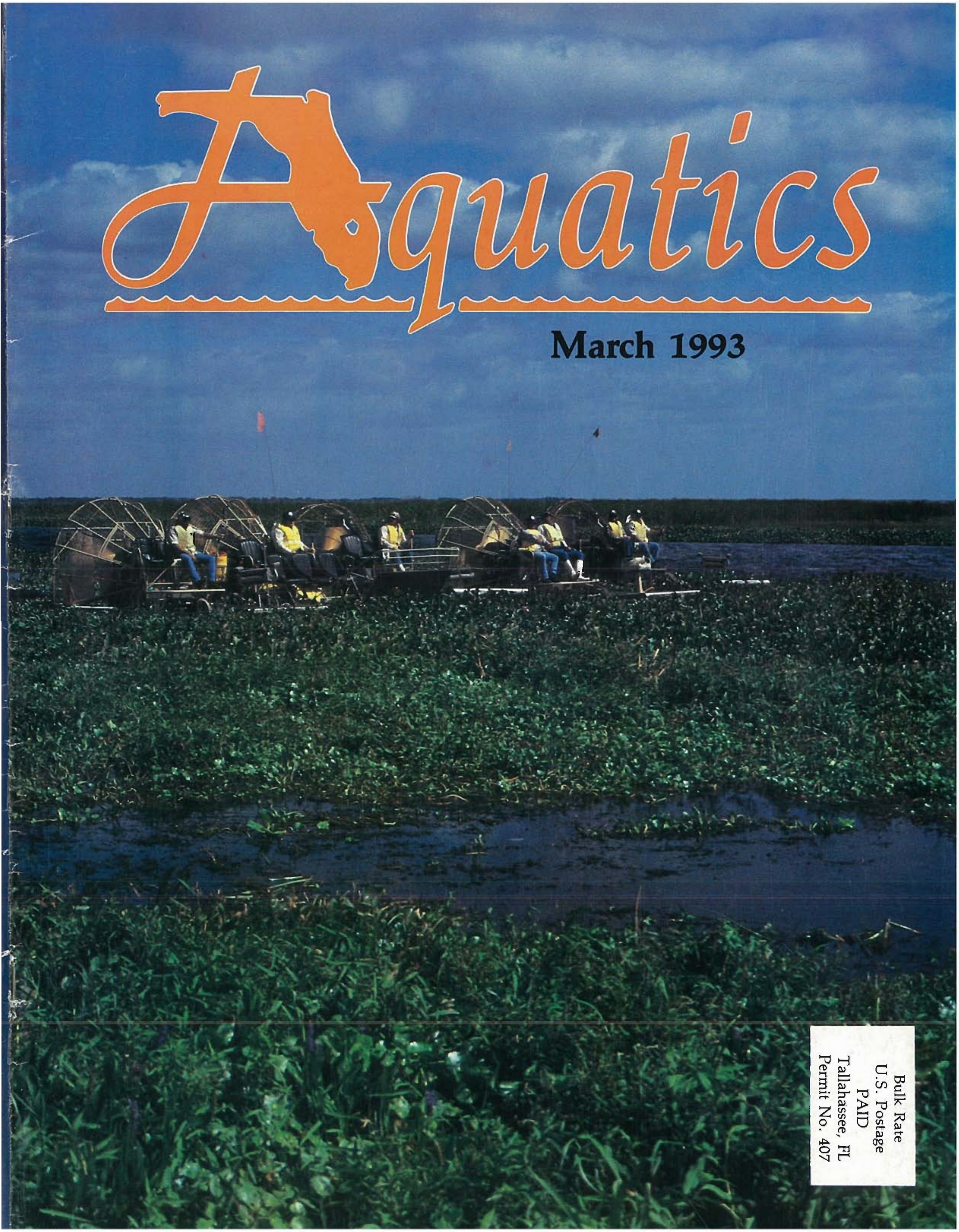
Aquatics

March 1993



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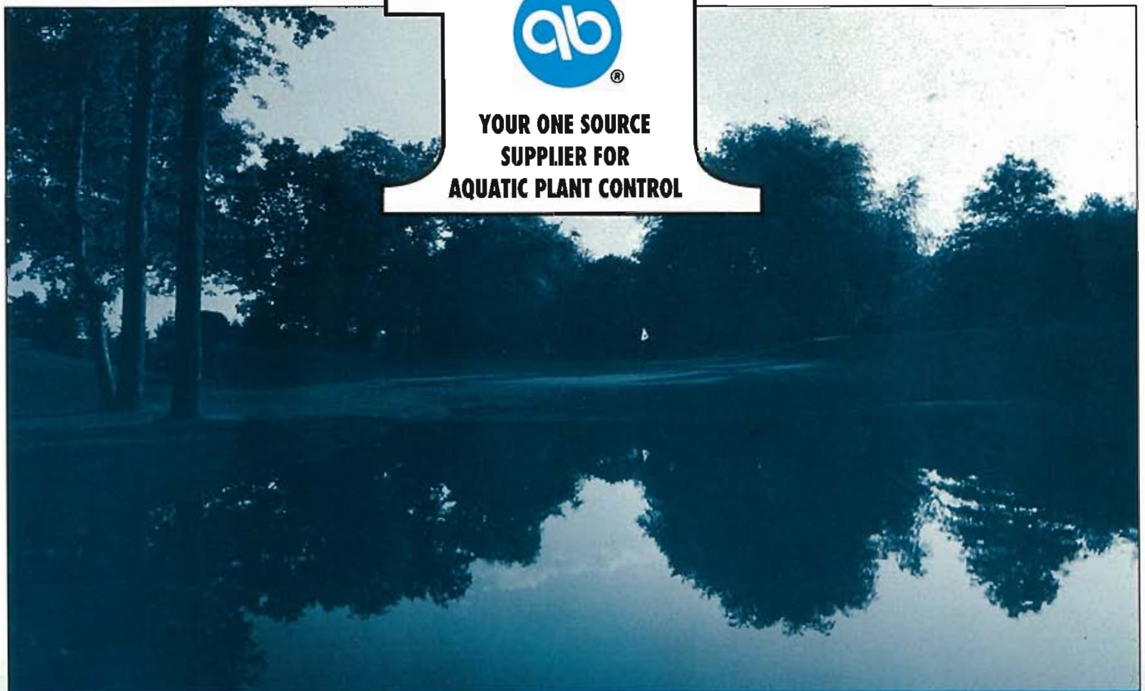

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Letter to the Editor

Excellence. The term seems to be over-used here lately. You see it at football stadiums "Commitment to Excellence" and hear it on radio talk shows "Excellence in Broadcasting". Why even two dudes from the West Coast had an "Excellent Adventure". In these days of specialization, achieving true excellence may be a realistic goal, especially considering the technological advancements in aquatic plant management.

Most folks know my background. I majored in Broadcast Applications with a minor in Sub-Surface at Eichhornia U.. My major professor was Dr. John Bean, Ph(gfc). Now, I'm among the first to realize that this school campus is still crowded and continues to turn out some "Excellent Grads". I'm also one of the first to know that some of these students need a shove over the threshold of the mundane and towards the sublime.

So, for you front-line applicators that have felt the nudge, go on with it. Reach for the stars. Go for the gold. You have a wealth of information readily available to you and a multitude of seasoned veterans that will be more than happy to assist you in your pursuits to attain excellence.

Also for those of you who haven't shoved anyone lately, grab your boat oars, push poles, frog gigs or whatever you're holding, and start pushing. Whether it be a definite push or just a simple word of encouragement.

The number one objective of this society is.... "to assist all aquatic plant managers in their profession". If we can persuade one applicator to Commit to Excellence, then we have truly met that objective. So what do you say? Let's make 1993 FAPMS's "Year of Excellence".

