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On the Stock Size of the Atlanto-Scandian Herring

by

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The first attempt of the quantitative assessment of the adult portion of the Atlanto-Scandian herring stock was made by Norwegian workers in 1957 on the basis of the tagging scheme conducted in the previous years (O. Dragesund, 1958). A well known formula was taken as a basis for the assessment, by which the catch is related to the stock and the number of returns is related to that of individuals tagged. For the years 1955-57 the calculations showed that the stock comprised 33-37 million tons of herring.

In 1961, as a result of new tagging experiments and additional calculations, Norwegian and Icelandic investigators (O. Dragesund and J. Jakobsson, 1961) came to the conclusion that the stock of the Atlanto-Scandian adult herring in the years 1955-57 ranged within 10-13 mill. tons, and by 1959 it decreased to 5 mill. tons. The Norwegian scientists' data indicate that in the following years the stock continued decreasing, roughly by 25-30% annually. Thus, the stock of the adult Atlanto-Scandian herring approximated 3.5-3.7 mill. tons, 2.6-2.8 mill. and about 2 mill. tons in 1960, 1961 and 1962, respectively.

In the Soviet Union investigations on the stock size of the Atlanto-Scandian herring and on the causes affecting changes therein have become more intensive in the recent 5 or 6 years. The Soviet workers made attempts to assess the stock size of the herring by using the method suggested by Academician A.N. Derzhavin in 1922 (Ju.Ju. Marty and S.S. Fedorov, 1961). The method provides for the assessment of the stock size by the catch in a given year and the occurrence of year-classes in the catches in successive years, the natural mortality being ignored. However, the analysis of the mortality of some generations in years when the fishing intensities were different enabled us to estimate, of course rather roughly, the fishing and the natural mortality, and thus, to put some corrections into the estimate.

Up to 1925 the stock of herring at the ages of 3 and older was calculated as 1.5-2.0 mill. tons. The total mortality for the specimens of similar ages was 5-7%. Knowing that the fishing mortality in those years was 4-6 times lower than the natural mortality due to a lesser fishing intensity, the stock size should be increased by the same number of times. In this case the stock was assessed as 10 mill. tons.

In 1955-56 the stock size was estimated by A. Derzhavin's method and amounted to 7-8 mill. tons, the natural mortality in that period being about 1/4-1/5 of the fishing mortality. Thus, the total fishing stock of herring approximated also 10-11 mill. tons. In 1959 and 1960 the stock was, as the calculations of Soviet workers show, 4.0-4.5 and 3.0-3.5 mill. tons, respectively.

In December 1959 the Polar Research Institute of Marine Fisheries and Oceanography for the first time carried out a hydro-acoustical survey of the winter concentrations of herring. The survey showed that the stock amounted to 6.04 mill. tons. In December 1961 and further in 1962 with application of more improved techniques the All-Union Research Institute of Marine Fisheries and Oceanography (VNIRO), Polar Research Institute (PINRO), and Atlantic Research Institute (AtlantNIRO) made a joint hydro-acoustic survey to evaluate the herring stocks in the area of the East-Icelandic current with application of underwater photography for the assessment of winter concentrations of herring. The aims, methods and course of the survey carried out on board BMRT "Murmansk" on December 10-20, 1962 are shown below.

The primary objective being to evaluate the total herring stock distributed in winter in the area of the East-Icelandic current, provisions were also made to estimate separately the stocks of adult and young herring of 1959 and 1960 year-classes known as being very rich. During the cruise two echo-sounding surveys were carried out to investigate the area of winter herring and two hydro-acoustic surveys were made to detect herring concentrations. Series of underwater photographs of aggregations were made by means of underwater photo-automatic devices.

The investigations carried out during several years support the evidence that the East-Icelandic current area which was studied by the expedition seems to be the only place, where the adult herring from the Atlanto-Scandian stock spent the winter. As to the young maturing and immature herring this statement cannot be true since some other places where younger age-groups of herring occur in winter (S. Fedorov, 1959, 1960, 1962) are known. Thus we may conclude that the survey covered only some part of the young herring which spent the winter together with the adult specimens. The investigations covered the whole area where the herring spent the winter within the East-Icelandic current due to the fact that seven research vessels took part in the survey.

At the same time, and in order to get a better control of the complete covering of the winter places, some photographs were made from the radar screen to show the location of the fishing boats in operation. In the hydro-acoustic and echo-sounding surveys all up-to-date fish-detecting techniques and navigation equipments available on board BMRT "Murmansk" were used. The assessment of the density of concentrations was made by different methods enabling us to obtain more accurate data on the abundance of herring by comparing the results.

The relative density of concentrations was estimated by measuring signal ranges in the horizontal direction by means of a fishing asdic "Lodar" and electronic oscilloscope at a standard 1000 m distance in db, and in the vertical direction by means of the echo-sounders "Elak", "Senior" and oscilloscope.

