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Results of Research on the Distribution, Age, Growth and General Mortality of Stocks of Red Hake, *Urophycis chuss* Walbaum, on Georges Bank and in Adjacent Waters, 1965-1966

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Abstract

Research on the distribution, age, growth and general mortality of stocks of red hake, *Urophycis chuss* W. on Georges Bank and in adjacent waters was carried out by the West Atlantic Laboratory, AtlantNIRO, in 1965-1966. Results show the existence of separate stocks on the Nova Scotia shelf, northwest and southwest slopes of Georges Bank and in the waters west of the ICNAF Convention Area.

The commercial resource of red hake in all the areas consists mainly of fish 2-5 years old. Differences in the rate of growth were observed. Most rapid growth was shown by hake from the northwest slope of Georges Bank and the slowest growth by the hake from the southwest slope. Red hake from the other two areas show an intermediate growth rate.

Definition of coefficients of general mortality, $\bar{z}$, and rates of losses in percentage shows a certain increase in the mortality rate of red hake from the southwest slope of Georges Bank between the beginning and the end of 1965.

Introduction

In the western part of the Atlantic Ocean, representatives of the genus *Urophycis* are wide-spread with the red hake (*U. chuss* W.) being most numerous. It may be found in the continental waters from the southern end of the Grand Bank south to the Mid-Atlantic States (Bigelow and Schroeder, 1953). They are probably most abundant in the area from Georges Bank to Hudson Canyon.

Since 1966 when red hake has become an important object of Soviet fishery (Table 1) there has been an accompanying study of some of its biological aspects, without knowledge of which it is impossible to deal with the problem of stock evaluation and fishing regulation.

Special attention was given to the discovery of local groups of red hake in the major fishing areas. Also some data on agė composition, growth rate and the value of general mortality were obtained.

Results of the study are given below.

MATERIAL AND METHODS

The material was collected in the ICNAF Div. 4W, 5Z and in the area west of Div. 5Z. The sampling areas are denoted by figures I-IV (Fig. 1). Samples for the identification of stock and length-age composition studies were taken from the catches by the research vessels operating in the commercial fishing areas.

The material used in this report was collected mainly during the fishing seasons of 1965 and 1966. A number of samples was taken in summer 1962, in Div. 5Z.

To differentiate the stocks of red hake inhabiting areas I-III (Fig. 1), a morphometric analysis was made. Meristic features only were used: the number of rays in the first and second dorsal, pectoral and anal fins as well as the number of vertebrae. We had to refuse from the use of plastic features because of the absence of data on variability of these features in relation to the length and age, and also because of the considerable body deformation of some individuals examined. Authenticity of the differences was established by Student's t-test.

The other method used to recognize red hake local groups in areas II-IV was by a comparison of the form, length and weight of otoliths of fish of the same body length. The methods of Templeman and Squires (1956), Kotthaus (1961) and Trout (1961) served as a basis for this comparison.

Table 2 lists the materials used during the investigation of stock localities. Otolith measurements were made by binocular (MBS-I) with the aid of an ocularmicrometer powered 8 x 0.6. Otolith weights were determined by torsion balance to the nearest 0.1 mg. The absence of the authentic differences between left and right otoliths was established and made it possible to use one otolith only taken from each fish by random. In order to avoid the influence of sexual dimorphism, the comparison was made separately for males and females.

Table 3 lists length-age sampling data.

The age of red hake was estimated from otoliths. Craigie (cited from Bigelow and Schroeder, 1953) who estimated age from the scales encountered great difficulty in demarcating the annual growth zones. The majority of massive red hake otoliths are also far from ideal, nevertheless on cross-section it is possible, though difficult, to define annual zones. Definition of age is made difficult by a great number of additional zones in the first year of life. But sometimes otoliths can be found with their cross-sections showing a very clear picture of annual growth zones. These may be used as a standard.

Preservation of otoliths in alcohol does not improve the visibility, nor make it possible to estimate the age from whole otoliths.

Till January 1, age was always determined as a certain number of years with new growth, e.g. 2+ in spite of the zone of winter growth very often having been well formed. Beginning from January 1, age was determined as a whole number of years with completed growth, in the above example 3 years.

Further processing of the data consisted of composing length-age keys and recalculating age into length composition.

RESEARCH ON STOCK DIFFERENTIATION BY MORPHOMETRIC STUDIES

A morphometric study was conducted on the hake from three areas - Nova Scotia Shelf (I), northern (II) and southern (III) slopes of Georges Bank.

A degree of authenticity of differences in average means of hake features from areas I and III is shown in Table 4. It is evident from the data that the differences in four of five analysed features are statistically significant; this points out the isolation of hake populations on Nova Scotia Shelf and the southern slope of Georges Bank.

Differences in meristic features of hake from areas II and III are shown in Table 5. In two cases the differences were highly significant. It should be noted, that the systematic position of the genus *Urophycis*, found on the northwest slope of Georges Bank remains obscure. Vladykov and McKenzie, and Battle (cited from Leim and Scott, 1966) determined in some areas such great variations and overlappings in the principal diagnostic features of *U. tenuis* and *U. chuss* that they considered these to be a single species. The absence of strongly expressed diagnostic features is probably characteristic of the area on the northwest slope of Georges Bank and of the adjacent waters of the Gulf of Maine as well. Taking this fact into consideration it was decided not to allocate, at present, the hake from the northwest slope of Georges Bank to a definite species, but to denote it simply *Urophycis sp.* However, irrespective of its species designation, the evidence of isolation (or connection) of this group from the hake populations in areas III and IV is necessary to obtain a precise idea regarding the state of the resources and to work out fishery regulation measures for these areas

OTOLITHS STUDIES

Having analysed the length-depth relationship (l/d) of otoliths from the fish of the same total length, one can readily see essential differences between the hake of 28-36 cm in length for males and of 30-38 cm for females from area III and from area IV (Fig 2) In both cases l/d of otoliths in area III was higher than that in area IV, which indicates that the hake otoliths are different in the areas compared. Great differences have been found between the l/d of otoliths of females from area II and IV. In area II the value l/d appeared to be appreciably greater in that 34-38 cm length range. There was no opportunity to compare male otoliths from samples obtained in area II, because of the small number of specimens of the required length range.

