Proceedings of the Florida Lake Management Society's 1996 Annual Meeting, May 22-24, 1996, in Ocala, Florida

FLMS

Florida Lake Management Society

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12:00	Lunch: On your own

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Session 1: Orange creek basin and management of Orange lake

Moderator: Jim Estes

1:00-1:15 (1) Evaluation of water management alternatives for Orange and Lochloosa lakes: effects on lake levels and wetlands. (G. B. (Sonny) Hall, C. Price Robison and Chris Ware, St. Johns River Water Management District, P. O. Box 1429, Palatka, Florida)

1:20-1:35 (2) Historical Trends in Aquatic Vegetation at Orange Lake, Florida. P. Kinser, D. Reed, and G. Dambek (Division of Environmental Sciences, St. Johns River Water Management District, P. O. Box 1429, Palatka, Florida 32178-1429)

1:40-2:55 (3) Stakeholder Involvement in Watershed Issues: An Integrated Approach to Surface Water Management in the Orange Creek Basin. Margaret A. Lasi, John Shuman, and Tim Smith. (Department of Water Resources. St. Johns River Water Management District, P. O. Box 1429, Palatka, FL 32178-1429)

2:00-2:15 (4) Views on lake management from a fish camp owner. Mr. Win Boggs (Finway Fish Camp, Lochloosa Lake, Highway 301 Hawthorne, Florida)

2:20-2:35 (5) Fish and Fishing on Orange Lake. James R. Estes, (Florida Game and Fresh Water Fish Commission, 7922 NW 71st Street, Gainesville, FL 32606)

2:40-3:00 Questions and Discussion

3:00-3:05 Door prize drawing

3:05-3:25 Break

Wednesday Afternoon, May 22, 3:25 pm - 5:35 pm

Session 2: Lake Apopka: past, present, and future

Moderator: Larry Battoe

3:25-3:40 (6) The Evolution of Political Efforts to Restore Lake Apopka. James Conner, David Stites, and Michael Coveney. (St. Johns River Water Management District P. O. Box 1429, Palatka, FL 32178-1429)

3:40-3:55 (7) A New Look at Lake Apopka: How it works. Roger W. Bachmann and Daniel E. Canfield, Jr.(Department of Fisheries and Aquatic Sciences, University of Florida, Gainesville, FL, 32653, (352) 392-9617 ext 251, e-mail rbach@nervm.nerdc.ufl.edu)

Wednesday Afternoon, May 22, 3:25 pm - 5:35 pm (continued)

3:55-4:10 (8) The Restoration Plan for Lake Apopka. James Conner, David Stites, and Michael Coveney. (St. Johns River Water Management District P. O. Box 1429, Palatka FL 32178-1429)

4:10-4:25 (9) P Loading Limit for Lake Apopka - The Essential First Step. Michael F. Coveney, David L. Stites, Edgar F. Lowe, Lawrence E. Battoe. (Department of Water Resources, St. Johns River Water Management District, P. O. Box 1429, Palatka FL 32178-1429. Tel: 904-329-4366, FAX: 904-329-4329)

4:25-4:40 (10) Citizens Advocacy - Lake Apopka. Jack Amon. (President, Friends of Lake Apopka. P.O. Box 772053. Winter Garden, FL, 34777-2053)

4:40-5:00 (11) The status of the Lake Apopka Restoration Program. Edgar F. Lowe, Larry Battoe, Michael Coveney, and David Stites. (St. Johns River Water Management District, PO Box 1429, Palatka, Fl. 32078-1429)

5:00-5:20 Questions and Discussion

5:20-5:50 General membership meeting: Goals for FLMS

5:30-5:35 Door prize drawing

5:35-7:00 Supper on your own

Wednesday Evening, May 22, 7:00 pm - 9:00 pm

Session 3: Non-professional Squeaky Wheel Workshop: How To Get Action on Your Lake Issue

Moderators: Sandy Fisher and Curtis Watkins.

Thursday Morning, May 23, 7:30 am - 10:25 am

7:30-8:00 Coffee

Session 4: Fish Populations in Florida

Moderator: Chuck Cichra

8:00-8:20 (12) Effects of hydrilla management on water quality and sportfish in Lake Istokpoga, Florida. M. K. Alam[1], L. A. Ager[1], T. M. Rosegger[1] and M. V. Phillips[2] ([1]Florida Game and Fresh Water Fish Commission, 3900 Drane Field Road, Lakeland, Florida 33811. [2]Florida Department of Environmental Protection, 1677 Highway 17S., Bartow, Florida 33830)

8:25-8:45 (13) Relations Between Trophic State Indicators and Fish in Florida Lakes. Roger W. Bachmann, Mark Hoyer, and Daniel E. Canfield, Jr. (Department of Fisheries and Aquatic Sciences, University of Florida, Gainesville, FL, 32653, (904) 392-9617, e-mail rbach@nervm.nerdc.ufl.edu)

Thursday Morning, May 23, 7:30 am - 10:25 am (Continued)

8:50-9:10 (14) Fish community response to lake eutrophication-a case study. Thomas R. Champeau (Florida Game and Fresh Water Fish Commission, 3900 Drane Field Road, Lakeland, FL 33811; 941/648-3202)

9:15-9:35 (15) Health Management and Disease Investigation in Florida's Largemouth Bass Populations. Ruth Francis-Floyd (DVM, MS, Department of Large Animal Clinical Sciences and Department of Fisheries and Aquatic Sciences, University of Florida, 7922 NW 71 Street, Gainesville, FL 32653)

9:40-10:00 (16) Sturgeon in Florida: a dilemma in conservation efforts. Frank A. Chapman (Department of Fisheries and Aquatic Sciences, University of Florida, 7922 N. W. 71 St Street, Gainesville, FL 32653)

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Thursday Morning, May 23, 10:25 am - 11:50 am

Session 5: Lake management "Players"

Moderator: Martin Kelly

10:25-10:40 (17) Classification and Assessment of Florida Lakes Using Benthic Macroinvertebrates. James L. Hulbert[1], Russe[l] Frydenborg[2], and Jeroen Gerritsen[3]. ([1]Florida Department of Environmental Protection, 3319 Maguire Blvd., Orlando, FL 32803; [2]Florida Department of Environmental Protection, 2600 Blair Stone Rd., Tallahassee, FL 32399; [3]Tetra Tech, Inc., 10045 Red Run Blvd., Owings Mills, MD 21117.)

