Response of Fish Populations to Aquatic Plant Management in Lake Yale

by

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Introduction

The importance of aquatic plants to fisheries has been studied extensively with variable results (Hoyer et al. 1985; Hinkle 1986). Many studies have indicated that moderate levels (10 to 40 percent) of aquatic vegetation may be beneficial to fisheries (Colle and Shireman 1980; Durocher, Provine, and Kraai 1984; Wiley et al. 1984; Hinkle 1986). Some have indicated that removal of macrophytes can be detrimental to game fish communities (Ware and Gasaway 1976; Durocher, Provine, and Kraai 1984; Porak et al. 1990), while inconsistent results have led others to believe removal of aquatic plants may not adversely affect fisheries (Moorman 1956; Bailey 1978; Stanley, Miley, and Sutton 1978; Hoyer et al. 1985).

Effects of dense vegetation on largemouth bass *(Micropterus salmoides)* may include reduced foraging efficiency (Savino and Stein 1982; Colle et al. 1987), lower standing crop (Borawa et al. 1978; Wiley et al. 1984), reduced condition (Colle and Shireman 1980), or no change in the harvestable population (Colle et al. 1987). Food availability and condition of sunfishes was lower in dense aquatic vegetation (Bailey 1978; Borawa et al. 1978; Colle and Shireman 1980). Too little vegetation may also result in a lower standing crop of largemouth bass (Ware and Gasaway 1976; Smith and Crumpton 1977; Moxley and Langford 1982; Durocher, Provine, and Kraai 1984; Wiley et al. 1984; Porak et al. 1990). High levels of aquatic macrophytes generally resulted in higher recruitment of largemouth bass (Ware and Gasaway 1976; Moxley and Langford 1982; Strange, Kittrell, and Broadbent 1982; Klussman et al. 1988; Porak et al. 1990). However, constant or improved recruitment has also been observed after aquatic macrophyte removal (Hoyer et al. 1985). Forage fish populations generally increased at greater coverages of aquatic plants (Borawa et al. 1978; Moxley and Langford 1982; Wiley et al. 1984; Klussman et al. 1988). Ware and Gasaway (1976) reported increased rough fish populations following removal of vegetation by grass carp *(Ctenopharyngodon idella).*

In some cases, reduction of aquatic vegetation has coincided with improving fisheries, while others have shown declining fisheries. More research is needed to determine when aquatic plant management will benefit, harm, or have no impact on fisheries. The objective of this study was to assess the immediate impacts of aquatic plant management on the native fish populations in Lake Yale.

Study Area

Lake Yale is a 1,636-ha lake located in Lake County near Eustis, FL. Hydrilla *(Hydrilla verticillata)* became established in the southern end of Lake Yale in 1980, at which time Illinois pondweed *(Potamogeton illinoensis)* covered 140 ha and was the dominant submersed plant. Hydrilla expanded from 1981 to 1984 despite various herbicide treatments that included Aquathol K, Diquat plus copper, and Sonar. Hydrilla (1,400 ha) was reduced (128 ha) after a large-scale Sonar treatment in April 1984, and Illinois pondweed expanded to 320 ha. No more hydrilla was found until 1987 (2 ha), while Illinois pondweed expanded to a peak 1,080 ha, and total plant coverage was 45 percent. Between

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1987 and 1990, 21,145 triploid grass carp (12.9/hectare) were stocked, but hydrilla growth continued. By 1991, hydrilla expanded to 1,340 ha, Illinois pondweed coverage declined to 325 ha, and total plant coverage peaked at 85 percent. Sonar treatments in 1992 and 1993 in addition to triploid grass carp nearly eliminated hydrilla by the end of 1993. By that time, Illinois pondweed declined to 140 ha, and total vegetation coverage was 20 percent (Hestand, Thompson, and Mallison in preparation).

