1995-97 Priorities

GREAT LAKES WATER QUALITY AGREEMENT

International Joint Commission
Commission mixte internationale

1995-97 Priorities

AND PROGRESS UNDER THE

GREAT LAKES WATER QUALITY AGREEMENT

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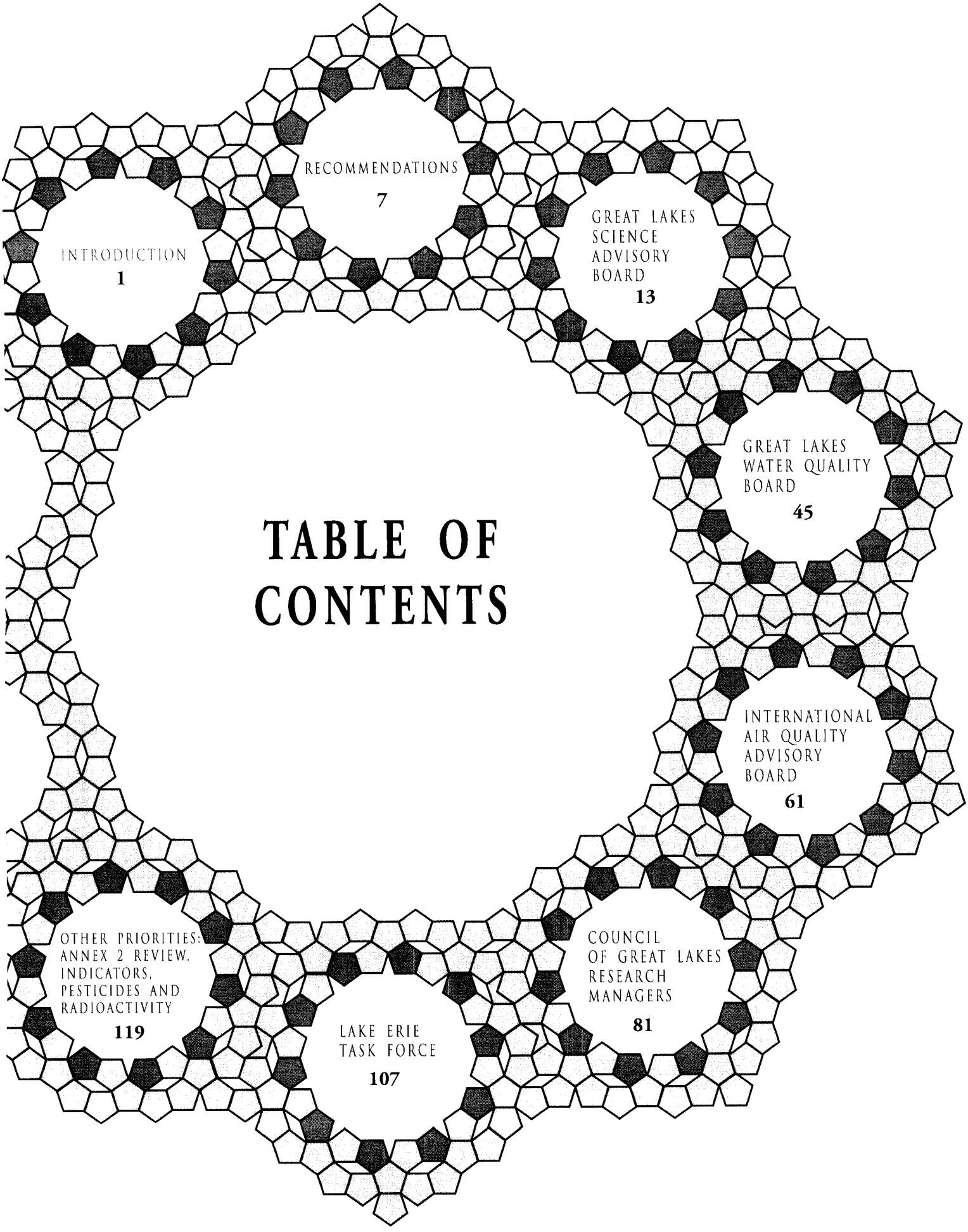

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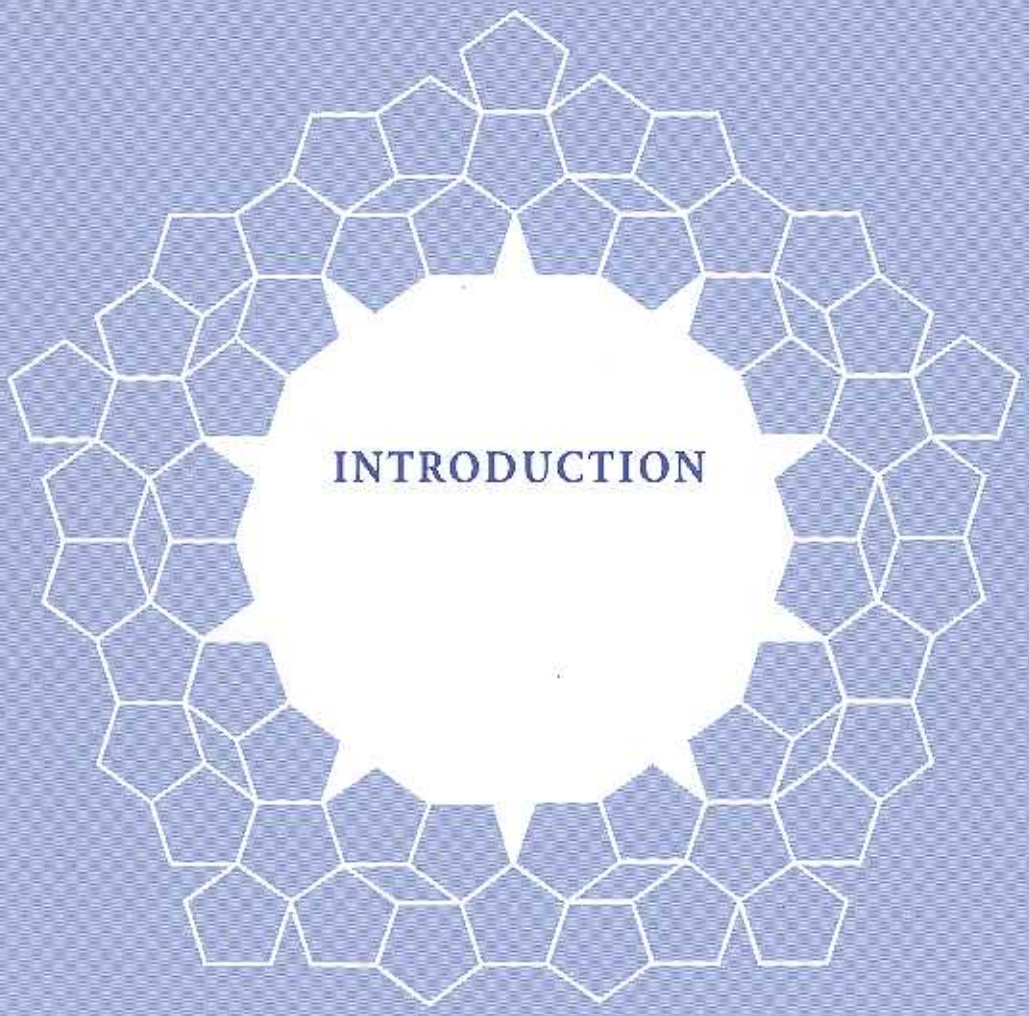

INTRODUCTION

INTRODUCTION

In the **Great Lakes Water Quality Agreement**, the **United States and Canada** (the Parties) agreed "to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem." To achieve this purpose, the Parties have undertaken numerous programs, policies and other measures and have obligated themselves to periodic reporting on their progress.

The **International Joint Commission**'s (IJC) role is to evaluate and assess the Parties' programs and provide a report at least every two years that presents its findings, advice and recommendations. To fulfill its evaluative role, IJC relies upon numerous sources. Major sources of information and assistance are the two joint institutions established under the Agreement -- the **Great Lakes Water Quality Board** (WQB) and the **Great Lakes Science Advisory Board** (SAB).

As principal advisor to IJC, WQB is composed of 20 program managers and administrators drawn from the two federal governments, the eight states and two provinces in the Great Lakes-St. Lawrence River basin. SAB, whose 18 members represent a broad range of disciplines, provides science advice to both IJC and WQB.

To provide advice related to Great Lakes research, IJC in 1984 established a **Council of Great Lakes Research Managers**, whose 22 members are responsible for research programs related to implementation of the Agreement. Given the significance of the air as a pathway by which contaminants reach the waters of the Great Lakes, IJC relies on its **International Air Quality Advisory Board** (IAQAB), established in 1966 under the auspices of the Boundary Waters Treaty, to provide advice in this regard. IJC also establishes task forces and other groups to address specific issues or subjects that are particularly germane to fulfilling the Agreement purpose.

Recognizing the need to secure the views and opinions of basin stakeholders, IJC also engages in a variety of public consultation activities. The information received from this broad-based consultation contributes significantly to the insight, advice and recommendations that IJC provides to governments through its biennial reports.

To focus its human and financial resources, IJC relies on a biennial priority setting process. The priorities for the current 1995-97 cycle were drafted in summer 1995, presented publicly for discussion at the September 1995 biennial meeting held in Duluth, Minnesota and formally adopted by IJC Commissioners on November 20, 1995. Subsequently, IJC undertook additional work related to indicators to evaluate Agreement progress and also defined the nature of the work to be undertaken in support of Annex 2 of the Agreement. The 1995-97 priorities are summarized in the following table. Responsibility to undertake the priorities was assigned to WQB, SAB, IAQAB, the Council, the Lake Erie Task Force, the Nuclear Task Force, the Indicators Implementation Task Force, and the Annex 2 Advisory Committee.

The six chapters in this report were prepared by the group or groups responsible for the identified priorities. They define and describe the specific investigations undertaken to support each priority and present the groups' findings, conclusions and recommendations. No attempt was made to harmonize the content or recommendations, as they represent each group's particular advice to IJC with respect to their charge and obligations.

This report is the second in a series. The first, published in August 1995, presented findings and advice for priorities established for IJC's 1993-95 biennial cycle.

The six chapters in this report . . . define and describe the specific investigations undertaken to support each priority and present the groups' findings, conclusions and recommendations.

PRIORITY	**PERSISTENT TOXIC SUBSTANCES: IMPACT ON HUMAN AND ECOSYSTEM HEALTH**
SUMMARY	Assemble and consider new evidence particularly pertaining to the disruption of the endocrine system of wildlife and humans by the 11 critical pollutants and other persistent toxic substances, and the effect of these substances on the neurobehaviour of animals and humans. Evaluate any progress made in reducing or eliminating effects as well as identification of policy issues.
RESPONSIBILITY	Lead: Science Advisory Board Support: Water Quality Board and Council of Great Lakes Research Managers
PRODUCT (CHAPTER)	1.2.1 - Trends in concentrations and effects — Page 16 1.2.2 - Neurobehavioural toxicology and policy implications — 21 2.4 - Uniform and fully protective fish consumption advisories — 50 4.2.3 - Research contributions — 90

PRIORITY	**PERSISTENT TOXIC SUBSTANCES: SIGNIFICANT SOURCES AND PATHWAYS, MEASUREMENT AND REDUCTION / ELIMINATION**
SUMMARY	• Identify significant pathways for persistent toxic substances to the Great Lakes. • Identify and quantify persistent toxic substances in the air, their human health and other effects, and suggest ways to decrease levels and effects. • Identify air deposition from sources internal and external to the basin. • Assess current information on research about emissions from incinerators and their contribution to persistent toxic substance loadings to the basin. • Review activities of the U.S. and Canadian governments under long-range transport of air pollutants. • Evaluate global reduction / elimination strategies and assess their implication in existing and possible future strategies for the Great Lakes.
RESPONSIBILITY	Lead: Water Quality Board and International Air Quality Advisory Board Support: Science Advisory Board
PRODUCT (CHAPTER)	3.3.1 - Overview — Page 65 3.3.2 - Key needs and priorities for problem assessment — 66 3.3.3 - Key needs and priorities for problem response — 67 3.3.4 - atmospheric transport and deposition, mass balance modelling and deposition monitoring, progress in emission reduction, beyond compliance programs — 69 3.2 - Policy statement: municipal waste incineration — 63 1.3.1 - PCBs: new equilibrium? — 25 1.3.3 - SOLEC: purpose and utility — 27 2.3 - Strategies — 50 2.5 - Sale of mercury — 51 4.2.3 - Research contribution — 90

PRIORITY	**PERSISTENT TOXIC SUBSTANCES: REMEDIATION AND MANAGEMENT OF CONTAMINATED SEDIMENT**
SUMMARY	Assess government activities and programs; identify available options and technologies for remediation, destruction and storage of persistent toxic substances in sediments, with particular consideration to the contaminated sediment component of RAPs and LaMPs, including methods of funding and public acceptance of the approaches.
RESPONSIBILITY	Lead: Water Quality Board Support: Science Advisory Board and Council of Great Lakes Research Managers
PRODUCT (CHAPTER)	2.2 - Overcoming sediment remediation obstacles — Page 47

PRIORITY	**PESTICIDES**	
SUMMARY	Because of potential impacts on fish and wildlife population and considerations of human health, assess changes in pesticide usage patterns and application rates, thereby helping to evaluate ongoing Parties' programs.	
RESPONSIBILITY	Lead: Great Lakes Regional Office	
PRODUCT (CHAPTER)	6.3 - Workshop and public consultation	Page 127

PRIORITY	**IMPROVING THE EFFECTIVENESS OF GREAT LAKES RESEARCH**	
SUMMARY	Given substantial budget cuts and scientific staff reductions to Great Lakes research programs, investigate improving the effectiveness of research by eliminating duplication, sharing information and programs to protect needed research, and identify cost-saving strategies.	
RESPONSIBILITY	Lead: Council of Great Lakes Research Managers, in consultation with Great Lakes researchers	
PRODUCT (CHAPTER)	4.2.2 - Budget survey: funding reductions	Page 84
	4.2.3 - White paper: improving research effectiveness	90
	4.2.4 - Advice from public meeting	94
	4.2.5 - Advice from SOLEC session	94
	4.2.6 - Advice from IAGLR plenary	98
	4.3 - Research inventory status	103

PRIORITY	**LAKE ERIE ECOLOGICAL MODEL**	
SUMMARY	Develop the framework and infrastructure necessary to sustain a process for ecosystem modelling of Lake Erie, thereby increasing understanding of that lake's ecosystem and leading to enhanced ability to evaluate Agreement progress and render resource management decisions. Adjust and improve the 1994-95 Lake Erie model by incorporating further proposed modifications. Consider also health issues related to persistent toxic substances.	
RESPONSIBILITY	Lead: Lake Erie Task Force Support: Water Quality Board, Science Advisory Board and Council of Great Lakes Research Managers	
PRODUCT (CHAPTER)	5 - Task Force investigations, model development and use	Page 107

PRIORITY	**INDICATORS**	
SUMMARY	To implement the advice provided by the Indicators for Evaluation Task Force in 1996	
RESPONSIBILITY	Lead: Indicators Implementation Task Force	
PRODUCT (CHAPTER)	6.2 - Task Force investigations	Page 125

COMMISSION PRIORITIES FOR 1995-97 (continued)

PRIORITY	**ANNEX 2: REMEDIAL ACTION PLANS AND LAKEWIDE MANAGEMENT PLANS**		
SUMMARY	To assist the Parties in the development and implementation of RAPs and LaMPs through: conducting status assessments to evaluate activities, workshops to transfer information and foster implementation, and RAP and LaMP reviews in order to gauge progress toward restoration of beneficial uses.		
RESPONSIBILITY	Lead:	Annex 2 Advisory Committee	
PRODUCT (CHAPTER)	6.1.1	- AOC special report	Page 121
	1.3.2	- AOC site visits: Detroit River and Hamilton Harbour	26
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	4.2.3	- Research effectiveness	90
	2.6	- Future of RAPs	52
	6.1.5	- LaMP status	123

PRIORITY	**NUCLEAR**		
SUMMARY	Provide an inventory of radionuclides in the basin		
RESPONSIBILITY	Lead:	Nuclear Task Force	
PRODUCT (CHAPTER)	6.4	- Task Force investigations, radioactivity sources, monitoring data, inventories and findings	Page 127

PRIORITY	**OTHER**		
SUMMARY	Identify and provide insight and advice on other topics relevant to fulfilling the Agreement purpose and in accordance to the directives to WQB and SAB, including emerging issues.		
RESPONSIBILITY	Lead:	All	
PRODUCT (CHAPTER)	1.4.1	- Governance	Page 30
	1.4.2	- Ecological economics	34
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RECOMMENDATIONS

RECOMMENDATIONS

The following 40 recommendations were developed by the Science Advisory Board, the Water Quality Board, the Council of Great Lakes Research Managers and the Lake Erie Task Force for the Commission's consideration. Substantiating details are provided in the sections indicated.

SCIENCE ADVISORY BOARD

Environmental Results: Trends in Concentrations and Effects of Persistent Toxic Substances Page 16

SAB recommends the following.

- The Parties commit to the long-term funding of herring gull egg and lake trout monitoring projects and formalize these projects as programs by naming them in the Agreement.
- The Parties formalize the use of addled eggs and sampled bald eagle blood as biological materials suitable for establishing trends in the concentrations of organochlorine pollutants in Great Lakes biota.
- The Parties make funding available to sample, radiodate and analyze representative sediment cores for persistent toxic substances from each Great Lake and results be made available to researchers undertaking retrospective injury assessment.
- The Parties formally name species to be used as indicators in relation to the virtual elimination policy contained in the Agreement and devise and implement a formal bilateral program for long-term monitoring of the changes in the observed rates of embryotoxic and functional teratogenic effects.
- The Parties request the Great Lakes Fishery Commission and fish and wildlife agencies to consider whether population declines and extirpations of certain Great Lakes fish and mammals during this century might be attributable, in part, to exposures to persistent toxic substances.
- The Parties investigate the feasibility of devising and implementing a formal program pursuant to the Agreement to document trends in the observed rates and severity of functional teratogenic effects on humans caused by exposures to persistent toxic substances.
- The Parties use information from studies of the structural teratogenic effects of contaminants in populations of wildlife as sentinels for teratogenic effects in humans.

PCBs, A New Equilibrium? Workshop on Steady State Page 25

SAB recommends the following.

- The Parties increase funding for monitoring PCBs and other persistent toxic substances in Great Lakes biota, air, water and sediment.

RAP Progress: Site Visits to Two Areas of Concern

Page 26

SAB recommends the following:

- IJC develop a systematic framework for evaluating RAPs.

State of the Lakes Ecosystem Conference

Page 27

SAB recommends the following:

- The Parties clarify to IJC the role of the State of the Lakes Ecosystem Conference in fulfilling their obligation to report on the status of the Great Lakes basin ecosystem.
- The Parties invite IJC's collaboration in preparation of SOLEC '98 and that IJC clarify how it proposes to fulfil its evaluative role at the completion of that conference.

Governance

Page 30

SAB recommends the following:

- The Parties, together with jurisdictional representatives and other basin stakeholders, form an expert binational committee to review the organizational and institutional arrangements that support the Agreement and offer recommendations needed to ensure the effective implementation of the Agreement in the 21st century.
- IJC diligently pursue its strategic-planning exercise through an inclusive process involving Commissioners, board members, staff, governments and all basin stakeholders.
- As part of the strategic planning process, IJC identify program evaluation as the highest priority and initiate necessary budgetary, staffing and work plan adjustments to support this priority.
- IJC explore and pursue measures necessary to ensure that the Parties respond publicly to all IJC recommendations in a timely and substantive manner.
- IJC encourage the Parties to use the biennial State of the Lakes Ecosystem Conference to provide an assessment of the state of the lakes as a basis for determining progress under the Agreement, as well as an opportunity to respond to IJC recommendations.
- The Parties conduct a review of the adequacy of the Agreement, given the evolving state of basin governance and the need for the Agreement and its institutions to both adapt to and influence that evolution.
- IJC document and quantify the benefits of its products and services in the form of a "return on investment" analysis for use by the Parties, legislative bodies and all basin stakeholders.
- IJC aggressively pursue the feasibility of alternative sources of funding to complement its current sole reliance on U.S. and Canadian federal appropriations.

Ecological Economics as an Emerging Issue

Page 34

SAB recommends the following:

- The Parties commission a study, using the methods of ecological economics, to evaluate the practical value of utilizing the ecological economics approach.

Foodweb Dynamics in Aquatic Systems as an Emerging Issue

Page 35

SAB recommends the following:

- Great Lakes researchers address water quality nutrient and contaminant issues together with monitoring for a quantitative assessment of foodweb and production dynamics in the Great Lakes.

- IJC foster linkages and increased communication with agencies responsible for fisheries management and exotic species (e.g. the Great Lakes Fishery Commission).

- IJC develop an interdisciplinary task force similar to its Lake Erie Task Force to explore developments, models, monitoring and data needs on the effects of foodweb structure and nutrient loading on contaminant levels in biota.

- IJC encourage new research initiatives in the following areas:
  1. quantitative evaluation of foodweb structure and trophic transfer on a lakewide basis, including diet analysis;
  2. relationships of contaminant bioaccumulation in relation to size, age and condition of the predominant prey fish in the Great Lakes (e.g. bloater, alewife, rainbow smelt);
  3. sources (i.e. atmospheric, sediments, landfill sites) of contaminants to the foodweb, to answer where do PCBs in fish come from?;
  4. the consequences of changing foodweb structure on contaminant levels in fish (e.g. linkages with Lake Erie Ecological Modelling Project); and
  5. development of appropriate and innovative monitoring tools (e.g. growth rates) that can be used to detect foodweb changes that have an impact on contaminant cycling.

WATER QUALITY BOARD

Fish Consumption Advisories Page 50

WQB continues to recommend the following.

- IJC emphasize to the Parties the need for uniform and fully protective fish consumption advisories.

Remedial Action Plans Page 52

WQB recommends the following.

- The Parties and RAP stakeholder groups adopt a step-wise approach to use restoration and demonstration of incremental progress in order to sustain RAP processes.

Other Great Lakes Issues Page 54

WQB recommends the following.

- IJC keep a balanced perspective as it establishes and addresses its 1997-1999 priorities.

Watershed Management Page 56

WQB recommends the following.

- IJC encourage the Parties to quantify and communicate to all stakeholders the values and benefits of practical actions to protect and enhance habitats ensuring continued progress toward healthy and sustainable watersheds and ecosystems.

Habitat 2001 Page 58

WQB recommends the following.

- Great Lakes water quality and fisheries institutions convene workshops and roundtable discussions focussing on sharing habitat knowledge and experiences, and transferring technologies, in order to help sustain management efforts, and to further progress toward endorsement of one common set of ecosystem objectives for each lake.

COUNCIL OF GREAT LAKES RESEARCH MANAGERS

Funding for Great Lakes Science Page 84

The Council recommends the following.

- The Parties, in cooperation with the jurisdictions, re-evaluate the direction, substance and mechanisms of proposed research program reductions in order to maintain the scientific foundation for management programs and to deliver on their commitments in the Agreement.
- IJC and the Parties take the view that investment in Great Lakes science results in substantial economic and ecosystem benefits.

Improving the Effectiveness of Great Lakes Research Page 101

The Council recommends the following.

- The use of existing partnership mechanisms continue and new mechanisms for establishing research partnerships be crafted with special emphasis on the formation of international partnerships.
- Government agencies collaborate with universities on focussed, client-driven research projects that will result in an improved scientific basis for management decisions.
- Researchers be actively involved in the decisionmaking processes of RAPs and LaMPs through membership on RAP and LaMP teams and advisory councils. In addition, research results must be incorporated in all RAP and LaMP reports to strengthen research management linkages.
- IJC, as a priority for the 1997-99 biennial cycle, address the effective communication of research results.
- Coordination of Great Lakes research vessels continue and IJC sponsor future vessel coordination workshops.
- To establish research priorities, government agencies share the responsibility with both scientists who are familiar with Great Lakes research needs and also users of research results.
- Government agencies support the concept of a lakewide, binational, coordinated, multi institutional project that would cover all aspects of a given problem domain in a given system.

LAKE ERIE TASK FORCE Page 107

The Lake Erie Task Force recommends the following.

- IJC mandate its Council of Great Lakes Research Managers to provide a regular forum for Lake Erie modellers, researchers and managers to share information, discuss progress and explore potential linkages among complementary Lake Erie modelling initiatives.
- IJC use ecosystem models in its evaluation of progress under the Agreement.

Chapter One:

GREAT LAKES SCIENCE ADVISORY BOARD

CHAPTER ONE *Contents*

1.1 INTRODUCTION

How do you know what you know? This was the question posed at a small workshop held May 29, 1997 to consider new evidence of the effects of chemicals found in the Great Lakes/St. Lawrence River system on human health, held in conjunction with the **Science Advisory Board's** (SAB) meeting in Hamilton, Ontario. How certain are scientists that eating contaminated Great Lakes fish prior to or during pregnancy results in neurobehavioural deficits in infants exposed *in utero*? How sure are we that the changes were caused by PCBs and not by DDE? How solid is the evidence that eating fish from the St. Lawrence River results in a loss of attention and memory in adults?

In the 19th century, philosophers played a significant role in the practice of science. In this century, philosophers and scientists have developed specialized disciplines for their spheres of interest and nowhere is this more apparent than in the environmental sciences. Is there a role for philosophers in the practice of environmental sciences and particularly in relation to bilateral approaches to transboundary pollution under the Great Lakes Water Quality Agreement?

A large part of the initiatives to manage pollutants in the U.S. and Canada is assumed under the policy of pollution prevention using well established risk-assessment methodologies. This approach is essential for addressing substances currently being released into the ecosystem or that are likely to come into commerce as new chemicals. The challenge for scientists and regulatory officials working in the Great Lakes basin however, is to address the continuing injury to human health and resources caused by past commercial practices involving persistent toxic substances. The scientific aspects of defining injury and its causes, assessing trends, and evaluating progress are the essence of the activities of SAB and central to the recommendations in this report.

Since the time of Aristotle, philosophers of science have pondered causes and effects, but only in the past 150 years have scientists applied epidemiologic methods to human health. Only in the past 40 years have health practitioners, authorities and researchers systematized the philosophical underpinnings of the knowledge of the causal relationship of certain diseases to specific pollutants. These were codified by the United States surgeon general in 1964, in relation to the causal relationship between lung cancer and cigarette smoking (U.S. Surgeon General 1964). They have been similarly codified as epidemiological criteria and applied by Sir Austin Bradford Hill to a range of occupational and environmental diseases and were addressed by SAB in its chapter of the 1993-95 Priorities Report (IJC 1995; Hill 1965). In terms of research on human health, recent initiatives have resulted in a series of definitive statements about the injury and the specific causal agents. In turn, these statements now form the specific knowledge on which regulatory officials can act to formulate new policies with confidence using existing laws to restore the integrity of the waters of the Great Lakes basin ecosystem.