Comparison of maximum length of otoliths did not show any notable differences between hake from areas III and IV, but it did reveal some differences between hake from area II and the two other areas, i.e. a greater length of otoliths for hake 34-38 cm in length from areas III and IV (Fig 3).

The weight of otoliths is certainly the most objective indication of their growth From Fig. 4 it is evident that the greatest differences in weight of otoliths have been observed among the hake from areas III and IV in the length ranges of 31-36 cm for males, and of 32-38 cm for females In the former area the weight of otoliths appeared to be considerably higher. In area II it was the same, as in area IV.

In some cases the differences observed in the weight of otoliths was confirmed statistically (Table 6).

Differences in the weights of otoliths, as shown by Templeman and Squires (1956) on the basis of haddock from Georges Bank, are accounted for by different rates of growth. As will be seen below (see section "Growth") this suggestion is true for red hake as well.

AGE-COMPOSITION AND GROWTH RATE OF HAKE FROM AREAS I-IV

Age

Red hake and hake (*Urophycis* sp.) from area II are very close by age-composition to silver hake encountered in the same areas (Noskov and Zakharov, 1964). The analysis of the most numerous age samples (Fig. 5) shows that the bulk of the catch is everywhere represented by fish 2-5 years of age, the great majority in this age range consisting as a rule of two generations. In some samples this is fish 2-3 years of age, in others 3-4 years old.

Figure 5 shows that in all the age samples 4-year-old fish are less abundant than 3-year-old ones. Assuming that by the third year the process of recruitment is mainly completed, it can be concluded that the age at which hake is considered to be fully represented in the catches for the first time falls on 3-year-old fish. From this age on the abundance of hake in catches decreases sharply and at 6-years of age its commercial value becomes neglible.

Growth

Growth of hake in length is shown in Fig 6 From the age of 3 years, when the majority reach maturity, the slope of the growth curves, for both males and females, are approximately the same for all the groups compared, suggesting the similar growth rates beginning from this age. However, a considerable difference in the curve levels is indicative of great differences in growth rate during the first two years of life From Fig. 6 it can be seen that the greatest growth rate at this period of life is characteristic of hake from area II

If the hake from this area are somewhat similar to those from the Gulf of Maine and Bay of Fundy, it is possible to get some idea of the growth rate in the first two years of life from data reported by Bigelow and Schroeder (1953) (Table 7). Approximately the same growth rate is characteristic of the hake from areas I and IV. Hake from area III grow a little slower during the first years of life. The differences are 2-3 cm, as is seen from Fig. 6. These are partly explained by different periods of sampling (April 1966 in area IV, October, December 1965 in area III). However, comparing data on growth rate during the same period a considerable difference in mean lengths of fish of the same year-class is obtained. The winter growth (December 1965 to April 1966 in area IV) is not more than 1 cm (Fig. 6).

DEFINITION OF TOTAL IMMEDIATE MORTALITY COEFFICIENTS AND RATES OF LOSSES IN PERCENTAGE

The definition of mortality rate is a necessary step in solving the problem of optimum fishing for one or another species.

The evaluation of immediate mortality coefficients has been made by different methods which are described by Beverton ahd Holt (1956).

The age-length composition data obtained in 1965 and 1966 have served as a base for our calculations.

In the section "Research on Stocks Differentiation,"the existence of local groupments of red hake on the southwest slope of Georges Bank (III) and in the area of Hudson Canyon (IV) has already been mentioned.

There is no doubt that the mortality values should be given separately for each stock. However, this is impossible because of the absence of sufficient original data. That is the reason only general and rather approximate values of mortality rate are presented for the hake from areas III and IV. But since the type of abundance dynamics is similar in general for both stocks, the values obtained for the hake from one stock can be applied to another one. In a given case an assumption is made, that in areas III and IV there exists a common stock of red hake. Gulland (1965) considers it quite possible to make such assumptions even regarding two species, which are fished in the same areas, by the same gear, and have similar growth and mortality rate.

The total immediate mortality coefficients were calculated by "integral" methods (by mean length and age) and by difference of natural logarithms of abundance between neighbouring age-groups. Special attention was given to the values obtained from data for March, October, and December 1965 in area III. In the first case, the material represented the length-age composition of the stock which was heavily exploited only two months previously. In the second case the material represented the length-age composition of the stock after the first season of heavy fishing was completed.

It should be said that the use of the data obtained in a year (in the beginning and at the end of heavy fishing season), in our view, makes it possible to define the effect of the fishery in the given year, because in this case the analysed data concern in the main the same year-classes, since the influence of new generations in the Soviet fishery of red hake in areas III and IV begins to be felt at best by the end of December.

The evaluation of immediate mortality coefficients by "integral" methods was made by the following formulae:

$$\bar{Z} = \frac{K(L_\infty - \bar{\ell}_1)}{\bar{\ell}_1 - \ell^1} \qquad \bar{Z} = \frac{1}{\bar{t} - t_1}$$

For the hake from area III, L_∞ and K appeared to be 51 cm and 0.16 respectively. The evaluation results are presented in Table 8.

