Fishery Survey – Pike Chain of Lakes
Bayfield County, 2010-2011
(WIBC codes: Buskey Bay 2903800, Lake Millicent 2903700, Hart Lake 2903200, Twin Bear Lake 2903100, Eagle Lake 2902900, Flynn Lake 2902800)

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Executive Summary

The Pike Chain of Lakes, hereafter Pike Chain, has supported diverse fish communities and a popular sport fishery. With the exception of muskellunge, natural reproduction supports all species. A 2010 fishery survey was conducted to determine the status of walleye, black bass, muskellunge, northern pike, and panfish.

Historically, the Pike Chain had been known for its excellent walleye fishery. Walleye abundance in 2010 was 2.0 adults/acre and was below the historic average of 6.0 adults/acre and below the statewide management objective for walleye of 3.0 adults/acre. Changes in length indices and age composition suggest a shift to larger, older fish with reduced levels of recruitment since 2002. Factors contributing to the decline in adult walleye abundance may be related to exotic species introduction, sporadic natural recruitment, changed weather patterns, increased largemouth bass abundance, and increased exploitation.

Smallmouth bass abundances increased nearly three-fold (31.5 fish/mile) and largemouth bass abundances increased 3,343 fold (46.8 fish/mile), since 1991. Creel surveys confirm the trend of electrofishing data, showing a 19-fold increase in anglers catch of largemouth bass from 1991 to 2010 in the upper lakes of the Pike Chain. Since angler harvest of both smallmouth and largemouth bass has remained relatively stable (especially in light of changes in estimated catches), angling likely has had little impact on the changes occurring in the Pike Chain.

Muskellunge angling popularity among gamefish was lower in comparison to other area lakes. Adult muskellunge density in 2010 was low (0.17 fish/acre $\geq$ 30 in), but fyke net catch data and angler catch rates suggest abundance has been similar since 1991. Muskellunge size structure in the Pike Chain has increased considerably since 1985 and could be considered excellent when compared to muskellunge lakes in northern Wisconsin.

Management recommendations for the Pike Chain include: 1) Manage for a balanced healthy fish community, while gathering social data on angler preference, 2) Enact more liberal regulations for largemouth bass harvest, 3) Continue muskellunge stocking in alternate years at a rate of 1 fish/acre.

Continue to mark stocked fish in order to determine contribution to the adult population of stocked and naturally reproduced muskellunge, 4) Model panfish populations under various regulation options to determine optimal regulation and collect growth data, 5) Monitor the effects of proposed changes to management on the Pike Chain by continued survey efforts, 6) Work with local residents and lake association to implement the current lake management plan.

Introduction

The Pike Chain of lakes is comprised of nine named lakes (from upstream to downstream): Pike Lake, Buskey Bay, Lake Millicent, Hart Lake, McCarry Lake, Twin Bear Lake, Muskellunge Lake, Eagle Lake and Flynn Lake. These lakes are located at the headwaters of the East Fork of the White River in central Bayfield County. Despite increasing shoreland development, the watershed remains largely forested with upland hardwood and pine. Water levels are stable and maintained above natural lake elevations by a recently reconstructed drop inlet dam on lowermost Flynn Lake. Fishery surveys both past and present have collected data from six lakes in the Pike Chain. For the purposes of this report and due to the similarities of some lakes within the chain, the lakes will be grouped as the upper lakes which include Buskey Bay, Lake Millicent, Hart Lake and Twin Bear Lake and the lower lakes which include Eagle Lake and Flynn Lake (Figure 1). McCarry Lake, Muskellunge Lake and Pike Lake, although connected to the Pike Chain, are not accessible with survey gear and have no public access of their own; thus, data was not collected for these lakes in the past or present.

The upper lakes have a combined area of 714 acres, an average maximum depth of 55 feet, total shoreline length of 14.1 miles and an average alkalinity of 59 ppm. The lower lakes have a combined area of 199 acres, an average maximum depth of 32 feet, total shoreline length of 5.1 miles and an average alkalinity of 51 ppm. The watershed area of the Pike Chain is 5,782 acres and nearly 72% contained forest cover types (Hoyman and Heath 2008). Public access is provided at three locations. The Town of Iron River owns a public access on the west side of Buskey Bay the and on the south side of Buskey Bay an access is privately owned. The largest public access is located on the northwest side of Twin Bear Lake and is owned by Bayfield County.

Water quality in the Pike Chain was of much higher quality than other lakes in the state and region (Hoyman and Heath 2008). The Pike Chain of Lakes Comprehensive Management Plan has an extensive primer on water quality data and analysis along with the most recent water quality data from the Pike Chain (http://www.pikechain.org/CompPlan/index.htm, accessed May, 2013). In addition, current Citizen Lake Monitoring data can be accessed at the Iron River Area Lake Association website (http://www.pikechain.org, accessed May, 2013).

The upper and lower Lakes of the Pike Chain have a diverse fish community 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 *Ameiurus natalis*, logperch *Percina caprodes*, johnny darter *Etheostoma nigrum*, bluntnose minnow *Pimephales notatus*, golden shiner *Notemigonus crysoleucas*, blacknose shiner *N. heterolepis*, spottail shiner *N. hudsonius*, mimic shiner *N. volucellous* and central mudminnow *Umbra limi*.

Historic fisheries management of the Pike Chain has included surveys, stocking, and various length and daily bag limit regulations. Historic surveys for walleye, utilizing Wisconsin Department of Natural Resources (WDNR) standardized treaty protocols (Hennessey 2002), occurred in 1984, 1991, 2001 and 2010. Basic fishery surveys, utilizing a variety of gear types, were conducted by WDNR in the late 1960s and early 1970s. Fall electrofishing surveys were utilized to assess recruitment of walleye in 1985 and each year from 1991 to 2010.

The Pike Chain has a long stocking history for a number of fish species, including walleye, muskellunge, largemouth bass, bluegill, crappie (species unknown), fathead minnow and sunfish (species unknown), since at least 1933 (Tables 1 and 2). On the upper lakes of the Pike Chain, nearly annual walleye and/or muskellunge stocking occurred from at least 1933 to 2000. Over 31,000,000 fry and 350,000 small fingerling walleye and 650,000 fry and 25,000 large fingerling muskellunge were stocked into the upper lakes of the Pike Chain. In contrast, the lower lakes of the Pike Chain were stocked with fewer fish over a shorter period of time. The lower lakes of the Pike Chain received nearly annual walleye stocking from 1948 to 1978 and three muskellunge stocking events occurred from 1948 to 1950. Over 900,000 walleye fry and 170,000 fingerling walleye were stocked into the lower lakes.

Electrofishing surveys from the upper lakes from 1969 to 1975 indicated that walleye were the dominant predator with muskellunge, northern pike, largemouth and smallmouth bass being present in lower, but generally similar, abundances (Weiher 1970; Rieckhoff 1973a; Rieckhoff 1973b; Rieckhoff 1976). These surveys also recommended the discontinuation of walleye stocking for all the upper lakes due to evidence of a naturally sustained population. Twin Bear Lake was the only one of the upper lakes to have had a recommendation of continued muskellunge stocking to supplement natural reproduction. In general, the management recommendations for the upper lakes focused on walleye with a secondary focus on northern pike, muskellunge, largemouth and smallmouth bass, and panfish. Electrofishing surveys from the lower lakes from 1970 and 1978 indicated that largemouth bass were the dominant predator followed by northern pike. Bluegill were the most common panfish species with yellow perch and black crappie listed as common (Weiher 1971; Rieckhoff 1979). Management recommendations for Eagle Lake from the 1970 survey included continued stocking of walleye to supplement the lack of natural reproduction, while survey recommendations for Flynn Lake from the 1978 survey included the introduction of an additional forage fish species through stocking while mechanically removing white sucker which were thought to be overly abundant.

Walleye fishing regulations have changed over time on the Pike Chain. There was no minimum length limit for walleye until 1990 when a 15 in minimum length limit was promulgated statewide. Survey results from 1991 indicated poor walleye growth and recruitment, as well as indications that the 15 in length limit was resulting in unacceptably high exploitation on the few large walleye present. These findings led to changing the walleye regulation in 1994 to no minimum length limit. In 1997, walleye regulations were again changed to no minimum length limit, but only 1 fish over 14 in was allowed. Bag limits for walleye have been adjusted annually according to tribal harvest declarations that began in 1989. Muskellunge and largemouth and smallmouth bass regulations have also changed over time. Muskellunge regulations for minimum length increased from 30 inches to 32 inches in 1983. A 40-inch minimum length limit was instituted in 1996. In 1989, a northern bass zone was created with an opening for 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. Other fish species have been managed via statewide length and bag limits.

Recent management has focused on stocking of large fingerling muskellunge and habitat restoration. In response to the introduction of rusty crayfish (*Orconectes rusticus*) and the coinciding reduction of macrophytes, the DNR was involved in the placement of 35 half logs in 1991 for smallmouth bass spawning habitat and 130 fish cribs in 1997 and 1998 to add structural complexity. In 2010, the DNR partnered with Bayfield County to implement a woody habitat restoration project at the Twin Bear Campground due to low abundance of near shore woody habitat in the Pike Chain. In 2011, DNR partnered with a private landowner to add wood to Eagle Lake.   The DNR was also involved with providing information and review of a comprehensive management plan for the Pike Chain developed by a third-party vendor for the Iron River Pike Chain of Lakes Association.

Methods

The Pike Chain was sampled during 2010-2011 following the Wisconsin Department of Natural Resources comprehensive treaty assessment protocol (Hennessey 2002). This sampling included spring fyke netting and electrofishing to estimate walleye, muskellunge, bass (both largemouth and smallmouth), northern pike and panfish abundance; fall electrofishing to estimate the 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 to the nearest 0.1 in) 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 by electrofishing. 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 angler harvest could be estimated. 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 returned to the lake from the first marking sample, C is the total number of fish captured in the recapture sample, and R is the total number of marked fish captured in the recapture sample. 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 for all walleye that were ≥ 15 in and sexable.

Adult muskellunge were captured in two consecutive years (2010-2011) using fyke nets during the spring spawning period (Hanson 1986). Muskellunge were measured to the nearest 0.1 in and marked with a finclip. Abundance of adult muskellunge (≥ 30 in) was estimated using the Bailey modification of the Petersen method (Ricker 1975). Muskellunge captured in the first year made up the marking sample, and those in the second year composed the recapture sample. Numbers in the recapture sample excluded newly recruited muskellunge assumed to be less than 30.0 in in 2010 based on growth increments by sex. Length comparisons for muskellunge were analyzed using data obtained during spring fyke netting surveys for 1985, 2001 and 2010. Muskellunge sampled in 1991 were not included in this analysis due to extremely small sample size. Length information from muskellunge sampled during 2010 and 2011 was pooled (excluding previously handled fish) to increase sample size.

Largemouth and smallmouth bass sampled during the second spring electrofishing runs were used to determine relative abundance and length frequency. The entire shoreline of the upper lakes of the Pike Chain were sampled; the lower lakes were not sampled. All surveys occurred in May of respective surveys years. Panfish netting occurred in early June in the upper lakes of the Pike Chain only.

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 of male and female walleye was compared to a 16 county regional mean (western half of Northern Region) using DNR ceded territory data from 1990 to 2009. 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 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). That value was then compared to surveys of similar waterbodies throughout Wisconsin using the Fisheries Assessment Classification Tool (FACT) to determine how that value compared to other fisheries. FACT comparisons were available for walleye, smallmouth bass, largemouth bass and bluegill. Changes in population size structure and differences between the size structure of angler and tribal harvest were determined using Kolmogorov-Smirnov tests utilizing $\alpha = 0.05$ 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 (whenever the clerk intercepted anglers that had finished angling for the day) 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).

Results

Total survey effort in 2010, included 124 fyke net lifts targeting spawning gamefish in the upper lakes and 23 fyke net lifts in the lower lakes of the Pike Chain. Muskellunge marking in 2010 in the upper lakes and recapture in 2011 in both the upper and lower lakes included 34 and 69 fyke net lifts, respectively. Panfish netting effort in 2010 in the upper lakes included 20 fyke net lifts. Three electroshocking surveys of the entire shoreline totaling 15.0 hours in spring (walleye recapture and bass surveys) and 5.8 hours in fall (walleye recruitment survey) were conducted.

Walleye. Adult walleye abundance (≥ 15 in and sexable fish) was 1,399 (CV = 5%, 2.0 adults/acre) in 2010 for the upper lakes of the Pike Chain. Adult walleye abundance in the upper lakes of the Pike Chain has generally decreased since 1991 (Figure 2). The average of the three walleye abundance point estimates through 2001 was 6.0 adults/acre.

