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Injury, Survival, and Growth of Northern Pike Captured by Electrofishing

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Alaska Department of Fish and Game

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INJURY, SURVIVAL, AND GROWTH OF NORTHERN PIKE CAPTURED BY ELECTROFISHING[1]

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ABSTRACT

Spinal injury, internal hemorrhage, survival, growth, and capture rates were examined for northern pike *Esox lucius* exposed to varying levels of pulsed direct current, frequency and voltages. Incidence of spinal injury in each of four treatment groups (sample size of 60 fish per group), and in a control group consisting of 34 fish, was examined in northern pike captured at George Lake. Incidence of spinal injury for northern pike exposed to 30 hertz was 5.0% at 100 volts and 10.0% at 400 volts; and, for 60 hertz spinal injury was 8.3% at 100 volts and 11.7% at 400 volts. Despite the trend of increased injury at higher pulse rate and voltage, injury rates were not significantly different among treatments (P=0.36). Of 54 northern pike captured in Minto Flats and examined for both spinal injury and internal hemorrhage, four exposed to 60 hertz pulsed direct current had severe internal hemorrhage. Short term survival (37 days) of 140 northern pike exposed to 120 hertz pulsed direct current at 300-600 volts was compared with that experienced by 70 fish in a control group in ponds at Colorado State University, and was 91 to 92% for both groups (P=0.79). Of these fish, 154 (105 shocked and 49 unshocked) were moved to College Lake to compare long-term survival (327 days) between shocked and unshocked fish; survival was 51% for shocked and 57% for unshocked fish (P=0.45). During field trials in Minto Flats, about three northern pike were captured with 60 hertz pulsed direct current for every one caught with direct current or 30 hertz pulsed direct current (P=0.08). Conventional electrofishing (60 hertz pulsed direct current at 100-400 volts) did not cause significant injury in adult northern pike but did capture them efficiently. Pulsed direct current at frequencies above 60 hertz should be avoided.

KEY WORDS: electrofishing, pulsed direct current, northern pike, *Esox lucius*, injury, spinal injury, survival, mortality, growth.

INTRODUCTION

Electrofishing is an effective tool for capturing fish for research and management (Reynolds 1983; Clark 1985; Copp 1989). Electrofishing permits the capture of fish in open waters that are often difficult to sample by other methods. Most agencies involved with quantifying freshwater fish populations use electrofishing.

Many studies, however, have implicated electrofishing as a cause of mortality, physical injury and physiological change to fish (Hauck 1949; Pratt 1954; McCrimmon and Bidgood 1965; Lamarque 1967; Spencer 1967; Maxfield et al. 1971; Schreck et al. 1976; Whaley et al. 1978; Hudy 1985; Mesa and Schreck 1989). Recently, Sharber and Carothers (1988) reported that up to 67% of large rainbow trout *Oncorhynchus mykiss* suffered spinal injury when captured by electrofishing in the Colorado River with pulsed direct current (PDC). Their report led to conservation concerns for rainbow trout as well as other species of fish captured by electrofishing. These concerns prompted a similar study by the Alaska Department of Fish and Game (ADF&G) on northern pike *Esox lucius*, which reported a spinal damage rate of 15.6%, internal hemorrhage rate of 18.8% and no difference in linear growth of northern pike as a result of capture with 60-Hz PDC, however, confidence intervals were not reported (Holmes et al. 1990).

Besides the desire to return electroshocked fish to the water with as little harm as possible, their survival after release is a major concern in mark-recapture experiments. It has been suggested there is an association between electrofishing-induced spinal abnormalities and survival of northern pike (Holmes et al. 1990). Mortality or a change in behavior that affects catchability may violate the assumption of equal probability of capture that several abundance estimation methods require (Ricker 1975).

The purposes of this study were to determine the nature and incidence of electrofishing-induced injuries to northern pike, and, if significant, to recommend electrofishing methods that reduce the incidence of injury and mortality without compromising capture efficiency. The objectives of this study were to:

1. describe and compare spinal damage and internal hemorrhage to northern pike from exposure to various voltages and frequencies of PDC under controlled conditions;

2. estimate the effects of electroshocking spinal injury on short-term (1-month), long-term (1-year) survival and growth of northern pike; and,

3. evaluate selected electrical waveforms and voltages for capture efficiency of northern pike under field conditions.

METHODS

The methods of this study were reviewed and approved by the Institutional Animal Care and Use Committee of the University of Alaska Fairbanks.

Injury

Incidence of spinal damage of northern pike from electroshocking was evaluated using x-rays and incidence of internal hemorrhage by necropsies.

Spinal Damage:

Northern pike were captured by seining in George Lake, Alaska (N=274; 30 May - 2 June 1991). Fish in George Lake had not previously been exposed to electrofishing. Each fish was assigned by random number to one of four PDC treatments to compare spinal damage: 30 Hz at 100 V, 30 Hz at 400 V, 60 Hz at 100 V and 60 Hz at 400 V (n=60 for each group); or, to a control group of no electric current (n=34). (All PDC was at 50% duty cycle; duty cycle is the duration the electrical pulse is on during one cycle, expressed as a percent of the cycle.)

Each fish was placed separately in a test tank (Kolz and Reynolds 1989) and exposed to a treatment for 5 s. After treatment, each fish was released alive into George Lake. The test tank was rigid plastic (61 x 46 x 91 cm) with metal electrodes at each end that spanned the complete cross section of water in the tank (Figure 1). Electrical wire connected the electrodes to a Coffelt Mark-10 variable voltage pulsator (VVP) and delivered a uniform electrical field in the water. Data collected included water temperature (C), water conductivity (μS/cm), voltage from the VVP, mean voltage gradient (V/cm) in the water, fork length (mm) and weight (g) of each fish, and a lateral whole body X-ray.

A MinXray MV200 MicroVet portable veterinary X-ray unit was used to take X-rays of three to four fish at a time on a 35 X 43 cm cassette. Exposure time was 0.25 s. Incidence of background spinal damage or abnormality was determined from the control group. Spinal damage was assessed from the X-ray based on the worst damaged vertebrae as follows:

0) no spinal damage obvious;

1) compression of vertebrae only;

2) misalignment of vertebrae, which may include compression; or,

3) fracture of one or more vertebrae or complete separation of two or more vertebrae.

Logistic regression was used to investigate the effects of treatment and length on the incidence of spinal injury to northern pike (Hosmer and Lemeshow 1989). A two-sided Kolmogorov-Smirnov test was used to compare length distributions of the treatment groups (Conover 1980).

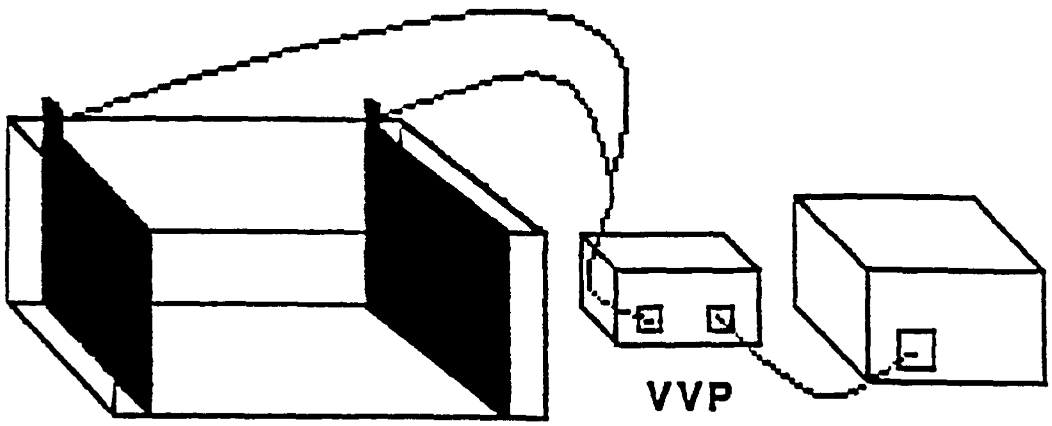

Figure 1. Schematic diagram of electroshocking test tank.

Internal Hemorrhage:

Northern pike were captured with hoop traps from sloughs in Minto Flats, Alaska (N=64; 19-23 August 1990). Minto Flats had previously been electrofished (most recently September 1989). Each fish was assigned by a random number to one of two PDC treatment groups: 30 Hz or 60 Hz (50% duty cycle; 50-300 V; n=27 for each group) to compare incidence of internal hemorrhage and spinal damage; or, to a control group of no treatment (n=8). Each fish was placed separately in the test tank and exposed to a uniform electrical waveform for 5 s. Data collected included water temperature, water conductivity, voltage from the VVP, mean voltage gradient in the water, recovery time, fork length, a lateral whole body X-ray, and a photograph of the fish after necropsy.

Spinal damage was assessed as previously described. Each necropsy was completed immediately after the X-ray was taken. Both sides of each fish were filleted so that the spinal column was exposed. The spinal column and muscle mass of each fillet were photographed. Internal hemorrhage was evaluated using the worst hemorrhage in the muscle mass as follows:

0) no hemorrhage apparent;

1) mild hemorrhage; one or more wounds in the muscle, separate from the spine;

2) moderate hemorrhage; one or more small ($\leq$ the width of one vertebra) wounds on the spine; or,

3) severe hemorrhage; one or more large (> width of one vertebra) wounds on the spine.

Survival and Growth

Northern pike were captured with gill nets and seines from Spinney Reservoir, Colorado (n=177) and from Thompson Lake, South Dakota (n=86) for a total of 263 fish. Fish in Spinney Reservoir and Thompson Lake had not previously been exposed to electrofishing. Each fish was assigned by a random number to the treatment group (n=174) or a control group (n=89) to compare survival rates. Fish in the treatment group were placed separately in the test tank and exposed to a uniform electrical field of 120-Hz PDC with 50% duty cycle at 300-600 V for 5 s. Floy tags were used for individual identification of each fish. Data collected included water temperature, water conductivity, voltage from the VVP, mean voltage gradient in the water, recovery time, fork-length and weight of each fish and a lateral whole body X-ray.

After treatment and measurements, control and shocked fish were randomly assigned to five holding ponds and held for 37 days (9 May - 15 June 1991) (Table 1). Ponds were monitored daily for dead fish, which were identified and recorded. After one month, ponds were drained, fish identified and counted. After removing northern pike from the ponds, 154 (105 shocked and 49 controls) were released in College Lake on the Foothills Campus of Colorado State University to compare long-term survival and growth of the shocked and

Table 1. Numbers of uninjured and injured northern pike exposed to electrofishing, and control northern pike released in five ponds at Colorado State University. (Number of fish that died in each pond are in parentheses).

Pond	Number of Fish		
		Shocked Fish	
	Controls	Uninjured	Injured
1	15 (3)	25 (3)	12 (0)
2	9 (0)	31 (4)	13 (0)
3	21 (0)	22 (0)	9 (2)
4 [a]	19 (19)	24 (24)	8 (8)
5	25 (3)	22 (2)	6 (0)

[a] Fish in this pond were killed by an herbicide treatment and removed from the survival experiment.

control fish. After 290 days (15 June 1991 - 1 April 1992) fish were recovered with gill nets, identified, and fork-length and weight measurements taken.

Logistic regression was used to investigate the effects of treatment and length on survival of northern pike (Hosmer and Lemeshow 1989). A Kolmogorov-Smirnov test was used to compare length distributions of the treatment group to the control group (Conover 1980). Anaylsis of covariance was used to investigate the effects of treatment on weight and length growth of northern pike (Neter et al. 1990).

Field Test

Thirty northern pike were captured in Minto Flats 13-24 August 1991 using a 6.1 m flat bottom electrofishing boat to compare capture rates of DC, 30-Hz PDC at 25% and 75% duty cycle, and 60-Hz PDC at 50% duty cycle. A 4-kw gasoline powered generator supplied power to the electrofishing system. The boat served as the cathode and the anode consisted of four flexible wire ropes (16 mm diameter) hanging from a boom that extended about 2 m from the bow of the boat. A Coffelt VVP-15 was used to control the pulse frequency, duty cycle, and voltage. The sequence of waveforms was determined randomly. Each treatment consisted of 10 min of shocking time. The same netters and boat operator were used throughout the experiment and the netters did not know the treatment. Data collected included water temperature, water conductivity, shocking time, voltage and amperage from the VVP, total fish captured, fork-length and a lateral whole body X-ray of each captured fish.

Capture rates of northern pike were compared between the different waveforms using the Kruskal-Wallis test with tied ranks (Zar 1984).

RESULTS

Injury

Fork length of northern pike in the spinal injury analysis ranged from 356 to 737 mm with a mean of 512 mm (Appendix A1). Length distributions of the treatment groups were similar ($D=0.12$, $P>0.10$; Figure 2). Water conductivity ranged from 109 to 132 μS/cm at 11 to 16° C. The mean voltage gradient in the water was 0.25 V/cm for 30 Hz at 100 V, 0.98 for 30 Hz at 400 V, 0.44 for 60 Hz at 100 V, and 1.76 for 60 Hz at 400 V.

Incidence of spinal injury ranged from 5.0% to 11.7% for shocked fish and there was no spinal damage detected in the control group (Table 2). Although a slight trend in injury with pulse rate and voltage was evident (χ^2=3.01, 1 d.f., P=0.08; Figure 3), treatment did not have a significant effect on injury (χ^2=3.23, 3 d.f., P=0.36). The mean length of the 21 northern pike that were shocked and sustained spinal damage was 572 mm; and that of the 219 northern pike shocked but not injured was 505 mm. The shocked-injured fish were significantly larger than the shocked-uninjured fish (χ^2=8.91, 1 d.f., $P<0.01$).

