COMMERCIAL FISHERIES REVIEW

February 1955 Washington 25, D.C. Vol. 17, No. 2

USE OF AN ELECTRICAL ATTRACTING AND GUIDING DEVICE IN EXPERIMENTS WITH A "FISH PUMP"

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SUMMARY

Results of fishing experiments using gear designed for pumping fish in combination with an electrical-guiding device and an automatic light dimmer show that, in calm waters, small herring (and probably other small phototropic fish) can be attracted and caught in a pump by use of a light for attracting them and a direct-current pulsating electric field for guiding them. These fish are not repelled at the outer fringe of the electric field. Instead, when attracted by the light they enter

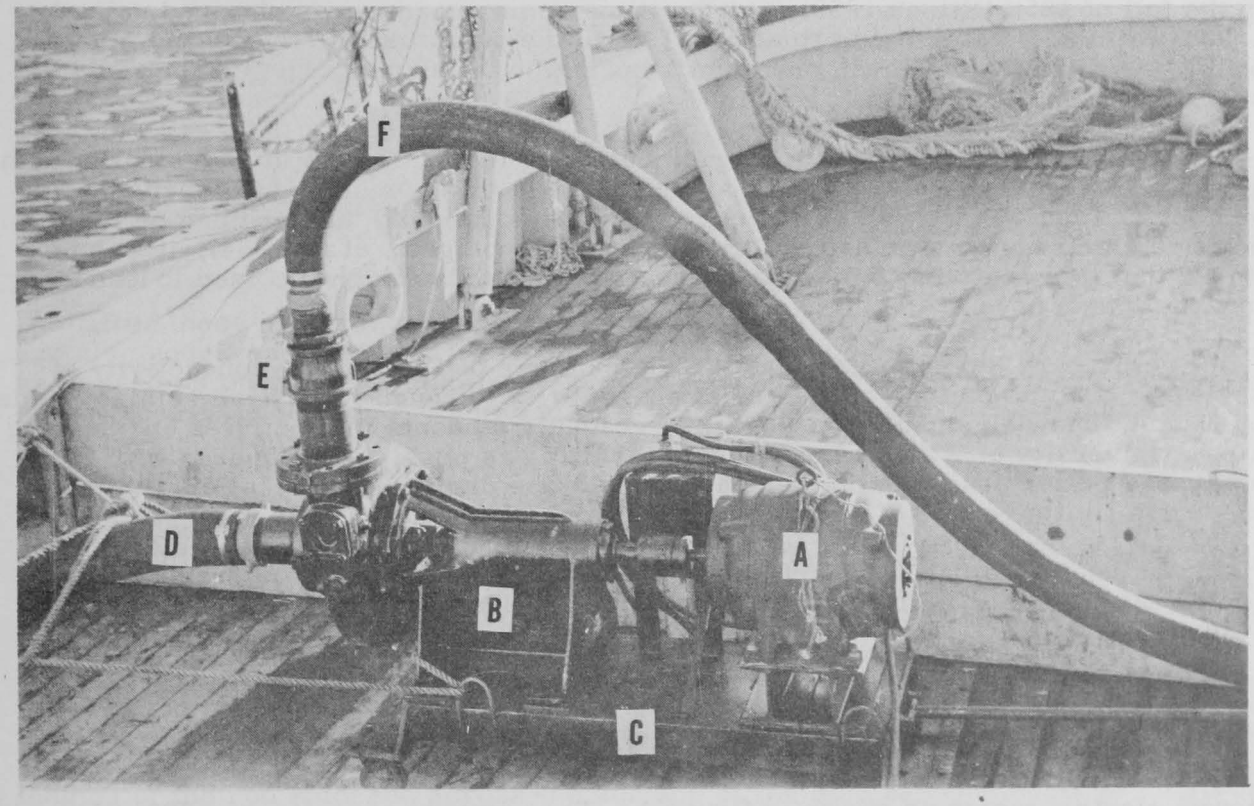

Fig. 1 - The "fish pump" used in the present and previous experiments.
A - Electric motor, 5 hp., 1,800 r.p.m., 3 phase, 60 cycle, 220 volts.
B - Pump, bladeless impeller type, 4-inch intake and outlet diameter.
C - Mounting carriage on rubber tire casters, secured with rope as shown.
D - Intake hose, 20 feet long, 4-inch inside diameter suction hose.
E - Pipe reducer, to reduce diameter from 4 inches to 3 inches (to prevent cavitation).
F - Discharge hose, 30 feet long, 3-inch inside diameter suction hose.

