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THE ELECTRIC "SHOCKER" AND ITS USE IN MICHIGAN STREAMS

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Sub-Title -- Fisheries biologists find that electricity is more efficient than a seine for catching trout.

For the last 20 years fisheries research workers interested in stream-inhabiting game fish have sought to perfect methods for estimating populations of stream fish. An efficient set of tools for performing this task appears to be at hand in the form of the electric "shocker".

The use of electricity for stream population studies seems to have originated in eastern Germany. The present author[1] in 1938 translated and reviewed a short article from a German fisheries publication which

[1] Shetter, David S. 1938. Review -- Hager, Franz: Use of electricity in fishing wild trout streams. U.S. Bur. of Fisheries, Memorandum I-131, "The Progressive Fish Culturist," No. 36, Feb. -March, 1938, pp. 32-33.

described the electrical equipment needed. This article also listed the standing crop of trout and its monetary value, for certain Bavarian trout streams in three different years. Biologists and technicians connected with the New York State Conservation Department assembled and employed the shocker in that state, first in 1939 (Haskell, 1939[2]; Haskell and Zilliox, 1940[3].)

For various reasons, Michigan did not obtain the necessary equipment until September, 1941. With the advice of David C. Haskell of the New York State Conservation Department, and through the assistance of Dr. P.I. Tack of Michigan State College, and Dr. J.W. Leonard, the first resident biologist at the Hunt Creek Fisheries Experiment Station, the Conservation Department's first "shocker" was operated on Hunt Creek in mid-summer of 1942. The original unit has received much use since then, and as there is an increasing demand, both from the biological staff and the hatchery personnel, for the services of this type of gear, an additional unit of higher wattage was acquired and placed in use this summer.

The source of power is a 1-H.P. gasoline motor which drives a generator of 500 watts capacity. The normal current varies between

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[2] Haskell, David C. 1940. An electrical method of collecting fish. Trans. Am. Fish. Soc. Vol. 69, 1939, pp. 210-215.

[3] Haskell, David C. and Robert G. Zilliox. 1941. Further developments of the electrical method of collecting fish. Trans. Am. Fish. Soc., Vol. 70, 1940, pp. 404-409.

$1\frac{1}{2}$ and $2\frac{1}{2}$ amperes, depending upon the conductivity of the water and the distance between the electrodes. The motor and generator are mounted on a carrying frame which can be portaged by two men or rested in the bottom of a boat. The electrical current is conducted to the water through a rubber-covered 2-wire cable to a pair of electrodes which are attached to wooden handles. As each electrode is connected to one pole of the generator, this forces the electrical current to use the water as a pathway in completing the circuit when the electrodes are submerged in the water. Depending on the shape and size of the electrodes and the depth of the water, the electrified field appears to be similar in shape (when viewed from above, and judging by the actions of the fish) to the conventional diagrams of fields of attraction around two magnetic poles. Any fish which enters the electrified field is momentarily stunned and may be picked up with a soap net. Apparently the rapid reversal of electrical current flow in an AC circuit affects their nervous system. The larger fish succumb readily to the "shocker," but the electrodes must be close together to knock out small fish (fingerlings and fry) since their smaller bodies do not absorb as great a portion of the electrical current as do the larger fish.

In field operations the captured fish are removed by soap net to fresh uncharged water. They recover in from 30 seconds to 5 minutes, depending upon the size of the fish and the severity of the shock. Less than one percent of the fish handled are killed. Only when a fish remains too long in the charged field, or comes to rest unobserved against an electrode are they "burned" mortally.

The present electrical hookup in use on the two Michigan "shockers" is the result of considerable experimentation on the part of Basil V. Hughes, resident manager of the state's Rifle River Area. The circuit diagram is shown in an accompanying figure. As will be noted from the drawing, electrical current passes through a $2\frac{1}{2}$-ampere fuse or circuit breaker which protects the generator from an overload. From this point it is passed through an ammeter, if desired, thence through a choke coil and fixed condenser to one electrode. When both electrodes are in the water, electrical current flows through the water to the other electrode and back to the generator to complete the circuit.

Modifications of electrodes have been numerous. Hager (1934)[4], the German experimenter, used 10-inch square copper plates on wooden handles to introduce the current to the water. The New York State operators drove a single steel stake or series of stakes into the stream bottom for one electrode, and floated a metal screen connected to the opposite pole of the generator for the other electrode. They noticed that this reduced the voltage available in the water for shocking fish in too many types of stream bottom soils, and instead of stakes

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[4] Hager, Franz. 1934. Die Electrizitat in Dienste der Wildbach fischerei. Osterreich Fischersiwirtschaft, Nr. 7/8, Juli-August, 1934, S. 1-5.

driven in the bottom substituted a bare copper wire. However, trials in Michigan with the latter electrode set-up proved unwieldy in snaggy streams, and the floating screen created a riffle which made for poor visibility of the fish shocked.

Our next electrodes were made from $\frac{1}{2}$-inch mesh hardware cloth soldered to a foot-shaped frame of $\frac{1}{2}$-inch reinforcing steel, and were about 16 inches long and 6 inches high at the heel. While these gave satisfactory results, they could not be operated much farther apart that 8 feet, and seemed to "burn" a number of the larger fish. Noting this difficulty, Mr. Hughes built and wired the rectangular type shown in an accompanying photograph, which is in reality a widely-spaced induction coil of bare wire on a wooden frame 14 x 6 x 1 inches. About 55 feet of copper or phosphor-bronze wire (#14, 16 or 18) are used. With the modified electrode it was possible to shock all sizes of fish passing between the electrodes when they were as much as 12 to 15 feet apart and in water up to $2\frac{1}{2}$ feet deep. However, in water deeper than this, the triangular model tends to cause the generator to overwork and heat up. Also, it does not give a large enough charged field, thus allowing many fish to escape, either on the bottom or near the surface. To offset this, a long narrow type of electrode has been built (36 x 6 x 1 inch) and wired with approximately 55 feet of wire spaced $1\frac{1}{2}$ inches apart.

