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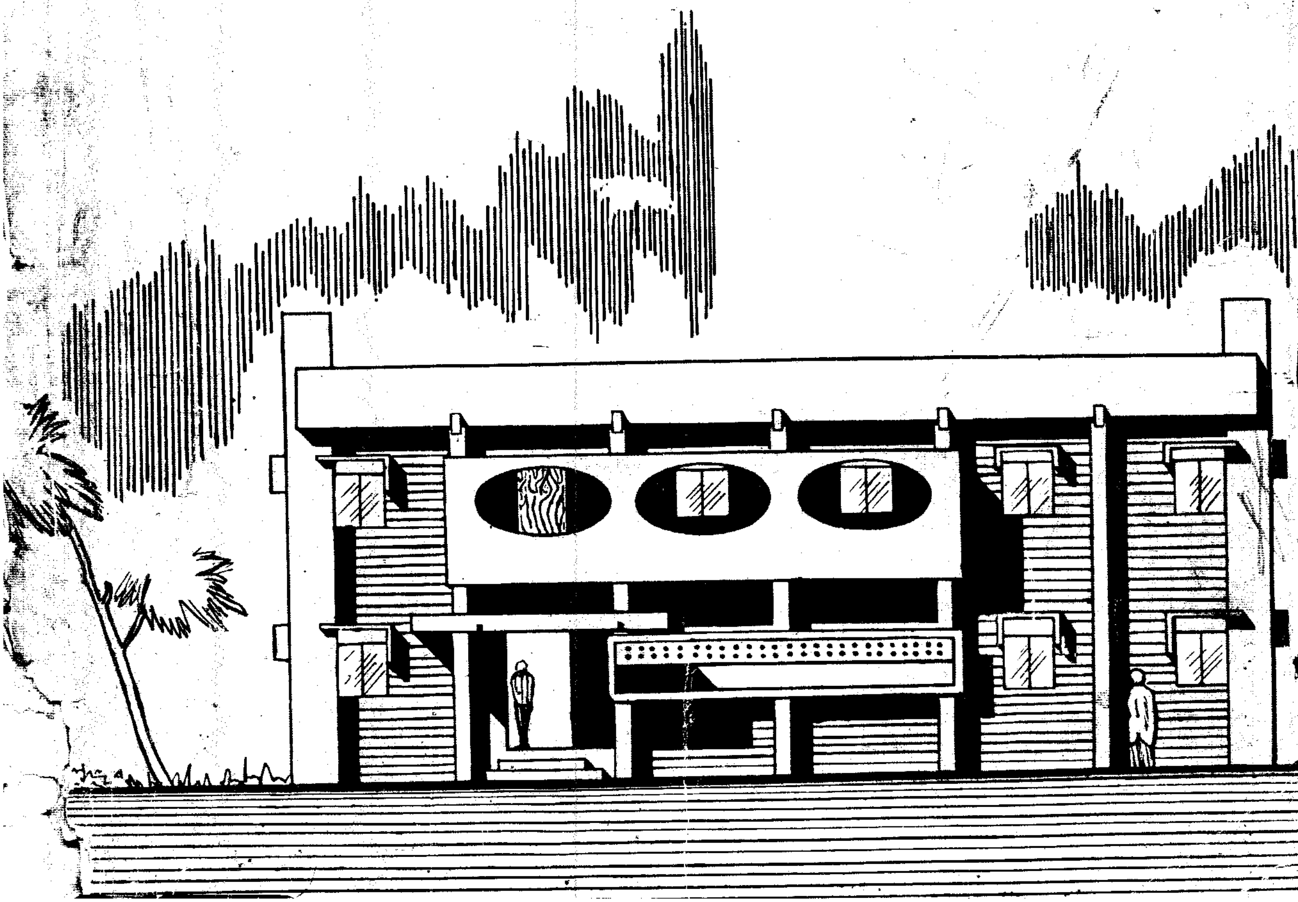

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# *Echo sounding

## -its principles and applications in fisheries

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We make use of different energies like light, electricity and sound for perceiving objects. In nature animals take advantage of light for vision but some like the bats are known to 'echo locate' objects using sound. All these energies travel in the form of waves. While the 'Radar' uses electric or radio waves for scanning the atmoshere the 'Sonar' and the 'Echosounder' use sound waves for underwater observations. Light and radio waves are less efficient or unsuitable for underwater observations due to the loss of the energy during travel through water. Sound or acoustic waves in this respect are found more suitable.