Walleye size structure in the Pike Chain has shifted toward larger fish. Length of walleye captured during fyke netting differed significantly for all years (1985 vs. 1991, D = 0.16, P < 0.001; 1991 vs. 2001, D = 0.04, P = 0.03; 2001 vs. 2010, D = 0.45, P < 0.001, 1985 vs. 2010, D = 0.31, P < 0.001; Figure 3). Mean length for sexable walleye decreased from 14.8 in (SD = 3.56, N = 948) to 13.7 in (SD = 1.98, N = 2,102) from1985 to 1991 then remained similar at 13.7 in (SD = 2.23, N = 2,100) in 2001. Mean length in 2010 was 15.7 in (SD = 2.61, N = 627) and was the highest of all survey years. Proportional stock density (PSD) decreased from 32 to 16 from 1985 to 1991, and remained at 16 in 2001. PSD in 2010 increased to 51, this value was less than 95% of surveys of similar waterbodies in Wisconsin. RSD-20 decreased from 9 to 1 from 1985 to 1991, and then increased to 3 and 7 in 2001 and 2010. The 2010 RSD-20 value was less than 82% of surveys of similar waterbodies in Wisconsin. Percent length frequency suggests there was an increase in the proportion of walleye in the 10 to 14.0 in length group from 1985 to 1991 and then a decrease in the 10.0 to 14.0 in group from 2001 to 2010 (Figure 3).

Walleye age distribution shows declining recruitment while growth rates have improved. Age of adult walleye sampled during the 2010 survey ranged from III to XVI. Male and female walleye first reached maturity at III and V, respectively. Walleye aged IV to VI accounted for 65% and 69% of the adult stock in 2010 and 2001, respectively. This result is in contrast to 1991 in which the same age walleye accounted for 82% of the adult stock. Age distribution data from 1991 and 2001 show consistent natural recruitment of walleye entering maturity at IV years of age. In contrast, the age IV year class in 2010 comprised a lower portion of the age sample (Figure 4). In 1991, walleye growth rates were below regional averages, while in 2001 and 2010 growth for walleye increased to nearly regional averages (Figure 5).

Relative abundance of young-of-year (YOY) walleye in the upper lakes in 2010 was 5.7 fish/mile. The average walleye YOY/mile for surveys completed from 1985 to 2010 by both WDNR and GLIFWC was 11.0 (SD = 8.66, N = 21), with a wide range from 1.0 fish/mile to 32.0 fish/mile (Figure 6). Average YOY/mile from 1991 to 2001 for the Pike Chain was 16.6 (SD = 8.37, N = 11); however, the average YOY/mile declined to 4.5 (SD = 2.92, N = 9) from 2002 to 2010. Furthermore, the eight lowest years of observed YOY/mile were between 2002 and 2010. Mean relative abundance of YOY walleye for naturally reproducing and stocked walleye lakes surveyed by WDNR in the ceded territory from 1990 to 2009 was 32.6 fish/mile (SD = 13.6, N = 806) and 5.7 fish/mile (SD = 6.7, N = 568), respectively.

Muskellunge and northern pike. Adult muskellunge abundance ($\geq$ 30 in) for both the upper and lower lakes of the Pike Chain in 2010-2011 was 159 (CV = 15%; 0.17 fish/acre), or about 1 muskellunge for every 6 acres of water. Catch per unit effort (CPUE; the number of muskellunge caught with each fyke net lift) decreased from 1.4 to 0.2 from 1985 to 1991, then increased slightly to 0.4 and 0.5 from 2001 to 2010.

Since 1985 the muskellunge size structure in the Pike Chain has shifted to larger fish (1985 vs 2001, D = 0.22, P = 0.14; 2001 vs 2010, D = 0.23, P = 0.12; 1985 vs 2010, D = 0.39 $P < 0.0001$; Figure 7). The average length of muskellunge decreased from 33.6 (SD = 5.5, N = 78) in 1985 to 32.8 (SD = 10.1, N = 41) in 2001 and then increased to 37.2 (SD = 7.4, N = 80) inches in 2010. The RSD-34 was 52, 90 and 86 in 1985, 2001 and 2010, respectively. RSD-40 was 11, 27 and 47 in the three survey periods.

Northern pike were relatively scarce (0.6 fish/net lift) in the upper lakes of the Pike Chain. Buskey Bay supported the highest abundance of northern pike (1.9 fish/net lift), likely due to the presence of greater amounts of macrophytes. Size structure of the northern pike population was poor. Although a few large individuals were present, nearly three-quarters of all pike sampled were < 21 in. PSD and RSD-30 was 28 and 4, respectively.

Smallmouth and Largemouth Bass. Smallmouth bass relative abundance in the upper lakes of the Pike Chain was 31.5 fish/mile for 2010. Relative abundance for smallmouth bass has increased over time from 11.2 and 21.9 fish/mile in 1991 and 2001 (Figure 8). Mean length of smallmouth bass for the 2010 survey was 11.8 in (SD = 2.5; N = 428) and had PSD and RSD-14 values of 61 and 17, which exceed 37% and 13% of surveys of similar waterbodies in Wisconsin. Size structure has increased significantly when comparing 1991 and 2010 but no significant difference was found when comparing other survey periods (1991 vs. 2001, D = 0.26, P = 0.17; 2001 vs. 2010, D = 0.23, P = 0.28, 1991 vs. 2010, D = 0.31, P = 0.05; Figure 9). Smallmouth bass PSD values were 47 and 65 and RSD-14 values were 13 and 23 for 1991 and 2001, respectively.

In 2010, largemouth bass represented 60% and smallmouth bass 40% of the total number of bass surveyed (N = 1,066). Largemouth bass relative abundance in the upper lakes was 46.8 fish/mile for 2010, an increase from 1.4 and 3.0 fish/mile in 1991 and 2001, respectively. This change in largemouth bass relative abundance in 2010 represented an exponential increase versus the linear increase in abundance observed for smallmouth bass (Figure 8). Size structure of largemouth bass increased significantly when comparing 2001 and 2010 and 1991 and 2010, but had no significant change between 1991 and 2001 (1991 vs. 2001, D = 0.17, P = 0.640; 2001 vs. 2010, D = 0.46, P = 0.001, 1991 vs. 2010, D = 0.51, P < 0.001; Figure 9). In the 2010 survey largemouth bass mean length was 11.1 in (SD = 1.9; N = 638) and PSD and RSD-15 values were 33 and 2, respectively. The PSD and RSD-15 values for 2010 exceeded 9% and 4% of surveys for similar waterbodies in Wisconsin. Historic size structure indices have remained similar for largemouth bass compared to 2001, when the PSD value was 30 and RSD-15 was 3.

Bluegill. Bluegill were the most abundant panfish species (N = 1,871) sampled in the upper lakes of the Pike Chain during the panfish fyke netting survey of 2010. Relative abundance of bluegill has remained similar with 97.3, 107.0, and 93.6 fish/net lift in 1985, 2001 and 2010, respectively. However, length frequency of bluegill captured in fyke nets in 1985, 2001 and 2010 suggests a significant shift in size structure between all years (1985 vs. 2001, D = 0.2, P < 0.0001; 2001 vs. 2010, D = 0.1, P < 0.0001; 1985 vs. 2010, D = 0.3, P < 0.0001; Figure 10). Mean total length of bluegill (panfish netting survey) decreased from 5.8 (SD = 1.2, N = 3,404) in 1985 to 5.4 in (SD = 1.1, N = 1,712) in 2001 and then remained unchanged in 2010 when average length was also 5.4 in (SD = 1.0, N = 1,871). PSD values for bluegill were 46, 38 and 41 for 1985, 2001 and 2010 and RSD-8 was < 1 for all survey years. PSD value for bluegill in 2010 was less than 97% of surveys for similar waterbodies in Wisconsin. Rock bass were the second most abundant (N = 96) sampled in the upper lakes of the Pike Chain during the panfish fyke netting survey of 2010.

Sport and Tribal Fishery. The creel survey on both the upper and lower Pike Chain Lakes accounted for 126 days and 252 counts in the open water season and 55 days and 110 counts in the ice fishing season. On the upper lakes, creel clerks gathered 388 completed angler interviews (angler interviews in which the angler had completed fishing for the day) in the open water season and 104 completed angler interviews in the ice fishing season. The lower lakes had 137 completed interviews in the open water season and 4 completed interviews in the ice fishing season. Angling pressure on the Pike Chain is high compared to regional averages. Anglers fished an estimated 34,867 hours (38.2 hrs/acre) during the 2010-2011 season on all lakes of the Pike Chain. This angling effort is above the average of 22.1 hrs/acre (SD = 9.8, N = 45) for Bayfield and Douglas County walleye lakes from 1990 to 2010 (WDNR unpublished data, Brule field office) and above the Northern Region (20 counties) average from 1990 to 2008 of 32.9 hrs/acre (SD = 24.2, N = 436). Fishing pressure on the upper lakes during the open water season has remained fairly consistent since

1986. The fishing pressure (hrs/acre) was 31.0, 38.4, 31.0 and 36.4 for 1986, 1991, 2001 and 2010, respectively.

Open water anglers accounted for 87% of all fishing effort. On the upper lakes of the Pike Chain in 2010-2011 directed effort, i.e. effort targeted toward a specific gamefish, was highest for largemouth bass (20.6%), followed by smallmouth bass (16.2%) and northern pike (11.6%). The most sought after panfish species was bluegill, with 17.5% of the directed effort. On the lower lakes, directed effort was highest for largemouth bass (23.4%), followed by smallmouth bass (18.7%) and northern pike (17.4%). The most sought after panfish species was bluegill, with 17.4% of the directed effort. In comparison to historic surveys on the upper lakes, walleye directed effort has declined by more than half from 1991 to 2010. Yellow perch directed effort has also declined but not to the same extent as walleye. Directed effort for largemouth bass has increased the most since 1991, however directed effort for northern pike, muskellunge, bluegill and black crappie were the highest in 2010 when compared to creel surveys from 1991 and 2001. Smallmouth bass directed effort has remained consistent over time (Figure 11).

Angler catch of both largemouth and smallmouth bass in the Pike Chain has increased, whereas harvest of both species has decreased. Angler projected catch of smallmouth bass was higher than largemouth bass in 1991 and 2001. In 2010, angler catch of largemouth bass far exceeded that of smallmouth bass (Figure 12). However, the percent of smallmouth bass caught that were harvested during the open water season decreased from 9% to 6% to 1% from to 1991 to 2001 to 2010. The percent of largemouth bass caught that were harvested decreased from 24% to 5% to 1% from 1991 to 2001 to 2010. Angler projected harvest of both smallmouth and largemouth bass was low in all creel survey years. Angler projected harvest of smallmouth bass was 49 in 2010 and was lower than the 1991 and 2001 average of 361. Angler projected harvest of largemouth bass was 139 in 2010 and was higher than the average of 1991 and 2001 of 111. Mean length of angler harvest for both smallmouth and largemouth bass was similar in 2010 and was 14.9 in and 14.7 in, respectively.

Angler exploitation of walleye paralleled abundance. Angler exploitation of walleye increased from 4% in 1991 to 11% in 2001, and then decreased to 8% in 2010. In the upper lakes of the Pike Chain, an estimated 144 walleye were harvested by anglers in the open water and ice season of 2010 compared to 975 and 1,106 in 1991 and 2001. Anglers projected catch of walleye also declined from 7,354 walleye in 1991 to 1,955 in 2001 to 214 in 2010. In 2010, average length of angler harvested walleye was 15.7 in (SD = 2.4, N = 23), which was longer than in 2001 (15.1 in, SD = 2.2, N = 30) but shorter than 1991 (16.3 in, SD = 2.1, N = 132).

Tribal harvest accounted for 243 walleye in 2010 (Krueger 2011), compared to the historic average harvest of 230 walleye (SD = 53.7, N= 22, Minimum = 172, Maximum = 402). Walleye harvested ranged from 12.0 to 26.4 in and averaged 15.6 in (SD = 1.9, N = 243). Tribal harvest represented 53% of the combined total harvest (sport angling plus tribal spearing) and tribal exploitation of the adult walleye population was 17.4%. Tribal exploitation was 4.2% and 4.4% in 1991 and 2001, respectively. Length of harvested walleye by tribal spearers was similar compared to that of sport anglers (D = 0.09, P = 1.0; Figure 13). Male and female walleye represented 90% and 6% of the total tribal harvest, respectively. The remaining 4% were walleye of unknown sex. Total walleye exploitation (sport and tribal) increased from 8% to 15% to 26% from 1991 to 2001 to 2010.

Northern pike were the third most exploited (harvest = 136) gamefish in 2010 on the upper lakes of the Pike Chain and had the third highest directed effort (11.6%) of gamefish. On the lower lakes of the Pike Chain, northern pike where the second most exploited (harvest = 29) of gamefish and had the third highest directed effort (17.4%) of gamefish. Both upper and lower lakes had an estimated catch of northern pike of 3,464 in 2010. Directed effort for northern pike decreased from 16.7% to 10.0% from 1991 to 2001. Northern pike estimated catch remained stable from 1991 to 2001 at 709 and 970, respectively. Estimated harvest also remained stable from 266 to 205 from 1991 to 2001. Mean length of harvested northern pike remained the same and then increased from 21.1 to 21.1 to 23.6 inches from 1991 to 2001 to 2010, respectively.

Muskellunge anglers accounted for 9.7% of the directed effort on the Pike Chain. In comparison, the directed effort for muskellunge was 7.5% and 6.4% in 1991 and 2001. In the open water season of 2010 in the upper lakes of the Pike Chain an estimated 147 muskellunge were caught, none of which were harvested. No tribal harvest occurred for muskellunge in 2010 (Kruger 2011). Historically, a total of 12 muskellunge have been tribally harvested from the Pike Chain.

