Fishery Survey – Lake Owen
Bayfield County, 2007-2008
WBIC Code – 2900200

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Executive Summary

Lake Owen has supported diverse fish communities and a popular sport fishery. With the exception of walleye, good natural reproduction supports all species. A 2007 fishery survey suggests shifts in species abundance appear to be occurring.

Historically, Lake Owen had been known for its excellent smallmouth bass fishery. While smallmouth bass were still present in numbers similar to past survey years (8.7 fish/mile), largemouth bass were more than twice as abundant (19.4 fish/mile). Largemouth bass were not found in surveys in 1975 and 1988 in Lake Owen so the presence and abundance of largemouth bass is likely a symptom of changes occurring in the fishery during the past 30 plus years. The reasons for the change in largemouth bass abundance may include climate change, species interaction and habitat shifts. Since angler harvest of both smallmouth and largemouth bass has remained relatively stable (especially in light of changes in estimated catches), it is thought angling has had little impact on the changes to bass populations occurring in Lake Owen. Historically largemouth and smallmouth bass have been regulated as one species. Lake Owen may be an excellent candidate to attempt to manage the two species separately. Liberalizing angler harvest regulations and actively encouraging harvest of largemouth bass may help to reduce their abundance.

Despite frequent walleye stocking, adult walleye abundance (≥ 15 in and sexable fish) declined from 1988 to 1994 and has remained stable during the four surveys since that time from 0.9 to 1.8 adult walleye per acre. Adult walleye abundance was 1,592 (CV = 13%; 1.2 adults/acre) in 2007. Factors contributing to the decline in adult walleye abundance may be related to landscape position (low lake productivity),sporadic natural

recruitment, unsuccessful small fingerling stocking, increases in largemouth bass abundance, increased exploitation, or changes in weather patterns. Results from the 2007-2008 survey suggest that combined walleye exploitation (tribal and sport) of 45% is not sustainable without the potential of collapsing the stock. By utilizing a combination of stocking and angling regulation changes it is anticipated that walleye abundance will increase. Large fingerling walleye stocking may have more promise in helping to bolster Lake Owen walleye populations. Restricting angler harvest of walleye to fish over 18 in would give most females in the population at least one opportunity to spawn and potentially lower exploitation. The intention of a more restrictive regulation would be to protect adult stock thus increasing natural recruitment so intensive stocking efforts would be unnecessary in the future.

Management recommendations for Lake Owen include: 1) Decreasing largemouth bass abundance from 17.5 fish/mile to an average of historic survey abundance on Lake Owen of 1.2 fish/mile as measured by 2020 by liberalizing length regulations and increasing walleye abundance, 2) Increasing walleye abundance to the ceded territory large stocked lake average of 2.3 adults/acre from 1.2 adults/acre found in the 2007 Lake Owen survey by 2020 by enacting more conservative regulations and stocking of large walleye fingerling, 3) Monitoring the effects of proposed changes to management on Lake Owen by continuing survey efforts and marking of stocked walleye and 4) 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

Lake Owen is a 1,323 acre drainage lake at the headwaters of the Long Lake Branch of the White River. The Long Lake Branch of the White River is located in southeastern Bayfield County and flows into the White River near the town of Mason. Maximum depth of Lake Owen is 95 feet with a mean depth of 27 feet and an alkalinity of 64 mg/L. The lake has a highly developed shoreline with the exception of the 5.8 miles of shore that is in public ownership as Chequamegon National Forest lands and one mile of shore that consists of islands also under public ownership as State of Wisconsin lands. Lake Owen has a convoluted shoreline which results in a total shoreline length (including islands) of 25 miles. Public access is provided at two developed sites on federal land. One is located at the northwestern side of the lake near the outlet and the other is located at the Two Lakes Campground on the northeastern side of the lake. In addition to these developed access sites, there are also two undeveloped platted access sites at the south end of the lake (Johannes et al. 1971).

Water quality measurements taken for Lake Owen indicate low levels of nutrients. Average summer secchi disk depth trophic state index (TSI) value for the northern deep hole on Lake Owen was 29.9 (SD = 2.4, N = 28), for the time period between 1992 and 2007. TSI is an index for evaluating trophic state or nutrient condition of lakes (Carlson 1977; Lillie et al. 1993). 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 Lake Owen indicate the nutrient condition was oligotrophic (low productivity) when considering secchi disk TSI indices.

Water quality in Lake Owen was assessed through the use of fossil diatoms in 2005 (Garrison 2005). Garrison (2005) summarized that the overall water quality in the lake was good; however it has declined compared to 100 years prior. There were also differences in water quality when comparing the north basin and the rest of the lake and that Sister Bay's shoreline development may be having an adverse impact on water quality. Garrison (2005) recommended beginning efforts to maintain Lake Owen water quality, reducing impacts of shoreline development, determining the source of nutrients for the northern third of the lake and reducing the impact of high density development.

Lake Owen has a diverse fishery consisting of walleye *Sander vitreus*, northern pike *Esox 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*, logperch *Percina caprodes*, Iowa darter *Etheostoma exile*, bluntnose minnow *Pimephales notatus*, central mudminnow *Umbra limi*, cisco *Coregonus artedii* and lake whitefish *Coregonus clupeaformis*. Rainbow trout *Salmo gairdneri* were stocked in 1976, 1978, 1979, 1983 and 1987 in an attempt to establish a two story fishery and provide additional angling opportunities. Trout stocking was discontinued after 1987 due to little carry over and lack of public demand (Kamke 1989). It is assumed rainbow trout no longer exist in Lake Owen.

Historic fisheries management of Lake Owen has included surveys, stocking, and various length and daily bag limit regulations. Historic surveys for walleye occurred in 1988, 1994 and 2007 utilizing Wisconsin Department of Natural Resources (WDNR) standardized treaty protocols (Hennessey 2002). Additional walleye surveys estimating adult population were conducted by the Great Lakes Indian Fish and Wildlife Commission (GLFWC) in 1999, 2001 and 2003 using a different sampling protocol, i.e. electrofishing to both mark and recapture walleye. Basic fishery surveys utilizing a variety of gear types were conducted by WDNR in 1964, 1970-71, 1975 and 1986. Fall electrofishing surveys were utilized to assess recruitment of walleye in 1985, 1986, 1988, 1990-2006 and 2008.

Lake Owen has a long stocking history and has been stocked with a number of fish species, including walleye, largemouth bass, rainbow trout, northern pike and various panfish species, since at least 1933 (Table 1). Nearly annual walleye stocking occurred from at least 1933 to 1967, when over 17,000,000 fry, over 202,000 small fingerlings and 2,000 large fingerlings were stocked into Lake Owen. A basic inventory of the Lake Owen fishery found that walleye stocking was unnecessary after 1967 because a self sustaining fishery had been established (Rieckhoff 1976). Nevertheless Reickhoff (1976) noted that local resort owners periodically complained of too few walleye and suggested to continue stocking. He also found that the complaints more or less mirrored the presence or absence of dominant walleye year classes and/or forage abundance. For example, the 1971-1972 fishing seasons were considered good due to strong year classes recruiting to the fishery from 1969 and 1970, and after 1972 complaints again began to increase. Apparently, due to these complaints walleye stocking was resumed in 1980. The 1989 lake survey report recommended continued alternate year stocking of small fingerling walleye while exploring the possibility of stocking large fingerling walleye in an attempt to increase survival of stocked fish (Kamke 1989). Small fingerling walleye stocking was discontinued after 1994 due to past efforts being unsuccessful at providing measureable benefits. Management recommendations from a 1996 fishery survey report discussed whether or not higher walleye densities should be a goal for Lake Owen considering the lakes oligotrophic characteristics (Scholl 1996). However, if increasing walleye densities remained a goal for the fishery large fingerling walleye were proposed to increase first year survival. It was also recommended to mark large fingerling walleye that were stocked to evaluate the success of stocking efforts (Scholl 1996).

