Fol. 41 H

International Council for
the Exploration of the Sea

C.M. 1988/H:46
Pelagic Fish Committee

AVOIDANCE REACTIONS OF HERRING TO A SURVEY VESSEL, STUDIED BY SCANNING SONAR

By

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Abstract

The behavioural response of a shallow herring layer to a steaming vessel has been studied by the use of a high-resolution scanning sonar technique. When the vessel was completely darkened, no significant reaction important for biomass estimation was observed, either at three or at nine knots speed. With usual deck lights, however, the reaction was severe, and the integrator system strongly underestimated the true herring density.

Introduction

If fish avoid the measuring vessel, the biomass estimated with conventional echo sounder systems may be seriously negatively biased. The particular problems of measuring shallow concentrations of pelagic fish have been stressed for several years by OLSEN (1971,1979,1980), OLSEN et al (1982), DINER & MASSE (1987) and MISUND (1987).

Two stimuli important for avoidance reaction are vessel noise and vessel light. Seasonal and species differences of reaction pattern are also evident.

Previous investigations of fish avoidance to a surveying vessel have mainly used a stationary transducer as an observation platform when single fish or layers of fish have been studied. Multibeam sonars have, however been used to study school avoidance. In this paper we study the reaction of herring in a shallow, medium-density layer by use of a high-frequency, narrow-beam, scanning sonar, resolving single fish targets within a distance of 100 m. A method of treating the data, combined with examples of the sonar display are described.

Material and methods

The oservations were made in January, in Ofotfjorden, outside Narvik, Norway, on adult herring, mean length: 31 cm, SD: 1.3 cm, of the 1983 year-class. During daytime the winter-hibernating herring formed large schools at depths from 150 to 250 m, but rose and spread out over the entire fjord into a medium density layer at about 25 m depth during the night.

A 330 kHz Simrad FS 3300 scanning sonar with a circular 2.6^0 opening angle (ONA & EGER 1986,1987) was mounted under the bow bulb of the research vessel "Eldjarn", a 60 m combined purse seiner/trawler. Under operation, the sonar scanned a 180^0 thin slice with radius of 70 or 100 m, transversely to the track of the vessel (Figure 1). Actually, under the fastest scanning speed at 13.8^0/sec, the 180^0 sector is completely scanned after 13 sec, when the sonar is automatically reversed. At the used vessel speed, 3 and 9 knots, the represented slice is at angles of 5.6^0 and 16.3^0, respectively, zig-zaging through the herring layer.

The sonar data were taped on a standard video recorder, Panasonic NV-870, and stored for subsequent analysis. From the video data, the herring layer appearing on the screen was divided into five equal cells, each 26 or 38 m wide (Fig. 1), depending on the used scale. The registered density within each cell was classified according to six levels, from 0 to 5, by two scientists working independently. It was further analyzed statistically by standard methods. A significantly lower fish density in the central cell, the only one sampled by the echo sounder system, is interpreted as vessel avoidance.

The analysis was repeated under three different experimental conditions. First, the vessel was completely darkened and operated under low-noise conditions, at 3 knots. Secondly, the speed was increased to normal surveying speed, 9 knots. Lastly, standard deck lights were put on at this same speed of 9 knots.

Results

A typical fish distribution pattern in the 200 m section transverse to the vessel path, with a completely darkened vessel, is shown in Figure 2. Of the total analysis of 80 scans, 60 at 3 knots and 20 at 9 knots, no significant density reductions in the cental cell below the vessel were observed. The accumulated density estimates from the classified sets are shown in Table 1 together with the significance level for equal cell density (X-square) Zar (1974). The parallel, independent sets of classified data are strongly correlated (r= 0.997), hence only one set is presented.

At full speed, the density was nearly constant across the slice, p= 0.93, while the lower significance level at 3 knots is caused not by the central cell, but rather by the slightly higher density in the outer starboard cell (Table 1).

When operating the vessel with the usual light level on the fish deck, on the latter half of the vessel, avoidance reaction of the herring was clear (Figure 3). The density in the central cell did not exceed density level 1, and the real density of the layer was underestimated by a factor of four (Table 1) by the integrator system. Compared to the outermost cells, 70-100 m on each side of the ship, the tendency to density reduction can also be seen in the cells next to the central cell.

As the reduced density was also clearly observed on the echosounder system and disturbed the abundance measurements, only a few minutes of observations were made with the deck lights on.

Discussion

The material clearly demonstrates the possibility of investigating vessel avoidance from the research vessel itself. The high-frequency sonar has a limited operational range for single-fish detection, but has a high resolution. As most of the documented avoidance reactions in similar situations have occurred within 100 m of the vessel, it is our opinion that this frequency is well suited for these kinds of experiments. Even large schools seldom react at larger distances than 100 m (MISUND, 1987).

