WISCONSIN DEPARTMENT OF NATURAL RESOURCES

2022 Crescent Lake Fisheries Survey Report

Waterbody Code: 1564200

Photo Credit: Lakeland Aerial

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February 2024

Table Of Contents

Methods 6
Survey effort 6
Population demographics 7
Results 9
Black crappie 9
Bluegill 10
Largemouth bass 10
Muskellunge 12
Northern pike 14
Pumpkinseed 15
Rock Bass 16
Smallmouth Bass 17
Walleye 17
Yellow Perch 21
Other species 22
Discussion 22
Recommendations 24
Acknowledgments 25
References 25

Introduction

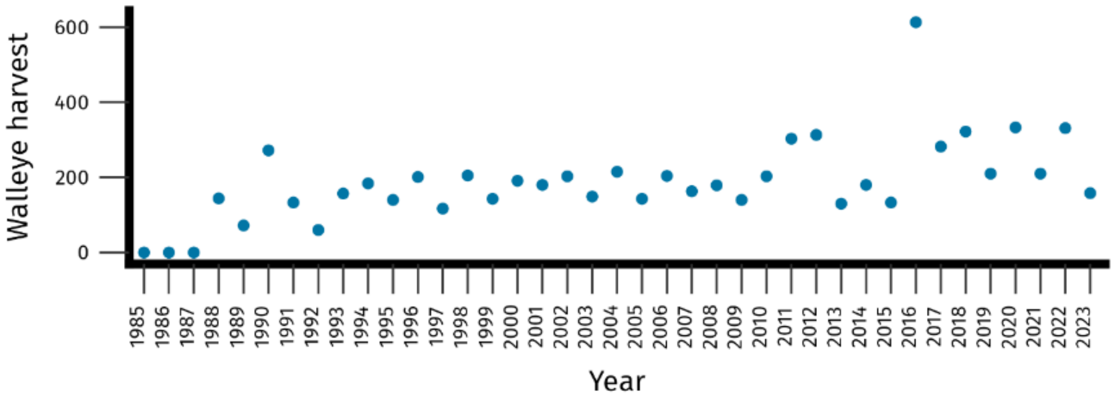
Crescent Lake is a 616-acre, deep, lowland lake 11 miles west of Rhinelander in south central Oneida County, Wisconsin. Public access is provided to Crescent Lake off U.S. Highway 8 by a ramp updated in 2005. Crescent Lake has about 7.4 miles of shoreline and an average depth of 17 feet. Water conditions in Crescent Lake support aquatic life, recreation, public health and welfare and wildlife. Crescent Lake is a fertile system facilitating ample aquatic vegetation growth. Invasive species of Eurasian watermilfoil, purple loosestrife, rusty crayfish and yellow iris have established in Crescent Lake. Additional information on Crescent Lake can be found at the Wisconsin Department of Natural Resources' (DNR) Lake Page.

The 237 property owners, one camp, the public and tribal members utilize Crescent Lake year-round. A complex-cool-clear water fishery allows anglers to target a variety of fish species within Crescent Lake (Rypel et al. 2019). Winter angling was the preferred fishing season on Crescent Lake during the most recent creel survey in 2010-2011 (Tobias 2011). Walleyes were commonly targeted when angling, with harvest around 900 individuals each year (Tobias 2011). Tribal members utilize the fishery during the spring, harvesting an average of 283 walleyes and 2.5 muskellunge per year (Figure 1). Anglers also regularly target yellow perch, muskellunge and northern pike within Crescent Lake (Tobias 2011).

The DNR consults with the Crescent Lake District, Crescent Lake Association, Great Lakes Fish and Wildlife Commission (GLIFWC) and Sokaogon Chippewa Community Mole Lake Band of Lake Superior Chippewa while managing Crescent Lake. Aquatic plant management began in 2016 by the lake district (Gabbard and Premo 2021), with hand removals of Eurasian watermilfoil and herbicide treatments in 2019 (Table 1). Fishery monitoring has been conducted by the DNR, GLIFWC, Sokaogon Chippewa Community Mole Lake Band of Lake Superior Chippewa and the University of Wisconsin–Stevens Point focusing on species of high recreational value (Table 2). Fishery monitoring suggested a decrease in reproductive success of muskellunge and walleye, resulting in stocking to rehabilitate those fisheries (Table 3). Water quality has been monitored through the Citizen Monitoring Program since 1986.

The objectives of the 2022-2023 fishery survey on Crescent Lake were to:

1. assess the status of the fish community.
2. attain bass, muskellunge and walleye population estimates.
3. update fisheries management recommendations.



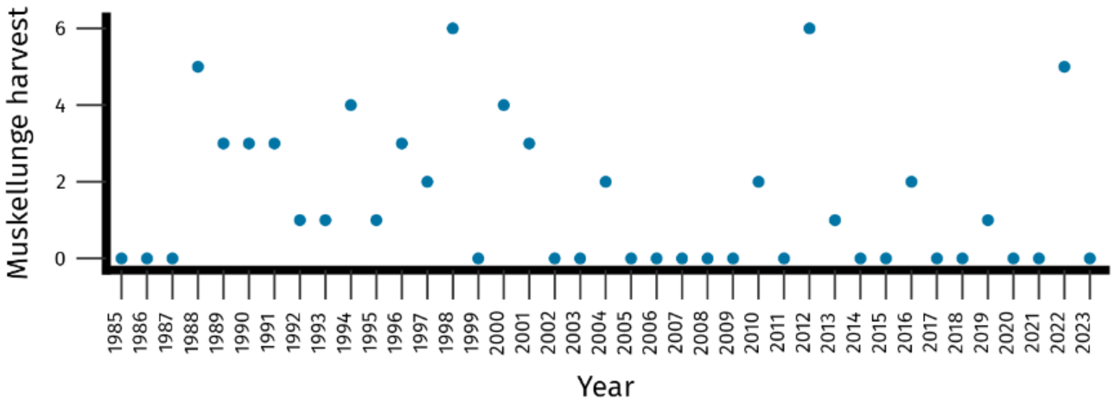


Figure 1. Tribal spearing harvest for walleye (top) and muskellunge (bottom) on Crescent Lake, Oneida County, Wisconsin through time.

Table 1. Aquatic plant management conducted by the lake district and lake association in Crescent Lake, Oneida County, Wisconsin.

YEAR	TREATMENT	EFFORT
2016	hand removal	41 hours
2017	hand removal	148.5 hours
2018	hand removal	472 hours
2019	procellaCOR	15.2 acres treated
	diver assisted suction	213 hours
2020	procellaCOR	11.23 acres treated
	diver assisted suction	114.5 hours
2021	procellaCOR	21 acres treated
2022	procellaCOR	67 acres treated
	diver assisted suction	3 days
2023	diver assisted suction	4 days

Table 2. Fish surveys from 1976-2023 on Crescent Lake Oneida County, Wisconsin.

YEAR	TYPE	GEAR	TARGET SPECIES	SURVEY PURPOSE
1976	SN 1	fyke net	walleye	mark-recapture census
	SN 2	fyke net	muskellunge	relative abundance
	SE 2	boom shocker	walleye	population estimate
	FE	boom shocker	juvenile walleye	recruitment monitoring
1980	FE	boom shocker	juvenile gamefish	recruitment monitoring
1988	FE	boom shocker	juvenile walleye	recruitment monitoring
1989	SN1	fyke net	walleye	mark-recapture census
1990	FE	boom shocker	juvenile walleye	recruitment monitoring
1991	FE	boom shocker	juvenile walleye	recruitment monitoring
1992	SE 1	boom shocker	walleye	population estimate
	Creel	survey	all	effort and harvest
	FE	boom shocker	juvenile walleye	recruitment monitoring
1993	FE	boom shocker	juvenile walleye	recruitment monitoring
1994	FE	boom shocker	juvenile walleye	recruitment monitoring
1995	FE	boom shocker	juvenile walleye	recruitment monitoring
1996	FE	boom shocker	juvenile walleye	recruitment monitoring
1997	FE	boom shocker	juvenile walleye	recruitment monitoring
1998	FE	boom shocker	juvenile walleye	recruitment monitoring
1999	FE	boom shocker	juvenile walleye	recruitment monitoring
2000	SN 1	fyke net	walleye	mark-recapture census
2001	FE	boom shocker	juvenile walleye	recruitment monitoring
2002	FE	boom shocker	juvenile walleye	recruitment monitoring
2003	FE	boom shocker	juvenile walleye	recruitment monitoring
2004	FE	boom shocker	juvenile walleye	recruitment monitoring
2005	FE	boom shocker	juvenile walleye	recruitment monitoring
2006	SE 1	boom shocker	walleye	population estimate
2006	FE	boom shocker	juvenile walleye	recruitment monitoring
2007	FE	boom shocker	juvenile walleye	recruitment monitoring
2008	FE	boom shocker	juvenile walleye	recruitment monitoring
2009	FE	boom shocker	juvenile walleye	recruitment monitoring
2010	SN 1	fyke net	walleye	mark-recapture census
	SN 2	fyke net	muskellunge	relative abundance
	SE 1	boom shocker	walleye	population estimate
	SE 2	boom shocker	basses	population estimate
	FE	boom shocker	juvenile walleye	recruitment monitoring
	Creel	survey	all	effort and harvest
2011	SN 2	fyke net	muskellunge	population estimate
2012	FE	boom shocker	juvenile walleye	recruitment monitoring
2013	FE	boom shocker	juvenile walleye	recruitment monitoring
2014	FE	boom shocker	juvenile walleye	recruitment monitoring
2015	SE 1	boom shocker	walleye	population estimate
	FE	boom shocker	juvenile walleye	recruitment monitoring
2016	FE	boom shocker	juvenile walleye	recruitment monitoring
2017	FE	boom shocker	juvenile walleye	recruitment monitoring

YEAR	TYPE	GEAR	TARGET SPECIES	SURVEY PURPOSE
2018	FE	boom shocker	juvenile walleye	recruitment monitoring
2019	FE	boom shocker	juvenile walleye	recruitment monitoring
2021	FE	boom shocker	juvenile walleye	recruitment monitoring
2022	SN 1	fyke net	walleye	mark-recapture census
	SN 2	fyke net	muskellunge	relative abundance
	SE 1	boom shocker	walleye	population estimate
	SE 2	boom shocker	basses	population estimate
	FE	boom shocker	juvenile walleye	recruitment monitoring
2023	SN 2	fyke net	muskellunge	population estimate
	FE	boom shocker	juvenile walleye	recruitment monitoring

Table 3. Fish stockings from 1955-2023 into Crescent Lake, Oneida County, Wisconsin.