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the field to a point where they involuntarily swim to the anode and are swept into the pump by the flow of water.

The gear took fish most successfully when both the underwater light and pulsating field were in operation. Small catches, however, were made using light alone. Sudden movement of the light and electrode assembly frightened the herring away. Thus, movement such as that caused by the rolling of the vessel prevented the herring from approaching the gear closely. Dimming the light did not cause herring to approach closer. The best catches were invariably made in the early morning during the approach of daylight.

Further work in attracting and guiding fish to a point of capture in the seas might be implemented by the use of light of the proper wave length and by sounds of proper pitch and intensity. More effective use of white light and an electrical field can be made by use of a better electrode design and a more stable support for the attracting and guiding assembly.

BACKGROUND

With gear designed for pumping fish from the sea, experiments were conducted aboard the U. S. Fish and Wildlife Service's exploratory fishing vessel John N. Cobb in the fall of 1952 (Ellson 1953). At that time some success was obtained using two 1,000-watt underwater lights to attract fish to the pump intake. A maximum of about 1,000 fish was caught in one night's operation of the pumping gear between the hours of 8 p.m. and 6 a.m.

Another series of tests was carried out using the same gear in combination with an electrical-guiding device and an automatic light dimmer during October and November of 1954. Since various workers have demonstrated that fish can be led to a positive electrode by a pulsating direct current (Applegate, et al, 1954), it was believed that this reaction of the fish to electrical stimulus might be used to lead them into the intake hose of the "fish pump."

Preliminary studies were made in the summer of 1953 on the conductivity of sea water and the pattern of electrical current flow through it. These studies, made by Duane Chadwick and Joseph Christie, graduate students in electrical engineering at the University of Washington, indicated that it was possible to produce with the amount of power available on the John N. Cobb the desired electrical current flow through a limited space of sea water. The work of Groody, Loukashkin, and Grant (1952) on the behavior of the Pacific sardine (Sardinops caerulea) in an electrical field was used as a basis for defining the necessary conditions of current flow and for calculating the power required to produce the desired effect on Pacific herring (Clupea pallasii).

GEAR

Approximately the same pumping arrangement was used as in the 1952 experiments. This consisted of a 4-inch bladeless-impeller pump coupled to a 5-horsepower electric motor as shown in figure 1. The pumping capacity was 220 gallons of water per minute. The intake hose was passed through a closed chock into the sea water, and the discharge hose was run to the receiving tank and firmly fastened.

The receiving tank was built on the after deck as shown in figure 2. This tank was 8 feet wide and 13 feet long and could be filled to a depth of approximately 10 inches when the vessel was in calm water.

Tests were made with various temporary lighting and electrical guiding arrangements. These tests indicated that both lighting and electrical guiding were necessary to lead fish into the pump intake. Without the light, fish were not attracted to the electrical field, and only those inadvertently entering the field were caught.

With the light on but with no electrical field applied, most of the fish that had been attracted to the light were able to escape. The water current near the intake was not so swift as to sweep a large number of fish involuntarily into the pump. On the contrary, when the fish felt the water current, most of them were able to swim against it and thus avoid being captured.

Fig. 2 - Receiving tank used to collect the fish which were pumped on board.

After these preliminary gear tests had been made, the arrangement of lighting and electrodes was designed as shown in figure 3. Four carbon plates $12\frac{1}{4}$" x $6\frac{1}{4}$" x $\frac{1}{4}$" were used as the positive electrode (anode). It was necessary to use carbon because the metals tested, including stainless steel, were rapidly disintergrated by electrolysis. Stainless steel, however, was found to be a suitable material for the negative electrode (cathode).

