Minnesota Department of Natural Resources
Division of Fisheries and Wildlife

Completion Report

Large Lake Sampling Program Assessment Report for Leech Lake 2011

by

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Large Lake Program Assessment Report
Leech Lake
2011

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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 control, the walleye regulation, 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. The current 18-26" protected slot limit (PSL) on the walleye population was first implemented in 2005 and continued in 2011 with public support.

This report primarily addresses the 2011 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 open water season (Schultz 2009). Recent surveys have indicated substantial improvements to the walleye population and its fishery over the course of a few years. 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. Currently invasive plant species are not widely distributed within

Leech Lake. 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 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 used by spawning walleye (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 during this time period, to index growth rate, to collect structures necessary for stocking evaluations, and to estimate potential 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 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 is not used for estimating the potential strength of a year class.

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 that would destroy the gear. Catch rates of YOY walleye in trawl hauls and gill net sets are, to date, the best tools for forecasting the potential strength of a walleye year class. Acknowledging that 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, year class strength is not determined until after the first winter. 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 improve on the trawl-only and trawl-gillnet methods currently employed. 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) that are typically sampled weekly beginning in early-July using the parallel-to-shore method, were not sampled in 2011 due to a state shutdown from July 1 through 20. The following methods are those typically completed. Two hauls are made at each station using a bag seine (100-ft. long, 5-ft. deep, 0.25-in. untreated mesh). The area seined is 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 is then multiplied by the distance of the pull (150 feet) and results in an area of 13,500 ft^2 (0.310 acres) per seine haul.

All fish are 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 are sub-sampled due to an extremely large number of fish captured. In these instances a representative portion of fish in a volumetric sub-sample are measured, by species, and the total number obtained in the sub-sample is expanded to the total volume sampled. Age-0 walleye and age 1+ fish of other species are individually counted and measured before sub-sampling occurs. Up to 20 YOY walleye and yellow perch are collected from each haul when possible. These fish are 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 16 through August 23, 2011 using a semi-balloon bottom trawl (25-ft. headrope, 0.25-in. mesh cod end liner). Eight trawls were conducted at Five Mile Point (TR-1), seven Goose Island (TR-2), and five at Whipholt Beach (TR-s), for a total of 20 trawls. Hauls at the three long-term stations consisted of five-minute tow times at a 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 were collected per haul 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 estimated 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 relative cohort strength based on the relative abundance of age-0 fish will inherently be highly variable. In spite of this 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 (1987-2009; $F = 10.72$; $R^2 = 0.53$; $P = 0.0008$) than using trawl catch rates of YOY walleye independently (1987-2009; $F = 3.85$; $R^2 = 0.16$; $P = 0.0637$). 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 201was conducted during September 15-26 using a Coffelt pulsed-DC electrofishing boat (VVP 2E; array anode). Favorable weather allowed for successful sampling of all four stations this year. Sampling sites were approximately 3-5 feet deep on sand/gravel/cobble shorelines. Sampling runs consisted of 20 minutes of continuous on-time from the starting point (Figure 1). Up to 25 age-0 walleye per run 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.

Results

Seine

Seine hauls did not occur in 2011 due to the state shutdown from July 1 through 20. 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 Leech Lake in 2011 at the three long-term stations collecting 17 different species (Table 2). The overall catch rate of YOY walleye was 40 fish/hour and is below the 1987-2011 mean of 136 fish/hour (Figure 2). The overall catch rate of YOY yellow perch was 16,430 fish/hour and is above the long-term average of 9,766 fish/hour (Figure 2).

This year's trawl catch rate predicts a walleye year class strength (± 95% CI) of 0.88 ± 0.27 (Table 3). However, inclusion of the YOY walleye gillnet catch rate suggests a potential year class strength of 1.11 ± 0.29 (Table 3; Figure 3). Both methods predict a year class with below-average strength. The previous four year classes are still within the 2011-2015 management plan objective (Figure 4).

Electrofishing

All 12 electrofishing stations were successfully sampled during September 2011. The electrofishing catch rate of YOY walleye was 173 fish/hour (Figure 2) and is the highest catch rate observed since electrofishing stations were initiated in 2005. Electrofishing catch rates should be viewed with caution as several consecutive years of consistent sampling are required before its utility for indexing walleye year class strength can be effectively evaluated. Furthermore, a change in anode type during 2009 (from spherical to array) could have increased catchability, which in turn would be reflected as a higher catch rate. More information is needed to draw sound conclusions on the utility of electrofishing catch rates of age-0 walleye for forecasting year class strength. In the near term, mean length of YOY walleye captured during electrofishing should continue to be evaluated as a possible means to improve upon the existing trawl-gillnet model.

YOY Growth Indices

Growth of YOY percids was indexed by mean weekly length and condition during July through September. Mean length-at-week was below long-term averages for both species (Figure 5). Condition of walleye, indexed using weekly K-factors, were average and varied little on a week-to-week basis. Age-0 yellow perch were not weighed to save sample processing time during staffing shortage; thus, a condition index was not calculated.

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, personal communication) 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. Therefore, the magnitude of a year class is not simply determined by the number of fry that are successfully produced, but more so through annual changes in the gauntlet of age-0 mortality sources and the severity each mortality source acts on a cohort during any given year.

Due to the high degree of variability in young walleye survival, forecasting recruitment (ie. year class strength) based on age-0 metrics will inherently be accompanied by uncertainty. For example, diversity 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 is 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 nearly 20+ 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.

The predicted year class strength for the 2011 cohort of walleye is below average with the upper 95% confidence interval approaching average. Thus, a cohort near average strength is optimistically possible but will be largely dependent on first-winter survival. Given the presence of several average or stronger year classes produced during recent years some suppression of the 2011 year class is possible.

GILLNET SURVEY

Introduction

Gillnet surveys on Leech Lake have been completed annually during the first two weeks of September. Gillnets are the most effective method for assessing walleye and yellow perch 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, and year class strength. 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 5 through September 16, 2011. Four sets were made in each of 9 different areas (Figure 6). 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 2011 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. Sex and maturity were assigned to fish destroyed by crayfish based on the frequency of occurrence in 25-mm length intervals within each basin using a modified version of an age-length key assignment program (Isermann and Knight 2005).

Ages were estimated using sagittal otoliths from all walleye and a single cleithrum from esocids. Otoliths were removed from a minimum random subset of five yellow perch and five cisco per sex per mesh panel of 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 was then assigned individually to fish not aged using observed length and sex frequencies (Isermann and Knight 2005) within 25-mm length intervals. 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 2011 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 291 walleye were sampled in gillnets. The 2011 gillnet catch-per-effort (CPE) of 8.08 walleye/net is below the catch rate observed during 2010 (7.86 walleye/net) but still above the 1983-2011 average of 7.6 walleye/net (Figures 7 and 8). Historical gill net catch rates have ranged from 4.6 fish/set (1993) to 13.4 fish/set (1988). Of walleye captured during the 2011 gillnet survey, 66% were sampled in main lake sets. By sampling area, walleye gillnet CPE ranged from 3.5 (Steamboat Bay) to 22.0 fish/net (Portage Bay). The overall 2011 gillnet catch rate is below the 2011-2015 management objective of 8.5 walleye/net (Figure 9); 8.5 walleye/net represents the 75th percentile of the historical time series.

Walleye from 6 to 26 inches (total length; TL) were present in the gillnet sample (Table 5; Figure 10). Observed median lengths of the 2010, 2009, and 2008 year classes were approximately 9, 12, and 15 inches TL, respectively. While older year classes are still above the long-term length-at-age average, growth rates appears to have returned to historical levels (Figure 10; Tables 6, 7, and A1-A4). Of sampled walleye, 34% were shorter than 15 inches TL; this is below the 2011-2015 management plan objective range of 45-65% (Figure 11). Standing stock biomass of mature female walleye was estimated to be 1.82 pounds/acre, which is within the 2011-2015 management goal of 1.50-2.00 pounds/acre (Figure 12).

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, have shown cause for concern (Figures 13 and 14). While the same holds true for 2011 in that two of these BPIs still exceed their respective thresholds, the status of these metrics continues to improve. The continuation of the current 18-26" protected slot limit will promote metrics returning to "safe" levels as post-2005 year classes grow into the slot limit and begin maturing. Therefore, while BPIs that are most influenced by growth still exceed threshold values, nearly all BPIs indicate an overall improvement to the population.

Yellow Perch

Similar to the walleye catch rate, the 2011 yellow perch gillnet catch-per-effort of 17.22 fish/net is down slightly from 2010 observations (24.31 fish/net) but above the 1983-2011 average of 21.94 fish/net (Figures 7 and 8). Historically, gill net catch rates have ranged from 12.9 fish/net (2005) to 37.7 fish/net (1995). By area, yellow perch gillnet catch rates ranged from 3.25 fish/net (Pelican Island) to 35.75 fish/net (Kabekona Bay). The 2011 overall gill net catch rate for yellow perch was above the respective 2011-2015 Leech Lake management plan objective (Figure 9).

Lengths of yellow perch sampled with gillnets ranged from 4 to 12 inches TL (Figure 15). Of yellow perch sampled, approximately 37% were 8 inches or longer and 13% were 10 inches or longer. This is the fourth consecutive year since 2001 that the proportion of perch 10 inches or longer has exceeded 10%, and suggests that yellow perch size structure has improved. Both yellow perch size structure objectives outlined in the 2011-2015 management plan were met in 2011.

In general, growth of yellow perch, measured by mean length-at-age of fish caught in gillnets, was generally above the long-term average for nearly all male and female age groups in both basins (Tables A5-A8). Similar to walleye, yellow perch grow slightly faster in the main lake than in the western bays. Growth rates between sexes are consistently higher for females at all ages. Length and age of female yellow perch at 50% sexual maturity were approximately 6.2 inches in both the main lake and west bays and 2.3 years, respectively (Tables 8). Males tend to reach sexual maturity before they are effectively sampled by gillnets (Table 9).

Northern Pike

The 2011 gillnet catch rate of northern pike of 5.89 fish/net is up from 2009 (4.08 fish/net) and is higher than the long-term average of 4.81 fish/net (Figures 7 and 8). Northern pike gillnet catch rates have been relatively stable, ranging from 3.6 fish/net (1993) to 6.2 fish/net (1995). The overall northern pike gill net catch rate was higher than the 2011-2015 management plan objective in 2011 (Figure 9).

Consistent with long-term trends, mean catch rate during 2011 was higher in the western bays (6.94 fish/net) than in the main lake (4.42 fish/net) (Table 4), likely due to the dense vegetation frequently found in the western bays that supports a higher density of northern pike. By area, gillnet catch rates of northern pike ranged from 2.25 fish/net (Pelican Island and Agency Bay) to 10.25 fish/net (Steamboat Bay) (Table 7). Lengths of northern pike ranged from 10 to 37 inches (Figure 17). Northern pike size structure objectives outlined in the 2011-2015 management plan were at or above their respective targets in 2011.

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 3, 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 2011 catch rate of 1.86 fish/net was below the 1983-2011 average of 5.53 fish/net (Figures 7 and 8). Gillnet catch rates of cisco have varied considerably, ranging from 0.6 fish/net (2006) to 18.5 fish/net (1987). Catch rates were lower in the western bays (0.38 fish/net) than in the main lake (3.05 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. Cisco, particularly in the main lake, likely benefited from the cooler summer weather patterns during 2008-2009. Year classes produced during 2007-2009 are apparent, and this trend is consistent with other nearby large lakes (eg. Winnibigoshish and Cass). Lengths of cisco sampled in gill nets ranged from 8 to 17 inches.

Bullheads

The gill net catch rate for black bullhead (*Ictalurus melas*) was 0.17 fish/set, which is below the long-term mean catch rate of 5.53 fish/set. The catch rate of yellow bullhead (*I. natalis*) was 1.00 fish/set and is below the long-term mean of 1.56 fish/net. The catch rate of brown bullhead (*I. nebulosus*) was 0.61 fish/net, which is also below the long-term average (1.65 fish/set). Of the 64 bullhead sampled, 34% were brown bullhead, 10% were black bullhead, and 56% were yellow bullhead.

Other Species

Other species, which include bowfin, burbot, lake whitefish, muskellunge, rock bass, pumpkinseed, bluegill, largemouth and smallmouth bass, and black crappie 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 1983-2011.

Discussion

Overall, gillnet catch rates of walleye and northern pike increased in 2011and were above the long-term average, while yellow perch catch rates declined for the fourth consecutive year and are now below the long-term average. Metrics associated with the 2011-2015 Leech Lake Management Plan (Schultz 2010a) were also near or above management objectives in most cases. The consistency in the walleye population since 2005 has been positive responses to recent management actions. The protected slot limit on walleye has successfully protected mature females in Leech Lake, thereby maintaining the reproductive capacity of the population. The recruitment and fast growth of the 2005-2007 walleye year classes have been the primary cause for the increase in overall walleye abundance and numerous reports of improved fishing quality in Leech Lake. However, density is an important factor regulating growth, maturity, and recruitment (Spangler et al. 1977; Muth and Wolfert 1986; Schueller et al. 2005). As a result, walleye population metrics in Leech Lake, which are indexed by the BPIs, have been trending towards levels more concordant with historical averages. Some of these, such as female age and length at 50% maturity, had already begun improving towards historical levels at the time of the 2007 assessment. Furthermore, the 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).

Double-crested cormorant control efforts have reduced predatory pressures on yellow perch. While reductions in cormorant numbers coincided with increases in perch abundance and size structure initially with no other management actions directed specifically at the perch population, concrete conclusions should be reserved for a thorough evaluation of yellow perch population dynamics and cormorant diet studies. As evidenced in the 2011 gill net survey, the yellow perch population will continue to fluctuate despite significant reductions in cormorant predation.

Significant improvements in the cisco population were observed during the 2009 assessment; however, catch rates have declined substantially the past two years. 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 and potentially hamper natural reproduction. 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. 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 primarily 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-2000's was a product of an extended period between large year classes. Proposed causes of missing year classes included double-crested cormorant predation on juvenile walleye, lower reproductive success by Leech Lake walleye in recent years, and potentially higher walleye egg mortality via rusty crayfish predation. Jarnot (2009) investigated the potential effects of rusty crayfish predation on walleye eggs and Göktepe (2008) evaluated cormorant predation on Leech Lake walleye. Therefore, the objectives of this portion of the 2011 large lake work was to directly estimate walleye hatch rates and total fry density in Leech Lake, to compare hatch rates observed in Leech Lake to those in other systems where similar quantitative methods have been used, and to compare total walleye fry densities to eventual recruitment as indexed by age 1-3 gill net catch rates.

Methods

During May 19 – May 22, 2011, 22.02 million Woman Lake/Boy River strain walleye fry were stocked into Leech Lake. All stocked fry were marked with oxytetracycline, 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 trawling, fall electrofishing, and gillnet sampling events. Thirty-nine additional trawls were conducted from 8/5 through 8/23at the three long term stations and seven other locations (Table 13) in an attempt to recover the missing OTC sample size that was not collected because of cancelled seining. 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.

Results

A total of 300 YOY walleye were collected using bottom trawling (August) and shoreline electrofishing (September) and examined for the presence of an OTC mark. Shoreline seining (July) did not occur in 2011 due to the state shutdown from July 1 through 20. Of the fish examined, 69% were identified as stocked fish; fish held and examined separately for efficacy demonstrated 100% mark retention. The 2011 wild fry hatch rate was estimated to be 0.21% (Table 12. The wild fry population estimate was 10.0 million and the estimated number of total fry (stocked plus wild) was 32.0 million. Fry densities were 172 wild fry/littoral acre (LA) and 552 total fry/LA. The 2005-2007 year classes of walleye were established with densities less than 600 total fry/LA. Furthermore, higher fry densities during recent years have not produced stronger year classes (Figures 18-19).

Discussion

Red Lake, with its windswept gravel substrate, has historically been considered ideal habitat for a self-sustaining walleye population. The collapse of the Red Lake walleye fishery during the 1990's provided a unique opportunity to characterize walleye recruitment dynamics during the recovery period. 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. Recently hatch rates have also been estimated for other walleye lakes as part of an ongoing study (D. Logsdon, unpublished data).

The range of walleye hatch rates in Leech Lake is very similar to other walleye fisheries in Minnesota. These data strongly suggest there is no fundamental problem with walleye reproduction in Leech Lake and discount concerns that rusty crayfish are negatively impacting walleye recruitment. The proportion of marked (stocked) to unmarked (wild) fry has ranged between 23-86%, and has tended to be 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 18). Similarly, higher fry densities resulting from higher stockings during 2005-2011 have not resulted in higher recruitment to date (Figure 19). 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 (this would require a three-fold increase in spawner biomass), one would expect to see more marked fish upon examination.

These data therefore warrant investigations after 2014 that 1) comprehensively evaluate the capacity for natural reproduction to support the fishery, and 2) if further stocking is demonstrated to be a necessary and appropriate management action, more effective fry densities and/or stocking frequencies should be pursued.

OTHER WORK

Water Quality

Water samples were not collected in 2011 due to the state shutdown from July 1 through 20. Typically, the Minnesota Department of Agriculture Chemistry Laboratory in St. Paul, Minnesota analyzes 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, there has been no apparent change in water quality since the inception of the Large Lake Program. In general, Walker Bay is less productive with better water clarity than the main lake (Table 14). 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. Due to staffing shortages and the state shutdown, temperature-oxygen profiles were also not completed during 2011 (Figure 20).

Aquatic Invasive Species

A survey of Leech Lake boat harbors in 2004 found established beds of Eurasian watermilfoil (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 not yet discovered rooted EWM outside of harbors to date 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 in July 2011. EWM was found in 8 boat harbors (Figure 21.). Of the 8 infested harbors, all 8 were chemically treated. EWM is now considered widespread across the main basin boat harbors of Leech Lake, but has yet to be discovered outside of boat harbors.

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.

