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THE DEVELOPMENT OF ACOUSTIC INSTRUMENTATION IN FISHERIES RESEARCH AND COMMERCIAL FISHERIES IN NORWAY

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INTRODUCTION

Acoustic instrumentation for fish detection was first recognized by Bokn (Anon. 1934). Sund (1935) applied the technique of echo sounding to detecting cod concentrations in the Lofoten area. In 1936 Runnström (1941) applied the same technique to the detection of the spawning concentration of Atlanto-Scandian herring off the Norwegian coast. These experiments were so successful that the most go-ahead fishermen ordered this equipment and applied it to the commercial fisheries. Rollefsen in 1935 (Hjort and Ruud 1938) used an echo sounder to detect a soft-floor, which is the usual habitat for shrimps, by careful inspection of the bottom echo traces.

SONAR was applied for the first time for herring detection off the Norwegian coast by Lea in 1946 on K.N.M. Eglantine. Gerhardsen, later chief engineer at the electronic firm SIMRAD, took part in these first successful experiments (Gerhardsen 1946). In the following two years the experiments were continued, Devold being in charge in 1948. The results were so promising that in 1950 a SONAR system was built for the Norwegian research vessel "G.O.Sars", this being the first system made for fish detection. During the early fifties both echo sounders and SONAR sets were used by Devold for herring location (e.g. Devold 1951). Sunds' results from the Lofoten area encouraged the systematic surveying of the Lofoten spawning grounds to find the distribution and concentration of the mature cod stock. By 1955 echo sounding was applied to the systematic investigation of cod and haddock in the Barents Sea. This was the first attempt at recording echoes from single fishes at depths down to 300 m. The white line echo trace was developed by the research team on R.V. "G.O.Sars" to distinguish clearly between the bottom echo and fish echoes close to the bottom (Midttun, Sætersdal, Vestnes 1957).

Close cooperation between the Norwegian electronic firm Simrad and the

Institute of Marine Research in Bergen led to the development of specialized forms of echo sounders and SONAR sets for use in both fisheries research and the commercial fisheries.

General reviews of the application of acoustics on fish detection including also the activities in Norway, have been given by Cushing, Devold, Marr and Kristjonsson (1952) and by Hodgson and Fridriksson (1955).

APPLICATION TO MARINE RESEARCH

Equipment

At present both the research vessels, "G.O.Sars" and "Johan Hjort", are equipped with Simrad Research SONAR / Sounder, and in addition each ship has three other sounders working on different frequencies. The Research SONAR / Sounder works on two frequencies (11Kc/s and 30Kc/s) and both can be used as either SONAR or echo sounder. This research equipment also includes an oscilloscope which makes it possible to measure the precise value of the echo intensity level. The source level and the sensitivity of the receiving unit are calibrated by the usual microphone method. The instrument includes an amplifying circuit to automatically compensate for the geometrical spreading of the acoustic beam, both for the transmitted and reflected signals. This enables the target strength to be measured directly. The 30Kc/s echo sounder is connected to a system, developed at the Institute of Marine Research by Hoff (Dragesund and Olsen 1965), which integrates the sum of the echo signals over the period of time triggered by the ships' log. The other echo sounders are standard equipment working at 18Kc/s and 50Kc/s. Furthermore a 38.5Kc/s echo sounder has two simultaneously working recorders and three different oscillators for alternative uses. For operation and maintenance of the equipment one engineer and two assistants are always on board the ship.

Application

One of the most important applications has been the studying of the distribution and migration pattern of herring in the Norwegian Sea and in the coastal areas of Norway. This investigation has been introduced and carried out by Devold (Devold 1950, 1951, and 1962).

By a combination of SONAR and echo sounding it proved possible to map out the precise distribution of the shoals at any time of the year. Hydrographical observations were made along the path of the survey and a close correlation has been found between the hydrographical conditions and the distribution of the herring shoals, which enabled Devold to plan the survey route more thoroughly. By a series of surveys Devold has been able to forecast the time and the location of the arrival of the herring shoals to the spawning grounds. During the migration towards the coast and on the winter herring grounds as well as during the feeding period in the Norwegian Sea he has been able to advise the fishing fleet where to go.

A research team consisting of Midttun, Sætersdal, and Vestnes has been working in the Barents Sea. This team started a survey programme in the mid-fifties mapping out the distribution of cod and haddock in the Barents Sea. The programme was extended to include the migration route of cod from the western part of the Barents Sea over the coastal banks to the spawning grounds in the Lofoten area (Midttun and Sætersdal 1956 and 1958, Midttun, Sætersdal and Vestnes 1957). The investigation also revealed a relationship between the distribution of the fish and the hydrographical conditions. This was most pronounced during the spring cod fishing off the coast of Finnmark and on the eastern fishery grounds of the Barents Sea during autumn. Since the distribution of cod and haddock affects the availability, it is important that the fishing fleet knows of these conditions (Hylen, Midttun, and Sætersdal 1961, Midttun 1965).

