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THE INVESTIGATION OF NOISE PRODUCED BY FISHING GEAR

by

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INTRODUCTION

There are many potential sources of acoustic noise within most practical fishing gears. In any device which moves through water, vortex shedding and other hydrodynamic effects cause noise radiation, either directly or by exciting oscillations of mechanical parts. The towing vessel is a powerful noise source and, in the case of bottom fishing gears, noise also arises from contact of the gear with the sea-bed.

Noise which is so generated may have considerable practical significance. It is well established(1) that commercially important species of fish can detect low level sounds over the frequency range 30-500 Hz, and that they may react to acoustic stimuli. Indeed, the efficiency of most fishing gears appears to be as much influenced by such behavioural responses as by purely engineering considerations.

This paper describes equipment developed for investigation of the acoustic fields generated by fishing gears, especially the otter trawl. The system is based on an array of hydrophones laid on the sea-bed, which can provide information on the location of the fishing gear in addition to monitoring the noise field. The technique is of general application, and could well be applied to the study of other fishing methods. Further, preliminary experience with the array suggests that it may be of value in tracking other underwater sound sources, such as fish fitted with acoustic tags.

Two ships are required to make noise measurements on the otter trawl. The first tows the trawl under test, and contains a logger for recording data on certain physical characteristics of the gear. The second is a silent listening vessel, containing signal conditioning and recording equipment, which is joined by cables to the hydrophone array.

HYDROPHONES AND RECORDING EQUIPMENT

The main elements of the signal processing system are shown in Figure 1.

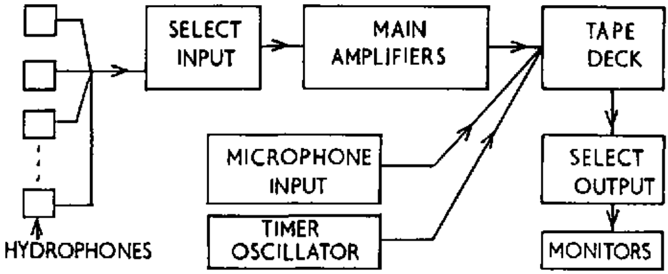

FIG. 1. HYDROPHONE RECORDING SYSTEM

The array consists of up to 20 separately laid hydrophones, each including a fixed gain pre-amplifier next to the transducer element. Low cost hydrophones are preferred for this application, as damage to hydrophone installations during trawling operations has to be expected and allowed for. For the same reason a simple and quick means of cable laying is vital. The maximum cable length required is 2000 metres, and 1000 metre lengths have already been laid in the course of development work. It is clear that lengths much over 1000 metres will require the development of different techniques and more elaborate equipment for cable handling.

All the hydrophone cables are run to a marker buoy, near the listening ship, where they are attached to a tether line and terminated in water resistant connectors. The cable ends are taken aboard the listening ship for connection to the recording equipment, but the link may be quickly broken at the connectors in an emergency.

The hydrophone connecting cable has four cores, two for signal and two for power. It has not been found necessary to use an overall screen on this cable, provided the system is balanced and the main amplifier has a differential input with good common mode rejection properties. The wideband electrical noise contributed by a submerged 1000 metre length of unscreened cable was measured on trials and found to be well below that from the hydrophone pre-amplifier.

The hydrophone signals are matched to the recorder inputs by variable gain amplifiers, adjusted manually. Usually the 14 available tape recorder channels will not be sufficient to allow simultaneous recording of all available hydrophone signals. A jack plug selector panel is therefore provided between the hydrophones and amplifiers, so that the most useful set of hydrophones may be easily connected up during the experiment. A microphone for commentary, and a timer which provides an accurately known p.r.f.

for reference, are also connected to the recorder input. A monitor facility is provided so that any input to or output from the recorder can be routed to one of two monitor channels, for connection to an oscilloscope, loudspeaker or other display device.

The frequency range of interest for the analysis of trawl noise is 1 Hz to 10 kHz. In this case the use of a frequency modulated (FM) tape recorder channel is indicated, as good signal to noise ratio and low frequency performance are required. However, the use of acoustic pingers to determine the position of the gear requires a better high frequency performance than is normally possible using FM. This requires the use of a direct record (DR) channel instead. These conflicting requirements are met by connecting each hydrophone in parallel to one FM and one DR channel of the tape recorder. The main amplifier driving each channel incorporates a filter to limit the frequency range input to the recorder, according to the type of channel. The frequency performance depends also on tape speed, the higher the speed the better. A limit is set by the playing time required per tape, which must be sensibly related to the duration of an experimental tow. Typically an FM channel can cover the range 0 to 5 kHz, while a DR channel extends from 50 Hz to 75 kHz, for a playing time of 60 minutes. Thus almost all noise frequencies of interest are recorded on the FM channel, with good overlap for extrapolation to higher frequencies using the DR channel recording.

ANALYSIS

Before any quantitative analysis of noise recordings can be done, it is necessary to locate the various parts of the trawl gear relative to the hydrophone array. The data required to do this can be classified as information on

(a) Gear geometry

(b) Array geometry

(c) Location of the gear relative to the array

For the first of these, a number of instruments are available which can be attached to the gear to measure certain of its physical characteristics[2].

In the case of the array, the relative positions of the hydrophones can be accurately determined using a synchronised pinger, an instrument which emits acoustic pulses at a well defined pulse rate. Before and after each experimental tow, the pinger is lowered to the sea-bed at several points around the array, and the pulse arrival times at the various hydrophones are used to compute the required position data from an initial approximation. Four independent pinger points provide enough information to compute the relative positions of three or more hydrophones. The use of a transponding system would be a more direct process, but is not practical in this application because of the need to simplify the expendable underwater installations as far as possible.

During an experimental tow, the location of the gear relative to the array can also be determined by acoustic means, using a pinger attached to the gear at some suitable point (usually the headline centre). The gear orientation will become known from a plot of successive positions, or by using a second pinger.

Starting with this information, the analysis of trawl noise recordings could proceed in a number of ways. Which will be the most profitable will become clear once full scale trials are under way. Correlation of the signals from a number of hydrophones could locate specific noise sources, if these were sufficiently localised in space and had an appropriate time dependence. On the other hand, the gear as a whole would contribute to the spectrum of the signal from a single hydrophone. By presenting such an analysis as a chart showing 'isobars' of sound pressure around a gear, some idea of herding efficiency may be obtained, and comparisons of different designs made.

When tape recordings are replayed for analysis, pinger pulses, being modulated at a relatively high frequency (ca 20 kHz), can be easily detected by a bandpass filter/discriminator for timing purposes. Broad band noise, however, has to be digitised for interface to a computer, where these data can be accessed for frequency and other analysis by program. A fast ADC is required for this, but relatively limited resolution (8 bits or more) is sufficient. The operating speed of the ADC is directly related to the upper frequency limit of the analysis. If real time analysis by a computer on line to the tape recorder is required, then the top frequency may instead be limited by program running times. In either case, the top frequency may be effectively increased by replaying the tape at a speed lower than the record setting. This technique does introduce other problems, of course, but can be made to work if there is no other way of reaching the required top frequency.

REFERENCES

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(2) MacLennan, D.N. 1969. "Instrumentation for the on-line measurement of the environment and performance of fishing gears." Oceanology Conference, Brighton, Feb. 1969.