The anode assembly consisted of a funnel-shaped wooden box inside which the carbon plates were fastened. The small end of the funnel was attached to the intake hose of the pump (figure 3). Wires from the positive pole of the direct current generator were connected to the plates by brass bolts extending through the sides of the funnel. These bolts also held the plates in position.

The cathode was made of a 36-inch-diameter disc of stainless-steel wire screen. This screen, which had 20 wires per inch, was supported by a stainless-steel rod of $\frac{1}{4}$-inch diameter soldered around the circumference of the disc and by two 36-inch lengths of the rod soldered across the surface of the disc perpendicular to each other. Wires from the negative pole of the generator were attached at intervals around the edges of the cathode as shown in figure 3.

The anode assembly was mounted in a fixed position at one end of a 2" x 4" wooden support as shown in figure 3. The distance between the anode and the cathode could be adjusted from 0 to 10 feet by securing the cathode at various positions along the support. Lights could also be fastened to the support at any position along its length.

Power for electrical attraction was supplied by a 600-ampere d.c. welding machine. This machine was of a combination motor-generator type. It was driven by one of the ship's 220-volt, 3-phase, 30 kilowatt generators.

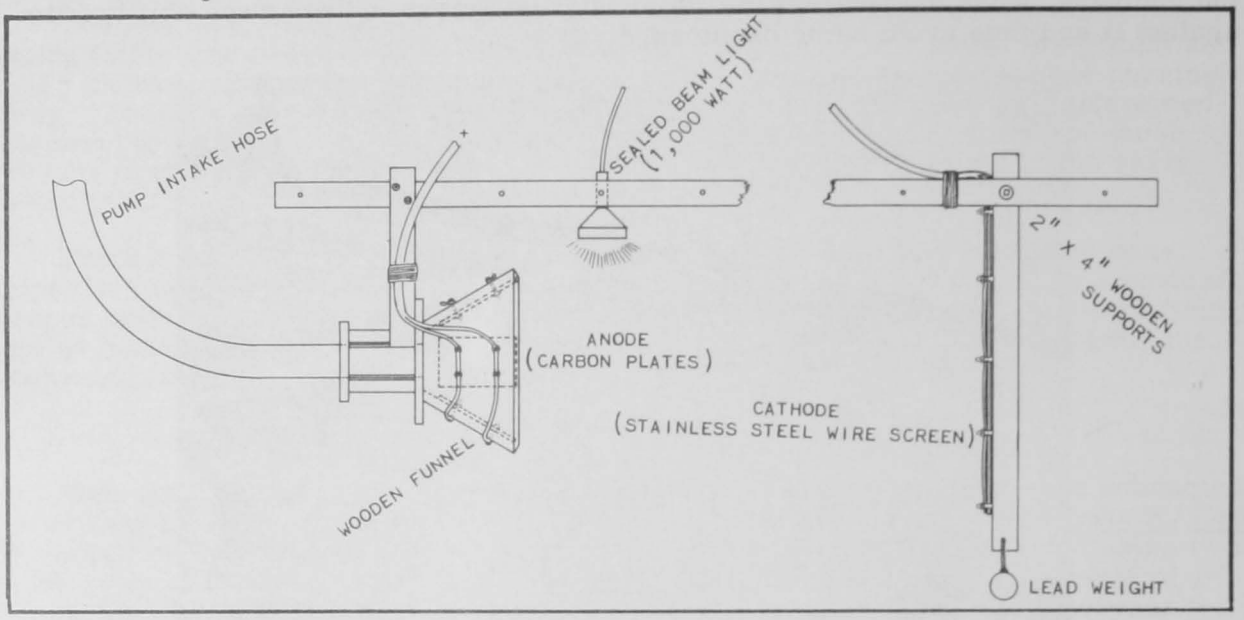

Fig. 3 - Diagram of electrodes and pump intake.

