UNIVERSITY OF FLORIDA

Center for Aquatic Weeds

AQUAPHYTE

International Plant Protection Center

AQUATIC WEED PROGRAM

VOLUME 2, NUMBER 2 GAINESVILLE, FLORIDA/U.S.A. FALL 1982

MECHANICAL CONTROL OF AQUATIC WEEDS

Of the various classes of aquatic plant controls, mechanical control is the most energy intensive to implement. Heavy duty machines, some large enough to hold tons of collected plants, use sheer force to push pull, rake, stab, lift, pound, squeeze, throw, haul, bundle, load and carry away tons and tons of vegetable matter. Very high growth densities for aquatic "weeds" mean that one acre of fresh plant mass can weigh 150 tons and more. If a mechanical system could remove an average of two acres of high-density plant mass per hour from an infested 400 acre lake, the crew would still be there five weeks later. Consider the thousands of lakes and untold thousands of miles of rivers and drainage systems which require weed control. For example, according to H. Price (1981), the 5.5 million hectares of agricultural land in England and Wales is drained by a system of channels, the total length of which is estimated to exceed 70,000 km. (In his review of current mechanical controls, Price names several European companies which produce weed cutting and harvesting machines used for waterway and bank weed control.)

Mechanical control systems have been the subject of recent studies in North America and in Europe. Some weed specialists attribute interest in mechanical control to the heightened public concern about the use of chemical controls and their potential effects on aquatic ecosystems. Others do not want to rely on biological controls using exotic species which mav compete with native species. Other researchers believe carefully integrating all of these controls has the best chance to reduce explosive plant growth to natural and manageable rates. Manipulation of the environment through integrated control (IPM) is in its infancy and is being examined world-wide. However, many severe infestations demand the immediate, tangible results provided by the use of mechanical controls.

FIRST LARGE MACHINES

The first large experimental machinery used to combat aquatic weeds was designed and built for the Army Corps of Engineers in 1900. The mechanical control device consisted of a pick-up conveyor and sugar cane crusher mounted on a steamboat. Its job was to clear water hyacinth from the waterways of Louisiana. According to an article written in 1938 by W.E. Wunderlich (with the New Orleans District of the Corps), this slow and cumbersome machine was abandoned after only two years of operation in favor of the quicker and cheaper method of spraying arsenic on the infested waterways. For 35 years, arsenical solutions were the main control of water hyacinths. Wunderlich wrote, the

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UNIVERSITY OF FLORIDA CENTER FOR AQUATIC WEEDS

The Center for Aquatic Weeds of the University of Florida is the State's lead agency for developing and coordinating research efforts to control noxious plants. Located in Gainesville, Florida, the Center features offices, laboratories and support facilities from which scientists in several disciplines operate. Botanists, hydrologists, biologists, engineers, chemists, agronomists and entomologists, as well as scientists from other departments, conduct research under the auspices of the Center.

Cooperative research with state and federal department is also conducted at the Center. In a Cooperative Agreement with the United States Department of Agriculture, the Center is:

1) evaluating new compounds for aquatic weed control (Dr. W.T. Haller)

2) evaluating the effects of water and substrate on hydrilla growth (Dr. D.E. Canfield)

3) investigating the interrelationships between periphyton, algae and macrophytes (Dr. L.M. Hodgson)

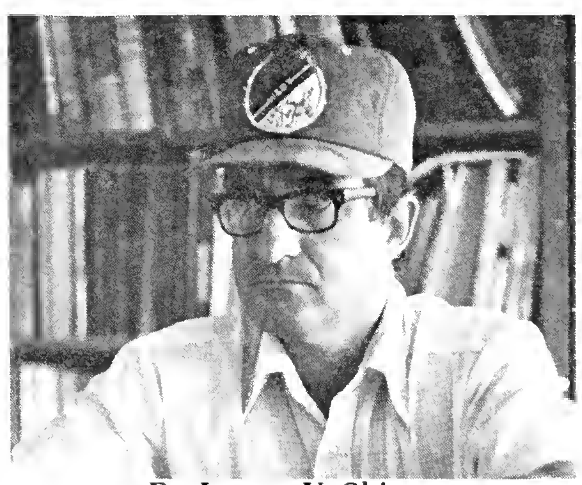
4) surveying aquatic weeds for viral infections (Dr. J.R. Edwardson)

5) studying competition among aquatic plants (Dr. D.L. Sutton)

6) using electrophoresis to determine the identity of bio- and ecotypes of aquatic weeds (Dr. R. Wain)

7) investigating the use of an aquatic grasshopper (*Parapoynx spp*) for hydrilla control (Dr. D. Habeck).

Among on-going Center research is that conducted by Dr. Jerome V. Shireman, fish biologist, and his associates, R. Rottmann and R. Aldridge. Shireman is particularly recognized for his work on the grass carp, *Ctenopharyngodon idella*, and the hybrid cross between the grass carp and the bighead carp. At the Center's Fish Culture Laboratory, (a complex of buildings, tanks and ponds) Shireman, Rottmann and Aldridge are investigating methods for the artificial spawning and culturing of the hybrids in large numbers. The sterile hybrids have the potential for controlling hydrilla and other problem water plants. Because the hybrids are sterile, there is little chance of their reproductive competition with native fish.



Dr. Jerome V. Shireman

Dr. William T. Haller, Acting Director

Center for Aquatic Weeds, 8001 N.W. 71st Street, Gainesville, Florida 32606/USA

FRESHWATER BIOLOGICAL ASSOCIATION

The Freshwater Biological Association, grant-aided by the Natural Environment Research Council, is the principal British institute researching the biology of freshwaters. The FBA has about 2,000 members. It operates two laboratories, a field unit and a technical library which provide research facilities for its own 120 staff members and a few visiting workers. Laboratories are the Windermere Laboratory, The Ferry House, Ambleside, Cumbria LA22 OLP, and the River Laboratory, East Stoke, Wareham, Dorset BH20 6BB, United Kingdom.

The FBA supports research groups in the following areas: Chemistry, Physics, Microbiology, Protozoology, Mycology, Algology, Palaeolimnology, Macrophytes, Invertebrates, Fish, Statistics, Electronics, Library and Information Services, as well as the Finance and laboratory staffs. Macrophyte studies are conducted under the direction of F.H. Dawson and D.F. Westlake.

The FBA has published more than 1500 papers by members of its staff and associated researchers since its founding in 1929. A monthly library list is also produced for staff and others.

According to Miss J.V. Bird, Information Scientist, the FBA library staff scans books and journals for items in the field of freshwater studies and classifies the items by subject. Among the subjects is "higher plants" which includes about 300 aquatic plant citations per year. The citations are compiled into a list divided into subject sections at the end of each month. At the end of each year the lists are accumulated and produced as separate main subject sections.

Annual membership is open to interested parties for ten pounds. Membership information can be obtained from E.D. LeCren, Director of the Association at the Windermere Laboratory. Library list information and subscription rates can be obtained from J.E.M. Horne, Librarian, also at the Windermere Laboratory.

Officers of the Freshwater Biological Association (April 1982) are as follows:

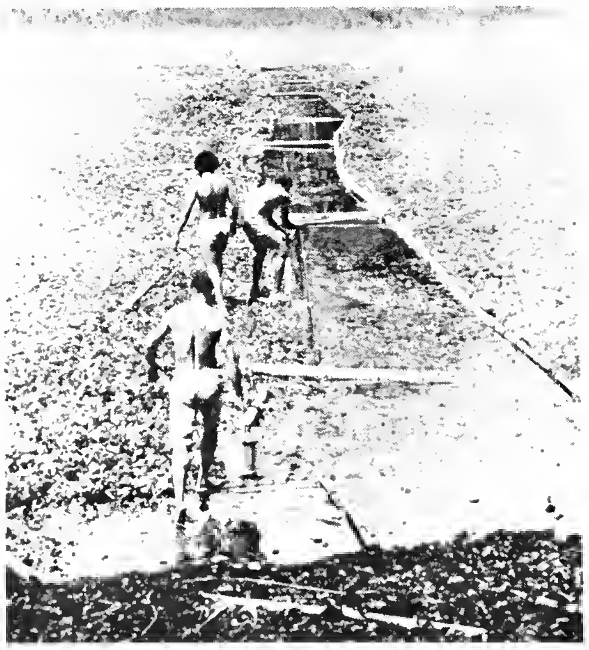
President, Sir Edwin Arrowsmith; Chairman of Council, Professor G.E. Fogg; Hon. Treasurer, K.F. Roberts; Chairman, Scientific Advisory Committee, Professor W.D.P. Stewart.

SALVINIA -- POSSIBLE BIOLOGICAL EFFECTS ON FISH IN PAPUA NEW GUINEA?

By David Coates, Senior Biologist, Fisheries Research and Survey Branch, Department of Primary Industry, Box 417, Konedobu, Papua New Guinea.

Salvinia molesta was accidentally or intentionally introduced into the Sepik River System of Papua New Guinea in the early 1970s. The problems caused by the weed infestation were described in 1980 by Mitchell, Petr and Viner. The Sepik is a huge floodplain river that drains most of the northern part of P.N.G. Very little scientific work has ever been done on the river. In the lower reaches of the floodplain are numerous ox-bow lakes, formed as the river meandered and changed its course, and a small number of depression lakes. *Salvinia* predominates in these lotic (still) waters. The weed is reported to have caused many problems but most have yet to be quantified.

