BEAVER LAKE

2017 FISHERY SURVEY

Friends of BEAVER LAKE

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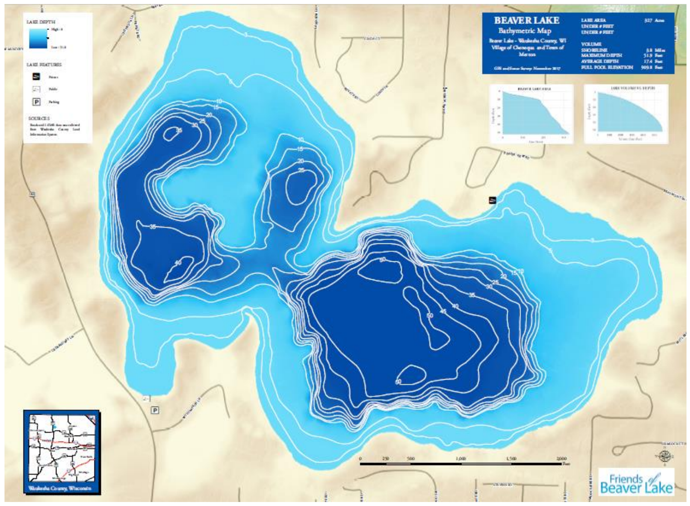
Introduction

Historically, smallmouth bass (*Micropterus dolomieu*), largemouth bass (*Micropterus salmoides*), rock bass (*Ambloplites rupestris*), bluegill (*Lepomis macrochirus*), black crappie (*Pomoxis nigromaculatus*), yellow perch (*Perca flavescens*), yellow bullhead (*Ameiurus natalis*), northern pike (*Esox lucius*), and white sucker (*Catostomus commersonii*), have resided in Beaver Lake. Longnose gar (*Lepisosteus osseus*), white bass (*Morone chrysops*), walleye (*Sander vitreus*), green sunfish (*Lepomis cyanellus*) and common carp (*Cyprinus carpio*)) have also been reported in Beaver Lake. At the request of the Friends of Beaver Lake, a survey of the fish community of Beaver Lake was conducted from March 23 - 28, 2017 and April 20, 2017. The objective of the survey was to determine the current status of the Beaver Lake fishery: species composition, relative abundance, growth rates, and size structure. Special emphasis was put on targeting walleye to gain data for stocking. Information from this survey is presented to the Friends of Beaver Lake in this report for the purpose of guiding future management of Beaver Lake.

Study Area

Beaver Lake is a 327-acre lake located in Waukesha County, Wisconsin. The lake has an average depth of 17.4 feet, with a maximum depth of 51.9 feet and approximately 3.8 miles of shoreline based on the bathymetry done fall of 2017. It is a spring-fed lake with only one inlet/outlet, which connects to Pine Lake to the west. The bottom substrate consists mostly of marl, sand and rock. The lake has exceptionally clear water throughout most of the year. Beaver Lake contains very little aquatic plant growth overall, with concentrations of plants located along drop-offs. Muskgrass (*Chara spp.*) (a type of complex algae) covers most of the bottom of the shallow flats. Plant beds consist mostly of sago pondweed (*Stuckenia pectinata*), variable pondweed (*Potamogeton gramineus*), bushy pondweed (*Najas flexilis*) and spiny naiad (*Najas marina)*. The lake also contains the exotic invasive species Eurasian watermilfoil (*Myriophyllum spicatum)*, zebra mussels (*Dreissena polymorpha*), and limited amounts of purple loosestrife (*Lythrum salicaria*).



Beaver Lake is a semi-private lake with only carry-on access for the public. A private boat launch is located on the northeast corner of the lake, and is controlled by the Beaver Lake Yacht Club. Residents use the lake not only for fishing, but for water skiing, inner-tubing, and jet skiing. **Table 1** contains the Wisconsin DNR fishing regulations for the fish encountered during the survey (WDNR 2017).

Table 1 Fishing Regulations for Beaver Lake at the time of the 2017 survey.

Fish	Season	Regulation
Panfish (bluegill, pumpkinseed, sunfish, crappie and yellow perch)	Open All Year	No minimum length limit and the daily bag limit is 25.
Largemouth bass and smallmouth bass	May 6, 2017 to March 3, 2018	The minimum length limit is 14" and the daily bag limit is 5.
Northern pike	May 5, 2017 to March 3, 2018	The minimum length limit is 26" and the daily bag limit is 2.
Walleye	May 6, 2017 to March 4, 2018	The minimum length limit is 15" and the daily bag limit is 5.
Bullheads	Open All Year	No minimum length limit and the daily bag limit is unlimited.
Rock bass	Open All Year	No minimum length limit and the daily bag limit is unlimited.

General Waterbody Restrictions

- Motor Trolling is Permitted (check local boating ordinances for restrictions on use of motors)

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Methods

Sampling

A comprehensive fisheries survey was conducted on Beaver Lake in the spring of 2017. A fyke net survey was conducted March 22 - 28, 2017 and a follow up electrofishing survey was conducted April 20, 2017.

During the fyke-net survey fish were captured with 3' x 5' fyke nets having 50' leads and ½" bar mesh. Nets were set at ten locations throughout Beaver Lake. A total of 60 net-nights were completed during the survey. The length of each fish was recorded for use in later data analysis. Aging structures (scales) and weights were collected from all northern pike, walleye, bluegill, smallmouth bass, largemouth bass, and rock bass. Top caudal (tail) fin clips were performed on largemouth bass, smallmouth bass, and walleye to estimate populations. The presence or absence of a fin clip was recorded for each fish captured throughout the survey.

The follow-up electrofishing survey was conducted in the evening, from before dusk into total darkness. The intent was to target fish that would normally not be shallow enough to shock due to clear water conditions. A Kann Mfg. custom electrofishing boat with an ETS electrofishing system was used. This system was powered by a Honda 7000-watt invertor generator. Electricity was transferred to the water through 8 ft booms and Kann Mfg. custom umbrella electrodes. During this survey, species and length were recorded from all fish, and scales were taken from target fish. Fin-clipped fish from the fyke net survey were noted for later population estimates.

Beaver Lake property owners volunteered to help each day with lifting nets, counting fish, and taking scale samples. Two Cason & Associates biologists were present each day to lead volunteers in sampling the fish.

A survey to analyze walleye spawning habitat was conducted on the final day of the fyke net survey (March 28). A near shore map of the lake was made by jon boat and areas of rocky and/or gravely substrate were recorded on a paper map. Areas with sediment covering substrate were analyzed by leaving the boat and wiping the substrate off with a hand or boot. Removing the sand or organic matter would expose the substrate for identification.

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Data Analysis

Data from the surveys were used to calculate parameters of the fish community. Length frequency, total catch, proportional stock density, length-at-age, and population mortality were calculated for each species. Length-at-age was plotted along with state averages to compare growth rates for each species. State averages for length-at-age of each species were provided by the Wisconsin DNR. Mortality was estimated using catch curve analysis. Total mortality estimates were determined for all species that were common enough during the survey to provide adequate data.

Mark-recapture method data was collected throughout the survey for all gamefish, namely walleye, smallmouth and largemouth bass. The Chapman population estimator model was used to estimate population size along with the standard error.

Chapman Population Estimator
N=((M+1)(C+1)/(R+1))-1, where M is the total marked (fin clipped), C is the number of fish caught, and R is the number of recaptures (Lagler 1956).

The scale samples that were collected were used to determine ages of the fish. The scales were viewed under a microfiche projector where annuli count and locations were determined. A process called back-calculating was performed on the scale samples to determine the length of the sampled fish at each previous age. This data was used to calculate an average length-at-age for each species to compare growth from Beaver Lake with regional averages. Age data was also used in estimating mortality for each species.

Results

Summary of All Fish Encountered

A total of 10 species of fish were captured during the spring 2017 surveys, and are shown in **Table 2**. A total of 13 mudpuppies *(Necturus maculosus)* were also captured during the survey. The average length for all species captured, and catch-per-effort for fyke-netting can also be found in **Table 2**. The catch-per-effort is the average number of fish caught in one net in one night. Catch-per-effort was not calculated for the electrofishing survey.

Table 2. Average length of measured fish, total number caught and catch-per-effort (CPE) (effort = 1 net-night) on Beaver Lake, during the spring 2017 fyke-netting survey.