10:45-11:00 (18) Lake Holden: A Case Study of a Successful Lakefront Homeowner's Association. Richard A. Baird (Orange County Environmental Protection Department, 2002 E. Michigan Street, Orlando, FL 328)

11:05-11:20 (19) Development of a comprehensive lakes management plan for the City of Lakeland, Florida. Gene Medley[1], Rick Powers[2] and Walter Reigner[2]. ([1]City of Lakeland, 407 Fairway Ave., Lakeland, Fl. 33801, [2]BCI, P. O. Box 5467, Lakeland, Fl. 33807)

11:25-11:40 (20) Are You in Charge of the Lakes?" - Responsibility at the Local Level. Mike Britt (P. E., Lakes Manager City of Winter Haven 550 7th Street, S. W., Winter Haven, Florida 33880, (941) 291-5850)

11:45-11:50 Door prize drawing

11:50-1:00 Lunch on your own

Thursday Afternoon, May 23, 1:00 pm - 3:15 pm

Session 6: Florida Water Management Districts

Moderator: Tyler Mc Millan

1:00-1:15 (21) Northwest Florida Water Management District lake and river planning and management programs. Tyler L. Macmillan (AICP Director, Resource Planning Section Northwest Florida Water Management District Route 1, Box 3100, Havana, Florida 32333-9700)

1:15-1:30 (22) Surface Water Improvement and Management Program Initiatives in the Suwannee River Water Management District. Robert A. Mattson (Biologist, Suwannee River Water Management District, 9225 County Road 49 Live Oak, FL 32060)

1:30-1:45 (23) St. Johns River Water Management District's Water Resource Management Programs. Charles A. Padera[1] and Lawrence E. Battoe[2] ([1]Director, Department of Water Resources [2] Assistant Director, Division of Environmental Sciences, St. Johns River Water Management District, P. O. Box 1429, Palatka, Florida 32178-1429)

1:45-2:00 (24) Swim, freshwater and the Southwest Florida Water Management District. Martin H. Kelly (Senior Environmental Scientist Surface Water Improvement and Management Department, Southwest Florida Water Management District 7601 Highway 301 North Tampa, Florida 33637)

2:00-2:15 (25) Lake Restoration Efforts in South Florida. Barry H. Rosen (South Florida Water Management District. PO Box 24680, West Palm Beach, Fl. 33416)

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Moderator: Garth Redfield

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3:40-4:00 (27) Water Supply Issues for Lake Okeechobee. Barry H. Rosen and Susan Gray (South Florida Water Management District, PO Box 24680, West Palm Beach, Fl. 33416)

4:05-4:25 (28) Lakes and wetland impacts, West Coast Regional Water Supply Authority Jurisdictional Area. Andy Smith.(Southwest Florida Water Management District, 7601 HWY 301 N, Tampa, Florida 33637)

4:30-4:50 (29) Consumptive use permitting in SWFWMD. Becky Ayesh (Environmental Confederation of Southwest Florida, 421 Verna Road, Sarasota, Florida)

Thursday Evening, May 23

6:00-7:00 Social in exhibit hall

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7:30-8:00 Coffee

Session 8: Aquatic plant management in Florida

Moderator: Christy Horsburgh

8:00-8:20 (30) An overview of aquatic plant control in lakes. F. N. Nnadi (Department of Civil and Environmental Engineering University of Central Florida Orlando, Florida 32816-0450 Phone: (407) 823-6513 Fax: (407) 823-3315)

8:25-8:45 (31) Aquatic herbicide safety. Paul L. Thayer (University of Florida, Gainesville, Florida)

8:50-9:10 (32) The decision making process for Florida's aquatic plant management program. Jeffrey D. Schardt (Department of Environmental Protection, Bureau of Aquatic Plant Management, Tallahassee, Florida 32310, Phone: (904) 488-5631, Fax: (904) 488-1254)

9:15-9:35 (33) Successful control of hydrilla and reestablishment of native species on lake Okahumpka despite long odds. Brian Nelson (Southwest Florida Water Management District, 2379 Broad Street, Brooksville, FL 34609-6899)

9:40-9:50 (34) Using Remote Sensing and GIS to Support Melaleuca Management Efforts in Lake Okeechobee. Charles Hanlon (Okeechobee Systems Research Division, South Florida Water Management District, 3301 Gun Club Road, West Palm Beach, Florida 33416-4680; 407-687-6748; e-mail charles.hanlon@sfwmd.gov).

9:55-10:00 Door prize drawing

10:00-10:15 Break

Friday Morning, May 24, 10:15 am - Noon

Session 9: Florida Rivers

Moderator: Tom Cuba

10:15-10:30 (35) Interaction of light, nutrients and phytoplankton in a black-water river, St. Johns River, Florida. Aldridge, F. J.[1], C. L. Schelske[1], A. D. Chapman[2] and R. Brody[2] ([1]Department of Fisheries and Aquatic Sciences, University of Florida, 7922 N. W. 71 Street, Gainesville, FL 32653. [2]St. Johns River Water Management District, P. O. Box 1429, Palatka FL 32178-1429.)

