Sampling efficacy of passive gear in the non-native emergent *Phragmites australis* subsp. *australis*

Jesse Gardner Costa, David T. Reddick, Abby G. Wynia, Susan E. Doka, Clint Jacobs, and Jonathan D. Midwood

Fisheries and Oceans Canada
Ontario and Prairie Region (Fisheries Ecology Section)
Great Lakes Laboratory for Fisheries and Aquatic Sciences
867 Lakeshore Road
Burlington, ON L7S 1A1

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Sampling efficacy of passive gear in the non-native emergent *Phragmites australis* subsp. *australis*

by

Jesse Gardner Costa[1], David T. Reddick[1], Abby G. Wynia[2], Susan E. Doka[1], Clint Jacobs[3], and Jonathan D. Midwood[1]

[1] Fisheries and Oceans Canada
Ontario and Prairie Region
Fisheries Ecology Section
Great Lakes Laboratory for Fisheries and Aquatic Sciences
867 Lakeshore Road
Burlington, ON L7S 1A1

[2] Environment and Climate Change Canada
867 Lakeshore Road
Burlington, ON L7S 1A1

[3] Walpole Island First Nation
2185 River Road North,
Walpole Island,
R.R. 3 Wallaceburg, ON N8A 4K9

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ABSTRACT

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In the summer of 2017, Fisheries and Oceans Canada (DFO) in partnership with Walpole Island First Nation used multiple passive gear types (large-mesh gill net, small-mesh gill net, and Windermere traps) to assess fish community assemblages in three different emergent vegetation types (*Phragmites*, *Typha* spp., and *Schoenoplectus* spp.) in the St Clair River delta. The objective of this study was to determine the optimal gear for effectively sampling fish community assemblages in stands of emergent vegetation in general, and *Phragmites* in particular. Non-parametric paired comparisons across gear type detected significantly greater catch-per-unit effort (CPUE, fish/m^2/hr) in Windermere traps than either small- or large-mesh gill nets (Wilcoxon's signed rank test: $p < 0.05$, df = 8 for small-mesh gill nets; $p < 0.01$, df = 8 for large-mesh gill nets). While not part of the paired analysis, limited surveys were also undertaken with Fyke nets finding comparable CPUE between Fyke and Windermere traps. Fyke nets caught fish 100% of the time, and had higher species richness within catches despite less effort spent in terms of number of nets set. Therefore this report recommends the use of Fyke nets for a field study planned in 2018 to assess the potential effect of *Phragmites* on fish and fish habitat. These results are also of use for the Fisheries Protection, Aquatic Invasive Species, and Species-at-Risk programs within DFO when considering sampling design and the selection of gear type for surveying emergent vegetation.

RÉSUMÉ

Gardner Costa J., Reddick D.T., Wynia A.G., Doka S.E., Jacobs, C., and Midwood J.D. 2020. Sampling efficacy of passive gear in the non-native emergent *Phragmites australis* subsp. *australis*. Can. Manuscr. Rep. Fish. Aquat. Sci. 3197: vi + 27 p.

À l'été 2017, Pêches et Océans Canada (MPO), en collaboration avec la Première nation de Walpole Island, a utilisé divers types d'engins passifs (filets maillants à grandes mailles, filets maillants à petites mailles et pièges Windermere) pour évaluer les ensembles de communautés de poissons vivant dans trois différents types de végétations émergentes (*Phragmites*, *Typha* spp. et *Schoenoplectus* spp.) à l'intérieur du delta de la rivière Sainte-Claire. Cette étude visait à déterminer le meilleur engin pour échantillonner efficacement les ensembles de communautés de poissons vivant dans les peuplements de végétations émergentes en général et plus particulièrement dans les peuplements de *Phragmites*. Les comparaisons par paires non paramétriques effectuées entre les types d'engins ont révélé des prises par unité d'effort nettement plus importantes (PUE, $poisson/m^2/h$) dans les pièges Windermere que dans les filets maillants à petites mailles ou à grandes mailles (test de Wilcoxon pour observations appariées : $p < 0,05$, df = 8 pour les filets maillants à petites mailles; $p < 0,01$, df = 8 pour les filets maillants à grandes mailles). Bien qu'ils ne fassent pas partie de l'analyse par paires, des relevés de petite envergure ont aussi été effectués avec des verveux à ailes et ont permis de constater que les PUE dans les verveux à ailes étaient comparables à celles dans les pièges Windermere. Les verveux à ailes ont permis de prendre des poissons 100 % du temps et les prises présentaient une plus grande richesse spécifique malgré un effort moindre en ce qui concerne le nombre de filets mis en place. Par conséquent, le présent rapport recommande l'utilisation de verveux à ailes pendant l'étude sur le terrain prévue en 2018 pour évaluer l'effet potentiel des *Phragmites* sur les poissons et leur habitat. Les présents résultats sont également utiles dans le cadre du Programme de protection des pêches, du Programme sur les espèces aquatiques envahissantes et du Programme sur les espèces en péril du MPO lorsqu'il s'agit d'élaborer un plan d'échantillonnage et de choisir le type d'engin pour surveiller la végétation émergente.

INTRODUCTION

Non-native *Phragmites australis* ssp. *australis* (herein *Phragmites*) has rapidly colonized nearshore freshwater areas throughout the Laurentian Great Lakes (Wilcox et al. 2003; Tulbure and Johnston 2010), replacing native species of emergent vegetation that provide critical spawning, nursery, and foraging habitat for a wide variety of fishes (Killgore et al. 1993; Smokorowski and Pratt 2007). The extent to which this invasive species provides comparable habitat for freshwater fishes is currently unquantified, although generally thought to be unsuitable based on studies in marine tidal areas and brackish marshes (Warren et al. 2001; Hunter et al. 2006). In the Great Lakes context, the invasion of *Phragmites* has important management implications for invasive species, fisheries, and fish habitat given its rapid spread, ability to colonize disturbed soils, and challenges associated with removing *Phragmites* once it is established (Wilcox 2012; Environment Canada 2014; Jung et al. 2017). Assessing the potential influence of *Phragmites* on fish habitat and fish community assemblages is therefore essential.

A challenge with sampling fish communities in *Phragmites* is determining the correct gear given the physical challenges of sampling for fish in emergent vegetation (i.e., high stem density). Fishing gear are generally divided into active (e.g., electrofishing and seining) and passive approaches (e.g., trap nets or gill nets), with more active approaches tending to capture larger more sedentary species while passive gear are more likely to capture mobile fishes (Bohlin et al. 1989; Cvetkovic et al. 2012). Past studies have surveyed fishes within emergent vegetation stands using both approaches; however, active methods have generally been more species-specific (e.g., Common Roach [*Rutilus rutilus*]; Okun and Mehner 2005) rather than community-focused (e.g., Jacobus and Webb 2005; Aday 2007). Determining an optimal gear for effectively sampling fish community assemblages in stands of emergent vegetation in general and *Phragmites* in particular, is therefore necessary in order to accurately assess the potential effect of *Phragmites* invasion on fish and fish habitat.

In the summer of 2017, Fisheries and Oceans Canada (DFO) in partnership with Walpole Island First Nation (WIFN; Bkejwanong First Nation) used multiple passive gear types (gill nets, traps, and Fyke nets) to assess fish community assemblages in three different emergent vegetation types (*Phragmites*, *Typha* spp., and *Schoenoplectus* spp.) in the St Clair River delta. Complementary habitat data (water chemistry, stem density, etc.) were also collected at all sites to help identify potential drivers behind observed differences in fish community metrics. While, the primary objective of these surveys was to compare fish species richness, abundance, size distribution, and biomass among the three emergent vegetation stands, an important secondary objective, and the focus of the present report, was to compare the efficacy of the gear for sampling fishes in emergent vegetation. The results from this report will be used to develop a more spatially expansive sampling program to assess fish community assemblages among emergent vegetation types throughout the lower Great Lakes. Ultimately, these studies will help determine whether active management of *Phragmites* is necessary to ensure there is no loss of freshwater fisheries production as a result of its expansion. Given continued expansion of *Phragmites,* quantifying its potential negative impacts on fisheries production is essential for an accurate implementation of fish habitat offsetting measures, especially in urban or degraded areas where *Phragmites* may already be present and benefit from newly exposed substrates.

METHODS

STUDY SITE

The St. Clair River delta sits at the junction between the St. Clair River and Lake St. Clair. The Delta contains extensive marshes and a diversity of native fishes (including many species at risk) (MacKey 2011; J. Gardner Costa, S.M. Larocque, D.T. Reddick, M. Croft-White, E. Budgell, C. Jacobs, S.E. Doka, and J.D. Midwood, Walpole 2015 unpublished data). Ten study sites were selected across the Delta and sampled between June 9 and July 28, 2017 (Figure 1). A site was selected based on the presence of all three emergent species (Phragmites, Typha spp., and Schoenoplectus spp.) within a physiographically distinct area; however, larger areas (i.e., Goose Lake ~2 km wide) were occasionally split into two separate sites.