An electronic pulse generator was connected to the field circuit of the welding machine to produce a pulsating field. The pulse generator was operated by 110 volts a. c. from the auxiliary generator of the vessel and by 150 volts d. c. from the exciter of the welding machine. The rate of the pulsations could be varied from 3 to 13 per second, and the average current could be varied from 0 to about 600 amperes. This machine was never run at full capacity, however, owing to the high resistance at the anode and to the inability of the auxiliary generator to produce sufficient power. No provision was made for separating the pulses. Therefore, each pulse built up immediately after the preceding one dropped to zero current.

The above described method of electronically controlling the field was used to avoid the necessity of controlling and interrupting a high-intensity direct current mechanically, which would require elaborate and expensive equipment.

OPERATION AND RESULTS

With the fish attracting, guiding, and pumping gear, 29 tests were made in Puget Sound and off Cape Flattery. These tests were run for varying lengths of time. The tests in Puget Sound were made in areas in which schools of fish were indicated by feeding birds and by tracings of an echo-sounder. The tests off Cape Flattery were set "blind" in outside waters on Swiftsure Bank and in Mukkaw Bay.

The gear was put into the water at nightfall; the underwater light was turned on; and a watch was kept to observe any fish that rose to the light. The assembly was suspended in the water by a single cable from the boom at a depth of 5 to 15 feet, the whole apparatus lying in a horizontal position parallel to the axis of the boat. When the assembly was suspended at this depth, the reactions of the fish in the lighted space could be observed from the after deck if the surface of the water was relatively calm.

When a school of fish began to enter the field of light, the pump was started, and the electric pulse was turned on. Fish present between the electrodes within approximately 2 feet of the anode turned involuntarily and swam toward the anode. As these

fish approached to within 2 or 3 inches of the open end of the funnel, they became stunned by electrical shock and were carried into the funnel by the flow of water. Fish continuing to rise to the light were caught in the electrical field and led to the anode in this manner. Under ideal conditions of tide, wind, and availability of small herring, the fish rose up to the light and into the pump in a continuous stream.

At such ideal times, small 3-inch herring were caught at a maximum rate of 1,178 fish per minute or 70,720 per hour. The average rate of catch for the 5 best catches made on 4 different nights was 717 fish per minute or 43,022 fish per hour. Catches ranged from these values down to 0, the better catches always being made between 4 a. m. and 6 a. m. during the approach of daylight. The tests showing the best results are listed in table 1.

Table 1 - Data on Tests Made With Fish Pump and Electrical Attracting and Guiding Device[1/]

Place	Date	Depth	Duration	Lights (1,000 Watts)			Electricity			Catch		
				No.	Distance From Anode	Height Above Center of Anode	Pulses	Potential	Current	Number of Herring	Weight	Average Length of Herring
		Feet	Minutes		Feet	Feet	No. Per Second	Volts[2/]	Amperes[2/]		Pounds	Inches
Squamish Bay	10-28-54	8	60	1	1	1.5	9	77	85	687	-	3.5
	10-29-54	8	60	1	1	1.5	9	93	105	676	-	3.3
Friday Harbor	11-2-54	12	20	1	0	3	0	0	0	-	26.5	3.0
	11-2-54	12	30	1	0	3	9	97	85	-	25.25	3.0
	11-3-54	12	30	1	1	1.5	9	77	85	31,255	353	2.9
	11-4-54	15	30	1	1	1.5	9	77	175	35,360	331.5	3.1
	11-4-54	15	30	1	1	1.5	9	78	170	23,120	216	3.1
	11-5-54	6-8	60	1	1	1.5	9	78	170	19,200	204	3.0
Westsound	11-6-54	12	30	2	1 & 5	1.5 & 1.5	13	57	140	8,950	89.5	2.9
	11-6-54	5	46	2	1 & 5	1.5 & 1.5	Varied	Varied	Varied	2,850	28.9	2.9
	11-7-54	15	60	2	1 & 2.5	1.5 & 1.5	6-13 8	78	160	4,790	57.4	3.2

1/ These 11 tests shown here were made in the Puget Sound area; 16 other tests were also made in this area; and 2 other tests were made in the area off Cape Flattery. In all the tests for which data are not given, negligible quantities of fish were caught.
2/ Approximate average value.

