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Pelagic Fish (Northern) Committee

REPORT OF THE WORKING GROUP ON ATLANTO-SCANDIAN HERRING

Copenhagen, 21st to 25th April 1969

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INTRODUCTION

A. Terms of Reference and Participation

Acting on a general concern about the Atlanto-Scandian herring stocks, expressed at the NEAFC Meeting in May 1968 in Reykjavik, the Liaison Committee of ICES requested the Pelagic Fish (Northern) Committee to set up a Working Group to consider the present state of the stocks of Atlanto-Scandian herring and of the fisheries, based on them. The concern expressed stems from a serious decline in the catches of all the major fisheries based on adult Atlanto-Scandian herring since 1966. The situation is thus comparable to that in the late fifties and early sixties, when a similar drop in the catches of adult herring led to the setting up of a Working Group of the Herring Committee.

The Working Group, appointed by the Pelagic Fish (Northern) Committee in October 1968 in Copenhagen, met from 21st to 25th April 1969 in Charlottenlund Castle and included the following scientists:-

Mr. Yu. K. Benko	(U.S.S.R.)
Mr. A. C. Burd	(U. K.)
Mr. O. Dragesund	(Norway)
Dr. S. S. Fedorov	(U.S.S.R.)
Mr. J. Jakobsson	(Iceland)
Mr. K. Hoydal	(Denmark)
Mr. K. Popp Madsen	(Denmark)
Dr. K. Schubert	(Germany)
Mr. J. J. Zijlstra	(Netherlands), Chairman.

In addition, Mr. J. Møller Christensen, in his capacity as Secretary of the Liaison Committee, attended the meeting.

B. Material and Agenda

The task of the Working Group was facilitated considerably by the availability of the reports of a former Working Group, dealing with the Atlanto-Scandian herring. That Working Group met three times, in April 1963, in April 1964 and in May 1965, and reported to the Herring Committee in 1963, 1964 and 1965. These reports dealt with the state of the Atlanto-Scandian herring stocks and their exploitation up to the year 1963, including some information on 1964. They formed the basis of an Assessment Report to NEAFC, presented in 1965. (ICES, Coop.Res.Rep., Series B, 1965).

Data on the situation in 1964-1968 were available in the form of reports in different issues of ICES periodicals and national periodicals. In addition, new information was submitted to the Working Group by the participants.

The former Working Group reports dealt in detail with stock units in the Atlanto-Scandian herring. The present report, therefore, includes only a brief outline of the stock built-up (Section I).

The Working Group decided to concentrate mainly on the Norwegian spring-spawning components of the Atlanto-Scandian herring, which is at present the major stock, and the decline in the catches since 1966 mainly concerned that stock (Section II). The Working Group considered the adult stock, its fisheries, yield, stock size, mortality rates, etc. (Section II a); the immature stock, fisheries etc. (Section II b); changes in spawning grounds, feeding grounds and migration routes (Section II c); and a conclusion on the present state of stock and fisheries (Section II d).

Some attention was paid to the fate of the spring- and summer-spawning components of the Atlanto-Scandian stocks around Iceland (Section III).

Finally, the Working Group considered the causes of recent changes and flcutuations in abundance of the Norwegian and Icelandic stocks units and the causes of the decline in their yields (Section IV).

I. DESCRIPTION OF STOCK UNITS IN THE ATLANTO-SCANDIAN HERRING

A. Norwegian Spring Spawners

The Norwegian spring spawners form the largest units in the Atlanto-Scandian herring tribe. Their spawning grounds are situated mainly along the Norwegian coast. In addition, at least since 1950 there has been a considerable spawning of Norwegian spring spawners off the Faroe Islands. Feeding grounds are found off north-east Iceland and, in recent years, near Spitsbergen (see Section II c). The nursery areas are in the Norwegian fjords, the Barents Sea and in the southern and north-eastern areas of the Norwegian Sea. At an age of 2-3 years the juvenile herring migrate to a large area between the central Norwegian Sea and the Polar Front. Maturation takes place at ages between 3-7 years, depending on the growth-rate. The herring is potentially long-living, and the spawning stock usually consists of many age-groups. The individual fish may spawn many times during its life.

B. Icelandic Spring Spawners

The spawning grounds of this stock unit are found along the Icelandic south coast, where spawning takes place in March-April. The feeding grounds are variable; in former years they were situated mainly off northern Iceland, but at present off southern and western Iceland (see Section III).

C. Icelandic Summer Spawners

Icelandic summer spawners spawn from July-September along the south coast of Iceland. As in the spring spawners, the feeding grounds are variably situated around Iceland (see Section III).

D. Northern North Sea and Scottish NW-Coast Spring Spawners

Little is known about this spring-spawning stock(s). The spawning grounds are found on the northern and eastern edges of the North Sea and to the north-west of the British Isles, where spawning occurs in varying intensity in the months January-May.

Their feeding grounds in the northern North Sea and to the west of Scotland are at least partly the same as those of the autumn-spawning stocks in these areas.

II. NORWEGIAN SPRING SPAWNERS

II a. The Adult Herring Fisheries

A. Total Catch

Tables 1-3 show the catches of adult and pre-recruit Norwegian spring-spawning herring. In arriving at the total catch it has been necessary to extract that component of the total national catches, which comprised Icelandic spring- and summer spawners. In practice this only affects the Icelandic and Norwegian catches in the summer- and autumn fisheries. The Icelandic laboratory provided proportions of the individual stocks units in their catches. These proportions have been used on the total summer-and autumn catches of Iceland and Norway to obtain an estimate of the catch of Norwegian spring spawners and the Icelandic stocks. Table 1 also includes all catches of U.S.S.R., Faroes and Germany, which could not be ascribed to the spawning fisheries along the Norwegian coast, so that it comprises both the catches from the summer-feeding fisheries and the over-wintering grounds. Table 2 gives an estimate of the catches in the winter-spawning fishery. Finally, Table 3 shows the total catch of Norwegian spring-spawning herring during the period 1950-1968. There are some slight differences between these tables and similar tables in previous reports, due to the use of more refined methods in the present assessment.

During the period 1950-1968 there have been considerable changes in the yields of the two seasonal fisheries, as appears from Tables 1 and 2. During the periods 1950-57 and 1961-68 the summer-and autumn fisheries increased from about 200.000 tons to about 600.000 tons. At the same time the winter-spawning fishery decreased from a level of about 900.000 tons to about 300.000 tons. Taking the total catch statistics (Table 3), there were two periods of high yields, viz. 1954-57 and 1964-67, which coincided with the recruitment to the adult stock of large year-classes. Both periods of high catch were followed by a decline, the most recent one, in the years 1966-68, being the most striking. The catch of 1968 (257.000 tons) is the lowest recorded for Norwegian spring spawners since about 1925.

B. Effort

The composition of the fleets fishing for Norwegian spring spawners was available for three countries (Iceland, Norway, and U.S.S.R.), which together harvested more than 90% of the catch in the years considered. These are shown in Table 4. It appears that:-

(i) The number of boats in the Norwegian purse-seine fleet increased up to 1957, and then decreased up to 1962, after which an increase of modern vessels, using the power block system, took place.

(ii) The number of boats in the Norwegian drift-net fleet decreased up to 1961, after which no information was available to the Working Group.

(iii) The number of boats in the Icelandic purse-seine fleet increased up to 1957, remained fairly constant up to 1965, but then decreased considerably after 1966.

Since 1962 the average tonnage of the vessels has risen from 99 to 280 GRT, and the fishing efficiency of the vessels has increased due to the introduction of sonar and power block.

(iv) In the U.S.S.R. fishery changes took place in the number of boats used in different seasons. In later years there was a clear tendency to employ the boats in the more profitable seasons, e.g. in the winter half-year.

The Working Group decided that it was not advisable to use number of boats as an index of the effort exerted, because of the changes in the composition of the fleets and in the fishing efficiency of the vessels. To obtain estimates of the total effort exerted, however, there were a number of national estimates of catch per effort available. These comprised data for the Soviet and Norwegian drift-net fleets and data on catch per boat of purse-seiners for Iceland and Norway. Of the estimates available the Working Group decided to use only the U.S.S.R. drift-net data for the following three reasons:-

(1) The fishing practice in the Soviet fleet remained relatively more constant than in the highly developing techniques of the purse-seiners, at least in the period after 1957.

(2) The U.S.S.R. fleet fish the stock throughout the year and covers a large part of the area occupied by the stock, which is not the case in any of the other fisheries.

(3) The U.S.S.R. catch forms a substantial part of the total annual catch.

Two measures of catch per effort of the U.S.S.R. drifter fleet are given in Table 5, based on the annual catch (a) and on the spawning-fishery catch (b). The latter was used to eliminate changes in the fishing season, taking place in the U.S.S.R. fishery, as mentioned previously. Since 1958 the changes in the catch per effort follow more or less the changes in the total catch of adult herring and probably reflect changes in abundance of the adult herring stock.

The U.S.S.R. catch per drift-net was used to calculate the total effort exerted on the Norwegian spring-spawning herring. Dividing the total catch of this stock by the average catch per U.S.S.R. drift-net gives an estimate of the equivalent effort in drift-net units, which would have been necessary to make this catch. Effort estimates have been obtained by using the annual average catch per drift-net and the average catch per drift-net in the spawning fishery (Table 6). The estimates, computed for 1958-1968, both show an increase. Comparing the periods 1958-62 and 1963-67, this increase was about 30% using the annual catch per effort (a) and about 80% using the February catch per effort (b). Both estimates show a large drop in the effort in 1968 to less than half its value in 1967.

C. Age-Composition

The age-composition of the Norwegian spring spawners, as derived from the Norwegian winter fishery, is given in Table 7. It shows the great variability of year-class strength in this stock of herring, with the strong year-classes of 1943, 1944, 1947, 1950, 1959, and 1960. The entrance of the year-classes 1950 and 1959-60 in the adult fisheries gave rise to periods of high catch, mentioned in the section on catch.

