

**FISH SURVEY
REPORT**

Lake Latonka

January 9, 2018

Prepared for:
Lake Latonka POA
18344 Chickasaw Trail
Plymouth, IN, 46563

Prepared by:
Aquatic Control Inc.
P.O. Box 100
Seymour, IN 47274

Table of Contents

Introduction.....	1
Results and Discussion	1
Water Chemistry	1
Fish Collection.....	3
Brook silverside	4
Bluegill.....	5
Largemouth bass	6
Other species.....	7
Summary and Recommendations.....	11
Appendix A.....	12
General Information.....	12
Equipment and Methods	15
Literature Cited and Reference List	17
Appendix B-Fish Collection Table	21

List of Figures

Figure 1. Temperature and dissolved oxygen profiles for Lake Latonka.....	2
Figure 2. Relative abundance of species collected.....	4
Figure 3. Photograph of brook silverside.....	4
Figure 4. Photograph of bluegill	5
Figure 5. Bluegill length frequency.....	5
Figure 6. Bluegill standard weight comparison	6
Figure 7. Photograph of largemouth bass	6
Figure 8. Largemouth bass length frequency	7
Figure 9. Largemouth bass standard weight comparison.....	7
Figure 10. Photograph of walleye	8
Figure 11. Photograph of yellow perch.....	8
Figure 12. Photograph of warmouth	9
Figure 13. Photograph of grass pickerel	9
Figure 14. Photograph of black crappie	10
Figure 15. Photograph of yellow bullhead	10

List of Tables

Table 1. Water quality data.....	2
Table 2. Species collected.....	3

INTRODUCTION

Lake Latonka is an 82-acre impoundment in Marshall County, Indiana. A Standard Survey of the fish community and other physical, biological, and chemical factors directly affecting the fish community was completed at Lake Latonka on November 13, 2017.

The major objectives of this survey and report are:

1. To provide a current status report on the fish community of the lake.
2. To compare the current characteristics of the fish community with 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

WATER CHEMISTRY

The results of selected physio-chemical parameters from Lake Latonka are presented in Table 1. Water temperatures ranged from 44.6 degrees Fahrenheit at the surface to 44.2 degrees Fahrenheit at the bottom. Dissolved oxygen ranged from 11.08 parts per-million (ppm) at the surface to 10.44 ppm at the bottom (Figure 1). A desirable oxygen level for maintenance of healthy stress-free fish was present throughout the water column. These numbers indicate Lake Latonka was de-stratified at the time of the survey, which is typical for this time of year (See Appendix A for further details on lake stratification). The alkalinity level was 85.5 ppm at the surface and at the bottom. The hardness level was 153.9 ppm at the surface and at the bottom. The pH was 7.27 at the surface and 7.36 on the bottom. These numbers are normal for lakes in this area and indicate the lake is capable of good fish production. The Secchi disk depth was measured at 5.0 feet. Nitrate-nitrogen levels were 0.3 ppm at the surface and 0.5 ppm on the bottom. Ortho-phosphate levels were 0.01 ppm at the surface and on the bottom. Lake Latonka appears to have water quality which is capable of supporting a healthy fish population.

Table 1. Selected water quality parameters measured on Lake Latonka, November 13, 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	44.6	11.08	7.27	85.5	153.9	0.30	0.01	0.20
3	44.6	11.06	-	-	-	-	-	-
6	44.6	11.05	-	-	-	-	-	-
9	44.5	10.87	-	-	-	-	-	-
12	44.3	10.57	-	-	-	-	-	-
13	44.2	10.44	7.36	85.5	153.9	0.50	0.01	0.33

*Dashes indicate no sample was taken at selected depth for given parameter.

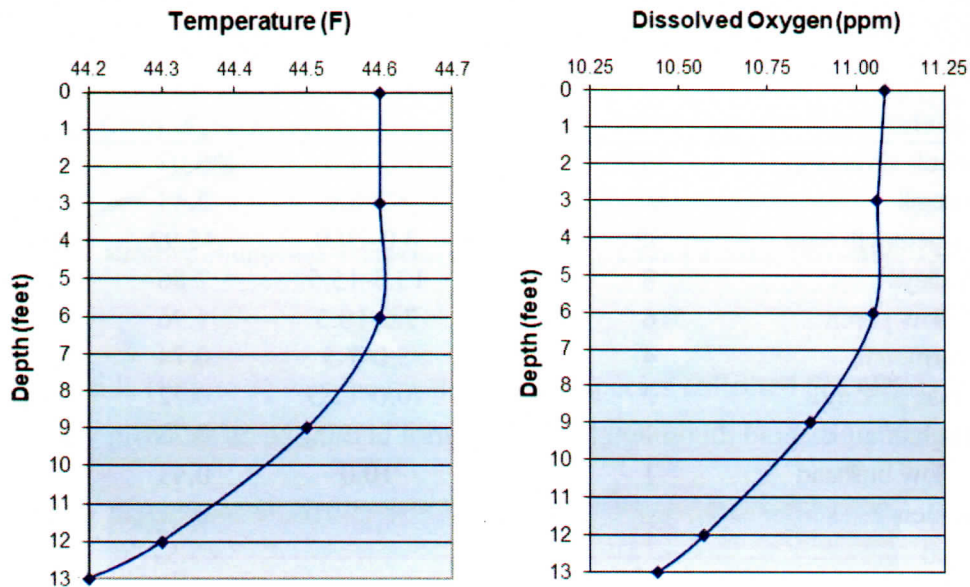


Figure 1. Temperature and dissolved oxygen profiles for Lake Latonka, November 13, 2017.

