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USSR Ichthyoplankton Investigations Within the Framework to the Flemish Cap Project in 1978-1983

by

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ABSTRACT

As a result of ichthyoplankton surveys eggs and larvae of 4I fish species have been recorded in the Flemish Cap area. Throughout the investigated period the highest abundance was shown by larval redfishes while cod and Amierican plaice larvae displayed extreme scarcity. The Spawning in redfishes was first recorded in the south - western part of the bank to be continued later in the north-eastern and north-western areas at depths of 350-800 m and at water temperature of 4-6^{o}C. The larva abundance increased from March to April to reach maximum during the second part of April zn and to be fully accomplished in May. The spawning seemed to be most intensive along the northern, north-western and south-western slopes of the Bank above depths of 300-800 m. The second peak of spawning fell on July-August.

Newly extruded larvae moved upward to drift in the upper IO--20 m layer. The larvae drifted southeastward and eastward from the spawning grounds located along the northern - north-western and south-western slopes, respectively. Larval redfish were recorded throughout the entire area surveyed in May and were frequently entrained to the central shallows of the bank with the anticyclonic

gyre. The gyre destruction is found to be responsible for ichthyoplankton transport outside the bank as it was the case in 1983. A supposition is put forward that strong year-classes of redfish, cod and american place are unlikely to be expected in the years when the anticyclonic gyre is destroyed.

INTRODUCTION

International investigations have been conducted in the Flemish Cap area since 1978 in order to reveal the causes of fluctuations in commercial fish year classes abundance. Flemish Cap is located in the northwestern Atlantic Ocean east of the Grand Bank with a narrow deep-water strait between them. The pattern of water circulation on Flemish Cap (Buzdalin and Elizarov, 1962; Kudlo and Burmakin, 1972; Hill et al. 1973; Borovkov and Kudlo, 1980) predetermines the routes of egg and larva passive migrations and is responsible for the occurence of isolated populations of cod, redfish and American plaice in the area (Postolaky, 1962; Templeman, 1962; Templeman, 1974; Templeman, 1976; Serebryakov, 1967; Serebryakov, 1978; Cross and Payne, 1978). Based on the above assumption Dr. K.G. Konstantinov recommended ICNAF Scientific Council to choose the Flemish Cap as an area for research on reasons for abundance fluctuations in fish year classes (ICNAF Redbook 1975). In May 1977 in Murmansk ICNAF ad hoc Working Group on the Flemish Cap Project considered general oceanographical and ecological aspects and worked out main principles of the international program to investigate abundance fluctuations of the commercial fish year classes on the Flemish Cap (ICNAF Redbook 1977). A bit later, at the meeting in September 1977 Canadian specialists discussed 12 hypotheses on influence of 4 principal factors (oceanological environmental conditions, predotion, food availability, state of the spawning population) on the abundance fluctuations in the fish year classes and worked out practical ways of realization of the program (Akenhead, 1978).

The results of the international surveys in the Flemish Cap area have been presented in the preliminary reports and papers (Postolaky, 1980; Anderson, 1982a,b; Borovkov and Kudlo, 1979; Kudlo and Borovkov, 1980; Anderson and Akenhead, 1981) and some summarizing works (Anderson, 1983; Konstantinov, 1980). This paper provides the results of the ichthyoplankton surveys carried out by PINRO vessels.

MATERIAL AND METHODS

The ichthyoplankton surveys on Flemish Cap were conducted in spring and summer of 1978-1981 and 1983 on a standard grid of stations. Annually two or three surveys were conducted.

Ichthyoplankton was sampled with the egg conical net (80 cm diameter opening, 0.5 mm mesh gauze) in 1978, 1979 and 1980. Three methods of towing were usually used at each station: a total vertical haul from the bottom to the surface (from the maximum depth of 500 m in waters deeper than 500 m) and two horizontal hauls - near-surface and oblique. The net was retrieved at ca I m/sec during vertical hauls.

In 1978 near-surface and oblique hauls for ichthyoplankton were simultaneously made while the vessel was underway at dead slow of some 0.I knot with a I0 minute circulation. The nets for horizontal hauls - near-surface and at 25 m - were made fast along the same wire 50 m apart each other. During near-surface hauls the condition of complete lowering the sampling array was strictly kept: the upper hoop edge of the net was towed just below the surface and was visible well. The other net with an attached 20kg load fished at 25 m and during retrievals made oblique hauls at upper 25 m.

In 1979 and 1980, total vertical and horizontal near-surface hauls apart, the 50 m depth was fished at each station during a I0 minute vessel circulation at 2.5-3,0 knots with oblique hauling at upper 50 m during retrievals.

In 1981 IKS-80 was used only for total vertical hauling from both the bottom and 500 m depth to the surface.

During the first two surveys of 1983 the vertical, near-surface and two oblique IKS-80 hauls were made during a 10 minute vessel circulation at 2.5-3.0 knots. In the third survey two hauls were made at each station: vertical IKS-80 and oblique Bongo-61 tows.

At each station sampling included temperature (near-bottom - - surface) and salinity profiles were made.

Initial processing of the samples was made aboard during the cruises. Ichthyoplankton samples were fixed in 2 - 4% formalin. The samples were further analyzed _in vitro_. The ichthyoplankton was sorted out under binoculars, and egg and larva growth stages were determined (Rass, 1946). The egg diameter and larva zoological length were measured. Eggs and larvae were identified on the basis of the egg and larva identification deys (Ehrenbau,1905--1909; Pertseva, 1936; Rass, 1949; Russel, 1976; Serebryakov,1980, and others).

The data obtained with the vertical IKS-80 hauls counted under 1 m^2 were used for plotting egg and larva distribution charts. Total abundance of redfish larvae was determined applying the stratification method (Buchanan-Wollastone, 1926) and a special computer program was used. The data obtained with vertical, as well as the other, hauls at each station were used to list ichthyoplankton species composition and larva length frequency distribution.

RESULTS

Species composition

More than 26 species of fish occur in ichthyoplankton samples on Flemish Cap (Serebryakov, 1978). 16 species have been recorded during cruises of the Polish r/v "Wieczno" in April 1978 (Grimm _et al_. 1980). Our surveys have revealed eggs and larvae of 41 fishes (Tables 2,3,4,5,6). For the first time _Nansennia groenlandica_, _Maurolicus muelleri_, _Leptoclinus maculatus_, _Anarhichas denticulatus_, _Anarhichas lupus_, _Conger conger_ and others have been caught on Flemish Cap. The species composition list of the Flemish Cap area can be, thus, sufficiently supplemented now.

Besides, from the larval distribution it is possible to say that cusk (Brosme brosme) may spawn on the Flemish Cap.

Redfish larvae appeared to be the most abundant item of the Flemish Cap ichthyoplankton throughout all the years and seasons of the surveys.

Number of cod eggs and larvae captured was unexpectedly small.

Redfish larvae

Redfish larvae are not classified into species in the present paper despite the fact that it has recently become possible (Serebryakov, 1978; Templeman, 1980; Magnusson, 1981; Penney, 1982). Distribution is given for larvae of all the Sebastes spp. combined.

General distribution. Surveys in March were conducted in 1980, 1981 and 1983. Redfish larvae were observed in each of those surveys. In 1980 and 1981 larvae in amount of 30-78 spec./m^2 were found on the southwestern Flemish Cap in the Beothuk Knoll area and in 1983 on the northern Flemish Cap (Fig. 1a,b,c). The larvae, judging by their length (Fig. 2), were newly extruded. The greatest larval abundance in March was marked in 1980 - 0.25×10^{12} larvae, whereas in 1981 it amounted to 0.19×10^{12} and in 1983 - - 0.06×10^{12} specimens (Table 7).

The only survey in the first half of April was made in 1979. Distribution of the larvae (judging by their size recently extruded) was similar (Fig. 3) to that of the second half of March 1980 (Fig. 1), and they numbered 1.62×10^{12} specimens at the survey moment.

In the second half of April surveys were conducted in 1981 and 1983. In 1981 the greatest larval abundance of more than 100 specimens per m^2 was found on the northern and northeastern Flemish Cap above the depths of 1000 to 300 m, and in 1983 larvae in such a great number were observed on the eastern, southeastern and southwestern slopes of the Flemish Cap (Fig. 4). The larval abundance in 1983 was more than 5 times as large (15.37×10^{12} spec.) as in 1981 (3.03×10^{12} spec.). In 1983 the peak of the larval length range fell on 7 mm and in 1981 - on 9 mm.

Two surveys were also made in the first half of May, in 1979 and 1980. In 1979 the highest larval concentrations were found on the northern Flemish Cap above the depths of 300 - 400 m, on the south-western - above 200 - 300 m, and southeast of the Flemish Cap above the depths of more than 1000 m (Fig. 5). The peak of the overall larval length composition for the whole area surveyed fell on 8 mm in those years. The larvae numbered 4.38×10^{12} and 3.54×10^{12} specimens in 1979 and 1980, respectively.

In the second half of May surveys were conducted in 1978, 1981 and 1983 (Fig. 6a,b,c). In 1978 the maximum numbers of larvae (more than 100 spec./m^2) occured north, west and south of the shallow part of the Flemish Cap. The length composition peak was 10 mm, and the larvae in amount of more than 10 spec./m^2 were distributed within the 300 m isobath on the northeastern slope of the Flemish Cap. In 1981 the larval distribution was limited with the 400 m isobath, and, besides, in 1983 the larvae in amount of 500 spec./m^2 were observed on the southwestern slope and in number of more than 10 spec./m^2 on the northern and northeastern slopes of the Flemish Cap. The abundance of the larvae in those years constituted 1.46×10^{12}, 0.79×10^{12} and 1.59×10^{12} specimens, respectively.

Only in 1980 was a survey in June made. Larvae (more than 10 spec./m^2) with the length range peak of ca 9 mm were distributed everywhere within the Flemish Cap and near the southern slopes above the depths of more than 1000 m. The maximum larval abundance was sampled over the shallow central Flemish Cap (Fig. 7). The larvae amounted to 0.79×10^{12} specimens.

In July there was also the only survey coducted - in 1978. Newly extruded larvae with length of 6 - 7 mm and larvae of 10 - 12 mm were represented in catches on the eastern and western Flemish Cap above the depths of 300 - 400 m (Fig. 8).

The percentage of the length composition in redfish larvae on the Flemish Cap in May, June and July throughout different years of the surveys is shown in Fig. 9.

Cod eggs

The number of cod eggs sampled throughout all the years of the surveys was low (Figs. 10, 11, 12). The record catch was 36 spec/m^2. Cod eggs occured mainly in March within the southeastern Flemish Cap (1980) and on the northern and northeastern slopes (1981) within the 400 m isobath. In March 1983 cod eggs were not observed (Fig. 12). A modicum of cod eggs was found outside the Flemish Cap above the oceanic depths. In April cod eggs were practically caught within the shallow part of the Flemish Cap only, much closer to its centre than in March (Figs. 11, 12). In May separate cod eggs were captured both within the Flemish Cap and above the oceanic depths (Figs. 11, 12). On the central Flemish Cap some cod eggs were caught even in July (Fig. 10).

A very small number of cod larvae was represented in catches. The maximum catch of them amounted to 12 spec./m^2 in May 1979 in the Beothuk Knoll area. In April, May and June the larvae were distributed within the 400 m isobath (the closer to the Flemish Cap centre the later the survey was conducted).

American plaice

American plaice eggs occured on the central Flemish Cap already in March (Figs. 13, 14), but they were chiefly found in May both there and in the adjacent area within the 300 m isobath. A few eggs were sampled above the oceanic depths in the southeastern area as well.

American plaice larvae were captured during the surveys only twice.

DISCUSSION

Spawning

One can get fairly adequate picture of redfish spawning grounds location and dates of spawning in the Flemish Cap area by comparing the larval distribution charts (Figs. 1, 3 - 8) and length composition data (Fig. 2), the maturity stages tables (Tables 8,9), the charts of redfish spawning females distribution (Figs. 15, 16) and also redfish larval abundance data available from different surveys. Redfish start spawning in mid-March in the southwestern Beothuk Knoll area, as well as on the northwestern and northern slopes of the Flemish Cap, where newly extruded larvae (Fig. 1) and spawning fish (Fig. 15a) have been found in March. In April spawning redfish specimens have been distributed practically everywhere on the slopes of the Flemish Cap at 800 - 1000 m (Fig. 15b). The peak of spawning is likely to.fall on mid-to-late April, which is confirmed by the maximum, for the whole period of observations, abundance of larvae with length of 6 - 7 mm on the 16 - 22 April and a large amount of larvae with length of 7 - 8 mm in early May (Figs. 2, 9). Spawning takes place on all the slopes but larvae are extruded most intensively on the northern, northeastern slopes and in the southwestern Flemish Cap area. Redfish spawning is over in May. The second peak of redfish spawning is observed in July - August, when a small number of spawning fish and larvae with length of 7 mm has been found (Tables 8, 9). Extrusion of larvae occurs probably in the depths of 350 - - 800 m at 4.0 - 6.0°C.

