FISHERIES RESEARCH BOARD OF CANADA

UNDER THE CONTROL OF

THE HON. THE MINISTER OF FISHERIES

BULLETIN No. LXIII

USE OF THE ECHO SOUNDER TO LOCATE HERRING IN BRITISH COLUMBIA WATERS.

BY

ALBERT L. TESTER

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INTRODUCTION

The instrument known as the "echo sounder" is primarily designed for instantaneous depth sounding, and is used chiefly on sea-going ships as an aid to navigation in coastwise waters. Several different types of instrument are manufactured, some giving a temporary visual or audible indication of depth and others giving a permanent visual record on paper. Although primarily designed for depth recording as an aid to navigation, certain types of echo sounder have also proved useful for other purposes, such as hydrographic surveying and charting, identification of the type of bottom (whether rock, clay, silt, etc.), locating submerged objects such as wrecks, finding beds of seaweed, and locating shoals of fish.

In 1939, Dr. C. R. Elsey, of British Columbia Packers, Limited, became interested in the possible use of the echo sounder in locating herring and other fish in British Columbia waters, and asked for whatever information was available in this regard. The literature was searched and letters were written to various fishery scientists in other parts of the world to determine what success had been encountered in locating fish. The results were sufficiently encouraging to warrant the trial of the echo sounder in local waters.

By agreement with the Fisheries Research Board of Canada, in October, 1942, the British Columbia Packers, Limited, purchased one of these instruments and installed it on their boat, the *Nishga*, with the understanding that it would be tested under scientific supervision and that the findings would be made available to the industry at large.

HISTORICAL SURVEY

On September 2, 1933, the English periodical, *Fishing News* (*vol. 21, no. 1067, p. 26*) carried an article by R. Balls, Master of the *Violet and Rose*, and a letter by James Mackay of the *Nobles*, describing initial successes in the use of the Marconi Echometer in locating shoals of herring on North sea fishing grounds during the hours of darkness. These reports established the fact that the echo sounder recorded the presence of shoals of herring, gave the depth at which they occurred and some indication of their density and extent. It was stated that the instrument had been a most useful aid to fishing and showed promise of still

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further usefulness when its full advantages could be brought out by further investigation and experimental work.

In a letter to *Nature* (*vol. 135, no. 3423, p. 953, June 8, 1935*) Oscar Sund, a well-known Norwegian fisheries scientist, reproduced original records, made with a Husun Echo Sounder installed on the research vessel *Johan Hjort*, showing large shoals of cod below the surface in the Lofoten area of Norway. Further tests conducted with the echo sounder in Norwegian waters during 1936 showed that it could be effectively used for locating shoals of sprat and herring and for detecting bottoms of suitable character for prawn fishing. On one occasion, "herring were found in very deep water in the Ofoten fjord during the day time; and with the fading out of daylight their rising was observed and as they were approaching the surface the purse seiners present in the neighbourhood could be warned and shown to the spots where the herring were in the best position to be caught." (*Conseil International pour l'Exploration de la Mer: Rapports et Procès-Verbaux, vol. 105 (2), p. 10, 1937*).

To obtain information on the practical use of the echo sounder in European waters, letters were written in 1939 to Messrs. E. Ford, W. G. Hodgson and F. M. Davis (England), G. P. Farran (Ireland), Henry Wood (Scotland), and Oscar Sund (Norway). Replies were eventually received from all except Dr. Sund, who was doubtless prevented from replying by wartime conditions. To the knowledge of the fishery investigators, the echo sounder had not been put to practical use by English, Irish or Scottish fishermen in locating shoals of herring. However, all referred to its probable use in Norwegian waters in the case of cod.

Dr. Henry Wood, Scottish Home Department, Aberdeen, referred to the early favourable report of the herring boat *Nobles* but stated that in spite of this "the echo-sounder has not been adopted by the Scottish herring fishermen for the location of fish shoals, and it would appear that the apparatus in question has not had, in Scottish waters, the success necessary to render its adoption a matter of course."

The following excerpt from Dr. Wood's communication (October 23, 1939) deals with experiments conducted in Scotland:

"Numerous trials have been made with the echo-sounder both by day and by night by the research vessel of the Fishery Board for Scotland on the drift-net grounds off the east and west coasts of Scotland during the summer, and in the Forth estuary during winter, but results so far have been negative. Obviously conditions are very different from those obtaining in Norwegian fjords where the echo-sounder has had marked success in the location of concentrations of cod and herring."

"The main herring fishery off the east coast of Scotland is carried on during summer by drift nets. In the deeper grounds, 70 to 100 miles from land, herring are caught at the bottom by trawl during autumn. On the drift net grounds the water temperatures vary little from the surface to the sea floor and accordingly there is no barrier to the vertical movements of the shoals. Drift net fishing is carried on successfully at night only, and it is clear that the shoals move towards the upper water layers during the hours of darkness corresponding with the movement of the food organisms. The shoals, however, rarely become so dense in any one zone as to be recorded by the echo-sounder. In this respect it is significant that all attempts to catch herring on the open sea drift-net grounds by seine or ring nets have invariably failed."

"The experiments in the Forth estuary were made when both drift and ring net vessels were operating with success, but again no indication was given in the sounder recordings of the shoals which were known to be present on the grounds. In this case the densest shoals were lying close to the shore within a depth of 10 fathoms and the failure of the experiments is considered to have been due mainly to the shallowness of the water."

"The success of this device for locating shoals depends mainly on local conditions. Two essentials would appear to be a considerable depth of water and some degree of layering of the fish in the immediate water layers."

Dr. Wood's communication indicated that the echo sounder might not prove successful in locating British Columbia summer herring, which, like the Scottish herring, are scattered feeding fish which are not seined to any large extent. On the other hand, it indicated that the instrument might prove effective in the case of winter herring, which support the main British Columbia fishery, for these are densely schooled and occur in water of a considerable depth, thus fulfilling, at least in part, the conditions as stated for the successful use of the echo sounder.

In 1942 further information was obtained. According to Mr. Stanley Hiller, President, Santa Cruz Oil Company, San Francisco, during test fishing operations in Newfoundland a vessel equipped with an echo sounder had obtained clear records of schools of fish, presumably herring, at Humber arm, bay of Islands. Unconfirmed reports were also received of similar recordings in British Columbia waters by coastal patrol vessels.

It was finally decided that the accumulated information was sufficiently promising to warrant the purchase and test of an echo sounder under practical conditions.

THE ECHO SOUNDER

The instrument procured was the Husun British Admiralty Pattern Straight Scale Recording Echo Sounder (fig. 2), manufactured by Henry Hughes and Son, London, England (The Ontario Hughes Owens Company, Ottawa, Ont., Canadian distributors; R. F. Bovey Ltd., Vancouver, B.C., agent). Echo sounders are also manufactured by other companies, but opportunity has not been available to test their merits in locating fish.