The measurements indicate that a reduced light level on the research vessel is very important when measuring the abundance of shallow layers of fish. This has been pointed out for several years by Islandic scientists (Halldorsson, 1982), who have found no diving reaction of shallow herring when the vessel was darkened and operated at low speed. This argument has been further supported by the fact that no effect of avoidance appears on in situ target strength estimates on herring (FOOTE, 1987). A diving reaction when the fish is observed by the split- beam transducer should reduce the average target strength because of the tilt angle effect. However, in situations where the stimuli is rapidly changed, as during a stop for trawling and during the trawl operation, sudden reductions of target strength occationally have been observed.

The relative insensitivity of the herring to the darkened vessel was additionally confirmed by experiments with the sonar mounted on the towed body. By towing the body at 5-10 m depth, 20- 50 m behind the vessel propeller, only a slight density-reduction was seen in the central part of the layer (Figure 4). With the sonar gradually moving down close to the layer, and operated at short, 10- and 20- m range, the density of herring could be determined by measuring the individual distance between the fish in the layer.

Acknowledgements

Dr. K.G. Foote is thanked for helpful corrections and comments to the manuscript.

REFERENCES

DINER, N. and MASSE, J. 1987. Fish school behaviour during echo survey observed by acoustic devices. Coun. Meet. int. Coun. Explor. Sea, 1987 (B:30): 1-17. [Mimeo.]

HALLDORSSON, O. 1983. On the behaviour of the Islandic summer spawning herring (*Clupea harengus* L.) during echo surveying and depth dependence of target strength. Coun. Meet. int. Coun. Explor. Sea, 1983 (H:36):1-35. [Mimeo.]

FOOTE, K. 1987. Fish target strength for use in echo integrator surveys. J. Acoust. Soc. Am. 82(3):981-987.

MISUND, O.A. 1987. Sonar observations of horizontal extension, swimming behaviour, and vessel and purse-seine avoidance of herring schools. International symposium on Fisheries acoustics, June 22-26, Seattle, Washington, USA: Paper no. 89: 1-32.

OLSEN, K. 1971. Influence of vessel noise on behaviour of herring. In Modern fishing gear of the world, 3: ed. H.Kristjonsson., London, Fishing news (Books) Ltd., for FAO, pp.291-294.

OLSEN, K. 1979. Observed avoidance behaviour in herring in relation to passage of an echo survey vessel. Coun. Meet. int. Coun. Explor. Sea, 1979 (B:18): 1-21. [Mimeo.]

OLSEN, K.1980. Echo surveying and fish behaviour. Fish Reaction Working Group, Reykjavik, May 1980: 1-20.

OLSEN, K., ANGELL, J., PETTERSEN, F. and LØVIK, A. 1982. Observed fish reaction to a surveying vessel with special reference to herring, cod, capelin and polar cod. FAO Fish. Rep.,300:131-138.

OLSEN, K., ANGELL, J. and LØVIK, A. 1982. Quantitative estimation of the influence of fish behaviour on acoustically determined fish abundance. FAO Fish. Rep.,300:139-149.

ONA, E. and EGER, K. 1987. Sonar observations of trawl performance. International Symposium on Fisheries Acoustics, June 22-26, 1987, Seattle, Washington, USA: Paper no. 99:1-10.

ZAR, J. H. 1974. Biostatistical analysis. Prentice-Hall Inc., Englewood Cliffs, N. J., 620 pp.

Table 1. Observed accumulated density indicator in the 5 cells. Cell no. 3 is the central cell. No. of scans analysed, speed of vessel, light level on the vessel and the χ-square significances level for equality.

Cell no.					Nos. of scans	Speed (knots)	Light	Prob.
1	2	3	4	5				
152	115	144	131	123	60	3	No	0.143
42	48	48	42	44	20	9	No	0.937
12	11	3	6	15	3	9	Yes	0.001

