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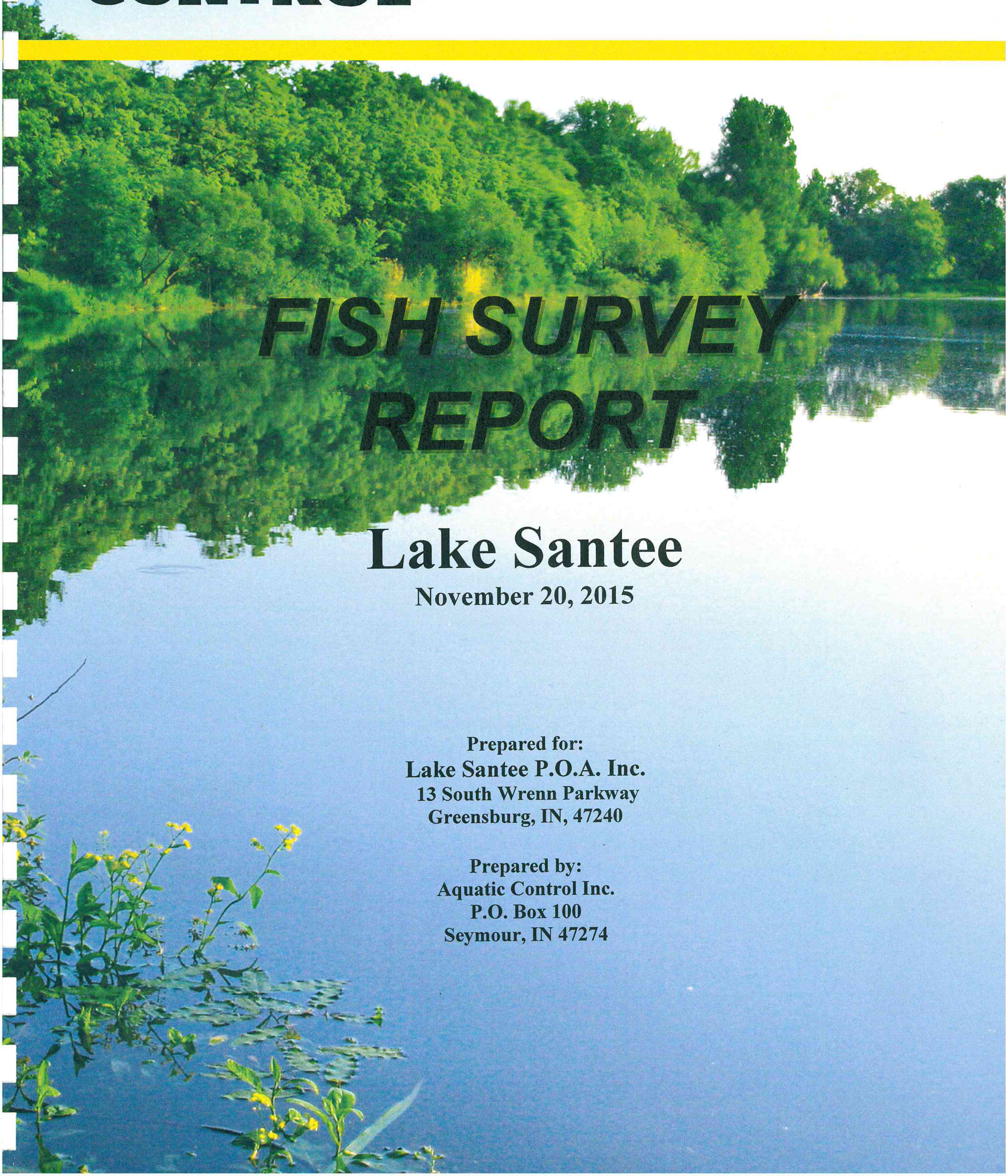

FISH SURVEY REPORT

Lake Santee

November 20, 2015

Prepared for:
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INTRODUCTION

A Standard Survey of the fish community and other physical, biological, and chemical factors directly affecting the fish community was completed at Lake Santee on October 12, 2015. 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 and with past surveys on Lake Santee.
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 Santee are presented in Table 1. Water temperatures ranged from 65.9 degrees Fahrenheit at the surface to 62.7 degrees Fahrenheit at the bottom. Dissolved oxygen ranged from 8.02 parts per-million (ppm) at the surface to 0.00 ppm at the bottom (Figure 1). A desirable oxygen level for maintenance of healthy stress free fish was present to a depth of 15.0 feet. These numbers indicate Lake Santee 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 119.7 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 7.1 at the surface and 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 1.5 feet. Nitrate-nitrogen levels were 1.0 ppm at the surface and on the bottom. Ortho-phosphate levels were 0.01 ppm at the surface and 0.03 ppm on the bottom. Lake Santee appears to have water quality which is capable of supporting a healthy fish population.

Table 1. Selected water quality parameters measured on Lake Santee, October 12, 2015.

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	65.90	8.02	7.1	119.7	153.9	1.00	0.01	0.38
3	65.60	7.87	-	-	-	-	-	-
6	65.50	7.87	-	-	-	-	-	-
9	65.10	7.86	-	-	-	-	-	-
12	64.70	6.67	-	-	-	-	-	-
15	64.40	6.00	-	-	-	-	-	-
18	64.20	4.38	-	-	-	-	-	-
21	63.70	2.27	-	-	-	-	-	-
23	62.50	0.00	7.1	119.7	153.9	1.00	0.03	0.57

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

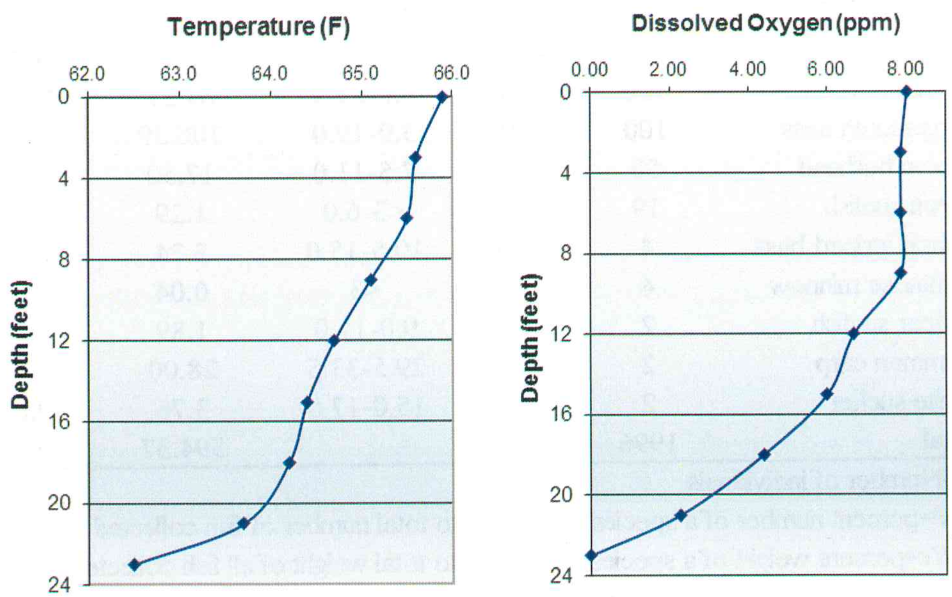

Figure 1. Temperature and dissolved oxygen profiles for Lake Santee, October 12, 2015.

