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Management of Hydrilla in the Santee Cooper Reservoirs, South Carolina: Experiences from 1982 to 2004

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ABSTRACT

The history of hydrilla (*Hydrilla verticillata* (L.f.) Royle) management and its impacts to various user groups in the Santee Cooper reservoirs, South Carolina is summarized and discussed. Hydrilla was first discovered during 1982 and unsuccessfully managed with herbicides through 1988. From 1989 through 1996, a total of 768,500 triploid grass carp (*Ctenopharyngodon idella* Valenciennes) were stocked. Hydrilla eventually infested a total of 48,000 acres system-wide and coverage peaked at 38,000 acres during 1994. Triploid grass carp largely eliminated hydrilla by 1997, and since then submersed aquatic vegetation has remained sparse. Impacts from hydrilla were both positive and negative for fisheries and waterfowl but only negative for boating and hydropower. Tourism appeared unaffected. Triploid grass carp in the Santee Cooper system provided effective, long-term control. Hydrilla was controlled through 2004 at a cost of less than $10 per acre yearly and low triploid grass carp densities (less than one fish for every seven formerly vegetated acres) continue to maintain control.

Key words: triploid grass carp, hydrilla control, management strategies.

INTRODUCTION

Hydrilla has invaded a number of large, southern reservoirs including Lakes Conroe (Texas), Guntersville (Alabama), Seminole (Georgia-Florida), Thurmond (Georgia-South Carolina), Marion, Moultrie, Murray (South Carolina), and Norman (North Carolina) with severe impacts to many

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water use activities. Over the years, management strategies in these multi-use reservoirs have included use of triploid grass carp, water level drawdowns, mechanical harvesting, and registered herbicides with varying degrees of success.

Man-made reservoirs are typically highly managed to support a variety of water uses such as hydropower generation, municipal and industrial water withdrawals, navigation, residential development, flood control and recreational activities. Aquatic plant managers routinely try to balance the cost of hydrilla control with impacts to these uses and the numerous user groups.

Aquatic plant management, using grass carp, herbicides, or both, can be controversial. Triploid grass carp generally provide less expensive and longer lasting control than alternative control methods (Wattendorf and Anderson 1986, Leslie et al. 1987, Allen and Wattendorf 1987), but have been problematic in terms of impacts to non-target vegetation, migration, and their propensity to eliminate most submersed aquatic vegetation (Stott and Robson 1970, Fedorenko and Fraser 1978, Noble et al. 1986, Bain et al. 1990, Bain 1993, Chilton and Poarch 1997, Elder and Murphy 1997). Properly selected and applied aquatic herbicides can be both selective and effective—but are expensive. Maceina et al. (1999) reported a yearly cost of $327 per acre to control hydrilla in Lake Seminole. In recent years, the annual cost of herbicides for hydrilla control in South Carolina ranged from $217 to $651 per acre.

This study reviews the 22-year history and efficacy of hydrilla management in the Santee Cooper reservoirs, South Carolina. The impacts of hydrilla and hydrilla control to different reservoir users are assessed.

MATERIALS AND METHODS

This study is a review of existing information contained in a mixture of journal articles, on-going surveys, and agency reports. Triploid grass carp population size was estimated yearly using methods described by Morrow et al. (1997). Estimating the population size of triploid grass carp involved collection using skilled bowfishers, extraction and sectioning of lipillar otoliths, using a catch curve to determine total annual mortality, and population models to project the population decline. Yearly population estimates began during 1994 (Morrow et al. 1997) and continued through 2004. Aquatic plant coverage data was provided by the South Carolina Public Service Authority (Santee Cooper) who routinely estimated aquatic plant coverage using aerial photography and boat surveys.

The cost of herbicide application was provided by the S.C. Department of Natural Resources. The cost of control provided by triploid grass carp was calculated by adding the cost of all grass carp stocked from 1989 to 1996 and dividing the total cost of triploid grass carp by the area known to have been infested by hydrilla (about 48,000 acres) times the interval since control was established (a total of 8 years from 1997 until 2004) to estimate the annual cost of control.

