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THE EFFECT OF FISHING VESSEL ACOUSTIC FIELDS ON THE BEHAVIOUR OF SPEEDY FISH CONCENTRATIONS

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INTRODUCTION

It is known that fish without the Weberian apparatus and air bladder perceive acoustic vibrations in the range of 100-2500 Hz, while fish with the Weberian apparatus and air bladder perceive in the range of 20-1300 Hz. The latter can perceive impulse signals of a higher frequency. The acoustic information channel as compared with optical and other channels provides fish with a larger amount of information and enables them to freely orientate in a complex situation, see danger in advance and avoid it. Therefore fish perceive unknown acoustic emissions in shape of danger signal. After that may occur either adaptation to acoustic emission or fixation of negative reaction. It depends both on the characteristics of the acting acoustic field and on the physiological state of the fish.

A fishing vessel in normal operational regime forms an acoustic field of complex structure in energy, spectrum and space aspects. The main source of these fields are emissions of the vessel's hull and engine, emissions of scouting and navigation equipment, and hydrodynamic noise of trawling gear. Characteristics of these fields depend on rate of movement of the vessel, its dimensions, acoustic properties of the hull, type of scouting equipment and trawling gear.

OBSERVATIONS AND METHODS

Speedy fish: mackerel, horse mackerel and sardine most often form compact and dense concentrations. These concentrations vary from 5 to 100 m vertically and from 40 to 300 m horizontally. When moving, these concentrations as a rule take on a streamlined (for example, drop-like) shape. Rate of movement of speedy fish concentrations varies in the range of 0.5-2 knots. Maximum speed at moments of danger exceeds 6 knots. This means that fishing such concentrations with trawling gear becomes problematic as in favourable conditions the maximum speed of a trawling vessel may reach 5.5-6 knots.

Numerous observations of behaviour of horse mackerel concentrations made during echometric surveys and multiple measurements of movement parameters ascertained some of the peculiarities of their reaction to the effect of acoustic fields of a vessel in full operation. Each source of vessel acoustic field is characterized by a different reaction of concentrations. The effect of hull and engine emissions in daytime, when horse mackerel concentrations lay at a depth of 100-250 m brought about the following reaction. As soon as the vessel passed over the concentration the latter quite energetically changed its depth, increasing the depth by 50-100 m. During observations stable negative reaction was noted. However, at night no reaction to vessel noise was registered though the depth of concentrations was considerably smaller (30-90 m). It is necessary to note that with twilight, dense and compact concentrations came up to the surface and broke up.

The effect of scouting and navigation acoustic equipment also caused stable negative reaction of a horse mackerel concentration. It was most distinct in measuring the parameters of movement with the help of a sonar and manifested itself in a change in movement trajectory. Concentrations moving towards the vessel passed it at a safe threshold distance. This distance was determined by sonar emission intensity and physiological state of fish. Thus with sonar KCS-502 manufactured by Kaide Denki, Japan, in full operation for horse mackerel concentrations in pre-spawning and spawning state, threshold distances on an average came to 250 m. A 50% decrease in intensity of sonar impulses cut the threshold distance up to 160 m. The effect of echo-sounder emission caused similar reaction, while operation of other equipment against the background of vessel noise made no noticeable effect on the behaviour of concentrations.

In the zone of fishing with a pelagic midwater trawl horse mackerel concentrations were affected by the noise of the vessel and by hydrodynamic noise of the trawl. Reaction to such an effect most often manifested itself only after the concentration passed the mouth of the trawl. The concentration made a U-turn in the netting of the trawl and freely left it, then it left the zone of fishing as well. Less often with the help of a trawl-sonde one could observe fish leaving the fishing zone for greater depth. In the first case distinct disorientation of concentrations in acoustic fields occurred. The engagement of sight, smell and other receptors on entering the trawl gave fish concentrations information about danger and helped their correct and timely reaction. In the second case concentrations estimated danger through the acoustic channel, correctly orientated themselves and left the trawl fishing zone in good time. In the dark when concentrations came up to the surface and dispersed, no noticeable reaction to the effect of hydrodynamic noise from fishing gear was observed.