FISH COLLECTION

A total of 1996 fish weighing 594.37 pounds and representing twelve species was collected from Lake Santee (Table 2 & Figure 2). Bluegill *Lepomis macrochirus* was the most abundant species comprising 55.81% of the fish collected. Gizzard shad *Dorosoma cepedianum* was the second most abundant species (20.49%), followed by black crappie *Pomoxis nigromaculatus* (8.12%), channel catfish *Ictalurus punctatus* (6.41%), largemouth bass *Micropterus salmoides* (5.01%), brown bullhead *Ameiurus nebulosus* (2.51%), green sunfish *Lepomis cyanellus* (0.95%), hybrid striped bass *Morone chrysops X Morone saxatilis* (0.20%), bluntnose minnow *Pimephales notatus* (0.20%), redear sunfish *Lepomis microlophus* (0.10%), common carp *Cyprinus carpio* (0.10%), and white sucker *Catostomus commersonii* (0.10%). Smallmouth bass, white crappie, golden shiner, spotfin shiner, hybrid sunfish, and goldfish were collected in past surveys, but were not represented in this survey. All of these species are desirable in a lake of this size with the exception of gizzard shad, brown bullhead, green sunfish, and common carp.

Table 2. Species collected from Lake Santee, October 12, 2015.

Species	N	% N	Size Range (in)	Total Weight (lbs.)	% Wt	N/hr.
Bluegill	1114	55.81	<3-7.5	147.22	24.77	279
Gizzard shad	409	20.49	4.0-15.5	194.50	32.72	102
Black crappie	162	8.12	4.0-9.5	28.97	4.87	41
Channel catfish	128	6.41	4.0-23.0	61.57	10.36	32
Largemouth bass	100	5.01	3.0-19.0	106.39	17.90	25
Brown bullhead	50	2.51	7.5-11.0	17.50	2.94	13
Green sunfish	19	0.95	<3-6.0	1.29	0.22	5
Hybrid striped bass	4	0.20	10.5-15.0	3.24	0.55	1
Bluntnose minnow	4	0.20	<3	0.04	0.01	1
Redear sunfish	2	0.10	9.0-11.0	1.89	0.32	1
Common carp	2	0.10	29.5-33.5	28.00	4.71	1
White sucker	2	0.10	15.0-17.5	3.76	0.63	1
Total	1996	100.00		594.37	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

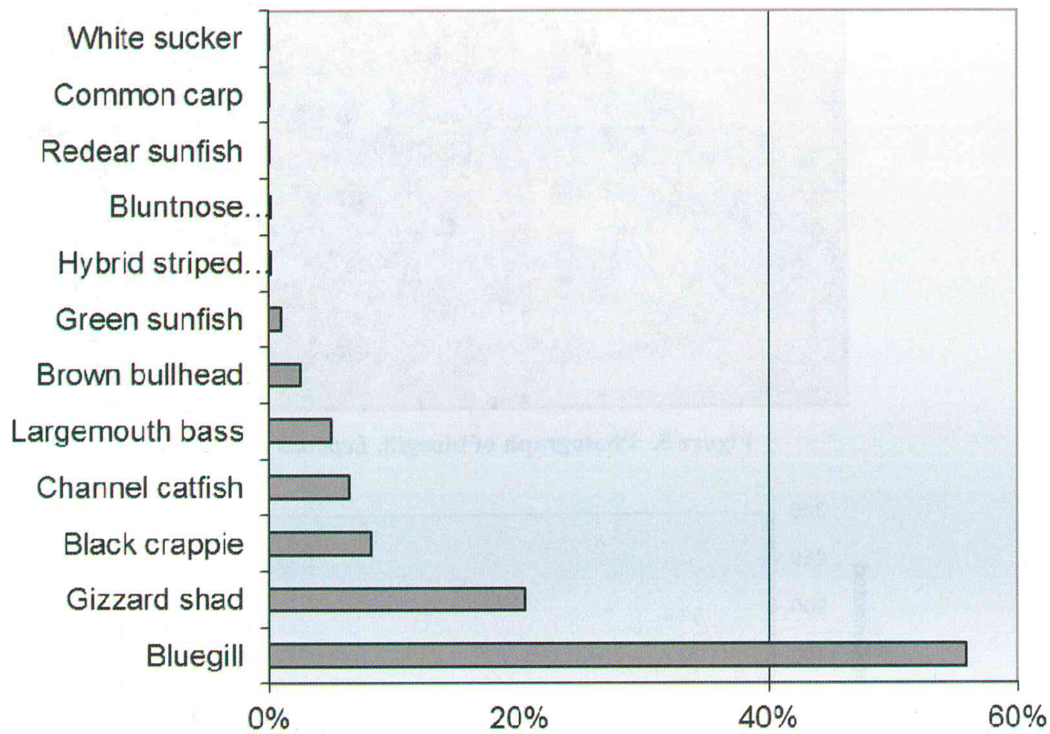

Figure 2. Relative abundance of species collected from Lake Santee, October 12, 2015.

Bluegill

Bluegill (Figure 3) was the most abundant species collected (55.81%) and ranked second by weight (24.77%). Individuals ranged in size from less than 3.0 to 7.5 inches (Figure 4). Nearly 11% of bluegill collected were 3.5 inches or less, indicating poor reproduction occurred in 2015. There was a large number of quality bluegill collected. This led to a proportional stock density of 76, which is well above the desired range of 20-40 for bluegill (proportion of quality fish within a population, see Appendix A). The PSD for bluegill has increased dramatically from 16 in the 2012 survey. The CPUE (Catch-Per-Unit-Effort) was 279 fish/hour compared to 491 fish/hour in the previous survey. The relative abundance of bluegill collected over the past four surveys is displayed in Figure 5. Condition factors (measurement of overall plumpness) were below average for most size ranges. Bluegill weights were also found to be below standard weights in most size ranges (Figure 6).