On the upper lakes of the Pike Chain anglers pursuing panfish fished an estimated 14,529 hours and accounted for 31% of the total directed angling effort for the 2010-2011 open water and winter seasons combined. Estimated catch and harvest of bluegill decreased then increased from 1991 to 2001 to 2010. Conversely, yellow perch catch and harvest on the upper lakes decreased then increased from 1991 to 2010. Black crappie catch and harvest was low in all survey years (Figure 14). On the lower lakes anglers pursuing panfish fished an estimated 4,576 hours and accounted for 30% of the total directed angling effort for the 2010-2011 open water and winter seasons combined. Similar trends of catch and harvest occurred for bluegill, black crappie and yellow perch on the lower lakes as was found on the upper lakes from 1991 to 2001 to 2010 (Figure 15). Bluegill were the most sought after panfish species by anglers followed by black crappie and yellow perch for both the upper and lower lakes for the open water and winter seasons in 2010-2011.

Discussion

The Pike Chain has supported a diverse fish community and a popular sport fishery. With the exception of muskellunge, natural reproduction has supported all species. Shifts in species abundance appear to be occurring and mirror trends in lakes of similar type in the region. This shift includes an increased abundance of both black bass species, while the abundances of percid species (walleye and yellow perch) have declined or remained low.

Historically, the Pike Chain has been known for its excellent walleye fishery. Walleye abundance in 2010 was low (2.0 adults/acre) and the size structure had shifted to older and larger fish with fewer younger and small fish. Factors contributing to the decline in adult walleye abundance may be related to exotic species introduction, sporadic natural recruitment, a changed regional climate, increased largemouth bass abundance, and increased exploitation.

Rusty crayfish, an exotic species, may have had an effect on fishery composition by dramatically reducing the amount of aquatic vegetation since they were first found in the 1980s in the Pike Chain. The reduction by rusty crayfish of structural complexity in the littoral zone habitat has been reported in both natural and laboratory conditions (Wilson et al. 2004; Lodge and Lorman 1987). Anecdotal observations suggest that the abundance of rusty crayfish has declined in the Pike Chain in recent years, which has coincided with an increased abundance of aquatic plants. Another exotic species, Eurasion watermilfoil (*Myriophyllum spicatum*), was first detected in the channel between Hart and Twin Bear Lakes in 2004. In 2005, herbicide treatments intended to selectively control Eurasian watermilfoil covered approximately 6 acres. By 2009, approximately 35 acres were proposed for herbicide control (Hoyman and Heath 2008). The overall increased abundance of both native and exotic aquatic plants may have impacts on fish species composition. Dibble and Harrel (1997) found in tank experiments that adult largemouth bass diets when feeding in common pondweed constituted 86% macroinvertebrates and 14% prey fish, yet diets constituted 25% macroinvertebrates and 75% prey fish when feeding in Eurasian watermilfoil. Similarly, diets of juvenile largemouth bass in pondweed consisted of 71% macroinvertebrates and 29% prey fish, whereas 67% of their diets was prey fish and only 33% was macroinvertebrates in Eurasian watermilfoil. These results suggest that the architecture of a particular species of aquatic plant may contribute to differences in diets of adult and juvenile largemouth bass. Aquatic plant data collected in 2005 and 2007 by WDNR and Onterra, LLC on the Pike Chain will provide a valuable reference for future changes in species composition and abundance.

Variations and reduction in the abundance of YOY walleye in fall surveys may be a natural phenomena. Isermann (2007) found that walleye recruitment across 20 populations in North America was highly variable, which made it difficult to determine the effects of regulation management both pre- and post-regulation change. Climate change impacts could play a role in reduced YOY walleye abundance since

2002. Serns (1982) found 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 in Escanaba Lake in northern Wisconsin. In addition, phytoplankton abundance in spring, summer and fall could be altered due to warmer water temperatures earlier in the year (Elliot et al. 2006). Low phytoplankton abundance during larval and early juvenile life stages of walleye could lead to energy depletion and increased mortality among larval and juvenile walleye (Jonas and Wahl 1998).

Since 2002, abundance of YOY walleye in fall surveys has been low and has coincided with the increase in abundance of largemouth bass. Fayram et al. (2005) found that the survival of stocked walleyes was negatively related to largemouth bass abundance, but also that 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. The Pike Chain has not been stocked with walleye since 1978 and since then, abundance had been driven by variable, but large naturally reproduced year classes.

Walleye exploitation (tribal and sport) was 26% and was nearly double exploitation found in 2001 and triple the exploitation found in 1991. 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). 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. Unfortunately, only about 30% of total exploitation results from sport anglers; thus, any further management actions to limit walleye exploitation by sport anglers is unlikely to have a major impact on walleye populations. In addition, studies have shown that restricting angler harvest will not necessarily increase walleye abundance. Stone and Lott (2002) found that walleye recruitment, growth, condition, and abundance did not change significantly from pre-regulation to post-regulation periods in a South Dakota impoundment. However, they did find that proportional stock density increased significantly in the years following the implementation of the more restrictive regulation. Isermann (2007) found 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 on two Minnesota lakes. 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 Stone and Lott (2002) and Isermann (2007) studies were conducted on lakes with strong naturally reproducing walleye populations as where historically found on the Pike Chain. Restricting angler harvest of walleye to fish over 18 in could potentially benefit current walleye populations on the Pike chain particularly if recruitment continues to fail, large fingerling stocking was eventually initiated, and tribal harvest declined based on a recruitment model change or voluntary reductions.

Both black bass species have increased in abundance over the past several decades, with largemouth bass increasing at a much higher rate. Factors influencing this shift in abundance, along with that of lower walleye numbers, may include climate change, species interaction and habitat shifts. Angling has likely had little impact on the changes occurring in the Pike Chain, as angler harvest of both smallmouth and largemouth bass has remained relatively stable (especially in light of changes in estimated catches). Although angling has likely had little impact on the change in abundance on the Pike Chain, changes in angler directed effort could produce higher harvest in the future. It may also be likely that angling has had an effect on size structure of bass as size structure has increased since the implementation of the 14 in minimum length limit was implemented. Elimination of the early catch and release season for largemouth bass will be voted on during the spring hearing of the Conservation Congress in 2013. If this regulation goes into effect an additional harvest opportunity will be added for largemouth bass. In addition, there is a possibility that the WDNR will be implementing separate smallmouth and largemouth regulations on a select group of lakes, the Pike Chain would be a good candidate for this regulation scenario. The intention would be to provide a harvest opportunity for largemouth bass with no minimum length limit and a daily bag limit of 5 fish. Smallmouth could be managed with a continuation of the 14 in minimum length limit and a daily bag limit of 5 fish or an 18 in minimum length limit with a daily bag limit of 1 fish.

Climate change has been identified as a potential mechanism causing a shift of cool and warmwater species to more northern areas where they had been uncommon in the past. Numerous authors (Shuter et al. 2002, Jackson and Mandrak 2002, Chu et al. 2005, and Sharman et al. 2007) predicted that 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 there are no comparative historic data on coverage of vegetation in the Pike Chain it is possible that an increased abundance of vegetation could favor survival of largemouth bass. Future aquatic plant surveys should be comparable to surveys completed in 2005 and 2007 and will document changes within the aquatic plant community.

Although muskellunge abundance in the Pike Chain was low, the improved size structure attracted muskellunge anglers. Directed effort toward muskellunge in the Pike Chain (9.7%) was similar to the nearby Lower Eau Claire (6.5%; 2007) and lower than Middle Eau Claire (16.1%; 2010), Upper Eau Claire (14.9%; 2001), Amincon (25.2%; 2006) and Namakagon (27.6%; 2002). In comparison with other muskellunge waters in northern Wisconsin, the Pike Chain is at the low end of the reported range of abundance. Hanson (1986) found a mean density of 0.33 fish/acre (range 0.16 – 0.61 fish/acre) in eight lakes. Margenau and AveLallemant (2000) found mean densities of 0.42 fish/acre and 0.38 fish/acre for fifteen lakes during two separate sampling periods. Density range during these periods for the fifteen lakes was from 0.05 fish/acre to 0.99 fish/acre.

Muskellunge size structure in the Pike Chain has increased considerably since 1985. In 2010, muskellunge had RSD-34 and RSD-40 values of 86 and 46, respectively. This compares well to the 15 study lakes in northern Wisconsin that had an RSD-34 average of 59 and an RSD-40 average of 13 (Margenau and AveLallemant 2000). White Sand Lake (Vilas County) had the highest RSD-34 and RSD-40 values of 78 and 40, respectively in the 15 study lakes (Margenau and AveLallemant 2000). High minimum length limits along with increased voluntary release of muskellunge were likely responsible for this shift.

Contribution of stocked and naturally recruited muskellunge to the adult population is unknown. Since 2006, stocked muskellunge have been marked with a fin clip in order to help answer these unknowns. The stocked muskellunge were not recruited to the adult population in 2010 and therefore future surveys should serve as a better evaluation of contribution of stocked muskellunge and status of natural reproduction.

Although northern pike were relatively scarce in the Pike Chain and the size structure was poor, angler directed effort was higher for northern pike than walleye in 2010. Northern pike had the 3rd highest angler harvest among gamefish species in 2010. Continued monitoring of the northern pike population is warranted due to its relative popularity among anglers.

The panfish community has remained stable since 1985, though bluegill size structure has declined and was considered fair to poor for all survey years. Cross and McInerny (2005) found that as bluegill abundance increased, size structure decreased. Also, Beard and Kampa (1999) found from a large data set of panfish netting samples from Wisconsin lakes collected from 1967 to 1991 that the average size of bluegill had decreased over time. Modeling of angler harvest of bluegill has shown that increased angler harvest can reduce the mean size of harvested bluegill by four times (Beard and Essington 2000). In addition, Jacobson

(2005) found in eight Minnesota lakes that the length frequency of the population increased if angler harvest of bluegill was reduced through more restrictive bag limits. Angler harvest and abundance of bluegill on the Pike Chain has remained similar, yet the mean length of bluegill has decreased. As the abundance of bluegill in the Pike Chain is high in comparison to area lakes, reducing the bag limit may increase abundance and have the unintended result of reducing size structure. If abundance is not driven by angler harvest and rather by variations in recruitment, then reducing the bag limit may help to improve size structure. Angler directed effort for panfish was approximately one third of the total directed effort, indicating that panfish provide an important angling opportunity on the Pike Chain. Future surveys should continue to monitor panfish populations in order to discern emerging trends with an additional focus on growth. Modeling panfish populations under various regulation scenarios could help to determine if changes should be made to the current regulations.

Summary and Management Recommendations

1. The main management goal for the Pike Chain of Lakes is to have a balanced healthy fishery. This goal is currently being met even with a declining walleye population and an increasing bass population. Historically the Pike Chain management has focused on walleye, muskellunge and smallmouth bass. With changing climate conditions and other variables that are known and unknown, continuing to manage as has been done historically may or may not be achievable, however, data are lacking as to angler preferences on the Pike Chain. Soliciting user group management preference is a key component of formulating future management recommendations and working with interested partners to gather this data should be a top priority.
2. Maintain current angling regulations for walleye while continuing to monitor exploitation and natural reproduction. If year class strength continues to be weak and adult population abundance continues to decline consideration should be given to restricting angler harvest of walleye to fish over 18 in in length. Reduced year class strength since 2002 in combination with higher exploitation may have been related to the decline in walleye abundance. Results from the 2010-2011 survey suggest that combined

walleye exploitation was 26% and was nearly double exploitation found in 2001 and triple the exploitation found in 1991. Continued monitoring of walleye exploitation is needed to ensure exploitation does not exceed 35%. Given that only a small percent of the exploitation occurs from sport angling, potential length limit restrictions will likely have little effect on walleye numbers. It may be that with the changing fish assemblage in the Pike Chain that the walleye population will not be able to withstand the stressors of both competition with largemouth bass and human exploitation. Restricting angler harvest of walleye to fish over 15 and 18 in in 2010 would have eliminated approximately 40% and 90%, respectively, of the projected angler harvest. Adopting a 15 in length limit for angler harvest would not have allowed female walleye to spawn at least once, since in 2010, females did not reach maturity until 16 in in length. If in future surveys walleye abundance declines below 2.0 adults/acre consideration should be given to stocking large fingerling walleye in conjunction with implementing a more restrictive angler harvest regulation as stated above. Though no genetic records exist from the early walleye stocking in the Pike Chain, these fish likely originated from Chippewa River strain fish. If stocking is considered in the future, genetic source of gametes warrants discussion (Franckowiak et. al. 2009). Young of the year walleye monitoring completed annually should help to discern if year class strength increases or remains similar to abundances found since 2002.

