Nantuckett Lake Fisheries Assessment

1500-3263 Nantucket Dr., Hwy. 6
College Station, TX 77845
Surveyed in October 2004

by

WFSC 410 Fisheries Management Class
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Nantuckett Lake Fisheries Background Information

Students in the Fisheries Management course accompanied by Donna Anderson (Graduate Teaching Assistant, Texas A&M University), and Fran Gelwick (Professor, Texas A&M University) surveyed Nantucket Lake, on Hwy 6, Brazos county, TX during October 2004. For this project students were asked to provide information to property owners that would help in making management decisions for the lake. There are three components of management: habitat, fish, and people. The habitat includes factors such as water quality and quantity, vegetation, and food sources. The fish includes factors such as native and exotic species, abundance, age and growth (length and biomass). The people component includes factors such as various types of lake use and regulations for fish harvest. To learn about the lake fishery, students met with current stakeholders on October 4, 2004. Some of the stakeholders who regularly fish at the pond (Gerald Atmar, Ken Knauer, Mike Kickirillo, and David Reed) provided fisheries-dependent data (records of their catch) and information about pond history and future goals for management. Students returned on October 25, 2004 to collect their own fisheries-independent data, which was combined with fisheries dependent data as the basis of their analysis and this report of their results and recommendations.

The lake was impounded about forty years ago and has an area of approximately 32 acres with an average depth of 7', and ranges from 3' near the boat dock to 15' at the caliche dam. The spillway drains into Alum Creek. The soil type is clay, and a small spring may provide some natural flow, although primarily water is from overland flow and rainfall, which may intermittently connect the lake to Peach Creek. In addition, a few small ponds are in the upstream drainage, one of which contains blue tilapia (*Tilapia aurea*). Approximately 95% of the 220 homes have septic systems, which can be a source of excess nutrients if the soil becomes water logged and systems overflow before adequate treatment. The lake habitat includes flooded timber, old stream channels, and many coves. Lake regulations allow only homeowners and their guest to fish and harvest their catch. Seven years ago (1997), after deciding that coverage by vegetation was greater than desired, residents obtained a permit from Texas Parks and Wildlife to stock the lake with 212 grass carp (*Ctenopharyngodon idella*), and (as required by the permit) a fence was constructed to prevent escape of fish downstream when water ran over the spillway. Subsequent to the decline in vegetation cover, residents perceived that the lake had become murky and anglers perceived a decline in quality of largemouth bass angling. The overall goal for the fishery is to provide a generally high quality angling experience, especially for largemouth bass, including increased catch rate and increased average size of fish captured by anglers.

Field Procedures

Moderate rainfall had occurred a few days prior to our initial pond visit, which may have increased water turbidity. However, on the day of our sampling, weather conditions were sunny and calm, and air temperature was about 35^{o}C (95^{o}F). Dissolved oxygen, temperature, and conductivity were measured (using a YSI-85 multimeter) at the boat launch and fishing pier near Pelican Point Park.

Two sampling methods were used. Seining (an active method) was conducted along shallow littoral zones at several different locations along the park shore to collect smaller schooling fishes, which use these areas to feed and avoid predators. Seine samples were continued until no new sizes or species of fishes were observed in our catch. Seined fish were counted and measured, and then released.

Electrofishing (another active method) began at approximately 1 p.m., and was used to sample fishes in a larger variety of habitat types including shoreline vegetation, fishing pier, boat houses, islands, creeks, woody debris. This also allowed fish to be collected from a wider range of water depths that are not accessible by seining. The electroshocking gear was provided by TAMU Wildlife and Fisheries Science graduates, Paul Dorsett (owner of Total Lake Management), and operated by his employee Cory Ging, who also drove the boat. Gear was mounted in a 15' aluminum jon boat powered by a 25 hp outboard motor, and included a generator, shocker box, and T-shaped boom, which carried a array of electrodes. A student on the bow netted stunned fish using a long-handled 14" wide net, and a second student helped place fish into the live-well. All three passengers had a pfd and lineman's gloves (10,000 kv) for safety. Three separate electrofishing runs were carried out, each by a different group of students. A zigzag pattern was used to cover ample surface area of each habitat type and to ensure adequate collection of fish from representative areas of the lake. We collected all game and forage species that were stunned. An important area sampled was near flooded timber, in order to target largemouth bass, which are attracted to such structure. Shocked fish were counted and measured then released, except for three to five individuals (fish > minimum length for that species) which represented each inch class in order to determine species age and growth rates.

