

Soviet Investigations on the Atlanto-Scandian Herring
in the Norwegian Sea in 1970

by

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Summary

Studies of the stock of grown up herring showed, that the main regularities of their distribution and migrations are still valid, inspite of their small abundance. Herring pertaining to older age groups come to spawn first. During the feeding migrations also herring of older age groups penetrate further to the north.

The main bulk of the herring spawning stock spawned on the Norwegian Shallows. In the areas of the Faroes and the Lofotens the spawning was very poor.

Studies of the age structure of the herring stock showed that the diminishing of the stock due to natural and fishery mortality is greater than the recruitment to the stock.

During 1970 herring formed fishing concentrations only in the Norwegian home waters in January-February.

The ichthyoplankton survey in the areas of the Norwegian Shelf, the Faroe and the Lofotens showed, that herring spawning was extremely inefficient.

The conditions for egg development and survival of larvae were unfavourable.

The 1970 year class of herring can be considered the poorest in the whole history of studies of herring.

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Two research and two scouting vessels took part in the investigations in 1970.

At the beginning of January, only few concentrations of herring, migrating to the east, were found in the area from 2° to 7°W and from 62°30' to 64°00'N. Herring were registered occasionally in the drift-net catches, among these herring of the 1959-1961 year classes were predominant (Figure 1). The number of recruits did not exceed 2%.

At the beginning of February the areas of herring migrations, from the Faroe Islands to the Norwegian Shallows, were investigated once more. Very poor concentrations were found along 1°E from 64° to 65°30'N.

In February, as well as in January the herring migrated in an easterly direction, the range of temperature being 3-7°.

On February 15-16 the first herring with running sex products appear in the areas of Frøya Bank.

On February 23-24 an accumulation of herring, performing a spawning migration, took place in the zone of great gradients in the area of Grip-Frøya, and this was the result of the contiguity of warm waters of the Norwegian Current with a wide strip of cold coastal waters (temperature drop being 7.5-5.7° per mile). Echo-sounding surveys, conducted on board R/V "Akademik Knipovich", showed that 50 small (5-7 m high) and 6 great (25-30 m high) herring shoals distributed in an area of 40 square miles.

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On February 26-28 the south-western winds caused the penetration of warm waters on the shallows, the temperature decreased to 0.5° and this fact conditioned dispersal of herring over the shallows.

In the second half of February very poor herring concentrations were registered on the north-western extremity of the Halten Bank.

On the Norwegian Shallows herring spawning took place from the second decade of February up to the first decade of April inclusive, i.e. nearly two weeks longer than in 1969. The main spawning grounds of herring were situated in the areas of Bogrunnen Bank at a depth of more than 200 m, on the Frøya Bank and in the north-western part of the Halten Bank at depths below 200 m.

In January-March 1970 herring 30-33 cm long at the age of 9-11 years and pertaining to the 1959-1961 year classes constituted the main part of the catches taken by research and scouting vessels (82.7%).

The main feature of herring spawning migrations is the appearance on the Norwegian Shallows first of herring pertaining to the older age groups, and then of younger herring. This was also noted in 1970, when the spawning stock was in a state of depression. In February the average age of producers on the shallows was 10.22 years, in March it was 9.24 years and in April 8.18 years (Figure 1).

Pre-spawning herring were registered in small numbers on the shelf to the east of the Faroes in mid-February. Among these the specimens pertaining to the 1959-1961 year classes were predominant (87.1%). The first individuals with running sex products were caught on February 26.

Very small and dispersed herring concentrations were observed on Røste and Traena Banks in April. They pertained mainly to the 1964 year class (Figure 1), recruits being predominant among them.

In May only a few concentrations of post-spawning herring were observed in the south-western area (Figure 1, Area 9). They mainly consisted of individuals 5-9 years old.

From May 30 to June 22 complex oceanographic investigations in co-operation with scientists from Iceland were carried out in the Norwegian Sea. No herring concentrations were registered all over the area of the Norwegian Sea: Herring specimens were singly met within catches of blue whiting in the area of $64^{\circ}40' - 64^{\circ}50'N$ and $9-10^{\circ}W$.

