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Completion Report

Large Lake Sampling Program Assessment Report for Leech Lake 2013

by

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Completion Report

Large Lake Program Assessment Report
Leech Lake
2013

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INTRODUCTION

Minnesota's ten largest walleye lakes account for nearly 40% of the annual statewide walleye *Sander vitreus* harvest and provide significant contributions to resource-based economies on both local and statewide scales (MNDNR 1997). Prior to 1983, fisheries assessments on these lakes were infrequent and highly variable in their methods. As a result, these surveys were unreliable for assessing fishery status as well as any fishery response to management actions. Recognizing the importance of these systems and the need for robust data to effectively identify and evaluate trends in fish stocks, the Minnesota Department of Natural Resources initiated the Large Lake Program (LLP) in 1983. Goals of the LLP include annual fishery surveys using standardized methods to facilitate comparisons among years and lakes, to detect management needs and evaluate management actions, and to enhance public outreach.

Sampling guidelines for the large lakes were outlined in the Large Lake Sampling Guide (Wingate and Schupp 1984). Since published in 1984, large lake sampling methods have been adapted on a lake-specific basis to ensure information collected is valid for both research and management applications; ineffective methods or those with poor reliability have been eliminated or de-emphasized. In some cases, additional targeted sampling has been added to augment methods delineated within the LLP. The primary focus of the LLP and its survey methods is to promote sound management of important sport fish populations. Leech Lake is the third largest lake within state boundaries and is one of eleven lakes monitored by the LLP (MNDNR 1997).

Leech Lake is renown among anglers as an exceptional multi-species fishery; however, most anglers target and harvest walleye. In 2009-2010, the MN DNR convened a citizen input committee (Leech Lake Advisory Committee; LLAC) comprised of stakeholders representing local and statewide interests in Leech Lake management. This group outlined walleye population management objectives and actions, including double-crested cormorant management, walleye regulations, and walleye fry stocking (LLAC 2010). These recommendations were incorporated into DNR's Leech Lake Management Plan, 2011-2015 (Schultz 2010a). These management goals, where appropriate, are referenced in this report.

This report primarily addresses the 2013 Leech Lake fishery assessment. Fishing quality on Leech Lake, indexed by targeting angler catch rates, has improved significantly from the historic lows observed during 2005 to record highs during the 2008-2011 open water seasons (Ward and Schultz 2012). Recent surveys have indicated sustained improvements to the walleye population and its fishery since 2005. The completion and thorough evaluation of these efforts will refine current management strategies on Leech Lake as well as identify the needs for new ones.

Aquatic invasive species currently found in Leech Lake include rusty crayfish, heterosporosis, curly-leaf pondweed, Eurasian watermilfoil, purple loosestrife, and banded mystery snail. Invasive plant species are not widely distributed within Leech Lake, but Eurasian water milfoil is expanding with evidence of beds established in new areas outside of harbors. Other aquatic invasive species are increasing in prevalence throughout Minnesota and pose a likely risk. Anglers and boaters alike are encouraged to properly dispose of bait in the trash, to drain all water from bait containers, livewells, and watercraft, and properly inspect and remove all vegetation from the watercraft, anchor, and trailer when leaving a lake.

STUDY AREA

Leech Lake has approximately 112,000 surface acres. In its original state the lake covered about 106,000 acres. In 1884, a dam was built on the Leech River, raising the water level about two feet and increasing the surface area to its present size (Wilcox 1979). The maximum depth of the lake is near 150 feet; however, nearly 80 percent of the lake is less than 35 feet deep. Leech Lake has approximately 57,994 littoral acres (≤15 feet).

Leech Lake is located in three glacial zones and has an irregular shape with many large and small bays. Leech Lake varies considerably from a morphological perspective. Some large bays, such as Steamboat and Boy, display highly eutrophic water characteristics whereas other large bays, such as Walker and Kabekona, have properties more congruent with oligotrophic lakes. The main portion of the lake, like most large Minnesota walleye lakes, is mesotrophic. Previous estimates of shoreline miles have varied, but using remote sensing technology, the estimate is 201 miles. Approximately 23 percent of the shoreline consists of a gravel-rubble-boulder mixture, nearly all of which is suitable walleye spawning habitat (Wilcox 1979).

The diversity of the Leech Lake shoreline and substrate, as well as its extensive littoral zone, provides excellent spawning and nursery habitats for a number of fish species, in particular for percids and esocids, which dominate the fish community. Walleye, northern pike *Esox lucius* and muskellunge *E. masquinongy* are the principal predators and are located throughout the lake. Although most fish species are found in every portion of the lake, the largest walleye and muskellunge concentrations exist in the mesotrophic areas. Northern pike are most common in eutrophic bays supporting large areas of dense vegetation. Yellow perch *Perca flavescens* are abundant throughout the lake and are the primary forage for walleye and northern pike. Cisco *Coregonus artedi* and lake whitefish *C. clupeaformis* are an important forage base for muskellunge and trophy northern pike (Engstrom-Heg et al. 1986) and are typically found in the mesotrophic and oligotrophic areas. Other species present in the lake include: white sucker *Catostomus commersoni*, burbot *Lota lota*, rock bass *Ambloplites ruspestris*, bowfin *Amia calva*, shorthead redhorse *Moxostoma macrolepidotum*, bullheads *Ameiurus spp.*, pumpkinseed *Lepomis gibbosus*, bluegill *L. macrochirus*, largemouth bass *Micropterus salmoides*, smallmouth bass *M. dolomieui*, and black crappie *Pomoxis nigromaculatus*.

YOUNG-OF-YEAR ASSESSMENT

Introduction

The objectives of this assessment are to index the relative abundance of young-of-year (YOY) walleye and yellow perch, characterize early growth rates, collect structures necessary for stocking evaluations, and to estimate walleye year class strength. Standardized shoreline seining has been completed on Leech Lake since 1983. Seine catch rates can be strongly influenced by several factors, including fish behavior and size. Furthermore, seining occurs relatively early in the life-history stages before numerous first-year mortality processes, such as predation and growth, have fully acted on the cohort. Consequently, seining is reserved for collecting early information on YOY growth and stocking evaluations and is not used for estimating year class strength.

Three long-term trawling stations were established in 1987. Other stations had been attempted in the past but were discontinued due to contours that were difficult to sample, abundant vegetation, or frequent snagging of wood that would destroy the gear. The relationships between YOY walleye catch rates in various gears and ensuing year class strength remain subject to the numerous mortality processes driving recruitment variability. Fall electrofishing was added to the suite of YOY walleye assessment tools in 2005 and standardized long-term stations were established in 2007 to improve on year class estimation. Electrofishing has proven to be a useful method for predicting walleye year class strength on some of Minnesota's other large walleye lakes and, in time, has the potential to more accurately estimate year class strength on Leech Lake. Electrofishing catch rates are highly dependent on water temperature, water clarity, and weather. Consequently, not all stations may be sampled during years of frequent inclement weather.

Methods

Seining

The five long-term seining stations (Figure 1) were sampled weekly throughout July from 1983-2010 using the parallel-to-shore method. Seining was not conducted in 2011 due to a state shutdown and stations were not sampled in 2012 according to the standardized protocols due to staffing shortages. In 2012, each of the five long-term stations were seined on three occasions during July solely to collect YOY walleye for stocking evaluations. Standardized protocols resumed in 2013. In 2013, two seine hauls were completed at each of the five stations per week over a two week time period for a total of 20 seine hauls.

Hauls were made at each station using a bag seine (100-ft. long, 5-ft. deep, 0.25-in. untreated mesh). The area seined was determined by assuming the actual lakeward distance covered by the seine was 90 feet, which compensated for the bow in the seine created by water resistance during pulling. This figure was then multiplied by the distance of the pull (150 feet) and resulted in an area of 13,500 ft^2 (0.310 acres) per seine haul. All fish were identified to species when possible and measured to total length (TL, mm). With exception to minnows, fish judged as young-of-year (YOY) were measured separately. When necessary, seine hauls were sub-sampled due to an extremely large number of fish sampled. In these instances a representative portion of fish in a volumetric sub-sample were measured, by species, and the total number obtained in the sub-sample was expanded to the total volume sampled. Age-0 walleye and age 1+ fish of other species were individually counted and measured before sub-sampling occurred. Up to 20 YOY walleye and yellow perch per station per date were retained for individual measurement (total length (TL), mm; weight (W), g) no later than the following day.

Trawling

Trawling was conducted at the three long-term stations (Figure 1) from August 13 through August 22, 2013 using a semi-balloon bottom trawl (25-ft. head rope, 0.25-in. mesh cod end liner). Eight hauls were conducted at Five Mile Point (TR-1), six at Goose Island (TR-2), and six at Whipholt Beach (TR-3), for a total of 20 hauls. Hauls at the three long-term stations consisted of five-minute tows at a fixed speed of 3.5 mph for a total effort of 100 minutes of trawl time. Fish were identified, measured, and enumerated as per the methods described for shoreline seining. Up to 20 YOY walleye and yellow perch per station per date were retained for individual measurement (TL, mm; W, g) no later than the following day.

Walleye year class strength is indexed by the respective relative abundance of age 1-3 walleye in gillnet catches and has traditionally been predicted using trawl catch rates of age-0 fish. However, numerous factors influence the survival of young walleye and eventually the size, or strength, of any given cohort. As a result, any measure of cohort strength based on the relative abundance of age-0 fish will be highly variable. The incorporation of additional metrics, such as indices of growth or YOY walleye catch rate in experimental gillnet sets, can explain some of the additional year-to-year variability for a more precise estimate. For Leech Lake, more variability in walleye year class strength can be explained when it is predicted using both trawl and gillnet catch rates of YOY walleye (1987-2013; $F = 8.32$; $R^2 = 0.42$; $P = 0.0019$) than using trawl catch rates of YOY walleye independently (1987-2013; $F = 4.98$; $R^2 = 0.17$; $P = 0.0352$). Inclusion of YOY walleye growth, as indexed by mean TL (mm) during the 34^{th} Julian week (mid-August), provides no substantial improvement over the trawl-gillnet based approach at this time.

Fall Electrofishing

Fall nighttime electrofishing targeting YOY walleye was initiated in 2005 and stations were standardized in 2007. Sampling in 2013 was conducted during September 12-19 using a MLM-Infinity pulsed-DC electrofishing boat (twin spider array anode). Standardized stations consist of four clusters of sites, each of which contain three transects. Transects were approximately 3-5 feet deep on sand/gravel/cobble shorelines. Transects consisted of 20 minutes of continuous on-time from the starting point (Figure

1). Up to 25 age-0 walleye per transect were kept for individual measurement (TL, mm; W, g) and otolith removal no later than the following day; all age-1+ walleye captured were measured (TL, mm) and released. Smallmouth bass were also sampled, measured (TL, mm), and released.

Results

Seine

A total of 20 seine hauls occurred in July 2013 at the five long-term stations sampling 19 species (Table 1). In 2013, a total of 160 YOY walleye were sampled, while 109 were retained to meet sample size needs for OTC mark detection. The overall catch rates of YOY walleye were 5/haul and 18/acre (Figure 2). These compare to the 1983-2013 means of 16/haul and 61/acre. Similarly, the overall catch rates of YOY yellow perch were 166/haul and 536/acre (Figure 2). These compare to the 1983-2013 means of 219/haul and 850/acre. Seine catch rates are not used to index the relative abundance or the potential year class strength of YOY percids because it occurs too early in the life-history process.

Trawl

A total of 100 minutes were trawled in August 2013 at the three long-term stations sampling 13 species (Table 2). In 2013, a total of 226 YOY walleye were sampled, while 114 were retained to meet sample size needs for OTC mark detection. The overall catch rates of YOY walleye was 346/hour (Figure 2). This compares to the 1983-2013 mean of 145/hour. Similarly, the overall catch rate of YOY yellow perch was 6,049/hour (Figure 2). This compares to the 1983-2013 mean of 9,274/hour. In 2013, a total of 114 YOY walleye were collected during trawling to meet sample size needs for OTC mark detection.

This year's trawl catch rate predicts a walleye year class strength ($\pm$ 95% CI) of 1.65 $\pm$ 0.36 (Table 3). Inclusion of the YOY walleye gillnet catch rate suggests a potential year class strength of 1.51 $\pm$ 0.31 (Table 3; Figure 3). Both methods predict a year class with near-average strength. The 2011-2015 management plan objective of establishing two year classes with average or greater strength (1983-2009 mean of 1.35) over a continuous four year time period, continues to be met (Figure 4).

Electrofishing

A total of 240 minutes were electrofished in September 2013 at the 12 long-term stations sampling walleye and smallmouth bass. In 2013, a total of 352 YOY walleye were sampled, while 178 were retained to meet sample size needs for OTC mark detection. The overall catch rate of YOY walleye was 88 fish/hour (Figure 2). This compares to the

2005-2013 average of 98/hour. Electrofishing catch rates should be viewed with caution as several years of consistent sampling are required before its utility for indexing walleye year class strength can be effectively evaluated. However, a strong relationship is evident between year class strength and average length of age-0 walleye sampled electrofishing (R^2=0.5831; Figure 5). A very similar relationship (R^2 = 0.592) is observed on Lake Vermillion (D. Williams, MN DNR, personal communication). This relationship underscores the influence first-year growth has on eventual recruitment to the fishery and highlights the utility of fall electrofishing when assessing recruitment potential.

YOY Growth Indices

Growth of YOY walleye was indexed by mean weekly length and condition during July through September. Mean length-at-week was consistently below long-term averages for walleye (Figure 6). The average length of walleyes was 2.7, 5.1, 5.9 inches while seining, trawling, and electrofishing in 2013, compared to the long-term averages of 3.8, 5.5, and 6.1 inches, respectively. Walleye condition, indexed using weekly K-factors, was slightly above long-term averages.

Discussion

Walleye recruitment in natural lakes is highly variable across years and is influenced by a number of physical and biological effects. High abundances of adult walleye can suppress ensuing year classes via predation (Chevalier 1973; K. Reeves, MN DNR, unpublished data) and competition (Madenjian et al. 1996; Beard et al. 2003). Similarly, high adult abundances of other species, such as yellow perch, can exert enough predation on a walleye year class to significantly influence its outcome (Hansen et al. 1998). Spring warming rates have a strong influence on incubation times, egg survival, and food availability for newly-hatched fry (Madenjian et al. 1996; Hansen et al. 1998). Furthermore, first-winter survival of YOY walleye is size-specific and therefore strongly influenced by growth rate (Madenjian et al. 1996) and condition (Bandow and Anderson 1993) during the first summer. The larger an individual becomes during its first growing season, the higher the likelihood it survives its first winter and eventually recruits to the fishery (for more detail see Fry Stocking, page 20).

Due to the high degree of variability in young walleye survival, forecasting recruitment (i.e. year class strength) based on age-0 metrics will inherently be accompanied by uncertainty. For example, variability exists among Minnesota's ten largest walleye lakes as to which YOY walleye sampling methods are the best predictor of ensuing year class strength. Fall electrofishing catch rate is the best metric on Cass, Kabetogama, Rainy, and Vermillion lakes. Conversely, trawling has been the preferred method on Lake of the Woods, Leech, Mille Lacs, and Winnibigoshish lakes. Upper Red Lake is the only lake where seining is the best tool for predicting walleye year class strength, and all three gears are used on Lake Pepin. Therefore, while 30 years of annual survey work has determined the best gear(s) for predicting walleye year class strength in each of these systems, no estimate is without error from year to year because of the dynamic mortality processes that determine recruitment. Furthermore, changes in lake ecology, such as the introduction of an invasive species, have the potential to alter these predictive relationships.

The predicted year class strength for the 2013 cohort of walleye is above average, but the 95% confidence interval around the point estimate includes the long-term average. The mean length of YOY walleye (5.9 inches) in mid-September was below average, inferring a lower probability for recruitment strength at the upper end of the 95% confidence interval.

GILLNET SURVEY

Introduction

Gillnet surveys on Leech Lake have been completed annually between early and mid-September starting in 1983. Gillnets are the most effective method for assessing walleye, yellow perch, and pike populations; however, information on other species is also collected. Experimental nets (50-ft. panels of 0.75, 1.00, 1.25, 1.5, and 2.0-inch bar mesh; 250-ft. total net length) are used to reduce size-selective biases encountered when using nets of a single mesh size. Standardized methods include net design, net location, net orientation, and time of year.

Since the LLP began in 1983, four nets have been fished at fixed locations within each major bay (Wingate and Schupp 1984); the Pelican Island sets were added in 1984 for a total of 36 net sets per year. Data collected with gillnets measure trends in population metrics, such as relative abundance, spawner stock biomass, age- and size-structure, growth rates, mortality rates, and recruitment. Gillnet catch rates are also used to establish population management goals that can be quantitatively evaluated over time.

Methods

Standard experimental gillnet sets were lifted at 36 different locations throughout the lake from September 8-20, 2013. Originally scheduled for September 1-14, the survey was postponed a week due to water temperatures in the mid-70s on August 30. Four sets were made in each of 9 different areas (Figure 7). For some analyses, gill net data were separated into western bays (17,927 acres) and main lake (93,914 acres) areas because differences in walleye abundance, growth, movement, and yield (Schupp 1978) between areas suggest the potential for contrasting population responses to fishing pressure and other environmental changes. Western bays sets included net stations 1-16 and main lake sets included net stations 17-36. Gill net locations in 2013 were nearly identical to locations sampled annually since 1984.

All fish captured were identified to species, measured (TL, mm), and weighed (g) with a 6.8-kg capacity digital scale. Sex and maturity data were recorded for all walleye, yellow perch, cisco, and northern pike when possible. Data were recorded separately for each of the five mesh sizes within each net. Weights and lengths were converted from metric units to English units for better comparison with historical data.

Ages were estimated using sagittal otoliths from all walleye and a single clithera from esocids. Otoliths were removed from a minimum random subset of five yellow perch and five cisco, per sex and per mesh panel, from each net. In most cases, sub-sampling for yellow perch otolith collection only occurred within the 0.75 and 1.00-inch mesh sizes. To estimate age, a per-basin maximum subsample of 10 otoliths within 25-mm length intervals for both yellow perch and cisco were randomly selected and aged for each sex. Age assignment was basin-specific for each species because differences observed in walleye population metrics among basin types, particularly growth rate (Schupp 1978), also exist for other species (Schultz 2008a).

Results

Catch rates and length-frequency distributions of all species caught during the 2013 gillnet survey are summarized in Tables 4 and 5; historical gillnet catch summaries are in Table A13 and Figure A1 in the Appendix.

Walleye

A total of 321 walleye were sampled in gillnets. The 2013 gillnet catch-per-effort (CPE) of 8.9 walleye/net was slightly below the catch rate observed during 2012 (9.4 walleye/net) and above the 1983-2013 average of 7.7 walleye/net (Figures 8 and 9). Historical gill net catch rates have ranged from 4.6 fish/set (1993) to 13.4 fish/set (1988). Of walleye captured during the 2013 gillnet survey, 68% were sampled in main lake sets. By sampling area, walleye gillnet CPE ranged from 1.5 (Steamboat Bay) to 22.3 fish/net (Main Basin North). The overall 2013 gillnet catch rate exceeded the 2011-2015 management objective of 8.5 walleye/net (Figure 10); 8.5 walleye/net represents the 75th percentile of the historical time series (1983-2010).

Consistent with long-term trends, mean catch rate during 2013 was higher in the main lake (10.95 fish/net) than in the western bays (6.38 fish/net) (Table 4). Walleye from 6 to 27 inches (total length; TL) were present in the gillnet sample (Table 5; Figure 11). Observed median lengths of the 2012, 2011, 2010, and 2009 year classes were approximately 10, 13, 16, and 17 inches TL, respectively. Walleye from age 0-17 were sampled in the main lake, while walleye from age 1-13 were sampled in the western bays (Tables 6, 7, Tables A1-A4). Of sampled walleye, 42% were shorter than 15 inches TL; this is below the 2011-2015 management plan objective range of 45-65%, indicating higher proportion of larger walleye than specified by the objective range (Figure 12). Standing stock biomass of mature female walleye was estimated to be 2.21 pounds/acre, which exceeds the 2011-2015 management goal of 1.50-2.00 pounds/acre and is the second highest observed to date (Figure 13).

A suite of biological performance indicators (BPIs), or population response metrics, were developed to monitor exploitation of Minnesota's large lake walleye populations (Gangl and Pereira 2003). Exceedence of BPI threshold levels can indicate overharvest or, more precisely, increased mortality. One of the first physical signs of increased mortality is increased growth and earlier maturity rates. During 2000-2010, mean length at age-3, omega, and female age at 50% maturity, all three of which are either direct measures of growth or are strongly influenced by growth, indicated cause for concern (Figures 14 and 15). Schultz et al. (2013) found statistical differences in walleye recruitment, growth, and maturity among the 1992–1997, 1998–2004, and 2005–2011 time periods, which represent pre-colonization, population buildup, and the management eras of the cormorant colony. The differences in these metrics across these respective time periods were indicators of population responses to increased mortality. Similar percid population responses were observed on Lake Huron (Fielder 2008, 2010). As of 2013, mean length at age-3 and omega have declined below their respective thresholds while female length and age at 50% maturity has increased above its respective threshold. Therefore, walleye population metrics in Leech Lake, which are indexed by the BPIs, have all at a minimum returned to levels concordant with historical averages. However, as walleye density has increased, some density dependent responses are becoming evident in the adult population. These include increases in age at maturity for adult walleyes (Figure 15) and declines of walleye condition (Figure 16).

Yellow Perch

A total of 435 yellow perch were sampled in gillnets. The 2013 yellow perch gillnet catch-per-effort of 12.08 fish/net is down from 2012 observations (14.53 fish/net) and dropped below the 1983-2013 average of 21.38 fish/net and was the lowest rate observed in the past 31 years (Figures 8 and 9). Historically, gill net catch rates have ranged from 12.1 fish/net (2013) to 37.7 fish/net (1995). By area, yellow perch catch rates ranged from 1.5 fish/net (Main Lake South) to 36.5 fish/net (Steamboat Bay). The 2013 overall catch rate for yellow perch was below the respective 2011-2015 Leech Lake management plan objective of 16.25 fish/net and declined for the sixth consecutive year (Figure 10).

Consistent with long-term trends, mean catch rate during 2013 was higher in the western bays (15.00 fish/net) than in the main lake (9.75 fish/net) (Table 4). Lengths of yellow perch sampled with gillnets ranged from 3 to 13 inches TL (Figure 17). Of yellow perch sampled, approximately 34% were 8 inches or longer, 18% were 9 inches or longer, and 11% were 10 inches or longer. Both of the yellow perch size structure objectives outlined in the 2011-2015 management plan were met in 2013 (Figure 18).

Yellow perch from age 2-10 were sampled in the main lake, while yellow perch from age 2-8 were sampled in the western bays (Tables 8, 9). In general, growth of yellow perch, measured by mean length-at-age of fish caught in gillnets, was above the long-term average for nearly all male and female age groups in both basins (Tables A5-A8). Also, similar to walleye, yellow perch growth has been returning towards the historical range. Statistical differences were observed in yellow perch growth among the 1992–1997, 1998–2004, and 2005–2011 time periods (Schultz et al. 2013). The differences in these metrics across these respective time periods were indicators of population responses to increased mortality. Similar yellow perch population responses were observed on Lake Huron (Fielder 2008, 2010). These time periods represent pre-colonization, population buildup, and the management eras. Yellow perch growth is slightly faster in the main lake than in the western bays and is consistently faster for females at all ages. Length and age of female yellow perch at 50% sexual maturity were 6.5 inches and 2.5 years (Figures 19-20, Tables 8). Males tend to reach sexual maturity before they are effectively sampled by gillnets (Table 9).

Northern Pike

A total of 162 northern pike were sampled in gillnets. The 2013 gillnet catch rate of northern pike of 4.61 fish/net is up slightly from 2012 (4.33 fish/net) and is similar to the long-term average of 4.82 fish/net (Figures 8 and 9). Northern pike gillnet catch rates remain stable, ranging between 3.6 fish/net (1993) to 6.2 fish/net (1995). The 2013 northern pike gill net catch rate was higher than the 2011-2015 management plan objective of 4.08 (Figure 10).

Consistent with long-term trends, mean catch rate during 2012 was higher in the western bays (5.00 fish/net) than in the main lake (4.30 fish/net) (Table 4). By area, gillnet catch rates of northern pike ranged from 2.00 fish/net (Portage Bay) to 8.50 fish/net (Steamboat Bay). Northern pike size structure objectives outlined in the 2011-2015 management plan were above their respective targets in 2012 (Figure 18). Lengths of northern pike ranged from 13 to 32 inches (Figure 21).

Growth rates of northern pike, indexed by length-at-age of fish captured in gillnets, were similar to the long-term averages for most age classes of males and females in both basins (Tables A9-A12). The majority of both male and female northern pike sampled had reached sexual maturity by age-1 and age-2, respectively (Tables 10 and 11). Generally, males and females have similar lengths through age-2, after which females grow faster and achieve larger sizes. Similar to walleye and yellow perch, northern pike in Leech Lake tend to grow slightly faster in the main lake than in the western bays.

Cisco (Tullibee)

The 2013 catch rate of 3.33 fish/net was below the 1983-2013 average of 5.39 fish/net (Figures 8 and 9). Gillnet catch rates of cisco have varied considerably, ranging from 0.6 fish/net (2006) to 18.5 fish/net (1987). Catch rates were similar in the western bays (3.38 fish/net) and the main lake (3.30 fish/net; Table 4). Cisco catch rates had been in a general state of decline since the mid-1990’s, and this trend was most prominent in the main lake where coldwater refuge for this species is limited during summer months. Lengths of cisco sampled in gill nets ranged from 7 to 17 inches. Cisco sampled ranged from age 1 through 11, with the 2008 (24%) and 2009 (34%) year classes being the most frequently sampled.

Bullheads

The gill net catch rate for black bullhead (*Ictalurus melas*) was 0.03 fish/set, which was below the long-term mean catch rate of 5.18 fish/set. The catch rate of yellow bullhead (*I. natalis*) was 0.42 fish/set and was also below the long-term mean of 1.49 fish/net. The catch rate of brown bullhead (*I. nebulosus*) was 0.22 fish/net, which is also below the long-term average (1.56 fish/set). Of the 24 bullhead sampled, 63% were yellow bullhead, 33% were brown bullhead, and 4% were black bullhead.

Other Species

Other species, which include black crappie, bluegill, bowfin, largemouth bass, muskellunge, pumpkinseed, rock bass, and white sucker are not effectively sampled by experimental gill nets or are present in low numbers. Gill net catch rates for these species were within observed ranges from 1983-2013. Targeted spring sampling for largemouth and smallmouth bass, bluegill, and black crappie using electrofishing was first conducted in 2012 and is scheduled to be completed every three years.

Discussion

Gillnet catch rates of walleye remained above the long-term average for the seventh consecutive year and overall walleye biomass sampled (lbs/net) has increased steadily since 2004. Conversely, gillnet catch rates of yellow perch have decreased for the sixth consecutive year and the 2013 catch rate was the lowest observed since the large lake program began in 1983. Gillnet catch rates of northern pike continued to remain similar to long-term averages.

Metrics associated with the 2011-2015 Leech Lake Management Plan (Schultz 2010a) were near or above management objectives in most cases. The consistency in the walleye population since 2005 suggests a positive response to current management actions. The protected slot limit on walleye has successfully protected mature females in Leech Lake and has increased the reproductive capacity of the population; wild fry production has averaged 402 fry/LA since 2007 (see Fry Stocking, page 20). Walleye recruitment has also become less variable since 2007, and this is similar to post-regulation recruitment patterns observed on Upper Red Lake (Kennedy 2013) and Lake Winnibigoshish (Schultz and Staples 2010a). Density is an important factor regulating growth, maturity, and recruitment (Spangler et al. 1977; Muth and Wolfert 1986; Schueller et al. 2005). As walleye density has increased, some density dependent responses are becoming evident in the adult population. These include declines of walleye condition and increases in age at maturity for adult walleye. Changes in the walleye population have led to considerable improvements to the recreational fishery as indicated by summer creel surveys conducted during 2008-2011 (Schultz 2009; Schultz 2010b; Vondra and Schultz 2011, Ward and Schultz 2012). Overall, walleye metrics indicate the population has at least returned to its pre-2000 levels, while some metrics indicate the population density has exceeded those levels to the detriment of the prey base.

Specific causes of recent declines in yellow perch abundance are undescribed, but walleye predation is strongly suspected. Recent year classes have consistently been near the long-term average in terms of strength; this has resulted in a consistently high forage demand by juvenile walleyes. Juvenile walleye far outnumber adult walleye in all populations, have considerably higher metabolic rates and energy demand, and therefore also have higher consumption rates on a per-pound basis (Kitchell et al. 1977; Hartman and Margraf 1992; Madon and Culver 1993). The harm in managing for excess fry densities are it reduces physiological fitness and recruitment potential, and fish that do not survive to recruit to the fishery still consume forage until they die. In addition to increased predation pressure, other mortality sources include higher annual perch harvest in the winter (Schultz and Vondra 2011). Winter creel surveys are proposed in two of the next three winters and should quantify this further. Double-crested cormorants are not the driver of this recent decline because total annual fish consumption by cormorants has been reduced by 90% relative to 2004 levels and are similar to pre-2000 levels (Schultz et al. 2013).

Double-Crested Cormorant control efforts have reduced predatory pressures on fish populations. Schultz et al. (2013) concluded that total feeding effort and fish consumption was reduced by nearly 90% between 2004 and 2011, (16.81 lbs/ha in 2004 and 1.61 lbs/ha in 2011) and by 46–73% annually, depending on the number of birds arriving each spring and the applied culling intensity. Modeling also determined the predation potential on juvenile walleye by cormorants was high enough during 2000-2004 to impact walleye recruitment (Schultz et al. 2013). The 2000-2005 year classes of walleye were five of the worst seven year classes observed lakewide, and this trend was most prevalent in the main lake basin where cormorants fed almost exclusively. Statistical differences were observed in walleye recruitment, growth, and maturity and yellow perch growth among the 1992–1997, 1998–2004, and 2005–2011 time periods. These time periods represent pre-colonization, population buildup, and the management era. The differences in these metrics across these respective time periods were indicators of population responses to increased mortality.

Cisco catch rates have been highly variable, and peaks in the gill net time series have been associated with strong year classes of age-1 and/or age-2 fish. Cisco are a primary and important forage species for top predators. Cooler summers in 2008 and 2009 reduced thermal stress that can lead to significant summer kills. Population increases during periods of cooler summers are more prominent in the shallower, windswept main lake basin of Leech Lake where oxygen-rich coldwater habitat is limited but spawning habitat is abundant. When unusually warm air temperatures are combined with strong winds, the entire water column is mixed and water temperatures increase markedly over a short period. In the case of coldwater species (e.g. cisco), as environmental temperatures exceed the thermal optima for proper physiological functions and are sustained at unusually high levels for extended periods (days to weeks), basic cellular processes begin to operate less efficiently. As explained more specifically by Pörtner (2001) and Pörtner and Knust (2007), oxygen demand for metabolic processes at the cellular level in fish increases exponentially with increases in temperature. At the same time, the capacity for water to retain oxygen diminishes with increasing temperature. Thermal stress occurs when aerobic metabolic demands exceed the capacity of the oxygen delivery system (respiration and circulation). Therefore, thermal stress in fish can be defined as an oxygen-limiting process, much like human aerobic performance at high altitudes. As temperatures continue to increase beyond the onset of physiological stress, or as this stress is prolonged, an oxygen deficiency can occur and eventually lead to mortality. Consequently, as the cisco population in Leech Lake will be limited to the constraints of temperature-mediated mortality as dictated by summer climate trends, the potential exists for impacts on other species, specifically the growth rates of predatory species.