Species	Catch	Average Length	CPE (fish/net night)
Bluegill	36	8.2	.17
Rock Bass	40	8.3	.60
Smallmouth Bass	72	12.8	.58
Largemouth Bass	84	11.8	.23
White Sucker	34	19.6	.02
Northern Pike	9	22.0	.15
Walleye	40	13.6	.32

As shown in **Figure 2**, largemouth bass dominated the fish community in Beaver Lake, comprising 26% of the total fish captured during spring 2017 surveys.

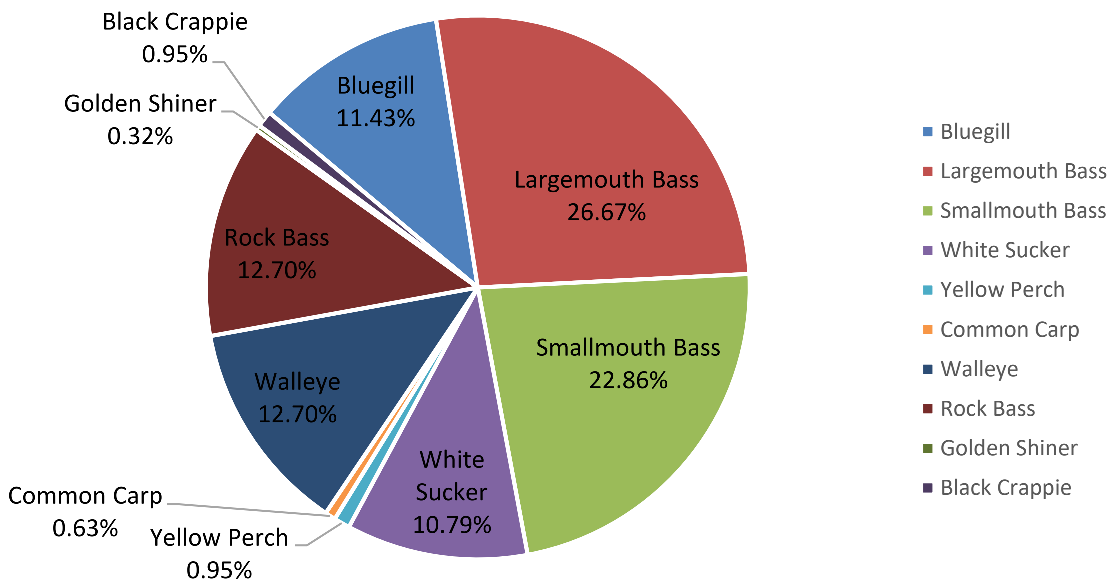

Figure 2. Total catch (fyke-net and electrofishing), Beaver Lake, spring 2017.

Mortality Estimates

Mortality estimates for a fish population can be an important tool for managing a fishery. Total mortality is the combination of natural and fishing mortality. Although it is difficult to separate natural and fishing mortality from total mortality, fishing mortality can be manipulated to decrease or increase total mortality.

Mortality values were determined for each species using frequency of fish-at-age of each species. Frequency of fish-at-age was estimated using the determined average length-at-age data calculated for Beaver Lake. The natural log (ln) of each frequency of fish-at-age was determined and converted into a catch curve (**Figure 3**). A trendline can be added from the first fully recruited

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age through the last for each species. The slope of the line determines the instantaneous total mortality (Z). This number isn't very useful alone, but it can be used to provide an estimate for total annual mortality rate (A) (natural mortality + human harvest) (Ogle 2012). This is done using the following formula:

$$A=1-e^{-Z}$$

These estimates are made assuming it is a closed population (no additions or subtraction of individuals, such as migration) and that the instantaneous total mortality rate is a constant among all age groups (Ogle 2012). **Figure 3** below illustrates the catch curves for each species with adequate data. **Table 3** shows the total mortality estimates for common fish species encountered during the spring 2017 surveys. We have also included the mortality estimates from the March 2012 survey for comparison (**Table 4**).

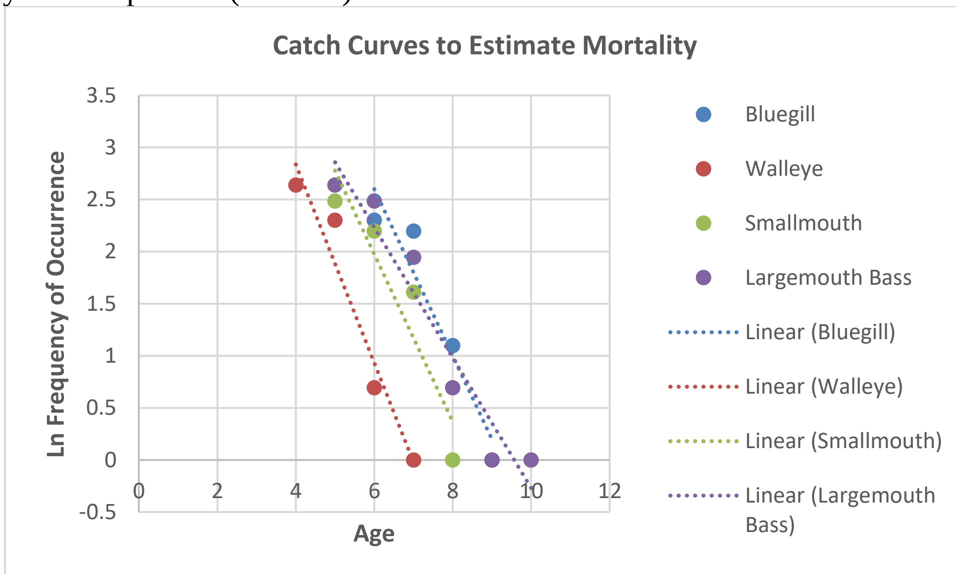

Figure 3. Catch curves of fish species, Beaver Lake, spring 2017 surveys. Slope of the line is instantaneous total mortality (Z).

Table 3. Below is a table of instantaneous total mortality (Z), estimated total annual mortality (A), and R^2 values (how well the line fits, 1=perfect). Beaver Lake, spring 2017 surveys.

	Largemouth Bass	Smallmouth Bass	Bluegill	Walleye
Instantaneous (Z)	**0.6258**	**0.8043**	**0.8006**	**0.973**
Estimated Annual Mortality (A)	**46.5%**	**58.3%**	**55.09%**	**61.43%**
R^2	**0.9309**	**0.8748**	**0.9155**	**0.9436**

Table 4. Below is a table of instantaneous total mortality (Z), estimated total annual mortality (A), and R^2 values (how well the line fits, 1=perfect). Beaver Lake, March 2012 survey.

	Largemouth Bass	Smallmouth Bass	Bluegill
Instantaneous (Z)	**0.6292**	**1.0575**	**1.3730**
Estimated Annual Mortality (A)	**46.7%**	**65.3%**	**74.7%**
R^2	**0.9742**	**0.9355**	**0.9934**

Largemouth and smallmouth bass, bluegill, walleye, and rock bass, were the only species of fish with enough data to reasonably estimate total mortality. Other species such as northern pike, black crappie and yellow perch did not offer enough samples. White sucker, green sunfish and yellow bullhead were not aged, and therefore mortality was not estimated.

According to estimates, walleye exhibited the highest total mortality rate, with an estimated 61.43% of each cohort dying on an annual basis. (Cohort is another term for an age group, such as all 3-year-old fish in the lake). The species with the lowest estimated mortality rate was largemouth bass, with 46.5% of each cohort dying on an annual basis. As you can see from **Table 4** annual mortality decreased from 2012 to 2017 for bluegill and smallmouth bass.

Northern Pike

There were 9 northern pike captured during the survey ranging from 11.0 inches to 34.5 inches (**Figure 4**). The average length for all northern pike captured during the survey was 22.0 inches. The 2012 survey did not capture any fish smaller than 18 inches (**Figure 5**). However, the 11-12" northern pike caught in 2017 indicate some successful recruitment.

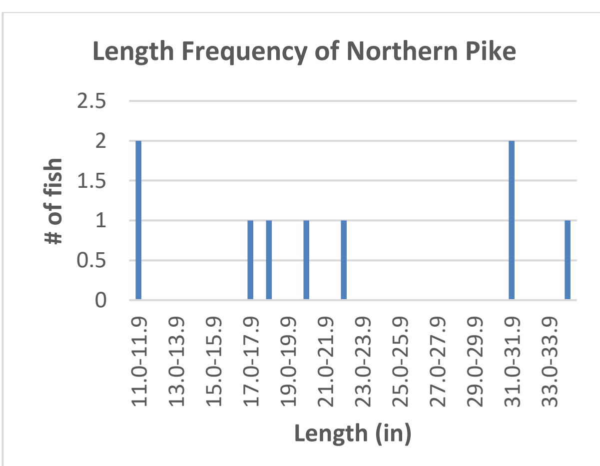

Figure 4. Length frequency of northern pike captured on Beaver Lake during the spring 2017 surveys.