In October the herring distributed along the western border of the Barents Sea from $76^{\circ}10' - 70^{\circ}00'N$ (Figure 1). Herring 28-37 cm long and 7+ - 11+ years old distributed in the northern part of the shelf (Figure 1, Areas 1b, 2b) (according to Smitt). Herring 25-37 cm long at the age of 4+ to 11+ years distributed in the southern part of the shelf (Figure 1, Areas 3c, 6 and 10).

A change in the size composition of herring from north to south was characteristic in the eastern part of the sea. Thus, in Area 1b the average length of herring was 35.19 cm, in Area 2b it was 32.98 cm, in Area 6 - 31.92 cm, and in Area 10 - 31.82 cm. This fact supports the statement concerning the whole of the Norwegian herring stock, which implies, that larger herring perform more prolonged migrations to the north.

In the northern areas (1b, 2b) no recruits were registered, whereas in the southern areas the immature herring and the recruits made up 4.3%.

Concerning the western Norwegian Sea, in November and December herring occurred only in the southern part of the Central Basin (Figure 1, Area 7). Herring 31-35 cm long at the age of 6+ to 11+ constituted samples. In the areas, where herring are usually wintering (Figure 1, Areas 22a, 22b), practically no concentrations were found.

Investigations in 1970 showed that all the year round no herring fishing concentrations were observed in the Norwegian Sea, with the exception of the Norwegian home waters, where about 20 300 tons of winter herring were caught by Norwegian fishermen in January-February (Fiskets Gang, No. 52, 1970).

In 1970 no echometrical survey of concentrations of wintering herring was conducted. Calculations show that generally the herring stock made up less than 80 000 tons by the beginning of 1971, fishing yield, changes of size-age composition, and absence of recruitment being taken into consideration.

In the catches taken in 1970 by the research and scouting vessels the portion of herring pertaining to 1959-1961 year classes made up 73.4%, older herring 1.9%. Recruitment to the herring stock of the 1963-1967 year classes, which are poor in abundance, is so insignificant, that practically no decrease in the average age of the herring stock takes place, though natural mortality of herring of older age groups is increasing: the average age of herring was 9.12 years in 1969; in 1970 it was 9.24 years.

An ichthyoplankton survey along the Norwegian coast between 62°20' and 65°00' was carried out three times: on March 20-30, on April 2-7, and 9-16. In addition to the 89 standard stations, 7 daily hydrographical and 6 ichthyoplankton stations were worked. During the survey 68 herring larvae were caught (Table 1). As seen from Table 1, the quantity of larvae in 1970 was the smallest one, as compared with 1965-1969 year classes, which were very poor in abundance. Therefore, we have good reasons to speak of a still lower efficiency of herring spawning in 1970.

What are in our opinion the reasons which have caused the appearance of a poor year class?

Temperature conditions on the spawning grounds usually change comparatively little (Seliverstov, Penin, 1969), but in 1970 the temperature in the bottom layers were lower than in 1966, when it was cold in this area. In 1970 the whole area of Bogrunnen Bank, where in 1965-1969 the greatest part of the herring spawned, was occupied with fresh water from the surface to the bottom, its salinity being 34.36 - 34.73‰. In April fresh waters occupied the south-western part of Halten Bank. On Bogrunnen Bank the temperature of the bottom layers were 0.7° lower than in 1969, and 0.4° lower than in 1966.

Apparently, due to the considerably wide penetration of cold fresh waters into the area of Bogrunnen Bank, the herring spawned to the northwest of this area at depths above 200 m, where they found Atlantic waters with a salinity of 35.2‰ and a temperature of 6.9 - 7.2°.

At the end of March a water temperature of 6° was registered in the bottom layer on Frøya Bank. This is 1.1° lower than in February. In the samples taken from the bottom up to 45% of herring eggs were observed to have perished at the beginning of the stage of eye pigmentation. As shown by the experiments of incubation of herring eggs, carried out on board the R/V "Akademik Knipovich", a decrease in temperature causes not only an increase in the time of incubation, but also in the mortality of eggs to 15-20% at the beginning of the stage of eye pigmentation. A considerable quantity of egg producers could be eaten by predators.

