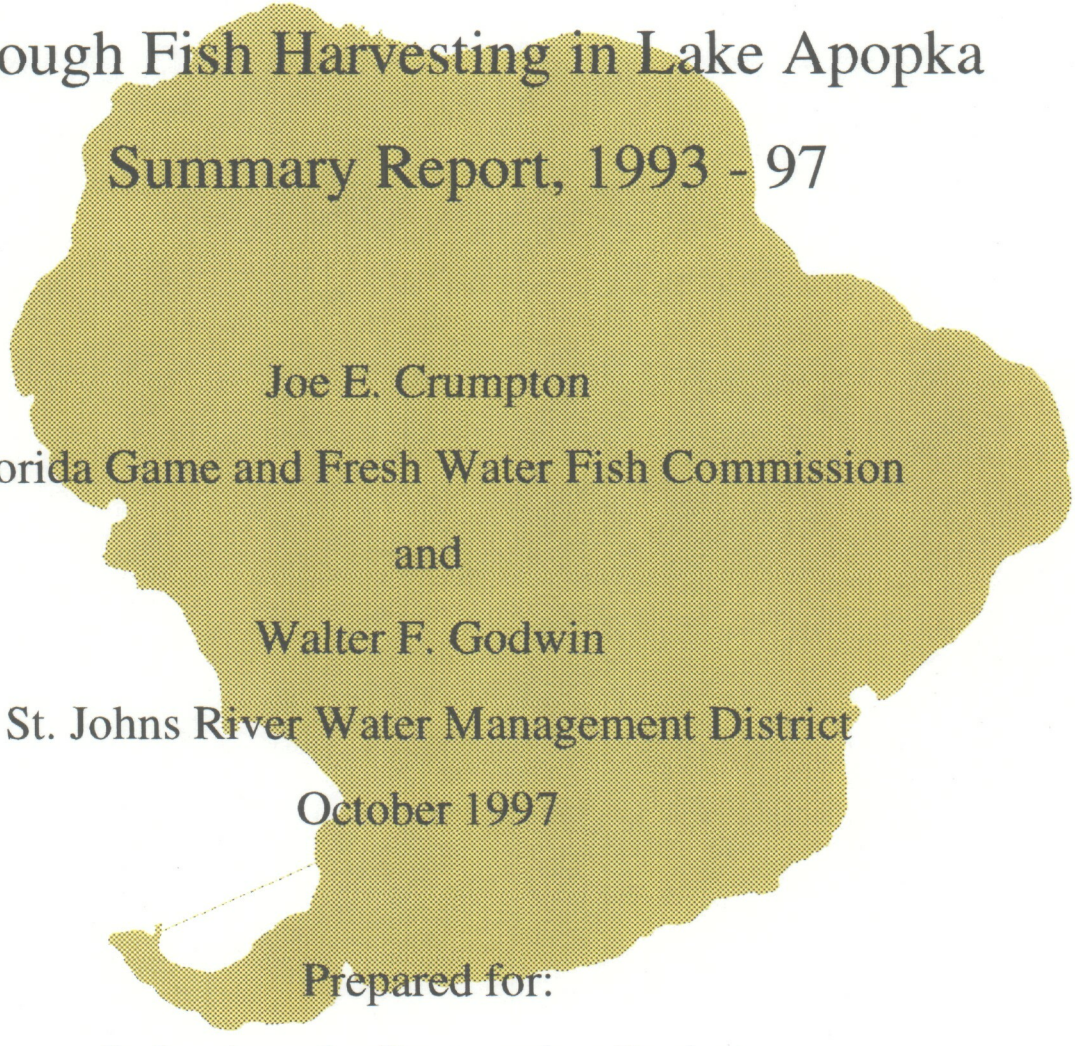
Special Publication SJ97-SP23

# Rough Fish Harvesting in Lake Apopka

# Summary Report, 1993 - 97



Joe E. Crumpton

Florida Game and Fresh Water Fish Commission

and

Walter F. Godwin

St. Johns River Water Management District

October 1997

Prepared for:

Lake Apopka Restoration Project

St. Johns River Water Management District

## EXECUTIVE SUMMARY

Lake Apopka is a shallow, hypertrophic 12,400-hectare (ha) lake located in Lake and Orange counties and is approximately 24 kilometers (km) northwest of Orlando, Florida. Degradation of the lake began with construction of canals to lower the level of the lake, alteration of the lake marshes to create "muck farms," and the loading of nutrients to the lake from point and nonpoint sources. The first major algal bloom reportedly occurred in the lake in 1947. Completion of a water control structure in 1956 on the Apopka-Beauclair Canal dampened long-term water-level fluctuations in the lake. Sportfishing has declined in the lake since the 1950s and lake water quality has deteriorated from nutrient loading to the point that the lake experiences continuous algal blooms. The decreased water clarity has eliminated most submerged vegetation and the continuous sedimentation of algal cells has resulted in accretion of a flocculent sediment layer over one foot thick in most areas of the lake. The lake is currently used primarily for the harvest of catfish and gizzard shad and recreational fishing remains poor.

The St. Johns River Water Management District (SJRWMD) requested that the Florida Game and Fresh Water Fish Commission (GFC) allow the large-scale harvest of rough fish from the lake. The fish removal would export nitrogen and phosphorus from the lake as well as potentially change the lake food chain. Target fish species were gizzard shad, gar, and tilapia. The suggested method of harvest was by commercial gill nets. Because largemouth bass and sunshine bass had been stocked in the lake and recent creel censuses suggested a potential resurgence of the black crappie stocks, by-catch from the rough-fish harvest would be evaluated to determine any potential detrimental effects of the harvesting activity to the gamefish stocks in the lake.

Permits to harvest target fish species by gill net were issued by the GFC. Ten permits were issued to commercial fishermen in 1993, 20 in 1994, 30 in 1995 and 1996, and 21 in 1997. The winter-spring fishery usually operated from January through May. The summer-fall fishery was established in 1995 for the warm-weather period of the year. For this fishery, a total of 30 permits to harvest rough fish by commercial gill net was provided to the Organized Fishermen of Florida (OFF) for distribution among its members. In addition, other potential harvesting gear (a modified purse/gill net and a modified "pair trawl") were tested in the lake in 1995 and 1996.

The total catch of gizzard shad from both fisheries ranged from a high of almost 1.7 million pounds in 1994 to a low of about 636,000 pounds in 1995. The average daily catch of gizzard shad ranged from a high of 3,425 pounds/boat/day in 1995 to a low of 2,201 pounds/boat/day in 1997. The highest annual catch of gar was 12,779 pounds in 1995. Catches of tilapia were never of significance.

