# THE FISH-FINDING SONAR OF "OREGON II"

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Horizontal scanning sonar for fish finding has developed considerably in the past decade. It has become indispensable to the purse-seine fishermen of northern Europe, whereas aerial spotting is used by American purse-seine fishermen for locating fish schools. This difference may be due, in part, to unfavorable experiences with early models of sonar; these were usable only in deep water, were expensive, and required extensive training in sonar operation and interpretation. New interest in the use of sonar was aroused in the Gulf of Mexico purse-seine fishery by sonar demonstrations aboard the BCF exploratory fishing vessel Oregon II during the last quarter of 1967.

Personnel of the BCF Exploratory Fishing and Gear Research Base at Pacagoula, Miss., were exposed to the newly installed, high powered, horizontal-scanning sonar aboard the Oregon II (recently delivered by the builder). Portions of the shakedown cruise were devoted to familiarizing personnel with the operations and capabilities of the sonar. This activity is one of the main purposes of the Base's Sonar Technology Program.

This paper outlines some methods used during our preliminary trials and the limitations we discerned in using sonar.

## DESCRIPTION OF SONAR EQUIPMENT

The sonar aboard the Oregon II operates at a frequency of 20 kHz (kilohertz = 1,000 cycles per second). Two acoustic power modes, 4.5 kw. (kilowatt) and 0.5 kw., can be selected manually for matching with pulse durations of 1, 3, or 10 milliseconds. This sonar can be operated at four range scales: Range I (0-275 fathoms), Range II (0-550 fathoms), Range III (0-1,100 fathoms), and IV (0-2,200 fathoms). The sonar beam configuration, measured at the -3 decibel level, is slightly eliptical in cross section, being $13^{\circ}$ horizontally and $15^{\circ}$ vertically. A shallow-water suppressor circuit was installed in the unit to reduce bottom echo interference. This change permits effective school location in water as shallow as 4 fathoms (safe inner limit of operation for Oregon II).

## METHODS

As the personnel of the Sonar Technology Program gained proficiency in the use of Oregon II's off-the-shelf sonar, attempts were made to evaluate its suitability for delineating horizontal dimensions of fish schools. The effective use of sonar to estimate fish school dimensions requires accurate determination of the distance between the school and the sonar transducer (range), complete penetration of the acoustical signal through the school (horizontal school width), and accurate determination of the degrees of arc (scan degrees) occupied by the school.

The number of degrees of scan through which a school could be detected was determined from the transducer bearing indicator, the equivalent of the center of the sonar beam. If we assume that acoustic power sufficient to generate echoes from a fish school would be within the known beam angle of $13^{\circ}$, a correction factor of one beam width of $13^{\circ}$ could be subtracted from the scan angle determinations to establish more accurately the degrees of arc occupied by the school. This is the reason for the correction: When the sonar beam is scanned across a fish school, an echo is picked up when the leading edge of the beam first contacts the target, about $6.5^{\circ}$ ahead of the center of the beam in this example (fig. 1). Similarly, as the beam is scanned past the target, the trailing edge of the beam should record the target for about $6.5^{\circ}$ behind the center of the beam.

Sonar scans of fish schools were made in conjunction with the Base's Aerial Fishery Survey Program. Measurements taken from aerial photographs of scanned fish schools were used to compare sonar measurements. In this evaluation, the greatest school

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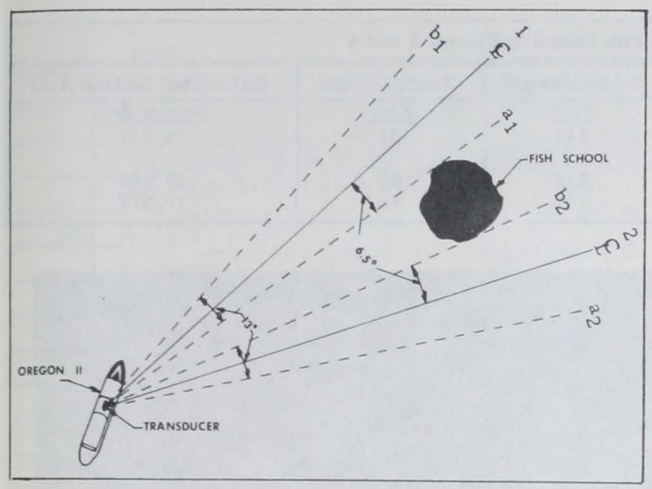


