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Note

Comparison of point and transect-based electrofishing to sample American eel (*Anguilla rostrata*) in wadeable riverine habitats

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Abstract – Dramatic declines in American eel (*Anguilla rostrata*) recruitment have resulted in strong conservation measures being implemented. Recovery actions in Ontario have included stocking of glass eels. Given the financial costs and imperative to undertake effective recovery actions, post-stocking monitoring is essential. In this study, point- and transect electrofishing sampling were compared in terms of eel detection, catch rates, size-selectivity, and power to detect changes in abundance. Transect sampling was more likely to detect eels and captured over twice the number of eels than point-sampling. Differences in catch rates and statistical power were dependent on the catch-per-unit-effort measure (i.e. sampling unit vs. time). Results support a transect-based sampling program for stocked eels in Lake Ontario tributaries.

Key words: Monitoring / Rivers / American eel / *Anguilla rostrata*

1 Introduction

In Ontario (Canada), a dramatic decline in American eel (*Anguilla rostrata*) abundance and recruitment over the past two decades led to closures of commercial and recreational fisheries (Mathers and Stewart 2009), and the species being assessed as Endangered (OMNR 2006). Decline has been attributed to both local (fishing and dams) and large scale factors (declines in oceanic productivity) (COSEWIC 2006; Bonhommeau et al. 2008). As part of efforts to recover depleted populations, stocking of glass eels into the upper St. Lawrence River and Lake Ontario has been initiated; with approximately 4 million stocked between 2006 and 2010 (Verreault et al. 2010). The success of this stocking program will depend on outcomes such as strong post-stocking survival, the production of large and predominately female eels, and successful spawning out-migrations to the Sargasso Sea. Given the financial costs associated with stocking and the imperative to undertake effective recovery actions, post-stocking monitoring is an essential component of this stocking program.

Electrofishing is recognized as an efficient method to characterize eel distribution patterns, sample various sizes of eel, and obtain quantitative assessments of population size (Naismith and Knights 1993; Lobon-Cervia et al. 1995; Laffaille et al. 2005; Lasne and Laffaille 2008). Currently, transect-based boat-electrofishing surveys are used to monitor eels stocked into Lake Ontario (Bay of Quinte) and the upper St. Lawrence River. Stocked eels have been incidentally captured during backpack electrofishing of wadeable habitats along the lower reaches of Lake Ontario tributaries (Reid, unpublished data). Historically, these watersheds provided a substantial component of habitat available to maturing eels (MacGregor et al. 2010). Information on upstream dispersal, growth and maturation of stocked eels is, therefore, of great value to recovery efforts. In small watercourses (<6 m wide), eel population monitoring has typically been based on removal-based (depletion) electrofishing methods (Fuenteun et al. 1998; Briand et al. 2005; Machut et al. 2007; Acou et al. 2009; Pedersen 2009). However, the use of block-nets is impractical for larger watercourses. Point-sampling (PASE: point abundance sampling by electrofishing, Nelva et al. 1979) is an alternate strategy to characterize eel populations and is applicable to a wider range of watercourse sizes (Lafaille et al. 2005; Lasne et al. 2008).

Sampling strategy comparisons can assist in optimizing timing, effort, sample unit configaration, and the approach used to select study sites (i.e. random vs. fixed sites) (Flotemersch and Blocksom 2005; Quist et al. 2006; Reid and Mandrak 2009). Prior to undertaking watershed-wide surveys for American eel, I undertook a pilot study to compare electrofishing data collected using point- and transect-based sampling strategies. The two strategies were selected as they are applicable to a range of watercourse sizes, provide site-level

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sample replication and, are currently applied to sample eels and other riverine fishes (Lafaille et al. 2005; Lapointe et al. 2006; Flotemersch and Blocksom 2005). Strategies were compared based on: (i) likelihood of eel detection; (ii) eel catch rates; (iii) size-selectivity; and (iv) power to detect changes in eel abundance.

