Effects of Triploid Grass Carp and Sonar Treatments on Aquatic Plants in Lake Yale

by

Rue S. Hestand III,[1] *Boyd Z. Thompson,*[1] *and Craig T. Mallison*[1]

Introduction

Hydrilla (*Hydrilla verticillata*) has become a problem in many large Florida lake systems, and traditional control with herbicides is very costly. Triploid grass carp (*Ctenopharyngodon idella*) are efficient, functionally sterile herbivores. Information on using this fish to control hydrilla without detrimentally affecting desirable plants in large water bodies of Florida is generally lacking. Lake Conway, a 430-ha lake located in Orange County, Florida, is the only large lake where diploid grass carp have been studied with the objective of leaving desirable submerged aquatic plants while controlling hydrilla (Nall and Schardt 1978). This lake was similar to Lake Yale in that it had a large native aquatic plant population dominated by Illinois pondweed (*Potamogeton illinoensis*). Lake Conway was stocked in September 1977 with supplemental stockings in 1984 and 1987. To date, the grass carp have successfully controlled hydrilla but temporarily eliminated Illinois pondweed. Submerged aquatic plants remain in the lake, but the population makeup has been altered.

The objective of this study was to determine if triploid grass carp stocked at seven fish/hectare of lake area could control[2] hydrilla regrowth without detrimentally impacting the submerged native plants.

Study Area

Lake Yale is a 1,636-ha lake located in Lake County near Eustis, FL. Hydrilla became established in the southern end of Lake Yale in 1980. The dominant submerged plant at that time was Illinois pondweed, which covered approximately 140 ha and ranged to a depth of 3 m. In 1981, 22 ha of hydrilla were treated with Diquat plus copper and Aquathol K. In 1983, the hydrilla had expanded to 1,200 ha, and 252 ha were treated with various herbicides including Sonar (fluridone). These treatments destroyed the spatterdock (*Nuphar luteum*) that had dominated the south end of the lake. In 1984, 1,400 ha of hydrilla were reported, and a large-scale Sonar treatment was scheduled. Ten 10-ha plots were treated with Sonar (310 kg active) in April 1984. By October 1984, only 128 ha of hydrilla remained, and pondweed had expanded to 320 ha. No hydrilla was found after the October 1984 survey until March 1987, when approximately 2 ha were found in the south end of the lake. At that time, pondweed had expanded to 1,080 ha and reached a depth of 5 m. Between July 1987 and February 1989, 14,945 triploid grass carp were stocked (Table 1). Hydrilla expansion continued; in January 1990, 42 ha of dense hydrilla in the south end of the lake were treated with Aquathol K, and 6,200 additional triploid grass carp were stocked. The hydrilla continued to expand until treated with Sonar in 1992 and 1993. These treatments virtually eliminated hydrilla, and the grass carp have severely impacted the remaining submerged plant population.

Materials and Methods

Six permanent transects were established in 1987 to representatively sample plant communities in Lake Yale (Figure 1). Point samples were taken at 15-m intervals along each

---

[1] Florida Game and Freshwater Fish Commission, Eustis, FL.

[2] Target plant is kept below problematic levels so that it does not interfere with the intended use(s) of that water body.

Table 1
Date and Number of Triploid Grass Carp Stocked in Lake Yale, Hydrilla Coverage, and Frequency of Occurrence (Total fish equals fish stocked minus estimated mortality)

