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Distribution of redfish, Sebastes mentella Travin, at different depths of the north Newfoundland Shelf

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Results of investigations and fisheries in deep-sea parts of the Shelf obtained in recent years induced us to revise and analyse in detail the data on redfish collected during many years.

~~As far as~~ Since the great depths in the area to the north of the Newfoundland Island are more strongly investigated at present, we decided to give in this paper only the results of our analysis for the area mentioned (3K). That area is a rather wide part of the Shelf including elevations and deep-sea gullies which are important for the distribution of redfish. In this area the cold Labrador Current consists of two main streams, one of which runs along the shore and the other, a stronger one, goes offshore. Between them there is a great cyclonic gyre which, as well as deep-sea gullies, is probably of great importance for the distribution of redfish and especially of spawning concentrations of females. Unlike other areas where redfish are mainly spread in a form of a narrow band along the oceanic part, on the North-Newfoundland Shelf they occur all over the elevations and in deep-sea gullies to the extent of the cold coastal stream.

Great numbers of redfish S.mentella are found at depths of 200-700 m (near-bottom temperature is not lower than 2.5-3.0°C). Usually at depths more than 700 m there are no observed great concentrations of redfish.

As results of our investigations and fishery showed, the density and qualitative composition of redfish concentrations at different depths are greatly non-homogeneous. Some results of the analysis of catches taken at different depths were given in ~~the~~ paper submitted ~~at~~ the ICNAF Annual Meeting in 1965 (Savvatimsky, P.I. and Sidorenko, I.N. "Results of Investigations of Deep-Sea Redfish"). ~~As far as~~ Since the results represented in that paper were mainly based on data collected during one year, we decided to analyse all the materials on "beaked" redfish obtained on the North-Newfoundland Shelf in 1958/65. It should be noted that apart from the two main species of redfish-S.marinus and S.mentella - one can find different intermediate forms of redfish in this area especially at small depths, 200-400 m. By their appearance the redfish of an interme-

diate type are similar to "beaked" redfish and that's why we considered them to be of the same length-frequencies. Only redfish which strongly differ by their indices from the two main types, S.marinus and S.mentella, were discussed separately.

The combining of size-frequencies according to 100 m depths (200-300, 300-400 m etc.) during all the years of our investigations led to more interesting and, from our point of view, important results.

As it is known, males of redfish ripen earlier than females. The earlier maturity and slow growth rate (connected with the earlier maturity) lead to the shortening of males life cycle. As a rule, size and age-frequencies of mature males are considerably shorter than in females (Figs.1, 3). According to this index it is easy to distinguish between the groups of mature and immature fishes. The group of mature fishes or the group with a good predominance of mature specimens always has size curves with two peaks; the first peak falling within smaller sizes is concerned with males; the second one falling on greater lengths is to females. The group of immature fishes or the group with a predominant number of immature specimens has the size lines with one peak. In this case the shape of size curves of males and females are almost of the same type, their peaks usually coincide with each other and fall on the same lengths (Figs.1,3).

In this paper we mainly deal with redfish of 30 cm in length and longer when they can reach sexual maturity and also occur in great numbers in catches taken by a bottom trawl.

From Fig.1 illustrating the size composition of "beaked" redfish in Division 3K from different depths (data for 1958/1965) one can see that the total length-frequencies covering depths between 200 and 700 m have different peaks, the left one of males and the right one of females. This fact indicates the predominance of mature redfish in catches. Similar pattern, i.e. well isolated size curves with different peaks (that of males falls on 32-37 cm and that of females on 38-45 cm), is characteristic of two upper 100 m layers (200-400 m). In three lower layers (400-700 m) the

size curves are of principally different character. The descending parts and peaks of size lines for males and females coincide with each other. Their shapes are so similar that they are almost put on each other. The comparison of mean lengths of redfish according to different depths shows (Table 1) that the size compositions of males at depths from 200 to 600 m are almost identical, changes in average lengths are very insignificant. The mean length of males at depths of 300-600 m increases very slowly on the average by 1 cm from one depth to another (33.9 cm - the smallest from the depth of 300-400 m and 36.1 cm - the greatest from the depth of 500-600 m). Only at the greatest depth, 600-700 m, one can find a sharp increase of the average length up to 39.1 cm.

