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PROGRESS REPORT ON MIDWATER TRAWLING STUDIES CARRIED OUT OFF THE NEW ENGLAND COAST IN 1961 BY M/V DELAWARE

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ABSTRACT

Experiments with midwater trawling gear were conducted in 1961 by the U. S. Bureau of Commercial Fisheries with the research vessel Delaware. The principal objective of work in 1961 was to modify midwater trawling gear so that it could be controlled accurately. A depth-sounder transducer was mounted on the headrope of a trawl to allow a constant check to be made on the relation of the net to the bottom and to fish schools. In limited fishing trials, carried out with the transducer-equipped net, over 25 species of marine animals were sampled. Atlantic herring were caught in amounts up to 4,500 pounds per tow. Other commercially-desirable species taken included whiting (silver hake), mackerel, and butterfish. The midwater gear experiments and explorations are scheduled to continue.

INTRODUCTION

Widespread interest has developed and been maintained during the past decade in finding and using various fishery resources known to occur in mid-depths of the oceans.1/ Ordinary fishing techniques, such as seining and trawling, are for the most part applicable only in situations where the fish sought can be seen from the vessel or the air (as in seining) or are known to be close to or on the bottom (as in otter trawling). Some fish occurring in mid-depths have been harvested by gill nets, traps, long lines, and a few other types of gear, but more versatile gear for the midwater depths has long been needed.

Recent encouraging catches of fish by midwater trawls in the northeastern Pacific and off northern Europe have aroused interest in possible uses for this gear in other areas of the world, including the waters off the northeastern states of the United States.

Several workers (including Parrish 1959, Schaefers and Powell 1958, and Steltner 1961) have stressed that development of midwater trawling techniques depends largely on two factors: (1) finding the fish, or other marine life, in the mid-depths; and (2) controlling the fishing depth of the gear.

Finding concentrations of marine animals has been made less difficult by the development and use of sonic fish-finding devices (Kristjonsson 1959); and several ways of positioning the trawl in the proper depth have been developed in the past several years (Smith 1957, McNeeley 1958). But a means of controlling the trawl so that it stays in the desired depths has only been developed recently (Scharfe 1960).

The studies under discussion here were started early in 1961 by the U. S. Bureau of Commercial Fisheries. Principal immediate objective was to obtain gear that could be placed in position and controlled readily. The experiments were designed, also, as part of a larger-scale study having the ultimate objective of establishing the availability, to commercial fishermen, of stocks of fish or invertebrates (shrimp and other animals) capable of supporting fisheries off the northeastern United States.

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1/ "Mid-depths" and "mid-depths resources"--also "midwater" and "midwater resources"--are terms used in this report to denote all layers and resources of the sea from just below the sea surface to immediately above the sea bottom.

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BACKGROUND

Several years ago Barraclough and Johnson (1956, 1960) developed a one-vessel midwater trawl that proved successful in British Columbia waters. Schaefers and Powell (1958) used similar trawls and controlled their position in the water with a Bureau-designed depth indication device (McNeely 1958).

More recent developments in midwater gear design have come from European experiments described by Scharfe (1960). Scharfe mounted a depth-sounder transducer on the headrope of the trawl to aid in orienting the gear during tows. This and other techniques have since been modified and used successfully in Bureau studies in the Gulf of Mexico (Bullis 1961).

Off the New England coast, various approaches to one-vessel midwater trawling have been attempted from time to time. Single-vessel trawls were used by the Bureau as sampling gear as early as 1956 in herring surveys off Maine, and a few early attempts were made by the Bureau to develop a controllable trawl for use with commercial draggers. The attempts were terminated, however, owing to the lack of proper instrumentation, time, and facilities at that time.

COVERAGE

In 1961, primary effort was devoted toward obtaining and adapting gear and establishing techniques to be used in a long-term effort aimed at defining midwater resources. Four cruises by the Delaware were carried out (table 1) with main stress on adapting suitable midwater trawls and gaining familiarity with fish-finding techniques (U. S. Fish and Wildlife Service 1961a, b, c, e). Secondary effort was devoted to supplementary sampling techniques, i. e., night-light collections and gill-net sampling.

Table 1 - Midwater Trawl Cruises of the M/V Delaware, 1961

Cruise No.	Area	Date	No. of Sea Days	Midwater Trawl Tows	Average Time Per Tow	Principal Species Represented in Catches
61-1	Nantucket Light Vessel - Hudson Canyon	Jan. 23-Feb. 2, 1961	11	8	60 minutes	Silver hake, butterfish, scup, spiny dogfish, Atlantic mackerel
61-8	Gulf of Maine - N. Georges Bank	May 24 - June 7, 1961	8	16	60 minutes	Herring, mackerel, silver hake
61-11	Gulf of Maine and Georges Bank	July 6-14, 1961	9	10	60 minutes	Spiny dogfish, Atlantic herring, silver hake, butterfish, Atlantic mackerel, alewife
61-18	Gulf of Maine - Georges Bank- Nantucket Shoals	Oct. 10-18, 1961	9	6	90 minutes	Haddock (young of year), silver hake, butterfish, herring, dogfish, shrimp

During the four cruises, the midwater trawl gear was set only 40 times. Two additional sets with the gear were made on a herring survey cruise (Delaware 61-15) near Mt. Desert Island off the coast of Maine (U. S. Fish and Wildlife Service 1961d).

METHODS AND MATERIALS

Early in 1961, limited trials were made with a standard No. 36 eastern otter trawl of $2\frac{1}{2}$-inch-mesh webbing. To allow for an extension or underhang in the lower leading portion of the net, the trawl was fished upside down with 50 floats on what would otherwise have been the footrope. Also used in a few early trials was a 40-foot square "sampling net" made of 5-inch-mesh webbing. Both trawls were fished with 14-fathom legs and $3\frac{1}{2}$- by $6\frac{1}{2}$-foot bracket doors. Trawl depth was determined, roughly, from a curve of vessel speed and tow warp

length that was obtained in gear trials, with a vessel riding over the towed net recording the depth of the trawl headrope at varying speeds and with varying lengths of wire out. (This technique has been described by Scharfe.)

