Final Report On The Use Of Concentrated Sulfuric Acid For The Control Of Florida Elodea (*Hydrilla verticillata*)

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INTRODUCTION

Located approximately 68 miles north of Tampa, Florida, on U. S. 19-98 in Citrus County, is the town of Crystal River, Florida. The Crystal River has its origin in an area known as Hunter Bay. It is a small bay located within two hundred yards of downtown Crystal River where several large boils or springs are located. The abundant and continuous supply of nitrates, bicarbonates, and phosphates from these springs makes Hunter Bay on the Crystal River an ideal situation for a vegetation problem. Commercial net fishermen, crabbers, shrimpers, oyster fishermen, charter boat operators, and fish camps have operated in this area some twenty-five to fifty years. Recently they have been joined by resort motels, real estate developers, retirement homes, and a host of new business operations dealing in merchandise and services. Dense growth of Florida elodea and other aquatic plants seriously reduced the tempo of the economy of Crystal River as they invaded Hunter Bay and the rest of the river.

HISTORY

It became clear that the vegetation problem in Crystal River must be solved if the economy of the area was to be maintained. Several attempts were made by chemical companies and aquatic plant control agencies to find a suitable herbicide capable of eradicating or controlling the Florida elodea in the river and bays without success.

A local citizen, Mr. Robert Hyde, after studying the problem suggested using acid as a method of biological control. He reasoned that if the pH were lowered the plant would be destroyed.

Sulfuric acid was chosen because of its availability in the area. Large amounts are used in the phosphate industry located within ninety miles of Crystal River. The acid was purchased in 50,000 pound lots and delivered by tank truck to the Crystal River area.

The Fisheries Restoration Team of the Florida Game and Fresh Water Fish Commission was assigned the task of determining what effect the addition of large amounts of sulfuric acid to the river would have on the fish population present in the area, also to determine how it would effect reproduction of all species of fish.

MATERIALS AND METHODS

Bottom Sampling

Mr. J. E. Burgess of the Florida State Board of Health collected bottom samples of invertebrates in both treated and untreated areas with an Ekman Dredge which measured 6 by 6 inches. The bottom sediments of each dredge sample were emptied into a container where the sediments could be examined and the bottom type recorded. The sdiments were then transferred to a dip net with a one millimeter mesh bag. The fine sand and organic particles were removed by swirling the bag through the water. The remaining material was then transferred to one-gallon wide-mouth jars partially filled with water. Benthic organisms were subsequently sorted from the debris in a white enamel pan and placed in 95 percent alcohol.

The organisms were identified in the laboratory and placed into significant taxonomic groups with the calculated number per square meter (Tables 1 and 2).

Electro-fishing Sampling

Electro-fishing samples were made with a portable Milwaukee 120-240 AC Volt, 2500 Watt Generator mounted in a fourteen foot plywood boat with two portable electrodes at the bow. The boat was equipped with a bow-rail and a foot operated dead-man switch to prevent injury to personnel that might fall overboard. Sample periods of one-half hour duration were made along the shore. The stunned fish were picked up with dip nets, placed in a live box, identified, measured in one inch size groups, weighed to the nearest one-tenth pound and recorded on field data sheets (1).

Rotenone Spot Sampling

Rotenone spot samples were made with five percent emulsifiable rotenone. The standard procedure of pouring the chemical from the bow of a moving boat was used to distribute one quart of rotenone over approximately one acre.

TABLE 1. INVERTEBRATE FAUNA OF FLORIDA ELODEA, VALLISNERIA AND MUCK BOTTOM IN CRYSTAL RIVER, CITRUS COUNTY, FLORIDA.

Organism	Vallisneria[1]	Florida Elodea[1]	Muck Bottom[2]
Oligochaeta	435	335	0
Hirudinea	14	13	0
Palaemonetes	14	0	0
Amphipoda (scuds, side swimmers)	261	144	0
Isopoda (sow bugs)	100	0	0
Hydracarina	315	13	0
Ostracoda	13	0	0
Chironomidae	113	231	0
Ceratopogonidae	0	0	44
Trichoptera	0	13	0
Anisoptera	14	13	0
Zygoptera	57	29	0
Hemiptera	0	361	44
Castropoda	579	13	0
Ferrissia	91	0	0
Total	2,006	1,160	88

[1]Number of organisms per m² calculated from four 6 inch by 6 inch Ekman dredge samples each.