From January 1993 through June 1997 commercial fishermen harvested a total of about 5,467,484 gizzard shad weighing about 4,888,813 pounds from Lake Apopka. Harvesting removed about 178 fish/acre and exported about 34,322 pounds of phosphorus and 102,665 pounds of nitrogen from the lake. A stock assessment completed in 1995 indicated the most probable population of harvestable gizzard shad prior to the 1995 harvest to be about 3,877,582 fish or about 127 fish/acre. The highest of three estimates for the harvestable gizzard-shad stock in 1996 was 2,073,744 fish or about 68 fish/acre. The lowest stock estimate for 1996 was about 726,288 harvestable gizzard shad or about 24 fish/acre. The estimated harvest for 1996 was about 1,186,364 shad or about 39 fish/acre. Even allowing for production and growth of young shad, commercial fishermen have apparently harvested a significant portion of the standing stock of adult gizzard shad in the lake. A decline in the lake gizzard-shad stock is further supported by a decrease in mean weight of harvested shad from 1.3 pounds to 0.7 pounds per fish between 1993 and 1996.

A number of unsuccessful attempts were made to market gizzard shad for human consumption which included test marketing of gizzards and roe. Most gizzard shad harvested from Lake Apopka were marketed as bait for the crayfish industry in Louisiana and for the blue-crab fishery in Florida and Louisiana. The economic returns to both the commercial fishermen and fish processor were low or nonexistent because of high harvest costs experienced by the fishermen and high processing, shipping, and handling costs experienced by the fish processor. Even when the cost of harvesting and marketing was shared by SJRWMD, the economic incentive to remove gizzard shad from Lake Apopka was very limited and both commercial fishermen and processors will participate in the program only when other fishing opportunities are limited.

The catch of non-target fish species from observed commercial gill nets was low with gizzard shad comprising an average of 98 percent of the total catch. Black crappie was the species taken most often as by-catch with catfish, sunshine bass, redear sunfish,

bluegill sunfish, largemouth bass, bowfin, and Atlantic needlefish being taken infrequently. The total gamefish catch from all commercially-fished gill nets over the 1993-97 period was calculated to be 30,636 fish or less than one gamefish per acre of lake.

Initial mortality of gamefish caught in commercial gill nets during the 5-year period was 1,684 fish. The majority of this mortality was black crappie. A total of 443 gamefish taken in commercial gill nets was placed in "holding pens" and observed for 48 hours to determine secondary mortality. High survival of gamefish was observed during the winter-spring fishery period (84 percent). Survival of gill-net caught fish in the summer-fall fishery period was lower (40 percent); control fish taken by electrofishing experienced similar mortality (50 percent). Total gamefish mortality from harvesting about 5.5 million gizzard shad was estimated to be about 7,218 fish over the 5-year period of the project.

Modified purse gill nets and trawls were not successful for harvesting gizzard shad in Lake Apopka; however, standard gill nets were found to be an appropriate method for harvesting target fish species from the lake. Catches were adequate for large-scale fish removal and the incidental catch of non-target species was low. The survival of gill-net caught and released gamefish was very high during the winter-spring fishery period. Warm weather survival was lower but results were inconclusive because of similar low survival of gamefish taken by electrofishing and used as controls. Overall, the impact to gamefish from harvesting gizzard shad from the lake was insignificant. Harvesting appeared to have a substantial impact on the gizzard-shad stock and was responsible for significant nutrient removal from the lake. Current market demand for gizzard shad from Lake Apopka is low and attempts to develop new markets for products from the fish have not been successful. Because of the weak market position, the harvesting of gizzard shad from the lake is not yet self-sustaining.

# Table of Contents

# List of Figures and Tables

# INTRODUCTION

Lake Apopka, although termed the fourth largest of Florida's natural lakes, functions technically as a reservoir since the installation of a structure on the Apopka-Beauclair Canal in 1956. Since that time, water-level fluctuation has been substantially dampened. Prior to the 1950s, excellent fishing for largemouth bass (*Micropterus salmoides*), black crappie (*Pomoxis nigromaculatus*), and bream gave the lake a nationwide reputation and the lake was considered to be a sportfishing paradise (Burgess 1964). As many as 18 fishing resorts and camps thrived along the eastern and southern shores of the lake until the early 1950s. The first algal bloom was documented in 1947 (DeQuine 1950). Sportfishing success has continually declined since that time and the lake has evolved into a hypereutrophic, algal-ridden body of water used mainly for the harvest of catfish by the local commercial fishing industry.

Following a mandate to improve the water quality of Lake Apopka, the St. Johns River Water Management District (SJRWMD) requested that the Florida Game and Fresh Water Fish Commission (GFC) allow the large-scale harvest of rough fish to remove nitrogen and phosphorus from the lake. Development of this fishery would allow access to a previously unused resource. The suggested method of harvest was by gill net and it was also suggested that commercial fishermen be permitted to harvest gar (*Lepisosteus* spp.) and tilapia (*Tilapia aurea*) as well. The project would be managed by personnel of the GFC Commercial Fisheries Project and entail harvest, processing, and sale of fish by a commercial fish company or companies. The catch of non-target species would need to be evaluated because GFC had stocked largemouth bass and sunshine bass *(Morone saxitilis* X *M. chrysops)* in the lake and recent creel censuses suggested a potential resurrection of the black crappie fishery,

A rough-fish removal program was initiated in 1993 in cooperation with GFC. The initial objectives of the project were to determine if gill nets could produce a large-scale harvest of rough fish at reasonable cost with insignificant impact to gamefish stocks in the lake. Later stages of the program were devoted to maximizing the removal of gizzard shad from the lake. This report provides results of the rough-fish removal program for the 1993-97 period.

## STUDY AREA

Lake Apopka is a shallow, hypertrophic lake located in Lake and Orange counties (Figure 1) and is approximately 45 miles (24 km) northwest of Orlando, Florida. Historically, the lake covered an area of about 50,000 acres (20,200 ha) and was the second largest lake in Florida. The lake was characterized by extensive marshes in the northern portion, by clear water with abundant submersed aquatic vegetation, and as a nationally renowned sportfishing site. Degradation of the lake began with construction of canals to lower water levels in the lake, alteration of the lake marshes to create "muck farms," and the loading of nutrients to the lake from point and nonpoint sources. Because of the basin alterations, Lake Apopka is now only about 30,640 acres (12,400 ha). Sportfishing has declined in the lake since the 1950s and lake water quality has deteriorated from nutrient loading to the point that the lake experiences continuous algal blooms. The decreased water clarity has eliminated most submerged vegetation and continuous sedimentation of algal cells has resulted in development of a soft sediment layer over one foot (30 cm) thick in most areas of the lake. The lake is currently used primarily for the harvest of catfish and gizzard shad and recreational fishing remains poor.