Sound is a process of oscillation or vibration which we hear as noise. It is based on vibration of the actual material of the medium through which it is transmitted whether liquid, gas or solids and are recognised as the periodic variation of pressure in the medium. Because of this, sound cannot travel in vacuum. Sound travels at about 300 m/second in air. In water it is more quick, travelling at about 1500 m/second. In salt water it is faster than in fresh water and is faster in warm water than in cold water.

The number of oscillations (waves) produced in a second is called frequency. One cycle signifies one oscillation per second. 1000 oscillations or cycles are called one kilocycle. This terminology is also expressed as 'Hertz' (Hz) and Kilo Hertz (kHz).

The human ear senses sound frequencies between about 16 and 20,000 cycles/second. This is the audible or 'Sonic' sound. Sounds above this range which human ear cannot hear are called 'ultrasonic' sound. In echo sounding chiefly ultrasonic sound frequencies are used.

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The property of sound waves reflecting back when it hits another medium different from the one in which it travels is echoing. This is well illustrated in such common place phenomena as the echo of a shout or of the echo from a woodcutter's axe. The echoes are heard after a time lapse depending on the distance of the barrier which reflects back the sound. This time lapse is equal to the time taken by the sound to travel to and back from the barrier. The distance of the object which echoed the sound can be calculated since we know the speed of sound per unit of time in the medium. This principle is made use of in echo sounding. In water objects such as fish and sea bottom reflects the sound back.

Ultrasound will be reflected better by smaller objects such as fish; also most of the audible noise from the engine and running of the ship will not be picked up when using a receiver tuned to ultra sonic frequencies. However, the range of ultrasonic sound is shorter than that of audible sound. But, for fish finding purposes and normal navigational uses ultra sonic sounder range is found to be suitable. A standard ultrasonic echosounder is able to measure depths upto about 2000 m. Echo sounders were first developed only to find the depth of water by sending sound waves (sounding) vertically. During the course of the last quarter century this has been perfected for fish finding and other instruments for horizontal scanning of the water around have also been developed. Horizontal scanning sounders are conventionally known as 'Sonar' (Sound Navigation and Ranging) or (Asdic). Nowadays acoustic methods have been incorporated as part of the standard operational technology in commercial fishing, by modern fishing fleets.

In echosounding a high voltage electric pulse of predetermined frequency generated by a pulse generator which after sufficient amplification is converted into an ultrasonic sound pulse and transmitted into the water by an instrument called the transducer. The transmitting transducer also acts as a receiver of the sound when reflected back from the bottom of the sea or from objects like fish. The receiver can also be separate instrument mounted near the transmitter but often one transducer serves the function of transmission and receiving in ordinary instruments.

