International Council for
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On the formation of the first winter zone in blue whiting otoliths

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Abstract. Otolithes of juvenile blue whiting when recruiting to the industrial fishery in the Norwegian Deep in early autumn (August-October 1970-72) could be divided into two groups, without or with a very insignificant hyaline ring. During the autumn a hyaline ring (a Bowers zone) was laid down followed by new opaque material. A true hyaline winter zone was laid down later in the winter.

This paper not to be cited without prior reference to the author.

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Introduction. The otoliths of blue whiting have been described by Scott (1905) and Sæmundsson (1929). The broken surface of the otolith display an alternation of hyalin and opaque zones when examined under a low power microscope. These zones have by several workers been interpreted as seasonally formed, with the hyalin laid down during the winter and the opaque zones laid down during the summer. The validity of this interpretation has been studied and confirmed by Raitt (1968).

On the basis of the age reading Raitt (loc. sit) found that blue whiting in the area west of Scotland and around the Faroe Islands in their first year of life reach a length of 18-20 cm in the spring. Similar growth the first year has been reported from the Mediterranean (Bas 1965), the Bay of Biscay (Guichet 1968, 1969), the Porcupine Bank (Polonsky 1967) and the Norwegian Sea (Zilanov 1968). This is a very fast growth the first year for a fish that only rarely exceeds 40 cm in length, and Raitt (loc. sit) was unable to fit a von Bertalanffy growth curve to the growth pattern of blue whiting.

Bailey (1970) reexamined some of the blue whiting material kept at the Marine Laboratory, Aberdeen, formerly aged as coming from 0-group fish. He found that the otoliths could be separated into two groups according to the width in the dorsoventral plane of the otolith and the possession of an inconspicuous zone in the otolith. He interpreted these two groups as two agegroups. The 0-group with no zone and a smaller otolith width and 1-group fish with a tiny zone and a greater otolith width. He finally concluded that juvenile blue whiting stayed planctonic for 1 1/2 year and that fish between 17 and 22 cm formerly aged as 1 group were 2 years old and that to all previous age readings of blue whiting should be added one more year. With this revision it was also possible to fit a von Bertalanffy growth curve to the growth pattern of blue whiting.

The Bailey method of ageing blue whiting is now widely accepted and is used at most laboratories working on blue whiting.

A significant part of the catches in the norwegian trawlfishery for industrial purposes in the North Sea is composed of juvenile blue whiting in the length-range 10-25 cm, (Jákupsstovu 1974a).Since 1970-71 this fishery has been sampled regularely at the Institute of Marine Research, Bergen, (Lahn-Johannesen 1973). While working on the agecomposition of blue whiting in these catches it was difficult to use the criteria set up by Bailey (loc. sit) for separating the first age groups. Many of the juvenile fish that entered the North Sea in the autumn had one zone in the otolith, some had two and later in the winter even more zones could be counted. It was therefore necessary with a closer study of the zone formation the first winter blue whiting spent in this area.

Material and methods.

The most characteristic feature of the length distribution of blue whiting in the industrial landings from the North Sea is the recruitment each autumn of juvenile fish 10-17 cm (Jákupsstovu 1974a). This group (fig. 1 a & b) has a fairly normal length distribution and it is a relative simple task to separate this group from any older fish in a sample. And for this paper only fish coming from the recruiting group have been taken into consideration.

The material consists of 10 samples from the period February 1970 to May 1973. Of these 3 samples are from the autumn (Sept.-Oct.), 5 from the winter and 2 from the spring. 9 of the samples are from the Viking Bank area and 1 from the area west of Ireland (fig. 2 a & b, table 1).

Each fish in the sample is measured to the nearest 1/2 cm below as soon as possible after the capture. The sacculus otolith was then dissected out and each pair kept separated in paper evenlopes.

For age determination the method described by Gambell and Messtorff (1964) was adopted. The otolith is broken transversally, and a beam of light striking the side of it is transmitted upwards through it, illuminating the hyaline and opaque zones on the broken surface. During the reading the dorsoventral diameter of the surface was measured. The edge was grouped into the following characters: Hyaline (H), mainly hyaline but with some opaque material somewhere on the edge (Ho), opaque (O) and mainly opaque but with some hyaline material at the edge (Oh).

During reading any hyaline ring in the otolith was recorded and if possible the greatest inner diameter measured.

Results and discussion.

The distribution of the edge character is set out in fig. 3. Although the number of samples is too small to draw any conclusion, the results are in accordance with Raitt´s (1968) findings with mainly hyaline edges in the winter and mainly opaque edges in the spring. A special feature is the high percentage with hyaline edges in the autumn. The number of otoliths with opaque and hyaline-opaque

edges in the winter is also remarkably high.
In table 1 each sample is divided into groups according to the number of rings counted in the otoliths; here is counted any ring that is possible to detect even if it is not possible to follow the ring all the way around the broken surface of the otolith.
In fig. 4 a-d each sample is split in the same groups and for each group the distribution of the otolith width and the distribution of the ring diameters recorded as percent of the number in sample.
The distribution of the otolith ring width is in eyepiece unit. The corresponding fish lengths taken from fig. (5) is indicated below.
In the autumn samples from 1970 and 1972 mainly two groups of otoliths can be recognised either without or with one ring. Most of the rings in the sample from 1970 could be measured, thus indicating that they were layed down when the length distribution was from 6-12 cm. None of the rings in the autumn sample could be measured.
The autumn sample from 1971 is grouped into three groups, viz. none, one and two ringers. The one ringers layed down the ring when the length distribution was from 8-16 cm. The two ringers layed down their first when the fish were from 7 to 14 cm and the second when the fish were from 11 to 16 cm.
The winter sample from 1970 although divided into 4 groups is dominated by two ringers. The first of these layed down when the fish were from 4-10 cm and the second from 11,5-18 cm.
Also in the winter sample from 1971 4 groups were recognised with two ringers dominating. The relative number of one and two ringers is however higher in this sample then in the winter sample from 1970.
In the winter sample from 1972 only one and two ringers are found while in the winter sample from 1973 three groups are recognised.
The spring sample from 1971 is divided into four groups viz. 1, 2, 3 and 4 ringers. Of these two and three ringers are dominating.
The spring sample from 1973 on the other hand is divided into three groups with 3 ringers as the dominating group. Of these the first group is laid down when the fish were from 4-12 cm, the second when the fish were from 12-16 cm and the third when the fish were 16-22 cm.
In fig. 6 the autumn sample from 1972 is set up against an autumn sample from west of Ireland the same year. This last has been grouped into 0, one and two ringers.
Although there is a great variation from sample to sample most of them are grouped into two dominating groups. The juvenile fish entering the fishery in the autumn is mainly 0 and one ringers. During the autumn a new hyaline ring is laid down followed by new opaque material resulting in mainly one and two ringers in the winter samples. In late winter a second ring is laid down and in the spring mainly two and three ringers are found.

The relation between fish length and otolith width in eyepiece units (fig. 5) has no point for fish smaller than 9 cm. Extrapolating beyond this point, however, indicates that the first ring is laid down when the fish are from 4-10 cm, the second when the length is from 12-16 cm and the third when the length is from 15-21 cm.

The ring laid down in the autumn is probably connected with the shift in depth regime from the upper pelagic zone to the deeper in the Norwegian Deep and the corresponding shift in diet. A similar ring is found in whiting otoliths and is by Gambell and Messtorff (1964) named a Bowers zone.

The ring laid down later during the winter is the most conspicous and is a true winter zone. The ring which is found in some of the otoliths from the autumn samples is probably the same as Bailey (1970) termed the first winter ring. Bailey found in his material that otoliths with such a ring on avarage had higher otolith width than those without. This has been tested on this material with an F test. The H_o that all groups are from the same population was not rejected in any case when 5 % probability was used. When 1 % probability was used, however, the H_o was rejected for the winter samples 1971 and 1972.