FISH COLLECTION

A total of 674 fish weighing 68.87 pounds and representing ten species was collected from Lake Latonka (Table 2 & Figure 2). Brook silverside *Labidesthes sicculus* was the most abundant species comprising 74.48% of the fish collected. Bluegill *Lepomis macrochirus* was the second most abundant species (14.39%), followed by largemouth bass *Micropterus salmoides* (7.72%), walleye *Sander vitreus* (1.19%), yellow perch *Perca flavescens* (0.89%), warmouth *Lepomis gulosus* (0.59%), grass pickerel *Esox americanus vermiculatus* (0.30%), black crappie *Pomoxis nigromaculatus* (0.15%), yellow bullhead *Ameiurus natalis* (0.15%), and golden shiner *Notemigonus crysoleucas* (0.15%).

Table 2. Species collected from Lake Latonka, November 13, 2017.

Species	N	% N	Size Range (in)	Total Weight (lbs.)	% Wt	N/hr.
Brook silverside	502	74.48	<3-4.0	5.02	7.29	335
Bluegill	97	14.39	<3-8.0	5.44	7.90	65
Largemouth bass	52	7.72	4.0-20.0	45.92	66.68	35
Walleye	8	1.19	13.5-15.5	7.86	11.41	5
Yellow perch	6	0.89	7.5-10.5	1.96	2.85	4
Warmouth	4	0.59	5.0-7.5	0.74	1.07	3
Grass pickerel	2	0.30	10.0-12.5	0.72	1.05	1
Black crappie	1	0.15	11.5	0.75	1.09	1
Yellow bullhead	1	0.15	10.0	0.45	0.65	1
Golden shiner	1	0.15	<3	0.01	0.01	1
Total	674	100.00		68.87	100.00	

N=Number of individuals

%N=percent number of a species compared to total number of fish collected

%Wt=percent weight of a species compared to total weight of all fish collected

N/hr.=catch rate of species (number of fish of a species collected/hr. of electrofishing effort)

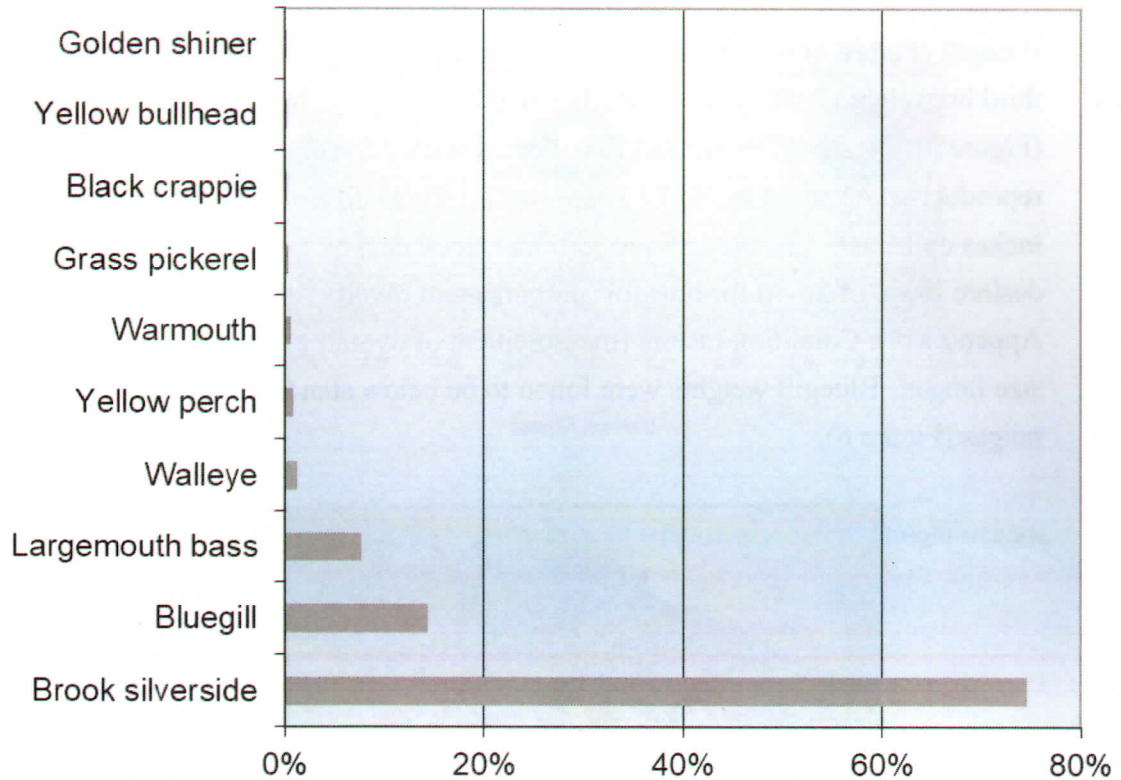


Figure 2. Relative abundance of species collected from Lake Latonka, November 13, 2017.

