Use of Cast Nets and Seine Hauls to Estimate Abundance of Age-0 Yellow Perch

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Knowledge about fish population dynamics is essential for developing management plans and evaluating management success. In many lakes, yellow perch (*Perca flavescens*) are the main forage for many upper level predators and recreational fish species. To better manage recreational fisheries, an accurate estimate of prey abundance is necessary. The objectives of the study were to sample the littoral and limnetic zone to better estimate population of age-0 yellow perch, and obtain an estimate of the proportion of yellow perch being missed by traditional littoral seining methods. Littoral seines were conducted at three randomly selected locations in the south basin of Lake Bemidji. Starting points for cast net transects were chosen at random around the lake and transects were run from the shore to the deepest portion of the lake. A cast net was thrown 10 times at every 1.5 m depth interval throughout each transect. Analysis of the data indicated that traditional methods of estimating population using littoral seines were in fact missing a proportion of the population. Analysis of the data resulted in a population estimate of 3,851,254. The estimate using seine hauls and cast net transects showed an increase by 163% from the population estimate of 1,464,864 using just littoral seines. This more accurate estimate of age-0 yellow perch recruitment will result in better management decisions.

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Introduction

Wide fluctuations in year class abundance of yellow perch (*Perca fiavescens*) occur frequently (Koonce et al. 1977; Anderson et al.1998; Marsden and Robillard 2004), and factors potentially influencing perch recruitment have been assessed. Yellow perch year-class strength has been correlated with water levels and spawning habitat availability (Nelson and Walburg 1977; Henderson 1985), water temperatures (Koonce et al. 1977), food availability and size (Whiteside et al. 1985), and predation rates (Forney 1971; Hartman and Margraf 1993). Despite the factors that cause reduced year-class strength, the ability to identify a weak cohort would help in both assessment and management of yellow perch fisheries, and fisheries that rely on yellow perch as the main forage species.

Inconsistent recruitment of yellow perch can lead to a variable sport fishery due to the role that yellow perch play in the food web (Anderson et al. 1998). Yellow perch are an important food source for top predators such as walleye (*Sander vitreus*) (Colby et al. 1979), northern pike (*Esox Lucius*) (Forney 1971), and muskellunge (*Esox Masquinongy*) (Deutsch 1986). These top predators are important sport fisheries species (Olson and Cunningham 1989), and play critical roles in structuring aquatic ecosystems, both directly through predation on prey populations and indirectly through modification of energy flow and nutrient cycling at lower trophic levels (Carpenter et al. 1985).

The determination of an accurate year-class will allow for improved management decisions that can lead to a more consistent fishery. Management agencies conduct annual assessments of adult populations to estimate growth, age, and relative abundance, and have also begun to sample early life stages to anticipate weak year-classes that could result in future reductions in adult abundance (Anderson et al. 1998; Sammons and Bettoli 1998). Commonly practiced methods for estimating age-0 yellow perch populations estimate relative abundance using beach seines, benthic sleds, drop nets, and push trawls (Dembkowski et al. 2012). Relative abundance estimates are commonly used to make management decisions, mostly due to the ease of data collection, but better decisions could result from more accurate population estimates. The objective of this study was to estimate abundance of age-0 yellow perch for an entire lake using littoral seine hauls and cast net transects that would sample fish in the depths unable to be sampled by seines.

Methods

Age-0 yellow perch were sampled in Lake Bemidji, in northern Minnesota, during the fall of 2013. Seine hauls were conducted at 11 sites between 29 August and 12 September, and 6 cast net transects were conducted between 24 September and 13 October. Littoral seines were conducted using a 1.2 m by 15 m seine that had 6 mm mesh. At each sample site, GPS coordinates were taken at the two end points of the seine to record seine width, and start and stop points were taken to record the distance seined. After each seine, age-0 yellow perch were counted and released and the process was repeated for each site. The length cut-off for age-0 yellow perch was determined to be >100 mm based on unpublished data from a previous study conducted on Lake Bemidji.

Transects were run from a starting point in the littoral zone to the deepest part in the lake, which is 23 m in the northern basin, and 16 m in the southern basin. Transect start locations were created using ArcMap to create random points around the lake. Each start point was assigned a random number and was sorted from largest (sampled first) to smallest (sampled last); the resulting order was used to determine the date each site would be sampled. A total of six transects were conducted, four in the northern basin and two in the southern basin. Cast net transects consisted of ten throws at each 1.5 m lake depth interval using a 1.82 m radius cast net that had 4.8 mm mesh. During each transect counts of age-0 yellow perch were recorded.