## METHODS

Advertisements for commercial fishermen wishing to participate in the program were placed in newspaper classified sections. Information also was passed word-of-mouth through the commercial fishing community.

Permits were issued from the Tallahassee GFC office in 1993 and 1994, and by Commercial Fishery Project personnel at the Eustis Fisheries Research Laboratory in 1995, 1996, and 1997. Ten permits were available in 1993, 20 in 1994, and 30 in 1995, through 1997. Permits were filled in order of application receipt. Prior to issuance of the permits, applicants were subjected to law enforcement background checks, and boats and equipment were inspected by GFC personnel to verify that permit criteria were met.

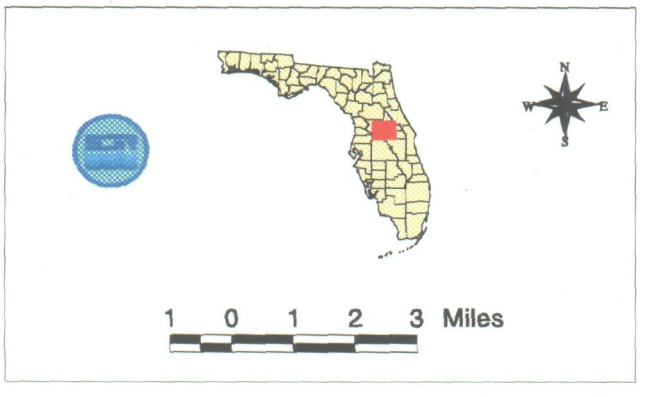




Figure 1

Counties, Roads, and Other Features Local to Lake Apopka

In 1993 and 1994, fish harvested during the winter-spring segments (gizzard shad and gar) were handled and processed by Fisherman's Market of Ocala, Florida. Fish were off-loaded (shoveled) from one to three boats at a time into wooden vats of 1,100 to 1,500 lb (500 to 680 kg) capacity, weighed by certified digital scale, and carried by forklift to a refrigerated truck. Fish were trucked to Fisherman's Market where shad were bagged in 50 lb (22.7 kg increments), boxed, and flash frozen for shipment. Gizzard-shad roe and gizzards were removed from some fish, packaged in 5 lb (2.3 kg) bags, frozen, and shipped to the Far East and Europe for test marketing. Gar were skinned and filleted by hand, bagged in 5, 10, and 20 lb (2.3, 4.6, and 9.1 kg ) increments, boxed, and frozen for shipment.

In 1995 and 1996, harvested gizzard shad, gar, and tilapia were handled and processed by Raffield Fish Company, Port St. Joe, Florida. Fish were off-loaded into 80 lb (36.4 kg) baskets, dumped onto a mechanized conveyor, dumped into wooden vats of 1,500 lb (680 kg) capacity, weighed (digital scale), iced, and carried by forklift to a refrigerated truck. Fish were trucked to the Port St. Joe facility, processed through a brine tank (a tank with refrigerated salt water that lowered fish temperature to almost freezing), bagged in 25, 50, and 75 lb (11.4, 22.7, and 34.1 kg) increments, and frozen for shipment.

A second harvest program was implemented in July 1995. The program allowed Organized Fishermen of Florida (OFF) to issue up to 30 permits for individual commercial fishermen to harvest target fish to use themselves as blue-crab bait or for local sales. Rules for permittees were the same as in the winter-spring fishery with the exception that commercial fishermen could fish as few or many days as they wished. Permits were acquired by commercial fishermen on a weekly basis by contacting OFF. Fishermen were periodically observed by GFC personnel, and catch of both target and non-target fish species was documented.

Daily catch weights were recorded for each permittee in the form of a weight voucher or trip ticket by a representative of the fish company at dockside. Trip tickets were collected weekly by GFC or OFF personnel. Randomly selected commercial fishermen were observed and catches for specific time periods documented from 2 to 3 days a week during harvest periods. Catches were periodically sampled and measurements were taken from target and non-target species by GFC personnel. Fish

were measured to the nearest millimeter (mm) for total length (TL) and weighed to the nearest gram (gm). Catch per unit of effort (CPUE) was expressed in standard fishing units (SFU) with an SFU equal to 100 meters of net fished for 1 hour.

Initial mortality of gamefish species was assessed by counting gamefish released from the gill nets and documenting the number that did not recover quickly after release. Secondary mortality of gamefish species released from commercial catches and observed for longer time periods also was assessed. Up to 25 gamefish were collected from commercially-fished nets and retained in a holding pen for 48 hours. Control fish were obtained by electrofishing and also placed in holding pens as with gill-net caught fish. Fish were checked at 24- and 48-hour intervals. Holding pens were constructed of four fiberglass rings approximately 5 ft (1.5 m) in diameter covered with 2.5 inch (62 mm) stretch mesh nylon webbing. Pens were approximately 10 ft (3 m) long. Dates, species held, initial numbers held, numbers survived, dissolved oxygen concentrations, and surface temperatures were recorded for each mortality run. Up to four pens were located around the lake to minimize the time between removal of gamefish from gill nets and placement of the fish in holding pens.

Two types of alternative fishing gear were tested for appropriateness for this program. A modified purse/gill net of 4 in (102 mm) stretch mesh, $\pm$ 600 yd (549 m) length was modified with rings on the weight line and tested in winter-spring 1995. The net was stretched, circled, and the bottom pursed. The net was pulled on board and the fish were removed. A modified pair trawl was tested in winter-spring of 1996. The trawl body was of 2.5 in (63 mm) stretch netting and was approximately 56 ft (17 m) in length. Wings, approximately 56 ft (17 m) in length, 11 ft (3.3 m) deep, of 4 in (102 mm) stretch mesh were attached to the trawl-net body. The net was towed by two boats for durations of 10 to 30 minutes. Fish taken were counted by species and non-target fish species released. Samples of non-target fish species were assessed for secondary mortality by retention in holding pens.

## RESULTS AND DISCUSSION

### Fish Harvest

The winter-spring cost-shared fishery operated from 1993 through 1996. Table 1 includes data from each of these periods. The winter-spring gizzard-shad catch was highest in 1994 when the harvest was estimated at 1,686,406 lb (764,942 kg). The lowest catch was in 1995 with only 477,408 lb (216,549 kg) being taken. The catch of gar was highest in 1995 at 12,604 lb (5,717 kg) and was lowest in 1993 at 5,007 lb (2,271 kg). Catches of tilapia were never of significance.

