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Redfish Distribution in Flemish Cap During the Period 1988-1990

by

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#### INTRODUCTION

In recent years, very few data about Flemish Cap redfish distribution have been recorded. Only redfish status assessments have been published. Otherwise, a stock assessment cannot be correctly made without a deep knowledge of the periodical distribution changes and of how these changes influence the population structure of each species.

In 1988, Spain-EEC started a stratified bottom-trawl survey project in the Flemish Cap. Redfish distribution has been studied in the last three years.

In this paper, every *S. marinus* and beaked redfish year-class has been identified; Their position over the bank and depth distribution of each main mode has been analyzed. Mean depth has been calculated and studied for each size-class.

#### MATERIALS AND METHODS

During the summer of 1988, 1989 and 1990, three stratified random bottom trawl surveys were made in Flemish Cap (Vazquez, 1989, 1990 and 1991). Table 1 shows tow number per stratum every year sampled. Strata were defined in Doubleday (1981).

*S. marinus*, and beaked redfish (*S. mentella* and *S. fasciatus*) were separated into two different groups. In addition to this, in 1990, the smaller than 18-19 cm individuals were considered as belonging to another different group, because we assume that separating these individuals per specie is a great time consuming process on board.

For *S. marinus* the age was determined at the three surveys (1988, 1989 and 1990) and for beaked redfish in 1989 and 1990.

In 1988 and 1989 age was determined by scales as it was described by Kosswig (1980). In 1990, age was fixed reading otoliths. These otoliths were kept dried inside envelopes. Later, the otoliths were burned in a conventional oven at 200 degrees C during one hour, more or less. In this way, an homogenously burned otolith is obtained, what permits a more accurate reading. An alcohol and glicerine mixture was used for cleaning the otolith. Tables 2-6 show age-length key for *S. marinus* and beaked redfish.

In this paper three groups are considered:

Juveniles.- All smaller than 20 cm individuals. In 1990 the above mentioned group was taken. In 1988 and 1989 these individuals, both *S. marinus* and beaked redfish, were separated from the original data.

*S. marinus*.- All longer than 20 cm *S. marinus*.

Beaked redfish.- Longer than 20 cm *S. mentella* and *S. fasciatus* together.

In this paper all future analysis will be made in each of these groups separately.

## RESULTS

Figs. 1-9 show length-frequency distribution by tow by species in the sampled years. The tows were classified by depth. Depth ranges are the different strata according to Table 1. The strata position in the Flemish Cap is shown in Fig. 10.

### JUVENILES

Figs. 1, 2 and 3 show the length-frequency juvenile distribution by depth in the years 1988, 1989 and 1990 respectively.

In 1988 an around 12 cm mode that belongs to the 1985 year-class (age 3) is observed. This modal group, ranged between 11 and 13 cm, is located from 250 m to 380 m (Fig. 1); this is the zone formed by the strata from 7 to 11. It seems there is a trend in the distribution that longer individuals head for deeper depths. So, 13 cm individuals have the highest frequency around 350 m, while the 11 and 12 cm individuals are preferably around 250 m. The distribution on the bank is shown in Fig 11. We can see this year-class mainly located in the strata 8 and 9. An hardly noticeable (it is not recruited yet) mode, is detected at about 8-9 cm. This is the 86 year-class of two years old. Around 18-19 cm other low peaks may be observed.

In 1989 (Fig. 2) a 4 years old strong mode, around 15 cm, is present again. It is the 1985 year-class. This cohort is distributed from 270 to 400 m. The bulk for the 15 cm individuals is found around 340 m and for the 16-17 cm ones at 400 m. This year-class is placed in the strata 12, 13 and 15 (Fig. 11). An abundance area, perhaps *S. marinus*, is also noticed around 260 m, and is located in strata 10. The 1986 year-class, now with 12 cm, follows being very weak and it is distributed over the bank in the same way as that mode in 1988 (Fig. 11). The 1987 year-class does not appear.

In 1990 (Fig. 3), the year-class is completely recruited and is very abundant. It is 18 and 19 cm long and was detected from 270 to 440 m. The bulk is at around 350 m (where 17-18 cm size-class is predominant) and

at 420 m (where 19 cm size-class is). There seems to be, again, a separated group around 270 m. It could be *S. marinus* and was sited preferably in the stratum 11 (Fig. 11). They are particularly concentrated (as it is normal in this species). Otherwise, the individuals of this cohort being left are located, very spread out, in the strata 12, 13 and 15. The 1986 year-class is around 15 cm long and in the strata 7, 10, and 11 (Fig. 11), but it follows being very weak. The 1987 year-class does not appear. In 1990, the 1988 year-class with a 8-9 cm mode, appears with great abundance and it is placed from 260 to 320 m in the strata 10 and 11 (Fig. 11).

### *S. marinus*

In the 1988 summer (Fig. 4) the *S. marinus* length frequency distribution by depth is shown. Following the different year-classes begins to be difficult. We may observe a group formed by around 20 cm individuals, sited between 200 and 270 m in the strata 5 and 6 (Fig. 12), but little abundant. Over 360 m a great abundance of *S. marinus* with a size-class between 23 and 34 cm is observed. Two apparent modes are present, one in the 26 cm (more abundant) and another in 32 cm. These year-classes are considerably concentrated on the south area of the Flemish Cap (Fig. 12). Finally, at about 600 m a 30-40 cm group appears, probably beaked redfish individuals, badly classified.

In the 1989 summer, *S. marinus* remains very concentrated like last year, but this year it is located around 280 m (Fig. 5). Three modes, 26, 29 and 32 cm, that presumably correspond to ages 8, 9, 10 and 11 (Table 2) prevail. The 22-23 cm modal group (age 7) is also found around 120 m, in the strata 1 and 2 (Fig. 12). Both size groups are preferably sited in the stratum 10 (Fig. 12). The reason why *S. marinus* is found in a lower depth remains unknown.

In 1990 (Fig. 6) the distribution area for *S. marinus* is situated further northern (Fig. 12), in a depth range from 140 m, where 21-22 cm size-class (age 7) is dominant, to 300 m, where there are two modes, in 30 and 33 cm (ages 10, 11 and 12). Like last years, they are considerably concentrated and their distribution area is very limited (Fig. 12).

### BEAKED REDFISH

In the three sampled years (Figs. 7, 8 and 9) two modes, one around 24-28 cm and another between 32-36 cm are observed. The former represents the 1981 year-class (Tables 3 and 4), while the latter aged 13-15 individuals.

In 1988, 24-25 cm modal group (7 years old, 1981 year-class) is detected from 300 to 500 m all over the periphery of the bank; above all in its Eastern and Northern part (Fig. 13). 35 cm modal class is identified in a deeper bottom, from 500 m to the deepest area of the bank (Fig. 7). Its distribution area is shown in the Fig. 13.

In 1989 (Fig. 8), a range from 25 to 27 cm makes up the main mode and corresponds to the 1981 year-class, that is, 8 years old (Table 3). It is always below 250-300 m, in the strata 7-19 (Fig. 13) and with an upper limit around 520 m. 35 cm mode is placed much deeper, between 550 and 700 m. The bank distribution area is

shown in the Fig. 13. The year-class tracking of this group turns out to be impossible, because of high overlapping in their size range, but it includes 12-16 year-old individuals approximately. An interesting phenomenon is observed in the Fig. 8: A redfish group is placed around 220 m and consists of both modes. This group is clearly separated and identified in the strata 3 and 6 (Fig. 13). Basing ourselves on depth distribution and on the size range we assume that this aggregation is *S. fasciatus*.

Once and again the story recurs in 1990 (Fig. 9), but this time the 1981 year-class, now aged 9, is sited at 27 and 28 cm, in depths ranging from 300 to 500 m and all over the west and south of the bank (Fig. 13). The oldest mode (around 35 cm) takes place mainly between 500 and 700 m (Fig. 13).

#### DISCUSSION

Beaked redfish means two species, *Sebastes mentella* and *S. fasciatus*. These species were not separated on board in the Spanish surveys made up to now. But, is it possible with these data to distinguish both species by their distribution ?.

