FISH SURVEY REPORT

Cordry & Sweetwater Lakes

January 9, 2018

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Table of Contents

List of Figures

List of Tables

INTRODUCTION

A survey of the fish populations and other physical, biological, and chemical factors directly affecting the fish populations was completed at Cordry & Sweetwater Lakes on October 9 and October 17, 2017 respectively. The major objectives of this survey and report are:

1. To provide a current status report on the fish community of the lakes
2. To compare the current characteristics of the fish community with past surveys and established indices and averages for Indiana lakes
3. To provide recommendations for management strategies to enhance or sustain the sport fish community

The data collected are adequate for the intended uses; however, there will be unanswered questions regarding aspects of the fish population and other related factors of the biological community in the lake. All fish numbers used in the report are based on the samples collected and should not be interpreted to be absolute or estimated numbers of fish in the lake. General information regarding water chemistry, fish communities, and methods are described in Appendix A. A detailed fish collection table is presented in Appendix B.

RESULTS AND DISCUSSION – Cordry Lake

WATER CHEMISTRY

The results of selected physio-chemical parameters from Cordry Lake are presented in Table 1. Water chemistry parameters and dissolved oxygen / temperature profiles were taken near the dam in 68 ft. of water. The cord on our dissolved oxygen meter was only 33 ft. long. As a result, dissolved oxygen and temperature readings were taken to only 33 ft. Water temperatures ranged from 71.9 degrees at the surface to 51.2 degrees at 33 ft. Dissolved oxygen ranged from 8.02 parts per-million (ppm) at the surface to 4.28 ppm at 33 ft. (Figure 1). A desirable oxygen level for healthy stress-free fish was present to a depth of 30 ft. These numbers indicate Cordry Lake was stratified at the time of the survey, with the thermocline near 24 ft. (See appendix A for further details on lake stratification). The alkalinity level was 85.5 ppm at the surface and 68.4 ppm on the bottom. The hardness level was 51.3 ppm at the surface and 102.6 ppm on the bottom. The pH was 7.43 at the surface and 6.99 on the bottom. The Secchi disk depth was measured at 14.5-feet which is excellent for Southern Indiana waters. Nitrate-nitrogen levels were 0.9 ppm at the surface and 0.4 ppm on the bottom. High nitrates can contribute to excessive aquatic plant growth. Ortho-phosphate (phosphorus that is readily available for up take by plants) levels were below detection limits at the surface and 0.28 ppm at the bottom. Total phosphorus was 0.08 ppm on the surface and 0.43 ppm on bottom. These water chemistry parameters are considered to be within acceptable ranges. Cordry Lake appears to have excellent water quality capable of supporting a healthy fish population.

Table 1. Selected water quality parameters measured on Cordry Lake, October 9, 2017.

Sample Depth (ft.)	Temp.(°F)	Dissolved Oxygen (ppm)	pH (standard units)	Total Alkalinity (ppm)	Total Hardness (ppm)	Nitrate Nitrogen (ppm)	Ortho Phosphate (ppm)	Total Phosphorus (ppm)
Surface	71.9	8.02	7.43	85.5	51.3	0.90	0	0.08
3	71.8	8.00	-	-	-	-	-	-
6	71.6	8.03	-	-	-	-	-	-
9	71.4	8.07	-	-	-	-	-	-
12	71.3	7.98	-	-	-	-	-	-
15	71.2	7.93	-	-	-	-	-	-
18	71.2	7.87	-	-	-	-	-	-
21	71.1	7.73	-	-	-	-	-	-
24	66.6	6.33	-	-	-	-	-	-
27	61.3	5.41	-	-	-	-	-	-
30	55.9	5.35	-	-	-	-	-	-
33	51.2	4.28	-	-	-	-	-	-
68	-	-	6.99	68.4	102.6	0.4	0.28	0.43

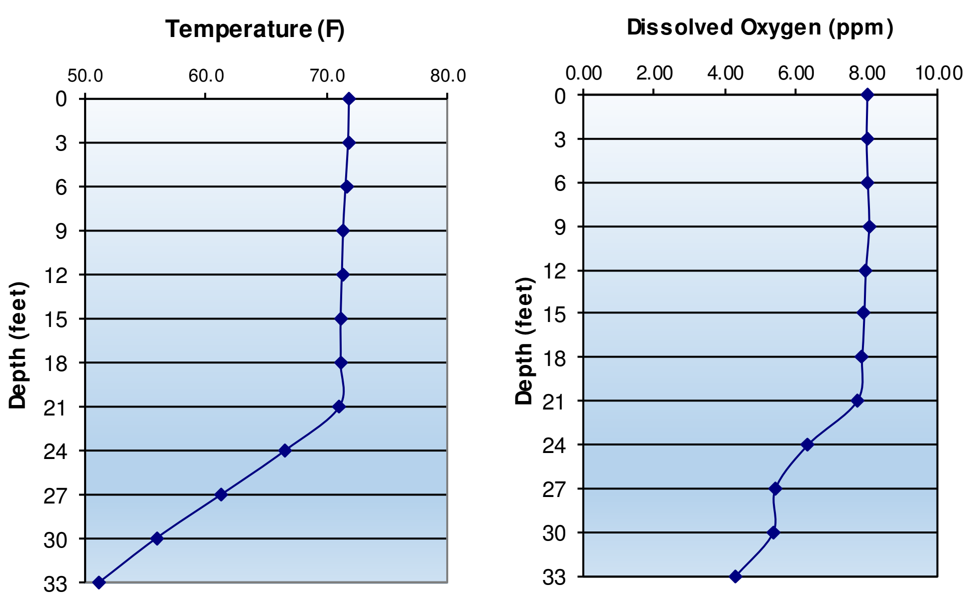

Figure 1. Dissolved oxygen and temperature profiles for Cordry Lake, October 9, 2017.

FISH COLLECTION

A total of 833 fish weighing 123.85 pounds and representing ten species was collected from Cordry Lake (Table 2). Bluegill was the most abundant species comprising 73.95% of the fish collected. Largemouth bass was the second most abundant species (15.97%), followed by green sunfish (3.12%), bluntnose minnow (2.40%), black crappie (1.20%), yellow perch (1.20%), redear sunfish (0.96%), smallmouth bass (0.84%), yellow bullhead (0.12%), Johnny darter (0.12%), and spotfin shiner (0.12%). These numbers are illustrated in Figure 2.

Table 2. Species collected from Cordry Lake, October 9, 2017.

Species	Scientific Name	N	%N	Size Range (in.)	Total weight (lbs.)	%Wt.	N/hr.
Bluegill	*Lepomis macrochirus*	616	73.95%	<3.0-9.5	15.45	12.47%	274
Largemouth bass	*Micropterus salmoides*	133	15.97%	<3.0-17.0	96.04	77.55%	59
Green sunfish	*Lepomis cyanellus*	26	3.12%	<3.0-7.5	2.27	1.83%	12
Bluntnose minnow	*Pimephales notatus*	20	2.40%	<3.0-3.0	0.20	0.16%	9
Yellow perch	*Perca flavescens*	10	1.20%	<3.0-3.0	0.20	0.16%	4
Black crappie	*Pomoxis nigromaculatus*	10	1.20%	<3.0-12.5	3.43	2.77%	4
Redear sunfish	*Lepomis microlophus*	8	0.96%	3.5-11.0	3.56	2.87%	4
Smallmouth bass	*Micropterus dolomieu*	7	0.84%	5.0-10.0	2.07	1.67%	3
Yellow bullhead	*Ameiurus natalis*	1	0.12%	10.00	0.61	0.49%	0
Johnny darter	*Etheostoma nigrum*	1	0.12%	<3.0	0.01	0.01%	0
Spotfin shinner	*Cyprinella spiloptera*	1	0.12%	<3.0	0.01	0.01%	0
	TOTAL	833			123.85		

N = number of individuals
%N = percent number of a species as compared to the total number of fish collected
%Wt = percent weight of a species as compared to the total number of fish collected
N/hr. = catch rate of a species (number of fish of a species collected per hour of electrofishing effort)

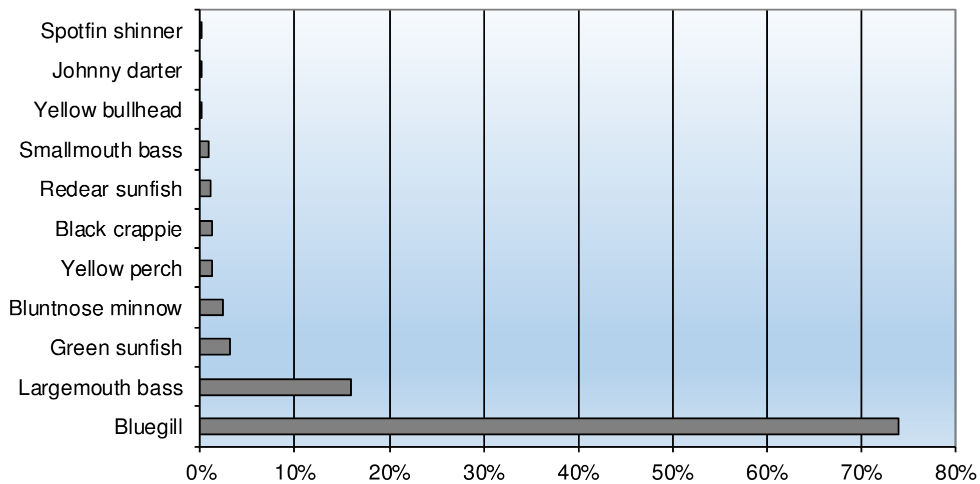

Figure 2. Species collected from Cordry Lake, October 9, 2017.

Bluegill

Bluegill (Figure 3) was the most abundant species collected (73.95%) and ranked second by weight (12.47%). They ranged in size from less than 3.0 to 9.5 inches (Figure 4). Approximately 73% of bluegill collected was less than 3.0 inches indicating successful reproduction occurred in 2017. Condition factors (measurement of overall plumpness) and relative weights were below average for most size ranges (Appendix B). Standard weights were also below average for most size ranges (Figure 5). The proportional stock density (PSD) was 14 which is below the desired range of 20-40 for bluegill and indicates the population has a low number of quality bluegill (Figure 6). While the PSD has improved slightly since the last survey (PSD was 3 in 2000 and 11 in 2009), it still appears that smaller bluegill are not being utilized to their potential by predator species. The result is an overabundance of small, slow growing bluegill. Larger bluegill may have inhabited deeper water at the time of the survey and may be present in greater numbers than indicated.

Figure 3. Photograph of bluegill, *Lepomis macrochirus*.