In 1980 a programme of control was initiated. It is led by Mr. P.A. Thomas, Department of Primary Industry, BMS, Wewak, P.N.G. In addition, Fisheries Research and Surveys Branch of the Department of Primary Industry are directly concerned with the effects of the weed on the fish and fisheries of the area. The weed does interfere with river transport and the setting of nets but it is not clear to what extent. The weed has also been blamed for the decline of the local salted fish industry, based on Tilapia (*Oreochromis mossambicus*), but any attempts to relate this decline with an increase in *Salvinia* are conjectural.



Mitchell, D.S.; T. Petr; A.B. Viner. 1980. The water-fern *Salvinia molesta* in the Sepik River, Papua New Guinea. Environmental Conservation 7:115-122.

Research has been undertaken to try to find out exactly what effect the weed has. Full results will be presented shortly. *Salvinia* does have its usual effect of lowering in-water primary production in permanently infested areas resulting in a reduction in oxygen levels. Benthic fauna is usually obliterated under permanent mats. However, as usual, *Salvinia* has a considerable in-fauna associated with the plant itself. In the Sepik, *Salvinia* represents a considerable increase in available fish food (invertebrate fauna) in areas (ox-bows) which anyway are very low in abundance of natural food. Extensive gill-net surveys have been undertaken. There appears to be little difference in catch rates between heavily infested and clear areas. At present the weed is thought to have had little effect on the fish production of the area. The main reason for this is that the weed is usually restricted to areas with naturally low productivity. For example, T.A. Redding-Coates has been studying the biology of Sepik tilapia. It is thought that the majority of fish production occurs on the floodplain during the flood. *Salvinia* does not normally predominate in this environment. However, the situation is certainly complex and efforts are hampered by an almost complete lack of previous research in the area.

The Aquatic Weed Program database has proved invaluable in obtaining references to similar or related work but it is clear that much more is known about the effects of fish on weeds than the effects of weeds on fish! We would certainly like to hear from anybody who has worked on similar problems.

Aquatics

AQUATICS Magazine is an informative, four-color quarterly magazine, the official publication of the Florida Aquatic Plant Management Society. It features articles on aquatic plants and their control, particularly in Florida. Special features deal with techniques of controls, new developments from industry, articles from regulatory agencies, discussions of legislative and administrative actions which affect aquatic weed control and progress reports from the resarch community. AQUATICS is edited by Paul C. Myers. Membership/subscriptions cost only $5.00 (U.S.) per year. According to Myers, orders should be sent to Mr. Jim McGehee, Treasurer, Florida Aquatic Plant Management Society, P.O. Box 212, Maclenny, Florida 32063.

In addition to other news items and announcements, the June, 1982 issue of AQUATICS features the following articles:

1) *The Watermilfoils of Florida* by Anita Tiller. A review of the six *Myriophyllum* species now found in Florida.

2) *Hydrilla - Miracle or Migraine for Florida's Sportfish* by Douglas E. Colle. Documents three sportfish populations in the presence of hydrilla.

3) *The Waterhyacinth Weevils* by Ted D. Center. Reviews the taxonomy and identification, the biology and life histories, the pathological effects and population conservation of these biological controls.

4) *Herbicides vs. Grass Carp* by John A. Osborne. Compares the short- and long-term economics of two hydrilla controls.

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Newsletter of the Center for Aquatic Weeds and the IPPC Aquatic Weed Program of the University of Florida. The Center for Aquatic Weeds is in the Institute of Food and Agricultural Sciences (IFAS). The International Plant Protection Center (IPPC) is a unit of Oregon State University and is funded by the United States Agency for International Development.

Editor: Victor Ramey

AQUAPHYTE is distributed to three thousand aquatic biologists and agencies world-wide. Comments, announcements, news items and other information relevant to aquatic plant research are solicited.

MECHANICAL CONTROL OF AQUATIC PLANTS

Continued from page 1

"deadly poison" was a "hazard to the operating personnel of the sprayboat, the residents living along the streams which were sprayed, and animal life in general ... the loss of livestock from time to time and the physical inconveniences experienced by the personnel of the sprayboat only served to emphasize the necessity for some effective means of combating this aquatic growth which would not entail the use of poisonous materials." According to Wunderlich, neither did arsenic have effect on a newly arrived aquatic weed, alligatorweed (*Altermanthera philoxeroides*).

So, after 35 years, the Corps of Engineers was again authorized to conduct the necessary tests to design a machine for the control of aquatic weeds.

The result was the construction in 1937 of the "Kenny", a motorized steel barge fitted with a conveyor which scooped up the hyacinth and conveyed the plants to onboard machinery which crushed the plants. The mangled hyacinths were then washed overboard to decompose in the water. The 80 X 24 foot barge employed a crew of five. Several other workers were employed in the raking and feeding of plants to the barge. According to Wunderlich, the Kenny was operated around the clock and had a capacity of more than 200 acres of surface vegetation per month. A detailed description of the Kenny is found in *The Military* Engineer 30:5-10 (1938). Wunderlich concluded, "Mechanical destruction machines of this type ... will prove to be entirely satisfactory ... and will definitely supplant the older and more hazardous method of destruction by spraying with poison."

Between 1937 and 1950 the development and use of smaller boats ("saw boats") for the clearance of canals and small rivers increased. Submerged blades cut the plants and left them to decompose in the water.

With the advent of a new generation of chemical controls such as 2, 4-D, the Kenny was retired in 1951. These chemicals and the improved techniques for their safer use began to replace mechanical devices.

In another article in 1967, Wunderlich reviewed the history of mechanical controls and concluded, "It would appear that a well planned combined mechanical/chemical approach is the most satisfactory method of keeping our waterways open at a reasonable cost ... caution is advised against the mistaken belief that either chemicals or machinery will produce a one-time cleanup operation that can be walked away from and forgotten."

MODERN MACHINES

Several mechanical control systems and sizes are now manufactured. However, none can perform all of the tasks necessary to control all problem species. Most devices which are suitable for canal maintenance are too small for large river or lake maintenance. Systems which only cut below the water cannot be used to collect floating plants. A system which cuts to a maximum depth of 2.5 feet may not effectively control plants which grow in water deeper than 2.5 feet. Some aquatic plants reach several feet above the surface of the water, while others form thick mats on the surface requiring a multiplicity of machine capabilities.

Most harvesting operations require at least the cutting, collecting and loading, transporting to shore, unloading and then conveying to other locations for the decomposition and/or utilization of the nuisance plants. Because the bulk of plants such as water hyacinth is so great, onboard processing of the plant to reduce its mass is sometimes an additional operation.

Effectiveness of mechanical systems is measured in terms of acres per hour harvested and/or average tons per hour harvested. Biomass per acre varies substantially between target species; hydrilla, 20 tons/acre; water hyacinth, 150 tons/ acre; and watermilfoil two tons/acre.

Nutrient availability, temperature, time of year and other conditions can cause wide variation in the biomass data of a single species. A system might perform with twice the efficiency on one species than on another. And, of course, weather conditions, water velocity and the condition of the system and crew all contribute to the system's efficiency. "Downtime" for maintenance and repair is also figured into a system's efficiency. Some systems show a 25% downtime under field conditions, possibly raising the system's real cost to unacceptable levels.

Questions as to the desire for small or large area control must be considered in choosing systems. Other basic questions to consider might be: can the system outstrip the growth of the weed, will the harvest have retardant effects on the re-establishment and growth of the target plant, will harvesting reduce the nutrient load of the water column, and does the actual problem justify the actual financial and environmental costs of mechanical control.

The U.S. Army Corps of Engineers considers a system which can harvest and dispose of 80 to 100 tons/hr to be efficient enough to control the known growth rates of water hyacinth and hydrilla (M.M. Culpepper; J.L. Decell. 1978. Mechanical harvesting of aquatic plants. Tech. Rep. A-78-3. Rep.1 V.1).

In 1975, the Jacksonville district of the Army Corps requested a thorough evaluation of the most advanced off-the-shelf large-scale mechanical control system. According to the report, "local opposition to the use of chemicals to control water hyacinths and the lack of a federally registered chemical to control hydrilla" prompted the request. Consequently, the Corps' Waterways Experiment Station in Vicksburg, Mississippi chose the three part system known as the Aqua-Trio (manufactured by Aquamarine Corporation) for detailed operational tests. After tests under many conditions, their major findings were that even the most advanced off-the-shelf system does not meet the Corps' fundamental efficiency requirement to be able to harvest and dispose of 80 to 100 tons/hr." Among their conclusions: (a): total Aqua-Trio system productivity was less than 10 tons/hr with the pacing component being the transport in water hyacinth and the harvester in hydrilla; (b) of the three components of the Aqua-Trio, only the onshore conveyor had production rates that demonstrated a potential for reaching 80 tons/hr; the other components involved excessive mechanical handling of the plants; and (c) transporting the harvested material over water appeared to be the major pacing problem in developing a high-production mechanical harvesting system." The two-volume report by Culpepper and Decell includes detailed time charts of tasks performed by each component of this system.

The Army Corps' "first totally operational test of a mechanical system for hydrilla control" was conducted by J.T. McGehee in 1977. Using an Aqua-Trio System, 65 hectares of Orange Lake, Florida were maintained during June-October. During this period, 1100 loads of hydrilla were cut and disposed of in the water and on land. Total control costs per hectare for the period was approximately $1,125.00. One of McGehee's conclusions, "Trails for navigation from access points in the lake to natural open water fishing areas and cut fishing areas were maintained useably free of hydrilla at a cost that was competitive with chemical methods of control."