The fish caught were predominately herring and, with the exception of 14 fish ranging from 6 to 8.7 inches in length, were all of a uniformly-small size. They averaged 3.05 inches in length and were in their first year of life as determined by scale analysis. Individual larger herring 6 to 7 inches in length were occasionally seen at the periphery of the lighted space at a distance of approximately 12 feet from the light. Only very rarely was a fish of this size caught.

The better catches were almost invariably made when both the light and electric pulse were in operation. In one test, however, 26.5 pounds of herring were caught in 20 minutes using only the light (table 1).

Small numbers of anchovies (Engraulis mordax) and eulachon (Thaleichthys pacificus) were caught along with the herring.

Gradual dimming of the light was tried in hope that the fish, particularly the larger ones, would rise nearer to the light as it became dimmer. Such a reaction was not observed, however, during the tests conducted. The herring seemed best attracted when the lamp was operated at its full brilliancy. Tests using more than one lamp, however, did not result in an increased catch.

The light could apparently be used at only one position to best advantage. The maximum catches were made when the light was placed 12 inches in front of the anode and 18 inches above the center of it. When additional lamps were used at other positions, catches were not increased.

A number of uncontrolled factors influenced the catch. The more important of these were (1) availability of fish, (2) presence of predators, (3) movement of the vessel caused by wind and tide (any movement of the light and electrode assembly, which was suspended from the vessel, frightened the fish), and (4) the changing time of day (herring were observed to approach the light in greatest numbers for a period of approximately 1 to 2 hours at daybreak).

As the fish came out of the discharge hose into the receiving tank, an estimated 60 percent of them were dead or dying. These fish were killed either by physical abrasion while coming through the hose and pump or by electric shock, or by both. It is likely that any fish that made a firm contact with the anode was electrocuted. Bruised and descaled areas were observed about the head and along the back of both live and dead fish.

