ASSESSING ABUNDANCE OF CENTRARCHIDS AND JUVENILE YELLOW PERCH IN NORTHERN WISCONSIN LAKES WITH DIFFERENT WALLEYE RECRUITMENT HISTORIES

By

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Abstract

Walleye *Stizostedion vitreum* recruitment in some northern Wisconsin lakes has declined because of recruitment bottlenecks occurring at or before mid-July and these declines have coincided with increases in adult Largemouth Bass *Micropterus salmoides* abundance. Increased abundance of adult Largemouth Bass may be an indicator that abundance of juvenile Largemouth Bass and other centrarchids has increased. However, standard sampling gears used by the Wisconsin Department of Natural Resources do not effectively sample fish < 100 mm total length (TL) making it difficult to evaluate trends in juvenile centrarchid abundance. These small centrarchids may interact with larval Walleye through predation or competition. Yellow Perch *Perca flavescens* are another important component of these fish communities, yet data needed for indexing trends in perch recruitment are not available because targeted sampling is not conducted. Consequently, the objectives of my research were to determine if: 1) sampling precision, efficiency, and length and age frequency distributions of centrarchids and juvenile Yellow Perch varied among multiple sampling gears that might be used to target fish < 100 mm TL; 2) a qualitative index of small fishes based on visual assessment during electrofishing accurately reflected overall abundance of fish ≤ 75 mm TL; 3) Walleye recruitment success was related to current relative abundance estimates for centrarchids and juvenile Yellow Perch; and 4) Walleye recruitment success was related to historical measures of centrarchid and juvenile Yellow Perch relative abundance.

In 2019 and 2020, eleven lakes in northern Wisconsin were sampled using mini-fyke nets, cloverleaf traps, modified boat electrofishing, and electrofishing from a boat using a hand-held probe. Modified boat electrofishing is similar to standard boat electrofishing except boat speed was reduced and netters focused on capturing small fish (≤ 150 mm TL) and used dip nets with finer mesh (4.76-mm). No gear was effective at sampling Black Crappie *Pomoxis nigromaculatus*, Rock Bass *Ambloplites rupestris*, and Pumpkinseed *Lepomis gibbosus*. Mini-fyke nets were the only gear that were able to catch ≥ 50 Smallmouth *Micropterus dolomieu* and Largemouth Bass in more than two lakes. For Bluegill *Lepomis macrochirus* and Yellow Perch, modified boat electrofishing had the most precise catch per effort (CPE) and required the fewest number of samples to detect a 50% change in mean CPE; however, cloverleaf traps required fewer 8-h workdays to detect a 50% change in mean CPE. These gears may be effective to index year-class strength of these species, but future research will need to determine if relative abundance of fish captured in these gears can accurately predict year-class strength.

A qualitative approach for estimating abundances of small fish (≤ 75 mm TL) using observations made by netters while boat electrofishing did not significantly correlate with summed CPE estimates for overall abundance of small fish, but did significantly correlate with individual estimates of Yellow Perch and *Lepomis* spp. Probability of Walleye recruitment success was not related to relative abundance of centrarchids or Yellow Perch in contemporary sampling (2019–2020). Probability of historical Walleye recruitment success from 1997–2006 was positively related to relative abundance of Yellow Perch and Smallmouth Bass in mini-fyke net sampling conducted from 2000–2006. Our results indicate that additional effort to understand Yellow Perch and Walleye relationships and Yellow Perch recruitment trends is warranted and this information could contribute to a better understanding of Walleye recruitment trends and fish community shifts in north temperate lakes.

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Introduction

Sustainability of recreational fisheries relies upon successful recruitment (Beverton and Holt 1957; Maceina and Pereira 2007), yet recruitment is notoriously variable (Sissenwine 1984; Houde 2009) as small fluctuations in juvenile survival rates can lead to large changes in year-class strength (Houde 1987, 1989). Factors influencing early survival can be complex and difficult to understand as they are regulated by direct and indirect processes influenced by multiple abiotic and biotic factors (Ludsin et al. 2014). Nevertheless, understanding the mechanisms driving recruitment variation is crucial to effective fisheries management (Ricker 1975; Sissenwine 1984). In particular, understanding the causes of low or failed recruitment is important in identifying where management actions like stocking or more restrictive harvest regulations are warranted (Noble 1986; Isermann and Paukert 2010; Trushenski et al. 2010).

In some north temperate lakes, poor recruitment and apparent population declines in Walleye *Stizostedion vitreum* (Robillard and Fox 2006; Bethke and Staples 2015; Rypel et al. 2018) are concerning as Walleye support important recreational and subsistence fisheries (Embke et al. 2020; Mrnak et al. 2018) and play ecologically significant roles in lakes as predators (Nate et al. 2011). In Wisconsin, the number of Walleye populations that are supported by natural recruitment has declined, while the number that are supported either in part or totally by stocking has increased (Raabe et al. 2020).

Walleye can exhibit highly variable recruitment which is often related to environmental factors (Bozek et al. 2011). Walleye recruitment has been intensely studied in north temperate systems, and appears to have declined in some lakes due to a recruitment bottleneck occurring in the first year of life (Gostiaux et al. *in press*). Although the exact mechanisms resulting in recruitment declines are currently unknown and likely complex (Peters et al. 2007; Soranno et al. 2014), these declines are potentially related to climate-induced changes in lake environments (Hansen et al. 2015b). Walleye recruitment has been related to temperature (e.g. variation in May water temperature, degree-days, and first winter severity; Hansen et al. 1998, 2015a; Honsey et al. 2020), which may influence synchrony among Walleye populations (Koonce et al. 1977; Schupp 2002; Beard et al. 2003). Moreover, Walleye recruitment declines have coincided with increases in warmwater species like Largemouth Bass *Micropterus salmoides* in Wisconsin (Hansen et al. 2015b, 2015c) and Ontario, Canada (Robillard and Fox 2006), but whether this is an environment-induced correlation or cause-and-effect remains unknown.

Changes in environmental conditions can lead to large-scale declines in certain species while providing for increased prevalence of other species (Lyons et al. 2010; Lynch et al. 2016; Hansen et al. 2017). For example, after analyzing data from 359 lakes in Wisconsin, Hansen et al. (2018) reported the effect of warming temperatures on Walleye recruitment was negative in 198 lakes (55%) and positive in 161 lakes (45%), and the negative effect of warmer temperatures was greater in lakes where adult Largemouth Bass abundance was high. Warming trends resulting from climate change may provide for increased recruitment of Largemouth Bass in northern lakes (Ludsin and DeVries 1997; Parkos and Wahl 2002; DeVries et al. 2009). Predation by adult Largemouth Bass on juvenile Walleyes was hypothesized to be a factor limiting Walleye recruitment, but diet studies have observed low predation (Fayram et al. 2005; Freedman et al. 2012; Kelling et al. 2016) and it is unlikely that adult bass are influencing age-0 Walleye survival in the first two months of life (i.e., when the recruitment bottleneck is occurring). However, it remains possible that young Largemouth Bass (< age 3) may influence Walleye recruitment, but bass of these ages are not routinely collected in standard WDNR sampling. For example, recruitment of age-0 Largemouth Bass is not indexed in Wisconsin as it is in other states by methods such as boat and backpack electrofishing (New Hampshire Fish and Game 2016; Pennsylvania Fish and Boat Commission 2004, 2016). Therefore, there is limited information on the abundance and ecological role of young Largemouth Bass in northern Wisconsin lakes.

Increased abundance of adult Largemouth Bass may also indicate that abundance of centrarchids in general may have increased in northern Wisconsin lakes (Lyons et al. 2010; Alofs et al. 2014). Additional centrarchid species present in most northern Wisconsin lakes include Bluegill *Lepomis macrochirus*, Pumpkinseed *Lepomis gibbosus*, Black Crappie *Pomoxis nigromaculatus*, Rock Bass *Ambloplites rupestris*, and Smallmouth Bass *Micropterus dolomieu* (Becker 1983a). These additional centrarchid species may interact with Walleye in multiple ways. Competition for prey is possible because zooplankton are consumed by larval Walleye (Mathias and Li 1982; Hoxmeier et al. 2006; Bozek et al. 2011) and by centrarchids at multiple life stages depending on species and prey availability (Lemly and Dimmick 1982; Becker 1983a; Cooke and Philipp 2009). However, Gostiaux et al. (*in press*) found no difference in zooplankton abundance between lakes that were classified as having sustained natural recruitment or declining natural recruitment of Walleye, but these analyses were restricted May–June when larval percids were pelagic. Many centrarchid species may be piscivorous at small sizes (Scott and Crossman 1973; Becker 1983b; DeVries et al. 2009), which could result in predation on larval and juvenile Walleye. Boehm (2016) observed no predation of larval Walleye by centrarchids in northern Wisconsin lakes, but most centrarchids examined were > 100 mm TL and this sampling was somewhat limited in scope. However, negative effects on juvenile Walleye have been attributed to centrarchids (Schiavone 1985; Santucci and Wahl 1993; Schneider 1997; Quist et al. 2003). Specifically, juvenile centrarchid density has negatively affected survival of Walleye stocked as juveniles (Hoxmeier et al. 2006), but additional studies are needed to determine if this is true for Walleye populations where stocking does not occur and by what mechanism(s) juvenile centrarchids may be affecting juvenile Walleye. Hence, estimates of centrarchid abundance at early life stages, which may also serve as indices of centrarchid recruitment, are needed (e.g., Michaletz and Siepker 2013; Kaemingk et al. 2014) as WDNR currently has none.

Yellow Perch *Perca flavescens* represent another important component of most northern Wisconsin fish communities (Becker 1983b). Yellow Perch relative abundances and size structure have decreased markedly among Minnesota lakes (Bethke and Staples 2015, Holbrook et al. *in press*), and in Wisconsin, angler catch and harvest rates for Yellow Perch have decreased over time (Feiner et al. 2020). However, little information on Yellow Perch populations is available because targeted sampling for this species is not conducted by the WDNR; although perch are collected in other WDNR sampling efforts (Brandt et al. *in press*; Feiner et al. 2020). Specifically, data needed for indexing trends in Yellow Perch recruitment are not available. Walleye recruitment may exhibit a positive relationship with higher abundances of age-0 Yellow Perch because perch are both a prey item (Maloney and Johnson 1957; Engel et al. 2000) and prey buffer (Forney 1974, 1976) for juvenile Walleyes. Negative interactions are also possible through diet competition because young Yellow Perch consume zooplankton (Mills et al. 1989; Graeb et al. 2006; Roswell et al. 2013), but this is unlikely happening (Gostiaux *in press*). Also, Yellow Perch can shift to piscivory at a small size (Graeb et al. 2006; Parker et al. 2009) and have consumed juvenile Walleye as prey (Regier et al. 1969; Colby et al. 1979), but Boehm (2016) suggested that perch predation on Walleye rarely occurs in northern Wisconsin lakes. Initial work has shown that larval Yellow Perch densities were not significantly different between lakes with different Walleye recruitment histories (Gostiaux *in press*).

To determine if juvenile Yellow Perch and centrarchids may affect Walleye recruitment, they must first be effectively sampled. Currently, the WDNR samples centrarchids through means of boat electrofishing (Simonson 2015), but smaller fish are not as susceptible to being captured by electrofishing as larger fish (e.g., Anderson 1995) because effective fish immobilization is related to body size (Dolan and Miranda 2003). Furthermore, netters likely tend to target larger fish (Devries et al. 1995; Rogers et al. 2003) and standard dip nets used by WDNR have 9.5-mm mesh bags (Simonson 2015), which small fish may pass through. However, differences in habitat use and size among species and age-groups within a species can cause considerable variation in capture probability regardless of the gear used to sample fish (Latta 1959; Laarman and Ryckman 1982; Milewski and Willis 1991).

Fyke nets are also used to sample centrarchids and Yellow Perch by the WDNR (Simonson 2015; Feiner et al. 2020). Capture probability of passive capture gears is dependent on fish: 1) encountering the gear; 2) being captured by the gear; and 3) being retained by the gear (Anderson 1998; Hubert et al. 2012). Smaller fish often move less than larger fish of the same species at certain times of the year, making them less likely to encounter a passive gear (e.g., Ridgway et al. 2002). Fyke nets also tend to select for larger fish sizes (Laarman and Ryckman 1982; Milewski and Willis 1991; Kraft and Johnson 1992) as minimum size of fish selected by fyke nets is determined by mesh and throat size (Latta 1959; Shoup et al. 2003). For example, in Wisconsin Yellow Perch are not fully recruited to fyke nets until age-3 at approximately 152–178 mm (Brandt et al. *in press*). Standard fyke nets used by the WDNR have 19.1-mm mesh (bar measure) and 17.9-cm square throats (Simonson 2015). Therefore, the standard sampling gears (boat electrofishing and fyke nets) used by the WDNR may not effectively sample fish < 100 mm total length (TL), yet fish < 100 mm TL. Consequently, there is little information available to assess trends in overall centrarchid and Yellow Perch abundance because large segments of the populations are not fully vulnerable to capture with current standard sampling gears.