In another Corps test (1980), P.A. Smith reported the mechanical removal efficiency of water hyacinths and hydrilla in two Florida locations. In the riverine test, the system harvested an average 1.94 acre/hr, but demonstrated peak production rates in excess of 2.3 acre/hr (approximately 18 tons/hr). This 121 page report also reviews many problems of mechanical control systems in general and makes recommendations as to appropriate areas of systems research and development. Smith concluded that the major limiting component for mechanical systems was not their cutting but their conveying components: "No complete conveying system exists that adequately fulfills the requirements of removing plants from on-water storage areas. The major problem with conveying is maintaining the proper feed of plants to the conveyor." In a second part of this study, Smith collected data on the on-shore decomposition of harvested hydrilla and water hyacinths. In test hydrilla stockpiles, only 17 percent of the original volume remained after 30 days.

J.L. Smith performed hydrilla control tests in 1979-80 using the Limnos Harvester. This system cuts and collects plants and moves them to an on-board hammermill where the harvested hydrilla is chopped into quarter-inch fragments. The plant fragment/slurry is pumped to barges for transportation to on-shore disposal sites. Based on numerous tests in the Withlacoochee River and Orange Lake (Florida), the cutter by itself averaged 4.26 acres/hr. When the hammermill and barge components were figured into the system, the overall harvesting average was 1.79 acres/hr. Smith recommends specific improvements to increase harvesting productivity.

Test results of the Aquamarine highballer and H-650 Harvester were reported by L. J. Touzeau of the Florida Game and Freshwater Commission in 1972. Tests were conducted on the wide St. John's river (Florida).

The Milfoil Harvesting Program Report (1982), prepared by METRO, Seattle, Washington, reports this city's mechanical control program of *Myriophyllum spicatum*. It details their experiences with two MUDCAT harvesters over a two-year period in several Seattle area lakes. Records of costs incurred (machines, personnel, hours, repairs, etc.), problems and successes are presented. Data on acres harvested and cubic yards handled are included in graph form.

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MECHANICAL CONTROL OF AQUATIC PLANTS

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Results of operational tests of a variety of mechanical weed control devices on *Myriophyllum spicatum* was reported by G.D. Armour in 1980. His is one of many reports by the government of British Columbia on controls of watermilfoil. In their attempt to eradicate watermilfoil from their lakes, nine devices were used and evaluated. Technical design specifications and operating statistics for rotavators, H-650 harvesters, a diving system, a dredge, fragment containment booms and a diver dredge are presented.

REVIEWS

The most recent review (Nov. 1981) of off-the-shelf mechanical control systems is by G.Canellos of the MITRE Corporation. An exhaustive review of the literature, this report features a section on the current status of dredging, cutting and harvesting equipment. Technical specifications and costs of several systems, as well as user results, are presented in this 140-page report.

Other reports include S.A. Nichols' survey of harvesting experiences in Wisconsin before 1974 and A.V. Kozloff's (1973) comparison between chemical and mechanical controls. Because chemically treated plants are left to decompose in the water, adding to the lake's fertility, Kozloff concluded, "Harvesting is the only current method that solves the problems of excessive nutrient content in a body of water."

A catalogue of surface-operating aquatic weed equipment was compiled by A.E. Deutsch and published in 1974 by IPPC-Oregon State University. Aquatic weed cutters, rakes, harvesters and barriers built by twelve companies were described.

HARVESTING EFFECTS

The Aquatic Weed Database has few reports of the short- and long-term effects of mechanical controls on the ecosystem or on regrowth of the target plant.

A conference at the University of Wisconsin in 1979 did address the effects of harvesting. The *Proceedings of the Aquatic Plants, Lake Managment, and Ecosystem Consequences of Lake Harvesting Conference*, edited by J.E. Breck, R.T. Prentki and O.L. Loucks includes 27 papers divided into sections titled macrophyte biology, nutrient loading and flux of phosphorus from sediment, effects of harvesting on the consumer community, mechanical harvesting options, institutional settings and an overview. Most of the papers have to do with *Myriophyllum spicatum*.

Short-term effectiveness of a multiple cut strategy and the seasonal variation in carbohydrate translocation and accumulation in *M. spicatum* were evaluated by Perkins and Sytsma (1981) to determine long-term biomass reductions and changes in community composition following harvest operations of watermilfoil. Among their conclusions : "Harvesting had a very definite impact upon carbohydrate accumulation by eurasian watermilfoil and, if we assume that reserve carbohydrates are significant in terms of overwinter survival and subsequent spring growth flush, proper timing of the harvest may lead to substantial long-term reductions in biomass ... Tentatively, a multiple cut harvesting program would seem necessary in order to provide short term reduction in aquatic plant biomass with a mandatory late season cutting if longer term benefits are desired."

J.C. Kimbel and S.R. Carpenter (1981), in a study of the non-structural carbohydrate content and extent of regrowth of *M. spicatum* in harvested and control plots concluded: "Harvesting, even once per growing season, can reduce *Myriophyllum spicatum* growth" in following seasons.

L.C. Collett, A.J. Collins, P.J. Gibbs and R.J. West in 1981 reported on the dredging control of *Zostera* and *Ruppia* in New South Wales: "All species of macrophytes had re-established in the shallowest (1.0M) plot withing four months but had failed to colonize the deeper plots up to twelve months after dredging. Recolonization of dredged plots by most of the 63 zoobenthic species present in control plots had occured within eight months of treatment."

S.R. Carpenter and M.S. Adams of the University of Wisconsin's Center for Biotic Systems reported (1977) the environmental impacts of mechanical harvesting of submersed vascular plants. Immediate and long-term effects of harvesting on the physical and chemical aspects of lakes and effects on the biota and ecosystmes of lakes are proposed. Among their conclusions: "Although current information on macrophyte harvesting is limited, harvesting offers unique opportunities for experimental manipulation of lake ecosystems. As a management tool, harvesting appears to offer a good deal of unexplored potential although its environmental impacts are not well-known."

B. Sabol wrote in 1980, "If barging could be eliminated as a necessary step in harvesting operations, operational cost could be cut by up to 50 percent." In a later report to the 16th Annual APCRP meeting (1981), Sabol reported on the predicted and actual results of aquatic disposal of chopped hydrilla in Orange Lake, Florida. He reported the "lack of a detectable oxygen sag," no problem algal bloom, and very little hydrilla fragment regrowth in the lake disposal test.

However, in a 1978 report discussing the acceptability of disposing of weed slurry directly into New Zealand lake water, B.T. Coffey, G.W. Coulter, and J.S. Clayton wrote, "The case against disposal of harvested weed in water is sufficiently clear to be accepted as a principle where further enrichment of a water body is not desired."

COMPUTER MODELS

Mathematical and computer models of control technologies and their effects help users and engineers in the development of more efficient systems. A computer simulation model was described by E.R. Perrier and A.C. Gibson in 1982. This updated version of the Winfrey Model (developed by Dr. Sam Winfrey) is entitled "Simulation for Harvesting of Aquatic Plants (SHAP)". The publication is actually a manual for the use of the SHAP program. SHAP requires no prior computer programming experience for its use.

Another mathematical model was used by M.J. Mara in predicting the annual costs of mechanical control of water hyacinths on a 400 acre lake under specified conditions to be $13,500 or $33.75/acre in 1976. Mara suggests: "The high cost of mechanical harvesting in comparison to the cost of chemical control suggests that a combination of mechanical and chemical methods may be optimal from society's point of view. Mechanical methods could be used to rid the water body of most of the infestation. Hyacinths remaining could then be spot sprayed with chemicals to further cut the infestation."

J.H. Neil of Limnos Ltd. (1979) used a computer model "to predict the overall capacity of the harvesting system for a specific set of (up to 14) conditions." The model was applied to a test of the Limnos Harvester, but, according to Neil, the model can be applied to other mechanical equipment as well.

T.D. Hutto (1981) discussed computer models which aid in the evaluation and design of existing and proposed mechanical harvesting systems. He particularly described HARVEST, a first-generation computer model being developed by the Army Corps Waterways Experiment Station in Vicksburg, Mississippi. He presented performance predictions for two equipment mixes for each of three existing mechanical control systems. According to Hutto, the predictive model can be applied to several makes and models of harvesting systems.

The Aquatic Weed Database has 450 articles catalogued under the catagory "Mechanical control". Selected articles, including those cited above, are listed on page 6.