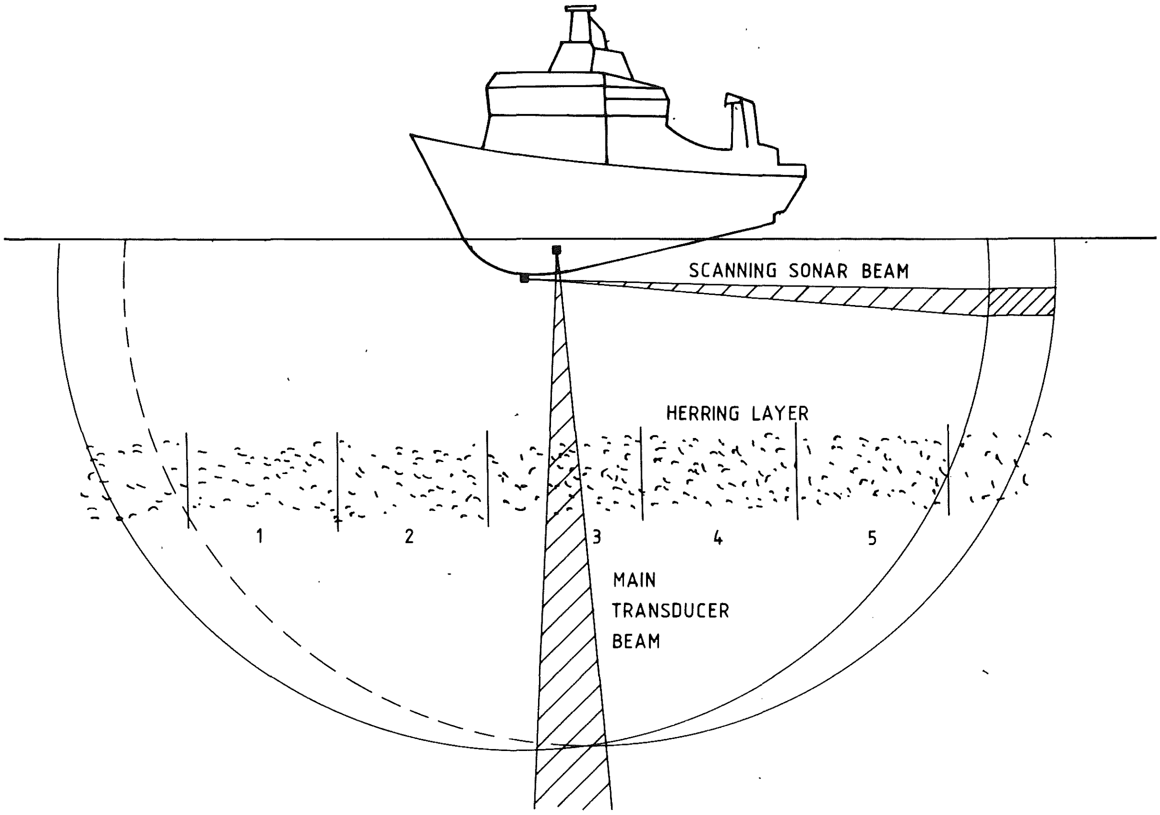
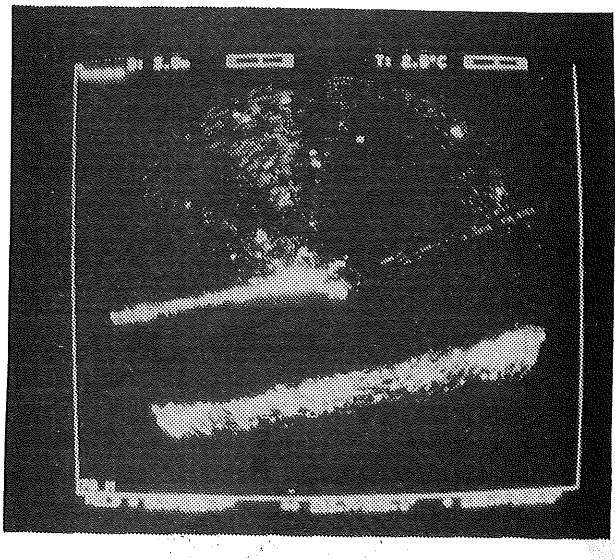


Figure 1. The high-frequency scanning sonar mounted on the bow of the vessel, with scan mode, herring layer and main transducer beam indicated. The cells, 1 - 5, in wich the density classification was made is shown.