Multiple sampling gears have been used to capture small fish (see Chapters 6-9 in Zale et al. 2012), but all gears have species- and length-related biases (Bonar et al. 2009), and differ in terms of effort needed to meet sampling objectives (e.g., Van Den Avyle et al. 1995; Collins et al. 2017). Effective sampling techniques need to provide precise estimates of length distributions and relative abundance with minimal sampling effort (Colvin 2000). A multi-gear approach is likely needed to effectively sample multiple species and sizes of fish in a population (e.g., Ruetz et al. 2007; Clement et al. 2014; Koch et al. 2014). Some methods used to sample small fish that may be effective at indexing juvenile centrarchids and Yellow Perch include mini-fyke nets (Weaver et al. 1993; Fago 1998), cloverleaf traps (Jolley et al. 2010; Kaemingk and Willis 2012; Sullivan et al. 2019), a hand-held electrofishing probe used from a boat (Jackson and Noble 1995; Sammons et al. 1999), and visual assessment (Brewer and Ellersieck 2011). Mini-fyke nets have successfully captured small centrarchids and Yellow Perch (Weaver et al. 1993; Fago 1998). Cloverleaf traps have been used to sample small fish including Bluegill, Black Crappie, and Yellow Perch (Weber and Brown 2012; Kaemingk and Willis 2012; Sullivan et al. 2019). Electrofishing using a hand-held probe from a boat has been used to sample juvenile Largemouth Bass (Jackson and Noble 1995; Sammons et al. 1999) and may be an effective method to sample other small fish. Both above and below water visual assessment has been used to determine the distribution and abundance of age-0 smallmouth bass in rivers (Brewer and Ellersieck 2011) and may be an effective technique for centrarchids and Yellow Perch in lakes.

The goals of my research were to better understand centrarchid and Yellow Perch populations in northern Wisconsin lakes and to assess whether abundance of these species were related to Walleye recruitment success. Consequently, the objectives of my research were to determine if: 1) sampling precision, efficiency, and length and age frequency distributions of centrarchids and juvenile Yellow Perch vary among multiple sampling gears that might be used to target fish < 100 mm TL; 2) a qualitative index of small fishes based on visual assessment during electrofishing accurately reflects overall abundance of fish ≤ 75 mm TL; 3) Walleye recruitment success is related to current relative abundance estimates for centrarchids and juvenile Yellow Perch; and 4) Walleye recruitment success was related to historical measures of centrarchid and juvenile Yellow Perch relative abundance.

Methods

Data Collection

Sampling for objectives 1–3 occurred in northern Wisconsin on 11 of the 13 lakes used by Gostiaux et al. (*in press*) to identify timing of Walleye recruitment bottlenecks (Table 1). These lakes were classified as either having “successful” or “unsuccessful” Walleye recruitment using age-0 electrofishing catch rates from 2007–2019. Lakes with mean age-0 Walleye CPE > 6.2 age-0 Walleye/km were classified as supporting successful recruitment (Hansen et al. 2015a, 2018).

Sampling gears used for objectives 1-3 included mini-fyke nets, cloverleaf traps, modified boat electrofishing, and a hand-held electrofishing probe used from a boat. All sampling gears were used to sample shallow habitats (depths < 5 m) in five lakes in northeastern Wisconsin in 2019 and six lakes in northwestern Wisconsin in 2020 from August 1st through September 15th of each year (Table 1). This sampling period was selected to avoid spring and fall periods when WDNR sampling efforts are already intensive, as the potential of WDNR to adopt additional sampling procedures at these times would not be possible.

Mini-fyke nets (0.92 x 0.92-m frames, 4.76-mm mesh, 0.61-m diameter hoops, a single 50.8 x 50.8-mm throat, and 25.4-mm mesh exclusion netting) were deployed with the net frames completely submerged by fixing the lead onshore (Sullivan et al. 2019). Lead lengths varied based on habitat the net was set in. Cloverleaf traps (three-lobed, height = 41-cm, 50-cm diameter, 6.0-mm bar wire mesh with 12.7-mm wide opening between lobes, and an attractant [chicken liver]) were deployed near shore and were completely submerged (Sullivan et al. 2019). For two consecutive nights at each lake, mini-fyke nets and clover leaf traps were deployed concurrently by mid-afternoon and lifted the following morning. One cloverleaf trap and one mini-fyke net were set at each location, in the same general kind of habitat, with a minimum of 50 m between the two sets to prevent one gear from influencing catch of the other gear. Targeted number of nets and traps fished per night for lakes < 100 ha, 100–300 ha, and > 300 ha were 6, 8, and 10, respectively. Sampling locations were spatially distributed throughout each lake and selected to reflect representation of major habitat types (e.g., submerged vegetation, sand, rock, and depth). For the second day of sampling, mini-fyke nets and cloverleafs traps were moved a minimum of 100 m from their previous locations, but kept in same habitat type and general area of the lake, to fish a new section of shoreline.

Modified boat electrofishing took place at night using a boat equipped with an AC Wisconsin-style MBS-2DH-40 electrofishing control box (ETS Electrofishing Systems) and two booms equipped with dropper arrays. Boat speeds were reduced from standard boat electrofishing and fish were collected at 20-min shoreline transects. Hand-held electrofishing took place at night from a 4.9 m flat-bottomed aluminum boat with a 60-horsepower motor, using a DC hand-held circular anode powered through a Midwest Lake Electrofishing Systems Infinity Box. This configuration was similar to those used by Jackson and Noble (1995) and Sammons et al. (1999). Fish were collected at 10-min shoreline transects. For both types of electrofishing, starting points of transects were spatially distributed throughout each lake and selected to reflect spatial representation of major habitat types (e.g., submerged vegetation, sand, rock, and depth). Dip nets used for both types of electrofishing had 4.76-mm mesh bags and netters were told to net fish ≤ 150 mm TL. Targeted number transects for lakes < 100 ha, 100–300 ha, and > 300 ha were 4, 5, and 6 for hand-held electrofishing respectively, and 3, 4, and 5, for modified boat electrofishing respectively. In Sand, Spillerberg, and Windfall lakes the last modified boat electrofishing transect was < 20 min because the entire shoreline of each lake was shocked. In Spillerberg and Windfall lakes the last hand-held electrofishing transect was < 10 min because the entire shoreline was shocked.

Fish collected using each gear were identified to species, counted, and a minimum of 20 fish of each species from each net, trap, or transect were measured for total length (TL; mm). *Lepomis* spp. < 30 mm were not easily identified to species and were recorded as unspecified *Lepomis* spp. and TLs were not always measured for these fish. Fish > 150 mm TL were not included in CPE estimates or any analysis as they were rarely caught and were not targeted. For fish ≤ 150 mm TL of each species, five fish from each 10-mm TL group were retained and frozen for removal of otoliths. A crew size of three was used for all types of sampling and time required to complete each type of sampling was recorded for each sampling trip. Whole and cracked otoliths were viewed under a dissecting microscope to estimate age using methods similar to Dembkowski et al. (2017).

Objective 1

Species-specific CPE for each gear were defined as catch per lift for mini-fyke nets and cloverleaf traps, and fish per h for both types of electrofishing. Precision of species-specific CPE estimates among sampling gears were described using coefficients of variation (CV; [SD/mean CPE] × 100). Using methods described by Sullivan et al.

(2019), I estimated the minimum number of samples (one unit of effort of an individual gear) required to detect a 50% change in mean CPE across gear types for each species or species group (e.g., Allen et al. 1999; Tate et al. 2003; Sullivan et al. 2019). I selected a 50% change because it aligns with categorizing populations as having either high or low relative abundance, a useful classification dichotomy for fishery managers. Furthermore, previous research has shown that detecting smaller changes in CPE can require levels of sampling effort that would not be feasible for the WDNR (e.g., Sindt 2018; Sullivan et al. 2019). A significance level of $\alpha = 0.10$ was chosen compared with a conventional value of 0.05. Type II errors were deemed more important than type I errors (e.g., Parkinson et al. 1998; Dauwalter et al. 2010) because I was more concerned about failing to detect a difference in CPE among lakes when a difference existed, rather than detecting a difference when there was none. A statistical power level of $1 - \beta = 0.80$ was used for all sample size estimates since power ≥ 0.80 is deemed acceptable in fisheries survey data (Wagner et al. 2013).

To compare sampling efficiency among gears, I calculated the number of 8-h workdays needed for a crew of three to complete the estimated sampling effort required to detect a specified 50% change in mean CPE (E_{ik}):

$$E_{ik} = N_{ik}H_k/8,$$

where N_{ik} is the number of units of sampling effort needed to detect a 50% change in mean CPE of species i in sampling gear k and H is the hours required to complete one unit of effort for gear k. Hours required to complete one unit of effort were estimated for each gear by recording on-the-water start and stop times for all sampling trips. For example, if 1 h is required to set 4 cloverleaf traps and 3 h are required to lift the traps and process fish (4 h needed for 4 units of effort), 1 h is required to complete one unit of effort. If 30 cloverleaf trap lifts are required to detect a specified change in mean CPE of Bluegill, then approximately 30 h of work or 3.5 workdays would be required to complete the estimated level of sampling effort. The gear requiring the fewest workdays to detect a specified change in mean CPE value was considered the most efficient.

Coefficients of variation, the number of samples required to detect a 50% change in mean CPE, and efficiency, were calculated for each gear in each lake and then averaged across lakes for lakes where at least 50 fish of a species were captured by a specific gear because I considered 50 fish the minimum number needed to describe length and age distributions (Jackson and Noble 1995).

Using age estimates from otoliths, I assigned ages to all fish collected using age–length keys (Isermann and Knight 2005; Ogle 2016). At the end of this process, every fish had an age either directly estimated from otolith or assigned from an age–length key. To average length and age frequencies across lakes where different numbers of fish were caught, composite total length and age frequency distributions were constructed for each species-gear combination by standardizing distributions from individual lakes to 100 fish such that each lake would contribute 100 fish to the composite distribution (N = 1,100 fish if a species was collected by a gear in all 11 lakes). Only gears that captured ≥ 20 fish of an individual species in a lake were included in constructing composite distributions, as < 20 fish was deemed insufficient to accurately determine the lengths of fish that a gear was selecting for. Composite total length and frequency distributions were compared among gears using Kolmogorov-Smirnov tests (K-S test; Conover 1999; Neumann and Allen 2007) using the Fisheries Analysis (FSA) package (version 0.8.30;

Ogle 2016, 2020) in Software Version 4.0.2 (R Core Development Team 2021). Because *Lepomis* spp. < 30 mm TL were not identified to species, age and total length frequency distributions and K-S tests only included fish ≥ 30 mm. Statistical significance was set at $\alpha = 0.05$ and were Bonferroni-corrected to maintain family-wise error rates of 0.05.

Objective 2

To address objective 2, the relative abundance of small fish (approximately ≤ 75 mm TL; all species combined) was assigned a rating (i.e., the confetti index) by netters after completing standard WDNR fall electrofishing surveys on a subset of study lakes in the same years my sampling occurred (L. Eslinger, WDNR, *personal communication*). Observers may not be able discern among species or even families during visual surveys but observed small fishes are likely to include centrarchids, Yellow Perch and Walleye, and other small fish such as cyprinids and darters. Therefore, these observations did not provide specific estimates of centrarchid or Yellow Perch relative abundance. After completion of electrofishing, WDNR personnel were asked to rate the relative abundance of small fish as: poor (observed little or none), fair (observed periodically), good (observed frequently), or excellent (observed abundantly; L. Eslinger, WDNR, *personal communication*). Abundances of individual species (Black Crappie, Bluegill, Pumpkinseed, Rock Bass, Yellow Perch, and cyprinids) were also rated separately as: none, present (< 100), common (100-1,000), or abundant (> 1000; L. Eslinger, WDNR, *personal communication*). Electrofishing surveys were completed by WDNR or Great Lakes Indian Fish and Wildlife Commission personnel. Confetti estimates were assigned for each transect, so whenever there were multiple ratings that differed, biologists were consulted, or the highest index was taken.

I summed CPEs of centrarchids, Yellow Perch, and cyprinids ≤ 75 mm TL from the four sampling gears used in Objective 1 to provide composite relative abundance indices that could be correlated to confetti index ratings that also included fish ≤ 75 mm TL. As cyprinids were not a target species of objective 1, few lengths were recorded. Therefore, all cyprinids caught were included as being ≤ 75 mm TL. Summing CPEs among gears to provide composite indices of abundance is an approach that has been used in previous studies (e.g., Hinch et al. 1991; Phelps et al. 2009, 2014). Specific species and species group indices were developed using the same methods. For example, if CPE of Largemouth Bass ≤ 75 mm TL was 27 per net night for mini fyke nets, and 5 per net night for cloverleaf traps, 6.7 per h in hand-held electrofishing and 12.3 per h in modified boat electrofishing, then the composite index of relative abundance for Largemouth Bass was 51 for that individual lake. These composite indices were unitless given differences in CPE units of measure among gears. Individual confetti index ratings of Bluegill and Pumpkinseed were combined by using the highest rating taken of either species, and Bluegill and Pumpkinseed CPEs were grouped, to create a *Lepomis* spp. group. Kendall rank correlation tests were used to determine if ranked confetti index ratings were correlated with ranked multi-species, species group, species-specific composite indices of abundance for my sampling gears used to address Objective 1. Statistical significance was set at $\alpha = 0.05$.