The manufacturers:

Air-Lec Industries, Inc., 3300 Commercial Avenue, Madison, Wisconsin 53714/USA (608) 244-4754

Allied Aquatics International, Inc., 5029 Flournoy Lucas Road, Shreveport, Louisiana 77129/USA (318) 688-0545

Aquamarine Corporation, Box 616, Waukesha, Wisconsin 53186/USA (414) 547-0211

Aztec Development Company, P.O. Box 3348, Orlando, Florida 32802/USA (305) 849-6420

Hockney Company, 913 Cogswell Drive, Silver Lake, Wisconsin 53170/USA (414) 889-4581

Lantana Boatyards, Inc., 808 N. Dixie Highway, Lantana, Florida 33462/USA (305) 585-9311

Limnos Ltd., 22 Roe Avenue, Toronto, Ontario, CANADA (416) 487-8874

Mudcat Division, National Car Rental Company, P.O. Box 16247, St. Louis Park, Minnesota 55416/USA (612) 893-6400

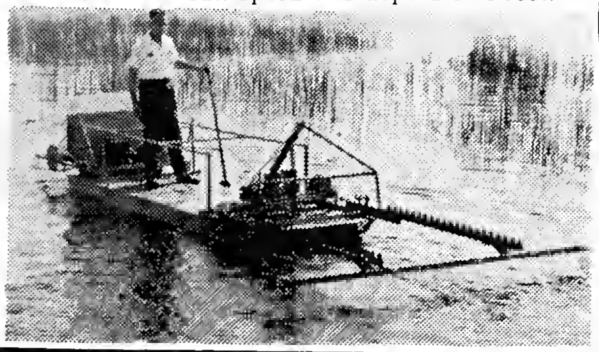
Rolba Limited, Charlwoods Road, East Grinstead, East Sussex RH19 2HU, ENGLAND

John Wilder Engineering Ltd., Hithercroft Works, Wollingford, Oxon, OX10 9 AR, ENGLAND.

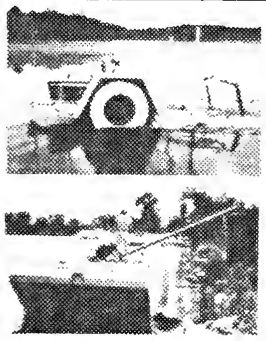
HOCKNEY

Hockney produces an underwater bar weed cutter barge. The HC-10 has a cutter width of 10 feet and can operate down to 5 feet.

The HP-7 is a bar-type portable cutter which can be purchased separately and mounted on small boats. Its cutter width is 7 feet and it can operate to depths of 4 feet.



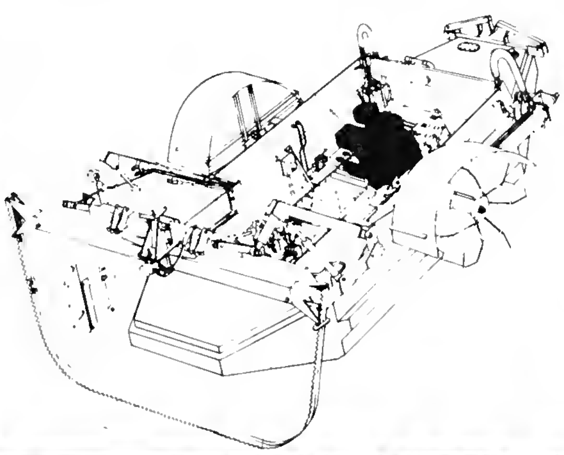
LIMNOS

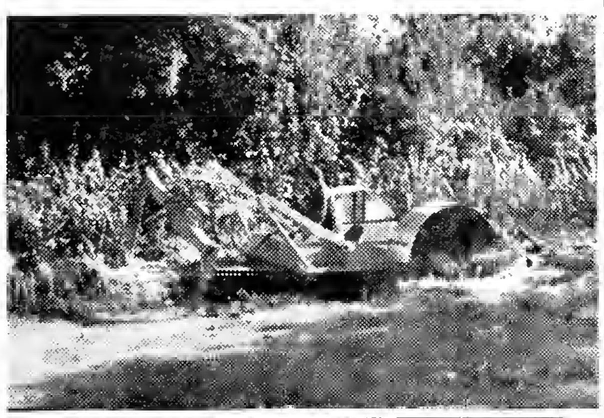


This company produces an aquatic weed harvesting system. The system consists of a cutter, a harvester and two barges. The cutter can clean an 18 foot path to depths of 8 feet. The cut plants are harvested and sent to an on-board grinder which can produce 30 tons/hour of plant slurry. The slurry is transported to shore in 15-ton capacity barges which then pump it to waiting tanker trucks for disposal.

JOHN WILDER ENGINEERING

The WATER WARRIOR has a twelve foot cutter bar which can work to a maximum depth of 5'6". It also features a moveable paddle propulsion system and a twelve foot weed rake.

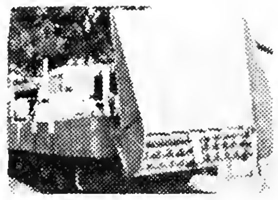




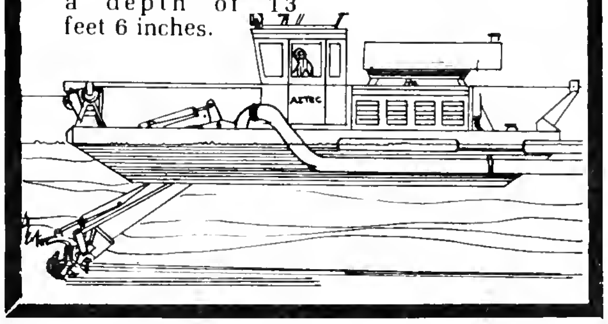
AZTEC

This company produces the WATER VAC and the WATER WEEDER.

The WATER VAC is a system which can dredge plants and hydrosoil in an 8 foot swath to a depth of 15 feet 6 inches. It can penetrate one foot into the hydrosoil removing rooted plants and muck and pump or airblast the dredged material to shore.

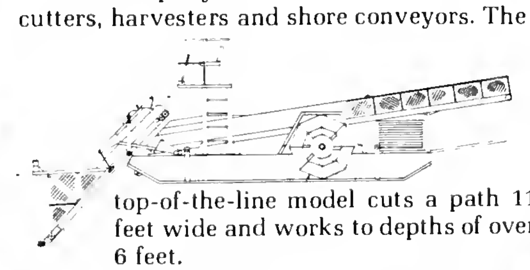


The WATER WEEDER collects floating or rooted plants, grinds them and then air-blasts the slurry up to 125 feet away. It has a working width of 12 feet and can work to a depth of 13 feet 6 inches.



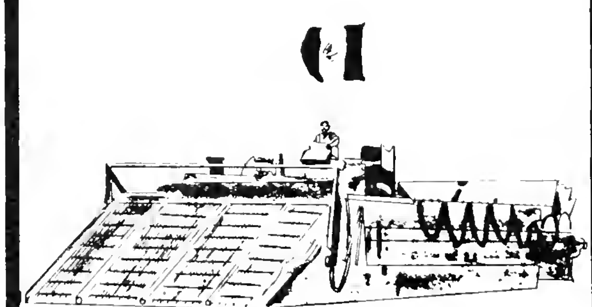
MUDCAT

This company offers several models of cutters, harvesters and shore conveyors. The top-of-the-line model cuts a path 11 feet wide and works to depths of over 6 feet.



ALLIED AQUATICS INTERNAT'L.

Allied produces the WATER BUG cutter and the ALPHA I harvester. The WATER BUG cuts a 12 foot path to a depth of 4 feet. The ALPHA I has a harvesting width of 15 feet and an 18-ton capacity.



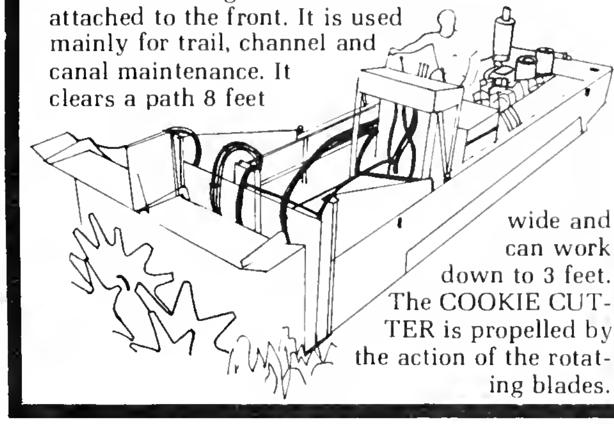
ROLBA LIMITED

Rolba does not manufacture weed cutting equipment but acts as agent for Aquamarine and Gibeaux.

The Rolba-Gibeaux weed cutting boat features a T-shaped cutting attachment that has a cutting width of 2.34 M and operates to a maximum depth of 1.15M.

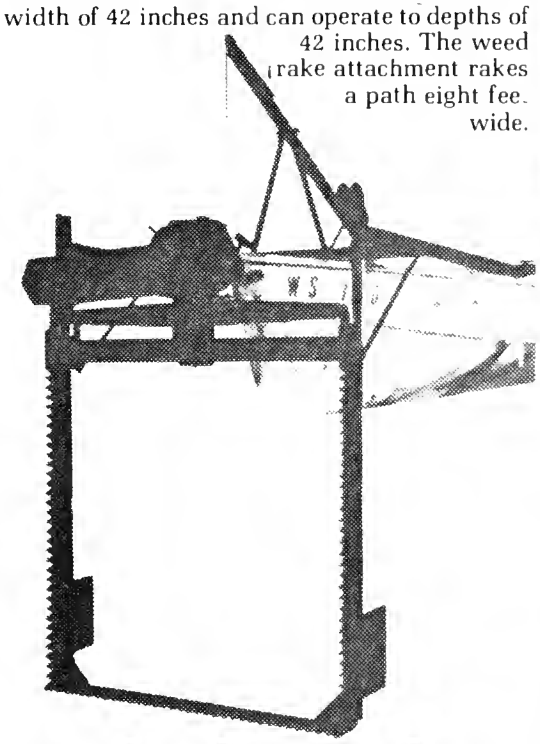
LANTANA

The COOKIE CUTTER is a barge with two circular rotating cutter blades 5 feet in diameter attached to the front. It is used mainly for trail, channel and canal maintenance. It clears a path 8 feet wide and can work down to 3 feet. The COOKIE CUTTER is propelled by the action of the rotating blades.