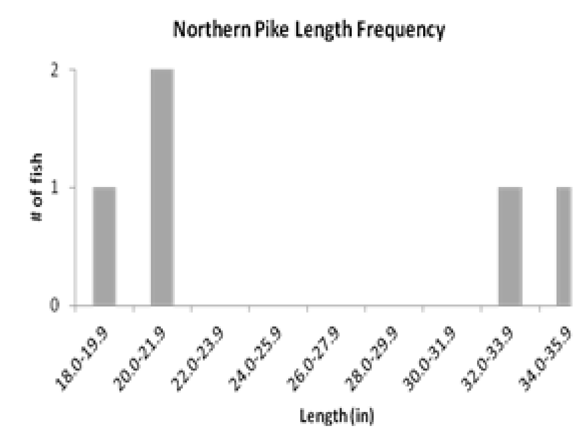

Figure 5. Length frequency of northern pike captured on Beaver Lake during the March 2012 fyke-net survey.

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Age was determined for all northern pike sampled, and was used to create average length-at-age data to examine growth (**Figure 6**). The length-at-age data from 2012 shows faster growth than the state average (**Figure 7**). The data from 2017 was similar to the state average. The difference shown here may be because of the larger number of samples in 2017. The state average is included for comparison in both figures. Out of the 9 northern pike sampled during the fyke-net survey, the oldest was 8 years old. Northern pike in Beaver Lake exhibited a comparable growth rate to the state average.

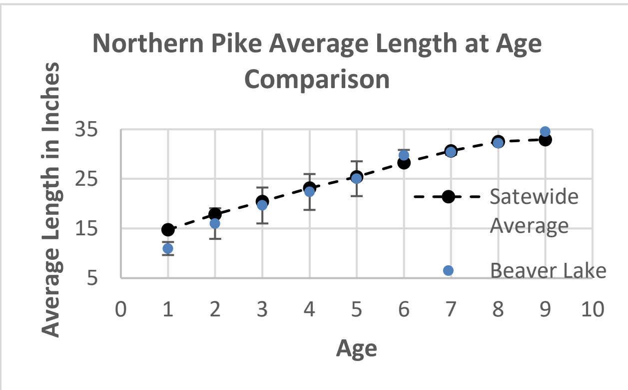

Figure 6. Average length-at-age of northern pike and 1 standard deviation determined from back-calculated scale samples collected during the spring 2017 Beaver Lake surveys.

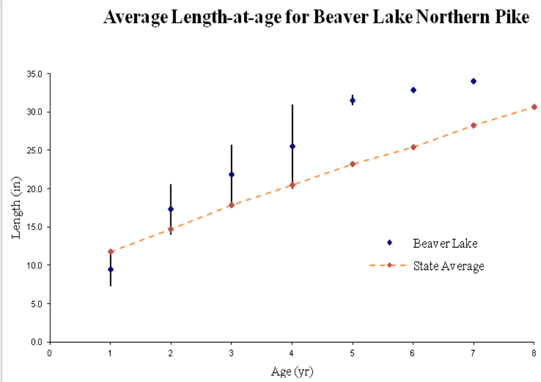

Figure 7. Average length-at-age of northern pike and 1 standard deviation determined from back-calculated scale samples collected during the March 2012 Beaver Lake survey. n=5

Proportional stock density is a good way to evaluate the population size structure for a species. The terms PSD-quality, PSD-preferred and PSD-memorable are used to describe the percentage of the population that is above a certain size, specific to the species. For example, stock, quality, preferred, and memorable size for northern pike are ≥ 14 inches, ≥ 21 inches, ≥ 28 inches, and ≥ 34 inches, respectively. The PSD is a ratio of the number of fish over quality, preferred, or memorable size, and the total fish over stock size. The ideal "≥ stock-size population" would have 50% of the fish over quality size, 25% over preferred size, and 12.5% over memorable size. These standard percentages are widely used to analyze fish populations. **Figure 6** illustrates northern pike PSD versus the target value. Since there were only 9 northern pike captured during the survey, the proportional stock densities may not be a true representation of the entire population. Overall, the size structure of northern pike appeared good, with a high ratio of large fish to small fish.

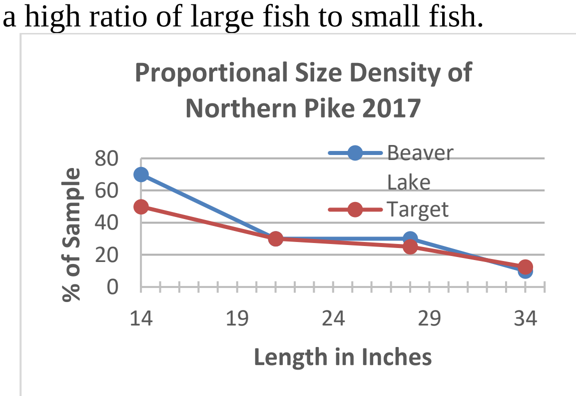

Figure 8. Northern pike proportional stock density (PSD) from Beaver Lake during the spring 2017 surveys.

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Largemouth Bass

There were 84 largemouth bass captured during the survey ranging from 9.3 inches to 17.2 inches (**Figure 8**). The average length of all largemouth bass captured during the survey was 11.8 inches. The 2012 length frequency histogram shows a consistent skew towards smaller fish in both surveys (**Figure 9**).

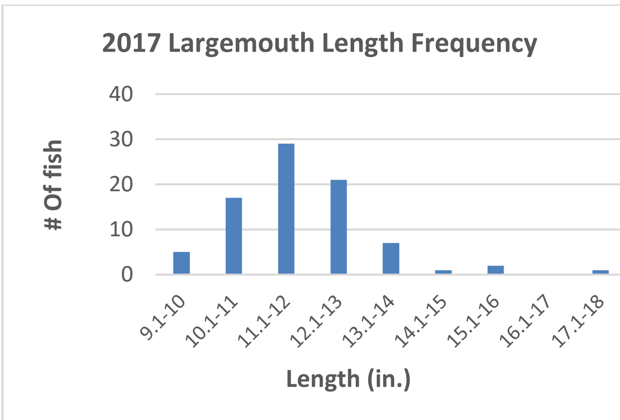

Figure 8. Length frequency of largemouth bass captured on Beaver Lake during the spring 2017

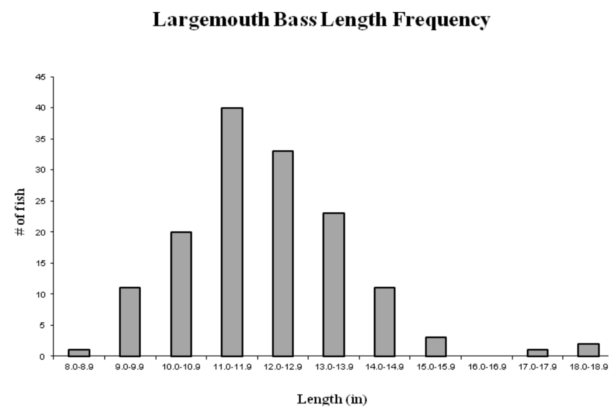

Figure 9. Length frequency of largemouth bass captured on Beaver Lake during the March 2012 fyke-net survey.

Age was determined for 84 largemouth bass sampled and was used to calculate the average length-at-age **(Figure 10)**. In the colder climate of Wisconsin, largemouth bass usually have slow growth rates and can live over ten years (Becker 1983). Out of the 84 largemouth bass that were aged, the oldest was 10 years. The state average length-at-age is included for comparison. Beaver Lake largemouth bass exhibited growth rates similar to the state average over the first 4 years. After 4 years old growth slows to below state average. This trend of slowing growth was also shown in the length-at-age comparison done in 2012 (**Figure 11**).

A total of 35 largemouth bass were marked during the fyke net portion of the survey. Population estimates for largemouth bass get closer to the actual number as there are more samples to draw from. According to the mark-recapture data gathered, it is estimated there were 923 largemouth bass in Beaver Lake. However, we were unable to calculate confidence intervals because recapture was too low (< 2).