Materials and Methods

The game, forage, and rough fish populations (Table 1) in Lake Yale were evaluated through annual block-net sampling. Nets (0.4 ha) were set in two fixed shoreline stations (depth 0.5 to 3 m) and two fixed offshore stations (depth 3 to 5 m) during May or June each year. Aquatic vegetation was primarily maidencane *(Panicum hemitomon)*, arrowhead *(Sagittaria lancifolia)*, and spikerush *(Eleocharis* spp.*)* in shoreline areas and Illinois pondweed, hydrilla, and southern naiad *(Najas guadalupensis)* in offshore areas. Nets were sampled using rotenone at a concentration of two parts per million. Fish were collected over a 3-day period, identified to species, and individually measured (total length) and weighed. Harvestable game fish were classified as follows: largemouth bass ≥360 mm, black crappie *(Pomoxis nigromaculatus)* ≥240 mm, chain pickerel *(Esox niger)* ≥360 mm, and bluegill *(Lepomis macrochirus)*, redear sunfish *(L. microlophus)*, warmouth *(L. gulosus)*, spotted sunfish *(L. punctatus)*, and redbreast sunfish *(L. auritus)* ≥160 mm.

The Lake Yale largemouth bass population was further investigated through quarterly electrofishing surveys. Twelve fixed shoreline transects were established at the beginning of the study period. Each transect was fished for 15 min (pedal time) in February and August of each year. Largemouth bass were individually weighed, measured, and returned to the lake. Data is reported from spring electrofishing samples (February and May samples combined).

Table 1
Classification of Fish Species Caught During Lake Yale Block-net Sampling Between 1987 and 1993

Game Fish	Forage Fish	Rough Fish
Black crappie	Eustis pupfish	Bowfin
Bluegill	Florida flagfish	Brown bullhead
Chain pickerel	Banded killifish	Yellow bullhead
Largemouth bass	Bluefin killifish	White catfish
Redbreast sunfish	Least killifish	Florida gar
Redear sunfish	Seminole killifish	Longnose gar
Spotted sunfish	Mosquitofish	Atlantic needlefish
Warmouth	Pirate perch	Gizzard shad
	Pugnose minnow	Lake chubsucker
	Redfin pickerel	
	Sailfin molly	
	Golden shiner	
	Taillight shiner	
	Brook silverside	
	Inland silverside	
	Bluespotted sunfish	
	Dollar sunfish	
	Swamp darter	
	Tadpole madtom	
	Threadfin shad	
	Banded topminnow	
	Golden topminnow	

Results and Discussion

Total native fish biomass (four block-net totals) ranged from 105 to 145 kg/hectare in all years except 1988 where 60 kg/hectare were collected (Figure 1). In 1993, biomass of all groups (game, forage, and rough fish) approximated 1987 values. Shoreline nets made up 55 to 60 percent of the sample from 1987 to 1989, 41 percent in 1990, 64 percent in 1991 and 1992, and 86 percent in 1993. Biomass in shoreline nets averaged 122 kg/hectare from 1987 to 1992 (45- to 85-percent vegetation coverage in the lake) and increased by 90 percent to 231 kg/hectare in 1993 (20-percent vegetation coverage in the lake). Biomass in offshore nets averaged 95 kg/hectare from 1987 to 1992 and declined by 60 percent to 38 kg/hectare in 1993.

Game fish biomass ranged from 79 to 119 kg/hectare except in 1988 where it dropped to 44 kg/hectare. Game fish biomass in shoreline

