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HADDOCK AVOIDANCE REACTIONS DURING TRAWLING

by

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ABSTRACT

Fish reaction to the whole trawling operation was studied using a stationary echo sounder-system observing the fish in front of the vessel and during trawl passage. Strong avoidance reactions were observed on haddock, with both horizontal and vertical movements of the fish. The observations indicate that the fish density available for the bottom trawl at shallow depths may be significantly higher than estimated by the echo integration system on board the trawling vessel, and that vessel avoidance may be an important trawl selection factor.

INTRODUCTION

Obtaining a non- or near- non-selective sample of the fish community is of major importance to several of the methods used in stock assessment. Using a selective sampling gear like the trawl, a detailed knowledge of the different selection factors is needed, both for error analysis, corrections and improvement of the methods. Through the use of divers, remotely operated vehicles and photographic tecniques, fish behaviour patterns in the proximate fishing zones of the trawl, extending from the trawl doors to the cod end, have been elucidated. Most of this information is summarized in BEN-TUVIA & DICKSON (1969) and in WARDLE (1984). When the aim is to take a representative sample of the fish community with a one boat-trawl, it is also neccessary to consider the well-documented reaction of fish to vessel noise (OLSEN 1969, 71, 79, 80; OLSEN et. al. 1982 a, b,). Despite measurements showing that vessel noise level is increased during trawling (CHAPMAN & HAWKINS 1969; BUERKLE 1977), only a few direct observations of trawling avoidance have been reported, and these have focused exclusively on pelagic fish like herring (SHÄRFE 1955, OKONSKI 1969). Since cod and other demersal species can discriminate and localize noise from the ships engine and propeller above the background noise level at distances of more than a kilometer (BUERKLE 1977), avoidance reactions at least at the highest intensity levels during a passage are to be expected. This work will present evidence for such an avoidance behaviour by demersal fish, and discuss its significance for total trawl selectivety.

MATERIAL AND METHODS

Direct observation of fish behaviour were made using a stationary echo sounder system, the SIMRAD EY-M scientific echosounder with NAKAMICHI 550 cassette tape recorder, mounted onboard the launch of the Norwegian rescearch vessel R/V ELDJARN. The transducer, with nominal full beamwidth of 20^{o}, was lowered to 3 meters depth to avoid most of the research vessel´s wake. The reseach vessel was a 200 feet combined purse seiner/trawler with a main engine developing 3400 HP at

600 rpm, and using about 1000 HP at 460 rpm when towing the pelagic trawl at 3 knots.
The launch, which had its own engine off during the entire period of observations, was approached by the research vessel at different speeds from a distance of about one nautical mile. The passage was made as close as possible (<5m), or just enough for clearance by the warps. The general set-up is shown in Fig. 1.

The investigations were originally planned to be made during bottom trawl hauls, but heavy gill netting in the actual area prevented this. To create the general noise level for trawling, the drag was produced by the standard small meshed capelin trawl, a 16/16 fathoms square opening pelagic trawl with paired, 110 m bridles. As the total drag of this trawl is similar to the drag using the CAMPEL 1800 bottom sampling trawl, vessel noise level is assumed to be comparable.

RESULTS

For comparison of fish reaction under different vessel noise conditions, several runs were made without trawl using normal surveying speed, 9 knots, and trawling speed, 3 knots. Two examples of such runs are shown in Figs 2 and 3. No strong vessel avoidance was observed in the pre-vessel zone, Fig. 1, except for the disappearance of the uppermost fish traces at 3 knots. At the moment of propeller passage, and in zone II, a slight density reduction with general downwards movement is observed at full speed, while the total density here is rather increased at 3 knots. A general downwards migration after propeller passage is also seen at this speed.