Double-crested cormorant control

A total of 2,181 adult cormorants were removed from Leech Lake during 2011, bringing the overall total to nearly 19,000 birds culled since work began in 2005 (Figure 22) and making Leech Lake the largest single control site in the U.S. (S. Mortensen, LLBO Division of Resource Management, personal communication). Small yellow perch have been the most common component of cormorant diets (LLBO 2007), though cisco have also been common in diets when available. The results of the diet study will be used to evaluate various cormorant control scenarios and to determine the appropriate cormorant population level that Leech Lake can support without impacting fishing quality. Due to the high year-to-year variability in cormorant diets, diet work has been completed by the DRM during 2005, 2006, 2007, and 2010 (S. Mortensen, personal communication).

SUMMARY

Recent management actions and favorable environmental conditions have allowed for sustained improvements in the Leech Lake walleye populations. Cormorant control efforts since 2005 have likely contributed to the increase of yellow perch, particularly in the main lake. Good recruitment and favorable growing conditions have led to the establishment of strong walleye year classes in 2005-2007. The strength of the 2011 year class will hinge largely on winter survival as average length of the cohort had exceeded 6.0 inches during September, indicating good growth was accrued during the summer.

Growth of recent walleye year classes, indexed by length at age, continues to return to historical levels. Fast growth greatly contributed to the rapid improvements in fishing quality that walleye anglers have been enjoying since 2007. The current 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) has benefited 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 during 2008-2011 by anglers with harvest rates similar to pre-regulation periods.

Regarding walleye reproduction, walleye hatch rates in Leech Lake have been very similar to those observed in other walleye lakes, some of which are infested with rusty crayfish. These findings suggest that there is no systemic problem with walleye reproduction in Leech Lake.

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 (50^{th} percentile) or higher produced during any two of four consecutive years. The estimated spawner biomass in 2011 was 1.82 pounds of walleye per acre, and remained within the management objective range for the second consecutive year. The gillnet catch rate in 2011 was 8.1, and remained just below the management objective range for the second consecutive year but above the long-term average for the fifth consecutive year. Of the 291 walleye sampled in 2011 gillnet sets, 34% were shorter than 15.0 inches. This percentage has remained below the management objective range for the third consecutive year, due to an increasing percentage of fish occurring within the protected slot limit. Length-based metrics such as this one will inherently be subject to variability in recruitment and growth, especially when gill net selectivity is considered. Furthermore, strong year classes of walleye were produced annually from 2005 through 2008, meaning a substantial number of fish (66% of the 2011 gill net sample) are now longer than 15.0 inches.

In addition to the dramatic improvements to the walleye and populations, 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 is above average, 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 four 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.

Thus far, the aggressive monitoring and treatment of Eurasian watermilfoil (EWM) appears to have kept this invasive plant in check. Unfortunately, the plant continues to be found at new locations around the lake each year. Constant awareness by users and property owners alike is paramount to prevent the spread and establishment of EWM to new locations.

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 detrimental 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 is in the process of being 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 watermilfoil is planned for 2012. 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.

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 of concern.

Muskellunge, largemouth bass, bluegill and black crappie sampling is planned to be conducted during the spring of 2012. 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 scheduled in the future.

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, 2011. Age 1+ includes all non-YOY fish captured. Seining was not conducted in 2011 due to the state shutdown from July 1-20.

NOT COMPLETED IN 2011 DUE TO STATE SHUTDOWN

Table 2. Trawl catch rates (CPUE, number/hour) of all species and ages captured, Leech Lake, 2010. Age 1+ includes all non-YOY fish captured.

Standard trawling

Number of Hauls: 20
Total haul time for all stations: 01:39:30
First Haul Date: 08/16/2011
Last Haul Date: 08/23/2011
Target Species: N/A

Abbr	Species	Age	Total Number	Number Measured	Mean Length (inches)	Length Range (inches) Min	Max	Catch Rates num /haul	num/hour
IOD	Iowa Darter	All	2	2	1.89	1.77	2.01	0.10	1.21
JND	Johnny Darter	All	6	6	1.81	1.50	2.01	0.30	3.62
BLC	Black Crappie	YOY	2	2	2.62	2.09	3.15	0.10	1.21
BLG	Bluegill	YOY	7	7	1.09	0.98	1.22	0.35	4.22
BNM	Bluntnose Minnow	All	14	14	2.34	1.42	2.91	0.70	8.44
LMB	Largemouth Bass	YOY	12	12	2.91	2.36	3.74	0.60	7.24
LGP	Logperch	All	15	15	2.77	1.65	3.78	0.75	9.05
MMS	Mimic Shiner	All	165	113	2.03	1.22	3.46	8.25	99.50
NOP	Northern Pike	All	1	1	18.86	18.86	18.86	0.05	0.60
RKB	Rock Bass	YOY	2	2	1.71	1.54	1.89	0.10	1.21
SMB	Smallmouth Bass	YOY	5	5	2.18	1.77	2.80	0.25	3.02
SPO	Spottail Shiner	YOY	57	10	1.20	1.06	1.38	2.85	34.37
SPO	Spottail Shiner	≥ 1	81	81	3.41	1.61	4.45	4.05	48.84
TPM	Tadpole Madtom	All	30	27	1.94	1.06	2.99	1.50	18.09
TRP	Trout-Perch	All	8	8	2.06	1.61	3.62	0.40	4.82
TLC	Tullibee (Cisco)	YOY	14	14	2.98	2.80	3.23	0.70	8.44
WAE	Walleye	YOY	66	66	4.83	3.35	5.55	3.30	39.80
WAE	Walleye	≥ 1	34	34	12.59	6.81	22.24	1.70	20.50
YEP	Yellow Perch	YOY	27,247	328	1.68	1.26	2.24	1,362.35	16,430.38
YEP	Yellow Perch	≥ 1	187	94	4.17	2.60	11.18	9.35	112.76

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	1.95		
2007	31	1.47	27	1.78		
2008	508	0.00	42	1.38		
2009	**153**	**0.03**	**164**	**0.24**	**1.08±0.23**	**1.29±0.23**
2010	**80**	**0.03**	**56**	**1.81**	**1.18±0.25**	**1.18±0.25**
2011	**40**	**0.03**	**175**		**0.88±0.27**	**1.11±0.29**
Mean	140.7	0.31	64	1.32		

Equation 1: YCS = (0.00159*trawl CPE) + 1.04808; R-sq = 0.15

Equation 2: YCS = (0.00175*trawl CPE) + (0.70222*gillnet CPE) + 0.79249; R-sq = 0.46

Table 4. Gillnet catch-per-effort (fish/net) summary by species and basin for Leech Lake, 2011.

		Western Bays			Main Lake			Overall (Whole Lake)		
			1983-2011			1983-2011			1983-2011	
Code	Species	2011	Mean	s.e.	2011	Mean	s.e.	2011	Mean	s.e.
BLB	Black bullhead	0.31	9.45	1.81	0.05	2.34	0.65	0.17	5.53	1.10
BLC	Black crappie	0.44	0.35	0.07	0.50	0.47	0.08	0.47	0.41	0.06
BLG	Bluegill	1.38	0.77	0.15	0.15	0.29	0.06	0.69	0.50	0.09
BOF	Bowfin	0.19	0.11	0.02	0.10	0.04	0.01	0.14	0.07	0.01
BRB	Brown bullhead	1.13	2.04	0.23	0.20	1.21	0.20	0.61	1.65	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	0.19	0.09	0.03	0.00	0.03	0.01	0.08	0.06	0.02
LMB	Largemouth bass	0.06	0.12	0.03	0.10	0.09	0.02	0.08	0.10	0.02
MUE	Muskellunge	0.13	0.05	0.01	0.00	0.01	0.01	0.06	0.04	0.01
NOP	Northern pike	6.94	5.37	0.22	5.05	4.42	0.15	5.89	4.84	0.14
PMK	Pumpkinseed	0.50	1.08	0.14	0.15	0.54	0.10	0.31	0.77	0.09
RKB	Rock bass	2.19	3.13	0.30	0.65	0.30	0.04	1.33	1.58	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	0.38	4.85	0.88	3.05	6.10	1.01	1.86	5.53	0.81
WAE	Walleye	6.19	5.78	0.31	9.60	9.10	0.67	8.08	7.63	0.45
WTS	White sucker	1.13	1.28	0.09	1.15	1.72	0.16	1.14	1.53	0.11
YEB	Yellow bullhead	2.13	2.32	0.28	0.10	0.92	0.16	1.00	1.56	0.18
YEP	Yellow perch	23.94	26.19	1.31	11.85	18.49	1.79	17.22	21.94	1.27

Table 5. Length-frequency distribution of all species sampled in experimental gillnet sets, Leech Lake, 2010.

Standard gill net sets

(Field work conducted between 09/05/2011 and 09/16/2011)

	BLB	BLC	BLG	BOF	BRB	LKW	LMB	MUE	NOP	PMK	RKB	TLC	WAE	YWAE	WTS
< 3.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3.00 - 3.49	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
3.50 - 3.99	-	-	7	-	-	-	-	-	-	1	-	-	-	-	-
4.00 - 4.49	-	-	1	-	-	-	-	-	-	2	-	-	-	-	-
4.50 - 4.99	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
5.00 - 5.49	-	3	1	-	-	-	2	-	-	1	1	-	-	-	-
5.50 - 5.99	-	5	1	-	-	-	-	-	-	-	-	-	-	-	-
6.00 - 6.49	-	1	-	-	-	-	-	-	-	1	3	-	-	1	-
6.50 - 6.99	-	-	-	-	-	-	-	-	-	1	2	-	-	-	-
7.00 - 7.49	-	-	-	-	-	-	-	-	-	1	3	-	-	-	-
7.50 - 7.99	-	-	1	-	-	-	-	-	-	3	10	2	3	-	-
8.00 - 8.49	-	-	5	-	-	-	-	-	-	-	6	10	7	-	-
8.50 - 8.99	-	-	7	-	-	-	-	-	-	-	4	7	8	-	-
9.00 - 9.49	-	-	2	-	-	-	-	-	-	-	2	1	9	-	2
9.50 - 9.99	-	-	-	-	-	-	-	-	-	-	10	-	11	-	1
10.00 - 10.49	1	1	-	-	-	-	-	-	1	-	2	-	9	-	3
10.50 - 10.99	-	-	-	-	-	-	-	-	-	-	3	2	12	-	1
11.00 - 11.49	-	-	-	-	2	-	-	-	-	-	-	-	4	-	2
11.50 - 11.99	1	2	-	-	6	-	-	-	-	-	-	-	2	-	3
12.00 - 12.99	4	4	-	-	10	-	-	-	4	-	-	9	8	-	4
13.00 - 13.99	-	1	-	-	2	-	-	-	2	-	-	13	8	-	2
14.00 - 14.99	-	-	-	-	2	1	-	-	5	-	-	14	18	-	2
15.00 - 15.99	-	-	-	-	-	-	1	-	4	-	-	4	23	-	1
16.00 - 16.99	-	-	-	-	-	1	-	-	1	-	-	4	20	-	3
17.00 - 17.99	-	-	-	-	-	1	-	-	7	-	-	1	22	-	7
18.00 - 18.99	-	-	-	1	-	-	-	-	14	-	-	-	32	-	8
19.00 - 19.99	-	-	-	-	-	-	-	-	25	-	-	-	32	-	1
20.00 - 20.99	-	-	-	-	-	-	-	-	38	-	-	-	21	-	-
21.00 - 21.99	-	-	-	-	-	-	-	-	15	-	-	-	19	-	1
22.00 - 22.99	-	-	-	2	-	-	-	1	29	-	-	-	9	-	-
23.00 - 23.99	-	-	-	-	-	-	-	1	27	-	-	-	7	-	-
24.00 - 24.99	-	-	-	-	-	-	-	-	12	-	-	-	3	-	-
25.00 - 25.99	-	-	-	1	-	-	-	-	8	-	-	-	2	-	-
26.00 - 26.99	-	-	-	-	-	-	-	-	7	-	-	-	1	-	-
27.00 - 27.99	-	-	-	1	-	-	-	-	3	-	-	-	-	-	-
28.00 - 28.99	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-
29.00 - 29.99	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
30.00 - 30.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31.00 - 31.99	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
32.00 - 32.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
33.00 - 33.99	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-
34.00 - 34.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
35.00 - 35.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
= > 36.00	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-

	BLB	BLC	BLG	BOF	BRB	LKW	LMB	MUE	NOP	PMK	RKB	TLC	WAE	YWAE	WTS
Total	6	17	25	5	22	3	3	2	212	11	48	67	290	1	41
Min. Length	10.35	5.31	3.58	18.98	11.06	14.25	5.16	22.09	10.47	3.43	4.80	7.72	7.52	6.42	9.09
Max. Length	12.83	13.03	9.13	27.83	14.57	17.40	15.55	23.31	37.68	7.72	10.75	17.24	26.97	6.42	21.89
Mean Length	11.96	8.64	6.81	23.42	12.42	16.21	8.67	22.70	21.56	5.84	8.30	12.32	16.36	6.42	14.86
# Measured	6	17	25	5	22	3	3	2	212	11	48	67	290	1	41
No Lengths for	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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 measured fish

Table 5 continued. Length-frequency distribution of all species sampled in experimental gillnet sets, Leech Lake, 2010.

Standard gill net sets

(Field work conducted between 09/05/2011 and 09/16/2011)

	YEB	YEP
< 3.00	-	-
3.00 - 3.49	-	-
3.50 - 3.99	-	1
4.00 - 4.49	-	-
4.50 - 4.99	-	-
5.00 - 5.49	1	7
5.50 - 5.99	-	94
6.00 - 6.49	-	108
6.50 - 6.99	1	60
7.00 - 7.49	1	60
7.50 - 7.99	-	61
8.00 - 8.49	1	47
8.50 - 8.99	2	44
9.00 - 9.49	2	37
9.50 - 9.99	2	21
10.00 - 10.49	5	28
10.50 - 10.99	6	27
11.00 - 11.49	9	15
11.50 - 11.99	3	5
12.00 - 12.99	2	5
13.00 - 13.99	1	-
14.00 - 14.99	-	-
15.00 - 15.99	-	-
16.00 - 16.99	-	-
17.00 - 17.99	-	-
18.00 - 18.99	-	-
19.00 - 19.99	-	-
20.00 - 20.99	-	-
21.00 - 21.99	-	-
22.00 - 22.99	-	-
23.00 - 23.99	-	-
24.00 - 24.99	-	-
25.00 - 25.99	-	-
26.00 - 26.99	-	-
27.00 - 27.99	-	-
28.00 - 28.99	-	-
29.00 - 29.99	-	-
30.00 - 30.99	-	-
31.00 - 31.99	-	-
32.00 - 32.99	-	-
33.00 - 33.99	-	-
34.00 - 34.99	-	-
35.00 - 35.99	-	-
= > 36.00	-	-

	YEB	YEP
Total	36	620
Min. Length	5.39	3.86
Max. Length	13.94	12.17
Mean Length	10.41	7.66
# Measured	36	620
No Lengths for	0	0

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 measured fish

Table 6. Age-length frequency distribution of immature and mature (bold, right) female walleye captured in experimental gill nets, Leech Lake, 2011.

	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			3																3	**0**
8.0-8.9			9																9	**0**
9.0-9.9			5		1														6	**0**
10.0-10.9			5		4														9	**0**
11.0-11.9			1		5														6	**0**
12.0-12.9					4														4	**0**
13.0-13.9					3		1												4	**0**
14.0-14.9					3		7												10	**0**
15.0-15.9					1		4		1										6	**0**
16.0-16.9					1		3		2		1								7	**0**
17.0-17.9									9	**4**									9	**4**
18.0-18.9									5	**3**		**3**							5	**6**
19.0-19.9									2	**3**	3	**8**	1	**2**					6	**13**
20.0-20.9									1	**1**	1	**9**	1	**3**					3	**13**
21.0-21.9											2	**6**		**3**		**1**		**1**	2	**11**
22.0-22.9												**3**	2	**2**				**1**	2	**6**
23.0-23.9												**1**						**6**	0	**7**
24.0-24.9																		**3**	0	**3**
25.0-25.9																		**2**	0	**2**
26.0-26.9																		**1**	0	**1**
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**	23	**0**	22	**0**	15	**0**	20	**11**	7	**30**	4	**10**	0	**1**	0	**14**	91	**66**

Table 7. Age-length frequency distribution of immature and mature (bold, right) male walleye captured in experimental gill nets, Leech Lake, 2011.

	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	1																		1	**0**
7.0-7.9																			0	**0**
8.0-8.9			7																7	**0**
9.0-9.9			14		1														15	**0**
10.0-10.9			9		3														12	**0**
11.0-11.9																			0	**0**
12.0-12.9					1		3												4	**0**
13.0-13.9					3		1												4	**0**
14.0-14.9					2		2	**4**											4	**4**
15.0-15.9						**1**	3	**8**		**5**									3	**14**
16.0-16.9								**1**		**11**		**1**							0	**13**
17.0-17.9										**6**		**3**							0	**9**
18.0-18.9										**4**		**14**		**1**		**2**			0	**21**
19.0-19.9												**6**		**6**		**1**			0	**13**
20.0-20.9												**1**		**1**				**3**	0	**5**
21.0-21.9																		**6**	0	**6**
22.0-22.9																		**1**	0	**1**
23.0-23.9																			0	**0**
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	1	**0**	30	**0**	10	**1**	9	**13**	0	**26**	0	**25**	0	**8**	0	**3**	0	**10**	50	**86**

Table 8. Age-length frequency distribution of immature and mature (bold, right) female yellow perch captured in experimental gill nets, Leech Lake, 2011.