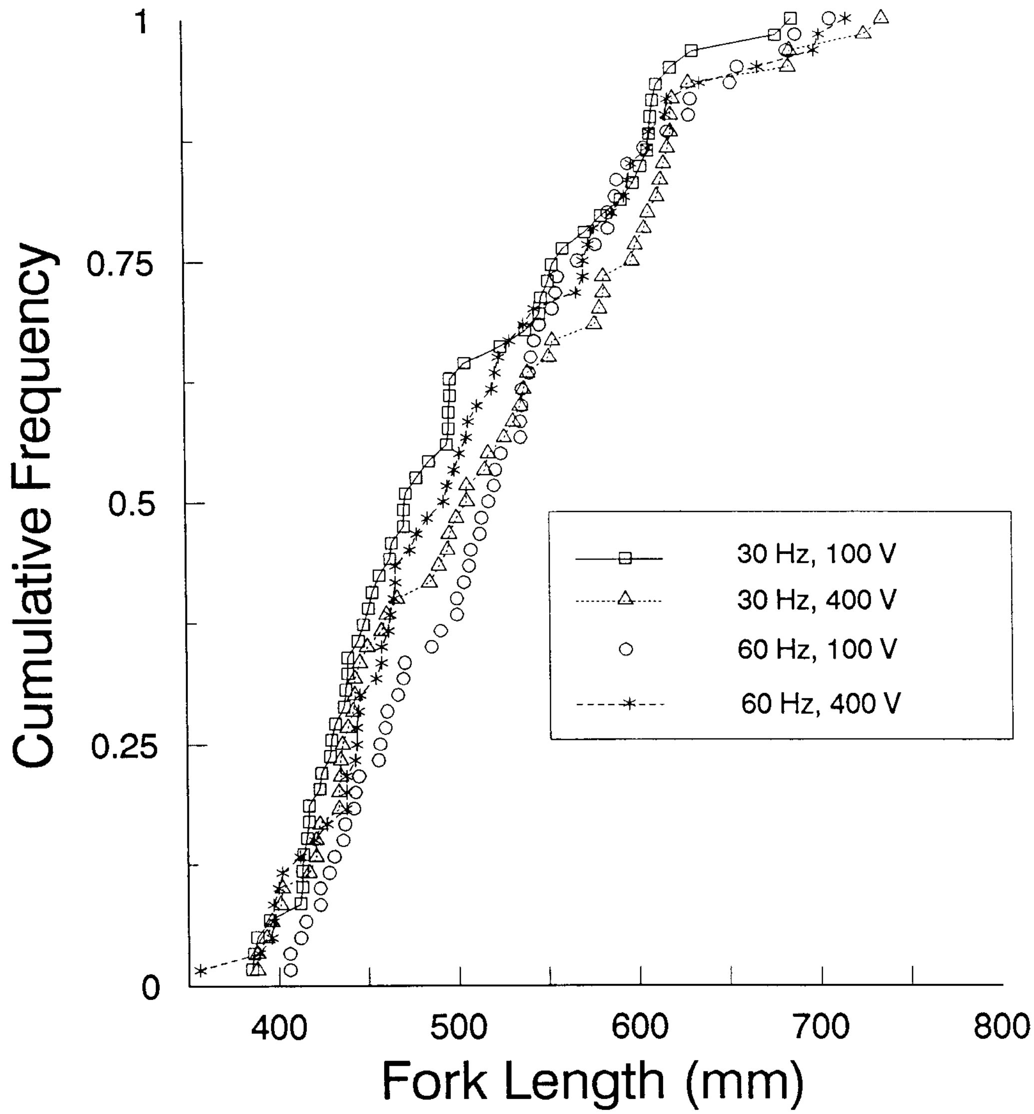

Figure 2. Cumulative length frequencies of northern pike exposed to various forms of PDC for spinal damage evaluation.

Table 2. Spinal injury of northern pike from George Lake by waveform and injury rating.[a]

Treatment			Spinal Injury			Total Injured		
Frequency	Voltage	N	1	2	3	Number	Percent	(95% CI)
60-Hz	100	60	0	4	1	5	8.3	(3-18)
60-Hz	400	60	0	6	1	7	11.7	(5-24)
30-Hz	100	60	0	3	0	3	5.0	(1-14)
30-Hz	400	60	0	6	0	6	10.0	(4-20)
Control	0	34	0	0	0	0	0.0	(0)

[a] (1=compression only, 2=misalignment/compression, 3=fracture/ separation).

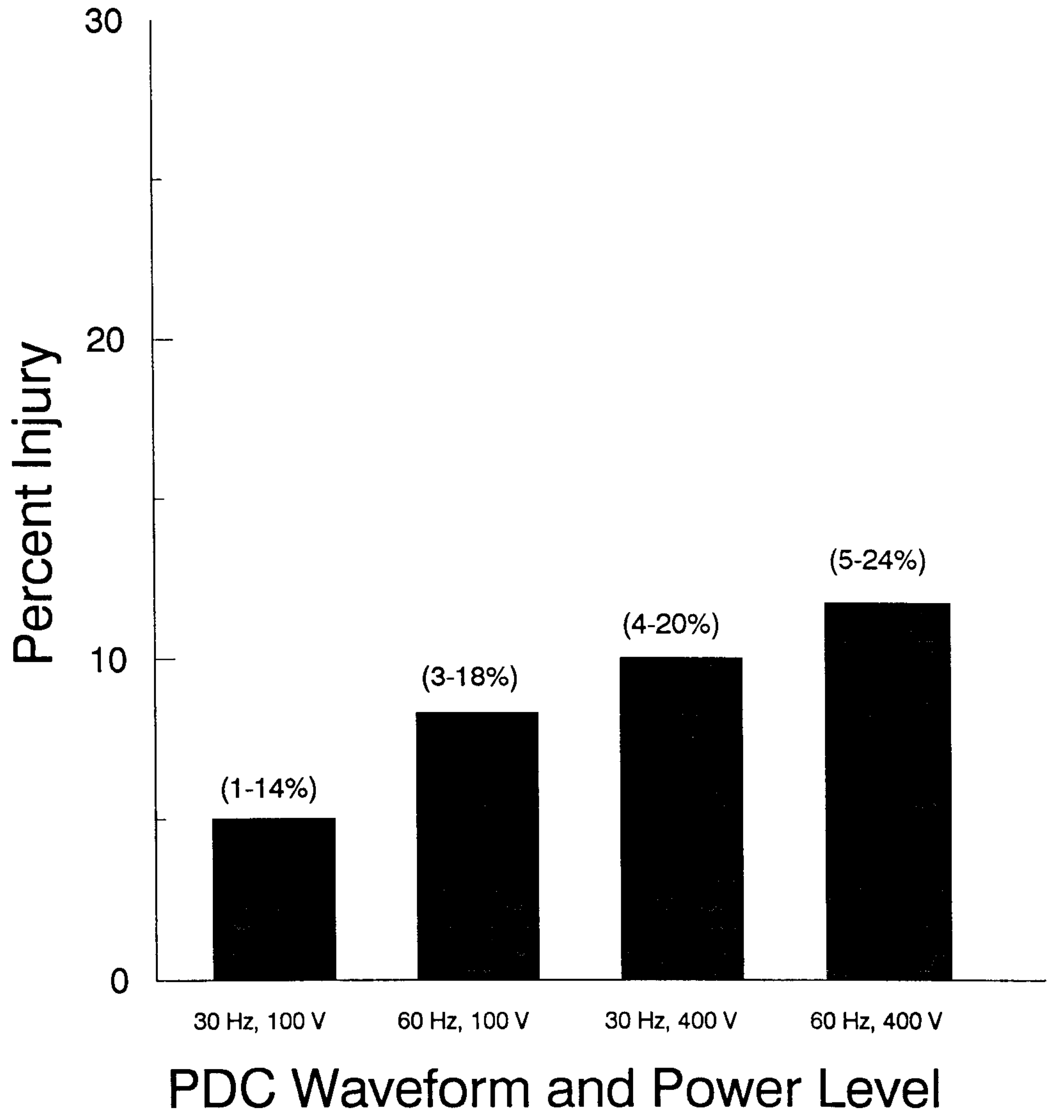

Figure 3. Percent of northern pike with spinal damage after being exposed to PDC at 30 or 60 Hz, 100 V or 400 V.

Fork lengths of northern pike for the internal hemorrhage analysis ranged from 523 to 679 mm with a mean of 607 mm (Appendix A2). Water conductivity ranged from 158 to 188 μS/cm at 11 to 15° C.

Of the 54 northern pike examined for both spinal injury and internal hemorrhage, four exposed to 60-Hz PDC had internal hemorrhage injuries. All northern pike with internal hemorrhage also had spinal injuries and all internal hemorrhage injuries were severe (injury rating 3).

Survival and Growth

Extreme algal growth occurred while the northern pike were held in the ponds in Colorado. An attempt was made to control the algal growth with a herbicide treatment. In one pond, however, all fish died because of oxygen depletion caused by an overdose of the herbicide. These fish were left in the pond over night; recovery of carcasses was poor. It was suspected that scavengers carried away many of the fish during the night. Fish from this pond were not included in the survival experiment. Therefore, beginning sample sizes for the survival experiment were reduced to 140 shocked fish and 70 controls.

Fork length of fish in the short-term survival experiment ranged from 378 to 768 mm with a mean of 562 mm (Appendix A3). Length distribution of the treatment group was similar to the control group (D=0.09, P=0.81; Figure 4). Water conductivity ranged from 1,017 to 1,090 μS/cm at 10 to 13° C. The mean voltage gradient in the water was 0.93 V/cm.

Of the northern pike used in the survival experiment, incidence of spinal injury was 28.6% with the more intense waveform (120-Hz PDC, 300-600 V), compared to 30-Hz PDC at 400 V (10.0%) and 60-Hz PDC at 400 V (11.7%) for the injury experiment (G=27.44, 2 d.f., P<0.01). However, 92% of shocked fish and 91% of control fish survived (Table 3). Of the shocked fish, 95% with spinal injury and 91% without spinal injury survived (Figure 5). There was no difference in survival between shocked and control fish (χ^2=0.07, 1 d.f., P=0.79).

The mean length of the 40 northern pike that were shocked and sustained spinal damage was 573 mm; and that of the 100 northern pike shocked but not injured was 560 mm. The shocked-injured fish were not significantly larger than the shocked-uninjured fish (χ^2 = 0.41, 1 d.f., P=0.52).

Fork length of fish in the long-term survival experiment ranged from 378 to 766 mm with a mean 555 mm (Appendix A4). Of the 154 northern pike released in College Lake, 105 were shocked fish and 49 were controls. The mean length of the shocked fish was 557 mm and that of the control fish was 551 mm. There was no significant difference in the length distributions of the two groups (D=0.08, P=0.95; Figure 6). In a three-pass removal experiment, 82 of these fish were captured (54 shocked and 28 controls) with gill nets 327 days after release. It was estimated that 76% of the fish remaining in the lake were captured with each pass. Of the northern pike used in this experiment, the estimated number in the lake at the time of the removal experiment was 83 with a standard error of 1.28 (White et al. 1982).

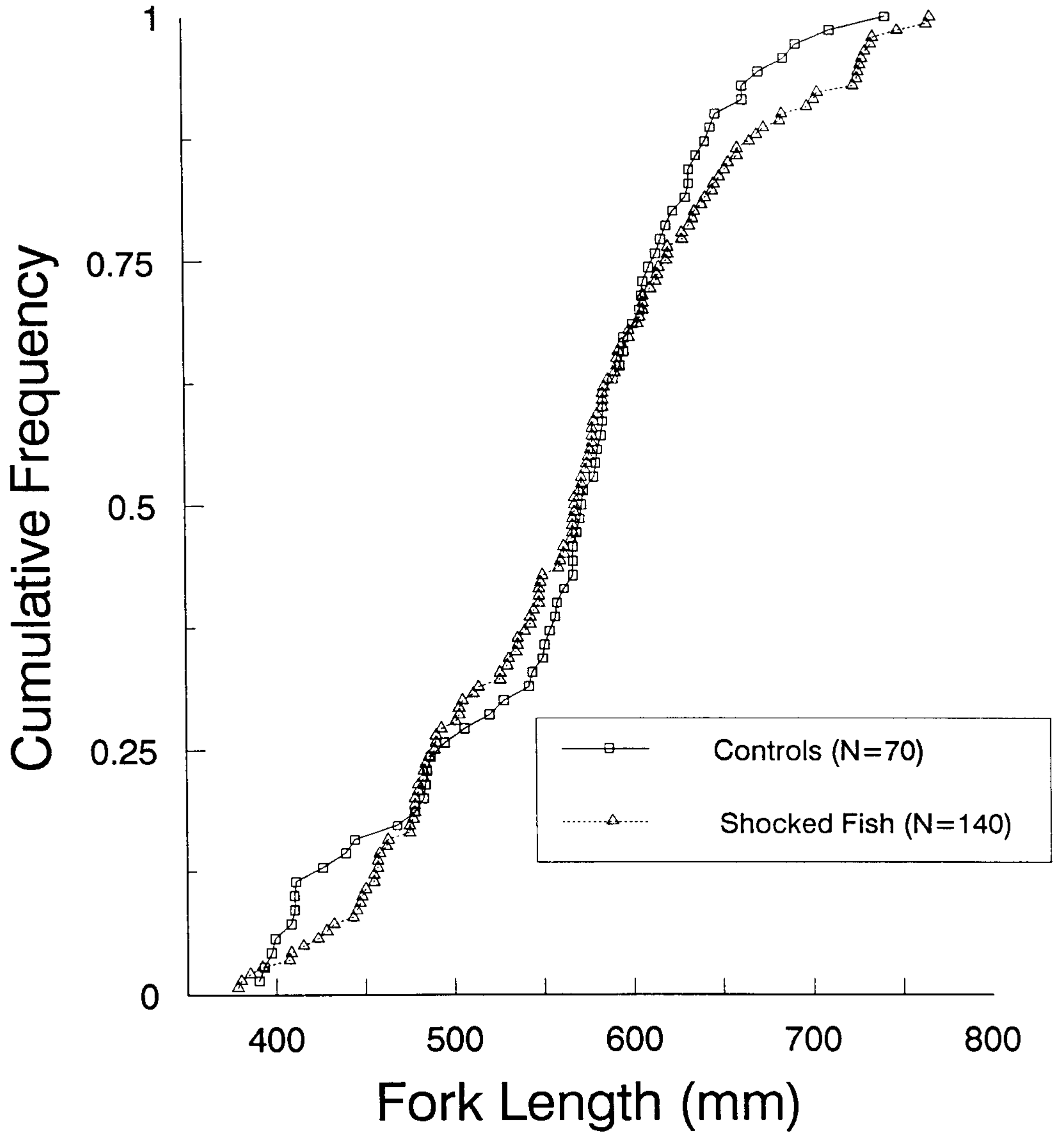

Figure 4. Cumulative length frequencies of northern pike exposed to 120-Hz PDC and control fish for short-term survival comparison.