Objective 3

Similar to objective 2, I summed CPEs from the four sampling gears used in Objective 1 to provide composite indices of centrarchid and Yellow Perch relative abundance, but in this case fish ≤ 150 mm TL were included rather than just fish ≤ 75 mm TL. Species-specific and species group indices were developed using the same methods. Bluegills and Pumpkinseeds were grouped for this analysis to create a *Lepomis spp.* group. I then tested whether the probability of a lake supporting successful Walleye recruitment was related to multi-species, species group, and species-specific composite indices of centrarchids and juvenile Yellow Perch relative abundance, using logistic regression:

$$ln\left(\frac{p}{1-p}\right) = a + \beta_1 X$$

where p is the probability of successful Walleye recruitment, a is the intercept (the natural log of odds of Walleye recruitment being successful relative to being unsuccessful), and β_1 is the regression coefficient for a predictor variable X (i.e., centrarchids or Yellow Perch). Statistical significance was set at $\alpha = 0.05$.

Objective 4

To address objective 4, I used historical (2000–2006) estimates of centrarchid and juvenile Yellow Perch abundance in mini-fyke net surveys, that were available for 489 Wisconsin lakes, but not all lakes were included in my analyses. Mini-fyke net surveys were conducted from July through September as a panfish and community assessment tool (Treaty Fisheries Assessment Team (TFAT 2005; Simonson 2006). Mini-fyke nets typically had either 0.92 x 0.61-m or 0.92 x 0.92-m frames, 4.76-mm mesh, 0.61-m diameter hoops, and sometimes 25.4-mm mesh exclusion netting and were fished 1–2 d on each lake in all major habitat types in each lake (TFAT 2005; Simonson 2006). On lakes ≤ 202 ha, at least 6 nets were fished, and on lakes > 202 ha, at least 8 nets were fished (TFAT 2005; Simonson 2006).

Lakes where mini-fyke netting occurred were classified as having “successful” or “unsuccessful” Walleye recruitment based on mean CPE of age-0 Walleye in fall electrofishing conducted from 1997–2006. I included age-0 Walleye CPE from 1997–1999 in our analyses because most lakes were not electrofished in every year and this increased the number of lakes where electrofishing sampling had been conducted in more than one year. Lakes with mean age-0 Walleye CPE > 6.2 age-0 Walleye/km were classified as supporting successful recruitment (Hansen et al. 2015a, 2018). Using logistic regression, I tested whether the probability that a lake supported successful Walleye recruitment from 1997–2006 was related to multispecies, species group, and species-specific composite indices of centrarchid (Black Crappie, Largemouth Bass, *Lepomis* spp., Rock Bass, and Smallmouth Bass) and juvenile Yellow Perch relative abundance in mini-fyke nets. Relative abundances (CPE) for each species or species group were calculated as fish per net-night. Lakes included in this analysis had more than one annual estimate of age-0 Walleye CPE from 1997–2006. Statistical significance was set at α = 0.05.

Results

Objective 1

No gear was able to capture ≥ 50 Rock Bass in any lake and in only 2 instances did any gear (one lake for hand-held electrofishing and one lake for mini-fyke nets) catch ≥ 50 Black Crappie in a single lake; (Table 2).

Mini-fyke nets were the only gear that captured ≥ 50 Largemouth Bass in any lake (*N* = 6 lakes*;* Table 2). Modified boat and hand-held electrofishing captured Largemouth Bass; however, 17 to 44 electrofishing transects would be required to collect 50

Largemouth Bass (Appendix 1). Of the Largemouth Bass captured by mini-fyke nets, 99% were age-0 and < 100 mm TL (Figures 1, 2). Of the Largemouth Bass captured by modified boat electrofishing, 85% were age-0 (Figure 2) and 89% were < 100 mm TL (Figure 1). Of the Largemouth Bass captured by hand-held electrofishing, 85% were age-0 and < 100 mm TL (Figures 1, 2). Mean CV for mini-fyke nets was 100%, number of replicates to detect a 50% change in CPE was 111, hours per replicate was 0.47, and the number of workdays to detect a 50% change in mean CPE was 6 (Table 2).

Mini-fyke net sampling caught ≥ 50 Smallmouth Bass in 5 lakes which was more frequent than modified and hand-held electrofishing (*N* = 2 lakes) and cloverleaf traps (no lakes; Table 2). Smallmouth Bass captured by mini-fyke nets and hand-held electrofishing were almost always (99%) age-0 and < 100 mm TL (Figures 1, 2). Modified boat electrofishing caught a few larger Smallmouth Bass, but 94% were < 100 mm (Figure 1) and 95% were age-0 (Figure 2). Length and age frequencies were similar among gears in all instances except in Escanaba Lake where lengths captured by hand-held electrofishing and mini-fyke nets were significantly different (Table 3). In Escanaba Lake 11% of fish captured by mini-fyke nets (N = 677) were ≥ 70 mm TL, while only 4% of fish captured by hand-held electrofishing (N = 236) were ≥ 70 mm TL.

In most lakes, all gears captured ≥ 50 *Lepomis* spp. (Table 2). Number of lakes where a specific gear caught ≥ 50 *Lepomis* spp. was highest for mini-fyke nets (all 11 lakes), followed by cloverleaf traps (*N* = 10 lakes), and then modified and hand-held electrofishing (*N* = 9 lakes; Table 2). When CVs were averaged across lakes, modified boat electrofishing provided the lowest CV in CPE (mean CV = 59%) and therefore required the fewest average number of replicates (42) to detect a 50% change in mean

CPE (Table 2). Sampling with cloverleaf traps required the least amount of time per replicate (0.18 h), but CPE was not as precise as that observed for modified boat electrofishing (CV = 79%; Table 2). Because modified boat electrofishing took the greatest amount of time per replicate (0.97 h), cloverleaf traps were considered the most efficient gear, taking approximately 2 workdays to complete the number of replicates to detect a 50% change in mean CPE (Table 2). Bluegill dominated the catch in the *Lepomis* spp. group as ≥ 20 Pumpkinseed were captured in only 1–3 lakes for each gear (Figures 1, 2).

Variation in composite Bluegill TL and age frequencies was apparent among gears (Figures 1 and 2). Most Bluegill captured by mini-fyke nets and cloverleaf traps were < 90 mm TL, while electrofishing captured fish up to 150 mm TL. Specifically, over 96% of Bluegill 30–150 mm TL captured by both mini-fyke nets and cloverleaf traps were < 90 mm TL, while over 35% of Bluegill caught in both modified boat electrofishing and hand-held electrofishing were ≥ 90 mm TL (Figure 1). At the individual-lake level, TL frequencies differed significantly between gears in most lakes except for modified boat electrofishing and hand-held electrofishing, where distributions differed significantly in only 2 of 10 lakes (Table 3). Age frequency distributions from mini-fyke nets and cloverleaf traps were skewed towards younger fish when compared to both types of electrofishing (Figure 2). Specifically, < 1% of Bluegill captured by both mini-fyke nets and cloverleaf traps were > age-3, while 16% and 14% of Bluegill caught in both modified boat electrofishing and hand-held electrofishing respectively were > age-3 (Figure 2). Age frequencies of Bluegill differed between gears in ≥ 50% of the lakes used for KS tests, except between modified boat electrofishing and hand-held electrofishing, and between cloverleaf traps and mini-fyke nets (Table 3).

In the majority of lakes, all gears captured ≥ 50 Yellow Perch (Table 2). Number of lakes where a specific gear caught ≥ 50 Yellow Perch was highest for mini-fyke nets and hand-held electrofishing (*N* = 7 lakes), followed by modified boat electrofishing and cloverleaf traps (*N* = 6 lakes; Table 2). When CVs associated with CPE were averaged across lakes, modified boat electrofishing provided the most precise CPEs (mean CV = 62%) and therefore required the fewest average number of replicates (49) to detect a 50% change in mean CPE (Table 2). As noted preciously, cloverleaf traps were more time efficient (0.18 h per replicate), but on average CPE was not as precise as modified boat electrofishing (CV = 116%; Table 2). Because modified boat electrofishing required the greatest amount of time per replicate (0.97 h), cloverleaf traps were the most efficient gear, taking approximately 3 workdays to complete the predicted number of replicates required to detect a 50% change in mean CPE (Table 2). Of the Yellow Perch captured in cloverleaf traps 62% were ≥ 70 mm TL, while 70%, 67%, and 73% captured in modified boat electrofishing, hand-held electrofishing, and mini-fyke nets respectively were < 70 mm TL (Figure 1). Of the Yellow Perch captured in cloverleaf traps 42% were age-0, while 72%, 71%, and 78% captured in modified boat electrofishing, hand-held electrofishing, and mini-fyke nets respectively were age-0 (Figure 2). Between most gears at the individual lake level, TL frequencies of Yellow Perch were significantly different in 75% of instances except for comparisons between modified boat electrofishing and mini-fyke nets, and modified boat electrofishing and handheld electrofishing, where TL frequencies were significantly different in 38% and 22% of instances respectively (Table 3; Figure 1). Age frequency distributions of Yellow Perch were significantly different in 5 out of 8 lakes included in comparisons between cloverleaf traps and mini-fyke nets, while age frequency distributions were significantly different in ≤ 50% of instances in all other gear comparisons (Table 3; Figure 2).

Objective 2

Confetti index ratings were obtained for all lakes except for Spillerberg Lake. Confetti index ratings were not significantly correlated with composite indices for centrarchids, Yellow Perch, and cyprinids ≤ 75 mm TL ($\tau = 0.47$, $P = 0.08$; Figure 3). Species group and species-specific confetti ratings for *Lepomis* spp. ($\tau = 0.55$, $P = 0.04$) and Yellow Perch ($\tau = 0.60$, $P = 0.03$) were significantly correlated with composite CPE estimates from my sampling. However, species-specific confetti ratings for Black Crappie ($P = 0.40$), Rock Bass ($P = 0.06$), and cyprinids ($P = 0.16$) were not significantly correlated with composite CPE estimates from my sampling (Figure 4).

Objective 3

Summed centrarchid CPE for lakes ($N = 6$) supporting successful Walleye recruitment ranged from 128–1,540 (mean ± SE = 867 ± 251) and from 279–1,799 (918 ± 256) in lakes with unsuccessful Walleye recruitment. Yellow Perch summed CPE of lakes ($N = 5$) supporting successful Walleye recruitment ranged from 3–9,601 (mean ± SE = 2,332 ± 1,518) and from 28–1389 summed CPE (493 ± 276) in lakes with unsuccessful Walleye recruitment. Probability that a lake supported successful Walleye recruitment was not significantly related to current summed CPE of all centrarchids or the summed CPE of any specific species or species group ($P > 0.19$; Table 4, Figure 5).

Objective 4

Probability of Walleye recruitment success from 1997–2006 was significantly related to CPE of Smallmouth Bass (*P* = 0.03, *Z* = 1.3, *N* = 124) and Yellow Perch (*P* = 0.01, *Z* = 2.8, *N* = 186) in historical mini-fyke net sampling, but not to CPE of all centrarchids or any other species or species group (*P* > 0.15.; Table 5, Figure 6). The likelihood that a lake supported successful Walleye recruitment from 2000–2006 increased by 3% when the composite CPE of Yellow Perch increased by 5, and by 48% when composite CPE of Smallmouth Bass increased by 5.

Discussion

This study provides important information evaluating and refining methods to sample juvenile centrarchids and Yellow Perch. My results suggest that using one gear to index multiple centrarchid species and Yellow Perch ≤ 150 mm TL may not be universally effective. This is not surprising given that life histories and behavior vary among species (Becker 1983a, 1983b). Specifically, none of my sampling gears appeared to effectively capture juvenile Black Crappie, Rock Bass, and Pumpkinseed. Low catch rates may reflect low abundance of these species in my sampling lakes or that none of the gears I used were not effective for sampling these species. Previous sampling techniques for juvenile Black Crappie have included trap nets (Allen et al. 1999; Michaletz and Siepker 2013), seines (Hanson and Qadri 1984; Tuten et al. 2015), and otter trawls (Allen et al. 1999; Pine and Allen 2001). Seines have been used to sample juvenile Pumpkinseed (Hanson and Qadri 1984; Bernard and Fox 1997) and juvenile Rock Bass (George and Hadley 1979).

