ACOUSTIC CHARACTERISTICS OF DEEP SCATTERING LAYERS AS RELATED TO OCEANOGRAPHIC PROVINCES

O. Z. Bluy, R. H. Adlington and R. P. Chapman
Defence Research Establishment Atlantic
of the Defence Research Board
Dartmouth, Nova Scotia, Canada

The characteristics of sound backscattered from layers of biological origin in the deep ocean have been the subject of several investigations. These characteristics give information on the densities and sizes of scatterers and their distribution with depth. The parameter most often measured is the scattering strength as a function of frequency, time of day, and location. Near-surface fired explosives were used as sound sources and hydrophones as omnidirectional and directional wideband receivers. The directional unit, an inverted cone reflector containing a line hydrophone, permits a constant, narrow beamwidth over three octaves; thus it is superior to the conventional single frequency echo-sounder for detecting the resonant scatterers of biological origin which are the main contributors to reverberation from the ocean volume. Measurements made in the North and South Atlantic and in the Pacific over a wide variety of oceanographic conditions indicate that major changes in scattering behaviour occur near oceanographic boundaries.

Sound backscattered from the volume of the ocean has become a subject of considerable interest to marine biologists and underwater acousticians. This phenomenon, called volume reverberation, is caused by inhomogeneities in the ocean, such as bathypelagic fish and other marine organisms. When these contain gas bladders they scatter sound at selective frequencies and this permits underwater acoustics to be a powerful tool for obtaining information on the sizes and numbers of these organisms.

In the deep ocean, marine organisms are found in horizontal layers in the depth interval between the sea surface and about 1000 meters. Some undergo daily migrations, rising toward the sea surface at sunset and returning to depth at sunrise. Since the scattering properties of these organisms depend on their depth and size, pronounced changes in the properties of scattering layers would be expected with time of day and location.

Since 1959, DREA has been engaged in a program to measure the acoustic properties of deep scattering layers. Most of the measurements have been made in the North Atlantic, although within the past year the investigation has been expanded to include sites in the South Atlantic and in the North and South Pacific.

The extent of coverage is shown in Figure 1. A total of 136 sets of measurements were carried out during sixteen cruises in the North Atlantic, usually starting two hours before and ending two hours after sunset. A number of sites, particularly those between Halifax and Bermuda and Halifax and the Azores, were visited more than once.

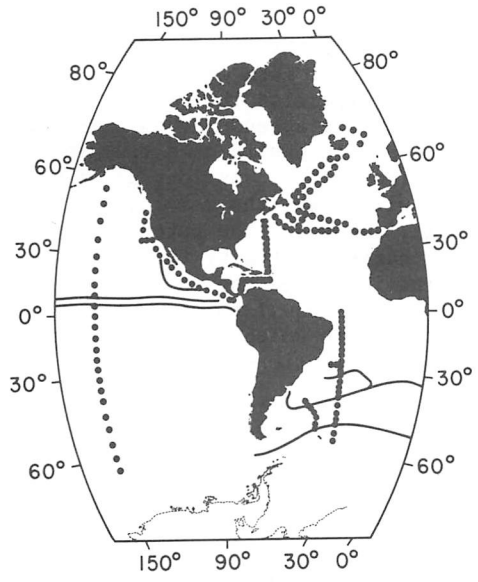

Fig 1 - Acoustic Station Locations

Thirty-two sites were occupied in the North Pacific along the western coast of North America, forty-five sites in the South Atlantic and twenty-four in the Pacific along 150°W. The solid lines represent some of the oceanographic boundaries crossed.

Explosive charges were used as acoustic sources because of their wide frequency range and non-directional properties. The resulting reverberation was received on an omnidirectional hydrophone and on directional receivers. In the past thirty months the directional receiver used has been a line hydrophone on the axis of a 90° cone of 2m aperture. Figure 2 shows this array. The effective aperture, and hence beamwidth is varied by selecting various lengths of the line hydrophone. It is thus possible to maintain a similar beampattern over several octaves. The "cone" receiver is easy to handle and produces signals which can be interpreted without extensive additional signal manipulation. Sample records of the same shot from the omnidirectional hydrophone and cone receiver are compared in Figure 3. The layers at 450 and 600 m

Fig 2 - Cone Receiver Being Launched

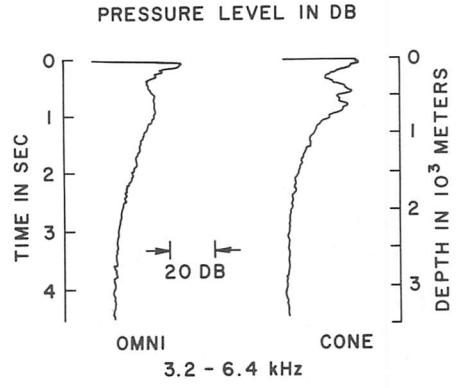

Fig 3 - Received Pressure Levels

are much more readily discernible in the right-hand trace. The initial rise is due to the direct received signal from the charge.

Use of the directional receiving array has produced some interesting results from stations occupied in different oceanographic areas. Scattering strengths tend to change in a fairly well behaved manner over distances of many hundreds of miles, with the more dramatic changes occurring in the neighbourhood of oceanographic boundaries. Deep non-migratory layers have been observed at low frequencies in some areas, indicating relatively large scatterers.