Results from these early trials made it obvious that more elaborate gear and equipment was necessary. In particular, gear was needed that could be controlled accurately, and equipment was needed that would allow such control and give a constant reading on (1) net depth and (2) relation of the net to the bottom and to fish schools. The European gear and equipment described by Scharfe (1960) appeared to fulfill these requirements. Trials of comparable gear were witnessed in the Gulf of Mexico, and soon after, similar gear was obtained for use with the Delaware.

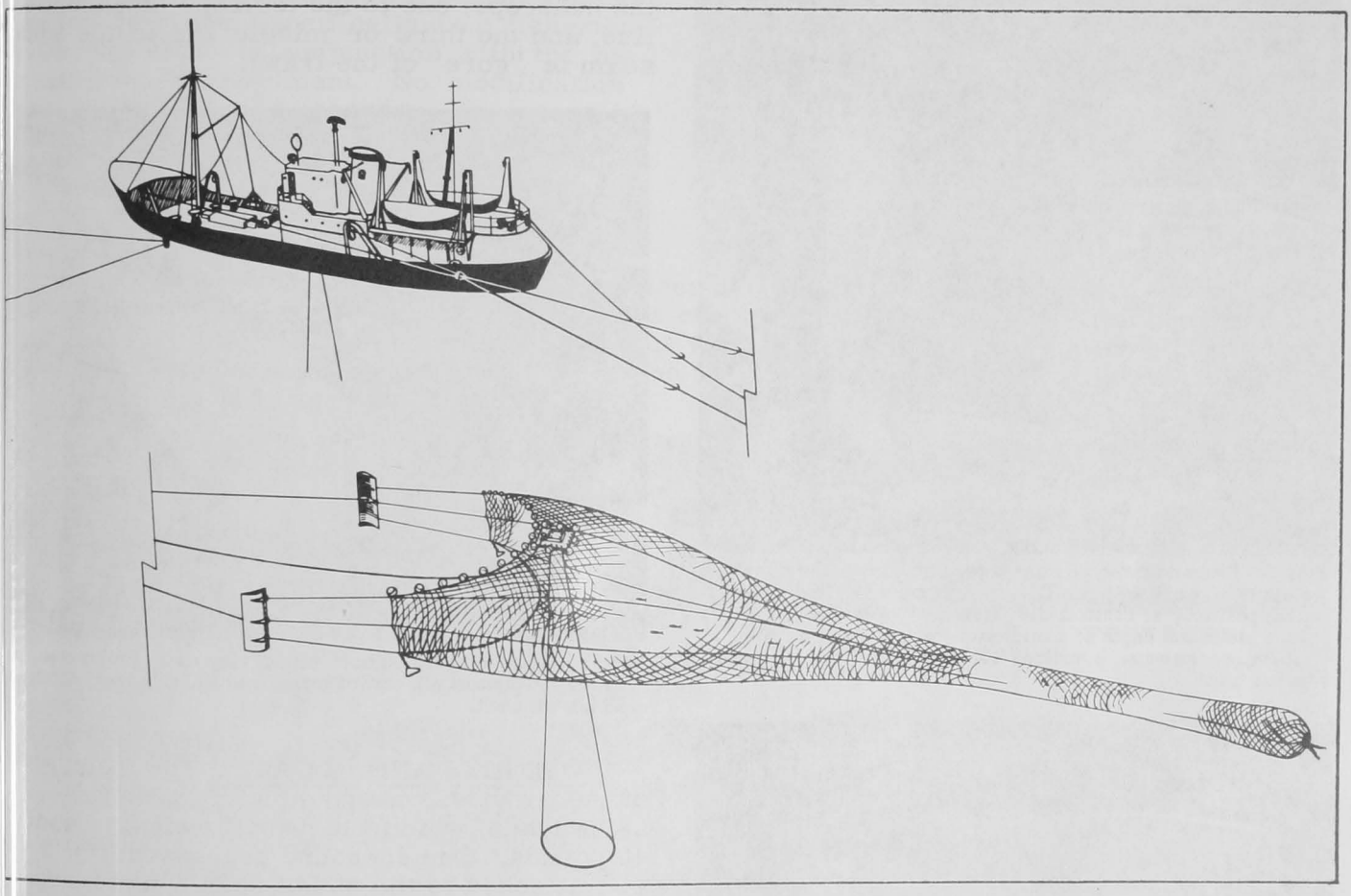

Fig. 1 - Diagram illustrating the midwater trawling system used during 1961 Delaware pelagic explorations. A transducer is mounted on the net and connected to the vessel through a net transducer cable. The approximate vertical and horizontal fields of the echo-ranging and echo-sounding equipment are shown.

The complete system (fig. 1) consists of the net, doors, legs, warp, depth-recorder, and 2 transducers--one mounted on the headrope of the net and connected to the vessel by means of a conductor cable and the other mounted in the vessel hull.

THE NET: The net is a modification of that described by Scharfe. It is built on a 2-seam design, of nylon webbing graded from 6-inch stretched measure in the mouth and wings to $1\frac{1}{4}$-inches in the extension piece and cod end. The trawl is fitted with heavy nylon riblines and reinforcing lines. Headrope and footrope are both approximately 70 feet long. The measured distance between headrope and footrope under fishing conditions varied from 30 to 42 feet depending on the speed of the towing vessel.

OTTER BOARDS AND LEGS: "Suberkrub" otter boards, developed in Hamburg, Germany, were used exclusively in tests with the 2-seam trawl. The boards are of hydrofoil design and, as described by Scharfe, consist of cylinder segments. Those used measured $3\frac{1}{2}$ by 8 feet and weighed 480 pounds each. The boards fish with their longest dimension in a vertical plane (fig. 2), in contrast to conventional bottom trawl otter boards. They were connected to the trawl net by $\frac{3}{4}$-inch combination manila-wire rope legs that were 15 fathoms long. Three legs were used on each door--one attached to the headrope, one to the footrope or groundline, and the third or middle leg to the side seam or "gore" of the trawl.