Although many of the sampling gears I used had low catch rates for specific species, these gears may still provide useful indices for monitoring and detecting trends in juvenile abundance, just with smaller overall sample sizes (< 50 fish) unless considerable effort is expended. On the surface, choosing a gear that consistently catches low numbers of fish over a gear that captures far more fish would seem an odd choice, even if the gear with lower catch rates provided catches that are more precise. However, if gears that provide lower catch rates can be shown to accurately predict recruitment measured later in life, they may be useful monitoring tools. This validation would require long-term sampling efforts in multiple lakes to determine if catch in these gears was related to year-class strength. In general, further research will be needed to evaluate whether any of the gears I used might provide accurate indices of recruitment measured later in life.

My results suggest that mini-fyke nets likely represent the most effective gear to sample juvenile Largemouth and Smallmouth Bass in northern Wisconsin lakes. Modified boat electrofishing and hand-held electrofishing have been used to catch juvenile Largemouth and Smallmouth Bass in southern reservoirs (Michaletz and Siepker 2013; Jackson and Noble 1995) but in most lakes I was unable to capture ≥ 50 Smallmouth Bass using electrofishing and I did not catch ≥ 50 Largemouth Bass in any lake using electrofishing. Michaletz and Siepker (2013) used indices of age-1 black bass captured in spring using modified boat electrofishing, while I conducted electrofishing in the late summer and most fish were age-0. Jackson and Noble (1995) also struggled to collect at least 50 age-0 Largemouth Bass in a hand-held electrofishing sample using multiple transects and had to increase electrofishing time to collect a sufficient sample size. Nearly all Largemouth and Smallmouth Bass collected in mini-fyke nets were age-0. Consequently, mini-fyke net sampling may be effective for indexing recruitment of these species at age-0 in Northern Wisconsin if year-class strength is set by late summer or early fall (e.g., Jackson and Noble 2000; Smith et al. 2005). Future research will need to determine if abundance of age-0 black bass in Northern Wisconsin indexed in the late summer or early fall correlates with abundance of age-1 fish the following year and year-class strength.

All gears were able to capture relatively large numbers of both Bluegill and Yellow Perch, but modified boat electrofishing or cloverleaf traps are likely the most effective gears for capturing both Bluegill and Yellow Perch. For these two species, modified boat electrofishing provided more precise estimates of CPE, but cloverleaf traps were more efficient. Modified boat electrofishing caught larger Bluegill than cloverleaf traps, while cloverleaf traps tended to catch larger Yellow Perch than modified electrofishing. Lack of larger and older Bluegill in mini-fyke nets and cloverleaf traps was likely a function of the 25.4 mm turtle exclusion netting on mini-fyke nets and the 12.7 mm wide opening between lobes on cloverleaf traps. Sullivan et al. (2019) caught larger Bluegill in mini-fyke nets that did not have turtle exclusion netting. When selecting among these two gears, biologists may have to decide what sizes or ages of fish they are targeting. Cloverleaf traps may be better suited to specifically sample substock-length Bluegill (fish ≤ 80 mm TL; Gabelhouse 1984; Sullivan et al. 2019), while modified boat electrofishing may be more useful for sampling relatively larger Bluegill. Conversely, modified boat electrofishing caught higher percentages of age-0 Yellow Perch than cloverleaf traps. Determining when year-class strength is set for both Bluegill and Yellow

Perch in Northern Wisconsin is an important piece of future research to determine what gear will be the most effective to index recruitment for both species. Additional research is needed to determine if catches of age-0 or age-1 Yellow Perch and Bluegill correlate with year-class strength of those species.

Mini-fyke nets, cloverleaf traps, and modified boat electrofishing could be conducted by the WDNR during the late summer when other sampling efforts are typically not extensive. Standard boat electrofishing is already routinely used by the WDNR to index Walleye recruitment and to assess adult panfish and black bass abundance (Simonson 2015). By modifying boat speed and dip-net mesh size while instructing netters to target smaller fish, boat electrofishing might provide a viable and familiar method sampling for Bluegill and Yellow Perch ≤ 150 mm TL.

Potentially, a lack of training and/or biases among netters may have caused inaccurate confetti index ratings on some lakes which may explain why confetti ratings were not always correlated with summed values of CPE observed in my sampling. Netters were not specifically instructed to characterize Largemouth and Smallmouth Bass abundance during confetti index sampling (L. Eslinger, WDNR, *personal communication*), as the confetti index was designed to be an index of “forage fish”, but while summed CPE estimates from my sampling included Largemouth and Smallmouth Bass, which are known to be consumed by Walleye (Kelling et al. 2016). Also, some confetti index ratings were considered questionable as they were not recorded on data sheets from the night of sampling but were relayed after sampling took place. However, significant correlations between confetti ratings and summed CPE of Yellow Perch and

Lepomis spp. suggests a confetti-index approach may have some practical applications, at least for some species.

My results indicated that Walleye can successfully recruit across a broad range of both juvenile centrarchid and juvenile Yellow Perch abundances. Although a previous study reported that potential for Walleye recruitment success was negatively related to Largemouth Bass abundance in Wisconsin lakes (Hansen et al. 2018), my analyses suggest that Walleye can recruitment successfully in lakes with high abundances of juvenile Largemouth Bass and other centrarchids. The apparent difference in conclusions across studies may exist because I only included juvenile centrarchids and not adults. Walleye recruitment success may be related to adult Largemouth Bass abundance, but not related to juvenile Largemouth Bass abundance. Additionally, high abundance of juvenile Largemouth Bass may not be directly related to high abundance of adult Largemouth Bass if year-class strength is not set early in life.

Recently, much focus has been placed on relationships between Largemouth Bass and Walleye (Kelling et al. 2016; Hansen et al. 2018), but this study suggests that Walleye recruitment success is positively related to juvenile Smallmouth Bass abundance, as Walleye recruitment success was positively related to Smallmouth Bass abundance in historical mini-fyke net data. Walleye likely share a greater degree of similarity in habitat preferences or needs with Smallmouth Bass than Largemouth Bass. For instance, the optimal temperature for growth for Smallmouth Bass and Walleye is 22° C (Huh 1976; Whitledge et al. 2002), while for Largemouth Bass it is 26° C (Zweifel et al. 1999). Lakes with relatively high abundance of Smallmouth Bass, especially with low relative abundance of Largemouth Bass, may indicate lakes with habitat more likely to warrant successful Walleye recruitment and effective stocking. However, Van Zuiden and Sharma (2016) determined that in Ontario, Canada Smallmouth Bass and Walleye preferred different environmental conditions and Walleye abundance was about 2.5 times lower in lakes with Smallmouth Bass. Conversely, Wagner et al. (2020) determined that Smallmouth Bass and Walleye co-occur in north temperate lakes in Minnesota more often than predicted by habitat and environmental variables. Further research on the relationships between Smallmouth Bass and Walleye in north temperate lakes and determining if a positive relationship between Walleye recruitment and Smallmouth Bass abundance occurs in other areas of the Midwest, may be useful in identifying lakes where Walleye conservation may likely be more successful.

Analysis of contemporary pairings of Yellow Perch relative abundance from my study lakes and probability of Walleye recruitment success from 11 lakes did not corroborate results from my analysis of lakes (N = 186) with historical mini-fyke data. I also used logistic regression to test whether the probability of a lake supporting successful Walleye recruitment was related to multi-species, species group, and species-specific composite indices of centrarchids and juvenile Yellow Perch relative captured in just mini-fyke nets and no relationship was significant. Historically, it appears that probability of Walleye recruitment success was related to abundance of juvenile Yellow Perch abundance, suggesting that both species may be responding similarly to environmental filters (Sharma et al. 2011). Moreover, Brandt et al. (*in press*) suggests that recruitment of Walleye and Yellow Perch may be regulated by similar environmental factors. Consequently, Yellow Perch may be susceptible to the same factors causing declines in Walleye recruitment observed in some Wisconsin lakes (Gostiaux et al. *in* *press*). Alternatively, in some lakes Walleye recruitment declines could be caused by declines in Yellow Perch recruitment through direct interspecific interactions. Yellow Perch are both a prey item (Gostiaux et al. *in press*; Engel et al. 2000) and prey buffer (Forney 1974, 1976) for juvenile Walleyes. Walleye and Yellow Perch population dynamics may be strongly linked through predator-prey interactions, particularly when Yellow Perch are the main prey source for Walleye (Forney 1971; Mills et al. 1987). Despite the low sample size, my analysis of contemporary data demonstrates that the relationship between probability of Walleye recruitment success and abundance of juvenile Yellow Perch is not universally applicable, as several lakes supporting successful Walleye recruitment had relatively low relative abundance of Yellow Perch.

Feiner et al. (2020) and Bethke et al. (2015), suggest that some Yellow Perch population in the midwestern U.S. may be in decline. Along with declines in abundance, there are strong indicators to suggest that Yellow Perch size structure has decreased (Beard and Kampa 1999; Holbrook et al. *in press*; Rypel et al. 2016) along with recreational harvest rates in Wisconsin (Feiner et al. 2020). Recently, much focus has been placed on the resiliency of Walleye populations in northern Wisconsin, while Yellow Perch populations have received limited attention. One potential hurdle to evaluating trends in Yellow Perch populations is a lack of long-term standardized data. Current sampling does not provide a means to assess Yellow Perch recruitment early in life (age-0 or age-1), which is the case in many other states and provinces (Irwin et al. 2009; Dembkowski et al. 2016; Zhang et al. 2017). Establishing standardized Yellow Perch sampling protocols will help biologists continue to answer questions about the mechanisms driving Yellow Perch recruitment and abundance and any linkages between

Walleye and Yellow Perch population dynamics. Future research should determine whether Yellow Perch are susceptible to recruitment bottlenecks and if these are occurring at the same time and in the same lakes as Walleye. A study design could mirror Gostiaux et al. (*in press*), to determine if and when Yellow Perch recruitment bottlenecks are occurring.

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Table 1. Walleye recruitment classification, area, and sampling year for 11 study lakes located in northern Wisconsin.

Recruitment Classification	Lake	Area (ha)	Year Sampled
Successful	Big Arbor Vitae	433	2019
	Escanaba	123	2019
	Little John	61	2019
	Sand	384	2020
	Spillerberg	30	2020
	Windfall	42	2020
Unsuccessful	Big Sissabagama	326	2020
	Bony	77	2020
	Durphee	80	2020
	Kawaguesaga	283	2019
	Sawyer	73	2019

Table 2. Number of lakes included in analysis (*N Lakes*), coefficients of variation (CV), mean number of units of sampling effort to detect a 50% change in mean CPE (N [$\alpha = 0.10$; $1 - \beta = 0.80$]), hours required to complete one unit of effort (H), and number of 8-h workdays needed to complete the estimated sampling effort E for Black Crappie, Largemouth Bass, *Lepomis* spp. (Bluegill and Pumpkinseed), Rock Bass, Smallmouth Bass and Yellow Perch captured using modified boat electrofishing, cloverleaf traps, hand-held electrofishing, and mini-fyke nets. Catch per effort for each gear were defined as catch per lift for mini-fyke nets and cloverleaf traps, and fish per h for both types of electrofishing. Metrics were calculated for each gear in each lake and then averaged across lakes. Only lakes where ≥ 50 fish of a species were caught by a specific gear were included in this analysis.

Gear	*N Lakes*	CV	*N*	*H*	*E*
		Black Crappie			
Modified Boat Electrofishing	0	NA	NA	NA	NA
Cloverleaf Trap	0	NA	NA	NA	NA
Hand-held Electrofishing	1	126	158	0.68	13
Mini-fyke Net	1	164	269	0.47	16
		Largemouth Bass			
Modified Boat Electrofishing	0	NA	NA	NA	NA
Cloverleaf Trap	0	NA	NA	NA	NA
Hand-held Electrofishing	0	NA	NA	NA	NA
Mini-fyke Net	6	100	111	0.47	6
		***Lepomis* spp.**			
Modified Boat Electrofishing	9	59	42	0.97	5
Cloverleaf Trap	10	79	72	0.18	2
Hand-held Electrofishing	9	68	57	0.68	5
Mini-fyke Net	11	110	133	0.47	8
		Rock Bass			
Modified Boat Electrofishing	0	NA	NA	NA	NA
Cloverleaf Trap	0	NA	NA	NA	NA
Hand-held Electrofishing	0	NA	NA	NA	NA
Mini-fyke Net	0	NA	NA	NA	NA
		Smallmouth Bass			
Modified Boat Electrofishing	2	88	100	0.97	12
Cloverleaf Trap	0	NA	NA	NA	NA
Hand-held Electrofishing	2	76	59	0.68	5
Mini-fyke Net	5	106	125	0.47	7
		Yellow Perch			
Modified Boat Electrofishing	6	62	49	0.97	6
Cloverleaf Trap	6	116	148	0.18	3
Hand-held Electrofishing	7	91	94	0.68	8
Mini-fyke Net	7	130	212	0.47	12

Table 3. Number of Kolmogorov–Smirnov tests that were significantly different for pairwise comparisons of centrarchid and Yellow Perch total length (L) and age (A) frequency distributions from modified boat electrofishing (BEF), cloverleaf traps (CLV), mini-fyke nets (FYKE), and hand-held electrofishing (HEF). Total number of study lakes (*N*) included in tests is reported as only gears with ≥ 20 fish sampled of a single species in each lake were included. For example, for the Bluegill modified boat electrofishing and cloverleaf Kolmogorov-Smirnov tests, there were 10 lakes that met the criteria for this analysis to be performed (*N* = 10). Of these 10 lakes, 9 of them had significantly different lengths of Bluegill caught in each gear (L = 9) and 8 of them had significantly different ages of Bluegill caught in each gear (A = 8).