Wayne Corbin, President

About The Cover

The SFWMD crew was out in full force on Lake Okeechobee to take advantage of a strong wind. Crews pushed water hyacinth mats away from a water intake area and let the wind do the rest. (Terry Peters was supervising.) Once the mats were away from the intake area, they could be sprayed.

Photo by Karen Brown, October '91.

Aquatics

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CONTENTS

AQUATICS: 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.

EDITORIAL: Address all correspondence regarding editorial matter to Ken Langeland *Aquatics* Magazine, .

Does 2,4-D Use Increase the Risk of Cancer

The following abstract was reprinted, with kind permission, from a manuscript, which we will make available upon request to FAPMS members, while the supply lasts. Anyone in a position of responding to questions from the public or employees on this subject should obtain a copy. Call Ken Langeland (904/392-9613, SC 622-9613) if you are interested in obtaining a copy.

A Comprehensive, Integrated Review and Evaluation of the Scientific Evidence Relating to the Safety of the Herbicide 2,4-D

Abstract

The safety of 2,4-D to farm and forestry workers, commercial applicators and the general public has been of continuing concern because certain epidemiological studies of groups potentially exposed to 2,4-D have suggested a relationship between 2,4-D use and increased risk of soft tissue sarcoma, Hodgkin's disease or non-Hodgkin's lymphoma. This review on 2,4-D is unique in that the appoach taken was to integrate data from worker exposure studies, whole animals, metabolic and other relevant laboratory studies with the epidemiological findings to assess the extent to which there is scientific support for the hypothesis that 2,4-D exposure is associated with any increased risk of human cancer.

The case-control epidemiological studies that have been the source of the cancer risk hypothesis are inconclusive. Problems in assessing exposure based on patients' memories make these studies difficult to interpret. Cohort studies of exposed workers do not generally support the specific hypothesis that 2,4-D causes cancer. Taken together, the epidemiological studies provide, at best, only weak evidence of an association between 2,4-D and the risk of cancer.

Importantly, the cancer hypothesis is not supported by other data. A critical evaluation of the exposure data indicates that exposure to 2,4-D in user groups is intermittent and much lower than the doses tested chronically in long-term animal studies that have not shown evidence of tumor induction. Moreover, the structure of 2,4-D does not suggest it would be a carcinogen, 2,4-D is a simple organic acid, that is largely excreted unchanged, and there is no evidence that it is metaabolized to critically reactive metabolites or accumulates in tissues. This evidence is supported by a large body of negative studies on genotoxicity, which taken together with metabolic studies, clearly indicates that 2,4-D is highly unlikely to be a genotoxic carcinogen. Futhermore, 2,4-D has no known hormonal activity and does not induce proliferative changes in any tissue or organ, indicating that it does not posses any of the characteristics of non-genotoxic animal carcinogens. Thus the available mechanistic studies provide no plausible basis for a hypothesis of carcinogenicity.

In this review, data relating to potential neurotoxicity, immunotoxicity and reproductive toxicity also were evaluated. There is no evidence that 2,4-D adversely affects the immune system and neurotoxic and reproductive effects only have been associated with high toxic doses that would not be encountered by 2,4-D users.

Historical exposures to 2,4-D by user groups, particularly farmers, forestry workers and commercial applicators, would be higher than those sustained under present rigorous standards for application which involve the use of protective clothing and other measures to reduce exposure. Proposed label changes indicate that in the future exposures will be even further reduced. Viewed in this context, the available data indicate that the potential public health impact of 2,4-D, including the risk of human cancer, was negligible in the past and would be expected to be even smaller in the present and future.

Possible New Treatment Technique

Philip Fields and Steve De Kozlowski
South Carolina Water Resources Commission

The Control of nuisance aquatic plants in drinking water supplies with aquatic herbicides usually requires disruption of water withdrawals for up to two weeks, costly monitoring of herbicide residue concentrations, or maintaining a certain distance (e.g. one-half or one-quarter mile) from intake structures, which are often the areas that need control the most. These restrictions pose unique management challenges.

Waterhyacinths are generally easy to control with regular and frequent treatments; however, their control in drinking water supplies is a literal nightmare because of use restrictions. One herbicide that can be used in potable waters is Komeen, a chelated copper formulation by Griffin Corporation. While typically used to control a variety of submersed aquatic plants, some interesting new studies are underway that target emergent and floating species.

The Water Resources Commission in conjunction with Griffin Corporation and Aquatic Vegetation Control are conducting studies to control waterhyacinths with Komeen using a variety of new techniques. One promising technique was discovered this past fall. Waterhyacinths were treated with an invert application of Komeen at a rate of seven gallons per acre. Shortly after treatment the plants began exhibiting symptoms of stress and inspection of the plots two weeks later indicated complete control. The results were exciting enough to schedule further testing of the technique at lower rates and on larger plots this spring. The University of Florida Center for Aquatic Plants is also studying the potential of waterhyacinth control with copper compounds. We will keep you posted on the results.

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Control of Berchtold's Pondweed and Southern Naiad In a Recirculating Cooling Water Reservoir With Low Concentrations of Fluridone

by
David H. Schiller
Carolina Power and Light Co.

Portion of Sutton Lake looking toward power plant in June, 1992, two years after application of Sonar SRP.

Worker clearing weeds from power plant intake structure during an episode of weed impingement.

Introduction

Recent research has centered on the use of very low concentrations of fluridone, the active ingredient in Sonar® , over extended periods for hydrilla control (Fox and Haller 1991; Steve de Kozlowski, South Carolina Water Resources Commission, Personal Communication). This study reports on field operations using low concentrations of fluridone for controlling Berchtold's pondweed (*Potamogeton berchtoldii* Fieber) and southern naiad (*Najas guadalupensis* (Sprengel) Magnus) in a southeastern United States power plant cooling lake.

Sutton Lake, a 445 ha (1,100 ac) lake near Wilmington, North Carolina, was built by Carolina Power and Light Company (CP&L) in 1972 to provide cooling water for the 588 megawatt, coal-fired L. V. Sutton Electric Plant (Figure 1). The lake bottom is essentially flat with an average depth of 2 m (6.5 ft). Water for cooling the power plant enters the plant's intake structure at the south end of the lake, is pumped through the plant, and returns to the lake via a 1.2 km (.75 mi) long canal. Several dikes divide the lake into eight sections and force the circulating water in a counterclockwise direction to provide for maximum cooling before being withdrawn again. Except for extreme rainfall events, no water is released from the lake, making it a closed system. When all of the power plant's circulating water pumps are in operation, the entire volume of the lake can be exchanged in slightly less than four days.

Clearly, it just makes good sense to be careful when controlling aquatic weeds!