Friday Morning, May 24, 10:15 am - Noon (Continued)

10:35-10:50 (36) Evaluation of the effects of nutrient removal and the "Storm of the Century" on submersed vegetation in Kings Bay - Crystal River, Florida. Bishop, J. H., and D. E. Canfield, Jr. (Department of Fisheries and Aquatic Sciences, University of Florida, Gainesville, FL, 32653, (904) 392-9617)

10:55-11:10 (37) The effects of recreation on the water chemistry and submersed plant community of the Rainbow River, Florida. Michael T. Mumma and Charles E. Cichra (Department of Fisheries and Aquatic Sciences, University of Florida, Gainesville, FL, 32653, (904) 392-9617 ext. 249)

11:15-11:30 (38) An estimate of nutrient loads from properties with septic tanks to Allen's creek. Mariben Espiritu-Andersen, Donald D. Moores, Thomas R. Cuba and Hans W. Zarbock (Pinellas County Department of Environmental Management, 300 South Garden Avenue, Clearwater, Florida 34616)

11:35-11:50 (39) Effects of groundwater seepage on nutrient loadings and bacteriological inputs to Clear Lake. Harvey H. Harper (Environmental Research & Design, Inc. 3419 Trentwood Blvd., Suite 102, Orlando, FL 32812 Phone: 407/855-9465 Fax: 407/826-0419)

11:55-12:00 Door prize drawing

12:00-1:15 Lunch provided with registration.

Friday Afternoon, May 24, 1:15 pm - 3:00 pm

Session 10: The Best For Last

Moderator: Mike Britt

1:15-1:25 (40) The Role of Models in the Water Quality Research Program of Lake Okeechobee. R. Thomas James and K. E. Havens (Okeechobee Systems Research Division, South Florida Water Management District, 3301 Gun Club Road, P. O. Box 24680 West Palm Beach, Florida 33416-4680)

1:30-1:50 (41) Structure and dynamics of sublittoral zone benthic invertebrate communities as indicators of Lake Okeechobee trophic status. Gary L. Warren (Florida Game and Fresh Water Fish Commission, 3991 SE 27th Court, Okeechobee, FL 34974, 941 -763-4666)

1:55-2:15 (42) Sources of Organic Carbon in the Food Webs of Three Florida Lakes Indicated by Stable Isotopes. Binhe Gu, Mark V. Hoyer and Claire L. Schelske. (Department of Fisheries and Aquatic Sciences, University of Florida, 7922 NW 71st Street, Gainesville, FL 32653)

2:20-2:35 (43) Polynuclear Aromatic Hydrocarbons: Sediment and Plant Interactions. Seán Ernst McGlynn and Robert J. Livingston (Center for Aquatic Research and Resource Management, Department of Biological Science, Florida State University, Tallahassee, Fl, 32306-2043)

2:40-2:55 (44) Response of a small Orlando lake to hydrated lime additions. Forrest E. Dierberg Thomas A. DeBusk[1] and Kevin McCann[2]·([1]DB Environmental Laboratories, Inc., Rockledge, FL, [2]Stormwater Utility Bureau, City of Orlando, Orlando, FL)

Effects of hydrilla management on water quality and sportfish in lake Istokpoga, Florida

M. K. Alam[1], L. A. Ager[1], T. M. Rosegger[1] and M. V. Phillips[2] ([1]Florida Game and Fresh Water Fish Commission, 3900 Drane Field Road, Lakeland, Florida 33811. [2]Florida Department of Environmental Protection, 1677 Highway 17S., Bartow, Florida 33830)

Abstract

Fluridone treatment and introduction of triploid grass carp in Lake Istokpoga, an open, large-lake system, temporarily reduced the frequency of hydrilla coverage. Hydrilla regrowth and expansion in coverage were correlated with increased Secchi disc transparency, reduced total phosphorus, chlorophyll a concentrations and trophic state index. Largemouth bass and bluegill densities declined due to poor year class production associated with decreased hydrilla coverage, while harvestable-size bluegill and redear sunfish densities increased. An unusually strong year class of black crappie was indicated in 1993 and may be associated with decreased hydrilla coverage in 1992. Introduction of logistically reasonable numbers (# / hectare) of 11.3 triploid grass carp per hectare in Lake Istokpoga did not prove effective for hydrilla management.

Introduction

Macrophytes are important components of aquatic ecosystems because they are integral in nutrient and energy cycling, support intricate food webs and provide important habitat for macroinvertebrates and fish (Frohne 1938, Wetzel 1964, Wetzel and Hough 1973). The role of aquatic vegetation in aquatic ecology is important in Florida (Conrow et al. 1990). Macrophytes influence fish species diversity and recruitment by providing spawning substrate and cover (Cross et al. 1992), foraging areas (Posey et al. 1993) and protective habitat for larval (Venugopal and Winfield 1993) and sub-adult fishes (Porak et al. 1990). Aquatic plants also influence fish biomass and distribution, and predator-prey interactions (Barnett and Schneider 1974, Moxley and Langford 1982). Schramm et al. (1983) reported a positive correlation between fish abundance and vegetation density. They concluded plant densities were more important than species composition in determining fish distribution and abundance.

Lake Istokpoga, the fifth largest freshwater lake in Florida (11,080 ha) is located in Highlands County. The lake is relatively shallow, with an average depth of 1.8 m. Two creeks, Josephine and Arbuckle, discharge into the lake. Historically, the only outlet was Istokpoga Creek, which drained southeast into the Kissimmee River. Istokpoga Canal was constructed parallel to the creek to reduce flooding and provide agricultural irrigation. As part of an extensive flood control and water supply project, a second canal (C-41A) equipped with a water control structure (S-68) was

added in 1962 on the southeast shore. Annual maximum water level fluctuation was reduced from 2.1 m prior to 1962 to 1.0 m because of S-68 operation (Milleson 1978). In 1991 the fluctuation was further reduced to 0.6 m by a regulation schedule change (38.0 msl to 39.5 msl).