On having been extruded in March - April, redfish hatchlings move off the depth of 350 - 800 m to the upper layers and drift at upper 10 or 20 m. The hatchlings drift from the spawning grounds on the northern and northwestern slopes southeastward and from the spawning grounds in the southwestern area eastward. The direction of the drift can be found out on the basis of changings of the larval length composition in the various parts of the bank during the same survey (Fig. 17a,b,c,d,f,g) and by shift of patches of the highest larval concentrations (Figs. 1,3 - 8). In May redfish larvae are distributed practically everywhere within the Flemish Cap, and, being involved in the anticyclonic gyre on the bank, they drift. The patches of the highest concentrations of large larvae (more than 9 mm length) appear on the central, comparatively shallow, Flemish Cap (Figs. 6,7) in late May - June. However, not all the real situations fit this scheme of redfish larval distribution and drift on the Flemish Cap. Thus, for instance, in the last week of May 1983 larvae in amount of 800 spec./m2 with length of 10.5 - 13.5 mm have been found on the southeastern slope of the bank above the depth of 800 m. This indicates that the larvae, having been probably extruded on the northern slope, happened then possibly to be "washed off" from the bank. The possibility of ichthyoplankton removal from the Flemish Cap has been previously marked (Serebryakov, 1967; Serebryakov, 1978; Templeman, 1976; Kudlo and Borovkov, 1977; Kudlo and Boytsov, 1978). Kudlo et al. (1983), discussing stability of the anticyclonic quasi-steady gyre in the Flemish Cap area, distinguished 4 types of water circulation on the bank. Under action of two of them the anticyclonic gyre is destroyed and "the transient flow crosses the Bank as if washing it... The circulation frequency of this type accounts just for 7.4%" The maximum densities of ichthyoplankton distribution observed on the south-eastern Flemish Cap may depend upon this very type of water circulation on the bank. If the anticyclonic gyre destruction did have place in May 1983, which is suggested by redfish larval distribution, possibility of strong year classes of redfish, cod and American plaice to appear looks very improbable.

Cod egg (Figs. 10,11,12) and spawning fish (Fig. 18a,b) distribution and correlation of trawl caught specimens with gonads of different stages of maturity (Tables 10, 11) confirm previously published data on cod spawning in this area in March (Mankevich, 1962; Postolaky, 1963; Serebryakov, 1965; Serbryakov, 1967; Templeman, 1976). In 1983, the spawning peak seems to have shifted on April. Discussion on the patterns of eggs and larval distribution and drift and, moreover, changings in their abundance from season to season and from year to year is impossible due to an insufficient amount of eggs and larvae available in all the surveys.One may say only about the complete absence of cod larvae in catches for 1978 and 1979 and a larger amount of them in 1983 comparing with 1980 and 1981. Besides, it is worth paying some attention to the larval transport from the bank into the ocean (Figs. 10,11,12), which has been earlier mentioned (Serebryakov, 1962; Serebryakov, 1965; Serebryakov, 1967; Serebryakov, 1978) and seems to be an important factor for cod year classes abundance formation.

American plaice appears to spawn in May as the bulk of spawning fish (Tables 12, 13; Fig. 19) and eggs occur at this very time. Egg extrusion takes place close to the shallow central Flemish Cap as have been earlier noted (Nevinsky and Serebryakov, 1973; Templeman, 1976; Serebryakov, 1978).

The total number of the eggs and larvae caught is too small to draw any conclusions on the peculiarities of production and early ontogenesis of American plaice on the Flemish Cap. One may only suggest that the eggs and larvae are involved in the anticyclonic gyre, and with some amount of them being removed out of the boundaries of the Flemish Cap.

CONCLUSION

The USSR ichthyoplankton surveys conducted on Flemish Cap in 1978-81 and 1983 revealed eggs and larvae of 41 fish species to supplement substantially the list of fishes occurring in the area larval Sebastes spp. showed the highest abundance throughout the entire period of surveys. Eggs and larvae of cod and American plaice were scarce compared to redfish. The maximum abundance of cod eggs was 36 specimens /m². Cod eggs were recorded mainly in March within the 400 m isobath along the northern and northeastern slopes and in the southeastern area of the bank. Larval cod were caught in April, May and June in the areas closer to the central part of the bank and the total abundance was not high. American plaice occurred mainly in May in the central part of the bank and adjacent areas.

Spawning in redfish seemed to start in the south-western areas in the vicinity of Beothuk Knoll and to occur later along the north-eastern and north-western slopes. Larvae were first extruded in mid - March at the water temperature of 4-6^{0} at the depth of 350-800 m. The number of larvae extruded increased from March to April to reach maximum during the second part of April. The distribution of spawning redfish and of newly-extruded larvae in late April is indicative of intensive spawning along all the slopes with peaks along the northern, north-eastern and south-western slopes.

within the 300-800 m isobaths. The spawning was fully accomplished in May. The second, but lower peak of spawning fell on July - August.

Newly extruded larvae moved to the surface to drift in the upper 10-20 m layer and were entrained with the anticyclonic gyre to the central shallows of the bank. The larvae drifted southeastward and eastward from the spawning grounds located above the northern and north-western slopes, respectively. However the gyre breaking (Kudlo, et.al., 1983) may result in ichthyoplankton transport outside the bank as it was likely to take place in 1983. It is supposed that the stability of the anticyclonic gyre accompanied by favourable evironmental conditions governs the year class strength in the main commercial fishes on Flemish Cap or i.e. in the years when the gyre is destroyed abundant year classes of redfish, cod and Amierican plaice are unlikely to be expected.

The USSR ichthyoplankton studies on Flemish Cap have demonstrated feasibility of the surveys to elucidate causes of year-class abundance fluctuations in the area.

To estimate population abundance of redfish the following recommendations are given:

- to continue regular standard ichthyoplankton surveys which can be carried out in the second part of April and early May;
- to develop methods for identification of larvae of the genus Sebastes;
- to sample data in the spawning fish abundance on the individual absolute fecundity in age-groups composing the spawning part of the population and on the maturity ogives.

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Table 1. Data on ichthyoplankton surveys in 1978-1981 and 1983.

Year	Dates of sampling	Number of stations	Gear	HAULS ver-tical	sur - face	0-25	0-50	Total
I978	25.05-02.06	39	IKS-80	45	38	2	36	I2I
	I7.07-29.07	45	IKS-80	58	38	-	38	I34
	Total	84		I03	76	2	74	255
I979	07.04-20.04	42	IKS-80	55	40	-	40	I35
	03.05-I0.05	42	IKS-80	53	39	-	39	I3I
	Total	84		I08	79	-	79	266
I980	I9.03-3I.03	54	IKS-80	53	48	-	48	I49
	02.05-I2.05	56	IKS-80	53	48	-	48	I49
	3I.05-II.06	6I	IKS-80	6I	55	-	55	I7I
	Total	I7I		I67	I5I	-	I5I	469
I98I	22.03-05.04	47	IKS-80	47	-	-	-	47
	23.04-30.04	48	IKS-80	48	-	-	-	48
	2I.05-30.05	48	IKS-80	48	-	-	-	48
	Total	I43		I43				I43
I983	08.03-22.03	4I	IKS-80	37	3I	36	-	I04
	I6.04-29.04	80	IKS-80	80	80	79	-	239
	24.05-3I.05	4I	IKS-80 vertical Bongo-61 (0-50)	4I	4I	-	4I	I23
	Total	I62		I58	I52	II5	4I	466
Total number of stations		644		679	458	II7	345	I599

Table 2. Species composition of ichthyoplankton on the Flemish Cap in 1978.

Nos.	Species	I3.05-2.06						I7.07-29.07					
		eggs, stages of development					larvae	eggs, stages of development					larvae
		I	II	III	IV	Σ		I	II	III	IV	Σ	
1.	Cyclotone sp.	–	–	–	–	–	7	–	–	–	–	–	I4
2.	Maurolicus mülleri (Gmelin)	I	–	–	–	I	–	–	–	–	–	–	–
3.	Argentina silus Ascanius	–	–	–	–	–	I	–	–	–	–	–	–
4.	Nansenia groenlandica (Reinhardt)	–	–	–	–	–	I	–	–	–	–	–	–
5.	Benthosema glaciale (Reinhardt)	–	–	–	–	–	5	–	–	–	–	–	I6
6.	Anguilliformes g. sp.	–	–	–	–	–	–	–	–	–	–	–	I
7.	Brosme brosme (Ascanius)	I4	7	I	–	22	–	–	–	–	–	–	–
8.	Rhinonemus sp.	4	–	–	–	4	–	–	–	–	–	–	–
9.	Gadus morhua morhua Linné	I	I	9	–	II	–	9	I5	6	–	30	–
10.	Anarhichas lupus Linné	–	–	–	–	–	I	–	–	–	–	–	–
11.	Ammodyites sp.	–	–	–	–	–	4	–	–	–	–	–	–
12.	Sebastes spp.	–	–	–	–	–	35I8	–	–	–	–	–	III
13.	Hippoglossus hippoglossus (Linné)	–	–	–	–	–	–	–	–	–	–	–	–
14.	Hippoglossoides platessoides limandoides (Bloch)	I27	I72	33	4	336	–	–	–	–	I	I	–

Table 3. Species composition of ichthyoplankton on the Flemish Cap in 1979.

Nos.	Species	7.04-20.04						3.05-I0.05					
		eggs, stages of development					larvae	eggs, stages of development					larvae
		I	II	III	IV	Σ		I	II	III	IV	Σ	
I	2	3	4	5	6	7	8	9	I0	II	I2	I3	I4
1.	Cyclotone sp.	–	–	–	–	–	2	–	–	–	–	–	I2
2.	Maurolicus mülleri (Gmelin)	–	–	–	–	–	–	–	–	–	–	–	I
3.	Benthosema glaciale (Reinhardt)	–	–	–	–	–	69	–	–	–	–	–	9
4.	Brosme brosme (Ascanius)	–	–	–	–	–	–	53	9	4	–	66	–
5.	Rhinonemus cimbrius Linné	–	–	–	–	–	4	–	–	–	–	–	3
6.	Urophycis chuss (Walbaum)	3	–	–	–	3	20	–	–	–	–	–	I0
7.	Molva molva (Linné)	–	I	–	–	I	–	–	–	–	–	–	–
8.	Melanogrammus aeglefinus (Linné)	I	–	–	–	I	–	–	I	–	–	I	–
9.	Gadus morhua morhua Linné	2	I	–	–	3	II	5	–	–	–	5	I8
10.	Anarhichas denticulatus Kröyer	–	–	–	–	–	I	–	–	–	–	–	–
11.	A. lupus Linné	–	–	–	–	–	I						2
12.	Lumpenus lampretaeformis (Walbaum)	–	–	–	–	–	3	–	–	–	–	–	I
13.	Leptoclinus maculatus (Fries)	–	–	–	–	–	–	–	–	–	–	–	4
14.	Lumpenus sp.	–	–	–	–	–	I	–	–	–	–	–	I
15.	Sebastes spp.	–	–	–	–	–	23154	–	–	–	–	–	56901
16.	Triglops murrayi Günter	–	–	–	–	–	I	–	–	–	–	–	–
17.	Myoxocephalus scorpius (Linné)	–	–	–	–	–	I	–	–	–	–	–	–
18.	Hippoglossus hippoglossus (Linné)	7	2	–	–	9	–	I	2	4		7	–
19.	Hippoglossoides platessoides	3	–	I	–	4		I00	6I	I		I62	–
	limandoides (Bloch)		–	–	–	–		–	–	I	I	2	2
20.	Limanda ferruginea (Storer)	–	–	–	–	–		–	–	I			
21.	Gliptocephalus cynoglosus (Linné)	–	–	–	–	–	I	–	–	–	–	–	–

Table 4. Species composition of ichthyoplankton on the Flemish Cap in 1980.

