Fishery Survey – Middle Eau Claire Lake
Bayfield County, 2004-2005
WBIC Code – 2742100

Scott Toshner
Senior Fisheries Biologist
Wisconsin Department of Natural Resources
Northern Region - Brule
March, 2006

Executive Summary

The fisheries of Middle Eau Claire Lake (Bayfield County) were surveyed during 2004-2005. Results indicated adult walleye abundance (≥ 15 in and sexable fish) was 4.5 adults/acre, similar to previous surveys on Middle Eau Claire Lake and higher than the Bayfield/Douglas County average for naturally recruiting walleye lakes, and the statewide management objective of 3.0 adults/acre. The walleye size structure has changed significantly between survey periods but has consistently included lower mean lengths. Muskellunge and northern pike were both present in low abundance. Smallmouth and largemouth bass densities were both 0.2 fish/acre and were considered low. Bluegill relative abundance from 2004 has declined by 58% since 1983, however average length of bluegill has increased. Angling pressure during the 2004-2005 fishing season was 21.9 hr/acre which was near average for Bayfield and Douglas County creel surveys. Walleye and muskellunge were the most sought after gamefish species (34% and 11% respectively of directed effort). Anglers harvested 1,299 walleye and tribal spearers harvested 217 walleye in 2004-2005. Estimated exploitation (sport angling plus tribal spearing) of walleye ≥ 15 in and sexable was 30.2%. Management recommendations include, 1) Maintaining existing walleye regulations (no minimum size limit only one fish over 14 in may be kept) and exploring alternate regulations through modeling and literature research, 2) Maintaining stocking of marked muskellunge to evaluate stocking success and natural recruitment, 3) Maintaining existing bass regulation due to current low exploitation by anglers, 4) Implementing a regulation change of 10 panfish/day should be considered to prevent over harvest of a declining population of bluegill, 5) Working with local residents, associations and groups to develop a lake management plan and aquatic plant management plan that addresses fisheries management goals, habitat protection and rehabilitation as well as education of users and riparian residents.

Introduction

Middle Eau Claire Lake is a 902 acre soft water drainage lake on the Eau Claire Lakes Chain in the southwestern section of Bayfield County. The Eau Claire River runs through the chain from Upper to Middle to Lower Eau Claire Lake. In addition, Bony Lake drains into Middle Eau Claire Lake. Maximum depth of Middle Eau Claire Lake is 66 feet with a mean depth of 17 feet and total alkalinity of 63 mg/L. The lake has a highly developed shoreline and public access through a boat landing located at the southeast end of the lake. Historically Middle Eau Claire Lake was considered an outstanding waterfowl lake (Weiher 1968). Average summer secchi disk depth trophic state index (TSI) value for the deep hole on Middle Eau Claire Lake was 34.7 (SD = 3.47, N = 141), for the time period between 1987 and 2004. Average summer chlorophyll-a and total phosphorus TSI values for the deep hole on Middle Eau Claire Lake were 41.6 (SD = 4.27, N = 10) and 49.3 (SD = 3.04, N = 11) for the time period between 2002 and 2004. TSI is an index for evaluating trophic state or nutrient condition of lakes. TSI values can be computed for water clarity (secchi disk measurements), chlorophyll-a, and total phosphorus values. TSI values represent a continuum ranging from very clear, nutrient poor water (low TSIs) to extremely productive, nutrient rich water (high TSIs). The data on Middle Eau Claire Lake indicate the nutrient condition was mesotrophic when considering total phosphorus and chlorophyll-a TSI indices and oligotrophic for secchi disk TSI index.

Middle Eau Claire Lake has a diverse fishery consisting of walleye *Sander vitreus*, muskellunge *Esox masquinongy*, northern pike *E. lucius*, largemouth bass *Micropterus salmoides*, smallmouth bass *M. dolomieui*, bluegill *Lepomis macrochirus*, pumpkinseed *L. gibbosus*, warmouth *L. gulosus*, rock bass *Ambloplites rupestris*, black crappie *Pomoxis nigromaculatus*, yellow perch *Perca flavescens*, white sucker *Catostomus commersoni*, yellow

bullhead *Ictalurus natalis*, black bullhead *I. melas*, brown bullhead *I. nebulosus*, golden redhorse *Moxostoma erythrurum*, logperch *Percina caprodes*, iowa darter *Etheostoma exile*, least darter *E. microperca*, brook silverside *Labidesthes sicculus*, bluntnose minnow *Pimephales notatus*, common shiner *Notropis cornutlus*, mimic shiner *N. volucellus*, blackchin shiner *N. heterodon*, and spottail shiner *N. hudsonius*.

Historic management of Middle Eau Claire Lake has included fishery surveys, stocking, and various length and bag regulations. Historic surveys for walleye occurred in 1993 and 1998 utilizing Wisconsin Department of Natural Resources (WDNR) standardized treaty protocols (Hennessey 2002). A walleye survey was also conducted in 1983 by WDNR which attempted to calculate a population estimate using the Chapman modification of the Petersen estimator. However, the recapture rate was low and the Schnabel method needed to be used to estimate the walleye population. Additional walleye surveys were conducted in 1991 and 1996 using a different sampling protocol, i.e. electrofishing to both mark and recapture walleye for a population estimate.

Middle Eau Claire Lake has a long stocking history (Table 1) and has been stocked with a number of fish species, including walleye, muskellunge, largemouth bass and various panfish species, since at least 1933. From 1951 to 1965, it received only walleye, between 1965 and 1982 there was no stocking due to evidence of adequate natural reproduction of all species present (Weiher 1968). Rainbow trout were also stocked in 1985, 1988 and 1991 and discontinued thereafter due to poor returns to creel (Scholl 1994). Walleye stocking began again in 1982 with fry and in alternate years with fingerlings starting in 1987. Walleye stocking in 1987 was initiated because the 1983 population estimate indicated that densities were below the 3 adult/acre statewide management objective. Walleye stocking was discontinued after 1993 due to increased density of adults and adequate natural reproduction (Scholl 1994). In 1984 muskellunge stocking began in an attempt to introduce an additional

shallow water predator to help control abundant slow growing panfish (Schram 1984). Muskellunge were stocked on an annual basis from 1987 to 1998 with the exception of 1994 and 1995, when no muskellunge were stocked, due to hatchery renovations in Spooner. Since 2000, muskellunge have been stocked on an alternate year basis.

Walleye fishing regulations have changed over time in Middle Eau Claire Lake. There was no minimum length limit for walleye until 1990 when a 15 in minimum length limit was instituted statewide. A no length limit, but only one walleye over 14 in bag limit was instituted in 1997 when survey data indicated that there was a high density, slow growing population which had a suspected high natural mortality rate (Scholl 1994). The new regulation intended to focus harvest on abundant smaller walleye and provide some measure of protection to larger walleye. Bag limits for walleye have been adjusted annually according to tribal harvest declarations that began in 1988. Muskellunge regulations for minimum length increased from 30 in to 32 in in 1983 and a 40 in in 1996. With the exception of walleye and muskellunge, other fish species have largely been managed via statewide length and bag limits.

Recent management has focused on muskellunge stocking, regulation changes, public outreach and education and habitat protection/enhancement. Rusty crayfish *Orconectes rusticus,* have been present in Middle Eau Claire Lake since at least the 1980s, however it has not been well documented when they first entered the lake. Rusty crayfish, from anecdotal accounts, have reduced the amount of aquatic vegetation dramatically. In an effort to mimic habit that was once provided by the aquatic plant communities 84 fish cribs were installed between 1988 and 2002.

The objective of the 2004-2005 survey was to determine the status of the walleye, muskellunge, northern pike, largemouth and smallmouth bass populations, along with sport and tribal use of these species. More specifically, we were interested in determining population

abundance, growth, size structure and harvest of walleye, largemouth and smallmouth bass. We also hoped to determine some population parameters of panfish in Middle Eau Claire Lake.

Methods

Middle Eau Claire Lake was sampled during 2004-2005 following the Wisconsin Department of Natural Resources comprehensive treat assessment protocol (Hennessey 2002). This sampling included spring fyke netting and electroshocking to estimate walleye, bass (both largemouth and smallmouth) and northern pike abundance, late June fyke netting for panfish abundance, August mini-fyke netting for non-game fish, fall electroshocking to estimate year class strength of walleye young-of-the-year (YOY), and a creel survey (both open water and ice). Mini-fyke netting and fall electroshocking also followed protocols of Wisconsin's statewide baseline monitoring program (Stewart 2001).

Walleye were captured for marking in the spring shortly after ice out with fyke nets. Each fish was measured (total length; inches and tenths) and fin-clipped. Adult (mature) walleyes were defined as all fish for which sex could be determined and all fish 15 in or longer. Adult walleyes were given a lake-specific mark. Walleyes of unknown sex less than 15 inches in length were classified as juveniles (immature) and were marked with a different lake-specific fin clip. Marking effort was based on a goal for total marks of 10% of the anticipated spawning population estimate. To estimate adult abundance, walleyes were recaptured 1-2 days after netting. Because the interval between marking and recapture was short, electrofishing of the entire shoreline was conducted to ensure equal vulnerability of marked and unmarked walleyes to capture. All walleyes in the recapture run were measured and examined for marks. All unmarked walleyes were given the appropriate mark so that a total population estimate could be estimated. To estimate total walleye abundance, a second electrofishing recapture run was conducted 2 weeks after the first recapture run. Again, the entire shoreline of the lake was

electrofished. Population estimates were calculated with the Chapman modification of the Petersen Estimator using the equation:

$$N = \frac{(M+1)(C+1)}{(R+1)}$$

where N is the population estimate, M is the total number of marked fish in the lake, C is the total number of fish captured in the recapture sample, and R is the total number of marked fish captured. The Chapman Modification method is used because simple Petersen Estimates tend to overestimate population sizes when R is relatively small (Ricker 1975). Abundance and variance were estimated by the total for walleye that were ≥ 15 in and sexable.