Studies of the behaviour of concentrations of another speedy fish, sardine ivasi, have shown some peculiarities of reactions to the effect of acoustic fields. First of all it is necessary to note that sardine ivasi is a warm-water species and the lower border of favourable temperatures is 8-9°C which is the factor determining the threshold level of its sense of smell. Undoubtedly, hydrodynamic noise of the hull of the vessel and engine affects sardine ivasi concentrations and causes negative reaction. But as sardine keep mainly in pre-surface layers to make reliable estimation of this effect with the help of traditional methods and equipment is difficult.

A more detailed study of the effect was made with the sounding impulses of Simrad sonar ST used for measuring movement parameters. During such measurements which were carried out in daytime two types of reaction of concentrations were observed. The first type characteristic of sardine consisted in changing the trajectory of movement. Sardine concentrations skirted the vessel with sonar in operation at safe threshold distance and proceeded by the previous course. Threshold distance averaged 100 m, the sonar in this case operating at 1/10 of full power. Such reaction was rarely observed and is likely to be characteristic of migrating concentrations. More often observed was reaction of another type. Concentrations found at a distance of 60-80 m reacted to the effect of sounding impulses in a dual way: they either quickly took the shape of small schools and scattered in different directions or quickly came up to the surface. No regularity of such reactions are established.

The effect of hydrodynamic noise of the trawl occurred against the powerful background noise of the vessel. Therefore, as with horse mackerel, disorientation took place in this case. Most often it occurred when trawling in contrary direction. In this case sardine ivasi concentrations flew into the trawl without an attempt to escape through side wings. All concentrations registered by the vessel echo-sounders entered the trawl. This situation is typical of cases when information about movement parameters of concentrations and conditions made it possible to trawl in required direction. Fig. 1 shows an echogram of a vessel echo-sounder, Fig. 2 an echogram of a trawl-sonde with entries of the same concentrations. The results of trawlings confirm these entries. Trawlings on other tracks in good commercial situation were less resultative. Fig. 3 shows an echogram of trawling heading in a direction different from the counter course. Sardine concentrations easily escaped the trawl evidently correctly getting their bearings. In other words, acoustic fields of a fishing vessel, depending on the trawling course, may dually affect sardine ivasi concentrations: either drive them into the trawl, or, on the contrary, scare them away from the fishing gear.

DISCUSSION

The effect of fishing vessel acoustic fields on speedy fish concentrations mainly causes negative reaction in daytime. At night no such reaction has been observed.

Negative reaction of concentrations adversely affects both results of fishing and estimation of their biomass. First of all for successful fishing of horse mackerel the following measures can be recommended: measuring movement parameters of concentrations in the fishing area and determining threshold distances of the effect of vessel acoustic fields. After that the course and depth of trawling should be chosen. For successful fishing for sardine ivasi by pelagic trawl the main factor is the course of trawling which is determined by the course of the concentration.

Estimation of speedy fish biomass should be made with allowance for speed and direction of concentration movement and with regard to degree of the effect of vessel acoustic fields. Negative stable reaction of concentrations of two speedy fish species makes it possible to suggest similar reaction of concentrations of other species. Decrease in the effect of vessel acoustic fields is reached with improved hydrodynamics of the vessel and fishing gear and the use of more sophisticated acoustic equipment.