The distribution area seems to be different for each species. We can find *S. fasciatus* in shallow waters and *S. mentella* in deeper ones (Templeman, 1976; Ni, 1982; Penney et al., 1984). For this reason the mean length by depth of beaked redfish was calculated for every sampled year. Graphic representation of this calculation is shown in the Fig. 14. There seems to be two depth zones. One of them is extended from 250 m to 350 m, with a mean length which oscillates between 22 and 32 cm (all primarily observed length range for redfish in these surveys). Another depth area is extended from 400 m to a deeper bottom of the Flemish Cap bank, with a mean length ranged from 25 to 35 cm. If, as we will see below, there is a correlation between depth and size, that is, different size individuals are arranged at different depths, the explanation to the existence of these two areas is that the former corresponds to *S. fasciatus* and the latter to *S. mentella*. Following this conclusion, *S. fasciatus* would be mainly between 200 and 350 m, while *S. mentella* would be from 400 to 700 m, what agrees with other authors' observations (Penney et al, 1984).

*S. fasciatus* lives in a very narrow depth range, this is the explanation of those peaks (Fig. 14). Otherwise, *S. mentella* lives in a broad range depth. In addition to this, There would be a mixture area in the intermediate zone. This separation is also possibly observed in the Fig. 8.

Fig. 15 shows length frequencies and different modes were identified thanks to length-age keys (Tables 2, 5 y 6). It is possible to track the progression of the different year-classes in these three years.

Noticing the progression in beaked redfish is difficult because it shows an evident bimodal distribution.

Unlike the above-mentioned, it is possible to identify the modes in juveniles and *S. marinus*. The 78-81 year-classes turn out to be very abundant in contrast to those of 82, 83 and 84. In 1990, the 1980 cohort (age 10) is identified around 30 cm, while the 1984 one (age 6) around 20 cm. Observing these modes in Fig. 15, 18 cm modal group corresponds with the 1985 year-class and that of 8-9 cm with the 1988 year-class. This relationship supposes a growth rate of about 3-4 cm at 2-3 years old; 3 cm up to age 10 and 2 cm during the following years. *Sebastes* would reach, following this progression, 8 cm at age 2, what agrees with otolith

readings (very few) made by us during last year and with those ones of other authors (Gavaris et al., 1981; Anderson, 1984).

However, the first year-class mode does not appear. In bottom trawl surveys, it does not appear because the mesh size is too great and it does not either in the Flemish Cap plankton surveys, perhaps because the plankton gear is not adequate for 3-4 cm fishes.

The Flemish Cap cod stomachs analyzed (Lilly et al., 1982; Casas et al, 1991; Paz et al, 1990) do not show the said redfish. It may be that, if we assume that one-year old redfish is still completely pelagic, this year-class would not be available for cod. Juvenile cod (O-group), perhaps pelagic, eats redfish larvae (Paz, per. comm.) but it would be too small to eat 3-4 cm redfish.

Lilly (1986) displayed two arguments that could prove that first year-class is the 8 cm mode. He compared Flemish Cap to redfish growth in other banks. Anderson (1984) records a different growth rate in Flemish Cap comparing it with Labrador Shelf and Gulf of Maine.

Another argument was the inconsistency between age reading and the interpretation of the length-frequencies in Atkinson (1985). Age readings, in 1982 and following years (Atkinson, 1985, Table 7) do not seem to be correct, but this argument does not invalidate two-year age readings, but those of three years old and following ones (1982 and consecutive years readings).

Juvenile redfishes have around 1.6 cm in the first summer (Anderson, 1982). In accordance with calculated growth rate (Anderson, 1984; Radtke, 1980) *Sebastes* would have between 4 and 5 cm during the first year. Second year, between 2 and 3 years old, redfish presents a similar growth, as it was above-mentioned. It is not possible, yet, to know if the 8 cm mode is 1 or 2 years old. More studies about this fact must be carried out. In the remainder of this paper, the modal group of 8-9 cm is referred to as age group 2.

Another important feature is the depth distribution by length. Its mean depth for each size-class was calculated in every studied group. Fig. 16 shows mean depth by length per year and per group.

Juveniles are located from 230 to 330 m. Each year-class is placed in a different depth, what produces that peculiar increment towards a deeper bottom in the graphics. So, 2 year-old individuals are found at around 280 m, three years old at 305 m, at 330 m for the aged 4 and, finally, the aged 5 are placed around 350 m. Because all the three species form this group, it is difficult to know where each species is, but we can say juvenile redfish lives deeper as older as they are.

Beaked redfish (Fig. 16) also shows this depth distribution: the ones of 20 cm long (aged 6) are placed at around 350 m, then they move to 450 m, when they are 32 cm long (aged 12) and later to 500 m when they are 40 cm long. *S. fasciatus* and *S. mentella* are mixed in this group. For this reason this curve is a mixture between *S. fasciatus* (low slope) and *S. mentella* curve (elevated slope) and for every year-class any conclusion about specific depth distribution in each beaked redfish can be extracted.

*S. marinus* (Fig. 16) is located from 200 and 275 m. Aged 6 individuals are found around 200 m, descending as far as 250 m when they are 25-26 cm. The older size classes stay from 250 to 275 m. In 1988,

mean depth-length curve is above the 1989 and 1990 curves, perhaps because of different depth distributions or probably because that year had poorly classified individuals.

The 1985 year-class at age 2 is distributed mainly in two areas (Fig. 11), in the south and in the east. At age 3 (Fig. 11) the southern area has disappeared, and now a broad western area appears. At age 4 (Fig. 11) the eastern area has moved to join the western area in the north. So at age 4 there is only one distribution area over the bank. This year-class has suffered a movement from South to North.

Throughout the three years, 25 cm mode of *S. marinus* underwent a similar movement (Fig. 12), but it was always at depths over 300 m. It is more evident in the 32 cm mode (Fig. 12).

In beaked redfish it is possible follow the distribution movement of the 25 cm mode and of the 32 cm mode (Fig. 13). It is observed that the eastern nucleus, which appeared in 1988, disappeared towards the west, and in the 25 cm mode also towards the south.

As we can see, in all modal groups in all categories considered there is a movement to the north and west from the east of the Flemish Cap. This movement does not seem to be related to temperature, as it does not change much from year to year (Templeman, 1976; Saborido et al., 1990; 1990 Spanish CTD data, unpubl. data). Neither is it a movement related with age because it is observed in all modes in the same way. The reason is unknown.

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length	2	3	4	5	6	7	8	Age 9	10	11	12	13	14	15	16+	total
16			2	1												4
17			1													1
18																1
19			1													1
20																1
21																1
22																1
23																1
24																1
25																1
26																1
27																1
28																1
29																1
30																1
31																1
32																1
33																1
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35																1
36																1
37																1
38																1
39																1
40																1
41																1
42																1
43																1
44																1
45																1
46																1
47																1
48																1
49																1
50																1
51																1
51																1
																486

Table 3.- Age-length key for *S. marinus* in July, 1989.

length	2	3	4	5	6	7	8	Age 9	10	11	12	13	14	15	16+	total
15			2	1												5
16				5	4											11
17			1	3	7	1										16
18					4	9										14
19					1	8										21
20					1	8										17
21					3	12										20
22					2	4										17
23					1	12										17
24						1										22
25																23
26																25
27																23
28																33
29																31
30																29
31																27
32																33
33																30
34																20
35																21
36																16
37																13
38																10
39																5
40																8
41																5
42																4
43																5
44																1
45																3
46																1
47																1
48																1
49																1
50																1
51																2
52																1
																530

Table 4.- Age-length key for *S. marinus* for July, 1990.

length	2	3	4	5	6	7	8	Age	9	10	11	12	13	14	15	16+	Total
1			3	1													5
2																	1
3																	1
4				1													1
5																	1
6																	1
7																	1
8																	1
9																	1
10																	1
11																	1
12																	1
13																	1
14																	1
15																	1
16+																	1
Total			4	5	33	96	103	77	85	81	75	85	54	48	1525		

Table 5.- Age-length key for Beaked redfish for July, 1989

length	2	3	4	5	6	7	8	Age	9	10	11	12	13	14	15	16+	Total
1			3	4													5
2																	1
3																	1
4																	1
5																	1
6																	1
7																	1
8																	1
9																	1
10																	1
11																	1
12																	1
13																	1
14																	1
15																	1
16+																	1
Total			4	7	8	38	121	162	109	73	62	45	51	49	293		1102

Table 6.- Age-length key for Beaked redfish for July, 1990.

