and were readily available to the purse-seine fleet. The shifts in tuna distribution have been favorable to the purse-seine fleet, which is equipped to harvest the yellowfin tuna appearing in quantity in the Gulf of California and the bluefin tuna that appeared off Baja California and southern California. The bait fleet fishing off Central America found very poor fishing for yellowfin tuna, and much of the fishing effort was concentrated in the distant grounds for skipjack off northern Peru.

SUMMARY

In the past several years there have been radical changes in the composition of the fleets fishing for tuna in the Eastern Pacific Ocean. Conversion of many of the bait vessels to purse-seine fishing has built up a large fleet of modernized seine vessels, many of which are capable of operating over the entire range of the fishery from California to Peru. Technological improvements in gear and fish handling have been responsible for a portion of the increase in seiner fishing success, the remainder being attributed to increased availability of the stock, in recent years, to this type of gear.

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Air-Bubble and Electrical-Field Barriers as Aids to Fishing

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THE U. S. BUREAU OF Commercial Fisheries Research Station at Boothbay Harbor, Maine, has for several years conducted fishing gear experiments with new and unconventional methods for catching the Atlantic herring *(Clupea harengus)* that are canned as Maine sardines. Two such methods, called the Air-Bubble Curtain and the Marine Electric Fence, also show some promise of being useful for guiding and driving other species of fish. A considerable amount of work has been done in the field of electrical fishing by private industry in the menhaden fishery during recent years, and as an adjunct to the herring work it has also been learned that some schools of large menhaden can be guided by means of air-bubble curtains.

Maine Sardine Fishing Gear

In order to appreciate the need for these methods in Maine, we must consider conventional sardine fishing gear and its limitations. There are two methods commonly used, the "weir" or "trap" method and the "stop-seining" method. Both types of gear are restrictive and confine fishing operations to very shallow waters and to areas of smooth bottom and low tidal flow. Combined with natural fluctuations in abundance, these restrictions often cause shortages in the herring supply resulting in cannery shut-downs and associated instabilities in the sardine industry.

A sardine weir is constructed of pilings that are driven into the bottom, over which cotton or nylon seine netting is stretched. A rounded heart-shaped wier is usually placed in a location where the water depth does not exceed six fathoms at high tide. A weir lead constructed in the same manner is run into the V of the body of the weir, usually extending out to it from the shoreline (Figure 4). The depth of this trap is limited by the length of pilings and stakes that can be obtained at minimum cost from nearby woods.

A stop seine is a straight piece of netting 7- to 10-fathoms deep with a lead line on the bottom and a cork line on the top. It is made up in 100-fathom lengths of nylon or cotton netting of ¾- to 1⅛-inch-mesh size (stretched mesh measure). Two to ten (rarely more) of these lengths are generally laced together to make a sardine "shut off." The stop seine is set behind a school of herring after the school has migrated into a shallow cove or up on to a smooth shallow beach. Seines of greater depth than 10 fathoms are not practical because the greater bulk of netting presents more resistance to tidal flow resulting in the raising of the lead line off the bottom and consequent escape of the trapped herring. (All of the Maine coastal waters are subject to rapid tide currents because of high tidal ranges.)

The Maine sardine fisherman is further restricted by the necessity of catching herring schools alive and holding them alive for periods of one day to several weeks. They are held in seine "shut offs" or in square enclosures of seine twine called "pockets."

The fish are held in these impoundments for periods of from 8 hours to several days, or in extreme cases, to several weeks until it is convenient for the sardine-carrier vessels, owned by the canneries, to pick them up. It is generally necessary to hold the sardines for at least one day to allow their intestines to clear out food and fecal matter which would spoil the sardine pack.

Stop-seine gear is very efficient in the respect that it catches one hundred per cent of the school, when schools can be located in suitable position. As effective as sardine weirs and stop-seines are, however, they have a common and serious weakness. This weakness is that both are passive and completely dependent upon the migration of the herring to shallow water fishing sites. During the months of late spring, summer, and fall, schools of herring usually migrate from the deeper waters of the open bays and oceans on what is generally believed to be a feeding migration up into the smaller coves and bays. It is during these migrations that the opportunity for catching the herring is presented. Unfortunately, the schools often fail to run inshore far enough to be caught with stop-seines or weirs. Such schools can often be located, even during periods of great demand, lying in the deeper water of the larger bays and inlets along the Maine coast where they remain sometimes for periods of weeks but fail to make their expected migrations up into shallow waters. Thus, a situation of scarcity, while plenty of herring are under observation, frequently exists along the Maine coast.

Air-Curtain Trials on Herring

When the Maine herring gear project was started, it became obvious that there was a need to extend the fishery into deeper waters and into tidal currents. Also, a method was needed for sweeping the schools of herring that occurred beyond the range of seine gear to closer inshore areas where they could be captured. It was decided to try a string of air-bubbles discharged at the ocean bottom for this purpose. The most practical material for this air line was found to be flexible polyethylene pipe. This pipe was weighted to make it sink, drilled with holes of 36/1000 to 13/1000 of an inch diameter, and connected to an air compressor capable of supplying 130 cubic feet per minute (cfm) of air at up to 80 pounds per square inch pressure.

Figure 1 illustrates the method of setting the air-curtain pipe in the water. It is run off the reel at the stern of the boat. The lead weights sink it to the bottom and the air supplied by the compressor aboard the boat is discharged at the sea bottom from the small holes bored at 1-foot spacings in the pipe.