	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					5														5	**0**
5.50-5.99					26		9	**5**	5	**3**									40	**8**
6.00-6.49					17	**15**	9	**6**	16	**10**									42	**31**
6.50-6.99					6	**8**	5	**12**	2	**11**		**2**							13	**33**
7.00-7.49						**3**	5	**14**	1	**18**	2	**4**							8	**39**
7.50-7.99						**1**	1	**9**	1	**21**	2	**6**	1						5	**37**
8.00-8.49						**2**		**6**	1	**16**		**10**		**3**					1	**37**
8.50-8.99						**3**		**8**		**13**		**12**		**2**					0	**38**
9.00-9.49								**2**		**21**	1	**5**		**3**				**2**	1	**33**
9.50-9.99								**1**		**6**		**7**		**4**				**2**	0	**20**
10.00-10.49								**2**		**3**		**13**		**6**				**3**	0	**27**
10.50-10-99										**5**		**6**		**6**		**4**		**5**	0	**26**
11.00-11.49														**6**		**3**		**4**	0	**13**
11.50-11.99														**2**				**3**	0	**5**
12.00-12.99										**1**		**1**						**3**	0	**5**
13.00-13.99																			0	**0**
14.00-14.99																			0	**0**
> 14.99																			0	**0**
Total	0	**0**	0	**0**	54	**32**	29	**65**	26	**128**	5	**66**	1	**32**	0	**7**	0	**22**	115	**352**

Table 9. Age-length frequency distribution of immature and mature (bold, right) male yellow perch captured in experimental gill nets, Leech Lake, 2011.

	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**							0 **2**
5.50-5.99			**17**	**20**	**7**	**2**				0 **46**
6.00-6.49			**8**	**17**	**4**	**6**				0 **35**
6.50-6.99			**1**	**3**	**4**	**6**				0 **14**
7.00-7.49				**5**	**4**	**2**		**2**		0 **13**
7.50-7.99				**1**	**9**	**6**	**1**	**2**		0 **19**
8.00-8.49				**1**	**3**	**4**	**1**			0 **9**
8.50-8.99						**3**	**1**	**1**	**1**	0 **6**
9.00-9.49				**1**		**2**				0 **3**
9.50-9.99							**1**			0 **1**
10.00-10.49						**1**				0 **1**
10.50-10-99								**1**		0 **1**
11.00-11.49									**2**	0 **2**
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**	0 **28**	0 **48**	0 **31**	0 **32**	0 **4**	0 **6**	0 **3**	0 **152**

Table 10. Age-length frequency distribution of immature and mature (bold, right) female northern pike captured in experimental gill nets, Leech Lake, 2011.

	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			1																1	**0**
13.0-13.9			1																1	**0**
14.0-14.9			3																3	**0**
15.0-15.9																			0	**0**
16.0-16.9				**1**															0	**1**
17.0-17.9			1		1	**1**													2	**1**
18.0-18.9						**8**													0	**8**
19.0-19.9						**3**													0	**3**
20.0-20.9						**15**		**3**											0	**18**
21.0-21.9						**3**		**3**											0	**6**
22.0-22.9						**1**		**10**		**3**		**2**							0	**16**
23.0-23.9							1	**9**		**8**									1	**17**
24.0-24.9										**5**		**2**		**1**					0	**8**
25.0-25.9										**4**		**2**		**1**					0	**7**
26.0-26.9										**4**		**1**		**1**					0	**6**
27.0-27.9												**3**							0	**3**
28.0-28.9												**2**		**1**					0	**3**
29.0-29.9																**1**			0	**1**
30.0-30.9																			0	**0**
31.0-31.9																		**1**	0	**1**
32.0-32.9																			0	**0**
33.0-33.9																		**3**	0	**3**
34.0-34.9																			0	**0**
35.0-35.9																			0	**0**
> 36.0																		**1**	0	**1**
Total	0	**0**	6	**1**	1	**31**	1	**25**	0	**24**	0	**12**	0	**4**	0	**1**	0	**5**	8	**103**

Table 11. Age-length frequency distribution of immature and mature (bold, right) male northern pike captured in experimental gill nets, Leech Lake, 2011.

	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				**3**															0	**3**
13.0-13.9			1																1	**0**
14.0-14.9				**2**															0	**2**
15.0-15.9				**3**		**1**													0	**4**
16.0-16.9																			0	**0**
17.0-17.9						**4**													0	**4**
18.0-18.9						**5**		**1**											0	**6**
19.0-19.9					2	**13**	1	**6**											3	**19**
20.0-20.9						**6**	2	**7**	1	**3**		**1**							3	**17**
21.0-21.9								**3**		**2**		**3**		**1**					0	**9**
22.0-22.9								**2**		**7**		**4**							0	**13**
23.0-23.9									1	**4**		**3**		**1**					1	**8**
24.0-24.9												**1**		**2**		**1**			0	**4**
25.0-25.9														**1**					0	**1**
26.0-26.9										**1**									0	**1**
27.0-27.9																			0	**0**
28.0-28.9																			0	**0**
29.0-29.9																		**1**	0	**1**
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	0	**0**	1	**8**	2	**29**	3	**19**	2	**17**	0	**12**	0	**5**	0	**1**	0	**1**	8	**92**

Table 12. Summary of walleye fry stocking for five Minnesota lakes, 1999-2011 and Leech Lake, 2005-2011. SSB refers to spawner stock biomass estimated from gillnet catches of mature female walleye the previous fall.

						Fry per LA	
Lake	Year	SSB (lbs/A)	Amount Stocked/LA	YOY Marked (%)	Hatch 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
	Mean	1.60	311	54	0.34	266	577
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	0.91	153	29	0.48	373	526
	2009	0.94	600	56	0.56	467	1,067
	2010	1.63	733	72	0.20	277	1,010
	2011	2.43	820	67	0.18	406	1,226
	Mean	1.48	577	56	0.35	381	957
Woman	2007	1.37	2,448	73	0.88	896	3,344
	2008	1.3	1,516	60	1.01	1014	2,530
	2009	1.13	580	83	0.15	117	697
	2010	0.32	995	97	0.26	28	1,023
	2011	1.02	1,002	96	0.06	41	1,043
	Mean	1.03	1,308	81.8	0.47	419	1,727
Winnibigoshish	2009	1.82	623	83	0.06	132	755
	2010	1.85	514	88	0.04	72	586
	2011	2.28	693	74	0.1	239	932
	Mean	1.98	610	82	0.07	148	758
Vermillion	2010	1.14	400	37	0.7	666	1,066
	2011	0.82	1,000	60	0.97	665	1,665
	Mean	0.98	700	49	0.84	666	1366

Table 13. Trawling locations for 2011 that include the three standard long-terms stations (TR-1 through TR-3) and the ten other locations sampled (STR1 through STR-10). 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	0	0
TR-2	Goose Island	7	35	0	0
TR-3	Whipholt Beach	5	25	0	0
STR-1	Sand Point	2	10	0	0
STR-2	Goose Island	2	10	13	78
STR-3	Big Hardwood Point	5	25	2	4.8
STR-4	Second Duck Point	6	30	74	148
STR-5	Ottertail Beach	5	25	11	26.4
STR-6	Fivemile Point	2	10	0	0
STR-7	Pine Point	3	15	11	44
STR-8	Whipholt Beach	2	10	45	270
STR-9	Grassy Point	6	30	2	4
STR-10	Trader's Bay	6	30	27	54

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, 1984-2011.

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]		-	-	-	-	-	-	-		-	-	-	-	-	-	-
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

[1] water quality data was not collected in 2011 due to state shutdown from July 1-20.

FIGURES

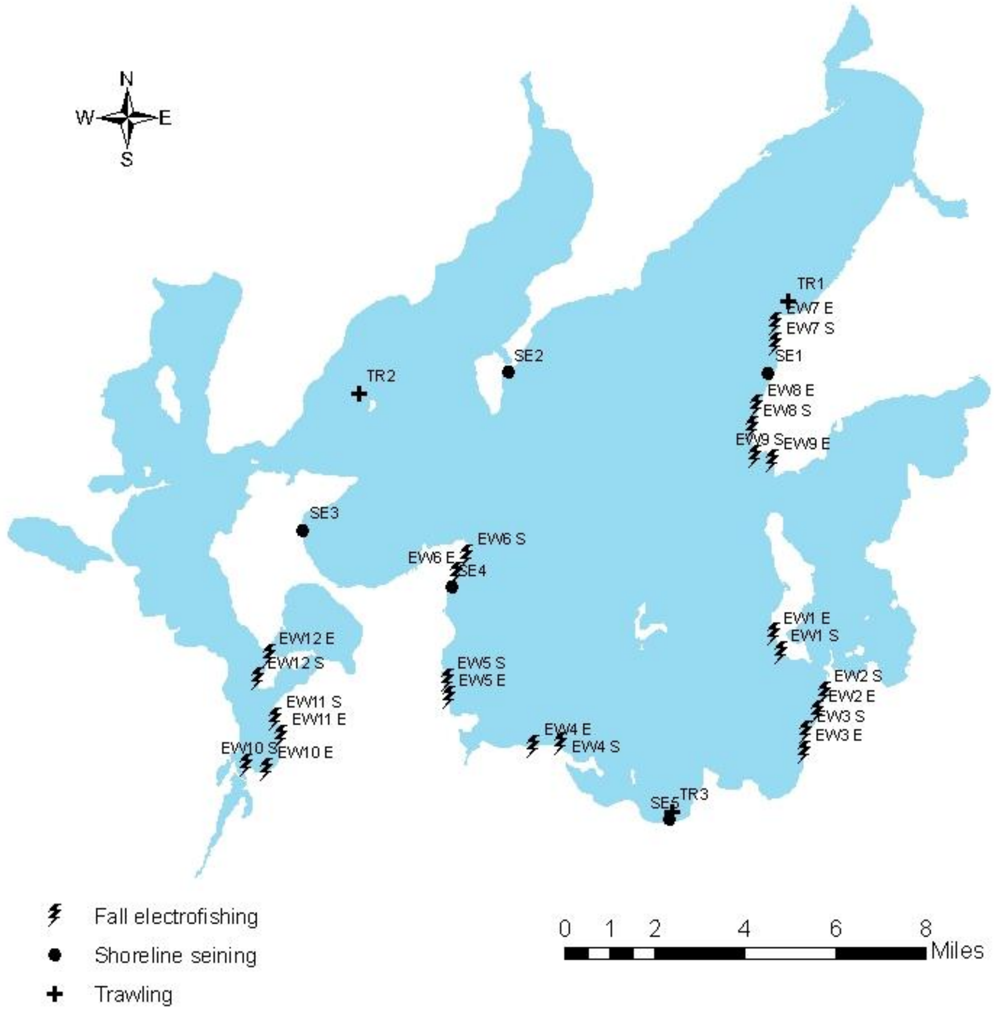


Figure 1. Long-term sampling stations targeting young-of-year percids in Leech Lake.

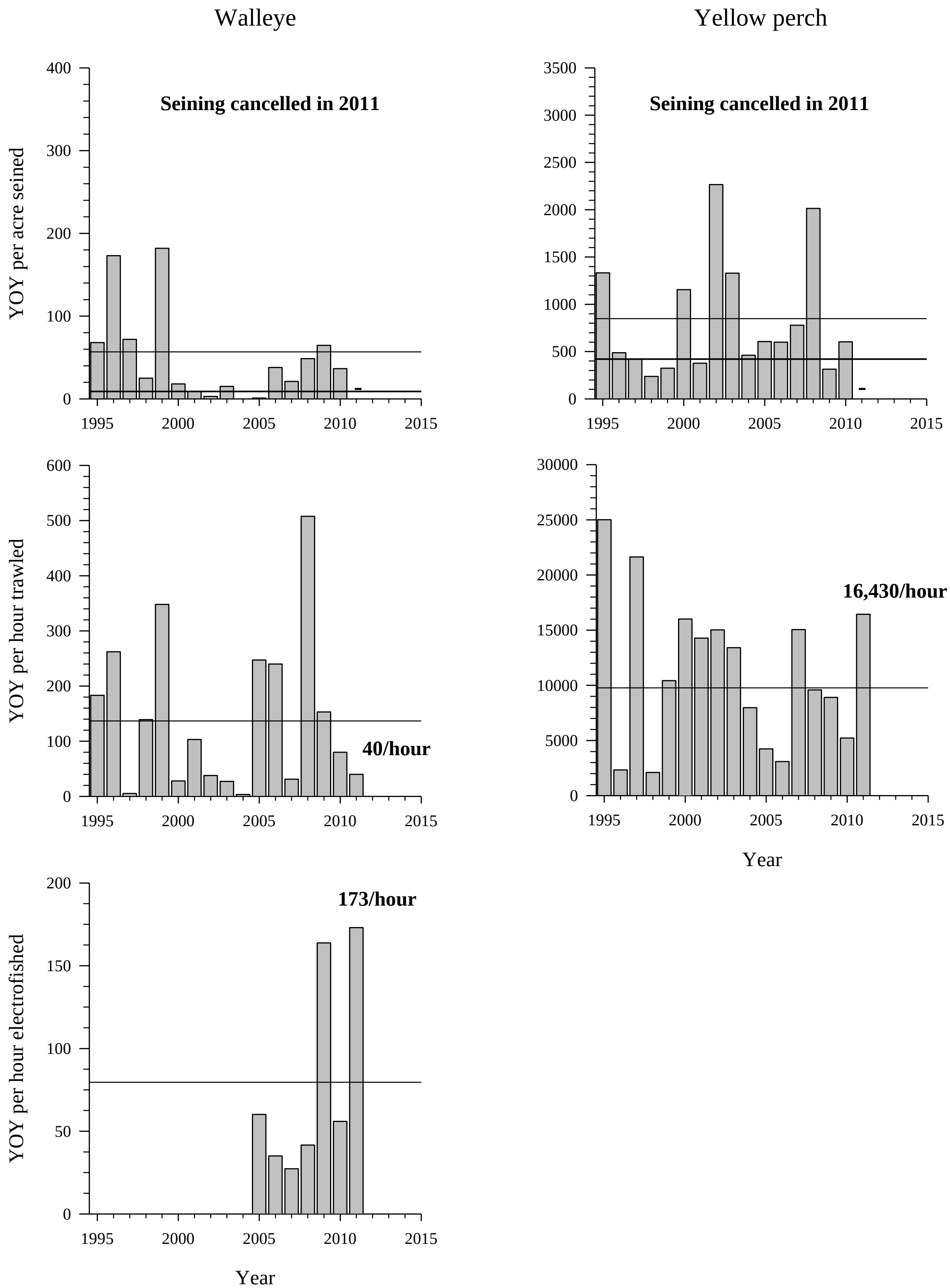


Figure 2. Catch-per-effort (bars) and historical averages (lines) of young-of-year (YOY) walleye (left column) and yellow perch (right column) at long-term sampling stations, Leech Lake, 1983-2011.

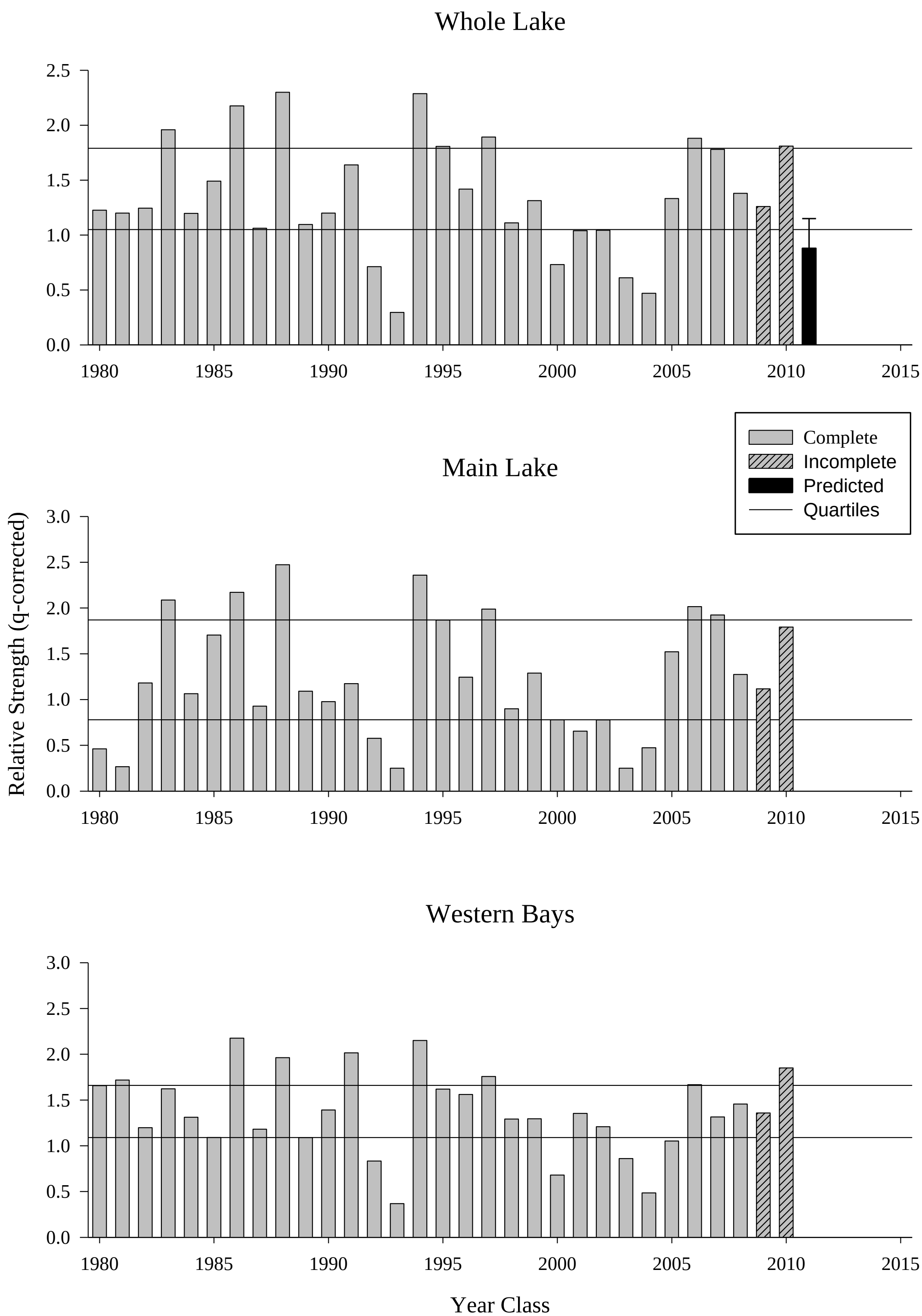


Figure 3. Year class strength index of walleye in Leech Lake (top panel) and by basin (bottom panels), 1980-2011.

