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Report of Meeting of Atlanto-Scandian Herring Working Group

Bergen 22nd-26th April 1963

Terms of Reference and Participation

In accordance with a recommendation made at the Herring Symposium in 1961, and confirmed by the Herring Committee at its subsequent Annual Meetings in 1961 and 1962, the terms of reference of the Working Group were as follows:-

"In view of the recent serious decline in the fisheries based on the Norwegian spring spawning tribe and of the complexity of the scientific problems involved the Symposium recommends that a Working Group be set up, composed of representatives from all countries with fisheries based on this tribe, to examine all available data relating to the elucidation of its causes, including the part played by the fisheries for juvenile, pre-recruit herring" (see Report of Herring Symposium).

The Working Group duly met at the Institute of Marine Research, Bergen from Monday 22nd - Friday 26th April 1963, under the chairmanship of Mr. Finn Devold (Norway), and the following representatives from Norway, Iceland, Germany (Fed. Rep.), the USSR and Scotland participated:-

Mr. Finn Devold (Norway) Chairman
Dr. G. Hempel (Germany) Chairman of Herring Committee
Mr. O.J. Østvedt (Norway)
Mr. O. Dragesund "
Mr. P.T. Hognestad "
Mr. O. Dahl "
Mr. J. Jakobsson (Iceland)
Mr. E. Jónsson "
Dr. S.S. Federov (USSR)
Dr. K.A. Lyamin "
Mrs. L.G. Nasarova "
Mr. B.B. Parrish (Scotland) Rapporteur

Mr. G. Vasseller (Brazil) also attended some of the sessions as an observer.

Agenda and Subject Matter

In view of the wide and complex distribution of the Norwegian spring spawning group and of the known existence of other spawning groups within its total range of distribution, the Working Group's discussions were not confined to this group alone, but included an appraisal of the available information on the distribution, composition and biology of the whole Atlanto-Scandian "race", and of the status of the fisheries based on it. The following main agenda items were therefore discussed:-

- I. Description, identification and mixing of the various stock units within the Atlanto-Scandian "race".
- II. The present status of the stocks and the fisheries exploiting them.
- III. Possible causes of recent changes and fluctuations in the abundance of the stock units.

I Description, identification and mixing of stock units

A. Description of stock units

The Working Group first examined the available information on the distribution, general biological characters and life history of the Atlanto-Scandian herring, which were defined as the population of large, oceanic herring living in the Norwegian Sea and adjacent areas, with widespread spawning grounds situated on the neighbouring continental shelves. Detailed attention was paid to:-

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- (a) the time and location of spawning
- (b) the biological characters of the spawners in each area
- (c) the distribution and movements of the spawning products and adolescent pre-recruit herring
- (d) the distribution and movements of the adult herring during the feeding and immediate pre-spawning periods.

Detailed statements on these biological features of the herring spawning at Iceland, Faroe, off the Norwegian west coast and along the northern and eastern edges of the North Sea shelf and to the west of the British Isles were presented by the participants from Iceland, USSR, Norway and Scotland. Summaries of these statements, relating to the Norwegian spring spawners, the Icelandic spring and summer spawners and the North Sea-Scottish West Coast spring spawners, prepared by the USSR, Icelandic and Scottish representatives are given in Appendices I-IV.

From the data available in published documents and those presented at the meeting, the Working Group drew the following conclusions regarding the distribution of spawning and the characters of the spawners within the range of distribution of the tribe..

(1) The race is composed of groups of both spring and summer spawners. The main spawning centres for the spring spawners occur off the west coast of Norway, along the south coast of Iceland, on the Faroe plateau and along the eastern and northern edges of the North Sea shelf and to the north and west of Scotland.

The main centre of summer spawning is along the south and west coasts of Iceland in the same general localities as the spring spawners (Liamin, 1956) but some summer spawning also takes place around the Faroes.

The spawning centres for both spring and autumn spawners are shown in Figure 1.

(2) The biological characters of the spring spawners from each of these localities are very similar, the main difference, used by Icelandic, Russian and Norwegian workers to distinguish Icelandic from Norwegian spring spawners (especially the "Northern" type) in mixed samples, being the winter-ring and growth zone patterns on the scales (or otoliths) - (see report of Atlanto-Scandian Methods Working Group, 1962). Although possessing some close similarities to the spring spawners (e.g. size, longevity, etc.), the summer spawners differ from them in a number of important respects, especially in maturation cycle, fecundity, egg size, otolith type and scale (otolith) ring pattern. This is shown in Table 1 which summarises some of the main biological characters of the spring and summer spawners from the different areas.

Table 1

Some biological characteristics of Atlanto-Scandian spawning groups

Spawning Group	Average V.S.	Month of main spawning	Season of main gonad maturation	Av. Fecundity ^{x)} (for herring of 32 cm) (in 000's)	Egg diam. ^{x)} for stage VI fish (mm)	Average l ₁ (cm)
Norwegian spring spawners	c.57.2	March	Autumn-Winter	48	1.5-1.7	8-11
Icelandic spring spawners	c.57.2	"	" "	69	1.1-1.3	9-11
North Sea-NW Scotland spring spawners	c.57.0	Feb.-March	" "	64	1.4-1.5	10-12
Icelandic summer spawners	c.56.9	July-September	Spring	140-190	0.8-1.1	6-7

^{x)} From Russian observations.

