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Catch Composition, Abundance and Mortality Rate of Herring in the Norwegian Deep of the North Sea, 1962 - 1965

by

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Abstract

1. Three periods of the Soviet herring fishery in the Norwegian Deep, North Sea, are considered in this report: November 1962 - May 1963, October 1963 - May 1964 and October 1964 - May 1965.

   Data are given on catch composition, relative abundance, rate of recruitment, losses and mortality of summer-autumn and winter-spring herring.

2. The bulk of the catches for the periods concerned consisted of summer-autumn herring: 79% in 1962/63; 61% in 1963/64; and 76% in 1964/65.

3. Age structure of the herring shoals was characterised by the presence of the very strong 1956 and 1960 year-classes of summer-autumn herring, and a 1959-brood of winter-spring herring.

   The total catch of summer-autumn herring for the three fishing periods was 652.31 million specimens, and that of winter-spring herring 264.6 million specimens, of which 106.94 millions were of the 1956 year-class, 119.60 millions of the 1960 year-class, and 88.66 millions of the 1959-brood.

4. An accordance was found between mean values of herring losses and total mortality rates, which increased from 6-7+year among summer-autumn herring and from 5+ - 6+year among winter-spring herring.

5. The absence of seasonal fluctuations of catches per unit of effort between different fishing periods, the data on catch composition by broods, and on the rate of recruitment, losses, and total mortality prove the high abundance of herring in the Norwegian Deep in 1962-1965.

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Introduction

Until 1962 the Soviet herring fishery in the North Sea was rather weak. The average annual catch of herring in 1957-1961 was only 202,600 metric centners. Since 1962 the catches increased considerably (Table 1) as a result of the development of a drift herring fishery in the north-eastern part of the North Sea, i.e. the Norwegian Deep. It is also seen from Table 1 that the Norwegian Deep is the main area of Soviet herring drift fishery.

While herring have been extensively studied in most of the North Sea areas little attention was paid to the Norwegian Deep (Report of the Herring Assessment Group on the North Sea Herring and its Exploitation, 1963; Cooperative Research Report, 1966).

The present report gives the results of the investigations on catch composition, relative abundance, recruitment, losses and mortality rates of summer-autumn and winter-spring herring in the Norwegian Deep of the North Sea.

Material and Methods

Material and biological characters of herring in the Norwegian Deep were collected by scientific scouting vessels of AtlantNIIO during 28 cruises to this area, from November 1962 until May 1965.

Herring for analysis was taken from the drift catches. The length of the fish was measured from the tip of the snout to the middle rays of the caudal fin, to the nearest 1 cm.

When analysing the catch composition the fish was sub-divided into one group of summer-autumn spawners and one of winter-spring spawners according to the degree of gonad maturity. This sub-division was carried out by the use of age-samples taken from the catches at random, since a selective sampling would give a distorted picture of the relationship between summer-autumn and winter-spring herring, an assumption being made that such samples correspond to the composition of the commercial catches.

Such an assumption is justified by the identity of fishing gear used by scouting and fishing vessels. Besides, herring in the Norwegian Deep are distributed over a small area in autumn, winter and spring where drift fishing is conducted, and where the scientific scouting vessels also make their control haul. With a random sampling, a mistake on the young and old age-groups is inevitable. However, its magnitude may not be taken into account because these age-groups make up a small part only of the catches.

Age was determined by scales by using microscope "MBS"-1. The first annual ring of the summer-autumn spawning herring is formed late in autumn or in winter of the next year, therefore its age would be over-estimated by one year in comparison with the direct reading of the annual rings. Such an over-estimate was not made for winter-spring herring. This factor was taken into account when year-classes were determined.

Age and size composition of herring was combined by months, and then by seasons and periods of fishing. A year of fishing consists of three seasons: autumn, winter and spring. In the present paper the following periods are considered: November 1962 - May 1963, October 1963 - May 1964, and October 1964 - May 1965.

The total catch of all age-groups in terms of millions of specimens and in numbers was determined by using the data on the monthly total catches and catch per unit of effort, as well as by the individual average weight. The total amount of herring of all year-classes (in numbers) was calculated for each year-class by using the percentage age composition of catches. Rates of relative recruitment and of losses from the commercial stock (in percentage) were determined by year-classes calculated in numbers of fish per fishing effort.