Economic impacts of hydrilla to the local communities was described by Henderson et al. (2003). Angler creel surveys conducted by the South Carolina Department of Natural Resources were modified to include economic and perception questions. Proprietary economic models were then used to project economic benefits to the communities surrounding the system using different aquatic plant coverage scenarios.

The impacts of the hydrilla infestation to tourism were assessed by the amount of accommodation taxes paid by motels and hotels in the counties surrounding the Santee Cooper system. Accommodation tax revenues are an indication of visitation to the area through hotel occupancy.

The Corps of Engineers, Charleston District, provided the costs associated with the loss of hydropower production caused by hydrilla entering the St. Stephen Hydroelectric facility. Subsequent fish kill information in the Santee River was provided by the South Carolina Department of Natural Resources (White and Lamprecht 1991).

Dissolved oxygen concentrations cited as evidence of decreased habitat suitability were reported by Chappelear (1990) and Foltz and Kirk (1994) in surveys of water quality in Lake Marion. Waterfowl harvest information cited in this study was provided by the South Carolina Department of Natural Resources.

RESULTS AND DISCUSSION

The Santee Cooper reservoirs consist of Lakes Marion, Moultrie, and a connecting canal (Figure 1). The system covers approximately 170,000 acres and was impounded in 1941 for commerce, navigation, power production, and water supply (South Carolina Code 58-31-30). Hydrilla was first discovered in 1982 in Lake Marion (Morrow et al. 1997) and rapidly spread. As coverage expanded, herbicides (mostly Aquathol K® and Diquat®) were applied annually to control hydrilla. Eventually about $12,000,000 worth of herbicides were used. Management through use of herbicides was subsequently abandoned because bathymetric maps suggested that hydrilla could occupy 55% of the system. An alternative management strategy was implemented and 768,500 triploid grass carp were stocked between 1989 and 1996 (Kirk et al. 2000). While triploid grass carp rapidly achieved control in upper Lake Marion, hydrilla spread throughout both lakes in the system. Ultimately, hydrilla infested 48,000 acres. Coverage peaked in 1994 at 38,000 acres (see Figure 2), but hydrilla was essentially eliminated by 1997 (Kirk et al. 2000). Population attributes and movements of triploid grass carp were monitored in published studies (Morrow et al. 1997, Kirk et al. 2000, 2001, Kirk and Socha 2003) as well as unpublished yearly surveys. By 2004, triploid grass carp had declined to an estimated population of 7,000 or approximately one fish for every seven formerly vegetated acres.

The elimination of hydrilla and most submersed vegetation was unpopular with both waterfowl hunters and anglers (S. Lamprecht, biologist with the South Carolina Department of Natural Resources). Angler creel surveys (Malvestuto et al. 1978) that solicited preferences for submersed aquatic vegetation were performed during 2000 and 2001 by the South Carolina Department of Natural Resources. Henderson et al. (2003) analyzed these data and found that all categories of anglers preferred submersed aquatic vegetation and concluded more submersed vegetation would result in more angling and economic benefit to the surrounding communities.