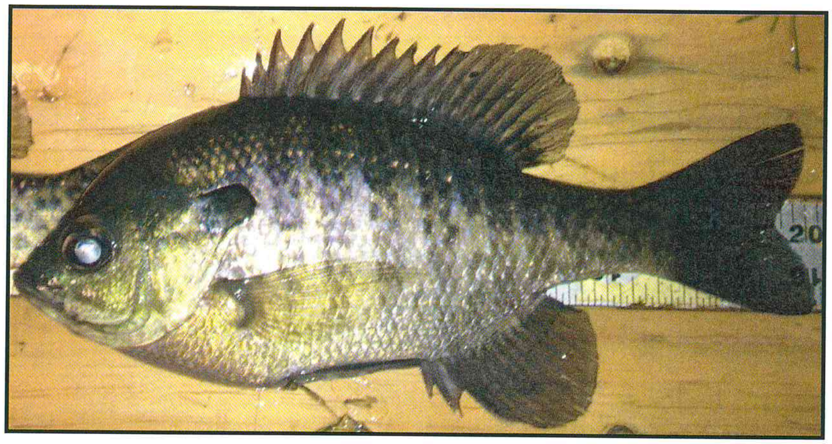

Figure 3. Photograph of bluegill, *Lepomis macrochirus.*

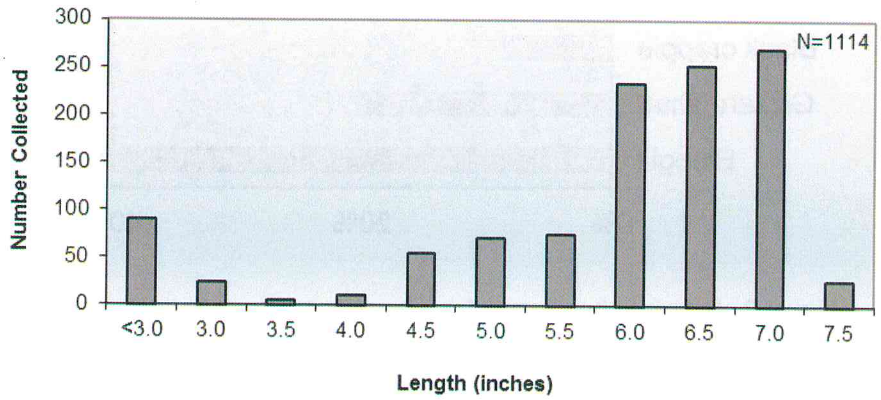

Figure 4. Length frequency distribution of bluegill collected from Lake Santee, October 12, 2015.

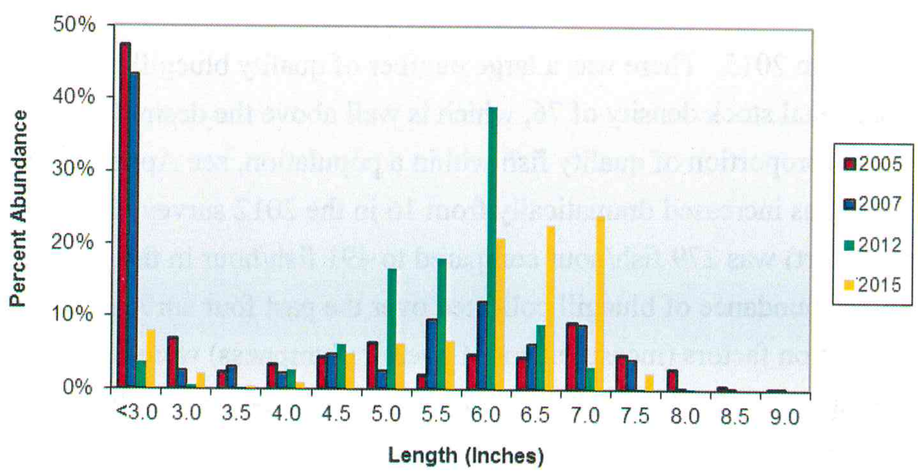

Figure 5. Relative abundance of bluegill collected from Lake Santee over the past four surveys.

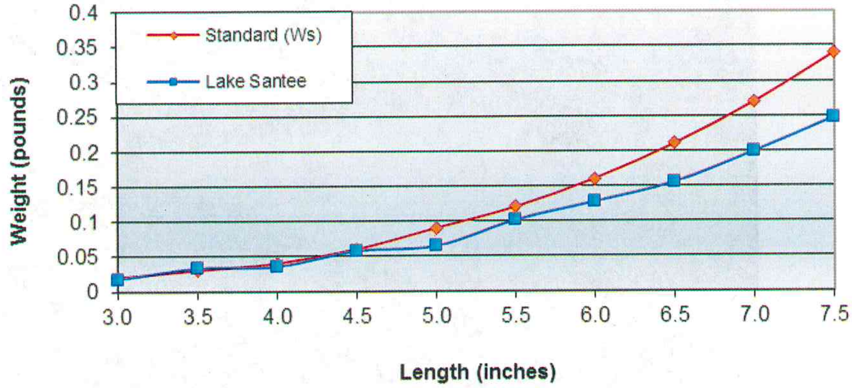

Figure 6. Comparison of Lake Santee bluegill weights to standard bluegill weights.

Gizzard shad

Gizzard shad (Figure 7) was the second most abundant species collected (20.49%), and ranked first by weight (32.72%). Individuals ranged in size from less than 4.0 to 15.5 inches (Figure 8). Figures 9 and 10 illustrate the relative abundance of gizzard shad at 0.5 length groups over the past four surveys. The CPUE for this survey was 102, compared to 163 (2012), 138 (2007), and 102 (2005) (Figure 11). As observed in previous surveys, bluegill don't grow well in lakes containing this species. This may be due to competition with gizzard shad for food and space or largemouth bass switching to gizzard shad as their primary forage causing bluegill to become overabundant and slow growing. Largemouth bass typically grow well in the lakes containing gizzard shad, especially individuals that are 15.0 inches and larger; however, gizzard shad grow rapidly and reach sizes that bass cannot eat. Small shad also negatively affect desirable species through competition for food resources and habitat. This species has a very high reproductive potential. The gizzard shad population should continue to be monitored closely, and predator stockings should also continue in an attempt to prevent the shad population from growing larger.

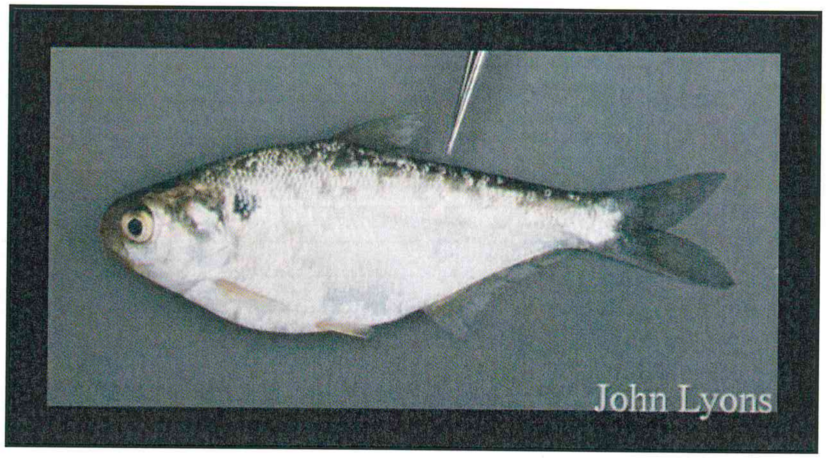

Figure 7. Photograph of gizzard shad, *Dorosoma cepedianum*.

