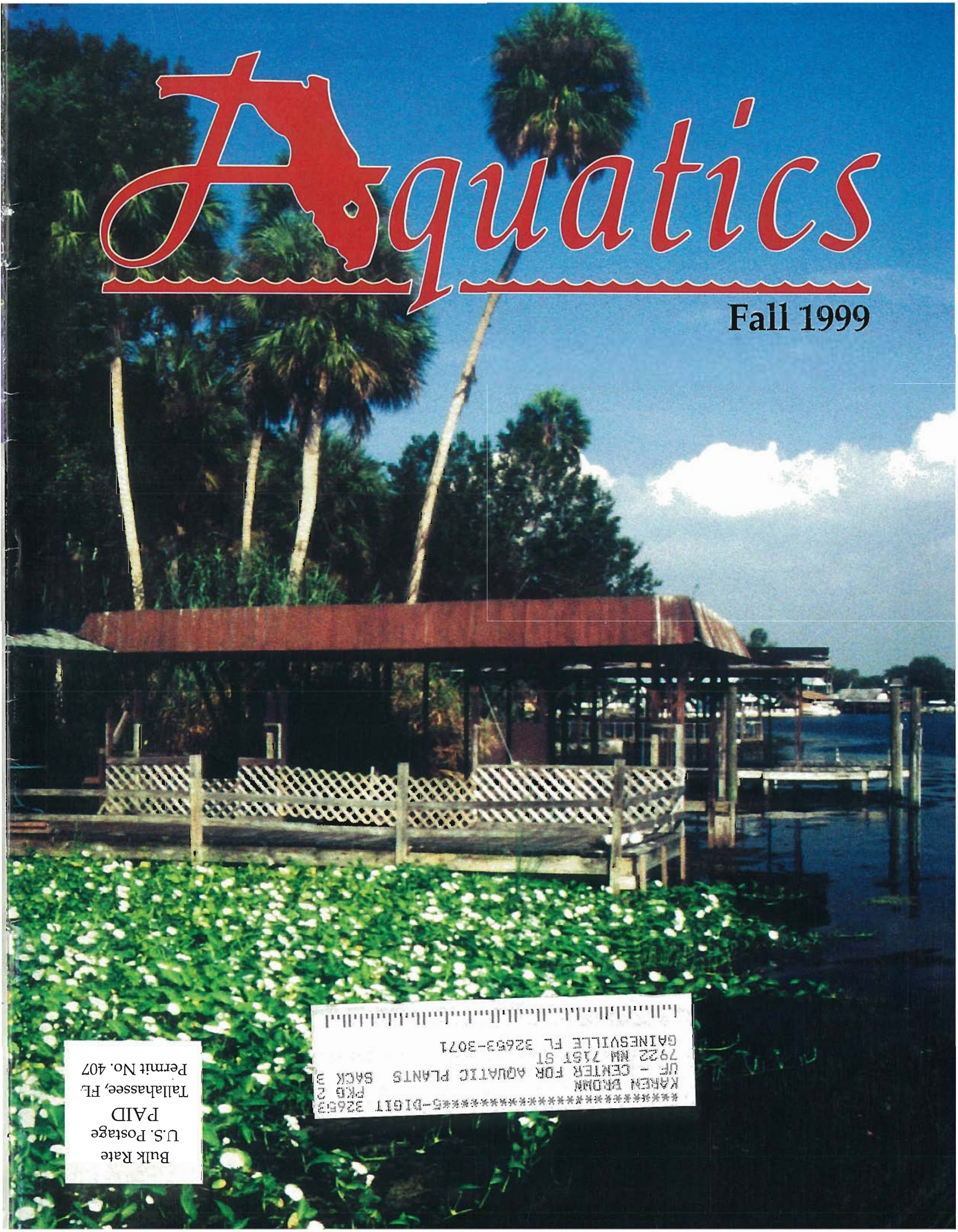
Aquatics

Fall 1999



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Letter to the Editor
Breaking down the borders: the need for a North American Center for Biological Invasions

Don C. Schmitz

During the past five years, there has been a growing awareness about the damaging impacts of biological invasions throughout the world. In July 1996, the United Nations Conference on Alien Species identified invasive species as a serious threat to global biological diversity. In the U. S., a recent estimate calculated the annual economic impact of biological invasions as over $130 billion, primarily caused by losses in agricultural lands, forests, rangelands, and fisheries. Unfortunately, new invasions are still occurring and we can expect even more of them in the future.

Perhaps the single greatest new threat in North America is the Asian long-horned beetle, which first appeared in Brooklyn, N.Y., in late 1996 and has since been discovered in smaller infestations on Long Island, N.Y., and in Chicago. Probably imported independently to the three sites in wooden packing crates from China, the beetle poses a multibillion-dollar threat to U.S. forests because of its extraordinarily wide host range. So far, thousands of trees have been cut down and burned in the infested areas, and a rigorous quarantine has been imposed to attempt to keep firewood and living trees from being transported outside these areas. Other biological invaders abound in North America. For example, the South American fire ant has just reached California, African ticks, carriers of heartwater (a highly lethal disease of cattle, deer, sheep, and goats) are arriving via the booming reptile trade, and three million acres of productive rangelands in western states are lost every year to invasive nonindigenous plant species that are mostly unpalatable to cattle and native herbivores.

In the face of these and other threats, President Clinton signed an executive order on February 3, 1999, creating a new federal interagency Invasive Species Council charged with producing, within 18 months, a broad management plan to minimize the effects of invasive species. Additionally, the executive order encourages interactions between federal agencies, state agencies, municipalities, and private managers of land and waterways, although it does not spell out specifically how such interactions should be initiated and organized. And so far, the response has been fragmented. This situation is not surprising.

Several extensive studies have documented specific problems in the U.S. such as insufficient interaction between scientists, resource and agricultural managers, and policy makers, little framework for rapid responses to new invasions, ineffective use of existing information, too many jurisdictional disputes and turf issues, and few direct means to reach the public about biological invasions. Similar problems also plague Canadian and Mexican prevention and management efforts. Complicating this situation even more is growing international trade, the single greatest pathway for harmful introduced species. Without the creation of a new centralized network in North America for both animal and plant invasions in agricultural and environmental arenas, we can

Continued on page 12

A robust infestation of water spinach (*Ipomoea aquatica*) was found on the Homosassa River, FL this year. This prohibited aquatic plant has since been eradicated by Citrus County spray crews. Please contact DEP if you find this plant. Photo by Jim Kelley.