AIR-LEC

Air-Lec manufactures cutter and rake attachments for small boats. The cutter has a width of 42 inches and can operate to depths of 42 inches. The weed rake attachment rakes a path eight fee. wide.

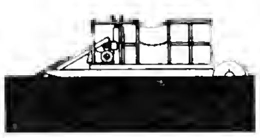


AQUAMARINE

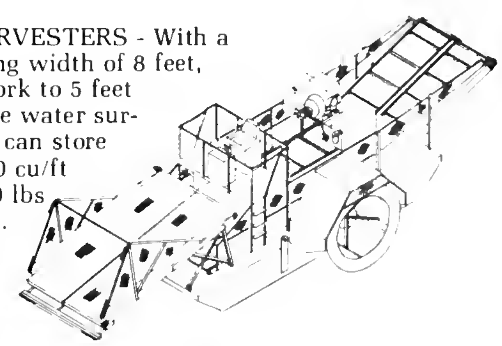
This company produces several machines for aquatic weed control:

1) SAWFISH - A cutting machine which cuts a swath 8 feet wide to a maximum depth of 3.5 feet.

2) CHUB - A cutter-harvester utility boat which cuts 4 feet wide and works to a maximum depth of 5 feet. Its deck can store up to 200 cu/ft or 1500 lbs. of weeds.

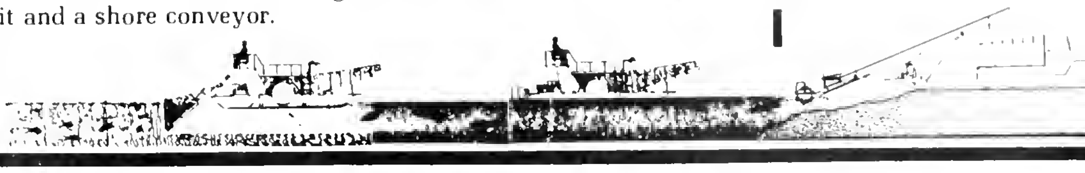


3) HARVESTERS - With a harvesting width of 8 feet, it can work to 5 feet below the water surface and can store up to 650 cu/ft or 10,000 lbs of weeds.



4) HYBALLER - For canals and rivers, this machine picks up hyacinth, chops it up and throws it 120 feet to shore.

5) AQUA-TRIO - This harvesting system features a cutter/harvester, a large transport unit and a shore conveyor.



Abd El Sayed, J.K.; A. Tolba; A.H. Druijff. 1978. Evaluation of some machines for mechanical control of aquatic weeds in Egypt. Proc. European Weed Res. Soc. Symp. Aquatic Weeds. 5:359-67.

Armour, G.D.; R.S. Hanna; I.P. Walters; M.D. Maxnuk. 1980. Studies on aquatic macrophytes. Part XIV. Summary of mechanical aquatic plant management, Okanagan Valley, 1978. Province of British Columbia, Ministry of Environment, Inventory and Engineering Branch. 36 pp.

Bagnall, L.O. 1980. Intermediate technology screw presses for dewatering aquatic plants. American Soc. Agricultural Engineers Paper No. 80-5044. 14pp.

Bagnall, L.O. 1981. Aquatic plant harvesting and harvesters. American Soc. Agricultural Engineers Paper No. 81-5019. 6pp.

Baitsch, B. 1967. Possibilities and limitations of mechanical ditch cleaning. Erbeg. Ewrc Intern. Symp. Wasserpflanzen. 2:12-21.

W.D. 1965. A study of turbidities caused by re-dredging the intracoastal waterway in Currituck Sound, North Carolina. Mimeographed. Spec. Rept., Dingell-Johnson Proj. F-16-R-1. 6pp.

Bakker, J.P. 1978. Changes in a salt-marsh vegetation as a result of grazing and mowing - a five-year study of permanent plots. Vegetatio. 38(2):77-87.

Behari, R.; N.K. Behl; S. Ram. 1972. Investigations on time of cutting under water and length of submergence of cut stubbles of *Typha latifolia*. Second Ann. Rept. (1970-71). Agr. Univ. India, Haryana p. 101.

Bernatowicz, S. 1965. Effects of mowing on the occurrence of macrophytes in the Dgalmaly Lake. Acta Hydrobiol. 7(1):71-82.

Beule, J.D. 1979. Control and management of cattails in S.E. Wisconsin Wetlands. Technical Bulletin Department of Natural Resources, Wisconsin. 112:40pp.

Bhattacharya, A.P.; S.V. Singh. 1973. Studies on aquatic weed control in irrigation channels in Uttar Pradesh by chemical and mechanical control. In: Regional Seminar on Noxious Aquatic Vegetation in Tropics and Sub-Tropics, Abstracts. New Delhi, India: UNESCO, 70pp. pp.33-34.

Biology Branch Division of Laboratories. 1972. Kawartha lakes water management study-ecological philosophy of aquatic weed harvesting. Biology Branch Division of Lab. Ontario Water Resources Commission. 7pp.

Blanchard, J.L. 1970. Mechanical and herbicidal lake weed management. Hyacinth Contr. J. 8(2):36-37.

Brooker. M.P.; J.H. Baird. 1974. Cost evaluation of watercourse management in Essex. Surveyor. 16:34-37.

Brown, A.H. 1948. The control of water hyacinths by mechanical means. Proc. Soil Sci. Soc. of Fla., 9:66-74.

Bruhn, H.D.; D.F. Livermore, F.O. Aboaba. 1971. Processing characteristics of macrophytes as related to mechanical harvesting. Trans. Am. Soc. Agr. Engrs., 14:1004-8.

Bruhn, H.E.; et al. 1974. Processing of aquatic vegetation as an aid to mechanical control in irrigation and drainage channels. September 1974. Commission Internationale du Genie Rural, VIIIth International Congress of Agricultural Engineering, Tlevohof, The Netherlands.

Bryan, A.D. 1978. Experimental hydraulic dredging for aquatic weed control in Vernon Arm Okanagan Lake 1975. Part VIII. Studies on Aquatic Macrophytes. Province of British Columbia, Ministry of the Environment. Inventory and Engineering Branch. 158pp.

Bryant, C.B. 1974. Aquatic weed harvesting costs and equipment - 1972. Hyacinth Contr. J. 12:53-55.

Bryant, C.B. 1973. Control of aquatic weeds by mechanical harvesting. Pest Articles and News Summaries. 19(4):601-606.

Burton, T.M.; D.L. King; J.L. Ervin. 1978. Aquatic plant harvesting as a restoration technique. Lake restoration - Proc. of a Natl. Conf. Aug., 1 State of the Art Research. pp. 177-185.

Canellos, G. 1981. Aquatic plants and mechanical methods for their control. The Mitre Corporation, Metrek Division, McLean VA. MTR-81W55. 140pp.

Carpenter, S.R.; M.S. Adams. 1977. Environmental impacts of mechanical harvesting of submersed vascular plants. Madison, WI: Univ. Wisconsin Center for Biotic Systems. IES Rept. 77. 30pp.

Carpenter, S.R.; A. Gasith. 1978. Mechanical cutting of submersed macrophytes: immediate effects on littoral water chemistry and metabolism. Water Res. 12:55-57.

Coffey, B.T.; G.W. Coulter; J.S. Clayton. 1978. Report of working party on waterplant harvesting for officials committee on eutrophication. March 1978. Hamilton, New Zealand: Officials Committee on Eutrophication. 13pp.

Collett, L.C.; A.J. Collins; P.J. Gibbs; R.J. West. 1981. Shallow dredging as a strategy for the control of sublittoral macrophytes: a case study in Tuggerah Lakes, New South Wales. Aust. J. Mar. Freshwater Res. 32:563-571.

Corns, W.G.; R.K. Gupta. 1968. Mowing experiments with Richardson's pondweed (*Potamogeton richardsonii*). Can. Nat. Weed Comm. West. Sect. Res. Rept. pp. 255-56.

Crafts, A.S. 1975. Weed control in irrigation and drainage ditches, lakes & streams. In: Modern Weed Control. Berkeley: Univ. California Press, 440pp. pp. 340-57.

Culpepper, M.M.; J.L. Decell. 1978. Field Evaluation of the Aqua-Trio System. In: Tech. Rept. A-78-3, Mechanical Harvesting of Aquatic Plants (2 Vols). Vicksburg, MS: U.S. Army Engr. Waterways Expt. Sta. 406pp.

Dassanayake, M.D. 1976. Noxious aquatic vegetation control in Sri Lanka. In: Aquatic Weeds in S.E. Asia. ed. by C.K. Varshney & J. Rzoska. Dr. W. Junk Publishers. The Hague, Netherlands. 396pp. pp. 59-61.

Dawson, F.H. 1978. Aquatic plant management in semi-natural streams: the role of marginal vegetation. J. Environ. Management. 6:213-21.

Deutsch, A. 1974. Some equipment for mechanical control of aquatic weeds. International Plant Protec. Center, Oregon State Univ., Corvallis, Oregon. Rep. No. 74-2. 17pp.

