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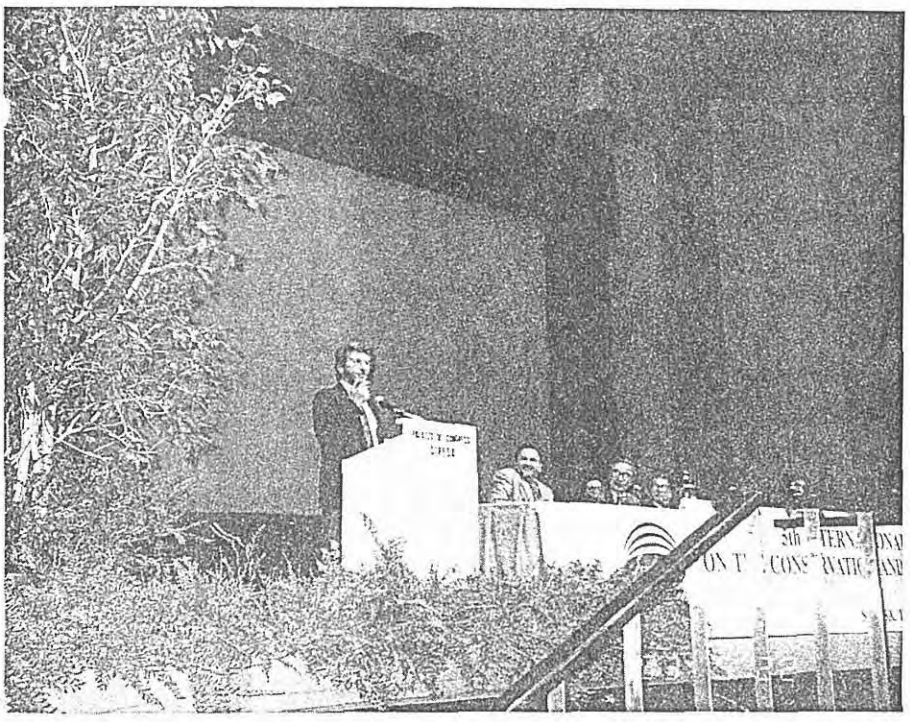
NEWSLETTER

INTERNATIONAL LAKE ENVIRONMENT COMMITTEE FOUNDATION

— For Better Lake Management —

This Newsletter is also available in Japanese.

Stresa '93



ILEC organized the 5th International Conference on the Conservation and Management of Lakes (World Lake Conference) at Stresa, Italy, on 17 - 21 May 1993. More than 350 people, including scientists, administrators and citizens, met on the shore of Lake Maggiore, the second largest lake in Italy, to discuss the environments of lakes and reservoirs around the world.

Almost two hundred contributions were made at the Conference held at the Congress Centre located at the central part of Stresa. Participants came from more than 40 countries around the world. The UNEP Regional Office for Asia and the Pacific (Bangkok, Thailand) and the Overseas Environmental Cooperation Center (Tokyo, Japan) kindly provided financial assistance for total 11 participants from develeloping countries.

Since its initiation at Shiga, Japan, in 1984, the conference has provided an arena for scientists, administrators and citizens to discuss and collaborate on the lake/reservoir environments. It could be said that conference of this new style has finally established with high scientific achievements.

At the opening address, Dr. Walter Rast of UNEP illustrated socio-economic aspects of lakes as a basic resource for development focusing upon the role of decision-makers. Governor Minoru Inaba from Shiga, Japan, called for all participants and people outside of the hall to take actions before it becomes too late.

The conference chose eight themes as main topics: (1) Scientific basis for managing eutrophication, (2) Water quantity and quality in lakes and reservoirs for human uses, (3) The fate and effects of in-lake micropollutants, (4) Non-point nutrient sources and their control, (5) Acid rain and effects on aquatic ecosystems on a global scale, (6) Scientific findings and their utilization at socio-economic and administrative levels for lake/reservoir management, (7) Lakes and environmental education, and (8) Citizen participation.

"A survey of the contributions presented reveals that eutrophication and problems connected with it, is still the topic which attracts most attention, even though there has been successful discussion of other environmental issues that can longer be considered of secondary importance, such as the problem of the distribution of organic and metallic micropollutants, as

well as the quality of atmospheric deposition and its negative impact on life in aquatic environments."