Fish were weighted and measured, and representative fish were killed (and returned to residents who prepared a meal) in order to remove saggital otoliths (largest of three pairs of earstones inside the skull of bony fishes) used to age the fish. Aging by examining scales (for which fish need not be killed) is inaccurate for fish occurring in warmer habitats that have milder winters resulting in little or no variation in growth rates of scales. Each fish was assigned an identification number in order to associate all data for individual fish. In the laboratory, the otoliths were placed in glycerol to help make them more transparent, and then examined using a dissecting microscope. Under a microscope the annuli (annual growth rings) can be identified and distance between each measured using an ocular micrometer. The measurements recorded were the radius from the center of the otolith to each annular ring (annulus), and a total length from the center to the outermost edge. The annuli of larger otoliths of some species are too thick to view annuli directly, so they must be sectioned. We followed methods of Maceina (1988) to mount the otolith in thermoplastic on a microscope slide and grind it to a thin section.

Water Chemistry

Dissolved oxygen — concentration and availability of dissolved oxygen (DO) are critical to the health and survival of fish. The concentration of dissolved oxygen in any body of water varies over time due to plant photosynthesis (net increase in DO), microbial and animal respiration (net decrease in DO), wind and temperature (higher diffusion mixing possible under turbulent conditions; cooler water holds more dissolved oxygen if atmospheric pressure is constant). Oxygen enters the water from the air as the two are mixed together naturally by wind and waves or artificially by aerators, paddlewheels, and sprayers (Lock 2004). Oxygen is produced by plants (macrophytes and phytoplankton) during photosynthesis, but is also consumed by plants, fish, insects, zooplankton (microscopic organisms), and bacteria. Concentration can be measured as the number of milligrams of oxygen dissolved in one liter of liquid as parts per million (ppm), as milligrams per liter (mg/L), or as the percent saturation of the maximum amount of oxygen the liquid can hold at a particular temperature and atmospheric pressure. Lethal levels depend on the species of fish. Desirable DO concentration in fresh water is usually > 5.0 mg/L, although the growth of largemouth bass slows when oxygen levels are < 8 mg/L, and poor feed conversion efficiency occurs at values < 4 mg/L (Stuber et al. 1982). Largemouth bass actively avoid water having DO < 3 mg/L, but can tolerate values near 1 mg/L at 25^{o} C for short periods (hours).

Transparency — (not measured, but included for information) estimates with a Secchi disc are a function of light reflection, which is affected by the absorption characteristics and the particulate matter suspended in the water (Royce 1996). The disk is round and divided by radii into quarters; opposite quarters are painted black or white. It is mounted on a pole or rope on which depth measurements are marked. The disk is lowered in the water until it is no longer visible, which is the Secchi depth. Water clarity is reduced by both suspended clay particles and blooms of microscopic algae. The transparency range is useful in evaluating phytoplankton blooms, but is also affected by turbidity due to clay, mud, and silt (Texas Chapter of the American Fisheries Society 2005). Suspended clays are undesirable and may be reduced by addition of aluminum sulfate (alum) or calcium sulfate (gypsum). Visibility < 152 mm (< 6 inches) indicates a critical condition, and < 30 cm (< 12 inches) signifies an undesirable heavy bloom, 46 to 61 cm (18 to 24 inches) indicates a healthy bloom, and > 61 cm indicates an undesirable amount of phytoplankton. Transparency also influences the foraging success for some fishes. Largemouth bass, which feed by sight, require water clarity > 15" to adequately feed, but do best in clarity of > 24" (Davis and Lock 1997).

Conductivity — the ability of water to conduct electricity is measured in µSiemens (µS) and is measured as the flow rate of charged particles between two electrodes (Dodson 2004). Conductivity of fresh water ranges from 20 to 1500 µS. Changes in conductivity can occur because of rainfall, herbicides used for weed control, runoff and drainage from the watershed, and fertilization. These influence the concentration of various ionized molecules in the pond, including nitrate and phosphate (two important plant nutrients). Conductivity changes the effectiveness of electrofishing, so it was measured to understand the voltage gradient for sampling. Health of most freshwater fish species is should only be a concern at conductivity > 15,000 µS.