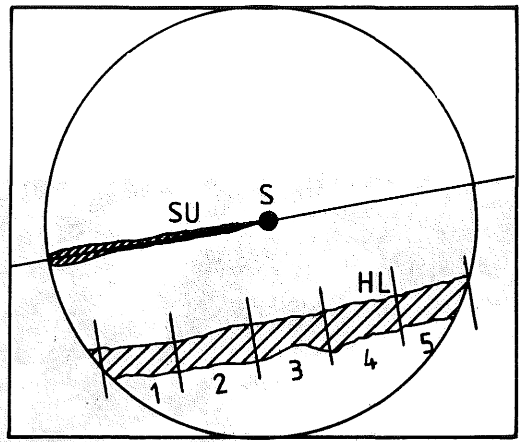
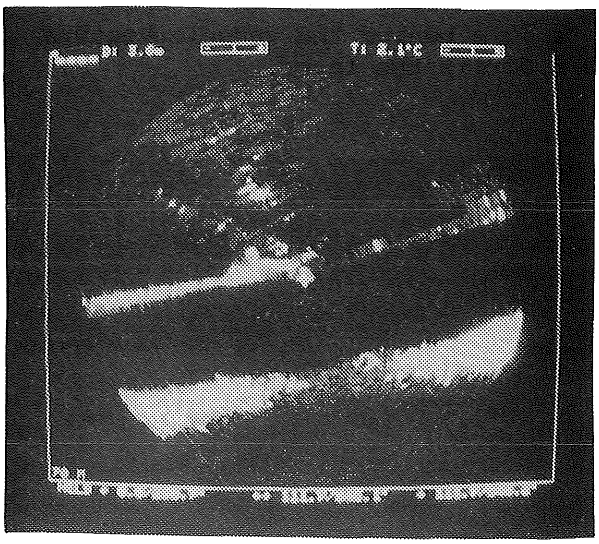


Figure 2. Sonar display taken at 9 knots with darkened vessel, showing the herring layer (HL) 25 m below the surface (SU). Scan radius from sonar (S) is 70 m, with equal density in the indicated cells.



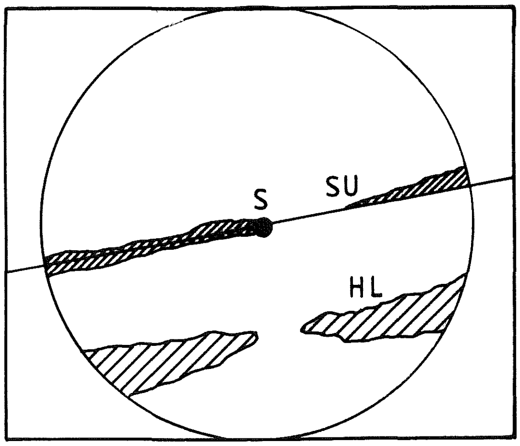


Figure 3. Sonar display taken at 9 knots with deck ligths on. Herring layer is split, with a remaining faint blue intensity in the central cell.

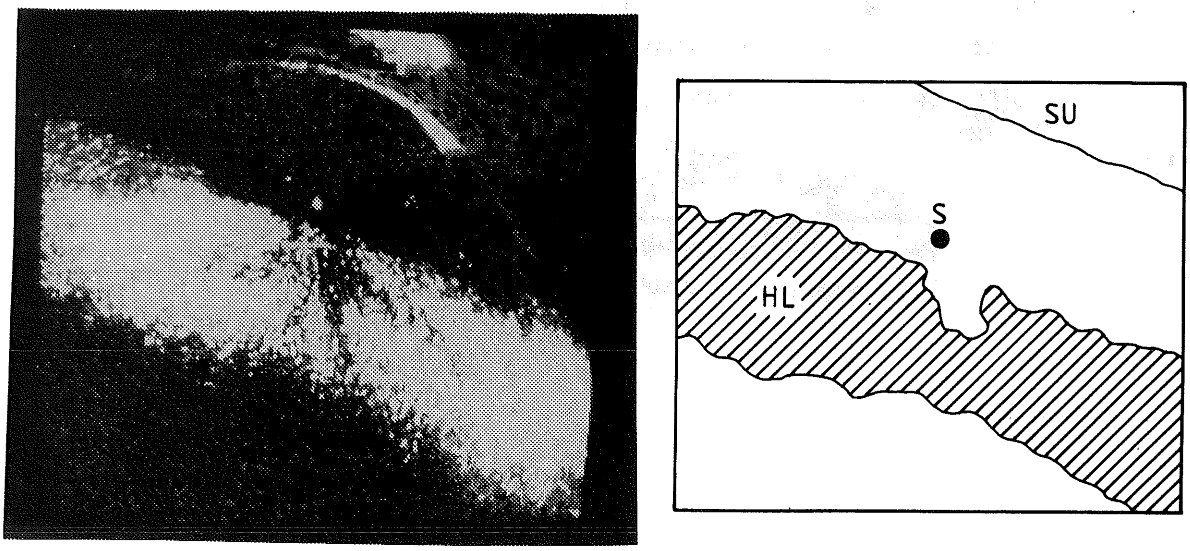


Figure 4. The scanning sonar mounted on the towed body (S), 20 m below the surface (SU) and 5 m above the herring layer (HL). Speed of vessel is 5 knots, and the body is 50 m behind the vessel. Picture is zoomed, and show aproximately 80 m across the layer.