Walleye fishing regulations have changed over time on Lake Owen. There was no minimum length limit for walleye until 1990 when a 15 in minimum length limit was instituted statewide. Scholl (1996) recommended an 18 in minimum length limit for walleye that was not implemented. Bag limits for walleye have been adjusted annually according to tribal harvest declarations that began in 1987. Largemouth and smallmouth bass regulations have also changed over time. In 1989, a northern bass zone was created with an opening of the harvest of bass starting the 3rd Saturday in June with a 12 in minimum length limit. In 1998, the minimum length limit for bass was increased to 14 in. Both Kamke (1989) and Scholl (1996) recommended increasing the minimum length limit to 15 in for bass, or creating a protective slot to allow harvest of some smaller length bass. With the exception of walleye, other fish species have largely been managed via statewide length and bag limits.

Recent management has focused on stocking of large fingerling walleye from tribal, private and state sources and determining success of these stocking attempts. The Department has been involved with the fisheries committee of the Lake Owen Association and the Red Cliff Tribal Hatchery to facilitate the walleye stocking effort.

The objective of the 2007-2008 survey was to determine the status of the walleye, 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.

Methods

Lake Owen was sampled during 2007-2008 following the Wisconsin Department of Natural Resources comprehensive treaty assessment protocol (Hennessey 2002). This sampling included spring fyke netting and electrofishing to estimate walleye, bass (both largemouth and smallmouth) and northern pike abundance, fall electrofishing to estimate year class strength of walleye young-of-the-year (YOY), and a creel survey (both open water and ice).

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 total abundance 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 electroshocked. 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 spring electrofishing runs were used to determine relative abundance. The entire shoreline of the lake (25 miles) was sampled in 1988, 1994, 2002 and 2007. In 1975, 15.2 miles of shoreline was sampled. All surveys occurred in mid to late May with the exception of 2002 which occurred in mid June. For comparison purposes catch per unit effort (CPUE: the number of largemouth or smallmouth bass caught/mile of electrofishing) was calculated from the spring electrofishing surveys, because historic surveys collected bass during these surveys provided the most comparable data with the largest amount of shoreline sampled. Size structure for the 2007 survey utilized all largemouth and smallmouth bass captured from the spring electrofishing survey.

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 and differences between the size structure of angler and tribal harvest were determined using Kolmogorov-Smirnov tests utilizing $ά = 0.05$ to determine significance.

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. Angler exploitation of adult walleye was estimated by dividing the projected number of fin-clipped walleye harvested during the course of the fishing season by the total number of marked walleye at large (Beard et al. 2003). Due to difference in methods the 1988 creel survey could not be used for comparisons of catch, harvest and walleye exploitation. Comparisons to the 1988 creel survey could be made using fishing pressure and length of harvested fish.

Results

Total survey effort in 2007 included 114 fyke net lifts targeting spawning walleye. Three electrofishing surveys of the entire shoreline totaling 18.0 hours in spring (first and second recapture surveys) and 8.8 hours in fall (walleye recruitment survey) were conducted.

Walleye. Adult walleye abundance (≥ 15 in and sexable fish) was 1,592 (CV = 13%; 1.2 adults/acre) in 2007. Adult walleye density declined from 1988 to 1994 and has remained stable during the four surveys since that time (Figure 1). Density estimates during this period ranged from 3.1 to 0.9 fish/acre in six sampling periods. Adult walleye density in 2003 was the lowest of all surveys conducted; the highest occurred in 1988.

Length of walleye captured in fyke nets in 1988, 1994, 1999, 2001, 2003 and 2007 suggests significant shifts in size structure between all years (1988 vs. 1994, D = 0.14, P = 0.0018; 1994 vs. 1999, D = 0.36, P <0.001; 1999 vs. 2001, D = 0.11, P <0.001; 2001 vs. 2003, D = 0.30, P <0.001; 2003 vs. 2007, D = 0.49 P <0.001; 1988 vs, 2007, D = 0.41, P <0.001; Figure 2). The proportional stock density of walleye captured in fyke nets remained similar (72, 72, 76 and 69) from 1988 to 2001 and then increased (91 and 95) in 2003 and 2007. PSD values through 2001 indicated a quality size structure of the walleye population. PSD values in 2003 and 2007 indicated an exceptional quality size structure of the walleye population. RSD-20 values of 8 in 1999 and 2001 were low compared to values of 25, 39, 16 and 63 in 1988, 1994, 2003 and 2007 respectively, which indicated a walleye population that had a high abundance of fish over 20 in in length. Mean length for sexable walleye ranged from a low of 16.4 in (95% CI = 0.13, N = 1,148) in 1999 to a high of 20.8 (95% CI = 0.37, N = 355) in 2007 (Figure 3).

Age of adult walleye sampled during the 2007 survey ranged from II to XVII. Male and female walleye first reached maturity at II and IV, respectively. Age VI walleye accounted for 28% of the adult stock. Age distribution data from 1988, 1994, and 2007 indicate inconsistent naturally reproduced year classes (Figure 4). Growth rates for both sexes were dimorphic with males reaching 15 inches at age IV and females between ages III and IV in the 2007 survey. Growth rates in 1988, 1994 and 2007 were predominately above Northern Region averages (Figure 5).

Relative abundance of Young of Year (YOY) walleye in Lake Owen in 2007 was 2 fish/mile (5 fish/hour). The average walleye YOY/mile was 9.7 (SD = 12.9, N = 20) for surveys completed from 1985 to 2007 by both WDNR and GLIFWC. Fingerling relative abundance has been highly variable from 1985 to 2004 with a range of 0 fish/mile to 39.4 fish/mile (Figure 6). Mean relative abundance of YOY walleye for naturally reproducing and stocked walleye lakes surveyed by WDNR in Bayfield and Douglas Counties from 1991 to 2007 was 28.2 fish/mile (SD = 57.35, N = 73) and 10.4 fish/mile (SD = 18.54, N = 41), respectively.

Smallmouth and Largemouth Bass. Smallmouth bass relative abundance in Lake Owen was 8.7 fish/mile for 2007. Relative abundance for smallmouth bass has decreased over time (with the exception of 1994) and was inversely related to largemouth bass abundance during spring electrofishing surveys from 12.0, 12.8, 22.6 to 10.6 fish/mile for 1975, 1988, 1994 and 2002 (Figure 7). Mean length of smallmouth bass for the 2007 survey was 11.3 in (SD = 2.83; N = 218) and had PSD and RSD-14 values of 54 and 22, respectively which indicated good size structure. Size structure has remained similar since the 1988 survey and improved since the 1975 survey. Smallmouth bass PSD values were 54, 55 and 63 and RSD-14 values were 10, 14 and 16 for 1988, 1994 and 2002. PSD and RSD-14 values for smallmouth bass were 31 and 4 in 1975.

In 2007, largemouth bass represented 69% and smallmouth bass 31% of the total number of bass surveyed (N = 702). Largemouth bass relative abundance in Lake Owen was 19.4 fish/mile for 2007. Relative abundance for largemouth bass increased over time and since 1994 has been inversely related to smallmouth during spring electrofishing surveys (Figure 7). Size structure of largemouth bass for the 2007 survey was fair with a mean length of 12.0 in (SD = 2.58; N = 484) and PSD and RSD-15 values of 64 and 11, respectively. Historic size structure has remained similar for largemouth bass. PSD values were 63 and 43 and RSD-15 values were 11 and 4 for 1994 and 2002, respectively. No largemouth bass were surveyed in 1975 and 1988 in Lake Owen.