Nos.	Species	19.03-31.03 eggs, stages of development I	II	III	IV	Σ	larvae	2.05 - 12.05 eggs, stages of development I	II	III	IV	Σ	larvae	31.05 - 11.06 eggs, stages of development I	II	III	IV	Σ	larvae
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1.	Mallotus villosus villosus (O.Müller)	–	–	–	–	–	I*	–	–	–	–	–	–	–	–	–		–	–
2.	Cyclotone sp.	–	–	–	–	–	5	–	–	–	–	–	7	–	–	–		–	5
3.	Maurolicus mülleri (Gmelin)	–	–	–	–	–	–	I	–	–	–	I	–	–	–	–		–	
4.	Argentina silus Ascanius	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–		–	2
5.	Bathylagidae sp.	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–		–	–
6.	Benthosema glaciale (Reinhardt)	–	–	–	–	–	5	–	–	–	–	–	2I	–	–	–		–	24
7.	Notoscopelus sp.	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–		–	–
8.	Diogenichthys atlanticus (Taning)	–	–	–	–	–	–	–	–	–	–	–	I6	–	–	–		–	–
9.	Brosme brosme (Ascanius)	–	–	–	–	–	–	I6	2	I	6	25	–	–	–	–		–	–
10.	Rhinonemus cimbrius Linné	–	–	–	–	–	–	2	–	–	–	2	6	4	I	2		7	3
11.	Urophycis chestri (Goode and Bean)	–	–	–	–	–	2	–	–	–	–	–	I	–	–	–		–	3
12.	Urophycis tenius (Mitchill)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		–	I
13.	Urophycis sp.												4						6
14.	Molva molva (Linné)	4	–	–	–	4	–	2I	I6	4	3	44	–	2	I	2	I	6	–
15.	Gadus morhua morhua Linné	I3	II	29	2	55	I	2	3	9		I4	I0	–	–	–	–	–	4
16.	Anarhichas lupus Linné	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–
17.	A. minor Olafsen	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	2
18.	Stichaeidae g.sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
19.	Lumpenus lampretaeformis (Walbaum)	–	–	–	–	–	4	–	–	–	–	–	I	–	–	–	–	–	I
20.	Ammodytes dubius Reinhardt	–	–	–	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–
21.	Thunnus atlanticus (Lesson)	–	–	–	–	–	–	–	–	–	–	–	I	–	–	–	–	–	–
22.	Myoxocephalus scorpius (Linné)	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–
23.	Sebastes spp.						6368						33639						28533
24.	Hippoglossoides platessoides limandoides (Bloch)	59	22	–	–	8I	–	I85	66	9	2	262	–	I	–	–	–	I	–

Table 5. Species composition of ichthyoplankton on the Flemish Cap in 1981.

Nos.	Species	22.03 – 5.04: eggs, stages of development I	II	III	IY	Σ	larvae	23.04 – 30.04: eggs, stages of development I	II	III	IY	Σ	larvae	21.05 – 30.05: eggs, stages of development I	II	III	IY	Σ	larvae
1.	Cyclotone sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
2.	Myctophidae g.sp.	–	–	–	–	–	I	–	–	–	–	–	I	–	–	–	–	–	6
3.	Brosme brosme (Ascanius)	–	–	–	–	–	–	I	–	I	–	2	–	I	–	–	–	I	–
4.	Melanogrammus aeglefinus (Linné)	–	2	–	–	2	–	I	–	I	–	2	–	–	–	–	–	–	–
5.	Gadus morhua morhua Linné	27	26	I3	3	69		7	6	4	I	I8	5						2
6.	Chirolophis ascanii (Walbaum)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	I
7.	Sebastes spp.	–	–	–	–	–	77	–	–	–	–	–	I096	–	–	–	–	–	285
8.	Hippoglossoides platessoides limandoides (Bloch)	I	–	–	–	I	–	8	2	–	–	I0	–	I2	–	–	–	I2	–

Table 6. Species composition of ichthyoplankton on the Flemish Cap in 1983.

Nos.	Species	8.03 – 22.03: eggs, stages of development I	II	III	IY	Σ	larvae	16.04 – 29.04: eggs, stages of development I	II	III	IY	Σ	larvae	24.05 – 31.05: eggs, stages of development I	II	III	IY	Σ	larvae
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1.	Cyclothone braueri Yespersen et Taning	–	–	–	–	–	I5	–	–	–	–	–	–	–	–	–	–	–	I
2.	Gonostomatidae	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	I
3.	Argyropelecus olfersi (Cuvier)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	I
4.	Chauliodes sloanei Bloch et Schneder	–	–	–	–	–	I	–	–	–	–	–	–	–	–	–	–	–	–
5.	Protomyctophum arcticum (Lutken)	–	–	–	–	–	–	–	–	–	–	–	I	–	–	–	–	–	–
6.	Myctophum punctatum Rafinesque	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	I
7.	Benthosema glaciale (Reinhardt)	–	–	–	–	–	27	–	–	–	–	–	I6	–	–	–	–	–	2I
8.	Ceratoscopelus maderensis (Lowe)	–	–	–	–	–	–	–	–	–	–	–	I	–	–	–	–	–	–
9.	Myctophidae g. sp.	–	–	–	–	–	I	–	–	–	–	–	–	–	–	–	–	–	9
10.	Anguilliformes g.sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
11.	Brosme brosme (Ascanius)	I	–	–	–	I	–	II	4	–	I	I6	–	8	I	–	–	9	–
12.	Urophycis chuss (Walbaum)	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–
13.	Pollachius vireas (Linné)	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–	2
14.	Gadus morhua morhua Linné	30	46	I7	6	99		3I	23	6	I4	74	I9		3	4	I	8	3
15.	Anarhichas minor Olafsen	–	–	–	–	–	I	–	–	–	–	–	I	–	–	–	–	–	–
16.	Lumpenus lampretaeformis (Walbaum)	–	–	–	–	–	I	–	–	–	–	–	I	–	–	–	–	–	–
17.	Ammodytes dubius Reinhardt	–	–	–	–	–	–	–	–	–	–	–	II	–	–	–	–	–	3
18.	Scomber scombrus Linné	–	–	–	–	–	–	–	–	–	–	–	45	–	–	–	–	–	–
19.	Sebastes spp.	–	–	–	–	–	II5	–	–	–	–	–	II428	–	–	–	–	–	4993
20.	Hippoglossoides platessoides limandoides (Bloch)	6	–	–	–	6	–	366	400	20	3	789	–	–	7	5	–	9	–
21.	Limanda ferruginea (Storer)	I	–	–	–	I	–	–	–	–	–	–	–	–	–	–	–	–	–

Table 7. Data on larvae of redfishes taken by research vessels on the Flemish Cap in 1978-1981 and 1983.

Year	Date	Number of stations	Abundance in survey area, spec.x 10^{12}	Water temperature at 50 m layer of standard ground, min-max
I978	25.05-02.06	39	I,46	I.06 - I0.34
	I7.07-22.07	45	0,08	0.I2 - I4.58
I979	07.04-20.04	42	I,62	I.8I - 8.04
	03.05-I0.05	42	4,38	0.08 - 9.I2
I980	I9.03-3I.03	54	0,25	I.33 - 7.50
	02.05-I2.05	56	3,54	0.70 - I0.54
	3I.05-II.06	61	2,89	I.30 - 6.26
I98I	22.03-05.04	47	0,I9	0.22-8,96
	23.04-30.04	48	3,03	I.94 - 6.I0
	2I.05-30.05	48	0,79	I.66 - 7.68
I983	08.03-22.03	38	0,06	0.68 - 6,32
	I6.04-20.04	7I	I5,37	-0.I8 - 5.28
	24.05-3I.05	40	I,59	-I.29 - II.34

Table 8. Maturity of <u>Sebastes mentella</u> females from trawl catches taken by research vessels on the Flemish Cap in 1978-1983: %.

Month, year		GONAD MATURITY STAGES*												Number of spec.
		I	II	III	IY	Y	YI	YI-II	YII	YIII	IX	IX-II	IX-III	
January	I978		I0,3	3,I	I4,I	65,2	4,I	3;I	-	-	-	-	-	290
July	I978	3,97	I4,82	54,49	6,05	-	-	-	-	0,2I	-	20;46	-	479
August	I978		4,0	5I,7	4,0	-	-	-	-	I,0	0,5	38,8	-	20I
Mar, Apr	I979	0,9	49,4	3,8	I,I	I,8	I,8	-	2,4	I5,3	6,I	I7,4	-	786
June	I979	24,2	37,0	I0,7	-	0,3	-	-	I,0	0,8	-	26,0	-	384
September	I979		II,I	39,9	3I,8	-	I,8	3,0	-	-	-	I2,4	-	396
Apr, May	I980		II,2	6,6	-	0,6	0,2	-	0,4	3,5	3,2	-	74,3	534
Jul, Aug	I980		38,7	43,5	9,2	-	-	-	-	0,3	-	-	8,3	I083
June, July	I98I		45,6	27,5	-	I,0	2,0	-	4,4	-	-	-	I9,5	502
December	I98I		35,0	7,0	I2,0	44,0	0,6	-	-	-	0,6	0,8	-	802
January	I982		48,0	I,5	3,5	6,0	8,0	-	28,0	2;0	I,5	I,5	-	333
April	I982		26,4	2,2	-	-	I,2	2,5	0,I	I,4	37,0	9,4	I9,8	727
July	I982		60,6	32,8	I,3	-	-	-	-	-	-	5,3	-	527
February	I983	I,8	2I,5	I,8	I0,8	2I,5	39,2	-	I,8	-	-	I,8	-	39I
May	I983	0,2	29,7	I4,5	2,0	0,I	0,6	0,8	I,I	I,2	I,8	48,0	-	799

* by the scale developed by V.P.Sorokin (1958)

Table 9. Maturity of Sebastes marinus females from trawl catches taken by research vessels on the Flemish Cap in 1978-1983: %.

Month, year		GONAD MATURITY STAGES												Number of spec.
		I	II	III	IV	V	VI	VI–II	VII	VIII	IX	IX–II	IX–III	
January	I978	2,4	2I,6	I2,9	7,7	54,0	I,4	–	–	–	–	–	–	287
July	I978	4,0	3I,I	58,2	–	–	–	–	–	–	–	–	6,7	273
August	I978		7,0	70,4	–	–	–	–	–	–	–	–	22,6	7I
Mar, Apr	I979	–	80,8	–	–	3,8	–	–	II,6	3,8	–	–	–	26
June	I979	47,8	I5,2	2I,8	–	–	–	–	–	–	–	I5,2	–	46
September	I979	–	I9,0	53,4	I7,3	–	–	–	–	–	–	I0,3	–	58
June, July	I98I	–	87,9	5,0	–	–	–	–	I,0	–	–	6,I	–	99
December	I98I	–	58,8	3,0	23,5	I4,7	–	–	–	–	–	–	–	34
April	I982	–	38,6	5,3	0,9	–	0,9	–	3,5	2,6	2I,I	9,6	I7,5	II4
February	I983	–	49,I	26,4	24,5	–	–	–	–	–	–	–	–	53

*by the scale developed by V.P.Sorokin (1958)

Table 10. Maturity of cod females from trawl catches taken by research vessels on the Flemish Cap in 1978-1983, %.

Month, year		GONAD MATURITY STAGES								Number of spec.
		I	II	III	IV	IV–V	V	VI	VI–II	
January	I978	–	49,2	45,9	4,7	–	0,I	–	0,I	9I5
July	I978	5,43	43,27	0,65					20,65	460
August	I978	–	49,6	–	–	–	–	–	50,4	I49
March, April	I979	0,9	55,0	2,5	0,9	0,4	3,I	II,9	25,3	522
June	I979	8,I	67,8	–	–	–	–	0,5	23,6	584
Sep, Nov	I979	–	54,0	I0,7	–	–	–	0,5	34,8	I78
Apr, May	I980	–	65,0	0,2	–	–	–	0,2	34,6	507
July	I980	–	62,I	–	–	–	–	–	37,8	4I7
June, July	I98I	2,5	32,7	0,I	–	0,I	0,8	–	I4,I	388
December	I98I	–	79,2	I2,5	8,3	–	–	–	–	569
April	I982	–	79,8	0,4	–	0,8	0,8	5,5	I2,7	252
July	I982	–	I00,0	–	–	–	–	–	–	238
February	I983	–	92,4	7,6	–	–	–	–	–	2II
May	I983	5,5	8I,5	–	–	–	0,2	I,7	I0,I	476

Table 11. Maturity of cod males from trawl catches taken by research vessels on the Flemish Cap in 1978-1983, %.

Month, year		GONAD MATURITY STAGES							Number of spec.
		I	II	III	IY	Y	YI	YI–II	
January	I978	–	2I,9	37,7	40,0	–	–	0,4	I035
July	I978	6,35	60,24	5,4I	–	–	0,7I	27,29	425
August	I978	–	2I,0	49,3	I,5	0,8	–	27,4	I24
March, Apr	I979	0,9	40,9	2,9	2,4	I5,4	20,I	I7,4	667
June	I979	I0,4	65,3	0,I	–	0,I	6,0	I8,I	636
Sep, Nov	I979	–	39,3	39,8	3,I	–	–	I7,8	I63
Apr, May	I980	–	54,5	0,2	0,2	I,7	23,6	I9,8	529
July	I980	–	55,0	–	–	–	I,7	43,3	4II
June, July	I98I	3,2	25,8	4,0	2,5	–	4,I	I0,I	384
December	I98I	–	60,7	I6,2	I9,6	3,5	–	–	593
April	I982	I8,3	34,9	2,4	I2,3	I0,5	I0,8	I0,8	333
July	I982	–	94,3	4,5	–	–	–	I,2	246
February	I983	–	88,2	5,I	6,7	–	–	–	3I4
May	I983	I3,8	70,6	I,3	0,8	0,4	2,8	I0,3	528

Table 12. Maturity of American plaice females from trawl catches taken by research vessels on the Flemish Cap in 1978-1983, %.