Largemouth and smallmouth bass encountered during fyke netting and subsequent electroshocking runs (adult and total walleye) were marked. Bass ≥ 12.0 in were given the same primary (adult) fin-clip given to walleye for that lake. Bass 8.0-11.9 in were given the secondary (juvenile) fin-clip for the lake. Recaptures were made during electroshocking runs made during mid-late May. The entire shoreline of the lake was sampled. A total of four electroshocking surveys were conducted. The first electroshocking run was conducted within a week of pulling the fyke nets. The second run was conducted approximately two weeks after the first electroshocking run. Third and fourth electroshocking runs were conducted at approximately weekly intervals thereafter. Bass populations were estimated after both the third and fourth runs. Population estimates were calculated using the Chapman modification of the Petersen estimator, as described above for walleye population estimates. Abundance and variance were estimated by the total for both largemouth and smallmouth bass that were ≥ 8 inches. The recapture run yielding the lowest coefficient of variation is the population estimate reported. Both largemouth and smallmouth bass were not targeted in the 1993 and 1998 surveys which did not include second, third or fourth electroshocking periods. The results presented are derived from the 2004 survey. Population estimates for largemouth and smallmouth bass in

2004 were derived from the fourth and third electroshocking surveys, respectively. For comparison purposes catch per unit effort (CPUE: the number of largemouth or smallmouth bass caught/hour of electroshocking) was calculated from the first and second electroshocking surveys, because historic surveys did not complete third and fourth electroshocking surveys. Size structure for the 2004 survey utilized all largemouth and smallmouth bass captured from the first through fourth electroshocking surveys.

Walleye age and growth were determined from dorsal spine cross sections viewed microscopically at 100X (Margenau 1982). Age and growth of other fish species were determined by viewing acetate scale impressions under a 30X microfilm projector. Growth rates for all species were compared to an 18 county regional mean (Northern Region) using the Fisheries and Habitat database. Size structure quality of species sampled was determined using the indices proportional (PSD) and relative (RSD) stock densities (Anderson and Gutreuter 1983). The PSD and RSD value for a species is the number of fish of a specified length and longer divided by the number of fish of stock length or longer, the result multiplied by 100 (Appendix Table 1). Changes in population size structure were determined using Kolmogorov-Smirnov tests.

Creel surveys used a random stratified roving access design (Beard et al. 1997; Rasmussen et al. 1998). The survey was stratified by month and day-type (weekend / holiday or weekday), and the creel clerk conducted interviews at random within these strata. The survey was conducted on all weekends and holidays, and a randomly chosen two or three weekdays. Only completed-trip interview information was used in the analysis. The clerk recorded effort, catch, harvest, and targeted species from anglers completing their fishing trip. The clerk also measured harvested fish and examined them for fin-clips.

Results

Total survey effort in 2004 included 40 fyke net lifts targeting spawning gamefish. In June a second fyke-netting period targeted spawning panfish and included 22 fyke net lifts. A total of 8 mini-fyke net lifts targeting non-game fish were completed in August. Five electroshocking surveys of the entire shoreline totaling 12.8 hours in spring (first through fourth recapture surveys) and 3.4 hours in fall (walleye recruitment survey) were conducted.

Walleye. Adult walleye abundance ($\geq$ 15 in and sexable fish) was 3,859 (CV = 6; 4.5 adults/acre) in 2004. Adult walleye density has remained stable since 1991 (Figure 1). Density estimates during this period ranged from 4.5 to 5.7 fish/acre in four sampling periods. Adult walleye density in 1983 was the lowest of all surveys conducted, but may reflect a gear bias (net mark/net recapture).

Length of walleye captured in fyke nets in 1983, 1993, 1998 and 2004 suggests significant shifts in size structure between all years with the exception of 1983 vs. 2004 (1983 vs. 1993, $D = 0.48$, $P < 0.0001$; 1993 vs. 1998, $D = 0.10$, $P = 0.0008$; 1998 vs. 2004, $D = 0.39$, $P < 0.0001$; 1983 vs. 2004, $D = 0.03$, $P = 0.96$; Figure 2). The proportion of walleye captured in fyke nets 14 in or greater decreased from 81% to 42% between 1983 and 1993 and increased from 46% to 83% between 1998 and 2004. Mean length for sexable walleye ranged from 15.7 (SD = 2.05, N = 446), to 14.0 (SD = 1.81, N = 576), to 14.2 (SD = 2.06, N = 1364), to 15.7 (SD = 2.08, N = 1177) in for survey years 1983, 1993, 1998 and 2004. Proportional stock density (PSD) values of 64 and 65 for 1983 and 2004 indicated a fair quality size structure of the walleye population. PSD values of 16 and 26 for 1993 and 1998 indicated a poor quality size structure of the walleye population. In contrast, RSD-20 values ranging from 2 to 4 in all years sampled indicated a walleye population that had a low abundance of fish over 20 in in length.

Age of adult walleye sampled during the 2004 survey ranged from III to XV. Male and female walleye first reached maturity at III and IV, respectively. Age VI walleye accounted for 24% of the adult stock. Age distribution data from 1993, 1998, and 2004 indicate consistent naturally reproduced year classes (Figure 3). Growth rates for both sexes were dimorphic with males reaching 15 inches between ages V and VI and females between ages IV and V in the 2004 survey. Growth rates in 1993, 1998 and 2004 were predominately below Northern Region averages, especially for old aged walleye (age VII and older; Figure 4).

Relative abundance of Young of Year (YOY) walleye in Middle Eau Claire Lake in 2004 was 115 fish/mile (261 fish/hour). The average walleye YOY/mile was 94.0 (SD = 126.3, N = 19) for surveys completed from 1985 to 2004 by both WDNR and GLIFWC. However, fingerling relative abundance has been highly variable from 1985 to 2004 with a range of 2.6 fish/mile to 525.5 fish/mile (6.7 fish/hour to 986.8 fish/hour; Figure 5). Mean relative abundance of YOY walleye for naturally reproducing walleye lakes surveyed by WDNR in Bayfield and Douglas Counties from 1991 to 2002 was 35.9 fish/mile (SD = 71.3, N = 33).

Muskellunge and Northern Pike. Relative abundance (the number of fish caught with each fyke net lift) of muskellunge was 0.2, 0.2 and 0.5 fish/net lift in 1993, 1998 and 2004 survey years. There was not an adequate number of muskellunge marked to perform a population estimate; however, the density of muskellunge appeared to be low. Mean length for muskellunge (fyke net samples) decreased and then increased from 32.9 (SD = 5.21, N = 8) to 29.6 (SD = 10.66, N = 15) to 30.2 (SD = 6.71, N = 23) inches from 1993 to 1998 to 2004. RSD-34 and RSD-40 increased and then decreased from 50 to 64 to 23 and from 13 to 18 to 9 for 1993, 1998 and 2004 respectively. The largest muskellunge caught during the 2004 fyke netting survey was 48.3 in.

Relative abundance of northern pike was 1.4, 1.7 and 1.0 fish/net lift in 1993, 1998 and 2004 survey years. Similar to muskellunge, there was not an adequate number of northern pike marked to estimate abundance; however, the density of northern pike appeared to be low. Mean length for northern pike (fyke net samples) increased from 16.0 (SD = 5.07, N = 45) to 16.6 (SD = 3.56, N = 171) to 19.9 (SD = 6.27, N = 48) inches from 1993 to 1998 to 2004. PSD for spring fyke net samples was 15, 12 and 50 for 1993, 1998 and 2004. RSD (30) for spring fyke net samples was 0, 0 and 5 for the same time period. The largest northern pike caught during the 2004 fyke netting survey was 38.0 in.

Largemouth and Smallmouth Bass. In 2004, largemouth bass represented 28% and smallmouth bass 72% of the total number of bass surveyed (N = 134). Largemouth bass abundance (≥ 8 inches) in Middle Eau Claire Lake was 180 (CV = 52; 0.2 fish/acre) for 2004. Relative abundance for largemouth bass for the first and second electroshocking surveys was 4.1, 3.5 and 2.4 fish/hour for 1993, 1998 and 2004 and was considered low for all years sampled. Size structure for the 2004 survey was excellent with a mean length of 16.9 in (SD = 2.49; N = 38) and PSD and RSD-12 values of 95 and 29, respectively (Figure 6). Growth of largemouth bass for the 2004 survey was above NOR region averages until age IX and below NOR region averages to age XVI (Figure 7).

Smallmouth bass abundance (≥ 8 inches) in Middle Eau Claire Lake was 198 (CV = 0.43; 0.2 fish/acre) for 2004. Relative abundance for smallmouth bass for the first and second electroshocking surveys was 0.3, 3.4 and 1.8 fish/hour for 1993, 1998 and 2004 and was considered low for all years sampled. Mean length of smallmouth bass for the 2004 survey was 12.4 in (SD = 3.69; N = 96) and had PSD and RSD-12 values of 17 and 13, respectively (Figure 8). Growth for smallmouth bass for the 2004 survey was above or equal to NOR region averages for all ages (Figure 9).

Panfish. Bluegills were the most abundant panfish species (N = 788) sampled in Middle Eau Claire Lake during the panfish fyke netting survey of 2004. Relative abundance of bluegill captured in panfish survey fyke nets decreased then increased from 84.4 to 22.0 to 35.8 fish/net lift in 1983, 1993 and 2004 respectively. Length frequency of bluegill captured in fyke nets in 1983, 1993 and 2004 suggests a significant shift in size structure between 1983 and 2004 (1983 vs. 1993, D = 0.17, P < 0.0001; 1993 vs. 2004, D = 0.15, P = 0.0001; Figure 10). Mean total length of bluegill (panfish netting survey) increased from 5.5 (SD = 1.56, N = 1,350) to 6.2 in (SD = 1.14, N = 330) to 6.6 in (SD = 1.27, N = 788) from 1983 to 1993 to 2004. PSD for bluegill increased from 50 to 63 to 74 for survey years 1983, 1993 and 2004. RSD-8 for bluegill was 0, 0 and 1 for survey years 1983, 1993 and 2004. PSD values for bluegill indicate a good size structure for the 2004 survey.