The fish reaction to the noise when trawling is shown in Fig. 4. As is evident from this registration, a comparable slight reaction is seen in the pre-vessel zone, but with a sudden and vigorous diving reaction just after propeller passage. The fish is also concentrated throughout the dive, the upper layer beeing at a steeper angle than the lower. The situation is

stabile again at about 400 meters after passage, or 4.5 minutes.
This situation with vertically migrated young haddock, is representative of late evening and night-time registrations in the shallower areas near the coast of eastern Finnmark, northern Norway. No classical vertical migration pattern were observed in these areas in February and April 1986. The difference between night and day is better described through the degree of clumping or aggregation.

Besides demonstrating the low fish density available to the pelagic sampling trawl due to propeller noise, an imaginar bottom trawl would experience a fish density significantly higher than that found at its sampling depth prior to and during the first stage of vessel passage.

DISCUSSION

The observations clearly demonstrate that noise produced by the vessel creates a fish behaviour pattern that will affect the efficiency and selectivity of the trawl, even for demersal fish. Considering the difference in swimming capacities among specimens and size groups of the same fish species, the noise may actually be an effective trawl selection factor.

With the evidence both for long-range detection (BUERKLE 1977) and directional hearing (SCHUIJF 1975) among gadoids, a larger pre-vessel avoidance was expected than actually observed. That the main stimulus for reaction is the rate of change in sound pressure and not the actual sound pressure level, is supported by the observations.

Analysis of the different components of trawling noise shows that the dominant part of the noise is produced by propeller cavitation (URICK 1967; BUERKLE 1977). Besides being pulsed by the beats of the propeller blades, it is also highly directive (POMERANZ 1943: POMERANZ & SWANSON 1945). An indication of the - 10dB and half intensity angles of propeller noise is given in Fig 1. If the directivity pattern of noise from a freighter of same size as the research vessel is comparable, less noise is radiated in the for and at directions than abeam. This due to screening by the hull in the forward direction and by the wake in the rear (URICK 1967).

If we combine this information with the observations on fish behaviour during vessel passage, the sudden response beneath the propeller can be explained through the extreme noise gradient experienced by the fish when entering the "main lobe" of the noise. In shallow waters the noise intensity is increased by a factor of 10 -100 within a few seconds, comparable to the supersonic boom caused by aircraft exceeding the sound barrier. In the abeam direction, a horisontal escapement of the fish is to be expected from the transversely directed noise lobes. For pair trawling, directive propeller cavitation noise will move the fish effectivly towards the trawl path, and may explain the high catch rates obtained with this gear.

To which degree the escape reaction vertically and horizontally will affect the total selectivity, compared to the other selection factors in zone III and IV, is difficult to quantify at this time. Further observations on fish behaviour patterns towards trawling noise are needed before such conclusions can be drawn.

Pre-vessel avoidance seems to be less significant than expected prior to the investigations. Using data from the Barents Sea bottom trawl surveys in 1985 and 1986, a comparison of total echo abundance during trawling compared to mean echo abundance in four neighbouring 5 nautical mile cells, have been made to study pre-vessel avoidance. The observation parameter:

$$I = E_T/E_N$$

where

E_T = total echo abundance in the 5 nautical mile containing the trawl station.

E_N = mean echo abundance in four neigbouring 5 nautical mile cells.

is calculated under the following restrictions:

a) The depth variation within the observed 25 nautical miles is less than 10%.

b) The trawl station is pre-set, e.g., randomly picked position before the survey.

The results from this analysis are shown in Fig 5. If no pre-vessel avoidance occurs, the probability of observing $I > 1$ and $I < 1$ should be equal. No significant trend towards values below $I=1$ is observed, $(P > 0.25)$, in the avaiable material. Fig 5. also show that no significant trend was found on pre-vessel avoidance as a function of depth over the range 150-420 meters. Depth variations were too great within the necesarry distance at the shallower trawl survey stations to perform this type of analysis. Choosing a survey grid along the depth contours instead of crossing them, together with a higher resolution than 5 nautical miles on the stored integrator data would improve the analysis.