YEAR	SPECIES	AGE CLASS	NUMBER STOCKED	SOURCE
1955	walleye	fingerling	6,600	DNR
1956	muskellunge	fingerling	33	DNR
1957	muskellunge	fingerling	1,490	DNR
1958	muskellunge	fingerling	276	DNR
1960	walleye	fingerling	5,600	DNR
1961	muskellunge	fingerling	275	DNR
1962	muskellunge	fingerling	500	DNR
1964	muskellunge	fingerling	3,382	DNR
1966	muskellunge	fingerling	935	DNR
1967	walleye	fingerling	13,625	DNR
1968	muskellunge	fry	825	DNR
1969	walleye	fingerling	10,000	DNR
1970	muskellunge	fingerling	1,200	DNR
1971	walleye	fingerling	13,475	DNR
1972	muskellunge	fingerling	800	DNR
1974	walleye	fingerling	15,000	DNR
1975	muskellunge	fingerling	667	DNR
1976	walleye	fingerling	30,000	DNR
1978	muskellunge	fingerling	1,184	DNR
1980	muskellunge	fingerling	1,200	DNR
1982	muskellunge	fingerling	125	private
1982	walleye	fingerling	30,000	DNR
1984	muskellunge	yearling	775	DNR
1985	muskellunge	yearling	12	private
1986	muskellunge	fingerling	1,200	DNR
1988	muskellunge	fingerling	1,286	DNR
1989	walleye	fingerling	30,000	DNR
1990	muskellunge	fingerling	200	DNR
1990	muskellunge	fingerling	1,000	DNR
1991	muskellunge	fingerling	300	DNR
1992	muskellunge	fingerling	300	DNR
1993	muskellunge	fingerling	300	DNR
1996	muskellunge	fingerling	1,200	DNR
1998	muskellunge	large fingerling	600	DNR
2000	muskellunge	large fingerling	600	DNR
2015	muskellunge	large fingerling	153	DNR
2016	muskellunge	large fingerling	154	DNR
2018	muskellunge	large fingerling	140	DNR
2021	walleye	small fingerling	21,555	DNR
2022	muskellunge	large fingerling	154	DNR
2023	walleye	large fingerling	9,236	DNR

Methods

A fishery survey was conducted on Crescent Lake following the comprehensive treaty assessment protocol [(Cichosz 2021)]() during the spring and fall of 2022 and 2023. Spring fyke netting for walleye (SN 1), northern pike (SN 1) and muskellunge (SN 2), early spring electrofishing for walleye (SE 1), late spring electrofishing for bass and panfish (SE 2) and fall electrofishing (FE) for juvenile gamefish occurred (Figure 2).

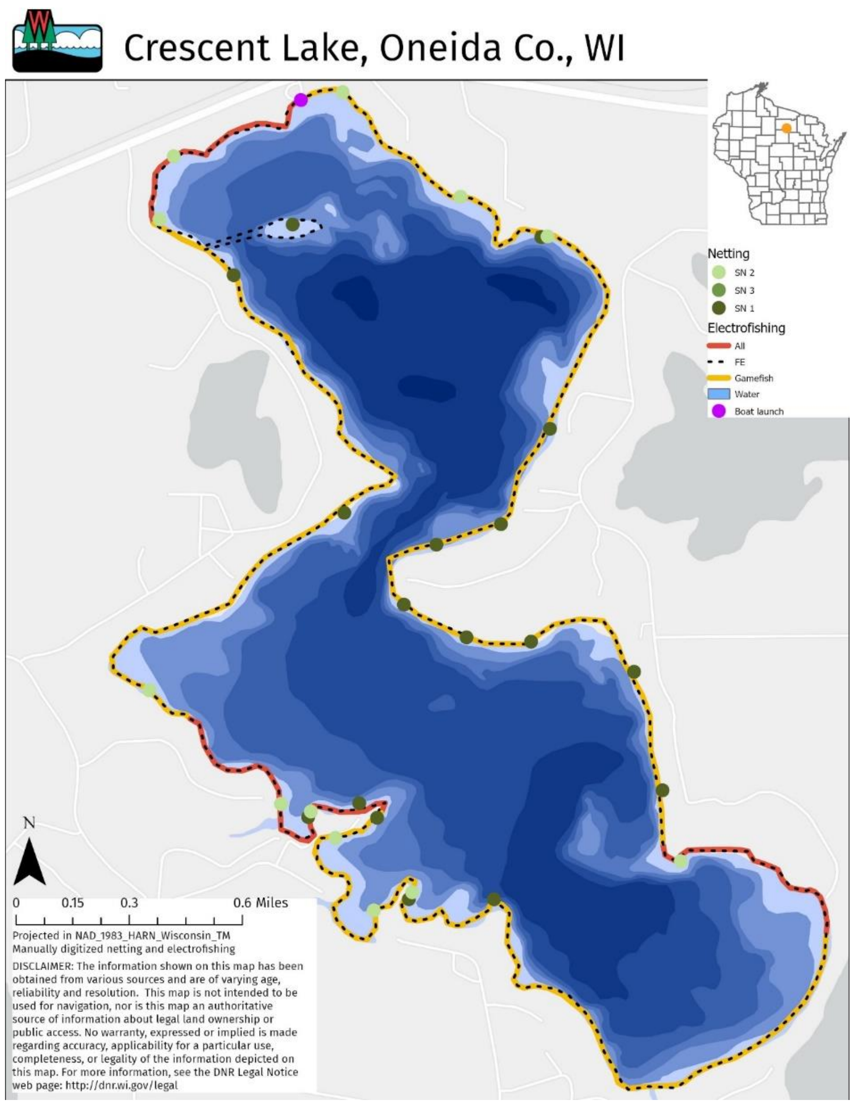


Figure 2. Sampling locations among the various capture gears used within Crescent Lake during the 2022-2023 comprehensive survey.

SURVEY EFFORT

Spring netting surveys were conducted in 2022 (SN 1 and SN 2) and 2023 (SN 2) on Crescent Lake. Following ice-out, fyke nets were set on May 2 and fished until May 9, 2022 targeting walleye and muskellunge. Fyke nets set on May 9 and fished until May 12, 2023 targeted muskellunge.

Early spring electrofishing (SE 1) targeting walleye was conducted on the night of May 6, 2022. Three late spring electrofishing (SE 2) runs targeting bass and panfish were conducted during 2022. One of those SE 2 runs included 3 half mile stations where all fish species were targeted, while over the remaining shoreline gamefish were targeted. Subjectively selected areas throughout Crescent Lake were sampled with nonstandard boat electrofishing by the University of Wisconsin–Stevens Point on May 25 and May 26, 2022, increasing the number of largemouth bass and smallmouth bass marks at large for population estimation. Fall electrofishing targeted juvenile gamefish across the entire shoreline on the nights of September 14, 2022 and September 20, 2023.

Gamefish captured during sampling were measured to the nearest 0.1 inch, and sex was noted when evident based on expression of eggs or milt. Largemouth bass, northern pike, smallmouth bass and walleyes were marked with a left ventral fin clip and released in 2022. Muskellunge were checked for a PIT (passive integrated transponder) tag, and if one was not found, a PIT tag was placed internally adjacent to the dorsal fin and released. Newly captured adult muskellunge had their first anal fin ray removed for age estimation. Dorsal fin rays were collected from five walleyes within every half-inch increment of each sex for age estimation. Counts were recorded for all other species.

POPULATION DEMOGRAPHICS

Abundance was indexed with a population estimate and density (number per acre) for select species. Walleye (individuals ≥ 15 inches or sexable), largemouth bass (≥8 inches) and smallmouth bass (≥8 inches) populations were estimated using Chapman's version of the Petersen method (Chapman 1951) utilizing the proportion of marked to unmarked individuals

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

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 (≥30 inches or sexable) population was estimated using the Bailey's version of the Peterson method (Bailey 1951) utilizing the proportion of marked to unmarked individuals

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

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. The abundance of muskellunge in 2022 was adjusted for recruitment over the 1-year time period. Females < 32 inches and males < 31 inches were excluded from the adult population estimate because they were assumed to have been < 30 inches during the 2022 marking.