Brook silverside

Brook silverside (Figure 3) was the most abundant species collected (74.48%). This species likely provides an additional forage fish for largemouth bass and other predatory fish.

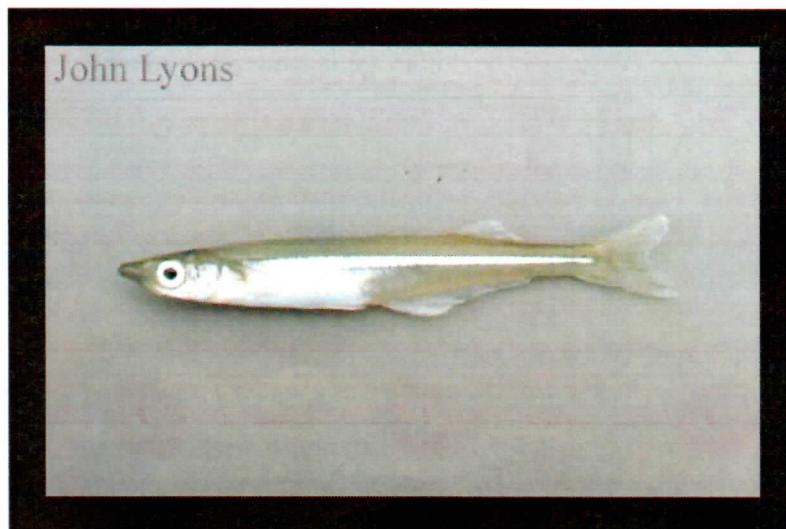


Figure 3. Photograph of brook silverside, *Labidesthes sicculus*.

Bluegill

Bluegill (Figure 4) was the second most abundant species collected (14.39%) and ranked third by weight (7.90%). Individuals ranged in size from less than 3.0 to 8.0 inches (Figure 5). Nearly 67% of bluegill collected were 3.5 inches or less, indicating good reproduction occurred in 2017. There was a very small amount of bluegill over 3.5 inches collected. The bluegill proportional stock density is 25, which is within the desired range of 20-40 for bluegill (proportion of quality fish within a population, see Appendix A). Condition factors (measurement of overall plumpness) were low for most size ranges. Bluegill weights were found to be below standard weights in most size ranges (Figure 6).

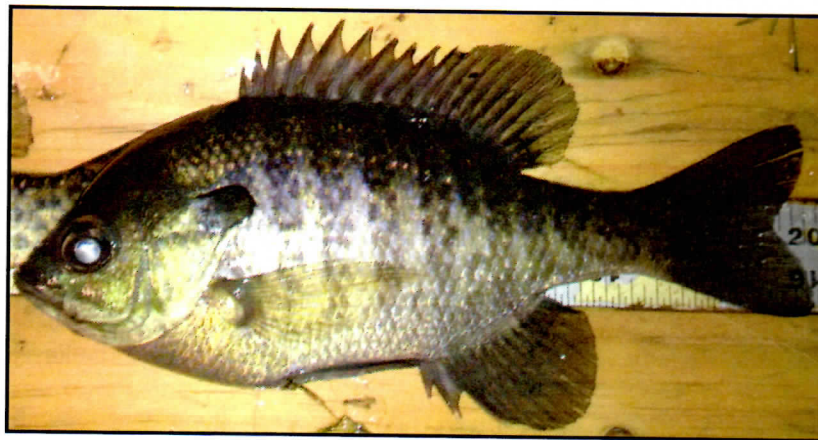


Figure 4. Photograph of bluegill, *Lepomis macrochirus*.

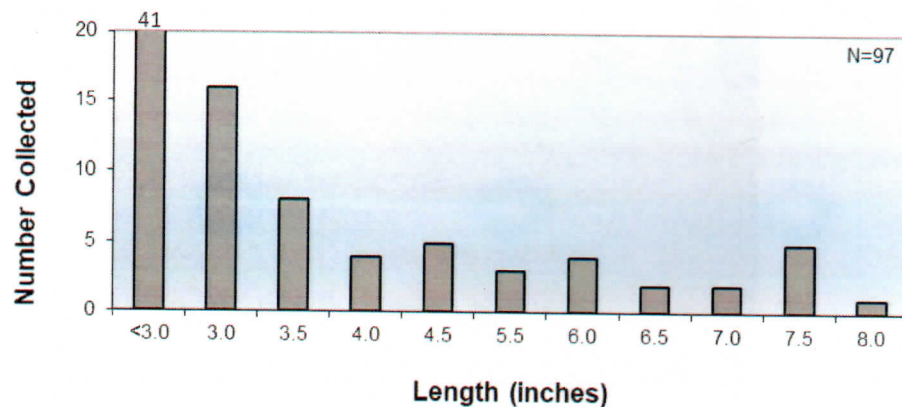


Figure 5. Length frequency distribution of bluegill collected from Lake Latonka, November 13, 2017.