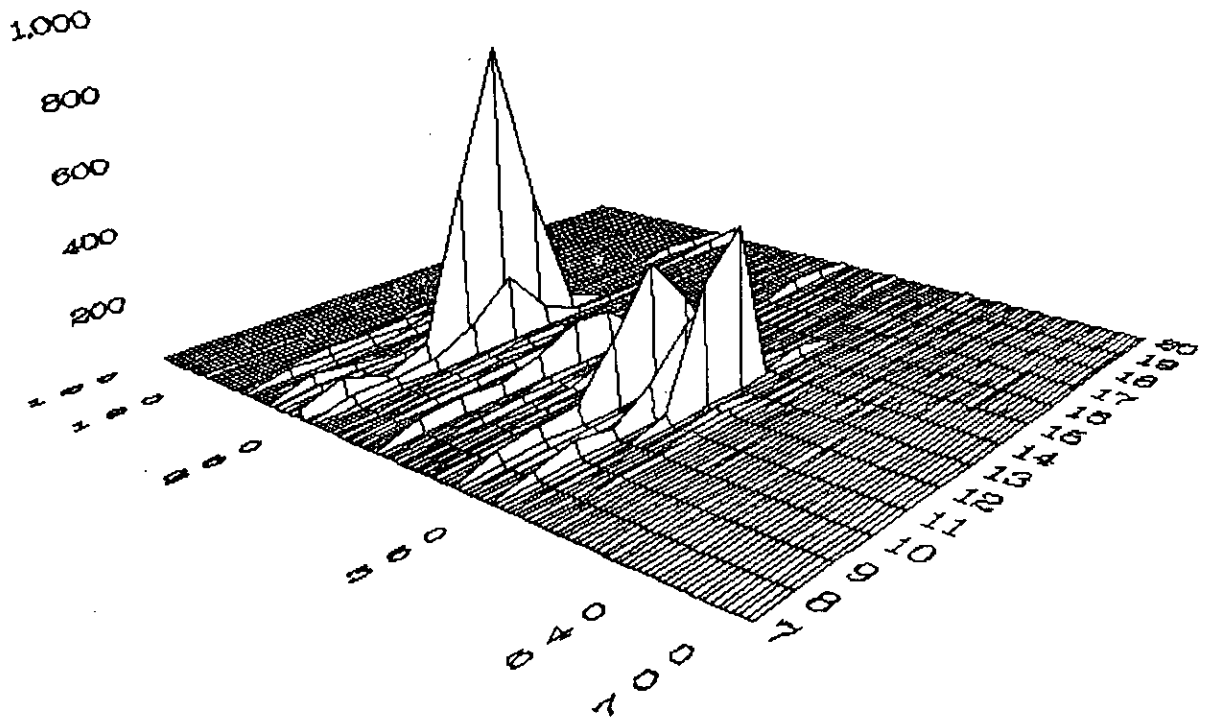


Fig. 1. Juvenile redfish length frequencies by tow in 1988

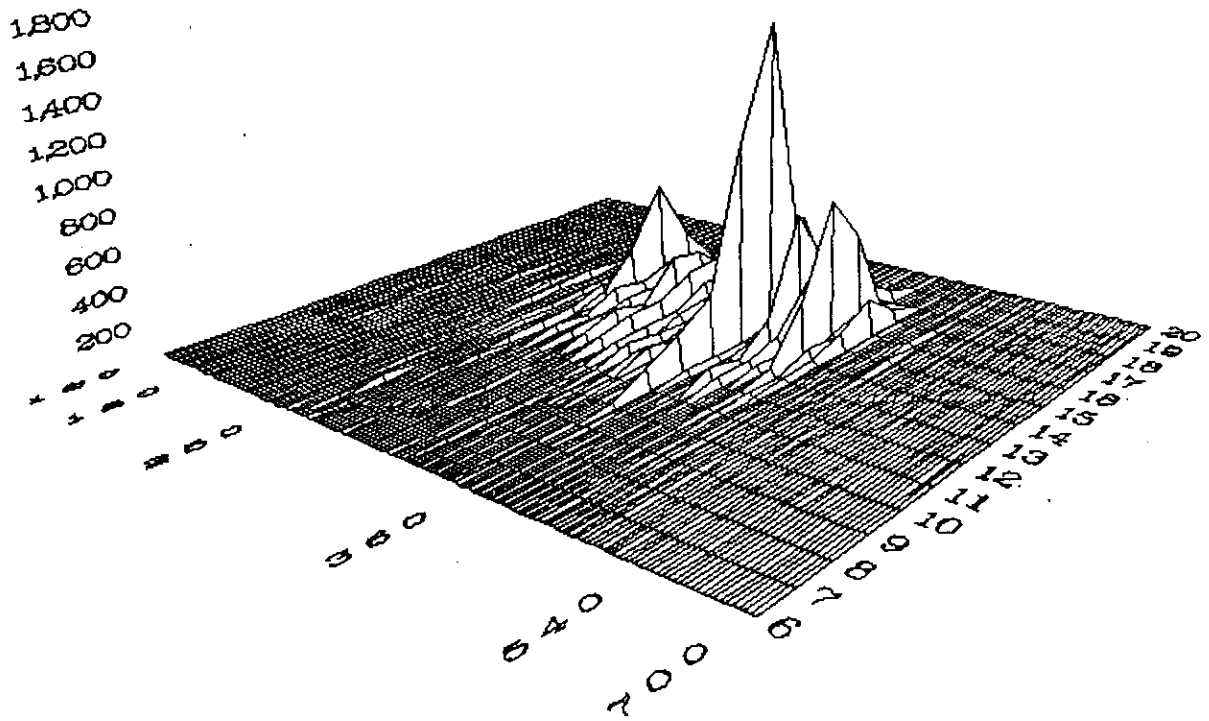


Fig. 2. Juvenile redfish length frequencies by tow in 1989

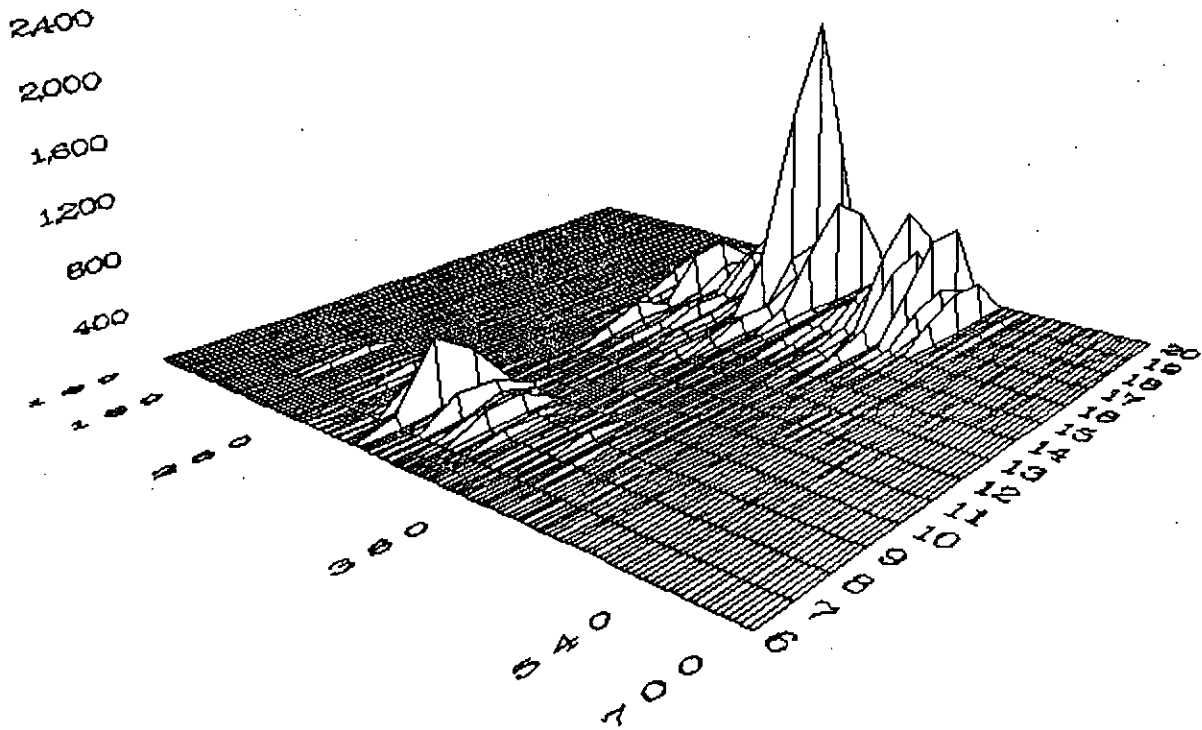


Fig. 3. Juvenile redfish length frequencies by tow in 1990

