Status of the Muskellunge Fishery
Deer Lake, Polk County, WI, 2003
MWBIC Code: (2619400)

By

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Executive Summary

Deer Lake was chosen as a muskellunge *(Esox masquinongy)* trend monitoring lake by the Wisconsin Department of Natural Resources. Since 1998, muskellunge fishing regulations have consisted of a 40-inch minimum length limit, with a daily bag of one fish. Data from three sampling periods 1988, 1993 and 2003 were available to monitor trends in muskellunge population parameters and to determine the effect of a 40-in minimum length limit.

Muskellunge adult densities ($\geq$ 30.0 in) ranged from to 0.91, 0.89 to 0.49 fish/acre during the 1988, 1993 and 2003 sampling periods, respectively. In 2003, muskellunge adult densities have decreased 45% and 46% when compared to 1993 and 1988, respectively. Although adult densities have decreased over this time period, the number of legal length muskellunge ($\geq$ 40 in) has increased . In 2003, abundance of legal length muskellunge was 0.11/acre compared to .09/acre and .05/acre in 1993 and 1988, respectively. The abundance of legal length muskellunge in 2003 represented an increase of 21% and 55% since 1993 and 1988, respectively.

It's likely that a reduction in the muskellunge fingerling stocking regime is responsible for the decrease in muskellunge abundance. In addition, the increase in muskellunge $\geq$ 40 in is likely related to the existing regulation which was been in place since 1998 as well as possible changes in angler attitudes. Low numbers of muskellunge recruiting into the adult fishery and the absence of large trophy fish (45+ in) may be related to a combination of mortality and intraspecific competition affecting available food resources. Changes in stocking practices are recommended to maintain or improve the fishery, and future monitoring should occur within the next 8-10 years.

Introduction

Deer Lake is a 807-acre drainage lake with a maximum depth of forty-six feet and a mean depth of twenty-six feet located in western Polk County near St. Croix Falls, Wisconsin (Figure 1). The lake has an intermittent inlet and permanent outlet. A small concrete dam is located on the outlet with a head of approximately two feet. Private residential development is common along most of the shoreline of Deer Lake.

Muskellunge management began in Deer Lake in 1967. Muskellunge are not native to Deer Lake or any Polk County lakes (Becker 1983). The angling classification for Deer Lake is a Class A2 muskellunge water (WDNR 1996). The A2 classification is for waters that provide the most consistent angling action, and have the potential to produce some larger fish. The reproductive classification for Deer Lake is a Category 3 muskellunge water (WDNR 1996). The Category 3 classification describes waters where known natural reproduction of muskellunge is absent and stocking is necessary to provide maintenance of the population. Stocking of large fingerling muskellunge ($\geq$ 7 in) in Deer Lake has varied considerably since its initiation (Figure 2). Annual stocking of muskellunge occurred from a period of 1973-1993. Hybrid muskellunge were also stocked during this period (1973-1978). Inconsistent stocking occurred from 1993-2000 largely due to the closure/renovation of the hatchery in Spooner. Alternate year stocking of muskellunge began in 2000. Stocking rates of fingerling muskellunge have varied from 1-2 fish/acre.

Sport fishing regulations for muskellunge on Deer Lake have changed several times. In 1995, the minimum length limit was increased from 32- to 34-in. Three years later (1998) the minimum length limit was increased again from 34- to 40-in. Daily bag limit during this time remained at one fish.

Tribal spring spear harvest of muskellunge on Deer Lake began in 1990 and has occurred annually from 1995-2003. In addition, a tribal winter spear harvest occurs. However, harvest is not recorded during winter spearing and it is unknown what level of harvest occurs from this effort.

This study is part of a statewide long-term monitoring effort of muskellunge populations in Wisconsin. Specific parameters of muskellunge populations to be monitored include population abundance, size structure and growth. Knowledge of these population parameters allows for responsible management of the muskellunge fishery and sets the foundation for future management of muskellunge in Deer Lake.

Methods

Adult muskellunge were captured in two consecutive years using fyke nets (24-h sets) during the spring spawning period (Hanson 1986). Fyke nets had 4 X 6 ft frames with 1-in bar mesh and leads from 50 to 100 ft. Muskellunge were measured to the nearest 0.1 in (total length) and marked with a fin clip. All muskellunge handled were sexed (when possible) by presence of eggs or milt or by visual inspection of the urogenital pore (LeBeau and Pageau 1989). A subsample of muskellunge were also weighed to the nearest ounce.