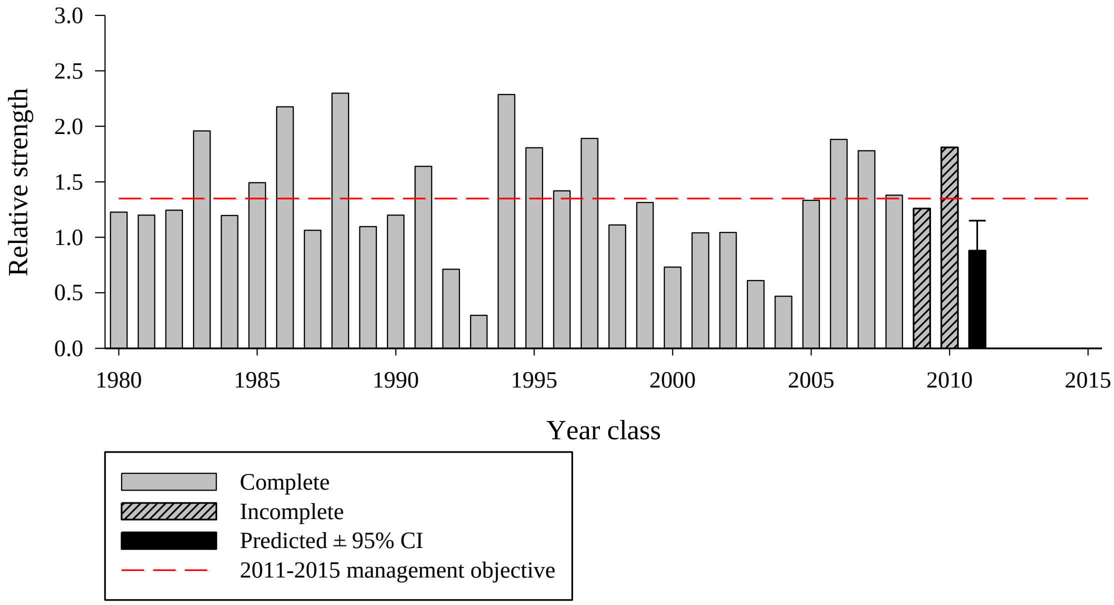


Figure 4. Walleye year class strength index relative to the 2011-2015 Leech Lake Management Plan objective for walleye recruitment (Schultz 2010a).

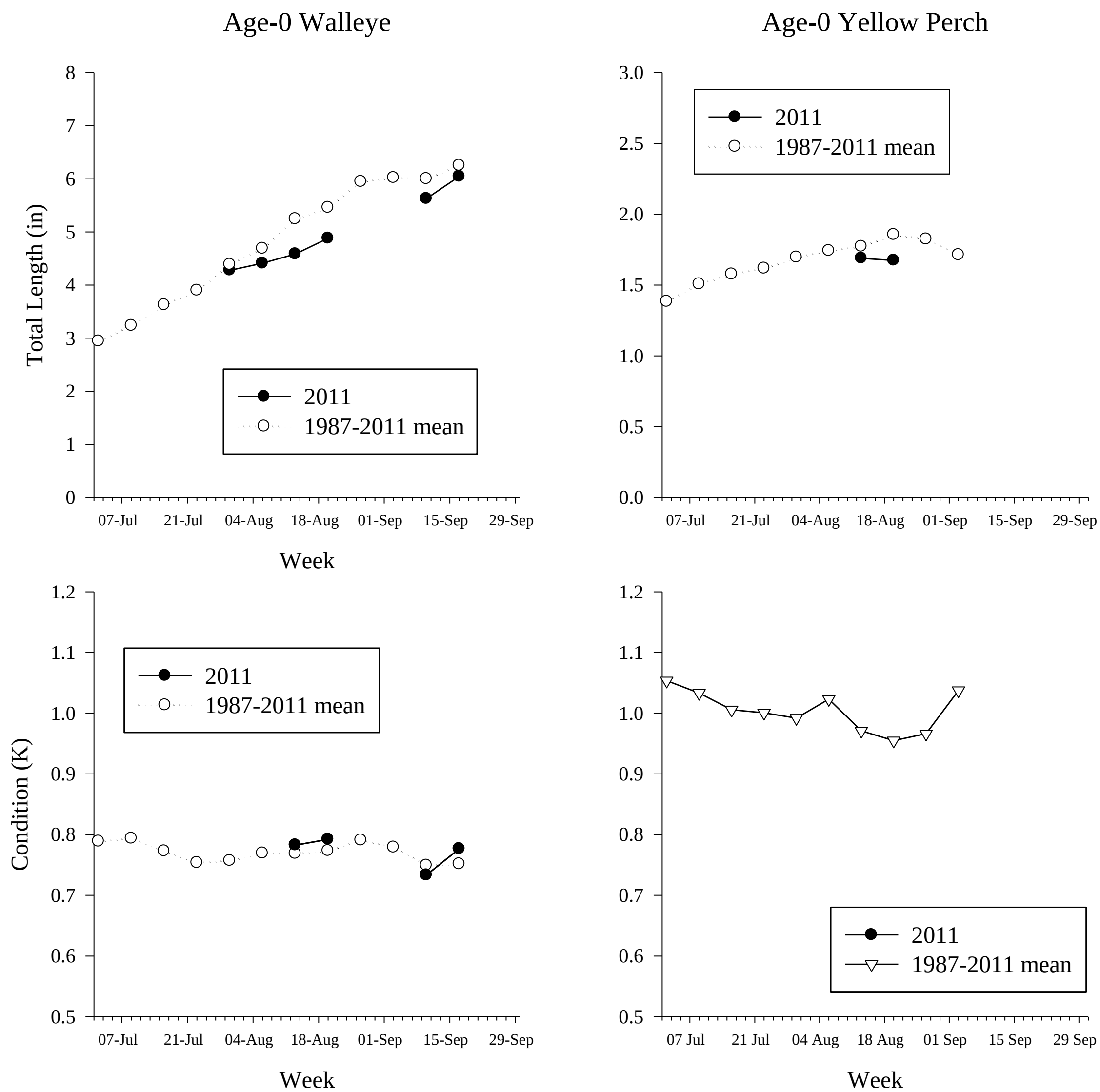


Figure 5. Mean weekly growth (top row) and condition (bottom row) of age-0 walleye (left column) and yellow perch (right column) captured in Leech Lake during the annual young-of-year assessment, 2011. Conditions factors were not calculated for yellow perch.

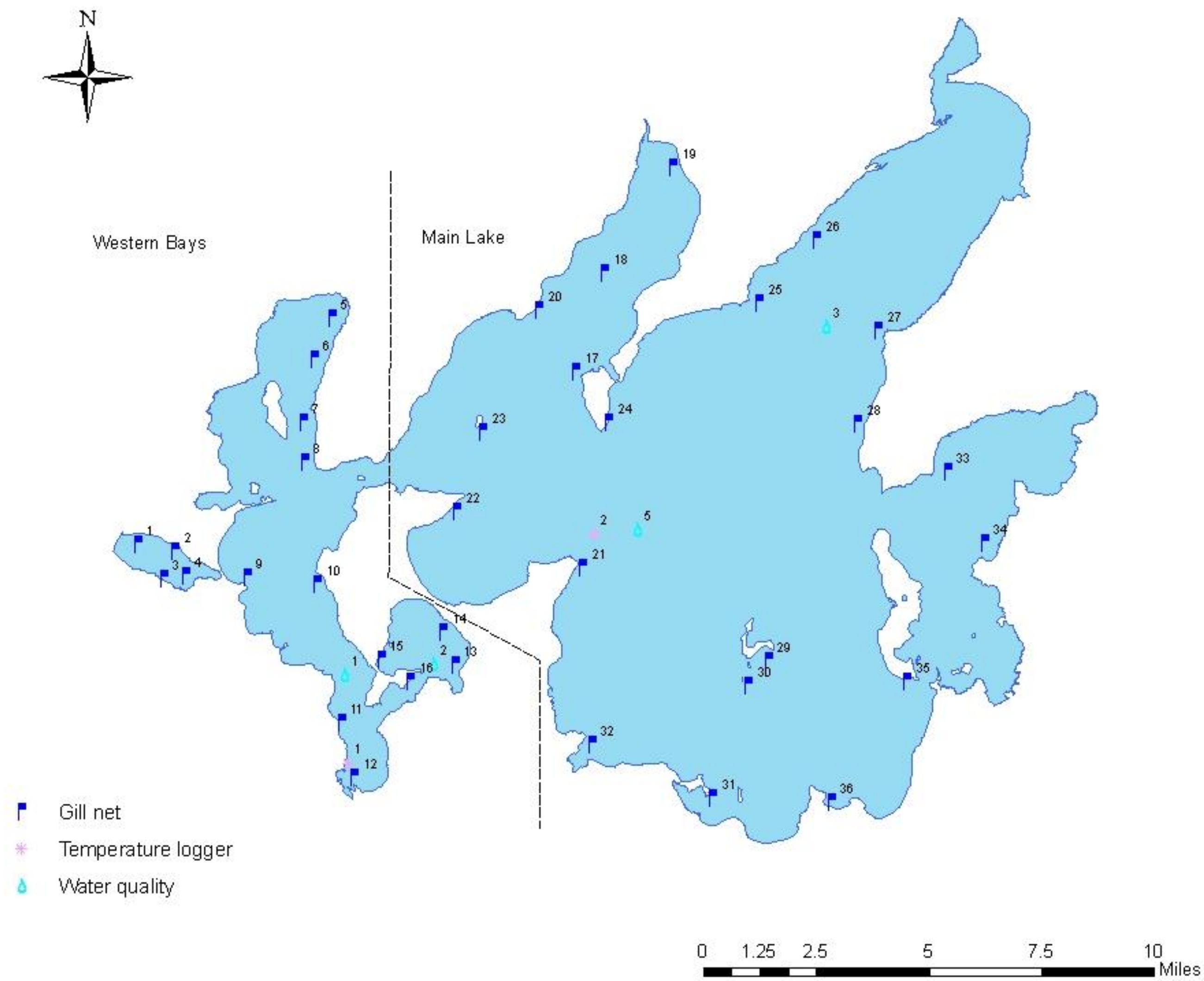


Figure 6. Gillnet (flags), temperature loggers (dots) and water quality (droplets) sampling locations on Leech Lake.

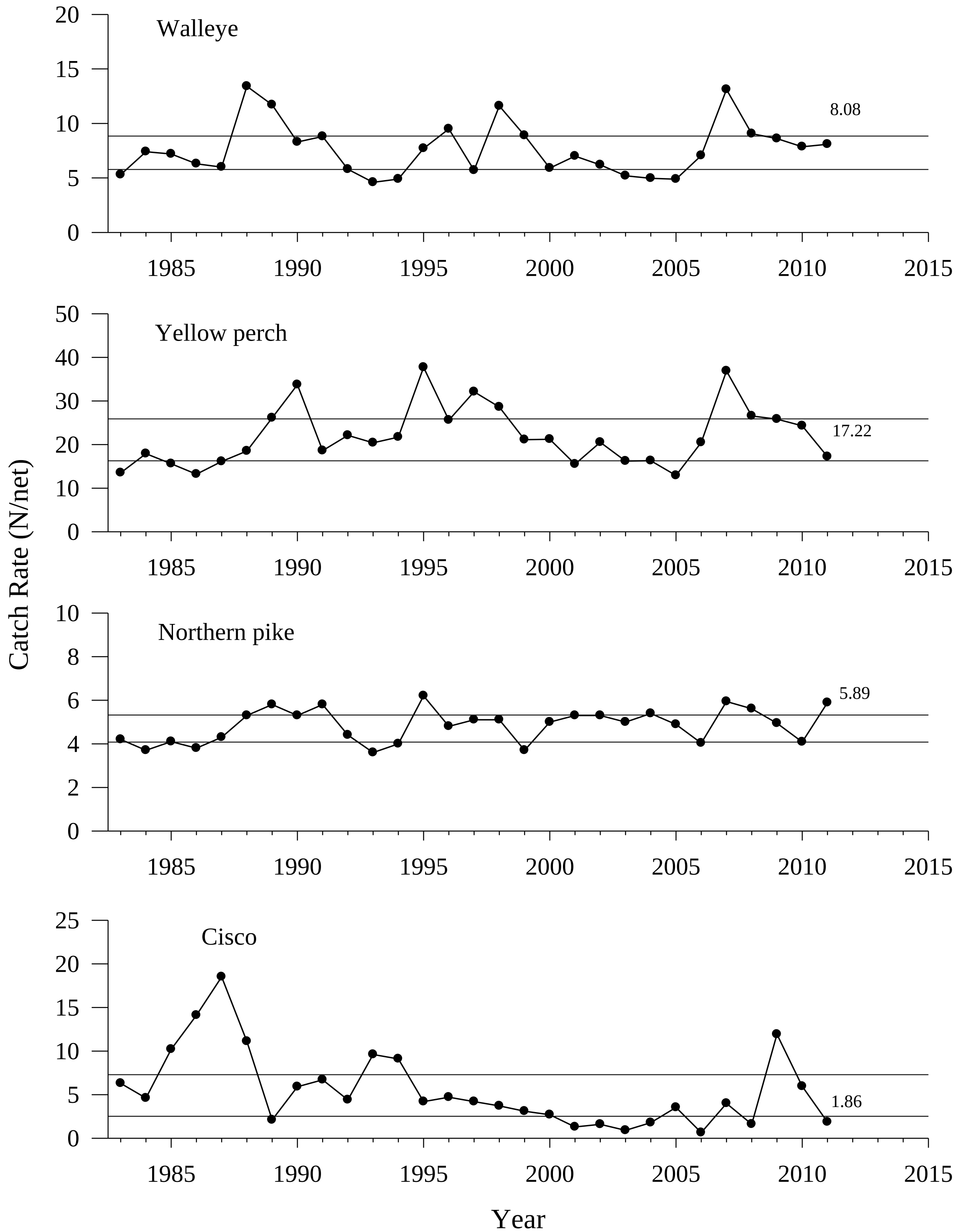


Figure 7. Gillnet catch rates (fish/net) of selected species in Leech Lake, 1983-2011. Horizontal lines represent respective upper (3rd) and lower (1st) quartiles.

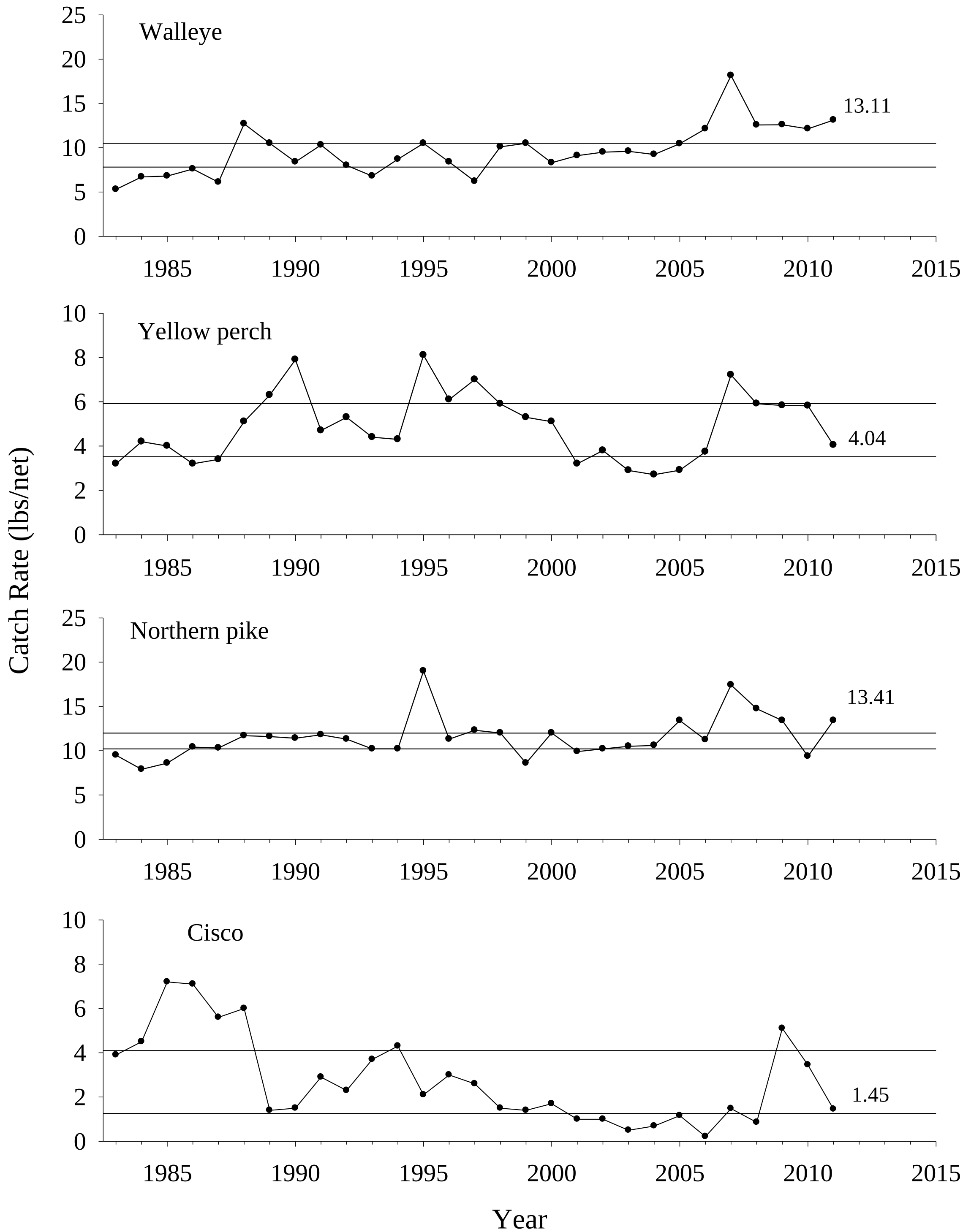


Figure 8. Gillnet catch rates (lbs/net) of selected species in Leech Lake, 1983-2011. Horizontal lines represent respective upper (3rd) and lower (1st) quartiles.