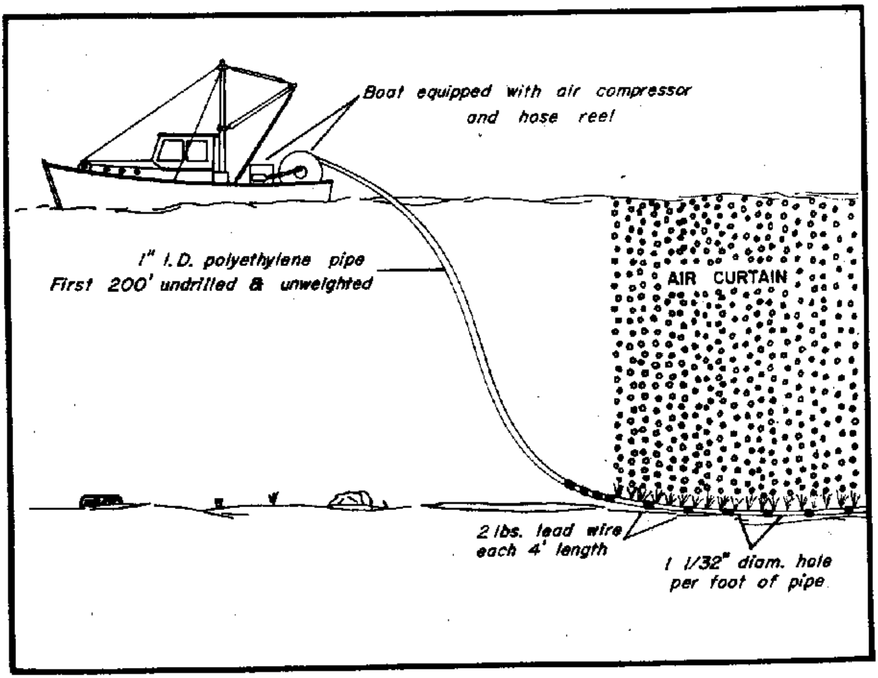

FIGURE 1. Diagram of the air-bubble curtain as set from the stern of a boat.

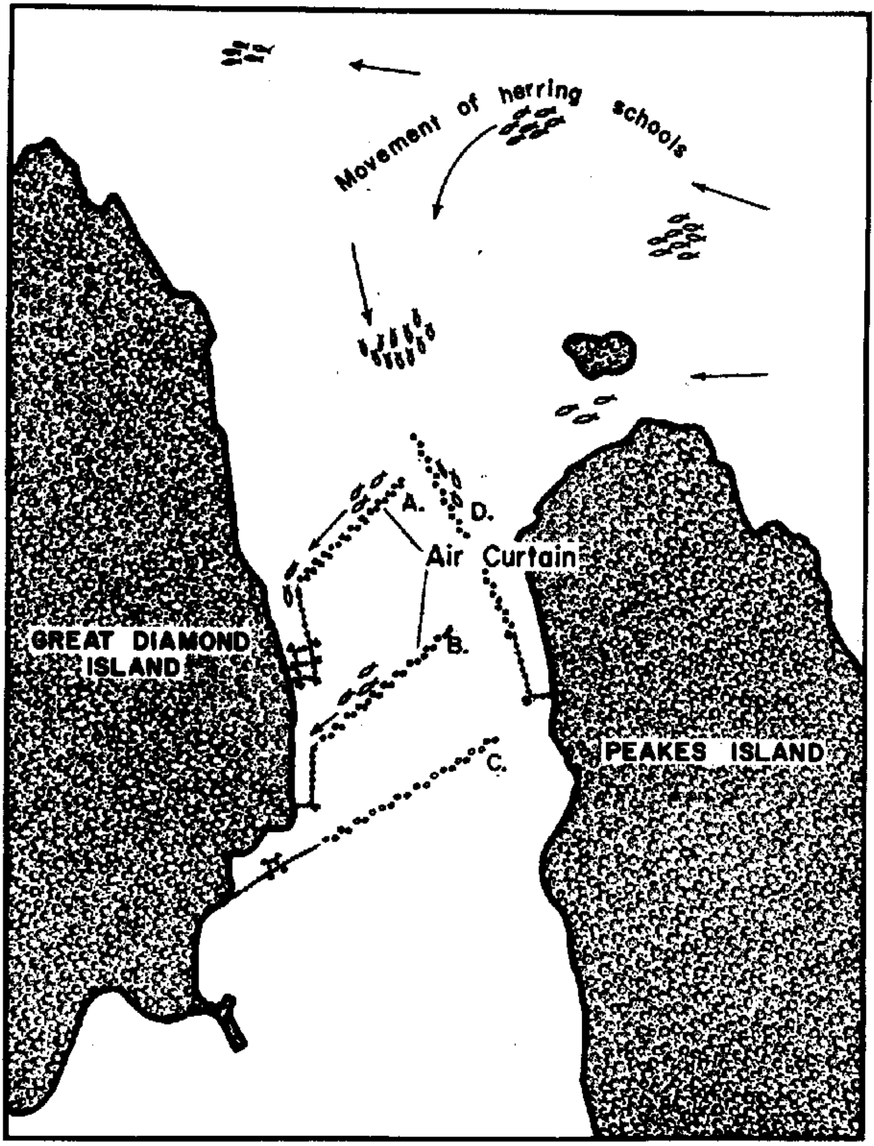

FIGURE 2. Diagram of air-curtain trials in Casco Bay.