2 Materials and methods

2.1 Field sampling

Eighteen tributary sites along the north shore of Lake Ontario (44 09′N; –77 15′W) were sampled at low flow levels during September and October, 2010. Sites were located along Cobourg Creek, Moira River, Salmon River, Napanee River, and Trent River. Mean channel width, water temperature and conductivity were 51.2 m (range: 14–130), 15.6 °C (range: 8–22), and 185.9 µs cm^{-1} (range: 99–310), respectively. Surficial geology of the study area is a complex mix of Precambrian and Paleozoic (limestone) bedrock, glacial deposits and limestone till (Chapman and Putnam 1984); resulting in a wide range of flow and bed material characteristics across sampling sites (Reid et al. 2005).

Sampling was carried out with Smith-Root backpack electrofishing gear (Pulsed DC settings: 200–300 V, 50–60 Hz, 4–6 ms) and one netter. At each site, 50 units (Garner 1997) were sampled in a systematic manner using point and transect strategies. Sample units were located at 10 m intervals along the channel, and separated by 2 m across the channel. Point-electrofishing effort at each unit was standardized at 30 s over ~1 m^2 (Laffaille et al. 2005). Electrofishing effort along each 10 m transect (~1 m wide) was variable, with a mean level of effort of 49 s (Standard Error (SE) = 0.4). Eels captured from each sample unit were held in separate buckets until processing. Sites were re-sampled with the alternate strategy within 14 days. Total time spent sampling (site delineation, electrofishing and eel processing) was longer for transect-sampling (transect: mean = 2.14 h, SE = 0.05; point: mean = 1.57 h, SE = 0.02; Paired t-test, $t = -4.47$, $p < 0.001$).

2.2 Data analysis

Re-sampling methods were used to generate detection curves. For sample sizes of five to fifty units (increments of five), randomized sets of eel presence/absence data were generated from pooled electrofishing datasets. Sites where eels were not captured by either approach were not included. Simulated data (based on sampling with replacement, and 10 000 randomizations) was used to calculate mean probabilities of detection. The estimated number of units required to obtain a probability of detection equal to 0.95 was compared between sampling strategies. While this approach permits an assessment of detectability based on single sampling events, more robust estimates of detection probability require repeat sampling events (MacKenzie and Royle 2005). Data were simulated using Excel Add-in: PopTools Version 2.6.9 (Hood 2005).

Table 1. Summary of point- and transect-based American eel catch data from Lake Ontario tributaries.

Variable	Point	Transect
Number of sites where eel detected	9	15
Total number of eels	95	248
Mean (±SE) $CPUE_{time}$	3.5 (1.4)	5.1 (2.2)
Mean (±SE) $CPUE_{unit}$	0.11 (0.04)	0.28 (0.12)

Differences between point- and transect-based catch-per-unit-effort (CPUE) were tested using the paired t-test. CPUE was calculated using two measures of effort: (i) number per sample unit ($CPUE_{unit}$); and (ii) number per 1000 s of electrofishing ($CPUE_{time}$). Sample unit refers to a individual point or transect sampling event. The Spearman Rank correlation was used to assess whether differences in abundance among sites for each sampling were in agreement. Differences between eel lengths (mean and maximum) at each site during point- and transect sampling were also tested with the paired t-test. Differences between length frequency distributions (based on pooled datasets) were tested using the Kolmogorov-Smirnov (K-S) test.

I conducted prospective power analysis to compare the likelihood of each sampling strategy to detect changes in eel abundance between two sample periods. Power was estimated using an Excel-based sample size/power calculator (Gerow 2007; available from www.statsalive.com). The calculator is based on the non-central t-distribution, which is expected to provide more accurate power estimates than those based on either the z- or t-distributions (Gerow 2007). Estimates were calculated using: (i) sample sizes of 10 to 50 units; (ii) increases in mean CPUE ($CPUE_{unit}$ and $CPUE_{time}$) ranging from 10 to 40%; (iii) p of 0.05 and; (iv) a paired-site sampling design. In the paired-site design, the correlation between two sample periods is incorporated into sample size calculations. For this analysis, a moderate level of correlation ($r = 0.6$) was assumed. Re-sampling methods (see above) and pooled electrofishing data were used to estimate CPUE means and standard deviations for each sample size. As inclusion of data from sites without eels would inflate variances and reduce power estimates, the dataset only included sites where eels were captured by either method. Interpretation of "high" or "sufficient" statistical power was based on the convention of 0.8 (Cohen 1988; Peterman 1990).