Month, year		GONAD MATURITY STAGES								Number of spec.
		I	II	III	IY	IY–Y	Y	YI	YI–II	
January	I978	–	84,5	II,I	4,4	–	–	–	–	3I6
July	I978	2,9	54,3	7,3	–	–	–	0,2	35,3	5I0
August	I978	–	35,2	II,2	–	–	0,4	I,2	52,0	250
March	I979	–	46,4	I0,4	29,6	–	0,8	–	I2,8	I25
June	I979	–	24,6	3,6	8,7	I,4	0,7	I,4	59,6	I38
September	I979	–	42,5	50,0	–	–	–	–	7,5	80
May	I980	–	I7,6	27,7	30,3	I0,9	–	–	I3,5	II9
July	I980	–	34,6	28,5	4,7	0,9	0,5	–	30,8	2I4
June, July	I98I	3,3	33,3	I6,5	I3,2	3,0	I,7	0,3	28,7	303
December	I98I	–	I7,7	22,0	58,5	I,8	–	–	4,0	64
April	I982	–	35,7	I8,8	20,2	–	2,9	2,5	I9,9	277
July	I982	–	48,4	3,I	0,8	–	–	–	47,7	I30
May	I983	–	67,8	5,0	3,7	–	3,I	9,4	II,0	456

Table 13. Maturity of American plaice males from trawl catches taken by research vessels on the Flemish Cap in 1978-1983, %.

Month, year		GONAD MATURITY STAGES							Number spec
		I	II	III	IV	V	VI	VI–II	
January	I978		I3,4	4,8	79,4	I,2		I,2	I64
July	I978	6,9	9,0	4,9	22,9	II,I	32,3	I2,9	288
August	I978		8,0	II,4	9,3	27,7	26,7	I6,9	3I4
March	I979		I2,9	9,4	23,6	49,4	3,5	I,2	85
June	I979		2,4			48,0	42,4	7,2	I25
September	I979		40,0	3I,I	8,9	6,7		I3,3	45
May	I980		5,I	0,6	4,0	80,I	9,6	0,6	I77
July	I980		7,7	5,9	2,4	36,7	40,8	6,5	I69
June, July	I98I	3,0	I0,7	I0,7	I7,3	32,5	I8,I	7,7	27I
December	I98I		9,3	6,7	75,0	7,5	4,5		5I
April	I982	I,I	28,5	4,5	24,0	82,2	9,5	6,2	I79
July	I982		I6,I	49,4	5,7	3,5	6,9	I8,4	87
May	I983		I2,2	6,4	I5,8	50,7	7,8	7,I	295

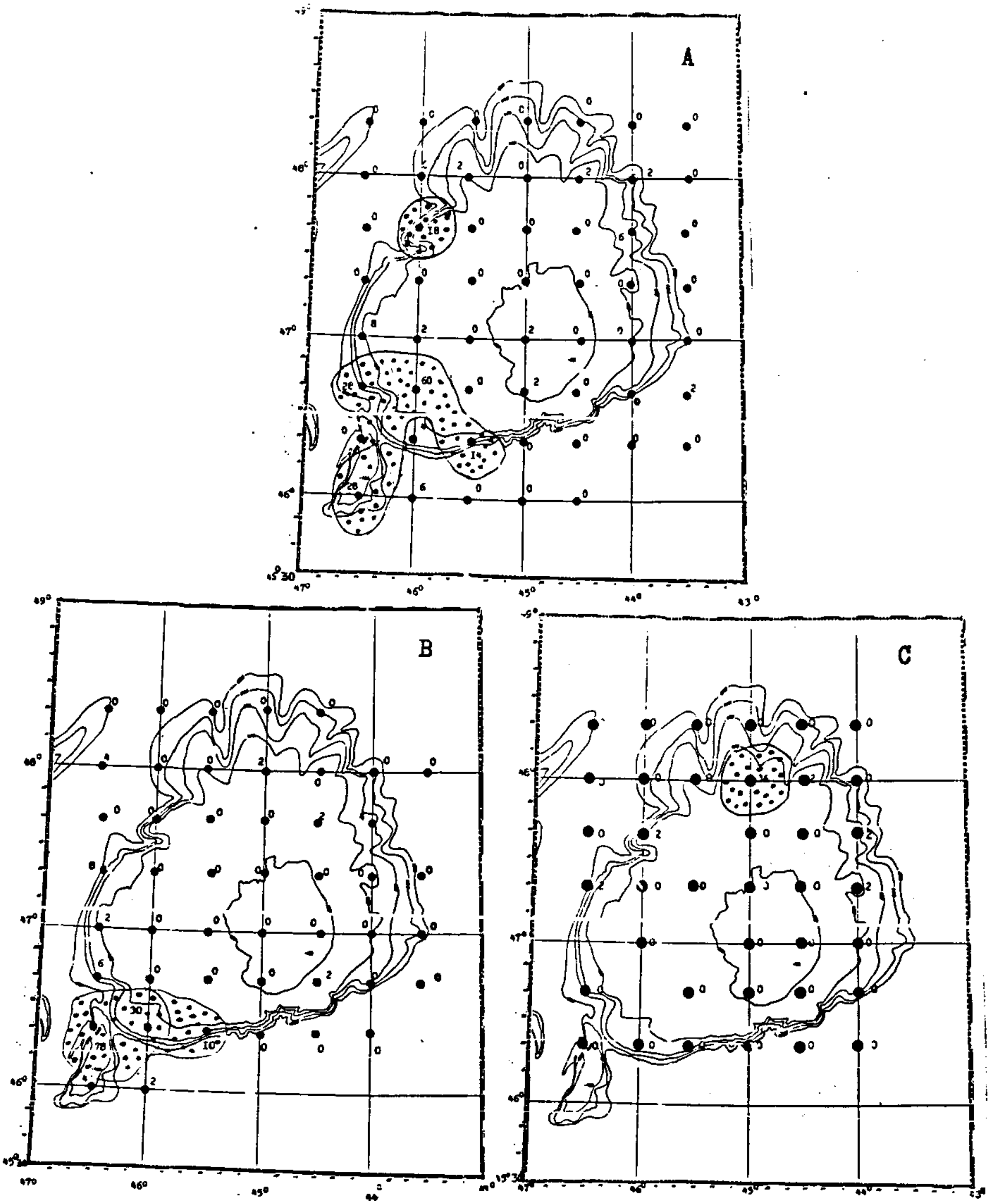

Fig. I Distribution of larval redfishes on Flemish Cap:
A - March I9-3I, I980; B - March 22 - April 5, I98I;
C - March 8-22, I983.

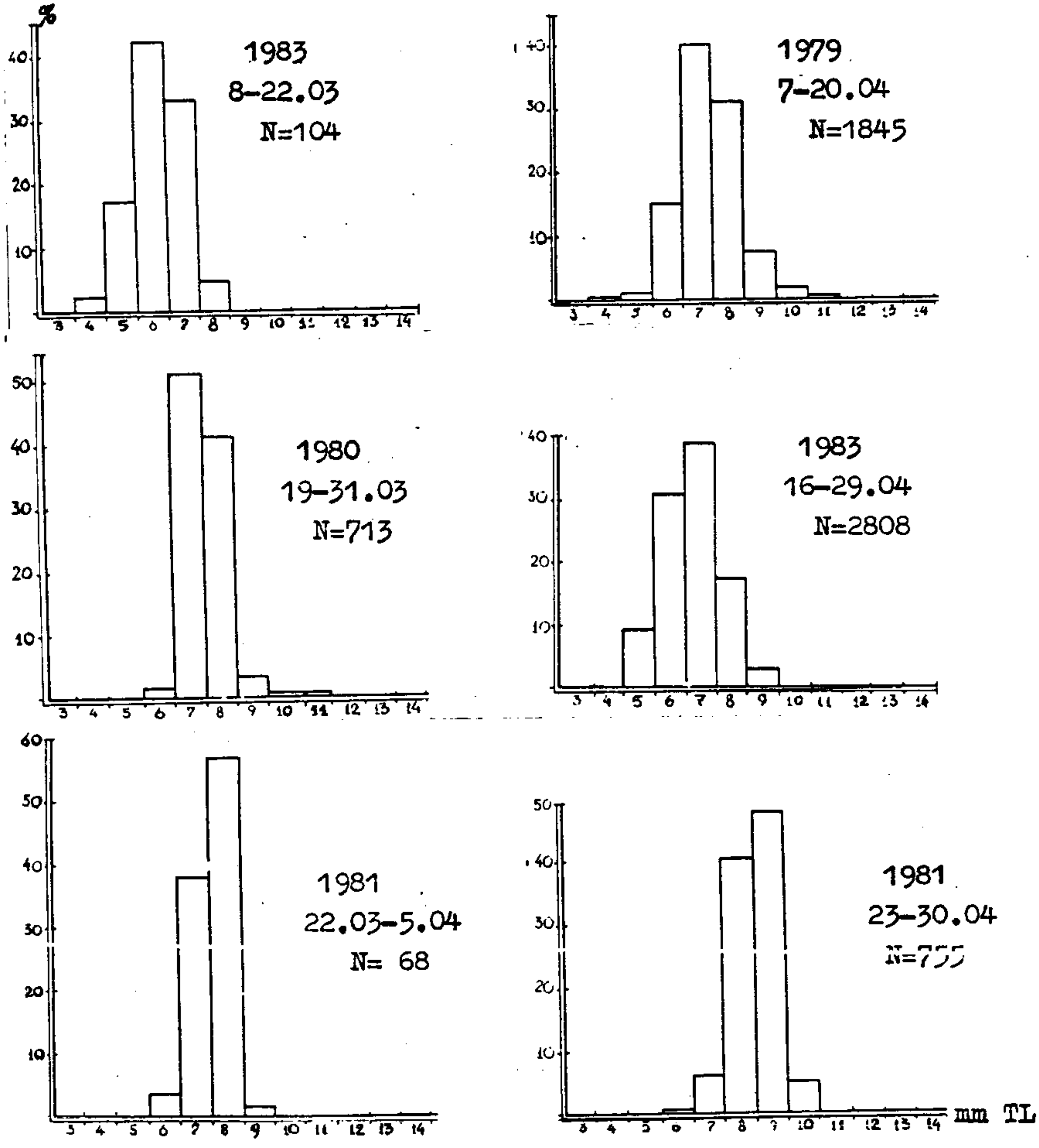

Fig.2 Length ratios (%) in larval redfishes on Flemish Cap in March - April of different years.

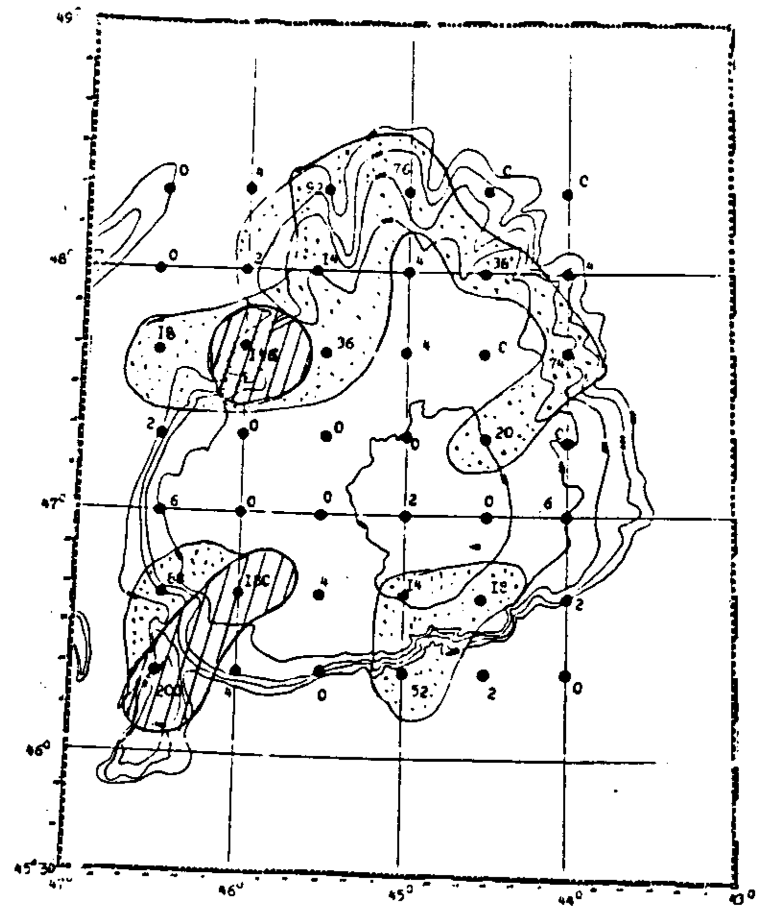

Fig. 3. Distribution of larval redfishes on Flemish Cap during April 7-20, 1979.