Fig. 1 - Schematic illustration of sonar beam pattern initiating fish school echoes during scans: (1) center of sonar beam approaching fish school, (2) center of sonar beam passing beyond fish school, (℄) center line of sonar beam as indicated by transducer bearing indicator, ($a_1$) leading edge of sonar beam with sufficient acoustic power to generate a detectable fish-school echo trace, ($b_2$) trailing edge of sonar beam with sufficient acoustic power to generate a detectable fish-school echo trace.

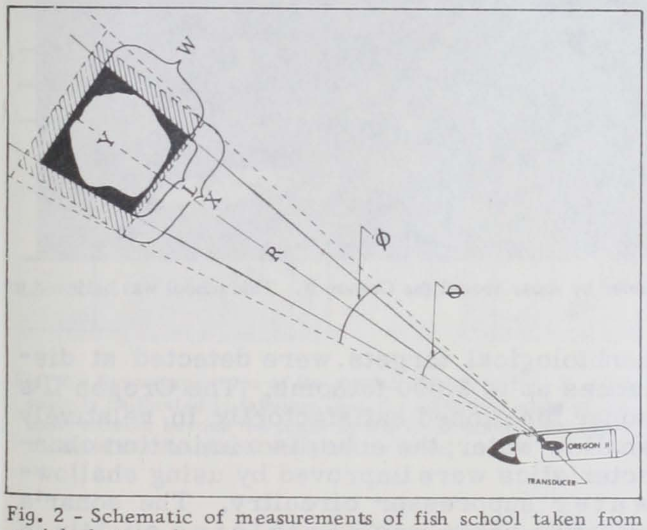


Fig. 2 - Schematic of measurements of fish school taken from aerial photograph; school angle ($\Theta$), school width (W), and school length (L), superimposed over measurement of the same fish school determined from sonar data; scan angle ($\emptyset$), sonar trace length (Y), calculated school length (X), and school range from the vessel (R).

dimensions from the photographs were used because these dimensions more closely approached the type of data obtained from the sonar. Figure 2 shows the method used to obtain fish school dimensions from photographs and to reconstruct school dimensions from sonar data.

The sonar tape provided an estimate of school range and school width along the sonar beam axis. The degrees of arc occupied by the fish school (scan degrees) were read directly from the sonar transducer bearing indicator and were recorded during each scan of a fish school. Using this sonar data we could estimate greatest horizontal length, perpendicular to the sonar beam for the school by the formula $L = R \tan \emptyset$ where:

$L$ = school length (feet)
$\emptyset$ = scan angle (degrees)
$R$ = range or distance (feet) from the sonar transducer to the near side of the fish school

## RESULTS

The range and estimated horizontal school widths from the sonar traces appeared to be within the limits of measurement error when compared with the school dimensions from the aerial photographs. Apparently the 4.5-kw. sonar acoustic signal was powerful enough to be reflected from fish on the near side of the school as well as to penetrate through the school to the far side, providing a sonar trace indicative of the school width. Reverberation on the far side of the school apparently did not significantly extend the sonar trace, as frequently occurs during vertical echo sounding.

Comparisons of sonar and aerial photograph measurements revealed considerable differences in values for scan angles and, consequently, calculated school length. The maximum surface area of a school determined from the photograph was compared with the surface area calculated from the sonar data. The discrepancy in surface area estimates by the two methods is shown in figure 2 and in table.