3 Results

A total of 343 eels were collected from 15 of 18 sites. Transect-sampling captured eels at more sites than point-sampling (Table 1). It is also estimated to require less sampling effort to reach the 0.95 detection threshold (Fig. 1, Transect = 20 units; Point = 30 units). Transect-sampling resulted in a greater total number of eels being captured than point-sampling (Table 1), and a significantly greater $CPUE_{unit}$ ($t = -3.358$, $p = 0.004$). However, $CPUE_{time}$ was not significantly different ($t = -1.589$, $p = 0.13$). For both CPUE measures, the pattern of eel abundance among sites was strongly correlated between sampling strategies (r_s: 0.78 & 0.79; $p <$ 0.002).

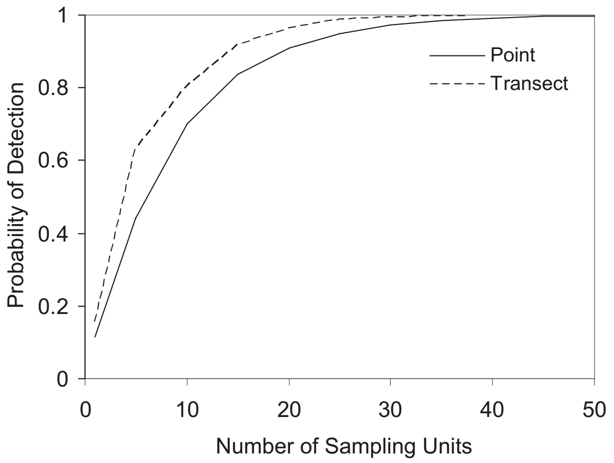

Fig. 1. Comparison of probability of eel detection curves generated from randomized sets of point- and transect-based electrofishing data.

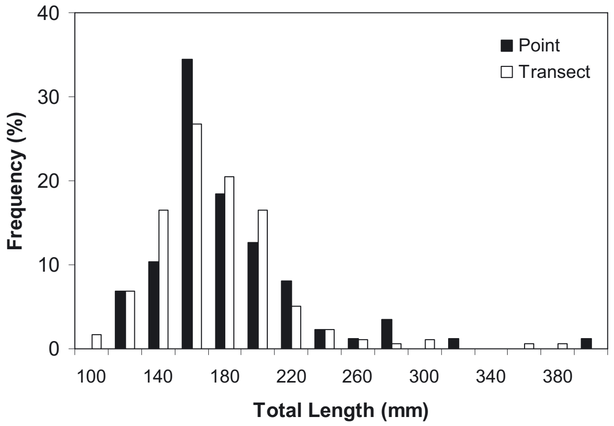

Fig. 2. Length-frequency distributions of American eel captured by point- and transect-based electrofishing.