FRY STOCKING

Introduction

Recruitment variability, or the variability in the size, or strength, of a year class, is influenced by a host of factors, including spawner abundance (Ricker 1975), predation (Hansen et al. 1998; Beard et al. 2003; Quist et al. 2003), spawning conditions (Hansen et al. 1998), forage abundance (Chevalier 1973), and lake morphology (Nate et al. 2001). In Minnesota's ten largest walleye lakes, strong year classes, as indexed by gillnet catch rates of juvenile walleye, are defined as cohorts having a relative abundance in the upper 75^{th} percentile of historically observed values. Strong year classes typically occur every 3 to 5 years in the large lakes. However, variable spawning and summer growing conditions can intermittently alter this frequency. Unfavorable reproductive conditions, a limited forage base, or high abundances of adult walleye can extend the time between large year classes. Fishing quality, defined by angler catch rates, closely parallels the occurrence of a strong year class. The downturn in the Leech Lake walleye fishery during the mid-2000s was a product of several consecutive below-average year classes. Schultz et al. (2013) strongly implicated cormorant predation on juvenile fish as a likely factor contributing to the poor recruitment observed and associated declines in the fishery. The objectives of this portion of the 2013 large lake work include estimating walleye hatch rates and total fry density in Leech Lake, comparing hatch rates observed in Leech Lake to those in other systems where similar quantitative methods have been used, comparing total walleye fry densities to eventual recruitment, which is measured as year class strength and, assessing factors that have influenced age-0 walleye growth.

Methods

During May 31 – June 1, 2013, 7,527,478 Boy River strain walleye fry were stocked into Leech Lake. All stocked fry were marked with oxytetracycline (OTC), an antibiotic that leaves an indelible mark on fish bones that allows researchers to identify them as a stocked fish. By stocking a known number of fry, the total number of wild fry at the time of stocking was estimated using a Peterson mark-recapture equation (Logsdon 2006); this is based on the ratio of marked (stocked) to unmarked (wild) YOY walleye collected during the seining, trawling, electrofishing, and gillnet sampling events. The hatch rate of wild fry can then be estimated as a percentage of estimated eggs carried the previous fall by mature females that hatched into fry the following spring at the time stocking occurred. Fish used during this evaluation were collected by standard seining, standard trawling, and standard electrofishing. Two additional trawl hauls were conducted in mid-August among long term stations (Table 12) to increase the sample size and more evenly distribute sampled individuals among the standard trawl stations.

Simple linear regression was used to standardize annual age-0 lengths the 34th week of the year, or approximately August 15. The standardized lengths were then used as the response variable in a series of single-parameter linear regression models. Independent variables tested included fry stocking density (StockedDen; fry/LA), total fry density (TotalDen; fry/LA), and cumulative growing degree days of 5 °C (GDD5) as an index of growing season length on recruitment. Since fish activity and metabolism in temperate zones can be determined by water temperature, GDD5 was calculated from air temperature data to characterize cumulative growing units among years. The linear relationship between air and lake surface temperature during ice-free months supports the use of GDD5 as a robust surrogate for lake temperature. As total fry density and growing season independently had a strong influence on recruitment, a multiple regression model was fitted to describe the effect of fry density and growing season on recruitment.

Results

A total of 1,038 YOY walleye were sampled using seining (July; n = 109) bottom trawling (August; n = 577) and shoreline electrofishing (September; n = 352). A subsample of 356 YOY walleye equally distributed among gear types and weeks were examined for the presence of an OTC mark. Of the fish examined, 23% (83) were identified as stocked fish. Fish held in ponds to determine mark efficacy demonstrated 100% mark retention. The 2013 wild fry hatch rate was estimated to be 0.38% (Table 13). The wild fry population estimate was 24.5 million and the estimated number of total fry (stocked plus wild) was 32.0 million. Fry densities were 422 wild fry/littoral acre (LA) and 130 stocked fry/LA, totaling 552 total fry/LA (wild plus stocked). For comparison, the strong 2005-2007 year classes of walleye were established with fry densities less than 600 total fry/LA, and higher stocking densities or total fry densities have led to weaker year classes (Figures 4, 22). Growth analysis provided insight on likely reasons for this.

First-year growth was not strongly associated with stocked fry density but was negatively related to total fry density, as indicated during the mid-September electrofishing assessment (Figure 23). As expected, increased temperatures indexed as a larger GDD5 value, which represents a longer and/or warmer summer, resulted in faster growth (Figures 24, 25). There was no strong relationship between total fry density and temperature, suggesting each factor tested acted independently on age-0 walleye growth. Walleye recruitment is strongly influenced by growing season and total fry density (F = 8.25; df = 2,5; P = 0.0261; R^2 = 0.77). Based on these data, walleye recruitment in Leech Lake is maximized at total fry densities ranging from 400-600fry/LA. The variability in walleye recruitment potential increases as fry density decreases below 400 fry/LA as a function of growing season, and recruitment potential consistently decreases as total fry density exceeds 600 fry/LA.

Discussion

Walleye hatch rates in Red Lake were estimated from 1999-2003 using methods similarly described for Leech Lake and have served as a description, or benchmark, of good reproduction in self-sustaining walleye populations (mean 0.22%, range 0.02-0.60). More recently hatch rates have also been estimated for other walleye lakes as part of an ongoing study evaluating total fry densities in walleye spawn-take lakes in Minnesota (Table 13).

The range of walleye hatch rates in Leech Lake is very similar to other walleye fisheries in Minnesota. These data confirm there is no fundamental problem with walleye reproduction in Leech Lake and discount concerns that rusty crayfish are negatively impacting walleye recruitment. To date, walleye hatch rates have averaged higher in lakes infested with rusty crayfish. This should not be interpreted as rusty crayfish having a positive effect on walleye reproduction, but instead that both species benefit from rock/gravel substrates.

The proportion of marked (stocked) to unmarked (wild) fry has ranged between 14-86%, and has always been higher in years of higher stocking density. This phenomenon does not infer higher fry stockings have resulted in higher recruitment or greater overall contribution, as indicated by comparing the relative strengths of stocked year classes (2005-present) to year classes produced by natural reproduction alone (1988-2004) (Figure 4). Similarly, higher total fry densities resulting from higher stockings during 2005-2011 have not resulted in increased recruitment (Figure 22). It instead reflects mathematical probabilities: by stocking nearly three times more marked fry into the system with an amount of wild fry that has not increased three-fold, one would expect to see more marked fish upon examination. The curve-linear and/or declining relationship between total fry density and recruitment suggests density-dependent effects are occurring (Figure 25).

Mean length of age-0 walleye sampled via trawling (August) from 1987 through 2012 were compared among years to determine if growth rates have changed over time. Growth rates continue to be variable, similar to the pre-stocking time series. However, three of the five poorest growth observations occurred during years stocked with 20-22.5 million walleye fry. This prompted further questions on the influence of total walleye fry density on first- year growth which, in turn, could reduce winter survival (Figures 5, 23). First-winter survival of age-0 fish is a significant bottleneck affecting eventual recruitment of young fish to a fishery; this survival is positively associated with early growth and size entering winter as evidenced by the relationship between mean length while electrofishing in the fall and year class strength. Consequently, management activities that have an adverse effect on growth could negatively impact recruitment.

Based on the existing relationship between total fry density and eventual recruitment, and the inverse relationship between total fry density and first-year growth, wild fry production appears to be at an appropriate level for good first-year growth and sustained recruitment. Future management decisions should therefore consider managing for total fry densities that optimize growth and recruitment potential. Lower fry densities combined with longer, warmer summers have increasing potential to create strong year classes; however, lower fry densities combined with cooler, shorter summers have similarly increasing potential for weak year classes. In short, the "boom-bust" potential of a walleye year class appears to be strongly tied to fry density and growing season. Conversely, walleye recruitment also decreases as fry densities increase above 600 total fry/LA, regardless of growing season length. This is because food, space, and other resources become increasingly limited and more young walleyes must compete with each other. In turn, growth decreases overall and survival and eventual recruitment also decline.

OTHER WORK

Water Quality

Water samples were collected at stations 1 (Walker Bay) and 5 (Stony Point) on July 15, 2013. The Minnesota Department of Agriculture Chemistry Laboratory in St. Paul, Minnesota analyzed the samples collected for total phosphorus concentration, conductivity, chlorophyll a, pH, total alkalinity and total dissolved solids.

When looking at the long term data set collected by the MNDNR, there has been no apparent change in water quality since the inception of the Large Lake Program (Table 14). Water clarity data is available from the University of Minnesota at http://lakes.gis.umn.edu. Water quality monitoring data is also available at: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/tmdl-projects/upper-mississippi-river-basin-tmdl/leech-lake-river-watershed.html.

In general, Walker Bay is less productive with greater water clarity than the main lake. Typically, deep water stations thermally stratify and experience dissolved oxygen depletion near the thermocline while main lake stations do not thermally stratify and maintain good dissolved oxygen concentration throughout the water column. This was evident in 2013, with stations in Walker Bay, Agency Bay, Kabekona Bay, being thermally stratified by mid-August, while stations at Stony Point and Portage Bay did not thermally stratify (Figure 26).

Aquatic Invasive Species

A survey of Leech Lake boat harbors in 2004 found established beds of Eurasian water milfoil (EWM) in several harbors between Stony and Rogers points and were immediately treated with aquatic herbicide. Every year since 2004 harbors have been checked for EWM by DNR personnel and treated when necessary. Extensive searches have only discovered rooted EWM outside of harbors at one location, in Miller Bay on the south side of the main lake, and treatments have resulted in the eradication of EWM from some harbors. However, this invasive species continues to be discovered in new harbors throughout Leech Lake.

Reports from lakeshore owners were investigated in conjunction with harbor searches by DNR crews from July 22 to August 2, 2013. A total of 27 sites on Leech Lake were evaluated in three days of field work in 2013. Fifteen of these harbors had large mats of EWM and were treated on September 20, 2013 (Figure 27). Plans for 2014 are to have a treatment permit issued by June 1st and perform the treatments in late-June and/or early-July. EWM is now considered widespread across the main basin boat harbors of Leech Lake, and now appears to be establishing in open areas of the main lake despite annual control efforts.

While conducting EWM harbor searches on Leech Lake during 2009 curly-leaf pondweed (CLP) (*Potamogeton crispus*) was identified and removed from a harbor near Whipholt Beach. This is not the first occurrence of CLP in Leech Lake as it has been previously documented in the Leech River Bay near Federal Dam. Like EWM, CLP can be an aggressive invasive aquatic plant and DNR personnel and lakeshore owners will continue to monitor CLP presence in Leech Lake.

The Division of Ecological and Water Resources spent 1,881 hours conducting 5,228 inspections among Shingobee, Federal Dam, Walker City Park, Stony Point, Erickson's Landing, Sugar Point, and Sucker Bay accesses in 2013. Preliminary 2014 plans include a similar schedule; however, new infestations within Cass County could result in schedule adjustments.

Double-Crested Cormorant management

The spring and fall cormorant numbers on Leech Lake in 2013 were 1,455 and 1,028, respectively (Figure 28). A total of 478 adult cormorants were removed from Leech Lake during 2013, bringing the overall total to 21,798 birds culled since work began in 2005 (Figure 29) and making Leech Lake the largest single control site in the U.S. (S. Mortensen, LLBO Division of Resource Management, personal communication). Fewer adults arrived and built nests in the spring of 2013 than in any year since 2000. The MNDNR continues to annually contribute $33,000 in funding for cormorant management. Schultz et al. (2013) concluded that total feeding effort and fish consumption was reduced by nearly 90% between 2004 and 2011, (16.81 lbs/ha in 2004 and 1.61 lbs/ha in 2011) and by 46–73% annually, depending on the number of birds arriving each spring and the applied culling intensity. Averaged across all years and periods, fledged cormorants consumed 1.65 lb·bird−1·d−1 and nestlings consumed 0.99 lb·bird−1·d−1.Respectively, average fledged and nestling diets were comprised of Yellow Perch *Perca flavescens* (61.0% and 77.4%), *Coregonus* spp. (12.3% and 9.4%), minnows *Notropis* spp. (9.9% and 2.2%), Trout-perch *Percopsis omiscomaycus* (4.1% and 0.4%), and Walleye *Sander vitreus* (4.6% and 3.6%), though considerable seasonal and temporal variability was observed.

Zooplankton Sampling

In 2013, zooplankton were sampled monthly at five locations lakewide from mid-May through mid-October. Sampling stations included sites in Walker Bay, Kabekona Bay, Agency Bay, Stony Point (Main Lake), and Five Mile Point (Portage Bay). The sites selected were the deepest locations in each respective area. After locating each site and holding the boat with the motors with the stern into the wind, a zooplankton net with a 30 cm mouth diameter and 80 μm mesh was lowered so that the bucket of the net was approximately 0.5 meters from the bottom and raised at 0.5 to 1 meters per second to the surface. The sample was rinsed from the bucket of the net into a plastic bottle and preserved with 100% reagent alcohol.

The MNDNR's Division of Ecological and Water Resources Biology Lab processed the zooplankton samples. Sample volumes were adjusted to a known volume by filtering through 80 μm mesh netting and rinsing specimens into a graduated beaker. Water was added to the beaker to a volume that provides at least 150-200 organisms per 5 ml aliquot. The beaker was swirled in a figure-eight motion to ensure thorough mixing. A 5 ml aliquot was withdrawn from each sample using a bulb pipet and transferred to a counting grid. Individual zooplankters were identified to the lowest taxonomic group possible, counted, and measured using a dissecting microscope and a computerized analysis system. Density (number/liter), biomass (μg/liter), percent composition by number and weight, mean length (mm), mean weight (μg) and total count of each taxon identified was generated by an analysis system and recorded in the MNDNR zooplankton database (J. Hirsch, MN DNR).

The number and biomass of zooplankton sampled at each of the five sites throughout 2013 was variable and without discernible trends. Total densities and biomass were typical for lakes in this region. The number of zooplankton sampled per liter ranged from 6-29 in Agency Bay, 11-24 in Walker Bay, 11-38 in Kabekona Bay, 18-99 in Portage Bay, and 26-63 near Stony Point (Table 15). The biomass of zooplankton (µg/liter) sampled per liter ranged from 32-123 in Agency Bay, 49-122 in Walker Bay, 29-110 in Kabekona Bay, 41-123 in Portage Bay, and 56-266 near Stony Point (Table 15). The overall diversity of taxa sampled at the five sites throughout the season was high for lakes in this region, with 19 species identified (Table 16). The proportion of cladocerans to copepods sampled was 70:30, and was typical for lakes in this region not infested with *Bythotrephes* (spiny waterflea). When spiny waterflea are present, small cladocerans commonly decline or disappear. No spiny waterflea or zebra mussel veligers were found in any of the samples. Most individual taxa identified were typical of lakes in this region; however two somewhat rare species were sampled. One was *Daphnia longiremis*, which is a cold/deep water daphnia which spends most of its life below the thermocline. Other regional lakes this species has been sampled include Cass, Ten Mile, and Carlos. The other rare species sampled was a large copepod *Limnocalanus macrurus*, which is a glacial relict. This species has only been sampled in the large deep lakes in the state, such as Lake of the Woods, Rainy, Namakan and Sand Point Lakes. These are two species we will closely monitor when assessing how climate change, AIS, and other influences affect Leech Lake.

Data in 2013 indicate a lower overall density (number/liter) and biomass (μg/liter) of zooplankton were sampled at most stations and during most months, when compared with 2012. The average number of zooplankton sampled at all stations throughout the season was 38.8 and 28.2/L in 2012 and 2013, respectively. The average biomass of zooplankton sampled at all stations sampled throughout the season was 105.9 and 87.3

μg/L in 2012 and 2013, respectively. Species diversity was similar between seasons with 20 species being sampled in 2012 compared with 19 species in 2013. The proportion of cladocerans to copepods sampled was 70:30 in 2013 compared to 60:40 in 2012.

Muskellunge Egg Take

Muskellunge from Miller Bay near Whipholt are currently collected and spawned for the statewide broodstock program every four years. Fish were sampled using ten trap nets from May 17 through May 24, 2013. Of the nets deployed, six were 5 x 6-ft-frame trap nets with 50-ft leads and four were 3 x 6-ft-frame trap nets with 100-ft leads. Water temperature ranged from 52-55 ºF throughout this effort. Trap netted fish were transported 1.75 miles from Miller Bay to net pens at Huddle's Resort marina. Fish captured for the first time were measured, sexed, scales and fin rays were taken for age estimation, scales were removed for genetic analysis, and a passive integrated transponder tag (PIT tag) was inserted under the skin at the base of the dorsal fin so individual fish could be identified in subsequent spawning seasons. Fish were then separated by sex and condition to individual pens prior to spawning.

A total of 51 individual fish were captured throughout this time period, of which 23 were female and 28 were male. Females ranged in length from 39-53 inches, while males ranged from 31-46 inches. Catch rates were 0.93 fish/net in 2013, compared to catch rates of 0.30, 0.26, 0.49, and 0.43 in 2004, 2005, 2009, and 2010, respectively. Of fish sampled in 2013, 5 females (22%) and 6 males (21%) had fin rays removed in previous assessments (2009 or 2010). Females ranged in age from six through sixteen, while males ranged in age from five through fifteen. Males were spawned a maximum of two times, and all spawned fish transported 0.6 miles and released at the south end of Pipe Island.

Hatch rates of the eggs were 43% and 197,024 fry were produced for statewide distribution. A total of 620 fingerlings at a rate of 9.3 fish/pound were stocked in Miller Bay in October 2013 as part of standard put back policy for spawn take operations. The next muskellunge egg take is scheduled for spring 2017.

Walleye Regulation Review

Prior to 2005 Leech Lake walleye regulations were consistent with statewide regulations. Following a formal regulation proposal and public input process in 2004, an 18-26" protected slot limit (PSL), bag of 4, with one fish over 26" allowed in possession, was implemented in May 2005. The objective was to protect walleye spawning stock and promote natural reproduction. A formal review of this regulation occurred in 2010 as part of the Leech Lake Management Planning Process, which resulted in strong support for the continuation of the regulation. As an outcome of this review, criteria were established for relaxing the protected slot under certain predetermined conditions. Exceedence of the spawner stock biomass objective range of 1.5 – 2.0 pounds/acre for two consecutive years would initiate consideration for relaxing the 18-26" PSL to a 20-26" PSL (bag limit unchanged)". These criteria were met, with the spawner stock biomass objective range being exceeded in 2012 and 2103 (Figure 13). News releases announcing the potential regulation change and soliciting comments were circulated on July 18, 2013 and August 28, 2013. An open house to discuss potential regulation changes was held at the Walker Community Center on October 9. Of the 112 comments received, 53 (47.3%) supported relaxing the regulation to a 20-26"PSL, 45 (40.2%) supported some type of alternate regulation, and 14 (12.5%) supported maintaining the current regulation of 18-26" PSL. The DNR has proceeded as outlined to modify the 18-26" PSL to a 20-26" PSL bag of 4, with one fish over 26" allowed in possession effective May 10, 2014. Special summer and winter creel surveys are planned for the 2014 angling season to quantify the effect of the regulation change on annual fishing pressure and walleye harvest. Normally-scheduled creel surveys are planned for 2016 and 2017.

SUMMARY

Recent management actions have allowed for improvements in the Leech Lake walleye population. Cormorant control efforts since 2005 benefitted juvenile walleye survival and led to short-term increases of yellow perch, particularly in the main lake. Specific causes of recent declines in yellow perch abundance are unknown, but walleye predation is suspected as a primary influence, and this theory is supported by the consistently lower condition values of adult walleye. The strength of the 2013 walleye year class will hinge largely on winter survival. Average length of the YOY walleye sampled during September electrofishing was 5.9 inches, indicating below average growth was accrued by greater than 50% of the cohort.

Above average 2010, 2011, and 2012 year classes will provide anglers harvest opportunities throughout 2014. The walleye regulation (protected slot limit where all walleye from 18 inches to 26 inches must be immediately returned to the water, possession limit of four fish, one of which can be longer than 26.0 inches) that was in place from 2005-2013 contributed to improved fishing quality by increasing the number of older, larger walleye in the population for anglers to catch. This has been reflected by overall higher walleye catch rates in the summer creel surveys during 2008-2011, when compared to the 2004-2005 summer creel surveys. The new walleye regulation (protected slot limit where all walleye from 20 inches to 26 inches must be immediately returned to the water, possession limit of four fish, one of which can be longer than 26.0 inches) will result in about 25% of angler-caught walleye being protected, compared to 30-35% under the previous regulation .

Regarding walleye reproduction, walleye hatch rates in Leech Lake (mean 0.41%, range 0.12-0.89%) have been very similar to those observed in other Minnesota walleye lakes (mean 0.34%, range 0.02-1.11). Furthermore, observed wild fry production in 2013 (422 fry/LA) and projected wild fry production in 2014 (434 fry/LA) based on spawner biomass estimated from the 2013 survey, average egg production per pound of mature female, and the observed average hatch rate, are in the optimum 400-600 fry/LA range for consistent walleye recruitment identified by OTC fry stockings. These findings illustrate there is no systemic problem with walleye reproduction in Leech Lake and, when taken in combination with cormorant diet studies, suggest that annual fry stockings, particularly at the elevated rate, are no longer warranted. Future efforts should seek to define how stocking can and should be most appropriately used as a management tool in subsequent years.

Benchmarks used to evaluate the success of the 2011-2015 management plan designed to maintain the walleye population included a standing stock biomass of mature females maintained at 1.5-2.0 pounds/acre, an increase in the walleye gillnet catch rate to at least 8.5 fish/net, between 45% and 65% of walleye sampled in experimental gillnets being shorter than 15.0 inches, and walleye year classes having a measured strength of the long-term average (50th percentile) or higher produced during any two of four consecutive years. The estimated spawner biomass in 2013 was 2.21 pounds of walleye per acre, and exceeded the management objective range for the second consecutive year. The gillnet catch rate of 8.92 fish/net exceeded the management objective was above the long-term average for the seventh consecutive year. Of the 321 walleye sampled in 2013 gillnet sets, 42% were shorter than 15.0 inches. This percentage is below the management objective range of 45-65% and indicates a higher proportion of larger individuals are currently present in the walleye population. Similar to the 2010-12 year classes, the 2013 year class has a predicted relative strength that exceeds the long-term average and the management plan objective.

In addition to the improvements to the walleye population, Leech Lake continues to support numerous sportfish populations that appear relatively healthy or unchanged, and remains a destination for many anglers pursuing quality multi-species angling opportunities. Northern pike abundance exceeds the management objective, and size structure indices suggest a relatively balanced population. The size structure of the yellow perch population continues to be good; however, catch rates indicate abundance has declined each of the past six years. Anglers frequently report catching quality bluegill and black crappie. Leech Lake continues to be a destination for several bass, muskellunge, and walleye fishing tournaments each year.

Although the monitoring and treatment of Eurasian water milfoil (EWM) has likely slowed the spread of this invasive plant, it continues to be found at new locations around the lake each year in both harbors and areas of the main lake proper. Constant awareness by users and property owners alike is paramount to prevent further spread and establishment of EWM to new locations, as well as the spread of other AIS to new waters.

RECOMMENDATIONS

Leech Lake supports a diverse fish population and maintains good water quality. However, human development continues to expand throughout the area and, as more people relocate to this area and recreate on and around Leech Lake, the opportunities for further effects from human activities will continue to increase. Habitat protection measures should continue to be a priority to ensure the ecological resilience of Leech Lake is not compromised. This can be done through scrutinizing development proposals within the watershed using the environmental review process. Projects that are approved should use techniques that minimize impacts to the resource. Landowners within the watershed should be encouraged to use Best Management Practices (BMPs), especially along the lakeshore. A comprehensive list of sensitive shoreline that is prone to development was drafted to prioritize conservation action, particularly on new developments. In addition, these landowners should be contacted and made aware of options such as conservation easements. Efforts such as these provide the best opportunities to sustain the quality resources that Leech Lake provides.

Education and communication efforts are extremely valuable in changing attitudes and perceptions about what does or does not impact ecosystem health. News releases, articles in local papers, and newsletters such as the Leech Lake Update to resorts and interested clientele are some of the avenues that should be continued and expanded.

Continued monitoring and treatment of harbors with Eurasian water milfoil is planned for 2014. Additional educational contacts should be made to those that use the harbors, with increased effort during high use periods. Cooperation of the harbor owners is critical to successful outreach. Similar efforts are needed to prevent the introduction of other exotic species, such as zebra mussels or spiny waterflea, which have already established in other Minnesota systems. Attendance of a DNR volunteer boat inspector training session, participating on the Cass County Invasive Species Task Force, increased boat inspections at public accesses, requiring all watercraft participating in fishing tournaments to have an AIS inspection, increased AIS signage at public accesses, and educating those staying at resorts are all measures that are being taken to slow the spread of invasive species.

Annual monitoring of fish populations and water quality analyses should continue. The vegetation study that began in 2002 was completed in 2005, and the information obtained will further our understanding of fish habitats and identify areas to focus future protection efforts on based on species presence and abundance. A future vegetation study to assess changes in species presence and abundance should be a priority. A future shoreline habitat survey, similar to Wilcox (1979), to evaluate changes in shoreline substrates and spawning areas should also be a priority.

Muskellunge egg collection and fingerling put-back stocking took place in 2013, with the next egg collection and stocking event scheduled for 2017. Double-Crested Cormorant control efforts on Leech Lake should continue as prescribed by the management plan for this species. Finally, to completely evaluate the full capacity of walleye reproduction in Leech Lake stocking blanks (years where no stocking occurs) should be considered in the future.

Continued summer and winter creel surveys as frequently as possible will assist in monitoring changes in pressure, catch, catch rates, harvest, and harvest rates for all species. Guide diaries were pursued as a surrogate for creel surveys during years in which creel surveys were not scheduled. Poor overall participation resulted in a sample size that was inappropriate for statistical comparisons during the trial year in 2011.

Many of the above action items were outlined in the Leech Lake Management Plan, 2011-2015 (Schultz 2010a).

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TABLES

Table 1. Seine catch rates (CPUE, number/haul) of all species and ages captured, Leech Lake, 2013.

Number of hauls: 20
First haul date: 07/15/2013
Last haul date: 07/23/2013

Abbreviation	Species	Age	Total number	Number measured	Mean length (inches)	Length range (inches) Min	Max	Catch rates num/haul
JND	Johnny Darter	All	13	0	N/A	N/A	N/A	0.65
BMS	Bigmouth Shiner	All	1	0	N/A	N/A	N/A	0.05
BLG	Bluegill	All	2	2	4.29	3.39	5.20	0.10
BNM	Bluntnose Minnow	All	89	0	N/A	N/A	N/A	4.45
CSH	Common Shiner	All	13	0	N/A	N/A	N/A	0.65
FHM	Fathead Minnow	All	3	0	N/A	N/A	N/A	0.15
LMB	Largemouth Bass	YOY	118	107	1.56	1.26	2.28	5.90
LGP	Logperch	All	18	0	N/A	N/A	N/A	0.90
LND	Longnose Dace	All	4	0	N/A	N/A	N/A	0.20
MMS	Mimic Shiner	All	11,308	0	N/A	N/A	N/A	565.40
NOP	Northern Pike	YOY	1	1	6.14	6.14	6.14	0.05
PMK	Pumpkinseed	All	2	2	4.61	3.46	5.75	0.10
SMB	Smallmouth Bass	YOY	8	8	1.22	0.94	1.57	0.40
SFS	Spotfin Shiner	All	22	0	N/A	N/A	N/A	1.10
SPO	Spottail Shiner	All	2	0	N/A	N/A	N/A	0.10
TLC	Tullibee (Cisco)	YOY	1	0	N/A	N/A	N/A	0.05
WAE	Walleye	YOY	109	109	2.65	1.38	3.82	5.45
WTS	White Sucker	All	24	0	N/A	N/A	N/A	1.20
YEP	Yellow Perch	YOY	3,321	500	1.49	0.20	1.97	166.05
YEP	Yellow Perch	≥1	155	78	4.03	2.36	7.28	7.75

Table 2. Trawl catch rates (CPUE, number/hour) of all species and ages captured, Leech Lake, 2013.

Number of hauls: 20
Total haul time for all stations: 01:40:00
First haul date: 08/13/2013
Last haul date: 08/22/2013

					Mean	Length range		Catch rates	
			Total	Number	length	(inches)			
Abbreviation	Species	Age	number	measured	(inches)	Min	Max	num/haul	num/hour
JND	Johnny Darter	All	11	11	1.78	1.18	2.09	0.55	6.60
BLC	Black Crappie	YOY	1	1	0.98	0.98	0.98	0.05	0.60
BNM	Bluntnose Minnow	All	11	11	2.36	1.93	2.91	0.55	6.60
BUB	Burbot	YOY	3	3	2.57	2.44	2.68	0.15	1.80
LMB	Largemouth Bass	YOY	9	9	2.66	2.09	3.15	0.45	5.40
LGP	Logperch	All	36	36	3.12	1.97	3.74	1.80	21.60
MMS	Mimic Shiner	All	3,756	141	2.02	1.61	2.52	187.80	2253.60
SMB	Smallmouth Bass	YOY	3	3	1.97	1.65	2.44	0.15	1.80
SPO	Spottail Shiner	All	26	26	3.92	3.23	4.57	1.30	15.60
TPM	Tadpole Madtom	All	2	2	2.56	2.44	2.68	0.10	1.20
TLC	Tullibee (Cisco)	YOY	30	30	2.94	2.68	3.11	1.50	18.00
WAE	Walleye	YOY	577	114	4.64	2.72	6.06	28.85	346.20
WAE	Walleye	≥1	25	25	11.77	7.64	22.52	1.25	15.00
YEP	Yellow Perch	YOY	10,081	338	1.74	1.38	2.44	504.05	6048.59
YEP	Yellow Perch	≥1	148	62	3.89	2.99	6.06	7.40	88.80

Table 3. Catch-per-effort (CPE) of young-of-year walleye in selected gears and associated year class strength (YCS) indices. Incomplete estimates of observed and predicted walleye YCS (± 95% confidence intervals) are in bold.

				Year Class Strength (Pereira)		
Year Class	Trawl CPE (fish/hour)	Gillnet CPE (fish/net)	Electrofishing CPE (fish/hour)	Observed (q-adj)	Eq. 1 Predicted	Eq. 2 Predicted
1983		0.22		1.96		
1984		0.36		1.20		
1985		0.03		1.49		
1986		0.08		2.18		
1987	49	0.11		1.06		
1988	128	1.81		2.30		
1989	62	0.06		1.10		
1990	72	0.03		1.20		
1991	58	0.47		1.64		
1992	103	0.00		0.71		
1993	16	0.00		0.30		
1994	493	0.08		2.29		
1995	183	0.51		1.81		
1996	262	0.14		1.42		
1997	5	0.29		1.89		
1998	139	0.47		1.11		
1999	348	0.56		1.31		
2000	28	0.14		0.73		
2001	103	0.69		1.04		
2002	38	0.31		1.04		
2003	27	0.08		0.61		
2004	3	0.00		0.47		
2005	247	0.03	60	1.33		
2006	240	0.69	35	1.88		
2007	31	1.47	27	1.78		
2008	508	0.00	42	1.38		
2009	153	0.03	164	1.23		
2010	80	0.03	56	1.76		
2011	**40**	**0.03**	**175**	**1.48**	**1.18±0.24**	**0.98±0.23**
2012	**148**	**0.47**	**237**	**1.67**	**1.34±0.20**	**1.49±0.18**
2013	**346**	**0.06**	**88**		**1.65±0.36**	**1.51±0.31**
Mean	145	0.30	98	1.38		

Equation 1: YCS = (0.00159*trawl CPE) + 1.04808; R-sq = 0.17

Equation 2: YCS = (0.00175*trawl CPE) + (0.70222*gillnet CPE) + 0.79249; R-sq = 0.45

Table 4. Gillnet catch-per-effort (fish/net) summary by species and basin for Leech Lake, 2013.

