Fishery Survey – Upper St. Croix Lake
Douglas County, 2009-2010
WBIC Code – 2747300

Paul Riordan, fisheries technician (left) and Doug Nagel, display an Upper St. Croix Lake walleye caught during sampling in 2009. Photo: Scott Toshner

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June, 2011

Executive Summary

Upper St. Croix Lake supports a diverse fish community and a popular sport fishery. With the exception of walleye and lake sturgeon, good natural reproduction sustains all species. A 2009 fishery survey suggests shifts in species abundance may be beginning to occur.

Upper St. Croix Lake walleye population estimates remain near historic averages; although angler catch and harvest indicate a declining walleye population. In 2009, walleye exploitation was above 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. Upper St. Croix Lake appears to be able to maintain adult walleye abundance in the face of high exploitation rates, possibly in part due to apparent additive effects of walleye stocking to year class abundance and the lakes higher productivity. However, the adult population sampled in 2009 consisted of a high proportion of fish from a strong 2005 year class (age 4). Inconsistent and strong year classes of fish can lead to misinterpretation of overall population health and size structure as they move through the fishery. Continued monitoring of walleye abundance, size structure, growth and exploitation are needed to discern whether more conservative regulations are needed in the future.

Smallmouth bass abundance has remained stable and relatively low, while largemouth bass abundance has increased. Both electrofishing and creel surveys indicated an increase in largemouth bass abundance between two and six fold in a 12 year time span. Although largemouth bass abundance has increased in Upper St. Croix Lake, when compared to area lakes, the change could be considered moderate.

Northern pike were popular among anglers, and abundance and angler catch and harvest have remained stable over time. Bluegill and black crappie abundance was high as was angler catch and harvest.

Management recommendations include: 1) Continue to monitor walleye abundance and exploitation to discern if a more conservative angling regulation is needed, 2) Continue to stock

small fingerling walleye in alternate years at 35 fish/acre, 3) Continue to monitor bass populations in light of the increase of largemouth bass since 1997 and discuss with stakeholders future management options if abundance continue to increase, 3) Continue to monitor northern pike and panfish populations which are important to the fishery and are seeing positive trends, 4) Continue stocking lake sturgeon to reestablish this native species, 5) Work with local residents, associations and groups to continue implementation of a lake management plan and aquatic plant management plan that addresses fisheries management goals, habitat protection, rehabilitation and restoration as well as education of users and riparian residents.

Introduction

Upper St. Croix Lake is an 855 acre drainage lake at the headwaters of the St. Croix River. Upper St. Croix Lake is located in eastern Douglas County and flows into the St. Croix Flowage. Maximum depth of Upper St. Croix Lake is 22 feet with an alkalinity of 42 mg/L. The lake has a highly developed shoreline with the exception of the 1.7 miles of shore which includes state owned land on the north end of the lake and privately owned lands on southern end of the lake including the island. Upper St. Croix Lake has a long narrow form which results in a total shoreline length (including island) of 10 miles. Five named and 4 unnamed streams flow into Upper St. Croix Lake. The watershed that flows into Upper St. Croix Lake is 34.8 square miles (Turyk et al. 2009). Public access is provided at 5 locations, 4 of which are owned by the Village of Solon Springs along the western side of the lake and the other is located on state land on the northern portion of the lake.

Water quality measurements taken for Upper St. Croix Lake indicate moderate levels of nutrients. Average summer secchi disk depth, total phosphorus and chlorophyll-a trophic state indices (TSI) values for the southern basin were 51 (SD = 5.7, N = 46), 55 (SD = 3.8, N = 36) and 51 (SD = 10.6, N = 36) for the time period between 1995 and 2010. 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 Upper St. Croix Lake indicate the nutrient condition was eutrophic (high productivity) when considering secchi disk, total phosphorus and chlorophyll-a TSI indices. In addition to Citizen Lake Monitoring data, several studies along with a lake management report have been completed on Upper St. Croix Lake (http://www.uscwa.org/archive.htm, visited April 2011). In general, these reports contain data for water quality, aquatic plant communities, algal blooms, internal loading and watershed dynamics.

Upper St. Croix Lake has a diverse fishery consisting of walleye *Sander vitreus*, muskellunge *Esox masquinongy*, northern pike *E. lucius*, largemouth bass *Micropterus salmoides*, smallmouth bass *M. dolomieui*, brook trout *Salvelinus fontilalis*, brown trout *Salmo trutta*, bluegill *Lepomis macrochirus*, pumpkinseed *L. gibbosus*, warmouth *L. gulosus*, rock bass *Ambloplites rupestris*, black crappie *Pomoxis nigromaculatus*, yellow perch *Perca flavescens*, bowfin *Amia calva*, white sucker *Catostomus commersoni*, channel catfish *Ictalurus punctatus*, yellow bullhead *I. natalis*, black bullhead *I. melas*, tadpole madtom *Etheostoma nigrum*, greater redhorse *Moxostoma valenciennesi*, common carp *Cyprinus carpio*, logperch *Percina caprodes*, Iowa darter *Etheostoma exile*, johnny darter *E. nigrum*, brook silverside *Labidesthes sicculus*, bluntnose minnow *Pimephales notatus*, fathead minnow *P. promelas*, carpsucker *Carpiodes velifer*, creek chub *Semotilus atromaculatus*, golden shiner *Notemigonus crysoleucas*, brassy minnow *Hybognathus hankinsoni*, common shiner *Notropis cornutlus*, blackchin shiner *N. heterodon*, and spottail shiner *N. hudsonius*.

Historic fisheries management of Upper St. Croix Lake has included surveys, stocking, and various length and daily bag limit regulations. Historic surveys for walleye occurred in 1992, 1997 and 2009 utilizing Wisconsin Department of Natural Resources (WDNR) standardized treaty protocols (Hennessey 2002). In 1984, a survey was conducted for walleye that utilized fyke netting for both mark and recapture. Basic fishery surveys utilizing a variety of gear types were conducted by WDNR in 1960, 1966 and 1973. Fall electrofishing surveys were utilized to assess recruitment of walleye in 1988, 1990 - 2005 and 2007 - 2010.

Upper St. Croix Lake has a long stocking history and has been stocked with a number of fish species, including walleye, largemouth bass, smallmouth bass, northern pike, lake sturgeon, bluegill, bullhead (species unknown) and sunfish (species unknown), since at least 1933 (Table 1). Nearly annual walleye stocking occurred from at least 1933 to 1958, when over 16,000,000 fry and over 230,000 small fingerlings were stocked into Upper St. Croix Lake. Electrofishing surveys in

1960, 1966 and 1973 indicated walleye were the dominant predator with northern pike being common (Butters 1960; Weiher 1968 and Rieckhoff 1975). A total of 6 largemouth bass were captured in all three historic surveys with no smallmouth bass found. In 1975, common carp were first noted as being present, although thought to be a small population that was not posing a problem to the fishery. In 1984, walleye continued to be the most abundant predator with northern pike having the second highest abundance (Kampa 1985). Largemouth bass young of the year were abundant in the July seine haul and smallmouth bass were found for the first time. Bluegill were considered abundant and the most common panfish species found followed by yellow perch, black crappie and pumpkinseed. Management recommendations from the 1984 survey included; assessing sturgeon populations, assessing young of the year walleye, stocking rainbow trout and walleye, and restoring gravel spawning areas in inlet streams where walleye were thought to spawn.

Walleye fishing regulations have changed over time on Upper St. Croix Lake. There was no minimum length limit for walleye until 1990 when a 15 in minimum length limit and daily 5 fish bag was instituted statewide. Bag limits for walleye have been adjusted annually according to tribal harvest declarations that began in 1989. 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. 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 small fingerling walleye and large fingerling lake sturgeon. The Department has been involved with the Upper St. Croix Lake Association in reviewing lake water quality studies and the development of a lake management plan. In 2010, a large wood restoration demonstration project was initiated with the intent of increasing large woody habitat, thought to be more abundant historically.

Methods

Upper St. Croix Lake was sampled during 2009-2010 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 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 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. Abundance and variance in 1984 were calculated using the Schnabel method (Ricker 1975).

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 lake (10 miles) was sampled. All surveys occurred in May.

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 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 $\acute{\alpha} = 0.05$ 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 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 2009 included 55 fyke net lifts targeting spawning gamefish. Three electroshocking surveys of the entire shoreline totaling 8.8 hours in spring (walleye recapture and bass surveys) and 3.2 hours in fall (walleye recruitment survey) were conducted.

Walleye. Adult walleye abundance (≥ 15 in and sexable fish) was 2,573 (CV = 0.07, 3.0 adults/acre) in 2009 for Upper St. Croix Lake. Adult walleye abundance in Upper St. Croix Lake increased from 1984 to 1992 and then decreased in 1997 and 2009 (Figure 1). The average of walleye abundances over the 4 sampling events was 3.1 fish/acre. Walleye size structure decreased since 1984. Percent length frequency suggests there was an increase in the proportion of walleye 10 to 14.0 in and a decrease in walleye 15 in and larger in 1992, 1997 and 2009 compared to 1984 (Figure 2). Length of walleye captured during fyke netting differed significantly for all years (1984 vs. 1992, $D = 0.26$, $P < 0.001$; 1992 vs. 1997, $D = 0.14$, $P < 0.001$; 1997 vs. 2009, $D = 0.09$, $P = 0.0044$, 1984 vs. 2009, $D = 0.24$, $P < 0.001$). Mean length for sexable walleye decreased from 16.4 in (SD = 2.3, N = 962) to 15.5 in (SD = 2.0, N = 583) from1984 to 1992 then increased to 15.8 in (SD = 2.1, N = 678) in 1997. Mean length in 2009 increased slightly from 1997 to 15.9 in (SD = 2.2, N = 696). Proportional stock density (PSD) decreased from 75 to 54 from 1984 to 1992, and then increased to 67 in 1997. PSD in 2009 declined to 58. RSD-20 decreased from 6 to 2 from 1984 to 1992, and then increased to 3 and 6 in 1997 and 2009. Interestingly, these findings suggest that while the overall walleye size structure has decreased the proportion of larger walleye (> 20 in) in 2009 was similar to 1984.

Age of adult walleye sampled during the 2009 survey ranged from II to XVII. Male and female walleye first reached maturity at II and III, respectively. Age IV and VI walleye accounted

for 76% of the adult stock in 2009 in contrast to 1997 in which the same age walleye accounted for 42% of the adult stock and 1992 in which age V and VI accounted for 59% of the adult stock. In 2009, walleye abundance from stocked years made up the majority of the population. In 1992 and 1997, the effect of stocking was harder to discern and natural reproduction in non-stocked years was evident (Figure 3). Growth rates for both sexes were relatively consistent. In 1992 and 1997 growth rates were below regional averages, while in 2009 growth for both male and female walleye improved to nearly regional averages (Figure 4). Growth was dimorphic, male and female walleye reaching 14 in sometime during the fifth and fourth growing season, respectively.

