WISCONSIN DEPARTMENT OF NATURAL RESOURCES
Muskellunge Survey Report for Bone Lake, Polk County, Wisconsin 2024-2025
WATERBODY IDENTIFICATION CODE: 2628100

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Executive Summary

A low-moderate density muskellunge population with good size structure was present in Bone Lake that supports a popular fishery among anglers. The adult population (sexes combined ≥ 30 inches) during 2024 was estimated to be 401 fish (95% CI: 257 - 545), or 0.23 adult fish/acre; CV = 0.18). The population has declined during every survey since 1995 but now resembles the mean density (0.22 fish/acre) for A1 muskellunge lakes across Wisconsin, which should continue to provide good angling action while producing larger-bodied fish. Despite declining adult densities, the population remains healthy with good size structure, body condition and average growth rates. High survival of stocked muskellunge in Bone Lake has successfully maintained a quality fishery. However, the balance between mortality (natural, angler harvest and delayed fishing mortality and tribal harvest) and recruitment (stocking) appears skewed as the population has been in decline since at least the early 2000's. Survival of stocked fish to adult age classes was variable and thus, stocking efficacy and recruitment of stocked year classes to the fishery should be closely monitored in the future. The stocking rate of 1 large fingerling/acre on an alternate year basis should continue to maintain the population within the target population density range of 0.2 – 0.4 adults/acre. The 50-inch minimum length limit effectively prevents most angler harvest and will remain in place.

Introduction

Bone Lake is a 1,667-acre drainage lake located in Central Polk County, Wisconsin. The lake has a maximum depth of 43 feet and a mean depth of 23 feet. Bone Lake has 12.5 miles of shoreline, most of which is developed. The watershed is primarily forested followed by agriculture. The lake has several small inlets, and there is one outlet, Fox Creek, which drains to the Apple River. There are two public boat launches; one located along the northern shoreline off Bone Lake Park Ln (45.564, -92.396; latitude, longitude) and another along the southern shoreline off Dueholm Dr. (45.501, -92.381). Bone Lake is located within 50 miles of the St. Paul-Minneapolis metropolitan area and receives moderate-heavy recreational boating use and angling pressure but has retained quality and diverse fisheries.

Bone Lake is a fertile, mesotrophic - eutrophic system classified as a complex-warm-dark lake (Rypel et al. 2019). The July-August mean Trophic State Index (TSI) values for total phosphorus was 59.1 and the mean TSI has generally remained stable over the past decade. The water is generally clear in early summer but often becomes green as moderate algal blooms occur during summer. Submerged aquatic macrophytes are abundant in the nearshore littoral areas. Currently, recognized invasive species include Chinese mystery snail, banded mystery snail, curly-leaf pondweed, purple loosestrife, rusty crayfish and zebra mussels.

The sport fish community in Bone Lake consists of bluegill, pumpkinseed, black crappie, largemouth bass, smallmouth bass, yellow perch, northern pike, rock bass, and muskellunge.

Bone Lake supports a quality muskellunge fishery that is popular among anglers. The Wisconsin Department of Natural Resources (DNR) currently designates Bone Lake as a Class A1 muskellunge fishery or 'premier muskellunge water'. Premier muskellunge waters in Wisconsin provide the best muskellunge fishing opportunities and consistently produce trophy-sized muskellunge, due to a lower abundance of adult muskellunge compared to other waters (Simonson 2018). Despite a thriving fishery, muskellunge are not native to Bone Lake and were first stocked by the DNR in 1935. Management of muskellunge has consisted primarily of stocking (Appendix Table 1), as suitable spawning habitat is largely absent and little evidence of natural recruitment has been observed (Cornelius and Margenau 1999). The reproductive classification of the Bone Lake muskellunge fishery is Category 3, where stocking is necessary to maintain the population (Simonson 2018). Muskellunge have been extensively stocked into Bone Lake with fry, small fingerlings and large fingerlings at varying rates. Large fingerling stockings occurred relatively consistently since the 1950's. Alternate year stocking of muskellunge at a rate of 1 - 2 large fingerlings per acre began during 2001 (Benike 2007). The current stocking rate has been maintained at approximately 1.0 fish per acre during alternate years, but state hatchery production shortages resulted in fewer fish stocked into Bone Lake during 2017 (0.5 fish/acre) and 2021 (0.5 fish/acre).