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Proportional stock densities (PSD) for bass are shown in **Figure 12**. Stock, quality, preferred, and memorable size for largemouth bass are ≥ 8 inches, ≥ 12 inches, ≥ 15 inches, and ≥ 20 inches, respectively. Out of the 84-fish captured, all were over "stock" size, 36 were over "quality" size, and 3 were over "preferred" size. The size structure of the largemouth bass population is slightly below average. The data suggests there was a lack of "preferred" and "memorable" sized fish. A comparison of the PSD's from 2012 and 2017 shows the number of quality (>12") fish had reached target levels. However, preferred, memorable, and trophy sizes were still well below target.

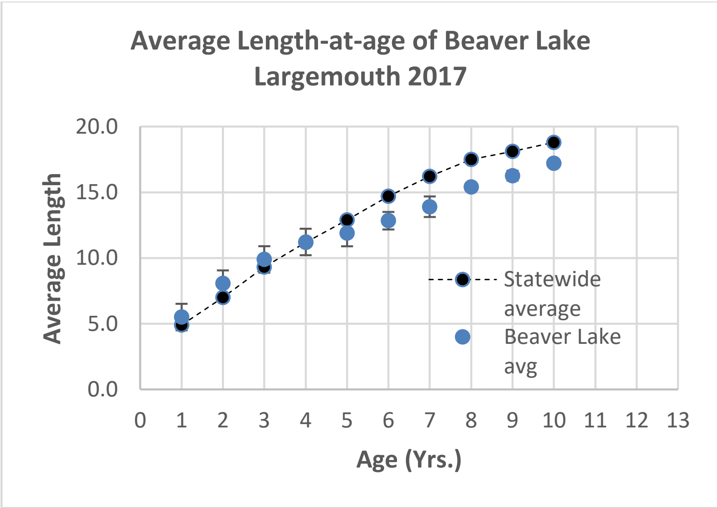


Figure 10. Average length-at-age and 1 standard deviation for largemouth bass, determined from back-calculated scale samples collected during the spring Beaver Lake survey.

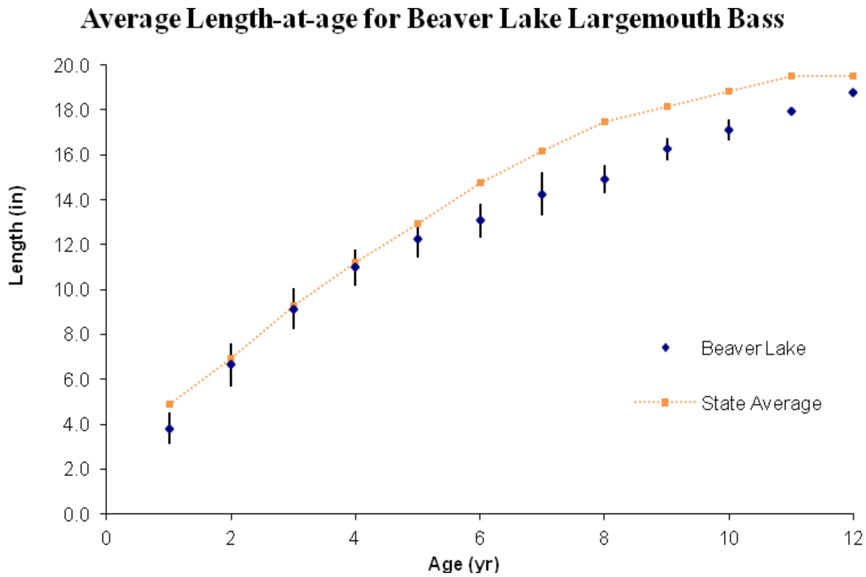
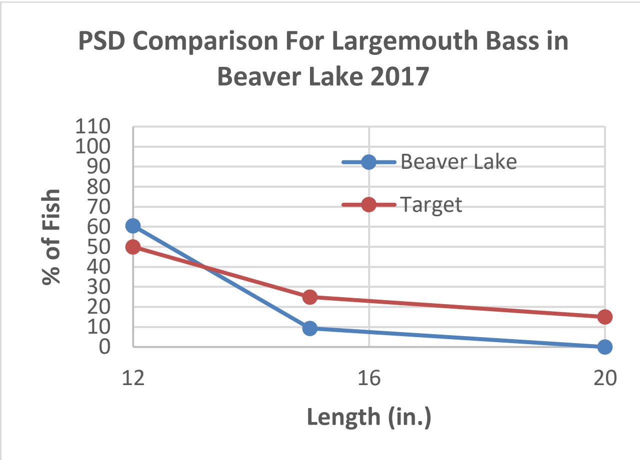


Figure 11. Average length-at-age and 1 standard deviation for largemouth bass, determined from back-calculated scale samples collected during the March 2012 Beaver Lake survey. n=93



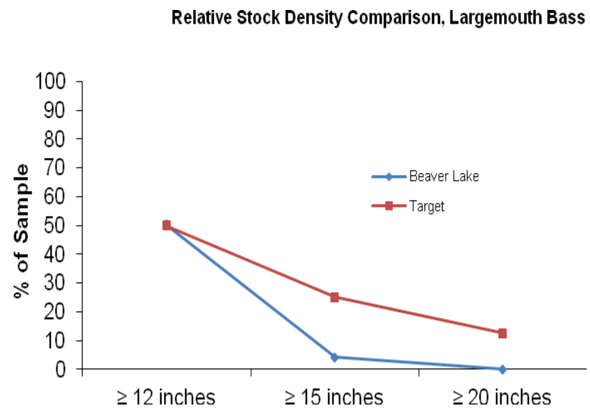


Figure 12. Largemouth bass proportional stock density (PSD) from the Beaver Lake spring 2017 surveys.

Figure 13. Largemouth bass proportional stock density (RSD) from Beaver Lake during the March 2012 survey.

Smallmouth Bass

There were 52 smallmouth bass captured during the survey, ranging from 7.1 inches to 15.1 inches (**Figure 14**). The average length for all smallmouth bass captured during the survey was 12.82 inches. A comparison of the length histogram from the 2012 survey (**Figure 15**) and the 2017 survey (**Figure 14**) shows the overall size structure remains similar. However, the number of large fish and small fish was lower in 2017.

Age was determined for 52 smallmouth bass sampled, and was used to calculate average length-at-age to examine growth for smallmouth bass on Beaver Lake (**Figure 16**). The state average is included for comparison. When you compare 2017 length-at-age to 2012 (**Figure 17**), you see a change in growth. In 2017 growth slows to below state average after 5 years. This was not the case in the 2012 survey data. This is an indication the correct forage was not accessible to allow fish to grow quickly.

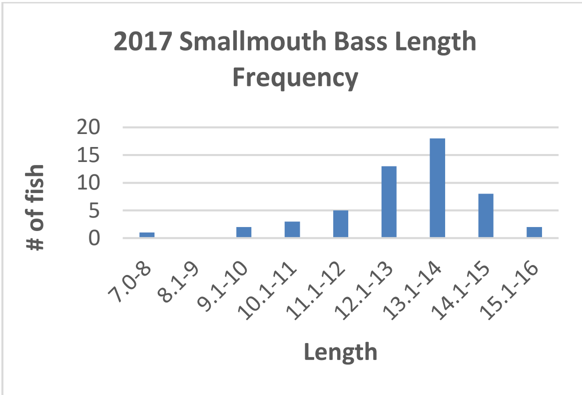


Figure 14. Length frequency of smallmouth bass captured on Beaver Lake during the spring 2017 surveys.

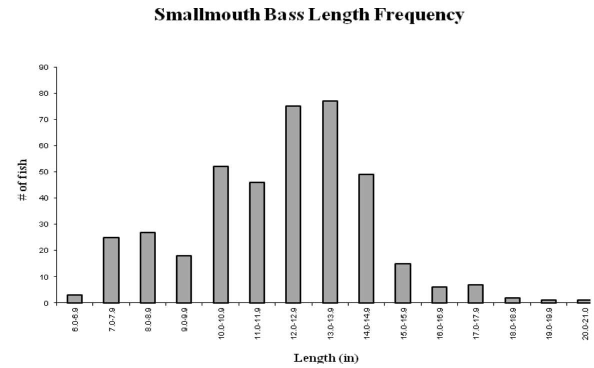


Figure 15. Length frequency of smallmouth bass captured on Beaver Lake during the March 2012 fyke-net survey.

All sampled smallmouth bass were marked during the fyke-net survey. Population estimates for smallmouth bass get closer to the actual number as the number of marked fish increases. According to the mark-recapture data gathered, it is estimated there were701 smallmouth bass in Beaver Lake. Recapture numbers were too low to provide confidence intervals (< 2).