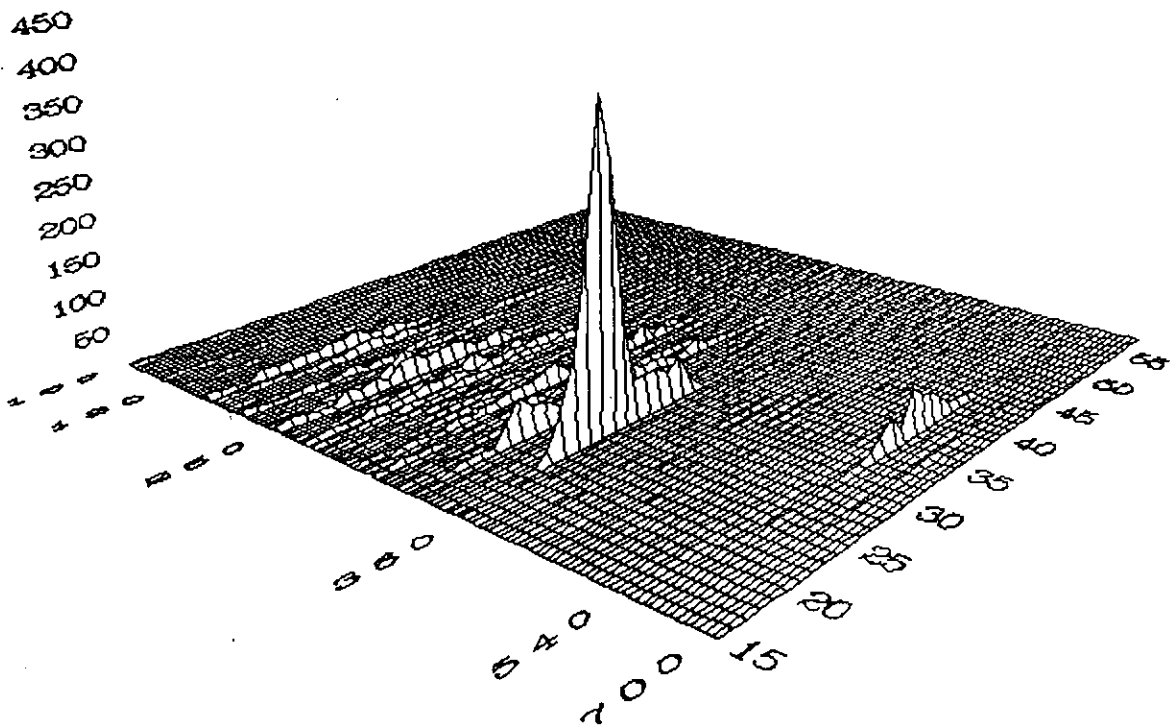


Fig. 4. *S. marinus* length frequencies by tow in 1988

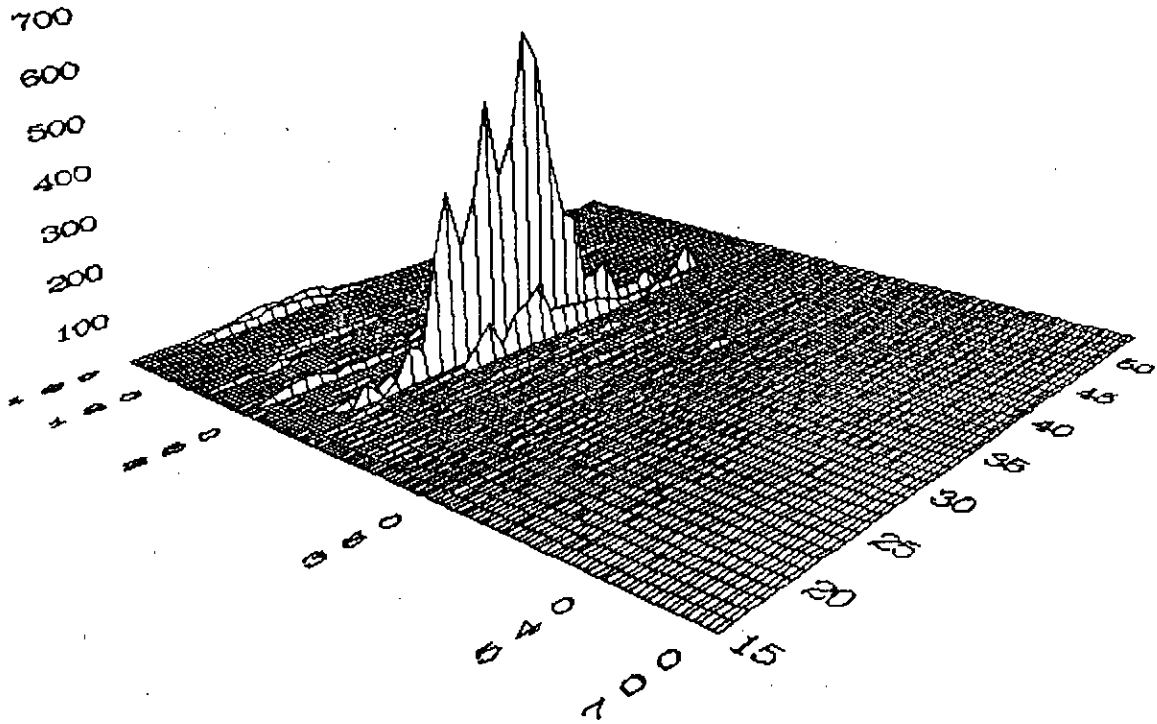


Fig. 5. *S. marinus* length frequencies by tow in 1989

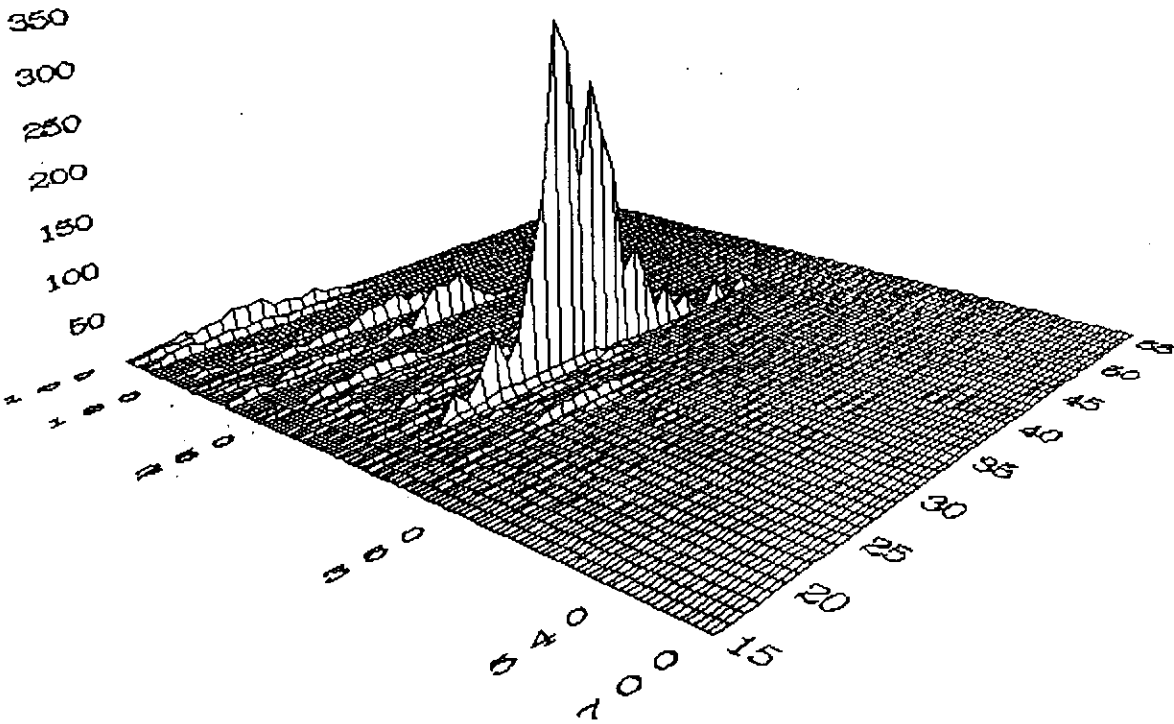


Fig. 6. *S. marinus* length frequencies by tow in 1990