In fulfilling its broad mandate to provide science advice under the Agreement, SAB's three work groups (Ecosystem Health, Emerging Issues and Parties Implementation) addressed an IJC priority for the 1995-97 biennial cycle on health, and identified several other topics upon which it developed its independent advice. While each activity has its own salience, taken together, they could also be viewed in terms of new scientific knowledge or research needs, and its relevance for policymakers in implementing the Agreement and sustaining progress.

"The scientific aspects of defining injury and its causes, assessing trends, and evaluating progress are the essence of the activities of SAB and central to the recommendations in this report."

It is clear, based on findings from the Workshop on Environmental Results: Monitoring and Trends of Effects Caused by Persistent Toxic Substances; the Workshop on PCBs, the New Equilibrium?; and Foodweb Dynamics in Aquatic Systems, that increased monitoring is needed in order to evaluate progress towards restoration. Similarly, the review of institutional performance in terms of remedial action plan (RAP) progress, State of the Lakes Ecosystem Conference (SOLEC) and governance, reveals the need for a systematic approach to achieve the purpose of the Agreement, based on efficacy and accountability. As an emerging issue, ecological economics holds potential as a new way to understand the effect of man's activities by applying economic analysis to model the interaction between the economy and the ecosystem. Finally, creating a linkage between science and policy, the Workshop on Policy Implications of Evidence Regarding Toxic Substances and Human Health, held September 5-7, 1997, addressed what actions are needed to respond to the new research findings related to neurobehavioural effects of persistent toxic substances. The findings and recommendations from this workshop will be submitted to IJC as a special report from SAB.

1.2 WORK GROUP ON ECOSYSTEM HEALTH

1.2.1 Environmental Results: Trends in Concentrations and Effects of Persistent Toxic Substances

Introduction

Article IV of the Boundary Waters Treaty states that the boundary waters shall not be polluted on either side to the injury of health or property on the other. During the first half of the present century, the Great Lakes became progressively more contaminated with a variety of persistent toxic substances. In 1978, the Parties to the Great Lakes Water Quality Agreement agreed to a new policy stating that the discharges of any or all persistent toxic substances be virtually eliminated. The second half of the present century has been marked by extensive investment by governments and industries to treat and control discharges and emissions of pollutants, including persistent toxic substances. The results have been encouraging, and concentrations of many persistent toxic substances have decreased markedly during the past 25 years, though the recent data indicate little, if any, change in the concentrations of persistent toxic substances in the past decade.

There is extensive evidence that concentrations of persistent toxic substances were sufficiently high to have resulted in toxicological effects on populations of exposed organisms, including humans. The assumption has been made that with the decreasing levels of these substances in the Great Lakes, the incidence of these toxicological effects would concomitantly decline. IJC, in preparing its 1995-97 priorities for the work to be undertaken by SAB, directed it to host a workshop examining this assumption and report on the adequacy of the monitoring programs undertaken by the Parties to determine trends in the concentrations and effects of persistent toxic substances in the Great Lakes basin.

Workshop on Environmental Results

SAB held a Workshop on Environmental Results September 12-13, 1996 in Windsor, Ontario. The workshop commenced with a keynote address by Donald Tillitt describing the advances that had been made in demonstrating causal relationships between the observed effects in wild populations and exposures to a few persistent toxic substances. There were subsequent presentations on the results of monitoring for trends in concentrations of persistent toxic substances in a variety of media such as air, water and sediments, as well as in biota, such as lake trout and other fish species, herring gull eggs and human blood. Presenters were Paul Baumann, Christine Bishop, William Bowerman, David Carpenter, Carol Edsall, Peter Ewins, Glen Fox, Keith Grasman, Diane Henshel, Raymond Hoff, Hal Humphrey, James Ludwig, Melanie Neilson, Wolf Scheider, Deborah Swackhammer, Chip Weseloh and Mike Whittle.

Presentations were made on a variety of effects noted at various levels of biological organization in populations of species that have been shown to have been affected by exposures to persistent toxic substances in the Great Lakes basin. These effects include the trends in the reproductive and population status of bald eagles, ospreys, herring gulls, double crested cormorants, lake trout and snapping turtles; differential recruitment of Caspian terns to colonies in the United States and Canada; the incidence of a variety of anomalies in physiological and biochemical markers, such as porphyrins, vitamin A storage and thyroid status in herring gulls; and the incidence of papillomas and liver tumours in brown bullheads. Populations of humans have been exposed to persistent toxic substances from Great Lakes foodwebs and a presentation was made concerning effects in humans and particularly their offspring. The detailed technical papers are to be published as proceedings in the peer-reviewed literature in *The Environmental Monitoring and Assessment Journal.*

Reasons for Monitoring for Trend

Monitoring for the observed rates of effects should be an integral part of the procedures for the assessment of toxic chemicals for environmental management and cleanup. In most cases, scientists investigating chemically-induced effects start with either an analytical finding of contaminants in the environment or a biological observation of effects occurring in wildlife. Frequently, both are found and lead to the formulation of hypotheses about possible causal relationships. The contaminant levels and the observed effects are linked in an exposure assessment from which preliminary inferences about cause and effect are made. Hypotheses are then formulated and tested through laboratory studies to determine whether the particular chemicals detected could have caused that kind of effect. These inferences about the putative causal agents can lead to further refinement and to agent identification.

Agent identification is complex in the Great Lakes environment and in many other environments because the contaminants are so strongly correlated. One of the most difficult tasks in determining causal relationships is in

providing defensible evidence that contaminant A, rather than contaminant B, is the critical agent contributing to the observed effect when this is indeed the case. The identification of a critical agent is necessary to provide scientifically defensible advice on which regulatory interventions can be based. The attainment of this objective may be made even more difficult by additive and interactive effects, such as synergism or antagonism. In addition, there may be confounding factors from physical stressors such as temperature, light and humidity. Once the agents have been identified, critical sources can be identified and connected to the environmental and biotic contamination with an environmental transport model.

The information about the identification of the agent and the specific sources can be transmitted to the authorities responsible for source management. There are two kinds of source management relevant to the Great Lakes. One is a very broad scale, such as the banning of pesticides, the banning of lead in gasoline or the limitation of PCBs to closed systems. In addition, there is management of local sources, including the clean up of specific hazardous waste sites that are contributing to the general contamination of the Great Lakes. Much of this source management has been helpful. There have been changes in the levels of contamination and changes in the magnitude and nature of some of the effects. Scientists can investigate these changes to refine the process, improve the evidence for cause-effect relationships and give the managers better information to manage the sources.

"Much of this source management has been helpful. There have been changes in the levels of contamination and changes in the magnitude and nature of some of the effects."

Source management can lead to some changes in contamination levels that can be measured for trends which, in turn, can lead to trends in effects. With measurements showing changes in contamination levels and information on how these relate to the changes in effects, exposure assessments can be revised, and inferences about cause and effect can be verified. The question of whether the original inference that the observed effect was due to contamination with a specific chemical usually leads to additional laboratory studies.

Differential changes in contamination, when one chemical's level changes more than another chemical's level, can lead to some further verification of agent identification, an improvement in the evidence for identifying specific chemicals, improvement of source identification and in the environmental transport modelling. Finally, these findings can lead to informing the managers of the effectiveness of their actions concerning the sources, and to a reevaluation of their programs.

The elements in the process with the greatest uncertainty are the cause-and-effect inferences, and particularly in relationship to fish and mammals. In humans, the cause-and-effect relationships are difficult to establish because the various sources of exposures to substances cannot be controlled. There has been considerable difficulty in agent identification because different chemicals and possible confounding factors appear in the same places and tend to correlate with many of the effects. Similarly, there has been some difficulty with source identification, but this has improved because sources are now much better characterized. As well, there has been improvement in the verification of environmental transport models enabling managers to better understand pathways and mass balance in terms of the whole system.

Adequacy of the Parties' Programs for Monitoring for Effects

In determining the adequacy of the Parties' programs for monitoring changes in the concentrations of persistent toxic substances and in the observed rates of effects, there is a need to develop a set of criteria by which to evaluate the development of a program.

Species

The workshop participants reviewed several candidate species that have been used and that could be used for monitoring trends in concentrations and effects. The preparation of the lists of candidate species relies on accumulated knowledge of the species that should be present in the Great Lakes region and on those that were extirpated or injured due to exposures to persistent toxic substances. It is assumed that as the concentrations of persistent toxic substances decline, the injured populations will recover and extirpated species can be reestablished. A series of review papers has been published relating the various outbreaks of disease in the Great Lakes to exposures to persistent toxic substances (Gilbertson 1989; Mac and Gilbertson 1990; Best, Gilbertson and Hudson 1990; Addison, Fox and Gilbertson 1991; Gilbertson 1992; Schneider 1991). There are several databases of effects and exposures that could be used to compile further linkages between causes and effects on a retrospective basis and taking potential confounding factors into consideration, particularly for fish and mammals.

In evaluating the adequacy of the Parties' programs, there is a need to review the selected species in relation to the geographic and temporal scale being indicated. There should not be only species sampled to report on large-scale trends, such as declines in the incidence of pollutant effects in an entire lake, but also adequate sampling of species to reflect changes at the local or regional level. Similarly, the program should be sufficiently flexible to respond to the possibility that the introduction of new species into the Great Lakes may create new critical pathways of pollutants to indigenous species. For example, the introduction of the zebra mussel to the Great Lakes has led to the increased

contamination of scaup and old squaw ducks while on their Great Lakes wintering grounds, and there are indications that these species are experiencing reproductive anomalies at their breeding grounds in the Arctic.

Observational, Sampling, Archiving and Analytical Protocols

In the evaluation of the Parties' programs there is a need to evaluate the degree of standardization of the various protocols for observation of the rates of effects in the field or, in the case of humans, in clinical examinations. With declines in the concentrations of persistent toxic substances in the past 25 years, more sensitive biological measurements have been developed. Similarly, the sampling strategies, including sampling frequency, for the collection of biological materials for analysis and archiving should be assessed. The evaluation should include consideration of the quality assurance/quality control for the chemical analytical determinations.

The adequacy of systems to store, retrieve and process information on the concentrations of pollutants and on the outbreaks of chemically-induced disease and deformities should be assessed. Similarly, trends in the concentrations of persistent toxic substances and in the observed rates of effects that can be reported on a regular basis, in the scientific literature or on a web site, should be investigated.

Interpretation of Results

The purpose of the Parties to the Agreement is "to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem." To help achieve this end, the policy, in part, states "the discharge of any or all persistent toxic substances be virtually eliminated." The evaluation should consider whether the Parties have formulated realistic biological objectives by which to judge whether the policy has been achieved.

Funding

The implementation of a program to determine long-term trends in the concentrations of persistent toxic substances and in the incidence of biological effects requires committed long-term funding. Thus, the Parties' programs should be evaluated in terms of a long-term commitment to funding.

Assessment for Trend

The most reliable means for the retrospective assessment of contamination in the Great Lakes basin with persistent toxic substances is from analysis of radiodated sediment cores. Sampling of other abiotic materials, such as air and water, and of biological materials, such as fish and wildlife, started after the peak concentrations of persistent toxic substances occurred in the early 1970s. Sediments can be recovered from a period before the contamination with most of the pollutants of concern. About seven sites have been analyzed and show that Lake Ontario was generally more contaminated than Lake Michigan, which was more contaminated than Lake Superior. The sediment data show that the period of greatest contamination occurred between about 1958 and 1973. Levels declined significantly until the early 1980s, since which time declines in concentrations have generally become progressively smaller or nonexistent.

There have been extensive sampling and analysis of water samples since 1986 to determine the long-term changes in concentrations, particularly in the connecting channels. The available data are consistent with the evidence from the sediment samples and show that the concentrations have been decreasing slowly in the past decade. The program to monitor the concentrations of persistent toxic substances in air was started in 1990, and thus the air data are even more recent than the water data. The results from the first five years of sample collection and analysis are not inconsistent with the trends indicated by the sediment and water analyses.

". . . the Parties' programs should be evaluated in terms of a long-term commitment to funding."

Lake trout have been sampled for trend evaluation by the Canada Department of Fisheries and Oceans, since 1977 and their analyses provide a reliable data set. Samples of lake trout tissues have been archived for retrospective analysis. Concentrations have declined in the past 20 years, but there has been no perceptible change in concentration in the last decade.

There are excellent long-term data for herring gulls since the monitoring project was started in 1974 by the Canadian Wildlife Service. There is an extensive tissue archive that has been used to compare results from different analytical methodologies, to identify previously undetected substances and retrospectively to construct exposures. The results show that the concentrations of organochlorine pollutants declined rapidly between 1975 and the early 1980s, but that further declines have been slow or imperceptible.

There are no established projects to determine trends in the concentrations in Great Lakes populations of mammals, amphibians, reptiles or humans.

There are essentially no projects being undertaken to document trends in the observed rates of effects in any group of organisms except birds. There are effects documented in the reproduction of lake trout, snapping turtles and in human development, but there are no data on the trends in the observed rates of these effects in these organisms.

The evidence for the long-term trends in the observed rates of effects in birds from exposures to persistent toxic substances is remarkably well developed. The data for the status of the Great Lakes population of bald eagles originated in the mid-1960s when the concentrations of organochlorine pollutants were still increasing. The Great Lakes bald eagles were the most heavily contaminated of all the populations studied at that time, and the population was almost extirpated from throughout the Great Lakes region by 1970. With the decline in the concentrations of DDT, dieldrin, PCBs and other organochlorine compounds during the 1980s, some Great Lakes shoreline populations have been reestablished, naturally or artificially, with offspring from less-contaminated inland populations. Similarly, the decline in the organochlorine concentrations has resulted in the reestablishment of ospreys in Georgian Bay, aided by the involvement of local communities in protecting the breeding habitat and in constructing artificial nesting platforms.

"The sediment data show that the period of greatest contamination occurred between about 1958 and 1973. Levels declined significantly until the early 1980s, since which time declines in concentrations have generally become progressively smaller or nonexistent."

There are extensive long-term data on the status of Great Lakes populations of double crested cormorants and a reliable set of causal relationships established between observations of specific effects and exposures to specific organochlorine pollutants. This species was almost extirpated from the Great Lakes basin as a result of eggshell thinning and breakage caused by exposures to DDT and metabolites. This species also is susceptible to exposures to compounds with a toxicological mode of action similar to the polychlorinated dibenzo-*p*-dioxins, including the planar PCBs and the polychlorinated dibenzofurans. The observed rates of deformities and of embryo mortality in various Great Lakes colonies is correlated with this dioxin-like activity on a colony basis. With the decline of concentrations of these organochlorine compounds in the Great Lakes, the populations of double crested cormorants have dramatically increased. Similarly, there are data showing that the incidence of deformities in cormorant chicks has declined, but there are still areas of the Great Lakes, such as Green Bay and Saginaw Bay, where the incidences of deformities are high.

One of the longest data sets on Great Lakes birds is the banding of Caspian terns. Caspian terns can be successfully recaptured in their colonies with the use of cannon nets. Analysis of banding returns has suggested that chicks fledged from Canadian colonies tend to be less contaminated than United States colonies, are more viable and are recruited as adults into the breeding colonies at a higher rate. In addition, birds fledged in Canadian colonies tend to be recruited as breeding adults into the United States colonies at a much greater rate than United States birds. The most recent data, collected for 1990-92, do not indicate that the young from the United States colonies are yet being recruited into the U.S. breeding colonies at a comparable rate.

"Caspian terns can be successfully recaptured in their colonies with the use of cannon nets . . . birds fledged in Canadian colonies tend to be recruited as breeding adults into the United States colonies at a much greater rate than United States birds."

Findings and Recommendations

Trends in Concentrations in Organisms and the Environment

SAB finds that the Parties to the Agreement have adequate long-term monitoring projects to document gross trends in the concentrations of organochlorine pollutants in Great Lakes biota. These monitoring projects include the annual sampling, analysis and tissue storage of herring gull eggs and lake trout. SAB recommends the following.

- **The Parties commit to the long-term funding of herring gull egg and lake trout monitoring projects and formalize these projects as programs by naming them in the Agreement.**

SAB finds that the removal of addled eggs and sampling of bald eagle blood and their analysis and storage have been a valuable means for documenting the trends in the concentrations of organochlorine pollutants in locations where the Great Lakes population was not extirpated by organochlorine pollutants or where the population has reestablished territories. SAB recommends the following.

- **The Parties formalize the use of addled eggs and sampled bald eagle blood as biological materials suitable for establishing trends in the concentrations of organochlorine pollutants in Great Lakes biota.**

The use of radiodated sediment cores as a means of reconstructing the history of contamination of the Great Lakes is a recent technological advance. Based on the few available results, the period of most severe contamination occurred between about 1958 and 1973. The concentrations of persistent toxic substances declined markedly between 1975 and 1980 but since then, trends have been less evident. SAB recommends the following.

- **The Parties make funding available to sample, radiodate and analyze representative sediment cores for persistent toxic substances from each Great Lake and results be made available to researchers undertaking retrospective injury assessment.**

Based on the available evidence from long-term monitoring of the concentrations of persistent toxic substances in the eggs of herring gulls and tissues of lake trout and from radiodated sediment cores, SAB finds that the concentrations of organochlorine compounds declined between the mid-1970s and the early 1980s, but decline since the mid-1980s has been less evident.

Trends in Effects in Great Lakes Organisms

SAB finds that, while the Parties to the Agreement have several projects investigating the potential use of various species and toxicological measurements, there is no formal program for monitoring the long-term changes in the observed rates of the effects of organochlorine pollutants on any Great Lakes species. Reliable causal links have been established between toxicological measurements at various levels of biological organization and exposures during this century to a few specific organochlorine pollutants in a few species. These measurements included the rates of deformities, reproductive failure, biochemical or behaviourial anomalies or the demise and recovery of populations of several Great Lakes species. These few species include the bald eagle, herring gull, double crested cormorant, Caspian tern, Forster's tern and snapping turtle. These persistent toxic substances include DDT and metabolites, dieldrin, PCBs, dibenzo-*p*-dioxins and dibenzofurans. These persistent toxic substances are both embryotoxic and structural and functional teratogens. SAB recommends the following.

- **The Parties formally name species to be used as indicators in relation to the virtual elimination policy contained in the Agreement and devise and implement a formal bilateral program for long-term monitoring of the changes in the observed rates of embryotoxic and functional teratogenic effects.**

SAB finds that there is a noteworthy lack of case studies relating effects in Great Lakes fish and mammal populations to exposures to persistent toxic substances and, thus, no fish or mammal species can be recommended at this time as an indicator of changes in the observed rates of effects of persistent toxic substances. In the Gulf of St. Lawrence, the status of the beluga whale population has been related to exposures to persistent toxic substances, some of which come from the Great Lakes. SAB recommends the following.

- **The Parties request the Great Lakes Fishery Commission and fish and wildlife agencies to consider whether population declines and extirpations of certain Great Lakes fish and mammals during this century might be attributable, in part, to exposures to persistent toxic substances.**

Observed rates of effects on populations of Great Lakes species exposed to persistent toxic substances have been surveyed. Based on available evidence, SAB finds that embryonic deformities and mortality in gulls, terns and cormorants still occur in highly contaminated areas. The rates have declined compared with the rates in the 1970s, and are highest in the areas that are most contaminated with compounds with dioxin-like activity. The reestablishment of subpopulations of bald eagles on Great Lakes shorelines still contaminated with persistent toxic substances has resulted in increased reports of deformed eaglets.

Trends in Concentrations and Effects in Humans

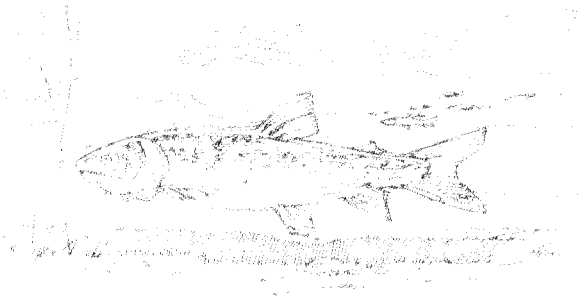
The evidence from a limited number of epidemiological studies shows that the consumption of Great Lakes fish by humans has resulted in elevated levels of persistent toxic substances. SAB finds that there is no formal program under the Agreement to document trends in concentrations of persistent toxic substances in the Great Lakes population.

Prenatal exposure of human infants to persistent toxic substances from maternal consumption of Great Lakes fish has resulted in effects on neurological development, though the scale of the occurrence and severity of this phenomenon within the Great Lakes population has not been documented. SAB finds that the Parties do not have a formal program to monitor the long-term trends in the incidence of teratogenic effects in human infants. SAB recommends the following.

- **The Parties investigate the feasibility of devising and implementing a formal program pursuant to the Agreement to document trends in the observed rates and severity of functional teratogenic effects on humans caused by exposures to persistent toxic substances.**

The documentation of observed rates in the incidence of teratogenic effects on human health from exposures to persistent toxic substances may not be feasible in the immediate future. Thus, there is a need for an indicator of structural and functional teratogenesis in humans. PCBs are the major persistent toxic substances causing structural deformities in various species of fish-eating birds in the Great Lakes basin and suspected to be causing functional anomalies in neurological development in humans. SAB recommends the following.

- **The Parties use information from studies of the structural teratogenic effects of contaminants in populations of wildlife as sentinels for teratogenic effects in humans.**



1.2.2 Persistent Toxic Substances: Neurobehavioural Toxicology and Policy Implications

Introduction

During the past 15 years, the scientific community has expressed a growing awareness and interest in the effects of persistent toxic substances on neurological structure and function of exposed Great Lakes organisms. In October 1995, IJC assigned a priority of addressing human and ecosystem health to SAB that comprised three elements:

- assemble and consider new evidence, particularly pertaining to the disruption of the endocrine system of wildlife and humans, by the 11 critical pollutants and other persistent toxic substances and the effect of these substances on the neurobehaviour of animals and humans;
- organize an international scientific meeting to identify what is known regarding factors that normally affect neurobehaviour and the effects of persistent toxic substances through the endocrine system, especially gender-specific neurobehaviours; and
- hold a workshop with invited experts on the policy implications on behalf of IJC.

SAB directed its Work Group on Ecosystem Health to undertake these assignments.

Within the past five years, several international conferences have been held addressing various aspects of the neurotoxicological effects of persistent toxic substances and particularly those that have disrupted endocrine systems in humans. In June 1993, a workshop was held at Berkeley, California on perinatal exposure to dioxin-like compounds (Golub and Jacobson, 1995). An extensive review of the functional aspects of polyhalogenated aromatic hydrocarbons, based on a workshop held May 1994 in Wageningen, Netherlands, and organized by the European Environmental Research Organization, has recently been published (Brouwer et al. 1995). Many of the leading researchers studying neurobehavioural toxicology convened at a workshop held November 5-10, 1995 in Erice, Sicily and reached a consensus that the dioxin-like compounds can and have affected the neurobehavioural development of human infants. They produced a consensus statement that detailed their concerns (Colborn et al. in press).

Epidemiological Evidence and Review of Neurobehavioural Effects

The first epidemiological evidence of neurobehavioural injury to infants from prenatal exposure to Great Lakes pollutants was reported in 1984 from a cohort established in 1980 in western Michigan (Fein et al. 1984). Infants of mothers who had eaten Lake Michigan fish prior to and

during pregnancy had higher levels of PCBs in the cord blood, lower birth weight and a smaller head circumference than those infants whose mothers reported eating no fish. The exposed infants had a shorter gestational age and had poorer neuromuscular development. In subsequent testing at seven months, the more highly exposed infants exhibited poorer visual recognition memory and were smaller than the reference group (Jacobson et al. 1985). At four years, there was an inverse exposure dependent relationship with verbal and numerical memory and short-term memory processing ability (Jacobson et al. 1990). At 11 years, the strongest effects related to memory and attention. The most highly exposed children were three times as likely to have low IQ scores and twice as likely to be at least two years behind in reading comprehension (Jacobson and Jacobson, 1996a).

Another cohort, the Oswego cohort, was established in 1990 through 1994 in New York. The objective was to investigate the neurological effects of maternal consumption of Lake Ontario fish on offspring (Lonky et al. 1996). The more highly exposed group of infants showed the same psychomotor deficits at birth as those documented in the western Michigan cohort in the 1980s. An additional assessment showed the infants habituated poorly to an aversive stress.

In addition to these Great Lakes epidemiological studies of the neurobehavioural effects of PCBs, relevant studies have been undertaken in other parts of the world, including the North Carolina cohort in the United States (Rogan et al. 1986), the Yu-Cheng cohort in Taiwan (Lai et al. 1993) and a cohort of infants in the Netherlands (Huisman et al. 1995).

Since the original research was reported there has been lively discussion because of the social, economic and political implications of the findings. Schantz (1996), in her review of the evidence of teratogenic effects in humans, raised questions relating to research methodology and to differences in the effects observed between studies. Jacobson and Jacobson (1996b) responded to these methodological issues in relation to potential confounding factors, unmeasured control variables and selection of the participants in the cohort. In addition, they reviewed four possible factors involved in the reported variability of the effects between the various studies and commented on the similarity to the variability of the effects reported in studies of prenatal exposures to alcohol and lead on infant development. These four factors were: 1) the pattern and timing of the exposure; 2) the socioeconomic status of the cohort; 3) the reliability of the outcome measures assessed; and 4) the procedures followed in administration of the assessments.

The Health Conference '97 - Great Lakes/St. Lawrence River

Since the late 1980s, the Parties have spent more than $30 million for various investigations on the effects of pollutants on human health under the Agreement. In the United States, Congress amended the Great Lakes Critical Programs Act in 1990 and supported a program of health research on persons residing in the Great Lakes basin. The **Agency for Toxic Substances and Disease Registry** was designated as the responsible agency for overseeing the Great Lakes Human Health Effects Research Program. This program was designed to investigate and characterize the potential for short- and long-term health effects, particularly in susceptible populations, from exposures to Great Lakes contaminants. In 1989, as part of the Great Lakes Action Plan, Health Canada undertook a program to study the impact of the region's environment on the health of the human population in the Great Lakes basin. In 1993, Health Canada and the Quebec Ministry of Health and Social Services jointly implemented the St. Lawrence 2000 Action Plan as a federal-provincial research program with five years of funding. These agencies held a conference in Montreal, May 12-15, 1997, to enable the various scientists involved in the research to present their results. Research relevant to the interpretation of this information and the risk communication issues related to it also was presented.