Relative abundance was used as an index of abundance for species when no population estimate was generated. Bluegill, pumpkinseed and rock bass relative abundance was indexed as the number of individuals per shoreline mile during electrofishing. Black crappie, northern pike and yellow perch relative abundance was indexed as the number of individuals per net night during netting.

Size structure of fish were described using length frequencies, descriptive statistics, proportional size distribution (PSD; Gabelhouse, J., D. W. 1984A) and Kolmogorov-Smirnov tests. Length frequencies were created for each species from all individuals measured within that species among all capture gears. The mean, minimum and maximum length of each fish species was calculated. The PSD value for a species was calculated as the number of fish of a quality size and longer divided by the number of stock length fish or longer and multiplied by 100. Quality-sized fish are 36% of the world record length and preferred-sized fish are 45% of the world record length representing fish lengths anglers likely enjoy catching (Table 4). Kolmogorov-Smirnov tests compared the 2022 size structure to the 2010 size structures within each species.

Table 4. Proportional size distribution values for select fish species in Crescent Lake, Oneida County, WI.

SPECIES	STOCK SIZE	QUALITY SIZE	PREFERRED SIZE
black crappie	5	8	10
bluegill	3	6	8
largemouth bass	8	12	15
northern pike	14	21	28
pumpkinseed	3	6	8
rock bass	4	7	9
smallmouth bass	7	11	14
walleye	10	15	20
yellow perch	5	8	10

Growth was quantified by length at age. Ages were assigned to collected structures for each muskellunge and walleye. Age was then assigned to each unaged fish that was measured using an age-length key. Age-length keys were created from the proportion of each age within each 1 inch length group for each sex within each species (Isermann and Knight 2005). Mean length at age was then calculated using the entire sample from assigned ages. Predicated maximum mean length was calculated using Von Bertalanffy's growth equation of:

$$l_t = L_\infty(1 - e^{-K(t-t_0)})$$

If the initial growth model did not converge, a Francis parameterization was fit instead of the standard parameterizations. Growth equations for muskellunge were completed by pooling sexes for each year because of data limitations, despite sex-specific growth variation. Growth equations were calculated for each year and sex data were available for walleyes.

Mortality was estimated from a catch curve. A weighted regression using the natural log of catch at age was determined (Miranda and Bettoli 2007) for muskellunge and walleyes. Catch curve estimates were compared among years using analysis of variance if available.

Population estimates, relative abundance indices, mean length and growth of each fish species were compared to the lake class standard for Wisconsin's lake systems with complex-cool-clear lake class (Rypel et al. 2019), statewide and to the northern region averages (18 counties in the northern region of Wisconsin) when appropriate.

Results

BLACK CRAPPIE

A total of 1,040 black crappies were captured while surveying Crescent Lake. Black crappie catch rate was 10.7 per net night during netting and 10.0 per mile during electrofishing. Black crappie catch per mile was in the 56th percentile statewide and catch per net night was above the 75th quartile for complex-cool-clear lakes.

Lengths of measured black crappies varied between 4.4 inches and 15.1 inches with a mean length of 9.0 inches (Figure 3), which is above the 95th percentile for complex-cool-clear lakes. Consistent black crappie reproduction has likely occurred over the past few years with multiple peaks found in the size structure representing distinct year classes (Figure 3). Size structure comparisons between 2010 and 2022 should be limited as no black crappies were measured in 2010. The black crappie PSD-8 size index of 82 is greater than what is generally accepted for a balanced population (Gabelhouse 1984B) and indicates some potential for big fish.

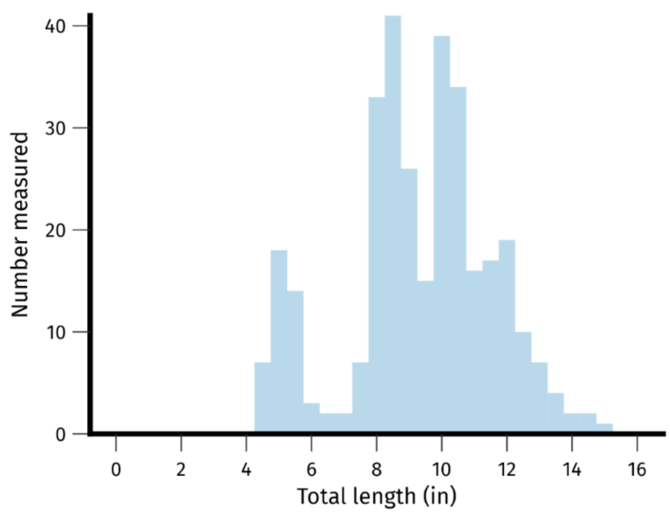


Figure 3. Length frequency of black crappies captured in Crescent Lake during the 2022-2023 comprehensive survey. Lengths bins are every 0.5 inches.

BLUEGILL

A total of 538 bluegills were captured while surveying Crescent Lake. Bluegill catch rate was 3.8 per net night during netting and 114.7 per mile during electrofishing. Bluegill catch per mile was in the 58th percentile statewide and above the 50th percentile for complex-cool-clear lakes.

Lengths of measured bluegills varied between 1.4 inches and 9.1 inches with a mean length of 5.1 inches (Figure 4). Mean bluegill length is above the 90th percentile for complex-cool-clear-lakes. PSD-6 was 25 and PSD-8 was 3 for bluegills. Size structure comparisons between 2010 and 2022 should be limited as too few bluegills were measured in 2010. The bluegill PSD-6 size index value of 25 was within the generally accepted range for a balanced bluegill population (PSD-6 = 20-60), while the bluegill PSD-8 of 4 is close to the lower end of the recommendation (PSD-8 = 5-20; Anderson 1985).

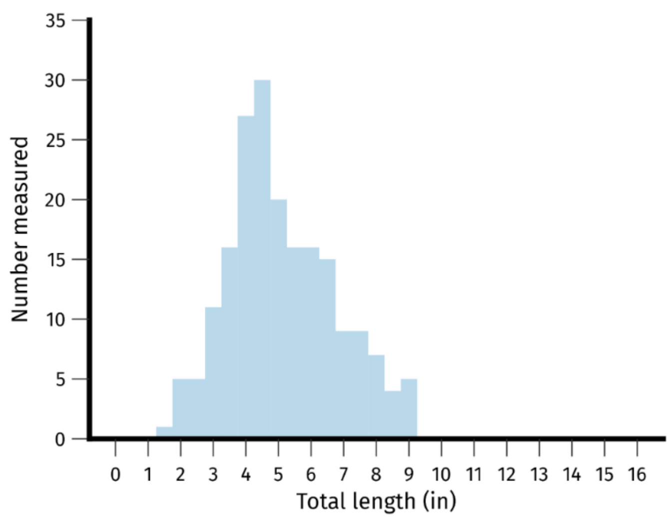


Figure 4. Length frequency of bluegills captured in Crescent Lake, Oneida County, WI during the 2022-2023 comprehensive survey. Lengths bins are every 0.5 inches.

LARGEMOUTH BASS

A total of 732 largemouth bass were captured while surveying Crescent Lake. Of the largemouth bass captured during population estimate sampling, 419 new largemouth bass were captured, and 8 previously marked individuals were captured. The University of Wisconsin–Steven Point marked an additional 139 largemouth bass and recaptured 4 marked individuals that were incorporated into the population estimate only. The largemouth bass population was estimated to be 4,603 ± 1,173 fish (7.4/acre; CV = 0.26) in 2022 and was the first time an estimate was able to be generated. An additional 162 largemouth bass were captured outside of the population estimate period or were less than 8 inches. Catch rate for largemouth bass was 0.8 per net night during netting and 17.7 per mile during electrofishing. Largemouth bass catch per mile was in the 85th percentile statewide and in the 75th percentile for complex-cool-clear lakes.

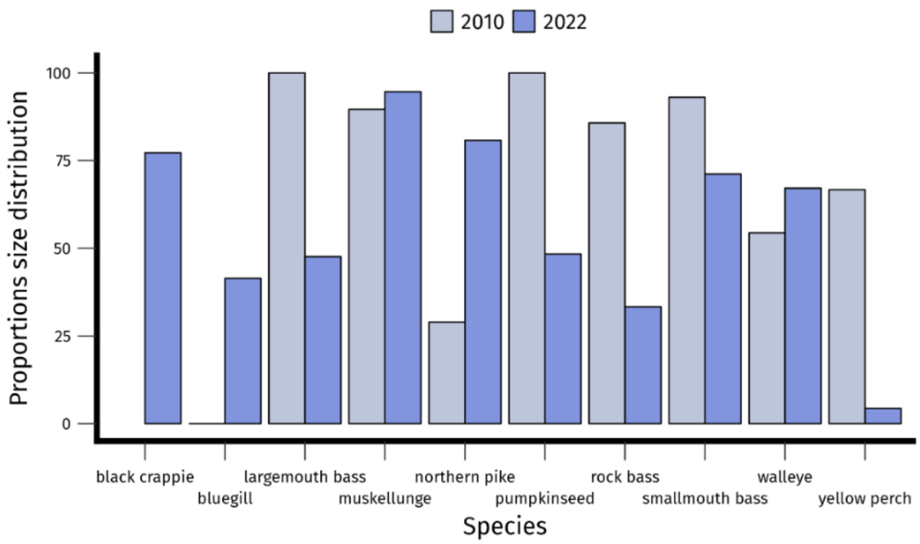


Figure 5. Proportional size distributions of fish species captured in Crescent Lake, Oneida County, WI during comprehensive surveys. The number of fish of a quality size and longer divided by the number of stock length fish or longer multiplied by 100.