(3) The distribution of the adolescent, pre-recruit herring derived from the Norwegian spawning concentrations is widespread, ranging from the fjords in northern Norway to the open oceanic regions of the Norwegian and Barents Seas, extending to as far north as Spitzbergen; in general their distribution in these areas varies between different year-classes, depending on the intensity and extent of larval drift, the hydrographic conditions in the area and year-class strength. In particular, the size and extent of the oceanic concentrations, relative to the coastal (fjord) concentrations appears to be larger for rich year-classes than for poor ones.

The main centres of distribution of the adolescent Icelandic spring spawners probably occur in Icelandic coastal waters, and unlike those of the Norwegian spring spawners do not appear to extend extensively into the open ocean, at least during the first 3-4 years of life.

As with the Icelandic spring spawners, the main centres of distribution of the Icelandic summer spawners are probably also in Icelandic coastal waters, especially in the coastal bays and fjords along the south-west and west coasts.

Little is known of the centres of distribution of the adolescent herring derived from spawning at the Faroes and along the edge of the continental slope to the north and west of the British Isles. However, from the known current systems in this area, it seems likely that those of the youngest herring are mostly in the south-eastern parts of the Norwegian Sea extending northwards with age and size to mix in the Barents Sea with those derived from the Norwegian spawning concentrations.

(4) The main feeding areas of the adult Norwegian spring spawners are located in summer and autumn in the region to the north of Iceland, where they are fished by the Icelandic, Russian and Norwegian fishing fleets. The Norwegian spawners migrate to this area as recovering spents and become concentrated during the summer mostly along the southern and eastern boundaries of the east Icelandic arctic current. In general, the range of distribution of these groups during the feeding phase increases with age.

The distribution of the adult Icelandic spring spawners during the feeding phase is also mostly to the north of Iceland. In the main the younger age-groups occupy the western part of the area where mixing with Norwegian spawners is small, while the older ones have a wider, more easterly distribution, where they mix with the Norwegian spawners.

The adult Icelandic summer spawners have two major feeding periods, before spawning in spring and early summer, and after spawning in autumn and early winter. The distribution of fish older than 7-8 years at both times is again mostly to the north of Iceland, along the western edge of the east Icelandic current where they mix with the spring spawners. The younger age-groups (4-7 years old) on the other hand, feed mostly off the south and west coasts.

B. Identification and mixing of stocks

The Working Group considered the available evidence on the important question of the unity and degree of mixing of the three main spawning groups described above both on the spawning and feeding grounds. The Group noted the following results of research, of special relevance to this problem:-

- (1) Adult herring tagged in summer, off the north coast of Iceland have been recaptured subsequently on each of the major spawning grounds (Norwegian west coast and Icelandic south and west coasts).
- (2) Spawning herring tagged on the spawning grounds off the SW coast of Iceland in spring have been recaptured on the north coast feeding grounds in summer and again subsequently on the SW coast spawning grounds, but not on the Norwegian spawning grounds. Further, the recaptures of these herring in the north coast area are taken almost entirely in the Icelandic fishery which is more coastal and further to the west than the Norwegian and Russian fisheries.

- (3) Whereas within each spawning group most of the year-classes generally retain their relative strengths throughout their fished life-spans, the occurrence of rich and poor year-classes is not the same for all of the groups. Thus, during post-war years, the 1943, 1947 and 1950 and 1959 year-classes have been dominant amongst Norwegian spring spawners, while the 1945, 1949, 1950 and 1956 year-classes have been the strongest amongst Icelandic spring spawners. (Fridriksson. In press). On the other hand during the postwar period there has been general agreement between the occurrence of rich and poor year-classes between the Icelandic spring and summer spawners. (Fridriksson, l.c.).
- (4) Whereas the biological characters of the two main spring spawning groups are similar (but see paras. (5) and (6) below), they differ from those of the summer spawners in a number of important respects (see Table 1), chief amongst which are spawning time and maturation cycle, fecundity and egg size, average VS, scale and otolith type, and growth pattern. (Einarsson 1958, Fridriksson 1958).
- (5) Although having similar general biological characters, differences exist between the characters of the scales (and otoliths) of members of the Norwegian and Icelandic spring spawning groups. Amongst the Norwegian spawning concentrations two scale (otolith) types are found - the so-called "Northern" (N) type and a "Southern" (S) type. No "N" type scales are found amongst the Icelandic spring spawning concentrations, their scale type being similar to (but distinguishable from^x) the Norwegian "S" type.
- (6) Although the "N" and "S" scale types occur together amongst the Norwegian spawning herring and amongst the summer, oceanic feeding concentrations, their relative proportions differ between year-classes and with age. (Østvedt, 1958). Thus in all year-classes hatched during the 1930's, the "N" type predominated, in all but the youngest age-groups (4-5 years old), whereas in several of those hatched during the 1940's the "S" type was the dominant one. In general, the "N" type is found to be predominant in rich year-classes of Norwegian spawners, and the "S" type in weak ones. Further, Russian observations on the distribution of the "N" and "S" types amongst the oceanic concentrations of adults suggest that the "S" type scales are formed in the herring which spend their adolescent life in the warm waters of the south-eastern part of the Norwegian Sea, and the "N" type in those growing up in the more northerly colder sub-arctic waters of the Barents Sea and the east Icelandic arctic current.