Table 3. Fate of control and electroshocked northern pike in ponds at Colorado State University 37 days after treatment.

	Number				
	Dead	Alive	Total	Survival	(95% CI)
Not Injured	9	91	100	91	(84-95)
Injured	2	38	40	95	(83-98)
All Shocked	11	129	140	92	(86-95)
Controls	6	64	70	91	(82-96)
Total	17	193	210	92	

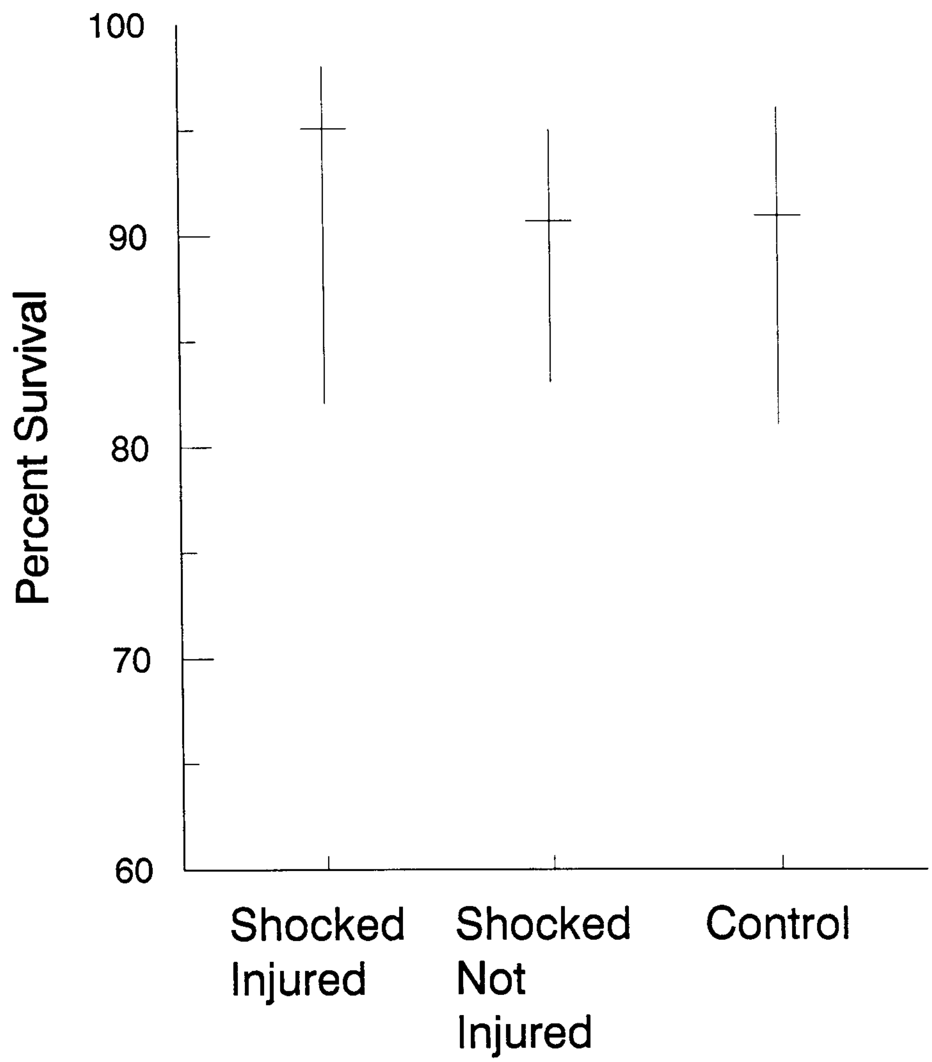

Figure 5. Percent survival of northern pike 37 days after exposure to 120-Hz PDC at 300-600 V.

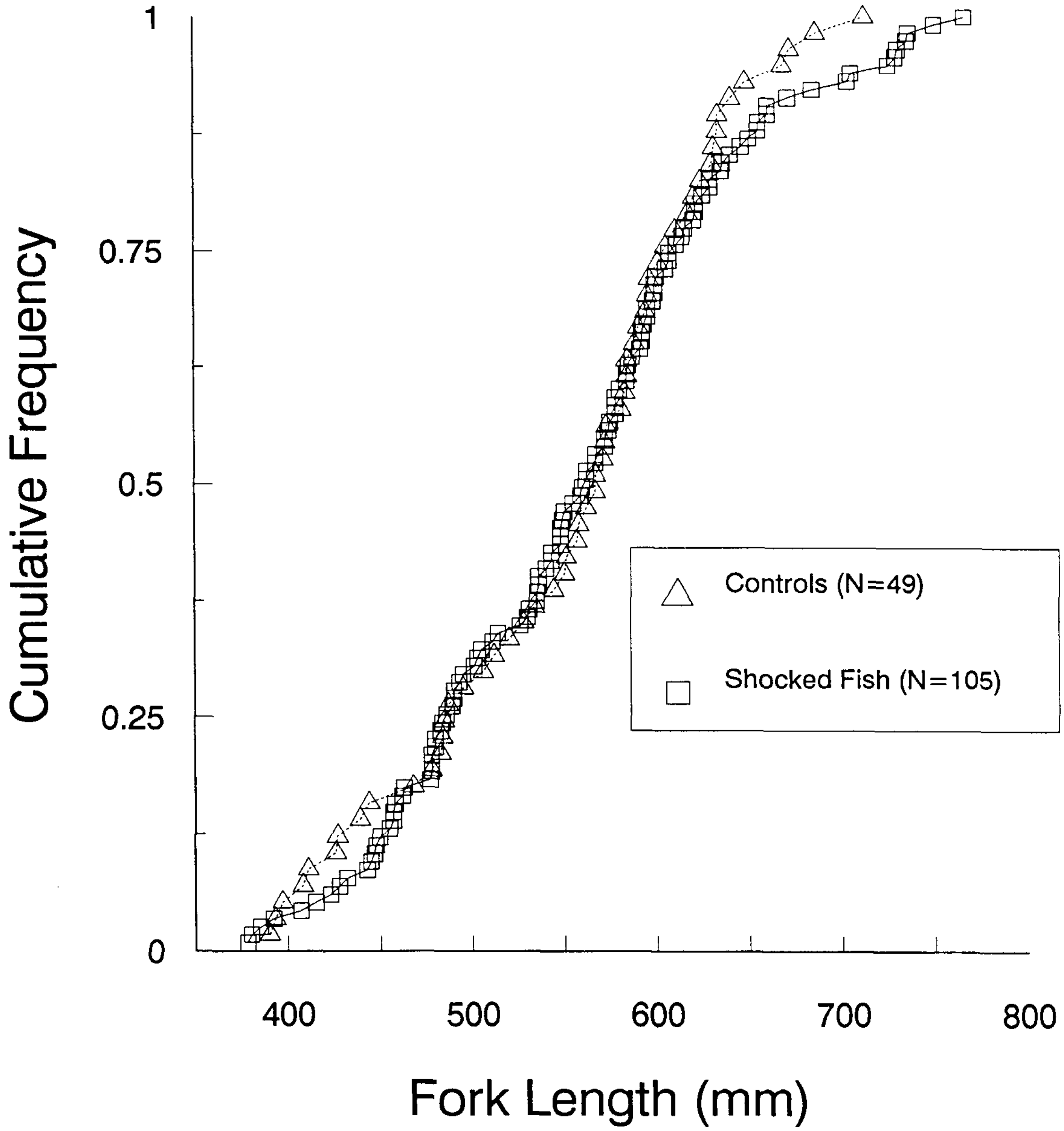

Figure 6. Cumulative length frequencies of northern pike exposed to 120-Hz PDC and control fish for long-term survival comparison.

Fifty one percent of the shocked fish and 57% of the control fish survived (Table 4; χ^2=0.57, 1 d.f., P=0.45). For both the control fish and the shocked fish, recovery rates one year later were higher for larger fish (χ^2=5.46, 1 d.f., P=0.02). The length distributions were different for recaptured fish (mean FL = 578) and fish not recaptured (mean FL = 534; D=0.27, P=0.003; Figure 7). However, there was no difference in length distributions of shocked fish (mean length = 584 mm) and control fish (mean length = 566 mm) that were recaptured (D=0.14, P=0.85; Figure 8).

The northern pike recovered in College Lake had grown in length and weight (Table 5). These gains were similar for shocked and control fish (original length and weight were corrected for in the analysis). The mean increase in fork length was 32 mm for shocked fish and 31 mm for control fish (F=0.27, 1 d.f., P=0.60). Mean increase in weight was 239 g for shocked fish and 326 g for control fish (F=1.76, 1 d.f., P=0.19).

Field Test

Fork length of captured northern pike ranged from 332 to 962 mm with a mean of 613 mm (Appendix B1). The conductivity of the water ranged from 66 to 182 μS/cm at 10 to 18° C.

Total shocking time was 5.34 hours with 60-Hz PDC, 4.48 hours with 30-Hz PDC (25% duty cycle), 4.57 hours with 30-Hz PDC (75% duty cycle), and 5.41 hours with DC (Table 6; Appendix B2). Capture rates of northern pike were higher using 60-Hz PDC (Hc=6.69, 3 d.f., P=0.08) compared to the other waveforms (Table 6; Figure 9).

DISCUSSION

The test tank used in these experiments allowed the benefit of knowing the electrical field (Reynolds and Kolz 1988; Kolz and Reynolds 1989) imposed upon each fish in the water, which has not been reported in other studies. The parallel electrodes on each end of the test tank covered the complete cross section of the water giving a uniform electrical field (i.e. V/cm were similar throughout the tank and were consistent among treatments).

Naturally occurring spinal abnormalities were identified by comparison of X-rays from shocked and control fish. Dark calcification and densely-fused vertebrae were considered natural (Sharber and Carothers 1988). All non-natural abnormalities in treated fish were considered electroshocking injuries. Even though most spinal injuries due to electroshocking of the northern pike consisted of slight misalignments, severe vertebra fractures occurred in two of 240 shocked northern pike. Since only four of 54 northern pike examined for internal hemorrhage had internal hemorrhage injuries and all fish with internal hemorrhage injuries also had spinal damage, the assumption was made that fish with internal hemorrhage were a subset of fish with spinal damage. This enabled fish used in the other experiments to be returned to the lake or stream alive.

Table 4. Fate of control and electroshocked northern pike in ponds at Colorado State University 327 days after treatment.