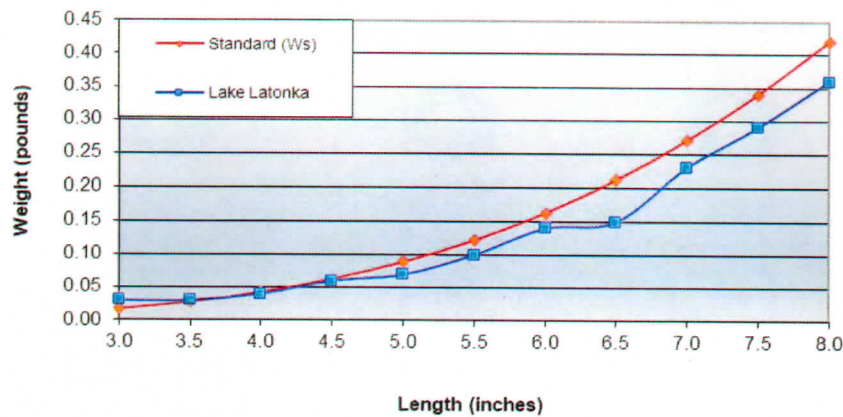


Figure 6. Comparison of Lake Latonka bluegill weights to standard bluegill weights.

Largemouth Bass

Largemouth bass (Figure 7) was the third most abundant species collected (7.48%) and ranked second by weight (7.72%). A total of 52 largemouth bass ranging in size from 4.0 to 20.0 inches was collected (Figure 8). Approximately 6.00% of largemouth bass collected were less than 7.5 inches indicating poor reproduction and recruitment has occurred in the past two years. Of the largemouth bass collected, nearly 64% were between 10.0 and 13.0 inches. This led to a PSD of 53 for largemouth bass, which is within the desired range of 40-60. Condition factors (measurement of overall plumpness) were average for most size classes. The average weights for the bass were below average compared to standard weights in most sizes collected (Figure 9).



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

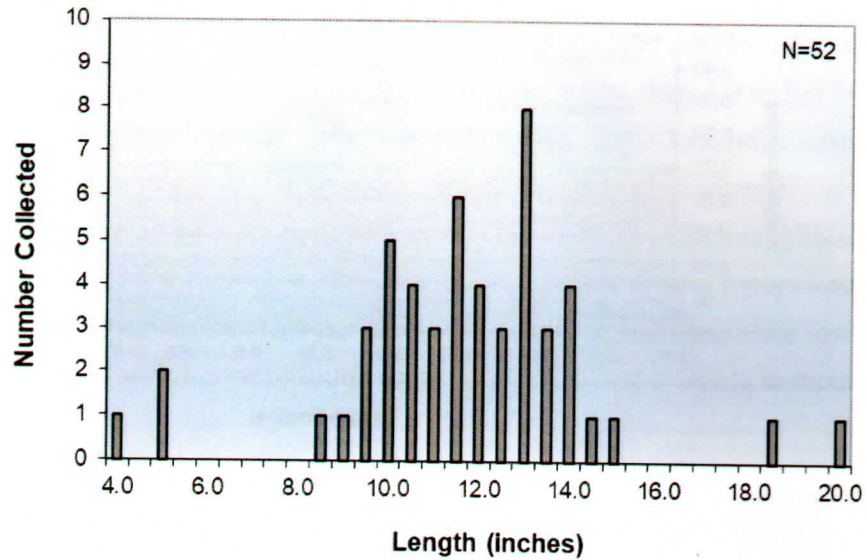


Figure 8. Length frequency distribution of largemouth bass collected from Lake Latonka, November 13, 2017.

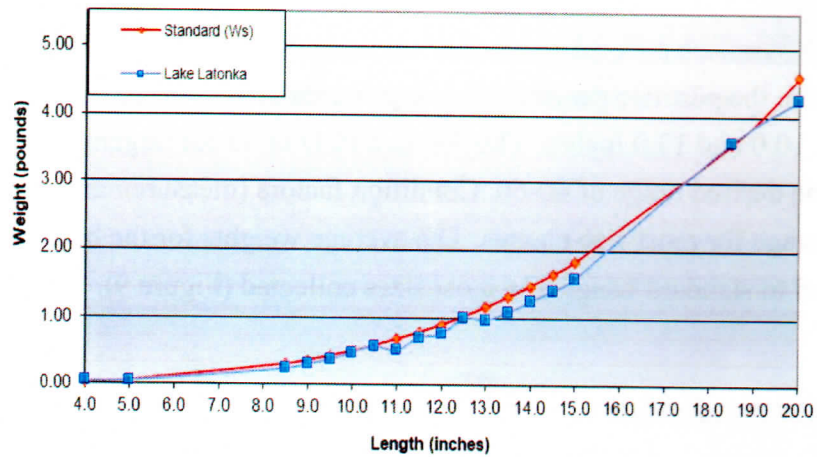


Figure 9. Comparison of Lake Latonka largemouth bass weights to standard largemouth bass weights.