Date	Fish Stocked	Total Fish	Hydrilla Coverage, ha	Hydrilla Frequency of Occurrence, %
3/87			2	
5/87			41	
7/87	5,400	1,200	81	20
11/87	750	1,950	90	21
12/87	775	2,537	90	
1/88	1,000	3,386	100	
2/88	550	3,777		26
5/88	1,500	5,262	130	
6/88	2,100	6,982		30
10/88	1,400	7,824	162	25
2/89	1,470	8,885	162	28
5/89		8,489	196	29
8/89		8,332	410	30
11/89		8,272	520	32
1/90	6,200	13,433	800	53
12/90		12,188	1,310	81
12/91		11,304	1,340	83
12/92		10,394	650	63
12/93		9,237	0	0
Total	**21,145** **13/hectare**	**—** **6/hectare**		

line quarterly. Plants were sampled using a pole with hooks that was lowered through the water and rotated. Percent frequency of occurrence was recorded of all plants collected. A recording fathometer (Raytheon DE-719B) was also run quarterly on eight additional transect lines (totaling 17 km) to estimate total coverage of aquatic plants (Figure 1). Biomass sampling (Nall and Schardt 1978) was conducted semiannually starting in 1989 to determine biomass (metric tonnes) of each plant species. Vegetation maps for major plant species were constructed using the Loran coordinates of 200 biomass sampling stations.

Mortality estimates from the first triploid grass carp stocking in July 1987 were made by stocking a subsample of fish in ponds at the Richloam Hatchery. Thereafter, estimates of the number of fish remaining in the lake were corrected using an estimate of 25-percent mortality for the first year after stocking, 5 percent each of the next 2 years, 10 percent each year of the next 3 years, and 25 percent per year thereafter (Hestand, Thompson, and Clapp 1990).

In 1992, 200 kg (active ingredient) of Sonar was applied to the northwest portion of Lake Yale with biweekly treatments from January 13 to March 30 (Figure 1). Water samples to be analyzed for fluridone were collected biweekly through June and once in July, September, and October by Lake County Water Authority personnel. These samples were analyzed for fluridone by Dr. John Rodgers, University of Mississippi, Biological Field Station.