Measured largemouth bass lengths varied between 5.5 inches and 17.5 inches with a mean length of 11.3 inches (Figure 6), which is above the 75th percentile for complex-cool-clear lakes. Largemouth bass size structure decreased since 2010 with a lower proportion of individuals of quality and preferred sizes found in 2022 (KS Test; D=0.64, P <0.001; Figure 5). PSD-12 was 39, and PSD-15 was 3 for largemouth bass in 2022, decreasing from the PSD-12 of 100 and PSD-15 of 71 observed during the 2010 survey. The largemouth bass PSD-12 index of 40 in 2022 is on the lower end of the generally accepted range of values for a balanced population (PSD-12 = 40–70; Gabelhouse 1984A).

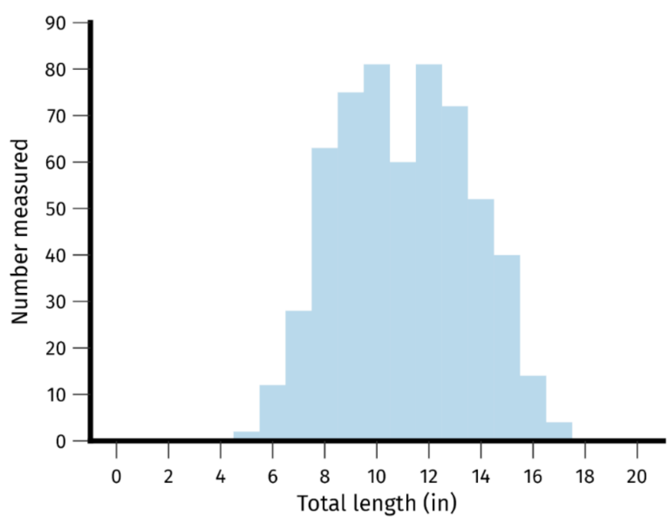


Figure 6. Length frequency of largemouth bass captured in Crescent Lake, Oneida County, WI during the 2022-2023 comprehensive survey. Lengths bins are every 1.0 inch.

MUSKELLUNGE

A total of 115 muskellunge were captured while surveying Crescent Lake. Of the muskellunge captured during population estimate sampling, 80 new individuals were identified and tagged, while the remaining 19 individuals had been previously handled and identified by the presence of a PIT tag. An additional 16 muskellunge were captured outside of the population estimate period or were less than 30 inches and were not included in the population estimate. Muskellunge catch rate was 1.1 per net night during netting and 0.2 per mile during electrofishing. Catch per net night of muskellunge was in the 75th percentile statewide and above the 90th percentile for complex-cool-clear lakes. Muskellunge were estimated at 124 ± 24 fish (0.20/acre; CV = 0.16) in 2022, which is similar to the 2010 estimate of 124 ± 24 individuals (0.20/acre; CV = 0.19) but lower than that of the 1988 estimate (Figure 7).

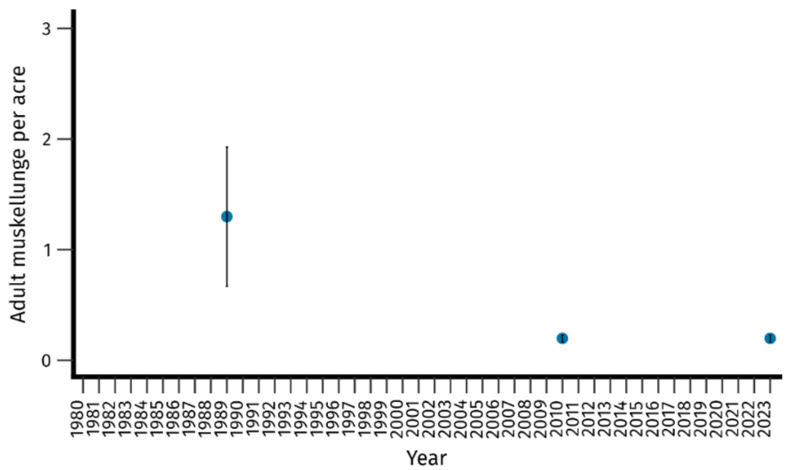


Figure 7. Population estimates (±1 standard deviation) for adult muskellunge in Crescent Lake, Oneida County, WI.

Lengths of muskellunge varied between 17.3 inches and 48.5 inches with a mean length of 38.8 inches (Figure 8), which is above the 100th percentile for complex-cool-clear lakes. Muskellunge size structure increased since 2010 with a greater proportion of individuals of quality and preferred sizes (KS Test; D= 0.37, P= <0.001, Figure 5). Muskellunge PSD-38 was 65, and PSD-42 was 24 in 2022, increasing from the PSD-38 of 42 and PSD-42 of 10 found during the 2010 survey.

Muskellunge were found to grow quicker up to age 10 during the 2022 survey in Crescent Lake compared to other lakes in the northern region of Wisconsin and other complex-cool-clear lakes. Male growth slowed and was lower than average for the northern region of Wisconsin after age 10 in Crescent Lake, but female growth remained quicker (Figure 9). The predicated theoretical mean maximum length for both sexes combined from the von Bertalanffy growth model in 2022 and 2023 was 46.9 inches, decreasing from the 2010 survey of 53.4 inches (Figure 10). Total annual mortality estimated from a catch curve regression model was 12.6% (ages 7 – 16), a slight but not significant increase from the 11.6% total annual mortality found in 2010 (P = 0.5).

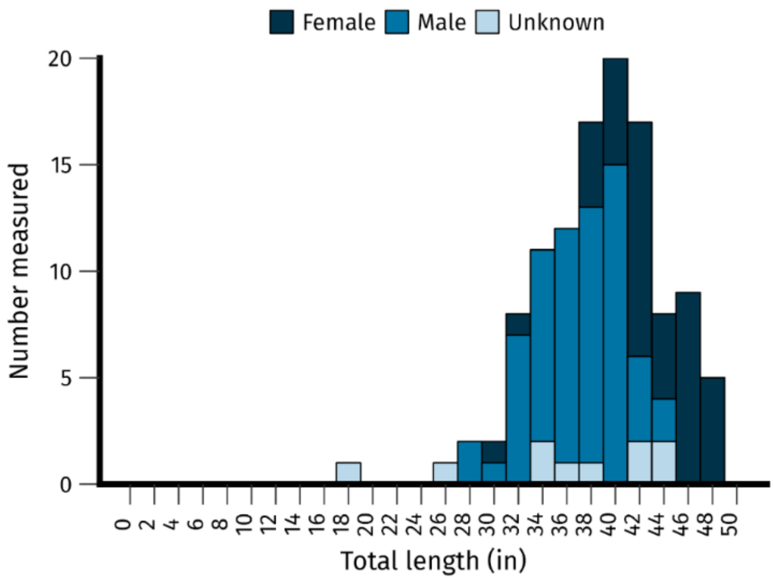


Figure 8. Length frequency of muskellunge captured in Crescent Lake, Oneida County, WI during the 2022-2023 comprehensive survey. Length bins are every 2 inches.

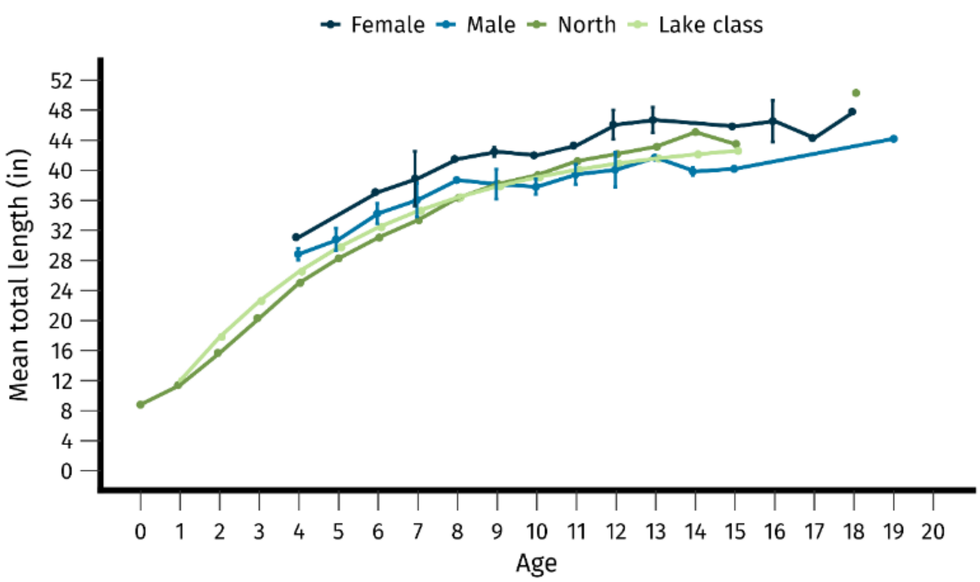


Figure 9. Mean total length (±1 SD) at estimated age of muskellunge within Crescent Lake for each sex. Muskellunge ages were assigned using anal fin rays. Length of individuals with an unknown age were assigned an age with a sex specific age-length key. The median length at age for similar complex-cool-clear Wisconsin lakes is represented by the light green line. Mean length at age estimates from the 18 counties in the northern region of Wisconsin is represented by the dark green line.