	Number				
	Not Recovered	Recovered	Total	Survival	(95% CI)
All Shocked	51	54	105	51	(42-59)
Controls	21	28	49	57	(46-70)
Total	72	82	154	53	

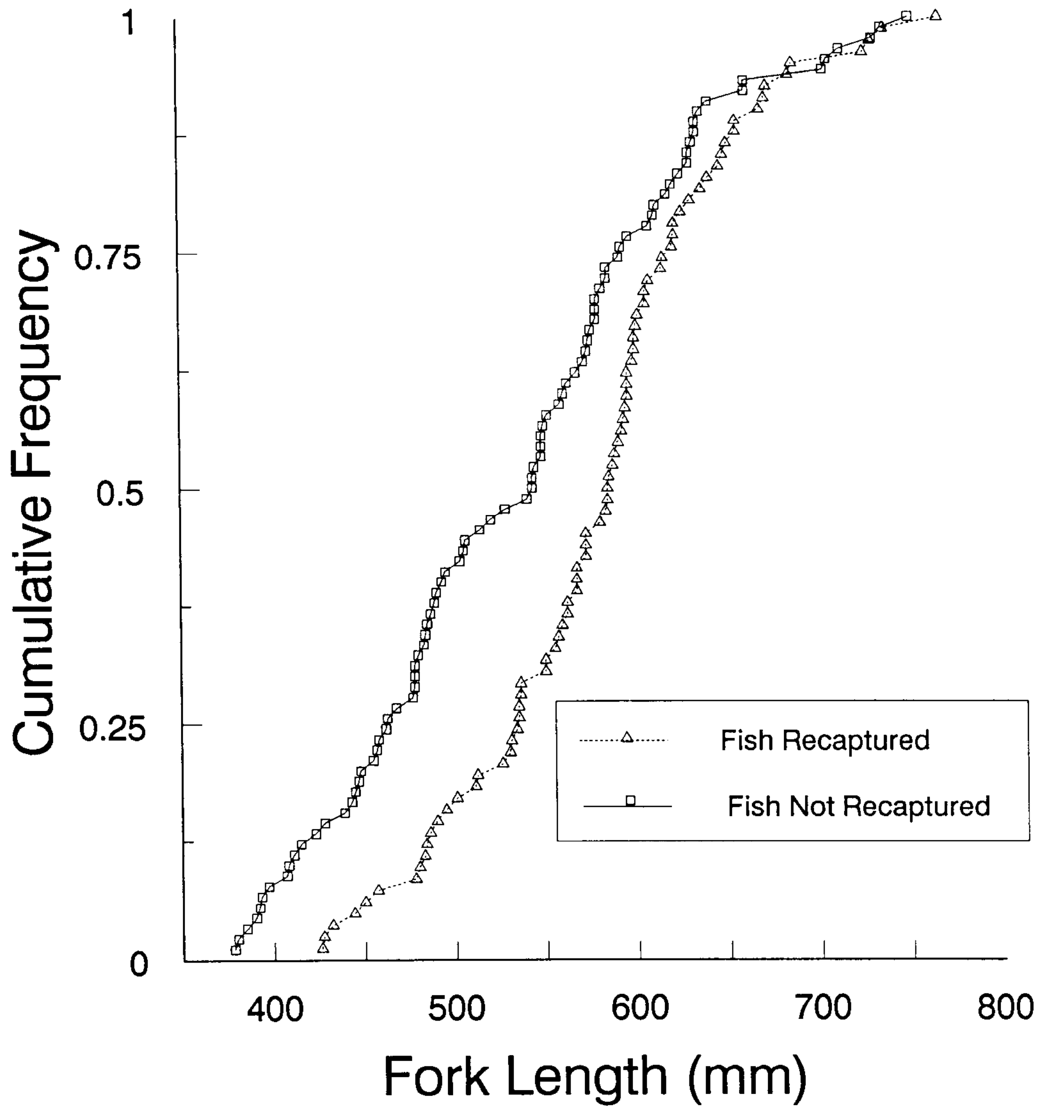

Figure 7. Cumulative length frequencies of recaptured and not recaptured northern pike released in College Lake for long-term survival comparison.

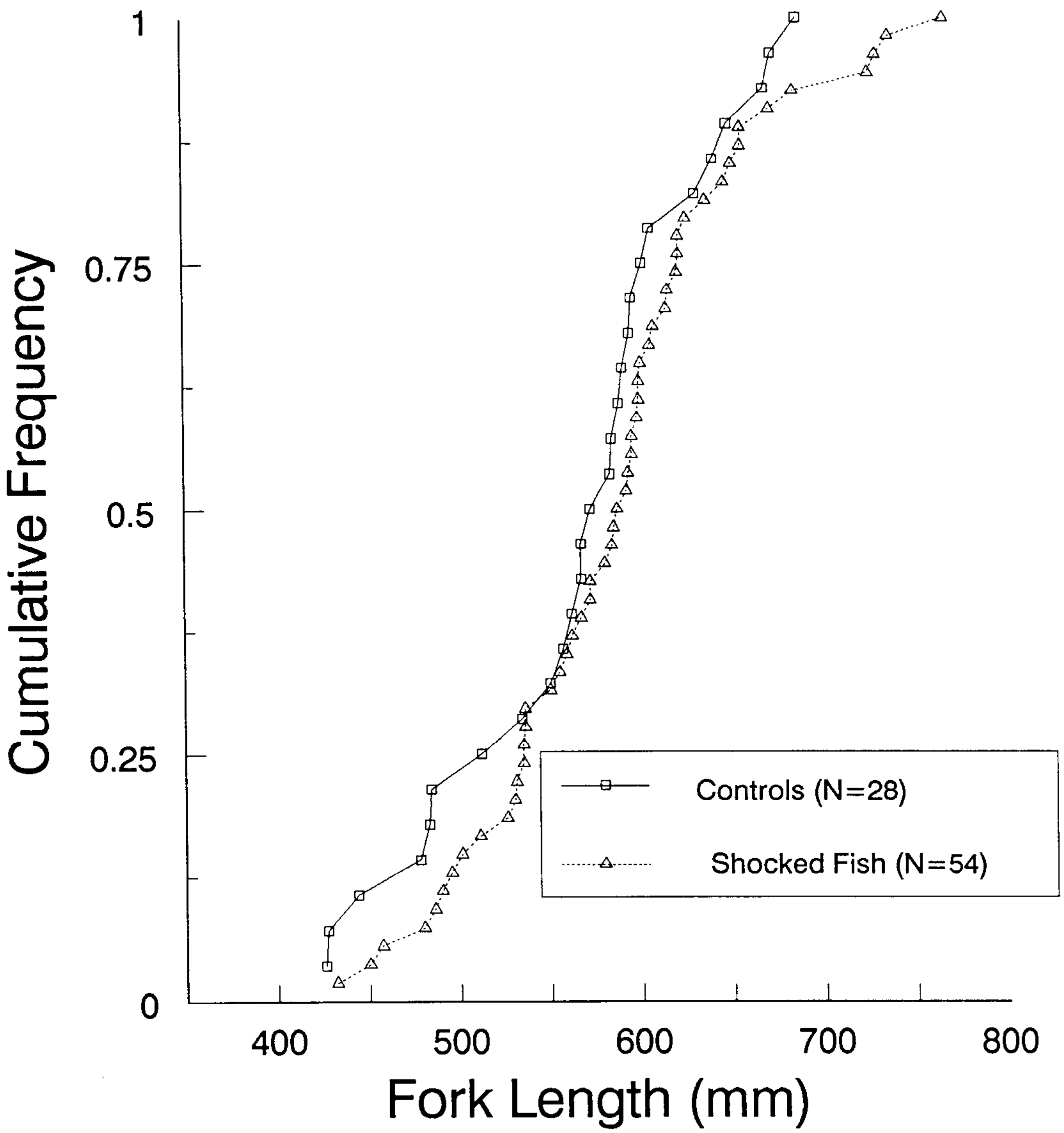

Figure 8. Cumulative length frequencies of recaptured northern pike exposed to 120-Hz PDC and control fish for long-term survival comparison.

Table 5. Mean incremental length (mm) and weight (g) of 20 control and 44 electroshocked northern pike 327 days after treatment in College Lake, Colorado State University.

	Treatment	
Growth	Controls (s.d.)	Shocked Fish (s.d.)
Length	31 (28)	32 (27)
Weight	326 (256)	239 (218)

Table 6. Total time electrofished, total number of northern pike captured in Minto Flats and catch per hour by treatment.

Treatment		Total Time (hours)	Total Catch (fish)	Catch Per Hour
Frequency	Duty Cycle			
60-Hz	50%	5.34	16	3.0
30-Hz	25%	4.48	5	1.1
DC	-	5.41	5	0.9
30-Hz	75%	4.57	4	0.9

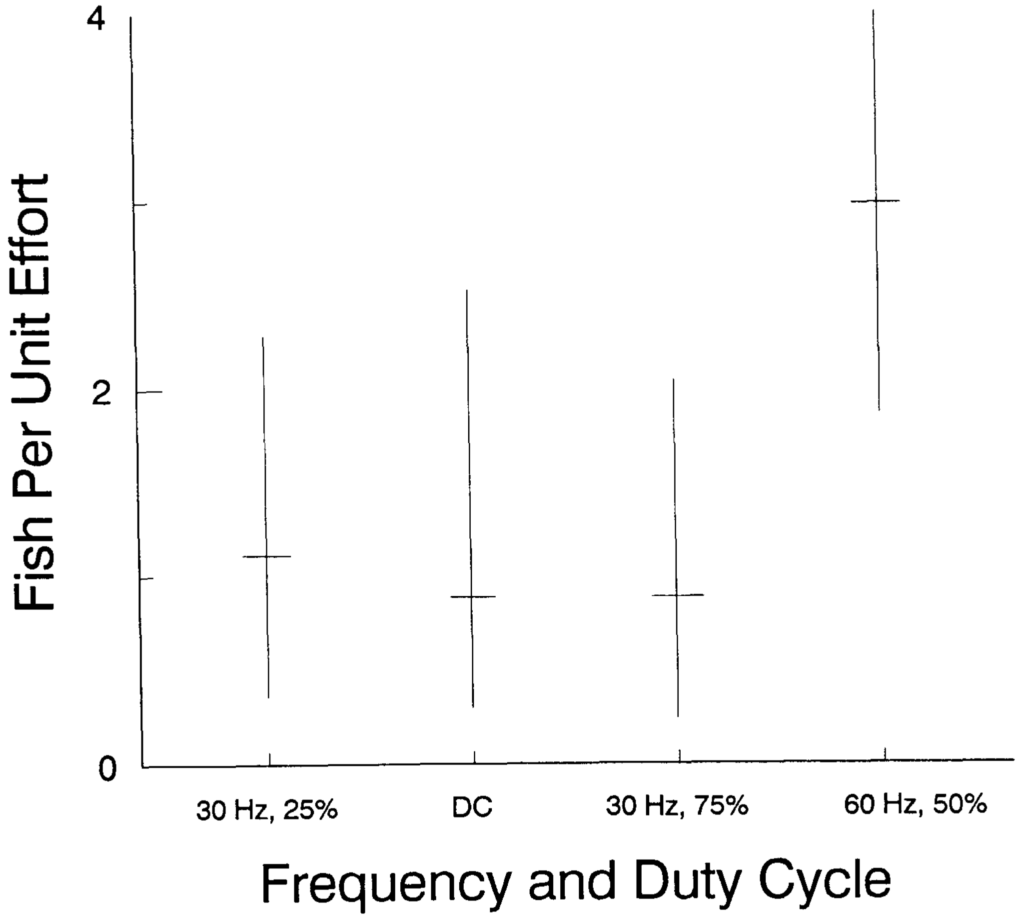

Figure 9. Number of fish captured per unit of electrofishing effort with DC and several forms of PDC.

In the field test, capture rates for all wave forms were low because of the timing of the experiment. There was a small window of opportunity in Minto Flats just before freeze-up when electrofishing was ideal. During this time, 60-Hz PDC is preferred because of the general belief that this wave form has more "holding power" than 30-Hz PDC, a belief supported by these results. During this time, northern pike have been captured at rates as high as 30 per hour using 60-Hz PDC (J. H. Clark, Alaska Department of Fish and Game, personal communication).

Larger fish may be easier to capture and more susceptible to injury from electrofishing because of larger muscle mass and a greater head-to-tail voltage gradient than smaller fish (Ellis 1975; Reynolds 1983; Kolz 1989). Holmes et al. (1990) reported a mean length of 625 mm for four shocked northern pike that sustained spinal damage compared to 536 mm for 28 shocked northern pike that did not sustain spinal injury (t=1.62, P<0.10). This study did not contradict the notion that larger northern pike are more susceptible to spinal injury than smaller ones but the results were not conclusive. In the injury experiment, shocked-injured fish were significantly larger than shocked-uninjured fish but not significantly larger in the survival experiment. It was not tested if larger fish are easier to capture by electrofishing because of the small number of fish captured during the field trials.

One criticism of electrofishing northern pike has been the possible violation of the "equal-survival" assumption for marked and unmarked fish (i.e., shocked and unshocked). These results indicate that survival rates are not significantly affected when northern pike are electroshocked and sustain these injury levels. Electroshocking also had no apparent affect on growth in length or weight after nearly one year. In addition, Holmes et al. (1990) reported immediate mortality was lower for northern pike captured by electrofishing than fish caught with hook and line, gill nets, or trap nets (χ^2=19.39, P<0.01).

Holmes et al. (1990) reported average monthly growth of 3.30 mm for electroshocked northern pike and 2.72 mm for controls (t=1.08, P>0.25) in Minto Flats, Alaska. This growth was similar to the growth of the fish held in College Lake for this study, which had an average monthly growth over 10.5 months (15 June 1991 - 1 April 1992) of 2.94 mm for electroshocked fish and 2.84 mm for controls (Z=0.29, P=0.77). Growth rates of these two studies are not directly comparable, however, both suggest that there is no difference in growth between shocked fish and controls. A good portion of the yearly growing season was not represented in the length measurements of the northern pike used in the survival experiment. It is likely that average monthly growth would have been greater because growth would have accelerated during 1 April to 15 June 1992. Growth rates of northern pike in College Lake have averaged as high as 6.98 mm per month when averaged over a full twelve months (J. H. Clark, Alaska Department of Fish and Game, unpublished data).