Abundance of adult muskellunge ($\geq$ 30 in) was estimated using Bailey's modification of the Petersen method (Ricker 1975). Muskellunge captured in the first year were marked for recapture in the second year. Numbers of fish captured in the second year were adjusted for recruitment over a 1-year period using sex-specific growth rates. Several independent estimates were calculated: (1) mature muskellunge of each sex 30 in and greater and (2) mature muskellunge, sexes combined, 30.0-33.9 in, 34.0-37.9 in, 38.0 in and greater, and 40.0 in and greater. Number of adult muskellunge 40 in and greater was determined from the proportion of muskellunge 40 in and greater handled in the marking run times the abundance estimate for fish 38 in and greater.

Size structure and condition of muskellunge were determined from spring sampled fish. Relative stock density (RSD) was used to describe population size structure (Anderson and Gutreuter 1983), with 30 in as stock size (Hanson 1986), and relative weight (*W*r; Neumann and Willis 1994) to describe condition of muskellunge. RSD represents the percent of fish larger than the stock length that are larger than a specified length (e.g. RSD-34). Relative weight values from 1988 and 1993 were not available for comparison purposes.

Growth information for muskellunge was derived from cleithra collected from a representative sample in 2004 (Margenau and AveLallemant 2000). Growth information was compared with a growth standard for the species (Casselman and Crossman 1986) by calculating percentages of the standard (ages 5-10). In addition, growth information was fitted to a von Bertalanffy equation (Prager et al. 1989) to predict the maximum asymptotic length ($L\infty$) of male and female muskellunge in Deer Lake. Changes in population size structure were determined using Kolmogorov-Smirnov test and changes in mean length using *t*-tests.

Results

Abundance of adult muskellunge (≥ 30 inches) has decreased since 1988 (Table 1). Abundance of adult muskellunge in 2003 was 392 (0.49 fish/acre). In comparison, abundance in 1993 was 726 (0.90 fish/acre) and in 1988 was 730 (0.90 fish/acre) . Lower abundance was especially noticeable in the smaller length groups. Abundance of 30.0-33.9 in muskellunge was 43 in 2003 compared to 153 (1993) and 350 in 1988 (Table 1). Similarly, abundance of 34.0-37.9 in muskellunge decreased from 408 in 1993 to 187 in 2003 (Table 1). Abundance of large muskellunge (≥ 40 in) increased. In 1988, large muskellunge abundance was estimated at 40 fish, increased to 70 fish in 1993, and to 87 fish in 2003 (Table 1).

Mean length of muskellunge in Deer Lake has increased since 1988. Mean length of all adult muskellunge (sexes combined) has increased from 34.8 in in 1988 to 35.7 in in 1993, and then to 37.3 in in 2003. Mean length of male muskellunge has increased significantly in each of the three sampling periods (Table 2). Mean length of male muskellunge increased from 33.2 in (1988) to 34.5 in (1993) to 35.6 in (2003). Mean length of female muskellunge has increased from 1988 to 2003, however no significant increase occurred from 1988 to 1993 (Table 2). Mean length of female muskellunge during the three sampling periods was 37.5 in (1988), 37.4 in (1993), and 39.1 in (2003).

The overall size structure of adult muskellunge has shifted to a higher percentage of larger fish since previous surveys. This shift occurred between both the 1988 and 1993 surveys ($D = 0.16$, $P = 0.0002$) and the 1993 and 2003 surveys ($D = 0.22$, $P < 0.0001$). Changes in the size structure of muskellunge was also evident with stock density indices (RSD). RSD-34 values increased from 63 to 78 between 1988 and 1993, and then again to 85 in 2003 (Table 3). RSD-40 values were 22 in 2003 compared to 10 and 8 in 1988 and 1993, respectively. It appears that the greatest shift occurred since 1993 with increased numbers of muskellunge from 38- to 46-in (Figure 3).

Adult muskellunge in Deer Lake were in good condition in 2003 as suggested by relative weight values. Relative weight of muskellunge 30-33.9 in was 102 (SE = 2.8, N = 18). Larger muskellunge length groups had mean relative weights that were lower (34 –37.9 in, Wr = 96, SE = 1.0, N = 77; 38+ in, Wr = 97, SE = 1.0, N = 68), however still considered to be in good condition.