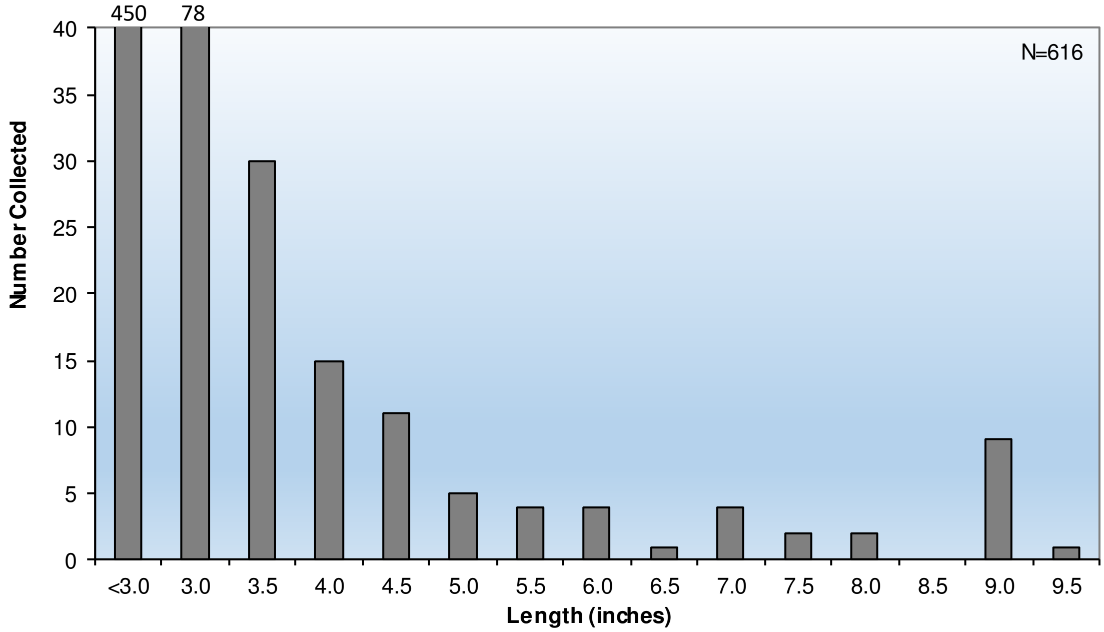

Figure 4. Bluegill collected from Cordry Lake, October 9, 2017.

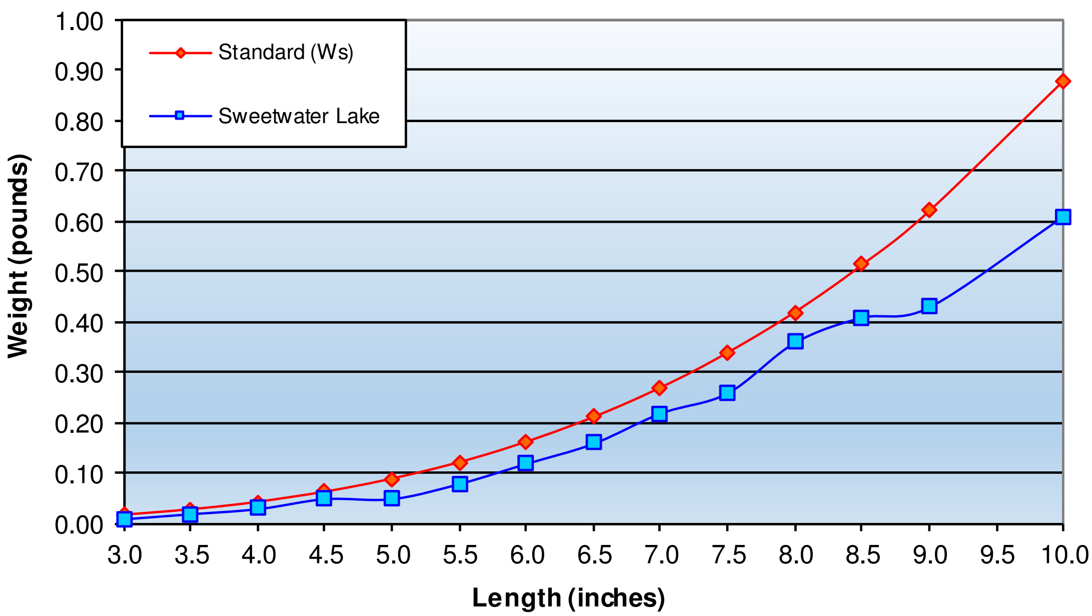

Figure 5. Bluegill collected from Cordry Lake compared to standard weights.

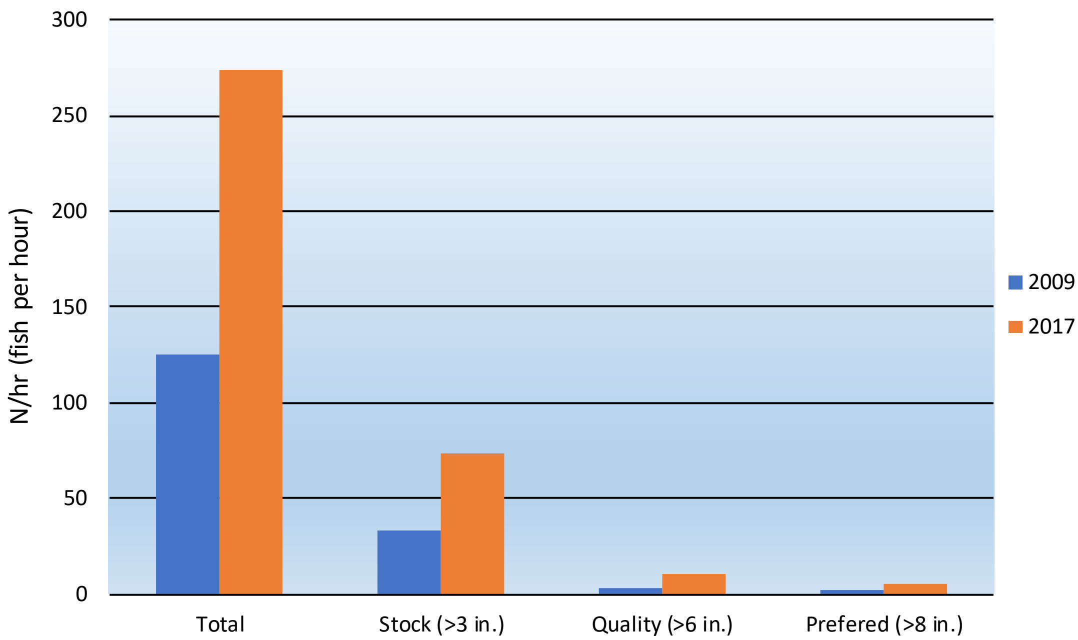

Figure 6. Cordry Lake bluegill N/hr. comparison.

Largemouth Bass

Largemouth bass (Figure 7) was the second most abundant species collected (15.97%) and ranked first by weight (77.55%). A total of 133 largemouth bass ranging in size from less than 3.0 to 17.0 inches was collected (Figure 8). Only 17% of largemouth bass collected were less than 9.0 inches indicating poor reproduction and recruitment has occurred in the past 2 to 3 years. Condition factors were just slightly below normal for most length ranges (Appendix B). Largemouth bass weights were also slightly below standard weights (Figure 9). Approximately 83% of largemouth bass collected were between 7.5 and 14.0 inches. The PSD for largemouth was 69, which is above the desired PSD of 40-60 (for more information of PSD see Appendix). Catch rate of quality (>12 in.) and preferred (>15 in.) sized individuals increased slightly compared to the previous survey in 2009 (Figure 10).

Figure 7. Photograph of largemouth bass, *Micropterus salmoides*.

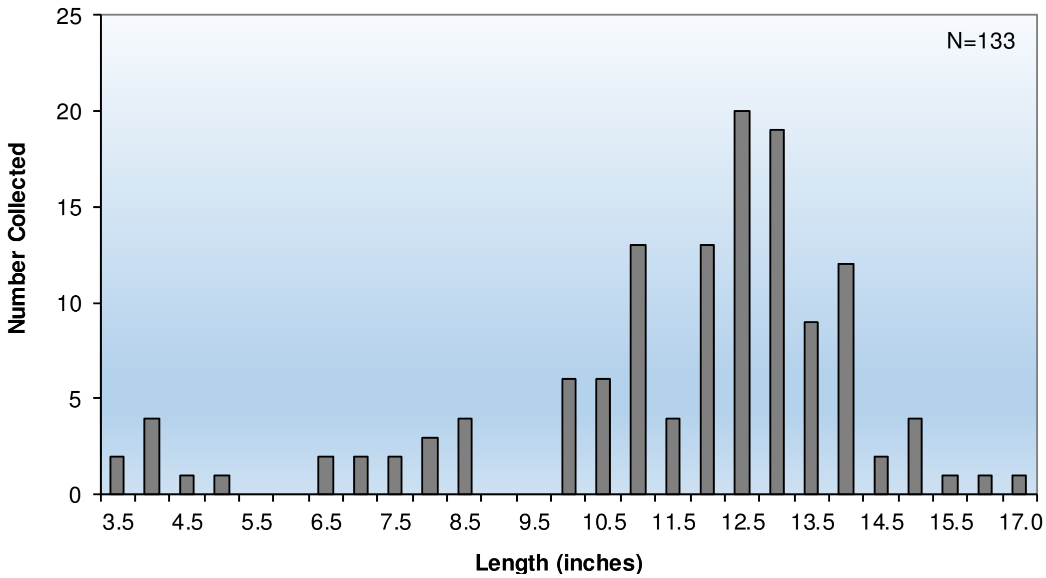

Figure 8. Largemouth bass collected from Cordry Lake, October 9, 2017.