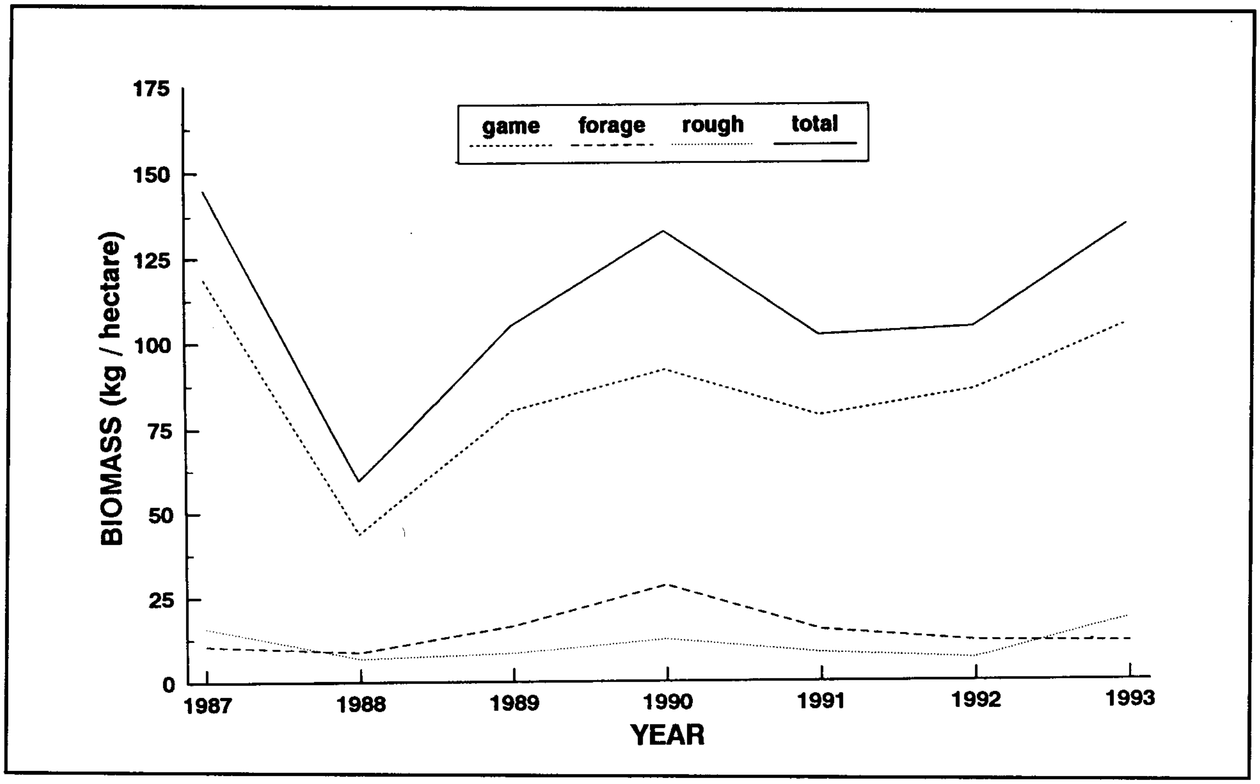

Figure 1. Lake Yale block-net results for biomass of game, forage, and rough fish from 1987 to 1993

and offshore nets revealed similar trends until 1993, when 89 percent of the sample was collected in shoreline nets (Figure 2A). Game fish biomass shifted to vegetated shoreline areas in 1993, when submersed plants were greatly reduced in offshore areas. Offshore game fish biomass peaked in 1990 at 112 kg/hectare (61 percent of game fish biomass). Biomass of harvestable game fish showed a similar pattern as offshore biomass peaked in 1987 and 1990 at 30 kg/hectare (56 percent of the samples), while 94 percent of the 1993 sample was collected in shoreline nets (Figure 2B).

Bluegill dominated game fish biomass at an average 38 kg/hectare and 40 to 50 percent of game fish biomass (Figure 3). Redear sunfish was next at an average of 16 kg/hectare and 15 to 30 percent of game fish biomass. Largemouth bass biomass averaged 11 kg/hectare and made up 10 to 15 percent of game fish biomass. There was an overall decline in the numbers and biomass of all harvestable game fish except chain pickerel (Figure 4). Redear sunfish was the dominant harvestable game fish and averaged 41 percent of the biomass and 45 percent of the number. Harvestable redear sunfish biomass peaked at 16 kg/hectare (88 fish/hectare) during peak hydrilla growth (1991) and declined to 5 kg/hectare (28 fish/hectare) in 1993. Bluegill was the second most common harvestable game fish by biomass and number, but declined to less than 1 kg/hectare (2 fish/hectare) in 1993. Chain pickerel increased substantially in 1993 and dominated harvestable biomass at 43 percent (29 percent of the number), while redear sunfish remained most abundant at 40 percent of the number of harvestable game fish (28 percent of the biomass).

Total biomass of largemouth bass declined over the study from 16 kg/hectare in 1987 to 11 kg/hectare in 1993, and the number of fish declined by 43 percent (Figure 4). From 1987 to 1990, most of the largemouth bass were captured offshore, while shoreline nets contained the majority of the sample in 1991 through 1993 (Figure 5). In 1993, 80 percent of the sample was collected in shoreline nets. The largemouth bass, like other game fish species, moved into vegetated shoreline areas.

