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JACK MACKEREL SCHOOL DEFENCE REACTION TO A SURVEYING VESSEL

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INTRODUCTION

It is known that in fishing operations or in carrying out research, for instance in estimating abundance, defence reactions of fish to the vessel may considerably effect the accuracy of the results[1,2,3]. Special investigations have shown that due to the fact that fish avoid the vessel carrying out an acoustic survey, estimates of concentration density in different species may be reduced by 40 to 90%[4].

Reaction of fish is in inverse proportion to depth, i.e. the stronger reaction is in shallow water. Reaction can also depend on the season, day or night and water temperature[2,4,5,6,7].

Most of the data on this matter have been obtained for cod and herring. Acoustic investigations rarely take into account the dimensions and physiological state of fish though it is these that are the main factors determining the level of defence reaction in fish[8,9].

This paper discusses results of observations on jack mackerel (Trachurus simmetricus murphyi schools avoiding a vessel in areas where fish differed both in size composition and physiological state.

METHOD AND DEVICES

Work was done on board a vessel type 'Superatlantic' of 5270 ton displacement with an engine of 3880 HP at a speed of 8 knots. Omnidirectional scanning sonar KCS-502 (Kaijo Denki, Japan) was used in conjunction with a Doppler current meter DC-20B (same manufacturer) and a vessel gyrocompass. With the help of this equipment the following parameters were registered: speed and direct distance to the object, depth of location, speed and direction of school movement. At the same time an echo-survey was being carried out with the help of echo-sounder EKS-38 (Simrad, Norway) and echo-integrator SIORS (USSR). Horizontal and vertical dimensions of the schools passing under the bottom of the vessel was determine by echo-sounders KCS-210 (Kaijo Denki, Japan) and EKS-38.

During observations account was taken of all schools located within 90° of the course. Depending on the range, automatically every 20-60 s , the new location of schools were fixed and parameters of their movement were calculated. Observations of the behaviour of jack mackerel schools were made only in day time. Biological characteristics: commercial length, stage of gonad maturity and degree of viscera obesity (by a four-point scale) were determined from trawl catches. Fishing was made in the dark when schools broke up and fish came up to the very surface of water.

Jack mackerel defence reactions were observed in three adjacent areas. Weather conditions were unstable with swell up to force 5.

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RESULTS

In surveyed areas jack mackerel formed dense schools 20-27 m in length and 10-20 m in height. Besides, there were concentrations up to 2,000 m in length and 4-8 m in height consisting of small schools. Echometric estimate of volume density of fish in different areas was 0.12 sp/m, 0.04 sp/m and 0.05 sp/m respectively.

As the vessel approached, some of the jack mackerel schools ahead of the vessel avoided the vessel, moving aside at an angle of 30°-90°, others did not change their direction of movement. Cases were observed when large concentrations, with the vessel approaching, broke up into two parts and passed the vessel on both sides. All schools and concentrations reacted to the vessels by increasing depth. As a rule the depth of descent did not exceed 80 m and on an average was 62-63 m (Table 1). There were exceptions; a school was observed quickly descending to a depth up to 200 m. The reaction of jack mackerel to an approaching vessel was accompanied by changing speed of movement. Fig. 1 shows dependence of school speed on distance to the vessel. Before reaction, fish moved at an average speed of 0.4-0.5 m/s. When reacting, the speed increased 2-4 times. Speed increased at schools from areas 1 to 3. Similarly, distance at which fish reacted to the vessel also increased. Thus, jack mackerel schools in area 3 reacted at a distance twice as long as that in area 2 and four times longer than the distance in area 1. In area 3 a large number of schools were also observed avoiding the vessel (Table 1).

Besides the described elements of reaction of jack mackerel to an approaching vessel, it was also observed that some schools became denser and changed shape from depressed to ellipsoid.

According to data obtained in biological analyses, jack mackerel from the three areas differed in average size and physiological state (Table 1). In the first area, jack mackerel that had recently spawned predominated, at gonad maturity stage VI-II with a low point of viscera obesity. In the second and third areas the number of fish at gonad maturity stage VI-III a high level of obesity were quickly developing (Table 1).