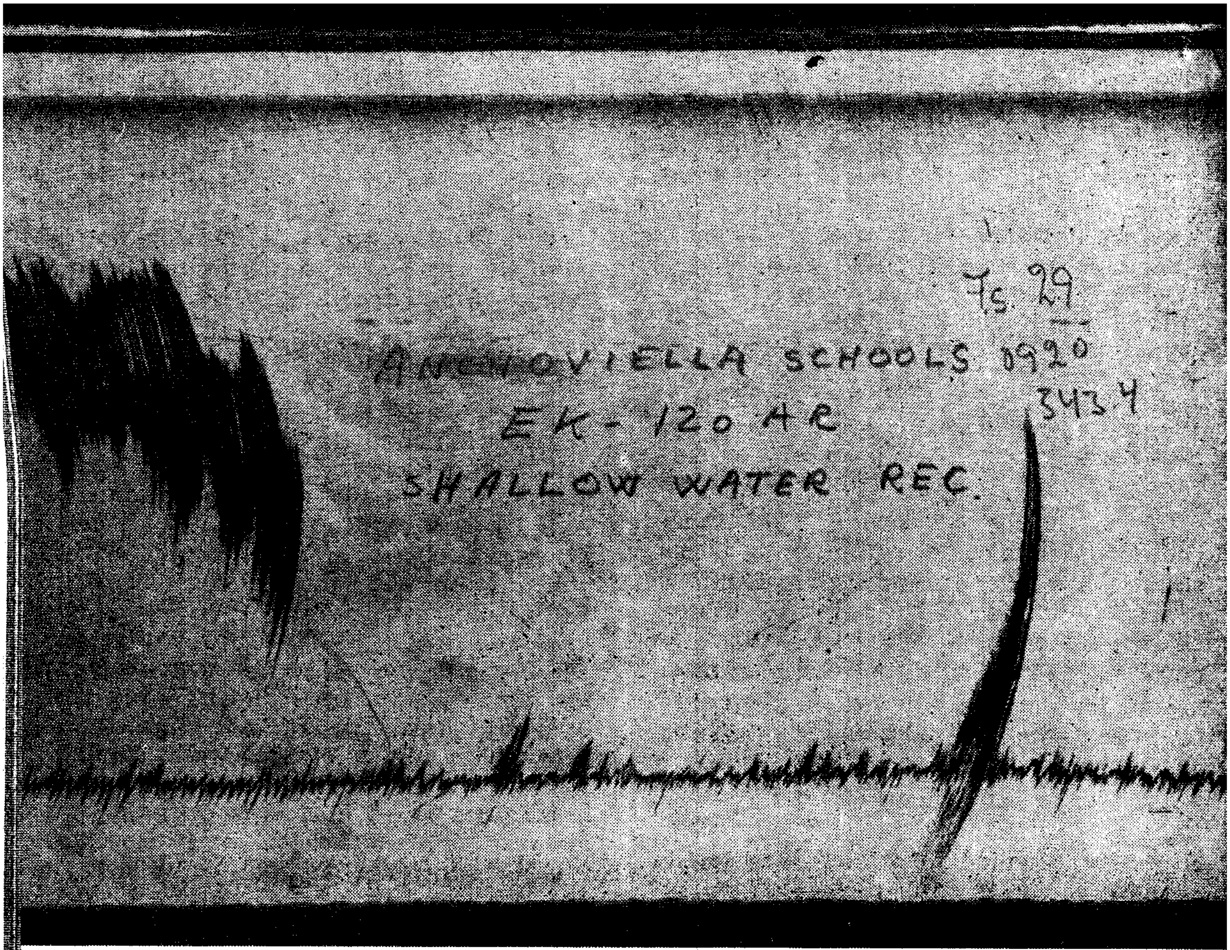
Structurally a commonly used transducer is a pile of laminates of feromagnetic substances such as nickel or nickel like alloys. These are termed 'magnetorestrictive' transducers where the material used expands and contracts according to the strength and direction of the magnetic field induced by the applied electrical pulse. Such transducers are used for low frequencies upto 100 kHz. In high frequency 'Electrorestrictive' transducers other materials like Barium titanate and lead zirconate titanate are used. These materials exhibit electro-restrictive property where a change of diamension takes place in relation to the magnitude of the applied electric field. Piezoelectric transducers like those made of quartz crystals are based on the 'piezo electric' effect where certain crystals when subjected to pressure, generate electric charges or they contract or expand a bit when electric charges are passed on to them thus generating vibrations. The conventional magnetorestrictive transducer of echosounders is about the size of 10 x 20 cm and the size selected depends upon the required power output and wave length of sound transmission and usually not greater than 30 x 30 cm. Transducer mounting position on the hull is selected so as to avoid extraneous disturbances like propeller noise airbubble interference etc. and is usually fitted in the anterior third of the hull. Transducer assembly may be external (limpet mounting) or partly internal using a steel housing (inserted mounting). Piezo-electric transducers have to be fitted in a water tight container.