In our opinion it is not possible to estimate recruitment and loss rates on the basis of yearly catches of individual year-classes, since the effort is not the same in various seasons. Therefore, for estimating the rates of recruitment and loss, we have used the data on separate year-classes calculated per fishing effort.

In determining the rates of recruitment and losses in 1962-1963 and 1963-1964, the number of herring in 1962-1963 was taken as 100%, while for determination of rates of recruitment and losses in 1963-1964, and 1964-1965 the number of herring in 1963-1964 was taken as 100%.

The average catch curves were plotted by the Beverton and Holt (1958) method. Total mortality factors were determined by the difference of natural logarithms of fish numbers between neighbouring age-groups.

Results

In the fishing periods discussed, summer-autumn herring were represented in the catches from the Norwegian Deep by 19-31 cm size groups and winter-spring herring by 21-31 cm size groups (Figure 1).

The size composition of summer-autumn herring was characterised by the predomination of fish of 26 and 27 cm in 1962-1963, 24, 25, 26 and 27 cm in 1963-1964, and 25, 26 and 27 cm in 1964-1965. The size composition of winter-spring herring was characterised by the predomination of fish of 27 and 28 cm in 1962-1963, 25, 26 and 27 cm in 1963-1964, and 27, 28 and 29 cm in 1964-1965.

In 1962-1963 the bulk of the catches of summer-autumn herring was represented by a very strong 1956 year-class, averaging 33.3% for the fishing period concerned. The 1959 year-class predominated in the winter-spring herring, averaging 29.2% (Figure 1).

In 1963-1964 the importance of the 1956-brood among summer-autumn herring decreased considerably (13.8% of the catches) as a result of fishing and natural mortality, and the bulk of the catches consisted of several year-classes: 1960, 1959, 1958 and 1957 (15.3%, 28.7%, 20.9% and 15.9% of the catches respectively). The summer-autumn herring of the 1959-brood was poor. However, it yielded the highest catch for this fishing period, since a very strong 1956 year-class began to lose its importance,while the following highly successful year-class, that of 1960, had not yet fully entered the fishery.

Among winter-spawning herring the 1959-brood predominated, accounting for 40% of the catch.

In 1964-1965 the bulk of the catches (34.3%) was represented by a highly successful 1960 year-class of summer-autumn herring. Among winter-spring herring the 1959-brood was predominant (31.6%).

The main portion of the catches in the Norwegian Deep consisted of summer-autumn herring (Table 2).

A characteristic feature of correlation in the catches between summer-autumn and winter-spring herring is the higher quantity of summer-autumn spawners in 1962-1963 (79%) and in 1964-1965 (76%), as compared with 1963-1964 (61%). This circumstance is evidently accounted for by the fact that in the 1962-1963 catches a very strong 1956 year-class was the most important, and in 1964-1965 it was the one from 1960. In 1963-1964, when the 1956-brood began to lose its importance and the 1960-brood had not yet fully entered the fishery, the percentage of summer-autumn herring decreased.

The total catches and catches per unit of effort were determined by the correlation between summer-autumn and winter-spring herring (Table 3).

The catch of summer-autumn herring in 1962-1963 was 209.86 million specimens, and that of winter-spring fish was 86.61 million, while in 1963-1964 it was 243.43 and 119.18 millions respectively, and in 1964-1965 199.02 and 58.82 million, respectively. In all 652.31 million specimens of summer-autumn herring and 264.64 million of winter-spring herring were caught during three fishing periods.

The catch of a very strong 1956 year-class of summer-autumn herring in 1962/63 was at a maximum and consisted of 70.16 million specimens. In 1963/64 it decreased to 32.30 million and in 1964/65 to 4.48 million. In all for three fishing periods the yield of this year-class reached 106.94 million specimens. Summer-autumn herring of the very strong 1960 year-class gave 16.01 million specimens in 1962-1963, in 1963-1964 it increased to 35.20 million specimens, and in 1964-1965 to 68.69 million specimens. The total catch of this year-class was 119.90 million specimens for three periods.

The yield of the very strong 1959 year-class of winter-spring herring approached 22.72 million specimens in 1962-1963, 46.97 million in 1963-1964, and 18.97 million in 1964-1965. In all for the three fishing periods the yield of this year-class was 88.3 million specimens.

Data on catch per unit of effort indicate that in 1962-1963 on an average 186 specimens of summer-autumn herring and 74 of winter-spring herring were caught per net, while in 1963-1964 299 and 135, and in 1964-1965 242 and 73 were caught respectively.