3. Provide additional angler harvest opportunity for largemouth bass while continuing to protect smallmouth bass. The Pike Chain has been known in recent history for its excellent smallmouth bass fishery. While smallmouth bass increased in abundance compared to past survey years, largemouth bass were approximately 15 fish/mile more abundant than smallmouth and have increased over 16-fold when compared to the most recent survey. The abundance of largemouth bass is likely a symptom of changes occurring in the fishery during the past 10 plus years. In the near future it is likely the early catch and release season for largemouth bass in the northern management zone will be eliminated, for smallmouth bass the early catch and release season will remain in effect. There is also a good chance

that bass species will be able to be managed with separate regulations in the near future on a select set of lakes. If the above happens, a consumption opportunity for anglers for largemouth bass could be added by implementing a no minimum length limit and a daily bag limit of 5 fish. Smallmouth bass harvest could then be regulated with a 14 in minimum length limit and a daily bag limit of 5 fish or an 18 in minimum length limit with a daily bag limit of 1 fish. Angler preferences have been shown to change in relation to fish population changes (Figure 11), with potential changes in regulations this could result in increased harvest of largemouth bass while still providing a quality angling opportunity for smallmouth bass.

4. Muskellunge stocking in alternate years at a rate of 1 fish/acre should continue. In addition, stocked fish should be marked in order to determine contribution to the adult population of stocked and naturally reproduced muskellunge. Abundance of muskellunge has remained low and size structure has improved considerably. Continued stocking of muskellunge while monitoring effects would help to preserve this high quality fishery.
5. 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 surveys may not represent true abundance because of timing and targeting of these fish. Using fyke nets for northern pike while some ice remains on the lakes and locating them in likely spawning areas may yield different results.
6. Model potential regulation effects on improving panfish size structure. The panfishery in the Pike Chain represents the greatest amount of angler interest. The current size structure is not desirable. Reduced bag limits are an option but may have adverse effects. Utilizing population metrics from bluegill various regulation options can be tested prior to actual implementation. In future survey efforts gathering growth data for bluegill should be a top priority to assess whether reducing the bag limit may have an adverse impact on growth.

7. Monitor the effects of proposed changes to management on the Pike Chain of Lakes. Walleye and muskellunge population estimates and bass and panfish abundances will be collected every 6 years (2016 is next scheduled survey). Creel surveys should be conducted whenever fiscally feasible and at least once prior to 2020. Fall walleye YOY surveys should be completed annually to index year class strength.
8. Work with local residents, the IRALA to add to and implement the current lake management plan. The current management plan addresses many (if not all) areas of management concern. From a fisheries perspective, protection and restoration of valuable shoreline and littoral zone habitats are imperative. 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 and woody habitat 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. Stocking history of the upper Pike Chain Lakes (Buskey Bay, Hart Lake, Millicent Lake and Twin Bear Lake) combined, Bayfield County, Wisconsin.

Year	Species	Number Stocked	Size
1933	Walleye	35,135	NA
1935	Walleye	1,927,100	Fry
	Muskellunge	20,000	Fry
1936	Walleye	2,381,400	Fry
	Muskellunge	25,000	Fry
	Bass (sp?)	800	NA
	Bluegill	320	NA
	Sunfish (sp?)	320	NA
1937	Walleye	3,375,400	Fry
	Muskellunge	90,900	Fry
1938	Walleye	3,431,208	Fry
	Muskellunge	90,000	Fry
	Crappie (sp?)	150,153	Fry
1939	Walleye	2,060,000	Fry
	Muskellunge	75,000	Fry
	Largemouth Bass	444	Yearling
1940	Walleye	5,000,000	Fry
	Muskellunge	100,000	Fry
	Largemouth Bass	2,500	Fingerling
1941	Walleye	2,270,000	Fry
	Muskellunge	1,500	Fingerling
	Muskellunge	25,000	Fry
1942	Walleye	1,150,000	Fry
	Muskellunge	1,100	Fingerling
	Muskellunge	92,961	Fry
1943	Walleye	4,000	Fingerling
	Walleye	1,000,000	Fry
	Muskellunge	1,000	Fingerling
	Muskellunge	90,000	Fry
1944	Walleye	3,000	Fingerling
	Walleye	800,000	Fry
	Muskellunge	700	Fingerling
	Muskellunge	30,000	Fry
	Largemouth Bass	2,150	Fingerling
1945	Walleye	5,400	Fingerling
	Walleye	1,140,000	Fry
	Muskellunge	350	Fingerling
	Muskellunge	41,250	Fry
	Largemouth Bass	5,150	Fingerling
1946	Walleye	3,500	Fingerling
	Walleye	616,000	Fry
	Muskellunge	345	Fingerling
	Largemouth Bass	1,980	Fingerling
1948	Walleye	31,062	Fingerling
	Walleye	3,480,000	Fry
	Muskellunge	3,442	Fingerling
	Largemouth Bass	1,590	Fingerling
1949	Walleye	7,200	Fingerling
	Walleye	1,726,000	Fry
	Muskellunge	1,722	Fingerling
	Largemouth Bass	8,580	Fingerling
1950	Walleye	32,131	Fingerlings
	Muskellunge	1,376	Fingerlings
	Largemouth Bass	9,070	Fingerlings
1951	Walleye	13,610	Fingerling
	Largemouth Bass	650	Fingerling
1952	Walleye	21,500	Fingerling
1953	Walleye	11,900	Fingerling
1954	Walleye	11,500	Fingerling
1955	Walleye	3,740	Fingerling
1956	Walleye	11,500	Fingerling
1957	Walleye	8,300	Fingerling
1958	Walleye	3,832	Fingerling
1960	Walleye	34,500	Fingerling
1963	Walleye	50,100	Fingerling
1966	Walleye	42,600	Fingerlings
1968	Walleye	5,500	Fingerlings
1969	Walleye	3,570	Fingerling
1970	Walleye	3,500	Fingerling
1971	Walleye	3,500	Fingerling
1972	Walleye	3,560	Fingerling
1976	Muskellunge	800	Large Fingerling
1977	Walleye	768,000	Fry
	Muskellunge	410	Large Fingerling
1978	Walleye	128,000	Fry
	Muskellunge	225	Large Fingerling
1979	Muskellunge	686	Large Fingerling
1980	Muskellunge	410	Large Fingerling
1983	Muskellunge	410	Large Fingerling
1984	Muskellunge	410	Large Fingerling
1985	Muskellunge	940	Large Fingerling
1986	Muskellunge	360	Large Fingerling
1987	Muskellunge	360	Large Fingerling
1988	Muskellunge	440	Large Fingerling
1989	Muskellunge	440	Large Fingerling
1990	Muskellunge	230	Large Fingerling
1991	Muskellunge	460	Large Fingerling
1992	Muskellunge	460	Large Fingerling
1993	Muskellunge	460	Large Fingerling
1996	Muskellunge	550	Large Fingerling
1997	Muskellunge	275	Large Fingerling
2000	Muskellunge	550	Large Fingerling
2002	Muskellunge	944	Large Fingerling
2002	Muskellunge	944	Large Fingerling
2004	Muskellunge	945	Large Fingerling
2006	Muskellunge	520	Large Fingerling
2008	Muskellunge	945	Large Fingerling
2010	Muskellunge	719	Large Fingerling

Table 2. Stocking history of lower Pike Chain Lakes (Eagle Lake and Flynn Lake) combined, Bayfield County, Wisconsin.

Year	Species	Number Stocked	Size
1946	Largemouth Bass	450	Fingerling
1948	Walleye	3,470	Fingerling
	Walleye	620,000	Fry
	Muskellunge	592	Fingerling
	Largemouth Bass	300	Fingerling
1949	Walleye	1,400	Fingerling
	Walleye	300,000	Fry
	Muskellunge	296	Fingerling
	Largemouth Bass	1,480	Fingerling
1950	Walleye	7,150	Fingerling
	Muskellunge	296	Fingerling
	Largemouth Bass	3,980	Fingerling
1951	Walleye	2,960	Fingerling
1952	Walleye	9,970	Fingerling
1953	Walleye	6,900	Fingerling
1954	Walleye	5,400	Fingerling
1955	Walleye	2,700	Fingerling
1956	Walleye	5,400	Fingerling
1957	Walleye	5,400	Fingerling
1958	Walleye	1,800	Fingerling
1960	Walleye	16,200	Fingerling
1963	Walleye	16,200	Fingerling
1966	Walleye	12,594	Fingerling
1969	Walleye	3,300	Fingerling
1970	Walleye	3,000	Fingerling
	Walleye	332	Large Fingerling
1971	Walleye	3,200	Fingerling
1972	Walleye	3,280	Fingerling
	Walleye	7,020	Large Fingerling
1973	Walleye	8,034	Fingerling
1974	Walleye	8,030	Fingerling
1975	Walleye	8,030	Fingerling
1976	Walleye	8,125	Fingerling
1977	Walleye	10,508	Fingerling
	Walleye	5,510	Large Fingerling
1978	Walleye	6,032	Fingerling
1980	Fathead Minnow	10,000	Adult
1982	Fathead Minnow	10,000	Adult

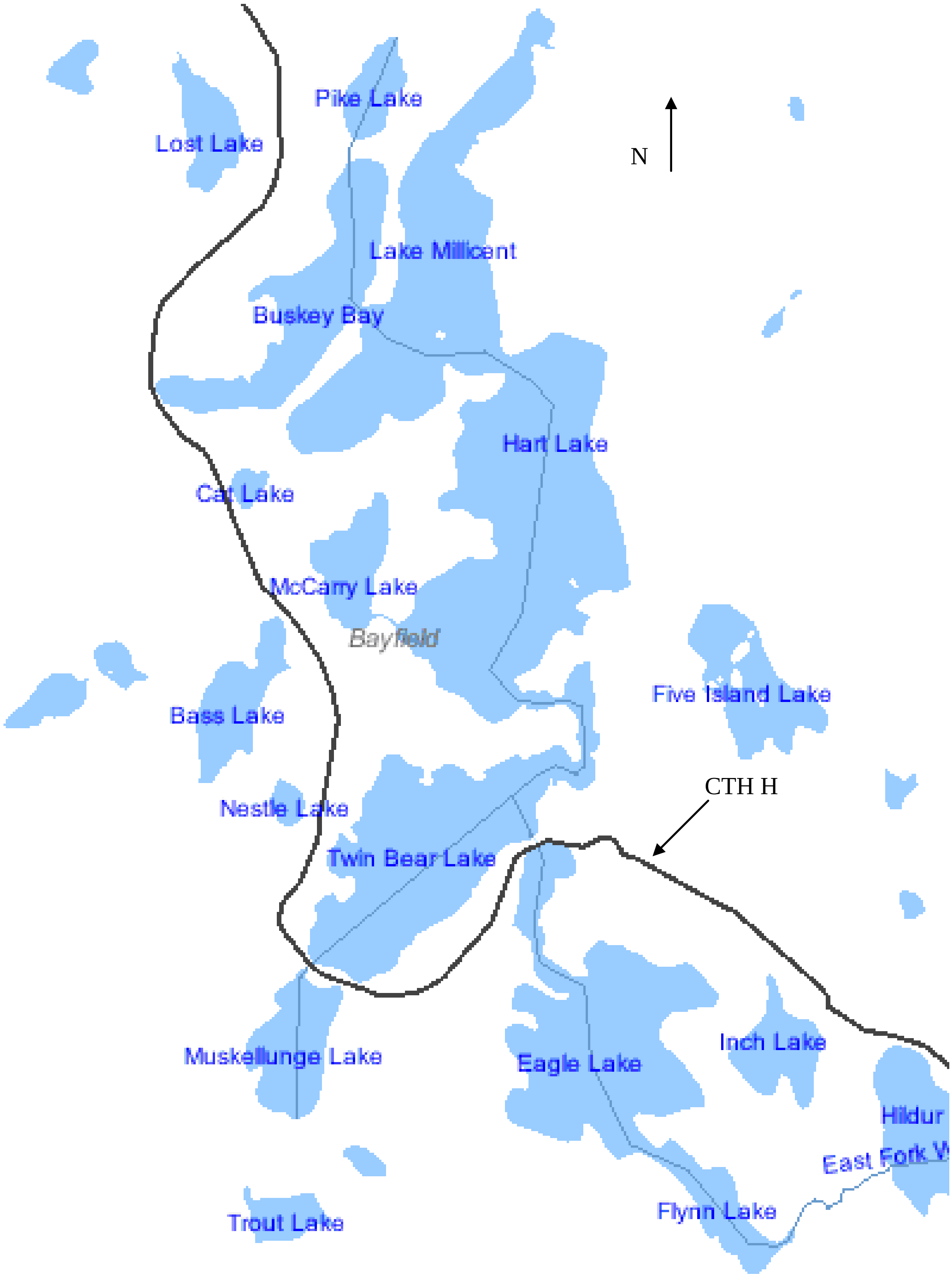

Figure 1. Map of the Pike Chain of Lakes, Bayfield County, Wisconsin.