		Western Bays			Main Lake			Overall (Whole Lake)		
			1983-2013			1983-2013			1983-2013	
Code	Species	2013	Mean	s.e.	2013	Mean	s.e.	2013	Mean	s.e.
BLB	Black bullhead	0.06	8.84	1.74	0.00	2.19	0.61	0.03	5.18	1.06
BLC	Black crappie	0.56	0.34	0.07	1.15	0.49	0.07	0.89	0.42	0.06
BLG	Bluegill	1.13	0.77	0.14	1.25	0.31	0.07	1.19	0.51	0.09
BOF	Bowfin	0.00	0.11	0.02	0.00	0.04	0.01	0.00	0.07	0.01
BRB	Brown bullhead	0.25	1.92	0.23	0.20	1.15	0.19	0.22	1.56	0.19
BUB	Burbot	0.00	0.02	0.01	0.00	0.07	0.01	0.00	0.05	0.01
HBS	Hybrid sunfish	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
LKW	Lake whitefish	0.00	0.08	0.03	0.00	0.02	0.01	0.00	0.05	0.01
LMB	Largemouth bass	0.06	0.13	0.03	0.10	0.10	0.02	0.08	0.11	0.02
MUE	Muskellunge	0.06	0.05	0.01	0.00	0.01	0.01	0.03	0.04	0.01
NOP	Northern pike	5.00	5.34	0.21	4.30	4.40	0.14	4.61	4.82	0.14
PMK	Pumpkinseed	1.50	1.06	0.14	1.25	0.55	0.10	1.36	0.78	0.09
RKB	Rock bass	2.19	3.06	0.29	0.85	0.31	0.04	1.44	1.55	0.13
SHR	Shorthead redhorse	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SMB	Smallmouth bass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TME	Tiger muskellunge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TLC	Tulibee/cisco	3.38	4.73	0.83	3.30	5.95	0.95	3.33	5.39	0.76
WAE	Walleye	6.38	5.74	0.29	10.95	9.29	0.65	8.92	7.73	0.43
WTS	White sucker	1.31	1.31	0.09	0.65	1.67	0.16	0.94	1.51	0.11
YEB	Yellow bullhead	0.63	2.21	0.27	0.25	0.88	0.15	0.42	1.49	0.18
YEP	Yellow perch	15.00	25.68	1.28	9.75	17.90	1.72	12.08	21.38	1.25

Table 5. Length-frequency distribution of all species sampled in experimental gillnet sets, Leech Lake, 2013.

	BLB	BLC	BLG	BRB	LMB	MUE	NOP	PMK	RKB	TLC	WAE	YWAE	WTS	YEB	YEP
< 3.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3.00-3.49	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
3.50-3.99	-	-	13	-	-	-	-	12	-	-	-	-	-	-	-
4.00-4.49	-	-	11	-	-	-	-	5	3	-	-	-	-	-	-
4.50-4.99	-	1	10	-	-	-	-	6	4	-	-	-	-	-	-
5.00-5.49	-	-	1	-	-	-	-	9	5	-	-	-	-	-	28
5.50-5.99	-	3	1	-	-	-	-	9	3	-	-	-	-	-	87
6.00-6.49	-	1	1	-	-	-	-	6	2	-	-	1	-	-	76
6.50-6.99	-	1	2	-	-	-	-	-	-	-	-	1	-	-	43
7.00-7.49	-	3	1	-	-	-	-	1	2	2	1	-	-	-	33
7.50-7.99	-	7	-	-	-	-	-	1	3	2	3	-	1	-	27
8.00-8.49	-	4	-	-	1	-	1	-	1	4	2	-	-	1	32
8.50-8.99	-	-	-	-	1	-	1	-	4	-	8	-	2	-	35
9.00-9.49	-	-	1	-	-	-	1	-	1	-	12	-	1	2	15
9.50-9.99	-	2	1	-	-	-	1	-	10	4	15	-	-	-	11
10.00-10.49	-	4	-	-	-	-	-	-	11	3	16	-	-	2	17
10.50-10.99	-	3	-	-	-	-	-	-	2	9	8	-	3	1	15
11.00-11.49	-	-	-	-	-	-	-	-	1	3	6	-	-	2	10
11.50-11.99	-	-	-	-	-	-	-	-	-	5	9	-	2	3	2
12.00-12.99	-	1	-	4	-	-	-	-	-	17	17	-	3	3	3
13.00-13.99	1	2	-	2	1	-	3	-	-	13	13	-	4	1	-
14.00-14.99	-	-	-	2	-	-	4	-	-	8	22	-	3	-	-
15.00-15.99	-	-	-	-	-	-	7	-	-	36	32	-	1	-	-
16.00-16.99	-	-	-	-	-	-	6	-	-	13	19	-	2	-	-
17.00-17.99	-	-	-	-	-	-	12	-	-	1	20	-	8	-	-
18.00-18.99	-	-	-	-	-	-	7	-	-	-	15	-	3	-	-
19.00-19.99	-	-	-	-	-	-	20	-	-	-	28	-	1	-	-
20.00-20.99	-	-	-	-	-	-	25	-	-	-	21	-	-	-	-
21.00-21.99	-	-	-	-	-	-	26	-	-	-	18	-	-	-	-
22.00-22.99	-	-	-	-	-	1	14	-	-	-	15	-	-	-	-
23.00-23.99	-	-	-	-	-	-	9	-	-	-	12	-	-	-	-
24.00-24.99	-	-	-	-	-	-	9	-	-	-	4	-	-	-	-
25.00-25.99	-	-	-	-	-	-	2	-	-	-	1	-	-	-	-
26.00-26.99	-	-	-	-	-	-	6	-	-	-	1	-	-	-	-
27.00-27.99	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-
28.00-28.99	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-
29.00-29.99	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
30.00-30.99	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-
31.00-31.99	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-
32.00-32.99	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
33.00-33.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34.00-34.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
35.00-35.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
≥ 36.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

	BLB	BLC	BLG	BRB	LMB	MUE	NOP	PMK	RKB	TLC	WAE	YWAE	WTS	YEB	YEP
Total	1	32	43	8	3	1	166	49	52	120	319	2	34	15	435
Min. length	14.0	4.8	3.5	12.4	8.4	22.6	8.4	3.5	4.1	7.1	7.4	6.4	7.9	8.4	3.2
Max. length	14.0	13.4	9.8	14.1	13.4	22.6	32.8	7.8	10.8	17.6	27.5	6.9	19.9	13.2	12.4
Mean length	14.0	8.7	4.7	13.2	10.2	22.6	20.9	5.0	8.1	13.5	16.0	6.7	14.4	11.1	7.3
# measured	1	32	43	8	3	1	166	49	52	120	319	2	34	15	435

Note: Unless all fish were measured in the catch, totals shown for some length-frequency distributions may differ from the total number of fish in the catch, due to rounding of fractions used in the estimation of length frequency from a subsample of measu

Table 6. Age-length frequency distribution of immature and mature (bold, right) female walleye captured in experimental gill nets, Leech Lake, 2013.

	Age																			
Length Group	0		1		2		3		4		5		6		7		8+		Total	
< 4.0																			0	**0**
4.0-4.9																			0	**0**
5.0-5.9																			0	**0**
6.0-6.9	2																		2	**0**
7.0-7.9			1																1	**0**
8.0-8.9			5																5	**0**
9.0-9.9			11																11	**0**
10.0-10.9			10		1														11	**0**
11.0-11.9			3		5														8	**0**
12.0-12.9					7		1												8	**0**
13.0-13.9					9		2												11	**0**
14.0-14.9					11		6												17	**0**
15.0-15.9							8		2										10	**0**
16.0-16.9							9		2										11	**0**
17.0-17.9							4		3			**1**							7	**1**
18.0-18.9									3			**1**		**1**					3	**2**
19.0-19.9									1	**1**		**6**		**5**				**1**	1	**13**
20.0-20.9														**4**		**5**			0	**9**
21.0-21.9														**3**		**10**		**2**	0	**15**
22.0-22.9														**2**		**5**		**8**	0	**15**
23.0-23.9														**1**		**2**		**7**	0	**10**
24.0-24.9																**1**		**3**	0	**4**
25.0-25.9																		**1**	0	**1**
26.0-26.9																		**1**	0	**1**
27.0-27.9																		**1**	0	**1**
28.0-28.9																			0	**0**
29.0-29.9																			0	**0**
> 30.0																			0	**0**
Total	2	**0**	30	**0**	33	**0**	30	**0**	11	**1**	0	**8**	0	**16**	0	**23**	0	**24**	106	**72**

Table 7. Age-length frequency distribution of immature and mature (bold, right) male walleye captured in experimental gill nets, Leech Lake, 2013.

	Age																			
Length Group	0		1		2		3		4		5		6		7		8+		Total	
< 4.0																			0	**0**
4.0-4.9																			0	**0**
5.0-5.9																			0	**0**
6.0-6.9																			0	**0**
7.0-7.9			1																1	**0**
8.0-8.9			3																3	**0**
9.0-9.9			19																19	**0**
10.0-10.9			13		1														14	**0**
11.0-11.9					6														6	**0**
12.0-12.9					7														7	**0**
13.0-13.9					2		2												4	**0**
14.0-14.9					3		3												6	**0**
15.0-15.9					1		4	**14**		**1**									5	**15**
16.0-16.9								**5**		**4**									0	**9**
17.0-17.9								**3**		**5**		**3**				**1**			0	**12**
18.0-18.9										**2**		**3**		**4**		**1**			0	**10**
19.0-19.9												**2**		**3**		**7**		**2**	0	**14**
20.0-20.9														**3**		**3**		**3**	0	**9**
21.0-21.9																**1**		**5**	0	**6**
22.0-22.9																		**1**	0	**1**
23.0-23.9																		**2**	0	**2**
24.0-24.9																			0	**0**
25.0-25.9																			0	**0**
26.0-26.9																			0	**0**
27.0-27.9																			0	**0**
28.0-28.9																			0	**0**
29.0-29.9																			0	**0**
> 30.0																			0	**0**
Total	0	**0**	36	**0**	20	**0**	9	**22**	0	**12**	0	**8**	0	**10**	0	**13**	0	**13**	65	**78**

Table 8. Age-length frequency distribution of immature and mature (bold, right) female yellow perch captured in experimental gill nets, Leech Lake, 2013.

	Age																			
Length Group	0		1		2		3		4		5		6		7		8+		Total	
<4.00																			0	**0**
4.00-4.49																			0	**0**
4.50-4.99																			0	**0**
5.00-5.49					2		1												3	**0**
5.50-5.99					4	**3**	8		4										16	**3**
6.00-6.49					2	**3**	14	**8**	3	**1**		**1**							19	**13**
6.50-6.99						**1**	5	**7**	3	**9**		**1**							8	**18**
7.00-7.49							1	**5**	2	**3**	2	**4**							5	**12**
7.50-7.99							1	**2**		**5**	1	**1**							2	**8**
8.00-8.49								**4**	1	**4**	1	**4**		**4**					2	**16**
8.50-8.99								**4**		**2**		**4**		**3**		**5**			0	**18**
9.00-9.49										**4**		**2**				**3**			0	**9**
9.50-9.99												**2**		**3**					0	**5**
10.00-10.49										**2**		**2**		**3**				**1**	0	**8**
10.50-10-99										**1**		**1**		**1**		**2**		**3**	0	**8**
11.00-11.49												**2**		**3**		**4**			0	**9**
11.50-11.99																**1**		**2**	0	**3**
12.00-12.99														**1**		**2**			0	**3**
13.00-13.99																			0	**0**
14.00-14.99																			0	**0**
> 14.99																			0	**0**
Total	0	**0**	0	**0**	8	**7**	30	**30**	13	**31**	4	**24**	0	**18**	0	**17**	0	**6**	55	**133**

Table 9. Age-length frequency distribution of immature and mature (bold, right) male yellow perch captured in experimental gill nets, Leech Lake, 2013.

	Age																			
Length Group	0		1		2		3		4		5		6		7		8+		Total	
<4.00																			0	**0**
4.00-4.49																			0	**0**
4.50-4.99																			0	**0**
5.00-5.49					1	**1**		**2**											1	**3**
5.50-5.99					1	**10**		**11**		**1**									1	**22**
6.00-6.49						**2**		**10**		**6**									0	**18**
6.50-6.99								**4**		**5**									0	**9**
7.00-7.49								**5**				**1**							0	**6**
7.50-7.99								**1**		**2**		**2**							0	**5**
8.00-8.49										**1**		**1**		**2**					0	**4**
8.50-8.99										**1**		**1**		**4**		**1**			0	**7**
9.00-9.49										**1**				**1**		**2**			0	**4**
9.50-9.99												**4**		**1**					0	**5**
10.00-10.49														**2**		**2**		**3**	0	**7**
10.50-10-99																**1**		**2**	0	**3**
11.00-11.49												**1**							0	**1**
11.50-11.99																			0	**0**
12.00-12.99																			0	**0**
13.00-13.99																			0	**0**
14.00-14.99																			0	**0**
> 14.99																			0	**0**
Total	0	**0**	0	**0**	2	**13**	0	**33**	0	**17**	0	**10**	0	**10**	0	**6**	0	**5**	2	**94**

Table 10. Age-length frequency distribution of immature and mature (bold, right) female northern pike captured in experimental gill nets, Leech Lake, 2013.

	Age																				
Length Group	0		1		2		3		4		5		6		7		8+		Total	
< 4.0																			0	**0**
4.0-4.9																			0	**0**
5.0-5.9																			0	**0**
6.0-6.9																			0	**0**
7.0-7.9																			0	**0**
8.0-8.9																			0	**0**
9.0-9.9																			0	**0**
10.0-10.9																			0	**0**
11.0-11.9																			0	**0**
12.0-12.9																			0	**0**
13.0-13.9																			0	**0**
14.0-14.9			2																2	**0**
15.0-15.9			2			**1**													2	**1**
16.0-16.9						**2**													0	**2**
17.0-17.9						**2**		**1**											0	**3**
18.0-18.9						**3**		**2**											0	**5**
19.0-19.9						**1**		**9**		**1**									0	**11**
20.0-20.9								**6**		**2**									0	**8**
21.0-21.9								**8**		**7**		**1**							0	**16**
22.0-22.9								**2**		**5**		**2**							0	**9**
23.0-23.9										**4**		**1**							0	**5**
24.0-24.9								**1**		**4**		**2**							0	**7**
25.0-25.9												**1**		**1**					0	**2**
26.0-26.9										**2**		**3**		**1**					0	**6**
27.0-27.9																			0	**0**
28.0-28.9										**1**		**1**		**2**					0	**4**
29.0-29.9														**1**					0	**1**
30.0-30.9														**2**					0	**2**
31.0-31.9												**1**				**2**		**1**	0	**4**
32.0-32.9												**1**							0	**1**
33.0-33.9																			0	**0**
34.0-34.9																			0	**0**
35.0-35.9																			0	**0**
> 36.0																			0	**0**
Total	0	**0**	4	**0**	0	**9**	0	**29**	0	**26**	0	**13**	0	**7**	0	**2**	0	**1**	4	**87**

Table 11. Age-length frequency distribution of immature and mature (bold, right) male northern pike captured in experimental gill nets, Leech Lake, 2013.

	Age																			
Length Group	0		1		2		3		4		5		6		7		8+		Total	
< 4.0																			0	**0**
4.0-4.9																			0	**0**
5.0-5.9																			0	**0**
6.0-6.9																			0	**0**
7.0-7.9																			0	**0**
8.0-8.9	2																		2	**0**
9.0-9.9	2																		2	**0**
10.0-10.9																			0	**0**
11.0-11.9																			0	**0**
12.0-12.9																			0	**0**
13.0-13.9				**2**															0	**2**
14.0-14.9				**3**															0	**3**
15.0-15.9				**3**		**1**													0	**4**
16.0-16.9						**3**		**1**											0	**4**
17.0-17.9						**3**		**4**											0	**7**
18.0-18.9								**3**											0	**3**
19.0-19.9								**7**		**3**									0	**10**
20.0-20.9								**1**		**13**		**3**							0	**17**
21.0-21.9										**7**		**1**		**1**					0	**9**
22.0-22.9								**1**		**1**		**1**		**1**					0	**4**
23.0-23.9										**2**		**3**		**1**					0	**6**
24.0-24.9										**1**		**1**							0	**2**
25.0-25.9																			0	**0**
26.0-26.9																			0	**0**
27.0-27.9																			0	**0**
28.0-28.9																			0	**0**
29.0-29.9																			0	**0**
30.0-30.9																			0	**0**
31.0-31.9																			0	**0**
32.0-32.9																			0	**0**
33.0-33.9																			0	**0**
34.0-34.9																			0	**0**
35.0-35.9																			0	**0**
> 36.0																			0	**0**
Total	4	**0**	0	**8**	0	**7**	0	**17**	0	**27**	0	**9**	0	**3**	0	**0**	0	**0**	4	**71**

Table 12. Trawling locations for 2013 that include the three standardized long-terms stations (TR-1 through TR-3) with the standardized numbers of trawls. The additional trawls that were conducted at the standardized locations to obtain more age-0 walleye (STR2 and STR-6) are also included. The number of trawls, age-0 walleye sampled, and CPE (fish/hour) is also indicated.

Station	Location	Number of trawls	Minutes trawled	Number age-0 WAE sampled	Age-0 WAE CPE (#/hr)
TR-1	Fivemile Point	8	40	30	45
TR-2	Goose Island	6	30	7	14
TR-3	Whipholt Beach	6	30	540	1,080
STR-2	Goose Island	2	10	101	606
STR-6	Fivemile Point	2	10	23	138

Table 13. Summary of walleye fry stocking for five Minnesota lakes, 1999-2013 and Leech Lake, 2005-2013. SSB refers to spawner stock biomass estimated from gillnet catches of mature female walleye the previous fall.

		SSB	Amount	YOY	Hatch	Fry per LA	
Lake	Year	(lbs/A)	Stocked/LA	Marked (%)	Rate (%)	Wild	Total
Leech	2005	1.91	130	39	0.22	203	334
	2006	1.04	380	86	0.12	61	440
	2007	1.67	129	23	0.54	432	561
	2008	2.13	382	55	0.31	317	699
	2009	1.32	391	50	0.60	385	775
	2010	1.49	388	57	0.40	290	678
	2011	1.67	380	69	0.21	172	552
	2012	1.82	129	14	0.89	779	908
	2013	2.28	130	23	0.38	442	552
	Mean	1.70	271	46	0.41	342	611
Red	1999	0.08	522	86	0.60	86	607
	2001	0.59	400	70	0.16	174	574
	2003	0.33	414	97	0.02	11	425
	2004	3.68	127	9	0.18	1,325	1,452
	2005	1.05	49	14	0.15	290	339
	Mean	1.15	302	55	0.22	377	679
Ottertail	2008	0.99	153	29	0.48	373	526
	2009	1.02	600	56	0.56	467	1,067
	2010	1.77	733	72	0.20	277	1,010
	2011	2.65	820	67	0.18	406	1,226
	2012	0.97	1728	67	1.11	854	2,582
	2013	1.42	586	64	0.26	329	915
	Mean	1.61	577	59	0.35	381	957
Woman	2007	1.49	2,448	73	0.88	896	3,344
	2008	1.41	1,516	60	1.01	1014	2,530
	2009	1.23	580	83	0.15	117	697
	2010	0.35	995	97	0.26	28	1,023
	2011	1.11	1,002	96	0.06	41	1,043
	2012	0.70	1,350	71	0.95	551	1,901
	2013	1.33	584	97	0.02	21	605
	Mean	1.12	1,308	82	0.47	419	1,727
Winnibigoshish	2009	1.98	623	83	0.06	132	755
	2010	2.02	514	88	0.04	72	586
	2011	2.48	693	74	0.1	239	932
	2012	1.75	133	49	0.08	140	272
	Mean	2.06	491	74	0.07	146	636
Vermillion	2010	1.24	400	37	0.7	666	1,066
	2011	0.90	1,000	60	0.97	665	1,665
	2012	1.98	773	62	0.27	474	1,247
	2013	2.01	773	12	2.85	5,533	6,306
	Mean	1.53	737	43	1.20	602	2,571

Table 14. Mean chlorophyll-a (Chlor-a), total phosphorous (Total P), pH, alkalinity, total dissolved solids (TDS), Secchi depth, and mean calculated trophic state index (TSI) by basin, Leech Lake, 1984-2013.

	Main Lake								Western Bays							
Year	Station	Chlor-a (ppb)	Total P (ppm)	pH	Alkalinity (ppm)	TDS (ppm)	Secchi (ft.)	Mean TSI	Station	Chlor-a (ppb)	Total P (ppm)	pH	Alkalinity (ppm)	TDS (ppm)	Secchi (ft.)	Mean TSI
1984		4.0	0.022	-	133	169	-	-		4.0	0.011	-	132	147	-	-
1985		-	-	-	-	-	-	-		-	-	-	-	-	-	-
1986	7	3.0	0.011	8.51	134	158	4.7	-	1	3.0	0.006	8.61	135	160	9.3	-
1987	7	3.0	0.014	8.35	131	154	3.9	-	1	4.0	0.014	8.50	147	153	8.2	-
1988	5	3.0	0.031	7.85	133	169	7.7	-	1	3.0	0.017	8.00	46	377	7.9	-
1989	5	3.0	0.017	7.85	132	172	7.6	-	1	3.0	0.008	8.54	128	176	9.8	-
1990	3	3.0	0.015	8.61	130	168	7.3	-	1	3.0	0.015	8.40	130	164	12.2	-
1991	5	1.0	0.020	8.49	127	180	7.7	-	1	1.0	<0.005	8.60	126	172	7.9	-
1992	5	2.0	0.016	8.44	139	178	11.4	-	1	3.0	0.010	8.54	139	168	13.2	-
1993	5	6.4	0.013	8.58	140	156	8.5	-	1	4.9	0.014	8.62	128	180	13.0	-
1994	5	5.5	0.023	8.58	138	170	6.0	-	1	2.9	0.016	8.66	140	168	8.0	-
1995	7	11.9	0.018	8.57	136	192	8.9	-	1	6.5	0.012	8.70	136	180	11.5	-
1996	7	3.1	0.055	8.50	133	176	8.9	-	1	2.4	0.020	8.73	136	224	10.6	-
1997	7	3.1	0.041	8.54	132	172	9.9	-	1	4.4	0.044	8.64	133	192	13.6	-
1998	3	6.5	0.028	8.64	131	152	-	-	1	4.2	0.029	8.66	133	172	-	-
1999	5	5.1	0.028	8.56	129	172	7.5	49	1	3.8	0.025	8.62	135	180	13.0	45
2000	3	4.2	0.028	8.46	139	180	6.0	49	6	2.4	0.019	8.62	138	176	17.2	41
2001	3	5.6	0.033	8.73	125	170	7.0	49	6	4.0	0.016	8.76	126	168	11.0	43
2002	3	5.4	0.020	8.66	133	164	6.5	49	6	4.1	0.020	8.75	136	176	11.0	44
2003	3	7.2	0.020	8.42	139	160	6.5	50	6	4.1	0.010	8.64	140	160	11.0	44
2004	3	3.4	0.013	8.50	143	176	9.0	44	6	2.4	0.010	8.69	146	176	13.1	40
2005	3	4.4	0.016	8.62	143	172	5.0	50	6	3.7	0.016	8.57	141	176	8.5	45
2006	3	8.4	0.016	8.51	140	148	6.0	51	6	4.2	0.010	8.51	135	144	10.0	44
2007	3	8.9	0.019	8.46	144	168	8.2	48	6	3.6	0.011	8.61	143	168	10.5	42
2008	5	3.4	0.013	0.85	146	172	6.5	39	1	5.2	0.012	8.50	148	168	10.5	38
2009	5	7.6	0.019	8.42	143	188	-	49	1	5.1	0.011	8.43	148	196	-	43
2010	5	7.0	0.017	8.46	144	188	6	43	1	3.4	0.012	8.56	143	188	11.0	36
2011 [1]		-	-	-	-	-	-	-		-	-	-	-	-	-	-
2012	5	7.3	0.030	8.15	141	188	6.5	45	1	4.5	0.024	8.36	140	180	10.5	40
2013	5	8.7	0.023	8.46	142	152	7.2	44	1	5.8	0.011	8.42	141	140	10.9	37
Mean		4.9	0.022	8.2	135.7	169.4	7.3	47.8		3.7	0.016	8.6	133.0	180.8	11.0	42.5

Table 15. Density (number/liter) and biomass (µg/liter) of zooplankton sampled by month at the five standardized zooplankton sites on Leech Lake in 2013.

Date	Unit	Walker Bay	Agency Bay	Portage Bay	Kabekona Bay	Stony Point	**Average**
5/28/13	(#/L)	11.1	6.7	37.6	15.5	27.2	**19.6**
	(µg/L)	39.5	35.8	107.0	39.1	68.5	**58.0**
6/13/13	(#/L)	13.9	24.5	17.8	37.8	52.1	**29.2**
	(µg/L)	49.0	94.3	115.8	101.1	266.4	**125.3**
7/17/13	(#/L)	22.7	27.9	33.1	28.2	31.8	**28.8**
	(µg/L)	121.8	112.1	41.3	109.3	56.4	**88.2**
8/19/13	(#/L)	19.7	17.9	99.4	11.4	62.7	**42.2**
	(µg/L)	51.7	31.9	123.0	28.6	111.3	**69.3**
9/24/13	(#/L)	23.9	24.3	37.8	17.0	31.5	**26.9**
	(µg/L)	94.8	85.0	61.6	53.7	109.1	**80.8**
10/16/13	(#/L)	11.4	29.4	26.9	19.4	25.9	**22.6**
	(µg/L)	76.6	122.8	114.8	81.6	114.7	**102.1**
Average	**(#/L)**	**17.1**	**21.8**	**42.1**	**21.6**	**38.5**	**28.2**
	(µg/L)	**72.2**	**80.3**	**93.9**	**68.9**	**121.1**	**87.3**

Table 16. The overall density (number/liter) of zooplankton at each of the five sample sites, by species, Leech Lake 2013.

Taxa	Walker Bay	Agency Bay	Portage Bay	Kabekona Bay	Stony Point	**Station Average**
nauplii	2.9	3.4	5.6	4.3	3.1	**6.1**
copepodites	1.6	2.5	6.2	1.9	4.0	**4.3**
Diaptomidae	3.1	3.4	2.7	2.6	3.4	**5.3**
Epischura lacustris	0.0	0.1	0.3	0.1	0.4	**0.0**
Limnocalanus macrurus	0.2	0.1	0.0	0.0	0.0	**0.0**
Mesocyclops edax	1.0	0.9	1.6	0.9	1.0	**1.6**
Diacyclops bicuspidatus thomasi	3.0	4.4	3.3	5.9	4.2	**2.4**
Tropocyclops prasinus mexicanus	1.1	3.0	11.6	0.6	5.4	**3.4**
Daphnia galeata mendotae	1.5	1.1	2.5	1.7	6.6	**2.4**
Daphnia retrocurva	0.3	0.7	2.2	0.9	2.5	**2.9**
Daphnia longiremis	0.9	0.8	0.1	0.3	0.0	**0.9**
Bosmina sp.	0.5	1.2	2.3	1.7	3.1	**4.5**
Eubosmina coregoni	0.3	0.0	0.7	0.0	1.7	**1.3**
Chydorus sphaericus	0.4	0.1	1.6	0.4	1.7	**1.3**
Holopedium gibberum	0.0	0.0	0.0	0.0	0.1	**0.1**
Diaphanosoma birgei	0.3	0.2	0.3	0.0	0.5	**1.7**
Eurycercus lamellatus	0.0	0.0	0.0	0.0	0.1	**0.0**
Ceriodaphnia sp.	0.0	0.1	0.9	0.0	0.6	**0.5**
Daphnia pulicaria	0.1	0.4	0.1	0.1	0.1	**0.1**
Total	**17.1**	**22.3**	**42.1**	**21.6**	**38.5**	**38.7**

FIGURES

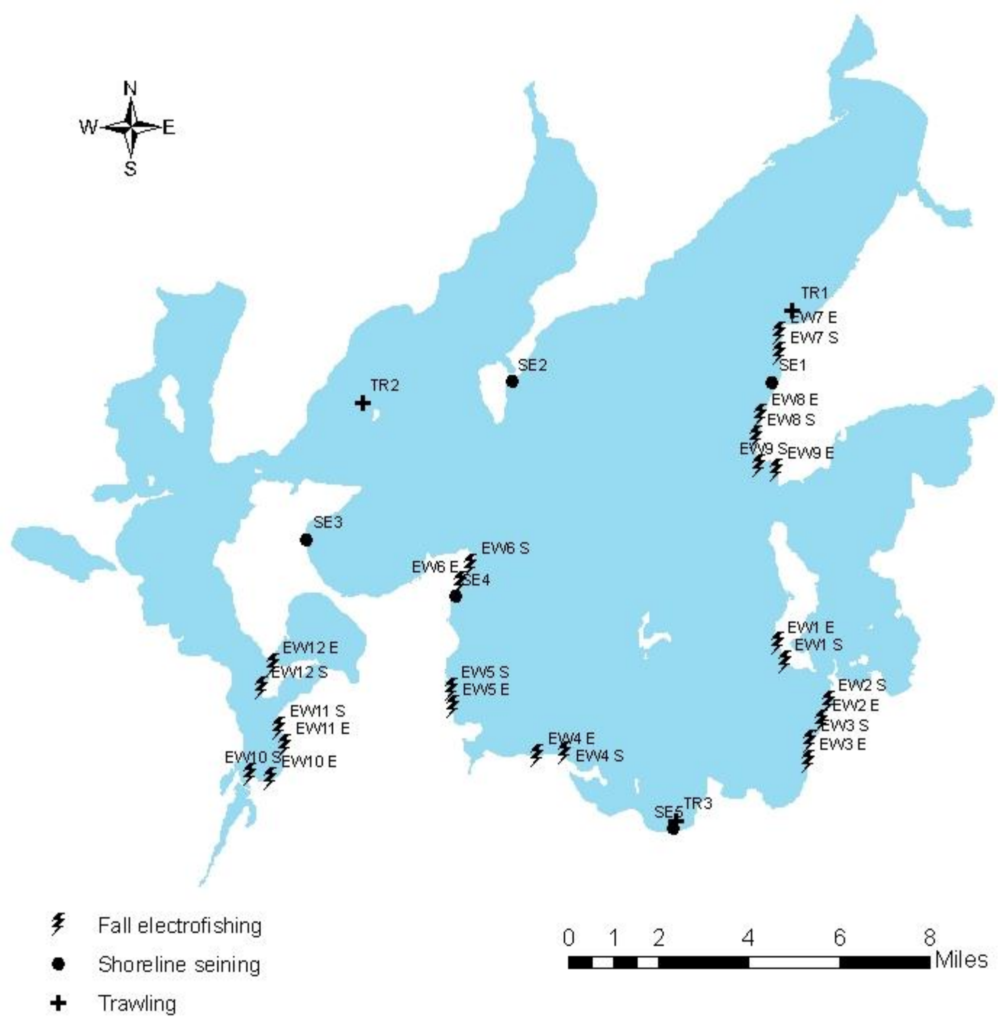

Figure 1. Long-term sampling stations targeting young-of-year percids in Leech Lake.