The absolute density was determined in different locations of some aggregations in the following ways:-

1. Analytical calculations based on experimental data previously obtained while calibrating the echo-sounder upon targets-equivalents. This enabled us to establish a relation between the echo-range and density expressed in number of fish per unit of volume.
2. An underwater automatic photographic apparatus was lowered to different levels of fish concentrations where the echo-ranges were measured by the echo-sounder.
3. The receiving-transmitting acoustic system of the oscillator from the small echo-sounder "Atlas-658" was put down directly into the fish concentrations. Due to the fact that a smaller number of fish occurred in the zone of the operation, the accuracy of detection of individuals increased. The oscillator installed directly among the fish concentrations echoed some specimens on the recorder of the echo-sounder.

The data on the absolute density of fish concentrations obtained by the underwater photography and transmitting system of the oscilloscope installed among the herring concentrations, were used to determine the number of herring in a certain volume of water, and they showed that 68 specimens were contained in 100 m³ on an average.

Samples for biological analyses were taken from the catches of a 30 m mid-water trawl with a small-mesh chafing gear.

The observations indicate that in mid-December the heaviest aggregations of the adult herring together with a considerable number of young herring (1959 and 1960 year-classes) gathered over a small area within the south-western edge of the cold wedge of the East-Icelandic current. The young herring were quite active and distributed over a larger area, but they did not move outside a certain region where the older herring spent the winter. The physiological studies helped to determine that out of all the young herring distributed over the East-Icelandic current only 20-25% would spawn in 1963.

Test trawl catches at different levels revealed that the range of diurnal vertical migrations of young maturing herring of the 1959 year-class became more extensive than in the previous year and differed slightly from that of the adult herring. The difference was observed only to the extent of their predominance in certain concentrations with the depths of trawling. The immatures were mainly distributed in higher layers than the maturing specimens, or, especially, matures.

The results obtained in the hydro-acoustical and echo-sounding surveys, by underwater photography, biological analyses and by other methods enabled us to estimate the stock of the Atlanto-Scandian herring in the Norwegian Sea in December 1962 and to compare it with similar data obtained in previous years (Table 1). The data suggest only the size of the main stock of the aggregations which were distributed in the East-Icelandic current in winter by the end of 1962.

In view of the above-mentioned the young generations were, mainly, immature and since they are known to occur in winter in some other areas the strength of the 1959 and 1960 year-classes is supposed to be greater than the estimate obtained in the surveys. The surveys also supported the main parameters of the total stock of the adult herring assessed by different methods by Norwegian, Icelandic and Soviet investigators as well as the results of a similar research carried out in 1961 (Ju.Ju. Marty and I.G. Judanov, 1962; M.D. Truskanov and M.N. Shcherbino, 1962).

Consequently, proceeding from the above-mentioned methods of quantitative assessment of the Atlanto-Scandian stock of herring, the conclusion should be made that since 1957 the stock has been fastly and considerably reduced. Substantial changes in the stock size were confirmed by numerous observations and fishing experiments mentioned in papers of workers from different countries.

It is also worthwhile dwelling briefly on the probable factors causing the sharp decline in the herring stock.

Table 1 The stock of the Atlanto-Scandian herring in the Norwegian Sea based on the data obtained in the hydro-acoustic and echo-sounding surveys and on biological analyses in December of the years 1958, 1961, 1962, respectively.

Nos.	Indices	1958	1961	1962
		31.12	12-13.12	18-19.12
1.	Mean catch per net in kg	102	54	76
2.	Number of wasted cruises in %	5.0	10.5	1.7
3.	Extension of echo-records per unit of route in %	85	53	50
4.	Mean concentration depth in m	70	85	105
5.	Total area of fish concentrations in m ²	260	142	267.2
6.	Total volume of fish concentrations (m ³)	18.5	15.5	21.3
7.	The number of herring per 100 m ³	95	45	68
8.	The number of young herring in catches in %	2.2	6.6	75.5
9.	Total stock of herring in mill. numbers:	17575	6975	14485
10.	Including adult herring	17185	6515	3549
11.	Including young herring	390	460	1036
12.	Including the 1959 year-class	-	-	10140
13.	Mean weight of specimen in g	344	359	196.5
14.	Total stock of herring in 1000 tons:	6046	2504	2847
15.	Including adult herring	6011	2464	1300
16.	Including young herring	35	40	1547
17.	Including 1959 year-class	-	-	1495

The decline in the Atlanto-Scandian stock can be explained by a joint effect of natural factors and fishing efforts. It should be noted that the fishing intensity tries to be equal to the upper possible level of the stock, and when a decline in the fishing stock is caused by natural factors the effect of fishing increases approximately by as many times as the stock decreases.

The periodicity of occurrence of rich year-classes is known to range widely, sometimes they are observed in the adjacent years (1943-44) or at much greater intervals (1904-18). In the recent period rich year-classes appeared in 1923, 1930, 1937, 1943, 1944, 1950 and 1959. Rich generations are observed to have begun occurring more often since the 30's with the heating of the Arctic. It also coincides with some intensification of warm currents and increase in the thermal regimes in the Norwegian, Greenland and Barents Seas (S. Fedorov, 1962). It was expected that the 1953, 1954 and 1957 year-classes would be abundant, but up-to-date their occurrence in catches is almost negligible (Table 2).