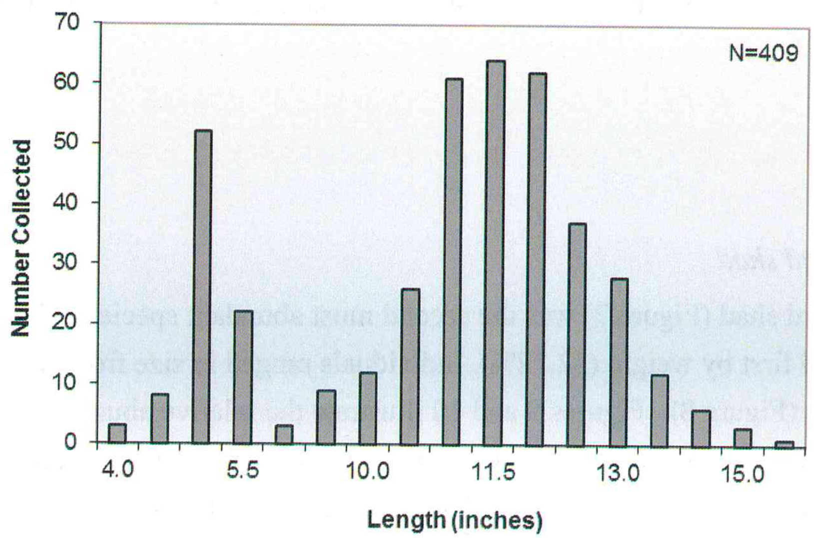

Figure 8. Length frequency distribution of gizzard shad collected from Lake Santee, October 12, 2015.

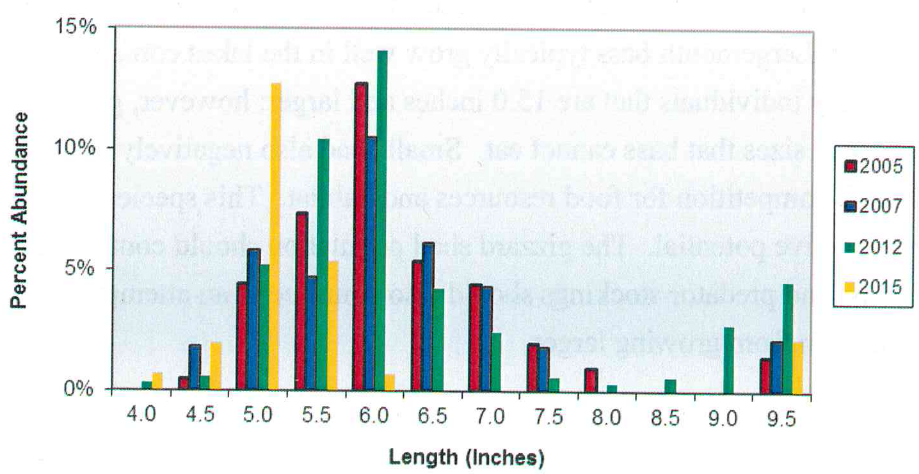

Figure 9. Relative abundance of gizzard shad (4.0-9.5 in.) collected from Lake Santee over the past four surveys.

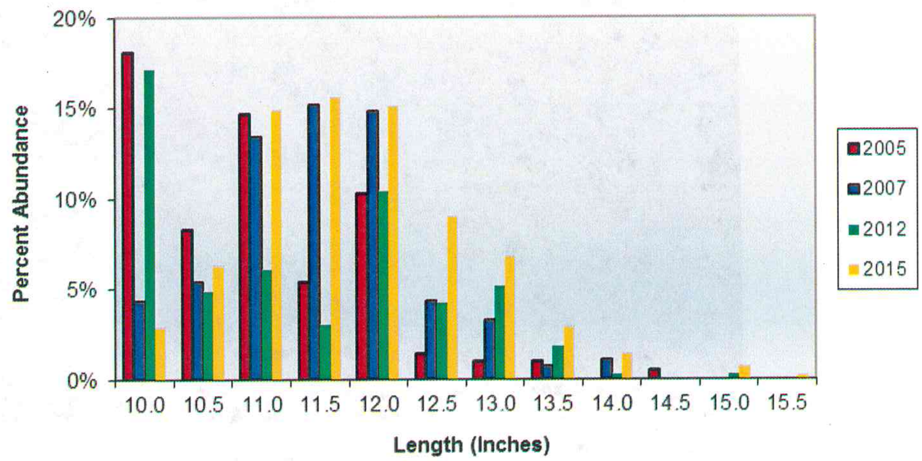

Figure 10. Relative abundance of gizzard shad (10.0-15.5 in.) collected from Lake Santee over the past four surveys.

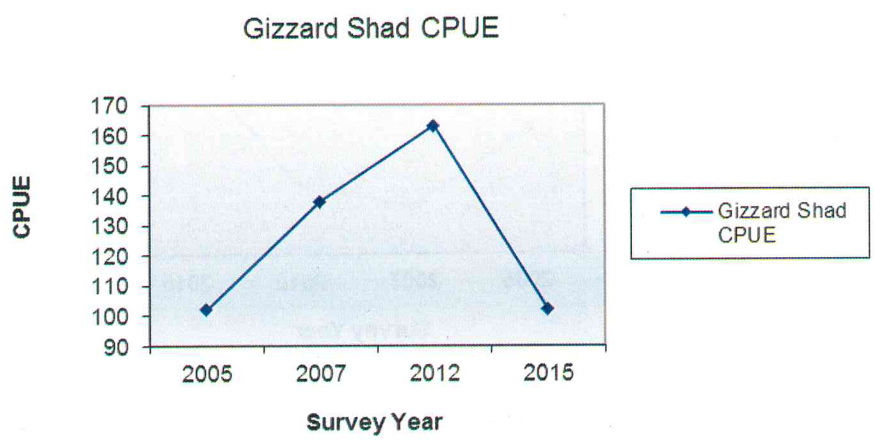

Figure 11. Gizzard shad CPUE over the past four surveys.

Black crappie

Black crappie (Figure 12) was the third most abundant species collected (8.12%) and ranked fifth by weight (4.87%). They ranged in size from 4.0 to 9.5 inches. Almost 92% of crappie collected were 7.0 to 8.0 inches. The CPUE for this species was 41 fish/hour compared to 27 fish/hour in 2012 (Figure 13). It appears that the crappie population has increased since the last survey (Figure 14); however, crappie inhabit deeper water and are usually not well represented in electrofishing surveys, so the crappie population is most likely larger than indicated by the survey.

Figure 12. Photograph of black crappie, *Pomoxis nigromaculatus*.