Table 1 Some characteristics of jack mackerel school reaction and physiological state of fish

Area	No. of schools obser.	No. of schools avoided ship %	Depth of schools location before reaction $\bar{h}$, m	Depth of schools location after reaction $\bar{H}$, m	Length of specimen $\bar{l}$, sm	Viscera obesity stage		Gonad maturity	
						point	sp. %	state	sp. %
1	87	40	36±8.7	62± 9.4	34	1	95	VII-III	10
2	145	35	36±4.7	63± 8.3	36	2-3	35	VII-III	30
3	65	65	28±3.8	62±10.7	39	3	50	VII-III	65

Thus, the results of investigations have shown that the force of reaction of a jack mackerel school to an approaching vessel was different in areas where fish differed in length and physiological state.

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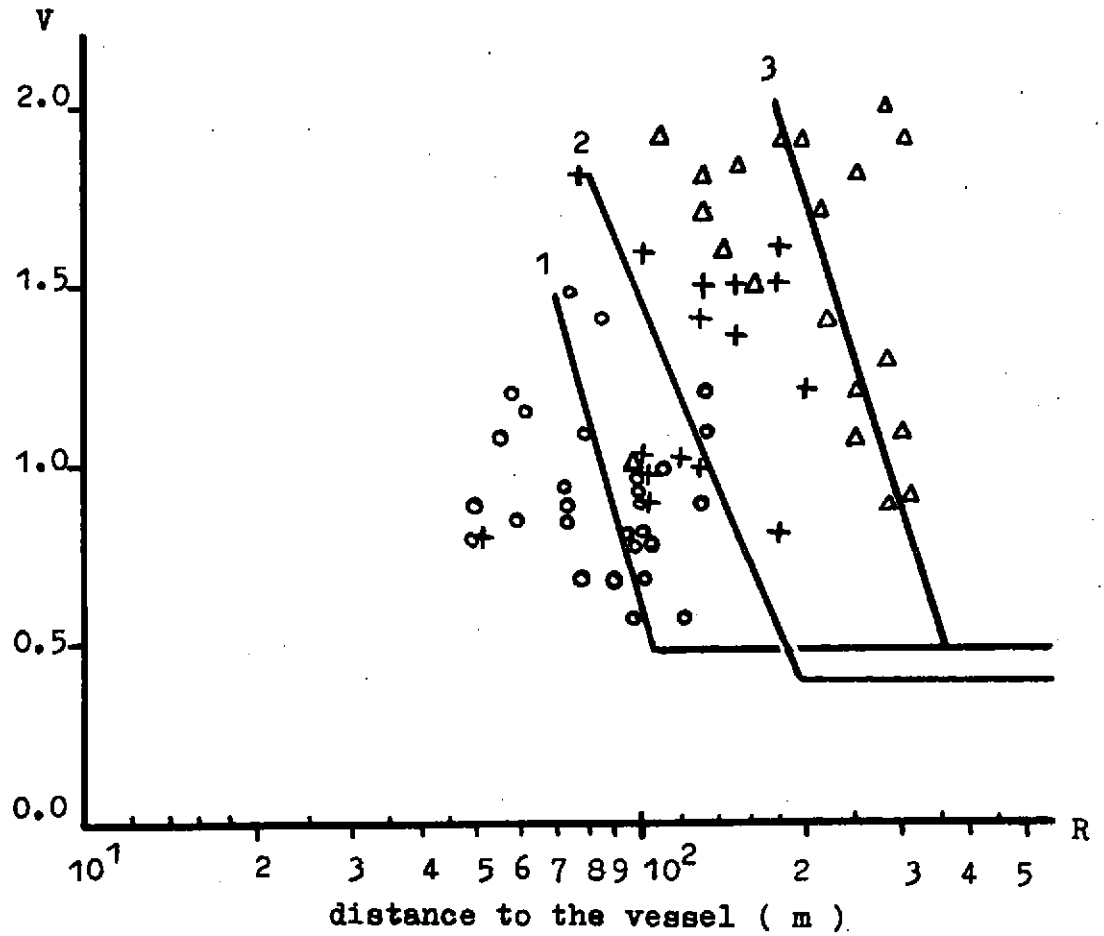

Fig. 1 Dependence of speed of jack mackerel schools on distance from vessel. Slope section in diagrams is obtained by least squares method. Equations of logarithmic regression for corresponding areas are as follows:

Area 1: R = 84.01 lnV -28.18 r = -0.5466
Area 2: R = 134.60 lnV -81.60 r = -0.6426
Area 3: R = 341.10 lnV -83.30 r = -0.6868

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DISCUSSION

Investigations in jack mackerel (Trachurus simmetricus murphyi) have shown that defence reactions of this species to an approaching vessel are similar to the behaviour of such species as sardinella[10], Pacific mackerel[5], cod, polar cod, capelin and herring[4].