Type

Of the various Husun sounders available, Type M.S. III was chosen chiefly because its initial full-range sounding scale of 0 to 90 fathoms includes the depths at which herring are usually caught and might be expected to occur on typical British Columbia fishing grounds. However, the instrument will also sound up to 290 fathoms, or more, by "phasing'," that is, by increasing the depth range by successive steps of 50 fathoms. Type M.S. III also has straight rather than curved scale recording which simplifies the interpretation of the records to some extent. In addition it has a feature which subsequently proved very useful, namely, a variable sensitivity control.

Description

The echo sounder consists essentially of a recorder-amplifier unit, a contactor unit, and a pair of magneto-striction oscillators, one acting as a transmitter and the other as a receiver of a high frequency sound impulse. The following brief explanation of the principle of operation is taken from *Pamphlet List E. 128* (Henry Hughes and Son, Ltd.):

"The Recorder unit contains all the control elements of the equipment. These comprise a constant-speed motor, driving rotary switches in step with a reciprocating . . . marking stylus. The speed of travel of this stylus is proportional to the speed of sound in water, having regard to the scale for which the machine is calibrated. A strip of sensitized paper passes slowly beneath the stylus. The paper, which is automatically moistened, is sensitive to the passage of a small current, the latter causing the appearance of a sharply defined sepia stain. . ."

"The sequence of operation is as follows: The control switch in the Recorder closes and operates the transmitter relay in the contactor unit, allowing a range of current to pass from a charged condenser through the windings of the transmitter, thus causing the emission of a sound impulse. The impulse returns from the sea-bottom as an echo, which is received and applied, after amplification, to the recording stylus, leaving on the paper a mark at a point in the travel of the stylus proportional to the echo-time. The successive marks on the slowly moving paper form into a continuous contour chart, showing clearly the smallest variations in depth, and even affording an indication of the constitution of the sea-bed. . ."

Installation

The echo sounder was installed on the M.V. *Nishga* (fig. 1). This vessel, with an overall length of 52 feet and a beam of 14.3 feet, is a small packer of the seineboat type. It is powered with a 60 H.P. Fairbanks-Morse semi-diesel, and has a cruising speed of between 7½ and 8 knots.

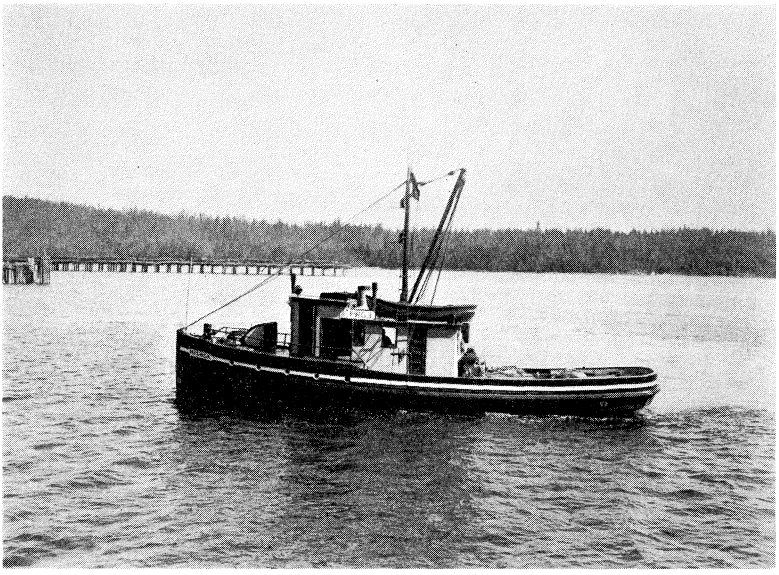

Figure 1. The M.V. *Nishga*, on which the echo sounder was installed.

The recorder-amplifier unit was mounted on an inside wall of the pilot house at a convenient working level (fig. 2). In a specially-constructed locker on the floor were placed the 2-volt "A" battery and the four 90-volt "B" batteries which supply power to the amplifier. The "A" battery was charged from the ship's electrical system (32-volt) through a resistance.

The contactor unit was mounted on a bulkhead in the engine room. A rotary converter, consisting of a 110-volt generator, driven by a 32-volt motor

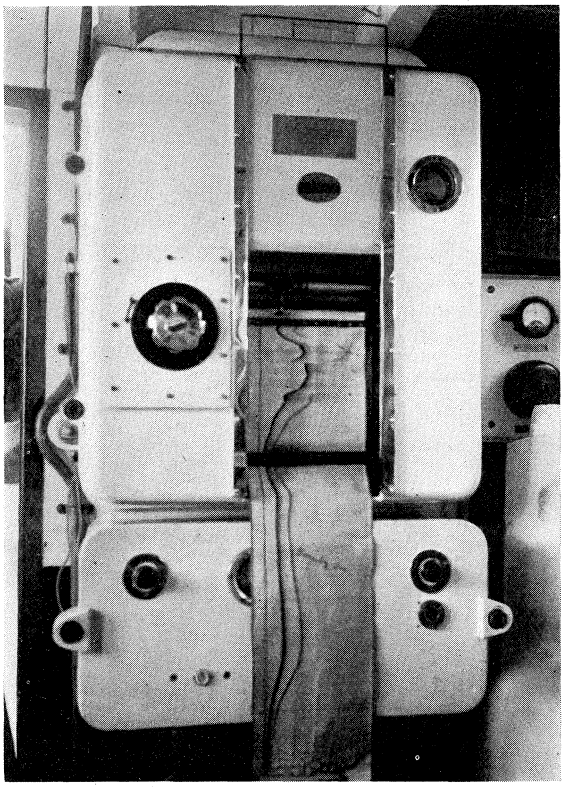

FIGURE 2. The echo sounder (recorder and amplifier units) mounted on the pilot house wall of the *Nishga*.

which was connected through a switch to the ship's batteries, was installed in an engine room locker. The generator provided the current necessary to run the constant speed motor in the recorder unit. An auxiliary charging system, a Delco, was also installed in the engine room to cope with the added load on the ship's batteries of the echo sounder and a radio telephone.

To install the transmitter and receiver units, it was necessary to cut two holes, each 17 inches in diameter, in the planking of the hull. These were placed one on either side of the keel, about one-third of the length from the bow.

In these were fitted watertight metal tanks, faced on the outside by a steel plate which was curved to fit the flare of the hull.