To calculate mortality rates the age-composition has been converted into numbers for the years 1962-68. For the winter fishery (Table 2) the catches were converted into numbers, making use of unpublished Norwegian weight data, giving annual estimates of number of fish per ton. These annual catches in number were then divided according to the percentage age-composition (Table 7) In the case of the summer fishery the catches of Table 1 were similarly converted into numbers of fish, using unpublished Icelandic weight data. The percentage age-distribution of the Norwegian spring-spawning fish in the Icelandic catches was available and was used to compute the numbers per age-group caught annually. The percentage age-composition of the Icelandic summer catches are shown in Table 8a for the period 1960-68. The estimates of both summer and winter fisheries have been summed in Table 9.

Table 9 should show the actual numbers of adult and pre-recruit Norwegian spring spawners per age-group, caught by all fleets in the years 1962-68, provided that the composition of the catches of other nations was the same as those of the Norwegian catch in the spawning fishery and as the summer-autumn catch in the Icelandic fishery. The major part of the remaining catch, not taken by Norwegian and Icelandic boats, was caught by the U.S.S.R. fleet. Table 8b shows the age-composition of the U.S.S.R. catch in the period 1962-68 over the whole year. A comparison with the age-composition of Norway and Iceland up to 1966 indicates younger fish in the Soviet catches. The absence of weight data made it impossible to convert the U.S.S.R. catch into numbers. In the light of the age-composition of U.S.S.R. catches, Table 9 tends to attribute too many old fish in the total catch.

Using the two estimates of total effort calculated for the U.S.S.R. drift-net data, the catches per effort are presented in Table 10, which shows that in the period 1962-68 the 1950, 1959 and 1960 year-classes have been the main support of the fishery. Again, Table 10 tends to overestimate the number of old fish.

D. Estimates of Absolute Stock Abundance

Previous estimates of the absolute abundance of the adult stock of Norwegian spring spawners in mid-winter, based on the data on total catch and tag returns over the years 1953-59, show a large decrease in stock size after 1956 from about 14 million tons in 1955/56 to 5 million tons in 1959/60 (Dragesund and Jakobsson, 1963). Soviet estimates of stock size from echo-surveys and underwater photography over the pre-spawning, wintering concentrations show a further decline from 1959 to 1962(Fedorov, Truskanov and Yudanov, 1964). In the following three years the stock size increases with the rich 1959 year-class from 2.8 million tons in 1962/63 to about 7 million tons in 1964/65 (Table 11). From 1966 onwards a rapid decrease again took place, reaching a level of 2 million tons in 1968.

The two independent estimates of stock size have been shown in Figure 1, together with the adult and immature herring catches. The Figure shows a close agreement between the two independent stock estimates. The relative annual changes in stock size are reflected in the annual fluctuations in the adult catch. It should be noted, however, that the stock size was on a much higher level in the period 1954-57 than during the later period of high catches (1964-67), which points to a far higher rate of exploitation in the later period.

E. Mortality Rates

A number of estimates of total mortality are available for the Norwegian spring-spawning herring.

a. Instantaneous coefficients of total mortality, obtained from age-composition data, were available for the period 1947-1960, using abundance indices for the Norwegian drift-net fishery (Østvedt, 1963). These data have been summarized in Table 12.

Table 12. Mortality rates derived from the Norwegian drift-net fishery (Østvedt).

Year-Period	Z	Year-Period	Z
1950/51	0.23	1955/56	0.15
1951/52	0.18	1956/57	0.32
1952/53	-0.04	1957/58	0.18
1953/54	-0.07	1958/59	-0.03
1954/55	0.69	1959/60	0.46
Mean	0.20	Mean	0.22

b. A comparable series of total mortalities for the period 1962-68 has been derived from the catches per effort on age-groups in Table 10. Recruitment has been considered complete at 6 years old and 7 years old, giving two sets of Z values. These have been obtained by taking ratios of the total abundance of fish older than 5 years (or 6) in year (n) to the total abundances of fish older than 7 years (or 8) in year (n+1). The results are given in Table 13.

Table 13. Instantaneous mortality coefficients.

(a) From total catch per effort.
(b) From winter catch per effort.

Years	Recruitment at 6 years		Recruitment at 7 years	
	(a)	(b)	(a)	(b)
1962/63	0.08	-0.31	0.08	-0.31
1963/64	0.58	0.46	0.58	0.46
1964/65	-0.18	0.11	-0.18	0.12
1965/66	0.39	0.20	0.94	0.76
1966/67	0.42	0.81	0.59	0.98
1967/68	0.95	1.18	0.99	1.26
Mean 1962/65	0.16	0.09	0.16	0.09
Mean 1965/68	0.59	0.73	0.64	1.00
Grand Mean	0.38	0.41	0.40	0.54

It is seen that there is a good agreement in the estimates, but those derived from the winter fishery are somewhat higher in the later period.

An estimate of total mortality was also calculated for the 1959 year-class separately, giving Z = 0.54.

c. Using estimates of total stock from tagging data, the total numbers of the 1959-61 year-classes were calculated for each year, using Norwegian age and weight data. These stock numbers per year-class for each year are given in Table 14.

Table 14. Total stock numbers (10^7) of the 1959-61 year-classes.

Year-class	Years					
	1963	1964	1965	1966	1967	1968
1959	34.2	753.5	1628.3	1392.1	681.3	413.2
1960	-	58.5	277.9	722.1	448.1	301.3
1961	-	-	83.1	268.5	187.1	121.6

From these data exploitation rates ($\frac{F}{F+M}$) have been derived, using the following formulation:

$$\frac{F}{Z}\ (N_1 - N_2) = C$$

where N_1 is the stock in numbers of a year-class at the beginning of year 1,

N_2 is the stock in numbers of the same year-class at the beginning of year 2,

and C is the total catch in numbers of that year-class in year 1

Estimates of $Z = (F+M)$ were calculated from the ratios of the stock numbers of a year-class in successive years from the data of Table 14, accepting full recruitment at an age of 6 years. The estimates of exploitation rates and the components of mortality are given in Table 15.

Table 15. Estimates of exploitation rate, $\frac{F}{F+M}$, and components of mortality.

Year-class	$\frac{F}{F+M}$	F+M	F	M
1959	0.66	0.47	0.31	0.160
1960	0.62	0.42	0.26	0.160
1961	0.64	0.43	0.28	0.155

It should be noted that the three estimates of M are very close.

d. Direct estimates of the exploitation rate can be calculated from the data in Figure 1, combining information of Tables 3 and 4. The two estimates of stock size obtained from echo-abundances and tagging have been expressed in tons.

Fishing mortality coefficients (F) have been obtained from ratios of total catch to the mean values of stock-size estimates in the beginning and end of the years, as shown in Table 16.

Table 16. Estimates of F derived from independent stock indices in mid-winter.

Year	Tagging	Echo	Mean stock index	Year	Stock $\frac{(n)+(n+1)}{2}$	Catch	F	
1954	12.500		12.500	12.300		1306	0.16)	
1955	12.100		12.100	13.000		1218	0.10)	
1956	13.900		13.900	12.950		1461	0.12)	
1957	12.000		12.000	10.700		1148	0.11)	0.13
1958	9.400		9.400	7.850		785	0.10)	
1959	6.600	6.000	6.300	5.650		883	0.17)	
1960	5.000	-	5.000	4.050		821	0.23)	
1961	-	3.100	3.100	2.800		498	0.20)	
1962	-	2.500	2.500	2.650		551	0.23)	
1963	-	2.800	2.800	3.470		651	0.21)	0.22
1964	5.000	3.300	4.150	5.700		1118	0.22)	
1965	7.700	6.800	7.250	6.920		1326	0.21)	
1966	6.600	-	6.600	5.300		1723	0.39)	0.43
1967	4.000	-	4.000	3.000		1131	0.47)	
1968	-	2.000	2.000	-		-	-	

The total mortalities obtained for the different periods and by different methods are summarized in Table 17.

Table 17. Summary of estimates of total mortalities (Z) and fishing mortalities (F).

	Z	F	Source
1950/55	0.20		Table 12
1955/60	0.22		Table 12
1962/65	0.16		Table 13 (a) average
	0.09		Table 13 (b) average
1965/68	0.62		Table 13 (a) average
	0.87		Table 13 (b) average
1962/68	0.43		Table 13 Grand Means, average
Year-Class Estimates			
1959 (65/68)	0.54		Calculated from Table 10
1959 (65/68)	0.47	0.31	Table 15
1960 (66/68)	0.42	0.26	Table 15
1961 (67/68)	0.43	0.28	Table 15
Stock Size Catch			
1954/59		0.13	Table 16
1960/65		0.22	Table 16
1966/67		0.43	Table 16

Estimates of total and fishing mortality rates, shown in Tables 12-16 and summarized in Table 17, strongly suggest an increase in both parameters in the years considered.

Estimates of F, obtained from stock size and catches (Table 16) increased from 0.13 in the period 1954-59 to 0.22 in the years 1960-65, whereas in most recent years (1966-67) an F of up to 0.47 was observed. These data therefore suggest an increase in the fishing rate on the adult stock by about three times in the last few years as compared with the fifties. It should be noted that the estimates of F, obtained by this method, were remarkably steady from year to year, showing no great fluctuations.

Estimates of Z, obtained from age-composition and catch per effort data appeared to be far more variable (Tables 12-13). This high variation is probably caused by changes in the availability of herring to drift-net fishing from year to year. The low Z estimates found for the years 1962-65 (Table 13) could partly be attributable to overestimating the older herring in this period, as set out in section II.a.C. On average the total mortality rate was found to be 0.21 in the years 1950-60 and 0.43 in the years 1962-68. With a constant natural mortality this would also mean an increase in the exploitation rate. Accepting 0.16 for the natural mortality M, as found by the method described under section II.a.C (Table 15), this increase would have been more than five times, as F increased from 0.05 in 1950-60 to 0.27 in 1962-68. With a lower M value the increase in the exploitation rate would have been less drastic, an M of 0.10 giving for instance a threefold increase.

The values found for Z obtained from estimates of stock size per year-class (Table 15) for the period 1965-68 were in reasonable agreement with the other estimates for that period (Table 17). It would seem that the total mortality rate in the later years, i.e. after 1962, ranged somewhere between 0.40 - 0.50. The fishing mortality estimates (F), obtained by method c (Table 15), tended to be somewhat lower than those obtained by the stock size-catch method (Table 16) in the same period, which could again point to an overestimation of M by the method described in para.c (page 6)

II b. The Immature Herring Fisheries

A. Total Catch

The exploitation of the adolescent stages are divided in two categories: the fishery for small herring (less than 51 grammes), conducted almost exclusively by Norway and the fishery for fat herring carried out by Norway and U.S.S.R. The small-herring catches contain mainly 0- and I-group fish, while the fat-herring catches consist of I- to IV-group herring with a predominance of II- and III-groups.