SAB was one of several sponsors of the conference, thereby fulfilling its responsibility under the IJC priority, to convene an international scientific meeting. Its support was provided so that researchers who had relevant data on neurodevelopmental effects from outside the Great Lakes/St. Lawrence River basin could present their information. A roundtable discussion on the Public Health Implications of Neurobehavioural Effects specifically addressed the current human research in this area. The panelists were Joseph Jacobson, Corine Koopman-Esseboom, Walter Rogan and Thomas Darvill. The discussants were Deborah Rice and Renate Kimbrough. The session was facilitated by Susan Schantz. The results of the studies on five human cohorts exposed to PCBs/dioxins *in utero* were briefly presented. Discussion of the limits of epidemiologic studies and the role of mercury as a possible confounder occurred. The majority opinion on the panel was that the weight of evidence supports PCBs (or more specifically a set of PCB congeners) as the agent responsible for neurodevelopmental effects (dioxin in the Dutch cohort) and that, taken together with the Michigan, North Carolina, Dutch, Yu-Cheng and Oswego cohorts provide a coherent epidemiological picture of neurodevelopmental effects related to PCBs/furans/dioxins. There is ongoing research with Inuit communities and with the Oswego cohort that will help determine which PCB congeners are involved in neurobehavioural effects and what role other persistent toxic substances may play in an additive or interactive fashion.

In other studies reported at the conference, one showed a dose-response correlation between Lac St-François and Lac St-Louis fish consumption and motor slowing and attention deficits in adult fish consumers (Mergler et al. 1997). However, another study's preliminary results indicate that fine motor slowing in older fish eaters in a Michigan cohort was not evident (Schantz et al. 1997). Preliminary research also was presented that shows consumption of contaminated fish may affect fertility. A negative effect on fertility on retrospective assessment was found in a Michigan cohort (Courval et al. 1997), but not in a New York cohort (Buck et al. 1997). Research on both cohorts is ongoing and these studies may provide very important information once the final results of the prospective assessments are in.

General Assessment

Earlier research found an increase in birth weight associated with PCBs related to fish consumption, but at exposure levels lower than the Jacobson cohort that found a negative effect (Dar et al. 1992). Another study failed to find evidence of fetal death related to PCB exposure through fish consumption (Mendola et al. 1995). The growing body of animal evidence, from both the laboratory and from wild populations in the field and from mechanistic research, indicates that dioxin-like compounds are definitely neurotoxic for mammals and birds. Developmental effects found in reptiles, amphibians and fish are consistent in implicating the same chemicals although the effects are not specifically neurotoxic. This work indicates that changes in thyroid hormones and neurotransmitters individually or together at critical periods of *in utero* development are involved in the observed neurological changes. These effects have been found in wildlife and experimental animals at levels of exposure that overlap the range of exposures and body burdens found in the North American human population (Brouwer et al. 1995; Henshel et al. 1997a,b, and in press; DeVito et al. 1995).

"PCBs/dioxins or a specific subset of congeners are the agents responsible for at least part of the observed difference in neurobehavioural outcomes for the infants exposed to these teratogenic agents in utero."

Human health effects, including a reduction in IQ for the children exposed *in utero*, are clearly evident in the Yu-Cheng cohort exposed to PCBs and associated polychlorinated dibenzofurans and quaterphenyls (Chen et al. 1992). A similar reduction has been found in the Michigan cohort for whom PCB exposure was much lower (Jacobson et al. 1996a). Neurodevelopmental effects have been reported in the Oswego cohort at even lower levels of exposure (Lonky et al. 1996; Darvill et al. 1997).

There is coherence of the epidemiological evidence among the various studies and a corroboration of that evidence with the findings in wildlife and laboratory experimental studies. This coherence and corroboration provide support for the conclusions of the researchers undertaking the studies of the Michigan and North Carolina cohorts and of the preliminary conclusions from the Oswego cohort, that PCBs/dioxins or a specific subset of congeners are the agents responsible for at least part of the observed difference in neurobehavioural outcomes for the infants exposed to these teratogenic agents *in utero*.

Despite the limits and weaknesses of individual pieces of research, the collective weight of evidence indicates that certain PCB/dioxin-like compounds found in fish in the Great Lakes/St. Lawrence River basin, and elsewhere, can cause and have caused neurobehavioural deficits of Great Lakes fish consumers. The evidence indicates that these compounds have produced some effects in the offspring highly exposed *in utero*. The importance of these effects at current levels of PCBs in fish, either to the individual or a population basis, is not known.

There may be a threshold at which these effects are not significant even as a population-wide effect. However, there is the possibility of widely based, though subtle effects, on fish consumers that would be very difficult to demonstrate conclusively by epidemiological methods. The weight of evidence indicates there also may be reproductive and immunological effects. Public health and other policy responses are therefore warranted. Similar conclusions were reached by the Agency for Toxic Substances and Disease Registry. As a consequence, this agency cooperated with U.S. EPA Region 5 in distributing 1.5 million fish-consumption advisories in Michigan.

The effects on individuals are likely to be in terms of subtle functional deficits, such as a decrease in IQ, and do not represent a severe public health danger even for high-risk populations in the Great Lakes basin. The public health case for action is based on the change in a measure of functional capacity, such as IQ, within the exposed population. In terms of a distribution curve, the proportions of the population that fall into the high and low ends of the curve could be significantly altered. Thus, in an exposed population, there could be a reduced number of potentially gifted individuals and an increased number of disabled individuals. The case for action also is based on the rights of individuals and communities to know the risks to which they are exposed. These risks are addressed in part through fish-consumption advisories.

The research at the Montreal Conference highlighted other relevant factors.

- There is significant variation in exposure to PCBs and methyl mercury, depending on where the fish were caught and which fish species consumed.
- There are considerable health benefits from fish consumption that can be demonstrated in human populations with "background" exposure to persistent toxic substances through other dietary sources.
- Wildlife consumption is important economically and culturally for many communities in the Great Lakes/St. Lawrence River basin, especially American Indian/First Nation communities.

The research presented at the conference has provided much better estimates of the patterns of fish consumption in the Great Lakes/St. Lawrence River region and on the

size of the population exposed. It is, however, not clear what the exposure threshold is for human-health effects related to PCBs/dioxins in the fish. It is also clear that mercury exposure for some communities is the more significant concern. A broad range of chemicals has been identified as potential endocrine disruptors but only lead, mercury, PCBs and dioxins have been shown epidemiologically to actually affect the neurobehavioural development of human infants.

The weight of evidence accumulated through the research efforts of the Parties and the public health interventions taking place through fish consumption advisories make it imperative to have a fuller exploration of the policy implications of the presence of these toxic substances in Great Lakes/St. Lawrence River basin fish.

Policy Goals

Issues in several areas need to be articulated into a series of practical options to address the following policy goals.

- The reduction of inputs of mercury, PCBs and dioxins into airsheds and watersheds wherever possible (e.g. the effort to eliminate incineration of medical polyvinyl chloride waste in the United States (Thornton et al. 1996).
- The clean up of hazardous waste sites and destruction of stored PCBs in order to reduce the leakage of PCBs into the environment.
- Fish-consumption advisories that communicate the right message effectively. These messages must balance risks and benefits and be based on personal/community choices as much as possible in order to reduce the consumption of the most contaminated fish species and fish populations.

Policy Implications Workshop

The Work Group on Ecosystem Health hosted a workshop on Policy Implications of Evidence Regarding Toxic Substances and Human Health. The workshop was held at the Wingspread Conference Center in Racine, Wisconsin, September 5-7, 1997. The workshop comprised a select group of approximately 35 persons from diverse sectors of the Great Lakes community. The action-oriented discussion from the workshop will produce information to help IJC fulfill its Agreement obligations. The results from the Montreal conference were integrated and made accessible for the participants of this workshop to help ensure that all participants shared a common base of information about the scientific underpinnings of related policy issues. The policy implications workshop was therefore the link between scientific findings and the identification of policies and actions that are warranted.

"The weight of evidence accumulated through the research efforts of the Parties and the public health interventions taking place through fish consumption advisories make it imperative to have a fuller exploration of the policy implications of the presence of these toxic substances in Great Lakes/St. Lawrence River basin fish."

1.3 WORK GROUP ON PARTIES IMPLEMENTATION

1.3.1 Workshop on PCBs, the New Equilibrium?

A workshop entitled PCBs, the New Equilibrium? was held September 10, 1996 in Windsor, Ontario, under the auspices of the Work Group on Parties Implementation. Work Group members and 19 invitees gathered to hear a number of presentations and to discuss issues around the question of whether PCB concentrations in the Great Lakes are reaching a new equilibrium. Presenters were Ross Norstrom and Craig Hébert, Paul Mac Berthoeux, Stephen Carpenter, Daniel Smith, Craig Stow and Leland Jackson. John Giesy served as moderator.

The term "new equilibrium" as applied to the lack of change in concentration of PCBs in the Great Lakes was brought to light in 1993 by a discussion in the preamble to proposed U.S. EPA rules widely referred to as the Great Lakes Initiative (U.S. EPA 1993). That discussion centred on PCB and DDT concentration trends in lake trout and salmon that seem to indicate a slowing in the rate of decline. The discussion highlighted the policy implications by concluding that, " ... if a new equilibrium is being reached, given current mass loadings, then substantial further reductions in mass loadings to the lakes will be necessary to eliminate fish advisories." It is noteworthy that quite early in the workshop, objection was raised to the use of the term "equilibrium" in this context because of the theoretical thermodynamic connotations. There was consensus that a better term, such as "steady state" or "quasi-steady state," would be more appropriate, and these terms were used throughout the remainder of the workshop.

The impetus for the workshop came from a debate emerging in the literature over whether PCB concentrations in Great Lakes biota are indicating the establishment of a steady state with existing loadings. Dr. Stow was the main presenter in support of the position that a steady state is being approached. His focus was on sophisticated regression analysis of data from biota. Dr. Smith was the main presenter of an alternative view that available data from biota are not very useful for addressing the question, and that other data tend to refute the steady-state hypothesis. He supported his position using a combination of mathematical and mechanistic reasoning. Mr. Hébert made a presentation partially corroborating this position by presenting one possible foodchain mechanism in operation. Because many of the analyses presented at the workshop were based on herring gull egg data collected by the Canadian Wildlife Service, Dr. Norstrom described the nature of the data and the implications of trying to analyze them. As Dr. Stow's work is heavily rooted in statistical regression modeling, Dr. Berthoeux presented a primer on this topic with an emphasis on the challenges environmental data can present. Professor Carpenter and Dr. Jackson discussed aspects of monitoring and management of PCBs in the Great Lakes. A variety of reference materials were distributed to the attendees in advance of the workshop (Smith 1995a,b,c; Jeremiason et al. 1994; Stow 1995a,b; Stow et al. 1994, 1995).

Findings and Recommendation

There was clear consensus that when this issue is discussed in the future, the term "steady state" should be used to characterize the hypothesized phenomenon rather that the term "equilibrium."

While there was no consensus on the main question, there was general agreement by the participants that PCB levels will continue to decline. Dr. Smith suggested a reasonable estimate for biota in lakes Ontario and Superior over the next 10 years might be 5 percent average annual decline. Dr. Stow declined to make a quantitative estimate, preferring to characterize the likely declines in the near future as small or nearly zero.

There was also general agreement that even the most optimistic assumption of a constant percentage annual decline will mean lower and lower absolute declines every year. This will make the detection of those declines even more difficult.

Given the likelihood of ever-decreasing absolute declines in PCB concentration, the importance of continued and increased monitoring, not only of biota, but also of abiotic (i.e. air, water and sediment) components will grow. Current decreases in funding of such monitoring are opposite of what is needed if there is to be any hope of understanding how PCB concentration trends are proceeding.

Options for the abatement of PCB levels in biota on a basinwide scale are limited by the widespread and diffuse nature of the major sources (e.g. atmospheric input and sediment recycling). This does not mean that abatement is necessarily impractical in localized areas, such as Areas of Concern, or other areas where sources are well characterized and can be controlled.

Factors that cause perturbation of the foodchain (e.g. weather effects, population collapse, exotic species introductions, stocking programs) can cause fluctuations in biota

PCB levels that are unrelated to system loadings and concentrations. Consequently, biota trends cannot be assumed to reflect trends in loading (see discussion in section 1.4.3).

Changes in analytical methodologies over the years can confound the ability to discern trends in PCBs in the environment. Some workshop participants suggested that researchers should analyze for trends, both with and without early portions of the data record to learn if this confounding is significant.

As the workshop produced no clear answer to the question of PCBs in the Great Lakes approaching steady state, no recommendations on such a finding are forthcoming. However, based on the conclusions from the workshop, SAB recommends the following.

- **The Parties increase funding for monitoring of PCBs and other persistent toxic substances in Great Lakes biota, air, water and sediment.**

Without such expanded monitoring, the scientific basis for policy decisions regarding persistent toxic substances in the Great Lakes will continue to erode. The workshop made it clear, moreover, that monitoring of biota alone is insufficient to elucidate trends.

1.3.2 RAP Progress: Site Visits to Two Areas of Concern

The mandate of the Work Group on Parties Implementation is to assess the activities of the Parties in meeting their obligations under the Agreement. Fundamental among those obligations are the remedial action plans (RAPs) for the Areas of Concern. In the past two years, there have been major reductions in government funding for RAP activities. The Work Group previously expressed concern regarding the potential for these cuts to reduce the effectiveness of RAPs, but also has sought to meet with selected RAP participants to learn firsthand about progress under RAPs and how budget reductions might affect that progress.

The first meeting was held in Detroit, Michigan, November 20, 1996. The Detroit River RAP, like other connecting channel RAPs, includes participation from both countries, and thus two frameworks for legislation, administration and infrastructure. The second meeting was held in Burlington, Ontario, May 27-28, 1997, to discuss the Hamilton Harbour RAP.

The objective of these meetings was to focus on the scientific issues associated with RAPs, particularly examining the research challenges related to contaminated sediments, airborne deposition and biological effects. Each meeting offered an opportunity to hear invited presentations by scientists currently working on RAP-related research, advisory committee members and other interested parties.

The Work Group heard a variety of evidence. The complexity of each RAP and the diversity of information available pointed to the need for a systematic basis of comparison. Without such a basis, the Work Group concluded that a direct comparison of any one RAP with another and with its own stated goals would be almost impossible. Conclusions from the presentations follow.

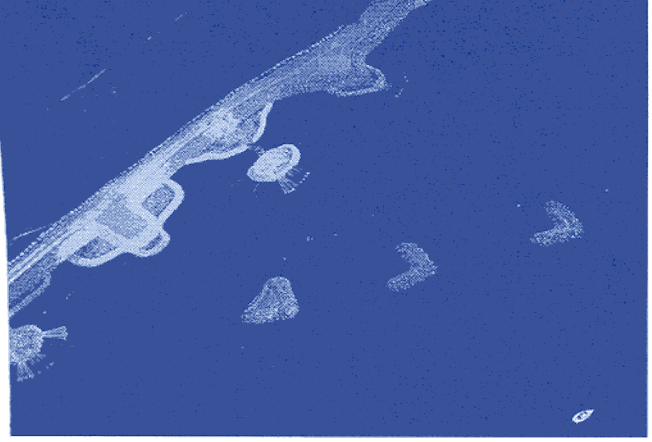
- Each RAP was able to demonstrate progress in some respects (e.g. reductions in the volume and frequency of combined sewer overflows in both areas, improved quality and extent of wildlife habitat in Hamilton Harbour). Progress on remediation of contaminated sediments has, however, been slow in both RAPs. The reasons for this appear to relate to delays in source controls, incomplete or inconsistent scientific evidence regarding the source of the problem and the efficacy of proposed remedial measures, and the need to share clean-up costs among public and private sources.

- Progress in some areas may be constrained by highly variable sources (e.g. sewage treatment plant effluents, combined sewer overflows) and by continuing population growth within the RAP areas. Indeed, the present and historic sources of persistent toxic substances and the current status of those sources may be unknown.

- Funding cuts are having a local impact and affecting RAP progress. In relation to binational RAPs, such as the Detroit River, these cuts may constrain the ability of the RAP to sustain a binational public process to complete the plans. Funding cuts also have affected the availability of research funding, particularly in Canada, and thus the availability of research in key areas that would support implementation choices/ decisions with confidence.

- Sometimes, funding cuts are achieved by reducing funding for independent (e.g. university-based) research and relying solely on government research. This can result in the loss of outside peer review, a process that is essential for the preservation of scientific integrity and the maintenance of the scientific credibility of the conclusions and recommendations of RAP developers. Reduction of independent research funding and peer evaluation also may limit the dissemination of scientific knowledge which could be applied elsewhere in the basin.

- The Detroit River RAP has defined a scope based on political, rather than watershed boundaries. As a result, broader ecosystem, including foodweb, impacts resulting from local air emissions and cumulative effects may be overlooked or underestimated. This may limit the utility of the "ecosystem approach" as envisaged under Annex 2 of the Agreement. In contrast, the Hamilton Harbour RAP has taken a watershed approach.



Habitat enhancement such as these nesting islands for colonial waterbirds has been a very successful component of the Hamilton Harbour RAP.

This May 1997 photograph demonstrates the considerable recreational use of Hamilton Harbour despite the continued input of contaminants from industry.

"the Hamilton Harbour RAP has taken a watershed approach."

A positive, trust-based relationship was evident in Hamilton among government agencies, university researchers, members of the general public and other interested stakeholders. This relationship appears to be central to the development of consensus about the importance of individual sources and the urgency of remedial measures. Good communication among stakeholders also may facilitate risk communication and risk management where sources and mechanisms of impact are complex.

Where communication problems do exist among stakeholders, as appears to be the case in the Detroit River RAP, dispute resolution procedures may be helpful in restoring trust among the participants.

See Chapter 6 for additional discussion of the Detroit River and Hamilton Harbour RAP reviews.

Recommendation

SAB recommends the following.

- **IJC develop a systematic framework for evaluating RAPs.**

The framework should include elements such as:

1. clear goals and objectives;
2. resource inputs (e.g. human and fiscal resources for administration, contractors, government and university/other research);
3. number of peer-reviewed publications related to the program and its goals;
4. number and type of activities (e.g. public outreach, industrial and municipal liaison);
5. total and annual number of participants in program activities;
6. nature and extent of volunteer participation;
7. nature and number of stakeholders who consistently decline to participate and their expressed reasons;
8. total and annual funding for monitoring and surveillance activities since program initiation;
9. reactions in the community directly attributed to the program including, for example, measurable changes of knowledge, practice and skills; and
10. changes in environmental condition (i.e. movement toward delisting goals) directly attributable to RAP activities.

This framework should be applied by IJC and its advisers when undertaking RAP site assessments and also would be beneficial as guidance during the development of the RAPs.

1.3.3 State of the Lakes Ecosystem Conference

The 1978 Agreement, as amended in 1987, marked a major shift in how both IJC and the Parties interpreted and responded to the terms of the Agreement. The most evident shift was in the manner in which planning, data acquisition, analysis and reporting took place to assess the state of the Great Lakes basin ecosystem and to evaluate the Parties' progress under the Agreement.

The most significant reporting initiative by the Parties since 1987 has been a biennial State of the Lakes Ecosystem Conference (SOLEC) with the most recent taking place in November 1996. Two objectives of the first conference, SOLEC '94, " ... were to promote better decision-making through improved availability of information, and to review current information and to find out where there were data gaps" (United States and Canada, 1995). The process adopted involved the preparation of topical background papers that became the focus for discussion at the conference itself. Six papers were prepared and distributed prior to the conference: aquatic health, human health and health risks, aquatic habitat and wetlands, toxic contaminants, nutrients and economy-environment linkages. A

summary integration document also was prepared. The Parties selected a number of indicators to assess the health of and stresses on various components of the ecosystem. Of particular note is the continuing success the Parties have achieved in addressing the nutrient stresses in the lakes. The Parties highlighted the continuing loss of both the quantity and quality of habitat and wetlands.

While SOLEC '94 spanned both nearshore and open-lake issues, but was limited in its objectives, SOLEC '96 was more limited in geographic scope, but broader in its objectives. SOLEC '96 identified five objectives:

- inform local decisionmakers of environmental issues affecting nearshore areas of the Great Lakes basin;
- provide information on the state of the nearshore ecosystem to help strengthen decisionmaking and management within the basin;
- develop support for an integrated environmental information system and help direct plans and programs;
- provide information on existing Great Lakes strategies and build cooperative actions needed to strengthen and complement them; and
- provide a forum for improved communication and network building for involved groups and individuals within the basin.

Five background discussion papers were prepared addressing nearshore waters, coastal wetlands, nearshore terrestrial (land by the lakes), land use, and information and information management. The Parties acknowledged that land use continues to be the major source of stress on the nearshore ecosystem. The prevailing pattern of development of urban sprawl consumes vast areas of land and destroys natural habitat and farmland.

While the two conferences provided forums for presentation of a range of technical papers and discussions related to the Great Lakes basin ecosystem, neither conference provided a comprehensive assessment of the state of the lakes. By scheduling the conferences between the issuance of IJC biennial reports under the Agreement, and by titling the conferences "State of the Lakes Ecosystem," it was assumed by some members of the Great Lakes community that SOLEC was intended to be a mechanism for Party reporting under the Agreement.

Prior to amending the Agreement in 1987, biennial reporting of the state of the Great Lakes basin ecosystem and progress under the Agreement was carried out mainly through a committee infrastructure under the Water Quality Board (WQB). The Great Lakes International Surveillance Plan provided the basis for responding to the requirements specified in Annex 11 of the Agreement. Surveillance and monitoring data and information collected by the Parties and jurisdictions, sometimes raw but most often already interpreted, were provided to IJC's Great Lakes Regional Office. Here they were assembled and draft state-of-the-lake reports prepared by WQB's Surveillance Work Group. Data provided included facilities' compliance records from municipal and industrial sources, nonpoint source pollution, airborne toxic substances, radioactivity and other monitoring data related to the Great Lakes basin ecosystem. WQB subsequently reported biennially to IJC on such areas as "Progress under the Agreement" and "State of the Lakes." The last such report to IJC took place in 1989 as responses to the 1987 amendments were evolving. While WQB's reports were brief summaries of the surveillance and monitoring data available to the Surveillance Work Group, a more comprehensive appendix was prepared to support the findings, conclusions and recommendations of the WQB's report.

"The Parties acknowledged that land use continues to be the major source of stress on the nearshore ecosystem. The prevailing pattern of development of urban sprawl consumes vast areas of land and destroys natural habitat and farmland."

In 1989, subsequent to the 1987 amendments to the Agreement, WQB's committee infrastructure was dissolved. The Parties committed to the biennial preparation of state-of-the-lakes reports and also the development of a binational surveillance and monitoring program for the Great Lakes. The 1987 amendments also added new annexes and revised existing ones. The new annexes focused on such areas as RAPs and LaMPs, pollution from nonpoint sources, contaminated sediment, airborne toxic substances, pollution from contaminated groundwater and research and development. Many annexes specified that the Parties would report to IJC biennially their progress in implementation.

"While committed to reporting biennially on the state of the lakes, as well as on specific annexes, reporting by the Parties has remained sporadic and inconsistent."

While committed to reporting biennially on the state of the lakes, as well as on specific annexes, reporting by the Parties has remained sporadic and inconsistent. The last U.S. report to IJC, in September 1995, was not responsive to the reporting requirements addressing the state of the lakes. Canada also reported in 1995, submitting its "First

Progress Report Under the 1994 Canada-Ontario Agreement respecting the Great Lakes Basin Ecosystem." Again, the report was essentially a program overview responsive to the Agreement targets and not an assessment of the state of the lakes. In each case, the reports were not coordinated binationally nor did they report on the requirements for a joint surveillance and monitoring program. WQB's 1989 report to IJC, supported by the Surveillance Work Group's 1987 Appendix B (GLWQB 1989a,b) still remains as the most recent and most comprehensive assessment of the status of the Great Lakes basin ecosystem and, therefore, progress under the Agreement.

Finally, the problem of assessing the status of the Great Lakes basin ecosystem and reporting on progress towards the goal of sustainability was considered by the National Roundtable on the Environment and Economy in their report "Pathways to Sustainability: Assessing Our Progress" (Hodge et al. 1995). The National Roundtable noted three criteria for effective assessment and reporting on progress as:

- the freedom and resources to function independently;
- the stature and capability to link successfully with any appropriate element of the existing institutional web; and
- assured longevity of existence to ensure that an institutionalized memory is created and assessment is undertaken periodically.

It concluded that IJC was the only existing mechanism that has the potential of meeting these criteria.

SOLEC '98 will focus on the issue of indicators, providing an opportunity to build on the report, "Indicators to Evaluate Progress under the Great Lakes Water Quality Agreement," prepared by IJC's Indicators for Evaluation Task Force (IETF 1996). As noted in the report, "The development of indicators and evaluation of progress are dynamic, interactive and evolving processes that will require coöperation between the governments and the Commission. The Task Force hopes this report will provide the Commission with useful guidance to encourage governments and others to consider a set of desired outcomes and associated indicators, as well as the data and information necessary and sufficient to evaluate progress under the Agreement." SOLEC '98 would be an excellent opportunity for IJC to collaborate with the Parties in determining the process for measuring, reporting and evaluating Agreement progress and for ensuring that the data and information needs necessary for the success of the process are identified. IJC, however, must ensure that its role as an independent evaluator is not compromised as a result of this collaborative initiative.

Recommendations

SAB recommends the following.

- **The Parties clarify to IJC, the role of SOLEC in fulfilling their obligation to report on the status of the Great Lakes basin ecosystem.**

- **The Parties invite IJC's collaboration in the preparation of SOLEC '98 and that IJC clarify how it proposes to fulfil its evaluative role at the completion of that conference.**

"IJC, however, must ensure that its role as an independent evaluator is not compromised as a result of this collaborative initiative."

1.4 WORK GROUP ON EMERGING ISSUES

1.4.1 Governance

Introduction

By its very nature, Great Lakes basin governance is in a continuous state of evolution, adapting to the ever-changing socioeconomic, environmental and political priorities of policy makers and opinion leaders. Basin governance must overcome the incongruency between geo-political and hydrologic boundaries -- a formidable challenge in an expansive, binational setting where the magnitude and complexity of the physical ecosystem is rivalled by that of the institutional ecosystem. Multi-jurisdictional, basin-oriented institutions play a pivotal role in this process. They provide a forum within which stakeholders can coordinate their shared implementing roles and focus on a common set of problems and opportunities. They provide a framework for nurturing new ideas and governance innovations, while functioning as a buffer to temper the impact of individual and collective change among relevant political jurisdictions. Further, in often subtle ways, such institutions can have a substantive impact on the nature and direction of basin governance.

Great Lakes basin governance is in the midst of profound change, brought on by equally profound changes in jurisdiction philosophies and approaches toward environmental protection and resource management. As a preeminent binational institution operating under the authority of the Boundary Waters Treaty of 1909 and the Agreement, IJC must demonstrate vision and leadership in this time of change. To succeed, the IJC must be open to change itself and to a fundamental rethinking of its mission and procedures and a willingness to adopt any resultant structural and operational innovations.

SAB, through its Work Group on Emerging Issues, emphasizes the importance and timeliness of an objective review and reassessment of IJC roles and procedures in the context of basin governance. SAB further recognizes that a window of opportunity has presented itself. An IJC strategic planning process is presently underway, affording an excellent opportunity for the governments, Commissioners, board members, staff and constituents to assess current efforts and prepare for the future. Further, following release of the next IJC biennial report, Article X of the Agreement calls on the Parties to "conduct a comprehensive review of the operation and effectiveness of this Agreement." And, finally, in April 1997, President Clinton and Prime Minister Chrétien requested that IJC "examine its important mission" and advise on how it "might best assist the parties to meet the environmental challenges of the 21st century."