The spinal injury rate of 11.7% (n=60) at the high voltage level of 60-Hz in this study was similar to the injury rate of 15.6% (n=32) reported by Holmes et al. (1990) for fish captured by electrofishing with 60-Hz PDC (Z=0.71, P=0.52). However, due to the low injury rates of electroshocked northern pike and no significant difference in survival or growth between shocked and control fish, there is little evidence to suggest that the waveform of choice, 60-Hz PDC (50% duty cycle), should not be used. Fishery biologists, however, must be aware of the potential spinal injury that electrofishing may cause to northern pike and avoid waveforms with pulse rates higher than 60 Hz and extreme voltage levels because of the trend of increased injury with increased frequency and voltage.

ACKNOWLEDGEMENTS

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APPENDIX A

Appendix A1. Voltage gradient (V/cm), immediate recovery time (s), tag number, fork length (mm) and spinal injury rating of northern pike exposed to various electrical waveforms (30 May - 2 June 1991).[a]

Treatment	Voltage Gradient	Recovery Time	Tag Number	FL	Spinal Injury Rating[b]
Control	0.00	0	57200	468	0
Control	0.00	0	57218	481	0
Control	0.00	0	57222	417	0
Control	0.00	0	57263	690	0
Control	0.00	0	57264	580	0
Control	0.00	0	57291	539	0
Control	0.00	0	57283	532	0
Control	0.00	0	57314	612	0
Control	0.00	0	57293	422	0
Control	0.00	0	57430	545	0
Control	0.00	0	57435	560	0
Control	0.00	0	57432	682	0
Control	0.00	0	57428	482	0
Control	0.00	0	57418	654	0
Control	0.00	0	57437	450	0
Control	0.00	0	57424	490	0
Control	0.00	0	57281	nd	0
Control	0.00	0	57284	nd	0
Control	0.00	0	54522	nd	0
Control	0.00	0	55342	654	0
Control	0.00	0	57500	394	0
Control	0.00	0	57517	390	0
Control	0.00	0	57484	411	0
Control	0.00	0	57545	478	0
Control	0.00	0	57544	542	0
Control	0.00	0	57450	438	0
Control	0.00	0	57683	425	0
Control	0.00	0	57678	551	0
Control	0.00	0	57676	474	0
Control	0.00	0	57693	428	0
Control	0.00	0	78495	657	0
Control	0.00	0	57871	452	0
Control	0.00	0	57869	671	0
Control	0.00	0	57860	590	0
30-Hz PDC	0.22	180	57214	620	0
30-Hz PDC	0.25	80	57207	472	0
30-Hz PDC	0.24	50	57202	496	0
30-Hz PDC	0.24	80	57219	610	0
30-Hz PDC	0.24	70	57216	416	0
30-Hz PDC	0.25	60	57203	413	0
30-Hz PDC	0.25	120	54887	445	0

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Treatment	Voltage Gradient	Recovery Time	Tag Number	FL	Spinal Injury Rating[b]
30-Hz PDC	0.24	0	54500	448	0
30-Hz PDC	0.23	105	54593	608	0
30-Hz PDC	0.24	80	57253	581	0
30-Hz PDC	0.24	30	57247	505	0
30-Hz PDC	0.24	145	57234	603	0
30-Hz PDC	0.23	0	57228	678	0
30-Hz PDC	0.26	205	20338	497	0
30-Hz PDC	0.24	260	54246	607	2
30-Hz PDC	0.24	305	57273	417	0
30-Hz PDC	0.28	20	57307	429	0
30-Hz PDC	0.21	155	55799	612	0
30-Hz PDC	0.25	60	57279	412	0
30-Hz PDC	0.25	95	57266	539	0
30-Hz PDC	0.27	160	57304	496	0
30-Hz PDC	0.26	175	57311	430	0
30-Hz PDC	0.25	30	57229	471	0
30-Hz PDC	0.24	300	57297	485	0
30-Hz PDC	0.23	185	57312	451	0
30-Hz PDC	0.24	25	57436	552	0
30-Hz PDC	0.23	160	57441	554	2
30-Hz PDC	0.22	140	57423	599	2
30-Hz PDC	0.24	265	57431	632	0
30-Hz PDC	0.28	65	57471	386	0
30-Hz PDC	0.27	126	57543	457	0
30-Hz PDC	0.25	116	57538	414	0
30-Hz PDC	0.27	116	57521	478	0
30-Hz PDC	0.25	109	57446	453	0
30-Hz PDC	0.25	0	57469	385	0
30-Hz PDC	0.25	125	57550	439	0
30-Hz PDC	0.24	148	55293	560	0
30-Hz PDC	0.28	5	54619	592	0
30-Hz PDC	0.26	36	57468	395	0
30-Hz PDC	0.26	184	57540	495	0
30-Hz PDC	0.25	102	57466	388	0
30-Hz PDC	0.26	125	57692	438	0
30-Hz PDC	0.24	205	57690	572	0
30-Hz PDC	0.24	155	54089	439	0
30-Hz PDC	0.25	100	54603	464	0
30-Hz PDC	0.26	120	57736	413	0
30-Hz PDC	0.26	160	57734	417	0
30-Hz PDC	0.24	70	54586	432	0
30-Hz PDC	0.24	5	57695	471	0
30-Hz PDC	0.25	160	57752	525	0

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Appendix A1. (Page 3 of 7).

Treatment	Voltage Gradient	Recovery Time	Tag Number	FL	Spinal Injury Rating[b]
30-Hz PDC	0.24	40	57726	424	0
30-Hz PDC	0.24	90	54736	437	0
30-Hz PDC	0.27	120	56296	463	0
30-Hz PDC	0.24	0	57704	423	0
30-Hz PDC	0.24	215	54310	609	0
30-Hz PDC	0.25	220	57702	548	0
30-Hz PDC	0.24	0	57770	497	0
30-Hz PDC	0.25	5	57701	547	0
30-Hz PDC	0.24	155	57298	687	0
30-Hz PDC	0.23	60	57429	481	0
30-Hz PDC	0.89	175	57208	538	0
30-Hz PDC	1.05	115	57201	434	0
30-Hz PDC	1.06	105	57210	421	0
30-Hz PDC	0.95	150	57223	582	0
30-Hz PDC	1.00	130	57235	443	0
30-Hz PDC	0.97	125	57252	577	0
30-Hz PDC	0.97	115	57255	435	0
30-Hz PDC	0.92	125	57237	450	0
30-Hz PDC	0.92	135	57240	439	0
30-Hz PDC	0.92	170	96445	582	0
30-Hz PDC	0.90	155	57232	727	2
30-Hz PDC	1.00	105	57236	485	2
30-Hz PDC	0.94	215	57298	685	0
30-Hz PDC	0.90	220	57317	532	2
30-Hz PDC	0.94	100	57268	458	0
30-Hz PDC	0.93	210	57272	527	0
30-Hz PDC	0.86	310	57270	536	0
30-Hz PDC	0.95	135	57269	388	0
30-Hz PDC	0.87	200	57308	630	0
30-Hz PDC	0.95	145	57310	423	0
30-Hz PDC	0.95	140	57271	401	0
30-Hz PDC	0.94	135	57309	442	0
30-Hz PDC	1.02	180	57292	467	0
30-Hz PDC	0.93	205	57303	506	2
30-Hz PDC	0.92	195	57434	607	0
30-Hz PDC	0.89	175	26806	686	0
30-Hz PDC	0.91	205	57439	506	0
30-Hz PDC	0.85	185	57422	614	0
30-Hz PDC	0.95	235	97163	620	0
30-Hz PDC	0.92	185	57425	490	2
30-Hz PDC	0.93	195	55910	540	0
30-Hz PDC	1.11	170	57419	598	0
30-Hz PDC	1.19	110	57447	417	0

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Treatment	Voltage Gradient	Recovery Time	Tag Number	FL	Spinal Injury Rating[b]
30-Hz PDC	1.17	250	57539	620	0
30-Hz PDC	1.00	473	57502	436	0
30-Hz PDC	0.93	45	23246	621	0
30-Hz PDC	1.17	278	57511	402	0
30-Hz PDC	0.96	118	57505	446	0
30-Hz PDC	0.93	233	57527	618	0
30-Hz PDC	0.97	95	57536	421	0
30-Hz PDC	0.96	184	57542	495	0
30-Hz PDC	0.95	147	57528	435	0
30-Hz PDC	0.99	128	57460	434	0
30-Hz PDC	1.01	157	57470	388	0
30-Hz PDC	0.98	360	54246	605	0
30-Hz PDC	0.96	99	57479	396	0
30-Hz PDC	1.16	226	55452	500	0
30-Hz PDC	1.20	122	56621	461	0
30-Hz PDC	0.96	100	57452	393	0
30-Hz PDC	0.99	248	54981	580	0
30-Hz PDC	1.04	231	57672	612	2
30-Hz PDC	0.94	235	57678	616	0
30-Hz PDC	1.05	214	54352	552	0
30-Hz PDC	0.92	200	57681	600	0
30-Hz PDC	1.27	250	57753	443	0
30-Hz PDC	0.91	230	54148	516	0
30-Hz PDC	0.85	165	57700	554	0
30-Hz PDC	1.15	135	57865	518	0
30-Hz PDC	1.12	250	57868	737	0
30-Hz PDC	0.91	165	57874	496	0
60-Hz PDC	0.45	240	57209	653	0
60-Hz PDC	0.43	245	57211	486	0
60-Hz PDC	0.46	120	57205	428	0
60-Hz PDC	0.44	90	57262	513	0
60-Hz PDC	0.44	90	57251	467	0
60-Hz PDC	0.43	5	57245	470	0
60-Hz PDC	0.43	140	57241	554	0
60-Hz PDC	0.45	180	54042	491	0
60-Hz PDC	0.48	160	57285	589	0
60-Hz PDC	0.42	120	57296	461	0
60-Hz PDC	0.42	235	57305	618	0
60-Hz PDC	0.41	10	57290	585	2
60-Hz PDC	0.42	135	57316	541	0
60-Hz PDC	0.44	5	54479	443	0
60-Hz PDC	0.48	370	57433	684	0
60-Hz PDC	0.36	220	97232	631	0

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Treatment	Voltage Gradient	Recovery Time	Tag Number	FL	Spinal Injury Rating[b]
60-Hz PDC	0.45	135	57427	437	0
60-Hz PDC	0.46	125	57438	507	0
60-Hz PDC	0.47	115	57442	460	0
60-Hz PDC	0.47	175	57440	457	0
60-Hz PDC	0.46	270	57420	557	0
60-Hz PDC	0.43	230	57548	568	0
60-Hz PDC	0.48	114	57251	471	0
60-Hz PDC	0.41	212	57530	630	0
60-Hz PDC	0.48	205	57529	585	0
60-Hz PDC	0.44	195	55689	406	0
60-Hz PDC	0.50	169	57513	431	0
60-Hz PDC	0.44	137	57504	423	0
60-Hz PDC	0.42	165	57552	445	0
60-Hz PDC	0.46	0	57465	412	0
60-Hz PDC	0.45	25	57549	500	3
60-Hz PDC	0.48	127	57455	406	0
60-Hz PDC	0.48	97	57448	442	0
60-Hz PDC	0.47	144	54031	556	0
60-Hz PDC	0.46	140	57694	456	0
60-Hz PDC	0.47	175	57689	522	0
60-Hz PDC	0.46	145	57739	504	0
60-Hz PDC	0.42	140	56236	542	2
60-Hz PDC	0.46	160	57696	578	0
60-Hz PDC	0.48	120	57751	514	2
60-Hz PDC	0.40	60	57691	415	0
60-Hz PDC	0.43	10	54949	596	0
60-Hz PDC	0.45	150	57740	436	0
60-Hz PDC	0.44	180	57699	508	0
60-Hz PDC	0.43	210	57767	518	0
60-Hz PDC	0.45	205	57703	605	0
60-Hz PDC	0.42	180	56686	537	0
60-Hz PDC	0.37	115	57766	500	0
60-Hz PDC	0.42	140	54151	536	0
60-Hz PDC	0.41	195	57768	547	0
60-Hz PDC	0.41	180	78494	537	2
60-Hz PDC	0.48	285	57863	708	0
60-Hz PDC	0.40	85	57861	423	0
60-Hz PDC	0.46	120	57866	590	0
60-Hz PDC	0.47	145	57867	544	0
60-Hz PDC	0.46	140	57877	536	0
60-Hz PDC	0.42	190	57862	689	0
60-Hz PDC	0.43	10	57870	525	0
60-Hz PDC	0.46	175	57873	521	0

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Appendix A1. (Page 6 of 7).