It should be said that in analysing the tabular data, the values of $\bar{Z}$ obtained from material for June 1962, cannot be used for comparison with similar values for subsequent years to define the fishing effect, since in 1962 the commercial stock was represented by quite different year-classes. Nevertheless, the data for March, October, and December 1965 seem to be quite comparable, and make it possible to draw a conclusion about some increase of $\overline{Z}$ at the end of the first season of heavy fishing. Next year there was no notable increase of $\overline{Z}$, though the intensity of fishing was somewhat higher, judging from the catches.

The definition of $\overline{Z}$ by difference of natural logarithms of adjacent age-groups is shown in Fig. 7. Average monthly catch per hauling hour for ships of the BMRT class was taken as an index of abundance.

The variances in values of $\overline{Z}$ obtained from the length and age distribution data appeared to be considerable. However, the relation of December and March values was close in all cases (1.40; 1.58 and 1.64 respectively), though the increase of $\overline{Z}$ at the end of the year was greater from the age composition data (40.58 and 64% respectively).

The percentage rates of relative losses were obtained from age composition data for March and December 1965 by means of successive calculation of percentage loss between neighbouring age-groups beginning from the year-class fully represented in the catches for the first time (Table 9).

The percentage increase of loss in December depended evidently on the influence of previous fishing.

It is necessary to proceed with these studies, in order to obtain values of mortality which will permit drawing more definite conclusions.

SUMMARY

The results of morphometric analysis and otolith study show several local groups of red hake. One group inhabits the Nova Scotia Shelf, another the northwest slope of Georges Bank, a third the southwest slope, and a last one inhabits the western part of ICNAF Subarea 5 and the area of Hudson Canyon.

The degree of mixing, which undoubtedly takes place especially between hakes of the two latter areas cannot be determined on the basis of data used in the present report.

The analysis of the age composition of hake from the various areas leads to a conclusion that this fish refers to the species with relatively short life span. The bulk of the commercial stocks consists mainly of fish aged 2-5.

Among the singled-out groups the differences in growth rate can be observed during the first two years of life, and this agrees well with the differences on otolith weights. The greatest rate of growth is characteristic of hake from the northwest slope of Georges Bank, and the slowest growth rate characterizes the hake from the southwest slope. After maturity the rate of growth of hake in the populations compared becomes more stable.

The results of definition of the total immediate mortality ($\overline{Z}$) coefficients and that of the loss in percent permit us to draw a preliminary conclusion about the influence of 1965 fishing on the length-age structure of the hake stock inhabiting the southwest slope of Georges Bank. This influence was shown by the increase of $\overline{Z}$ (by 40-64%), and of the total loss in percent (by 20%), from the initial level (March 1965)

Comparative high rate of loss during the period before 1965 may also be indicative of high natural mortality.

REFERENCES

BEVERTON, R. J. and S. J. HOLT. 1956. A review of methods for estimating mortality rates in exploited fish populations with special reference to sources of bias in catch sampling. Rapp. Cons. Explor. Mer 140:67-80.

BIGELOW,H. B. and W. C. SCHROEDER. 1953. Fishes of the Gulf of Maine. Bull. Fish. and Wild, Serv. 53: 223-230.

GULLAND,J. A. 1965. Manual of methods of fish stock assessment. Part 1. Fish populations analysis. FAO Fish. Techs. Paper No. 40 Revision 1: 70.

KOTTHAUS,E.A.1961. Preliminary remarks about redfish otoliths. Spec. Publ. Int. Comm. Northw. Atlant. Fish., No. 3: 45-50.

LEIM, A. H. and W. B. SCOTT. 1966. Fishes of the Atlantic Coast of Canada. Bull. Fish. Res. Bd. Canada, No. 155: 217-219.

NOSKOV, A. S. and G. P. ZAKHAROV. 1964. Soviet Research Report, 1963. Int. Comm. Northw. Atlant. Fish., Redbook 1964, Pt. 2: 92-112.

TEMPLEMAN, W. and H. J. SQUIRES. 1956 Relationship of otolith lengths and weights in haddock *Melanogrammus aeglefinus* (L) to the rate of growth of fish. J. Fish. Res. Bd. Canada, 13 (4): 467-487.

TROUT, G. C. 1961 *Sebastes viviparus* (Kryer) and the redfish problem, Spec. Publ. Int. Comm. Northw. Atlant. Fish., No. 3: 94-99.

Table 1. Red hake catches taken by the USSR Fleet by years and areas (in tons)

Years	AREAS Subarea 5	West of ICNAF Subarea 5
1963	3475	770
1964	3588	8372
1965	58546	11745
1966	85106	25722
1967	-	11160

Table 2. Material used in the study of red hake stock differentation

Sampling Areas	Morphometric analysis (number of specimens)	Number of otoliths
I	70	-
II	199	116
III	200	310
IV	-	264

Table 3. Number of fish lengths and age determinations

Areas	Year month	Number of measured fish	Number of age definitions
I	1965 May	-	61
	1965 November	-	97
II	1965 September	-	98
	1965 December	-	94
	1966 October	-	92
	1966 November	910	166
III	1962 July	952	89
	1965 March	630	203
	1965 October	303	182
	1965 December	800	116
	1966 January	500	100
	1966 February	500	189
	1966 March	623	-
IV	1965 January	550	-
	1965 February	793	-
	1965 December	400	85
	1966 February	274	-
	1966 April	1051	298

Table 4. Differences in meristic characteristics of hake from areas I and III

Characteristics	Degrees of Freedom	t-test	Extreme values for two confidence levels	
			95%	99%
Number of rays in the first dorsal fin	268	3.60	1.97	2.60
Number of rays in the second dorsal fin	"	3.80	"	"
Number of rays in the pectoral fin	"	3.10	"	"
Number of rays in the anal fin	"	11.05	"	"
Number of vertebrae	"	0.94	"	"