In fig. 7 a selection of otoliths from the material used in this paper is shown. The figure is based on sectioned otoliths (Jákupsstovu 1974b). And in fig. 8 two sections of older fish is shown. The arrows indicate the ring, I interprete as layed down in late winter. In the older otolith the Bower´s zone and the first ring is clear while in the younger a number of rings can be sean.

The juvenile blue whiting caught in the Norwegian Deep during autumn, winter and spring belong to one yearclass and most of them lay down two hyaline rings during that period. It is therefore difficult to comprehend that the same fish during their first year of life only lay down an inconspicious hyaline ring at a time when they supposedly are found in the uppermost layers of the sea.

In addition if the blue whiting entering the Norwegian Deep during autumn is 1 group fish quite a substantial amount of blue whiting less than 10 cm is to be found somewhere in the nort-east Atlantic during winter and spring. But so far this size group has only been reported caught during summer and early autumn.

On this background I interpret the juvenile blue whiting entering the Norwegian Deep in the autumn as 0-group fish rather than 1-group fish. This interpretation, however, may not be valid for other nursery areas with a different abiotic and biotic milieu.

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TABLE 1.

Position, date and number of fish in the samples used

Date	Position	No measured	No of otoliths	No with rings 0	1	2	3	4
26.02.1970	58°07´N-05°15´E	105	105	3	3	92	7	
01.10.1970	60°48´N-03°24´E	49	49	33	14	2		
21.02.1971	61°22´N-03°01´E	121	85	1	12	57	15	
26.05.1971	Viking Bank	100	91		12	41	32	6
24.10.1971	59°14´N-03°27´E	101	101	15	72	14		
02.03.1972	62°00´N-02°37´E	50	50		31	19		
27.09.1972	61°17´N-02°19´E	100	100	61	39			
13.03.1973	60°45´N-04°37´E	128	50	8	29	13		
29.05.1973	61°15´N-02°03´E	120	53			9	44	

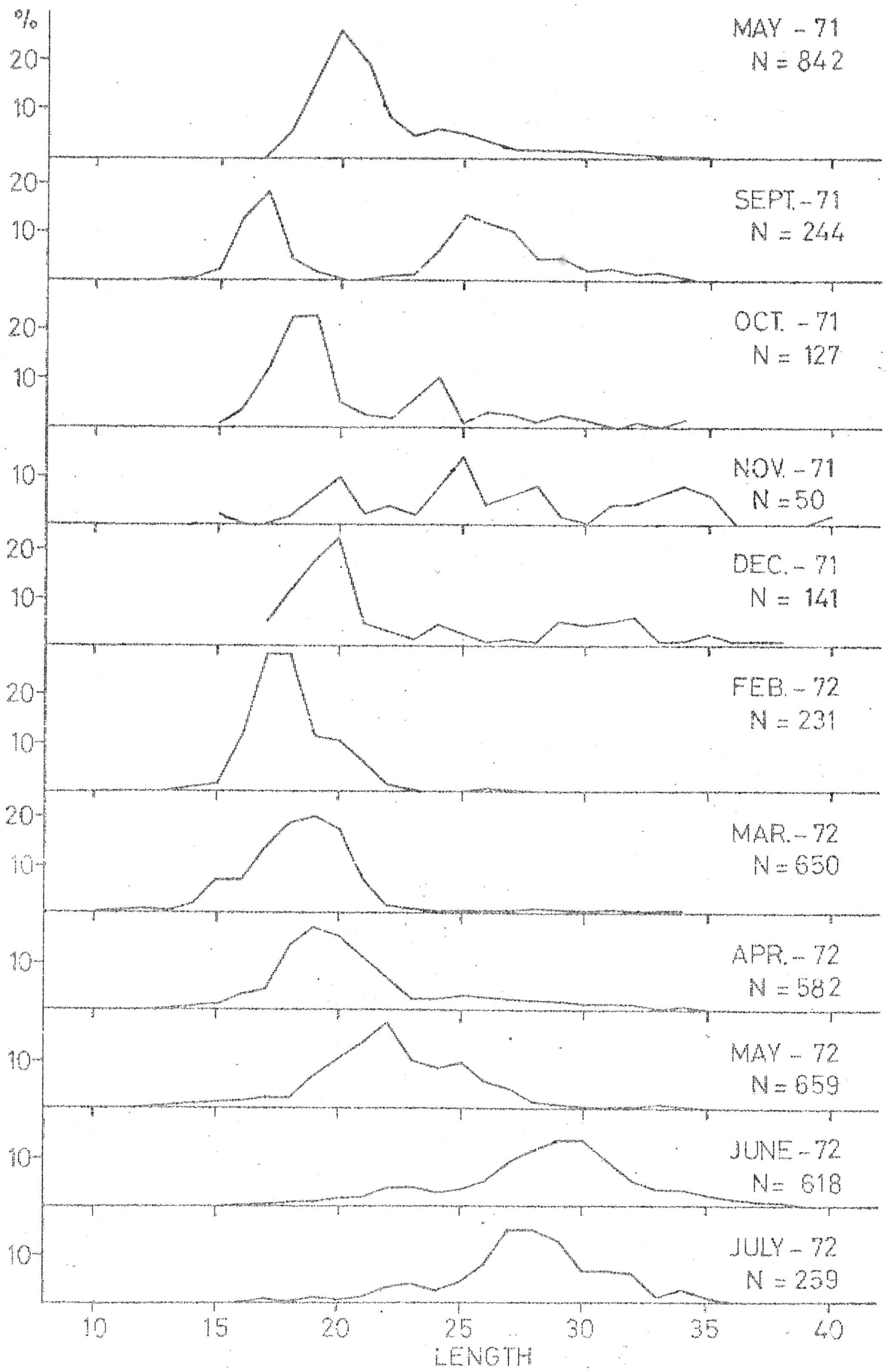


fig. 1a. Lengthdistribution of blue whiting from the industrial trawlfishery in the North Sea May 1971 - July 1972.

