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USE OF ECHO SOUNDERS IN THE FISHERIES

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INTRODUCTION

Since early times man has been interested in fish. Almost as long as he has been interested he has taken fish commercially to sell or trade to others, but the tools of the commercial fisherman have changed little in recorded history. True, bone hooks have long since been replaced by steel. Fabric netting has in some cases given way to nylon or other synthetics. "Elbow grease" has in some instances been replaced by powered net hoists. But there have actually been few significant or revolutionary advances. Of course, gasoline or Diesel engines for motive power have also replaced oars and sails in fishing boats and automatic power reels have been introduced to aid the deep-water line fisherman, but of all the advances in the fishery industries, the most outstanding has been the introduction and use of echo-sounding gear.

Echo-sounding gear has given the commercial fisherman new eyes—eyes that see through water, clear or cloudy, to depths once thought unfathomable. "Underwater Radar," "Electronic Fish Finder," "Underwater Road Map," are only a few of the familiar nicknames given to this equipment by fishermen.

Echo-sounding gear is revolutionizing the methods of operation of almost all types of commercial fishing. Fishermen throughout the world, at first somewhat cautious in accepting this new idea, are now demanding this gear in such quantities that manufacturers are hard pressed to meet the demand.

PRINCIPALS OF ECHO SOUNDING

For a thorough understanding of the importance of this revolutionary gear, it is necessary first to understand the principles of echo sounding as now employed.

Echo sounding—the name is ultimately descriptive—is literally the function of measuring the depth of water by means of echoes bounced off the bottom and timed in their passage. The equipment to accomplish this function could be, and once was, simply an audible sound-making device, a stop watch or other timing mechanism, and a sound amplifier for reception of the echo. Actually, the sound employed for this purpose may be of any frequency within the audible or superaudible range. Years of research and practice, however, have shown that frequencies of from 20 to 50 thousand cycles per second are best suited for this purpose. Fortunately, sound frequencies anywhere within the sonic and ultrasonic range have the characteristic of traveling at essentially the same speed in the same medium and of being affected but little by changes in the degree of salinity or temperature of the water.

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To be scientific, however, it must be admitted that the changes in the character of the water do cause inaccuracies. Actually, the speed of sound in any liquid is given by the relation: velocity in meters per second = the square root of k/p (where k is the adiabatic bulk modulus of elasticity, and p is the density of liquid). In fresh water at a temperature of 8° C. (46.4° F.), this velocity is 1,427 meters (4,681.7 feet) per second. In sea water of 35-percent salinity, the relation becomes: velocity in feet per second equals 4,756 (13.8t + 0.12t^2 where t is the temperature of the water). At 8° C. (46.4° F.) the velocity from this relation is 4,858.7 feet per second. It will be noted that the difference in velocity between fresh water and salt water at the same temperature is small enough to be of interest only to surveyors and of no importance to the commercial fisherman. As most echo sounders are designed for use in sea water and not provided with compensators for changes in density or temperature, the maximum error of approximately 177 feet per second (only 3.6 percent) is encountered only by the unusual fishing boat which may operate in both sea water and fresh water.

Incidentally, some time ago, a rumor was circulated to the effect that the energy emitted from some echo sounders was harmful or disturbing to fish. This rumor was without foundation. In fact, there is conclusive evidence that fish are oblivious to energies of the strength and frequency emitted by most echo-sounding devices.

Present-day mechanisms for producing the sound, timing the passage, and receiving and indicating the echo are generally combined into a single-unit system. The timing, which is the heart of the mechanism, is accomplished by means of a constant speed motor drive which carries the transmitter keying contact and some means for producing an indication of the echo, and relating the time of reception to the time of transmission along a graduated scale. An indicating echo sounder commonly employs a revolving disc to which is attached an electric lamp. At the zero position of the disc, the transmitter is energized and the sound is emitted from the underwater soundhead or oscillator mounted in the hull. When the echo is received and amplified, it causes a flash in the electric lamp which has meanwhile been rotated to an angular position corresponding to the elapsed time. The indicator is so constructed that the flash of light from the lamp is immediately comparable to a graduated scale marked in units of depth so that a direct reading of depth is obtained. To obtain maximum benefit and utility from such an indicator it would be necessary to observe the flashes continuously and to record the data thus obtained in the form of a graph. This would require two operators, one to observe and one to record. For this reason the depth indicator has limited application except for purely navigational purposes, as a single operator finds it impossible to observe the indications continuously and to visualize the true contour or other characteristics of the surfaces from which echoes are received.

