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Methods and Results of Echometric Surveys on the Assessment of the Grand Newfoundland Bank Capelin Abundance in Spring-Summer 1978

by

V. A. Ermolchev, S. M. Kovalev and A. S. Seliverstov
Polar Research Insitute of Marine Fisheries and Oceanography (PINRO)
Murmansk, USSR

Abstract

This paper contains the data on distribution, size-age composition and biological state of pre-spawning capelin concentrations. Data on capelin abundance and biomass in Division 3L are given. The data were obtained by hydroacoustic method during the cruise of RV "Poisk".

Introduction

Abundance and biomass of the Newfoundland capelin have been assessed by instrumental methods since 1975 (Serebrov L.I., Bakanev V.S., Kovalev S.M. 1975; Seliverstov A.S., Kovalev S.M. 1976; Kovalev S.M., Seliverstov A.S., Zaferman M.L. 1977). The researches on distribution and abundance of capelin during their migration to the spawning grounds were done by hydroacoustic vessel "Poisk" in May-June 1978. The spring-summer period of 1978 turned out to be unfavourable for the researches as far as their organization and conducting were concerned. Due to anomalous hydrological conditions capelin did not practically approach the traditional spawning ground (Division 3N). The data obtained characterize the abundance and biomass of pre-spawning capelin concentrations distributing in Division 3L in the above-mentioned period.

Material and methods

Echometric surveys were conducted by means of EK-120 echo sounder(Norway,SIMRAD) and hydroacoustic mean density measurer of fish concentrations ISP-1 connected to it(USSR, PINRO).Five-channel echo-integrating and echo-counting systems measuring a set of echo-signals parameters in each channel were used in ISP-1.This set includes the number of echo-signals from single fish,groups of fish,total echo-intensity from all fish and the number of echo-signals emitted by the echo sounder(Ermolchev V.A.,1977).Single fish and groups are taken in acoustic sense:one or several fish respectively are found in the scattering element of space limited by a half-long emitted signal and directional diagram of acoustic antenna.Measured echo-signals parameters are automatically registered on the echo sounder record as the number of deflections of the echo-counting and echo-integrating systems per each nautical mile.Each mile the echo-counting and echo-integrating systems of ISP-1 are reset by the log contacts in the initial position,and EK-120 records time.Capelin concentrations in the survey areas were observed above the depths no more than 200 m and were mainly recorded in the 10-150 m layer.Therefore,the range of EK-120 was 250 m,the channels in ISP-1 operated in the following ranges:first - 10-25 m, second - 25-50 m,third - 50-100 m,fourth - 100-150 m,fifth-150-200 m.The set of echo-signals parameters measured by ISP-1 permitted to conduct by acoustic method directly on capelin concentrations a calibration of echo-counting and echo-integrating systems in absolute units:number of fish per square mile per one deflection of ISP-1.The calibration was made as follows: the mean number of echo-signals from one fish $\bar{k}$ and the square of the area of EK-120 operation were culculated on scattered concentrations by the number of echo-signals from single fish $K_{sf.}$ and groups of fish $K_{gf.}$ at the outputs of ISP-1 echo-counting system and by the number of echo-recordings from fish N_f on the echogram.

The following equations were used(TVG - 40 log r):

$$K_{sf.} + K_{gf.} = \bar{K} N_f + d_c; \quad D_I = \frac{4 \cdot 1852 \cdot V \cdot \bar{K}}{\pi \cdot 60 \cdot Q};$$

$$D_2 = D_I \frac{\operatorname{tg} \Theta_2}{\operatorname{tg} \Theta_I}; \quad \Theta_{eI} = \operatorname{arctg} \frac{D_I}{2 r_{sh}}; \quad \Theta_{e2} = \operatorname{arctg} \frac{D_2}{2 r_{sh}};$$

$$S_e = \pi r_{sh}^2 \operatorname{tg} \Theta_{eI} \operatorname{tg} \Theta_{e2}, \qquad (1)$$

D_1, D_2 - diameters of section of the area of echo sounder operation in longitudinal and cross planes of the vessel respectively at the depth r_{sh}, in m;

S_e - section of the area of echo sounder operation at the depth r_{sh}, in m^2;

Θ_1, Θ_2 - certificate angles of directional diagram of acoustic antenna in longitudinal and cross planes of the vessel, in degrees;

Θ_{e1}, Θ_{e2} - actual angles of directional diagram of acoustic antenna for the given fish species, in degrees;

V - speed of the vessel, in knots;

Q - frequency of the repeated signals emitted by the echo sounder, in pulses/min.;

d_K - constant coefficient.

