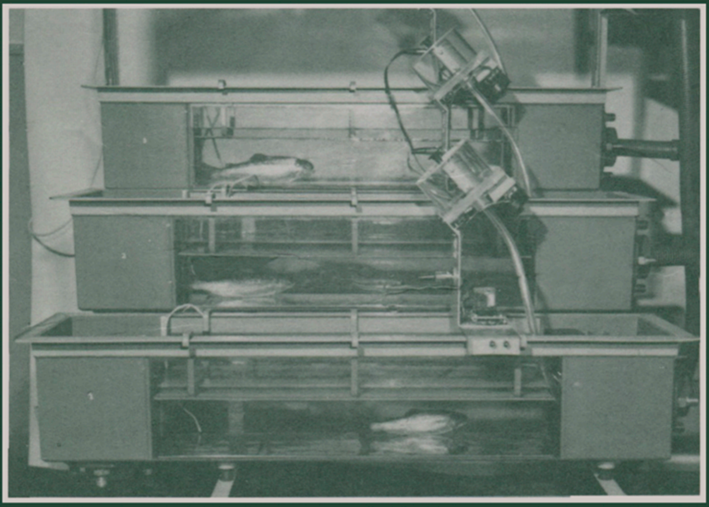
BIOLOGICAL MONITORING IN WATER POLLUTION



JOHN CAIRNS Jr.,
VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY, BLACKSBURG, VIRGINIA, USA

AND COLLABORATORS
A L BUIKEMA, Jr. D S CHERRY E E HERRICKS R A MATTHEWS
B R NEIDERLEHNER J H RODGERS, Jr. W H VAN DER SCHALIE

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JOHN CAIRNS, Jr.

and collaborators

A. L. Buikema, Jr.
D. S. Cherry
E. E. Herricks
R. A. Matthews
B. R. Niederlehner
J. H. Rodgers, Jr.
W. H. van der Schalie

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This book is dedicated to

Dr RUTH PATRICK

Senior Curator, Academy of Natural Sciences of Philadelphia
who was practising biological monitoring
before the term became fashionable

FOREWORD

This book on Biological Monitoring was planned so that individual self-contained parts on various aspects of the subject of Biological Monitoring could appear as review articles in the international technical journal *Water Research* (published by Pergamon Press for IAWPRC). The advantages of this arrangement were that subscribers to *Water Research* and members of the International Association on Water Pollution Research and Control, IAWPRC (formerly the International Association on Water Pollution Research, IAWPR), received parts of the book as soon as they were available, but it also allowed the costs of the book to be kept to the minimum by using the same text for both the review articles and the book.

This latter advantage causes a slight disadvantage which it is hoped will not inconvenience readers: since the parts in *Water Research* did not appear in sequence and were spread over several of its issues, the pages in the book are not numbered in proper sequence. However, the Table of Contents in the book gives the first and last pages for each part and in the text the parts are separated by a contrasting inserted page giving the part number and title. Each item is listed in the index by part number and page number within that part.

The information given in Part I has been expanded and updated by a supplementary section written nearly two years after the original part first appeared. This supplement is printed immediately after the original part. Please note that although a Part IIA appeared there will be no Part IIB.

S. H. JENKINS
Executive Editor, IAWPRC

PREFACE

The field of biological monitoring exists because no instrument has been devised by man that can measure toxicity! Only living material can be used effectively for this purpose. However, a biological response unaccompanied by chemical/physical data has very low information content. As a consequence, biological monitoring should be carried out in concert with chemical/physical monitoring. Although chemical/physical tests will not be emphasized in this volume, it is a *sine qua non* that all biological tests discussed are meant to be accompanied by appropriate chemical/physical tests.

For years, estimates of toxicity were based almost entirely on chemical analyses. Abundant evidence eventually accumulated that this approach was unsatisfactory. Unfortunately, biologists had not given this problem the attention it deserved and few tests were available when the need for them was recognized. However, when toxicity test methods came into favor, additional evidence quickly accumulated on the inadequacy of the use of chemical measurements alone for the determination of toxicity: (a) biological effects often occur at concentrations below analytical capabilities, (b) toxicants and other sources of stress may act quite differently in mixtures than individually, (c) environmental quality strongly mediates toxic response.

The field of biological monitoring is plagued by two needs which often appear virtually incompatible. The first is the need for replication so that experiments and tests can be repeated and validated by others and so sufficient evidence of a similar nature can be gathered for customary statistical analyses. The second is the requirement that the results be applicable and useful in the "real world", which is a highly variable complex system guaranteed to frustrate an investigator interested in replication. As one might expect, the need for replication triumphed, and the single species toxicity test carried out under highly artificial, nonvariable conditions emerged as the principal means of biological monitoring. Until relatively recently, tests were usually short term and involved lethality as an end point. In the last few years, increased attention has been given to lengthening the period of exposure and involving more than one life history stage. Even the strongest supporters of single species tests admit that the tests do not accurately reflect either the variability or the complexity of natural systems. The important question is how useful are such tests in predicting events in natural systems, particularly where pollutional effects are concerned.

Although single species toxicity tests are conducted in the laboratory, the results are generated with the intent to protect living things in natural systems. Since the assumption was made that single species tests would provide a means of estimating harm to the biota in natural systems, it is curious that the validity of this assumption has not been extensively tested in a scientifically justifiable way. There is no question that the single species test, effectively used, has reduced the number of fishkills and other catastrophic events. Nevertheless, it is regrettable that no substantive body of evidence confirming the reliability of predictions of ecosystem protection made on the basis of single species testing has been generated. Although this deficiency has been noted for years and attention continues to be called to it (e.g. Cairns *et al.,* 1981), the amount of evidence upon which one can determine the effectiveness of the single species test in predicting the response at higher levels of biological organization remains uncertain. Since prevention of harm to the environment before it occurs is the objective of ecologists, there is ample justification for developing a predictive capability that will enhance estimation of the probability of harm before material enters the environment. Determination of the accuracy of these predictions to serve as a form of error control in correcting the predictive methods is also essential. An expression of these concurrent needs for a single point discharge is depicted in Fig. 1. A variety of biological methods for carrying out both of these activities will be discussed in this book.

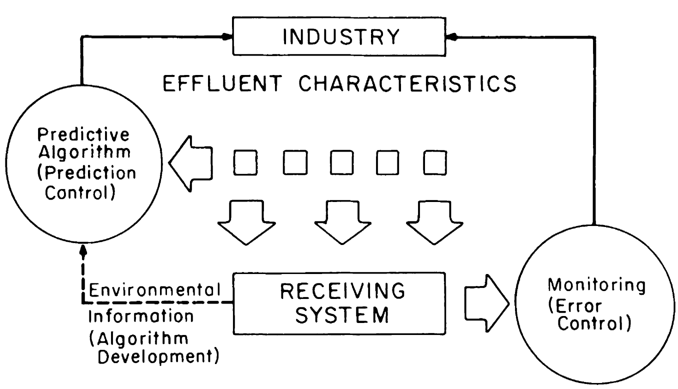

Fig. 1. Information flow in environmental control processes (from Herricks and Cairns, 1979).