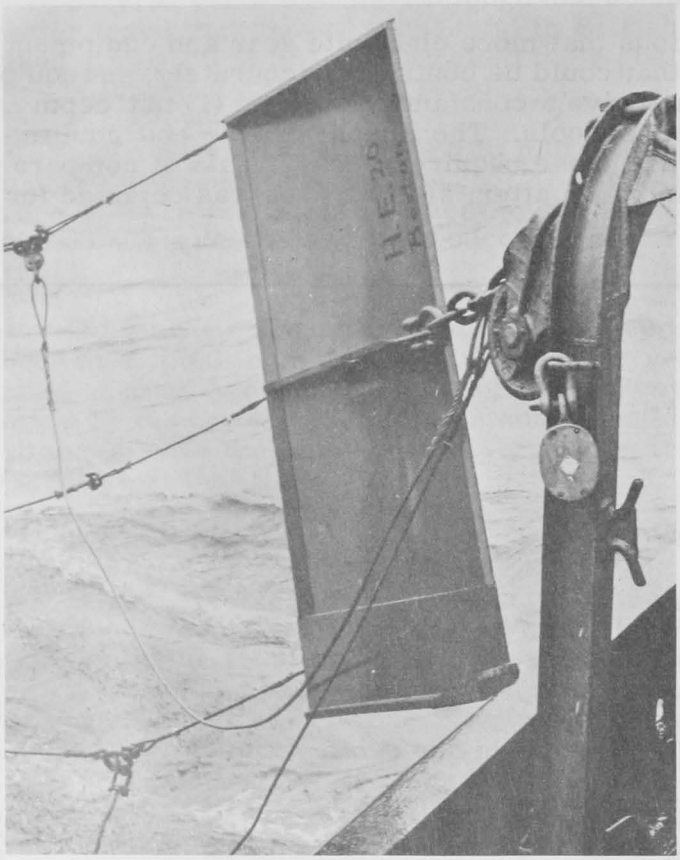

Fig. 2 - "Suberkrub"-type otter board outboard of the aftergallows of the Delaware. These boards are fished in the vertical position, as illustrated. With them rapid changes can be made in the depth of a midwater trawl by altering the r.p.m. of the vessel's engine. Three legs lead from the doors to the trawl.

Fig. 3 - Depressor used on each of the wing ends of midwater trawl. Depressors are cast of bronze and weigh approximately 45 pounds each.

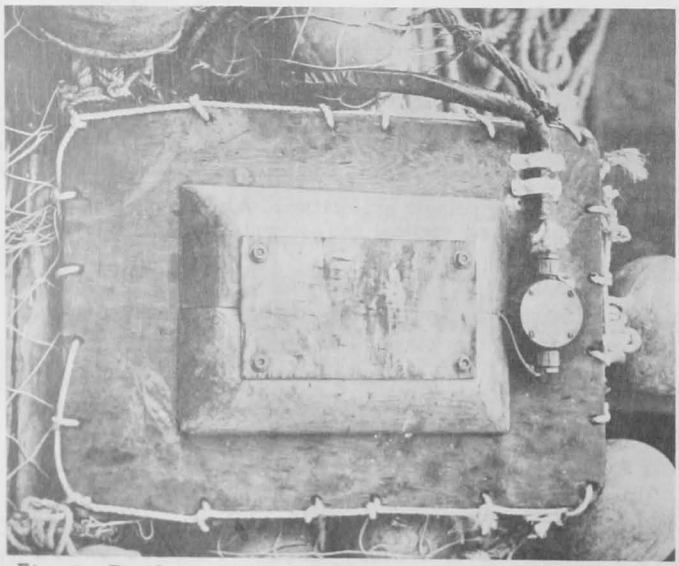

Fig. 4 - Depth transducer board mounted on the headrope of the midwater trawl. A conventional transducer is mounted in wood blocks at the center of the board. The junction box between transducer and cable is filled with silicone compound. The transducer cable is covered with a rubber hose at net to help reduce the effect of possible chafing.

WEIGHTS AND FLOATS: The footrope of the trawl was weighted with mackerel seine leads, which had a total weight of about 40 pounds. One 45-pound depressor (fig. 3) was attached to the end of each wing to help spread the gear. Fifty 8-inch-diameter aluminum floats were spaced evenly along the headrope.

ECHO SOUNDING AND RANGING EQUIPMENT: The most significant departures from conventional trawling gear and procedure were the addition and use of an unmodified standard depth-sounder transducer that was mounted on a board attached to the headrope of the net (fig. 4). A satisfactory watertight connection was made between the transducer and the $\frac{1}{2}$-inch, rubber-covered, 2-conductor (No. 10) cable that led to the vessel by using a bronze junction box filled with silicone paste. The transducer system gave no serious trouble during the experiments.

The cable used measured over 200 fathoms in length and allowed the net to be operated at depths up to 50 or 60 fathoms. It was covered with a 30-foot section of rubber garden hose at the net end for protection against abrasion at the point where the transducer cable was seized to the headrope of the net. The cable was set and hauled back from a hydraulically-powered reel mounted on the stern of the Delaware (fig. 5).

A vessel-mounted depth-sounder and recorder designed specifically for fisheries work was used in conjunction with the net transducer arrangement. No modification was required to the recorder. By means of a simple switch in the pilothouse the recorder could be made to record either the net and hull transducers at the same time or the hull transducer only.

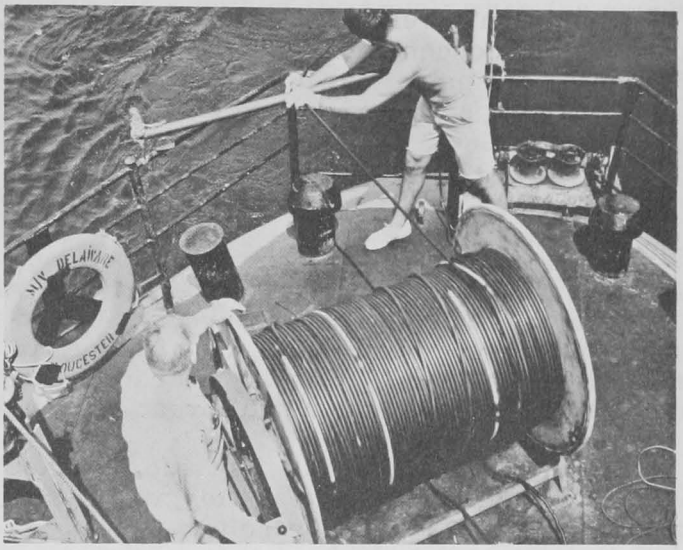

Fig. 5 - The hydraulically-powered cable reel mounted on stern of M/V Delaware. A 2-conductor (No. 10) rubber-covered electric cable is used to transmit power to the transducer on the trawl.

