Effects of Aquatic Vegetation Removal on the Trophy Bass Fishery of Caney Creek Reservoir

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Abstract: After efforts to eradicate hydrilla *(Hydrilla verticillata)* with herbicide applications proved to be unsuccessful in Caney Creek Reservoir, triploid grass carp *(Ctenopharyngodon idella)* were introduced in an effort to control the expansion of the exotic, while leaving total aquatic plant coverage at a beneficial level of 15%–30%. After 2 years, the aquatic vegetation population that had been dominated by submerged species was composed primarily of emerged species. Aquatic vegetation coverage was reduced to <15% for the remainder of the study. Releative abundance of largemouth bass *(Micropterus salmoides)* and number of angler efforts were directly proportional with the reduction in aquatic vegetation coverage. Angler success was slightly increased. Water quality parameters and nutrient levels were not appreciably changed.

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Caney Creek Reservoir is a 2,025-ha impoundment located in Jackson Parish in north central Louisiana. The lake was impounded in February 1986, but did not attain pool stage until January 1989 due to its small watershed (107.5-km^2). All timber was harvested from the lake bottom during the late 1970s. Before inundation, however, regrowth had occurred by pines *(Pinus sp.),* black willow *(Salix niger),* and oaks *(Quercus. sp),* reaching heights of 5 m. By 1993, the flooded terrestrial vegetation had deteriorated , leaving aquatic vegetation as the primary form of cover.

Caney Creek Reservoir is mesotrophic and has an average depth of 5 m. The watershed is infertile and primarily used for pine silvaculture. The lakeshore is developed with single family homes, camps, and 2 marinas. Recreation is the primary use of the reservoir.

Largemouth bass are the most popular gamefish species in Caney Creek Reservoir. The lake has received national recognition for producing trophy bass and is 1 of 2 in Louisiana classified as trophy lakes. The Louisiana State record largemouth bass (7.25 kg) and 17 of the top 20 listed record fish were caught in Caney Creek Reservoir.

From April 1991 until July 1993, harvest regulations for largemouth bass included a protective length range of 356 to 432 mm with a creel limit of 8 fish. A maximum of 4 bass could be harvested larger than 432 mm in total length. . Trophy lake regulations were imposed in 1993, including a protective length range of 381 to 483 mm with a creel limit of 8 bass. Only 2 bass in the angler's daily creel may be larger than 483 mm in total length.

Hydrilla was first discovered in Caney Creek Reservoir in 1989. At that time, hydrilla was not widespread in Louisiana and the Department of Wildlife and Fisheries (LDWF) was attempting to chemically eradicate all new occurrences. In Caney Creek Reservoir, a hydrilla eradication program was initiated and 3 separate herbicide applications were made. In 1989, 25.5 hectares were treated with 18.9 liters of Diquat (diquat dibromide) and 9.5 liters Cutrine Plus (copper)/ha of infestation. Subsequent inspections in 1989 indicated 95% control in all treated areas. The lake was surveyed in early June 1990. Regrowth of hydrilla was noted in all areas treated in 1989. Sixteen additional isolated infestations were documented and 8 km of shoreline infestations were found around the lake.

During 1990, a total of 160 ha of hydrilla were treated with Sonar (fluridone). Application rates were 33.6 kg/ha in waters $\leq$1.5m and 68.9 kg/ha in waters $>$1.5 m deep. Ninety-five percent of the infestation was controlled within 60–90 days. A re-evaluation of the applications was made on 29 May 1991. Seventeen to 24 ha of hydrilla were found during the inspection. In July 1991, 21.5-ha of hydrilla were treated with Sonar and Hydrothol 191 (endothall). Evaluations of the 1991 applications were made on 11 May, 15 June, and 25 June 1992. Approximately 200 ha of hydrilla were found throughout the reservoir. Based on these findings (an 8-fold increase in hydrilla, even with the expenditure of approximately $250,000), the eradication program using herbicides was terminated.