Table 5. Differences in meristic characteristics of hake from areas II and III

Characteristics	Degrees of Freedom	t-test	Extreme values for two confidence levels	
			95%	99%
Number of rays in the first dorsal fin	397	1.9	1.96	2.59
Number of rays in the second dorsal fin	"	1.2	"	"
Number of rays in the pectoral fin	"	8.1	"	"
Number of rays in the anal fin	"	0.2	"	"
Number of vertebrae	"	3.7	"	"

Table 6. Differences in the weight of otoliths from fish of the same body length

		Females				Males						Females			
Length, cm		36		38		32		34		36		36		38	
Areas		II	III	II	III	III	IV	III	IV	III	IV	III	IV	III	IV
Degrees of Freedom		21		35		54		39		32		37		28	
t-test		3.71		5.04		4.10		3.45		4.62		4.00		4.47	
Extreme values	95%	2.08		2.04		2.01		2.02		2.04		2.02		2.05	
	99%	2.83		2.75		2.68		2.70		2.75		2.70		2.76	

Table 7. Red hake growth (in cm) (Data from Bigelow and Schroeder, 1953)

Area	Sex	Length (cm) at age		
		1	2	3
The Bay of Fundy	♂♂	20.0	32.5	40.0
	♀♀	20.0	35.0	47.0

Table 8. Immediate mortality ($\bar{Z}$) values by "integral" methods in area I

Year	Month	First Method	Second Method
1965	November	-	1.01
1962	July	0.88	1.60
1965	March	0.90	1.54
1965	October	1.10	-
1965	December	1.26	2.44
1966	January	1.33	-
1966	March	1.28	-

Table 9. Rate of loss in percent

Months	Rate of loss (%) from ages			Mean loss (%)
	3-4	4-5	5-6	
March	22.7	80.3	52.0	52.0
December	67.5	63.0	86.0	72.5