Milleson (1978) documented an increase in littoral aquatic vegetation from 881 to 1,294 ha in Lake Istokpoga between 1944 and 1975 due to persistently low lake levels and subsequent reduction of the natural frequency of seasonal drying and inundation. However, the amount of quality fish habitat had been reduced by the formation of extensive floating mats of vegetation, tussocks, and dense cattail (Typha sp.) communities. Without natural dewatering events, germination of diverse emergent aquatic plant seeds was reduced, consolidation and compaction of organic sediments did not occur, and formation and expansion of floating mats of water-hyacinths (Eichhornia crassipes), and other species common to tussock communities occurred further reducing quality fish habitat. These mats reduced overall fish productivity and diversity of the marsh and littoral zone. In 1991 floating tussock communities occupied 415 ha, excluding the island areas, and cattail coverage had increased by 87% since 1977. Hydrilla (Hydrilla verticillata) expanded in Lake Istokpoga from 1,441 ha (13%) in 1987 to more than 5,261 ha (47%) in 1988, and ultimately to 8,028 ha (72%) in 1994.

Coordination of water quality, fisheries and aquatic plant management are vital for maintenance of recreational fisheries and water quality goals (Wiley et al. 1984). In this paper, we discuss the relative success of hydrilla management efforts in Lake Istokpoga and observed responses of these efforts on water quality and sport fish.

Methods

Fluridone Treatments Effect of fluridone (1-methyl-3-phenyl-5-[3-(trifluoromethyl) phenyl]-4(1H)-pyridinone) treatments (Table 1), and introduction of triploid grass carp on aquatic macrophyte communities were evaluated in Lake Istokpoga by the Florida Game and Fresh Water Fish Commission (GFC) and the Florida Department of Environmental Protection (FDEP). The agencies identified and mapped major plant communities, each October from 1988 through 1994. Hydrilla coverage was mapped using Loran-C navigational equipment. Emergent vegetation was mapped by both boat and aerial surveys. Lakewide coverage of submersed vegetation was estimated from sampling along pre-selected transects at approximately 30-m intervals using a weighted grappling hook dragged along the bottom. The dominant plant at each transect was defined as the plant occurring in the majority of the grabs. The dominant plants were grouped by type, relative to plant management objectives for Lake Istokpoga, as follows: target plant- hydrilla, nontarget plants- Illinois pondweed, cattail, eelgrass and other plant species. Fluridone was applied via airboat (cyclone spreader) and /or helicopter, beginning in March of 1988, at a rate of 5 pounds active ingredient (AI) per hectare. Additional regrowth was treated annually in the winter-spring through 1992 (Table 1).

Eight pre-selected vegetation transects were established (Figure 1) and sampled at 90-day intervals from March 1989 to November 1994 to determine the effectiveness of the fluridone treatments on hydrilla. Transects were conducted using an airboat operating at a steady speed of 1,200 to 1,400 rpms on a set compass heading. Vegetation presence or absence was recorded using a Lowrance X-16 fathometer paper chart recorder. One or two observers recorded plant species sighted every 15 seconds along each transect. Computer analyses of hydrilla coverage per transect expanded findings to provide lake-wide estimates of percent coverage.

Triploid Grass Carp Introduction During winter and spring 1992 and 1993, a total of 125,000 triploid grass carp (Ctenopharyngodon idella) (11.3/ha), 305 mm in total length (TL) minimum size to minimize predation, were introduced to provide extended control of hydrilla in Lake Istokpoga. This rate was found to be successful in smaller lakes where fish could be adequately contained (Shireman 1979) or where predation was much less.

Water Quality Water samples were collected quarterly, from 1987 to 1994, at 9 stations on Lake Istokpoga (Figure 1) previously determined to best represent water quality for that given area of the lake. Field measurements included depth, Secchi disk transparency (SD), pH, dissolved oxygen (DO), and temperature. Water samples collected were measured for turbidity, hardness, total nitrogen (TN), ortho phosphorus (OP), total phosphorus (TP), ammonia (NH_3), nitrate (NO_3), total organic nitrogen (TON) and chlorophyll a. All parameters were determined by use of methods recommended by American Public Health Association (APHA 1989). Trophic state index (TSI) was calculated by the methods of Huber et al. (1982). Relationships between sample size and various water quality parameters for samples collected from 1987 to 1994 were examined using a one-way analysis of variance (ANOVA) and the relationships between selected fall water quality parameters and hydrilla coverage were determined using polynomial regression at the second-degree.

Fish Population Fish population data were collected by use of blocknets and electrofishing. Six 0.4 ha blocknet samples were collected (Figure 1) with 2.0 mg/l liquid rotenone from 1992 through 1994. The common aquatic plant communities of giant bulrush (Scirpus californicus), spatterdock (Nuphar luteum sp.), cattail, Illinois pondweed (Potamogeton illinoensis), hydrilla, duck potato (Sagittaria lancifolia), pickerelweed (Pontederia sp.), eelgrass (Vallisneria americana), and bladderwort (Utricularia sp.) were identified in blocknet samples. Fish were collected over a 3-day period per net, identified to species, measured to 2-cm length-group, and weighed. Sub-samples of sub-adults were assessed when appropriate. Relationships between fish species collected and sample size from 1992 to 1994 were examined using a one-way analysis of variance (ANOVA).

At least 6-hr of electrofishing, along 24 transects (15 minutes per transect) randomly chosen around the lake (Figure 1), were conducted semi-annually during spring and fall 1992, 1993 and 1994 using an electrofishing boat operating on pulsed direct current varying from 6-7 amperes. Electrical output was regulated by a Smith-Root model VI-A electrofisher, utilizing the aluminum boat hull as the cathode and circular bow-mounted electrode arrays as anodes. Only largemouth bass were collected, measured, and weighed.