Total catch since 1901 are shown in Table 18 as yearly averages for the first 5 decades and by yearly catches for the period 1951-68. The small-herring fishery shows a steady increase up to a peak in 1952, caused by the very abundant year-class 1950. Another peak is reached in the early sixties, when two new abundant year-classes, 1959 and 1960, entered the fishery. In recent years the small-herring catches indicate a declining trend, 1968 showing the lowest catch figure since the early start of the fishery.

The development of the fat-herring fishery is also influenced by the abundant year-classes mentioned above but differs from the small-herring fishery in the very pronounced increase in catch in 1967 and 1968.

B. Abundance

Dragesund (in press) made abundance estimates of 0-group herring, covering both coastal and offshore occurrences. Indices obtained by acoustic methods are shown below:-

Year-class	1959	1960	1961	1962	1963	1964	1965
0-group abundance	49.6	22.4	5.7	2.2	8.2	11.4	0.5

In Figure 2 the indices of 0-group echo-abundances of year-classes 1959, 1960, and 1961 are plotted against the numbers of the same year-classes at 5 years caught per net by the U.S.S.R. drift-net fisheries. The Figure indicates a close correlation between the two independent estimates of year-class strength. An estimate of total stock abundance is obtained by the tagging experiments (Table 11) and the U.S.S.R. echo- and underwater

photographic surveys. In Figure 3 total stock in numbers of year-classes 1959-62 at 6 years of age are plotted against 0-group echo-abundance indices. Also in this case a very close correspondance is demonstrated.

It appears that estimates of relative year-class strength of total biomass of the Norwegian winter-herring stock have attained a high degree of accuracy.

C. Effect of Fishing

In Table 19 the catch in numbers by year-class is shown for the year-classes 1959-65. Figures for small-herring are taken from Dragesund (in press), and the fat-herring figures have been derived from Dragesund (in press) and Annales Biologiques 24 and 25. The high catches of fat-herring in 1967 and 1968 (Table 18) are reflected in the high numbers caught of year-classes 1963 and 1964.

Table 19. Total numbers caught in the small- and fat-herring fisheries in relation to 0-group abundances for the year-classes 1959-65.

Year-class	Abundance Index 0-group a	Inshore Stock in % of Total 0-group stock	Catches in Numbers		Measures of Exploitation Rate	
			Small Herring b	Fat Herring c	Small Herring 10 b / a	Fat Herring 10 c / a
1959	49.6	3.2	26.6×10^9	3.56×10^9	5.4	0.7
1960	22.4	4.8	25.0×10^9	1.97×10^9	11.2	0.9
1961	5.7	16.0	12.5×10^9	0.93×10^9	21.9	1.6
1962	2.2	16.9	8.0×10^9	0.24×10^9	36.4	1.1
1963	8.2	9.3	9.4×10^9	4.39×10^9	11.5	5.4
1964	11.4	4.8	8.4×10^9	6.30×10^9	7.4	5.5
1965	0.5	20.6	2.2×10^9	-	44.0	-

Small Herring. The small-herring catches consist of about 90% 0-group herring and 10% I-group herring. The fishery is only carried out in the Norwegian fjords. Dragesund (in press) has shown that the greater part of the 0-group stock is found in the open sea (Table 19). A comparison with total abundance indices shows that the more abundant year-classes have a proportionately greater offshore occurrence than the less abundant. Hence the fishery will have a comparatively greater effect on weak year-classes. In Table 19 is also shown a measure of the exploitation, expressed as the rate between the total numbers caught and the 0-group abundance index (Figure 4). A close connection between exploitation rate and the "inshore" percentage is evident.

Reliable estimates of fishing and natural mortalities could not be produced by the data available to the Working Group. It appears, however, that even if the small-herring fishery removed a substantial part of the inshore population, the overall effect on the stronger year-classes which in fact support the fishery for adult herring would be of a very small order.

Fat Herring. The fat herring are mainly caught by purse-seine in the open sea and at the entrances of the big fjords in northern Norway. From 1964 onwards the Norwegian purse-seiners introduced the power block and the purse-seine itself was made gradually deeper.

Accordingly, since this year the fleet became more efficient than prior to 1964, when the efficiency was considered to be fairly constant. The more modern SONAR equipment introduced during the period 1964-67 also increased the efficiency of the fleet.

The exploitation rate (Figure 5) of the different year-classes during the fat-herring stage was almost the same for 1959-62 year-classes, whereas for the 1963 and 1964 year-classes a sharp increase took place (Dragesund, in press). The main reason for this was: 1) an increase in the effort and 2) higher availability during the fat-herring stage.

The increase in effort was mainly due to higher efficiency of the fleet. Both the 1963 and 1964 year-classes were mainly distributed in offshore waters during the 0-group stage (Dragesund, in press), and during the subsequent adolescent phase these year-classes were concentrated off the eastern Finmark and Murman coast. Fat herring distributed in this region usually have a lower growth rate than those being distributed farther west and south of the Norwegian coast and consequently the duration of the returning phase of these year-classes from the nursery area of eastern Finmark to the feeding area in the Norwegian Sea was relatively long. This again resulted in a longer duration of the fat-herring stage than usual and thus increased the availability of these year-classes compared to the 1959-62 year-classes.

It is likely that the fishery on fat herring on the 1963 and 1964 year-classes has and will have a serious effect on the recruitment of these year-classes to the adult stock. The low relative abundances of these year-classes in the adult stock (Table 10) as compared with the relative abundance as immature shown in Table 19 could possibly indicate a serious reduction.

II.c. Changes in the Migration Pattern

The recent drastic changes in the migration pattern of the Norwegian spring-spawners are schematically shown on Charts 1-3. During the period 1950-1962 the spawning grounds of this stock gradually moved northwards as shown on Chart 1. The main summer-feeding grounds varied somewhat during this period but remained, however, in the Iceland-Jan Mayen area (Chart 1), and the densest summer concentrations were usually found near the borders of the East Icelandic current. In the autumn the herring assembled on the overwintering grounds situated off East Iceland near the southern and south-western borders of the East Icelandic current, whence they migrated at the beginning of the year to the Norwegian coast for spawning (Chart 1).

During the period 1963-66 a separate stock component (Devold and Jakobsson, 1968) had developed in addition to the stock component displaying the migration pattern described above, which had distinct spawning grounds off Lofoten, with feeding ground in the Bear Island region as shown on Chart 2. But at the end of the feeding period some of the herring which had spawned for the first time at Lofoten moved to the wintering grounds to the east of Iceland and recruited to the main component of the Norwegian herring stock. In addition it should be noted that some of the herring which had spawned at Lofoten migrated directly to the feeding area off East Iceland. However, the feeding part of the recruiting herring which spawned for the first time at Lofoten stayed at wintering grounds situated west off Bear Island. The main part of the pre-recruits were also wintering in this area (Benko, Seliverstov and Zilanov, 1966).

In the autumn of 1966 this separate stock component migrated all the way from the Bear Island feeding grounds to the overwintering grounds of East Iceland and mixed with the main component of the stock that traditionally overwintered in that area. In 1967-69 the stock has migrated as a single unit in the following way:-

The main spawning grounds have been off western Norway with no spawning in the Lofoten area. The summer-feeding grounds have been in the Bear Island - Spitsbergen area, whereas the overwintering grounds have been off East Iceland (Chart 3).

With reference to the change in summer-feeding grounds it should be noted that since 1965 the temperature in the East Icelandic current has fallen drastically (Joint Survey Repts., App. Ann.Biol., 1965-68), so that in practically the whole traditional feeding area as shown on Charts 1 and 2 the sea-temperature in the surface and intermediate layers in the spring of e.g. 1968 was below 0°C.

II.d. Conclusions

Total catches of adult herring were found to fluctuate in relation to the entrance of very large year-classes in the adult stock. Thus the recruitment of the large 1950 year-class caused high catches in the mid-fifties (1954-57), and the recruitment of the large 1959 and 1960 year-classes gave rise to a high catch level in the years 1964-67. Both periods of high catches were followed by a decline, which was most striking in the latter period, 1968 giving the lowest catch recorded since 1925.

All the evidence on stock and fisheries of the adult herring indicate that the rate of exploitation has increased in the last 10-20 years. This increase is most clearly demonstrated by a comparison of the total catch of adult herring with estimates of adult stock size, obtained from tagging data and by acoustic-photographic methods. From Figure 1 it is evident that the total catch constituted an increasing proportion of the adult stock, especially after 1959. Estimates of the fishing mortality rate, calculated from catch-stock size (Table 16) indicate an increase from about 0.13 in the years 1954-59 to about 0.22 in the years 1960-65. In the last two years, 1966-67, a further increase in the fishing mortality rate was observed, to a level of 0.43.

Estimates of fishing effort for the years 1958-68 obtained from the total catch and the catch-per-effort data of the U.S.S.R. drift-net fleet indicated also an increased exploitation rate in that period. Comparing the years 1958/62 and 1963/67, an increase of between 30-80% was found, again with the highest effort in the years 1966-67. For the year 1968 a strong decline in the effort was indicated (Table 6).

Estimates of total mortality rates (Z), obtained from abundance indices by age-groups, were found to be highly variable, but gave an average Z of 0.21 in the years 1950-60 compared with 0.43 in 1962-68. Accepting the calculated value for the natural mortality M = 0.16 (Table 16), the fishing mortality increased from 0.05 to 0.27, suggesting an increase in the exploitation rate of more than five times.

Summing up, the exploitation rate seems to have increased after 1959, reaching a level of at least twice as high in the period 1960-68 than in the fifties. For the years 1966-67, a higher effort was indicated than in the early sixties, but in 1968 a large drop in the effort was noted. The fishing mortality rate in the last years (1965-67) was probably on a level between 0.40 and 0.50. In the immature herring fisheries the catches of small herring - 0+I group - tended to decline since 1960. However, this decline was largely determined by the low abundance of the small herring due to a series of weak to moderate year-classes since 1960. The exploitation rate did not show a definite trend but seemed to be related to year-class strength, in the sense that weaker year-classes are more heavily exploited. Due to a more coastal distribution of weaker year-classes, the - mainly coastal - small-herring fishery takes a heavier toll of those year-classes. Although a reliable estimate of fishing and natural mortality could not be obtained, it appears however that the effect of the small-herring fisheries on the recruitment of stronger year-classes to the adult stock can only be of a small order.