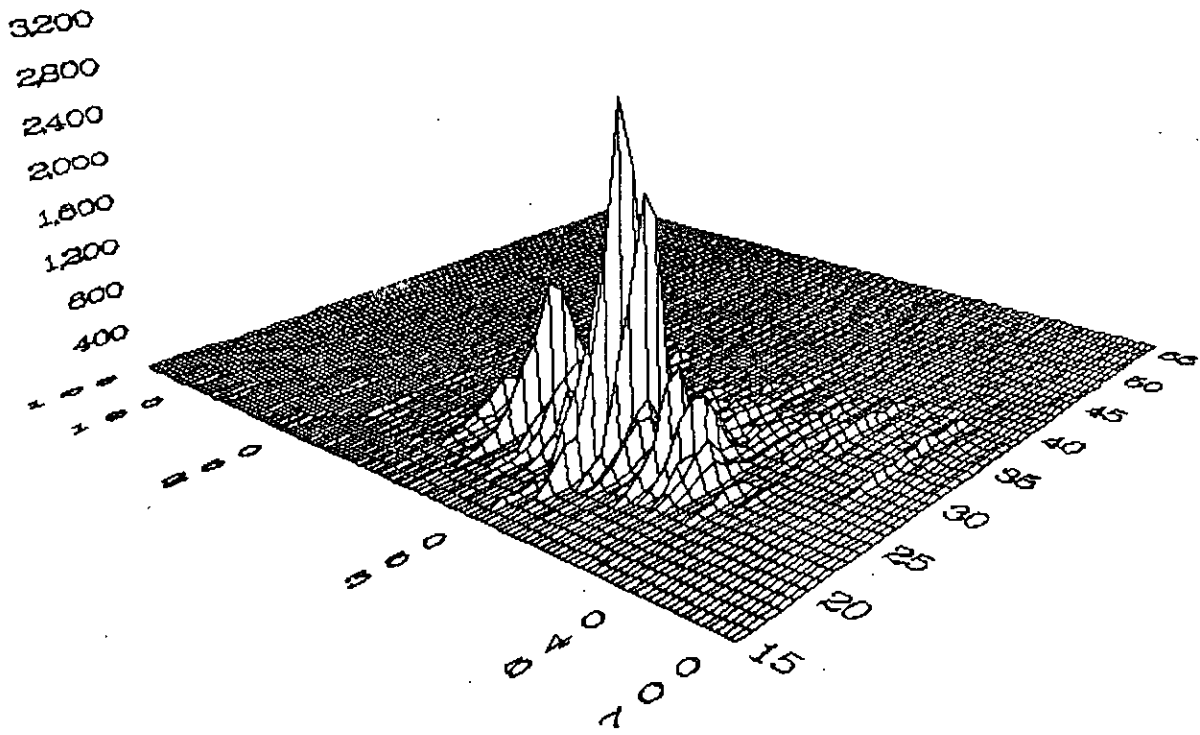


Fig. 7. Beaked redfish length frequencies by tow in 1988

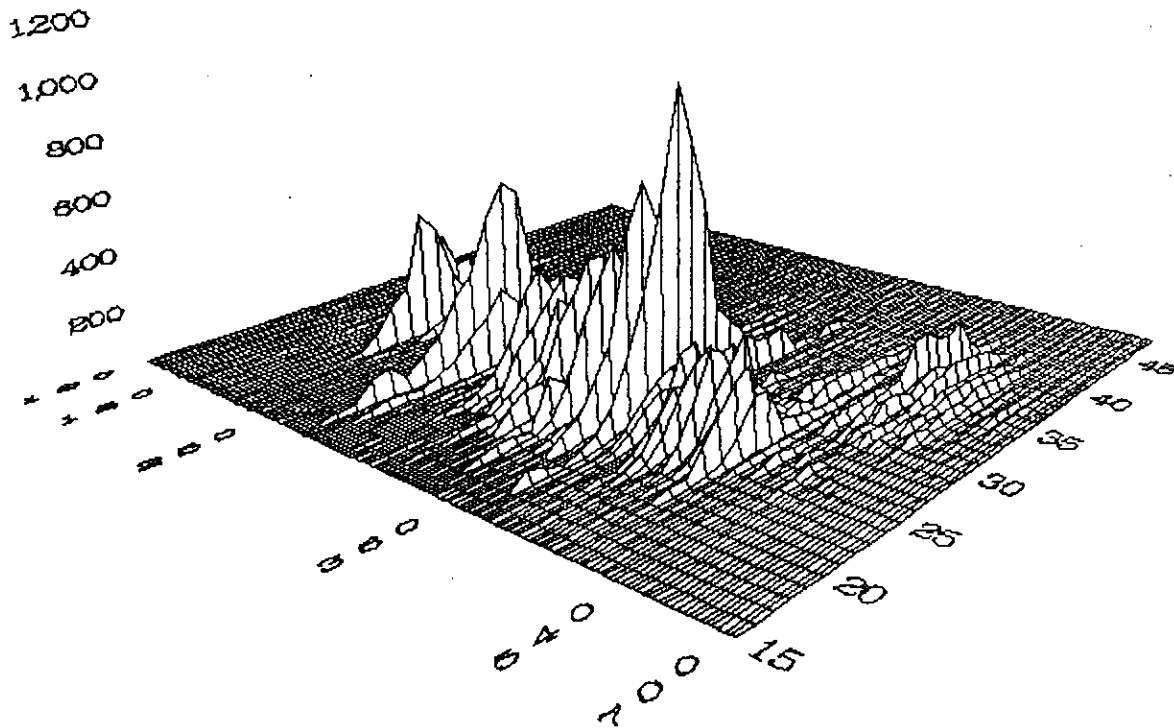


Fig. 8. Beaked redfish length frequencies by tow in 1989

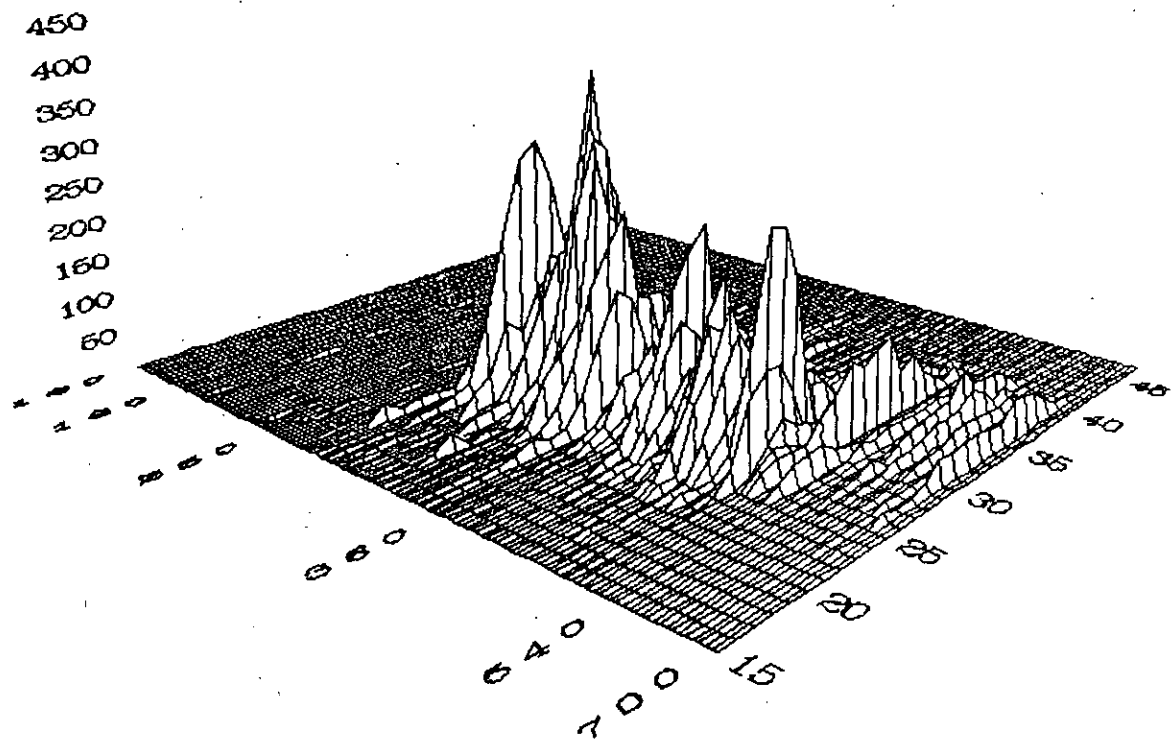


Fig. 9. Beaked redfish length frequencies by tow in 1990