Simultaneous impulses to the net transducer and to a similar transducer mounted on the Delaware's hull yielded pilothouse recordings of water depths between net headrope and the bottom and vessel hull and bottom. Indications were also given as to the opening of the trawl (distance from the headrope to the footrope) and the presence or absence of fish schools, within or below the net (fig. 6).

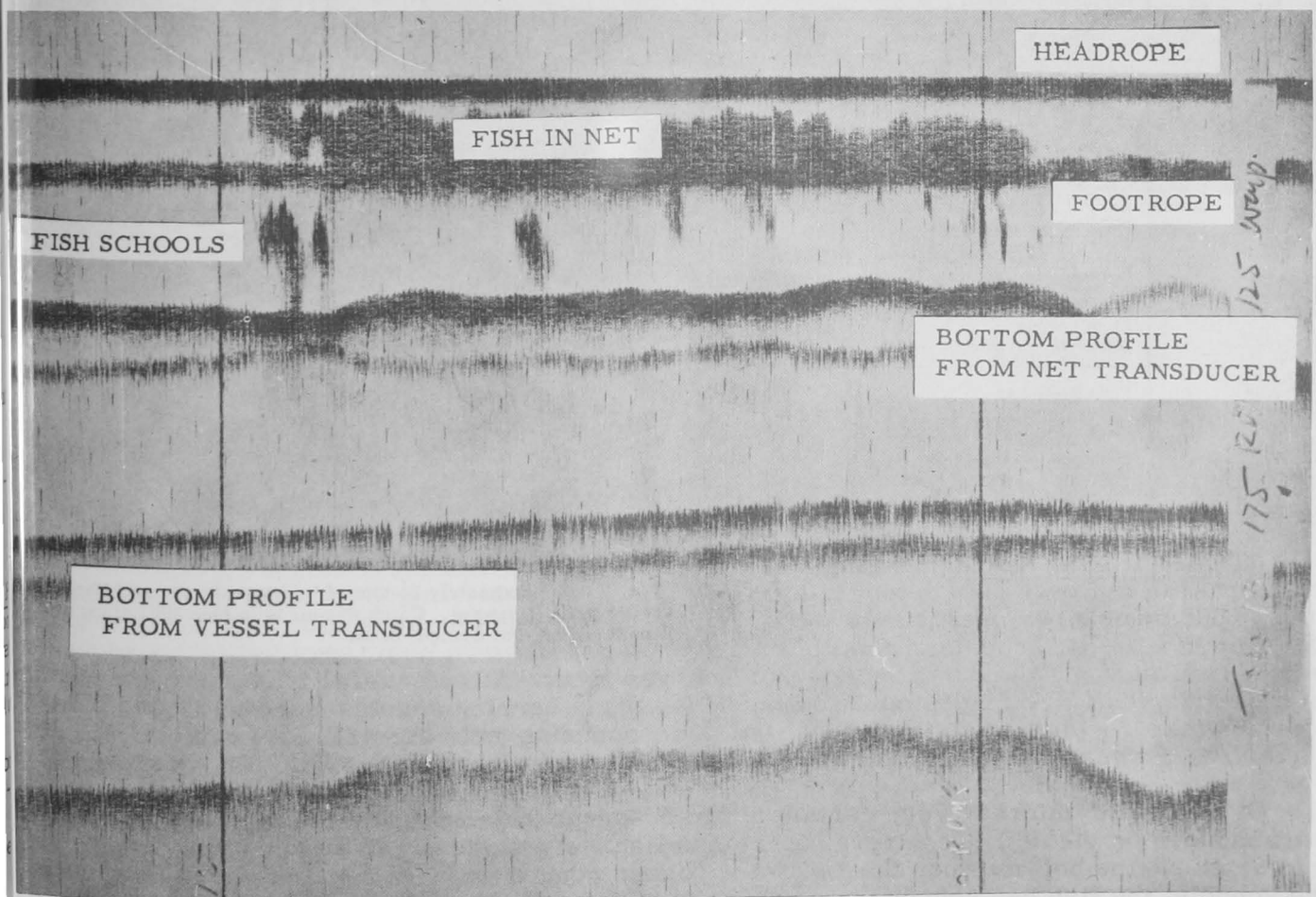

Fig. 6 - Recording showing the net over the bottom. Constant indications are given of the net's position in relation to the bottom, the presence of fish schools, and the size of the net opening (in this case about 40 feet between the headrope and footrope). This record was made along the northern edge of Georges Bank in June 1961 from the M/V Delaware.

In addition to vertical depth-sounding gear, echo-ranging or "ASDIC" equipment was also used to find concentrations of fish. This equipment operates in principle similar to that of the ASDIC equipment developed for submarine detection. Operational characteristics of the echo-ranging gear permit horizontal scanning of a zone up to 2,000 yards ahead or to either side of the vessel.

FISHING RESULTS

It became obvious early in the experiments that little in the way of catches could be anticipated unless the gear was set where positive indications of marine life appeared on the recorder or the echo-ranging screen. A need to relate the various echos received to actual catches also became obvious. The findings of Schaefers and Powell (1958), that certain types (species) of marine life display characteristics traces, seems verified, but success in associating these traces with actual organisms making them requires considerable interpretation.

Although 30 species of fish and invertebrates (table 2) were represented in the small number of midwater catches made, only 5 species were represented in catches five or more times, and just 4 species were taken in amounts of over 100 pounds per one-hour tow. Nevertheless, when fair to good signs of fish were indicated on the recording equipment, the gear used was usually effective.