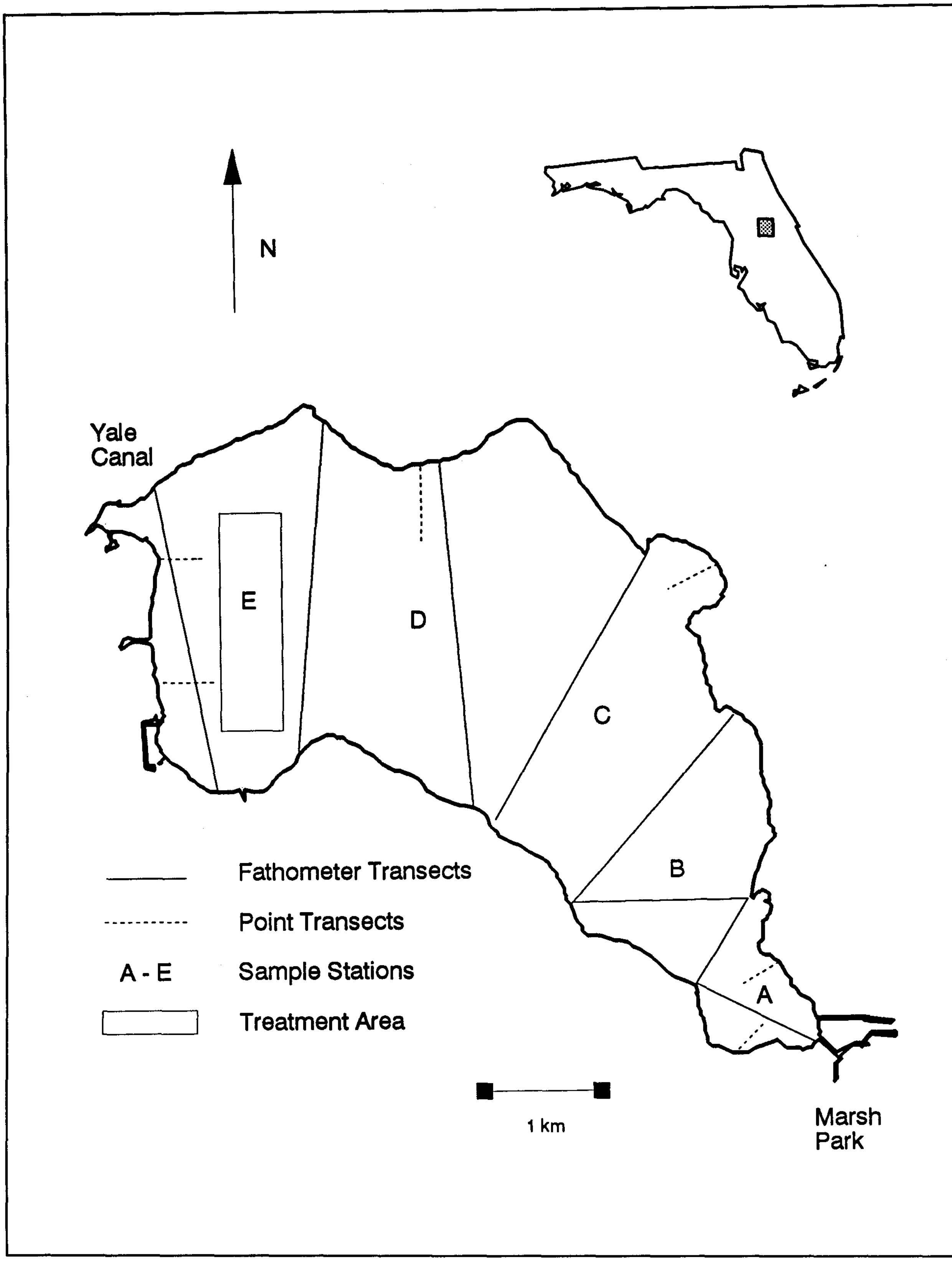

Figure 1. Map of Lake Yale illustrating the location of recording fathometer point transects, fluridone sample stations, and treatment area

In 1993, 181 kg (active ingredient) of Sonar was placed in the same area of Lake Yale as the 1992 treatment. However, this time the treatment was split into three applications over a 2-week period covering February and March.

Results and Discussion

The hydrilla that covered 2 ha in March 1987 had expanded to 41 ha by May 1987. The stocking of 3.7 triploid grass carp/hectare (146 fish/hectare of hydrilla) originally planned for May 1987 was delayed until mid-July 1987. Of the 6,000 fish ordered, 600 were placed in three ponds at the Richloam Hatchery (Florida Game and Fresh Water Fish Commission hatchery near Webster), where mortality ranged from 74 to 82 percent within 30 days. This mortality was likely due to shipping stress and stocking into warm water (31 °C). Thus, of the 5,400 fish stocked in July 1987, we estimated that only 1,200 fish survived longer than 2 weeks (15 fish/hectare of hydrilla). An additional 1,525, 6,550, 1,470, and 6,200 triploid grass carp were stocked in 1987, 1988, 1989, and 1990, respectively. Thus the highest density of triploid grass carp during the course of this study (excluding mortality) was 13/lake hectare or 20/hydrilla hectare in January 1990. Factoring in estimated mortality reduced these densities to eight/lake hectare or 17/hydrilla hectare in January 1990 (Table 1). Earlier work with diploid grass carp indicated that a minimum of 123 fish per hectare of hydrilla or 20 per metric ton of plants were necessary to eliminate hydrilla (Osborne 1982).

Hydrilla was concentrated in the south end of the lake (Marsh Park, Figure 1) during 1987 (90 ha). It expanded each year until December 1989 when it occurred in approximately 500 ha. During this same time period, there was a slow decline in coverage of Illinois pondweed that probably resulted from two factors: competition from expanding hydrilla and grazing from the triploid grass carp. On one transect, Illinois pondweed had a frequency of occurrence in November 1987 of 75 percent, but by November 1989 had declined to 10 percent, while hydrilla frequency of occurrence increased to 95 percent. The ability of hydrilla to exclude native plants has been described by Bowes et al. (1977), Haller and Sutton (1975), Van et al. (1977), Van, Haller, and Bowes (1976), and Van, Haller, and Garrard (1978). Even though triploid grass carp prefer hydrilla and feed heavily on it, they also consume Illinois pondweed (Figure 2). Hydrilla had a frequency of occurrence of 30 percent in the lake, but it was found in 90 percent of the triploid grass carp stomachs that were analyzed. Frequency of occurrence of Illinois pondweed was 42 percent in the lake, and it was found in 45 percent of the stomachs. Stomach analysis may be biased, as triploid grass carp were more easily collected where hydrilla was abundant. Telemetry data probably yielded a better picture of what the fish were eating. Hydrilla was found at 61 percent of radio telemetric locations of triploid grass carp and pondweed at 49 percent of the locations (Hestand, Thompson, and Clapp 1989).