CONCLUSIONS

A. Vessel noise during trawling will cause avoidance-reactions by demersal fish.

B. The primary source of noise causing strong downwards migration seems to be propeller cavitation.

C. Pre-vessel avoidance is weak, but a certain polarization of fish movement is observed down to about 50 meters depth. No trend towards lower fish densities during bottom trawling is seen at depths from 150-400 meters.

D. The downwards migration during propeller passage will reduce the available fish density to the pelagic trawls. The avaiable fish density for bottom trawls will be increased if the horizontal movement of the fish is more moderate.

E. Vessel avoidance at the level reported here will be a strong selection factor when sampling in mixed fish environments.

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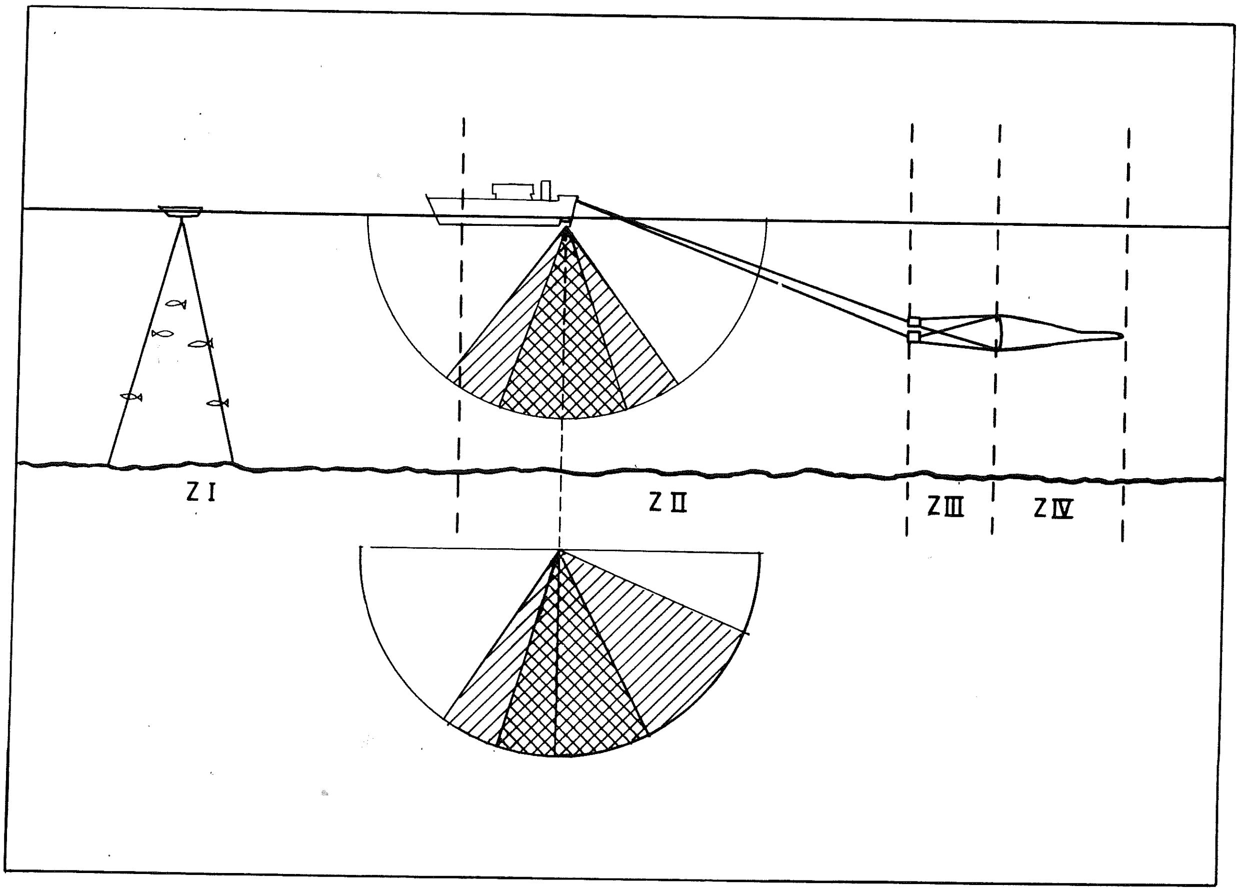