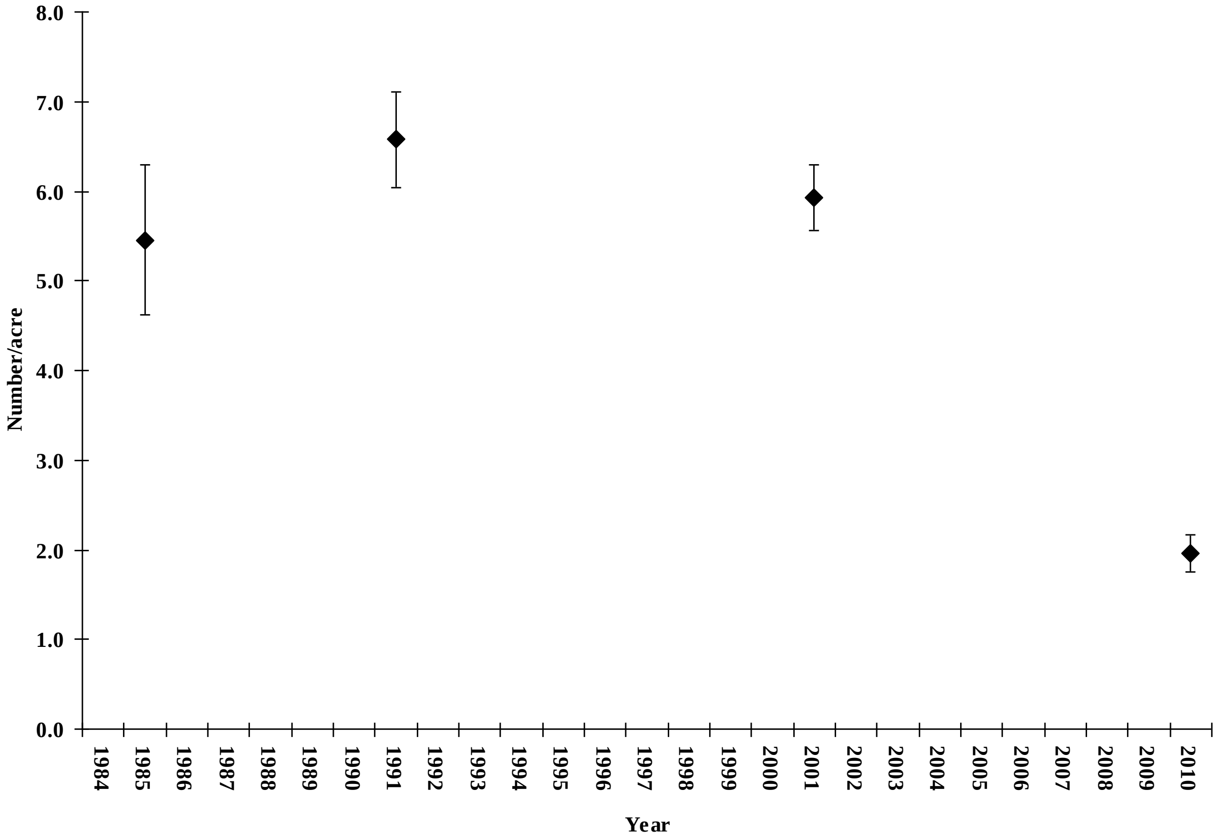

Figure 2. Estimated density and 95% confidence interval of adult walleye by year, upper lakes of the Pike Chain, Bayfield County, Wisconsin.

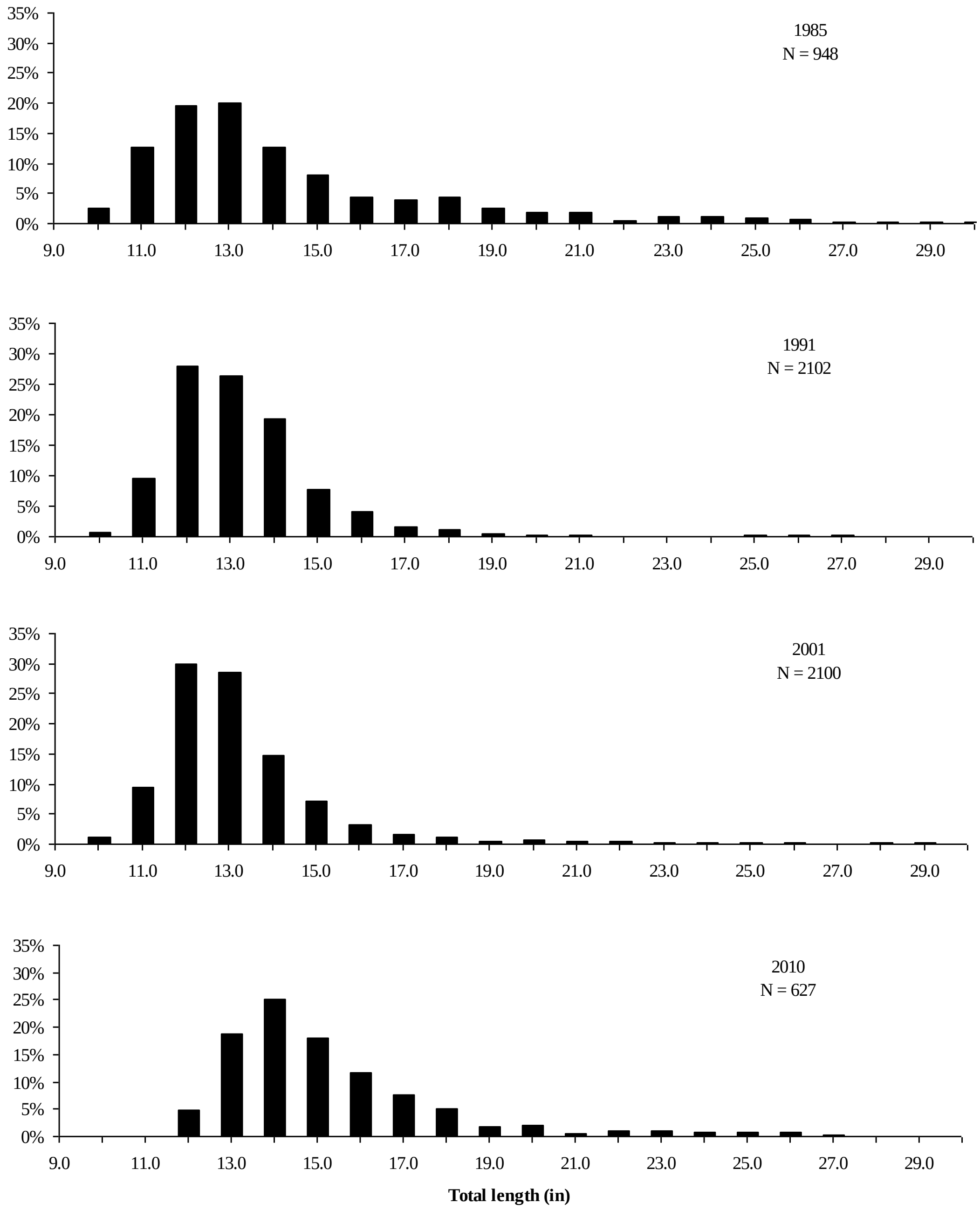

Figure 3. Percent length distribution of adult walleye sampled fyke-netting, upper lakes of the Pike Chain, Bayfield County, Wisconsin.

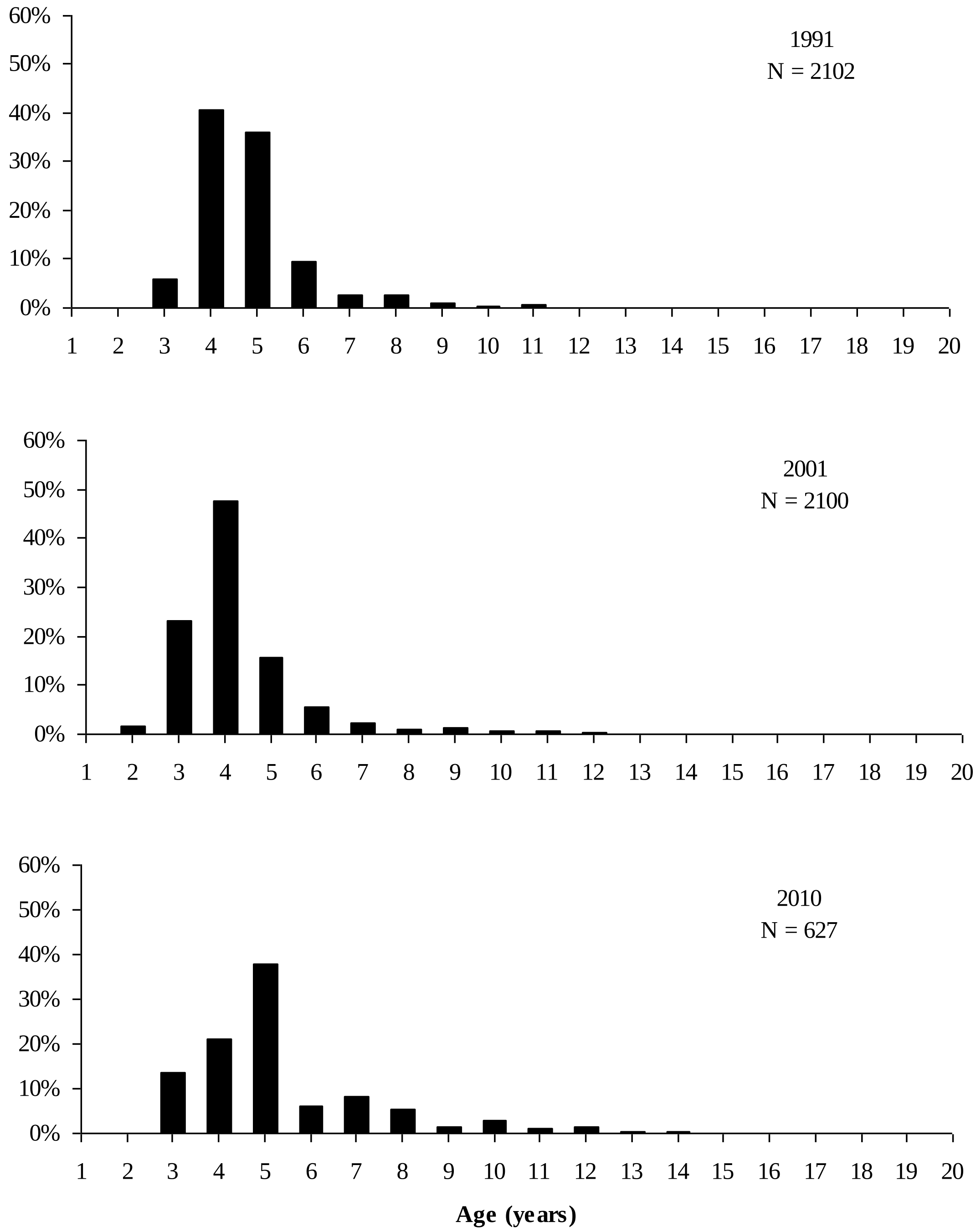

Figure 4. Percent distribution by age of walleye in the upper lakes of the Pike Chain, Bayfield County, Wisconsin.

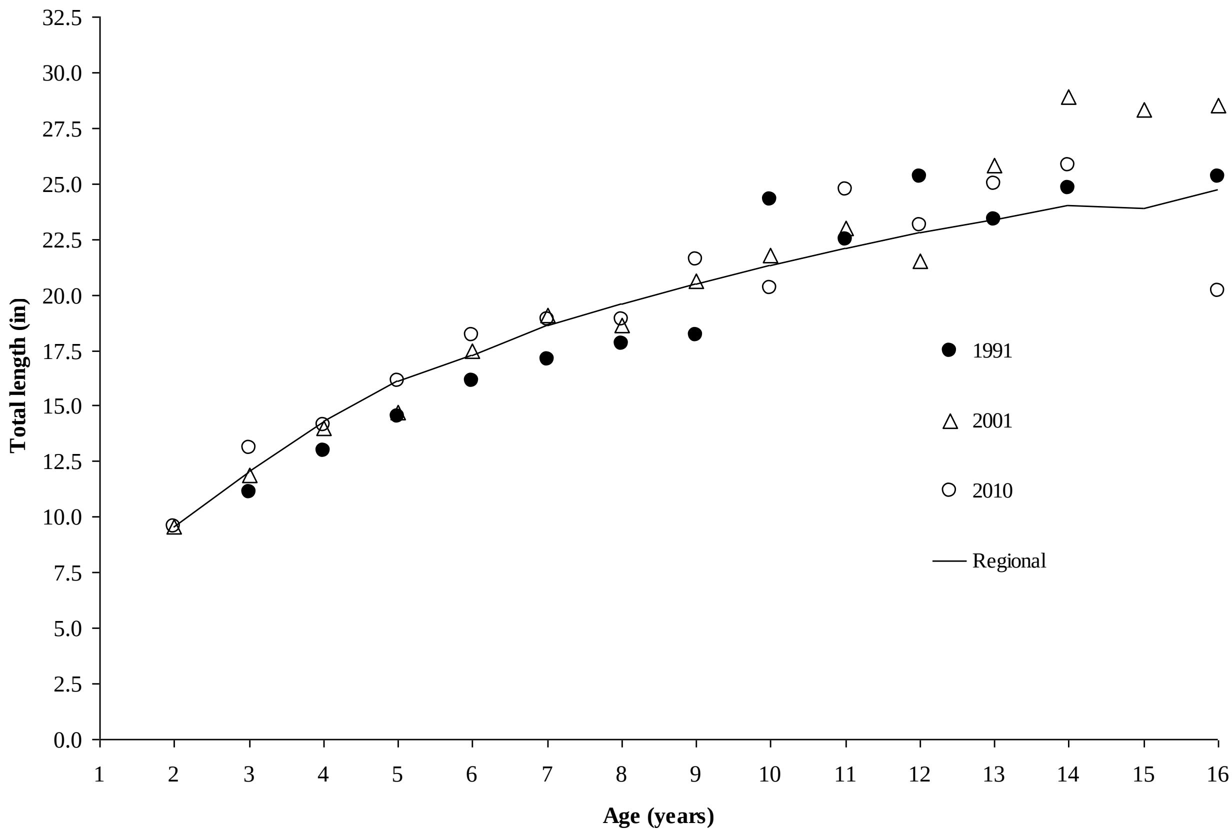

Figure 5. Age at length of walleye in the upper lakes of the Pike Chain, Bayfield County, Wisconsin.