The air-curtain gear was originally tested in West Penobscott Bay near Rockland, Maine. At this time, it was set up in the path of migrating herring schools that were observed to pass each night between two small islands. The first of these trials demonstrated that herring could be diverted from their normal migration pattern using the air-bubble curtain. Another trial indicated that the

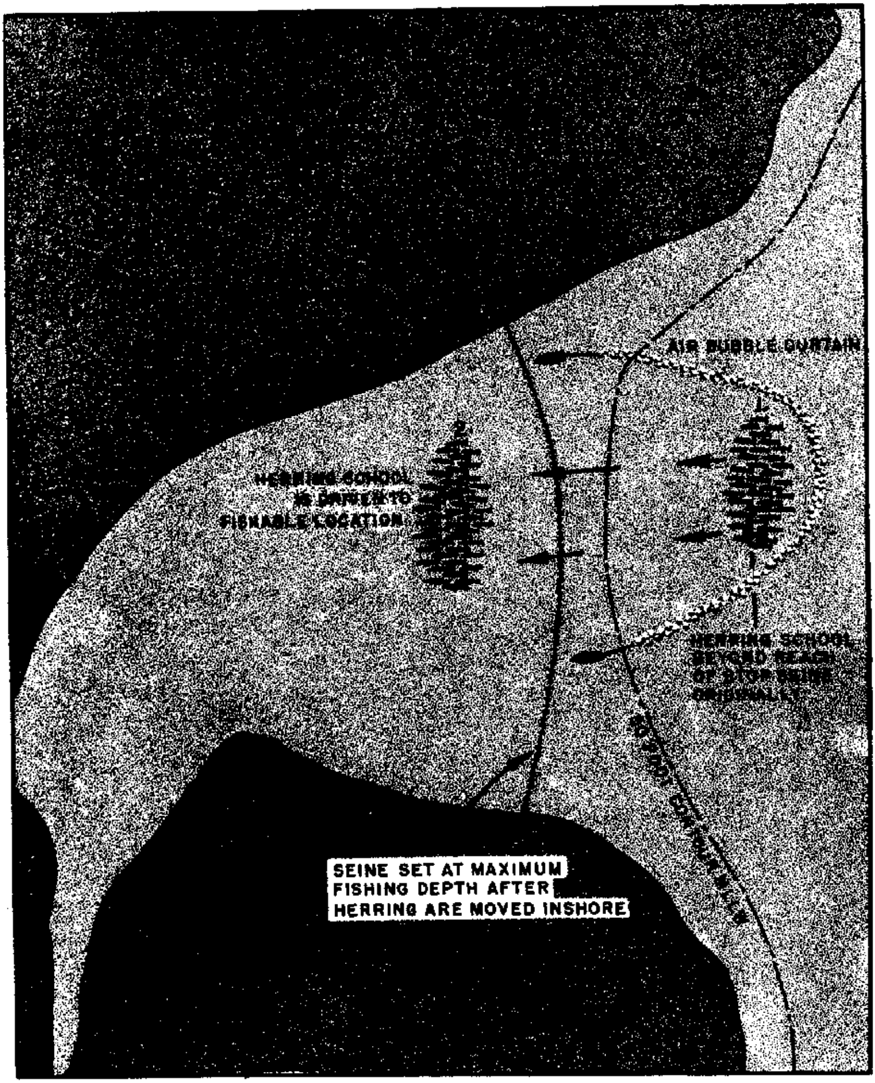

FIGURE 3. Method of driving herring school to fishing site.

schools could be stopped in their normal migration pattern and would react to the air curtain much as they react to a set of seine twine. That is, they would flatten against it and run along it toward one end or the other.

The site of the first trial of this gear in the commercial fishery is diagrammed in figure 2. Herring schools were found in this area to be moving down the channel between the two islands of Casco Bay, Great Diamond and Peaks Island, each evening shortly before complete darkness. They were remaining in the center of the channel away from stop-seine sites on each side of the

Diamond Island shore and Peaks Island shore. The air curtain was run out diagonally, shown in the diagram, in the several positions on several different nights. It was successful each time, when schools were known to be moving down the channel, in guiding the herring over to the seining sites at either shore where they were impounded in stop-seine gear.

In the seasons following these demonstrations, several sardine fishermen installed air-curtain gear of their own. Figure 3 and 4 show two applications of one fisherman's air-curtain gear. As mentioned above, herring schools often occur beyond the reach of the stop-seine twine. When this situation occurred