TRANSECT SAMPLING

Using a transect-based sampling approach, fish were sampled using Windermere traps and gill nets with two sizes of mesh in each of the emergent species' of interest (*Phragmites*, *Typha* spp., and *Schoenoplectus* spp.). Netting primarily occurred during the day (1000–1800 h); however, night sampling (2200–0400 h) was also attempted with the same methods from June 20 to June 22, 2017. Only three sites were sampled both during the day and night due to logistical concerns associated with night sampling. Each site had a total of nine transects, with three in each of the emergent vegetation species that were representative of the different gear types (large-mesh gill net; small-mesh gill net; and Windermere trap).Transects were 7.0 m long, running perpendicularily from the edge of the emergent vegetation stand towards shore. Selection of a transect's location was constrained by the extent of the emergent vegetation stand (needed to be able to contain the 7.0-m transect), the proximity of that stand to open water (needed to be adjacent to open water as opposed to another emergent vegetation species), and the water depth (minimum = 0.5 m and maximum = 1.6 m). Transects were set a minimum of 8.0 m from the nearest neighbouring transect.

Habitat conditions within transects were sampled prior to gear deployment. These data were collected at 1.0, 3.0, 5.0, and 7.0 m from the open water along each transect. Habitat parameters recorded included water depth (m), stem density (stalks/m^2), percent below surface cover (primarily of submerged aquatic vegetation [SAV]), SAV species composition, and substrate type. Water chemistry data were collected for Windermere traps and select gill net transects at 5 m and "open" (area in front of the transect) location. A YSI EXO multiprobe (YSI Inc. Yellow Springs, Ohio) was used to collect basic water chemistry information including: air pressure (mm Hg), dissolved oxygen (mg/L), conductivity (µS/cm), pH, turbidity (NTUs), and water temperature (^{o}C).

Windermere traps (3-hoop design, length = 1.0 m, mesh size = 3.1 mm, hoop diameter = 0.6 m, throat diameter = 0.1 m) were set along transects to align with sampling points at 1.0, 3.0, 5.0 and 7.0 m from open (openings perpendicular to the transect itself). Traps were oriented parallel to the edge of the emergent vegetation stand, such that the openings on either end of the trap were located at the same distance along the transects. An approximate six-hour soak time was used for the Windermere traps. Gill nets of two mesh sizes ("small": mesh size (stretched) = 3.8 cm, length = 4.0 m, depth = 0.5 m; "large": mesh size (stretched) = 8.9 cm, length = 4.0 m, depth = 0.5 m) were fixed to PVC frames and placed along transects in the same orientation as the Windermere traps, reaching from 1.0 to 5.0 m for approximately three hours.

All captured species were identified and their fork length (mm) and wet mass (g) were measured (using a balance with a resolution of 1.0 g) before they were released. Species caught in large numbers were batch-weighed after recording length and mass for the first 20 individuals, followed by counting the number of individuals remaining and weighing them together. Fish that required additional examination to confirm the species were vouchered. Vouchering involved euthanizing the fish in a clove oil mixture and preserving the specimen in ethanol in a secure vessel (i.e., Whirl-Pack, leak-proof jar) with descriptive labelling. In isolated cases (i.e., large specimens), the individual was not euthanized but rather vouchered by photographing key identifying features prior to release.

FYKE NETTING

On July 21, 22, 25, 26 and 27, 2017, fish communities in *Phragmites* stands were sampled using Fyke nets in Goose Lake (12 net sets) and Bass Bay (3 net sets). Fyke net sets were not part of the paired sample design as the other gear types and did not occur in the same locations. These surveys were conducted opportunistically with an objective of assessing whether this gear could catch fish specifically in this emergent vegetation type. Fyke nets (frame dimension = 1.2 m × 0.9 m × 0.9 m, hoop diameter = 0.8 m, throat diameter = 0.1 m, lead = 7.6 m × 0.9 m, wings = 3.6 m × 0.9 m, mesh size = 4.8 mm) were set in water depths of less than 1.1 m. The lead of the Fyke net was run perpendicular to the edge of the emergent stand, with wings set at a 45^{0} angle from the lead in the emergent stand, with the frame of the net within approximately 1.0 m in from the edge of the stand to exclusively sample fish within the stand. Sites' distance to shore had to be greater than the 7-m transects so the leads did not extend all the way to shore. Nets were set for a period of approximately 24 hours.

Habitat data were recorded at the connection between the frame of the net and the lead prior to processing. Habitat parameters included water depth (m), dominant vegetation species, sediment type, and basic water chemistry information (as detailed previously). Upon retrieval, the contents were emptied into an aerated 175 L, light-coloured plastic tote and fish were processed in the manner outlined previously for the transect surveys. Turtles that had been caught in the nets were recorded and released prior to sorting fish (Appendix Table A1).

Fyke nets were not initially included as part of the gear comparison for two reasons. First, there were concerns that stem density in emergent vegetation would be too high to allow for a sufficient portion of the lead and wings to be set within the emergent stand to ensure captured fish originated within the stand. Second, shallow water depths within the emergent stands were thought to be limiting for Fyke nets since the throats of the net must be fully submerged to fish effectively (min = 0.5 m). Water levels in the St. Clair delta were higher during sampling than anticipated, which allowed for Fykes to be set in *Phragmites* stands.

DATA ANALYSIS

Water chemistry data collected from the YSI multiprobe were used to calculate the Water Quality Index (WQI) based on the four-parameter equation developed by Chow-Fraser (2006). All data collected at each site (all available emergent types and gear) were pooled to calculate this index and the mean (with standard deviation [SD]) value for each of the five water chemistry parameters. We compared stem densities among gear type for each emergent vegetation type as well as stem densities among emergent vegetation types for all gear types (data were pooled) using a non-parametric paired t-test (Wilcoxon signed-rank test).

The percent (%) fished for nets (i.e., success rate) was calculated as the proportion of nets with the presence or absence of fish; Windermere traps were pooled along a transect for this assessment. Fish catch data were adjusted to incorporate sampling effort both in terms of time (duration of net set, measured in hours) and net surface area (large- and small-mesh gill nets = 2.0 m^2, Windermere trap = 1.1 m^2, and Fyke net = 6.8 m^2). The latter measurement refers to the surface area of the net or trap that a fish might encounter so, for the gill nets it is the entire panel, for the Windermere traps the hoop diameter, and for Fyke nets the leads (which acts to funnel fish into the trap). Catch per unit effort (CPUE) is typically calculated to account for time and not surface area (Neumann and Allen 2007), however, most studies do not directly compare gear types so we corrected for both to minimize any confounding factors when looking at the effect of the gear design on catch data. For reference or future analyses, Table A1 includes both measurements of CPUE.

The resulting estimates of CPUE (fish/m^2/hr) for each gear type were not normally distributed therefore data were analyzed using a non-parametric paired t-test (Wilcoxon signed-rank test) to distinguish significant differences among gear types (large-mesh gill net, small-mesh gill net, and Windermere trap), and emergent vegetation species (*Phragmites*, *Typha* spp., and *Schoenoplectus* spp.). For each replicate (site-gear-vegetation), there were four Winderemere traps for each large- and small-mesh gill net so the Windermere data were pooled for each transect before comparisons were made. Two Windermere traps within a *Phragmites* stand at “Fish Bay” caught significantly more fish than any other site (>500 young-of-the-year Largemouth Bass [*Micropterus salmoides*] compared to catches of 0–31 fish elsewhere) and were consequently removed prior to CPUE analysis, but still included in summary results. A statisitcal assessment was not undertaken with the Fyke net data since nets were not deployed at the same sites and days as the other three gear types. All summary values are shown as mean ± SD.

RESULTS

Mean wetland water temperatures ranged from 21.8 ^{o}C to 28.2 ^{o}C from June 9 to July 26, 2017, with generally comparable measures of conductivity, pH, and turbidity among sites and comparatively high variability (both within and among sites) for dissolved oxygen (Table 1). The WQI ranged from 1.0 to 1.7 for all sites across gear and emergent vegetation types, suggesting all sites fell within the very good category for the WQI (Chow-Fraser 2006). Stem densities of vegetation were generally not significantly different among gear type, except for lower values in the small-mesh gill nets compared to the Windermere traps within *Typha* stands (Wilcoxon's signed rank test: $p < 0.05$, df = 9). There were, however, significant differences among vegetation types (analyzed with all gear types pooled), with the stem density for *Phragmites* (68.5 ± 38.3 stems/m^2) significantly greater than either *Typha* (41.1 ± 21.8 stems/m^2, Wilcoxon's signed rank test: $p < 0.0001$, df = 29) or *Schoenoplectus* (44.5 ± 26.5 stems/m^2, Wilcoxon's signed rank test: $p < 0.0002$, df = 29; Table 2).