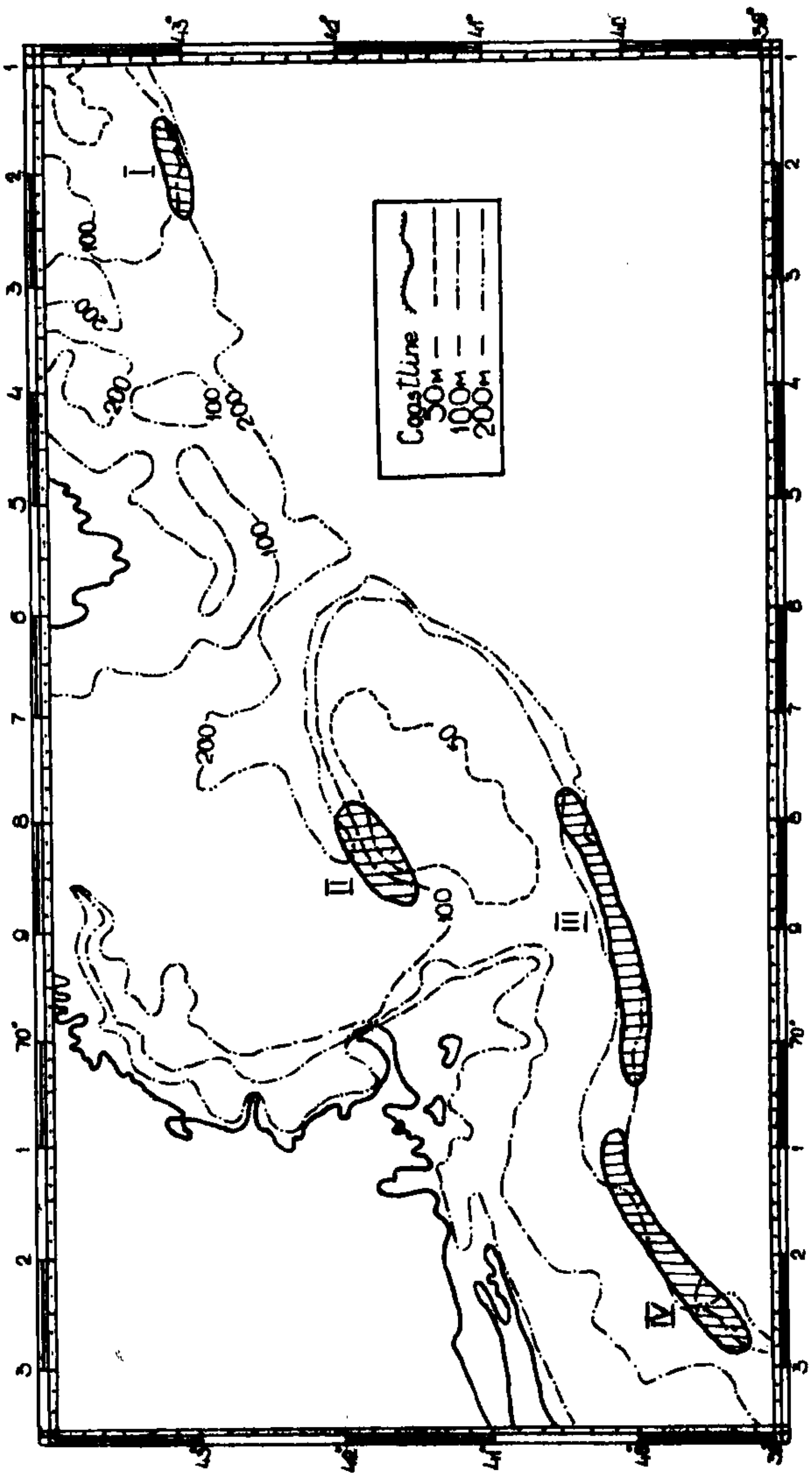

Fig. 1. Sampling areas

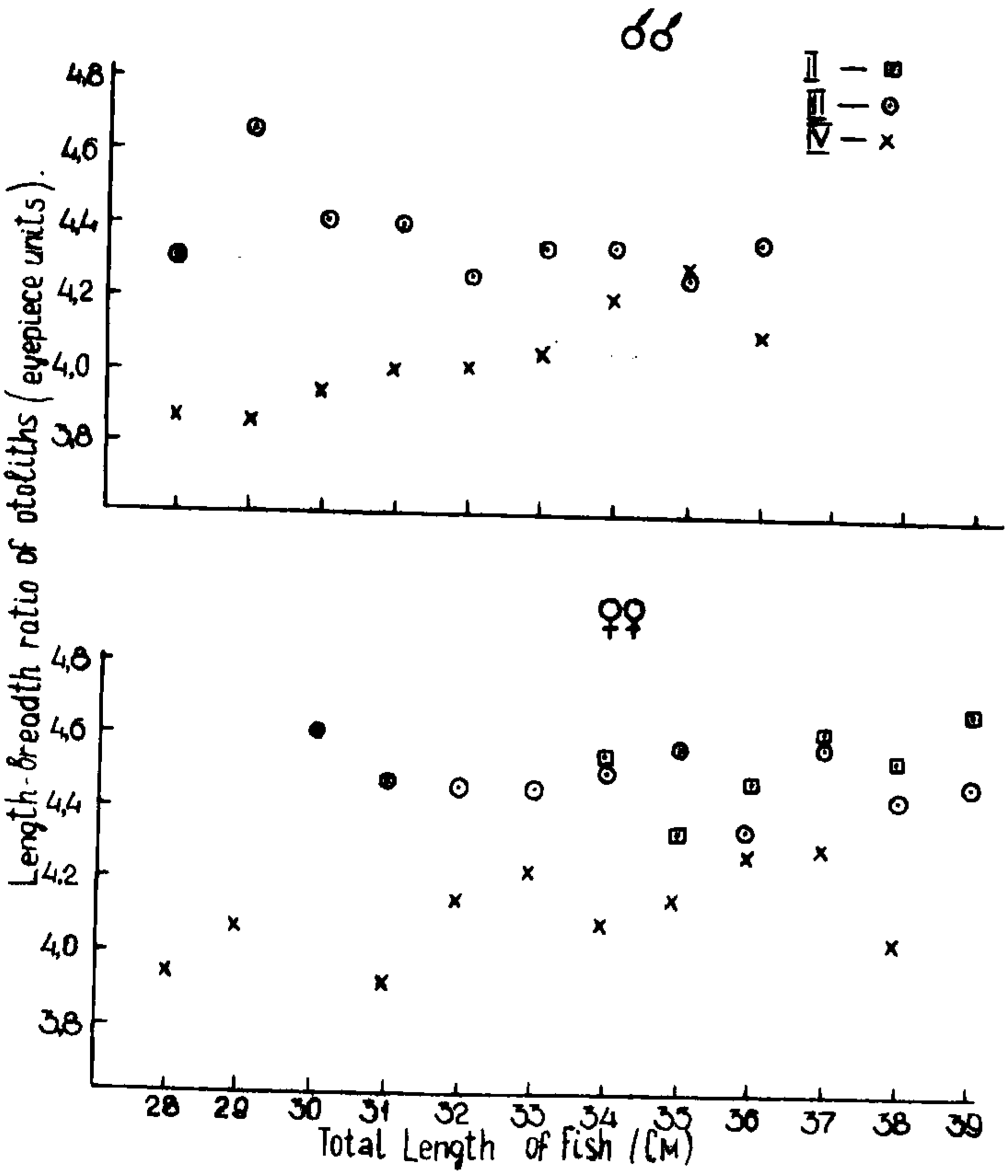

Fig. 2. Length-depth ratios of otoliths in relation to the length of fish from different areas.