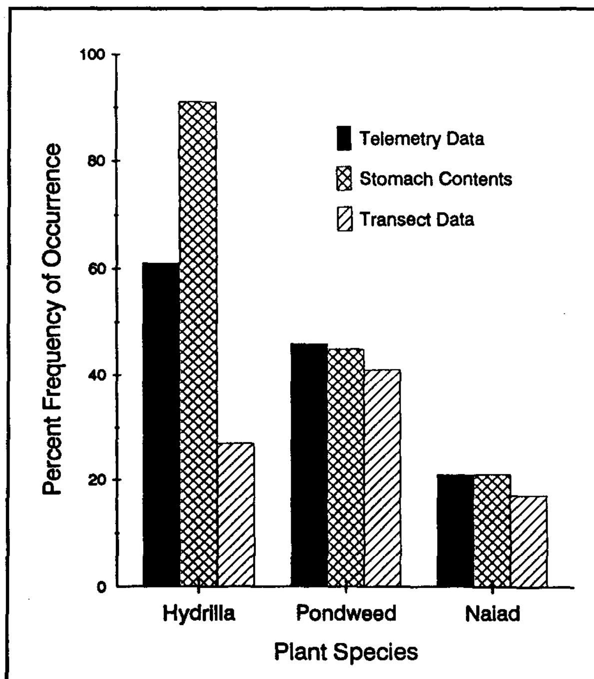

Figure 2. Estimated plant consumption by triploid grass carp based on stomach contents and carp location (telemetry) data. Transect data estimates relative abundance of major plant types

By October 1991, hydrilla had increased to 83-percent frequency of occurrence in biomass samples and made up 74 percent of the total plant biomass. The biomass and percent frequency of occurrence of Illinois pondweed showed little change from the severe decline in 1990. The biomass of southern naiad (*Najas quadalupensis*) was reduced by 50 percent, while the frequency of occurrence declined by 20 percent from November 1990, probably from competition from hydrilla. Southern naiad biomass increased each winter, then declined with the increase in hydrilla during the summer. The reduction in biomass through 1994 was probably due to grass carp feeding (Table 2).

Table 2
A Comparison of Biomass (MT = metric ton) and Percent Frequency of Occurrence (Freq) of Dominant Vegetation in Lake Yale

	Hydrilla		Illinois Pondweed		Southern Naiad		Total Plants	
Date	MT	Freq	MT	Freq	MT	Freq	MT	Freq
Apr 93	996	12	3,388	52	465	16	5,646	65
Oct 89	1,063	25	5,978	68	2,524	14	11,491	81
Apr 90	863	32	465	42	1,926	35	4,849	77
Oct 90	2,160	53	262	24	3,337	51	6,871	82
Mar 91	3,361	61	133	17	3,720	69	7,705	88
Oct 91	11,624	83	300	20	1,706	41	15,804	90
Apr 92	10, 916	82	280	13	2,106	43	15,618	93
Sep 92	2,143	63	1,014	22	1,276	45	7,280	89
Apr 93	355	40	170	17	2,215	55	3,988	71
Oct 93	1	2	175	9	1,789	30	3,569	48
Apr 94	2	2	1	0.4	2,377	24	4,149	36
Oct 94	3	2	0.3	0.4	723	19	3,405	40