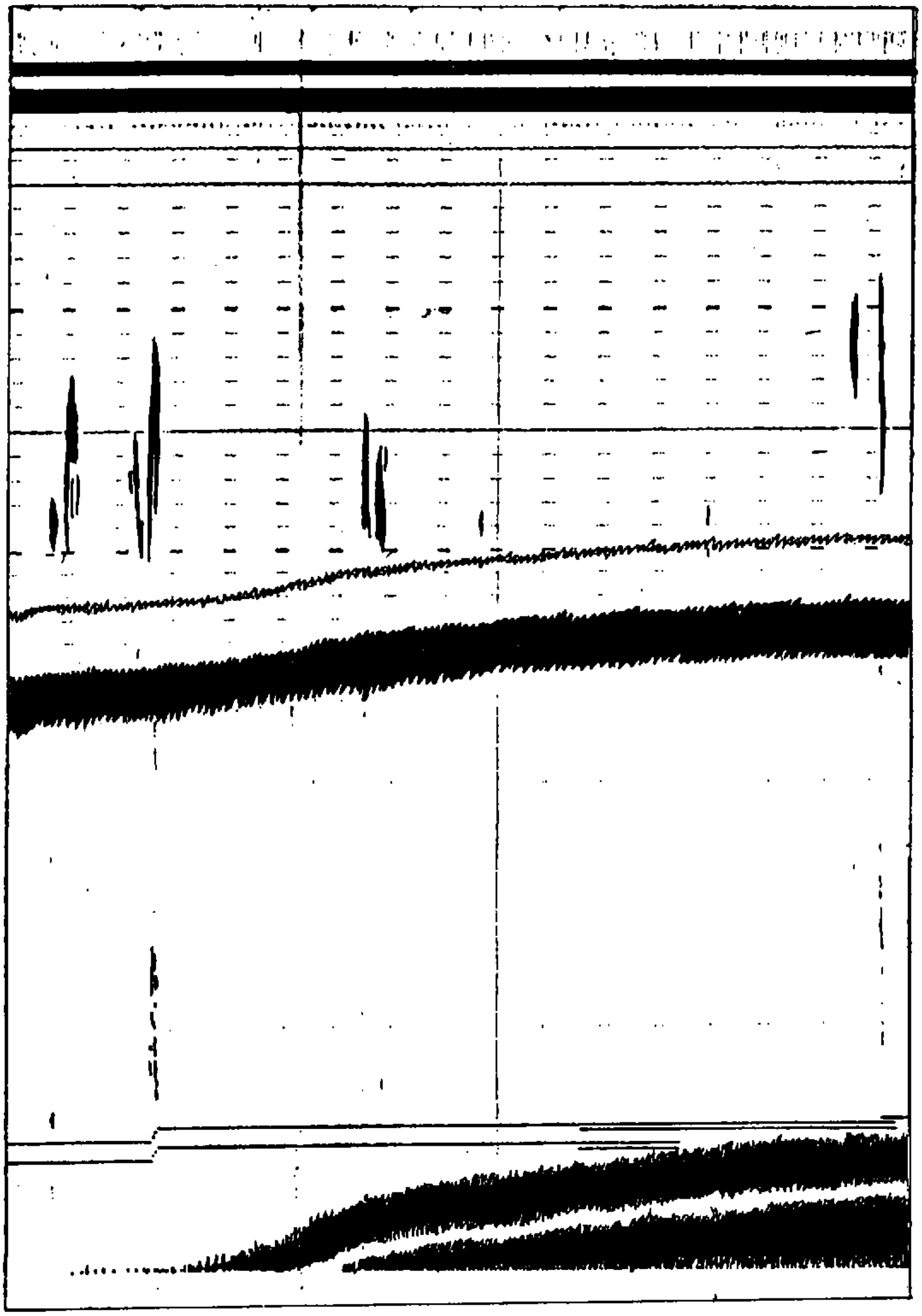

Fig. 1 Echogram of sardine concentrations under vessel's keel with trawling contrary to fish course.
Echo-sounder EK-S38, range 0-100 m, power 1/10, τ=1 ms.