Fig.1. General set-up for avoidance reaction experiments using a stationary echo sounder from the launch of the research vessel. Aproximate -3 and -10 dB angles of propeller noise is indicated with respectively heavy and light hachure in both planes. Four selection zones are indicated:

ZI - pre-vessel avoidance zone
ZII - propeller noise avoidance zone
ZIII - sweep /bridle selection zone
ZIV - mesh selection zone

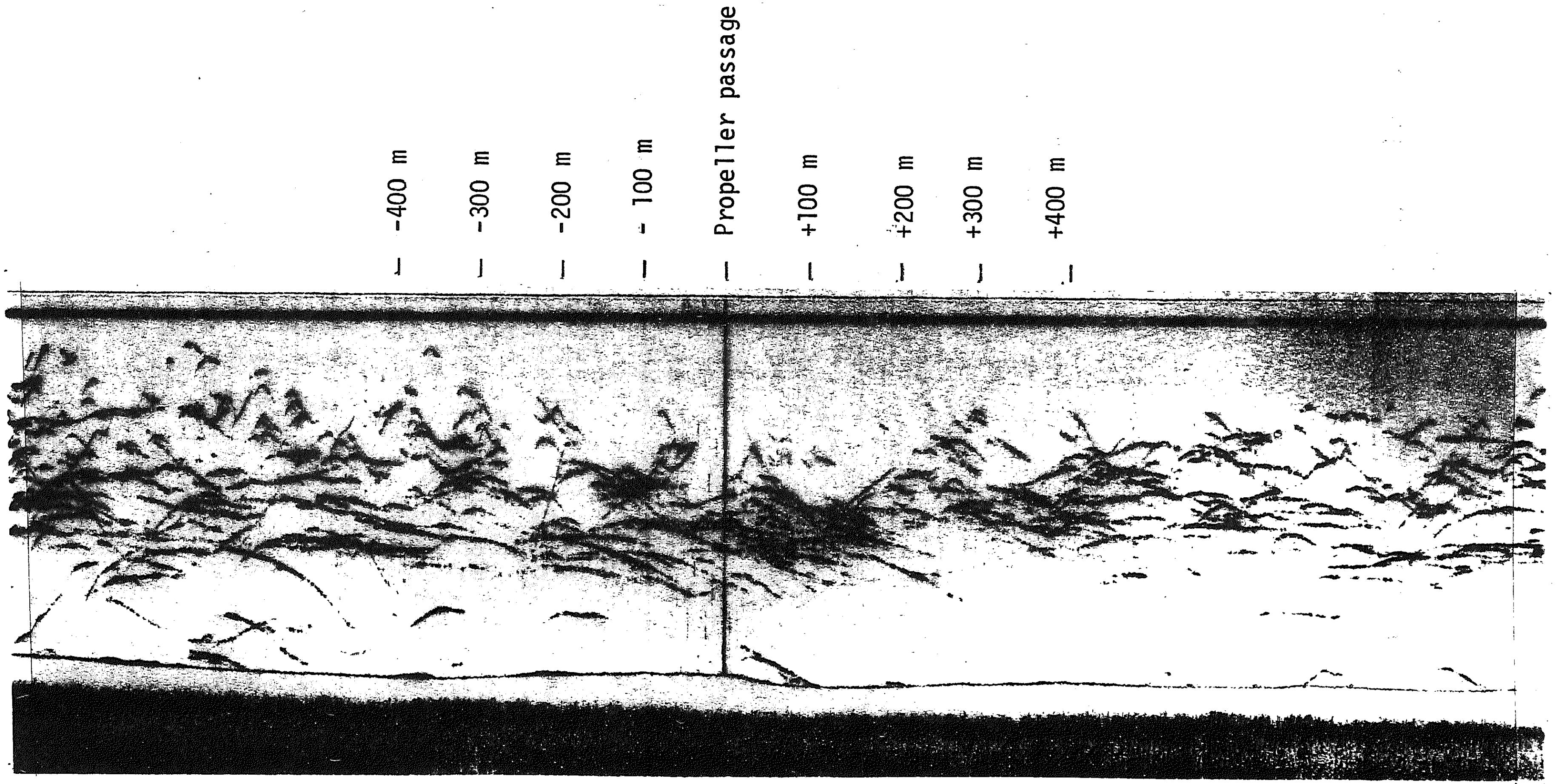

Fig. no 2. Moderate avoidance reaction observed when research vessel passes at 3.0 knots. Pelagic haddock. Distance to the research vessel is indicated above.

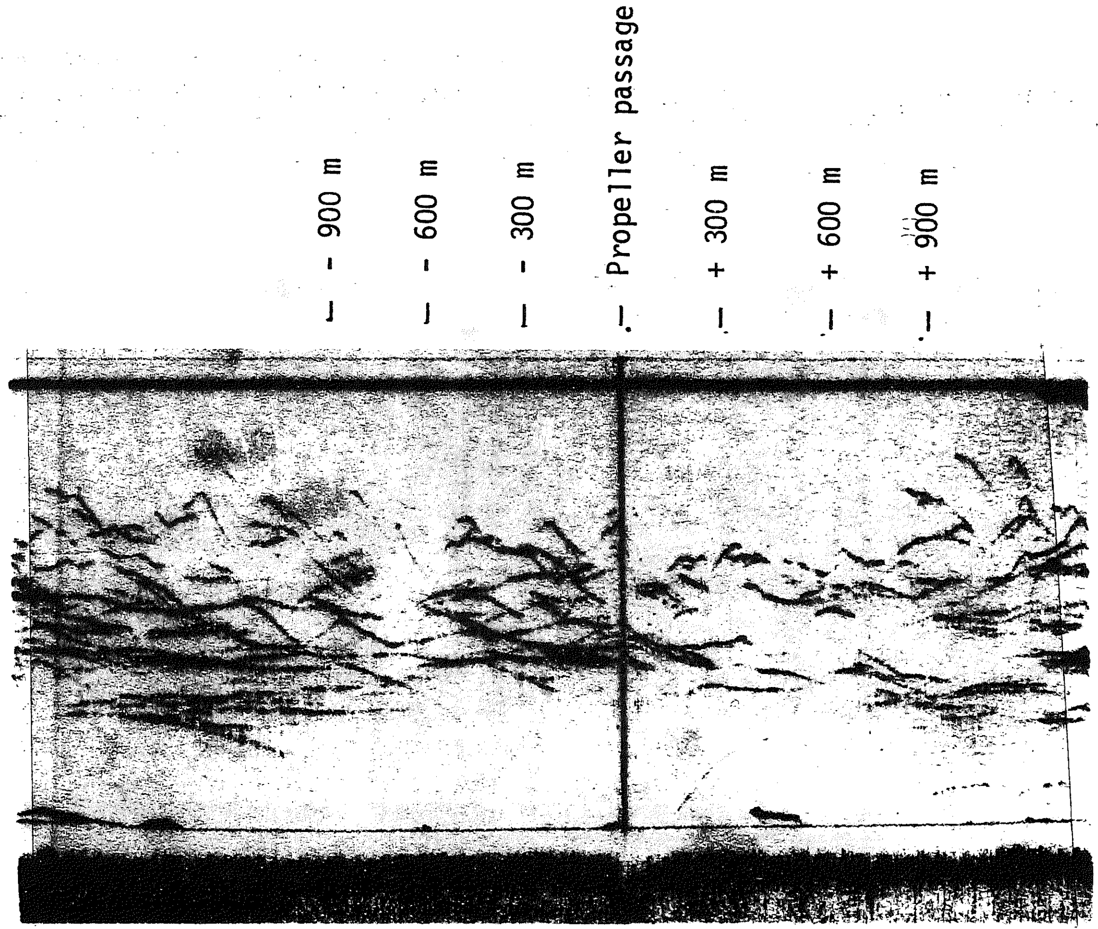

Fig. no 3. Slight avoidance reaction observed when research vessel passed at normal surveying speed, 9.0 knots.

