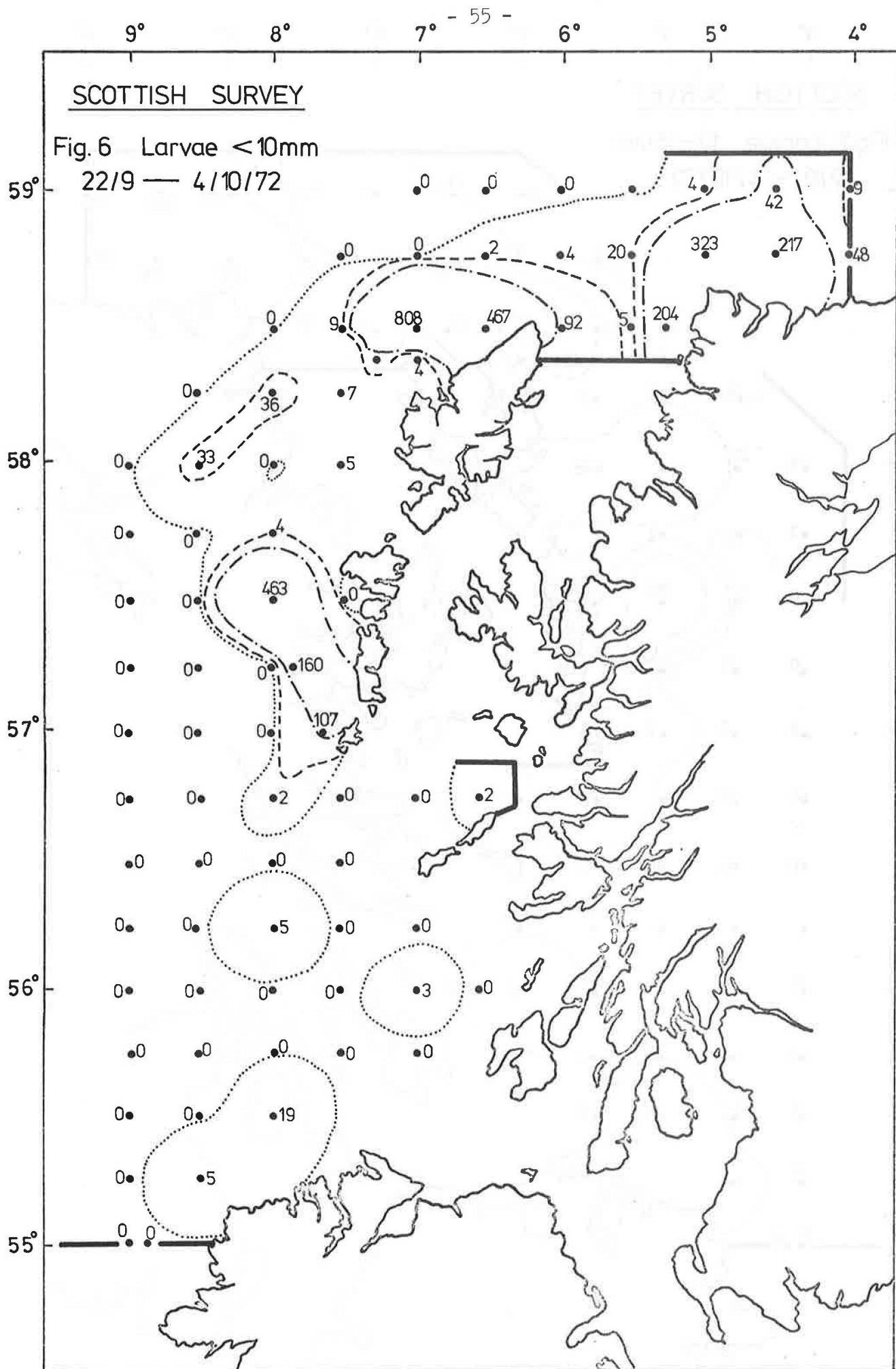


Figure 6. Numbers of larvae <10 mm below 1 sq metre, 22 Sep - 4 Oct 1972.

