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A Preliminary Study of the Efficacy of Hybrid Grass Carp For Hydrilla Control[1]

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ABSTRACT

Hydrilla biomass was monitored between November, 1980 and September, 1982 in six central Florida lakes to determine the efficacy of hybrid grass carp for hydrilla control. Hybrid grass carp from the 1979, 1980 and 1981 spawns (J. M. Malone and Sons, Enterprises) were used. Fish from the 1979 spawn were stocked in Lake Sybelia and Lake Wildermere at 14 and 16 fish mt^{-1}—FW hydrilla. Fish from the 1980 spawn were stocked at rates between 6 and 118 fish mt^{-1}—FW hydrilla and fish from the 1981 spawn were stocked at rates between 11 and 37 fish mt^{-1}—FW hydrilla. Hydrilla biomass increased in all of the lakes immediately after the fish were stocked. Some of the lakes had vegetation biomass increases of several orders of magnitude. The lack of control by the hybrid grass carp was probably due to several factors; the time of stocking, multiple stockings, the number of fish stocked, the low feeding rate of the hybrid grass carp relative to the growth rate of hydrilla, and losses of fish due to predation and mortality from hybridization. It was concluded that the hybrid grass carp was not effective as a hydrilla control agent at the stocking rates used in this study and since much higher stocking rates would probably be needed, the cost of the fish would severely limit their use in submersed aquatic weed management programs.

Key words: Aquatic weeds, biomass, growth, Florida, stocking rate, biomass sampling, *Ceratophyllum, Najas, Vallisneria.*

INTRODUCTION

The primary objective of this research project was to determine the efficacy of the hybrid grass carp (*Ctenopharyngodon idella* X *Aristichthys nobilis*) at controlling hydrilla (*Hydrilla verticillata* (L.f.) Royle) in central Florida freshwater lakes.

The hybridization of the bighead carp (*Aristichthys nobilis*) and the grass carp (*Ctenopharyngodon idella*) was first performed in 1968 in Szarvas, Hungary which resulted in triploid (2N = 72) hybrid grass carp as reported by

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Marian and Krasznai (6). The hybrid grass carp was first spawned in the United States by J. M. Malone and Sons, Enterprises, Lonoke, Arkansas (5). Malone reported successfully spawns of hybrid grass carp in June, 1979. S. Henderson (Arkansas Game and Fish Commission), M. Martin (U.S. Fish and Wildlife Service) and H. Buck (Illinois Natural History Survey) are reported to have assisted (11). Previous research efforts with the hybrid grass carp have dealt with feeding trials (3, 4, 10, 8), morphological comparisons of the hybrid grass carp and grass carp (2, 11) and karological comparisons (7).

METHODS AND MATERIALS

Description of the Study Lakes. Six lakes in central Florida were utilized in the study. The lakes were selected since they were to receive hybrid grass carp purchased by lakefront homeowners. The Florida Game and Fresh Water Fish Commission obtained the fish for the homeowners from J. M. Malone and Sons, Enterprises, reared the fish to a stockable size (20 cm total length), and stocked the lakes. The five study lakes stocked by the Commission were Lake Destiny (16.3 ha), Lake Pineloch (23.5 ha), Lake Sybelia (39.3 ha), Lake Sue (56.7 ha), and Lake Wildemere (14.2 ha). Lake Catherine (25.5 ha) was stocked by the homeowners with 1980 hybrid grass carp in March, 1981 and with 1981 hybrid grass carp in July, 1982. The lakes were a good representation of the freshwater impoundments located within the central Florida area (Seminole and Orange County). Due to the effect of eutrophication from cultural influences, they are meso-eutrophic. All of the lakes contained the exotic submersed plant, hydrilla (*Hydrilla verticillata* (L.f.) Royle), the target plant for weed control by the hybrid grass carp, even though many of the lakes contained other submersed species as well. Stonewort (*Nitella* spp) was found in three lakes, coontail (*Ceratophyllum dermersum* L.) in two lakes, southern naiad (*Najas quadalupensis* (Spreng.) Magnus) in six lakes, muskgrass (*Chara* sp) in four lakes, eelgrass (*Vallisneria americana* Michx.) in two lakes and pondweed (*Potamogeton illinoensis* Morong) in one lake. The biomass of these species was monitored, but only hydrilla will be discussed in this paper. All of the lakes received some herbicide treatments in the 1979 growing season prior to the introduction of the hybrid grass carp. In most instances, herbicide was not added to the lakes during the 1980-81 study year, but was added during 1981-82.