Rock bass were the second most abundant panfish species (N = 476) sampled in Middle Eau Claire Lake during the panfish fyke netting survey of 2004. Relative abundance of rock bass captured decreased then increased from 18.8 to 2.2 to 21.6 fish/net lift in 1983, 1993 and 2004 respectively. Length frequency of rock bass captured in fyke nets in 1983 and 2004 suggests a significant shift in size structure between (D = 0.40, P < 0.0001; Figure 11). [No comparison was done using 1993 due to low numbers sampled.] Mean total length of rock bass (panfish netting survey) increased from 6.8 (SD = 1.54, N = 300) to 7.3 (SD = 1.51, N = 33) to 7.8 (SD = 1.65, N = 476) inches from 1983 to 1993 to 2004. PSD for rock bass increased from 35 to 68 to 75 for survey years 1983, 1993 and 2004. RSD (9) for rock bass was 1, 1 and 22 for survey years 1983, 1993 and 2004. PSD and RSD (9) values indicate an excellent size structure of rock bass in the 2004 survey.

Yellow perch were the third most abundant panfish species (N = 62) sampled in Middle Eau Claire Lake during the panfish fyke netting survey of 2004. Mean total length for yellow perch was 5.8 (SD = 0.82) inches. PSD and RSD (10) values of 0 and 0 for yellow

perch indicated a poor size structure. The largest sample of black crappie was obtained during the walleye fyke netting period (N = 44). Mean total length of black crappie was 6.9 (SD = 1.98) inches. Only 8 pumpkinseed were sampled during the entire 2004 survey.

Sport and Tribal Fishery. Anglers fished an estimated 19,793 hours (21.9 hrs/acre) during the 2004-2005 season in Middle Eau Claire Lake, which is near the average of 21.5 hrs/acre for Bayfield and Douglas County walleye lakes (WDNR unpublished data, Brule field office) and below the Northern Wisconsin Region (18 counties) average of 33.1 hrs/acre. Open water anglers accounted for 81% of all fishing effort. The directed effort, i.e. effort targeted toward a specific fish, was highest for walleye (37.2%). The most sought after panfish species was yellow perch, with 14.3% of the directed effort. Fishing pressure has remained consistent since 1993. The open water fishing pressure (hrs/acre) was 22.4, 22.9 and 21.9 for 1993, 1998 and 2004 respectively.

Walleye were the most heavily exploited gamefish in Middle Eau Claire Lake. An estimated 3,785 walleye were caught in the open water and ice season of 2004-2005 of which 34% (1,299) were harvested. The open water season accounted for 90% of the total walleye harvest, which was in the same range for values from 1993 (93%) and 1998 (84%). Average length of angler harvested walleye was 15.2 in (SD = 2.5, N = 152, Table 2). This represents a decrease from 1993 when a 15 in minimum length was the regulation and an increase from 1998 when the current regulation was in effect. Projected total harvest by anglers has increased since 1993 (harvest = 365) and decreased slightly from 1998 (harvest = 1,511). Angler exploitation, calculated by the estimated number of marked walleye harvested divided by the total number of marked walleye, was 24.9% in 2004.

Tribal harvest accounted for 217 walleye in 2004 (Krueger 2005). Walleye harvested ranged from 10.2 to 26.0 in. Tribal harvest represented 14% of the combined total harvest (sport angling plus tribal spearing) and tribal exploitation of the adult walleye population was

5.3%. The mean length of tribally harvested walleye was 16.0 in (SD = 2.2, N = 217) and 68% were < 15 in. Male and female walleye represented 89% and 4% of the total tribal harvest, respectively. The remaining 7% were walleye of unknown sex. Total walleye exploitation (sport and tribal) increased from 5.5% to 21.3% to 30.2% from 1993 to 1998 to 2004. Exploitation levels below 35% are generally thought to be sustainable and are the exploitation levels that are used to determine total allowable catch for the combined fishery of angler and tribal harvest for walleye in the state of Wisconsin. Even though exploitation levels are increasing on Middle Eau Claire Lake they have remained below 35%.

The second most sought after gamefish species by anglers was muskellunge with 10.5% of the directed effort. In comparison, the directed effort for muskellunge was 7.7% and 12.7% in 1993 and 1998. In the open water season of 2004 an estimated 146 muskellunge were caught, 8 of which were harvested. Tribal harvest accounted for 9 muskellunge in 2004 (Kruger 2005). The average length of tribally harvested muskellunge was 33.6 in (SD = 8.1, N = 9).

Northern pike were the second most exploited (harvest = 117) gamefish in 2004-2005 on Middle Eau Claire Lake and had the least directed effort (7.5%) of gamefish. Estimated catch of northern pike was 1,234 in 2004-2005. Directed effort for northern pike decreased from 19.3% to 13.0% to 7.5% from 1990 to 1998 to 2004. Northern pike estimated catch fluctuated from 2,846 to 4,137 to 1,234 and estimated harvest decreased from 339 to 249 to 117 fish from 1993 to 1998 to 2004. Mean length of harvested northern pike increased and was 19.7, 20.2 and 23.5 inches in 1993, 1998 and 2004 respectively.

Smallmouth bass was the third most sought after gamefish in the open water season of 2004 on Middle Eau Claire Lake with 10.2% of directed effort. An estimated 1,147 smallmouth were caught, 12 of which were harvested. Directed effort toward smallmouth bass has increased from 1990 and 1998 to 2004. Catch of smallmouth bass has increased by 91%

since 1990 and 55% since 1998. Largemouth bass were the fourth most sought after gamefish by anglers in Middle Eau Claire Lake in 2004-2005 with 7.9% of directed effort. Estimated catch of largemouth bass was 544 with no recorded harvest. Tribal harvest accounted for 10 (2 of unknown length) largemouth bass in 2004 (Kruger 2005). The average length of tribally harvested largemouth bass was 18.9 in (SD = 1.3, N = 8).

Anglers pursuing panfish fished an estimated 9,385 hours and accounted for 28.5% of the total directed angling effort for the 2004-2005 open water and winter seasons combined. Yellow perch were the most sought after panfish species by anglers in 2004-2005 with 14.3% of the directed effort. Directed effort for yellow perch has increased from 1993 (2.8%) and 1998 (6.7%). Average length of harvest yellow perch was 8.6, 9.4 and 8.5 in for 1993, 1998 and 2004, respectively. Bluegills were the second most sought after panfish species by anglers in 2004-2005 with 10.4% of directed effort. Directed effort for bluegill has declined from 1993 (31.3%) and 1998 (19.1%) when bluegill were the most sought after panfish species. However, harvest of bluegill decreased from 4,896 to 4,460 to 1,052 from 1993 to 1998 to 2004. Mean length of harvested bluegill increased from 6.9 to 7.3 to 7.6 inches in the same time period. Estimated catch of bluegill in 2004 decreased by 81% and 78% from 1993 and 1998, respectively. Black crappie and rock bass were minor components of the panfish fishery in all survey years.

Discussion

Middle Eau Claire Lake has supported, and continues to support diverse fish communities and popular sport fisheries. With the exception of muskellunge, good to excellent natural reproduction supports all species. Harvest management aimed at maintaining self-sustaining stocks has been largely successful. Rusty crayfish, an exotic species, appears to have had an effect on fishery composition since they were first found in the 1980s by

dramatically reducing the amount of aquatic vegetation. The reduction of littoral zone habitat has been reported in both natural and laboratory conditions (Wilson et al. 2004; Lodge and Lorman 1987).

Results from the 2004 survey suggest that the objectives of the regulation change for walleye that included no minimum length limit but only one fish over 14 in were accomplished. Harvest of walleye increased from 1993 surveys and was a result of anglers' willingness to harvest walleye 15 in and less. Forty four percent of walleye harvested by anglers in 2004-2005 were less than 15 in and total harvest increased by over 250% from 1993. In addition, harvest of walleye 15 in and greater increased nearly 150% from 1993 to 2004. Even though harvest of walleye 15 in and greater has increased since 1993 size structure has also increased significantly. Size structure increases could be due to the effect of the current regulation in focusing harvest on walleye less than 14 in or a reflection of strong year classes in 1998 and 1999. Regardless, walleye densities have remained relatively stable from 1993 to 2004, and remain above the state walleye management objective of 3.0 adults/acre, the Bayfield and Douglas County average for walleye lakes of 3.6 fish/acre and the Northwest Wisconsin average of naturally reproducing walleye lakes of 3.8 fish/acre. Slow growth of walleye is likely density dependent in Middle Eau Claire Lake which has also been identified by Sass et al. (2004) in other high density northern Wisconsin walleye lakes. Slow growth could prohibit the effectiveness of a 14 to 18 in protected slot length regulation due to a low number of walleye growing to lengths longer than 18 in. Harvest of walleye would also likely decline under a 14 to 18 in protected slot length limit. For example, if the regulation had been in place in 2004, 73% of walleye $\geq$10 inches would be protected from harvest. Care should be taken to recognize that maintaining natural recruitment of walleye and resulting high densities of predators in Middle Eau Claire Lake may be, along with reduction of littoral zone habitat in the form of reduced aquatic plant coverage and near shore human induced impacts, resulting in a

trophic cascade or biomanipulation effect. This intermediate trophic state hypothesis (Carney 1990) may be more common on mestrophic lakes and is the result of high piscivore densities and low planktivore densities which allow zooplankton to reduce the amount of phytoplankton. The result is greater secchi disk transparency than expected from the lakes total phosphorus concentrations and is a possible reason that Middle Eau Claire had a mean secchi disk TSI value from the summer months of 2002 to 2004 of 34 (oligotrophic) while in the same time period the mean total phosphorus TSI value was 49 (mesotrophic).

Muskellunge relative abundance was low in 2004. Only 23 muskellunge were captured in fyke nets, of which 57% were less than 30 in. While a muskellunge sport fishery exists, the low abundance does cause some concern regarding survival of stocked fingerlings. Typically, low post-stocking survival is associated with predation and availability of prey items (Margenau 1992). Interestingly, northern pike, a prominent predator in many northern Wisconsin lakes capable of consuming large fingerling muskellunge (10-12 in), were in low abundance in Middle Eau Claire Lake. Muskellunge stocked in the future should be fin-clipped to evaluate stocking success and document any natural recruitment occurring.