Catches of the fat-herring fishery (I-IV group) increased considerably in the years 1967-68, having fluctuated with no definite trend in the years 1960-66. It could be shown that the rate of exploitation in the fat-herring fisheries increased by 5-6 times in 1967-68. The increased exploitation concerned the 1963 and 1964 year-classes, which were indicated to be of about average strength. As the natural mortality in these large immature herring (20-28 cm) is thought to be low, probably not higher than in the adult stock, and the numbers caught are high compared with the catches in numbers in the adult fishery, a serious effect of the fat-herring fisheries on the subsequent recruitment of year-classes 1963 and 1964 to the adult stock is to be expected.

The Norwegian spring-spawning stock was not only subjected to an increasing exploitation in the adult and fat herring stage in the years since 1960. It has been shown that, in addition, major changes took place in the pattern of distribution, spawning grounds and migration routes of the adult stock, starting in 1963 and continued in 1966 (Section II.c). These natural changes may have affected the yield of the fisheries to some extent, especially since 1968.

The recent relatively high exploitation rate in the adult phase as well as in the fat herring stage will reduce the size of the adult stock more than it did in the period 1950-60. With the same year-class strength as 0-group fish a smaller adult stock is to be expected. Although it is not possible at present to assess the effects of this reduction on the reproductive success of the stock, it should be noted that a large reduction in egg-production capacity will be the result of the increased exploitation.

III. ICELANDIC HERRING STOCKS

The previous Atlanto-Scandian Herring Working Group compiled a table showing the Icelandic catches of the two Icelandic herring stocks until 1963. Data covering 1963-67 as well as catches of Norwegian purse-seiners have now been added (Table 20). The annual total catch of spring spawners in the period 1957-60 was thus about 100 thousand tons. In 1961 and 1962 the catch was extremely large, or up to 305 thousand tons in the latter year. But since 1962 the yield of this stock has been steadily decreasing and in 1967 it was only 16.7 thousand tons. The annual yield of the Icelandic summer spawners was 67.3 thousand tons in 1961, reached 142.4 thousand tons in 1965, but was only about 60 thousand tons in 1966 and 1967. Thus the total yield of the Icelandic herring stocks was 103.8 thousand tons in 1957, increased to 403 thousand tons in 1962. In 1965 the catch had decreased to 204 thousand tons, and in 1966 and 1967 to about 80 thousand tons.

Until 1964 the fisheries had been based essentially on adult stocks, but in 1964 a substantial proportion of the south-coast catch was immature herring. This was especially pronounced in a new summer fishery, where 50% of the herring (by numbers) were immature. Every year since 1964 the immature component has been a substantial one, ranging from 40-65%.

At the same time, the age-composition showed (Jakobsson: Annls.biol., 1961-1968) that in the early 60's the average age of the herring in the south-coast fisheries was 5.5-6.6 years, while since 1964 it has been much lower (2.9-4.0 years) in the different fisheries. During the years 1964-67 the 3 year old recruit herring have dominated the age-distribution, so that the success of the fishery has, to a very large extent, been dependent on recruits and immature herring.

Stock estimates from tagging data indicate that since 1962 the total abundance of the stocks has been decreasing, from about 930 thousand tons in 1962 to about 270 thousand tons in 1966 (Jakobsson, 1967).

F was calculated from stock estimates and total catch (Table 21), and these estimates are at least twice as high as those found in the Norwegian herring stock (Table 17). As a result of the decline and the serious state of these Icelandic herring stocks their exploitation by the Icelandic fleet has been restricted by the Icelandic Government as follows:-

1967-68. It was illegal to land a catch comprising more than 50% (by number) of herring less than 23 cm. Since 1st February 1968, the minimum length was increased from 23 to 25 cm; a complete fishing ban for herring off the south and west coasts of Iceland was enforced from 1st March to 1st September, and a quota of 50,000 tons total catch of Icelandic herring stocks has been imposed.

IV. CAUSES OF THE RECENT DECLINE IN THE YIELDS OF ATLANTO-SCANDIAN HERRING

The causes for the recent drastic decline in the herring fisheries, based on adult Norwegian spring spawners, can be stated as follows:

There has been practically no recruitment to the adult stock since the 1959-1961 year-classes were fully recruited in 1966. Therefore, the stock size has decreased due to lack of recruitment. This decline of the stock has been accelerated by the higher exploitation rate in recent years as compared with earlier periods. It should also be noted that at least in 1968, the availability of the herring was reported to be low, mainly due to unusual shoaling and abnormal behaviour pattern.

As regards recruitment to the adult stock in the coming years, information from international echo-surveys indicate that the 1962 and 1965-68 year-classes are all very poor. The 1963-64 year-classes, which were probably of average strength, have been heavily exploited in the fat herring stage and their recruitment to the adult stock is expected to be seriously affected. Hence, it is clear that there will be a further decline of the stock, for another 3-4 years at least.

The Working Group concluded that the recent high exploitation rate of pre-recruits in the fat herring stage could seriously affect recruitment to the adult stock. It seems, therefore, advisable to restrict the fisheries on young immature herring. This is most necessary in the case of older pre-recruit herring (fat herring), although with weak year-classes a moderation of the small herring fisheries could also have a beneficial effect.

The present relatively low abundances of the adult stock can partly be attributed to fishery, the rate of exploitation having increased considerably in the last decade. Although environmental factors presumably play a major role in determining the reproductive success of this stock, an accelerated depletion of the adult stock and thereby its spawning potential caused by a high rate of exploitation might endanger the prospects for future reproduction.

A further increase in the fishing rate should probably be avoided and even some reduction of fishing be considered.

A decline in the fisheries based on Icelandic stocks was noted, due to reasons somewhat similar to those of Norwegian spring spawners, i.e. lack of recruitment and a very high rate of exploitation (F=0.6). Since 1964 the fishery has been almost entirely based on pre-recruit and recruit herring. The Working Group was informed about the conservation actions taken by the Icelandic Government, including a ban on the immature herring fisheries and a restriction of the fisheries on adult herring of these stocks in 1967 and 1968 (see page 12).

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VI. Tables (Tables 1-11, 18, 20-21; for other Tables, see text).

Table 1. Summer and Autumn Fishery.

Catch (in thousands of tons) of adult non-spawning herring 1950-1968.

Year	Iceland	Norway	U.S.S.R.	Faroes	Germany	Total
1950	30,7	10,1	14,0	-	-	54,8
1951	48,9	14,3	41,7	-	-	104,9
1952	9,2	19,6	61,0	-	-	89,9
1953	31,5	22,1	101,5	-	-	155,1
1954	15,2	11,4	133,3	27,4	-	187,3
1955	18,1	13,9	168,2	12,9	-	213,1
1956	41,2	14,8	188,8	23,0	-	267,8
1957	18,2	17,5	239,9	16,2	-	291,8
1958	22,6	11,4	306,1	15,8	-	355,9
1959	34,5	10,5	314,9	13,0	-	372,9
1960	26,7	18,3	365,7	9,4	-	420,1
1961	85,0	42,0	207,7	16,9	-	351,6
1962	176,2	72,1	259,6	9,8	-	517,7
1963	177,5	68,9	278,7	12,9	-	538,0
1964	367,4	80,1	231,9	18,3	-	697,7
1965	540,0	33,1	324,4	31,5	5.6	929,0
1966	691,4	37,0	296,6	44,0	22,7	1069,0
1967	359,3	52,1	236,2	17,7	7,4	665,3
1968	75,2	30,1	111,3	x)	1,1	216,6

x) No information available.

Table 2. Winter Fishery.

Catch (in thousands of tons) of Norwegian winter herring 1950-1968.

Year	Norway	U.S.S.R.	Faroes	Germany	Total
1950	771,3	-	-	-	771,3
1951	888,0	1,3	-	-	889,3
1952	820,5	8,9	-	-	829,4
1953	670,1	8,5	-	-	678,6
1954	1092,2	26,7	0,2	-	1119,1
1955	965,4	38,8	0,2	-	1004,4
1956	1145,9	46,2	0,7	-	1192,8
1957	795,6	60,1	0,8	-	856,5
1958	345,3	81,9	1,9	-	429,1
1959	416,4	93,1	0,7	-	510,2
1960	300,1	99,3	1,6	-	401,0
1961	69,0	77,3	-	-	146,3
1962	84,1	49,4	-	-	133,5
1963	61,5	71,3	-	-	132,8
1964	286,3	133,9	-	-	420,2
1965	226,4	164,8	-	-	391,2
1966	460,9	150,8	16,7	3,4	631,8
1967	371,6	67,7	17,2	2,3	458,2
1968	25,6	13,0	6,0	0,7	39,9

Table 3. Total Catch.

Catch (in thousands of tons) of adult and pre-recruit Norwegian spring-spawning herring 1950-1968.

Year	Iceland	Norway	U.S.S.R.	Faroes	Germany	Total
1950	30,7	781,4	14,0	-	-	826,1
1951	48,9	902,3	43,0	-	-	994,2
1952	9,2	840,1	70,0	-	-	919,3
1953	31,5	692,2	110,0	17,0	-	850,7
1954	15,2	1103,6	160,0	27,6	-	1306,4
1955	18,1	979,3	207,0	13,1	-	1217,5
1956	41,2	1160,7	235,0	23,7	-	1460,6
1957	18,2	813,1	300,0	17,0	-	1148,3
1958	22,6	356,7	388,0	17,7	-	785,0
1959	34,5	426,9	408,0	13,7	-	883,1
1960	26,7	318,4	465,0	11,0	-	821,1
1961	85,0	111,0	285,0	16,9	-	497,9
1962	176,2	156,2	209,0	9,8	-	551,2
1963	177,5	130,4	330,0	12,9	-	650,8
1964	367,4	366,4	365,8	19,3	-	1118,3
1965	540,0	259,5	489,2	31,5	5,6	1325,8
1966	691,4	497,9	447,4	60,2	26,1	1723,0
1967	359,3	423,7	303,3	34,9	9,7	1130,9
1968	75,2	55,7	124,3	x)	1,8	257,0

x) No information available

Table 4. Fleet composition and effort estimates.