Growth of male and female muskellunge in Deer Lake was slightly slower, but still similar to growth rates in 1995. In 2003, a male muskellunge would reach 30 in sometime during its 6th year of growth while

a female would likely reach 30 in sometime during the 5th year. Growth rates (ages 5-10) averaged 82% (SD = 0.02) of the growth standard and showed little variation with age (Table 4). Projected asymptotic maximum length ($L\infty$) of male Deer Lake muskellunge was 39.9 in (SE = 0.95, N = 4), and for female Deer Lake muskellunge was 44.4 in (SE = 1.83, N = 5). Considering the upper 95% confidence limits of these projections, a male muskellunge in Deer Lake could potentially reach 42 in, while a female muskellunge could reach 48 in. Based on growth interpretations, Deer Lake muskellunge had potential to live long lives, with male longevity up to 18 years and females up to 16 years.

Discussion

Muskellunge abundance in Deer Lake has decreased since 1988. Nevertheless, the current population (0.49 fish/acre) is slightly above the mean range (0.36-0.42 fish/acre) reported by Margenau and AveLallemant (2000) for 15 northern Wisconsin lakes. The 1988 and 1993 Deer Lake harbored a high-density muskellunge population. By 2003, the population decreased by nearly half. The reduction of the muskellunge population was likely caused by a change in stocking practices. Following 1993, muskellunge stocking was sporadic and less than half of what it had been in prior years . This change in stocking has likely reduced recruitment of muskellunge into the fishery lowering adult densities.

The muskellunge size structure shift toward larger fish in 2003 can likely be attributed to several factors. The 40-inch minimum length limit initiated in 1998 has provided protection to fish < 40 in and contributed not only to the increase in legal length fish, but also fish that may have been subject to harvest previous to the regulation change (Figure 3). A similar increase in legal length muskellunge occurred on nearby Bone Lake, Polk County, Wisconsin in response to a 40-inch minimum length limit (Cornelius and Margenau 1999). Another factor that may contribute to the increase in larger muskellunge is changes in angler attitude. Margenau and Petchenik (2004), in an opinion survey of anglers who fish muskellunge in Wisconsin, indicated that both muskellunge and general anglers were more likely to release a legal length muskellunge in 1999 than they were only ten years earlier in 1989. Considering the Deer Lake data set represents a similar time period (1988-2003) it is reasonable to assume that this change in angler attitude could also likely play a role in the increase in larger muskellunge in Deer Lake.

In spite of the improved size structure in Deer Lake, the muskellunge length distribution in all sampling years truncated in the mid-40 in range. The absence of fish 45 in and longer may be the result of several

factors. Muskellunge harvest, both sport angler and tribal, may contribute to the Deer Lake size structure. Because of it's proximity to the Minneapolis/St. Paul, MN metropolitan area, Deer Lake receives extensive pressure from nonresident muskellunge anglers in addition to resident muskellunge anglers. While no creel survey has ever been conducted on Deer Lake, observations of muskellunge sampled during spring netting in 2003 indicated 13% of fish handled (N = 207) had visually noticeable injuries/scars on the mouth/head region likely the result of a previous experience with being hooked and released. With such a high probability of encountering an angler, chances of a muskellunge being harvested as a trophy are expected to increase as fish length increases. (Margenau and Petchenik (2004) noted nearly all muskellunge anglers felt a muskellunge needed to be at least 40 in to be considered a trophy.) In addition, incidental mortality from handling and hooking injuries on released fish may have an effect on ultimate length in fisheries with high angling pressure. Tribal spearing harvest of muskellunge during spring 2003 was eight fish that averaged 39.3 in (Krueger 2004). It is reasonable that the combined effects of sport angler harvest, indirect mortality from hooking/handling, along with tribal spear harvest (open water and ice) may limit muskellunge in the Deer Lake population from reaching lengths > 50 in. Casselman et al. (1996) suggested that with a 2% increase in mortality, recruitment would need to be doubled to maintain the number of trophy muskellunge in a population.