The summer-fall fishery operated in 1995 and 1996. Table 2 includes data from these periods. The harvest from this activity was much smaller than from the winter-spring fishery with an estimated 158,669 lb (71,971 kg) of gizzard shad being harvested in 1995 and 67,971 lb (30,831 kg) harvested in 1996.

Through June 1997 commercial fishermen harvested a total of 4,888,813 lb (2,217,527 kg) of gizzard shad from Lake Apopka ( ~5,467,484 fish or 178 fish/acre [441 per ha]). This fish catch was responsible for the removal of more than 34,322 (16 metric tons) of phosphorus and 102,665 lb (47 metric tons) of nitrogen from Lake Apopka. In a preliminary stock assessment of gizzard shad in Lake Apopka for 1995 (Schramm and Pugh 1996), the most probable population estimate for shad > 7 inches (280 mm) was 3,877,582 fish (127 per acre [313 per ha]) with an estimated biomass of 4,841,068 lb (2,195,874 kg) or 158 lb/acre (157 kg/ha). Estimates for the harvestable stock in 1996 (Schramm and Pugh 1997) ranged from 2,073,744 (68 fish/acre) to 726,288 (24 fish/acre). The estimated harvest for 1996 was about 1,186,364 shad (39 fish/acre). Based on these population estimates, the decline in annual harvest rate is likely related to the impact netters have had on the adult gizzard-shad population over the past four years. Mean weight for gizzard shad harvested remained the same between 1993 and 1994 at 1.3 lb (0.6 kg). In 1995 the mean weight decreased to 1.0 lb (0.4 kg), and further to 0.7 lb (0.3 kg) in 1996. Even allowing for production and growth of young shad, commercial fishermen have harvested a significant portion of the estimated standing crop of adult shad.

**Table 1. Winter-spring gizzard-shad harvest from Lake Apopka**

| Time Period | Total Catch (kg) | Daily Catch (kg) | | | Permits Fishing | Shad Removed |
|---|---|---|---|---|---|---|
| | | Low | High | Average | Number | (#/ha) |
| Jan-May 1993 | 408,388 | 97 | 3,131 | 1,487 | 9 | 55 |
| Jan-May 1994 | 764,942 | 36 | 4,857 | 1,480 | 18 | 103 |
| Jan-Apr 1995 | 216,549 | 78 | 2,405 | 880 | 12 | 38 |
| Mar-May 1996 | 237,729 | 27 | 2,226 | 596 | 7 | 64 |
| Jan-June 1997 | 487,117 | 17 | 5,007 | 985 | 10 | 131 |

**Table 2. Summer-fall gizzard-shad harvest from Lake Apopka**

| Time Period | Total Catch (kg) | Daily Catch (kg) | | | Permits Fishing | Shad Removed |
|---|---|---|---|---|---|---|
| | | Low | High | Average | Number | (#/ha) |
| Aug-Dec 1995 | 71,971 | 15 | 1,261 | 673 | 12 | 13 |
| July-Dec 1996 | 30,831 | 50 | 1,229 | 514 | 12 | 8 |

## Marketing

Commercial fishermen participating in the program were paid $0.08 per lb ($0.18 per kg) of shad caught in 1993 and 1994. Gizzard shad were marketed by processors for crayfish (*Cambarus* spp.) bait in Louisiana and as blue-crab (*Callinectes sapidus*) bait in Florida and Louisiana during and following the 1993 and 1994 harvest periods. Prices received by processors in the bulk-bait market usually ranged from $0.16 to $0.17 per lb ($0.35 to $0.37 per kg) in 1993 and 1994. Small volumes of bait were sold to local blue-crab fishermen for as much as $0.22 per lb ($0.48 per kg) in 1993 and $0.23 per lb ($0.51 per kg) in 1994. Gar fillets were marketed in Louisiana for $2.00 per lb ($4.40 per kg) in 1993. More than 600 lb (272 kg) of roe and 300 lb (136 kg) of gizzards from shad were processed and shipped to the Far East and Europe in 1993 for test marketing. Roe and gizzards were sold at $2.50 per lb ($5.50 per kg) to foreign markets. Market acceptance was poor because the roe reportedly contained too many large veins and did not present well in packages. Also, gizzards were considered too dark in color. As a result, limited interest was shown in using these products even though roe and gizzards were rated "good" in palatability tests.

The majority of gizzard shad harvested from winter-spring period in 1995,1996, and 1997 also were sold to Louisiana's crayfish and blue-crab industries. Bulk market prices remained the same in 1995 as in 1993 and 1994 at $0.16 to $0.17 per lb ( $0.35 to $0.37 per kg), but increased in 1996 to $0.17 to $0.20 per lb ($0.37 to $0.44 per kg). Attempts were made to generate interest in gizzard shad from pet-food processors, but these contacts were not successful primarily because marine fish resources (scrap fish) are readily available at lower prices. Most pet-food processing facilities are located near marine ports in close proximity to landing points for the marine scrap-fish resource. Handling and transportation costs required to make Lake Apopka gizzard shad available to bulk-bait markets weakens the competitive position of shad. Proposed changes in entanglement-net and purse-seine regulations in Gulf coast (i.e., Louisiana) and south Atlantic coast (i.e., North Carolina and Virginia) states could impact the availability of competitive bait sources (menhaden and herring). Until the competing bait sources are significantly decreased, the prognosis for improved markets for Lake Apopka gizzard shad is not good. Interest in harvesting gizzard shad has been limited even though price to the commercial fishermen dockside (ex-vessel) increased to $0.10 per lb ($0.22 per kg) in

1995, and further to $0.12 per lb ($0.26 per kg) in 1996 and 1997. Because commercial fishermen are not local, the financial return for their fishing effort must be higher than usual because they must pay costs for food and lodging while harvesting fish.

Fisherman's Market reportedly suffered a financial loss from their participation in the winter-spring 1993 fishery. The cost of fish removal was shared by SJRWMD beginning in 1994 when Fisherman's Market was reimbursed $0.07 per lb ($0.15 per kg) of gizzard shad purchased from Lake Apopka. The company reportedly could not harvest and market fish at a profit in 1994 even with the partial cost reimbursement by SJRWMD. In 1995 Raffield Fish Company was contracted by SJRWMD to purchase and process fish and was reimbursed $0.10 per lb ($0.22 per kg) for shad removed from the lake. The reimbursement was increased to $0.16 per lb ($0.37 per kg) in 1996 with $0.12 per lb ($0.26 per kg) being paid to the commercial fishermen and $0.04 per lb being paid to Raffield Fish Company.