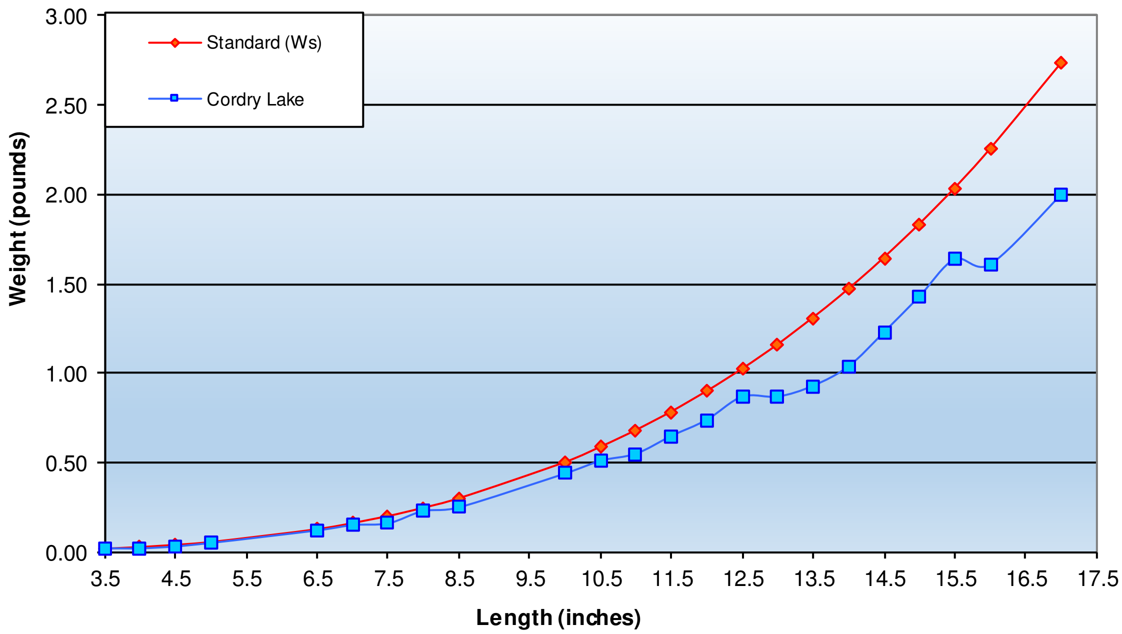

Figure 9. Largemouth bass collected from Cordry Lake compared to standard weights.

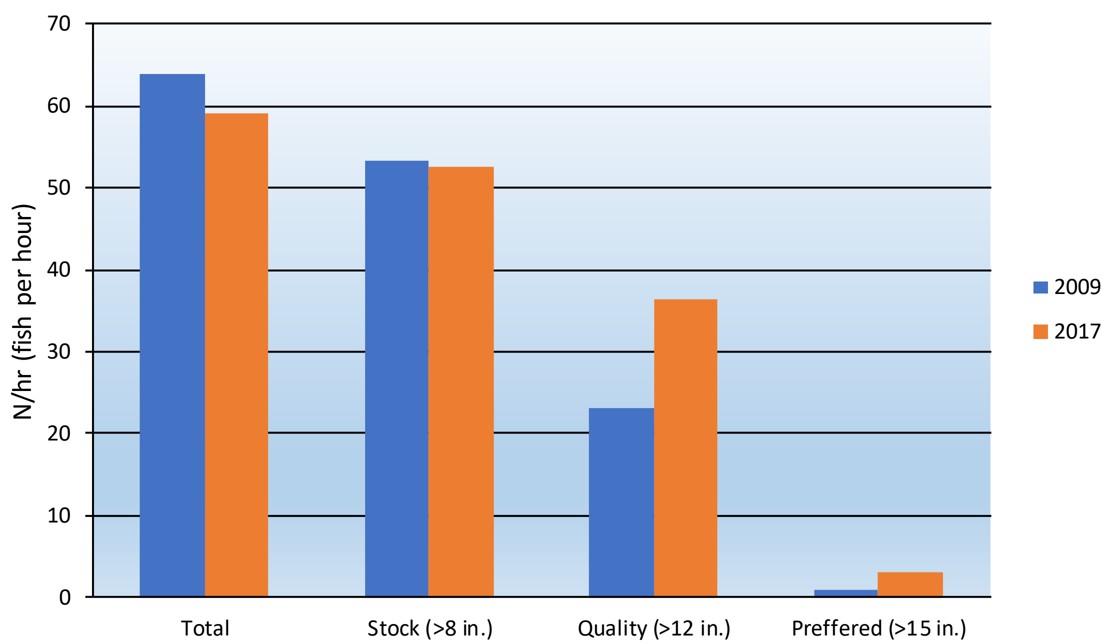

Figure 10. Cordry Lake largemouth N/hr. comparison.

Green Sunfish

Green sunfish was the third most abundant species collected and ranged in size from less than 3.0 to 7.5 inches (Appendix B). Twenty-six green sunfish were collected comprising 3.12% of the survey sample. This species has a tendency to form stunted populations and does not generally reach a desirable size. Due to their aggressiveness and tendency to compete with game species such as bluegill, green sunfish are not a desirable species. Anglers should remove every green sunfish that is caught. However, the population level at present is not a threat to the overall fishery. Figure 11 illustrates the morphological differences between green sunfish and bluegill.

Figure 11. Comparison of green sunfish, *Lepomis cyanellus* (top) with bluegill (bottom).

Bluntnose minnow

Bluntnose minnow (Figure 12) was the fourth most abundant species collected (2.40%). A total of 20 bluntnose were collected. The 2009 fish survey found bluntnose minnows at 7% relative abundance. Bluntnose are a valuable forage species for young bass, crappie and other predatory fish.

Figure 12. Photograph of bluntnose minnow, *Pimephales notatus*.

Yellow perch

Ten yellow perch (Figure 13) were collected ranging in size from less than 3.0 to 3.0 inches. This represents a similar number from the 2009 survey when nine yellow perch were collected. Larger individuals were likely inhabiting deeper water. Yellow perch have a small reproducing population in Cordry and will provide forage for predators as well as offer an additional angling opportunity.

Figure 13. Photograph of yellow perch, *Perca flavescens*.

Black crappie

Ten black crappie (Figure 14) were collected during electrofishing. They ranged in size from less than 3.0 to 12.5 inches. Crappie inhabit deeper water and are usually not well represented in electrofishing surveys. It is likely the crappie population is higher than indicated by the sample. Seventeen black crappie were collected in the 2009 survey.

Figure 14. Photograph of black crappie, *Pomoxis nigromaculatus*.

Redear sunfish

A total of 8 redear sunfish (Figure 15) ranging in size from 3.5 to 11.0 inches was collected. Twelve redear were collected in the 2009. Redear are not prolific spawners like bluegill. It is likely redear will not become abundant in the lake. Redear sunfish inhabit deeper water than bluegill and feed primarily on insects and snails. They also tend to grow faster than bluegill. This species should provide an additional sport fish in Cordry Lake. Due to their slower reproductive potential and small population, this species should be protected with more restrictive bag limits.

Figure 15. Photograph of redear sunfish, *Lepomis microlophus*.

Smallmouth bass

Seven smallmouth bass (Figure 16) were collected. They ranged in size from 5.0 to 10.0 inches. Five smallmouth were collected in 2009. The smallmouth's have developed a small, self sustaining population and will not become as abundant as largemouth but will provide some additional angling opportunity.

Figure 16. Photograph of smallmouth bass, *Micropterus dolomieu*.

Other species

One yellow bullhead (Figure 17), one Johnny darter (Figure 18), and one spotfin shiner (Figure 19) was also collected. Bullheads compete with desirable species for food and space and should be removed from the lake when caught. At present, it appears the population is low and poses little threat to the fishery. Darters and spotfin shiners are generally stream species but sometimes make their way into lakes. They pose no problems to the fishery.

Figure 17. Photograph of yellow bullhead, *Ameiurus natalis*.

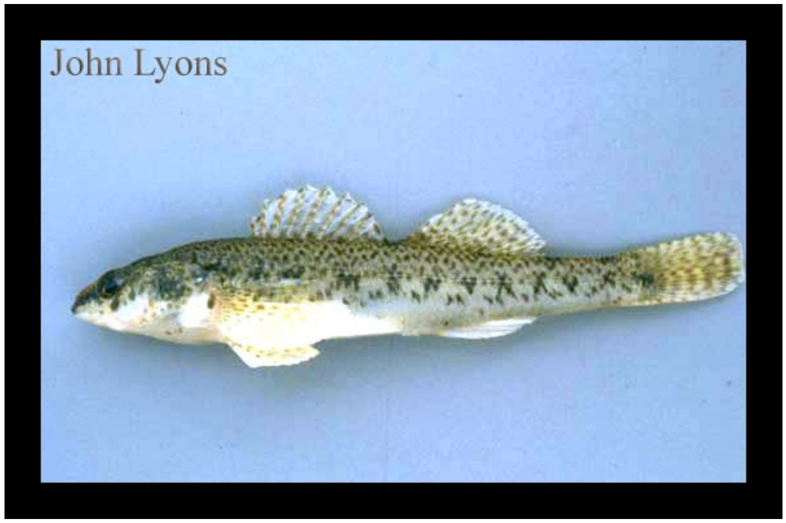

Figure 18. Photograph of Johnny darter, *Etheostoma nigrum*.

Figure 19. Photograph of spotfin shiner, *Cyprinella spiloptera*.

SUMMARY AND RECOMMENDATION – Cordry Lake

Cordry Lake continues to have excellent water quality. The nutrient levels are still in good condition and are reflected in the excellent water clarity. The survey indicates Cordry Lake has an imbalance in relation to the bluegill/largemouth bass fishery (see appendix for discussion of balance). Largemouth bass and other predators appear to be cropping the bluegill population around the 4.0-inch size range. This is likely due to the large number of largemouth bass in the 10.0 – 13.0-inch range. When a large number of a population are competing with one another for the same size food and resources it can lead to slow growth and prevent them from reaching their maximum potential. Largemouth bass PSD went up compared to the previous survey. This means a higher proportion of larger bass were collected, but this can be misleading. Maintaining the 14.0-inch size limit and continuing bag limits on bluegill harvest will continue to produce stunted largemouth bass under 14.0 inches and low numbers of quality bluegill. Implementing a slot limit can address these issues. By harvesting fish less than 13.0 inches, competition will be reduced and growth rates will increase for largemouth bass. This will also release some predation pressure on the bluegill population and allow more individuals to reach larger sizes.

The following recommendations, **listed in order of importance**, will help protect and enhance the fishery in Cordry Lake:

1. Slot Limit: 5 largemouth/smallmouth bass less than 13.0 inches or greater than 16.0 inches can be harvested (no more than 3 of 5 should be smallmouth). No more than one over 16.0 inches should be harvested. Harvest of fish less than 13.0 inches should be encouraged.

2. Limit bluegill/redear harvest to 15 per day for the next two years (no more than 10 of 15 should be redear).

3. Continue aquatic vegetation management practices.

4. Conduct a Standard Fish Survey in 2020 in order to monitor the effects of the above recommendations and assess needs for further management activities.

