Assessment of the Bone Lake Muskellunge Population, 2011-2012
Polk County, WI
MWBIC Code: (2628100)

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Executive Summary

Muskellunge *(Esox masquinongy)* were sampled in Bone Lake during 2011 and 2012 using mark and recapture methodology to estimate abundance and size structure of adult fish. Fish were collected in spring with fyke nets set shortly after ice out, marked, and sampled one year post marking. Abundance of adult (≥30 in) muskellunge was estimated using Bailey's modification of the Petersen single-census mark and recapture method. There were 167 adult muskellunge marked in 2011, and 27 of the 127 adult muskellunge collected in 2012 were recaptures from 2011. Abundance of adult muskellunge was estimated to be 743 individuals, and resulted in a density of 0.42 adult fish/acre. Population density has decreased slightly since the 2005 survey when it was estimated at 0.55 adult fish/acre. The 2011 length frequency distribution of muskellunge decreased and was considered significantly different than the 2005 and 1995 surveys. The greatest differences occurred in the larger length groups. The RSD-40 was 7 in 2011 compared to 19 in 2005 and 10 in 1995. It was estimated that 68-87 muskellunge were harvested during 2011-2012 tribal spear seasons. Based on the population estimate derived from the present survey the exploitation rate from tribal spearing was 9.2-11.7%. The reductions in abundance and size structure are likely attributed to an increase in exploitation because Bone Lake is a stocked population that should have stable recruitment. Bone Lake muskellunge face multiple sources of exploitation (e.g., angler harvest and delayed fishing mortality, tribal spring spear harvest, and tribal winter spear harvest). Exploitation appears to be reducing the trophy potential in this population. If the exploitation rate cannot be reduced, managing Bone Lake as a trophy muskellunge lake may be impractical. Bone Lake should continue to be stocked with 1.5 large fingerlings/acre every other year. For assessing population parameters (i.e., growth and mortality rates), all muskellunge stocked into Bone Lake should be implanted with Passive Integrated Transponders. Additional monitoring of the muskellunge population should occur within the next 8-10 years. Special attention should be given to changes in growth rates, condition, and size structure. In addition, the effectiveness of the 50 in minimum length limit should be evaluated by assessing the RSD-40, RSD-42, and RSD-50.

Introduction

Bone Lake is a 1,781-acre drainage lake in central Polk County, Wisconsin. The lake has a maximum depth of 43 feet, and a mean depth of 20 feet (Figure 1). There are approximately 12.5 miles of shoreline, nearly all of which is in private ownership. Anglers have access to the lake through two public boat landings. There is an outflow on the southeast portion of Bone Lake that forms the headwaters of Fox Creek. The lake is considered eutrophic. The fish community consists of muskellunge *(Esox masquinongy),* largemouth bass (*Micropterus salmoides),* bluegill (*Lepomis macrochirus),* pumpkinseed (*L. gibbosus),* black crappie (*Pomoxis nigromaculatus),* yellow perch (*Perca flavescens),* white sucker (*Catostomus commersoni),* bullheads (*Ameiurus* spp.), and golden shiner (*Notemigonus crysoleucas).* Northern pike (*E. lucius),* smallmouth bass (*M. dolomieu*), and walleye (*Sander vitreus)* are present in low numbers.

Bone Lake has long supported a well-known muskellunge fishery that attracts many resident and non-resident sport anglers. Although muskellunge are not native to Bone Lake (Becker 1983), the lake has been managed for muskellunge since 1935, when the Wisconsin Department of Natural Resources (WDNR) initially stocked muskellunge. Muskellunge are not known to naturally reproduce in Bone Lake; therefore, the reproductive classification is considered to be Category 3 where stocking is necessary to maintain the population (WDNR 2012).

Muskellunge have been stocked in Bone Lake at varying rates through the years, largely due to different management strategies and hatchery capabilities (Figure 2). Large (>7 in) fingerlings were first stocked at low levels in the mid-1950s. Stocking rates increased during the 1960s and 1970s, and were greatest from 1983 to 1993, when 2,500 large fingerlings were stocked annually. Stocking declined from 1994 to 1999 as the Spooner Fish Hatchery was renovated (Cornelius and Margenau 1999), and beginning in the early 2000s stocking was reduced to 2,500 large fingerlings on an alternate year basis. In addition, muskellunge fry were also stocked most years from 1983 to 2005 when Bone Lake was used as an egg source for the WDNR propagation. The current stocking regime of 2,500 large fingerlings every other year appears to be effective in maintaining a muskellunge fishery at the desired population density (Benike 2007).

Bone Lake has also had a variety of muskellunge length limits over the years. The general trend has been towards more restrictive length limits to increase the number of larger muskellunge, as angler perception of what constitutes a trophy continues to increase (Isermann et al. 2011). In 1983, the minimum length limit (MLL) was raised from 30 to 34 in (Cornelius and Margenau 1999). The 34-in MLL lasted until 1990 when a 40-in MLL was implemented. The muskellunge MLL was raised to 50 in during spring 2011, following the recommendation from a 2005 survey (Benike 2007). The objective of the most recent length limit increase was to improve the size structure; specifically, to increase the abundance of fish 45 in and larger. The new regulation also has the potential to cause an increase in fishing pressure as additional anglers are attracted to waters with the new 50-in MLL, and 50 inches is what most muskellunge anglers consider trophy size (Margenau and Petchenik 2004; Isermann et al. 2011).

Bone Lake is currently considered and managed as an A1 muskellunge water, defined by its ability to produce large fish, but the overall abundance of muskellunge is lower compared to other muskellunge waters (WDNR 2012). It was previously managed as an A2 muskellunge water, a high-density action muskellunge fishery. Due to the higher 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 (Cornelius and Margenau 1999). The high density provided good angling action for numbers of fish; however, the size structure and condition (*Wr*) of Bone Lake muskellunge declined when densities were high. This drop in condition suggested that the high muskellunge densities caused certain forage fish species to decline, which prompted the WDNR to alter the Bone Lake muskellunge management plan. Since 2001, the Bone Lake muskellunge stocking was reduced to 1.5 fish/acre every other year.