Poor growth rates, especially for muskellunge age 6 or older, may also limit the potential to reach 50 in. Slow growth or stunting often is associated with high density fisheries where food resources are limited. In Deer Lake adult densities have been near 1 adult/acre from 1988 until at least the mid-1990s. Such an abundance of top-level predators may have long lasting effects on the forage base. While muskellunge relative weight in Deer Lake was good (mean = 97) in 2003, no previous data exists to compare how condition was in previous sampling periods. In a similar case history, Bone Lake (Polk County) had good relative weights (mean = 96) in 1995, however these were considerably lower than in previous years when the mean was as high as 110 (Cornelius and Margenau 1999). The authors suggest that where artificially high densities of top predators such as muskellunge are established the fish community structure can be altered, and when these changes occur they will likely take a long time to correct. Of particular interest is our finding of lower relative weight values for larger muskellunge in Deer Lake. Muskellunge are known to utilize a large range in prey sizes, and as muskellunge size increases the size of potential prey also increases (Bozek et al. 1999). When large prey are in low abundance, foraging time and energy would be

increased thus reducing the amount of caloric intake available for somatic growth. While no data is available to substantiate the type and abundance of available forage in Deer Lake, such intraspecific competition by length group has been documented with walleye *Sander vitreus* (Porath and Peters 1997).

The maximum asymptotic length projections for Deer Lake seemed to fit the actual field data well in spite of low sample sizes that generated the estimates (males N = 4, females N = 5). The von Bertalanffy equation projected maximum length of a male muskellunge in Deer Lake between 39.9 and 42 in (mean plus upper 95% confidence interval). The largest male muskellunge handled in 2003-2004 sampling was 42.8 in. The projected maximum length for female muskellunge in Deer Lake was between 44.4 and 48 in (mean plus upper 95% confidence interval). The largest female muskellunge handled in 2003-2004 was 45.3 in. This tool will be of value in future assessments for following trends in growth and ultimate length potential.

The absence of smaller/younger-aged muskellunge in the fishery warrants attention. More specifically, abundance of 30.0-33.9 inch muskellunge was considerably lower in 2003 (N=47) when compared to 1993 (N=153) and 1988 (N=350). Changes in stocking regime in 1993 and inconsistent stocking since the mid-1990s has likely created this situation. Prior to 1993 the fishery was stocked on an annual basis with high numbers of large fingerling muskellunge. A similar decline of muskellunge in the same age/size of fish was also documented on Namekagon Lake in Bayfield County, Wisconsin (Toshner 2004). With a desirable density of adult muskellunge in Deer Lake (approximately 0.5 fish/acre) there is no need to re-initiate historic stocking rates and densities. A target stocking rate should be roughly half of what had been stocked based on historic stocking levels. When comparing historic stocking from 1980-1990, the mean stocking density was 1,470 large fingerlings/year. This resulted in a high-density fishery of 0.90 fish/acre. The existing density in 2003 was 0.49 fish/acre or 45% lower than historic records. If the stocking rate was changed to 1.5 fish/acre (1,210 fish) on an alternate year basis this stocking rate should be close in maintaining the abundance levels near 0.5 fish/acre.

Summary and Management Recommendations

1. The current 40-inch minimum length limit and daily bag limit of 1, has resulted in a quality-sized muskellunge population. Muskellunge densities $\geq$ 40 inches are 21% higher than before the initiation of the regulation change. The adult muskellunge fishery ($\geq$ 30 in) should be maintained between 0.4-0.6 fish/acre. The legal muskellunge numbers ($\geq$ 40 in) should be at least 0.10 fish/acre.
2. Muskellunge stocking should be maintained at 1.5 fingerlings/acre or 1,210 fish on an alternate year basis. This management strategy provides constant recruitment of muskellunge into the fishery and should maintain or improve the desired density/quality-sized fishery present in 2003. (Note: In 2005, Deer Lake was chosen as a candidate lake for a comparison stocking evaluation of Leech Lake (Minnesota) and Wisconsin strain Muskellunge. Stocking densities will likely be adjusted for a period of several years for the purposes of this study).
3. Periodic sampling of the muskellunge population on Deer Lake should continue. Deer Lake is in the existing muskellunge trends monitoring program and should be surveyed again within the next 8-10 years. Special attention should be given to changes in growth rates, size structure shifts that increase the number of muskellunge larger than 45 in, and recruitment of muskellunge into smaller length groups. Options should be considered to monitor sport angler pressure and harvest of muskellunge, and tribal ice/winter harvest. The former may be accomplished utilizing voluntary angler diaries while the latter may be available through the local tribal biologists or Great Lakes Indian Fish and Wildlife Commission. In addition, some assessment of the entire fish community in Deer Lake would be advantageous. This may be accomplished through the baseline monitoring protocol.