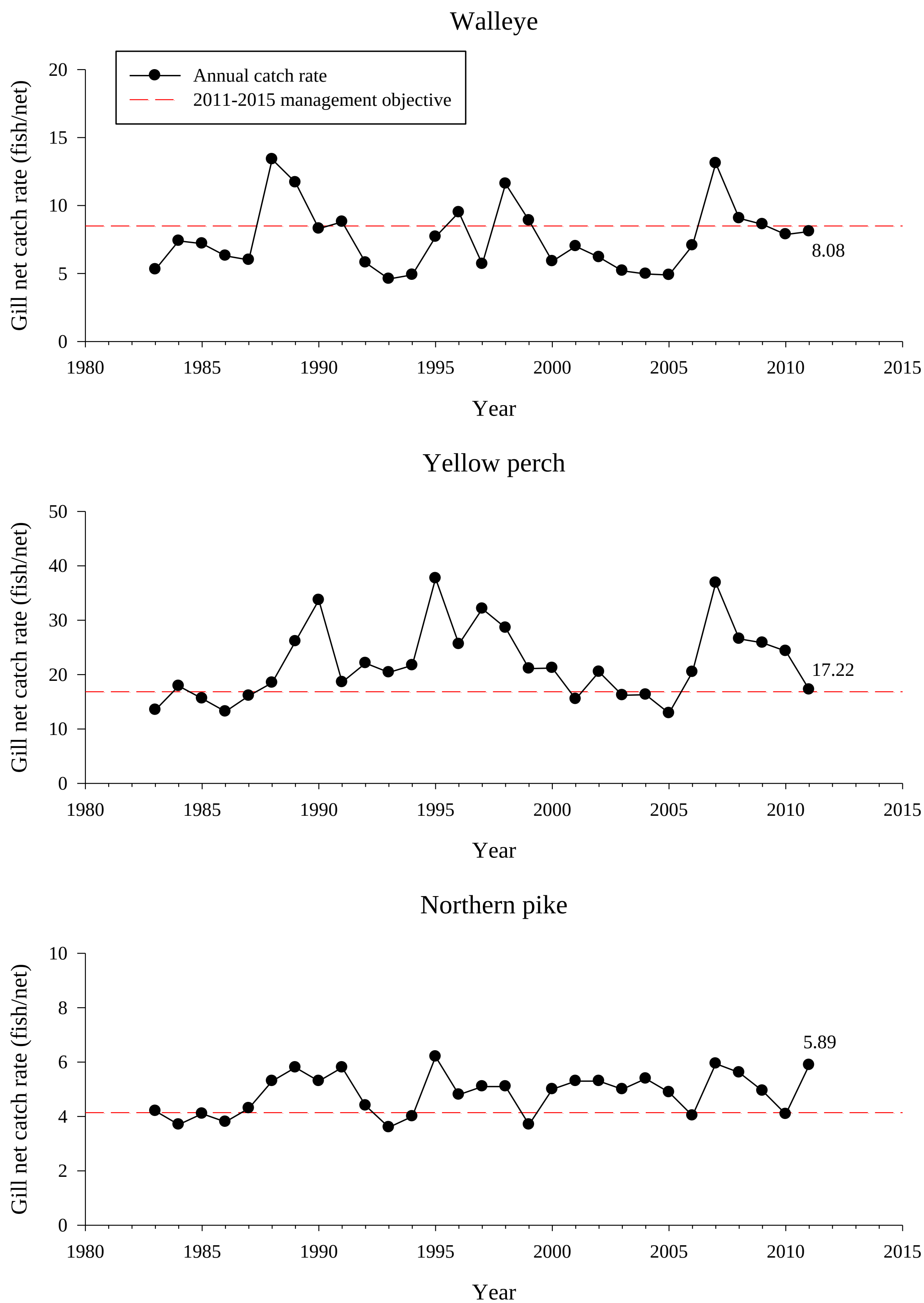


Figure 9. Gill net catch rates of walleye, yellow perch, and northern pike compared to 2011-2015 Leech Lake Management Plan objectives (Schultz 2010a).

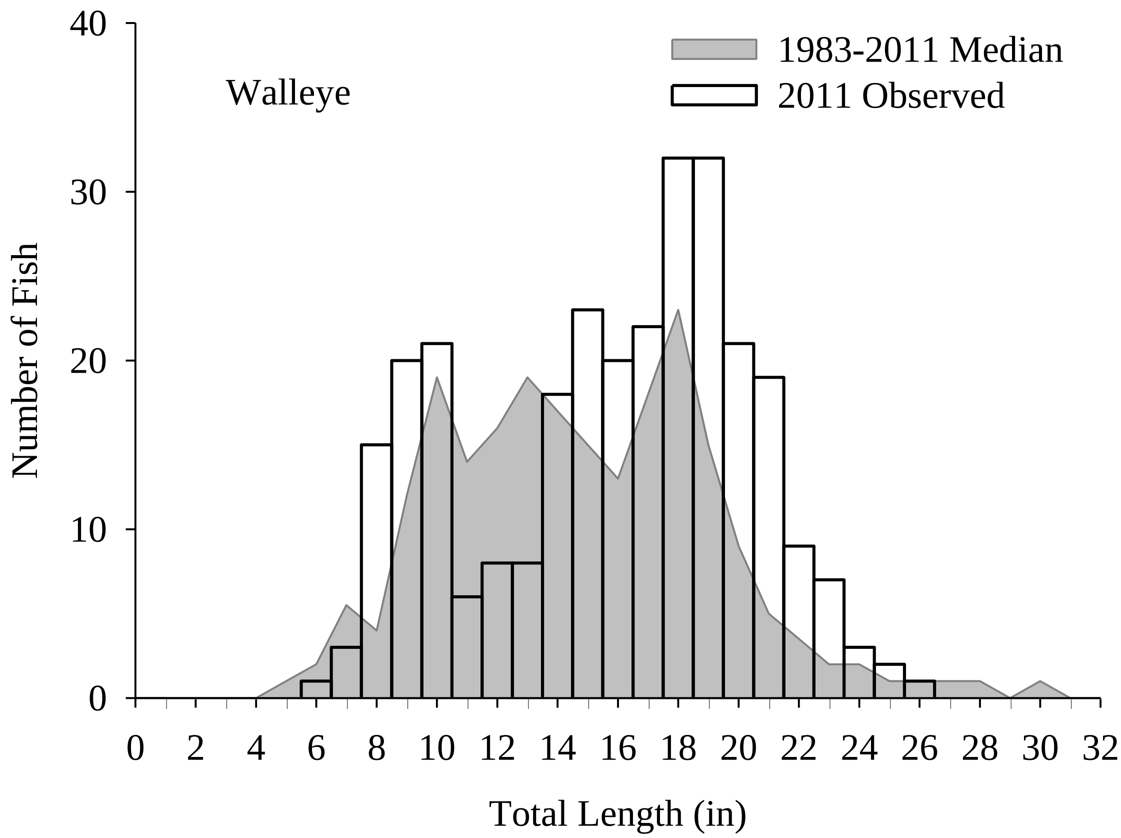


Figure 10. Length-frequency distribution of Leech Lake walleye sampled with experimental gillnets, 2011.

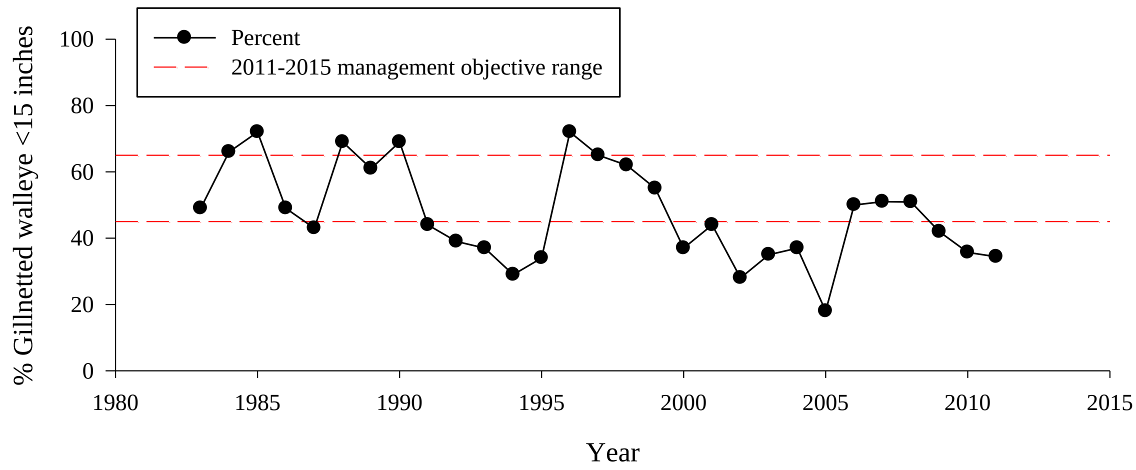


Figure 11. Proportion of gill net sampled walleye shorter than 15 inches relative to 2011-2015 Leech Lake Management Plan objectives (Schultz 2010a).

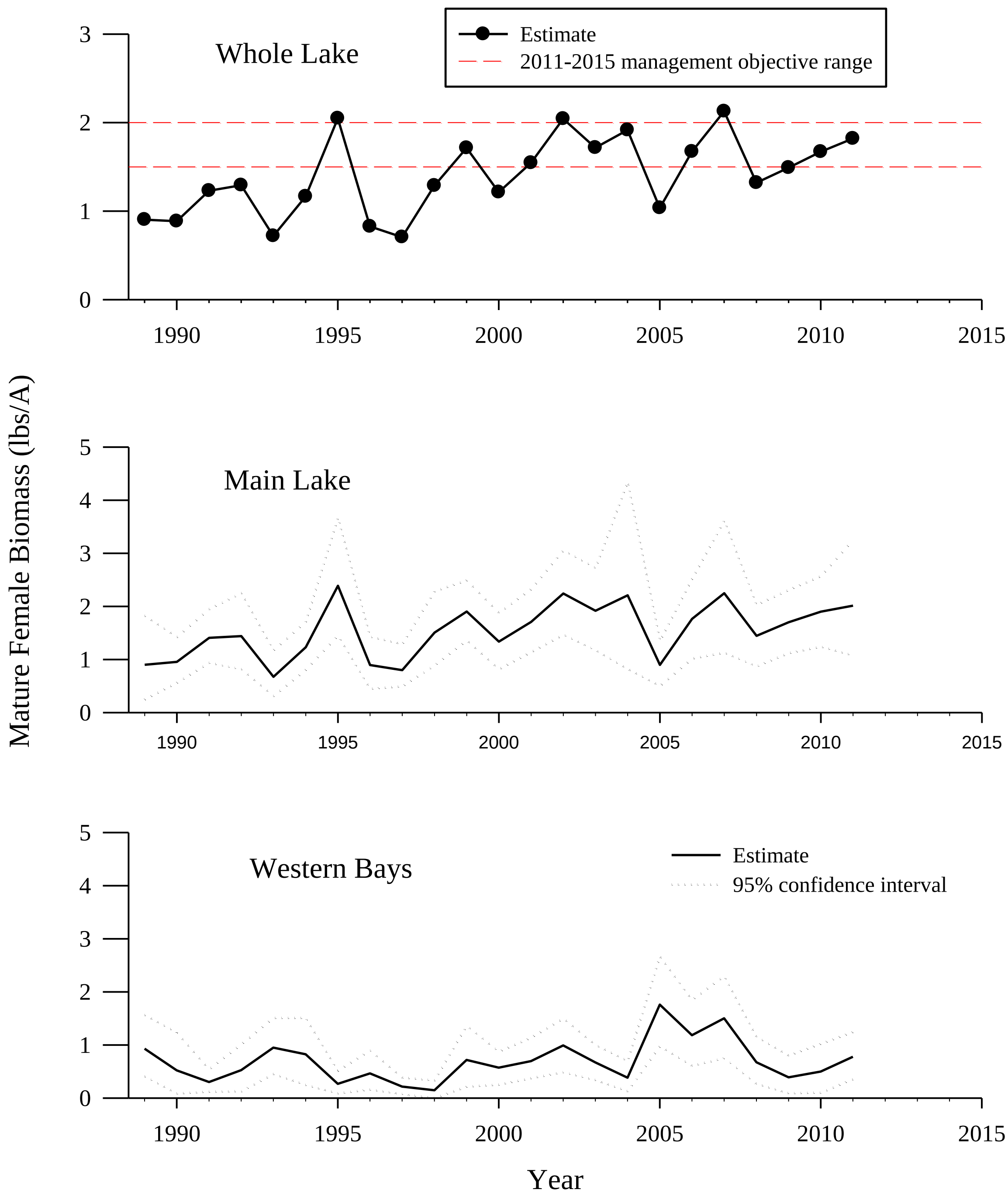


Figure 12. Estimated biomass (lbs/acre) of mature female walleye in Leech Lake, 1989-2011. Horizontal lines on the whole lake estimate (top) depict the current management objective range of 1.5-2.0 lbs/acre (Schultz 2010a). Basin-specific estimates are presented on the bottom two panels with 95% confidence intervals.

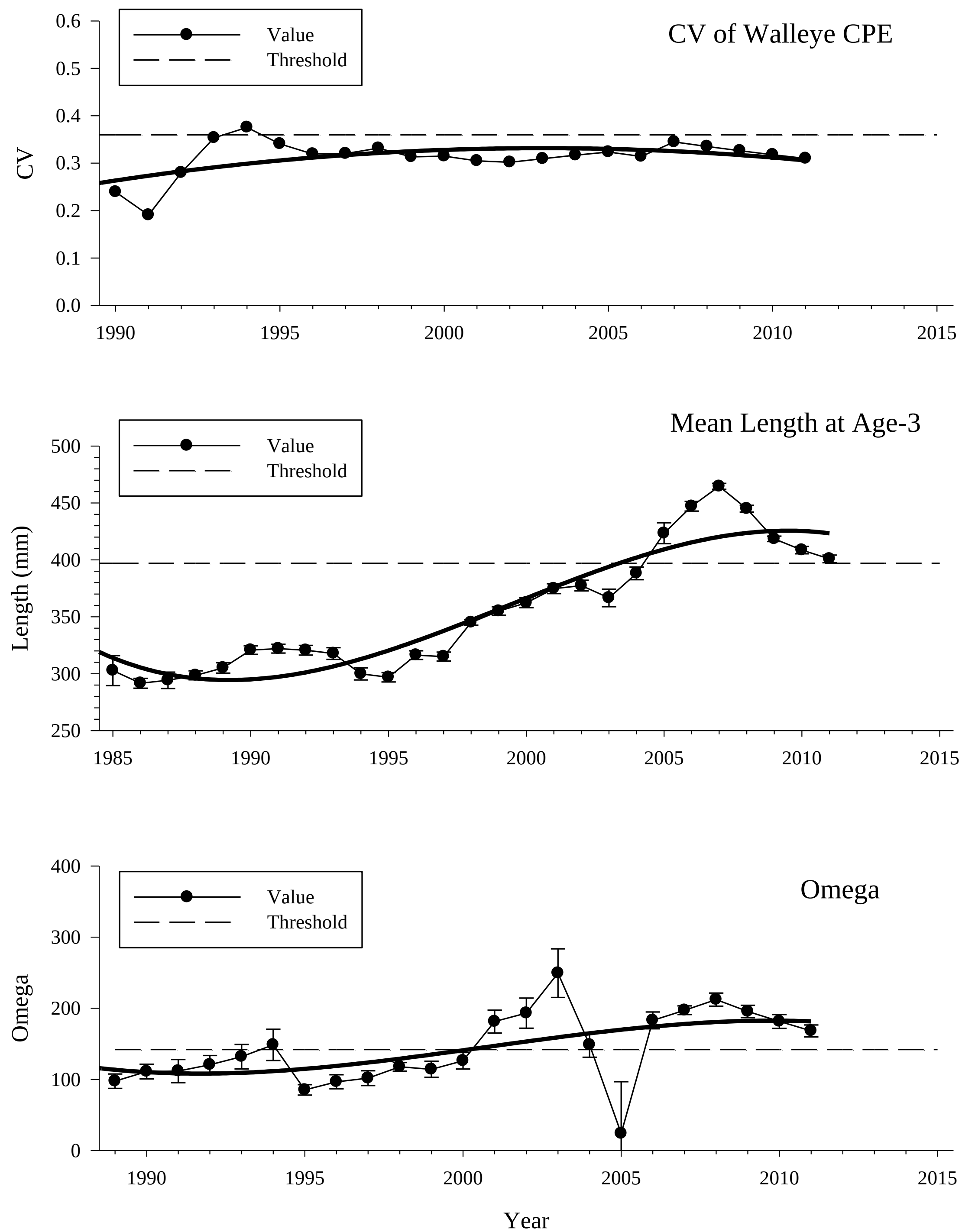


Figure 13. Coefficient of variation (CV) in gillnet catch-per-effort (CPE) of all walleye (top panel), mean length of all age-3 walleye sampled in experimental gillnets (middle panel), and omega values (bottom panel) for the Leech Lake walleye population. Values above the respective thresholds (dashed lines) indicate a potential population stress responses; error bars are standard error of the mean.