Conclusions

The Working Group agreed that, although many features of the distribution, movements and general biology of the spawning groups are still not clear, and require further detailed investigation, the following tentative conclusions can be drawn regarding their identities and interrelations:-

- (1) The Icelandic summer spawners are mostly distinct, biologically from the spring spawning groups and constitute an independent racial group.
- (2) The interchange of adult spring spawners between the Icelandic and Norwegian spawning grounds appears to be small, so that, for fishery assessment purposes, these spawning groups can probably be treated as independent stocks.
- (3) The relationship between these stocks and the Faroese and N. North Sea- NW Scotland spring spawners is not clear. It seems likely that members of the Norwegian stock contribute to the N. North Sea and NW Scotland spawning concentrations and Icelandic spring spawners may contribute to the Faroese spawning group, but in the main these spawners (especially the NW Scotland group) can be treated as independent of the other spawning groups.
- (4) The Norwegian stock is composed of two well defined "growth types" (N and S) which originate in different "nursery" areas having distinctive environmental characteristics.

^x) See Section IV for further consideration of this item.

(5) The distributions of these spawning groups during the post spawning, feeding phase, in the region to the north and east of Iceland overlap, the degree of overlap and range of distribution increasing with age.

II Present status of the stocks and fisheries

The Group considered the status of the spawning stocks and the fisheries exploiting them, separately with special reference to the Norwegian spring spawning stock.

A. Norwegian spring spawning stock

Information on the recent changes in the catches of adult, Norwegian spring spawners were presented by the Norwegian, Russian and Icelandic representatives. These are given for the years 1952-1962 in Table 2.

Table 2

Total catch (000's m. tons) of adult, Norwegian spring spawners. 1952-62.

YEAR	Norwegian west coast-winter-spring fishery	Russian ^{x)} Fishery	Icelandic and ^{xx)} Norwegian summer fisheries	TOTAL
1952	820	69	30	919
1953	670	110	54	834
1954	1092	159	28	1279
1955	965	204	32	1201
1956	1145	235	56	1436
1957	795	300	24	1119
1958	345	388	34	667
1959	416	408	45	869
1960	300	465	45	810
1961	69	285	127	481
1962	(<100)	(160)	(216)	-

^{x)} Total catches of Russian summer and winter fisheries for adult herring in Norwegian Sea.

^{xx)} Estimated from total catch in Icelandic and Norwegian summer fisheries from analysis of the relative proportions of Norwegian and Icelandic scale types.

These data show that from 1952-1956, the total catch of Norwegian spring spawners increased, but thereafter it decreased to reach in 1961-62, approximately a third of the 1956 peak level. The most striking changes are shown in the Norwegian fishery, which has declined dramatically since 1956, to reach less than 100,000 tons in 1961 and 1962. On the other hand, the Russian fishery increased steadily up to 1960, when its catch exceeded that of the Norwegian fishery, but it also decreased in 1961 and 1962. The catch of Norwegian spawners in the Icelandic and Norwegian summer fishery was relatively small and showed no upward or downward trend between 1952-1960, but in 1961 and 1962, the estimated catches increased markedly.

Data on fishing effort, and estimates of catch per unit effort for the Norwegian winter-spring and Russian summer and winter fisheries (Østvedt, Devold, Marty and Federov; in press) point to a marked decline in the abundance of the exploited stock (as indicated by catch per unit effort) after 1956. The following observations also confirm this:-

(1) During the period of marked decline in total catch and catch per unit effort in the Norwegian winter-spring fishery after 1956, recruitment to the spawning stock was at a very low level, with the result that the average age of the exploited stock increased progressively and the extent of the spawning area decreased. (Devold, l.c.).

(2) In the Russian fishery on feeding herring in the open sea in summer, the area of productive fishing dwindled progressively after 1956. Whereas in the years up to 1956 the main fishing area extended into the Barents Sea, to as far north as Spitzbergen, since 1956 it has become restricted to the south-eastern part of the Norwegian Sea (Figure 10 of Marty and Federov; in press). At the same time the density of the exploited concentrations within the feeding area has also decreased to such a level that the Russian fishery on the feeding concentrations ceased after 1960. The decrease in recruitment to the feeding concentrations is also shown by Russian age composition data from this fishery.

(3) In the Russian autumn-winter fishery on the prespawning concentrations in the open sea, catch data and the results of extensive echosounder surveys, accompanied by underwater photography have also shown a decrease between 1958-1962 in the wintering area and in the size of the adult stock (Marty and Federov, l.c.).

(4) Estimates of the absolute abundance of the adult stock of Norwegian spring spawners made from the total catch data (see Table 2) and returns over the years 1953-1959 from tagging experiments in Icelandic waters (Dragesund and Jackobsson, in press) show a large decrease in stock size after 1956. Russian estimates of stock size from echosurveys and underwater photography over the pre-spawning, winter concentrations in 1958, 1961 and 1962 also show a further decline between 1958 and 1962. These two sets of estimates are given in Table 3.

Table 3

Estimates of absolute abundance of adult stock of Norwegian spring spawners. 1953-1962.