Vegetation Sampling Method. Samples of hydrilla and other submersed vegetation were collected using the Osborne submersed aquatic plant sampler (1). The description and operation of the sampler is given in Osborne and Sassic (9) and is a standard method for obtaining biomass measurements of submersed vegetation (1). Samples of submersed vegetation were washed twice in nylon bags, spun in a garment washer at 540 rpm for 4 min to remove excess water, sorted by species, and massed to the nearest 0.001 kg to determine fresh weight per unit area (kg m^{-2}—FW). Total lake biomass of hydrilla in mt—FW was determined by extrapolating the mean biomass (kg m^{-2}—FW) for the lake on the basis of lake surface area (m^2).

With aerial photographs of the lakes provided by the Florida Game and Fresh Water Fish Commission, grid maps were constructed for the purpose of selecting random sampling stations. Utilizing a computer program, random sampling stations were chosen for each of the lakes. The number of sampling stations per lake was weighted by surface area. Lakes Wildemere and Sue were sampled quarterly, while the other four lakes were sampled bimonthly.

Stocking rates of the Hybrid Grass Carp. Lake Sybelia and Lake Wildemere received their first stocking of hybrid grass carp with fish spawned at the J. M. Malone and Sons, Enterprises fish farm in 1979, Table 1. Lake Sybelia and Lake Wildemere received these fish in multiple stockings between June and December, 1980. Hybrid grass carp from the 1980 spawn (J. M. Malone and Sons, Enterprises) were stocked into Lake Catherine in March, 1981, Lake Destiny in December, 1980, and Lake Pineloch and Lake Sue between May and June, 1981. Lake Sybelia, which was stocked on six seperate occasions with fish, received additional 1980 hybrid grass carp in June, 1981; likewise, Lake Wildemere received additional 1980 hybrid grass carp in June, 1981. The multiple stockings were necessary due to the inability of the hybrid grass carp to reach a stockable size (20 TL_{cm}, as determined by the Florida Game and Fresh Water Fish Commission) prior to stocking in spring. In any event, the hydrilla biomass at the time of the last stocking of hybrid grass carp was divided by the total number of hybrid grass carp in the lake to determine an estimate of the stocking rate based upon hydrilla biomass. These values are given in Table 1. They range from 6 fish mt^{-1}—FW hydrilla (Lake Sue) to 118 fish mt^{-1}—FW hydrilla (Lake Catherine). The fish ranged from 22-30 cm total length and were approximately 40 gm.

All of the lakes, with the exception of Lake Destiny, received hybrid grass from the 1981 spawn (J. M. Malone and Sons, Enterprises) during 1981 and 1982. The stocking rate per hydrilla biomass ranged from 11 fish mt^{-1}—FW hydrilla in Lake Pineloch to 37 fish mt^{-1}—FW hydrilla in Lake Wildemere, Table 1. These rates do not include the number of fish from previous stockings in 1979 and 1980.

To aid the second year stocking of hybrid grass carp (1981 spawn) herbicide was applied to many of the lakes by the Florida Game and Fresh Water Fish Commission, Table 2. Most of the treatments were applied during midsummer, 1982 at about the time the 1981 hybrid grass carp were stocked.

RESULTS AND DISCUSSION

Lake Catherine. Hydrilla biomass responsed in Lake Catherine as one might expect after a winter die back, Figure 1. Hydrilla reached its peak biomass in November, 1981 with a monthly mean value of 1.127 kg m^{-2}—FW. The late autumn maximal biomass (287.5 mt—FW) in Lake Catherine was nearly 35 times higher than the early spring value (8.5 mt—FW) when the fish were stocked. Lake Catherine failed to undergo a severe winter decline and had a much higher biomass in the following year; in May, 1982 the hydrilla biomass was nearly seven times higher than for that month in the previous year.

TABLE 1. STOCKING RATES AND TIMES FOR HYBRID GRASS CARP IN THE SIX CENTRAL FLORIDA LAKES.