To calculate a population estimate, the counts on sample plot method was used to estimate the population using the seine data (Van Den Avyle 1993). The population estimate from the seine data was then extrapolated to the entire lake using average counts for each depth interval from the cast net transects. The assumption was made that the average count for the 0-1.5 meter depth interval was represented by the estimate from the seine data. The average count for each depth interval ($\overline{x}$) was divided by the sum of the averages ($\sum\overline{x}$) from the cast net data to determine the proportion of the population each interval represented ($\propto$).

$$\propto = \frac{Interval\,\overline{X}}{\sum\overline{X}} \quad (1)$$

From the proportion for the 0-1.5 meter interval a whole lake population was estimated by dividing the seine haul population estimate by the proportion estimated to be in the 0-1.5 depth interval ($\propto$).

$$Population = \frac{Seine\quad Population}{\propto} \quad (2)$$

Once the whole lake estimate was calculated, the population estimate for each depth interval was calculated by multiplying the whole lake estimate by the proportion estimated to be in each depth interval ($\propto$).

$$\begin{matrix} Interval \\ Population \end{matrix} = \begin{pmatrix} Lake \\ Population \end{pmatrix} * \begin{pmatrix} Interval \\ \propto \end{pmatrix} \quad (3)$$

A 95% confidence interval was calculated for the cast net data using the variance in the proportions for each depth interval. Upper (UCL) and lower (LCL) confidence levels were then calculated for the resulting population estimate. New population estimates using the LCL and UCL proportions were calculated and the confidence interval calculated for the seine data was added to the UCL estimate and subtracted from the LCL estimate. The difference between the confidence intervals and the original population estimate was determined to be the confidence interval for the entire lake population estimate.

Results

The proportions from the cast net data provide evidence to suggest that the traditional method of using littoral seine hauls to estimate population only samples 38% of the actual population present (Figure 1). The proportions for each interval also suggest that age-0 yellow perch utilize different areas and habitat throughout the lake and are not just limited to the littoral zone (Figure 1).

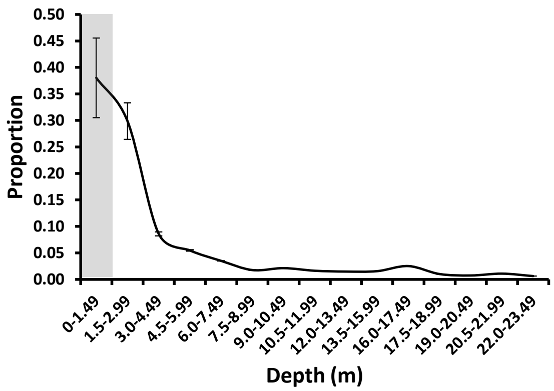

Figure 1. - The proportion of the total population of age-0 yellow perch for each depth interval in Lake Bemidji. Shaded area represents the depth that is effectively sampled using littoral seines. Black bars represent 95% CI.

Analysis of the average number of age-0 yellow perch caught using a cast net for each depth interval showed that the populations in the littoral zone were far more variable than the populations in the pelagic zone (Figure 2). Analysis of the densities of age-0 yellow perch at each depth interval showed that yellow perch were not limited to the littoral zone and were utilizing habitats outside of the littoral zone (Figure 3).

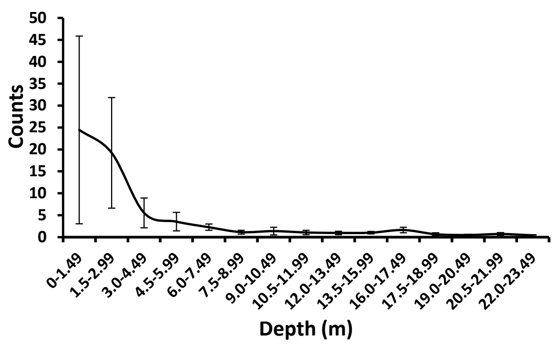

Figure 2. – Average number of age-0 yellow perch caught in cast nets at each lake depth interval in Lake Bemidji. Black bars represents 95% CI.

The resulting population estimate for age-0 yellow perch was 3,851,254 ± 3,338,249 (95% CI) (Table 1). The resulting population estimate from the seine haul and cast net data combined, increased by 163%, from the population estimate of 1,464,864 ± 211,908 (95% CI) using just seine data (Table 1).