In September 1993, an Aquatic Management Plan for Caney Creek Reservoir was developed by LWDF. In the plan, hydrilla was recognized as the species with greatest potential to negatively impact the multiple-use reservoir. However, because eradication efforts had failed, control efforts would address hydrilla as a part of total macrophyte coverage. Also in the Aquatic Management Plan was LDWF recognition of the beneficial aspects of aquatic macrophytes to fisheries at certain levels of coverage. LDWF recommendations included a macrophyte coverage range of 15%–30% as a goal. The LDWF next considered and evaluated the remaining options:

1. No Action: The unchecked growth of hydrilla would cause unacceptable damage to the aquatic ecosystem and severely restrict the intended utilization of the reservoir.

2. Water Level Manipulation: This method is used in many Louisiana reservoirs to manage aquatic habitat. However Caney Creek Reservoir has a small watershed and could take up to 3 years to re-fill after a drawdown.

3. Mechanical Control: Harvesters cost an average of $1,235–$3,000/ha (Thayer and Ramey 1986) to operate and typically harvest only 1.2–2.4 ha/day. Additionally, mechanical harvesting can spread hydrilla through fragmentation.

4. Biological Control: Potential agents include pathogens, insects, and fish that have evolved with and naturally suppress hydrilla in its native range. Several insect species have been tested and released in the United States. Their performance is still under study. The most effective biocontrol agent for control of hydrilla has been the grass carp. Sutton and Vandiver (1986) reported hydrilla is a preferred food for grass carp. Stocking rates ranged from 12 to 74 grass carp/ha in their report.

The LDWF decided to institute a biological control program utilizing triploid grass carp. A serial stocking strategy for triploid grass carp was developed, based on LDWF research with stocking rates, actual stocking regimes of numerous large reservoirs, the U.S. Army Waterways Experiment Station (WES) AMUR/STOCK simulation model (Boyd and Stewart 1995), and the Colorado GRASCARP stocking model (Swanson and Bergersen 1988).

Methods

Surveys of aquatic plant populations were initiated in August 1993 and continued throughout the project. Total plant coverage, species composition, and biomass were measured. Surveying and typemapping were accomplished using boats, contour maps, fathometers, and vegetation drags. Biomass samples were collected using a sampling barge with a hydraulically operated sampling device having a cross-sectional area of 0.29 m^2. Ten transect lines were established throughout the lake and a minimum of 10 samples were collected along each transect.

Through aerial photography and the geographic information system (GIS), it was determined that Caney Creek Reservoir had a total of 607.5 ha of submerged vegetation in 1993, most of which was hydrilla. Twenty triploid grass carp/vegetated ha (11,968 fish) were introduced into Caney Creek Reservoir in January 1994. Stocked triploid grass carp were of relatively uniform size and were at least 305 mm in total length. Global positioning system (GPS) and GIS were used to monitor coverage of vegetation after triploid grass carp introduction.

Fisheries dependent and independent sampling was conducted to determine the effects of vegetation removal by triploid grass carp on fish assemblages and population structures. All sampling was conducted according to LDWF standardized sampling procedures.

Nighttime electrofishing samples of largemouth bass were collected using boat-mounted gear (Smith Root GPP 5.0) from 1992 through 1998. Sampling was conducted for 900 seconds each at 6 established stations in spring (Mar–Apr) and fall (Oct–Nov). All collected bass were weighed, measured, and recorded. Spring largemouth bass abundance was indexed with electrofishing catch-per-unit effort (CPUE), defined as the number of fish captured/hour of sampling effort. Length frequency distributions (Anderson 1976) were calculated from collected data. Fall largemouth bass data were used for calculation of releative weight. Relative weights of all largemouth bass were determined using methods described by Anderson and Gutreuter (1983).