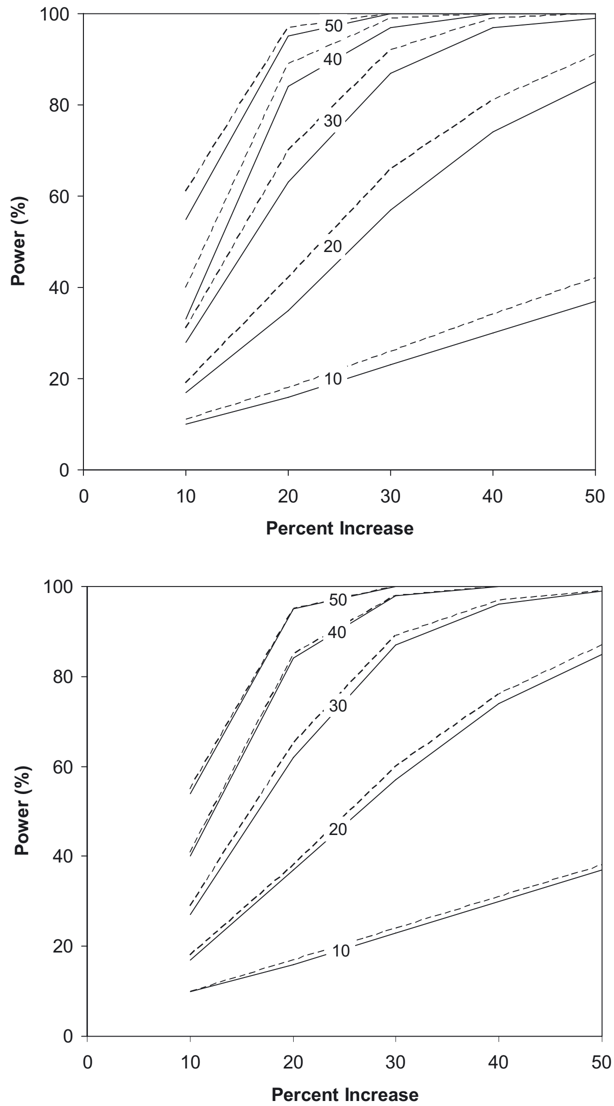

Fig. 3. Statistical power to detect increases in eel CPUE (upper graph: CPUEtime; lower graph: CPUEunit) between two time periods using transect (hatched line) and point-based (solid line) electrofishing. Power was estimated for sample sizes ranging from 10 to 50.

Mean and maximum eel length at each site did not vary significantly between sampling strategies ($t = -0.67$ & -0.78; $p > 0.52$). There was no significant difference between eel length-frequency distributions (Fig. 2) ($D = 0.09$, $p = 0.72$).

Trends in statistical power with increasing sample size and difference in eel abundance were similar for both sampling strategies, and CPUE measures (Fig. 3). Overall, sample designs with 40 or more samples are predicted to have sufficient power to detect increases in eel abundance of 20% or greater. Larger power estimates were associated with transect-sampling; although differences were only appreciable for lower samples sizes and $CPUE_{time}$.

4 Discussion

Monitoring programs require sampling designs that balance data quality and quantity requirements with practical and economic constraints. Point-sampling is a labour efficient strategy that has been applied to a wide range of research and monitoring studies (Copp 2010); including the characterization of riverine eel populations (Lafaille et al. 2005). However, by electrofishing less intensively over a larger area (~10 m^2), transect sampling was more likely to detect eels and captured over twice the number of eels than point-sampling. This result supports a transect-based eel sampling program for Lake Ontario tributaries that would be consistent with the boat-electrofishing strategy applied for Lake Ontario and St. Lawrence River. In areas of strong current and/or obstacles (boulders), point-sampling was felt to be safer to implement and eels were easier to detect and capture. Given the shorter sampling time required, eel detection rates could be improved by modest increases in the number of point-samples.

Size-selectivity is of concern when interpreting electrofishing catch data (Mahon 1980). While there were no differences between the lengths of eel captured by point- and transect electrofishing, I did not assess how representative catches were. Capture efficiency using fyke nets has been found consistently to be affected by eel size (Naismith and Knights 1990; Jellyman and Graynoth 2005). A consistent result has not been reported for electrofishing. While Naismith and Knights (1990) found electrofishing to select larger individuals, removal-based sampling of European eel from shallow ditches in a freshwater marsh did not identify a relationship between length and capture probability (Lambert et al. 1994). Additionally, Lafaille et al. (2005) did not detect any difference between eel lengths obtained from point- and removal-based sampling of small French rivers. Rather than indicating a gear-related bias, the small number of large (>300 mm) eels captured in this study likely reflects very low levels of natural recruitment of juvenile American eel (>400 mm) into Lake Ontario (Marcogliese and Casselman 2009). Likelihood of capture of large eels could be improved by complementing electrofishing of wadeable habitats with fyke nets set in non-wadeable habitats (Jellyman and Graynoth 2005).

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