Northern pike relative abundance has declined from 1993, however average length has increased. Angler catch and harvest of northern pike reflected the population, i.e., lower numbers but larger size, a similar association found in other northern Wisconsin lakes (Margenau et al. 2003). Hence, while northern pike only represents a small component of the sport fishery it does add to the lakes angling diversity along with offering some potential for a trophy fish.

Smallmouth and largemouth bass densities were both 0.2 fish/acre and were considered low. The 2004 smallmouth and largemouth population estimates were the first completed on Middle Eau Claire Lake and therefore comparisons can only be made to historic surveys by CPUE. The CPUE values for both smallmouth and largemouth bass were considered low for

all years indicating that bass have been present in low abundance since at least 1993. Smallmouth bass had higher relative abundance than largemouth bass for the 2004 survey and the creel survey total catch reflected the same trend. Although smallmouth bass catch was 1,147 only 12 were estimated to be harvested indicating low exploitation. Similarly, largemouth bass catch was 544 and none were estimated to have been harvested also indicating low exploitation. Hence, a more restrictive regulation on both bass species may prove to be a mute point, due to low exploitation, the intended effects of the regulation (to increase bass size structure and possibly increased predation on rusty crayfish) would not be realized because angler harvest is apparently not influencing size structure or population density.

The panfish community was targeted in surveys from 1983, 1993 and 2004. Bluegill relative abundance from 2004 has declined by 58% since 1983. The reduction in bluegill numbers could be due to several factors including, the reduction of littoral zone habitat due to the rusty crayfish invasion, the increase in density of walleye during the same time period which increased predation, and potential overexploitation by anglers. As a result of decreased abundance, bluegill average length has significantly increased since 1983. Of the three above potential factors, restricting angler harvest to a daily bag limit of ten panfish would provide the highest short-term benefit and help to protect the remaining bluegill population from overexploitation. In contrast, yellow perch estimated catch and harvest by anglers was highest for all panfish species in the 2004-2005 creel survey. Angler directed effort for yellow perch has increased in comparison to historic creel surveys. This could be a result of increased abundance of yellow perch in Middle Eau Claire Lake, however, the survey in 2004 did not show an increase in relative abundance but this may not have been an adequate sample due to timing and gear types. Rock bass angler directed effort and catch were low. However, 25% of rock bass that were caught were harvested in the 2004-2005 season. Length frequency of rock

bass has significantly increased from 1983 to 2004 while relative abundance has increased by 13% in the same time period.

Summary and Management Recommendations

1. Walleye abundance in Middle Eau Claire Lake is above regional averages and statewide management objectives. Exploitation of walleye was high although the fishery seems to be able to support the harvest that is occurring due to good natural reproduction and recruitment. The current regulation of no minimum length and only one fish over 14 in has met the objective of increasing harvest opportunity and increasing length frequency of the walleye population. Alternative regulations should be explored through modeling and literature research, with the goals of maintaining harvest opportunities, increasing length frequency and continuing to provide high abundance of predators in Middle Eau Claire Lake.
2. Muskellunge abundance is low in Middle Eau Claire Lake, yet were the second most sought after gamefish species in 2004. Stocking should continue for muskellunge on an alternate year basis at the rate of 0.5 fish/acre. Stocked muskellunge should be marked with a fin-clip to evaluate stocking success and natural recruitment in the future. Northern pike abundance was also low but still provides an important component of the sport fishery. The relatively low abundance of esocids in Middle Eau Claire Lake could be a result of a fishery dominated by piscivores and a reduced forage base or the decline of native aquatic plant communities that are important for spawning success due to the presence of rusty crayfish. It will be important to track further changes in esocid abundance in future surveys.
3. Largemouth and smallmouth bass remain at low abundance in Middle Eau Claire Lake. Harvest of both species is low and more restrictive regulations would most likely have

no effect on bass population abundance due to high levels of catch and release practiced by anglers.

4. Bluegill relative abundance has declined and length frequency increased over time in Middle Eau Claire Lake. Littoral zone aquatic plant loss, increase of walleye abundance and potential over exploitation by anglers are likely factors of this decline. A regulation change of 10 panfish/day should be considered to prevent over harvest of a declining population of bluegill. Yellow perch have become an important component of the fish assemblage in Middle Eau Claire Lake. Yellow perch undoubtedly provide an important forage fish for the lake's predators and have become the most sought after panfish by anglers. Future restrictions designed to protect bluegill (e.g., 10 panfish/day) would also likely benefit yellow perch.
5. Work with local residents, the Middle Eau Claire Lake Association, the Eau Claire Lakes Conservation Club and the WDNR lake grants program to create and adopt a lake management plan and aquatic plant management plan. 1) develop management objectives for fisheries including goals for densities and size structures for the various fish species found in the lake, 2) develop strategies for protecting and enhancing sensitive aquatic and shoreline habitats, 3) formally establish exotic species survey and control programs targeting satellite infestations, 4) provide educational and participation forum for environmentally sensitive shoreline living, 5) identify uses and user groups to facilitate all recreational uses on the lake, 6) continue water quality monitoring through the self help lake monitoring program. No amount of regulation or voluntary catch and release practices will change the need for healthy aquatic environments. Although water quality remains high, habitat loss, declining shoreline aesthetics, and exotic introductions are warning signs of cultural disturbances that are degrading ecosystem health. Currently, rusty crayfish are the only known exotic that has been identified in

Middle Eau Claire Lake and much of the shoreline remains in a natural condition. Preserving and enhancing the ecosystem vigilance for exotic species must continue and shoreline restoration projects in areas that are currently lacking buffers should be explored. Preventing the spread of exotics and enhancing habitat through restoration projects, as well as preserving the existing habitat will be far more beneficial than losing what is currently present and relying on stocking and artificial habitat improvements to maintain the fishery and ecosystem as a whole.

Acknowledgements

I would like to thank Lee, Sue, and Amy Wiesner and O. K. Hedlund who were volunteers for the Self-Help Lake Monitoring Program from 1987 to 2005, and gathered the water quality data presented in this report. I would also like to thank the biologists and technicians of the Wisconsin Department of Natural Resources who assisted with field collection of data, especially Cris Sand, Marty Kangas and Cordell Manz. The WDNR treaty assessment unit, especially Jamison Wendel, Scott Plaster, Todd Brecka, Rae Elliot, Tim Anderson and Jack Hubeny for data collection and entry and creel survey data collection, data entry and completion of the creel survey report. With special thanks to Terry Margenau who provided a critical review of the manuscript.

References

Anderson, R. O., and S. J. Gutreuter. 1983. Length, weight, and associated structural indices. Pages 283-300 *in* L. Nielson and D. Johnson, editors. Fisheries Techniques. American Fisheries Society, Bethesda, Maryland.

Beard, T. D., Jr., S. W. Hewett, Q. Yang, R. M. King, and S. J. Gilbert. 1997. Prediction of angler catch rates based on walleye population density. North American Journal of Fisheries Management 17: 621-627.

Carney, H.J. 1990. A general hypothesis for the strength of food web interactions in relation to tropic state. Verh. Int. Verein. Limnol. 24: 487-492.

Hennessy, J. 2002. Ceded territory fishery assessment report. Wisconsin Department of Natural Resources. Administrative Report 55, Madison.

Krueger, J. 2005. Open water spearing in northern Wisconsin by Chippewa Indians during 2004. Great Lake Indian Fish and Wildlife Commission Administrative Report 2005-01. Odanah, Wisconsin.

Lodge, D.M. and J.G. Lorman. 1987. Reductions in submersed macrophyte biomass and species richness by the crayfish *Oronectes rusticus*. Canadian Journal of Fisheries and Aquatic Sciences 44:591-597.

Margenau, T. L. 1992. Survival and cost-effectiveness of stocked fall fingerling and spring yearling muskellunge in Wisconsin. North American Journal of Fisheries Management 12:484-493.

Margenau, T. L. 1982. Modified procedure for aging walleye by dorsal spine sections. Progressive Fish-Culturist 44:204.

Margenau, T. L., S. J. Gilbert, and G. R. Hatzenbeler. 2003. Angler catch and harvest of northern pike in northern Wisconsin lakes. North American Journal of Fisheries Management 23:307-312.

Rasmussen, P. W., M. D. Staggs, T. D. Beard, Jr., and S. P. Newman. 1998. Bias and confidence interval coverage of creel survey estimators evaluated by simulation. Transactions of the American Fisheries Society 127: 460-480.

Ricker, W. E. 1975. Computation and Interpretation of Biological Statistics of Fish Populations. Bulletin of the Fisheries Research Board of Canada 191. Department of the Environment, Fisheries, and Marine Science, Ottawa. 382 p.

Scholl, D. 1994. 1993 Fishery Survey Summary, Middle Eau Claire Lake, Bayfield County. Brule – Office File.

Schram, S. 1984. Lake Survey Summary – Middle Eau Claire Lake, Bayfield County. Brule – Office File.

Sass, G. G., S. W. Hewett, T. D. Beard, A. H. Fayram, and J. F. Kitchell. 2004. The Role of Density Dependence in Growth Patterns of Ceded Territory Walleye Lakes of Northern Wisconsin: Effects of Changing Management Regimes. North American Journal of Fisheries Management 24:1262-1278.

Stewart, S. 2001. Baseline Lakes Protocol. Unpublished Guidance Document, Wisconsin Department of Natural Resources, Madison.

Weiher, W. 1968. Lake Survey of Middle Eau Claire Lake, Bayfield County. Brule – Office File.

Wison, Karen A., John Magnunson, David M. Lodge, Anna M. Hill, Timothy K. Kratz, William L. Perry, and Theodore V. Willis. 2004. A long-term rusty crayfish (Orconectes rusticus) invasion:dispersal patterns and community change in a north temperate lake. Canadian Journal of Fisheries and Aquatic Sciences 61:2255-2266.