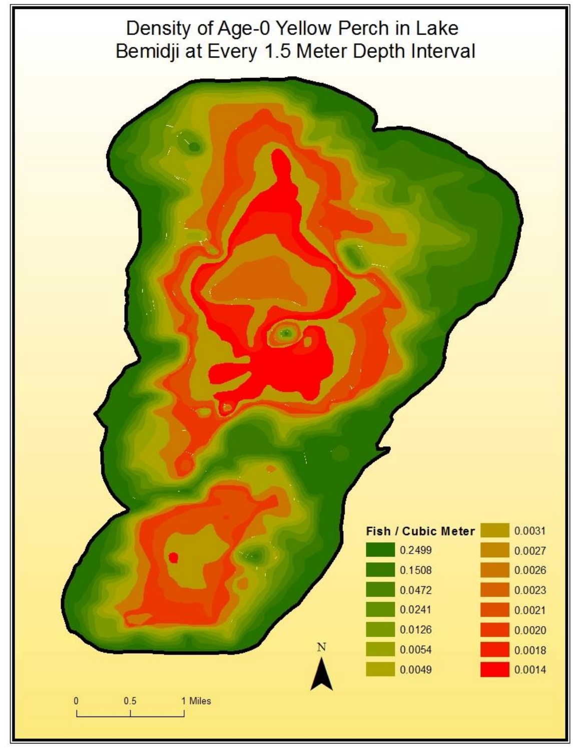

Figure 3. – The density of age-0 yellow perch ($fish/m^3$) present in each 1.5 meter depth interval in Lake Bemidji.

Table 1. – Comparison of the two sampling methods used to generate age-0 yellow perch population estimates for Lake Bemidji. Population estimates include 95% confidence intervals and upper (UCL) and lower (LCL) confidence limits.

Method	Estimate	95% CI	UCL	LCL
Littoral Seine	1,464,864	211,908	1,676,772	1,252,955
Littoral Seines and Cast Nets	3,851,254	3,338,249	7,189,504	513,005

The density of age-0 yellow perch was calculated using the population estimate for the entire lake. The population estimate resulted in a density of 0.014 $fish/m^3$ ± 0.012 (95% CI) (Table 2).

Table 2. – The density of age-0 yellow perch (fish/m^3) in Lake Bemidji compared to densities in Lake Michigan (Miehls and Dettmers, 2011), and two South Dakota lakes (Dembkowski et al. 2012)

Density (fish/m^3)	Littoral Zone	Entire Lake	UCL	LCL
Bemidji	0.194	0.014	0.026	0.002
Lake Michigan	NA	0.0095	0.015	0.004
Clear	0.07	NA	0.12	0.02
Pickerel	1.04	NA	1.09	0.99

Discussion

The analysis of the cast net data shows that age-0 yellow perch are utilizing the pelagic zone and are not limited to the littoral zone. Miehls and Dettmers (2011) observed that age-0 yellow perch have pelagic phase, and the habitat that is utilized shifts with growth. They found that the shift in habitat was related to size, and the shift between pelagic and benthic habitat occurred at sizes ranging from 30-70 mm (Janssen and Luebke 2004). During our study, the lengths of age-0 yellow perch were within the 30-70 mm size range, and it also is within our 100 mm cut-off from age-0 to age-1.

From the variance in the confidence intervals of the proportions seen in Figure 1, and the average number at each depth interval in Figure 2 suggest that the population that is utilizing the littoral zone is more variable than the populations that are utilizing the pelagic zone. This suggests that more intensive sampling of the littoral zone depths is needed to reduce the variance in the population estimates.

To determine if our estimates of age-0 yellow perch abundance were biologically sound, the density was compared to previous studies. The density of age-0 yellow perch for Lake Bemidji was similar to Lake Michigan with densities of 0.004-0.015 fish/m^3 reported by Miehls and Dettmers (2011) using trawls. By comparing the density of age-0 yellow perch in Lake Bemidji to the densities from Clear and Pickerel Lakes (Dembkowski et al. 2012), the density from Lake Bemidji falls between the Clear and Pickerel Lakes estimates. The density from Clear is less than the density from Bemidji, but the density from Pickerel is considerably larger than the density from Lake Bemidji. This shows that yellow perch populations can be highly variable.

The population estimate for the entire lake increased from the estimate using just littoral seines; however the confidence interval also increased. The size of the confidence interval increased because of a decision to use a conservative estimate based on the variance of the proportion of the average count from the cast net intervals. Due to the variation in the average counts for the shallower depth intervals, this caused the confidence interval to become fairly large. To reduce the size of the confidence interval, more sampling is needed in the shallower depths to decrease the variation in the average counts.

Even though the confidence interval is conservative and is fairly large, the population estimate shows that age-0 yellow perch are being under estimated and are utilizing areas of the lake outside the littoral zone. Even with the common method of using littoral seines to estimate abundance using the counts on sample plots method (Van Den Avyle 1993), it is important to note the actual area that can be sampled by seines, and this area needs to be calculated to ensure an accurate population estimate using this method.

With a better understanding of the habitat and the distribution of age-0 yellow perch, better decisions can be made to manage yellow perch populations as well as sport fisheries that rely on yellow perch as a forage base. Along with improved management, the understanding of what habitats age-0 yellow perch utilize could help to explain why yellow perch age classes are so variable.

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