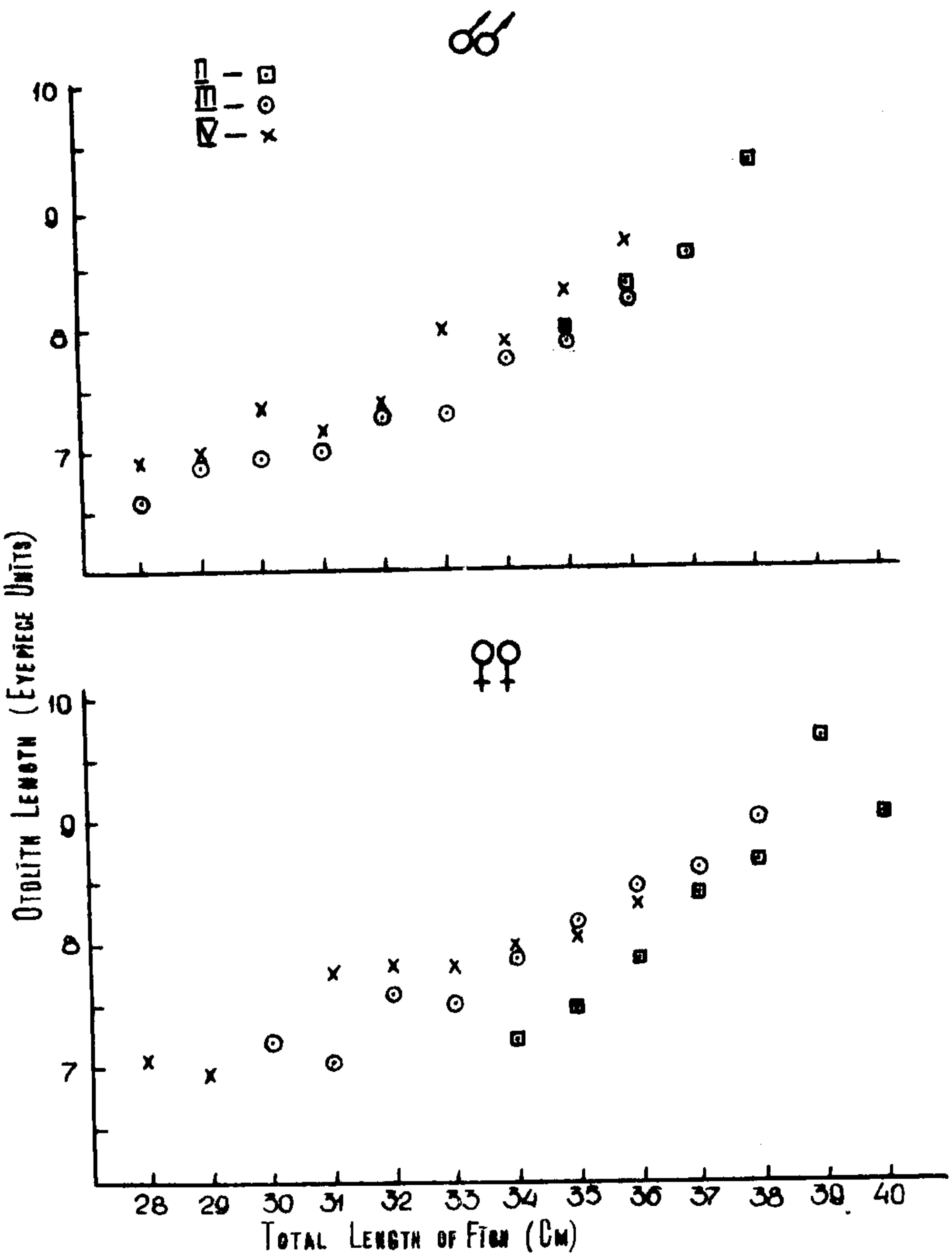

Fig. 3. Maximum otolith lengths and the length of fish from different areas.

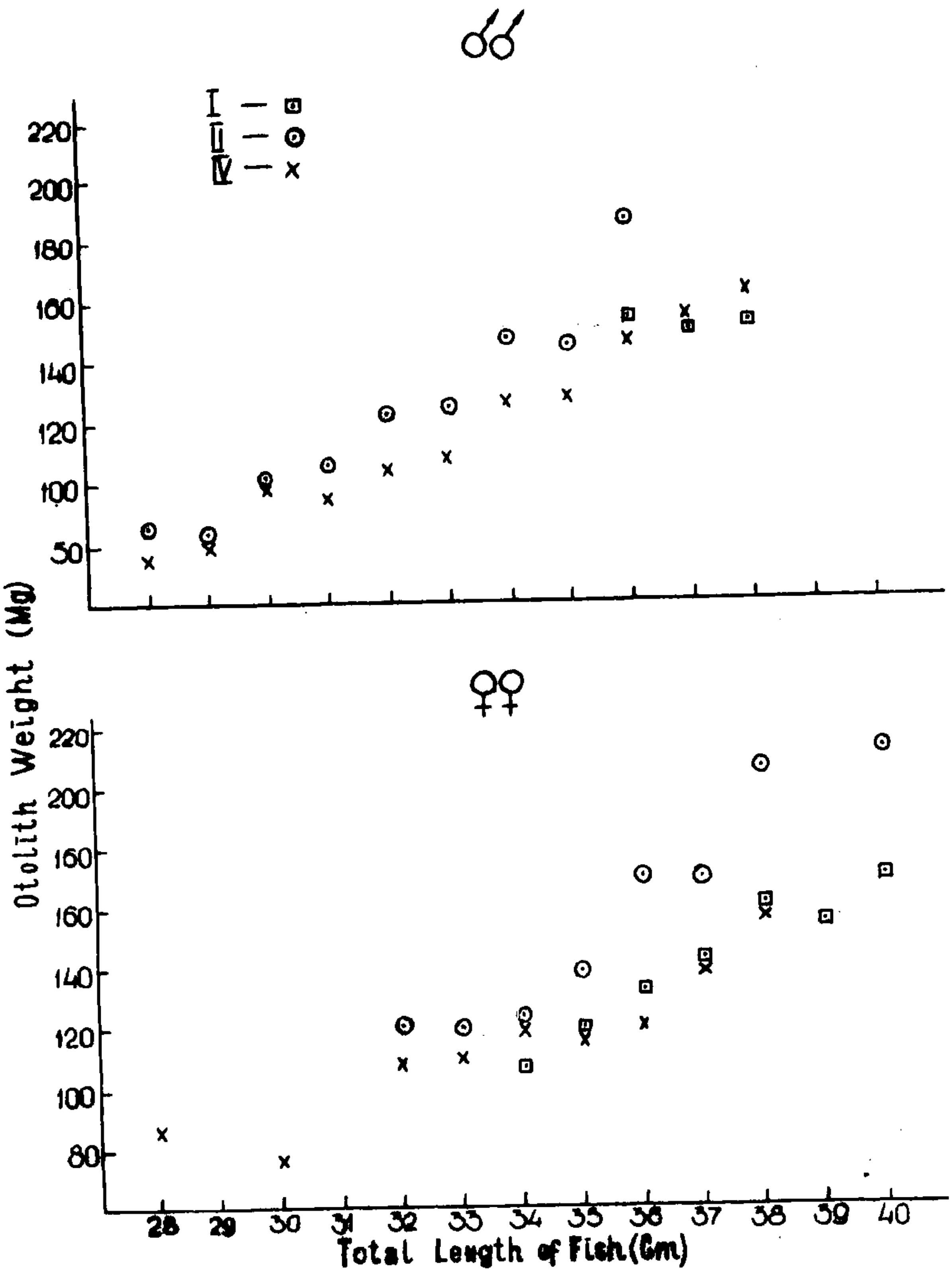

Fig. 4. The weight of otoliths and the length of fish from different areas.