Table 1. Fish stocking history of Middle Eau Claire Lake, Bayfield County, Wisconsin

Year	Species	Number Stocked	Age/Size
1933	Walleye	283,360	Fry
1936	Bass	600	Unknown
	Bluegill	160	Unknown
	Muskellunge	12,650	Unknown
	Walleye	793,800	Fry
1937	Muskellunge	18,180	Fry
	Black Crappie	850	Adult
1938	Largemouth Bass	122	Fingerling
	Muskellunge	25,000	Fry
	Perch	520	Fingerling
	Bluegill	7,584	Fingerling
1939	Largemouth Bass	500	Fingerling
	Largemouth Bass	272	Yearling
	Muskellunge	38,760	Fry
	Walleye	2,100,000	Fry
1940	Muskellunge	70,000	Fry
	Walleye	4,000,000	Fry
1941	Largemouth Bass	2,000	Fingerling
	Muskellunge	1,035	Fingerling
	Muskellunge	13,000	Fry
	Walleye	552	Fingerling
	Walleye	4,100,000	Fry
1942	Walleye	1,900,000	Fry
	Walleye	2,650	Fingerling
	Muskellunge	98,000	Fry
	Muskellunge	1,200	Fingerling
1943	Walleye	950,000	Fry
	Walleye	6,000	Fingerling
	Muskellunge	98,000	Fry
	Muskellunge	1,200	Fingerling
	Largemouth Bass	1,185	Fingerling
1944	Walleye	760,000	Fry
	Walleye	2,000	Fingerling
	Muskellunge	29,000	Fry
	Muskellunge	800	Fingerling
	Largemouth Bass	2,000	Fingerling
1945	Walleye	1,450,000	Fry
	Walleye	6,775	Fingerling
	Muskellunge	33,750	Fry
	Muskellunge	400	Fingerling
	Largemouth Bass	4,500	Fingerling
1946	Walleye	1,190,000	Fry
	Walleye	4,000	Fingerling
	Muskellunge	963	Fingerling
	Largemouth Bass	2,375	Fingerling
1947	Muskellunge	1,700	Fingerling

Table 1 (continued). Fish stocking history of Middle Eau Claire Lake, Bayfield County, Wisconsin.

Year	Species	Number Stocked	Age/Size
1947 Continued	Largemouth Bass	2,200	Fingerling
1948	Walleye	3,200,000	Fry
	Walleye	7,900	Fingerling
	Largemouth Bass	7,900	Fingerling
1949	Walleye	2,600	Fry
	Walleye	3,050	Fingerling
	Largemouth Bass	5,602	Fingerling
1950	Walleye	9,349	Fingerling
	Largemouth Bass	6,650	Fingerling
1951	Walleye	8,815	Fingerling
1952	Walleye	11,800	Fingerling
1953	Walleye	7,400	Fingerling
1954	Walleye	11,720	Fingerling
1955	Walleye	3,700	Fingerling
1956	Walleye	7,400	Fingerling
1957	Walleye	7,400	Fingerling
1958	Walleye	2,466	Fingerling
1959	Walleye	22,200	Fingerling
1962	Walleye	3,768	Fingerling
1965	Walleye	9,135	Fingerling
1982	Walleye	2,000,000	Fry
1984	Muskellunge	900	Fingerling
1985	Rainbow Trout	2700	Yearling
	Rainbow Trout	33	Adult
1987	Muskellunge	450	Fingerling
	Walleye	39,412	Fingerling
1988	Rainbow Trout	2,700	Yearling
	Muskellunge	1,000	Fingerling
1989	Walleye	46,044	Fingerling
	Muskellunge	900	Fingerling
1990	Muskellunge	450	Fingerling
1991	Walleye	454,000	Fry
	Muskellunge	900	Fingerling
	Rainbow Trout	2,700	Yearling
1992	Walleye	40,000	Fry
	Walleye	22,550	Fingerling
	Muskellunge	900	Fingerling
1993	Walleye	45,675	Fingerling
	Muskellunge	900	Fingerling
1996	Muskellunge	900	Fingerling
1997	Muskellunge	450	Fingerling
1998	Muskellunge	800	Fingerling
2000	Muskellunge	900	Fingerling
2002	Muskellunge	1,804	Fingerling
2004	Muskellunge	451	Fingerling

Table 2. Walleye angling catch and harvest by length group during openwater and ice fishing season, Middle Eau Claire Lake, Bayfield County. Percent of harvest by season is in parenthesis. Walleye regulations during sampling periods: 1993, 15 inch minimum size limit and 2 daily bag limit. 1998 and 2004, no minimum size limit with only 1 over 14 inches and 2 daily bag limit.

Year	Season	Projected Catch	Projected Harvest	Mean Length (in) (SD)	Harvest By Length (in)			
					10.0-14.9	15.0-19.9	20.0-24.9	25.0 +
1993	Openwater	3,787	337	15.7 (1.1)	66 (20)	265 (79)	6 (2)	0 (0)
	Ice	102	28	16.8 (2.0)	1 (4)	26 (93)	1 (4)	0 (0)
1998	Openwater	3,352	1,274	14.1 (1.8)	968 (76)	289 (23)	17 (1)	0 (0)
	Ice	316	237	15.0 (1.8)	135 (57)	101 (42)	2 (1)	0 (0)
2004	Openwater	3,649	1,173	14.9 (2.3)	542 (46)	604 (52)	27 (2)	0 (0)
	Ice	136	126	17.6 (2.7)	25 (20)	95 (75)	6 (5)	0 (0)

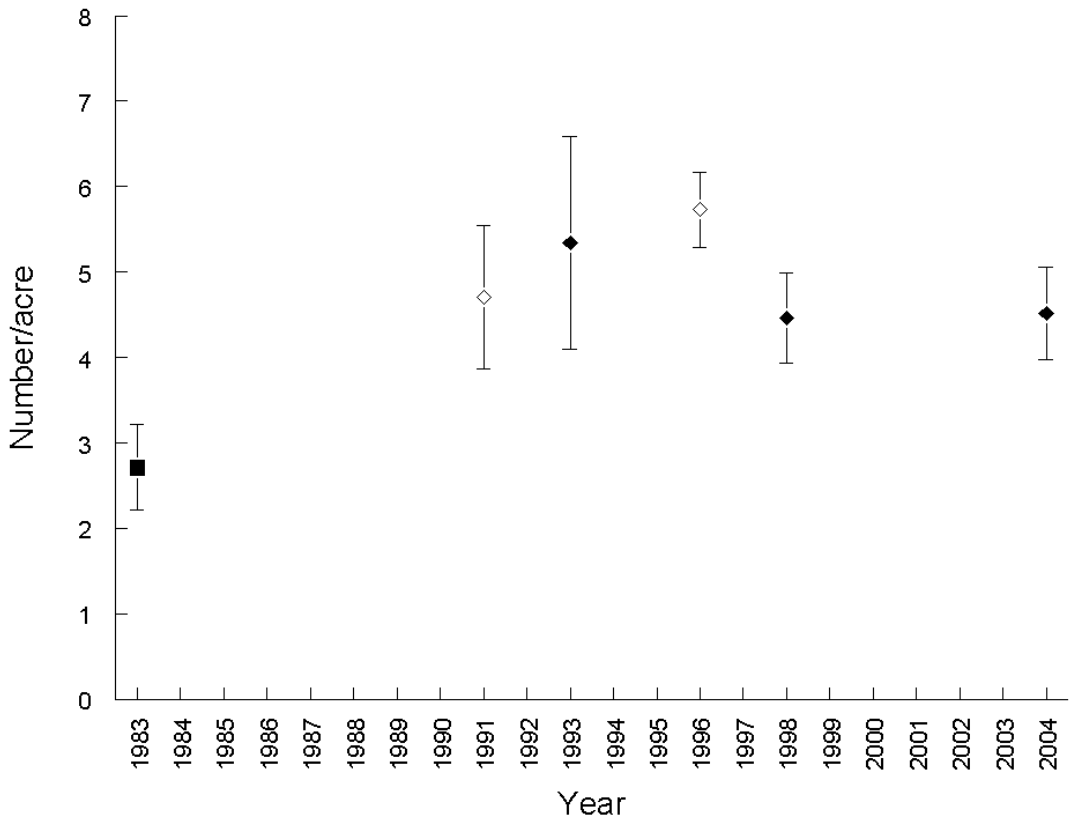

Figure 1. Number of walleye ≥15 in and sexable fish (number/acre ± 95% confidence intervals) by year in Middle Eau Claire Lake, Bayfield County, Wisconsin. Survey in 1983 utilized fyke netting for both marking and recapture. Surveys in 1991 and 1996 utilized electrofishing for both marking and recapture. Surveys in 1993, 1998 and 2004 utilized fyke netting for marking and electrofishing for recapture.

