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EXPERIENCES USING THE ES-400, SPLIT-BEAM ECHO SOUNDER, WITH SPECIAL REFERENCE TO THE SINGLE-FISH RECOGNITION CRITERION

by

E. Ona and I. Røttingen
Institute of Marine Research
P.O.Box 1870, N-5011 Nordnes, Norway

ABSTRACT

Realistic estimates of <u>in situ</u> target strength can be made when the fish concentrations are acoustically resolved into single individuals. In the split-beam echo sounder, as in all other systems available for <u>in situ</u> measurement of target strength, the pulse length of the received echoes is used for single-fish recognition. Measurements made in a clean layer of 0 and 1-group herring showed that the ES-400 echo sounder could produce unrealistically high target strengths when the fish density increased slightly above the level where all fish were resolved as individual targets. Results from comparing mean target strengths at several density levels indicate a too wide acceptance window in pulse length when measuring small fish.

INTRODUCTION

To obtain absolute acoustic estimates of fish density, detailed knowledge of the acoustic scattering properties of fish is needed. Results from different methods for obtaining this information is reviewed by MIDTTUN (1984). With the new SIMRAD ES-400 split-beam echo sounder, *in situ* measurements of fish target strength can be made continuously during a survey.

The split-beam principle and its specific use in the ES-400 is described by FOOTE *et al.* (1984). The single-fish recognition system used by the echo-sounder is based on measurement of the received pulse length of the echoes. A single-fish echo is accepted when its pulse, after filtering, amplification, TVG correction and beam pattern correction, is within 80 to 187 percent of the nominal pulse length, 1.0 ms. As the digitized data has a resolution of 10 cm, the pulse is accepted when its length, measured at threshold-level, is within 60 to 140 cm. An additional criterion is that the signal over at least 40 cm on each side of the pulse must be below threshold. (H. SOLLI, Simrad Subsea A/S, pers. comm.)

This report will present results obtained using the ES-400 on small herring, a situation in which the existing pulse length acceptance-window may be too wide.

MATERIAL AND METHODS

The measurements were made in Lavangen, a fjord in North Norway from the research vessel R/V G.O. Sars. Target strength observations were made at 4 and 8 knots during three surveys covering the stock of small herring in the fjord on the night between 24 and 25 November 1985. In two pelagic trawl hauls from the upper layers, the fish were identified as 0 and 1-group herring with a mean length of 13.2 cm. The layer was distributed over most of the fjord, in densities varying from zero to more than 1000 tons/nm^2 (Fig. 1).

The ES-400 was connected to the ND-10 computer which stored the data on the RS232 serial line from the echo-sounder. On the basis of integrated echo abundance and judging, the target strength data were classified into four typical density groups, and post-analysed in the actual depth layer and distance for each group.

RESULTS

In areas with very low fish densities, the ES-400 produced realistic estimates of mean target strength, comparable to earlier measurements on other species with the split-beam system. Already from the colour echograms and colour display, it was evident that when fish density increased, the upper tail of the target strength distribution exceeded the expected maximum values for this fish size. Examples of typical distributions obtained in low- and high-density areas are shown in Fig. 2. Calculated average target strengths obtained in samples from the different density areas is shown in Table 1. A general trend towards a higher mean target strength is seen with increasing fish density, with a maximum difference in mean value of 7.8 dB from very low to high density. A low, but significant increase is even seen from very low to low densities. From the echo traces on the colour printout, the upper tail of the TS-distribution seemed to be originating from several fish in "knots" being accepted as single fish. As most of the accepted dense-situation echoes come from the outskirt of the layer or school, the increase in mean target strength was non-regular, Table 1.

DISCUSSION

The main intention of this paper is to focus on the single-fish recognition system used in the ES-400 split-beam system. A general increase in mean target strength with increased fish density should not be expected if the system rejected all echoes from multiple targets. Even at low fish densities, the upper tail of the target strength distribution exceeds the expected difference between average and maximum target strength. From experimental work on fish directivity (NAKKEN & OLSEN 1977), this difference is estimated to be about 8-10 dB under normal fish behaviour conditions on large fish, and even less for fish of this size (FOOTE 1980). The observed difference observed on small herring is 10-14 dB. Considering also the threshold problem on the system, earlier mentioned by FOOTE et al. (1985), the observed difference may be larger if echoes near the threshold are rejected. This problem will not be considered here, but the lower limit of the pulse length window may be a effective threshold factor on small fish if echoes of lengths less than 60 cm above threshold are rejected. Both the threshold problems on small fish and the possible acceptance of multi-target echoes will force the average target strength towards a higher value.