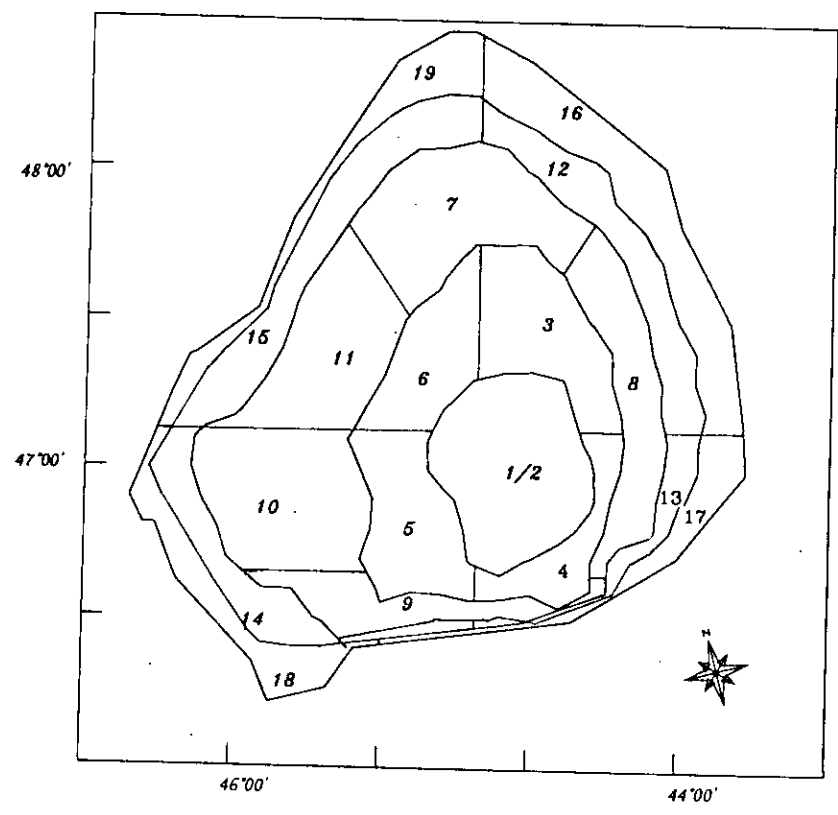
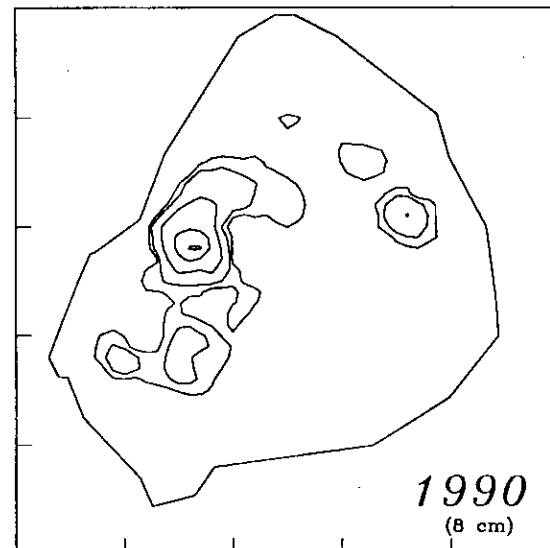
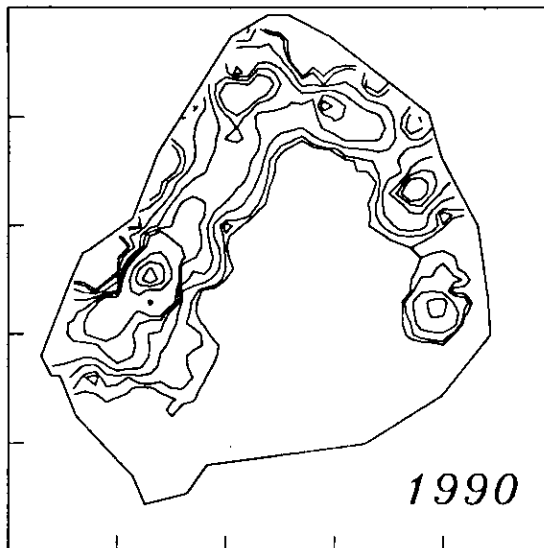
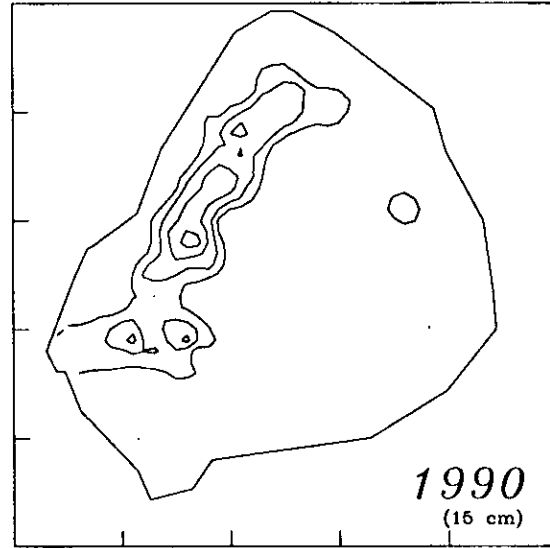
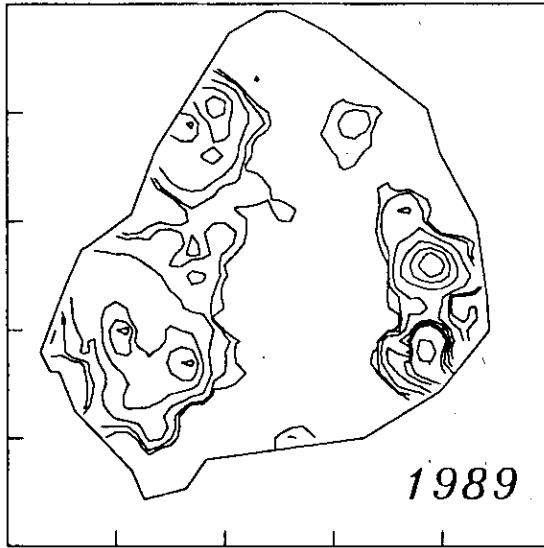
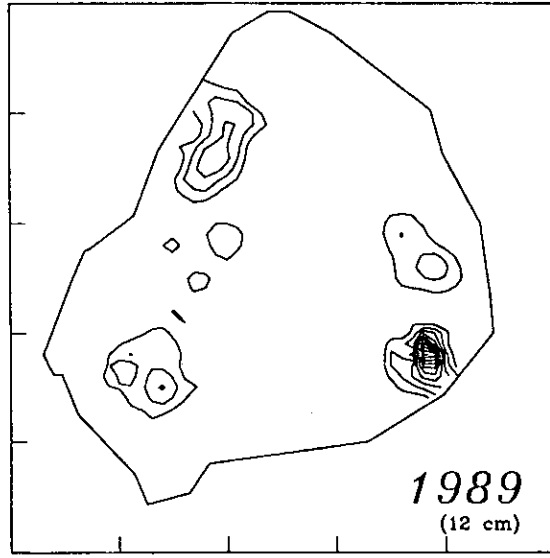
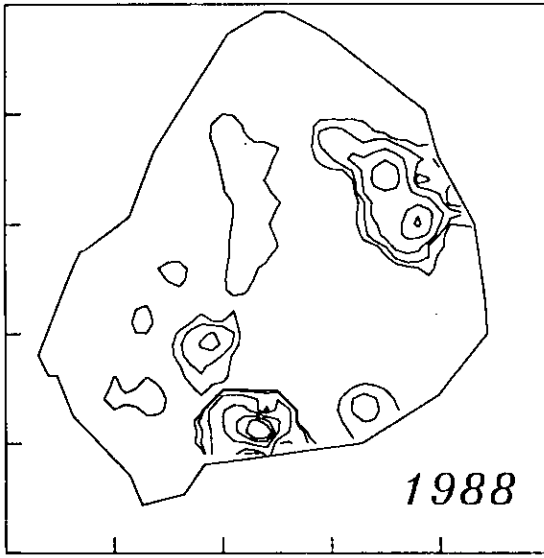


