Framework for Increasing Capture Efficiency and Sampling Precision of Electrofishing

Goal: develop and standardize *species x* sampling protocols to collect more accurate and precise data to characterize *species x* populations.

1. **Project scope –Select target species and size classes; if sampling an assemblage, select one or more representative species**

2. **Select electrofishing sampling gear**

   Delineate candidate gear types with their associated control box outputs (waveform capability: AC, DC, pulsed DC [PDC]; for PDC, determine any restrictions on combinations of frequency and duty cycle). The gear type choice may be clear; for example, if the habitat is non-wadeable, options may be limited to an electrofishing boat).

3. **Lab experiments**

   The purposes of lab experiments include identifying effective waveforms and capture-prone responses (e.g., presence of taxis) that can be used for electrofishing the target species as well as estimating effective fish conductivity to tune power goal tables.

   The more effective waveforms are defined as those that require less power to cause the target capture-prone response (as immobilization).

   a. **Decide upon desired fish reactions**

      These target reactions typically are immobilization and taxis. (Waveforms effective in causing immobilization and taxis should subsequently be field tested, since there may be uncertainty concerning which reaction is more advantageous and under what habitat conditions).

   b. **Select treatment levels**

      <u>Waveforms</u>: The choices are many. First, choose one or more major waveform categories (e.g., AC, continuous DC, and/or PDC) for evaluation. Important PDC attributes are frequency and duty cycle. You may evaluate a range of frequencies (e.g., 15 - 120 pps) at a constant duty cycle for the most effective setting, followed by a range of duty cycles (e.g., 10 – 50) at a

constant frequency. The frequency may be the most effective setting found in the previous experiment.

Note: waveform selection may be constrained by specifications of control boxes that will be used for sampling. For example, the VVP-15b has a good amount of options and flexibility. This control box produces AC, continuous DC, PDC, gated-burst or CPS PDC, PDC duty cycles between 10 - 80% (10, 20, 25, 30, 35, 40,…), and PDC frequencies between 5 - 120 pps (5, 10, 15, 20, 25, 30,…). While there is not continuous control of frequency and duty cycle, there still are a number of treatment combinations (waveform type, frequency, duty cycle).

Other factors: temperature and water velocity rates can be important to include in a lab study; typically, the influences of efficiency factors, as temperature and water flow, on capture probability are handled in the sampling design protocols (e.g., day sampling or night sampling, range of temperature or discharge sampling will be restricted to, etc.)

c. **Conduct study**

Important results include range of behaviors observed across waveform treatments, most effective waveforms to cause response(s) of interest (e.g., immobilization), threshold voltage gradients and power densities.

Additional experiments can be conducted to determine fish conductivity for tuning power standardization curves.

Software tools: *Electric Waveform Fish Conductivity Analysis Methods.xlsx*

4. **Develop a table of target voltage gradients/power densities by water conductivity.**

Note: A power goal table cannot be developed at this stage. Threshold voltage gradient and power densities from the lab studies are electric field attributes. These values must be coordinated with gear electric field maps to enable the creation of power, voltage, or amperage goal tables. This task will be achieved at a later phase. However, *voltage gradient* or *power density* tables can be built that may inform decisions on which gear types to use (that is, if the gear field maps are known). In other words, estimates of effective field size can rule out some gear types. If this approach is not helpful in your particular case, then this step is not necessary.

To implement this step, develop tables for each waveform that has promise for effective fish capture. For example, include waveforms that induce taxis in addition to waveforms that cause immobilization only.

Software tools: *Electric Waveform Fish Conductivity Analysis Methods.xlsx* ("PTT VG" tab), *EF Goal Power.xlsx* ("Voltage Gradient Goal" tab)

5. **Select electrofishing sampling gear**

   Make a final decision on the gear type to be used for sampling.

6. **Preliminary evaluation of electrode design**

   Measure total electrode resistance. Estimate anode and cathode resistance by measurement, equations, available data, etc. Calculate percent power to the anodes. Strive for 50% allocation to the anodes. For backpacks, 55% is a good distribution. For boats, 60 – 75% is a good distribution. If power distribution to the anodes is less than 50%, consider a design change.

7. **Field test effectiveness of the candidate waveforms; make selection of best waveform or set of waveforms**

   One approach consists of dividing a water body into sample units. Randomly assign sample units to candidate waveforms. Determine threshold voltage (amp and power) levels for each waveform in nearby locations outside of the sample units. Threshold settings are those that appear to result in "successful" electrofishing. This is the same method as the traditional approach to standardizing by power.

