

# QUICK-START GUIDE TO ELECTROFISHING

**Jim Reynolds<sup>1</sup>**  
**and**  
**Lisa Harlan<sup>2</sup>**

This guide provides fisheries personnel with essential information necessary to initiate *satisfactory electrofishing* — that is, a safe, effective electrofishing operation with minimal stress and injury to fish. This information applies to all types of electrofishing (e.g., boat, backpack), however it is not intended to replace sources of detailed information.

Electrofishing is hazardous work. To maximize safety while achieving success, practitioners must follow safety rules and use common sense. Smith-Root, Inc. (SRI), offers this guide as a service to fisheries professionals as a means of getting a “quick start” in electrofishing. The information in the guide is accurate only in a general sense and may not apply in all situations. SRI cannot be held liable for harm to life or property arising from practitioner use of the guide. Employees of agencies and organizations must first follow the safety requirements of their employers; they may also wish to consult electrofishing regulations of the U.S. Fish and Wildlife Service (<http://www.fws.gov/policy/241fw6.html>).

## Equipment Controls

Electrofishers are control units that receive power from a battery or generator and produce electrical waveforms through electrodes to create electrical fields in water. Lower power, self-contained units can be worn on a person’s back (backpack electrofishers) while higher power units are used in boats or from stream banks (boat and shore-based electrofishers).

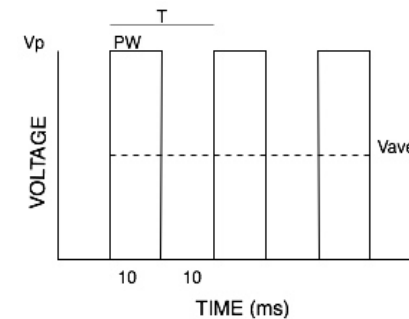
Alternating current (AC) and continuous direct current (DC) are waveforms not often used for electrofishing. AC is effective at low water conductivities but often more injurious to fish. DC is safer for fish but drains batteries quickly. Pulsed direct current (PDC) is commonly used because it can be manipulated to find a balance between fish capture and fish welfare.

<sup>1</sup>Professor Emeritus, University of Alaska, Fairbanks  
 jbreynolds@alaska.edu

<sup>2</sup>Biologist, Smith-Root, Inc., Vancouver, Washington  
 lharlan@smith-root.com

PDC is controlled by height and shape of the waveform. Waveform height refers to peak voltage (Vp) and is set by voltage selection. Waveform shape is set by frequency (pulses per second or hertz, Hz) and pulse width (milliseconds, ms) or duty cycle (percent on-time, %). Frequency (f) determines the period (T) of one cycle (time from start of one pulse to start of next pulse, ms). Period equals 1000 ms (1 second) divided by frequency (Hz), that is,  $T = 1000/f$ . Average voltage (Vave) depends on peak voltage, frequency and duty cycle.

Duty cycle (often called duty) is pulse width (PW) divided by period (T) times 100, that is,  $duty = (PW/T)100$ . An alternate formula is:  $duty = (PW \cdot f)/10$ . On some electrofishers, duty cycle can be set directly; on others, it is set indirectly by selecting frequency (thus, period) and pulse width.



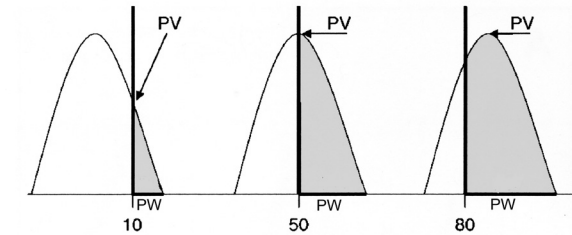
Here is an example of a PDC wave form with a period =  $T = 20$  ms and pulse width =  $PW = 10$  ms. Frequency =  $f = 1000/T = 1000/20 = 50$  Hz and duty cycle =  $(PW/T)100 = (10/20)100 = 50\%$ . Using the alternate formula:  $(10ms \cdot 50Hz)/10 = 500/10 = 50\%$ .

This table may be used to determine duty cycle for units requiring selection of frequency and pulse width:

Duty cycle (%) resulting from selections of frequency and pulse widths*	Frequency (Hz)						
	10	20	30	40	50	60	
Pulse Width (ms)	1	1	2	3	4	5	6
	2	2	4	6	8	10	12
	4	4	8	12	16	20	24
	6	6	12	18	24	30	36
	8	8	16	24	32	40	48
10	10	20	30	40	50	60	

\*Shaded area indicates range of commonly used duty cycles (10-50 %).

*Exception:* Smith-Root GPP electrofishers have a control called Percent of Range (POR) — also Percent of Power — that simultaneously changes voltage and pulse width; frequency is controlled independently. Increase in POR from 0% to 50% results in increase in voltage and pulse width. Above 50% POR, pulse width continues to increase but voltage changes little. Peak voltage at various POR settings depends on the voltage range selected: low range, 50-500 volts or high range, 100-1000 volts.



Percent of range

Credit: Miranda and Spencer, 2005. Understanding the output of a Smith-Root GPP Electrofisher. N. Am. Journal of Fisheries Management 25:848-852, with permission.

One must use an oscilloscope to measure peak voltage, period and pulse width at various POR values, in both voltage ranges, to enable a conversion from POR to peak voltage and duty cycle.

## Setting Controls

The key to setting controls in the field is to seek *threshold* settings, the minimums needed to achieve satisfactory electrofishing. Settings of PDC, in order of risk for fish trauma (highest to lowest), are frequency, voltage, and duty cycle (or pulse width).