The values $\bar{K}, S_e, \Theta_{eI}, \Theta_{e2}$ are the more precise, the smaller the fish concentration($K_{gf.} \to 0$), the more accurate the measurements of vessel's speed, the higher the frequency, the less the rolling of the vessel, the thiner the layer under study (5-10 m).

Capelin abundance ρ_{sc} per square mile was estimated on scattered and mixed concentrations by the readings of echo-counting system according to the expression (TVG - 20 log r):

$$\rho_{sc} = \frac{K_{sf.} + K_{gf.} \langle X \rangle}{S_e \cdot Q \cdot T} \cdot 1852^2 \qquad (2)$$

where

T - time of measurements in minutes,

<X>- mean number of fish in groups.

The value <X> was estimated by ratio: the number of echo-signals from fish groups $K_{gf.}$ to the number of echo-signals from single fish $K_{sf.}$ (Fig.1). <X> and ρ_{sc} are the more precise, the smaller the fish concentration and the more homogeneous the shoal, when the distribution of fish in the scattering element of space may be regarded as Poisson's distribution. Simultaneously, the echo-intensity I_{ISP} of the echo-integrating system in ISP-1 was measured. A statistic relationship for the capelin of mean length $\bar{L}$ = 13.7 cm and mean mass $\bar{P}$ = 14 g was revealed:

$$\rho_{sc} = C_{ISP} I_{ISP} + d_{ISP} = 30.86 \cdot 10^5 I_{ISP} + 2 \cdot 10^5; \; R = 0.94 \qquad (3)$$

where

C_{ISP} - coefficient of absolute calibration of ISP-1 echo-integrating system in number of fish per square mile per one deflection I_{ISP} per a mile,

d_{ISP} - constant coefficient,

R - correlation coefficient.

Coefficients C_{ISP} for other lengths were culculated from the expression (Nakken O., Dommasnes A, 1975):

$$C = C_n L^{-1,84} \qquad (4)$$

where

C_n - coefficient of conversion estimated for the known C and L values from the expression (4).

In the course of surveys capelin were mainly recorded as local shoals or as scattering layer with the concentration exceeding the resolving power of EK-120; dispersed and mixed capelin shoals were rarely recorded. Therefore, the echo-counting system of ISP-1 was used for absolute calibration of echo-integrating system, which readings were later used for the assess-

ment of fish abundance in the areas surveyed.

Discussions and conclusions

In May capelin distributed along the north-eastern slope of the Grand Newfoundland Bank (Division 3L). In the first ten days of May capelin concentrations were recorded by echo sounders as rare separate shoals, this conditioned unstable fishery situation.

In midMay pre-spawning capelin concentrated in the limited area from 46°50' to 47°20'N and between 50°30' and 51°00'W. In this area the capelin was observed till midJune.

Scientific-scouting works undertaken in June in Division 3O showed that the young capelin and sand eel distributed over a considerable expanse of the area. Mature capelin in this area were taken only as by-catch.

In the first ten days of May the mean length of males in the catches was 15.3 cm, of females - 14.3 cm. In the second and third ten days of May the fish of somewhat longer size was observed in catches. So, in the second ten days of May the mean length of males constituted 16.8 cm, of females - 15.8 cm; in the third ten days of May the mean length of males was 17.2 cm, of females - 15.8 cm. The specimens with gonads of the maturity stages 3-4 constituted the bulk of the catches. In late May the feeding intensity has grown: if in the first ten days of May the index of stomach fullness of 79% specimens was equal to 0 and only single fishes fed intensively, then in the second and third ten days of May up to 30% of specimens had indexes of stomach fullness equal to 1 and 2, 5-10% of fish fed intensively. In June the length composition of fish also fluctuated.

In the first ten days of June the mean length of males in the catches was 16.1 cm, of females - 14.8 cm. The specimens of maturity stages 3-4 and 4 constituted the bulk of the catches; the fish fed intensively.