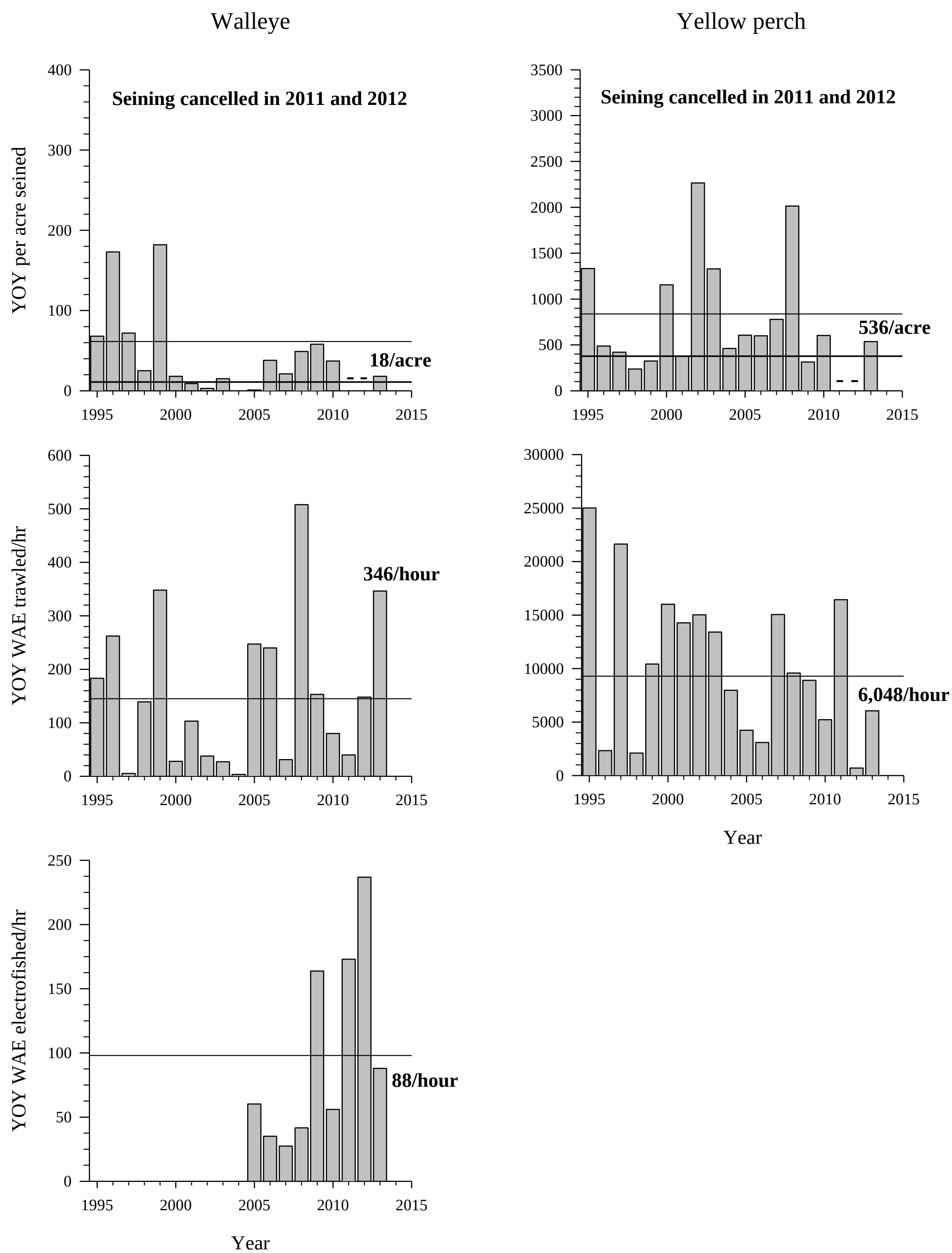

Figure 2. Catch-per-effort (bars) and historical averages (lines) of young-of-year (YOY) walleye (left column) and yellow perch (right column) at long-term sampling stations, Leech Lake, 1983-2013.

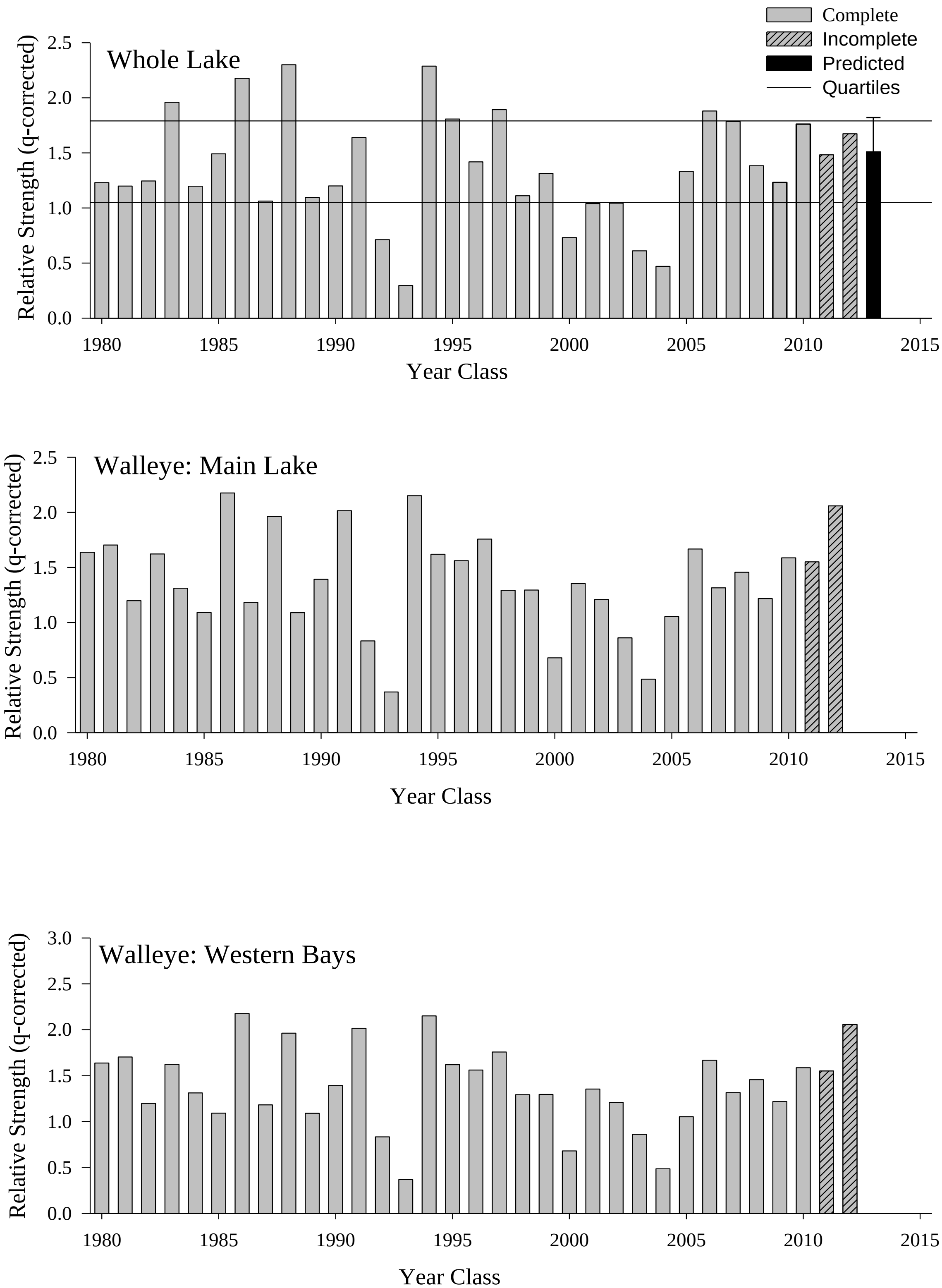

Figure 3. Year class strength index of walleye in Leech Lake (top panel) and by basin (bottom panels), 1980-2013.

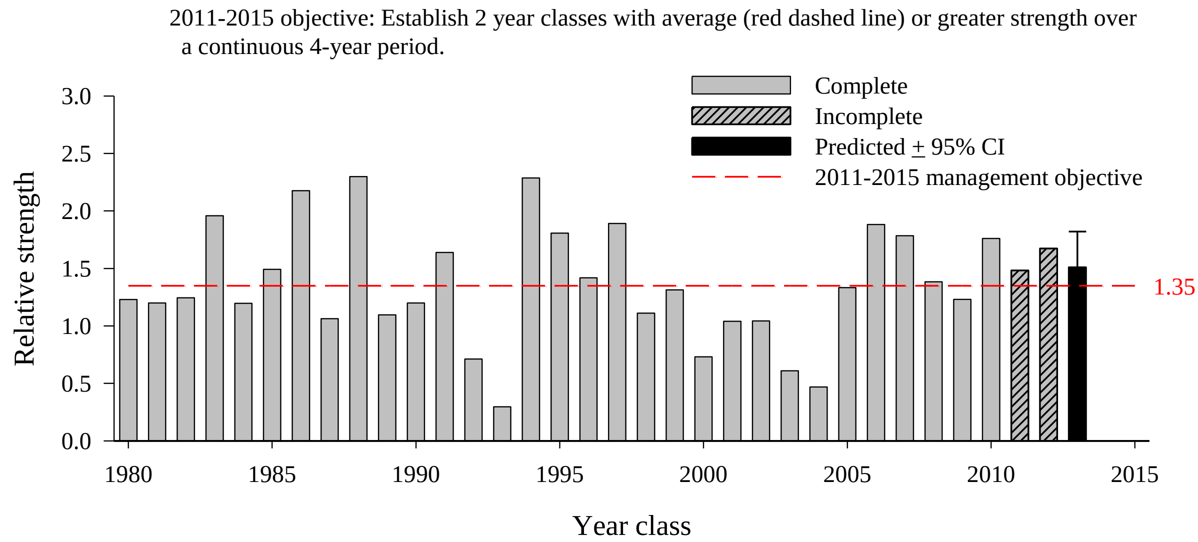

Figure 4. Walleye year class strength index relative to the 2011-2015 Leech Lake Management Plan objective for walleye recruitment (Schultz 2010a).

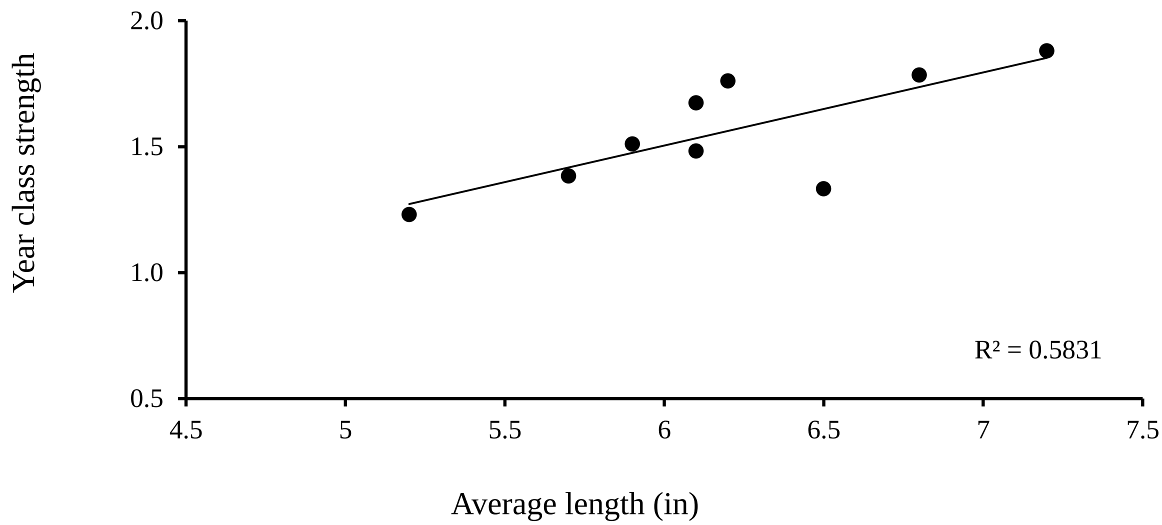

Figure 5. The average length (in) of young-of-year walleye sampled by electrofishing in mid-September and the resulting walleye year class strength in Leech Lake, 2005-2012.

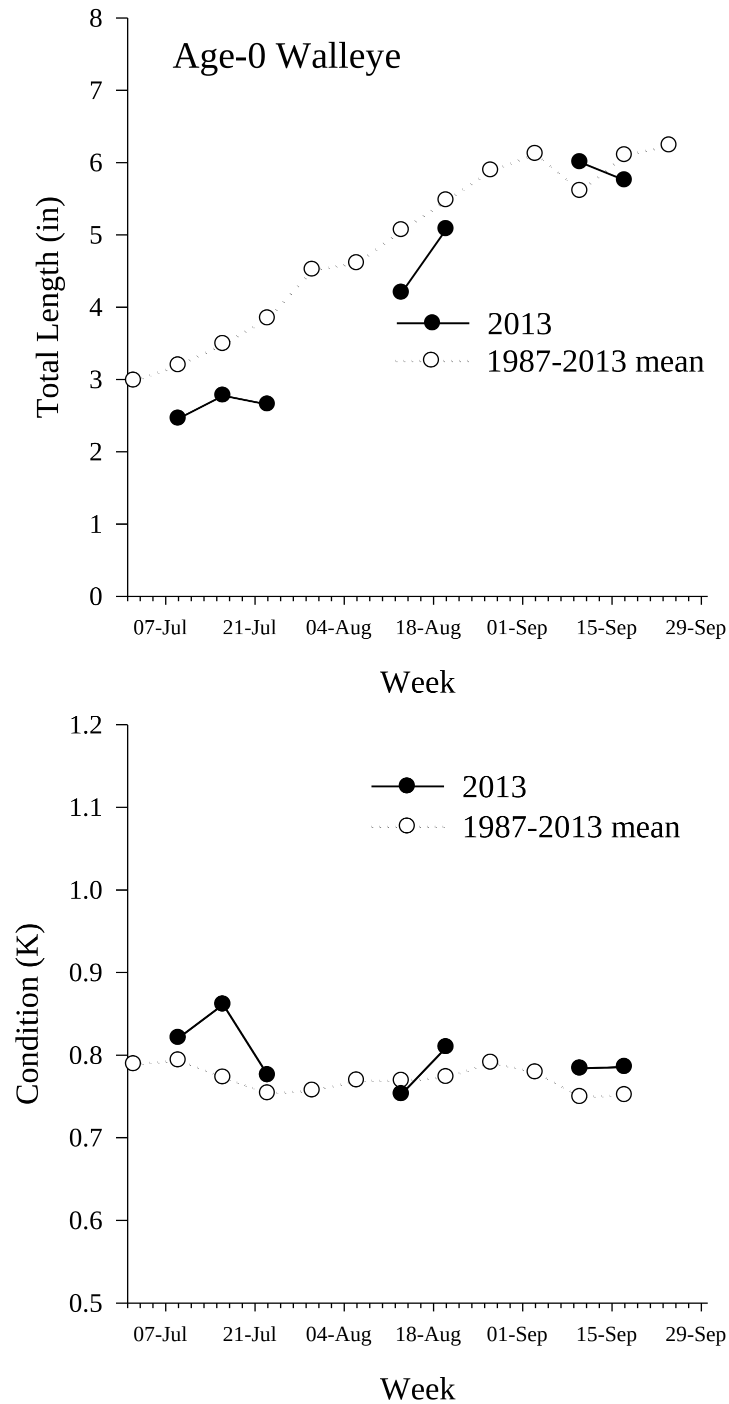

Figure 6. Mean weekly growth (top row) and condition (bottom row) of age-0 walleye (left column) captured in Leech Lake during the annual young-of-year assessment, 2013.

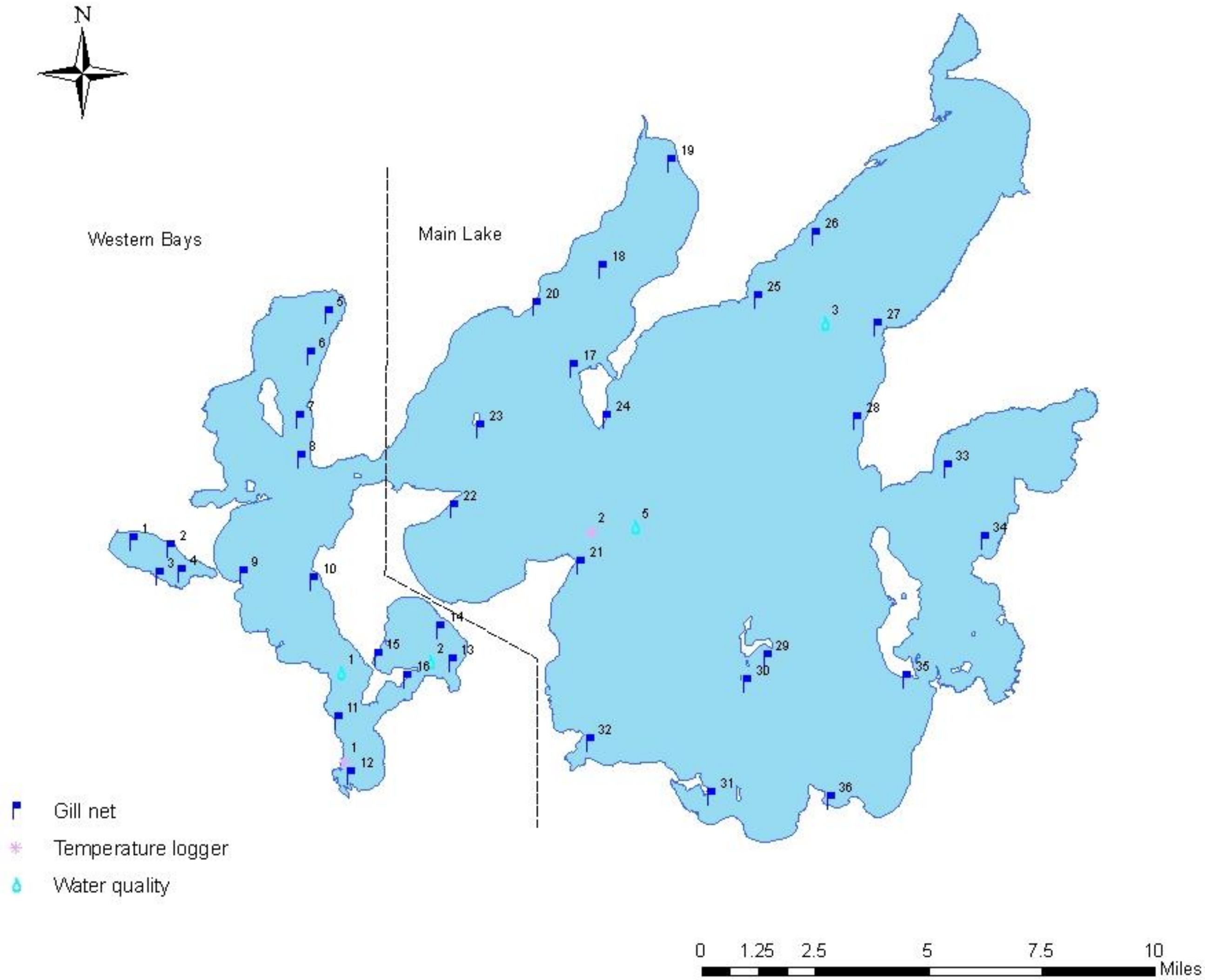

Figure 7. Gillnet (flags), temperature loggers (dots) and water quality (droplets) sampling locations on Leech Lake.

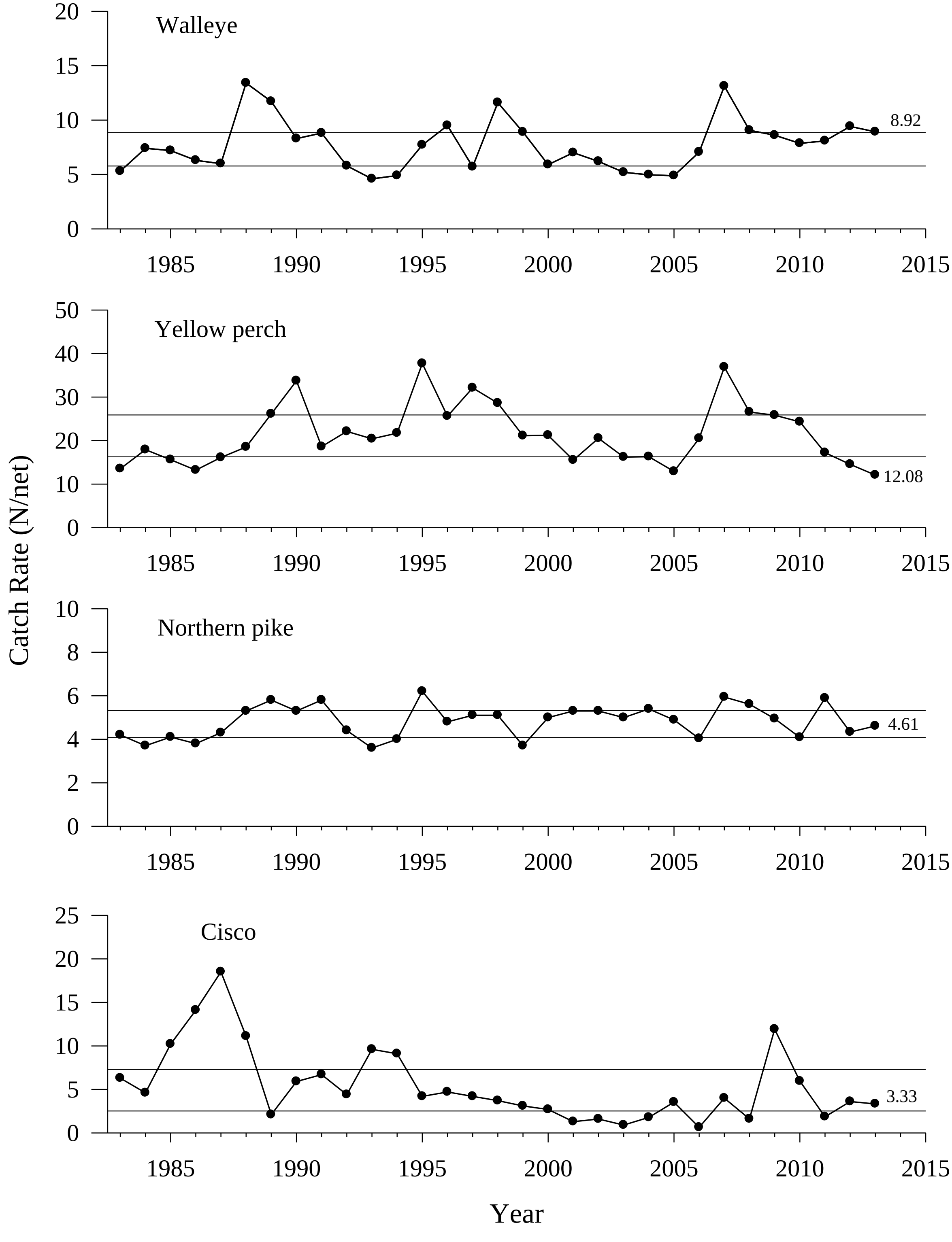

Figure 8. Gillnet catch rates (fish/net) of selected species in Leech Lake, 1983-2013. Horizontal lines represent respective upper (3rd) and lower (1st) quartiles.

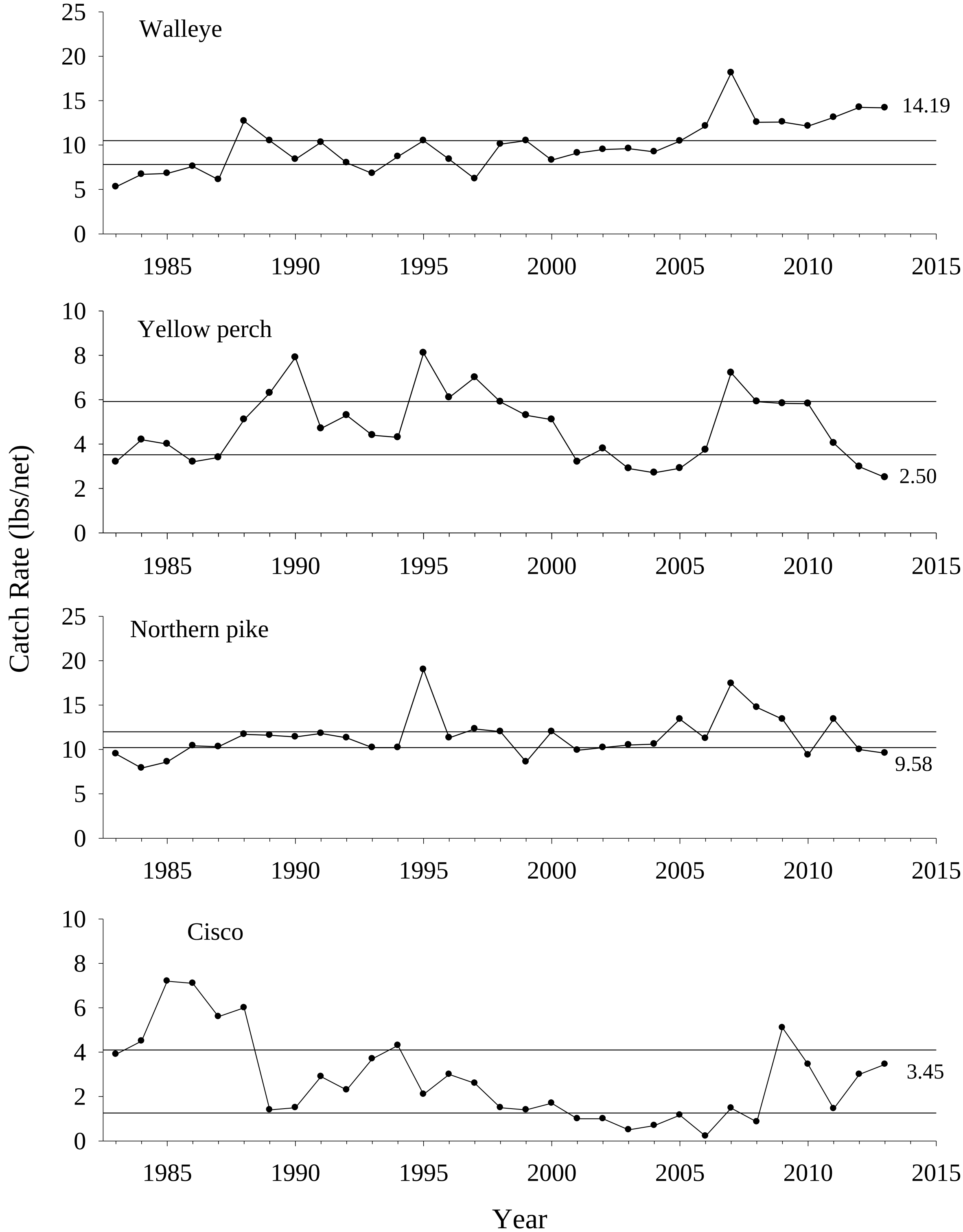

Figure 9. Gillnet catch rates (lbs/net) of selected species in Leech Lake, 1983-2013. Horizontal lines represent respective upper (3rd) and lower (1st) quartiles.

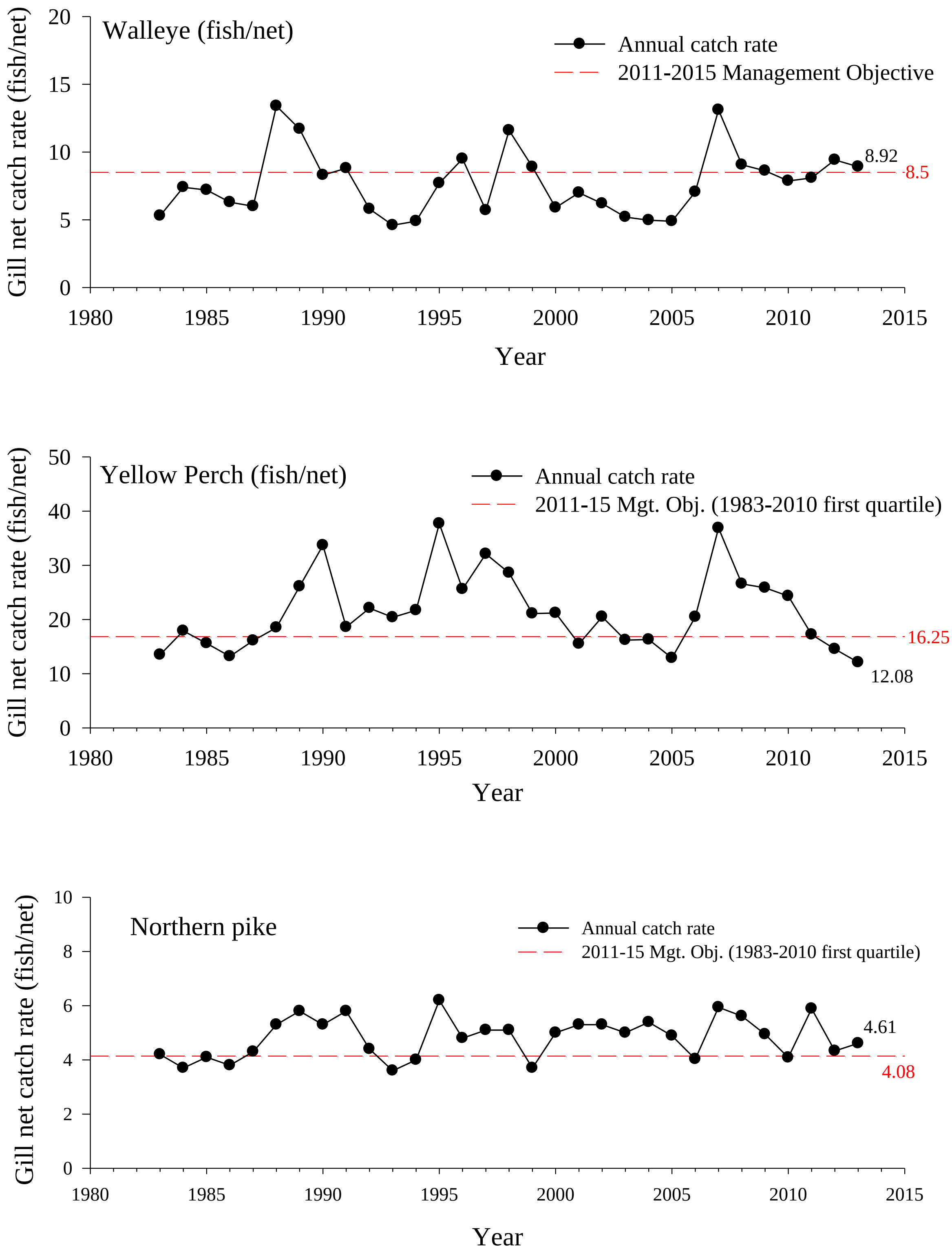

Figure 10. Gill net catch rates of walleye, yellow perch, and northern pike compared to 2011-2015 Leech Lake Management Plan objectives (Schultz 2010a).