Year	Estimates of average stock size in 000's tons	
	From tagging data	From echosurveys and underwater photography
1953	12,462	-
1954	12,183	-
1955	13,857	-
1956	11,997	-
1957	9,393	-
1958	6,603	6,011
1959	5,022	-
1960	-	-
1961	-	2,464
1962	-	1,300

Thus, it is evident from the tagging estimates that between 1955-56 and 1959 the adult stock size decreased by more than half, and the echosurvey estimates indicate that it declined even further between 1958-1962.

In addition to these considerations of changes in stock size and composition, the Working Group also examined the available information on changes in the mortality rates for the adult stock. Estimates of total mortality rate obtained from age composition (Østvedt, l.c.) and the tag return data (Dragesund and Jackobsson, l.c.) and of fishing mortality rate from the catch and stock size estimates (see Tables 2 and 3) are given in Table 4.

Table 4

Estimates of Total and Fishing Mortality rate

Year	Total Mortality Rate		Fishing Mortality Rate(F) (Catch/stock size)
	From tagging data (F + X)	From Age Comp. data (F + M)	
1953	0.26		0.06
1954	0.48	-	0.12
1955	0.41	0.28	0.09
1956	0.65	0.30	0.13
1957	0.58	0.44	0.13
1958	0.62	0.49	0.10
1959	0.62	-	0.17
1960	-	-	0.27
1961	-	-	0.21
1962	-	-	(0.38)

Although subject to several possible sources of bias and error, these estimates suggest that in the period 1953-1958 the fishing mortality rate (F) and rate of exploitation (F/F+M) remained approximately constant at about 0.10-0.13, and < 0.5 respectively. However, they point to an increase in the fishing mortality rate since 1958, especially in 1963 (provisional estimate) due to the large estimated increase in the catch of Norwegian spawners in the Icelandic, north coast summer fishery (see Table 1).

Conclusions

The Working Group therefore drew the following conclusions regarding the status of the Norwegian spawning stock:-

(a) In the postwar period up to 1956 the average adult stock size remained high but thereafter decreased progressively to reach in 1960-1962 between 10-25% of its level in the early fifties.

(b) This major decrease was due principally to a succession of poor recruit year-classes. This has resulted in a progressive increase in the average age of the stock, which has been dominated throughout the period of decline by the rich 1950 year-class.

(c) The decrease in stock size has been reflected in a substantial shrinkage in the size of the spawning and feeding areas and of a decrease in the density of the main concentrations in each. Since 1956 the centre of spawning has moved progressively further north, and started later (Devold, l.c.).

(d) During the period of increased fishing and greater yields during the early fifties, and the commencement of the decline after 1956, the fishing mortality rate remained approximately constant at about 0.10-0.13, but in more recent years it has tended to increase.

B. Icelandic Spring Spawners

Like the Norwegian fishery, the summer, feeding fishery off the north of Iceland has also been subject to large fluctuations in yield. This is illustrated by the data in Table 5, which gives the average annual yields from the Icelandic fishery in this area in the periods 1931-1935, 1936-1947; 1948-1958; 1959-1961. (Data from Jackobsson, in press).

Table 5

Average annual yields. Icelandic summer fishery
(in 000's m. tons)

Period	Yield
1931-'35	66.5
1936-'47	136.9
1948-'58	46.6
1959-'61	159.6

These data show that following a period of low yields throughout the late '40's and '50's, the north coast fishery recovered after 1958; in 1962 the yield increased further, to a record level.

While this recent increase in yield was due partly to the introduction of more efficient fishing methods and to an increase in fishing effort, the results of echosounder and Asdic surveys show that there was also an increase in the abundance of the available stock on the grounds.

Since the stock on these grounds is known to consist of members of both the Norwegian and Icelandic spring spawning stocks and of Icelandic summer spawners, in order to determine to which of these stocks the recent increase in stock size is attributable, the Working Group examined the results of scale type analyses for this area (Fridriksson; in press) and estimates of stock size from tagging data. Fridriksson's scale analyses show that, during the period of high yields during the 1940's, Norwegian spawners were the dominant component of the stock, but that during the period of fishery decline during the late '40's and '50's, they were replaced by Icelandic spring spawners as the dominant group, which, in the recent period of recovery of the fishery (since 1958), constituted over 60% of the stock, and would seem to be mainly responsible for the recovery. This is also indicated by estimates of the abundances of Norwegian and Icelandic spring spawners in the north coast stock, made from Icelandic tagging data. These are given in Table 6.

Table 6

Estimates of abundance of Norwegian and Icelandic spring spawners on north coast feeding grounds in summer (in 000's m. tons). 1953-60.

Year	Norwegian spring spawners	Icelandic spring spawners	Total
1953	1.96	0.38	2.24
1954	1.47	0.94	2.41
1955	1.16	0.74	1.90
1956	2.09	1.25	3.34
1957	1.01	1.43	2.44
1958	1.01	(1.70)	2.71
1959	1.38	3.24	4.62
1960	1.62	2.07	3.69

These estimates indicate that while the abundance of Norwegian spring spawners has shown no major trend during this period (although it has increased since 1958), the Icelandic spring spawners have increased since 1958 to about three times the earlier level.