Across ten sampling sites, 1005 fish were caught during the day in large-mesh gill nets, small-mesh gill nets, and Windermere traps; 33 fish were caught at night. All Fyke nets set in *Phragmites* captured fish, with a total of 652 individuals from 23 different species captured (Table 3). Despite high total catch and species richness, CPUE for the Fyke nets was comparable to that observed with Windermere traps, but with lower variance (Table 4; Figure 2), however, these data were not statistically tested because Fyke nets were not initially included in the experimental design.

For the paired sites "Fish Bay" had the highest number of fish encountered (>500 fish in just two Windermere traps as noted previously); however, many traps across sites captured no fish. Windermere traps (when pooled) had the highest capture success rate across vegetation types (70–100%), followed by small-mesh gill nets (30–60%), then large-mesh gill nets (10–20%) (Table 4). Fyke nets caught fish 100% of the time. We did not specifically test for differences in the number of fish caught among Windermere traps set along a single transect; however, in general, more fish were caught in the 5.0- and 7.0-m areas (Appendix Figure A1). Success rate also appeared to vary among transect distances: 40% at 1.0 m, 33% at 3.0 m, 57% at 5.0 m, and 60% at 7.0 m.

Largemouth Bass, Pumpkinseed (*Lepomis gibbosus*), and Bluegill (*Lepomis macrochirus*) made up the majority (1288 fish or 77%) of fish caught in all gear types. Species richness across all paired sites was 15 during the day, and 6 at night, although no sampling site fished more than three species. Twenty-three species were encountered in Fyke nets (Table 4). Two species at risk were encountered; one Lake Chubsucker (*Erimyzon sucetta,* federally and provincially listed as endangered) and four Grass Pickerel (*Esox americanus vermiculatus,* federally and provincially listed as special concern).

Fish Bay had the highest catch rate 5.2 ± 16.3 (fish/m^2/hour) with a total of 771 fish. Upper Bassett had the lowest catch rate, 0.0 ± 0.0 (fish/m^2/hour), though CPUE was generally low across all paired sites (Table 5). For statistical comparisons "Fish Bay" was removed due considerably higher catch (as noted previously). Using non-parametric paired comparisons, we found no significant differences in CPUE among vegetation types ($p > 0.05$). Non-parametric paired comparisons across gear type detected significantly greater CPUE in Windermere traps than either small- or large-mesh gill nets (Wilcoxon's signed rank test: $p < 0.05$, df = 8 for small-mesh gill nets; $p < 0.01$, df = 8 for large-mesh gill nets) (Figure 2).

Mean lengths of fish for all gear types are tabulated in Table 6. Fyke nets were not a part of the original paired site design and therefore statistical comparisons between Fyke nets and other gear types were not made, however, we plotted the length distributions of *Lepomis* spp. captured in Fyke nets and Winderemere traps to compare the size ranges of the lengths of fish between these gear types (Figure 3). Both gear types caught the highest proportion of fish around 50 to 75 mm in length, however, Fyke nets generally caught bigger fish than Windermere traps, with Windermere traps not capturing any species larger than 150 mm.

DISCUSSION

The primary objective of the present report was to compare the efficacy of passive gears for capturing fishes within three different types of emergent vegetation. We found evidence of clear differences among gear types for fishing success rate, CPUE, and species richness. Though our objective was to compare the effect of gear type rather the effect of vegetation across gear types, the latter may benefit from using Multi-gear Mean Standardization (MGMS), which is essentially a data transformation and removes the effect of gear type among passive and active gears (Gibson-Reinemer et al. 2016). This reference was included in this report for posterity and may be useful for some of our ongoing projects.

All sites surveyed within the St. Clair delta were found to have "very good" water quality (Chow-Fraser 2006), which is consistent with the lower levels of anthropogenic disturbance within the Delta and large and diverse coastal wetlands. For the present study, comparable site condition was essential to reduce the potential factors that could affect differences in fish catches among gear and vegetation types. Consistent with previous studies, there were differences in the stem densities among the three emergent vegetation types with *Phragmities* growing in denser patches than either *Typha* or *Schoenoplectus* (Lenssen et al. 2000).

The primary comparison of gear, which used a paired study design, was focused on different sizes of gill nets and Windermere traps as past studies have suggested that *Phragmites* primarily grows in shallow waters (<1.0 m, Altartouri et al. 2014), with a Lake Erie peak between 0.1 to 0.5 m (Jung et al. 2017). During the field survey for this study, however, it became clear that *Phragmites* regularly occurred in water depths of 1.0 m or greater in the St. Clair River delta; depths that would allow for effective fishing with Fyke nets. The efficacy of this gear was therefore also explored and it was comparable if not more effective than the Windermere traps, which were considerably more effective than either size mesh of gill net. In areas colonized by *Phragmites* with depths <1 m, such as coastal wetlands around the Great Lakes, our results suggest that Windermere traps would be a useful alternative when Fyke nets cannot be used.

Our results have allowed for a comparison of the relative benefits of gear types with a focus on fishing success rate, CPUE, and species richness. Windermere traps had a higher success rate than gill nets at the paired sites in all vegetation types, with a 48% success rate for individual traps across all sites and between 70% to 100% when the four traps at each transect were pooled. When compared with gill nets, the ~50% success rate of Windermere traps does not fair better than gillnets, however, the pooled totals for four Windermere traps at each transect are have better catch success than single gillnets set along a transect. Every Fyke net that was set in *Phragmites* captured fish.

Differences in catch success among gear may be partially related to the duration of the set, since large- and small-mesh gill nets, which were largely ineffective at catching fish, were only set for 3 hours, compared to 6 hours for Windermere traps and 20 to 24 hours for Fyke nets. Past studies have documented improvements in catch rates for gear set overnight because they are able to capture diurnal cycles of fish movement in and out of nearshore areas (Hardie et al. 2006; Ruetz et al. 2007). It was, however, deemed to be impractical to extend set times for gill nets because even within 3 hours, fish caught in the gill nets were found to have been eaten. Extending the set time would increase the likelihood a captured fish would be preyed upon, affecting fish capture rates, increasing mortality, and causing damage to gill nets, thereby reducing capture efficacy.

A small pilot study was undertaken concurrently with the present works in the Walpole delta at Goose Lake on July 25th to 28th to explore the benefits of 24-hour sets of Windermere traps (data not included in present report), given the greater diversity and catch rates during night sampling in wetlands (Midwood et al. 2016). This involved 30 traps being set in stands of *Phragmites* (one at each of 1.0, 3.0, 5.0, and 7.0 m into the stand). Mean CPUE was lower compared to the 6-hr Windermere trap sets (0.22 ± 0.23 fish/m^2/hr for 24 hr set, 1.02 ± 0.83 fish/m^2/hr for the 6 hour set [Table 4]), suggesting there may be greater benefit to fishing more traps than extending the set duration. There were no differences in species richness (8 for both set times), which given the discrepancy in total effort (120 traps at 6 hrs compared to 30 traps at 24 hours) would suggest that longer sets of the Windermere traps may yield a more comprehensive survey of the fish community and may represent better sampling effort in terms of addressing variation in the daily habitat use, foraging, and dispersal patterns of different species.

From the paired assessment, we found no differences in CPUE among vegetation types, likely due to overall low capture rates of fish regardless of gear type. The Windermere traps were found to have higher overall CPUE than gill nets, even when high catch rates at Fish Bay were excluded. When this site was dropped, CPUE for the Windermere traps were comparable to the Fyke nets and the variance in CPUE was also reduced.

Fyke nets caught more than half the number of fish (652) of all other gear types combined (1005) even though only 15 Fyke nets were set, compared to 180 sampling events for all other nets (30 small-mesh gill nets, 30 large-mesh gill nets, and 120 Windermere traps). These results are unsurprising as Fyke nets are a preferred gear type for sampling wetlands and are functional in dense vegetation, and result in lower mortality compared with gill nets (Brady et al. 2007). Half of the total catch from the gill nets and Windermere traps also came from a single trap, which was ultimately removed from the analysis since it was an order of magnitude larger than anything else observed. This type of rare large catch is not uncommon with passive gear as they frequently result in all-or-none capture of schooling fish species (Hubert et al. 2012). It does, however, make analysis challenging and, in the present survey, the Fyke nets appeared to fish more consistently in terms of total catch and success rate. Collectively these results suggest that Windermere traps and Fyke nets yield comparable estimates of CPUE, with slightly higher rates of capture success for Fyke nets on a per-net/trap basis.