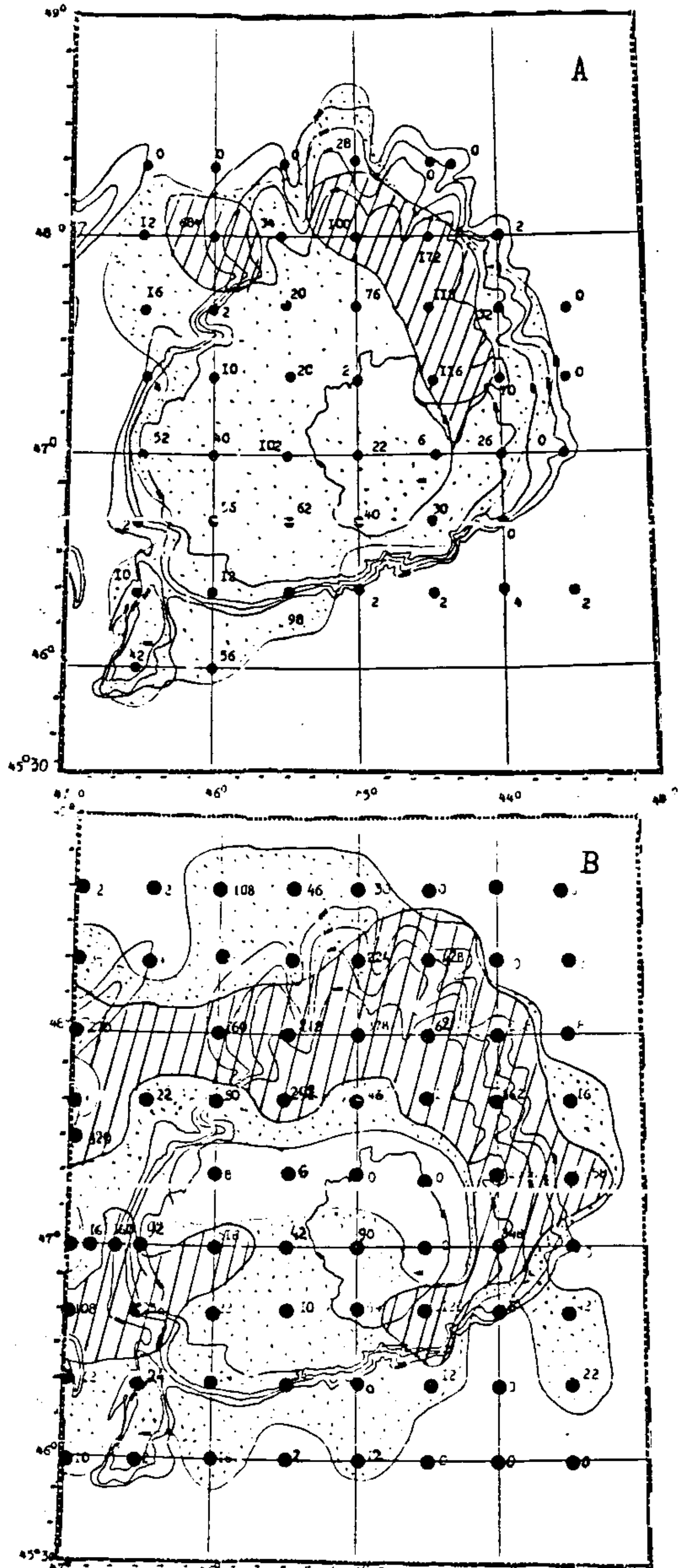

Fig.4 Distribution of larval redfishes on Flemish Cap:
A - April 23-30, 1981; B - April 16-29, 1983.

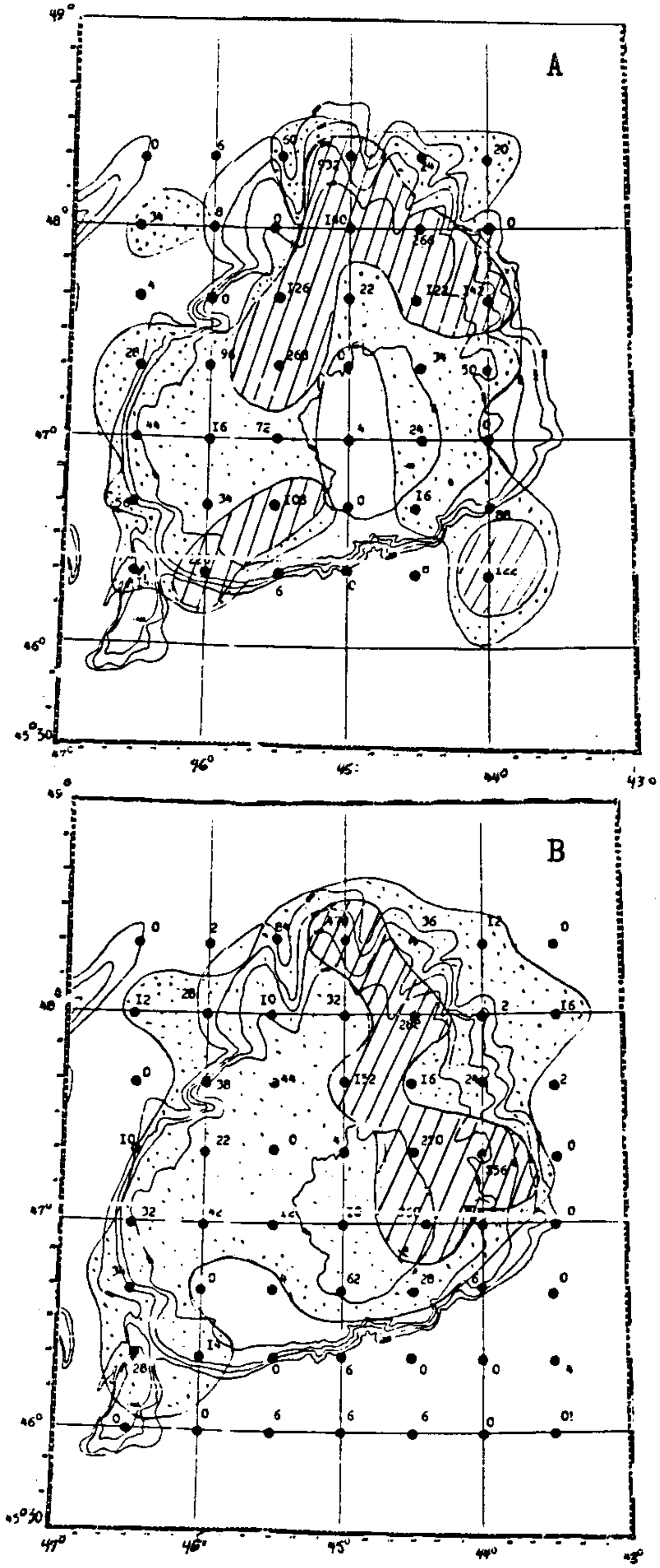

Fig.5 Distribution of larval redfishes on Flemish Cap:
A - May 3-10, 1979; B - May 2-12, 1980

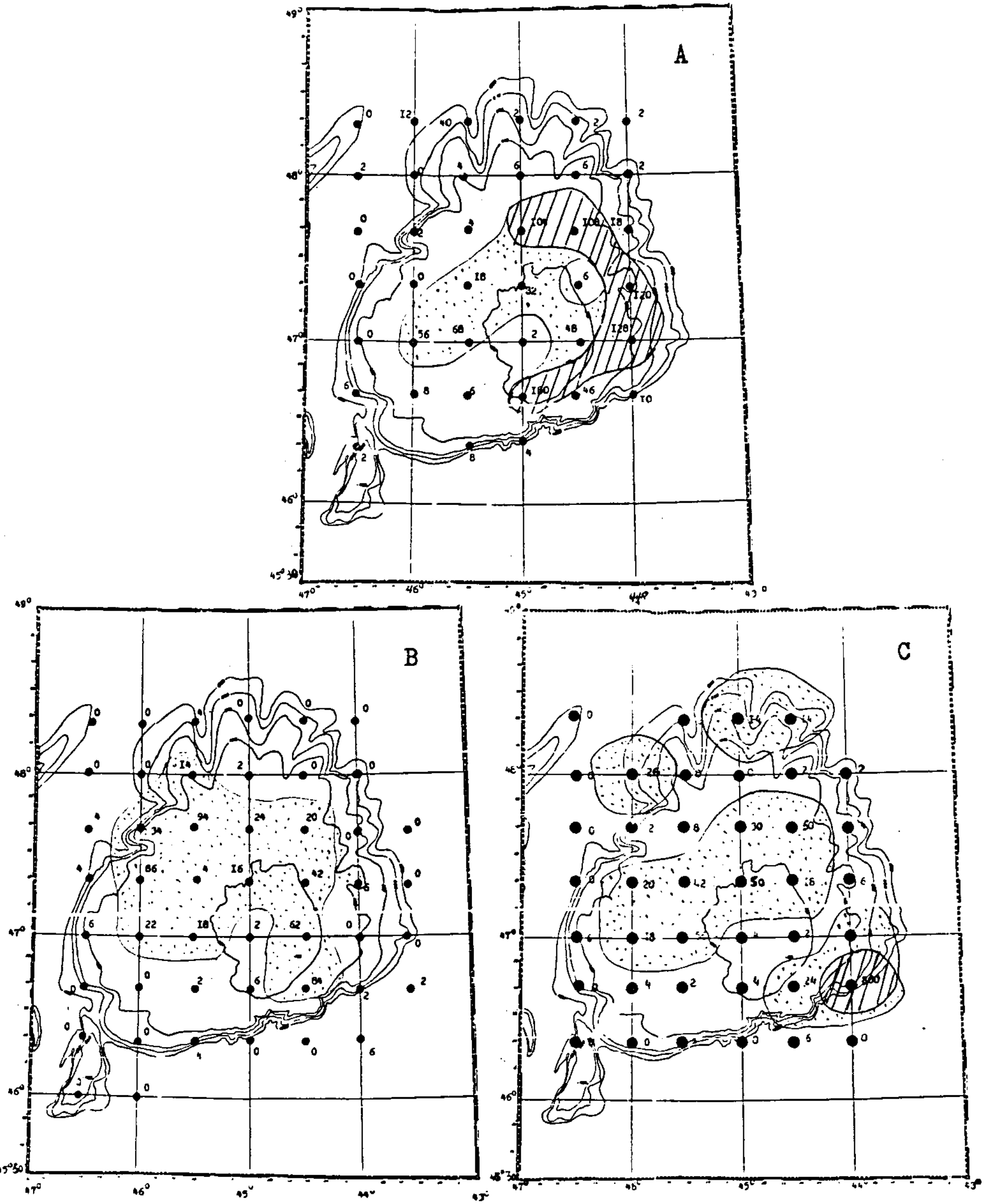

Fig.6 Distribution of larval redfishes on Flemish Cap:
A - May 25 - June 2, 1978; B - May 21-30, 1981.
C - May 24-31, 1983.

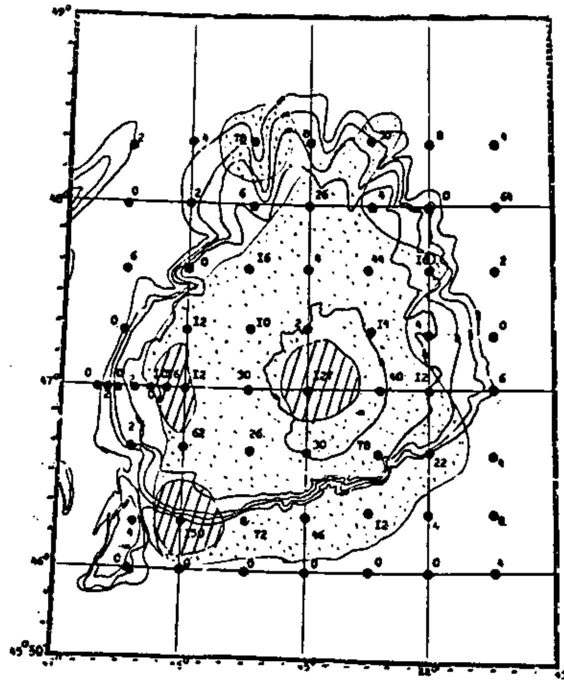

Fig.7 Distribution of larval redfishes on Flemish Cap the period from May 3I to June II, I980.

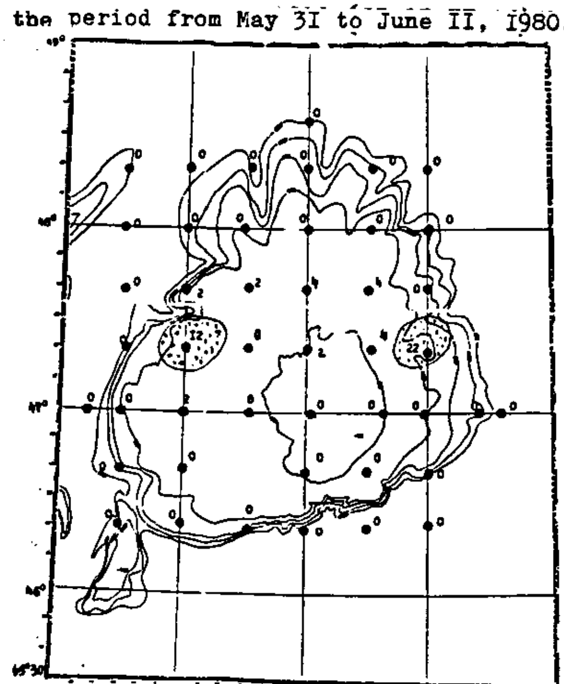

Fig.8 Distribution of larval redfishes on the Flemish Cap Bank in July I7-29, I978.