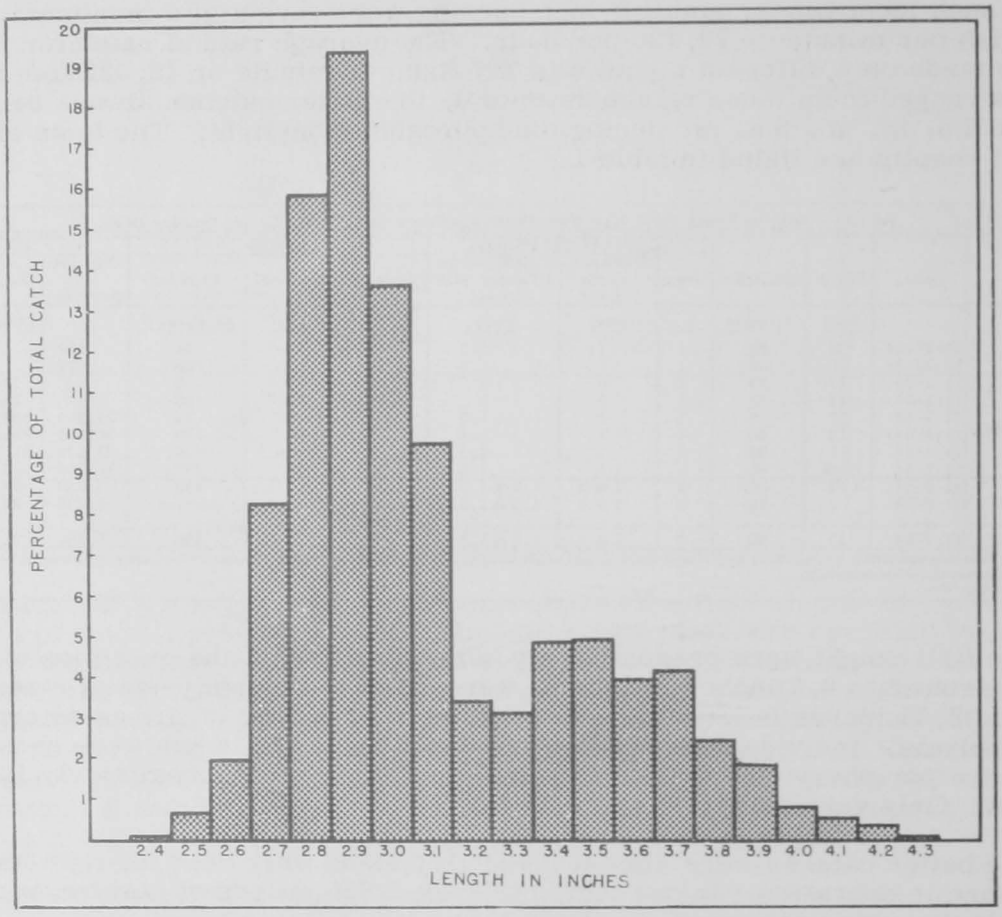

Fig. 4 - Length frequency distribution of herring catches.

No herring were observed in the outside waters off Cape Flattery, and the tests there were unsuccessful. Even if herring had definitely been present, however, the movement of the gear caused by the ocean swell and chop would probably have frightened them away. Hence gear of a different design should be tried if experiments on electrical attracting and guiding of fish are to be conducted in open ocean waters.

More experimental work is required before the method can be applied to catching fish on a commercial basis.

FIELD FOR FURTHER INVESTIGATION

The use of monochromatic lights to attract and guide fish to a point of capture might be tried. Experiments with various colors of light might lead to the discovery of a wave length that is much more effective than is white light.

The use of sound for fish attraction also presents a field for investigation. Sounds of the proper controlled frequency and intensity applied under water may result in the attraction of certain fish.

Knowledge is needed of the pattern of electrical current flow through an unlimited space of sea water, the amount of current per square inch necessary to guide fish of various sizes in sea water, and the optimum size and shape of, and distance between electrodes.

For work in the open ocean where the attracting and guiding assembly is subjected to the swell and the chop of the seas, a method of support must be designed which will leave the assembly independent of the vessel's motion. This support should also be designed to hold the assembly at a constant level in the water where it will be unaffected by movement of the surface of the water.

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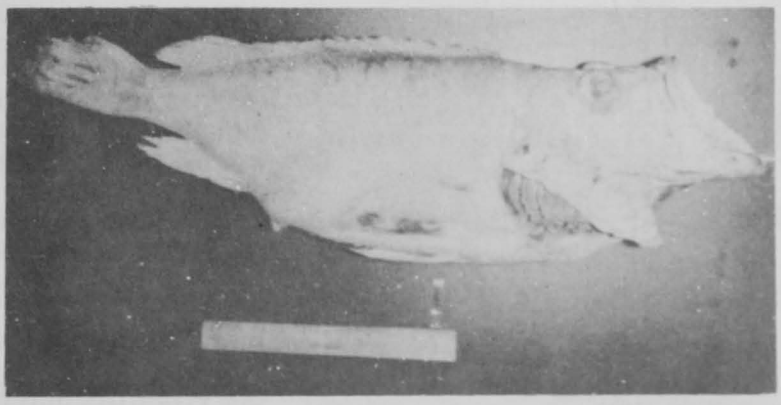
A GIANT OCEAN PERCH

A giant ocean perch was landed by a fishing trawler at Rockland, Maine, in January 1955. The fish weighed about 15 pounds and measured around 2½ feet. According to the trawler captain, the fish was caught on the Grand Banks at a depth of 160 fathoms.



Giant ocean perch caught by trawler on Grand Banks. Foot rule at the bottom gives an indication of the size of the fish.