Gizzard shad harvested during the summer-fall period in 1995 and 1996 were marketed entirely in Florida by the commercial fishermen who harvested them with no cost sharing by SJRWMD. Gizzard shad were sold as bait to blue-crab commercial fishermen and used as line bait and chum by longline operators. Bait prices were normally dictated by whether bait was delivered to dealers or picked up at the lake. Prices ranged from $0.20 to $0.25 per lb ($0.44 to $0.55 per kg) delivered, and from $0.17 to $0.20 per lb ($0.37 to $0.44 per kg) picked up at the lake.

## Observed Gill Nets

### Composition

Between late January 1993 and the end of June 1997, Commercial Fishery Project personnel observed 894 commercially-fished gill-net sets in six fishing periods on the lake. The observed net sets caught 236,005 fish. Summaries of catches (number) and composition from these observations are shown in Table 3. Gizzard-shad composition in observed fishing operations ranged from 96 to 99 %. Among nongame species observed, catfish composition ranged from 0.03 to 0.29 %, gar from 0.13 to 0.44 %,

**Table 3.** **Catch and species composition from observed commercial gill nets in Lake Apopka**

| Year | Species | Number Caught | Percent of Total No. |
|---|---|---|---|
| 1993 | Gizzard shad | 62,411 | 98.47 |
| | Gar | 277 | 0.44 |
| | Catfish | 47 | 0.07 |
| | Tilapia | 357 | 0.56 |
| | Black crappie | 256 | 0.40 |
| | Sunshine bass | 22 | 0.04 |
| | Redear sunfish | 12 | 0.02 |
| | argemouth bass | 1 | < 0.01 |
| | Bowfin | 1 | < 0.01 |
| | **Totals** | **63,384** | |
| 1994 | Gizzard shad | 19,663 | 98.70 |
| | Gar | 37 | 0.19 |
| | Catfish | 7 | 0.04 |
| | Tilapia | 39 | 0.20 |
| | Black crappie | 172 | 0.86 |
| | Sunshine bass | 4 | 0.02 |
| | **Totals** | **19,922** | |
| 1995 | Gizzard shad | 44,298 | 98.71 |
| | Gar | 108 | 0.24 |
| | Catfish | 14 | 0.03 |
| | Tilapia | 36 | 0.08 |
| | Black crappie | 391 | 0.87 |
| | Sunshine bass | 30 | 0.07 |
| | Redear sunfish | 1 | < 0.01 |
| | Largemouth bass | 1 | < 0.01 |
| | **Totals** | **44,879** | |

**Table 3. Catch and species composition from observed commercial gill nets in Lake Apopka (continued)**

| Date | Species | Number Caught | Percent of Total No. |
|---|---|---|---|
| 1996 | Gizzard shad | 58,630 | 95.95 |
| | Gar | 82 | 0.13 |
| | Catfish | 133 | 0.22 |
| | Tilapia | 203 | 0.33 |
| | Black crappie | 1,992 | 3.26 |
| | Bluegill sunfish | 8 | 0.01 |
| | Sunshine bass | 53 | 0.09 |
| | Redear sunfish | 6 | 0.01 |
| | Atlantic needlefish | 1 | < 0.01 |
| | **Totals** | **61,108** | |
| 1997 | Gizzard shad | 45,026 | 96.39 |
| | Gar | 78 | 0.17 |
| | Catfish | 134 | 0.29 |
| | Tilapia | 62 | 0.13 |
| | Black crappie | 1,331 | 2.85 |
| | Bluegill sunfish | 72 | 0.15 |
| | Redear sunfish | 9 | 0.02 |
| | **Totals** | **46,712** | |
| 1993-1997 | Gizzard shad | 230,028 | 97.47 |
| | Gar | 582 | 0.24 |
| | Catfish | 335 | 0.14 |
| | Tilapia | 697 | 0.30 |
| | Black crappie | 4,142 | 1.76 |
| | Sunshine bass | 109 | 0.05 |
| | Bluegill sunfish | 80 | 0.03 |
| | Redear sunfish | 28 | 0.01 |
| | Largemouth bass | 2 | < 0.01 |
| | Atlantic needlefish | 1 | < 0.01 |
| | Bowfin | 1 | < 0.01 |
| | **Totals** | **236,005** | |

tilapia 0.08 to 0.56 %, and Atlantic needlefish and bowfin appeared in only one segment with less than 0.01 %. Black crappie was the most abundant gamefish species observed but composition ranged only from 0.40 to 3.26 %. Crappie were followed by bluegill sunfish with compositions from 0.01 to 0.15 %, redear sunfish from 0.01 to 0.02 %, sunshine bass from 0.02 to 0.09 %, and largemouth bass less than 0.01 %.

Overall, gizzard shad comprised the greatest portion of the catch by number (97.47 %), followed by black crappie (1.76 %), tilapia (0.30 %), gar (0.24 %), catfish (0.14 %), sunshine bass (0.05 %), redear sunfish (0.01 %), and Atlantic needlefish, bluegill sunfish, bowfin and largemouth bass (<0.01 %).

Catch Per Unit of Effort

Between late January 1993 and the end of June 1997, Commercial Fisheries Project personnel observed 225,119 m of gill net fished for 5,239.9 SFU. CPUE (number) from observed gill nets are summarized in Table 4. Gizzard-shad CPUE ranged from 26.1 to 82.4 and averaged 43.9 for the period of observation. CPUE for all species of gamefish combined ranged from 0.38 to 1.17 and averaged 0.83.

