EFFECTS OF GRASS CARP ON NATIVE FISH POPULATIONS IN TWO FLORIDA LAKES

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ABSTRACT

Two natural ponds were studied to investigate the effects of introduced grass carp on native fishes. Biologically significant deleterious effects were determined for both fish populations. Largemouth bass populations were reduced in one pond and substantially altered at the second site. Fish population structures shifted and symptoms of overcrowding were evident. Bluegill numbers increased in both ponds. Warmouth were greatly reduced in one pond. Several species of forage fishes were eliminated.

During the last few years grass carp or white amur, *Ctenopharyngodon idella* Val., has been the subject of more controversy within the scientific community than any single fish species in this country. Basis for these concerned discussions results from the lack of scientific knowledge regarding this exotic, coupled with extensive publicity by news media and a rather extensive stocking program in Arkansas that immediately exposed the rivers and streams of the Central United States to invasions of grass carp. Aliens are popular topics and sometimes serve beneficial uses for man, but in all cases understanding the "biology of the beast" is imperative before sound management programs can be developed.

In 1972, the Florida Game and Fresh Water Fish Commission and the Florida Department of Natural Resources began a study in four small lakes to determine the ecological aspects of grass carp in Florida waters. Two sites supported dense aquatic plant communities and were selected as weed control experiments. The remaining two natural lakes were moderately vegetated and designated for fisheries impact studies. The purpose of this paper is to report the research findings relating to the effects of grass carp on native fishes in the two fisheries ponds. It should be understood that satisfactory explanations for many causes and effects in this study are not available from the limited data. The inference being that much research is needed before we fully understand the role of grass carp in natural systems.

MATERIALS AND METHODS

The selected study lakes were 6 acre Pasco Pond located near Land-O-Lakes, Florida, and 30 acre Suwannee Pond near the town of Live Oak. Suwannee Pond was typical of many north Florida mesotrophic lakes, having a margin of native vegetation, good water quality and habitat conditions. Pasco Pond was a typical cypress pond with low pH and moderate vegetation cover, including an adjacent marsh. A more complete description of the study sites is given by Gasaway et al (1976). Fishes found in each pond are presented in Table 1.

A three year study was conducted, beginning in August 1972 and terminating in August 1975. During the first year natural conditions were monitored without grass carp to provide baseline data. Prior to stocking fish there were two one-acre block net samples taken in Suwannee Pond and a one-half acre block net sample taken in Pasco. Sites were selected to best represent the habitat. At Suwannee Pond one station was located on the northwest shore while the second net was set in open water on the east shore. Both sets consisted of one-acre enclosed on four sides by netting. The Pasco sample was taken along the north shore. This set was enclosed on three sides by net and on the fourth side by shoreline. Each sample was treated with approximately 2 ppm rotenone, using weighted perforated hoses to distribute the chemical. Fishes were collected by dip net, sorted by species to inch groups and weighed to the nearest tenth of a pound. A three-day pickup for all samples was accomplished. This same block net procedure was repeated at the end of the study on each site and compared with results of a simultaneous total renovation. Data were used to evaluate changes in population composition, structure and standing crops.

Table 1. Check list of common and scientific names of fishes found in Pasco and Suwannee Ponds during the study period.

Scientific Names	*Common Name*	*Pond*
Lepisosteidae		
Lepisosteus platyrhincus	Florida gar	Suwannee and Pasco
Amiidae		
Amia calva	Bowfin	Suwannee
Anguillidae		
Anguilla rostrata	American eel	Pasco
Cyprinidae		
Notemigonus crysoleucas	Golden shiner	Suwannee
Catostomidae		
Erimyzon sucetta	Lake chubsucker	Suwannee and Pasco
Ictaluridae		
Ictalurus natalis	Yellow bullhead	Pasco
Ictalurus nebulosus	Brown bullhead	Suwannee
Cyprinodontidae		
Fundulus chrysotus	Golden topminnow	Suwannee and Pasco
Fundulus lineolatus	Lined topminnow	Suwannee and Pasco
Fundulus cingulatus	Banded topminnow	Pasco
Leptolucania ommata	Pygmy killifish	Pasco
Lucania goodei	Bluefin killifish	Pasco
Poeciliidae		
Gambusia affinis	Mosquitofish	Suwannee and Pasco
Heterandria formosa	Least killifish	Suwannee and Pasco
Atherinidae		
Labidesthes sicculus	Brook silverside	Pasco
Centrarchidae		
Elassoma evergladei	Everglades pygmy sunfish	Pasco
Enneacanthus chaetodon	Blackbanded sunfish	Pasco
Enneacanthus gloriosus	Bluespotted sunfish	Suwannee and Pasco
Lepomis gulosus	Warmouth	Suwannee and Pasco
Lepomis macrochirus	Bluegill	Suwannee and Pasco
Lepomis marginatus	Dollar sunfish	Suwannee and Pasco
Lepomis microlophus	Redear sunfish	Pasco
Micropterus salmoides	Largemouth bass	Suwannee and Pasco
Esocidae		
Esox americanus	Redfin pickerel	Pasco
Percidae		
Etheostoma fusiforme	Swamp darter	Suwannee and Pasco

A 125 yard trammel net was set in Pasco Pond at the beginning of the study. However, the procedure was not repeated at study termination so the data was not used in evaluating results.