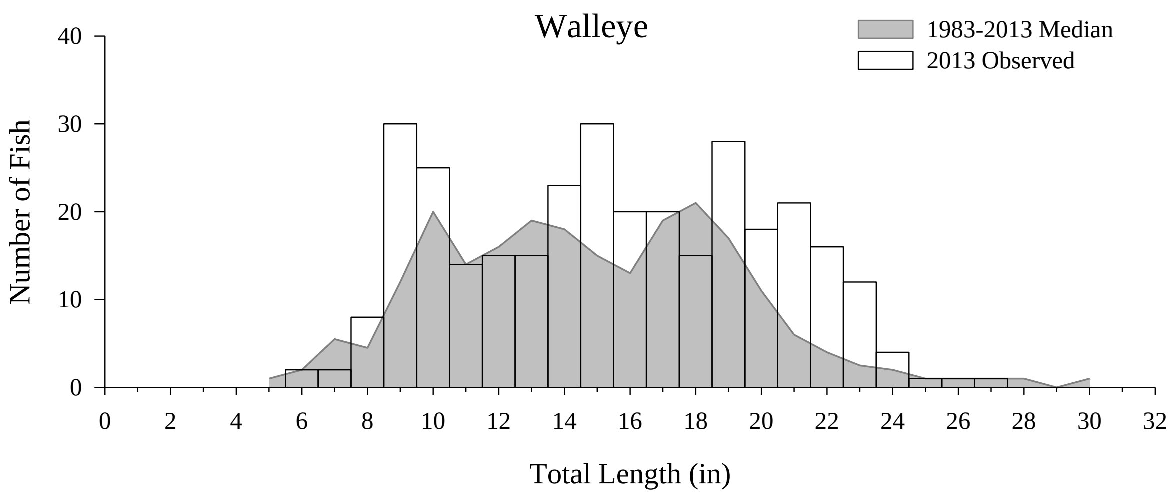

Figure 11. Length-frequency distribution of Leech Lake walleye sampled with experimental gillnets, 2013.

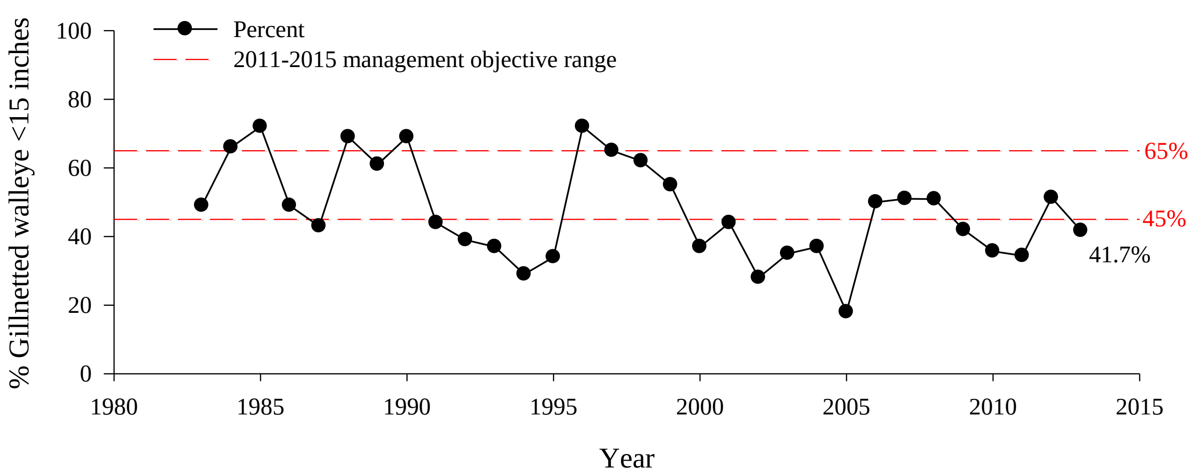

Figure 12. Proportion of gill net sampled walleye shorter than 15 inches relative to 2011-2015 Leech Lake Management Plan objectives (Schultz 2010a).

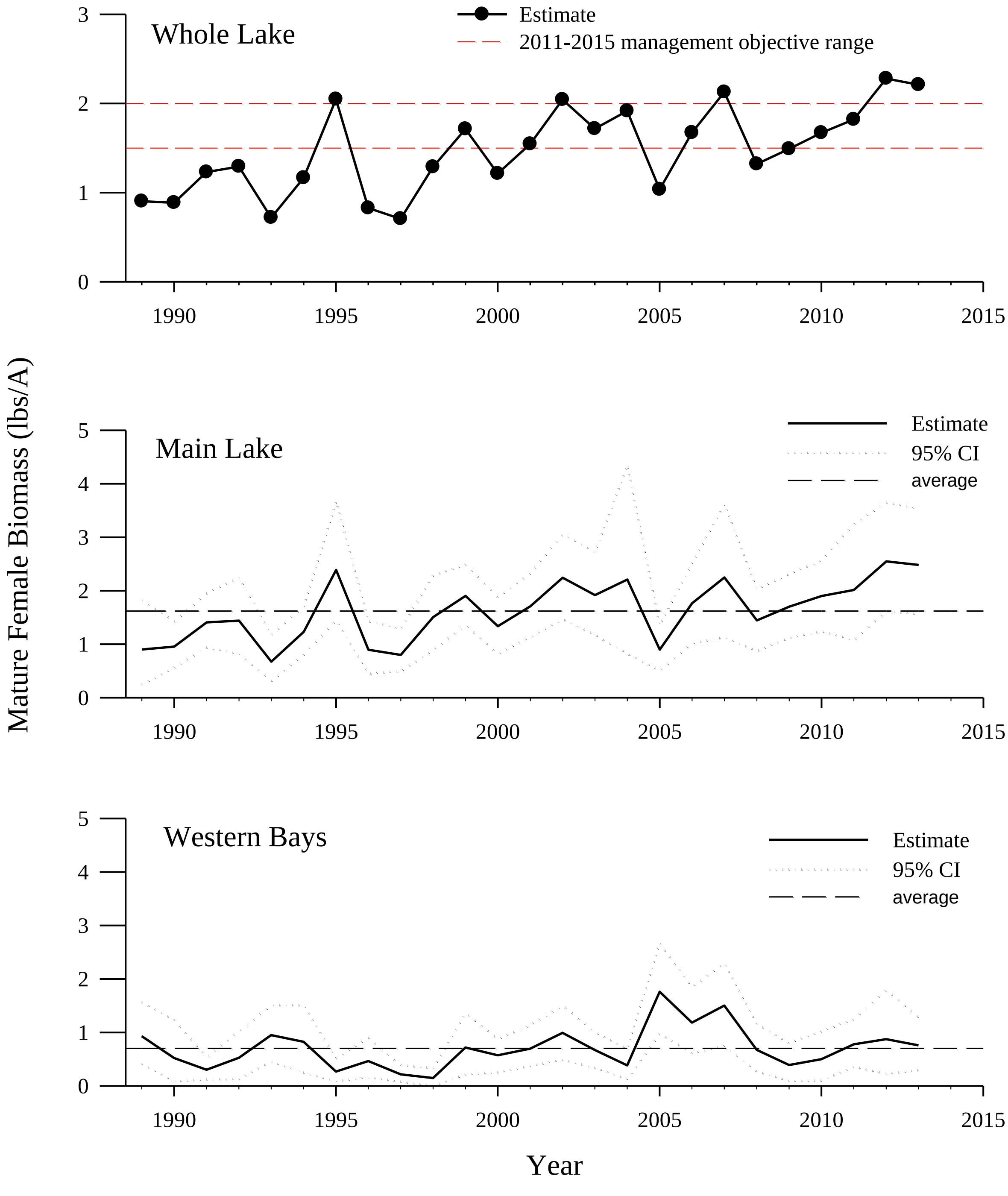

Figure 13. Estimated biomass (lbs/acre) of mature female walleye in Leech Lake, 1989-2013. Horizontal lines on the whole lake estimate (top) depict the current management objective range of 1.5-2.0 lbs/acre (Schultz 2010a). Basin-specific estimates are presented on the bottom two panels with 95% confidence intervals.

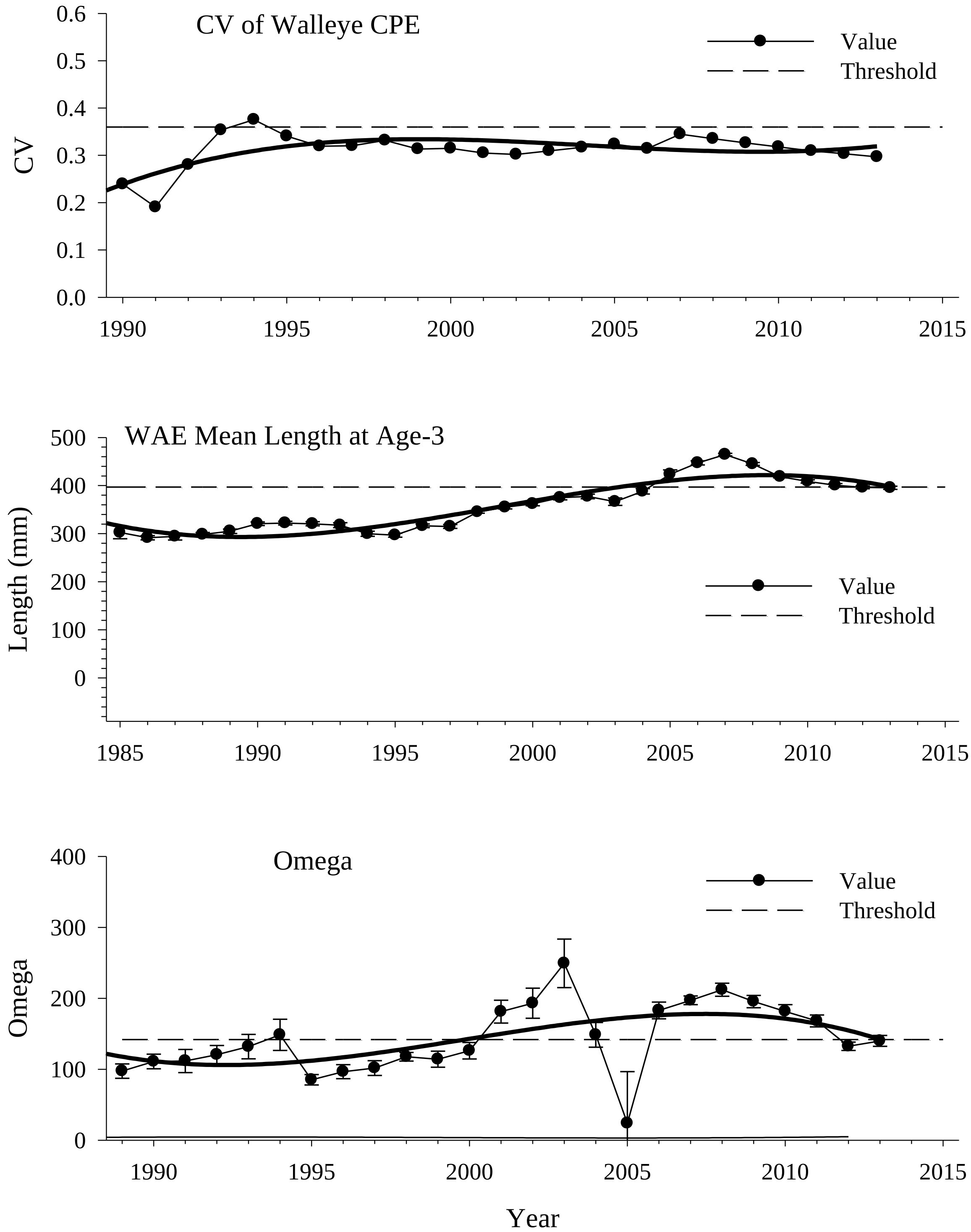

Figure 14. Coefficient of variation (CV) in gillnet catch-per-effort (CPE) of all walleye (top panel), mean length of all age-3 walleye sampled in experimental gillnets (middle panel), and omega values (bottom panel) for the Leech Lake walleye population. Values above the respective thresholds (dashed lines) indicate a potential population stress responses; error bars are standard error of the mean.

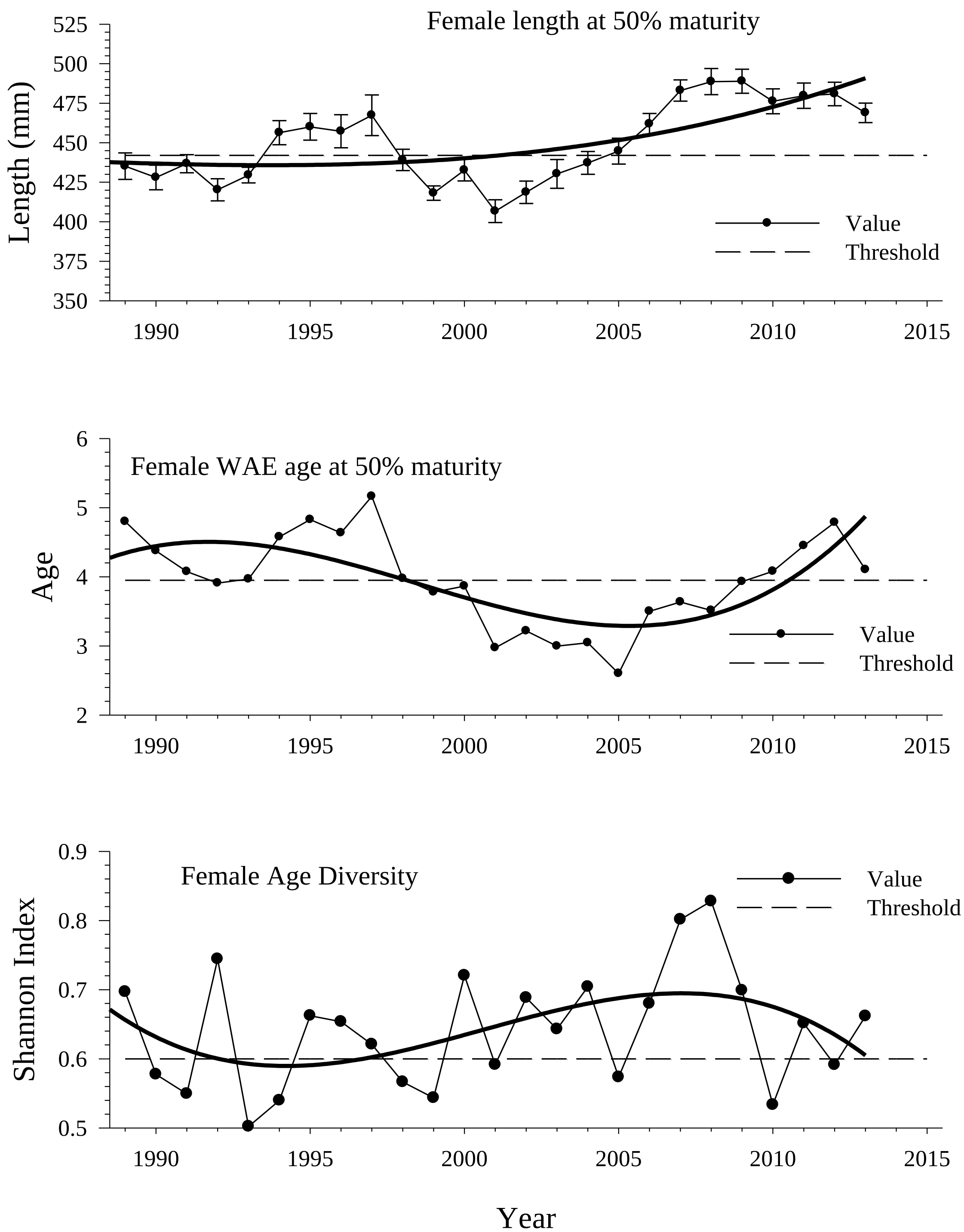

Figure 15. Mean length of female walleye at 50% maturity (top), estimated age of female walleye at 50% maturity (middle), and age diversity of female walleye sampled in experimental gillnets (bottom) from the Leech Lake walleye population. Values below the respective thresholds (dashed line) indicate a potential population stress response; error bars are standard error of the mean.

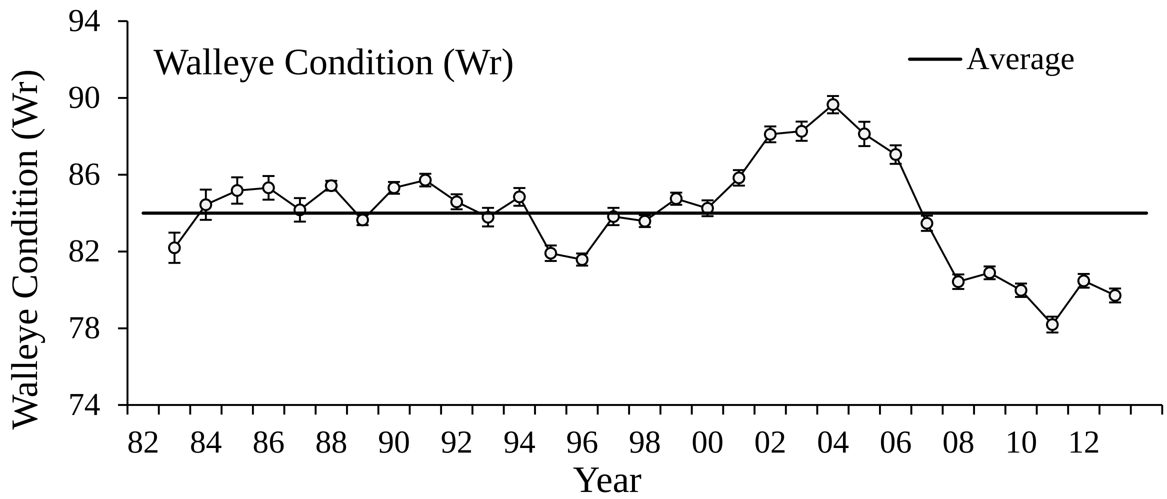

Figure 16. Condition (Wr) of walleye sampled in experimental gillnets in Leech Lake, 1983-2013.

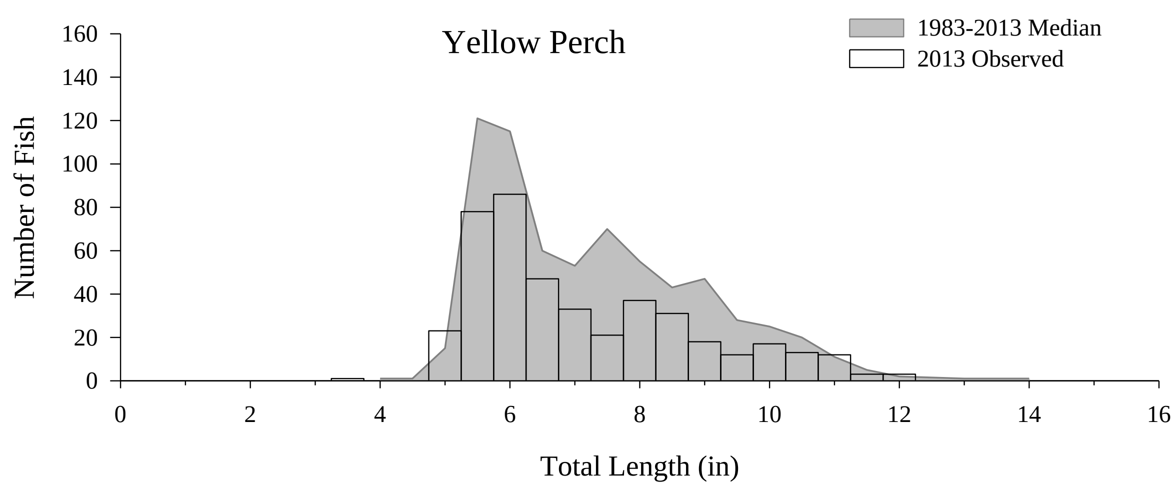

Figure 17. Length-frequency distribution of yellow perch sampled with experimental gillnets in Leech Lake, 2013.

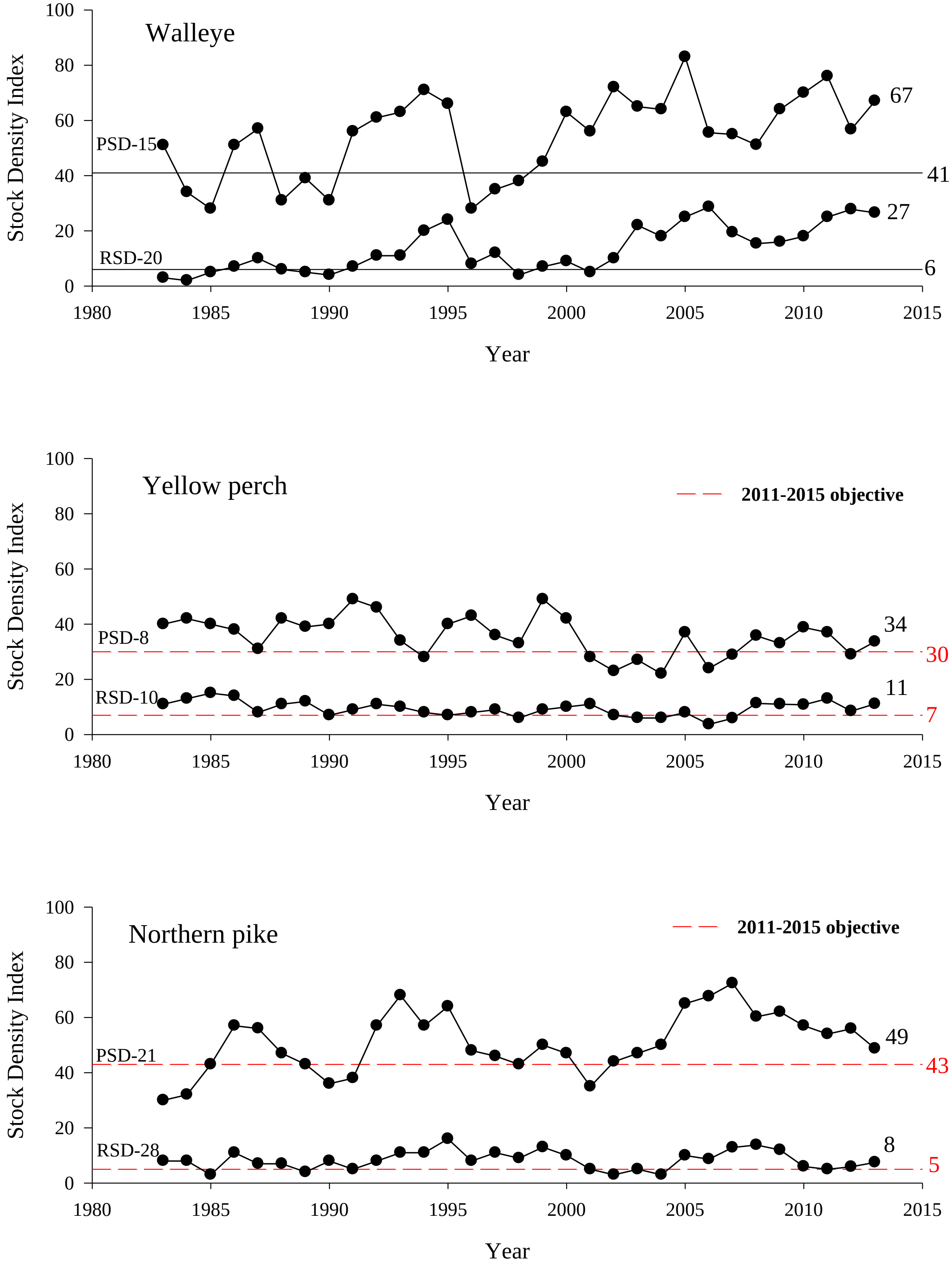

Figure 18. Size structure indices for yellow perch and northern pike relative to the 2011-2015 Leech Lake Management Plan (Schultz 2010a).

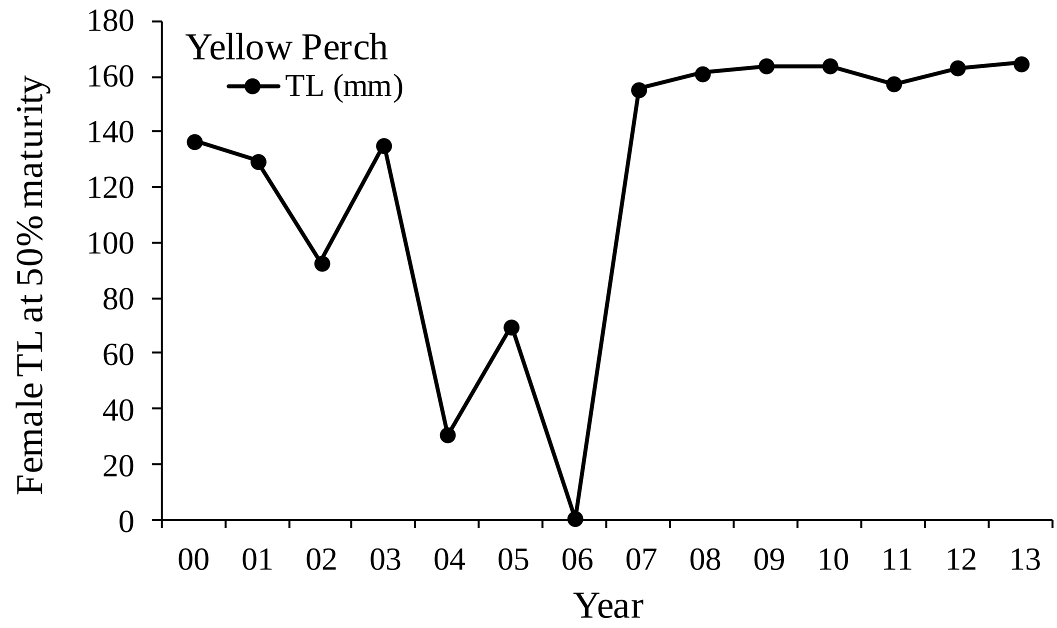

Figure 19. Total length of female yellow perch at 50% maturity sampled with experimental gillnets in Leech Lake, 2000-2013.

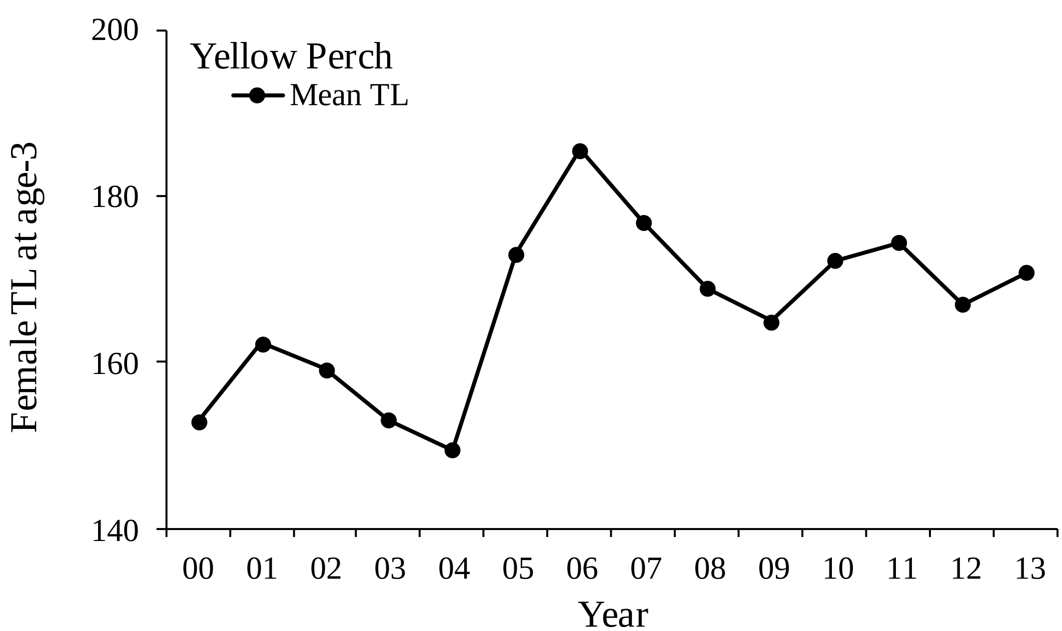

Figure 20. Total length of female yellow perch at age-3 sampled with experimental gillnets in Leech Lake, 2000-2013.

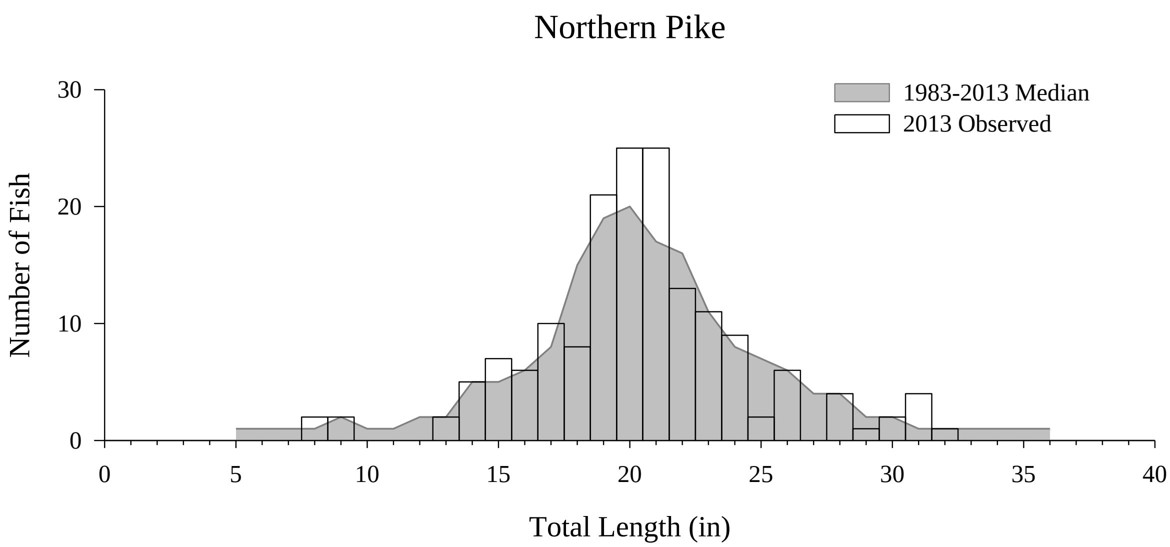

Figure 21. Length-frequency distribution of northern pike sampled with experimental gillnets in Leech Lake, 2013.

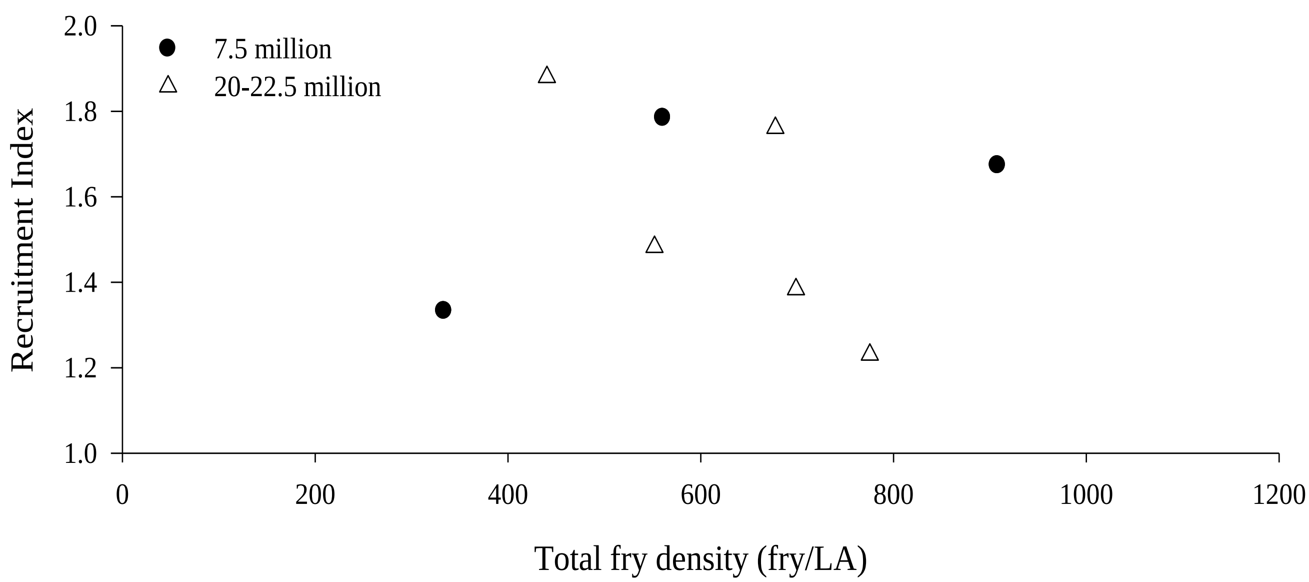

Figure 22. Total walleye fry density (fry/littoral acre) estimated with OTC marking and the resulting year class strength index at Leech Lake, 2005-2012. The number of fry stocked is also indicated.