Lake	Date Stocked	No. fish	No. fish/ha	No. fish/ mt—FW Hydrilla	Size (TL_{cm})
Lake Catherine	Mar. 23, 1981	500[b]			
	Mar. 30, 1981	500[b]	40	118	21.5
Lake Catherine	July 23, 1982	1000[c]	40		
Lake Destiny	Dec. 18, 1980	1400[b]	86	98	22.9
Lake Pineloch	June 9, 1981	700			
	June 10, 1981	800			
		1500[b]	64	6	—
	July 12, 1982	1000[c]	42	11	20-25
Lake Sue	June 10, 1981	574			
	June 11, 1981	954			
		1528[b]	27	10	—
	April 2, 1982	1121			
	April 26, 1982	1270			
	April 28, 1982	1226			
	April 29, 1982	804			
		4421[c]	79	22	20-25
Lake Sybelia	June 17, 1980	134			
	July 16, 1980	163			
	Sept. 15, 1980	273			
	Oct. 28, 1980	170			
	Dec. 16, 1980	446			
	June 11, 1981	1064			
		2250[a]	57	14	25-30
	July 8, 9, 1982		102[ac]	24	20-25
Lake Wildemere	July 16, 1980	700			
	Aug. 16, 1980	722			
	June 11, 1981	328			
		1750[a]	127	16	25-30
	June 17, 1982	796			
	July 2, 1982	267			
	July 7, 1982	1437			
		1800[c]	126	37	25-30

[a]1979 hybrid grass carp
[b]1980 hybrid grass carp
[c]1981 hybrid grass carp

Lake Destiny. With the exception of Lake Wildemere, Lake Destiny received the highest number of 1980 hybrid grass carp on a per surface area basis, Table 1. At the time of stocking in December, 1980, hydrilla biomass was fairly low in the lake, Figure 2, thus a reasonably high stocking rate per hydrilla biomass was achieved (98 fish mt^{-1}—FW hydrilla). The hydrilla biomass in Lake Destiny was slow to recover from the winter die back of 1980, Figure 2, but eventually reached a peak in September, 1981. As in Lake Catherine, the hydrilla biomass during the winter of 1981 was higher than the hydrilla biomass during the winter of

TABLE 2. HERBICIDE APPLICATION IN THE SIX CENTRAL FLORIDA LAKES.

Lake	Date Treated	Chemical/Rate	Treated Area (ha)
Lake Catherine	June-July, 1982	unknown	unknown
Lake Destiny	June, 1982	Aquathol K; Koplex/37 l ha^{-1}	6.0
Lake Pineloch	June, 1982	Aquathol K; Koplex/37 l ha^{-1}	15.0
Lake Sue	Jan., 1982	Hydrothol 191-Hydout/ 159 kg	2.4
Lake Sybelia	June, 1982	Sonar/4.7 l ha^{-1}	6.5
Lake Wildemere	May, 1982	Aquathol K/47 l ha^{-1}	2.4

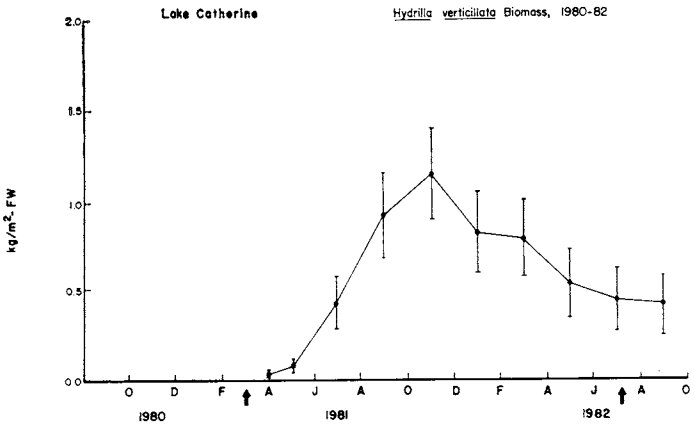

Figure 1. Monthly mean hydrilla biomass in Lake Catherine, Florida, April, 1981-September, 1982. The solid arrows indicate the month hybrid grass carp were stocked and the vertical lines represent the 95% confidence limits of the means.