[2]Number of organisms based on three samples.

TABLE 2. RESPONSE OF INVERTEBRATES TO CHANGE IN SUBSTRATE AFTER SULFURIC ACID TREATMENT AT PORT PARADISE

Organism	Boat Basin Pre-treatment 8-16-65	Boat Basin Post-treatment 11-12-65	Boat Basin Pre-treatment 8-16-65	Boat Basin Post-treatment 12-9-65
Oligochaeta	----	87	779	----
Hirudinca	----	87	----	----
Amphipoda	----	----	----	739
Hydracarina	----	----	----	----
Ostracoda	----	----	----	43
Chironomidae	87	1,044	----	267
Ephemeroptera	----	43	----	87
Trichoptera	----	43	----	----
Anisoptera	----	87	----	----
Coleoptera (Larvae)	----	43	----	----
Castropoda	----	----	----	43
Total	87	1,434	779	1,179

Trammel Net Sampling

A third sampling method was employed in 1965, 1966, and 1967, population studies. Two trammel nets measuring 125 yards in length were set in both untreated and treated areas. The following specifications describe the net: Three inch stretch mesh inter-net of No. 208 nylon; 12 inch stretch mesh outer-nets of No. 9 nylon hung in halves; 2.5 inch polyfoam floats on polyethelene one-fourth inch lines with the net hung five times between the floats and No. 9 leads with two ties between each lead.

All fish were identified, measured in one inch size groups, weighed to the nearest one-tenth of a pound and recorded on field data sheets.

Water Chemistry

Water chemistry was run on a Hach Direct Reading Engineer's Laboratory Kit, in the field. Water samples were collected from the three major springs and analyzed immediately.

Application of Acid

The method used in chemical application was simple, directed toward affecting an immediate solution for the property owner and supervised by Mr. R. W. Hyde, who developed the technique. The acid was discharged directly from a semi-trailer truck into the water from a point near the problem area. A pressurized tank was employed to expedite the flow of approximately 50,000 pounds of sulfuric acid through a four inch hose.

Discharge of the chemical was timed to coincide with the interval of high tide. The greater specific gravity of the chemical affected distribution, which may have been aided to some degree by the water movement of the ebb tide.

RESULTS

Results of Acid Treatment

Sulfuric acid as a control agent for Florida elodea has proven to be somewhat irregular. The principle cause for such irregularities was directly related to relying upon the high specific gravity of the chemical (1.8 sp. gr.) for distribution. Consequently, successful control depended upon the conformity of the bottom contour which would have been difficult to accurately assess because of the dense growth of vegetation. Deep holes tended to accumulate excessive quantities of the chemical causing a corresponding reduction in concentration in areas with significantly higher elevations.

The exact nature of the effects of acid on the plant as a whole is not known. All indications were that the lower portions of the plants in the higher acid concentrations were killed immediately. Much of the vegetation within the immediate area of application was significantly weakened and floated to the surface within three to seven days. The vegetation around the perimeter of the treated area gradually broke loose forming mats at the surface within ten to fourteen days.

The manner in which the vegetation beyond the area with higher concentrations was killed is not known. It is known, however, that the pH in the area of marginal treatment was not sufficiently strong to have affected a structural weakness of the stems which would cause the plants to break loose from the bottom. Since the roots were anchored in semi-consolidated materials containing considerable quantities of calcium carbonate, it appears likely that the evolution of carbon dioxide within the bottom sediment was of sufficient intensity to loosen the roots and reduce their ability to withstand the continuous drag of the currents. If this is true, the extensive mats of vegetation adrift at the surface were also an agent in removing or uprooting vegetation in the areas of marginal treatment.

The effect of sulfuric acid upon the bottom fauna was immediate and complete. No organisms were found within the bottom muds one week after treatment. However, the macroinvertebrates living on the vegetation above the mid-depth were unharmed by the acid. Vegetation mats at the surface contained a wealth of organisms, both in numbers and species diversity. Several of these forms have been found to be intolerant to acid pollution.