When reflected echoes hit transducer it vibrates in rythm with these sound waves producing corresponding electric pulses. The electric pulse generated by the returned echoes is amplified by an amplifier in a similar manner as sound volume is regulated in radio sets. With low amplification only strong echoes are indicated, while with higher amplification correspondingly weaker echoes will be recorded. Sophisticated amplifiers are now available with automatic control known as 'Time Varied Gain' which moderates the amplification in relation to depths. The time between transmission and return of the echoes is measured and synchronised with the recording by a 'time base'.

Display of received echoes from reflecting target is made to fit requirements. The most common method is the marking of the echoes converted as electric pulse, by a stylus of hard material such as tungsten on chemically treated paper, which shows a dark mark when an electric current is passed through it. Wet and dry papers are used. Wet paper is more sensitive to weak echoes and shows different degrees of colouring according to echo strength. But recordings fade away quickly. Dry paper keeps the marks permanently and can be studied even after a lapse of time. The echoes from the sea bed takes the pattern of the contour of the bed. Depth of sea or objects are measured by a transparent scale calibrated in relation to the recording paper width and mounted in front of the recording paper.

Echoes from different objects manifest themselves on recording paper differently. A trained eye can always distinguish recording of broadly different objects easily. Even recordings of similar objects like various species of fishes are identified by careful study. An auxillary equipment operated in conjunction with the echo-sounder in estimating the quantity of fish is the Echo-integrator. This instrument accummulates the electrical signals from the echoes from fish for each mile run by a ship and displays the values graphically in terms of millimeter deflections of a stylus. The sampling depths can be adjusted and echoes from the sea bottom, cut off while operating the Integrator. This has opened up a very quick and easy way of surveying fish resources by acoustic methods. The density of fish schools in terms of its size and number etc., can be calculated. Thus by a ship running fixed course tracks in any area of the sea could accumulate a lot of information on the types of fishes and approximate quantities of these fishes.

Oscilloscope flash display of the instant picture following every echo is another method used in echosounders. Recordings on an echo-sounder which are known as echograms are simple to read and intrepret. Fig. 1 shows a typical dry paper echogram as obtained from a simple SIMRAD echosounder. The sea surface (top horizontal line), fish schools (vertical dark patches), the sea bed (the irregular line profile at bottom) with some smaller fish schools are seen clearly.