Druijff, A.H. 1979. Manual and mechanical control of aquatic weeds in water courses. In: Weed Research in Sudan. Vol I: Proc. of a Symp. 152pp. ed. by M.E. Beshir & W. Koch. Wad Medani, Sudan: University of Gezira. pp. 137-145.

Dykyjova, D.; S. Jusak. 1973. The influence of summer cutting on the regeneration of reed. ed. by S. Hejny. Ecosystem Study on Wetland Biome in Czech. IBP/PT-PP Rept. No. 3. pp. 245-50.

Eaton, J.W.; K.J. Murphy; T.M. Hyde. 1981. Comparative trials of herbicidal and mechanical control of aquatic weeds in canals. In: Proc. Aquatic Weeds and Their Control, 1981. Oxford, England: Association of Applied biologists. 105-16.

Elser, H.J. 1966. Control of water chestnut by machine, in Maryland 1964-65. Proc. 20th Northeast Weed Control Conf., pp. 682-87.

Feichtinger, F. 1974. Mechanical ditch maintenance in Austria. Proc. EWRC 4th Intern. Symp. Aquatic Weeds, Wien. 4:84-86.

George, M. 1976. Mechanical methods of weed control in watercourses: an ecologist's view. Proc. Symp. Aquatic Herbicides. 16:91-99.

Haller, W.T.; J.V. Shireman; D.F. Durant. 1980. Fish harvest resulting from mechanical control of hydrilla. Trans. Am. Fish Soc. 109:517-20.

Hernandez, S. 1978. Weeds and their control in Senegal. In: Weeds and Their Control in the Humid and Subhumid Tropics. ed. by I.O. Akobundu. Ibandan, Nigeria: Weed Sci. Soc. Nigeria and Inst. Trop. Agr., 421pp. pp. 176-81.

Hoogerkamp, M.; G. Rozenboom. 1978. The management of vegetation on the slopes of waterways in the Netherlands. Proc. European Weed Res. Soc. Symp. Aquatic Weeds. pp. 203-11.

Hutto, T.D. 1982. Simulation modeling of mechanical control systems. In: Proc. 16th Annu. Meet. Aquat. Plant Control Res. Planning and Operations Review. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi. Misc. paper A-82-3. pp. 33-50.

Johnson, R.E.; M.R. Bagwell. 1979. Effects of mechanical cutting on submersed vegetation in a Louisiana lake. J. Aquat. Plant Manag. 17:54-57.

Kemmerling, W. 1974. The importance of building yards for the maintenance of aquatic systems. Proc. EWRC 4th Intern. Symp. Aquatic Weeds, Wien. 4:87-95.

Kimbel, J.C.; S.R. Carpenter. 1981. Effects of mechanical harvesting on *Myriophyllum spicatum* L. regrowth and carbohydrate allocation to roots and shoots. Aquat. Bot. 11(2): 121-27.

Koegel, R.G.; D.F. Livermore; H.D. Bruhn. 1977. Costs and productivity in harvesting of aquatic plants. J. Aquat. Plant Manag. 15:12-17.

Koegel, R.G.; D.F. Livermore; H.D. Bruhn; P.D. Bautz. 1973. Improving surface water conditions through control and disposal of aquatic vegetation. Phase II. Univ. Wisconsin Tech. Completion Rep. Proj. No. OWRR B-058-WIS. 59pp.

Koegel, R.G.; D.F. Livermore; H.D. Bruhn. 1974. Aquatic plant harvesting: economic, technical, and management aspects. Paper No. 75-5518, Dec. 1974. Amer. Soc. Agric. Engin. St. Joseph, MO.

Koegel, R.G.; D.F. Livermore. 1979. Reducing capital investment in aquatic plant harvesting systems. In: Aquatic Plants, lake Management, and Ecosystem Consequences of Lake Harvesting. ed. by J. Breck; R. Prentki, and O. Loucks. Institute for Environmental Studies, Univ. of Wisconsin, Madison Wisconsin. pp. 329-338.

Kozloff, A.V. 1973. A comparison of current aquatic vegetation control methods. Irvine, California. 23pp.

Krinke, H.; I. Dyckova. 1974. Films on embankment mowing machinery. Proc. EWRC Intern. Symp. Aquatic Weeds, Wien. 4:96-106.

Lagarde, V.E. 1980. Water depth limitations in mechanical harvester use in the St. Johns River, Florida. Aquatic Plant Control Res. Prog. Information Exchange Bull. A-80-1. 6 pp.

Lange, S.R. 1965. The control of aquatic plants by commercial harvesting, processing, and marketing. Proc. S. Weed Conf. 18:536-37.

Livermore, D.F.; H.D. Bruhn; B.W. Pollock. 1970. Processing characteristics of subsurface macrophytes of Madison, Wisconsin lakes in relation to mechanical harvesting systems. U.S Office Water Resources Res. Tech. Rept. OWRR B-018-WIS. 12pp.

Livermore, D.F.; R.G. Koegel; H.D. Bruhn. 1975. Aquatic plant harvesting: development of high-speed harvesters and processing and utilization of harvested vegetation. Univ. Wisconsin Water Resources Center Technical Report. Wis WRC 75-02, 46pp.

Livingstone, F.C. 1970. Water weed cutter redesigned. Water Sewage Works. 117(3):89.

Loucks, O.L. 1979. Conference findings: an overview. In: Aquatic Plants, Lake Management, and Ecosytem Consequences of Lake Harvesting. ed. by J. Breck; R. Prentki, and O. Loucks. Institute for Environmental Studies, Univ. of Wisconsin, Madison, Wisconsin. pp. 421-434

Maneewarn. T. 1974. H-650 Aquatic weed cutter. In: Proc Aquatic Weed Seminar. Nonthaburi: Electricity Generating Authority of Thailand (Egat). p. 100.

Mara, M.J. 1976. Estimated costs of mechanical control of water hyacinths. J. Environ. Econ. Management. 2(4):273-94.

Maxnuk, M.D. 1979. Studies on aquatic macrophytes. Part XXII. Evaluation of rotavating and diver dredging for aquatic weed control in the Okanagan Valley. Province of British Columbia, Ministry of the Environment, Water Investigations Branch. 53pp.

McGehee, J.T. 1979. Mechanical hydrilla control in Orange Lake, Florida. J. Aquatic Plant Manag. 17:58-61.

Miller, A. 1981. Prediction of hydrilla growth and biomass for mechanical harvesting operations. In: Proc. 15th Annu. Meet. Aquat. Plant Control Res. Planning and Operations Review. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi. Misc. Paper A-81-3. pp. 224-240.

Mitchell, D.S. 1979. Formulating aquatic weed management programs. J. Aquat. Plant Management. 17:22-24.

Municipality of Metropolitan Seattle. 1982. Milfoil harvesting program report 1980-81. METRO, Seattle, WA. 33 pp.

Murfitt, R.F.A. 1981. Some unanswered questions relating to the mechanical control of weeds in water channels. In: proc. of the Conf. Aquat. Weeds and Their Control. ed. by R.J. Makepeace. Wellesbourne, Warwick: Assoc. Appl. Biol. pp. 87-94.

Murphy, K.J.; J.W. Eaton. 1980. A survey of aquatic weed growth and control in the canals and river navigations of the British waterways board. Dept. of Botany, Univ. of Liverpool. 1980 British Crop Protection Conference-Weeds. pp. 707-714.

Murphy, K.J.; J.W. Eaton. 1981. Ecological effects of four herbicides and two mechanical clearance methods used for aquatic weed control in canals. In: Proc. of the Conf. Aquat. Weeds and their Control. ed. by R.J. Makepeace. Wellesbourne, Warwick: Assoc. Appl. Biol. pp. 201-17.

Musil, C.F.; C.M. Breen. 1977. The applications of growth kinetics to the control of *Eichhornia crassipes* (Mart.) Solms. through nutrient removal by mechanical harvesting. Hydrobiologia. 53(2):165-71.

Neil, J.H. 1980. Mechanical control technology development: a computer model and systems cost analysis of the limnos aquatic plant harvesting system. Proc. 14th Ann. Meet. Aquat. Plant Control Res. Plan. and Operations Rev. Misc. Paper A-80-3. Vicksburg, Mississippi. U.S. Army Engr. Waterways Expt. Sta. pp. 157-69.

Newroth, P.R. 1974. Studies on aquatic macrophytes. Part V. Aspects of aquatic weed control by mechanical harvester. Victoria, British Columbia: Water Investigations Branch, British Columbia Water Resources Service. Dept. Lands Forests & Water Resources. 54pp.

Nichols, S.A. 1971. The effects of harvesting aquatic macrophytes on algae. Trans. Wisconsin Acad. Sci. 61:165-173.

Nichols, S.A. 1974. Mechanical and habitat manipulation for aquatic plant management: a review of techniques. Wisconsin Dept. Nat. Resources. Tech. Bull. 77:34 pp.

Perkins, M.A.; M.D. Sytsma. 1981. Efficacy of mechanical harvesting and its influence upon carbohydrate accumulation in Eurasian watermilfoil. In: Proc. 15th Annu. Meet. Aquat. Plant Control Res. Planning and Operations Review. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi. Misc. Paper A-81-3. pp. 464-479.