The very strong 1956 and 1960 year-classes were represented in the catches per unit of effort on an average by 58 and 19 specimens in 1962-1963, 42 and 46 in 1963-1964, and 6 and 83 in 1964-1965, respectively.

The very strong 1959 year-class of winter-spring herring averaged in catches per unit of effort 13 specimens in 1962-1963, 50 in 1963-1964, and 24 in 1964-1965.

On the basis of such data rates of recruitment and loss rates were estimated, reflecting conditions of relative stock strength of summer-autumn and winter-spring herring in the Norwegian Deep (Table 4).

Table 4 shows that losses of the very strong 1956 year-class of summer-autumn herring were 28% in 1963-1964 and 86% in 1964-1965.

Recruitment of the very strong 1960 year-class of summer-autumn herring was 142% in 1963-1964, and 80% in 1964-1965.

Recruitment of the very strong 1959 year-class of winter-spring herring was 284% in 1963-1964, while the losses of this year-class reached 52% in 1964-1965.

In the 1963-1964 catches, summer-autumn herring were represented by 6 and 7 years old specimens, while winter-spring herring were 6-7 years. In 1964-1965 they were 5 and 7, and 3-4 years, respectively.

Zijlstra and Postuma (1963) made an attempt to determine a total mortality rate for the North Sea herring, disregarding the number of its stocks in the North Sea. They give the total mortality data for the northern, central and southern North Sea leaving aside the Norwegian Deep.

In our studies we attempted to determine the total mortality of summer-autumn and winter-spring herring in the Norwegian Deep based upon the Soviet fishery data. For this purpose the mean catch curves were plotted for the fishing periods of 1962-1963, 1963-1964, and for 1963-1964, 1964-1965 (Figure 2), and from their right side values of the total mortality (Z=F+M) were determined. These values are presented in Tables 5 and 6.

Summary

The herring population in the Norwegian Deep of the North Sea, is not homogeneous, but a mixture of stocks of summer-autumn and winter-spring spawners.

In the fishing periods 1962-1963, 1963-1964 and 1964-1965 the size groups of summer-autumn herring in the catches from the Norwegian Deep were 19-31 cm, and those of winter-spring herring were 21-31 cm.

Summer-autumn herring were represented in the catches by individuals not older than 10 years, while winter-spring herring were not above 9 years old, because older fish disappeared from the fishery due to natural and fishing mortality. Summer-autumn herring predominated in the catches: 79% in 1962-1963, 61% in 1963-1964 and 76% 1964-1965.

The age structure of the herring stocks in the Norwegian Deep depends upon the strength of its particular year-classes. During the three fishing periods were registered the very strong 1956 and 1960 year-classes of summer-autumn herring and 1959-brood of winter-spring herring. The catches of these for three fishing periods were 106.94 million, 119.90 million, and 88.66 million specimens, respectively. The total catch of summer-autumn herring for the three fishing periods was 652.31 million and that of winter-spring herring 264.61 million specimens.

Changes in the abundance of summer-autumn and winter-spring herring during all fishing periods considered were of a seasonal character. The number of fish of each brood increased from autumn to winter and decreased towards spring. Maximum values of the year-class strength in the Norwegian Deep in December-February are accounted for by the hibernation period of the herring, when their concentrations are most stable.

The mean value of the recruitment rate of the summer-autumn herring commercial stock was 462% higher than the rate of losses. This was caused by the recruitment to the fishery of the two very strong 1956 and 1960 year-classes. The mean value of the recruitment rate of the commercial stock of winter-spring herring was only 76% higher than the rate of losses due to the recruitment to the fishery of a single very strong 1959 year-class.

The total mortality of the summer-autumn herring in the Norwegian Deep increased from the age of 6 and 7 years, and that of winter-spring herring from 5 and 6 years, which is in accordance with the mean values of the rate of losses.

The absence of seasonal changes in the catches per unit of effort between different periods, data on the catch composition by year-classes on rates of recruitment and losses, as well as on the total mortality of summer-autumn and winter-spring herring suggest that the abundance of the commercial stocks of these herring in the Norwegian Deep of the North Sea, for the periods of 1962-1963, 1963-1964 and 1964-1965 was high.