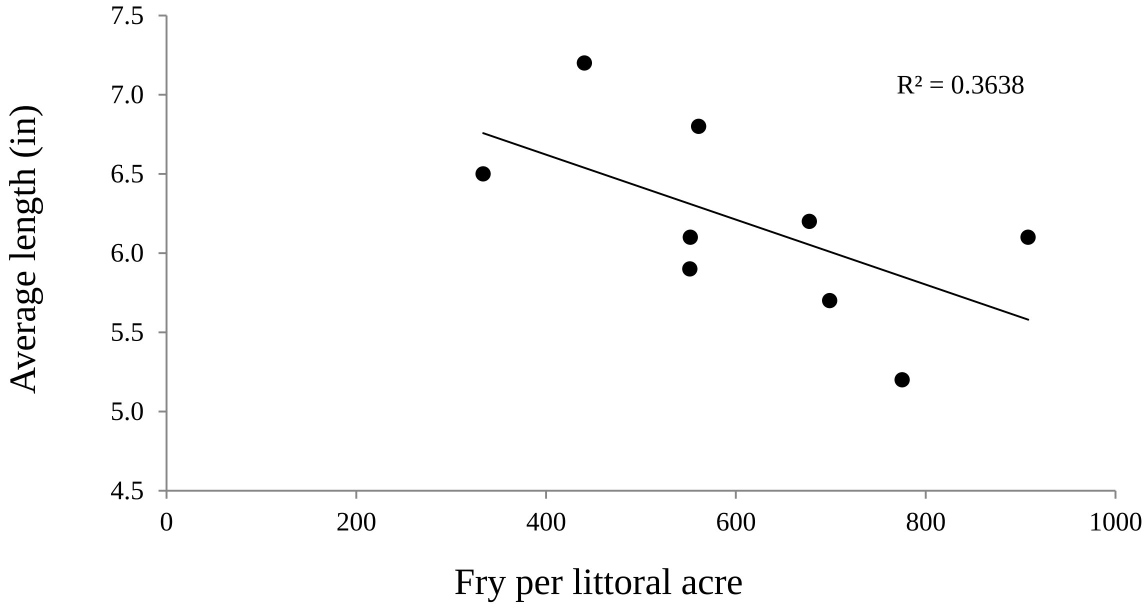

Figure 23. The total walleye fry density (fry/littoral acre) estimated with OTC marking and the average length (in) of young-of-year walleye sampled by electrofishing in mid-September at Leech Lake, 2005-2013.

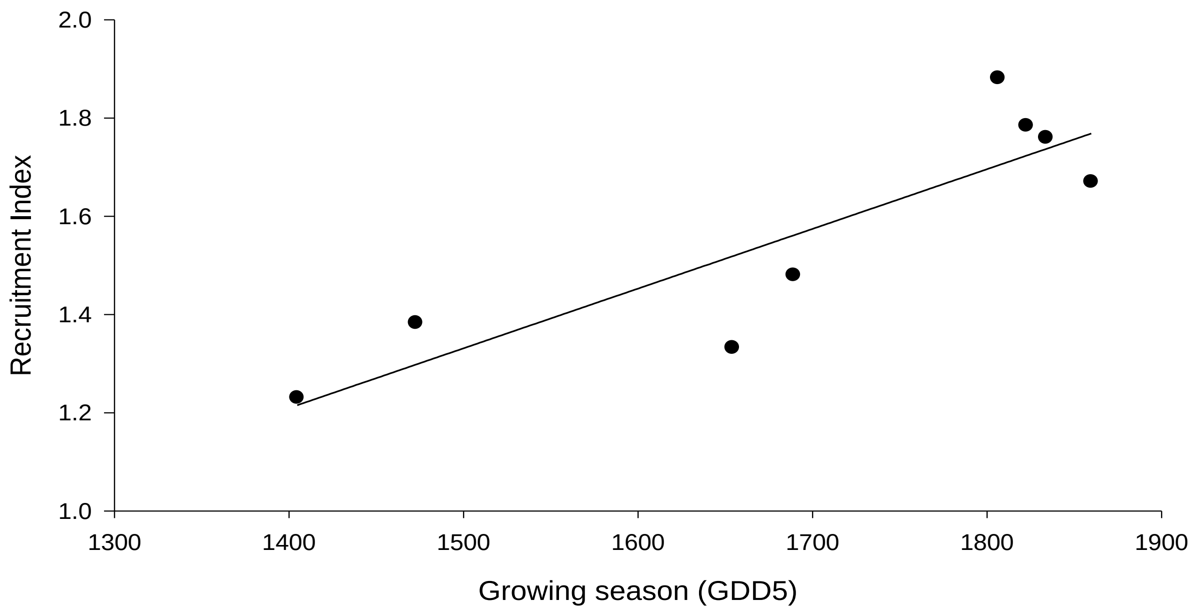

Figure 24. Growing degree days (GDD5) and the resulting walleye year class strength in Leech Lake, 2005-2012.

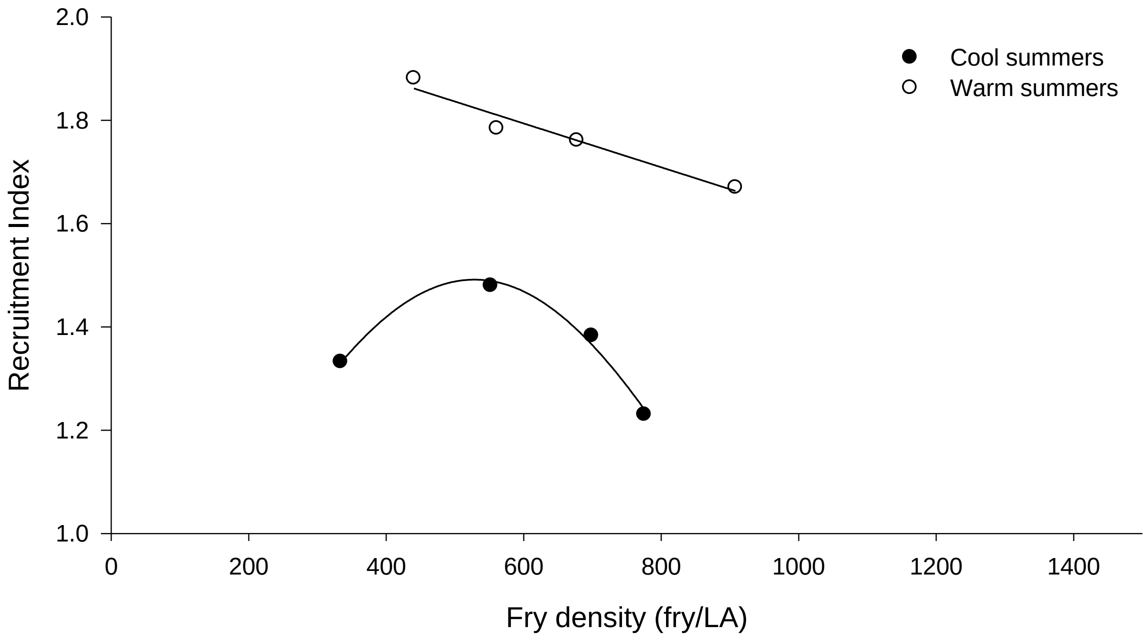

Figure 25. Total walleye fry density (fry/littoral acre) estimated with OTC marking and the resulting year class strength index at Leech Lake, 2005-2012 as a function of variability in growing season among years.

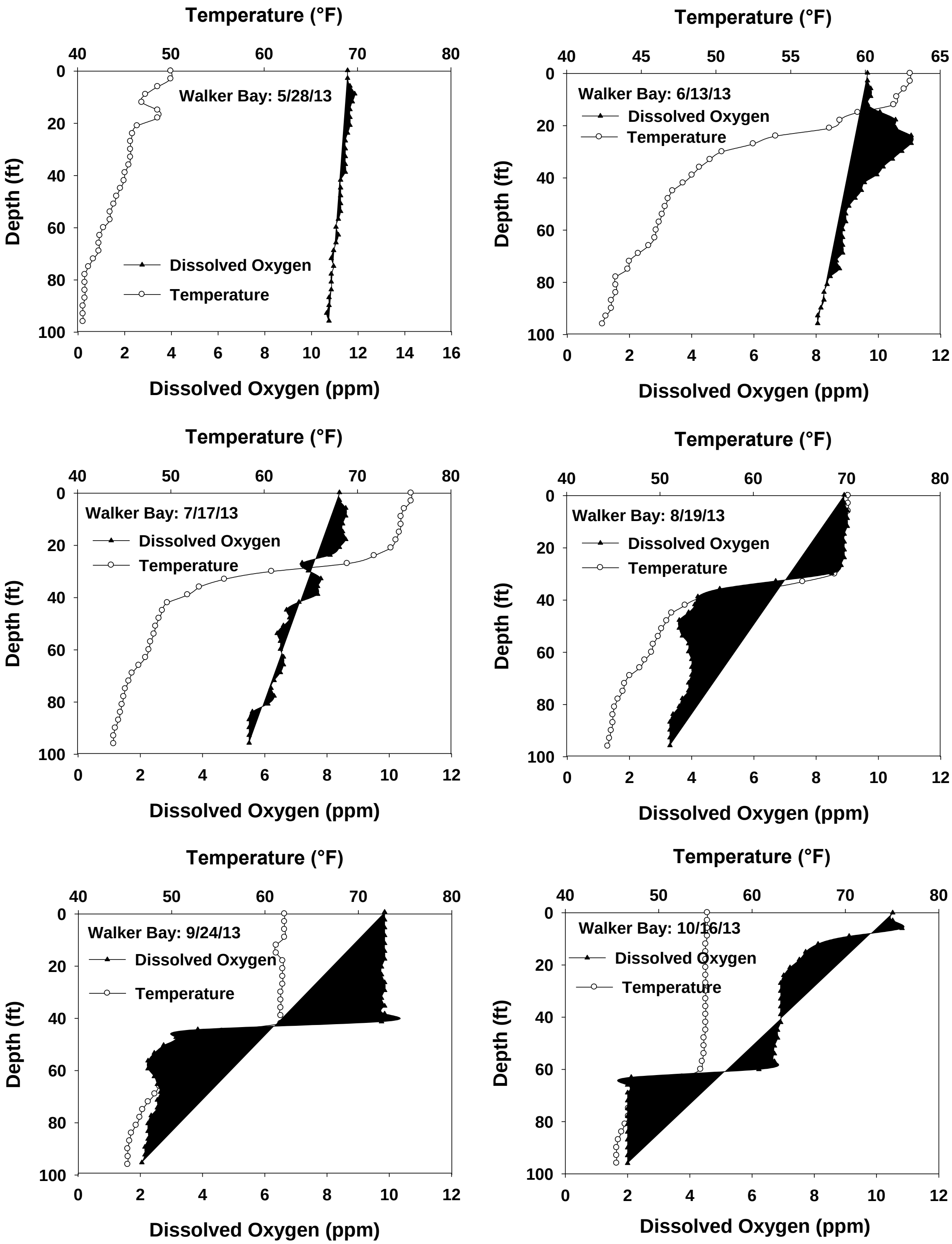

Figure 26. Monthly temperature and oxygen profiles at five locations in Leech Lake from mid-June through mid-October, 2013.

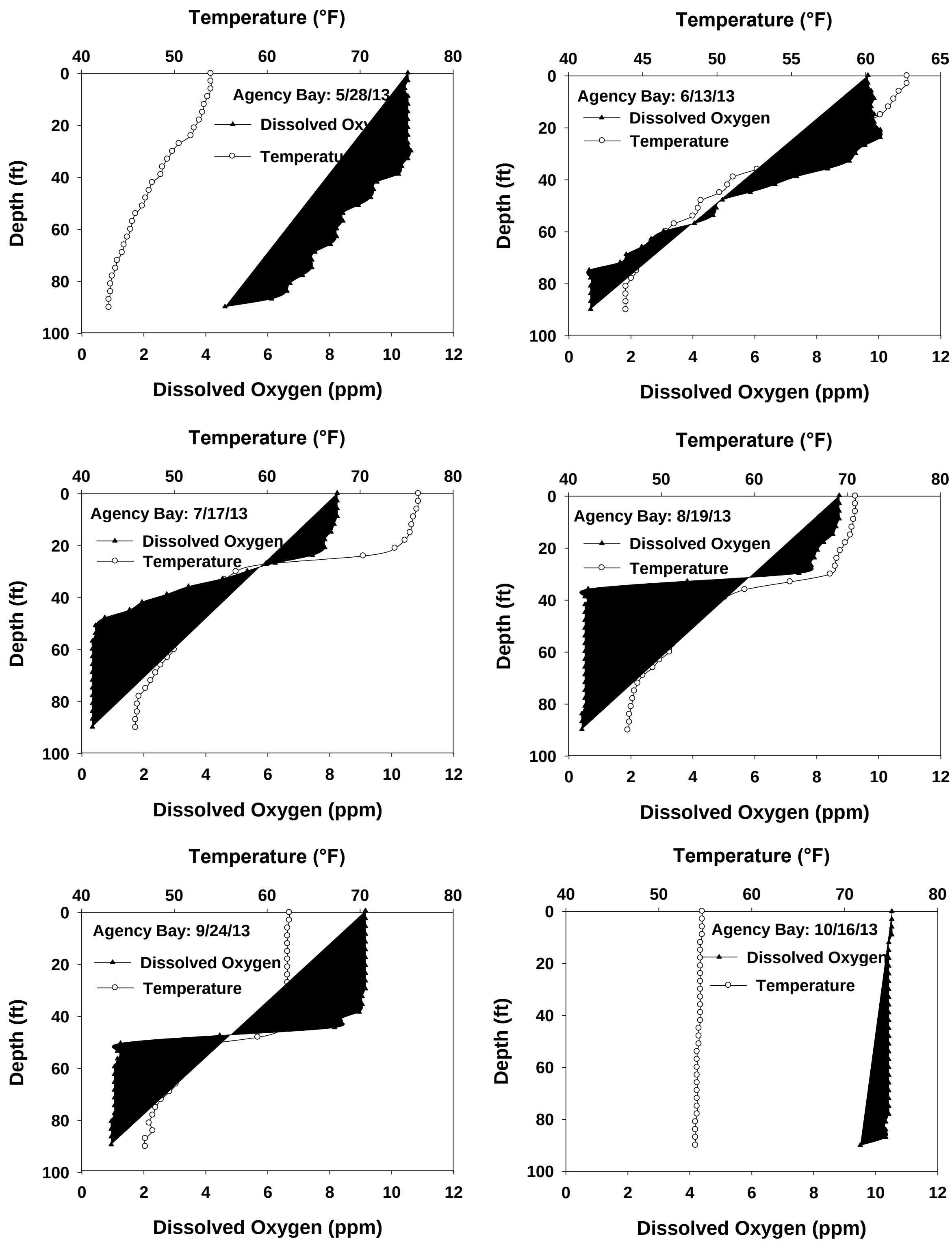

Figure 26 (continued). Monthly temperature and oxygen profiles at five locations in Leech Lake from mid-June through mid-October, 2013.

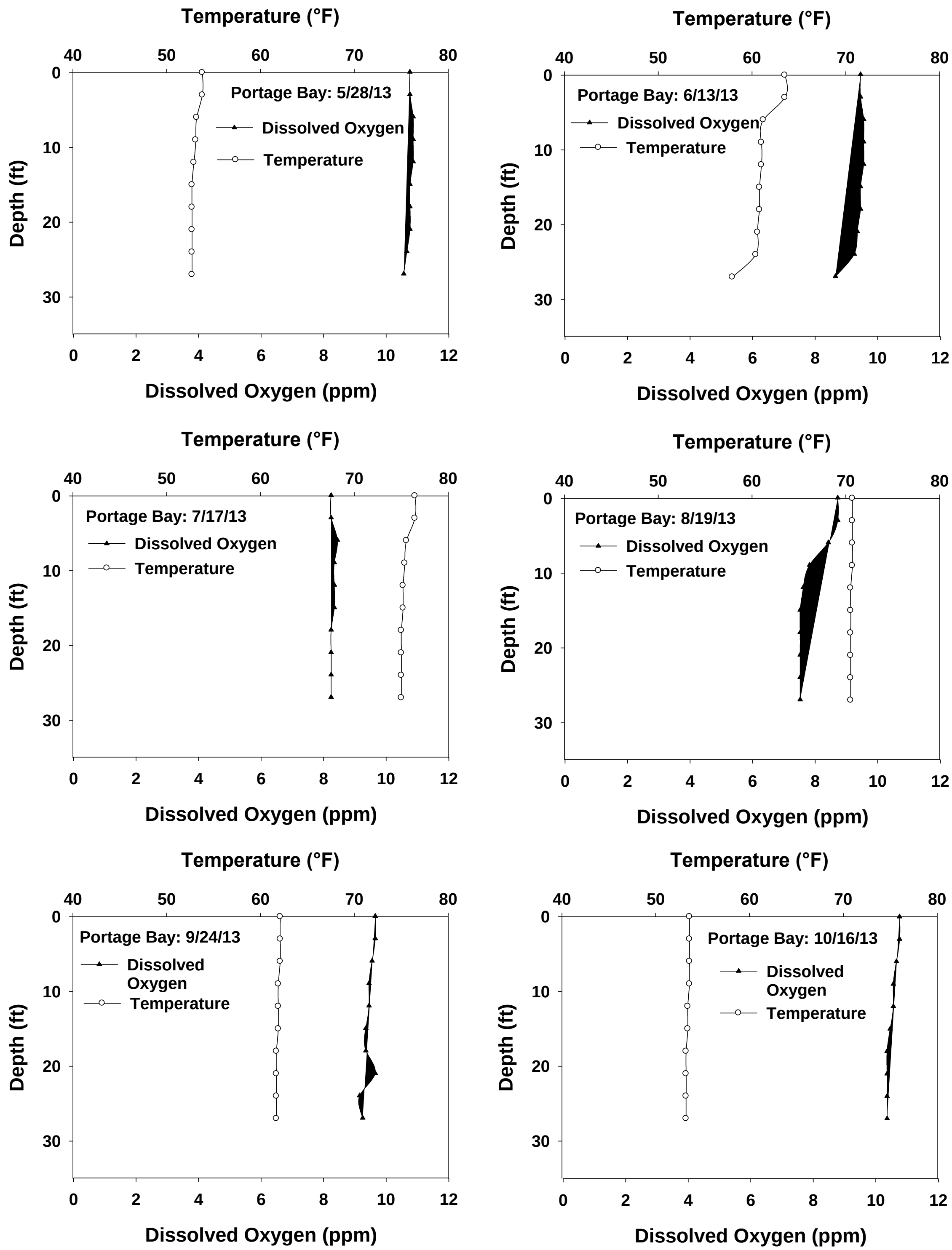

Figure 26 (continued). Monthly temperature and oxygen profiles at five locations in Leech Lake from mid-June through mid-October, 2013.

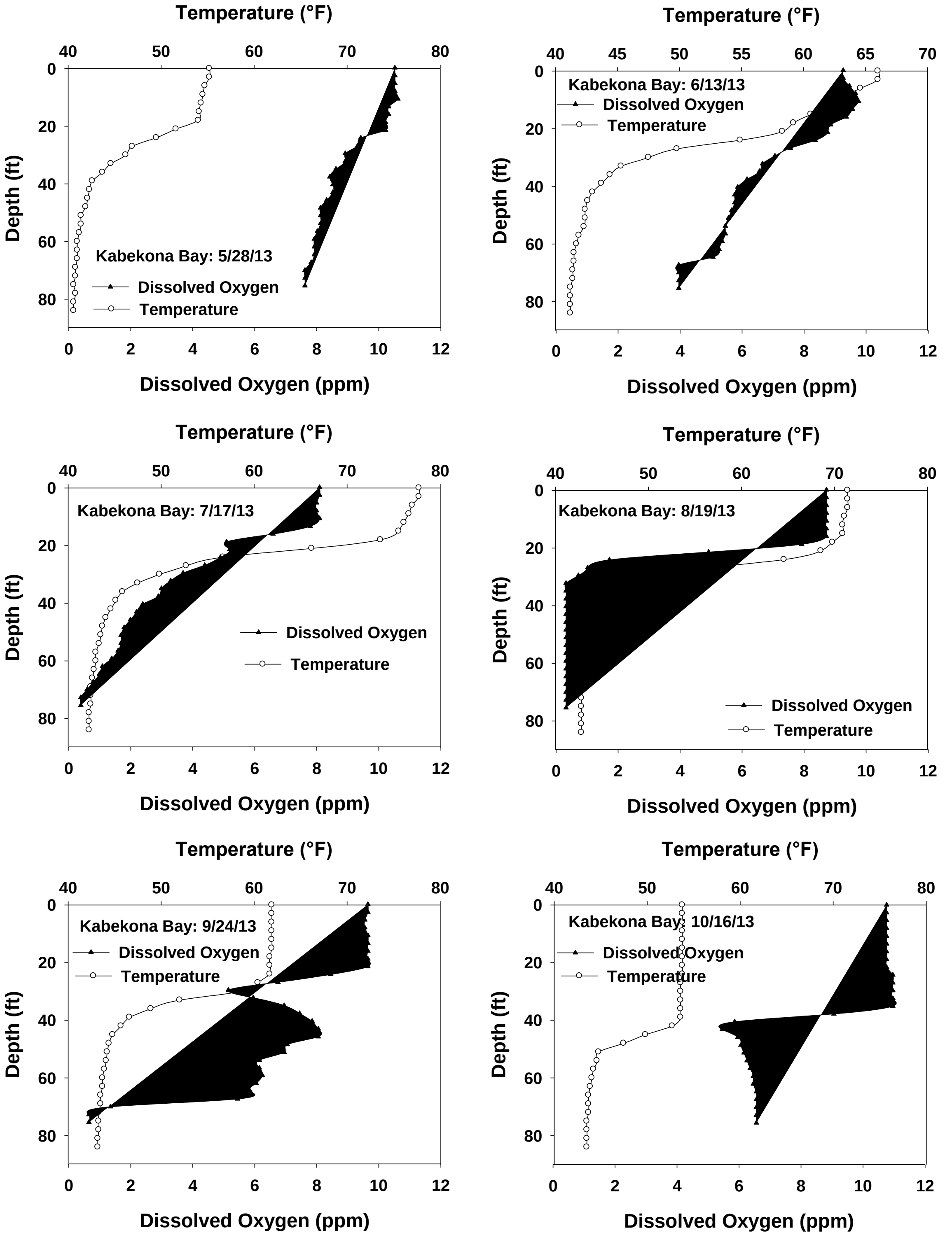

Figure 26 (continued). Monthly temperature and oxygen profiles at five locations in Leech Lake from mid-June through mid-October, 2013.

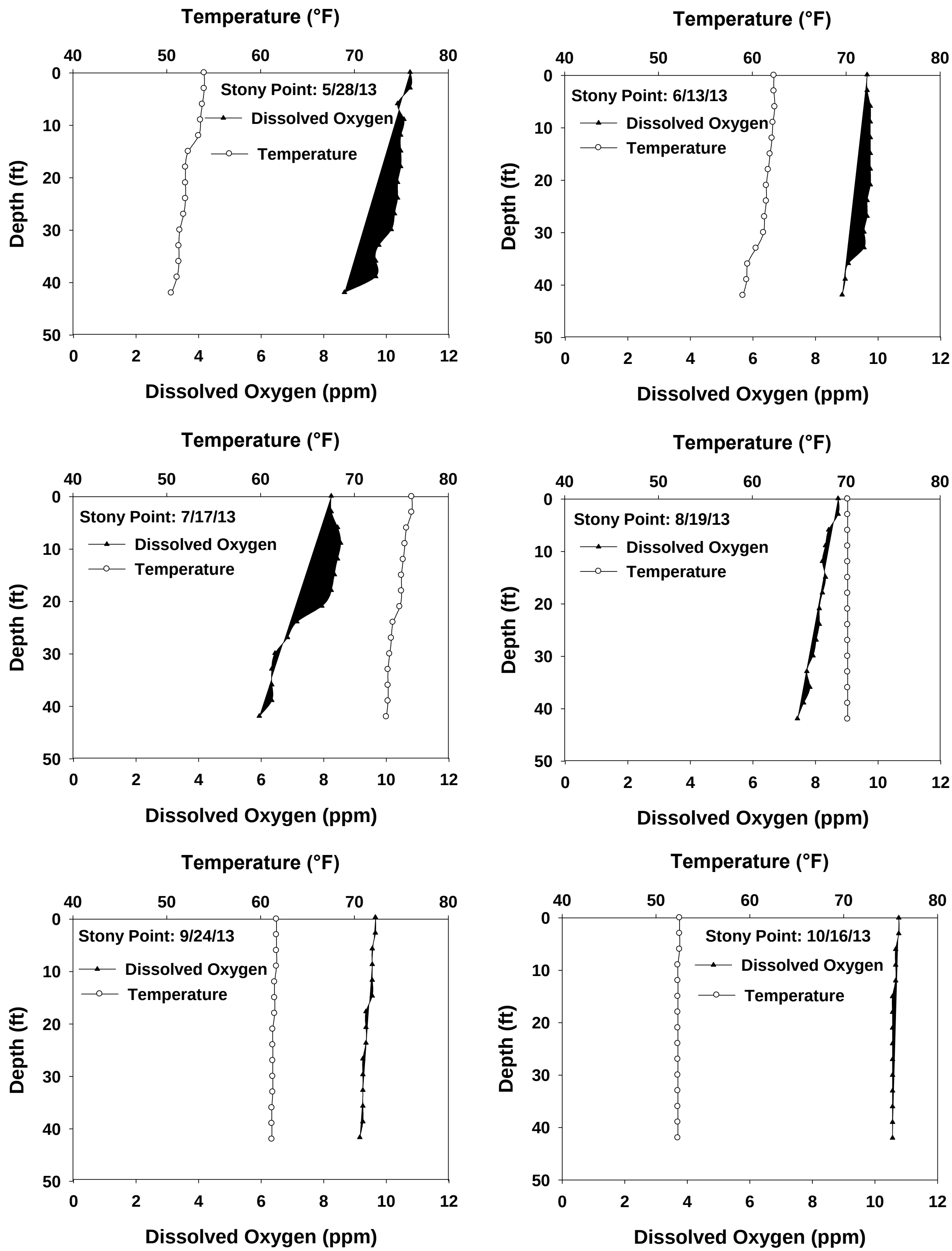

Figure 26 (continued). Monthly temperature and oxygen profiles at five locations in Leech Lake from mid-June through mid-October, 2013.

Figure 27. Areas on Leech Lake where boat harbors were inspected for Eurasian watermilfoil and treated if present in 2013.

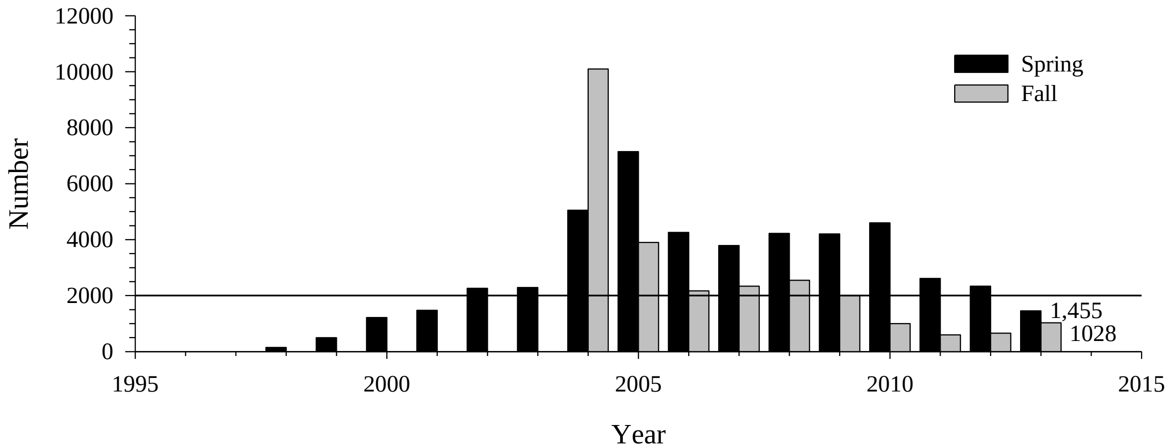

Figure 28. Spring and fall Double-Crested Cormorant numbers on Leech Lake, 1998-2012. The line depicts the current fall population goal of 2,000 birds ([500 nesting pairs x 2 adults] + 2 offspring/nest). (S. Mortensen, Division of Resource Management, Leech Lake Band of Ojibwe, personal communication).

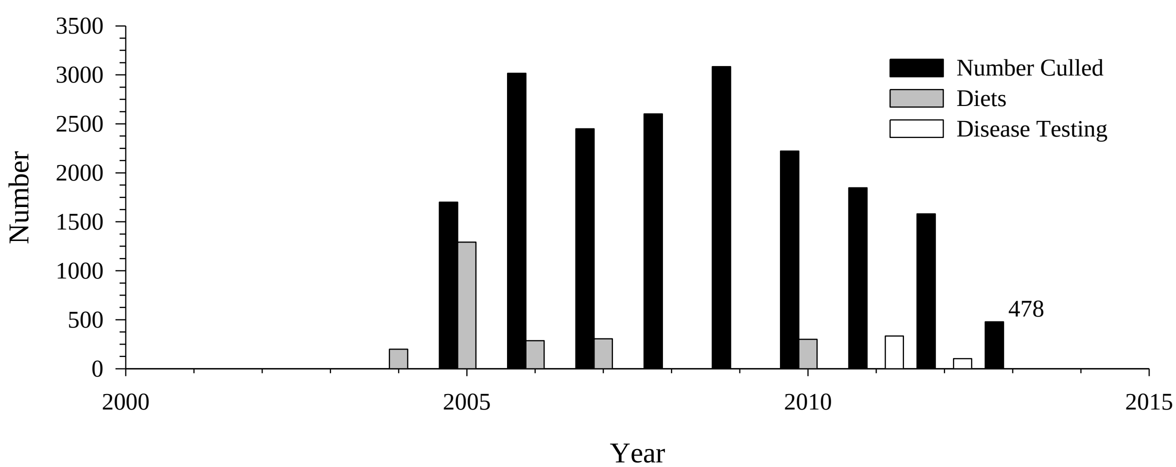

Figure 29. The number of Double-Crested Cormorants culled on Leech Lake, 2000-2012. The number of additional birds culled for diet and disease testing is also indicated. (S. Mortensen, Division of Resource Management, Leech Lake Band of Ojibwe, personal communication).

APPENDIX

Table A1. Mean length-at-age data of female walleye captured with experimental gillnets in the main lake basin, Leech Lake.

