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MICHIGAN DEPARTMENT OF NATURAL RESOURCES
FISHERIES DIVISION

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Studies of Warmwater Fish
Research Report 1982
September 12, 1990

J. C. Schneider

Page 3, last paragraph, third sentence from the end should read: Wiring was such that phase 1 created an electric field around the right electrodes, phase 2 created a field around the center electrode, and phase 3 created a field around the left electrode.

Also, page 7, Table 2. Under cage experiment, bluegill, line 3: number of deaths of bluegill should be 1 instead of 0.

Please make the necessary changes.

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USE OF 230-V AC ELECTROFISHING FOR MARK-RECAPTURE STUDIES OF WARMWATER FISH

James C. Schneider

[1]A contribution from Dingell-Johnson Project F-35-R, Michigan.

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Use of 230-V AC Electrofishing for Mark-Recapture Studies of Warmwater Fish

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Abstract.—The effect of electrofishing on survival and growth of several species of warmwater fish was evaluated under field conditions. The electrofishing gear had an output of 230-volts, 3-phase AC, and 2-7 amps. Shocked fish held in live cages or a pond experienced little or no mortality in 1-40 days. Tag recapture data for largemouth bass and walleye indicate survival and growth of shocked fish after 1-2 years was not different than fish captured by trap nets or angling. I conclude that 230-volt AC electrofishing can be a practical method to capture many warmwater species for mark and recapture studies in lakes with alkalinities of 26-144 ppm (conductivities of 66-520 micromhos/cm). Output amperage should be regulated so that fish are only briefly stunned.

Long-term, intensive studies of fish population dynamics require that large samples of fish be easily captured, marked, and released unharmed back into the wild. Further, after release these fish should survive, grow, and behave normally. All three basic types of electrofishing gear—AC, pulsed DC, and continuous flow (unpulsed) DC—are used to collect fish, depending on species sought and type of habitat. For example, within the Michigan Department of Natural Resources, through many years of practical experience, continuous 230-volt DC became accepted as the preferred gear for wadeable streams (especially for salmonids) and 230-volt AC became accepted as the most effective gear for lakes (especially for warmwater species). Technically, the unpulsed 230-volt DC is "rippled" because it is obtained by rectifying 230-volt, 3-phase AC. In the last decade, pulsed DC gear has been increasingly used in Michigan to sample small streams (backpack shockers), and rivers and lakes (boat "boom" shockers).

Despite the widespread use of AC gear for warmwater species in Michigan and throughout the country (Reynolds and Simpson 1978; Heidinger et al. 1983; Bayley et al. 1989), little information has been published on its effects on fish survival and growth under field conditions. An extensive literature already indicates DC gear is a good tool for ecological studies of salmonids under most conditions (e.g., Gatz et al. 1986; Pratt 1955; Mesa and Schreck 1989; Shetter et al. 1969), albeit with some risk of causing spinal deformity in large trout (Sharber and Carothers 1988). However, there is widespread concern about AC gear because it is more likely to cause death or spinal injury in salmonids (Taylor et al. 1957) and, under certain conditions, in warmwater species (Spencer 1967; Newburg 1974). On the other hand, Hudy (1958) reported less than a 2%

mortality rate for trout shocked with high-voltage AC. In addition, some published field reports (Shentyakova et al. 1970; Anonymous 1954) and many years of field usage of AC gear suggest no cause for alarm for warmwater species. The field experiments described below also indicate AC gear is a practical tool for ecological studies in warmwater lakes.

Methods

Three sets of experiments, conducted during mark-recapture studies, provided data on the effects of 230-volt AC electrofishing on growth and immediate or delayed mortality of fish. Fish species studied were: yellow perch (*Perca flavescens*), bluegill (*Lepomis macrochirus*), pumpkinseed (*Lepomis gibbosus*), largemouth bass (*Micropterus salmoides*), walleye (*Stizostedion vitreum*), lake chubsucker (*Erimyzon succetta*), and green sunfish (*Lepomis cyanellus*). Pertinent characteristics of the five natural waters used as study sites may be found in Table 1.

In the first set of experiments, 17 samples (total 642 fish) were collected from Cassidy and Mill lakes, Washtenaw County, in spring, summer, or fall by AC electrofishing (Table 2). Fish were temporarily held in a tub filled with fresh lake water for up to 1 hour, measured to total length, and given a caudal fin clip. Fish were then put in live cages within the lakes and held for 1 to 40 days without supplemental feeding. The cages were periodically inspected for dead fish.