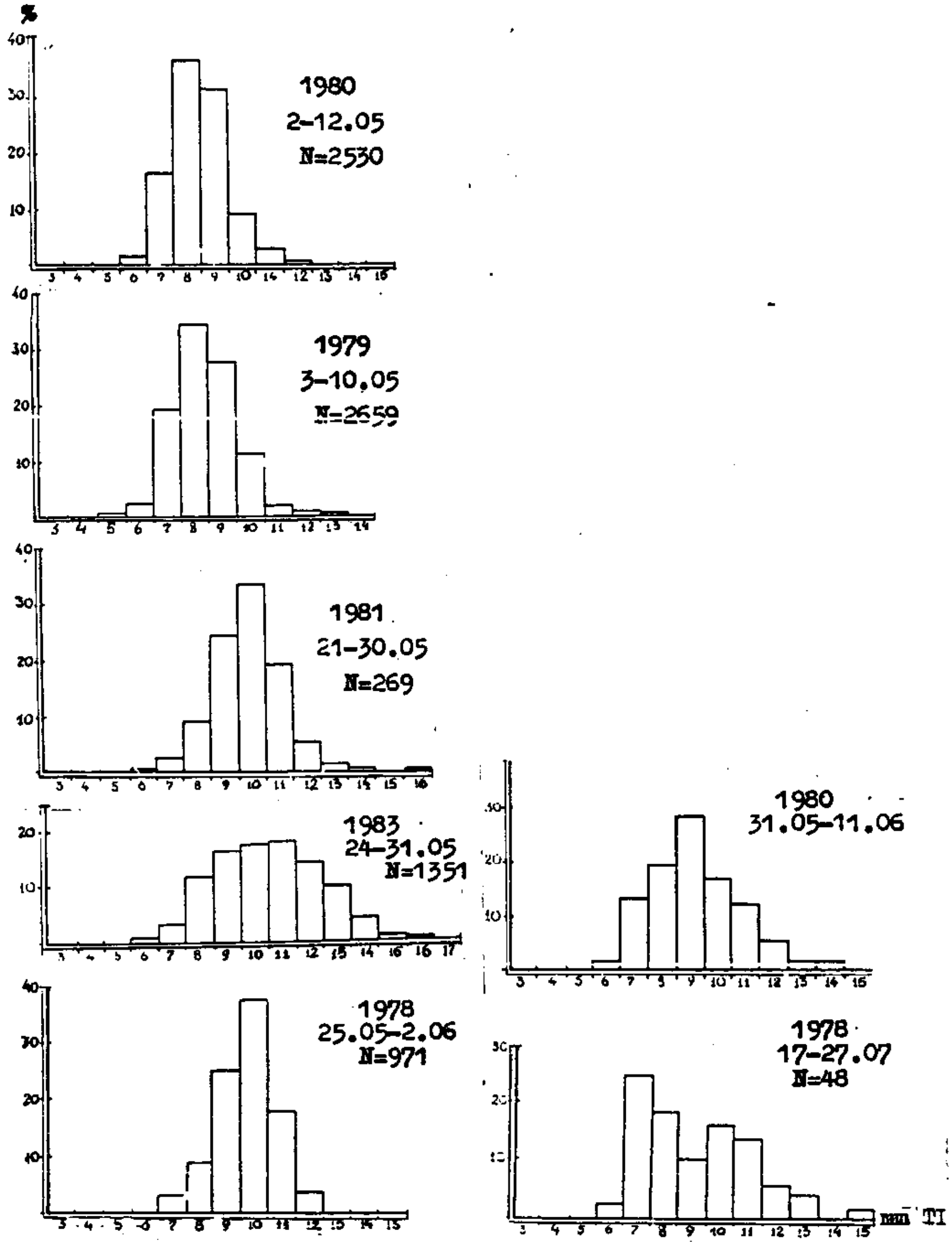

Fig. 9 Length ratios (%) in larval redfishes on the Flemish Cap Bank in May, June and July of different years.

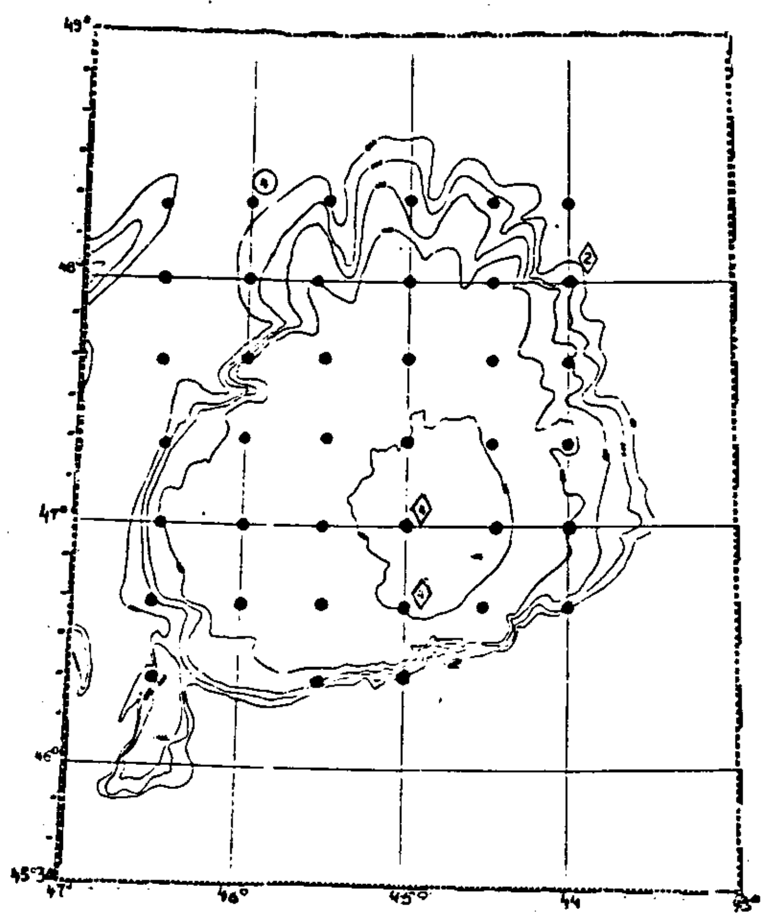

Fig. IO Distribution of larval cod on the Flemish Cap Bank in March (□), April (△), May (○), June (⏢) and July (◇), 1978.

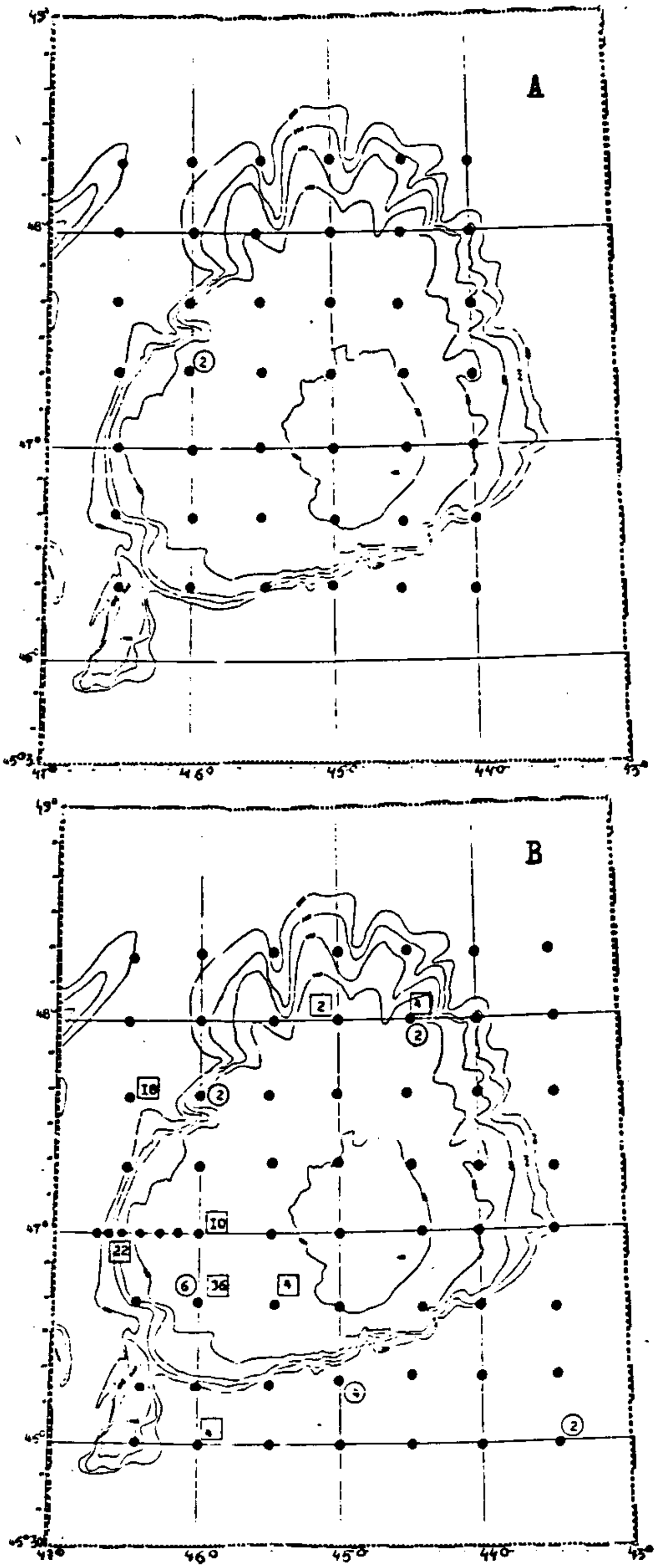

Fig. 11. Distribution of cod eggs on the Flemish Cap Bank by months in 1979 (A) and 1980 (B).

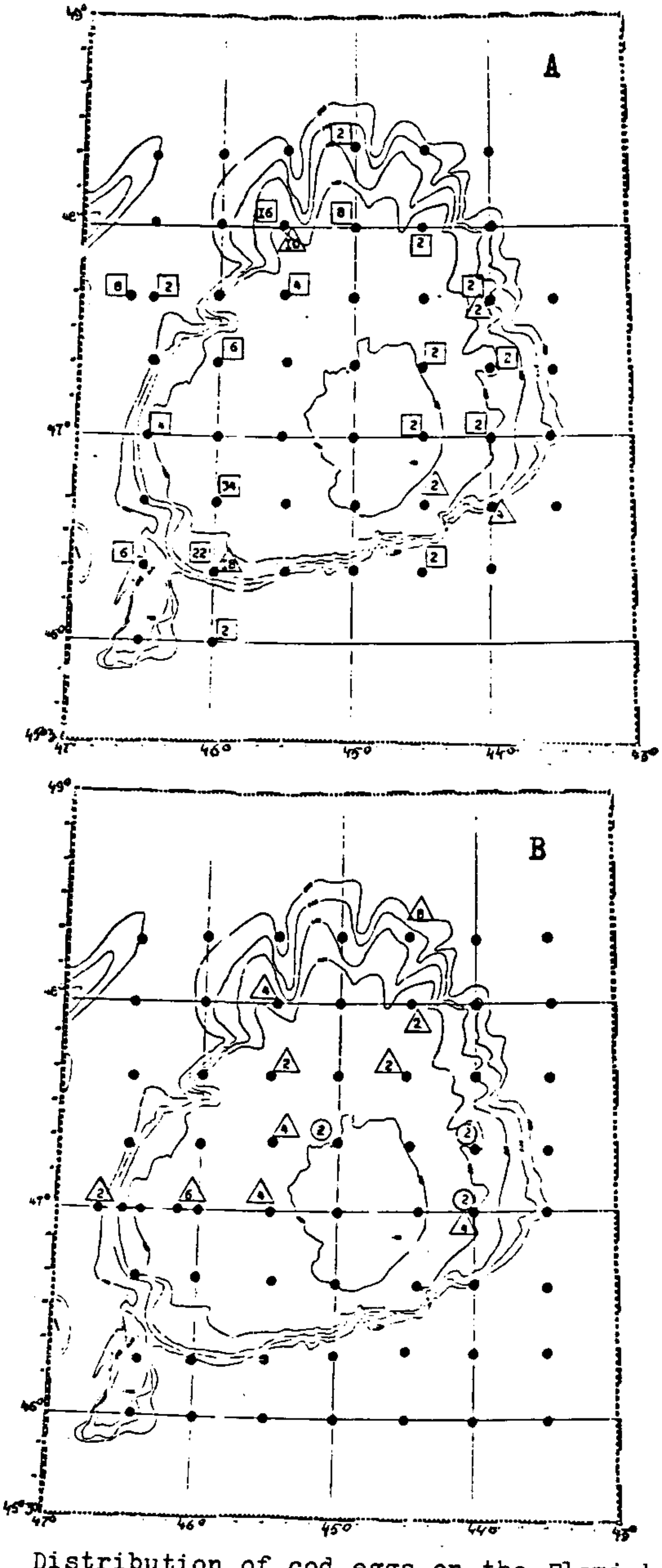

Fig. I2 Distribution of cod eggs on the Flemish Cap Bank in I98I (A) and I983 (B) by months.