Aquatics

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AQUATICS (ISSN 1054-1799): Published quarterly as the official publication of the Florida Aquatic Plant Management Society Registration No. 1,579,647. This publication is intended to keep all interested parties informed on matters as they relate to aquatic plant management particularly in Florida. To become a member of FAPMS and receive the Society newsletter and Aquatics magazine, send $20.00 plus your mailing address to the Treasurer.
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Confining Grass Carp with an Electric Barrier within an Embayment in Lake Seminole

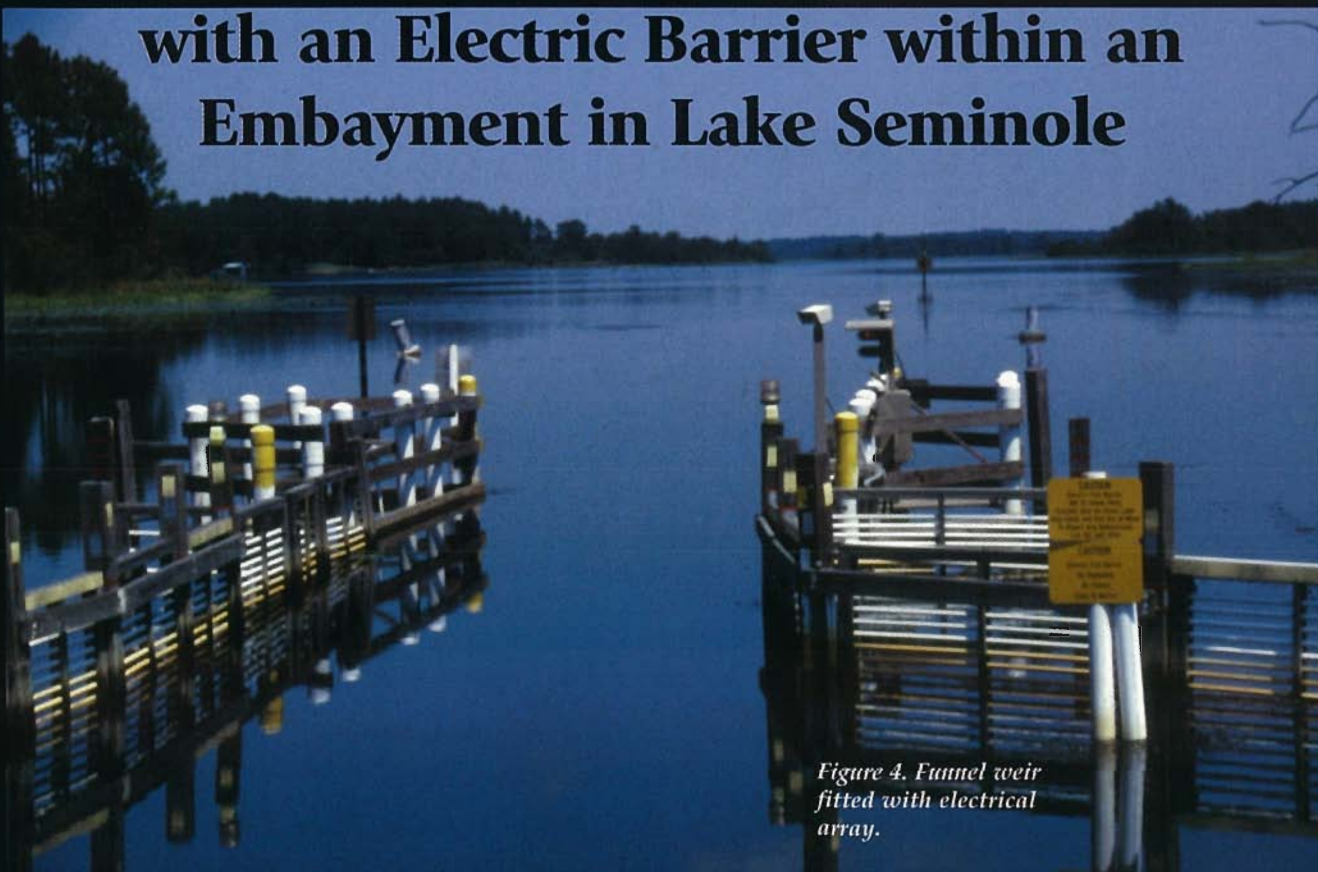

Figure 4. Funnel weir fitted with electrical array.

by
Mike Maceina and Jeff Slipke
Department of Fisheries and Allied Aquacultures
Auburn University, Alabama 36849

Figure 2. Aerial view of 'V' shaped weir on fish pond drain.

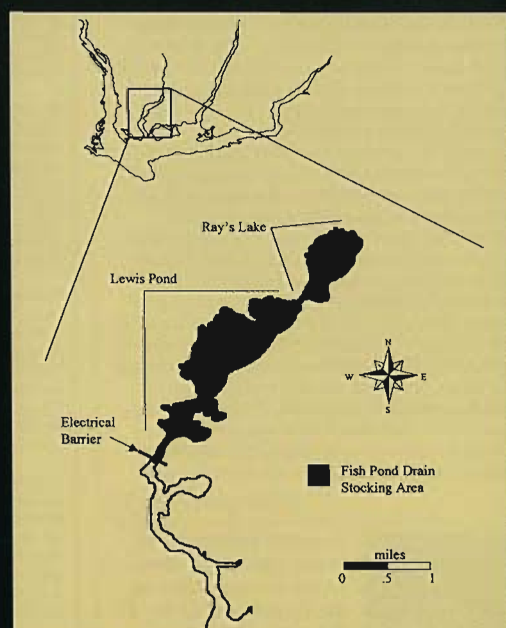

Figure 1. Lake Seminole, a 32,500 area reservoir. Box highlights the stocking area.