Table 2 - List of Species Taken in Midwater Trawl, M/V Delaware, 1961

Species	Scientific Name	Number of Tows Represented
Fishes:		
Atlantic herring	Clupea harengus	13
Whiting (silver hake)	Merluccius bilinearis	11
Spiny dogfish	Squalus acanthias	7
American mackerel	Scomber scombrus	5
Butterfish	Poronotus triacanthus	5
Lumpfish	Cyclopterus lumpus	3
Blueback herring	Alosa aestivalis	1
Longhorn sculpin	Myoxocephalus octodecemspinosus	1
Scup	Stenotomus chrysops	1
Atlantic wolffish	Anarhichas lupas	1
Goosefish	Lophius americanus	1
Haddock	Melanogrammus aeglefinus	1
Northern puffer	Sphaeroides maculatus	1
Snipe eel	Nemichthys scolopaceus	1
Viperfish	Chauliodus sloani	1
Lanternfish	Myctophum punctatum	1
"	Notoccopelus sp.	1
"	Hygophum sp.	1
1/	Pseudoscopelus altipinnis	1
1/	Chlorophthalmus agassizi	1
1/	Nessorhamphus ingolfianus	1
1/	Ceratoscopelus maderensis	1
Arthropoda:		
Euphausids	Nyctiphanes norvegica	4
	Rhoda inermis	1
Amphipod	Euthemisto compressa	1
Shrimp	Pandalus borealis	1
Ctenophora:		
Comb jelly	Pleurobrachia sp.	1
Annulata:		
Sea worm	Glycera sp.	1
Cephalopoda:		
Sea arrow	Ommastrepnes illilebrosa	1
Squid	Calliteuthis reversa	1
Octopus	Alloposus mollis	1

1/ No known common name.

Fig. 7 - Approximately 2¼ tons of midwater-trawl-caught herring aboard the Delaware. Catch was made in June 1961 along the northern edge of Georges Bank.

ATLANTIC HERRING: Herring were taken in 13 of the tows completed, in amounts up to 4,500 pounds per one-hour tow (fig. 7). During cruise 61-8, schools of small herring were abundant along the northern edge of Georges Bank. After several trial tows, good catches of herring could be made consistently. Most of the herring schools were in 25 to 35 fathoms of water. School depth (observed with echo-sounding gear and visually) varied from the surface to the bottom with time of day, state of tide, and other factors (fig. 8).

Of particular interest were certain of the observations made possible by the presence of a transducer on the net. On several occasions fish were sonically determined to be at a certain depth off the bottom when the Delaware passed over them. By the time the net reached the schools, the fish had sounded--in some cases as much as 10 fathoms. Movements of these fish must be anticipated and the net must be fished at the depth toward which the her-

ring move. Herring were also observed swimming in the mouth of the trawl; when the speed of the vessel was increased, these fish were "flushed" into the cod end.

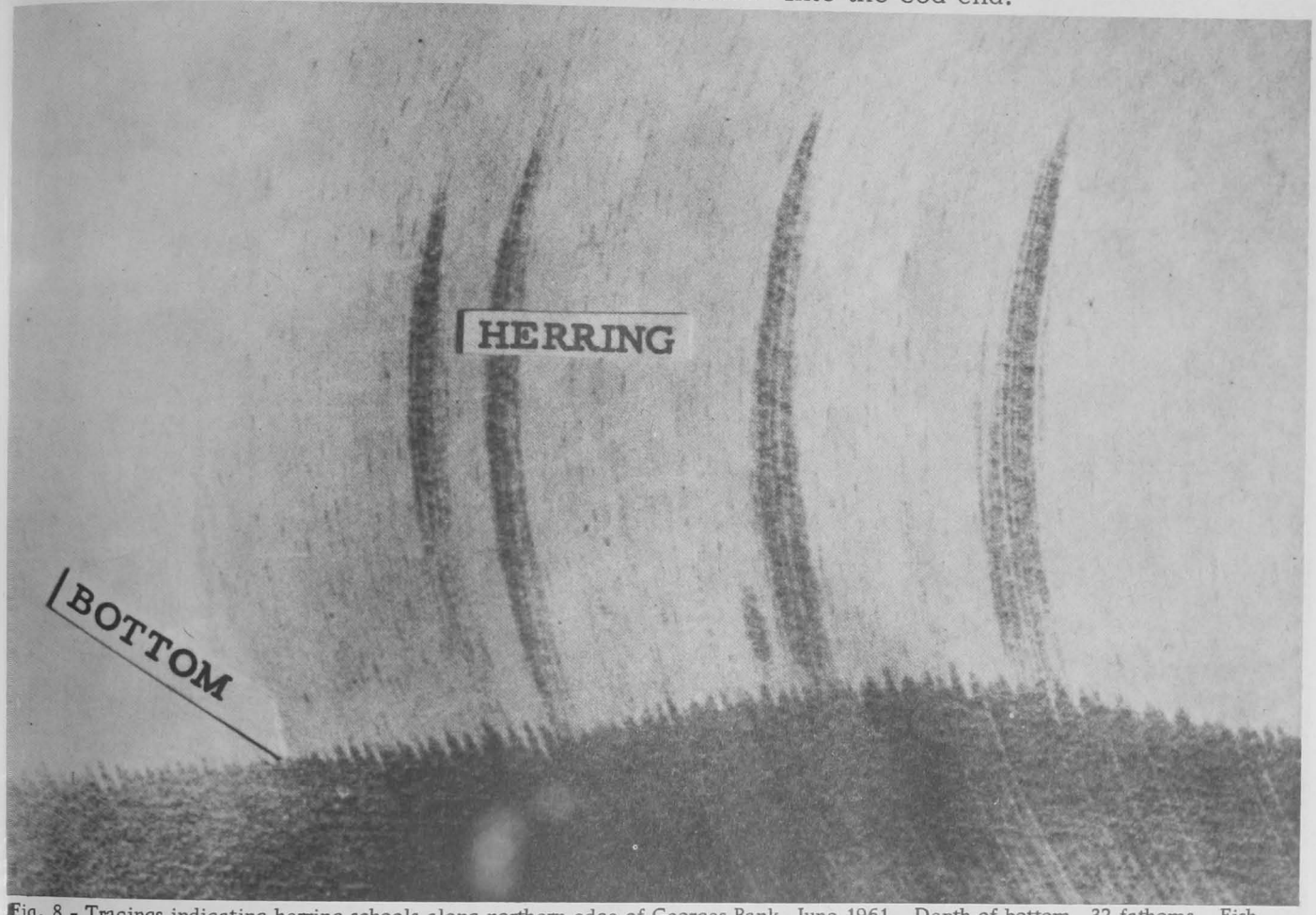

Fig. 8 - Tracings indicating herring schools along northern edge of Georges Bank, June 1961. Depth of bottom, 32 fathoms. Fish schools extended to about 15 fathoms over the bottom.