In 1970 spawning of saithe took place over that part of the shelf, situated from 62°40' to 63°40'N, i.e., directly in the area of the most intensive spawning of herring. Besides, considerable concentrations of haddock were registered in this area. In the food spectrum of saithe, herring accounted for 22.7%; in the food spectrum of haddock, herring eggs made up 51.5%.

Age determination of larvae, of the dates of beginning and termination of their hatching, calculations of velocities of the current and larvae drift were carried out in accordance with the methods used in 1966-1969 (Seliverstov, Penin, 1969; Seliverstov, 1970).

In 1970 the spawning grounds in Subarea IV was the most southern on the Norwegian Shallows (Figure 2). On March 22, larvae 1-8 days old were caught in this Subarea; they had hatched from the eggs on March 14-21. During the repeated survey on April 2-3 larvae also 1-8 days old were found in the samples, which had hatched on March 26 - April 3. The absence of larvae older than 8 days in the samples taken in Subarea IV gives reason to believe, that the time of drift to the northern border of this Subarea does not exceed 8 days.

In accordance with the data of the daily hydrographical stations, the remaining current situated on the eastern spawning ground of Subarea IV, had an easterly direction on the level of 50 m and at the bottom. The larvae drifted from this spawning ground into the Norwegian home waters (Figure 2). In the area of the

western spawning ground, situated at a depth of more than 200 m, the current had a north-north-easterly direction and carried the larvae into Subarea V to the western slope of Frøya Bank, where the current at the depth of 50 m had the same direction (the velocity being 0.24 knot).

On March 22-24, larvae 1-13 days old were found in Subarea V, their length being 8-11 mm; on April 2-7, larvae 8-28 days old were registered, their length being 9-14 mm. The greatest number of these larvae were brought here with the current from the western spawning ground, situated in Subarea IV. In March-April 1970 the calculated velocity of the drift of the water masses through the Subarea was 13 days. The average calculated time of the drift of the water masses through Subareas IV and V jointly made up 21 days. The average age of the larvae in the samples taken on April 2-7, and also at the daily station, worked on April 3-4, is 19 and 15 days i.e., it is within the limits of the calculated time of the drift of the water masses. However, 35% of larvae caught in the surface layer were at an age, exceeding the average calculated time. In the period preceding the survey, north-eastern and north-western winds had decreased the current velocity in the surface layer on Frøya Bank to 0.14 knot. At this velocity the time of passive larvae drift in Subarea V is 20 days. 8 days of larvae drift in the water column in Subarea IV and 20 days' drifting in the surface layer make up altogether 28 days. No larvae older than 28 days were found in Subarea V.

Studies of the velocity and the direction of larvae drift made it possible to determine the rate of natural mortality of that part of the larvae, which drifted outside the Norwegian home waters.

In the calculations, the number of larvae, which had hatched from the eggs on the western spawning ground of Subarea IV and on Frøya Bank in the period of March 13-23 and were caught on March 22-24, was taken for 100%. By April 6 the abundance of this group of larvae decreased to 96.3%.

If we assume, that the average duration of larvae drift in Subareas IV and V is 21 days, then the appearance of larvae of the control group in Subareas V and IV should be expected by April 9-16. The scheme of passive drift constructed on the basis of instrumental observations, shows that the stations covered the whole area, where larvae are likely to disperse. However, no larvae, which had hatched from the eggs on March 13-23, were observed there. So, we may then suppose that the mortality of larvae was close to 100%.

In the moment of transition of larvae from endogenous to ectogenous feeding, the available concentration of food organisms must not be less than 22 000 specimens per m^3 (Nikitinskaya, 1958), and to secure an average intensity of feeding, it is necessary, that not less than 800-1 000 specimens per m^3 should be registered (Lisivnenko, 1960).

In March-April 1970 in the zone, where the concentration of small zooplankton organisms was only 200 specimens per m^3 , up to 80% of larvae were registered, and only 10.3% of them were feeding. In the zone rich in food (more than 10 000 specimens per m^3) only several larvae were caught. Consequently, it may be supposed that the lack of zooplankton food was one of the reasons of the high mortality of the larvae.