Management actions aimed at improving the muskellunge fishery in Bone Lake have included several sport fishing regulation changes through time. Bone Lake was previously managed as a Class A2 muskellunge water, a high-density action muskellunge fishery with low size structure (Cole 2020). In 1983, the minimum length limit was increased from 30 – 34 inches with the goal of increasing the number of 34 inch and larger muskellunge present (Schweiger 1983). In 1990, the minimum length limit was increased from 34 – 40 inches with hopes to further improve size structure. This regulation change was successful as the proportion of muskellunge ≥ 40 inches doubled. Due to the high stocking rates during the 1980s and 1990s, more restrictive length limit regulations, and the increase in sport angler voluntary catch and release, the muskellunge density in Bone Lake became as high as 0.99 adult fish/acre in 1995 which provided good angling action (Cornelius and Margenau 1999). However, the abundance of larger fish (≥ 45 inches) remained low, but fish condition improved over the past decade with decreasing adult abundance which spurred implementation of the 50-inch minimal length one fish daily bag which has been in place since 2011 (Benike 2007). The relative abundance of muskellunge ≥ 45 inches did increase afterwards but it was primarily attributed to the reduced adult density (Cole 2020).

The Bone Lake muskellunge population supports both winter and spring spear fisheries for the Chippewa tribes under the Voigt decision. The spring spear fishery is more structured and regulated (see Cole 2020 for background details). In contrast, the winter spear fishery is less regulated because winter spearing of muskellunge is classified as an "inefficient gear." As a result, no safe allowable harvest quota has been established for the winter fishery. Harvest during the winter spear fishery is typically not recorded. However, the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) periodically conducts a creel survey of winter spearfishing effort and reports tribal winter spear harvest estimates (Cole 2020).

A mark-recapture survey was performed during 2024 – 2025 to estimate adult densities of muskellunge in Bone Lake. The objectives of this survey were to assess the current abundance, size structure and population demographics of adult muskellunge and make comparisons to previous surveys.

Methods

FIELD SAMPLING

The population abundance of adult muskellunge (≥ 30 inches) was estimated using mark-recapture methodology during the early spring netting surveys and Chapman's modification of the Peterson model (Ricker 1975):

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

where N = population estimate; M = the number of fish marked in the first (marking) sample; C = the total number of fish (marked and unmarked) captured in the second (recapture) sample; and R is the number of marked fish captured in the second sample.

Muskellunge surveys are two-year fyke netting surveys, so 2024 served as the marking year, and 2025 was the recapture year. Nets were set shortly after ice-out and checked every 24 hours for approximately one week each year. Muskellunge were measured to the nearest 0.1 inch and weighed to the nearest 0.1 pound. Anal fin rays were collected to determine age. The sex of captured fish was determined by the presence of eggs or milt or by visual inspection of the urogenital pore as described by LeBeau and Pageau (1989). All adult fish were marked during 2024, and fish < 30 inches received a separate mark. During the recapture year, all fish were checked for marks, and to prevent double counting fish, all 2025 fish received a mark unique from the 2024 marks. Muskellunge were implanted with a uniquely coded PIT tag if a tag was not already present. The abundance of fish in 2024 was adjusted for recruitment over the 1-year time period. For this, females < 32 inches and males < 31 inches collected in 2025 were excluded from the adult population estimate because they were assumed to have been < 30 inches during the 2024 marking event.

POPULATION DEMOGRAPHICS

Independent abundance estimates were calculated for mature muskellunge of each sex ≥ 30 inches and for immature muskellunge ≥ 30 inches, with sexes combined and including unknowns. Density estimates were compared to previous surveys and lake class standards when possible.

Muskellunge anal fin rays were cut with a Dremel saw and aged by two interpreters under a dissecting microscope with side illumination from a fiber optic light. Ages were assigned to recaptured muskellunge with PIT tags. These fish were either tagged at stocking (and considered "known age") or were tagged and aged during previous surveys. Mean length at age was compared to previous surveys, county averages (Barron and Polk counties) and lake class median estimates.

The von Bertalanffy (1938) growth model was determined using mean length at age data (sexes combined) to assess growth using the following equation:

$$Lt = L_{inf}\left(1 - e^{-k(t-t_0)}\right)$$

where L_t is length at time t, L_{inf} is the maximum theoretical length (length infinity), e is the exponent for natural logarithms, k is the growth coefficient, t is age in years and t_0 is the age when L_t is zero.