The data on the age composition of herring catches per unit of effort, and the data on the rate of recruitment, losses, and the total mortality make it possible to approach a forecasting of seasonal catches per unit of effort. However, to make the forecast more exact and reliable, one must know more about the time and intensity of herring entering the Norwegian Deep in autumn and leaving it in winter.

References

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		Cooperative Research Report. 1966. Ser.A. Cons.Int.Explor.Mer.
		"Report of the Herring Assessment Group on the North Sea Herring and its Exploitation". 1963. A.I. ICES.
Zijlstra J.J. & Postuma, K.H.	1963	"Fishing Effort and Mortality of North Sea Herring". C.M. 1963, Doc. No. 117. ICES.

Table 1. Catches of herring by USSR in the North Sea, 1962-1967. (AtlantNIRO Data).

Year	Total catch		Drift catch					Pair trawl catch[x]		Bottom-trawl catch		Purse-seine catch	
	Thous. netr. centn.	%	Total from the sea		In Norwegian Deep								
			Thous. netr. centn.	% of total catch	Thous. netr. centn.	% of total catch	% of drift catch	Thous. netr. centn.	% of total catch	Thous. netr. centn.	% of total catch	Thous. netr. centn.	% of total catch
1962	870	100	854	98.1	814	93.5	95.3	6	0.7	10	1.2	-	-
1963	814	100	545	66.9	523	64.2	95.9	162	20.0	107	13.1	-	-
1964	1,253	100	1,012	80.7	681	54.3	67.3	191	15.3	50	4.0	-	-
1965	472	100	334	70.7	210	44.5	62.8	39	8.3	99	21.0	-	-
1966	148	100	135	91.2	112	75.7	83.0	-	-	13	8.8	-	-
1967	235	100	78	33.2	41	17.8	52.5	42	17.9	8	3.4	107	45.5

x Note: Pair trawl fishing was mainly conducted in the Norwegian Deep, while purse-seines were used only in this area. Data on purse-seine, pair trawl and bottom trawl catches are given by "Zapryba" Central Board.

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Table 2. Percentages of autumn and winter-spring herring in the
Norwegian Deep, 1962-1965 (%).

Fishing period	Herring	
	summer-autumn	winter-spring
1962-1963	79	21
1963-1964	61	39
1964-1965	76	24

Table 3. The main indices of the herring drift fishery in the
Norwegian Deep, 1962-1965

Fishing period	Season	Herring catch			
		Total in centners		Per effort kg/net	
		Summer-autumn	Winter-spring	Summer-autumn	Winter-spring
1962/63	autumn	72,511	46,360	25.9	17.6
	winter	212,256	119,394	41.0	23.1
	spring	72,078	19,159	25.3	6.7
1963/64	autumn	69,367	23,122	60.0	19.3
	winter	195,913	141,868	61.9	44.8
	spring	92,150	61,434	17.8	11.8
1964/65	autumn	114,160	23,382	38.0	7.8
	winter	191,030	90,119	60.5	28.5
	spring	61,193	20,980	34.1	11.7

Table 4. Rates of recruitment and losses of summer-autumn and winter-spring herring in the Norwegian Deep in 1962-1965 by year-classes in catches per net unit (%).

Fishing period	Recruitment and losses by year-classes	Herring							winter - spring					
		2+/3- -3+/4	3+/4- -4+/5	4+/5- -5+/6	5+/6- -6+/7	6+/7- -7+/8	7+/8- -8+/9	8+/9 -9+/10	2/3- -3+/4	3/4- -4/5	4/5- -5/6	5/6- -6/7	6/7- -7/8	7/8- -8/9
1962-63 and	year-class	1960	1959	1958	1957	1956	1955	1954	1960	1959	1958	1957	1956	1955
1963-64	recruitment losses	+142	+291	+130	+98	-28	-73	-84	+262	+284	+78	-39	-62	-84
1963-64 and	year-class	1961	1960	1959	1958	1957	1956	1955	1961	1960	1959	1958	1957	1956
1964-65	recruitment losses	+700	+80	-56	-60	-57	-86	-83	-29	-38	-52	-56	-73	-40
	average	+421	+185	+37	+16	-42	-73	-96	+116	+123	+13	-47	-67	-62

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Table 5. Total mortality factors of summer-autumn herring in the Norwegian Deep of the North Sea.