It should be noted that pre-carp rotenone sampling in Suwannee Pond killed an additional 600 pounds of fishes (SWAG estimate) outside the nets (T.L. Vaughn, personal comm.). Based on total renovation data, the estimated fish kill represented approximately 14% of the total population. Although reliable composition data was not available 61 dead bass were recovered in sub-samples along with bluegill, lake chubsucker and bowfin. For the readers benefit, our colleagues with the Department of Natural Resources insist that this kill was the principal factor affecting changes in the fish population during the course of the study; therefore, it should be considered when judging the results.

Five Wegener ring (Wegener et al. 1974) rotenone samples were taken quarterly in each pond. When vegetation was present, two of these were taken in vegetated areas, two in open water areas and one sample included both vegetation and open water. The surface area of each ring was .001 acres. Collected fishes were grouped to species, counted and weighed in grams. These data were used to evaluate effects on shallow water fishes.

Based on early work by Sutton (1974), it was calculated that 60 pounds/acre (69kg/ha) of grass carp would be needed to remove a significant amount of aquatic vegetation. Each lake was stocked with this biomass during September and October 1973. Numerically,

Suwannee received 120 fish/acre (298 fish/ha) and Pasco was stocked with 73 fish/acre (185 fish/ha). Fish for Pasco Pond averaged 0.82 pounds in weight. Mixed sizes were used in Suwannee Pond due to limited availability of stocks.

RESULTS AND DISCUSSION

Baseline fish population data for Pasco and Suwannee Ponds were characteristic of many quality Florida lakes (Tables 2 and 3). Both systems supported healthy centrarchid populations dominated by bluegill and large mouth bass. Principal forage species included killifishes, shiners and small sunfishes. The major coarse species was lake chubsucker.

Pasco Pond

Prior to the introduction of grass carp, the bass population of Pasco Pond showed a well distributed population structure (Figure 1). Good reproduction was evident along with desirable numbers of bass in the intermediate and adult size-classes. On a per acre basis, there were 164 young-of-the-year, 34 intermediate, and 12 harvestable-sized adult bass. The estimated standing crop amounted to 22 pounds/acre. Considering the total fish community, largemouth bass ranked third in biomass (11.6% by weight). Of the 17 species recovered, only bluegill and lake chubsucker showed higher composition. The largest bass observed was a 10 pound specimen collected in trammel nets.

Following the introduction of grass carp into Pasco Pond significant deleterious effects occurred to the largemouth bass population; for that matter to the total fish population (Table 2). Based on block net rotenone data, the standing crop of bass was reduced from 22 pounds/acre to 2 pounds/acre, a 91% reduction. The healthy population structure found in August 1972 was reduced to a remnant of its former condition (Figure 1). Bass spawning was evident with 16 young-of-the-year acre. Recruitment was very weak, an estimated eight intermediate bass/acre, and no harvestable adults were recovered in the sample.

Lake renovation was used to validate the sampling data. Although similar trends were evident, overall changes were not as drastic as shown by block nets (Table 2). Bass numbers were reduced from 250/acre to 28/acre. Biomass was determined at 7.5 pounds/acre, a 66.0% reduction in standing crop. Composition of bass within the total population declined to 5.9% by weight. The adult population was reduced by one-half of its former abundance (6 fish/acre), while intermediates showed greater losses (less than 4 fish/acre). Although spawning was evident, production of young bass declined from an estimated 164 fish/acre to 16 fish/acre.

Table 2. Pasco Pond—Relative abundance of principal species, 1972-1975.