	BEF-CLV			BEF-FYKE			BEF-HEF			CLV-FYKE			CLV-HEF			HEF-FYKE		
Species	*N*	L	A	*N*	L	A	*N*	L	A	*N*	L	A	*N*	L	A	*N*	L	A
Black Crappie	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Bluegill	10	9	8	10	9	7	10	2	1	11	7	3	10	8	5	10	9	6
Largemouth Bass	1	0	0	3	2	0	2	1	0	1	0	0	1	0	0	2	0	0
Pumpkinseed	1	1	1	1	1	1	1	0	0	2	0	0	1	1	1	1	1	1
Rock Bass	0	0	0	1	0	0	2	1	1	0	0	0	0	0	0	1	0	0
Smallmouth Bass	0	0	0	3	0	0	3	0	0	0	0	0	0	0	0	3	1	0
Yellow Perch	8	6	4	8	3	1	9	2	1	8	6	5	8	6	3	8	6	2
Total	**20**	**16**	**13**	**27**	**16**	**10**	**27**	**6**	**3**	**22**	**13**	**8**	**20**	**15**	**9**	**25**	**17**	**9**

Table 4. Probabilities (*P*) of successful Walleye recruitment for study lakes (*N* = 11) in relation to summed catch-per-effort (CPE) of centrarchids and Yellow Perch captured in modified boat electrofishing, cloverleaf traps, hand-held electrofishing, and mini-fyke nets. Probabilities were estimated using logistic regressions. Successful Walleye recruitment was defined as mean CPE of age-0 Walleye > 6.2 fish/km in fall electrofishing from 2007–2019. Mean summed CPE (SE) of successful and unsuccessful lakes are reported.

Species	*P*	Successful Lakes Mean CPE (SE)	Unsuccessful Lakes Mean CPE (SE)
Centrarchids	0.88	867 (251)	918 (256)
Black Crappie	0.87	19 (15)	16 (7)
Largemouth Bass	0.30	23 (9)	40 (13)
Lepomis	0.75	733 (224)	833 (256)
Rock Bass	0.42	28 (14)	12 (3)
Smallmouth Bass	0.19	65 (26)	17 (5)
Yellow Perch	0.43	2332 (1518)	493 (276)

Table 5. Probabilities (*P*) of successful Walleye recruitment during 1997–2006 in relation to centrarchid and Yellow Perch catch-per-effort (fish/net night) in historical mini-fyke net sampling (2000–2006). Probabilities were estimated using logistic regressions (*N* and probability values [*P*] are reported for each regression). Successful Walleye recruitment was defined as mean CPE of age-0 Walleye > 6.2 fish/km in fall electrofishing. Mean CPE (SE) and total number (*N*) of lakes included in each test are reported. Bold italicized *P*-values denote significant differences (α = 0.05).

		Successful Lakes		Unsuccessful Lakes	
Species	*P*	Mean CPE (SE)	*N*	Mean CPE (SE)	*N*
Centrarchids	0.29	115 (18)	74	203 (53)	124
Black Crappie	0.60	8 (3)	42	39 (32)	60
Largemouth Bass	0.21	8 (2)	62	12 (2)	110
Lepomis	0.25	96 (18)	74	170 (44)	124
Rock Bass	0.16	3 (0)	65	2 (0)	96
Smallmouth Bass	***0.03***	6 (1)	65	3 (1)	59
Yellow Perch	***0.01***	172 (50)	74	18 (7)	112

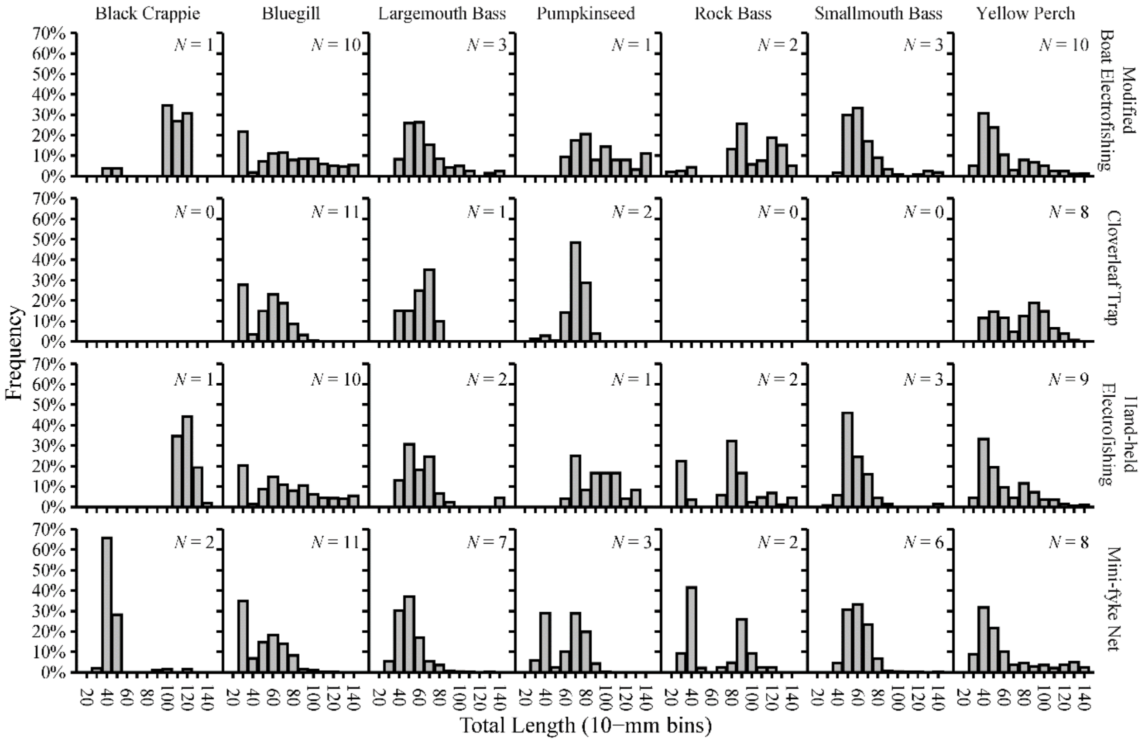

Figure 1. Composite total length (mm) frequency distributions of various centrarchid species and Yellow Perch captured by modified boat electrofishing, cloverleaf traps, hand-held electrofishing, and mini-fyke nets. Total number (*N*) of lakes is reported as only gears with ≥ 20 fish sampled of a single species in each lake were included. Composite total length frequency distributions were constructed for each species-gear combination by standardizing distributions from individual lakes to 100 fish such that each lake would contribute 100 fish to the composite distribution (N = 1,100 fish if a species was collected by a gear in all 11 lakes). Only gears that captured ≥ 20 fish of an individual species in a lake were included in constructing composite distributions.

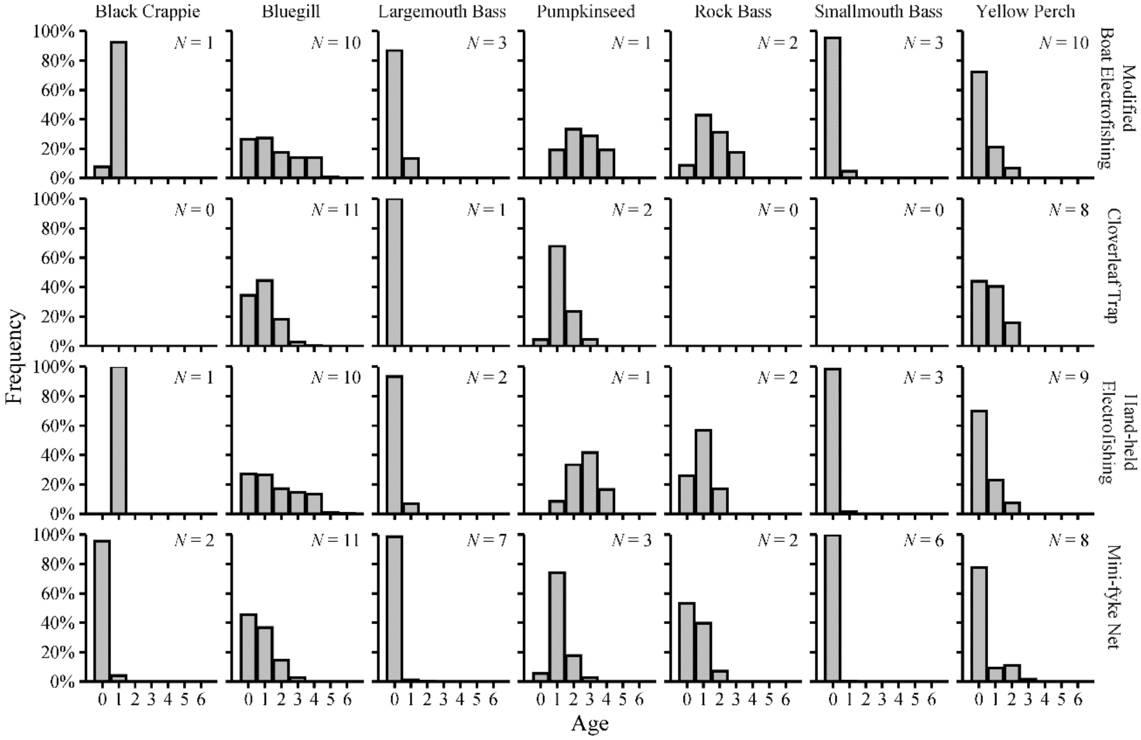

Figure 2. Composite age frequency distributions of various centrarchid species and Yellow Perch captured by modified boat electrofishing, cloverleaf traps, hand-held electrofishing, and mini-fyke nets. Total number (*N*) of lakes is reported, as only gears with ≥ 20 fish sampled of a single species in each lake were included. Composite age frequency distributions were constructed for each species-gear combination by standardizing distributions from individual lakes to 100 fish such that each lake would contribute 100 fish to the composite distribution (N = 1,100 fish if a species was collected by a gear in all 11 lakes). Only gears that captured ≥ 20 fish of an individual species in a lake were included in constructing composite distributions.

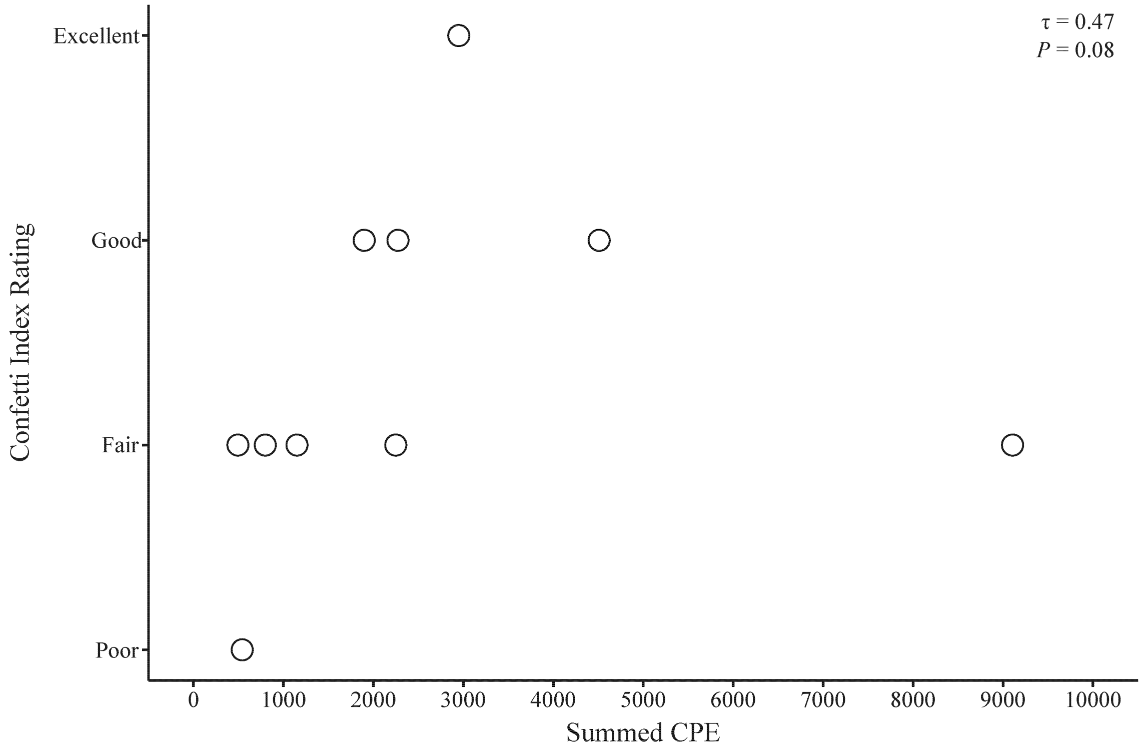

Figure 3. Confetti index ratings in relation to summed catch-per-effort (CPE) of centrarchids (Black Crappie, Cyprinids, Largemouth Bass, *Lepomis* spp., Rock Bass, and Smallmouth Bass) and Yellow Perch ≤ 75 mm total length captured in modified boat electrofishing, cloverleaf traps, hand-held electrofishing, and mini-fyke nets from all study lakes except for Spillerberg Lake (*N* = 10). Kendall rank correlation test statistic (*τ*) and probality value (*P*) are reported.

