

# GUIDELINES of LAKE MANAGEMENT

Volume 7

## Bio-manipulation in Lakes and Reservoirs Management

Editors:

R. De Bernardi and G. Giussani



International Lake Environment Committee  
United Nations Environment Programme

**Copyright © 1995 by the International Lake Environment Committee Foundation  
and the United Nations Environment Programme**

Opinions expressed in this volume are those of the author(s) and do not necessarily reflect those of the International Lake Environment Committee Foundation or the United Nations Environment Programme.

Designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the International Lake Environment Committee Foundation or the United Nations Environment Programme concerning the legal status of any country, territory, city or area, or of its authorities, or concerning the delineation of its frontiers or boundaries.

International Lake Environment Committee Foundation  
1091 Oroshimo-cho, Kusatsu  
Shiga 525, Japan

Text layout & Printing; Hanroku Type Ltd., Otsu, Japan

**SBN 4-906356-15-X**

## FOREWORD

*Tatuo Kira*

Lake ecosystems and island ecosystems seem to be homologous with respect to their intolerance to the invasion of alien species of plants and animals, probably because both ecosystems consist of the limited biota which could migrate by chance across the surrounding barriers of land or water and may therefore be less firmly organized as compared with those in the ocean or on the continent.

Due to the ever-increasing inter-continental communication and transportation, more and more alien species are being introduced either intentionally or by chance to a number of lakes, where they often propagate explosively, resulting in severe damage to native species. In certain extreme cases, the introduction of a single fish species may completely alter the structure of a whole lake ecosystem. This is a serious threat to the biodiversity of certain geologically old lakes in which many indigenous taxa were born through hundreds of thousands of years.

On the other hand, such variability of lake ecosystems may also indicate the possibility of effectively controlling their structure and thereby changing aquatic environments by artificial intervention in the biological processes within lakes - the so-called biomanipulation. Its practice is not new; people have long been trying to introduce various new organisms into their home lakes in order to increase fishery production, to remove unfavourable plants and animal species, etc.. However, systematic studies on biomanipulation have started rather recently. A lot of papers dealing with the subject are appearing in scientific journals, but it is still difficult for non-specialists to understand what has so far been achieved by those studies and how their results can be applied in the practical management of lake resources and environments.

This volume of the ILEC/UNEP guideline book series is expected to fill the need by offering a general introduction to the role of biomanipulation in lake management with emphasis on the control of excessive algal growth in lakes suffering from eutrophication. We hope that this new approach may give stimulative suggestions to lake environment managers worldwide.

The ILEC Foundation would like to sincerely thank the editors Dr. R. de Bernardi and Dr. Giussani and the other contributors for their efforts in preparing this useful and unprecedented book. The continued support to the serial publication by the United Nations Environment Programme is also heartily acknowledged.

*ILEC Foundation  
Kusatsu, Shiga, Japan*

# FOREWORD

*Jorge Illueca*

Eutrophication is surely the most important process affecting lakes and reservoirs worldwide. An important consequence of this process is the general reduction of the possibilities for water use, so that the importance of lakes and reservoirs as primary resources for socio-economic development can be seriously compromised. On the other hand, biological processes in eutrophic environments increase productivity, including fish yield and this process can be regarded positively as a source of protein in developing countries. It is well-known that eutrophication involves increasing nutrient inputs resulting from human activities. Historically, the way to prevent this process from eroding the quality of the environment and to rehabilitate freshwater environments once eutrophied, was engineering for the control and reduction of nutrient inputs. This costly process is unquestionably necessary in many cases, but it does not necessarily produce the expected improvement in a reasonable time, due to the resistance of the ecosystem itself.

For this reason several in-lake ecotechnologies have been proposed, developed and tested on a natural scale. These ecotechnologies have to be considered as an alternative to the engineer's reduction of nutrient loads. Among them, one of the most promising is the biomanipulation of the aquatic food chains.

Biomanipulation began in the late fifties as an approach to the study of ecosystem function. Since then many real scale experiments have proved that biomanipulation can ameliorate eutrophic water bodies. It is now clear that the principles of biomanipulation can be utilized to manage the ecosystem on a scientifically sound basis. This technique is still largely empirical and needs a more profound scientific basis. Nevertheless, biomanipulation holds great promise for the management of lake and reservoir quality. It is also important to stress that biomanipulation is not limited to remediating eutrophic lakes, but can also help improve fisheries in terms of both quality and quantity of products.