The following discussion presents an overview of the evolution of Great Lakes basin governance, the role of IJC, an acknowledgment of institutional analyses conducted in recent years and findings and recommendations SAB has endorsed.

In April 1997, President Clinton and Prime Minister Chrétien requested that IJC "examine its important mission" and advise on how it "might best assist the parties to meet the environmental challenges of the 21st century".

The Evolution of Great Lakes Basin Governance

Great Lakes basin governance might best be characterized as a century old experiment in institutional design. Both individually and collectively, the myriad political jurisdictions in the binational basin are constantly reorienting themselves to reflect the ever changing socioeconomic, environmental and political priorities of their constituents. Multi-jurisdictional, basin-oriented institutions must adapt accordingly to ensure that progress in meeting established goals is maintained.

The present era of basin governance, with its roots in the early to mid-1980s, features the transition from a top-down, command and control, government-dominated approach to a bottom-up, partnership-based, inclusive approach. The evolution to this new era was not the product of a single, orderly, calculated strategy. It was the outcome of multiple — and not necessarily mutually compatible — developments. For example, the past decade has seen a pronounced change in both U.S. federal/state and Canadian federal/provincial relationships. Devolution of authority has placed additional management responsibilities on state and provincial governments that, in turn, have looked to local governments to share those responsibilities. At the federal level, the regulatory emphasis of past years is tempered by a growing emphasis on voluntary

compliance and less-prescriptive means of achieving standards. Fiscal constraints, downsizing and the "reinvention" of government are commonplace. And, a rising ethic of self-determination, stewardship and collaboration at the local level has seen a growth in community empowerment and watershed-based institution building.

To some, transformation to this new era is regarded as a step backward: an era of declining budgets, a compromised regulatory framework, a research infrastructure at risk and government downsizing that does little more than pass the burden of stewardship from one level of government to the next. To others, the transformation is regarded as a step forward: management responsibilities are assumed by the level of government closest to the resource and the people; limited funds promote added efficiency; state, provincial and local governments are empowered; and an overly prescriptive regulatory framework is tempered by voluntary compliance.

While both perspectives offer legitimate arguments, ready agreement is reached on one point. All basin stakeholders, within government and out, need to develop and pursue creative approaches to basin governance that ensure efficiency and effectiveness in a time of change and uncertainty. Binational basin institutions have an obligation to meet this challenge, to shape an evolving governance regime in response to changes within individual political jurisdictions. To accommodate and influence change within the broader institutional ecosystem, basin institutions must be open to internal change as well. This is a critically important consideration for IJC, given its role in basin governance.

The International Joint Commission and its Role in Basin Governance

IJC is a permanent bilateral body created under the auspices of the Treaty to prevent disputes relating to boundary water usage and to settle questions arising along the "common frontier." IJC provides the framework for binational cooperation on questions relating to water and air pollution and the regulation of water levels and flows.

IJC's three principal functions are as follows.

- Quasi-judicial: Approves/disapproves applications from governments, companies or individuals for obstructions, uses or diversions of water that affect the natural level or flow of water on the other side of the international boundary.

- Investigative: Investigates questions on matters of difference along the common boundary, undertaking references that are presented by the two federal governments that entail fact finding and recommendations.

- Surveillance/coordination: Monitors and coordinates implementation of recommendations accepted by the governments, monitors compliance with Orders of Approval for structures in boundary waters and evaluates the governments' progress in meeting goals of programs established under the auspices of IJC.

IJC has specific Great Lakes responsibilities under the 1978 Agreement as amended. The Agreement calls on the two governments to "restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem."

"The Agreement's 25th anniversary in 1997 is indeed an appropriate occasion to celebrate remarkable and continuing success in many areas."

The Agreement is a comprehensive bilateral arrangement that functions both as a framework for cooperation and an instrument for implementation. As a framework for cooperation, the Agreement explicitly affirms the intent of the Parties to restore and protect the world's largest freshwater resource. IJC plays a credible and important role among citizens, industry and the scientific research establishment in the basin in promoting binational cooperation. This role is not easily achieved by governments, and IJC has been highly effective in terms of contributing to progress under the Agreement by bringing together representatives from diverse Great Lakes community groups to cooperatively discuss and move forward on Agreement issues. Within its own advisory institutions, IJC facilitates a consensus-based binational process involving Commissioners, professional staff and eminent volunteers in their personal and professional capacities. The Agreement also functions as an instrument aimed at achieving four central tenets:

- specific goal setting through the implementation of three policies of prevention, management and control of pollutants;

- commitments in terms of specific objectives, programs and research priorities;

- mechanisms for ongoing cooperation and reporting; and

- accountability and independent evaluation of progress through IJC, the joint institutions (i.e. WQB and SAB), the dissemination of public information and hearings.

The Agreement's 25th anniversary in 1997 is indeed an appropriate occasion to celebrate remarkable and continuing success in many areas. The Agreement has institutionalized U.S. and Canadian relationships on environmental protection and resource management concerns, offering a degree of stability and familiar, trusted mechanisms for

objective analysis and advice. The Agreement pioneered the notion of an "ecosystem approach" to management and, in so doing, helped promote interdisciplinary science and collegiality among the research, management and policy communities. And, more specifically, the Agreement is rightfully credited with significantly reducing problems of phosphorus and other conventional pollutants, highlighting concerns and promoting actions for control of toxic contaminants and encouraging "place-based," partnership-oriented initiatives through RAPs and LaMPs.

IJC, along with the Agreement and its institutions, have long been subject to the highest of expectations of basin stakeholders. As such, the aforementioned successes have been tempered by other examples where Agreement language and implementation activity has been the focus of some concern. Among others, concerns include an inadequate emphasis on evaluating progress, lack of accountability for the governments, inadequate resources for monitoring and data gathering, inadequate representation of American Indians/First Nations, the need for enhanced citizen participation and the absence of a strategic approach to ensure that the governments, along with Agreement institutions, meet Agreement goals in an efficient and cost-effective manner.

Assessments of the overall performance of the Agreement and its institutions tend to be both subjective and varied. However, even those with divergent views agree, to safeguard past progress and ensure future relevance, the Agreement and its institutions must be flexible and open to change in this era of evolving basin governance.

Embracing the Environmental Challenges of the 21st Century

Over the past two years, SAB has focussed on the issue of governance as an emerging issue. Prompted by the rapid and continuing transformation into a new era of basin governance, it focused on the challenge of ensuring continuing relevance and leadership of IJC, the Agreement and its institutions. One outgrowth of this focus was a recommendation that IJC initiate a strategic planning exercise to fundamentally evaluate — and explicitly state — its mission and goals and the necessary structure, procedures and actions to achieve them.

More recently, the issue of governance was raised in the form of a charge by the two federal governments. In reaffirming their commitment to IJC and "its important role in fostering cooperative action," the governments also acknowledged that "the environmental challenges faced collectively by our people have grown in size and complexity, requiring strengthened collaborative action." The governments then called upon IJC "to examine its important mission in the light of relevant agreements and references, and to provide the parties ... proposals on how the Commission might best assist the parties to meet the environmental challenges of the 21st century within the framework of their treaty responsibilities."

In responding to this challenge and, more generally, to facilitate change where warranted, IJC can draw on a wealth of analyses conducted over the last decade. Among others, these include:

- The Great Lakes Water Quality Agreement: An Evolving Instrument for Ecosystem Management (National Research Council and Royal Society of Canada, 1985);
- Institutional Arrangements for Great Lakes Management: Past Practices and Future Alternatives (Donahue 1987);
- Perspectives on Ecosystem Management for the Great Lakes (Caldwell 1988);
- The International Joint Commission Seventy Years On (Centre for International Studies 1981);
- Managing North American Transboundary Water Resources, Parts 1 and 2 (Dworsky et al. 1993a,b);
- Report and Recommendations of the Reconstituted Task Force on Commission Role and Priorities under the Great Lakes Water Quality Agreement (IJC 1991);
- An Evaluation of the Effectiveness of the International Joint Commission (Environmental Law Institute 1995); and
- The Great Lakes Water Quality Agreement: Its Past Successes and Uncertain Future (Botts and Muldoon, 1996).

"Collectively, [these various analyses] represent a cogent analysis of the institutional opportunities and challenges facing the United States and Canada in the joint management and protection of the Great Lakes."

The extent to which these various analyses address the issue of basin governance varies from one to another, in terms of rigor, focus and comprehensiveness. Collectively, they represent a cogent analysis of the institutional opportunities and challenges facing the United States and Canada in the joint management and protection of the Great Lakes. Their analyses suggest that 25 years of binational experience is sufficient for undertaking institutional reform now to support continued progress under the Agreement into the next millennium.

Findings and Recommendations

SAB has addressed the issue of basin governance through a methodical review of the literature, a series of invited workshop presentations and continuing SAB dialogue. These exercises have yielded several statements of findings and recommendations that IJC is urged to implement in the interest of meeting the environmental challenges of the 21st century.

To ensure its continuing relevance and leadership in basin governance in an era of change and uncertainty, IJC must be open to change itself. A fundamental, introspective examination of its past and present mission, structure and processes, coupled with an assessment of future challenges, is advised. This examination is currently under way through the strategic-planning process and development of the response to the recent charge from governments. SAB recommends the following.

- **The Parties, together with jurisdictional representatives and other basin stakeholders, form an expert binational committee to review the organizational and institutional arrangements that support the Agreement and offer recommendations needed to ensure the effective implementation of the Agreement in the 21st century.**

SAB is pleased IJC is acting on its earlier recommendation to initiate a strategic-planning process. SAB emphasized that such a process afforded IJC an opportunity for a thorough and fundamental review and evaluation of its mission, procedures and performance. A strategic plan also provides an opportunity to reaffirm or enhance organization relevance through fundamental change, if warranted. SAB recommends the following.

- **IJC diligently pursue its strategic-planning exercise through an inclusive process involving Commissioners, board members, staff, governments and all basin stakeholders.**

The process should not focus on procedural or operational "fine tuning," but on a fundamental review of the performance and future relevance of IJC, the Agreement and its institutions. One product must be a concise strategic plan presenting an organizational mission, goals, objectives and strategic actions.

Progress in meeting Agreement goals has been compromised by an inadequate emphasis on IJC's role in monitoring activities under the Agreement, evaluating the adequacy of the Parties' programs and holding the Parties accountable for progress. SAB recommends the following.

- **As part of the strategic-planning process, IJC identify program evaluation as the highest priority and initiate necessary budgetary, staffing and work plan adjustments to support this priority.**

- **IJC explore and pursue measures necessary to ensure that the Parties respond publicly to all IJC recommendations in a timely and substantive manner.**

- **IJC encourage the Parties to use the biennial State of the Lakes Ecosystem Conference to provide an assessment of the state of the lakes as a basis for determining progress under the Agreement, as well as an opportunity to respond to IJC recommendations.**

Following release of the IJC's next biennial report, Article X of the Agreement calls on the Parties to "conduct a comprehensive review of the operation and effectiveness of this Agreement." SAB recommends the following.

- **The Parties conduct a review of the adequacy of the Agreement, given the evolving state of basin governance and the need for the Agreement and its institutions, to both adapt to and influence that evolution.**

A decision as to whether the Agreement needs to be modified should not be predetermined, but should be an objective outcome of the review process. If modified, current Agreement language must be maintained or enhanced and additional emphasis placed on implementation.

"IJC has experienced a steady decline in U.S. and Canadian federal appropriations in recent years."

IJC has experienced a steady decline in U.S. and Canadian federal appropriations in recent years. This erosion of financial resources compromises the organization's ability to meet its mandate under the Boundary Waters Treaty and the Agreement. Further, it prevents IJC from evaluating the Parties' programs that support the Agreement. SAB recommends the following.

- **IJC document and quantify the benefits of its products and services in the form of a "return on investment" analysis for use by the Parties, legislative bodies and all basin stakeholders.**

Such an analysis could also quantify, to the extent possible, the economic and ecological consequences of program cutbacks due to budgetary constraints.

SAB recommends the following.

- **IJC aggressively pursue the feasibility of alternative sources of funding to complement its current sole reliance on U.S. and Canadian federal appropriations.**

Sources might include foundation grants, government contracts for references and studies and an endowment or

trust fund. Safeguards to ensure IJC's integrity and objectivity would be required.

In offering the above recommendations, SAB emphasizes that all can be pursued in the near term. It further urges IJC, in its strategic planning and related initiatives, to think openly and objectively about its current and prospective role in basin governance, and without constraints imposed by tradition. For example, should the Agreement be replaced with a broader Great Lakes Agreement that accommodates water quality and quantity considerations? Would a single IJC secretariat be advisable and strengthen IJC's binational character? Should provisions be made for IJC to accept public petitions for references, as is the case with the Commission on Environmental Cooperation? How might American Indian/First Nation constituencies be accommodated in institutional arrangements under the Agreement? These are but a few of the provocative questions raised in recent analyses that speak to the need for a fundamental review of IJC roles and responsibilities in the interest of meeting the environmental challenges of the 21st century.

1.4.2 Ecological Economics as an Emerging Issue

At its 16th meeting, the Work Group on Emerging Issues met with three experts in the field of ecological economics: Robert Costanza, Tony Friend and Ellie Perkins. Each is actively engaged in teaching, consulting and research in ecological economics and has published in economics literature.

In the view of some, neoclassical economics does not adequately deal with environmental issues. The Work Group on Emerging Issues has reviewed the emerging discipline of ecological economics. The following explains the discipline and suggests its relevance.

Ecological economics is based on the premise that the natural world, including local ecosystems, has a natural carrying capacity and finite resources and, in the long run, human activities must work within these constraints. Ecological economics involves evaluating the material economy in conventional terms, but also evaluating interactions with the ecosystem. Ecological economics incorporates neoclassical economics but holds that neoclassical economics is too limited. Ecological economics expands the analysis to incorporate the stocks and flows of natural resources and environmental pollutants and to model the interaction between the economy and the ecosystem. Some aspects of ecological economics involve systems modelling.

"Neoclassical economics assumes that a set of factors — land, labour, capital — is used to produce output. Ecological economics recognizes these three and adds two more: natural capital and organizational capital."

Neoclassical economics examines the satisfaction of human wants from a set of finite resources and seeks to achieve an efficient allocation of those resources to maximize consumer satisfaction. Ecological economics sets three additional goals: sustainable scale, fair distribution and efficient allocation. Sustainable scale means conducting economic activities on a scale that can be sustained eventually given the real limitations of natural resources and the ecosystem within which we live. Fair distribution deals with dividing the output of the economy and enjoyment of the natural environment, including consideration of which groups are adversely affected by resource consumption or pollutant discharge. Efficient allocation is the portion of the problem that is dealt with by neoclassical economics and refers to the use of available resources in a way that maximizes the consumer satisfaction that can be achieved from them or, to put it another way, minimizes the resources needed to achieve a given level of output.

In neoclassical economics, it is assumed that consumer satisfaction depends on the consumption of material goods and services. Ecological economics recognizes that individuals derive satisfaction out of doing useful work and out of living in harmony with the surrounding ecosystem. While the latter elements are not inconsistent with neoclassical economics, they are generally not included in neoclassical models.

Neoclassical economics assumes that a set of factors — land, labour, capital — is used to produce output. Ecological economics recognizes these three and adds two more: natural capital and organizational capital. Natural capital includes the stock of natural resources both renewable and nonrenewable. For example, when a stand of timber is harvested, neoclassical economics recognizes the economic activity involved in cutting and processing that timber while ecological economics also recognizes that the wealth of society has been diminished by the reduction in the stock of standing timber. Similarly, when fossil fuels are burned, ecological economics recognizes a reduction in the world's stock of available energy resources and the increase in air pollution levels and associated damage. Organizational capital represents the collective ability to organize for productive purposes, whether through forming corporations, government structures, or social and cultural organizations. Ecological economics recognizes that when a society has developed organizational capital, it has made a valuable investment; and when technological or social change renders those organizational forms or cultural practices obsolete, the society may lose something valuable.

Ecological economics is viewed by some as a process, not just an analysis. Supporters of this view believe strongly in

"Ecological economics has its problems and limitations. Obviously data needs are far greater than those of traditional economic models."

the participation of stakeholders in the process of defining values, structuring the model and evaluating the results.

While ecological economics is a multi-disciplinary, systems-model approach, many of the elements that it incorporates are not unfamiliar to the economics profession. Economists have been working for over two decades to develop an expanded system of national accounts that would measure not only traditional economic activities, but also the effects of these activities on stocks of natural resources and the quality of the environment. Much effort has gone into measuring costs of environmental pollution and changes to the natural environment.

Ecological economics has its problems and limitations. Obviously data needs are far greater than those of traditional economic models. While there is more than 200 years of experience in developing the data used in the system of national accounts that measure gross natural product, inflation and unemployment, much of the data that ought to be included in an ecological economic model is not routinely gathered. Some of the data are difficult even to define. The evaluation of environmental impacts has been the subject of much research, but it is still highly contentious. There is no reason to expect that agreement will be reached on how to value many of these variables much less on what the values will be in the immediate future. This lack of agreement places serious limits on the ability to fully implement ecological economic approaches in the near term.

Ecological economics can be applied on a global, national or local scale. It is perhaps most easily understood as a world-scale modeling exercise in which the relationship of all human economic activity can be related to the world stock of resources and environmental effects. However, it is equally appropriate to apply the same principles to very local issues, such as water pollution problems in a single harbour in the Great Lakes.

It would be useful to explore the application of ecological economic principles to some of the environmental problems faced by the Parties by sponsoring at least one pilot study using ecological economics. The study might deal with a single RAP, such as the Collingwood or the Hamilton Harbour RAP; it might address a single air pollutant, water pollutant or a family of pollutants. The choice of area and pollutant would depend in part on the availability of local ecological and economic data and models that could be developed for the study. The study would examine one or more policies for dealing with the specific environmental problem and evaluate the relative costs and benefits of those policies. The study could be conducted simultaneously with a conventional analysis so results could be compared.

Recommendation

SAB recommends the following.

- **The Parties commission a study, using the methods of ecological economics, to evaluate the practical value of utilizing the ecological economics approach.**

A particular environmental problem in a relatively small watershed within the Great Lakes could be selected. The results would include an assessment of whether further studies of this type are of value.

1.4.3 Foodweb Dynamics in Aquatic Systems as an Emerging Issue

Reducing contaminant loadings to the Great Lakes is a major goal of the Agreement. Traditional approaches to issues of water quality and contaminant loading have generally assumed that changes (i.e. reductions) in contaminant loadings would be reflected by reductions in contaminant levels in fish. It is generally assumed that organic and inorganic contaminants that reach the Great Lakes are passed through the foodweb and are increasingly concentrated in higher trophic levels. However, a growing body of evidence suggests that these assumptions are often incorrect. Thus, the research issue of how contaminants bioaccumulate in foodchains has long been of interest.

Recent data analyses and models have highlighted some of the complexities involved in contaminant cycling that can lead to counterintuitive results. Changes in the structure of the foodweb (e.g. shift in size/age distribution of prey species) can have dramatic effects on contaminant concentration levels in the fish (Jackson 1996a,b). For example, changes in the foodweb can change: the relative contribution of different sources of contaminants (e.g. sediment resuspension, atmospheric) to higher trophic levels; the relative shunting of contaminants to pelagic and benthic communities; the types of organisms likely to bioaccumulate contaminants; trophic transfer rates; and the amount and kinetics of contaminants in the water column. Structural changes in the foodweb can be induced by a number of factors, such as changes in the weather, introduction of exotic species and/or manipulation of stocking levels of predatory fish. Organic and inorganic contaminants may also directly affect Great Lakes biota and foodweb structure through toxic effects on eggs and subtle effects on biological processes. There is also an increasing body of evidence suggesting the concentrations of contaminants in the water and biota and the rates of bioaccumulation are dependent on the lakes' trophic status (i.e. eutrophic to oligotrophic) and nutrient loading and that contaminant transfer rates are

affected by the relationship between production at one trophic level and predatory demand at the next higher trophic level (Taylor et al. 1991, 1996; Almond et al. 1996). Predatory demand is affected by the invasion of exotic species and fisheries management policies that can alter foodwebs and trophic transfer directions and rates. For example, changes in stocking rates of salmonids, relative to prey availability, can cause significant increases in PCB levels in fish even at the same PCB loading rates (Jackson 1997). Likewise, the zebra mussel effects on phytoplankton levels and composition can cause changes in contaminant cycling and exposure levels to different parts of the foodweb. Therefore, the relationships among contaminant loadings, contaminant recycling, contaminant levels in fish and human-health risk are not clear.

The Great Lakes foodwebs and relative species composition have changed dramatically over the past decade. These changes are due to a combination of factors including invasions of exotic species, predator-prey imbalances and changes in habitat. Although the general character of these changes is known, there is little quantitative information on changes in abundances, predator-prey interactions or production levels in most trophic levels. Also, the effective nutrient reduction strategies in the Great Lakes will affect production levels and production dynamics at different trophic levels. Some of the top fish predators in the Great Lakes, such as lake trout and salmon, have shifted their diets in response to changing prey availabilities. What are the consequences of these diet shifts and changes in foodwebs and production dynamics to contaminant cycling and to contaminant levels in fish?

The Agreement mandate is to use an ecosystem approach to water quality issues. There is a clear interrelationship between fisheries management ("top-down" control), nutrient reduction strategies ("bottom-up" control), invasion of exotic species, contaminant cycling and habitat quality through the foodweb (Figure 1). The foodweb structure and trophic transfer rates and pathways have been modeled somewhat, but there is a clear lack of lakewide information on even the operation of the foodweb (i.e. what eats what, and when?), particularly for ecologically important species (e.g. deep water sculpin) that may not have direct economic value.

It is critical to understand the interconnectedness of foodweb structure, nutrient loadings and contaminant cycling to better interpret changes in contaminant levels in fish relative to changes in source loadings. This understanding could result in more effective monitoring programs and promote better public awareness of the effectiveness and complexities of cleanup efforts, particularly if decreases in contaminant loadings correspond to increases in contaminant levels in fish caused by changing foodwebs. SAB recommends the following.

- **Great Lakes researchers address water quality nutrient and contaminant issues together with monitoring for a quantitative assessment of foodweb and production dynamics in the Great Lakes.**

The recently completed report of IJC's Lake Erie Task Force (Dodge and Reutter, 1997) that included development of the Lake Erie Ecological Modeling Project

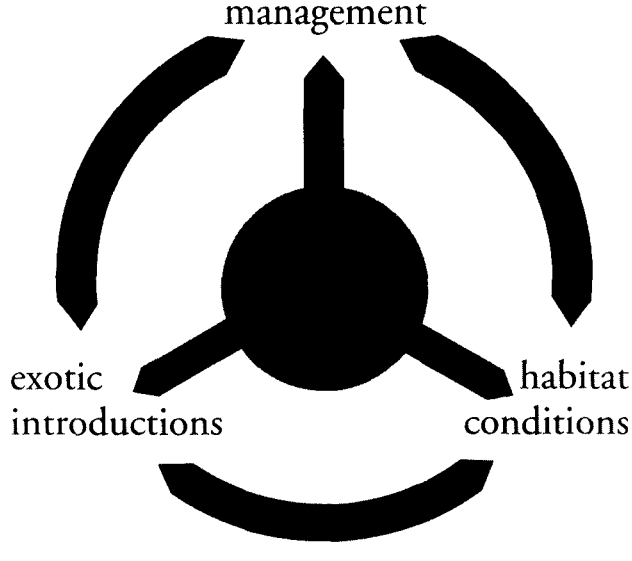


Figure 1 **Ecological/Environmental Variability**

(LEEMP) is a good example of the type of approach recommended. This Task Force led a collaborative process that included a Core Advisory Group of Lake Erie fishery and water quality managers that "provided ongoing advice, guidance and data to facilitate model development, as well as feedback on the scope and characteristics of the model." The model developed will be used by the binational Lake Erie Committee of the Great Lakes Fishery Commission and the Lake Erie LaMP Work Group. The value of the collaborative process was highlighted in the report: "The experience in developing a model in concert with an advisory group, the learning that occurred about the uses of the model and compromise in model resolution, and heuristics of model use were all positive, and the transfer to the LaMP has occurred through the involvement of LaMP participants in the LEEMP. The Task Force has created a much larger group or nucleus of people working together on ecosystem issues and have [sic] crossed boundaries — agencies, offices, communities, disciplines, etc." See Chapter 5 for further discussion.

SAB recommends the following.

- **IJC foster linkages and increased communication with agencies responsible for fisheries management and exotic species (e.g. the Great Lakes Fishery Commission).**

- **IJC develop an interdisciplinary task force similar to the Lake Erie Task Force to explore developments, models, monitoring and data needs on the effects of foodweb structure and nutrient loading on contaminant levels in biota.**

- **IJC encourage new research initiatives in the following areas:**

  1. **quantitative evaluation of foodweb structure and trophic transfer on a lakewide basis, including diet analysis;**

  2. **relationships of contaminant bioaccumulation in relation to size, age and condition of the predominant prey fish in the Great Lakes (e.g. bloater, alewife, rainbow smelt);**

  3. **sources (i.e. atmospheric, sediments, landfill sites) of contaminants, such as PCBs to the foodweb, to answer where do the PCBs in fish come from?;**

  4. **the consequences of changing foodweb structure on contaminant levels in fish (e.g. linkages with Lake Erie Ecological Modelling Project); and**

  5. **the development of appropriate and innovative monitoring tools (e.g. growth rates) that can be used to detect foodweb changes that have an impact on contaminant cycling.**

1.4.4 Public Survey Results

As scientific adviser to IJC and its WQB, SAB is charged with developing recommendations on matters of science pertaining to the identification, evaluation and resolution of current and anticipated problems. The Work Group on Emerging Issues invited the identification of emerging issues from the diverse public and scientific communities in the basin through a survey questionnaire published in the March/April 1997 edition of *Focus*, and also distributed to delegates attending the International Association for Great Lakes Research conference (IAGLR '97) in Buffalo, New York. Although the response was limited, a wide range of issues was submitted for consideration.

IAGLR '97 conference participants identified eight broad areas of interest:

- understanding how to quantify and measure ecosystem health and integrity;
- understanding the human health linkage to Great Lakes pollution;
- sustaining progress towards environmental quality;
- achieving sustainable development;
- atmospheric deposition, especially understanding its physical processes;
- increasing understanding of environmental responses to lake levels fluctuations;
- improving the integration of scientific findings; and
- permit trading as an economic incentive for pollution abatement.

The areas may be categorized as follows: ecological/biological, resource management, social/economic/cultural and physical process.