Relative abundance of young-of-year (YOY) walleye in Upper St. Croix Lake in 2009 was 2.8 fish/mile. The average walleye YOY/mile was 9.0 (SD = 13.2, N = 21) for surveys completed from 1988 to 2010 by both WDNR and GLIFWC. In stocked and non-stocked years the average YOY/ mile was 11.1 (SD = 12.3, N = 10) and 7.2 (SD = 14.3, N = 11), respectively. Fingerling relative abundance has been variable from 1988 to 2010 with a range of 0 fish/mile to 49.0 fish/mile (Figure 5). Mean relative abundance of YOY walleye for naturally reproducing and stocked walleye lakes surveyed by WDNR in the western portion of the ceded territory from 1990 to 2009 was 32.6 fish/mile (SD = 47.4, N = 1,021) and 5.7 fish/mile (SD = 16.0, N = 682), respectively.

Northern Pike. Northern pike were the second most abundant predator in Upper St. Croix Lake fyke netting survey in 2009, though their relative abundance was low. Catch per unit effort of northern pike (CPUE; the number of northern pike caught with each fyke net lift) increased from 4.6 to 9.5 from 1984 to 1992, then decreased to 9.3 and 3.6 from 1997 to 2009. Mean lengths of northern pike remained consistent and were 18.0 in (SD = 3.1, N = 220), 18.2 in (SD = 2.2, N = 237), 17.9 in (SD = 3.2, N = 267) and 18.9 in (SD = 3.3, N = 191) for survey years 1984, 1992, 1997 and 2009. PSD and RSD-28 indicated a poor size structure for northern pike. PSD for spring fyke netting samples were 14, 8, 14 and 18 for 1984, 1992, 1997 and 2009. RSD-28 was 1, 0, 1 and 3 for 1984, 1992, 1997 and 2009. Collectively, mean length, stock densities and percent length

frequency indicate a poor size structure in four consecutive survey periods (Figure 6). Mean length at age for northern pike was below the Northern Region averages for all ages except for age II and III (Figure 7).

Smallmouth and Largemouth Bass. In 2009, largemouth bass represented 74% and smallmouth bass 26% of the total number of bass surveyed (N = 204). Smallmouth bass relative abundance in Upper St. Croix Lake was 5.4 fish/mile for 2009. Relative abundance for smallmouth bass has been stable over time during spring electroshocking surveys and was 3.5 and 5.5 for 1992 and 1997 (Figure 8). Mean length of smallmouth bass for the 2009 survey was 12.3 in (SD = 2.7, N = 54) and had PSD and RSD-14 values of 60 and 30, respectively which indicated good size structure. Size structure has remained similar since the 1997 survey and improved since the 1992 survey. Smallmouth bass PSD values were 59 and 62 and RSD-14 values were 9 and 32 for 1992 and 1997, respectively.

Largemouth bass relative abundance in Upper St. Croix Lake was 15.0 fish/mile for 2009. Relative abundance for largemouth bass increased five fold since 1992 and 1997 which had relative abundances of 2.8 and 3.1 fish/mile, respectively. Size structure of largemouth bass for the 2009 survey was good with a mean length of 13.1 in (SD = 1.6, N = 150) and PSD and RSD-15 values of 83 and 13, respectively. PSD values have remained similar and were 76 and 70 for 1992 and 1997. While RSD-15 values increased from 4 to 50 in 1992 and 1997.

Panfish. Black crappie were the most abundant panfish species (N = 3,572) sampled in Upper St. Croix Lake during the spring fyke netting survey of 2009. Relative abundance of black crappie captured in fyke nets decreased then increased from 29.0 to 17.4 to 65.0 fish/net lift in 1992, 1997 and 2009 respectively. Length frequency of black crappie captured in fyke nets in 1992, 1997 and 2009 suggests no significant shift in size structure between 1992 and 2009 (1992 vs. 1997, D = 0.48, P < 0.0001; 1997 vs. 2009, D = 0.09, P = 0.0316; 1992 vs. 2009, D = 0.40, P < 0.0001; Figure 9). Mean total length of black crappie increased then decreased from 6.7 (SD = 1.6, N = 666) to 7.7

in (SD = 1.4, N = 395) to 7.5 in (SD = 1.5, N = 905) from 1992 to 1997 to 2009. PSD for black crappie also increased then decreased from 15 to 63 to 59 for survey years 1992, 1997 and 2009. RSD-10 for black crappie was 1, 2 and 0 for the same time period. PSD values for black crappie indicate a fair size structure for the 2009 survey.

Bluegill were the second most abundant panfish species (N = 2,058) sampled during the spring fyke netting survey of 2009. Relative abundance of bluegill captured in fyke nets increased from 25.7 to 28.9 to 37.4 fish/net lift in 1992, 1997 and 2009 respectively. Length frequency of bluegill captured in fyke nets in 1992, 1997 and 2009 suggests no significant shift in size structure between 1992 and 2009 (1992 vs. 1997, $D = 0.39$, $P < 0.0001$; 1997 vs. 2009, $D = 0.40$, $P < 0.0001$; 1992 vs. 2009, $D = 0.12$, $P < 0.0001$; Figure 10). Mean total length of bluegill increased then decreased from 6.6 (SD = 1.1, N = 592) to 7.3 in (SD = 1.3, N = 565) to 6.7 in (SD = 1.1, N = 920) from 1992 to 1997 to 2009. PSD for bluegill increased then remained unchanged from 84 to 88 to 88 for survey years 1992, 1997 and 2009. RSD-8 for bluegill increased then decreased from 6 to 30 to 4 for the same time period. PSD values for bluegill indicate a fair size structure for the 2009 survey. Yellow perch (N = 58), rock bass (N = 41) and pumpkinseed (N = 25) were found in low numbers during the spring netting survey.

Sport and Tribal Fishery. Anglers fished an estimated 33,071 hours (38.7 hrs/acre) during the 2009-2010 season in Upper St. Croix Lake, which is above the average of both 27.5 hrs/acre for Bayfield and Douglas County walleye lakes (WDNR unpublished data, Brule field office) and the Northwestern Wisconsin Region (13 counties) average of 29.9 hrs/acre. Open water anglers accounted for 69% of all fishing effort. The directed effort, i.e. effort targeted toward a specific game fish, was highest for northern pike with 10,060 hours (20.4%; Figure 11). The most sought after panfish species was bluegill, with 29.9% of the directed effort. Fishing pressure decreased then increased from 38.9 to 20.5 to 38.7 hours/acre in 1992, 1997 and 2009 respectively.

Walleye were the most heavily harvested gamefish in Upper St. Croix Lake. An estimated 1,394 walleye were caught in the open water and ice season of 2009-2010 of which 57% (787) were harvested. Estimated angler catch of walleye has declined since 1992 and 1997 when 3,589 and 3,989 fish were estimated to be caught respectively. Projected angler harvest of walleye has declined from 1,102 in 1992 to 859 in 1997 (Figure 12). The open water season accounted for 98% of the total walleye harvest, which was in the same range for values from 1992 (93%) and 1997 (98%). Angler exploitation, calculated by the estimated number of marked walleye harvested divided by the total number of marked walleye, was 24.3% in 2009-2010. Average length of angler harvested walleye has remained similar over time and was 16.6 in 2009 and 16.5 in for both 1992 and 1997.

Tribal harvest accounted for 194 walleye in 2009 (Krueger 2010). Walleye harvested ranged from 10.2 to 26.0 in. Tribal harvest represented 20% of the combined total harvest (sport angling plus tribal spearing) and tribal exploitation of the adult walleye population was 13.3%. The mean length of tribally harvested walleye was 15.6 in (N = 194, SD = 1.76) and 44% were < 15 in. Male and female walleye represented 90% and 10% of the total tribal harvest, respectively. Total walleye exploitation (sport and tribal) increased from 13.4% to 31.2% to 37.6% from 1992 to 1997 to 2009.

Northern pike were the second most exploited (harvest = 664) gamefish in 2009 on Upper St. Croix Lake of which 75% (N = 495) were estimated to be harvested during the ice fishing season. Estimated catch and harvest of northern pike was 2,708 and 664 in 2009 and has remained stable over time (Figure 11). Percent directed effort for northern pike has remained similar and was 22.5%, 21.4% and 20.4% in 1992, 1997 and 2009. Mean length of harvested northern pike has also remained similar among years and was 20.9, 20.5 and 20.8 inches in 1992, 1997 and 2009, respectively.

Angler catch and harvest of smallmouth bass has increased over time (Figure 12). Angler exploitation of bass as determined by division of estimated harvest by estimated catch has remained low and was 13%, 5% and 4% for 1992, 1997 and 2007. Largemouth bass followed a similar trend as smallmouth bass in regard to catch and harvest although catch and harvest of largemouth has been lower than smallmouth bass (Figure 12). Angler exploitation of largemouth bass was higher than smallmouth bass but still low overall and was 10%, 25% and 15% in 1992, 1997 and 2009, respectively. Mean length of angler harvest for smallmouth bass increased then decreased from 14.3 to 15.7 to 14.6 inches from 1992 to 1997 to 2009. Mean length of angler harvested largemouth bass also increased then decreased from 15.5 to 17.2 to 15.3 inches from 1992 to 1997 to 2009.

Interestingly, one muskellunge was reported caught by an angler in 2009. This generated an estimated catch of 9 muskellunge during the open water season.

Anglers pursuing panfish accounted for 51% of the total directed angling effort for the 2009-2010 open water and winter seasons combined. Estimated catch of bluegill declined by 460% from 1992 to 1997 and harvest declined by 600% in the same time period. Estimated catch and harvest of bluegill then increased to values higher than in 1992 from 1998 to 2009 (Figure 13). Average length of harvested bluegill has fluctuated from 7.4 to 7.8 to 7.5 inches in 1992, 1997 and 2009. Catch and harvest of black crappie followed the same pattern as bluegill, a decrease then an increase from 1992 to 1997 and 2009 (Figure 13). Average length of harvested black crappie increased from 9.8 to 9.9 then decreased to 9.1 from 1992 to 1997 and 2009. In comparison to bluegill and black crappie, catch and harvest of yellow perch was a minor portion of the panfishery on Upper St. Croix Lake. Pumpkinseed and rock bass had low values of catch and harvest in 2009 and historically in 1992 and 1997. Other species with low values of estimated angler catch and harvest were bowfin, yellow bullhead, common carp and white sucker in decreasing order of abundance in 2009.

Discussion

Upper St. Croix Lake supports a diverse fish community and a popular sport fishery. With the exception of walleye and lake sturgeon 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. Although walleye population estimates remain near historic levels, angler catch and harvest indicate a declining walleye population.

Adult walleye abundance has remained stable over time and was 3.0 fish/acre which is near or equal to the average for Upper St. Croix Lake (3.1 fish/acre) and Statewide management objectives of 3.0 fish/acre. Although walleye abundance remains stable, results from the 2009-2010 survey suggest that combined walleye exploitation (tribal and sport) of 38% 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). Upper St. Croix Lake 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 and regulations, their findings suggest that exploitation rates of 77 to 86% in lakes with a 15 inch minimum length limit for walleye increase the risk of induction of a decline in the walleye population above zero. Schueller et al. (2008) cautioned that field experiments need to be conducted to verify model results. Upper St. Croix Lake appears to be able to maintain adult walleye abundance in the face of high exploitation rates. However, the adult population sampled in 2009 consisted of a high proportion of fish from a strong 2005 year class (age 4). Inconsistent and strong year classes of fish

can lead to misinterpretation of overall population health as size structure and they move through the fishery. Continued monitoring of walleye abundance, size structure, growth and exploitation are needed to discern whether more conservative regulations are needed in the future.