Size structure was assessed using proportional size distribution (PSD) indices and compared to previous surveys (Neumann et al. 2013). The PSD 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. Stock length was set at 30 inches per DNR protocols. Kolmogorov-Smirnov (KS) tests with Sequential Holm-Sidak post-hoc corrections were used to statistically compare size structures between 2024 and previous survey years. Relative weight (*Wr*) was used to describe fish condition.

Relative weight is the ratio of a fish's weight at capture to the weight of a "standard" fish of the same length determined by a standard weight equation (Neumann and Willis 1994). The mean *Wr* was determined.

The instantaneous mortality (Z) and annual mortality ($A = 1-e^{-z}$) rates of muskellunge were determined using a catch curve regression fitted to those ages fully recruited to the gear (Miranda and Bettoli 2007).

To assess muskellunge stocking survival, an age-length key was used to estimate the abundances of muskellunge in each age class, assuming no natural reproduction and all fish were from stocked origin. Survival was estimated by dividing the population estimate for each age class by the total number of fish stocked for that year and multiplying it by 100. Cost per recruit was not calculated due to variability in the annual costs per large fingerling.

Results

There were 14 fyke nets set for seven nights in 2024, which totaled 92 net-nights of effort, and 15 fyke nets set for seven nights in 2025, which totaled 86 net-nights of effort. The catch per effort was 0.97 muskellunge per net-night in 2024 and 1.04 muskellunge per net-night in 2025, which was slightly above the 75th percentile (0.88 fish/net-night) for similar complex-warm-dark Wisconsin lakes but declined since the 2017 survey (1.9 and 3.3 muskellunge per net-night in 2017 and 2018, respectively). There were 90 adult muskellunge (≥ 30 inches; 38 males and 52 females) marked in 2024 and 118 adult muskellunge (55 males, 62 females and one unknown sex) collected in 2025. There were 9 muskellunge < 30 inches collected during 2024 and 2025.

The adult population (sexes combined ≥ 30 inches) during 2024 was estimated to be 401 fish (95% confidence interval (CI): 257 - 545), or 0.23 adult fish/acre (coefficient of variation (CV) = 0.18; Figure 1). The population in this survey decreased since 2017, when abundance was estimated to be 627 fish (95% CI: 503 - 750) or 0.35 adult fish/acre (Figure 1). However, since confidence intervals overlap between survey years, it is unlikely population densities varied significantly but a downward trend has occurred during every survey since 1995. The adult population (≥ 30 inches) of males was estimated to be 148 fish (95% CI: 73 – 223), or 0.08 males/acre (CV = 0.26) and the female population was estimated to be 240 fish (95% CI: 111 – 129), or 0.13 females/acre (CV = 0.24).
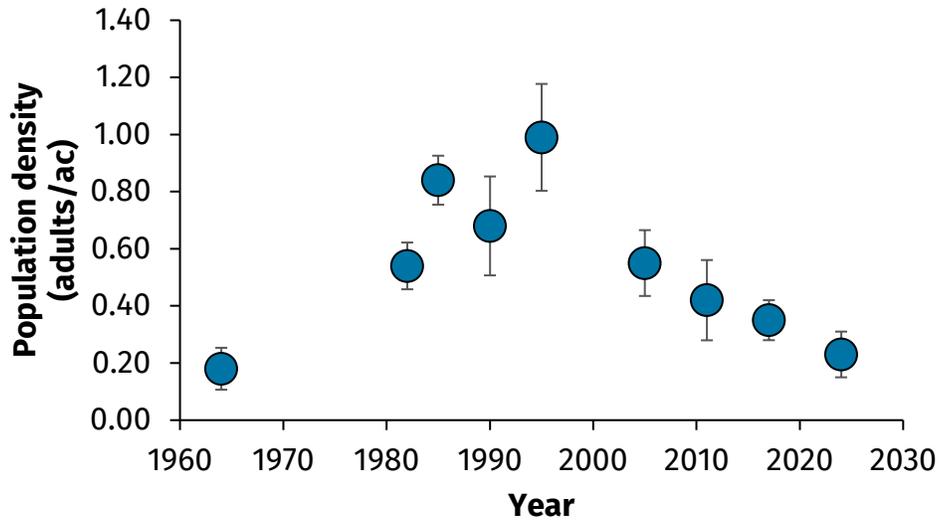
Figure 1. Population density estimates of adult (≥ 30 inches) muskellunge (with 95% confidence intervals) in Bone Lake, Polk County, WI 1964 - 2024.