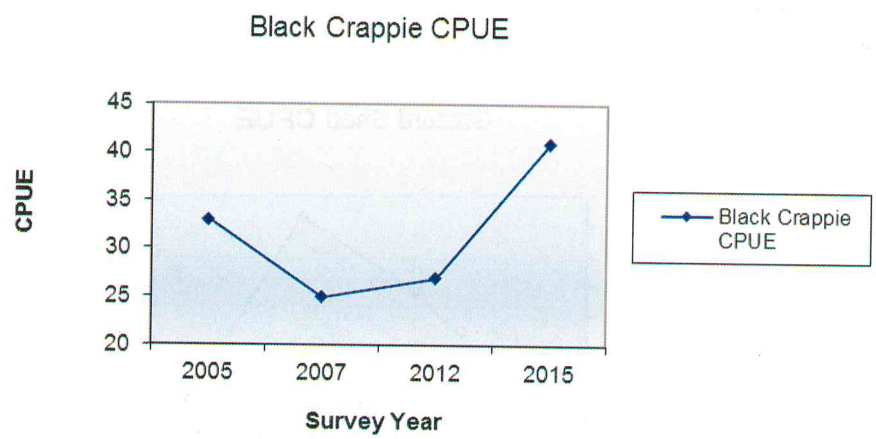

Figure 13. Black crappie CPUE over the last four surveys.

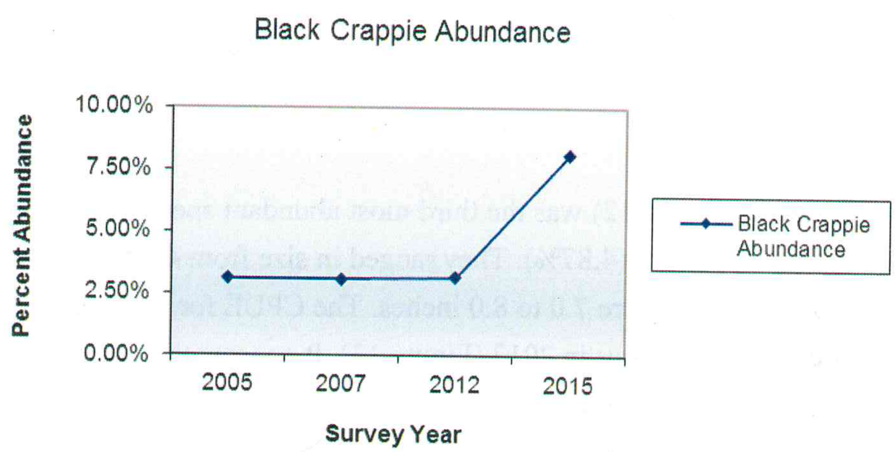

Figure 14. Black crappie relative abundance over the past four surveys.

Channel catfish

Channel catfish (Figure 15) was the fourth most abundant species collected (6.41%) and ranked fourth by weight (10.36%). Individuals ranged from 4.0 to 23.0 inches. This species is not typically sampled well with electrofishing equipment; however, channel catfish were well represented during the current survey. This may be due to the stocking in 2015. Young-of-the-year channel catfish are typically eliminated by largemouth bass and other predators leading to little or no recruitment into the population. Channel catfish should continue to be stocked periodically if they are desired in the fishery. This species is omnivorous and opportunistic in feeding. They consume many different types of living and dead material. Channel catfish will aide in putting pressure on overabundant populations of prey species.

Figure 15. Photograph of channel catfish, *Ictalurus punctatus*.

Largemouth Bass

Largemouth bass (Figure 16) was the fifth most abundant species collected (5.01%) and ranked third by weight (17.90%). A total of 100 largemouth bass ranging in size from less than 3.0 to 19.0 inches was collected (Figure 17). A small number of largemouth bass less than 7.5 inches were collected indicating reproduction/recruitment continues to suffer. Of the largemouth bass collected, nearly 40% were between 8.0 and 11.0 inches. The majority of the population was between 12.0 and 17.0 inches. This led to a PSD of 51 for largemouth bass, which is within the desired range of 40-60. Figure 18 shows the CPUE from the past four surveys. Relative abundance of largemouth bass hasn't changed much since the last survey. The largemouth bass collected appeared to be getting plenty of eat and in very good shape. Condition factors (measurement of overall plumpness) were excellent for most size classes. The average weights for the bass were also good compared to standard weights (Figure 19).

Figure 16. Photograph of largemouth bass, *Micropterus salmoides.*

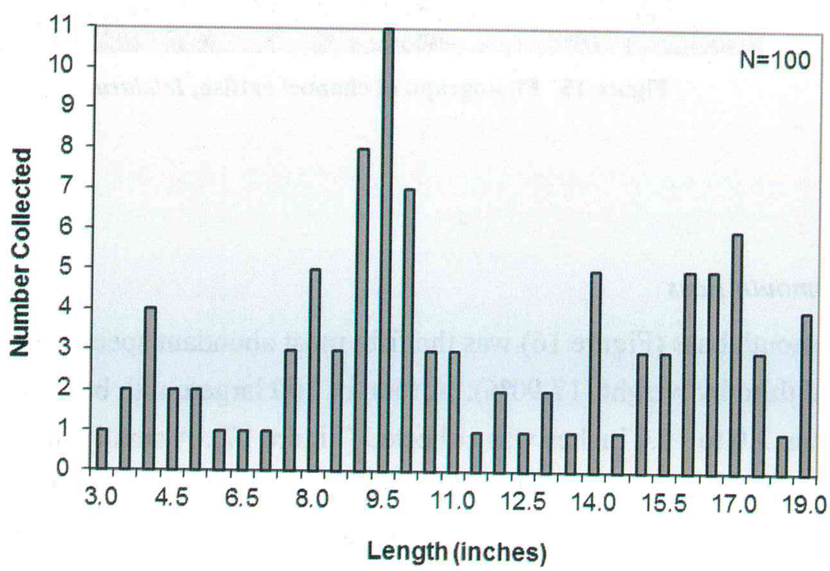

Figure 17. Length frequency distribution of largemouth bass collected from Lake Santee, October 12, 2015.