In addition to the popular sport fishery, the Bone Lake muskellunge population supports winter and spring spear fisheries for the Chippewa tribes under the Voigt decision. The tribal spring spear fishery began on Bone Lake in 1993, and has occurred annually since then. The muskellunge spring spear fishery is closely regulated with harvest quotas set from the most recent population estimates (whether from a population survey or a regression model) so that the risk of exceeding the maximum sustainable

exploitation rate of 27% for muskellunge is less than 1-in-40 (Staggs et al. 1990). In addition, Great Lakes Indian Fish and Wildlife Commission (GLIFWC) creel clerks count all speared fish and measure a sample of speared fish during the open water spearing season (Staggs et al. 1990). Since 1993, Chippewa Indians have speared 0-35 muskellunge from Bone Lake each spring (T. Cichosz, WDNR, personal communication; Table 1; data provided by GLIFWC). Typically, the annual quota has not been reached. The average number of muskellunge harvested each spring has been 12.3 (SE=1.8), and the average number allowed has been 18.5 (SE=3.7). The winter spear fishery is less regulated. Winter spearing of muskellunge is currently considered an "inefficient gear"; therefore, no safe allowable harvest quota exists. Harvest is typically not recorded during the winter spear fishery and fish are not measured by creel clerks. However, once every five years GLIFWC does conduct a creel on the winter spearfishing effort and reports on tribal winter spear harvest. Although little data exists for winter spearing of muskellunge, there have been increased concerns from members of the Bone Lake Management District and sport anglers that winter spearing of muskellunge has increased in recent years.

Bone Lake has been one of the most studied muskellunge lakes in Wisconsin. The most recent muskellunge survey was conducted in 2005, and indicated the muskellunge population to be at a moderate density (0.55 adult fish/acre), and have good size structure and condition (Benike 2007). The objectives of this survey were to 1) assess the size structure and abundance of adult muskellunge in Bone Lake and make comparisons to previous surveys; 2) determine the exploitation rate of muskellunge in Bone Lake from the winter and spring tribal spearing seasons; and 3) assess the current Bone Lake muskellunge management strategy and make recommendations, as necessary. Data from six previous sampling periods (1964-1965, 1982-1983, 1985-1986, 1990-1991, 1995-1996 and 2005-2006) were available to monitor trends in muskellunge population parameters. Hereafter, sampling periods will be referred to by their first year.

Methods

Muskellunge were collected during spring 2011 and 2012 using fyke nets. Fyke nets had 4 X 6 ft. frames with 1-in bar mesh and lead lengths of either 50 or 100 ft. long.

Nets were set shortly after ice-out, and checked every 24-h for approximately one week each year (Hanson 1986). Each muskellunge was measured to the nearest 0.1 in total length, and a subsample of fish was weighed to the nearest 0.1 lb. in 2011. Adult muskellunge were considered as fish ≥30-in. The sex of captured fish was determined by presence of eggs or milt or by visual inspection of the urogenital pore as described by LeBeau and Pageau (1989). All fish ≥30 in were marked in 2011, by cutting half the left pelvic fin with a scissors. Fish <30 in were marked by cutting the right pelvic fin. Fish were checked for marks during the recapture event in 2012. To prevent double-counting fish, all fish handled in 2012 were marked by clipping the top corner of the caudal fin. Abundance of adult muskellunge was estimated using Bailey's modification of the Petersen single-census method (Ricker 1975):

$$N=M(C+1)/(R+1);$$

where N = population estimate; M = the number of fish marked in the first 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.

The number of fish collected in 2012 was adjusted for recruitment over a 1-year period. For this, all females less than 33 in, and males less than 32 in captured in 2012 were excluded from analyses because they were assumed to have been less than 30 in during the 2011 marking event. These lengths were determined from recapture data; that is to say, all males recaptured in 2012 were at least 32 in and recaptured females were at least 33 in. No age and growth information was collected in this survey because scales and fin rays are often unreliable for accurate age determination, especially with older muskellunge, and using cleithra requires sacrificing fish (Casselman 1986; Fitzgerald et al. 1997).

Several independent abundance estimates were calculated: 1) mature muskellunge of each sex ≥30 in; and 2) mature muskellunge, sexes combined and unknowns, 30.0-33.9 in, 34.0-37.9 in, 38.0 in and greater, and 40.0 in and greater. The number of adult muskellunge 40 in and greater was determined from the proportion of muskellunge 40 in

and greater handled in 2011 multiplied by the population estimate for fish 38 in and greater.

Differences in the mean length of each sex and both sexes combined were compared to previous surveys using *t*-tests. Relative stock density (RSD) was used to further describe and compare population size structure with previous surveys (Anderson and Neumann 1996). Stock size was 30 in (Hanson 1986). Relative stock density represents the percentage of stock length individuals that are also greater than a specified length of interest. The RSD lengths of interests in this survey were 34 in, 40 in, and 42 in (i.e., RSD-34; RSD-40; RSD-42). Kolmogorov-Smirnov two-sample tests were conducted using R software to test for differences in the size distributions between muskellunge ≥20 in collected in the present survey to those collected in previous surveys (Neumann and Allen 2007). Relative weight (*Wr*) was used to describe condition of muskellunge. Relative weight is the ratio of a fishes weight at capture to the weight of a ‘‘standard’’ fish of the same length determined by the standard weight equation for muskellunge developed by Neumann and Willis (1994). The mean relative weight was determined and comparisons were made with previous surveys.

The annual exploitation rate for Bone Lake muskellunge was estimated by adding two of the three primary sources of exploitation that Bone Lake muskellunge face: open water tribal spear harvest and winter tribal spear harvest. Tribal harvest data were available from GLIFWCs 2011 open water spear season, and the winter spear harvest estimate was obtained from the 2011-2012 GLIFWC Bone Lake winter spearing creel (Luehring 2012). A lake-specific estimate of recreational exploitation (i.e., angler harvest and delayed fishing mortality) was unknown and therefore not factored into this the analysis. As such, the exploitation estimate was considered a conservative estimate.

Results

There were 167 adult muskellunge (87 males and 80 females) marked in 2011, of which, 27 (14 males and 13 females) were recaptured in 2012. There were also 100 unmarked adult muskellunge (54 males and 46 females) collected in 2012. The adult population was estimated to be comprised of 400 males and 343 females, for an overall estimate of 743 fish (95% CI: 498-989), and a density estimate 0.42 adult fish/acre (Table

2; Figure 3). The population was lower in this survey compared to the most recent survey in 2005, when abundance was estimated to be 973 (95% CI: 774-1172) and had a density of 0.55 adult fish/acre. Not only has the population declined since last survey, but the current population estimate is the lowest it has been since the first Bone Lake muskellunge assessment in 1964.