"Many of the contributions have on the other hand shown how the scientific knowledge and the appropriate technological solutions for many problems do in fact exist: we must believe, therefore, that the problem is one of allocation of funds, and in some cases one of political will. In this connection, it is highly significant how in the course of our work here it has emerged that a correct environmental education from the earliest years of elementary school and an active, responsible involvement by pressure groups formed by members of the public can be of great assistance in the common struggle to conserve the quality of existing healthy aquatic environments or to improve the quality of those which have to a greater or lesser extent suffered deterioration."

"It is our belief that today there is a need for greater international cooperation to effect a transfer of knowledge, technology and resources from the rich to the less rich countries, a transfer which must, however, take place on terms of absolute equality. To achieve this it is essential to create the conditions for the autonomous development of scientific and management capabilities also in developing countries, so that they can find in themselves the human resources and knowledge necessary for the correct management of their own territory."

(Excerpt of Dr. de Bernardi's closing address)

Seriousness and difficulty of the current global environmental problems, including lakes and reservoirs environment, require all human beings to cooperate to struggle with these problems. It is time for scientist who has scientific knowledge, administrator who makes policy and decision, and citizen and business people who are mostly affected by environmental change to get together and collaborate in each own field. This conference "Stresa '93" was the opportunity to promote the collaboration.

Next (6th) International Conference on the Conservation and Management of Lakes is scheduled for October 1995 at Ibaraki, Japan. (see ILEC Newsletter No. 21)

Bureau Meeting of the ILEC Scientific Committee

Bureau Members of the ILEC Scientific Committee met at Stresa, Italy, on 16 May 1993. After the ILEC activities since last General Meeting (June 1992) were reported, members discussed on ILEC's future direction especially new joint project with UNEP, collaboration with the UNEP International Environmental Technology Centre and new publication.

UNEP/ILEC International Training Course in Hungary

The Intrernational Training Course on Limnological Basis of Lake Management was held at Tihany, Hungary from 24 May through 5 June 1993. This course was organized by UNEP and ILEC with strong collaboration of the Balaton Limnological Research Institute of the Hungarian Academy of Sciences.

From Asia, Africa and eastern European countries, 25 trainees participated in this training course. The Course was to provide basic biological and chemical information on protection of lakes and reservoirs, harmful effects of different pollutants, as well as basic limnological knowledge necessary to identify sources of pollution, to plan and realize effective management measures. The Lake Balaton restoration program gives the practical aspect to the treainees.

Lectures were:

(1) **Role of ILEC in lake conservation and management** (T. Kira)

Six major problems which world lakes are facing today were introduced. They are acidification, decline of water level and decrease of water volume, eutrophication, accelerated siltation, contamination with toxic chemicals and extinction of indigenous ecosystem and biota.

(2) **Water quality managemant and sewage treatment** (L. Somlyody)

The chemical element circulations in freshwaters together with the description of trophic models were focussed on.

(3) **Origin and transport of hazardous substances in water basins** (S. Matsui)

Fate of heavy metals and pesticides were described, and the Ruhr River Basin case was introduced.

(4) **Biological monitoring of water quality** (J. Salanki)

General principles and advantages of using bioindicators in monitoring environmental pollution was outlined.

(5) **Environmental impact assessment of lakes and reservoirs** (J. Tundisi)

Adequate management of a (system of) reservoir(s) was mentioned. EIA, cost/benefit analysis, monitoring prior to/during the construction and the follow-up measures were focussed upon.

(6) **Water quality and lake management modelling** (S.E. Joergensen)

General overview of the mathematical models as management tools was provided. Attention was paid to the elements of modelling.

(7) **Basic principles of eutrophication** (S. Herodek)

Process of eutrophication and its concomitant effects, and different approaches to the solution were discussed in details.

(8) **Nitrogen loading and turnover in lakes** (J. Olah)

Main pathways of global nitrogen circulation, and nitrogen uptake and release within particular ecosystems were covered.

(9) **Use of algae in water quality monitoring** (J. Padisak)

Basic principles of some non-taxonomic ("bioassay") and taxonomic use of algae in monitoring saprobity, trophic states, pollution by heavy metals, hazardous organics and pesticides were mentioned.

(10) **Biomanipulation in conservation and management of lakes** (R. de Bernardi & I. Tatrai)

Philosophy and practice of biomanipulation as a tool of water quality regulation with planktonic organisms and fish were reviewed.

(11) **Management initiatives of fish stocks** (P. Biro)

Problems in managing fish populations, stocks or their environment were presented.