Fig. 10. Flemish Cap bank with the strata position



A

B

Fig. 11. Juvenile redfish distribution over the bank.  
A. The 1985 year-class B. The 1986 and 1988 year-classes



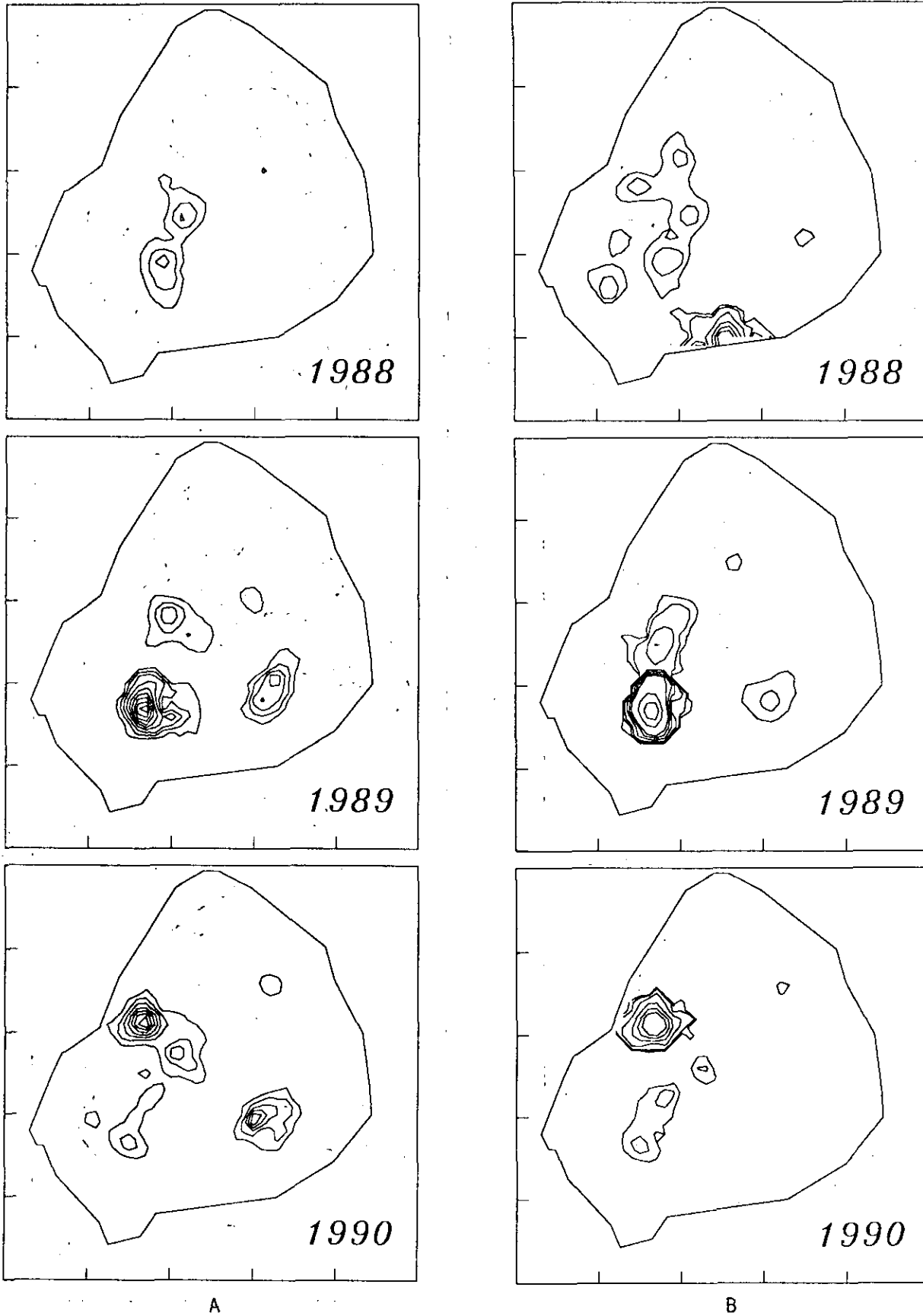


Fig. 12. *S. marinus* distribution over the bank.

A. The 22-26 modal group B. The 32-34 modal group

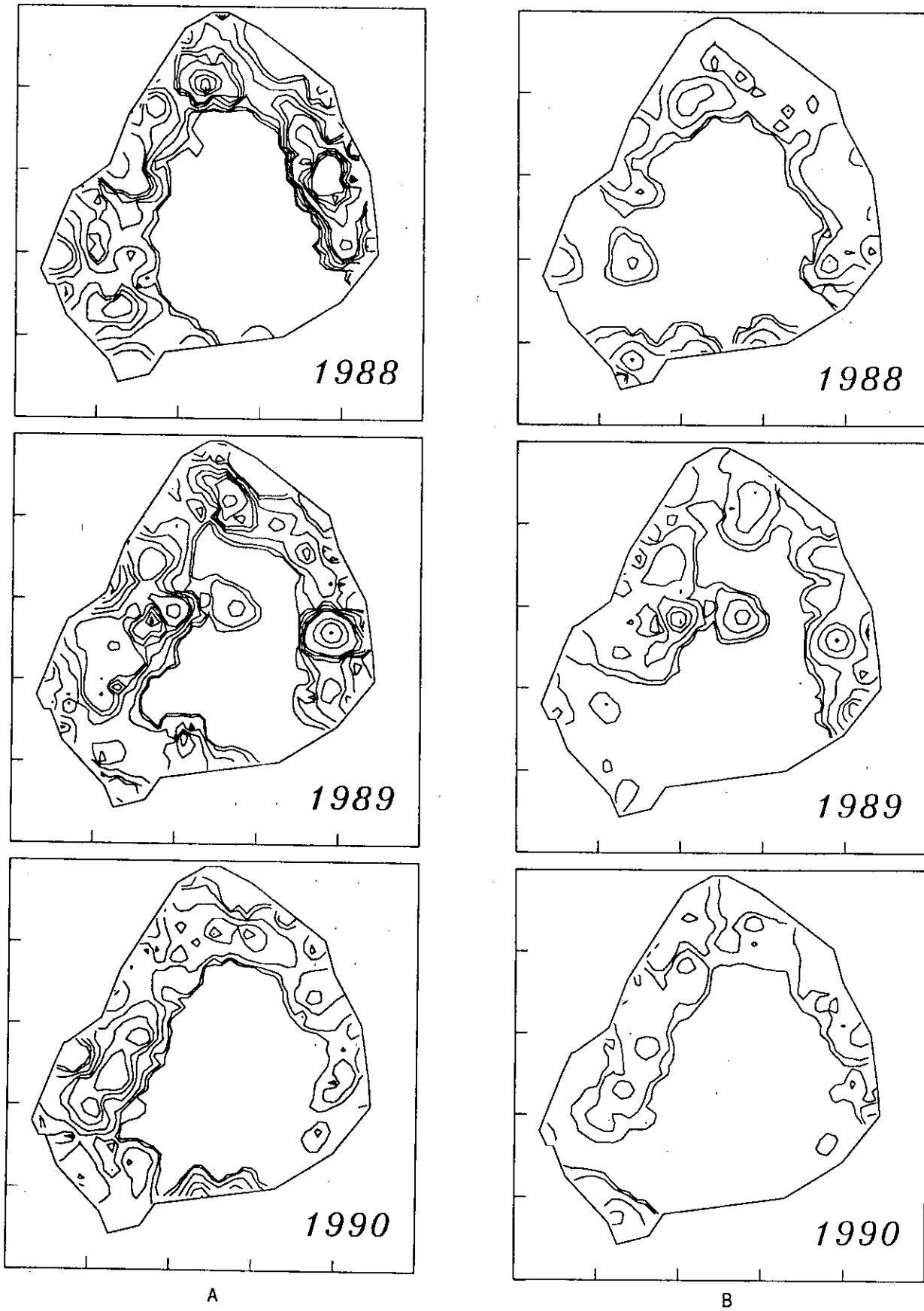


Fig. 13. Beaked redfish distribution over the bank  
A. The 23-29 modal group B. The 32-35 modal group