Fyke nets and Windermere traps had comparable CPUE; however, it is likely that we are overestimating the encounter area of the Fyke nets and therefore underestimating the CPUE of Fyke nets. Windermere traps and gill nets are always submerged, therefore encounter areas never change, whereas Fyke nets often vary in terms of how much of the leads are submerged, but it is almost always lower than our estimated area of 6.8 m^2. Set durations also likely impact CPUE, it is unlikely that catch rates are normally distributed across different periods of soak time but rather clumped into periods of peak activity. Soaking a gear type for a longer period increases the likelihood that the gear is deployed during a high activity period. To date, we are unaware of other studies that take these factors into consideration but future work should try to capture the effective encounter area of Fyke nets for more precise estimate of CPUE.

Although we did not run an adjustment for effort, Fyke nets captured over twice as many species compared to all other gear types. Fyke nets also caught larger fish species (Common Carp [*Cyprinus carpio*], Northern Pike [*Esox lucius*], and Bowfin [*Amia calva*]), that were not found in the paired assessment of gill nets and traps, although a Longnose Gar [*Lepisosteus osseu*s] was captured in the large gill net and not the Fyke nets. Given the distribution of *Lepomis* species for Fyke and Windermere gear types, it is clear that Fyke nets are able to capture a greater range of sizes of fish compared to Windermere traps. *Lepomis* species were chosen for visualization because both gear types were able to capture over 100 individuals to produce a distribution. Windermere traps appear to have an upper limit of 150 mm (15 cm), basically restricting catches to small species or juveniles. While this discrepancy may be partially due to differences in set duration and timing (overnight), the design of Fyke nets lend themselves to overall increased capture efficiency. The opening to the Fyke nets and Windermere traps are identical (1.1-m^2 frame and 0.1-m throat), but the lead of the Fyke net paired with the wings act to funnel fish into the net, whereas the Windermere traps have no such funnel. Regardless of the driver behind differences in species richness within each gear, at this time it appears that the Fyke net surveys are able to capture larger fish and a larger proportion of the fish community found within stands of *Phragmites*.

From a purely logistical perspective, setting a single Fyke net per vegetation stand was considerably easier than setting four Windermere traps, yet both approaches yielded comparable CPUE. Fewer overall nets would therefore need to be set and cleared to yield similar conclusions on differences among emergent vegetation types. A drawback to the 24-hour Fyke net sets is the extended duration (2 days) at a single site to complete the survey. This longer time commitment, however, is likely worth the effort given the increased likelihood of catching fish and the greater richness of species that would be encountered. The final logistical consideration that became apparent during this survey was the potential danger to personnel of setting and retrieving short set nets during the night-time. The deeper than anticipated waters within the Delta, limited visibility of both equipment and crew, temperature and potential surface and subsurface hazards (e.g., rebar or stalks of vegetation) all made extending this component of the project untenable. This element was initially included in the project to determine whether there were differences in fish use of the three emergent vegetation types during the day compared to the night. Some inferences on these types of differences may be possible to capture in the future through the use of daytime net sets paired with 24-hour net sets, or dusk until dawn net sets, both of which would preclude the need for field crews to be active during night-time hours (Portt et al. 2006).

Many studies have called for a multi-gear approach for effectively sampling fish assemblages in nearshore areas (e.g., Drake and Pereira 2002 and Van Snik Gray et al. 2005 as cited in Cvetkovic et al. 2012; Clement et al. 2014). Much of this blending of gears, however, has focused on pairing passive (i.e., traps or nets) and active (i.e., electrofishing and seining) gear. While this was considered during the planning stages of this project, concerns regarding stem density in emergent vegetation led us away from active sampling methods that require either nets to be moved through the vegetation (i.e., seining) or stunned fish to be netted (i.e., electrofishing). In the future, alternate sampling methods, such as larval fish traps, may be useful as they combine some of the benefits of passive surveys (longer survey period, set in a single place) with an attractant (light in this case) that can expand the area being surveyed (Mangan et al. 2005), especially considering that these complex habitats are ideal for larvae and young of year fishes. Regardless, the present study only focused on passive gear with clear evidence for the ineffectiveness of gill nets in this situation and some suggestion that Windermere traps may provide insight, provided sufficient effort is employed. Fyke nets, however, were by far the most effective method tested and will be used for future surveys of fish community assemblages in *Phragmites* and other emergent vegetation species, provided water depths are sufficient for their deployment. Windermere traps may prove to be a useful alternative in shallow-water situations or when sampling within a more restricted area is desirable (e.g., comparison of catch among different stem densities of an emergent vegetation species).

With the caveat that overall low capture rates in all gear types limit confidence in a comparison among emergent vegetation types, results from the present study suggest that while there are differences in the types of habitat provided by emergent vegetation types (i.e., stem density), there are no apparent differences in CPUE of fish. Also, sampling was completed in a high water year and results may be different in low water years when emergent vegetation has not been recently flooded. A more detailed exploration of this subject is thus essential to confirm or refute these preliminary findings. The objective of the larger project, of which this report is a small piece, is to compare fish community assemblages and production among the three emergent vegetation types. The ultimate gear selection must be able to consistently capture sufficient numbers of fish to allow for a comparison. At this time, neither the gill nets nor Windermere traps appear to be able to meet this requirement. Future studies may also consider using larval traps in addition to Fyke nets in three seasons (spring, summer, and fall) to capture habitat use by all life-stages of fish. *Phragmites* may be used by the larvae of some fish species that may not be present at later life-stages, consequently making the likelihood they would be detected by Fyke nets low.

CONCLUSION

The results from the present gear type comparison have informed the sampling regime for a more spatially expansive survey in 2018; only Fyke nets will be used to sample fish assemblages in emergent vegetation. For the paired sites, Windermere traps were most successful at catching fish; however, we found no differences among emergent vegetation types. Since the ultimate goal of the larger study is to determine whether fish utilize emergent vegetation differently depending on the plant species, Fyke nets will likely be the best method to evaluate this question. This study has provided guidance for future sampling and has provided the first direct comparative study of gear types and community diversity in *Phragmites* stands. From a management perspective, this study provides advice on sampling design and the selection of gear type for surveying emergent vegetation, which will be of use to the Fisheries Protection, the Aquatic Invasive Species, and Species-at-Risk programs within DFO and to other federal, provincial, and regional agencies (i.e., the Great Lakes *Phragmites* Collaborative and Ontario *Phragmites* Working Group) that seek to formally quantify the effects of *Phragmites* on fish and fish habitat.

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Table 1. Mean depth and water quality data ± standard deviations for all sites across gear type and vegetation type. The WQI was calculated using the four-parameter (temperature, conductivity, pH, and turbidity) equation from Chow-Fraser (2006).

Location	Depth (m)	Temperature (°C)	Conductivity (µs/cm)	pH	Turbidity (NTUs)	Dissolved Oxygen (mg/L)	WQI
Bass Bay	1.1 ± 0.1	28.2 ± 0.6	223 ± 2	7.9 ± 0.2	0.4 ± 0.2	6.9 ± 0.9	1.6 ± 0.4
Fish Bay	1.1 ± 0.2	25.4 ± 1.8	216 ± 19	8.3 ± 0.9	2.4 ± 3.9	9.4 ± 3.4	1.2 ± 0.9
Fish Bay (night)	1.2 ± 0.2	22.1 ± 1.2	208 ± 22	8.0 ± 1.0	1.0 ± 0.8	6.4 ± 3.9	1.6 ± 0.6
Goose Lake	1.0 ± 0.1	24.1 ± 1.1	230 ± 11	8.1 ± 0.4	0.7 ± 0.3	6.9 ± 1.1	1.4 ± 0.3
Goose Lake (night)	1.4 ± 0.2	23.4 ± 0.3	230 ± 7	8.3 ± 0.5	1.4 ± 0.4	7.9 ± 1.7	1.0 ± 0.2
Johnston Bay South	1.1 ± 0.2	23.8 ± 4.1	221 ± 5	8.5 ± 0.7	1.4 ± 0.5	10.4 ± 3.3	1.0 ± 0.1
Johnston Bay West	1.2 ± 0.2	23.1 ± 2.9	218 ± 9	8.5 ± 0.4	0.7 ± 0.7	9.6 ± 1.3	1.6 ± 0.6
Johnston Bay South (night)	1.2 ± 0.2	20.8 ± 0.5	217 ± 4	8.2 ± 0.3	1.4 ± 0.7	8.2 ± 1.6	1.1 ± 0.3
Lower Chematogan	1.2 ± 0.1	25.7 ± 0.2	224 ± 1	8.0 ± 0.1	0.4 ± 0.1	8.6 ± 0.6	1.7 ± 0.1
Lower Strahns	1.2 ± 0.2	22.0 ± 3.6	221 ± 2	8.6 ± 0.1	1.4 ± 0.8	9.9 ± 0.7	1.1 ± 0.2
Shut In Bay	1.0 ± 0.1	22.8 ± 1.7	225 ± 8	7.4 ± 0.2	1.4 ± 1.0	7.4 ± 2.0	1.3 ± 0.5
Upper Basset	1.3 ± 0.1	23.8 ± 0.3	226 ± 2	7.6 ± 0.3	1.1 ± 0.9	6.1 ± 1.6	1.6 ± 1.0
Upper Strahns	1.0 ± 0.2	21.8 ± 3.7	222 ± 2	8.2 ± 0.4	1.9 ± 1.4	8.6 ± 1.0	1.0 ± 0.5
Bass Bay (fyke)	1.1 ± 0.1	-	-	-	-	-	-
Goose Lake (fyke)	0.9 ± 0.1	24.6 ± 0.4	211 ± 55	8.0 ± 0.3	0.6 ± 0.3	7.0 ± 0.6	1.4 ± 0.2

Table 2. Mean stem density ± standard deviations of emergent vegetation for all sites, grouped by emergent species and gear type. *Phragmities'* stem density was significantly greater ($p < 0.001$) than either *Schoenoplectus* or *Typha,* denoted by [A] and [B], respectively.