OPERATION

The echo sounder mechanism is started or stopped by throwing three control switches, the first operating the rotary converter, the second, the motor in the recording unit, and the third, the amplifier unit. A variable sensitivity control on the amplifier unit adjusts the intensity of the echo-markings on the paper. By turning a control knob, the instrument is "phased-down" to depths greater than 90 fathoms with sounding ranges as follows:

0-phase	—	0 to 90 fathoms
+ 50-phase	—	50 to 140 fathoms
+ 100-phase	—	100 to 190 fathoms
+ 150-phase	—	150 to 240 fathoms
+ 200-phase	—	200 to 290 fathoms

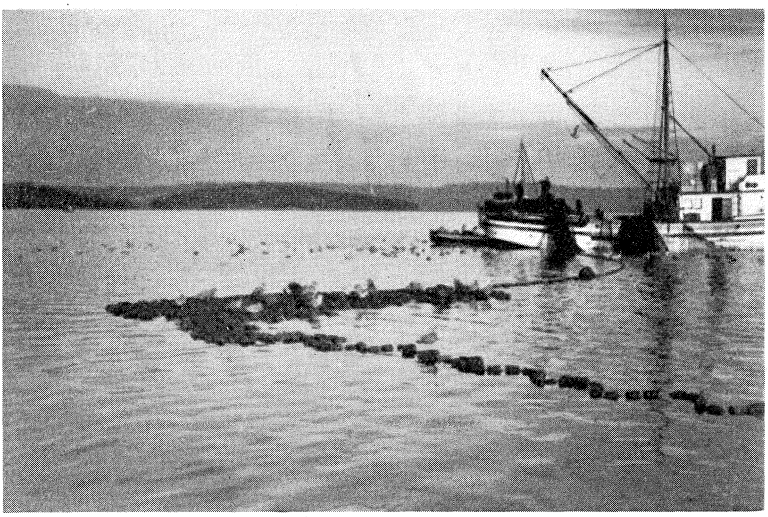

FIGURE 3. A typical herring seine boat with a set. Many of the echo sounder records were made by passing among the seiners while fishing was in progress.

However, in hunting for herring on most of the known fishing grounds, the 0-phase was used almost exclusively.

The instrument requires some attention from time to time. The roll of sensitized paper must be replaced when used up (after about 60 hours of continuous running). The water tank must be kept filled and the wick, used to moisten the paper, must be changed occasionally. The speed of the motor must be adjusted fairly frequently to a rate corresponding with 96 transmissions per minute to maintain accurate sounding. Contact points must be cleaned and moving parts must be oiled occasionally. The "A" battery must be kept

charged, preferably at a constant level, by throwing a charging switch when the sounder is not in operation. These services and adjustments are not difficult and could be performed readily by the skipper or engineer of a fishing boat, provided that due care was exercised.

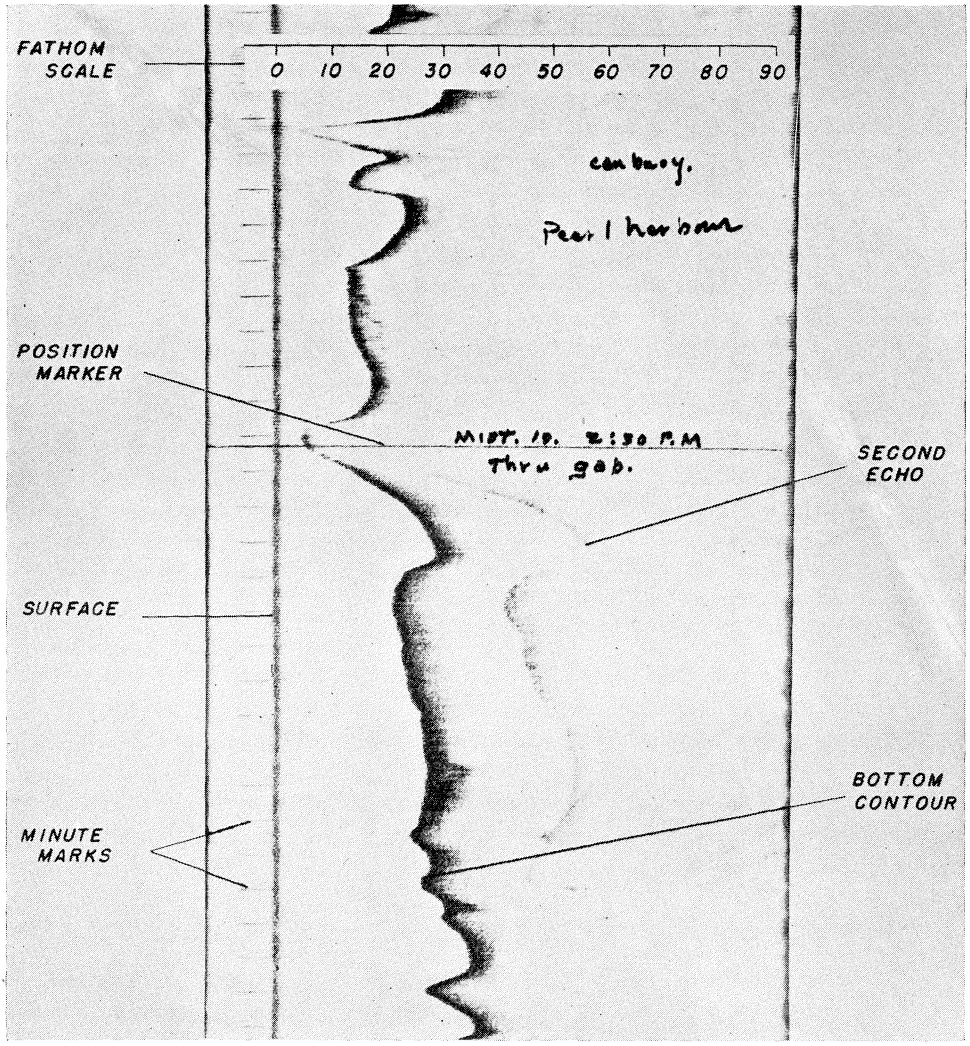

FIGURE 4. A typical echo sounder record with explanation of the markings.

During the three-month period of observation on the *Nishga* the echo sounder was not thrown out of adjustment by the rather considerable vibration of the main engine, nor did this vibration introduce any excessive interference with the reception of the echo signal. Twice during the period, repairs which

could not be effected by the operator, had to be made by technicians of the agency supplying the machine. These were due to faulty adjustment of the contactor assembly.

RECORD

A typical echo sounder record is shown in figure 4. Along the left-hand side are a series of short horizontal marks at regular intervals. These are the minute marks, each interval representing exactly one minute of time when the instrument is correctly adjusted to 96 transmissions per minute. To the right of the minute marks is a continuous vertical line representing the surface. To the right of this, at a distance depending on the depth, is the bottom contour line, the thickness and intensity of which varies with the type of bottom over which soundings are made. On hard bottom (rock or sand) the bottom contour is a broad heavy line; on soft bottom (mud or silt) it is a thin faint line. To the right of the bottom contour line and following its undulations, is another faint line representing the reception of a second echo of the original transmission. This shows only on hard bottom when the original echo is sufficiently strong to be received a second time after being reflected from the ship's hull. The horizontal line running across the record is made by pressing a button on the side of the instrument and is used for indicating positions and courses when underway. The notations are made with an electric stylus supplied with the instrument. Depths are indicated by a scale reading in fathoms. The record shown in figure 4 is in the position in which it is viewed while being made on the instrument. When subsequently re-examined, it is more conveniently placed with the surface line in the horizontal position.