Muskellunge ranged in length from 12.7 to 46.5 inches (Figure 2), and the mean length of muskellunge (sexes combined) was 36.6 inches which was above the 99th percentile (35.3 inches) for similar complex-warm-dark Wisconsin lakes and greater than mean lengths observed during the 2011 (35.2 inches) and the 2017 (35.7 inches) surveys. The mean length observed during the 2024 survey was the highest observed since 1964. The mean length by sex was 34.2 inches for males and 39.7 inches for females, both of which were high compared to previous surveys (Table 1). Muskellunge PSD-34 was 80, PSD-38 was 51, PSD-42 was 20 and PSD-46 was 1. Most PSD indices remained generally similar to the 2017 survey but greater than the 2011 survey (Figure 3). However, PSD-38 increased slightly since the 2017 survey. The PSD-42 remained above the target level for Class A1 muskellunge waters (17). The population relative length frequency during 2024 was considered different from 1982 and 2005 (KS test with Sequential Holm-Sidak corrections: P < 0.01 in both cases) but similar to all other survey years. The mean *Wr* was 104, which indicated muskellunge were in good condition and remained similar to 2017 (Mean *Wr* = 102) but still lower than 2011 (mean *Wr* = 111). There continues to be a strong relationship between mean *Wr* and density of adult muskellunge from Bone Lake, 1964 – 2024 (R^2 = 0.52, linear regression: P = 0.03; Figure 4; Cole 2020). The male-female sex ratio was nearly 1:1.
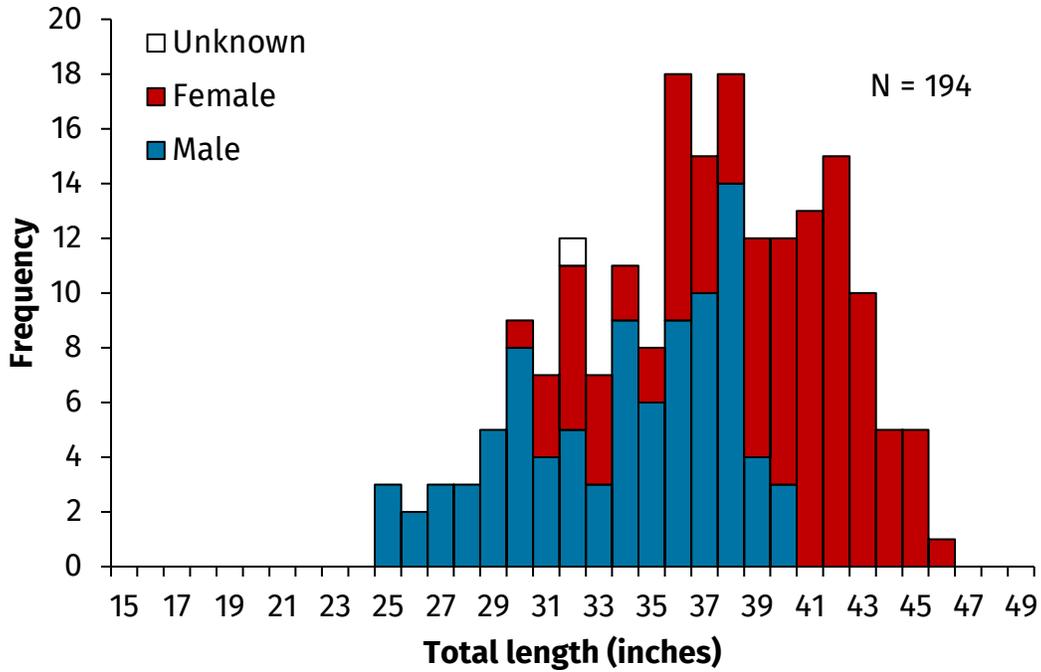
F*igure 2. Length frequency histogram for muskellunge captured with fyke nets in Bone Lake, Polk County, WI 2024-2025. Recaptures were excluded.*
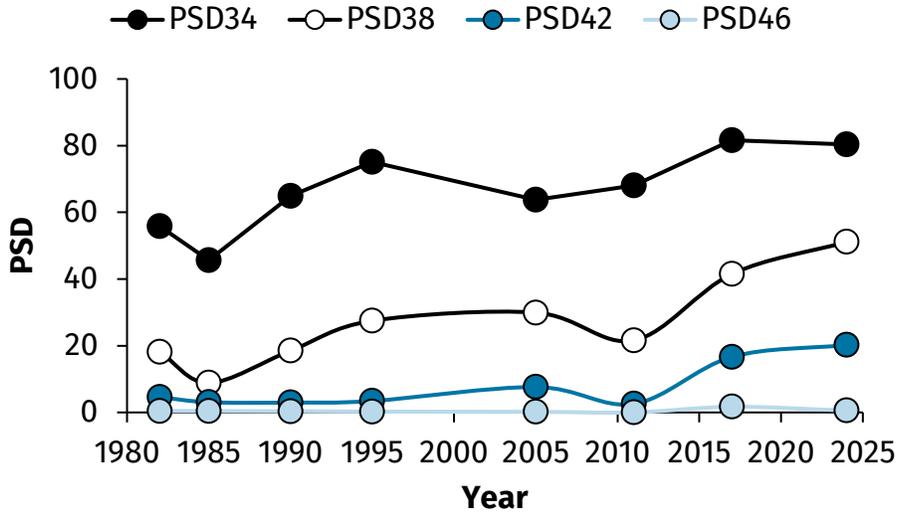