Population estimates by length group for 2011 were: 399 from 30.0-33.9 in; 320 from 34.0-37.9 in; 118 greater than 38 in; and 64 greater than 40 in (Table 2). Abundance in all of the length groups was lower in 2011 than 2005 except for the 30.0-33.9 in length group. The greatest differences were observed in the ≥38 in and ≥40 in groups. In general, abundance by length group in this survey were some of the lowest reported for Bone Lake, especially for the ≥38 in and ≥40 in length groups; only during the 1985 survey were the ≥38 and ≥40 in length groups lower than what was observed in this survey.

Mean length of muskellunge (sexes combined) was similar between 2011 (35.2 in; SE=0.18) and 2005 (34.9 in; SE=0.20; t =0.90, P=0.37; Table 3). There was a significant decrease in the mean length of female muskellunge between 2005 (38.3 in; SE=0.31) and 2011(37.0 in; SE=0.25; t =-3.47, P <0.001). Mean length of male muskellunge in 2011 was 33.7 in (SE=0.19) and was not significantly different from 2005 (33.2 in; SE=0.19; t =1.27, P=0.21).

The RSD-34 was 68 in 2011, which was a slight increase from 2005 (66), but less than it was in 1995 (75; Figure 4). Although RSD-34 increased, the RSD-40 decreased from 19 in 2005 to 7 in 2011. This amounted to a 63% decrease in RSD-40, which was the most drastic decline in the history of Bone Lake muskellunge assessments. Similarly, the RSD-42 was 3 in 2011, but was 8 in 2005.

The length frequency distribution of muskellunge ≥20 in collected during this survey was significantly different than fish collected from the 2005 survey (D=0.17, P<0.001; Figure 5), and the 1995 survey (D=0.19, P<0.001). Relative abundance of larger fish in this survey was less than the 1995 and 2005 surveys. Relative abundance was greater for all length groups greater than 40 in during the 2005 survey compared to this survey (Figure 6). However, relative abundance was greater for length groups from

32.0-39.9 in during 2011 compared to 2005. Likewise, relative abundance was greater in 1995 for all length groups greater than 36 in compared to 2011 (Figure 7).

Adult muskellunge collected in this survey were in good condition. The mean *Wr* was 110.9 (SE=1.1) which was the highest mean *Wr* recorded for Bone Lake. Mean *Wr* has continued to increase from 96 in 1995 and 104 during 2005. There was a strong relationship between mean *Wr* and density of adult muskellunge from Bone Lake, 1964-2011 (R^2=0.81; Figure 8).

There were 16 muskellunge speared during the 2011 open water spearing season, which met the tribal declaration (Table 1). Size structure of speared muskellunge also decreased in 2011. Mean length of speared muskellunge from the 2011 open water spear season was 36.1 in (SE=0.7; range: 32.5-42.5 in) which was the lowest mean length since the first open water spear season in 1993. It was estimated that 52-71 muskellunge were harvested on Bone Lake by tribal spearers during the winter spearing season of 2011-2012 (Luehring 2012). A total of 68-87 muskellunge were harvested from Bone Lake by tribal spearers during the 2011-2012 season. Based on the population estimate derived from the present survey (i.e., 743), the exploitation rate from tribal spearing was 9.2-11.7%.

Summary and Discussion

The Bone Lake muskellunge population has had a dynamic and varied history. From 1964-2011, adult muskellunge densities have ranged from 0.18 to 0.99 fish/acre. Looking at recent surveys, the muskellunge population has changed greatly from the 1995 and 2011 surveys. In 1995, Bone Lake had a high-density muskellunge population with the highest abundance of adult fish on record (0.99 adult fish/acre). Due to concerns of intra-specific competition and poor condition, stocking was reduced and the lake has been managed as a lower-density fishery since then. As a result the population density in 2005 (0.55 adult fish/acre) was nearly half of what it was in 1995 (0.99 adult fish/acre). Density of adult muskellunge has continued to decrease in 2011 (0.42 adult fish/acre) from 2005. The current population level is the lowest it has been since 1964; however, it is still within the target density level (0.4-0.6 adult fish/acre) for Bone Lake, and is

greater than the mean density of muskellunge (0.38 adult fish/acre) reported by Margenau and AveLallemant (2000) for 15 northern Wisconsin lakes.

With changing population levels, the size structure and condition of Bone Lake muskellunge have also varied through 1964-2011. The 1995 population had an RSD-40 of 10, and was primarily comprised of fish between 32.0 and 39.9 in. Size structure increased as the population decreased during the period from 1995 to 2005. The RSD-40 was at an all-time high (19) for the 2005 population. A more restrictive, 50-in MLL was implemented in 2011 with the overall goal of increasing the abundance of muskellunge >45 in by protecting fish over 40 in which were considered harvestable size with the 40-in MLL at the time. Despite the increase in size structure and RSD-40 during 2005, density of large (>40 in) muskellunge in 1995 and 2005 were both approximately 0.11 fish/acre. In contrast, the density of large muskellunge during the 2011 survey was only 0.04 fish/acre. The 2011 RSD-40 of 7 was the second lowest on record, 1985 (5) was the only survey lower. The decrease in size structure in this survey seemed to be due to the lack of larger-bodied females. The decrease in RSD-40 and overall reduction in size structure during this survey is of utmost concern, because muskellunge anglers are especially interested in large fish and the reputation or potential of a lake to produce large muskellunge is one of the main criteria used by muskellunge anglers in selecting where to fish (Casselman 2007; Isermann et al. 2011).

In recent years there has been considerable interest in managing muskellunge fisheries as trophy fisheries. However, this is often difficult since muskellunge are vulnerable to the impact of even small increases in exploitation because they are a long-lived species that naturally occurs at low population densities (Hanson 1986; Frohnauer et al. 2007). The trophy potential of a population is largely based upon its growth and mortality rates. Bone Lake muskellunge are known to have good growth rates (Cornelius and Margenau 1999), so managing the lake as a trophy muskellunge fishery seemed plausible. However, exploitation in Bone Lake is likely reducing the likelihood of attaining a trophy muskellunge fishery. Faust (2011) modeled the effects of exploitation on muskellunge in northern Wisconsin lakes and concluded that current levels of angling and spearing exploitation are influencing muskellunge size structure and trophy potential in some lakes. For example, his modeling indicated that medium-bodied muskellunge

populations with a 50-in MLL simulated with average levels of angling and spearing exploitation would experience a decline of 20.0% in the numbers of muskellunge greater than 50 in, and 12.5% in the numbers of muskellunge greater than 45 in. If that same population was subjected to the 95th percentile of observed angling and spearing exploitation rates, there would be a 40.0% reduction in fish greater than 50 in, and a 25.0% reduction in fish greater than 45 in. Both angling and spearing fisheries caused a decline in muskellunge population size structure as exploitation from either fishery increased; however, spearing appeared to have a greater influence on size structure in mixed fishery simulations.