Nutrients — (not measured, but included for information) aside from contributing to conductivity, influence primary production (growth of plants) and secondary production (growth of other organisms). Ammonia nitrogen (NH4-N) can be measured with a phenol-hypochlorite method using nitroprosside as a catalyst. The cadmium-reduction followed by diazotization can be used to measure nitrate nitrogen (NO3-N), nitrite nitrogen (NO2-N) and total nitrogen, converted to mg/L of water. Phosphate like nitrate is usually present in slight amounts in natural surface- and well-water because most is present in the particulate phase, which is incorporated into living biota. One of the primary sources of phosphorus in community ponds is from runoff containing sewage (McComas 2003), such as leaking septic tanks or sewer lines. The phosphate that is most available for biological productivity is that measured as soluble reactive phosphorus (PO4-P) remaining in a filtered water sample, and then Total phosphorus is measured after the water sample is oxidized by persulfate.

Nitrate and phosphate are generally nontoxic to fishes (Johnson 1985). Nitrite is an intermediate product between ammonia and nitrate that is formed as organic matter decomposes. Nitrite is changed quickly to nitrate when oxygen is present. Nitrite levels of more than 1 mg/L may be suspected if death to fish has been observed. Ammonia is a waste product that is produced by many organisms, including fish, and can be toxic. Any ammonia is undesirable, but > 2 mg/L can cause stress and death to fish. Fish can tolerate several hundred mg/L of phosphorus. Aside from promoting unwanted growth of algae or other plants in ponds, phosphorus (like nitrate) is considered harmless to fish.

pH— is a measure of the concentration of hydrogen ions in water, and is related to alkalinity. Proper alkalinity is critical for healthy fish populations. If pH values drop below 5 or rise above 10, then fish can become stressed and die (Lock 2004). Adequate buffering capacity is measured as total alkalinity, and is commonly described as mg/L of calcium carbonate. A total alkalinity of at least 20 mg/L is required for good pond productivity. Ponds with low alkalinity can have wide fluctuation in pH throughout the course of the day, causing unnecessary stress on fish. This also causes establishment of an adequate phytoplankton bloom to be a problem. Fertilization is ineffective if proper alkalinity is not present to buffer such changes.

Temperature— affects the metabolic rate of fish and proper range is critical for reproduction. Optimal temperature for growth of adult largemouth bass (Stuber et al. 1982) ranges from 24 to 30^{o}C (75 to 86^{o}F), and very little growth occurs < 15^{o}C (< 59^{o}F) or > 36^{o}C (> 97^{o}F). Largemouth bass become inactive at temperatures < 10^{o}C (50^{o}F) and > 27^{o}C (81^{o}F).

Laboratory Data Collection and Analyses

Length-at-age analyses were calculated using the Dahl-Lee method, which is used to estimate previous growth in body length and is proportional to the distance measured between annual rings in otoliths. The annuli are produced when a period of slow growth (e.g., fall and winter) follows fast growth (e.g., spring and summer), and is considered more accurate than annuli formed by scales for fishes that inhabit warmer areas with mild seasonal differences (Murphy and Willis 1996). The distance between annuli was measured to back calculate the length of the fish at previous ages. The growth of each annuli is assumed to be proportional to the fish's growth in length. The length and age characteristics determined using otoliths and measurements of the killed fish were used to calculate a length-at-age key, which allowed us to extrapolate the age of remaining fish in the sample that were measured and released alive. Length-at-age for largemouth bass in Nantuckett Lake was compared to standard values for largemouth bass in Texas statewide. An index of "plumpness" for individual fishes called relative weight (Wr) was also calculated. The Wr compares the weight of the fish sampled to a standard weight (nationwide) of fish of that same species and length class (Nielson and Johnson 1983). A Wr of 95-100 reflects physiological and ecological optimum conditions (Sigler and Sigler 1990), Wr < 95 indicates that food may be limiting fish growth, whereas Wr > 100 indicates food may be so highly abundant that more individuals could be supported.