1980. During January, 1980, the monthly mean hydrilla biomass was 0.087 kg m^{-2}—FW, while for January, 1981, it was 0.202 kg m^{-2}—FW, a difference of 56.9%. Hydrilla was found at its lowest level in Lake Destiny after herbicide was applied by a commercial applicator in late summer. While it appears that the hybrid grass carp may have kept the hydrilla in check during the early spring months of 1981, the higher levels of hydrilla during the winter of 1981 than in the previous winter of 1980 tends to nullify this assumption. If the hybrid grass carp had stressed the hydrilla during the spring of 1981, then a more rapid and larger winter die back would have occurred. The average annual tonage of hydrilla in Lake Destiny was 40.5 mt—FW for 1980-81 and 33.4 mt—FW for 1981-82. The difference between these values was mainly due to the large reduction in hydrilla biomass in July, 1982 (only 2.2 mt—FW hydrilla present) due to the application of herbicide.

Lake Pineloch. With the exception of Lake Sybelia, Lake Pineloch contained the largest tonage of hydrilla of the study lakes. From November, 1980 to July, 1981 the biomass of hydrilla in Lake Pineloch nearly doubled, Figure 3. The tonage of hydrilla ranged from 126.3 to 240.8 mt—FW between November, 1980 and April, 1981. Between June, 1981 and December, 1981 the biomass of hydrilla tended to level off, Figure 3. At the time, it was felt that perhaps the lake had reached its carrying capacity. This proved not to be the case as no winter decline in hydrilla occurred during the 1981 winter; instead the hydrilla biomass was found to increase from December, 1981 through April, 1982. The lack of the winter die back is suspected to have been caused by two factors: 1) a high growth response of hydrilla rebounding from a previous year when herbicide was used, and 2) leaf feeding by hybrid grass carp which would cause branching (8). By March, 1982, the tonage of hydrilla in the lake approached 400 mt—FW with a mean monthly value of 1.676 kg m^{-2}—FW, Figure 3. This was the highest level of hydrilla recorded in Lake Pineloch. After the introduction of herbicide in Lake Pineloch in June, 1982 the hydrilla biomass decreased by nearly 78%, Figure 3. The tonage of hydrilla in Lake Pineloch between July and September, 1982 was between 80 and 90 mt—FW. The annual mean biomass was 0.853 kg m^{-2}—FW (200.2 mt—FW) for 1980-81 and was 1.118 kg m^{-2}—FW (262.6 mt—FW) for 1981-82. The hydrilla biomass for November, 1980 was 56% higher than the biomass for November, 1981 (the season of maximum abundance).

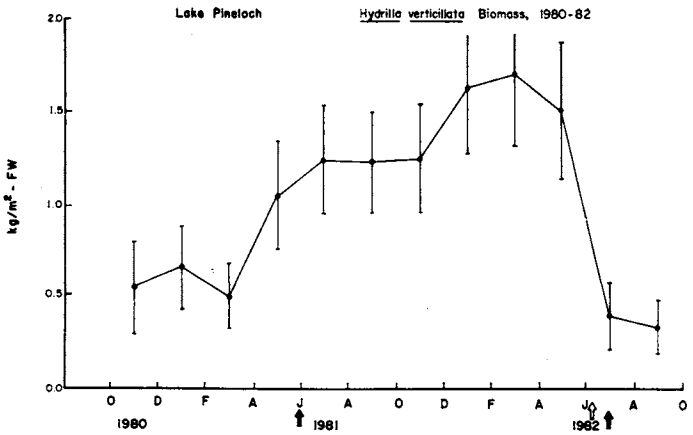

Figure 3. Monthly mean hydrilla biomass in Lake Pineloch, Florida, November, 1980-September, 1982. The solid arrows indicate the stocking times for hybrid grass carp, while the open arrow represents the time herbicide was applied to the lake. The 95% confidence limit of the means is represented by the vertical lines.

Lake Sue. Lake Sue, with a surface area of 56.7 ha, was the largest of the study lakes; it initially contained the least amount of hydrilla (32 mt^{-1}—FW in November, 1980). This was short-lived; by November, 1981 the hydrilla biomass in Lake Sue was higher by nearly an order of magnitude (284.9 mt^{-1}—FW). The annual trends for hydrilla were similar, but not as pronounced as in Lake Pineloch, Figure 4. Hydrilla was found to be lowest in February, 1981 (0.033 kg m^{-2}—FW) and highest in November, 1981 (0.503 kg m^{-2}—FW). As in Lake Pineloch, the winter decline in hydrilla in 1981 in Lake Sue did not approach the 1980 winter die back. The hydrilla biomass in February, 1982 was approximately 90% greater than that found in February, 1981, Figure 4. The annual average tonage of hydrilla in Lake Sue for 1980-81 was 108.1 mt—FW as compared to 194.9 mt—FW for 1981-82.