SCOTTISH SURVEY

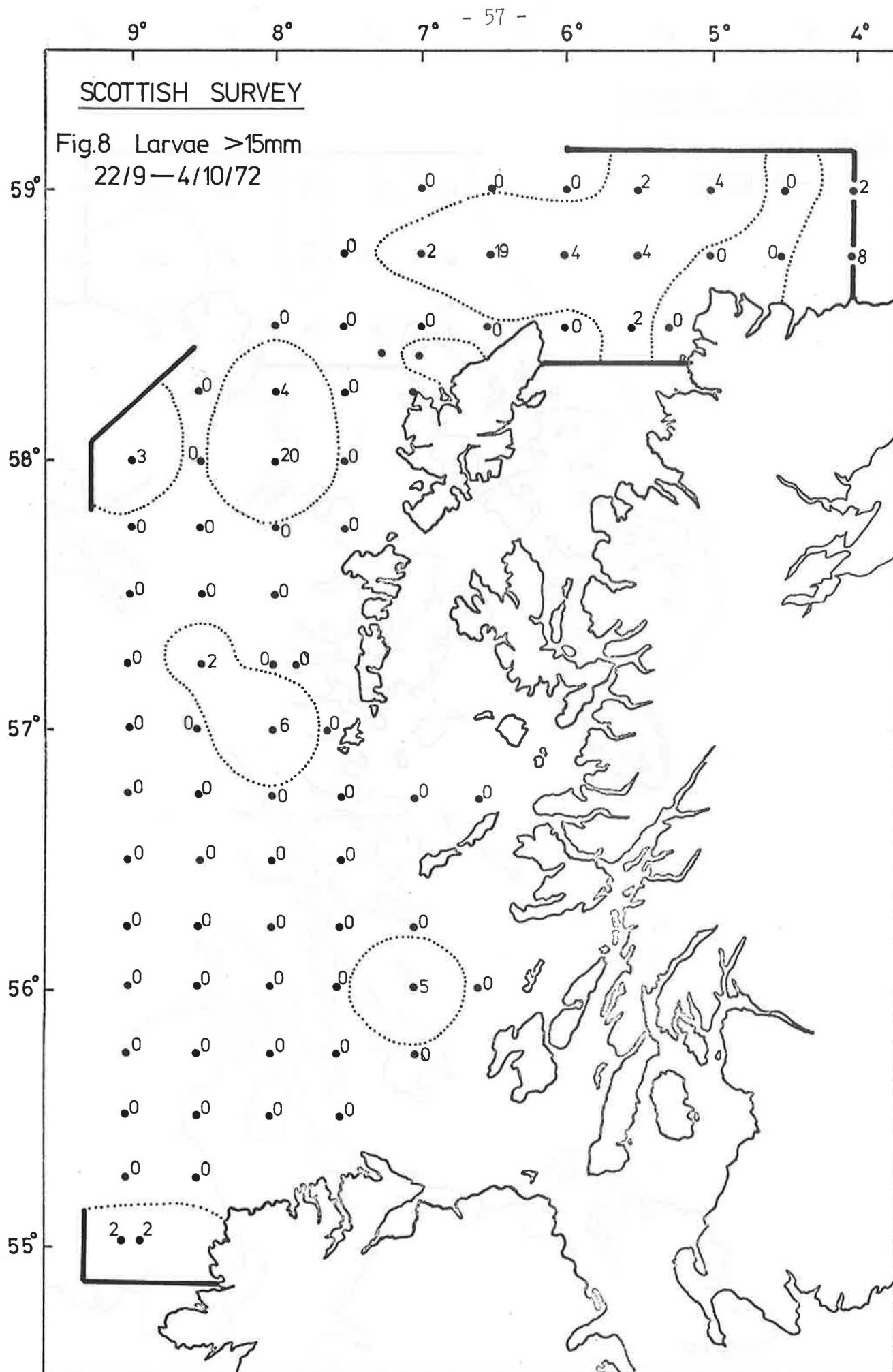


Figure 8. Numbers of larvae >15 mm below 1 sq metre, 22 sep - 4 Oct 1972.