In interpreting the records it should be remembered that the appearance of the bottom contour will depend on the speed at which the ship is travelling. At half and full speeds of 4 and 8 knots respectively, the ship will travel 406 and 812 feet per minute and individual soundings will be made every 4.23 and 8.46 feet. At these two speeds the depth scale is respectively about 10 and 20 times the distance (surface) scale. Consequently gentle undulations in the bottom may appear as rounded humps at half speed and as sharp peaks at full speed. If the ship is stationary, the bottom will show as a continuous straight contour line.

DETECTING AND RECORDING THE PRESENCE OF HERRING

The echo sounder was first used on fishing grounds at Satellite channel on the southeast coast of Vancouver island (fig. 5) where herring were being caught by purse seiners and were thus known to be present. It was later used on other fishing grounds in the strait of Georgia, and on grounds in Queen Charlotte strait and along the central and northern coastlines of the province.

The first records made with the sounder at Satellite channel on the evening of December 8, 1942, showed markings which could be interpreted as resulting from the presence of bodies of fish below the surface. Courses back and forth through the fishing fleet were taken and dark patches appeared on the record

in the area where the boats were fishing. In travelling through the fleet and back again over an approximately reversed course, irregularities in the shape of these dark patches were reproduced as reversed duplicates, or "mirror images" (fig. 6A and 6B, a to b, b to a). To prove that these markings on the records represented shoals of fish, a herring "feeling wire" was lowered. This device, consisting of a five pound lead weight attached to a hundred fathoms of steel "piano" wire on a reel, is generally used by British Columbia herring fishermen

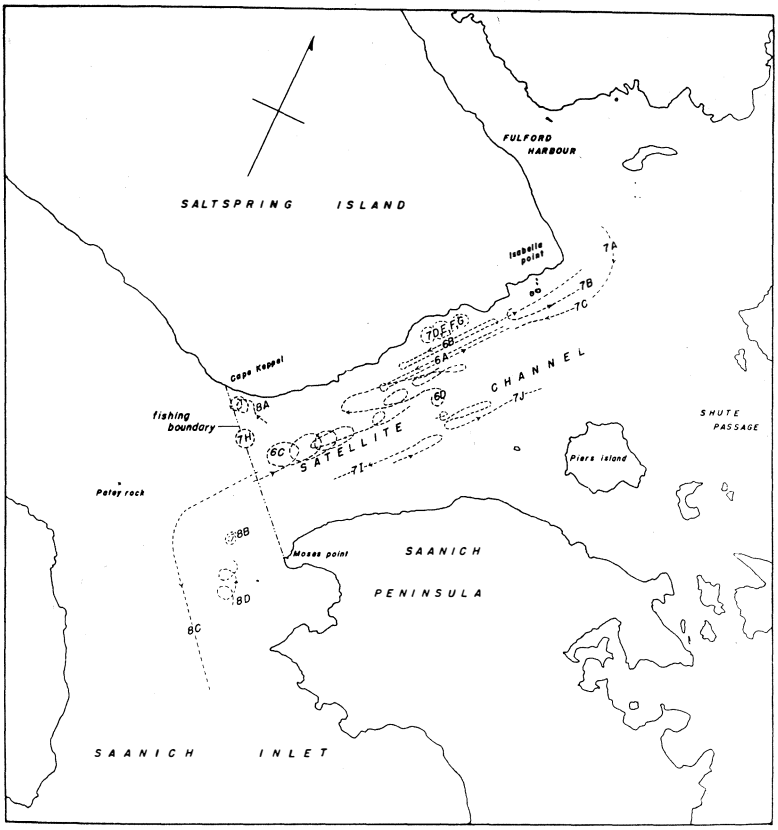

FIGURE 5. Map of Satellite channel showing the approximate courses followed in making the echo sounder records shown in figures 6, 7, and 8.

to locate the fish and to determine their speed, direction of travel and depth. The herring could be felt bumping against the wire where the dark patches on the records were heaviest. Similar tests were conducted later with experienced herring fishermen on board and it was established beyond any doubt that the echo sounder recorded the presence of the shoals of herring below the surface.

In figure 6B, the fish are seen as a relatively narrow layer extending from about 12 to 25 fathoms (c) and as an apparently dense mass extending from about

12 to 40 fathoms (d). In figure 6A, they appear to extend right to the bottom (d), but this is probably not the case as the lower limits of the shoal are confused by secondary echoes from the fish, which are partly superimposed on the original markings. These secondary echoes, which occur only when the herring are heavily concentrated, extend as a shaded area below the bottom contour line. The bottom line below the fish markings is also faint because of the interference by the fish with the transmission of the sound waves.

Several records were made on the Satellite channel fishing grounds and also at Deepwater bay and Clio channel, showing the presence of schools of herring close to the bottom in the late afternoon and their gradual rising with the approach of dusk. A typical record is shown in figures 6C and 6D for Satellite channel. The fish were first located at 4.46 p.m. (Pacific daylight saving time) on the bottom at a depth of between 43 and 48 fathoms near the western boundary of the fishing grounds (e). They gradually moved eastward along Satellite channel, the main body gradually rising (f) until by 6.03 p.m. they lay at a depth of between 20 and 25 fathoms (g), later approaching within 12 fathoms of the surface (h and i).

On most evenings during which records were made, as the herring approached the surface, the schools remained concentrated as more or less distinct units for a short time. They then rather abruptly dispersed, scattering to form a continuous body which usually extended over a large part of the fishing ground. Most of the purse seine sets, and particularly those producing over 100 tons of fish, were made after the schools had approached to within 15 to 25 fathoms of the surface where they could be readily reached with the nets, but while the schools were still concentrated. On most evenings the dispersal took place before 6.30 p.m. Apart from the first evening (December 8) when there was a particularly heavy concentration of fish on the grounds, once the fish had scattered they could not be felt on the wire except in occasional instances where local concentrations were indicated. With the echo sounder, however, the scattered fish could be readily detected and their limits, both horizontal and vertical, could be determined.

Figure 6C demonstrates a behaviour which was recorded only once but which may be a usual occurrence,—the "evening swim" or "evening rush" of fish towards the surface. From 5.08 to 5.24 p.m. (m to n) schools close to the bottom suddenly rose to within about 5 fathoms of the surface, whereas the main body of fish rose more gradually. During this "evening rush" several seine boats located the fish with the wire, aided by information from the *Nishga*, and made successful sets on them.

During the night the herring at Satellite channel remained scattered and in the morning they appeared to school again and to move gradually to greater depths. One set of records shows this gradual downward movement from about 25 fathoms at 8.25 a.m. (fig. 7A) to about 32 fathoms at 9.20 a.m. (fig. 7B), thence to about 40 fathoms at 9.53 a.m. (fig. 7C).