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Table 1. Abundance estimates of adult muskellunge by sex and length-group for Deer Lake, Polk County. 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
1988	468 (21.6)	262 (21.4)	350 (24.8)	286 (23.7)	101 (28.0)	40 (33.4)
1993	359 (15.5)	367 (24.4)	153 (22.7)	408 (16.7)	160 (44.7)	70 (45.1)
2003	174 (13.6)	218 (14.6)	43 (27.7)	187 (14.8)	153 (14.7)	87 (16.0)

Table 2. Mean (SE) total lengths (inches) of adult muskellunge sampled with fyke nets in Deer Lake, Polk County, Wisconsin. Whole numbers centered below means are sample size. Asterisks represent a significant difference ($P < 0.01$) in mean length from previous sampling period, and ns represents no significant difference ($P = 0.85$).

Year	Male	Female	Combined
1988	33.2 (0.19) 218	37.5 (0.28) 132	34.8 (0.19) 350
1993	34.5 (0.15) ** 216	37.4 (0.25) ns 138	35.7 (0.15) ** 354
2003	35.6 (0.21) ** 126	39.1 (0.26) ** 128	37.3 (0.20) ** 259

Table 3. Muskellunge relative stock density values , Deer Lake, Polk County, Wisconsin. 95% confidence intervals are in parenthesis.

Year	RSD-34	RSD-40
1988	63 (5)	10 (3)
1993	78 (4)	8 (3)
2003	85 (3)	22 (6)

Table 4. Calculated length at age (from cleithra) of Deer Lake muskellunge compared with the growth standard for the species (Casselman and Crossman 1986). Length is reported in inches and sample size for growth calculations for Deer Lake are in parenthesis.

Age	Deer Lake, WI	Growth Standard	Percent of Growth Standard
5	28.1 (12)	35.0	80.3
6	30.8 (12)	36.9	83.5
7	32.2 (11)	38.6	83.4
8	33.5 (10)	40.1	83.5
9	33.6 (7)	41.5	81.0
10	34.8 (7)	42.7	81.5
	Mean		82.2