<u>Northern Pike.</u> Northern pike caught in fyke nets were counted and measured only north of the narrows in Lake Owen in 2007. In 1988 and 1994 northern pike caught in fyke nets where measured and counted in the entire lake. There was not an adequate number of northern pike marked to estimate abundance, however the density of northern pike appeared to be low. Relative abundance of northern pike decreased over time and was 5.3, 1.5 and 1.1 fish/net lift in 1988, 1994 and 2007, respectively. Mean length for northern pike (fyke net samples) in 2007 was 23.0 in (SD = 3.31, N = 63). The size structure of northern pike has increased over time in Lake Owen. PSD for spring fyke net samples was 35, 54 and 79 for 1988, 1994 and 2007. RSD-28 for spring fyke net

samples was 1, 7 and 8 for the same time period. The largest northern pike caught during the 2007 fyke netting survey was 28.7 in.

Sport and Tribal Fishery. Anglers fished an estimated 31,811 hours (24.0 hrs/acre) during the 2007-2008 season on Lake Owen, which is near the average of 22.5 hrs/acre (SD = 9.56, N = 40) for Bayfield and Douglas County walleye lakes from 1990 to 2007 (WDNR unpublished data, Brule field office) and below the Northern Wisconsin Region (20 counties) average from 1990 to 2007 of 33.3 hrs/acre (SD = 24.64, N = 407). Open water anglers accounted for 94% of all fishing effort. The directed effort, i.e. effort targeted toward a specific fish, was highest for smallmouth bass (29.2%), followed by largemouth bass (23.2%) and walleye (10.7%). The most sought after panfish species was bluegill, with 15.6% of the directed effort. Fishing pressure has remained fairly consistent since 1988. The fishing pressure (hrs/acre) was 23.7, 17.8 and 22.5 for 1988, 1994 and 2007, respectively.

Angler catch of smallmouth bass increased from 4,763 to 9,284 from 1994 to 2007. However, the increase in angler catch of largemouth bass was far greater; 507 in 1994 to 11,369 in 2007. In 2007, the highest angler catch for gamefish was largemouth bass and in 1994 the highest gamefish catch was for smallmouth bass. Angler harvest of both smallmouth and largemouth bass was low in both 1994 and 2007. Angler harvest of smallmouth bass decreased from 408 in 1994 to 357 in 2007, while angler harvest of largemouth bass increased from 40 in 1994 to 612 in 2007. Mean length of angler harvest for both smallmouth and largemouth bass increased from 1994 to 2007. Average length of angler harvested smallmouth bass increased from 14.8 in in 1994 to 15.7 in in 2007, and also increased from 14.2 in in 1994 to 15.1 in in 2007 for largemouth bass.

Angler exploitation of walleye has increased from 10% in 1994 to 26% in 2007. An estimated 432 walleye were caught by anglers in the open water and ice season of 2007 compared to 813 in 1994. Anglers harvested an estimated 388 walleye in 1994 and 250 walleye in 2007. In 2007, average length of angler harvested walleye was 20.6 in (SD = 3.1, N = 46), which was an increase from 18.2 in in 1994.

Tribal harvest accounted for 302 walleye in 2007 (Krueger 2008). Walleye harvested ranged from 10.2 to 26.0 in. Tribal harvest represented 41% of the combined total harvest (sport angling plus tribal spearing) and tribal exploitation of the adult walleye population was 19%. Tribal exploitation has been variable over time and ranged from 3% to 19% from 1988 to 2007. Length of harvested walleye by tribal spearers was different compared to that of sport anglers ($D = 0.57$, $P < 0.001$; Figure 8). Male and female walleye represented 82% and 12% of the total tribal harvest, respectively. The remaining 6% were walleye of unknown sex. Total walleye exploitation (sport and tribal) increased from 17% to 45% from 1994 to 2007.

Northern pike were the second most exploited (harvest = 384) gamefish in 2007 on Lake Owen and had the least directed effort (8.5%) of gamefish. Estimated catch of northern pike was 2,448 in 2007. Directed effort for northern pike decreased from 18.3% to 8.5% from 1994 to 2007. Northern pike estimated catch remained stable from 1994 to 2007 at 2,543 and 2,448 respectively. Estimated harvest decreased from 657 to 384 from 1994 to 2007. Mean length of harvested northern pike increased from 22.2 to 23.2 inches from 1994 to 2007, respectively.

Anglers pursuing panfish fished an estimated 16,283 hours and accounted for 29% of the total directed angling effort for the 2007-08 open water and winter seasons combined. Estimated catch of bluegill increased from 3,984 in 1994 to 30,755 in 2007 and harvest more that doubled from 2,085 to 5,529 in the same time period. Average length of harvested bluegill increased from 6.6 in to 7.2 in. In contrast, catch and harvest of yellow perch decreased from 3,753 and 681 to 3,272 and 336 from 1994 to 2007. Average length of harvested yellow perch increased from 7.7 to 8.7 from 1994 to 2007. Black crappie had the largest increases in both catch and harvest of all panfish species between surveys. Catch of black crappie increased from 45 to 839 and harvest increased from 4 to 510 from 1994 to 2007. Average length of harvested black crappie decreased from 10.4 to 9.9 in during the sample time period. Rock bass were the second only to bluegill in catch and harvest among panfish in the 2007 creel survey. Rock bass catch and harvest had proportional increases that were similar to bluegill. Rock bass catch and harvest increased from 2,476 and 808 to 9,808 and 1,755 from 1994 to 2007.

As an observation, the creel clerk found a dead cisco 18 in in length washed up on shore during the summer of Lake Owen in 2007. This represented the only evidence of the species presence in Lake Owen during the 2007 surveys.

Discussion

Lake Owen has supported diverse fish communities and a popular sport fishery. With the exception of walleye, good natural reproduction supports all species. Shifts in species abundance appear to be occurring and mirror trends in lakes of similar type in the region. This shift includes increased abundances of centrarchid species bluegill, black crappie, and largemouth bass, while percid species walleye and yellow perch abundances have declined or remained low.

Historically, Lake Owen had been known for its excellent smallmouth bass fishery. While smallmouth bass were still present in abundances similar to past survey years (8.7 fish/mile), largemouth bass were more than twice as abundant (19.4 fish/mile). Creel surveys confirm the trend of electrofishing data, showing a 2,243 fold increase in anglers catch of largemouth bass from 1994 to 2007 in Lake Owen. Largemouth bass were not found in surveys in 1975 and 1988 in Lake Owen so the presence and abundance of largemouth bass is likely a symptom of changes occurring in the fishery during the past 30 plus years. The reasons for the change in largemouth bass abundance may include climate change, species interaction and habitat shifts. Since angler harvest of both smallmouth and largemouth bass has remained relatively stable (especially in light of changes in estimated catches), it is thought angling has had little impact on the changes occurring in Lake Owen.

Climate change has been identified as a potential shift of cold, cool and warmwater species to more northern areas where they had been uncommon in the past. Shuter et al. (2002), Jackson and Mandrak (2002), Chu et al. (2005) and Sharma et al. (2007) predicted increases in water temperature in response to climate change will have large implications for aquatic ecosystems in Canada, such as altering thermal habitat and potential range expansion of fish species. They surmised that warmwater fish species may have access to additional favorable thermal habitat under increased surface-water temperatures, thereby shifting the northern limit of the distribution of the species further north and potentially negatively impacting native fish communities.