   Within each sample unit, record catch-per-unit-effort (CPUE). The waveform with the highest catch rate is the most efficient. You may wish to repeat this test at two or more environmental conditions (high tide vs. low tide) to ascertain if the selection of waveform depends on other important efficiency factors. Be advised that, in some habitat conditions, immobilization may not be the response that leads to the highest capture rates.

   Another, more robust approach to compare waveform effectiveness involves estimating capture efficiency for each waveform through mark-recapture, depletion sampling, or complete census.

8. **Map electric fields**

   Map a lateral or forward vector from your anode array center. Record voltage gradient by distance (cm) from the anode center.

   Software tool: *Field Mapper and Standardization.xlsx*

9. **Derive power/voltage/amperage goal tables**

   Goal tables can be based on:

   1) power standardization field trials determined in Step #7 or in additional testing (power settings leading to "successful" electrofishing; "successful" is determined subjectively, by highest catch rates [CPUE], or by achieving a target capture efficiency)

      Software tools: *EF Goal Power.xlsx*, *EF with Power.xlsx* ("Power Goals" tab), *EF power standardization worksheet.xlsx*

   2) desired field characteristics using a lab-derived threshold voltage gradient at a target distance from the electrodes or an arbitrary voltage gradient located at some distance in an electric field that has resulted in "successful" electrofishing (as from Step #7); this couples lab data (or an arbitrary voltage gradient) and electric field map information to derive goal tables

      Locations in the electric field for the lab-derived threshold or the arbitrary voltage gradient are based on where these values occurred in an electric field that is considered to result in successful electrofishing or acceptable capture efficiency.

      Software tools: *Target Voltage Teaching Tool Size Class.xlsx*, *Electric Field Mapper and Standardization.xlsx*

10. **Compare the successful electrofishing range of the control box model with required power, voltage, and amperage levels**

    Estimate the water conductivity range that can be successfully electrofished by the selected electrode design and control box model given the target volts, amps, and power levels required for successful and power-standardized electrofishing. Control boxes and electrode designs that cannot achieve the desired electrical field in the sampling water conductivity range expected should not be used.

    Software tools: *Boat Power.xlsx*, *Backpack Power.xls*

11. **Consider different electrode designs (optional)**

If capture efficiency or electrofishing is unsatisfactory or appears low, consider different electrode designs. Very preliminary data suggests for successful boat electrofishing sampling of intermediate-sized sport fishes, the immobilization threshold should occur about 90 cm from the anode center. Using this or some other guideline, electrode designs can be evaluated based upon electric field characteristics and percent of system power allocated to the anodes. There is some balance point between extending the effective field size and percent power to the anodes.

Competing designs could be field-tested (similar to the waveform evaluation approach in Step #7). If a new electrode design is implemented, then repeat Steps #8 and #9.

Software tools: *EF with Power.xlsx* ("Electrode Resistances" tab)

12. **Test field operation protocols (optional)**

Another component of sampling design is the effect of other possibly important efficiency factors (e.g., day or night, turbidity, temperature, river discharge). Discuss if protocols should include provisions that restrict sampling based on the value of the efficiency factor. For example, sampling only occurs when temperatures are above a certain temperature, within a specified range of turbidity, during the night, below a specified discharge, etc. Protocols can be based on important habitat efficiency factors as well as use of chase boats, length of sampling unit, pedal-on continuously versus interrupted, number of dip-netters, etc. Once the entire sampling design and protocol is planned, run a study comparing protocol catch rates (as in Step #7). Use the power/voltage/amperage goal tables derived in step #9 for setting control box electrical output.

13. **Refine power/voltage/amperage goal tables (optional)**

Evaluate the behavior or value of the goal tables for informing electrical settings. In practice, the sampling approach may use the goal table to derive 1) the final settings used at that sample site, or 2) initial electrical settings and then conduct a brief fish sampling trial near the study site. The trial may result in fine tuning of the initial settings to maximize catch rate. Those adjusted settings would then be used in the actual site sampling.

After the most effective electrode design and operating protocol are selected, field test the tables in different conditions (as water conductivities). Use the power goal to establish a baseline and fine adjust by observation to try to obtain a higher catch rate. (Estimating capture efficiency via mark-recapture or depletion sampling could be valuable information in addition to CPUE or a subjective determination of success). Determine if the pattern of goal vs. conductivity match your goal tables derived earlier. If a small disparity exists, sampling protocols may need to include nearby trials prior to sampling. If a significant disparity exits, one solution may be to fit an empirical prediction equation to guide settings.