An analysis of the pond fish assemblage that measures the relative abundance of piscivorous (fish eating) predators and their forage species, includes calculation of two more indices. The indices of Proportional Stock Density (PSD) and Relative Stock Density (RSD) is calculated for each species as the proportion of fish counted in each of five size class. Size classes are based on percentages of world record sizes for each species, as determined from a national survey of anglers (Gabelhouse 1983).

Water Chemistry Results

Results of the water quality analysis (Table 1) show most measured variables to be within the range expected for this time of year and ambient conditions, which included the several days preceding sampling. They indicate modest amounts of plankton, which provide the food-web base for supporting young-of-the-year fishes, including sunfish species sampled in Nantuckett Lake (i.e., bluegill, largemouth bass, redear sunfish, and white and black crappies). The temperature was normal for early autumn in this part of Texas. The DO measurements were taken near mid-day, when aquatic plants (including phytoplankton) would normally be actively photosynthesizing. This would usually be expected to increase DO and reduce carbonic acid concentration in the water. However, expected values were lower because of the recent cloudy weather.

Table 1. Water quality analysis for Nantuckett Lake

Parameters	Recommended range	Values
Temperature (^oC)	variable	27
Dissolved oxygen (mg/l)	> 5.00	5.18
Oxygen saturation (%)	variable	53.8
Conductivity (µSiemens)	100-500	131
NO_3 -N (mg/l)	< 2.0	not measured
NO_2 -N (mg/l)	< 0.50	not measured
NH_4 -N (mg/l)	< 1.00	not measured
PO_4 -P (mg/l)	< 0.10	not measured
Total P (mg/l)	0.40-0.45	not measured
pH	5-10	not measured

Lower DO and % saturation are expected without the operation of any aeration (which though generally effective, is within a limited area of the pond). We did not measure pH, alkalinity and hardness, as they are a function of geology and soil types, so do not readily change. They are primarily of interest if a sufficient phytoplankton bloom does not regularly occur, or DO shows such wide ranges that stressed fish (gulping air at surface) are observed. Nitrate, nitrite, ammonia, and total phosphorus concentrations are a function of weather, runoff and atmospheric deposition of phosphate with rainfall, so multiple measurements over time are usually needed. Conductivity values indicated adequate conditions for effective sampling, which was confirmed by a range of species and sizes captured by electrofishing.

Fish Population Assessment

The species composition for Nantuckett Lake was determined using the data for both sampling methods (Table 2.). Total catch was recorded as the number of individuals collected using each gear. The number of fish collected in each size class for game and forage species (Table 3) are shown distributed among five size classes from smallest to largest (respectively as stock, quality, preferred, memorable, and trophy; Gablehouse 1984). Several young-of-the-year (< stock size) largemouth bass were collected (Tables 2 and 3) and many small bluegill sunfish were present in seining samples, indicating successful spawning had occurred during the recent spring and summer. No stock size (8 in, 20 cm) largemouth bass were collected from Nantuckett Lake.

Table 2. Catch of fishes collected by gear type from Nantuckett Lake.

Species	Seining	Shocking
Largemouth bass, *Micropterus salmoides*	3	113
White crappie, *Pomoxis annularis*	0	62
Black crappie, *Pomoxis nigromaculatus*	0	4
Bluegill, *Lepomis macrochirus*	12	51
Redear sunfish, *Lepomis microlophus*	1	15
Redear x Green sunfish hybrid	0	1
Warmouth, *Lepomis gulosus*	1	0
Tilapia, *Tilapia aurea*	1	0
Gizzard shad, *Dorosoma cepedianum*	0	9

Most of the largemouth bass were in the quality (12 in, 30 cm) and preferred (15 in, 38 cm) size classes, and indices were near a desired range for the Big Bass option. Bluegill is generally considered the major prey base for pond fisheries because it reproduces throughout the warm months, providing various sizes of prey fish. By comparison, redear sunfish usually have one reproductive bout, and in Nantuckett Lake they were generally much larger than the bluegill. In Nantuckett Lake, redear sunfish and bluegill together can provide prey of sizes suited to the range of game species and sizes present (primarily largemouth bass, white crappie, and a smaller relative abundance of black crappie).