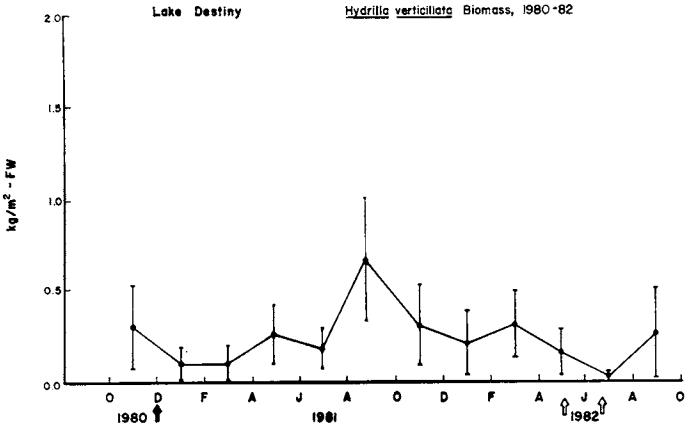

Figure 2. Monthly mean hydrilla biomass in Lake Destiny, Florida, November, 1980-September, 1982. The open arrows represent application times for herbicide, while the solid arrow indicates the stocking time for hybrid grass carp. The vertical lines represent the 95% confidence limits of the means.

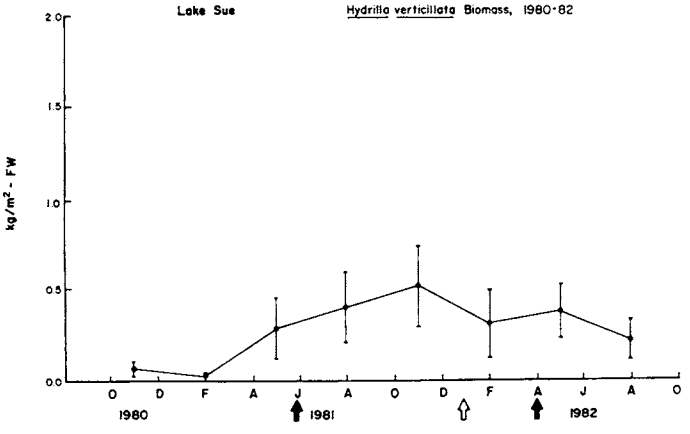

Figure 4. Monthly mean hydrilla biomass in Lake Sue, Florida, November, 1980-August, 1982. The open arrow represents the time herbicide was applied to the lake, while the solid arrows indicate the stocking times for hybrid grass carp. The vertical lines represents the limits for the 95% confidence limits of the means.

Lake Sybelia. Lake Sybelia was the recipent of the first stocking of 1979 hybrid grass carp by the Florida Game and Fresh Water Fish Commission. It also received the most stockings; from June, 1980 through June, 1981, this lake was stocked six times. The response of hydrilla over time in Lake Sybelia was not dissimilar to that observed in Lake Sue and Lake Pineloch, Figure 5. Hydrilla biomass was found to be at its lowest level in March, 1981, after a severe winter die back in the winter of 1980 and highest in November, 1981 at its peak seasonal biomass. As in the other study lakes previous discussed, the winter die back in 1981 was not as severe as during the previous year. As before, it is suspected that this resulted from the bounce back response after a previous year of herbicide treatment and from leaf feeding by the 1980 hybrid grass carp. The annual mean hydrilla biomass was 0.767 kg m^{-2}—FW for 1980-81 and was 1.136 kg m^{-2}—FW for 1981-82. During the autumn of 1981, Lake Sybelia contained the highest hydrilla biomass of any of the study lakes, Figure 5. In November, 1981 the tonage of hydrilla in Lake Sybelia was 614.7 mt—FW. The biomass of hydrilla in Lake Sybelia in November, 1982 was 63% greater than that in November, 1981, Figure 5.