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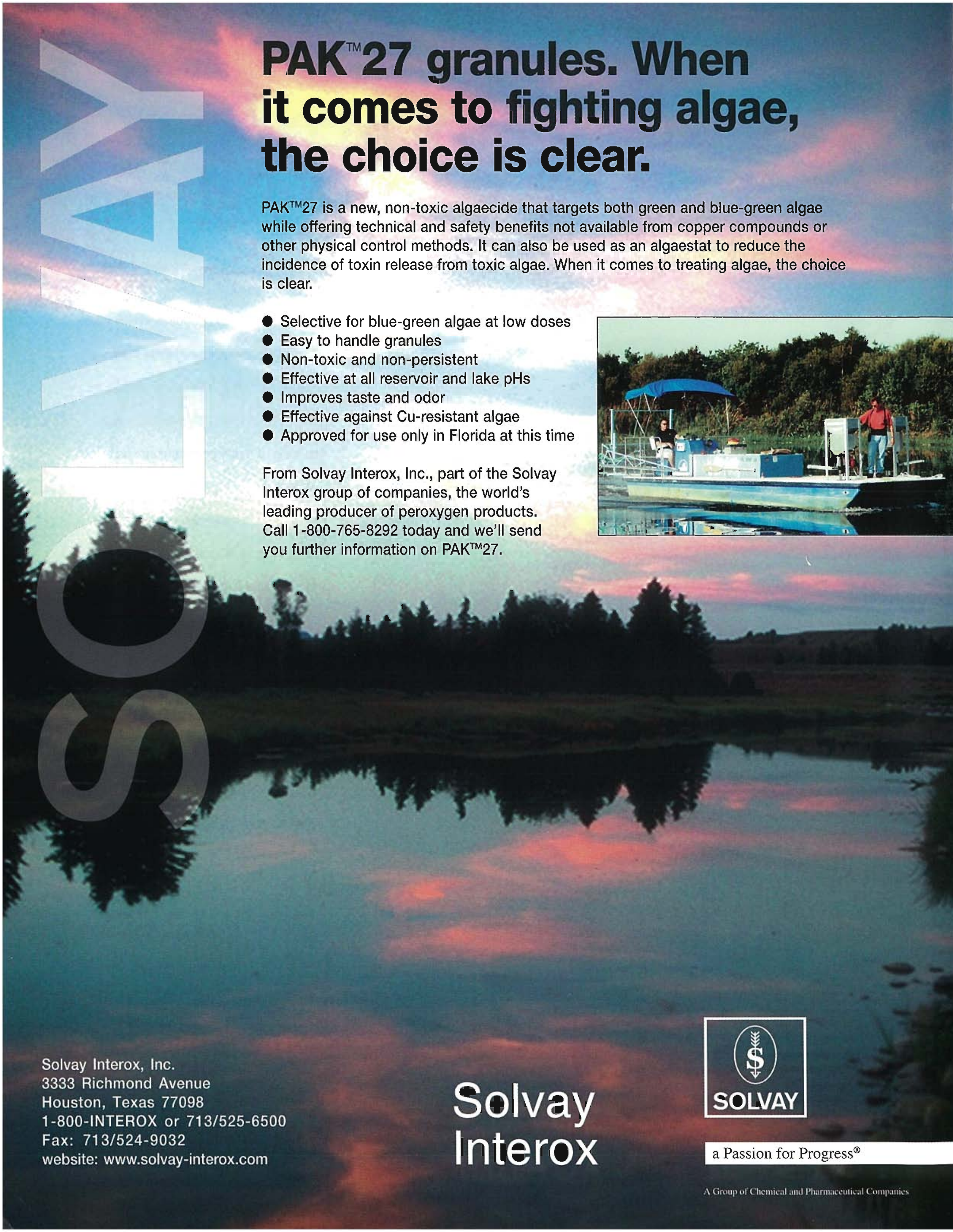
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Grass carp *Ctenopharyngodon idella* offer an inexpensive and cost effective method to control submersed macrophytes (Shireman 1982) and the use of triploid fish negates the possibility that these fish can reproduce. Cassani et al. (1995) was able to achieve some success in adjusting grass carp stocking rates to reduce, but not completely eliminate submersed aquatic plants in small Florida lakes (< 110 acres). However in larger water bodies, grass carp stockings have resulted in either complete elimination or negligible declines in aquatic plants (Shireman and Maceina 1981; Leslie et al. 1987; Bettoli et al. 1993; Cassani 1995). It is difficult to obtain stocking densities of grass carp to reduce, but not completely eliminate submersed macrophytes in larger water bodies. Uncontrolled events, such as increases in turbidity following high rainfall events and phytoplankton blooms induced by grass carp herbivory and nutrient release, often reduce submersed macrophytes due to light limitation.

Lake Seminole is a 32,500 acre reservoir located on the Georgia-Florida border (Figure 1). Hydrilla (*Hydrilla verticillata*) was introduced in the late 1960s and increased dramatically during the past 10 years. Lake Seminole is a shallow water body (mean depth 10 feet), annual water level fluctuations are typically less than 2 feet, and clear spring-fed water enters parts of this reservoir. These characteristics are conducive to aquatic macrophyte colonization. Submersed aquatic vegetation (primarily hydrilla) covered about 70% of the surface area of Lake Seminole in 1992, but declined to about 40% coverage by 1997 due to high rainfall events. Typically, only about 1,500 acres per year have been treated with herbicides. Unconfined release of grass carp at stocking rates that would be high enough to reduce hydrilla in Lake Seminole have been opposed by state conservation agencies and private interest groups primarily because 1) the loss of submersed aquatic vegetation could cause a decline in the recreational sport fishery, 2) a possible decline in waterfowl use, and 3) potential escape of grass carp downstream into the Apalachicola River and estuary could reduce aquatic vegetation in this area.

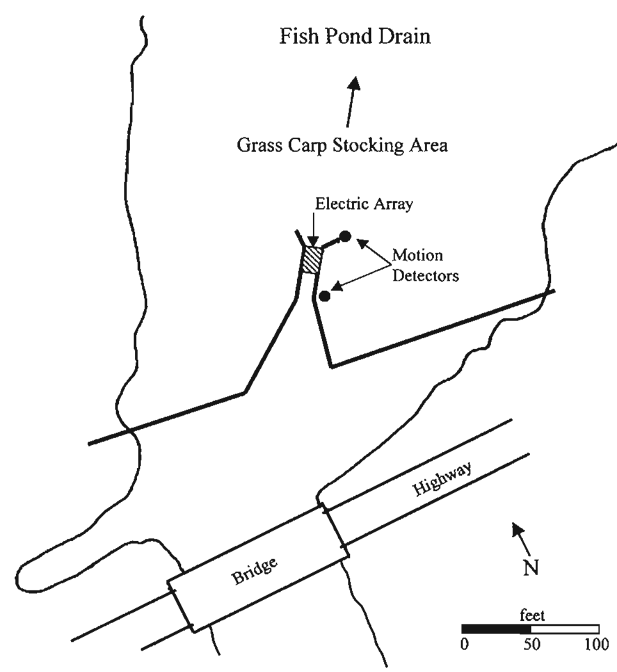

Figure 3. Detail of 'V' shaped funnel weir.

If grass carp could be confined within certain areas where persistence of some aquatic vegetation is not a high priority, then this approach could provide localized control of excessive aquatic macrophytes while maintaining plants in other regions of the reservoir. To test the feasibility of this concept, we cooperatively worked with and received funding from the U.S. Army Corps of Engineers and from the Florida Department of Environmental Protection Bureau of Invasive Plant Management to test the success of confining grass carp with an electric barrier in a 900 acre embayment of Lake Seminole. This area contained about 720 acres of hydrilla that typically formed dense mats every summer.

Methods

A V-shaped funnel weir was constructed across a narrow opening at a bridge on Fish Pond Drain (Figures 2 and 3). The barriers were constructed of 6 inch by 6 inch posts driven into the sediment with 1 inch PVC pipes (Schedule 40) spaced horizontally 1.5 inches apart to prevent grass carp larger than 12 inches from escaping. At normal reservoir elevations, the barrier was 3 feet above the water surface. The opening for the barrier was 12 feet and spanned about 320 feet across the mouth of Fish Pond Drain. The depth of the opening was 6 feet and the barrier at the opening came within 3 feet of the water surface

The V-shaped funnel weir was fitted with an electrical array constructed by Smith-Root Inc. that produced a low voltage (3-4 volts) DC field to repel grass carp (Figure 4). Power was supplied by a nearby power line adjacent to the bridge. The peak current output was 12 amps at a 10 milli-second pulse over a 500 milli-second duty cycle for an average current of 1.44 amps. The electric output was adjusted for these specifications by placing ten 14 to 16 inch triploid grass carp in a nylon net cage and observing avoidance behavior. Two motion detectors, placed at the entrance and exit of the electric array, turned off the system as boats passed through the barrier and the power stayed off for 30 seconds thereafter. The status of the system was continuously monitored by a computer modem that relayed the information to three different locations.