Proportional stock densities (PSD) for smallmouth bass are shown in **Figure 18**. A comparison to the 2012 PSD data (**Figure 19**) shows very little change. Stock, quality, preferred, memorable, and trophy size for smallmouth bass are ≥ 7 inches, ≥ 11 inches, ≥ 14 inches, ≥ 17 inches, and ≥ 20 inches, respectively. Out of the 52 fish captured, all were over "stock" size, 46 were over "quality" size, 12 were over "preferred" size, and no fish were over "memorable" or "trophy" size. The size structure of the smallmouth bass population is below target level for "preferred", "memorable" and "trophy" sizes, which suggests a below average population size structure.

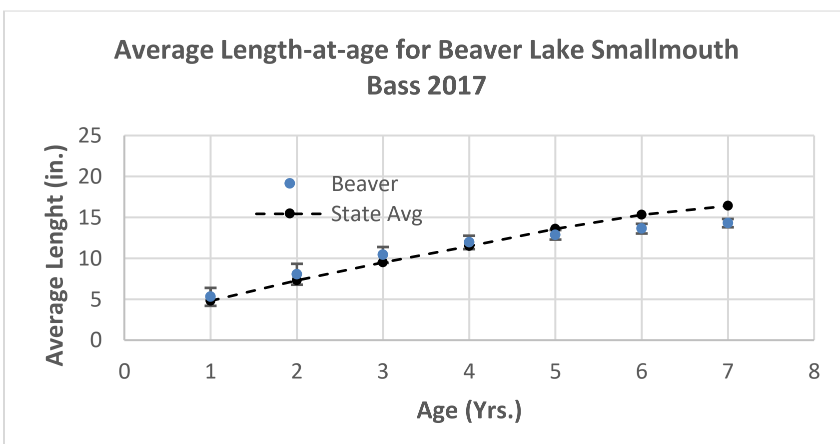


Figure 16. Average length-at-age and 1 standard deviation for smallmouth bass, determined from back-calculated scale samples collected during the spring Beaver Lake surveys.

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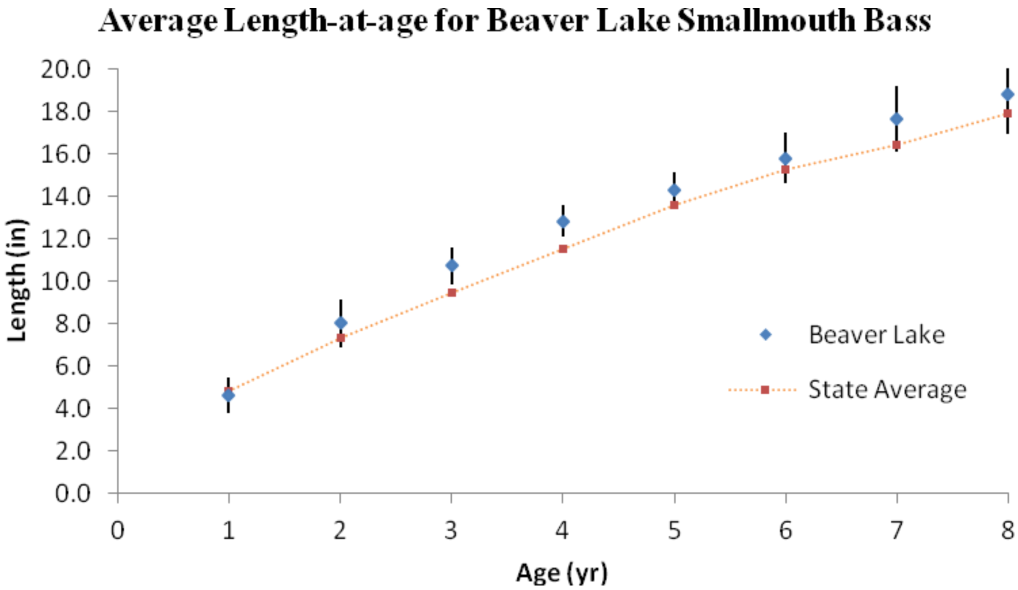

Figure 17. Average length-at-age and 1 standard deviation of smallmouth bass, determined from back-calculated scale samples collected during the March 2012 Beaver Lake survey. n=98

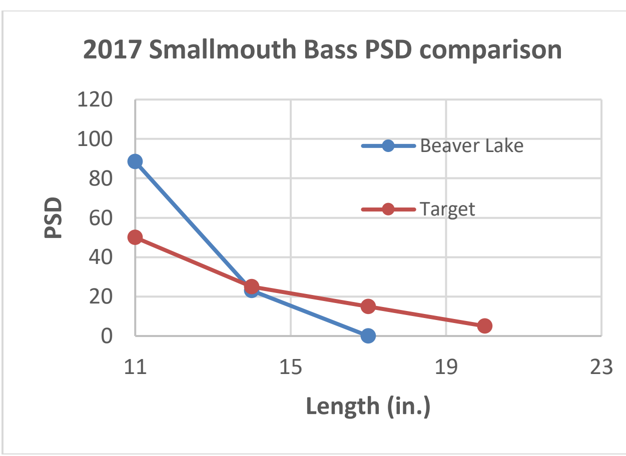

Figure 18. Smallmouth bass proportional stock density (PSD) from Beaver Lake during the spring 2017 surveys compared to target goal.

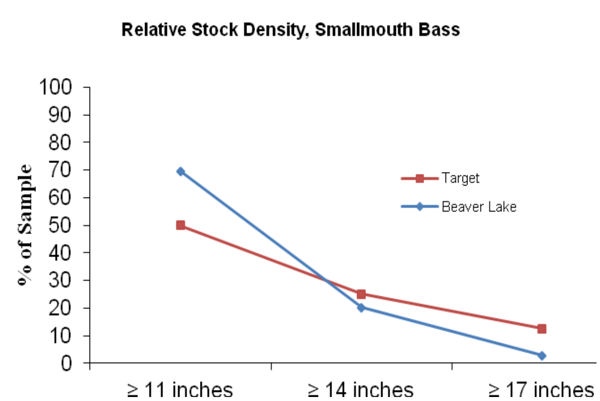

Figure 19. Smallmouth bass proportional stock density (PSD) from Beaver Lake during the March 2012 survey.

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Bluegill

There were 36 bluegills captured during the fyke-net and electrofishing surveys ranging from 4.2 inches to 10.1 inches (**Figure 20**). The average length for all bluegill captured was 8.2 inches.

Age was determined for all 36 bluegills sampled and was used to calculate average length-at-age data (**Figure 22**). The state average is included for comparison. Bluegill growth in Beaver Lake was well above the state average. The length frequency and length-at-age from the 2012 survey was also provided for reference (**Figures 21 and 23**). By comparing the data from the 2012 length frequency data (**Figure 21**) to the 2017 data (**Figure 20**) we can see a similar trend. Fish in both surveys grew quickly to 9" but very few made it beyond that size. Also, both surveys showed low numbers of young fish, which tend to be in abundance in many lakes.

Proportional stock densities for bluegill in 2017 and 2012 are shown in **Figures 24 and 25,** below. Stock, quality, preferred, and memorable size for bluegill are ≥ 3 inches, ≥ 6 inches, ≥ 8 inches, and ≥ 10 inches, respectively. Out of the 36 bluegill captured, all were above "stock" size, 32 were above "quality" size, 23 were above "preferred" size, and one was above "memorable" size. Fishing harvest may be responsible for the lack of larger fish.

The bluegill population size structure appeared skewed toward larger fish, but has a lack of memorable and trophy fish (**Figure 24)**. Memorable fish (>10") are present but in lower numbers than expected for a lake with fast growth. The 2012 survey (**Figure 25**) showed the same decline in large fish but did not have the same proportion of stock and quality sized fish.

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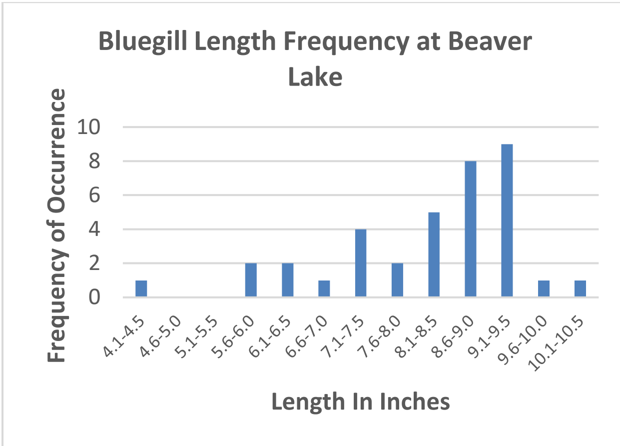

Figure 20. Length frequency of bluegill captured on Beaver Lake during the 2017 spring surveys.