A recording echo sounder employs the same basic principals as the indicator, but produces its data as a permanent (or in some machines semi-permanent) mark on a graduated chart, thus doing automatically and instantaneously the complete job which might be done by an indicator and two highly efficient operators. The recorder completes the job only started by the indicator, and produces a complete picture, in profile, of the bottom contour or of the size, shape, and density of reflective matter between the surface and the bottom. There is hidden importance in this last statement as it is from this ability that the name "Fish Finder" and a whole new field of application has arisen.

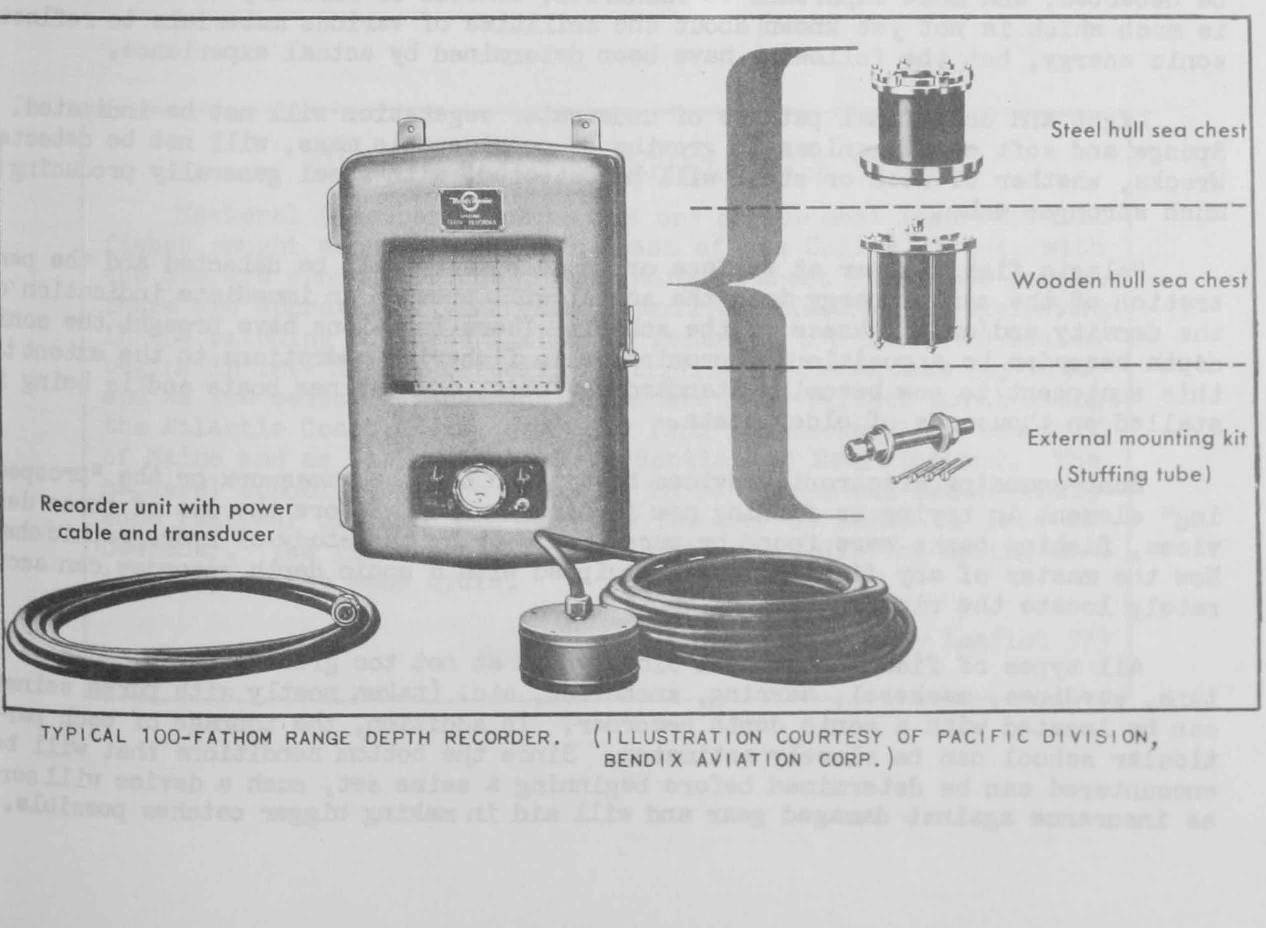
OPERATION OF RECORDING ECHO SOUNDERS

All technical details and references to actual application and installations of recording and direct-reading echo sounders which follow refer in most cases to one manufactured by a West Coast aviation corporation. It is used as an example in order to clarify the operations of such devices.

The direct-reading echo sounder produced by the West Coast company produces its record on dry, graduated paper by means of a moving wire stylus through which the amplified echo is passed to remove, electrically, the light gray coating from the surface of the record paper so that the black of the graphite-bearing paper bulk shows through. (However, devices manufactured by other companies use inking pens or wet paper.) The recording and direct-reading echo sounder under discussion produces a very detailed record as the amount of surface coating removed is dependent upon the strength of the echo which, at a given depth, is dependent upon the hardness and compactness of the bottom or other reflective surfaces. Sonic energy has the ability to penetrate most matter to a greater or lesser extent, and echoes are obtained from the depth of the penetration, descending in strength with the depth of penetration. Thus, by the darkness of the initial echo indication and by the fine degrees of shading resulting from the penetrating energies, the record produced gives an accurate indication of the hardness or compactness of the bottom. It is, therefore, possible to distinguish readily between rock, sand, and mud. With some experience and familiarity with the minute peculiarities of a particular machine, it is possible to go further and determine the approximate consistency of mixed bottoms or to detect small patches of harder material embedded in soft mud or sand, etc.