**Table 4. Catch and effort from observed commercial gill nets in Lake Apopka**

| Year | Species | Number Caught | No. / Hectare | Number/ CPUE | SFU |
|---|---|---|---|---|---|
| 1993 | Gizzard shad | 62,411 | 5.03 | 82.36 | |
| | Gar | 277 | 0.02 | 0.36 | |
| | Catfish | 47 | < 0.01 | 0.06 | |
| | Tilapia | 357 | 0.03 | 0.47 | |
| | Black crappie | 256 | 0.02 | 0.34 | |
| | Sunshine bass | 22 | < 0.01 | 0.03 | |
| | Redear sunfish | 12 | < 0.01 | 0.02 | |
| | Largemouth bass | 1 | < 0.01 | < 0.01 | |
| | Bowfin | 1 | < 0.01 | < 0.01 | |
| | **Totals** | **63,384** | **5.11** | **83.64** | **757.8** |
| 1994 | Gizzard shad | 19,663 | 1.59 | 66.77 | |
| | Gar | 37 | < 0.01 | 0.13 | |
| | Catfish | 7 | < 0.01 | 0.02 | |
| | Tilapia | 39 | < 0.01 | 0.13 | |
| | Black crappie | 172 | 0.01 | 0.58 | |
| | Sunshine bass | 4 | < 0.01 | 0.01 | |
| | **Totals** | **19,922** | **1.61** | **67.65** | **294.5** |
| 1995 | Gizzard shad | 44,298 | 3.57 | 59.98 | |
| | Gar | 108 | 0.01 | 0.15 | |
| | Catfish | 14 | < 0.01 | 0.02 | |
| | Tilapia | 36 | < 0.01 | 0.05 | |
| | Black crappie | 391 | 0.03 | 0.53 | |
| | Sunshine bass | 30 | < 0.01 | 0.04 | |
| | Redear sunfish | 1 | < 0.01 | < 0.01 | |
| | Largemouth bass | 1 | < 0.01 | < 0.01 | |
| | **Totals** | **44,879** | **3.62** | **60.76** | **738.6** |

**Table 4. Catch and effort from observed commerical gill nets in Lake Apopka (continued)**

| Date | Species | Number Caught | No. / Hectare | Number/ CPUE | SFU |
|---|---|---|---|---|---|
| 1996 | Gizzard shad | 58,630 | 4.73 | 26.11 | |
| | Gar | 82 | 0.01 | 0.04 | |
| | Catfish | 133 | 0.01 | 0.06 | |
| | Tilapia | 203 | 0.02 | 0.09 | |
| | Black crappie | 1,992 | 0.16 | 0.89 | |
| | Bluegill sunfish | 8 | < 0.01 | < 0.01 | |
| | Sunshine bass | 53 | < 0.01 | 0.02 | |
| | Redear sunfish | 6 | < 0.01 | < 0.01 | |
| | Atlantic needlefish | 1 | < 0.01 | < 0.01 | |
| | **Totals** | **61,108** | **4.93** | **27.21** | **2,245.5** |
| 1997 | Gizzard shad | 45,026 | 3.63 | 37.41 | |
| | Gar | 78 | 0.01 | 0.07 | |
| | Catfish | 134 | 0.01 | 0.11 | |
| | Tilapia | 62 | 0.01 | 0.05 | |
| | Black crappie | 1,331 | 0.11 | 1.11 | |
| | Bluegill sunfish | 72 | 0.01 | 0.06 | |
| | Redear sunfish | 9 | < 0.01 | 0.01 | |
| | **Totals** | **46,712** | **3.77** | **38.81** | **1,203.5** |
| 1993-1997 | Gizzard shad | 230,028 | 18.55 | 43.90 | |
| | Gar | 582 | 0.05 | 0.11 | |
| | Catfish | 335 | 0.03 | 0.06 | |
| | Tilapia | 697 | 0.06 | 0.13 | |
| | Black crappie | 4,142 | 0.33 | 0.79 | |
| | Sunshine bass | 109 | 0.01 | 0.02 | |
| | Bluegill sunfish | 80 | 0.01 | 0.02 | |
| | Redear sunfish | 28 | < 0.01 | 0.01 | |
| | Largemouth bass | 2 | < 0.01 | < 0.01 | |
| | Atlantic needlefish | 1 | < 0.01 | < 0.01 | |
| | Bowfin | 1 | < 0.01 | < 0.01 | |
| | **Totals** | **236,005** | **19.03** | **45.04** | **5,239.9** |

Overall, gamefish CPUE was virtually identical between winter-spring and summer-fall periods in 1995. However, the difference was more marked in 1996 with black crappie CPUE for the winter-spring period substantially higher than the summer-fall period. If a trend exists, it would indicate black crappie were less vulnerable in summer-fall months, at least in 1996.

## Initial and Secondary Mortality

### Initial Mortality

The estimated initial mortality of gamefish caught in gill nets for each fishing period is shown in Table 5. The total estimated initial mortality of all species of gamefish combined for all fishing periods was 6,364 (6 %), or 0.23 fish/acre (0.51 fish/ha). The estimated annual initial mortality for black crappie ranged from 91 in 1995 to 2,722 in 1997, and the estimated total initial black crappie mortality was 5,922 or 0.22 fish/acre (0.48 fish/ha) for the 5-year observation period. Bluegill sunfish were caught only during the 1996 and 1997 fishing periods, and the total estimated initial mortality was 279 fish (10 %) , or 0.01 fish/acre (0.02 fish/ha). The estimated annual initial mortality for sunshine bass ranged from 0 to 79 fish and the total initial mortality was 133 (6 %), or <0.01 fish/acre (0.02 fish/ha). The estimated annual initial mortality for largemouth bass and redear sunfish was 0.0.

### Secondary Mortality

One of the greatest issues concerning commercial net fishing was whether or not gill nets kill gamefish in large numbers. Secondary mortality results of gill-net-caught gamefish from commercially-fished gill nets and retained in holding pens are shown in Table 6. Of the 403 fish held during winter-spring periods, 86 % survived. Most (56 %) of the mortality occurred after 24 hours. Of the 152 fish held during summer-fall periods, 31 % survived, and 57 % of the observed mortality occurred during the first 24 hours.

**Table 5. Estimated gamefish by-catch, initial mortality, and percent survival from commercial gill nets in Lake Apopka**

| Year | Species | Estimated Catch (#) | Estimated Initial Mortality (#) | Estimated Survival (%) |
|---|---|---|---|---|
| 1993 | Black crappie | 2,801 | 112 | 96.0 |
| | Sunshine bass | 240 | 11 | 95.4 |
| | Redear sunfish | 131 | 0 | 100.0 |
| | Largemouth bass | 11 | 0 | 100.0 |
| | **Totals** | **3,183** | **123** | **96.1** |
| 1994 | Black crappie | 11,183 | 324 | 97.1 |
| | Sunshine bass | 259 | 0 | 100.0 |
| | **Totals** | **11,442** | **324** | **97.2** |
| 1995 | Black crappie | 5,669 | 91 | 98.4 |
| | Sunshine bass | 433 | 79 | 86.4 |
| | Redear sunfish | 15 | 0 | 100.0 |
| | Largemouth bass | 15 | 0 | 100.0 |
| | **Totals** | **6,132** | **170** | **97.3** |
| 1996 | Black crappie | 41,588 | 2,703 | 93.5 |
| | Sunshine bass | 1,127 | 43 | 96.2 |
| | Bluegill sunfish | 170 | 64 | 62.4 |
| | Redear sunfish | 128 | 0 | 100.0 |
| | **Totals** | **43,013** | **2,810** | **93.5** |
| 1997 | Black crappie | 47,757 | 2,722 | 94.3 |
| | Bluegill sunfish | 2,594 | 215 | 91.7 |
| | Redear sunfish | 325 | 0 | 100.0 |
| | **Totals** | **50,676** | **2,937** | **94.2** |
| **1993-1997** | **Totals** | **114,446** | **6,364** | **94.5** |