Figure 3. Size structure indices of muskellunge collected during the 1982, 1985, 1990, 1995, 2005, 2011, 2017 and 2024 surveys. The PSD-34, PSD-38, PSD-42 and PSD-46 are in descending order from top to bottom.

Table 1. Mean (SE) total lengths (inches) of adult muskellunge sampled with fyke nets in Bone Lake, Polk County, Wisconsin 1964-2024. Bolded values represent the highest values for each group.

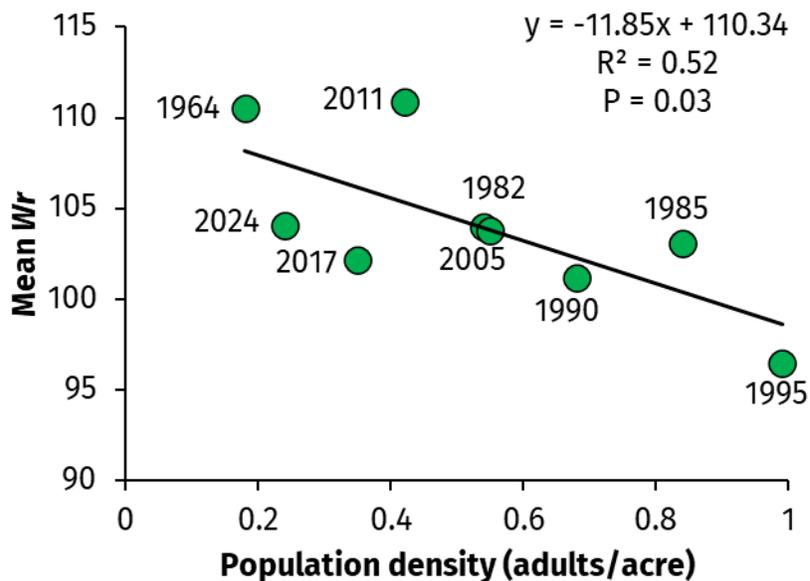| Year	Male	Female	Combined
1964	29.4 (0.23)	34.2 (0.41)	31.3 (0.24)
1982	31.5 (0.14)	36.8 (0.22)	33.4 (0.15)
1985	31.7 (0.10)	35.1 (0.15)	33.0 (0.09)
1990	33.6 (0.15)	36.7 (0.24)	34.7 (0.14)
1995	**34.8 (0.12)**	37.7 (0.18)	36.0 (0.11)
2005	33.2 (0.19)	38.3 (0.31)	34.9 (0.20)
2011	33.7 (0.19)	37.0 (0.25)	35.2 (0.18)
2017	33.3 (0.28)	38.6 (0.28)	35.7 (0.24)
2024	34.2 (0.43)	**39.7 (0.40)**	**36.6 (0.57)**

Figure 4. Mean Wr and population density of adult muskellunge sampled with fyke nets in Bone Lake, Polk County, Wisconsin, 1964-2024.