Negative species interactions have been identified between largemouth bass and walleye populations. Nate et al. (2003) indexed relative abundance of five gamefish species on the basis of general angler catch rates from creel surveys on 60 lakes in northern Wisconsin during 1990-2001. Analysis revealed higher angler catch rates (presumably greater abundance) of largemouth bass and northern pike on 30 lakes with "stocked" walleye populations (demonstrably lower walleye density), and higher angler catch rates for walleye and muskellunge on 30 lakes with "self-sustaining" walleye populations where angler catch rates (and presumed abundance) of largemouth bass were lowest. In a more recent analysis of 20 northern Wisconsin lakes with at least 50% natural recruitment of walleye, Fayram et al. (2005) reported a significantly negative relationship between adult walleye density and multi-season electrofishing capture rate of largemouth bass. They concluded, "Given the seemingly strong predatory interaction between walleyes and largemouth bass, management of both species in the same water body may be difficult. In addition, walleye stocking may be ill advised in lakes with even moderate abundances of largemouth bass, given their potentially large impact on survival of juvenile walleyes."

Habitat changes could be responsible for favoring largemouth bass over smallmouth bass. As adults and juveniles, largemouth and smallmouth bass occupy different microhabitats in the near shore areas of lakes (Miller 1975). Largemouth bass tend to occupy habitats dominated by aquatic vegetation and smallmouth bass occupy habitats with cobble substrate and little vegetation. Olson et al. (2003) found that juvenile largemouth bass consume aquatic insects at equal rates in vegetated and cobble habitats and smallmouth bass feed at higher rates in cobble than in vegetation, however, largemouth bass were more vulnerable to predation in cobble than in vegetation and smallmouth bass were more vulnerable to predation in vegetation. Although we do not have data on coverage of vegetation in Lake Owen it is possible that increased abundance of vegetation could favor survival of largemouth bass.

Historically largemouth and smallmouth bass have been regulated as one species. Lake Owen may be an excellent candidate to attempt to manage them separately. Liberalizing angler harvest regulations and actively encouraging harvest of largemouth bass may help to reduce their abundance. Even though largemouth are exploited at low rates by anglers, we hope that educational efforts aimed at increasing harvest of largemouth bass on Lake Owen will increase exploitation over time. WDNR can help to educate anglers about the need for increased largemouth harvest by placing signs at access points, providing flyers to local bait shops and working with the Lake Owen Association. Nearby counties in northwest Wisconsin are currently involved in these angler educational efforts which will help increase awareness on Lake Owen also.

Despite frequent walleye stocking, adult walleye abundance declined from 1988 to 1994 and has remained stable during the four surveys since that time. Changes in length indices and age composition suggests a shift to larger, older fish with little recruitment occurring. Factors contributing to the decline in adult walleye abundance may be related to landscape position (low lake productivity),sporadic natural recruitment, unsuccessful small fingerling stocking, increases in largemouth bass (or other centrarchid) abundance, increased exploitation, changes in weather patterns or unknown variables that are yet to be identified.

Low productivity, high landscape position and relatively low fish community diversity may limit the abundance of self-sustaining walleye abundance in lakes similar to Lake Owen (Nate et. al. 2001). Isermann (2007) found that walleye recruitment across

20 populations in North America was highly variable which made it difficult to determine effects of regulation management both pre and post regulation change. Large May water temperature variations due to rapid warming or cooling could also be partially responsible for low age-0 walleye abundance in Lake Owen. Serns (1982) found in Escanaba Lake in Northern Wisconsin significant negative correlations between the fall density of age-0 walleyes and both the standard deviation and coefficient of variation of the May water temperatures.

Small fingerling walleye stocking in Lake Owen appears to have had limited success. Stocking of small fingerling walleye has resulted in both high and low abundance of young of the year (YOY) walleye the following fall. However, since 1994 abundance of YOY walleye in fall surveys has been low and has coincided with the increase in abundance with largemouth bass. Supplemental small fingerling walleye stocking has been shown to have relatively little impact to YOY walleye abundance in fall of the same year of stocking. Jennings et al. (2005) studied 23 lakes in northern Wisconsin to assess differences in year class strength with and without supplemental stocking. The mean survival of stocked fingerlings until fall was 3.4% which was consistent with literature reports documenting successful supplemental stocking in 5% of case histories. Large fingerling walleye stocking may have more promise in helping to bolster Lake Owen walleye populations. Kampa and Hatzenbeler (2009) found that stocking large walleye fingerlings in September at a density of 10 fish/acre resulted in an age-1 catch per effort that was 4 times greater than small fingerlings stocked in June at a density of 50 fish/acre. They also found large fingerling stocking produced more consistent year-classes.

The increased largemouth bass abundance could have an effect on the success of small fingerling walleye stocking and large fingerling walleye stocking may be needed to avoid predation by largemouth bass. Fayram et al. (2005) found that survival of stocked walleyes was negatively related to largemouth bass abundance, but also largemouth bass abundances increased as walleye stocking increased. In their bioenergetics analysis of one lake they found that the largemouth bass population could consume up to 82,500 juvenile walleye per year, which indicated that largemouth bass interact with walleye strongly through predation. Santucci and Wahl (1993) found that largemouth bass preyed heavily on stocked small and medium fingerling walleye and were responsible for their almost complete mortality while the stocked large fingerling walleye survived in relatively high percentages. Wahl (1995) recommended that walleye be introduced in the fall at large (> 8 in) sizes in order to reduce losses to largemouth bass predation. Hoxmeier et al. (2006) recommended stocking large fingerling walleye in lakes where largemouth bass predation is high after finding little success (< 5 YOY walleye/mile in fall surveys) after stocking small and medium fingerling walleye. Large fingerling walleye have been stocked in Lake Owen in relatively low densities by the Red Cliff Tribe, Wisconsin DNR and the Lake Owen Association in 1995 (3.8 fish/acre), 1999 (0.2 fish/acre), 2001 (1.5 fish/acre), 2006 (0.4 fish/acre), 2007 (2.0 fish/acre) and 2008 (5.0 fish/acre). However, length of fish from these sources has been variable, and based on the above research findings may not have included fish of great enough length to increase post-stocking survival. Current DNR stocking guidance recommends stocking large fingerling (> 6 in) walleye at a rate of 10 fish/acre. While stocking length is variable between years for large fingerlings, retaining walleye in hatchery ponds longer prior to stocking may result in more cost-effectiveness in terms of survival.

Results from the 2007-2008 survey suggest that combined walleye exploitation (tribal and sport) of 45% is not sustainable without the potential of collapsing the stock. The maximum sustainable exploitation rate derived to set harvest quotas of the combined tribal and sport walleye fishery in the ceded territory of northern Wisconsin is 35% (Hansen et al. 1991). Lake Owen has experienced total exploitation rates that are rare when viewed from a northern Wisconsin perspective. The chance of exceeding 35% total exploitation is low according to a study of 210 lakes sampled from 1990-1998, where only 4 lakes or (1.9%) exceed that rate (Beard et al. 2003). Schueller et al. (2008) modeled the probability of decline of walleye populations under different exploitation rates. They concluded that as the exploitation rate increased, the average adult density decreased and the time to extinction decreased for all initial population densities.

