Effects of Water-Level Fluctuations on the Fisheries of Lake Tarpon

Final Report

September 2003

Mike S. Allen - Principal Investigator
W. Tate - Biological Scientist
K. I. Tugend - Biological Scientist
M. Rogers - Biological Scientist
K. J. Dockendorf - Graduate Research Assistant

Department of Fisheries and Aquatic Sciences
The University of Florida
7922 NW 71st Street
Gainesville, FL 32653

Submitted to

Don Hicks
Pinellas County Department of Environmental Management
Pinellas County
300 South Garden Ave.
Clearwater, FL 34616

Table of Contents

Executive Summary

Lake Tarpon supports important recreational fisheries in Florida and ranks among the top lakes in the state for largemouth bass *Micropterus salmoides*. In 1997, the Lake Tarpon Drainage Basin Management Plan proposed several management strategies to improve water quality at Lake Tarpon. One of these strategies was a revision to the existing operation schedule for the Lake Tarpon Outfall. Because water-level fluctuations can affect recruitment (i.e., the number of fish that survive to adulthood each year) of sportfish including largemouth bass and black crappie *Pomoxis nigromaculatus*, this study was intended to assess effects of water-level fluctuations on habitat quality and recruitment of largemouth bass and black crappie at Lake Tarpon from 1998-2003.

Although the revised operation schedule was not implemented during the course of this study, water level at the lake did drop to the levels proposed in the revised schedule for one year of the study due to drought conditions. Therefore, we were able to evaluate the effects of low water level on fish recruitment and fisheries habitat. In addition to this information, data collected during this study were used to evaluate the quality of the sport fish populations relative to the fishery goals in the Lake Tarpon Drainage Basin Management Plan.

Largemouth bass were sampled with electrofishing in February and April 1999 and March of 2000 - 2002. Black crappie were sampled with an otter trawl in September of 1998 - 2002. Water level data were obtained for 1995-2002, and catch rates of age-0 black crappie and age-1 largemouth bass were compared to seasonal water levels. Habitat maps of Lake Tarpon were constructed in July-August 1999 and August of 2001 using Global Positioning System (GPS) and ArcView software. Block net sampling was conducted in littoral and limnetic areas during summer 2000.

We found a positive trend between spring and summer water levels and largemouth bass recruitment. Seasonal trends in water levels were generally similar among years except for 2000, which had low water during summer reaching a minimum of 0.8 ft NGVD, which was below the proposed lowest water level (1.25 ft MSL) that would be obtained in the revised operation schedule. We found that low water level in the Spring and Summer of 2000 was related to a relatively weak 2000 largemouth bass year class. Nevertheless, water levels at Lake Tarpon fluctuate less than many other central Florida lakes.

Black crappie mean catch per minute in trawls was low in all years (1998-2001). Mean catch rates of age-0 black crappie indicated low recruitment to adulthood from 1998-2002. Lake Tarpon contained a low-density black crappie population during this study, but black crappie growth rates were very rapid relative to other Florida lakes and fish recruited to harvestable size by age-1. Nevertheless, poor black crappie recruitment continues to result in low adult abundance at Lake Tarpon. Age-0 black crappie abundance was not related to any water level variables.

Habitat maps revealed that inshore areas of Lake Tarpon had firm substrates consisting of sand and sand/mud and a relatively steep slope from the shoreline. Thus, small changes in water-level such as the fluctuations of less than 1 m annually in the revised schedule would not substantially reduce lake surface area or available habitat. Inshore areas contained a mix of mostly cattail *Typha spp.*, coontail *Ceratophyllum demersum*, hydrilla *Hydrilla verticillata*, and eel grass *Vallisneria americana*. Adult largemouth bass electrofishing catch rates did not differ with substrate type, macrophyte community composition, or shoreline type (residential vs. undeveloped) in 1999, but catch rates were higher in February than in April. Adult largemouth bass were collected at all habitats around the entire lake shoreline, suggesting that spawning habitats were not limited to one area of the lake.

Total fish biomass and density estimated from block nets were 441 kg/ha and 22,490 fish/ha, respectively. Total fish biomass estimates have increased since 1987, but estimates were similar to a 1995 study. Bluegill, largemouth bass, and redear sunfish made up about 85% of the total fish biomass, which was similar to historical data. Block net samples suggested that although fish biomass has increased in the last 15 years, the fish community is dominated by native fishes. Forage fish to carnivore ratio biomass ratios (F/C ratios) increased from 1 to near 6 from 1987 (historical data) to 2000 (this study). The optimal range of F/C ratio is 3 to 6. Thus, except for black crappie, the sport-fish populations at Lake Tarpon are of exceptional quality for recreational fishing and represent the characteristics of a fertile but well-balanced Florida lake. Nevertheless, future increases in nutrients could cause the forage fish to carnivore ratio (F/C) to climb out of the optimal range, potentially reducing the quality of the sport fishery.

Based on the results of this study, we suggest that resource managers should consider these recommendations.

1. We found evidence that low water level during spring and summer of 2000 was related to a weak largemouth bass year class. Spring or summer water levels below 1.25 ft MSL, the proposed minimum in the revised operating schedule, may cause relatively weak largemouth bass year classes at Lake Tarpon. We note that we only had one year of low water in this study so this result was not replicated. If a regulation schedule includes mean spring and summer water levels at or below 1.25 ft MSL, largemouth bass population responses should be monitored.
2. The Florida Fish and Wildlife Conservation Commission should consider implementing a 254-mm total length (TL) minimum length limit for black crappie at Lake Tarpon. Black crappie exhibited very rapid growth but low recruitment. A minimum length limit could protect fish from harvest until they surpass age-1 and could potentially improve adult fish abundance and recruitment of young fish at the lake. Given the rapid black crappie growth, a 254-mm length limit is unlikely to harm overall yield (i.e., weight of fish harvested by anglers).
3. The F/C ratios were increasing for the fish community at Lake Tarpon and could surpass the 3-6 target range within the next two to four years based on trends from 1987-2000. The increasing F/C ratio is likely due to increases in lake nutrient concentrations, and continued increases could reflect a declining sport fishery.

We recommend continued monitoring of the fish community at Lake Tarpon and reassessment of the F/C ratio within two to four years (i.e., during 2005-2007).

Introduction

Lake Tarpon is a 1,025-ha natural lake located in Pinellas County, Florida. It is an important recreational fisheries resource in the region, as the Florida Fish and Wildlife Conservation Commission (FWC) rates Lake Tarpon as one of the top 10 largemouth bass *Micropterus salmoides* lakes in the State. Historically the lake has also supported a popular black crappie *Pomoxis nigromaculatus* fishery, but in recent years the black crappie fishery has declined (T. Champeau and M. Hale, FWC, personal communication).

In 1997, the Lake Tarpon Drainage Basin Management Plan outlined several management strategies to improve water quality at Lake Tarpon. One of these strategies was a revision to the existing operation schedule for the Lake Tarpon Outfall Structure. The proposed revised fluctuation schedule would encompass a four-year cycle, with an extreme low water period down to a level of 1.25 ft NGVD in June of year one (Schedule A), years two and four having the least fluctuation (Schedule C), and year three having an intermediate amount of water-level fluctuation down to a level of 2 ft NGVD in June (Schedule B). The schedules would then repeat again starting with Schedule A in year five. The plan has not been implemented, but assessing effects of water level fluctuations on the fish populations at Lake Tarpon is important when considering water level manipulations. Potential benefits of the schedule include improved water quality (i.e., reduced nutrient concentrations), reduced frequency of algal blooms, aquatic macrophyte control, and use of runoff water for irrigation. However, potential effects of the water level fluctuations on the sport fisheries at Lake Tarpon required evaluation.

Water-level fluctuations can influence reproductive success of largemouth bass and black crappie. Strong largemouth bass year classes (e.g., the number of young fish that survive to adulthood) have been attributed to high water levels in the spring (Aggus and Elliot 1975; Houser and Rainwater 1975; Rainwater and Houser 1975; Shelton et al. 1979; Timmons et al. 1980; Miranda et al. 1984; Ploskey 1986; Meals and Miranda 1991; Ploskey et al. 1996). Inundated vegetation during high water provide quality spawning habitat for adults and provide food and shelter from predation for age-0 (less than one year old) largemouth bass, which may enhance recruitment compared to years with low water levels. Black crappie and white crappie *P. annularis* recruitment is often highly variable (Hooe 1991), with year-class failures occurring periodically in many systems. However, crappie recruitment has been positively related to water level, with strong crappie year classes generally occurring in years with high water levels during spring (Beam 1983; Mitzner 1991; McDonough and Buchanan 1991; Maceina and Stimpert 1998). Maceina and Stimpert (1998) found strong crappie year classes occurred when high water was present during winter and spring, and poor recruitment was associated with low winter water levels. Thus, the proposed high water during winter and spring may provide more consistent recruitment of black crappie in Lake Tarpon compared to variable spring water levels among years.

However, timing of the proposed reduction in water levels in April and May could influence sport-fish recruitment at Lake Tarpon. Low water levels may cause evacuation of nests by spawning fish, reduce productive spawning habitats, or eliminate shelter for age-0 fish and increase mortality via predation (Miranda and Hubbard 1994a, b). In years with late spawns of largemouth bass and black crappie, the proposed water-level reduction could disrupt spawning activities of these species. Because age-0 largemouth bass inhabit littoral areas and require shelter to avoid predation (Aggus and Elliot 1975; Miranda and Hubbard 1994b), low water in spring or summer could reduce recruitment in some years if adequate cover is not available in remaining littoral zones. Age-0 white crappie migrate to limnetic areas after hatching (O'Brien et al. 1984) and may not be strongly affected by reduced water levels in the littoral zone, but effects of low water on age-0 black crappie have not been identified.

The initial objectives of this project were to identify effects of the water-management plan on the sport fisheries at Lake Tarpon. However, the proposed plan was not implemented as scheduled, and therefore, we investigated effects of water-level fluctuations under the existing operation schedule on the largemouth bass and black crappie populations of Lake Tarpon. We also conducted block net sampling to compare fish community composition metrics to historical data from the lake.

Objectives

The objectives of this study are:

1) assess the relations among water-level fluctuations and the population abundance, size structure, and recruitment of largemouth bass and black crappie at Lake Tarpon,
2) implement a monitoring program to evaluate recruitment of largemouth bass and black crappie each year and provide data to optimize the water-level management plan for recreational fisheries,
3) assess changes in fish habitat quality with changes in water-levels using habitat maps,
4) assess fish community composition and biomass for comparison to historical records.

Methods

Water Level Fluctuation

Water level data for Lake Tarpon were obtained from the Southwest Florida Water Management District for January 1995 through July 2002. Data were collected from the gauge station located at the water outflow of Lake Tarpon. Mean monthly water levels were determined and grouped according to calendar seasons; winter (Jan, Feb, Mar), spring (Apr, May, Jun), summer (Jul, Aug, Sep), and fall (Oct, Nov, Dec). Mean seasonal and the range (i.e., minimum and maximum) in mean monthly water levels for each season were determined for each year.

Largemouth Bass Sampling

Largemouth bass were sampled with electrofishing in February and April 1999, and March of 2000-2002. Electrofishing transects (10-min each) were conducted along shore, and each transect was used as a replicate for mean catch-per-minute (CPM=fish/min) estimates. Fish were collected using pulsed direct current at 5 to 7 amperes. We used one person dipping fish for all transects. Start and end points of each transect were marked using Global Positioning System (GPS) for use in habitat mapping during 1999 (see below). All largemouth bass were measured for total length (TL, mm).

The age structure of Lake Tarpon largemouth bass was estimated from electrofishing samples made during spring 2001 and 2002. All largemouth bass collected were measured for total length (TL, mm). For fish less than 400-mm TL, five fish per centimeter group were returned to the lab where sagittal otoliths were removed. Otoliths were placed in plastic vials marked with an identification number for each fish. Because largemouth bass over 400-mm TL may have highly variable ages due to growth differences between males and females (Carlander 1977), all fish above 400-mm TL were returned to the laboratory for removal of otoliths.

Otoliths from fish ages 1 and 2 were usually read in whole view. Otoliths for older fish or those where the age was difficult to view clearly in whole view were prepared for sectioning by mounting the whole otolith on a glass slide using a hot glue gun. Sections (~2-3 sections, ~0.5 mm thick) were made through the focus using a Buehler® Isomet 1000 or a South Bay Tech® Model 650 low-speed saw. Sections were then mounted on glass slides using Thermo Shandon synthetic mount. Sections from all otoliths were read using a compound microscope by three independent readers. If disagreement occurred between readers, the readers discussed the disagreement and if necessary the otolith was resectioned and the process repeated until an age was agreed upon by all readers. Because fish were collected just prior to annulus formation (Crawford et al. 1989), the ages were assigned as the number of rings plus one for most fish. However, the outermost growth increment was evaluated on each otolith to insure that a new annulus had not formed near the otolith radius. Fish with a ring on the otolith radius were assigned an age equal to the number of rings.

The largemouth bass age frequency was estimated by combining the subsampled fish below 400 mm TL with all fish sampled over 400-mm TL. An age-length key (Ricker 1975) was used to estimate the age frequency of fish below 400-mm TL. The proportion of fish in the aged subsample (N = 5 fish/cm group) was extrapolated to the unaged fish below 400-mm TL to estimate their age based on length. The resulting age frequency from the age-length key was then added to the age frequency of fish over 400-mm TL.

We used two indicators of largemouth bass year class strength to relate to water levels. First, we used electrofishing data from 1998-2000 to assess year class strength. Age-1 fish each year were identified by evaluating otoliths. Mean CPM for age-1 fish was determined for each transect each year. Correlation analysis was used to relate mean seasonal water levels and the range in seasonal water levels to mean CPM of age-1 largemouth bass for the 1997-2000 year classes (i.e., sampled as age-1 in spring of 1998-2001). Because electrofishing catchability of largemouth bass increases with fish size (Bayley and Austin 2002), we were concerned that age-1 catch rates may not have been a reliable index of largemouth bass year class strength. Therefore, we also constructed catch curves (Ricker 1975) based on the estimated age frequency of largemouth bass at Lake Tarpon during 2001 and 2002. Residuals are the observed data point minus the value predicted by the regression line. Residuals from the catch curve may reflect the relative strength of each year class and can be related to environmental conditions (e.g., water levels) influencing year class strength (Maceina 1997). Studentized residuals are standardized to a normal distribution where 95% of residuals will be between ± 1.96 (Zar 1984). We used studentized residuals to assess relative strength (i.e., abundance) among year classes. We used correlation analysis to test if studentized residuals from catch curves in 2001 and 2002 were related to seasonal water levels, which provided a second measure of largemouth bass year class strength relations to water levels.