	Age										
YC	0	1	2	3	4	5	6	7	8	9	10
1980				12.99	16.17	16.04	18.53		20.55		
1981			10.85	13.26	14.20	16.15	18.73		21.73	23.70	25.80
1982		9.45	11.45	13.56	14.04	17.28	20.63	22.50	22.80		
1983		10.98	10.48	13.02	14.93	19.29	19.73	23.00		22.40	22.80
1984	7.00	9.93	12.18	13.15	16.89	18.13	18.93	21.04			
1985		9.65	11.07	13.31	15.84	18.31	19.67	20.00	20.80		23.88
1986		9.41	12.17	14.33	16.95	19.32	20.75	20.92	21.38	23.94	24.20
1987	7.10	10.60	13.20	13.39	16.97	20.01	20.20	21.75	21.95	25.60	21.25
1988	7.07	10.07	12.71	15.50	18.24	18.65	19.92	20.93	22.15	23.77	23.13
1989	6.50	10.39	14.01	14.50	18.80	19.34	19.31	22.40			
1990		11.10	13.76	15.47	17.52	19.47	21.80	21.85	22.70	23.10	24.50
1991	7.46	11.02	13.11	15.96	17.86	19.65	20.85	20.05	23.90	24.90	20.28
1992		9.85	12.52	15.00	18.27	19.70	19.30			24.88	
1993		9.33	13.35	15.45	16.60	17.76	18.70				
1994		10.16	12.47	14.83	17.53	19.33	19.70	20.75	20.27	21.60	24.06
1995	7.30	9.69	12.78	15.54	17.48	19.24	19.45	20.47	22.03	23.82	
1996	9.55	10.40	13.13	15.51	18.25	19.31	19.51	23.13			24.25
1997	6.85	10.30	13.80	16.63	18.53	19.18	21.08	21.46	23.20	23.27	23.85
1998	6.97	10.88	14.63	16.71	18.36	19.36	22.11		23.61		23.62
1999	6.99	10.49	14.13	17.27	19.54	18.96	20.29	23.26	23.74	24.74	24.88
2000	7.15	11.29	13.87	18.26	19.51	20.21		23.17			
2001	7.48	11.87	16.77	18.17	19.91	21.16	22.95		24.16	23.19	23.86
2002	7.04	12.54	14.31	18.95	20.27	21.48		22.17	24.23	23.19	25.98
2003	7.24	10.91	14.17	19.57	21.50	21.02			23.52		
2004		11.53	14.37	18.54	19.87	19.45			23.70	22.32	
2005		12.33	16.16	18.33	19.60	21.15	21.02	22.92	23.24		
2006	7.33	12.02	14.54	16.49	19.23	20.72	20.92	21.97			
2007	7.58	10.71	13.57	16.24	18.38	20.08	20.95				
2008		8.82	12.32	15.18	17.59	19.40					
2009		9.74	13.22	15.40	17.74						
2010		9.32	13.38	16.41							
2011		10.16	13.92								
2012	7.24	10.17									
2013	6.67										
Mean	7.25	10.49	13.30	15.71	17.89	19.28	20.21	21.78	22.61	23.63	23.76

Table A2. Mean length-at-age data of male walleye captured with experimental gillnets in the main lake basin, Leech Lake.

	Age										
YC	0	1	2	3	4	5	6	7	8	9	10
1980				13.80	14.58	14.37	16.68	18.90	18.50		
1981			10.87	12.43	14.48	16.24	17.43		18.90	18.10	
1982		10.05	11.81	13.89	14.67	16.09	17.72	18.70			
1983	7.17	11.03	10.96	13.55	14.73	17.75	18.53	18.96	19.30	20.60	19.55
1984	7.05	9.25	11.55	13.24	15.42	15.71	17.80		18.60		
1985		9.48	11.95	13.36	14.93	17.05	18.43	18.13		20.83	
1986	6.83	9.35	12.01	14.80	16.13	17.06	17.14	18.68	18.07	20.20	19.88
1987	6.80	10.50	13.00	14.04	16.58		18.13	18.87	18.58	21.20	
1988	7.01	10.14	12.75	15.29	17.01	17.41	18.39	18.50	19.10	20.50	20.43
1989	7.10	9.85	13.04	14.75	16.15	18.07	19.50	19.95		19.30	
1990		10.78	14.03	14.73	16.40	17.13	18.75	18.50		20.80	
1991	7.71	11.10	12.71	14.70	15.89	17.10	19.33		21.40	20.90	
1992		9.55	13.52	16.00	16.40	19.00	19.25				
1993		10.12			15.05					19.37	22.83
1994	6.35	9.99	12.23	14.64	15.94	17.82	17.87	18.71		20.13	20.33
1995	7.55	9.48	12.58	15.12	16.28	17.84	18.24	19.61	19.59	20.37	20.75
1996	6.60	9.96	13.13	15.09	16.08	18.09	18.16	19.96		20.04	20.35
1997	6.97	10.25	13.70	15.93	17.13	18.57	19.14	19.54	20.32	21.29	20.66
1998	7.27	10.98	14.58	16.03	18.12	17.38	19.75	19.29	20.28	20.59	21.22
1999	6.90	10.75	13.79	16.60	18.34	19.00	19.66	20.44	21.09		22.28
2000	7.07	11.09	14.61	17.36	18.54	19.51	19.92		19.69		
2001	7.43	11.83	15.58	16.52	18.74	19.00	19.78	19.75	20.79		21.54
2002	7.04	12.49	15.07	17.24	18.84	19.88	20.19		19.96	21.20	22.20
2003		12.03	14.65	17.24	18.15	20.71		19.67			
2004		11.61	16.69	18.31		18.90		19.09		21.10	
2005	6.57	12.32	15.74	17.45	17.90	18.75	19.55	20.03	20.83		
2006	7.41	12.01	14.26	16.22	17.61	18.78	19.61	19.64			
2007	7.34	10.63	13.35	15.75	16.98	17.93	19.36				
2008		8.88	12.91	15.32	17.44	18.23					
2009	5.16	9.78	13.31	15.28	17.18						
2010	6.80	9.67	13.29	15.78							
2011	6.42	10.35	13.92								
2012	7.08	9.98									
2013											
Mean	6.94	10.49	13.39	15.35	16.61	17.90	18.73	19.25	19.69	20.38	21.00

Table A3. Mean length-at-age data of female walleye captured with experimental gillnets in the western bays basin, Leech Lake.

	Age										
YC	0	1	2	3	4	5	6	7	8	9	10
1980				13.72	14.08	17.40	16.28	18.02		19.40	
1981			11.20	13.21	13.23	17.67	20.70	19.26	19.80		
1982		9.61	11.23	12.82	15.28	17.04	18.49	19.60	23.00		
1983		9.77	12.62	12.95	13.90	19.20	19.67				
1984		10.29	10.96	12.40	15.81	15.37	19.00	22.10	22.10		
1985	7.60	7.80	12.30	13.24	14.12	18.00	20.00				22.10
1986		9.30	11.37	13.61	16.39	17.69	20.02	21.05	22.47	21.20	21.10
1987	7.60	9.73	11.93	13.57	15.37	18.45	19.10	20.04			
1988		9.62	12.32	14.39	17.56	18.87	20.50	21.70	21.37	22.80	
1989		10.16	12.67	14.16	18.50	18.35		20.55			22.55
1990	6.30	9.89	12.11	13.78	15.65	16.50	19.40		22.40		
1991	7.25	9.89	10.57	13.20	14.82	18.44	19.30		19.20	20.50	
1992			10.70	12.90	15.40	18.20	19.60	18.70			
1993		8.82		14.30	17.10	15.30	16.60			25.39	
1994		8.97	11.28	13.18	15.90	17.90	18.87	18.94	18.94	18.98	
1995	6.50	8.50	11.12	14.18	14.90	18.16	17.52	19.24	23.66	24.49	21.38
1996	10.00	9.63	12.45	14.13	15.28	17.16	18.31		25.12		22.52
1997		10.00	12.63	14.83	16.56	17.69	19.15		19.55	21.34	24.20
1998	7.23	9.94	12.39	14.32	16.43	19.78	18.70		22.28	24.76	23.77
1999	6.30	9.31	11.92	14.30	18.12	19.29	19.89	22.87	24.45	22.58	
2000		9.79	13.22	14.37	17.70	19.07	20.59	21.67			
2001	7.09	10.42	14.37	15.65	18.73	20.10	21.27	21.99	21.73	24.02	
2002		10.37	12.83	16.17	18.55	20.26	20.60	22.30	23.76		23.86
2003		10.61	13.87	17.24	19.44	20.39	21.42		24.06		22.68
2004		10.37	14.09	17.03			18.86	21.54		22.53	
2005		11.47	14.67	16.34	18.99	21.15	21.33	23.19	22.50		
2006		10.71	13.55	14.98	17.65	19.45	20.59	21.13			
2007	7.01	9.57	11.77	14.53	17.30	18.74	19.51				
2008		9.27	11.60	15.13	16.89	17.40					
2009		9.96	12.07	14.96	17.09						
2010		9.08	11.63	14.23							
2011		9.88	12.15								
2012		9.16									
2013											
Mean	7.29	9.73	12.25	14.32	16.44	18.32	19.45	20.77	22.14	22.33	22.68

Table A4. Mean length-at-age data of male walleye captured with experimental gillnets in the western bays basin, Leech Lake.

	Age										
YC	0	1	2	3	4	5	6	7	8	9	10
1980				13.99	14.70	15.55	16.38		19.10		
1981			11.46	12.91	14.80	15.92	15.75	17.60	18.30	19.83	
1982		9.19	11.63	13.07	14.63	16.36	17.44	17.15	18.43	19.70	18.93
1983	6.80	9.83	11.46	13.20	14.35	16.92	17.03	18.57	19.05		20.90
1984		9.30	10.55	12.65	15.67	15.35	17.80	18.63	18.13		
1985		7.90	12.50	13.59	13.80	16.20	16.40	17.75		18.38	20.10
1986		8.74	11.18	13.10	15.45	16.68	18.46	18.22	18.82	16.80	19.60
1987		10.08	12.13	13.54	14.75	16.30		18.60			
1988		10.06	12.32	14.24	16.84	17.98	18.43	18.77	17.98		19.40
1989		9.64	12.38	15.55	16.05	16.75		19.30		18.85	
1990		10.00	12.70	12.84	14.50	18.80	16.30				
1991	7.20	9.29	11.26	13.48	15.04	15.90	17.50				
1992		7.80	10.59	11.50	14.30		18.40				
1993		10.08	11.25	12.80	14.90	18.90					
1994		8.55	11.21	13.29	14.80	16.20	18.10	19.21		19.45	19.50
1995	8.65	8.37	11.11	13.79	16.50	15.60	18.50		18.31		18.98
1996		9.00	11.37	13.40	16.10	18.90		19.09	18.80	18.50	19.69
1997		9.46	11.96	14.95	16.85	18.31		19.04	19.61	19.84	20.10
1998	6.90	9.87	12.60	15.07	17.64	17.32	18.76	19.85	18.54	20.59	
1999	5.50	9.95	12.02	15.19		16.97	19.25		19.51	18.19	20.22
2000		9.92	12.76	14.70	16.38		17.87		19.80		
2001	6.97	10.23	13.16	14.51	17.48	17.78	19.10	19.84	19.17	19.53	
2002	6.46	10.51	12.74	15.81	16.82	18.43	19.46	19.29	20.94		
2003	6.61	10.05	14.33	16.18	18.50	18.48		19.13		20.31	
2004		10.13	14.00					18.70		23.39	
2005		10.81	14.28	16.19	16.50	15.83		20.20			
2006	6.75	11.15	12.62	14.12	16.71	17.87		20.06			
2007	7.52	10.17	11.77	14.72	16.15						
2008		8.98	11.81	14.17	15.85	18.75					
2009		9.53	11.67	14.33	16.38						
2010		9.28	11.63	14.69							
2011		9.85	12.20								
2012		9.06									
2013											
Mean	6.94	9.57	12.09	14.05	15.80	17.12	17.83	18.90	18.97	19.49	19.74

Table A5. Mean length-at-age data of female yellow perch captured with experimental gillnets in the main lake basin, Leech Lake.

	Age										
YC	0	1	2	3	4	5	6	7	8	9	10
1980							10.27	9.31	11.95	10.50	
1981						8.89	9.27	10.97	9.80	11.07	11.30
1982					7.81	7.19	10.78	9.89	10.64	12.27	11.40
1983				6.67	6.80	9.40	8.61	9.99	11.13	10.84	13.20
1984				5.66	8.03	7.71	8.66	10.06	10.53	11.05	11.50
1985				7.12	6.74	8.52	9.68	9.98	9.79	10.15	10.37
1986			5.93	6.03	7.51	8.82	9.67	9.65	8.97	10.45	10.62
1987				6.42	7.42	8.04	9.03	8.68	9.85	10.14	9.90
1988				5.91	7.26	7.75	8.30	9.18	10.26	10.30	12.50
1989				5.45	6.51	7.19	8.07	8.94	9.61	10.80	11.93
1990				6.00	6.62	7.51	7.90	9.18	10.28	10.90	11.18
1991			5.60	5.60	5.62	6.81	7.85	9.78	10.70	11.28	11.30
1992				6.15			8.96	10.90	10.90		
1993				6.15	7.18	7.96	9.76	9.88	10.50		
1994				5.96	7.36	8.76	9.49	9.74	12.60		
1995				6.26	7.61	8.39	9.62	10.75		11.93	
1996				6.04	7.55	8.87		11.90			
1997				6.08	7.44		9.05	11.30	10.39		
1998			5.60	6.23		8.74	10.33	11.34			
1999			5.60		8.62	8.57	9.91				
2000				6.74	7.13	9.42	9.47	10.41			
2001			5.76	6.80	8.69	10.45	10.66	9.70	10.90		
2002			5.54	7.00	9.33	10.43	10.20	10.56	10.83	11.54	
2003			5.95	8.22	8.62	9.33	10.59	10.20	11.03	12.09	
2004			6.32	7.33	8.40	9.14	9.90	11.23	11.30		
2005		5.39	6.39	7.56	8.63	9.50	9.95	11.90	11.26		
2006			5.93	6.99	9.15	9.78	10.61	11.23			
2007		5.76	5.84	7.36	8.78	10.70	10.47				
2008			6.20	7.98	9.08	9.05					
2009			6.35	7.58	8.50						
2010			6.14	7.08							
2011			5.89								
2012											
2013											
Mean	-	5.58	5.94	6.61	7.78	8.73	9.52	10.25	10.63	11.02	11.38

Table A6. Mean length-at-age data of male yellow perch captured with experimental gillnets in the main lake basin, Leech Lake.

	Age										
YC	0	1	2	3	4	5	6	7	8	9	10
1980							8.90	7.70			
1981						8.96	7.48	10.27	9.30	10.80	9.60
1982					7.02	7.03	9.42	8.97	10.05		9.80
1983				6.10	5.96	8.88	8.85	9.10	9.67	9.65	10.70
1984			6.70	5.64	8.43	7.53	8.76	9.14	8.03	9.80	9.70
1985			5.40	7.02	6.73	7.84	8.25	8.66	9.85	10.13	
1986			5.84	5.87	7.29	8.07	8.24	7.83	8.35	9.45	9.15
1987		5.47		6.19	6.73	8.00	8.13	8.36	8.80	8.20	8.80
1988			5.00	5.37	6.25	7.20	7.44	8.64	8.70	9.04	11.00
1989				5.52	6.27	7.00	7.67	7.92	7.60	9.13	
1990				6.07	6.33	7.17	7.43	8.65	8.60		
1991				5.60	7.20	7.27		8.40	9.50		
1992				5.63	6.50		8.00	8.85	10.10		
1993			5.70	5.98	7.05	7.54	8.92	9.18	9.90		
1994			5.65	5.74	6.60	7.98	8.21	9.70			
1995				6.01	6.58	8.00	11.05				
1996				5.83	7.24	7.94		10.90			
1997				6.02	7.20						
1998			5.47	6.05		8.88					
1999			5.27		8.30	7.83					
2000				6.37	5.73	7.09					
2001			5.30	5.94	7.60				10.79		
2002			5.64	6.25	6.85	7.08	9.25	8.98	10.28		
2003			5.95	7.02	8.04	9.20	9.33	7.28			10.39
2004			6.02	6.44	6.79	6.98	9.37	7.48			
2005		5.25	6.01	6.90	7.68	9.42	8.74		10.75		
2006			6.06	6.31	7.46	8.48		9.76			
2007		5.81	5.51	6.37	7.74	9.53	9.98				
2008			5.92	6.76	8.23	8.90					
2009			5.86	6.56	7.88						
2010			5.86	6.51							
2011			5.77								
2012											
2013											
Mean	-	5.51	5.73	6.15	7.10	7.99	8.67	8.79	9.39	9.53	9.89

Table A7. Mean length-at-age data of female yellow perch captured with experimental gillnets in the western bays basin, Leech Lake.

	Age										
YC	0	1	2	3	4	5	6	7	8	9	10
1980							10.49	9.80	11.13	9.80	11.25
1981						9.35	8.80	10.95	10.38	11.43	10.95
1982					6.97	8.12	10.18	9.21	11.70	9.80	10.70
1983				6.41	6.61	9.19	8.25	10.93	10.90	10.53	10.00
1984				5.70	7.95	7.63	8.85	10.50	9.98	10.50	10.12
1985				7.21	6.67	8.65	9.34	9.49	9.86	9.50	9.35
1986			5.80	5.96	7.27	7.71	9.11	9.54	9.48	9.68	8.73
1987				6.74	7.51	7.79	8.83	9.20	9.42	9.67	11.00
1988				6.30	6.62	7.62	7.88	8.72	9.30	9.80	11.29
1989				6.30	6.55	6.89	7.20	7.45	10.10	10.44	
1990				5.62	6.05	7.28	7.45	9.70	10.13	10.80	10.87
1991				5.70	6.18	7.06	7.25	9.41	11.11	11.14	
1992				5.95	6.16	7.33	8.60	10.90	10.68	9.80	11.30
1993				5.55	6.10	8.02	9.38	9.96	10.27	11.00	10.00
1994				6.02	6.71	8.61	9.14	10.06	10.40	11.15	
1995				6.02	7.27	8.37	10.14	9.98		11.54	
1996				5.90	7.21	8.05	8.13	10.58	10.16		
1997				6.11	7.01	8.27	9.98	9.78	11.56		
1998			5.60	5.87	6.83	8.65	9.74	10.65		11.61	
1999			5.30	5.86	7.43	8.37	9.97	10.14	11.77	11.89	
2000				6.10	7.45	8..8	10.66			12.44	
2001			5.67	6.20	8.02	9.72	9.38	10.84	9.83	11.83	
2002			5.14	7.25	8.34	8.40	9.64	10.28	11.67	11.54	
2003			6.28	7.01	7.61	5.23	9.10	10.74	10.48	11.69	
2004			6.02	6.54	6.99	8.12	9.76	10.62	12.01		
2005			6.11	6.51	7.23	8.80	10.30	9.02	10.87		
2006			5.81	6.62	8.28	8.61	9.21	9.49			
2007		6.34	5.69	6.60	7.46	8.64	8.90				
2008			6.59	6.60	7.40	8.35					
2009			6.17	6.36	6.83						
2010			5.87	6.30							
2011		4.25	5.47								
2012											
2013											
Mean	-	5.30	5.82	6.26	7.10	8.10	9.13	9.92	10.57	10.80	10.46

Table A8. Mean length-at-age data of male yellow perch captured with experimental gillnets in the western bays basin, Leech Lake.

	Age										
YC	0	1	2	3	4	5	6	7	8	9	10
1980							10.80	7.76		10.28	10.60
1981						8.73	7.77	10.40	9.97	9.60	10.60
1982					6.66	7.20	9.50	8.94	10.33		10.75
1983				6.40	6.19	8.97	7.79	9.59		9.37	
1984				5.83	7.67	7.21	8.34	9.10	8.83	10.10	9.73
1985				7.08	6.26	8.37	8.10	8.60	8.60	9.00	10.10
1986			5.70	5.76	6.90	6.78	7.72	7.55		9.10	9.13
1987				6.00	6.40	6.96	8.00	8.10	9.50	8.10	9.83
1988				5.83	6.17	7.02	7.39	8.87	8.10	8.73	10.00
1989				5.67	6.08	6.87	7.74	7.60	8.23	9.48	10.25
1990				5.42	6.34	7.28	7.67	7.55	8.78	10.65	
1991			5.20	5.65	6.50	7.80	8.05	8.18	9.13	11.00	
1992			5.40	5.90	6.15	6.66	7.75	9.56	10.10	10.30	
1993				6.14		7.10	8.50	9.25			
1994			5.70	5.67	6.74	7.30	8.19	9.95		10.30	9.02
1995				5.92	7.02	7.93	9.10			9.69	
1996				6.02	6.70	7.70		10.00	8.98	10.77	
1997			5.30	5.77	6.80		9.12	9.77	10.47		
1998			5.30	6.65		7.92	9.40	8.88			
1999			5.50		8.08	8.70	9.87			10.43	
2000				6.36	7.11	9.35		8.95		9.17	
2001			5.73	5.84	6.90		7.74	9.40	9.88		
2002				6.29	8.23	6.63	8.70	9.97	9.49		
2003			6.30	6.28	6.82	7.73	8.59	8.02	10.37		
2004			5.89	6.51	6.41	7.06	9.55	8.51			
2005			5.55	6.15	6.36	7.11	8.31	9.48	10.41		
2006			6.32	6.00	7.40	7.31	9.13	9.73			
2007			5.66	6.60	6.73	7.65	8.84				
2008			6.30	6.17	6.99	8.95					
2009		5.41	5.95	5.88	6.62						
2010			5.39	5.98							
2011		4.61	5.45								
2012											
2013											
Mean	-	5.01	5.68	6.06	6.78	7.63	8.52	8.95	9.45	9.77	10.00

Table A9. Mean length-at-age data of female northern pike captured with experimental gillnets in the main lake basin, Leech Lake.

	Age										
YC	0	1	2	3	4	5	6	7	8	9	10
1980							22.02	26.55		29.80	
1981						24.15	27.58	30.70	28.00	32.50	
1982					23.04	26.61	29.48	27.20	29.40		
1983				19.08	23.93	28.20	29.40	31.50	28.70		
1984			16.13	21.59	23.86	22.10	33.90		33.80	33.40	
1985		18.20	21.25	22.08	23.00	22.00	27.37	28.15	30.45		28.60
1986		15.50	20.74	22.44	21.23	27.13	29.70		29.70	29.10	
1987		18.20	19.71	21.06	26.46	24.46	27.45		34.45	34.70	27.80
1988		15.35	20.24	22.15	24.09	25.62	27.09	29.28	27.80	34.50	
1989		17.80	21.13	22.61	23.87	25.32	29.63	32.50	32.40		
1990		13.10	20.85	22.40	25.08	25.03	26.95	26.70	33.65		
1991		16.77	21.87	22.99	24.91	27.48	29.00				
1992		16.79	22.42	21.78	23.36	26.93		33.00			
1993		17.27	20.38	21.79	26.73	27.72	31.10				
1994		17.43	20.91	22.54	24.64	30.15	32.05				
1995	10.10	15.91	19.90	22.11	24.98	27.70		29.20			
1996		16.10	20.35	22.25	25.64		25.50	24.60			
1997		18.08	19.44	22.08	24.07	27.20	25.43			30.47	
1998		15.73	19.98	21.59	23.48	23.78	29.57	36.16			
1999		18.35	19.08	21.81	23.86	25.43	30.14	25.20			
2000		15.30	21.18	22.47	23.37	25.26	25.94				
2001		16.43	20.54	22.12	22.62	26.57	26.70	32.17	28.36		
2002		16.90	22.52	23.98	25.94	28.07	28.99	27.41			
2003		18.31	21.46	23.79	25.85	26.72	30.50		33.62		
2004		16.57	21.98	25.02	26.65	28.46	28.73	37.68	37.05		
2005		17.31	20.49	24.53	25.06	29.79	26.17				
2006		17.17	20.39	24.16	25.12	25.49	28.11	31.57			
2007		17.32	20.60	24.26	24.99	27.69	28.90				
2008	8.50	15.80	21.90	22.91	24.29	25.55					
2009		18.54	19.92	22.78	23.66						
2010		15.85	18.28	20.77							
2011		15.51	16.73								
2012											
2013											
Mean	9.30	16.73	20.37	22.47	24.42	26.32	28.36	29.97	31.34	32.07	28.20

Table A10. Mean length-at-age data of male northern pike captured with experimental gillnets in the main lake basin, Leech Lake.

	Age										
YC	0	1	2	3	4	5	6	7	8	9	10
1980							21.55	21.85			
1981						22.04	22.60	26.80	23.90	29.35	21.70
1982					21.83	20.18	25.00	25.10		22.40	21.20
1983				19.47	20.68	21.79	22.90	23.90	20.90	23.40	
1984			15.10	19.90	21.93	22.54	21.40	22.90			
1985			15.40	21.10	21.80	20.40	23.83			21.40	
1986		15.00	18.55	20.33	20.50	20.00	21.60	23.06		22.67	
1987		15.03	18.25	18.44	21.47	21.74	22.80	20.00	21.60	17.07	
1988		12.90	17.65	20.04	20.23	22.14	22.63	23.80	24.20	20.80	
1989		15.70		20.24	20.59	20.83	22.68	22.58			
1990		17.80	18.90	21.60	21.10	22.37	20.80	26.20		31.40	
1991		16.20	19.68	19.68	21.05	18.65	21.35				
1992		17.00	18.55	20.48	21.50	20.86					
1993		15.78	16.78	20.20	20.63	21.25					
1994	9.25	17.10	17.83	19.40	22.45	22.90					
1995	10.00	13.95	17.90	20.35	21.33	23.70					
1996		15.83	18.68	20.11	22.38	21.10		21.35			
1997	9.00	15.47	17.96	20.37	22.40	21.40	22.55				
1998	9.60	15.20	18.09	20.54	21.12	21.51	22.64				
1999		14.90	18.19	20.28	21.49	21.77	24.09				
2000	12.00	16.20	19.40	20.47	20.97	23.19		22.36			
2001	9.63	14.05	17.58	20.39	21.65	24.02	23.46		22.52		
2002			19.45	20.42	22.62	23.98	23.11	22.94			
2003		16.73	17.83	21.36	22.80	22.13	22.13	23.54		29.02	
2004	9.41	14.84	19.66	21.59	21.50	22.36		24.76			
2005		17.24	20.98	21.33	20.24	26.56	24.31	22.80			
2006			18.84	20.69	20.74	22.51	21.34				
2007		15.90	19.68	21.37	22.57	22.93	23.05				
2008			19.74	20.81	21.30	22.56					
2009		17.52	18.86	20.32	21.26						
2010	8.98	14.81	16.77	19.52							
2011			17.78								
2012		14.58									
2013	8.43										
Mean	9.59	15.64	18.30	20.39	21.43	22.05	22.66	23.37	22.62	24.17	21.45

Table A11. Mean length-at-age data of female northern pike captured with experimental gillnets in the western bays basin, Leech Lake.

	Age										
YC	0	1	2	3	4	5	6	7	8	9	10
1980							28.00				
1981						22.73	26.68	29.07	27.00		
1982					21.24	20.90	26.60	29.44			
1983				19.33	24.93	27.78	23.40	30.00	35.60		
1984			15.78	19.23	25.40	22.80	28.30	31.80		33.90	28.05
1985			18.71	22.45	23.51	26.35	30.70	31.48	28.85		
1986		15.70	18.25	20.86	23.48	28.60	30.80	29.10	23.90	18.10	35.70
1987		16.26	18.71	22.06	23.15	25.75	32.50	27.06	31.53	27.80	
1988		15.43	18.76	21.37	26.58	25.18	25.45	30.05	28.70	33.40	
1989		16.50	19.05	22.15	24.80	27.90	32.40	17.20	30.34		
1990		15.15	18.62	22.14	24.20	25.00	24.65	33.40			
1991		15.95	17.05	21.77	25.21	25.48	27.08	32.40	29.00		
1992		14.93	20.10	20.74	23.38	24.63	29.93		35.70		
1993		14.90	20.12	21.57	25.29	26.10	30.90	32.07	31.03		
1994	9.40	16.65	19.17	21.56	23.92		30.00	35.40		34.60	
1995		15.23	20.13	20.30	27.55	26.83	27.28		30.20		
1996		14.19	18.08	21.93	26.98	23.90	29.20	30.64			
1997	10.55	14.71	17.68	21.31	23.20	24.59	24.47	27.95	32.80		
1998	8.50	13.57	18.93	20.12	22.56	23.00	26.78	34.49	30.85	35.08	
1999		14.72	17.75	21.09	22.91	26.27	26.62	27.24		29.17	
2000		15.14	17.50	20.17	22.13	26.88	29.46	30.38	31.72	27.95	
2001		13.47	18.42	20.96	23.91	25.62	30.15	28.84	31.18		
2002		15.21	19.38	21.91	24.26	27.28	28.19			33.43	
2003	9.70	14.33	18.73	21.94	24.24	25.93	26.28		32.24		
2004		17.76	19.30	22.78	23.34	26.72	24.63	29.21			
2005		15.75	19.47	21.95	25.73	27.49		30.91	31.34		
2006	10.45	14.89	19.54	22.49	25.72	26.42	26.85	31.73			
2007		14.41	18.90	22.15	24.01	27.49	28.38				
2008		15.93	20.27	22.18	23.28	25.91					
2009	13.46	16.78	19.84	20.70	22.16						
2010	9.53	14.35	17.96	20.31							
2011		14.23	17.80								
2012		15.17									
2013											
Mean	10.23	15.23	18.71	21.34	24.18	25.69	27.99	29.99	30.71	30.38	31.88

Table A12. Mean length-at-age data of male northern pike captured with experimental gillnets in the western bays basin, Leech Lake.

	Age										
YC	0	1	2	3	4	5	6	7	8	9	10
1980							21.37	23.60			
1981						19.50	24.20				23.10
1982					19.95	20.43	24.80		21.20		26.70
1983				17.95	20.84	23.43		21.00			
1984			16.96	17.25	21.39	24.55	22.70	23.70	28.20	25.17	
1985			16.82	19.65	20.89	21.50	22.47	18.00			24.30
1986		13.95	17.24	19.71	19.20	18.70		27.70	20.70	26.75	24.70
1987		15.02	17.39	19.36	20.58	20.80	22.20		21.65		
1988		14.26	17.32	18.29	20.10	21.07	19.95	23.77		22.90	
1989		15.44	17.62	21.09	20.18	22.30	22.58	21.10			
1990		16.25	18.36	19.97	18.70	22.00	21.50				
1991		15.70	17.25	19.50	19.60	20.17	23.65	27.80			
1992		13.80	18.30	18.50	20.98						
1993		14.36	17.49	21.03	21.08	23.88					
1994		14.90	17.11	19.93	20.80	25.00					
1995	8.80	14.07	16.16	19.30	18.30	24.87			25.20		
1996		12.83	17.48	20.45	21.16	24.00					
1997	9.30	13.93	17.58	19.64	19.89	20.70	22.73	20.71			
1998			17.08	18.88	20.70	21.10	20.75				
1999		14.36	17.82	19.57	20.37	21.71	11.54			23.27	
2000	10.00	14.60	18.06	18.98	21.61	22.56					
2001		12.96	16.75	18.76	20.38	24.71	22.64	26.57	20.51		
2002		14.17	17.11	18.53	21.26	21.94	19.41	21.69			
2003		13.69	18.74	21.34	22.09	20.57	24.29		29.49		
2004		14.86	17.79	20.10	20.95	21.73					
2005		15.10	17.10	19.19	20.00	16.97	21.65				
2006	9.90	15.59	18.38	20.98	17.83	22.69	24.09				
2007		13.33	17.52	20.00	22.22	25.08	21.69				
2008		17.17	18.49	19.76	21.73	21.77					
2009	11.26	15.64	19.13	19.64	20.25						
2010		12.78	18.01	18.35							
2011		13.57	16.54								
2012		14.25									
2013	9.27										
Mean	9.76	14.48	17.56	19.49	20.46	21.99	21.80	23.24	23.85	24.52	24.70

Table A13. Gillnet catch-per-effort (fish/net) by species for Leech Lake, 1983-2013.