Other species

Eight walleye (Figure 10) ranging in size from 13.5-15.5 inches were collected. Typically, this species does not sample well with electrofishing equipment. There is likely little reproduction occurring due to the fact that no young-of-the-year were

collected. Walleye require streams or offshore reefs to spawn. This means supplemental stockings will need to take place in order to maintain a viable population for the future.



Figure 10. Photograph of walleye, *Sander vitreus*.

A total of six yellow perch (Figure 11) ranging in size from 7.5 to 10.5 inches were collected during the sample. Typically, yellow perch don't sample well with electrofishing equipment. Gill nets are a much more effective means of sampling this species. The perch population is likely higher than indicated. This species should provide additional forage for walleye and additional angling opportunities.

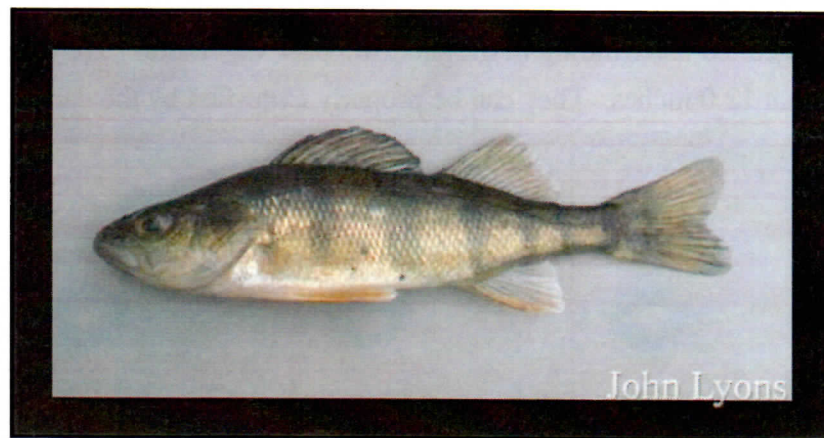


Figure 11. Photograph of yellow perch, *Perca flavescens*.

Nine warmouth (Figure 12) were collected while electrofishing. They ranged in size from less than 5.0 to 7.5 inches. This species is not desirable due to their tendency to reach smaller sizes and compete with more desirable species for food resources. Predators are currently keeping the population low; however, all warmouth caught should be harvested from the lake.



Figure 12. Photograph of warmouth, *Lepomis gulosus*.

Two grass pickerel (Figure 13) ranging in size from 10.0 to 12.5 inches were collected. Grass pickerel are a close relative of the northern pike and they are the smallest members of the pike family. They are native in the Great Lakes basins, and are commonly found in clear, vegetated lakes hiding in the shallows near vegetation. They rarely reach sizes larger than 12.0 inches. They can be properly identified by the dark sub-orbital (under the eye) bar that extends down under the eye.



Figure 13. Photograph of grass pickerel, *Esox americanus vermiculatus*.

A black crappie (Figure 14), yellow bullhead (Figure 15), and golden shiner (Figure 16) were also collected. Black crappie also typically don't sample well with electrofishing equipment, so their population is likely higher than indicated by the survey. This species could provide additional angling opportunities in the lake. Yellow bullheads are considered undesirable and compete with desirable species for food resources. They don't reach sizes comparable to channel catfish, and most anglers don't find them very palatable. All bullheads that are caught should be removed from the lake. Golden shiners likely provide additional forage for predatory fish species.



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

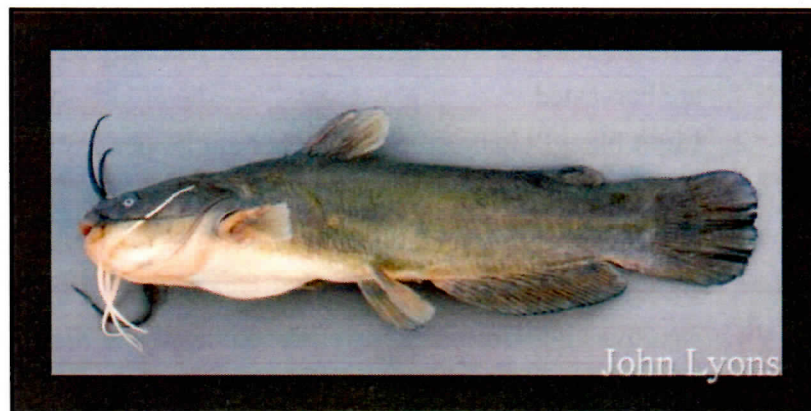


Figure 15. Photograph of yellow bullhead, *Ameiurus natalis*.

SUMMARY AND RECOMMENDATIONS

Lake Latonka should provide average fishing for bluegill and largemouth bass. There should also be some angling opportunities for walleye. The survey indicates Lake Latonka has an imbalance in relation to the bluegill/largemouth bass fishery (See Appendix A for discussion of balance). It appears that the overabundant largemouth bass population is over cropping bluegill. This is evident in the noticeable lack of smaller sized bluegill and crowding of largemouth bass in certain size classes. Generally, this condition leads to fewer small bluegill, but the remaining bluegill exhibit fast growth. Overall, the largemouth bass population appears to be in average condition, but exhibits some overcrowding in the 10.0 to 13.0-inch length classes. Removing some largemouth bass in this length group will reduce competition for food resources and allow for better growth rates for largemouth bass. Walleye are surviving in the lake; however, as evidenced by the survey, it is likely that little or no reproduction is taking place. Stockings should continue in order to maintain a viable population for the future. The lake has good structure and habitat with abundant aquatic submersed vegetation and lay downs. This is very important cover for adult and juvenile fish and should be allowed to remain in the lake; however, the vegetation should be kept at a maximum of 20% of the shoreline and shallow areas. The last fish survey Aquatic Control conducted at Lake Latonka was in September, 2002. Surveys should be completed every three years in order to effectively manage fish populations.