The Lake Tarpon Drainage Basin Management Plan (PBS&J 1998) suggested target ranges of 20-40% for the Relative Stock Density (RSD) of largemouth bass, which is the number of fish $\geq$ 360 mm total length divided by the number that are $\geq$ 200 mm total length*100%. Therefore, we calculated RSD values for largemouth bass collected with electrofishing from 1999-2002.

Black Crappie Sampling

Black crappie were collected with an otter trawl during September of 1998 - 2002. Bottom trawl catch rates have been a reliable index of black crappie year class strength in Florida lakes (Allen et al. 1998a). The trawl consisted of a 4.9-m long body with 38.1-mm stretch mesh in the body and 34.9-mm stretch mesh in the bag (Allen et al. 1998a). The mouth of the trawl was held open during towing with 2.5 x 5-cm floats attached to the top line of the trawl mouth and a chain line attached to the bottom line. The trawl was equipped with doors (38.1 cm x 76.2 cm) on each end of the mouth which spread the mouth open and kept the net in contact with the bottom. Each door was attached to the top and bottom lines of the net by 46-cm lead lines and then to the boat with 15.3-m tow lines. Trawls were fished at depths from 1.5 to 4-m in open-water areas of Lake Tarpon. Trawl speed was about 0.9 m/s, and each trawl (3 min) was treated as a replicate for mean catch-per-minute (CPM=fish/min). All black crappie were measured for total length (TL, mm), and otoliths were removed from fish to verify fish as age-0 or older. In 1999 and 2001, we removed otoliths on 5 fish/cm group and used an age-length key to estimate the age frequency (described above) and mean length-at-age.

We used a one-way analysis of variance (ANOVA) to test for differences in mean CPM of age-0 black crappie each year. Correlation analysis was used to relate mean seasonal and the range in seasonal water levels to CPM of age-0 black crappie for the 1998-2002 year classes. Data were log10 transformed prior to analyses, and all analyses were conducted using SAS (1996). Catch curve analyses could not be performed for black crappie because of few ages present in the population.

Habitat Mapping

We used a differentially corrected Trimble Inc. GPS to sample habitat at Lake Tarpon during July-August 1999 and August of 2001. Transects across the lake were spaced every 100-300 m moving latitudinally from north to south at the lake, and sample points along each transect were spaced every 50-150 m. Habitat variables recorded at each sample point included water depth (m), substrate type (i.e., sand, mud, muck), and presence of all aquatic macrophytes identified to species. Because we did not expect substrate to change substantially among years, substrate was measured only in 1999. Substrate categories for inshore areas were determined using a fiberglass pole to assess substrate firmness and retrieve a small core of bottom sediments. Offshore areas were sampled for substrate type and aquatic macrophytes using an Ekman grab sampler (McMahon et al. 1996).

The data from the GPS were exported to ArcView software to construct digital maps of the lake. The sample points were overlaid on background images of the Lake Tarpon region using a set of 3-meter Digital Orthophoto Quarter Quads (3m DOQQs) provided by the Florida Department of Environmental Protection. A procedure called "assign proximity" (ArcView Software option) was used to approximate continuous changes in substrate type and depth from the individual sample points. Aquatic macrophyte observations were classified as points (plant presence or absence) on the map.

In August 2002, we measured percent area coverage (PAC) and percent of lake volume inhabited (PVI) by aquatic macrophytes on a lake-wide scale. Estimates were derived using transects and a recording fathometer as described by Maceina and Shireman (1980).

To assess the habitat use by adult largemouth bass during spring 1999 in Lake Tarpon, we evaluated how substrate type, aquatic macrophyte species composition, and residential vs. undeveloped shoreline types affected electrofishing catch/min (CPM). Substrate types were classified as “firm” (sand and sand/mud mix) and “soft” (muck, loam, etc.). Aquatic macrophytes considered in the analysis included hydrilla *Hydrilla verticillata*, cattail *Typha* spp., coontail *Ceratophyllum demersum*, and eel grass *Vallisneria americana*. Aquatic macrophytes were grouped as plant types which included “no plants” (none of the plants present), “emergent” (only cattail), “submersed” (no cattails but all submersed species), and “mixed” (a mix of cattail and submersed plants). Residential versus natural shoreline was determined from background satellite images. We used multi-factor analysis of variance (ANOVA) to test if mean CPM of largemouth bass > 254 mm TL in 1999 varied with plant type, substrate type, residential vs. natural shoreline, sample month (February vs. April), and their interactions. Because CPM was not normally distributed, we used the $\log_e$ CPM after adding one to all values prior to the multi-factor ANOVA.

Block Net Sampling

The SWFWMD (2001) Lake Tarpon Surface Water Improvement and Management (SWIM) Plan called for regular monitoring of Lake Tarpon’s fish community to assess changes in community composition through time. We used block nets to collect data for comparison to historical block net data at Lake Tarpon. Eight 0.102-ha block nets (6-mm bar mesh) were set at Lake Tarpon during July 2000. Four nets each were set in littoral and limnetic zones of the lake, but all nets were placed along the eastern half of the lake because of high number of residents along the western shore. Littoral net sets were placed in water less than 2 m in depth and contained both emergent and submersed macrophytes, whereas limnetic sets contained no vegetation and were set at 2-3 m deep in adjacent offshore areas.

Each block net was treated with 3 mg/L of rotenone, and fish were collected for two days. After fish were removed on the second day, the nets were moved to another location for treatment. Subsampling of fish for weights and lengths followed the protocol of Bettoli and Maceina (1996). All largemouth bass were measured for total length and biomass calculated by weighing groups of fish. Other fish species were subsampled. Individual fish in the subsample were measured for total length (TL, mm) and weighed, and the weight of a subsample and total weight of each species was used to estimate the total number of fish in the entire sample (Bettoli and Maceina 1996). Fish collected on day two were also subsampled and their total weight and number were added to the first day's catch for each species. Mean biomass and density of each fish species was calculated for littoral and limnetic zones, and for the entire lake. We tested for differences in total fish biomass and total density using a Wilcoxon Sign-Rank test (SAS 1996).

To compare the relative success of largemouth bass, bluegill, and redear populations, we plotted biomass estimates for each species through time. Data were obtained from Champeau et al. (1991) for 1987 and 1990 samples and Champeau (1996) for 1995. We note that for 1987, 1990, and 1995, estimates were based on 0.4-ha block nets set in the littoral zone only. Therefore, we compared biomass estimates from 2000 to other years using littoral block nets only.

As suggested by the Lake Tarpon Drainage Basin Management Plan (PBS&J 1998), we evaluated the fish community balance (F/C) by using the ratio of forage biomass (kg/ha) to carnivore biomass (kg/ha) (Swingle 1950) and compared our estimates to data collected in 1987, 1990, and 1995 (Champeau et al. 1991; Champeau 1996). Forage fish included all species captured except for largemouth bass, black crappie, bowfin *Amia calva*, and Florida gar *Lepisosteus platyrhincus*, which were designated as carnivores. An F/C ratio ranging between 3.0 to 6.0 suggests a balanced prey-predator relationship (Murphy and Willis 1996).

Results and Discussion

Water-Level Fluctuations

Lake Tarpon water levels exhibited similar annual trends during 1998-2001, with water levels usually over 2.5 ft MSL in Jan. - Mar., declining water levels in April or May, and increasing water levels in July or August of each year (Figure 1). A brief but rapid drop in water level occurred in early February 1998 due to the control structure being accidently left open for 24 h (Figure 1). Water levels were lowest in May-July of 2000 and declined to below 1 ft (MSL) in mid June, which was the lowest water level of the study thus far and was lower than the most extreme year of fluctuation in the proposed revision to the regulation schedule (PBS&J 1998). Total days where water level was below 2 ft (MSL) were 13, 14, 86, and 8 for 1998-2001, respectively. Thus, water levels remained below 2 ft MSL for the longest duration in 2000.

However, Lake Tarpon water level fluctuations were not severe compared to other Florida lakes. The range of annual mean water levels at Lake Tarpon was 0.68 ft (2.28-2.96, Table 1). Conversely, at nine other Central Florida lakes, mean annual water levels ranged from 2 to over 10 feet in fluctuations among years (Table 1). The overall range in water level at Lake Tarpon was 2.5 ft (1.00 to 3.50 ft) from 1990-2002 (Table 1). The overall range in water levels varied from about 4 to about 12 feet across years for the other nine lakes. Lakes in Hillsborough and Pinellas counties generally fluctuated less than other lakes (Table 1). Nevertheless, water level fluctuations at Lake Tarpon were low compared to other Florida lakes, which was likely due to the regulation schedule implemented in 1990.

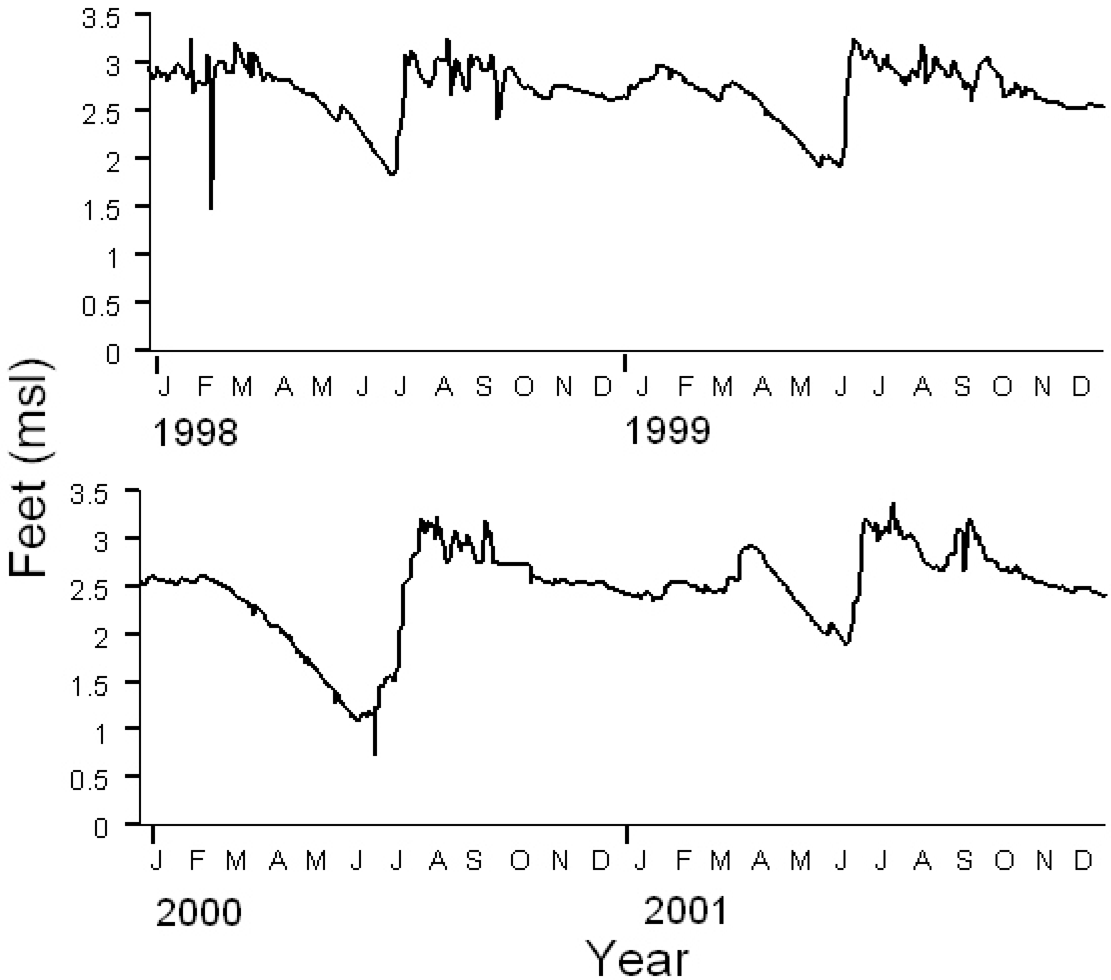

Figure 1. Daily water level readings (feet, mean sea level) at the water control structure at Lake Tarpon from January 1998 to December 2001. Data were obtained from the Southwest Florida Water Management District.

Table 1. Historical lake level (ft) means and ranges for lakes in Central Florida. Data were obtained from various Florida Water Management Districts.

Lake	County	Years	Range of Annual Means	Overall Range
Annie	Polk	1990 - 2001	109 - 116	108 - 117
Bonny	Polk	1988 - 2001	125 - 131	123 - 132
Crooked	Polk	1990 - 2001	107 - 118	106 - 119
Disston	Flagler	1992 - 2001	12.0 - 13.4	11.7 - 16.2
Island Ford	Hillsborough	1991- 2001	35.9 - 41.0	34.7 - 41.6
Hiawatha	Hillsborough	1991 - 2002	47.8 - 50.2	46.1 - 50.6
Keystone	Hillsborough	1991- 2002	39.4 - 41.3	37.8 - 42.5
Minneola	Lake	1991 - 2001	89.5 - 96.7	88.5 - 97.9
Panasoffkee	Sumter	1991 - 2002	37.4 - 40.0	36.8 - 42.5
Tarpon	Pinellas	1990 - 2002	2.28 - 2.96	1.00 - 3.50

Largemouth Bass Sampling

Electrofishing sample months and sampling effort was similar among years. We conducted electrofishing transects in February and April of 1999, and some areas sampled in February 1999 were sampled again in April 1999. Electrofishing transect in 2000-2002 were conducted in March. Transects were 10-min in 1999-2001 but 20-min in 2002, and sample sizes ranged from 46 (2001) to 99 (1999)10-minute transects. A total of 36 20-min transects were conducted in 2002, and thus, total sampling effort in 2002 was similar to 1998-2001.

Electrofishing catch rates in this study were lower than historical estimates. Mean largemouth bass catch/min (CPM) of electrofishing was 0.73 in February 1999 and 0.31 in April 1999. Mean CPM in March 2000 - 2002 were 0.50, 0.44, and 1.14, respectively. Champeau et al. (1991) found mean CPM of largemouth bass collected during spring at Lake Tarpon averaged 2.9 (range 2.5 - 3.1) from 1988 to 1990. Lower catch rates in this study compared to Champeau et al. (1991) may have been due to changes in largemouth bass abundance or sampling efficiency. We used only one person netting fish when electrofishing, whereas Champeau et al. (1991) used two people. Because we were only collecting largemouth bass, we do not believe that one dipper greatly reduced our sampling efficiency. However, our boat had a single electrofishing boom, whereas Champeau et al. (1991) used two booms, which may have contributed to our lower electrofishing catch rates.