	Year											
Species	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Black bullhead	11.25	9.72	13.75	7.97	11.19	15.06	21.33	11.56	16.53	9.80	4.33	3.92
Black crappie	0.13	0.50	0.17	0.33	0.31	0.36	0.28	0.28	0.53	0.20	0.17	0.19
Bluegill	0.00	0.06	0.00	0.22	0.06	0.08	0.64	0.33	0.14	0.40	0.33	0.19
Bowfin	0.03	0.03	0.06	0.03	0.08	0.19	0.03	0.03	0.00	0.10	0.03	0.03
Brown bullhead	2.50	1.08	0.58	0.75	1.06	0.94	1.83	0.92	3.14	1.50	1.69	2.17
Burbot	0.09	0.08	0.11	0.17	0.03	0.08	0.08	0.00	0.08	0.10	0.08	0.08
Hybrid sunfish	0.03	0.00	0.00	0.00	0.03	0.00	0.03	0.00	0.00	0.00	0.00	0.00
Lake whitefish	0.16	0.19	0.00	0.00	0.06	0.19	0.00	0.00	0.36	0.00	0.00	0.06
Largemouth bass	0.09	0.00	0.00	0.00	0.14	0.08	0.44	0.03	0.14	0.00	0.03	0.00
Muskellunge	0.03	0.03	0.00	0.00	0.00	0.00	0.25	0.08	0.00	0.00	0.06	0.00
Northern pike	4.19	3.72	4.08	3.78	4.25	5.31	5.83	5.33	5.81	4.40	3.58	4.03
Pumpkinseed	0.09	0.25	0.28	0.22	0.33	0.69	1.11	1.61	1.00	1.10	0.47	0.44
Rock bass	0.50	1.31	2.11	1.06	0.39	0.86	2.25	2.67	2.11	1.10	2.06	1.17
Shorthead redhorse	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
Smallmouth bass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tiger muskellunge	0.00	0.00	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Tullibee/cisco	6.31	4.56	10.19	14.06	18.47	11.08	2.11	5.94	6.67	4.40	9.64	9.14
Walleye	5.25	7.42	7.22	6.28	6.03	13.39	11.72	8.33	8.81	5.80	4.61	4.89
White sucker	1.31	1.78	1.78	1.06	2.36	2.56	2.06	2.14	1.75	2.00	1.64	1.86
Yellow bullhead	1.09	0.42	1.36	1.03	1.25	2.17	1.94	0.94	3.36	1.40	1.69	2.69
Yellow perch	13.50	17.94	15.61	13.19	16.06	18.47	26.08	33.67	18.64	22.10	20.39	21.67
Total fish/set	46.55	49.09	57.30	50.15	62.13	71.54	78.01	73.86	69.07	54.40	50.80	52.56
Total sets	32	36	36	36	36	36	36	36	36	36	36	36

Table A13 continued. Gillnet catch-per-effort (fish/net) by species for Leech Lake, 1983-2013.

	Year											
Species	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Black bullhead	0.88	0.67	1.49	2.50	1.75	0.54	0.69	1.22	1.25	4.25	3.50	1.44
Black crappie	0.12	0.14	0.11	0.17	0.31	0.20	0.36	0.31	0.56	0.25	0.39	0.64
Bluegill	0.09	0.08	0.14	0.17	0.11	0.57	0.64	1.00	0.50	0.78	2.08	1.14
Bowfin	0.00	0.03	0.03	0.06	0.33	0.17	0.06	0.11	0.03	0.11	0.00	0.00
Brown bullhead	0.91	0.58	0.66	1.28	3.25	2.09	2.08	0.86	0.94	1.61	4.11	2.00
Burbot	0.06	0.00	0.03	0.06	0.06	0.03	0.08	0.06	0.00	0.00	0.03	0.03
Hybrid sunfish	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lake whitefish	0.15	0.06	0.11	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Largemouth bass	0.03	0.08	0.03	0.22	0.08	0.03	0.06	0.31	0.25	0.11	0.03	0.08
Muskellunge	0.06	0.03	0.11	0.06	0.03	0.06	0.00	0.00	0.00	0.00	0.03	0.03
Northern pike	6.17	4.83	5.14	5.08	3.69	4.97	5.28	5.28	4.97	5.39	4.89	4.03
Pumpkinseed	0.24	0.47	1.09	0.72	0.39	0.43	1.11	1.08	1.61	0.81	2.06	0.64
Rock bass	2.71	2.89	2.03	2.25	1.83	0.89	1.86	1.22	1.28	2.00	0.58	0.47
Shorthead redhorse	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Smallmouth bass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00
Tiger muskellunge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tullibee/cisco	4.18	4.72	4.23	3.67	3.14	2.66	1.28	1.58	0.92	1.78	3.53	0.64
Walleye	7.74	9.50	5.69	11.64	8.92	5.91	7.03	6.19	5.17	4.97	4.89	7.06
White sucker	3.12	1.97	1.20	1.97	1.17	0.94	1.17	1.28	1.42	0.83	0.86	1.89
Yellow bullhead	0.41	0.33	0.91	0.83	0.86	0.37	0.53	1.61	1.28	2.72	2.56	1.69
Yellow perch	37.66	25.64	32.11	28.58	21.06	21.17	15.53	20.50	16.17	16.28	12.89	20.47
Total fish/set	64.56	52.02	55.11	59.26	47.01	41.06	37.73	42.64	36.33	41.91	42.43	42.25
Total sets	35	36	35	36	36	35	36	36	36	36	36	36

Table A13 continued. Gillnet catch-per-effort (fish/net) by species for Leech Lake, 1983-2013.

	Year											Quartiles	
Species	2007	2008	2009	2010	2011	2012	2013	Min	Max	Median	Mean	First	Third
Black bullhead	1.89	1.14	0.31	0.31	0.17	0.00	0.03	0.00	21.33	1.89	5.18	0.79	9.76
Black crappie	1.72	0.89	1.14	0.58	0.47	0.17	0.89	0.11	1.72	0.31	0.42	0.18	0.52
Bluegill	1.14	1.19	1.11	0.58	0.69	0.31	1.19	0.00	2.08	0.33	0.51	0.13	0.74
Bowfin	0.11	0.08	0.08	0.06	0.14	0.06	0.00	0.00	0.33	0.06	0.07	0.03	0.09
Brown bullhead	4.25	1.97	0.64	1.89	0.61	0.25	0.22	0.22	4.25	1.28	1.56	0.81	2.04
Burbot	0.06	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.17	0.06	0.05	0.00	0.08
Hybrid sunfish	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.03	0.00	0.00	0.00	0.00
Lake whitefish	0.00	0.06	0.03	0.06	0.08	0.00	0.00	0.00	0.36	0.00	0.05	0.00	0.06
Largemouth bass	0.22	0.08	0.11	0.11	0.08	0.39	0.08	0.00	0.44	0.08	0.11	0.03	0.13
Muskellunge	0.03	0.00	0.06	0.06	0.06	0.03	0.03	0.00	0.25	0.03	0.04	0.00	0.06
Northern pike	5.94	5.61	4.94	4.08	5.89	4.33	4.61	3.58	6.17	4.94	4.82	4.14	5.32
Pumpkinseed	1.33	1.47	0.67	0.28	0.31	0.42	1.36	0.09	2.06	0.67	0.78	0.36	1.11
Rock bass	1.33	2.39	2.17	1.03	1.33	0.78	1.44	0.39	2.89	1.33	1.55	1.05	2.11
Shorthead redhorse	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00
Smallmouth bass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00
Tiger muskellunge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00
Tullibee/cisco	4.00	1.61	11.92	5.94	1.86	3.61	3.33	0.64	18.47	4.18	5.39	2.39	6.49
Walleye	13.11	9.06	8.61	7.86	8.08	9.42	8.92	4.61	13.39	7.42	7.73	5.86	8.92
White sucker	0.72	0.61	1.08	0.64	1.14	1.50	0.94	0.61	3.12	1.42	1.51	1.07	1.93
Yellow bullhead	4.22	2.56	1.36	2.75	1.00	0.56	0.42	0.33	4.22	1.28	1.49	0.85	2.06
Yellow perch	36.86	26.56	25.83	24.31	17.22	14.53	12.08	12.08	37.66	20.47	21.38	16.12	25.74
Total fish/set	76.97	55.28	60.06	50.56	39.14	36.36	35.56	35.56	78.01	50.80	52.64	42.34	59.66
Total sets	36	36	36	36	36	36	36						

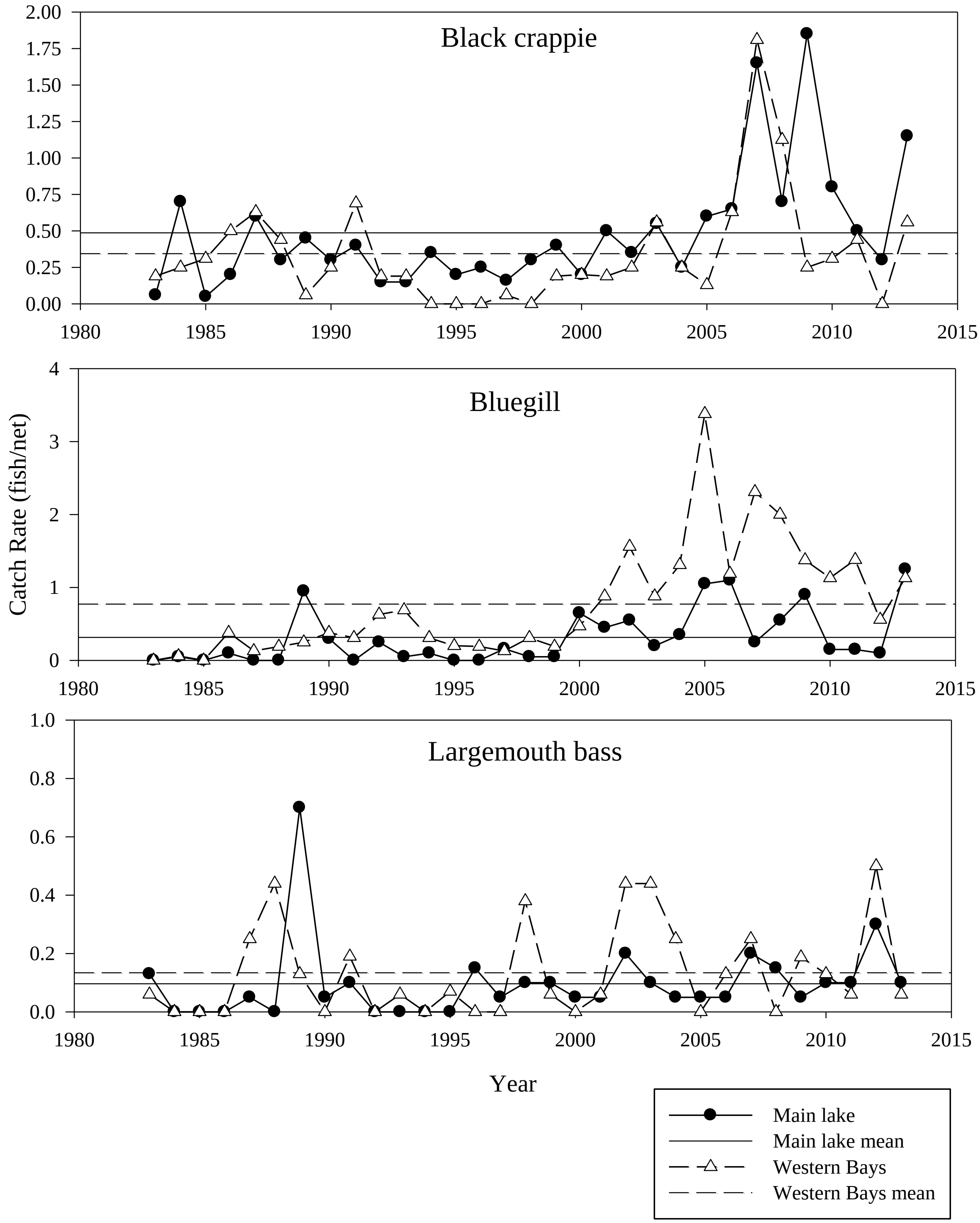

Figure A1. Basin-specific gillnet catch rates (fish/net) of selected species in Leech Lake, 1983-2013.

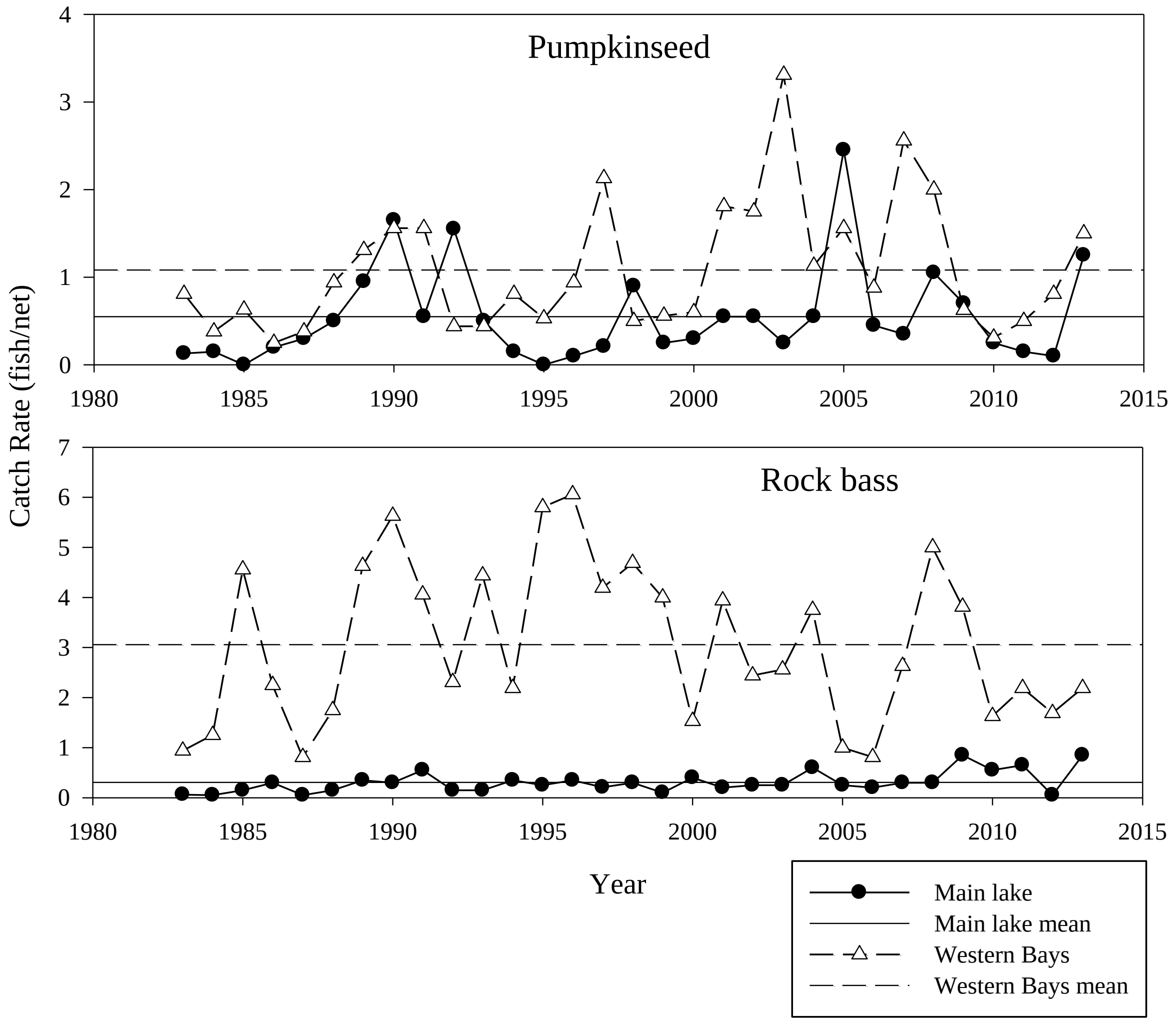

Figure A1, continued. Basin-specific gillnet catch rates (fish/net) of selected species in Leech Lake, 1983-2013.

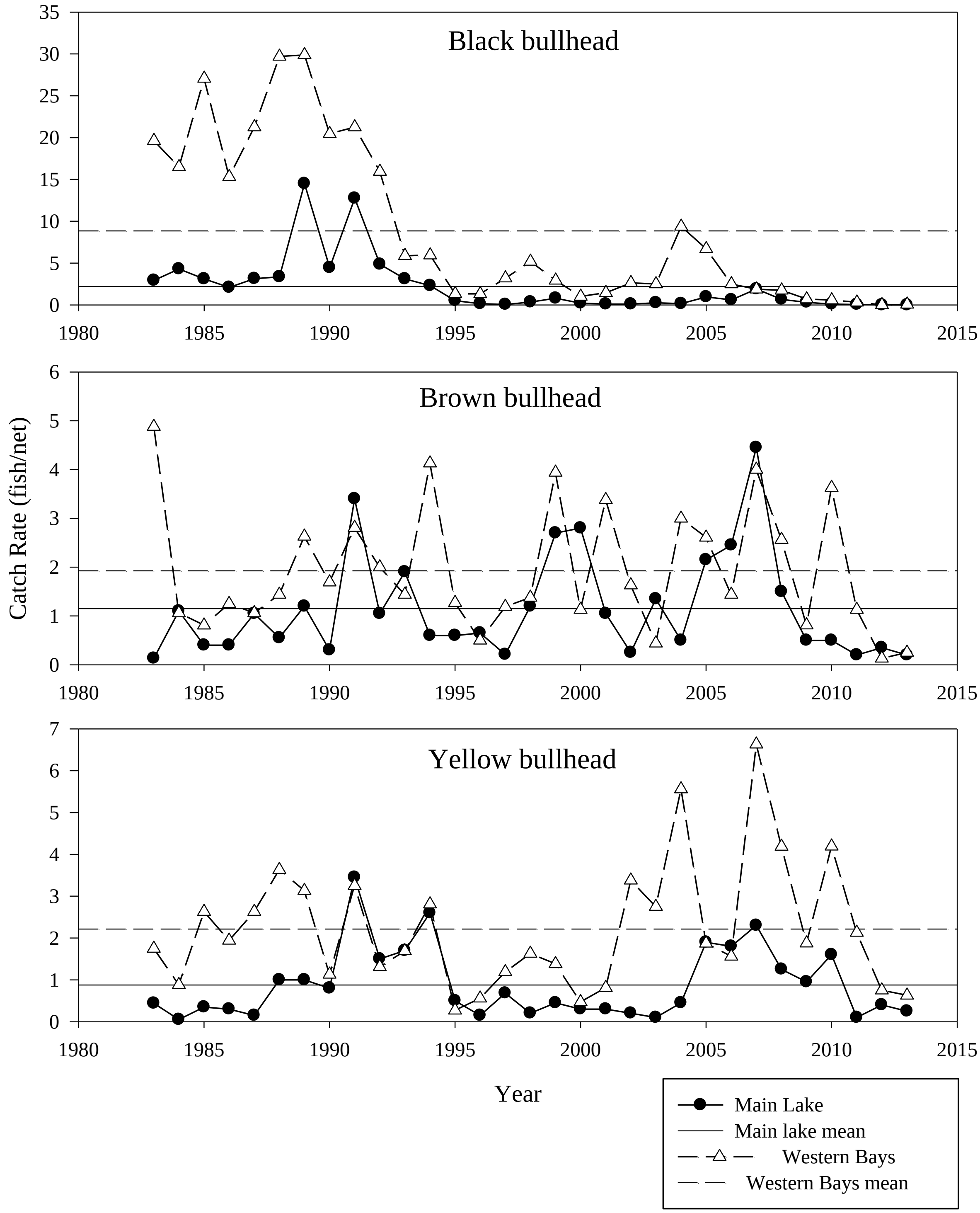

Figure A1, continued. Basin-specific gillnet catch rates (fish/net) of selected species in Leech Lake, 1983-2013.

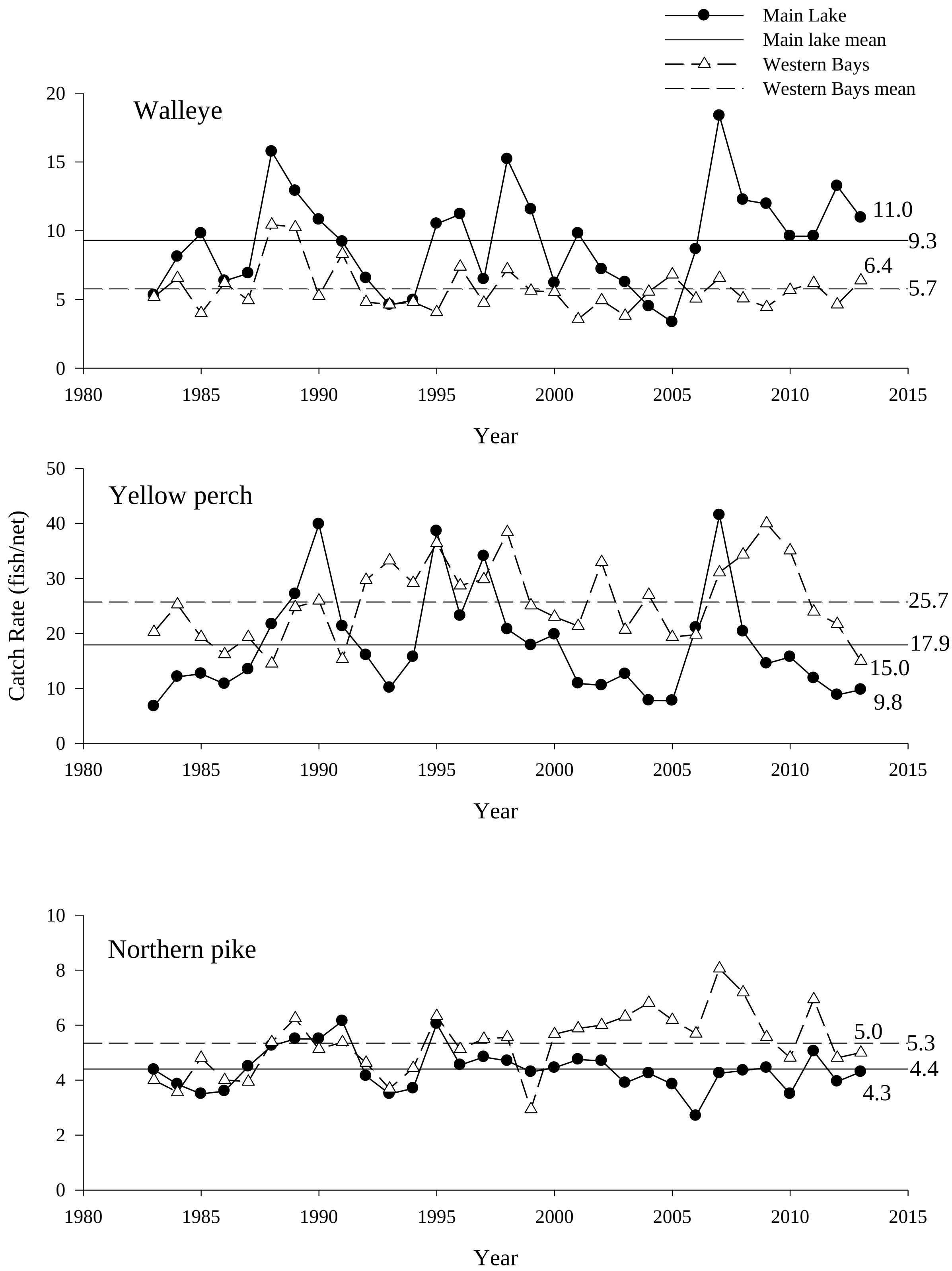

Figure A1, continued. Basin-specific gillnet catch rates (fish/net) of selected species in Leech Lake, 1983-2013.

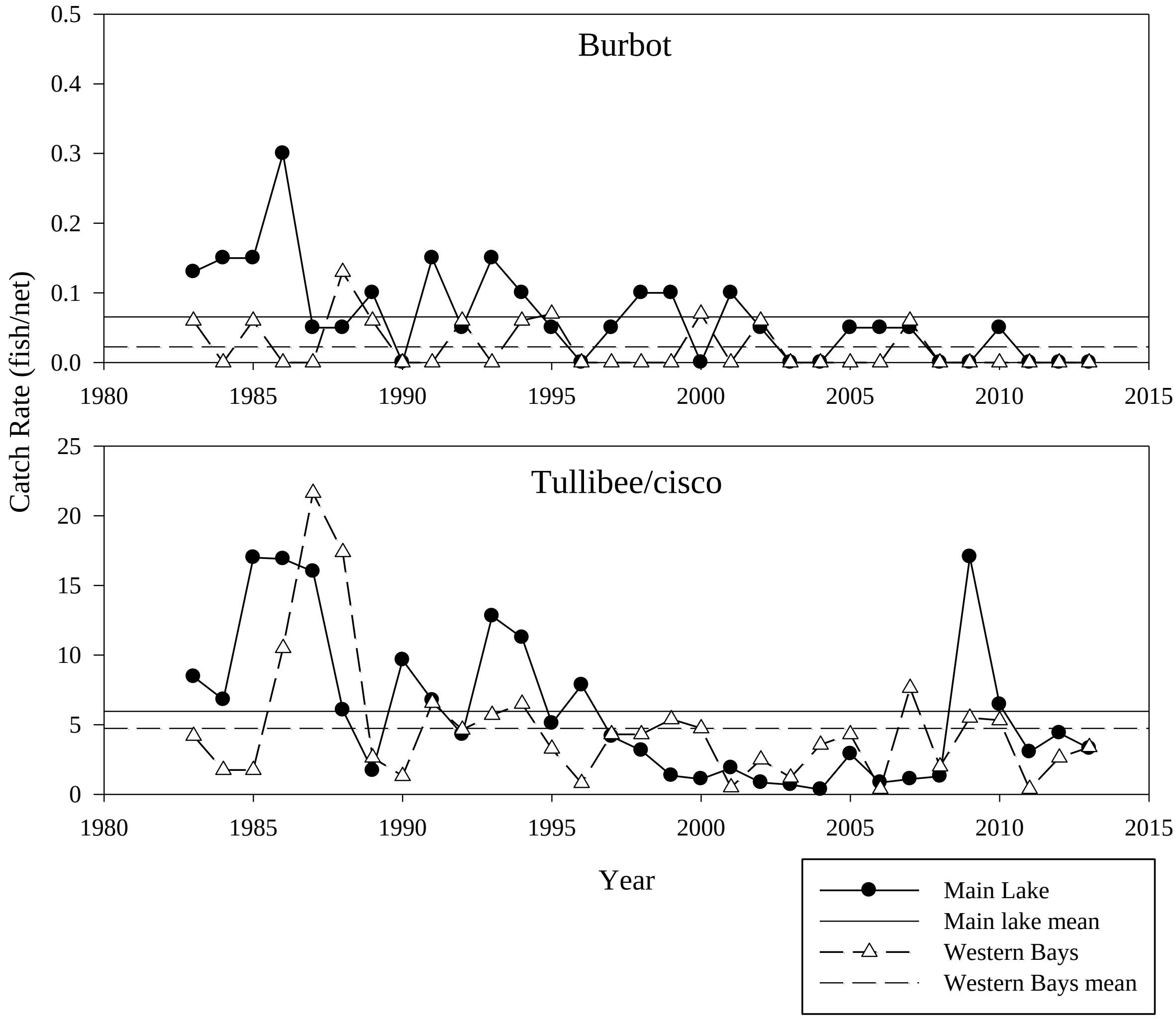

Figure A1, continued. Basin-specific gillnet catch rates (fish/net) of selected species in Leech Lake, 1983-2013.

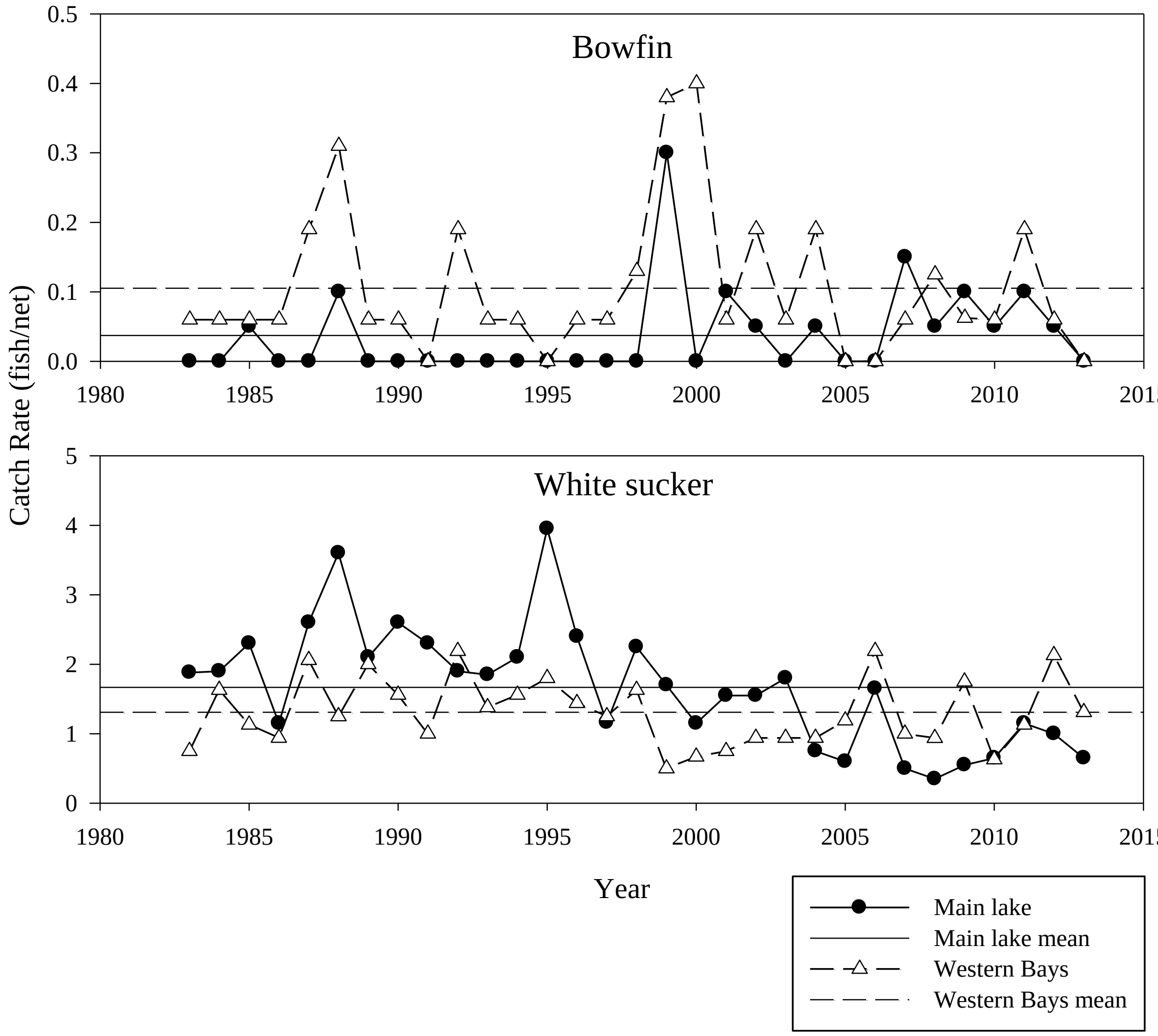

Figure A1, continued. Basin-specific gillnet catch rates (fish/net) of selected species in Leech Lake, 1983-2013.