Radio tags with an expected life

of three years (Advanced Telemetry Systems) were used to track grass carp. Tags were cylindrical, 4 inches long, ¾ inch in diameter, and weighed a little over one ounce. The tags were also fitted with a 24 h delayed mortality circuit that let us know if a fish was alive or if the fish had died or expelled the transmitter. Each fish transmitted a unique radio frequency signal.

In November 1997, radio transmitters were surgically implanted in the body cavity of 84 triploid grass carp that ranged in length from 21 to 23 inches long (about 4 lbs) (Figure 5). An incision was placed just posterior to the pelvic fin and once tags were placed into the cavity, they were manually pushed over the pelvic girdle. Four to five sutures closed the incision, and Betadine antiseptic was applied to the incision. After surgery was completed, fish were revived in 0.1 acre ponds for about 5 minutes by moving the fish back and forth in the water column. After being held in ponds for one month, fish were transported to Lake Seminole in December 1997 for release into Fish Pond Drain at a boat ramp upstream 2.5 miles from where the electric barrier was built.

Grass carp were tracked by boat using a hand-held antenna every other week from December 1997 until December 1998. Unless grass carp were within about 0.5 miles of the barrier, only approximate locations within the confined study areas were recorded. When grass carp were located close to the barrier, we marked their approximate locations on a map using directional and signal strength response.

Results

During the 13 months of tracking all but one fish were accounted for, no verified escapes occurred, and 13 fish either died or expelled the radio tags. During the last tracking trip in December 1998, a boat and subsequent aerial search failed to locate

Figure 5. Surgical implantation of radio transmitters into triploid grass carp.

the one missing fish. We suspected the tag malfunctioned for this fish. For 12 months, this fish was only found in Ray's Lake upstream, moved very little, and was always at least 2.5 miles from the barrier entrance. During 1998, another tag went undetected for three months, an aerial search failed to locate the fish in May 1998, but the tag became functional three months later with a live signal, then finally a dead signal was detected two weeks later. Nevertheless, assuming this fish did escape, the average annual maximum potential escape rate based on remaining live fish was 1.3%.

Until mid-April 1998, little grass carp movement was detected. At this time, 96% of the grass carp were found in Ray's Lake and most were in the upper region of this embayment (Figure 1). After mid-April, grass carp migrated and 55 to 68% of all fish emitting a live signal were found in Lewis Pond from mid-May to September 1998. During May and June 1998, 24 to 27 grass carp were within about 0.5 miles of the barrier. After this time, some of the grass carp found near the electric barrier moved upstream from the barrier. Only 8 fish were within 0.5 miles of the electric barrier by December 1998. At the end of September 1998, 32% of the active grass carp were in Ray's Lake, but by December 1998, 51% of these fish were found in this embayment as grass carp tended to move upstream into Fish Pond Drain between these time periods.

Summary

The electric array fitted at the opening of the funnel-weir barrier was effective at retaining grass carp in a 900 acre confined area for one year. In March 1998, 12 inches of rain fell in the Fish Pond Drain Basin and water levels rose nearly 3 feet at the barrier, but the electrical array continued to work. During the one year evaluation period, the electric barrier was non-operational for only 4 days in June 1998 when air temperature within the control box exceeded 115°F. A dehumidifier and shelter to provide shade were installed and the barrier was functional thereafter. Thus, an electric barrier system can provide for aquatic vegetation control using grass carp in specific locations in a water body and appeared to minimize the potential for escape. Mass stocking of grass carp in large water bodies where fish and wildlife are important is typically not a management option anymore. This barrier and confinement of enough grass carp allows managers the capability to "zone" water bodies, and permit complete elimination of submersed plants in certain areas while maintaining plants in other areas.

This method also permits aquatic plant managers to use a relatively inexpensive tool to control excessive aquatic vegetation, although initial costs can be high. The funnel-type barrier cost about $40,000 to build and the complete electric array system was about $32,000. The U. S. Army Corps of Engineers estimated average annual costs to control submersed macrophytes in Lake Seminole were $300 and $2,000 per acre per year for herbicides and mechanical harvesting, respectively. The estimated annual plant control with grass carp would cost about $40 per acre per year in the confined area of Fish Pond Drain over 10 years. This estimate included the installation of the physical and electric barrier, the initial stocking of about 16 triploid grass carp per vegetated acre, and supplemental stocking and maintenance costs.

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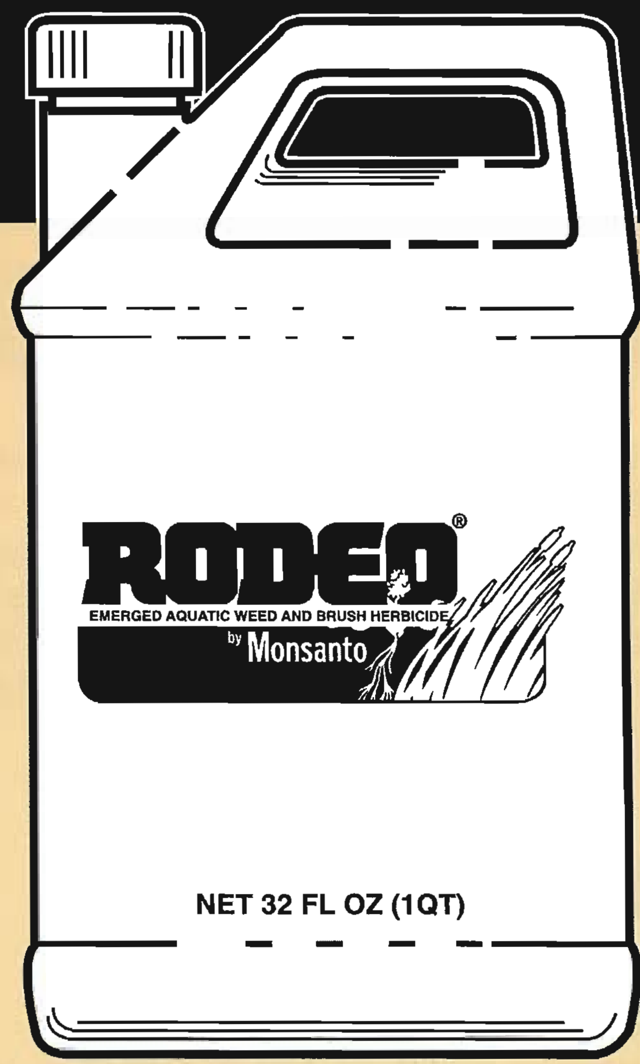