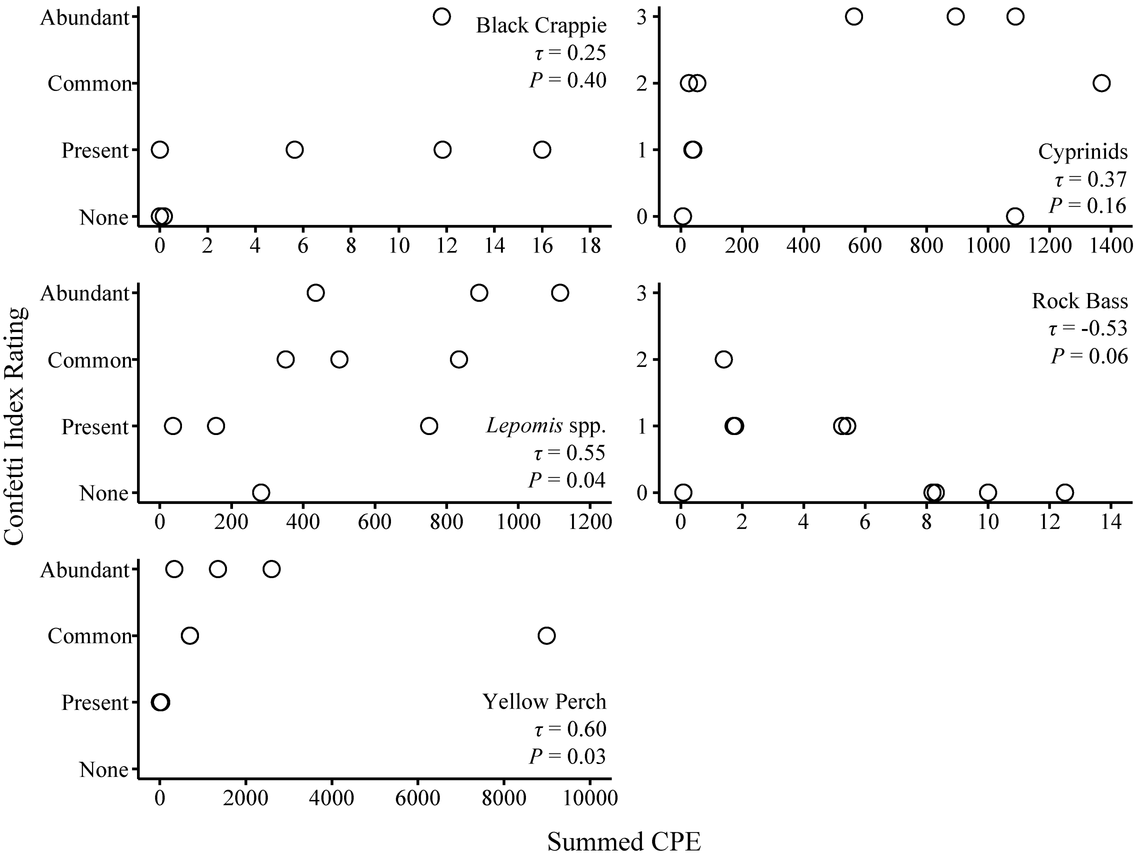

Figure 4. Confetti index ratings in relation to summed catch-per-effort (CPE) of Black Crappie, Cyprinids, *Lepomis* spp., Rock Bass, and Yellow Perch ≤ 75 mm total length captured in modified boat electrofishing, cloverleaf traps, hand-held electrofishing, and mini-fyke nets from all study lakes except for Spillerberg Lake (*N* = 10). Kendall rank correlation test statistics (*τ*) and probality values (*P*) are reported.

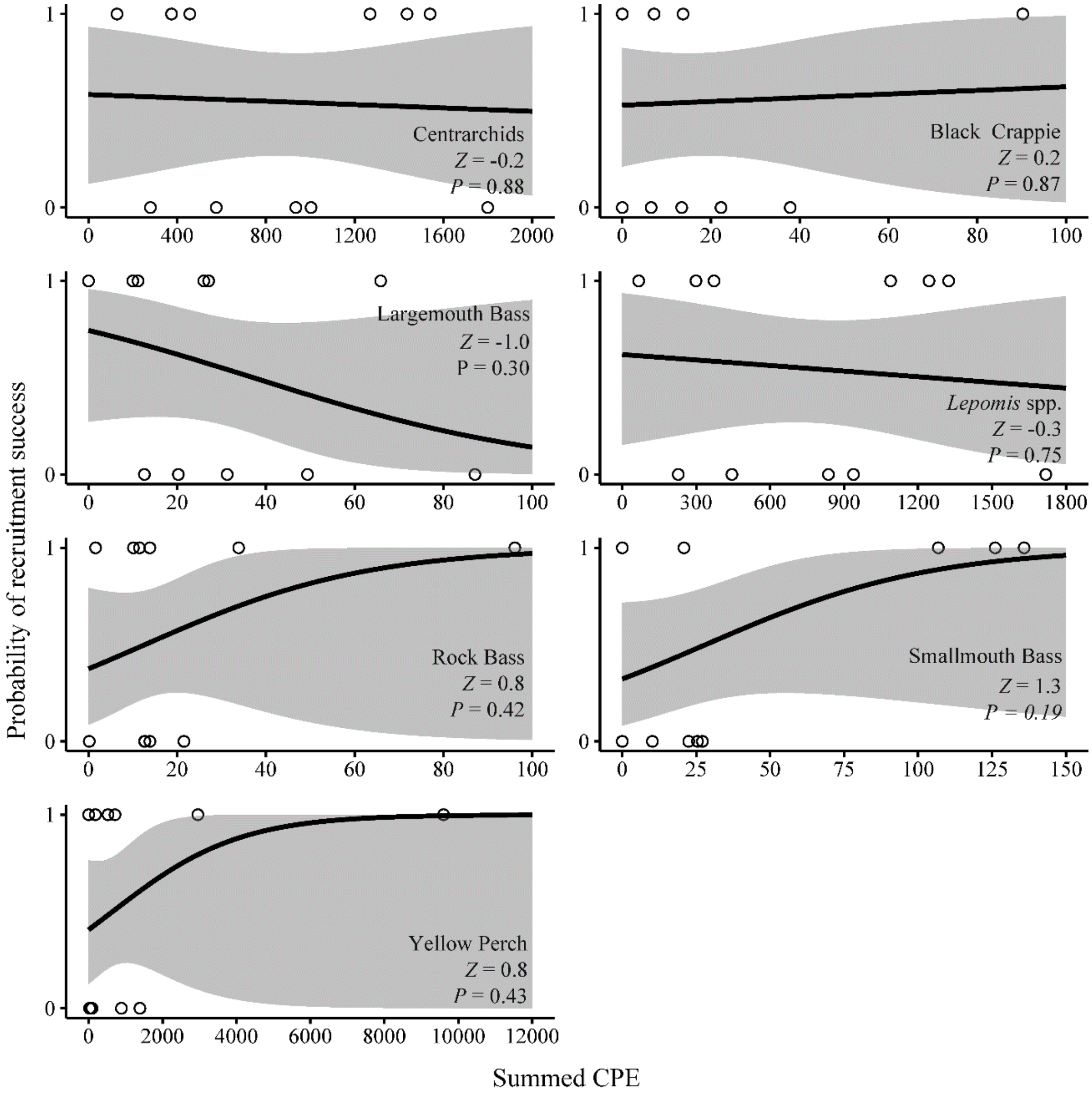

Figure 5. Probabilities (black lines) of successful Walleye recruitment for study lakes (*N* = 11) in relation to summed catch-per-effort (CPE) of modified boat electrofishing, cloverleaf traps, hand-held electrofishing, and mini-fyke nets. Probabilities were estimated using logistic regressions (*N* and probability values [*P*] are reported for each regression). Shaded area represents 95% confidence intervals. Successful Walleye recruitment was defined as mean CPE of age-0 Walleye > 6.2 fish/km in fall electrofishing from 2007–2019.

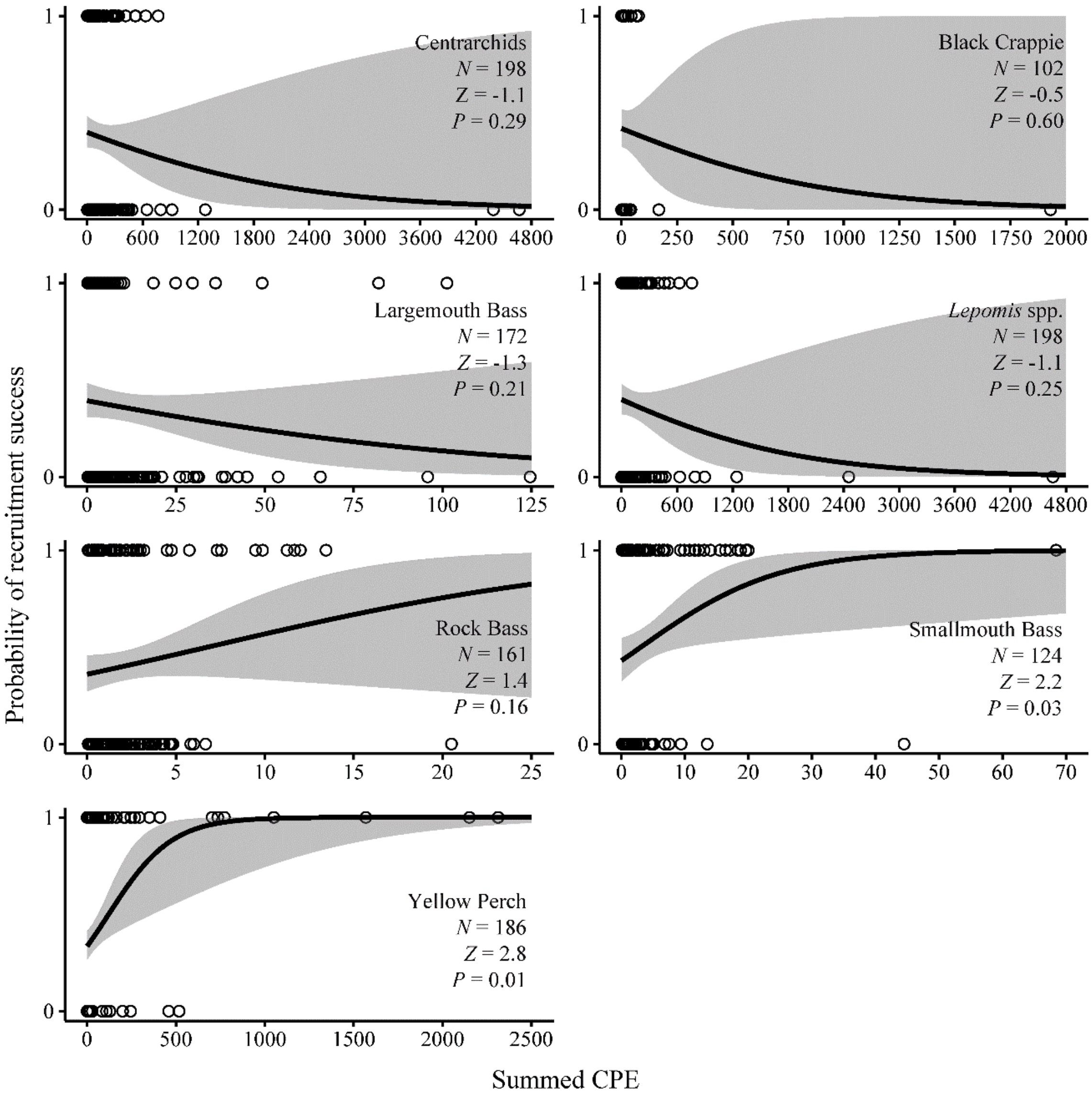

Figure 6. Probabilities (black lines) of successful Walleye recruitment during 1997–2006 in relation to centrarchid and Yellow Perch catch-per-effort (fish/net night) in historical mini-fyke net sampling (2000–2006). Probabilities were estimated using logistic regressions (*N* and probability values [*P*] are reported for each regression). Shaded area represents 95% confidence intervals. Successful Walleye recruitment was defined as mean CPE of age-0 Walleye > 6.2 fish/km in fall electrofishing. Walleye recruitment success after 2006 was based on electrofishing data collected from 1997–2006.