Perrier, E.R.; A.C. Gibson. 1982. Simulation for harvesting of aquatic plants. U.S. Army Engineer Waterways Experiment Station. Vicksburg, Mississippi. Tech. Rept. A-82-1. 54pp.

Peterson, S.A.; W.L. Smith; K.W. Malueg. 1974. Full-scale harvest of aquatic plants: nutrient removal from a eutrophic lake. Water Poll. Control Fed. 46(4):697-707.

Peverly, J.H. 1974. Effects of shading, cutting, and root-bed disruption on aquatic plant growth. Dept. Agronomy Mimeo 17. Ithaca, N.Y.: Cornell University. p.13.

Phillippy, C.L.; J.M. Perryman. 1972. Mechanical harvesting of water hyacinth (*Eichhornia crassipes*) in Gant Lake Canal, Sumter County, Florida. Tallahassee, Florida: Florida Game and Freshwater Fish Commission. 9pp. Appendixes A-F.

Price, H. 1981. A review of current mechanical methods. In: Proc. of the Conf. Aquat. Weeds and Their Control. Ed. by R.J. Makepeace. Wellesbourne, Warwick: Assoc. Appl. Biol. pp. 77-86.

Queijo, J. 1977. Harvesting a nusiance. Environment 19(2)

Robinson, S.C. 1975. The design of a collection system to remove cut vegetation from Buffalo Lake. April 1975. Univ. Wisconsin, Madison, Wisc.

Robson, T.O. 1974. The control of aquatic weeds - mechanical control. UNESCO. ed. by D.S. Mitchell. Paris. pp. 72-85.

Sabol, B.M. 1982. Field test of aquatic disposal of chopped hydrilla. In: Proc. 16th Annu. Meet. Aquat. Plant Control Res. Planning and Operations Review. U.S. Army Engineers Waterways Experiment Station, Vicksburg, Mississippi. Misc. Paper A-82-3. pp. 25-32.

Sassic, N.M. 1982. Harvesting: the future of aquatic plant control? Aquatic 4(1):14, 16.

Sharma, K.P. 1977. Effect of cutting on the growth and flowering behavior of *Typha elephantina* roxb. Curr. Sci. 47(8):275-276.

Shekhov, A.G. 1974. Effect of cutting time on renewal of stands of reed and cattail. Hydrobiol. J. 10(3):45-48.

Smith, J.L. 1981. Field tests of the limnos mechanical harvesting system. In: Proc. 15th Annu. Meet. Aquat. Plant Control Res. Planning and Operations Review. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi. Misc. Paper A-81-3. pp. 181-196.

Smith, P.A. 1978. Mechanical harvesting of aquatic plants: report 2, evaluation of selected handling functions of mechanical control. Aquatic Plant control Res. Program Tech. Rept. A-78-3. Vicksburg, Mississippi: U.S. Army Engineer Waterways Experiment Station Environmental Lab. 121pp.

Solomons, W.B. 1938. A simple weed cutter for ponds. Progressive Fish Culturist. 41:20-22.

Stewart, J.S. III. 1972. Energy and flow requirements for chopping water hyacinths. Master's Thesis Univ. of Florida, Gainesville. 47pp.

Szumiec. J. 1963. The influence of emergent vegetation and the manner of its mowing on the bottom fauna of fish ponds. Acta Hydrobiol. (IN POLISH). 5:315-335.

Taussig, J.K. 1969. The development cycle of a hydraulic aquatic weed control device. Proc. Northeast Weed Control Conf. 23:367-74.

Timmons, F.L. 1952. Results with chemical and mechanical methods of controlling common cattail (*Typha latifolia*). Progr. Rept. Western Weed Control Conf. 13:141-43.

Timmons, F.L. 1954. Use of underwater mower for control of cattails and water lily. West Weed Conf. Newsletter. 2:17-18.

Touzeau, L.J. 1972. Mechanical water hyacinth removal operations, Aquamarine Corporatlion, Blufton, Florida. Florida Game Freshwater Comm. Tallahassee, Florida 13pp.

Van Dyke, J.M. 1971. Mechanical harvesting of water hyacinth in Shell Creek Reservoir, Charlotte County, Florida. Florida Game Freshwater Fish Comm. Tallahassee, Florida 25pp.

Velu, M. 1976. Development of equipment for eradication of aquatic weeds. In: Aquatic Weeds in South East Asia. ed. by C.K. Varshney & J. Rzoska. Dr. W. Junk Publishers. The Hague, Netherlands. pp. 233-240.

Velu, M. 1969. A mechanical device tor eradication of submerged aquatic weeds. Fishery Technol. 6(1):18-25.

Wade. P.M. 1978. The effect of mechanical excavators on the drainage channel habitat. Proc. European Weed Res. Soc. Symp. Aquatic Weed. 5:333-342.

Webb, D.J.; R.F. Harbord. 1964. A mechanical cleaner for transport canals. Span. 7:40-41.

West, H.W. 1980. Mechanical control technology development: an overview. Proc. 14th Ann. Meeting, Aquat. Plant Control Res. Planning and Operations Rev. Misc. Paper A-80-3. U.S. Army Engr. Waterways Expt. Sta. Vicksburg, Mississippi. pp. 152-6.

Whickliff, E.L. 1925. Methods of controlling undesirable aquatic plants in ponds, lakes, and other quiet waters. Ohio Dept. of Agr. Bur. Fish Game. Bull. 20-C, 2pp.

Wile, I. 1974. Lake restoration through mechanical harvesting of aquatic vegetation. Verhandl. Intern. Verein. Limnol. 19(1):660-71.

Wile, I. 1978. Environmental effects of mechanical harvesting of aquatic vegetation. Verhandl. Intern. Verein. Limnol 19(1):660-71.

Wile, I. 1978. Environmental effects of mechanical harvesting. J. Aquat. Plant Manag. 16:14-20.

Woods, J.W. 1970. Mechanical removal and utilization of aquatic plants. Florida's Aquatic Weed Nenace, Proc. Aquatic Plant Res. Conf. governor's Aquatic Res. & Develop. Comm. Gainesville, Florida. pp. 10-15.

Wunderlich, W.E. 1967. The use of machinery in the control of aquatic vegetation. Hyacinth Control J. 6:22-24.

Wunderlich, W.E. 1938. Mechanical hyacinth destruction. Military Eng. 30:5-10.

Yount, J.L.; R.A. Crossman. 1970. Eutrophication control by plant harvesting. J. Water Pollution Control Federation. PT. 2. 42(5):173-83.

Zeiger, C.F. 1966. New equipment developed by the corps of engineers - for use in aquatic weed control. Weed Soc. Am. Meeting. 6:93

NEW PATHWAY FOR HYDRILLA?

Hydrilla verticillata is included in many of "the world's worst aquatic weeds" lists. An explosive grower, hydrilla has in recent years clogged rivers and lakes in many parts of the world, displacing water, slowing water flow, interfering with boat commerce, outcompeting native plant species and, not least of all, intercepting sunlight used by plants and animals which eventually are eliminated from beneath its stringy mats.

In Florida, hydrilla and water hyacinth (*Eichhornia crassipes*) now vie for top spot as the state's worst aquatic invader. It is estimated that hydrilla infests 25% of Florida's thousands of miles of waterways, though its first Florida disovery was only about 20 years ago. Hydrilla has now been reported in most continents with the notable exception of South America.

Dr. George Bowes examining PEP carboxylase enzyme data on a Cary 219 UV-Visible Spectrophotometer.

George Bowes, University of Florida botany professor associated with the Center for Aquatic Weeds, is investigating a key to hydrilla's competitive edge: it's photosynthetic mechanism. Among hydrilla's novel photosynthetic properties is its ability to adapt to different light conditions. It has a low light compensation point, which enables its photosynthesis to be driven at a lower light energy input than that required for many native species. Another important feature is hydrilla's ability to alter its photosynthetic carbon fixation pathway in response to environmental growth conditions, thus maximizing its photosynthetic efficiency. The known photosynthetic pathways for terrestrial plants, termed C3 and C4, do not accomodate hydrilla's photosynthesis. Hydrilla's pathway apparently incorporates elements of both the C3 and C4 modes, and Bowes has proposed that hydrilla and some other submersed aquatic macrophytes (SAM species) represent a previously unrecognized photosynthetic category.

Currently, Bowes is investigating the enzymes of hydrilla leaves using immunological techniques to pinpoint their exact location, and thereby further understand how hydrilla's novel pathway compares to the classical C3 and C4 systems. Dr. Bowes believes that the unique ability of hydrilla to switch photosynthetic pathways has wider implications than just for aquatic weed research, in that it could prove to be a key to improving the photosynthetic efficiency, and thus productivity, of many crop plants with the C3 pathway, when genetic engineering techniques become feasible.

Dr. Bowes' address is 3157 McCarty Hall, University of Florida, Gainesville, Florida, 32611, USA.

WEST AFRICAN WEED SCIENCE SOCIETY

The West African Weed Science Society's second international conference is scheduled to be held October 17-22, 1983 at Abidjan (Ivory Coast). Theme of the conference is "The weeds in tropical areas: knowledge and control"

The English/French conference will feature technical sessions on the following topics:

- botany, taxonomy
- biology, ecology
- competition and allelopathy
- weed control in agricultural crops
- weeding equipment
- special methods of weed control
- herbicides and residues in soil and plants
- herbicides and environment: safety in use

Organizers of the conference ask that interested parties contact them by October, 1982. A second circular will be available in November, 1982. Contact Mr. P. Marnotte Idessa, Secretary and Treasurer, DVC BP 635, Bouake, IVORY COAST.