WHITING (SILVER HAKE): Although whiting were never taken in great numbers (the best individual catch rate was only about 30 pounds per hour), they were present in 11 tows, and on all 1961 pelagic fishing cruises. Commercial fishermen have noted that the whiting sometimes tend to rise off the bottom and enter mid-depths at night. This was observed during Cruise 61-11. The Delaware was allowed to drift among the commercial whiting vessels from late afternoon on July 10 until morning on July 11 while depth-sounder recordings were made. Two one-hour midwater tows were made to sample the schools indicated on the recorder (fig. 9). The resulting catches yielded only 15 to 20 pounds of small 5- to 10-inch whiting. Although the whiting were present in some numbers in the mid-depths, they did not appear to be heavily concentrated at that time.

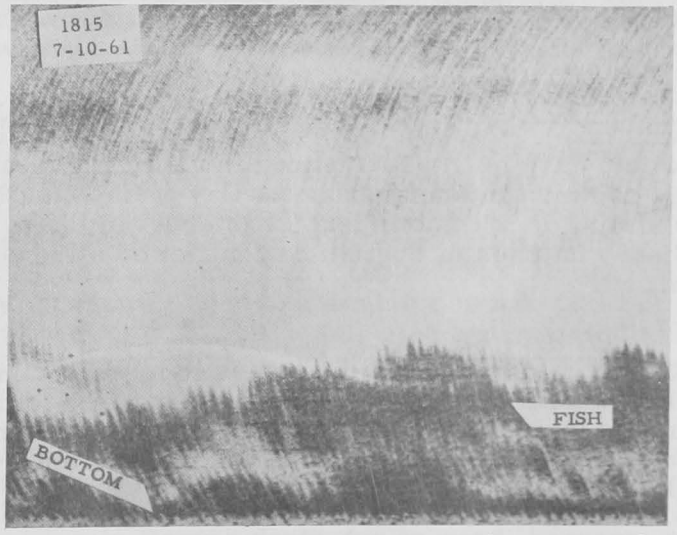

Fig. 9A - Fish starting to rise off bottom in early evening on the western edge of Georges Bank in about 43 fathoms. Recording was made while the Delaware was in the midst of the fishing fleet as whiting were being taken.

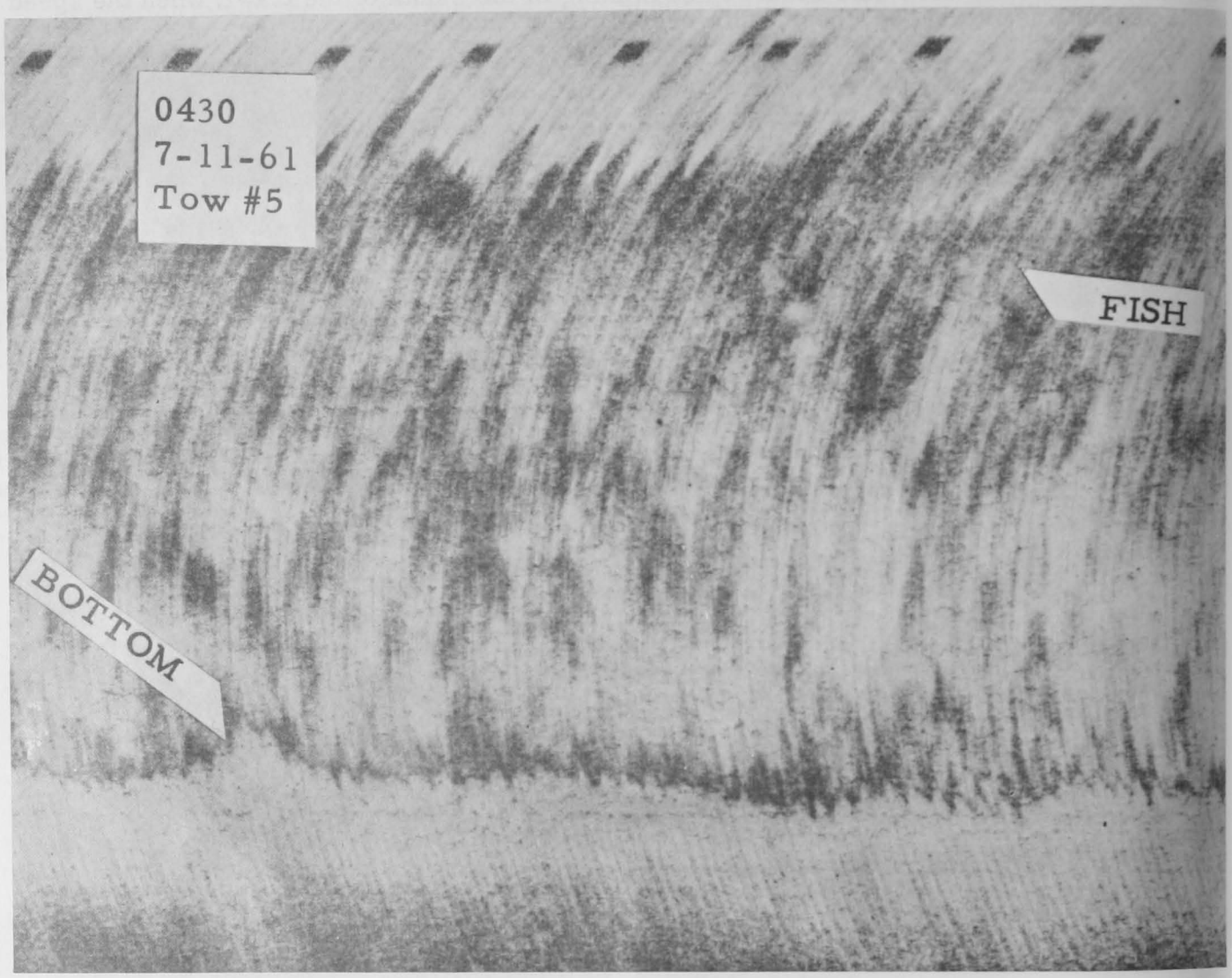

Fig. 9B - Depth sounder tracings made during midwater trawl tow. The principal catch consisted of whiting.