RESULTS AND DISCUSSION – Sweetwater Lake

WATER CHEMISTRY

The results of selected physio-chemical parameters from Sweetwater Lake are presented in Table 3. Water chemistry parameters and oxygen / Temperature profiles were taken near the dam in 104 ft. of water. The cord on our dissolved oxygen meter was only 63 ft. long. Water temperatures ranged from 68.4 degrees at the surface to 44.2 degrees at 63 ft. Dissolved oxygen ranged from 8.48 parts per-million (ppm) at the surface to 2.48 ppm at 63 ft. (Figure 20). A desirable oxygen level for healthy stress-free fish was present to a depth of 33 feet. These numbers indicate Sweetwater Lake was stratified at the time of the survey with the thermocline near 30 ft. (See appendix A for further details on lake stratification). The alkalinity level was 51.3 ppm at the surface and on the bottom. The hardness level was 102.6 at the surface and on the bottom. The pH was 7.17 at the surface and 6.99 on the bottom. The Secchi disk depth was measured at 14.5 ft. indicating excellent water clarity. Nitrate-nitrogen levels were 0.1 ppm at the surface and undetectable on the bottom. Total phosphorus was 0.08 ppm on the surface and 0.09 ppm on bottom. Ortho-phosphate was 0.02 on the surface and 0.03 on the bottom. These water chemistry parameters are considered to be within acceptable ranges. Sweetwater Lake appears to have excellent water quality capable of supporting a healthy fish population.

Table 3. Selected water quality parameters measured on Sweetwater Lake, October 17, 2017.

Sample Depth (ft.)	Temp.(°F)	Dissolved Oxygen (ppm)	pH (standard units)	Total Alkalinity (ppm)	Total Hardness (ppm)	Nitrate Nitrogen (ppm)	Ortho Phosphate (ppm)	Total Phosphorus (ppm)
Surface	68.4	8.48	7.17	51.3	102.6	0.10	0.02	0.08
3	68.4	8.48	-	-	-	-	-	-
6	68.4	8.49	-	-	-	-	-	-
9	68.4	8.48	-	-	-	-	-	-
12	68.3	8.46	-	-	-	-	-	-
15	68.2	8.38	-	-	-	-	-	-
18	68.1	8.34	-	-	-	-	-	-
21	68.0	8.31	-	-	-	-	-	-
24	67.9	8.24	-	-	-	-	-	-
27	67.8	8.25	-	-	-	-	-	-
30	66.7	7.32	-	-	-	-	-	-
33	64.7	6.10	-	-	-	-	-	-
36	58.5	4.40	-	-	-	-	-	-
39	53.1	2.71	-	-	-	-	-	-
42	51.0	2.91	-	-	-	-	-	-
45	49.4	2.96	-	-	-	-	-	-
48	48.3	2.94	-	-	-	-	-	-
51	46.9	2.71	-	-	-	-	-	-
54	46.2	2.95	-	-	-	-	-	-
57	45.6	3.29	-	-	-	-	-	-
60	44.5	3.14	-	-	-	-	-	-
63	44.2	2.48	-	-	-	-	-	-
104	-	-	6.99	51.3	102.6	0.00	0.03	0.09

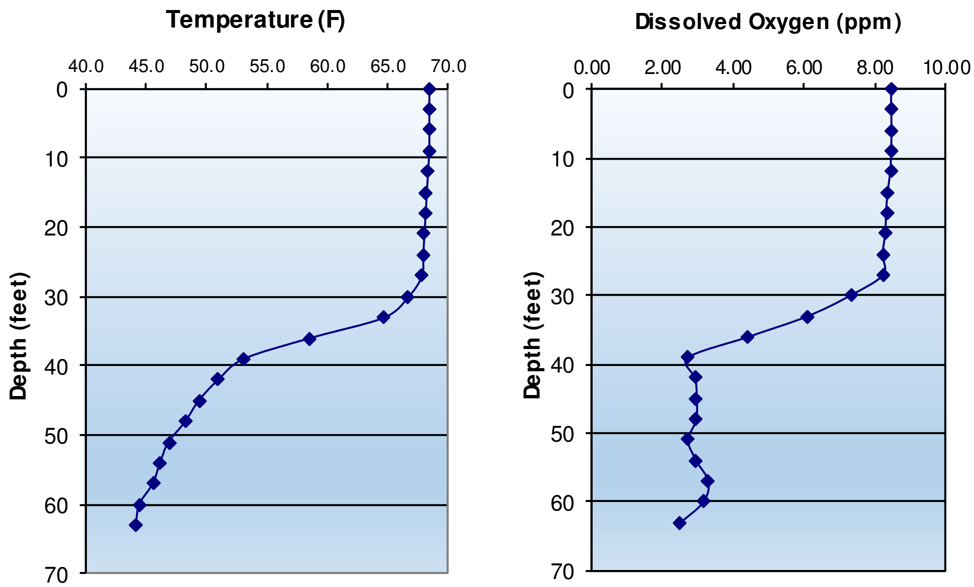

Figure 20. Dissolved oxygen and temperature profiles for Sweetwater Lake, October 17, 2017.

FISH COLLECTION

A total of 926 fish weighing 170.38 pounds and representing thirteen species was collected from Sweetwater Lake (Table 4). Bluegill was the most abundant species comprising 56.05% of the fish collected. Largemouth bass was the second most abundant species (16.31%), followed by brook silverside (13.50%), redear sunfish (6.05%), smallmouth bass (2.70%), black crappie (1.40%), bluntnose minnow (0.97%), green sunfish (0.97%), rock bass (0.97%), yellow perch (0.65%) flathead catfish (0.22%), yellow bullhead (0.11%), and golden shiner (0.11%). These numbers are illustrated in Figure 21.

Table 4. Species collected from Sweetwater Lake, October 17, 2017.

Species	Scientific Name	N	%N	Size Range (in.)	Total weight (lbs.)	%Wt.	N/hr.
Bluegill	*Lepomis macrochirus*	519	56.05%	<3.0-10.0	26.30	15.44%	189
Largemouth bass	*Micropterus salmoides*	151	16.31%	<3.0-21.0	104.13	61.12%	55
Brooke silverside	*Labidesthes sicculus*	125	13.50%	<3.0-4.0	1.25	0.73%	45
Redear sunfish	*Lepomis microlophus*	56	6.05%	3.5-11.0	17.60	10.33%	20
Smallmouth bass	*Micropterus dolomieu*	25	2.70%	4.0-13.5	8.96	5.26%	9
Black crappie	*Pomoxis nigromaculatus*	13	1.40%	3.0-11.5	5.52	3.24%	5
Bluntnose minnow	*Pimephales notatus*	9	0.97%	<3.0-4.0	0.09	0.05%	3
Rock bass	*Ambloplites rupestris*	9	0.97%	3.5-8.5	2.04	1.20%	3
Green sunfish	*Lepomis cyanellus*	9	0.97%	<3.0-7.0	1.47	0.86%	3
Yellow perch	*Perca flavescens*	6	0.65%	<3.0-8.0	0.29	0.17%	2
Flathead catfish	*Pylodictis olivaris*	2	0.22%	14.5-15.0	2.40	1.41%	1
Yellow bullhead	*Ameiurus natalis*	1	0.11%	8.5	0.32	0.19%	0
Golden shiner	*Notemigonus crysoleucas*	1	0.11%	3.5	0.01	0.01%	0
	TOTAL	926			170.38		

N = number of individuals
%N = percent number of a species as compared to the total number of fish collected
%Wt = percent weight of a species as compared to the total number of fish collected
N/hr. = catch rate of a species (number of fish of a species collected per hour of electrofishing effort)

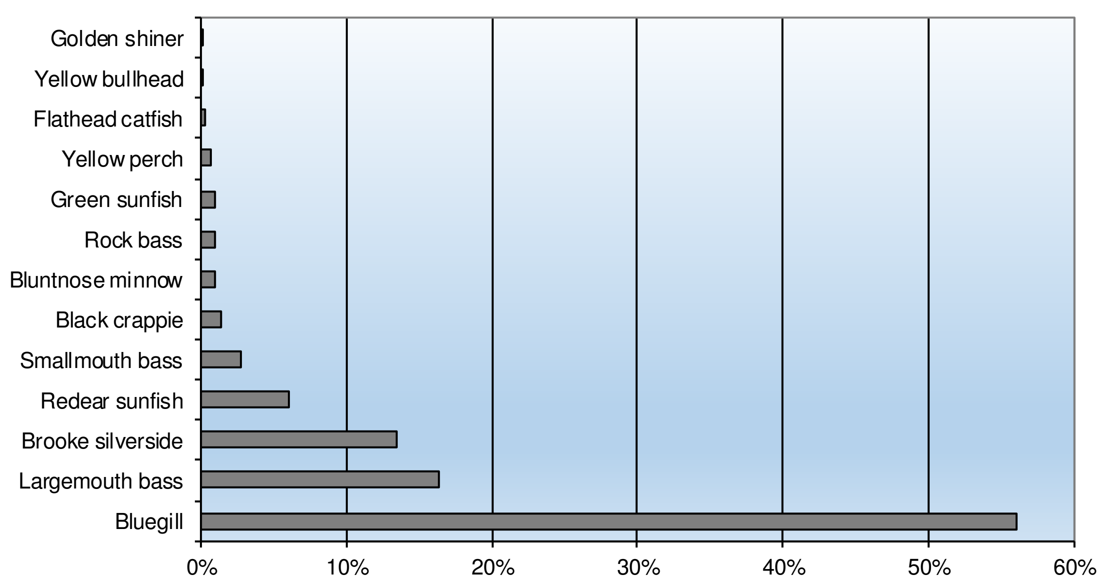

Figure 21. Species collected from Sweetwater Lake, October 17, 2017.

Bluegill

Bluegill was the most abundant species collected (56.05%) and ranked second by weight (15.44%). They ranged in size from less than 3.0 to 10.0 inches (Figure 22). Nearly 59% of bluegill collected was 3.0 inches or less. The proportional stock density (PSD) was 31 which is within the desired range of 20-40 for bluegill and indicates the population has a good ratio of large and small fish. This is the exact same as the previous survey in 2009. Average weights for bluegill were slightly below standard weights (Figure 23). There has been a clear decline in the number of quality bluegill in Sweetwater Lake. Figure 24 graphically illustrates the decrease in N/hr. (fish catch rate) of stock and quality size bluegill. However, the bluegill population in Sweetwater Lake still appears to be in good condition. Condition factors (measurement of overall plumpness) and relative weights were slightly below average for most size ranges, but they are good for such a clear, low nutrient lake (Appendix B).