	Depth (m)			Stem Density (stems/m^2)		
Emergent Species						
Phragmites[A]	1.1	±	0.2	68.5	±	38.3
Schoenoplectus[B]	1.3	±	0.2	44.5	±	26.5
Typha[B]	1.3	±	1.2	41.1	±	21.8
Gear Type						
Large Mesh	1.2	±	0.2	53.4	±	32.2
Small Mesh	1.3	±	1.2	48.2	±	31.3
Windermere	1.2	±	0.2	52.6	±	32.6

Table 3. Total number of fish captured of each species in nets, across all net sites in St. Clair River delta, 2017. Species in **bold** are Species At Risk.

	Total Number Caught					
Species (Common Name)	**Large Mesh**	**Small Mesh**	**Windermere**	**Fyke Nets (24 hr.)**	**Windermere (24 hr.)**	**All Gear (Night)**
Black Crappie	0	0	0	2	0	0
Blackchin Shiner	0	4	0	78	0	0
Blacknose Shiner	0	0	0	16	0	0
Bluegill	1	1	114	139	9	12
Bowfin	0	0	0	4	0	0
Brook Silverside	0	1	0	6	0	0
Brown Bullhead	0	0	1	2	0	1
Common Carp	0	0	0	3	0	0
Emerald Shiner	0	2	0	0	0	0
Gizzard Shad	0	0	0	10	0	0
Golden Shiner	0	1	0	28	0	0
Grass Pickerel	2	**1**	1	1	0	**0**
Lake Chubsucker	0	**1**	0	**26**	4	**0**
Largemouth Bass	1	4	713	131	6	7
Lepomis sp.	0	0	19	27	145	0
Longnose Gar	1	0	0	0	0	0
Northern Pike	0	0	0	1	1	0
Pugnose Shiner	0	0	0	2	0	0
Pumpkinseed	1	0	119	64	1	0
Rock Bass	0	0	10	35	5	2
Smallmouth Bass	0	2	1	2	0	0
Spotfin Shiner	0	0	0	37	4	0
Tadpole Madtom	0	0	0	0	0	4
Tubnose Goby	0	0	0	1	1	0
Yellow Bullhead	0	0	0	11	0	3
Yellow Perch	1	1	2	26	0	0
Total Catch	7	18	980	652	176	33
Species Richness	**6**	**10**	**9**	**23**	**9**	**6**

Table 4. Mean catch per unit effort (CPUE, fish/m^2/hour) ± standard deviation and percent (%) of nets that caught fish in each vegetation type. Fyke nets were only fished in *Phragmites*.

Vegetation Type	**Gear**	**Mean CPUE (± SD)**	**% Fished**
Schoenoplectus	Large Mesh	0.03 ± 0.06	20
	Small Mesh	0.05 ± 0.09	30
	Windermere	0.35 ± 0.45	70
Typha	Large Mesh	0.05 ± 0.11	20
	Small Mesh	0.09 ± 0.14	40
	Windermere	0.52 ± 0.73	70
Phragmites	Large Mesh	0.03 ± 0.08	10
	Small Mesh	0.17 ± 0.20	60
	Windermere	2.20 ± 6.48	100
	Windermere*	0.15 ± 0.11	100
	Fyke Net	0.30 ± 0.26	100
All	Large Mesh	0.04 ± 0.01	17
	Small Mesh	0.10 ± 0.05	43
	Windermere	1.02 ± 0.83	80
	Windermere*	0.34 ± 0.19	80

*value when Fish Bay site is excluded.

Table 5. Mean Catch per unit effort (fish/m^2/hr) ± standard deviation and total catch from all sites, grouped by gear type.

Location	Gear Type		Mean CPUE (± SD)			Total Catch
Bass Bay	Large Mesh		0.0	±	0.0	0
Bass Bay	Small Mesh		0.1	±	0.2	2
Bass Bay	Windermere		0.4	±	0.6	34
		Total	**0.3**	**±**	**0.5**	**36**
Fish Bay	Large Mesh		0.2	±	0.2	4
Fish Bay	Small Mesh		0.1	±	0.1	2
Fish Bay	Windermere		7.7	±	19.8	765
		Total	**5.2**	**±**	**16.3**	**771**
Goose Lake	Large Mesh		0.1	±	0.2	1
Goose Lake	Small Mesh		0.3	±	0.3	3
Goose Lake	Windermere		0.4	±	0.6	20
		Total	**0.3**	**±**	**0.5**	**24**
Johnston Bay South	Large Mesh		0.0	±	0.1	1
Johnston Bay South	Small Mesh		0.1	±	0.1	2
Johnston Bay South	Windermere		0.5	±	0.8	50
		Total	**0.4**	**±**	**0.7**	53
Johnston Bay West	Large Mesh		0.0	±	0.0	0
Johnston Bay West	Small Mesh		0.1	±	0.1	3
Johnston Bay West	Windermere		0.2	±	0.2	19
		Total	**0.2**	**±**	**0.2**	**22**
Lower Chematogan	Large Mesh		0.0	±	0.0	0
Lower Chematogan	Small Mesh		0.1	±	0.2	2
Lower Chematogan	Windermere		0.1	±	0.2	11
		Total	**0.1**	**±**	**0.2**	**13**
Lower Strahns Bay	Large Mesh		0.0	±	0.0	0
Lower Strahns Bay	Small Mesh		0.1	±	0.1	1
Lower Strahns Bay	Windermere		0.0	±	0.1	2
		Total	**0.0**	**±**	**0.1**	**3**
Shut In Bay	Large Mesh		0.0	±	0.1	1
Shut In Bay	Small Mesh		0.0	±	0.1	1
Shut In Bay	Windermere		0.8	±	1.3	74
		Total	**0.5**	**±**	**1.1**	**76**
Upper Basset	Large Mesh		0.0	±	0.0	0
Upper Basset	Small Mesh		0.0	±	0.0	0
Upper Basset	Windermere		0.0	±	0.1	2
		Total	**0.0**	**±**	**0.0**	**2**
Upper Strahns Bay	Large Mesh		0.0	±	0.0	0
Upper Strahns Bay	Small Mesh		0.1	±	0.2	2
Upper Strahns Bay	Windermere		0.0	±	0.1	3
		Total	**0.0**	**±**	**0.1**	**5**
Bass Bay	Fyke		0.79	±	0.08	340
Goose Lake	Fyke		0.18	±	0.07	312
		Total	**0.48**	±	**na**	**652**

Table 6. Mean length ± standard deviation of all captured species with all gear types**.**

Species	Large Mesh	Small Mesh	Windermere	Fyke
Black Crappie				236 ± 1
Blackchin Shiner		49 ± 4		46 ± 5
Blacknose Shiner				41 ± 11
Bluegill	82 ±		49 ± 17	89 ± 51
Bowfin				441 ± 61
Brook Silverside		71 ±		47 ± 26
Brown Bullhead			260 ±	248 ± 3
Common Carp				243 ± 17
Emerald Shiner		54 ± 10		
Gizzard Shad				39 ± 5
Golden Shiner		65 ±		44 ± 11
Grass Pickerel	248 ± 25	147 ±	111 ±	91 ±
Lake Chubsucker		46 ±		38 ± 4
Largemouth Bass	457 ±	49 ± 5	27 ± 12	48 ± 9
Lepomis sp.			23 ± 3	23 ± 3
Longnose Gar	690 ±			
Northern Pike				139 ±
Pugnose Shiner				43 ± 6
Pumpkinseed			54 ± 8	85 ± 27
Rock Bass			111 ± 53	173 ± 33
Smallmouth Bass		54 ±	26 ±	60 ± 4
Spotfin Shiner				69 ± 10
Tubenose Goby				34 ±
Yellow Bullhead				181 ± 115
Yellow Perch	182 ±	177 ±	38 ± 7	72 ± 32

Note: Where there is no value after ±, there were not enough samples to calculate SD.