It is recognized that tribal spearing is size selective towards larger fish (WDNR, unpublished data), which further hampers the trophy potential of a lake. Spring spearing is regulated with tribal quotas to maintain a sustainable fishery, as litigated in the LCO v. Voigt decision. In that decision, winter spearing of muskellunge was considered an "inefficient gear" and therefore not regulated by safe harvest declarations but by bag and size limits. Nevertheless, the majority (77-82%) of the tribal harvest during 2011-2012 occurred during the winter season. Safe harvest level for 2011 was 28 fish, and the estimated number of muskellunge harvested through tribal spearing was 68-87. In addition to the 2011-2012 GLIFWC winter creel survey, members of the Bone Lake Management District have recorded, from direct observations and on-lake visits with spearers, the number of muskellunge speared they observed during winters 2008 through 2011. Based on their reports, winter harvest in 2011 was low compared to previous years. They estimated 50 fish were harvested in 2011, 50 in 2010, 104 in 2009, and 178 in 2008 (B. Boyd, Bone Lake Management District, personal communication). All of their estimates were considered as minimum estimates. While these observations are without any scientific design, they do suggest the exploitation rate for Bone Lake muskellunge to be considerably greater in previous years. Such high exploitation rates may explain the reduction in population size.

With the current 50-in MLL, recreational harvest of Bone Lake muskellunge should be considered nil, because no fish in this survey would have been legal to harvest. Although the length limit was 40 in for the period between the 2005 and 2011 surveys, it is unlikely much recreational harvest occurred because muskellunge anglers typically

practice catch-and-release (Simonson and Hewett 1999; Margenau and Petchenik 2004) even with trophy-size fish (Isermann et al. 2011). The mean angling exploitation rate for 14 lakes with a 40 in MLL, creeled between 1992 and 2007, in the ceded territory was < 1% (WDNR, unpublished data).

The level of delayed mortality from fishing and spearing on Bone Lake muskellunge is unknown. The handling and release techniques used by experienced muskellunge anglers result in negligible levels of delayed fishing mortality, but higher levels of delayed fishing mortality are likely caused by inexperienced muskellunge anglers (Landsman et al. 2011). Similarly, muskellunge that escape from a spearing attempt suffer wounds, and depending on the extent, may later succumb to delayed mortality.

If recreational harvest is not the main component of exploitation, the restrictive 50-in MLL would be ineffective in managing Bone Lake as a trophy lake for muskellunge. Winter spearing currently contributes the greatest level of exploitation to the Bone Lake muskellunge population. High exploitation would make managing Bone Lake as a trophy water nearly impossible. If the overall exploitation cannot be reduced and continues to exceed what is thought to be allowable to maintain a "trophy" muskellunge fishery, Bone Lake should not be managed as a trophy lake for muskellunge.

Bone Lake muskellunge remain to be in good condition, the mean *Wr* observed was the highest recorded in Bone Lake history. The reduction in the density of muskellunge since 1995 has improved condition of Bone Lake muskellunge. The muskellunge density in Bone Lake should continue to be maintained between 0.4 to 0.6 adult fish/acre. This density provides the greatest density, and likely good angling action, without compromising the condition of muskellunge. In order to maintain the target abundance levels of adult muskellunge, the current stocking regime of 1.5 large fingerlings/acre on an alternate year basis should continue.

Understanding population parameters (i.e., growth, mortality, and exploitation) of Bone Lake muskellunge and comparing them to similar water bodies is critical for proper management of Bone Lake muskellunge in the future. Having reliable age estimates or known-age fish is imperative for assessing these parameters. Therefore, it is

recommended that all large fingerling muskellunge stocked into Bone Lake be implanted with a Passive Integrated Transponder (PIT) tag.

Management Recommendations

1. The adult muskellunge population (≥ 30 in) should continue to be maintained between 0.4-0.6 adult fish/acre. Abundance of large muskellunge (> 40 in) should be maintained at a density of at least 0.10 fish/acre. RSD-42 should be at or above 17, the target level for an A1 muskellunge water.

2. Exploitation appears to be reducing the size structure of Bone Lake muskellunge. The WDNR should work with the GLIFWC to determine the levels of exploitation that occurs from each of the three sources (i.e., angling, open water spearing, and winter spearing). If the overall exploitation rate exceeds what is thought to be allowable to maintain a "trophy" muskellunge fishery, either the exploitation needs to be reduced or Bone Lake should not be managed as a trophy lake for muskellunge.

3. To maintain stable recruitment, Bone Lake muskellunge stocking will continue at the current stocking rate of 1.5 large fingerlings/acre in alternate years. This rate appears to be effective in maintaining a good muskellunge fishery in terms of numbers without compromising the condition of the fish.

4. Implant passive integrated transponder (PIT) tags into all age-0 muskellunge prior to stocking to have known-age fish for purposes of determining growth and mortality rates and comparing them with other area lakes.

5. Continue with periodic monitoring of the Bone Lake muskellunge population. Bone Lake is in the muskellunge trends monitoring program and should be surveyed again within the next 8-10 years (2019-2021). The effectiveness of the 50-in MLL should be assessed by documenting any changes in the population

size, growth rates, condition, and size structure after the regulation has been in effect for 8-10 years.

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Table 1. History of open water spearing safe harvest levels, tribal declarations, number of muskellunge speared, and the mean length (in) and standard error (SE) of speared muskellunge from Bone Lake, Polk County, Wisconsin, 1993-2012.