As it is evident from Table 1, this is not the case with females. The difference in lengths of females caught at different depths reaches 2-3 cm. While the largest males (the average length is 39.1 cm) were only caught at depths of 600-700 m, the large females (the average size is 39.0-39.5 cm) dominated in catches both in the upper layer (200-300 m) and in the lower one (600-700 m). Smallest females (the mean size is 36.0 cm) were mainly taken at depths of 400-600 m.

Table 1 clearly shows that on the North-Newfoundland Shelf there is no smooth mechanical increase of redfish sizes with the depth. As to the size of catches of redfish taken at different depths, it mainly depends upon a seasonal pattern of the fish distribution and we shall say about it below. It should be noted that dense concentrations of "beaked" redfish, which can yield several tons per hour's trawling, can be found in any season and at all the depths investigated. The density and stability of these concentrations are in good agreement with physiological conditions of fish and environmental conditions.

Data obtained while studying the fish reproduction confirm the results of the analysis of size-frequencies which showed the predominant occurrence of mature "beaked" redfish in the upper layers of the Shelf (200-400 m) and immature in lower layers (400-700 m).

While the dissected fishes from depths of 450-750 m had mainly initial stages of gonad development - 1, 2 (independent of their length), at depths of 200-400 m there prevailed fishes with 3 to 6 stages of gonad development in males and 3-9 in females. Table 2 shows the distribution of mature and immature redfish.

When at depths 200-400 m the mature females amount to 80-90%, in the layer of 600-700 m they are essentially absent.

It's rather strange that the maturation period of redfish is very delayed, as evident from Fig.2, showing separately the age composition of mature and immature females. Parallel with the fishes which became mature with the length of 28-30 cm one can find the 48-50 cm specimens having only the very initial stages of the gonad development - 1-2. As Fig.2 shows, the mass maturation of females on the North-Newfoundland Shelf is usually observed with the length of 37-38 cm and in males (Fig.1) with that of 32-33 cm.

In the upper layers (200-450 m) the main bulk of males, 28 cm in length, is mature (usually at these depths their mean sizes are 33-35 cm). Great numbers of large fishes with the length of 38 cm and longer are observed in catches taken at depths of 450 m and deeper. Catches are maximum in the lower layer (600-700 m). As it is mentioned above, at these depths the average size of males reaches 39 cm. The increasing of the average size of males up to 36 cm in the layer of 500-600 m and up to 39 cm in the layer of 600-700 m is due to large immature fishes. The size-frequencies of mature males occurring at depths of 200-450 m is considerably shorter than that of immature ones living at great depths. The similar picture, i.e. the occurrence of large immature fishes at great depths, is also typical for females. However, their mean lengths both in the uppest layer (200-300 m) and in the lowest one (600-700 m) are almost equal (39 and 39.6 cm respectively). If at the depth of 200-300 m the redfish are almost all mature, in the layer of 600-700 m they completely immature.

Thus, Figs.1-3 and Tables 1-2 show that large, above 38 cm,

immature fishes of both sexes mainly concentrate at depths of 550-700 m. We reported in detail about these redfish in ~~the paper~~ Research Docum 46 submitted ~~at~~ the ~~15-th~~ 1965 Annual Meeting of ICNAF. In the same document we gave our hypothesis on the non-maturing of large redfish. This hypothesis ~~consists in the~~ is as follows. In connection with the fact that different intermediate forms of redfish are met in the Labrador-Newfoundland area, it is quite evident that in this area there taken place a natural hybridization between two main species of redfish S.marinus and S.mentella. Above all, mass crossing of the two species may result from the coincidence of the areas of their occurrence in the Labrador-Newfoundland area especially in summer and autumn when the fertilization of females takes place

Large immature redfish concentrating in lower layers (550-750 m) may be a heterotic group of fishes with gonad disorders. Sterility of some part of a population, which is observed while the crossing of different species takes place, is a quite regular phenomenon.