Nevertheless, catch rates and size structure of largemouth bass at Lake Tarpon would likely indicate a high-quality largemouth bass fishery. Mean CPM from spring electrofishing at Lake Kissimmee (one of Florida's top bass fisheries) averaged 0.83 (ranged 0.53 to 1.03) from 1989-1992 (Moyer et al. 1993). Thus, catch rates of largemouth bass at Lake Tarpon in this study were similar to those found at Lake Kissimmee. Totals of 453, 256, 203, and 819 largemouth bass were collected in 1999 - 2002, respectively.

The size distribution suggested largemouth bass that size structure of largemouth bass at Lake Tarpon met target goals. Relative Stock Density (i.e., RSD = number of fish $\geq$ 360 mm

TL/number of fish ≥ 200 mm TL) was 32% in 1999, 37% in 2000, 40% in 2001, and 32% in 2002. Thus, RSD values were within the targeted 20-40% for largemouth bass at Lake Tarpon (PBS&J 1998) in all years. Based on the length frequencies, 1998 - 2001 year class largemouth bass collected during spring of 1999 - 2002 were about 8 to 18 cm TL (Figure 2). Hoyer and Canfield (1996) found that mean total length of age-1 largemouth bass was about 15 cm in 56 Florida lakes, so values from Lake Tarpon (8 to 18 cm) were close to the average. The largemouth bass population contained a wide range of fish sizes, suggesting relatively consistent recruitment over the last several years.

Catch rates of age-1 largemouth bass collected in spring of 1999 - 2002 were similar. Mean CPM of age-1 bass in February and April 1999 was 0.07 (SD=0.23), whereas mean CPM in March of 2000 - 2002 were 0.08 (SD=0.09), 0.08 (SD=0.24), and 0.09 (SD = 0.09), respectively. Correlation analysis did not reveal any significant relationships between age-1 largemouth bass catch rates and mean seasonal water levels or the minimum and maximum mean monthly water levels in each season (N=4, all $P > 0.11$). Due to relatively consistent CPM of age-1 largemouth bass among years, and relatively consistent water levels, potential effects of water level fluctuations on age-0 largemouth bass at Lake Tarpon were not identified using electrofishing CPM.

Ages of 134 and 179 largemouth bass were determined from samples collected in March 2001 and 2002, respectively. Catch-curves for largemouth bass estimated instantaneous total mortality rates (Z) of 0.335 (i.e., the slope of the catch curve) in 2001 and 0.425 in 2002 (Figure 3). Age-1 fish were not included in the catch curves because of potential for gear bias between young and older fish (Ricker 1975). The total annual mortality rate (A) for largemouth bass in Lake Tarpon was estimated as 29% in 2001 and 35% in 2002 ($S=e^{-Z}$, $A=1-S$). Allen et al. (2002) reviewed mortality estimates for largemouth bass in Florida and found an average of about 50%. Thus, total mortality of largemouth bass in Lake Tarpon was low relative to average values in

Florida. The size-structure, age-structure, and total annual mortality rate suggest that Lake Tarpon supports a quality largemouth bass population.

Residuals from the catch curves indicated relatively consistent recruitment of largemouth bass among years, particularly in 2001. Studentized residuals from the catch curve in 2001 were all between ± 1.96, indicating relatively consistent recruitment among years (Figure 3). Residuals for the 2001 catch curve were not correlated with mean seasonal or the minimum and maximum mean monthly water levels in any season (all $P > 0.14$). In 2002, the 2000 year class studentized residual was -2.77, indicating a weak year class in 2000. Studentized residuals in 2002 were positively related to seasonal water levels in spring and summer (Figure 4) but not related to fall or winter (both $P > 0.11$). Mean spring water levels fluctuated about 1.5 feet among years, whereas mean summer water levels were nearly constant and ranged only about 0.3 ft among years (Figure 4). Additionally, the very low residual in 2000 strongly influenced the significance of the correlations (Figure 4). Nevertheless, water levels in 2000 were substantially lower in spring 2000 relative to other years (Figure 1), and fell below the minimum level that was proposed in the revised operating schedule (PBS&J 1998). Low water level in spring and summer of 2000 may have contributed to a relatively weak 2000 largemouth bass year class.

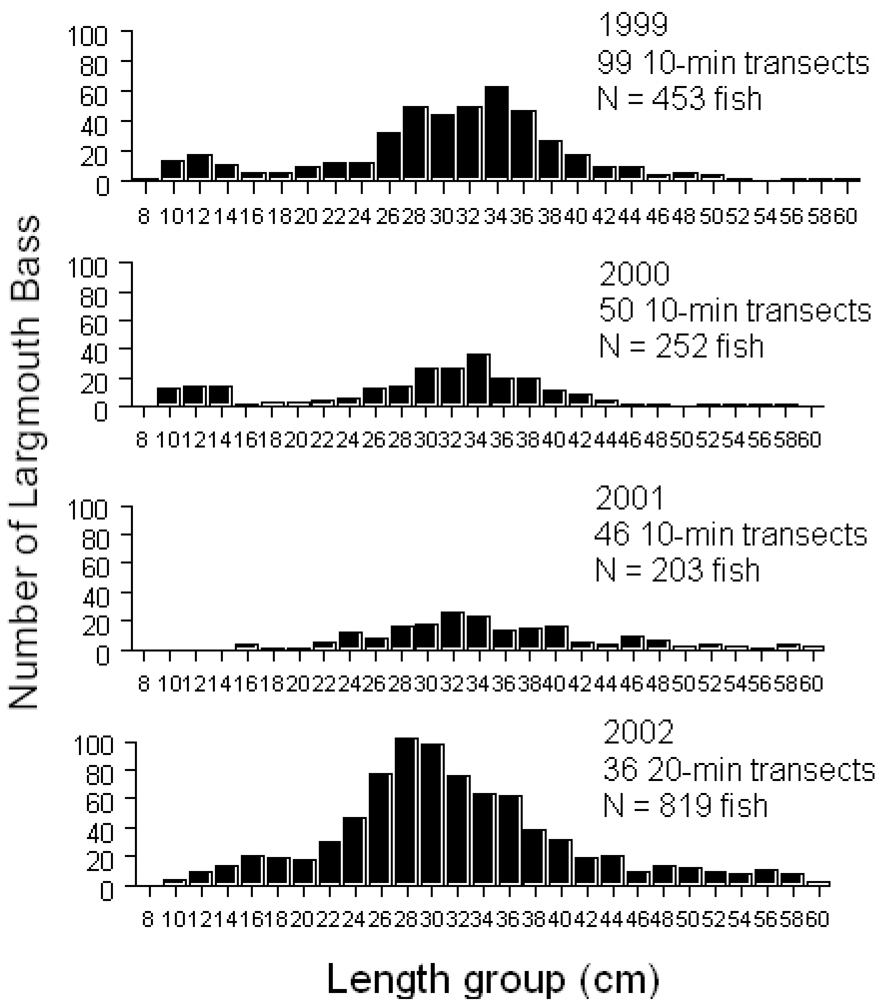

Figure 2. Number of largemouth bass collected for each length group (2-cm) from electrofishing transects at Lake Tarpon, during February and April 1999, and March of 2000 - 2002. Electrofishing transects were 10-min in 1999-2001 and 20-min in 2002.

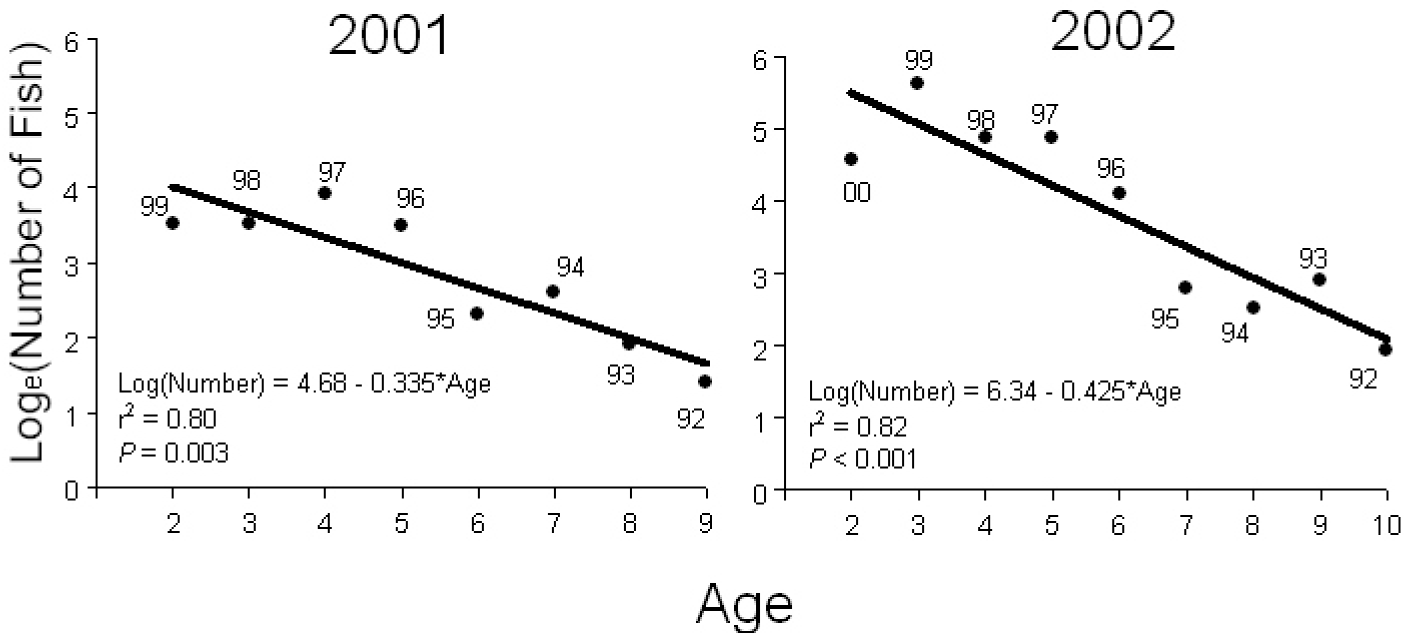

Figure 3. Catch-curve for largemouth bass collected during March 2001 (left panel) and 2002 (right panel). The equations for the regression lines and the r^2 are indicated on each panel. Numbers adjacent to each point represent the year class (i.e., 99 = 1999 year class).

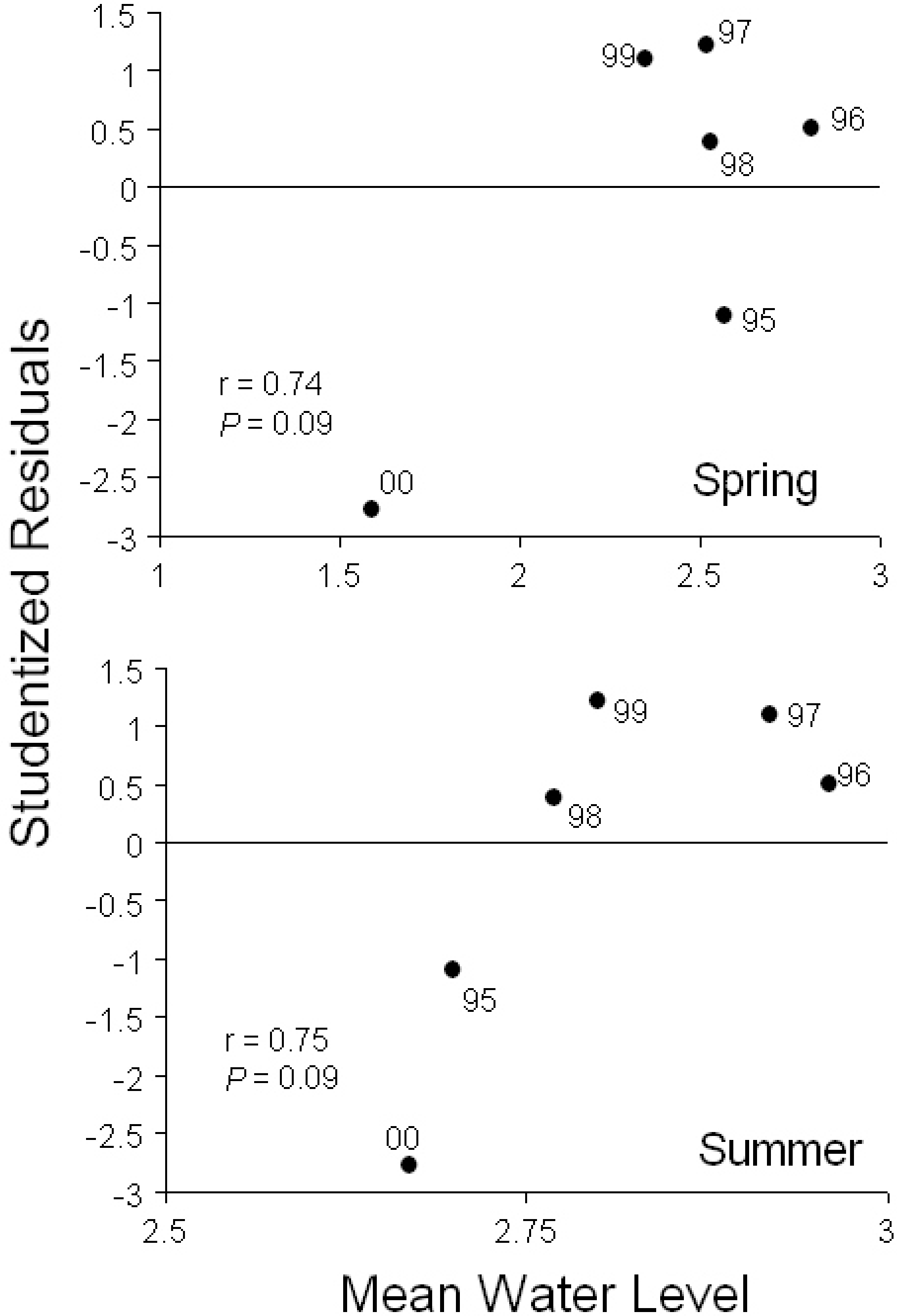

Figure 4. Studentized residuals from the 2002 largemouth bass catch curve plotted against mean water levels during Spring (April, May, June, top panel) and summer (July, August, September, bottom panel). Results of correlation analyses are shown. Numbers adjacent to each point represent the year class (i.e., 99 = 1999 year class).