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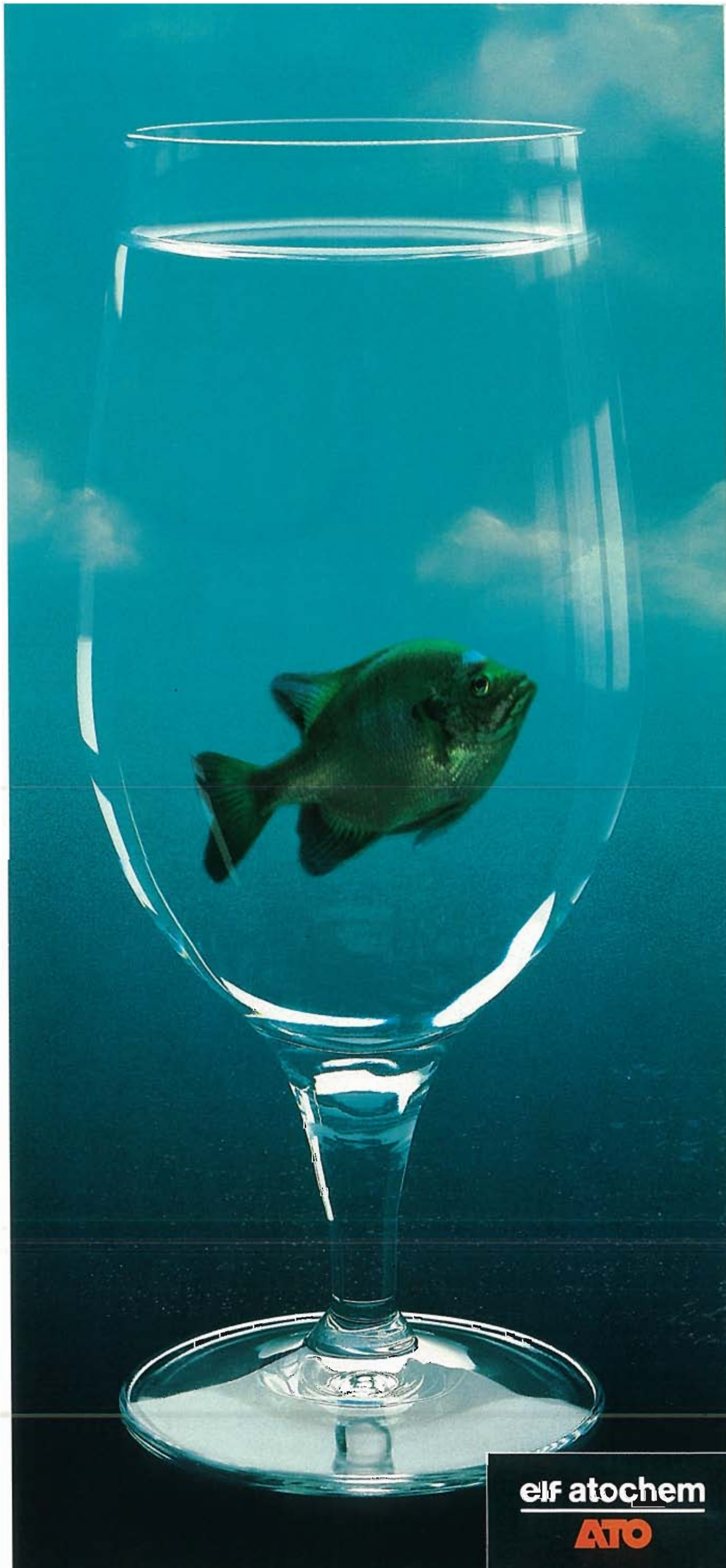

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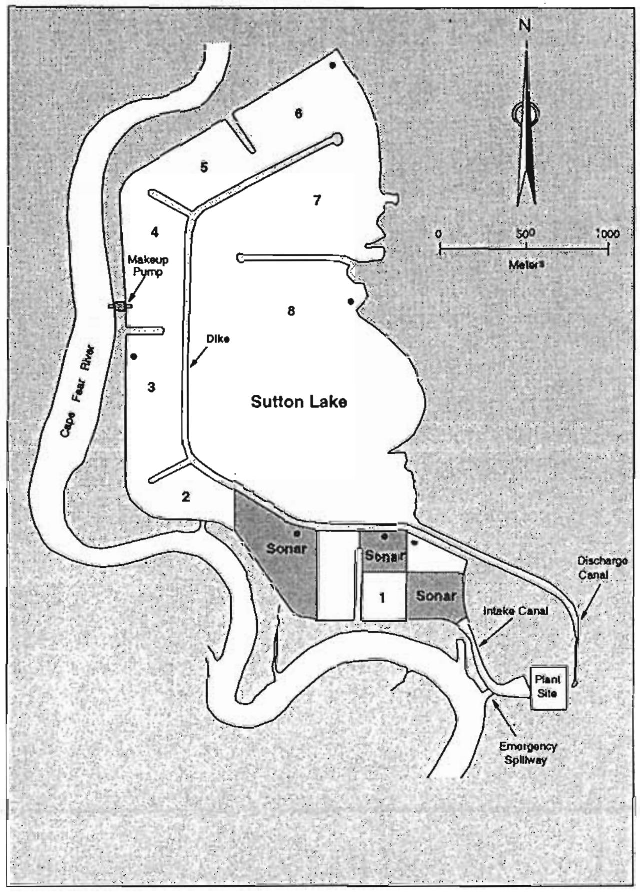
Because of its shallow depth and relatively clear water, the lake has supported large quantities of submersed aquatic vegetation (pondweed and southern naiad) since soon after it was created. During past years, large quantities of vegetation have broken free and were carried by wind and current to the intake structure where they blocked the openings and reduced the flow of cooling water. The power plant was forced to shut down on one occasion and nearly shut down on several others. To reduce this impact on operations, two applications of fluridone (in 1984 and 1990) were made in the lake. The objective was to maximize control of the species impacting power plant operations.

Methods and Materials

On April 11, 1984, 13.8 ha (34 ac) in section 1 of Sutton Lake were treated with 30.8 kg (68 lb) ai of fluridone (40 lb Sonar® 5P/ac) and 17.4 ha (43 ac) in section 2 were treated with 29.2 kg (64 lb) ai of fluridone (30 lb Sonar® 5P/ac). The herbicide was applied in the two sections nearest the power plant intake with the intent of reducing the vegetation most likely to be carried to the intake structure. Application was made from an airboat equipped with an electrically driven spreader. At the time of application, aquatic vegetation consisted of young pondweed shoots approximately 10 cm (4 in) long, spaced approximately 25 cm (9 in) apart. The application was planned for a period when the power plant was shut down for major repairs to reduce water movement. However, a series of tornadoes several days prior to the application damaged area electric transmission lines and the power plant was kept in operation so that the region would not be without electric service from other generation sources. Thus, water was circulating through the lake at the time of treatment and for the next 90 days. Water temperatures ranged from 22° to 35°C (72° to 95°F).

On May 11, 1990, 20 and 25.5 kg (44 and 56 lb) ai of fluridone, respectively, were applied to the same areas in sections 1 and 2 that were treated in 1984 (26 lb Sonar® SRP/ac). The power plant was not in operation until 10 days after treatment (DAT), ran continuously for the next 35 days, then intermittently for the remainder of the 90 DAT. Water temperatures ranged from 22° to 30°C (72° to 86°F) during the 90 DAT.



Water and hydrosoil samples were collected just before and at various times after the herbicide application in 1984 to determine fluridone concentrations. Samples were collected in treated and nontreated areas 23, 90, and 240 DAT. In 1990, only water samples were collected from section 1 immediately prior to application and 11, 31, 45, 63 and 103 days after. The use of a single sampling location in 1990 was the result of previous monitoring studies that demonstrated the homogeneous distribution of chemical constituents in Sutton Lake (unpublished CP&L data). All samples were collected in rinsed, polyethylene containers, immediately refrigerated at 4°C (40°F), and frozen within 10 days. Samples were kept frozen in darkness until overnight air shipment to commercial laboratories for analyses by high performance liquid chromatography.

Results and Discussion

Vegetative growth in the entire lake appeared to stop soon after the application of fluridone (Sonar® 5P) in 1984. Young pondweed plants that were present at the time of application did not elongate. Approximately 10 DAT, chlorosis, a typical symptom of fluridone injury, was observed on plants in section 3 of the lake. This location is approximately 1000 m (0.6 mi) "upstream" of the nearest treated area and the injury was attributed to water circulation which carried the fluridone around the lake to this area rather than diffusion from the treated area. The power plant was in operation during the period from the time of fluridone application through most of the spring and summer. During the remainder of 1984 and all of 1985, no submersed vegetation was observed in the lake.