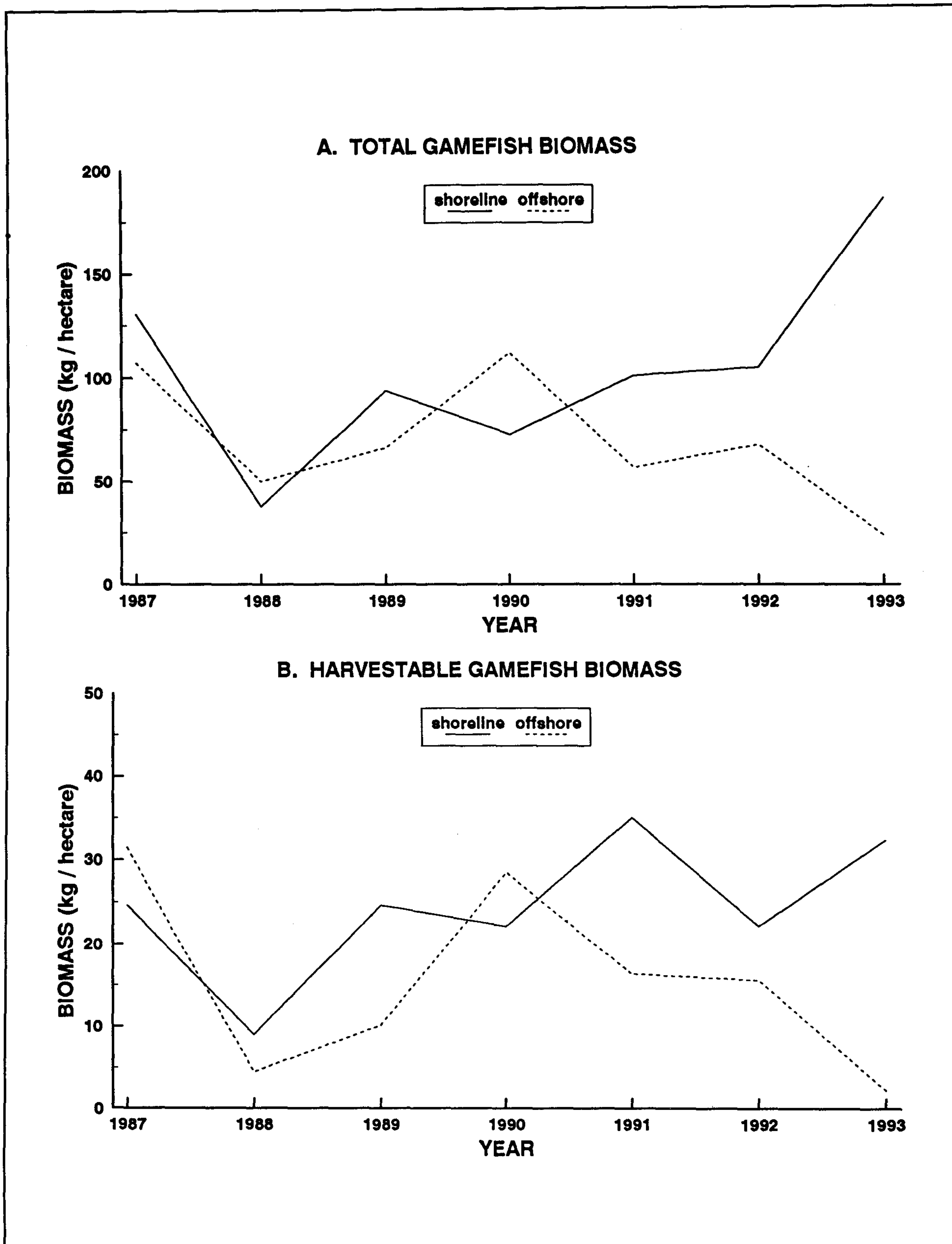

Figure 2. Lake Yale block-net results for biomass of (A) total and (B) harvestable game fish (largemouth bass, black crappie, chain pickerel, redear sunfish, bluegill, spotted sunfish, and warmouth) from 1987 to 1993