The concentrating of immature large redfish at the lower limit of their distribution (600-750 m) may be explained in the following way. Migrations from great depths to smaller connected with ripening and spawning which are typical for "beaked" redfish may not be peculiar to immature large redfish due to the sterility of gonads. The sterile redfish may gradually separate from redfish developing normally. Therefore, they concentrate at lower line of the distribution and sometimes form dense concentrations. From time to time such concentrations were successfully fished for by the vessels of DDR, Poland and the USSR (as reported in our previous paper).

Seasonal Dynamics of the Distribution of Redfish Sebastes mentella

The above mentioned pattern of the distribution of "beaked" redfish with a length of above 28-30 cm (viz. in two upper layers of 200-300 and 300-400 m there mainly occurred a mature part of

the stock, in two following layers, 400-500 and 500-600 m there is met a young immature part, i.e. a potential one, and within the lower line of the distribution of the species, 600-750 m, there is found a group of relatively large immature, may be sterile redfish) undoubtedly has the variations related with seasonal processes.

As the influence of the seasonal prevalence tells first of all on surface layers, the qualitative and quantitative changes in catches of redfish are especially observed in upper layers of the Shelf, 200-400 m.

At depths above 400 m the hydrological conditions are relatively constant during the year, but the regular migrations to smaller depths in summer are also typical to some extent for redfish living at these depths. Their migrations are less extensive and of shorter duration than those of the mature part of the stock observed in upper layers.

We shall discuss the distribution of redfish by depths in detail in connection with seasonal cycles of the life of adults during the year (Table 3, Fig. 3)

1. Winter period: December/March. Wintering of fishes and ripening of their gonads.

2. Spring-summer period: April/July. Larvae extrusion and the beginning of the feeding period.

3. Autumn period: August/November. The feeding of fish and fertilization of females.

December/March

The most severe conditions during this period are observed in the upper layer where redfish are found, 200-300 m. Favourable conditions for the life of redfish mainly for the maturation of females are observed at depths of 300-350 m. In winter, the main concentrations of ripening adult females are found at depths of 300-350 up to 400-450 m (50-60%) of the North-Newfoundland Shelf. So, in the layer of 200-300 m, where the catches are not so great in winter, males make up the main portion (60-70%). One can often find catches consisting of males. In the layer of 300-400 m the

percentage of males in catches decreases up to 42-50% (on the average 47% during the season)compared with the depth above mentioned. In winter, as a rule, the catches of redfish taken at depths of 300-450 m are considerably larger than at smaller depths. Their qualitative composition is considerably higher in connection with predominance of maturing females with average sizes of 38-40 cm than at depths of 200-300 m where males of 34-35 cm in average length and young immature fishes with the length from 20 to 30 cm form the basis of catches.

In winter, at depths from 450 to 550 m there are mainly observed immature females and those spawning for the first time with the average length of 34-37 cm and males (50-53%) both immature and ripening (the average length is 33.5-37 cm). At this depth the catches of "beaked" redfish are highly large in winter. However, due to the absence of large maturing females, the qualitative composition of catches is much worse than in the upper layers (the total average size is 35-35.8 cm).

A portion of large immature redfish with the prevalence of males (58%) occurs at depths above 500-550 m. The size compositions of males and females are almost similar, the average length of males is 39 cm, of females 40 cm.

April/July.