Proportional stock density (PSD) and relative stock density (RSD) — are indices of the sizes of fish in the community distributed among five size classes. PSD and RSD calculated as percentages are as follows:

$$\text{PSD} = [(\text{number} \geq \text{quality size}) / (\text{number} \geq \text{stock size})] \times 100$$

$$\text{RSD-P} = [(\text{number} \geq \text{preferred size}) / (\text{number} \geq \text{stock size})] \times 100$$

$$\text{RSD-M} = [(\text{number} \geq \text{memorable size}) / (\text{number} \geq \text{stock size})] \times 100$$

$$\text{RSD-T} = [(\text{number} > \text{trophy size}) / (\text{number} > \text{stock size})] \times 100$$

Table 3. Size distribution for the abundant fishes collected by electroshocking from Nantuckett Lake.

Size range	largemouth bass	white crappie	redear sunfish	bluegill
< stock	58	44	0	51
stock	0	9	0	2
quality	18	8	4	6
preferred	28	7	7	0
memorable	8	3	2	0
trophy	1	0	0	0

The PSDs for each species and recommended PSDs for three management plans (Table 4) are those generally applied to the most common species in small impoundment communities (largemouth bass and bluegill). No general standard for composition has been developed that includes catfish, crappie, or redear sunfish.

Table 4. Optimum PSD and RSD index values for three management plans and Nantuckett Lake.

Plan	largemouth bass			bluegill		redear sunfish			white crappie		
	PSD	RSD-P	RSD-M	PSD	RSD-P	PSD	RSD-P	RSD-M	PSD	RSD-P	RSD-M
Balance	40-70	10-40	0-10	20-60	5-20						
Panfish	20-40	0-10		50-80	10-30						
Big Bass	50-80	30-60	10-25	10-50	0-10						
Nantuckett	100	67	16	34	0	100	54	15	67	26	4

Redear sunfish and bluegill together can provide a good range of prey sizes for a fishery managed either to balance the catch of largemouth bass and bluegill, or to maximize production of big bass. Redear sunfish present in the two larger size classes also provide angling opportunities for panfish.

Length-at-age— averages for largemouth bass statewide in Texas, and for fishes collected from Nantuckett Lake were compared (Table 5). As for other species, largemouth bass growth rates are influenced by a number of factors including genetics, water and habitat quality and quantity, and forage availability. Based on examination of their otoliths, Nantuckett Lake largemouth bass appear to have below average growth compared to averages across Texas, taking about one year longer to reach stock size, and two years longer to reach preferred size (Table 5). On average in Nantuckett Lake, white crappie reached quality size at age three and preferred size at age five, whereas black crappie reached preferred size at age four. Redear sunfish in Nantuckett Lake reached quality size on average at age two and preferred size at age five. Bluegills in our sample were one year old and younger. However, coefficients of variation (CV) were higher for largemath bass than for white crappie, probably due to the smaller number of fish examined, however CVs for fewer redear were even lower than for either largemouth bass or crappie and similar to those of bluegill. This suggests much higher variation in average growth for largemouth bass and crappies.

Table 5. Mean growth in length for age classes (mm) of largemouth bass in Texas, and mean back-calculated length-at-age (mm) for largemouth bass and other species sampled in Nantuckett Lake in October 2004. The number of fish aged of each species is in parenthesis, as is the coefficient of variation for length at each age estimate given, unless only one fish of that age was collected. Size class abbreviations: Stock (S), Quality (Q), Preferred (P), Memorable (M), Trophy (T).

Age	Texas	Nantuckett Lake				
	Largemouth Bass	Largemouth Bass (15)	White Crappie (24)	Black Crappie (2)	Redear Sunfish (10)	Bluegill (6)
1	200, S	158 (0.35), < S	119 (0.27), < S	89 (0.49), < S	148 (0.15), S	91 (0.14) S
2	296, Q	241(0.36), S	158 (0.29), S	132 (0.51), S	193 (0.17), Q	
3	371, P	263 (0.38), S	214 (0.21), Q	142 (0.98), S	200 (0.14), Q	
4	420, P	265 (0.56), S	243 (0.06), Q	270 mm, P	223 (0.09), Q	
5	445, P	409, P	261 (0.03), P		235, P	
6		444, P			258, P	
7		478, P				

Relative weight (W_r)— is used to assess the condition (plumpness) of an individual fish (Murphy et al. 1991, Wege and Anderson 1978). These values are based on the ratio of a fish's weight (W) to that of an expected standard-weight (W_s) for a fish of that length and species that is considered to be in good condition (75th percentile of weight), as follows:

$$W_r = (W / W_s) \times 100$$

Table 6. Average relative weights (coefficient of variation) by size class for sport-fish and forage species sampled in Nantuckett Lake.