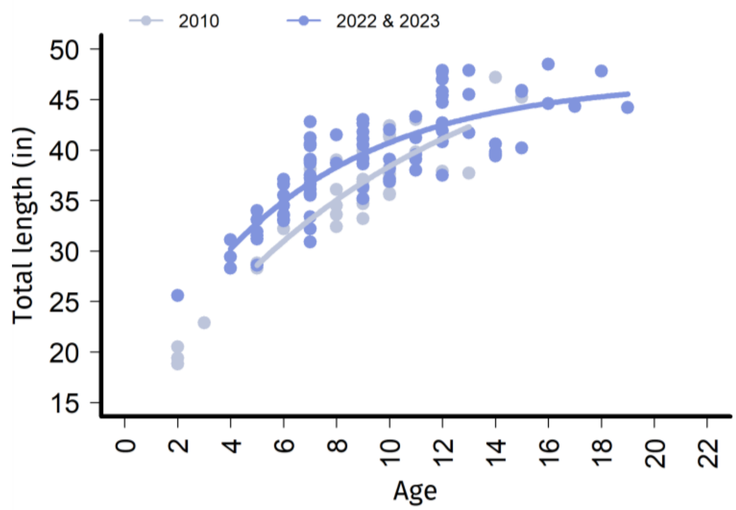


Figure 10. Total length at estimated age of muskellunge within Crescent Lake, Oneida County WI. Ages were assigned via anal ray. Both sexes were combined. Predicated growth rate from the Von Bertalanffy growth model for each year is represented by a uniquely colored line.

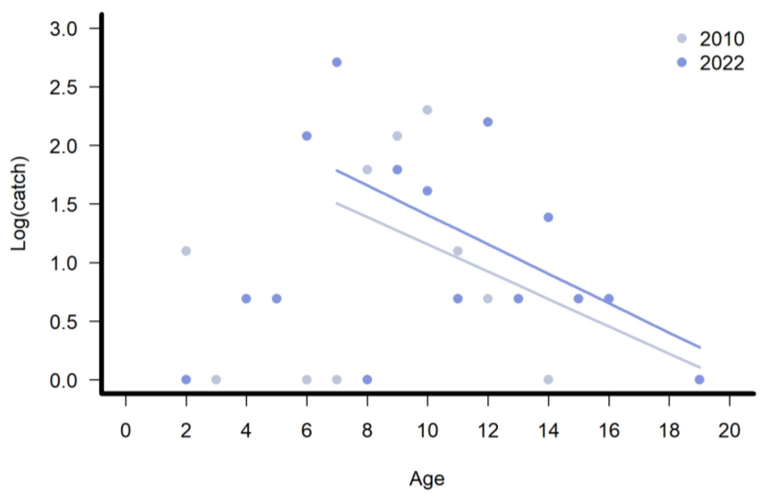


Figure 11. Natural log of catch at estimate ages of muskellunge within Crescent Lake, Oneida County, WI. Ages were assigned from anal rays. Best fit line assigned to fully vulnerable ages (7-19) where the catch curve started descending.

NORTHERN PIKE

A total of 74 northern pike were captured while surveying Crescent Lake. Northern pike catch rate was 0.7 per net night during netting and 0.6 per mile during electrofishing. Northern pike catch rate was in the lower 5th percentile for complex-cool-clear lakes. A minimal number of northern pike recaptures prevented the generation of a population estimate.

Lengths of northern pike varied between 18.6 inches and 36.0 inches with a mean length of 24.5 inches (Figure 12), which is above the 95th percentile for complex-cool clear-lakes. Northern pike size structure increased since 2010 with a greater proportion of individuals of quality and preferred sizes (KS Test; D= 0.74, P <0.001; Figure 5). Northern pike PSD-28 was 14, and PSD-34 was 1 in 2022, increasing from the PSD-28 of <1 and PSD-34 of 0 observed during the 2010 survey. The Northern Pike PSD-21 index of 81 in 2022 is above the suggested value for a balanced population (30-60; Anderson and Weithman 1978).

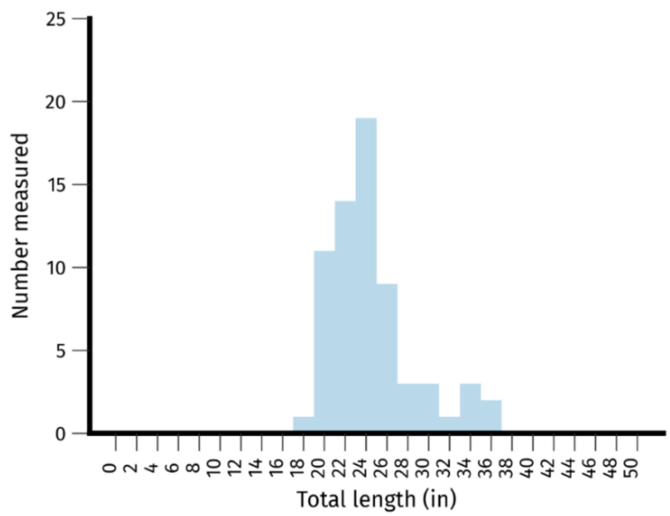


Figure 12. Length frequency of northern pike captured in Crescent Lake, Oneida County, WI during the 2022-2023 comprehensive survey. Lengths bins are every 2 inches.

PUMPKINSEED

A total of 131 pumpkinseed were captured while surveying Crescent Lake. Pumpkinseed catch rate was 0.8 per net night during netting and 33.3 per mile during electrofishing. Pumpkinseed catch rate was in the upper 90th percentile for complex-cool-clear lakes.

Lengths of pumpkinseeds varied between 3.0 inches and 7.9 inches with a mean length of 6.0 inches (Figure 13), which is in the 95th percentile for complex-cool-clear lakes. Pumpkinseed size structure has decreased since 2010 with a lower proportion of individuals of quality and preferred sizes (Figure 5). However, size structure comparisons between 2010 and 2022 pumpkinseed sizes should be limited as few were measured in 2010.

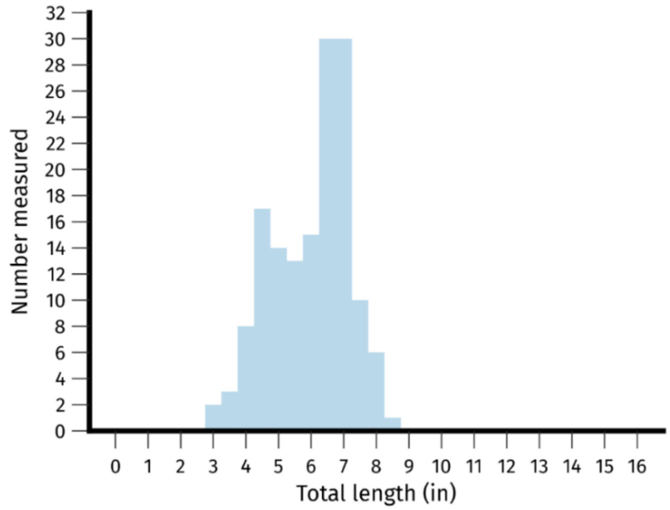


Figure 13. Length frequency of pumpkinseed captured in Crescent Lake, Oneida County, WI during the 2022-2023 comprehensive survey. Length bins are every 0.5 inches.

ROCK BASS

A total of 180 rock bass were captured while surveying Crescent Lake. Rock bass catch rate was 1.4 per net night during netting and 30.7 per mile during electrofishing. Rock bass catch rate was above the 75th percentile for complex-cool-clear lakes.

Lengths of measured rock bass varied between 3.1 inches and 8.1 inches with a mean length of 5.5 inches (Figure 14). Rock bass size structure decreased since 2010 with a lower proportion of individuals of quality and preferred sizes in 2022 (KS Test; D=0.63, P <0.001; Figure 5). Rock bass PSD-7 was 23, and PSD-9 was 0 in 2022,decreasing from the PSD-7 of 90 and PSD-9 of 45 observed during the 2010 survey.

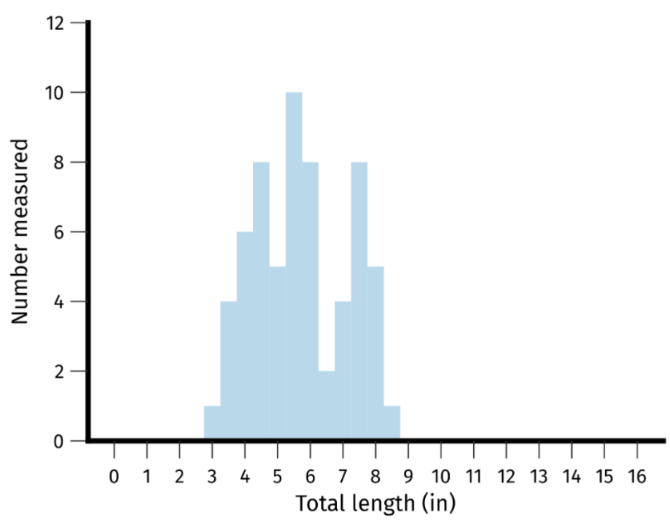


Figure 14. Length frequency of rock bass captured in Crescent Lake, Oneida County, WI during the 2022-2023 comprehensive survey. Length bins are every 0.5 inches.