In the spring/summer period the number of females at the depth of 200-300 m increases considerably. If in winter their number at depths of 200-300 m amounted to about 30-38%, then in summer, when the extrusion of larvae occurred, their portion increased to 50-70% (60%, on the average). In this period of time pre-spawning and spawning females often constitute 80-90% of the catches. The most dense concentrations of spawning females are observed in the west of the Ritu Bank, i.e. on the slope facing the shore, in the gully rounding this slope and on the shallows. Some part of spawning females forms concentrations in the offshore areas of North-Newfoundland Shelf at depths of 300-550 m (especially at the boundary with South Labrador in the north and Grand Newfoundland Bank in the

south). However, the efficiency of fishery shows that concentrations of spawning females on the offshore slope are much smaller than in the central part of the North-Newfoundland Shelf. The existence of a rather large spawning area in the central part of the Shelf is probably due to the cyclonic gyre which prevents redfish larvae from a great drifting into the southern areas and, thus, contributes to the conservation of abundance of local stock of redfish populating the area north of Newfoundland.

Dense concentrations of redfish, mainly of spawning females, occur in the central part of the North-Newfoundland Shelf. It was well demonstrated by the productive fishery in this area in April-June of the last three years. As a rule, the efficiency of fishery in the offshore part of the Shelf is not great at a depth of 300-450 m in the period of larvae extrusion. In April/June, the most dense concentrations are found at depths of 450 m and more. At the depth of 450-600 m there lives a group of young immature females with the mean length of 34-36 cm, the analogous group of males with the average length of 33-35 cm and a group of mature males which stay in the wintering areas (at great depths on the ocean slope) until the middle of summer, i.e. until the second half of June or July. The amount of males at depths of 400-600 m in this period is somewhat greater than that of females and constitutes 52-60%. At depths over 550-600 m rather dense concentrations of immature and comparatively large redfish, are observed and both males and females of that redfish have the length of 39-41 cm. The females with the greatest mean length (40-41 cm) are found at 200-300 m in May/June, i.e. just in the period of larvae extrusion. In July, movement of spent females into the feeding areas (partly to the slope down to 300-400 m, partly to the north into the Belle Isle area) results in a sharp drop in the efficiency of fishery in all the parts of the North-Newfoundland Shelf, and the mean length of females reduces from 41 to 37 cm.

August/November

The period of uneffective fishery on the North-Newfoundland Shelf resulted from dispersal, mobility and horizontal movements

of feeding redfish lasts till approximately September/October.

The fishery at great depths of 400-700 m becomes also uneffective in this period. Mature males at depths of 350-600 m migrate in summer into the more shallow-water regions, into the areas of feeding of spent females, where in August/September the fertilization of females takes place. The most dense mixed concentrations of mature males and females at depths of 200-350 m were found in all the years under investigations in August/September on the Sundall and Hamilton Banks.

In the area of the North-Newfoundland Bank the mean size of redfish in the catches taken at depths of 200-400 m reduces sharply down to 33-37 cm due to the dispersal and movement of mature redfish to the north and migration of small immature redfish from great depths up to the feeding shallow-water areas. Sex ratio at upper levels (200-350 m) gets balanced. At depths of 400-600 m the migration of mature males into the areas populated by adult females upsets the balance of sexes observed in winter and in the spring-summer period, and the amount of immature females rises to 60-75%.

Conclusions

The analysis of fisheries and biological data as applied to different depths enables us to get the following picture of the life and migration cycle of redfish Sebastes mentella in the area of the North-Newfoundland Bank:

1. The area inhabited by S.mentella on the Shelf north of Newfoundland is rather wide. As a matter of fact, redfish S.mentella are found over the whole area from the offshore part of the Shelf up to the cold coastal stream, shallows and deep-water gullies included. The upper limit of mass occurrence of S.mentella is the 200 m isobath, while the lower one are those of 700-800 m.

2. As redfish S.mentella grow, they gradually descend down to great depths (more than 400 m), where they remain till the full ripeness, undertaking insignificant seasonal migrations.

During almost all the seasons small, mostly immature redfish, and recruits with the mean length of 35-36 cm both in males and females composed the main bulk of catches taken at depths of 400-

550 m. Comparatively large (mean length of 39-40 cm) and usually immature redfish with the gonads at 1-2 stages of development were usually caught at depths more than 550 m (550-750 m).