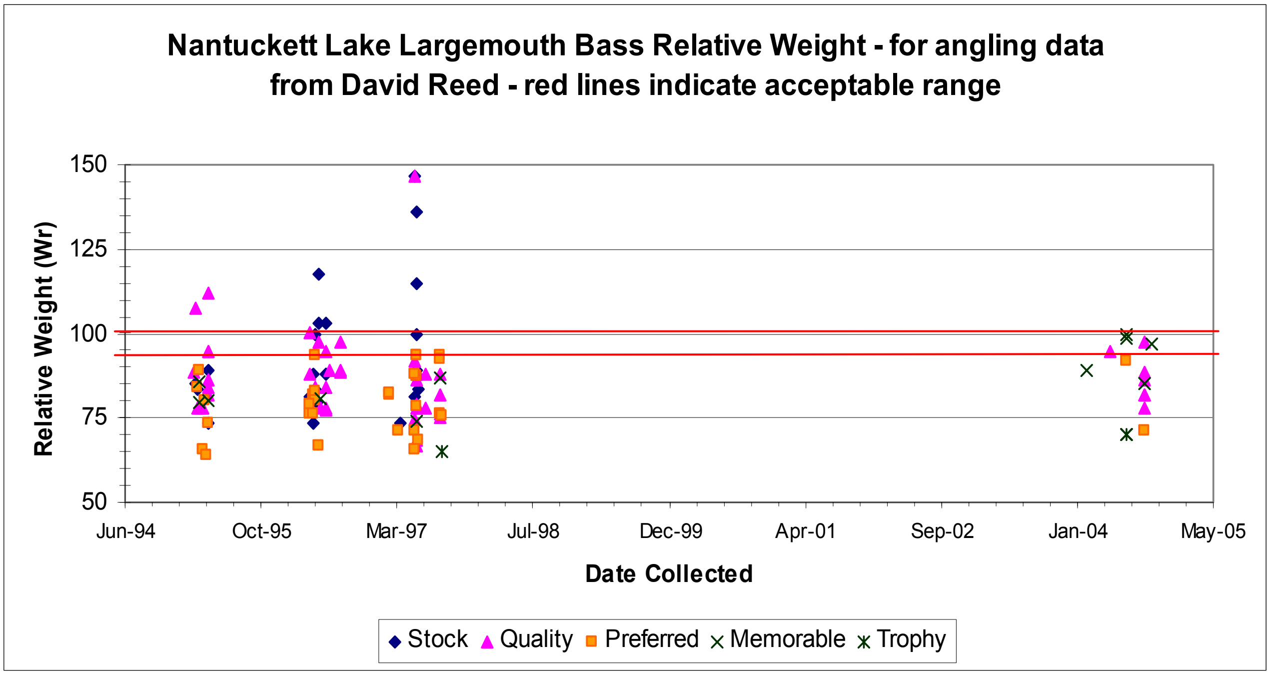
Species	Size	(in, mm)	Num of fish	W_r
largemouth bass	stock	(8, 200)	0	-
	quality	(12, 300)	18	88 (0.11)

	preferred	(15, 380)	28	96 (0.36)
	memorable	(20, 510)	8	97 (0.09)
	trophy	(25, 630)	1	122
white crappie	stock	(5, 130)	9	103 (0.11)
	quality	(8, 200)	8	99 (0.12)
	preferred	(10, 250)	7	102 (0.11)
	memorable	(12, 300)	3	79 (0.09)
black crappie	stock	(5, 130)	0	-
	quality	(8, 200)	1	85
	preferred	(10, 250)	2	93 (0.05)
	memorable	(12, 300)	1	86
redear sunfish	stock	(4, 100)	0	-
	quality	(7, 180)	4	87 (0.03)
	preferred	(9, 230)	7	90 (0.13)
	memorable	(11, 280)	2	93 (0.07)
bluegill	stock	(3, 80)	2	115 (0.08)
	quality	(6, 150)	6	85 (0.19)
	preferred	(8, 200)	0	-