A similar technique to that used by Devold for herring research has been successfully adopted by Olsen (Olsen 1960, Møller and Olsen 1961) for capelin in an attempt to follow the migration of the capelin to the spawning area.

An important application of the acoustic survey has been carried out on 0-group fishes in the Barents Sea and the north-eastern part of the Norwegian Sea. This work started in 1959 on 0-group herring by Dragesund (1959), and was later extended to include other important fish species such as cod, haddock, redfish, and capelin. These investigations have shown that the 0-group fishes in late summer and early autumn in this area appear as a scattering layer from the surface down to 50 or 100 metres. This layer was observed by Midttun, Sætersdal, and Vestnes in the mid-fifties, but was not then investigated symetically (Midttun 1959). In the investigations of observing 0-group fishes in the scattering layer there are two main problems at present, namely the question of identification and the measuring of the abundance of each particular species. However, by studying the trace pattern and/by frequent trawling, it is possible to get a fairly reliable estimate of the different species in the scattering layer. By measuring the total echo abundance of the scatterers with the echo integrator it is possible to establish the relative strength of the different species (Dragesund and Olsen 1965).

Using this method it is possible to estimate the year-class strength of the different species at the 0-group stage. This has especially been shown for herring (Dragesund and Hognestad 1959). This 0-group survey programme has for the last two years been carried out with the cooperation of the U.S.S.R., and last year Great Britain also joined in (Anon. 1965, 1966).

Aspects

Generally two main problems are involved in acoustic methods of fish abundance estimation. Firstly the problem of identification and secondly that of counting. Concerning the first problem, underwater photography has been used in Norway (Midttun and Sætersdal 1959, Olsen 1966). The intention is to carry on along these lines by improving instrumentation and technique. A direct acoustic identification might also be possible either on single fish or on shoals of fish. However, a detailed knowledge of their target strength is required. At the

Institute of Marine Research such measurements have been made on cod and coalfish (Midttun and Hoff 1962) showing differences in the reflectivity pattern which might be used for helping a direct identification of these species. A technique for measuring the target strength and recording the echo trace patterns from single fish at sea has been introduced (Midttun 1966).

Concerning shoals of fish it is most likely that the shoal patterns may show such peculiarities that identification is possible. Knowledge about this can only be gained through experience. Already some preliminary data has been obtained by applying the echo integrator to capelin shoals (Olsen and Hoff verbal communication).

The next problem is that of measuring the number of fish scatterers. A simple counting method can be used as long as the single fish can be distinguished. In denser layers and in shoals this method can not be used. There are two ways of solving the problem. Firstly by using such high resolution that single traces are countable. Encouraged by good results obtained in England where high frequency transducers have been used for the purpose, a 100Kc/s echo sounder is under development at the Institute of Marine Research. This instrument should give a narrow beam and a short pulse length. Secondly is that of measuring the multiple echoes by using the integrator, but more knowledge of the laws of multiple reflection is necessary to obtain full application of this method. A combination of the HF sounder and the echo integrator should probably give valuable information.

APPLICATION TO COMMERCIAL FISHERIES

Although some fishermen had obtained echo sounders at the end of the thirties it was not until after the Second World War that they were widely used and by the end of the forties most vessels were equipped with this apparatus.

Soon it was appreciated how very useful echo sounders were in the herring fleet, so that even the small "bas" boats were fitted out with them. By the mid-fifties Simrad had developed a device which could be used as both SONAR and echo sounder and this was soon widely used by the "bas" boats in the herring fleet. BASDIC, as it was called, had a transducer which could be both rotated and tilted to facilitate the search for herring shoals. The fishermen were encouraged by the results obtained by Devold from the R.V. "G.O.Sars" and by their own experience with the BASDIC. Soon they showed interest in the SONAR sets which were on the market and the purseine fishing boat "Ramoen" was the first in Norway to purchase such equipment in 1953. The Norwegian firm Simrad paid great attention to this type of equipment and by the late fifties most of the Norwegian herring fleet was using the Simrad apparatus.

The SONAR systems have been continously improved and Simrad has continued to develope new sets from that time to the present day, and now the herring fleet considers such apparatus to be necessary in their vessels.

At the same time as the SONAR sets were being introduced to the herring fisheries, there was much close cooperation between the Institute of Marine Research and Simrad in the improvement of echo sounders. By 1957 the white line recordings were introduced and this enabled both shoals and single fishes to be distinguished from the bottom / recording. This is of particular importance to trawlers. It was now possible to judge the density of shoals using this technique and therefore also the herring fleet made use of this apparatus.

As the fishing fleet was adopting more and more echo sounders and SONAR sets, it was very important to educate the fishermen in both the theoretical and practical application of the apparatus. Vestnes, who was also busy with the acoustic research work at the Institute of Marine Research in Bergen, made it his business to see that a very thorough training programme was carried out in many Norwegian fishery towns.

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