3. The mature specimens perform migrations in an opposite direction, i.e. in the areas with favourable hydrological conditions females just before the extrusion of larvae and males capable of fertilization rise to the surface levels of the Shelf (200-400 m). For the rest of their life they keep mainly to these depths and descend down to lower layers only in the coldest time of the year. In the period of larvae extrusion the movement of adult mature females to depths more than 400 m was insignificant in this area.

4. Migrations of mature redfish during the year are probably completed in the following way.

Adult females winter in December/March on the offshore slope and partly in the gullies at the depth of 300-400 m.

In April/June, in the period of larvae extrusion, the mass movement of females into the more shallow-water regions is observed. As a result, they concentrate on the western slopes of the Ritu Bank and in the gully. In July, when the feeding period begins, adult females are distributed over a large Shelf area.

During the feeding period in August/October, the concentrations of adult redfish are greatly scattered except the period of mating, and are encountered mainly at 200-400 m. At the end of the feeding period females again concentrate at depths of 300-450 m. Adult males are observed in winter at depths from 200 to 550 m. In April/June, when females migrate to the shallows to extrude larvae these males stay in the main wintering area on the slope at the 350-500 m depth. In July, males, just like females, rise from great depths up to the shallows (200-350 m) where they, together with females, are found during the whole of autumn.

5. Migrations of immature specimens which live at depths more than 400 m, are evidently rather limited and are chiefly characterized by summer movements from depths up to more shallow-water areas with greater food supply. After the cooling they usually descend down to greater depths.

TABLE 1. Average length of redfish S.mentella at different depths (in cm)[x].

Sex \ Depth :	200-300	300-400	400-500	500-600	600-700
males	34,6	33,9	35,2	36,I	39,I
females	39,0	38,7	36,3	36,5	39,5

x) Fig. 1 shows the number of redfish investigated.

TABLE 2. The percentage of immature[x] and mature redfish at different depths.

Sex, maturity \ Depth :	200-300	300-400	400-500	500-600	600-700
♂ immature	I3,2	26,2	44,0	66,5	86,2
♂ mature	86,8	73,8	56,0	33,5	I3,8
♀ immature	2I,2	9,8	60,4	92,3	98,2
♀ mature	78,8	90,2	39,6	7,7	I,8

x) Immature - stages 1-2,
Mature - stages 3-6 for males, 3-9 for females
(according to V.P.Sorokin)

TABLE 3. The ratio of males and females (%), their average lengths (cm), the number of redfish investigated (spec.) by periods and depths.

Period	Sex	200–300			300–400			400–500			500–600			600–700		
		%	cm	spec	%	cm	spec	%	cm	spec	%	cm	spec	%	cm	spec
I	♂	62	34,9	9598	47	33,6	293I4	56	35,7	255I	58	39,0	I504	-	-	-
winter	♀	38	39,7	5996	53	38,8	32263	44	35,9	I995	42	40,2	I03I	-	-	-
II	♂	40	34,9	5I02	48	34,3	I0674	49	35,2	5697	52	34,7	3055	46	39,I	2649
spring–summer	♀	60	39,6	7666	52	38,6	II377	5I	36,3	5846	48	35,2	2882	54	39,6	3I07
III	♂	50	32,2	I96I	44	33,8	60I8	36	34,3	I449	25	37,3	I09	-	-	-
autumn	♀	50	34,2	I95I	56	38,8	7637	63	36,8	2533	75	37,4	333	-	-	-

I — December, January, February, March (wintering)

II – April, May, June, July (spawning)

III – August, September, October, November (feeding, mating)