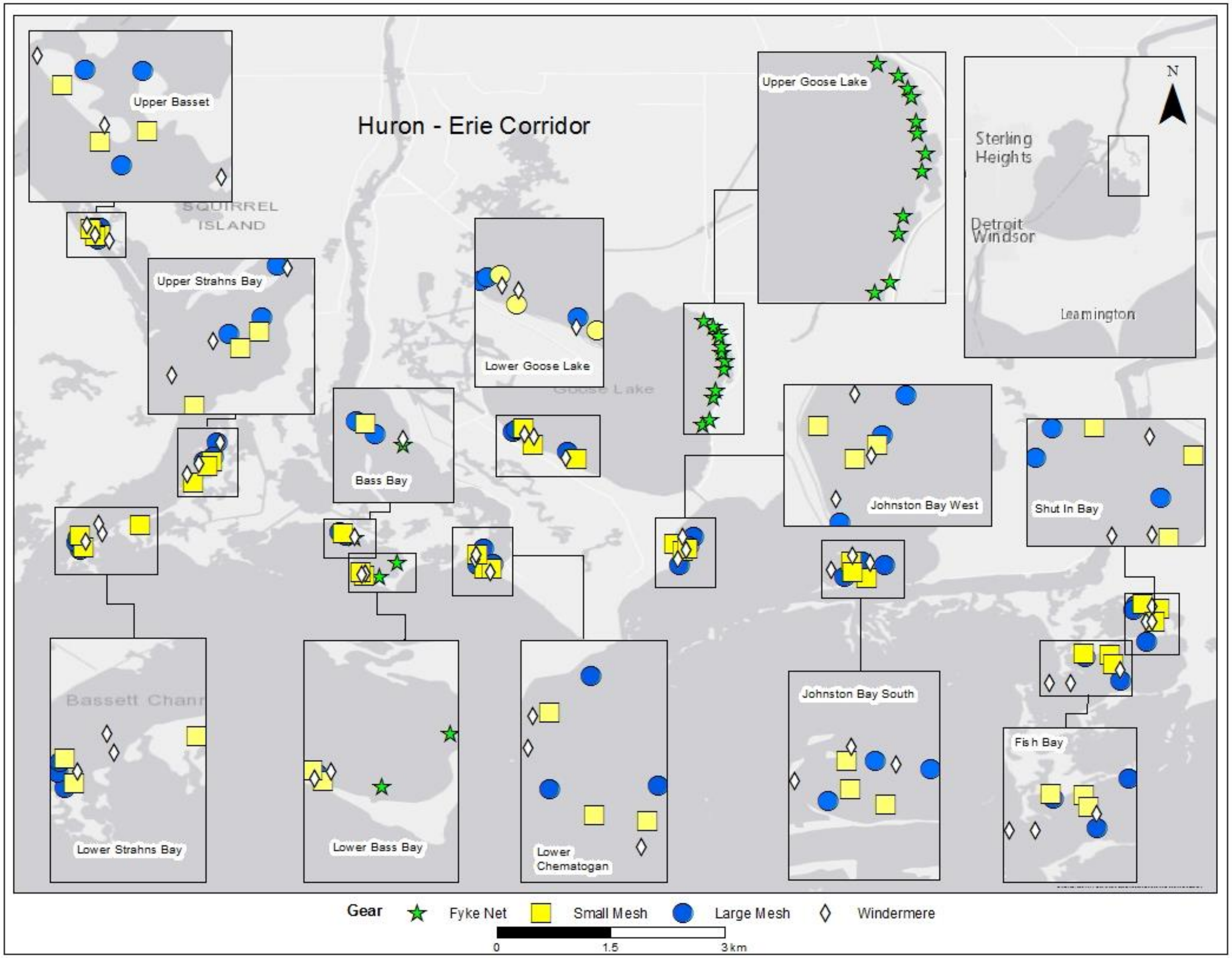

Figure 1. Sampling site locations in the St. Clair River delta (2017) for four different fishing gear types.

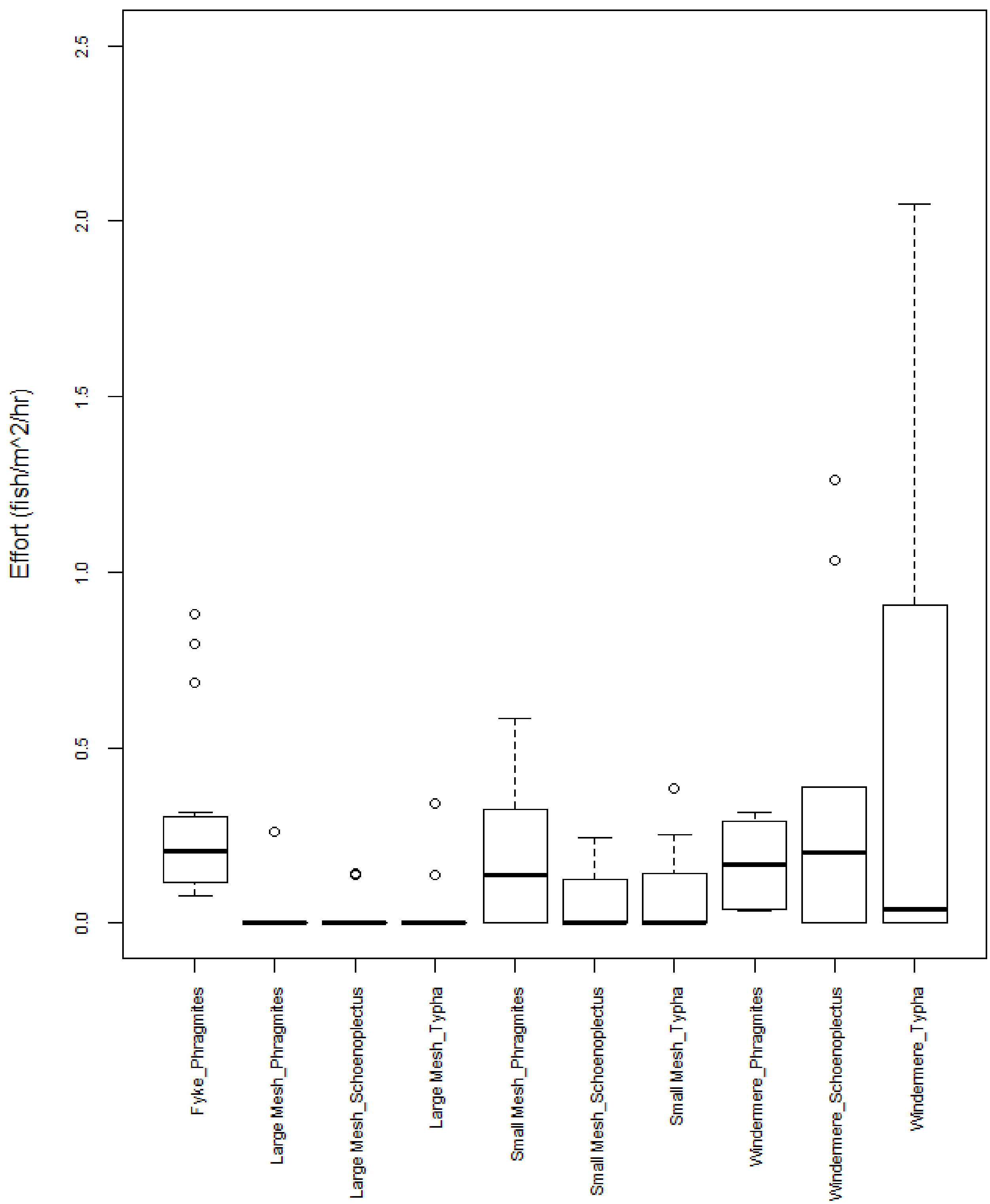

Figure 2. Boxplot of fish caught (fish/m^2/hr) across vegetation stands and gear types in the St. Clair River delta, 2017. Non-parametric paired comparisons across gear type detected significantly greater CPUE in Windermere traps than either small- or large-mesh gill nets (Wilcoxon's signed rank test: $p < 0.05$, df = 8 for small-mesh gill nets; $p < 0.01$, df = 8 for large-mesh gill nets).