	Pre-carp Block net—1972				*Post-carp Block net—1975*				*Total Renovation—1975*			
	No./A.	*No. Harvest Size/A.*	*Wt./A.*	*% Comp. by Wt.*	*No./A.*	*No. Harvest Size/A.*	*Wt./A.*	*% Comp. by Wt.*	*No./A.*	*No. Harvest Size/A.*	*Wt./A.*	*% Comp. by Wt.*
Largemouth bass	250	12	22.0	11.6	24	0	2.1	11.7	28.4	6.0	7.5	5.9
Bluegill	516	38	30.3	15.9	8,512	0	4.6	25.1	2,675.1	81.1	29.1	23.0
Warmouth	948	26	18.9	9.9	254	0	1.1	6.1	202.7	3.7	1.8	1.4
Bullheads (yellow & brown)	24	16	16.2	8.5	4	4	2.6	14.5	25.1	18.0	16.0	12.6
Lake chubsucker	684	—	92.8	48.7	36	—	7.5	41.9	109.8	—	52.1	41.2
Fla. spotted gar	18	—	10.2	5.2	0	—	0	0	19.8	—	14.2	11.2

Table 3. Suwannee Pond—Relative abundance of principal species, 1972-1975.

	Pre-carp Block nets—1972				*Post-carp Block nets—1975*				*Total Renovation—1975*			
	No./A.	*No. Harvest Size/A.*	*Wt./A.*	*% Comp. by Wt.*	*No./A.*	*No. Harvest Size/A.*	*Wt./A.*	*% Comp. by Wt.*	*No./A.*	*No. Harvest Size/A.*	*Wt./A.*	*% Comp. by Wt.*
Largemouth bass	89.5	37.5	22.6	36.2	751	10.0	17.4	15.4	335.4	13.4	24.7	15.6
Bluegill	1,953.8	90.0	34.8	55.8	17,817.5	167.0	57.2	50.6	5,201.5	220.8	50.4	31.9
Warmouth	7.5	2.0	0.5	0.8	23.5	0.5	0.3	0.3	102.7	0.5	0.4	0.3
Brown bullhead	0	0	0	0	42.0	42.0	16.2	14.3	96.0	26.5	49.8	31.5
Lake chubsucker	7.0	—	4.5	7.2	12.0	—	22.0	19.5	29.1	—	25.0	15.8
Fla. spotted gar	0	—	0	0	0	—	0	0	0.04	—	0.1	0.1

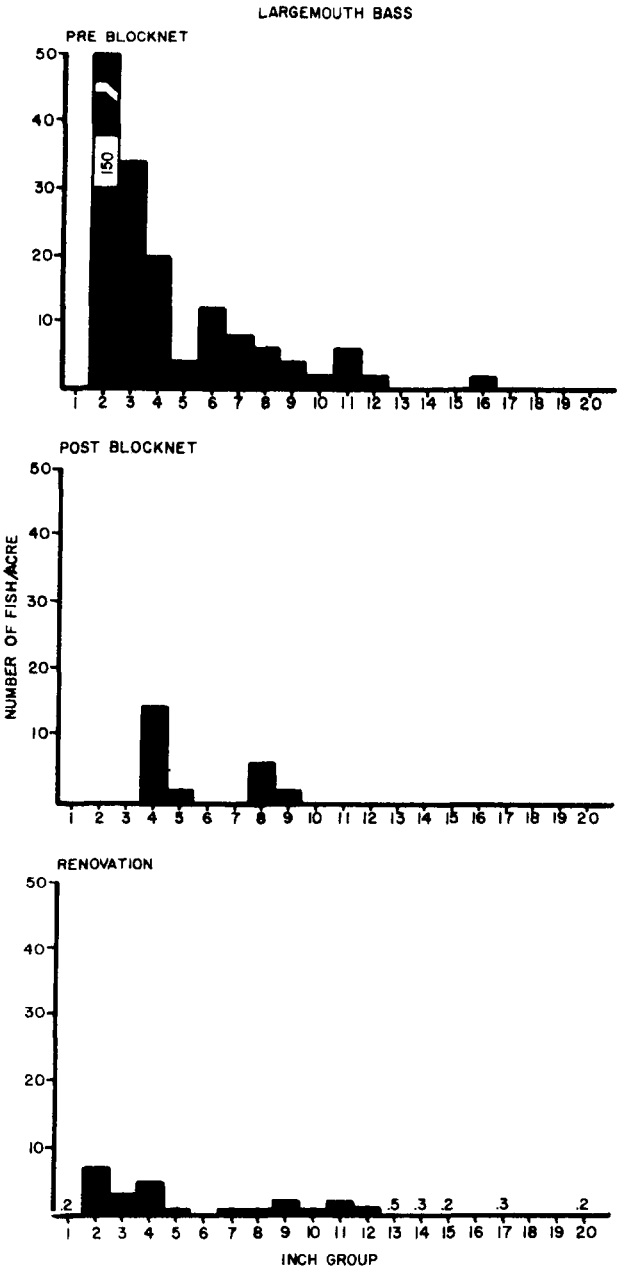

FIGURE I. PASCO POND, POPULATION STRUCTURES OF LARGEMOUTH BASS.