Results

Fluridone Treatments A partial 172 ha fluridone treatment in 1988 did not substantially reduce hydrilla coverage. A 971-ha treatment with fluridone was applied in spring 1989 and hydrilla coverage decreased from 5,261 ha (47%) in 1988 to 1,184 ha (11%) by fall 1989. Another fluridone treatment (1971 ha) was conducted in the spring of 1992 that reduced hydrilla coverage from 4,330 ha (40%) in 1991 to 810 ha (7%) by fall of 1992 (Table 1).

Triploid Grass Carp Triploid grass carp in our study emigrated downstream through an unbarriered water control structure and the extent to which grass carp were involved in the reduction of hydrilla in Lake Istokpoga cannot be estimated. Hydrilla has continued to expand, therefore, future changes that may occur in fish biomass and species composition will not be the result of triploid grass carp impacts. Triploid grass carp of 20 kg were repeatedly observed by various project personnel and reported by fishermen downstream in canals, Lake Okeechobee, and the Caloosahatchee River in schools up to 100 or more. These observations occurred shortly after water discharges were made from the lake in response to lake level regulation control by the South Florida Water Management District.

Water Quality Lake Istokpoga remained meso-eutrophic throughout the study period, based on trophic state index ($50 < TSI < 70$), and nutrient balanced ($10 < TN:TP < 30$). A decrease in concentrations of TP, TN, chlorophyll a, and an increase in Secchi depth in 1988 lowered the TSI of the lake from eutrophic condition ($TSI > 60$) to mesotrophic level ($TSI < 60$). The TSI changes measured during the falls of 1990-1994 were correlated to hydrilla coverage. Hydrilla expansion, to approximately 40 to 50% coverage, was inversely related with TP ($r = 0.82$), TN ($r = 0.76$) and chlorophyll a ($r = 0.60$) and directly related with Secchi depth ($r = 0.57$) for fall samples (Figure 2).

Fish Population Blocknet samples indicated significant decreases in numbers per hectare of largemouth bass and bluegill populations and a significant increase in redear sunfish populations in 1993 and 1994 (Table 2). Although, total number of harvestable-size bluegill in blocknet samples increased 17% from 1992 to 1994 and this increase may be due to increased production during expansion of hydrilla. Number of harvestable-size redear sunfish peaked in 1993. A peak in total number

of "young-of-the-year" (2-10 cm) black crappie of 328/hectare collected occurred in 1993 samples indicate a moderate production.

Relative stock density (RSD_{356}) values determined from electrofishing estimates increased from 27 and 31 in 1992 to 52 and 19 in 1993 and 35 and 39 in 1994. Size structure indices of largemouth bass are consistent with desirable RSD_{356} >35% goals stated in the Commission's 1994 - 1998 Strategic Plan, indicating adequate numbers of quality-size largemouth bass are still present. Electrofishing catch per unit effort (CPUE = fish per minute) decreased over time due to lower numbers of age I fish (4-20 cm) collected in samples (Figure 3).

Discussion

Changes in TP, TN, chlorophyll a and Secchi depth may be related to hydrilla coverage. Total P and chlorophyll a concentrations increased in falls of 1987, 1989 and 1992 when hydrilla coverage decreased (Table 1). The resulting increase in TP and chlorophyll a concentrations brought about a minor increase in fall TSI to 57.7 in 1989 from 55.2 in 1988. A 1,971 ha fluridone treatment in spring 1992 that resulted in a decrease of hydrilla coverage to 810 ha (7%) by fall was followed by a high TP, TN and chlorophyll a concentrations and an increase in TSI in fall 1992 (62.3) and a high annual TSI in 1993 (64.4). Concentrations of TP and chlorophyll a decreased in 1994 when hydrilla coverage increased to 8,028 ha (72%) (Table 1). The annual TSI value decreased from 66.02 in 1987 to 55.96 in 1988 due to hydrilla increasing from 1,441 (13%) to 5,261 ha (47%, Table 1). The changes in trophic state index were notable when lake hydrilla coverage increased in 1988, although high concentrations of TP and TN were recorded in Arbuckle Creek, a major nutrient source (Table 1).

The apparent link between changes in hydrilla abundance and changes in overall lake water chemistry, water clarity, and chlorophyll a concentrations observed in this study supports similar limnological changes reported for other Florida lakes (Scott and Osborne 1981, Osborne et al. 1983, Shireman et al. 1983). Scott and Osborne (1981) found that concentrations of chlorophyll a in Little Lake Barton were highest when hydrilla biomass was low and decreased with the onset of hydrilla growth. Osborne et al. (1983), and Shireman et al. (1983) measured higher chlorophyll a values in some Florida lakes after grass carp eliminated submersed macrophytes. Total P concentrations also decreased with increased coverage of hydrilla (Table 1). Because the response of certain water quality parameters to the loss of hydrilla was generally the inverse of the response that occurred as hydrilla levels increased, we suggest the importance of hydrilla and perhaps other submersed macrophytes is directly related to their overall coverage, biomass, standing crop and the percentage of a lake's total volume occupied. We found, however, that major changes in Lake Istokpoga's water quality generally were not significant until hydrilla coverage approached 40 to 50% of the lake area. For example, Secchi disc transparency data showed an increasing trend with the increase of hydrilla coverage (Table 1, Figure

2). This is similar to the results reported by Canfield et al. (1983) that a major increase in water transparency did not occur on Lake Baldwin until macrophyte coverage exceeded 60%. We suggest reduction of hydrilla on lakes with native aquatic plant communities and hydrilla coverage below 40 to 50% will have little effect on lake chlorophyll a concentrations, water clarity and overall lake chemistry.