(12) **Use of fish in monitoring water quality** (J. Nemcsok)

Conditions of using fish for texicological experiments in the field and in laboratory were specified.

Field trips were to Kis Balaton Reservoir and Lake Velence. Moreover, laboratory demonstrations were made every afternoon.

This Course contributed to broaden participated policy makers and researchers view for environmentally sound management of lake and reservoir basins especially in some countries where late development-first policy had neglected sustainability of freshwater resources.

Ramsar Conference successfully held in Kushiro

The 5th Meeting of the Conference of the Contracting Parties to the Ramsar Convention was successfully held at Kushiro in Japan from 9-16 June 1993, with over 900 registered participants (221 delegates from Contracting Parties, 26 from Observer States; 6 inter-governmental organizations; 42 international NGOs; 273 national NGOs, including 39 foreign NGOs; 70 local government organizations; 250 press and 49 Ramsar Bureau Staf.

The Kushiro Conference was held at a crucial time in the history of the Ramsar Convention. Since the last meeting in Montreux, the Convention has undergone an exciting period of the growth with an increase of almost 50% in the number of Contracting Parties, and of about 25% in the number of sites included on the Ramsar list. This expansion has come during a period of mounting global concern for environmental matters, evidenced by the UN Conference on Environment and Development in 1992.

Prior to the conference, the Government of Japan registered five additional wetlands, including Lake

Biwa in Shiga Prefecture, to the Ramsar list of wetlands of international importance, which includes more than 600 sites in 77 countries. This brings the total number of Japanese sites on the Ramsar list to nine. Representing local governments of Japanese Ramsar Sites, Mr. Minoru Inaba, Governor of the Shiga Prefecture, stated "I hope that international cooperation under the Ramsar Convention will be strengthened in the field of information and technical exchange regarding wetland conservation. I expect that such cooperation will expand the size of environmental conservation activities for securing water lands which are often very important habitats for waterfowl."

Technical discussions were held in four workshops, focusing on Conservation of Listed Sites, Wise Use of Wetlands, Establishment of Wetlands Resources and International Cooperation. The workshop on the Wise Use of Wetlands, one of the key concepts promoted by the Convention, attracted considerable attention. "Wise Use" was defined as sustainable use for the benefit of mankind in a way compatible with the maintenance of the natural properties of the ecosystem.

Mr. Daniel Navid, Secretary General of the Ramsar Bureau, stated "We should be pleased, important announcements have been made, new Ramsar sites have been designated, and financial support pledged. However, many crucial issues are still unresolved. The conference has to come up with new guidelines for implementing the Ramsar Convention. It must devise measures for international cooperation. And it needs to ensure that adequate financial provisions are made."

The meeting called upon the Global Environment Facility (GEF) jointly operated by World Bank, United Nations Development Programme (UNDP) and United Nations Environment Programme (UNEP) to fund wetland submitted via the Biodiversity convention.

GEMS/Water Steering Committee Meeting at WHO in Geneva on 28-29 July 1993

This committee that serves as the main coordination, information exchange and forward planning mechanism of GEMS/Water Programme normally meets about once a year. A recent session of the committee was held at WHO Headquarters in Geneva on 28-29 July 1993, attended by 19 representatives from main participating organizations such as UNEP, WHO, WMO, UNESCO and ILEC, to review the start-up period of GEMS/Water Phase 2 which commenced officially in April 1992 with a new UNEP project document (FP/4101-92-01).

At the beginning of the meeting, Dr. Vandeweerd, UNEP GEMS programme officer, reported that, at the 17th session of the Governing Council of UNEP in Nairobi, May 1993, there was criticism from developing countries that too much of UNEP's activities and budgets had been devoted to projects oriented towards developed countries, such as the Earth Watch Programme, and more of UNEP's resources should be mobilized for developing countries, involving "Capacity Building."

As part of Earth Watch programme, GEMS/Water also came in for criticism. However, this criticism was counterattacked by the claim that some 80% of the expenditure of GEMS/Water has been exclusively spent for "Capacity Building" in developing countries by means of providing training and analytical quality control services, producing guideline books, etc. All the participants at the meeting agreed that future activities of GEMS/Water should be concentrated on "Monitoring and Capacity Building" and the unfavourable image should be corrected through assisting developing countries in their Capacity Building, in particular, on a regional or basin basis.