The Shelf of the Faroe and the Lofotens

In the area of the Faroes only 1 larva was found. In the area of the Lofotens no herring larvae were registered.

References

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Table 1. Dates of collection of herring larvae on the Norwegian Shelf, their quantity and size composition.

Length of larvae (mm)	IV Bogrunnen 21-22 March	IV Bogrunnen 2-3 April	V Frøya 23 March	V Frøya 3-6 April	VI Halten 14-16 April	Total 21 March-16 April
6	3	1	-	-	-	4
7	3	4	-	-	-	7
8	6	9	2	-	-	17
9	2	13	3	2	-	20
10	-	-	6	1	-	7
11	-	-	2	1	-	3
12	-	-	-	4	2	6
13	-	-	-	2	-	2
14	-	-	-	2	-	2
Total	14	27	13	12	2	68

Number of larvae per sample (specimens)

Year	No. of samples	Number of samples with larvae	Total number of larvae	Average number of larvae in a sample
1965	384	89	9 019	33/101
1966	370	113	3 481	9/31
1967	607	178	1 408	2/8
1968	788	99	1 291	2/13
1969	877	109	1 374	2/12
1970	560	25	68	0.1/3

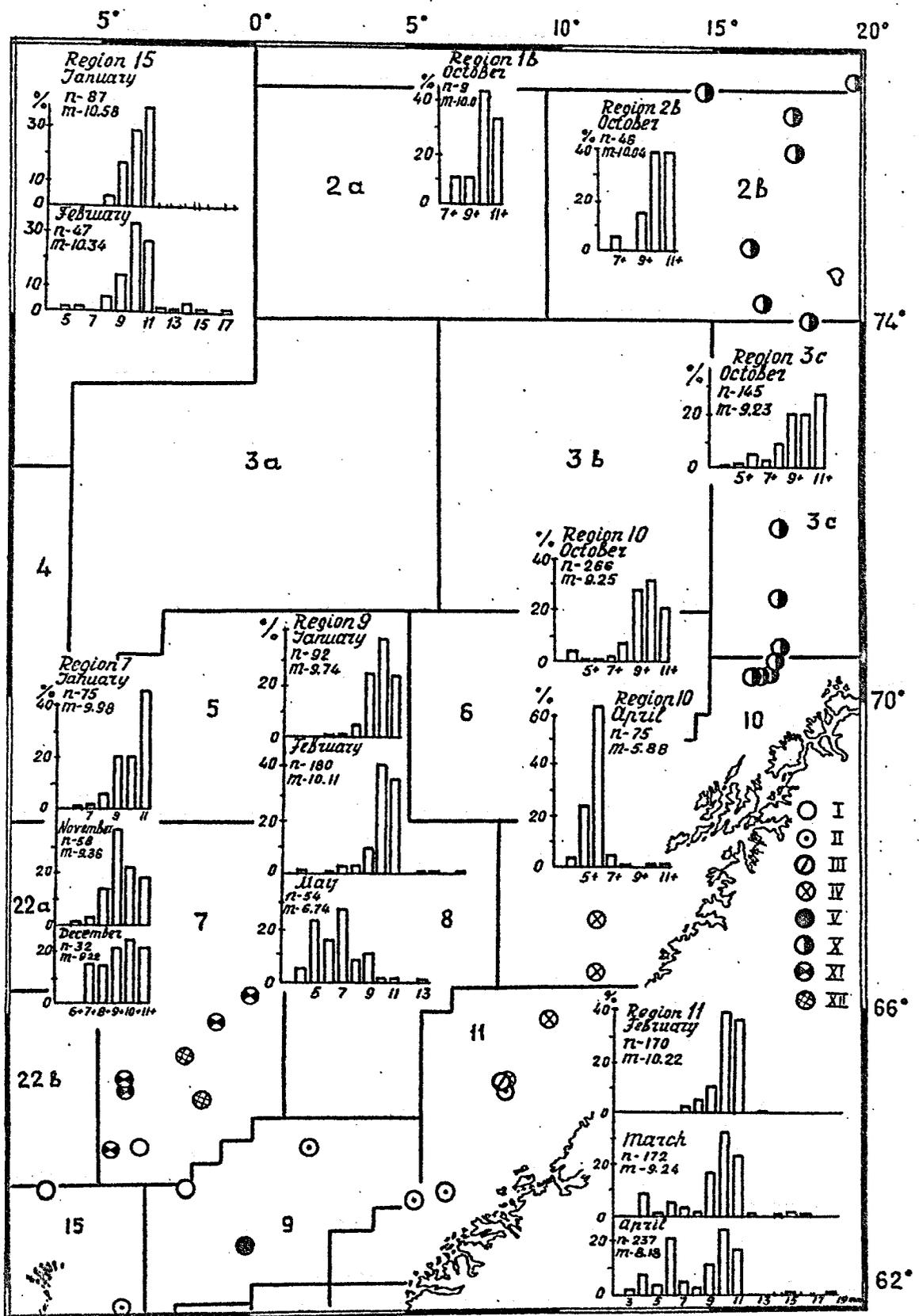


Figure 1. Distribution and age composition of herring in the Norwegian Sea in 1970 (Conventional symbols: I, II, X denote the corresponding months).

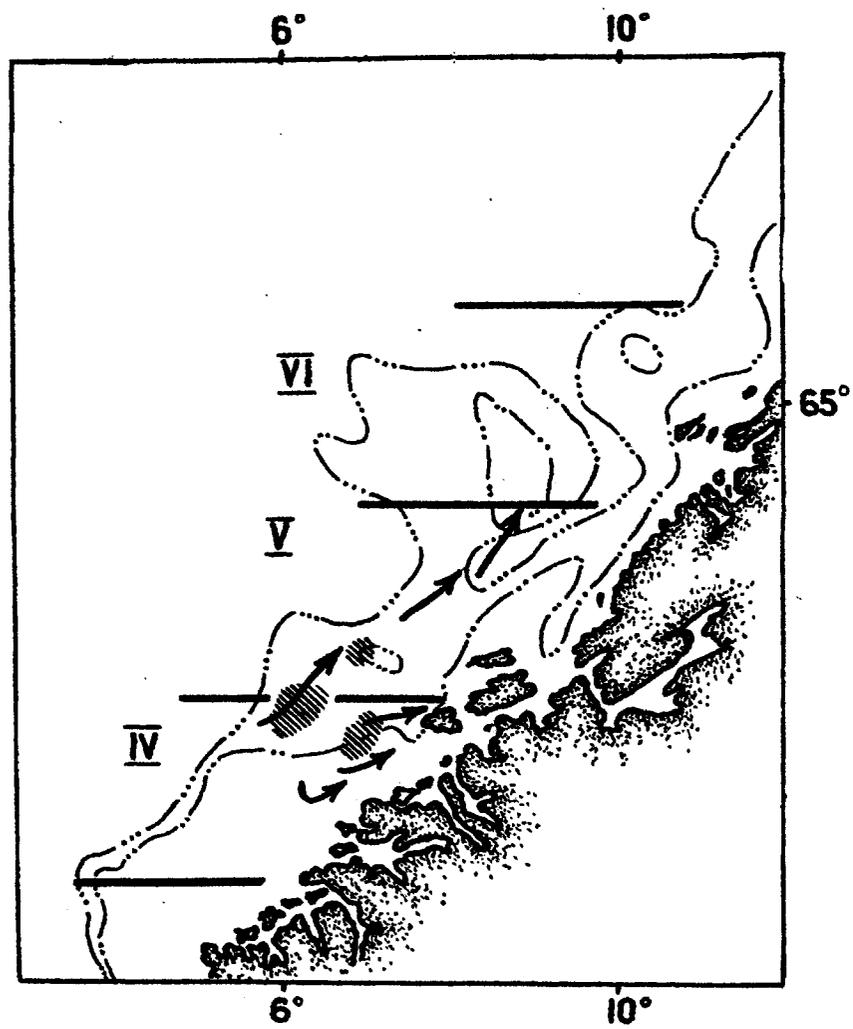


Figure 2. Location of spawning grounds and main directions of herring larvae drift in March-April 1970.