UNIVERSITY OF FLORIDA
Center for Aquatic Weeds
AQUAPHYTE
International Plant Protection Center
AQUATIC WEED PROGRAM

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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 may 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)

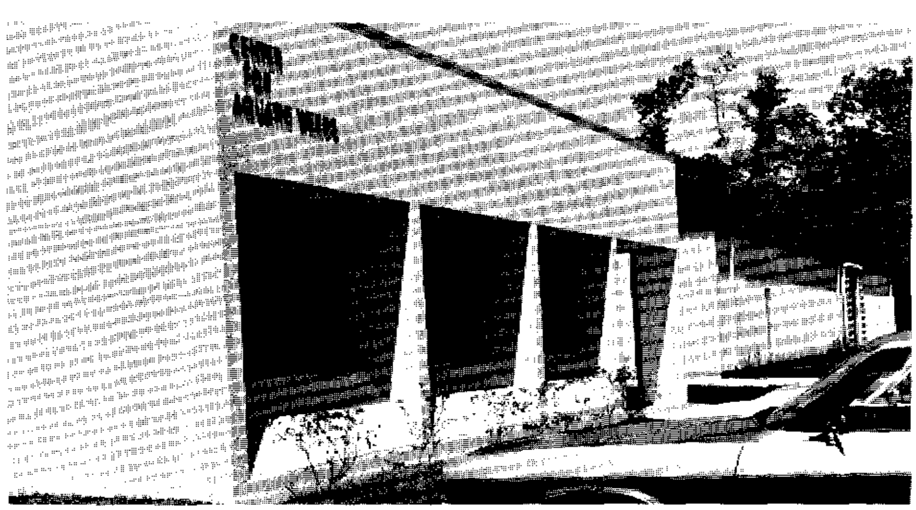
6) using electrophoresis to determine the identity of bio- and ecotypes of aquatic weeds (Dr. R. Wain)

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 Wind*ermere Laboratory. Library list information* and subscription rates can be obtained from J.E.M. Horne, Librarian, also at the Wind*ermere 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.

Center for Aquatic Weeds
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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

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"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 *(Alternanthera 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 decompositon 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 spi*catum* 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) 487-6874

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