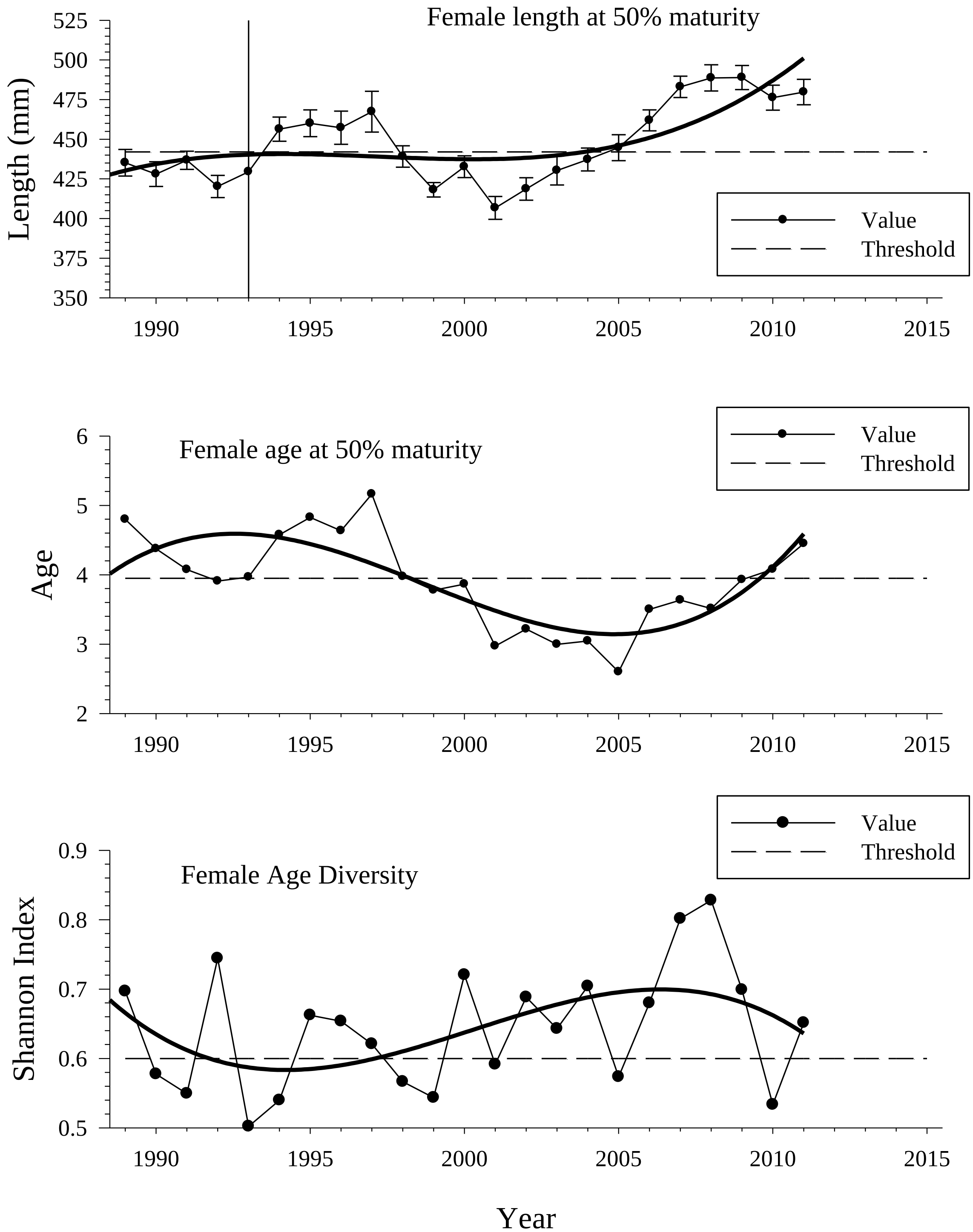


Figure 14. Mean length of female walleye at 50% maturity (top), estimated age of female walleye at 50% maturity (middle), and age diversity of female walleye sampled in experimental gillnets (bottom) from the Leech Lake walleye population. Values below the respective thresholds (dashed line) indicate a potential population stress response; error bars are standard error of the mean.

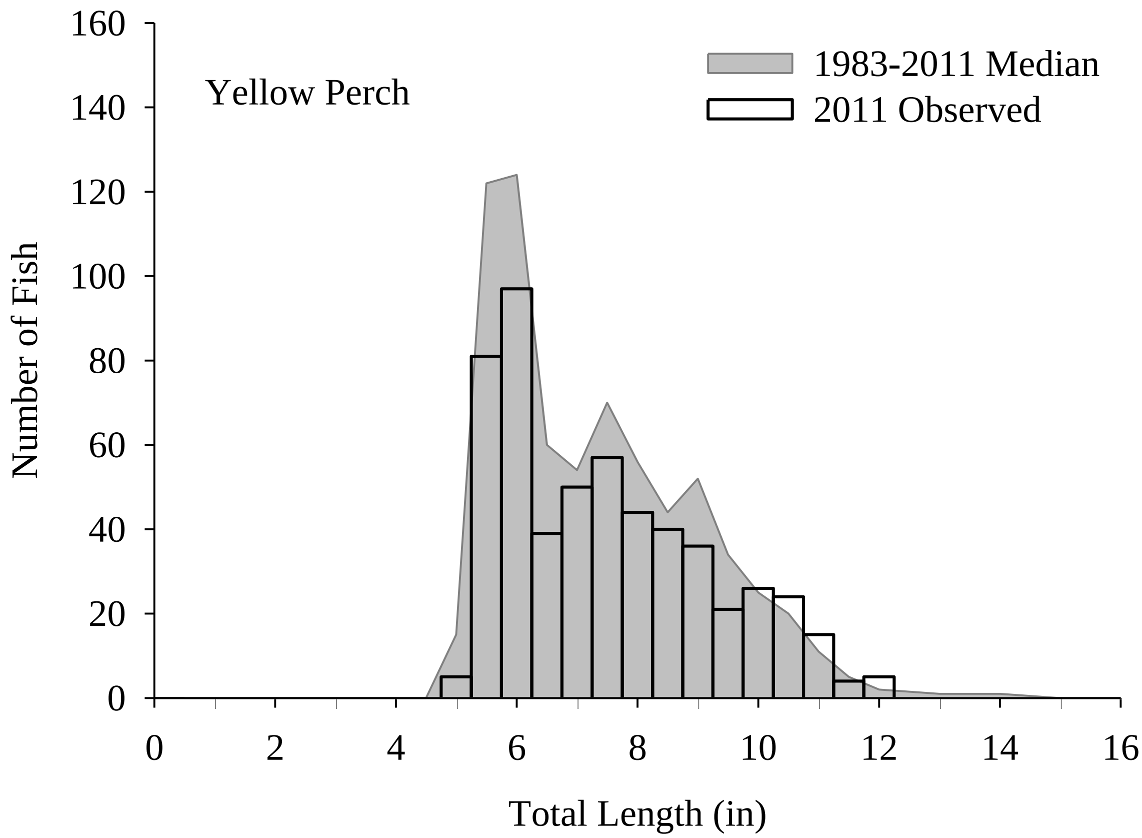
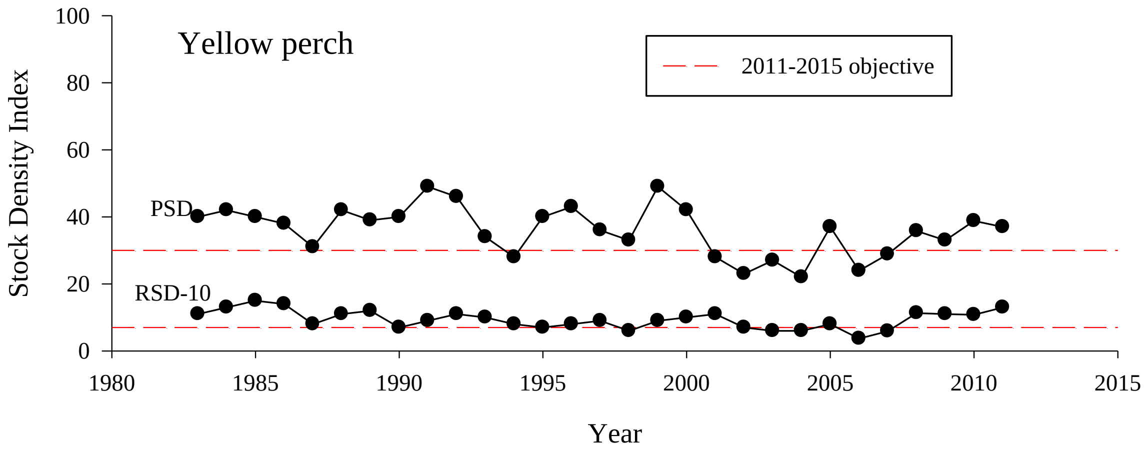


Figure 15. Length-frequency distribution of yellow perch sampled with experimental gillnets in Leech Lake, 2011.



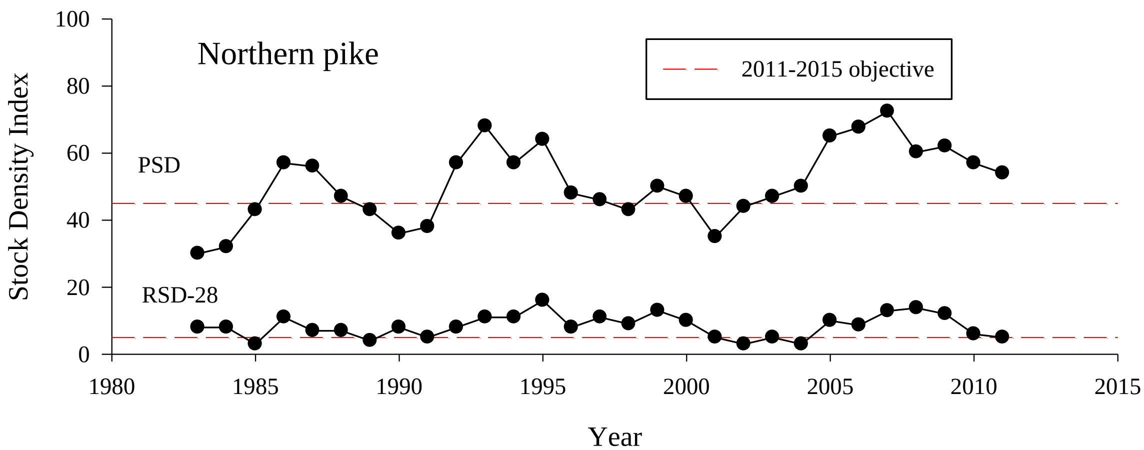


Figure 16. Size structure indices for yellow perch and northern pike relative to the 2011-2015 Leech Lake Management Plan (Schultz 2010a).

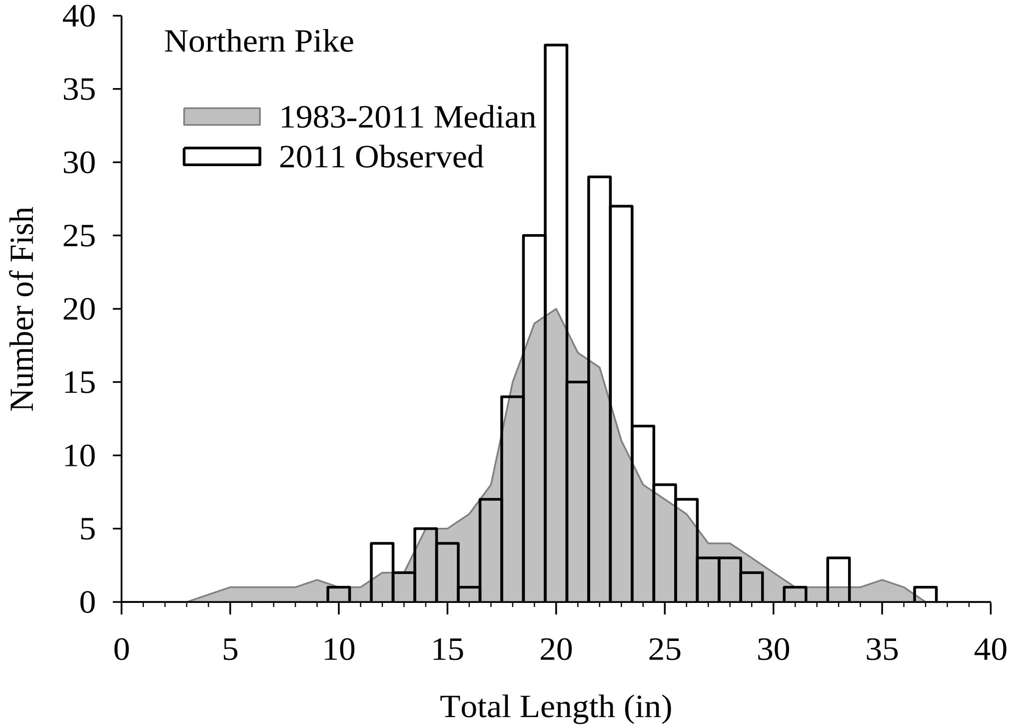


Figure 17. Length-frequency distribution of northern pike sampled with experimental gillnets in Leech Lake, 2011.

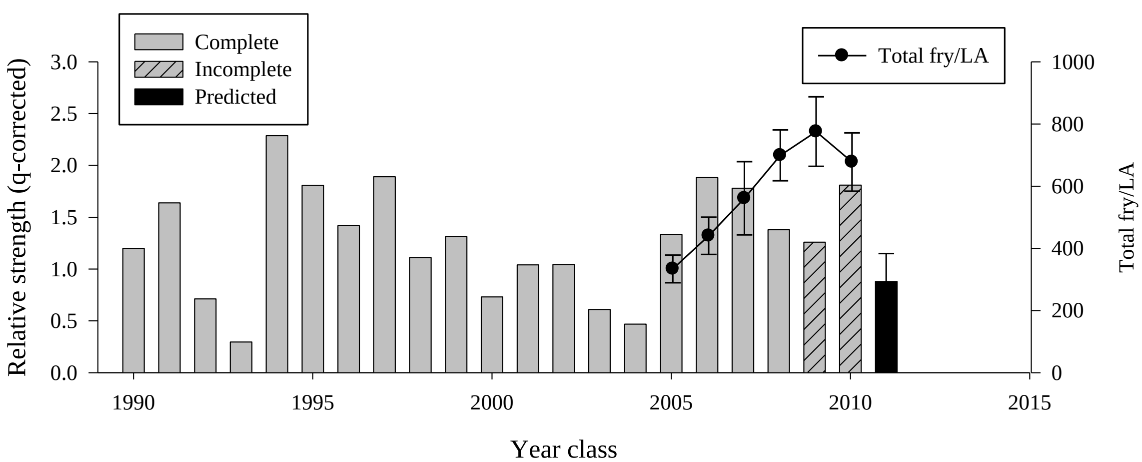


Figure 18. Year class strength index of walleye in Leech Lake (bars) and estimates of total walleye fry density (fry/littoral acre) of stocked cohorts (line), 1990-2010. Whiskers indicate respective 95% confidence intervals around fry estimates and the predicted strength of the 2011 year class. Respectively, walleye fry were stocked from 2005-2010 in the following amounts: 7.5, 22.0, 7.5, 22.1, 22.6, and 22.5 million.

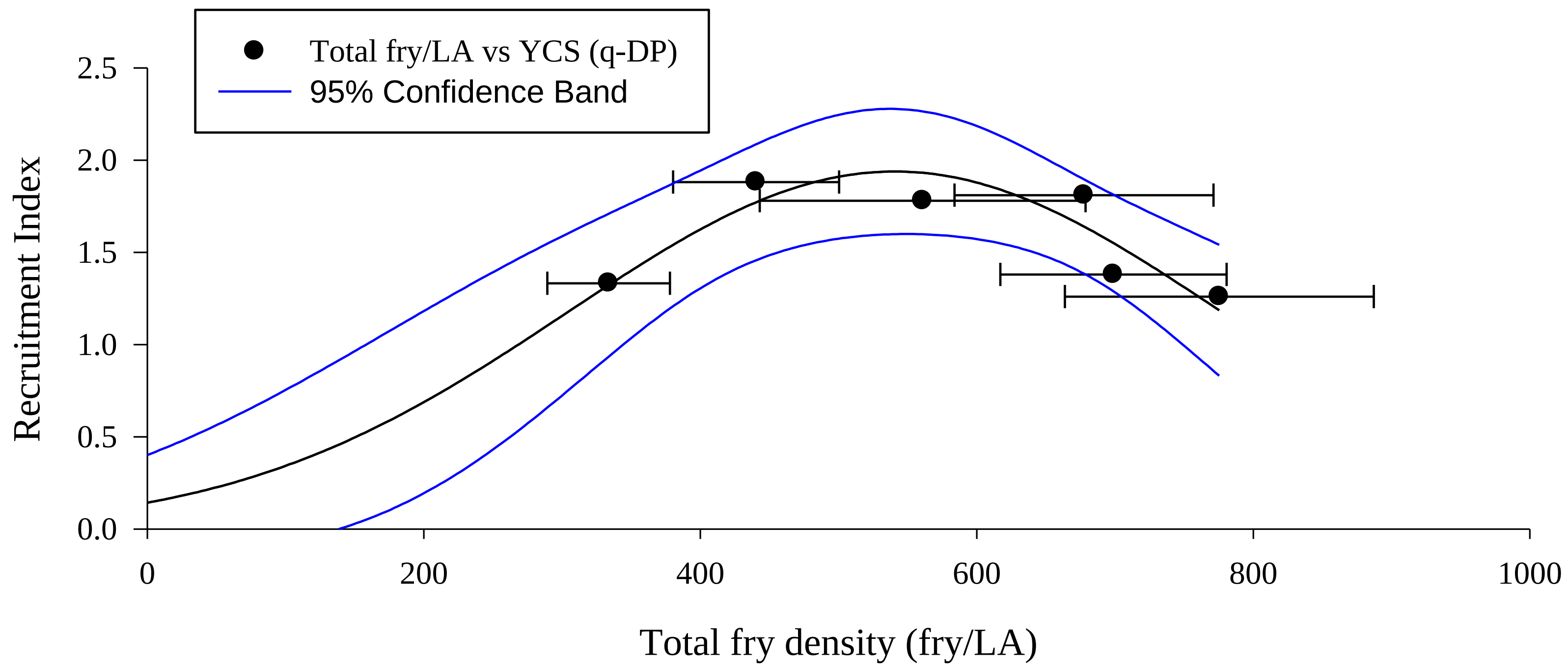


Figure 19. Comparison of the walleye recruitment index and the total fry density on Leech Lake, 2005-2010.