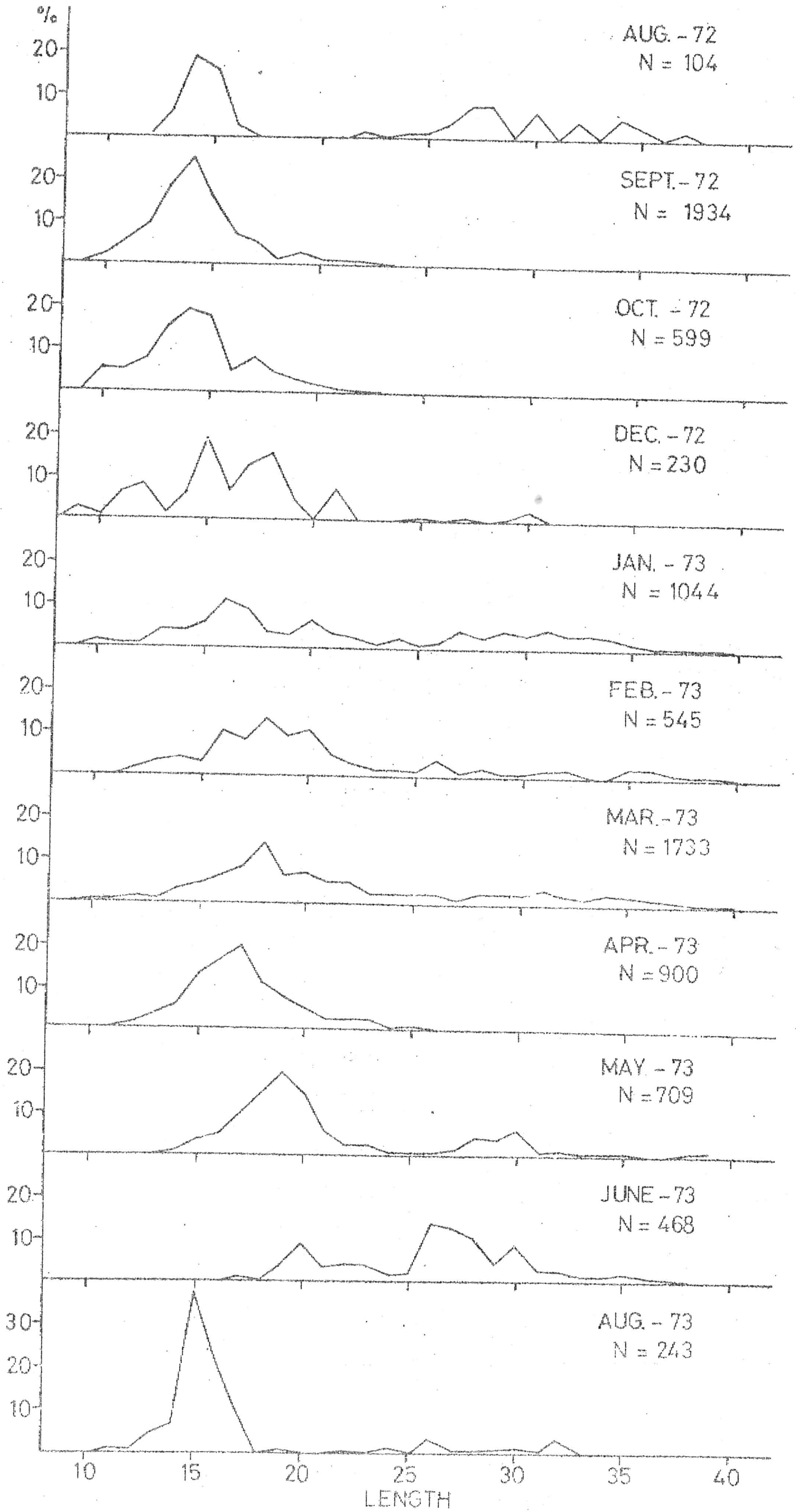


Fig. 1b. Lengthdistribution of blue whiting from the industrial fishery in the North Sea. Aug. 1972 - Aug. 1973.

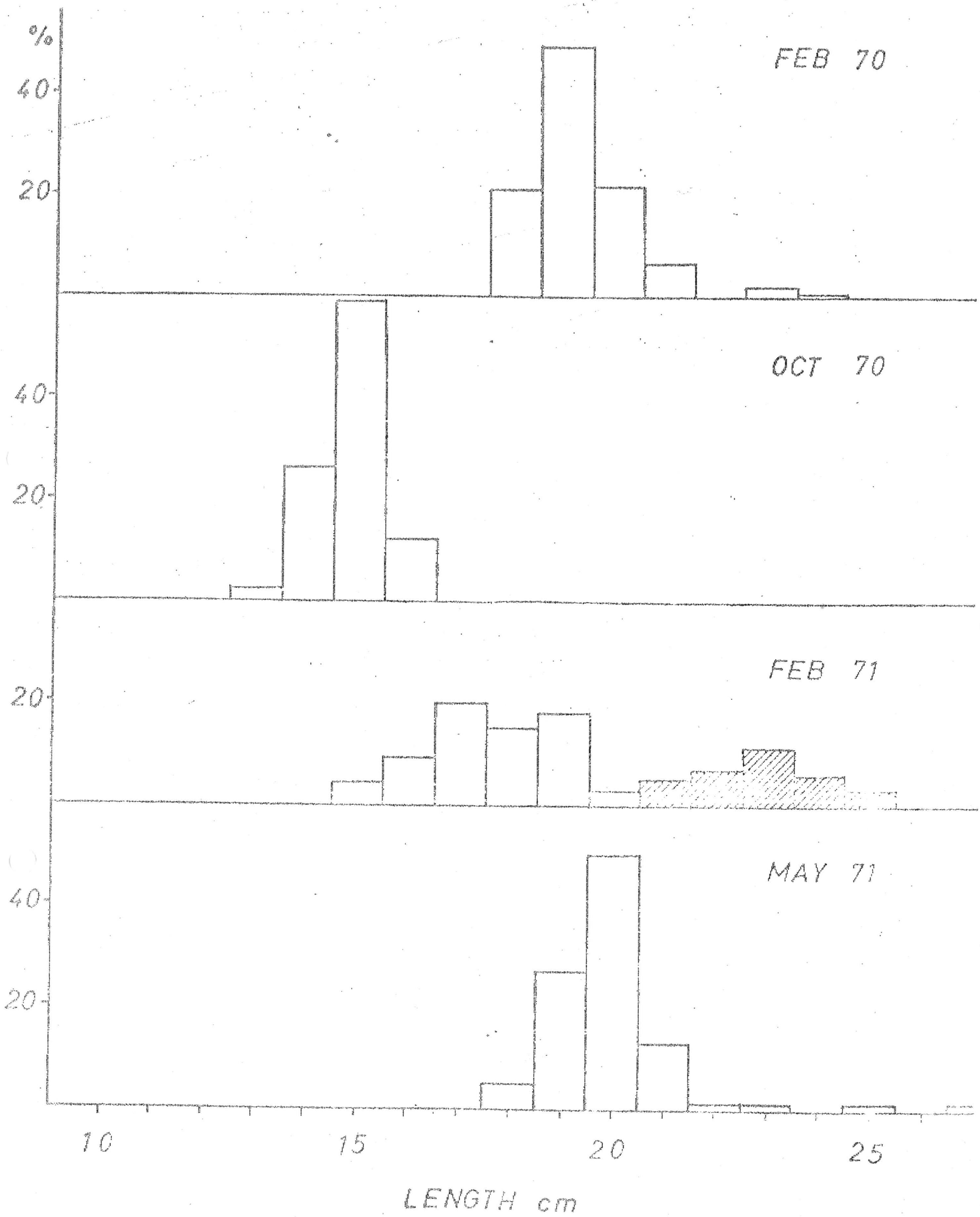


Fig. 2a. Lengthdistribution of blue whiting in the samples used.
Particulars in table 1.