During December, once the herring descended to a depth of about 40 fathoms

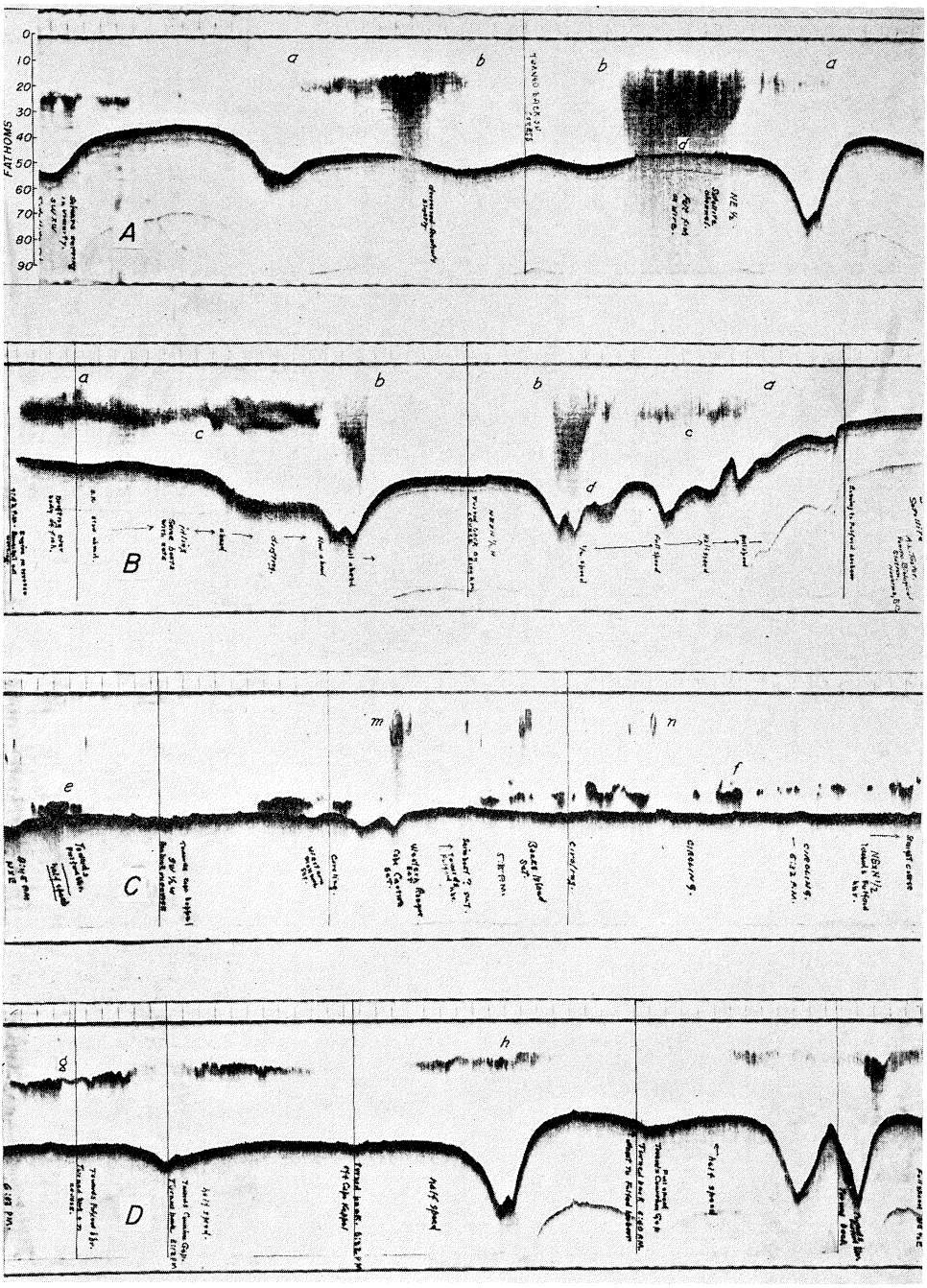

FIGURE 6. Echo sounder records made at Satellite channel in 1942: A—Dec. 8, 6.05 to 7.01 p.m.; B—Dec. 8, 7.42 to 8.39 p.m.; C—Dec. 9, 4.44 to 5.40 p.m.; D—Dec. 9, 6.03 to 7.00 p.m.