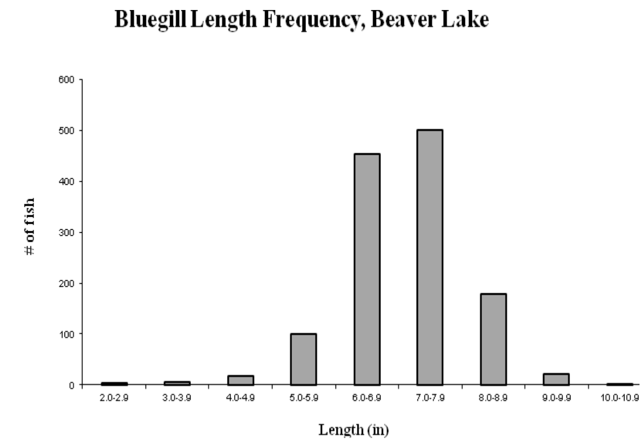

Figure 21. Length frequency of bluegill captured on Beaver Lake during the March 2012 fyke-net survey.

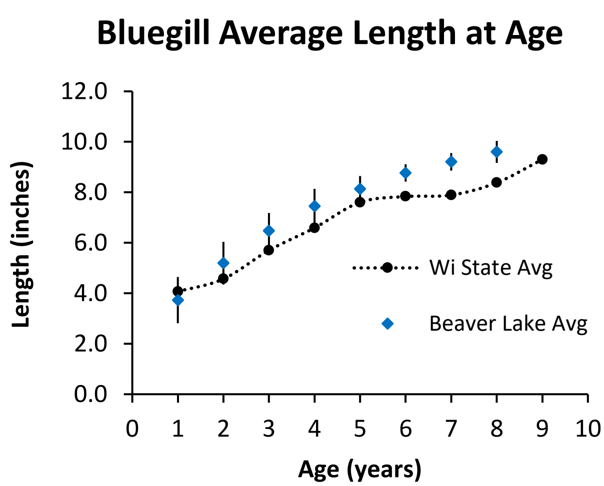

Figure 22. Average length-at-age and 1 standard deviation determined from back-calculated bluegill scale samples collected during 2017 spring Beaver Lake surveys.

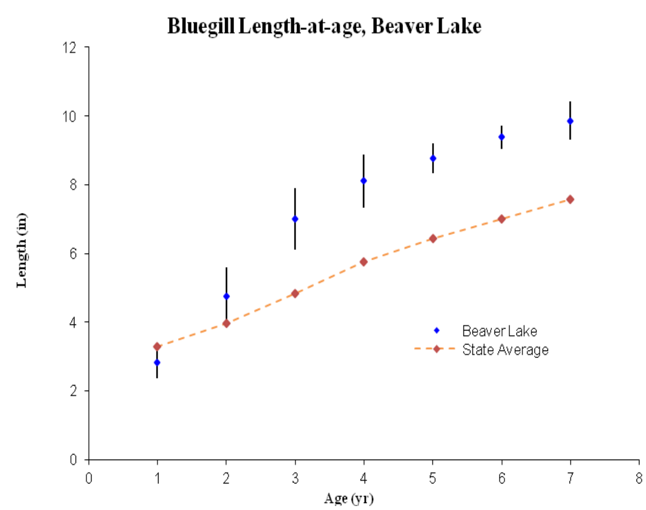

Figure 23. Average length-at-age and 1 standard deviation determined from back-calculated scale samples collected during the March 2012 Beaver Lake survey. n=97

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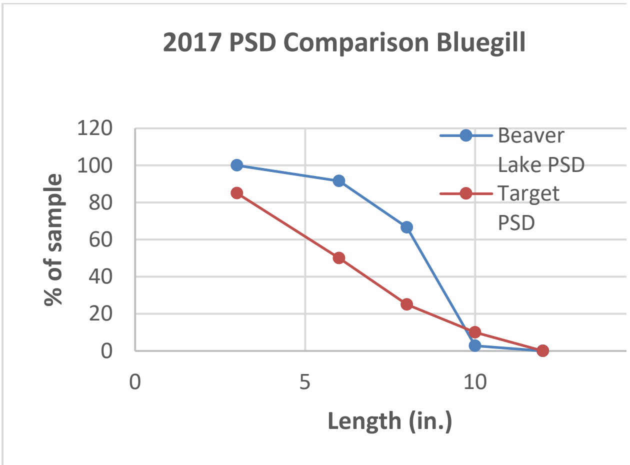

Figure 24. Bluegill proportional stock density (PSD) from Beaver Lake during the 2017 spring surveys.

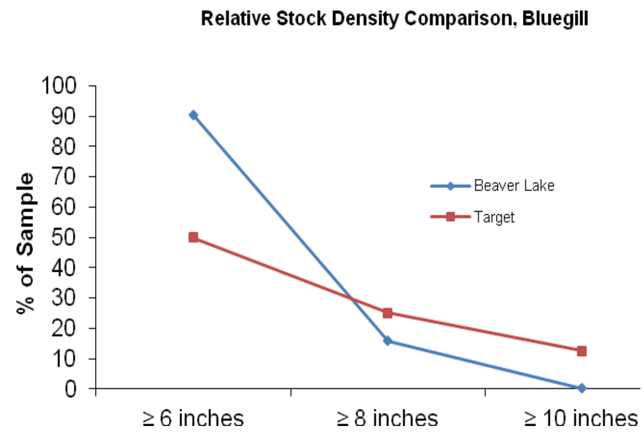

Figure 25. Bluegill proportional stock density (PSD) from Beaver Lake during the March 2012 survey.

Walleye

A total of 42 walleyes were captured during the spring 2017 surveys on Beaver Lake. The fish ranged from 7.6 inches to 17.0 inches with an average of 13.59 inches (**Figure 26**).

Age was determined for 40 walleyes and was used to calculate average length-at-age data (**Figure 27**). The state average is included for comparison. Growth for Beaver Lake walleye was similar to the state average. However, fish over age 5 exhibited slower than average growth. Only one walleye was captured during the survey in 2012. This fish was 19.2 inches long. The marked recapture estimates there are 239 walleyes in the lake.

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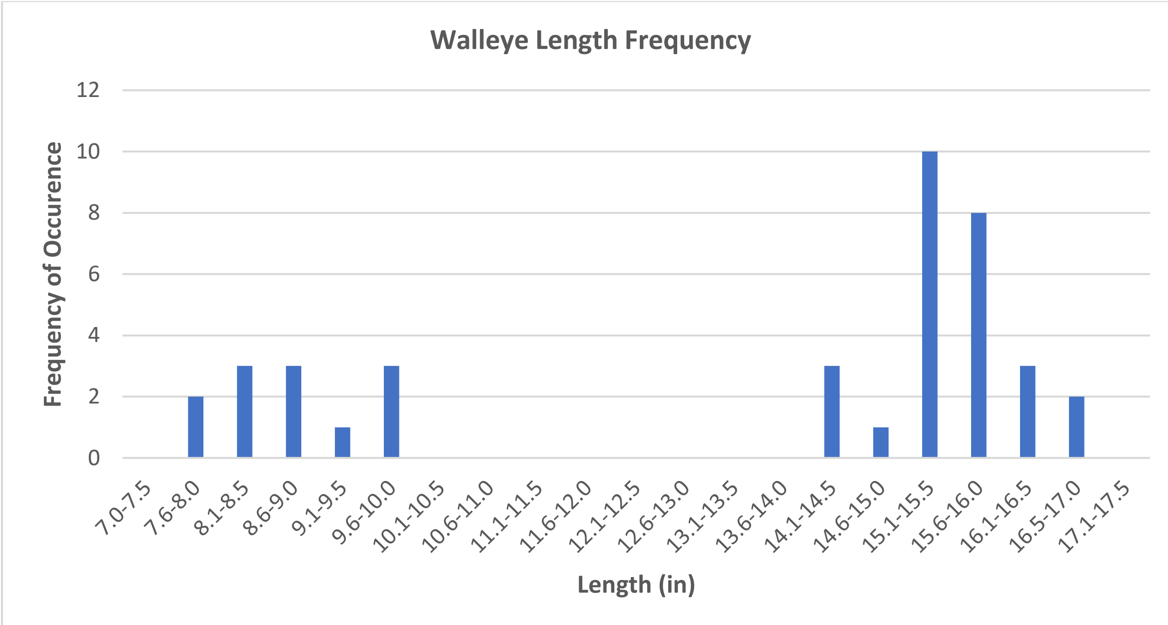

Figure 26. Length frequency of walleye captured on Beaver Lake during the spring 2017 surveys.