While the coverage of hydrilla continued to expand, Illinois pondweed suffered a dramatic decline in coverage and biomass. Following Sonar treatments in 1992 and 1993, hydrilla was virtually eliminated. The 1992 treatment resulted in an 80-percent reduction in hydrilla biomass by September 1992 (Table 2). This lakewide reduction was not expected since the calculated theoretical concentration of fluridone was 3.4 ppb, and a minimum of 5 ppb was thought to be needed to control hydrilla. Current work has found that mature hydrilla required exposure in excess of 500 FEDs (fluridone exposure days) to control hydrilla with significant regrowth appearing within 6 months (Fox, Haller, and Shilling 1994). Over 700 FEDs were required to repress regrowth for over 1 year. With FEDs of 350, only a 6-month suppression of hydrilla occurred. FEDs on Lake Yale ranged from 83 to 439 (Figure 3). However, when the standard deviation is figured, the high end of the confidence interval was 361 to 717 FEDs. This is within the necessary range for control and resulted in an 80-percent reduction in hydrilla biomass. Because of extensive regrowth, another treatment was scheduled in 1993. This Sonar treatment removed all hydrilla regrowth resulting in the grass carp reducing Illinois pondweed even more. In Lake Conway, Illinois pondweed virtually disappeared after hydrilla was eliminated (Schardt and Nall 1981). Stonewort (*Nitella* sp.) became the dominant plant following removal of hydrilla and Illinois pondweed by triploid grass carp. Subsequently, Illinois pondweed did return, but never reached its former density. In Lake Yale, southern naiad (*Najas guadalupensis*) and muskgrass (*Chara* sp.) are replacing Illinois pondweed (Table 3). However, their

Table 3
Respective Percent Frequency of Occurrence of Major Plant Species Sampled on Transect Lines in Lake Yale Between November 1987 and February 1994

Date	Illinois Pondweed	Coontail	Hydrilla	Southern naiad	Eelgrass	Bladderwort	Muskgrass	Bare
11/87	46.7	4.2	21.1	11.1	0.3	4.3	15.1	26.1
3/88	48.6	4.2	25.5	15.2	0.8	5.0	9.8	26.8
11/88	42.3	4.9	25.4	16.7	0.8	6.2	18.5	16.4
2/89	38.9	6.8	27.8	17.6	1.2	8.3	15.1	19.3
11/89	37.1	5.6	31.8	15.6	1.7	7.8	16.3	13.3
2/90	30.1	4.2	24.8	19.4	0.5	7.9	22.0	15.8
11/90	17.2	2.3	39.1	43.2	2.8	11.2	19.5	11.2
2/91	18.2	2.7	38.9	43.2	2.9	9.7	18.5	17.0
11/91	18.2	1.7	62.8	27.9	2.5	10.1	15.9	22.3
2/92	19.3	4.1	50.1	26.2	1.2	6.9	12.2	21.2
11/92	18.9	5.3	31.7	30.0	2.1	13.8	14.8	26.6
2/93	15.5	6.4	21.2	34.3	1.4	12.6	14.9	37.1
11/93	0.6	3.3	0	24.2	2.3	8.7	14.8	54.0
2/94	0.5	2.9	0.7	25.0	4.4	3.9	14.7	53.9
11/94	0	2.9	0.3	14.0	4.8	0.8	14.7	64.7