It seems logical that restricting angler harvest through more conservative regulations may help to reduce harvest and increase walleye abundance; 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 benefits of a more conservative regulation for walleye on Upper St. Croix Lake would likely be evidenced by increased size structure, not increased abundance.

On Upper St. Croix Lake walleye stocking appears to have an additive effect on year class strength, though natural reproduction is still evident when comparing abundance by ages. This is an anomaly to what Li et al. (1996a) found in a study of nearly 2,000 Minnesota lakes where stocking of walleye in lakes with natural reproduction had no effect on population abundance. Li et al. (1996b) also found in a study on the effects of walleye stocking in 200 Minnesota lakes that stocking decreased the abundances of year classes both one year younger and one year older than

the stocked year class. Whether or not this is occurring on Upper St. Croix Lake is unclear. Fall young of the year abundance of walleye show weak and strong year class strength in both stocked and non-stocked years. 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. If largemouth bass abundances continue to increase on Upper St. Croix Lake there is a possibility the success of walleye stocking will decline. Due to evidence of contribution to year class strength, stocking of small fingerling walleye in alternate years should continue on Upper St. Croix Lake at a rate of 35 fish/acre. Perhaps the largest positive impact to walleye populations and the fishery in general would be the restoration of near shore habitat and the protection of areas deemed important to the health of the fishery.

Electrofishing surveys in 1960, 1966 and 1973 on Upper St. Croix Lake found no smallmouth and only 6 largemouth bass. While smallmouth bass were still present in abundances similar to recent survey years (5.4 fish/mile), largemouth bass were more than twice as abundant (15.0 fish/mile) in 2009. Creel surveys confirm the trend of electroshocking data, showing a 668% increase in anglers catch of largemouth bass from the average of 1992 and 1997 (Catch = 197) to 2000 (Catch = 1,316). Largemouth bass were found in similar abundances to smallmouth bass in 1992 and 1997, so the increased abundance of largemouth bass was likely a symptom of changes occurring in the fishery during the past 15 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 Upper St. Croix Lake. If the goal is to maintain a balanced fishery which includes walleye as the main predator then further increases of largemouth bass abundance would warrant consideration of liberalizing regulations on largemouth bass to reduce numbers.

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 Sharman 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 electroshocking 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. Upper St. Croix Lake had aquatic plant surveys completed in conjunction with the priority watershed investigation and recently in conjunction with the Critical Habitat Designation process and WDNR lake grant funded surveys. Abundance of plants can not be compared between the various surveys due to changes in methodologies, however if aquatic vegetation has been increasing on Upper St. Croix Lake it is possible that could favor survival of largemouth bass.

Northern pike were relatively low in abundance during fyke netting surveys but were popular among anglers, especially during the ice fishing season. Angler catch and harvest has remained stable over time and size structure has remained poor. Poor size structure and growth rates for northern pike are common in many northern Wisconsin lakes where factors such as warm seasonal temperatures and appropriate forage limit northern pike from reaching preferred sizes (Margenau et al. 1998). In their study of 19 northern Wisconsin lakes average PSD was 30. PSD for Upper St. Croix Lake fell below 20 on all four sampling events. Considering northern pike had the second highest angler harvest among gamefish in 2009-2010 suggest they warrant management attention. Of particular importance is the angler opportunities provided during the ice fishing season. Margenau et al. (2003) suggested the two seasonal fisheries for northern pike (open water

vs. ice) differ in catch and harvest behavior. The open water fishery is often characterized by a higher release rate whereas ice anglers are more apt to harvest their catch. These multiple components need to be considered in formulating a successful management strategy.

Panfish are an important part of the fishery on Upper St. Croix Lake. Abundance and angler catch and harvest of both bluegill and black crappie have increased to historic highs. Average length of bluegill surveyed and harvested in 2009 show that size structure is fair to good. Higher abundance of bluegill can lead to a lower size structure of the population (Cross and McInerny 2005); size structure has decreased as abundance has increased on Upper St. Croix Lake. Modeling of angler harvest of bluegill has shown that increased angler harvest can reduce mean size of harvested bluegill by four times (Beard and Essington 2000). Average size of harvested bluegill has not dropped dramatically. Abundance of bluegill ≥ 8 inches both in survey and angler harvest continues to be low and is likely the result of size selective angler harvest. Abundance and angler catch and harvest of black crappie have followed similar trends as bluegill. Size structure of black crappie has been and continues to be fair, while abundance was high. Like bluegill abundance of black crappie ≥ 9 inches both in survey and angler harvest continues to be low and is likely the result of size selective angler harvest.

In 2009, the only occurrence of muskellunge was from an angler reporting catching one during the creel survey. Muskellunge have been found historically in Upper St. Croix Lake and could be from stocking occurring in the Eau Claire Chain of lakes or in the St. Croix Flowage. Muskellunge can be nomadic and can be expected to continue to occur in Upper St. Croix Lake as a result of populations connected by both the St. Croix and Eau Claire Rivers.

Lake sturgeon are a native species in Upper St. Croix Lake. The last known record from a lake sturgeon was from August 16th, 1993. Dennis Scholl (DNR – Fisheries Biologist) received a report of a large sturgeon washed up on the shore. The fish measured 84 inches in length and was 54 years old according to a pectoral fin ray taken from the dead fish. Lake sturgeon have been

stocked into Upper St. Croix Lake since 2002 when they have been available. Continued stocking of lake sturgeon could help reestablish a native fish to the lake.

Summary and Management Recommendations

1. Upper St. Croix Lake walleye population estimates remain near historic levels; although angler catch and harvest indicate a declining walleye population. In 2009, walleye exploitation was above 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. Upper St. Croix Lake appears, in the short-term, to be able to maintain adult walleye abundance in the face of high exploitation rates, possibly in part due to apparent additive effects of walleye stocking to year class abundance and highly productive trophic state. Nevertheless, high exploitation is a concern for the long-term health of this fishery. Continued monitoring of walleye abundance, size structure, growth and exploitation are needed to discern whether more conservative regulations are needed in the future. Continue stocking of small fingerling walleye in alternate years at 35 fish/acre, and large fingerling walleye if they are available.
2. Smallmouth bass abundance has remained stable and relatively low, while largemouth bass abundance has increased. Both electrofishing and creel surveys indicated an increase in largemouth bass abundance between two and six fold in a 12 year time span. Although largemouth bass abundance has increased, when compared to area lakes could be considered moderate. If abundance of largemouth bass reaches 20 fish/mile in spring electrofishing surveys, consideration should be given to liberalizing angling regulations.
3. Continue to monitor northern pike and panfish population through spring fyke netting surveys. Northern pike were popular among anglers and abundance and angler catch and

harvest have remained stable over time. Bluegill and black crappie abundance was high as was angler catch and harvest.

4. Continue to stock lake sturgeon into Upper St. Croix Lake with the objective of reestablishing this native species.
5. Continue to monitor fishery through baseline lakes monitoring program and comprehensive treaty monitoring protocol. Upper St. Croix Lake has been put on a 6 year rotation for baseline fishery surveys which includes netting and electrofishing, but not a creel survey. The treaty rotation was commonly 10 to 12 years, however the current treaty rotation expires in 2013 and the new rotation is not yet known, so it is unknown when the next comprehensive fishery survey (including creel survey) will be completed. Since walleye exploitation is a concern, creel surveys in the future will provide valuable data. In lieu of creel surveys, walleye population estimates completed at 6 year intervals should track abundance changes through time.
6. Protection of inshore habitat is important for long-term health of fisheries. Work with local residents, the Upper St. Croix Lake Association, the Friends of the Upper St. Croix Watershed Association and the WDNR lake grants program to continue in the development of 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) where the public is willing implement recommendations from the critical habitat designation process, 3) continue restoring woody habitat along conducive shorelines working with willing riparian landowners, 4) continue Clean Boats Clean Waters Program to prevent spread of aquatic invasive species and help educate the public, 5) provide educational and participation forum for environmentally sensitive shoreline living, 6) identify uses and user groups to facilitate all recreational uses on the lake, 7) 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. Indications of declining water quality, habitat loss, declining shoreline aesthetics, and exotic introductions are warning signs of cultural disturbances that are degrading ecosystem health. Preserving and restoring 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.

Acknowledgements

I would like to thank Jim Heim who is a volunteer for the Self-Help Lake Monitoring Program from 1992 to 2007, and gathered the water quality data presented in this report and Bud Hinaus and Doug Nagel who volunteered during the fyke netting period. I would also like to thank the biologists and technicians of the Wisconsin Department of Natural Resources who assisted with field collection of data, especially Cris Sand, Marty Kangas and Paul Riordan. The WDNR treaty assessment unit, especially Jamison Wendel, Scott Plaster, Todd Brecka and Jill Sunderland for data collection and entry and creel survey data collection, data entry and completion of the creel survey report. With special thanks to Terry Margenau who provided a critical review of the manuscript.

Reviewed and approved – Steve AveLallemant- NOR Fish Supervisor -12/30/13

References

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

Beard, T. D. Jr. and T. E. Essington. 2000. Effects of angling and life history processes on bluegill size structure: insights from an individual-based model. Transactions of the American Fisheries Society Volume 129: Pages 561-568.

Beard, T. D., P. W. Rasmussen, S. Cox, and S. R. Carpenter. 2003. Evaluation of a management system for a mixed walleye spearing and angling fishery in northern Wisconsin. North American Journal of Fisheries Management 23:481-491.

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

Butters, J. 1960. Upper St. Croix Lake - lake survey fish collection summary. Brule office file.

Carlson, R. 1977. A trophic state index for lakes. Limnology and Oceanography. 22(2):361-69.

Chu, C., N. F. Mandrak and C. K. Minns. 2005. Potential impacts of climate change on the distributions of several common and rare freshwater fishes in Canada. Diversity and Distributions, 11, 299-310.

Cross, T. K. and M. C. McInerny. 2005. Spatial habitat dynamics affecting bluegill abundance in Minnesota bass–panfish lakes. North American Journal of Fisheries Management Volume 25: Pages 1051-1066.

Fayram, A. H., M. J. Hansen and T. J. Ehlinger. 2005. Interactions between walleyes and four fish species with implications for walleye stocking. North American Journal of Fisheries Management, 25: 4, 1321 - 1330.

Hansen, M. J., M. D. Staggs, and M. H. Hoff. 1991. Derivation of safety factors for setting harvest quotas on adult walleyes from past estimates of abundance. Transactions of the American Fisheries Society Volume 120: Pages 620-628, 1991.

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

Isermann, D. A. 2007. Evaluating walleye length limits in the face of population variability: case

histories from western Minnesota. North American Journal of Fisheries Management Volume 27: Pages 551-568.

Jackson, D. A. and N. E. Mandrak. 2002. Changing fish biodiversity: fredicting the loss of cyprinid biodiversity due to global climate change. pp. 89-98 in: N.A. McGinn (ed.), Fisheries in a Changing Climate. American Fisheries Society, Symposium 32, Bethesda, Maryland.

Kampa, J. 1985. Lake survey summary – Upper St. Croix Lake, Douglas County. Brule office file.

Krueger, J. 2010. Open water spearing in northern Wisconsin by Chippewa Indians during 2009. Great Lake Indian Fish and Wildlife Commission Administrative Report 2009-01. Odanah, Wisconsin.

Li, J., Y. Cohen, D. H. Schupp and I. R. Adelman. 1996a. Effects of walleye stocking on population abundance and fish size, North American Journal of Fisheries Management, 16: 4, 830 - 839.