Chairman of the Organizing Committee:
Prof. Tchoume M. Ensa
08 BP. 35
Abidjan 08
IVORY COAST

Coordinating member of the Organizing Committee:
Mr. B. Mallet Ctft
08 BP. 8033
Abidjan 08,
IVORY COAST

BOOKS

STUDIES ON AQUATIC VASCULAR PLANTS. Proceedings of the International Colloqium on Aquatic Vascular Plants, Brussels, 1981. Edited by J.J. Symoens, S.S. Hooper and P. Compere. Otto Koeltz Science Publishers, P.O. Box 1380, D-6240 Koenigstein, Federal Republic of Germany. More than 418 pages. DM 100.00.

This book is a collection of 69 colloquium presentations arranged in the following sections: Systematics-Morphology; Physiology-Reproduction Strategies; Ecology-Community Metabolism and Production; Phytosociology-Distribution; Water Quality-Weed Control; and Regression-Introduction-Conservation.

CHEMICAL AND TROPHIC STATE CHARACTERISTICS OF FLORIDA LAKES IN RELATION TO REGIONAL GEOLOGY. Prepared by Daniel E. Canfield, Jr., Project Leader. 1981. Center for Aquatic Weeds, University of Florida, Gainesville, Florida, USA. 444 pages.

This is a limnological survey of the chemical and trophic state characteristics of 165 of Florida s more than 7,700 lakes. Climate, geology, water chemistry, water quality and chlorophyll *a* concentrations for all 165 lakes is presented. Though the lakes range from ultra-oligotrphic to hypereutrophic, the report states, "As a group, Florida lakes can be characterized as productive, soft-water lakes."

CLASSIFICATION OF WETLANDS AND DEEPWATER HABITATS OF THE UNITED STATES. L.M. Cowardin, V. Carter, F.C. Golet, E.T. LaRoe. 1979. Fish and Wildlife Service, U.S. Department of the Interior. 103 pages.

This new system has become the official wetland classification system of the Fish and Wildlife Service. The five systems and their subsystems are described. Within the subsystems, classes are described. Classes are based on substrate material and flooding regime, or on vegetative life form. Keys to the systems and classes are included. Photographs depicting 56 different classifications are included.

INVERTEBRATES AND VERTEBRATES ATTACKING COMMON REED STANDS (*Phragmites communis*) IN CZECHOSLOVAKIA. V. Skuhravy, V. Pokorny, J. Pelikan, M. Skuhrava, K. Hudec, B. Rychnovsky. 1981. Academia nakaladatelstvi Ceskoslovenske Akademie ved, Praha. 113 pages.

Reed is an economic plant in Czechoslovakia, grown for cellulose production. This is a collection of descriptions of reed's principal pests, their development (biology and ecology) and their influence on reed production. Included are data on their distribution in Czechoslovakia and Europe. Among reed's principal pests are the caterpillar *Archanara geminipuncta*, flies of the genus *Lipara*, gall midges, *Platycephala planifrons*, the mite *Steneotarsonemus phragmitidis*, as well as the muskrat, water vole and the greylag goose, *Anser anser*.

IMPROVING TECHNOLOGY FOR CHEMICAL CONTROL OF AQUATIC PLANTS. K.K. Steward. 1982. Misc. Paper A-82-4, prepared by Aquatic Plant Management Laboratory, U.S.D.A., Science and Education Administration, Fort Lauderdale, Florida, for the U.S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Mississippi. 52 pages.

Responding to the "need to modify existing aquatic herbicide evaluation techniques," this protocol describes procedures for evaluating conventional and controlled-release herbicides. Three CR formulations, one coded-confidential compound, one growth retardant and six conventional herbicidal formulations are evaluated. Also, iron chelates were evaluated for enhancing efficacy of diquat and potassium endothall against hydrilla. Eleven aquatic plants were treated with herbicides in the course of this study.

INTERNATIONAL CONFERENCE ON WATER HYACINTH

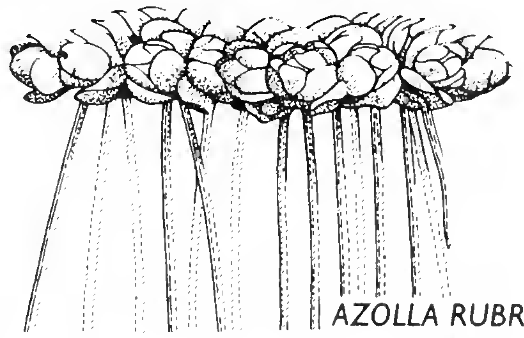
An International Conference on Water Hyacinth is scheduled for February 7-11, 1983 in Hyderabad, India. It is sponsored by the Council of Scientific and Industrial Research (India), the Commonwealth Science Council (London) and the United Nations Environment Programme (Nairobi).

The Conference is timed to synchronize with the conclusion of the CSC-UNEP *Management of Water Hyacinth* Project and its final review.

The Conference language will be English and the following topics will be discussed: Environment and Ecology, Biology, Chemistry, Engineering, Utilization, Control and International Cooperation.

Registration fee is $100 (US). Registration form and fee should reach the Conference Secretariat before November 30, 1982. Thereafter, the fee will be $110 (US). Deadline for submission of abstracts is October 15, 1982.

All correspondence concerning the Conference should be addressed to:
International Conference on Water Hyacinth
c/o Dr. G. Thyagarajan
Director, Regional Research Laboatory
Hyderabad 500 009 INDIA



AZOLLA RUBRA

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NEW ZEALAND LAKES

The well-being of New Zealand's lakes, especially the Rotorua lakes, is the main interest of The Lake Weed Control Society, according to its secretary, Denis F. Dunlop. Aquatic weeds, such as *Lagarosiphon major*, "affect the tourist industries as well as the lives and intersts of people living hereabouts." These lakes are well-known for their rainbow trout angling.

Reservoirs behind New Zealand's hydro-electric dams are also threatened by aquatic weeds, according to Dunlop. Blockage of intake screens of the dams and capacity reduction of the reservoirs are some of the problems directly attributable to aquatic weed infestation. The fact that hydro-electric dams are the main sources of energy for New Zealand emphasizes the fundamental nature of their aquatic weed problems.

Lagarosiphon major

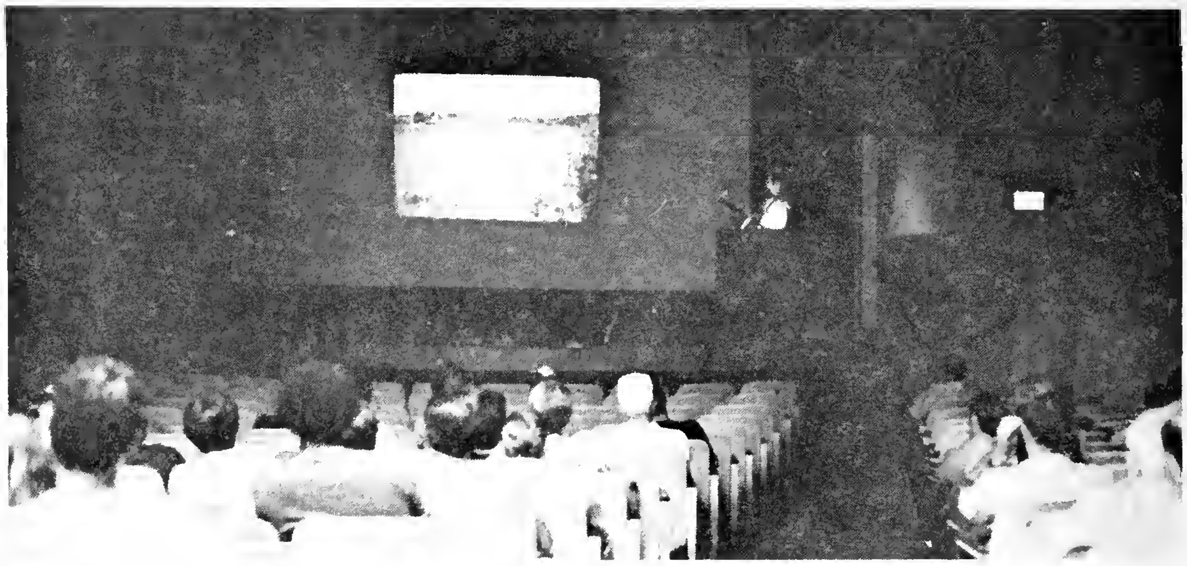
For more information on the activities of The Lake Weed Control Society, write: R.D. 4, Otaramarae, Rotorua, NEW ZEALAND.

SHORT COURSE SUCCESS

The Aquatic Weed Short Course held June 21-25 at the University of Florida, was attended by more than 100 researchers, teachers and field personnel.

The sessions served to update the aquatic weed control community in the latest information about the spread, ecology, environmental effects, government regulations and recent developments in the chemical, mechanical and biological controls of aquatic weeds.

Organizers Vernon Vandiver and William Haller expect to repeat the course in June, 1984.



Dr. William T. Haller updates the conference audience on the use of several of the newer aquatic herbicides.

AQUATIC WEED PROGRAM
2183 McCarty Hall
University of Florida
Gainesville, FL 32611 USA