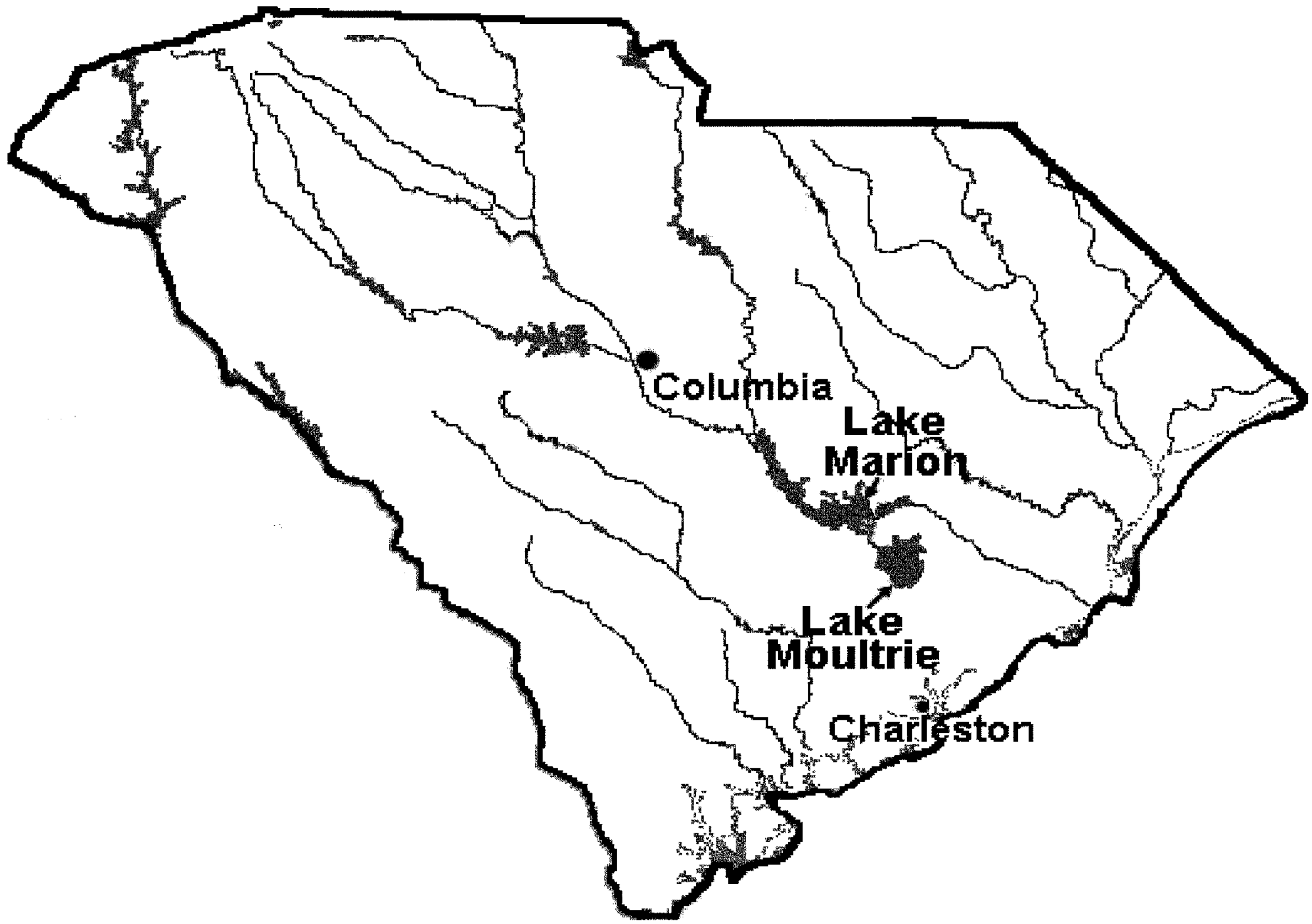

Figure 1. Lakes Marion and Moultrie, South Carolina.

As a consequence of concerns by the angling and waterfowl interests, the South Carolina Department of Natural Resources and the South Carolina Public Service Authority set a goal of about 10% coverage, system-wide of native aquatic vegetation. Through 2004, submersed aquatic vegetation remained sparse but floating vegetation became more abundant. Surveys performed by the South Carolina Public Service Authority estimated all types of aquatic vegetation covered approximately 10,000 acres (or 6% of the surface area of the system) during 2004. To date, maintenance stocking of triploid grass carp has not been initiated and system-wide hydrilla control has been achieved since 1997 at a yearly cost of less than $10 per formerly vegetated acre.

Hydrilla beds may have improved habitat for certain species such as largemouth bass (*Micropterus salmoides*). The benefit of hydrilla to largemouth bass and the role of aquatic vegetation in largemouth bass production is somewhat conflicting (see articles in this journal by Maceina (1996) and Hoyer and Canfield (1996). However, fisheries managers generally agree—aside from impoundments managed for balance (Swingle 1950)—that an intermediate level of aquatic vegetation is optimal for largemouth bass (Durocher et al.1984, Maceina and Reeves 1996).

Extensive, dense stands of hydrilla limited boat and bank access to anglers as has been reported in Florida (Colle et al. 1987). Further, summertime water temperatures and dense stands of hydrilla produced extensive areas with dissolved oxygen too low to support fish. Chappelear (1990) and Foltz and Kirk (1994) repeatedly documented extensive sections of upper Lake Marion with dissolved oxygen concentrations below 1 ppm during 1989 and 1991.