Fishing period	Age	3+/4-4+/5 4+/5-5+/6	4+/5-5+/6 5+/6-6+/7	5+/6-6+/7 6+/7-7+/8	6+/7-7+/8 7+/8-8+/9	7+/8-8+/9 8+/9-9+/10	8+/9-9+/10 9+/10-10+/11	Total mortality, 2 last groups inclusive and exclusive	
1962-63 and 1963-64		0.09	0.04	0.32	0.82	1.27	1.33	0.50	0.64
1963-64 and 1964-65		–	0.23	0.23	0.68	0.86	1.71	0.50	0.74

Table 6. Total mortality factors of winter-spring herring in the Norwegian Deep of the North Sea.

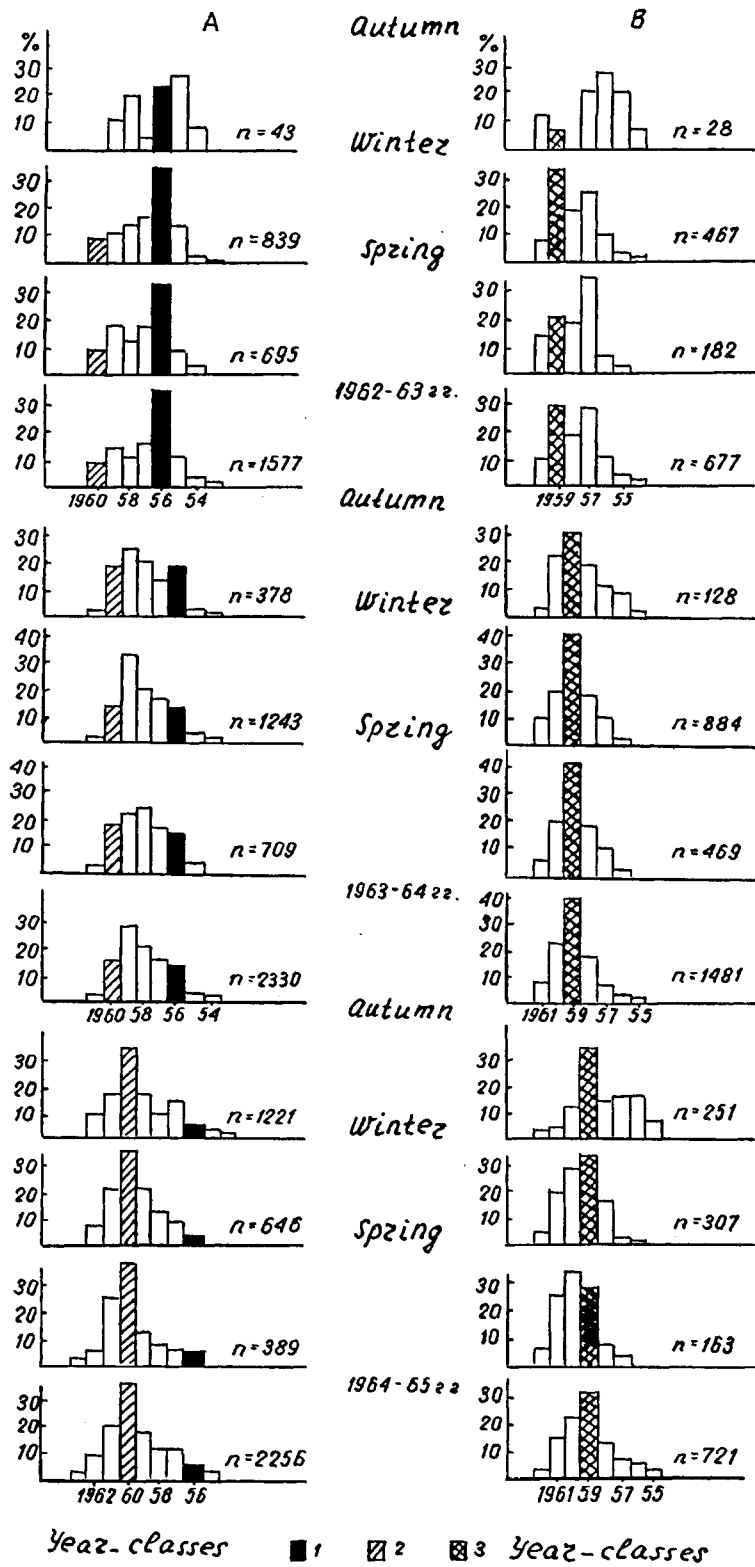| Fishing period	Age	3/4-4/5 4/5-5/6	4/5-5/6 5/6-6/7	6/7-7/8 7/8-8/9	7/8-8/9 8/9-9/10	Total mortality, 2 last groups inclusive and exclusive	
1962-63 and 1963-64		0.06	0.66	0.61	1.15	0.38	0.56
1963-64 and 1964-65		–	0.74	0.37	1.70	0.49	0.79

Figure 1. Age composition of summer-autumn (A) and winter-spring (B) herring in the Norwegian Deep, 1962 - 1965.