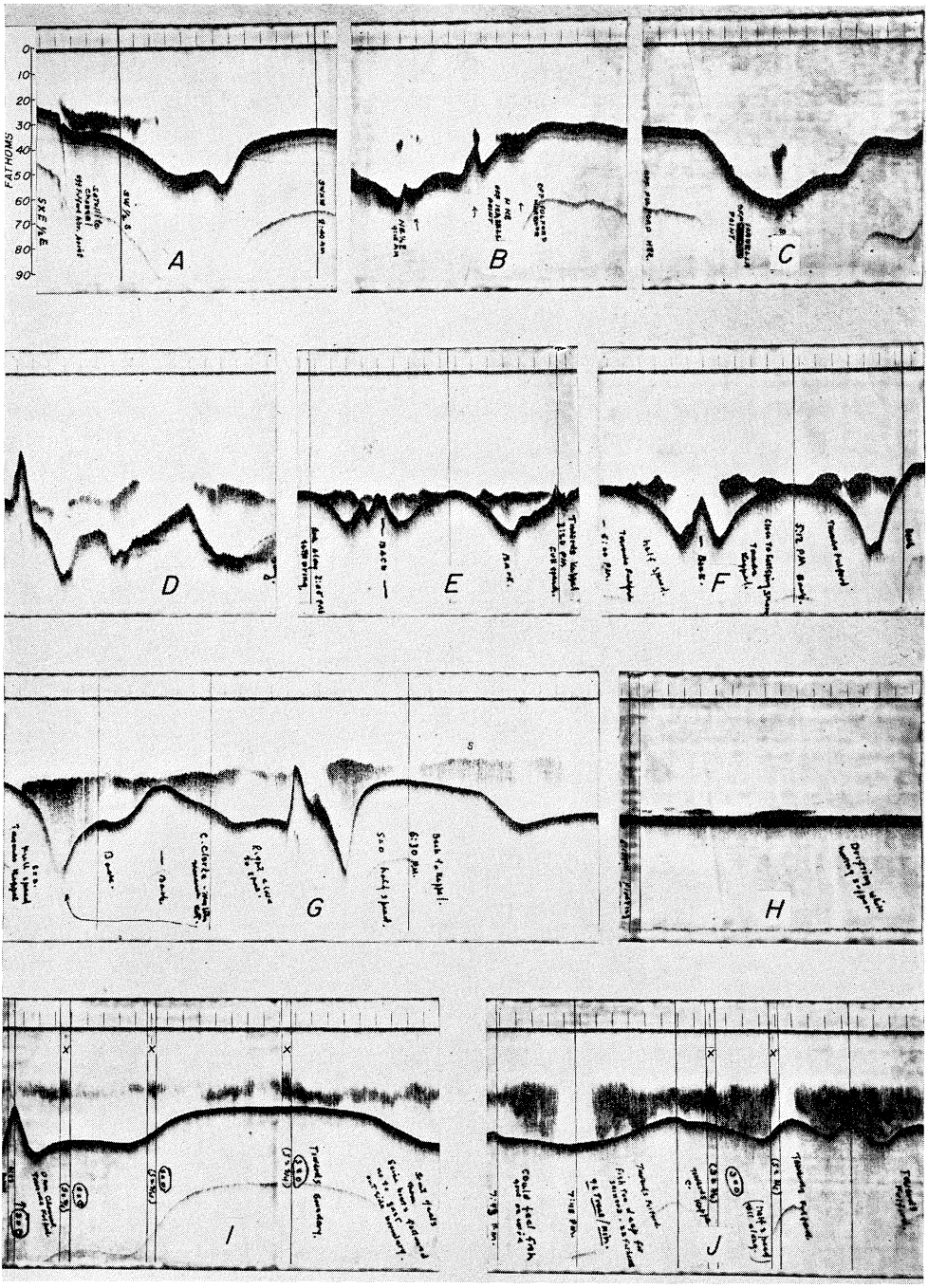

FIGURE 7. Echo sounder records made at Satellite channel in 1942-43: A—Dec. 9, 8.21 to 8.41 a.m.; B—Dec. 9, 9.12 to 9.29 a.m.; C—Dec. 9, 9.45 to 10.02 a.m.; D—Jan. 7, 10.23 to 10.39 a.m.; E—Jan. 7, 2.05 to 2.21 p.m.; F—Jan. 7, 5.00 to 5.19 p.m.; G—Jan. 7, 6.05 to 6.43 p.m.; H—Dec. 18, 5.15 to 5.35 p.m.; I—Dec. 17, 6.52 to 7.19 p.m.; J—Dec.17, 7.43 to 8.09 p.m.

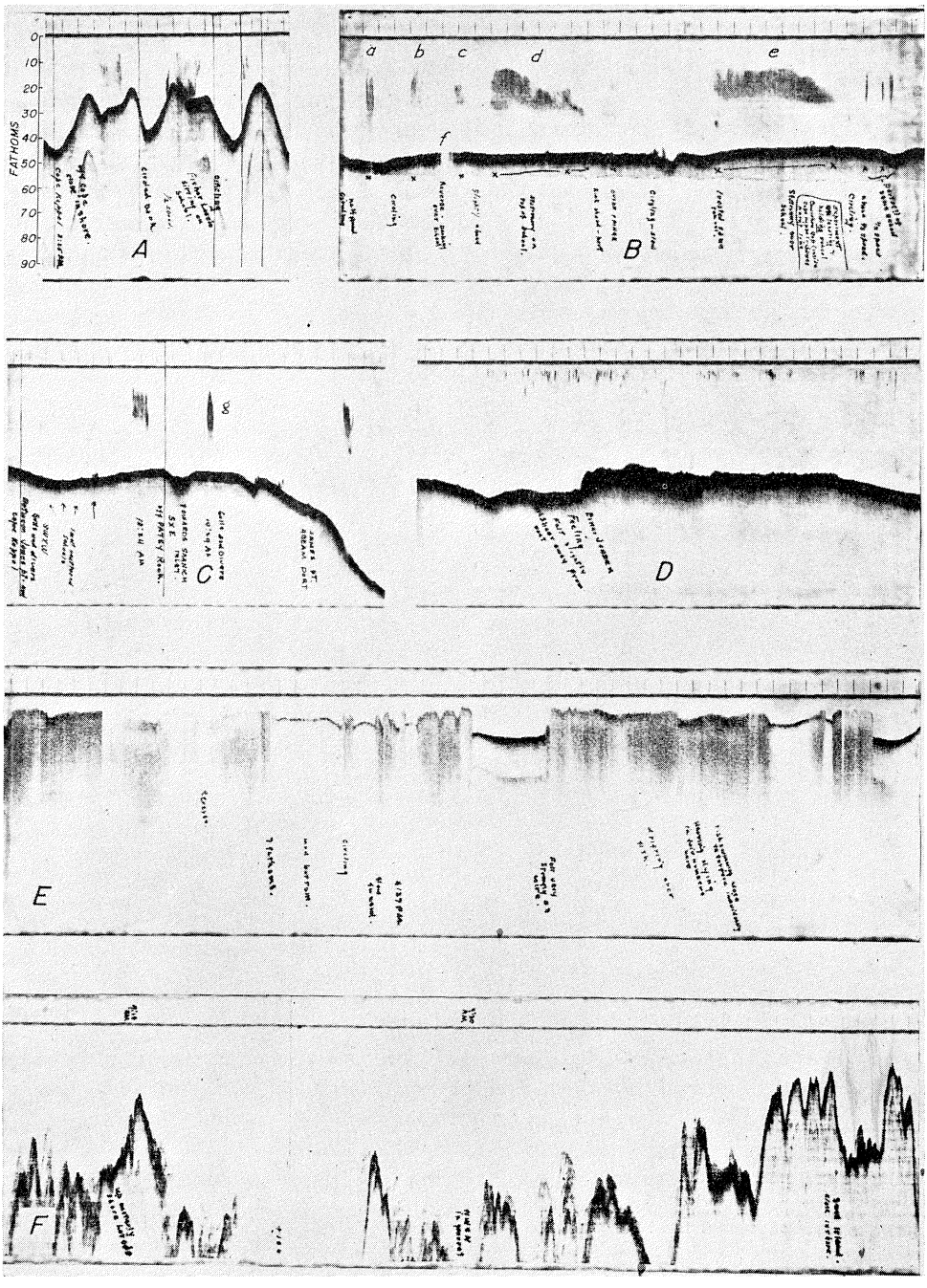

FIGURE 8. Echo sounder records made in 1942-43: Satellite channel, A—Dec. 9, 3.23 to 3.40 p.m.; B—Dec. 9, 1.06 to 1.38 p.m.; C—Dec. 14, 10.16 to 10.39 a.m.; D—Dec. 14, 1.15 to 1.47 p.m. Comox harbour, E—Jan. 26, 4.07 to 5.04 p.m. Laredo inlet, F—9.02 to 9.58 a.m.

in the morning, they seemed to disappear and could not be located on or close to the bottom of either Satellite channel or adjacent waters during the daytime. However, as will be described later, "daytime" schools were found at the entrance to Saanich inlet, although these did not seem to be present in sufficient quantity to account for the main body fished in the late afternoon and evening. Possibly the herring were massed so close to the bottom that they could not be distinguished from it on the echo sounder record. In any event, schools swimming close to the bottom were usually located in late afternoon at the entrance to Saanich inlet and their movement across the boundary into Satellite channel was traced. In one experiment, the *Nishga* was kept as nearly as possible in one position on the boundary line and, as shown in figure 7H, schools very close to the bottom appeared on the record for two or three minutes and then disappeared, thus showing their passage under the boat.