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

1. Implement a 13.0 to 16.0-inch slot limit. Under this limit, 5 bass under 12.0 inches and 1 bass over 16.0 inches can be harvested per angler per day. One bass over the slot could be kept, but catch and release of larger fish should be encouraged. This limit will only be effective if smaller bass are harvested.
2. Limit bluegill harvest to 15 fish per angler per day for the next two years.
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. Remove all warmouth and yellow bullhead that are caught.
5. Maintain 20-40% coverage of native vegetation with focus on control of invasive species.

6. If desired, stock a minimum of 25 or a maximum of 50 walleye fingerlings per acre (2,050-4,100). This stocking will need to take place in order to maintain a viable population for the future.

Prepared by: Aquatic Control Inc.
Jimmy Ferguson, 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 warms 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 algacide 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 some 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 than 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 a YSI ProODO oxygen-temperature meter with 60 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 photospectrometer.

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 Midwest Lake Electrofishing Systems Infinity Box powered by a 6500-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 300 to 500 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 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.

LITERATURE CITED AND REFERENCE LIST

- Anderson, R. 1973. Applications of theory and research to management of warmwater fish populations. *Trans. Am. Fish. Soc.* 102(1):164-171.
- Anderson, R. 1976. Management of small warmwater impoundments. *Fisheries* 1(6): 5-7, 26-28.
- Anderson, R., and S.J. Gutreuter. 1983. Length, weight, and associated structural indices Pages 283-300 in L. A. Nielsen and D. L. Johnson, editors. *Fisheries Techniques*. American Fisheries Society, Bethesda, Maryland.
- Arnold, D.E. 1971. Ingestion, assimilation, survival, and reproduction by *Daphnia pulex* fed seven species of blue-green algae. *Limnology and Oceanography*. 16: 906-920.

- Bennett, C. W. 1971. Management of lakes and ponds. Van Nostrand Reinhold. G. New York 375 pp.
- Boyd, C.E. 1990. Water quality in ponds for Aquaculture. Auburn Univ. Ag. Exp. Sta. Auburn, Al. 252 pp.
- Calhoun, A. (editor) 1966. Inland Fisheries Management. State of California. Dept. of Fish & Game, 546 pp.
- Carlander, K. D. 1969 & 1977. Handbook of freshwater fishery biology. Vols. 1 & 2. Iowa State University Press, Ames, Iowa, Vol 1. 752 pp, Vol 2, 409 pp.
- Cole, Gerald, A. 1983. Textbook of Limnology. 3 ed. Dept. of Zoology, Arizona State Univ. Tempe, AZ. The C.V. Mosby Co. St. Louis.
- D'Itri, F. (editor) 1985. Artificial reefs Marine and Freshwater applications, Lewis Publishers, Inc. Chelsea, MI 589 pp.
- Funk, J. L. (editor) 1974. Symposium on overharvest and management of largemouth bass in small impoundments. North Central Div. Am.Fish. Soc. Sp. Publ. No. 3 116 pp.
- Hayes, J. W., and T. E. Wissing. 1996. Effects of stem density of artificial vegetation on abundance and growth of age-0 bluegills and predation by largemouth bass. Transactions of the American Fisheries Society 125:422-433
- Hillman, W.P. 1982. Structure and dynamics of unique bluegill populations. Master's Thesis. University of Missouri, Columbia.
- Indiana Dept of Nat. Res. 1966, 1985, 1988, Guidelines for the evaluation of sport fish populations in Indiana. Unpublished data.
- Johnson, D.L. & Stein, R.A. 1979. (editors) Response of fish to habitat structure in standing water. North Cen. Am. Fish Soc. Sp. Publ. No. 6. 77pp.
- Kornman, L.E. 1990. Evaluation of a 15-inch minimum size limit on Black Bass at Grayson Lake, Bull. #90. State of KY Dept. of Fish & Wildlife Res. 71pp.
- Kwak, T. J., M. G. Henry. 1995. Largemouth bass mortality and related causal factors During live release fishing tournaments on a large Minnesota lake. North American Journal of Fisheries Management 15: 621-630.
- Lawrence, J.M. 1958. Estimated size of various forage fishes largemouth bass can swallow. Proc. of 11th Annual Conf. S.E. Assoc. Fish & Game Comm. 220-225.
- Lyons, John. Fish of Wisconsin Identification Database. Picture of Brook Silverside.