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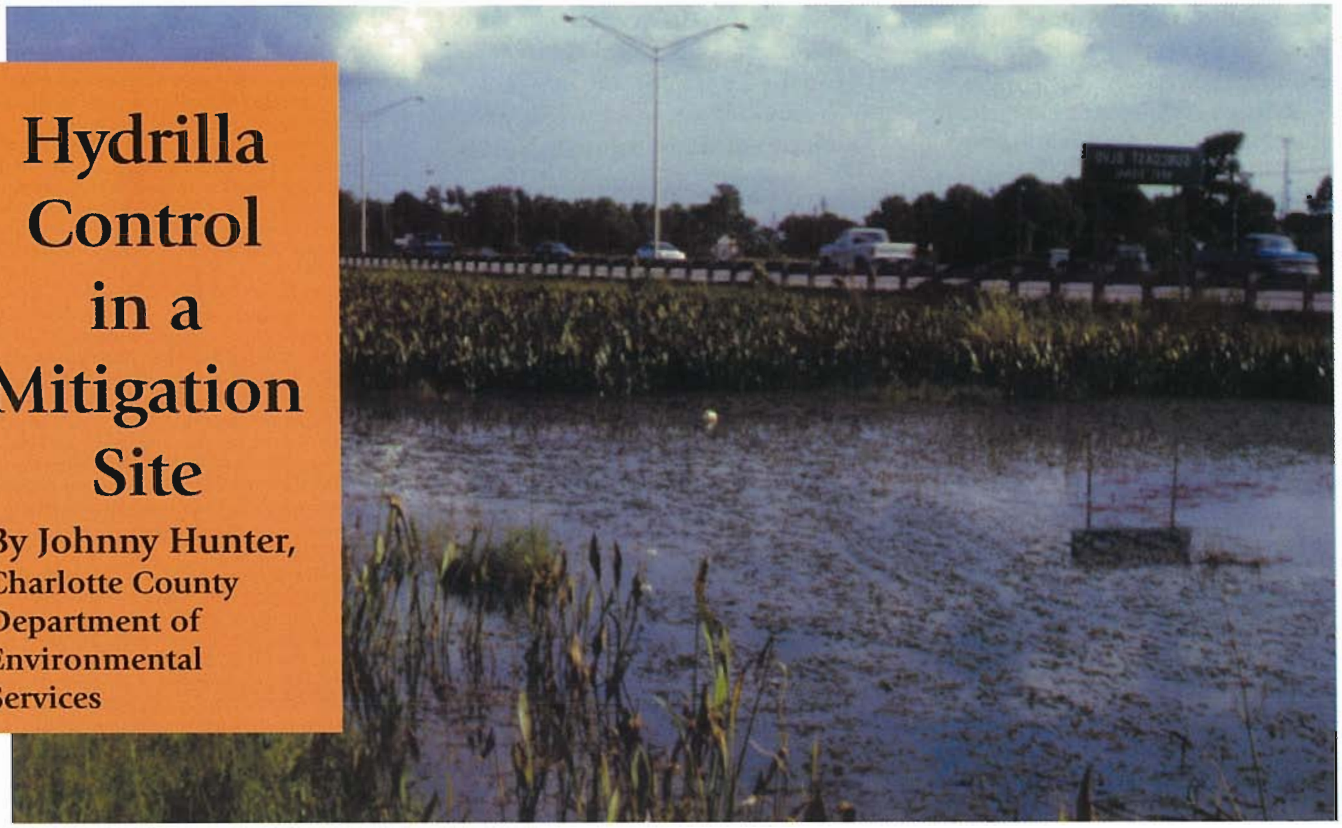

Hydrilla Control in a Mitigation Site

By Johnny Hunter, Charlotte County Department of Environmental Services

Note: This paper was presented at the 1998 FAPMS Annual Meeting

Background

The Charlotte County Department of Environmental Services is comprised of two divisions; Municipal Solid Waste and Pest Management. The Pest Management Division is comprised of the Mosquito control and Aquatic and Exotic Vegetation control Sections, in which I work. The aquatic Section is responsible for the control of aquatic weeds in County waterways. In 1992 the section expanded its area of expertise by accepting responsibility for the monitoring and maintenance of selected County mitigation sites.

Site History and Description

The Kings Highway mitigation site, a Southwest Florida Water Management District (SWFWMD) permitted project, is designed as a stormwater retention and conveyance system in conjunction with expansion of Kings Highway in Charlotte County from two to four lanes. This project was completed in 1993 and consisted of 15 inter-connected ponds, ranging in size from 0.8 acre to 5.9 acres, with a total surface area of 37.7 acres (Figure 1). Each pond has an open pool area and a littoral shelf planted with, *Eleocharis* (spikerush), *Sagittaria* (arrowhead), *Pontederia* (pickerelweed), *Polygonum* (smartweed), *Scirpus* (bulrush), *Thalia* (fireflag), *Panicum* (maidencane), and *Salix* (willow).

A private contractor was responsible for the monitoring and maintenance of this project until January of 1997. During that interval, Hydrilla verticillata (hydrilla), *Ludwigia* (water primrose), *Panicum repens* (torpedograss), and *Typha* (cattails) infested the system. Hydrilla eventually covered approximately 100% of 4 ponds, including the littoral shelves among the planted vegetation (Figure 2).

The SWFWMD notified the Charlotte County Public Works Division that the system was out of compliance with permit conditions due to insufficient native plant coverage and the abundance of exotic and other undesirable vegetation. As a result, Public Works asked Environmental services to add this site to our area of responsibility for the County.

Figure 2 (above) Topped out hydrilla in the mitigation site. Note planted littoral area.

Figure 1. Aerial view of interconnected ponds along Kings Highway.

Application Method and Results

Environmental Services assumed responsibility for monitoring and maintenance of the system in January of 1997, and working with the SWFWMD, developed a plan to bring the system into compliance with permit conditions.

Initially, the Department began mechanical (hand pull) and selected chemical treatments of emergent vegetation, applying Rodeo, in spray plots. As we gained control of the emergent vegetation, we continued to research and formulate the most effective method of removing the hydrilla. Since this is a planted site, the use of triploid grass carp (*Ctenopharyngodon idella*) was not an alternative. The department decided to make 4 applications of Sonar SRP to the four hydrilla infested ponds (10.3 acres) over an 8 week period (every 14 days). This equated to a total application rate of 50 ppb. This rate of application we selected would eliminate the target species, but not adversely affect the desirable species located within the target zone. The Sonar pellets were applied to the open (upstream) section of each pond with no direct application in the littoral areas. This method allowed for the herbicide to be concentrated in the area with the highest level of targeted vegetative mass, but also allowed for the product to filter slowly into the littoral shelves downstream.