The Working Group noted that a productive Icelandic spring fishery on the spawning grounds also started since 1959.

It also noted that the return of tags per unit weight caught in the south-west coast spawning fishery is greater than of Icelandic spring spawners in the north coast summer fishery. This suggests that the spawning stock is smaller than the feeding stock of these fish, pointing to additional spawning areas for the older members of this stock.

Conclusions

With regard to the present status of the Icelandic spring spawning stock, the Working Group drew the following conclusions:-

(1) In recent years, the stock of Icelandic spring spawners has increased in size, and has contributed to the increased yields in the north coast fishery. At the same time the stock of Norwegian spawners in the north coast area, although relatively smaller than the Icelandic stock has also increased, due presumably to its concentration and higher availability on the fishing grounds.

(2) The stock of Icelandic spring spawners on the north coast feeding grounds appears to be larger than on the SW coast spawning grounds. This suggests that part of the stock, especially the older age-groups, spawns in other areas.

C. Icelandic Summer Spawners

The Working Group examined the available data on the proportions of Icelandic summer spawners, as judged by scale types, in the north coast fishery. According to Icelandic data, they appear irregularly in the fishery, mostly as spents in the extreme western and eastern fringes of the fishing grounds, and only rarely penetrating in large concentrations on to the main central, north coast grounds. Therefore, it is difficult to obtain accurate estimates from the catch data of the relative size of this stock and its changes from year to year. However, Fridriksson's estimates (Fridriksson; in press) point to a gradual increase in the proportion of this stock on the N. coast grounds throughout the '50's, constituting over 10% of the total stock in the period 1958-60. On the other hand Russian investigations (Lyamin 1956) claim that the relative size of the summer spawning stock is larger than that indicated by these Icelandic observations, due to the particular distribution and timing of the Icelandic north coast fishery. Their observations indicate that in 1960 and 1961, summer spawners made up 50-60% of the stock on the western part of the north coast, 20-30% in the central part and 25-30% in the eastern part. However, like the Icelandic ones, the Russian observations point to an increase in the size of this spawning stock, in recent years. Both sets of observations also show that, as in the Icelandic spring spawning stock, the 1950 and 1956 year-class were strong ones, and contributed to the build up of the stock.

The Working Group agreed that more information, especially of the overwintering areas of this stock, and of the range of distribution of the feeding concentrations in relation to the area fished is required before a proper assessment can be made of its size relative to that of the spring spawning groups.

III Causes of recent changes and fluctuations in abundance of stock units

On this item the Working Group confined its attention to the causes of the recent decline in the Norwegian spring spawning group. It agreed that from Norwegian and Russian evidence collected over a number of years, (see Section II A), it is clear that the main cause of the decrease, since 1956, in the size of this stock was due to a succession of 7-8 years of poor recruitment (i.e. since the rich 1950 year-class first recruited the stock in 1954). This had led to a gradual ageing of the stock, which in 1960-62 had an average age of 10-12, a shrinkage of the feeding and spawning areas and a shortening of the spawning (and winter fishing) season. At the

same time, no major change has been detected in the range of age-groups in the catches. Further, the total and fishing mortality rates of the fully recruited age-groups remained approximately the same during the early years of the decline, (up to 1959), but thereafter tended to increase.

The Group also noted that on previous occasions in the history of the Norwegian fishery, similar dramatic declines in the size of the Norwegian stock had taken place (Devold; in press), which were also associated with successions of poor recruit years.

The possible causes of the recruitment decline were discussed, with special reference to the possible effect of the growth of the Norwegian "Small" and "Fat" herring fisheries in the fjords of northern Norway.

Norwegian data on the catches from these fisheries since 1900 (Dragesund; in press) show that between 1950 and 1959, the average annual yield of these fisheries increased, but no clear relation could be found between the increase in catch and the decrease in recruitment to the adult stock. Also, the return of tags from tagging experiments conducted on the small herring (O Group) in a number of fjords in 1960-61, ranged between 2% and 21%. Since it is known that the exploited fjord concentrations only constitute a part of the total stock of pre-recruits and the natural mortality rate at these stages is probably high, these estimates suggest that the proportion of the total stock removed by this fishery is too small to account for the recruitment failure during the past 7-8 years. However, the Working Group noted that tag shedding and mortality of tagged O Group herring may be high, so that these estimates of the proportion of the exploited O Group stock taken by the fishery are probably substantial underestimates. It also recognised that the relative sizes of the exploited and unexploited parts of the adolescent stock are unknown. It therefore concluded that while the recent fishery and stock decline could definitely be attributed to a sustained failure in recruitment, it was not possible from current evidence to determine the part played by the fishery for "Small" and "Fat" herring as a governing factor in it. However, the Russian representatives expressed the view that this fishery probably has influenced the level of recruitment in recent years.

The possible influence of other factors on recruitment was also considered, with special reference to:-

- (a) the relation between recruitment and the size of the adult spawning stock
- (b) the possible effect of changes in the timing and location of spawning
- (c) the effect of adverse environmental conditions on the dispersal and survival of the spawning products.