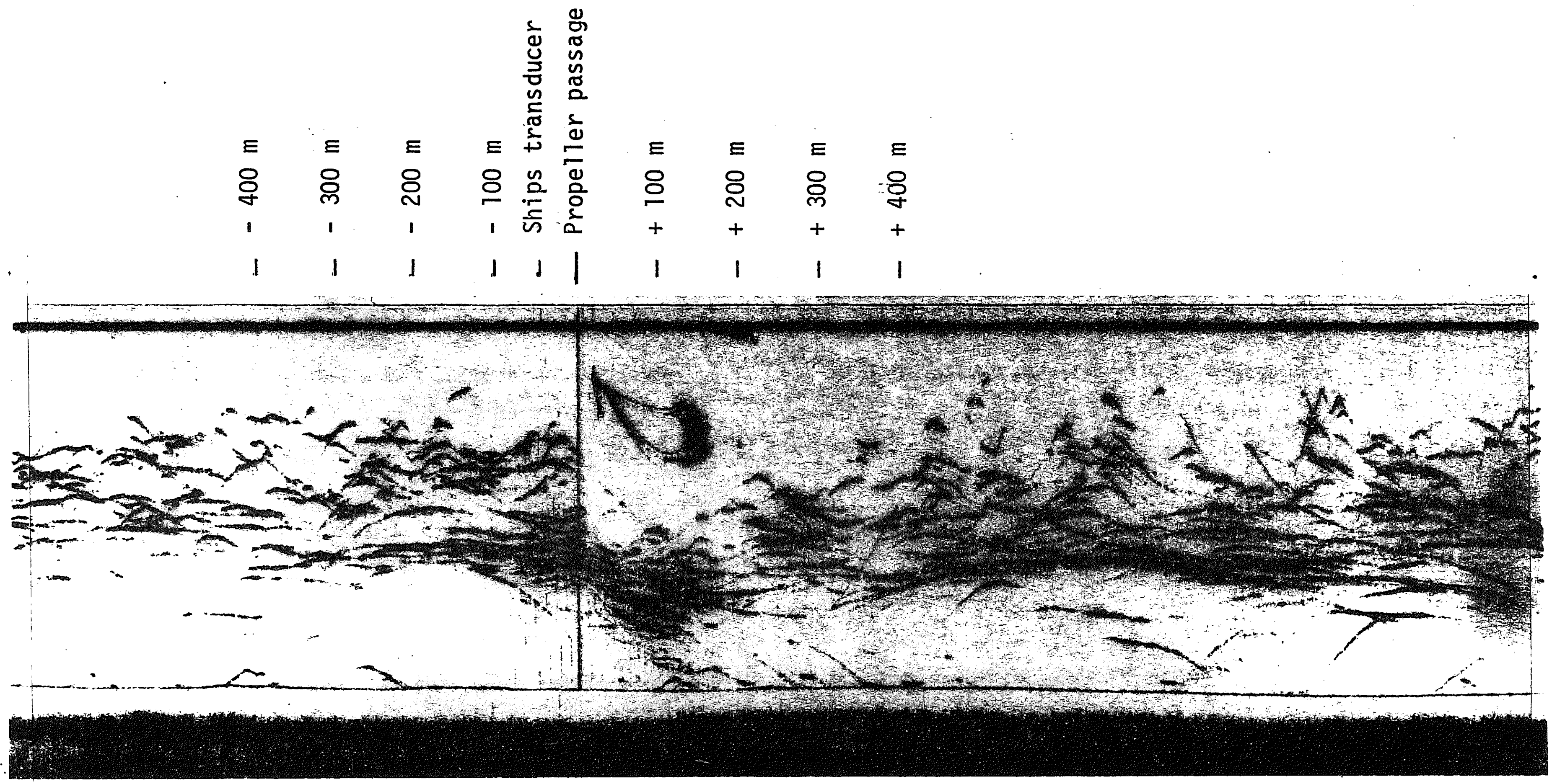

Fig.4. Fish avoidance to the trawling vessel. Haddock at 20 to 60 meters depth showing strong horisontal and vertical avoidance at and after propeller passage. Trawl door, upper and lower bridles, and front of the pelagic trawl is