30 June 2004. University of Wisconsin Center for Limnology, Wisconsin Sea Grant, Wisconsin Dept. of Natural Resources. 18 Dec. 2017.
< <http://www.seagrant.wisc.edu/home/Default.aspx?tabid=605&FishID=26>>

Lyons, John. Fish of Wisconsin Identification Database. Picture of Walleye.
30 June 2004. University of Wisconsin Center for Limnology, Wisconsin Sea Grant, Wisconsin Dept. of Natural Resources. 18 Dec. 2017.
< <http://www.seagrant.wisc.edu/home/Default.aspx?tabid=605&FishID=156>>

Lyons, John. Fish of Wisconsin Identification Database. Picture of Yellow Perch.
30 June 2004. University of Wisconsin Center for Limnology, Wisconsin Sea Grant, Wisconsin Dept. of Natural Resources. 18 Dec. 2017.
< <http://www.seagrant.wisc.edu/home/Default.aspx?tabid=605&FishID=166>>

Lyons, John. Fish of Wisconsin Identification Database. Picture of Black Crappie.
30 June 2004. University of Wisconsin Center for Limnology, Wisconsin Sea Grant, Wisconsin Dept. of Natural Resources. 18 Dec. 2017.
< <http://www.seagrant.wisc.edu/home/Default.aspx?tabid=605&FishID=11>>

Lyons, John. Fish of Wisconsin Identification Database. Picture of Yellow Bullhead.
30 June 2004. University of Wisconsin Center for Limnology, Wisconsin Sea Grant, Wisconsin Dept. of Natural Resources. 18 Dec. 2017.
< <http://www.seagrant.wisc.edu/home/Default.aspx?tabid=605&FishID=165>>

McComas, S. 1993. Lake Smarts The First Lake Maintenance Handbook. Terrene Institute, Washington, D.C. 215pp.

Mittelbach, G. G. 1981. Foraging efficiency and body size: a study of optimal diet and Habitat use by bluegills. Ecology 65:1370-1386

National Academy of Sci. 1969. Eutrophication, causes, consequences, correctives. Washington D.C. 658pp.

Nielsen, L.A. and Johnson, D.L. (editors) 1983. Fisheries Techniques. Am. Fish. Soc. Southern Printing Co., Inc. Blacksburg, VA. 468 pp.

Novinger, G.D. & Dillard, J. 1978. New approaches to the management of small impoundments. North Cen. Div. Am. Fish. Soc. Sp. Publ. No. 5. 132 pp.

Pereira, D.L., S.A. Pothaven, and B. Vondracek. 1999. Effects of Vegetation Removal on Bluegill and Largemouth Bass in Two Minnesota Lakes. North American Journal of Fisheries Management 19: 748-756.

Pflieger, W. L. 1975. The Fishes of Missouri. Missouri Department of Conservation. 343pp.

- Prather, K.W. 1990. Evaluation of a 12-16 Inch Slot limit on largemouth bass at Elmer Davis Lake. State of KY. Dept. of Fish & Wildlife Res. Bull. #89. 18pp
- Reynolds & Simpson. 1976. Evaluation of fish sampling methods and rotenone census. pages in: Novinger & Dillard. 1978. New approaches to the management of small impoundments. N.C. Div. Am. Fish. Soc. Sp. Publ. No. 5 132 pp.
- Ruttner, Franz. 1953. Fundamentals of limnology. 3rd edition. Univ. of Toronto Press. Toronto. 261pp.
- Sawyer, C. N. 1948. Fertilization of Lakes by Agricultural and Urban Drainage. Journal of the New England Water Works Association, 61 109-127.
- Savino, J.F., and R.A. Stein. 1982 Predator-prey interactions between largemouth bass and bluegills as influenced by simulated, submerged vegetation. Transactions of the American Fisheries Society 111: 255-256 Sport Fishing Inst. 1975. Black Bass Biology & Management. Washington. D.C. 534pp.
- Strange, R. J., C. R. Berry, and C. B. Schreck. 1975. Aquatic Plant control and reservoir fisheries. Pages 513-521 in R. H. Stroud, editor. Predator-prey systems in fisheries management. Sport Fishing Institute, Washington D.C.
- Taras, M. J., A. E. Greenberg, R. D. Hoak, and M. C. Rand eds. 1971. Standard Methods for the Examination of Water and Wastewater. American Public Health Association, Washington D.C. 874pp.
- U S E.P.A. 1976. Quality Criteria for Water. U.S. Govt. Printing Office. 256 pp.
- Vollenweider, R. A. 1968. Scientific Fundamentals of the Eutrophication of Lakes and Flowing Waters, with Particular Reference to Nitrogen and Phosphorous as Factors in Eutrophication. OECD Report No. DAS/CSI/68.27, Paris.
- Wege & Anderson. 1978. Relative Weight(Wr): A new Index of condition for largemouth bass. pages in: Novinger & Dillard. 1978. New approaches to the management of small impoundments. N.C. Div. Am. Fish Soc. Sp. Publ. No. 5. 132pp.
- Werner, E.E., and D.J. Hall. 1988. Ontogenetic niche shifts in bluegill: the foraging rate predation risk trade-off. Ecology 69:1352-1366
- Wiley, M. J. W. Gorden, S. W. Waite, and T. Powless. 1984. The relationship between aquatic macrophytes and sport fish production in Illinois ponds: a simple model. North American Journal of Fisheries Management 4:111-119.