Of these, the Working Group considered that (a) could probably be discounted as a major contributory factor, since most of the poor year-classes had been produced in years (1951-1956) when the adult spawning stock size was high, while the rich 1959 year-class, which had not yet recruited the spawning stock had been derived from a much smaller stock size. It was agreed, however, that the influence of changes in spawning stock size could not be assessed properly until the form of the spawning stock size-egg production-recruitment relationship, is known. The Working Group emphasised the need for more detailed studies of this relationship, including

- (a) the possible effect on the survival of spawning products (including eggs) of the shrinkage, northward shift and retardation of spawning in recent years
- (b) the differential survival of larvae from recruit and adult spawners, in relation to variations in the food supplies and other environmental factors subsequent to the spawning season.

The importance of the apparent, recent increase in fishing mortality rate of the exploited adult stock was also noted by the Group and especially stressed by the Russian representatives. Although it was generally agreed that the decrease in total stock size and the recruitment failure could not be directly attributed to this factor, the increase in fishing power of the fishing fleets (especially the Icelandic purse seiners) and the extension during the 1950's of the fishery on the Norwegian stock into the open sea, provided a large, additional exploitation potential, which could lead to further serious depletion of the reduced adult stock.

IV Recommendations for future research

In the course of the discussions, the Working Group paid special attention to important gaps in our knowledge of the biology, inter-relationships and dynamics of the exploited stocks of the Atlanto-Scandian tribe, which prevented firm conclusions being drawn regarding aspects of especially the present status of the component stocks and fisheries and the causes of the recent decline in the Norwegian spawning stock. Items of special relevance were:-

(a) the relations between the spring and summer spawning stocks and the means for identifying the members of each

(b) aspects of the distribution and biology of the adolescent and adult members of these groups

(c) the pre and postwar changes in total fishing effort on the different spawning stocks, and especially on the Norwegian spawning stock, the effects of fishing on it, and the magnitudes of its fishing and natural mortality rates

(d) the relative sizes of the exploited, inshore and unexploited, offshore stocks of pre-recruits of the Norwegian stock, and their rates of fishing and natural mortality

(e) the relation between spawning stock size, egg production and recruitment and the factors governing egg and larval survival.

The Working Group stressed especially the need for further studies of the inter-relationships between the Norwegian and Icelandic spring spawning stocks, and of the validity of the "scale type" method, currently used for identifying members of each of them. This is of importance not only to allow a more complete picture to be drawn of the distributions and life cycles of each group, but also because, with the growth of the open sea fisheries on mixed stocks, the reliability of estimates of the total fishing effort exerted on each stock is governed by the accuracy with which the total catches in these fisheries can be split into the component spawning groups. This is evident from Table 2, which shows that, in recent years the open sea fisheries have contributed a major share of the total catch of Norwegian spawners. The Working Group agreed that the biggest difficulty with this method is in distinguishing the Norwegian "S" type from the Icelandic spring spawners (see "Report on Meeting on Scale and Otolith typing and Other Methods in Atlanto-Scandian herring"). It therefore recommends that scale and otolith reading experts of countries with fisheries in this region (Iceland, USSR and Norway) should collaborate closely in the study of these criteria and should meet and exchange material at regular intervals to compare their criteria and methods of analysis, and if possible standardise them. Other possible characters for distinguishing the members of these groups should also be sought. In relation to this problem it also recommends that

(i) further comprehensive tagging experiments should be carried out on the Norwegian and Icelandic and Faroese spawning grounds, and over the summer, feeding and over-wintering grounds in the open sea, to determine the zones of mixing of the members of the different spawning groups during the feeding and prespawning seasons and their subsequent passages to the spawning grounds,

(ii) countries with fisheries based on the open sea feeding concentrations should prepare data on catch and fishing effort, age and maturity composition and "spawning type" in small area and time subdivisions.

The need for a better understanding of the origins of and relations between the "N" and "S" type Norwegian spawners was also stressed. The Working Group accordingly recommends that an examination of the scale and otolith characters of adolescent herring in the Norwegian coastal and open sea areas should be made with a view to determining the range of distribution of the two types, their areas of origin and the subsequent movements of each.

The importance of detailed information on the abundance, distribution, condition and survival of larvae in relation to the recent decline in recruitment to the Norwegian spawning stock was noted by the Group. It therefore recommends that

(i) the data collected by Norway and USSR in the course of extensive larval surveys along the west coast of Norway and in the open sea in past years should be combined and compared to provide a comprehensive picture of the main centres of production and dispersal,

(ii) close collaboration should be maintained between Norwegian and Soviet workers in the planning of future larval sampling programmes and in the analysis of the results so as to ensure as complete a coverage as possible of the area of larval distribution, both in space and time,

(iii) detailed studies of condition (wt/length relationship), growth and survival of larvae in different parts of the area should be made.

It also stresses the need for extensive larval surveys in

- (i) the Icelandic area following both the spring and summer spawning seasons
- (ii) the Faroese area in spring
- (iii) in the northern North Sea and to the west of the British Isles in spring.

The Working Group noted that the projected ICES "Fjord Station", should it be established, might provide important facilities for studying aspects of larval condition and survival, of importance in understanding the factors governing the fluctuations in recruitment in the Norwegian stock.