The photographic and sonar measurements in table were taken from the aerial photograph (fig. 3) and sonar trace number 1 in figure 4. This example contains data from one of our better sonar-aerial photograph comparisons. Most of our preliminary evaluations of fish-school dimensions did not agree as closely as the example; however, we wish to emphasize that the sonar aboard the Oregon II was not designed to obtain scientific acoustic measurements. Insufficient knowledge of acoustic signal transmission and the variable accuracy of sonar data among operators appeared to be the major sources of discrepancy between sonar and photographic data for the determination of fish school dimensions. An estimate of operator error could have been determined if sufficient scan-photo combinations had been available for statistical treatment. Any

Comparative Measurements from the Fish School in Figures 3 and 4

| Method | School Range | Scan Angle | School Length | School Width | Calculated Surface Area |
|---|---|---|---|---|---|
| | Feet | Degrees | Feet | Feet | Square Feet |
| Photograph . . . . . . . . . . | 1,343 | 7 | 141 | 101 | 14,241 |
| Sonar: | | | | | |
| Without angle correction . . . | 1,345 | 21 | 516 | 93 | 47,988 |
| With 13° angle correction . | 1,345 | 8 | 189 | 93 | 17,577 |

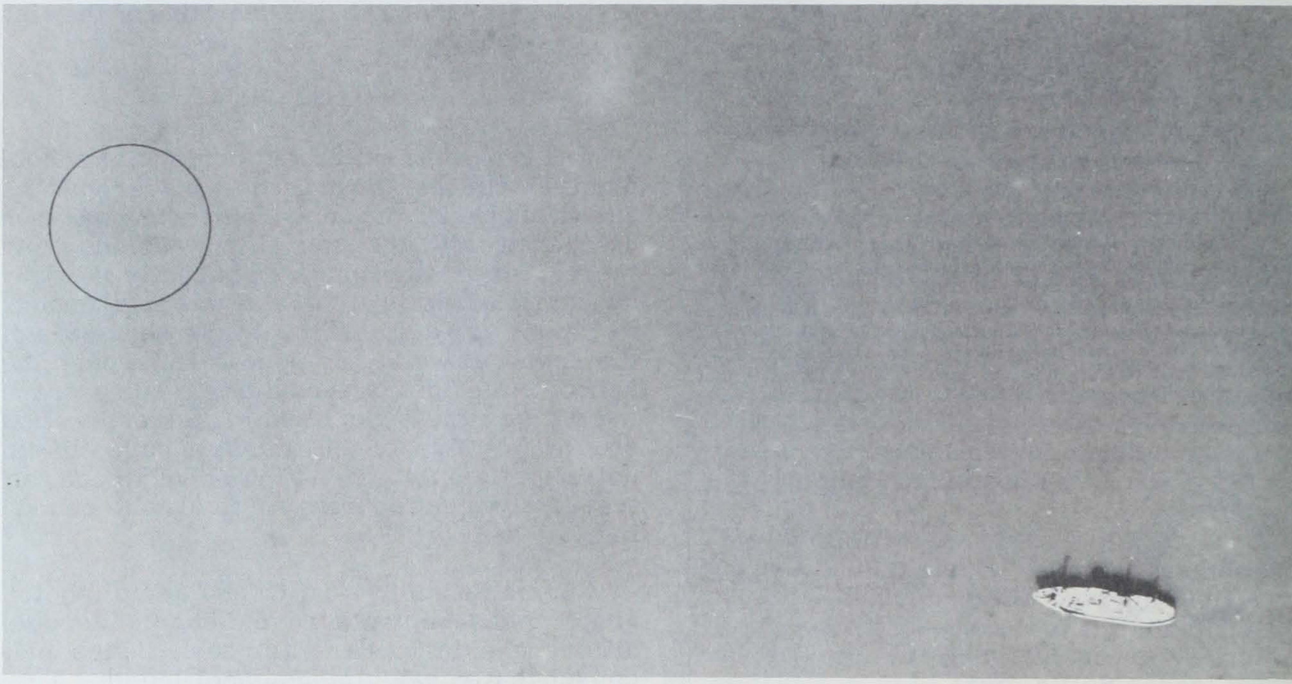

Fig. 3 - Aerial photograph of fish school (marked by circle) being scanned by sonar aboard the Oregon II. This school was believed to be composed of thread herring, Opisthonema oglinum.

further elimination of error would require calibrating the sonar equipment and evaluating the echo characteristics of fish schools.

The difficulty in obtaining fish school dimensions and calculating their surface areas was further compounded by the constant amoebalike changes in the fish school configurations. Figure 5 shows examples of variability in fish-school surface patterns.