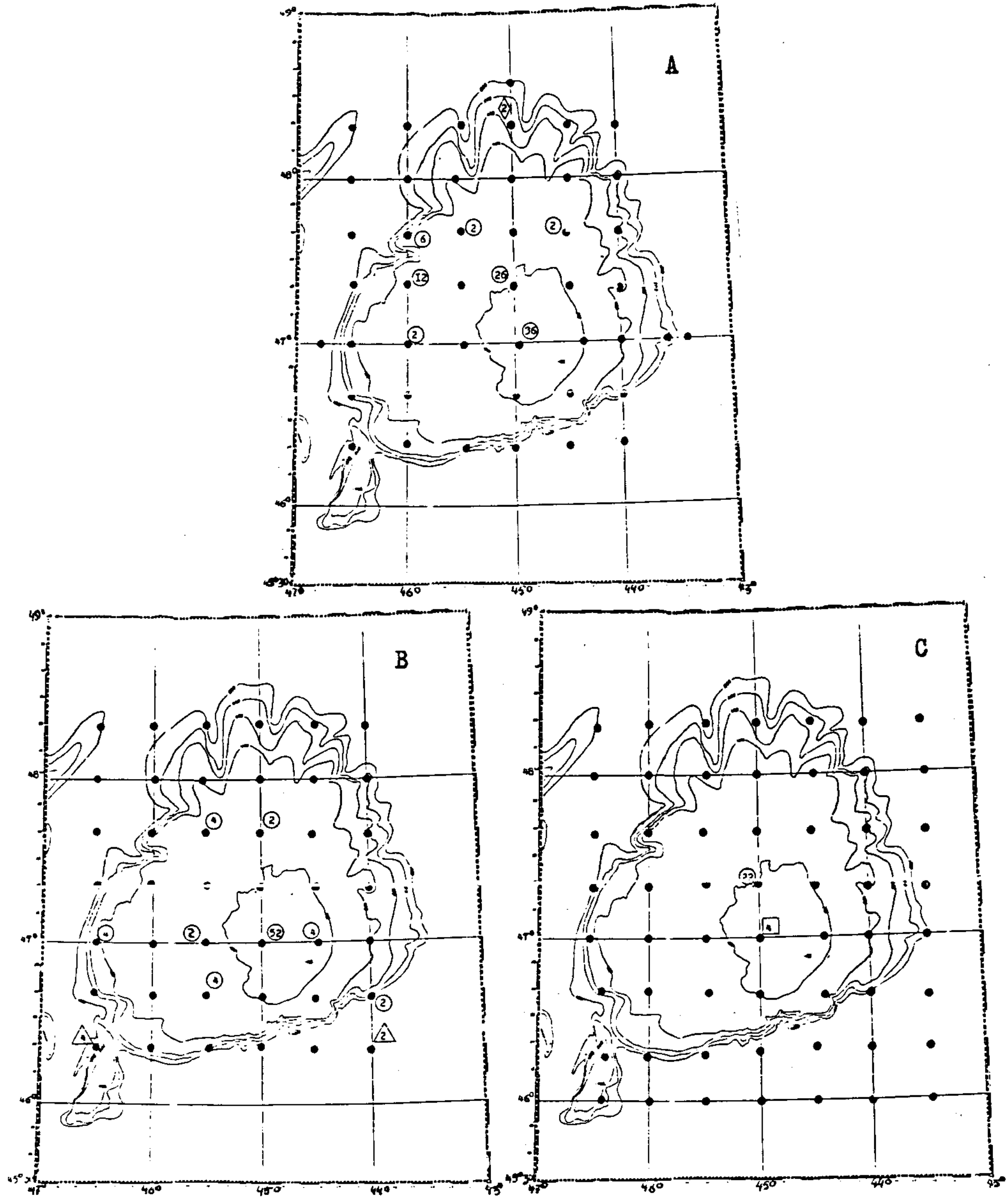

Fig. I3. Distribution of long rough dab eggs on the Flemish Cap Bank by months in I978 (A). I979 (B) and I980 (C).

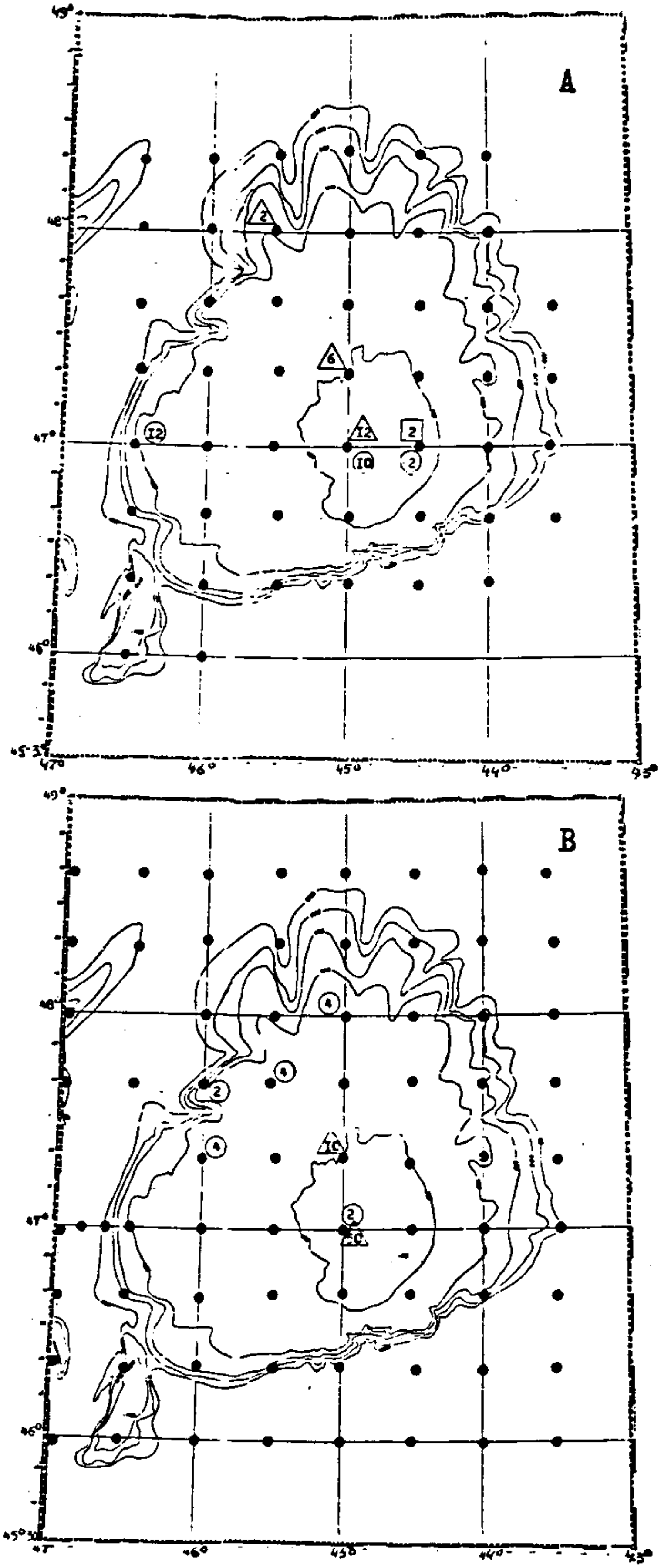

Fig. I4 Distribution of long rough dab eggs on the Flemish Cap Bank in I98I (A) and I983 (B) by months.

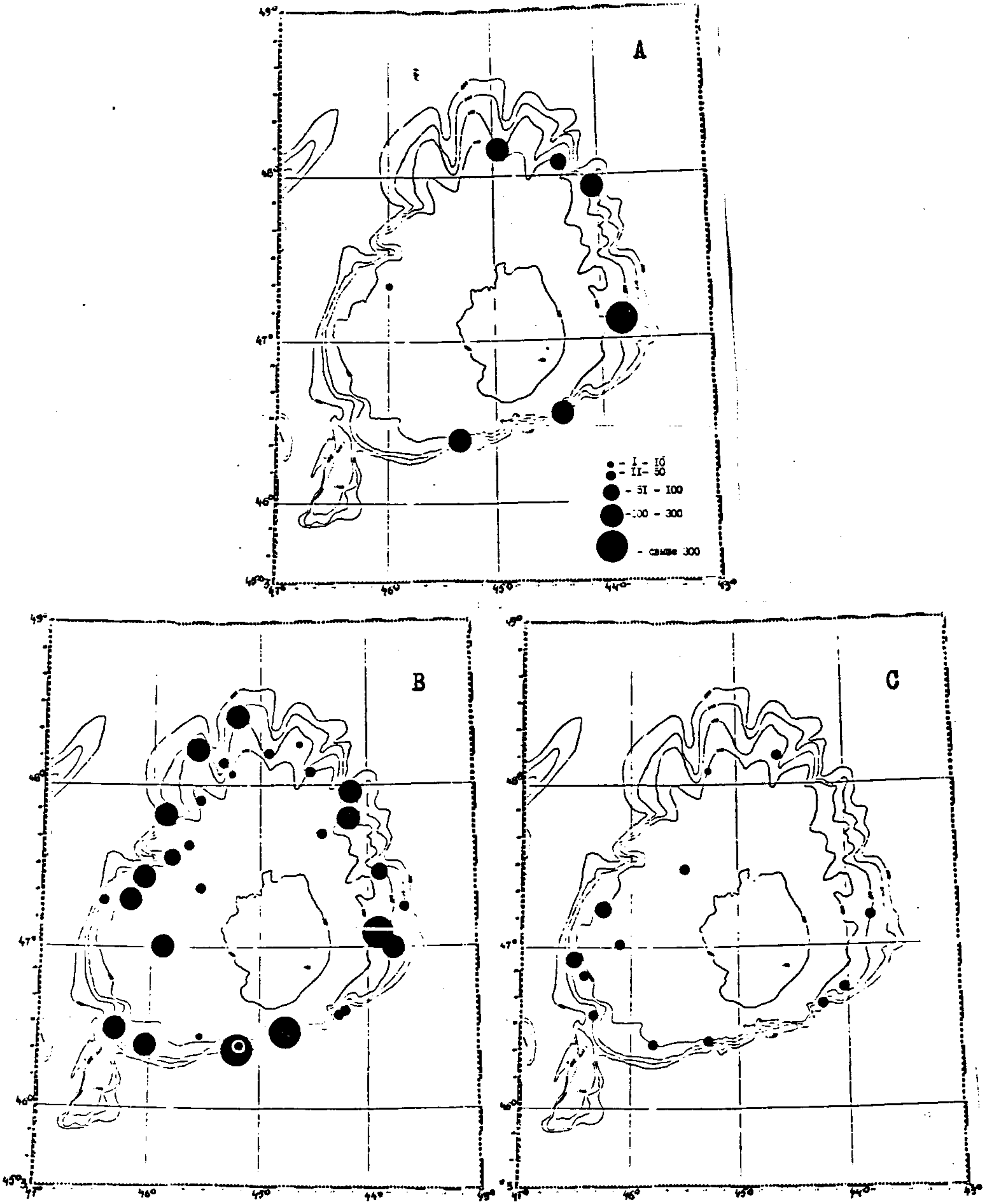

Fig. 15. Distribution of spawning females of Sebastes mentella on the Flemish Cap Bank in March 1979 (A), April 1980 and 1982 (B) and May 1979-83 (C) based on trawl surveys. Females numbers per trawling hour shown.

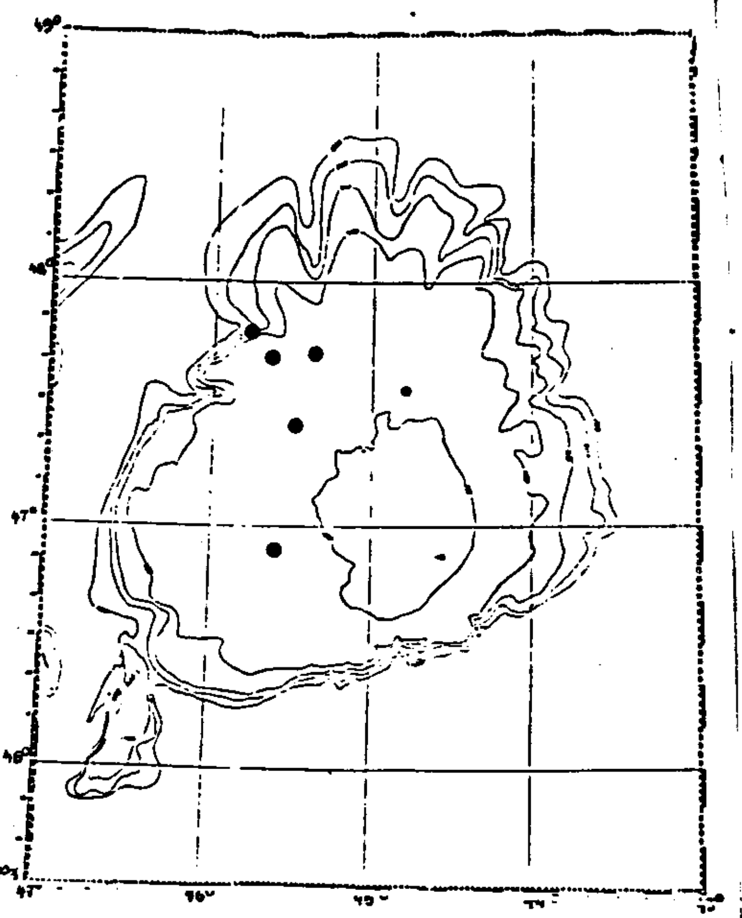

Fig. I6 Distribution of spawning females of sebastes marinus in April I980 and I982 based on trawl surveys.

