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INTEGRATOR SCALE CALIBRATION IN UNITS OF COMMERCIAL SIGNIFICANCE OF CONCENTRATIONS

V M Bondarenko

All-Union Research Institute of Marine Fisheries and Oceanography, 17a V. Krasnoselskaya, Moscow, USSR

INTRODUCTION

Acoustic methods of quantitative estimation of commercial fish have become regular in research of biological resources of the Worlds Oceans. However, the interpretation of the results of echometric surveys in relation to the tasks of operational control of fishing is difficult. This is because charts characterizing a field of fish distribution, in surface density units, give an incomplete idea of the feasible efficiency of fish capture, when fishing over concentrations being surveyed.

METHOD

In order to make such forecasts possible, the density of concentrations under survey should be determined in a layer equal in thickness to the vertical opening of the trawl. The technical characteristics of the fishing system should also be taken into account. It is proposed to use "commercial significance" as a factor incorporating parameters differing in their nature [1]:

$$Q = K_y \cdot W \cdot C \cdot M \qquad (1)$$

where Q = commercial significance of a fish concentration, kg/h,
K_y = catching efficiency coefficient of the main operation complex,
W = operation capacity of the main fishing complex, m^3/h,
C = integrator scale factor in volume density units, $kg/m^3/mm$,
M = integrator reading (mm) for an hour of trawling by the main operation complex for a layer equal in thickness to the vertical opening of the trawl.

The feasible efficiency of the main operation complex in kilograms per hour of trawling in a surveyed area is estimated by the commercial significance factor of a fish concentration. The main operation complex includes vessels of one or several types of approximately the same engine power and similar trawling gear predominately operating in the given fishing area.

In formula (1) catching efficiency K_y and operation capacity, W are the characteristics of the fishing system. The scale factor C and integrator readings M characterize density of fish distribution in a volume which is determined by the rate of trawling and the vertical opening of the trawl of the main operation complex. In other words, the parameters which characterize values of a different nature are in a certain way bound to each other. Despite the implicit character, this interconnection between the parameters can be taken into account with known technical characteristics of the fishing system. The rest of parameters can be verified, even though there are a number of factors which are not easy to assess. Such factors essentially influence the catching efficiency of the system. The analysis of the results of trawling shows that catching efficiency coefficient variation depends on changes in the size and species composition of concentrations and also the biological state, type of distribution and density of fish, time of the day, hydrological and meterological conditions and many other factors including the crew's experience.

The above suggests that it is necessary for scale calibration to be made for firm operational conditions. Thus it seems expedient to determine the parameters binding commercial significance and integrator readings in a generalized form thereby establishing the regularity of Q variation directly from M with the help of the commercial-acoustic constant C_{ca}:

$$Q = C_{ca} \cdot M \tag{2}$$

i.e. to calibrate the integrator scale in commercially significance units kg/h/mm by the results of control trawling.

The procedure of calibration is reduced to carrying out a number of trawlings by vessels belonging to the category of the main operation complex with acoustic control of the fished layer. The values of control catches are standardized and compared with integrator readings taken on corresponding trawling tracks. The results of individual measurements are averaged.

$$C_{ca} = \frac{1}{n} \cdot \sum_{i=1}^{n} C_{cai} = \frac{1}{n} \cdot \sum_{i=1}^{n} \frac{Y_i}{T_i \cdot M_i} \tag{3}$$

where C_{cai} is commercial-acoustic constant from the results of i trawling, kg/h/mm,

n = number of control trawlings,
Y_i = catch of i trawling, kg,
T_i = duration of i trawling, hour,
M_i = integrator reading during i trawling, mm.

Acoustic control of the fished layer can be made directly during any commercial trawling, i.e. calibration can be made in operational conditions of the fishing complex. The duration of trawling is a period of time from the moment of stopping the winch to the beginning of hauling the trawl. The vessel making acoustic control moves ahead of the trawling complex at a minimal distance from it. Both vessels should move at equal speed and in the same direction. Distance between the vessels is fixed with the help of radar and is taken into account in referring integrator readings to the trawling track. If the vessel intended for estimating commercial significance of concentrations is of the same category as the main operation complex, calibration can be made by the results of its own trawling.

It should be noted that it is useful to determine the calibration constant for each vessel equipped with appropriate acoustic devices. Given the calibration constant, the rate of filling the vessel's own trawl can be approximately estimated by integrator readings. When using the commercial-acoustic constant one should ensure that it is fair for the conditions and operational regimes of equipment for which calibration was carried out. Changes in any factor should be taken into account. The authenticity and reliability of the commercial-acoustic constant is checked by the method of making up confidence intervals. As practice shows, the number of control trawlings in a fishing area does not exceed twenty, the accuracy of measuring should be estimated with the help of a corrected standard deviation. The accuracy of the mean normally distributed random sample value (ε) is determined by the following formula [2] where,

$$\varepsilon = t_{\gamma}(k) \cdot \frac{S}{\sqrt{n}} \tag{4}$$

$t_{\gamma}(k)$ = random value determined by Students' distribution depending on the degree of freedom, $k = n - 1$ and reliability $\gamma = 0.95$.

$$S = \sqrt{\frac{\sum_{i=1}^{n} (C_{cai} - C_{ca})^2}{n - 1}}$$ is corrected sample standard, kg/h/mm.

The confidence interval for commercial acoustic constant is

$$I_{0.95} = C_{ca} \pm \varepsilon$$

Data on integrator calibration obtained in an area of fishing for sprat is cited as an example. The results of control trawling by four seiners referred to the category of the main operational complex are given in the following table

Y_i, kg	2,500	1,000	2,000	2,500
T_iM_i, h, mm	2.25	0.83	1.30	1.52
C_{cai}, kg/h/mm	1,110	1,210	1,530	1,640

The acoustic control of the fished area was made from a research vessel equipped with an echo-sounder EK-400(38 kHz) and echo-integrator QD. Sprat concentrations were registered in the bottom layer of about 3 metres in thickness. The operational regime was chosen from conditions ensuring qualitative registration of fish and stable performance of the bottom signal blocking scheme. Further, the chosen regime was left unchanged. Measurements were made in the daytime which is most favourable for fishing. The seiners were equipped with bottom trawls having vertical openings of about 3 m and the rate of trawling was about 3 knots. When estimating the commercial significance of sprat concentrations, integration intervals were equal to 3 miles. For the above conditions the mean value of the commercial-acoustic constant was 1,370 kg/h/mm, accuracy being 400 kg/h/mm (γ = 0.95, n = 4). The fishing vessels sent to the detected sprat concentrations had catches close to the forecast.

CONCLUSION

In the practice of echometric surveys, the method of acoustic calibration of equipment with the help of trawls has been known for a long time but has not been widely used. The latter is accounted for by the fact that when calibrating the scale of an integrator in units of surface density by the results of trawling it is required to measure the catching efficiency coefficient of the fishing complex, which involves great difficulties. The echo-integrator scale calibration in units of commercial significance and the catching efficiency coefficient of the fishing complex is incorporated in the commercial-acoustic constant. This is derived from the composition of the results of control trawling with the corresponding readings of the equipment. With the help of an echo-integrator calibrated in units of commercial significance it is possible to solve the task of forecasting catches of fishing vessels in the area under survey. In addition, control can be exercised of the degree of filling the vessel's own trawl and also make comparative analyses of the catching efficiency of fishing complexes of different types.

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