SMALLMOUTH BASS

A total of 420 smallmouth bass were captured while surveying Crescent Lake. Of the smallmouth bass captured during population estimate sampling, 243 new smallmouth bass and 13 previously marked individuals were captured. The University of Wisconsin–Stevens Point marked an additional 73 smallmouth bass and recaptured 12 marked individuals that were incorporated into the population estimate only. An additional 79 smallmouth bass were captured outside of the population estimate period or were less than 8 inches. The smallmouth bass population was estimated to be 893 ± 153 individuals (1.4/acre; CV = 0.17) in 2022, which is similar to the 2010 estimate of 792 ± 159 individuals (1.3/acre; CV = 0.20). Catch rate for smallmouth bass was 0.5 per net night during netting and 10.0 per mile during electrofishing. Smallmouth bass catch per mile was in the 85th percentile statewide and in the 75th percentile for complex-cool-clear lakes.

Smallmouth bass lengths varied between 6.0 inches and 18.6 inches with a mean length of 12.7 inches (Figure 15). Smallmouth bass size structure decreased since 2010 with a lower proportion of individuals of quality and preferred sizes (KS test; D = 0.33, P = <0.001; Figure 5). Smallmouth PSD-14 was 33, and PSD-17 was 1 in 2022, decreasing from the PSD-14 of 71 and PSD-17 of 21 observed during the 2010 survey.

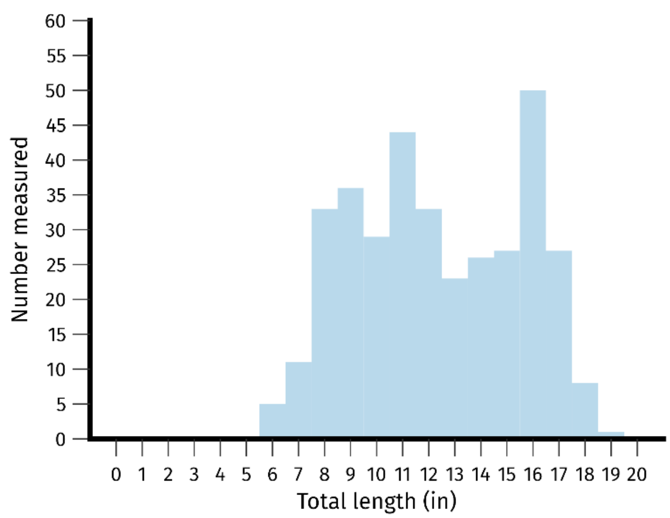


Figure 15. Length frequency of smallmouth bass captured in Crescent Lake, Oneida County, WI during the 2022-2023 comprehensive survey. Length bins are every 1.0 inch.

WALLEYE

A total of 851 walleyes were captured while surveying Crescent Lake with a male to female ratio of 0.4:1. Of the walleyes captured during population estimate sampling, there were 587 unique and 36 previously marked individuals. The walleye population was estimated to be 1,838 ± 264 fish (2.9/acre; CV = 0.14), the lowest estimate in Crescent Lake throughout the years (Figure 16). An additional 228 walleyes were handled outside the population estimate sampling or were less than 15 inches. Walleye catch rate was 15.6 per net night during netting and 9.9 per mile during electrofishing. Walleye catch per mile was in the 58th percentile statewide and below the 90th percentile for complex-cool-clear lakes.

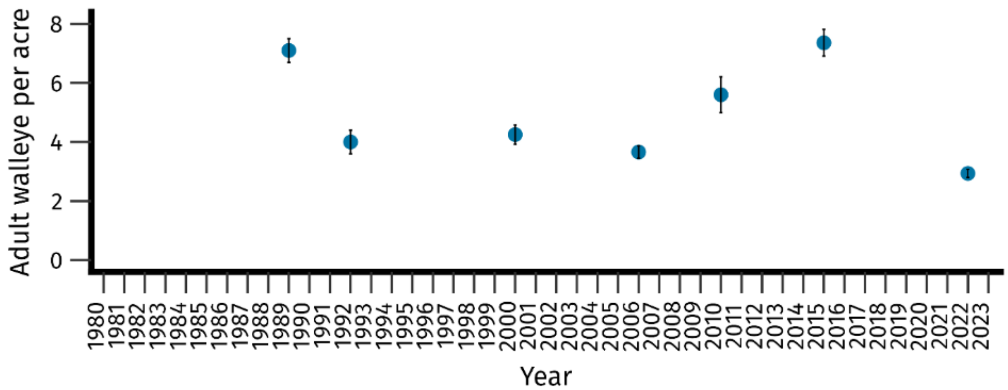


Figure 16. Adult walleye population estimate (±1 standard deviation) in Crescent Lake, Oneida County, WI.

Lengths of captured walleye varied between 6.5 inches and 26.0 inches with a mean length of 16.8 inches, which is above the 75th percentile for complex-cool-clear lakes (Figure 17). Size structure of walleye increased since 2010 with a greater proportion of individuals of quality and preferred sizes (KS test; D = 0.79, P = <0.001, Figure 5). Female walleyes tended to be larger than male walleyes (Figure 17). Walleye PSD-15 was 92, and PSD-20 was 3 in 2022, increasing from the PSD-15 of <1 and PSD-20 of 0 observed during the 2010 survey. Walleye PSD-20 of 3 is slightly below the suggested balanced population (PSD-20 = 10-20; Pedersen 2020), while PSD-15 of 92 is higher (30-60 Anderson and Weithman 1978).

Walleye were represented by 12 age classes varying from age 1 to age 12 in 2022. This is a decrease in the number of age classes from 2010 (ages 2-15) and an increase from 1992 (ages 3-11). Female walleyes grew faster than male walleyes in Crescent Lake during 2022 (Figure 18). Walleye growth was slower than your typical walleye in the northern region of Wisconsin and other complex-cool-clear lakes for both sexes during 2022 (Figure 18). Growth rates of males and females less than or equal to age 6 has increased over the years, while growth rates of individuals older than 6 has decreased (Figure 19). Total annual mortality of adult walleyes estimated using a catch curve regression model was estimated at 12% of the population in 2022, decreasing from the 26% found in 2010 and 33% in 1992 (Figure 20).

No age-0 walleyes were captured during the 2022 or 2023 FE runs. Five age-1 walleyes were captured in 2022, and 0 were captured in 2023. Declines in age-0 and age-1 walleyes per mile began in 2018 with 2022 being the first year no age-0 individuals were captured (Figure 21).

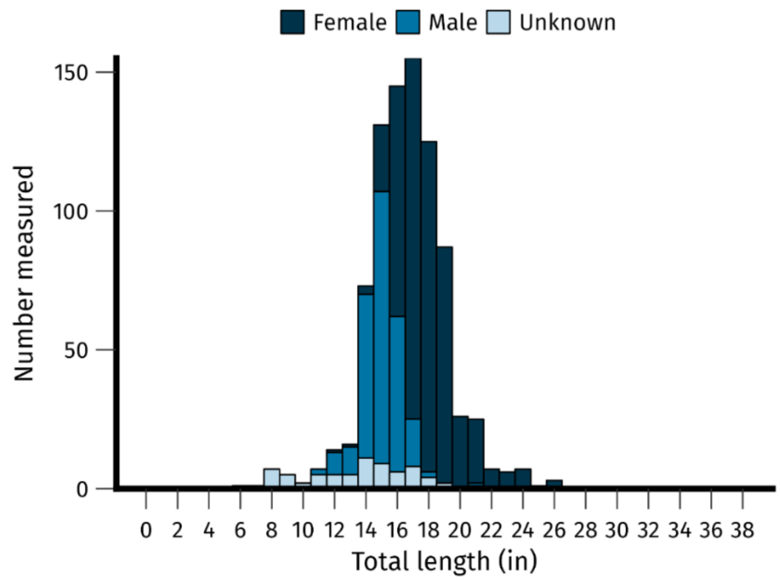


Figure 17. Length frequency of walleye captured in Crescent Lake, Oneida County, WI during the 2022-2023 comprehensive survey. Length bins are every 1.0 inch.