In the time at its disposal, the Working Group was unable to examine all the available data on relations between the changes in catch and fishing effort in the adult fisheries, and those for the adolescent stock. It therefore strongly recommends that a more detailed appraisal of these data should be made at a further meeting of the Group, at a convenient date in 1964. Participating countries are accordingly urged to prepare their available data on catch, effort, and age composition for both the adult and adolescent fisheries, broken down by small area subdivisions, for as many years as possible.

At the completion of the meeting the thanks of all participants were extended to their Norwegian hosts for the excellent meeting accomodation and facilities, and their kind and generous hospitality. Mr. Jakobsson also expressed the hope that, should another meeting of the Group take place that it would be possible to hold it in Iceland.

References

Much of the material examined by the Working Group was taken from papers which had already been published or were in pres (especially contributions to the 1961 Herring Symposium). The following is a list of those which were specially consulted:-

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Appendix I

Norwegian spring spawners

This group is the biggest spawning group in the Atlanto-Scandian tribe. Its high abundance is determined by the fact that the spawning stock consists of many age-groups, that they spawn many times during their life cycle and that they have an extensive feeding area.

The information available points to the existence of three main routes which adult herring take when they migrate to the feeding grounds. The first (the most easterly one) lies along the edge of the Scandinavian shelf north-eastward and northward; the second is along the western branch of the Norwegian Current northward; and the third (the most westerly one) takes the herring to the southern edge of the East Icelandic Current. From here some herring move northward to the Jan-Mayen area whereas others migrate north-westward and are distributed north and north-east of Iceland.

There seem to be three main nursery areas for the adolescent (small and fat) herring, viz: the Norwegian fjords, the Barents Sea and the southern and north-eastern areas of the Norwegian Sea. However it is difficult to estimate the proportions of young fish in each of these areas due to the lack of sufficient data. The young, immature herring leave the Norwegian fjords and move to the open sea at 2 to 3 years of age, and those distributed in the open sea, (where they were brought as larvae) occupy a very large area by 3-7 years of age, extending from the central area of the Norwegian Sea to the Polar front area.

With the onset of sexual maturity (which is a lengthy process) these young herring concentrate in more southern areas nearer to the spawning grounds, and after first spawning begin to perform regular feeding and spawning migrations. Both feeding and spawning migrations become longer with age for the herring derived from all of the nursery areas mentioned above (i.e. Norwegian fjords, Barents Sea and Norwegian Sea). The older herring occupy the extremities of the spawning and feeding grounds. There is a decrease in the distribution area with a decline in the stock abundance and vice versa.

Appendix II

Icelandic spring spawners

These herring are typical spring spawners with a spawning season during March and the first third of April, and an intensive feeding season during the summer and a resting season in the autumn and winter months. The spawning areas extend along the whole of the south coast of Iceland and since 1961 a commercial fishery has been based on spawning herring on the western part of the spawning grounds. Samples from this fishery show that the average age of the population in this part of the spawning area is at present between 6-7 years with an average length 32-34 cm. At present the 1956 year-class dominates in the samples.

Recent tagging experiments have confirmed the results of earlier scale analyses of a clockwise feeding migration of those younger herring during summer from the western part of the south coast along the west coast to the north coast. Icelandic scale analyses further show that the older year-classes which probably spawn off the eastern part of the south coast also migrate towards the north east and north coast in an anticlockwise direction and this older part of the population is found mixed with the Norwegian spring spawners throughout the summer. However, these large herring only constitute a minor part of the herring fished off the southwest coast in winter and in spite of the fact that they have a typical Icelandic scale pattern and year-class ratios it is not clear whether their spawning area is limited to the eastern part of the Icelandic south coast waters.

Thus, while the life history of the younger Icelandic spring spawners is reasonably clear more information is needed on the distribution and movements of the older part of the population.

Appendix III

Icelandic Summer Spawners

Icelandic summer spawners spawn from July to September along the south coast of Iceland from Reykjanes in the west to Stoksnes in the east. In some years spawning begins earlier, in the second half of June and in other years it ends later. Sometimes, some specimens with running sexual products occur as late as the middle of October.

These herring have two feeding periods, before and after spawning. The herring move to their feeding areas along the western and eastern coasts of Iceland and most of them feed north of Iceland. Some of them that feed in the Norwegian Sea migrate to their feeding areas along the western edge of the East-Icelandic Current. Their distribution is limited by latitude 71° in the North and by the 0° meridian in the East. Before spawning summer spawners constitute 10 til 30% of the catch north of Iceland, but their numbers increase considerably in samples taken in the same area after spawning - in August.

The area north of Iceland is the feeding area of summer spawners older than 7-8 years, whereas younger herring seem to feed to the south and west of Iceland; sometimes they move to the north of Iceland in small quantities and for a short time. In September, after feeding in northern areas older herring move southward again along both the eastern and western coasts. At the western coast of Iceland, concentrations of summer spawners feed as late as the end of December. Then they move westward or southwestward probably to their wintering grounds. In the area of the East Icelandic Current in winter summer spawners constitute on the average up to 10% of the samples. In June their numbers in the samples taken from the same area increase up to 15-20%.