**Table 6. Secondary mortality and percent survival of gamefish by-catch from commercial gill nets in Lake Apopka**

| Date Collected | Species | No. Held | Mort. 24h | Mort. 48h | % Survival | Temp. (C) |
|---|---|---|---|---|---|---|
| Winter/Spring 93 | Black crappie | 58 | 6 | 4 | 82.8 | 22.1 |
| | Largemouth bass | 3 | 2 | 0 | 33.3 | |
| | Redear sunfish | 2 | 0 | 0 | 100.0 | |
| | Sunshine bass | 1 | 0 | 0 | 100.0 | |
| Winter/Spring 94 | Black crappie | 62 | 2 | 5 | 88.7 | 20.0 |
| Winter/Spring 95 | Black crappie | 106 | 4 | 2 | 94.4 | 19.5 |
| | Sunshine bass | 6 | 0 | 0 | 100.0 | |
| Winter/Spring 96 | Black crappie | 94 | 5 | 13 | 80.9 | 21.7 |
| Winter/Spring 97 | Black crappie | 71 | 2 | 11 | 84.5 | 25.3 |
| **Totals** | | **403** | **21** | **35** | **86.1** | **21.7** |
| Summer/Fall 93 | Black crappie | 41 | 8 | 18 | 36.6 | 29.7 |
| | Bluegill sunfish | 5 | 0 | 0 | 100.0 | |
| | Largemouth bass | 4 | 2 | 0 | 25.0 | |
| | Redear sunfish | 8 | 0 | 0 | 100.0 | |
| Summer/Fall 94 | Black crappie | 5 | 0 | 0 | 100.0 | 29.5 |
| | Sunshine bass | 4 | 1 | 1 | 50.0 | |
| Summer/Fall 96 | Black crappie | 42 | 27 | 10 | 35.7 | 30.8 |
| | Redear sunfish | 3 | 1 | 1 | 33.3 | |
| Summer/Fall 97 | Black crappie | 40 | 21 | 15 | 10.0 | 31.4 |
| **Totals** | | **152** | **60** | **45** | **30.9** | **30.4** |

Control gamefish obtained by electrofishing were retained in holding pens along with gill-net-caught fish. Winter-spring fish numbered 195 of which 87 % survived (Table 7). Control gamefish were extremely difficult to collect during the summer-fall fishery period and numbered only 22, of which only 45 % survived. The majority of the mortality (75 %) occurred after 24 hours.

Some of the secondary mortality for control and gill-net fish may have been pen- or handling-related. All fish (net and control) were handled twice before being put into holding pens. Many of the surviving fish, both gill net and control, exhibited fin erosion, mucus loss, and scale loss at time of release from the holding pens. Crumpton (1982, unpublished data), Mazeaud et al. (1977), and Moring (1982) all indicated problems with fin erosion, fin splitting and scale loss in pen-held fish. These problems are likely related to stress from handling and confinement and physical damage from contact with the pen walls. Pen-and handling-related mortality would make estimated survival rates somewhat conservative. Temperature (Table 6) may have complicated survival. Survival rates were markedly higher in the winter-spring period than in the summer-fall period for both gill net and control fish. Almost all control fish mortality occurred when water temperature exceeded 20 $^{\circ}$C. Dissolved oxygen concentrations in holding pens during winter-spring ranged from 8.4 to 10.5 ppm (average = 9.5 ppm) during morning hours (samples = 6) and 8.0 to 11.5 ppm (average = 10.1 ppm) during afternoon hours (samples = 17). Summer-fall dissolved oxygen concentrations ranged from 5.2 to 13.9 ppm (average = 7.4 ppm) during morning hours (samples = 28). Therefore, dissolved oxygen was not considered to be a factor in fish mortality in holding pens.

An estimated 114,446 gamefish were taken as incidental catch during all fishing periods (winter-spring: 97,226; summer-fall: 17,220 ). Estimated secondary mortality of gamefish based on results of the pen study was 13,514 in winter-spring periods and 11,899 in summer-fall periods. The estimated total gamefish mortality from the 5- year fish removal effort was 31,777 fish or slightly over 1 fish/acre (2 fish/ha) of lake.

**Table 7. Secondary mortality and percent survival of gamefish collected by electrofishing in Lake Apopka**

| Date Collected | Species | No. Held | Mort. 24h | Mort. 48h | % Survival | Temp. (C) |
|---|---|---|---|---|---|---|
| Winter/Spring 94 | Black crappie | 134 | 4 | 10 | 89.5 | 19.0 |
| | Bluegill sunfish | 2 | 0 | 0 | 100.0 | |
| | Largemouth bass | 2 | 0 | 0 | 100.0 | |
| | Redear sunfish | 4 | 0 | 0 | 100.0 | |
| Winter/Spring 95 | Black crappie | 26 | 0 | 0 | 100.0 | 14.9 |
| | Bluegill sunfish | 1 | 0 | 0 | 100.0 | |
| | Largemouth bass | 1 | 0 | 0 | 100.0 | |
| Winter/Spring 97 | Black crappie | 25 | 1 | 10 | 56.0 | 22.5 |
| **Totals** | | **195** | **5** | **20** | **87.2** | **18.8** |
| Summer/Fall 93 | Black crappie | 4 | 1 | 3 | 0.0 | 29.6 |
| Summer/Fall 94 | Black crappie | 8 | 0 | 1 | 87.5 | 29.5 |
| | Sunshine bass | 4 | 1 | 2 | 25.0 | |
| Summer/Fall 97 | Black crappie | 6 | 1 | 3 | 33.3 | 31.7 |
| **Totals** | | **22** | **3** | **9** | **45.5** | **30.3** |

## Experimental Gear Evaluation

### Purse/Gill Net

In the first week of March 1995 on three occasions Raffield Fish Company attempted to catch gizzard shad in the lake with a purse/gill net. Commercial Fisheries Project personnel were present when the net was used. Each of the sets took approximately 3 to 4 hours. The mud bottom caused the net to bog down, making it difficult to pull and circle, or to roll up, making it almost impossible to purse. The first set caught 15 lb (6.8 kg) of shad with no incidental catch of nontarget species. The second set caught 25 lb (11.4 kg) of shad along with 2 catfish and 1 black crappie. The third set caught 75 lb (34.1 kg) of shad along with 2 black crappie. The weight line was lightened between attempts, but after the third try the commercial fishermen ceased operations. The commercial fishermen expended 57.75 SFU of effort for approximately 154 shad, an average catch rate of 2.7 shad per SFU. The catch rate for catfish was 0.03 per SFU and was 0.05 for black crappie. The incidental catch was released alive.