Bone Lake muskellunge had average growth rates. The mean lengths at age remained similar to 2017 (average difference in mean length at age: +1.7 inches), the median length at age for similar complex-warm-dark Wisconsin lakes (average difference in lengths at age: +0.9 inches) and the Barron and Polk counties average (average difference in mean length at age: +1.3 inches; Figure 5). Age-specific differences were greatest within the youngest age classes (Figure 5). All comparisons used fish ages 3 – 10. The von Bertalanffy growth model did not adequately represent population growth and thus was not presented.
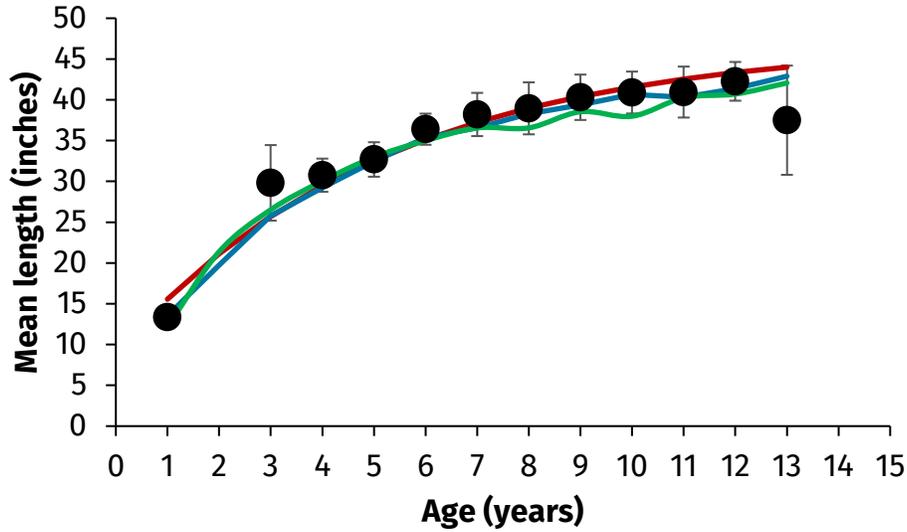
Figure 5. Mean length at age ± standard deviation of muskellunge (sexes pooled; black circles) sampled from Bone Lake during 2024 - 2025. The mean length at age estimates for Barron and Polk counties is represented by the blue line, the 2017 survey by the green line and lake class median length at age estimates by the red line.

The catch curve regression model (fitted to age-3 to age-13) estimated annual mortality to be 14.8% (Z= -0.16, R^2 = 0.17; Figure 6) which decreased from 2017 (23.8%, (Z= -0.27, R2 = 0.75). However, model fit was poor and interpretation should be cautioned.
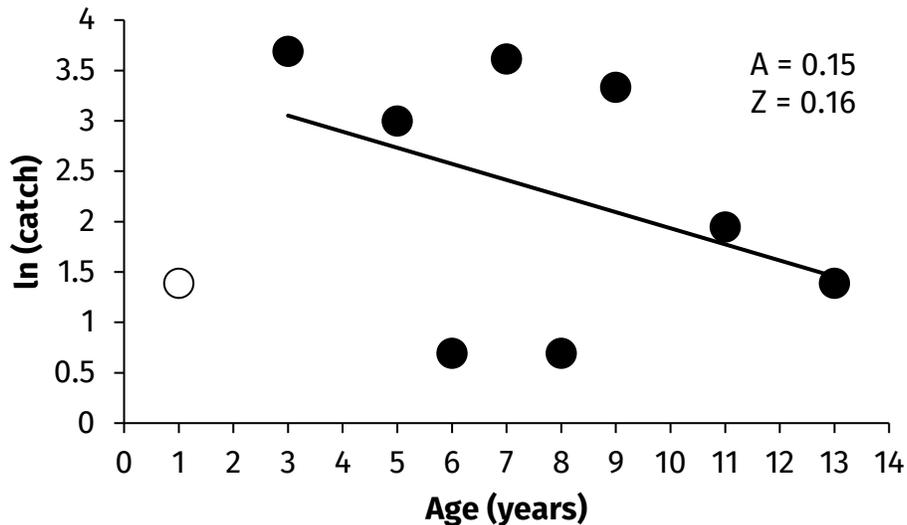

Figure 6. Catch curve analysis plot representing the natural logarithm of the catch for each muskellunge age class used in the analysis (black circles) and not (white circles). Z = instantaneous total mortality, A = annual total mortality rate.