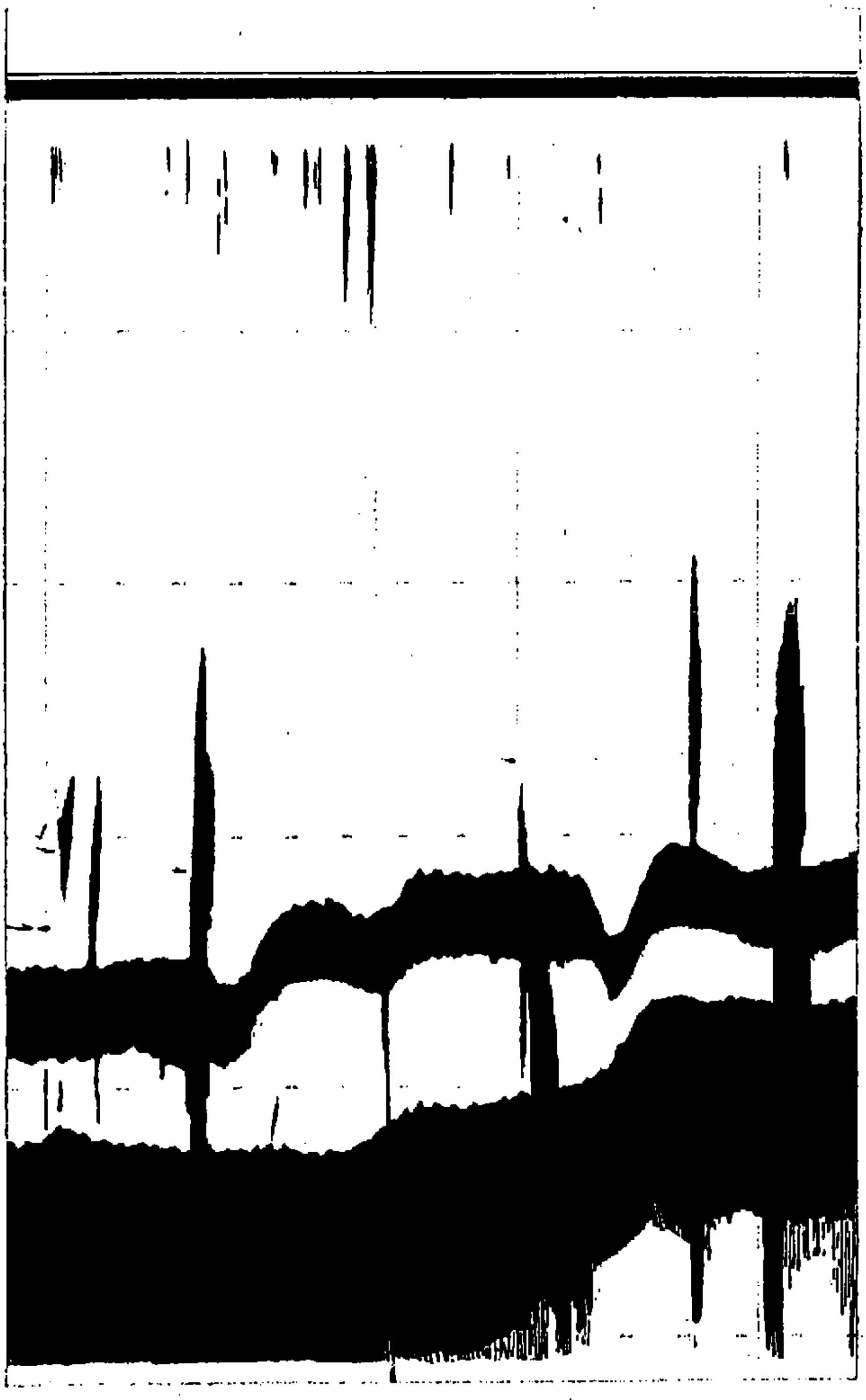

Fig. 2 Echogram of concentrations' entry with trawling contrary to fish course. Trawl sonde FB-3, range 0-100 m, τ=1 ms, operation mode "Downwards".