Fluridone concentrations in water and hydrosoil taken from the treated area in section 2 were 8.0 and 17 ppb, respectively, 23 DAT in 1984 (Table 1). After 90 days, the concentration in hydrosoil at that location had decreased to 6.0 ppb and none was detected in the water. However, the fluridone concentration at that time in hydrosoil in untreated section 6, located farthest from the treated areas, was 14 ppb. This confirmed the movement of fluridone throughout the lake. No fluridone was detected in hydrosoil immediately adjacent to the treated area 90 DAT in Section 1 nor was any detected in either hydrosoil or water from various locations throughout the lake 240 DAT.

Visual surveys in 1986 revealed

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the presence of scattered patches of pondweed approximately 1 m (3.3 ft) in diameter throughout the lake. From 1987 through 1989, pondweed and southern naiad gradually increased and by 1990 had reached levels similar to those of 1983 (before herbicide application), which necessitated the second application.

Effects of the fluridone application in 1990 were much slower than those of 1984, possibly reflecting the use of the SRP formulation and/or the presence of larger quantities of vegetation than in 1984. At the time of application, most of the lake supported dense stands of pondweed and southern naiad. Twenty one DAT, the vegetation in the lake did not appear to be affected. However, 45 DAT, some breaking up of vegetation was observed and by 90 DAT (late summer), most of the vegetation consisted of detached floating mats of dead or dying plant material. During the fall, these mats declined and 180 DAT, no vegetation was observed in the lake. Submersed vegetation remained absent throughout 1991 and 1992.

Fluridone persistence in Sutton Lake water after the second application (1990) was longer than after the first application (Table 1). The concentration rose to 2.0 ppb 11 DAT, reached a maximum of 4.0 ppb 45 DAT, and declined to below detection limit (1.0 ppb) 103 DAT. The longer persistence time in 1990 may have been due to the use of the SRP formulation (as opposed to the 5P applied in 1984) or to the uptake by vegetation and then release back into the water during senescence. The application in 1984 would have resulted in a predicted whole lake concentration of 7.0 ppb and the 1990 application 5.0 ppb. The lower observed concentrations may have resulted from herbicide degradation over the two periods after application.

After the application in 1984, fluridone was not detected in water 23 DAT nor in hydrosoil 90 DAT. The longer persistence in hydrosoil agrees with observations of Muir *et al.* (1980) and West *et al.* (1990). Photolysis has been implicated as the primary cause of the degradation of fluridone in natural waters (Mossler *et al.* 1989; West *et al.* 1983), although microbial degradation has been shown to be a contributing factor (Mossler *et al. 1991)*. The half life in lake water has been reported to be from 5 to 60 days (Langeland and Warner 1986; Arnold 1979; West et al. 1983) while it may be detected in hydrosoils as long as one year after application (Muir *et al.* 1980).

The pattern of fluridone concentration in water after application appears to be largely dependent on the formulation of fluridone used. Application of the aqueous suspension (AS) formulation usually results in a high initial concentration that is followed by an exponential decrease (Langeland and Warner 1986; Osborne *et al.* 1989; Smith *et al.* 1991; Karamianos *et al.* 1989). However, the pelleted formulation (5P or SRP) results in a low initial concentration that rises to a maximum 18 to 150 DAT and then declines to undetectable levels (Langeland and Tucker 1987; Smith *et al.* 1991; West *et al.* 1990). This pattern is described as a two-termed exponential model (Rawlings 1988) where two processes are taking place at the same time. In the case of fluridone concentrations, the first process is the release of herbicide from the clay carrier and the second is its removal by plant and hydrosoil uptake and photolysis. Although data are insufficient after the application of fluridone in Sutton Lake in 1984 to verify this pattern, the concentrations in 1990 clearly follow the two-termed model. Fluridone concentrations in water after both applications were low and, in 1990, persisted for an extended period.

Anderson (1981) found that Sago pondweed (*P. nodosus*) was sightly more susceptible to fluridone than was American pondweed (*P. pectinatus*) when both were exposed for 10-15 days at a concentration of 1.0 ppm. Marquis *et al.* (1981) also treated Sago pondweed and Richardson's pondweed (*P. richardsonii*) with fluridone for up to 14 days at 1.0 ppm fluridone and observed heavy injury, especially in new and young leaves. No damage was observed in mature leaves and the experiment was terminated before determination could be made if the plants died. Wells et.al (1986) determined in the laboratory that exposure of curly leaf pondweed (P. crispus) to 1.0 ppm fluridone for 60 days caused chlorosis in new growth and some necrosis in young leaves. However, plants regained their color after being transferred to and grown in fluridone-free water. The general lack of control of various species of pondweed in these laboratory studies compared to the control realized in the present study suggests either large differences in sensitivity of the genus *Potamogeton* to fluridone or that laboratory experiments may not accurately reflect the effects observed after field applications.

Days After Treatment	Sample Location(s)	Fluriodone Concentration (ppb) Hydrosoil	Water
		1984	
0	1	ND[1]	ND
23	2	17	8.0
90	2	6.0	ND
90	6	14	ND
90	1	ND	NS[2]
240	1,3,6,8	ND	ND
		1990	
0	1	NS	ND
11	1	NS	2.0
31	1	NS	3.0
45	1	NS	4.0
63	1	NS	3.0
103	1	NS	ND

[1]Not detected
[2]Not sampled

Table 1. Concentrations of fluridone in Sutton Lake water and hydrosoil at various times after applications in 1984 and 1990.

Recent field operations have indicated that concentrations as low as 10 ppb of fluridone are effective for control of hydrilla if exposure time is long enough. Split applications in a tidally influenced fresh water creek in South Carolina in 1991 that were calculated to maintain a concentration of 10 ppb for 40 days resulted in control over a 10 km (6.2 mi) length of the creek (Steve de Kozlowski, South Carolina Water Resources Commission, personal communication). Analyses of water samples for herbicide residues indicated that the maximum fluridone concentration reached was 5.0 ppb, but for only a brief portion of the period. A similar split application made in 1989 with a target concentration of 15 ppb fluridone in the lake systems of the St. John's and Withlacoochee Rivers in Florida also resulted in control of hydrilla (Fox and Haller 1991). The degree of control of pondweed and southern naiad in the present study suggests that these two species are more sensitive to fluridone over long (> 50 days) exposure periods than is hydrilla. Implications for management of these and other species of similar sensitivity are to utilize split applications in flowing water or to restrict water exchange in order to maximize herbicide contact time.

Acknowledgements

The author expresses thanks to Mr. J. M. Swing of Carolina Power and Light Company for assistance in field work and to Mr. D. P. Tarver of DowElanco Company for technical advice. Special appreciation is to the personnel of the L. V. Sutton Electric Plant for assistance in field operations and sampling.

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Management Results from 1992

by
Jeffrey Schardt
Florida Department of Natural Resources

In November 1992, the aquatic plant survey of 452 public lakes and navigable rivers conducted by the Bureau of Aquatic Plant Management was completed. Although it will take several months to compile all of the data, figures have been tabulated for hydrilla, waterhyacinth and waterlettuce. The survey provides a good report card to assess the results of the management programs which are designed to keep invasive exotic plants in check. Using that analogy, high marks were scored in 1992.

Hydrilla

Expectations were high at the beginning of the year that increased funding would allow managers to reverse the alarming trend of hydrilla expansion. Poor funding and adverse weather conditions during the previous two years meant reduced hydrilla control efforts, which in turn translated into record levels of hydrilla infesting public waterways. Hydrilla increased from 42,000 acres in 1989 to 67,000 acres in 1991. In 1992, the Bureau was granted Legislative authority to spend the balance in the Aquatic Plant Trust Fund while legislation was being reviewed to acquire a more adequate source of recurring funding. Nearly $2.0 million of the $2.5 million funding increase subsequently approved by the Legislature was directed toward managing hydrilla.