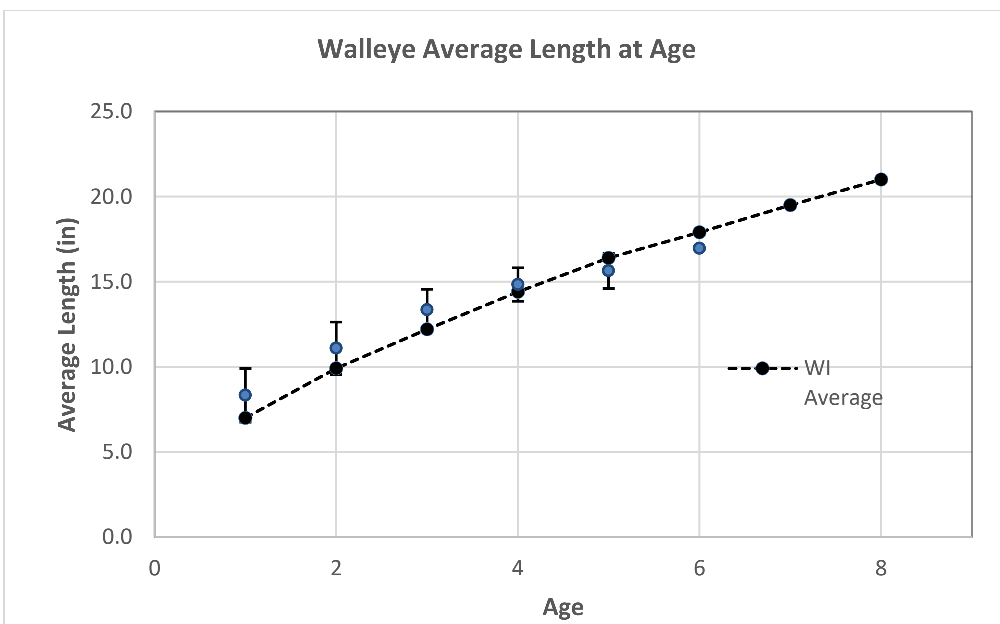

Figure 27. Average length-at-age and 1 standard deviation for walleye, determined from back-calculated scale samples collected during the spring 2017 Beaver Lake surveys.

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Proportional stock densities for walleye are shown in **Figure 28**. Stock, quality, preferred, and memorable size for walleye are ≥ 10 inches, ≥ 15 inches, ≥ 20 inches, and ≥ 25 inches, respectively. Out of the 43 walleye captured, 30 were above "stock" size, 24 were above "quality" size, and no fish were above "preferred" or "memorable" sizes. The Beaver Lake walleye population size structure appeared to be comprised of smaller fish. The size structure of the walleyes in Beaver Lake is heavily dependent on stocking. Recent stocking of extended growth fingerlings in 2016 brings the overall size of the population down, and fish stocked in 2014 had not grown into the preferred size class yet.

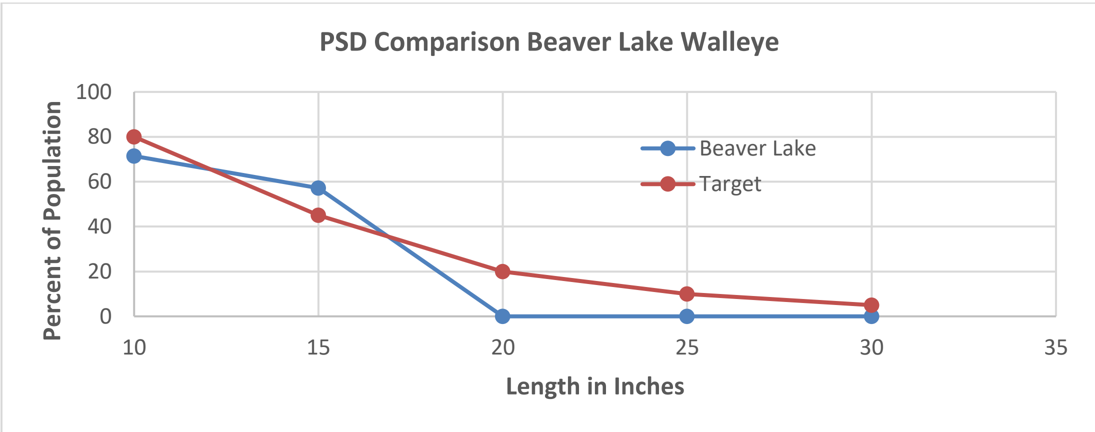

Figure 28. Walleye Proportional stock density (PSD) from Beaver Lake during the spring 2017 surveys.

A total of 35 white suckers were captured during the survey, averaging 19.5" in length. The largest was 23.3 inches long (**Figure 29**).

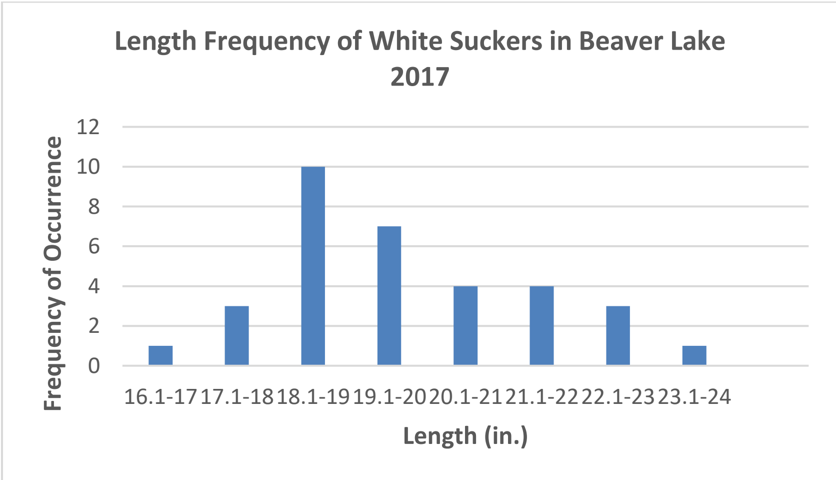

Figure 29. Length frequency of white sucker captured on Beaver Lake during the spring 2017 surveys.

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Rock Bass

A total of 40 rock bass were captured during the surveys. These fish averaged 8.2 inches long with a maximum length of 10.5 inches.

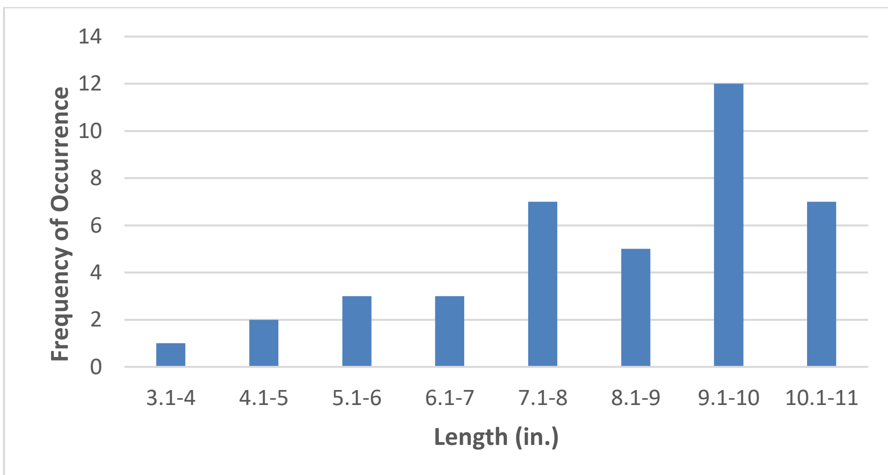

Figure 30. Length frequency of rock bass captured on Beaver Lake during the spring 2017 surveys.

Black Crappie and Yellow Perch

Only one black crappie and 3 yellow perch were caught in the two surveys. The black crappie measured 10 inches long and the yellow perch were 6.7, 9.8, and 2.0 inches long. However, lake residents have encountered a fair number of yellow perch throughout the 2017 open water season. Black crappies showed up in the 2012 survey and likely a small population still exists. It is likely that perch and crappies were under sampled within the time constraints, and capture limitations of the surveys.

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Other Species Encountered

Other fish species encountered during the survey include golden shiners and common carp. Thirteen mudpuppies and four crayfish were also captured during the surveys.