Fig. 14. Beaked redfish mean length by depth

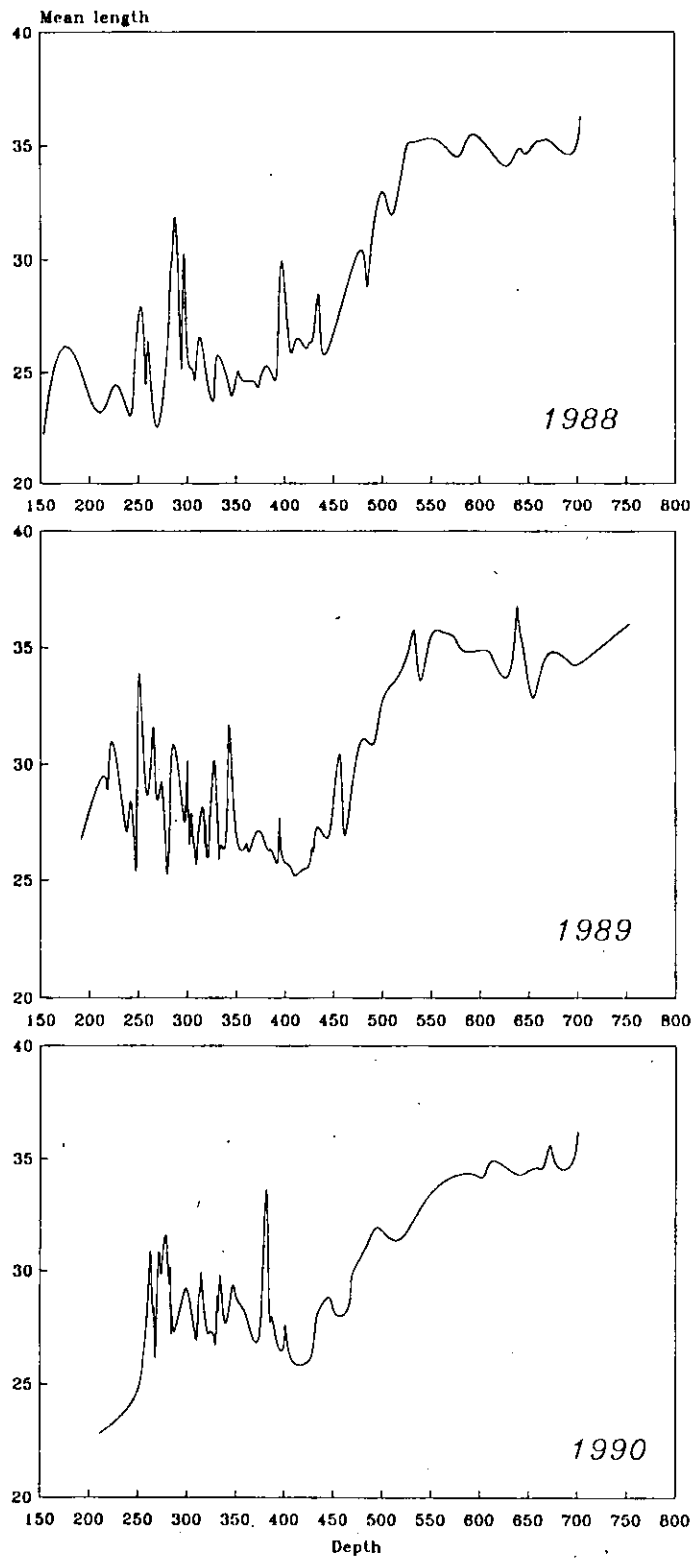


Fig. 15. Length (cm) frequencies in 1988-1990

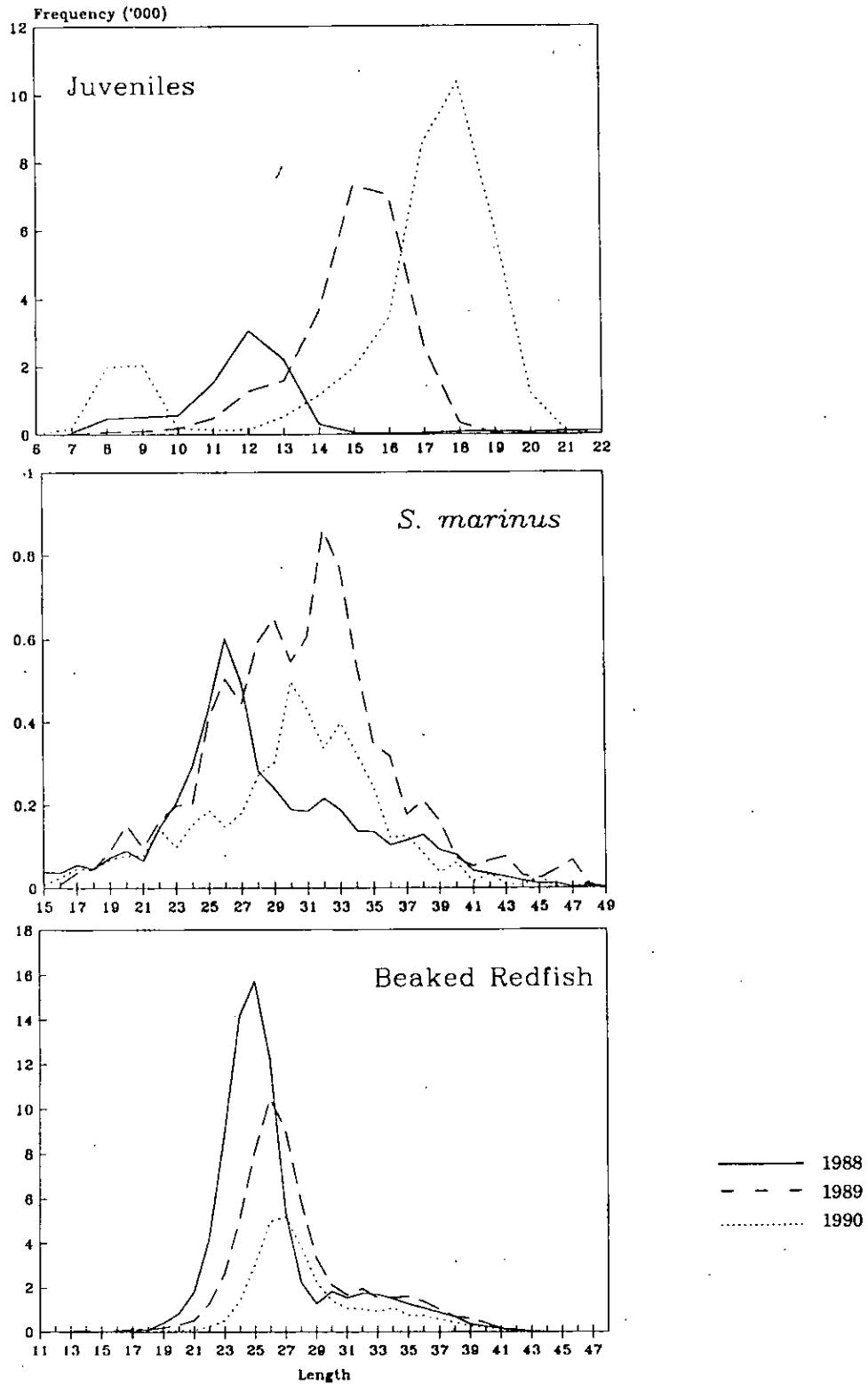


Fig. 16. Mean depth by length (cm) 1988-1990