Li, J., Y. Cohen, D. H. Schupp and I. R. Adelman. 1996b. Effects of walleye stocking on year class strength, North American Journal of Fisheries Management, 16: 4, 840 - 850.

Lillie, R. A., S. Graham, and P. Rassmussen. 1993. Trophic state index equations and regional predictive equations for Wisconsin Lakes. Bureau of Research – Wisconsin Department of Natural Resources, Research Management Findings, Number 35.

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

Margenau, T. L., P. W. Rasmussen, and J. M. Kampa. 1998. Factors affecting growth of northern pike in small northern Wisconsin lakes. North American Journal of Fisheries Management 18:625-639.

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

Miller, R. J. 1975. Comparitive behavior of centrarchid basses. Pages 85-94 in R. H. Stroud and H. Clepper, editors. Black bass biology and management. Sport Fishing Institute, Washington D. C.

Nate, N.A., M.A. Bozek, M.J. Hansen, C.W. Ramm, M.T. Bremigan, and S.W. Hewett. 2003. Predicting the occurrence and success of walleye populations from physical and biological features of northern Wisconsin lakes. North American Journal of Fisheries Management 23:1207-1214.

Olson, M. H., B. P. Young and K. D. Blinkoff. 2003. Mechanisms underlying habitat use of juvenile largemouth bass and smallmouth bass. Transactions of the American Fisheries Society 132: 398 – 405.

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

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin of the Fisheries Research Board of Canada 191. Department of the Environment, Fisheries, and Marine Science, Ottawa. 382 p.

Rieckhoff, J. L. 1975. Lake survey – Upper St. Croix Lake, Douglas County. Brule office file.

Schueller, A. M., M. J. Hansen, and S. P. Newman. 2008. Modeling the sustainability of walleye populations in Northern Wisconsin Lakes. North American Journal of Fisheries Management Volume 28: Pages 1916-1927.

Sharman, S., D. A. Jackson, C. K. Minns, and B. J. Shuter. 2007. Will northern fish populations be in hot water because of climate change? Global Change Biology Volume 13 Issue 10, Pages 2052 – 2064.

Shuter, B.J., C.K. Minns and N. Lester. 2002. Climate change, freshwater fish and fisheries: Case studies from Ontario and their use in assessing potential impacts. pp. 77-88 in: N.A. McGinn (ed.), Fisheries in a Changing Climate. American Fisheries Society, Symposium 32, Bethesda, Maryland.

Stone, C. and J. Lott. 2002. Use of a minimum length limit to manage walleyes in Lake Francis Case, South Dakota. North American Journal of Fisheries Management Volume 22: Pages 975-984.

Turyk, N., P. McGinley, J. Macholl and R. Bell. 2009. Water quality and algae in Upper St. Croix Lake – summary report. University of Stevens Point Center for Watershed Science and Education. Unpublished report.

Weiher, W. 1968. Survey – St. Croix Lake, Douglas County. Brule office file.

Table 1. Stocking history of Upper St. Croix Lake, Douglas County, WI.

Date	Species	Number Stocked	Size
1933	Walleye	73,920	NA
1934	Walleye	176,580	NA
1935	Bass (sp?)	1,520	NA
1936	Bass (sp?)	1,000	NA
	Bluegill	400	NA
	Bullhead (sp?)	2,000	NA
	Sunfish (sp?)	400	NA
	Walleye	1,587,600	Fry
1937	Walleye	1,100,700	Fry
	Walleye	200	Fingerlings
	Yellow Perch	75,000	Fingerlings
1938	Largemouth Bass	4,697	Fingerlings
	Yellow Perch	48,244	Fingerlings
	Sunfish (sp?)	59,830	Fingerlings
	Walleye	1,247,712	Fry
1939	Walleye	600,000	Fry
1940	Bluegill	140	Adult
	Bluegill	218	Fingerlings
	Largemouth Bass	74	Fingerlings
	Sunfish (sp?)	32	Adult
	Walleye	2,150,000	Fry
1941	Walleye	1,300,000	Fry
1942	Walleye	2,000,000	Fry
	Walleye	5,530	Fingerlings
1943	Walleye	2,000,000	Fry
	Walleye	17,610	Fingerlings
1944	Walleye	1,600,000	Fry
	Walleye	6,000	Fingerlings
1945	Walleye	15,000	Fingerlings
	Walleye	1,000,000	Fry
1946	Walleye	1,470,000	Fry
	Walleye	6,290	Fingerlings
1947	Walleye	10,000	Fingerlings
1948	Walleye	6,906	Fingerlings
1949	Walleye	4,200	Fingerlings
	Smallmouth Bass	300	Fingerlings
1950	Walleye	21,061	Fingerlings
1951	Walleye	10,650	Fingerlings
1952	Walleye	11,575	Fingerlings
1953	Walleye	7,660	Fingerlings
1954	Walleye	11,520	Fingerlings
1955	Walleye	3,900	NA
1956	Walleye	7,800	Fingerlings

Table 1 (continued). Stocking history of Upper St. Croix Lake, Douglas County, WI.

Date	Species	Number Stocked	Size
1957	Walleye	7,800	Fingerlings
1958	Walleye	2,600	Fingerlings
1978	Walleye	1,000,000	Fry
1979	Walleye	1,500,000	Fry
1980	Walleye	1,000,000	Fry
1981	Walleye	3,250,000	Fry
1982	Walleye	1,000,000	Fry
1985	Walleye	42,780	Fingerlings
1988	Walleye	43,716	Fingerlings
1991	Walleye	10,215	Fingerlings
1992	Walleye	42,750	Fingerlings
1994	Walleye	43,002	Fingerlings
1996	Walleye	15,667	Fingerlings
1999	Walleye	42,750	Fingerlings
2001	Walleye	42,750	Fingerlings
2002	Lake Sturgeon	174	Large Fingerlings
2003	Lake Sturgeon	593	Large Fingerlings
	Walleye	42,750	Fingerlings
2005	Lake Sturgeon	961	Large Fingerlings
	Walleye	43,947	Fingerlings
2006	Lake Sturgeon	1,069	Large Fingerlings
2007	Walleye	1,080	Large Fingerlings
2009	Walleye	30,083	Fingerlings
2010	Lake Sturgeon	1,469	Large Fingerlings

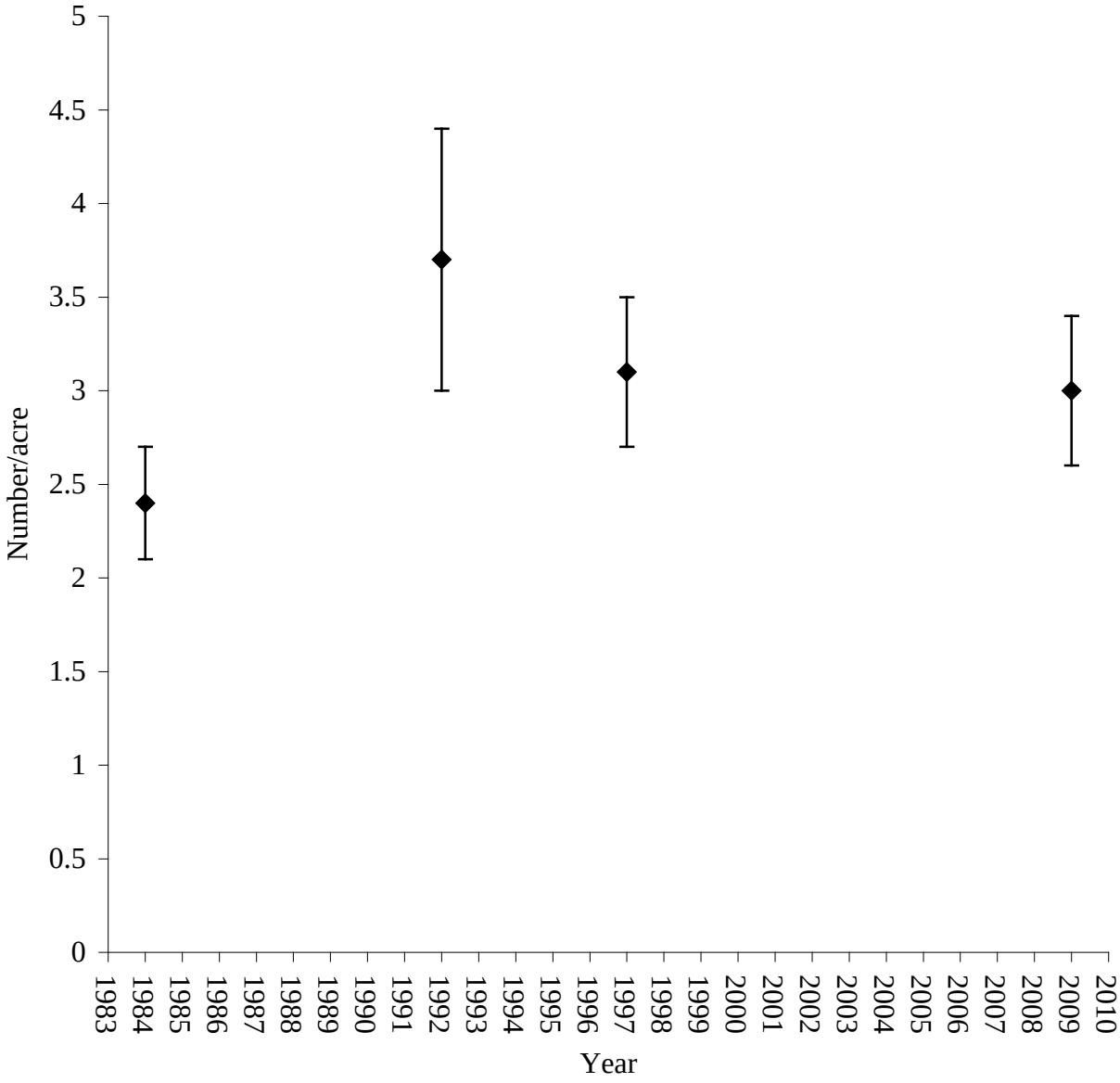

Figure 1. Estimated density and 95% confidence interval of adult walleye by year, Upper St. Croix Lake, Douglas County, Wisconsin. Schnabel procedures utilizing fyke nets was used to estimate density in 1984. The Chapman modification of the Petersen estimator was used to estimate density after 1984, utilizing fyke netting and electrofishing for the marking and recapture samples, respectively.