Growth is highly variable for very small fishes. Therefore, a minimum length for each species is used in calculating relative weight (Murphy et al. 1991). A satisfactory range for W_r is 95 to 100. The average W_r values for fish in different length categories in the Nantuckett Lake sample were compared (Table 6). Because relative weight is a function of many factors such as available forage, environmental conditions (e.g., temperature, DO), and fish length, a comparison of relative weights for fish in different length classes is very informative. Average Wr values within the expected range for fish in a size class indicates forage species of appropriate sizes are readily available. Lower Wr values indicate fish that are under-weight for their size, possibly because the available forage species are not adequately abundant or in the appropriate size range for predatory species. Values of Wr > 100 indicate that additional fish of that size class can probably be supported by the available prey base.

In Nantuckett Lake, acceptable W_r was observed for largemouth bass in the most abundant size class (preferred) although the variability in this value was rather high. Low W_r values were observed for largemouth bass of quality size. Largemouth bass in the memorable size class had adequate W_r, and values for trophy class fish were quite high, but the latter cannot be taken as representative because only

Figure 1. Comparison of relative weight (Wr) for largemouth bass in Nantuckett Lake captured by angling from 1994-2004 by David Reed.



one fish of that size class was captured in the sample. White crappie of most size classes in the sample were in or near adequate range for W_r , except memorable size fish, which were underweight for their size, as were black crappie of quality, preferred, and memorable size, and redear sunfish. The two bluegill of stock size had high W_r, but values were low for quality size fish.

Data recorded by David Reed for largemouth bass captured in previous years by angling indicate that low relative weights may be common for all size classes in Nantuckett Lake (Figure 1), assuming length measurements reported were for total length (i.e., measured from lower jaw to tip of tail when both upper and lower fins are squeezed together). If this is not the case, length is underestimated and actual values would be lower.

Summary

Sport fishes — The largemouth bass is the most popular sportfish in Texas and usually the top predatory species in pond communities. The northern subspecies is native to Texas and has been widely stocked since the early 1900s. Although the Florida subspecies grows to a larger size, it is more sensitive to very cold temperatures and is more difficult to catch than is the native northern subspecies. If both subspecies are stocked into the same pond, they will cross to produce an intergrade offspring. Over time, a mixture of crosses and back-crosses among subspecies will result in a mixture of genetic types, which can provide both the advantages and disadvantages of both species.

Both black and white crappie were captured in our sample. These are native Texas species adapted for the dynamic and nutrient rich habitats found in floodplain oxbow lakes produced by naturally free-flowing rivers. They often are incidentally trapped during stream impoundment or are stocked by hopeful anglers. In natural oxbows and river backwaters, large numbers of young crappie are spawned during high flows, but offspring are rapidly consumed by predators whose hunger is increasing with water temperature and their own impending spawn. As predators reduce the density of offspring, the surviving young take advantage of the increasingly available zooplankton and macroinvertebrate prey, and can rapidly grow to a size at which they themselves can not only eat fish, but are able to better avoid predators. These characteristics make crappies undesirable in the more steady environmental conditions of managed ponds, which are usually less productive and have fewer large predators. Thus, a larger number of crappie young will survive to compete among themselves and similarly sized sunfishes (including desired bluegill and largemouth bass) for a more limited abundance of prey, as well as prey on young largemouth bass. Moreover, because even small crappie will rapidly mature and reproduce, crowding commonly leads to stunted populations.