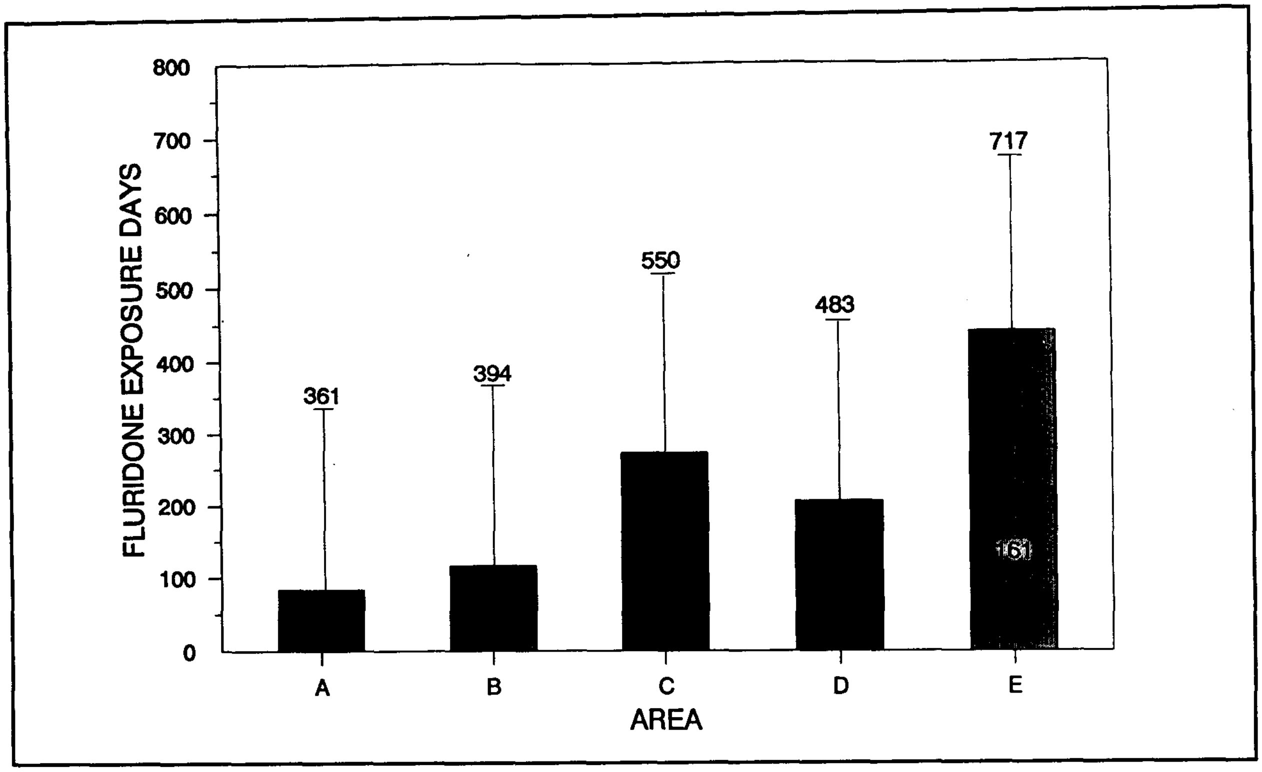

Figure 3. Fluridone exposure days at different sites in Lake Yale following a 1992 Sonar treatment

respective biomass will not sustain the number of grass carp in the lake. There are approximately five grass carp per metric ton (MT) preferred food and 2.6/MT of total submerged plants (Figure 4). If mortality is excluded, there are six/MT, which is enough grass carp to decimate the aquatic plant population (Leslie et al. 1987).

Conclusions

Because of the continued expansion of hydrilla, a stocking rate of 13 triploid grass carp/hectare (8/hectare adjusted for mortality) or 17/hydrilla hectare (adjusted) did not prevent the regrowth of hydrilla to problematic levels in Lake Yale. The Sonar treatments in 1992 and 1993 eliminated hydrilla, putting the native submerged plants at risk of being totally consumed by the triploid grass carp. It is possible that given the variability in the growth rate of hydrilla, it may be impossible to fine tune the triploid