Thirty-one submissions (14 U.S. and 17 Canadian) were received in response to the questionnaire published in *Focus*. Respondents identified themselves as follows: civil engineer, hydrogeologist, biologist, toxicologist, ecologist, health liaison officer, mayor, economics adviser, policy analyst, writer, environmental activist, underwater archaeologist, amateur historian, computer data technician, software engineer, speech pathologist and educator.

In response to the question, "Which new issue, or understanding of an old issue is most likely to enable us to achieve [the] goals [of the Agreement]?" the following issues were identified:

Water Quality Issues

- nonpoint source pollution
- amphibian deformities
- sulfonyl urea and dieback of plants

- toxin impact on biodiversity
- agricultural chemical drift and atmospheric deposition (pesticides and nitrogen)
- dredged *versus* undredged sediment quality
- storm sewer discharge and combined sewer overflows
- importance of sediment management to ecological recovery
- linkages between pollutants and biota health
- sodium levels in Lake Michigan (near carrying capacity) and other Great Lakes
- airborne pollutants from United States to Canada (soft coal)
- deep burial of nuclear waste
- understand phosphorus cycling
- land use, impervious surfaces and runoff problems

Water Quantity Issues

- land use, impervious surfaces and runoff problems
- water diversion projects from the basin

Other Issues

- sustainable development
- biodiversity
- re-evaluate information provided to news media
- public apathy to environmental issues
- re-establish public confidence in restoration efforts
- publish a guide to sites and monuments where history of the 17th and 18th centuries unfolded (for tourism and culture)
- targeting areas for habitat restoration
- habitat relation to fisheries management
- institutional analysis and design
- government support for RAPs
- changes in roles of governments and environmental organizations
- privatization of publicly owned treatment works, drinking water systems and sewage treatment facilities
- put legal means behind goals so industry is forced to comply
- implement effective cleanup measures in times of resource constraint to implement the Agreement.

The issues were categorized by respondents as predominantly social, governance or institutional problems rather than resource management, physical processes or ecology. A slight majority thought their issue(s) could be addressed through the existing or a revised Agreement, while a substantial minority indicated that another initiative would be required. Education was identified by several respondents as a specific example of another initiative.

Almost half the respondents perceived measuring progress to resolve their identified issue in terms of policy analysis and program review and evaluation. An equally strongly held position would measure progress through environmental monitoring and assessment, though it was recognized that expanded efforts would be required. Suggestions included:

- monitor people, not just the environment: "Record of KASA (knowledge, attitude, skills, abilities) changes at the local level in officials who have decisionmaking responsibility for local land use;"
- monitor economic and social factors;
- "Reports on the State of the Great Lakes need to bring in these factors (how environmental protection applies to daily life, such as personal health, economic health, and health of culture and community) if people are to clearly understand the links between ecosystem health and human well-being;"
- survey for understanding and attitude;
- make laws enforceable;
- measure tax incentives for businesses investing in environmental improvements; and
- identify critical areas.

SAB finds that periodic surveys of this nature are helpful in identifying current and emerging issues for prospective consideration by IJC. All survey responses will be considered by SAB in developing its candidate priorities under IJC's priority planning process in the upcoming 1997-99 biennial period.

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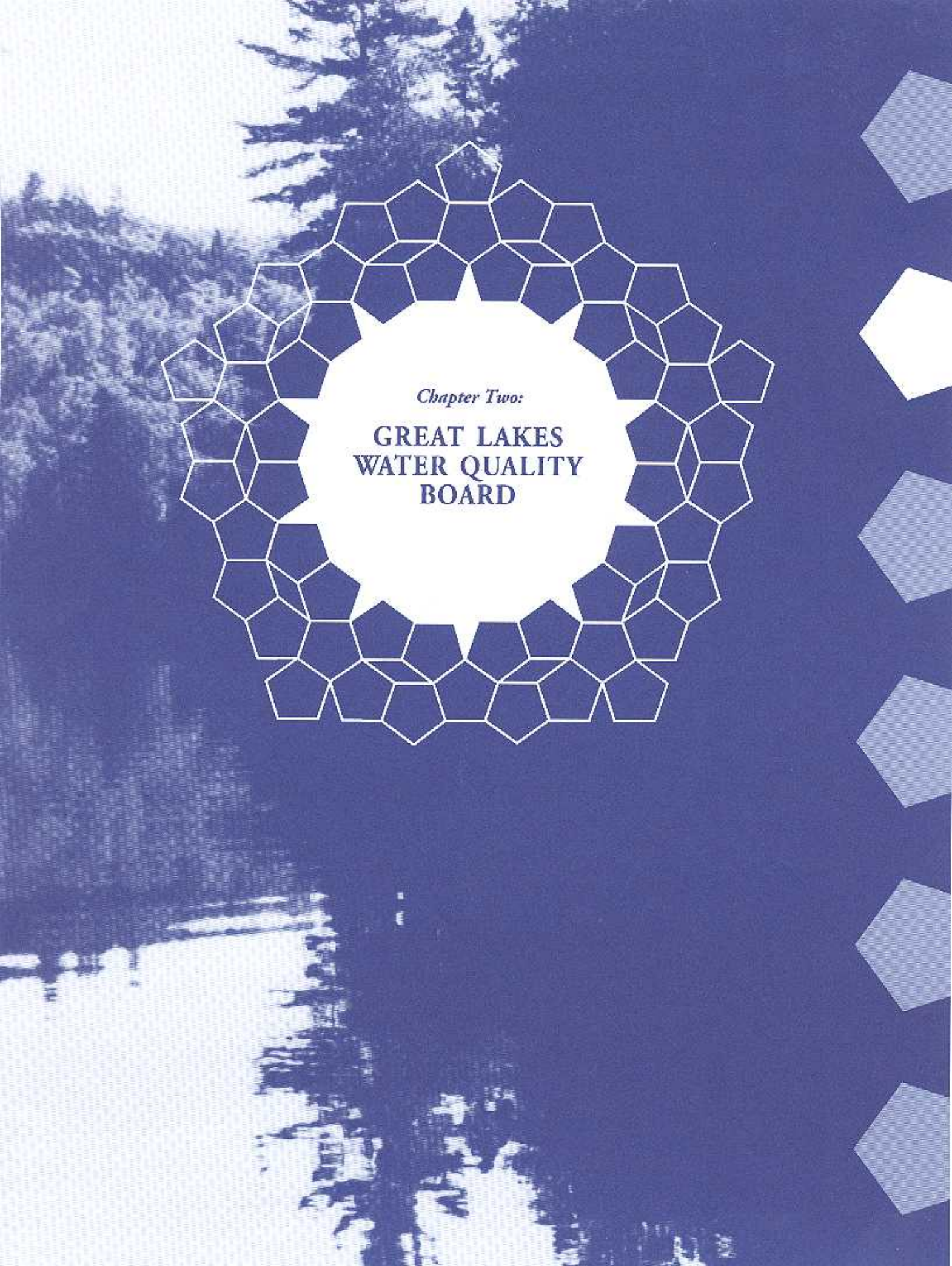
④ Work Group on Emerging Issues

1.7 SCIENCE ADVISORY BOARD SCHEDULE OF MEETINGS FOR THE PERIOD 1995-97

- 100th Meeting, December 6-7, 1995, Washington D.C., hosted by the Water Science and Technology Board of the National Research Council.
- 101st Meeting, February 28-29, 1996, Windsor, Ontario.
- 102nd Meeting, May 22-23, 1996, Windsor, Ontario.
- 103rd Meeting, September 10-11, 1996, Windsor, Ontario.
- 104th Meeting, November 20-21, 1996, Detroit, Michigan, in association with a public meeting on scientific issues of relevance to the Detroit River remedial action plan.
- 105th Meeting, February 19-20, 1997, Windsor, Ontario
- 106th Meeting, May 28-29, 1997, Hamilton, Ontario, at Canada Centre for Inland Waters, involving a tour of the Harbour and briefing on the status of the Hamilton Harbour remedial action plan.



Chapter Two:

GREAT LAKES WATER QUALITY BOARD

CHAPTER TWO *Contents*

2.1 INTRODUCTION

During the 1995-1997 priorities cycle, the **Great Lakes Water Quality Board** (WQB) was involved in several issues. WQB directed a priority on contaminated sediment and collaborated with the **International Air Quality Advisory Board** (IAQAB) on a priority relative to loadings, sources and pathways of persistent toxic substances (see Chapter 3.3). In addition, WQB developed position statements on uniform and fully protective fish consumption advisories, federal sale of mercury, the future of Great Lakes **remedial action plans** (RAPs) and the importance of other Great Lakes issues such as habitat and biodiversity. WQB also co-sponsored the following conferences and public meetings: a conference entitled Linking Local Watershed Management Efforts Across the Lake Ontario Basin in Rochester, New York on October 18-19, 1996; a conference entitled Practical and Cost Effective Watershed Management in Livonia, Michigan on May 3, 1996; and a workshop entitled Habitat 2001 in Sault Ste. Marie, Ontario on February 25-27, 1997. The following is a summary of each.

"Contaminated sediment is a major cause of environmental problems and a key factor in many impairments to beneficial uses of the Great Lakes. Based on application of chemical guidelines, all 42 Great Lakes Areas of Concern have contaminated sediment."

2.2 IDENTIFYING IJC'S VALUE-ADDED ROLE IN OVERCOMING OBSTACLES TO SEDIMENT REMEDIATION IN THE GREAT LAKES BASIN

Contaminated sediment is a major cause of environmental problems and a key factor in many impairments to beneficial uses of the Great Lakes. Based on application of chemical guidelines, all 42 Great Lakes Areas of Concern have contaminated sediment. This universal obstacle to environmental recovery in Areas of Concern can potentially pose a challenge to restoring 11 of the 14 beneficial use impairments identified in Annex 2.1.c of the **Great Lakes Water Quality Agreement**. Adequate knowledge of impact is essential for determining the degree of impairment. A variety of sediment management options is available, ranging from source control and natural recovery to full-scale remediation depending on the severity of the problem. Further, it is critical that some of these concentrated deposits of contaminated sediment be addressed relatively quickly, because over time these contaminants may be transported from a river or harbour to the open waters of the Great Lakes. Once dispersed into the lakes, cleanup is virtually impossible.

Contaminated sediment is a major problem being addressed in RAPs and **lakewide management plans** (LaMPs), and is known to be an issue in other areas of the Great Lakes basin. In recognition of the scope of this problem and the limited progress in addressing it, IJC identified contaminated sediment as a priority for the 1995-1997 biennial cycle. IJC assigned this priority to WQB and asked it to review the magnitude of the contaminated sediment problem and make recommendations to overcome major obstacles to sediment remediation.

WQB, with representatives from the **Science Advisory Board** (SAB) and **Council of Great Lakes Research Managers**, convened a scoping meeting in March 1996 to determine the breadth of the issues to be examined. Specifically, this scoping meeting was charged with determining whether or not there was a value-added role for WQB and IJC in moving forward on the contaminated sediment issue and, if so, detailing the nature of that contribution, the deliverables and the need for a workshop or working meetings.

As a result of this meeting, it was proposed that a sediment white paper be prepared summarizing the contaminated sediment problem, specifying key obstacles and identifying options to address them. The sediment white paper would serve as the basis for a workshop. This approach was presented and endorsed by IJC at its April 1996 Semi-Annual Meeting in Washington, D.C. It also was recognized that there are undoubtedly other aspects of the contaminated sediment issue that require further investigation and should be addressed in the future.

WQB established a **Sediment Priority Action Committee** (SedPAC) to prepare the white paper and organize the workshop. The white paper noted that progress has been made in the remediation of contaminated sediment, but contaminated sediment problems in Areas of Concern have been brought to closure (delisting) at only one, Collingwood, Ontario. In most Areas of Concern, progress has been slowed or completely stalled at one of two stages: decisionmaking or implementation.

RAP decisionmaking related to contaminated sediment has been limited by the complex and often conflicting requirements of environmental laws and regulations; the lack of a comprehensive decisionmaking framework geared toward resolution of sediment management problems; and the limitations of science alone in setting cleanup targets. In Areas of Concern where the decision to remediate (or not) has been made, implementation has often been limited by lack of funding and resources, reluctance of industry and the private sector to become involved and the lack of public and local support.

Science can determine the state of sediment quality, while socioeconomic and political forces govern the final cleanup targets. Since success is measured on a site-specific basis, this presents a challenge for those who may choose to enter into a partnership agreement for cleanup. Success should be defined as the degree to which the environmental or ecological impact of contaminants from sediment have been reduced or eliminated. The assessment of success should also recognize whether the "local" goals and uses of the area are achieved. Further, there is a need for pubic acceptance of a step-wise, incremental approach to management of contaminated sediment and restoration of beneficial uses, since complete rehabilitation requires a long-term effort. Success should include both incremental gains in environmental recovery of the system and extensive public participation in the decision-making process. Certainly there can be and has been progress in advancing projects toward remediation; however, implementation is the only step that results in progress toward restoration of the ecosystem.

In the sediment white paper, SedPAC grouped major obstacles to sediment remediation into six categories to assist in communication and broad-based understanding:

- limited funding and resources;
- regulatory complexity;
- lack of a decision-making framework;
- limited corporate involvement;
- insufficient research and technology development; and
- limited public and local support.

SedPAC then identified, as IJC options, those activities IJC could undertake that could make a value-added contribution to overcoming obstacles to sediment management actions. SedPAC also ranked them as either high or lower priority options. Copies of the sediment white paper,

Overcoming Obstacles to Sediment Remediation in the Great Lakes Basin, are available from IJC's Great Lakes Regional Office, as is additional information about obstacles and options to overcome them.

Copies of the sediment white paper, Overcoming Obstacles to Sediment Remediation in the Great Lakes Basin, are available from IJC's Great Lakes Regional Office, as is additional information about obstacles and options to overcome them.

On June 18, 1997 a workshop entitled Identifying the Value-Added Role of the IJC in Overcoming Obstacles to Sediment Remediation in the Great Lakes Basin was convened in Collingwood, Ontario. Approximately 35 individuals participated, including representatives from WQB, SAB, Council, and SedPAC, and two Commissioners.

In general, workshop participants concurred with the categories of obstacles to sediment remediation that were identified in the white paper. Two breakout groups were then used in the workshop to identify the two or three most important IJC options to help overcome obstacles to sediment remediation. It was felt that incentives to corporate involvement are generally weak and poorly articulated, and that in most areas there is limited public and local support for sediment remediation. In addition, lack of a consistent but flexible decision-making framework continues to confound and frustrate RAP processes and other local sediment initiatives.

Workshop participants recommended two very important, value-added contributions IJC could make to help address current obstacles to sediment remediation:

- compile and disseminate information on the economic and environmental benefits of sediment remediation; and
- develop guidance for making decisions regarding management of contaminated sediment.

Workshop participants also noted a number of other options IJC may want to pursue depending upon time and resource availability. These include: Commissioners could be opportunistic advocates for sediment funding and legislation (e.g. through Hamilton Harbour Status Assessment); IJC could recommend in its Biennial Report that the Parties and jurisdictions provide adequate staff to support sediment remediation efforts; and IJC could prepare materials and launch a binational marketing campaign that would address the importance of contaminated sediment management.

SedPAC reviewed the two primary workshop recommendations and has proposed action plans for IJC's 1997-99 cycle to address each recommendation (Tables 1 and 2). Specifically, these action plans lay out a series of complementary activities that could be taken by IJC and other organizations to help overcome obstacles to sediment management.

WQB is reviewing the workshop's recommendations and providing specific advice to IJC in fall 1997.

Table 1 **An Action Plan Proposed by SedPAC to Utilize Benefits Assessment to Help Promote Implementation of Sediment Management Actions.**

ACTIVITY	MECHANISM	TIMEFRAME	RESPONSIBLE PARTY
Compile methodologies to quantify environmental and economic benefits	Great Lakes Economic Valuation Guidebook	Initiate: fall 1997 Duration: 6-9 months	Northeast Midwest Institute in cooperation with the WQB, SAB and Council
Select preferred methodologies	Sediment Forum	Initiate: spring 1998 Duration: 3 months	WQB in cooperation with Northeast Midwest Institute, SAB and Council
Compile and summarize best available data on environmental and economic benefits as they pertain to contaminated sediment cleanup (both inside and outside the basin)	Summary report	Initiate: January 1999 Duration: 6 months	WQB contract with Northeast Midwest Institute or academic organization
Disseminate data and information from summary report using a comprehensive communications strategy	Brochures, home page, Commissioner and IJC staff presentations	Initiate: fall 1999	Commissioners, IJC staff, communications specialist
IJC leverage implementors for funding, resources and priorities	Meetings with senior management and industry; legislative briefings	Initiate: fall 1997 Duration: 2 years	Commissioners, IJC staff

Table 2 **An Action Plan Proposed by SedPAC to Encourage Use of Compatible Decisionmaking Frameworks for Management of Contaminated Sediment.**

ACTIVITY	MECHANISM	TIMEFRAME	RESPONSIBLE PARTY
Compile information on relevant sediment decisionmaking frameworks	White paper	Initiate - fall 1997 Duration - 9 months	SAB or WQB in cooperation with Council
IJC leverage Parties/jurisdictions for funding, resources, and priorities for developing decisionmaking framework	Meetings with senior management	Initiate - fall 1997 Duration - approximately 6 months	Commissioners
Develop guidelines for binational approach for decisionmaking	Binational workshop to strive for consistent/ compatible approaches	Initiate - fall 1998 Duration - 6 months	WQB and Parties in cooperation with SAB and Council
Test, validate and finalize subset of decisionmaking frameworks (pilot testing)	Summary report	Initiate - spring 1999 Duration - 6 months	Parties and jurisdictions in cooperation with WQB
Advocate use of consistent/ flexible decisionmaking frameworks	Distribution of information through reports, home pages, meetings with senior management	Initiate - spring 1999 Duration - ongoing	Commissioners and IJC staff

"WQB is reviewing the workshop's recommendations and providing specific advice to IJC in fall 1997."

2.3 SIGNIFICANT SOURCES, PATHWAYS AND REDUCTION-ELIMINATION STRATEGIES FOR PERSISTENT TOXIC SUBSTANCES

For the 1995-1997 cycle, IJC identified significant sources, pathways and reduction/elimination strategies for persistent toxic substances as one of its priorities. IJC's **International Air Quality Advisory Board** (IAQAB) and WQB collaborated on this priority and co-sponsored a workshop on May 21-22, 1997 to evaluate four background reports: air sources and pathways; an evaluation of programs called for under Annex 15; use of mass balance modeling to determine relative contribution of contaminants; and an evaluation of beyond compliance programs. The workshop also identified critical research, assessment and management needs and priorities. A summary of key findings and recommendations from this workshop, prepared jointly by WQB and IAQAB, is presented in Chapter 3.

WQB is reviewing the workshop's recommendations and providing advice to IJC in fall 1997.

Delivery of this priority relied on collaboration between WQB and IAQAB. Such working ties within the IJC family help ensure an integrated multimedia approach with strong linkages among research, monitoring and management.

2.4 POSITION STATEMENT ON UNIFORM AND FULLY PROTECTIVE FISH CONSUMPTION ADVISORIES

Annex 2 of the Agreement calls for restoration of beneficial uses in Areas of Concern. One of the use impairments identified is restrictions on fish and wildlife consumption. Annex 12 calls for the Parties to establish action levels to protect human health. These provisions make this an issue of interest to WQB, IJC and others in the basin. A protocol for development of fish consumption advisories was recommended by the Great Lakes Sport Fish Advisory Task Force to the Council of Great Lakes Governors for adoption in 1993 and three states are presently implementing it.

Advisories, usually provided with fishing license materials, inform prospective consumers of Great Lakes fish regarding human health risks from contaminants in the fish. They also recommend, when warranted, restricted consumption of certain species, especially for the most vulnerable consumers, such as women of child-bearing age and children. A series of studies involving children born to women who ate Lake Michigan fish during the 1970s reported neurological deficits associated with concentrations of PCBs in the mother. Another study of women who ate Lake Ontario fish at current contaminant concentrations has reported similar findings.

Ultimately, members of the public make individual dietary decisions. This is only appropriate. It also is appropriate for jurisdictions to provide information empowering individuals to exercise personal responsibility, as recognized in Annex 12.

One practical way for governments to move forward collectively on protection of human and ecosystem health is the issuance of uniform fish consumption advisories. In 1996 WQB advised IJC on the importance of uniform, fully protective fish consumption advisories for the Great Lakes. In its advice, WQB noted that there are currently three different state fish consumption advisories on Lake Michigan. This situation confuses the public and does not fully protect public health. Concern was raised that citizens of Michigan were entering the fishing season with inadequate information about the health risks associated with eating contaminated fish from the Great Lakes.

Based on WQB's advice, IJC sent letters to the Great Lakes Sport Fish Advisory Task Force, the U.S. secretary of state and the Canadian minister of foreign affairs urging the governments in the basin to adopt fully protective, uniform fish consumption advisories. In response to inconsistent fish consumption advisories for Lake Michigan and concern expressed for this situation, **U.S. Environmental**

2.5 POSITION STATEMENT ON FEDERAL SALE OF MERCURY

Protection Agency (EPA) issued a supplementary fish consumption advisory to be used together with Michigan's fish consumption advisory for Great Lakes waters. The state of Michigan will be taking steps over the next year to develop more complete and protective information about health risks associated with eating contaminated fish from the Great Lakes. In addition, the director of the Michigan Department of Community Health recently wrote to U.S. EPA Administrator Browner requesting a joint scientific panel be assembled. The panel would be made up of members of U.S. EPA's Science Advisory Board and the Michigan Environmental Science Board. The goal of the panel would be to resolve outstanding disagreements over fish consumption advisories.

WQB continues to recommend the following.

- **IJC emphasize to the Parties the need for uniform and fully protective fish consumption advisories.**

"In its advice, WQB noted that there are currently three different state fish consumption advisories on Lake Michigan. This situation confuses the public and does not fully protect public health."

As principal advisor to IJC, WQB has provided advice on a critical issue -- federal sale of mercury. Mercury is a persistent, bioaccumulative, toxic substance that governments have targeted for virtual elimination as called for in the Agreement. The U.S. holds more than 11 million pounds of mercury in its national stockpile. This mercury has been declared surplus and slated for sale worldwide. The U.S. Department of Defense is completing an environmental assessment of the implications of selling this stockpile. A preliminary review of sales in November 1995 by the Department of Defense concluded that there was no policy basis for ending sale. This review did not consider effects of sale on the world commodity market and the resulting health and environmental impacts.

WQB unanimously agrees on the need for global reduction of mercury use. Concern was raised regarding federal sale of mercury based on both environmental and economic grounds. However, a few members felt that WQB should wait for the completion of the environmental assessment to have more complete information on environmental and economic impacts. Concern also was raised that if the U.S. halted this sale of mercury, it might be perceived as controlling supplies or that this action would have no cumulative effect because other countries could increase supplies to meet demand.

Proponent WQB arguments for halting the federal sale of mercury include:

- mercury is a persistent, bioaccumulative, toxic substance that governments have targeted for virtual elimination as called for in the Agreement;
- the federal sale of mercury will increase the world supply of mercury, thereby lowering price and increasing use;
- this position is targeted at ending U.S. public subsidies to supply, not controlling supply;
- alternatives to mercury use are available, except for high-efficiency lighting, hence ending sale will not have a negative impact on the North American economy;
- federal sale of mercury presents a "collective action problem" of how to change public policies across a group of nations that collectively do such things as subsidize unprofitable mines, sell unwanted mercury holdings and require recycling while preventing

retirement of unwanted mercury (the collective impact of these policies is substantial, making mercury much cheaper and more heavily used than without these policies);

- mercury sale represents an environmental justice issue in that it increases a flow of mercury from the U.S. to nations with less awareness of mercury hazards; and

- halting federal sale of mercury will demonstrate responsibility within U.S. borders and potentially influence others through such action (conversely if U.S. sold its mercury stockpiles, this could potentially send the wrong message to the rest of the world).

In summary, WQB strongly agrees that there needs to be global reduction in mercury use. WQB briefed IJC and formally requested a copy of the Department of Defense environmental assessment when it becomes available. By letters of September 13, 1996 to the governments of Canada and the United States, IJC expressed concern that the release of mercury to the environment is fundamentally inconsistent with the provisions of the Agreement. IJC has specifically recommended in its Sixth Biennial Report on Great Lakes Water Quality that the use of mercury be sunset and in its Eighth Biennial Report that actions to prevent, control and eliminate persistent toxic substances in production and commerce be pursued on a global basis. Therefore IJC recommended that the U.S. Government not proceed with the sale of its mercury stockpile.

52 WQB will continue to track the status of the environmental assessment in order to provide timely information and advise IJC on proposed federal sale of mercury.

2.6 POSITION STATEMENT ON THE FUTURE OF GREAT LAKES REMEDIAL ACTION PLANS

It has been over ten years since the Parties and jurisdictions committed to the development and implementation of RAPs to restore all beneficial uses in Areas of Concern. Recently, federal, state and provincial budget constraints have resulted in less support for RAPs and **public advisory committee** (PAC) activities. Further budget cutbacks are anticipated. Numerous RAP stakeholders and many PACs have indicated that further progress will be difficult. In light of the fact that WQB is the originator of RAPs, principal advisor to IJC on water quality matters, charged with assessing the adequacy and effectiveness of Great Lakes programs, and in response to concern for recent government cutbacks in RAP funding, WQB prepared a position statement on the future of RAPs based on its practical experiences over the last 11 years. **The complete position statement can be found on the WQB's home page at www.ijc.org/boards/wqb/wqbrap.html(.)**

"RAP implementation and continued progress toward watershed and ecosystem-based management can and must continue to thrive with strong local leadership and initiative, despite reductions in some state, provincial and federal programs."

WQB recognizes that much has been accomplished through RAPs and yet much needs to be done to fulfil the Agreement goal of restoring all beneficial uses in Areas of Concern. The erosion of governmental funding support for RAPs is real. Budget constraints have impacted most Great Lakes programs. However, with such budget constraints comes an opportunity to re-evaluate how RAPs have been developed and implemented, and to look for ways to form partnerships, pool resources, compensate for program restraint measures and still accomplish the important goals of restoring uses in Areas of Concern.

RAPs provide the framework to restore and sustain healthy ecosystems and communities. The RAP process draws on community members to develop a collaborative vision for a healthy ecosystem in the 42 Areas of Concern. The ecological, economic and societal factors affecting each area should drive the problem-solving approach, involving citizens in setting environmental goals and monitoring and evaluating outcomes over time.

WQB concludes that RAPs are on the cutting edge of community-based and ecosystem-based management processes. The RAP process is out in front regarding how to address local, environmental problems and are precedent setting for other regions and areas.