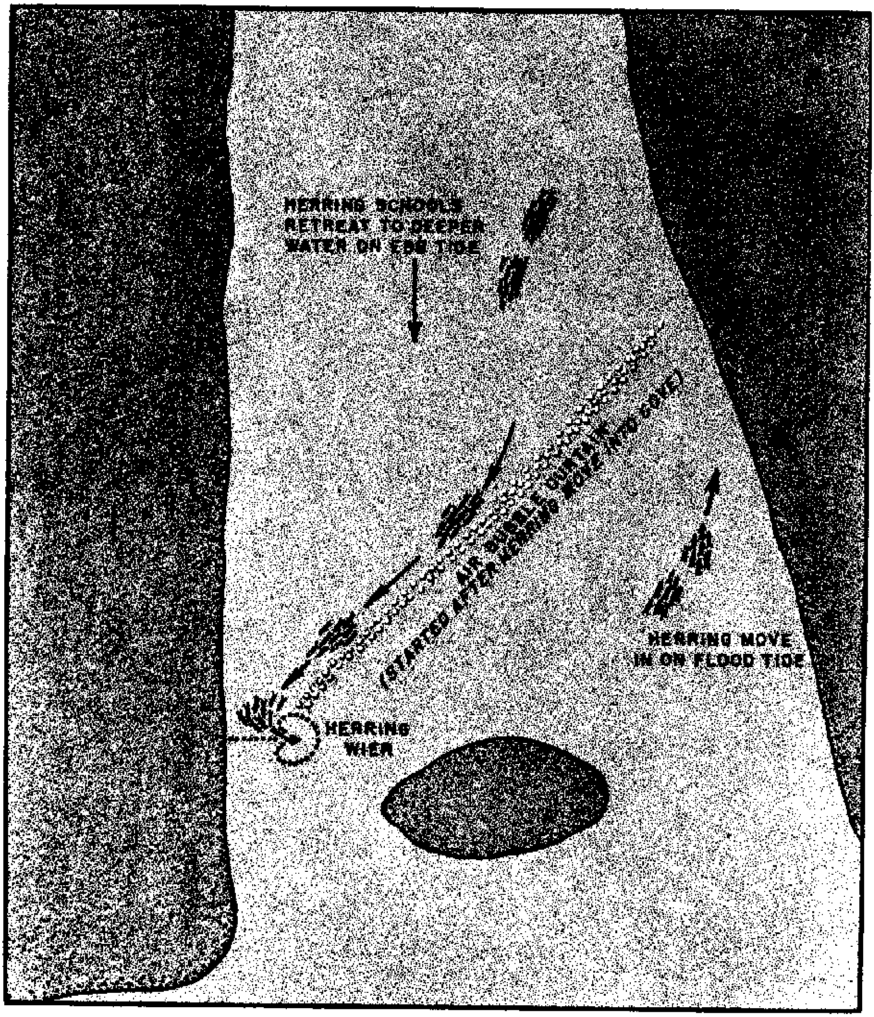

FIGURE 4. Air-bubble curtain used as an ultra-long deep-water weir lead.

repeatedly, at a location called Sandy Cove near Lubec, Maine, an air curtain was used to drive the herring school inshore where it could be impounded behind the seine.

The air curtain was looped around the school of fish, which is shown in position beyond the 50-foot contour. The plastic pipe was then towed slowly inshore by boats on each end, driving the herring school to within range of the stop-seine gear shown set at its maximum depth.

Another diagram (Figure 4) shows the same unit of gear as applied as a weir-lead in Cutler Bay, Maine, also near Lubec. In this application, the polyethylene pipe was laid on the bottom and left idle there until herring schools, moving in on the flood tide, had progressed to a position beyond the weir and beyond the polyethylene pipe. The air-compressing gear was then started, setting up the air-bubble curtain. At ebb tide, the retreating herring schools encountered the air curtain and were guided along it to the lead of the herring weir, from there they were diverted by the lead into the weir.

Menhaden Trials

Another aspect of the field testing of air-curtain gear of more concern to the Gulf and South Atlantic area is its possible application in the menhaden fishery. During the Bureau's association with the Smith Research and Development Company, subsidiary of the Fish Products Company of Lewes, Delaware, concerning electrical-attracting devices for herring, the company became interested in the possible use of air-bubble curtains in conjunction with electrical-fishing apparatus, as it might be applied to menhaden fishing. A unit combining the two methods was designed and the menhaden boat *Rappahannock* was brought to Maine for field trials of the unit on herring as a preliminary to trying the unit on menhaden. While searching for herring schools by aerial reconnaissance, on which to try the gear, schools of menhaden were located in Casco Bay near Portland, Maine.

The menhaden were observed to be moving in-and-out of Gun Point Cove in Casco Bay, so the air-curtain gear was set up as shown in Figure 5. Two 200-hundred fathom lengths of the air-curtain gear were laid down in a V-fashion so as to trap the retreating menhaden schools as they swam out of the cove at ebb tide. An electrode, similar to that used to assist in the unloading of purse seines in the menhaden fishery, was fastened at the apex of the V in a position about 40 feet from the boat. The object of this test was to determine: (1) whether or not menhaden schools could be guided by air-bubble curtains and (2) whether they would approach the electrode close enough, when guided in this fashion, to come under its influence and be drawn on into it.

Menhaden schools, starting in the position at the top of the diagram, progressed downward to position 1 as shown, then to position 2 where the indicated school moved down along the air curtain, avoided passing through it and gradually with some working in-and-out towards the curtain progressed to position 3. At this point, some of the fish were observed to move over to position 4 then to 5, which is about as close as the fish ever approached the vessel and the electrode assembly. In this position they milled around remaining 50 to 60 feet away from the electrode and nearly 100 feet from the boat until the test was ended due to darkness. It appeared that the fish were able to detect the presence of the large white boat in the water and also that as they