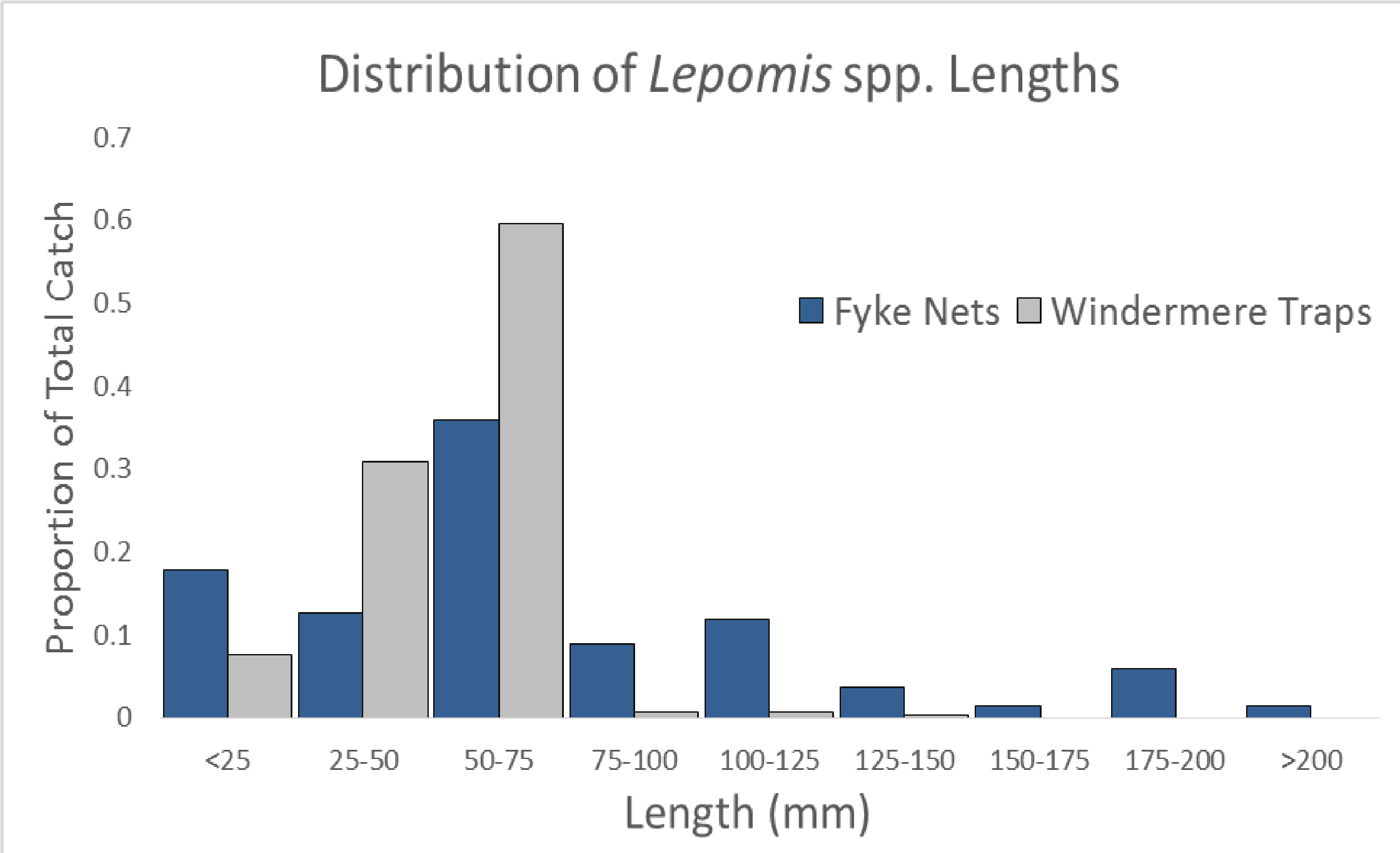

Figure 3. Distribution of *Lepomis* spp. lengths for Fyke nets and Windermere traps.

APPENDIX

Table A1. Mean Catch per unit effort (fish/m^2/hr and fish/hr) and total catch from all sites, grouped by gear type, and vegetation type. This table is a reference of the raw data we used for statistical analyses.

Location	Site Code	Gear Type	Emergent Vegetation	CPUE fish/m^2/hr	CPUE fish/hr
Bass Bay	BB-E-4	Fyke	*Phragmites*	0.68	4.69
Bass Bay	BB-E-5	Fyke	*Phragmites*	0.80	5.45
Bass Bay	BB-E-6	Fyke	*Phragmites*	0.88	6.01
Goose Lake	GL-E-10	Fyke	*Phragmites*	0.20	1.40
Goose Lake	GL-E-7	Fyke	*Phragmites*	0.29	1.98
Goose Lake	GL-E-9	Fyke	*Phragmites*	0.08	0.53
Goose Lake	GL-E-8	Fyke	*Phragmites*	0.21	1.42
Goose Lake	GL-E-11	Fyke	*Phragmites*	0.11	0.78
Goose Lake	GL-E-12	Fyke	*Phragmites*	0.19	1.28
Goose Lake	GL-E-6	Fyke	*Phragmites*	0.32	2.17
Goose Lake	GL-E-5	Fyke	*Phragmites*	0.18	1.25
Goose Lake	GL-E-2	Fyke	*Phragmites*	0.10	0.70
Goose Lake	GL-E-1	Fyke	*Phragmites*	0.11	0.74
Goose Lake	GL-E-3	Fyke	*Phragmites*	0.12	0.82
Goose Lake	GL-E-4	Fyke	*Phragmites*	0.23	1.55
Bass Bay	BB-PH-1	Large Mesh	*Phragmites*		
Bass Bay	BB-SCH-2	Large Mesh	*Schoenoplectus*		
Bass Bay	BB-TYP-3	Large Mesh	*Typha*		
Fish Bay	FB-PH-3	Large Mesh	*Phragmites*		
Fish Bay	FB-SCH-1	Large Mesh	*Schoenoplectus*	0.14	0.27
Fish Bay	FB-TYP-2	Large Mesh	*Typha*	0.34	0.68
Goose Lake	GL-SCH-2	Large Mesh	*Schoenoplectus*		
Goose Lake	GL-PH-2	Large Mesh	*Phragmites*	0.26	0.52
Goose Lake	GL-TYP-2	Large Mesh	*Typha*		
Johnston Bay South	JBS-TYP-3	Large Mesh	*Typha*	0.14	0.27
Johnston Bay South	JBS-SCH-1	Large Mesh	*Schoenoplectus*		
Johnston Bay South	JBS-PH-3	Large Mesh	*Phragmites*		
Johnston Bay West	JBW-SCH-2	Large Mesh	*Schoenoplectus*		
Johnston Bay West	JBW-TYP-1	Large Mesh	*Typha*		
Johnston Bay West	JBW-PH-2	Large Mesh	*Phragmites*		
Lower Chematogan	LC-PH-3	Large Mesh	*Phragmites*		
Lower Chematogan	LC-SCH-3	Large Mesh	*Schoenoplectus*		
Lower Chematogan	LC-TYP-3	Large Mesh	*Typha*		
Lower Strahns Bay	LSB-PH-1	Large Mesh	*Phragmites*		
Lower Strahns Bay	LSB-SCH-3	Large Mesh	*Schoenoplectus*		
Lower Strahns Bay	LSB-TYP-1	Large Mesh	*Typha*		
Shut In Bay	SI-TYP-2	Large Mesh	*Typha*		
Shut In Bay	SI-SCH-1	Large Mesh	*Schoenoplectus*	0.14	0.29
Shut In Bay	SI-PH-1	Large Mesh	*Phragmites*		