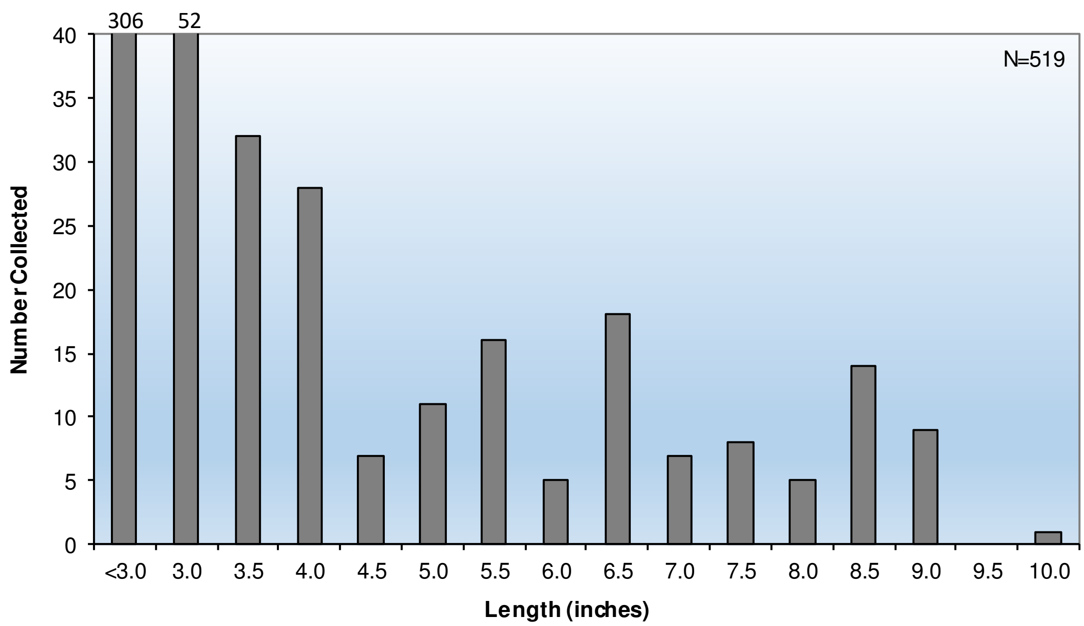

Figure 22. Bluegill collected from Sweetwater Lake, October 17, 2017.

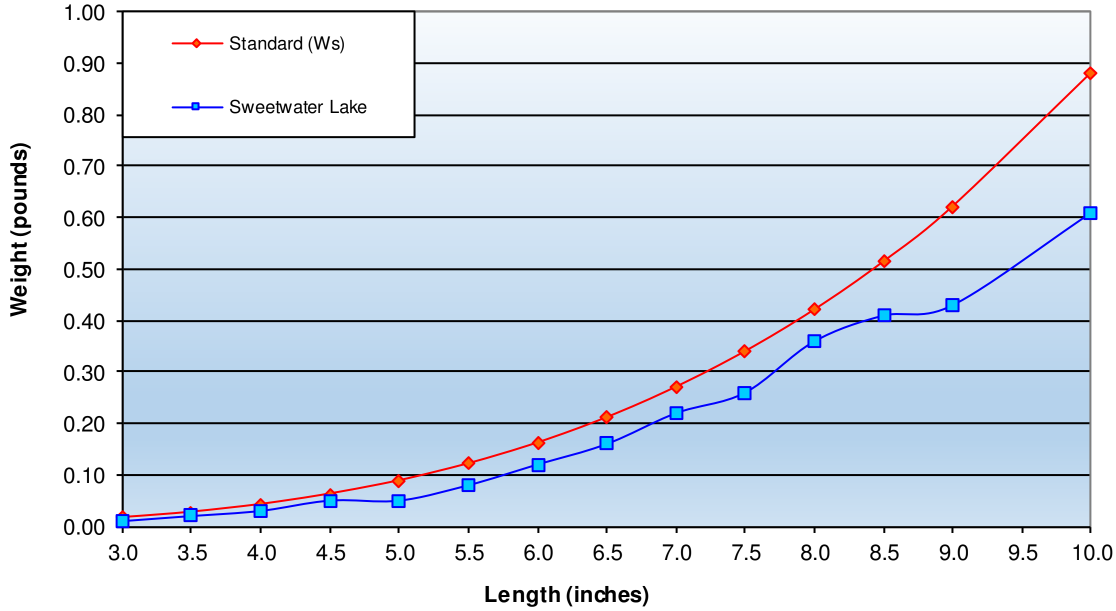

Figure 23. Bluegill collected from Sweetwater Lake compared to standard weights.

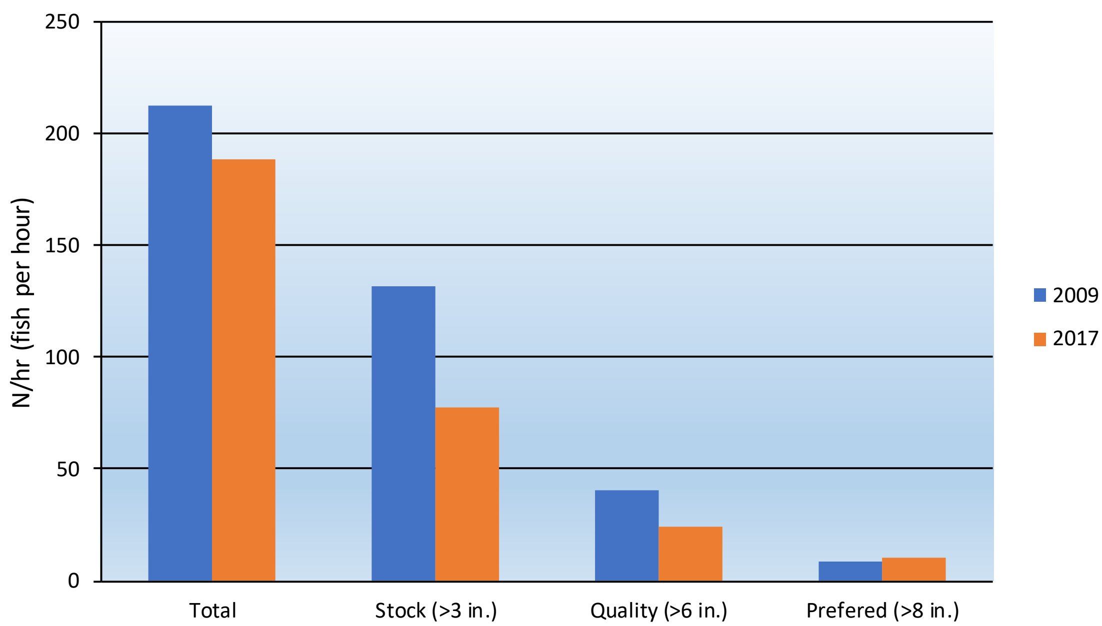

Figure 24. Sweetwater Lake bluegill N/hr. comparison

Largemouth Bass

Largemouth bass was the second most abundant species collected (16.31%) and ranked first by weight (61.12%). A total of 151 largemouth bass ranging in size from less than 3.0 to 21.0 inches was collected (Figure 25). The PSD for largemouth was 45, which is inside the desired PSD range of 40-60. This is an improvement from the 2009 PSD of 35. Condition factors were just slightly below normal for most length ranges (Appendix B). Largemouth bass weights were also slightly below standard weights (Figure 26). Figure 27 shows the catch rates (N/hr.) of largemouth bass compared to the 2009 survey. The total catch rate declined minimally, but catch rates of individuals greater than 8.0 inches has improved. Still, there is crowding in the 10.0 – 13.0-inch range. This is common in lakes with 14.0-inch size limits.

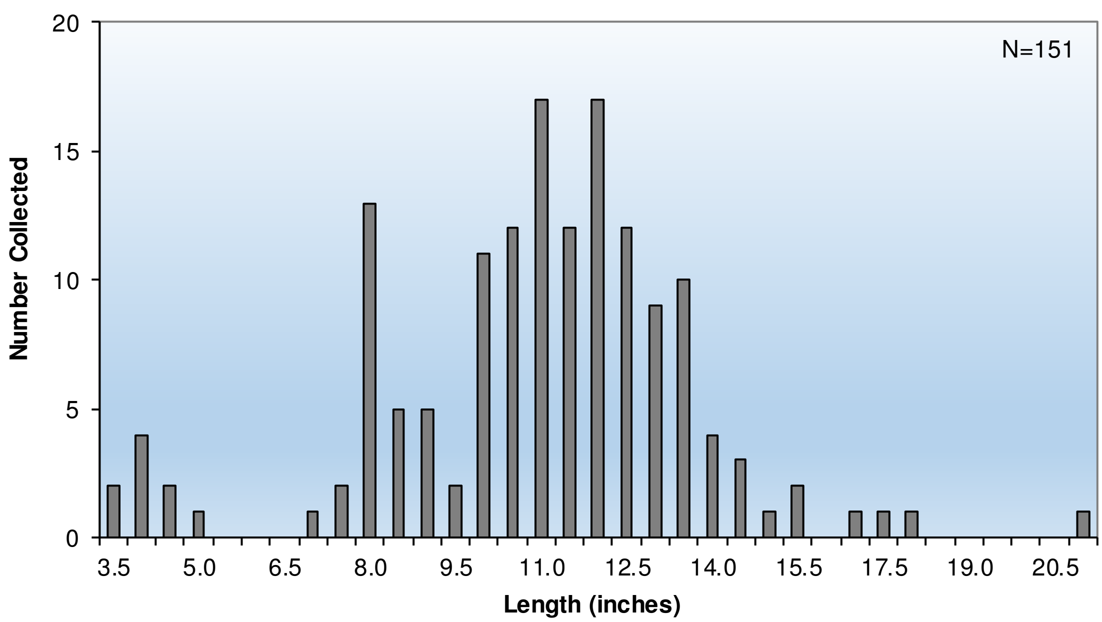

Figure 25. Largemouth bass collected from Sweetwater Lake, October 17, 2017.