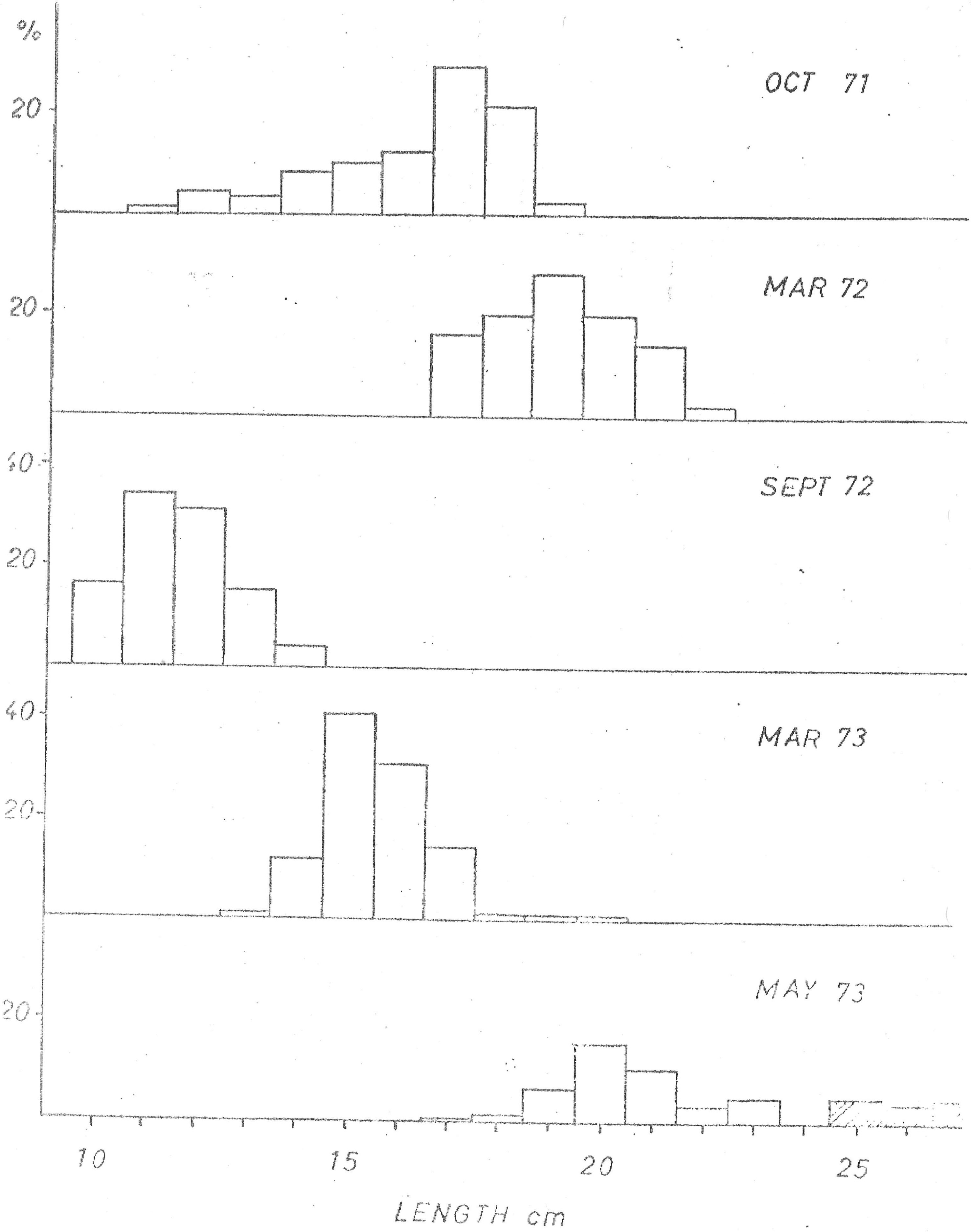


Fig. 2b. Lengthdistribution of blue whiting in the samples used.
Particulars in table 1.

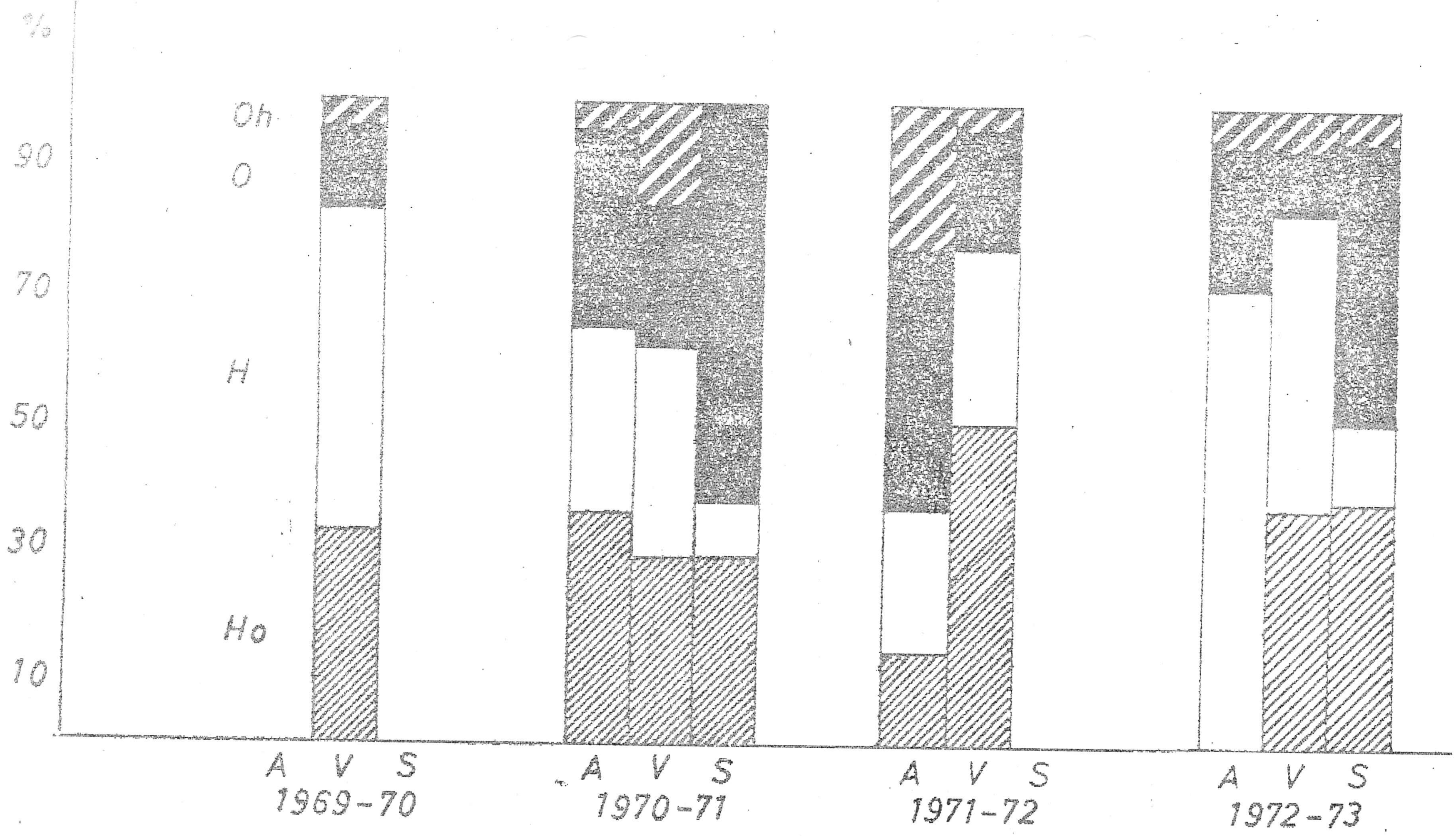


Fig. 3. Edgecharacter in present of the number of otoliths in the samples. Oh Mainly opaque, but with some hyaline material in the edge. O opaque. H hyaline and Ho mainly hyaline, but with some opaque material at the edge.

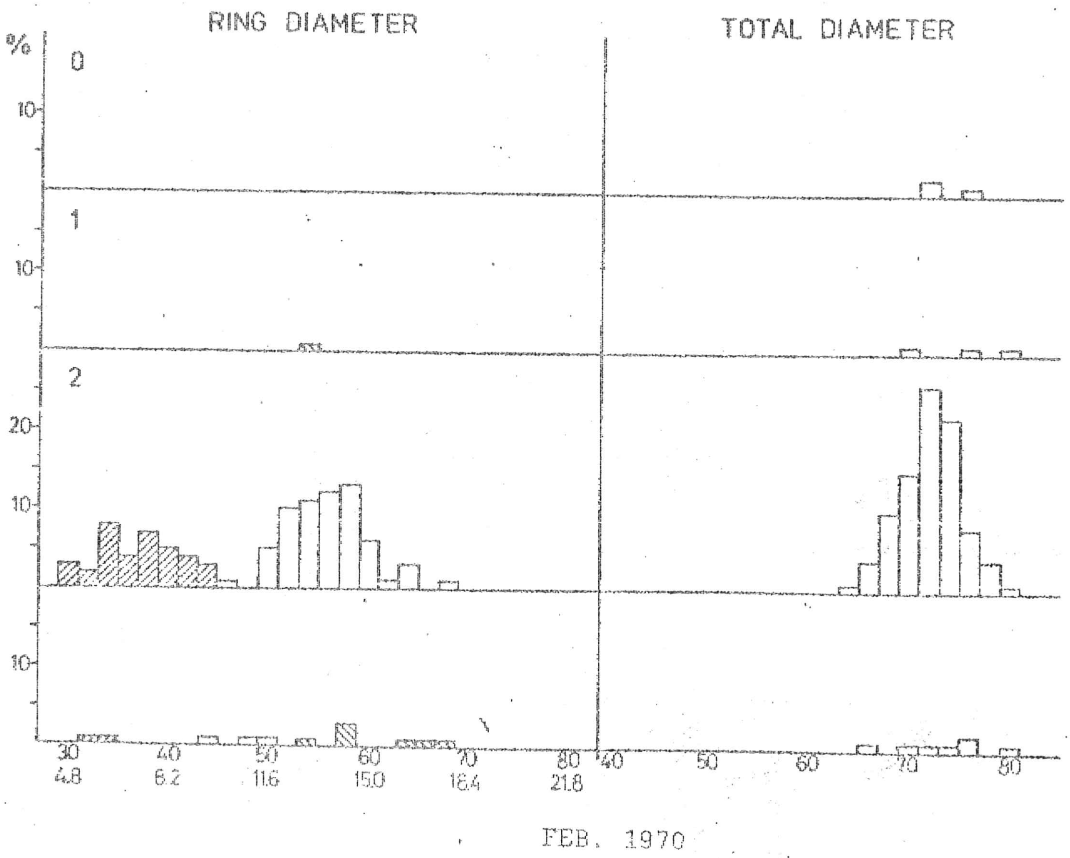


Fig. 4a. The distribution of otolith width and ringdiameter in eyepiece units for the groups within each sample used in the paper (table 1). Further explanation in the text.