Recreational angler surveys were conducted for 12-month periods during 1993, 1994, 1996, and 1998 to determine angler effort and catch rates. A rate of 6 randomly selected sample days/month was utilized during high recreational use periods (Feb–Jul). Sampling for high recreational use periods included 4 weekend days and 2 week days. A reduction to 3 days/month (2 weekend days and 1 week day) was used during periods of low use (Aug–Jan). Interviews were scheduled to include either morning or evening hours. Roving surveys were made at random during each scheduled interview period to allow expansion of data to estimate total angler attributes.

Because harvest regulations restricted possession of bass in the protective length range, questions were included in the survey to determine number of bass caught and released smaller than, within, and larger than the protective length range. Any bias to data collected by the questions is assumed to be uniform throughout the study.

Water quality sampling was conducted at 3 stations from January 1993 through November 1998. Stations were selected to represent the lower, middle, and upper regions of the impoundment. Parameters including pH and temperature were measured at mid-day at 1-m intervals with a Hydrolab Surveyor II. Sampling for May, June, and July 1994 was conducted to monitor an abnormally high phtyoplankton bloom. Water clarity was measured with a 20-cm secchi disk in conjunction with the measurements of pH and temperature. From January 1994 through November 1998, epilimnetic water samples were collected, placed on ice, and delivered to the Northeast Louisiana University Soils Lab for analysis of chlorophyll-A, ortho-phosphate, and total phosphate.

Results

Hydrilla biomass decreased from 831.5 g/m^3 in 1993 to 760 g/m^3 in 1994 (Fig. 1). In 1995, total biomass fell to 1.5g/m^3, with only a trace of hydrilla in the samples. No further biomass samples were taken after this time after 1995.

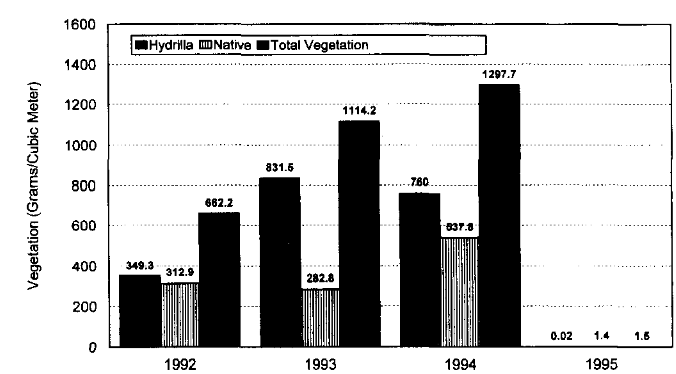

Figure 1. Caney Creek Reservoir vegetative biomass, 1992–1995.

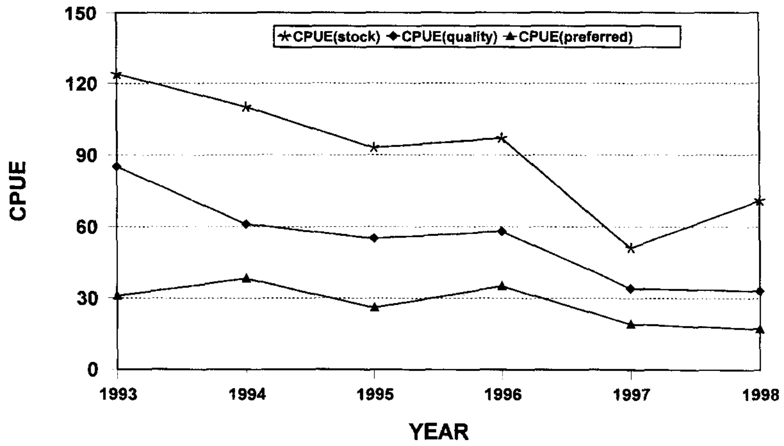

Figure 2. Catch/hour (CPUE) of largemouth bass stock, quality, and preferred size groups from springtime electrofishing.