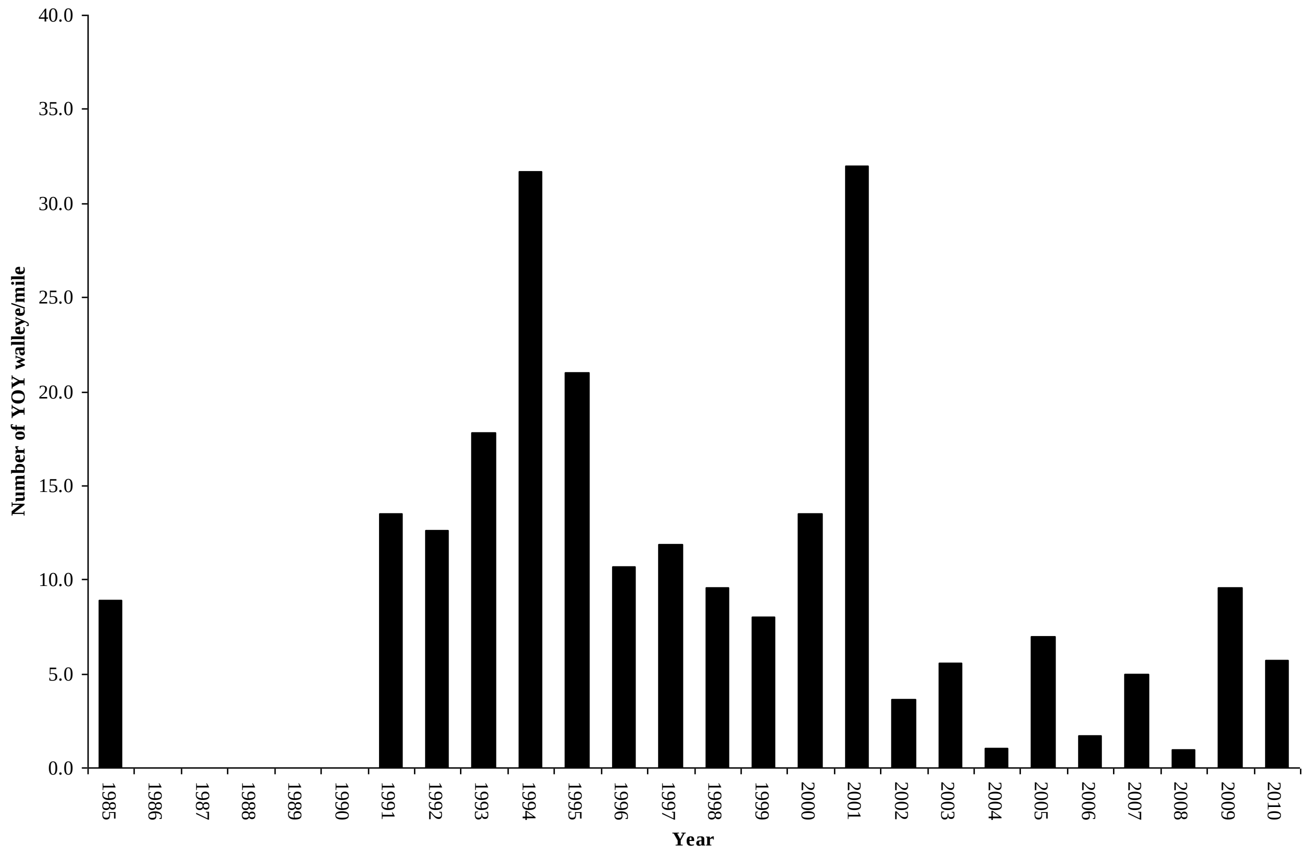

Figure 6. Relative abundance of young of the year (YOY) walleye determined by fall electrofishing, upper lakes of the Pike Chain, Bayfield County, Wisconsin. No surveys completed from 1986 - 1990.

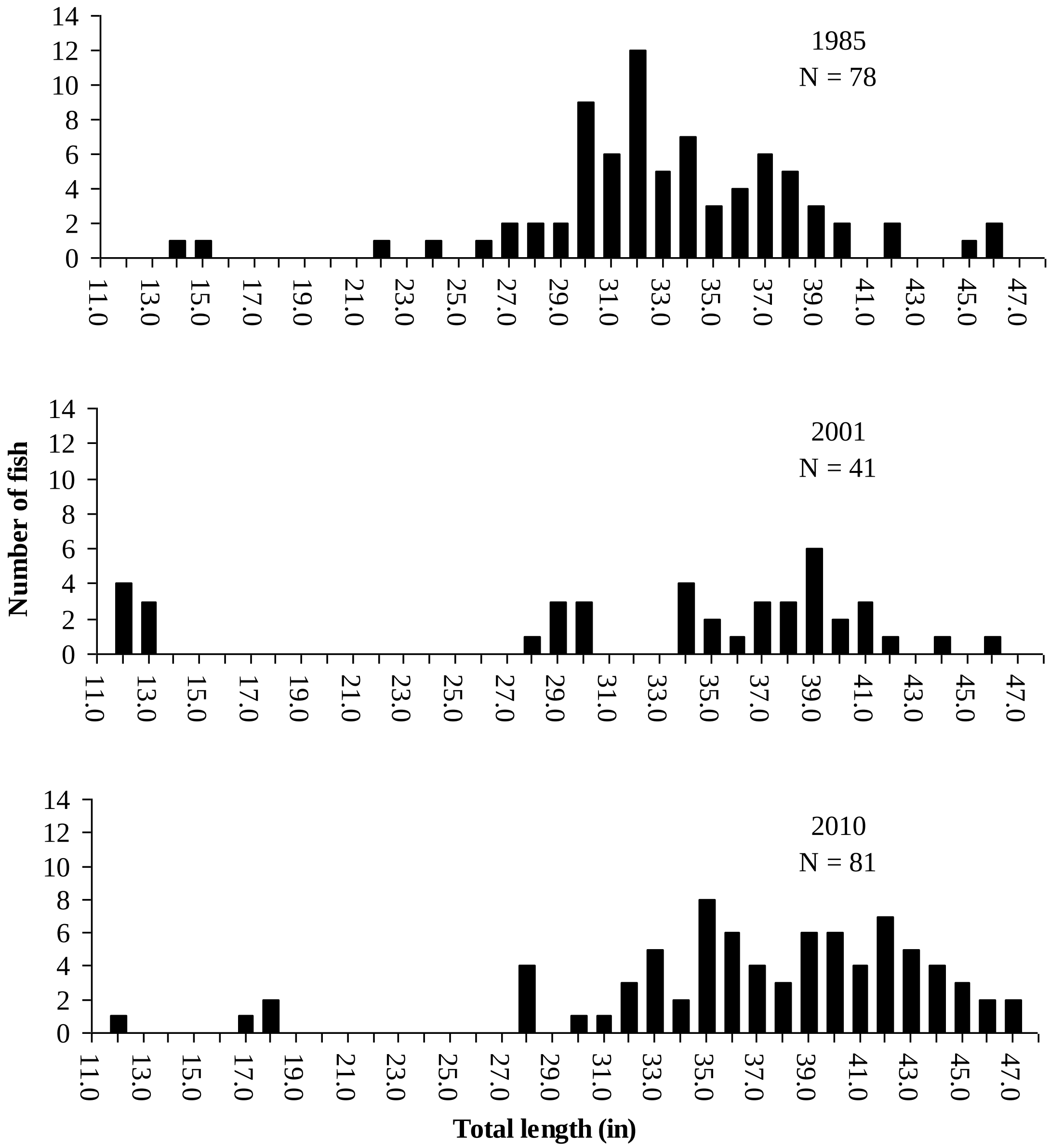

Figure 7. Length distribution of muskellunge sampled fyke-netting, Pike Chain, Bayfield County, Wisconsin.

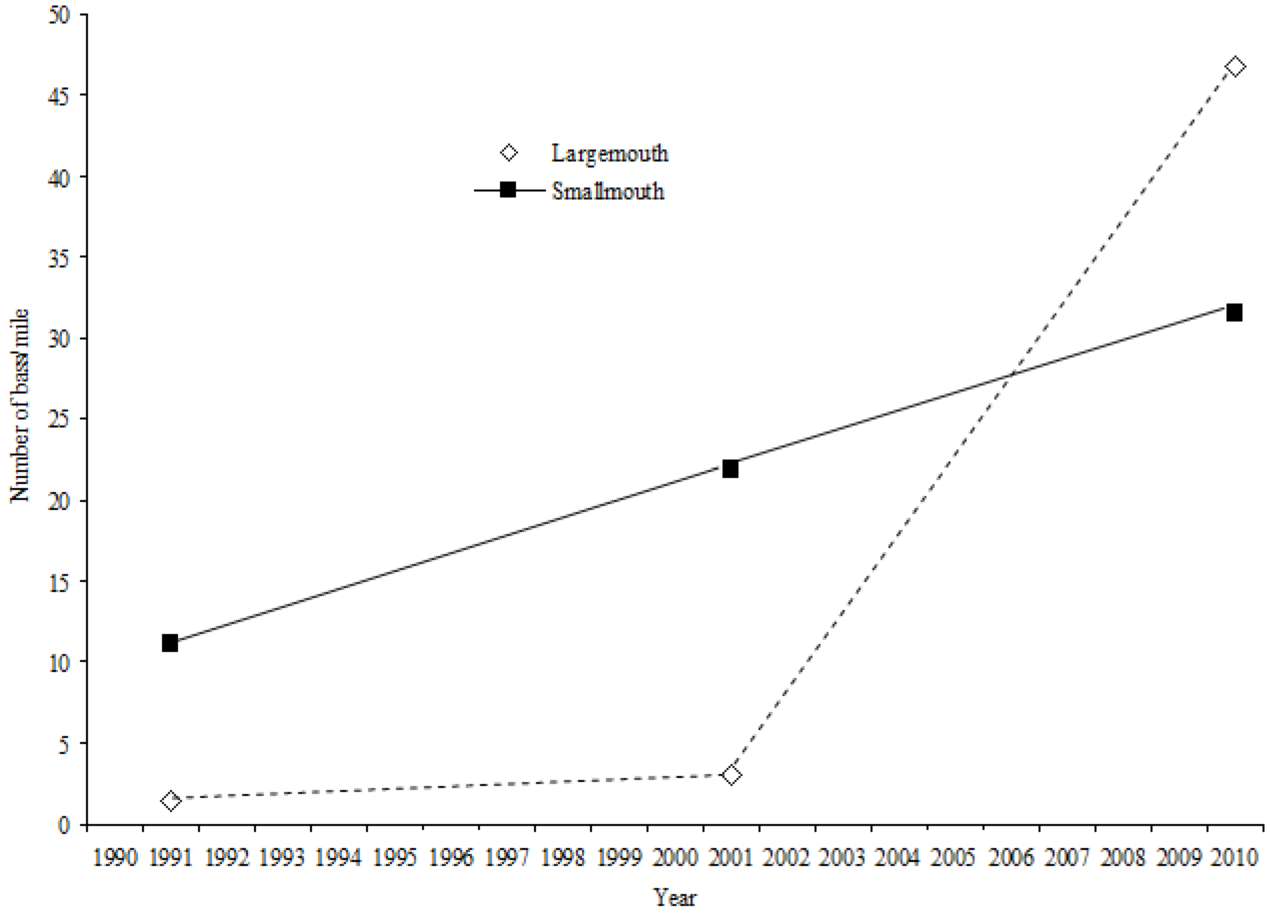

Figure 8. Relative abundance of largemouth and smallmouth bass (#/mile) from spring electrofishing surveys in the upper lakes of the Pike Chain, Bayfield County, Wisconsin.

