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SONAR IN FISHERIES

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AN EXPERIMENTAL SURVEY OF A HERRING FISHERY BY LONG-RANGE SONAR

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1. INTRODUCTION

Since 1969 the National Institute of Oceanography has been using a long range side-scan sonar[1] (project G.L.O.R.I.A.) to view the floor of the N.E. Atlantic and the Mediterranean out to a range of 12 miles. From the shallow water propagation studies of Weston et al[2], and their estimates of pilchard shoal target strengths in the Bristol Channel[3], it seemed likely that the performance of the G.L.O.R.I.A. sonar would enable it to detect pelagic fish shoals out to ranges of a few miles in the shallow waters of the continental shelf. Accordingly, a trial experiment was arranged for late September 1971 in the Sea of the Hebrides, south of the Minch, where an autumn herring fishery exists. The full results of this experiment are to be found in a paper by Rusby et al[4], while the present lecture gives an outline of this work.

2. THE SURVEY AREA

The chosen area lay directly to the N.W. of the islands of Tiree and Coll, and south of Skye. Before the sonar was launched the Sea of the Hebrides was surveyed in detail using a short range side-scan sonar on board 'DISCOVERY' and precision echo-sounder. Data was also obtained from the Hydrographer who kindly made available detailed 1 : 50,000 sheets of the bathymetry of the Sea based on Hyfix surveys. From this data it was apparent that the area was a suitable and safe one, adequate towing depths existed over rock free, low backscattering, ground of mud and sand. G.L.O.R.I.A. runs could be made along NE-SW base lines a few miles off Hawes Bank which lay between the flat sea floor and the islands of Tiree and Coll. The survey also showed that the rocks of Hawes Bank were likely to form a useful backdrop to the scene to be portrayed by the long-range sonar, so that the position of fish over the smooth ground could be fixed relative to identifiable rock targets on Hawes Bank.

Time was also spent studying the distribution, density and depth of midwater fish shoals over the smooth ground and on Hawes Bank using a narrow beam sounder. Contrary to the information given by the local herring purse-seine fleet, adequate fish targets were seen lying well off the Bank over the smooth mud floor, in addition to those found over the sandstone rock of Hawes Bank. Observations made along one 7-mile base line for over 36 hours showed that the fish lay at 110-130 metres during the day over the smooth floor, which was typically 150 metres deep. About half an hour after sunset they rose to within a few metres of the surface (< 20m) and remained there until just before sunrise. During the day they had a somewhat ragged distribution, with poorly defined shoals connected by smaller groups of fish or possibly by individuals. At night it was difficult to perceive the exact form of the distribution since the fish lay in the scattering layers close to the surface. But there was one very characteristic feature at night which could clearly be seen, the formation of dense 'pendulous' shoals hanging down from the surface rather like wasps' nests. These might be up to 300m across and 60m deep, and were usually found in groups connected by regions of lower fish density. Perhaps the most surprising thing about them was their endurance, some were found to last through an overcast night when the incident light level was believed to be less than 10^{-5} metrecandles. These shoals were a purse-seiner's delight, and were often fished to 0300 hours, when the vessels then left the grounds for the market in Mallaig.

3. G.L.O.R.I.A. RESULTS

After completion of the initial survey the G.L.O.R.I.A. vehicle was launched and runs started using 10 kilowatts of acoustic power at 6.5kHz, with a correlation processing gain of 26dB from the 4 second 100Hz bandwidth pulse employed. Runs continued for the next 4 days.

The first runs were made at 7 knots along a 7 mile NE-SW base line looking SE to Hawes Bank which lay 10 miles away. It was soon found that the propagation conditions were very poor and no targets were detected beyond 2-3 miles. There were also indications on the display that the sound beam was being refracted downwards strongly. Examination of the sound velocity data obtained during the initial survey showed that at a towing depth of 30 metres the sonar vehicle was in the top part of a strong thermocline, produced by the calm bright weather of the previous week. For a number of reasons it was not feasible to run the vehicle at 20 metres or less, which would have placed it in the surface isothermal layer.