Black Crappie Sampling

Trawl catches of black crappie collected in late September 1998-2002 are shown in Table 2. Catch rates were highly variable as indicated by coefficients of variation over 100% (Table 2). However, catch rates of age-0 fish in 1998 (mean CPM=0.81) and 2001 (mean CPM = 1.17) were significantly higher than 1999, 2000 and 2002 (mean CPM=0.06, 0.40, and 0.08, respectively)(one-way ANOVA followed by least squares means, all $P = 0.001$). Mean CPM in 1998 and 2001 did not differ significantly (least squares means, $P = 0.11$). Thus, abundance of age-0 black crappie were highest in 1998 and 2001 compared to the other years. Black crappie sample sizes were not adequate for estimates of Relative Stock Density for this species. Black crappie total length ranged from 8 to 34 cm among years (Figure 5). Bluegill *Lepomis macrochirus* and redear sunfish *L. microlophus* dominated trawl catches numerically and by biomass in all years. Other commonly captured species included brown bullhead *Ameiurus nebulosus*, yellow bullhead *A. natalis*, threadfin shad *Dorosoma petenense*, and largemouth bass.

Age-and-growth analysis revealed that black crappie in Lake Tarpon exhibited very rapid growth relative to other Florida lakes. Mean total length-at-age of age-1 fish was 228 mm in 1999 and 256 mm in 2001, whereas the mean TL-at-age 1 from Florida lakes was 125 mm TL (Table 3). This is the highest black crappie mean length at age-1 we have observed in Florida lakes, and fish reach harvestable size of 200 mm TL prior to age-1. Allen et al. (1998b) found density-dependent growth of black crappie in Florida lakes, where lakes with low fish density exhibited rapid growth. Similarly, Lake Tarpon contains low densities of black crappies (based on catch rates in the trawls), but fish grew rapidly and recruited to harvestable size by age-1. Low abundance and very rapid growth rates indicate that the black crappie population at Lake Tarpon could benefit from a minimum length limit (e.g., 254-mm minimum length limit). A 254-mm minimum length limit would protect age-1 fish from harvest and would probably not harm overall yield (i.e., weight of fish harvested by anglers, Allen and Miranda 1995).

Only one black crappie was collected from the spring electrofishing transects in 1999 and 2001. Four black crappie were collected in electrofishing transects in March 2000, and none were collected with electrofishing in 2002. Thus, electrofishing data corroborated the results from trawl samples indicating low black crappie abundance at Lake Tarpon.

Correlation analysis did not reveal any significant relationships between age-0 black crappie catch rates from the 1998-2002 year classes and mean seasonal water levels or the minimum and maximum seasonal water levels (N=5, all $P > 0.6$). Age-0 black crappie abundance at Lake Tarpon remained low relative to other Florida lakes of similar trophic status (Allen 2000), and factors other than water level may be influencing recruitment to adulthood.

Potential mechanisms for low black crappie recruitment include high mortality of larval or juvenile fish, limited prey abundance or predation, or low adult densities resulting in low larval black crappie production. Dockendorf (2002) evaluated mechanisms influencing age-0 black crappie at Lakes Tarpon, Lochloosa, and Wauberg in 2000 and 2001. He found that age-0 black crappie abundance in early summer was positively related to adult abundance the previous fall, suggesting that a stock-recruitment relationship may exist. Lake Tarpon had the lowest adult abundance and lowest age-0 fish abundance in both years compared to the other two lakes (Dockendorf 2002). Thus, low abundance of adult black crappie may be limiting production of age-0 fish, and protecting adult fish with a minimum length limit could potentially increase adult fish abundance and thus, increase recruitment of black crappie at Lake Tarpon. A minimum length limit would protect fish from harvest until they surpass age-1 (Table 3) and could improve adult fish abundance and recruitment of young fish at the lake.

Table 2. Year, size group, mean catch-per-minute (CPM=fish/min), the range (minimum and maximum observations), standard deviation (SD), sample size (N = number of trawls), and coefficient of variation (SD /$\bar{x}$*100%) for black crappie collected with a bottom trawl at Lake Tarpon.

Year	Size Group	Mean CPM	N	SD	Range	CV
1998	Age-0	0.81	35	1.01	0 - 3.67	126
1999	Age-0	0.06	39	0.15	0 - 0.67	254
2000	Age-0	0.40	51	0.79	0 - 4.33	197
2001	Age-0	1.17	50	1.32	0 - 5.33	112
2002	Age-0	0.08	52	0.17	0 - 0.67	220
1998	> 200 mm	0.01	35	0.06	0 - 0.33	592
1999	> 200 mm	0.17	39	0.29	0 - 1.00	173
2000	> 200 mm	0.06	51	0.22	0 - 1.33	339
2001	> 200 mm	0.31	50	0.49	0 - 2.00	157
2002	> 200 mm	0.36	52	0.48	0 - 2.33	135
1998	All	0.82	35	1.02	0 - 3.67	125
1999	All	0.23	39	0.36	0 - 1.33	160
2000	All	0.50	51	0.87	0 - 4.67	176
2001	All	1.49	50	1.48	0 - 6.00	99
2002	All	0.44	52	0.53	0 - 2.67	121

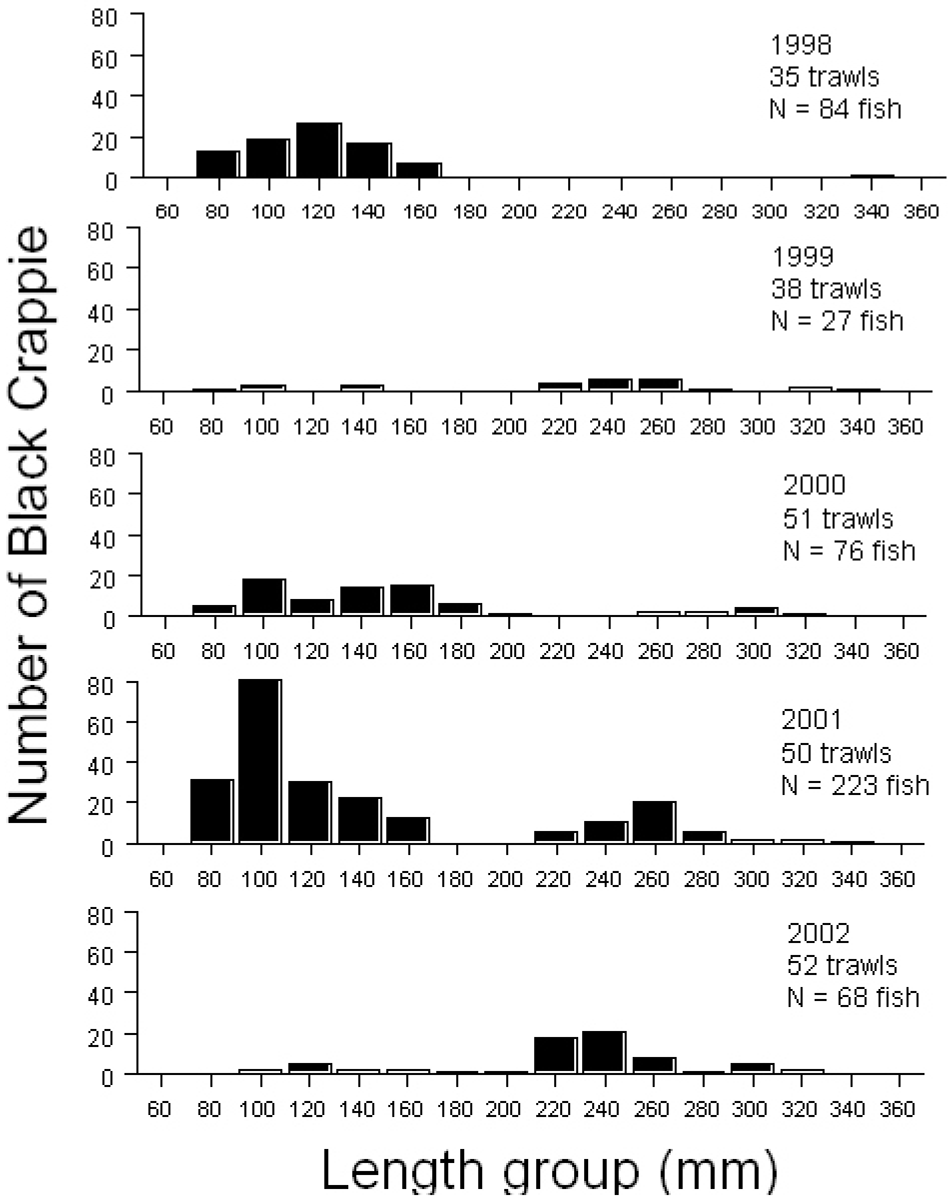

Figure 5. Number of black crappie collected for each length group (20-mm) from trawl sampling at Lake Tarpon during September of 1998 - 2002. The total number of trawls and fish collected for each year are indicated.

Table 3. Age, mean length-at-age (mm, TL), sample size (N), standard deviation (SD), and range for black crappie collected with trawls from Lake Tarpon during 1999 and 2001. Mean length-at-age from a statewide survey of black crappie populations is shown. Blanks indicate missing data.

	1999				**2001**				(Allen et al. 1998b for Florida Lakes)
Age	Mean TL (mm)	N	SD	Range	Mean TL (mm)	N	SD	Range	Mean TL (mm)
0	124	7	22.3	98 - 154	127	48	20.6	93 - 159	
1	228	5	5.35	219 - 232	256	42	16.4	213 - 284	125
2	257	11	12.9	242 - 279	305	3	22.5	286 - 330	203
3	273	1			323	3	13.6	314 - 339	245
4		0				0			
5	338	3	8.90	331 - 348		0			

Habitat Maps

Habitat maps were constructed using similar methods in 1999 and 2001 (Figure 6). The 1999 maps revealed a range of substrate types at Lake Tarpon. Substrate types ranged from mostly firm substrates inshore (sand, sand/mud) to highly flocculent substrates in offshore areas (Figure 7). Highly flocculent substrates (e.g., loam, muck) in inshore areas were found only in small sections at the south end of the lake and the Salmons Bay on the northwest side, but most of the inshore areas contained either sand or sand/mud substrates extending about 100-700 m offshore (Figure 7). Inshore areas of Lake Tarpon were generally either 0-1 or 1-2 m deep and maximum depths in the center of the lake were 4-5 m (Figure 8). Most areas had relatively steep drops from the shoreline to 1 m depths, suggesting that minor water-level fluctuations (i.e., < 1 m) would not substantially change lake surface area or available fish habitat (Figure 8). Differences in the 1999 and 2001 depth maps resulted from changes in water level or differences in specific locations of depth measurements.

The predominant aquatic macrophytes at Lake Tarpon were cattail, coontail, hydrilla, and eel grass. Cattail beds were spaced intermittently along the entire shoreline in both 1999 and 2001 (Figure 9). Coontail was found along shore in most areas of the lake in 1999 and was present at more sample points in 1999 (21%) than in 2001 (11%) (Figure 10). Hydrilla was common in 1999 and found at 17% of the sample points, whereas no hydrilla was found in 2001 (Figure 11) likely due to herbicide treatments in 2000 (D. Hicks, Pinellas County Dept. of Environmental Management, personal communication). Eel grass was also spaced around the lake and occurred at similar coverages between years (i.e., 9% in 1999 versus 6% in 2001) (Figure 12). Aquatic macrophytes were found almost entirely in inshore areas of Lake Tarpon extending < 200 m from shore (Figures 7-12). Other plant species observed included water fern *Salvinia spp*., maidencane *Panicum hemitomon*, spatterdock *Nuphar luteum*, water primrose *Ludwigia spp.*, duckweed *Lemna spp*., giant bulrush *Scirpus californicus*, and water hyacinth *Eichhornia crassipes*. However, these species were much less common than the four listed above. In 2002, lake-wide percent area coverage of aquatic plants (PAC) was 33% and percent of lake volume inhabited by aquatic macrophytes (PVI) was 4%.

Mean CPM of largemouth bass > 254-mm TL in 1999 did not differ among substrate types, shoreline types, or macrophyte types in the multi-factor ANOVA (all $P > 0.2$). Sample month was the only factor that differed in mean CPM, with February having higher catch rates of adult largemouth bass (0.54 fish/min) than April (0.28 fish/min). Higher CPM in February than in April may have resulted from changes in fish distribution (i.e., more fish inshore) and thus vulnerability to the gear between sample periods. No interactions in the multi-factor ANOVA were significant (all $P > 0.05$), suggesting that largemouth bass CPM did not differ between habitat factors and sample periods (February vs. March). Mean CPM did not differ between residential and undeveloped shorelines or firm vs. soft substrates. Plant types failed to yield significant differences in largemouth bass CPM, but most transects around the lake contained a mixture of emergent and submersed macrophytes and thus were similar macrophyte habitats. Variability around mean CPM estimates was high with CV ($SD/\bar{x}*100\%$) values of 60-90%. Thus, statistical power to detect differences in mean CPM was likely low, and we were unable to identify habitats that were important spawning habitats from electrofishing in Spring 1999. Adult largemouth bass were collected throughout the entire lake shoreline and associated habitats, suggesting that spawning habitats were not limited to one area of the lake. Nevertheless, due to the variability of these analyses and low statistical power, they were not repeated for the habitat map in 2001.