Treatment	Voltage Gradient	Recovery Time	Tag Number	FL	Spinal Injury Rating[b]
60-Hz PDC	0.43	195	57878	657	0
60-Hz PDC	2.27	185	57217	427	0
60-Hz PDC	1.92	240	57221	502	0
60-Hz PDC	1.74	180	57204	524	0
60-Hz PDC	1.97	245	57206	466	0
60-Hz PDC	1.67	300	57224	608	0
60-Hz PDC	1.77	220	57212	465	0
60-Hz PDC	1.63	330	57248	617	0
60-Hz PDC	1.75	165	54522	397	0
60-Hz PDC	1.76	105	57238	444	0
60-Hz PDC	1.81	150	57254	717	0
60-Hz PDC	1.86	120	57243	445	0
60-Hz PDC	1.85	160	55946	577	0
60-Hz PDC	1.70	185	54300	356	0
60-Hz PDC	1.66	210	57250	636	2
60-Hz PDC	1.57	180	54202	699	2
60-Hz PDC	1.72	100	57246	538	2
60-Hz PDC	1.68	140	57249	571	2
60-Hz PDC	1.75	105	57244	443	0
60-Hz PDC	1.75	150	57315	495	0
60-Hz PDC	1.77	225	54339	507	0
60-Hz PDC	1.72	210	57318	587	0
60-Hz PDC	1.74	235	57282	522	0
60-Hz PDC	1.82	150	57306	493	0
60-Hz PDC	1.70	160	57421	607	0
60-Hz PDC	1.65	250	57417	594	0
60-Hz PDC	1.70	190	57426	484	0
60-Hz PDC	1.70	180	57459	512	0
60-Hz PDC	1.73	298	57531	574	0
60-Hz PDC	1.88	155	57516	389	0
60-Hz PDC	1.80	208	57537	458	0
60-Hz PDC	1.82	135	57501	400	0
60-Hz PDC	1.74	207	57526	598	0
60-Hz PDC	1.80	165	57541	499	0
60-Hz PDC	1.70	248	57534	618	0
60-Hz PDC	1.73	187	57546	571	0
60-Hz PDC	1.72	128	57705	446	0
60-Hz PDC	1.78	123	57463	458	0
60-Hz PDC	1.76	140	57464	397	0
60-Hz PDC	1.69	231	57462	596	2
60-Hz PDC	1.78	277	57480	412	0
60-Hz PDC	1.76	127	57461	402	0
60-Hz PDC	1.77	109	57458	438	0

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Treatment	Voltage Gradient	Recovery Time	Tag Number	FL	Spinal Injury Rating[b]
60-Hz PDC	1.77	112	57472	396	0
60-Hz PDC	1.81	140	57467	444	0
60-Hz PDC	1.71	160	57495	438	0
60-Hz PDC	1.80	140	57485	420	0
60-Hz PDC	1.79	133	57551	438	0
60-Hz PDC	1.81	182	57490	466	0
60-Hz PDC	1.91	288	57680	668	0
60-Hz PDC	1.71	423	57675	520	0
60-Hz PDC	1.84	266	57673	506	0
60-Hz PDC	1.72	179	57682	462	0
60-Hz PDC	1.80	199	57677	474	0
60-Hz PDC	1.90	183	54047	530	0
60-Hz PDC	1.72	165	57697	544	0
60-Hz PDC	1.69	230	57754	567	0
60-Hz PDC	1.66	210	57769	455	0
60-Hz PDC	1.68	365	54225	478	3
60-Hz PDC	1.55	600	78493	702	2
60-Hz PDC	1.60	150	57698	463	0

[a] Water temperature ranged from 11 to 16°C, water conductivity ranged from 109 to 132 μS/cm and current was 2A.

[b] Rating is as follows: 1 = compression only, 2 = misalignment/compression, 3 = fracture/separation.

Appendix A2. Voltage gradient (V/cm), immediate recovery time (s), tag number, fork length (mm), internal hemorrhage rating and spinal injury rating of northern pike exposed to various electrical waveforms (19-23 August 1990).[a]

Treatment	Voltage Gradient	Recovery Time	Tag Number	FL	Injury Rating[b] Hemorrhage	Injury Rating[b] Spinal
Control	0.00	0	361	665	0	0
Control	0.00	0	366	609	0	0
Control	0.00	0	371	627	0	0
Control	0.00	0	372	572	0	0
Control	0.00	0	395	646	0	0
Control	0.00	0	401	608	0	0
Control	0.00	0	423	660	0	0
Control	0.00	0	426	656	0	0
30-Hz PDC	0.08	5	344	665	0	0
30-Hz PDC	0.07	0	349	660	0	0
30-Hz PDC	0.05	100	352	600	0	0
30-Hz PDC	0.03	10	353	607	0	0
30-Hz PDC	0.03	1	427	631	0	0
30-Hz PDC	0.03	7	431	554	0	0
30-Hz PDC	0.01	10	440	649	0	0
30-Hz PDC	0.01	7	442	611	0	0
30-Hz PDC	0.02	0	444	572	0	0
30-Hz PDC	0.01	0	450	594	0	0
30-Hz PDC	0.15	110	346	560	0	0
30-Hz PDC	0.10	5	354	540	0	0
30-Hz PDC	0.12	175	360	654	0	0
30-Hz PDC	0.12	190	403	523	0	2
30-Hz PDC	0.12	185	406	600	0	0
30-Hz PDC	0.14	226	415	645	0	2
30-Hz PDC	0.14	5	428	649	0	2
30-Hz PDC	0.11	195	451	597	0	0
30-Hz PDC	0.11	180	454	559	0	0
30-Hz PDC	0.21	115	345	608	0	0
30-Hz PDC	0.23	nd	362	624	0	0
30-Hz PDC	0.28	156	378	562	0	0
30-Hz PDC	0.22	240	384	625	0	0
30-Hz PDC	0.21	274	411	635	0	0
30-Hz PDC	0.22	186	443	679	0	0
30-Hz PDC	0.21	195	447	588	0	0
30-Hz PDC	0.18	164	452	568	0	0
60-Hz PDC	0.10	nd	347	610	0	0

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Appendix A2. (Page 2 of 2).

Treatment	Voltage Gradient	Recovery Time	Tag Number	FL	Injury Rating[b]	
					Hemorrhage	Spinal
60-Hz PDC	0.10	129	358	595	0	0
60-Hz PDC	0.10	185	375	597	0	2
60-Hz PDC	0.09	23	377	594	0	0
60-Hz PDC	0.05	180	391	602	0	2
60-Hz PDC	0.06	192	404	633	0	0
60-Hz PDC	0.09	145	413	579	0	0
60-Hz PDC	0.08	nd	419	623	3	2
60-Hz PDC	0.09	240	421	553	0	2
60-Hz PDC	0.26	nd	343	625	3	3
60-Hz PDC	0.32	130	365	618	0	0
60-Hz PDC	0.35	134	374	571	0	0
60-Hz PDC	0.29	276	393	633	3	2
60-Hz PDC	0.26	270	398	627	0	0
60-Hz PDC	0.26	245	402	647	0	0
60-Hz PDC	0.25	223	409	577	0	0
60-Hz PDC	0.31	200	424	601	0	0
60-Hz PDC	0.30	nd	435	587	3	2
60-Hz PDC	0.32	130	348	620	0	0
60-Hz PDC	0.54	150	357	572	0	0
60-Hz PDC	0.58	nd	367	604	0	0
60-Hz PDC	0.56	160	376	608	0	0
60-Hz PDC	0.46	186	383	582	0	0
60-Hz PDC	0.48	170	385	552	0	2
60-Hz PDC	0.46	273	399	620	0	0
60-Hz PDC	0.45	150	429	565	0	2
60-Hz PDC	0.45	280	439	594	0	0

[a] Water temperature ranged from 11 to 15° C and water conductivity ranged from 156 to 188 μS/cm.

[b] Hemorrhage injury rating is as follows: 1 = mild, 2 = moderate, 3 = severe. Spinal injury rating is as follows: 1 = compression, 2 = misalignment/compression, 3 = fracture/separation.

Appendix A3. Voltage gradient (V/cm), immediate recovery time (s), tag number, fork length (mm), spinal injury rating and short-term survival (9 May to 15 June 1991) of northern pike after being exposed to 120-Hz PDC (nd=fish killed by herbicide treatment and removed from the experiment).[a]

Treatment	Voltage Gradient	Recovery Time	Tag Number	FL	Injury Rating[b]	Survival
120-Hz PDC	0.35	160	470	490	0	yes
Control	0.00	0	471	594	0	yes
120-Hz PDC	0.34	270	472	425	0	nd
120-Hz PDC	0.37	390	476	458	0	yes
120-Hz PDC	0.41	280	474	531	3	yes
120-Hz PDC	0.40	245	475	607	2	yes
120-Hz PDC	0.34	260	477	479	0	nd
120-Hz PDC	0.34	225	478	562	2	yes
120-Hz PDC	0.34	235	479	455	0	yes
Control	0.00	0	484	444	0	yes
120-Hz PDC	0.35	260	481	463	3	yes
120-Hz PDC	0.34	320	482	575	1	nd
120-Hz PDC	0.53	270	511	501	0	yes
120-Hz PDC	0.51	350	486	483	0	yes
Control	0.00	0	487	550	0	yes
Control	0.00	0	489	506	0	yes
120-Hz PDC	0.49	270	488	537	2	nd
Control	0.00	0	490	485	0	yes
120-Hz PDC	0.47	190	491	514	0	yes
Control	0.00	0	492	439	0	yes
Control	0.00	0	497	551	0	yes
Control	0.00	0	496	484	2	yes
120-Hz PDC	0.45	300	494	455	2	yes
120-Hz PDC	0.46	190	495	523	0	nd
120-Hz PDC	0.49	265	498	548	2	yes
120-Hz PDC	0.73	240	508	480	0	yes
120-Hz PDC	0.57	200	500	530	0	yes
120-Hz PDC	0.50	230	501	447	2	yes
Control	0.00	0	503	400	0	nd
120-Hz PDC	0.50	300	502	462	2	yes
120-Hz PDC	0.47	240	504	478	0	yes
120-Hz PDC	0.48	230	505	526	2	no
120-Hz PDC	0.48	360	506	477	0	yes
120-Hz PDC	0.47	375	513	536	0	yes
Control	0.00	0	515	512	0	nd
120-Hz PDC	0.46	265	514	446	0	nd
120-Hz PDC	0.45	315	516	478	0	yes
120-Hz PDC	0.51	240	517	511	0	yes
Control	0.00	0	518	487	0	yes

-continued-

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Treatment	Voltage Gradient	Recovery Time	Tag Number	FL	Injury Rating[b]	Survival
120-Hz PDC	0.50	265	519	493	3	yes
120-Hz PDC	0.52	310	520	457	0	yes
120-Hz PDC	0.52	250	521	448	0	yes
Control	0.00	0	523	478	0	yes
Control	0.00	0	524	538	0	nd
Control	0.00	0	525	393	0	yes
120-Hz PDC	0.45	240	522	526	2	nd
Control	0.00	0	527	572	0	yes
120-Hz PDC	0.45	310	526	540	1	yes
120-Hz PDC	0.44	200	528	475	0	yes
Control	0.00	0	530	567	0	yes
120-Hz PDC	0.44	245	529	486	2	yes
120-Hz PDC	0.43	195	531	567	2	yes
Control	0.00	0	532	483	0	yes
Control	0.00	0	533	495	0	yes
120-Hz PDC	0.42	265	534	671	0	yes
120-Hz PDC	0.43	250	535	385	0	yes
Control	0.00	0	536	408	0	nd
120-Hz PDC	0.43	240	537	408	0	yes
120-Hz PDC	0.44	300	538	489	3	yes
120-Hz PDC	0.42	230	539	407	0	yes
120-Hz PDC	0.41	255	540	415	0	yes
120-Hz PDC	0.42	270	541	478	0	yes
120-Hz PDC	0.43	160	542	392	0	yes
Control	0.00	0	544	410	0	yes
Control	0.00	0	545	397	0	yes
120-Hz PDC	0.40	390	543	419	2	nd
120-Hz PDC	0.40	280	546	445	2	yes
Control	0.00	0	548	426	0	yes
120-Hz PDC	0.40	250	547	456	0	nd
120-Hz PDC	0.40	195	549	378	0	yes
Control	0.00	0	551	468	0	yes
120-Hz PDC	0.41	190	550	443	0	yes
120-Hz PDC	0.40	185	552	380	0	nd
Control	0.00	0	553	390	0	yes
Control	0.00	0	554	408	0	yes
120-Hz PDC	0.40	245	555	399	0	nd
120-Hz PDC	0.39	280	556	383	2	nd
120-Hz PDC	0.41	265	557	457	0	yes
120-Hz PDC	0.45	260	568	428	0	yes
120-Hz PDC	0.46	350	559	475	0	yes
Control	0.00	0	560	402	0	nd
120-Hz PDC	0.45	235	561	450	0	yes

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Treatment	Voltage Gradient	Recovery Time	Tag Number	FL	Injury Rating[b]	Survival
120-Hz PDC	0.46	240	562	423	0	yes
Control	0.00	0	563	411	0	yes
Control	0.00	0	566	410	0	yes
120-Hz PDC	0.44	265	564	432	0	yes
Control	0.00	0	567	399	0	yes
120-Hz PDC	0.46	210	565	380	0	yes
Control	0.00	0	571	557	0	yes
120-Hz PDC	1.74	255	569	591	0	nd
120-Hz PDC	1.73	240	570	629	0	yes
Control	0.00	0	575	672	2	yes
120-Hz PDC	1.61	280	572	569	0	nd
120-Hz PDC	1.52	200	574	550	0	yes
Control	0.00	0	577	648	0	yes
Control	0.00	0	576	615	0	nd
Control	0.00	0	578	743	0	yes
120-Hz PDC	1.57	240	579	536	0	yes
120-Hz PDC	1.56	285	580	592	2	yes
Control	0.00	0	581	590	0	yes
120-Hz PDC	1.48	345	582	558	1	nd
120-Hz PDC	1.50	245	583	503	0	yes
120-Hz PDC	1.43	450	584	727	0	no
120-Hz PDC	1.46	380	585	566	0	yes
120-Hz PDC	1.71	380	586	642	0	no
120-Hz PDC	1.48	305	587	567	0	yes
Control	0.00	0	588	570	0	nd
Control	0.00	0	591	606	0	yes
Control	0.00	0	590	693	0	yes
120-Hz PDC	2.21	240	592	636	0	yes
120-Hz PDC	2.15	330	593	650	1	yes
120-Hz PDC	2.14	265	594	568	0	yes
120-Hz PDC	1.97	225	595	584	0	yes
Control	0.00	0	596	610	0	yes
Control	0.00	0	597	680	2	nd
120-Hz PDC	1.96	270	598	577	0	yes
Control	0.00	0	600	673	0	nd
120-Hz PDC	1.94	255	599	578	2	yes
120-Hz PDC	1.84	345	601	548	2	yes
Control	0.00	0	699	645	0	no
120-Hz PDC	1.90	305	602	632	0	nd
120-Hz PDC	1.78	295	604	735	0	yes
120-Hz PDC	1.86	325	605	503	0	yes
Control	0.00	0	606	528	0	yes
120-Hz PDC	1.68	330	607	768	0	no