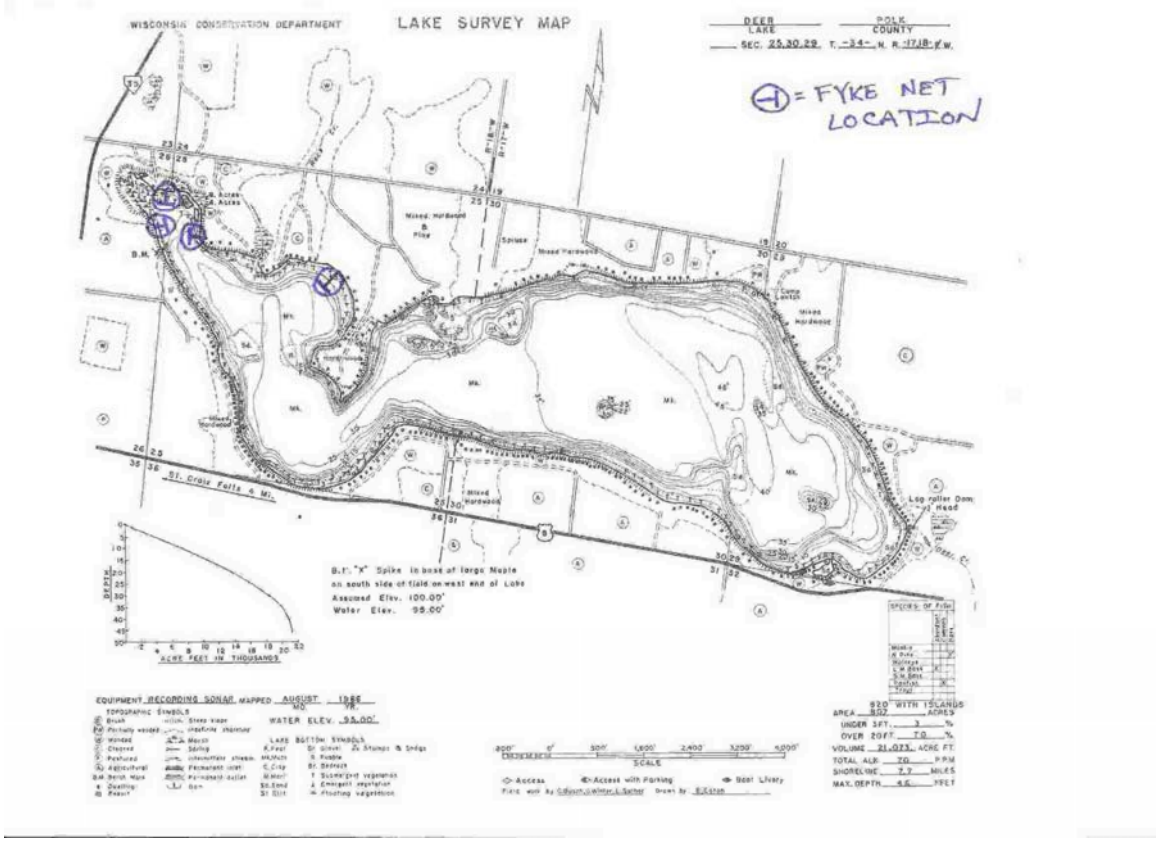

Figure 1. 2003-2004 fyke netting locations for muskellunge, Deer Lake, Polk County, Wisconsin.