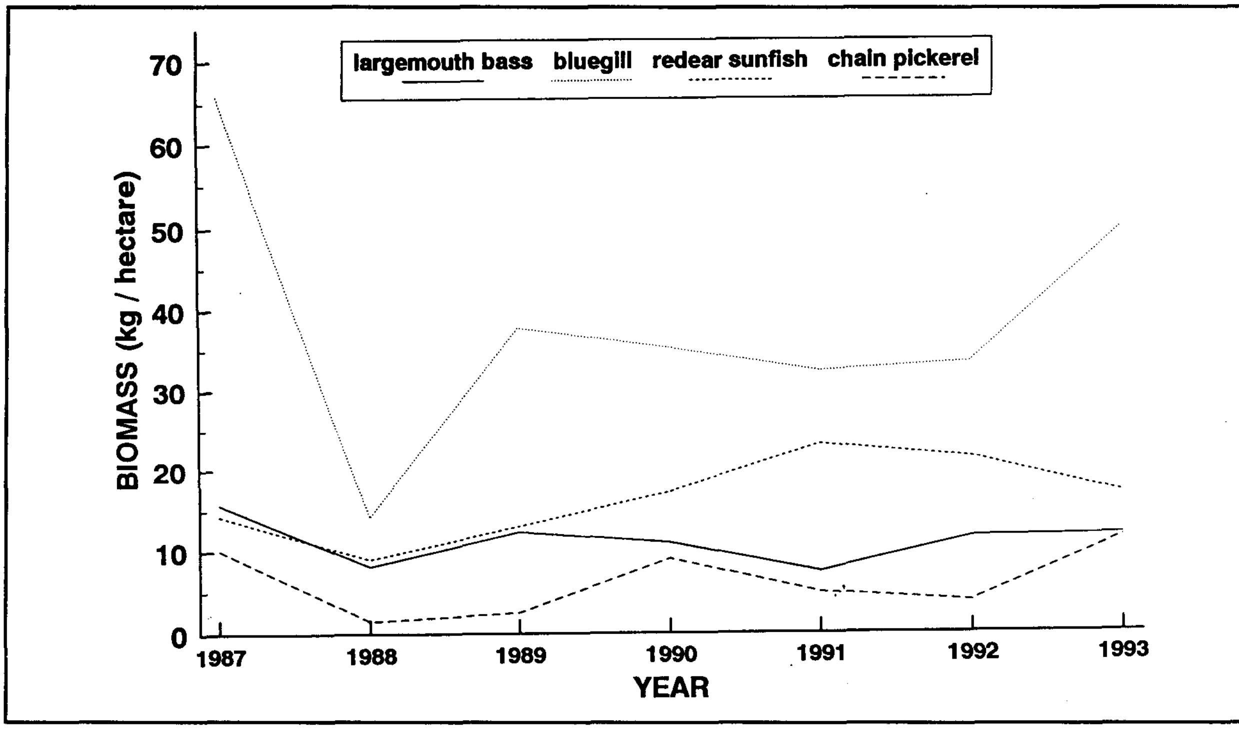

Figure 3. Lake Yale block-net results for biomass of major game fish from 1987 to 1993

The number of harvestable largemouth bass dropped from six fish/hectare (7 kg/hectare) in 1987 to four fish/hectare (3 kg/hectare) in 1993.

Electrofishing results for largemouth bass indicated that recruitment (number less than 200 mm total length) was highest in 1988 (peak Illinois pondweed coverage) and 1990 to 1992 (peak hydrilla coverage) (Table 2). Electrofishing revealed increases in the number of quality-size (greater than 300 mm total length) and harvestable fish, proportional stock density (PSD), relative stock density (RSD), and relative weight (W_r) (Anderson and Gutreuter 1983). The largemouth bass fishery improved from 1987 to 1990 as the number of quality-size fish doubled, PSD increased from 37 to 45 percent, the number of harvestable fish increased by more than 50 percent, and RSD increased from 10 to 14 percent (Table 1). By 1993, the number of quality-size fish increased to 142, PSD increased to 62 percent, the number of harvestable fish nearly doubled again to 70, and RSD increased to 30 percent. Relative weight improved slightly from 86 to 89 over the study period, possibly a result of increased availability of forage fish because of less submersed aquatic plants in 1992 and 1993 (Bailey 1978; Colle and Shireman 1980; Savino and Stein 1982). Although electrofishing may give reliable estimates of largemouth bass density (Hall 1986), the higher numbers of large fish in the 1993 Lake Yale sample reflect increased susceptibility to the sampling gear as fish have moved into vulnerable shoreline areas. The increased number of harvestable largemouth bass in 1993 samples (five-fold increase in electrofishing and four-fold increase in blocknets since 1992) may have been influenced by reduced adult mortality resulting from the establishment of a minimum-length limit at 356 mm on July 1, 1992. In addition, the dominant year classes (1990 and 1991) reached harvestable and quality size in 1993. The lowest number and biomass of harvestable largemouth bass were collected (electrofishing and block-nets) during peak hydrilla coverage (1991 and 1992). Young-of-the-year survival was correlated with increasing levels of hydrilla in 1990 and 1991, as observed in numerous other studies (Ware and Gasaway 1976; Moxley and Langford 1982; Colle et al. 1987; Klussman et al. 1988; Porak et al. 1990).