Restricting angler harvest of walleye to fish over 18 in would give most females in the population at least one opportunity to spawn since females reach sexual maturity at an average of 17.4 in. The intention of a more restrictive regulation would be to increase natural recruitment so that intensive stocking efforts would be unnecessary in the future. However, studies have shown that restricting angler harvest will not necessarily increase walleye abundance. Stone and Lott (2002) found that in a South Dakota impoundment walleye recruitment, growth, condition, and abundance did not change significantly from pre-regulation to post-regulation periods. However, they did find that proportional stock density increased significantly in the years following the implementation of the more restrictive regulation. Isermann (2007) found on two Minnesota lakes that no direct evidence existed to indicate that adult walleye abundance, size structure, or age structure was improved after implementation of length limits or that the regulations reduced annual variation in size structure. In light of recruitment variation, meaningful evaluation of walleye length limits will require long-term annual sampling efforts designed to monitor the fate of multiple year-classes of similar magnitudes during both pre-regulation and post-regulation periods. Furthermore, he found that observed improvements in fishery-related metrics, such as size structure of harvested fish, may merely reflect changes in angler behavior rather than actual improvements in the population. The combination of more restrictive walleye harvest regulations, concerted efforts of stocking large fingerling walleye and liberalization of largemouth bass regulations on Lake Owen have the greatest chances of achieving the desired effects of decreasing largemouth abundance and increasing walleye abundance. Future evaluations should include additional water bodies in a broader study attempting to assess bass/walleye community changes when implementing regulation changes intend to increase harvest on largemouth bass and decrease walleye harvest while utilizing the stocking of large fingerling walleye to increase walleye populations while decreasing largemouth bass populations.

Summary and Management Recommendations

1. Decrease largemouth bass abundance from 17.5 fish/mile to an average of historic survey abundance on Lake Owen of 1.2 fish/mile as measured by 2020. Historically, Lake Owen had been known for its excellent smallmouth bass fishery. While smallmouth bass were still present in abundances similar to past survey years, largemouth bass were now more than twice as abundant. Largemouth bass were not found in surveys in 1975 and 1988 in Lake Owen so the presence and abundance of

largemouth bass is likely a symptom of changes occurring in the fishery during the past 30 plus years. With the objective of reducing largemouth bass populations a submitted regulation change proposal (July 2009) would remove the minimum length restriction for angler harvest of largemouth bass. Along with angler education efforts aimed at increasing harvest of largemouth bass, stocking of large fingerling walleye and more restrictive walleye harvest regulations it is anticipated that largemouth abundance will decline in abundance.

2. Increase walleye abundance to the ceded territory large stocked lake average of 2.3 adults/acre from 1.2 adults/acre found in the 2007 Lake Owen survey by 2020. Despite frequent walleye stocking, adult walleye abundance (≥ 15 in and sexable fish) declined from 1988 to 1994 and has remained stable during the four surveys since that time. By utilizing a combination of stocking and angling regulation changes it is anticipated that walleye will increase in abundance. Large fingerling walleye > 8 in stocking may have more promise in helping to bolster Lake Owen walleye populations. The Lake Owen Association is planning on stocking of large fingerling walleye until 2012. After 2012 large fingerling walleye will be requested through the state hatchery system at a stocking rate of 10 fish/acre on an alternate year basis. Results from the 2007-2008 survey suggest that combined walleye exploitation (tribal and sport) of 45% is not sustainable without the potential of collapsing the stock. Therefore, restricting angler harvest of walleye to fish over 18 in would give most females in the population at least one opportunity to spawn since females reach sexual maturity at an average of 17.4 in. The intention of a more restrictive regulation would be to increase natural recruitment so that intensive stocking efforts

would be unnecessary in the future. If adult walleye abundances equal or exceed 2.3 fish/acre by 2020 stocking should be discontinued in order to determine if the population can be self sustaining in the future.

3. Monitor the effects of proposed changes to management on Lake Owen. Walleye population estimates and bass abundances will be collected every 6 years (2013 is next scheduled survey). Creel surveys should be conducted whenever fiscally feasible and at least once prior to 2020. All walleye stocked in Lake Owen should be marked in order to identify stocked from naturally reproduced fish. Stocking evaluations on large fingerling walleye will be conducted the following spring after stocking in order to determine survival and contribution to age I. Future spring netting surveys will measure all gamefish and a subset of panfish in order to establish a more detailed dataset.
4. Efforts should be made to continue tracking northern pike abundance through spring fyke netting and importance to anglers through creel surveys. Northern pike although not abundant are an important component of angler harvest. Northern pike had the 2^{nd} highest estimated harvest among gamefish in the 2007 creel survey, over 50% of which came during the ice fishing season.
5. Work with local residents, the Lake Owen Association 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 stocking 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. Preserving and enhancing the ecosystem and 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.

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Table 1. Fish Stocking History of Lake Owen, Bayfield County, Wisconsin DNR

Year	Species	Number Stocked	Age/Size
1933	Walleye	703,700	Fry
	Black Bass	1,362	Unknown
1935	Walleye	825,900	Fry
	Black Crappie/bluegill	900	Unknown
1936	Walleye	1,587,600	Fry
	Sunfish	560	Unknown
	Bluegill	560	Unknown
1938	Walleye	1,559,640	Fry
	Largemouth Bass	2,000	Fry
1939	Walleye	1,000,000	Fry
	Largemouth Bass	1,848	Fry
1940	Walleye	1,000,000	Fry
	Largemouth Bass	5,000	Fry
	Largemouth Bass	3,000	Small Fingerling
1941	Walleye	1,000,000	Fry
	Largemouth Bass	10,000	Small Fingerling
1942	Walleye	3,650	Small Fingerling
	Largemouth Bass	9,000	Small Fingerling
	Northern Pike	200,000	Fry
1943	Walleye	1,000,000	Fry
	Walleye	5,000	Small Fingerling
	Northern Pike	126,000	Fry
1944	Walleye	800,000	Fry
	Walleye	3,000	Small Fingerling
	Largemouth Bass	1,500	Small Fingerling
	Northern Pike	152,300	Fry
	Smallmouth Bass	1,420	Small Fingerling
1945	Walleye	2,675,200	Fry
	Walleye	10,000	Small Fingerling
	Largemouth Bass	7,100	Small Fingerling
1946	Walleye	2,983,175	Fry
	Walleye	6,000	Small Fingerling
	Largemouth Bass	4,000	Small Fingerling
	Smallmouth Bass	250	Small Fingerling
1947	Walleye	2,000,000	Fry
	Walleye	10,000	Small Fingerling
1949	Walleye	5,600	Small Fingerling
	Largemouth Bass	250	Small Fingerling
1950	Walleye	21,905	Small Fingerling
	Largemouth Bass	3,000	Small Fingerling
	Smallmouth Bass	10,000	Small Fingerling
1952	Walleye	27,345	Small Fingerling
1953	Walleye	9,627	Small Fingerling
1954	Walleye	8,400	Small Fingerling
1955	Walleye	1,260	Small Fingerling
1956	Walleye	8,400	Small Fingerling
1957	Walleye	8,400	Small Fingerling
1958	Walleye	2,800	Small Fingerling
1961	Walleye	30,500	Small Fingerling

Table 1 (continued). Fish Stocking History of Lake Owen, Bayfield County, Wisconsin

Year	Species	Number Stocked	Age/Size
1964	Walleye	25,000	Small Fingerling
	Walleye	2,000	Large Fingerling
1967	Walleye	15,500	Small Fingerling
1976	Rainbow Trout	3,500	Yearling
1978	Rainbow Trout	3,500	Yearling
1979	Rainbow Trout	3,500	Yearling
1980	Walleye	1,300,000	Fry
1981	Walleye	62,494	Small Fingerling
1982	Walleye	19,800	Fry
	Walleye	29,480	Small Fingerling
	Walleye	12,988	Large Fingerling
1983	Walleye	62,240	Small Fingerling
	Rainbow Trout	7,652	Yearling
1985	Walleye	8,357	Small Fingerling
1987	Rainbow Trout	3,000	Yearling
1988	Walleye	49,731	Small Fingerling
1989	Walleye	5,800	Large Fingerling
1991	Walleye	22,541	Large Fingerling
1992	Walleye	70,793	Small Fingerling
	Walleye	110,000	Fry
1994	Walleye	67,278	Small Fingerling
	Walleye	950	Large Fingerling
1995	Walleye	4,984	Large Fingerling
1999	Walleye	200	Large Fingerling
2001	Walleye	2,000	Large Fingerling
2006	Walleye	474	Large Fingerling
2007	Walleye	2,581	Large Fingerling
2008	Walleye	6,150	Large Fingerling