The Bone Lake muskellunge population was primarily composed of fish from stocked years. Natural recruitment remained low as non-stocked year classes represented very little of the population age structure (Figure 7). However, age cohorts corresponding with stocked year classes composed 97% of the population, indicating stocking efforts have successfully maintained a quality population with multiple year classes present (Figure 7). Survival of stocked large fingerling muskellunge to ages 3, 5, 7 and 9 was 18.9%, 3.9%, 16.6% and 3.1%, respectively. Age-3 muskellunge were not yet fully mature nor entirely susceptible to survey methods, which likely lowered survival estimates. Survival of stocked large fingerlings to age 5 in Bone Lake was lower compared to recent survival estimates to ages 4 or 5 (age first susceptible to survey methods) for Wapogasset and Bear Trap lakes, Rice Lake and Deer Lake (12.9 ± 5.4%, mean ± standard error). Survival of stocked large fingerling muskellunge to ages 11 and 13 were similar at 0.8% and 0.4%, respectively. Stocking remains necessary to maintain a muskellunge population in Bone Lake.
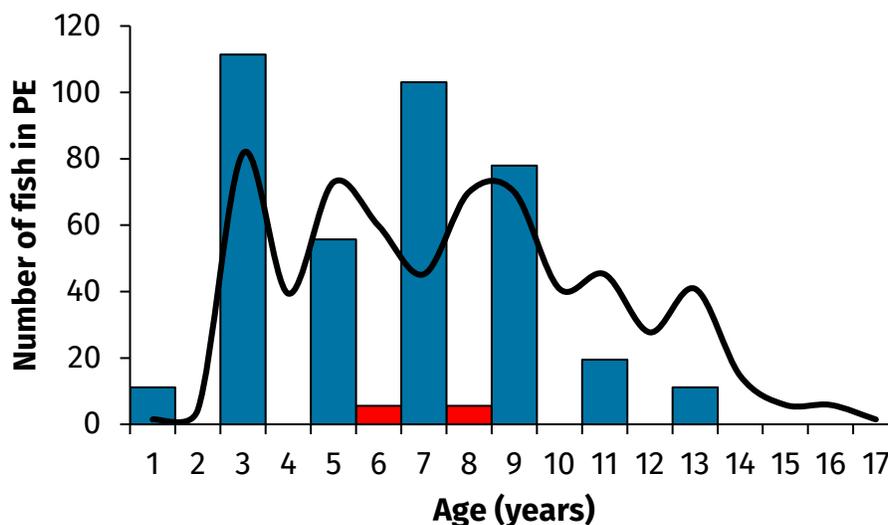

Figure 7. Population age structure of muskellunge during 2024 in Bone Lake, Polk County, WI. Blue bars represent stocked years and red bars represent non-stocked years. Population age structure during 2017 is represented by the black line.

Tribal spearers harvested 3 muskellunge during the 2025 open water spearing season, which was less than the declaration of 12 and the average of the previous six years (10.2 muskellunge speared. An estimate of muskellunge harvested by tribal spearers during the winter spearing season was not available. Therefore, excluding winter spear harvest, the exploitation rate from tribal spearing based on the population estimate derived from the present survey was 0.75%.

Discussion

A low-moderate density muskellunge population with good size structure was present in Bone Lake. The current population estimate was the lowest since the first Bone Lake muskellunge assessment in 1964 and has declined steadily since the highest observed density during the 1995 survey (0.99 fish/acre). The 2024 adult population density (0.23 fish/acre) was lower than recent density estimates (average density = 0.39 fish/acre; range = 0.24 – 0.63 fish/acre) for other popular muskellunge fisheries in Barron and Polk counties (Wapogasset and Bear Trap lakes, Sand Lake, Deer Lake, Big Moon Lake and Rice Lake). The current Bone Lake muskellunge density now resembles the mean density (0.22 fish/acre) for A1 muskellunge lakes across Wisconsin, which should continue to provide good angling action while producing larger-bodied fish.

Despite declining adult densities, the population remains healthy with good size structure. The size structure in Bone Lake (PSD-34 = 80) was comparable to the average of recent PSD estimates (average PSD-34 = 78; range = 56 – 88) for these same lakes. However, muskellunge exceeding 42 inches composed a high proportion of the Bone Lake population as PSD-42 was higher than most other popular muskellunge fisheries in Barron and Polk counties and exceeded the minimum trophy requirement for A1 waters. Muskellunge fisheries often display strong inverse relationships between density and size structure, where lower density populations typically have higher size structure and good fish condition, and vice-versa, which is typically the result of intra-specific competition. The Bone Lake muskellunge population estimate was lower than other muskellunge lakes in Barron and Polk counties, which should support fast growth and 'trophy' size potential. Muskellunge remained in fair condition and the relative abundance of muskellunge ≥ 45 inches remained similar to 2017 despite maintaining the 50-inch minimum length limit and one fish daily bag limit. It is possible exploitation of adult muskellunge remains too high to observe a noticeable increase in muskellunge ≥ 45 inches.