NOT COMPLETED IN 2011 DUE TO STATE SHUTDOWN

Figure 20. Temperature and oxygen profiles in Leech Lake, 2011.

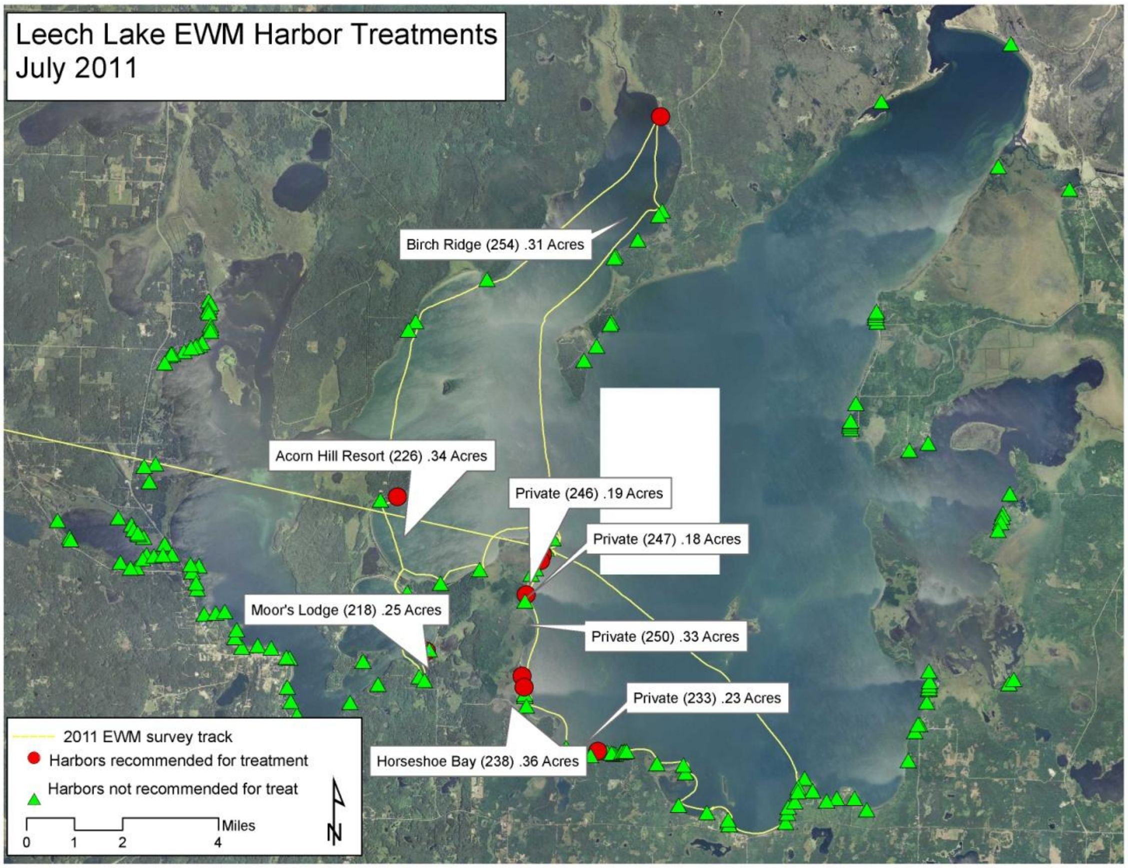


Figure 21. Leech Lake boat harbors where Eurasian watermilfoil was identified and chemically treated during July 2011.

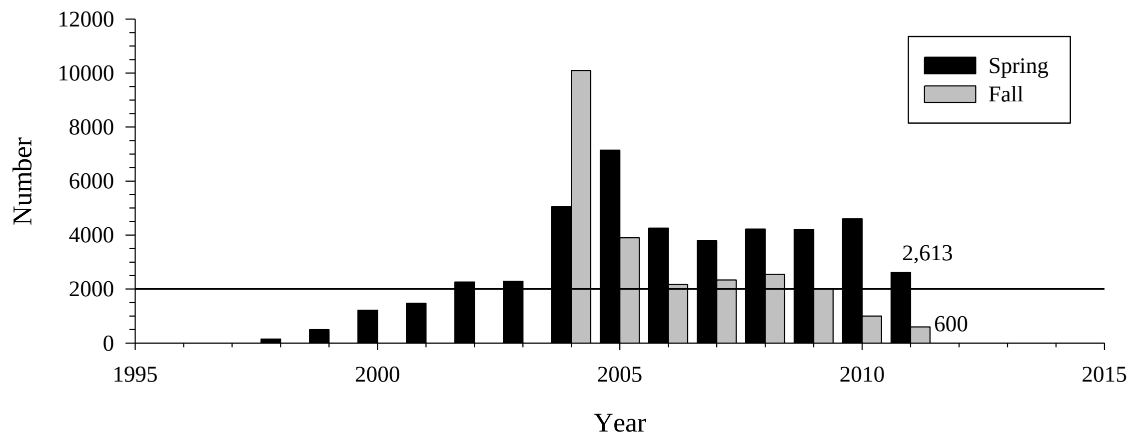


Figure 22. Spring and fall double-crested cormorant numbers on Leech Lake, 1998-2010. The line depicts the current fall population goal of 2,000 birds ([500 nesting pairs x 2 adults] + 2 offspring/nest). (S. Mortensen, Division of Resource Management, Leech Lake Band of Ojibwe, personal communication).

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	
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					
2005		12.33	16.16	18.33	19.60	21.15	21.02				
2006	7.33	12.02	14.54	16.49	19.23	20.72					
2007	7.58	10.71	13.57	16.24	18.38						
2008		8.82	12.32	15.18							
2009		9.74	13.22								
2010		9.32									
2011											
Mean	7.29	10.51	13.28	15.69	17.90	19.25	20.14	21.70	22.51	23.72	23.60

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	
2003		12.03	14.65	17.24	18.15	20.71		19.67			
2004		11.61	16.69	18.31		18.90		19.09			
2005	6.57	12.32	15.74	17.45	17.90	18.75	19.55				
2006	7.41	12.01	14.26	16.22	17.61	18.78					
2007	7.34	10.63	13.35	15.75	16.98						
2008		8.88	12.91	15.32							
2009	5.16	9.78	13.31								
2010	6.80	9.67									
2011	6.42										
Mean	6.93	10.52	13.37	15.34	16.56	17.89	18.67	19.18	19.61	20.34	20.89

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		
2003		10.61	13.87	17.24	19.44	20.39	21.42		24.06		
2004		10.37	14.09	17.03			18.86	21.54			
2005		11.47	14.67	16.34	18.99	21.15	21.33				
2006		10.71	13.55	14.98	17.65	19.45					
2007	7.01	9.57	11.77	14.53	17.30						
2008		9.27	11.60	15.13							
2009		9.96	12.07								
2010		9.08									
2011											
Mean	7.29	9.74	12.28	14.30	16.40	18.34	19.41	20.60	22.12	22.31	22.52

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			
2004		10.13	14.00					18.70			
2005		10.81	14.28	16.19	16.50	15.83					
2006	6.75	11.15	12.62	14.12	16.71	17.87					
2007	7.52	10.17	11.77	14.72	16.15						
2008		8.98	11.81	14.17							
2009		9.53	11.67								
2010		9.28									
2011											
Mean	6.94	9.58	12.10	14.02	15.78	17.05	17.83	18.75	18.97	19.06	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		
2004			6.32	7.33	8.40	9.14	9.90	11.23			
2005		5.39	6.39	7.56	8.63	9.50	9.95				
2006			5.93	6.99	9.15	9.78					
2007		5.76	5.84	7.36	8.78						
2008			6.20	7.98							
2009			6.35								
2010											
2011											
Mean	-	5.58	5.92	6.55	7.70	8.63	9.44	10.15	10.56	10.94	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			
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				
2006			6.06	6.31	7.46	8.48					
2007		5.81	5.51	6.37	7.74						
2008			5.92	6.76							
2009			5.86								
2010											
2011											
Mean	-	5.51	5.72	6.12	7.02	7.89	8.60	8.74	9.30	9.53	9.82

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		
2004			6.02	6.54	6.99	8.12	9.76	10.62			
2005			6.11	6.51	7.23	8.80	10.30				
2006			5.81	6.62	8.28	8.61					
2007		6.34	5.69	6.60	7.46						
2008			6.59	6.60							
2009			6.17								
2010											
2011											
Mean	-	6.34	5.85	6.26	7.09	8.07	9.14	9.98	10.49	10.76	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				
2006			6.32	6.00	7.40	7.31					
2007			5.66	6.60	6.73						
2008			6.30	6.17							
2009		5.41	5.95								
2010											
2011											
Mean	-	5.41	5.72	6.08	6.78	7.57	8.49	8.89	9.38	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			
2005		17.31	20.49	24.53	25.06	29.79	26.17				
2006		17.17	20.39	24.16	25.12	25.49					
2007		17.32	20.60	24.26	24.99						
2008	8.50	15.80	21.90	22.91							
2009		18.54	19.92								
2010		15.85									
2011											
Mean	9.30	16.77	20.59	22.52	24.45	26.29	28.35	29.87	30.86	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			
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				
2006			18.84	20.69	20.74	22.51					
2007		15.90	19.68	21.37	22.57						
2008			19.74	20.81							
2009		17.52	18.86								
2010	8.98	14.81									
2011											
Mean	9.73	15.69	18.38	20.42	21.44	22.00	22.71	23.41	22.62	23.56	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					
2006	10.45	14.89	19.54	22.49	25.72	26.42					
2007		14.41	18.90	22.15	24.01						
2008		15.93	20.27	22.18							
2009	13.46	16.78	19.84								
2010	9.53	14.35									
2011											
Mean	10.23	15.28	18.78	21.40	24.29	25.60	28.02	29.86	30.67	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					
2007		13.33	17.52	20.00	22.22						
2008		17.17	18.49	19.76							
2009	11.26	15.64	19.13								
2010		12.78									
2011											
Mean	9.85	14.53	17.58	19.53	20.42	21.87	21.67	23.24	23.85	24.52	24.70

Table A13. Gillnet catch-per-effort (fish/net) by species for Leech Lake, 1983-2011.

	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, 1983-2011.

	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, 1983-2011.

	Year									Quartiles	
Species	2007	2008	2009	2010	2011	Min	Max	Median	Mean	First	Third
Black bullhead	1.89	1.14	0.31	0.31	0.17	0.17	21.33	2.50	5.53	1.14	9.80
Black crappie	1.72	0.89	1.14	0.58	0.47	0.11	1.72	0.31	0.41	0.19	0.50
Bluegill	1.14	1.19	1.11	0.58	0.69	0.00	2.08	0.33	0.50	0.11	0.69
Bowfin	0.11	0.08	0.08	0.06	0.14	0.00	0.33	0.06	0.07	0.03	0.10
Brown bullhead	4.25	1.97	0.64	1.89	0.61	0.58	4.25	1.50	1.65	0.91	2.08
Burbot	0.06	0.00	0.00	0.03	0.00	0.00	0.17	0.06	0.05	0.03	0.08
Hybrid sunfish	0.00	0.00	0.00	0.00	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	0.36	0.03	0.06	0.00	0.06
Largemouth bass	0.22	0.08	0.11	0.11	0.08	0.00	0.44	0.08	0.10	0.03	0.11
Muskellunge	0.03	0.00	0.06	0.06	0.06	0.00	0.25	0.03	0.04	0.00	0.06
Northern pike	5.94	5.61	4.94	4.08	5.89	3.58	6.17	4.97	4.84	4.08	5.33
Pumpkinseed	1.33	1.47	0.67	0.28	0.31	0.09	2.06	0.67	0.77	0.33	1.10
Rock bass	1.33	2.39	2.17	1.03	1.33	0.39	2.89	1.33	1.58	1.06	2.11
Shorthead redhorse	0.03	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	0.03	0.00	0.00	0.00	0.00
Tiger muskellunge	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	0.64	18.47	4.23	5.53	2.11	6.67
Walleye	13.11	9.06	8.61	7.86	8.08	4.61	13.39	7.22	7.63	5.80	8.81
White sucker	0.72	0.61	1.08	0.64	1.14	0.61	3.12	1.42	1.53	1.08	1.97
Yellow bullhead	4.22	2.56	1.36	2.75	1.00	0.33	4.22	1.36	1.56	0.91	2.17
Yellow perch	36.86	26.56	25.83	24.31	17.22	12.89	37.66	20.50	21.94	16.28	25.83
Total fish/set	76.97	55.28	60.06	50.56	39.14	36.33	78.01	52.02	53.79	42.64	60.06
Total sets	36	36	36	36	36						

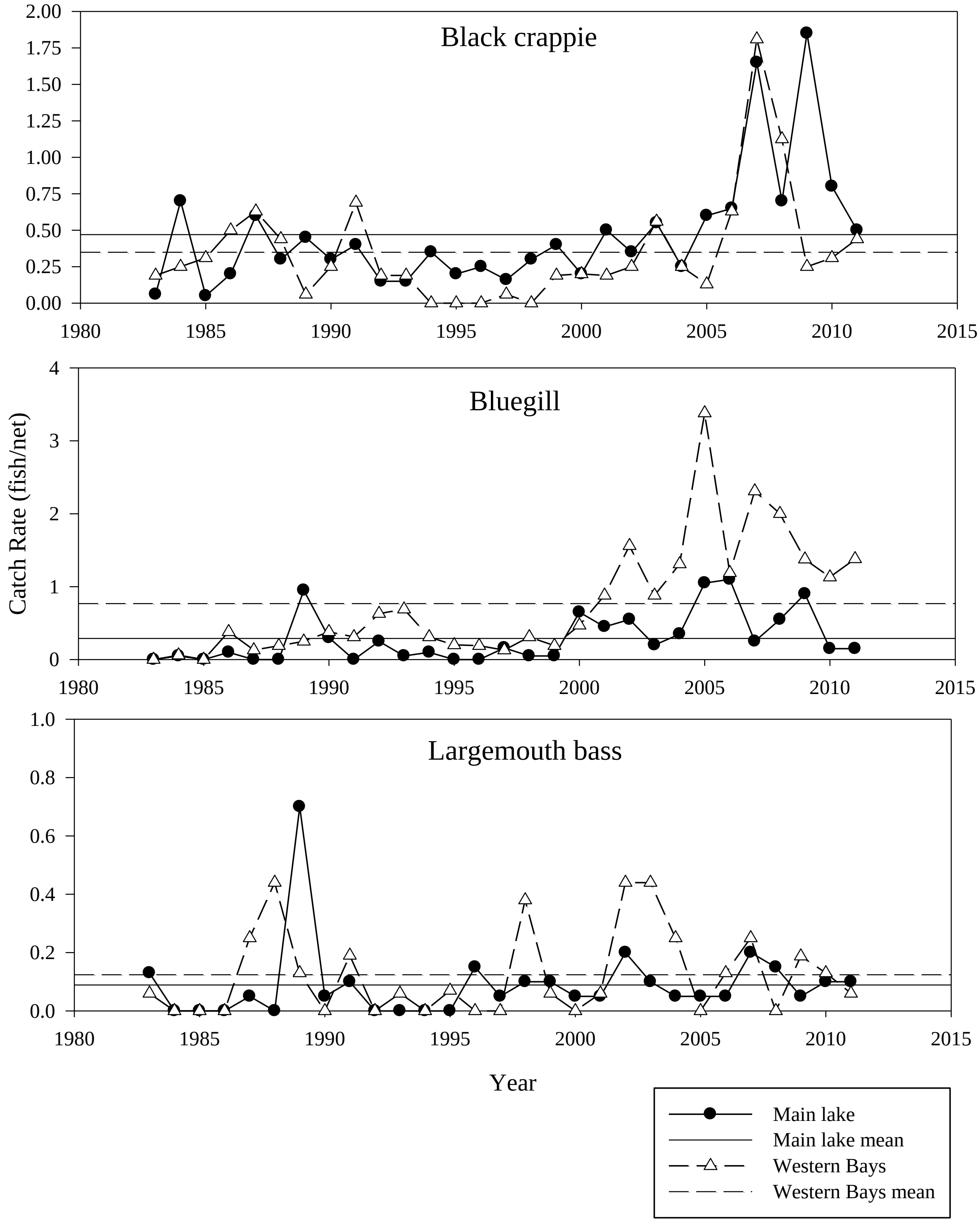


Figure A1. Basin-specific gillnet catch rates (fish/net) of selected species in Leech Lake, 1983-2011.