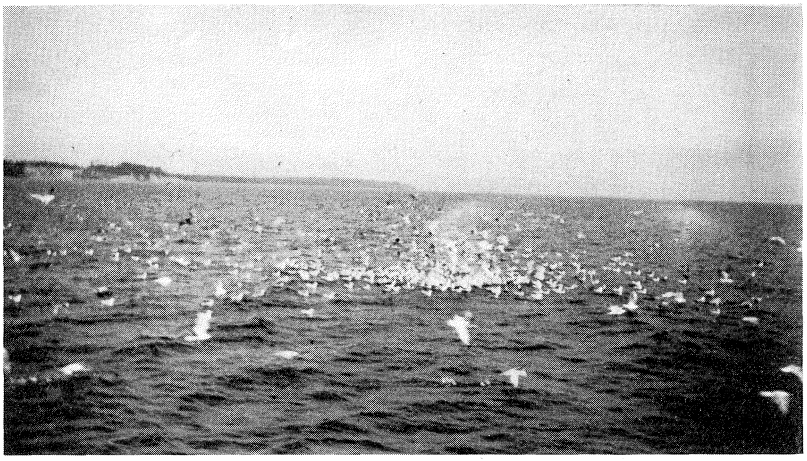

FIGURE 9. Gulls "working" on herring at the surface. Records of fish were almost invariably obtained when the *Nishga* was run through flocks of birds such as this.

In January, herring were located during the daytime in Satellite channel close to the Saltspring island shore. During the morning (fig. 7D) they were found at a depth of about 45 fathoms. During the afternoon (fig. 7E) they lay at a depth of about 50 fathoms, rising slightly about 5 p.m. (fig. 7F). From 6.00 p.m. on (fig. 7G), they continued to rise, coming to within 25 fathoms of the surface by 6.30 p.m. when they started to scatter (s).

Schools of herring encountered during the daytime at the entrance to Saanich inlet had a considerably different appearance to those recorded in the late afternoon and evening. Typical large daylight schools are shown in figure 8C. With the ship travelling at full speed, these are recorded as narrow elongated masses, extending from a depth of 10 to 30 fathoms. However, a school such as that in the centre of figure 8C (g) represents a substantial body of fish.

Assuming it to be circular in cross section, its diameter may be calculated at approximately 250 feet, its depth at 120 feet, and its volume at nearly 6 million cubic feet. A school of this size would probably contain several hundred tons of fish.

Only a few large daytime schools such as that described above were encountered at the entrance to Saanich inlet. On running the *Nishga* through masses of gulls and divers which were obviously "working" on fish (fig. 9), records such as that shown in figure 8D resulted. This shows numerous small schools of fish mostly between 2 and 10 fathoms from the surface which were scattered over a large area. It was obvious, when the records were being made, that a few fish from these schools occasionally came to within less than half a fathom of the surface, for the gulls were able to pick them from the water. It is possible that the schools were right at the surface and that they went down when the boat passed over them. An experienced fisherman who was on board could feel the fish on the wire but only to a slight extent, and he concluded that they sheered away from the boat as it travelled forward. It is probable that purse seine sets on these small scattered daytime schools would yield only a few tons of fish.

Figure 8B illustrates an experiment in locating and "holding" a large daytime school of herring. The school was recorded first when travelling at full speed. It was located and passed over a second time (a) on circling at half speed and a third time (b) on circling slowly with the clutch disengaged. By going slow astern the ship backed over the school (c). A kick ahead then brought the ship to a stationary position above the school and it remained there for approximately seven minutes (d) before it drifted off. On circling very slowly the school was again located and the ship stayed over it for a second period of eight minutes (e). Had seine boats been allowed to fish in this area they could readily have been signalled and could easily have encircled the school whose position was held by the echo sounder. It is clear from this experiment that the sound impulses from the sounder do not scare away the fish.

Figure 8A shows a school of herring in shallow water of Satellite channel, off cape Keppel. A herring scout had located these fish with the wire, and the *Nishga* came alongside to investigate. It was apparent from the record that if a set had been made, the seine (26 strips) would have snagged on the bottom (20 fathoms).

A recording of a dense shoal of herring in the very shallow water of Comox harbour (behind Comox spit) is shown in figure 8E. The record was made while circling and drifting at slow speed and the fish could be felt very strongly on the wire. It will be noted that the herring were so concentrated that wherever they occurred secondary echoes were strongly projected and the bottom contour line was obscured. The record was made during daylight.

An attempt was made to calibrate the echo markings in terms of tons of fish, but this proved to be an exceedingly difficult task. It was found that the intensity of the markings could be varied by varying the sensitivity control from

0 to ¾, at which latter point the transmission line (a dark band just below the surface line representing the transmission of the original sound impulses to the bottom) appeared on the records. As shown in figures 7I and 7J (x), increasing the sensitivity from 0 to ¾ increased both the intensity of the markings and the apparent thickness of the body of fish. The latter may be due to the reception of additional echo signals from fish scattered above and below the main body. During December trials at Satellite channel, it was found that if fish were recorded with the sensitivity control at zero, they could be felt on the wire. It was concluded that they were then present in sufficient abundance to warrant setting on them, and that the size of the set would be roughly proportional to the intensity of the markings, provided of course that the seine encircled the body of fish being recorded and that the set was completed without complications. However, it was later noted that the sensitivity of the instrument varied with the condition of the "A" battery supplying the amplifier unit. In order to interpret the markings even roughly in terms of abundance of fish the battery had to be kept at a constant level of charge.

There is no doubt that the sounder is very sensitive in recording the presence of herring, even when the fish are thinly scattered. In one case, while the *Nishga* was drifting on the fishing grounds at night, a continuous record of herring was obtained, even though none could be felt on the wire in the vicinity. Further investigation gave slight indications of fish on the wire alongside and under the ship. A few scattered fish were drifting along with the vessel, attracted by the deck lights.

It is not clear at present how the sound impulse is echoed from the school of fish. It may possibly be reflected from the bodies of the fish, from the mass of scales which are being shed, or from air bubbles which are being given off continuously. In one instance there were indications that echo markings were obtained from either scales in the water or from bubbles emanating from a dried-up set while the fish were being brailed. It is known that air bubbles in the water effectively block the passage of the sound impulse. As illustrated in figure 8B (f) transmission to the bottom is completely cut off when the engine is thrown in reverse and the water churned by the propeller is washed under the transmitter and receiver units in the hull.