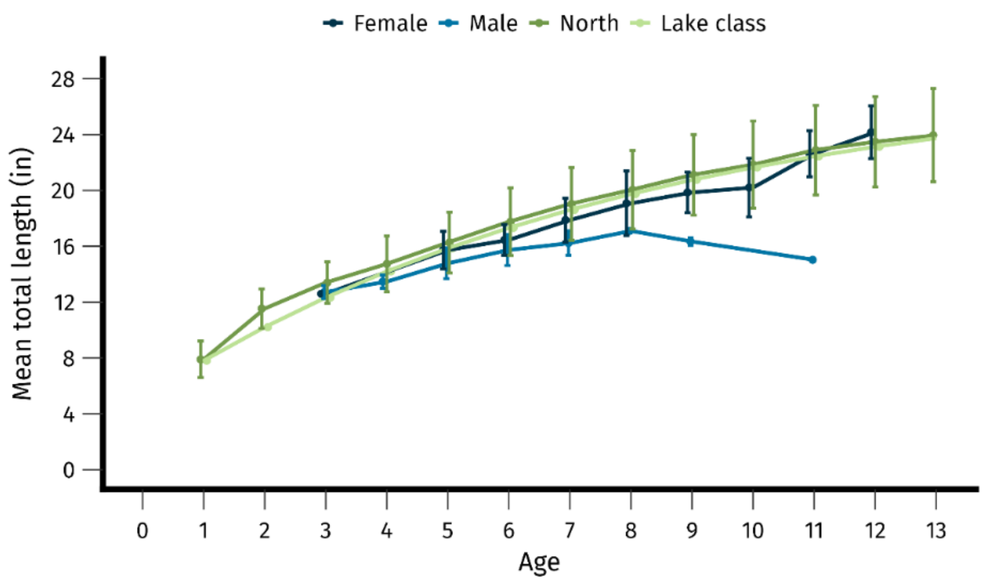


Figure 18. Mean total length (± 1 SD) at estimated age of walleye within Crescent Lake, Oneida County, WI for each sex. Fish ≤ 12 inches were assigned aged by scales, and fish > 12 inches were assigned ages using dorsal spines. Lengths with unknown age from the entire sample were assigned an age with a sex specific age-length key. The median length at age for similar complex-cool-clear Wisconsin lakes is represented by the light green line. Mean length at age estimates from the 18 counties in the northern region of Wisconsin is represented by the dark green line. Points and error bars are offset to avoid overlap of points of the same ages.

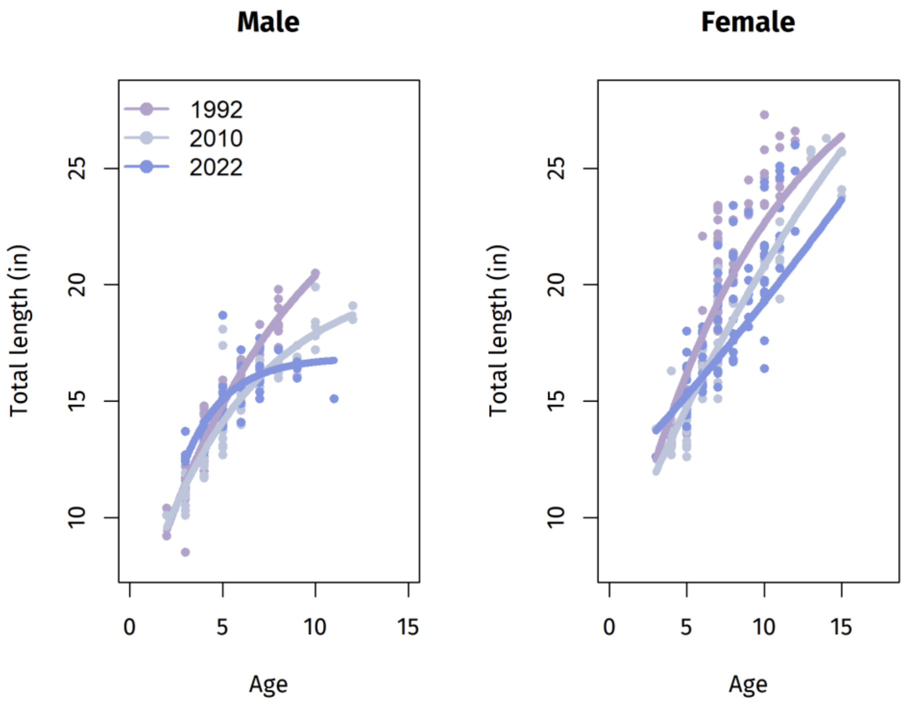


Figure 19. Total length at estimated age of walleye within Crescent Lake, Oneida County, WI for each sex. Fish ≤ 12 inches were assigned aged by scales, and fish > 12 inches were assigned ages using dorsal spines in 2010 and 2022. All ages from 1992 were estimated using scales. Predicated growth rate from the Von Bertalanffy growth model for each year is represented by uniquely colored lines.

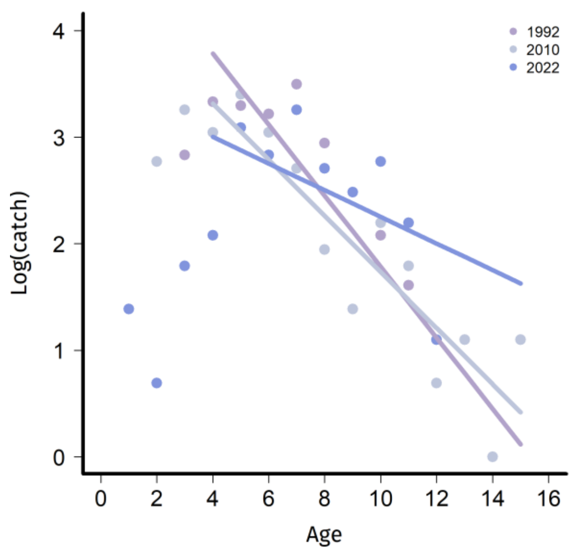


Figure 20. Natural log of catch at estimate ages of walleye within Crescent Lake, Oneida County, WI. Ages were assigned from dorsal spines. Best fit line assigned to fully vulnerable ages (4-15) where the catch curve started descending.

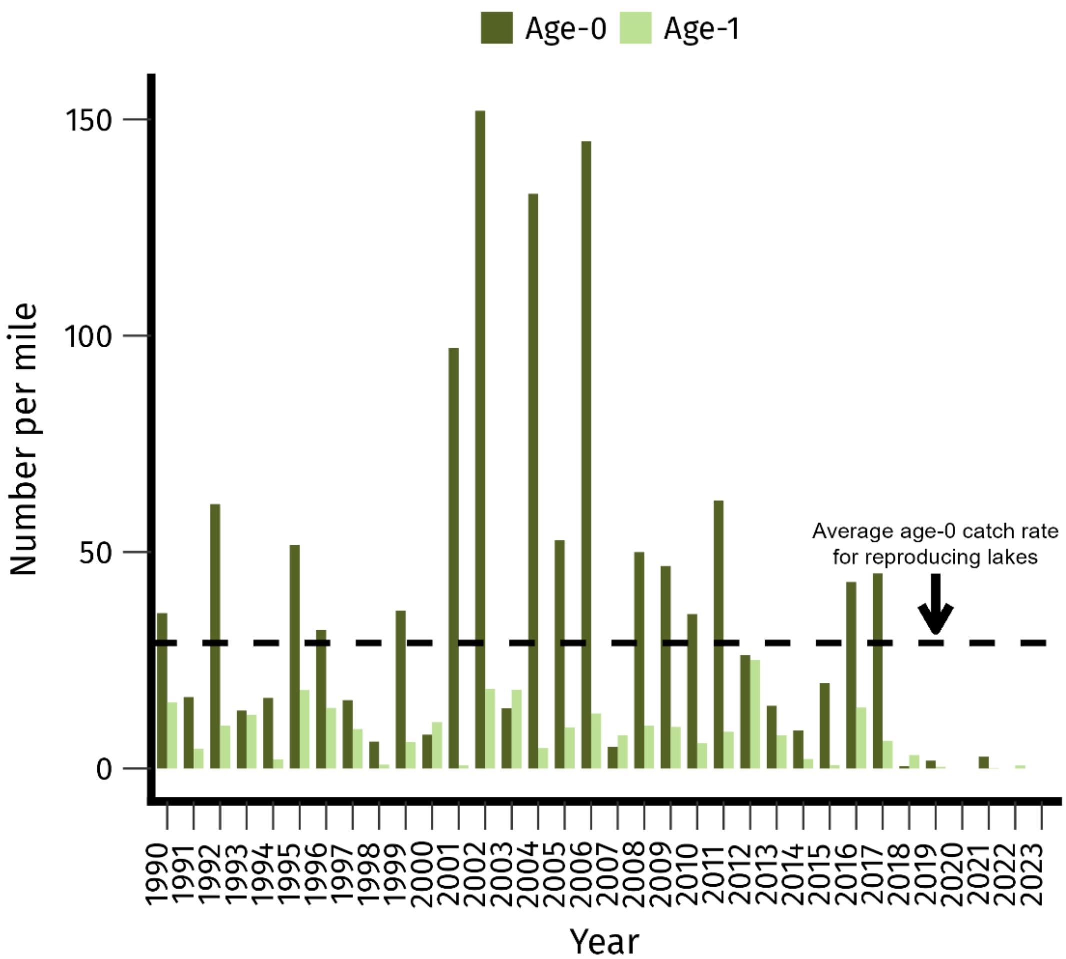


Figure 21. Number of age-0 and age-1 walleye per mile within Crescent Lake, Oneida County, WI throughout time. Fish ages were assigned by scales.