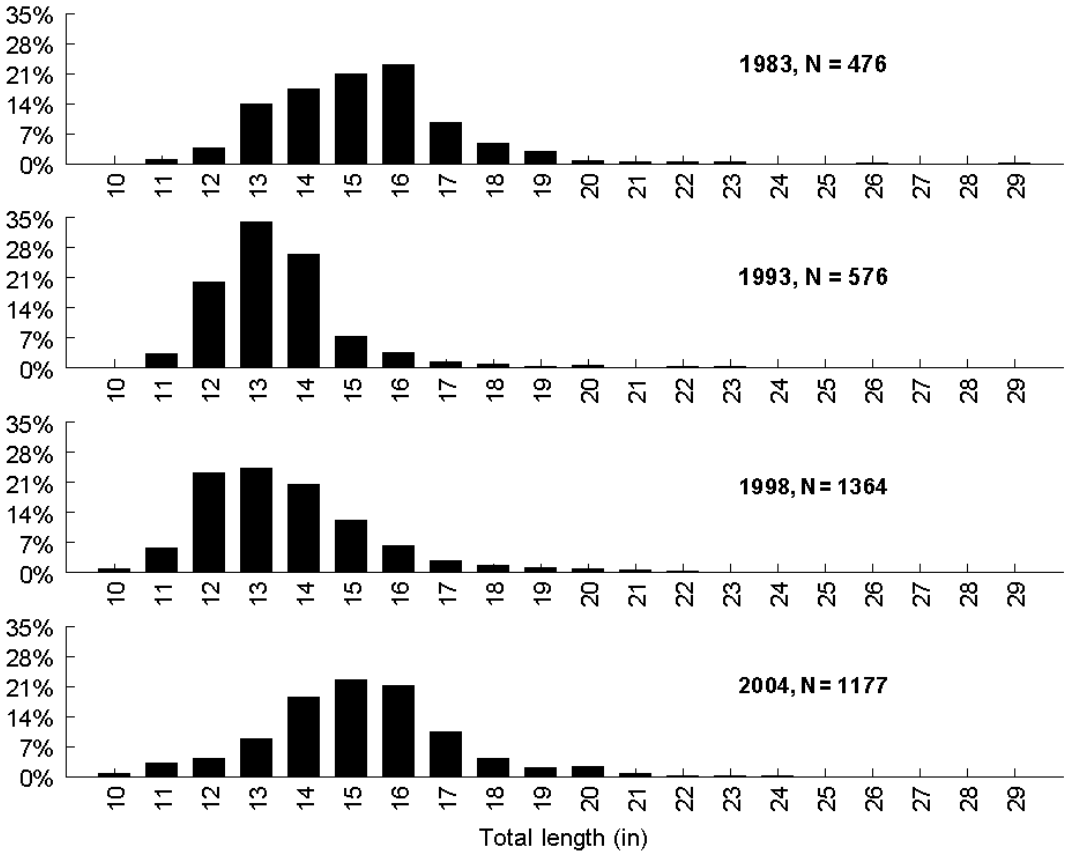

Figure 2. Percentage length frequency of fyke net catches for walleye by length interval in Middle Eau Claire Lake, Bayfield County, Wisconsin.

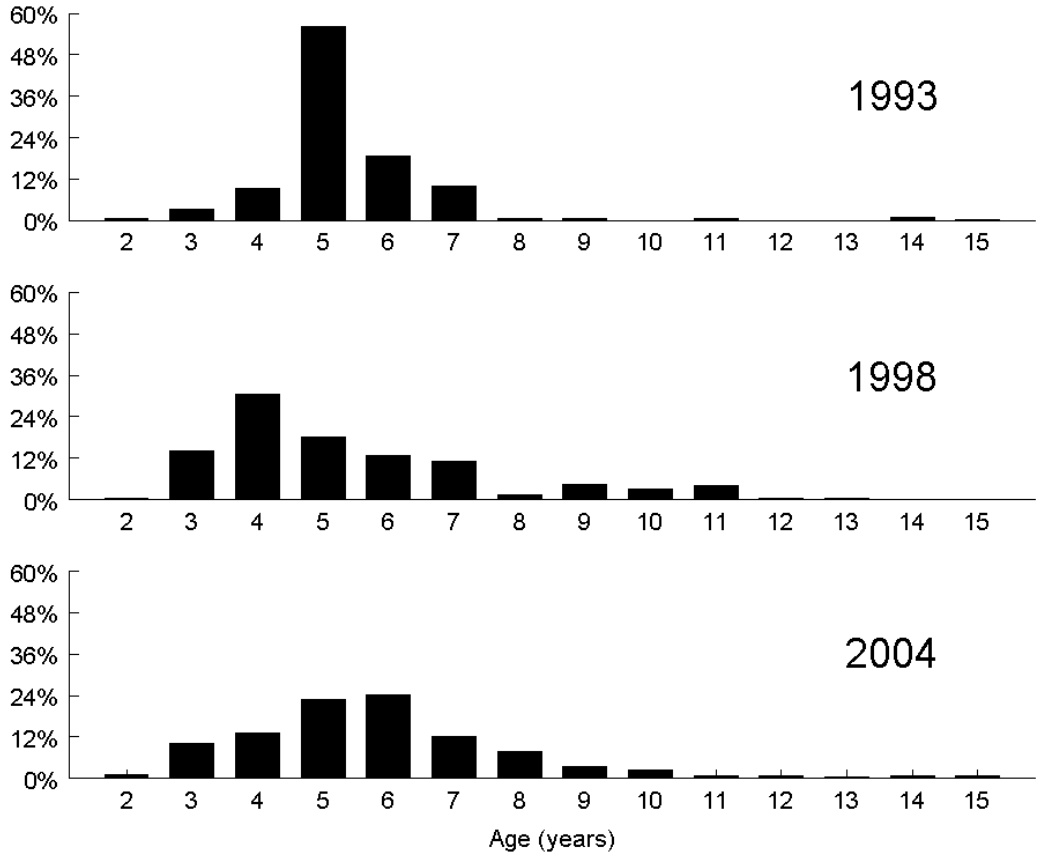

Figure 3. Percent distribution by age of walleye in Middle Eau Claire Lake, Bayfield County, Wisconsin.

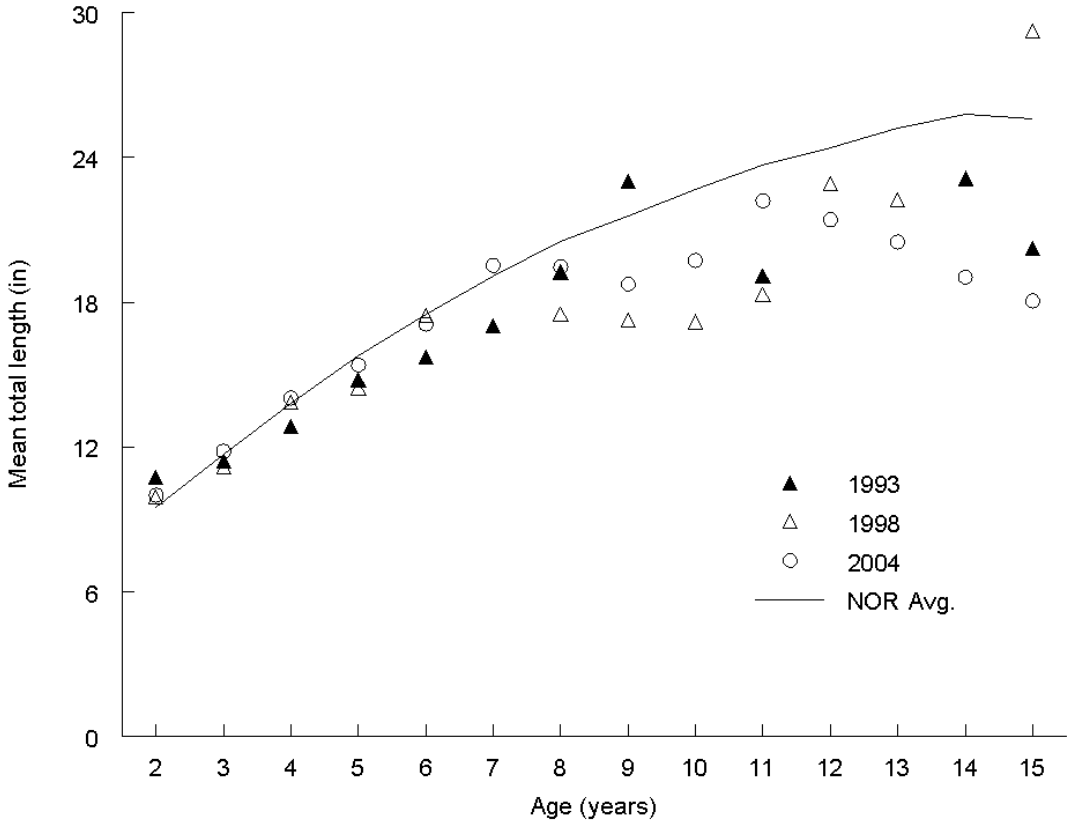

Figure 4. Age at length of walleye in Middle Eau Claire Lake, Bayfield County, Wisconsin.

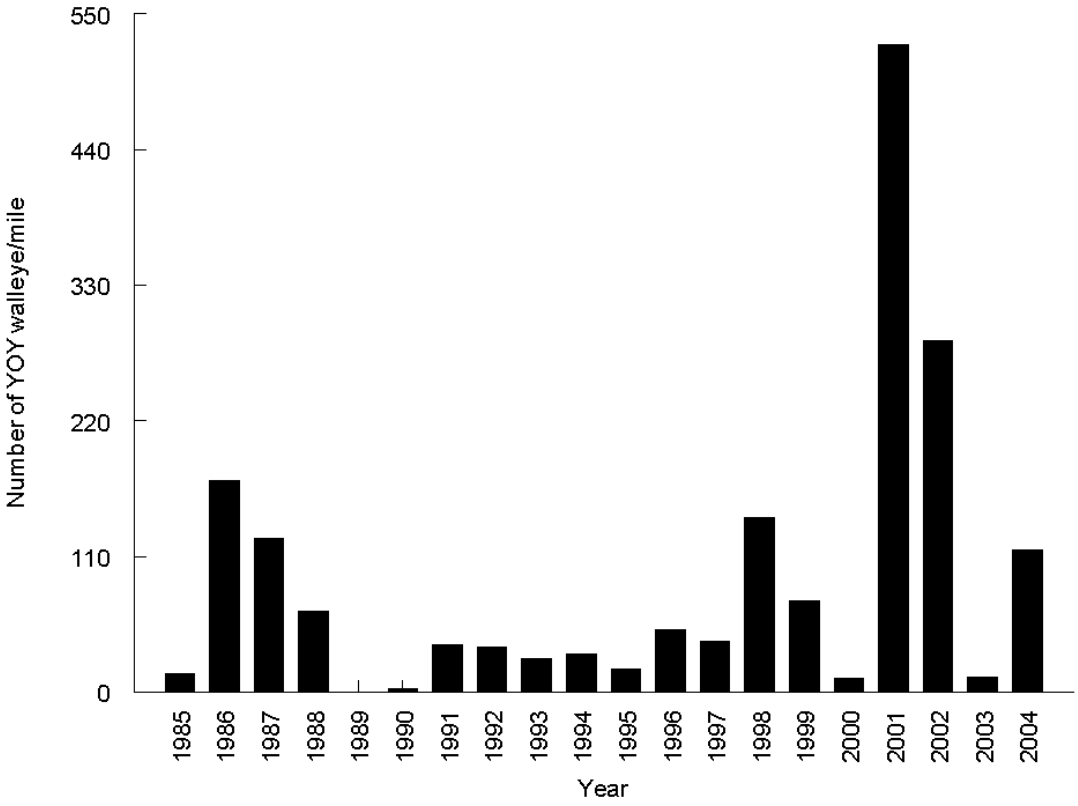

Figure 5. Young of the year walleye relative abundance determined by fall electroshocking in Middle Eau Claire Lake, Bayfield County, Wisconsin. A survey was not completed in 1989.