Recent trials with this deep-water electrode indicate that it will shock more of the fish from pools 4-6 feet deep than were reached by the older types of electrodes. With this latest model of electrode the charged field seems to be narrower but deeper.

In actual stream-side use, the motor is started with no load on the generator, and after a short warm-up period the electrodes are plugged in and submerged. The customary procedure is to work upstream against the current. In this manner, the crew is not roiling the water to be shocked, and the stunned fish are carried to them by the water current. Although the equipment can be operated by two individuals, the ideal crew size for intensive work is six men. In population study operations each electrode is handled by one man. The electrode carriers wade on the outside of the area to be shocked, and usually between and slightly behind them one or two additional assistants are stationed to net the shocked fish as rapidly as they are seen. A fifth individual carries a pail of fresh water to receive the fish, or pulls the boat floating the "shocker," and keeps the connecting wire free of snage. The sixth member of the party tallies the fish handled and records measurements, tag numbers or missing fins of marked fish recovered, or any other data required.

In conducting population studies in a section of a stream, two complete trips are made. On the first trip, all fish captured are given a distinctive mark before they are released, such as clipping a small piece from the tail fin (which can be recognized easily for a short time). Careful record of the number of fish caught and so marked is kept. Two or three days later the shocking crew will go over the same water, and a record is made of the number of marked and unmarked trout captured on the second trip. From these records on the number of marked fish in the stream and the number of marked and unmarked fish taken in the second check, the total population of the stream can be computed. A simple example will illustrate the procedure: On a certain day we shock one mile of stream, and mark 100 legal brook trout. Two days later we go over the same water with the "shocker" and capture 75 marked legal brook trout and 27 unmarked legal brook trout. As the entire stream area is covered each time in a random manner, our recovery of unmarked brook trout should be at the same rate as it is for the marked trout. The number (x) of unmarked brook trout present in the stream can be found by solving the simple proportion: 75/100 equals 27/x, in which x=36. In other words since 3/4 of the marked fish were recovered on the second run, the number of unmarked trout taken in that run (27) represents 3/4 of the total number of unmarked fish present in the stream. The total population of legal brook trout in our theoretical mile of stream is therefore the sum of the marked fish (100) plus the estimated number of unmarked fish (36) or 136 legal brook trout.

By conducting population studies on portions of trout streams where intensive creel census data also are available, it is hoped to learn how many legal fish must be present per acre or per mile of stream to furnish sport of decent quality for Michigan anglers. Eventually such data will make possible more accurate and economical dispersion of hatchery-reared fish where they are needed.

The "shocker" is a time-saving device where stream collections of fish must be made, particularly in brushy, snag-filled water where a seine cannot be handled. It will probably be used frequently in the future by stream survey parties, in place of long seines.

Several investigators have found that fish collections for various studies can be obtained with a minimum of time and effort. In the past, almost all the wild brook trout used in the organoleptic tests described by Baeder, Tack and Hazzard[5] were collected with the "shocker."

The "shocker" is useful also to hatchery personnel. For the past 18 months, the waste ditches of the Oden Hatchery have been shocked semi-annually to remove escaped trout residing in the waste ditches. Such fish are possible sources of infection and disease for the hatchery stock. Another use of this equipment would be to eliminate unwanted

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[5] Baeder, Helen A., Tack, Peter I., and Albert S. Hazzard. Trans. Am. Fish. Soc., Vol. 75. In press.

fish from hatchery ponds, or from natural streams, before stocking with fingerling fish.

Contrary to the reports of the earlier investigators, we have not found any great danger connected with the use of the "shocker" as long as reasonable care and precautions are taken. All wiring that is likely to be handled is well-insulated, and the crew is advised to wear nonleaking boots or waders. Relatively little discomfort is felt if only one hand is immersed in the water when the power is on, and most of our assistants do not hesitate to plunge one arm in to the elbow to net a fish in deep water. A much more severe "poke" results when two hands are placed in the charged field simultaneously. In Michigan to date, only one individual has been shocked in what might be called a severe manner. His waders had a long open tear which permitted free passage of both the water and the electric current. He had worked for about an hour with this bad leak but had suffered no discomfort until he happened to get both hands in the water at the same time in reaching for a fish in a deep hole. The current was cut off immediately, but the resulting jolt left him breathless for a short time. It is the concensus of opinion of those who have worked with the equipment that no serious injury would be incurred unless someone were to be completely immersed under or close to an electrode when the power is on. With ordinary precautions on the part of those concerned, this situation is not likely to occur.

To sum up briefly, in the "shocker" we have a research tool that is several times more efficient than any previously available for capturing fish alive for stream fish research. Also it appears to have possibilities in certain fields of fish-cultural operations, and could be utilized for controlling rough fish, such as suckers and carp in natural waters. Minor disadvantages are its weight and bulk, and the fact that stunned fish cannot be observed when streams are roiled by rains or floods. Despite these slight disadvantages the "shocker" will play a part of increasing importance in stream researchs in the future.

Installing a net "fence" to keep fish within a stream section to be censused.

A three-man team operating the electrodes of the shocker and picking up the stunned fish with scap nets.

Electrode, rectangular in shape, used with the shocker