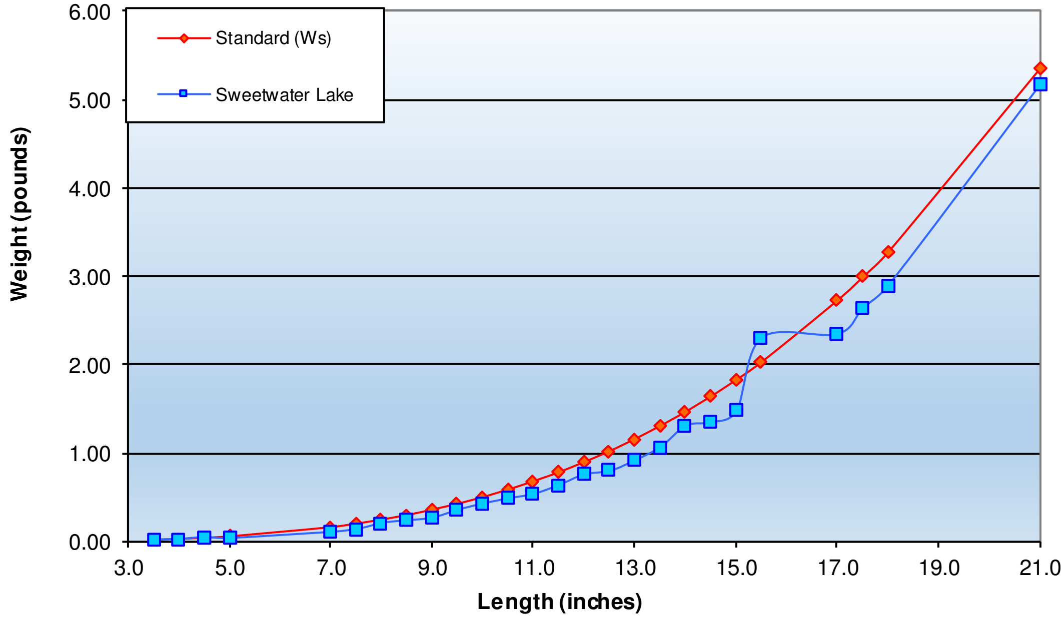

Figure 26. Largemouth bass collected from Sweetwater Lake compared to standard weights.

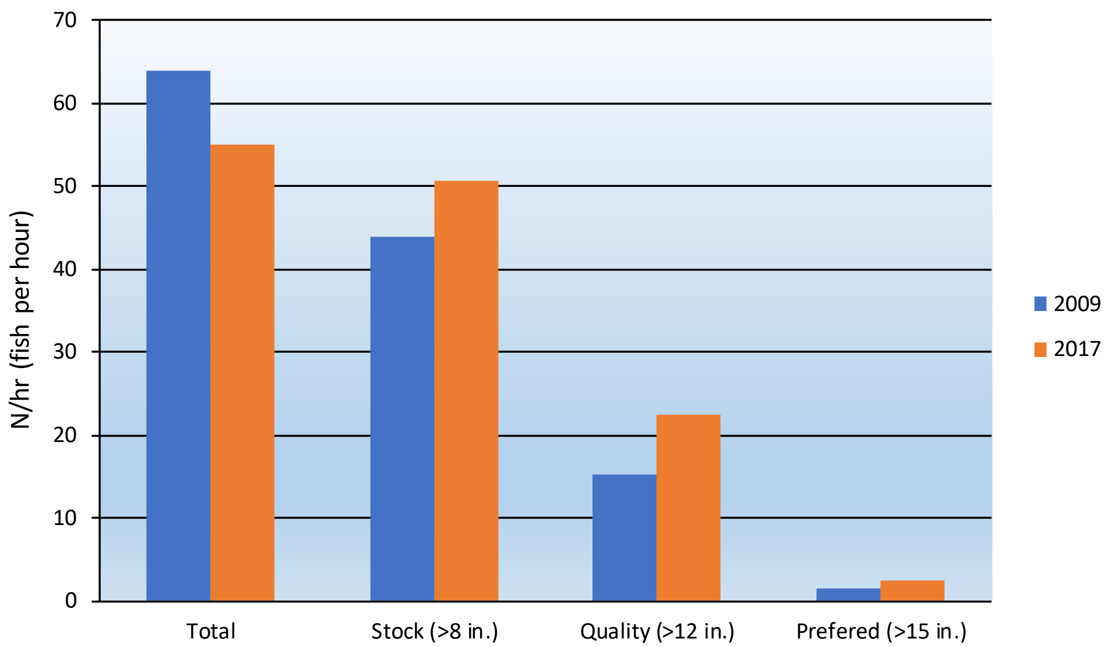

Figure 27. Sweetwater Lake largemouth N/hr. comparison

Brook silverside

Brook silverside (Figure 28) was the third most abundant species collected (13.5%). A total of 125 brook silverside were collected. This species appears to be new to the lake. It was likely introduced through dumping of bait buckets into the lake. Brook silverside can be a valuable forage species for young bass, crappie and other predatory fish.

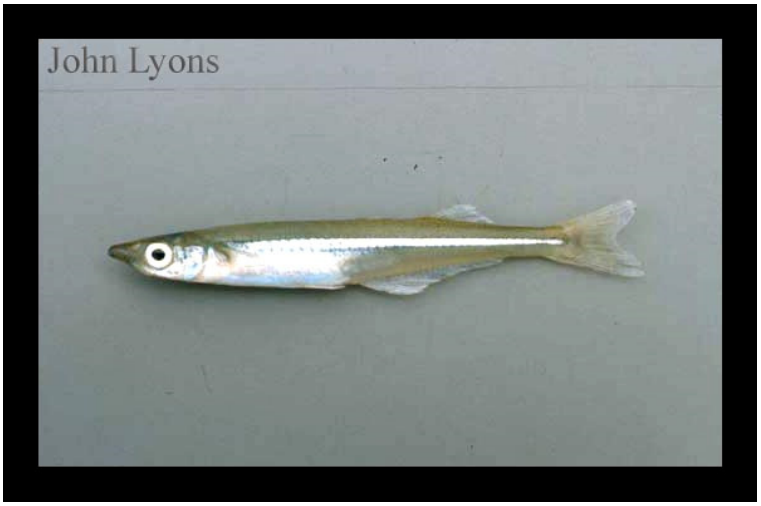

Figure 28. Photograph of brook silverside, *Labidesthes sicculus*.

Redear sunfish

Redear sunfish was the fourth most abundant species collected (6.05%) and ranked third by weight (10.33%). A total of 56 redear sunfish ranging in size from 3.5 to 11.0 inches were collected. The redear population continues to provide a great additional angling opportunity. Due to their slower reproductive potential and small population, this species should be protected with more restrictive bag limits.

Smallmouth bass

Twenty-five smallmouth bass were collected. They ranged in size from 4.0 to 13.5 inches. The three most recent surveys all have similar catch rates for smallmouth bass. They have developed a small, self-sustaining population and will not become as abundant as largemouth but will provide some additional angling opportunity.

Black crappie

Thirteen black crappie were collected during electrofishing. They ranged in size from less than 3.0 to 11.5 inches. It is likely the crappie population is higher than indicated by the sample.

Other species

Seven additional species were collected that represented a combined 4% of the total fish collected. These species included: bluntnose minnow, rock bass, green sunfish, yellow perch, flathead catfish, yellow bullhead, and golden shiner. Green sunfish and yellow bullhead are undesirable species and should be removed when caught. Currently, these species are not a threat to the fishery. Rock bass, yellow perch, and flathead catfish, even at low numbers, can provide additional angling opportunities.

Figure 29. Photograph of rock bass, *Ambloplites rupestris*.

Figure 30. Photograph of flathead catfish, *Pylodictis olivaris*.

Figure 31. Photograph of golden shiner, *Notemigonus crysoleucas*.

SUMMARY AND RECOMMENDATION – Sweetwater Lake

Sweetwater Lake continues to have excellent water quality. The nutrient levels are lower than past surveys and are reflected in the excellent water clarity. The survey indicates Sweetwater Lake has a balanced bluegill fishery. Largemouth bass, however, seem to be slightly crowded in the 9.5 to 13.5-inch length groups. When a large number of a population are competing with one another for the same size food and resources it can lead to slow growth and prevent them from reaching their maximum potential. Steps should be taken to correct this situation. Implementation of a slot limit for bass and maintaining the current bluegill harvest limits will improve the fishery. The survey suggests the smallmouth bass population is small, but it seems to be self-sustaining and will continue to provide additional angling opportunity to fishermen.

The following recommendations, **listed in order of importance**, will help protect and enhance the fishery in Sweetwater Lake:

1. Slot Limit: 5 largemouth/smallmouth bass less than 13.0 inches or greater than 16.0 inches can be harvested (no more than 3 of 5 should be smallmouth). No more than one over 16.0 inches should be harvested. Harvest of fish less than 13.0 inches should be encouraged.

2. Maintain current bluegill/redear harvest limits (no more than 10 of 25 should be redear).

3. Conduct a Standard fish survey in 2020 in order to monitor the effects of the above recommendations and assess needs for further management activities.

4. Continue aquatic vegetation management treatment. Excessive weed growth can severely impact the fishery.

Prepared by: Aquatic Control Inc.
Wes Goldsmith, Aquatic Biologist

APPENDIX A

GENERAL INFORMATION

In order to help understand our analysis and recommendations, basic principles of water chemistry and the physical attributes of water must be understood. Sources of dissolved oxygen (D.O.) in water include uptake from the atmosphere and photosynthesis. Decreases in D.O. are mostly attributed to the respiration of plants, animals, and aerobic bacteria that occur in a lake or pond. Large quantities of plants may produce oxygen depletion during the nighttime hours as plants stop photosynthesis and utilize oxygen for respiration. Dissolved oxygen levels below 5.0 are considered undesirable in ponds and lakes (Boyd, 1991). Lower levels of D.O. may stress fish and decrease the rate of decomposition of organic matter entering or produced within a lake or pond. If oxygen depletion is determined to be a problem in a lake or pond, solutions exist to help improve conditions. Vegetation control to reduce overly abundant vegetation may improve conditions. Aeration systems may also be used to increase oxygen levels and promote the breakdown of organic matter.

Water temperature of a lake or pond affects the activity of "cold-blooded" animals such as fish and invertebrates as well as the amount of D.O. that water is capable of holding. Deeper ponds and lakes may thermally stratify in the summer months and result in deeper waters becoming depleted of oxygen. Lake stratification is a result of the peculiar property of water density changes with temperature. The density of all liquid changes with changes in temperature, however, water behaves in a special way. As most liquids are cooled the density, or relative weight, of the liquid increases due to the compaction of the molecules in the liquid, and conversely, as liquids are heated the density decreases. Water, because of its unique characteristics, is at its maximum density at 4 degrees Centigrade, or approximately 39.2 degrees Fahrenheit. When water is either heated above this temperature or cooled below this temperature its density decreases. This is why ice floats, or forms on the surface of lakes and ponds. A normal cycle of stratification in lakes in our region of the country, in early spring after ice out is as follows: the lake water will all be nearly the same temperature shortly after ice out and wind action on the lake surface will induce circulation of the entire volume of water. As spring advances and the increased sunlight energy warm the surface waters, these become lighter and tend to separate from the deeper waters and essentially float on top of the cooler water. This continues until there is a very stable "layering" or stratification of water in the lake. There are three distinct layers of water in stratified lakes, as described by limnologists:

1. Epilimnion (upper warm layer) - this is, generally speaking, confined to the top 10 ft. to 15 ft. of the lake volume. This is a warm region, mixed thoroughly by wind to a more or less uniform temperature. It is also the zone of most photosynthetic production and is usually high in dissolved oxygen.