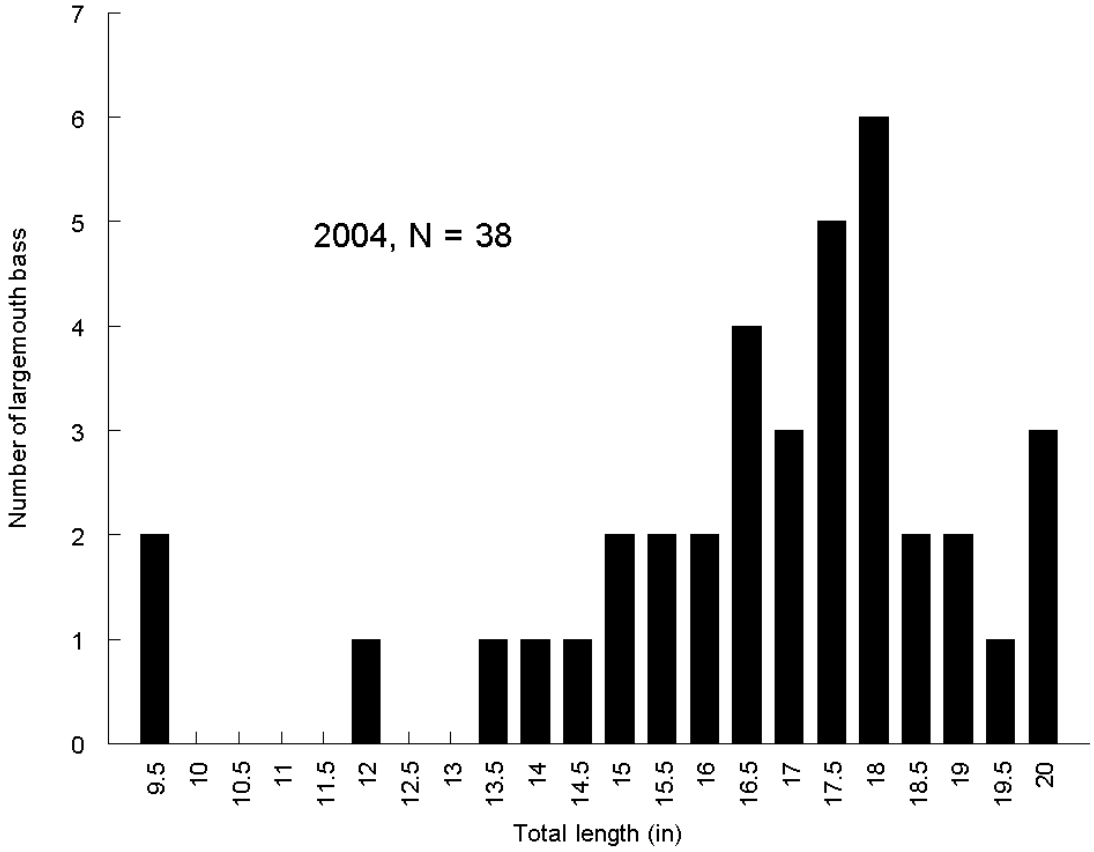

Figure 6. Length frequency of first through fourth electroshocking surveys for largemouth bass by length interval in Middle Eau Claire Lake, Bayfield County, Wisconsin.

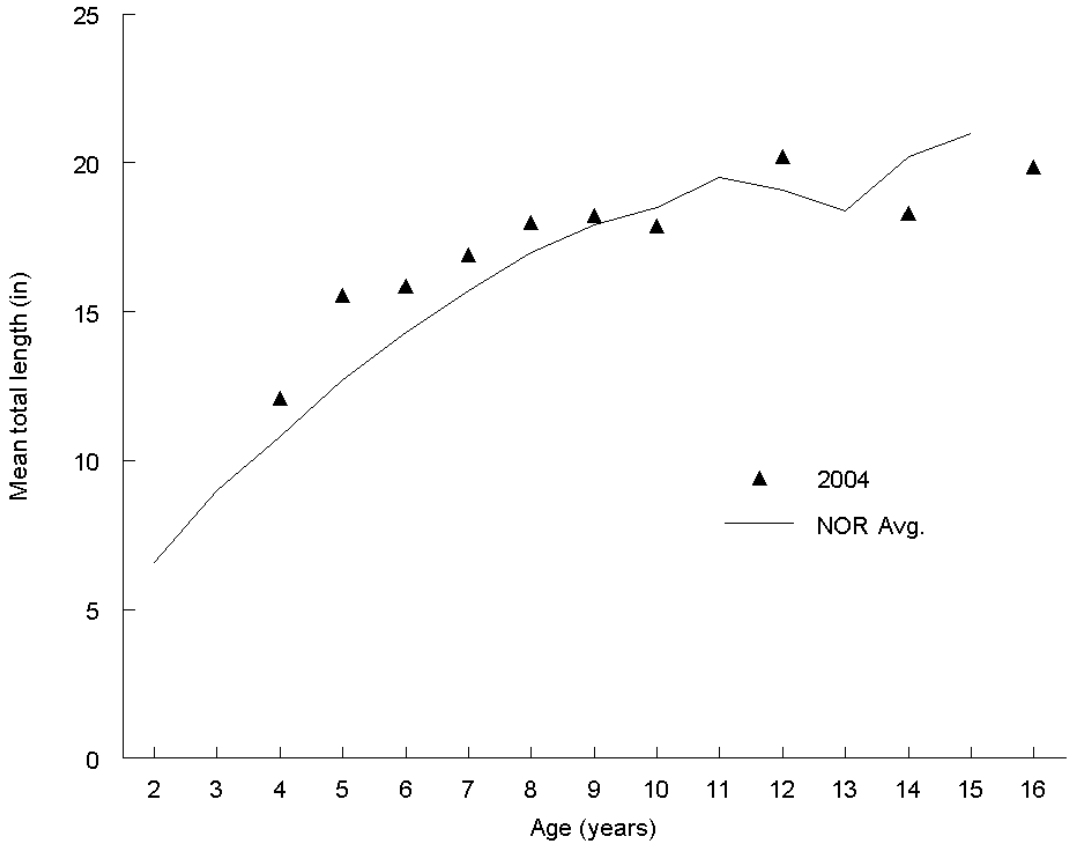

Figure 7. Age at length of largemouth bass in Middle Eau Claire Lake, Bayfield County, Wisconsin, and the 18 county NOR region average.

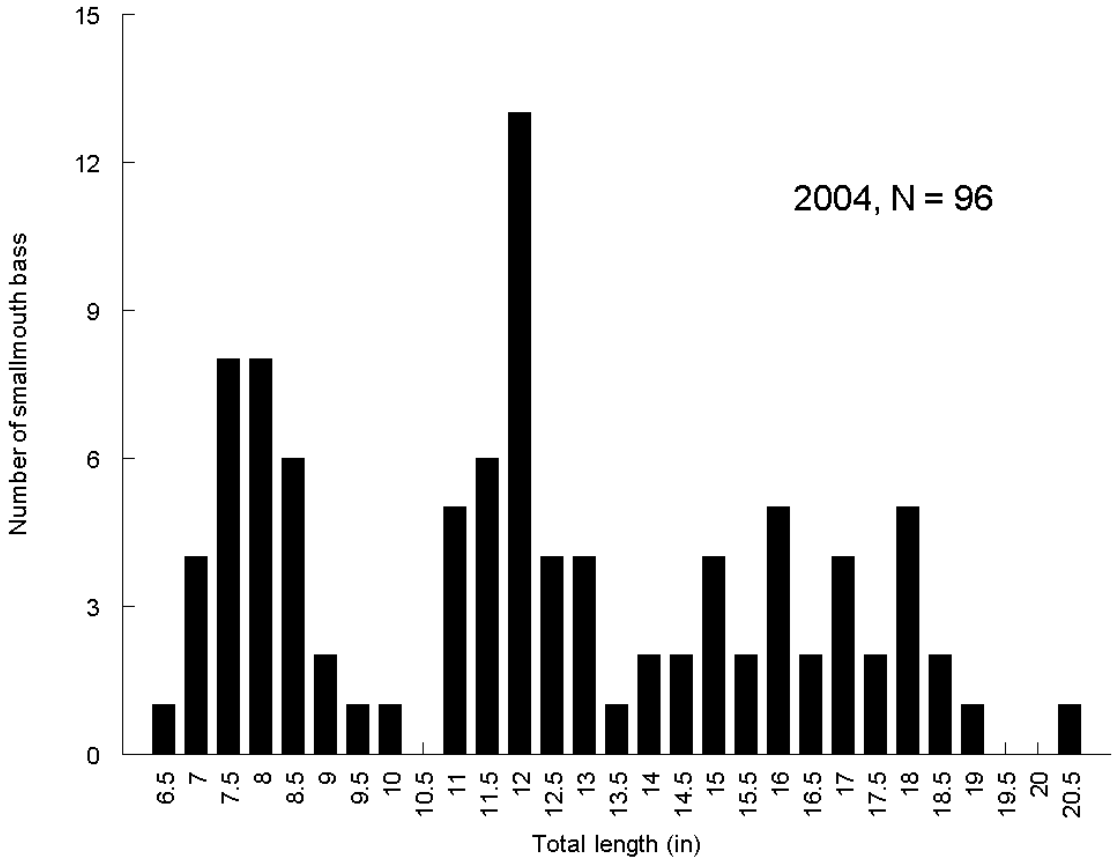

Figure 8. Length frequency of first through fourth electroshocking surveys for smallmouth bass by length interval in Middle Eau Claire Lake, Bayfield County, Wisconsin.