As the chairperson, Dr. Helmer, WHO, stressed the pressing needs for GEMS/Water to implement in the future such programmes toward monitoring and assessment as to be useful for management. Furthermore, he stressed the need to shift the approach from monitoring to research and to make more use of research studies for data collection in the light of increasing difficulties in obtaining long-term support from researchers. Dr. Rast, Chief Programme Officer of UNEP/Water Unit, stated that collaboration and joint activities between UNEP/Water Unit and GEMS/Water would be further strengthened and expanded.

Guideline-book Vol. 5 was released

ILEC/UNEP's fifth guideline book on lake management was published a few days before the 5th World Lake Conference at Lake Maggiore in Stresa.

As the other guideline book, a part of the book is devoted to the lake management problems and their possible solutions and another part focuses on case studies.

After introduction, which defines the problem, the second chapter is devoted to the source of this pollution problem: mainly the increasing use of fossil fuel in regions, where the surface water has a low buffer capacity (low hardness). The third chapters look into the effects of acidification on water chemistry, on phytoplankton, macrophytes, zooplankton, fish, birds, reptiles and amphibians. It is clear that acidification implies drastic changes of the entire lake, including the water chemistry and the entire biological structure. The fourth chapter is concerned with the abatement methods including restoration of acidified lakes. The last chapter of the first part reviews the modeling effort in this area and the application of the models for setting up a management strategy for solution of the problem.

The second part consists of three chapters, covering three case studies. The first case study is a detailed description of the acidification of lake Orta, Italy, and the successful restoration of the lake by the use calcium hydroxide powder. The second case study review the alteration observed on plant communities in Scandinavian shallow lakes and wetlands as a result of acid precipitation. The third case study is devoted to a review of the damages observed in another region, threaten by acidification of lakes in Canada.

Two appendices give an overview of the global sulfur emission and the application of log-log diagram in water chemistry to enable a quick assessment of pH and the buffer capacity of lake water.

The volume gives many references to the original literature and contains a useful index.

ILEC PUBLICATIONS

"Survey of the State of World Lakes" - Data Book -

Each Japanese 10,000 yen

Vol. 1 (1988), Vol. 2 (1989), Vol. 3 (1990) and Vol. 4 (1991)

"Guidelines of Lake Management"

Each Japanese 1,500 yen

Vol. 1 (1989) - Principles of Lake Management -
Editors: S.E. Joergensen/R.A. Vollenweider

Vol. 2 (1991) - Socio-Economic/Aspects of Lake Reservoir Management -
Editor: M. Hashimoto

Vol. 3 (1990) - Lake Shore Management -
Editors: S.E. Joergensen/H. Loeffler

Vol. 4 (1991) - Toxic Substances Management in Lakes Reservoirs -
Editor: S. Matsui

Vol. 5 (1993) - Management of Lake Acidification -
Editor: S.E. Joergensen

"Workshop Report" Each Japanese 500 yen

Report of the "UNCRD/ILEC/UNEP Expert Group Workshop River/Lake Basin Approaches to Environmentally Sound Management of Water Resources" 8 - 16 February 1988, Nagoya & Otsu

Report of the Second Expert Group Workshop River/Lake Basin Approaches to Environmental Sound Managementof Water Resources: Focus on Policy Responces to Water Resources Management Issues and Problems, 16 - 25 January 1989, Bangkok and Hat Yai, Thailand

Report of the Third Expert Group Workshop River/Lake Basin Approaches to Environmentally Sound Management of Water Resources: Improving Water Resources Management in River/Lake Context, 12 - 17 February, 1990, Otsu Japan and The Training Seminar on River/Lake Basin Management: Focus on Water Quality Enhancement, 19 - 22 February 1990, Okazaki, Japan

'Towards Wise Use of Asian Wetlands"
3,000 Japanese yen

Proceedings of the Asian Wetland Symposium,15 - 20 October 1992 Otsu and Kushiro, Japan

ILEC will offer above publications free of charge to qualified applicants from developing countries. However, postage and bank charges must be covered by the applicants. Publications mentioned above are available from the ILEC. Prices are exclusive of postage and lifting charge.

Lake Model - a computrer software, produced by ILEC

ILEC has recently released a computer software, "Lake Model"(Japanese 10,000 yen + postal charge). The teaching software gives an explanation on thermocline formation, release of nutrients from the sediment, oxygen and temperature profiles in lakes and several other important lake processes. It also contains a series of multiple choice questions with important information on the world's lake.