2. Thermocline or Metalimnion (middle layer of rapidly changing temperature) - this layer is the area in the lake where temperature decreases rapidly, usually about 1 degree centigrade or more per meter (or approximately 3 ft.). Oxygen depletion generally begins in this layer.

3. Hypolimnion (deep, cold layer) - this layer is relatively unaffected by wind mixing or motor boat activity, and is often devoid of oxygen. Oxygen is depleted by the decomposition of dead organic matter falling from the upper waters as well as external sources such as leaves and grass clippings that sink to the bottom of the lake.

Once this stratification is established (usually by early to mid-June, in our area) it is very stable and stays intact until the fall turnover, which is caused by decreasing surface water temperatures (causing increased density), and the mixing of the lake waters by the wind. The lake then circulates completely for a period of time, usually until ice cover forms, sealing off the surface of the lake from the atmosphere. A reverse stratification then sets in where the water just under the ice is just above 32 degrees Fahrenheit with increasing temperature with depth to a temperature of 39.2 degrees Fahrenheit. Decomposition continues in the bottom throughout the winter, resulting in oxygen depletion in the bottom waters. This progresses towards the surface throughout ice cover and can cause an oxygen depletion fish kill under the ice during severe winters. After the ice melts, the lake begins to circulate again, and the cycle has completed itself. This phenomenon has a profound affect on the biological and chemical components of the lake ecosystem.

Alkalinity is the ability of water to buffer against pH changes upon the addition of an acid or base. The alkalinity of a lake or pond is generally determined by the characteristics of the watershed or local geology. As a general guideline a well-buffered system has an alkalinity of 50 parts per million (ppm) or greater. Well buffered systems have potential for moderate to high productivity. Alkalinity is important in determining algaecide dosages, particularly copper sulfate. The maximum safe dosage for fish of copper sulfate if total alkalinity is less than 50 ppm is 0.25 ppm or .68 pounds / acre-foot, 1.00 ppm or 2.7 pounds / acre-foot for a total alkalinity range of 50 to 200 ppm, and 1.5 ppm or 4.0 pounds / acre- foot for a total alkalinity greater than 200 ppm.

Hardness is a measure of the calcium and magnesium (and other ions) concentrations in water. The concept of hardness comes from the field of domestic water supply. It is a measure of soap requirements for adequate lather formation and is an indicator of the rate of scale formation in hot water heaters. Hardness and alkalinity are sometimes used interchangeably; however, these parameters sometimes have very different values. Waters containing a hardness measure of greater than 75 ppm may be considered hard and are often clearer and weedier then soft waters (Walker et al., 1985).

Nitrogen can exist in several forms within a body of water, including: ammonia, nitrite, nitrate, and organic nitrogen (amino acids and proteins). Ammonia results from the biological decomposition of organic matter by bacteria. During the process of nitrification, nitrate (which is directly available for plant uptake) is formed from the complete biological oxidation of ammonia in which nitrite is an intermediate product. Nitrate is a major plant nutrient. The most important forms of nitrogen for the growth of algae include ammonia and nitrate. Total nitrogen levels above 1.9 ppm are generally indicative of nutrient enrichment or eutrophic conditions (Wetzel, 1983). Inorganic nitrogen (nitrite, nitrate, ammonia, and ammonium) levels greater than 0.30 ppm are indicative of eutrophic lakes and ponds (Sawyer, 1948). Nitrogen in surface waters cannot be controlled by any economical method. Blue-green algae can fix nitrogen directly from the atmosphere unlike other forms of plants.

Phosphorus is a major plant nutrient and is most often the limiting factor for algae and macrophyte (vascular plants) growth within an aquatic system. Total phosphorus levels in excess of 0.03 ppm indicate eutrophic conditions (Vollenwieder, 1968). Waters with excessive plant growth high nutrients and degraded water quality are typical of eutrophic lakes and ponds. Ortho-phosphorus is a measure of the dissolved inorganic phosphorus available for immediate plant uptake. Concentrations of ortho-phosphate above 0.045 ppm may be considered critical concentrations above which nuisance algae blooms could be expected (Sawyer, 1948). The remainder of the total phosphorus is most likely bound onto particulate material and although not immediately available for uptake, could become available through biochemical degradation. Dissolved phosphorus is absorbed from the water column primarily by phytoplankton. Phosphorus supply to aquatic macrophytes is primarily from the sediment rather than from the water column. Phosphorus is released from sediment under anaerobic conditions but is precipitated to the sediment under aerobic conditions. Phosphorus can be precipitated from the water column by use of alum (aluminum sulfate). Sediment phosphorus can be inactivated and made unavailable to macrophytes by heavy applications of alum to the sediment surface.

EQUIPMENT AND METHODS

Water quality analysis equipment used in this survey included an YSI oxygen-temperature meter with 50 ft. remote sensing probe, a Hach field test kit, and a Wildco Alpha Water bottle sampler. The following water quality parameters were measured and recorded: dissolved oxygen, temperature, pH, total hardness, total alkalinity, nitrate-nitrogen, and orthophosphate. The parameters selected are the major water quality factors influencing the lakes productivity and fish health. Water quality testing to determine nutrient levels was completed in the lab using a Hach DR/2010 spectophotometer.

Fish sampling was done with the use of an electrofishing boat. Electrofishing is simply the use of electricity to capture fish for the evaluation of population status. Various types of equipment are in use today, however, most fisheries biologists agree that pulsed DC current is more efficient and less harmful to the fish collected than AC current. Electrofishing with an experienced crew using proven equipment is probably the least selective method of sampling warm water fish species in the temperate waters of our area. Evaluation of electrofishing efficiencies have shown that night electrofishing is a reliable method for sampling populations of largemouth bass, bluegill, and redear sunfish, and generally detects the presence of green sunfish and other scaled fish species. The method is less efficient for sampling populations of channel catfish, bullheads, and crappie (Reynolds and Simpson, 1976). The largest bias in electrofishing is generally that of collecting more large fish of a given species than smaller individuals. This is due to the differential effect of the electric current on fish of different sizes, interference with collection from dense weed beds, if present, as well as the potential bias of the person dipping stunned fish (Nielsen & Johnson, 1983). Many years of experience by our personnel has reduced this bias to an acceptable level.

Electrofishing equipment used in this survey consisted of a 16 foot workboat equipped with a Smith-Root Type VI electrofisher powered by a 4000 watt portable generator and a boom mounted electrosphere designed by Coffelt Manufacturing. The electrosphere allows the use of higher voltages at lower amperage. This has proven to improve the efficiency of the electrofishing technique with lower damage to captured fish. The electrofisher was operated in the pulsed DC mode using an output level of 400 to 750 volts. The increased effectiveness of this electrofishing system makes fish of all species, including channel catfish, more vulnerable to capture. This results in a better sampling of all fish species with a higher capture rate of the more vulnerable species (bass, bluegill, redear, and green sunfish) in the samples taken. All fish collected were placed in water filled containers aboard the sampling boat for processing. A sub-sample of up to five specimens from each species was taken in each one-half inch group. The individual fish in these sub samples were weighed to the nearest hundredth pound for average weight determinations. Additional specimens were recorded by length group.

Field data was summarized and is presented in table and graph form. Condition factors and relative weight calculations (standard measurements of the relative plumpness) were calculated for important species using standard formulas (Anderson and Gutreuter, Carlander 1977, Hillman 1982, Wege and Anderson 1978). Relative weight is a comparison of fish weights at certain sizes to standard calculated weights at those sizes. Relative weights of 100 or greater are considered good. An important procedure used in our evaluation of the largemouth bass/ bluegill populations, and other species to a lesser extent, is the Proportional Stock Density Index. This population index was developed by intensive research into dynamics of fish population structure, primarily in largemouth bass - bluegill dominated populations (Anderson 1976), and subsequent field testing by numerous fisheries research and management biologists in mid-western states. Bluegill samples are divided into three major groups: those less than 3.0 inches in length, those 3.0 inches and larger, and those 6.0 inches and larger. The group 3.0 inches and larger are called the "stock". The 6.0-inch and larger individuals are considered to be "quality" or harvestable size. Bluegill PSD is the percentage of bluegill "stock" that is in the harvestable size. Largemouth bass samples are separated into "stock size" (8.0 inches plus) and quality size (12.0 inches plus), for PSD calculations. Largemouth bass PSD is the percentage of bass "stock" that are of a "quality" or harvestable size.

This study, and subsequent studies and application of the techniques developed in those studies, have shown that fish populations that are producing, or are capable of producing, a sustained annual harvest of "quality" largemouth bass and bluegill have certain characteristics. These include the following:

1. Reasonably high numbers of bluegill smaller than 2.5 inches (young-of-the-year)
2. Proportional Stock Density index of 20 - 40 for bluegill.
3. Bluegill growth which results in a length of 6.0 inches by age III or IV, with low numbers of age V or older fish.

4. Proportional Stock Density index of 40 - 60 for largemouth bass.
5. A minimum of 20 adult bass per acre.
6. A maximum of 50% annual mortality (harvest) of bass in age II - V.
7. Growth rate that results in 8 inch bass reaching quality size (12 inch plus) in approximately 1 year.
8. No missing year classes in ages 0 - V.
9. A maximum of 10% of the lake bottom covered by dense weed beds.

These parameters, and other factors, are used in the evaluation and development of recommendations from Aquatic Control surveys.