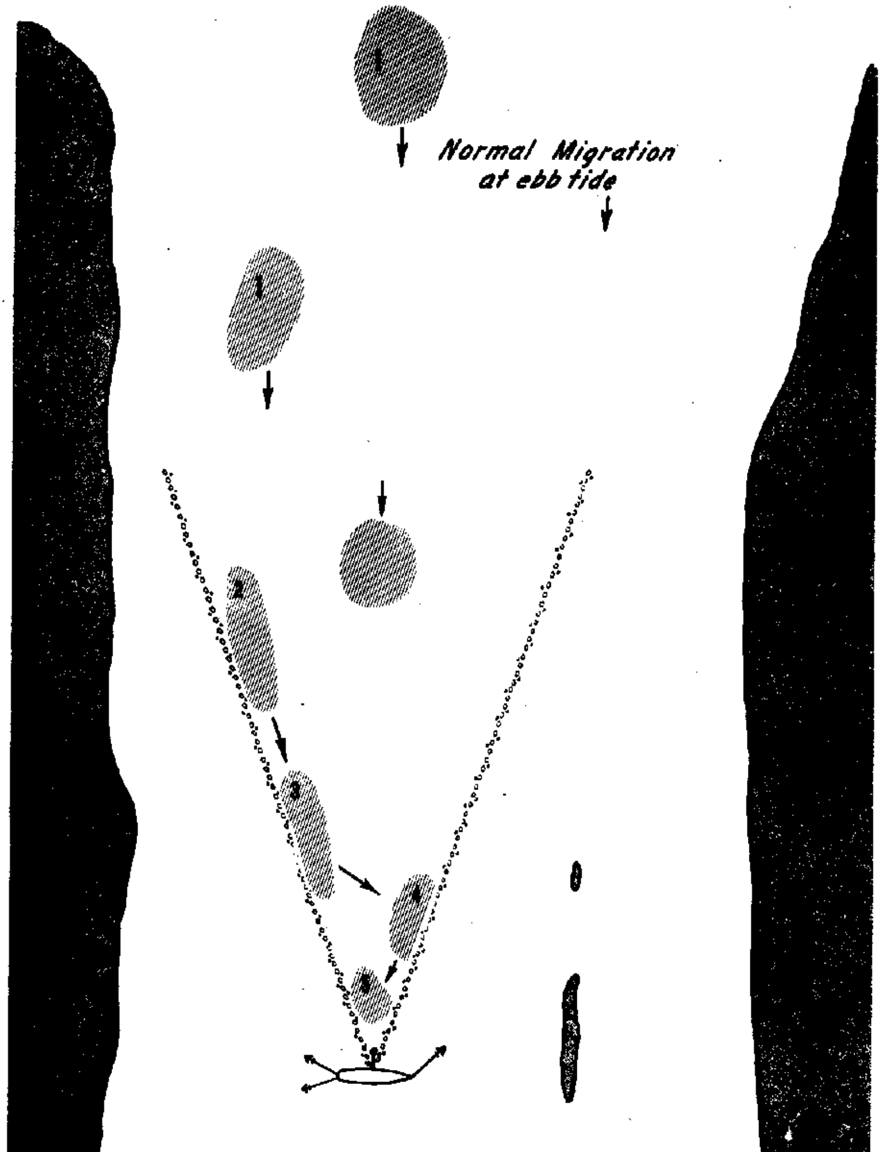

FIGURE 5. Air curtain and electrofishing trials on menhaden, Gun Point Cove, Casco Bay, Maine.

approached the tighter enclosure of the bubble curtain, they refused to progress any further toward the bubbles.

Menhaden schools were picked up again at a later date in Winnegance Bay of Casco Bay and trials were made of the possibility of enclosing and holding the schools within an *enclosure* of the air-bubble curtain. The 200-fathom lengths were laid out in this location much the same as they had been at Gun Point Cove except that they were spread at a wider angle.

This set is shown in Figure 6. The bubble-curtain legs were left in the wide-V position during a period of ebbing tide as menhaden schools were moving out of the cove in the direction indicated. After a number of the schools had entered the area between the legs, the ends were towed together forming the roughly squared-shaped enclosure. The schools were then watched from the air for a period of several hours to determine what their reaction might be when enclosed in this manner.

The movements of the school, in the lower right-hand corner of the diagram, was of particular interest. It moved up against the air curtain, backed off away from it, then moved up against it again, as shown by the arrows. This action was repeated several times while the school was being watched and it never did break through the air curtain. Neither, however, did the schools ever closely approach (that is, within 100 feet) the boat and electrode assembly shown at the bottom. None of these trials permitted a good test of the electrode assembly and the pulse generator unit attached to it because of the fear of the fish for the boat and electrode. Schools were held in this enclosure for a maximum period of ten hours.

Figure 7 represents, not an actual trial, but a proposal for a trial of air-curtain gear for fishing menhaden schools in the actual commercial fishing areas. The cross hatched area represents a section of coast line, the black representing the water and the small light patches schools of menhaden. In the area represented by the diagram, menhaden schools have been observed by fish spotters and boat captains to move in approximately the patterns indicated by the arrows. They move out of the bay and southward along the coast. Also, schools move southward from upper parts of the coast, running fairly close along the shore, usually within 3 miles of the shoreline. The air-bubble curtains would be laid in the positions indicated by 1 and 2. These curtains would be up to 1 mile in length and would utilize approximately 225 cubic feet of air per minute. The first objective, as indicated at position 1, would be to concentrate schools, particularly the small scattered ones that run down the coast in this area, so that they may be seined in this position. Such preconcentrating would be of value since, at many times, it is difficult to find a large enough school in position for making a seine set. If the results of the type of set, as indicated in position 1, show promise, then further work might be done to design some kind of holding device or trap at the apex of the curtains, as shown in position 2. Ideally, electrical driving and attracting gear would be used in this position to load the menhaden aboard the carrier vessels.