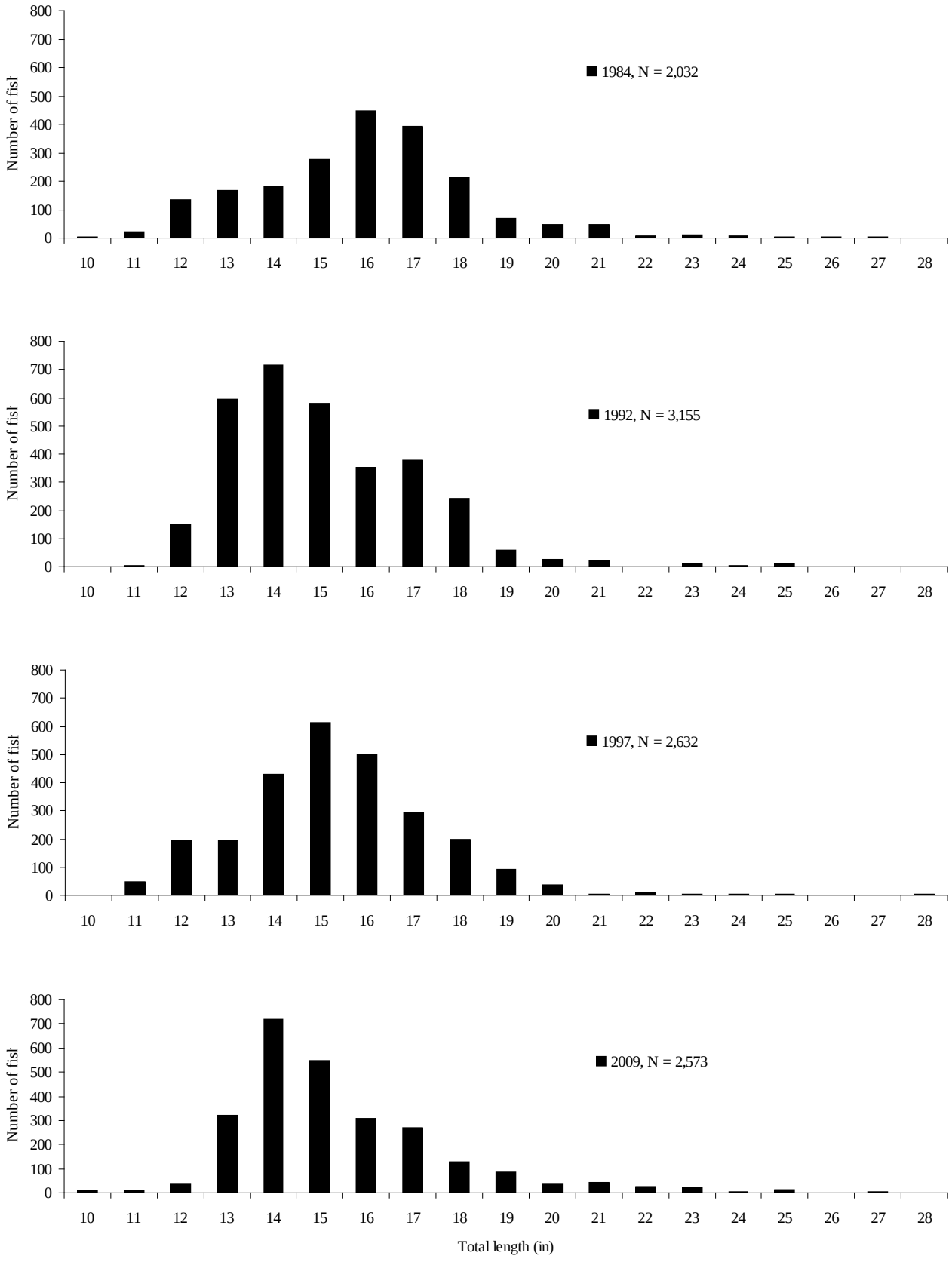

Figure 2. Percent length frequency of walleye expanded to population estimate, Upper St. Croix Lake, Douglas County, Wisconsin.

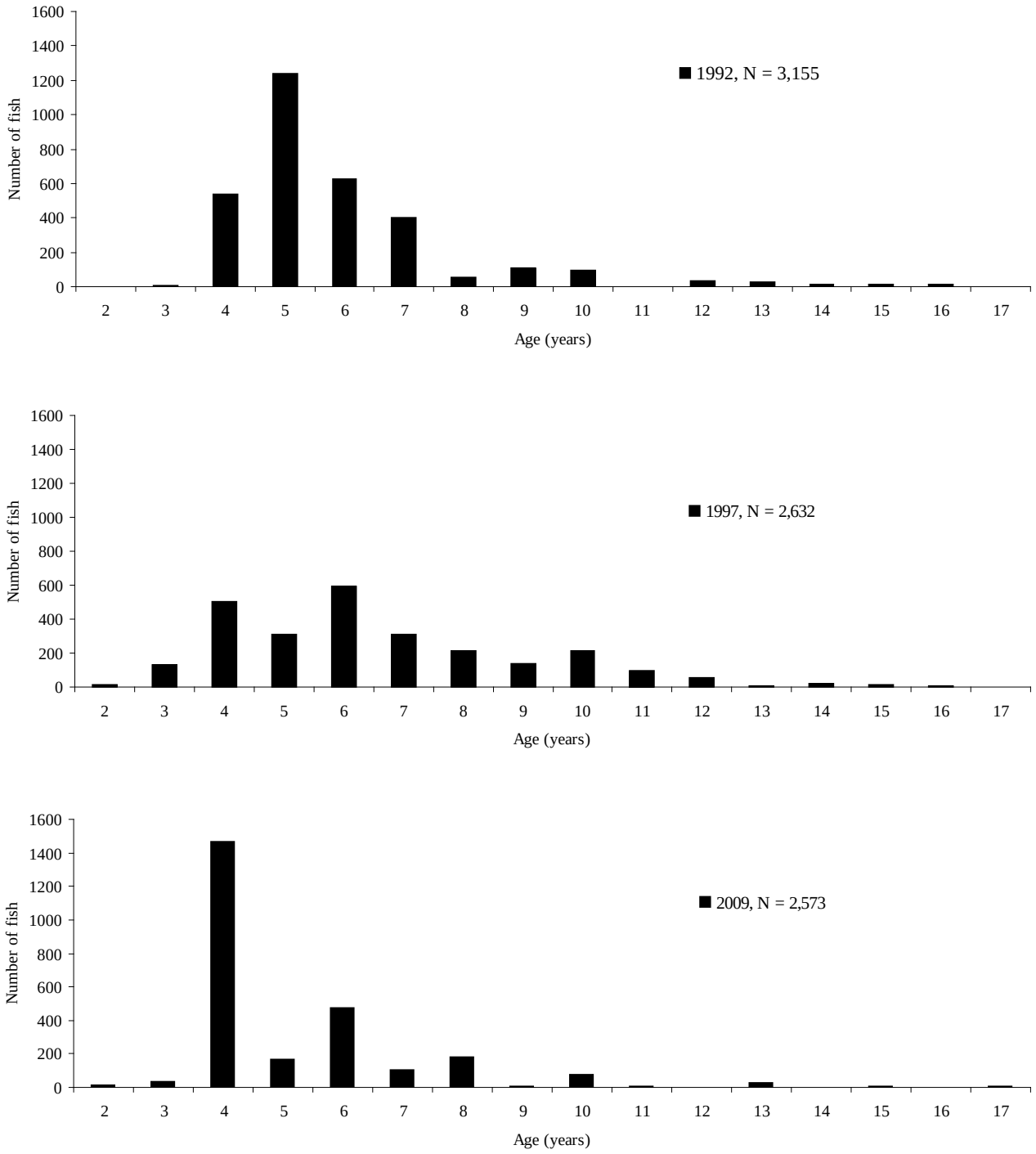

Figure 3. Estimated abundance of adult walleye by age, Upper St. Croix Lake, Douglas County, Wisconsin.

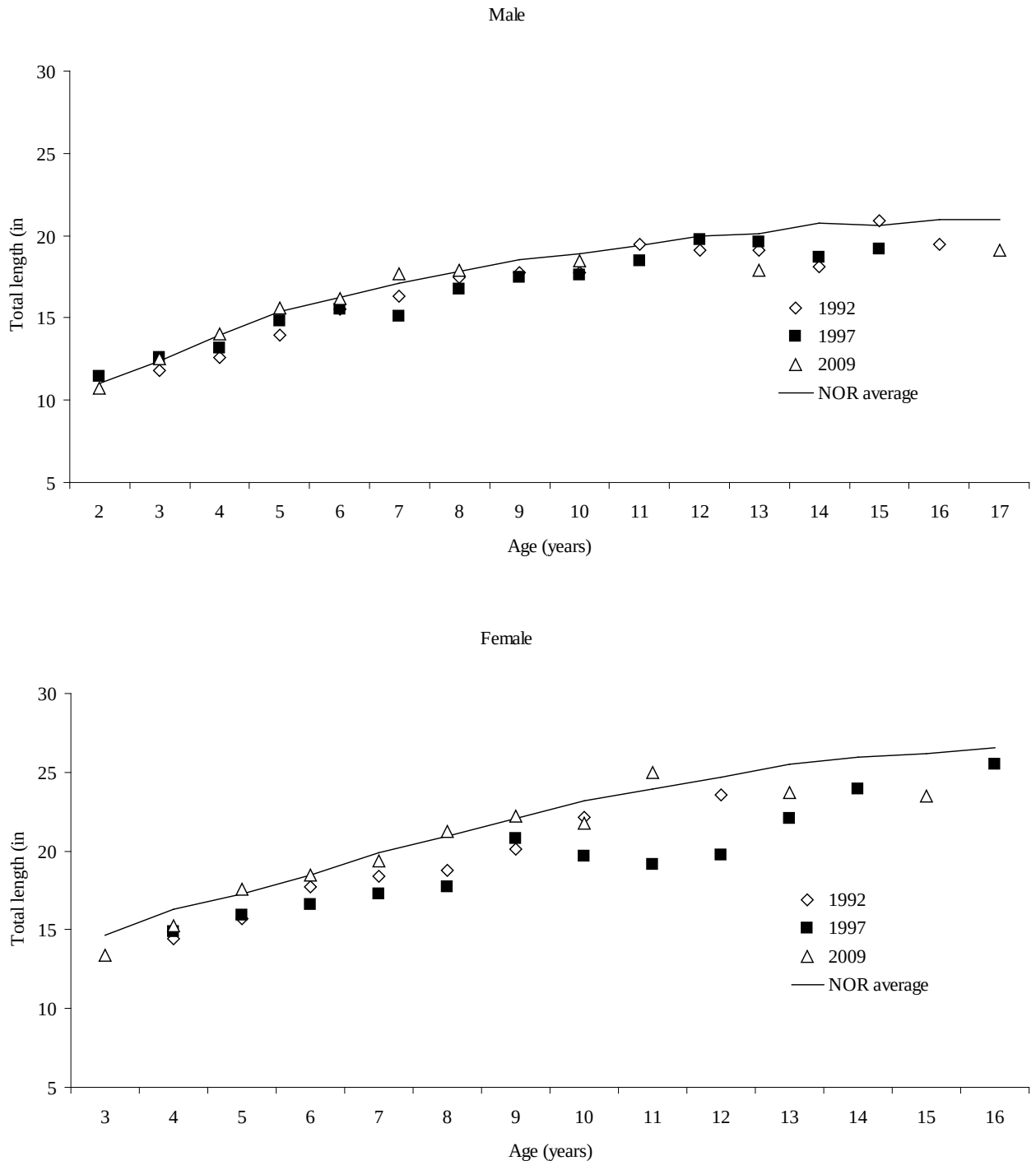

Figure 4. Length at age of Upper St. Croix Lake walleye, Douglas County, Wisconsin.