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Appendix B

Fish Collection Table, Cordry Lake

Size Group (IN)	NUMBER	PERCENTAGE	AVERAGE WEIGHT (lbs.)	TOTAL WEIGHT (lbs.)	CONDITION FACTOR	RELATIVE WEIGHT
BLUEGILL						
<3.0	450	73.05%	0.01	4.50	-	-
3.0	78	12.66%	0.01	0.78	3.70	61
3.5	30	4.87%	0.04	1.05	8.16	129
4.0	15	2.44%	0.03	0.42	4.38	66
4.5	11	1.79%	0.05	0.51	5.05	74
5.0	5	0.81%	0.06	0.30	4.80	68
5.5	4	0.65%	0.09	0.36	5.41	74
6.0	4	0.65%	0.11	0.44	5.09	68
6.5	1	0.16%	0.16	0.16	5.83	76
7.0	4	0.65%	0.21	0.84	6.12	78
7.5	2	0.32%	0.29	0.58	6.87	85
8.0	2	0.32%	0.32	0.64	6.25	76
9.0	9	1.46%	0.48	4.32	6.58	77
9.5	1	0.16%	0.55	0.55	6.41	74
TOTAL	616			15.45		
LARGEMOUTH BASS						
<3.0	1	0.75%	0.01	0.01		
3.5	2	1.50%	0.02	0.04	4.66	113
4.0	4	3.01%	0.02	0.08	3.13	74
4.5	1	0.75%	0.03	0.03	3.29	76
5.0	1	0.75%	0.05	0.05	4.00	91
6.5	2	1.50%	0.12	0.24	4.37	94
7.0	2	1.50%	0.15	0.30	4.37	93
7.5	2	1.50%	0.16	0.32	3.79	80
8.0	3	2.26%	0.23	0.69	4.49	93
8.5	4	3.01%	0.25	1.00	4.07	84
10.0	6	4.51%	0.44	2.64	4.40	88
10.5	6	4.51%	0.51	3.06	4.41	87
11.0	13	9.77%	0.55	7.15	4.13	81
11.5	4	3.01%	0.65	2.60	4.27	83
12.0	13	9.77%	0.74	9.62	4.28	82
12.5	20	15.04%	0.87	17.40	4.45	85
13.0	19	14.29%	0.87	16.53	3.96	75
13.5	9	6.77%	0.93	8.37	3.78	71
14.0	12	9.02%	1.04	12.48	3.79	71
14.5	2	1.50%	1.23	2.46	4.03	75
15.0	4	3.01%	1.43	5.72	4.24	78
15.5	1	0.75%	1.64	1.64	4.40	81
16.0	1	0.75%	1.61	1.61	3.93	72
17.0	1	0.75%	2.00	2.00	4.07	73
TOTAL	133			96.04		

GREEN SUNFISH

<3.0	5	19.23%	0.01	0.05
3.0	2	7.69%	0.02	0.03
3.5	5	19.23%	0.03	0.13
4.0	3	11.54%	0.04	0.12
4.5	2	7.69%	0.05	0.10
5.5	2	7.69%	0.13	0.26
6.0	2	7.69%	0.16	0.32
7.0	3	11.54%	0.22	0.66
7.5	2	7.69%	0.30	0.60
TOTAL	26			2.27

BLUNTNOSE MINNOW

<3.0	18	90.00%	0.01	0.18
3.0	2	10.00%	0.01	0.02
TOTAL	20			0.20

YELLOW PERCH

<3.0	3	30.00%	0.01	0.03
3.5	2	20.00%	0.01	0.02
4.0	3	30.00%	0.01	0.03
6.0	1	10.00%	0.05	0.05
6.5	1	10.00%	0.07	0.07
TOTAL	10			0.20

BLACK CRAPPIE

<3.0	1	10.00%	0.01	0.01
3.0	1	10.00%	0.01	0.01
3.5	1	10.00%	0.01	0.01
6.5	1	10.00%	0.10	0.10
8.5	1	10.00%	0.30	0.30
9.5	1	10.00%	0.41	0.41
10.0	1	10.00%	0.43	0.43
10.5	2	20.00%	0.58	1.16
12.5	1	10.00%	1.00	1.00
TOTAL	10			3.43

REDEAR SUNFISH

3.5	1	12.50%	0.03	0.03
5.0	1	12.50%	0.10	0.10
6.0	1	12.50%	0.11	0.11
8.5	1	12.50%	0.37	0.37
9.0	1	12.50%	0.50	0.50
10.0	1	12.50%	0.80	0.80
10.5	1	12.50%	0.70	0.70
11.0	1	12.50%	0.95	0.95
TOTAL	8			3.56

AQUATIC CONTROL

SMALLMOUTH BASS

5.0	1	14.29%	0.05	0.05
7.5	1	14.29%	0.18	0.18
8.5	1	14.29%	0.26	0.26
9.0	1	14.29%	0.36	0.36
9.5	1	14.29%	0.34	0.34
10.0	2	28.57%	0.44	0.88
TOTAL	7			2.07

YELLOW BULLHEAD

10.0	1	100.00%	0.61	0.61
TOTAL	1			0.61

JOHNNY DARTER

<3.0	1	100.00%	0.01	0.01
TOTAL	1			0.01

SPOTFIN SHINNER

<3.0	1	100.00%	0.01	0.01
TOTAL	1			0.01

Fish Collection Table, Sweetwater Lake

Size Group (IN)	NUMBER	PERCENTAGE	AVERAGE WEIGHT (lbs.)	TOTAL WEIGHT (lbs.)	CONDITION FACTOR	RELATIVE WEIGHT
BLUEGILL						
<3.0	306	58.96%	0.01	3.06	-	-
3.0	52	10.02%	0.01	0.52	3.70	61
3.5	32	6.17%	0.02	0.64	4.66	74
4.0	28	5.39%	0.03	0.84	4.69	71
4.5	7	1.35%	0.05	0.35	5.49	80
5.0	11	2.12%	0.05	0.55	4.00	57
5.5	16	3.08%	0.08	1.28	4.81	66
6.0	5	0.96%	0.12	0.60	5.56	74
6.5	18	3.47%	0.16	2.88	5.83	76
7.0	7	1.35%	0.22	1.54	6.41	81
7.5	8	1.54%	0.26	2.08	6.16	77
8.0	5	0.96%	0.36	1.80	7.03	86
8.5	14	2.70%	0.41	5.74	6.68	80
9.0	9	1.73%	0.43	3.87	5.90	69
10.0	1	0.19%	0.61	0.61	6.10	69
TOTAL	519			26.36		
LARGEMOUTH BASS						
3.5	2	1.32%	0.02	0.04	4.66	113
4.0	4	2.65%	0.03	0.12	4.69	111
4.5	2	1.32%	0.05	0.10	5.49	127
5.0	1	0.66%	0.04	0.04	3.20	73
7.0	1	0.66%	0.11	0.11	3.21	68
7.5	2	1.32%	0.14	0.28	3.32	70
8.0	13	8.61%	0.21	2.73	4.10	85
8.5	5	3.31%	0.24	1.20	3.91	80
9.0	5	3.31%	0.27	1.35	3.70	75
9.5	2	1.32%	0.36	0.72	4.20	84
10.0	11	7.28%	0.43	4.73	4.30	86
10.5	12	7.95%	0.49	5.88	4.23	83
11.0	17	11.26%	0.54	9.18	4.06	79
11.5	12	7.95%	0.64	7.68	4.21	82
12.0	17	11.26%	0.76	12.92	4.40	85
12.5	12	7.95%	0.80	9.60	4.10	78
13.0	9	5.96%	0.92	8.28	4.19	79
13.5	10	6.62%	1.07	10.70	4.35	82
14.0	4	2.65%	1.31	5.24	4.77	89
14.5	3	1.99%	1.35	4.05	4.43	82
15.0	1	0.66%	1.48	1.48	4.39	81
15.5	2	1.32%	2.31	4.62	6.20	114
17.0	1	0.66%	2.35	2.35	4.78	86
17.5	1	0.66%	2.65	2.65	4.94	88
18.0	1	0.66%	2.90	2.90	4.97	88
21.0	1	0.66%	5.18	5.18	5.59	97
TOTAL	151			104.13		

BROOK SILVERSIDE

<3.0	6	4.80%	0.01	0.06
3.0	37	29.60%	0.01	0.37
3.5	76	60.80%	0.01	0.76
4.0	6	4.80%	0.01	0.06
TOTAL	125			1.25

REDEAR SUNFISH

3.5	1	1.79%	0.03	0.03
5.5	1	1.79%	0.09	0.09
6.0	3	5.36%	0.12	0.36
6.5	4	7.14%	0.17	0.68
7.0	10	17.86%	0.20	2.00
7.5	6	10.71%	0.25	1.50
8.0	10	17.86%	0.29	2.90
8.5	10	17.86%	0.37	3.70
9.0	3	5.36%	0.42	1.26
9.5	4	7.14%	0.56	2.24
10.0	2	3.57%	0.66	1.32
10.5	1	1.79%	0.70	0.70
11.0	1	1.79%	0.82	0.82
TOTAL	56			17.60

SMALLMOUTH BASS

4.0	2	8.00%	0.04	0.08
4.5	1	4.00%	0.03	0.03
6.5	2	8.00%	0.11	0.22
7.0	1	4.00%	0.15	0.15
7.5	2	8.00%	0.19	0.38
8.0	3	12.00%	0.21	0.63
8.5	1	4.00%	0.30	0.30
9.0	3	12.00%	0.31	0.93
9.5	2	8.00%	0.35	0.70
10.5	3	12.00%	0.50	1.50
11.0	1	4.00%	0.59	0.59
11.5	1	4.00%	0.70	0.70
12.0	1	4.00%	0.70	0.70
13.0	1	4.00%	0.95	0.95
13.5	1	4.00%	1.10	1.10
TOTAL	25			8.96

BLACK CRAPPIE

3.0	1	7.69%	0.01	0.01
8.0	1	7.69%	0.21	0.21
8.5	1	7.69%	0.24	0.24
9.0	3	23.08%	0.30	0.90
9.5	2	15.38%	0.41	0.82
10.0	1	7.69%	0.50	0.50
10.5	1	7.69%	0.50	0.50

11.0	1	7.69%	0.70	0.70
11.5	2	15.38%	0.82	1.64
TOTAL	13			5.52

ROCK BASS

3.5	1	11.11%	0.02	0.02
4.0	1	11.11%	0.06	0.06
4.5	1	11.11%	0.08	0.08
5.0	1	11.11%	0.11	0.11
7.5	2	22.22%	0.27	0.54
8.5	3	33.33%	0.41	1.23
TOTAL	9			2.04

GREEN SUNFISH

4.5	1	11.11%	0.06	0.06
5.0	3	33.33%	0.09	0.27
6.0	2	22.22%	0.15	0.30
7.0	3	33.33%	0.28	0.84
TOTAL	9			1.47

BLUNTNOSE MINNOW

<3.0	4	44.44%	0.01	0.04
3.0	4	44.44%	0.01	0.04
4.0	1	11.11%	0.01	0.01
TOTAL	9			0.09

YELLOW PERCH

<3.0	3	50.00%	0.01	0.03
4.5	1	16.67%	0.04	0.04
5.5	1	16.67%	0.08	0.08
8.0	1	16.67%	0.14	0.14
TOTAL	6			0.29

FLATHEAD CATFISH

14.5	1	50.00%	1.10	1.10
15.0	1	50.00%	1.30	1.30
TOTAL	2			2.40

YELLOW BULLHEAD

8.5	1	100.00%	0.32	0.32
TOTAL	1			0.32

GOLDEN SHINNER

3.5	1	100.00%	0.01	0.01
TOTAL	1			0.01