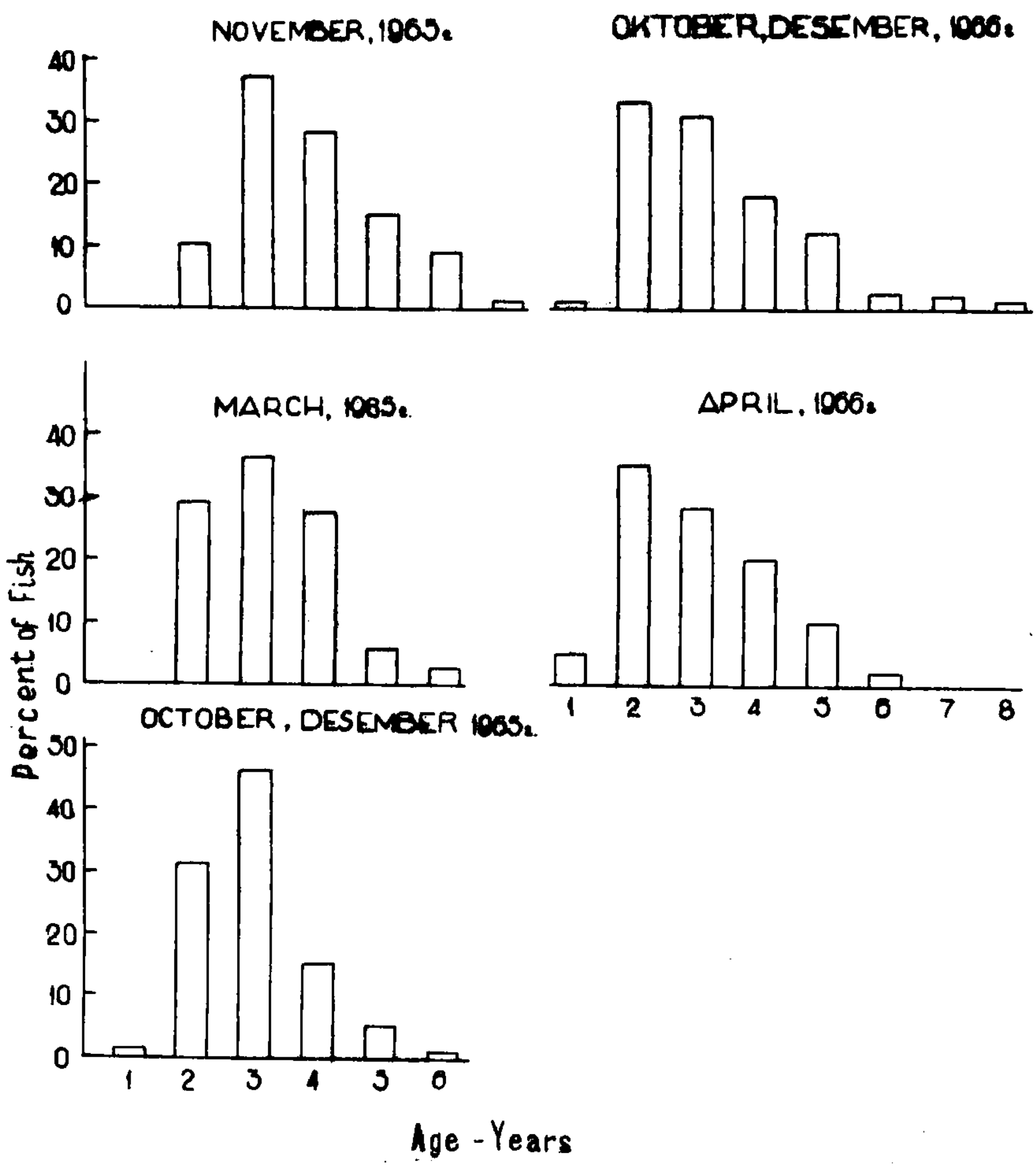

Fig. 5. Age composition of red hake from different areas.