Year / Country	Norway		Iceland			U.S.S.R.				
						Drift-Net				Purse-Seiner
						Winter Season		Summer Season		
	Purse-Seiner No. of Boats	Drift-Net No. of Boats	Purse-Seiner No. of Boats	Number of Days in Action	Average Tonnage	No. of Boats	Total No. of Nets shot (in millions)	No. of Boats	Total No. of Nets shot (in millions)	No. of Boats
1954	492	1450	-	-	-	188	0.94	199	2.4o	-
1955	549	1435	132	-	-	231	1.26	253	2.90	-
1956	561	1321	187	-	-	273	1.49	293	3.58	-
1957	599	1408	234	-	-	400	2.36	372	4.12	-
1958	593	1413	241	-	-	436	2.73	380	4.57	-
1959	564	1297	224	-	-	491	2.83	410	4.18	-
1960	439	1162	258	-	-	524	4.25	244	3.30	-
1961	254	789	275	-	-	455	3.26	251	3.19	-
1962	197	-	224	16761	99	302	2.68	164	1.26	-
1963	214	-	226	19697	109	344	3.27	184	2.51	-
1964	268	-	233	22507	183	384	3.08	187	2.12	-
1965	318	-	189	31176	145	488	3.91	107	0.95	-
1966	382	-	191	33089	181	484	4.16	92	1.23	7
1967	418	-	139	23397	220	342	3.97	43	0.58	19
1968	397	-	80	7500	280	137	1.73	10	0.21	69

Table 5. Catches per effort of the U.S.S.R. drift-net fishery. (a. From the annual catch. b. From the February catch = spawning fishery only).

Years	a.	b.
	Catch per drift-net (from total catch) kg	Catch per drift-net (February) kg
1958	53.5	131.0
1959	63.3	132.0
1960	60.2	115.2
1961	44.4	76.0
1962	57.3	56.1
1963	61.6	87.2
1964	66.4	108.0
1965	94.4	113.5
1966	79.0	115.0
1967	56.3	55.3
1968	28.3	26.3

Table 6. Estimates of total effort in drift-net units.

Year	Total Number of nets in Millions (Total Catch)	Total Number of Nets in Millions (February only)
1958	14.65	6.0
1959	13.95	6.7
1960	13.64	7.13
1961	11.21	6.55
1962	9.62	9.83
1963	10.56	7.46
1964	19.84	10.35
1965	14.04	11.68
1966	21.68	14.89
1967	20.09	20.45
1968	9.11	9.77

Table 7. Percentage age-composition 1950-1968. Norwegian winter fishery.

Year / Age	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
2	.1	-	.1	.1	.1	-	-	.2	-	-	-	-	-	-	-	-	-	-	-
3	8.3	.2	1.3	4.0	1.3	1.5	.6	.4	.5	.4	-	-	.1	-	.2	-	-	-	-
4	5.5	11.6	2.0	1.9	25.2	6.3	5.0	7.4	1.0	1.3	.3	.4	-	6.9	5.9	5.2	.1	.2	-
5	5.5	5.2	19.9	4.1	3.3	46.9	5.9	4.3	6.1	1.4	1.6	.9	.5	.4	60.6	13.6	8.8	.4	.7
6	16.3	4.8	4.5	14.4	5.4	2.7	50.6	5.6	4.7	7.5	1.2	3.3	.9	.4	.3	66.3	28.9	12.8	1.3
7	18.7	15.2	6.7	3.2	11.0	4.3	2.3	56.5	6.6	5.1	6.5	2.9	2.5	.5	.1	.1	54.5	33.7	12.1
8	2.3	17.7	12.4	4.2	2.8	5.8	3.9	1.8	50.5	7.8	3.5	7.7	1.5	1.7	.2	.2	.2	48.5	35.0
9	2.5	2.0	12.2	12.0	4.2	1.7	4.6	2.6	2.6	47.3	5.0	4.8	8.0	1.0	.8	.1	.1	.2	47.7
10	3.1	2.2	2.4	14.4	9.2	4.0	2.2	2.4	3.5	2.2	58.1	6.5	4.0	8.6	.5	.3	.1	-	.1
11	2.4	2.6	2.5	2.0	9.5	5.5	3.5	1.6	3.4	3.3	1.6	59.0	6.6	3.6	3.4	.5	.2	.1	-
12	5.4	2.7	3.1	2.8	1.7	3.3	4.1	2.2	2.3	4.5	3.8	4.4	63.5	8.2	1.8	1.4	.2	.3	.2
13	10.4	6.7	3.0	2.9	1.9	1.0	1.9	2.7	2.2	1.9	4.1	3.0	2.1	60.0	2.6	.8	.6	.2	.2
14	1.6	9.1	5.0	3.0	2.5	1.4	.9	1.5	1.8	2.3	1.5	2.3	3.6	2.0	20.9	1.3	.6	.5	.3
15	2.7	1.5	7.0	6.6	2.2	1.8	1.2	.5	1.1	2.2	1.0	1.5	3.4	2.7	.6	9.2	.4	.3	.5
16	4.8	3.0	1.6	7.0	3.4	1.9	1.4	.6	.6	.9	1.3	1.4	0.7	2.0	.7	.3	5.0	.3	.4
17	1.1	4.0	2.2	2.2	4.3	2.2	1.7	.8	.7	.5	.9	.9	1.0	.8	1.1	.3	-	2.5	-
18	.5	.4	3.4	2.9	1.7	1.3	1.6	1.0	.7	.7	.5	.3	1.0	.5	.1	.3	-	-	1.4
19	-	.2	.8	2.9	1.4	1.5	.6	.7	.5	.4	.3	.4	.3	.4	.1	-	.3	-	-
20	.1	-	.1	.7	1.0	.7	.6	.3	.3	.3	.5	.1	-	.2	.1	-	-	-	-
21	-	.1	-	.1	.1	.2	.3	.2	.2	.2	.3	.1	.2	-	-	.2	-	-	-
22	-	-	-	-	.1	.1	.1	-	-	.1	.1	.1	-	-	-	-	-	-	-
> 22	-	-	-	-	-	-	-	-	-	.1	.1	-	.1	.1	-	-	-	-	-
?	8.6	10.8	9.8	8.6	7.8	5.9	7.0	6.6	10.6	10.0	7.8	-	-	-	-	-	-	-	-
M =	3973	3841	3336	2796	4839	4174	4998	2779	972	1116	1155	452	398	399	1481	1402	2531	1599	138

Table 8. Age-compositions 1962-1968 in %.

a) Iceland - Summer

Age \ Year	1962	1963	1964	1965	1966	1967	1968
1	-	-	-	-	-	-	-
2	3.4	0.3	0.1	1.5	-	-	-
3	17.4	2.3	4.0	0.4	2.7	0.1	0.1
4	0.1	22.9	10.1	5.8	0.8	1.2	0.2
5	0.0	0.2	46.8	12.7	7.9	1.1	2.4
6	0.2	0.0	0.4	42.3	18.7	11.6	2.1
7	0.7	0.1	0.0	0.6	49.8	31.8	13.0
8	0.5	0.7	0.0	0.4	1.1	50.3	31.4
9	2.2	0.9	0.6	0.2	0.4	0.3	47.2
10	3.0	4.4	1.0	0.5	0.5	0.3	0.3
11	7.7	4.7	2.1	1.1	0.7	0.1	0.2
12	48.2	8.5	2.6	2.7	1.2	0.2	0.1
13	2.9	41.6	5.2	3.2	1.8	0.3	0.4
14	3.4	4.3	21.2	4.0	1.9	0.5	0.4
15	4.6	3.0	1.7	19.2	2.9	0.5	0.2
16	1.9	3.3	1.5	2.2	8.9	0.5	0.5
17	1.8	1.4	1.5	1.6	0.5	1.3	0.7
18	0.8	1.1	0.3	0.9	0.3	0.1	0.6
19	0.8	0.3	0.7	0.4	0.2	-	-
20	0.4	0.1	0.4	0.3	0.1	-	-
21	-	-	-	0.2	-	-	-
22	0.1	-	-	-	-	-	-
n =	2429	3190	3416	4853	6103	552	2935

b) U.S.S.R. - All Areas

1962	1963	1964	1965	1966	1967	1968
-	-	-	-	-	-	-
4.2	2.2	-	0.5	-	-	+
46.8	10.2	6.5	0.1	0.7	0.2	+
1.8	66.3	15.5	6.8	0.2	1.4	0.1
2.4	3.1	66.7	20.6	8.7	0.4	2.1
5.2	1.5	1.9	63.9	28.1	9.9	1.4
2.9	1.0	0.6	0.8	56.0	26.5	13.7
4.2	1.6	0.6	0.4	0.6	51.9	34.1
6.2	2.0	0.8	0.7	0.4	0.8	43.6
7.2	2.8	1.0	0.9	0.3	0.3	0.5
7.3	2.7	1.5	1.0	0.4	0.6	0.6
8.5	5.2	0.8	1.3	0.6	0.7	0.7
1.5	0.7	2.5	1.2	0.9	1.1	0.6
0.8	0.5	1.4	1.2	0.9	1.5	0.7
0.5	0.2	0.1	0.5	1.3	1.3	0.7
0.3	-	0.1	0.1	0.7	2.1	0.6
0.1	-	-	+	0.1	1.0	0.5
0.1	-	-	+	+	0.1	0.1
-	-	-	-	0.1	0.1	-
-	-	-	-	-	0.1	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
7352	11769	14046	7228	8564	10269	6982

Table 9. Total catch in numbers of Norwegian spring-spawning herring in the adult fisheries (in millions).