SPINY DOGFISH: This species, presently regarded as a pest by New England fishermen, was taken on seven different occasions. Had dogfish been the object of trawling, little trouble would have been experienced in capturing almost unlimited numbers. Dogfish were especially common in Massachusetts Bay from June through October 1961 (fig. 10). Aside from the existing lack of commercial interest in them, dogfish are avoided because of the damage that heavy catches of dogfish can inflict on a trawl net, particularly on a light nylon midwater trawl.

OTHER SPECIES: Mackerel as large as 10 inches long were taken on five occasions. Mackerel as large as 10 inches long were taken on five occasions. Best catch was roughly 100 pounds. Butterfish were present in 5 tows, but only in small numbers. Other species represented in catches and the frequency of their occurrence are listed in table 2. One catch of 500 pounds of euphausids (krill) resulted from a short (less than one-hour) tow off Mt. Desert Rock, Maine (fig. 11).

DISCUSSION

Accelerated worldwide interest in the ability to harvest fish with midwater trawl gear has led to new developments which make such harvesting more feasible. To date, the most obvious successes have been in the capture of various species of herring, certain other fishes

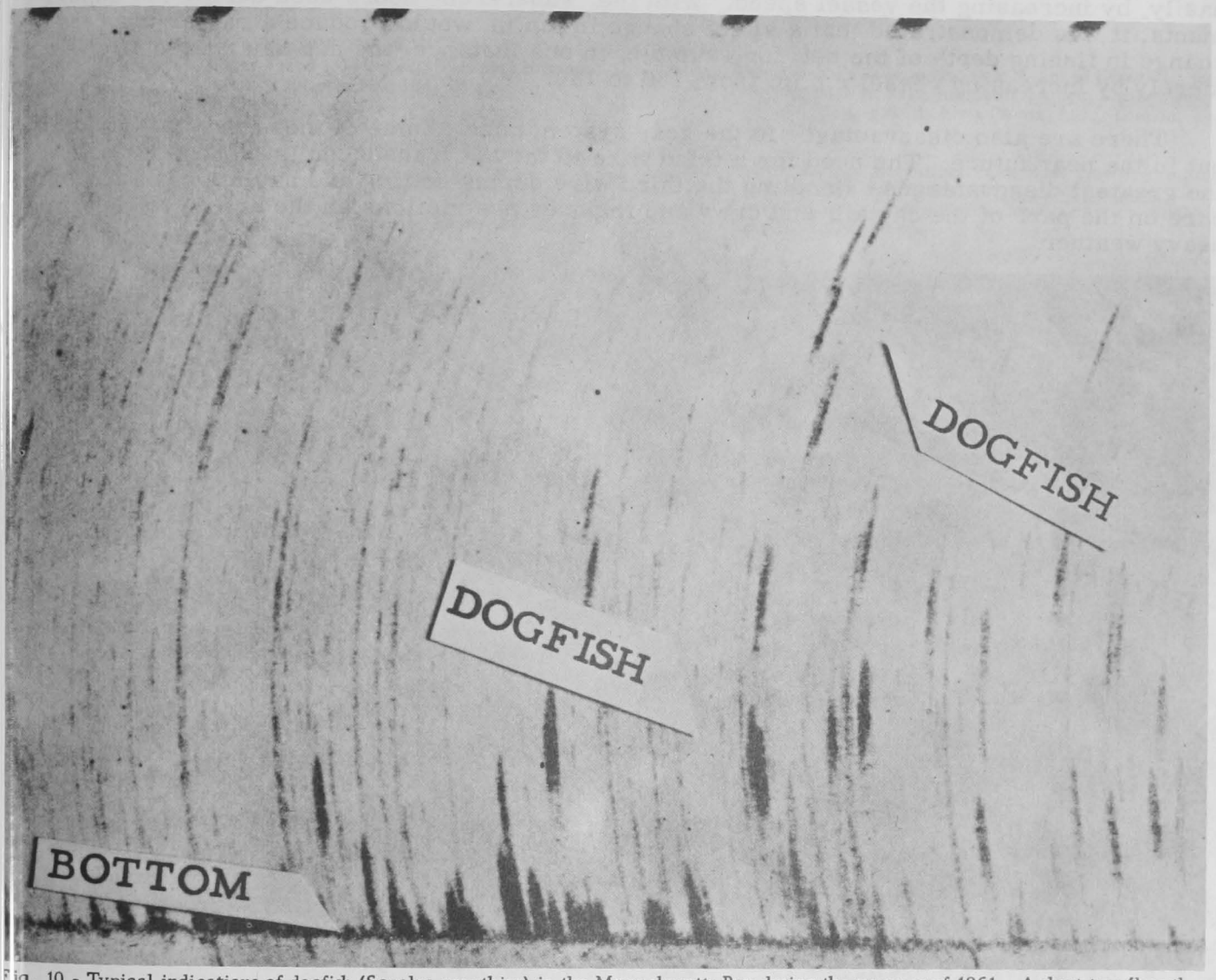

Fig. 10 - Typical indications of dogfish (Squalus acanthias) in the Massachusetts Bay during the summer of 1961. A short tow (less than one-hour long) yielded 700 pounds of dogfish.

related to herring, mackerel, and some of the hake. The difficulty in gaining capacity loads of fish in short periods has become a factor contributing to the present unstable economic condition of the New England trawl fishery. The midwater trawling technique offers the possibility of increasing harvests in existing fisheries under some natural circumstances. Fish that leave the bottom during part of the day might possibly be fished profitably with midwater trawls. Such fishes include ocean perch (redfish), whiting, cod, haddock, pollock, scup, and butterfish. Other fish stocks in unknown supply, presently of no particular commercial interest, or not fully used, could be caught with midwater gear. Included here are, particularly, the herring, pilchard, shad, menhaden, and their close relatives, and the mackerel, spiny dogfish, squid, and possibly even tuna.