Differences in fish community assemblages have been described in littoral zones of lakes (Benson and Magnuson 1992). These differences have been attributed to a number of biological and physical factors. Biological parameters include benthic invertebrate communities (Posey et al. 1993), phytoplankton density (Oglesby 1977), and vegetation density (Conrow et al. 1990). Largemouth bass and bluegill densities declined due to poor year class production associated with decreased hydrilla coverage, while harvestable-size bluegill and redear sunfish densities increased and strong year class of black crappie was observed in Lake Istokpoga. Our results are in agreement with the findings of Colle and Shireman (1994) that mean standing crop estimates of adult bluegill in Lake Baldwin and adult redear sunfish were negatively correlated with plant coverage. They also reported the elimination of submersed vegetation in Lakes Baldwin and Pearl resulted in significant population declines in both systems for various fish species including young-of-year largemouth bass. Our results show that gizzard shad (Dorosoma cepedianum) and threadfin shad (Dorosoma petenense) abundance increased significantly in Lake Istokpoga, a similar trend was noted by Colle and Shireman (1994). The effects of hydrilla management on Lake Istokpoga's sport fishery are in a state of flux. As hydrilla coverage changes, species expand or decline. The population estimates presented in this paper reflect various factors and management activities and cannot be evaluated simply in terms of the effects of hydrilla coverage. Fish population, water quality, and aquatic plants are linked such that an alteration in one may affect the others. As reported here, hydrilla abundance exceeding 40 to 50% coverage seems to be the present driving force behind significant changes observed in the Lake Istokpoga ecosystem.

Triploid grass carp emigration from a given body of water has the potential to cause undesired impacts on vegetation communities in connected waters (Stanley et al. 1978; Ellis 1974; Nixon and Miller 1978). Some studies of grass carp movement and behavior have been conducted, but most of this work took place in small (less than 100 ha) lakes (Mitzner 1978), canals (Hockin et al. 1989; Cassani and Maloney 1991), or reservoir (Bain et al. 1990) systems, or for short (less than 30 days) periods of time (Nixon and Miller 1978). Comparatively little research has been conducted to answer questions concerning the movement and behavior through time of triploid grass carp in large, natural lakes. The different results reported in large lake studies emphasize not only the need for consistency in describing fish movement and behavior but also the importance of the duration of telemetry studies in determining fish emigration and behavior patterns (Clapp et al. 1994). The extent to which grass carp were involved in the reduction of hydrilla in our study cannot be estimated from observations nor measured from the data. However, grass carp reduced hydrilla regrowth and coverage when stocked in wire exclosures prior to

large stocking in Lake Istokpoga. If containment of triploid grass carp had been possible in-Lake Istokpoga, then long-term control and substantial aquatic plant management might have occurred. In Lake Istokpoga, following fluridone treatments and grass carp stocking subsequent reduction in hydrilla coverage occurred. Based on our open large lake experience, we hypothesize that lakes containing native plant communities with sparse hydrilla coverage less than 40 to 50% no appreciable overall change in water quality, water clarity, chlorophyll a concentrations or fish population structure following hydrilla reductions or elimination would be observed. When macrophyte coverage exceeds this level, a change in trophic state classification (Canfield et al. 1983) may have very noticeable effects.

The invasive characteristics and resulting biomass of hydrilla have allowed it to dominate Lake Istokpoga's ecosystem and fluctuations in fish populations are most likely attributable to extreme fluctuations in the hydrilla coverage. Based on the Lake Istokpoga experience, for effective results, we suggest grass carp barriers should be provided and maintained on all systems where grass carp are stocked. Large, open systems like Lake Istokpoga do not lend themselves to effective barriers and even if enough triploid grass carp are stocked initially, hydrilla control may be effective, after few months. We believe that management of hydrilla and other aquatic plants in many water bodies is possible with prudent integration of biological, physical and chemical methods. This approach may also encourage the growth of desirable native aquatic plants.

Acknowledgments

We thank numerous personnel of the Florida Game and Fresh Water Fish Commission and the Florida Department of Environmental Protection who helped with data collection and analysis. We thank Lawson Snyder, Scott Hardin, Jerry Shireman, and James Estes for their comments on the early draft of the manuscript.

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Table 1. Effect of hydrilla coverage on TP, TN, chlorophyll a, Secchi depth and TSI in Lake Istokpoga from 1987 to 1994. Values with a letter in common in a row are significantly different at p 0.05 and there is no significant difference for values without a letter.

Parameter	1987	1988	1989	1990	1991	1992	1993	1994
Hydrilla treated (ha)[1]	-	172	971	243	1360	1971	-	-
Hydrilla coverage (ha) (% coverage)[1]	1441 (13)	5261 (47)	1184 (11)	3524 (32)	4330 (40)	810 (7)	3642 (33)	8028 (72)
TP (mg/l)[2]	0.069	0.048	0.068	0.067	0.063	0.073	0.075	0.069
F[3]	0.075	0.043	0.064	0.039	0.057	0.073	0.057	0.064
C[4]	0.07	0.08	0.12	0.10	0.09	0.13	0.10	0.11
TN (mg/l)[2]	0.89	0.85	0.83[a]	0.87	0.73[b]	0.99	1.15[a b]	1.04
F[3]	0.98	0.79	0.82	0.76[a]	0.72[b]	1.25[a b]	0.95	1.09
C[4]	0.74	0.99	1.15	0.75	0.83	1.33	1.14	1.27
Chl a (mg/m^3)[2]	22.45	8.60	10.11	11.90	11.61	12.19	13.61	8.54
F[3]	21.25	8.00	12.00	4.45	3.20	10.10	12.40	4.98
SD (m)[2]	0.72[a]	1.06	1.16[ab]	0.92	0.85	1.04	0.77[b]	1.02
F[3]	0.72[a]	1.03	1.16[a]	1.03	0.90	0.82	1.06	1.20
C[4]	0.76	0.71	0.87	0.70	0.70	0.70	0.87	0.68
TSI[2]	66.02	55.96	57.12	60.33	60.13	59.42	64.38	58.46
F[3]	66.43	55.20	57.66	51.86	52.93	62.33	58.79	54.12

[1] Hydrilla was treated with fluridone each spring and coverage was estimated each fall
[2] average annual data
[3] fall data with hydrilla coverage
[4] Arbuckle Creek data

Table 2. Mean number of fish per hectare recorded in blocknets from Lake Istokpoga (1992- 994). Number of sportfish with a letter not in common in a row are significantly different at $p < 0.05$.