Year-Class	Years						
	1962	1963	1964	1965	1966	1967	1968
1948	64.1	60.6	43.2	52.1	8.8	0.0	0.0
1949	49.3	79.8	46.1	70.2	14.9	1.9	-
1950	959.3	932.7	771.6	703.0	392.7	64.3	5.4
1951	138.9	174.1	151.9	137.7	96.9	14.3	4.1
1952	59.8	92.5	83.2	106.9	72.1	14.3	3.6
1953	64.1	107.7	96.3	100.5	69.1	17.5	1.8
1954	13.3	9.3	29.3	40.0	11.0	8.9	2.6
1955	20.2	18.3	24.9	19.1	26.1	8.5	2.5
1956	6.5	3.5	3.0	7.4	17.4	3.5	0.8
1957	2.0	1.7	1.5	14.9	14.4	5.7	1.1
1958	1.4	4.9	13.1	19.5	38.0	8.9	2.0
1959	255.7	408.9	1917.7	2195.8	2868.3	1718.2	345.9
1960	49.8	38.2	307.6	570.4	1290.6	1135.0	134.8
1961	-	-	90.2	245.9	459.1	422.2	93.9
1962	-	-	2.2	12.1	26.5	27.0	14.3
1963	-	-	-	45.1	80.6	25.7	15.2
Total	1684.4	1932.2	3581.8	4340.6	5486.5	3475.9	628.0

Table 10. Catches in numbers per drift-net shot per net of Norwegian spring-spawners in the years 1962-1968, using:

Upper figure: equivalent effort from Soviet annual catch per net (drift-net fishery)

Lower figure: equivalent effort from Soviet February catch per net (drift-net fishery).

Year-Class	YEAR						
	1962	1963	1964	1965	1966	1967	1968
1948	6.66 6.52	5.74 0.12	2.57 4.17	3.71 4.46	0.41 0.59	- -	- -
1949	5.12 5.02	7.56 10.70	2.74 4.45	5.00 6.01	0.69 1.00	0.09 0.09	- -
1950	99.72 97.59	88.32 125.03	45.82 74.55	50.07 60.19	18.11 26.37	3.20 3.14	0.59 0.55
1951	14.44 14.13	16.48 23.34	9.02 14.68	9.81 11.79	4.47 6.51	0.71 0.70	0.45 0.42
1952	6.16 6.08	0.76 12.40	4.94 8.04	7.61 9.15	3.33 4.84	0.71 0.70	0.40 0.37
1953	6.66 6.52	10.20 14.44	5.72 9.30	7.16 8.60	3.19 4.64	0.87 0.86	0.20 0.18
1954	1.38 1.35	0.88 1.25	1.74 2.83	2.85 3.42	0.51 0.74	0.44 0.44	0.29 0.27
1955	2.10 2.05	1.73 2.45	1.48 2.41	1.36 1.64	1.20 1.75	0.42 0.42	0.27 0.26
1956	0.68 0.66	0.33 0.47	0.18 0.29	0.53 0.63	0.80 1.17	0.17 0.17	0.09 0.08
1957	0.21 0.20	0.16 0.23	0.09 0.14	1.06 1.28	0.66 0.97	0.28 0.28	0.12 0.11
1958	0.15 0.14	0.46 0.66	0.78 1.27	1.39 1.67	1.75 2.55	0.44 0.44	0.22 0.20
1959	26.58 26.01	38.72 54.81	113.88 185.29	156.40 188.00	132.30 192.63	85.53 84.02	37.97 35.40
1960	5.18 5.07	3.62 5.12	18.27 29.72	40.63 48.83	59.53 86.67	56.50 55.50	14.80 13.80
1961	- -	0.49 0.70	5.36 8.71	17.51 21.05	21.18 30.83	21.02 20.65	10.31 9.61
1962	- -	- -	0.13 0.21	0.86 1.04	1.22 1.79	1.34 1.32	1.57 1.46
1963	- -	- -	- -	3.21 3.86	3.72 5.41	1.28 1.26	1.67 1.56
1964	- -	- -	- -	- -	- -	0.09 -	0.12 0.11

Table 11. Estimates of absolute abundance of adult stock of Norwegian spring spawners 1953/54 - 1967/68 (in million tons).

Years (Winter Season)	From Tagging Data	From Echo-Surveys and Underwater Photography
1953/54	12.5	-
1954/55	12.1	-
1955/56	13.9	-
1956/57	12.0	-
1957/58	9.4	-
1958/59	6.6	6.0
1959/60	5.0	-
1960/61	-	3.1
1961/62	-	2.5
1962/63	-	2.8
1963/64	5.0	3.3
1964/65	7.7	6.8
1965/66	6.6	-
1966/67	4.0	-
1967/68	-	2.0

Note

Tables 12 and 13 - see page 5
Tables 14 and 15 - see page 6
Tables 16 and 17 - see page 7

Table 18. Catches of small and fat herring (in 000's tons) taken by Norway and U.S.S.R.

Year	Small Herring		Total	Fat Herring		Total	Grand Total
	Norway	U.S.S.R.		Norway	U.S.S.R.		
1901-10	22.3	-	22.3	53.7	-	53.7	76.0
1911-20	65.3	-	65.3	40.5	-	40.5	105.8
1921-30	83.4	-	83.4	46.5	0.3	46.8	130.2
1931-40	155.6	-	155.6	53.2	36.7	89.9	245.5
1941/50	108.5	-	108.5	35.1	4.3	39.4	147.9
1951	190.1	10.5	200.6	80.5	2.5	83.0	284.2
1952	276.4	2.1	278.5	55.2	1.9	57.1	335.6
1953	147.0	3.8	150.8	84.7	5.2	89.9	240.7
1954	190.1	8.8	198.9	138.0	1.2	139.2	338.1
1955	94.3	3.0	97.3	36.0	9.0	45.0	142.3
1956	86.8	-	86.8	102.0	10.0	112.0	198.8
1957	118.5	3.8	123.3	46.4	1.5	47.9	171.2
1958	133.5	8.1	141.6	55.1	4.6	60.0	201.6
1959	164.5	7.2	171.7	46.8	9.5	56.3	228.0
1960	212.0	5.7	217.7	62.2	0.8	63.0	280.7
1961	222.7	0.9	223.6	108.5	0.1	108.6	332.2
1962	124.5	0.7	125.2	171.3	0.9	172.2	297.4
1963	157.9	-	157.9	143.8	12.0	155.8	313.7
1964	106.8	-	106.8	56.9	0.2	57.1	163.9
1965	116.9	-	116.9	94.3	10.7	105.0	221.9
1966	78.8	-	78.8	147.9	21.9	169.8	248.6
1967	107.1	-	107.1	346.0	92.6	438.6	545.7
1968	26.3	-	26.3	341.1	71.7	412.8	439.1

Note

Table 19 - see page 9.

Table 20. Total catch (thousands of tons) of Icelandic herring taken by Icelandic and Norwegian fishing fleets.

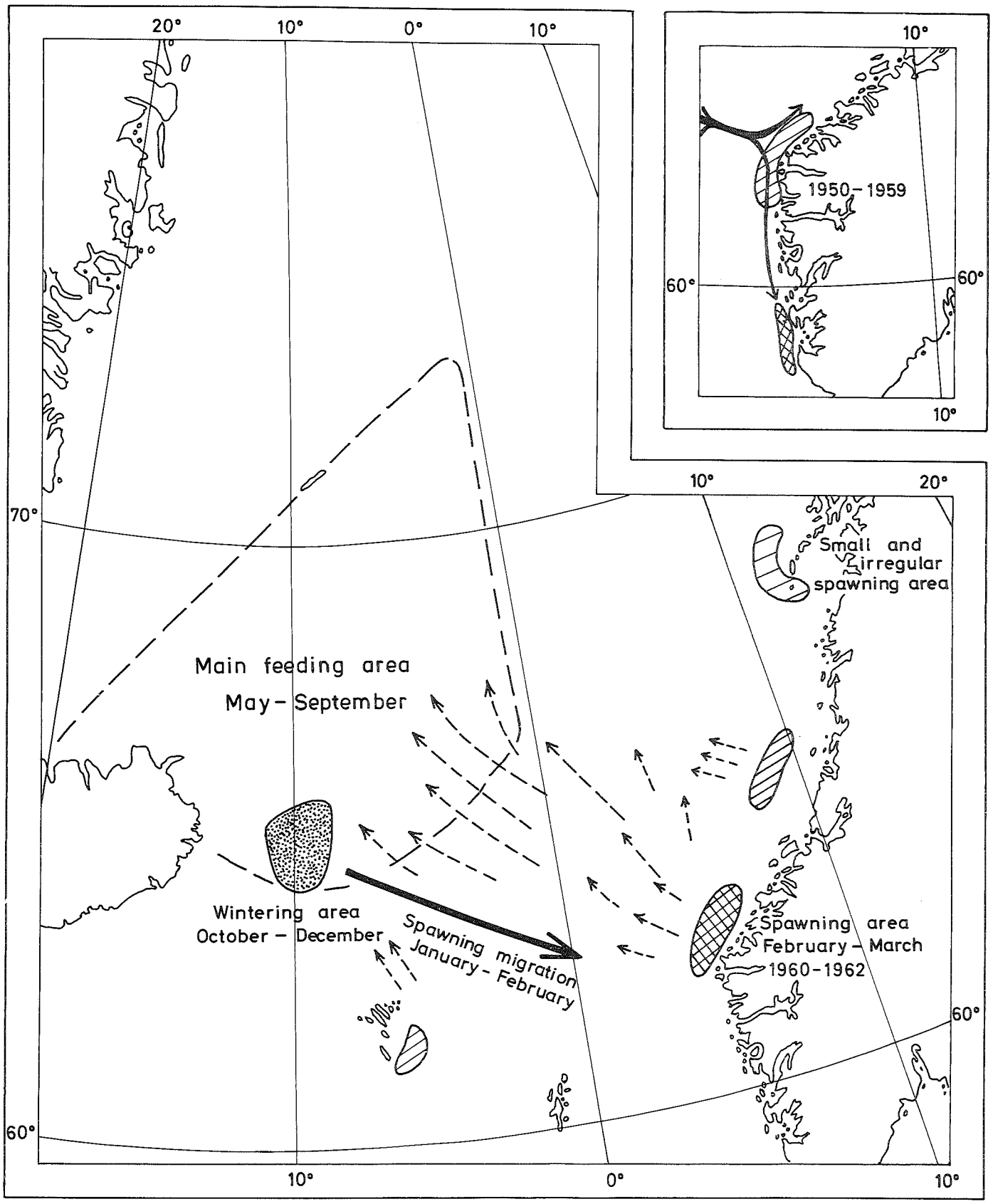
Year	Spring Spawners			Summer Spawners			?	GRAND TOTAL
	North Coast	South Coast	Total	North Coast	South Coast	Total	South Coast	
1957	62.1	-	-	22.7	-	-	19.0	103.8
1958	80.5	-	-	20.0	-	-	33.0	133.5
1959	147.6	-	-	23.8	-	-	28.0	199.4
1960	104.7	-	-	36.1	-	-	23.0	163.8
1961	192.6	42.7	235.3	3.4	64.9	68.3	-	303.6
1962	250.7	58.8	309.5	3.8	90.1	93.9	-	403.4
1963	85.2	30.7	115.9	12.0	91.4	103.4	-	219.3
1964	61.5	36.5	98.0	8.6	77.4	86.0	-	184.0
1965	23.0	38.4	61.4	11.6	131.6	143.2	-	204.6
1966	18.0	8.6	26.6	2.8	50.2	53.0	-	79.6
1967	2.4	14.3	16.7	0.3	65.2	65.5	-	82.2

Table 21. Estimate of F and stock size from tagging data.