The limited amount of work accomplished so far indicates that the type of midwater trawl gear described has great potential usefulness in midwater trawl fisheries. Among the advantages are: (1) the ability to keep constant watch over the depth of the net and (2) the ability to adjust the depth of the net to compensate for changes in fishing depth due to wind, current, or tide changes during a tow.

Observations made during the 1961 experiments indicate that changes in direction or speed of wind, current, or tide may affect the depth at which the trawl fishes. With the transducer-equipped net, such affect can be readily detected. Depth corrections can then be made,

easily, by increasing the vessel speed. With the "suberkrub" doors used during the experiments, it was demonstrated that a slight change in r.p.m. would produce a rather marked change in fishing depth of the net; for example, in one instance, the net was raised 10 fathoms merely by increasing vessel r.p.m. from 160 to 180.

There are also disadvantages in the gear system used. Some of these may be worked out in the near future. The need for a third wire to the net transducer is, perhaps, one of the greatest disadvantages. Handling the third wire during setting and hauling calls for extra care on the part of the captain and crew and imposes restrictions on the ability to fish in heavy weather.

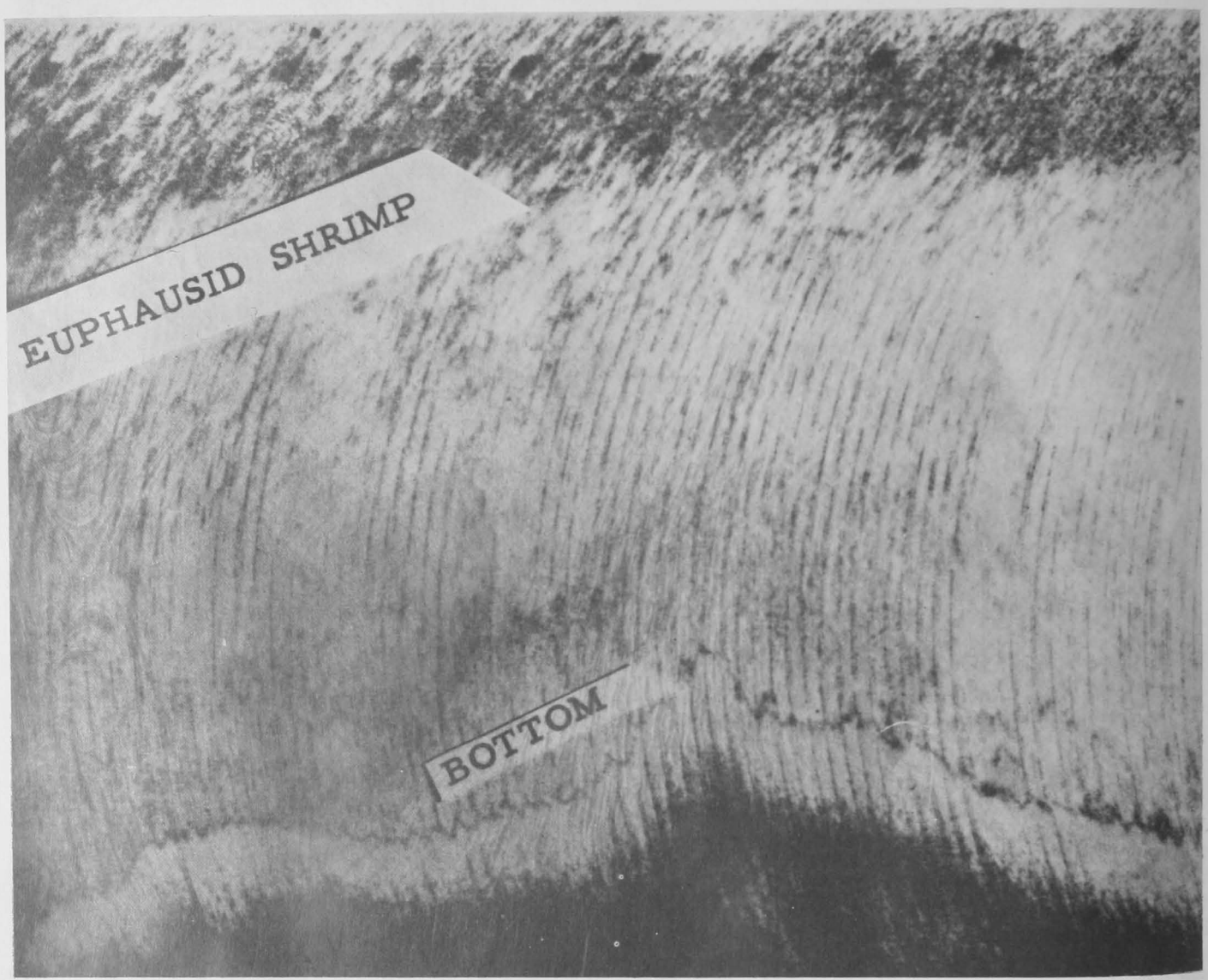

Fig. 11 - Depth recording made off Mt. Desert Rock (Maine) in September 1961. A midwater trawl tow, made coincident with the recording, yielded 500 pounds of euphausids and 15 pounds of small brit-size herring in less than one hour of fishing time.

Finally, development of an effective gear system, alone, does not assure development of a fishery. Particular attention in the future must be given to finding concentrations of marine animals and sampling them effectively. Supplementary gear may prove of value here, i.e., lift nets, long lines, gill nets, and lights. Detailed seasonal coverage must be obtained. Advanced concepts should also receive attention--among them electrical fields and their applications to harvesting midwater resources.

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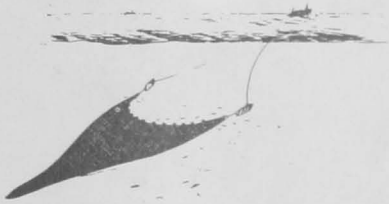

PICKS

A pick is a two- or three-pronged instrument set in a short wooden handle. It is used in gathering of hardshell clams and oysters.

Another instrument is known as a mussel pick. The mussel pick is a rod flattened at one end. It is used in gathering fresh-water mussels by inserting the rod between the shell of the mussel. A device similar to the mussel pick is sometimes used in taking oysters.

Clam pick.

Note: Excerpt from Circular 109, Commercial Fishing Gear of the United States, for sale from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., single copy, 40 cents.