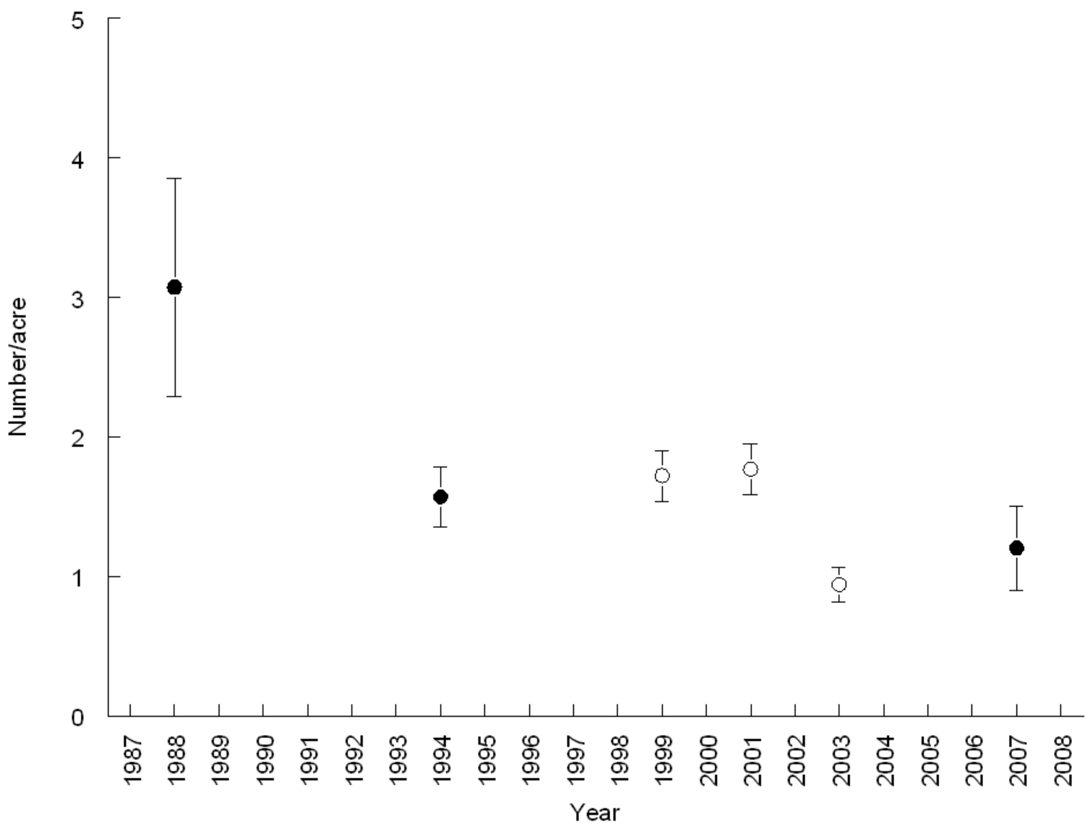

Figure 1. Number of walleye ≥15 in and sexable fish (number/acre ± 95% confidence intervals) by year in Lake Owen, Bayfield County, Wisconsin. Survey in 1994 utilized supplemental electrofishing to increase numbers of marked fish. Surveys in 1999, 2001 and 2003 utilized electrofishing for both marking and recapture. Surveys in 1994 and 2007 utilized fyke netting for marking and electrofishing for recapture.

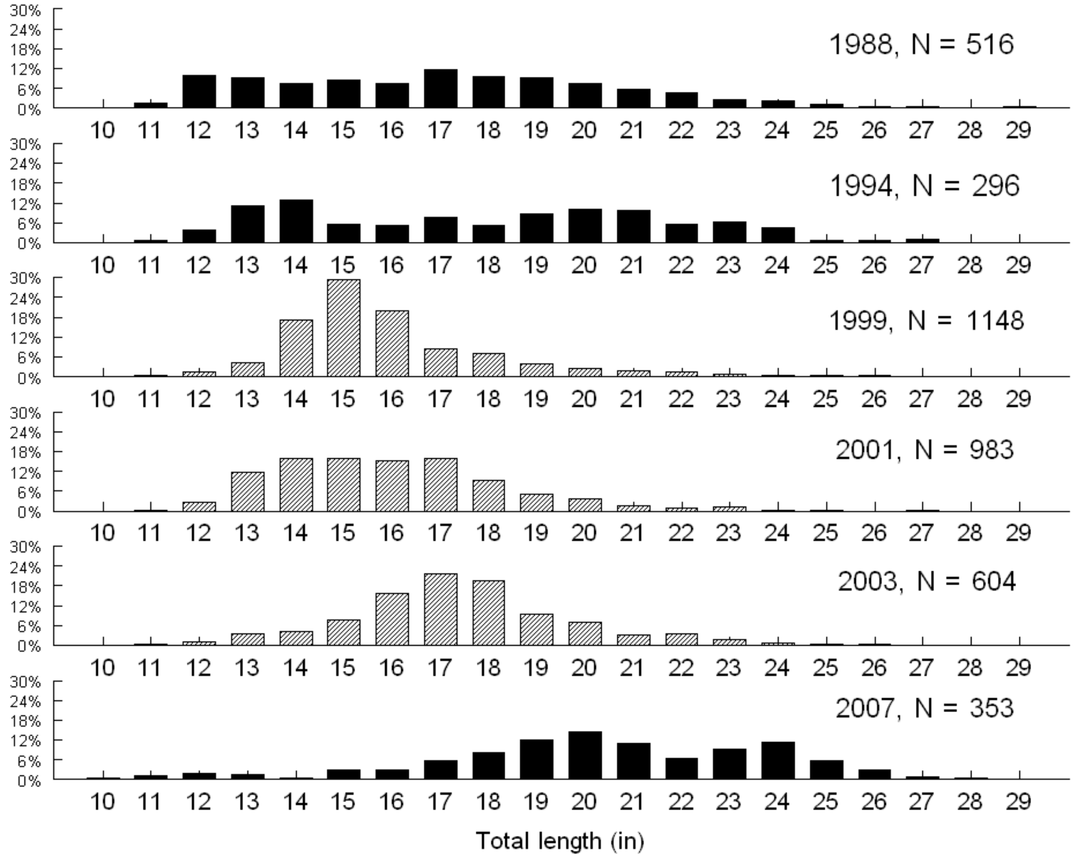

Figure 2. Percentage length frequency of spring fyke net and electrofishing catches for walleye by length interval in Lake Owen, Bayfield County, Wisconsin. Solid bars represent fyke net surveys, striped bars represent electrofishing surveys.