In the second experiment, 569 fish living in a pond at the Saline Fisheries Research Station were collected by AC electrofishing (Table 2). They were held in a tub of pond water for up to 30 minutes, measured, given a caudal fin clip, and released back into the pond. The pond was drained 10 days later and surviving marked fish were collected and counted.

In the third set of experiments, data on the long-term survival and growth of shocked and unshocked largemouth bass and walleye was provided by tagging studies at two lakes (Table 3). Bass were captured from Blueberry Lake, Livingston County, by either electroshocking, trapnetting, or angling with artificial lures in March-June, 1986-1988. A total of 263 bass from 9.3 to 12.9 inches long were collected. Walleyes were captured from Jewett Lake, Ogemaw County, by either electroshocking or trapnetting in September-October, 1979. The 87 walleyes were 11.0 to 22.0 inches long. Bass and walleyes were measured, scale-sampled for age determination, fin-clipped, and individually marked with Floy anchor tags (inserted through the intraneural bones of the soft dorsal fin) before they were released back into their lake. Recapture frequency and average annual growth increment were tabulated for fish recaptured 1 or 2 years after tagging. This procedure excluded data (possibly biased) from fish which had been exposed to more than one capture experience within a year. Data from all types of recapture gear were pooled. If electrofishing is no more harmful than trapnetting or angling, then recapture rate and growth should not differ according to type of gear used to capture fish for tagging.

The basic features of the AC electrofishing gear used in the experiments were as follows: Power was supplied by a 230-volt, 3-phase AC, 3.5-kilowatt, Homelite generator, passed through a custom-made control box with a rheostat to regulate amperage, and delivered to five electrodes suspended from booms in front of the boat. A circuit breaker in the control box, a safety mat, and a sturdy guardrail around the bow protected the person(s) picking up stunned fish with a long-handled scap net. Four of the electrodes were arranged in a rectangle, approximately 8 feet wide by 7 feet long; the fifth electrode was located in the center of the rectangular field. The electrodes were made of flexible conduit, 7/8 inch in diameter by 7 feet in length. Wiring was such that phase 1 created an electric field among the front and center electrodes, phase 2 created a field among the rear and center electrodes, and phase 3 created a field among all electrodes. Boat size and type varied, but an 18-foot, flat-bottom, aluminum boat was very satisfactory because of its stability and portability. A 9.5-hp outboard motor provided ample propulsion for small and weedy lakes.

During operation, output current was adjusted so that it was high enough to stun small fish as well as large fish, yet low enough so that even large fish recovered in less than approximately 30 seconds. At conductivities of 180-520 micromhos/cm, about 7 amps were required; at conductivities of 66 micromhos/cm, about 2 amps were required.

Results

Results from the 17 cage experiments indicate little or no mortality among shocked fish (Table 2). No mortality occurred in 11 tests and only 1 fish died in three other tests. The highest mortality rate, 2.34% per day, was in a long, 40-day experiment with yellow perch. However, this was more likely due to stress caused by handling, marking, confinement, and low food at relatively high summer temperatures (low 80's,°F) rather than to injury caused by electrofishing. No mortality occurred in five other perch tests, including two tests in which the most conspicuously damaged fish were selected. These fish, representing about 20% of the heavily stunned perch, had a small, bright red blood spot in the venous sinus anterior to the isthmus. This spot was reabsorbed within 1 day and these perch, and all other survivors, appeared to be in good condition at the end of the experiments.

Mortality of marked fish in the 10-day pond experiment was slightly higher than in the cage experiments: 0.12% per day for bluegill and over 0.9% per day for pumpkinseed and green sunfish (Table 2). Some of the losses could have been due to handling stress or incomplete recovery when the pond was drained. A thin layer of ice made it impossible to visually confirm that all survivors had been flushed out of the pond.

Tagging experiments indicated long-term survival and growth of largemouth bass and walleye captured by AC electrofishing was very similar to fish captured by other gear types (Table 3). For largemouth bass, recapture frequencies one and two years after tagging were 21.0%, 22.2%, and 25.8% for fish marked during trapnetting, electrofishing, and angling, respectively. Growth increments for these respective groups were 0.45, 0.52, and 0.84 inch/year. For walleye, recapture frequencies were 50.0% for shocked fish versus 52.5% for trap-netted fish, and respective growth increments were 1.15 versus 1.05 inch/year. The only statistically significant difference among any of these comparisons is that bass caught by angling grew better than bass caught by either electrofishing or trapnetting (ANOVA, $P<0.05$). This reflects that bass caught by angling were the faster growing individuals in the population both before and after tagging. At the time of tagging, average length at age was higher for bass caught by angling and, correspondingly, average age was lower—4.9 years, 5.6 years, and 5.8 years for bass caught by angling, electroshocking, and trapnetting, respectively.