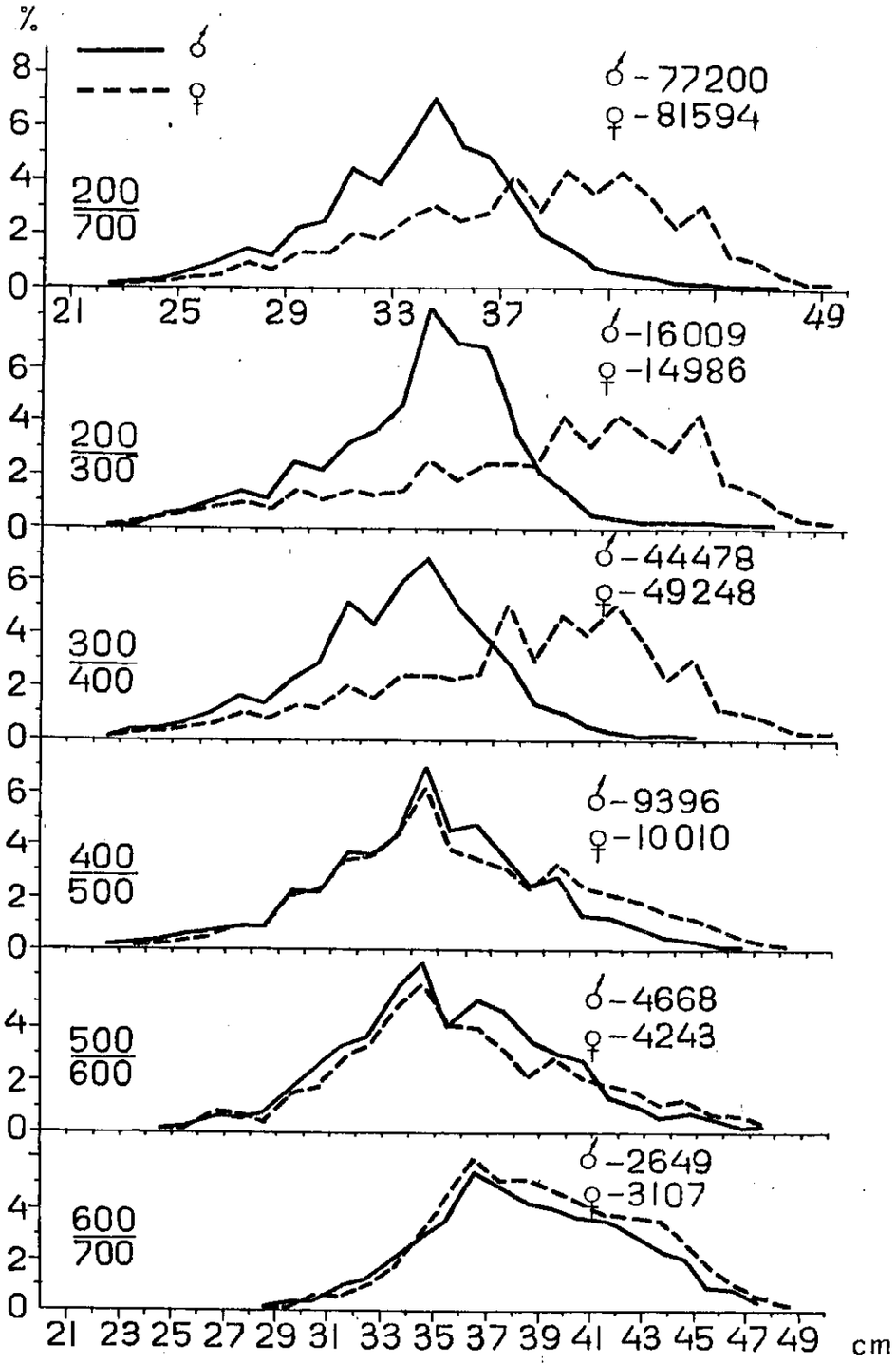

Fig. 1. Size composition of "beaked" redfish at different depths.