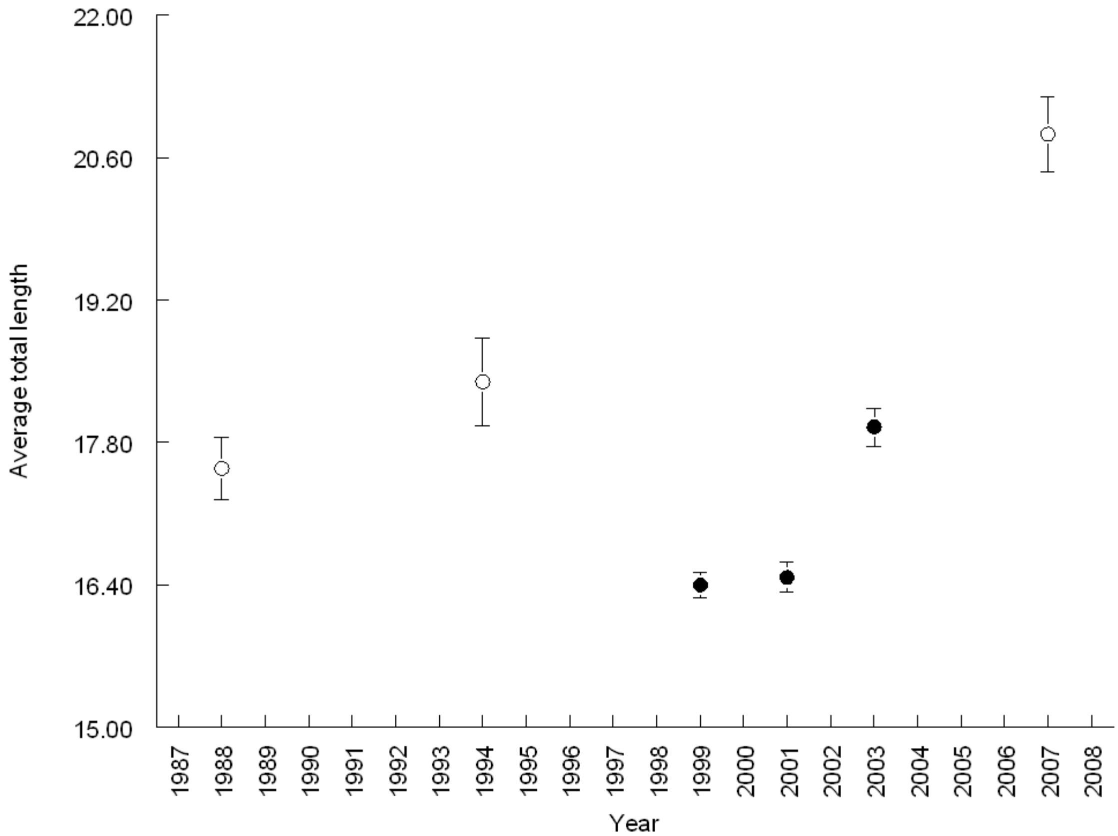

Figure 3. Average total length (± 95% confidence interval) of spring fyke net and electrofishing catches for walleye in Lake Owen, Bayfield County, Wisconsin. White circles represent fyke net surveys, black circles represent electrofishing surveys.

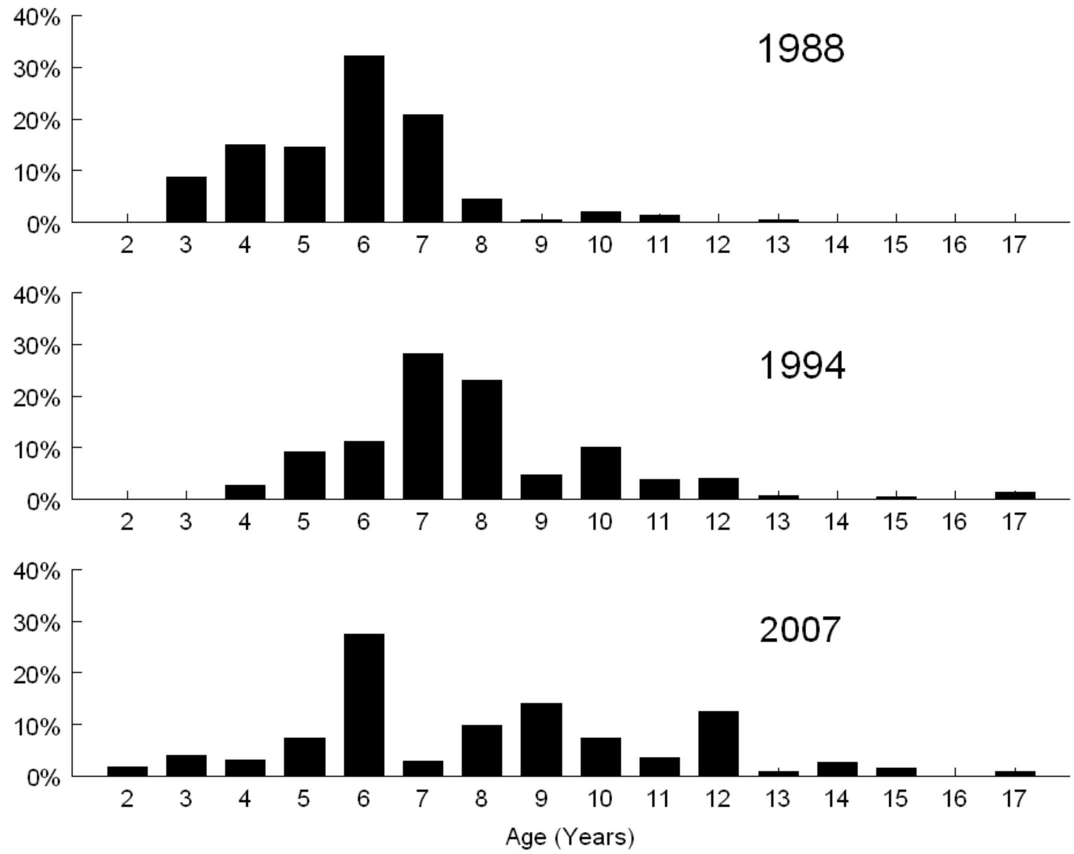

Figure 4. Percent distribution by age of walleye in Lake Owen, Bayfield County, Wisconsin.

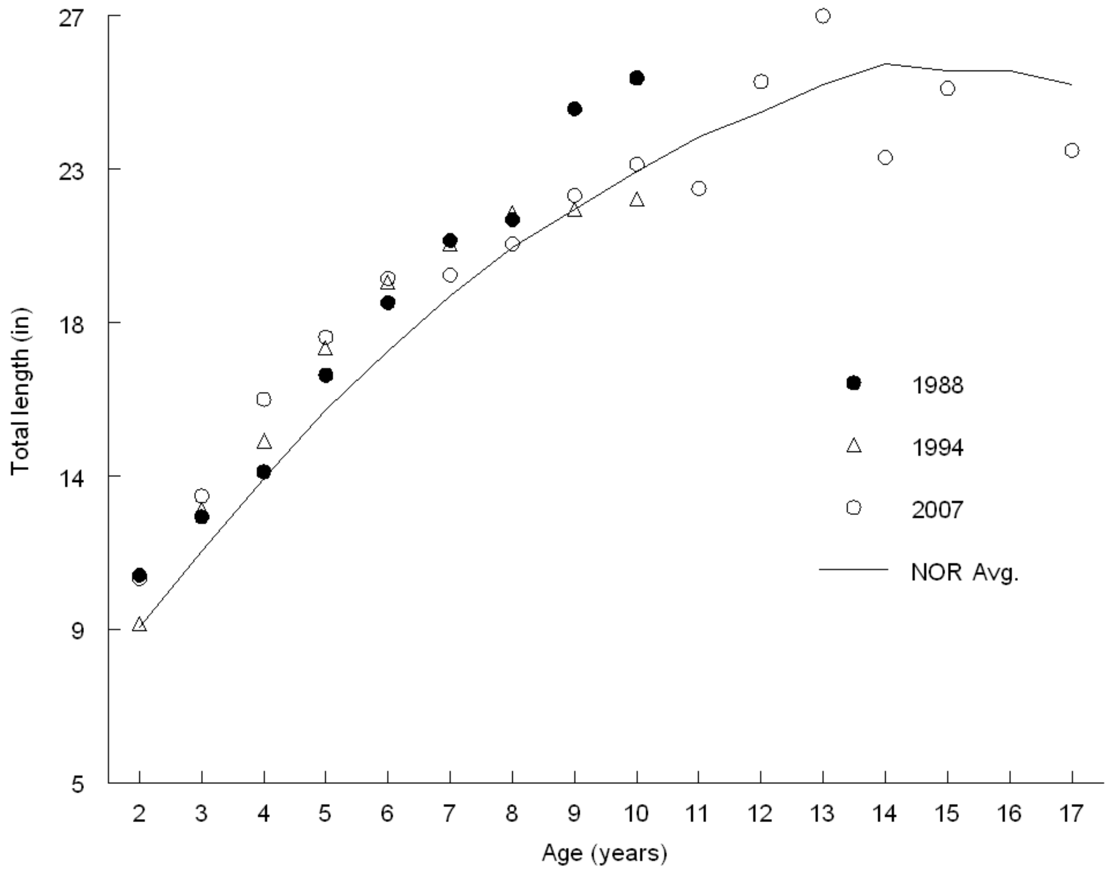

Figure 5. Age at length of walleye in Lake Owen, Bayfield County, Wisconsin.