Most of the large scale hydrilla treatments completed prior to the arrival of heavy rains in June and July were considered to be successful. Consequently, a net reduction of approximately 14,000 acres was recorded for 1992 (Figure 1). While the reason behind the 3,500 acre hydrilla decline in Lake Okeechobee is unclear, management with fluridone is responsible for hydrilla reductions in Lakes Istokpoga, Arbuckle, Winder, Poinsett, Jackson (Leon), Sampson, Newnans and Yale, as well as the Withlacoochee River. The 53,000 acres of hydrilla surveyed in public waters durng 1992 marks the end of the first phase in reducing hydrilla to the 40,000 acre level, a level not seen since the middle 1980's.

During 1992, the Bureau successfully supported legislation which transfers an additional $2.5 million to the trust fund each year for aquatic plant management. This now gives the Bureau the consistent source of funds needed to reduce and hold hydrilla at more acceptable levels. More than $5.0 million have been allocated to hydrilla management in 1993. About 85% will be spent on large scale programs scheduled for the 23 waterbodies listed in Figure 2.

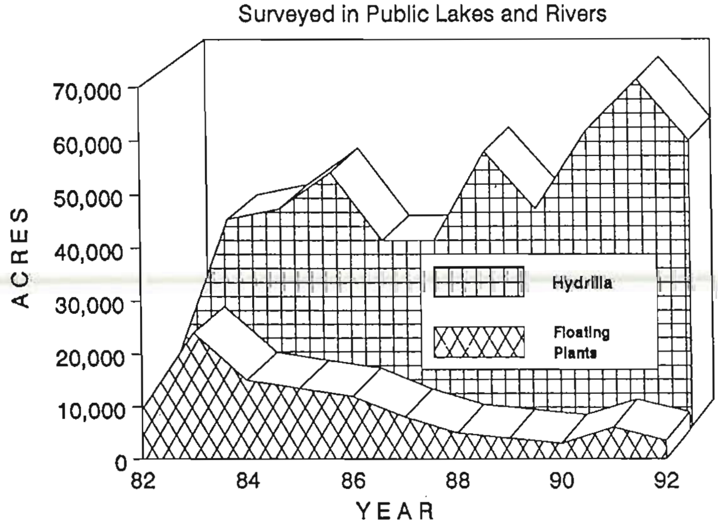
The greatest expansion of hydrilla is presently occurring in the Kissimmee River watershed where eight large scale treatments will be conducted in 1993. Thirty-seven percent of the hydrilla reported in public waters occurs in this area; 40% of the 1993 hydrilla control budget will be spent to keep it in check. One quarter million dollars will be spent managing hydrilla in Lake Weohyakapka (Polk County). Hydrilla, first noticed in Lake "Weo" in 1991, is expected to cover much of this 7,500 acre waterbody if not managed this year.

The 1993 management plans are designed to generate a net hydrilla reduction of 10,000 to 15,000 acres. Since hydrilla usually grows back within about two years after large scale fluridone treatments, the waters treated in 1992 will likely require retreatment in 1994. Similarly, those managed in 1993 will require additional work no later than 1995. Therefore, with current funding, technology and policies, the level of hydrilla which remains after the 1993 management programs are completed will represent the maintenance level in Florida's 1.25 million acres of public waters.

Floating Plants

Waterhyacinth and waterlettuce have been under maintenance control in Florida public waters since 1988. During this period, the two plants together have been under an average 5,000 acres, testimony to the intensive management effort applied against these invasive exotics. A total of 3,600 acres of waterhyacinth and waterlettuce were reported during the 1992 Survey. To achieve this level of managment,

Figure 1: Acres of Hydrilla and Floating Plants* Surveyed in Public Lakes and Rivers



* Floating plants = waterhyacinth and waterlettuce

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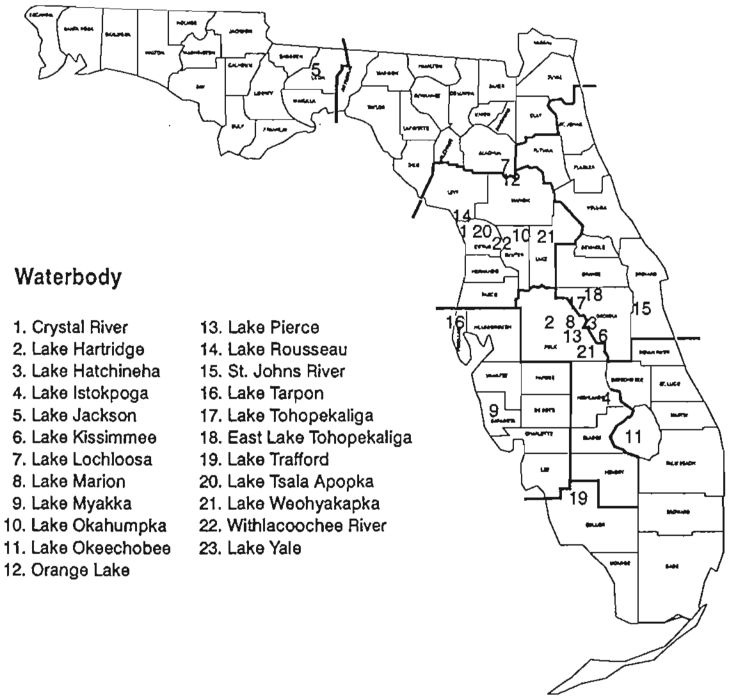
nearly $2.9 million were spent controlling 35,500 acres of plants. This is only slightly more than the average $2.5 million spent and 34,000 acres controlled each year since maintenance control was achieved in 1988. It is indicative of the level of management which will be necessary each year unless additional, effective biological controls are added to the program. Waterhyacinth was found in 60% of the public waters surveyed in 1992; waterlettuce was found in 31%.

Favorable weather conditions allowed managers to keep control pressure on floating plants in most waterbodies during 1992. As a result, there are no areas of extreme concern at the onset of 1993. The key to holding maintenance control through the summer months is to aggressively manage waterhyacinth and waterlettuce as they begin to grow in the spring. However, a third consecutive warm winter has continued to produce lush waterhyacinth growth as far north as the Georgia state line. Autumn and winter management operations in the northern third of the state, where freezes normally provide control through March, have already consumed a significant portion of the 1993 budget for floating plants. Consequently, while floating plants are expected to remain under maintenance control, management efforts and costs will likely exceed the 1992 levels.

Figure 2: Large Scale Hydrilla Management Projects Scheduled for 1993



Algae Control Using Grass Carp and Simazine

by
Richard Couch
Biology Department, Oral Roberts University
Tulsa, Oklahoma 74171

Public Service Company of Oklahoma, a corporately owned electric utility, has several natural gas and coal-fired electric generating plants in Oklahoma, one of which is located at Oologah, Oklahoma, about 48 km (30 mi) northeast of Tulsa. At this location is a 10 ha (25 ac) reservoir used for cooling tower water, water to flush coal cinders from furnaces, and a catchment basin for surface drainage from the plant site and sewage treatment plant effluent.

Eutrophic conditions in the Oologah power plant reservoir resulted in problems associated with frequent algae blooms. When algae blooms occur carbon dioxide is removed from the water, which causes pH to rise, resulting in pH values in excess of 9, which is the maximum allowed for discharge of water into public waters of Oklahoma. Also, filamentous algae frequently clogged intake screens at the Oologah power plant, which required laborious manual cleaning operations. The management objectives for this lake were to keep pH less than 9 by reducing planktonic algae growth, and to minimize laborious intake screen cleaning operations by reducing filamentous algae growth. Reduction of nutrient inputs were not practical in this situation. Therefore, in-lake corrective measures were necessary to manage algae growth.