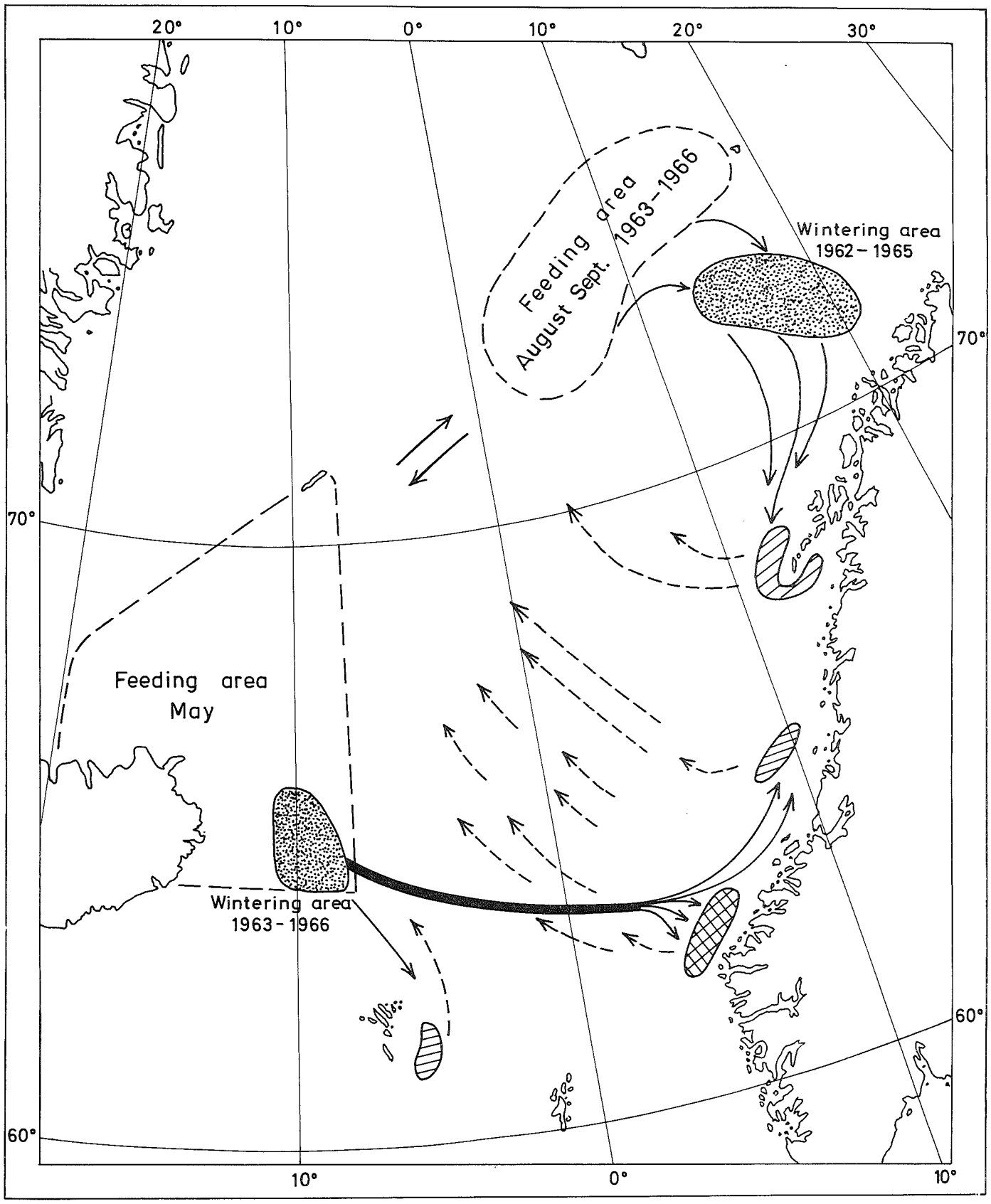
Year	F	Stock Estimate (thousands of tons)
1962	0.56	931
1963	0.44	619
1964	0.52	457
1965	1.11	304
1966	0.35	270