After June 20 the young capelin appeared on the vast expanse of Division 3NO. Their concentrations were recorded in water strata and in the near-bottom layer in the day-time, and closer to the water surface at night. Smaller fish with a length frequency of 6 to 10 cm (average length - 8 cm) were observed in the north of Division 3NO. In the south of Division 3O the length frequency of capelin was from 7 to 12 cm.

Inspite of the anomalous capelin distribution in spring-summer and also taking into account the peculiarities of their migration in May-June 1978, we still succeeded in the researches on determination of the dynamics of changes in abundance and biomass of capelin on their routes of migration to the spawning grounds.

The first echometric survey was done on May 8-9 in the area limited by 47°30' and 48°30'N and between 51°00' and 51°30'W, the second survey was performed on May 26-27 in the area from 46°50' to 47°20'N and between 50°00' and 50°40'W, the third one was done in the area from 46°55' to 47°10'N and between 50°30' and 51°00'W.

Figures 2-4 show the charts of the surveys conducted. The charts present the total echo-intensities per each nautical mile I_{ISP}. The results of processing the data obtained are summarized in Table 1.

Table 1. Results of data processing for capelin echometric surveys in May-June 1978.

Date of survey	Mean length $\bar{L}$ (cm)	Mean mass $\bar{P}$ (g)	$C_{ISP} \times 10^6$ spec/mile^2/ deflection I_{ISP}	Area S (mi^2)	Abundance $N \times 10^9$ spec	Biomass $W \times 10^6$ centners
1	2	3	4	5	6	7
8-9 May 78	13.7	14	3.086	550	9.177	1.28
26-27 May 78	15.87	28	2.255	272	9.576	2.67
8-9 Jun 78	15.43	23	2.388	587	13.433	3.07

The joint investigations undertaken by the Soviet hydroacoustic vessel "Poisk" and Canadian RV "Gadus Atlantica" aimed

at scouting od capelin spawning concentrations on the south-eastern and south-western slopes of the Grand Newfoundland Bank and on the spawning grounds were not successful. The terms and areas of spawning and migration routes of mature capelin in spring-summer 1978 remained indistinct. Such features of capelin distribution and their behaviour we consider to be associated with the peculiarities of temperature conditions of this year. Water temperature in the main branch of the Labrador Current turned out to be 1.5° higher than that of last year and 1° higher than the long-term mean. The main branch of the Labrador Current along the eastern slope of the Grand Newfoundland Bank was weak. The coastal branch turned out to be much stronger. In this context, in May and in the first half of June the commercial capelin concentrations distributed evidently closer to the coastal more cold branch. Anomalous high heat content of water masses observed on the spawning grounds in June (surface water temperature fluctuated from 10 to 11.6°) permits to suppose a possible capelin spawning in other areas.

As a result, the assessment of the pre-spawning capelin stock in 1978 is incompletely comparable with the stock estimates for previous years (Serebrov, Bakanev, Kovalev, 1975; Seliverstov, Kovalev, 1976; Kovalev, Seliverstov, Zaferman, 1977). Nevertheless with regard for the changes which occurred in capelin distribution in comparison with those of the previous years the results of the echometric survey may be taken as characteristic of stock state on the Grand Newfoundland Bank. In 1978, the investigations indicated a sharp reduction in capelin biomass and abundance (Table 2).

Table 2. Capelin abundance and biomass in 1975-1978.

Years	Abundance (10^6 spec)	Biomass (10^6 tons)
1975	29,829.2	1.05
1976	35,561.8	0.685
1977	38,614.5	1.00
1978	13,433.0	0.31

Some causes of the reduction of capelin abundance and biomass may be named:

1. Specimens of the abundant 1973 year class reached their age limit and their abundance reduced sharply after the spawning in 1977. None of the year classes at the age of 5 was known to prevail in the spawning stock (Kovalev, Seliverstov, Zaferman, 1977).

2. After 1973, no year classes comparable by abundance with the rich 1973 year class appeared.

3. Within the whole life cycle of the 1973 year class (after its entering the commercial stock) STACRES recommended annually one and the same level of total allowable catch (TAC)- 2 000 000 t. This recommendation had a pure practical aim - to check experimentally the level of TAC with the abundant year class in the commercial stock and total biomass of about 1 mill.t. The actual catch at the constant TAC level becomes to be an index of stock state. The total catch in all years was lower than the recommended TAC level, and since 1977 a tendency toward its reduction appeared (Table 3).