Year	Safe Harvest	Declaration	n Speared	Mean Length (in)	SE
1993	—	13	10	37.1	0.6
1994	—	0	0	—	—
1995	—	0	0	—	—
1996	—	15	15	39.5	0.5
1997	200	35	35	37.7	0.5
1998	—	16	14	38.1	0.8
1999	—	16	10	38.3	0.8
2000	27	16	16	36.8	0.7
2001	—	16	4	41.9	1.5
2002	27	16	14	37.3	0.9
2003	27	14	14	39.2	0.6
2004	26	15	12	41.2	0.9
2005	28	16	12	38.5	1.0
2006	27	16	16	37.6	1.4
2007	137	82	20	38.0	0.9
2008	29	17	6	38.0	1.0
2009	29	17	0	—	—
2010	29	17	17	38.1	1.3
2011	28	16	16	36.1	0.7
2012	28	16	14	37.3	0.7

Table 2. Abundance estimates of adult muskellunge by sex and length-group for Bone Lake, Polk County, Wisconsin 1964-2011. Coefficient of variation (CV = 100 X SD/mean) is in parenthesis.

	Sex		Length-group (in)			
Year	**Male**	**Female**	**30-33.9**	**34-37.9**	**>38.0**	**>40.0**
1964	175 (33.0)	150 (25.3)				
1982	493 (9.6)	468 (12.2)	475 (11.8)	328 (12.0)	156 (16.7)	76 (18.0)
1985	700 (6.6)	799 (8.1)	964 (7.3)	461 (8.3)	92 (12.3)	58 (15.6)
1990	554 (11.2)	651 (21.7)	432 (17.1)	426 (13.9)	243 (26.1)	114 (26.2)
1995	927 (11.6)	830 (15.4)	427 (18.2)	740 (12.4)	576 (20.2)	196 (20.2)
2005	487 (10.8)	546 (22.1)	284 (15.0)	368 (18.4)	321 (18.3)	190 (18.5)
2011	400 (22.1)	343 (22.61)	399 (41.5)	320 (21.0)	118 (25.8)	64 (16.1)

Table 3. Mean (SE) total lengths (inches) of adult muskellunge sampled with fyke nets in Bone Lake, Polk County, Wisconsin 1964-2011. Whole numbers centered below means are sample size.

Year	**Male**	**Female**	**Combined**
1964	29.4 (0.23)	34.2 (0.41)	31.3 (0.24)
	269	177	446
1982	31.5 (0.14)	36.8 (0.22)	33.4 (0.15)
	558	303	861
1985	31.7 (0.10)	35.1 (0.15)	33.0 (0.09)
	865	572	1437
1990	33.6 (0.15)	36.7 (0.24)	34.7 (0.14)
	397	224	621
1995	34.8 (0.12)	37.7 (0.18)	36.0 (0.11)
	500	337	837
2005	33.2 (0.19)	38.3 (0.31)	34.9 (0.20)
	352	177	529
2011	33.7 (0.19)	37.0 (0.25)	35.2 (0.18)
	176	146	322

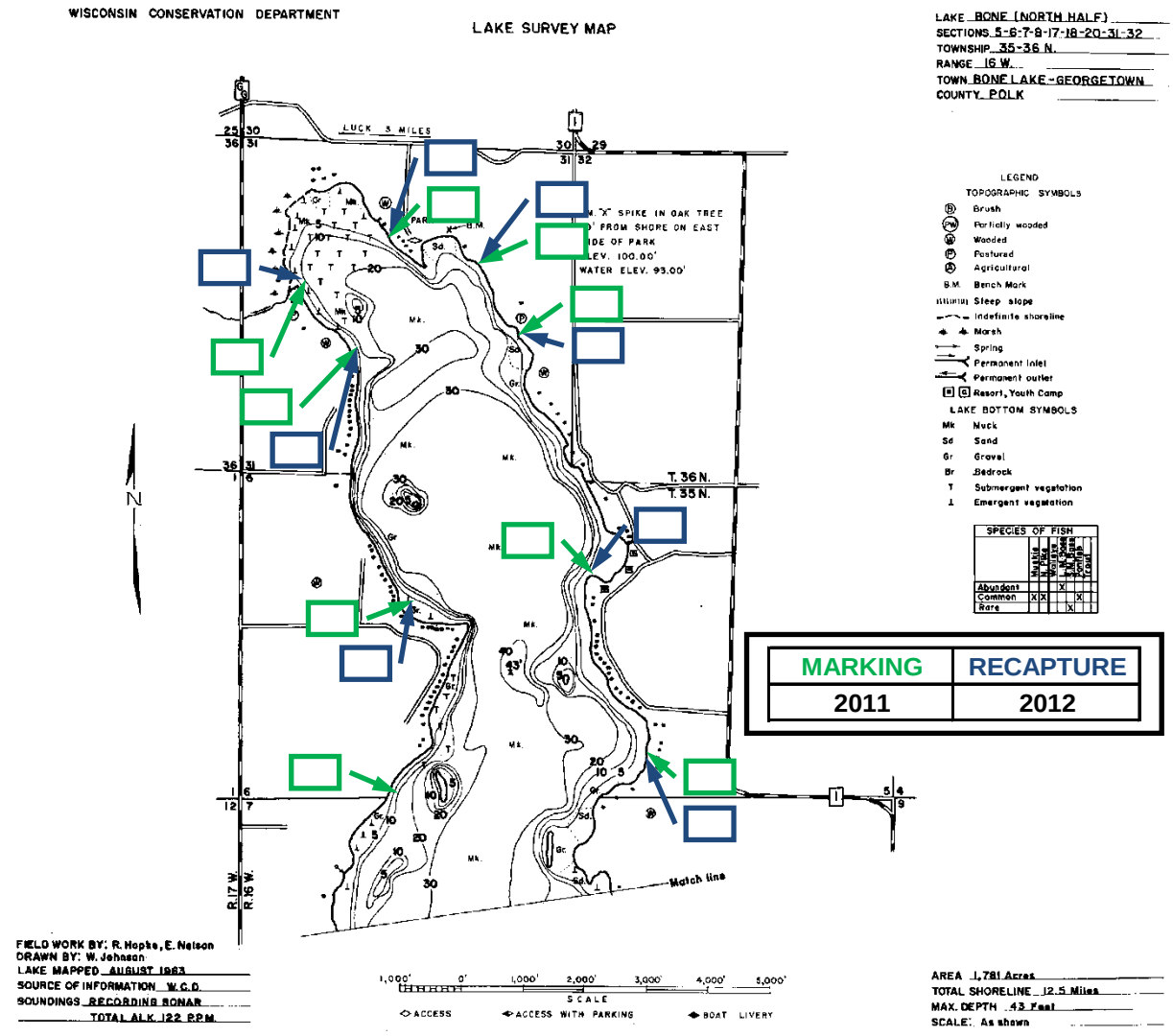

Figure 1a. Map of the 2011-2012 muskellunge fyke netting locations for the northern portion of Bone Lake, Polk County, Wisconsin.