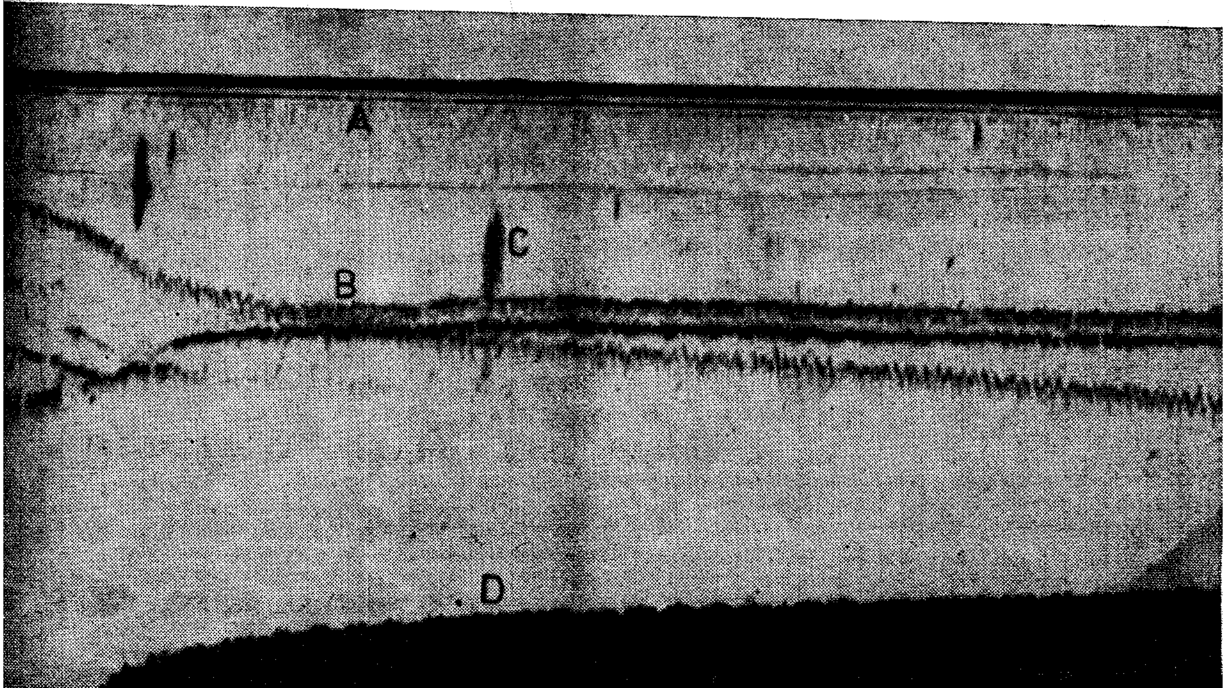



The recordings give different patterns depending on the type of fish, density of shoals etc. Large fishes will give different type of recordings from those of small ones, plankton etc. Fishes with air bladder has better sound reflecting properties i.e. to say that 'target strength' will be higher. Such properties are taken into consideration for identification of echo producing objects. A hard rocky sea bottom reflects sound better than a soft muddy bottom which absorbs more sound than the former. In the case of hard bottom or objects, what are called double echoes, are recorded. These come from a portion of the reflected sound side passing by the receiver, bouncing back to the bottom and returning to be received as before to give a weaker pattern of the original. This in a way helps to recognise the nature of the sea bottom which is of practical advantage in fishing operations. White line recording is an added facility in modern echo sounders to enable detection of fish very close to the bottom easily. Here the signals from the bottom which are stronger are clipped off partially or fully and the fish echoes displayed prominently. The bottom appears as a white line.

For observations on pelagic fish the 'Sonar' is used. In this a turnable transducer is used and it can be trained manually or automatically to transmit sound in nearly horizontal positions or tilted downward to be used as an ordinary echosounder. The scanning range of the 'Sonar' may be upto a distance of 3000 metres. Transmitter power and pulse length are greater in sonar. Long pulse length enables reflected echoes to be received as an audible tone and fish shoals can be 'heard'. A speaker is provided for this. The transducer is covered by a streamlined dome made of steel or fibreglass and is rigged for movement in different directions — the sonar has become a very useful aid in purse seining of pelagic fishes, and is a standard equipment with any modern purse seiner.

More sophisticated 'sonars' like the sector scanning sonar and frequency modulated sonar have been developed during the past few years and these instruments are used more for specialised studies on fish behaviour in relation to fishing gear and such other finer problems in fishing. In these equipments modifications are effected in the echo-receiving and display systems. The transmission and receiving functions are carried out by two different units in the frequency modulated sonars.

An instrument differently known as 'Net sonde', 'Trawl eye' etc. used in midwater trawling enables following of the trawl in operation, the state of opening of the trawl and the behaviour of the fish in and around the net. It is practically an echo-sounder unit with transducer housing attached on the head rope of the net and consisting of two transducers one sounding upwards and another downwards. The transducers are linked by a cable to the recorder unit on the bridge of the ship. The cable is spooled out from a shelf adjusting winch which regulates the tension of the cable according to time with the net under tow. Such instruments without cable are also in vogue when an extra receiving transducer mounted on the hull takes up the echoes for transmission to the recorder unit. Fig. 2 shows the



echogram patterns where a net sonde is in action during pelagic trawling. It shows the level of the head rope of the trawl (A), foot rope level (B), fish schools (C) and the sea bed (D).

'Sonar data display' is a system recently developed by SIMRAD of Norway for use in purse seining. This method projects the entire fishing operations assisted by a computer and displays the position, direction, relative motion of the vessel, marker buoy and fish semipictorially. A multibeam transducer is used in this case. Though not at present used for commercial use, this development is a significant step in the direction of making use of acoustic science for the betterment of fishing.

Very recently development of an ultrasonic imaging system has been reported from the United States. The equipment uses extremely high frequency sound waves. The reflected echoes are processed to form a picture similar to a television image. We may visualise that techniques like these further developed will help the fisherman to sea the pictures of fish schools as they are and help them to set their nets on schools they choose with deadly accuracy — a tremendous stride indeed if accomplished.