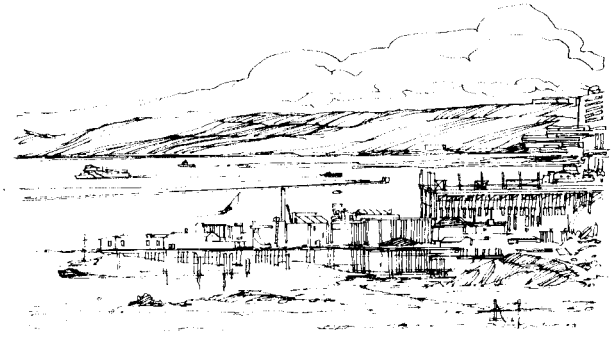
RAP implementation and continued progress toward watershed and ecosystem-based management can and must continue to thrive with strong local leadership and initiative, despite reductions in some state, provincial and federal programs. The Parties and jurisdictions, and IJC, must not abandon RAPs. Further, it is becoming well recognized that for LaMPs to be successful, RAPs will have to be successful. It is paramount that the federal, state and provincial governments continue to provide leadership and resources to fulfil commitments to RAPs as articulated in the Agreement. Governments should be viewed as facilitators of RAPs and partnership builders.

Based on a basinwide review of the Great Lakes RAP program, WQB concludes the following:

- there has been considerable progress in most RAPs and one Area of Concern (Collingwood Harbour) has been delisted;
- although progress is being achieved, it is not as fast as hoped for and contaminated sediments remain a significant obstacle in many Areas of Concern;
- greater emphasis should be placed on celebrating and marketing successes achieved over the last ten years;
- there is a need to obtain broad-based acceptance of a step-wise approach to use restoration and demonstration of incremental progress in order to sustain the RAP process (i.e. demonstration of progress is essential to sustain RAPs);
- identification of key actions and delineation of sequencing, timeframe and responsibilities are essential to ensure accountability for action;
- government agencies are not solely responsible for implementing RAPs and nongovernmental partners are essential implementors of RAPs;
- continued emphasis should be placed on planning cooperatively and sharing responsibilities for delivery of programs;
- a high priority should be building partnerships with municipalities, conservation authorities, counties, watershed councils, industries and other local organizations and institutions;
- governments must continue to provide resources and technical assistance to facilitate RAPs (these investments of resources often result in substantial leveraging of nongovernmental and private sector resources);
- a high priority should be placed on identifying creative financing strategies for RAPs (this is an important area where IJC can play a value-added role);
- coupling of research and management has proven to be cost- and ecosystem-effective; and
- continued emphasis should be placed on measuring and celebrating incremental progress and striving for continuous improvement in the RAP process.

WQB recommends the following.

- **The Parties and RAP stakeholder groups adopt a step-wise approach to use restoration and demonstration of incremental progress in order to sustain RAP processes.**



2.7 POSITION ON THE IMPORTANCE OF OTHER GREAT LAKES ISSUES

The purpose of the Agreement is "to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem." While not precisely defined, integrity is generally understood to include health of constituent populations of the ecosystem, biological diversity of ecological communities, and the ecosystem's ability to withstand stress or adapt to it.

WQB recognizes that prevention and remediation of persistent toxic substance problems is an important and continuing priority of IJC. WQB concurs with this emphasis and is pleased with its responsibilities to address the IJC priorities on loadings, sources and pathways of contaminants and contaminated sediment.

However, WQB continues to be concerned that other important issues are not receiving priority attention. Issues, such as loss of habitat and biodiversity and impacts of exotic species, should also be viewed as important Great Lakes issues. This has been a continuing key message of the **State of the Lakes Ecosystem Conference** (SOLEC).

SOLEC reports assess the state of the living components of the Great Lakes ecosystem, specifically the health of aquatic communities and humans. In addition, measures of physical, chemical and biological stresses that affect the ecosystem are equally important in describing the state of the lakes and providing vital information for programs designed to restore and protect the integrity of the ecosystem.

WQB recommends the following.

- **IJC keep a balanced perspective as it establishes and addresses its 1997-1999 priorities.**

WQB will continue to liaison with the Great Lakes Fishery Commission and other technical experts in the field to provide advice on habitat, biodiversity, exotic species and related issues.

"... WQB continues to be concerned that other important issues are not receiving priority attention. Issues, such as loss of habitat and biodiversity and impacts of exotic species, should also be viewed as important Great Lakes issues."

2.8 LINKING LOCAL WATERSHED MANAGEMENT EFFORTS ACROSS THE LAKE ONTARIO BASIN

On October 18-19, 1996 WQB and the **Finger Lakes-Lake Ontario Watershed Protection Alliance** (FL-LOWPA) co-sponsored a conference entitled Linking Local Watershed Management Efforts Across the Lake Ontario Basin in Rochester, New York. The conference was the first public meeting of WQB under IJC's revised policy to improve public involvement and consultation in its affairs. The conference was the product of a unique partnership between two water quality entities representing perspectives from different geographic levels -- local and basinwide -- which saw benefits in meeting together. FL-LOWPA is an alliance of 24 counties in New York's Lake Ontario basin committed to improving the health of the region's watersheds based on local, coordinated programs.

The conference provided a forum for exchanging ideas pertaining to watershed management between those in government agencies responsible for the development of basinwide management concepts and initiatives and those working at the local level to implement programs. The conference also provided an opportunity for these groups working on resource management at varying levels to discuss how they might reinforce and complement each other's work to strengthen watershed management in the Lake Ontario basin.

It was the general conclusion of the conference that responsibility for the future health of New York's watersheds rests mainly with local communities, supported by government at multiple levels. FL-LOWPA, in cooperation with its member counties and local, regional, state and federal organizations, can facilitate cooperative watershed management in the Lake Ontario basin by supporting:

- sharing of technical and program information;
- public education and involvement forums;
- community-based strategic planning;
- local leadership development; and
- grassroots initiatives to coordinate priorities across watersheds.

WQB has a strengthened commitment to foster communication between basinwide and local entities, including:

- exploring greater use of video conferences;
- fostering cooperative learning processes;
- distributing lists of resources and experts; and
- updating and widely distributing reports.

WQB also can help link institutionally separate issues, such as water quality, habitat and lake levels, providing a conceptual umbrella to assist local ecosystem-based watershed planning.

The conference steering committee **recommended** the following to improve the roles of FL-LOWPA and WQB in facilitation of cooperative watershed management.

- FL-LOWPA should continue to improve its conference cycle by using the model from the 1996 Lake Ontario basin forum and applying it to the subwatershed level, including Finger Lakes and river basins. The model guides a community-based process to stimulate watershed visions and goals and evaluate strategies for meeting goals. FL-LOWPA members should take ownership of the output from local conferences by: 1) using the output from these forums to continuously improve current watershed management strategies for the watersheds they represent; and 2) ensuring the implementation of specific conference recommendations where appropriate.

- FL-LOWPA's five-year conference cycle should be coordinated with IJC so that, every fifth year, the forum is co-sponsored by FL-LOWPA and IJC's WQB to bring together local and regional perspectives for a basinwide conference on Lake Ontario (see fifth recommendation below).

- FL-LOWPA should advocate the use of facilitated processes for community-based cooperative watershed management. Recognizing that resources are not consistently available at the local level for facilitated processes, FL-LOWPA should provide training to its membership in the cooperative watershed management model demonstrated at the 1996 conference and in facilitation methods.

- FL-LOWPA members should take responsibility for bringing basinwide information and perspectives from regional entities, such as IJC and the Lake Ontario LaMP, to discussion at the local level. As a starting point, FL-LOWPA representatives can offer the information in the October 18-19, 1996 conference report to cooperators involved in grassroots watershed management and planning efforts.

- IJC should use its review and evaluation role to convene LaMP, RAP, fishery management and other watershed stakeholders around Lake Ontario to review

progress collectively and promote integration/cooperation. IJC could convene one such meeting/forum on each of the five Great Lakes during a five-year, iterative cycle. Advantages of a five-year, iterative review cycle would be: one Great Lake is a realistic scale to review progress and the need for integration; such a meeting/forum would create efficiencies for IJC and state, provincial and federal governments; it would foster lakewide alliances (i.e. it could demonstrate the importance and need for local watershed efforts to achieve lakewide goals and objectives and that some impairments in Areas of Concern like fish consumption advisories cannot be solved by RAPs alone and will require whole lake action through LaMPs); and such a meeting/forum would serve as a good mechanism to celebrate successes and measure incremental progress (using a common set of indicators) consistent with practical application of an ecosystem approach and watershed management. FLOWPA should be a co-sponsor of the IJC meeting/forum for Lake Ontario.

- IJC should update or re-release the work of its Pollution from Land Use Activities Reference Group (PLUARG). Many people felt the work under PLUARG is still relevant and timely, considering the current emphasis on watershed planning and management. IJC could recommend that federal, state, provincial and local governments use the PLUARG report as a benchmark to measure progress in restoring waters within Lake Ontario and its basin. IJC could act as a facilitator/resource available to agencies in interpreting and applying the findings and recommendations of PLUARG.

WQB is reviewing the conference's recommendations and providing specific advice to IJC in fall 1997.

WQB is reviewing the conference's recommendations and providing specific advice to IJC in fall 1997.

2.9 PRACTICAL AND COST EFFECTIVE WATERSHED MANAGEMENT

On May 3, 1996 WQB co-sponsored a conference entitled Practical and Cost-Effective Watershed Management in Livonia, Michigan with 23 other organizations and agencies. The conference attempted to move beyond theory to practice by presenting practical and cost-effective methods for implementing watershed management. The conference included technical sessions on: practical methods to protect and enhance habitats; storm water management; theory, practice and institutional arrangements; and funding local activities to put watershed management into action.

Over 300 people participated, including elected township, village and city officials; planning and zoning officials; government managers and staff; developers; builders; consultants; planners; engineers; landscape architects; park and subdivision design and review consultants; road commissioners and staff; drain commissioners and staff; citizen groups; property owners; and other stakeholders. **More detailed information can be found in the summary report under the WQB's home page www.ijc.org/boards/greatw.html(.)**

The summary report:

- presents an overview of the key ideas and findings from the technical session on practical methods to protect and enhance habitats;
- presents the extended abstracts from all papers presented at the technical session on practical methods to protect and enhance habitats; and
- identifies key methods manuals and resource documents relative to protecting and enhancing habitats.

Session participants recognized that one major challenge in ensuring habitat is adequately addressed in watershed management efforts is that "habitat has no home" (i.e. physical habitat often "falls through the cracks" and does not receive adequate attention in traditionally separate water quality management and fish and wildlife management programs). To address this challenge, there must be a concerted effort to ensure habitat is an integral part of community master plans. Critical components of a process ensuring habitat is incorporated into community master plans include:

- compile habitat inventory;
- develop public participation;
- form intergovernmental coordinating committee; and

- develop public/governmental partnership in plan development.

Options to be considered in plan development include:

- no-action alternative (i.e. no development can result in habitat preservation, however, it also can translate into an economic "loss" for communities, depending upon the situation, by passing up an opportunity to modify hardened shorelines and enhance habitat);

- fully engineered alternative (i.e. construction of breakwalls and marinas is viewed as a "win" for development, yet a "loss" for habitat because such construction is often limited in or devoid of sinuosity or habitat value); and

- soft engineering alternative (i.e. an approach that ensures a "win" for development through marina construction or other development and a "win" for habitat by achieving sinuosity of shorelines and modification of structures to enhance habitat).

Higher priority must be given to soft engineering alternatives to achieve "win-win" outcomes for habitat and economic development, and so as not to preclude future options.

Higher priority must be given to adequate monitoring and assessment, including inventories and classification systems. Session participants suggested that individuals must get involved up-front in project planning to adequately address habitat and ensure adequate assessment and monitoring. In addition, habitat rehabilitation and enhancement projects should be viewed as experiments, helping to ensure follow-up assessment in order to guide future habitat projects.

From a strategic perspective, greater emphasis should be placed on "piggy backing" habitat protection and rehabilitation on other local and regional planning and development initiatives. For example, communities can capitalize on waterfront redevelopment to ensure habitat gets incorporated into master plans. Although a systematic and comprehensive process of habitat conservation, rehabilitation and restoration will be a long-term endeavour, considerable opportunities exist to move forward with short-term actions that will benefit habitat and other issues (e.g. land use, economy, agriculture and recreation). Some examples of practical actions include:

- incorporate habitat protection into master, land-use and watershed plans and zoning ordinances;

- seek permanent protection for ecologically significant habitats by purchasing land to establish easements;

- ensure individuals with fish and wildlife expertise get involved up-front in project planning for waterfront redevelopment, shoreline modification, sediment remediation and navigational structures to adequately address fish and wildlife enhancement opportunities and ensure adequate assessment and monitoring;

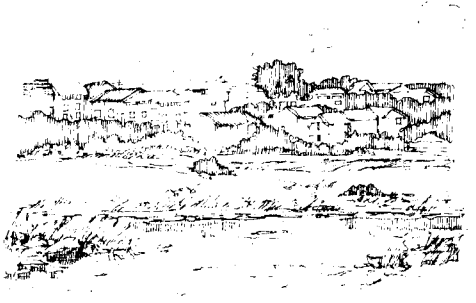
- ensure that agencies, such as state and local transportation departments, departments of public works, parks and recreation departments and others, incorporate ecological techniques that enhance fish and wildlife (e.g. bioengineering, incidental habitat enhancement of physical structures, willow posts, set backs and road crossings) into operating manuals and day-to-day operations; and

- establish citizen stewardship programs to help inventory habitat and work with landowners and agency personnel to enhance habitat.

Additional practical actions need to be identified.

WQB recommends the following.

- **IJC encourage the Parties to quantify and communicate to all stakeholders the values and benefits of practical actions to protect and enhance habitats ensuring continued progress toward healthy and sustainable watersheds and ecosystems.**



". . . ensure individuals with fish and wildlife expertise get involved up-front in project planning for waterfront redevelopment, shoreline modification, sediment remediation and navigational structures to adequately address fish and wildlife enhancement opportunities and ensure adequate assessment and monitoring."

2.10 HABITAT 2001

On February 25-27, 1997 WQB co-sponsored a workshop entitled Habitat 2001 dealing with the future of habitat restoration and protection on the Upper Great Lakes. Other co-sponsors included: Great Lakes Fishery Commission, Environment Canada, U.S. EPA, HabCARES Steering Committee, Ontario Ministry of Natural Resources, the Habitat Subcommittee of the Lake Superior Binational Program and the Lake Superior Programs Office. Over 50 Upper Great Lakes people with an interest in aquatic and terrestrial habitat attended.

Key issues addressed include: habitat science and technology; the continuing trend of habitat loss; the challenge of setting lakewide habitat objectives and delisting Areas of Concern; and information needs required to derive environmental objectives for the Upper Great Lakes. All workshop participants were challenged to provide leadership and become champions for action.

Important findings include: the science and technology of habitat rehabilitation and conservation is evolving rapidly; fish community objectives should be ecosystem-based; indicators are important to measure and celebrate progress; greater emphasis must be placed on linking aquatic and terrestrial habitat initiatives; issues of scale, communication and overlapping mandates must be addressed; and RAPs, LaMPs and watershed plans are vehicles to move forward with action. Table 3 presents breakout group summaries of next steps needed for each Upper Great Lake.

WQB recommends the following.

- **Great Lakes water quality and fisheries institutions convene workshops and roundtable discussions focussing on sharing habitat knowledge and experiences, and transferring technologies, in order to help sustain management efforts, and to further progress toward endorsement of one common set of ecosystem objectives for each lake.**

IJC should be a co-sponsor of these events, consistent with use of an ecosystem approach and especially Annex 2 of the Agreement.

Table 3 **Habitat 2001 Breakout Group Output of Next Steps Needed to Help Move Forward with Habitat Restoration and Preservation on the Upper Great Lakes.**

LAKE	NEXT STEPS IDENTIFIED IN HABITAT 2001 BREAKOUT GROUPS
Superior	• continue efforts to link land and water program initiatives • sustain combined efforts of LaMP, Lake Superior Technical Committee, and others • champion new focus on monitoring, indicators and target setting
Michigan	• need more fisheries and wildlife involvement in LaMP • LaMP must be broadened and be seen as more than a U.S. EPA exercise • issues of scope must be resolved (e.g. tributaries, land use) • the issue of objectives must be resolved
Huron	• workshops are needed to ensure integration of habitat • an initiative is needed to assess status of habitat (i.e. assess ecosystem components, compile and synthesize information by watershed, develop habitat objectives and targets) • a scoping meeting should be convened to initiate a process for establishing lakewide ecosystem objectives

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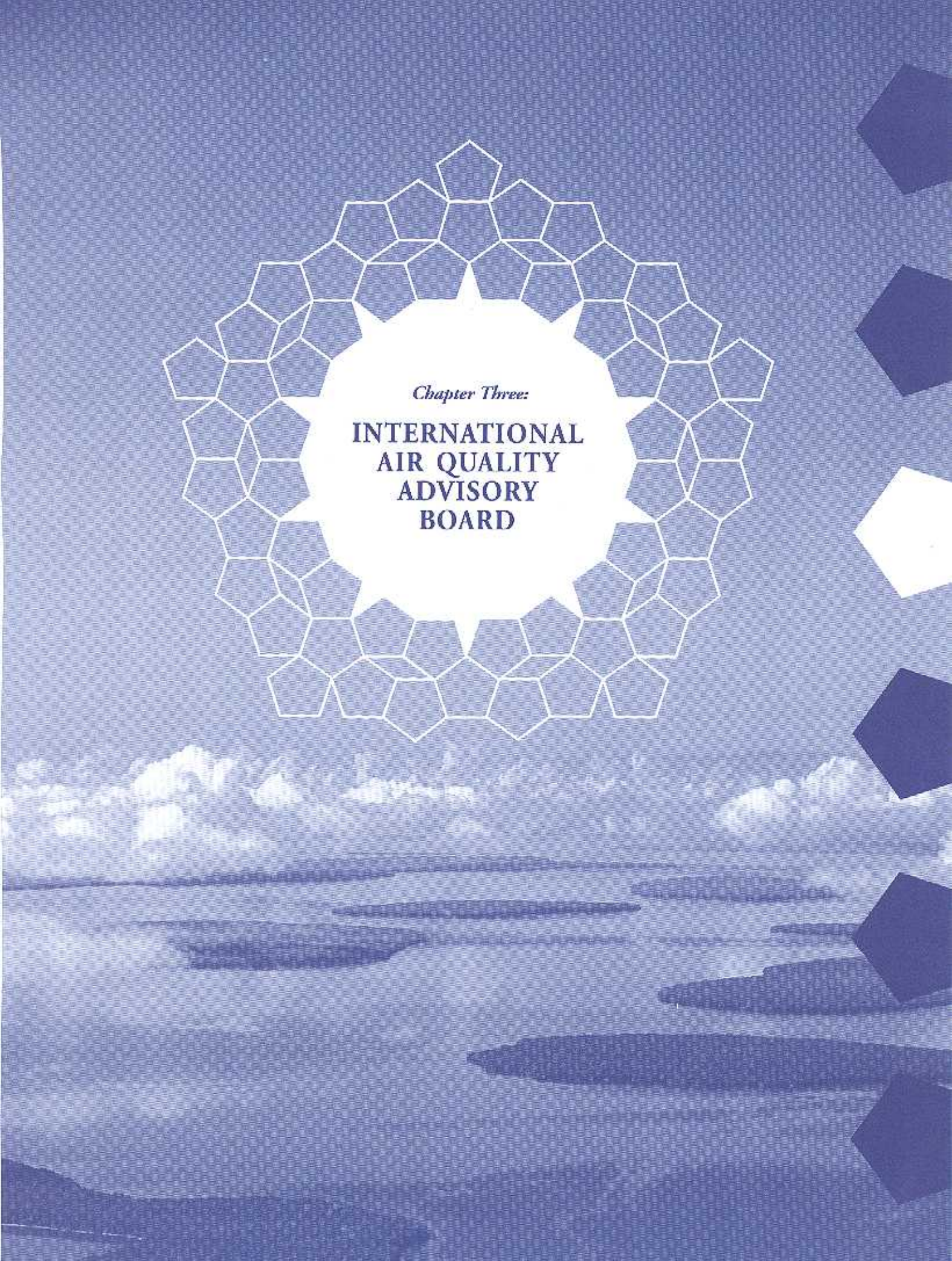


Chapter Three:

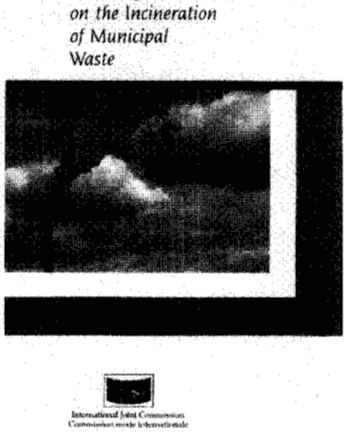
INTERNATIONAL AIR QUALITY ADVISORY BOARD

CHAPTER THREE *Contents*

3.1 INTRODUCTION

A portion of the **International Air Quality Advisory Board** (IAQAB) work during the 1995-1997 priority cycle was determining the extent of transport of persistent toxic substances to the Great Lakes from the atmosphere. Much of this work is summarized in the joint **Great Lakes Water Quality Board** (WQB) and IAQAB Workshop on Significant Sources, Pathways and Reduction/Elimination of Persistent Toxic Substances discussed in Chapter 3.3.

As part of this priority, IAQAB reviewed emissions from municipal solid waste incinerators and drafted the following policy statement, which was subsequently adopted by IJC. Technical analysis supporting the policy statement is contained in the report A Policy Statement on the Incineration of Municipal Waste. **Copies are available upon request from IJC and on the Internet at www.ijc.org/boards/iaqab/incin.html(.)**



3.2 A POLICY STATEMENT ON INCINERATION OF MUNICIPAL WASTE[1]

3.2.1 Preamble

The International Air Quality Advisory Board (IAQAB) fully endorses the principle of virtual elimination of persistent toxic substances to the Great Lakes and supports the need to manage municipal solid waste facilities toward this end. It further recognizes that municipal solid waste incinerators are sources of persistent toxic substances which can be transported long distances to or from the Basin and across national boundaries.

The IAQAB emphasizes that incineration is only one of a matrix of options and technologies available to currently address management of municipal solid wastes. Any incinerator application should be viewed in the larger context of an integrated solid waste management approach, which includes life-cycle analysis, with a priority on reduction and recycling initiatives. The IAQAB notes that there is an inherent conflict between the maximization of waste recycling, particularly of combustible fibre such as newsprint and cardboard, and sustainable, stable operation of an incinerator, as removal of such materials from the refuse significantly reduces its properties as a fuel.

The IAQAB recognizes that, if the incinerator option is chosen, facilities can be designed and operated to reduce the amount of toxic materials (including pathogens) in the waste, to concentrate the residual toxics in the ash and to minimize releases of same to the atmosphere. The health implications of release of fine (less than 10 microns) particulate matter from such sources must continue to be considered.

3.2.2 Principles

i) Consideration or deployment of municipal incinerators should not, in any way, compromise programs for waste reduction and recycling, which must remain the cornerstone of waste management.

ii) Should jurisdictions elect to build new incineration facilities, these, at minimum, should be in full compliance with the USEPA and MOEE requirements. Further, jurisdictions and proponents should recognize that emission control technology is constantly improving and should commit to incorporate such improvements at several points in the life span of any given facility.

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1 In September 1996, the International Joint Commission endorsed this policy statement as its position on municipal waste incineration.

In keeping with the principle of virtual elimination, the IAQAB wishes to state four additional principles, namely:

iii) Any further deployment of this technology by any jurisdiction should be done on the basis of a net reduction of emissions of persistent toxic substances, jurisdiction wide, from such facilities. Thus, existing units must be further controlled to new source performance standards or decommissioned by the year 2000. The USEPA regulations and those in some European jurisdictions contain this requirement, which should also be embraced by the Province of Ontario.

iv) The total amount of persistent toxic substances released by incineration facilities in a jurisdiction, defined as the sum of those to the atmosphere and in the residuals, must also be decreased whenever a new incineration facility is permitted.

v) Compliance with principle iii) also commits individual jurisdictions to the establishment and ongoing maintenance of publicly accessible emission inventories characterizing all regulated operating parameters, emissions and releases from these units.

vi) The operator and regulatory agencies must make a concerted and ongoing effort toward meaningful public involvement in all aspects of the facility. This includes significant public participation in initial selection of the incineration option, development of a comprehensive justification and related environmental assessment, construction and commissioning of the facility, as well as operation and final decommissioning. These considerations must extend beyond the facility to encompass measurement and publication of assessments of environmental quality including extensive ambient air quality monitoring for persistent toxic substances and other pollutants in the adjacent locale.

3.2.3 Technical Requirements

i) Operating facilities should be required to perform regular comprehensive ambient air and deposition monitoring in the vicinity of the plant and associated ash-disposal location.

ii) Emissions from the facility must be subject to continuous monitoring and manual sampling as provided for in the USEPA regulations. If necessary, further sampling to confirm the size distribution of particulate matter in the emission stream should be conducted.

iii) To the extent practicable for specific sites or waste flows, these units should be designed for extended stable operation, which could be realized, in part, by requiring the incorporation of electrical or other energy generation.

iv) The toxic content of residual ash and particulate should be determined at regular intervals to ensure associated disposal strategies are appropriate for the conditions encountered.

v) Source, ash residual and localized ambient air quality data should be collected and incorporated into an ongoing performance review program, with provision for effective public oversight.

vi) As an operational principle, Good Management Practice, including rigorous and certified operator training, is a must.

3.2.4 Financial Considerations

While finance is not an area of Board expertise, there is a need to ensure that adequate funds are available for:

i) continuous monitoring, appropriate maintenance activities and updating of process and control equipment throughout the lifespan of the facility;

ii) support for ongoing independent auditing of operations as part of a public review;

iii) sound decommissioning of both the unit and any associated residual disposal site, including long term monitoring of the integrity of any such site.

3.3 LOADINGS, SOURCES AND PATHWAYS OF PERSISTENT TOXIC SUBSTANCES

3.3.1 Introduction and Overview

The **Great Lakes Water Quality Agreement** calls for the virtual elimination of inputs of persistent toxic substances. In keeping with this objective, **Environment Canada** and **U.S. Environmental Protection Agency** (EPA), in cooperation with the Great Lakes state and provincial governments, developed The Great Lakes Binational Toxics Strategy -- Canada-United States Strategy for the Virtual Elimination of Persistent Toxic Substances in the Great Lakes. Specifically, the strategy commits federal, state and provincial governments to work with other public and private partners toward the goal of virtual elimination of persistent toxic substances resulting from human activity, particularly those that bioaccumulate, so as to protect and ensure the health and integrity of the Great Lakes ecosystem (Environment Canada and U.S. Environmental Protection Agency, 1997).

The **International Joint Commission** (IJC) identified significant sources, pathways and reduction/elimination strategies for persistent toxic substances as one of its priorities. IJC's **International Air Quality Advisory Board** (IAQAB) and **Great Lakes Water Quality Board** (WQB) collaborated on this priority and co-sponsored a workshop on May 21-22, 1997 to jointly evaluate four background reports (synopses of IAQAB reports on air sources and pathways and an evaluation of programs called for under Annex 15 of the Agreement; and synopses of WQB reports on use of mass balance modelling and an evaluation of beyond compliance programs) and identify critical research, assessment and management needs and priorities. Approximately 90 individuals, including researchers, air and water program managers and policy development specialists participated.