Prior to the 1987 legalization of grass carp (*Ctnopharyngodon idella*) importation into Oklahoma, algacides were the only reasonable control options for algae (Cook et al. 1986, Moore 1987, Nichols et al. 1988). Simazine was the only algicide registered in Oklahoma, which results in long term, broad spectrum algae control. It was sold, in Oklahoma as the 80 WP formulation until 1989 when it was sold as a 90% water dispersable granular formulation.

Simazine was used without other control measures (except for a single CuSO4 application in September 1984) to manage algae in the Oologah power plant reservoir from 1984 through 1986 (Table 1). Control of troublesome filamentous algae was consistently good. However, control was short term and repeat applications of simazine were necessary. Following the stocking of 200 grass carp into the reservoir in 1987, filamentous algae was not observed in sufficient quantity to cause intake screen clogging problems until 1991, at which time only spot treatments of simazine were necessary. The 1989 and 1990 simazine treatments were necessary to control planktonic algae blooms.

Grass carp have been observed to feed on filamentous algae growing in association with macrophytes (Leslie et al. 1987). However, grass carp are not normally considered an effective method for algae control even though young fish will feed on various filamentous species, such as *Cladophora* sp. and *Spirogyra* sp. (Sutton and Vandiver 1986).

Treatments[1]			Filamentous Algae Observed	Annual Cost($)	Control
			1984		
6/14	1.4	simazine	*Spirogyra* sp.	4,125	Good
9/25	0.8	CuSO4	*Oscillatoria* sp.		
			1985		
4/19	1.1	simazine	*Spirogyra* sp.	6,876	Good
6/25	1.1	simazine	*Oscillatoria* sp.		
8/13	0.5	simazine	*Oedogonium* sp.		
			1986		
3/8	1.1	simazine	*Spirogyra* sp.	5,435	Good
7/4	1.1	simazine			
			1987		
4/7	1.1	simazine	*Spirogyra* sp.	7,874	Good
6/15	1.1	simazine	*Vaucheria* sp.		
7/30	1.1	simazine			
10/9	200	grass carp		900	
			1988		
None required			None	0	Excellent
			1989		
9/2	1.1	simazine	None	3,030	Excellent
			1990		
5/5	1.1	simazine	None	2,930	Excellent
			1991		
7/8	40	grass carp	*Spirogyra* sp.	280	Good
7/15			spot tmt. W/36 lbai simazine	325	

[1]Herbicide treatments are reported in pounds ai/ac-ft, except where noted

Table 1. Herbicides and grass carp used to manage algae in the Oologah power plant reservoir near Tulsa Oklahoma.

The results of this management program provide convincing evidence that grass carp are a useful biological control agent for successful management of filamentous algae. Because small grass carp have been observed to do a better job of grazing on filamentous algae than do larger fish (Sutton and Vandiver 1986), periodic supplemental stockings with smaller fish is probably necessary to sustain good control; and algicide applications to control planktonic blooms may be necessary.

The use of grass carp in this management program provided dramatic cost reductions. Annual algicide treatment costs averaged $6,078 for the years 1984 through 1987, prior to grass carp stocking, but only $1,641 for the post stocking years, 1988 through 1991. Therefore, grass carp investments have been very cost effective for this management program.

Acknowledgements

The financial support of the Public Service Company of Oklahoma is gratefully acknowledged. Mr Vince Mrasek was supervisor of this project for the Public Service Company of Oklahoma during most of the period covered by this report and Mr. Bill Steen has now assumed responsibility.

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Editors note: Unfortunately, all aquatic registrations for simazine were cancelled in 1992. This paper demonstrates the usefulness of integrating herbicides and biological control methods for aquatic weed management and, hopefully, new products will be available in the future.

Studies of the Natural Control of Hydrilla in Florida

by
Patricia M. Dooris and Dean F. Martin

Introduction

Hydrilla (*Hydrilla verticillata*), since its introduction to Florida in 1959 (Holm *et al.*, 1969), has become a major pest in the state's waterways (Schardt, 1991). Seemingly, considering the extent to which it has infested state waters, the plant is able to grow prolifically in any waterbody into which it is introduced. However, research and observations since the mid-1970s suggest that some lakes and streams are more resistant to hydrilla infestation than others.

Matched Lake Studies

At the USF Institute for Environmental Studies, initial studies were concerned with matched-lake pairs. One lake would be infested with hydrilla, whereas an adjacent, presumably similar lake would be devoid of hydrilla. For example, Lake Carroll in northwest Hillsborough County was infested with hydrilla, while in adjacent White Trout Lake, which is connected to Lake Carroll, hydrilla was absent (Martin *et al.*, 1971). Subsequently, another lake in northwest Hillsborough County, Lake Saddleback, was infested with hydrilla, whereas the hydrilla in nearby Lake Starvation was stunted and limited (Martin, *et al.*, 1976 a,b). Chemical analyses indicated the similarity of the lakes with respect to hardness and other water chemistry parameters, but Lake Starvation had a higher organic carbon content. Further, bioassays of hydrilla growth in lake water indicated that something in the water from Lake Starvation inhibited the growth of hydrilla in the laboratory. A later study of six lakes in Hillsborough County did not reveal other hydrilla-inhibiting lakes like Lakes Starvation and White Trout (Martin *et al.*, 1976 a).

[1]Institute for Environmental Studies, Department of Chemistry, University of South Florida, Tampa, FL 33620-5250

Active Principle Studies

In other studies, natural materials termed "active principles" were investigated in an effort to explain why some lakes resist hydrilla infestation. The substance(s) (active principle) causing inhibition of hydrilla was sought by studying properties of aqueous extracts of sediments from White Trout Lake and Lake Starvation. Both lakes had sediment high in organic content that had arisen from degradation of cypress (*Taxodium distichum*). Molecular weight fractions were separated using ultrafiltration, and activity for hydrilla inhibition seemed greatest for materials in the 2,000-10,000 dalton range for both lakes (Dooris and Martin, 1980). Extracts of fresh material from *Taxodium distichum* did not affect hydrilla growth, and it appeared the mediation of a microorganism was an integral feature of the production of the active principle, a point that was later confirmed (cf Pompey and Martin, 1992).

The active principle was associated with iron, and its behaviour as a chelating agent and as a hydrilla-inhibitor seemed reasonable, based upon related studies of the effect of chelating agents on hydrilla (Victor and Martin, 1977) and the effect of aeration on hydrilla-iron relationships (Cooley *et all.*, 1980).

The active principle, being colored, could also inhibit the growth of hydrilla by means of photodynamic action (the light-lethal effect caused by the production of singlet oxygen by colored substances). While difficult to investigate with hydrilla, evidence for photodynamic action was confirmed for lettuce seeds grown in the presence of the hydrilla inhibitor. The inhibiting action could be destroyed by sodium azide, which is a diagnostic test for the presence of singlet oxygen (Barltrop and Martin, 1984).

Further investigation of the active principle was made using a Warburg apparatus and measuring the effect of the active principle on the rate of evolution of oxygen from hydrilla leaves. Results indicated that the rate of photosynthesis was inhibited and the rate of respiration was accelerated by the presence of the active principle (Barltrop *et al.*, 1984).

Subsequently, two different approaches to understanding the nature of the active principle were undertaken: (1) determining its physiological effect on the plant tissue and (2) characterizing the material by means of high performance liquid chromatography (HPLC). The first approach involved an examination of the effect of the active principle on the ultrastructure of hydrilla leaves (Dooris *et al.*, 1988). In these studies, the growth inhibitor affected starch accumulation in the plant and brought about a distortion of leaf chloroplasts. It was concluded that the inhibitor may be involved in the disruption of the normal mechanism which partitions photosynthate between starch and sucrose, causing an accumulation of starch. Alternatively, the inhibitor may prevent the normal degradation of starch to soluble products.