■ - I the very strong year-classes of 1956 of the summer-autumn herring.

▨ - 2 the very strong 1960 year-class of summer-autumn herring.

▧ - 3 the very strong 1959 year-class of winter-spring herring.

A

1962-63 и 1963-64 гг.

B

En of fish number in catches per 1 fishing gear

4
3
2
1

1963-64 и 1964-65 гг

4
3
2
1

1⁺/2 2⁺/3 3⁺/4 4⁺/5 5⁺/6 6⁺/7 7⁺/8 8⁺/9 9⁺/10
2⁺/3 3⁺/4 4⁺/5 5⁺/6 6⁺/7 7⁺/8 8⁺/9 9⁺/10 10⁺/11

age

1/2 2/3 3/4 4/5 5/6 6/7 7/8 8/9
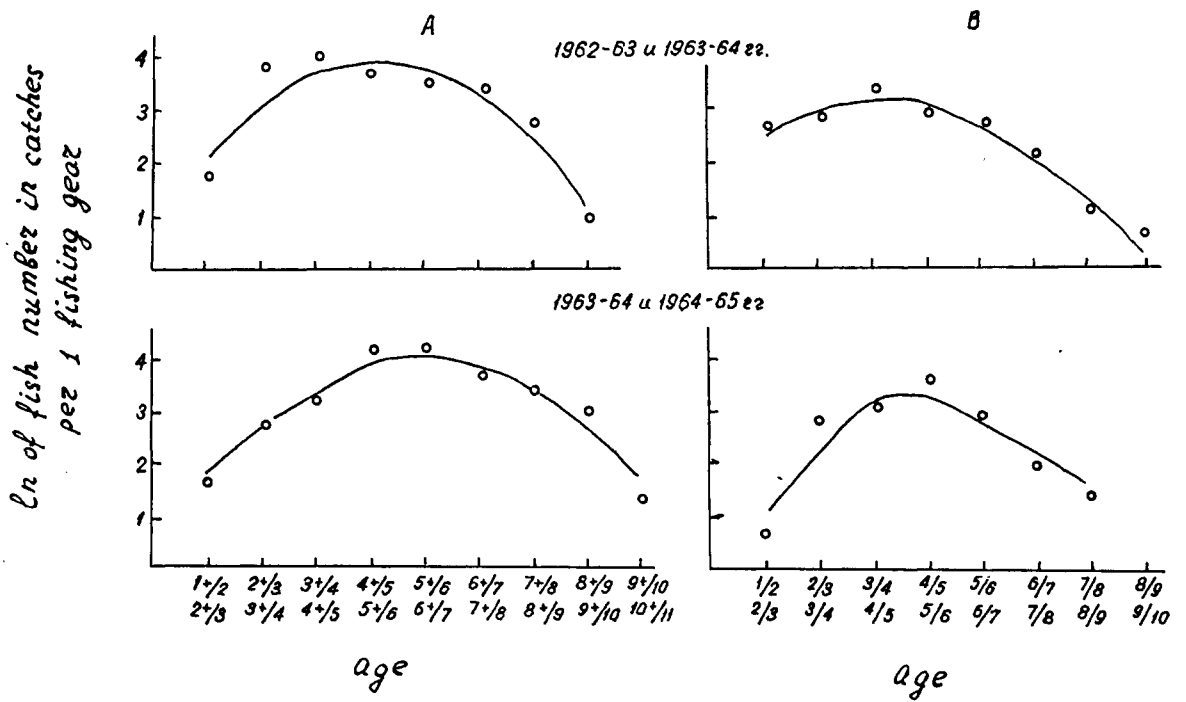2/3 3/4 4/5 5/6 6/7 7/8 8/9 9/10

age

Figure 2. Determination of total mortality of summer-autumn
(A) and winter-spring (B) herring in the Norwegian
Deep by natural logarithms of each age-group's
abundance.