Appendix B

Fish Collection Table

Size Group (IN)	NUMBER	PERCENTAGE	AVERAGE WEIGHT (lbs.)	TOTAL WEIGHT (lbs.)	CONDITION FACTOR	WS	RELATIVE WEIGHT
BROOKE SILVERSIDE							
3.0	72	14.34%	0.01	0.72			
3.5	367	73.11%	0.01	3.67			
4.0	63	12.55%	0.01	0.63			
TOTAL	502			5.02			
BLUEGILL							
<3.0	41	42.27%	0.01	0.41	-	-	-
3.0	16	16.49%	0.03	0.48	11.11	0.02	184
3.5	8	8.25%	0.03	0.24	7.00	0.03	111
4.0	4	4.12%	0.04	0.16	6.25	0.04	95
4.5	5	5.15%	0.06	0.30	6.58	0.06	96
5.5	3	3.09%	0.10	0.30	6.01	0.12	82
6.0	4	4.12%	0.14	0.56	6.48	0.16	86
6.5	2	2.06%	0.15	0.30	5.46	0.21	71
7.0	2	2.06%	0.23	0.46	6.71	0.27	85
7.5	5	5.15%	0.29	1.45	6.87	0.34	85
8.0	1	1.03%	0.36	0.36	7.03	0.42	86
TOTAL	97	67.01%		5.44			
	56						
LARGEMOUTH BASS							
4.0	1	1.92%	0.05	0.05	7.81	0.03	-
4.5	0	0.00%	-	0.00	0.00	0.04	-
5.0	2	3.85%	0.06	0.12	4.80	0.06	-
5.5	0	0.00%	-	0.00	0.00	0.07	-
6.0	0	0.00%	-	0.00	0.00	0.10	-
6.5	0	0.00%	-	0.00	0.00	0.13	-
7.0	0	0.00%	-	0.00	0.00	0.16	-
7.5	0	0.00%	-	0.00	0.00	0.20	-
8.0	0	0.00%	-	0.00	0.00	0.25	0
8.5	1	1.92%	0.25	0.25	4.07	0.30	84
9.0	1	1.92%	0.32	0.32	4.39	0.36	89
9.5	3	5.77%	0.39	1.17	4.55	0.43	91
10.0	5	9.62%	0.49	2.45	4.90	0.50	98
10.5	4	7.69%	0.59	2.36	5.10	0.59	101
11.0	3	5.77%	0.53	1.59	3.98	0.68	78
11.5	6	11.54%	0.72	4.32	4.73	0.78	92
12.0	4	7.69%	0.78	3.12	4.51	0.90	87
12.5	3	5.77%	1.01	3.03	5.17	1.02	99

13.0	8	15.38%	0.99	7.92	4.51	1.16	85
13.5	3	5.77%	1.10	3.30	4.47	1.31	84
14.0	4	7.69%	1.26	5.04	4.59	1.47	86
14.5	1	1.92%	1.42	1.42	4.66	1.64	86
15.0	1	1.92%	1.60	1.60	4.74	1.83	87
15.5	0	0.00%	-	0.00	0.00	2.03	0
16.0	0	0.00%	-	0.00	0.00	2.25	0
16.5	0	0.00%	-	0.00	0.00	2.48	0
17.0	0	0.00%	-	0.00	0.00	2.73	0
17.5	0	0.00%	-	0.00	0.00	3.00	0
18.0	0	0.00%	-	0.00	0.00	3.28	0
18.5	1	1.92%	3.61	3.61	5.70	3.58	101
19.0	0	0.00%	-	0.00	0.00	3.89	0
19.5	0	0.00%	-	0.00	0.00	4.23	0
20.0	1	1.92%	4.25	4.25	5.31	4.59	93
TOTAL		52	63.46%		45.92		

WALLEYE

13.5	2	25.00%	0.86	1.72			
14.0	2	25.00%	0.86	1.72			
14.5	1	12.50%	1.00	1.00			
15.0	1	12.50%	1.00	1.00			
15.5	2	25.00%	1.21	2.42			
TOTAL		8		7.86			

YELLOW PERCH

7.5	2	33.33%	0.17	0.34			
9.5	2	33.33%	0.37	0.74			
10.0	1	16.67%	0.40	0.40			
10.5	1	16.67%	0.48	0.48			
TOTAL		6		1.96			

WARMOUTH

5.0	1	25.00%	0.10	0.10			
5.5	1	25.00%	0.12	0.12			
6.5	1	25.00%	0.24	0.24			
7.5	1	25.00%	0.38	0.38			
TOTAL		4		0.74			

GRASS PICKEREL

10.0	1	50.00%	0.22	0.22			
12.5	1	50.00%	0.50	0.50			
TOTAL		2		0.72			

BLACK CRAPPIE

11.5	1	100.00%	0.75	0.75			
TOTAL		1		0.75			

YELLOW BULLHEAD

10.0	1	100.00%	0.45	0.45
TOTAL		1		0.45

GOLDEN SHINER

<3.0	1	100.00%	0.01	0.01
TOTAL		1		0.01