The bluegill population showed a substantial increase in numbers while total weight remained essentially the same when baseline data is compared with total renovation (Table 2). The original standing crop was estimated at 30.3 pounds/acre and total renovation data recovered 29.1 pounds/acre. Numbers changed from 516 to 2,675 fish/acre. Population structure at study termination shifted dramatically with greater numbers of adults than intermediate size bluegills. Numbers of young-of-year were extremely high, accounting for most of the population increase, and may have been early symptoms of overcrowding (Figure 2). Obviously, their abundance was evidence of inadequate population control through predation. Condition factors (K) for adult bluegill showed a substantial decline over baseline values, mean K decreased from 2.38 in 1972 to 1.77 in 1975 (Miley, 1976).

Pasco Pond supported a sizeable population of warmouth prior to the introduction of grass carp (Table 2). Block net data indicated 19/acre with 26 harvestable adults/acre. Composition by weight was 9.9% of the total fish population.

Post-carp sampling and total renovation data showed relatively good correlation for warmouth (Table 2). The population was reduced to 1.8 pounds/acre supporting less than four harvestable adults/acre. Composition by weight decreased to 1.4%. Numbers of warmouth declined from an estimated 948/acre to approximately 200 fish/acre. Population structure was drastically altered, composed largely of 1-and 2-inch fish (Figure 2).

Coarse species showed little change in population status, except for lake chubsucker (Table 2). Population estimates for chubsucker declined from 92.8 pounds/acre to 52.1 pounds/acre. A total of 17 grass carp were recovered at renovation amounting to 3.0 pounds/acre.

Suwannee Pond

Identifiable effects on the fish population of Suwannee Pond were not as evident as reported for Pasco. The bass population showed considerable change in structure with greater numbers of young-of-year and fewer adults (Figure 3). Intermediate-size bass were also reduced. Bluegill size-distribution shifted to smaller fish and heavy production of young-of-year. Coarse species increased substantially over baseline.

Block net sampling in 1972 (before carp) showed the size distribution of largemouth bass composed of 26 young-of-year, 25 intermediates and 38 harvestable adults per acre. The standing crop was estimated at 22.6 pounds/acre (Table 3). Two years following the introduction of grass carp, blocknets revealed a 23% decline in the bass population, an estimated 17.4 pounds/acre (Table 3). More significantly, however, was the decrease in the population size of harvestable adults from 38 bass/acre to 10 bass/acre, a 74% reduction. As stated in the Methods section, part of this decrease may be attributable to the rotenone caused fish kill during pre-carp sampling in 1972. However, subsequent year-classes in 1973 and 1974 were also very weak (Figure 3). If the rotenone kill was largely responsible for reduced bass numbers then it follows that at least one of these year-classes should have responded with increased production and survival; an expanding species responding to a population void (Bennett, 1962; Wyatt and Zeller, 1962). Whereas, if grass carp related effects were the principal factors involved, then these mechanisms were still affecting bass production through 1974. Finally in 1975 good bass production occurred at a time when the grass carp population was known to be reduced (determined at renovation).

Total renovation data showed reasonably close agreement with blocknet samples (Table 3). Numbers of harvestable adult bass were reduced to 13.4 fish/acre. Bass standing crop was 24.7 pound/acre. Population structure was altered substantially with lower numbers of intermediates (1974 year-class) and adult fish. Young-of-year showed a greater abundance indicating strong reproductive success. When population structures are compared before and after carp stocking, evidence of recent population stress is apparent with a substantial loss of adult and intermediate size fish and a corresponding increase in young-of-year. Survival and recruitment of the 1973 and 1974 year-classes were obviously affected during the study period.

The bluegill population showed a substantial increase in numbers of small, intermediate, and young adults. There was a corresponding decrease in numbers of large fish, 8-9-10 inch groups (Figure 4). Baseline data estimated over 50 bluegill/acre in the 9-and 10-inch size