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Treatment	Voltage Gradient	Recovery Time	Tag Number	FL	Injury Rating[b]	Survival
Control	0.00	0	609	538	0	nd
120-Hz PDC	1.70	230	608	599	0	yes
120-Hz PDC	1.71	480	610	766	0	yes
Control	0.00	0	611	520	0	yes
Control	0.00	0	612	573	0	yes
120-Hz PDC	1.72	350	613	750	0	yes
120-Hz PDC	1.77	320	614	543	0	yes
120-Hz PDC	1.80	270	615	571	2	yes
Control	0.00	0	618	728	0	nd
120-Hz PDC	1.81	315	616	483	0	yes
120-Hz PDC	1.83	270	617	562	0	yes
Control	0.00	0	620	544	0	yes
Control	0.00	0	621	712	0	yes
120-Hz PDC	1.77	225	619	560	3	yes
120-Hz PDC	1.71	240	622	667	2	nd
120-Hz PDC	1.72	260	623	550	0	nd
Control	0.00	0	624	567	0	yes
120-Hz PDC	1.71	290	625	685	1	yes
120-Hz PDC	1.76	210	626	572	0	yes
120-Hz PDC	1.75	255	651	578	2	yes
Control	0.00	0	654	686	0	yes
120-Hz PDC	1.70	170	652	505	0	yes
120-Hz PDC	1.73	225	653	545	0	yes
120-Hz PDC	1.73	420	655	736	0	yes
Control	0.00	0	656	560	0	nd
Control	0.00	0	657	614	0	yes
120-Hz PDC	1.61	165	658	626	0	nd
Control	0.00	0	660	571	0	yes
120-Hz PDC	1.60	275	659	629	0	yes
120-Hz PDC	1.51	290	661	730	0	yes
120-Hz PDC	1.53	270	662	599	0	yes
120-Hz PDC	1.56	270	663	592	0	yes
Control	0.00	0	664	624	0	yes
Control	0.00	0	665	721	0	nd
Control	0.00	0	666	633	0	yes
Control	0.00	0	669	663	0	yes
120-Hz PDC	1.66	430	667	595	0	yes
120-Hz PDC	1.61	305	668	549	1	yes
120-Hz PDC	1.56	310	670	649	0	nd
120-Hz PDC	1.64	270	671	615	0	yes
Control	0.00	0	672	574	0	nd
120-Hz PDC	1.55	280	673	635	0	yes
120-Hz PDC	1.54	295	674	621	0	yes

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Treatment	Voltage Gradient	Recovery Time	Tag Number	FL	Injury Rating[b]	Survival
120-Hz PDC	1.61	305	675	568	0	yes
120-Hz PDC	1.55	365	676	647	2	no
Control	0.00	0	677	562	0	yes
Control	0.00	0	678	620	0	yes
120-Hz PDC	1.45	285	679	610	0	nd
120-Hz PDC	1.57	280	680	640	0	yes
120-Hz PDC	1.54	390	681	621	0	yes
120-Hz PDC	1.49	245	682	658	1	nd
120-Hz PDC	1.55	295	683	614	0	yes
120-Hz PDC	1.50	260	684	616	0	yes
Control	0.00	0	687	663	0	no
120-Hz PDC	1.36	225	685	728	2	yes
120-Hz PDC	1.58	225	686	575	3	yes
120-Hz PDC	1.51	350	688	699	0	yes
120-Hz PDC	1.65	240	689	584	0	yes
Control	0.00	0	690	554	0	yes
120-Hz PDC	1.54	3	691	712	0	nd
120-Hz PDC	1.58	220	692	543	0	yes
120-Hz PDC	1.56	325	693	544	0	nd
120-Hz PDC	1.46	290	694	725	0	yes
120-Hz PDC	1.54	220	695	526	0	yes
120-Hz PDC	1.55	145	696	490	0	yes
120-Hz PDC	0.70	305	700	732	0	no
120-Hz PDC	0.78	275	701	559	2	yes
120-Hz PDC	0.61	280	702	538	0	nd
120-Hz PDC	0.45	375	703	729	0	yes
120-Hz PDC	0.47	200	704	548	0	yes
120-Hz PDC	0.48	195	705	483	0	nd
Control	0.00	0	708	642	0	no
120-Hz PDC	0.43	240	706	655	2	yes
120-Hz PDC	0.44	205	707	584	2	yes
120-Hz PDC	0.47	460	709	705	2	yes
Control	0.00	0	710	549	0	nd
Control	0.00	0	711	617	0	yes
120-Hz PDC	0.93	360	712	703	2	yes
Control	0.00	0	713	633	0	yes
Control	0.00	0	714	580	0	yes
120-Hz PDC	0.67	470	715	660	2	yes
120-Hz PDC	0.63	255	716	574	0	yes
120-Hz PDC	0.62	230	717	568	0	yes
Control	0.00	0	720	676	0	nd
120-Hz PDC	0.55	220	718	578	0	yes
120-Hz PDC	0.56	220	719	515	0	nd

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Treatment	Voltage Gradient	Recovery Time	Tag Number	FL	Injury Rating[b]	Survival
120-Hz PDC	0.52	275	721	684	2	yes
120-Hz PDC	0.52	215	722	585	2	yes
120-Hz PDC	0.48	250	723	579	1	yes
120-Hz PDC	0.51	280	724	633	0	no
120-Hz PDC	0.52	270	725	605	0	yes
120-Hz PDC	0.50	275	726	667	0	yes
120-Hz PDC	0.46	320	727	653	0	yes
Control	0.00	0	729	572	0	nd
120-Hz PDC	0.48	235	728	587	0	yes
120-Hz PDC	0.45	215	730	607	2	yes
Control	0.00	0	731	579	0	yes
Control	0.00	0	732	605	0	yes
120-Hz PDC	0.42	365	733	620	2	yes
120-Hz PDC	0.44	305	734	681	0	nd
120-Hz PDC	0.43	425	735	607	0	no
120-Hz PDC	0.39	350	736	660	0	yes
Control	0.00	0	738	601	0	yes
120-Hz PDC	0.40	240	737	572	0	yes
120-Hz PDC	0.40	250	739	623	0	nd
120-Hz PDC	0.40	220	740	535	0	yes
Control	0.00	0	741	569	0	yes
Control	0.00	0	743	631	0	yes
Control	0.00	0	744	567	1	yes
120-Hz PDC	0.37	290	742	561	0	nd
Control	0.00	0	746	584	0	yes
Control	0.00	0	747	583	0	yes
120-Hz PDC	0.40	380	745	611	0	yes
120-Hz PDC	0.32	180	748	567	0	yes
120-Hz PDC	0.31	320	749	566	2	nd
Control	0.00	0	750	607	0	no
120-Hz PDC	0.32	320	751	675	0	no
120-Hz PDC	0.34	250	752	576	0	yes
120-Hz PDC	0.34	240	753	505	0	nd
120-Hz PDC	0.33	255	754	591	0	yes
120-Hz PDC	0.32	250	755	604	0	no
Control	0.00	0	756	581	0	yes
Control	0.00	0	758	683	0	nd
120-Hz PDC	0.30	250	757	646	0	yes
Control	0.00	0	759	542	0	yes
Control	0.00	0	762	596	0	yes
120-Hz PDC	0.31	205	760	596	0	nd
120-Hz PDC	0.30	210	761	484	2	yes

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Treatment	Voltage Gradient	Recovery Time	Tag Number	FL	Injury Rating[b]	Survival
Control	0.00	0	763	637	0	no
Control	0.00	0	764	596	0	yes
Control	0.00	0	765	558	0	yes
120-Hz PDC	0.22	225	766	537	0	nd
120-Hz PDC	0.14	165	767	593	2	yes
Control	0.00	0	768	584	0	yes
Control	0.00	0	771	584	0	no
120-Hz PDC	0.28	265	769	581	0	no
120-Hz PDC	0.18	255	770	480	0	yes
Control	0.00	0	772	596	0	nd

[a] Water temperature ranged from 10 to 13° C, water conductivity ranged from 1017 to 1090 μS/cm and current ranged from 5 to 6 A.

[b] Spinal injury rating is as follows: (1=compression only, 2=misalignment/compression, 3=fracture/separation)

Appendix A4. Spinal injury rating, tag number, long-term survival (9 May 1991 to 1 April 1992), beginning fork length (mm), ending fork length, beginning weight (g), and ending weight of northern pike after being exposed to 120-Hz PDC.

Treatment	Injury Rating[a]	Tag Number	Long-term Survival	FL Beg.	FL End	Wt. Beg.	Wt. End
Control	1	744	yes	567	585	1,400	1,550
Control	0	518	no	487		800	
Control	0	497	no	551		1,150	
Control	0	523	yes	478	520	800	1,200
Control	0	732	yes	605	645	1,650	1,900
Control	0	471	yes	594	594	1,230	1,850
Control	0	738	yes	601	615	1,550	1,650
Control	0	571	yes	557	560	1,250	1,050
Control	0	743	no	631		1,750	
Control	0	678	no	620		1,600	
Control	0	563	no	411		400	
Control	0	746	no	584		1,450	
Control	2	496	yes	484	490	750	750
Control	2	575	yes	672	705	2,400	2,700
Control	0	711	no	617		1,500	
Control	0	621	no	712		2,450	
Control	0	660	no	571		1,250	
Control	0	765	no	558		1,300	
Control	0	713	no	633		1,550	
Control	0	492	no	439		1,150	
Control	0	611	no	520		1,000	
Control	0	606	no	528		1,050	
Control	0	548	yes	426	515	600	1,150
Control	0	577	yes	648	675	1,950	2,500
Control	0	545	no	397		400	
Control	0	553	no	390		450	
Control	0	490	no	485		850	
Control	0	487	yes	550	570	1,150	1,500
Control	0	620	no	544		1,200	
Control	0	677	yes	562	585	1,350	1,500
Control	0	654	yes	686	778	2,650	3,350
Control	0	533	no	495		85	
Control	0	489	no	506		950	
Control	0	747	yes	583	592	1,350	1,550
Control	0	666	no	633		1,750	
Control	0	596	no	610		1,700	
Control	0	762	no	596		1,450	
Control	0	612	no	573		1,250	
Control	0	515	yes	512	535	900	1,300

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Treatment	Injury Rating[a]	Tag Number	Long-term Survival	FL Beg.	FL End	Wt. Beg.	Wt. End
Control	0	527	yes	572	615	1,200	1,750
Control	0	532	yes	483	510	750	950
Control	0	551	no	468		650	
Control	0	768	yes	584	605	1,450	1,750
Control	0	664	no	624		1,400	
Control	0	484	yes	444	535	800	1,650
Control	0	756	no	581		1,750	
Control	0	530	yes	567	570	1,150	1,250
Control	0	554	no	408		450	
Control	0	525	no	393		400	
PDC 120-5	0	740	yes	535	550	1,050	1,000
PDC 120-5	0	517	yes	511	560	1,000	1,400
PDC 120-5	2	478	yes	562	685	1,450	1,990
PDC 120-5	2	601	no	548		1,100	
PDC 120-5	0	673	no	635		1,900	
PDC 120-5	0	521	no	448		650	
PDC 120-5	0	579	yes	536	575	1,100	1,350
PDC 120-5	2	501	no	447		500	
PDC 120-5	3	619	no	560		1,250	
PDC 120-5	0	561	yes	450	510	700	950
PDC 120-5	2	767	yes	593	605	1,400	1,600
PDC 120-5	0	614	no	543		1,000	
PDC 120-5	3	686	no	575		1,350	
PDC 120-5	3	519	no	493		750	
PDC 120-5	0	696	yes	490	515	800	850
PDC 120-5	0	610	yes	766	775	3,350	3,550
PDC 120-5	0	550	no	443		550	
PDC 120-5	0	587	yes	567	590	1,300	1,500
PDC 120-5	0	655	yes	736	740	2,550	2,550
PDC 120-5	0	661	no	730		2,600	
PDC 120-5	0	520	no	457		600	
PDC 120-5	2	531	no	567		1,100	
PDC 120-5	0	703	yes	729	750	2,750	3,200
PDC 120-5	0	695	yes	526	545	950	1,150
PDC 120-5	0	542	no	392		450	
PDC 120-5	2	721	yes	684	700	2,150	2,550
PDC 120-5	0	626	yes	572	590	1,250	1,500
PDC 120-5	0	491	no	514		900	
PDC 120-5	0	770	no	480		750	
PDC 120-5	0	506	no	477		750	
PDC 120-5	0	737	yes	572	605	1,500	1,750