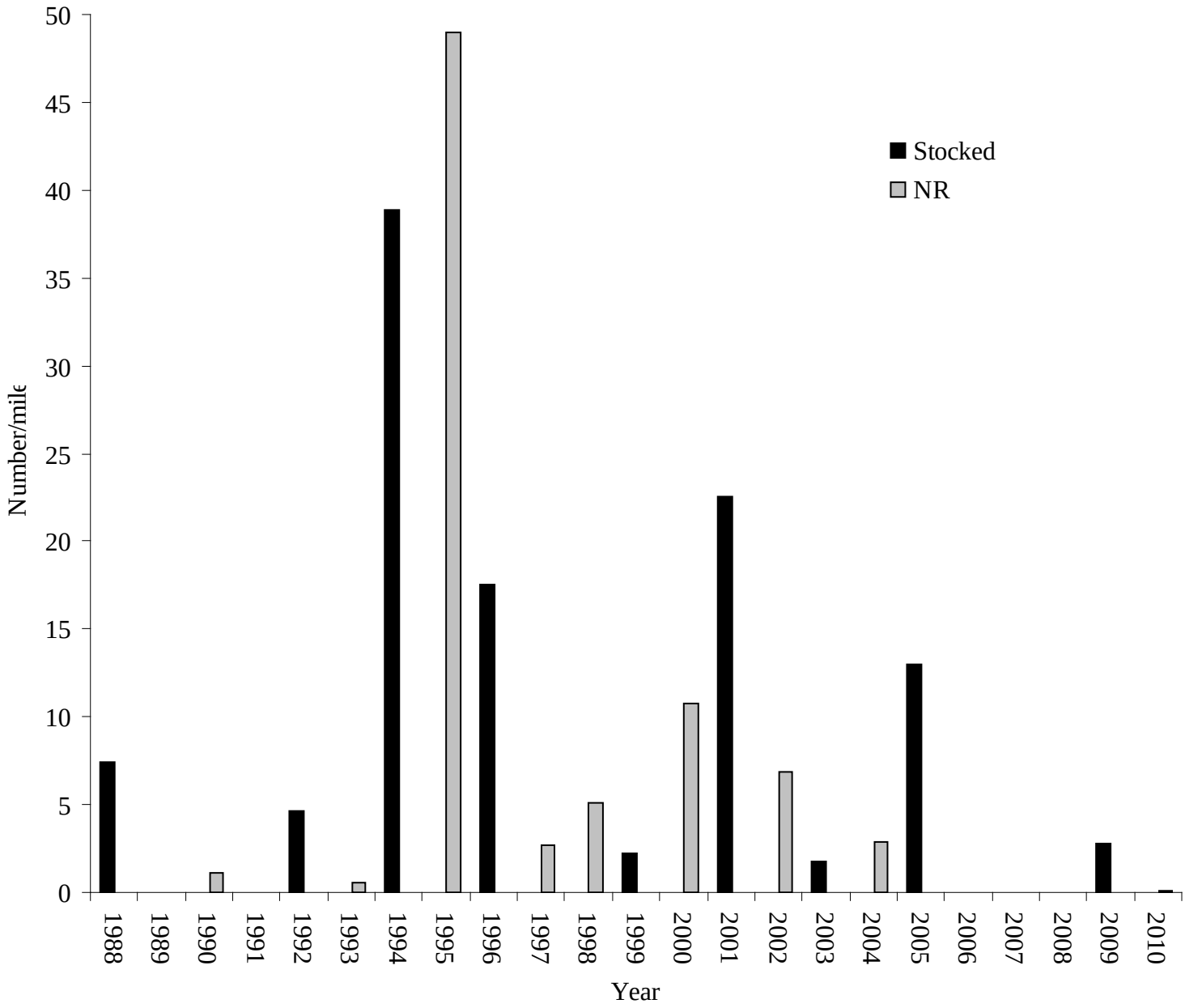

Figure 5. Young of the year walleye abundance determined by fall electrofishing, Upper St. Croix Lake, Douglas County, Wisconsin. Surveys were not completed in 1989 and 1991. Black bars represent years in which stocking occurred and grey bars represent years when no stocking occurred.

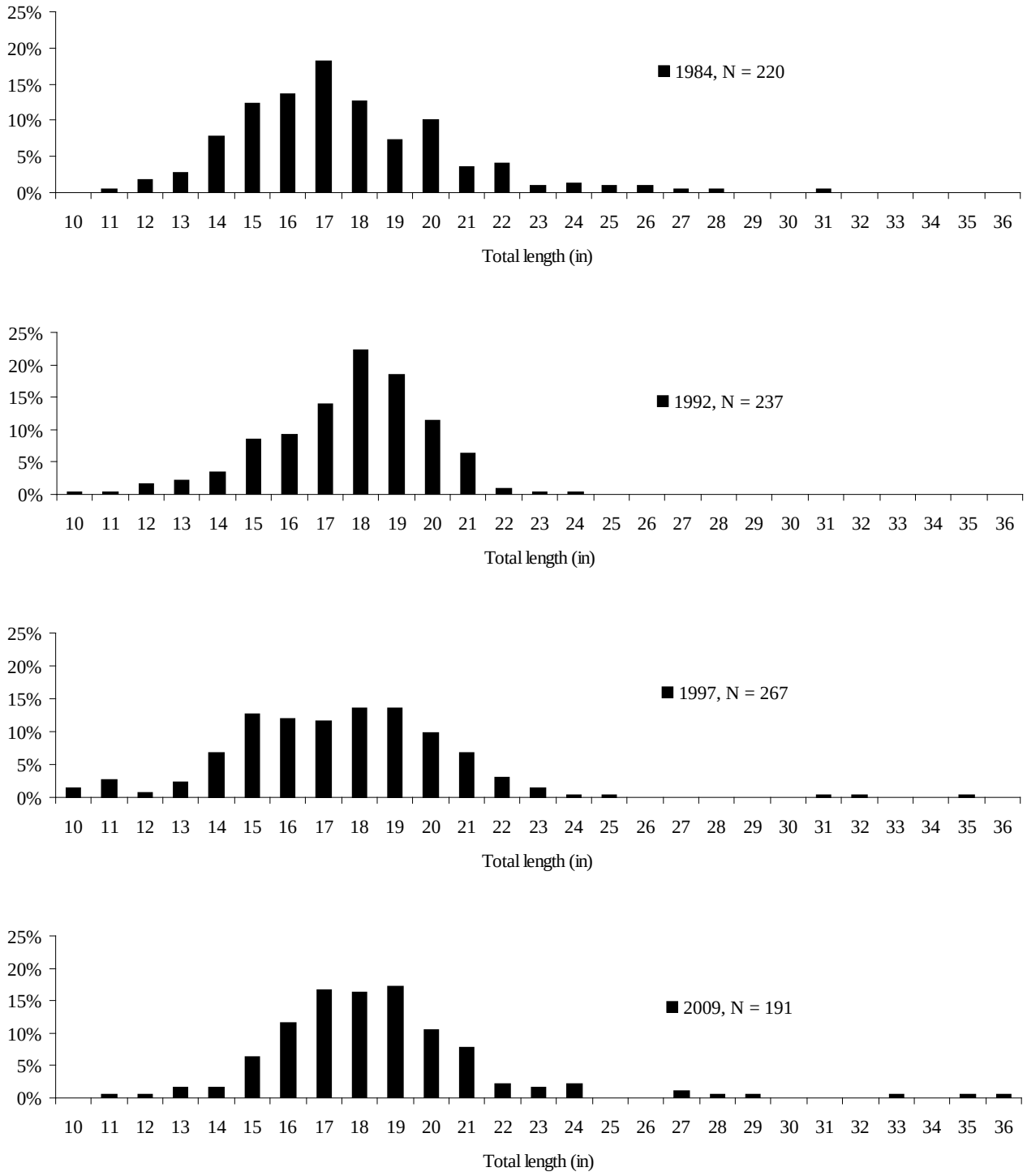

Figure 6. Percent distribution of northern pike in Upper St. Croix Lake, Douglas County, Wisconsin.

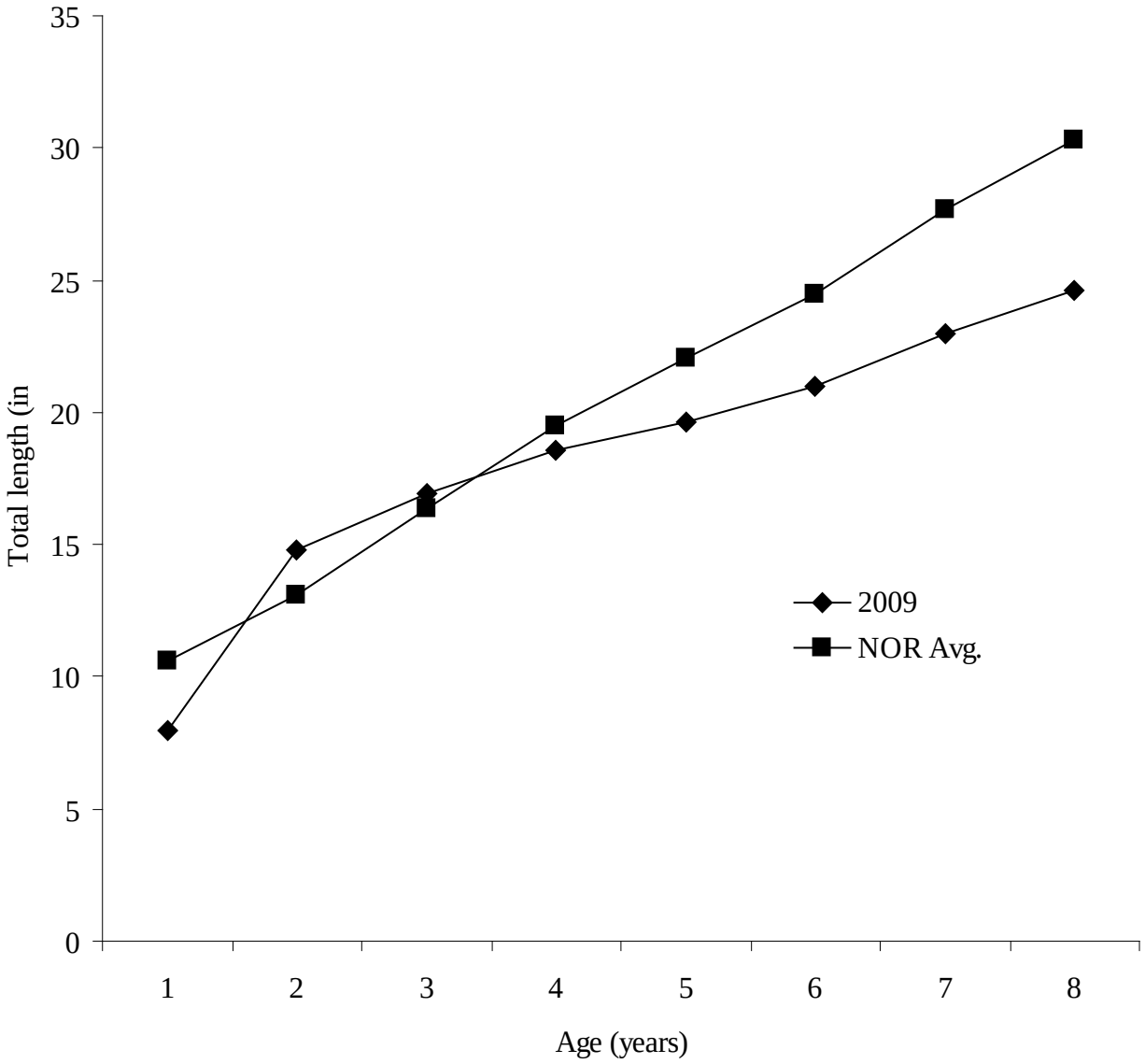

Figure 7. Mean length at age for northern pike, Upper St. Croix Lake, Douglas County, Wisconsin.