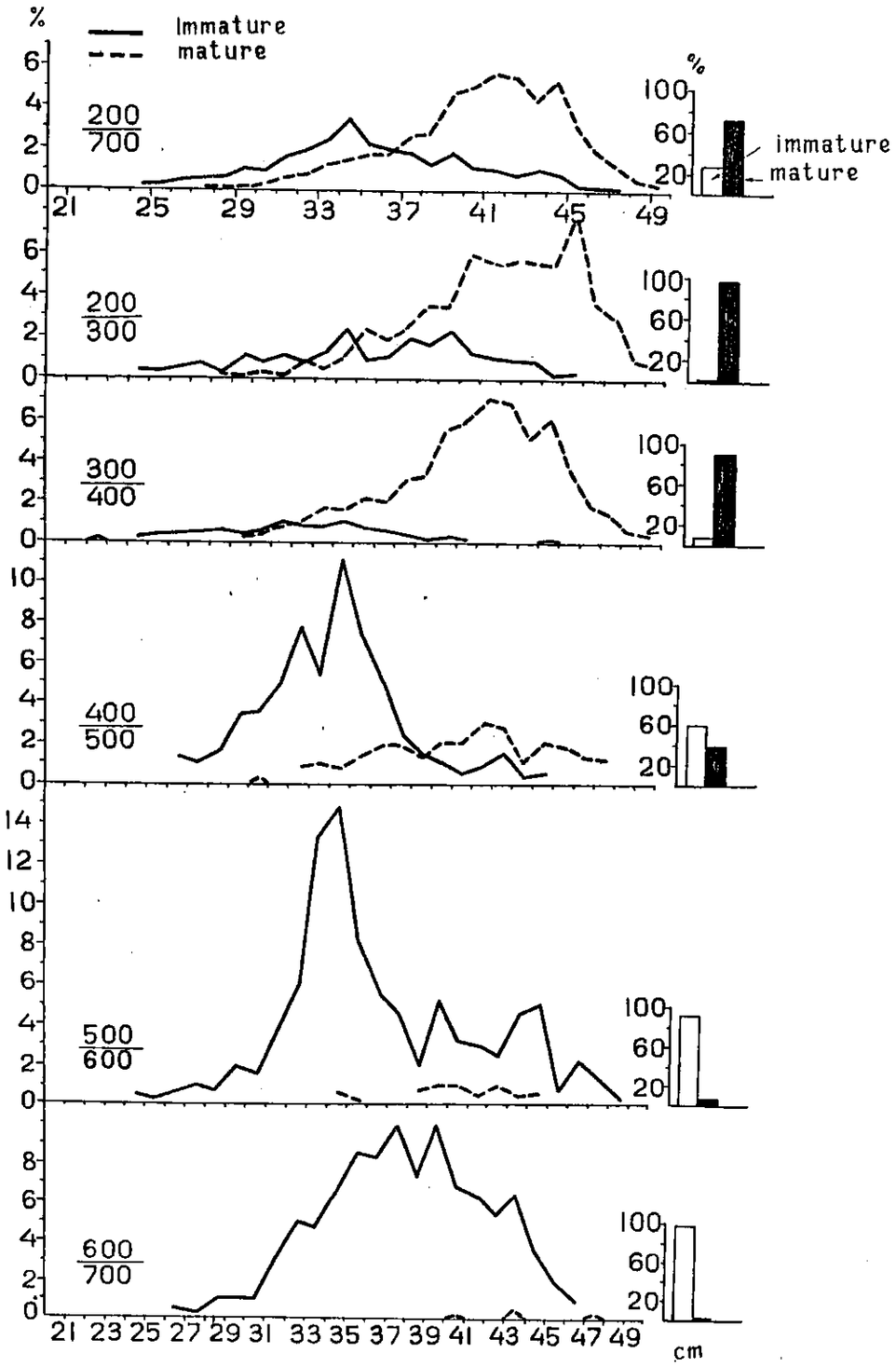

Fig. 2. Size composition and ratio of mature and immature females of "beaked" redfish at different depths.