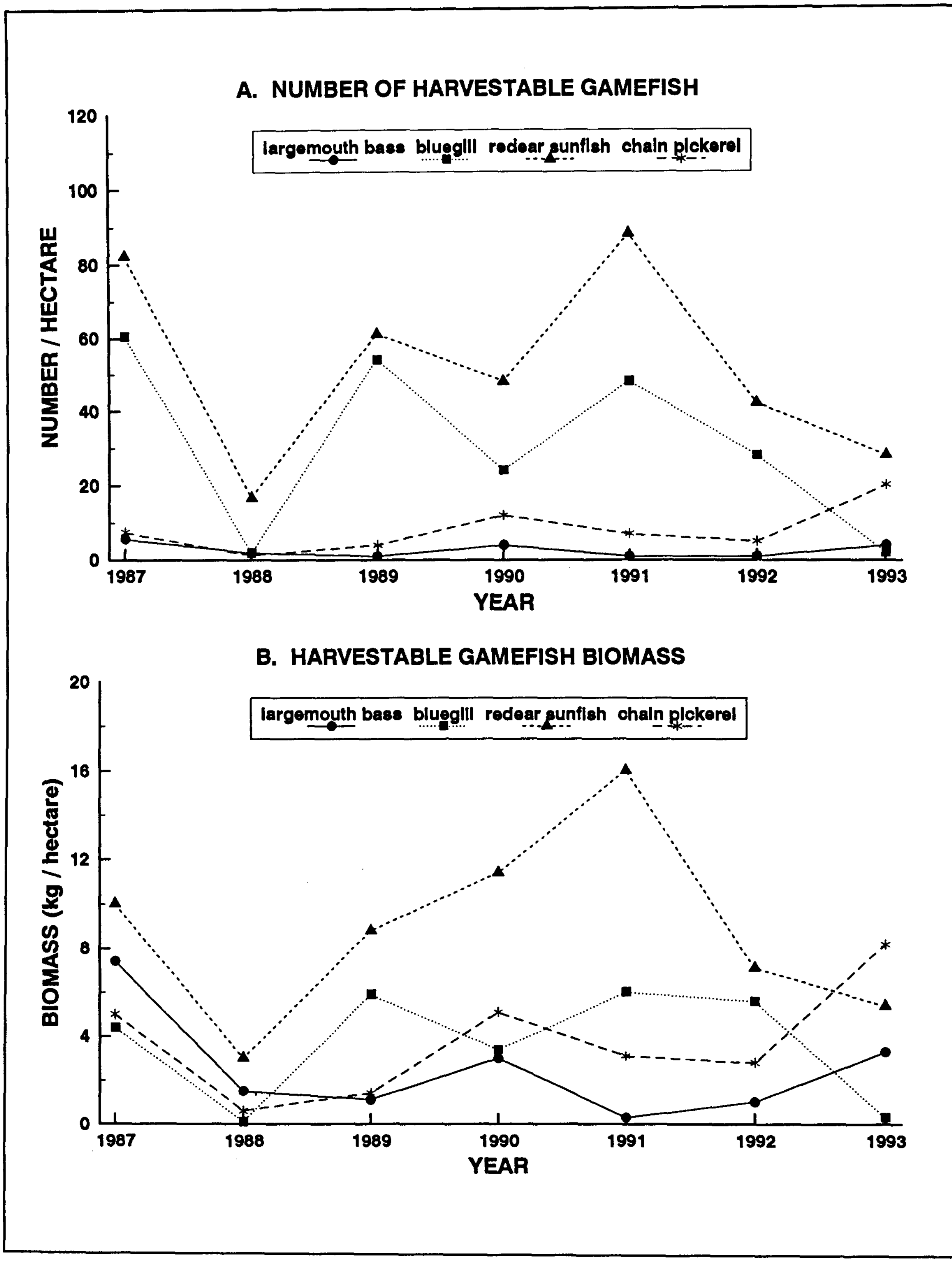

Figure 4. Lake Yale block-net results for (A) number and (B) biomass of harvestable game fish from 1987 to 1993