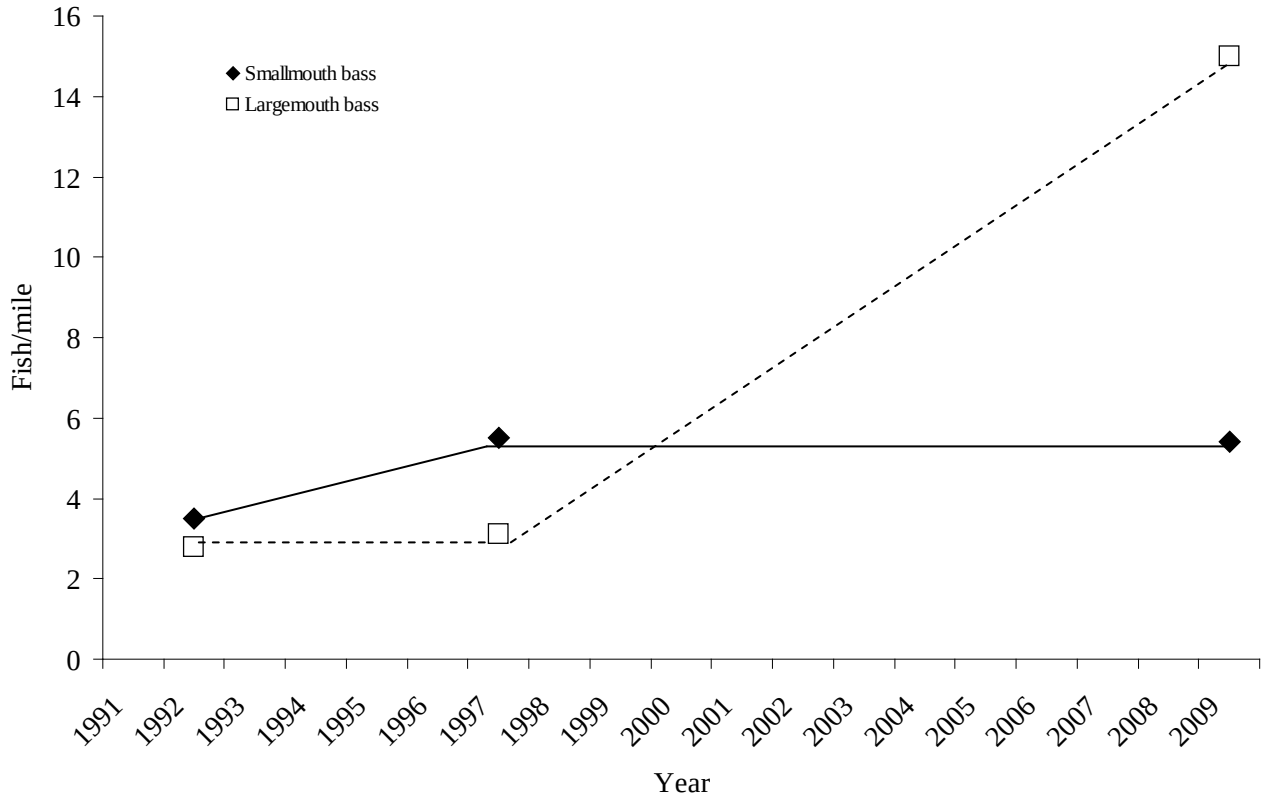

Figure 8. Relative of abundance of smallmouth and largemouth bass during spring electrofishing surveys on Upper St. Croix Lake, Douglas County, Wisconsin.

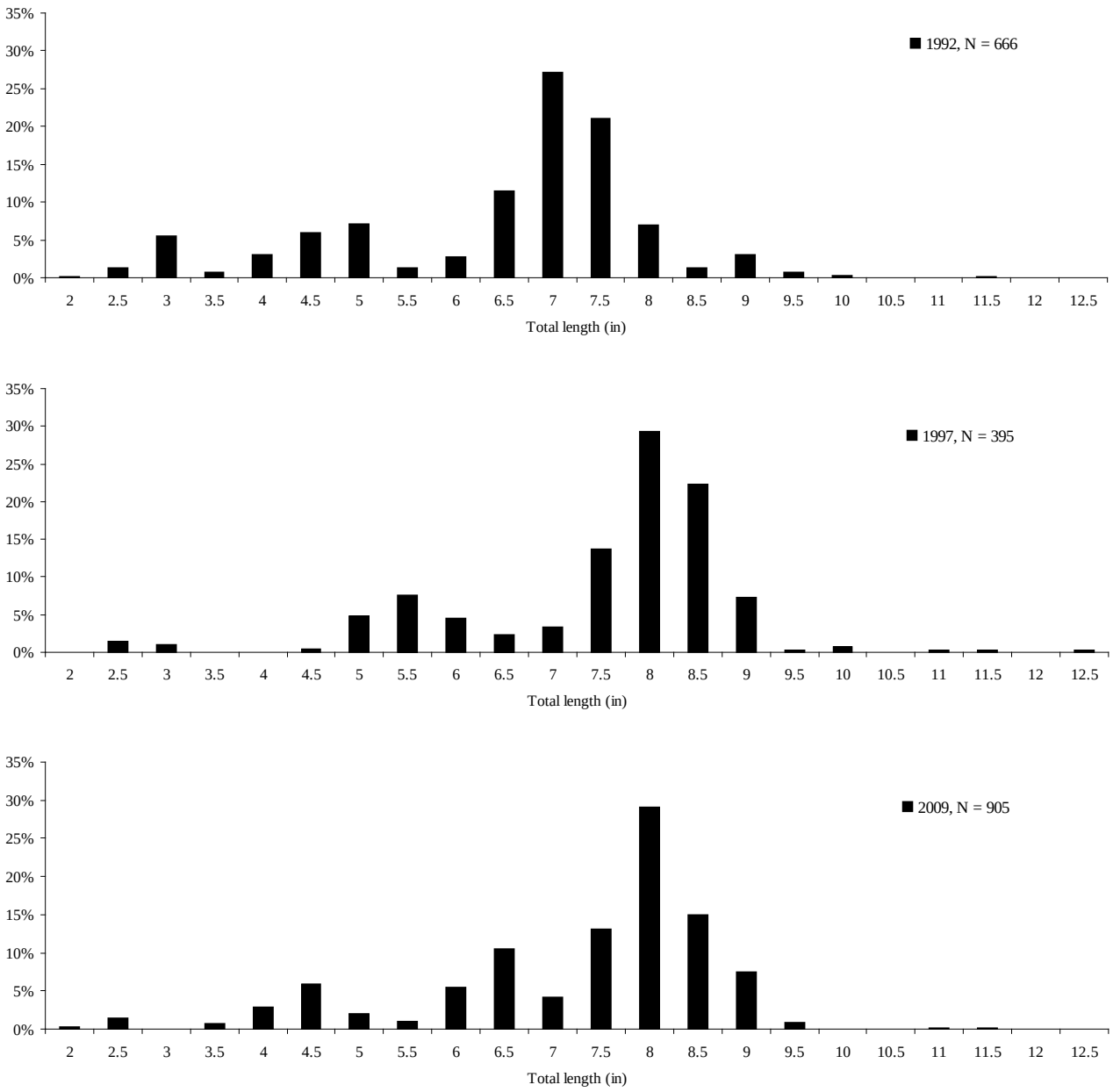

Figure 9. Percent distribution of black crappie in Upper St. Croix Lake, Douglas County, Wisconsin.

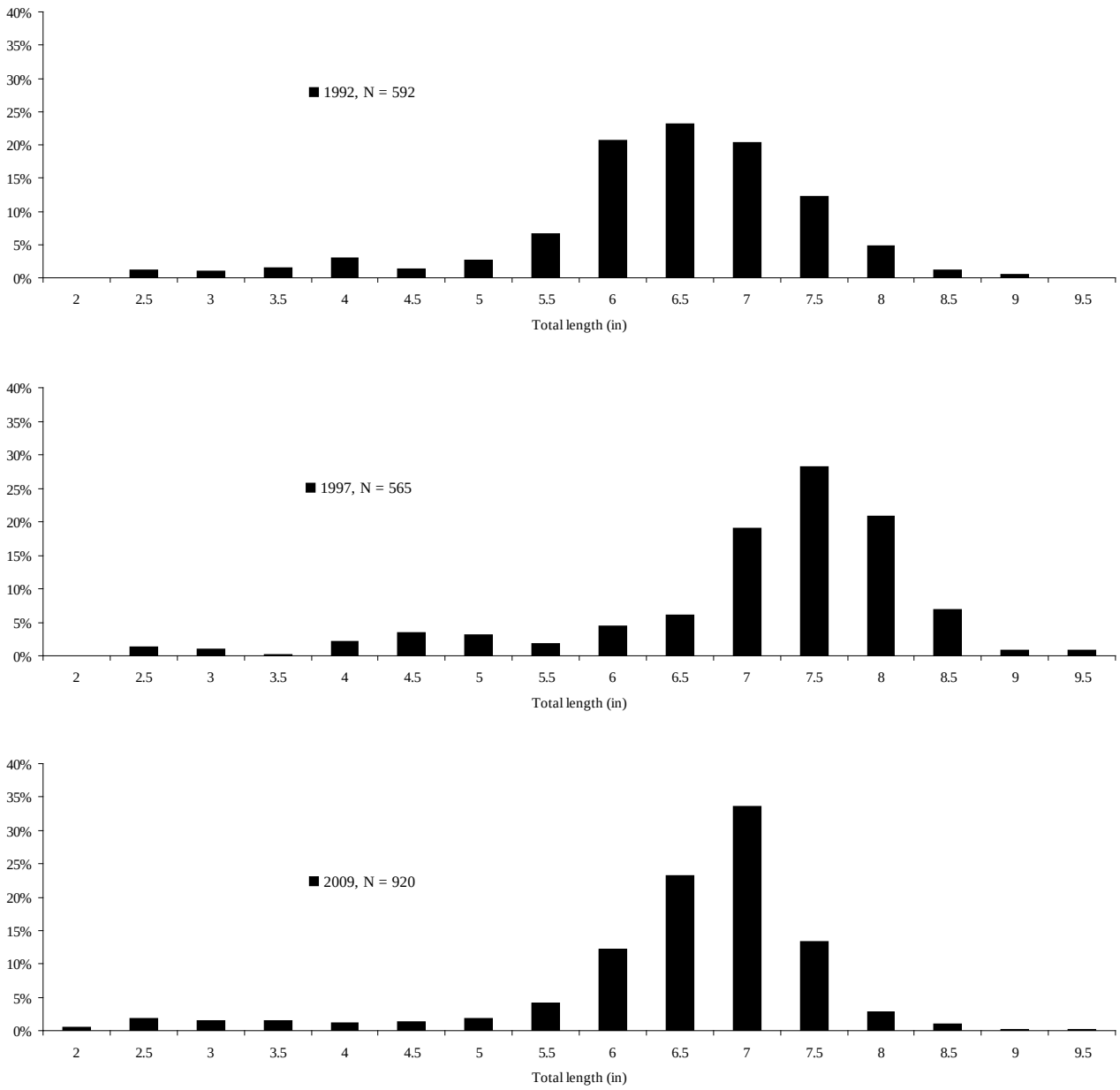

Figure 10. Percent distribution of bluegill in Upper St. Croix Lake, Douglas County, Wisconsin.