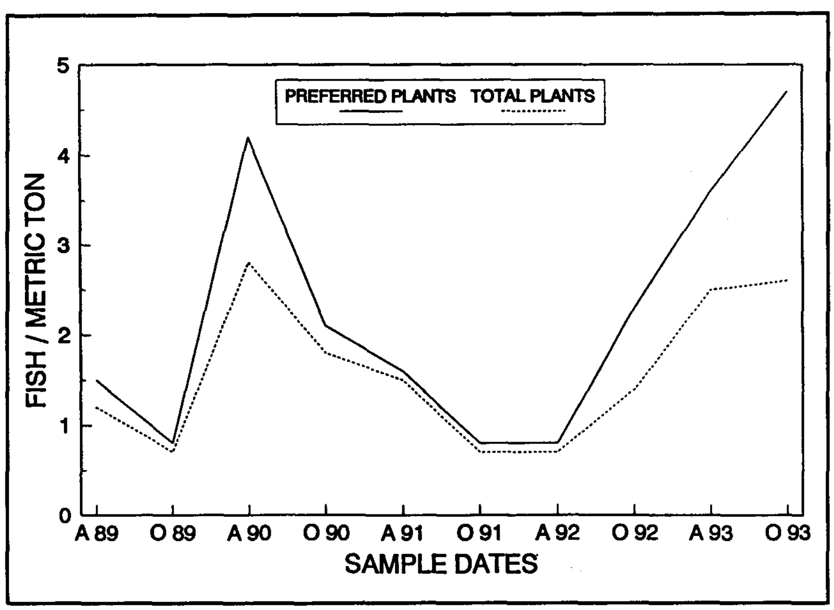

Figure 4. Comparison of number of triploid grass carp per metric ton of submerged plants to preferred plants in Lake Yale

grass carp stocking rate and not negatively impact preferred native plants that occur in lakes with hydrilla regrowing over the entire lake.

References

Bowes, G., Van, T. K., Garrard, L. A., and Haller,W. T. (1977). "Adaptation to low light levels by hydrilla," *J. Aquat. Plant Manage.* 15, 32-35.

Fox, A. M., Haller, W. T., and Shilling, D. G. (1994). "Use of fluridone for hydrilla management in the Withlacoochee River, Florida," J. Aquat. Plant Manage. 32, 47-55.

Haller, W. T., and Sutton, D. C. (1975). "Community structure and competition between *hydrilla* and *vallisneria*," *Hyacinth Control J.* 13, 48-50.

Hestand, R. S., Thompson, B. Z., and Clapp, D. F. (1989). "1987-89 Completion Report, Herbivorous Fish Project," Florida Game and Fresh Water Fish Commission, Tallahassee, FL.

________. (1990). "1989-90 Performance Report, Herbivorous Fish Project," Florida Game and Fresh Water Fish Commission, Tallahassee, FL.

Leslie, A. J., Jr., Van Dyke, J. M., Hestand, R. S., and Thompson, B. Z. (1987). "Management of aquatic plants in multi-use lakes with grass carp (*Ctenopharyngodon idella*)," *Lake and Reservoir Management* 3, 266-276.

Nall, L. E., and Schardt, J. D. (1978). "Large-scale operations management test of use of the white amur for control of problem aquatic plants; Report 1, Baseline studies; Volume I: The aquatic macrophytes of Lake Conway, Florida," Technical Report A-78-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Osborne, J. A. (1982). "Herbicide vs. Grass Carp," *Aquatics* 4, 13-14.

Schardt, J. D., and Nall, L.E. (1981). "An update on aquatic plant sampling in Lake Conway after the fourth study year," Report Bureau of Aquatic Plant Research and Control, Department of Natural Resources, Tallahassee, FL.

Van, T. K., Haller, W. T., and Bowes, G. (1976). "Comparison of the photosynthetic characteristics of three submerged aquatic plants," *Plant Physiol.* 58, 761-768.

Van, T. K., Haller, W. T., Bowes, G., and Garrard, L. A. (1977). "Effects of light quality on growth and chlorophyll composition in hydrilla," *J. Aquat. Plant Manage.* 15, 29-31.

Van, T. K., Haller, W. T., and Garrard, L. A. (1978). "The effect of day length and temperature on hydrilla growth and tuber production," *J. Aquat. Plant Manage.* 16, 57-59.