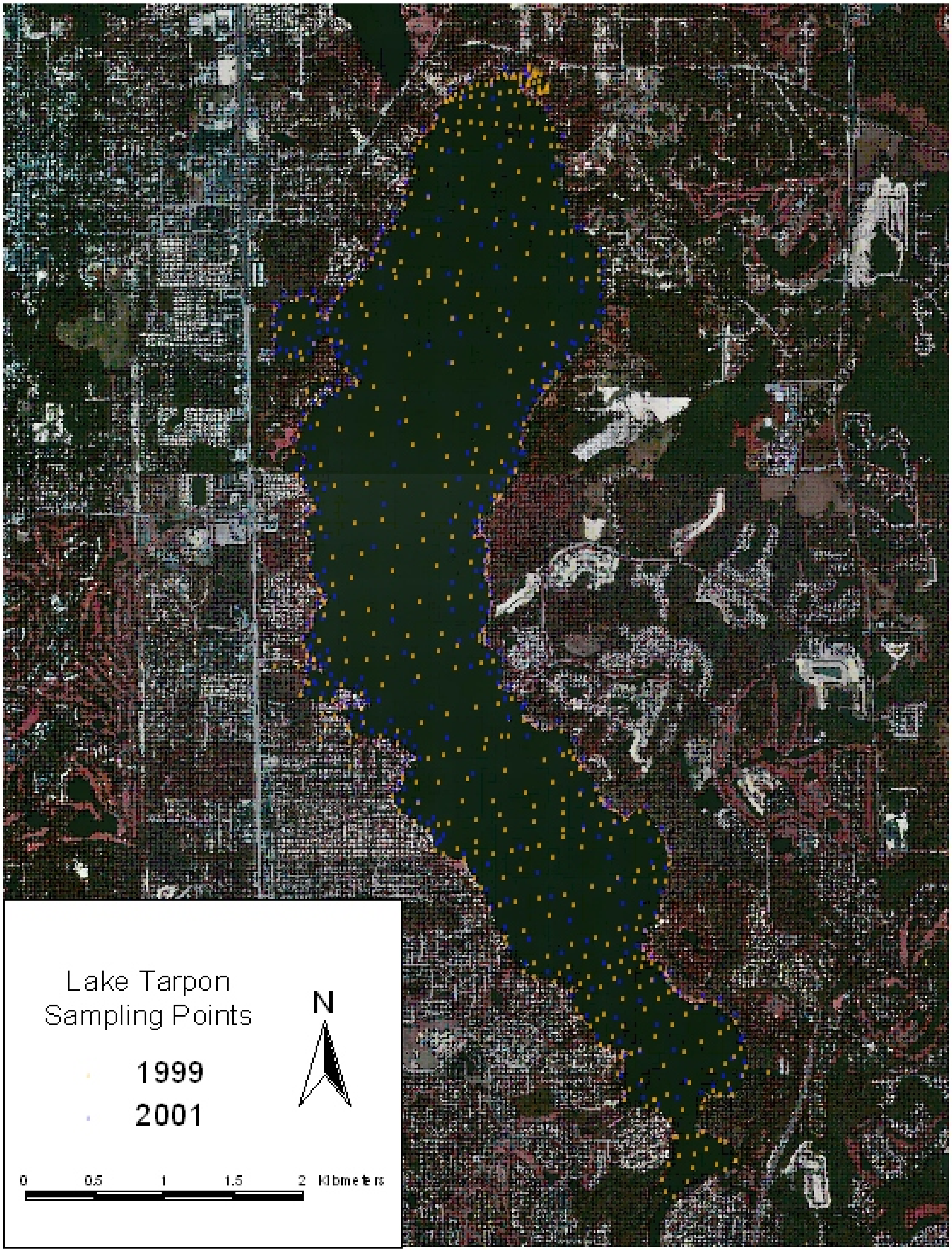

Figure 6. Sample points for habitat data collected in July and August 1999 and August 2001 at Lake Tarpon, Florida.

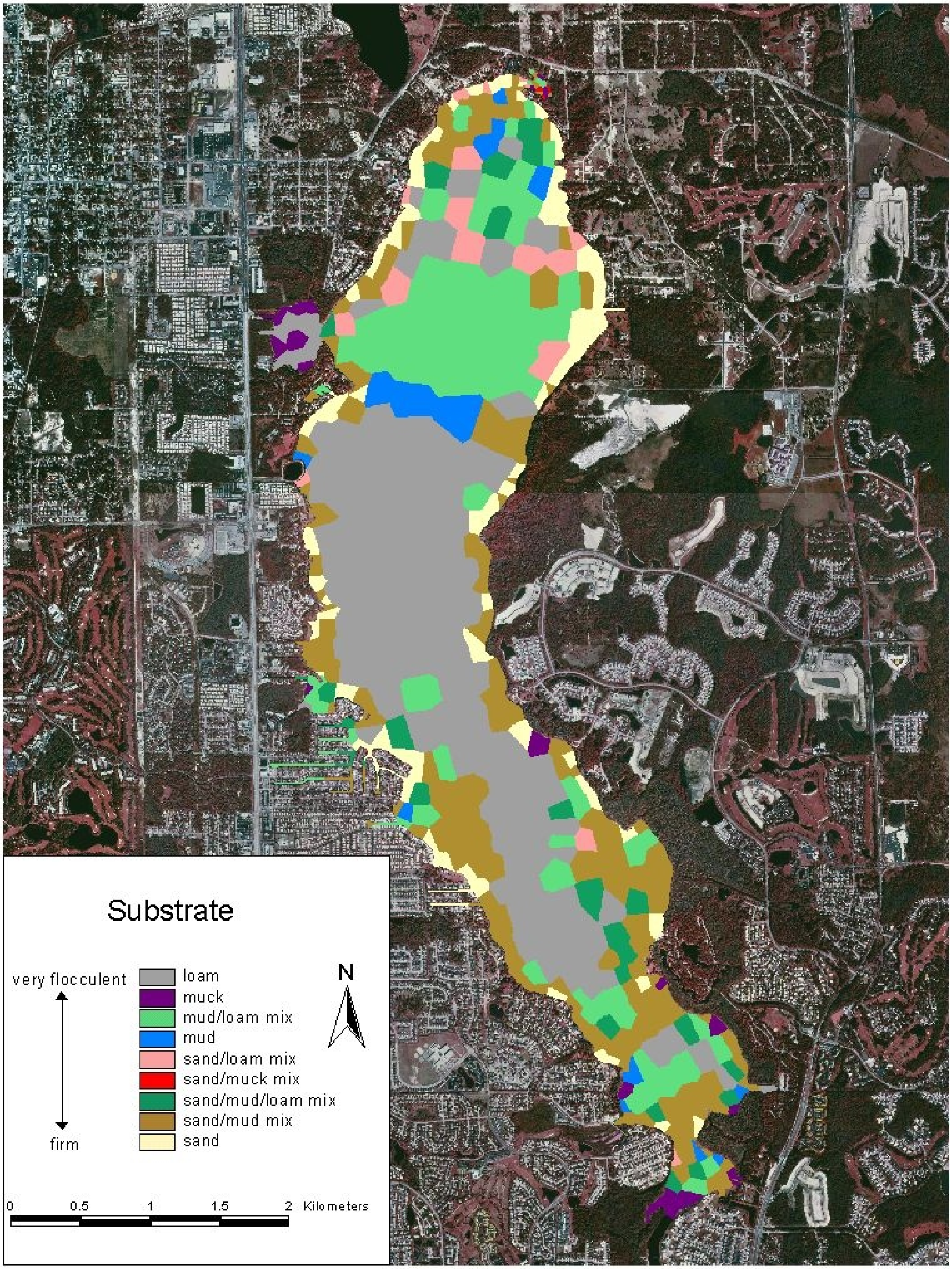

Figure 7. Substrate types at Lake Tarpon based on sample points collected in July and August 1999. ArcView Software was used to approximate changes in substrate types from individual sample points. Legend depicts changes in relative substrate firmness.

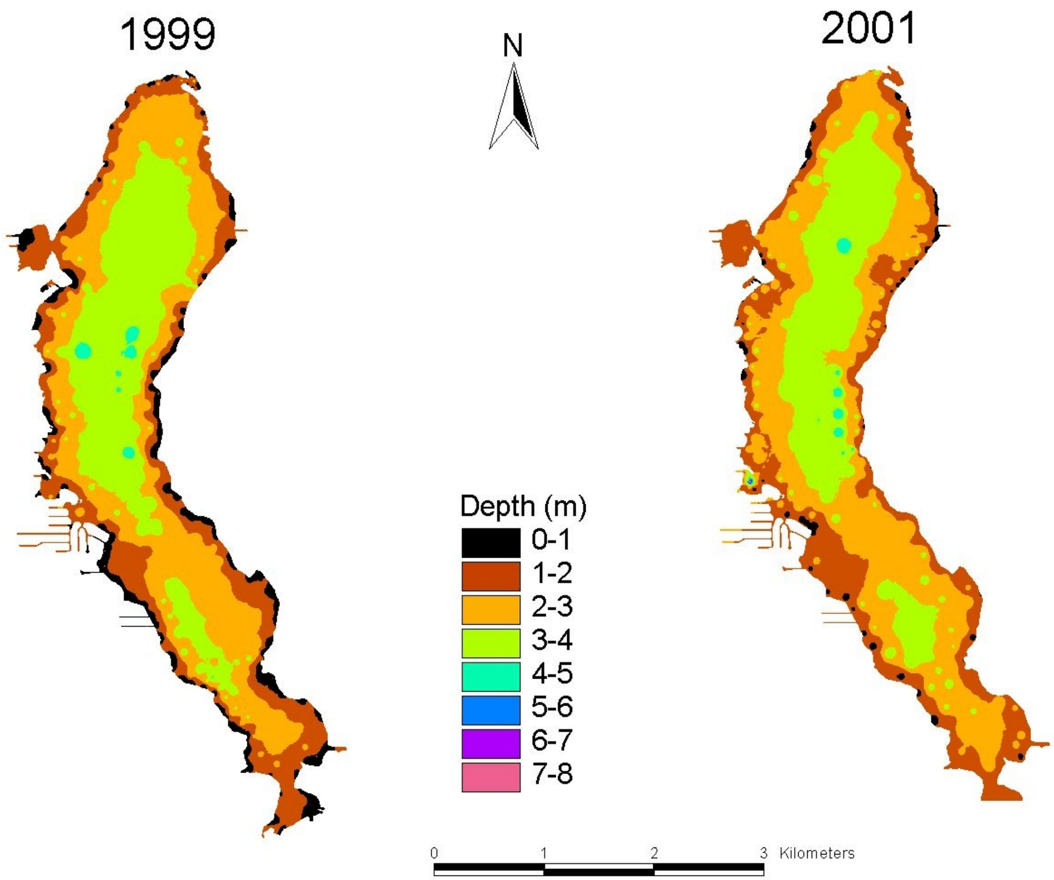

Figure 8. Depth (m) intervals at Lake Tarpon based on sample points collected in July and August 1999 (left map) and August 2001 (right map). ArcView Software was used to approximate continuous changes in depth from individual sample points. Water levels were 0.91 m during sampling in 1999 and 0.82 m in 2001.

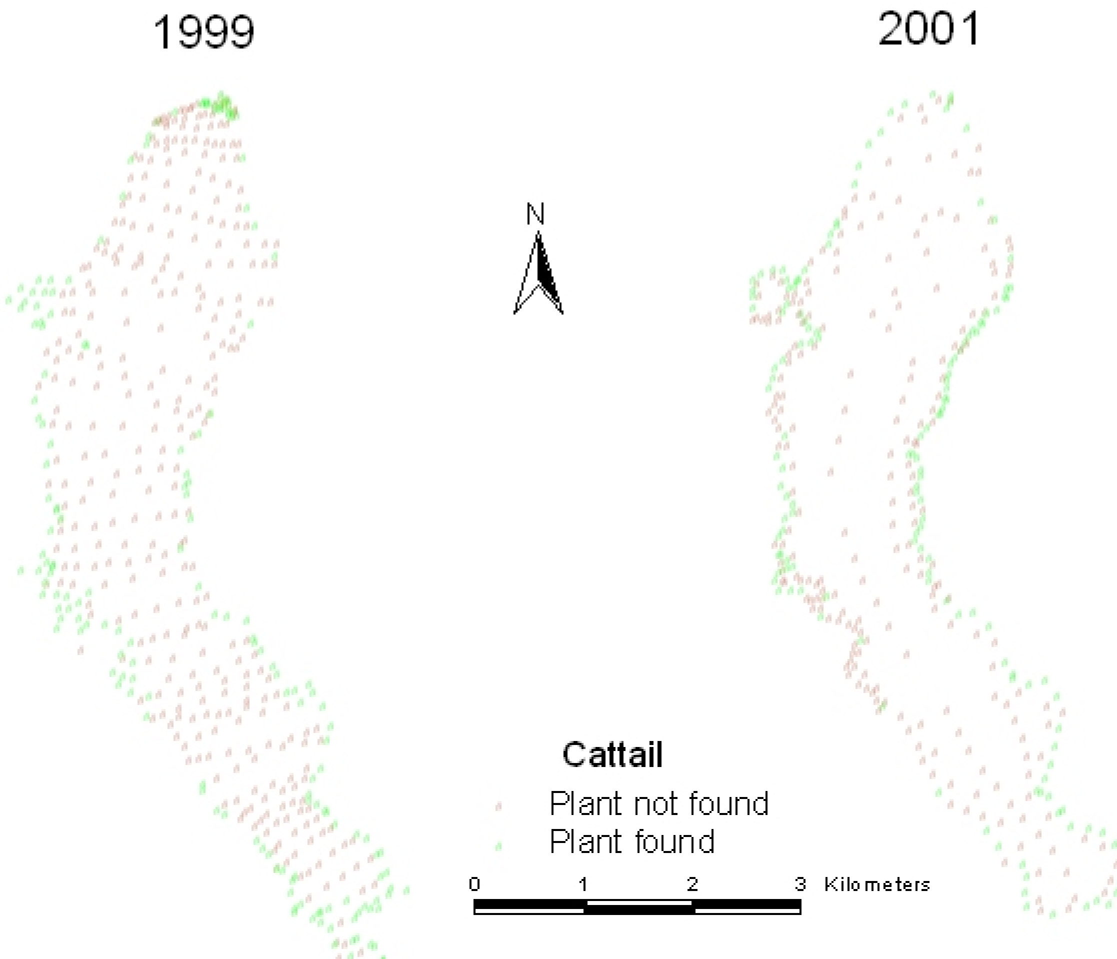

Figure 9. Cattail *Typha spp*. distribution from sample points collected at Lake Tarpon in July and August 1999 (left map) and August 2001 (right map). Points where cattail was collected (green points) and not collected (brown points) are indicated.