Aquatic macrophyte coverage was 33.2% in September 1993, before the stocking of triploid grass carp. Surface coverage was 38.1% in September 1994, after the grass carp were stocked. Between May and June 1995, hydrilla stems were observed floating in the lake that appeared to be dead or dying. In August 1995, total macrophyte coverage was 15.9%, predominately composed of watershield *(Brasenia schreberi)* and white water lily *(Nymphaea odorata)*. As the biomass samples indicated, submerged vegetation was severely reduced by this time. GPS surveys through September 1997 showed a decline in macrophyte coverage to 7.4%, all of which was emergent vegetation (watershield and white water lily). Only trace amounts of hydrilla in very shallow water were observed. Several other species of submergent and marginal plants were found in small amounts.

Electrofishing catch rates suggest a decrease in the relative abundance of largemouth bass, with CPUE (total) dropping from 139 bass/hour in 1993 to 106 bass/hour in 1998. Stock CPUE showed a marked decline from 129 bass/hour in 1992 to 71 bass/hour in 1998 (Fig. 2). CPUE for quality and preferred size groups also declined but to a lesser extent. Wr values indicate consistently good largemouth bass condition from 1992 through 1998, with all length categories ranging from 92 to 120. Length frequencies of largemouth bass populations by year (Fig. 3) confirm the decline in CPUE. Increased relative abundance of largemouth bass in the 381- to 483-mm size class is indicated. Catch indices remained relatively stable primarily due to a decrease in stock-size subquality fish. PSD values increased from a 1992 value of 33 to 68 in 1993. From 1993 to 1998 PSD dropped slightly from 68 to 65. RSD_{14} values increased from a 1992 value of 11 to 35 in 1998.

Largemouth bass anglers represented the majority of anglers on Caney Creek Reservoir in all recreational angler surveys. The percentage of total anglers primarily seeking largemouth bass ranged from 80% in 1993 to 87% in 1998. Estimated largemouth bass angler hour/ha/year increased from 1993 to 1994, but declined in

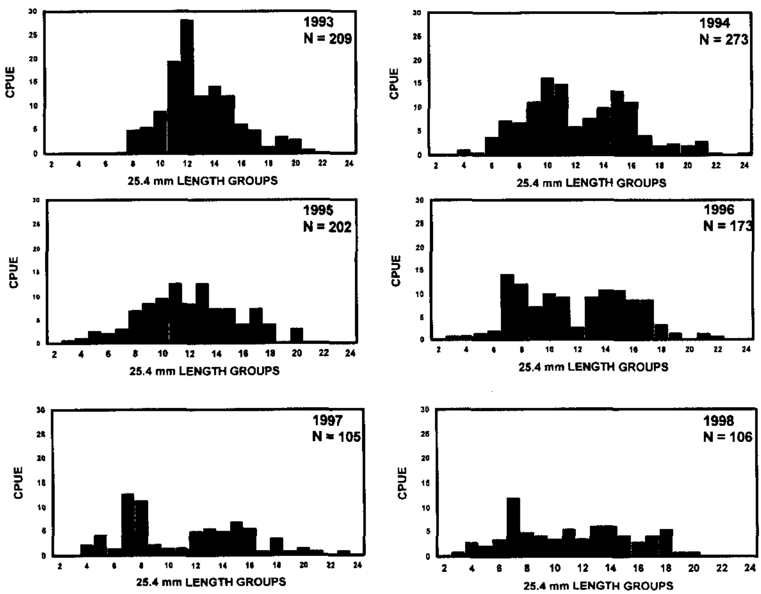

Figure 3. Length, frequency, number, and catch/hour (CPUE) of largemouth bass collected by springtime electrofishing. Caney Creek Reservoir, Louisiana, 1993–1998.