Environmental Services made the first application on March 27, 1998 with the final application occurring on May 21 1998. Within 30 days of the final application, visual inspections indicated that the hydrilla was being affected by the product (white / pink coloration) and was beginning to fall out in the open pool areas. The effects of the Sonar could also be seen on the torpedo grass throughout the treated ponds. Within 60 days post treatment, hydrilla was not visible in the ponds (Figure 3). Approximately 90 days after the treatments were completed, we used a grappling hook to scrape the bottom of the ponds in search of hydrilla. Only a few un-healthy looking stems were retrieved.

The department has begun a maintenance program, treating each pond at approximately 3.5 ppb monthly to prevent tuber production and re-infestation of the hydrilla. These treatments were suspended from March-June, 1999 due to low water levels. We have since resumed monthly treatments at the previously noted ppb level. Recent inspection of the water bodies revealed no regrowth of hydrilla.

I would like to acknowledge Sepro for technical assistance in this project.

Figure 3. Treatment results showing hydrilla-free open water (above) and healthy littoral areas (below).

Letter to the Editor

continued from page 3

expect more of the same: increasing agricultural costs, degraded natural areas, and new biological invasions in our nation's waterways.

A North American Center for Biological Invasions, modeled after the U.S. Centers for Disease Control and Prevention (CDC), is desperately needed to help bridge environmental interests with those of agriculture and commerce and to enhance information exchange among all affected federal, state, provincial, and local governments, as well as the private sector, to manage existing invasions better and to help prevent new ones from occurring. Because education is crucial in slowing the influx and spread of biological invasions, the center could take an active role in providing information about economic and environmental impacts in North America to the public, news media, and policy makers. This center would not replace existing legislatively mandated efforts, but would amplify them by:

- Helping detect and monitor new biological invasions in North America's natural and agricultural areas;
- Enhancing cooperation and coordination of existing prevention and control efforts;
- Enhancing informational exchange between scientists, government agencies, and private landowners in North America;
- Engaging university-based research to optimize management and prevention activities;
- Using diverse communication methods for wider, more effective delivery of public education about biological invasions.

Although the establishment of the North America Center won't solve all of our problems (such as inadequate funding and increased trade pressures), it would help provide a framework or structure to unify existing invasive species prevention and management efforts and will constitute a forum and informational clearinghouse that is presently lacking in North America.

Tussock Removal Using a Trackhoe on a Floating Barge

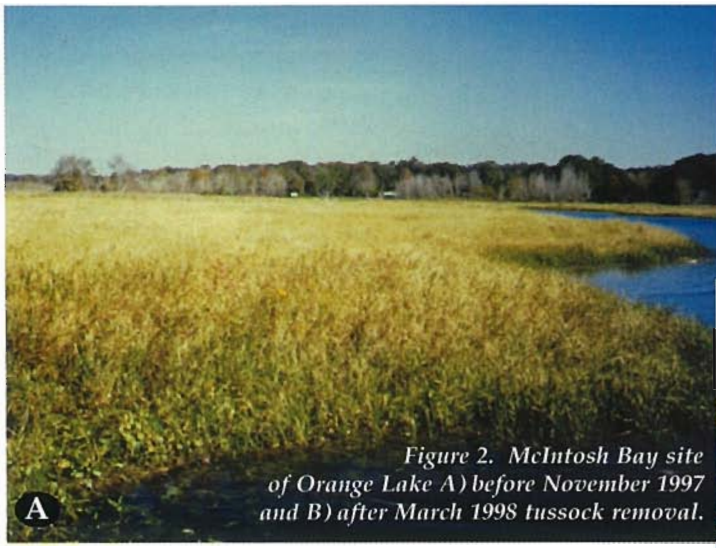

Figure 2. McIntosh Bay site of Orange Lake A) before November 1997 and B) after March 1998 tussock removal.

By Craig Mallison and Bob Hujik
Florida Game & Fresh Water Fish Commission
7922 NW 71st St., Gainesville, FL 32653

Introduction

Tussocks, commonly called floating islands, are composed of native or exotic plants growing on a buoyant mat consisting of plant roots and organic matter (detritus/muck). This definition includes small (less than one acre), free-floating islands and extensive, stationary vegetated mats which may cover hundreds of acres of water. Tussocks are common in many Florida lakes, including the Kissimmee and Alligator chains of lakes and Lakes Istokpoga, Walk-In-Water, Orange, and Lochloosa (Hujik 1994, Alam et al. 1996, Haller 1996, Clark and Reddy 1998), as well as other parts of the U.S. and across the world (Kaul and Zutshi 1966, Trivedy et al. 1978, Sasser et al. 1995, Sasser et al. 1996). Problems resulting from tussocks include blocking shorelines, impeding water flows and navigation, shading desirable submersed and emergent aquatic vegetation, contributing to poor water quality in terms of fisheries habitat (low dissolved oxygen levels and high accumulation of organic matter below tussocks), and interfering with recreational activities (Hujik 1994, Alam et al. 1996, Clark and Reddy 1998). Unmanaged tussocks play a role in succession from open water to marshes and swamps (Huffman and Lonard 1983, Lieffers 1984, Mallik 1989). As a result of these problems and wide distribution of tussocks across Florida, the Florida Game and Fresh Water Fish Commission (GFC) is exploring tussock management strategies. The primary objective of this project was to evaluate a new mechanical control method, using a trackhoe on a floating barge to remove tussocks. The secondary objective was to conduct the work in areas which would maximize public and fisheries/wildlife habitat benefits.

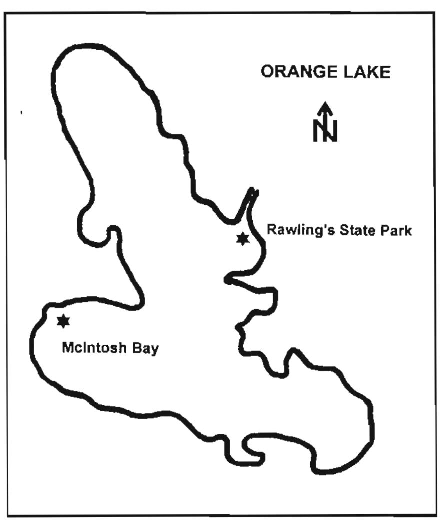

Figure 1. Project sites for the tussock removal project of 1997-98 and map of Orange Lake (Alachua County, Florida).

Study Area

Orange Lake (12,500 acres) is located 15 miles southeast of Gainesville, Florida in Alachua County. The lake has approximately 2,000 acres of tussocks located primarily along the east and south shorelines. One project site was located adjacent to Marjorie Kinnan Rawling's State Park boat ramp, where tussocks frequently interfere with boat launching and navigation (Figure 1). Mud tussocks were dominated by willow (*Salix* sp.), red maple (*Acer rubrum*), arrowhead (*Sagittaria* spp.), pickerelweed (*Pontederia cordata*), and bur marigold (*Bidens* sp.). Other common species included cattail (*Typha latifolia*), frog's-bit (*Limnobium spongia*), maidencane (*Panicum hemitomon*), sawgrass (*Cladium jamaicense*), Cuban bulrush (*Scirpus cubensis*), and water primrose (*Ludwigia* sp.). Floating mats contained a large amount of organic matter in addition to live plant roots, and ranged in thickness from 1 ft to 2.5 ft. The second project site, located in McIntosh Bay (Figure 1), contained tussocks dominated by Cuban bulrush and frog's-bit. Other common species included bur marigold, cattail, maidencane, pickerelweed, smartweed (*Polygonum* sp.), and willow. Floating mats consisted primarily of live plant roots with little or no organic matter, and ranged in thickness from 0.5 ft to 1 ft. Water depths in both project areas ranged from 2 ft to 8 ft.