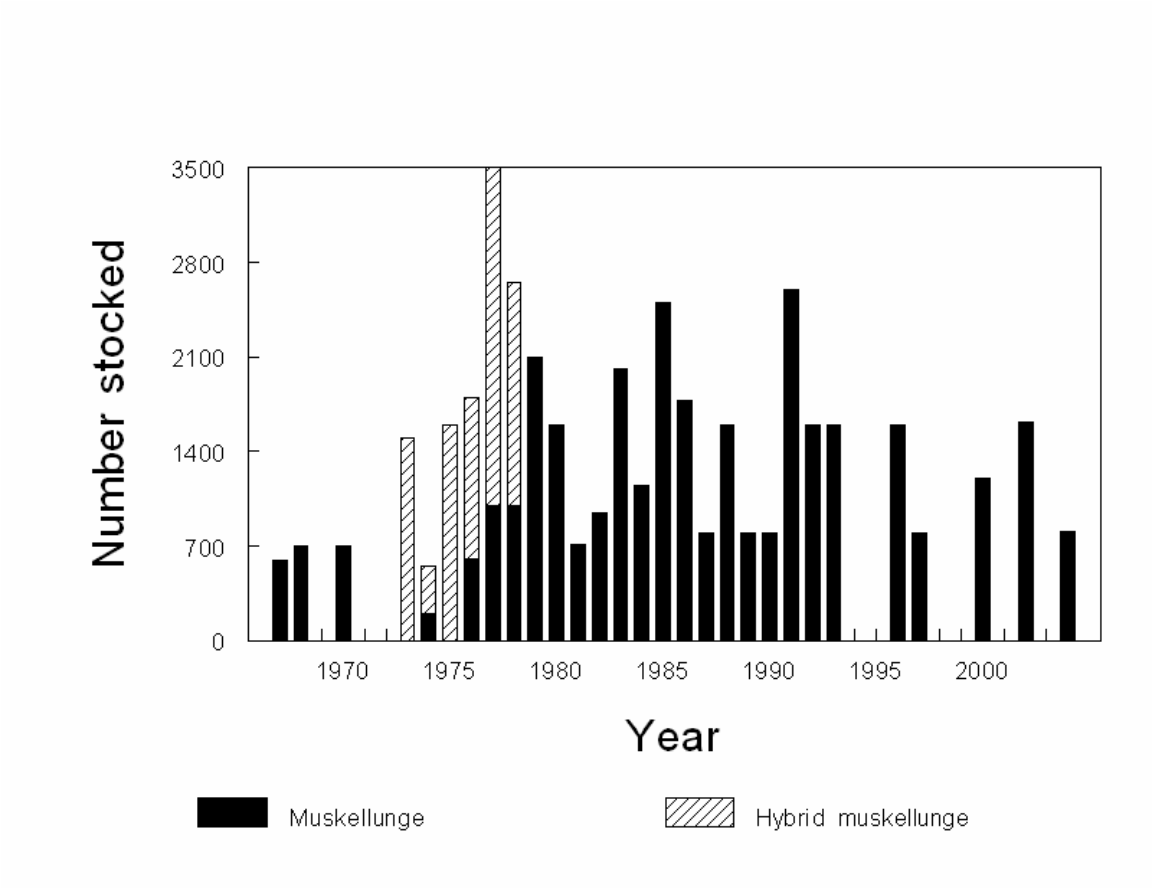

Figure 2. Large fingerling (≥ 7in) muskellunge stocking in Deer Lake, Polk County, Wisconsin.