Appendix 1

For each lake: Catch per effort (CPE) ± SE, number of replicates needed to capture ≥ 50 fish of a species (*N50*), coefficients of variation (CV), mean number of units of sampling effort to detect a 50% change in mean CPE (*N* [$\alpha = 0.10$; $1 - \beta = 0.80$]), hours required to complete one unit of effort (*H*), and number of 8-h workdays needed to complete the estimated sampling effort *E* for Black Crappie, Largemouth Bass, *Lepomis* spp. (Bluegill and Pumpkinseed), Rock Bass, Smallmouth Bass and Yellow Perch captured using modified boat electrofishing, cloverleaf traps, hand-held electrofishing, and mini-fyke nets. Catch per effort for each gear were defined as catch per lift for mini-fyke nets and cloverleaf traps, and fish per h for both types of electrofishing. Metrics were calculated for each gear in each lake and then averaged across lakes.

Big Arbor Vitae

Gear	CPE	*N*50	CV	*N*	*H*	*E*
Black Crappie						
Modified Boat Electrofishing	6.6 ± 2.6	23	87	NA	NA	NA
Cloverleaf Trap	0.3 ± 0.2	167	225	NA	NA	NA
Hand-held Electrofishing	4 ± 1.3	75	77	NA	NA	NA
Mini-fyke Net	5.6 ± 2.1	9	164	269	0.47	16
Largemouth Bass						
Modified Boat Electrofishing	9 ± 3.9	17	97	NA	NA	NA
Cloverleaf Trap	0.5 ± 0.2	100	141	NA	NA	NA
Hand-held Electrofishing	8 ± 4.6	38	140	NA	NA	NA
Mini-fyke Net	16.6 ± 4.2	3	109	120	0.47	7
***Lepomis* spp.**						
Modified Boat Electrofishing	453.6 ± 185.5	1	91	84	0.97	10
Cloverleaf Trap	53.4 ± 14.3	1	120	143	0.18	3
Hand-held Electrofishing	265 ± 110.2	1	102	104	0.68	9
Mini-fyke Net	652.4 ± 249.5	1	167	276	0.47	16
Rock Bass						
Modified Boat Electrofishing	12 ± 4.9	13	92	NA	NA	NA
Cloverleaf Trap	0.5 ± 0.1	100	105	NA	NA	NA
Hand-held Electrofishing	21 ± 6.3	14	74	NA	NA	NA
Mini-fyke Net	1.1 ± 0.2	45	90	NA	NA	NA
Smallmouth Bass						
Modified Boat Electrofishing	46.2 ± 27.8	3	134	180	0.97	22
Cloverleaf Trap	1.7 ± 0.6	29	164	NA	NA	NA
Hand-held Electrofishing	47 ± 18.1	6	94	NA	NA	NA
Mini-fyke Net	24.3 ± 9	2	162	261	0.47	15
Yellow Perch						
Modified Boat Electrofishing	592.2 ± 293	1	111	122	0.97	15
Cloverleaf Trap	13.7 ± 3.2	4	103	106	0.18	2
Hand-held Electrofishing	2142 ± 1102.2	1	126	159	0.68	13
Mini-fyke Net	409.8 ± 271.6	1	289	827	0.47	48

Big Sissabagama

Gear	CPE	*N*50	CV	*N*	*H*	*E*
			Black Crappie			
Modified Boat Electrofishing	1.2 ± 1.2	125	224	NA	NA	NA
Cloverleaf Trap	0	NA	NA	NA	NA	NA
Hand-held Electrofishing	12 ± 10.8	25	221	NA	NA	NA
Mini-fyke Net	0.4 ± 0.2	125	211	NA	NA	NA
			Largemouth Bass			
Modified Boat Electrofishing	20.4 ± 6.2	7	69	NA	NA	NA
Cloverleaf Trap	0.6 ± 0.2	83	117	NA	NA	NA
Hand-held Electrofishing	23 ± 11.3	13	121	NA	NA	NA
Mini-fyke Net	11.3 ± 1.5	4	58	34	0.47	2
			***Lepomis* spp.**			
Modified Boat Electrofishing	315 ± 54.4	1	39	16	0.97	2
Cloverleaf Trap	49.4 ± 6.3	1	57	34	0.18	1
Hand-held Electrofishing	418 ± 73.4	1	43	20	0.68	2
Mini-fyke Net	157.5 ± 43.2	1	123	150	0.47	9
			Rock Bass			
Modified Boat Electrofishing	1.2 ± 0.7	125	137	NA	NA	NA
Cloverleaf Trap	0.6 ± 0.2	83	161	NA	NA	NA
Hand-held Electrofishing	11 ± 3.6	27	80	NA	NA	NA
Mini-fyke Net	0.4 ± 0.1	125	129	NA	NA	NA
			Smallmouth Bass			
Modified Boat Electrofishing	4.2 ± 1.2	36	64	NA	NA	NA
Cloverleaf Trap	0.2 ± 0.1	250	316	NA	NA	NA
Hand-held Electrofishing	17 ± 8.1	18	117	NA	NA	NA
Mini-fyke Net	2.3 ± 0.7	22	126	NA	NA	NA
			Yellow Perch			
Modified Boat Electrofishing	409.2 ± 86.7	1	47	24	0.97	3
Cloverleaf Trap	4.3 ± 0.6	12	62	NA	NA	NA
Hand-held Electrofishing	949 ± 243.4	1	63	40	0.68	3
Mini-fyke Net	57.9 ± 11.9	1	92	84	0.47	5

Bony

Gear	CPE	*N*50	CV	*N*	*H*	*E*
Black Crappie						
Modified Boat Electrofishing	0	NA	NA	NA	NA	NA
Cloverleaf Trap	0	NA	NA	NA	NA	NA
Hand-held Electrofishing	0	NA	NA	NA	NA	NA
Mini-fyke Net	0	NA	NA	NA	NA	NA
Largemouth Bass						
Modified Boat Electrofishing	4 ± 2.6	38	115	NA	NA	NA
Cloverleaf Trap	1 ± 0.6	50	200	NA	NA	NA
Hand-held Electrofishing	6 ± 4.2	50	141	NA	NA	NA
Mini-fyke Net	4.2 ± 1.4	12	113	NA	NA	NA
***Lepomis* spp.**						
Modified Boat Electrofishing	97 ± 15.7	2	28	9	0.97	1
Cloverleaf Trap	50.5 ± 7.6	1	52	28	0.18	1
Hand-held Electrofishing	79.5 ± 13.7	4	35	13	0.68	1
Mini-fyke Net	50.7 ± 22.5	1	154	235	0.47	14
Rock Bass						
Modified Boat Electrofishing	7 ± 4.4	21	108	NA	NA	NA
Cloverleaf Trap	0.8 ± 0.3	60	118	NA	NA	NA
Hand-held Electrofishing	6 ± 3.5	50	115	NA	NA	NA
Mini-fyke Net	0.8 ± 0.3	60	118	NA	NA	NA
Smallmouth Bass						
Modified Boat Electrofishing	12 ± 6	13	87	NA	NA	NA
Cloverleaf Trap	0.8 ± 0.2	60	90	NA	NA	NA
Hand-held Electrofishing	12 ± 5.5	25	91	NA	NA	NA
Mini-fyke Net	2 ± 0.6	25	110	NA	NA	NA
Yellow Perch						
Modified Boat Electrofishing	377 ± 172.9	1	79	64	0.97	8
Cloverleaf Trap	23.8 ± 11.3	2	165	270	0.18	6
Hand-held Electrofishing	489 ± 139.8	1	57	34	0.68	3
Mini-fyke Net	20.8 ± 5.9	2	98	97	0.47	6

Durphee

Gear	CPE	*N*50	CV	*N*	*H*	*E*
		Black Crappie				
Modified Boat Electrofishing	2 ± 2	75	173	NA	NA	NA
Cloverleaf Trap	0	NA	NA	NA	NA	NA
Hand-held Electrofishing	4.5 ± 2.9	67	128	NA	NA	NA
Mini-fyke Net	0	NA	NA	NA	NA	NA
		Largemouth Bass				
Modified Boat Electrofishing	7 ± 1	21	25	NA	NA	NA
Cloverleaf Trap	0	NA	NA	NA	NA	NA
Hand-held Electrofishing	18 ± 2.4	17	27	NA	NA	NA
Mini-fyke Net	12.5 ± 5.9	4	163	263	0.47	15
		***Lepomis* spp.**				
Modified Boat Electrofishing	558 ± 237	1	74	55	0.97	7
Cloverleaf Trap	39.5 ± 8	1	70	50	0.18	1
Hand-held Electrofishing	348 ± 76.7	1	44	21	0.68	2
Mini-fyke Net	24.5 ± 9.4	2	133	178	0.47	10
		Rock Bass				
Modified Boat Electrofishing	0	NA	NA	NA	NA	NA
Cloverleaf Trap	0	NA	NA	NA	NA	NA
Hand-held Electrofishing	0	NA	NA	NA	NA	NA
Mini-fyke Net	0.3 ± 0.2	150	245	NA	NA	NA
		Smallmouth Bass				
Modified Boat Electrofishing	7 ± 4.4	21	108	NA	NA	NA
Cloverleaf Trap	1 ± 0.4	50	155	NA	NA	NA
Hand-held Electrofishing	12 ± 6.5	25	108	NA	NA	NA
Mini-fyke Net	15.2 ± 5.7	3	131	171	0.47	10
		Yellow Perch				
Modified Boat Electrofishing	43 ± 11.8	3	47	NA	NA	NA
Cloverleaf Trap	0.2 ± 0.1	300	245	NA	NA	NA
Hand-held Electrofishing	51 ± 26.1	6	102	NA	NA	NA
Mini-fyke Net	0.3 ± 0.1	150	155	NA	NA	NA

Escanaba

Gear	CPE	*N*50	CV	*N*	*H*	*E*
Black Crappie						
Modified Boat Electrofishing	0	NA	NA	NA	NA	NA
Cloverleaf Trap	0	NA	NA	NA	NA	NA
Hand-held Electrofishing	0	NA	NA	NA	NA	NA
Mini-fyke Net	0	NA	NA	NA	NA	NA
Largemouth Bass						
Modified Boat Electrofishing	6.8 ± 4.3	22	128	NA	NA	NA
Cloverleaf Trap	0.1 ± 0.1	400	283	NA	NA	NA
Hand-held Electrofishing	2.4 ± 1.5	125	137	NA	NA	NA
Mini-fyke Net	1.5 ± 0.4	33	98	NA	NA	NA
***Lepomis* spp.**						
Modified Boat Electrofishing	185.3 ± 41.2	1	44	21	0.97	3
Cloverleaf Trap	18.8 ± 5.8	3	125	155	0.18	3
Hand-held Electrofishing	66 ± 21	5	71	51	0.68	4
Mini-fyke Net	76.7 ± 16.9	1	88	78	0.47	5
Rock Bass						
Modified Boat Electrofishing	5.3 ± 1.9	29	72	NA	NA	NA
Cloverleaf Trap	1.8 ± 0.5	29	121	NA	NA	NA
Hand-held Electrofishing	3.6 ± 3.6	83	224	NA	NA	NA
Mini-fyke Net	3.5 ± 1.1	14	120	NA	NA	NA
Smallmouth Bass						
Modified Boat Electrofishing	54 ± 11.3	3	42	19	0.97	2
Cloverleaf Trap	0.5 ± 0.3	100	214	NA	NA	NA
Hand-held Electrofishing	72 ± 27.2	4	84	72	0.68	6
Mini-fyke Net	19.2 ± 4.5	3	93	87	0.47	5
Yellow Perch						
Modified Boat Electrofishing	412.5 ± 73.9	1	36	14	0.97	2
Cloverleaf Trap	15.5 ± 5.3	3	137	186	0.18	4
Hand-held Electrofishing	136.8 ± 39.7	2	65	43	0.68	4
Mini-fyke Net	317.5 ± 74.3	1	94	88	0.47	5