Marine Electric Fence

Another unit of gear was tried out last summer in the Maine sardine fishery, a device we call the marine electric fence. For a number of years some of the menhaden boats have been using electrified pump heads for easing the drying up and loading process when purse seining menhaden. One of these units was supplied by the Smith Research and Development Company and was tried out by the Bureau of Commercial Fisheries during the herring season in the fall of 1959 for pumping herring in the same fashion. Only a limited success was experienced with this unit, and we were not able to demonstrate to sardine fishermen any great advantages that could be attributed to the use of it.

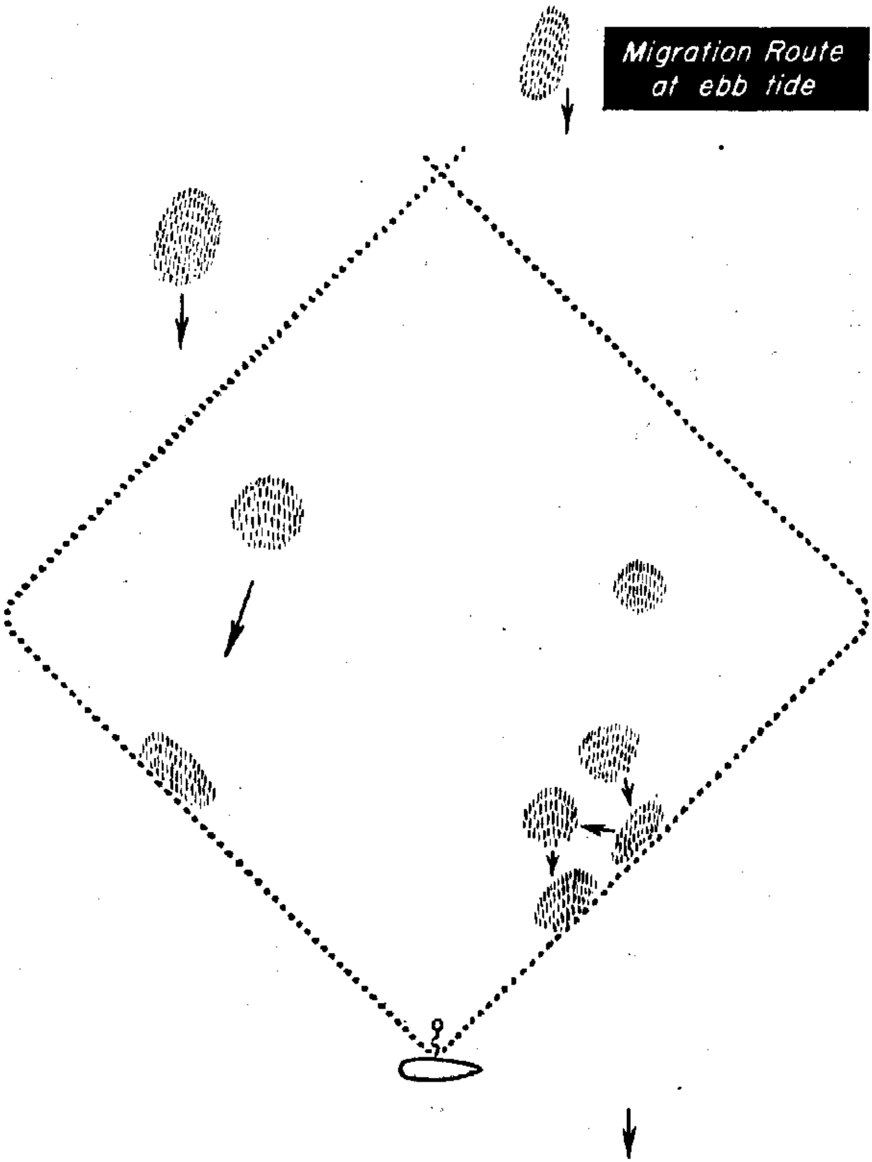

FIGURE 6. Holding trials on menhaden schools within an air-curtain enclosure.