The workshop began with plenary presentations on air sources and pathways and the use of mass balance frameworks to assess relative pollutant loadings, followed by a plenary discussion of progress, knowledge gaps and uncertainties. Presentations on an evaluation of programs called for in Annex 15 and on evaluation of beyond compliance programs followed. The workshop then used facilitated breakout sessions to address needs and priorities relative to problem assessment (e.g. research, assessment, monitoring and mass balance modelling) and problem response (e.g. policy and management actions). The workshop concluded with plenary presentations and discussion of the findings and recommendations from each breakout session.

Key findings and recommendations and brief synopses of the four background reports are presented in Chapter 3.3.4. **The complete background reports are available upon request from IJC.**

Both IAQAB and WQB reiterate the importance of the Agreement and the 1997 binational toxics strategy in making further progress in restoring and sustaining the integrity of the Great Lakes. IJC has significant responsibility to review and evaluate progress under the Agreement. As part of this responsibility IJC should track the Parties' progress comprehensively under the binational virtual elimination strategy.

The May workshop is a good example of necessary research-management dialogue on virtual elimination of persistent toxic substances. IJC is in an excellent position to further such dialogue and facilitate binational cooperation. Examples of high priority areas where IJC could have an value-added impact include:

- advocating and facilitating efforts that result in a strong coupling between research and management, thus ensuring that research questions/projects and management objectives/initiatives are complementary and reinforcing;
- advocating the coordination of inventories and data bases and efforts to make them more accessible;
- collaborating in the process of identifying and operationalizing a set of indicators to measure progress;
- advocating the coupling of monitoring, modelling and risk assessment in a truly integrated fashion;
- reviewing and evaluating progress under the Great Lakes Binational Toxics Strategy; and
- promoting the use of ISO 14000 to achieve further reductions in loadings of persistent toxic substances.

Greater emphasis should be placed on communicating research-management needs and the value and benefits of programs targeted at control and prevention of persistent toxic substance problems. IJC should continue helping facilitate such communication on a regular basis. Both IJC and the Parties/jurisdictions should work with industries and businesses to quantify the environmental and economic benefits of these programs in order to foster greater application throughout the Great Lakes basin ecosystem.

3.3.2 Key Needs and Priorities for Problem Assessment

Workshop participants considered what scientific issues need further assessment most urgently. In the course of the discussion, the following observations emerged.

- Good science is a prerequisite for good policy and effective control programs.
- In recognition of universal resource constraints, where feasible, initiatives identified at the workshop might best be developed and executed through ongoing multi-agency and bilateral planning and coordination, including joint funding of initiatives.
- Close and ongoing consultation is needed among modellers, emission inventory developers, monitoring specialists, policy and program managers and human health experts in the estimation of deposition and exposure routes of persistent toxic substances.
- The 1997 strategy and Annex 15, added to the Agreement in 1987, both require better quantification of emissions from major sources, source categories and source regions for the strategy's Level I and Level II contaminants than is currently available (see Table 4 on page 69).
- In order to produce better models of atmospheric transport, the physical and chemical properties of Level I and II substances must be better defined, especially for chemical families, such as PCBs and dioxins. For modelling purposes, emission inventories should also be extended to contain more information on the characteristics (e.g. stack heights and exit temperatures) of releases from major sources.
- For many contaminants transport is complicated by the "grasshopper effect;" they are deposited in one location under one set of circumstances (fall/winter), only to be resuspended, transported and deposited in another location (such as the Arctic) under a second set of circumstances (spring/summer). The Great Lakes basin is a part of this phenomenon needing further focused research.
- The differences in their potential for sustained transport (measured as atmospheric half-life) among the strategy contaminants suggest that some (e.g. hexachlorobenzene) require global coordination and others a continental or regional strategy. For example, management of hexachlorobenzene could involve the **United Nations** environmental activities; pollutants with a continental reach, the **Commission on Environmental Cooperation** (CEC); and those distributed on a regional or subregional basis, IJC.

Possible Future Actions

The workshop participants determined the following.

- Execution of the strategy could benefit from formation of a distinct structure for consideration and resolution of scientific issues. Simultaneous, coordinated, multinational and multidisciplinary approaches on emission inventories, pathways and multimedia modelling and long-term monitoring, should be among the needs managed under such a structure. Linkages to activities supported by CEC and the United Nations Economic Council for Europe should be considered.

"Routine, ongoing binational dialogue between emission inventory personnel and modellers, a cataloguing and linkage of central inventories and databases, and better integration of inventories and modelling efforts to support environmental decision management models, should be encouraged immediately."

- Further quantifying of sources and source regions of Level I and II contaminants, through improved, readily accessible emission inventories, linked binationally and coupled with models, should proceed. Information on sources, transport and deposition or loading from all pathways, and in biota, should include error estimates to allow more appropriate application.
- Routine, ongoing binational dialogue between emission inventory personnel and modellers, a cataloguing and linkage of central inventories and databases, and better integration of inventories and modelling efforts to support environmental decision management models, should be encouraged immediately. A refinement of and commitment to long-term compatible monitoring programs should be completed within the next five years.
- Building on the success of this workshop, IJC should play a role in these efforts initially, including hosting the first few bilateral consultations or technical workshops.
- A thorough binational assessment of the strengths, weaknesses and limits of currently available approaches, with related information requirements, including 1) mass balance, 2) rigorous application of atmospheric modelling linked with emission inventories, and 3) development and use of other indicators, focusing on human, particularly reproductive health,

should be carried out. Priority should be given to pollutant controls producing the most prompt and greatest positive effect on human health.

- Reductions in deposition of Level I and II substances resulting from controls or preventive actions on sources internal and external to the basin should be quantified on a binational basis. Inputs from other pathways (e.g. point source effluents, indirect discharges and sediment exchange) should be better quantified.

- Upgraded monitoring for more Level I and Level II pollutants in the atmosphere, waters and biota of the basin, including a focus on air/surface interchanges through the deployment of deposition monitoring units on the lake's surface, is necessary.

- Current activities for four contaminants — mercury (in several specific forms), toxaphene, atrazine and PCBs — should be enhanced. Mercury studies should focus on determination of physical and chemical properties of its various forms. Studies needed include: atmospheric emissions of particular forms (total, Hg^{o}, Hg^{2+}, $HgCH_3$ particulate and gaseous) from major point sources (with minor and areal sources estimated on a county basis); loading via effluent discharges; indirect discharges; revolatilization (grasshopper effect); and comprehensive multinational monitoring. Further research is necessary on atmospheric chemistry and surface exchange, aquatic speciation, methylation and bioaccumulation phenomena, and ultimately development of a model.

- Toxaphene research should address physical/chemical properties, determine any active basin sources and soil residues, and support intensive short-term monitoring to differentiate between near and distant sources. The aquatic chemistry of atrazine and its degradation products requires further study.

3.3.3 Key Needs and Priorities for Problem Response

The Great Lakes Binational Toxics Strategy as a Framework for Action

Workshop participants recognized the importance of the strategy as a framework for action. The strategy provides the systematic and comprehensive framework necessary to target chemicals and the remedial and preventive actions required to protect and ensure the health and integrity of the Great Lakes basin ecosystem (Environment Canada and U.S. Environmental Protection Agency 1997).

Workshop participants also recognized the need for good science as the foundation for good management actions (i.e. problem response initiatives). A good understanding of sources, pathways and processes is necessary in order to help prioritize management actions. Current needs include: enhancing the source inventory and loading data bases; acquiring better information on physical and chemical properties of contaminants; resolving the "old" versus "new" source question (e.g. grasshopper effect); and understanding processes of compound formation, such as dioxin.

It was well recognized that science will never be perfect, nor entirely complete. However, management must not be afraid to take action. Tools are available to prioritize management actions. Workshop participants noted a need for strong, effective leadership for implementation of the strategy. Governments should do more to lead by example. As part of an implementation framework, workshop participants reiterated the importance of strong linkages between research/assessment and management in order to identify and implement pragmatic, ecosystem-effective solutions.

Both Canada and the U.S. have made progress in controlling the input of persistent toxic substances, however, much more needs to be done to meet the goal of virtual elimination. It was suggested that future management actions should be guided by four principles: step-wise, integrated, incremental and accountable.

"It was suggested that future management actions should be guided by four principles: step-wise, integrated, incremental and accountable."

Regulatory programs continue to be a stimulant for beyond compliance programs. Beyond compliance programs should be targeted at persistent toxic substances. A balance should be achieved between regulatory and voluntary, beyond compliance programs. Prevention-based programs, such as ISO 14000, have tremendous potential to achieve environmental results. Following implementation of management actions, adequate post-project monitoring to evaluate effectiveness and document value and benefits (both environmental and economic) is needed. Such information on the value and benefits of voluntary, beyond compliance and regulatory programs can be used to market "win-win" solutions elsewhere. Recent experience with beyond compliance programs shows that the best environmental successes occur when there is cost savings.

Program Evaluation to Ensure Accountability

Participants agreed that most problem response actions are taken within an adaptive management framework (i.e. assess, set priorities and take action in an iterative process). Consistent with this adaptive management philosophy, participants recognized the importance of evaluating progress in reducing/eliminating persistent toxic substances. Specifically, binational evaluation of progress toward virtual elimination should be undertaken by IJC and its boards and should include all relevant Agreement annexes (e.g. Annex 2, 15). IJC and its boards may want to develop (over a six month period) a plan or strategy to review and

evaluate progress toward virtual elimination of persistent toxic substances in a comprehensive fashion. This review and evaluation plan or strategy would include, among other elements, the following:

- a prioritization of contaminants (beginning with PCBs, mercury and toxaphene);
- an identification of a spectrum of indicators;
- an inventory of data availability and gaps; and
- a mechanism to ensure linkages to lakewide management plans (LaMPs) and remedial action plans (RAPs).

Participants recognized a number of obstacles to undertaking such a comprehensive review and evaluation of progress:

- limited resources;
- insufficient data and information;
- incomplete integration of programs and limited comparability of data bases;
- institutional complexity; and
- concern for confidentiality of some information.

Although such obstacles exist, participants agreed with the high priority need to undertake binational review and evaluation of progress toward virtual elimination of persistent toxic substances. Benefits include ensuring greater accountability, demonstrating and celebrating progress and making mid-course management corrections.

Prevention-Based and Beyond Compliance Programs

More effort should be placed on fostering prevention-based programs. Federal, state, and provincial governments must ensure that burden of proof to prevent problems is placed on industry. In addition, governments should lead by example through manifesting pollution prevention and materials management initiatives. Within the area of ISO 14000 there is considerable opportunity to build on the environmental management system (EMS) foundation. For example, persistent toxic substances should be addressed as significant environmental aspects within the EMS process.

There is also an opportunity to "broaden the net" and establish more partnerships. For example, organizations like the Council of Great Lakes Industries, Cleveland's Advanced Manufacturing Center, the Canadian Pollution Prevention Centre in Sarnia, Chemical Manufacturers Association, Canadian Chemical Producers' Association and the Society of Environmental Toxicology and Chemistry should be encouraged to participate in and disseminate information on practical initiatives and technologies for pollution prevention and help manifest "win-win" solutions for environment and economy.

Barriers to fostering prevention-based programs include: few incentives for business/industry; low priority to small-medium sized businesses; measurement a low priority; governments do not provide enough recognition to pollution prevention plans and accomplishments; and the command-and-control mindset continues to result in lack of trust. There is considerable opportunity for IJC and governments to work in partnerships with other industrial organizations and professional societies to address these barriers and achieve greater environmental results. Further, since pollution prevention programs have been in place in all jurisdictions for some time, there is need to evaluate and share current information on pollution prevention program efficacy.

Communication

Breakout session participants also agreed on the need for effective communication. This workshop was an excellent example of the value and benefits from effective communication among air and water program managers, policy makers, researchers and academic scientists. Such coupling of science and management is a prerequisite for ecosystem-based management. Other opportunities ensuring effective communication on virtual elimination of persistent toxic substances include:

- IJC and the Parties/jurisdictions could sponsor more binational forums (e.g. there is an immediate need to identify and quantify sources of Level I and II contaminants identified in the Great Lakes Binational Toxics Strategy);
- LaMP committees should be seen as effective vehicles for science-management communication; and
- IJC and the Parties/jurisdictions should consider co-sponsoring events with organizations, such as CEC and the Council of Great Lakes Governors.

Efforts are needed to clarify roles and responsibilities, promote integration of programs, reach agreement on common goals and indicators and develop a common communication and information strategy (e.g. web-based with adequate linkages).

Other Issues

Workshop participants recognized there are other management response issues that eventually must be addressed. These issues may not be a high priority in the near term, but undoubtedly will require attention in the future. An example would be an evaluation of opportunities to move away from carbon-based fuels. Workshop participants suggested that management must continue to be open to different perspectives and new ideas.

3.3.4 Synopses of Background Reports

Atmospheric Transport and Deposition of Persistent Toxic Substances to the Great Lakes (IAQAB)

Since 1987, the significance of the atmospheric pathway for several contaminants, including PCBs, mercury and lead, has been well established by IJC and others. As one of its principal activities under IJC's priority on transport of persistent toxic substances to the Great Lakes basin, IAQAB commissioned a review (Cohen et al. 1997) of the state of the science regarding the emission, transport and deposition of Level I and Level II contaminants listed in the Great Lakes Binational Toxics Strategy. The strategy is focusses on approximately 27 compounds or classes of compounds as shown in Table 4 (Environment Canada and U.S. Environmental Protection Agency, 1997); 11 of the 12 Level I Substances were identified by WQB as critical pollutants in 1985. The review performed by Cohen and colleagues addressed:

- the capacity of substances to participate in long range atmospheric transport;
- the use of emissions inventories in identification of major sources and source regions;
- the use of modelling of transport and deposition initiatives to identify and verify pathways; and
- the use of ambient monitoring in quantifying deposition and verifying pathways.

Examination of physical and chemical properties of the strategy pollutants was a significant undertaking, as several are families of compounds, (such as the 209 congeners of PCBs), each with distinct properties. Cohen and colleagues determined that uncertainties and gaps in physical, chemical and/or atmospheric fate data for many of these substances limit the application of modelling and deposition determination techniques to these pollutants.

The potential of individual compounds for long range transport was assessed through consideration of evidence of emissions to the air; indirect indications of transport (such as detection at remote, isolated locations); and a determination of theoretical atmospheric lifetime, including consideration of physical/chemical properties, reactions in the atmosphere and deposition processes. Cohen's ranking (Table 5) indicates several contaminants have a global reach; others could be considered more continental, regional or subregional. Compounds with the longest atmospheric lifetimes include the chlorobenzenes, hexachlorobutadiene and elemental mercury. For these compounds, and possibly several others (e.g. DDT, mirex, hexachlorocyclohexanes, octachlorostyrene, and many of the PCBs), a global accounting may be necessary.

Table 4 **Persistent Toxic Substances (Level I and Level II) Identified in the Great Lakes Binational Toxics Strategy**

Critical pollutants identified by WQB in 1985 are indicated with an asterisk (*)
Persistent organic pollutants from CEC Council Resolution #95-5 are identified with a caret (^).

LEVEL I	LEVEL II
Aldrin ^ Dieldrin *^ Benzo(a)pyrene {B(a)P} * Chlordane ^ DDT, DDD, DDE *^ Hexachlorobenzene (HCB) *^ Alkylated lead * Mercury * and its compounds Mirex *^ Octachlorostyrene PCBs *^ Dioxins (PCDD; 2,3,7,8-TCDD) *^ Furans (PCDF; 2,3,7,8-TCDF) *^ Toxaphene *^ *NOTE: Hexabromobiphenyl and Pentachlorophenol are listed as POPs on the CEC Council Resolution #95-5 but are not included on the Strategy list.*	Cadmium and its compounds 1,4-Dichlorobenzene 3,3'-Dichlorobenzidine Dinitropyrene Endrin ^ Heptachlor and heptachlor epoxide Hexachlorobutadiene Hexachloro-1,3-butadiene Hexachlorocyclohexane (including alpha, beta, delta, lindane) 4,4'-Methylenebis(2-chloroaniline) Pentachlorobenzene Pentachlorophenol Tetrachlorobenzene (1,2,3,4- and 1,2,4,5-) Tributyl tin Polycyclic aromatic hydrocarbons (PAHs) ^ as a group, including but not limited to: Anthracene Benzo(a)anthracene Benzo(g,h,i)perylene Perylene Phenanthrene

Emission inventories are crucial to the determination of source regions and source-receptor relationships. Major inventories assembled by each country were reviewed. While a source of useful information, not all strategy contaminants were included, nor was there enough information on derivation, spatial and temporal resolution, quality assurance, or parameters (temperature, height, velocity of emission) specific to modelling source-receptor relations to provide input for modelling atmospheric transport.

Specific mercury compounds, as well as pentachlorophenol, PCBs and others need quantification; the treatment of banned or restricted biocides (dieldrin, DDT, mirex, toxaphene) should also be improved. Confidentiality agreements with individual facilities or sectors appear to be a significant hurdle in assembling emission information for modelling. The binational Great Lakes Regional Air Toxics Inventory, currently under development, shows promise and should be assessed more thoroughly as it matures.

The ambient air monitoring programs in the basin can provide an extremely useful set of data for comprehensive models of pollutant fate and transport. However, the list of contaminants monitored should be extended to better embrace Level I and Level II contaminants. While the **International Atmospheric Deposition Network** (IADN) determines ambient air concentrations and deposition for many of these compounds, others, such as dioxins and dibenzofurans, are not being monitored comprehensively, although some are determined by individual jurisdictional efforts.

Further water column pollutant monitoring and examination of air/water mass transfer processes to better estimate net loadings to and from the lakes are needed. The output of the **Lake Michigan Mass Balance Study** may address some of these concerns and put the atmosphere contribution in context with those from direct effluent discharge and indirect inputs, such as runoff and sediment resuspension.

Cohen and colleagues, in their consideration of modelling, noted that back-trajectory approaches applied to several of the strategy contaminants identified source regions, such as toxaphene transport from the southeast states. More comprehensive modelling approaches were used for heavy metals, including mercury, and toxaphene, hexachlorobenzene, dioxins and dibenzofurans; however, specific source-receptor relationships were only available in one case (dioxin). Again, improved emissions inventories are needed if specific sources and receptors are to be directly linked. Information on air/surface interactions are among items that must be improved. The grasshopper effect must also be accounted for in modelling several of these pollutants.

Cohen and colleagues concluded with the following recommendations.

1. The signing of the binational strategy should become the basis for a bilateral (or perhaps trilateral, including Mexico) structured and continual effort addressing source-receptor relationships for those contaminants whose transport to the basin, via the atmospheric pathway, appear to be significant.

2. This effort should address research on: physical-chemical properties of strategy chemicals/compounds and classes; chemical reaction rates and concentrations of reactants; rates of atmospheric photolysis; vapor/particle partitioning phenomena; wet and dry deposition processes; meteorological processes; development of data sets for model validation; modelling studies of transport; and further consideration of the "grasshopper effect."

3. Routine deposition and ambient air monitoring efforts in the Great Lakes region should be extended to the balance of Level I substances and several Level II substances, including specific mercury species, alkylated lead, 3,3'-dichlorobenzidine, 1,4-dichlorobenzene, PCDD/PCDF, dinitropyrenes, hexachloro-1,3-butadiene, pentachlorophenol and toxaphene. The addition of 4,4'-methylenebis(2-chloroanaline) and tributyltin compounds to the list of substances monitored might be implemented on a temporary basis to determine the potential significance of the air pathway to Great Lakes loadings for these compounds.

4. A bilateral (or trilateral) review and coordinated revision to emission inventories should be undertaken, including all appropriate strategy contaminants to a level of quality suitable for use in atmospheric transport models, yielding comparable results and with suitable access to individual source information.

5. A bilateral (or trilateral) review should be undertaken to:

   - identify the capabilities of individual models and the most appropriate models for application to particular contaminants; and

   - determine the availability of adequate support data, including emission inventories, atmospheric concentration and deposition measurements and other items noted under the research recommendation.

The focus of this review should be on the identification of models validated as capable of determining linkages between receptors and individual sources and the availability of required input information to support same.

Table 5 **Estimated Long-Range Air Transport Potential of Strategy Compounds**

LONG RANGE TRANSPORT RATING			
1 (High)	**2**	**3**	**4**
APPROXIMATE ATMOSPHERIC HALF LIFE			
1 year or more	1 week-few months	Few hours-few days	seconds-minutes
GEOGRAPHIC DISTRIBUTION (approximate average transport distance associated with half-life)			
global	1,000-10,000 km (possibly global)	100-1,000 km	local
elemental mercury	particulate mercury	aldrin (?)	aldrin (?)
hexachloro-1,3-butadiene	mercury dichloride	heptachlor (?)	heptachlor (?)
tetrachlorobenzenes	alkylated lead	4,4'-methylenebis(2-chloroaniline) (?)	4,4'-methylenebis(2-chloroaniline) (?)
pentachlorobenzene	cadmium		
hexachlorobenzene	DDT/DDD/DDE	tributyltin (?)	
	mirex	heptachlor epoxide	
	toxaphene	methoxychlor	
	hexachlorocyclohexanes (α, β, δ, γ)	dieldrin	
	pentachlorophenol	endrin	
	octachlorostyrene	phenanthrene	
	3,3'-dichloro-benzidine	anthracene	
	1,4-dichlorobenzene		
	PCDD/PCDF		
	PCBs		
	dinitropyrenes		
	benzo[a]pyrene		
	benzo[a]athracene		
	perylene		
	benzo[g,h,i]perylene		
	PAHs (as a group)		

Note: The (?) indicates that the classification for these substances is less certain and more approximate than for the other substances.

Use of Mass Balance Modelling and Deposition Monitoring to Assess Relative Pollutant Loadings (WQB)

U.S. EPA is using mass balance modelling to evaluate sources, transport and fate of toxic contaminants in the Great Lakes. Mass balance modelling allows prioritization of research and remedial and regulatory actions for water and air quality management. The primary goal of Great Lakes mass balance modelling studies is to develop and improve toxics reduction management tools based on sound, scientific information to guide future toxic load reduction efforts at the state and federal levels.

The mass balance approach requires the quantities of contaminants entering the system, less the quantities stored or transformed within the system, must equal the quantities leaving the system. Once a mass balance for selected contaminants is established and a mass balance model calibrated, additional contaminants can be modelled with limited data.

In a pilot mass balance study by U.S. EPA and the Wisconsin Department of Natural Resources, water-insoluble organic compounds were monitored in Green Bay, Wisconsin from 1988 to 1992 (Figure 2). This pilot study demonstrated the effectiveness of mass balance modelling in quantifying the relative contribution of contaminants and prioritizing management actions.

The first full-scale application of this methodology for toxic pollutants is the Lake Michigan Mass Balance Study (LMMBS), which will serve as the basis of any future mass balance modelling efforts for persistent, bioaccumulative chemicals. The analytical and modelling tools used in the study may be applied to other Great Lakes, Lake Champlain and coastal estuaries. LMMBS monitoring data are expected to be available by the end of 1997 and initial model output by 1998. In addition to LMMBS atmospheric monitoring, U.S. EPA's Great Lakes National Program Office manages, in cooperation with Environment Canada, a binational atmospheric monitoring network, IADN. Information from this network is used in the estimation of air toxics loadings to the lakes.

LMMBS is intended to develop a predictive capability, allowing determination of environmental benefits of specific load reduction scenarios for toxic substances and the time required to realize those benefits. This includes the evaluation of benefits of load reductions from voluntary programs and existing environmental statutes and regulations required under the U.S. Clean Air and Clean Water Acts. For this study, not only were atmospheric concentrations of toxic contaminants monitored by lake, but also concentrations of toxic substances in fish, phytoplankton, sediment and the water in tributaries.

This information is important for improving understanding of key environmental processes governing the cycling and

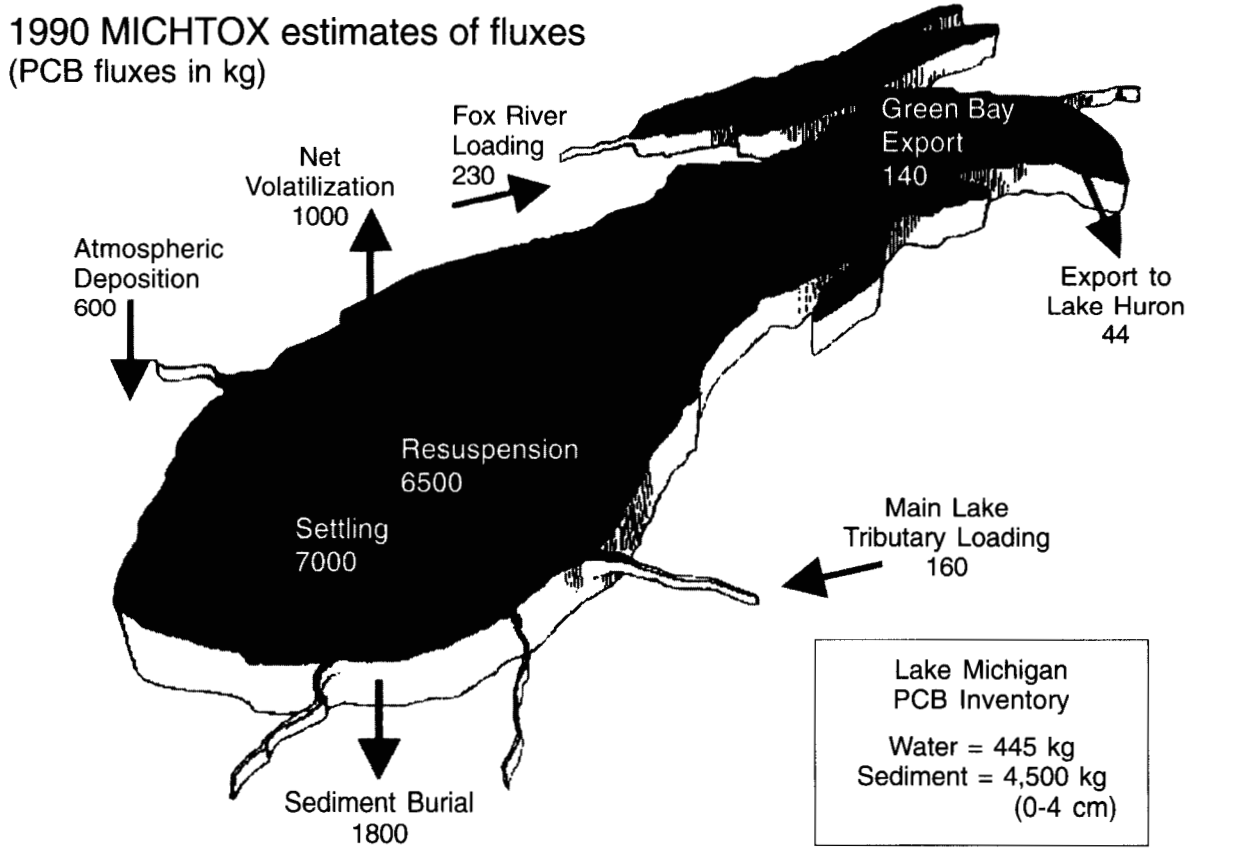

Figure 2 **1990 MICHTOX Estimates of Fluxes (Green Bay)**

bioavailability of contaminants within relatively closed ecosystems. It can also be utilized to construct a predictive model of contaminant cycling within the system. Processes and rates of processes of air-water or sediment-water transfer of contaminants are required to complete such a model and create a management tool to predict environmental effects of toxics loadings.