The problem of single-fish recognition will be similar in all other systems for in situ target strength measurement where only the length of the received echo is used as selection criterion. If the larger echoes that are observed are produced by interference between neighbouring pulses, but are still within the applied pulse length criterion, the stability of angular data through the pulse may provide the necessary information for rejection.

By post-processing data from the parallel line on the ES-400, where all raw data are available, several improvements, concerning both the threshold problem and selection criteria, obviously can be made.

Using data from the serial line, or directly the diagrams produced by the echo-sounder itself, a careful selection of the data must be made to avoid strong threshold or multiple target-effects on the distributions of target strength.

CONCLUSIONS

A. The existing pulse-length criterion in the ES-400 may accept echoes from multiple targets as single fish. This is especially troublesome for small fish.

B. Acceptance of just a few multiple-target echoes as single fish will destroy the measurement of mean target strength because of its high relative weight.

C. Care should be taken when measuring target strength in non-ideal resolved fish distributions. Careful scrutinizing of the sampled data should be made to pick out optimal conditions for target strength analysis.

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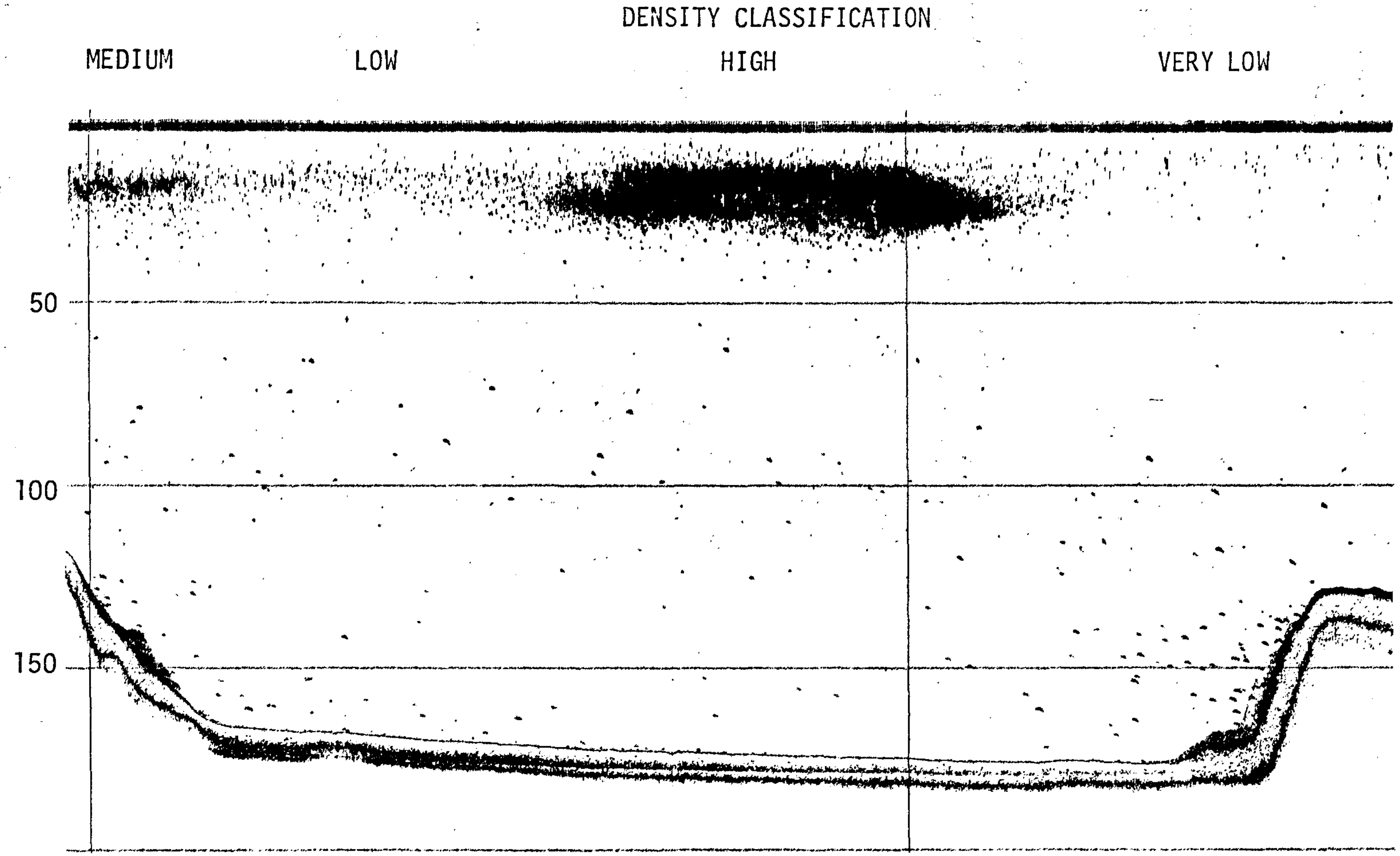
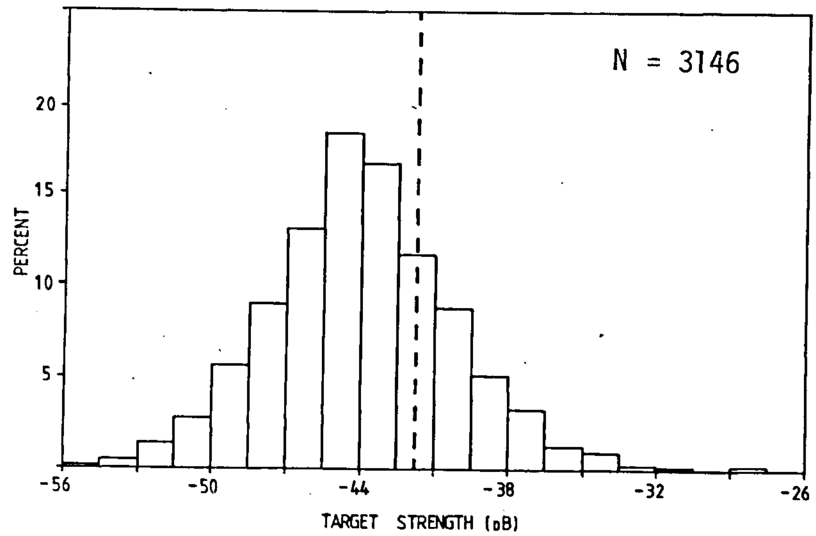