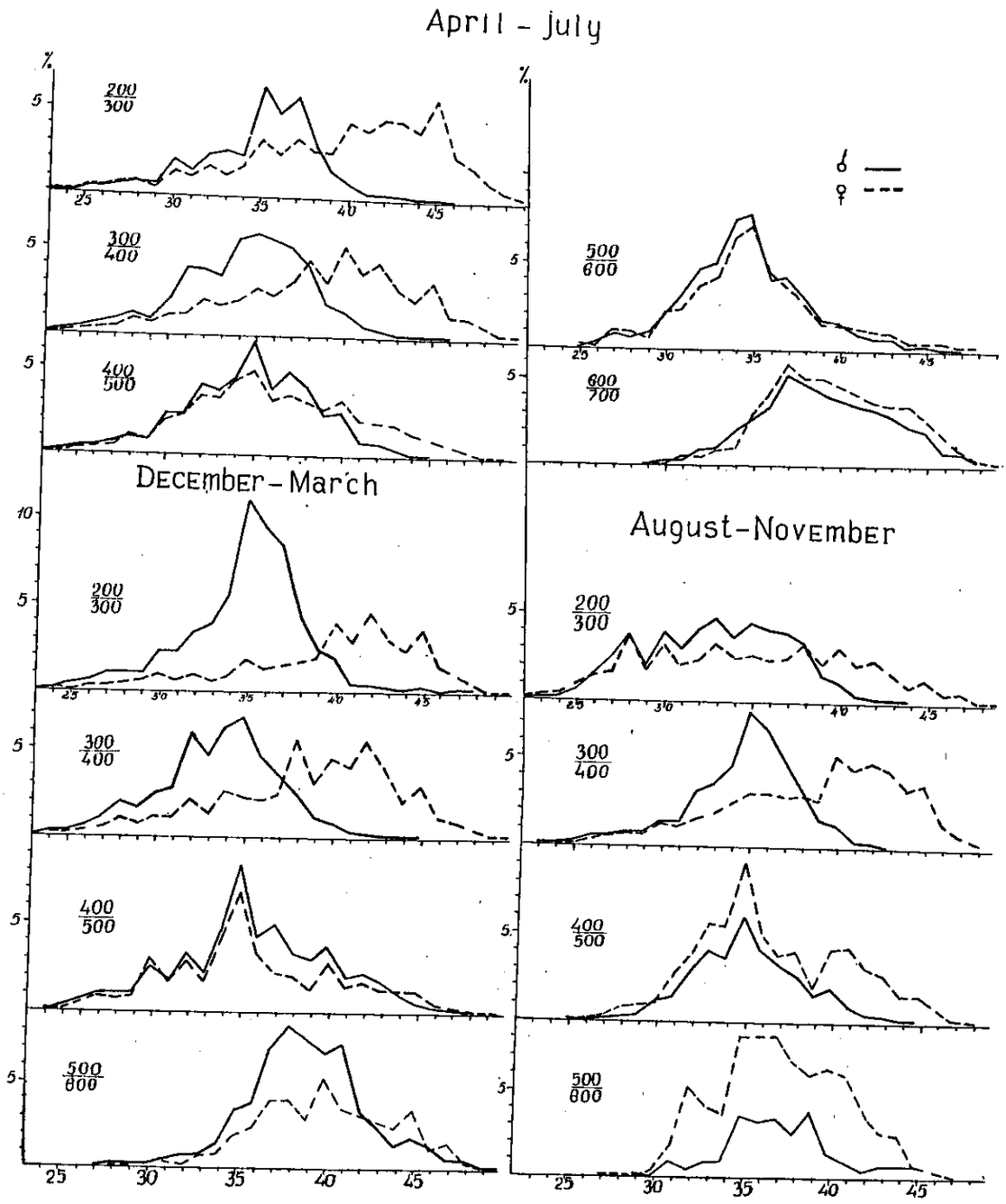

Fig. 3. Size composition of "beaked" redfish at different depths during particular periods.