1996 and in 1998 (Table 1). An inverse relationship was displayed between angler efforts and angler catch rates for largemouth bass. As angler efforts declined from 1994 through 1998, catch rates increased from 0.37 to 0.79 bass/hour. Harvest rates declined from 1993 through 1996 but increased in 1998.

Mean water temperatures for the 3 stations (at a depth of 1 m) displayed seasonal variation from 10 to 30 C, but was similar among all years sampled. The reservoir stratified thermally in April at a mean depth of 5 m each year, continuing into October. Thermal stratification was generally deeper in the lower region of the impoundment as a result of increased water clarity. The pH of Caney Creek Reservoir ranged from 5.5 to 7.0 during the sampling period. Seasonal trends were apparent with highest levels in the summer and lowest levels in the winter months. Variation in pH did not appear to be related to macrophyte removal. Secchi dish transparency varied seasonally and was indirectly proportional to temperature. Mean readings for January, April, July,

Table 1. Angler effort, catch rates, and harvest rates from Caney Lake Reservoir recreational angler surveys.

Survey year	Effort hour/ ha/year (SE)	Catch rates bass/hour (SE)	Harvest rates bass/hour (SE)
1993	7.1 (1.2)	0.61 (0.14)	0.17 (0.04)
1994	9.4 (2.2)	0.37 (0.03)	0.13 (0.03)
1996	8.0 (1.2)	0.50 (0.17)	0.14 (0.02)
1998	4.0 (0.6)	0.79 (0.19)	0.26 (0.04)

and October were 239, 180, 170, and 168 cm, respectively. Mean readings ranged from 99 cm in April 1994 to 269 cm in April 1996. Sample average readings for the months of May, June, and July 1994 were 94, 124, and 168 cm, respectively. Results of chlorophyll-A from samples collected before July 1994 is unavailable due to an analysis problem.

Chlorophyll-A levels after July 1994 showed seasonal variation and were directly proportional to water temperature with levels ranging from 0.9 to 3.4 mg/liters. Greatest variation and highest levels were measured in the 2 years immediately subsequent to macrophyte removal. July measurements in months of 1995 and 1996 were 3.4 and 2.7 mg/liters respectively. Orthophosphate was widely variable during the period January 1993 through April 1995 with levels ranging from 0.02 to 0.1 mg/liter. After July 1995, orthophosphate levels were more stable and never exceeded 0.02 mg/liter. Total phosphate levels showed seasonal oscillation with a range of 0.2 to 0.8 mg/liter. No relationship between total phosphate levels and the reduction in macrophytes was indicated.

Discussion

In February 1994, after herbicide treatments failed and all other options had been considered, triploid grass carp were stocked into Caney Creek Reservoir to primarily serve as a control agent for hydrilla. In the given physical conditions, potential for the exotic species to spread rapidly throughout the impoundment was high. Negative consequences, including interference with various water uses and displacement of native aquatic plants, seemed imminent. Triploid grass carp were introduced at a rate compiled from the best available information to control macrophyte coverage to within a desirable range of 15%–30% coverage. Hestand et al. (1989) introduced triploid grass carp at a rate of 9/ha into Lake Yale, Florida. After adjustments were made for mortality, the stocking rate was 5 fish/ha or 55 fish/ha of hydrilla. The Lake Yale triploid grass carp introduction did not control the spread of hydrilla. Lake Conroe, Texas, was stocked with grass carp at a rate 74 fish/vegetated ha in September 1981 (Klussman et al. 1987), resulting in the complete removal of submerged macrophytes by summer 1983. Lake Marion, South Carolina, was stocked with triploid grass carp in a serial stocking strategy over a 4-year period (de Kozlowski 1994). With a final stocking rate of 62 fish/vegetated ha, hydrilla increased in the first 2 years, but was reduced by 58% in the fourth year. The 20 carp/vegetated ha, rate for Caney Creek Reservoir was selected with the expectation that more carp would be required. Despite the rate that was considered to be conservative when compared to those used in other southeastern U.S. reservoirs, virtually all submerged vegetation had disappeared by July 1995.