	# /ha		
Species	1992	1993	1994
Largemouth bass	138[a]	103[b]	88[c]
Bluegill	9,659[a]	5,701[b]	3,418[c]
Redear sunfish	1,614[a]	2,307[a]	5,209[b]
Warmouth	580[a]	319[b]	1,599[c]
Spotted sunfish	5[a]	1[b]	48[c]
Black crappie	14[a]	331[b]	51[c]
Chain pickerel	64[a]	19[b]	7[c]
Brown bullhead	7[a]	4[ab]	47[c]
Bowfin	1	1	1
Gizzard shad	50[a]	39[b]	94[c]
Threadfin shad	109[a]	448[b]	2[c]
Lake chubsucker	40[a]	27[b]	113[c]
Golden shiner	582[a]	232[b]	918[c]
Tailight shiner	272[a]	157[b]	2[c]
Seminole killifish	4[a]	35[b]	169[c]
Bluefin killifish	126[a]	1,014[b]	672[c]
Brook silverside	2[a]	60[b]	5[ac]
Atlantic needlefish	5[a]	7[ab]	1[c]
Dollar sunfish	63[a]	5[b]	1,894[c]
Bluespotted sunfish	240[a]	67[b]	486[c]
Swamp darter	2[b]	7[a]	6[ab]
Mosquito fish	5[a]	1[b]	85[c]
Tadpole madtom	143[a]	73[b]	265[c]

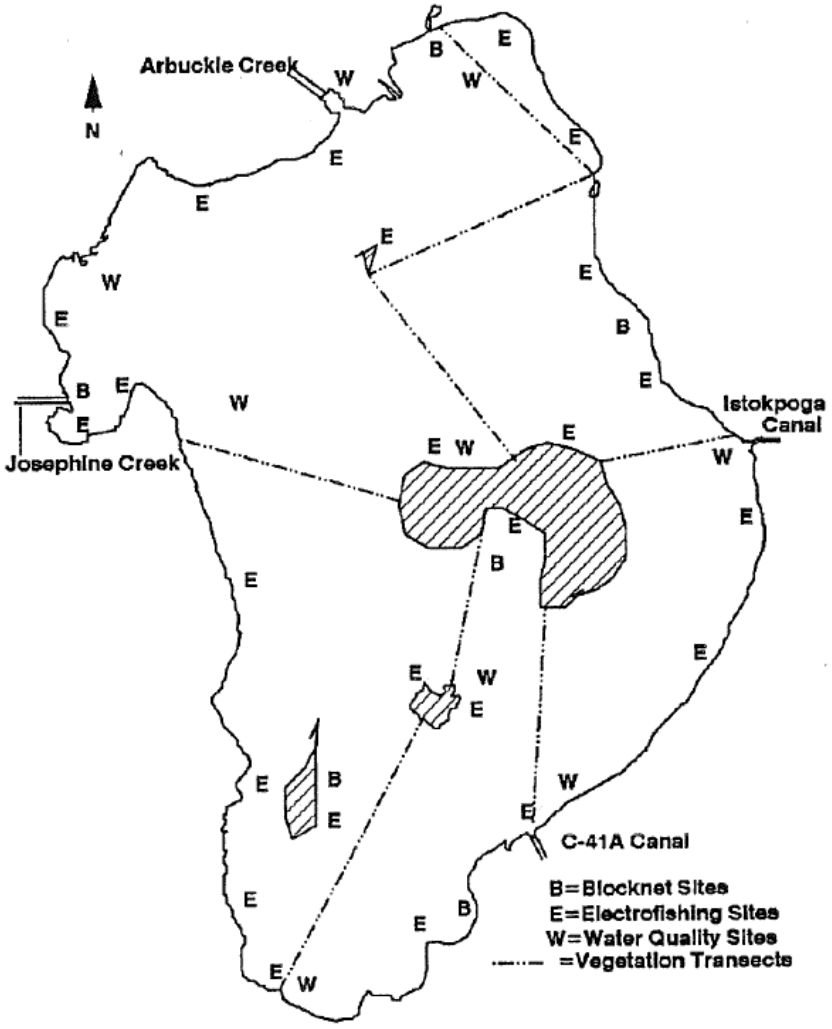

Figure 1. Location of blocknet, electrofishing, vegetation, and water quality sampling sites on Lake Istokpoga, Florida.