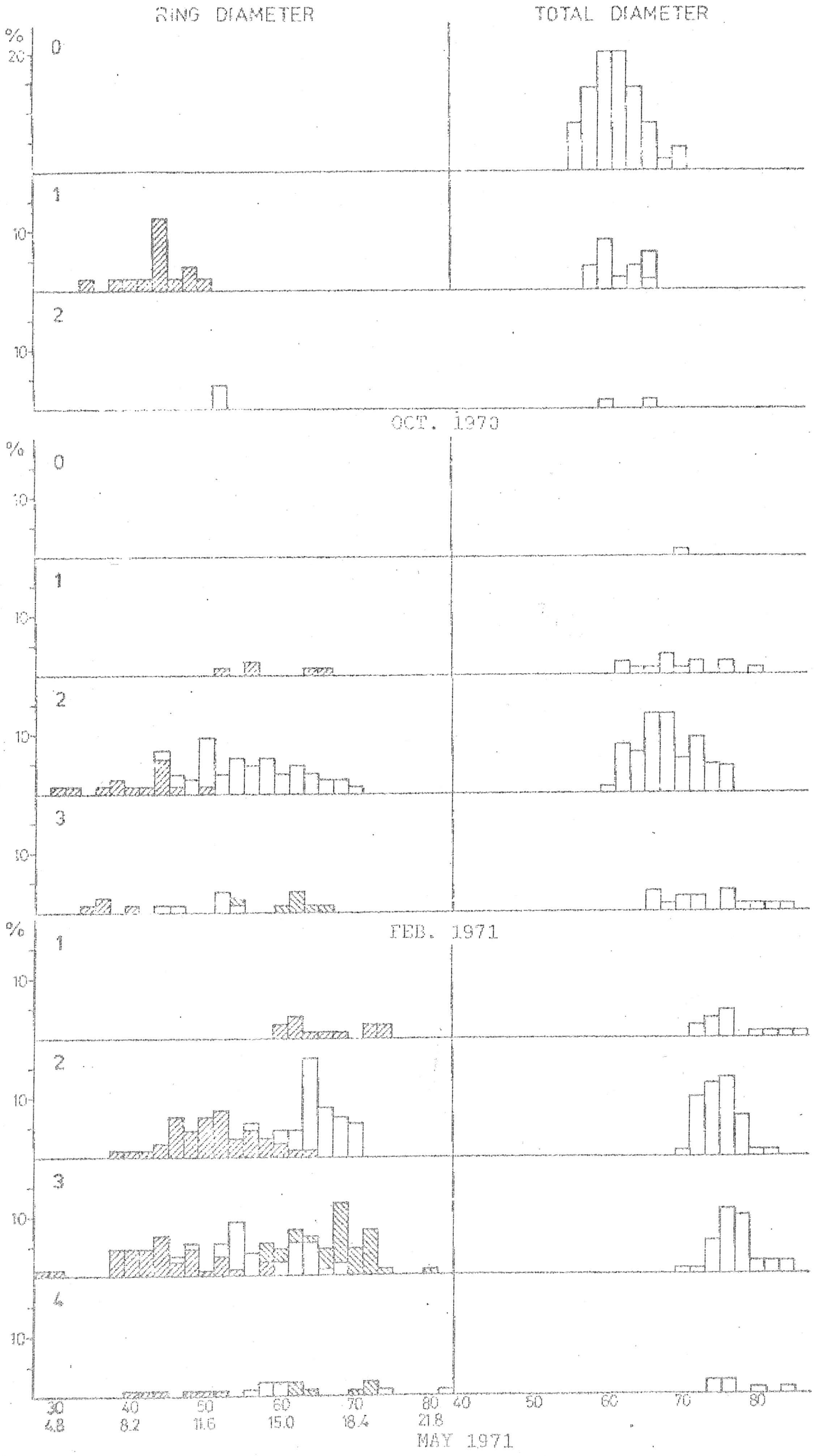


Fig. 4b. The distirbution of otolith width and ringdiameter in eyepiece units for the groups within each sample used in the paper (table 1). Further explanation in the text.