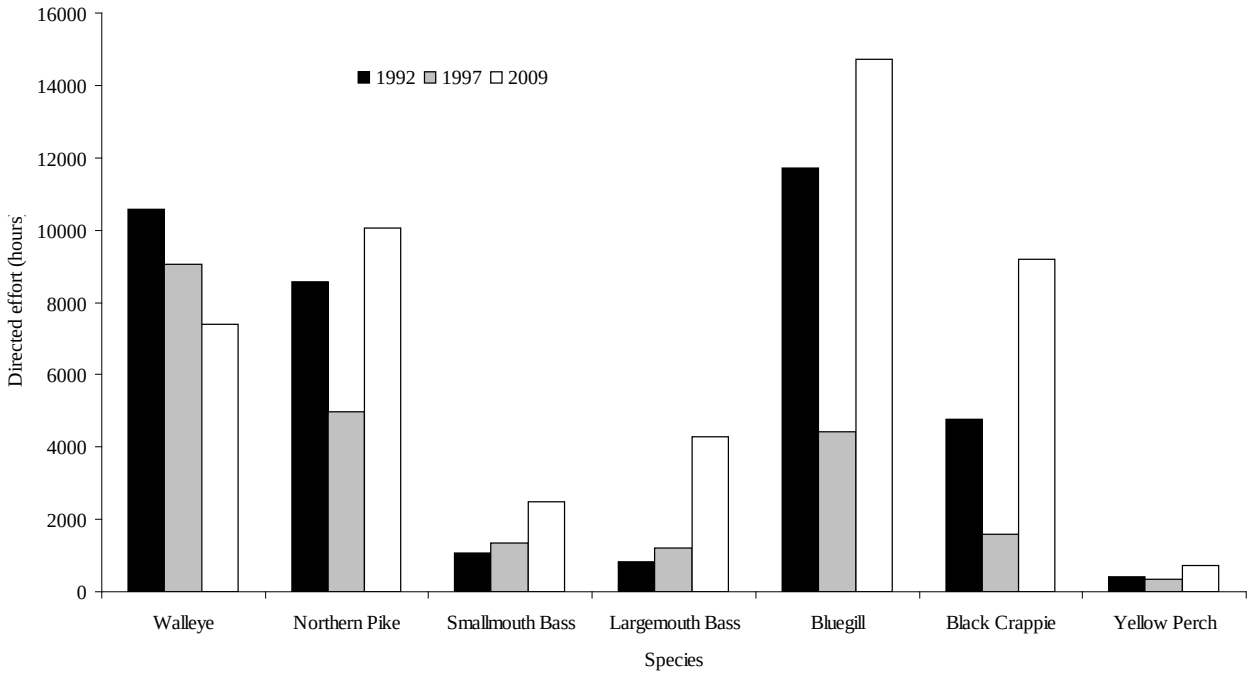

Figure 11. Directed sportfish effort, Upper St. Croix Lake, Douglas County, Wisconsin.

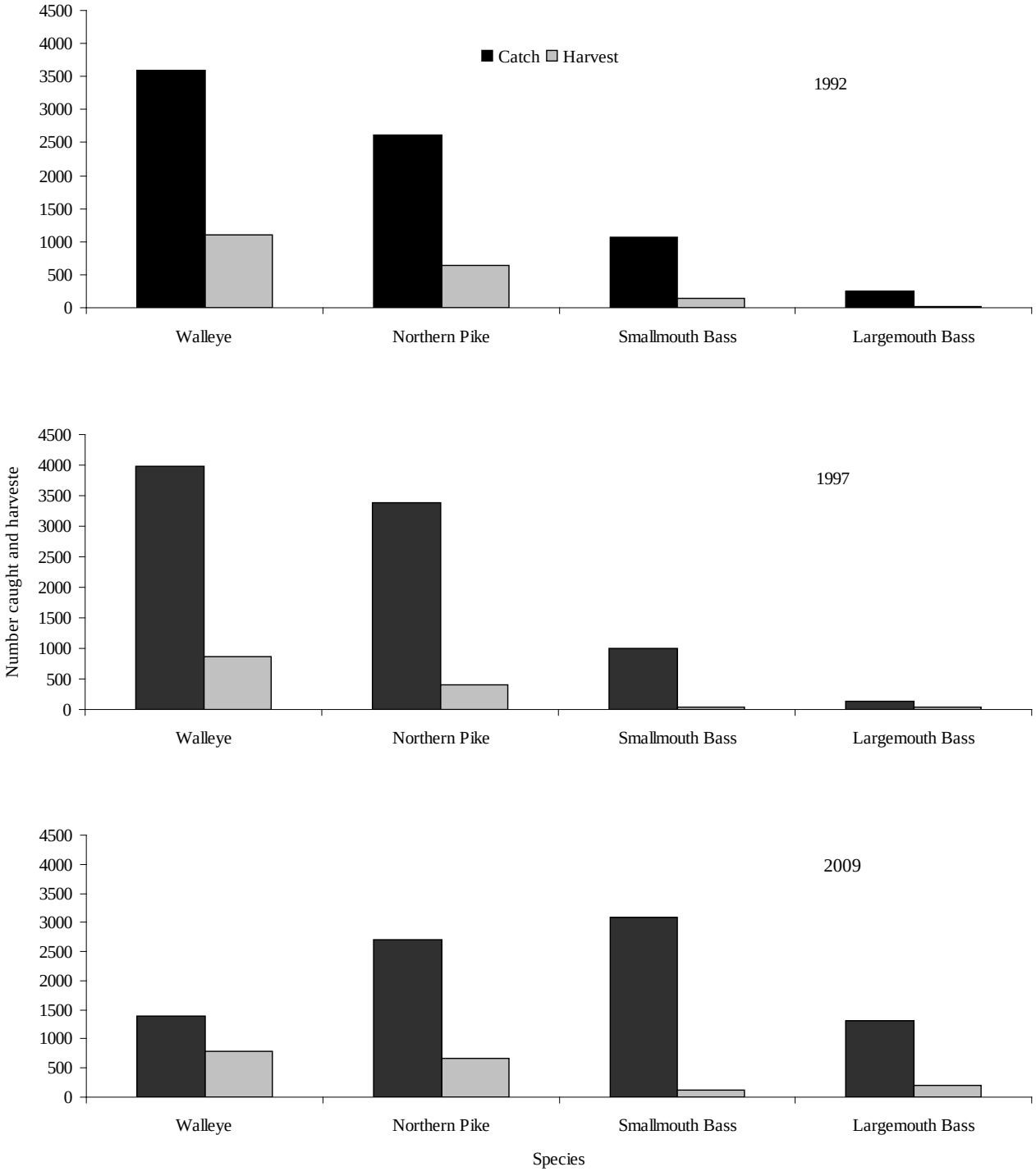

Figure 12. Gamefish catch and harvest, Upper St. Croix Lake, Wisconsin.

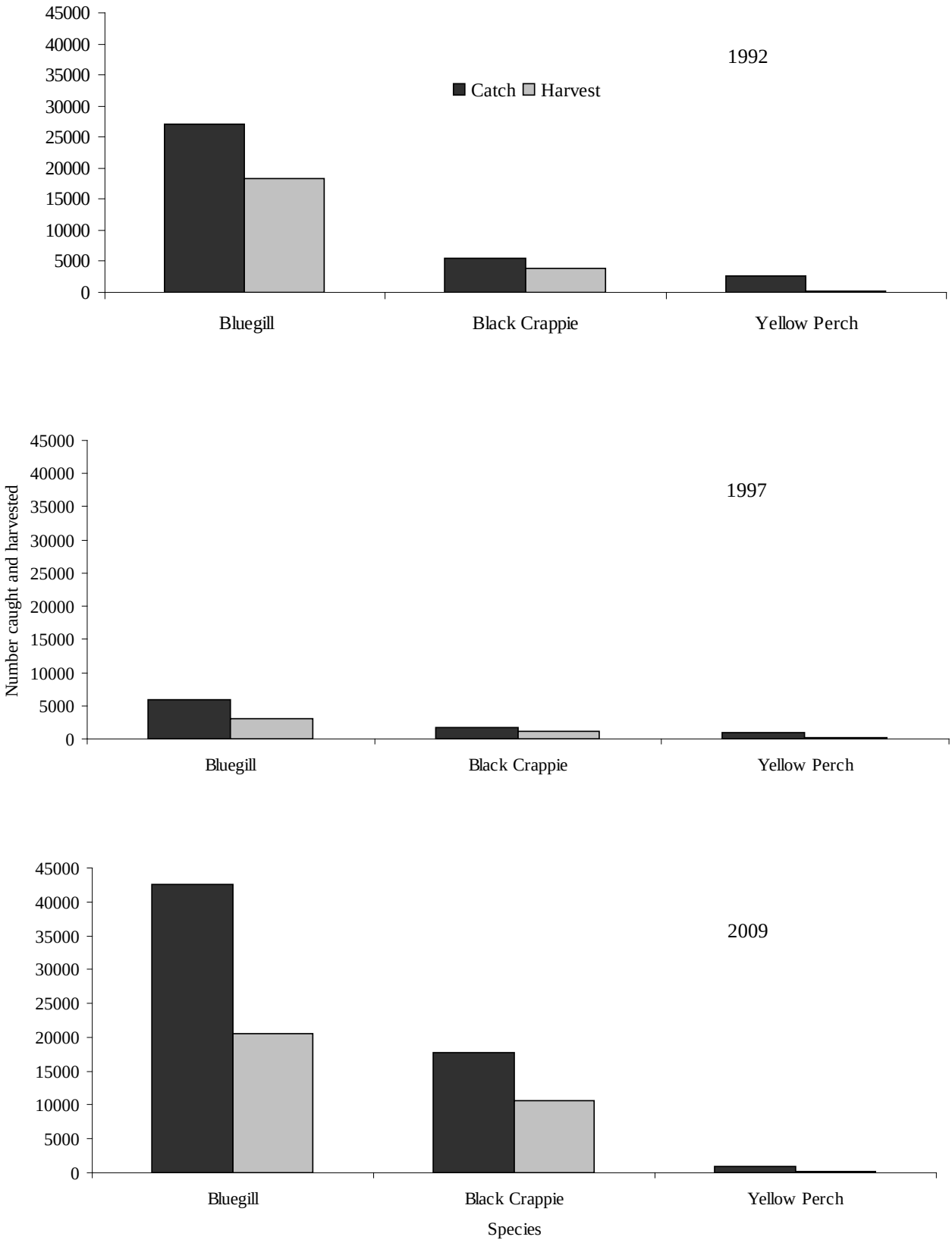

Figure 13. Panfish catch and harvest, Upper St. Croix Lake, Douglas County, Wisconsin.

Appendix Table 1. Proportional and relative stock density values.

Species	Stock Size (in)	Quality Size (in)	Preferred Size (in)
Black Crappie	5	8	10
Bluegill	3	6	8
Largemouth Bass	8	12	15
Northern Pike	14	21	28
Smallmouth Bass	7	11	14
Walleye	10	15	20