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Treatment	Injury Rating[a]	Tag Number	Long-term Survival	FL		Wt.	
				Beg.	End	Beg.	End
PDC 120-5	3	538	no	489		850	
PDC 120-5	0	541	no	478		750	
PDC 120-5	0	508	yes	480	500	800	1,050
PDC 120-5	0	671	yes	615	625	1,650	1,800
PDC 120-5	0	681	yes	621	645	1,550	1,800
PDC 120-5	0	652	no	505		950	
PDC 120-5	0	568	no	428		500	
PDC 120-5	2	701	yes	559	592	1,200	1,450
PDC 120-5	0	617	no	562		1,100	
PDC 120-5	2	580	no	592		1,500	
PDC 120-5	0	725	yes	605	625	1,500	1,550
PDC 120-5	0	663	yes	592	652	1,750	2,400
PDC 120-5	0	754	no	591		1,200	
PDC 120-5	3	481	no	463		1,600	
PDC 120-5	0	604	no	735		2,850	
PDC 120-5	0	674	yes	621	640	1,600	1,800
PDC 120-5	0	549	no	378		350	
PDC 120-5	2	546	no	445		650	
PDC 120-5	0	667	yes	595	595	1,350	1,200
PDC 120-5	1	593	yes	650	655	1,800	1,950
PDC 120-5	2	494	no	455		750	
PDC 120-5	2	709	no	705		2,250	
PDC 120-5	0	565	no	380		400	
PDC 120-5	0	535	no	385		450	
PDC 120-5	2	715	no	660		2,050	
PDC 120-5	0	476	no	458		650	
PDC 120-5	0	557	yes	457	493	700	850
PDC 120-5	0	692	no	543		1,150	
PDC 120-5	0	683	yes	614	630	1,550	1,750
PDC 120-5	0	562	no	423		450	
PDC 120-5	0	613	no	750		2,550	
PDC 120-5	0	564	yes	432	485	550	600
PDC 120-5	1	668	no	549		1,100	
PDC 120-5	2	730	yes	607	670	2,000	2,300
PDC 120-5	0	511	yes	501	545	900	1,300
PDC 120-5	0	500	yes	530	655	1,100	1,400
PDC 120-5	0	592	yes	636	675	1,850	2,150
PDC 120-5	0	513	yes	536	570	1,000	1,650
PDC 120-5	0	470	no	490		750	
PDC 120-5	0	504	no	478		850	
PDC 120-5	1	526	no	540		1,050	
PDC 120-5	0	736	no	660		2,100	

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Appendix A4. (Page 4 of 4).

Treatment	Injury Rating[a]	Tag Number	Long-term Survival	FL Beg.	FL End	Wt. Beg.	Wt. End
PDC 120-5	0	757	yes	646	660	1,850	1,990
PDC 120-5	0	570	no	629		1,750	
PDC 120-5	2	712	no	703		2,450	
PDC 120-5	0	516	no	478		900	
PDC 120-5	0	716	no	574		1,300	
PDC 120-5	0	605	no	503		950	
PDC 120-5	2	706	yes	655	666	1,850	2,050
PDC 120-5	2	761	no	484		700	
PDC 120-5	2	733	yes	620	650	1,550	2,150
PDC 120-5	0	486	no	483		700	
PDC 120-5	2	599	no	578		1,300	
PDC 120-5	0	704	no	548		1,150	
PDC 120-5	0	659	no	629		1,650	
PDC 120-5	0	680	no	640		1,700	
PDC 120-5	0	534	yes	671	763	1,950	2,100
PDC 120-5	0	662	yes	599	640	1,600	1,400
PDC 120-5	2	498	no	548		1,200	
PDC 120-5	0	728	yes	587	600	1,450	1,750
PDC 120-5	3	474	yes	531	580	1,050	2,000
PDC 120-5	0	745	no	611		1,600	
PDC 120-5	0	689	yes	584	605	1,450	1,520
PDC 120-5	2	651	no	578		1,350	
PDC 120-5	2	475	no	607		1,250	
PDC 120-5	0	574	yes	550	585	1,200	1,450
PDC 120-5	0	694	yes	725	725	2,500	2,400
PDC 120-5	0	539	no	407		450	
PDC 120-5	2	502	no	462		550	
PDC 120-5	0	718	no	578		1,300	
PDC 120-5	0	540	no	415		450	
PDC 120-5	0	608	yes	599	605	1,400	1,450
PDC 120-5	2	529	yes	486	521	850	1,250
PDC 120-5	0	595	no	584		1,400	

[a] Spinal injury rating is as follows: (1 = compression only, 2 = misalignment/compression, 3 = fracture/separation)

APPENDIX B

Appendix B1. Water temperature (C), water conductivity (μS/cm), VVP V, tag number, fork length (mm) and spinal injury rating of fish captured in Minto Flats by DC and PDC electrical waveforms (13 - 24 August 1991).

Temperature	Conductivity	Treatment (Hz, duty cycle)	VVP V	Tag Number	FL	Injury Rating[a]
15	145	DC	200	77002	628	0
15	133	DC	200	77007	690	nd
17	156	DC	150	77009	745	2
15	182	DC	200	77113	580	0
13	101	DC	200	77698	505	nd
16	150	30, 25%	300	77004	690	nd
14	105	30, 25%	200	77952	962	nd
18	133	30, 25%	210	77072	818	2
15	182	30, 25%	200	77114	555	0
10	66	30, 25%	225	77700	750	nd
15	133	30, 75%	150	77006	531	0
15	182	30, 75%	200	77117	578	0
15	182	30, 75%	200	77119	482	3
13	101	30, 75%	200	77699	805	nd
16	150	60, 50%	200	77003	553	0
16	150	60, 50%	200	77005	652	0
17	156	60, 50%	200	77008	625	0
14	105	60, 50%	200	77010	640	0
14	105	60, 50%	200	77011	618	0
14	105	60, 50%	200	77012	694	0
18	103	60, 50%	250	77068	574	1
18	103	60, 50%	250	77069	729	3
18	103	60, 50%	250	77070	598	nd
18	112	60, 50%	200	77071	575	0
18	133	60, 50%	210	77073	385	0
15	182	60, 50%	200	77115	480	0
15	182	60, 50%	200	77116	479	0
15	182	60, 50%	200	77118	605	0
15	182	60, 50%	200	77120	559	0
15	182	60, 50%	200	escaped	nd	nd

[a] Spinal injury rating is as follows: (1=compression only, 2=misalignment/compression, 3=fracture/separation, nd=no datum)

Appendix B2. Water temperature (C), water conductivity ($\mu S/cm$), VVP V, amperage, fishing time (s) and number of fish captured in Minto Flats by DC and PDC electrical waveforms (13 - 24 August 1991).

Temperature	Conductivity	Treatment (Hz, duty cycle)	VVP V	Amps	Fishing Time	Fish Cap-tured
15	137	DC	100	5.0	600	0
15	137	20, 75%	150	7.5	600	0
15	137	20, 75%	200	10.0	600	0
15	141	20, 75%	150	7.5	600	0
15	141	DC	150	7.5	604	0
15	141	20, 25%	300	16.0	621	0
15	141	60, 50%	150	7.5	528	0
15	145	DC	100	5.0	600	0
15	145	20, 25%	150	7.5	602	0
15	145	DC	200	10.0	600	0
15	145	60, 50%	150	7.5	600	0
15	145	20, 75%	150	9.0	600	0
15	145	DC	200	10.0	600	1
15	145	20, 75%	200	12.5	602	0
16	150	20, 25%	150	10.0	637	0
16	150	60, 50%	200	14.0	605	1
16	150	60, 50%	150	10.0	602	0
16	150	60, 50%	200	12.5	608	0
16	150	30, 75%	200	15.0	604	0
16	150	30, 25%	200	14.0	616	0
16	150	30, 75%	200	11.0	607	0
16	150	30, 25%	300	15.0	604	1
16	150	DC	100	5.0	600	0
16	150	DC	200	10.0	605	0
16	150	60, 50%	200	10.0	603	1
16	150	30, 25%	200	10.0	606	0
16	150	DC	200	12.0	611	0
16	125	60, 50%	150	7.5	600	0
16	125	30, 25%	200	10.0	600	0
16	125	60, 50%	200	11.0	625	0
16	125	30, 25%	300	17.0	600	0
16	125	30, 75%	150	8.0	616	0
16	125	DC	100	5.0	608	0
16	125	30, 25%	200	10.0	617	0
15	133	30, 25%	300	15.0	602	0
15	133	30, 75%	200	12.5	600	0
15	133	30, 75%	150	7.5	600	0
15	133	30, 75%	200	11.0	600	0
15	133	60, 50%	150	8.0	600	0
15	133	60, 50%	200	12.5	602	0

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Appendix B2. (Page 2 of 3).

Temperature	Conductivity	Treatment (Hz, duty cycle)	VVP V	Amps	Fishing Time	Fish Captured
15	133	30, 75%	150	9.0	611	1
15	133	60, 50%	200	12.5	630	0
15	133	DC	200	12.0	654	1
15	133	30, 25%	150	10.0	609	0
17	156	DC	200	12.0	614	0
17	156	30, 25%	200	12.5	635	0
17	156	30, 75%	200	12.0	608	0
17	156	DC	150	9.0	628	0
17	156	60, 50%	200	12.5	603	1
17	156	30, 75%	200	15.0	600	0
17	156	DC	150	9.0	643	1
17	156	60, 50%	150	9.0	620	0
14	105	60, 50%	200	5.0	608	2
14	105	30, 75%	200	7.5	600	0
14	105	30, 75%	200	7.5	605	0
14	105	30, 25%	200	7.5	600	0
14	105	DC	200	7.5	600	0
14	105	30, 25%	200	7.5	600	0
14	105	60, 50%	200	7.5	649	0
14	105	30, 25%	200	7.5	612	0
14	105	60, 50%	200	7.5	600	0
14	105	30, 25%	200	9.0	600	0
14	105	DC	200	7.5	600	0
14	105	DC	200	7.5	600	0
14	105	30, 25%	200	9.0	614	0
14	105	30, 75%	200	8.0	600	0
14	105	30, 75%	200	9.0	608	0
14	105	30, 25%	200	7.5	613	0
14	105	DC	200	7.5	662	0
14	105	30, 25%	200	7.5	620	1
14	105	60, 50%	200	7.5	618	0
14	105	30, 25%	200	7.5	600	0
14	105	60, 50%	200	7.5	628	0
14	105	DC	200	7.5	625	0
14	105	30, 75%	200	9.0	606	0
14	105	60, 50%	200	9.0	465	1
18	103	DC	200	5.0	635	0
18	103	30, 25%	225	5.0	280	0
18	103	30, 75%	250	6.0	330	0
18	103	DC	200	6.0	644	0
18	103	30, 75%	200	6.0	618	0
18	103	60, 50%	250	6.0	653	3
18	112	30, 75%	200	10.0	765	0

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Appendix B2. (Page 3 of 3).

Temperature	Conductivity	Treatment (Hz, duty cycle)	VVP V	Amps	Fishing Time	Fish Captured
18	112	DC	200	7.5	600	0
18	112	30, 75%	200	9.0	600	0
18	112	30, 25%	225	9.0	605	0
18	112	60, 50%	200	9.0	600	0
18	112	60, 50%	200	10.0	603	1
18	133	DC	200	7.0	604	0
18	133	30, 25%	210	7.5	628	1
18	133	60, 50%	225	12.0	647	1
18	133	DC	200	10.0	614	0
18	133	60, 50%	200	10.0	600	0
18	133	DC	200	10.0	606	0
15	182	30, 75%	200	15.0	603	0
15	182	DC	200	12.5	600	1
15	182	DC	200	12.5	615	0
15	182	30, 75%	200	15.0	600	0
15	182	30, 75%	200	15.0	612	0
15	182	30, 25%	200	15.0	618	1
15	182	60, 50%	200	15.0	608	2
15	182	30, 75%	200	16.0	618	1
15	182	30, 25%	200	15.0	607	0
15	182	60, 50%	200	14.0	631	0
15	182	DC	200	14.0	454	0
15	182	30, 25%	200	14.0	627	0
15	182	60, 50%	200	13.0	600	1
15	182	30, 75%	200	15.0	648	1
15	182	60, 50%	200	15.0	443	2
13	101	60, 50%	200	4.0	623	0
13	101	30, 75%	250	6.0	618	0
13	101	DC	200	5.0	620	1
13	101	60, 50%	250	7.0	600	0
13	101	DC	200	5.0	600	0
13	101	30, 25%	250	9.0	600	0
13	101	30, 25%	200	7.5	613	0
13	101	30, 75%	200	7.5	610	0
13	101	60, 50%	250	7.5	594	0
13	101	DC	200	7.5	600	0
13	101	30, 75%	200	7.5	600	0
13	101	30, 75%	200	7.5	613	1
13	101	60, 50%	250	7.5	615	0
13	101	30, 25%	225	8.0	600	0
13	101	DC	200	7.5	600	0
10	66	30, 25%	225	5.0	607	1
10	66	DC	200	2.5	637	0
10	66	30, 75%	200	2.5	159	0