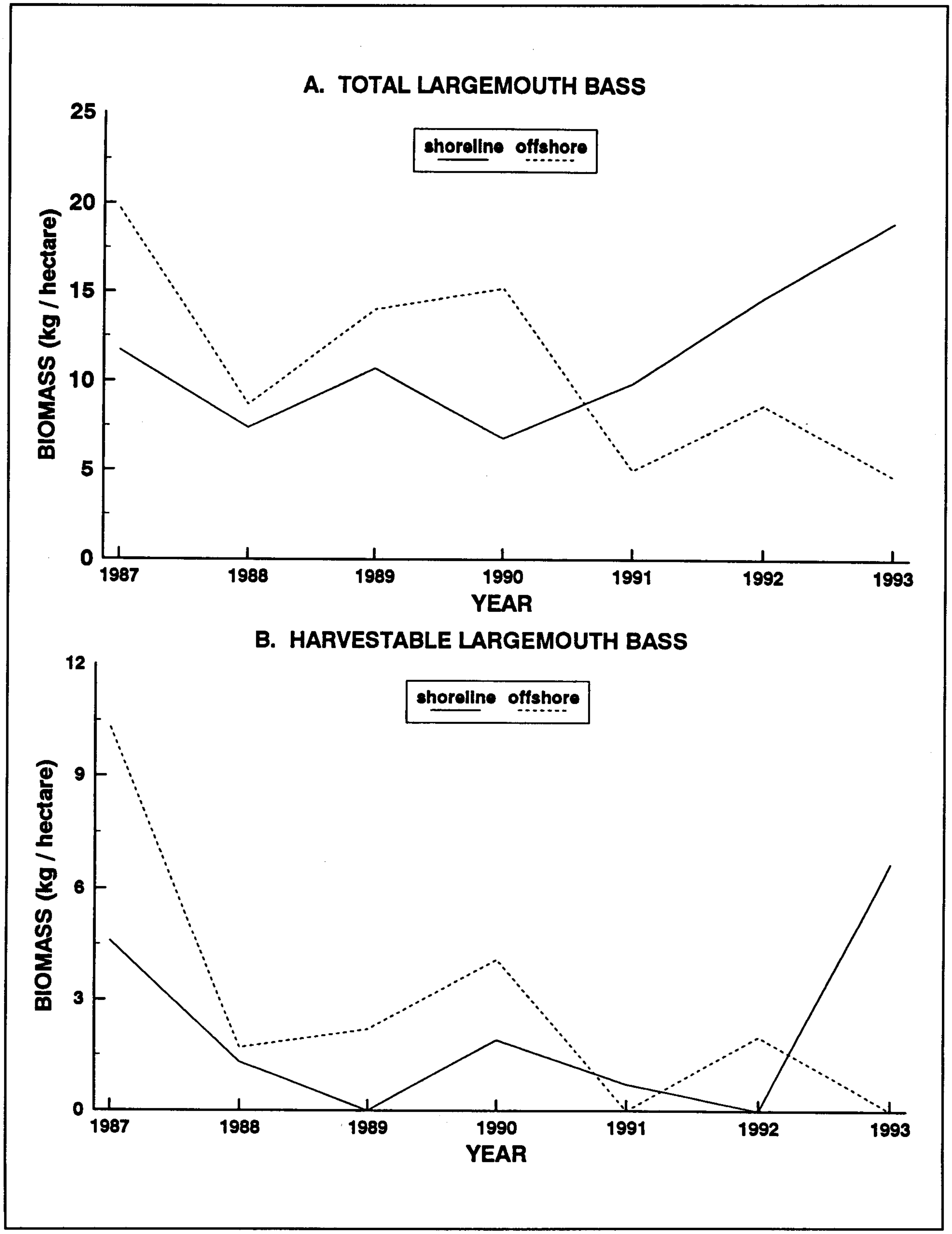

Figure 5. Lake Yale block-net results for biomass of (A) total and (B) harvestable largemouth bass from 1987 to 1993

Table 2
Lake Yale Spring Electrofishing Results (February and May samples combined, total 6 hr per year) for Largemouth Bass, 1987-1993