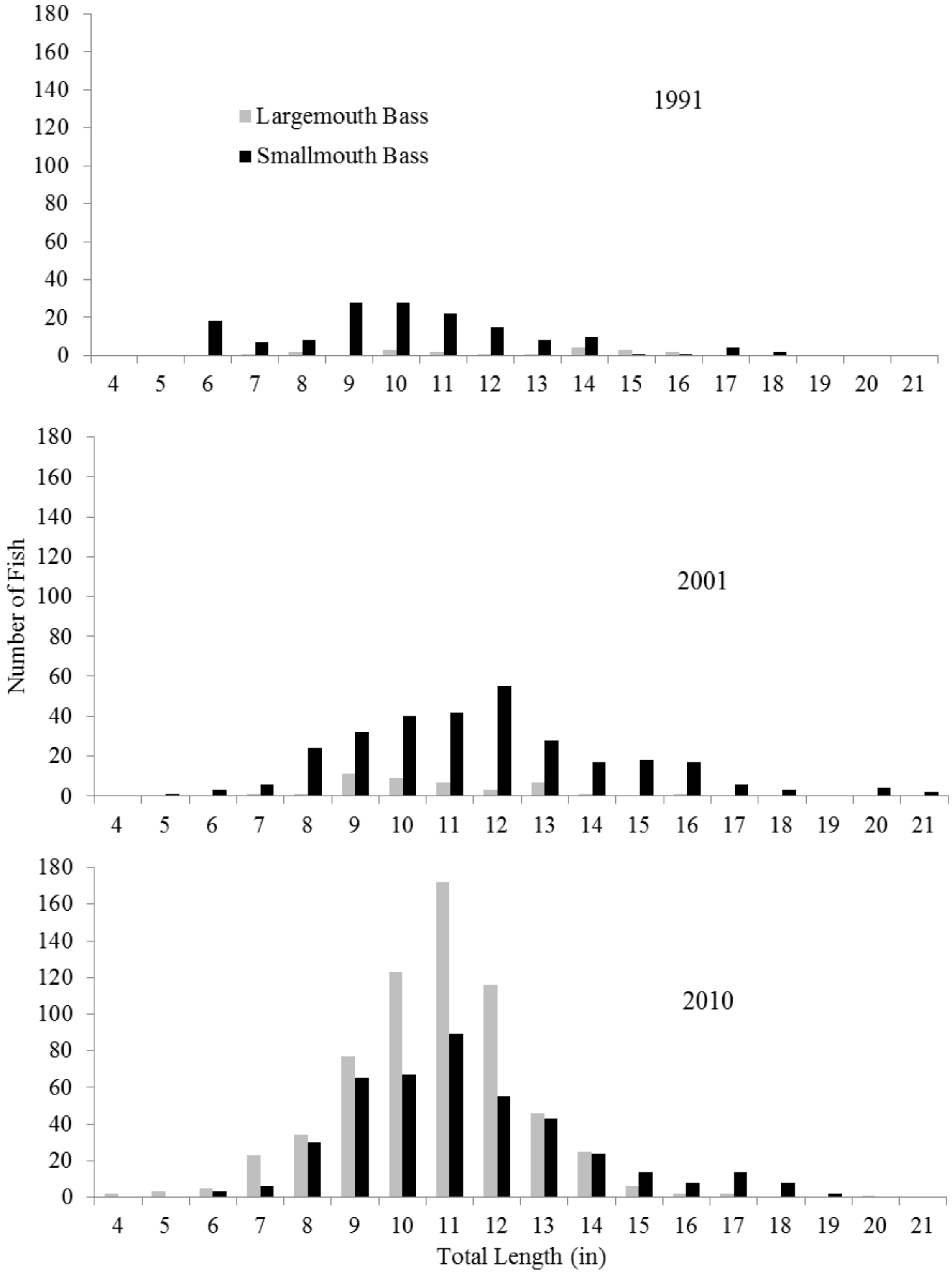

Figure 9. Length distribution of largemouth and smallmouth bass determined by second run spring electrofishing, upper lakes of the Pike Chain, Bayfield County, Wisconsin.

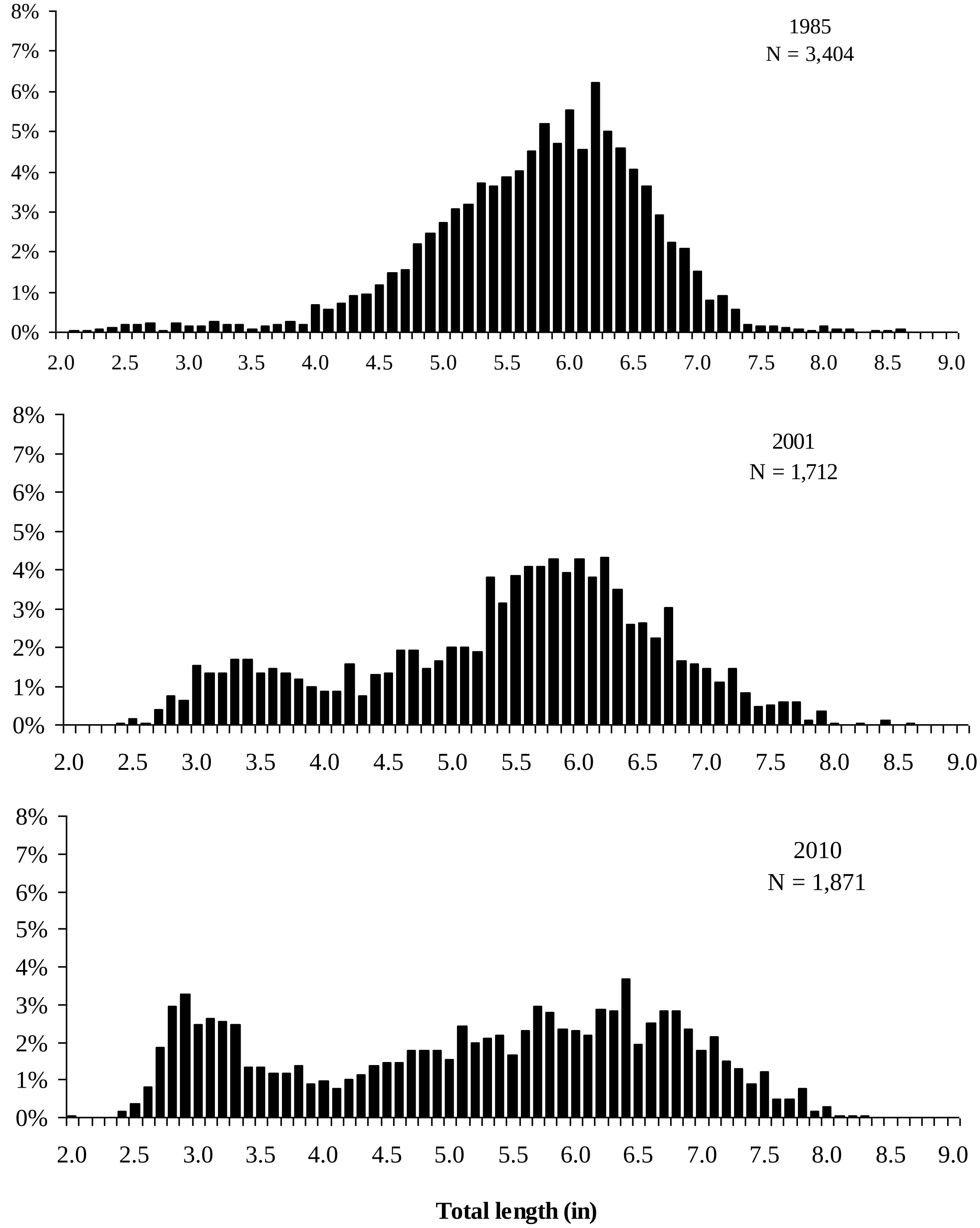

Figure 10. Percent length distribution of bluegill sampled fyke netting, upper lakes of the Pike Chain, Bayfield County, Wisconsin.

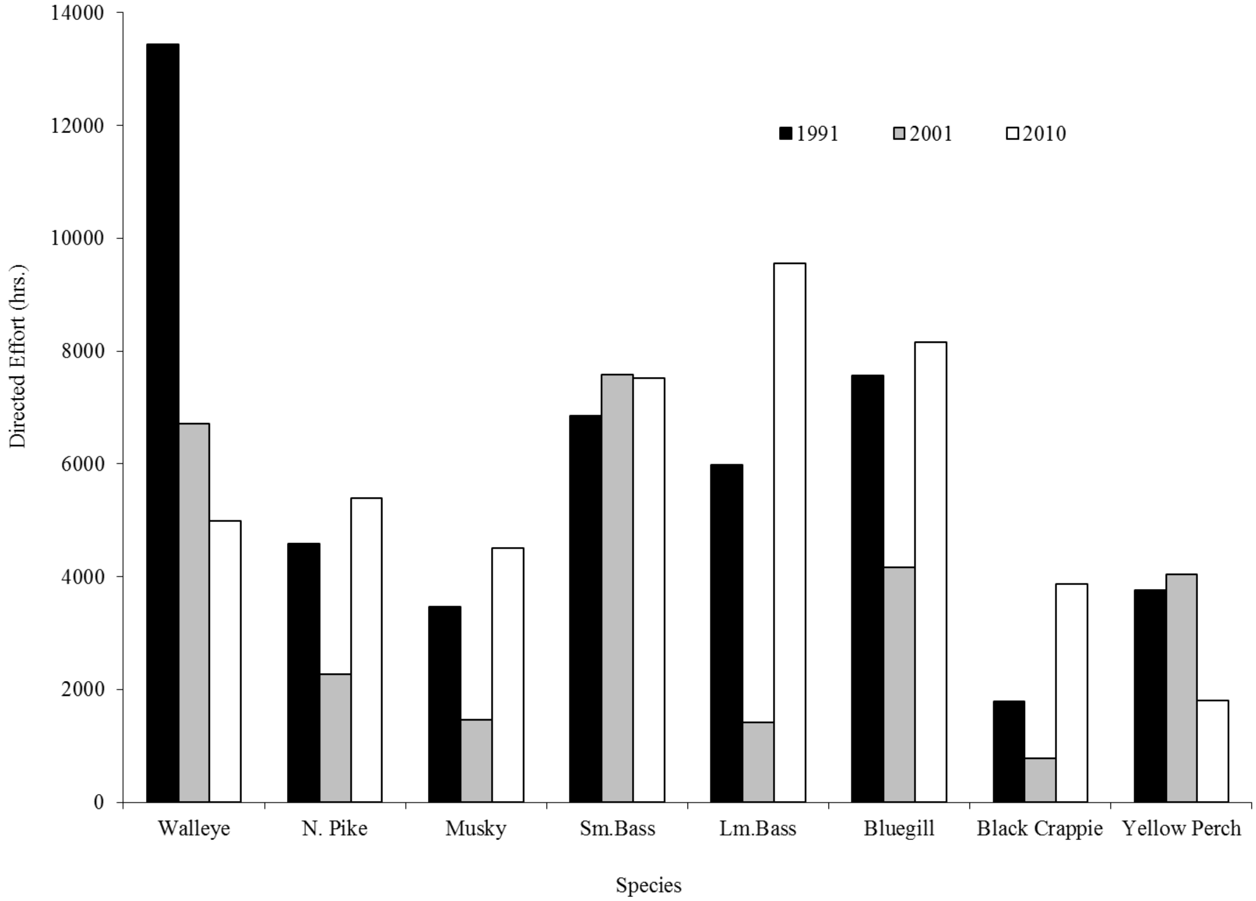

Figure 11. Annual directed angler fish effort 1991, 2001 and 2010, upper lakes of the Pike Chain, Bayfield County, Wisconsin.

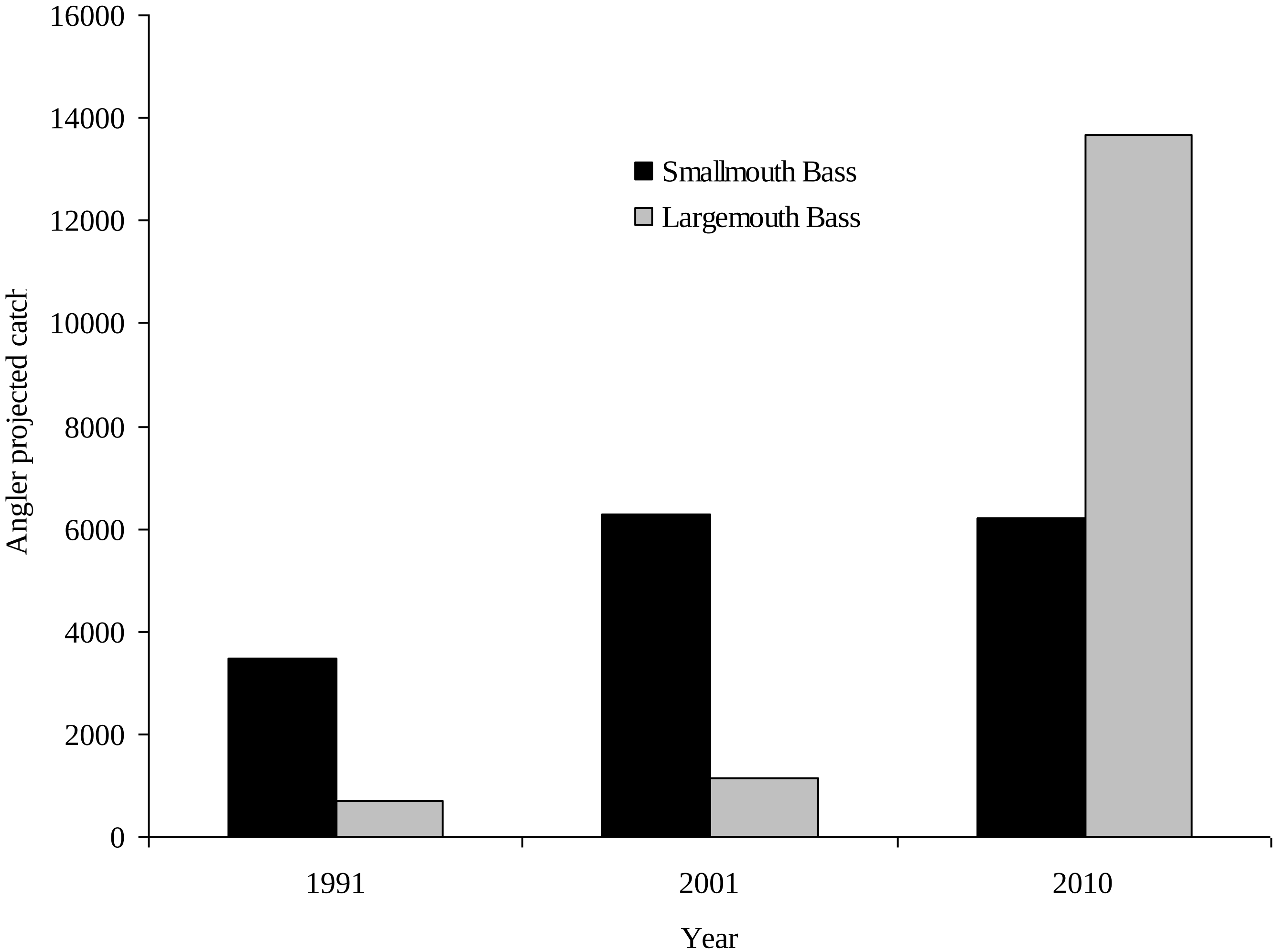

Figure 12. Angler projected catch of black bass for the upper lakes of the Pike Chain, Bayfield County, Wisconsin.