Fig.9 Larvae <10mm
5—6/10/72

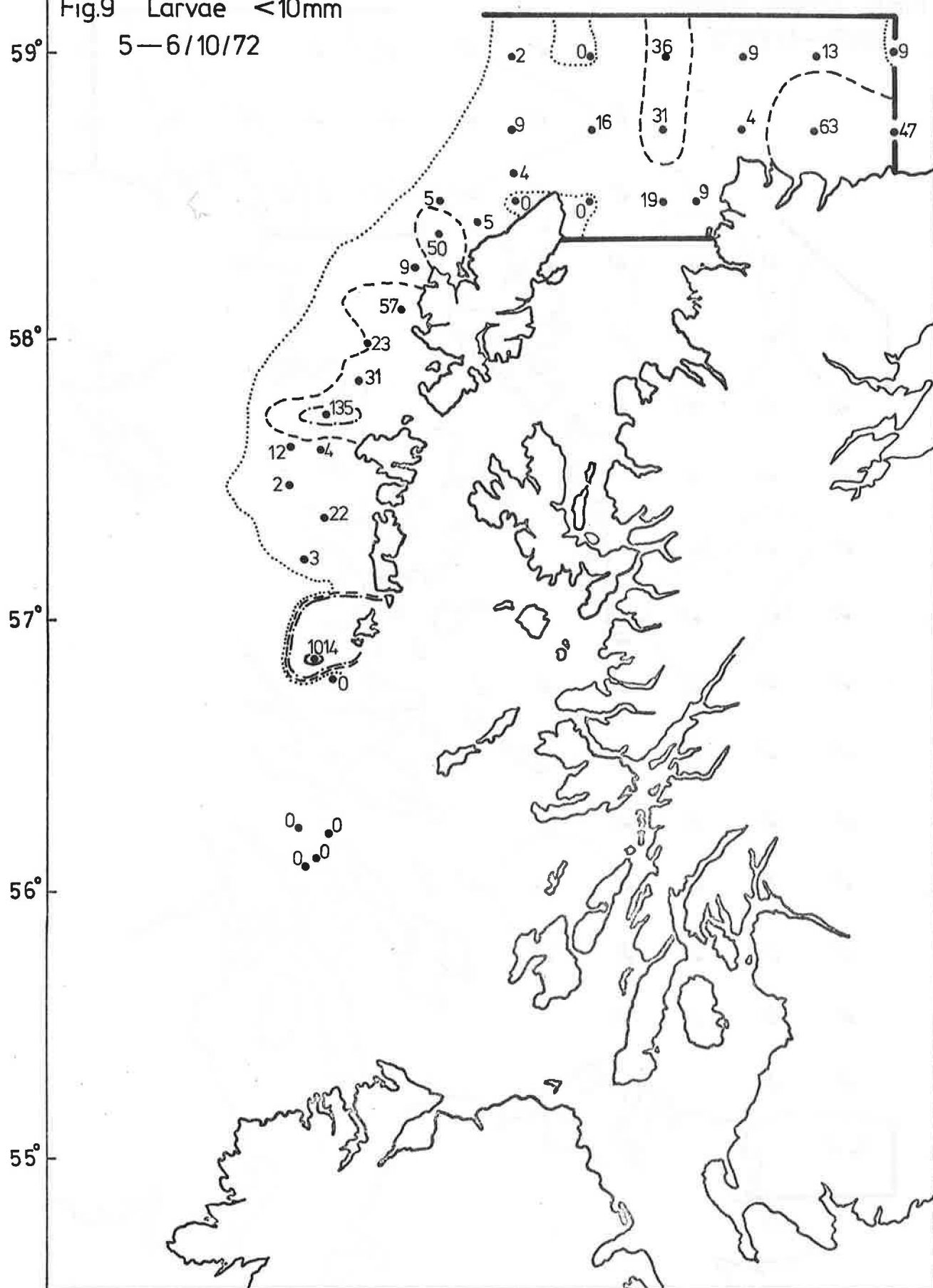
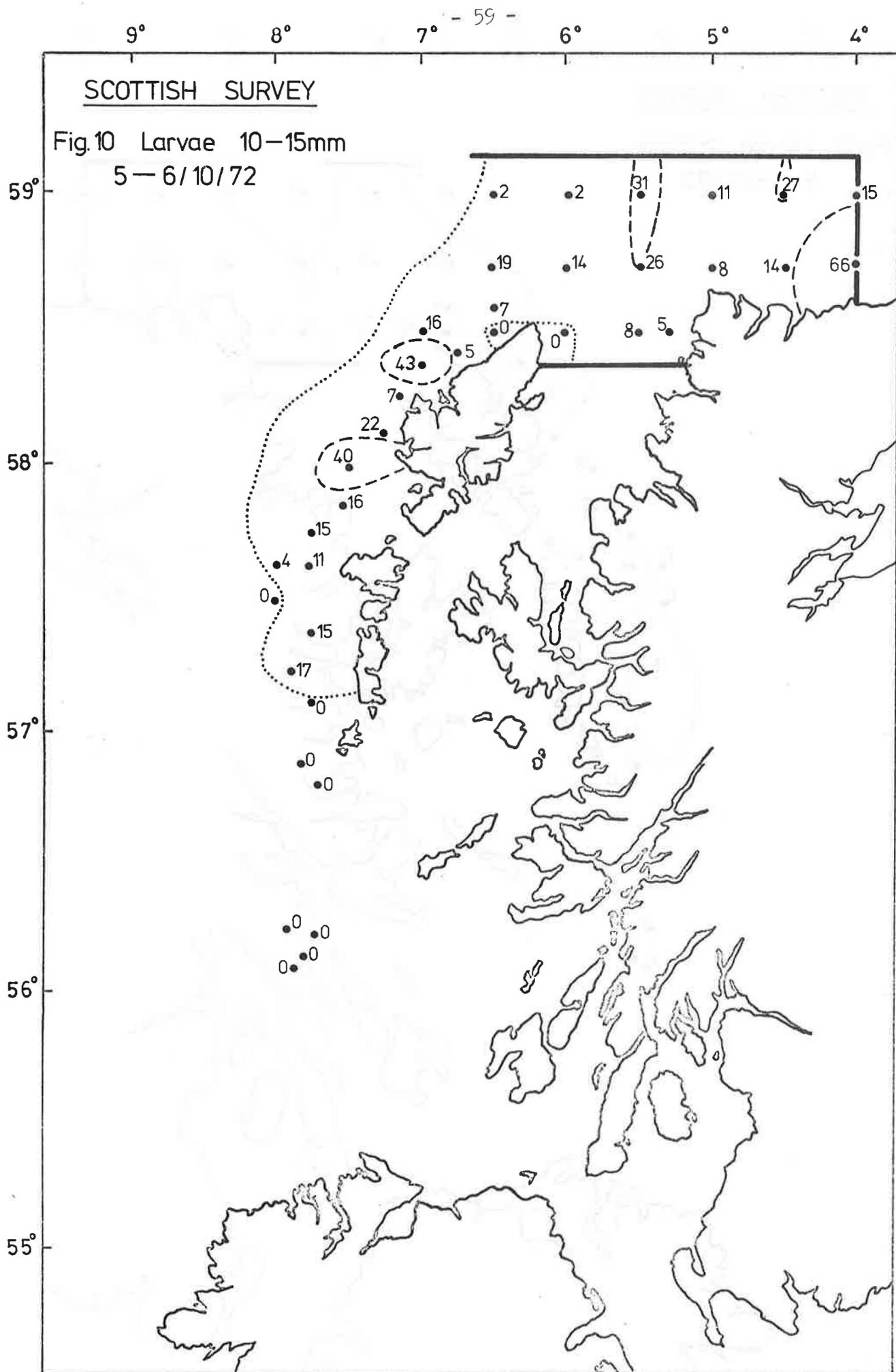


Figure 9. Numbers of larvae <10 mm below 1 sq metre, 5-6 Oct 1972.