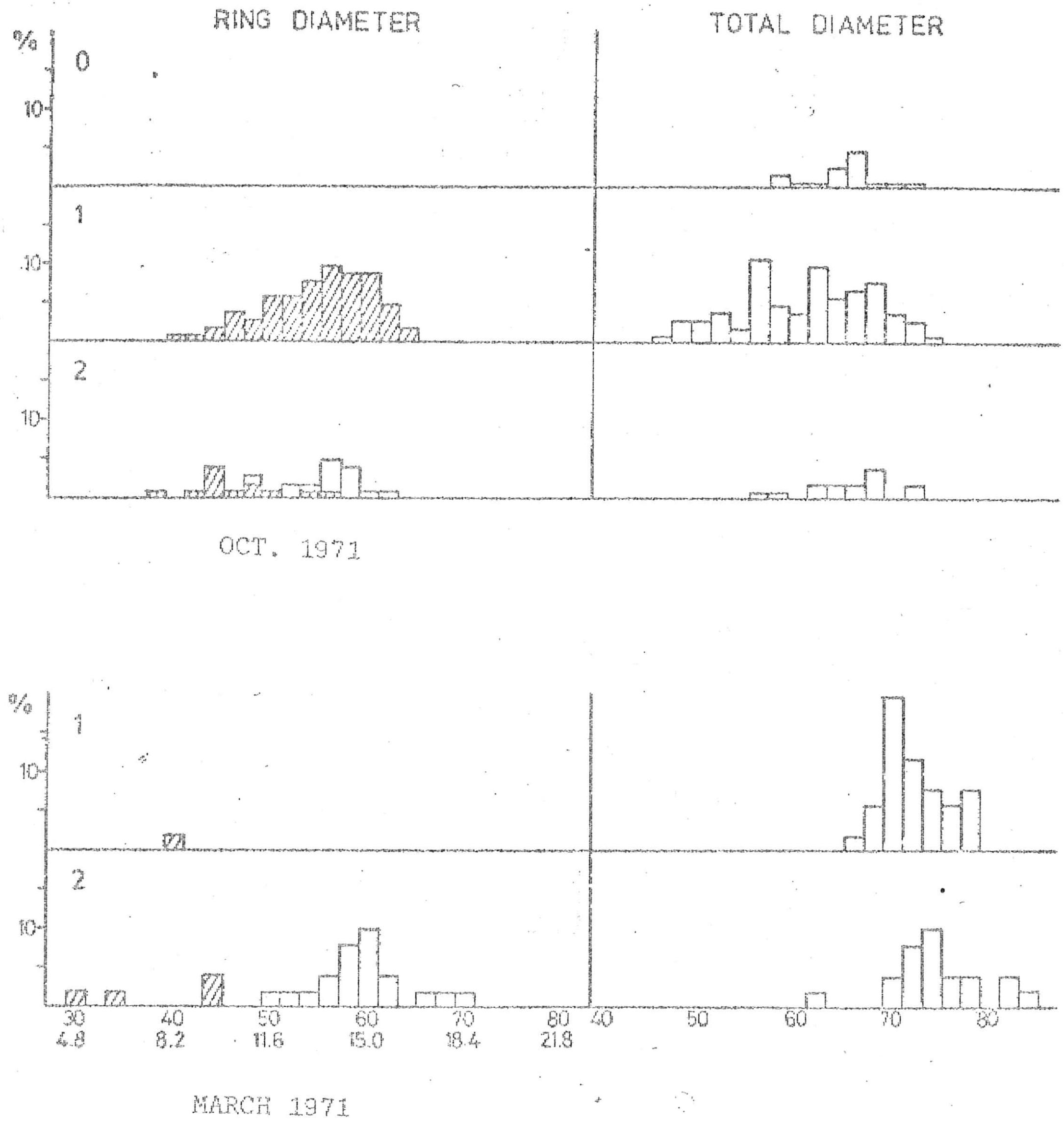


Fig. 4c. The distribution of otolith width and ringdiameter in eyepiece units for the groups within each sample used in the paper (table 1). Further explanation in the text.

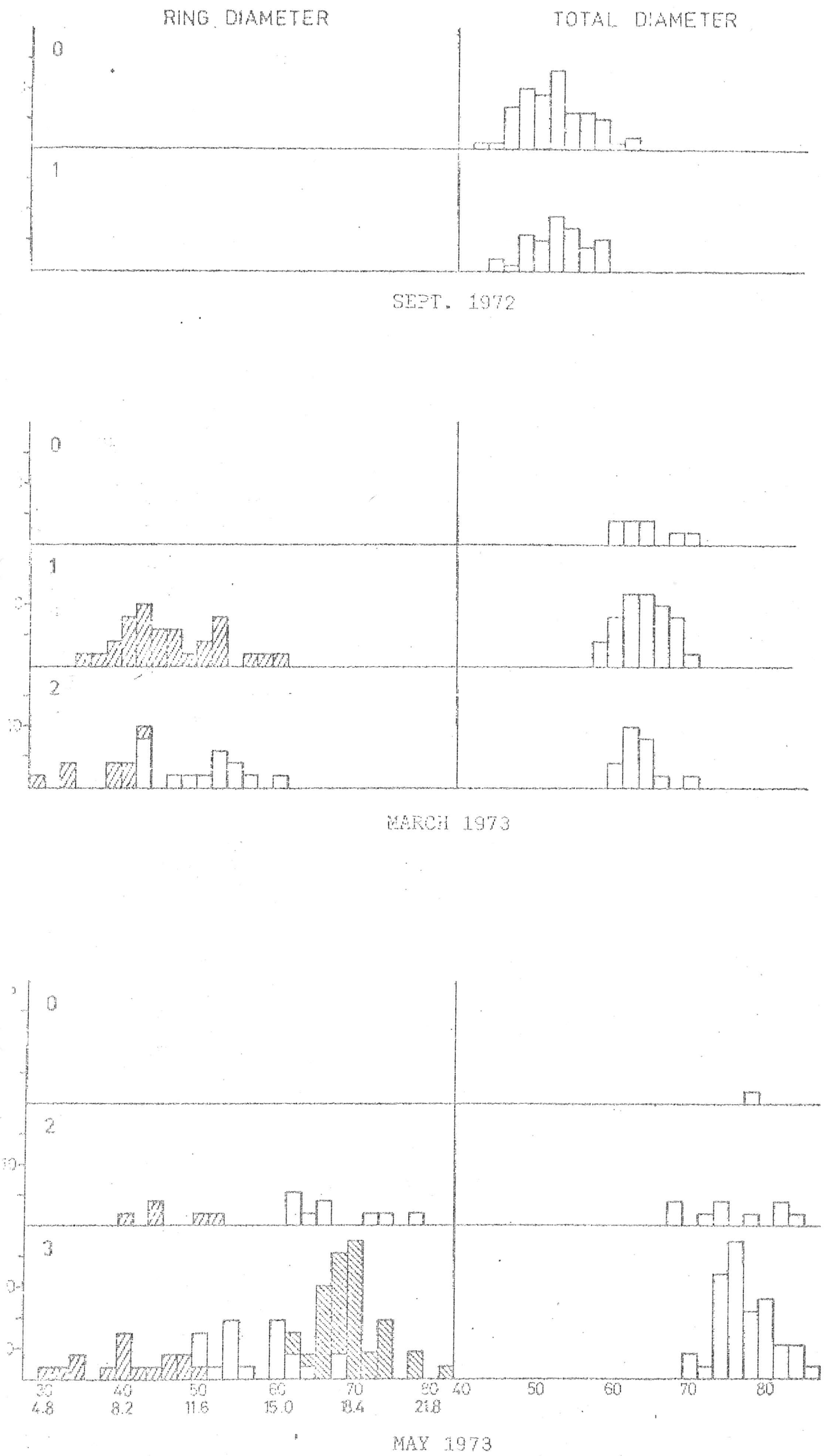


Fig. 4d. The distribution of otolith width and ringdiameter in eyepiece units for the groups within each sample used in the paper (table 1). Further explanation in the text.

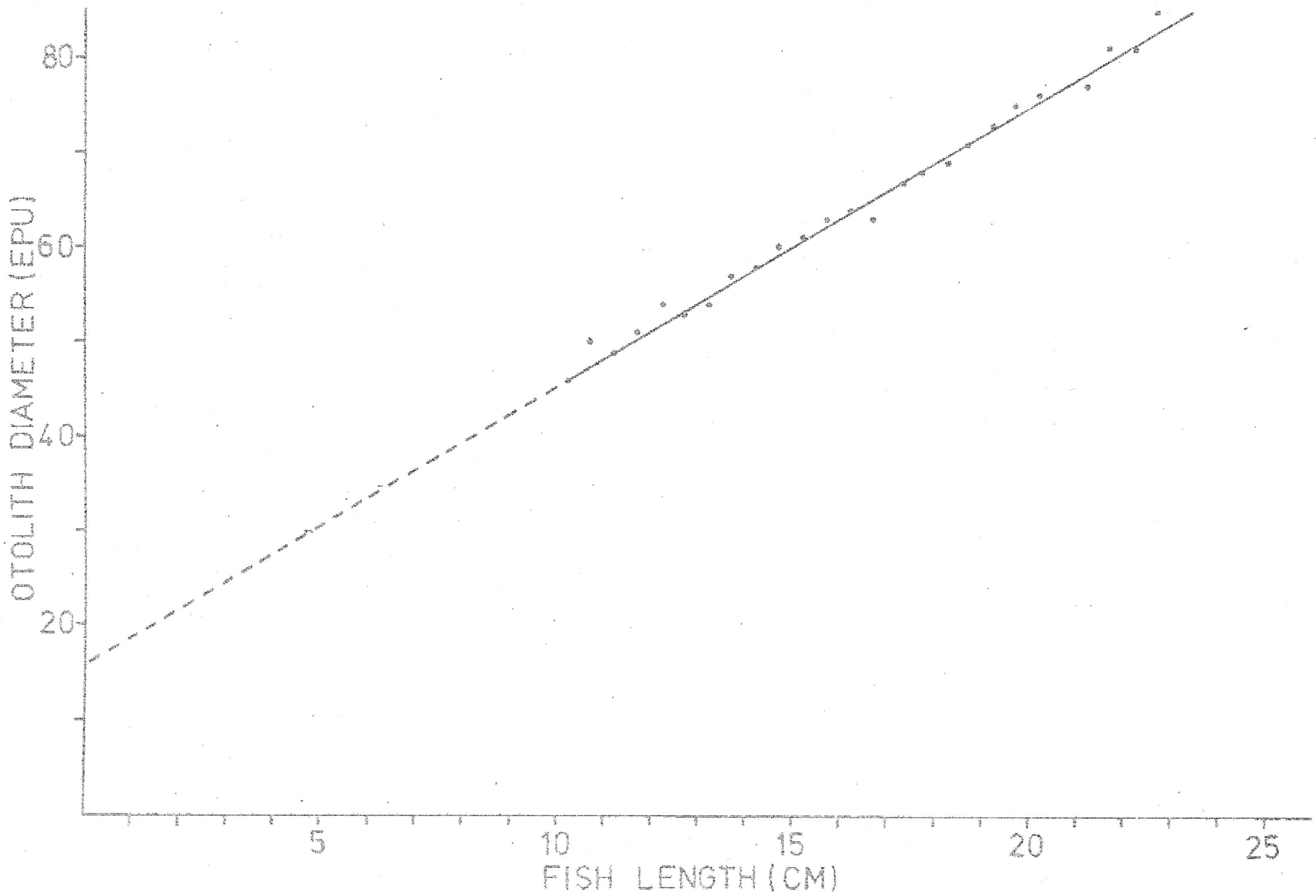


Fig. 5. Fish length in cm and corresponding otolith width in the dorso ventral plane i n eyepiece units.