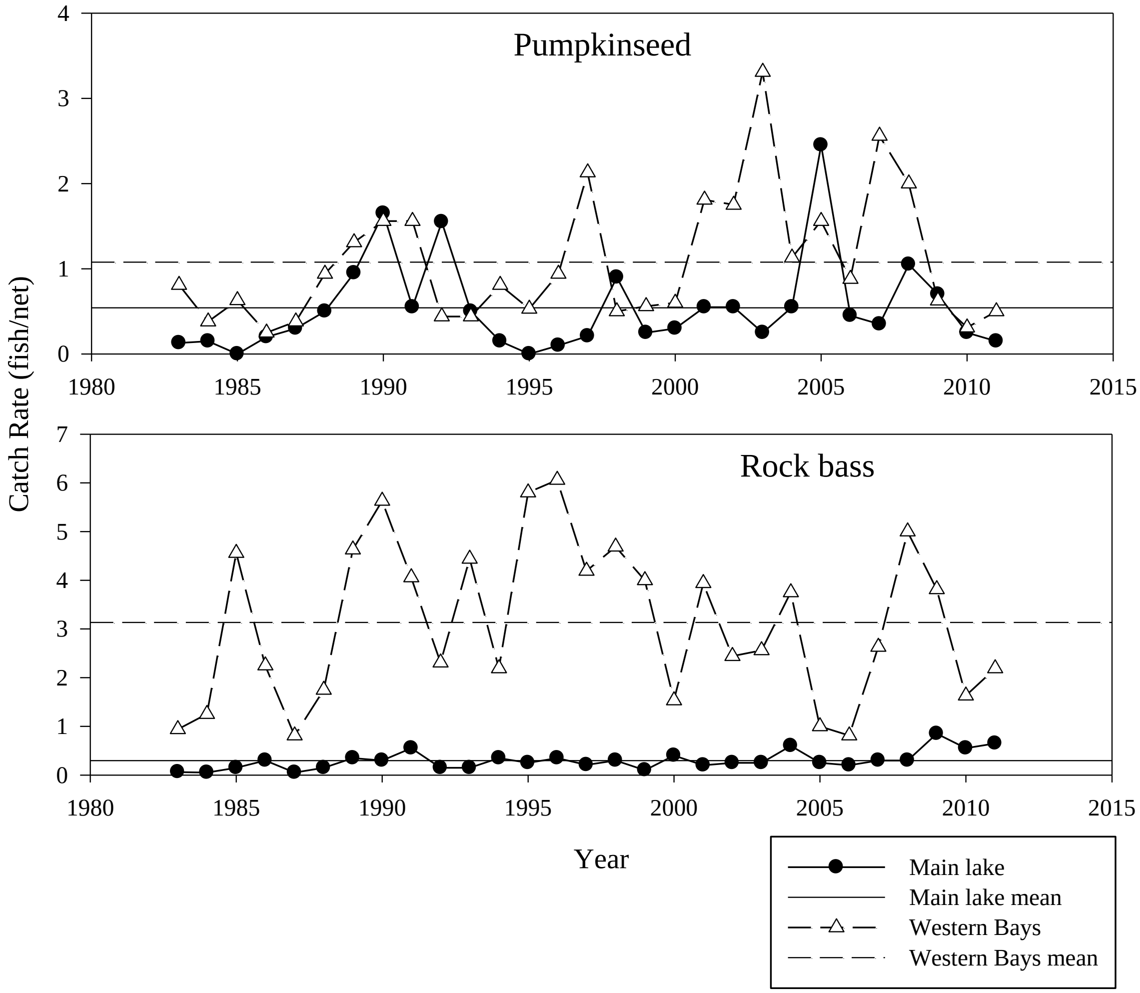


Figure A1, continued. Basin-specific gillnet catch rates (fish/net) of selected species in Leech Lake, 1983-2011.

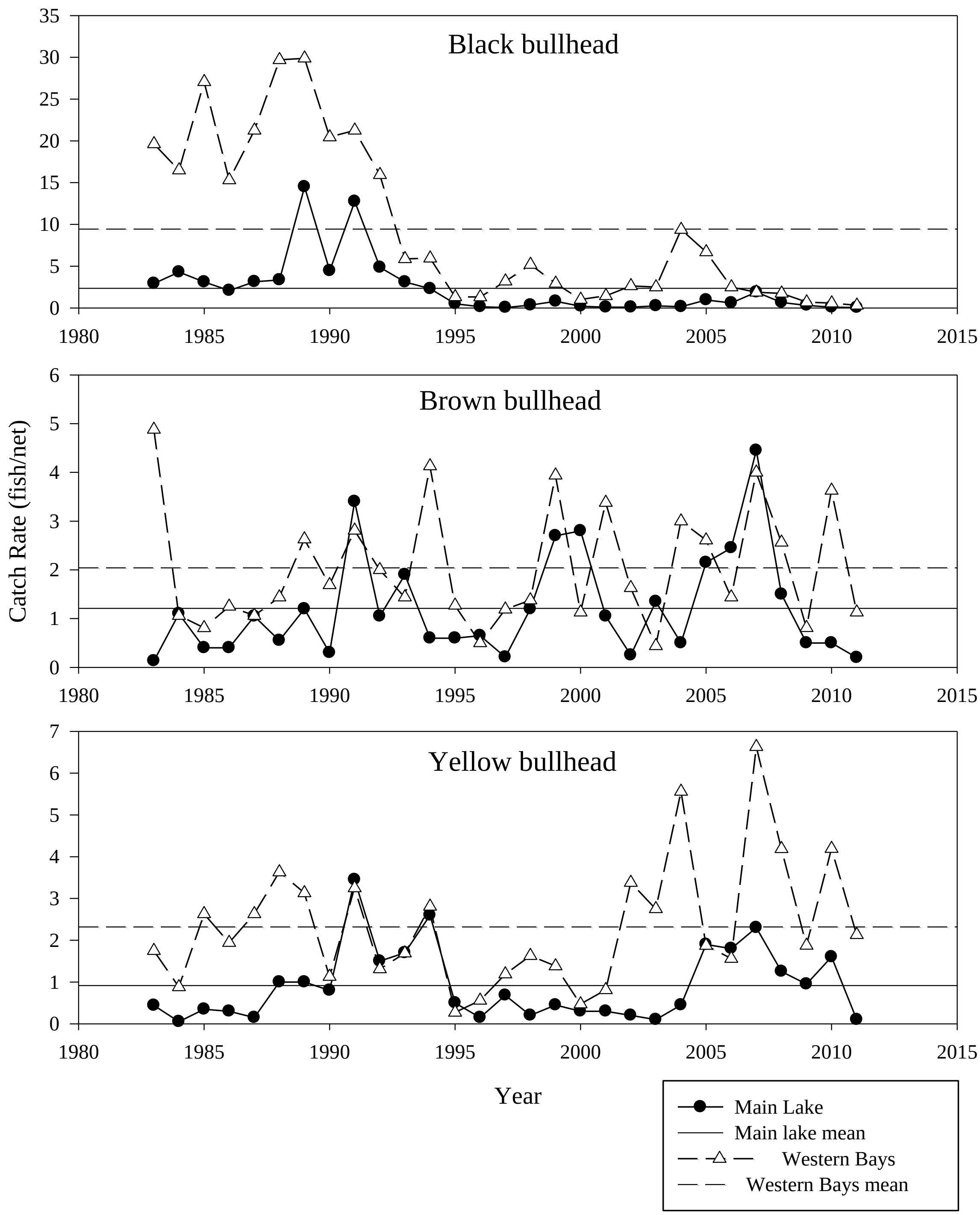


Figure A1, continued. Basin-specific gillnet catch rates (fish/net) of selected species in Leech Lake, 1983-2011.

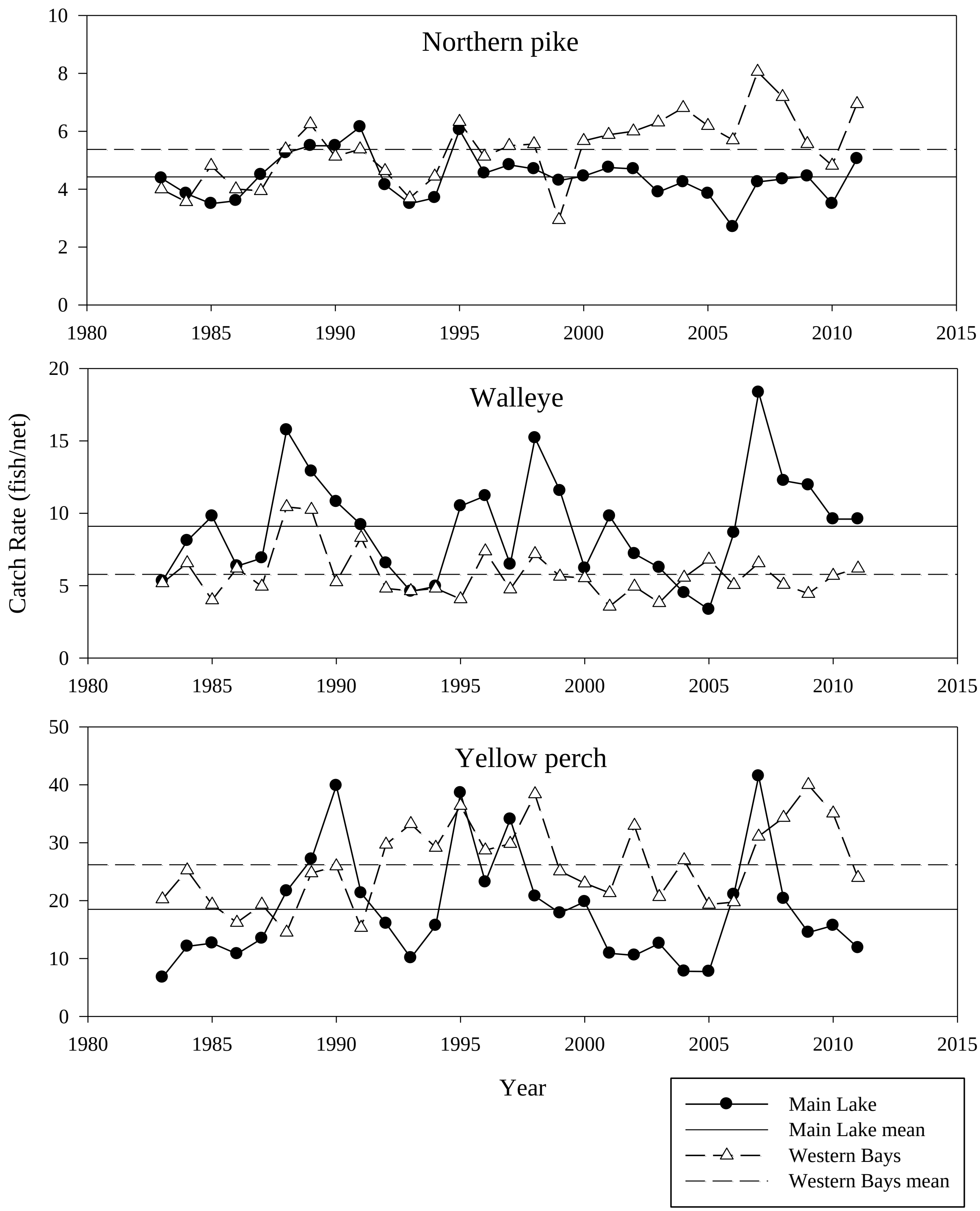


Figure A1, continued. Basin-specific gillnet catch rates (fish/net) of selected species in Leech Lake, 1983-2011.

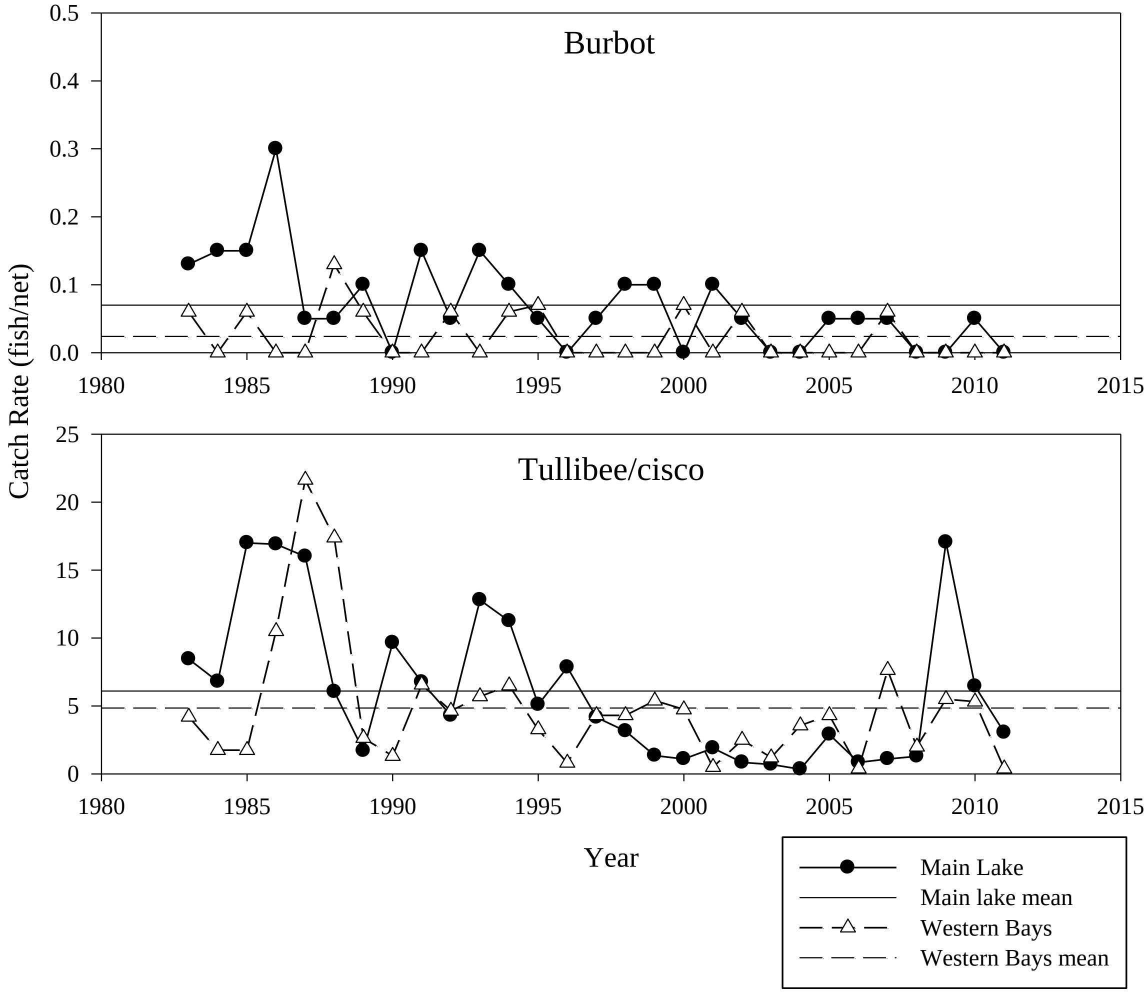


Figure A1, continued. Basin-specific gillnet catch rates (fish/net) of selected species in Leech Lake, 1983-2011.

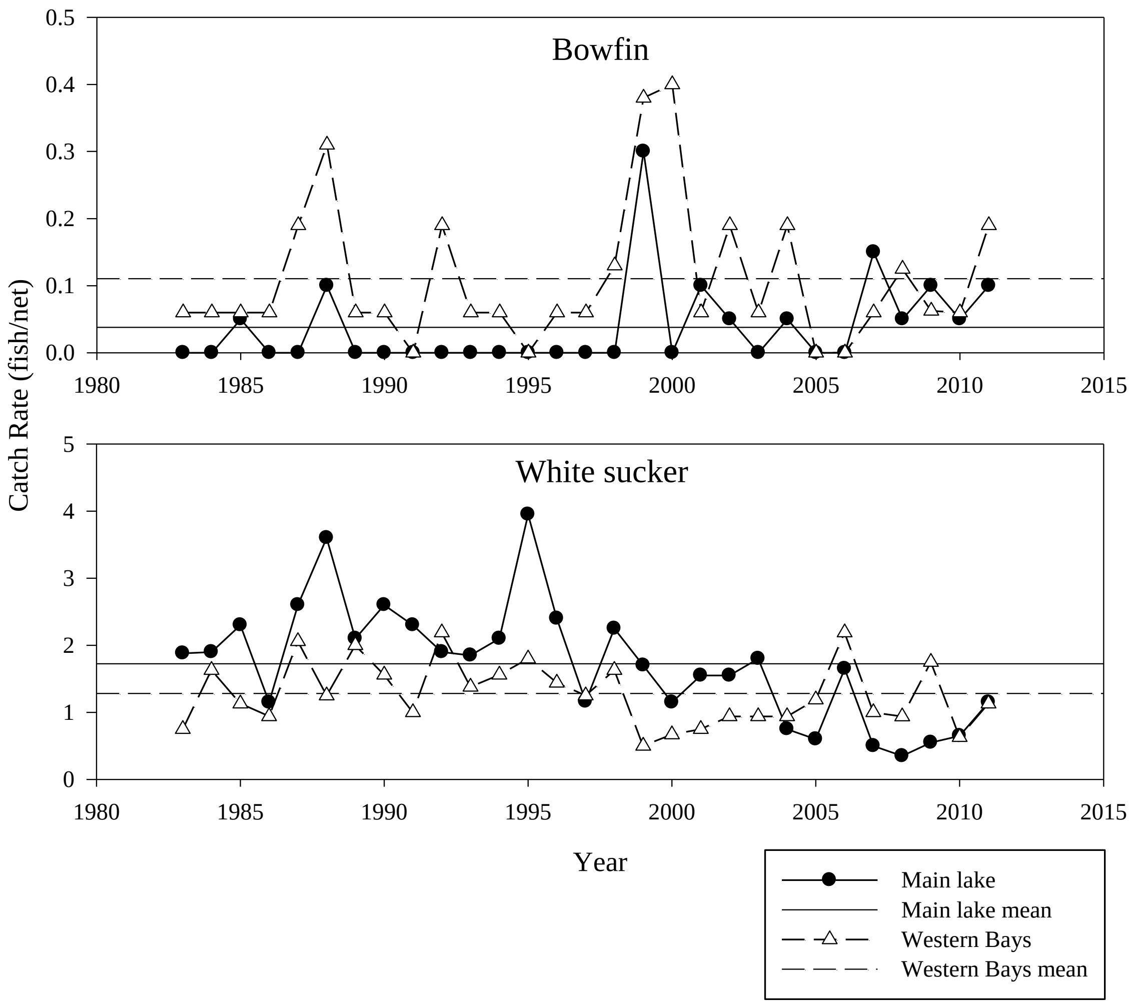


Figure A1, continued. Basin-specific gillnet catch rates (fish/net) of selected species in Leech Lake, 1983-2011.