The model has four state variables: soluble phosphorus, soluble nitrogen, sediment phosphorus and sediment nitrogen. It is easy to use. The information needed for the use of the model for a particular lake can be given in a table. It is such information as the volume and area of the lake, the inputs of nutrients to the lake and the retention time of the water. If a thermocline is formed during the year a correction factor for the retention of nitrogen and phosphorus also should be given. Two case studies, a shallow lake and a deeper lake with thermocline, for which the data are included in program, illustrate the use of the model. The model contains furthermore the results of a comprehensive regression analysis relating the soluble phosphorus and the soluble nitrogen in the water to phytoplankton concentrations, transparency, primary production, zooplankton concentration, denitrification and fish population.

The model is rather simple. It can therefore not replace a more complex eutrophication model as management tool, but can be used for a first estimation in management context or in cases, where the data do not allow to develop and apply a more elaborate model. It also may consider a first introduction to the use of models as lake management tool.

The software which runs on most IPM/PC compatibles will hopefully be widely used as an educational program in lake management.

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ANNOUNCEMENT

The Interntional Association for Theoretical and Applied Limnology (SIL), in cooperation with ILEC, is preparing a Directory of Limnology and Wetland Science in the Developing Countries. The Directory will include personal particulars and fields of interest of individual scientists engaged in studies of all inland waters and wetlands throughout the developing world. The individuals from the developed countries working in the developing countries would also be listed. The directory will also include information on institutions where these studies are carried out.

All researchers are requested to send the necessary information to, and contact for further details, the chairman of the SIL Committee on Limnology in Developing Countries, Dr. Brij Gopal, School of Environmental Sciences, Jawaharlal Nehru University, New Delhi 110067, India.

IMPACT OF THE ZEBRA MUSSEL ON THE GREAT LAKES ECOSYSTEM

Dr. Frank M. D'Itri and Dr. Cal McNabb
(Department of Fisheries and Wildlife, Michigan State University, U.S.A.)

Dreissena polymorpha (Pallas), the zebra mussel, is a small mollusk that is native to the fresh and brackish waters of the Caspian Sea region of Eurasia. With the development of inland transportation routes on rivers and canals some 200 years ago, the mollusk began to spread from the Caspian Sea through Europe and portions of Russia west of the Ural Mountains. Individual mussels presumably attached themselves by byssal threads and were carried on the hulls of vessels. By the mid-1800s the species was widespread from the Caspian Sea northward to the Baltic States and westward to Europe's Atlantic coast and the British Isles (Mackie et al., 1990).

In North America the first zebra mussels were reported in Lake St. Clair in June, 1988 (Herbert et al., 1989). They were apparently introduced as an ocean-crossing vessel emptied its ballast into Lake St. Clair sometime during 1985 or 1986. Proliferating in Lake Erie, downstream from Lake St. Clair, the mussels occupied virtually all solid substrates available for attachment in Lake Erie by fall, 1989 (Griffiths et al., 1989). During 1989 and 1990, the zebra mussel was reported in all five of the Great Lakes (Figure 1). By 1991 zebra mussels had spread down the St. Lawrence River into New York's Hudson and Mohawk rivers via the Erie Canal and into the Illinois River via the Chicago Sanitary Canal. They were also found in the Ohio River and upper portions of the Mississippi, Tennessee and Cumberland Rivers. Therefore, the zebra mussel has made its way into the Mississippi River Basin. Snyder et al. (1991) predicted that the mussel will extend its range from the Great Lakes to most major interconnected drainage basins in the United States and southern Canada. Based on the European experience this assessment appears to be realistic.

As early as 1981 Environment Canada documented the seriousness of the problem of "ballast water hitchhikers." This study showed that about 17 species of animals arrived alive in each ship with numbers of small individuals ranging from 10,000 to approximately 8 billion. A future problem with zebra mussels was predicted unless preventive measures were instituted. Almost a decade later the United States Congress passed "The Non-indigenous Aquatic Nuisance Prevention and Control Act of 1990," which requires ships entering the Great Lakes after November 29, 1992, to exchange their ballast water on the open sea, or to treat ballast in an environmentally sound manner to kill hitchhiking organisms (Anon., 1990). Consequently, the threat by new invasions of exotic species into the Great Lakes from this source may be minimized.