Fish were perhaps the least affected of any aquatic life. Adult largemouth bass (*Micropterus salmonides*), bluegills (*Lenomis macrochirus*), creek chubsucker (*Erimyson oblongus*), and mullet (*Mulgil spp.*) were observed in the treatment areas both during and after treatment. The hogchocker (*Trinectes maculatus*), the blue crabs (*Calinectes spp.*) and recent hatch bluegills were the only forms observed to have experienced significant mortalities. Since the blue crabs and the hogchocker frequent the bottom, their mortality can be associated directly with the acid. In the case of the recent hatch bluegills which were not closely associated with the bottom, it appeared likely that the evolution of carbon dioxide as the acid reacted with the calcium carbonate of the bottom sediments, would be the cause for their mortality.

Results of Fish Population Sampling

The results of fish population sampling completed in 1965 and early 1966 have not been included in this paper since they were reported in earlier reports (2).

Trammel net, electro-fishing, and some rotenone spot samples indicated a larger fish population in locations where sulfuric acid was applied to remove Florida elodea. This increase was composed of either bottom feeders or scavengers which may have invaded the area to feed on

the remains of organisms left as a result of treatment (Table 3).

Trammel netting was made difficult by large beds of Florida elodea that interferred with the operation of the nets and may have restricted the normal movement of fishes which could have reduced the catch in untreated waters (Table 4).

The mullet population became more active in the fall of 1966 this is reflected in the results of the pre-treatment electro-fishing, trammel net, and rotenone samples.

Rotenone spot-samples conducted during the observation period were considered below normal compared to work completed on other Central Florida rivers. The poor results have been caused by certain chemicals which interferred with the normal action of rotenone, thereby reducing its effectiveness (Table 5).

A second and the probable reason for the low numbers and pounds of fish taken by rotenone spot-samples in Crystal River was the low turbidity of the water. Rotenone is an effective method of sampling where the water is clear and the fish have a number of escape routes. The rotenone spot-sample taken following treatment in Hunter Bay points out this fact quite clearly. A total of 604 individuals weighing 149.6 pounds were picked up prior to treatment, and in the same area following treatment only 44 individuals weighing 5.0 pounds were collected. The fact that young individuals of the salt water fish, (*Mojarra spp.*) were collected in the sample following treatment indicates that reproduction of both salt water and fresh water species was not affected by treating the area with sulfuric acid.

Water Chemistry Results

The results of the water chemistry tests revealed the waters of Crystal River had a high pH and a low turbidity. The high pH of the flowing water from the springs located in Crystal River was a factor in neutralizing the concentrated sulfuric acid when it was used as a control for Florida elodea (Table 6).

The methyl orange test for free acidity was made three days after the application of several acid drops. All tests revealed the absence of free acid in the water area. The acid had been diluted and neutralized to such an extent in three days that our testing equipment could not detect its presence.

TABLE 3. RESULTS OF ELECTRO-FISHING POPULATION SAMPLING PRIOR AND FOLLOWING TREATMENT OF CRYSTAL RIVER WITH SULFURIC ACID.

Species	Pre-treatment Number	Post-treatment Number
Largemouth bass	32	22
Bluegill	14	0
Shellcracker	21	24
Stumpknocker	19	2
Chubsucker	5	31
Golden shiner	17	0
Florida spotted gar	1	0
Seminole killifish	2	0
Pinfish	12	0
Mullet	38	10
Mojarra	5	48
Needlefish	1	0
Gizzard shad	0	1
Ladyfish	0	1
Total	167	141

TABLE 4. RESULTS OF 250 YARD TRAMMEL NET SAMPLING PRIOR TO AND FOLLOWING TREATMENT OF CRYSTAL RIVER WITH SULFURIC ACID.

Species	Pre-treatment Number	Post-treatment Number
Largemouth bass	4	0
Bluegill	9	2
Chubsucker	61	48
Golden shiner	7	3
Yellow bullhead	9	7
Brown bullhead	1	6
Mullet	5	7
Blue crab	2	0
White catfish	0	1
Tarpon	0	1
Total	98	75

TABLE 5. RESULTS OF ROTENONE SPOT SAMPLE PRIOR TO AND FOLLOWING TREATMENT OF CRYSTAL RIVER WITH SULFURIC ACID.