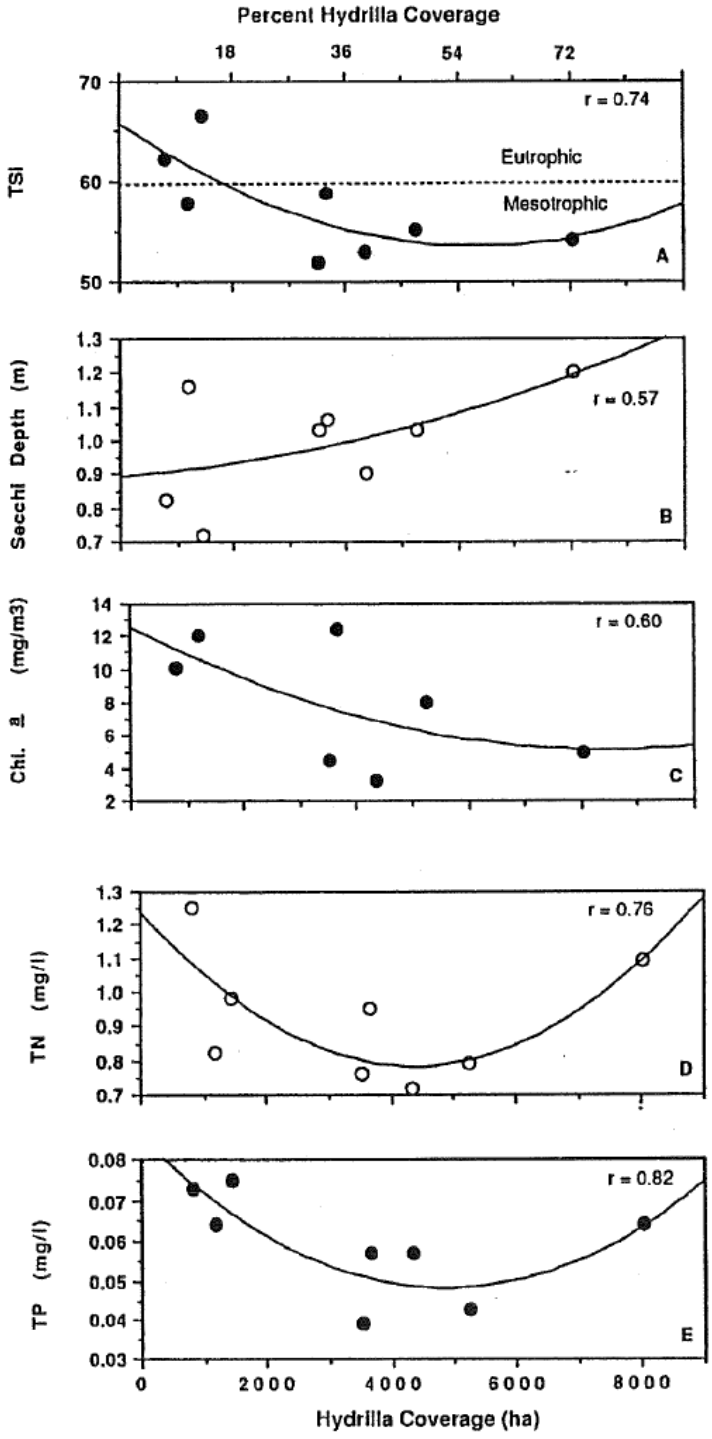

Figure 2. Effect of hydrilla coverage on fall TP, TN, Chlorophyll a, Secchi depth and trophic state index (TSI).

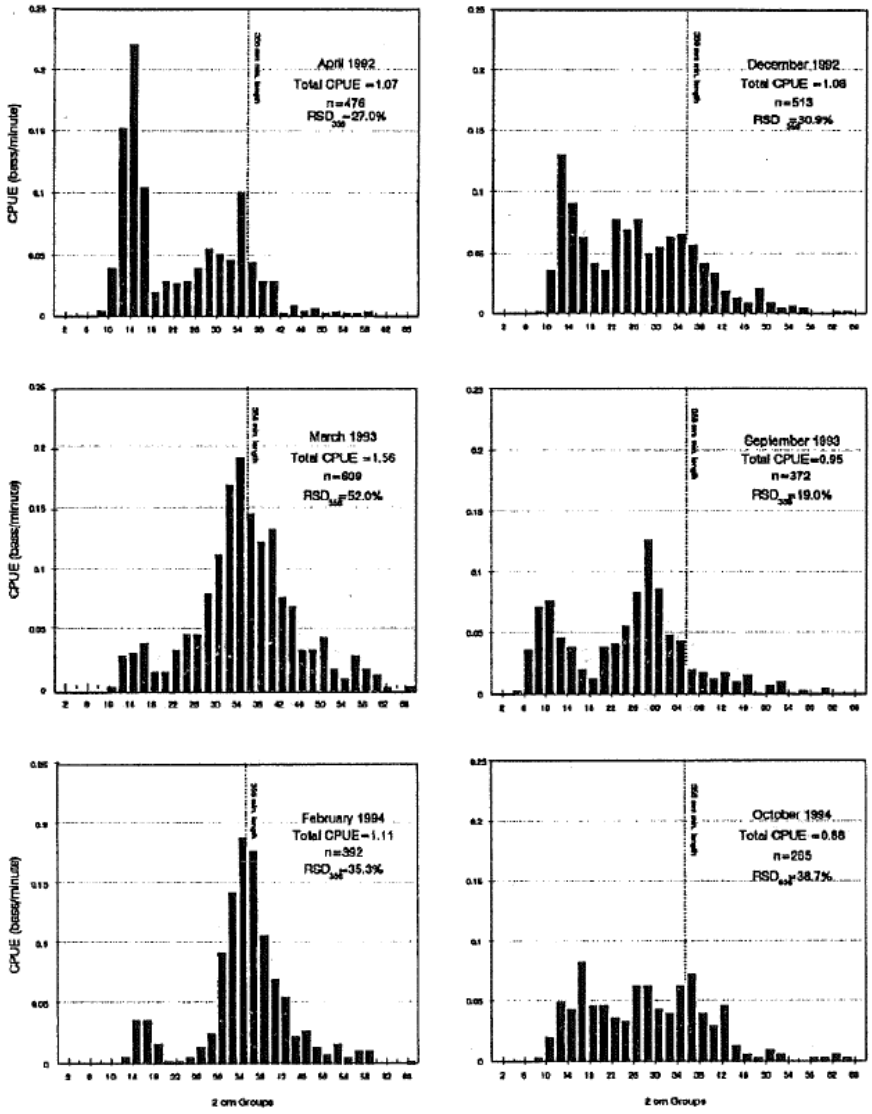

Figure 3. Length frequency of largemouth bass in two-centimeter length groups from electrofishing, Lake Istokpoga (April 1992 through October 1994).