Table 3. Actual catch of capelin in Division 3LNOP (000 tons)

Years	1974	1975	1976	1977	1978
Catch	161	167	144	72	27

As said above, the actual catch equal to 167 000 t. in 1975 may be supposed to be extremely high for the stock of 1 mill.t., when there is one abundant year class unit.

On the basis of the stock assessment in 1978, to prevent the further stock abundance reduction and to preserve the possibility of controlling the stock state, the TAC of 20 000 t. may be recommended for 1979. If a new rich year class comparable by abundance with the 1973 year class, recruit the stock, the TAC may be increased to the level not higher than 100 000 t.

References

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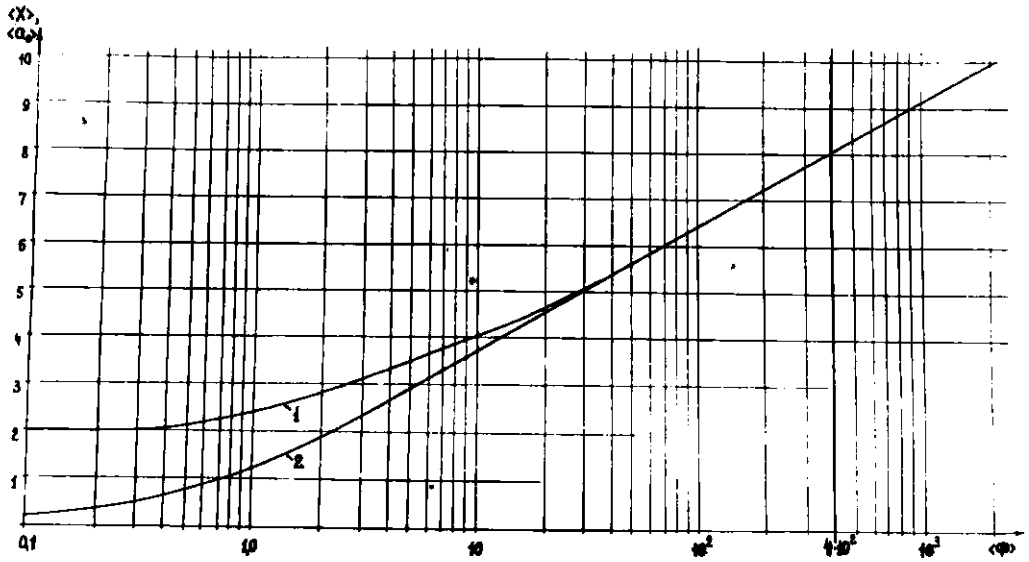

Fig. 1. Dependence of mean number of fish in groups <X> (1) and scattering elements $\langle a_o \rangle$ (2) on the relation $\langle \varphi \rangle$ of the number of echo-signals from groups of fish to the number of echo-signals from single fish with Poisson's distribution of fish in scattering elements.

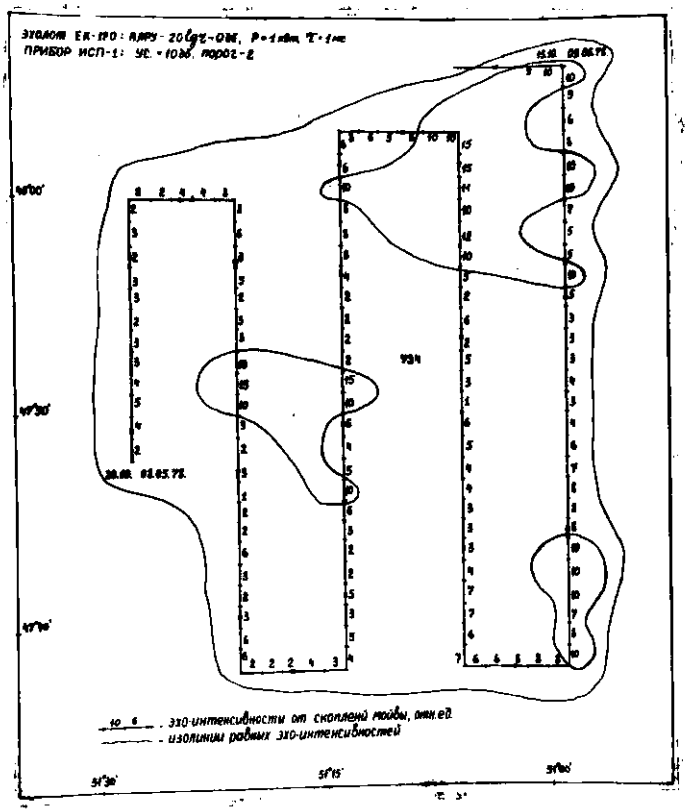

Fig. 2. Chart of the echometric capelin survey on 8-9 May 1978.