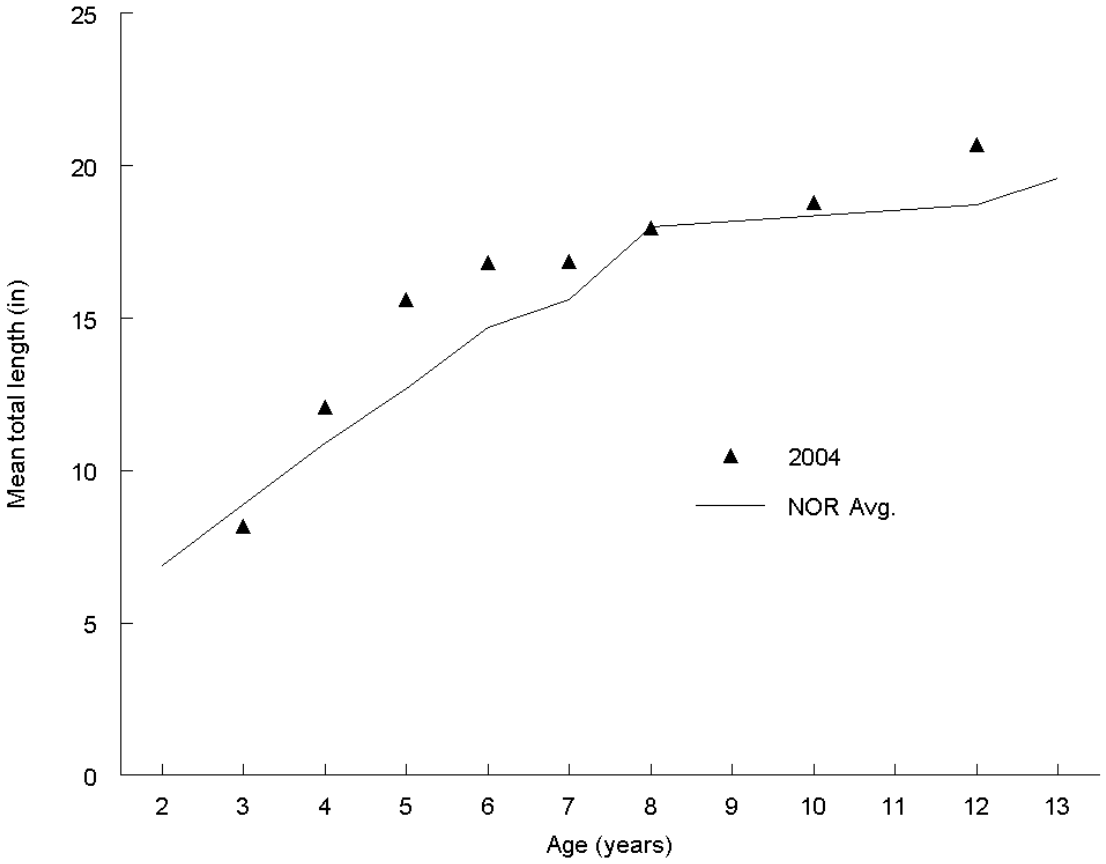

Figure 9. Age at length of smallmouth bass in Middle Eau Claire Lake, Bayfield County, Wisconsin, and the 18 county NOR region average.

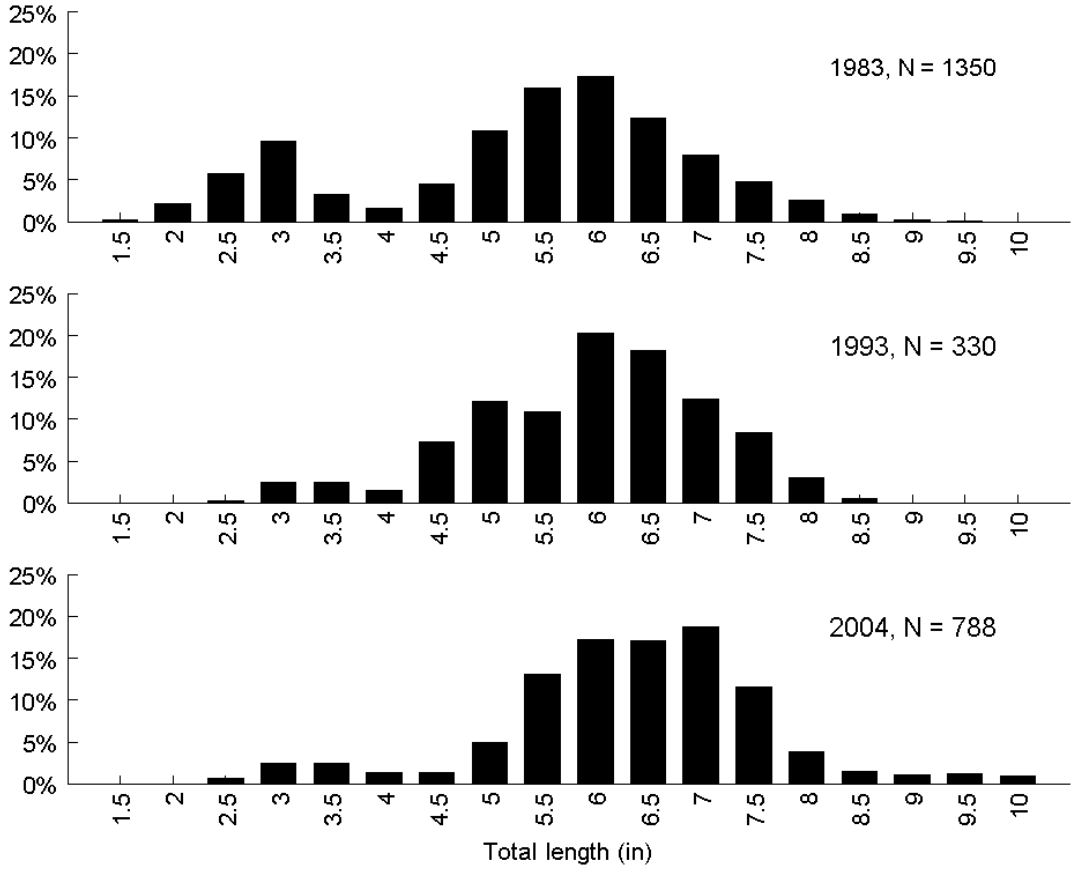

Figure 10. Percentage length frequency of fyke net catches for bluegill by length interval in Middle Eau Claire Lake, Bayfield County, Wisconsin.

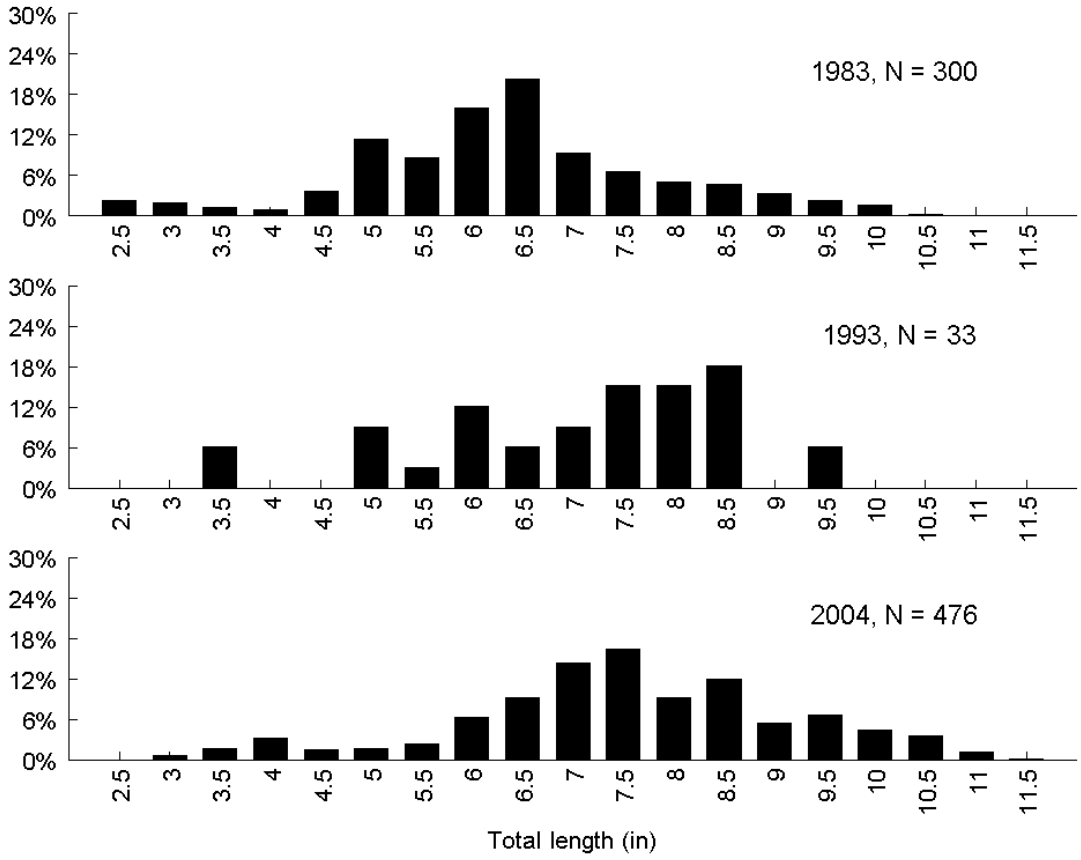

Figure 11. Percentage length frequency of fyke net catches for rock bass by length interval in Middle Eau Claire Lake, Bayfield County, Wisconsin.

Appendix Table 1. Proportional and relative stock density values.

Species	Stock Size (in)	Quality Size (in)	Preferred Size (in)
Bluegill	3	6	8
Largemouth Bass	8	12	15
Muskellunge	20	30	38
Northern Pike	14	21	28
Rock Bass	4	7	9
Smallmouth Bass	7	11	14
Walleye	10	15	20
Yellow Perch	5	8	10