This booklet, the 7th in the Guidelines of Lake Management series, explains the scientific bases of biomanipulation in detail, illustrating the techniques with case studies of successful lake recovery. Some chapters also illustrate how appropriate biomanipulation can help enhance fisheries.

*Assistant Executive Director  
Environmental Management Division  
UNEP*

## AUTHORS

*Riccardo de Bernardi*

Istituto Italiano di Idrobiologia  
Consiglio Nazionale delle Ricerche  
Pallanza (NO), Italia

*Gianluigi Giussani*

Istituto Italiano di Idrobiologia  
Consiglio Nazionale delle Ricerche  
Pallanza (NO), Italia

*Peter Kasprzak*

Institute of Freshwater Ecology and Inland Fisheries  
Department of Limnology of Stratified Lakes  
Heuglobsow, Germany

*Moshe Gophen*

Israel Oceanographic and Limnological Research Ltd.  
Tiberias, Israel

*Ramesh Gulati*

Netherlands Institute of Ecology  
Centre for Limnology  
Nieuwersluis, The Netherlands

*Péter Biró*

Balaton Limnological Research Institute  
Hungarian Academy of Sciences  
Tihany, Hungary

*Brian Moss*

The University of Liverpool  
Department of Environmental and Evolutionary Biology  
Liverpool, England

*S. E. Jørgensen*

Royal Danish School of Pharmacy  
Copenhagen, Denmark

*Gaetano Galanti*

Istituto Italiano di Idrobiologia  
Consiglio Nazionale delle Ricerche  
Pallanza (NO), Italia

*István Tótrai*

Balaton Limnological Research Institute  
Hungarian Academy of Sciences  
Tihany, Hungary

*Akira Kurata*

International Lake Environment Committee  
Kusatsu, Shiga, Japan

*C. H. D. Magadza*

University Lake Kariba Research Station  
University of Zimbabwe

# CONTENTS

	<i>Page</i>
<b>Chapter 1</b>	
Bio-manipulation: Bases for a Top-down Control .....	1
<i>Riccardo De Bernardi and Gianluigi Giussani</i>	
<b>Chapter 2</b>	
Objectives of Bio-manipulation .....	15
<i>Peter Kasprzak</i>	
<b>Chapter 3</b>	
Food Web Alterations by Physical Changes: .....	33
Eutrophication and selective fisheries	
<i>Moshe Gophen</i>	
<b>Chapter 4</b>	
Manipulation of Fish Population for Lake Recovery .....	53
from Eutrophication in the Temperate Region	
<i>Ramesh D. Gulati</i>	
<b>Chapter 5</b>	
Management of Eutrophication of Lakes to Enhance fish Production .....	81
<i>Péter Bíró</i>	
<b>Chapter 6</b>	
Manipulation of Aquatic Plants .....	97
<i>Brian Moss</i>	
<b>Chapter 7</b>	
Modelling and Bio-manipulation .....	113
<i>S. E. Jørgensen</i>	
<b>Chapter 8</b>	
Case study: Lake Candia (Northern Italy) .....	135
<i>G. Giussani and G. Galanti</i>	

<b>Chapter 9</b>	
Food-chain Manipulation as a Tool in Management of Small Lakes .....	147
in the Netherlands: The Lake Zwemlust Example	
<i>R. D. Gulati</i>	
<b>Chapter 10</b>	
Case studies: Lake Balaton (Hungary) .....	163
<i>I. Tátrai</i>	
<b>Chapter 11</b>	
Long Term (1970-1990) Whole Lake Biomanipulation .....	171
Experience Case Study: Lake Kinneret (Israel)	
<i>M. Gophen</i>	
<b>Chapter 12</b>	
Management by Food Chain Manipulation of Lake Biwa (japan) .....	185
<i>Akira Kurata</i>	
<b>Chapter 13</b>	
Reservoir Management Using Food Chain Manipulation .....	197
<i>C. H. D. Magadza</i>	