Location	Site Code	Gear Type	Emergent Vegetation	CPUE fish/m^2/hr	CPUE fish/hr
Upper Basset	UB-PH-1	Large Mesh	*Phragmites*		
Upper Basset	UB-TYP-3	Large Mesh	*Typha*		
Upper Basset	UB-SCH-3	Large Mesh	*Schoenoplectus*		
Upper Strahns Bay	USB-TYP-1	Large Mesh	*Typha*		
Upper Strahns Bay	USB-SCH-1	Large Mesh	*Schoenoplectus*		
Upper Strahns Bay	USB-PH-1	Large Mesh	*Phragmites*		
Bass Bay	BB-TYP-2	Small Mesh	*Typha*		
Bass Bay	BB-PH-2	Small Mesh	*Phragmites*	0.34	0.68
Bass Bay	BB-SCH-3	Small Mesh	*Schoenoplectus*		
Fish Bay	FB-PH-2	Small Mesh	*Phragmites*	0.14	0.29
Fish Bay	FB-TYP-1	Small Mesh	*Typha*	0.14	0.29
Fish Bay	FB-SCH-2	Small Mesh	*Schoenoplectus*		
Goose Lake	GL-PH-3	Small Mesh	*Phragmites*	0.58	1.17
Goose Lake	GL-TYP-1	Small Mesh	*Typha*	0.25	0.50
Goose Lake	GL-SCH-3	Small Mesh	*Schoenoplectus*		
Johnston Bay South	JBS-PH-1	Small Mesh	*Phragmites*		
Johnston Bay South	JBS-TYP-1	Small Mesh	*Typha*	0.13	0.25
Johnston Bay South	JBS-SCH-2	Small Mesh	*Schoenoplectus*	0.12	0.25
Johnston Bay West	JBW-PH-3	Small Mesh	*Phragmites*	0.13	0.26
Johnston Bay West	JBW-TYP-2	Small Mesh	*Typha*		
Johnston Bay West	JBW-SCH-3	Small Mesh	*Schoenoplectus*	0.24	0.49
Lower Chematogan	LC-PH-2	Small Mesh	*Phragmites*	0.32	0.65
Lower Chematogan	LC-SCH-2	Small Mesh	*Schoenoplectus*		
Lower Chematogan	LC-TYP-1	Small Mesh	*Typha*		
Lower Strahns Bay	LSB-SCH-2	Small Mesh	*Schoenoplectus*		
Lower Strahns Bay	LSB-PH-2	Small Mesh	*Phragmites*	0.16	0.33
Lower Strahns Bay	LSB-TYP-2	Small Mesh	*Typha*		
Shut In Bay	SI-PH-3	Small Mesh	*Phragmites*		
Shut In Bay	SI-TYP-3	Small Mesh	*Typha*		
Shut In Bay	SI-SCH-2	Small Mesh	*Schoenoplectus*	0.15	0.30
Upper Basset	UB-PH-2	Small Mesh	*Phragmites*		
Upper Basset	UB-TYP-2	Small Mesh	*Typha*		
Upper Basset	UB-SCH-2	Small Mesh	*Schoenoplectus*		
Upper Strahns Bay	USB-TYP-2	Small Mesh	*Typha*	0.38	0.77
Upper Strahns Bay	USB-PH-2	Small Mesh	*Phragmites*		
Upper Strahns Bay	USB-SCH-2	Small Mesh	*Schoenoplectus*		
Bass Bay	BB-PH-3	Windermere	*Phragmites*	0.66	0.75
Bass Bay	BB-SCH-1	Windermere	*Schoenoplectus*	1.15	1.30
Bass Bay	BB-TYP-1	Windermere	*Typha*	3.15	3.57
Fish Bay	FB-TYP-3	Windermere	*Typha*	5.34	6.05
Fish Bay	FB-PH-1	Windermere	*Phragmites*	82.56	93.45
Fish Bay	FB-SCH-3	Windermere	*Schoenoplectus*	4.14	4.69
Goose Lake	GL-PH-1	Windermere	*Phragmites*	0.67	0.75
Goose Lake	GL-SCH-1	Windermere	*Schoenoplectus*		
Goose Lake	GL-TYP-3	Windermere	*Typha*	3.62	4.10
Johnston Bay South	JBS-TYP-2	Windermere	*Typha*		

Location	Site Code	Gear Type	Emergent Vegetation	CPUE fish/m^2/hr	CPUE fish/hr
Johnston Bay South	JBS-PH-2	Windermere	*Phragmites*	1.26	1.43
Johnston Bay South	JBS-SCH-3	Windermere	*Schoenoplectus*	5.05	5.71
Johnston Bay West	JBW-PH-1	Windermere	*Phragmites*	1.16	1.32
Johnston Bay West	JBW-SCH-1	Windermere	*Schoenoplectus*	1.56	1.76
Johnston Bay West	JBW-TYP-3	Windermere	*Typha*		
Lower Chematogan	LC-SCH-1	Windermere	*Schoenoplectus*	1.39	1.57
Lower Chematogan	LC-PH-1	Windermere	*Phragmites*	0.31	0.35
Lower Chematogan	LC-TYP-2	Windermere	*Typha*		
Lower Strahns Bay	LSB-TYP-3	Windermere	*Typha*	0.14	0.15
Lower Strahns Bay	LSB-PH-3	Windermere	*Phragmites*	0.13	0.15
Lower Strahns Bay	LSB-SCH-1	Windermere	*Schoenoplectus*		
Shut In Bay	SI-SCH-3	Windermere	*Schoenoplectus*	0.44	0.50
Shut In Bay	SI-PH-2	Windermere	*Phragmites*	0.88	1.00
Shut In Bay	SI-TYP-1	Windermere	*Typha*	8.20	9.29
Upper Basset	UB-TYP-1	Windermere	*Typha*	0.15	0.17
Upper Basset	UB-PH-3	Windermere	*Phragmites*	0.14	0.16
Upper Basset	UB-SCH-1	Windermere	*Schoenoplectus*		
Upper Strahns Bay	USB-PH-3	Windermere	*Phragmites*	0.15	0.17
Upper Strahns Bay	USB-SCH-3	Windermere	*Schoenoplectus*	0.15	0.17
Upper Strahns Bay	USB-TYP-3	Windermere	*Typha*	0.15	0.17

Table A2. Total turtles caught in gear types for each sampling location in 2017, grouped by species. Specific locations have been withheld to protect any species at risk.

Location	Gear	Snapping	Painted	Map	Musk	Blandings	Total Turtles
Bass Bay	Fyke Net	3			1		4
Fish Bay	Fyke Net	3	5				8
Goose Lake	Fyke Net	5	7	1	3		16
Goose Lake	Windermere		1		1		2
Johnston Bay South	Fyke Net	5	6				10
Johnston Bay South	Windermere		1				1
Johnston Bay West	Fyke Net		1	1	1		3
Johnston Bay West	Windermere		1				1
Shut In Bay	Fyke Net	1	1				2
Upper Strahns Bay	Fyke Net				1		1

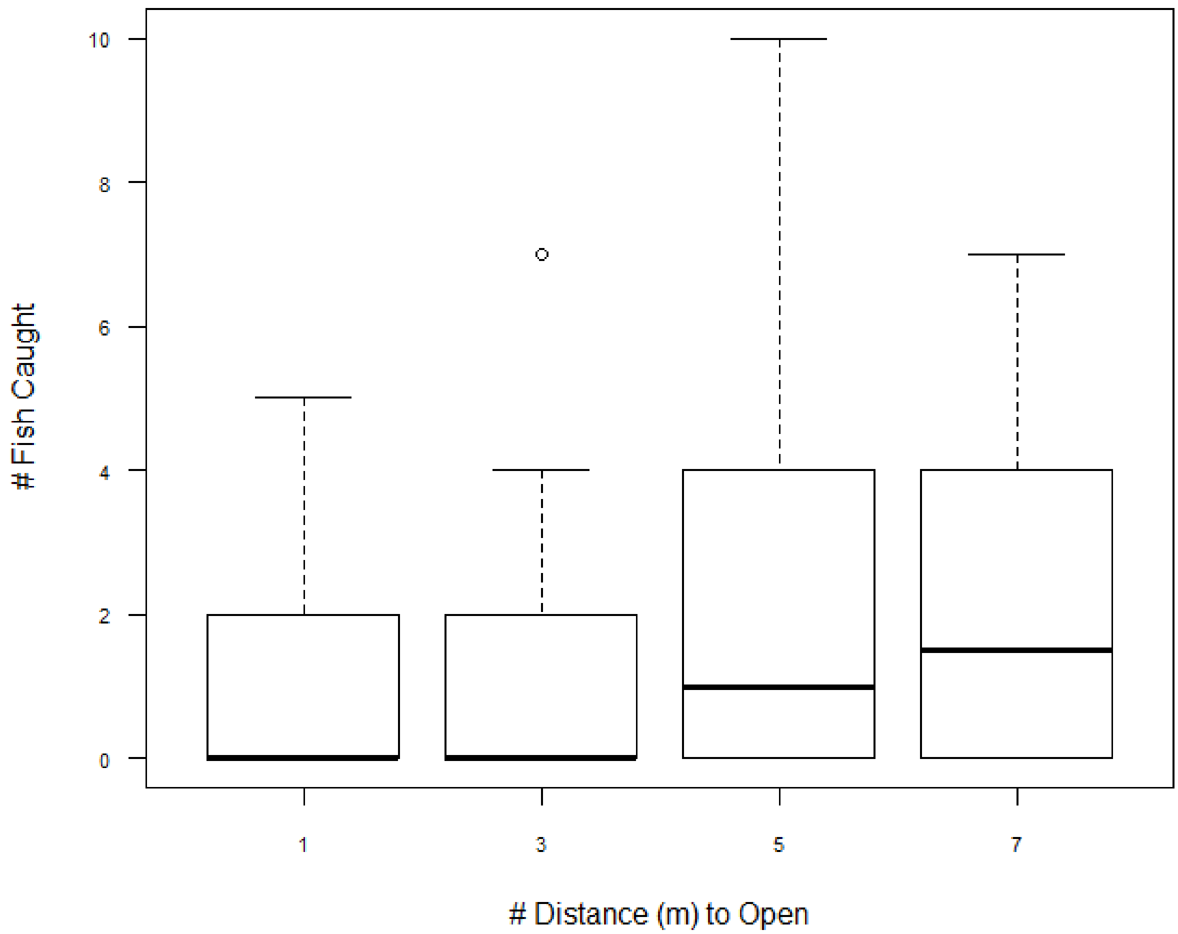

Figure A1. Mean ± standard deviation of fish caught for Windermere traps during the day for all sites in the St. Clair River delta, 2017.