In summary, hydrilla had both positive and negative impacts upon angling. Despite large areas of anoxic water during summer months and difficulty in boating access, all categories of anglers agreed that hydrilla had been beneficial to fishing effort (Henderson et al. 2003).

Figure 3 shows the relation between waterfowl harvest in the Santee Cooper Wildlife Management Areas, hydrilla coverage, and the statewide harvest of waterfowl. Initial observations suggest that waterfowl harvest increased with hydrilla coverage. However, harvest in the Santee Cooper Wildlife Management Areas tracks that of the entire state and sug-

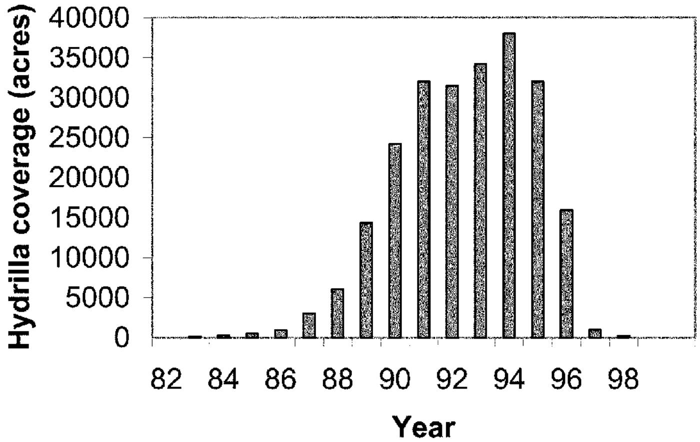

Figure 2. Hydrilla coverage (acres) in the Santee Cooper reservoirs, South Carolina from 1982 through 1998.

gests that factors other than hydrilla coverage are operating to affect waterfowl harvest in the Santee Cooper reservoirs.

A review of the literature suggests that hydrilla affects waterfowl in both positive and negative ways. A series of studies have concluded that hydrilla improved open water habitat and caused extensive winter use by waterfowl (Gasaway et al. 1977, Mantalbano et al. 1979, Esler 1990). Hydrilla has been popular with hunters because it attracts waterfowl, and some organized waterfowl groups oppose efforts to manage hydrilla using triploid grass carp. The major negative impact of hydrilla to waterfowl has been its association with Avian Vacoular Myelinopathy (AVM), a neurological disease produced by epiphytic cyanobacteria associated with hydrilla that is ingested by waterfowl (Wilde et al. 2004). The fatal disease has killed thousands of coots (*Fulica americana*), other waterfowl, and at least 90 American bald eagles (*Haliaeetus leucocephalus*) that fed on afflicted waterfowl. While no waterfowl on the Santee Cooper system are known to have died from AVM, the potential exists.

Boating and hydropower were negatively affected by hydrilla. Boating access in large tracts, especially upper Lake Marion, was hindered by hydrilla. Hydropower was affected by hydrilla during 1991 when a raft of hydrilla floated into the intake screens at the St. Stephen Hydroelectric Power Station. The raft shut down the turbines after discharging substantial amounts of shredded hydrilla into the Santee River. The result was the largest fish kill in the history of South Carolina (White and Lamprecht 1991) that included 20 federally endangered shortnose sturgeon (*Acipenser brevirostrum*) and a reported loss by the Corps of Engineers of $4,000,000 in hydropower production and associated costs.

Tourism was likely not affected by hydrilla in the Santee Cooper reservoirs. While anglers preferred hydrilla (Henderson et al. 2003) other users probably balanced out less angling effort as hydrilla coverage decreased. Figure 4 shows accommodation tax receipts increasing steadily, and despite no formal analysis, we believe tourism was not depressed by the elimination of hydrilla.