Lake Wildemere. Lake Wildemere received the largest stocking rate of 1981 hybrid grass carp per surface area (126 fish ha^{-1}) and the highest stocking rate per hydrilla biomass (37 fish mt^{-1}—FW hydrilla). Lake Wildemere provided an unique aquatic plant environment as vegetation was restricted from the center of the lake by depth. Except for the period when herbicide was applied to Lake Wildemere, monthly mean hydrilla biomass values were higher during the 1981-82 study year than during the previous year, Figure 6. The mean biomass value for hydrilla in November, 1982 was 59% higher than the November, 1981 value, while the mean biomass in February, 1982 was 43% higher than in February, 1981. Had it not been for the reduction in hydrilla biomass after the May, 1982 herbicide application the annual mean tonage of hydrilla would have been greater for 1981-82 than for 1980-81. The tonage of hydrilla in August, 1982 was only 2.3 mt—FW hydrilla. The

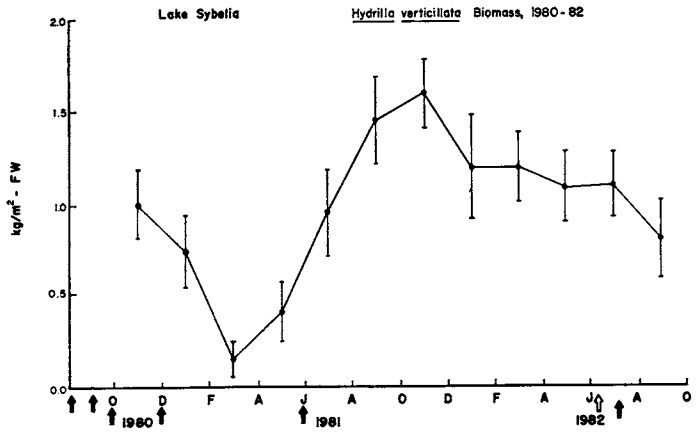

Figure 5. Monthly mean hydrilla biomass in Lake Sybelia, Florida, November, 1980-September, 1982. The solid arrows indicate stocking times for hybrid grass carp, while the open arrow indicates the time herbicide was applied. The vertical lines are the 95% confidence limits of the means.

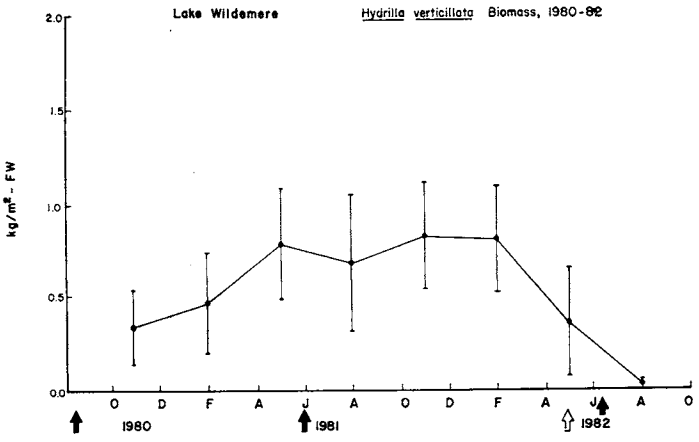

Figure 6. Monthly mean hydrilla biomass in Lake Wildemere, Florida, November, 1980-August, 1982. The solid arrows indicate times the hybrid grass carp were stocked, while the open arrow indicates the time of application of herbicide. The vertical lines represent the 95% confidence limits of the means.

hydrilla biomass for the previous August (1981) was 95.4 mt—FW. As was the case in the other study lakes, the winter die back of hydrilla in Lake Wildemere was not as severe during the second winter as in the first winter, Figure 6. The biomass of hydrilla in Lake Wildemere was 0.791 kg m^{-2}—FW in February, 1982 but was only 0.451 kg m^{-2}—FW in February, 1981. It should be pointed out that during the last sampling month (August, 1982) hydrilla biomass was greatly reduced by herbicide (Figure 6), but short (2-5 cm), dense hydrilla was obtained in the sampler. This new growth is presumed to be the regrowth of hydrilla after the herbicide treatment; there was no apparent control of this vegetation by the hybrid grass carp.

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