High survival of stocked muskellunge in Bone Lake has successfully maintained a quality fishery. The current stocking rate is average (1.0 fish/acre) relative to other stocked lakes in Barron and Polk counties (mean stocking rate = 1.0 fish/acre) and statewide (mean stocking rate = 0.6 fish/acre). However, state hatchery production shortfalls caused reduced stocking rates during 2017 (0.5 fish/acre) and 2021 (0.5 fish/acre) which could have contributed to the 0.12 adults/acre decline observed since 2017. Fewer fish are also stocked now relative to the past (1.5 large fingerlings stocked/acre during 1990 – 2015) which could have contributed to the decline in adult density. Despite this, Bone Lake is a stocking-dependent system with high recruitment of stocked fish and a low probability of establishing natural recruitment. Survival of stocked fish to adult age classes was variable and thus, stocking efficacy

and recruitment of stocked year classes to the fishery should be closely monitored in the future. The stocking rate of 1 large fingerling/acre on an alternate year basis should continue to maintain the population within the target population density range of 0.2 – 0.4 adults/acre.

In 2011, a 50-inch minimum length limit with a daily bag limit of one fish was implemented on the Bone Lake muskellunge population to enhance trophy potential. While the regulation did not appear to further improve the population's size structure after 2017, it likely continues to support a low-to-moderate density population with trophy potential. The 50-inch minimum length limit effectively prevents most angler harvest and will remain in place.

Spring and winter Tribal spear harvest (combined) exploitation rates were estimated at 11.7% in 2011 and 1.8% in 2017 (Cole 2013, Cole 2020). However, since a GLIFWC winter creel was not conducted during this survey, an accurate assessment was not possible. Exploitation during 2017–2025 likely remained within or above this range. Since exploitation directly influences adult density, population structure and trophy potential, understanding total harvest, particularly winter spear harvest, is essential for accurate management. Without reliable harvest data, it is impossible to accurately quantify exploitation rates or adjust management actions accordingly. Despite this uncertainty, the balance between mortality (natural, angler harvest and delayed fishing mortality and tribal harvest) and recruitment (stocking) appears skewed as the population has been in decline since at least the early 2000's. This sustained decline suggests that current recruitment levels have not sufficiently offset the cumulative sources of mortality.

The muskellunge fishery in Bone Lake should continue to be managed at a low - moderate density (0.2 to 0.4 adults/acre), which should promote a high size structure and opportunities for 'trophy size' muskellunge. The current stocking rate will be maintained at 1.0 fish/acre. Muskellunge will continue to be managed with the 50-inch minimum length limit and one fish daily bag limit to maintain low angler harvest mortality. All muskellunge will continue to be implanted with PIT tags, and recaptures of those fish by both anglers and future fishery surveys will benefit future population assessments.

Management Recommendations

1. The adult muskellunge population (≥ 30 inches) should be maintained between 0.2 – 0.4 adult fish/acre. PSD-42 should be at or above 17, the target level for Class A1 muskellunge waters.
2. Bone Lake muskellunge stocking should be maintained at 1.0 large fingerling/acre in alternate years. Survival rates of stocked fish should continue to be evaluated in future surveys.

3. All muskellunge collected during future fisheries surveys will be implanted with PIT tags and an anal fin ray will be extracted for aging.
4. The next survey report should include a synopsis of tribal spear harvest following the next GLIFWC winter creel survey.
5. Bone Lake is on a six-year survey rotation and will be sampled next during 2031 but is subject to change depending on local and statewide sampling plans.

Acknowledgments

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Appendix

Appendix Table 1. Muskellunge stocking records for Bone Lake, 1989 – 2025.

YEAR	AGE CLASS	NUMBER STOCKED
1989	Large Fingerling	2,500
1990	Large Fingerling	2,070
1991	Large Fingerling	2,500
1992	Large Fingerling	2,500
1993	Large Fingerling	2,500
1996	Large Fingerling	2,500
1997	Large Fingerling	727
2000	Large Fingerling	2,000
2001	Large Fingerling	2,500
2003	Large Fingerling	3,027
2005	Large Fingerling	2,494
2007	Large Fingerling	1,667
2009	Large Fingerling	2,494
2011	Large Fingerling	2,497
2013	Large Fingerling	2,500
2015	Large Fingerling	2,500
2017	Large Fingerling	622
2019	Large Fingerling	1,433
2021	Large Fingerling	590
2023	Large Fingerling	1,615
2025	Large Fingerling	1,624