Fig.1. Echo recording showing a typical example of the fish density variations in which the target strength measurements were made. 0 and 1-group herring in the upper 50 meters.



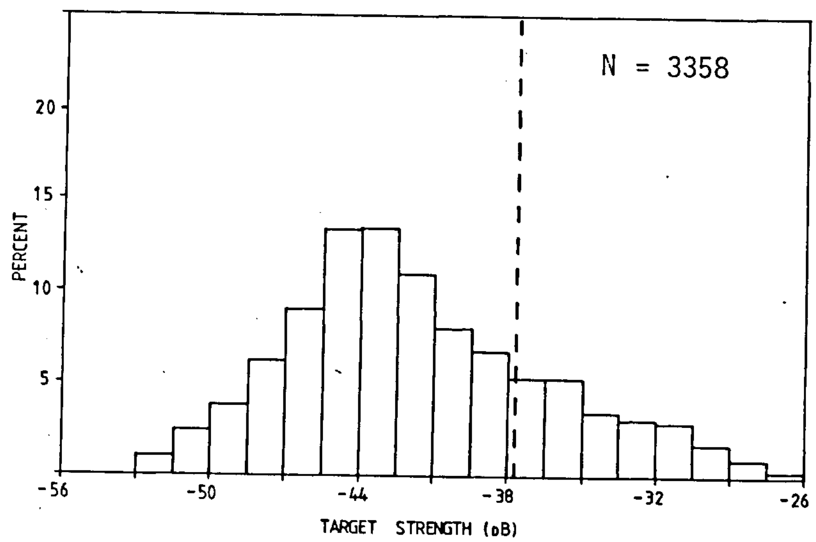


Fig.2. Examples of target strength distributions obtained in a very low-density area (A), with only a few multiple targets accepted, and (B); an example of a target strength distribution obtained in a medium to high density area. Note the heavy upper tail of the distribution, containing accepted echoes from multiple targets.

Table 1. Observations of average *in situ* TS measured by the ES-400 echo sounder on different densities of small herring. Average of 200 to 1000 single observations is shown. Absolute integrator output (m^2/naut.mile^2), together with the survey number is indicated.

	VERY LOW DENSITY M < 100	LOW DENSITY 100 < M < 1000	MEDIUM DENSITY 1000 < M < 5000	HIGH DENSITY M > 5000
I	-43.5 -43.9	-42.6 -41.6 -42.0	-39.5 -39.8 -38.3	-36.5 -38.1 -38.1
II	-43.1 -44.4	-41.6 -41.7	-39.9	-37.8
III	-43.0 -43.4 -44.1 -43.7	-42.9 -42.7 -43.3 -43.5	-42.5	-36.6 -40.5