These data make it possible to suggest that in pelagic schooled species there is a single stereotype of defence reaction to vessel, which is fairly important for estimating the accuracy of the echometric method.

Such elements of school behaviour as increased density, changing shape from depressed to spherical form, breaking up of large schools into two parts and so on - are similar to reactions of schooled fishes to a natural predator[11].

The ability of fish to localise a source of sound[12] and, according to certain evidence[13], determine distance to this source, as well as perception of an approaching vessel as dangerous (predatory), in our opinion, allow fish to easily adapt to new irritants and successfully avoid them. There is evidence, however, that not all fish avoid an approaching vessel but only some of them, and that the number of avoiding fish or schools varies with species[4]. The results obtained show that there is a relationship between the reaction force of fish and their size and physiological state. Increasing distance of reaction to an irritant with a rise in these parameters is especially important from the viewpoint of timely avoiding danger.

Thus, in estimating the abundance of schooled fish by acoustic methods as well as by trawl catches, considerable underestimation of biomass is accounted for by fish avoiding the vessel in the horizontal direction. For example, in the case of jack mackerel the error came to 35-65%. Besides, according to investigations, the error may also occur in estimating the size characteristics of fish.

The new method of estimating abundance with the help of horizontal range sonars can become a radical method of solving the problem of the avoidance effect on the accuracy of echometric estimation.

REFERENCES

[1] Kazakov, Z. N., 1948. Experience and tasks of aviascouting. Rybnoye Khozajstvo No. 5, p. 8 (Russian).

[2] Radakov, D. V., 1956. Studying fish behaviour during fishing. In: Voprosy ikhtiologii. M. 'Nauka', issue 6, pp. 37-46 (Russian).

[3] Olsen, K., 1971. Influence of vessel noise on behaviour of herring. pp. 291-294 In: Kristjohnsson. H., ed. Modern Fishing Gear of the World: 3, Fishing News (Books) Ltd. London.

[4] Olsen, K., Angell, J. Pettersen, P., Lovic, A., 1982. Observed fish reactions to a surveying vessel with special reference to herring, cod, capelin and polar cod. ICES Symp. on Fish. Acoust. Bergen, Norway, No. 48. 16 pp. mimeo.

[5] Neproshin, A. U., 1978. Japanic mackerel behaviour under effect of vessel noise field. In: Voprosy ikhtiologii. M. 'Nauka", v. 18, issue 4 (III), pp. 781-784 (Russian).

[6] Diner, N., Masse, J., 1987. Fish school behaviour during echo survey observed by acoustic devices. Int. Symp. Fish. Acoust. Seattle. No. 30. 14 pp. mimeo.

[7] Misund, O. A., 1987. Sonar observation of horizontal extension, swimming behaviour and vessel and purse-seine avoidance of herring schools. Int. Symp. Fish. Acoust., Seattle, 1987. No. 89, 22 pp. mimeo.

[8] Manteifel, B. P., 1970. Behaviour of animals in their ecology and evolution. In: Biological fundamentals of fish behaviour control. M. 'Nauka', pp. 12-35 (Russian).

[9] Malinovsky, U. E., Rekubratsky, V. A., 1960. Methods of studing behaviour of schooled fish. Scientific reports of Higher school; Biological sciences, issue 4, pp. 20-27 (Russian).

[10] Lisovoy, A. P., 1973. Vessel noise influence on behaviour of surface fish concentrations. Rybnoye Khozajstvo, No. 3, pp. 20-23 (Russian).

[11] Radakov, D. V., 1977. School formation as ecological phenomenon in fish. M. 'Nauka', p. 190 (Russian).

[12] Olsen, K., 1976. Evidence for localization of sound by fish in schools. Pages 257-270. In: A. Schuijf and A. D. Hawkins, eds. Sound reception in fish. Elsevier, Amsterdam.

[13] Blaxter, J. H. S., 1985. The herring: a successful species? Can. J. Fish. Aquat. Sci. 42:21-30.