Conclusions & Recommendations

Beaver Lake appeared to support a diverse and quality fishery. Many fishing opportunities are available for sportsmen/women, from catching a meal of panfish to targeting trophy gamefish. It is rare to have this combination in a lake with the amount of fishing pressure and human activity that takes place on many lakes. That being said, a few minor changes in the management and some habitat improvement may increase the overall fishing experience on Beaver Lake both now and for future generations.

Fish Harvest and Stocking

Upon analyzing the data gathered throughout the survey, there were a few notable findings. First, there was a very apparent panfish and bass relationship. Both largemouth and smallmouth bass, play an important role in keeping the panfish (rock bass, bluegill, yellow perch, black crappie) population in check.

Often lakes have a “stunted” bluegill population. This is usually caused by a high density of bluegill competing for the same resources, or becoming sexually mature at an early age (therefore slowing their growth) (Aday, Phillip, and Wahl 2006). There are many reasons why this can happen, such as over-fishing, an unbalanced predator-prey relationship, excessive vegetation growth, etc. The Beaver Lake bluegill population has benefited from their relatively low population densities, and show above-normal growth rates and body condition. The drawback is panfish numbers are very low.

According to the bluegill growth rates and size structure found on Beaver Lake, fishing pressure is one of the reasons why “memorable” bluegills were not abundant in the lake. Surprisingly the estimated bluegill mortality rate was average to low (55%). This may have been a product of sample size (n=36) or the timing of the surveys. In 2012, the mortality of bluegills was 79%, which is what we would expect to see if we had a larger sample size. It is possible educating lake owners has reduced harvest of larger bluegills, as well as, allowing annual mortality to be reduced. Bluegill on Beaver Lake should have the ability to grow larger if they can survive to reach older ages, living up to around 10 years (oldest fish captured during the survey was 8 years old).

One management recommendation to encourage the growth of large bluegills is for anglers to keep smaller bluegills for consumption. This would mean throwing back the 9 inch fish and keeping a

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7 inch fish for the frying pan. Over time, size structure should improve and trophy sizes (over 10 inches) will become more common (MDNR, 2013).

However, the survey indicated low numbers of fish under 6 inches in the system. Bluegills in Beaver Lake reached 6 inches in less than 4 years. Juvenile bluegill, are often targeted by walleye (Kelling 2016) and even more so when other prey numbers seem to be low. This adds strain to the fishery. For this reason, we recommend pushing for a reduced daily bag limit on bluegills from 25 fish down to 10 fish. To help reduce future strain on bluegill populations we recommend suspending scheduled walleye stocking in 2018 (based on every other year stocking) and re-analyze the lake before the 2020 stocking.

Although bluegills exhibited incredible growth rates in Beaver Lake, the bass did not. Largemouth and smallmouth bass had a growth rate similar to the state average up to 4-5 years of age before slowing to below average. This could indicate young bass are able to find enough aquatic invertebrates to grow, but once they get to age 4-5, they need to start eating larger forage to keep up. The bass body condition in the 2012 survey indicated food was limiting growth. Body condition was poor during the 2017 survey as well. The overall size structure of large and smallmouth bass has shifted since the 2012 (**Figures 8, 9, 14 and 15**). There were even more small-sized bass in Beaver Lake in 2017 and fewer of the quality and memorable sized fish. With such a large number of bass swimming around in Beaver Lake, food may be scarce. One way to promote larger bass is to reduce the population, but by doing so, it is possible the quality of the panfish may suffer at some point. However, the current amount of predation on bluegills is unsustainable.

Habitat

A visual assessment of the walleye spawning habitat in Beaver Lake was conducted during the last day of the fyke net survey. Critical spawning habitat exists on the points in the middle of the lake. These areas catch favorable winds regardless of direction and offers preferred slopes and water depths and some protection from siltation. This shoreline on the west side of the lake has a similar slope and has some good areas of rock and gravel. This shoreline often is protected from wind and thus not favorable for spawning. The eastern shore catches the prevailing winds during the average spring. Unfortunately, the eastern shore has a very gradual slope and is heavily covered in sand. Walleye will spawn on sand, but eggs may have lower success rates. There is some gravel on the east end of the lake. However, this gravel is very shallow and may be out of the water if water tables are lower than average.

We recommend areas around the points be protected if the goal is walleye spawning. This can be done by planting aquatic vegetation on either side of the points and using tree drops if possible. Both methods will help catch sand, silt and organic matter. These three sediment types tend to fill the holes in gravel that are needed for walleye eggs. They can also suffocate eggs that are already laid. The eastern side of lakes tends to be very important to spawning fish. The lack of strong spawning habitat in this area may limit overall spawning success indefinitely.

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One major factor in fish growth and size structure is the presence of the correct size of prey. Medium sized prey-fish are virtually non-existent in Beaver Lake. These fish are key to growth of walleye, bass, and northern pike. They also play a role in panfish numbers by offering an alternate food source for predators. We recommend stocking golden shiners and fathead minnows in the lake. Golden shiners occur naturally in Beaver Lake, but in very low numbers. Stocking these fish could help prevent a panfish population crash due to over predation and enhance growth for gamefish. In lakes with excellent water clarity these fish need cover to avoid predation.

The Friends of Beaver Lake have built and installed some fish cribs in past years. We recommend adding more cribs to increase structural habitat. Wooden cribs grow algae on their surfaces, which feeds plankton and macro invertebrates, charging the food chain. They also provide hiding spots for prey. On the downside, cribs can congregate fish and make them more accessible to fishermen. The addition of more cribs not only provides more cover and promotes algae growth, but it makes it harder for fishermen to narrow down which crib to fish. However, cribs don't completely address the problem of cover. Cribs must be put in deeper water to maintain safe boating conditions. There is a large need for cover in shallow near-shore areas where many of the fish in Beaver Lake spend most of their time.

Tree drops can provide some shallower near shore cover. Trees are felled into the water and pushed 5-10ft off shore. Then they are chained to the shoreline, or an existing live tree, so they don't shift and move when ice develops during the winter. This provides more shelter and invertebrate life to the clear shallow areas of the lake as well as shelter. Another benefit of tree drops is it provides an area for yellow perch to deposit their eggs. Yellow perch lay long strings of eggs called skein. These strings need to hang on something to avoid sticking together and/or being smothered. If lake residents are willing to participate, tree drops would be very beneficial. There is grant money available for this type of project through the Wisconsin's Healthy Lakes Implementation Plan. The "fish sticks" program does require public access for grant approval, but the walk-in access may be enough for funding.

The addition of aquatic vegetation provides cover and food for plankton and macro invertebrates. It also provides cover for small fish and habitat for some spawning fish, such as northern pike and yellow perch. During the 2012 survey there was a large hatch of mayflies (*Hexagenia sp*.). These mayfly nymphs could be the cornerstone of the Beaver Lake fishery and should be protected. To protect aquatic invertebrates, it is imperative that there is continued work done to promote aquatic plant growth and other structure. This type of cover helps young fish feed and grow without leaving the safety of cover. We recommend planting aquatic vegetation in shallow areas that are protected from wave action. These areas are well used by fish and protection from wind ensures that the plants are protected from waves pulling them up. Good areas for plantings are the northwest corner of the lake, along with Turtle Bay on the southwest side.

Summary of Recommendations

- Implement prey stocking
    - Yearly stocking of fathead minnows recommended
    - Stocking of golden shiners to support fish growth recommended
- Maintain bluegill to bass ratio to ensure quality bluegill fishery remains.
    - Recommend reduction of panfish limit from 25 to 10 fish
    - Recommend removal of largemouth bass size limit
- Reduce or eliminate walleye stocking temporarily to even out fishery
    - Eliminate the 2018 walleye stocking
    - Evaluate fishery prior to walleye stocking in 2020
- Improve near-shore habitat for nurseries for juvenile fish and habitat for aquatic insects.
    - This would include native plantings, placement of structure around docks and shoreline, decreasing boat activity in shallow areas, tree drops, etc.
    - Improve spawning habitat for fish such as northern pike and yellow perch. (see recommendation above)
- Recommend wake protected areas
    - Decrease the disruption of sediment from boating activity, as well as by decreasing common carp population.
    - Encourage submergent and emergent plant growth, while controlling all exotic species (Eurasian watermilfoil, purple loosestrife).

Acknowledgments

Thanks to all the volunteers that helped in gathering data. Sampling of the fishery could not have been done in such a timely manner without the help of all the volunteers.

Thanks you!
Paul Raab, Alex Raab, Ryan Kaiser, Chip Curtes, Professor Bob Anderson, Joe Gehl, and other volunteers from Wisconsin Lutheran College.




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