USES OF A SONIC DEPTH RECORDER IN MARINE AND FISHING OPERATIONS

As a navigational aid, the depth recorder is extremely valuable. By following the contour of the bottom, grounding and stranding may always be avoided, and pinpoint positioning may be obtained by comparing the record graph with navigational charts. Thus, a depth recorder may be considered a necessity for navigating shoal



TYPICAL 100-FATHOM RANGE DEPTH RECORDER. (ILLUSTRATION COURTESY OF PACIFIC DIVISION, BENDIX AVIATION CORP.)

waters, particularly in uncharted areas or areas unfamiliar to the boat's navigator. The bottom contour is shown in great detail--the presentation of bottom irregularities being most faithful and dependent only on the number of soundings per lineal unit of bottom covered and the scale range of the device. For the utmost in accuracy, the depth recorder used should take the maximum possible number of soundings per lineal unit of bottom covered and should have a scale range not exceeding the maximum depth of interest, so as to obtain greatest enlargement of contour. Reference to soundings per lineal unit may be misleading as this will actually depend only upon the lineal speed of the boat. The rate of sounding is limited by the scale range as sufficient time must be allowed between the soundings for passage of sound from the soundhead to the bottom and return, and for recovery of the electronic circuits. Thus, soundings cannot be emitted more frequently than given by the relation: soundings per second = $v/2d$ (where v is the velocity of the sound and d is the depth in feet). Assuming a nominal velocity of 4,800 feet per second, it may be seen that for a depth range of 400 fathoms, soundings cannot be taken more often than one per second, as it would take approximately one second for the sound to travel to the bottom and return. Actually, the recovery time of electronic circuits, the necessity for avoiding any possibility of overlap, and certain mechanical considerations dictate that soundings be taken at from 1/4 to 1/2 of this maximum rate. As the lineal distance traveled by the boat between soundings may be sufficient to result in a serious loss of bottom detail, it is important that, when ultimate in bottom detail is required, the boat be held to a low speed. For average use, however, sonic depth recorders have been designed to give sufficient detail at average boat speeds of from 8 to 15 miles per hour.