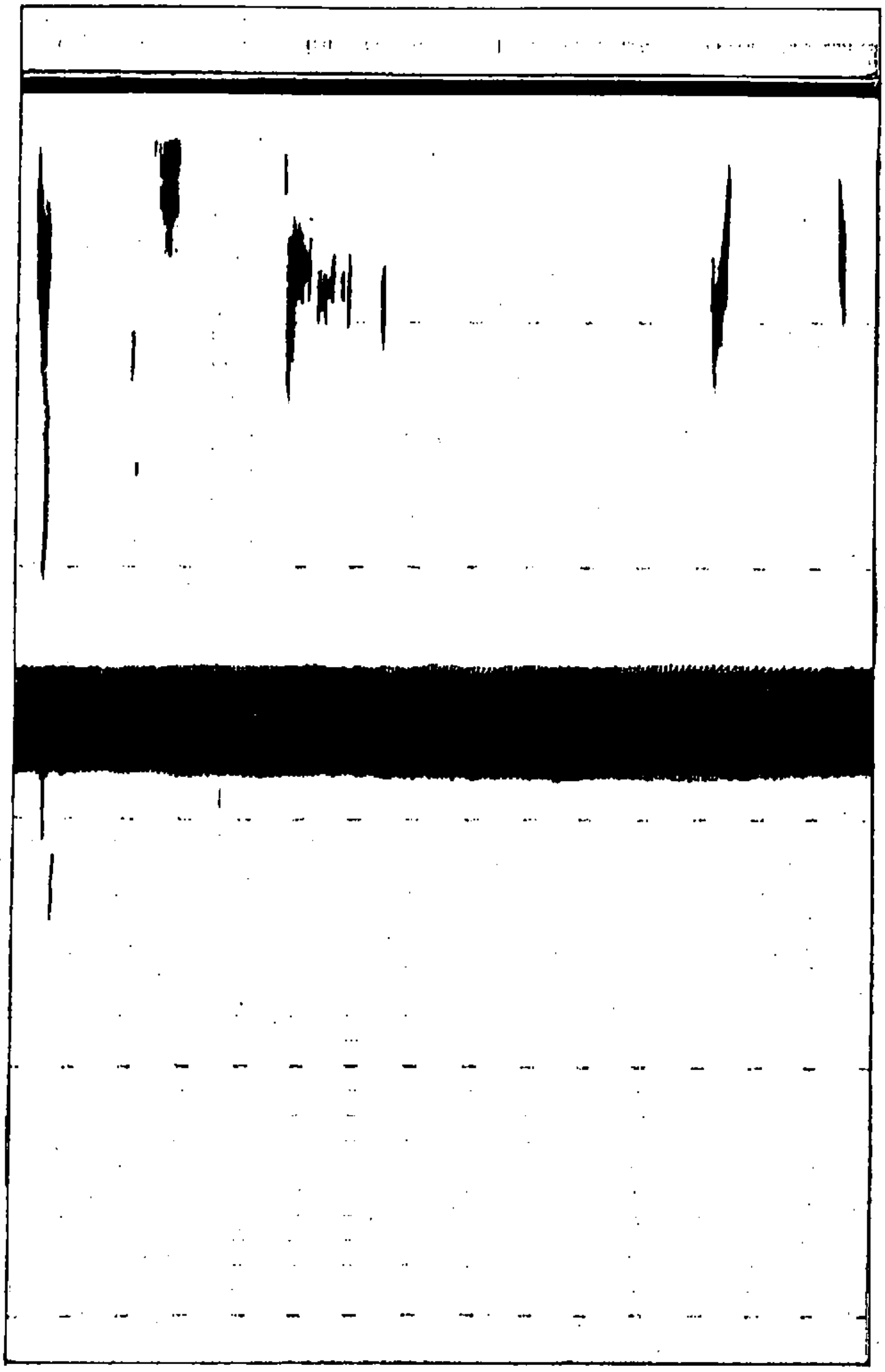

Fig. 3 Echogram of sardine getting out of trawl mouth. Trawl sonde FB-3, range 0–100 m, τ=1 ms, operation mode "Downwards".