Migration routes 1950 – 1962

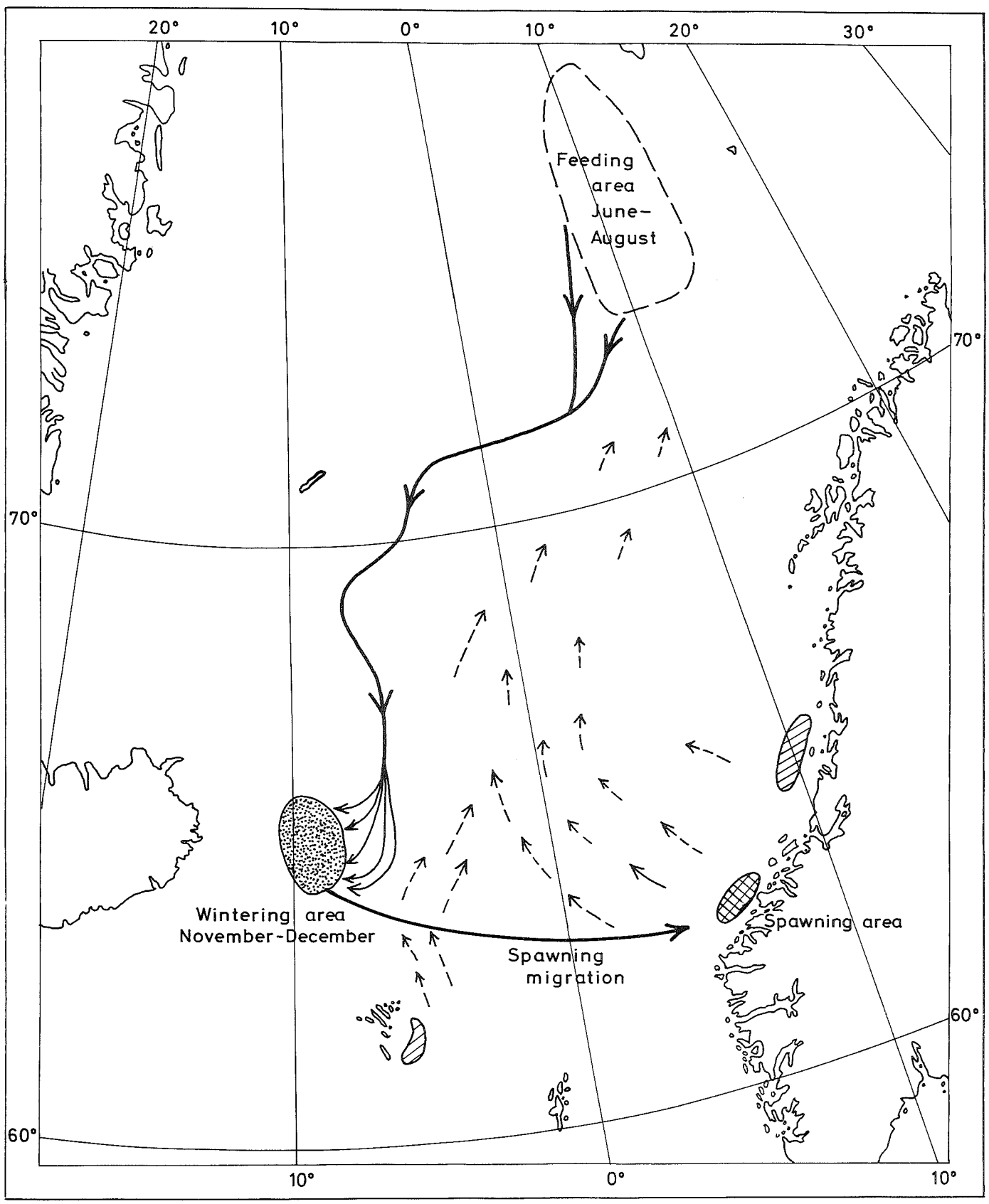
Chart 1



Migration routes 1963 – 1966 Chart 2



Migration routes 1967 – 1968 Chart 3



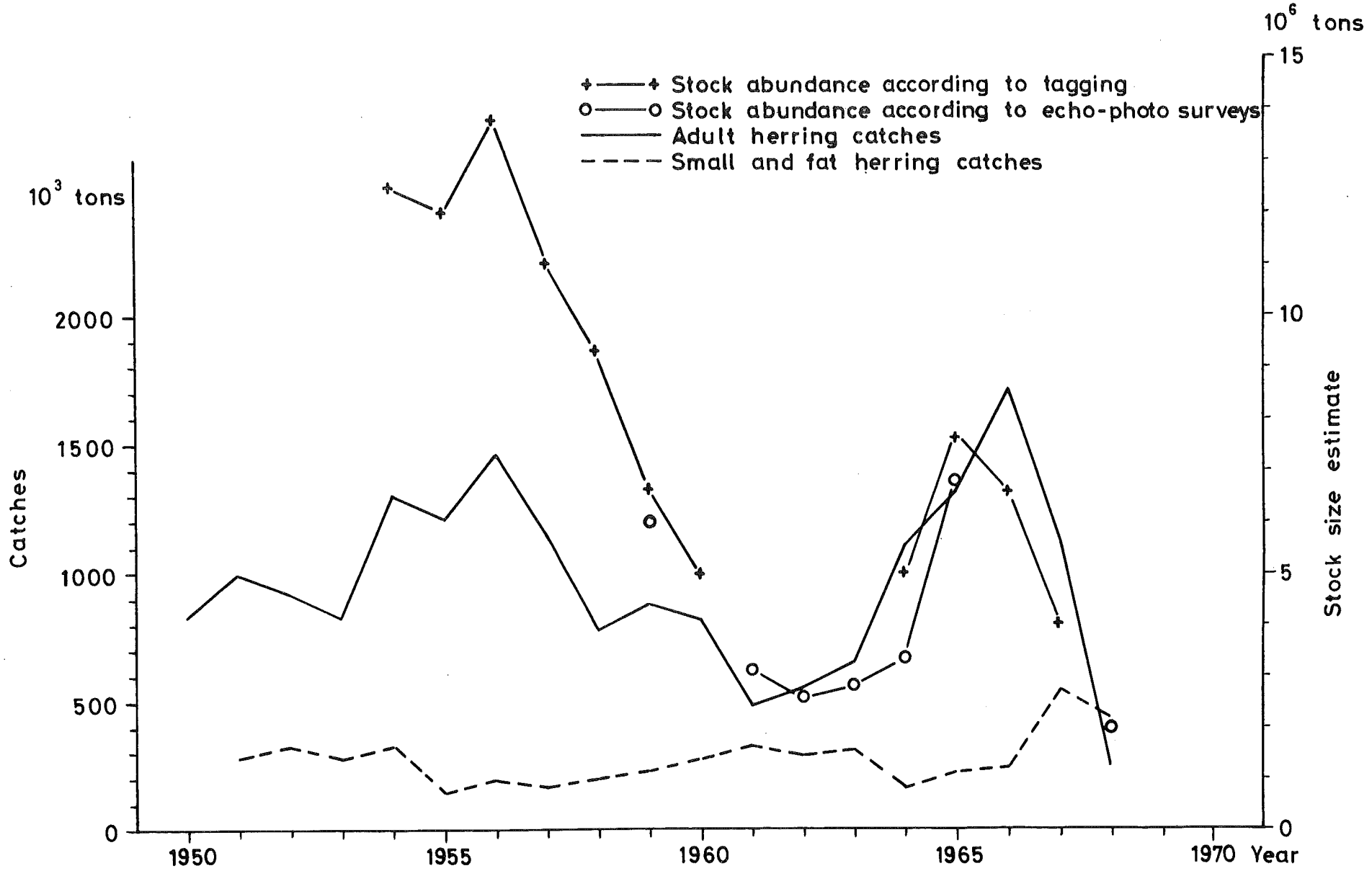


Figure 1. Stock size and catches of Norwegian spring spawning herring 1950–1968

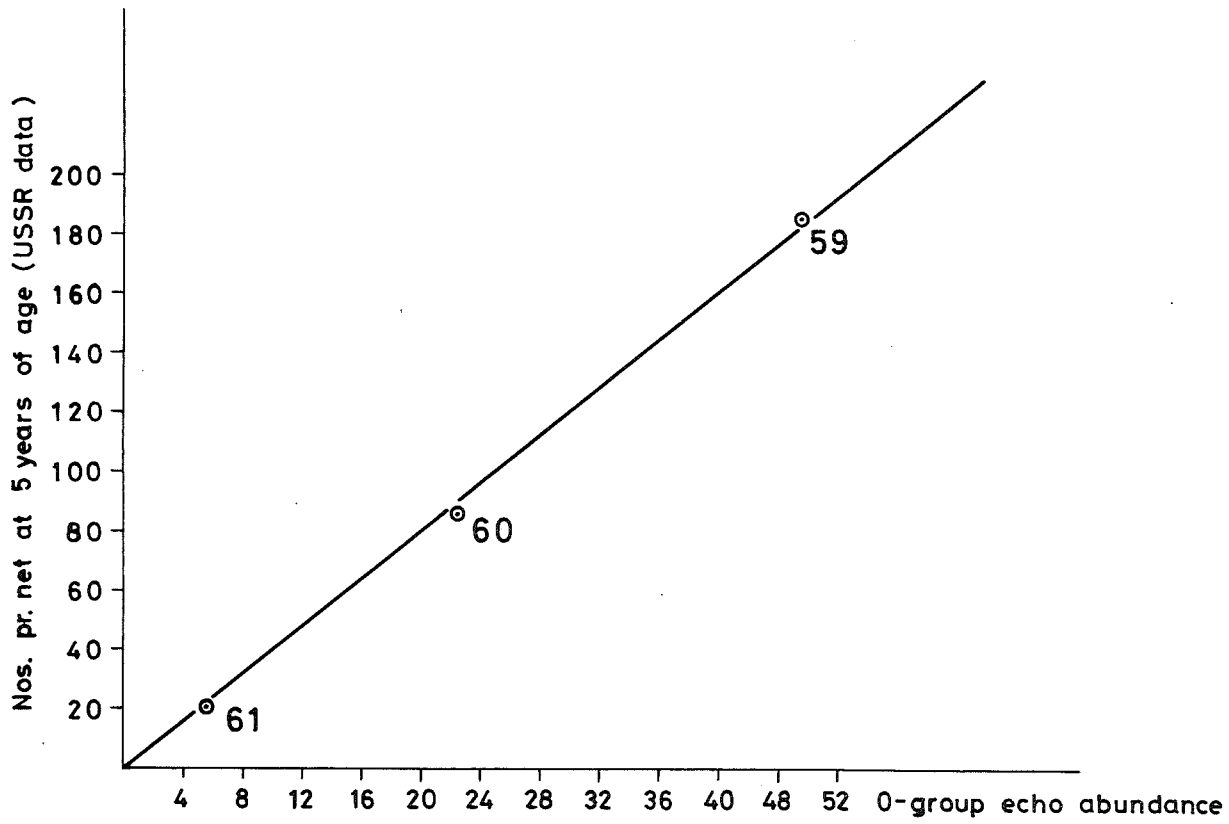


Figure 2. Catch per unit of effort of year-classes 1959-61, at 5 years of age, in the Russian drift-net fishery on respective 0-group abundance determined by Norwegian echo-surveys.

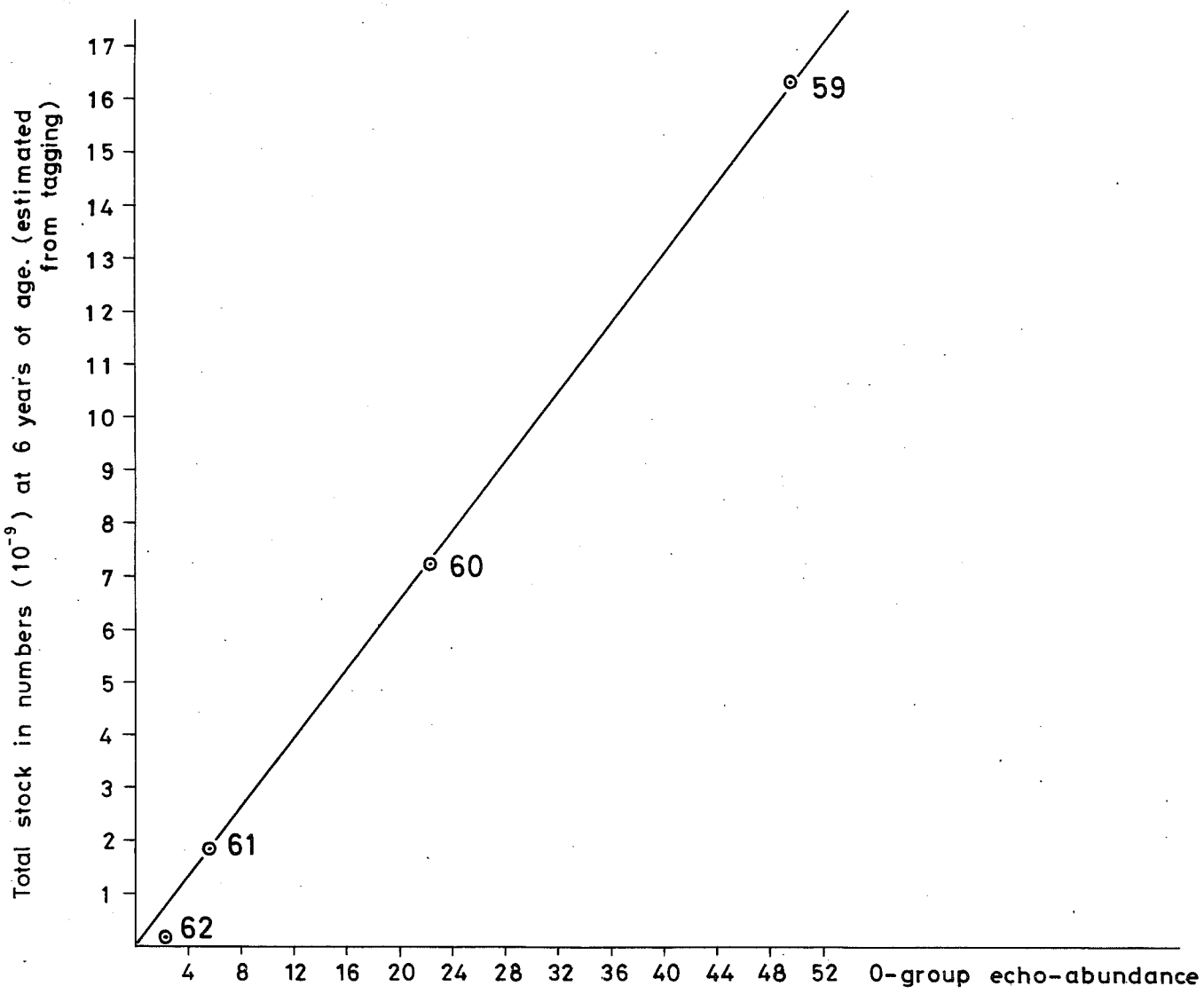


Figure 3. Total stock in numbers of year-classes 1959-62, at 6 years of age, estimated from tagging on respective 0-group abundance determined by Norwegian echo-surveys.