As has already been mentioned, the sonic depth recorder has the ability to detect and present the evidence of any reflective matter suspended in the water between the soundhead and the bottom. Thus, heavy masses of seaweed or suspended debris may be detected, and most important to fisheries, schools of fish may be detected. There is much which is not yet known about the abilities of various materials to reflect sonic energy, but the following have been determined by actual experience.

Light and occasional patches of underwater vegetation will not be indicated. Sponge and soft coral, unless in growths of considerable mass, will not be detected. Wrecks, whether of wood or steel will be detected, with steel generally producing a much stronger echo.

Pelagic fish, either at surface or in deep water will be detected and the penetration of the sonic energy into the school will provide an immediate indication of the density and/or thickness of the school. These functions have brought the sonic depth recorder to a position of prominence in fisheries operations to the extent that this equipment is now becoming standard equipment on most new boats and is being installed on thousands of older boats.

Echo-sounding electronic devices have taken out the guesswork or the "prospecting" element in trying or finding new fishing grounds. Before the use of these devices, fishing banks were found by pure chance or by the study of hydrographic charts. Now the master of any fishing vessel equipped with a sonic depth recorder can accurately locate the richest fishing banks.

All types of fish that school closely and at not too great a depth, such as tuna, sardines, mackerel, herring, anchovies, etc. (taken mostly with purse seines) can be located with a sonic depth recorder. In addition, the tonnage of each particular school can be closely estimated. Since the bottom conditions that will be encountered can be determined before beginning a seine set, such a device will serve as insurance against damaged gear and will aid in making bigger catches possible.

Because gill-net fishermen find that by placing their nets along the edge of a ledge at a certain specified depth that catches are considerably larger, a sonic depth recorder makes it possible for this type of fisherman to determine exactly where a ledge is and in which direction it runs, regardless of visibility. The device enables the fisherman to spot his gear near the edge of the ledge and assures him that it will be set where he wants it.

Trawlers have found that generally it is often considered not economically feasible to fish where unknown bottom conditions exist because serious damage or loss of trawl nets coupled with the loss of time involved can make this type of fishing a losing proposition. However, a sonic depth recorder should aid the trawler captain to determine bottom conditions. This will aid him to avoid obstructions and to fish the types of bottom most likely to contain fish. It is also reported that an experienced user of a sonic depth recorder aboard a trawler can frequently spot fish on the device several minutes before his trawl reaches them and, if necessary, he can change his course so that his net will pass through the heaviest concentration.

Sonic depth recorders have applications and uses also in trolling, set-line fishing, the shrimp fishery, and live-bait fishing. As the use of sonic depth recorders in the fisheries increases, new applications or variations of older applications are being and will be discovered.

ATLANTIC COAST MACKEREL PURSE SEINE

Mackerel (Scomber scombrus) is one of the most important food fishes caught along the Eastern Coast of the United States, with the average annual production amounting to about 35,000,000 pounds. There are approximately 100 vessels and 1,000 fishermen participating in the catching of these fish. In general, the mackerel season begins in late March, or early April, in the Chesapeake Bay area, and as the season advances, catches are made further north along the Atlantic Coast. June and July find the mackerel in the Gulf of Maine and as far north as Nova Scotia and Newfoundland. The mackerel schools begin to break up in September but occasionally some reappear off Cape Cod where a few may be taken as late as December. The fish then disappear until the following spring when they repeat the same cycle.

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