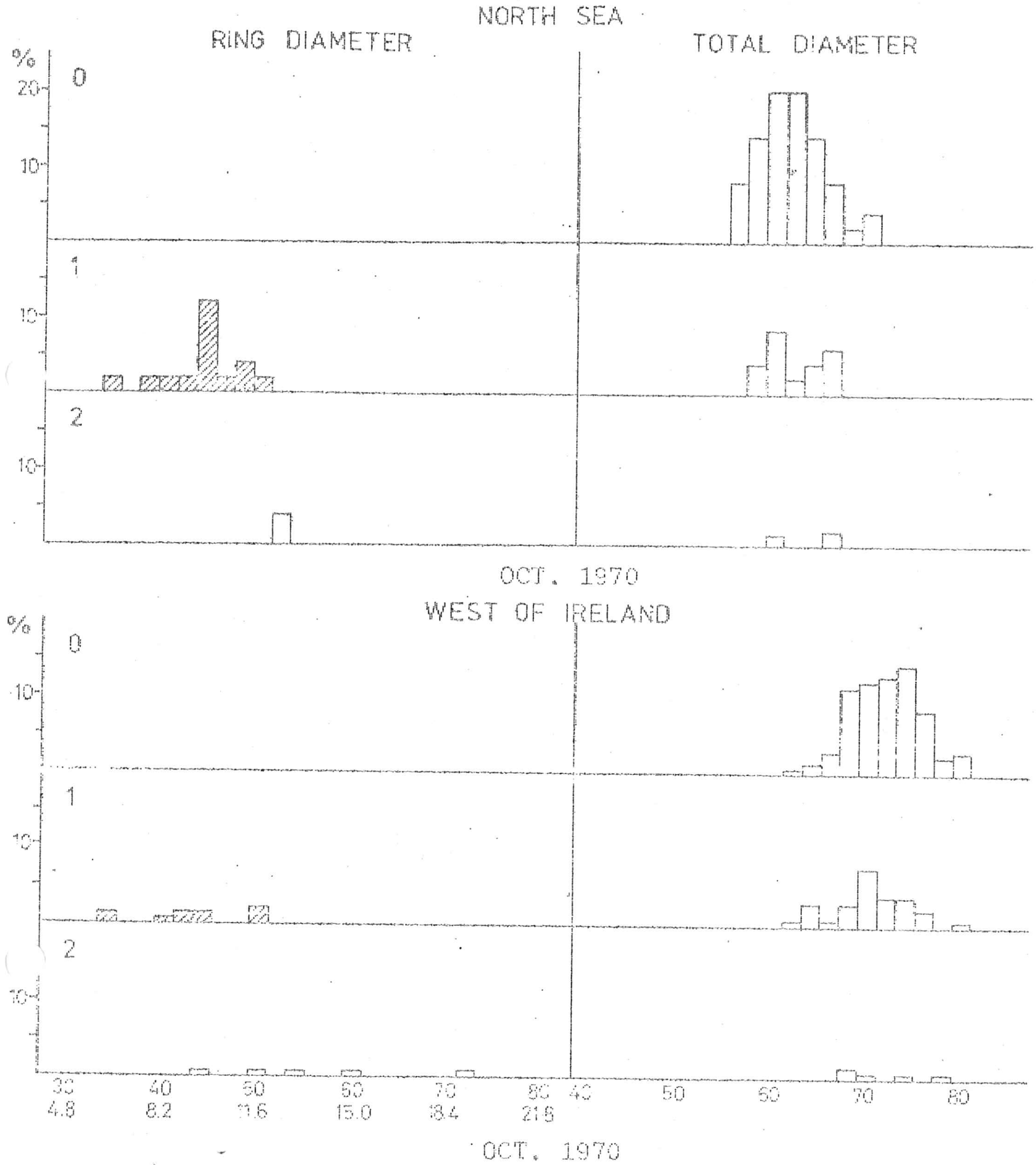


Fig. 6. The distribution of otolith eidth and ringdiameter in eyepiece units for the autumn sample 1970 from the North Sea and a sample from approximately the same time fished west of Ireland.

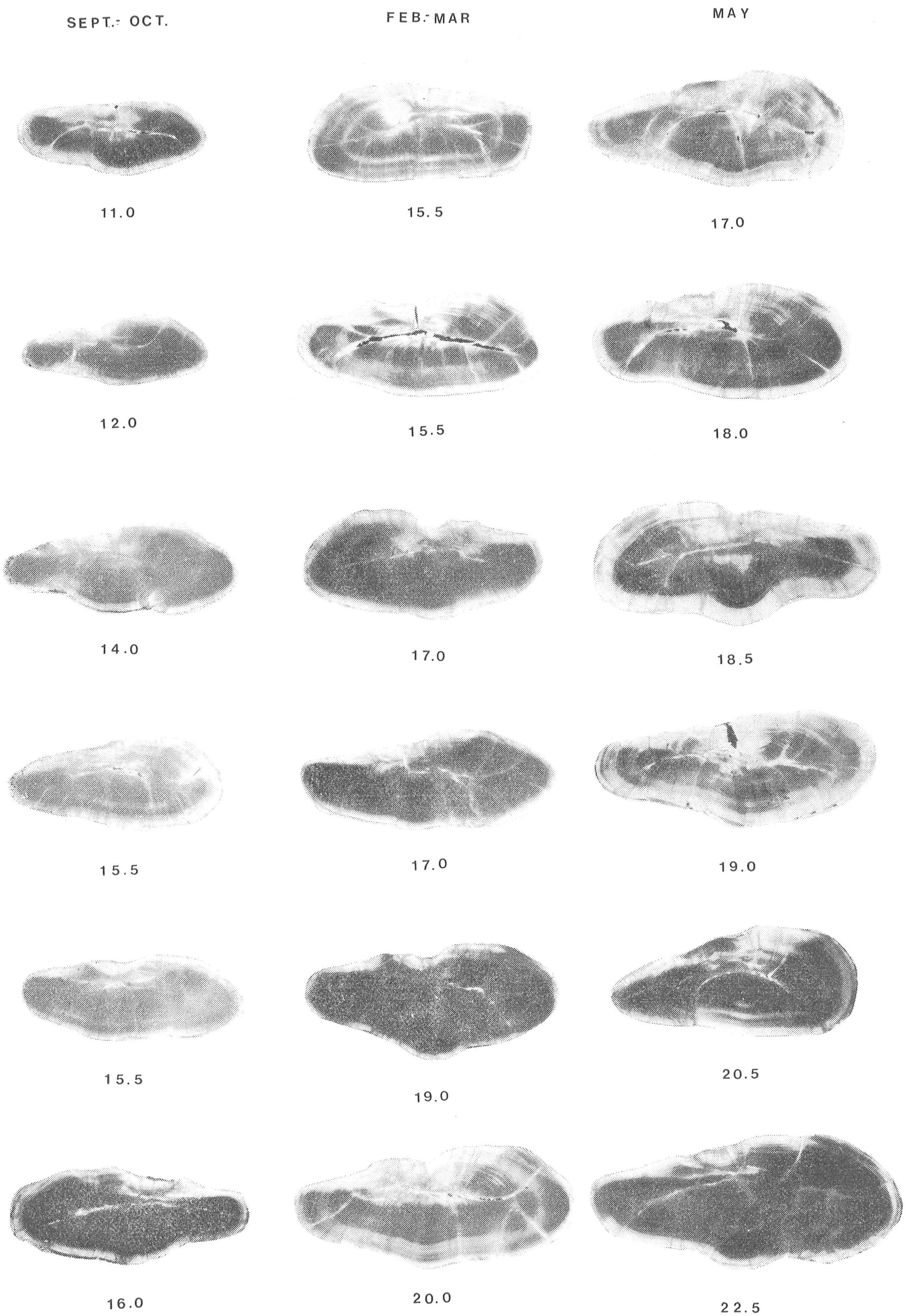


Fig. 7. A selection of sectioned blue whiting otoliths. The corresponding fish length in cm is indicated.