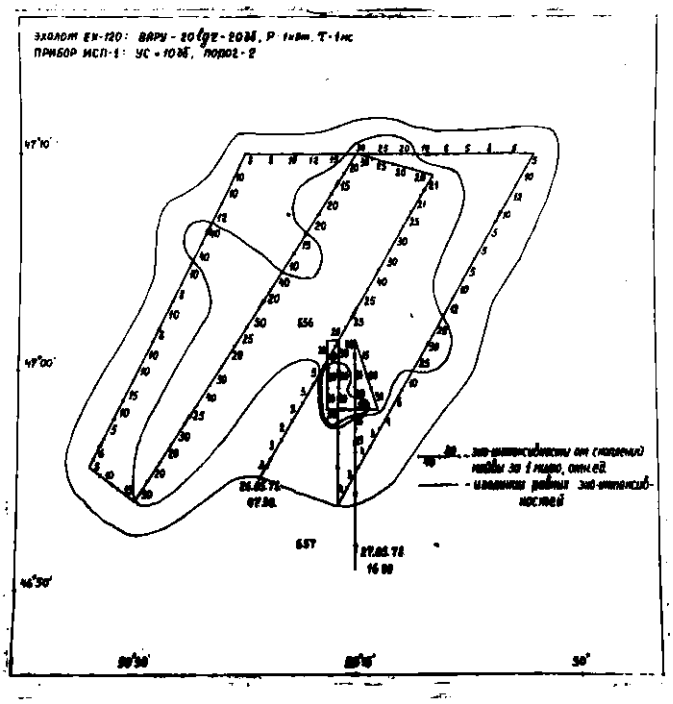

Fig. 3. Chart of the echometric capelin survey on 26-27 May 1978.

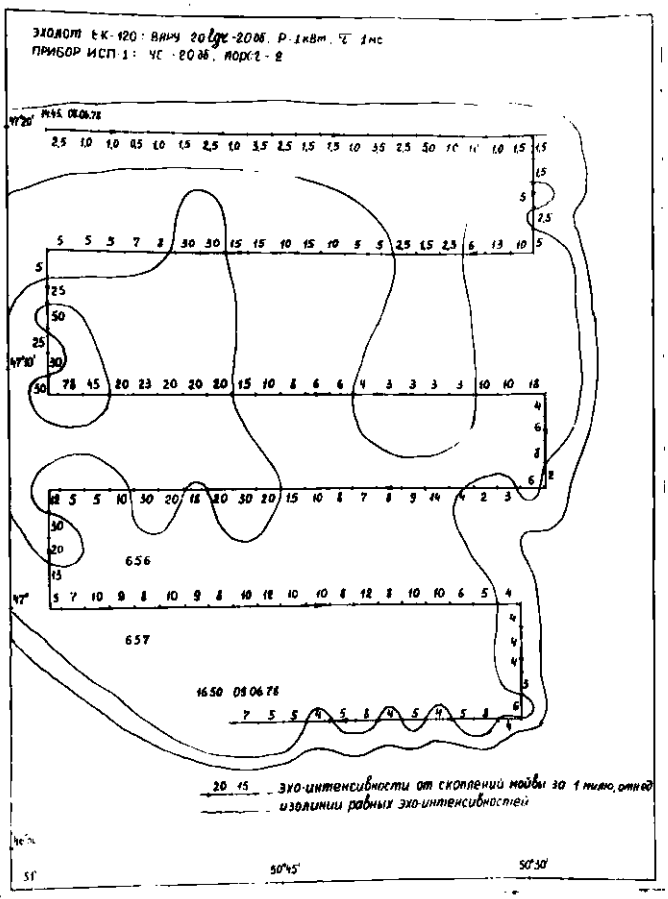

Fig. 4. Chart of the echometric capelin survey on 8-9 June 1978.