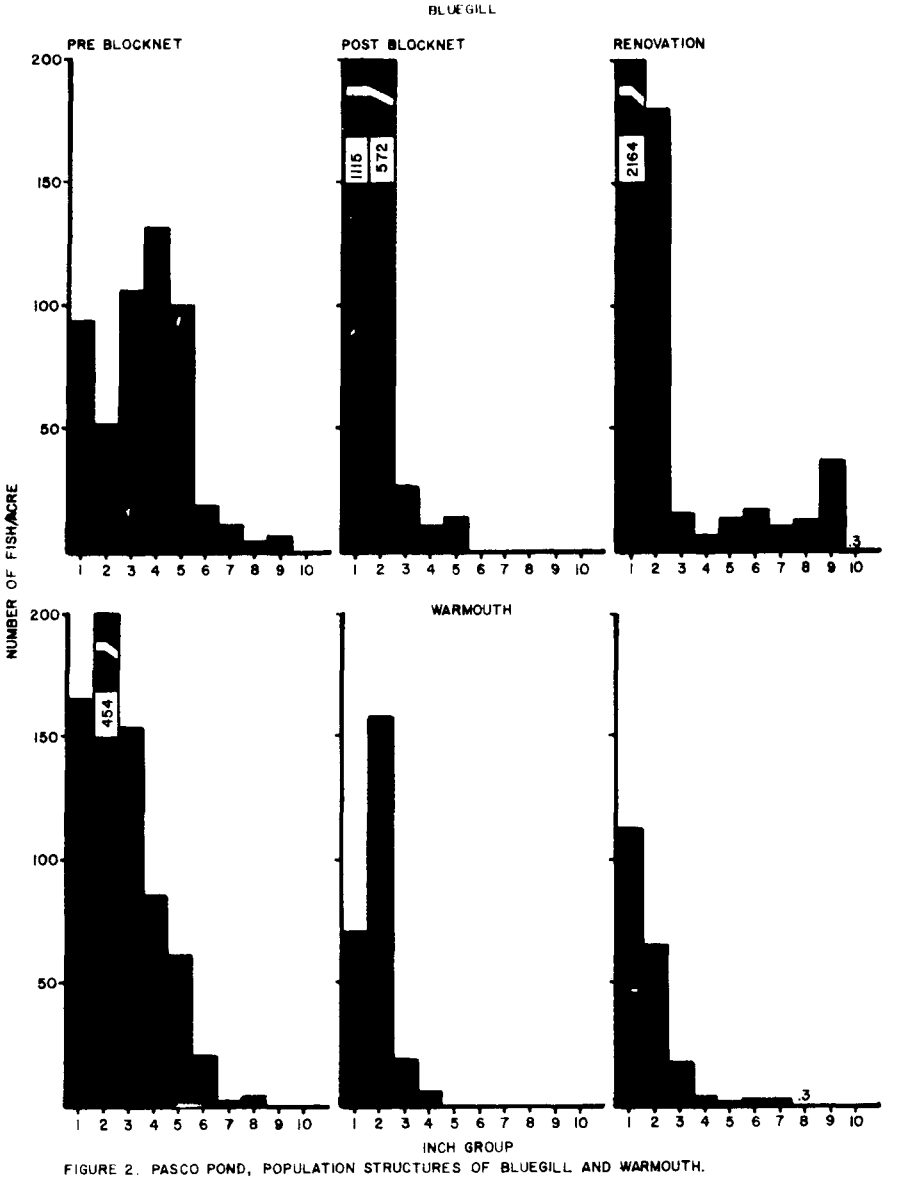

FIGURE 2. PASCO POND, POPULATION STRUCTURES OF BLUEGILL AND WARMOUTH.

class prior to stocking grass carp. At total renovation, there were only two 9-inch fish/acre and 10-inch bluegill were practically eliminated from the population. Conversely, numbers of bluegill in the 7-inch group and smaller increased substantially, largely due to the strong year classes produced in 1973 and 1974. Expansion of the bluegill population was probably facilitated by reduced bass predation. Standing crop estimates increased from 34.8 pounds/acre to 50.4 pounds/acre. Condition factors for adult bluegill measured by average K, declined from 1.60 to 1.41 during the course of the study (Miley, 1976).