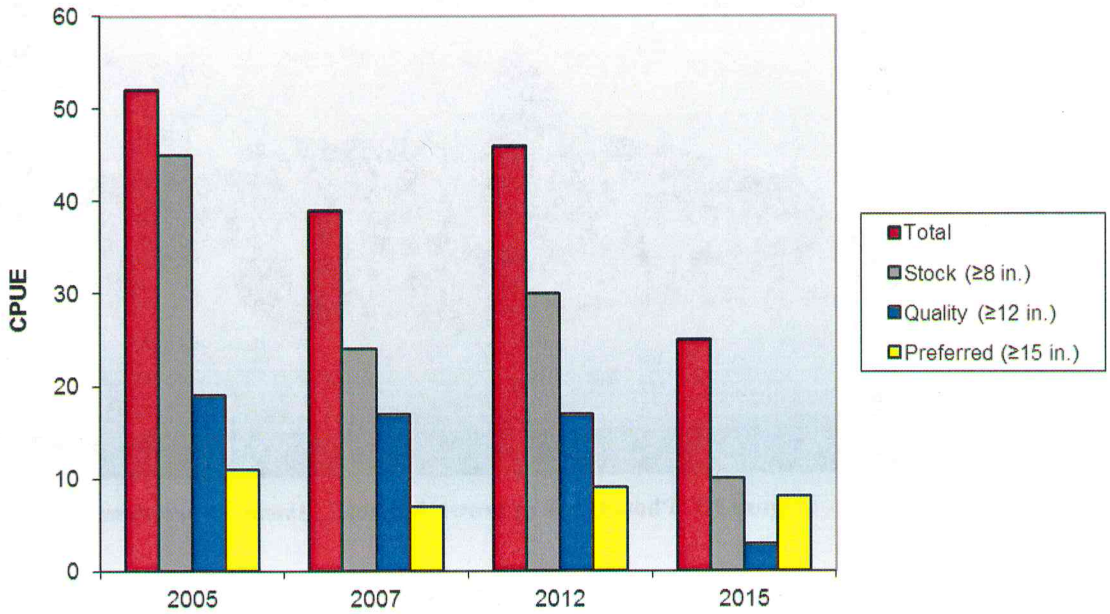

Figure 18. Largemouth bass CPUE comparison over the past four surveys.

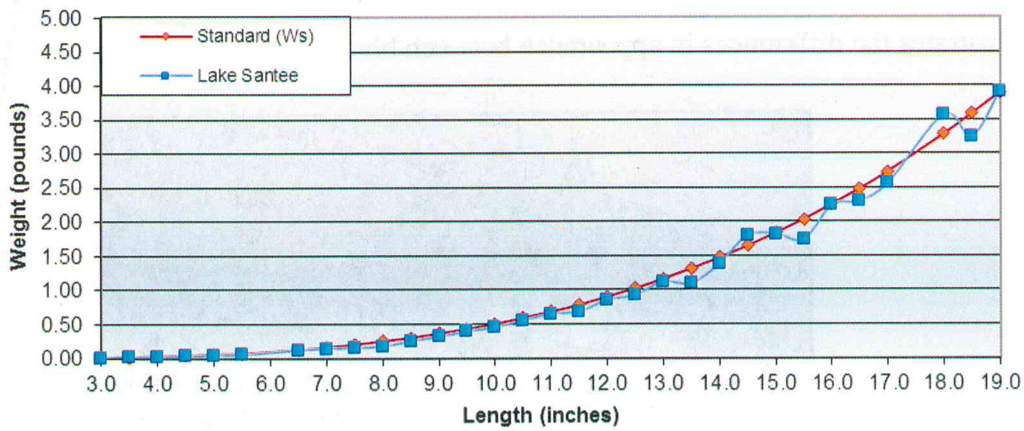

Figure 19. Comparison of Lake Santee largemouth bass weights to standard largemouth bass weights.

Other species

Fifty brown bullheads (Figure 20) were collected while sampling. Brown bullheads are considered undesirable and compete with desirable species for food resources. This species isn't usually considered an important game fish. 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.

Figure 20. Photograph of brown bullhead, *Ameiurus nebulosus.*

Nineteen green sunfish were collected during the survey. It appears that predators are keeping the population under control, as it hasn't changed much since the last survey. Green sunfish are undesirable due to their tendency to overpopulate and compete with bluegill for food resources. Green sunfish look superficially like bluegill. They can easily be distinguished by their larger mouths and more rounded pectoral fins. Figure 21 illustrates the differences in appearance between bluegill and green sunfish.

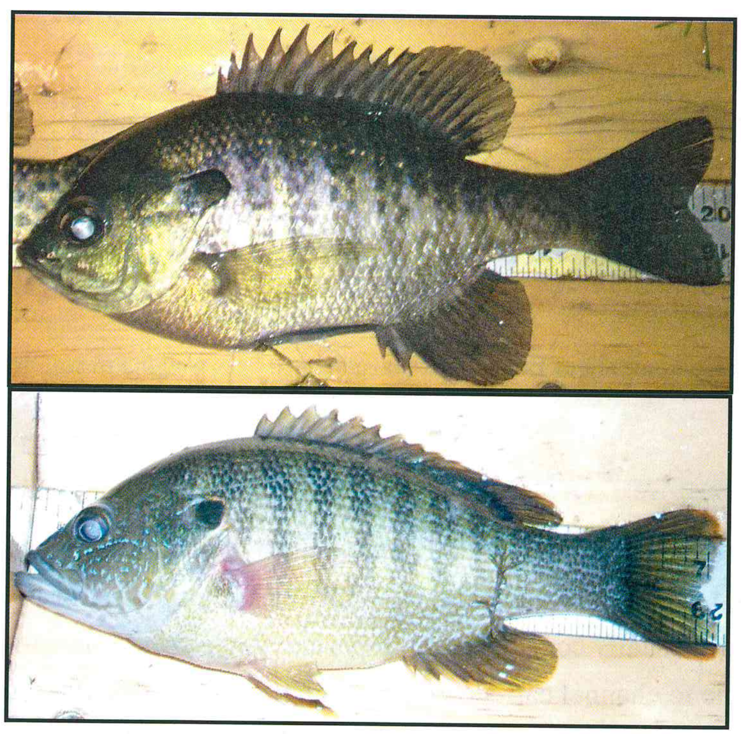

Figure 21. Photographic comparison of bluegill (top) and green sunfish (bottom), *Lepomis cyanellus.*

Four hybrid striped bass ranging in size from 10.5 to 15.0 inches were collected. Hybrid striped bass (Figure 22) also don't sample well in electrofishing surveys. These fish inhabit open water, and feed almost exclusively on gizzard shad. They are occasionally picked up in shallow water areas where the surveys take place. Hybrid striped bass should continue to be stocked in order help keep the gizzard shad population under control. This will also continue to provide an excellent angling opportunity. Reproduction is rare, so the population is entirely dependent on repeated stockings.

Figure 22. Photograph of hybrid striped bass, *Morone chrysops X Morone saxatilis.*

Four bluntnose minnows (Figure 23) were also collected while electrofishing. This species likely provides another forage fish for largemouth bass and other predators.