Fish-finding sonars are designed primarily to locate fish schools or other targets at a distance from the vessel, and then are used to direct the vessel for effective capture of the target. The sonar aboard the Oregon II was capable of detecting fish schools at a range of at least 800 fathoms, and then was used to direct the vessel over the school for target confirmation by vertical echo sounder. Under favorable conditions, nonbiological targets were detected at distances up to 2,000 fathoms. The Oregon II's sonar functioned satisfactorily in relatively shallow water; the echo discrimination characteristics were improved by using shallow-water suppressor circuitry. The sonar's effective range was restricted slightly in less than 10 fathoms and in rough seas.

The value of sonar for supplementing aerial reconnaissance was clearly demonstrated during the initial cruise. Thread herring schools were abundant off the west coast of Florida while the sonar was being tested. Following BCF advice, several commercial purse seine vessels with aerial fish spotters had moved into the area. On several occasions, when water turbidity and lighting conditions were unfavorable for reliable aerial detection, the sonar aboard the Oregon II was used to direct the purse seiners to fish schools.

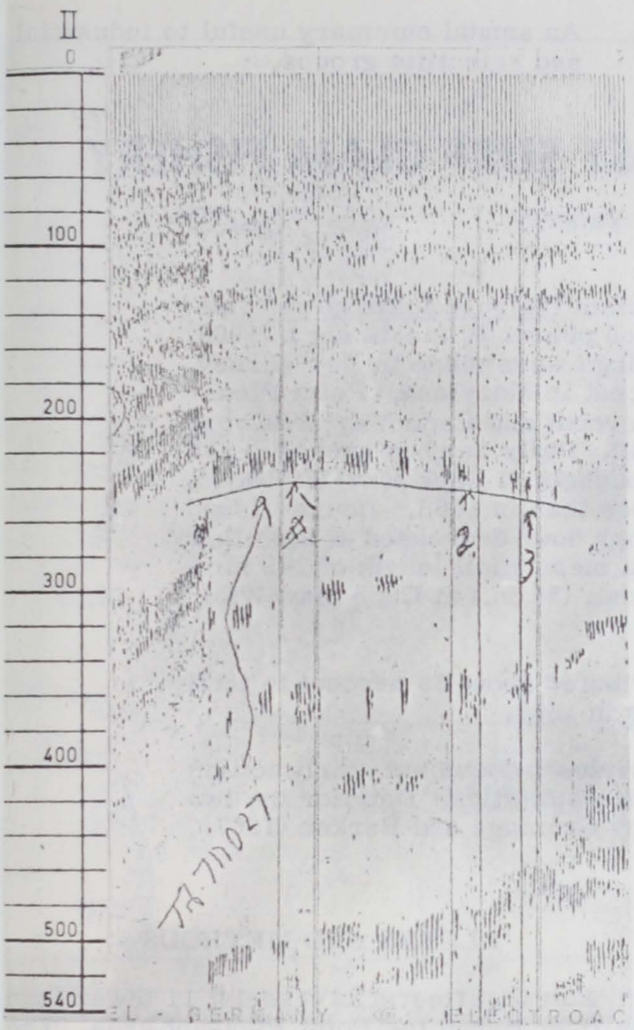


Fig. 4 - Sonar paper tape of fish school circled in fig. 3. The scale is calibrated in fathoms, and the effective range of the sonar extends beyond the scale in this illustration. Measurements of this fish school are given in table.

Fig. 5 - Aerial photograph of fish schools (thread herring) showing variability in their surface configurations. A dye marker dropped by the photo airplane can be seen near the Oregon II.

The vessel returned to the area of fishing off west Florida during December when the fishing industry asked for sonar assistance. As a consequence of this sonar demonstration, some industrial fish companies have considered equipping vessels with sonar.

This preliminary sonar experience has provided a nucleus of trained sonar operators who familiarized other Base personnel with applications of fishery sonar. For the reader interested in the principles of sonar operation and fishing tactics, this information is presented in two books by D. G. Tucker, "Underwater Observations Using Sonar" and "Sonar in Fisheries," both published by Fishing News (Books) Ltd., London.

Our early field work has revealed problems associated with acoustical measuring techniques and has provided sufficient background experience to develop program aims and equipment requirements for future efforts of acoustic fish-school evaluation.