As a result of poor recruitment the stock has become reduced. Changes in the Atlanto-Scandian stock have taken place in the period of intensified efforts in the large herring fishery. So the total catch of large herring during the recent decade has doubled as compared with the two previous decades. From 1931 to 1940 the catch of large herring was about 4 mill. tons, from 1941 to 1950 it was reported to be 4.5 mill. tons, while in 1951-60 the catches of only Norway and the USSR amounted to 9.4 mill. tons of large herring.

Along with the development of the large herring fishery which was of great importance to the increase in the herring catches of Norway and the Soviet Union, a fishery for small herring at the ages of 1-2 took place in the Norwegian waters (O. Dragesund, 1961). Of course, the latter had already been known for a long time, but the present scope is quite incomparable with that of those days, and besides, it is worth mentioning that the intensity in the large herring fishery was also far less than nowadays (O. Østvedt, 1961).

Consequently, with the intensification in efforts in the adult herring fishery, the catches of young herring also increased, amounting to 1.7 mill. tons in the recent decade against 0.2 mill. tons taken in 1900-10, i.e., the recent catches are about eight times greater as compared to the first decade of the century.

Table 2 Age composition of the herring from the Atlanto-Scandian Stock.
Data obtained during the Soviet investigations, 1950-62
(in %).

Age	Years of investigations													
	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	
2- 2+	1.5	0.1	3.8	0.7	0.2	0.1	-	-	-	-	-	1.4	2.5	
3- 3+	5.5	0.1	1.9	10.0	1.0	0.5	0.5	0.2	0.1	0.4	-	0.6	46.9	
4- 4+	2.0	4.2	2.7	4.0	21.9	6.7	5.5	2.3	0.5	1.4	1.1	1.3	2.2	
5- 5+	1.5	3.2	8.1	5.9	8.6	31.9	11.8	2.8	3.6	1.8	2.7	4.8	1.7	
6- 6+	10.3	4.1	5.3	12.0	5.9	9.5	35.4	14.7	5.8	6.8	3.9	4.8	2.7	
7- 7+	18.9	13.7	6.1	5.6	8.4	5.1	6.7	38.2	13.2	10.3	9.2	4.2	3.2	
8- 8+	5.2	16.7	15.5	7.6	5.3	7.0	7.7	4.7	39.2	16.9	10.3	8.3	3.8	
9- 9+	4.1	6.6	12.2	14.9	5.4	5.1	6.9	6.5	8.6	34.1	20.9	11.7	7.3	
10- 10+	7.7	7.9	8.2	11.1	13.6	7.9	5.7	8.9	7.4	9.1	31.5	18.0	7.3	
11- 11+	15.2	9.5	8.9	6.7	9.7	8.5	5.3	3.4	6.7	5.3	7.7	30.0	8.4	
12- 12+	12.9	14.3	8.4	6.2	4.7	5.3	5.4	5.6	4.2	4.7	4.4	4.7	9.7	
13- 13+	7.9	10.2	9.9	6.1	4.7	3.7	3.9	5.3	2.8	3.0	3.3	3.4	2.3	
14- 14+	3.3	6.5	7.1	4.3	4.5	2.8	1.1	3.9	3.3	2.2	1.9	3.2	0.8	
15- 15+	3.0	2.4	1.2	3.2	3.1	2.6	1.8	1.6	2.2	1.4	1.3	1.6	0.7	
16- 16+	0.7	0.5	0.5	1.2	2.0	1.8	1.3	1.2	1.2	1.3	1.0	1.1	0.3	
17- 17+	0.2	0.2	0.1	0.4	0.6	0.7	0.8	0.5	0.6	0.7	0.5	0.7	0.1	
18- 18+	0.1	0.1	0.1	0.1	0.3	0.3	0.2	0.2	0.3	0.4	0.2	0.2	0.1	
19- 19+	-	-	-	-	0.1	-	-	-	0.2	0.2	0.1	-	-	
20- 20+	-	-	-	-	-	-	-	-	0.1	-	-	-	-	
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	

It is quite obvious that the year-classes of 1951-58 were much poorer than those of 1943, 1944 and 1950.

The ratio between the strengths of the poor and rich year-classes is roughly equal to 1/8 - 1/14, while the ratio between the catches of the same generations at the age of 1-1+ is only 1/2 - 1/3. This supports the evidence that, at present, the fishing stock could be well recruited on the account of generations born after 1950, were they not subject to intensive fishing at early ages.

In the past when the scope of the Atlanto-Scandian herring fishery was rather limited the catch of some dozens thousand tons of young herring would have no noticeable effect on the adult herring fishery. At the time being with a sharp increase in the fishing activity for the adult herring, heavy catches of young herring also seem to deplete the stock of adult fish.

Proceeding from the above the conclusion can be made that certain changes found in the stock size of the Atlanto-Scandian herring should be attributed not only to natural causes, but also to the increased fishing activity both in the adult and young herring fisheries.

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