Fortunately the next day the wind steadily increased and blew at around 25-30 knots for about 12 hours. After this period of high winds the sound propagation steadily improved, and it was possible to detect targets out to a range of 7-8 miles. Sound velocity measurements made later showed that the effect of the wind had been to increase the depth of the surface isothermal layer to 40 metres, so that the sonar was now included in this layer and had a good near-surface propagation path. During the final two days of the experiment over 40 runs were made along a 7-mile base line lying about 7 miles off Hawes Bank, enabling a plan view of a 50 square mile area of the fishery to be generated every 1¼ hours. Examples of the records obtained are given in reference 4, including a discussion of the results and their possible value.

The G.L.O.R.I.A. records showed an abundance of targets over the smooth ground off Hawes Bank, some small and dispersed, others of considerable extent and coherence. Large fish targets could be very large, and examples were seen of fish ribbon aggregations up to 3 miles long, especially during the day.

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Some of the larger aggregations, with a characteristic shape, could be plotted relative to identifiable rock targets on Hawes Bank as they appeared on successive records at intervals of just over an hour. The degree of coherence of the aggregations varied, some lasted in a recognisable form for about 9 hours, others would change shape or form after one or two hours. Plots were made during the day and night and some tentative fish movement vectors are given in reference 4 alongside the relevant tidal stream data.

During this period one of the local purse-seine vessels, 'LUNAR BOW', was under contract to 'DISCOVERY' so that positive identification of targets could be made by catching. On the last night of the experiment she caught three times under the direction of the long range sonar, catching 240 crans of herring well away from Hawes Bank where the other 13 members of the fleet were fishing. This proved to be the best catch of the night. It was found best to try and direct the fishing vessel within 1-2 miles of a dense aggregation just as an updated detection was made; the latest position of the target was then quickly computed and compared with 'LUNAR BOW's' position by radar, a new course and range for interception was then passed to the catcher. Using her own sonar she could complete detection when she was within 1/2-1/4 mile of the selected target. During 'LUNAR BOW's' reconnaisance of the last target, a few minutes before shooting the net, her skipper Mr. Buchan made the comment by radio that the sonar 'mark' appeared to be at the end of a group of 'marks' lying away to the SE, in agreement with the form of the extended target scan seen on the G.L.O.R.I.A. display. From this reconnaisance the volume of the shoal was estimated to be 2×10^5 m^3, and it was subsequently found to contain approximately 8×10^4 herring from the landed weight of fish. This gives a mean fish spacing of 1.2m, and an estimated shoal target strength of +5dB for the G.L.O.R.I.A. sonar.

4. DISCUSSION

The long-range results raised a number of points which are discussed in some detail in reference 4. It is worth commenting on a few here.

The first point, chronologically, arises from the problems of propagation encountered. 'Summer' water conditions prevailed with a 3 °C difference between the surface and bottom. Under such conditions it is obviously important to position the array of a long-range sonar in either the near-surface or near-bottom isothermal layer if reasonable ranges are to be achieved. In this context a true variable depth sonar has advantages. It is hoped to repeat the experiment under 'winter', i.e. fully isothermal conditions, possibly in the autumn of 1973.

From theoretical comparisons of the possible biological target strengths involved, and the directed catch results, it is clear that the targets seen over the smooth ground were herring. At 6.5kHz the air bladder of this pelagic fish is still able to provide a useful increase in target strength over that of a non-bladder fish such as mackerel. What is not so obvious is the detailed composition of a typical target 'aggregation' of herring seen by the sonar. The size of the larger aggregations or groups suggests that they contain a number of shoals connected by regions

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of lower fish density, both during the day and at night. At night the shoals, in the form of the pendulous variety, no doubt have a higher density of fish, but they still appear to be constituents of much larger groupings. The form of an aggregation is believed to change when either visual or olfactory links are lost in the sparser regions of such a group.

The ability to view a large area in plan form, to track the movement of fish targets and to remotely direct catching vessels may have research and/or commercial applications. A powerful tool for fish movement and population studies would be a fixed sonar with electronic scanning facilities capable of generating a wide sector (or 360°) plan view every few minutes. Such an array could be semi-portable, connected either to a parent ship or shore station. As Weston and Revie[3] have demonstrated, a fixed sonar distinguishes clearly between moving and stationary targets. Towed variable depth sonars could be used to survey large areas quickly, but would require a second vessel in attendance to identify sample targets. It is possible that they could also be used in commercial fishing to improve efficiency, with a detector vessel standing off from the catching fleet transmitting total or selected target information. Time spent in 'hunting' could be significantly reduced, and a wider knowledge of the fishery gained for conservation.

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