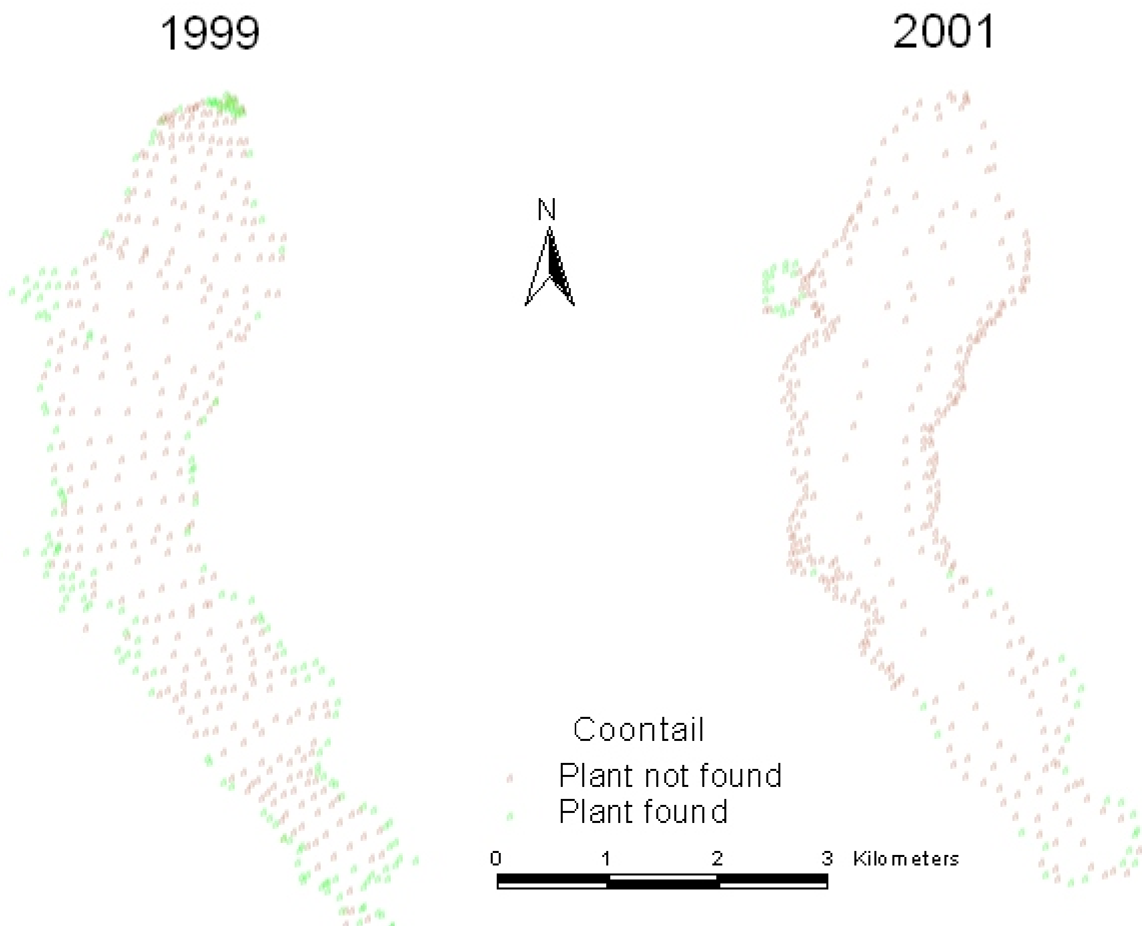

Figure 9. Coontail *Ceratophyllum demersum* distribution from sample points collected at Lake Tarpon in July and August 1999 (left map) and August 2001 (right map). Points where coontail was collected (green points) and not collected (brown points) are indicated.

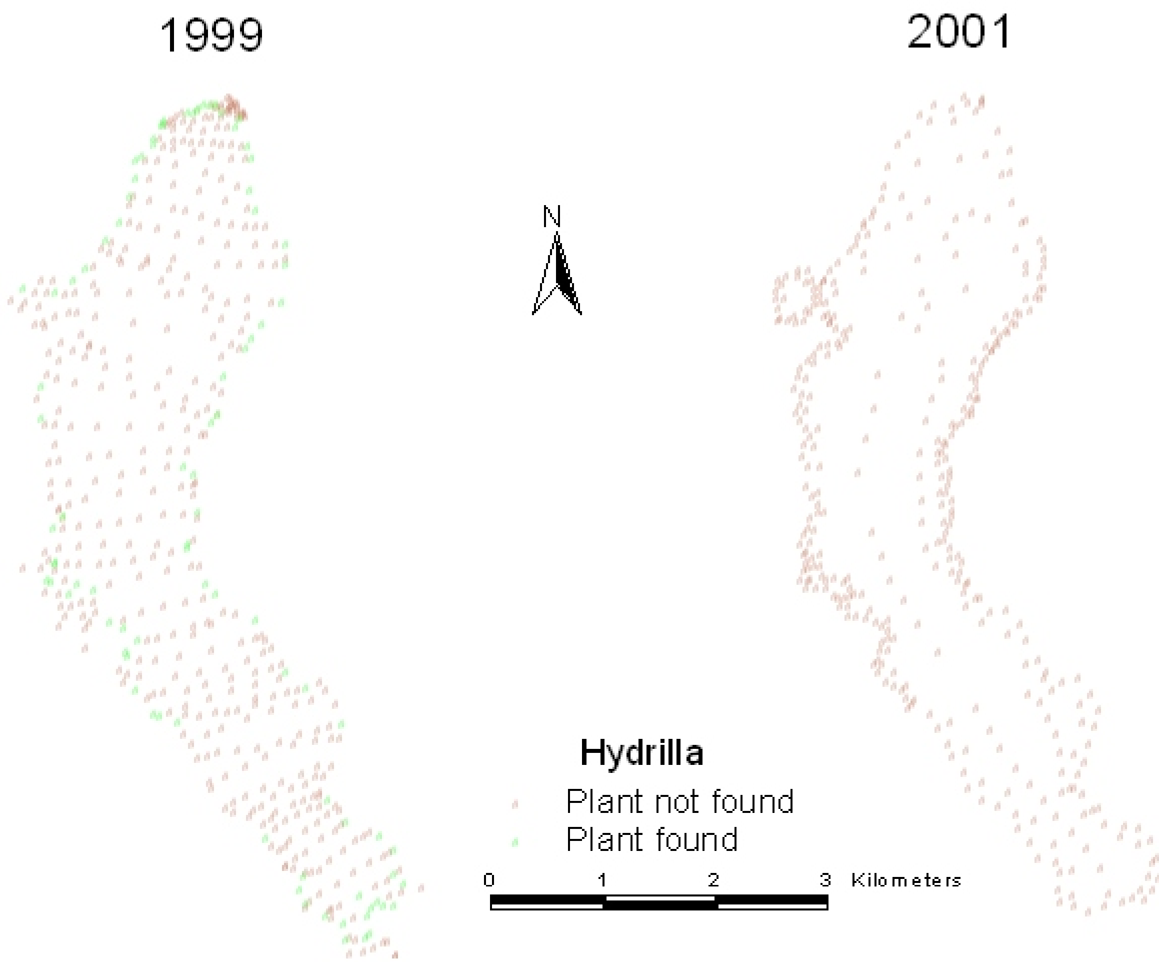

Figure 10. Hydrilla *Hydrilla verticillata* distribution from sample points collected at Lake Tarpon in July and August 1999 (left map) and August 2001 (right map). Points where hydrilla was collected (green points) and not collected (brown points) are indicated.

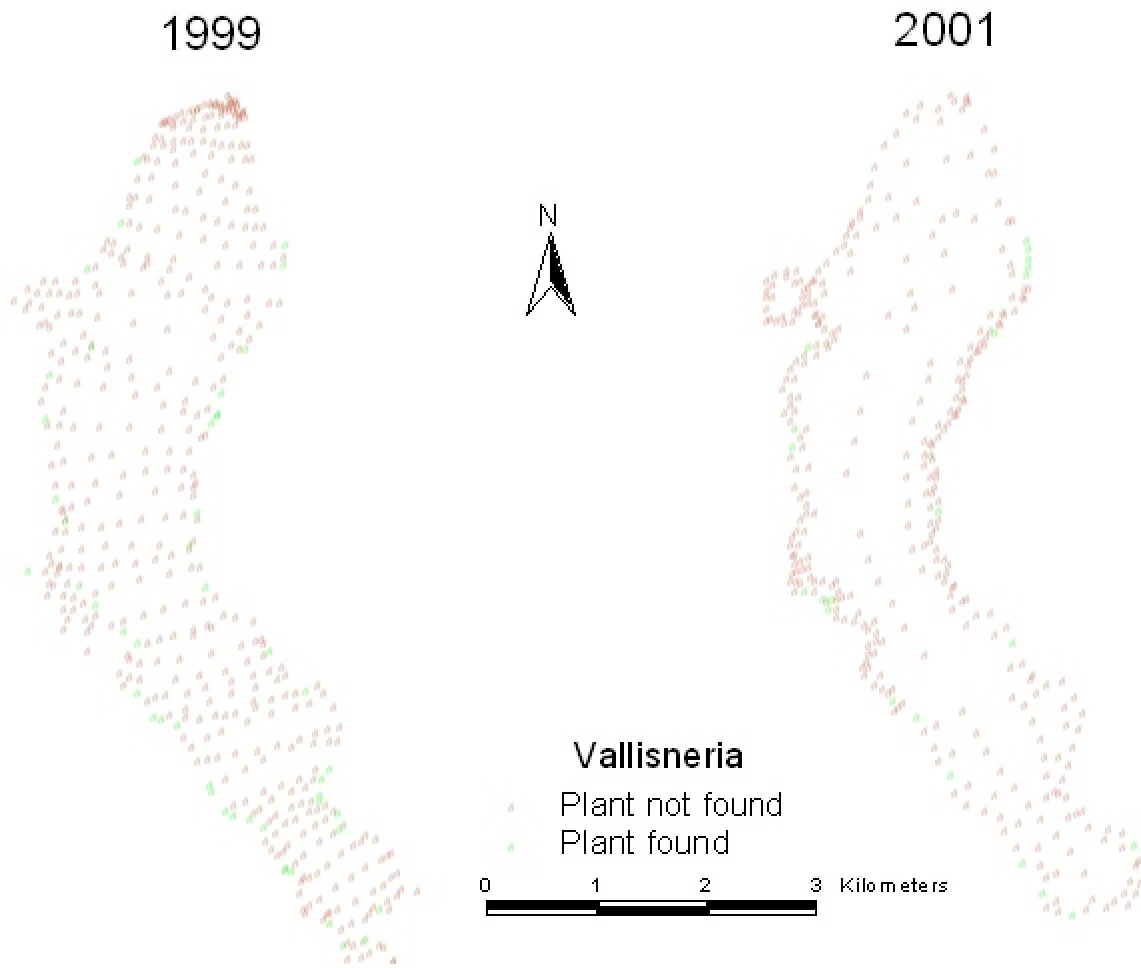

Figure 11. Eel grass *Vallisneria americana* distribution from sample points collected at Lake Tarpon in July and August 1999 (left map) and August 2001 (right map). Points where eel grass was collected (green points) and not collected (brown points) are indicated.

Block Net Sampling

A total of 24 species representing 11 families were collected in block net samples during summer 2000 (Table 4). Bluegill sunfish, redear sunfish, largemouth bass, brook silverside *Labidesthes sicculus*, inland silversides *Menidia berrylina*, seminole killifish *Fundulus seminolis*, and threadfin shad *Dorosoma petenense* were collected at all of the eight sample sites. Seven species (black acara *Cichlasoma bimaculatum*, bluespotted sunfish *Enneacanthus gloriosus*, lake chubsucker *Erimyzon succeta*, spotted sunfish *L. punctatus*, warmouth *L. gulosus*, yellow bullhead *Ameiurus natalis*, and blue tilapia *Oreochromis aureus*) were captured only in littoral zones, whereas the bay anchovy *Anchoa mitchilli* (n=1) was the only fish collected exclusively in the limnetic zone. Champeau et al. (1991) collected 15 species in littoral block nets during 1987 and 1990, and 25 species were collected in 1995 (Champeau 1996). The species collected in this study were almost identical to the 1995 samples, except that we collected clown goby, bay anchovy, and inland silverside which were not collected in 1995. Champeau (1996) collected hogchoker *Trinectes maculatus*, bowfin, florida gar, and *Gambusia* spp., which were not collected in our study. Differences in the number of species caught may have resulted from limnetic sets in our study, differences in sample area, or differences in fish identification.

We found total mean fish biomass of about 441 kg/ha (Table 5), and total mean fish density of about 22,000 fish/ha (Table 6). The littoral zone of the lake had a mean biomass of 658 kg/ha (Table 5) and density of 40,400 fish/ha (Table 6), whereas the limnetic zone had mean biomass and density of 282 kg/ha and 15,600 fish/ha, respectively. The littoral zone had significantly higher density (Wilcoxon Z= -5.41, N=104, p<0.001) and biomass (Wilcoxon Z= -4.85, N=104, p<0.001) than the limnetic zone. Of all species collected, the threadfin shad was the most dense (mean density = 6,705 fish/ha), and bluegill accounted for the largest portion of overall biomass (mean biomass = 184 kg/ha). Mean density and biomass for all fishes captured are shown in Tables 5 and 6, respectively.

Total fish biomass appeared to increase from 1987-2000, but was similar between 1995 and 2000. Total fish biomass averaged 133 and 90 kg/ha in littoral areas during 1987 and 1990, respectively (Champeau et al. 1991). In 1995, total fish biomass averaged 595 kg/ha in littoral areas (Champeau 1996). In this study, total fish biomass in littoral areas averaged 658 kg/ha. Thus, fish biomass appeared similar between 1995 and 2000 samples with both near 600 kg/ha.

Bluegill, redear, and largemouth bass made up about 85% of the total fish biomass in our study, with bluegill being about 50% of the total biomass. Similarly, Champeau et al. (1991) found that these three species comprised about 80% of the total fish biomass in littoral areas of Lake Tarpon, with bluegill encompassing 31 and 48% of the total fish biomass in 1987 and 1990, respectively. In 1995, bluegill, redear, and largemouth bass made up 74% of the total biomass with bluegill encompassing 43% (Champeau 1996). Thus, native sport fishes such as bluegill and redear continued to dominate the total fish biomass at Lake Tarpon, and introduced fishes (i.e., blue tilapia, black acara) made up less than 1% of the total fish biomass in our study and in 1995 (Champeau 1996). Black crappie mean biomass was below 1 kg/ha in 1987 and 1990 (Champeau et al. 1991), but was 19 kg/ha in 1995 (Champeau 1996). In this study, black crappie biomass was less than 1 kg/ha. Thus, historical data and this study suggest that black crappie biomass at the lake is relatively low but may be variable (e.g., 1995).

Biomass of sport fishes generally increased at Lake Tarpon from 1987 to 2000. Mean total biomass of largemouth bass in 2000 was similar to 1995 but higher than in 1987 and 1990 (Figure 13). Total bluegill biomass, however, was similar to 1995 estimates and higher than 1987 and 1990 (Figure 13). Bluegill and redear biomass both appeared to increase from 1987 to 2000 (Figure 13).