Forage fish — in Nantuckett Lake primarily included bluegill, redear sunfish, and gizzard shad. Bluegill is the only species which can produce the large numbers of small fish needed as food for largemouth bass across a range of size classes. This is because bluegill spawn repeatedly throughout the spring and summer, so that a range of sizes are available throughout the growing season. Overproduction and stunting of bluegill can be due to over harvest of predators, but is usually due to excessive weed cover (> 20% of pond surface area as a general guideline) in which small bluegill can hide from largemouth bass, but in which food production is less than in open water. Redear sunfish are an excellent supplemental forage species, and larger individuals increase the angling opportunities for another species of panfish. Because redear sunfish eat snails, they produce an added benefit by reducing the risk of white grub (parasitic worm) infection in the meat of fishes by breaking the parasite life cycle (from piscivorous birds, to snails, to fish, to piscivorous birds, etc…). Gizzard shad can rapidly grow too large for most sportfish to eat. Moreover, high densities of young gizzard shad can decrease production of young bluegill because of competition for food. Gizzard shad do, however, provide forage for trophy-sized fish, but the potential for negative impacts on largemouth bass and bluegill recruitment to adult size is a hazard.

The low relative weight of smaller size classes of largemouth bass and higher relative weights for crappies, suggest a negative impact of crappie on largemouth bass. The lack of stock size largemouth bass and highly variable growth and condition indices for preferred size classes, suggests that few largemouth bass recruited to stock size this year and that growth during this time is highly variable. Together with the fisheries dependent data, there appears to be generally slower growth of largemouth bass in Nantuckett Lake as compared with Texas waters statewide. This might also be attributed to the low DO values that were measured if these are representative of general conditions, rather than due to recent weather as assumed at the time of sampling. In addition to potential for competition with crappies and gizzard shad, tilapia that may have washed into the lake from upstream ponds. These could have been an additional stress factor for largemouth bass, if many more tilapia were present than those represented in our seining sample. Tilapia will harass nesting largemouth bass, allowing an opportunity for sunfish to periodically enter unguarded nests, and consume eggs and fry.

Recommendations

1. Bluegill can be harvest at every opportunity as they are prolific and repeat spawners. As largemouth bass consume bluegill, they reduce competition leading to greater numbers of quality-sized bluegill, and a balanced fishery with additional bluegill angling opportunities. The larger redear also provide good variety in angling opportunities, as well as forage for larger largemouth bass.
2. If large bass are desired, incorporate a slot limit (release of fish within 12-15 in size range) and harvest of all fish < 12 in. Keep the harvest of bass that are > 15 in. to a minimum in order to provide more opportunity to catch larger fish. If trophy size largemouth bass are desired, remember that higher catch rates are traded away for such opportunities. Consider use of a 14-18 in. or even a 15-22 in. slot length limit, and attempt to remove twenty-five 8-15 in. (total weight 15-40 lb) per acre each year. This total will also depend on good recruitment of largemouth to catchable sizes as well as good availability of prey fish.
3. If species such as large flathead catfish, and crappies are captured by anglers, these should be harvested and removed as they will compete with largemouth bass for forage. If large numbers of green sunfish, hybrid sunfish, small crappie, and warmouth produce many young, they can increase competition for small largemouth bass (unless adequate numbers of bluegill are readily available) and possibly reduce recruitment of juvenile bass to larger size classes.
4. No catfish were collected, however, blue and channel catfish do not compete with largemouth bass and can provide additional angling opportunities. Follow guidelines of Texas Chapter of the American Fisheries Society (2005) with regard to number and size to stock if these species are desired.
5. If conditions of low DO and high turbidity are chronic, further assessment as to the reasons for these problems will be needed. Follow guidelines of Texas Chapter of the American Fisheries Society

(2005) for these and other habitat-related actions (including nutrients and cover or nesting structure) that may be needed.

6. Addition of a public fishing pier and a fish cleaning station would increase use of the fishery by a variety of community members, especially those that do not own boats.
7. The pond can also provide additional enjoyment to community members if areas to attract wildlife are established. Nesting boxes placed in the pond can provide artificial cavities for wood ducks (Lock 2004). Native shrubs and trees can be allowed to grow along parts of the shoreline, which will attract birds and other wildlife. However, abundant dead trees that extend above the water are attractive perching areas for cormorants, which can consume large numbers of fish. Consider cutting several of these dead trees below the water level and deep enough to avoid being hit by boats and motors.
8. Anglers should be encouraged to help maintain a record of their catches as this provides an estimate of the size composition and relative abundance of game species. This can be followed over time for trends, and if done regularly systematically (Texas Chapter of the American Fisheries Society 2005) can be comparable to electrofishing for estimating size structure and abundance of game species.

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