The zebra mussel has the characteristics of an opportunistic species. A small mollusk (3-4 cm) with a short life span (3-5 years), it becomes sexually mature at an early age. In its second and subsequent years it reproduces throughout the temperate growing season. The animal's fecundity is high; 30,000 to 40,000 eggs are produced per female per year. The sexes are separate, and the ratios vary around 1:1 in North America and European populations. The eggs are fertilized outside the mussel's shell and develop into weakly swimming planktonic veliger larvae about 40-70 micrometers in diameter within a few days. They are carried away from the beds of attached adults by water currents. Veligers remain in the plankton stage for 2-3 weeks. During this time they may travel many miles on currents or attached to boats, fishing gear, aquatic plants, sticks, logs and floating debris. When they settle on solid objects, juveniles quickly become attached and transform into double-shelled mussels that mature within a year.

The zebra mussel secretes about 200 strong, slender threads with which it can attach to any hard surface, including other zebra mussels (Amato, 1991). Population densities are as high as 750,000/square meter on cement shorezone structures in Lake Erie. Beds commonly contain 30,000 to 70,000 per square meter.

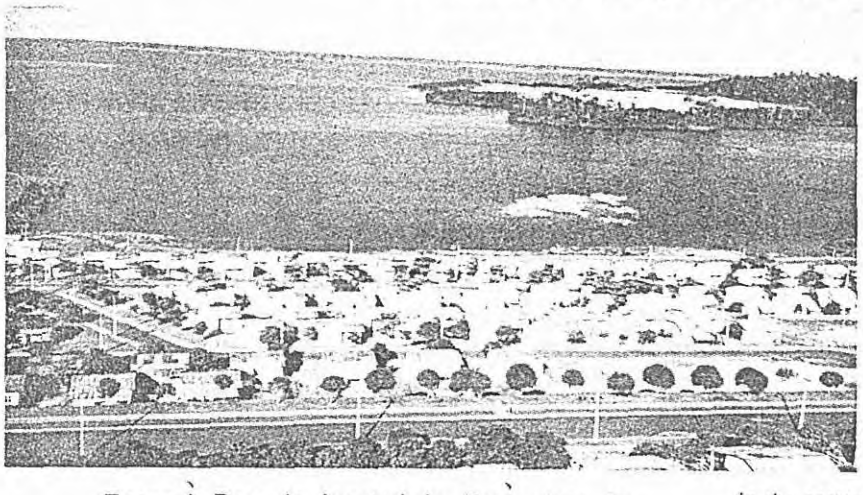
Zebra mussels have the potential to control the organization of freshwater biological communities because of their ability to densely occupy space to the detriment of other organisms. They attach to other living organisms, such as crayfish, native clams and other zebra mussels, as well as to rocks and reefs. On soft sediments, sticks and shells serve as nuclei for initial attachment; then carpets of mussels grow as they attach to one another. The habitat of burrowing mayflies and other organisms that dwell in soft sediments is drastically altered by the development of such carpets. The mussels can also alter the amounts of suspended solids in water. Relatively tolerant of high turbidity, zebra mussels can control the abundance of solids by filtering them from the water, digesting a fraction as food, and eliminating the remainder in mucous pseudofeces.

Pseudofeces can alter the benthic environment around the beds of mussels. Their biological oxygen demand

equipment such as boats, trailers, scientific instruments and the like, and they must be out of the water (and rain) a minimum of 10 days, but preferably 14 days, to be sure that mussels are killed by drying. If the equipment must be returned to another watercourse earlier, the most effective procedure is to scrape or blast the surfaces clean with high pressure (250 psi) followed by bleach disinfection (MDNR, 1990). Although some citizens are unlikely to be aware of the complications and others will not accept the responsibility, it is important that the zebra mussel infestation be slowed as much as possible and research efforts be concerned on reducing their negative efforts.

LAKES OF THE WORLD Tucurui Reservoir in Brazil

YATSUKA SAIJO (AICHI UNIVERSITY)



Tucurui Dam is located in Para state in Northeastern Brazil. The dam was constructed on the Tocanitins River about 300 km from Belem, the capital of the state as well as an important port near the mouth of the Amazon River. The dam was completed in 1984. The electric power generated is 4,000,000 KW, and eventually will reach 7,300,000 KW. It is the largest electric power plant in Brazil. The length of the bank is about 11 km, and the mean water depth is about 19 m. Some 2,430 km² (about 3.6 times the area of Lake Biwa in Japan) of virgin forest has thus been submerged. In the forest, there were once many trees having a height of 50 m or so.