Discussion

These experiments demonstrated that 230-volt, 3-phase AC electrofishing did not measurably increase the mortality of several species of warmwater fishes. Some of the observed mortality should be attributed to stress and infection induced by any form of capture, handling, marking, and confine-ment. In addition, some entirely "natural" deaths would be expected during the confinement period.

Growth of largemouth bass and walleye which had been shocked once a year was not reduced compared to bass and walleye caught with other gear types. Other studies have found no growth retardation unless fish are shocked frequently. Gatz et al. (1986) recommended that trout not be shocked more often than every three months. Gatz and Adams (1987) reported growth of hybrid sunfish shocked every week was reduced compared to fish shocked at 2-, 4-, or 12-week intervals.

I have used this gear since 1964 for intensive mark-recapture studies at lakes and rivers with alkalinities of 34-200 ppm and have found it very satisfactory for most uses. My work has been mainly done in spring and fall, when temperatures are less than 70°F and the risk of inducing stress and disease by handling is lowest. Very few out-right deaths or spinal deformities have been observed even though study lakes were sampled frequently. Fish smaller than 3 inches long have been readily collected with the gear, but it has been difficult to obtain reliable population estimates for them because of their frailty and high abundance. Based on my experience, the key to success is to use no more amperage than needed to briefly stun both large and small fish. Even so, large esocids, salmonids, and catostomids seem to be high risks for AC electrofishing, and probably are best sampled with DC gear if their survival is important. Fish in very soft water are also more vulnerable to injury, because higher voltages are necessary to catch fish. Clady (1970) reported some injury to smallmouth bass (*Micropterus dolomieui*) and white sucker (*Catostomus commersoni*) collected with 560-volt AC gear.

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Table 1.—Selected characteristics of study sites.

Site	County	Area (acres)	Maximum depth (ft)	Alkalinity (ppm)	Conductivity (micromhos/cm)
Cassidy Lake	Washtenaw	46.0	11	132	365
Mill Lake	Washtenaw	136.0	25	127	370
Saline Pond #2	Washtenaw	0.4	5	144	520
Blueberry Lake	Livingston	20.0	24	92	180
Jewett Lake	Ogemaw	12.9	17	26	66

Table 2.—Cage and pond experiments, 1-40 days duration, on the mortality of electroshocked fish.

Species	Days	Month	Number of fish	Size (inches)	Number of deaths	Percent mortality per day
Cage experiments						
Bluegill	1	May	16	5.1-6.5	0	0.00
	1	May	28	2.0-6.9	0	0.00
	31	Jul-Aug	51	2.0-4.9	0	0.06
	31	Jul-Aug	51	5.0-7.9	1	0.06
Pumpkinseed	1	May	74	3.0-7.9	0	0.00
	4	Aug	100	2.2-7.3	1	0.25
	22	Sep	50	2.7-5.2	6	0.55
	22	Sep	50	5.1-7.7	1	0.09
Yellow perch	3	May	20*	2.0-3.9	0	0.00
	3	May	20**	2.0-3.9	0	0.00
	10	Oct-Nov	33*	3.0-4.9	0	0.00
	10	Oct-Nov	33**	3.0-4.9	0	0.00
	30	Oct-Nov	46	3.9-4.9	4	0.23
	38	Oct-Nov	6	8.0-10.5	0	0.00
	40	Aug-Sep	16	3.4-7.4	15	2.34
Lake chubsucker	1	May	41	2.0-9.9	0	0.00
Golden shiner	1	May	7	2.0-4.0	0	0.00
Pond experiment						
Bluegill	10	Nov-Dec	166	2.7-4.7	2	0.12
Pumpkinseed	10	Nov-Dec	352	2.7-5.0	33	0.94
Green sunfish	10	Nov-Dec	51	2.7-4.9	5	0.98

* Visible accumulation of blood anterior to isthmus.
**Control.

Table 3.—Number of largemouth bass and walleye caught by different types of gear and tagged, frequency of recapture 1 or 2 years later, and annual growth increment (mean ±2 standard errors).

Tagging		Recapture		Annual growth
Gear	Number	Number	Percent	(inches)
Largemouth bass				
Electrofishing	135	30	22.2±7.2	0.52±0.09
Trap net	62	13	21.3±10.3	0.45±0.09
Angling	66	17	25.8±10.8	0.84±0.09
Walleye				
Electrofishing	26	13	50.0±20.2	1.15±0.32
Trap net	61	32	52.5±12.8	1.05±0.17

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