Kawaguesaga

Gear	CPE	*N*50	CV	*N*	*H*	*E*
	Black Crappie					
Modified Boat Electrofishing	20.3 ± 13.8	7	137	NA	NA	NA
Cloverleaf Trap	0.3 ± 0.1	200	185	NA	NA	NA
Hand-held Electrofishing	15.6 ± 7.7	19	111	NA	NA	NA
Mini-fyke Net	3.8 ± 1.1	13	116	NA	NA	NA
	Largemouth Bass					
Modified Boat Electrofishing	9.8 ± 2.3	15	46	NA	NA	NA
Cloverleaf Trap	1.4 ± 0.4	36	110	NA	NA	NA
Hand-held Electrofishing	4.8 ± 2.2	63	105	NA	NA	NA
Mini-fyke Net	10 ± 2.1	5	82	69	0.47	4
	***Lepomis* spp.**					
Modified Boat Electrofishing	729.8 ± 225.1	1	62	39	0.97	5
Cloverleaf Trap	24.3 ± 7.3	2	120	145	0.18	3
Hand-held Electrofishing	916.8 ± 535.7	1	131	170	0.68	14
Mini-fyke Net	119.1 ± 32.7	1	110	121	0.47	7
	Rock Bass					
Modified Boat Electrofishing	6 ± 2.1	25	71	NA	NA	NA
Cloverleaf Trap	0.4 ± 0.2	133	198	NA	NA	NA
Hand-held Electrofishing	6 ± 1.9	50	71	NA	NA	NA
Mini-fyke Net	0.9 ± 0.3	57	155	NA	NA	NA
	Smallmouth Bass					
Modified Boat Electrofishing	4.5 ± 3.6	33	159	NA	NA	NA
Cloverleaf Trap	0.3 ± 0.1	200	185	NA	NA	NA
Hand-held Electrofishing	4.8 ± 2.2	63	105	NA	NA	NA
Mini-fyke Net	1.5 ± 0.4	33	94	NA	NA	NA
	Yellow Perch					
Modified Boat Electrofishing	27 ± 10.7	6	80	NA	NA	NA
Cloverleaf Trap	2.4 ± 0.9	21	151	NA	NA	NA
Hand-held Electrofishing	33.6 ± 14.6	9	97	NA	NA	NA
Mini-fyke Net	2.9 ± 0.7	17	94	NA	NA	NA

Little John

Gear	CPE	*N*50	CV	*N*	*H*	*E*
Black Crappie						
Modified Boat Electrofishing	4 ± 2	38	87	NA	NA	NA
Cloverleaf Trap	0	NA	NA	NA	NA	NA
Hand-held Electrofishing	3 ± 3	100	200	NA	NA	NA
Mini-fyke Net	0.3 ± 0.2	150	245	NA	NA	NA
Largemouth Bass						
Modified Boat Electrofishing	39 ± 3	4	13	NA	NA	NA
Cloverleaf Trap	2.5 ± 0.5	20	70	NA	NA	NA
Hand-held Electrofishing	10.5 ± 6.7	29	127	NA	NA	NA
Mini-fyke Net	30.2 ± 7.9	2	90	82	0.47	5
***Lepomis* spp.**						
Modified Boat Electrofishing	785 ± 501.1	1	111	122	0.97	15
Cloverleaf Trap	136.7 ± 32.2	1	82	67	0.18	1
Hand-held Electrofishing	342 ± 68.7	1	40	18	0.68	1
Mini-fyke Net	98.2 ± 25.4	1	90	81	0.47	5
Rock Bass						
Modified Boat Electrofishing	26 ± 5	6	33	NA	NA	NA
Cloverleaf Trap	1.7 ± 0.4	30	90	NA	NA	NA
Hand-held Electrofishing	67.5 ± 9.9	4	29	NA	NA	NA
Mini-fyke Net	3.5 ± 0.7	14	67	NA	NA	NA
Smallmouth Bass						
Modified Boat Electrofishing	34 ± 7.8	4	40	NA	NA	NA
Cloverleaf Trap	0.7 ± 0.2	75	122	NA	NA	NA
Hand-held Electrofishing	75 ± 25.3	4	67	46	0.68	4
Mini-fyke Net	33.5 ± 6.8	1	70	50	0.47	3
Yellow Perch						
Modified Boat Electrofishing	415 ± 56.2	1	23	7	0.97	1
Cloverleaf Trap	11 ± 2.5	5	80	65	0.18	1
Hand-held Electrofishing	93 ± 70.6	3	152	229	0.68	19
Mini-fyke Net	28.3 ± 7.6	2	93	87	0.47	5

Sand

Gear	CPE	*N*50	CV	*N*	*H*	*E*
Black Crappie						
Modified Boat Electrofishing	0	NA	NA	NA	NA	NA
Cloverleaf Trap	0	NA	NA	NA	NA	NA
Hand-held Electrofishing	0	NA	NA	NA	NA	NA
Mini-fyke Net	0	NA	NA	NA	NA	NA
Largemouth Bass						
Modified Boat Electrofishing	16.6 ± 15.9	9	214	NA	NA	NA
Cloverleaf Trap	0.1 ± 0.1	500	316	NA	NA	NA
Hand-held Electrofishing	9 ± 3.7	33	101	NA	NA	NA
Mini-fyke Net	2.8 ± 1.3	18	163	NA	NA	NA
***Lepomis* spp.**						
Modified Boat Electrofishing	36.8 ± 17.8	4	108	NA	NA	NA
Cloverleaf Trap	3.5 ± 1.7	14	213	NA	NA	NA
Hand-held Electrofishing	22 ± 9.4	14	104	NA	NA	NA
Mini-fyke Net	12.2 ± 4.9	4	140	196	0.47	11
Rock Bass						
Modified Boat Electrofishing	4.2 ± 1.5	36	81	NA	NA	NA
Cloverleaf Trap	0.4 ± 0.1	125	129	NA	NA	NA
Hand-held Electrofishing	9 ± 6.1	33	167	NA	NA	NA
Mini-fyke Net	0.8 ± 0.3	60	140	NA	NA	NA
Smallmouth Bass						
Modified Boat Electrofishing	0.6 ± 0.6	250	224	NA	NA	NA
Cloverleaf Trap	1.5 ± 0.4	33	119	NA	NA	NA
Hand-held Electrofishing	11 ± 9.8	27	219	NA	NA	NA
Mini-fyke Net	17 ± 3.7	3	75	57	0.47	3
Yellow Perch						
Modified Boat Electrofishing	3966.6 ± 1379	1	78	61	0.97	7
Cloverleaf Trap	38.9 ± 12.9	1	149	220	0.18	5
Hand-held Electrofishing	5589.7 ± 2379.5	1	104	109	0.68	9
Mini-fyke Net	51.5 ± 18.1	1	122	148	0.47	9

Sawyer

Gear	CPE	*N*50	CV	*N*	*H*	*E*
			Black Crappie			
Modified Boat Electrofishing	14 ± 5.3	11	65	NA	NA	NA
Cloverleaf Trap	0	NA	NA	NA	NA	NA
Hand-held Electrofishing	7.5 ± 4.5	40	120	NA	NA	NA
Mini-fyke Net	1.5 ± 0.5	33	117	NA	NA	NA
			Largemouth Bass			
Modified Boat Electrofishing	48 ± 5.2	3	19	NA	NA	NA
Cloverleaf Trap	3.3 ± 0.6	15	65	NA	NA	NA
Hand-held Electrofishing	33 ± 11.1	9	67	NA	NA	NA
Mini-fyke Net	8.8 ± 2.5	6	99	98	0.47	6
			***Lepomis* spp.**			
Modified Boat Electrofishing	214 ± 52.9	1	43	20	0.97	2
Cloverleaf Trap	62 ± 9.9	1	55	32	0.18	1
Hand-held Electrofishing	157.5 ± 40.4	2	51	28	0.68	2
Mini-fyke Net	84.5 ± 21.9	1	90	81	0.47	5
			Rock Bass			
Modified Boat Electrofishing	9 ± 3.5	17	67	NA	NA	NA
Cloverleaf Trap	0.7 ± 0.2	75	122	NA	NA	NA
Hand-held Electrofishing	12 ± 4.9	25	82	NA	NA	NA
Mini-fyke Net	0.3 ± 0.1	150	155	NA	NA	NA
			Smallmouth Bass			
Modified Boat Electrofishing	0	NA	NA	NA	NA	NA
Cloverleaf Trap	0	NA	NA	NA	NA	NA
Hand-held Electrofishing	0	NA	NA	NA	NA	NA
Mini-fyke Net	0	NA	NA	NA	NA	NA
			Yellow Perch			
Modified Boat Electrofishing	21 ± 13.5	7	112	NA	NA	NA
Cloverleaf Trap	3 ± 0.8	17	89	NA	NA	NA
Hand-held Electrofishing	4.5 ± 1.5	67	67	NA	NA	NA
Mini-fyke Net	1.5 ± 0.4	33	101	NA	NA	NA

Spillerberg

Gear	CPE	*N*50	CV	*N*	*H*	*E*
			Black Crappie			
Modified Boat Electrofishing	0	NA	NA	NA	NA	NA
Cloverleaf Trap	0	NA	NA	NA	NA	NA
Hand-held Electrofishing	0	NA	NA	NA	NA	NA
Mini-fyke Net	0	NA	NA	NA	NA	NA
			Largemouth Bass			
Modified Boat Electrofishing	0	NA	NA	NA	NA	NA
Cloverleaf Trap	0	NA	NA	NA	NA	NA
Hand-held Electrofishing	0	NA	NA	NA	NA	NA
Mini-fyke Net	0	NA	NA	NA	NA	NA
			***Lepomis* spp.**			
Modified Boat Electrofishing	21 ± 5.2	7	43	NA	NA	NA
Cloverleaf Trap	34.8 ± 4.5	1	41	18	0.18	0
Hand-held Electrofishing	55.5 ± 21.1	5	76	NA	NA	NA
Mini-fyke Net	556.8 ± 86.3	1	54	30	0.47	2
			Rock Bass			
Modified Boat Electrofishing	0	NA	NA	NA	NA	NA
Cloverleaf Trap	0	NA	NA	NA	NA	NA
Hand-held Electrofishing	1.5 ± 1.5	200	200	NA	NA	NA
Mini-fyke Net	0.2 ± 0.1	300	245	NA	NA	NA
			Smallmouth Bass			
Modified Boat Electrofishing	0	NA	NA	NA	NA	NA
Cloverleaf Trap	0	NA	NA	NA	NA	NA
Hand-held Electrofishing	0	NA	NA	NA	NA	NA
Mini-fyke Net	0	NA	NA	NA	NA	NA
			Yellow Perch			
Modified Boat Electrofishing	30 ± 9.2	5	53	NA	NA	NA
Cloverleaf Trap	10.2 ± 2.1	5	65	43	0.18	1
Hand-held Electrofishing	83.3 ± 27.8	4	67	45	0.68	4
Mini-fyke Net	132.3 ± 47.2	1	124	153	0.47	9

Windfall

Gear	CPE	*N*50	CV	*N*	*H*	*E*
Black Crappie						
Modified Boat Electrofishing	12.3 ± 4.9	12	68	NA	NA	NA
Cloverleaf Trap	0	NA	NA	NA	NA	NA
Hand-held Electrofishing	78 ± 49.1	4	126	158	0.68	13
Mini-fyke Net	0	NA	NA	NA	NA	NA
Largemouth Bass						
Modified Boat Electrofishing	4.8 ± 0.9	31	33	NA	NA	NA
Cloverleaf Trap	0.3 ± 0.2	150	245	NA	NA	NA
Hand-held Electrofishing	4.5 ± 2.9	67	128	NA	NA	NA
Mini-fyke Net	3.3 ± 0.8	15	62	NA	NA	NA
***Lepomis* spp.**						
Modified Boat Electrofishing	458.4 ± 97.8	1	37	15	0.97	2
Cloverleaf Trap	108.5 ± 22.4	1	71	52	0.18	1
Hand-held Electrofishing	795.5 ± 381.5	1	96	92	0.68	8
Mini-fyke Net	32 ± 8	2	61	39	0.47	2
Rock Bass						
Modified Boat Electrofishing	0	NA	NA	NA	NA	NA
Cloverleaf Trap	0.7 ± 0.2	75	122	NA	NA	NA
Hand-held Electrofishing	9.6 ± 7.7	31	161	NA	NA	NA
Mini-fyke Net	0.3 ± 0.2	150	173	NA	NA	NA
Smallmouth Bass						
Modified Boat Electrofishing	0	NA	NA	NA	NA	NA
Cloverleaf Trap	0	NA	NA	NA	NA	NA
Hand-held Electrofishing	0	NA	NA	NA	NA	NA
Mini-fyke Net	0	NA	NA	NA	NA	NA
Yellow Perch						
Modified Boat Electrofishing	0	NA	NA	NA	NA	NA
Cloverleaf Trap	0.2 ± 0.1	300	245	NA	NA	NA
Hand-held Electrofishing	3 ± 1.7	100	115	NA	NA	NA
Mini-fyke Net	0.7 ± 0.5	75	173	NA	NA	NA