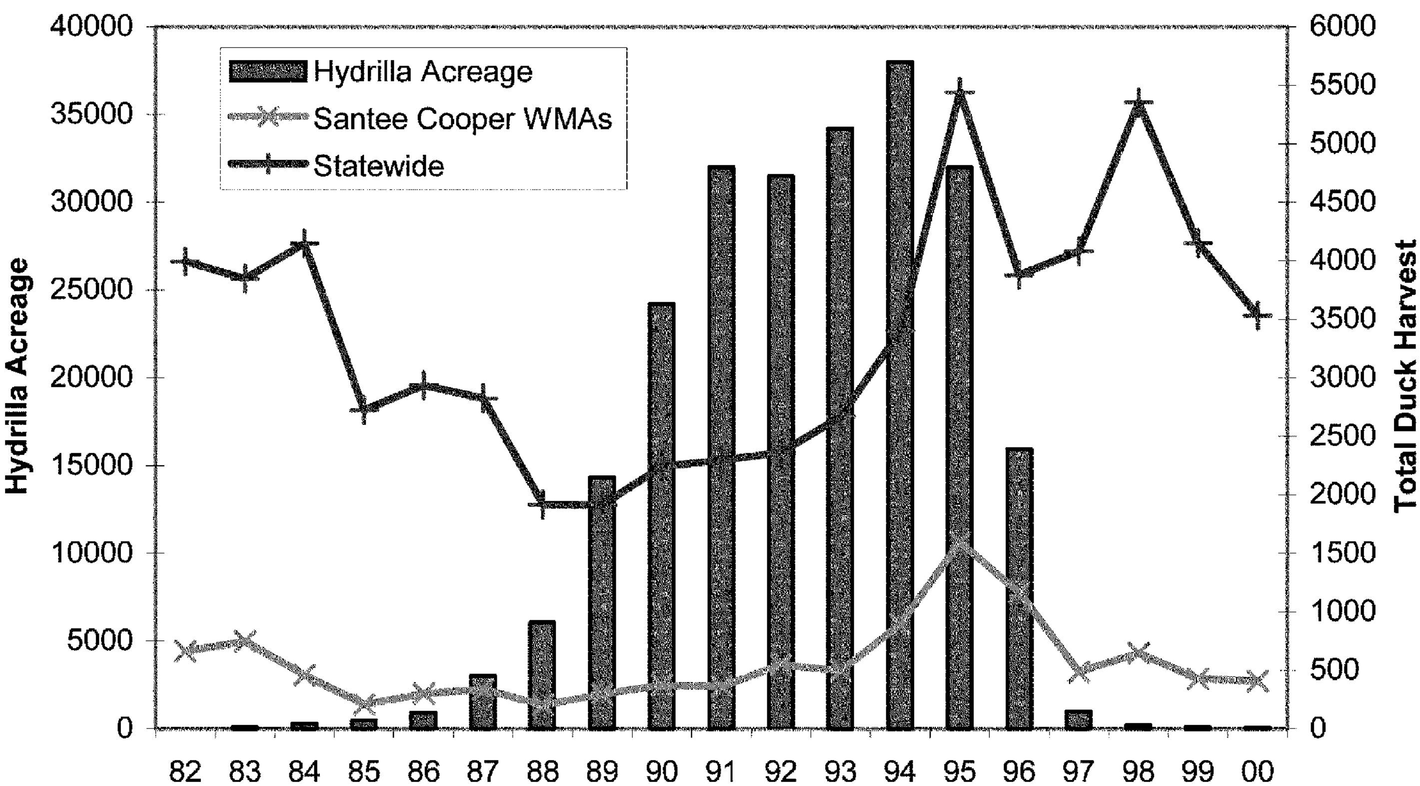

Figure 3. The relation between hydrilla coverage in the Santee Cooper reservoirs, South Carolina, waterfowl harvest in the Santee Cooper Wildlife Management Areas, and total South Carolina statewide waterfowl harvest from 1982 through 2000.