Most of the living fauna and flora in this region have died. At first sight, it was suggested that 85 % of the forest be cut down in advance, but valuable trees were scattered throughout the forest, so only 5 % of the forest was eventually cut before the submergence. This huge underwater forest has water in the reservoir. Eutrophication progressed rapidly, and dense algal mats were produced in the region of the dead forest. A large amount of small shrimp can be found in the algal mat, leading to an increase of the Tucunare, a popular fish and important source of protein for inhabitants, at least during a limited period.

On the other hand, with the decomposition of organic matter in the water anaerobic conditions prevail in the deeper layer, thereby producing a large amount of hydrogen sulfide.

The occurrence of the hydrogen sulfide in the deeper layer is a well-known phenomenon in the reservoirs in Amazone. Its corrosive effect on turbines and other parts of the electric power plant has caused serious problems. Furthermore, in the Tucurui Reservoir, the odor of hydrogen sulfide discharged with the water is very strong downstream of the gate. It is probable that this gas will be an important source of acid rain as the final product.

In 1967, geologists of the US Steel Company, who had been prospecting for manganese resources, found a huge vein of iron in the eastern part of Amazon by a chance, forced landing of their helicopter. Later, bauxite, manganese cupper, tin and other large ones were also found. A large-scale project to develop the mineral resources in this region was launched. It was in connection with this project that the Tucurui Reservoir was constructed, especially to supply electricity to the aluminium refining plant near Belem.

A modern city was built almost overnight in the middle of the tropical forest for the people working in the construction and maintenance of the dam. Its clean, well paved streets are lined with comfortable homes graded into A, B and C classes, together with a school, hospital, hotels, shopping center etc. This city seems to be something like that of a mini Brasilia. Its population peaked at about 58,000 in 1982, then decreased to about 28,000 in 1985.

On the other hand, about 3,000 families of inhabitants, including the Indio group, made their living in the submerged area. They were forced to move to newly constructed plain houses in the forest. Viewed from a boat shore in half-hidden conditions in humble cottages. This was conditions created by the electric company.

In advance of the submergence, a comprehensive environmental research project was carried out with the assistance of specialists from the INPA- National Research Institute of the Amazon and other institutes. Major studies are including Limnology, Aquatic Macrophyte, Flora, Seismology, Meteorology, Endemic Diseases, Ichthyofana

(BOD) degrades typically clean and aerobic rock and gravel environments that are used as spawning areas by fish species. Walleye, white bass, and smallmouth bass populations are ordinarily maintained by recruits hatched on clean, well oxygenated rock and gravel substrates. These species are projected to decline in the Great Lakes as zebra mussel populations increase and degrade spawning areas. Additionally, because they can out compete the zooplankton which also feed primarily on phytoplankton, food chains are disrupted for most larval and juvenile fishes as well as adult forage fish that feed on plankton. Consequently, fisheries experts expect a long term negative effect on the Great Lakes fisheries.

The zebra mussel colonization in Lake Erie in 1989 was estimated to be large enough for them to filter the entire volume of the lake every few days (Snyder et al., 1991). On the plus side, their filtration and deposition of pseudofeces has apparently been responsible for clarifying the water in the lake. Huber (1989) reported that average secchi disk readings in the western basin of the lake improved from 1.5 m in mid-May, 1988, before the influx of mussels, to 3.6 m in mid-May, 1989. Schloesser (1990) reported that secchi disk transparencies have generally improved by 70 percent in the western basin of Lake Erie since 1989, and by 85 percent in the central basin. In littoral portions of the lake improved light penetration appears to have caused major alterations. Primary productivity of submersed macrophytes has increased and plants have expanded in area and density.

As the current data are limited, the long term fate of the zebra mussel in the Great Lakes and other North American waters is still uncertain. Ecologists believe, however, that the infestation/acclimatization process for these animals will be similar to that of other exotic animals introduced into the Great Lakes. Thus, zebra mussels are expected to develop large populations for a few years after infestation, and then crash as their food supply becomes limiting. They are likely to repeat this cycle several times before equilibrium populations are established. Size of equilibrium populations will depend on physical, chemical and biological characteristics that control the carrying capacity of the individual lakes. Research in Europe indicates that explosive growth like that observed in Lake Erie was generally followed by drastic populations declines Populations of zebra mussels declined because they filtered algae out of a water column at a rate greater than it was replaced. This suggests that zebra mussels would retain their high densities only in the most eutrophic areas of the Great Lakes such as Saginaw Bay, Lake Erie, Green Bay and Lake St. Clair.