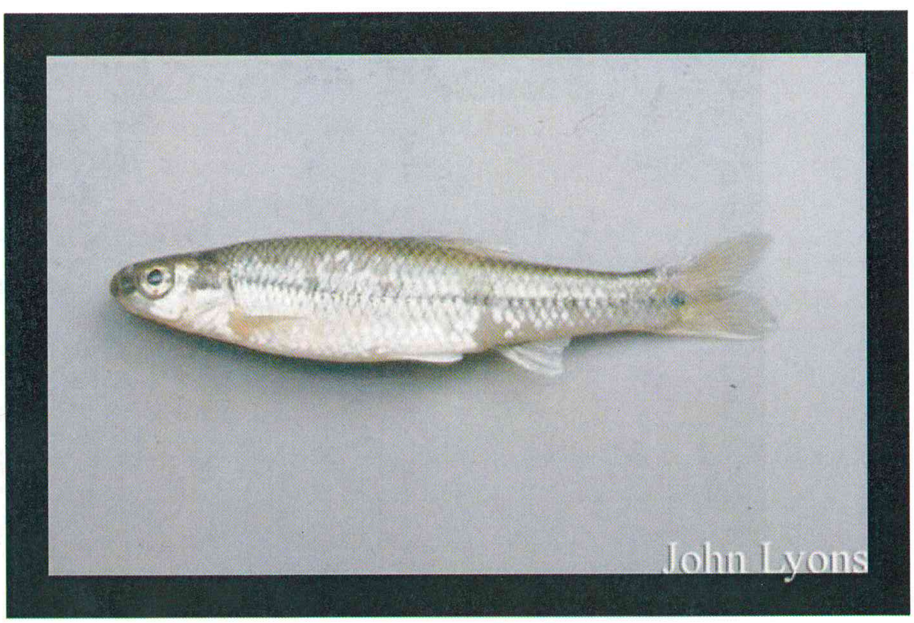

Figure 23. Photograph of bluntnose minnow, *Pimephales notatus.*

Two redear were collected while sampling (Figure 24). 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 Lake Santee. Due to their slower reproductive potential and small population, this species should continue to be protected with more restrictive bag limits in order to sustain a viable population for the future.

Figure 24. Photograph of redear sunfish, *Lepomis microlophus.*

Two common carp (Figure 25) ranging in size from 29.0 to 33.5 inches were collected. Carp have the potential to disrupt a fishery by destroying bass and bluegill nests as well as increasing turbidity levels. This disruption is caused by their foraging habits. The continued lack of small carp implies that this species is still being controlled by predators and does not pose a serious threat to the fishery; however, all carp caught should be removed from the lake.

Figure 25. Photograph of common carp, *Cyprinus carpio.*

Two white suckers (Figure 26) were collected during the sample. White suckers have the same potential to disrupt a fishery as common carp from their foraging habits. Currently this species is also being controlled by predators. This species currently isn't negatively impacting the fishery in Lake Santee.

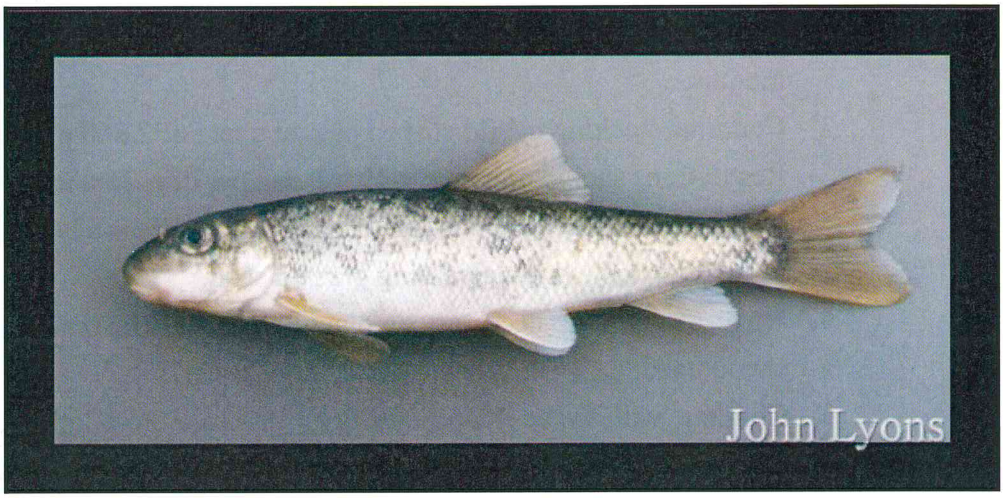

Figure 26. Photograph of white sucker, *Catostomus commersonii.*

SUMMARY AND RECOMMENDATIONS

Lake Santee should provide good angling opportunities for trophy largemouth bass, bluegill, black crappie, channel catfish, and an occasional hybrid striped bass. Largemouth bass collected appear very healthy and are likely experiencing rapid growth rates; however, reproduction and recruitment continues to suffer. The supplemental stockings that have taken place each year since the previous survey appear to be sustaining the population. If these stockings do not continue, the largemouth bass population may not be able to sustain itself. Largemouth bass supplemental stockings should be the highest management priority.

The bluegill population appears to be dominated by individuals in the 6.0 to 7.0 inch length range. This is a definite improvement compared to bluegill collected in past surveys. Predator stockings should result in further reduction of the gizzard shad population. The bluegill population should continue to improve with lowered gizzard shad numbers

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

1. Stock 4,000 5.0 to 8.0 inch largemouth bass per year for the next two years. Supplemental stockings are needed to sustain and increase the population due to very poor natural recruitment.
2. Encourage "catch and release" only on largemouth bass. This can be adjusted for tournaments, but tournament fishermen should exercise extreme caution when handling fish, especially during hot summer months.
3. Continue stocking hybrid striped bass at a rate of 2,000 per year. Restrictions should continue with a 1 fish per day, 21.0 inch minimum length limit. This will continue to ensure that there is a healthy population in the lake and aid in decreasing gizzard shad.
4. No restrictions are necessary on bluegill harvest. Harvest of this species is encouraged.
5. Continue with the addition of artificial structure. Poor light penetration continues to limit the amount of submerged vegetation. Artificial structure should be the means of replacing this vegetation. Artificial structure should be placed in areas where it won't interfere with boat traffic, but cannot be placed so deep that it goes below the thermocline.
6. Conduct a Standard Fish Survey in 2018 in order to monitor the effects of the above recommendations and assess needs for further management activities.
7. Continue to work with local landowners in the watershed and encourage the utilization of best land management practices concerning farming techniques. Examples of these practices are the creation of permanent wetlands, no-till farming, or the installation of filter strips.
8. Continue with nuisance bluegreen algae bloom control with targeted EPA algaecide applications. Applications to control problematic bluegreen algae blooms aid in increased water clarity as well as the reduction of extreme dissolved oxygen fluctuations that have been a persistent problem at Lake Santee in the past. Nuisance bluegreen algae blooms also affect juvenile fish. Juvenile fish feed on zooplankton. Bluegreen algae is not a preferred food item for these very beneficial zooplankton. Reduction in gizzard shad numbers could also help reduce the severity of bluegreen algae blooms.
9. Maintain the limit redear sunfish harvest to 15 per day.
10. Continue the limit on crappie harvest to 25 per day

11. Continue to remove all brown bullheads, green sunfish, and common carp when caught.
12. If channel catfish are desired, continue to stock every 2-3 years.

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 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 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 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 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 photospectometer.

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 350 to 375 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.