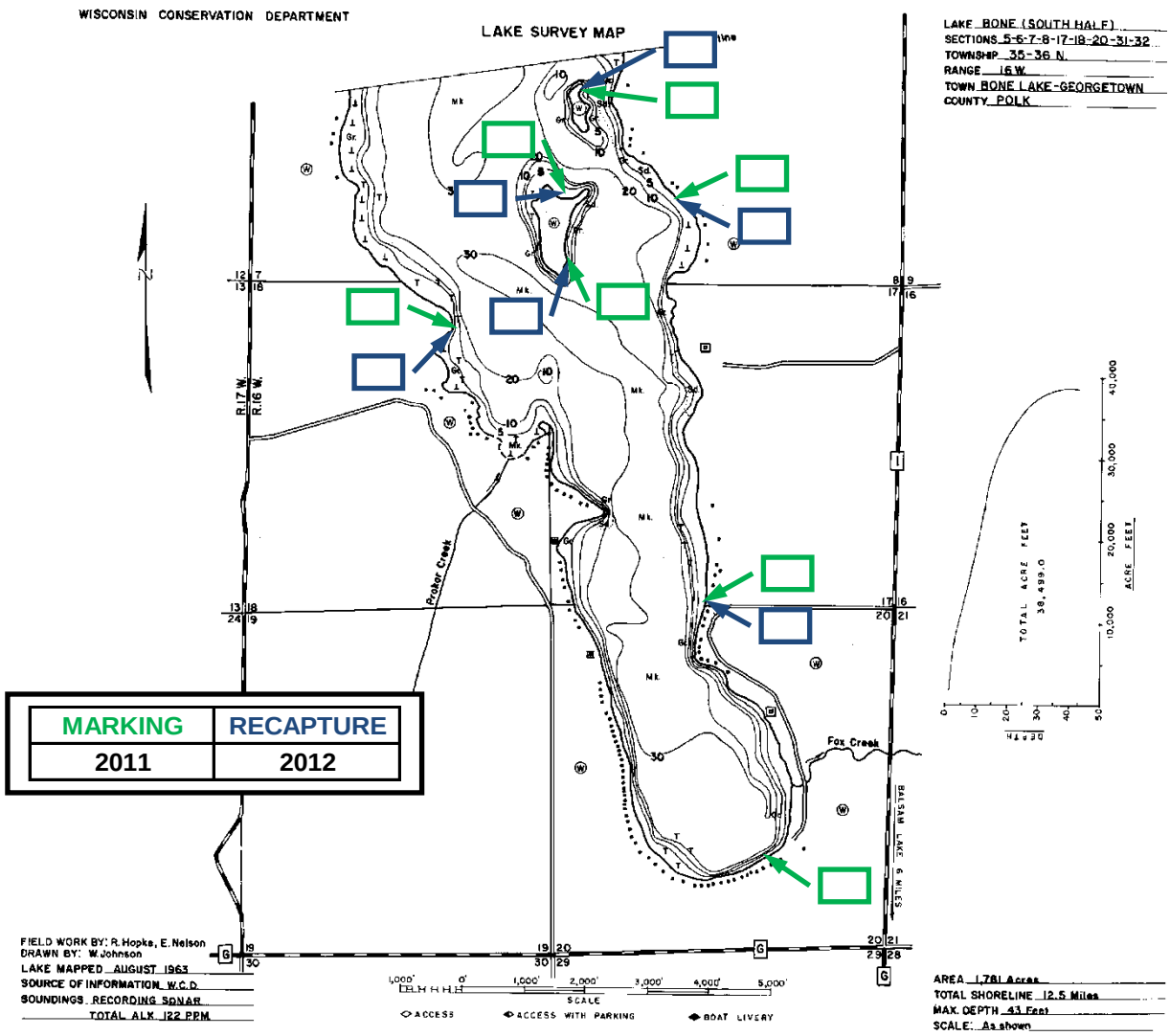

Figure 1b. Map of the 2011-2012 muskellunge fyke netting locations for the southern portion of Bone Lake, Polk County, Wisconsin.

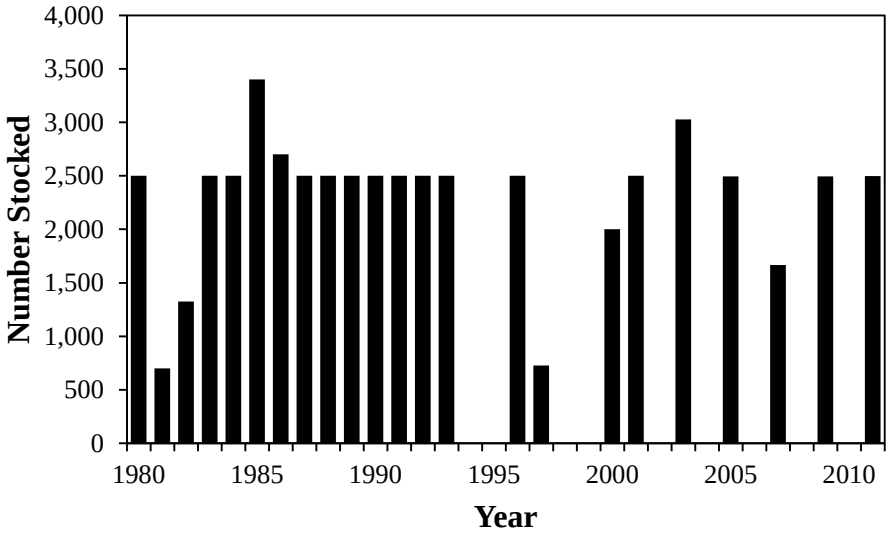

Figure 2. Stocking history of large fingerling (>7 in) muskellunge stocked into Bone Lake, Wisconsin, 1980–2011.