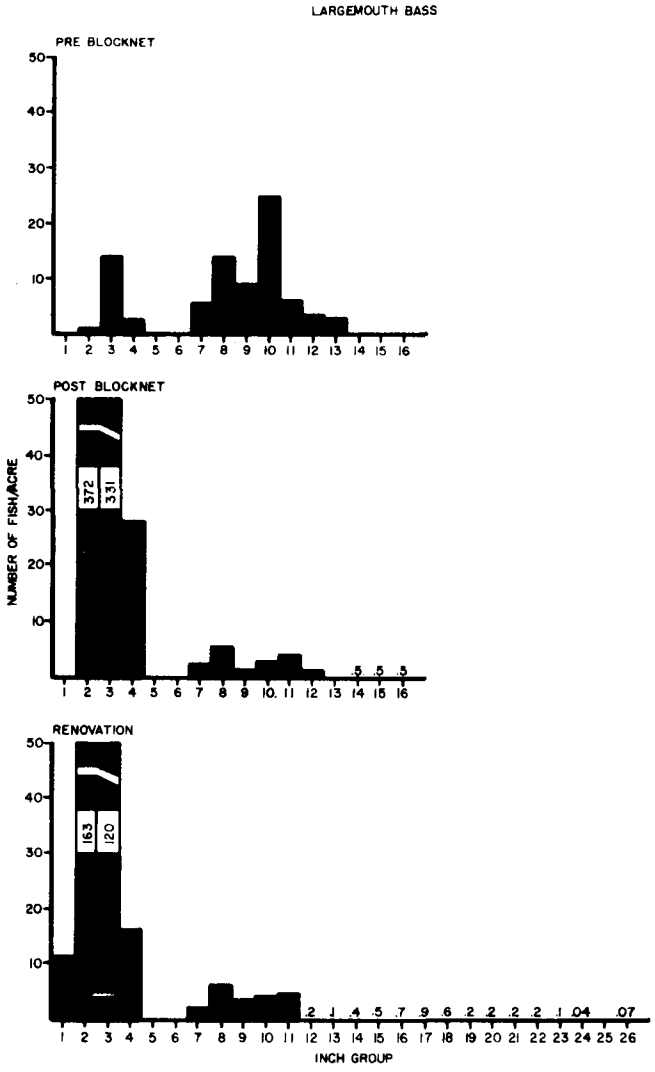

FIGURE 3. SUWANNEE POND, POPULATION STRUCTURES OF LARGEMOUTH BASS.

Warmouth was a minor species in Suwannee Pond (Figure 4). Pre-carp sampling indicated two harvestable fish/acre and a total standing crop of .5 pounds/acre. At the end of the study renovation data showed 0.5 harvestable fish/acre and a standing crop of 0.4 pounds.