Overall, most biologists predict that the zebra mussel will not only become an integral part of the food chain, but it also may become one of the most destructive and costly biological invaders yet to be introduced. They have already impaired a number of social uses of the Great Lakes and threaten to disrupt the food web on which the fishery depends. In heavily infested areas, dense colonies have clogged water intakes and delivery systems for municipal and industrial water supplies and electric power generation stations. They have fouled boat hulls and water intakes of boat motors and converted sandy beaches into piles of shells. In addition, zebra mussels can colonize and disable sensitive recording instruments such as pH and DO probes, causing serious problems for in-lake environmental sensing. The U.S. Fish and Wildlife Service estimates that zebra mussels may cause $5 billion in damage to factories, ships, power plants, fisheries and water supplies in the United States and Canada over the next decade.

Dealing with the zebra mussel problem will not only be enormously expensive but also difficult until more is learned about their life cycle, physiological limits, and other conditions that control their growth. Many studies have been initiated to test methods such as heating, oxidizing agents like chlorine and ozone, electric shock and sonic vibrations to control the infestation of zebra mussels on water intake structures. Another method that shows promise for use at water intakes is sand filtration. While some treatments are effective to control the mussels in concentrated areas such as pipe lines or boat hulls, experts have yet to find a method control them on a lake wide basis.

Once an exotic species such as the zebra mussel becomes established in an aquatic system, it usually cannot be eradicated; and reactionary procedures are costly and mostly ineffective. Therefore, it is important not only to inform the public of this problem but also to develop procedures to prevent or at least slow their inadvertent introduction into uninfested waters. This is very difficult because it requires that informed individuals, recreational sportspersons as well as scientific researchers, be willing to take the necessary precautions. Their potential success is based on the fact that neither the veligers nor adult zebra mussels can survive drying or disinfection.

While veligers attached to boats, trailers, fishing equipment, and scientific instruments cannot survive drying, they can live in residual water. Therefore, all bilge water, live wells, bait buckets and engine compartments must be drained and allowed to dry thoroughly in order to prevent their spread. The live wells and bait buckets must be disinfected with a 10 percent bleach solution for several hours to be certain of killing any remaining veligers. Water must not be allowed to be trapped in equipment such as instruments or boat trailers, and all plant debris where zebra mussels could hide should be removed from boats and trailers.

While the veligers are microscopic and the juveniles are sometimes difficult to see, the adult zebra mussels are very rugged and can survive drying many days when they are removed from water and even longer in moist or damp environments. Therefore, water must be drained from

and Evaluation of Fishing Potential, Fauna, Soils and Consequence Control Downstream of the Tucurui Dam.

To preserve the animal species inhabiting the areas later submerged, boats used in the dam construction were used to transfer some 284,211 animals to new ground in 1984-85. However, when one considers the size of the submerged area, it is obvious that the measures were completely insufficient.

There are many plans to construct such dams in the Amazon region. However, given the very flat morphological character of this area, it is highly probable that a huge forest area would have to be sacrificed to obtain only a rather small amount of electric power.

Forthcoming Event

NEW EARTH '93 / Global Environment Technology Show

Date : Dec 7-10, 1993

Venue : Intex Osaka Fairgrounds, Suminoe Osaka, Japan

Organizers : Osaka International Trade Fair Commission, The Japan Society of Industrial Machinery Manufactures and Research Institute of InnovativeTechnology for the earth

Expected Number of Stands : 1,000 Stands (1 stand : 9 m²)

Expected Number of Visitors : 50,000

Concurrent Event : International Synposium for Environmental Technology

GLOBE 94 / International Trade Fair and Conference - Developing the Business of the Environment -

Date : Mar 21 - 25, 1994

Venue: The Vancouver Trade and Convention Center, Vancouver, Canada

Organizer: Asia Pacific Foundation of Canada (non-profit foundation)

Sponsors: The Government of Canada, Province of British Columbia and Vancouver city

The event's three components, the Trade Fair, Conference and Business contacts Centre, are designed to complement and reinforce each other.

ILEC

INTERNATIONAL LAKE ENVIRONMENT COMMITTEE FOUNDATION

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