Year	Number of Fish	Mean W_r	Recruitment (No. <200 mm)	No. Quality (PSD)	No. Harvestable (RSD)
1987	236	86	72	60 (37%)	17 (10%)
1988	422	88	162	75 (29%)	22 (9%)
1989	368	87	98	145 (54%)	35 (13%)
1990	376	86	110	119 (45%)	36 (14%)
1991	407	85	172	82 (35%)	16 (7%)
1992	238	87	113	56 (45%)	13 (10%)
1993	321	89	91	142 (62%)	70 (30%)
Mean	338	87	117	97 (44%)	30 (13%)

Forage fish biomass peaked at 28 kg/hectare (21 percent of total block-net biomass) in 1990, when hydrilla biomass increased by 150 percent (Figure 1). In 1991, hydrilla expanded by 250 percent and forage fish biomass declined to 15 kg/hectare. Forage fish biomass ranged from 9 to 16 kg/hectare in all other years and was 11 kg/hectare in the beginning and ending years. The number of forage fish collected in 1993 was more than twice that of 1987, illustrating a greater abundance of small fish (primarily cyprinids) at less than half the vegetation coverage. In 1993, 74 percent of forage fish biomass was collected in shoreline nets (compared with 63 percent in 1987).

In 1989 and 1990, 70 percent of the forage fish biomass was collected in offshore nets and was dominated by bluespotted sunfish *(Enneacanthus gloriosus)* at 44 percent of the sample. Golden shiners *(Notemigonus chrysoleucas)* were next with 18 percent of the biomass in 1989 and 1990. In other years, dollar sunfish *(Lepomis marginatus)*, Seminole killifish *(Fundulus seminolis)*, and bluefin killifish *(Lucania goodei)* dominated at a combined 50 to 60 percent of the forage biomass. In 1993, dollar sunfish comprised 33 percent of the sample and increased by 68 percent over the study period, while bluespotted sunfish diminished to less than 1 kg/hectare. Golden shiner biomass ranged from 10 to 20 percent of the forage base (1 to 6 kg/hectare) throughout the study. Threadfin shad *(Dorosoma petenense)*, with biomass less than 1 kg/hectare, have been insignificant (less than 5 percent of the sample) except for 1987 where 2 kg/hectare (18 percent of forage fish biomass) were collected.

Biomass of rough fish ranged from 7 to 16 kg/hectare over the study period, peaking in 1993 at 18 kg/hectare and 14 percent of total block-net biomass (Figure 1). More than 75 percent of the rough fish sample was taken in shoreline nets in all years. Bowfin *(Amia calva)* was the dominant rough fish from 1987 to 1989 at 3 to 7 kg/hectare, but declined by 38 percent over the study. Lake chubsucker *(Erimyzon sucetta)* was the dominant rough fish from 1990 to 1993 at 4 to 10 kg/hectare and has increased by 238 percent since 1987.

Conclusions

Aquatic plant coverage in Lake Yale fluctuated from 45 to 85 percent between 1987 and 1992 and declined to 20 percent in 1993. No immediate impact on total native fish biomass was observed. However, shoreline nets contained twice the biomass and offshore nets less than half the biomass in 1993 (20-percent vegetation coverage) than the averages of all other years (45- to 85-percent vegetation coverage). The number and biomass of harvestable game fish (except chain pickerel) declined during the study, and total harvestable biomass was 15 percent less in 1993 than the average of all other years. This could not be directly attributed to the changes in the vegetation since biomass began to decline before removal of submersed vegetation. Game fish migrated to vegetated shoreline areas in 1993 in response to the declining aquatic plant community in offshore areas. Forage fish biomass was the same in the beginning and ending years, while the number of forage fish in 1993 was more than twice the 1987 number. Rough fish biomass increased by 15 percent over the study period.

Largemouth bass biomass and number (total and harvestable) collected by electrofishing declined over the study period, and the lowest catch samples of harvestable largemouth bass were collected during peak hydrilla coverage. There was a positive correlation between recruitment of largemouth bass and aquatic vegetation coverage. The number of quality-size and harvestable fish, PSD, RSD, and relative weight collected by electrofishing was highest in 1993, when submersed vegetation coverage was lowest (20 percent). These improvements were attributed primarily to migration of largemouth bass into vulnerable shoreline areas (more susceptible to the gear) and, to a lesser extent, to improved foraging success with vegetation removal, recruitment of dominant year classes to quality and harvestable sizes in 1993, and reduced adult mortality resulting from a minimum length limit imposed in 1992.

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