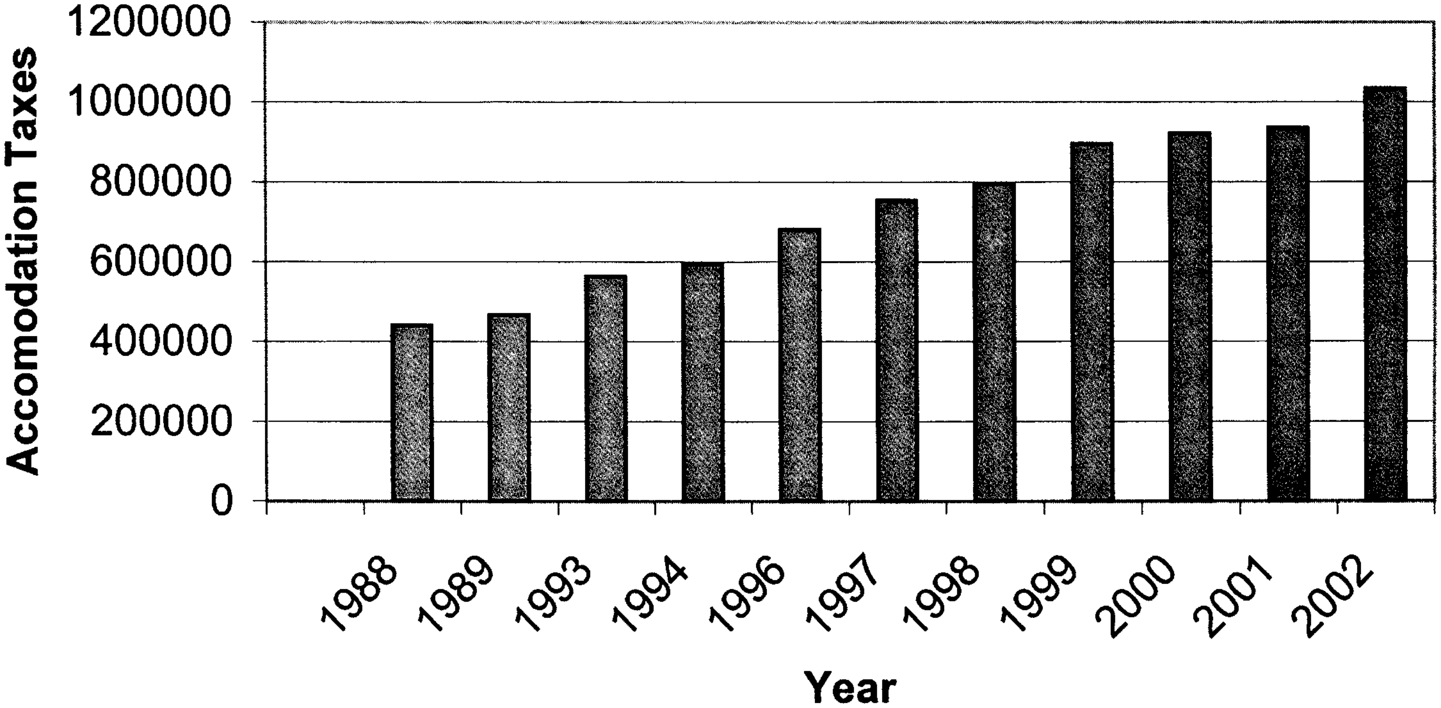

Figure 4. Summary of motel and hotel accommodation taxes (in dollars) collected in the counties surrounding the Santee Cooper reservoirs, South Carolina from 1988 through 2002.

Herbicide applications failed to control the spread of hydrilla in the Santee Cooper reservoirs and were expensive. Triploid grass carp have controlled hydrilla for 8 to 12 years (depending upon reservoir location) at a yearly cost of less than $10 per formerly vegetated acre. In the future it may be possible to maintain triploid grass carp in the Santee Cooper system at a density sufficient to control hydrilla but not eliminate all submersed native vegetation. In that regard, life span, density, and mortality data developed since 1994 in the Santee Cooper reservoirs will be useful in determining such stocking rates.

Aquatic plant managers make hydrilla management decisions on a reservoir by reservoir basis. Control strategies are based on reservoir use and purpose, potential area of infestation, actual and potential economic and environmental impacts of hydrilla, and cost and effectiveness of control. The experience on the Santee Cooper system is that hydrilla infestations resulted in negative impacts to a majority of water uses and users. Initial herbicide treatments were expensive and could not provide sufficient control. The use of triploid grass carp has provided long-term, cost effective control resulting in improved water quality (i.e., higher dissolved oxygen concentrations), improved boater access and use, and unimpaired hydropower production. Native aquatic vegetation goals have been set to address concerns expressed by anglers and waterfowl hunters.

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