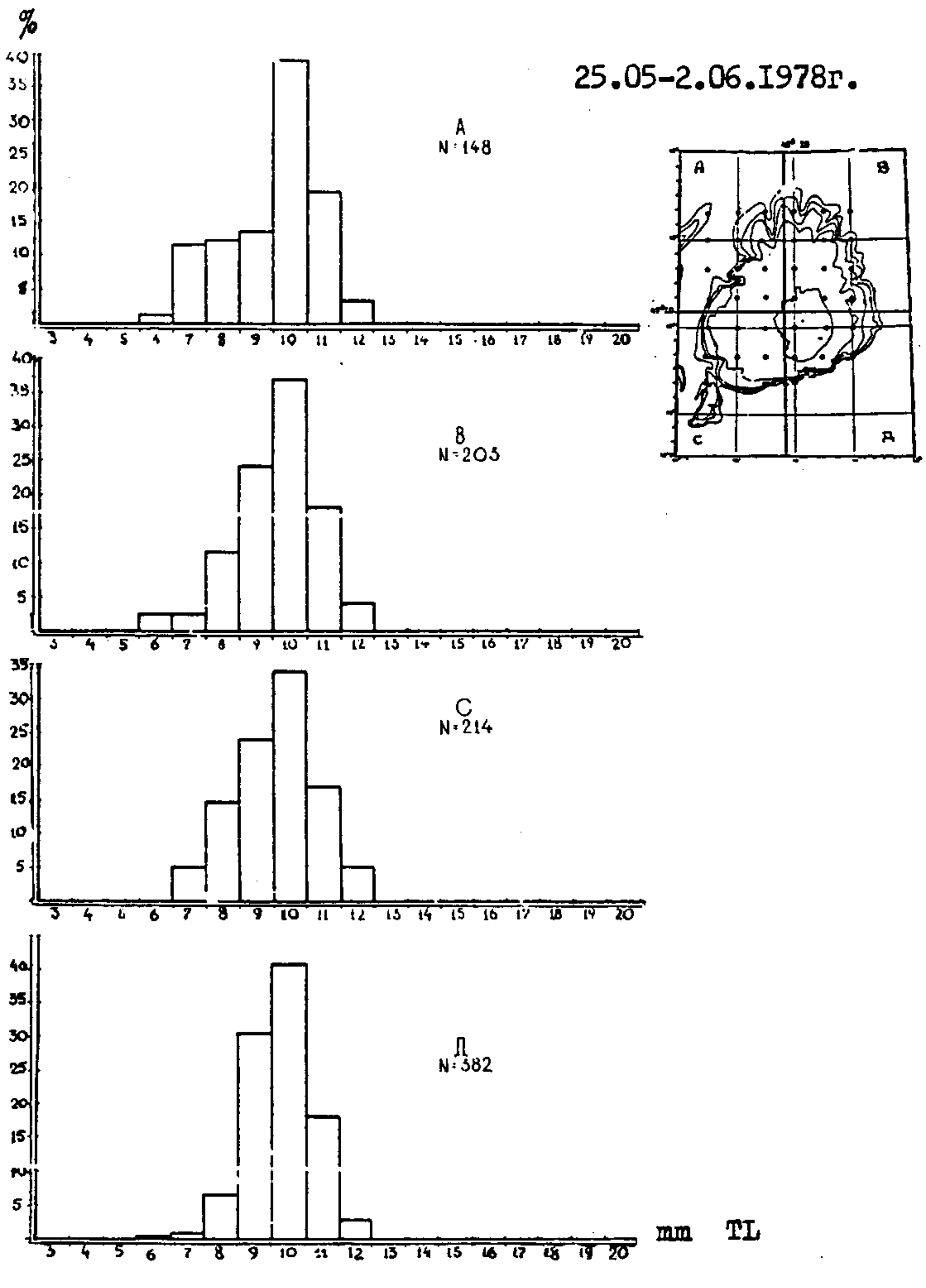

Fig. I7 A Length of larval sebastes spp on the Flemish Cap Bank in I978-I98I from survey data.

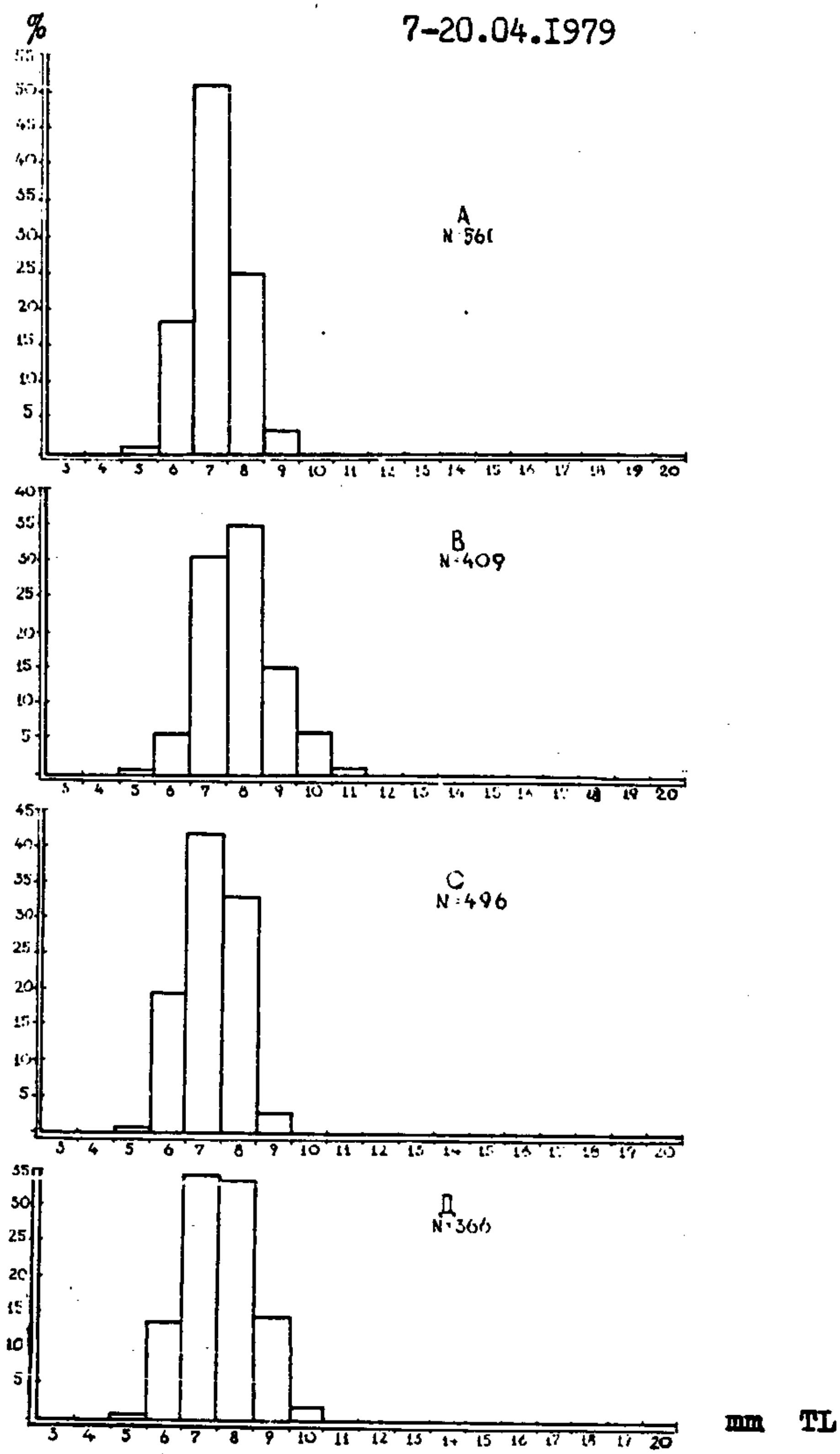

Fig. I7 B Length of larval sebastes spp on the Flemish Cap Bank in I978-I98I from survey data.

3-I0.05.I979

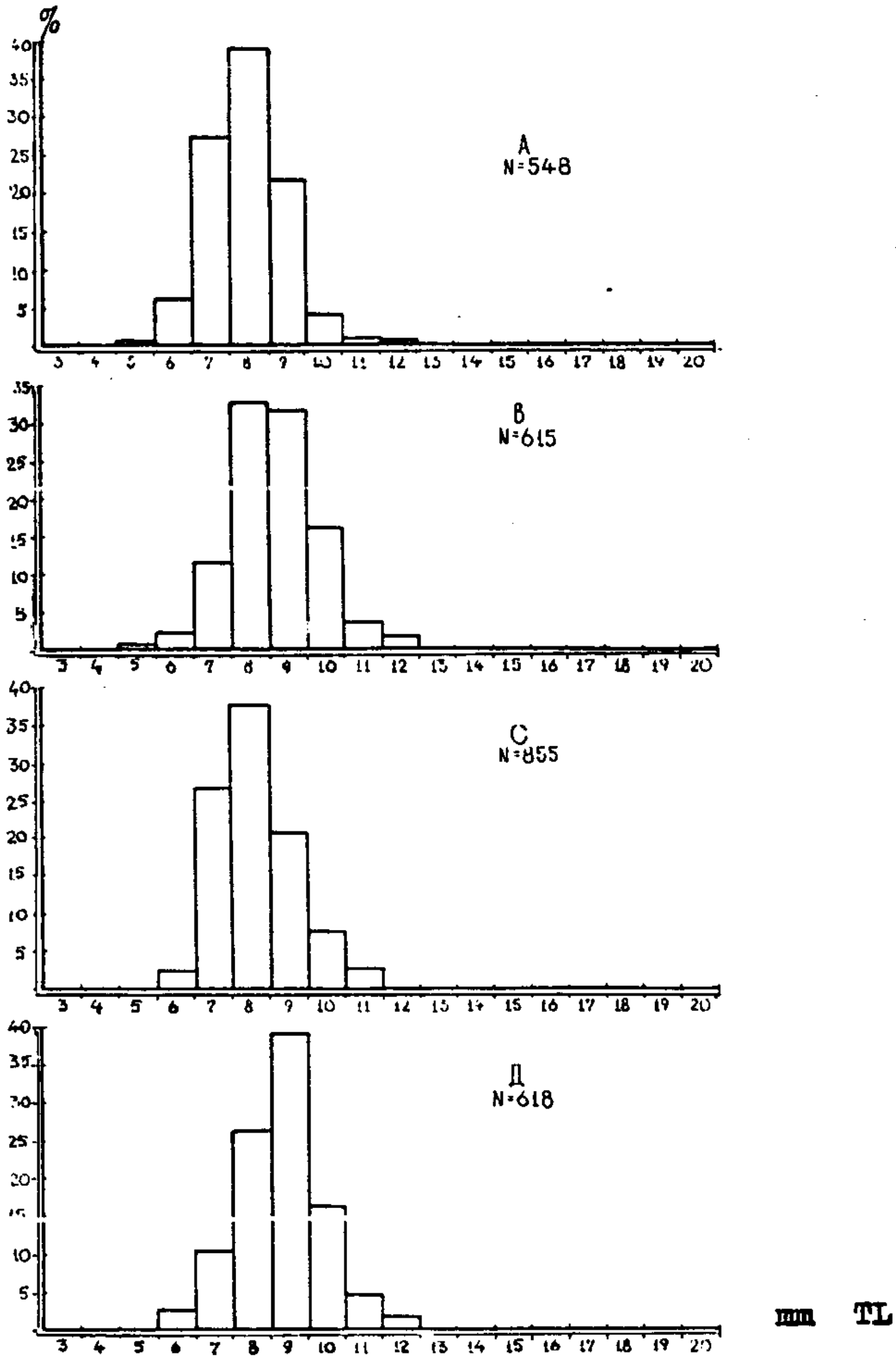

Fig. I7 C Length of larval sebastes spp on the Flemish Cap Bank in I978-I98I from survey data.