### Pair Trawl

Between March 25 and April 24, 1996 Raffield Fish Company attempted to catch gizzard shad using a modified "pair" trawl. The trawl was designed to be towed at or near the surface, but because of the vertical net height and the shallow water depth of the lake, fished the entire water column. Commercial Fisheries Project personnel observed a total of 16 tows. Attempts were made to modify the trawl four times during the evaluation period to improve catchability.

The results of trawl tows are shown in Table 8. As modifications were made to the trawl, gizzard-shad catch rates did increase, but as numbers of shad increased so did

**Table 8. Catch and effort in experimental trawl tows in Lake Apopka**

| Date | Time Trawled (Min.) | Catch G. Shad #(#/Min.) | Catch Gamefish #(#/Min.) | Catch Catfish (#) | Catch Other (#) | % |
|---|---|---|---|---|---|---|
| **Trawl Net** | | | | | | |
| 03/25/96 | 11 | 46 (4.2) | 2 (0.2) | 0 | 0 | 4.2 |
| 03/25/96 | 15 | 1 (0.1) | 2 (0.1) | 0 | 0 | 66.7 |
| 03/26/96 | 12 | 26 (2.2) | 0 (0.0) | 1 | 0 | 3.7 |
| **Totals** | **38** | **73 (1.9)** | **4 (0.1)** | **1** | **0** | **6.4** |
| **Trawl Net with Wings** | | | | | | |
| 04/09/96 | 22 | 90 ( 4.1) | 28 (1.3) | 15 | 7 | 35.7 |
| 04/09/96 | 32 | 60 ( 1.9) | 28 (0.9) | 3 | 7 | 38.8 |
| 04/09/96 | 27 | 80 ( 3.0) | 7 (0.3) | 1 | 2 | 11.1 |
| 04/10/96 | 25 | 26 ( 1.0) | 5 (0.2) | 0 | 1 | 18.9 |
| 04/10/96 | 37 | 63 ( 1.7) | 9 (0.2) | 4 | 3 | 20.3 |
| 04/11/96 | 17 | 100 ( 5.9) | 28 (1.7) | 70 | 6 | 51.0 |
| 04/11/96 | 17 | 300 (17.7) | 10 (0.6) | 45 | 0 | 15.5 |
| 04/11/96 | 23 | 250 (10.9) | 13 (0.6) | 30 | 2 | 15.3 |
| 04/11/96 | 23 | 500 (15.0) | 51 (2.2) | 50 | 12 | 18.4 |
| 04/11/96 | 22 | 500 (22.7) | 55 (2.5) | 60 | 6 | 19.5 |
| 04/24/96 | 13 | 100 ( 7.7) | 21 (1.6) | 1 | 2 | 19.4 |
| 04/24/96 | 10 | 150 (15.0) | 11 (1.1) | 18 | 2 | 17.1 |
| 04/24/96 | 10 | 150 (15.0) | 20 (2.0) | 28 | 2 | 25.0 |
| **Totals** | **316** | **2,369 ( 8.5)** | **286 (1.0)** | **325** | **52** | **21.9** |



21

numbers of gamefish as incidental catch. Twenty-five gill-net observations were made during the same time period in April 1996. Overall incidental catch in the April gill-net observations was only 2.7 %. The overall incidental catch in trawls was 21.5 % - markedly higher than in commercial gill nets. Incidental catch of gamefish in gill nets was 1.9 % as compared to 9.3 % in trawls, and the catfish catch was 0.3 % in gill nets as compared to 10.5 % in trawls.

Mr. Raffield's request for a permit to trawl further was not approved for two reasons. First, the catch rate (Table 8) for gamefish was about 0.9 per minute and for catfish was 1.0 per minute. These data extrapolated to a normal 8-hour work day, would mean a daily catch of 432 gamefish (8.6 bag limits per day) and 480 catfish. Second, black crappie taken by trawl and retained in holding pens suffered 100 % mortality at 48 hours. Therefore, the projected incidental catch and mortality of gamefish and commercial catfish species would not be acceptable when less disruptive methods of harvesting gizzard shad are available.

## CONCLUSIONS

Commercial gill nets permitted by GFC were successfully used to substantially reduce the stock of gizzard shad in Lake Apopka at reasonable cost. The incidental catch and mortality of gamefish taken in the commercial gill net fishery was low, and until the gamefish catch reaches much higher levels the impact to gamefish stocks will be insignificant. It was necessary for SJRWMD to cost-share the harvesting of gizzard shad from the lake because of the weak economic demand for shad, which could only be marketed as bait. The economic incentive to catch gizzard shad from Lake Apopka was weak even with a cost-share from SJRWMD, and the prognosis is that the fishery will not become self-supporting until marketing conditions change.

## RECOMMENDATIONS

1. Continue to monitor and evaluate the program to remove rough fish from the lake.
2. Continue to collect initial and secondary mortality information. The sample size needs to be larger.
3. Attempt to stimulate interest by more fishermen in the summer-fall fishery because it is self sufficient (no SJRWMD cost-share involved).

## LITERATURE CITED

Burgess, J.E. 1964. Summary report of Lake Apopka. Florida State Board of Health, Jacksonville, Fla.

DeQuine, J.F. 1950. Results of rough fish control operations in Lake Apopka during December 1949 and January 1950. Florida Game and Fresh Water Fish Commission, Tallahassee, Fla.

Mazeaud, M.M., F. Mazeaud, and E.M. Donaldson. 1977. Primary and secondary effects of stress in fish. *Trans. Amer. Fish. Soc.* 106 (3): 201-212.

Moring, J.R. 1982. Fin erosion and culture-related injuries of Chinook salmon raised in floating pens. *Prog. Fish Cult.* 44 (4): 189-191.

Schramm, H.L. and L.L. Pugh. 1996. Gizzard shad stock estimate for Lake Apopka, Florida, 1995. Special Publication SJ97-SP10. St. Johns River Water Management District, Palatka, Fla.

Schramm, H.L. and L.L. Pugh. 1997. Gizzard shad stock estimate for Lake Apopka, Florida, 1996. Special Publication SJ97-SP11. St. Johns River Water Management District, Palatka, Fla.