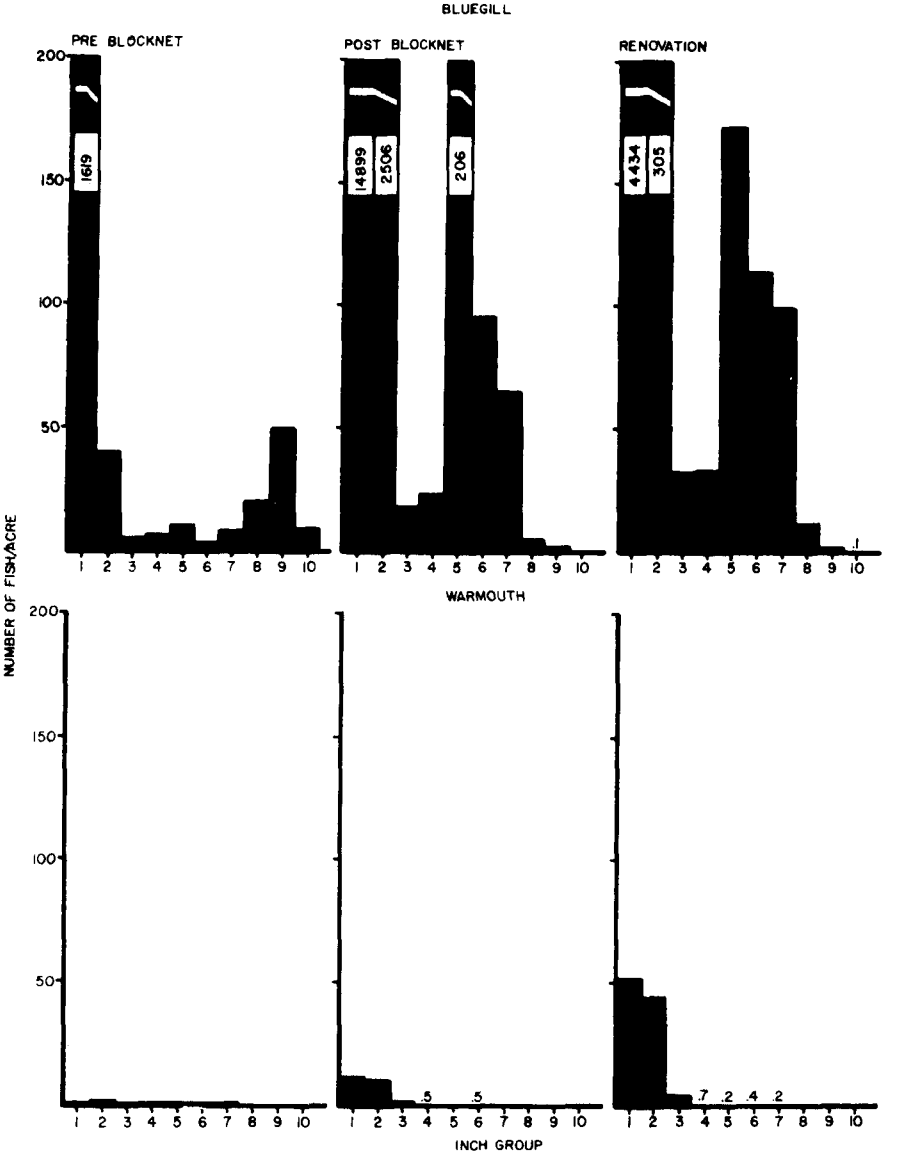

FIGURE 4. SUWANNEE POND, POPULATION STRUCTURES OF BLUEGILL AND WARMOUTH.

Coarse species, chiefly brown bullhead and lake chubsucker, showed major increases in population levels following introduction of grass carp. Brown bullheads were not recovered in baseline samples, probable sampling error, while renovation data showed 96 individuals/acre weighing 49.8 pounds. Lake chubsucker increased from seven fish/acre weighing 4.5 pounds to 29 fish/acre weighing 25 pounds (Table 3). The combined weight of

coarse fishes comprised 47.3% of the fish population in Suwannee Pond at study termination. Prior to the introduction of grass carp, coarse species ranked third in percent composition by weight of the total population. A total of 21 grass carp weighing 96 pounds were recovered during total renovation of Suwannee Pond.

Shallow Water Fishes

Several Florida biologists have emphasized the importance of shallow water fishes found in and around aquatic vegetation (Wegener and Holcomb, 1972; Wegener et al., 1973; Barnett and Schneider, 1974). Wegener ring data indicate the effects of grass carp on these populations in Pasco and Suwannee Ponds.

In Pasco Pond, prior to stocking grass carp, 18 fish species were recovered in Wegener ring samples. Numbers and weight by species are presented in Table 4. Dominant fishes were represented by seven species, including lake chubsucker, warmouth, mosquitofish, bluespotted sunfish, swamp darter, bluegill and golden topminnow. Lake chubsucker and mosquitofish ranked one and two by number, respectively.

Combined data during the first year after grass carp stocking showed a decline from baseline diversity by four species; redear sunfish, blackbanded sunfish, bluefin killifish, and redfin pickerel. An additional species, banded topminnow, was encountered. Biomass estimates also declined compared to pre-carp data (Table 4).

The final year of sampling yielded 10 species in the pooled catch, indicating a loss of seven fishes over baseline diversity. Biomass continued to decline but substantial increases were noted with dollar sunfish and largemouth bass fry. It is noteworthy that recruitment of these bass fry (taken in June samples) was relatively poor as only 16 young-of-year/acre were recovered during renovation in August.

Trends in Suwannee Pond were similar to those in Pasco Pond. First year data contained 13 species. Numbers and weights by species are presented in Table 5. Dominant species were swamp darter, mosquitofish, warmouth, bluegill, and pigmy sunfish. Swamp darter and mosquitofish ranked first and second by number, respectively.

Data for the first year after grass carp introduction showed a diversity loss of five species. These were pigmy sunfish, bluespotted sunfish, golden topminnow, lake chubsucker and golden shiner. Bluegill and swamp darter were first and second in dominance by number. Changes in biomass and numbers are illustrated in Table 5.

During the final year, six species were represented in Wegener ring samples. Changes in species diversity showed a loss of three additional fishes. These were dollar sunfish, lined topminnow, and warmouth. Everglades pygmy sunfish reappeared in the samples. Biomass estimates (wt.) showed a substantial decline compared to previous years (Table 5).

Summarized data for both ponds showed similar trends. There was a noticeable reduction in number of species, shifts in species dominance and reduction in biomass for several fishes. Seven species were eliminated from the combined populations based on renovation data. These were blackbanded sunfish, redfin pickerel, brook silverside, banded topminnow, pygmy killifish in Pasco Pond and spotted sunfish and bluespotted sunfish in Suwannee. Wegener ring data showed a close correlation between relative abundance and diversity of shallow water fishes and reduction of aquatic vegetation cover (Ware et al., 1975).

CONCLUSIONS

The data presented in this report demonstrate significant adverse effects on native fish populations when high numbers of grass carp are used for vegetation control. Largemouth bass populations were reduced or negatively altered, especially production of catchable size bass and sub-adults. In one pond the bluegill population structure shifted towards overcrowding and large fish were substantially reduced. Condition factors for adult bluegill decreased at both sites. The warmouth population in Pasco Pond showed a major decline in both numbers and biomass. Coarse species increased substantially in Suwannee Pond. Seven fish species were eliminated from the combined endemic populations.