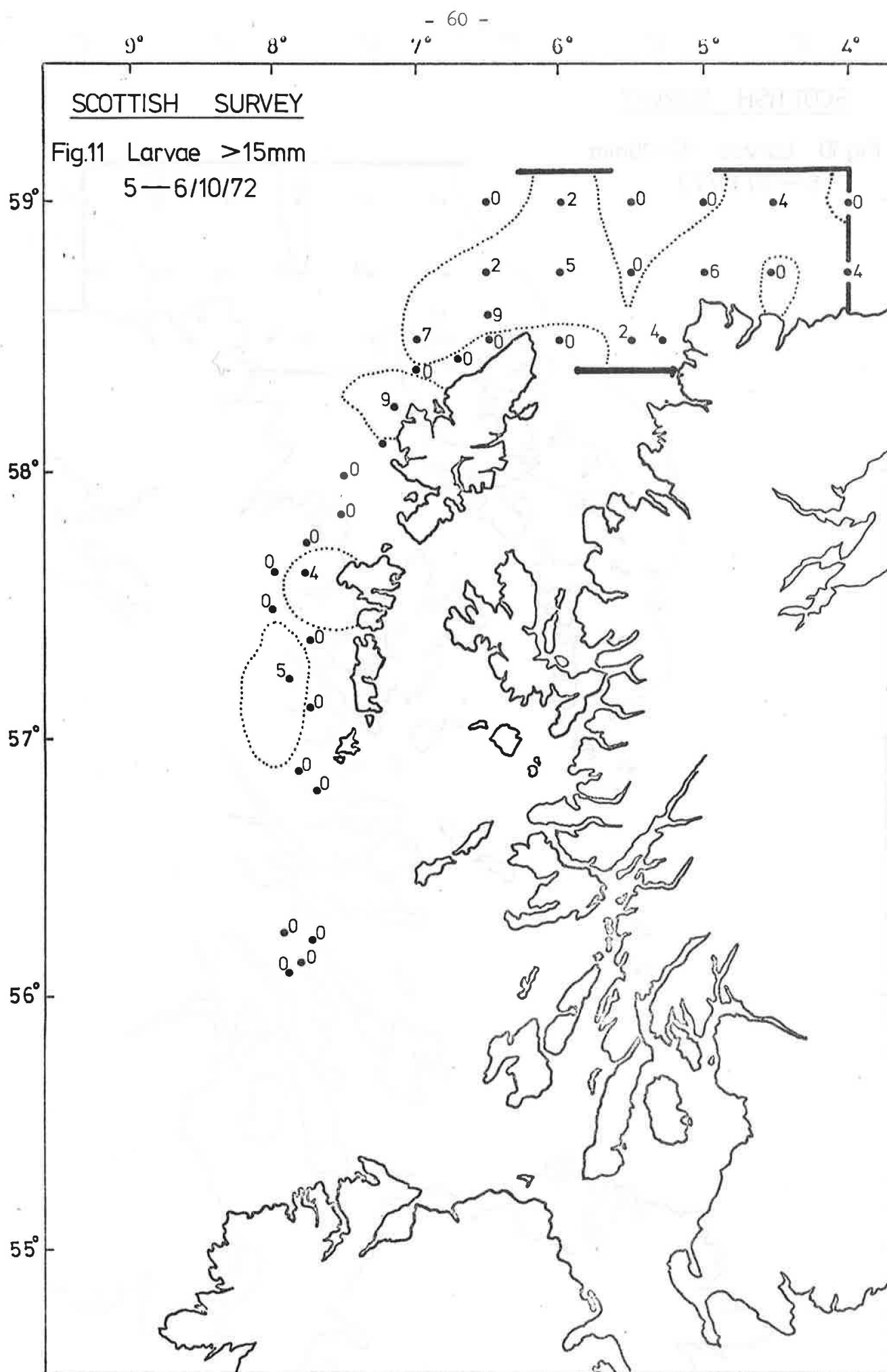


Figure 11. Numbers of larvae >15 mm below 1 sq metre, 5-6 Oct 1972.