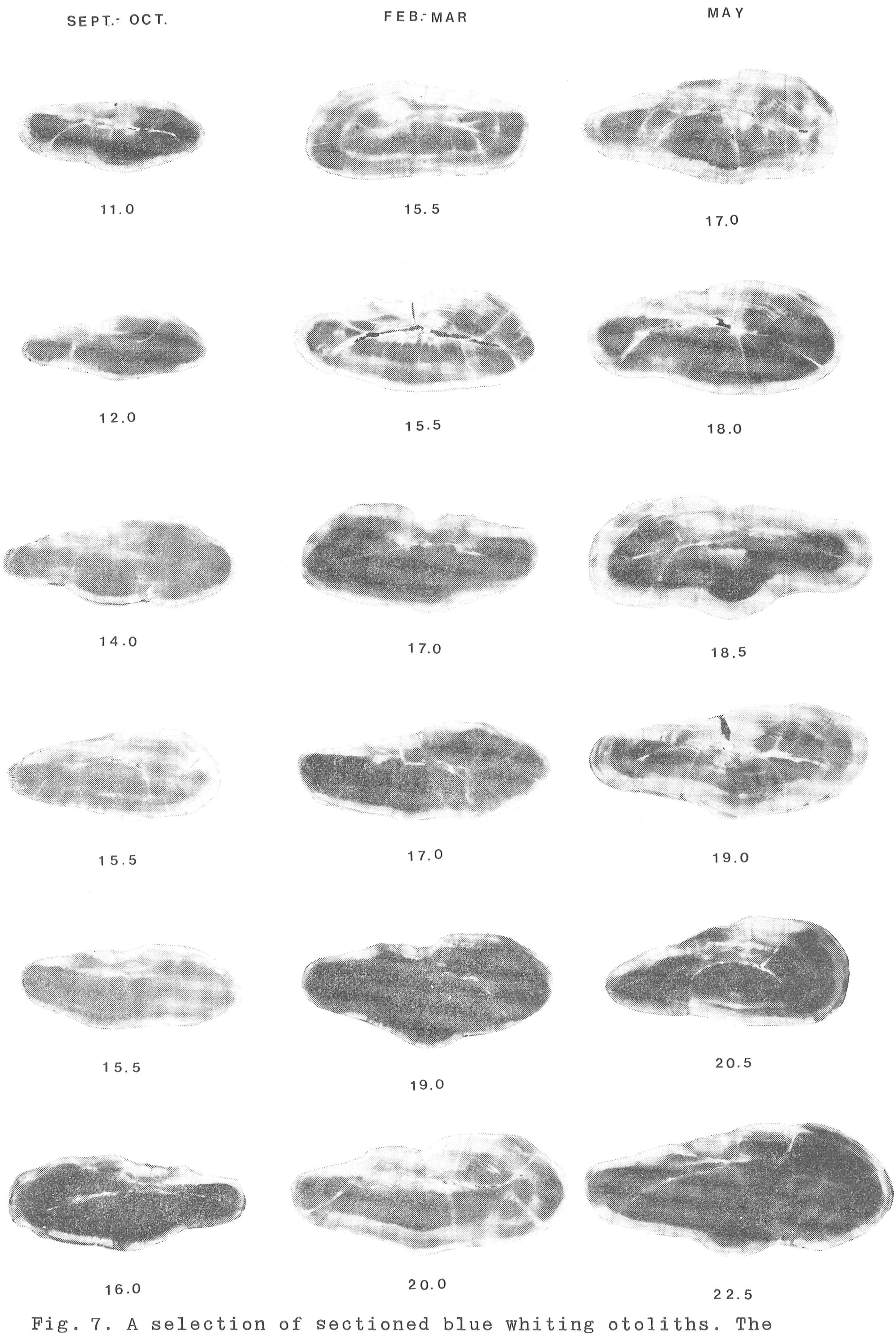
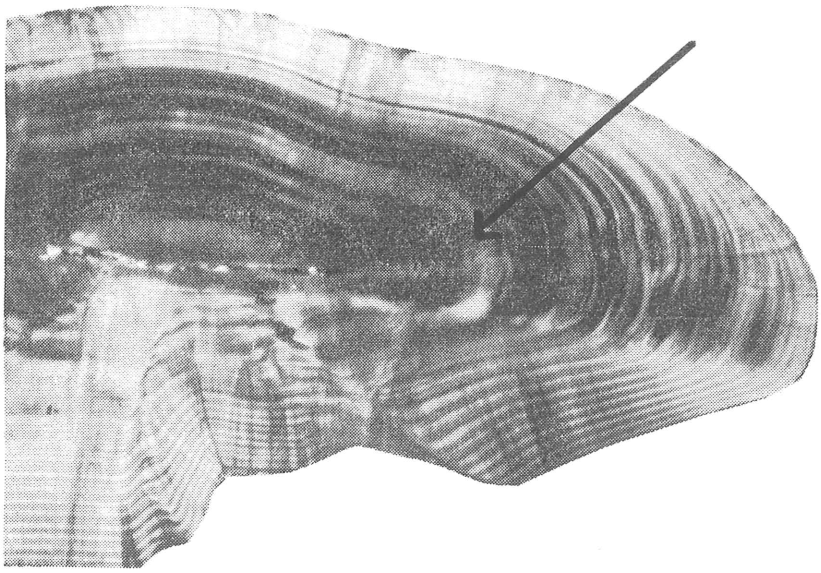


Fig. 7. A selection of sectioned blue whiting otoliths. The corresponding fish length in cm is indicated.



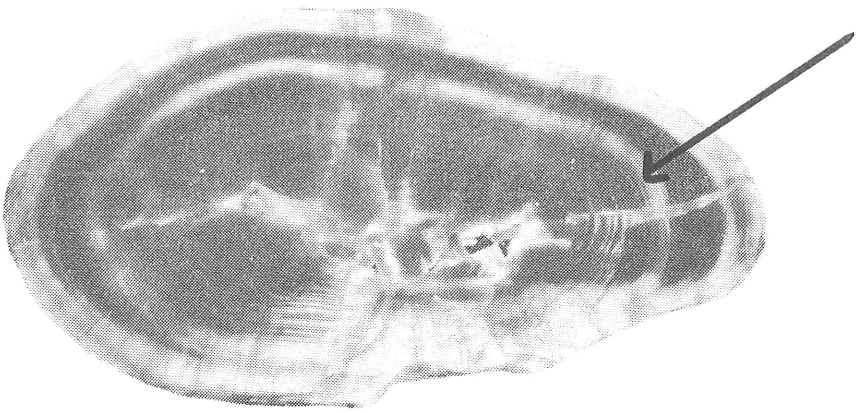


Fig. 8. Two sections of blue whiting otoliths. The arrows indicate the ring interpretated as the first winterzone.