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Appendix B

Fish Collection Table

Size Group (IN)	NUMBER	PERCENTAGE	AVERAGE WEIGHT (lbs.)	TOTAL WEIGHT (lbs.)	CONDITION FACTOR	WS	RELATIVE WEIGHT
BLUEGILL							
<3.0	90	8.08%	0.01	0.90	-	-	-
3.0	24	2.15%	0.02	0.43	6.67	0.02	111
3.5	5	0.45%	0.03	0.17	7.93	0.03	125
4.0	11	0.99%	0.04	0.40	5.63	0.04	85
4.5	55	4.94%	0.06	3.19	6.36	0.06	93
5.0	71	6.37%	0.07	4.62	5.20	0.09	73
5.5	75	6.73%	0.10	7.65	6.13	0.12	84
6.0	234	21.01%	0.13	29.95	5.93	0.16	79
6.5	253	22.71%	0.16	39.47	5.68	0.21	74
7.0	270	24.24%	0.20	54.00	5.83	0.27	74
7.5	26	2.33%	0.25	6.45	5.88	0.34	73
TOTAL	1114			147.22			
GIZZARD SHAD							
4.0	3	0.73%	0.04	0.11			
4.5	8	1.96%	0.03	0.26			
5.0	52	12.71%	0.05	2.60			
5.5	22	5.38%	0.06	1.23			
6.0	3	0.73%	0.06	0.17			
9.5	9	2.20%	0.33	2.93			
10.0	12	2.93%	0.34	4.10			
10.5	26	6.36%	0.43	11.08			
11.0	61	14.91%	0.47	28.79			
11.5	64	15.65%	0.54	34.82			
12.0	62	15.16%	0.65	40.30			
12.5	37	9.05%	0.70	25.90			
13.0	28	6.85%	0.72	20.10			
13.5	12	2.93%	0.89	10.63			
14.0	6	1.47%	0.95	5.71			
15.0	3	0.73%	1.48	4.44			
15.5	1	0.24%	1.33	1.33			
TOTAL	409			194.50			
BLACK CRAPPIE							
4.0	4	2.47%	0.03	0.13			
4.5	1	0.62%	0.04	0.04			
6.0	1	0.62%	0.10	0.10			
6.5	4	2.47%	0.12	0.47			

7.0	28	17.28%	0.15	4.20
7.5	82	50.62%	0.19	15.25
8.0	39	24.07%	0.20	7.96
8.5	2	1.23%	0.24	0.48
9.5	1	0.62%	0.34	0.34
TOTAL	162			28.97

CHANNEL CATFISH

4.0	1	0.78%	0.04	0.04
6.0	1	0.78%	0.09	0.09
7.0	1	0.78%	0.14	0.14
8.0	6	4.69%	0.26	1.58
8.5	17	13.28%	0.32	5.44
9.0	52	40.63%	0.30	15.50
9.5	22	17.19%	0.39	8.62
10.0	11	8.59%	0.45	4.95
10.5	2	1.56%	0.54	1.08
11.5	1	0.78%	0.41	0.41
13.0	1	0.78%	0.60	0.60
13.5	2	1.56%	0.81	1.61
14.0	3	2.34%	0.85	2.55
14.5	1	0.78%	0.82	0.82
15.5	1	0.78%	1.40	1.40
16.5	1	0.78%	1.50	1.50
17.0	1	0.78%	1.70	1.70
18.5	1	0.78%	2.50	2.50
19.0	1	0.78%	2.14	2.14
22.0	1	0.78%	3.75	3.75
23.0	1	0.78%	5.15	5.15
TOTAL	128			61.57

LARGEMOUTH BASS

3.0	1	1.00%	0.02	0.02	7.41	0.01	-
3.5	2	2.00%	0.03	0.06	7.00	0.02	-
4.0	4	4.00%	0.03	0.11	4.30	0.03	-
4.5	2	2.00%	0.04	0.08	4.39	0.04	-
5.0	2	2.00%	0.06	0.11	4.40	0.06	-
5.5	1	1.00%	0.06	0.06	3.61	0.07	-
6.5	1	1.00%	0.13	0.13	4.73	0.13	-
7.0	1	1.00%	0.15	0.15	4.37	0.16	-
7.5	3	3.00%	0.16	0.49	3.86	0.20	-
8.0	5	5.00%	0.18	0.92	3.59	0.25	75
8.5	3	3.00%	0.26	0.78	4.23	0.30	87
9.0	8	8.00%	0.32	2.59	4.44	0.36	90
9.5	11	11.00%	0.40	4.40	4.67	0.43	94
10.0	7	7.00%	0.46	3.23	4.62	0.50	92
10.5	3	3.00%	0.56	1.68	4.84	0.59	95
11.0	3	3.00%	0.66	1.97	4.93	0.68	96
11.5	1	1.00%	0.69	0.69	4.54	0.78	88
12.0	2	2.00%	0.86	1.72	4.98	0.90	96

12.5	1	1.00%	0.93	0.93	4.76	1.02	91
13.0	2	2.00%	1.13	2.25	5.12	1.16	97
13.5	1	1.00%	1.10	1.10	4.47	1.31	84
14.0	5	5.00%	1.39	6.95	5.07	1.47	95
14.5	1	1.00%	1.80	1.80	5.90	1.64	109
15.0	3	3.00%	1.83	5.48	5.41	1.83	100
15.5	3	3.00%	1.74	5.22	4.67	2.03	86
16.0	5	5.00%	2.24	11.22	5.48	2.25	100
16.5	5	5.00%	2.30	11.52	5.13	2.48	93
17.0	6	6.00%	2.57	15.41	5.23	2.73	94
18.0	3	3.00%	2.14	6.43	3.68	3.28	65
18.5	1	1.00%	3.25	3.25	5.13	3.58	91
19.0	4	4.00%	3.91	15.64	5.70	3.89	100
TOTAL	100			106.39			

BROWN BULLHEAD

7.5	1	2.00%	0.21	0.21
8.0	1	2.00%	0.26	0.26
8.5	3	6.00%	0.29	0.87
9.0	24	48.00%	0.30	7.15
9.5	12	24.00%	0.40	4.75
10.0	4	8.00%	0.45	1.79
10.5	4	8.00%	0.50	1.98
11.0	1	2.00%	0.49	0.49
TOTAL	50			17.50

GREEN SUNFISH

<3.0	4	21.05%	0.01	0.04
4.0	2	10.53%	0.04	0.07
4.5	5	26.32%	0.06	0.28
5.0	4	21.05%	0.10	0.41
5.5	1	5.26%	0.10	0.10
6.0	3	15.79%	0.13	0.39
TOTAL	19			1.29

HYBRID STRIPED BASS

10.5	1	25.00%	0.48	0.48
11.0	1	25.00%	0.49	0.49
13.5	1	25.00%	0.77	0.77
15.0	1	25.00%	1.50	1.50
TOTAL	4			3.24

BLUNTNOSE MINNOW

<3.0	4	100.00%	0.01	0.04
TOTAL	4			0.04

REDEAR SUNFISH

9.0	1	50.00%	0.65	0.65
11.0	1	50.00%	1.24	1.24
TOTAL	2			1.89

COMMON CARP

29.0	1	50.00%	0.26	13.50
33.5	1	50.00%	0.73	14.50
TOTAL	2			28.00

WHITE SUCKER

15.0	1	50.00%	1.45	1.45
17.5	1	50.00%	2.31	2.31
TOTAL	2			3.76

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