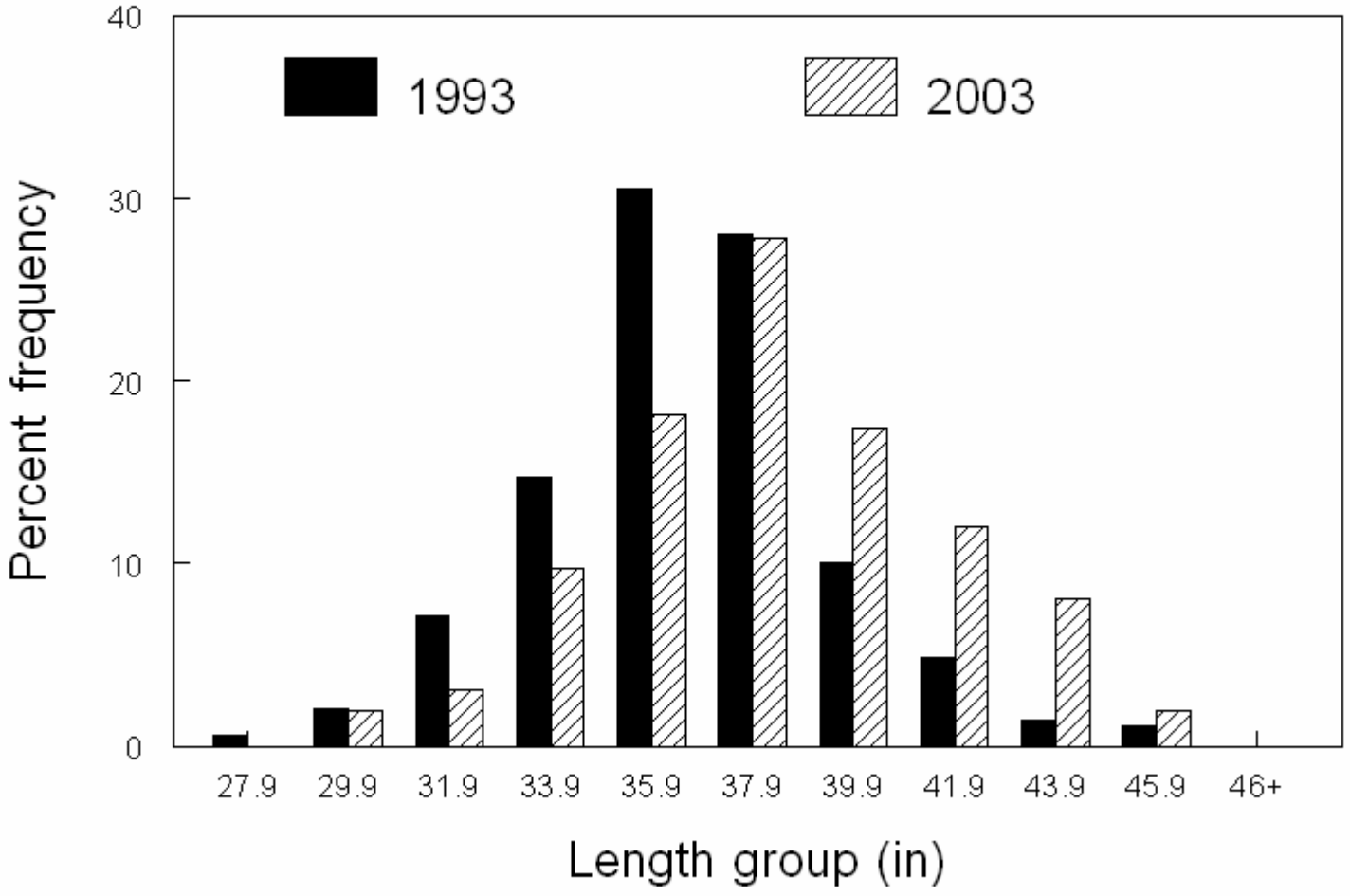

Figure 3. Percent length frequency distribution of muskellunge in Deer Lake, Polk County, 1993 (N = 354) and 2003 (N = 259). Length intervals on x-axis are two-inch groups with the upper increment listed (i.e. 39.9 length group includes fish measuring from 38.0 to 39.9 inches).

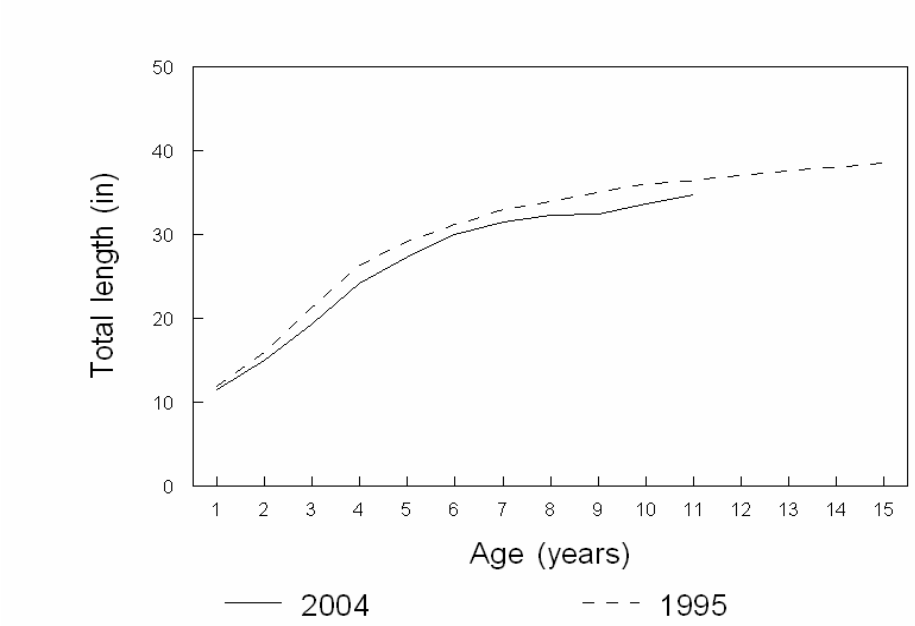

Figure 4. Growth of male muskellunge in Deer Lake, Polk County, 1995 and 2004.

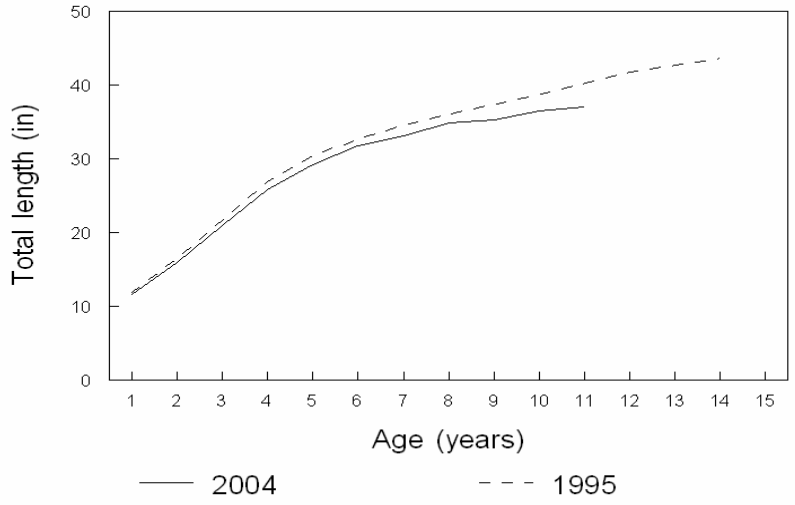

Figure 5. Growth of female muskellunge in Deer Lake, Polk County, 1995 and 2004.