Table 4. Shallow water fishes collected from Pasco Pond using Wegener rings, 1973-1975.

	1973		*1974*		*1975*	
	Pre-grass Carp		*Post-grass Carp*		*Post-grass Carp*	
	No.	*Wt. (gms.)*	*No.*	*Wt. (gms.)*	*No.*	*Wt. (gms.)*
Lake chubsucker	347	1,054.72	19	160.90	104	62.90
Warmouth	105	314.98	138	82.00	13	30.90
Mosquitofish	205	43.14	131	20.20	53	14.20
Everglades pygmy sunfish	18	1.46	4	0.60	10	1.50
Lined topminnow	27	30.10	35	26.30	4	1.70
Least killifish	19	2.20	9	1.56	5	0.10
Redear	2	3.18	—	—	—	—
Bluespotted sunfish	157	140.70	36	14.40	—	—
Pygmy killifish	4	0.73	1	0.01	—	—
Redfin pickerel	14	23.94	—	—	—	—
Swamp darter	77	18.51	108	23.90	142	15.20
Largemouth bass	5	13.65	3	1.30	218	31.60
Bluegill	72	58.49	207	272.90	10	38.60
Dollar sunfish	2	11.86	3	4.50	441	151.20
Blackbanded sunfish	6	2.40	—	—	—	—
Golden topminnow	67	54.17	6	1.505	—	—
Bluefin killifish	1	0.08	—	—	—	—
Banded topminnow	—	—	1	2.50	—	—
TOTALS	1,128	1,774.31	701	612.57	1,000	347.90

Table 5. Shallow water fishes collected from Suwannee Pond using Wegener rings, 1973-1975.

	1973		*1974*		*1975*	
	Pre-grass Carp		*Post-grass Carp*		*Post-grass Carp*	
	No.	*Wt. (gms.)*	*No.*	*Wt. (gms.)*	*No.*	*Wt. (gms.)*
Everglades pygmy sunfish	49	7.09	—	—	4	0.20
Dollar sunfish	7	39.39	5	18.00	—	—
Bluespotted sunfish	11	14.30	—	—	—	—
Mosquitofish	139	29.48	3	1.40	21	4.50
Warmouth	62	148.55	12	341.40	—	—
Swamp darter	148	38.31	50	13.40	83	16.00
Bluegill	60	345.64	68	279.40	166	118.40
Least killifish	22	1.75	1	0.10	2	0.10
Golden topminnow	7	2.72	—	—	—	—
Largemouth bass	3	5.96	1	41.30	5	11.70
Golden shiner	9	1.24	—	—	—	—
Lined topminnow	10	11.10	5	7.40	—	—
Lake chubsucker	1	56.40	—	—	—	—
Totals	528	701.93	145	702.40	281	150.90

A basic assumption with this project was that high numbers of grass carp would be necessary to reduce plant communities in a relatively short period of time. Sutton (1974) demonstrated that control of submerged aquatic vegetation (*Hydrilla verticillata*) in Florida ponds required over 200 pounds of grass carp/acre. He concluded that weed control using grass carp would be more effective in conjunction with chemical or mechanical methods.

We believe most of the changes in Suwannee and Pasco Ponds resulted from two essential factors. First, both lakes were macrophyte-based systems requiring aquatic vegetation for biological health and maintenance. Changes in this basic structure through feeding activity of the grass carp (eliminating aquatic vegetation) altered all trophic levels with a resultant negative response in top level predators (Gasaway, 1976). Secondly, the stocking density of grass carp exceeded carrying capacity estimates for any native species in either lake. Therefore, it is appropriate to consider that such poundages of large fish introduced into "balanced" systems would cause dramatic and extensive impacts on food, space and habitat requirements of other organisms.

In Florida lakes the value of rooted aquatic vegetation for the production of sport fishes, especially largemouth bass, has been demonstrated by several workers (Wegener and Holcomb, 1972; Wegener et al., 1974; Ware et al., 1975). In both study ponds, grass carp eliminated the dominant submerged aquatic plants within nine months after stocking. Emergent plants, i.e., lilies, watershield and umbrella-grass, were also eliminated or substantially reduced. Both sites were essentially void of vegetation at study termination (Drda, 1976). Accordingly, the production and stability of sport fish populations were substantially altered, at least in part, as a basic response to the loss of aquatic vegetation.

Based on these findings, further use of grass carp in Florida should be restricted to closed, highly manageable situations where the fish can be easily removed. The establishment of this species in public waters either by escapement and natural reproduction or wholesale stocking would have potentially harmful effects on Florida's largemouth bass and the sport fishing industry.

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