Methods

Private contractors bid on the project (highest number of acres for a set dollar amount), and Casper Colisimo & Sons, Inc. was awarded the contract to remove 80 acres of tussocks, resulting in a rate of $2,000/acre. The contractor crane-launched nine sections of a 77 ft x 36 ft x 4 ft barge into a canal at Rawling's State Park on 24 and 25 October 1997. The barge was assembled and loaded with a tool shed, fuel tanks, compressor/generator, wooden mats and a trackhoe. The trackhoe was a Caterpillar 325 with a 28-ft reach and a custom-made 2-yd^3 clam-shell bucket designed specifically for tussock removal. Later in the project, a second barge (40 ft x 30 ft x 5 ft)was brought in to distribute weight of harvested tussocks and decrease draft of loaded barges, thereby allowing the contractor to work in reduced water depths. The secondary barge was used solely for transport of harvested material and included 2.5 ft wooden containment walls, constructed of plywood and 2 in x 4 in boards, located along the perimeter of the barge. The barges were fastened together with rope and cable, and were moved to and from work sites with a tug boat and/or by pushing off the lake bottom with the trackhoe. Manpower requirements for the contractor included a full-time trackhoe operator and an assistant(s) to conduct miscellaneous tasks on the barge deck and to operate the tug boat when barges had to be moved.

An airboat and tug boat were frequently used to push small (less than 0.5 acres) free-floating tussocks to the barges. On occasion, barges were moved to harvest larger free-floating tussocks that broke away from the work site. However, the majority of the work was completed with the contractor positioning the barges adjacent to stationary tussocks. The trackhoe loaded the primary barge, then moved that material to the secondary barge, and reloaded the primary barge. Loaded barges were moved to predetermined in-lake disposal areas (water depth 3-4 ft) and unloaded.

Results

From 29 October to 25 November 1997 and 9 March to 7 April 1998 (total 42 work days), 16 acres of mud tussocks were removed at the Rawling's State Park location (Table 1). Removal rate averaged 0.4 acre/day over the work period and was timed at 22 hr/acre

Table 1. Tussock removal rates using a trackhoe on a floating barge at Rawling's State Park (mud tussocks) and McIntosh Bay (Cuban bulrush/ frog's-bit tussocks) in Orange Lake, 1997-98.

Site	No. work days	Acres removed	Rate (acre/day)	Rate (hr/acre)	Spoil island area (acres)
Rawling's S.P.	42	16	0.4	22	0.2
McIntosh Bay	57	47	0.8	9	0.8
Total	99	63	0.6	12.5	1.0

during two evaluation loads of 0.2 and 0.3 acres. Harvested material was used to create one spoil island that was 0.2 acres and up to 14 ft above the water surface. This resulted in a ratio of 1 acre of spoil island to 80 acres of mud tussocks.

From 26 November 1997 to 6 March 1998 (57 work days), 47 acres of Cuban bulrush and frog's-bit tussocks were removed at the McIntosh Bay site (Table1). Removal rate averaged 0.8 acre/day and was timed at 9 hr/acre during one evaluation load of 0.5 acres. Harvested material was used to create two spoil islands totaling 0.8 acres and up to 12 ft above the water surface. This resulted in a ratio of 1 acre of spoil island to 60 acres of Cuban bulrush and frog's-bit tussocks. Near-historic high lake levels in early 1998 expanded the range of barge-accessible water to the natural shoreline (i.e. mean high water contour) at the McIntosh Bay site. As a result, three private docks and two fish camps that were surrounded by tussocks at the beginning of the project had clear lake access when tussock removal was completed (Figure 2). Overall, 63 acres of tussocks were removed in 99 work days, resulting in 62 acres of open water and 1 acre of spoil island.

The procedure was time consuming since some tussock material had to be handled up to five times during loading and unloading. A full load (1/4-3/4 acre of tussocks) took as long as 9 hr to complete. Removal of Cuban bulrush and frog's-bit tussocks was more efficient than mud tussocks due to plant type/growth pattern (smaller species with intertwining roots to hold tussocks together) and thinner mat with little or no muck. In addition, efficiency was improved by pushing the barges into Cuban bulrush and frog's-bit tussocks, which compressed these tussocks into a smaller area and allowed the trackhoe to get more material per bucket load. The heavy equipment was capable of handling any type of dense vegetation that was encountered in this project and had no trouble removing trees (up to 1 ft in diameter) and dense mats of mud tussocks. The trackhoe was never limited by the size nor density of

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material to be removed.

The primary limiting factor for this method was water depth. A fully loaded barge had a draft of 4 ft, therefore the deep water in the project zone (water depths of 4-8 ft) was required for optimum removal. The contractor was able to remove tussocks in water as shallow as 3 ft by reducing the amount (weight) of material per load. This reduced efficiency since it required more time moving to disposal sites and positioning the barges, leaving less time for tussock removal. The contractor was unable to operate in water depths less than 3 ft, where tussock growth often occurs. Another disadvantage was the inability of the heavy equipment to clean up small floating pieces of vegetation that broke off during tussock removal. A harvester was needed (donated by University of Florida) to prevent "floaters" from filling canals and blocking docks at fish camps and waterfront properties adjacent to work locations. Any future projects employing barge mounted trackhoes should include a harvester to maintain a clean work area.

Evaluation

During this project, the trackhoe/barge at $2,000/acre cost an average of $163/hr for tussock removal. This comes out to $3,600/acre for removal of mud tussocks (22 hr/acre) and $1,500/acre for removal of Cuban bulrush and frog's-bit tussocks (9 hr/acre) (Table 2). The contractor stated that any future tussock removal with the trackhoe/barge would likely cost 2-3 times this amount.