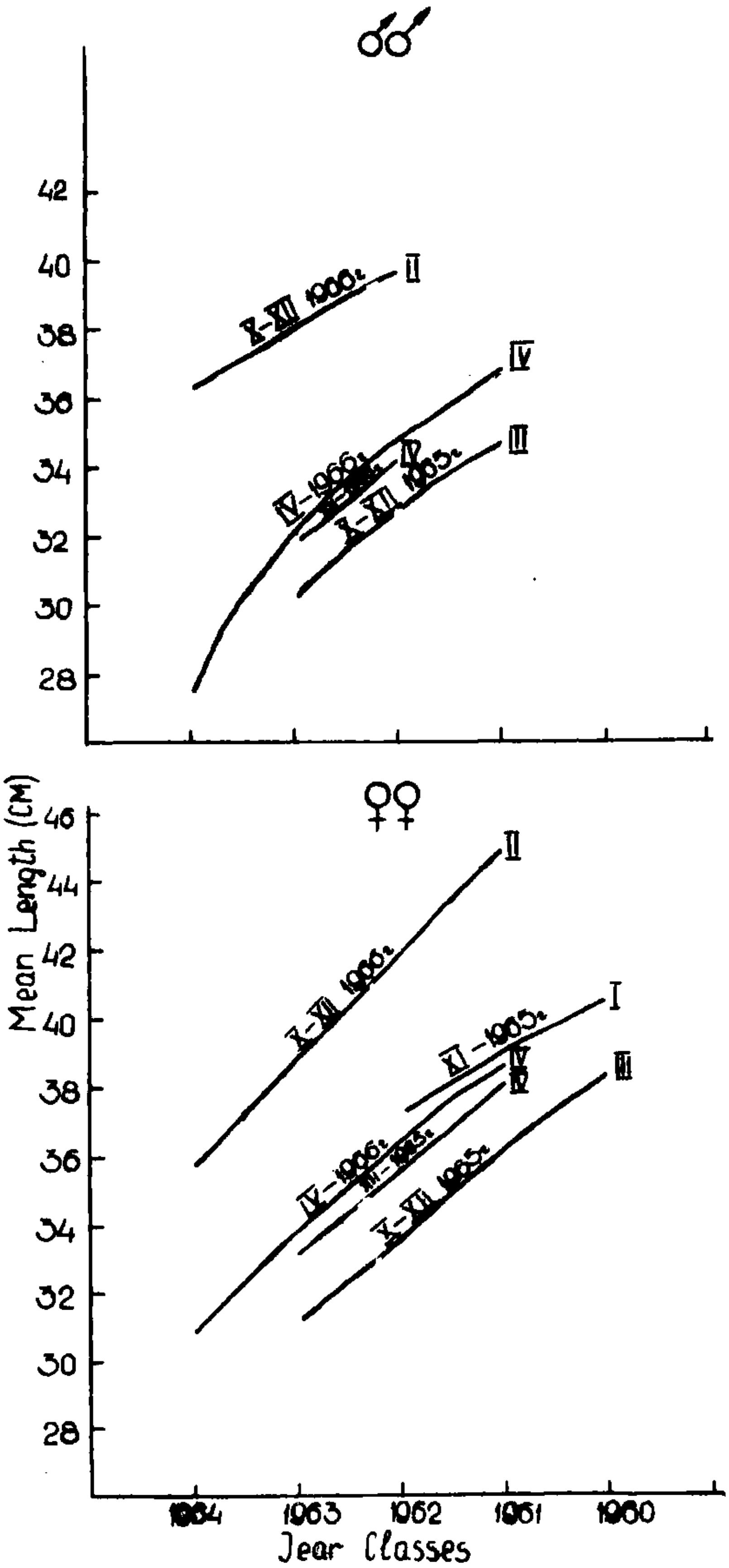

Fig. 6. Red hake growth in different areas.

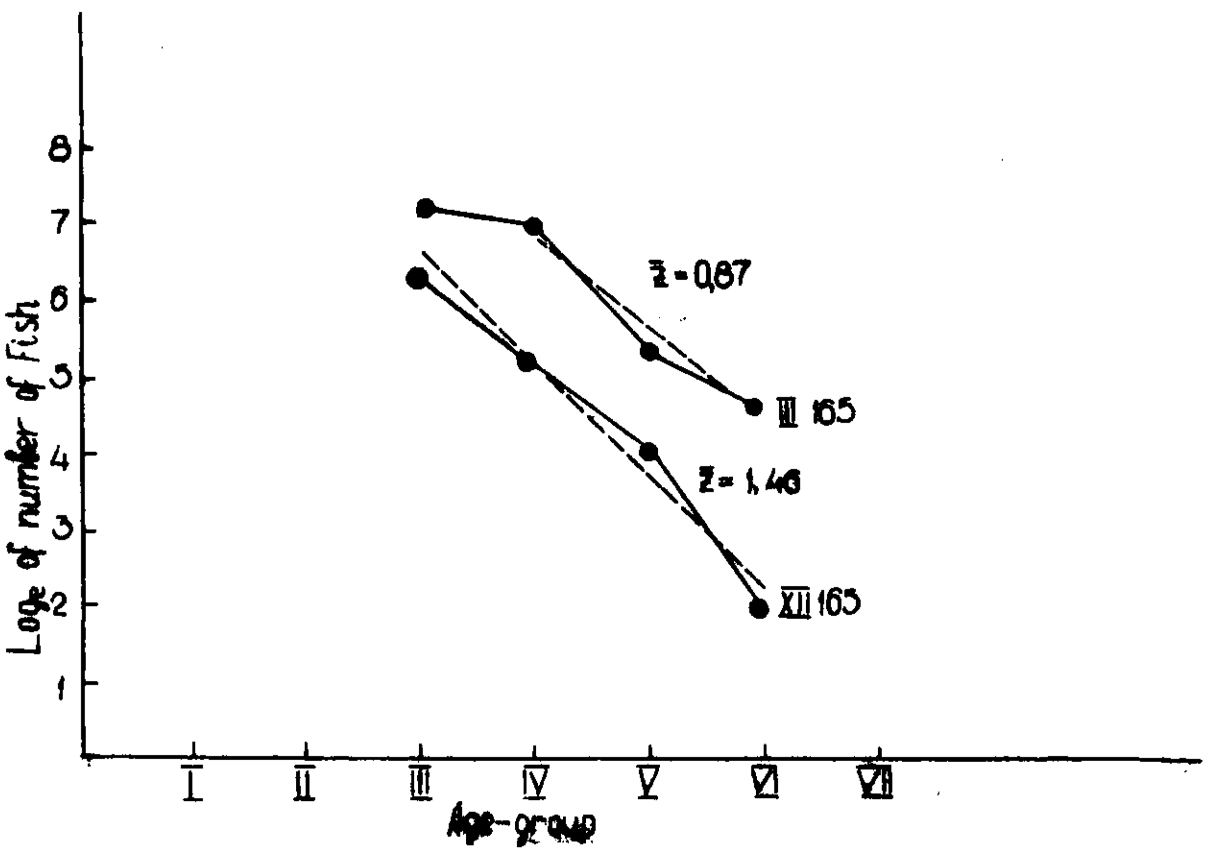

Fig. 7. The evaluation of the total immediate mortality ($\bar{Z}$) coefficients by difference of natural logarithms of abundance of neighbouring age-groups.