Start with lower frequency and pulse width or duty cycle. Duty cycle may be as low as 10% but should not exceed 50% — 20-25% is optimal. Scale-less and fine-scaled fishes (e.g., salmonids, ictalurids, anguillids, cottids) are more sensitive to electroshock; start at 20-30 Hz frequency and 10-20% duty cycle (5-10 ms pulse width). Fishes with heavier scaling (e.g., centrarchids, percids, esocids, cyprinids) are less sensitive to electroshock; it may be necessary to start with 50-60 Hz and 20-30% duty cycle (3-6 ms pulse width).

Threshold PDC settings may be determined by the following procedure:

1. Start electrofishing at low voltage and 10% duty cycle; increase voltage in 20-V, 50-V or 100-V steps to maximum.
2. If electrofishing is not satisfactory, increase duty cycle or pulse width; repeat step 1.
3. If duty cycle reaches 50% without satisfactory results, reset duty cycle to 10%.
4. Increase frequency and repeat steps 1, 2, 3.
5. Continue the process until satisfactory electrofishing is achieved.

Note: Threshold determination can be done quickly with a series of 2-5 minute trials.

## Safety

**Equipment:** Detailed maintenance should be done annually. Visual inspection should occur at the beginning of each operation. Hand-held electrodes should not double as dip nets.

**Crew:** At least two members should be first aid and CPR certified. Leaders should be formally trained and have many hours (e.g., 100) of electrofishing experience. All personnel should have orientation to the equipment and procedure to be used. Never operate alone.

**Gloves:** Smith-Root, Inc.'s policy requires use of gauntlet-style electrician's gloves rated for 7,500 V, cloth gloves may be inserted for comfort.

**Boots:** Smith-Root, Inc.'s policy requires use of non-breathable waders, such as rubber or neoprene; "breathable" waders must not be used. Chest waders are recommended for wading operations; hip waders may also be used if work site water depth is known to be shallow. Knee boots or hip waders are required in boats.

**PFDs:** Required according to USCG regulations in boats, and recommended during wading when water is judged as swift or deep.

**Fire extinguisher:** Type ABC required in boats.

**Weather:** Stop operations during thunderstorms and when crew clothing becomes wet.

**Communication:** At a minimum, all crew should use hand signals. In boats, wireless voice sets improve safety.

**Procedure:** Never begin electrofishing until all crew are ready and a signal is given. Do not change settings unless output power is turned off.

## Electrodes

The combined surface area of all electrodes, along with water conductivity, determines the power requirement of an electrofishing system. Higher water conductivity and surface area requires more power. For a given set of electrodes, water conductivity alone will determine the power requirement. However, power requirement can be reduced if frequency and duty cycle are decreased while maintaining sufficient voltage for capture. Measuring water conductivity during every electrofishing operation will be helpful in understanding the effects of conductivity on performance limits of a system and capture success.

Anode selection is useful in dealing with size selectivity and fish trauma. Most anodes are used as cylinders or rings; in both cases, the thickness (diameter) of the material is the critical feature determining the size and intensity of the electrical field. Small-diameter anodes (e.g., 1/8-inch to 1/4-inch thickness) create small, intense fields useful for capture of small fish while allowing larger fish to escape. However, the intense field near small-diameter anodes increases the risk of harm to fish, especially larger ones surprised nearby when the power is turned on. Larger-diameter anodes (e.g., 1/4-inch to 1/2-inch thickness) create larger fields with less intensity near the anode; they are useful for capturing larger fish while allowing smaller fish to escape.

## Sampling

In PDC electrofishing, the anode (positive electrode) is the capture device. The cathode (negative electrode) is only used to complete the circuit although it will on occasion capture fish as well. Anodes can be used in two ways: continuous power and intermittent power. Continuous power works best when the habitat is homogeneous (continuous cover) and fish can be expected at any point. Intermittent power is best suited to habitat with patchy cover; approach cover with power off, then turn power on when 3 feet or closer. In all types of electrofishing, proceed slowly to increase efficiency. In wading operations, dip netters should stay next to anode handlers, poised and ready to capture fish. Anode handlers should repeatedly draw the anode from cover toward the dip net. In boat operations, move forward toward cover, avoiding anode damage by stopping short of cover; turn on power during approach; allow time for dip netters to work; then turn power off, back away and move to the next sampling point.

For a given species, electrofishing is size selective. Vulnerability increases as individual size increases; that is, threshold voltage is higher for smaller individuals and decreases with size. Also, netters may have a bias for capturing larger fish. The selectivity and bias result in larger fish being over-represented in samples. Netting all individuals, regardless of size, will reduce the bias but not the selectivity; this outcome must be recognized when evaluating sample data. The advantage of size selectivity in electrofishing is the tendency to capture adults for stock assessment while reducing capture of juveniles. Conversely, it is more difficult to focus on sampling of juvenile fish while avoiding adults (but consider the suggestion under Electrodes).

## Fish Capture and Handling

Risk of fish trauma increases when they are immobilized. Try to capture fish while they are swimming — easier said than done but worth it for fish welfare. Avoid cumulative electroshock to fish by netting them immediately or turning power off when they are immobile in the electrical field. Do not allow fish to accumulate in the dip net. Allow fish to recover in darkened, quiet water maintained at ambient temperature and adequate dissolved oxygen; use a tank in boats or in-stream containers while wading — be sure the holding container is away from electric field. Change water frequently if flow-through systems are not used. Fish should regain equilibrium in one minute or less; excessive recovery time or injury (e.g., bruising) means that fish are being over-exposed to electroshock. If fish can be easily hand-captured while being held, they are not ready for release. When they are ready, release fish into quiet backwaters near cover.

We wish you safe and successful sampling!

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(360) 573-0202  
info@smith-root.com  
www.smith-root.com