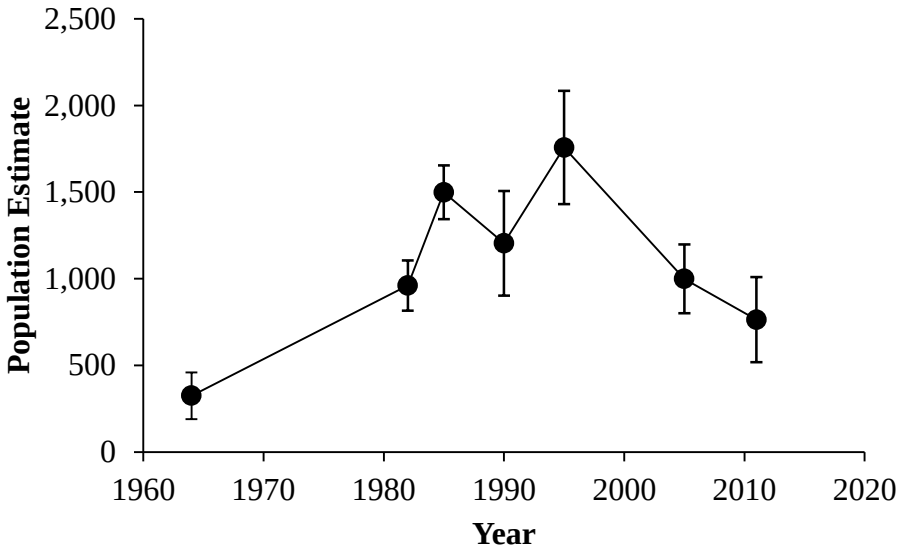

Figure 3. Population estimates of adult muskellunge (with 95% confidence intervals) in Bone Lake, Polk County, WI 1964-2011.

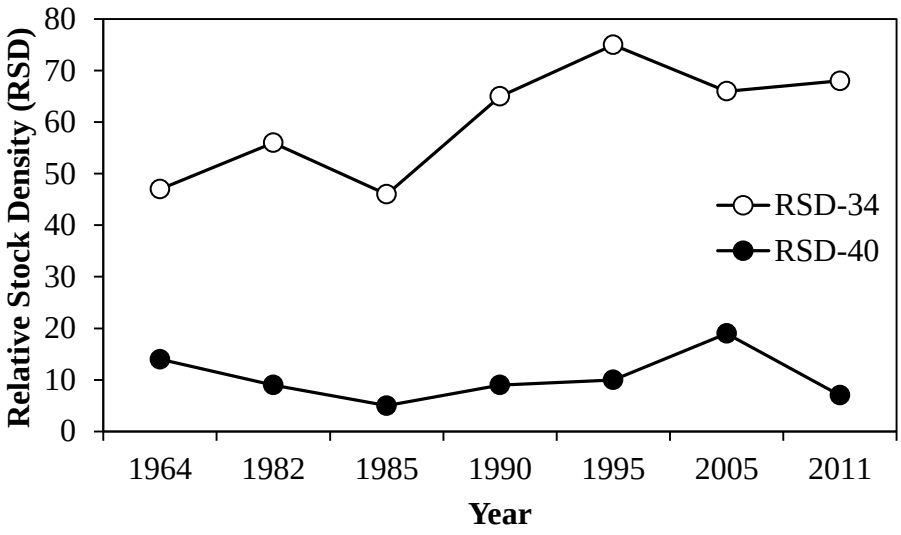

Figure 4. Relative stock densities for fish 34 in and greater (RSD-34) and 40 in and greater (RSD-40) for Bone Lake muskellunge, Polk County, WI 1964-2011. Stock length was 30 in.

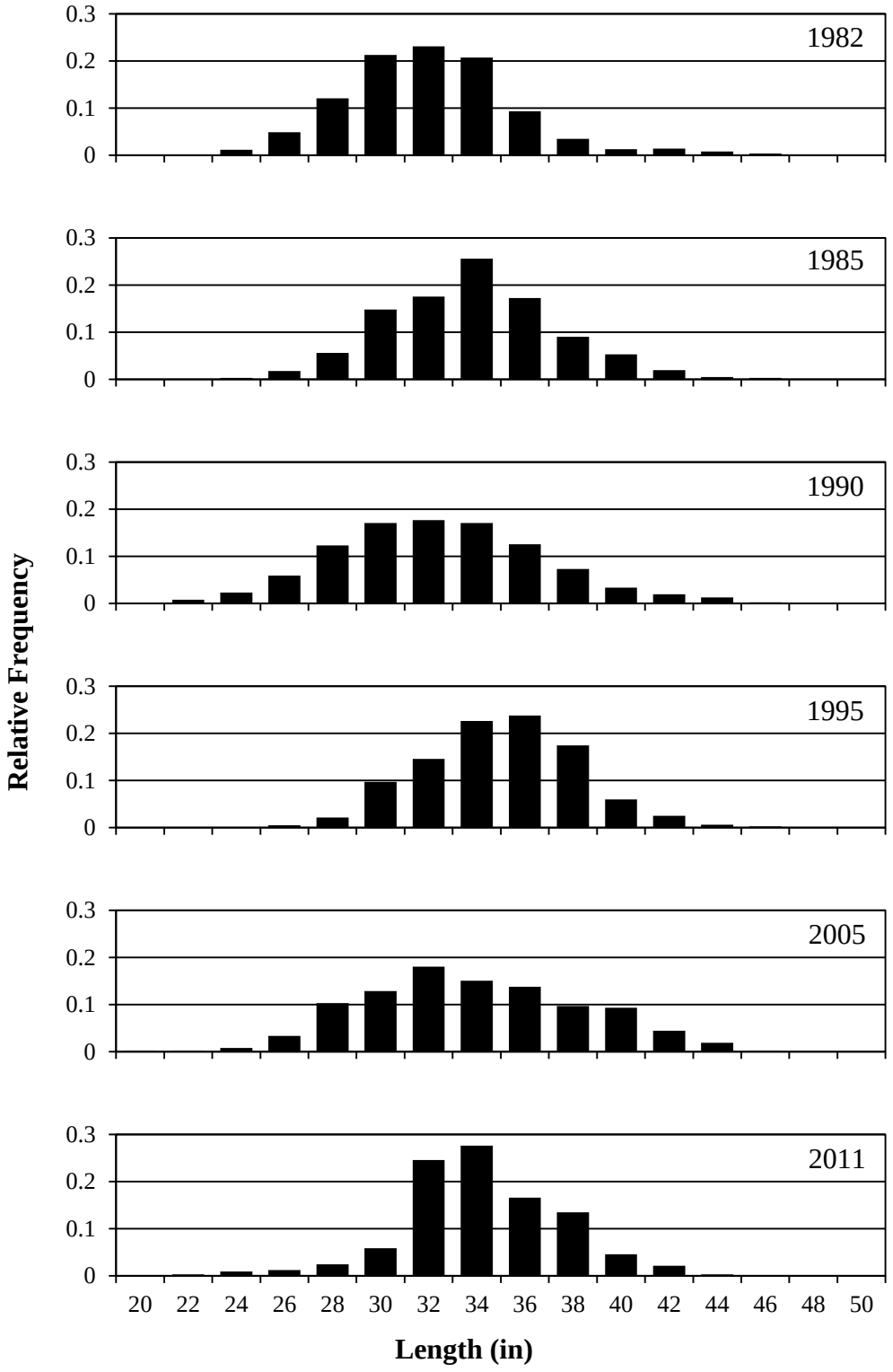

Figure 5. Relative frequency distributions of muskellunge collected from Bone Lake, Polk County, Wisconsin, 1982-2011.