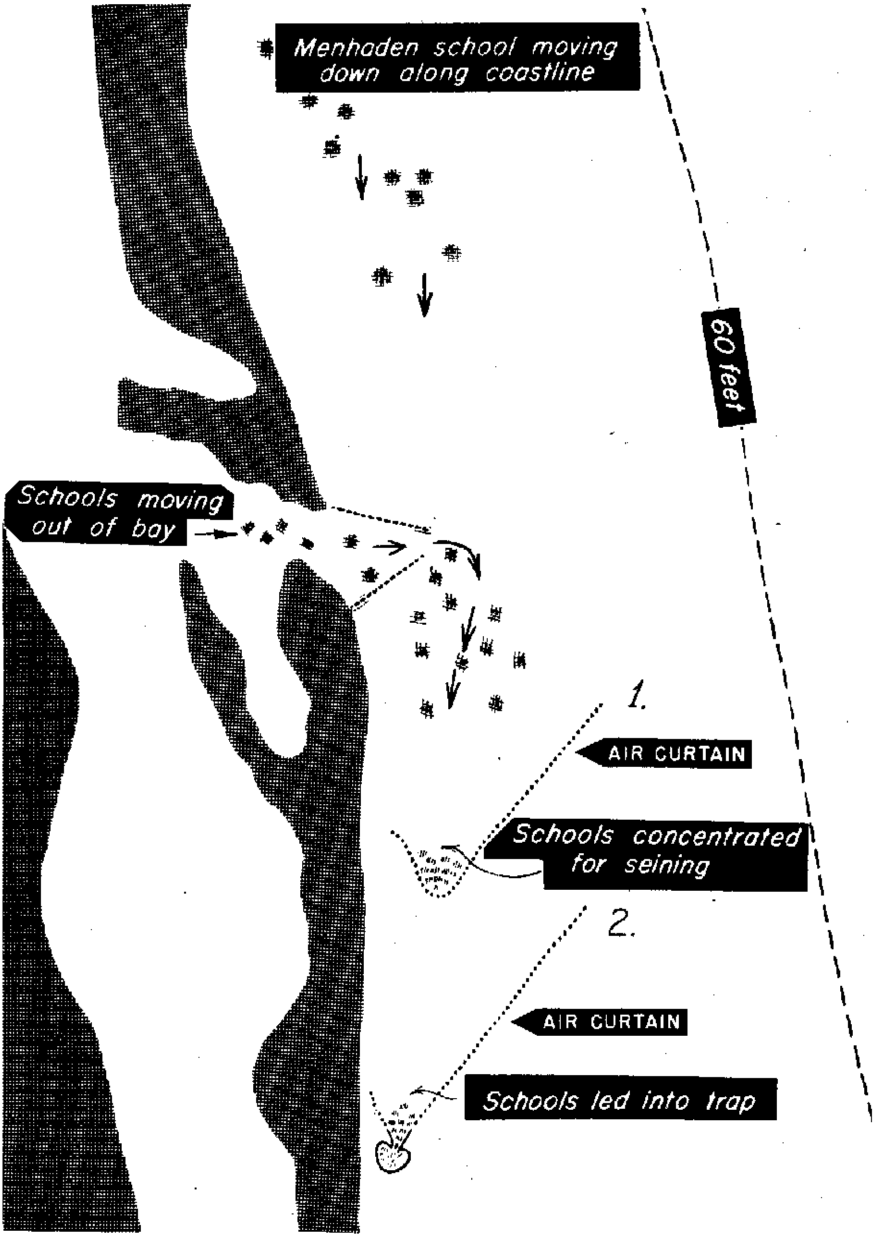

FIGURE 7. Diagram of a proposed trial of air-bubble gear in a commercial menhaden fishing area.

Although the loading process was eased, indications were that herring, killed or badly stunned by electrocution during the loading process, did not ingest the salt preservative as active fish do upon entering the carrier-vessel's hold and so, were in a less desirable condition for packing when delivered to the cannery. Also, the yield of valuable scales removed by the standard screening method appeared to decrease.

However, a similar unit has been used during the last two seasons for pumping herring aboard a vessel of a Maine fish meal and oil plant. The crew of this vessel reports that their unit is of considerable assistance in loading herring for reduction purposes. Also, progress was made in controlling the amount of electric shock received by the fish so that they entered the hold alive.

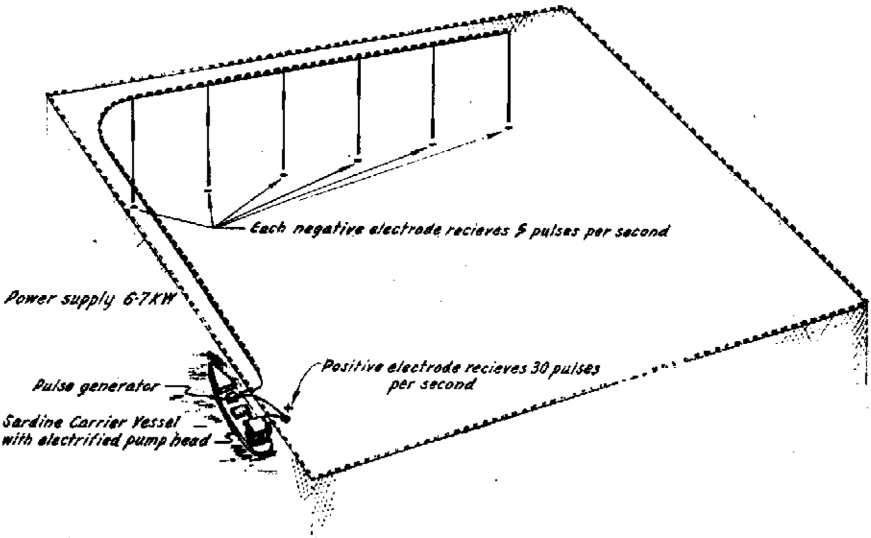

FIGURE 8. Marine electric fence as tested in Maine sardine seine pocket.

Figure 8 is a diagram of a stop-seine pocket with a carrier vessel alongside it in position for loading. (Disregard for the moment the negative electrodes showing in the upper part of the pocket.) A small purse seine is normally set by hand inside this pocket. The seine is pursed by hand and the fish are drawn up by hand to a position adjacent to the carrier vessel, at which point the fish are pumped out by the standard fish pump method. (In the electrical fishing trials a positive electrode was placed at the pump head which was designed to attract fish to the pump head where they would be swept in by the water current and pumped into the hold of the vessel.) The hardest task connected with stop-seine operations is this hand purse seining of the sardine pocket. For this operation, *three* to *five* men are required, where other stop seining operations can be handled by *two* to *three* men. Also, since the work is done by hand, it requires a great amount of human effort and is a slow, laborious task.