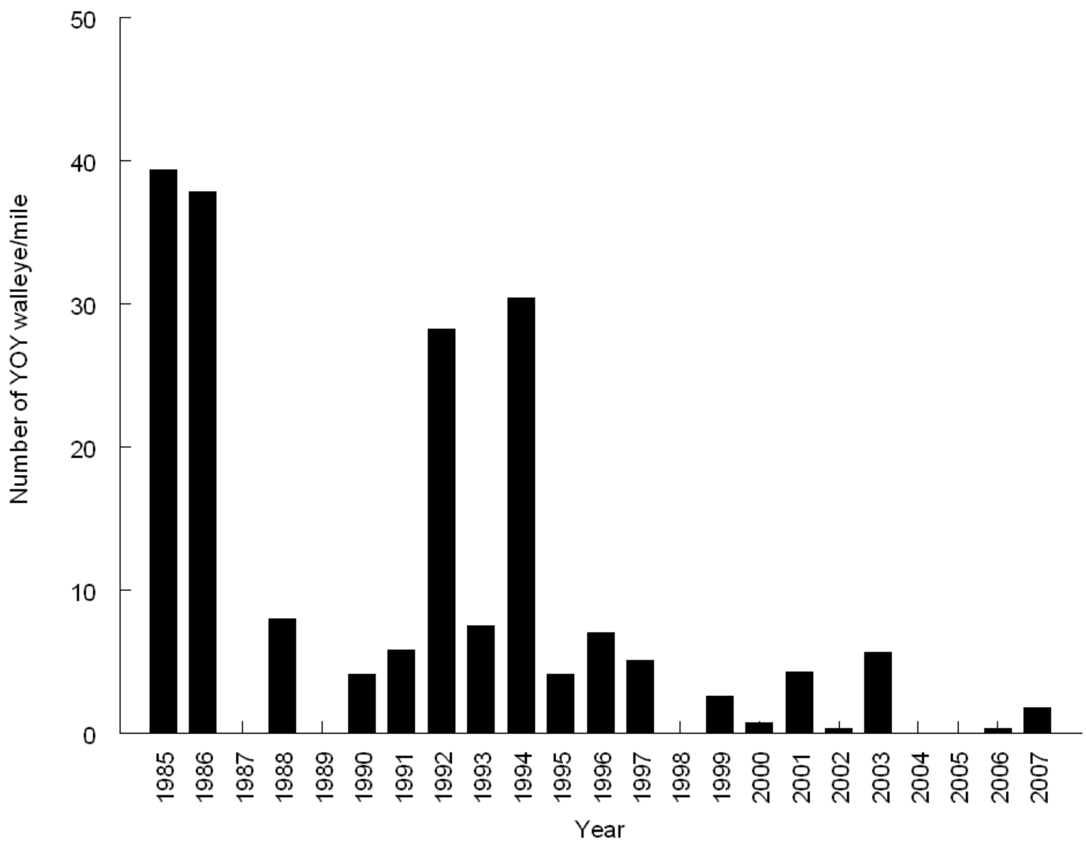

Figure 6. Young of the year walleye relative abundance determined by fall electrofishing in Lake Owen, Bayfield County, Wisconsin. Surveys were not completed in 1987, 1989 and 1998.

Figure 7. Relative abundance of bass (#/mile) of spring electrofishing surveys in Lake Owen, Bayfield County, Wisconsin.

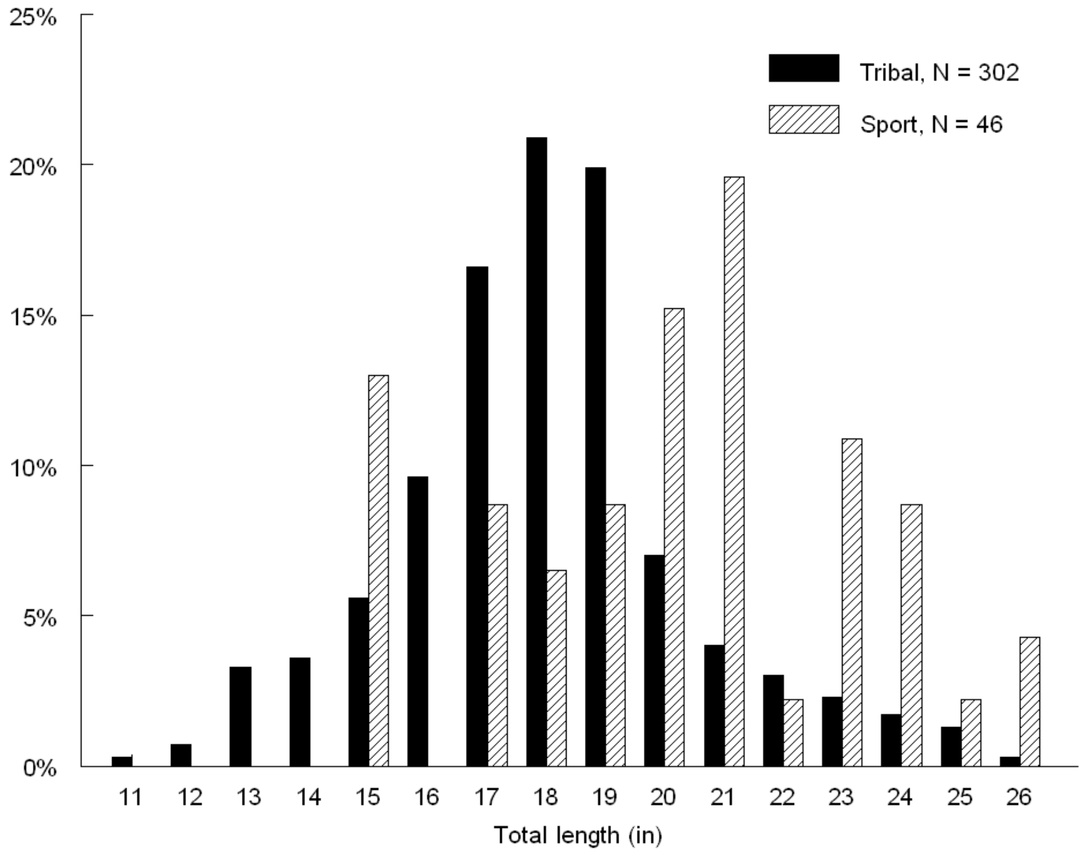

Figure 8. Tribal and sport harvest of walleye in Lake Owen, Bayfield County, Wisconsin. Numbers represent measured fish only.

Appendix Table 1. Proportional and relative stock density values.

Species	Stock Size (in)	Quality Size (in)	Preferred Size (in)
Largemouth Bass	8	12	15
Northern Pike	14	21	28
Smallmouth Bass	7	11	14
Walleye	10	15	20