seen. The distance to the research vessel from the stationary transducer is indicated above.

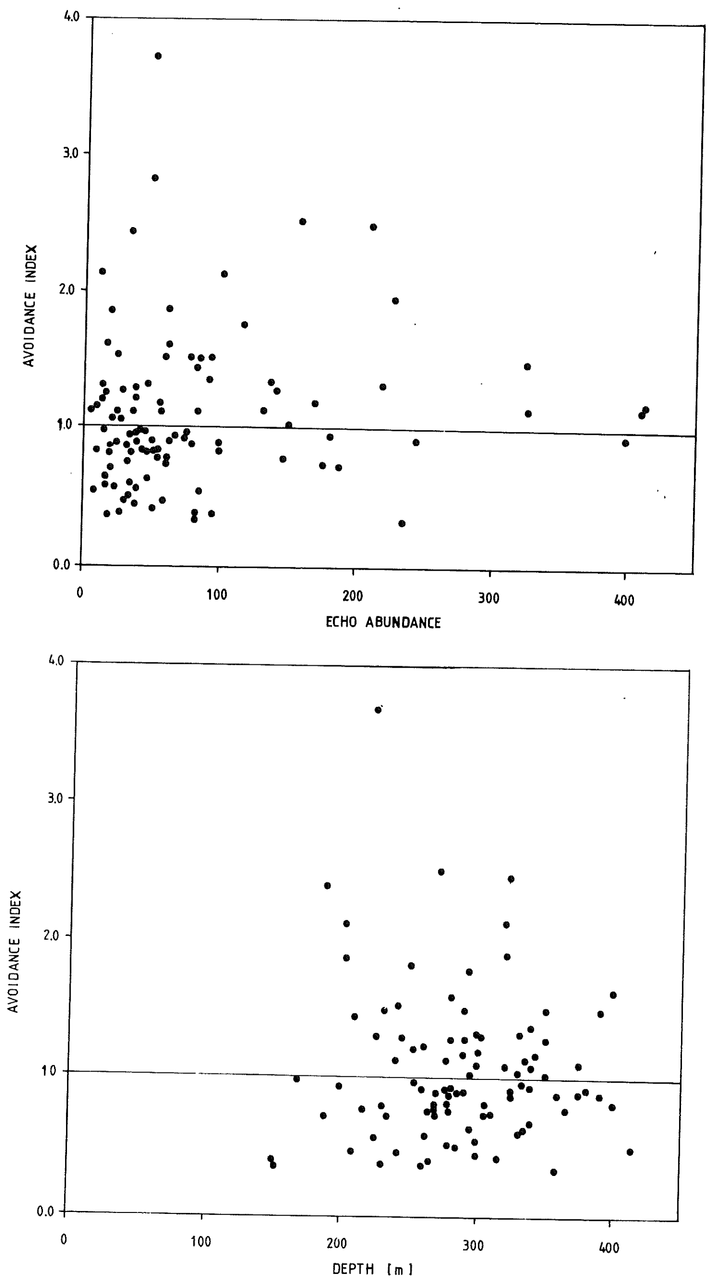

Fig.5. Pre-vessel avoidance index from standard trawl survey-stations on cod and haddock as a function of total echo abundance (A), and depth (B).