Previous evaluation of the Kelpin harvester at rates of $200/hr (1998 cost, Mike Hulon, GFC, personal communication) and 13 hr/acre for removal of mud tussocks (Haller 1996) indicates a cost of $2,600/acre. On floating plants (Cuban bulrush/frog's bit tussocks), the Kelpin harvester at 5 hr/acre would cost $1,000/acre. A cookie-cutter/harvester combination was evaluated at rates of $200/hr and 10 hr/acre on mud tussocks (Joe Hinkle, Florida Department of Environmental Protection, personal communication), which is a rate of $2,000/acre. Both of these methods are capable of removing tussocks in water depths as shallow as 2 ft, but are unable to remove trees larger than 2-3 in in diameter. Current cost for muck removal in a drawdown bid for Lake Tohopekeliga is $1.20/$yd^3$ (Mike Hulon, GFC, personal communication). For removal of Cuban bulrush and frog's-bit tussocks (assuming an average mat thickness of 0.75 ft), this would cost $1,460/acre and for mud tussocks (average mat thickness of 1.5 ft) $2,920/acre. This method is capable of removing tussocks to the waterline during drawdown, but is limited to areas with a hard bottom (to support heavy machinery) and water control structures that allow lowering of lake levels.

Table 2. Comparative rates for tussock removal techniques.

Method	Cost ($/hr)	Cost ($/acre)	Rate (hr/acre)	Rate (acre/8 hr day)
MUD TUSSOCKS				
Trackhoe (1997-98)[1]	160	3,600	22	0.4
Kelpin harvester[2]	200	2,600	13	0.6
Cookie cutter/harvester[3]	200	2,000	10	0.8
Bulldozer/dumptruck (drawdown)[4]		2,900		
CUBAN BULRUSH & FROG'S-BIT TUSSOCKS				
Trackhoe (1997-98)[1]	160	1,500	9	0.9
Kelpin harvester[2]	200	1,000	5	1.6
Bulldozer/dumptruck (drawdown)[4]		1,500		

[1] Future cost substantially higher
[2] Haller (1986)
[3] Joe Hinkle, Florida Department of Environmental Protection, personal communication
[4] projected rate based on $1.20/yd3 (Mike Hulon, Florida Game and Fresh Water Fish Commission, personal communication)

Summary

The purpose of this study was to evaluate tussock removal with a trackhoe on a floating barge, and to compare production rates with known or previously tested equipment. Limitations to the trackhoe/barge system were primarily water depth (most efficient at depths of 4 ft or more) and handling the removed material up to 5 times to load and unload. As might be expected, the trackhoe could move thick mud islands populated with large trees, which cannot be removed with conventional equipment. However, it was not as efficient (time nor cost) as other equipment when used on mud tussocks without trees and Cuban bulrush/frog's-bit tussocks.

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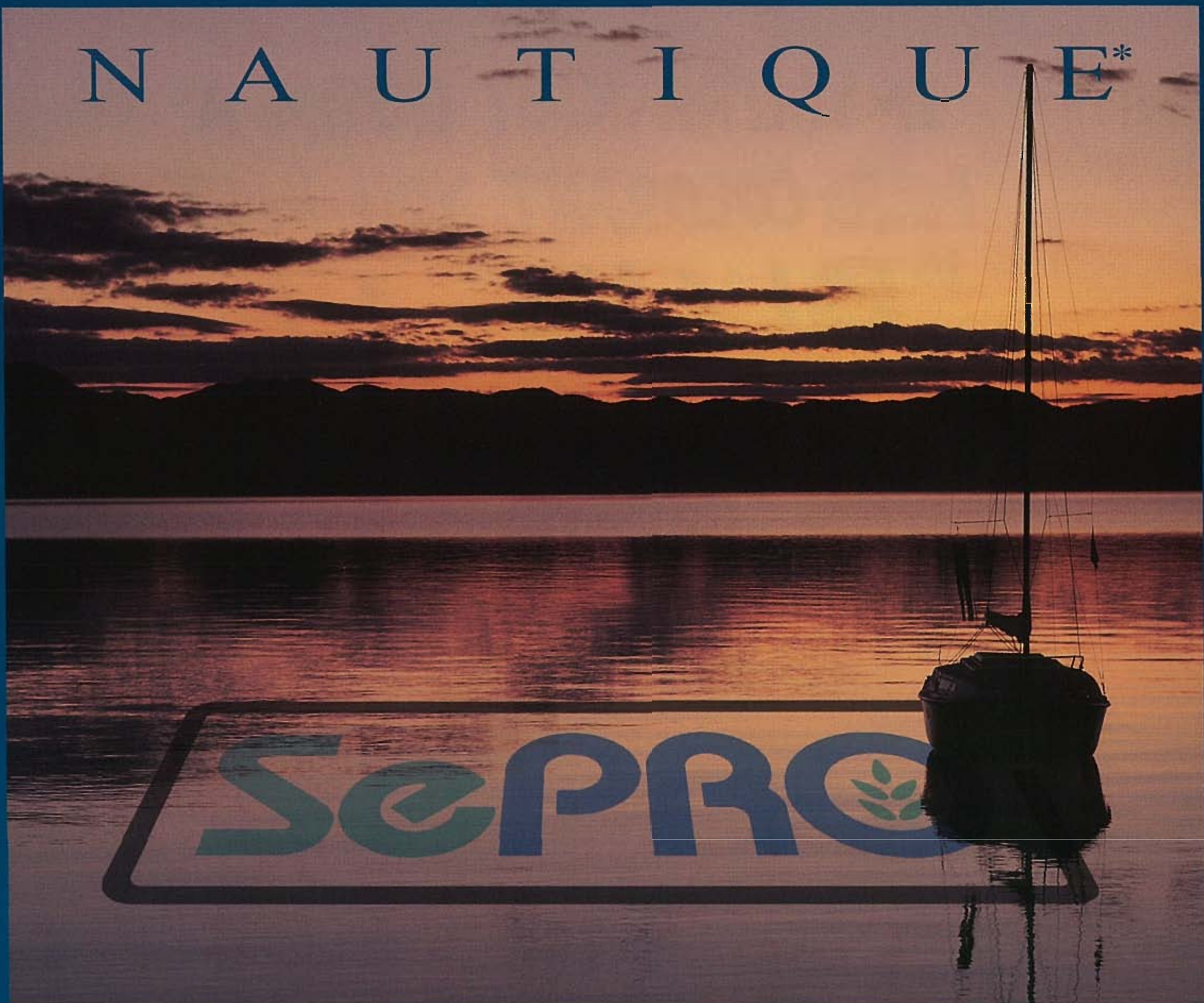
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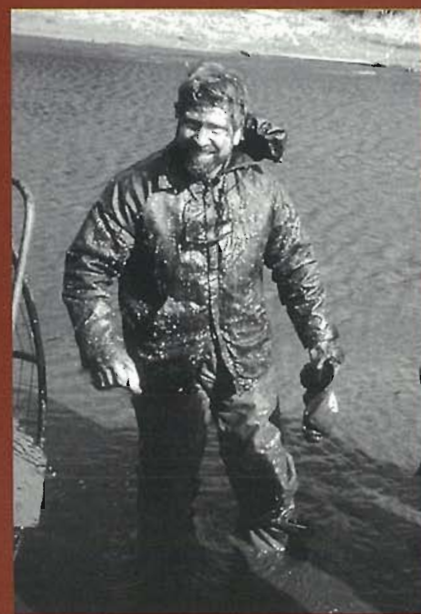

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