In figure 8F is shown a record of the bottom of Laredo inlet along the central coastline of British Columbia, made close to the shore. The bottom contour, indistinctly defined and irregular, is typical of the long inlets of the central and northern areas where bottom deposits of mud or silt occur. To an inexperienced observer, these bottom deposits might be mistaken for schools of fish. There is also a possibility of misinterpretation of the records when a layer of silt makes its appearance over a hard even bottom. For the most part, however, the herring recordings are of greater intensity than these superficial bottom deposits and can be distinguished from them.

LOCATING HERRING FOR THE SEINE BOATS

During the preliminary investigations at Satellite channel in December, some assistance was given to the seiners in showing them the locations of the schools before they were found on the wire, and also in showing them on what part of the fishing ground the heaviest concentrations of fish occurred. However, there were so many boats cruising and drifting in such a limited area that the full merits of the echo sounder could not be demonstrated in the general confusion of fishing.

Following the holiday closure (December 20 to January 3) herring were not found in Satellite channel and the boats moved farther north along the east coast of Vancouver island to Nanoose bay. Echo sounder records made at Nanoose bay on January 4 showed only a small concentration of fish to be present. The *Nishga* then returned to Satellite channel to keep watch in that area. On January 6, herring were located with the echo sounder in Satellite channel during the daytime at a depth of about 50 fathoms, and the information was transmitted to the fleet. On January 7 they were again located during the daytime and their gradual rising to within 25 fathoms of the surface towards evening was recorded (fig. 7D to 7G). The seine boats, which had arrived in the meantime, were shown where the fish were present and successful sets were made on them. These, however, were not as productive as those made during December as the fish remained deeper, with the result that only the surfaces of the schools were skimmed by the nets.

On January 27, records of herring were made at Deepwater bay at the southern part of Discovery passage, where seine boats were fishing with only moderate success. The records showed that there was not a large body of fish present. The *Nishga* then proceeded to the Queen Charlotte strait area, between the northern part of Vancouver island and the mainland, where likely fishing grounds were scouted. A small body of herring was located in Clio channel on January 28. These fish behaved in a manner similar to those at Satellite channel, remaining close to the bottom at a depth of 60 to 65 fathoms in the daytime, rising to within 25 or 30 fathoms of the surface in the late afternoon as a compact body, and then abruptly scattering and rising to a depth of about 20 fathoms in the evening. Seine boats were summoned to Clio channel, but by the time they arrived, February 2, the fish had become somewhat less abundant. Moreover, they scattered before rising to a distance from the surface where they could be readily reached by the seines. No sets were made, although doubtless a small quantity of fish could have been caught.

During February, the *Nishga* scouted many potential fishing grounds between Queen Charlotte strait and the Alaska boundary, including Llama passage, Klemtu passage, Meyers passage, Laredo inlet, Surf inlet, Prince Rupert harbour, Chatham sound, Cunningham passage, Wark channel, Union bay, Steamer passage, Khutzemateen inlet, Wales passage, and Pearse canal. No herring were located in any of these waters during the times at which they were visited and it was concluded that none were present. Evidently during the

1942-43 season the fish did not approach inshore fishing grounds along the central and northern coastlines until just before the ontset of the spawning period (March). No attempt was made to locate the shoals of fish offshore.

MERITS OF THE ECHO SOUNDER IN LOCATING HERRING

Without doubt, use of the echo sounder is a more satisfactory and more efficient method of locating shoals of herring than the use of the feeling wire. (1) The sounder will record the presence of fish at depths to 65 fathoms (as proven) and probably to 90 fathoms or more. The wire, on the other hand, can be used satisfactorily only at depths to about 50 fathoms. Below that, the impulses caused by the wire striking the fish are muted and indiscernible from the vibrations caused by the wash of the boat. (2) The sounder shows the exact depth, and both the upper and lower limits or "thickness" of the school. While the depth can be fairly accurately estimated with the wire, knowing the length being used and allowing for the slant when it is trailed behind the boat, the wire gives the depth of only the upper portion of the school. (3) The sounder gives a continuous record of the bottom as well as of the school of fish, thus reducing the chances of "snagging". (4) The sounder will locate herring when they are so thinly scattered that they cannot be felt on the wire. Although in such cases they are not sufficiently concentrated to warrant large-scale fishing, the information that scattered fish are present is useful knowledge when scouting, as they will probably school in the vicinity during twilight hours. (5) With the sounder, herring can be located when the ship is travelling at full speed whereas, with the wire, it must travel very slowly. Consequently a relatively large area can be covered in a short period of time. (6) Fish can be located with the sounder regardless of weather conditions, which sometimes limit the use of the scout boat and wire.

There was no opportunity of determining whether the echo sounder could be used in place of the wire in actually setting the seine around a school of fish. In the present method of making a set, while the seine is running off the turntable and over the stern, the course of the boat is usually guided by the scout who is feeling with the wire. Were the echo sounder installed on a seine boat it is possible that sets could be made with equal or perhaps even greater facility from the echo markings, provided that complications were not introduced by having to steer and control the ship from the wheelhouse where the sounder would be located rather than from the bridge.

Whether or not the advantages of the echo sounder over other means of locating herring are sufficiently great to justify the capital expended in purchasing and installing, or the expense incurred in renting this equipment, can be satisfactorily determined only by the practical use of the *Nishga* and its echo sounder during future commercial fishing operations. It must be pointed out that with the methods at present in use a high degree of proficiency in locating herring has been attained. Usually certain boats are assigned to each major fishing area by the companies. These scatter over the area and scout the

waters where fish have been caught in the past or investigate "signs" of fish (gulls, shags, etc.) by means of the feeling wire. Once fish are located, word passes quickly and seine boats converge on the fishing ground, remaining there as long as fish are being caught or until they are attracted elsewhere by more favourable reports. Of the several advantages of the echo sounder listed in a preceding paragraph, probably the one most likely to justify its adoption by the fleet would be its ability to quickly and thoroughly scout large areas for fish.

The *Nishga* was equipped with both echo sounder and radio telephone with the object of locating herring independently of the fleet and conveying the news immediately to the nearest boats. It was found that the usefulness of the information was limited by the time taken for the seine boats and packers to arrive on the scene. Moreover, even with the advantage of scouting while travelling at full speed, it was impossible for the one boat to thoroughly cover the whole British Columbia coastline.

Should future experience justify the adoption of the echo sounder by the fishing companies, it would be desirable to have at least one scout or seine boat, equipped with both sounder and telephone, in each of the major fishing areas during the season. This might be accomplished to best advantage by some co-operative arrangement between the various companies.

Judging from the success encountered in locating sprat and cod in Norway, the echo sounder might be expected to record the presence of species such as pilchards and anchovies which school in British Columbia waters. However, even if this were found to be the case, it would still have to be determined whether the sounder could be used to advantage in the commercial fishery for these species. Such information can only be obtained by actual trial of the sounder under practical fishing conditions.