Consideration of the apparently simple cause and effect relationship between triploid grass carp and absence of aquatic macrophytes in Caney Creek Reservoir should be expanded to include the potential for additional environmental control factors. Before July 1995, dead hydrilla stems were observed floating throughout the reservoir. The occurrence of floating hydrilla stems would not have been considered unusual at all. However, dead hydrilla stems could have been an indicator of a control agent that was not recognized or sampled by LDWF. Negative influence to plant growth by additional agents or a combination thereof, in addition to consumption by triploid grass carp, could have contributed to an initial reduction in submerged plant biomass. The number of triploid grass carp in the reservoir after such a macrophyte reduction would have been sufficient to suppress plant regeneration.

Eight years after impoundment, Caney Creek Reservoir had achieved national recognition for producing trophy size largemouth bass. Three successive Louisiana State record bass and many others weighing in excess of 5.4 kg were attributed to a successful management program. One component to the success at Caney Creek Reservoir was aquatic macrophyte coverage within a range of coverage considered to be beneficial to fisheries. Levels of coverage considered to be beneficial to game fish in Hinkle (1986) and Wiley et al. (1987) range from 10%–40%. Durocher et al. (1984) concluded that a reduction in submerged vegetation below 20% would result in a reduction in largemouth bass recruitment and standing crop. Because the status of fisheries in Caney Creek Reservoir was considered to be excellent with the 33% areal macrophyte coverage that existed in 1993, there was angler concern that the introduction of grass carp and any associated reduction in macrophyte coverage would have negative consequences to angling success. Much of that concern originated from widely publicized accounts of the Lake Conroe case history. No related decrease in abundance of adult largemouth bass was found in Klussman et al. (1987), but angler catch rates for largemouth bass and crappie were significantly reduced after macrophyte removal. A subsequent Lake Controe study (Webb et al. 1997), did indicate a significant decrease in largemouth bass abundance.

With the absence of other forms of complex cover in Caney Creek Reservoir, the reduction of aquatic macrophyte coverage also produced a reduction in largemouth bass abundance. Stock largemouth bass CPUE was reduced by 45%. Protection afforded by the 381- to 483-mm protective length range likely delayed subsequent reductions to larger bass.

Largemouth bass angler success increased slightly throughout the study period. Unfortunately, those values are more a function of reduced angler usage than increased catch rate. With the removal of available cover, largemouth bass became more difficult for most anglers to locate in the reservoir. Largemouth bass angler efforts decreased by 44% during the study period. Many of the anglers who continued to fish Caney Creek Reservoir after macrophyte removal were locals who were familiar with the topography of the area before impoundment. Knowledge of underwater topographic irregularities provided an advantage for some anglers since the features attract largemouth bass and are unknown to other anglers. An increase in average size of harvested bass was concurrent with macrophyte removal, but is attributed to an increased protective length range.

Temperature, pH, and stratification pattern followed seasonal influence and were not influenced by the reduction in macrophyte coverage. However, there was variation in nutrient values during the study period that was influenced by the shift from a macrophyte-based system to a plankton-based system. Secchi dish transparency varied seasonally with some exception. Reduced water clarity from April through June 1994 served as a limiting factor to macrophyte growth.

The issue of invasive nonindigineous aquatic plants is not a new problem in Louisiana. However, the challenge of hydrilla control in Caney Creek Reservoir was particularly difficult. Physical characteristics of the reservoir provided ideal growing conditions for hydrilla with limited options available for control. However, with scarce complex cover available, maintenance of a beneficial coverage of aquatic macrophytes was of great importance to the nationally recognized trophy largemouth bass fishery. Unfortunately, there are influences to the equation of hydrilla and grass carp that are beyond the control of resource managers. The experience of Caney Creek Reservoir will stand as a case history in which one set of problems was exchanged for another.

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