Our results may have underestimated the density and biomass of harvestable sportfish due to the size of our block nets. We used 0.104-ha block nets, whereas earlier studies used 0.4-ha nets (Champeau et al. 1991; Champeau 1996). Large fish are more likely to evade capture in smaller nets than small fish, potentially reducing our density and biomass estimates. Thus, our biomass and density estimates may be biased downward compared to historical data.

The F/C ratio showed decreases in carnivore biomass in proportion to forage biomass from 1987 to 2000. Estimates of F/C increased from 0.88 in 1987 to 5.45 in 2000 (Figure 14), which indicated that F/C ratios have increased to about 1 to nearly 6 from 1987 to 2000. Desirable fish community balance is an F/C between 3 and 6 (Murphy and Willis 1996, Figure 14). Increased fish community F/C ratio is probably a result of increased nutrients at Lake Tarpon since 1988 (SWFWMD 2001). Ney (1996) reviewed trophic state effects on fish community structure and found that sport fish biomass accounts for a smaller part of total fish biomass as nutrient levels increase in lakes and reservoirs. Lake Tarpon exhibited a similar trend, with increasing nutrient levels from 1988-2000 (SWFWMD 2001) and concurrent increasing F/C ratios over the same time period (Figure 14). Given the increasing F/C trend from 1987 to 2000, the F/C ratio at Lake Tarpon could increase to undesirable levels in the future. We believe that monitoring of F/C ratios at Lake Tarpon should be conducted again between 2005 and 2007 to further assess changes in fish community composition through time.

Nevertheless, block net samples in 2000 suggested that Lake Tarpon contains a desirable fish population dominated by native fishes and high total fish biomass. Although total fish biomass has increased over the last 13 years, the population in 2000 was still desirable and had an F/C ration below 6. We believe the fish population was of exceptional quality for recreational fishing during 2000 and represented the characteristics of a fertile but well-balanced Florida lake. Nevertheless, future increases in nutrients could cause the F/C ratio to climb further and potentially reduce the quality of the sport fishery.

Table 4. The fishes collected following rotenone application to block nets in littoral and limnetic zones of Lake Tarpon, FL during 2000.

Family Species	Common Name
Atherinidae	
Labidesthes sicculus	Brook silverside
Menidia beryllina	Inland silverside
Catostomidae	
Erimyzon sucetta	Lake chubsucker
Centrarchidae	
Enneacanthus gloriosus	Bluespotted sunfish
Lepomis gulosus	Warmouth
Lepomis macrochirus	Bluegill sunfish
Lepomis microlophus	Redear sunfish
Lepomis punctatus	Spotted sunfish
Micropterus salmoides	Largemouth bass
Pomoxis nigromaculatus	Black crappie
UID *Lepomis*	
Cichlidae	
Cichlasoma bimaculatum	Black acara
Oreochromis aureus	Blue tilapia
Clupeidae	
Dorosoma cepedianum	Gizzard shad
Dorosoma petenense	Threadfin shad
Cyprinidae	
Notemigonus crysoleucas	Golden shiner
Notropis maculatus	Taillight shiner
Engraulidae	
Anchoa mitchilli	Bay Anchovy
Fundulidae	
Fundulus seminolus	Seminole killifish
Lucania goodei	Bluefin killifish
Gobiidae	
Microgobius gulosus	Clown goby
UID Goby	
Ictaluridae	
Ameiurus nebulosus	Brown bullhead
Ameiurus natalis	Yellow bullhead
Noturus gyrinus	Tadpole madtom
Percidae	
Etheostoma fusiforme	Swamp darter

Table 5. Mean biomass (kg/ha), standard deviation (SD), coefficient of variation (CV=100*SD/mean), and range for each of 23 fish species collected from Lake Tarpon, FL during 2000. Largemouth bass were subdivided into adult and age-0 fish. Largemouth bass, black crappie, redear sunfish and bluegill sunfish were grouped as sportfish. Mean total biomass for littoral and limnetic sets as well as mean total biomass is also provided. N= the number of nets used in the analysis.

SPECIES	Mean Biomass	N	SD	CV	MIN	MAX
Bay anchoy	0.01	8	0.01	282	0.00	0.04
Blue tilapia	4.73	8	9.58	202	0.00	26.29
Bluegill	184.0	8	210.27	114	21.74	674.23
Black acara	0.09	8	0.19	208	0.00	0.56
Black crappie	0.56	8	1.54	277	0.00	4.36
Bluefin killifish	1.09	8	2.32	212	0.00	6.64
Brown bullhead	11.3	8	16.64	146	0.00	43.30
Brook silverside	0.17	8	0.12	69	0.01	0.42
Bluespotted sunfish	0.13	8	0.18	139	0.00	0.50
Clown goby	0.19	8	0.21	112	0.00	0.47
Gizzard shad	3.58	8	7.72	216	0.00	21.74
Golden shiner	10.7	8	13.83	128	0.00	38.27
Inland silverside	1.54	8	2.23	145	0.07	6.66
Lake chubsucker	0.08	8	0.18	231	0.00	0.51
Largemouth bass	62.1	8	54.87	88	2.81	158.42
Adult	53.1	8	48.20	90	2.32	141.36
Age-0	8.98	8	9.22	102	0.40	24.29
Redear sunfish	125.5	8	108.67	86	14.81	322.53
Seminole killifish	1.51	8	1.71	113	0.01	3.96
Spotted sunfish	0.08	8	0.18	215	0.00	0.49
Swamp darter	0.01	8	0.02	164	0.00	0.06

Table 5 (cont'd)

SPECIES	Mean Biomass	N	SD	CV	MIN	MAX
Taillight shiner	0.06	8	0.10	179	0.00	0.30
Tadpole madtom	1.2	8	2.31	191	0.00	6.77
Threadfin shad	18.9	8	22.34	118	1.52	68.74
UIDGoby	0.15	8	0.20	133	0.00	0.46
UIDLepomis	0.59	8	1.25	209	0.00	3.56
Warmouth	12.1	8	19.76	162	0.00	48.62
Yellow bullhead	0.27	8	0.42	155	0.00	1.03
Sportfish	310.1	8	286.41	92	134.4	996.8
Limnetic	282.3	4	183.09	65	142.5	542.1
Littoral	657.8	4	302.63	46	409.8	1098.2
Total	440.7	8	309.77	70	142.6	1098.2

Table 6. Mean density (number of fish/ha), standard deviation (SD), coefficient of variation (CV=100*SD/mean), and range for each of 23 fish species collected from Lake Tarpon, FL during 2000. Largemouth bass were subdivided into adult and age-0 fish. Largemouth bass, black crappie, redear sunfish and bluegill sunfish were grouped as sportfish. Mean total biomass for littoral and limnetic sets as well as mean total biomass is also provided. N = the number of nets used in the analyses.

SPECIES	Mean Density	N	SD	CV	MIN	MAX
Bay anchoy	1.2	8	3.4	282	0.0	9.9
Blue tilapia	55.6	8	123.6	222	0.0	355.7
Bluegill sunfish	2563.0	8	2181.0	85	256.9	5960.0
Black acara	16.1	8	33.8	210	0.0	98.8
Black crappie	2.5	8	4.6	185	0.0	9.9
Bluefin killifish	1923.0	8	4080.0	212	0.0	11700.0
Brown bullhead	716.0	8	1010.0	141	0.0	2656.0
Brook silverside	227.3	8	198.5	87	9.9	592.9
Bluespotted sunfish	65.5	8	82.2	125	0.0	207.5
Clown goby	261.9	8	307.3	117	0.0	790.5
Gizzard shad	4.9	8	10.6	213	0.0	29.6
Golden shiner	950.5	8	1020.0	107	0.0	2163.0
Inland silverside	2728.0	8	4144.0	151	118.6	12060.0
Lake chubsucker	7.4	8	14.7	198	0.0	39.5
Largemouth bass	1209.0	8	1469.0	121	79.1	4394.0
Adult	222.3	8	174.0	78	9.9	484.2
Age-0	986.3	8	1360.0	137	69.2	4058.0
Redear sunfish	2036.0	8	1799.0	88	494.1	5574.0
Seminole killifish	447.5	8	389.6	87	9.9	998.0
Spotted sunfish	3.7	8	7.4	198	0.0	19.8
Swamp darter	19.8	8	31.3	158	0.0	79.1

Table 6 (cont'd)

SPECIES	Mean Density	N	SD	CV	MIN	MAX
Taillight shiner	63.0	8	93.3	148	0.0	217.4
Tadpole madtom	1007.7	8	1769.4	175	0.0	5138.9
Threadfin shad	6704.9	8	7619.3	113	691.7	19409.8
UIDGoby	169.2	8	215.4	127	0.0	592.9
UIDLepomis	549.5	8	1237.2	225	0.0	3577.6
Warmouth	281.7	8	449.9	159	0.0	1072.6
Yellow bullhead	35.8	8	60.0	167	0.0	168.0
Sportfish	5810.4	8	3689.6	63	2092.9	10981.0
Limnetic	15578.4	4	13490.0	87	3168.4	27353.0
Littoral	40378.3	4	17623.0	44	23220.0	55577.0
Total	22050.0	8	17649.2	80	3168.4	55577.0

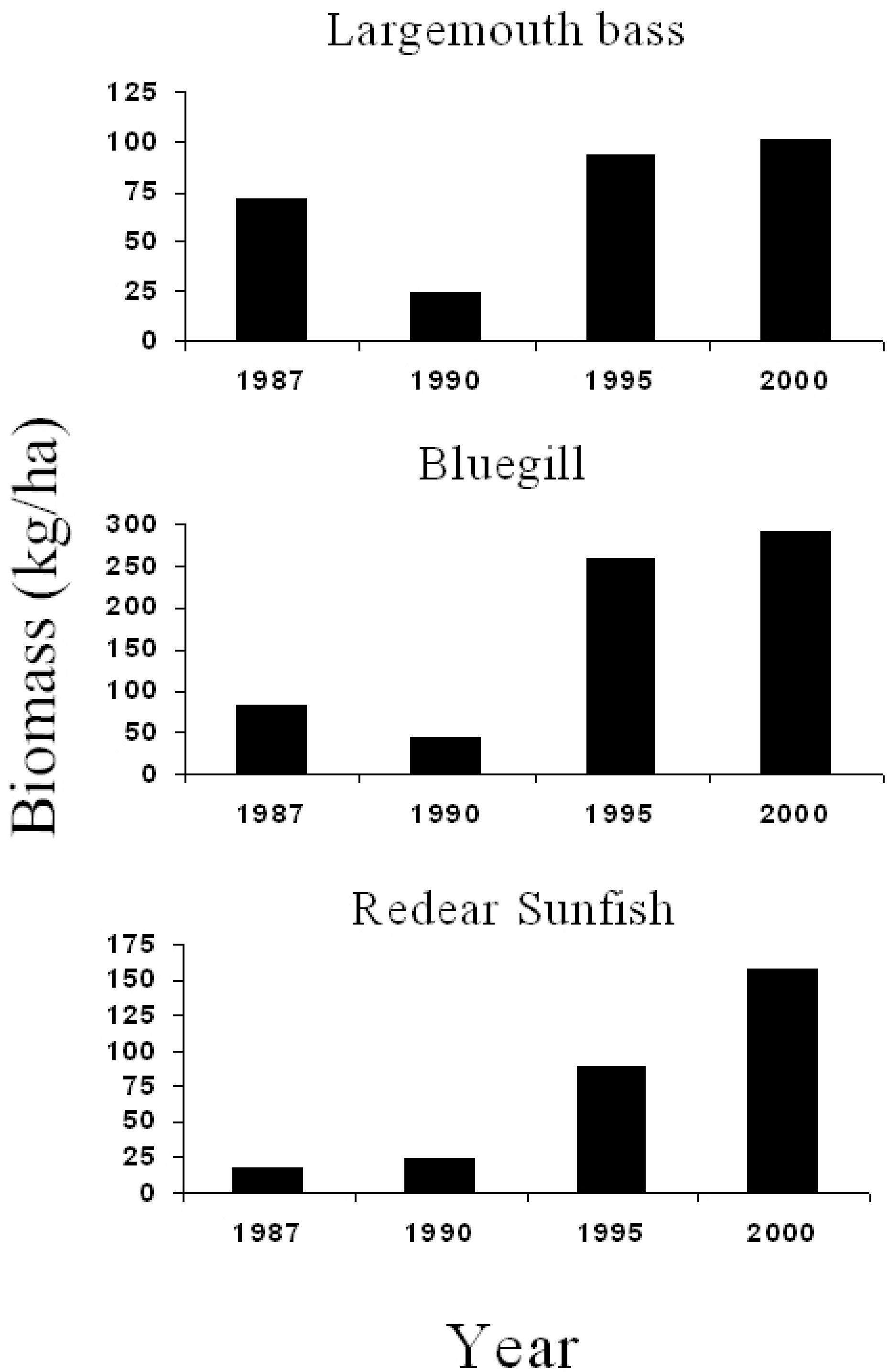

Figure 13. Mean total biomass estimates for three sport fish collected with block nets at Lake Tarpon, Florida. Data prior to 2000 are from Champeau et al. (1991) and Champeau (1996).