The second approach to an understanding of the nature of the active principle involved using HPLC and a specialized column to characterize the material in water taken from various sources (Martin *et al.*, 1986). We found that the active principle had a characteristic peak in the HPLC chromatogram, and the height of the peak was related to concentration of the active principle. Thus in areas of the Withlacoochee River of north central Florida where the concentration of the active principle was high, hydrilla occurrence tended to be low, and in areas where the relative concentration was low, the occurrence of hydrilla was high. Aqueous extracts of White Trout Lake and Lake Starvation sediments gave good HPLC chromatograms and reproducible results for the analysis of the active principle. In addition, other lakes known to be inhibitory toward the growth of hydrilla (some mysteriously so) were found to contain the active principle. On the other hand, it was demonstrated that the presence of colored water did not necessarily indicate the presence of the active principle (the Hillsborough River at Fletcher Avenue was a good example of this (Martin *et al.*, 1986).

Further, we investigated the generation of the active principle by organism(s) from material present in lake sediments. Organisms isolated from White Trout Lake sediment were used in the study. We presumed that the organism involved was a fungus capable of degrading cellulose, so the medium was based upon a cellulose degradation product, cellobiose. The hypothesis seemed to be valid, based upon the results (Pompey and Martin, 1992), and the presence of the active principle was indicated by bioassays and by HPLC analysis.

The active principle, depending upon the concentration, can have several effects, including photodynamic action, chelation, delivery of a transition metal in supra-optimal levels, and even shading.

Chemical Control of Shading

A previous study (Manker and Martin, 1984) demostrated a bioassay technique for showing the effect of shading (physical effect) by a material introduced into a lake versus the chemical effects on the growth of hydrilla. In this study, a dye mixture called Aquashade® (Manker and Martin, 1984) was used. This dye is thought to function as a shading agent and reduce the photosynthetically active region (PAR) light available to submerged plants. We were able to confirm that the dye did, in fact, act in the expected manner because our bioassays were designed to allow no chemical contact between the dye and the plant (Manker and Martin, 1984).

Control of hydrilla by shading is indicated in several sources. An annotated bibliogrophy of Aquashade® is available (Martin and Martin, 1992), and reminds us that Osborne (1979) provided the spectrum of this product in the photosynthetically active region (PAR). Osborne (1979) reported that by maintaining Aquashade® at 3 ppm for a year, the occurrence of hydrilla steadily decreased in a 41 ha pond in Orlando.

Previous work has indicated the ability of hydrilla to adapt to low light levels (Bowes *et al.*, 1977).

Specifically, hydrilla was able to adapt to 10-12 μeinsteins/m²/sec (about 0.5% full sunlight). Presumably this was dioecious hydrilla. Steward (1991) studied light requirements for growth of monoecious hydrilla from the Potomac River. He reported, "Growth should not occur below 1% of incident solar PAR, and probably will not occur below the 5% level" (Steward, 1991).

Presently, we are collaborating on an investigation of the possibility that other natural products, suitably treated, may have acceptable shading and/or (chemical) inhibitory properties. The material now being tested has obvious shading effects, as revealed by experiments involving the reduction of light to hydrilla in flasks using the Manker and Martin (1984) technique in which the hydrilla does not come in contact with the shading material. In addition, the substance also has chemical effects, as revealed by studies with a Warburg apparatus (Hassell, *et al.*, 1993).

Expanded Lake Study

Finally, a preliminary study was done of the relative ability of lakes to support hydrilla. In this 31-lake study, the data suggested that lakes do vary in their ability to support hydrilla (Dooris *et al.*, 1983). This is hardly a surprising result in view of the extensive study by Canfield and Hoyer (1992), but our emphasis was on using hydrilla bioassays to study potential growth in highly colored lakes. Unfortunately, available resources did not permit us to investigate a larger number of lakes nor to conduct sufficient replicate trials in the experiments. Therefore, because the results were promising, we believe that expanding this work will be very beneficial.

Acknowledgments

We are grateful for the support and encouragement received from many individuals and for financial assistance from Southwest Florida Water Management District; Bureau of Aquatic Plant Management, Florida Department of Natural Resources, and Aquatic Plant Control Research Program, USAE Waterways Experimental Station.

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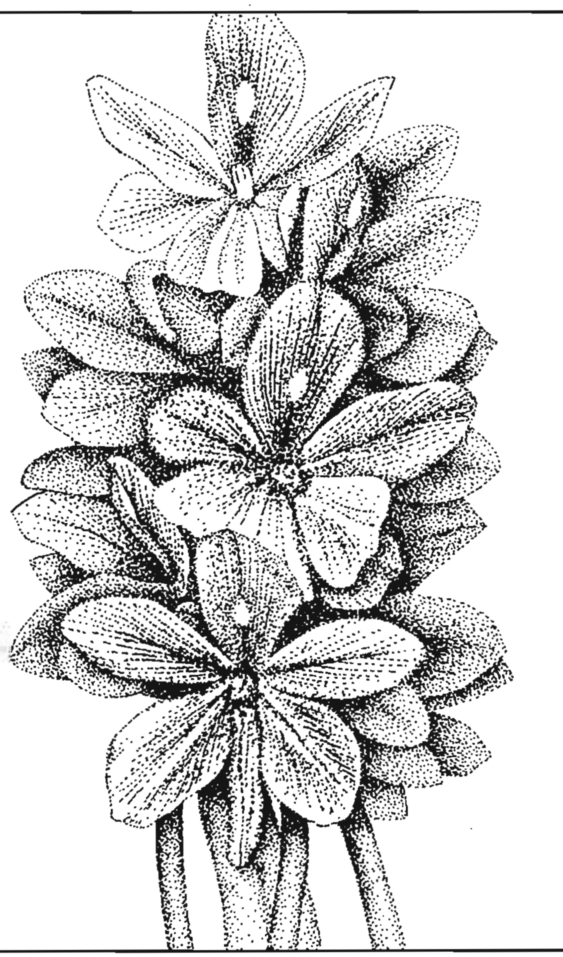

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AQUAVINE

Accolades

Wendy Andrew was awarded the Master of Agriculture degree from the UF, IFAS Agronomy Department in December at the University of Florida Commencement exercises at the "O'dome'. Over the past three years Wendy has commuted from Brooksville to attend classes and conduct independent research in Gainesville. No doubt she would receive an "A" on "identification of landmarks on I-75."

On The Move

Wendy Andrew has accepted a position with Walt Disney World Department of Parks and Pest Control. Judy Ludlow will fill a new position with the Florida Department of Natural Resources as Environmental Specialist III on Lake Rousseau, which the state has recently accepted responsibility for, from the Corps of Engineers. Nancy Allen, who was formerly biologist on Lake Rousseau for the Corps of Engineers will have new responsibilities for supervising operations in about ¼ of the state from the North Florida Operations Office in Inverness. Ed Harris has accepted a position as Biologist III with the DNR Bureau of Aquatic Plants, Orlando Office (Judy's old Job). Brian Nelson has accepted the position of Aquatic Plant Manager for the Southwest Florida Water Management District.

UF, IFAS Center for Aquatic Plants Videotape Update

Three new programs are now available from the Center for Aquatic Plants Educational Videotape Series:
"WHAT MAKES A QUALITY LAKE?" with Dr. Canfield explains the natural and human factors that contribute to the eutrophication, or nutrient enrichment, of Florida Lakes. Different trophic states are defined in terms of water clarity, algae, higher plants, and fish. 24 minutes.