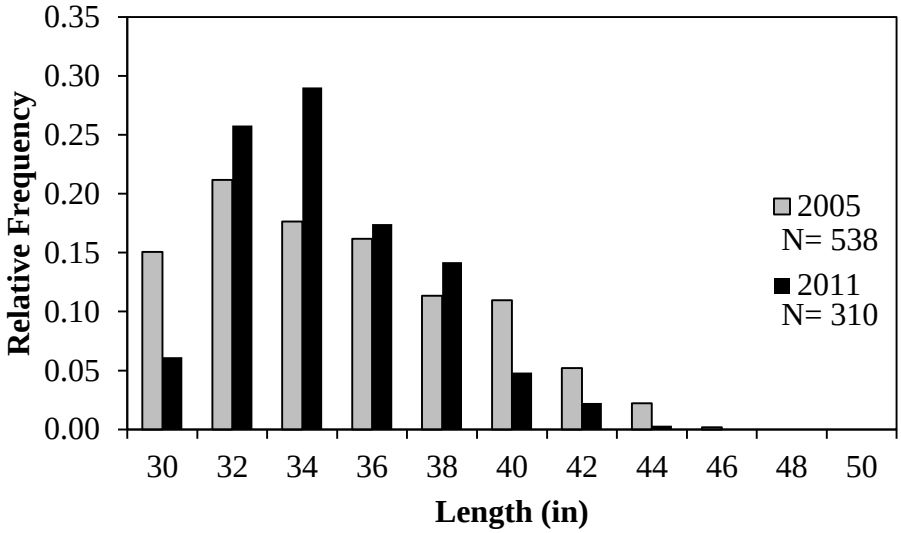

Figure 6. Relative frequency distribution of adult muskellunge (≥30 in) captured in Bone Lake, Wisconsin during the 2005 (N=538) and 2011 (N=310) muskellunge surveys.

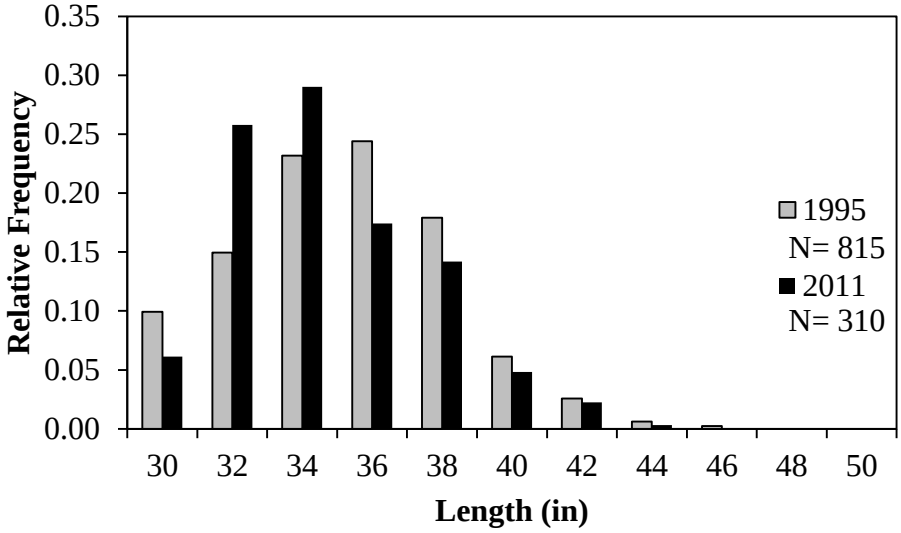

Figure 7. Relative frequency distribution of adult muskellunge (≥30 in) captured in Bone Lake, Wisconsin during the 1995 (N=815) and 2011(N=310) muskellunge surveys.

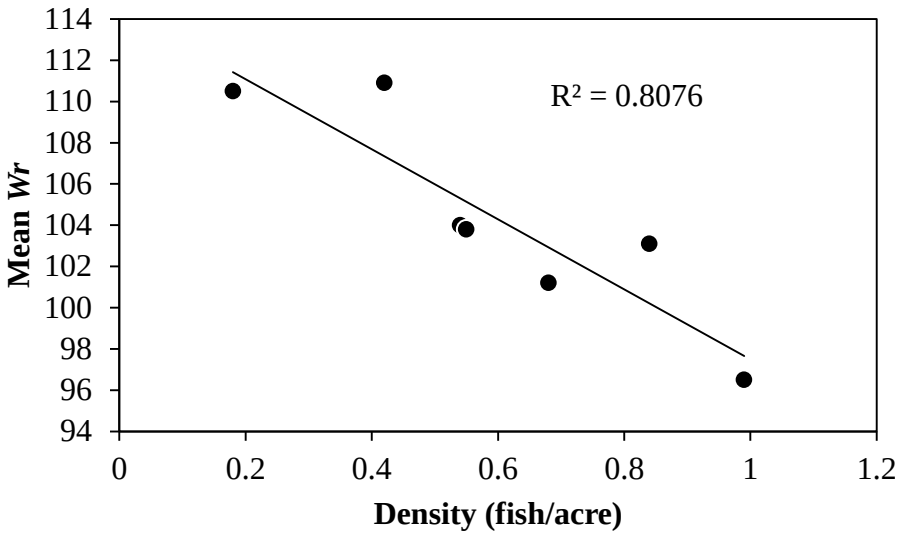

Figure 8. Mean relative weight (*Wr*) in relationship to density of adult muskellunge Bone Lake, Polk County, WI 1964-2011.