Michigan Department of Natural Resources
Fisheries Technical Report 2005-3, 2005

Sample Sizes for Inland Lake Habitat and Lakeshore Development Metrics

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*Abstract.–*Sample sizes for two inland lake habitat, and three lakeshore development, metrics were evaluated for eight southern Michigan lakes, three large lakes, and three impoundments. Habitat metrics were index of vegetation cover and counts of submerged trees. Lakeshore development metrics were dwelling and dock counts, and percentage of shoreline armored. Metrics were sampled from a boat cruising parallel to the shoreline. Boat transects were 1,000 ft in length, as measured using a handheld Global Positioning System (GPS) unit. The entire shoreline was sampled for each lake or impoundment. For the eight southern Michigan lakes, bootstrapping techniques indicated that sampling 5 transects captured most of the variation for each metric. Only minimal increases in measured variation occurred by sampling 10 transects. Two additional levels of precision were considered using parametric methods. First was the sample size needed to detect maximum change in the mean value for each metric. Maximum change for vegetation cover was ±1 (change to an entirely different category), count of submerged trees was ±4, dwelling counts was ±10, dock counts was ±6, and percentage of shoreline armored was ±50%. Second was sampling effort required to detect relatively small changes in the mean where additional sampling would provide only modest improvements in precision. To detect maximum change for the eight southern Michigan lakes, a sample size of 2 transects was necessary for the index of vegetation, 1 for submerged trees counts and for dwelling counts, 4 for dock counts, and 2 for estimating the percentage of shoreline armored. Sampling effort required to detect relatively small changes in the mean was 15 transects for index of vegetation and submerged trees; and 20 for dwelling counts, dock counts and percentage of shoreline armored. Index of vegetation was not sampled for the three large lakes or the three impoundments. To detect maximum change for the three large lakes, a sample size of 1 transect was necessary for submerged trees counts, 3 for dwelling counts, 4 for dock counts, and 2 for estimating the percentage of shoreline armored. Sampling effort required to detect relatively small changes in the mean was 10 for submerged trees counts, 20 for dwelling counts, 25 for dock counts, and 20 for percentage of shoreline armored. To detect maximum change for the three impoundments, a sample size of 18 transects was necessary for submerged tree counts, 1 for dwelling counts, 3 for dock counts, and 2 for percentage of shoreline armored. Sampling effort required to detect relatively small changes in the mean was 30 for submerged tree counts, 15 for dwelling counts, 25 for dock counts, and 20 for percentage of shoreline armored. The finite population correction (fpc) term was not included in previously given sample size evaluations. An example of fpc benefit is presented; inclusion of fpc greatly increased the precision of mean dwelling count for the eight southern Michigan lakes. Measurement error introduced by GPS was evaluated for transect lengths of 100–2,000 ft. For a 1,000-ft transect, error was ±9.8% of transect length (±98 ft). Inclusion or exclusion of a metric unit (e.g., dock) in a transect is associated with lake lot width. For a minimum lot width of 60 ft, greatest reduction in edge effect was achieved with a transect length of 500 ft and only minimal improvements occurred for transects over 1,000 ft. For our study, a boat transect of 1,000 ft sampled a mean shoreline of 1,320.4 ft. Shoreline sampled per 1,000 ft boat transect was not significantly different between eight southern Michigan lakes, three large lakes, or three impoundments ($P = 0.63$). Similarly, shoreline sampled and lake circumference were not significantly correlated ($P = 0.88$), and shoreline sampled and shoreline development index were not significantly correlated ($P = 0.29$). Shoreline sampling for most Michigan lakes takes a minimal amount of time. Twenty-six transects can be sampled in ~1 h. Recommendations of this study are that the entire shoreline should be sampled for all lakes and impoundments less than 3,500 acres. For lakes and impoundments greater than 3,500 acres, a minimum of 30 randomly selected shoreline transects should be sampled, and additional transects should be sampled whenever possible.

Introduction

Human activities can negatively affect inland lake ecosystems through alterations in water quality and physical habitat. For example, increased nutrient loadings from septic seepage and lawn fertilizers can increase primary production, increase algae and aquatic vegetation to nuisance levels, and decrease concentrations of dissolved oxygen when excess algae and vegetation decompose. In addition, the quantity and quality of physical habitat available to fishes in the littoral zone can be altered by removal of coarse woody debris, by an increase or decrease (via chemical or mechanical removal) of aquatic macrophytes, and by homogenization of the shoreline through erosion control efforts (e.g., rip-rap and sheet piling). Such changes in water quality and habitat features have been shown to negatively impact fish growth (Schindler et al. 2000), limit natural reproduction of certain fish species (Rust et al. 2002), and reduce fish species richness and shift assemblage structure towards more tolerant species (Jennings et al. 1999). Consequently, monitoring, assessing, and regulating the influence of human activities on the condition of inland lake systems is necessary for sound management of these resources.

A primary goal of the Michigan Department of Natural Resources' Lakes Status and Trends Program (Hayes et al. 2003) is to monitor and assess the impacts of human activities on inland lakes. However, few guidelines are available for setting appropriate sample sizes for measuring human impacts, especially to assess status and detect trends for a large number of lakes distributed across the State. The allocation of sampling effort must strike a balance between collecting quality data for individual lakes and being able to rapidly assess conditions in a relatively large number of lakes.

The objective of this study was to evaluate sample sizes for characterizing littoral zone habitat and human lakeshore development for Michigan inland lakes. Metrics for this study were visually