"MAINTENANCE CONTROL OF AQUATIC WEEDS — WHAT IT IS NOT" with Dr. Joe Joyce explains how regular management of aquatic weeds reduces costs, herbicide use, and overall environmental impacts, which makes maintenance control the most environmentally sound and economical method of aquatic plant management. 12 minutes.

"FLORIDA LAKE WATCH — JOIN THE TEAM!" introduces an organization of citizen volunteers who work with University of Florida, Institute of Food and Agricultural Sciences researchers to monitor the water quality of lakes, rivers, and bays. 12 minutes.

Video programs may be **borrowed** by contacting the Information Office, Center for Aquatic Plants, 7922 N.W. 71st Street, Gainesville, FL 32606, 904/392-1799. They may be purchased for $15.00 plus $.90 sales tax in Florida from IFAS Publications, Building 664, Gainesville, Florida 32611, 904/392-1764.

Aquatic Pest Control Certified Applicator Certification Training Auto-tutorial Slide-Tape Available

This auto-tutorial slide set, produced by the UF,IFAS Center for Aquatic Plants, contains training material to prepare for the Certified Pesticide Applicator, Aquatics Category test. The material closely follows the format of the "Aquatic Pest Control Applicator Training Manual" (IFAS Publication SM-3). Topics covered include history of aquatic plant management, herbicide technology, calibration techniques, biological control, mechanical control, other methods of aquatic plant management, environmental considerations, and aquatic plant identification. The slide-set can be viewed in Cooperative Extension Offices in designated training and testing counties, and can be purchased from IFAS Publication (see above).

Aquatic Plant Research Review and Workshop on Aquatic Plant Management and Fishing

The annual research review meeting will be held on April 27-28, 1993 at the Reitz Union Auditorium, University of Florida in Gainesville, Florida. In addition to the annual review of research underway in Florida to address aquatic plant management and ecology, this year's meeting will also provide an opportunity for open discussion between university and agency personnel conducting fisheries habitat research and anglers and fish camp owners. This will be an attempt to find common ground between what is technically possible in fisheries habitat management and the desires of the angling public. Registration information will be mailed in the near future to our standard mailing list. For additional information contact:

Bobbi Goodwin
Center for Aquatic Plants
7922 NW 71st Street
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(904) 392-9613.

Position Available - MNDNR Eurasian Watermilfoil Coordinator

The Minnesota Department of Natural Resources is seeking to fill a vacancy in the position of Eurasian Watermilfoil Coordinator. The incumbent in this position manages Minnesota's statewide Eurasian Watermilfoil Control Program. The position is classified as a Natural Resources Specialist Senior, with a salary range of $30,318 -$41,530/yr. Starting salary would be from $30,318 to $32,448, dependent on qualifications of the person.

Principal job responsibilities are to develop and direct a statewide inventory of waterbodies infested with Eurasioan watermilfoil, a statewide control program, and a statewide public information and education program. The position requires someone with extensive knowledge of aquatic plant management as well as the demonstrated ability to communicate well and deal tactfully with people.

Interested parties should contact Howard Krosch or Steve Enger at:

Ecological Services Section
Box 25, DNR Building
500 Lafayette Road
St. Paul, MN 55155-4025

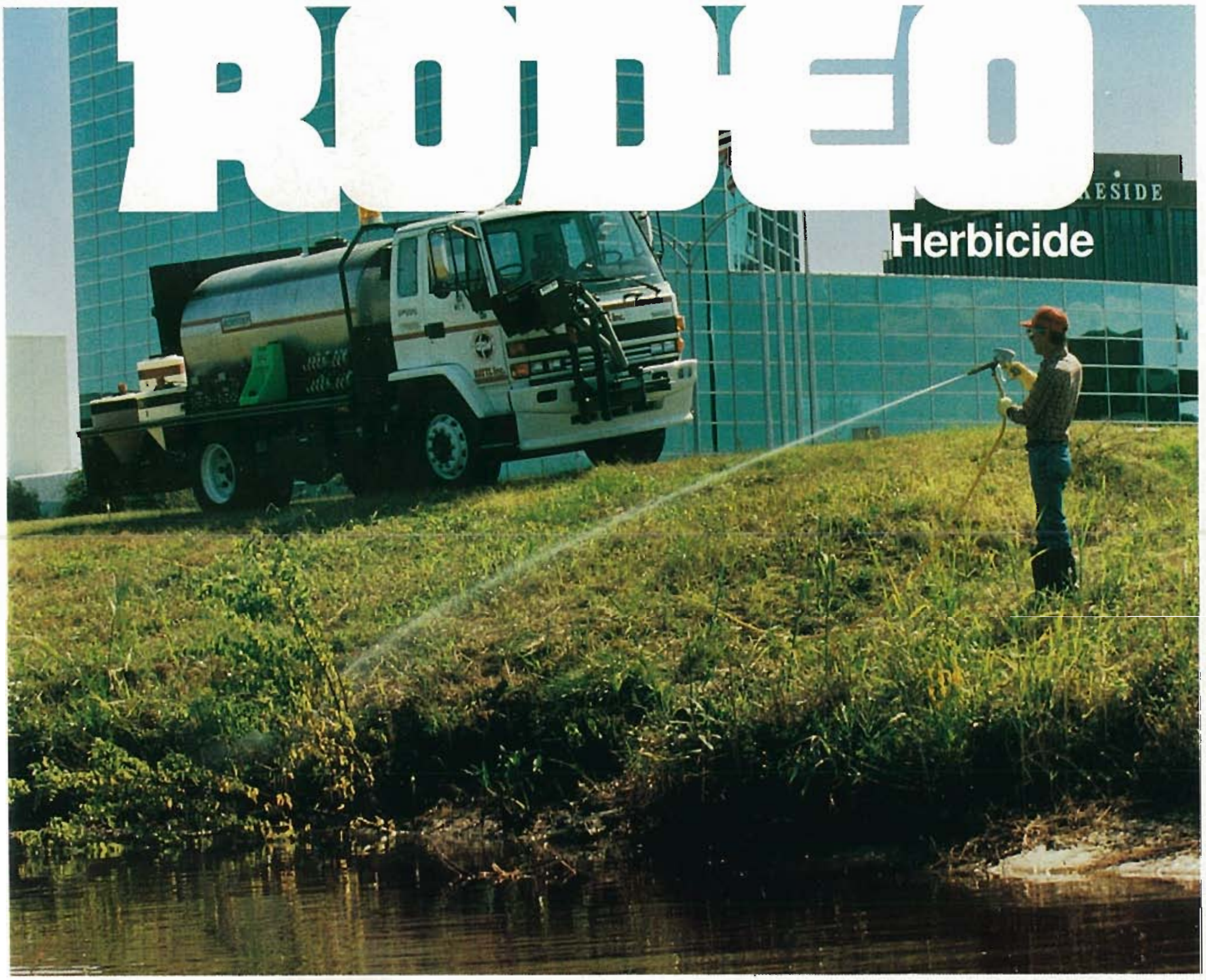
MNDNR Exotic Aquatic Plant Species Control Program Fills Two New Positions

Charles (Chip) Welling and Donna Sheridan started work in December, with the Minnesota Department of Natural Resources Aquatic Plant Species Control Program, and will be assisting with the MNDNR's purple loosestrife and Eurasian watermilfoil control programs. The programs are funded by a $1/yr surcharge on boat registration fees.

Chip Welling has a M. S. in botany from Iowa State and has done research on seed bank and recruitment dynamics in purple loosestrife in Minnesota. Before coming to Minnesota, he did research on patterns of recruitment in emergent plants in southern Manitoba wetlands.

Donna Sheridan has a M.S. in biology from the University of Wisconsin at Milwaukee, and has been working for the Minnesota DNR's county biological survey program.

HOW TO CONTROL VEGETATION IN AND AROUND WATER.



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