Appendix IV

Northern North Sea and Scottish NW coast spring spawners

Spawning of large spring spawning herring of the Atlanto-Scandian type is known to take place along the northern and eastern edges of the North Sea shelf and to the north west of the British Isles. These herring are fished as full, spawning and spent fish mixed with members of the North Sea autumn spawning stock by continental and Russian fleets along the eastern and northern edges of the North Sea (Norwegian Deep to north and west of the Shetlands) in the period January-May. Other concentrations, which sometimes enter coastal spawning areas off the Scottish north west coast are also fished by Scottish drifters and ring net vessels in February-April.

The biological characters of these herring are similar to the main body of Norwegian spawners. Mean vertebral counts, mean length/age and scale types show close similarities, with both the northern and southern Norwegian scale and otolith types being represented in samples of spawners.

Little is known of the precise location of the spawning grounds or of the dispersal of the spawning products and the location of the main nursery areas, but the available larval data suggest that spawning varies in intensity and position from year to year.

It seems clear that, after spawning the main body of these herring move out into the open ocean, as with the other members of the Atlanto-Scandian tribe, but whether they join or remain distinct from the main body of Norwegian, Faroes or Icelandic spring spawners during the oceanic feeding phase is not clear. However, some recovering spents of this group are found, mixed with maturing North Sea autumn spawners to the east and west of Shetland during the summer.

More detailed information on the biological characters and affinities of these herring are given in papers by Le Gall (1935) and Baxter (1958).

References to Appendix IV

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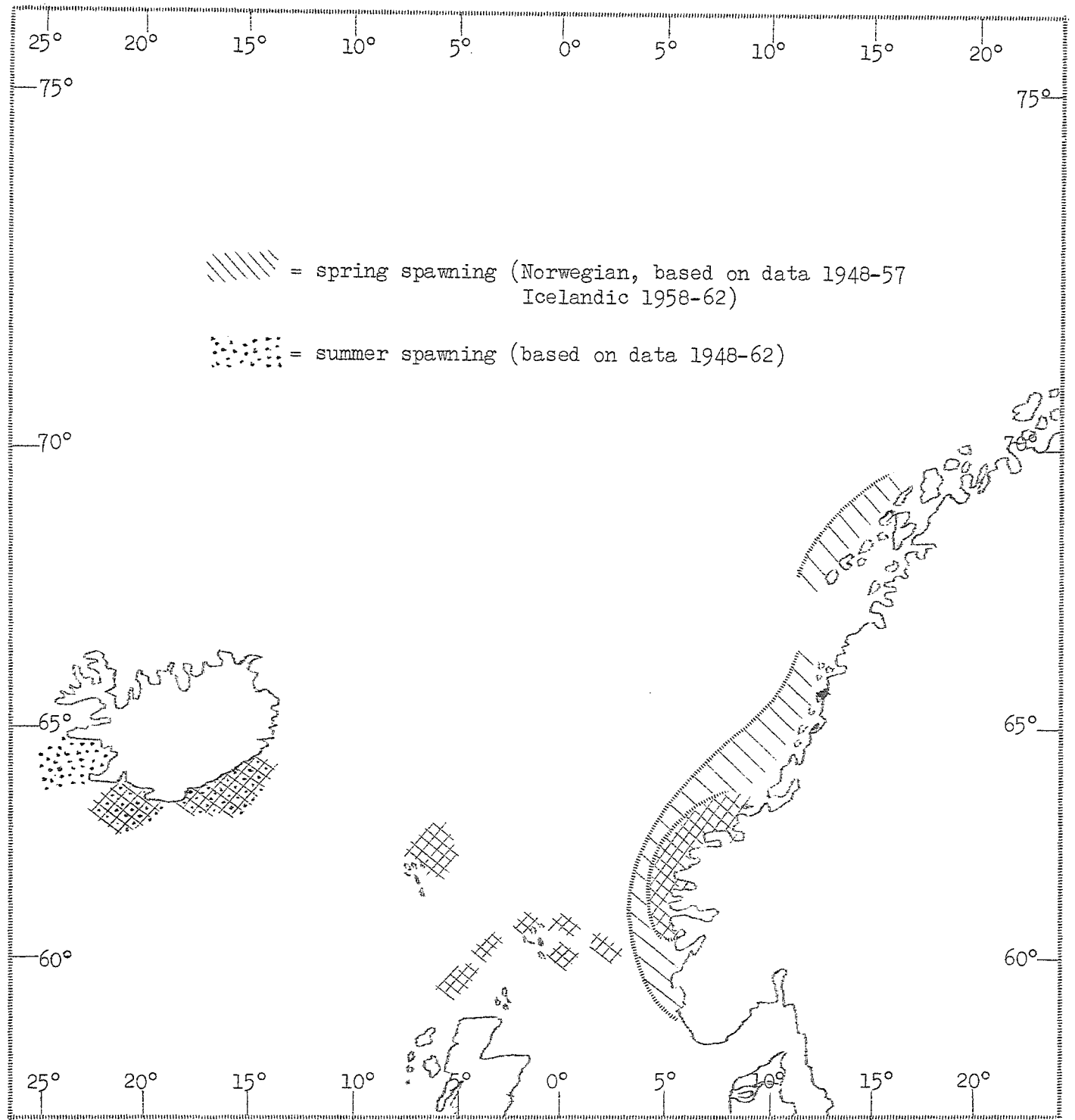


Figure 1 Distribution of Main Spawning Areas
for Atlanto-Scandian Tribe