YELLOW PERCH

A total of 1,598 yellow perch were captured while surveying Crescent Lake. Catch rate of yellow perch was 16.6 per net night during netting and 1.3 per mile during electrofishing. Yellow perch catch per mile was in the 8th percentile statewide, and number per net night was below the 75th percentile for complex-cool-clear lakes.

Yellow perch lengths varied between 3.8 inches and 8.3 inches with a mean length of 5.9 inches, which is in the 90th percentile for complex-cool-clear lakes (Figure 22). Yellow perch size structure has decreased since 2010 with a lower proportion of individuals of quality and preferred sizes (Figure 5), but a KS test indicated that the change was not significant (D= 0.57, P = 0.08). Yellow perch PSD-8 was <1, and PSD-10 was 0 in 2022, decreasing from the PSD-8 of 0 and PSD-10 of 66 observed during the 2010 survey. The yellow perch PSD-8 size index of <1 was below what is generally accepted as the range of a balanced population (PSD-8 = 30-60; Anderson and Weithman 1978).

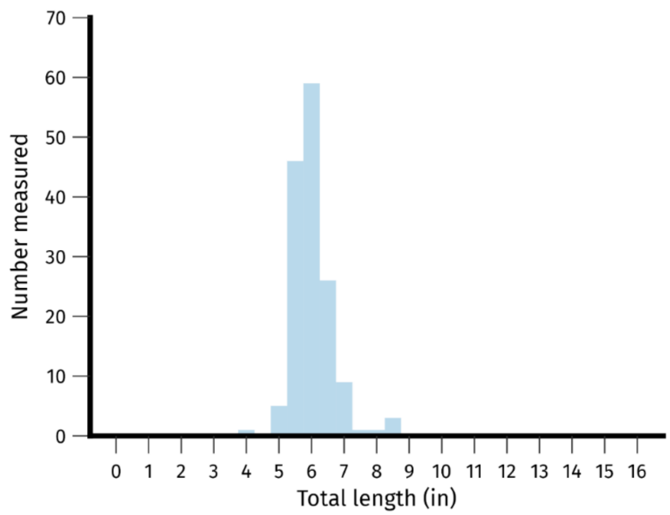


Figure 22. Length frequency of yellow perch captured in Crescent Lake, Oneida County, WI during the 2022-2023 comprehensive survey. Length bins are every 0.5 inches.

Other species

Other species encountered during sampling included bluntnose minnow (13), common shiner (7), creek chub (5), mimic shiner (59), white sucker (47) and yellow bullhead (5).

Discussion

Sixteen fish species were captured during the Crescent Lake survey, indicating a well-rounded and desirable fishery (Willis et al. 1993, Anderson and Weithman 1978; Gabelhouse, J., D. W. 1984A; Gabelhouse, J., D. W. 1984B). Adult walleyes were present right around the 3.0 per acre goal deemed healthy and able to be self-sustaining (U.S. Department of the Interior 1991). Muskellunge were in low abundance with a great size structure, providing trophy opportunities. Black crappies had typical abundance levels compared to northern Wisconsin lakes and were of desirable lengths. Size structures of predatory fish, such as muskellunge, northern pike and walleye, have improved since 2010, while prey base, such as bluegill, largemouth bass, smallmouth bass and yellow perch, has decreased. A combination of factors are likely influencing the fishery within Crescent Lake such as environmental change, which may not be able to be readily adjusted (Rypel et al. 2018), and other factors such as fish abundance, aquatic habitat abundance and complexity and species interactions, which may be more easily addressed. Management effort should focus on the manipulable aspects ensuring Crescent Lake remains a multiple use system and recreational destination.

Predator-prey interactions influence the functioning of a fishery. As predators reach high enough densities, they impart predation levels capable of reducing prey abundance and alter the sizes of surviving individuals to more desirable lengths. This is because of decreased intraspecific competition (Paukert et al. 2002, Gablehouse 1984B). This predator-prey interaction may be influencing the size and number of crappies, bluegills and pumpkinseeds in Crescent Lake. However, the abundance of bass, walleyes and muskellunge may be putting so much pressure on yellow perch that they are keeping the size structure and abundance level low (Fetzer et al. 2016; Dembkowski et al. 2015, Bozek et al. 1999; Rudstam et al. 1995). Interactions between largemouth bass and walleyes may improve walleye growth and size structure while also limiting walleye recruitment (Repp 2012). Persistent walleye recruitment declines, like those observed in Crescent Lake, lead to adult abundance declines.

Stocking is one of the most common methods to address declining fish abundance in North America (Heidinger 1999). Stocking has the potential to increase the adult abundance but more than often does not meet the management objective (Claussen and Philipp 2022). With the reduction in walleye reproduction within Crescent Lake, a few consecutive stocking events may supplement the population, allowing the system to return to a self-sustaining fishery. More muskellunge reproduction may also be occurring within Crescent Lake than initially thought. Over half (51%) of muskellunge captured during the 2022 survey were aged to a period when stocking did not occur (2000-2015; plus or minus 1 year). Stocking on top of reproduction seldom increases year class size (Li et al. 1996) and should be avoided. Identifying contributing sources (stocking vs reproduced) of walleye and muskellunge fisheries would inform future stocking practices. With the difficulties associated with assigning fish to a cohort based off age, particularly for older individuals (Crane et al. 2020; Dembkowski et al. 2017), parentage assignment should be considered (Logsdon et al. 2016) in addition to aging.

Aquatic habitat abundance and complexity also has the capability to direct the functioning of a fishery. Macrophyte levels (Aquatic Plant Explorer) and shoreline development have increased (Jennings et al. 2009), reducing woody habitat and shoreline complexity within Crescent Lake. Changes in aquatic habitat influence predator-prey interactions, fish behavior, fish distribution, nutrient cycling and food web structure (Meerhoff and Gonzalez-Sagrario 2021; Hixon 1986). Aquatic vegetation can be managed through chemical, manual or mechanical methods. However, herbicides have been found to negatively influence fish and zooplankton through lethal and sublethal mechanisms (Schleppenbach et al. 2022), while mechanical removal has been found to have mixed effects on the aquatic community through physical removal and alterations impacting predator-prey dynamics (Thiemer et al. 2021). Inputs of coarse woody debris, protection/promotion of aquatic vegetation and maintenance/restoration of vegetative buffers should be considered to increase shoreline complexity. Efforts to control or alter aquatic habitat need to balance the impacts of the alteration on the fish community and habitat with the effectiveness of the action towards its objective. Healthy Lakes in Wisconsin is a great resource to learn about steps that can be taken to alter aquatic habitats.

Angling regulations are also a common tactic to alter a fishery or resist change within a system (Feiner et al. 2021). Minimum length limits on bass have been found capable of increasing population size (Wilde 1997), slot limits excel at restructuring and increasing population size (Wilde 1997) and no minimum length limits reduced abundance of larger individuals with little impact on overall recruitment (Hoff 1995). Walleye minimum length limits have been found to have limited impacts on population structure while reducing angler harvest (Fayram et al. 2001), slot limits work well in slow growth, high mortality and high pressured systems (Brousseau and Armstrong 1987) despite being negatively perceived by anglers (Carlin et al. 2012), no minimum length limits decreased lengths and increased harvest (Fayram and Schmalz 2006) and high minimum lengths (28 inch) did not always increase angler catch or population size structure (Haglund et al. 2016). In any species, minimum length limits may cause fish to accumulate under the minimum length, producing fewer legal-sized fish, and a protected slot limit may be an equitable trade-off between abundance reduction and size structure (Schnell 2014). However, no matter the regulation implemented, angler mentality greatly influences the impacts and needs to be considered (Miranda et al. 2017; Allen et al. 2008). Monitoring should investigate impacts of regulations on target species such as catch rates, growth rates, population estimates and size structure as well as creel information. These metrics should be compared to previous survey data in before-after, control-impact study design ensuring goals of changes are met (Smith 2002).

Recommendations

1. Investigate the contribution of stocked and reproduced walleyes and muskellunge through parentage assessment of age-0, age-1 and adult fish, ensuring the survival of stocked product and little impact to genetic lineage.
2. Pursue bass regulation changes to improve their size structure and provide additional consumptive opportunities.
3. Pursue walleye regulation changes to reduce juvenile and adult mortality to increase adult abundance and improve age-0 and age-1 recruitment.
4. Evaluate the impacts of anglers, habitat changes, predators and regulation changes on the system by assessing gamefish and panfish species size structure, growth and relative abundance.
5. Consider completing a creel survey to investigate the impacts of any regulation change on exploitation and harvest of target species.
6. Initiate a Walleye Lake of Concern plan to bring together partners to collectively address the declining walleye population.

Acknowledgments

Thank you to the DNR staff that collected data and assessments over the years used in this report. Aaron Marti, Abbigail Ewert, Bob Consolo, Eric Brown, Eric Wegleitner, James Yach, Jason Halverson, John Kubisiak, Royce Zehr, Tim Tobias, Evan Priebe, students from University of Wisconsin–Stevens Point tree haven summer course, the Great Lake Indian Fish and Wildlife Commission and Sokaogon Chippewa Community Mole Lake Band of Lake Superior Chippewa assisted with field work in 2022 and 2023 and historic fall electrofishing surveys. Lawrence Eslinger calculated species specific population estimates in 2022. Claire Gaber, Jacob Kolanowski and Scott Toshner reviewed early drafts of this report and improved the overall quality.

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