Species	Pre-treatment Number	Post-treatment Number
Largemouth bass	81	0
Bluegill	17	0
Shellcracker	389	2
Blue spotted sunfish	12	0
Dollar sunfish	1	0
Hogchocker	4	0
Warmouth	1	0
Brown bullhead	4	0
Chubsucker	10	0
Mullet	39	9
Mudfish	1	0
Golden shiner	1	0
Pinfish	1	0
Mojarra	42	33
Needlefish	1	0
Total	604	44

TABLE 6. WATER SAMPLES FROM VARIOUS CRYSTAL RIVER SPRINGS

	Crystal Lodge Spring May 12, 1966	Banana Island Spring May 12, 1966	American Legion Spring Oct. 31, 1966
pH	8.6	8.6	8.6
Phenolphthalein Alkalinity	0.0 ppm	0.0 ppm	0.0 ppm
Total Alkalinity	90.0 ppm	90.0 ppm	80.0 ppm
CO_2	12.0 ppm	12.0 ppm	10.0 ppm
Calcium Hardness	70.0 ppm	110.0 ppm	60.0 ppm
Total Hardness	100.00 ppm	270.0 ppm	90.0 ppm
Magnesium Hardness	30.0 ppm	160.0 ppm	30.0 ppm
Chloride	10.0 ppm	10.0 ppm	17.5 ppm
O_2	7.5 ppm	7.5 ppm	6.5 ppm
Turbidity	0.00 Jackson Units	0.00 Jackson Units	0.00 Jackson Units
Total Acidity (Phenophthalein)	6.0 ppm	6.0 ppm	N.A.*
Free Acidity (Methyl orange)	0.0 ppm	0.0 ppm	N.A.*

*N.A — Not Available

SUMMARY

Sulfuric acid successfully controlled Florida elodea in Hunter Bay, Kings Bay, and the rest of Crystal River. Florida elodea has reinfested in a few small areas but the rate of growth has been greatly reduced up to this time.

Sampling of bottom organisms revealed that both vallisneria and Florida elodea samples contained more varieties and numbers of organisms than did muck bottom. The number of organisms in areas treated with sulfuric acid was larger than the number found in untreated areas. The removal of Florida elodea, upon which many organisms had been found, caused an increase in the number and variety of invertebrates on the bottom due to the absence of their original place of attachment.

Results of fish population sampling indicated that the addition of concentrated sulfuric acid to Crystal River had very little effect on the existing fish population and no visible effect on the reproduction of either salt or fresh water species. Young of the year of all game fish were found at one time or another during the two year period covering this investigation.

CONCLUSION

The use of concentrated sulfuric acid as a method of Florida elodea control in the State of Florida must meet the following requirements of the Florida Game and Fresh Water Fish Commission:

(1) The water area to be treated must have a high percentage of limestone bottom.
(2) The pH of the water must not fall below 8.0.
(3) An adequate amount of flushing action from both fresh water springs and tidal effect must be available to distribute and dilute the sulfuric acid.
(4) The public must be informed of the operation. Fishing, swimming, skin diving, and other water oriented activities must be halted until tests indicate the water to be free of sulfuric acid.
(5) All safety precautions required by the sulfuric acid industry for the handling of such material must be followed by participating personnel.
(6) Permits issued by the Chief of Fisheries, Florida Game and Fresh Water Fish Commission, are required before treating any water area within the State of Florida. All requests for permits to be investigated by Fisheries Division personnel on individual basis.
(7) All sulfuric acid treatments must be approved by the Florida State Board of Health.

LITERATURE CITED

1. Eddy, Samuel. 1957. How to Know the Freshwater Fishes. Wm. C. Brown Company, Dubuque, Iowa. 253 pp.
2. Phillippy, C. L. 1966. A Progress Report on the Use of Sulfuric Acid Treatment for Elodea Control. Hyacinth Control Journal, Vol. 5, 15-17.