The marine electric fence was designed and fishing trials were made to see if this pocket purse-seining operation could be eliminated by a method of electrically *herding* the fish to the positive electrode and the pump intake instead of physically forcing them with the purse seine. As the positive electrode attracts fish within a limited range, so the negative electrodes are known to scare or repel the fish. This unit was, therefore, designed to use the negative repelling charge on the *opposite* side of the pocket from the fish pump intake, from which position it could be slowly swept toward the positive. In order to get the optimum effect from the negative electrodes they were not connected in parallel but the 30 pulse per second power supply was *split* among the 6 negative electrodes so that each successive pulse was discharged through a different succeeding negative electrode. Thus each of the six negative electrodes received 5 pulses per second of the 30 applied to the positive electrode. This system allowed the maximum pulse strength possible around each of the negative electrodes. The electrodes are 25 feet long and hang down in the water from the main power line which is also a floatline. They are spaced 12 feet apart giving a total length of 72 feet, including the repelling field.

The extent of the repelling field in this arrangement was expected to range 6 feet from the electrode. The field trials, however, showed the effective range to be much less. The herring, when pressed close with this device, approached to within 3 feet of the electrodes and passed easily between them.

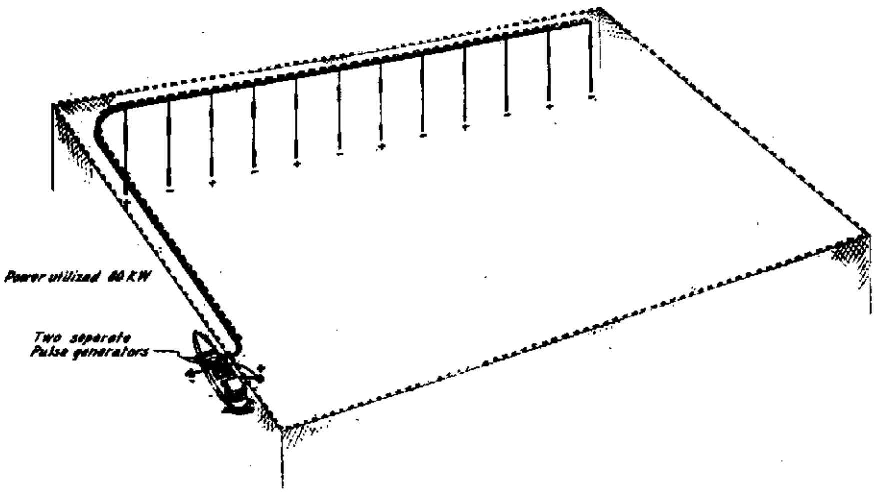

FIGURE 9. Marine electric fence No. 2.

So fence number 2 was designed as illustrated in Figure 9. There are 12 electrodes instead of six, labeled plus and minus. This unit operates on 60 pulses per second and will apply a full strength pulse to each electrode 10 times per second. As the applied pulses move down the line, each electrode receives successively a positive, then a negative charge. Thus an alternating current electric field, which also has a repelling effect on fish, is set up. This unit utilizes 60 kw of electric power, approximately nine times the amount used by the former model, which should give three times the effective range per field (as the strength decreases with the square of the distance from the electrodes.) The electrodes are spaced only half as far apart as before, which will also increase the effectiveness of the unit. Notice that a separate unit is used aboard the carrier vessel for charging the positive electrode on the pump head. The negative side of the pump head unit is grounded to the sea bottom on the other side of the boat.

This new unit has not yet been tried out on fish but is currently being built at the Smith Research Company. Plans are to make fishing trials again in the 1961 Maine sardine season, when once again *It's Roundup Time in Maine.*

Fishery Products and Food Additives

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MANY OF US ARE CONVINCED that our food doesn't taste like that which Mother used to cook. That view could be just the effect of comparing memories recorded in the technicolor of youth against the black and white of daily adult reality. But it is true that many of the foods that we now buy already prepared, processed, and conveniently packaged, contain ingredients that were never found in Mother's pantry. Often these ingredients, acting as antioxidants, emulsifiers, preservatives or in some other role, make possible, or are an inevitable accompaniment of, the modern form of the marketed food.

Such substances, now referred to as "food additives," have come into use in increasing numbers and in growing volume during the past two decades, until at last it was realized that a new law was needed to deal with them. Many of those already in use had not been studied sufficiently to make sure they were safe, because the old law did not require an additive to be proven safe before it was used in food. True, legal action could be taken if a food was found to contain any added ingredient that was poisonous or deleterious, unless such added ingredient was required or could not be avoided by good manufacturing practice and was covered by a tolerance, but the difficulty was that if a product was put on the market without adequate testing, the Food and Drug Administration had first to find out about it, then get samples, conduct long-term toxicity studies, and ultimately take legal action if the product was in fact found to contain a poisonous or deleterious component. Meanwhile, the public would be eating this particular food.

To improve this situation, in September, 1958, Congress enacted the Food Additives Amendment to the Federal Food, Drug, and Cosmetic Act. The amendment provides a system for regulating food additives and it is designed to give the consumer better protection. With certain exemptions, it defines a food additive as any substance which may reasonably be expected to become a component of food or otherwise affect its characteristics, whether added directly or indirectly. No substance coming within the definition may be used unless a regulation has issued permitting and specifying the conditions of its use.

The definition exempts those substances which are generally recognized as safe by experts qualified to evaluate them. There are, of course, a great many