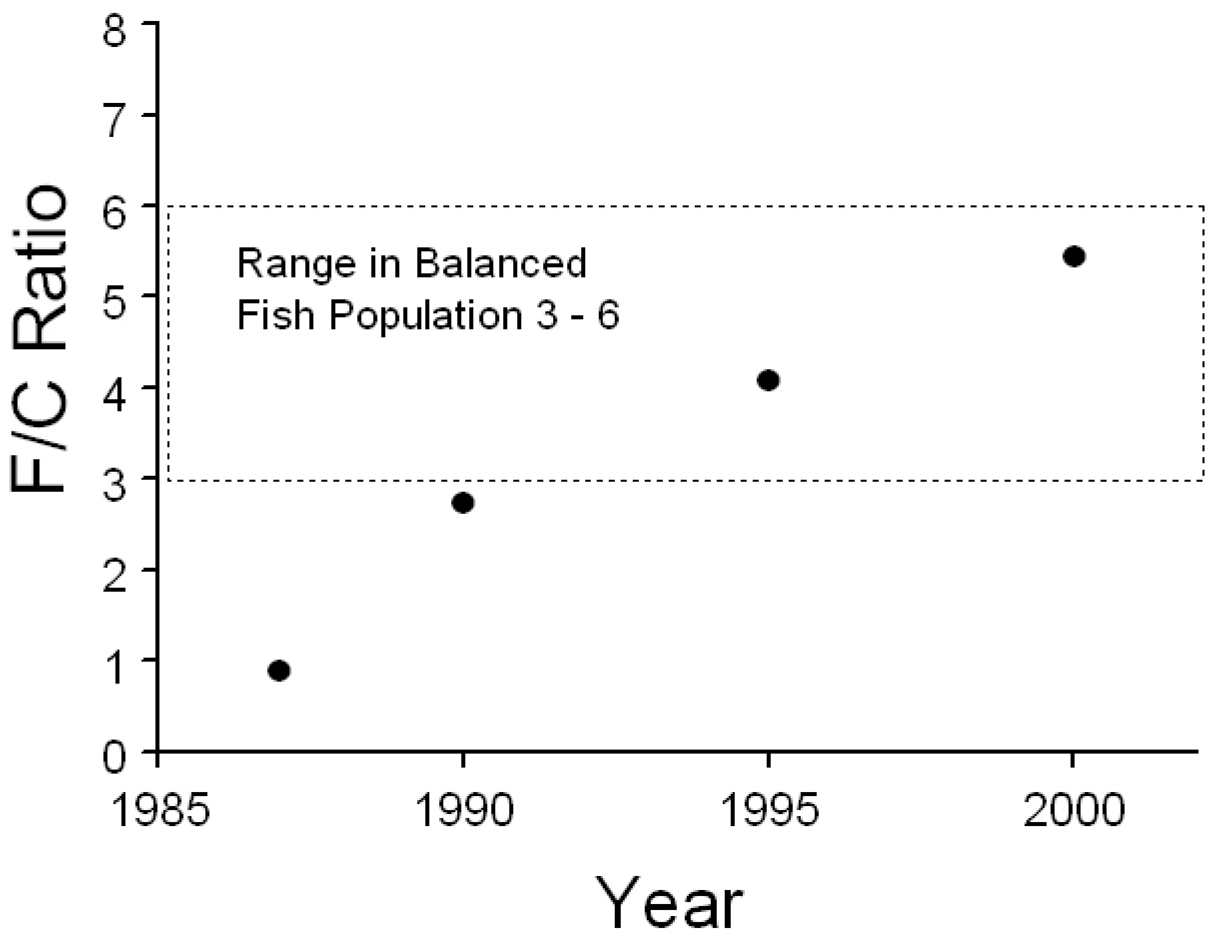

Figure 14. Ratio of forage fish biomass to carnivore biomass based on rotenone surveys at Lake Tarpon from 1987 to 2000. Data prior to 2000 were collected by Champeau et al. (1991) and Champeau (1996). Data result from littoral block nets in all years. Species classified as carnivores were largemouth bass, black crappie, Florida gar, and bowfin. All other fishes were classified as forage species. The range in F/C that corresponds to a balanced fish population (Swingle 1950) is shown.

Conclusions

Largemouth bass recruitment appeared relatively stable, with abundant fish of all size classes in both 1999 - 2002. Residuals from the 2002 catch curve indicated that the 2000 largemouth bass year class was weak, and year class strength indexed with residuals indicated a positive trend between spring and summer water levels and largemouth bass recruitment. Seasonal trends in water levels were generally similar among years except for 2000, which had low water during summer and was related to a weak 2000 largemouth bass year class. Thus, low water during spring and summer may have caused a relatively weak 2000 largemouth bass year class at Lake Tarpon. The Relative Stock Density for largemouth bass was within target ranges of 20-40% in all years.

Lake Tarpon contained a low-density black crappie population compared to other Florida lakes of similar trophic status, but fish exhibited very rapid growth. Low abundance of adult black crappie at Lake Tarpon is likely the result of poor recruitment for three or more years. Low adult black crappie abundance may be limiting juvenile black crappie production. Mean CPM of age-0 black crappie was not related to mean seasonal water levels in Lake Tarpon, but water levels were similar in all years except 2000.

Habitat maps revealed that most inshore areas of Lake Tarpon had a relatively steep slope and contained firm substrates extending offshore from 100-700 m. A relatively diverse inshore macrophyte community existed with a mix of emergent and submersed plants around most of the lake shoreline in both 1999 and 2001, but coverage of plants was lower in 2001 than 1999 likely due to herbicide treatments. Most habitats appeared suitable for spawning (i.e., firm substrates, diverse aquatic plant communities), and adult largemouth bass were collected at similar catch rates from habitats throughout the lake. Habitat maps indicated that minor water level fluctuations (i.e., < 1 m) would not substantially change lake surface area or available habitat for fish. Lake Tarpon water levels are relatively stable compared to many central Florida lakes, and the minor water-level fluctuations (e.g., < 1 m) may not strongly influence sport fish recruitment.

Block net samples suggested that although fish biomass has increased in the last 15 years, the fish community is dominated by native fishes. Sport fishes made up about 85% of total fish biomass in 2000. Except for black crappie, the sport-fish populations at Lake Tarpon are of exceptional quality for recreational fishing and represent the characteristics of a fertile but well-balanced Florida lake. Nevertheless, future increases in nutrients could cause forage to carnivore ratios (F/C) to climb, potentially reducing the quality of the sport fishery.

Management Recommendations

Based on the results of this study, we suggest that resource managers should consider these recommendations.

1. We found evidence that low water level during spring and summer of 2000 were related to a weak largemouth bass year class. Spring or summer water levels below 1.25 ft MSL, the proposed minimum in the revised operating schedule, may cause relatively weak largemouth bass year classes at Lake Tarpon. We note that we only had one year of low water in this study so this result was not replicated. If a regulation schedule includes mean spring and summer water levels at or below 1.25 ft MSL, largemouth bass population responses should be monitored.
2. We suggest that the Florida Fish and Wildlife Conservation Commission consider implementing a 254-mm TL minimum length limit for black crappie at Lake Tarpon. Black crappie exhibited very rapid growth but low recruitment. A minimum length limit could protect fish from harvest until they surpass age-1 and could improve adult fish abundance and recruitment of young fish at the lake. Given the rapid black crappie growth, a 254-mm length limit is unlikely to harm overall yield (i.e., weight of fish harvested by anglers).

3. We found evidence that the F/C ratios were increasing for the fish community at Lake Tarpon and could surpass the 3-6 target range within the next two to four years based on trends from 1987-2000. The increasing F/C ratio is likely due to increases in lake nutrient concentrations, and continued increases could reflect a declining sport fishery. We recommend continued monitoring of the fish community at Lake Tarpon and reassessment of the F/C ratio within two to four years (i.e., during 2005-2007).

Acknowledgments

B. Roth helped produce the ArcView habitat maps. T. Bonvechio, P. Cooney, C. Hanson, D. Hicks, K. Henry, W. Pine, and P. Wheeler provided help with field collections and data processing. D. Hicks and L. Garcia provided helpful comments on a previous draft of this report. Florida LAKEWATCH personnel including C. Horsborough conducted estimates of lake-wide plant coverage for this study. T. Champeau and J. Gilroy provided helpful historical fish and water level data for Lake Tarpon. L. Garcia provided water level data from the Southwest Florida Water Management District.

References

Allen, M. S. 2000. Abundance of black crappie at Lake Tarpon compared with other Florida Lakes: supplement to annual report 1999. Submitted to Pinellas County Department of Environmental Management.

Allen, M. S., and L. E. Miranda. 1995. An evaluation of the value of harvest restrictions in managing crappie fisheries. North American Journal of Fisheries Management 15:766-772.

Allen, M. S., M. M. Hale, and W. E. Pine III. 1998a. Comparison of trap nets and otter trawls for sampling black crappie in two Florida lakes. North American Journal of Fisheries Management 19:977-983.

Allen, M. S., M. V. Hoyer, and D. E. Canfield, Jr. 1998b. Factors related to black crappie occurrence, density and growth in Florida lakes. North American Journal of Fisheries Management 18:864-871.

Allen, M. S., W. Sheaffer, W. F. Porak, and S. Crawford. 2002. Growth and mortality of largemouth bass in Florida waters: implications for use of length limits. International Black Bass Symposium 2000, American Fisheries Society, Bethesda, Maryland.

Aggus, L. R., and G. V. Elliot. 1975. Effects of cover and food on year-class strength of largemouth bass. Pages 317-322 in R. H. Stroud and H. Clepper, editors. Black bass biology and management. Sport Fishing Institute, Washington, D. C.

Bayley, P. B., and D. J. Austen. 2002. Capture efficiency of a boat electrofisher. Transactions of the American Fisheries Society 131:435-451.

Beam, J. H. 1983. The effect of annual water level management on population trends of white crappie in Elk City Reservoir, Kansas. North American Journal of Fisheries Management 3:34-40.

Bettoli, P. W., and M. J. Maceina. 1996. Sampling with toxicants. Pages 303-333 in B. R. Murphy and D. W. Willis, editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Carlander, K. D. 1977. Handbook of freshwater fish biology, Volume 2. Iowa State University Press, Ames.

Champeau, T. R., K. W. Denson, P. W. Thomas, and M. J. Mounce. 1991. Lake Tarpon Fisheries Investigations. Completion Report. Florida Game and Fresh Water Fish Commission. Tallahassee.

Champeau, T.R. 1996. Lake Tarpon fisheries investigations. Florida Game and Fresh Water Fish Commission. Lakeland, FL.

Crawford, S., W. S. Coleman, and W. F. Porak. 1989. Time of annulus formation in otoliths of Florida largemouth bass. North American Journal of Fisheries Management 9:231-233.

Dockendorf, K. J. 2002. Relationships between zooplankton abundance and age-0 black crappie abundance and size at three productive Florida lakes. Master's thesis. University of Florida, Gainesville.

Hooe, M. L. 1991. Crappie biology and management. North American Journal of Fisheries Management 11:483-484.

Houser, A., and W. C. Rainwater. 1975. Production of largemouth bass in Beaver and Bull Shoals Lakes. Pages 310-316 in R. H. Stroud and H. Clepper, editors. Predator-prey systems in fisheries management. Sport Fishing Institute, Washington, D. C.

Hoyer, M. V., and D. E. Canfield, Jr. 1996. Largemouth bass abundance and aquatic vegetation in Florida Lakes: and empirical analysis. Journal of Aquatic Plant Management 34:23-32.

Maceina, M. J. 1997. Simple application of using residuals from catch curve regressions to assess year class strength in fish. Fisheries Research 32:115-121.

Maceina, M. J., and M. Stimpert. 1998. Relations between reservoir hydrology and crappie recruitment in Alabama. North American Journal of Fisheries Management 18:104-113.

McDonough, T. A., and J. P. Buchanan. 1991. Factors affecting abundance of white crappies in Chickamauga Reservoir, Tennessee, 1970-1989. North American Journal of Fisheries Management 11:513-524.

McMahon, T. E., A. V. Zale, and D. J. Orth. 1996. Aquatic habitat measurements. Pages 83-120 in B. R. Murphy and D. W. Willis, editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Meals, K. O., and L. E. Miranda. 1991. Variability in abundance of age-0 centrarchids among littoral habitats of flood control reservoirs in Mississippi. North American Journal of Fisheries Management 11:298-304.

Miranda, L. E., and W. D. Hubbard. 1994a. Length-dependent winter survival and lipid composition of age-0 largemouth bass in Bay Springs Reservoir, Mississippi. Transactions of the American Fisheries Society 123:80-87.

Miranda, L. E., and W. D. Hubbard. 1994b. Winter survival of age-0 largemouth bass relative to size, predators, and shelter. North American Journal of Fisheries Management 14:790-796.

Miranda, L. E., W. L. Shelton, and T. D. Bryce. 1984. Effects of water level manipulation on abundance, mortality, and growth of young-of-year largemouth bass in West Point Reservoir, Alabama-Georgia. North American Journal of Fisheries Management 4:314-320.

Mitzner, L. 1991. Effect of environmental variables upon crappie young, year-class strength, and the sport fishery. North American Journal of Fisheries Management 11:534-542.

Moyer, E. J., and seven coauthors. 1993. Completion report for Kissimmee Chain of lakes studies, study II: Lake Kissimmee investigations (1988-1993). Florida Game and Fresh Water Fish Commission, Tallahassee.

Murphy, B. R., and D. W. Willis. 1996. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda.

Ney, J. J. 1996. Oligotrophication and its discontents: effects of reduced nutrient loading on reservoir fisheries. Pages 285-295 *in* L. E. Miranda and D. R. DeVries, editors. Multidimensional approaches to reservoir fisheries management. American Fisheries Society Symposium 16.

O'Brien, W. J., B. Loveless, and D. Wright. 1984. Feeding ecology of young white crappie in a Kansas reservoir. North American Journal of Fisheries Management 4:341-349.

PBS&J, Inc. 1998. The Lake Tarpon Drainage Basin Management Plan. Final report prepared for the Pinellas County Board of County Commissioners and the Southwest Florida Water Management District.

Ploskey, G. R. 1986. Effects of water-level changes on reservoir ecosystems with implications for fisheries management. Pages 86-97 in G. E. Hall and M. J. Van Den Avyle, editors. Reservoir fisheries management: strategies for the 80's. Reservoir Committee, Southern Division American Fisheries Society, Bethesda, Maryland.

Ploskey, G. R., J. M. Nestler, and W. M. Bovine. 1996. Predicting black bass reproductive success from Bull Shoals Reservoir hydrology. American Fisheries Society Symposium 16:422-441.

Rainwater, W. C., and A. Houser. 1975. Relation of physical and biological variables to black bass crops. Pages 306-309 in R. H. Stroud and H. Clepper, editors. Predator-prey systems in fisheries management. Sport Fishing Institute, Washington, D. C.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada Bulletin 191.

SAS. 1996. User's guide, version 6. SAS Institute Inc., Cary, North Carolina.

Shelton, W. L., W. D. Davies, T. A. King, and T. J. Timmons. 1979. Variations in growth of the initial year class of largemouth bass in West Point Reservoir, Alabama and Georgia. Transactions of the American Fisheries Society 108:142-109.

SWFWMD (Southwest Florida Water Management District). 2001. Lake Tarpon surface water improvement and management (SWIM) plan. Southwest Florida Water Management District, Brooksville.

Swingle, H. S. 1950. Relationships and dynamics of balanced and unbalanced fish populations. Bulletin 274 of the Agricultural Experiment Station, Auburn University, Alabama.

Timmons, T. J., W. L. Shelton, and W. D. Davies. 1980. Differential growth of largemouth bass in West Point Reservoir, Alabama-Georgia. Transactions of the American Fisheries Society 109:176-186.

Zar, J. H. 1984. Biostatistical analysis, 2nd edition. Prentice-Hall, Englewood Cliffs, New Jersey.