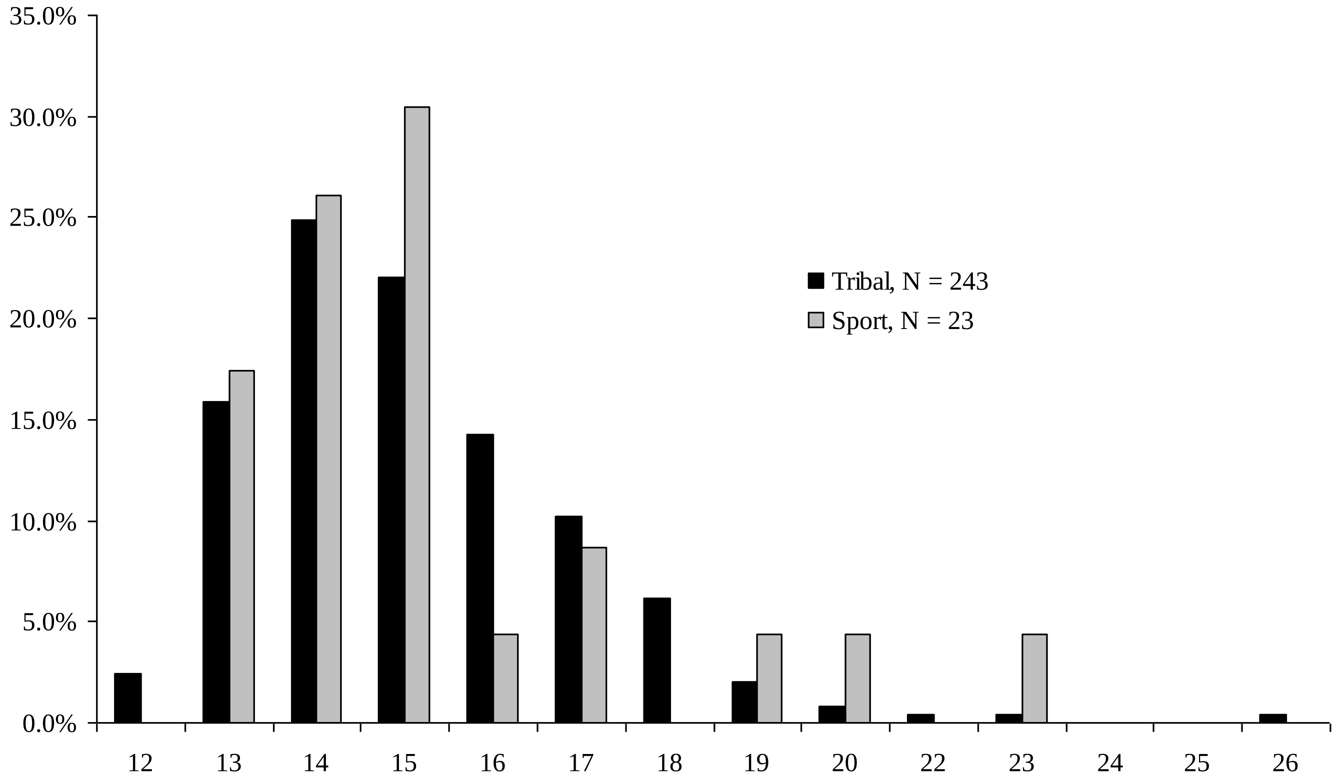

Figure 13. Tribal and sport harvest of walleye in the Pike Chain, Bayfield County, Wisconsin. Numbers represent measured fish only.

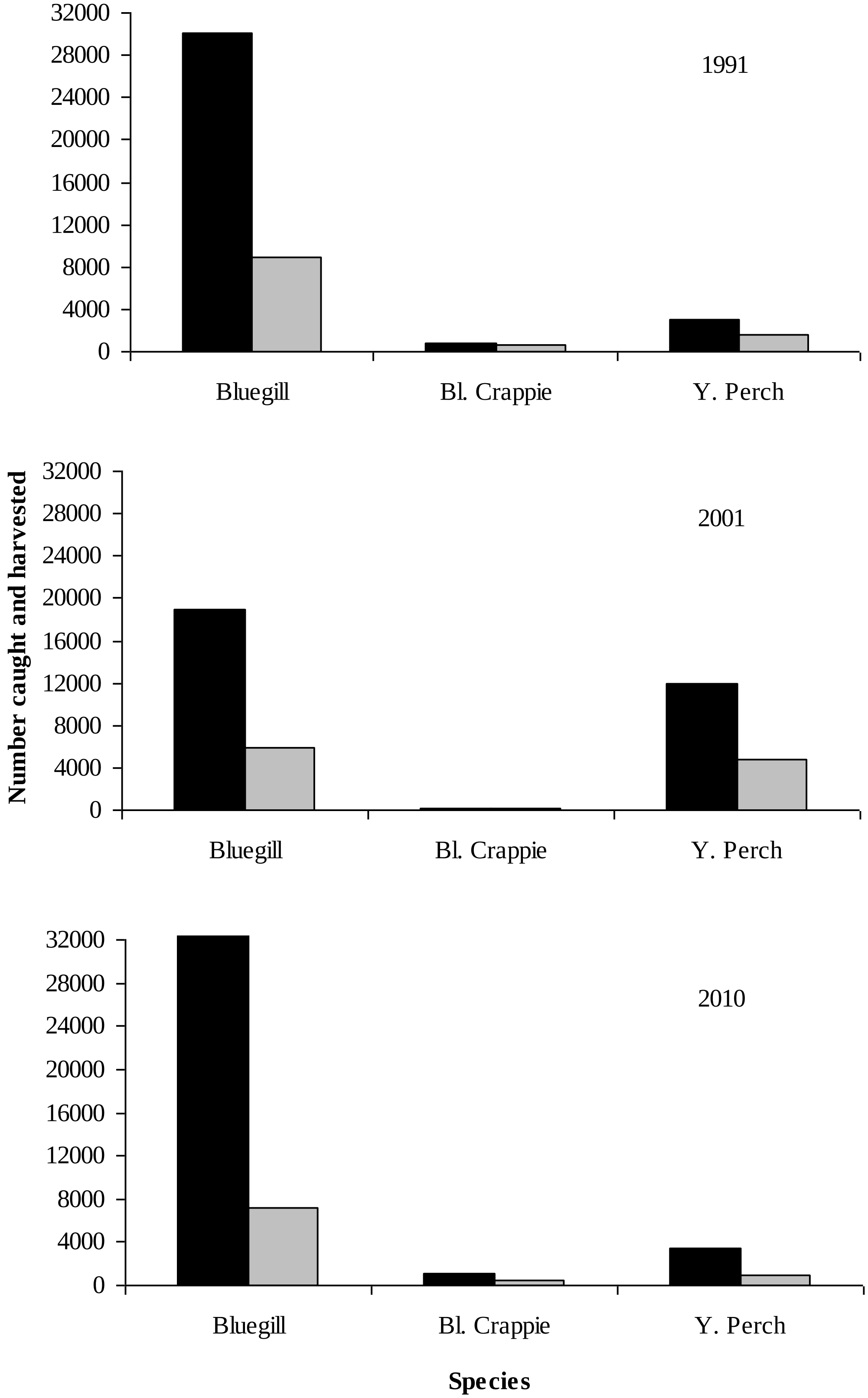

Figure 14. Panfish catch (black bars) and harvest (grey bars), upper lakes of the Pike Chain, Bayfield County, Wisconsin.

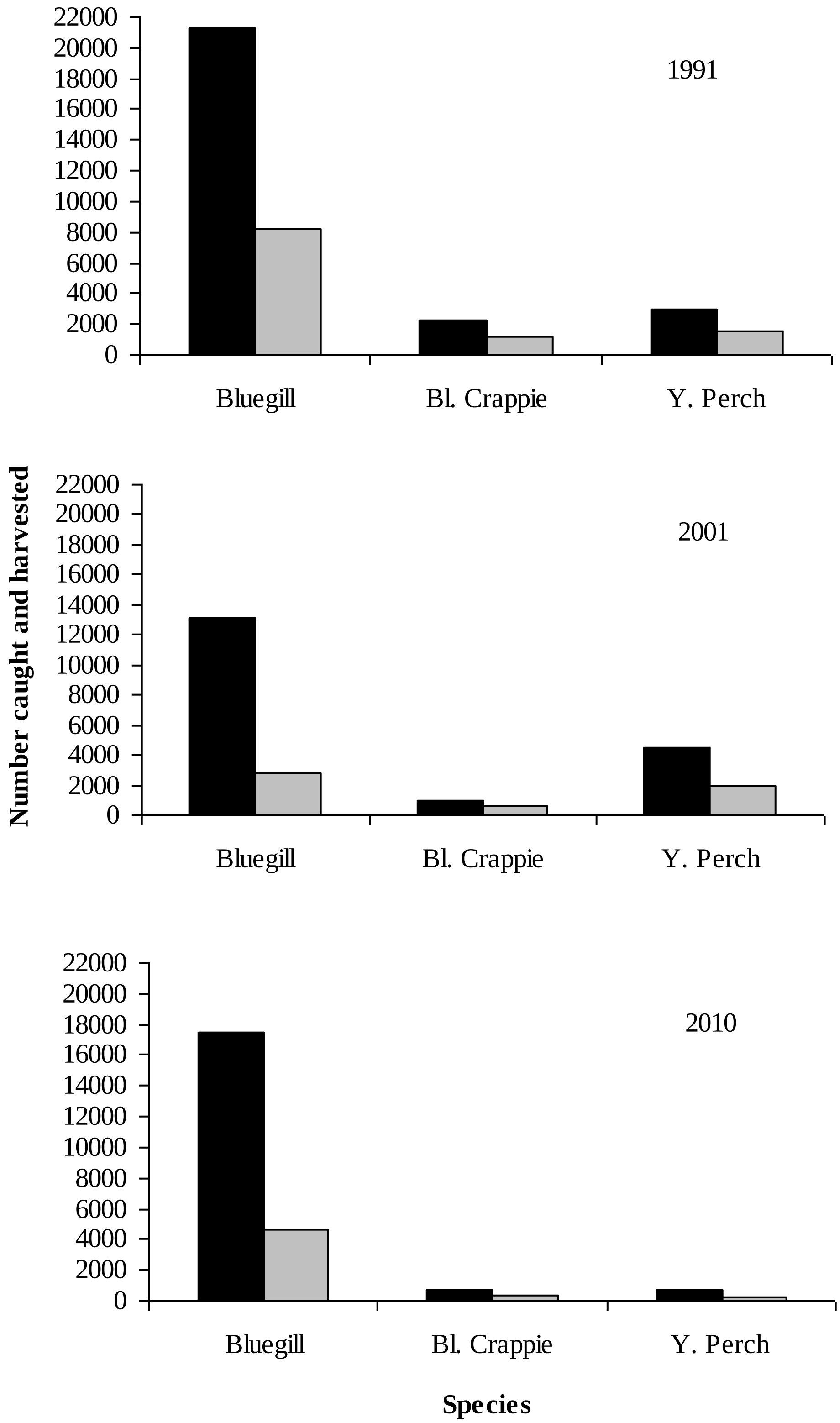

Figure 15. Panfish catch (black bars) and harvest (grey bars), lower lakes of the Pike Chain, Bayfield County, Wisconsin.

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
Northern Pike	14	21	28
Smallmouth Bass	7	11	14
Walleye	10	15	20