LMMBS was designed to predict how contaminant concentrations in the water column and target fish species are affected by loadings from air and water over a 25-year period. Pollutants chosen for the LMMBS model were total mercury, atrazine, trans-nonachlor and PCBs. Additional pollutants were monitored for model development purposes (e.g. nutrients, radionuclides, trace metals, organochlorine pesticides and PAHs). This required a two-year monitoring effort to collect all necessary information for the model.

The computer model developed on these monitoring data is based upon the linked sub-model approach used in the Green Bay Mass Balance Study. It includes the following submodels: hydrodynamics, sediment transport, sediment bed dynamics, eutrophication/sorbent dynamics, contaminant transport and fate and food web accumulation. Linkages were established with atmospheric transport and watershed delivery models to allow simulation of multimedia toxics transport and to relate watershed and airshed management to water quality.

Atmospheric data for the model are coming in part from IADN — a bilateral effort mandated by Annex 15 of the Agreement. In the U.S., the 1990 Clean Air Act amendments also require establishing one measurement site on each of the Great Lakes. IADN is intended to provide the necessary standardized methods, monitoring data and loadings estimates to assess the relative importance of atmospheric deposition compared to other inputs; determine temporal trends and geographical variations in deposition; and ultimately provide information about sources of these atmospheric pollutants.

IADN has indicated a reduction in lead deposition between 1988 and 1994 as a response to the ban on leaded gasoline in the U.S. and Canada. Arsenic deposition also has decreased.

1994 data for PCBs show a comparative increase in volatilization from the lakes and a decrease in wet and dry deposition to the lakes. The most recent estimates are of a net output of PCBs from the lakes (Hornbuckle et al. 1994), contrary to results obtained in 1988. Lakes Erie and Ontario appear to have the highest loading rates to the air (5,000 and 3,600 kilograms per year, respectively). The high gas transfer rates suggest that the water concentrations should be experiencing a noticeable decline or at least seasonal variation. However no studies on seasonal variation of PCB water concentration have been published (Hornbuckle et al. 1994). In addition, gas transfer rates are among the physical properties having a very high uncertainty associated with them.

PAHs are seen both in gas and particulate phase, but some of the most toxic PAHs are largely found in the atmosphere in the particle phase. Thus, for the most toxic PAHs, dry deposition is the main route of transport into the lakes (Hoff and Brice, 1994). 1994 results also suggest that outgassing of the pesticides lindane, DDT (and metabolites DDD and DDE) and dieldrin appears to occur.

"This pilot study demonstrated the effectiveness of mass balance modelling in quantifying the relative contribution of contaminants and prioritizing management actions."

The mass balance model should be responsive to this "two way traffic" of pollutants and further recognition of the Great Lakes themselves as, on occasion, a source of persistent toxic substances to the atmosphere.

Assessment of Parties' Progress under Annex 15 in Reducing Emissions of Persistent Toxic Substances (IAQAB)

Annex 15, added to the Agreement in 1987, recognizes the atmosphere as a significant pathway for persistent toxic substances and outlines the research, surveillance and monitoring and control measures needed to further quantify and reduce such transport. Under IJC's 1995-1997 priorities, IAQAB attempted an assessment of government efforts under Annex 15 toward immediate and forecasted reductions of emissions of persistent toxic substances from identified major sources. This assessment focussed on substances listed in the Great Lakes Binational Toxics Strategy. As shown in Table 4, most of the Level I substances in the strategy were designated as critical pollutants by WQB in 1985 and as persistent organic pollutants by CEC in 1995 (Council Resolution #95-5).

A survey questionnaire was sent to representatives of appropriate federal, provincial and state agencies; 50 percent responded. The limited submitted material indicated that, while the implementation of programs designed to reduce the use of those substances not already subject to a ban was proceeding on several fronts, cumulative quantification of reductions appeared largely unavailable.

In the last decade, the Canadian government has implemented laws, policies and programs designed to reduce emissions of Level I and many Level II substances. All Level I substances are listed in one or more programs or policies for virtual elimination. Most Level II substances are included in programs designed to reduce use, release and generation on a voluntary basis only. An example of results from the voluntary program Accelerated Reduction /

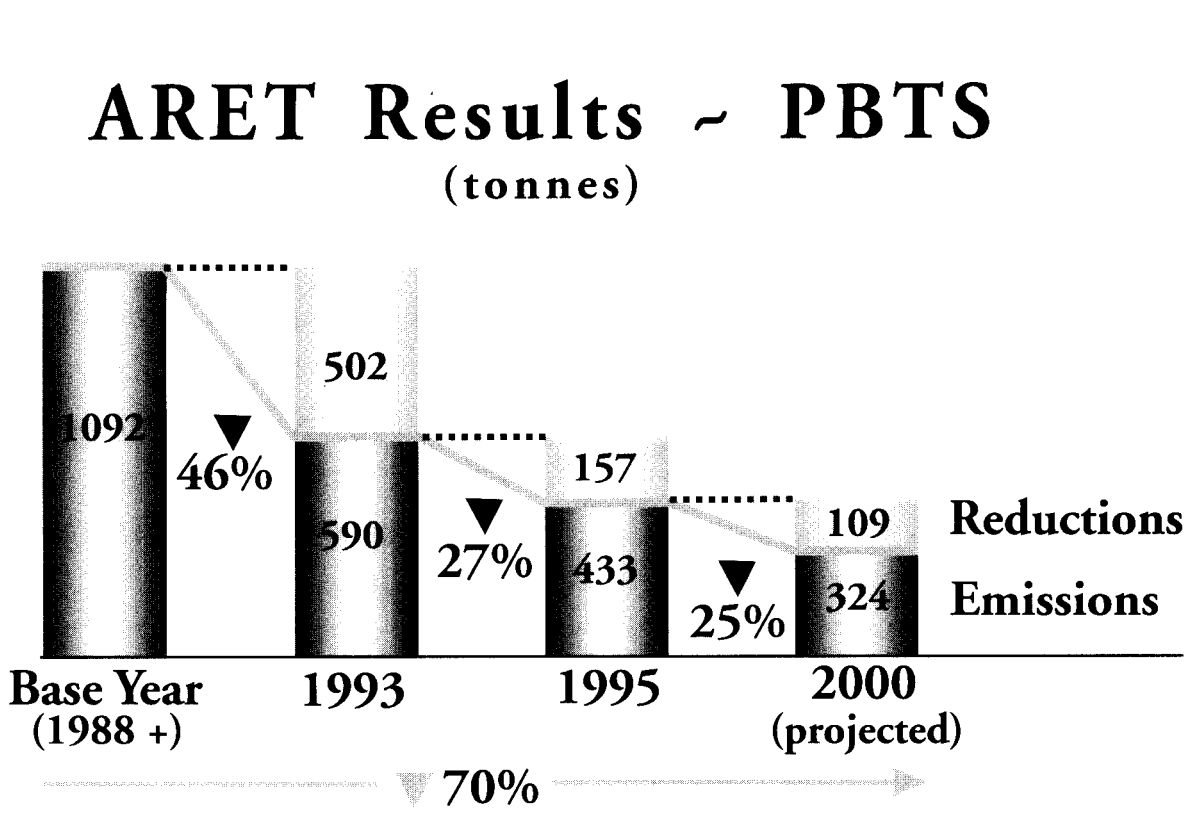

Figure 3 **Total Achieved and Predicted Reductions of the 30 Persistent Bioaccumulative Toxic Substances (PBTS) Targeted for Virtual Elimination by the Chemical Manufacturing Sector under the Voluntary Accelerated Reduction/Elimination of Toxics (ARET) Program. (Environment Canada)**

Elimination of Toxics (ARET) is presented in Figure 3.

Timelines and targets for virtual elimination are being developed for these Level II substances. Endrin and heptachlor are included in Canadian programs designed for virtual elimination. Hexachlorobutadiene, pentachlorobenzene and tetrachlorobenzenes are not targeted for reductions by any federal program or policy in Canada. Any reductions would be achieved with the active participation of the provinces; Ontario is expected to play a prominent role through its commitments under the Canada-Ontario Agreement. The response from Environment Canada included a tabular presentation by contaminant, offering a first estimate of annual emissions, citations of applicable legislation and reduction targets, where available.

While Canadian programs are comprehensive in scope, quantitative tracking of resultant overall emissions reductions with established precision and accuracy is not presently possible due to the lack of a comprehensive emissions database. Environment Canada is developing national inventories of estimated air releases for many substances for this purpose.

Federal and state governments in the U.S. have a variety of laws, policies and programs addressing persistent toxic substances. The United States government has created numerous programs and regulations to collect data regarding point and area emissions, monitoring, wet and dry deposition, loading estimates and the effects of toxic air substances on humans and the environment, as well as supporting modelling studies to better understand the sources and receptors of various pollutants. Together, these programs and policies have significant components concerned with most Level I and Level II substances.

A major federal initiative is targeted toward reducing emissions of mercury, a Level I substance, as detailed in the *Mercury Study Report to Congress*. As a result, most states implemented mercury reduction programs and can report emissions reductions through collections and proper disposal.

Particularly relevant sections of the Clean Air Act include section 112 (m), the Great Waters Program, under which U.S. EPA and the National Oceanic and Atmospheric Administration have supported deposition monitoring, emission inventory efforts, multimedia modelling and mass balance approaches in particular regions, including the Great Lakes.

Section 112 (c)(6) of the Clean Air Act Amendments of 1990 contains a program particular to seven specific pollutants -- alkylated lead compounds, polycyclic organic matter (including PAHs), hexachlorobenzene, mercury, PCBs, and 2,3,7,8-TCDD and TCDF. Within five years of

enactment, source categories accounting for not less than 90 percent of the aggregate emissions of each compound must be listed. Further, it must be determined that these emissions do not violate established health thresholds or they must be subject to further controls not later than 10 years after enactment. Electric utility steam generating units were exempted from specific promulgation requirements.

Emission inventories for the seven specific pollutants, largely using 1990 as a base year, were made available by U.S. EPA in June (1990 Emissions Inventory of Section 112 (c)(6) Pollutants, Emissions Monitoring and Analysis Division, U.S. EPA, Research Triangle Park, North Carolina). Estimated emissions from several source categories were lowered since 1990 due to continued activity toward development of various National Emission Standards for Hazardous Air Pollutants (NESHAPs), as well as further improvements in the precision of the estimates (U.S. EPA 1996). These two developments are reflected in the estimated nationwide dioxin emissions for 1990 and 1996 from three source categories (Figure 4). This ongoing inventory activity should allow further revised nationwide emission estimates for others of these seven Level 1 contaminants.

The United States federal **Toxic Release Inventory** (TRI) encourages recycling and pollution prevention, but is not a tool for enforced reductions in emissions of toxic substances. Most, but not all, persistent toxic substances are included in the TRI emissions data collection requirements.

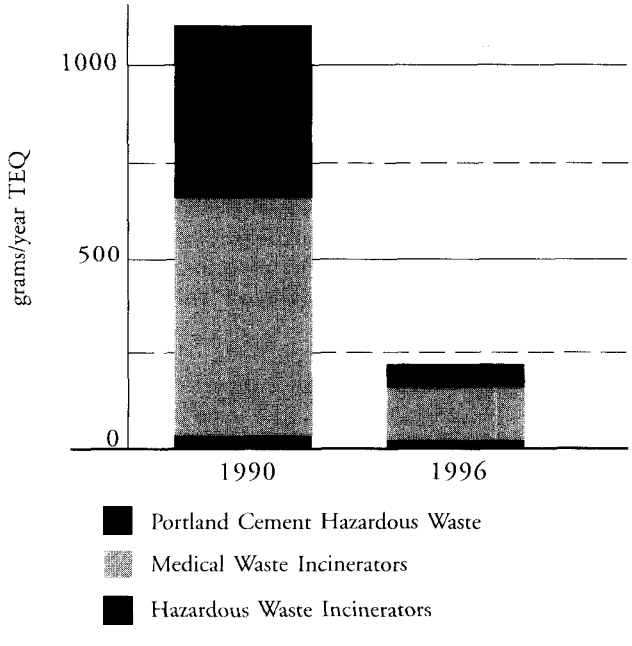

Figure 4 **Estimated National Dioxin Emissions for 1990 and 1996 for Three Major Source Categories (U.S. EPA)**

(Note: 1995 medical waste emissions extrapolated to 1996)

The United States Federal Insecticide, Fungicide, and Rodenticide Act and the Toxic Substances Control Act are designed to reduce emissions of Level I substances mercury, chlordane, DDT/DDE, hexachlorobenzene PCBs and toxaphene. No information regarding confirmed resultant reductions was returned in response to the survey questionnaire.

The United States also has several federal and state legislative tools designed to develop further programs to reduce the emissions of persistent toxic substances. These include the Superfund Amendments and Reauthorization Act, support for the multi-state Great Lakes Regional Air Toxic Emissions Inventory and the Indiana Department of Environmental Management's Strategic Plan.

"Both Canada and the United States have made marked progress in meeting their commitments under Annex 15 of the Agreement."

3.3

In the United States, the structure needed for creation of programs to reduce persistent toxic substances was established. However, for many substances under the binational toxics strategy, current quantitative information is lacking. Information presented at this workshop indicated that this situation was identified by U.S. EPA and is being addressed through improved emissions inventories and standards, including the Great Lakes Regional Air Toxic Emissions Inventory. However, at this time, based on the information made available under this survey, an estimate of quantified reductions for a great majority of Level I and Level II substances cannot be given.

Among the Great Lakes states, there is significant variability in programs regarding air toxics. The Illinois Toxic Air Contaminant Program has the potential to regulate emissions of all Level I and Level II persistent toxic substances except alkyl lead and tributyl tin. No information on quantified confirmed reductions was included in the survey response.

Michigan's Great Lakes Air Toxics Program includes the Michigan Air Toxics Rules requiring best available control technology for all Level I and Level II substances be installed on all new and modified sources. The rules also require source demonstration that impacts of toxic air contaminant emissions are below the health-based screening levels.

New York, Ohio and Pennsylvania all have programs by which new and existing sources of air toxics emissions and appropriate control requirements are reviewed on a case-by-case basis. Ohio and Pennsylvania require best available technology; in Ohio, this regulation applies to all sources, whereas in Pennsylvania, it is required only for new sources. Again, no report of confirmed emissions reductions was given in response to the survey questionnaire.

Table 6 **Examples of Successful Beyond Compliance Initiatives in the Great Lakes Basin**

PROJECT	**Automobile Pollution Prevention Project**
JURISDICTION(S)	All Great Lakes states
RESULTS	15% reduction in the overall releases of persistent toxic substances (a reduction of 0.18 kg of release for every vehicle manufactured in U.S. facilities)
PROJECT	**Trade Association Partnerships**
JURISDICTION	Ontario
RESULTS	Automobile Manufacturing - 150,000 tonnes per year reduction
	Metal finishing/electroplating - 287 tonnes per year reduction
	Automobile parts manufacturing - 660 tonnes per year reduction
PROJECT	**Mercury Pollution Prevention Project** (which targeted dental offices)
JURISDICTION	Michigan
RESULTS	591 kg of mercury were collected from dental offices in Detroit January-June 1996
PROJECT	**Accelerated Reduction / Elimination of Toxics (ARET) Program**
JURISDICTION	Canada
RESULTS	Over 100 organizations have participated and achieved: a 100% reduction in alkyl lead; a 40% reduction in benzo(a)pyrene; a 52% reduction in HCB; a 100% reduction in octachlorostyrene; and an 89% reduction in dioxins/furans.

In addition, the Great Lakes states, U.S. EPA and the Canadian and Ontario governments all support the continued development of the Great Lakes Regional Air Toxics Inventory effort, which should establish the baseline and, if maintained, allow for quantification of regional reductions of several Level I and II substances.

Both Canada and the United States have made marked progress in meeting their commitments under Annex 15 of the Agreement. Detailed assessment of progress under the annex in reducing persistent toxic substances is clearly an iterative process which is, as yet, in its early stages. With the signing of the strategy in April 1997, IJC should continue to track further quantification of emission reductions of Level I and II contaminants over the coming decade.

Applicability of Beyond Compliance Programs to the Great Lakes Binational Toxics Strategy (WQB)

There is no doubt the regulatory programs (i.e. compliance programs) are effective at reducing persistent toxic substance loadings to the Great Lakes, however, further reductions in loadings are required to achieve the virtual elimination goal. A current priority for management agencies is evaluating the potential role that voluntary, beyond compliance programs could play in the virtual elimination of persistent toxic substances.

WQB commissioned a study (Linett 1997) of current success of voluntary compliance programs in Illinois, Ontario, Michigan, Environment Canada and U.S. EPA Region 5. This study found that governments have developed a number of successful voluntary, beyond compliance programs. In general, the jurisdictions are expanding the number and reach of these programs. Additionally, the jurisdictions are actively developing experimental programs that offer program participants incentives in the form of administrative and regulatory flexibility.

Many of these beyond compliance programs have resulted in increasing participation rates and some have documented release reductions (Table 6). Whether these programs can be expanded and targeted to all Level I and II substances is, in part, a function of the contaminant source and how they are being used.

Many pesticides are banned in the U.S. and Canada; others are restricted. In addition, many contaminants have no commercial value and are generated as byproducts. Traditional, voluntary, beyond compliance programs, which generally have involved promoting pollution prevention through award, partnership and technical assistance programs, may have limited applicability in addressing these contaminants. Other contaminants, still used in production, services and activities (e.g. cadmium),

may be more conducive to traditional, beyond compliance programs. In other cases, such as octachlorostyrene, no intentional commercial production ever existed and the industrial process that generated this contaminant was discontinued in the 1970s. In still other cases (e.g. dioxin and PAHs), the substances are unintentional byproducts of current industrial practices.

In general, larger facilities with environmental health and safety staffs have been open to pollution prevention initiatives. Many costs previously associated with waste treatment and management are avoided. Many smaller facilities require technical assistance to realize the benefits associated with pollution prevention. Facilities may be willing to take further voluntary actions, but they need to realize benefits, such as longer permit terms, fewer reporting requirements and more flexibility in achieving environmental objectives.

New government policies directed at pollution prevention, as well as the threat of regulation, have spurred prevention actions. Regulatory flexibility and economic incentives can result in further reductions of persistent toxic substances. Whether voluntary, beyond compliance programs can generate sufficient reductions to satisfy ambient air level requirements is an open question. Governments should give voluntary, beyond compliance programs the opportunity to work and ensure that these programs are implemented in a cost-effective fashion.

Recommendations to IAQAB from Linett (1997)

- IJC and/or the Parties/jurisdictions need to develop an inventory of uses of persistent toxic substances and, to the extent possible, estimated release rates associated with users, or at a minimum user communities, to assess what types of incentives may be appropriate to spur action by user communities. A reasonably accurate inventory for some contaminants, for example mercury, cadmium and PCBs, has been established to identify sources. For those contaminants, incentive programs can be established to target voluntary reductions. Great Lakes mercury reduction programs demonstrate that targeted voluntary programs can be successful.

- IJC and/or the Parties/jurisdictions should identify which of these contaminants may be candidates for reduction through one or more incentive-based programs.

- IJC and/or the Parties/jurisdictions should plan a workshop in which government and industry can jointly develop and evaluate contaminant "use trees," identify where reductions are possible and evaluate incentives that the Parties/jurisdictions might provide industry in exchange for further reductions.

- IJC should challenge the Parties/jurisdictions to lead by example in reducing the generation of Level I and II substances as a result of their activities, products and services.

- IJC and/or the Parties/jurisdictions should provide leadership in helping to ensure that all organizations in the Great Lakes basin seeking to achieve ISO 14000 certification identify persistent toxic substances as "significant environmental aspects" of their activities, products and services.

- The Parties/jurisdictions should ensure that the sectors using Level I and II substances, processes and activities of concern are fully evaluated as part of technical assistance programs. Organizations reducing contaminants of concern should be eligible to receive some form of credit (e.g. regulatory flexibility).

- IJC and/or the Parties/jurisdictions should explore the use of market-based incentive programs to encourage remediation of contaminated sediment. For example, an industry could adopt an "orphan site" for remediation in exchange for longer permit terms, extended compliance deadlines or other form of regulatory flexibility.

- The Parties/jurisdictions should explore providing regulatory flexibility in exchange for an organizational commitment to conduct research and development to reduce the generation of Level I and II substances that are incidental byproducts (e.g. PAHs) of production and waste management processes.

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Chapter Four:

COUNCIL OF GREAT LAKES RESEARCH MANAGERS

CHAPTER FOUR *Contents*

4.1 INTRODUCTION: COUNCIL ACTIVITIES

The **Council of Great Lakes Research Managers** was established in 1984 to enhance the ability of the **International Joint Commission** (IJC) to provide effective leadership, guidance, support and evaluation of Great Lakes research programs with particular reference to programs required or funded pursuant to the provisions of the **Great Lakes Water Quality Agreement**. Its new terms of reference based on the Vision Workshop in 1995 and approved in 1996, direct the Council to compile a research inventory identifying research needs and to coordinate research projects. Additional charges now include assessing the adequacy of the Parties' research programs and promoting the transfer of research findings to basin policymakers, resource managers and the public. Membership consists of individuals managing and coordinating research programs of federal, state and provincial governments in the United States and Canada, and representatives of private institutions.

The primary Council activity for the 1995-97 priority cycle was identification of mechanisms for improving the effectiveness of Great Lakes research. The Council's efforts under this priority are reported in Chapter 4.2. While the Council has the lead for this priority, its members had significant involvement in additional priorities reported in other chapters, most notably the impact on human and ecosystem health (Chapter 1.2), remediation and management of sediment (Chapter 2.2) and the Lake Erie ecological model (Chapter 5). **The Great Lakes - St. Lawrence River Research Inventory** is produced by the Council every year; several recent improvements enhance its utility and accessibility. The status of the Research Inventory is reported in Chapter 4.3.

4.2 IMPROVING THE EFFECTIVENESS OF GREAT LAKES RESEARCH

4.2.1 Introduction

In October 1995, IJC asked the Council to take the lead on the priority, improving the effectiveness of Great Lakes research. The suggested approach was to build on the results of the Public Forum on the Future of Great Lakes Science, held at the 1995 Biennial Meeting in Duluth, Minnesota. The Council was to develop a strategy to involve research managers from both countries in identifying mechanisms to optimize research activities in the Great Lakes basin. Suggested activities included consultation with research managers and the research community through a workshop to develop a report and recommendations on identified mechanisms.

The Council first surveyed the Great Lakes research community to determine the extent of budget reductions and their likely impact on research supporting the Agreement.

The Council first surveyed the Great Lakes research community to determine the extent of budget reductions and their likely impact on research supporting the Agreement. The Council's analysis of the survey results is summarized in Chapter 4.2.2. A white paper was then prepared to introduce the topic to researchers and others likely to be interested. The white paper explained what the Council was working to accomplish and gave examples of successful areas of Great Lakes research. This is found in Chapter 4.2.3. The Council held a public meeting in November 1996 in conjunction with its fall meeting and the **State of the Lakes Ecosystem Conference** (SOLEC '96). Local researchers and interested public were invited to address the Council on this priority. The meeting is summarized in Chapter 4.2.4. At the request of SOLEC '96 organizers, the Council facilitated a roundtable discussion on the priority during the conference. The results are presented in Chapter 4.2.5. The Council also organized a panel discussion of the priority as a plenary session at the 40th Conference on Great Lakes Research held in June 1997. This discussion is summarized in Chapter 4.2.6. The Council's recommendations to IJC, as a result of these priority activities, are presented in Chapter 4.2.7.

4.2.2 Funding Reductions for Great Lakes Science: Results of November 1995 Research Budget Survey

Background and Methodology

Based on the results of the Public Forum on the Future of Great Lakes Science held at the IJC Biennial Meeting in Duluth in 1995, IJC directed the Council to determine the scope of budget reductions that affect commitments to research called for in the Agreement. The Council co-chairs designed a questionnaire that was sent to all members of the Council (representing 22 research programs) as well as 26 selected research inventory contacts throughout the Great Lakes basin. Due to the urgent nature of the concern, the questionnaire was kept intentionally brief to allow for a timely response. Key findings were presented in IJC's Eighth Biennial Report on Great Lakes Water Quality (released in 1996); these are elaborated on below. Also, this material appeared as a commentary in the Journal of Great Lakes Research, volume 22, number 2, in 1996.

In 1993, the Council estimated total Great Lakes and St. Lawrence River research funding to be approximately $107 million (U.S.) for the period 1991-1992. Most of this total was directed to the topics listed in Annex 17 of the Agreement. The questionnaire used in the 1995 survey was based on the same topics (see Table 9) but the research programs reported included additional topics. However, the total research funding reported below can be compared to the $107 million figure to assess representativeness for the survey. Information on individual projects was not requested because of time constraints.

Results and Potential Impacts

Resource Reductions

Thirty-one of the 48 research programs surveyed responded, including government agencies, as well as academic institutions that fund and conduct Great Lakes research. The programs that responded represented annual funding of as much as $88 million, or greater than 80 percent of the total funding reported in 1991-1992. This funding peaked in 1994 and is projected to decline by as much as 50 percent by 1997 (Table 7 and Figure 5). Similarly, research salary budgets also peaked in 1994 and were projected to decrease by as much as 35 percent by 1997. The number of researchers followed a similar trend (Table 8 and Figure 6). These represent the actual resources available for conducting Great Lakes research. The financial resources could potentially be restored at some point in the future, but the human resources (i.e. total number of researchers) are not easily replaced. If research positions are eliminated, it will be very difficult to regain a

Table 7 **Great Lakes Research Budget for 31 Selected Institutions, 1993-1997 (Actual and Projected)**

	Operating Budget	Salary Budget	Total Budget	% of 1994 Level
	($Million U.S.)			
1993	53.1	29.6	82.7	93
1994	57.2	31.7	88.9	100
1995	52.3	29.4	81.7	91.8
1996	46.8	25.7	72.5	81.5
1997	26.9-43.9*	17.3-21.8*	44.2-65.7*	49.7-73.9*

Table 8 **Great Lakes Research Positions for 31 Selected Institutions, 1993-1997 (Actual and Projected)**

	Total # of Researchers	% of 1994 Level
1993	621	87.7
1994	709	100
1995	697	98.3
1996	495	69.9
1997	269-378*	37.9-53.4*

*best and worst case projections

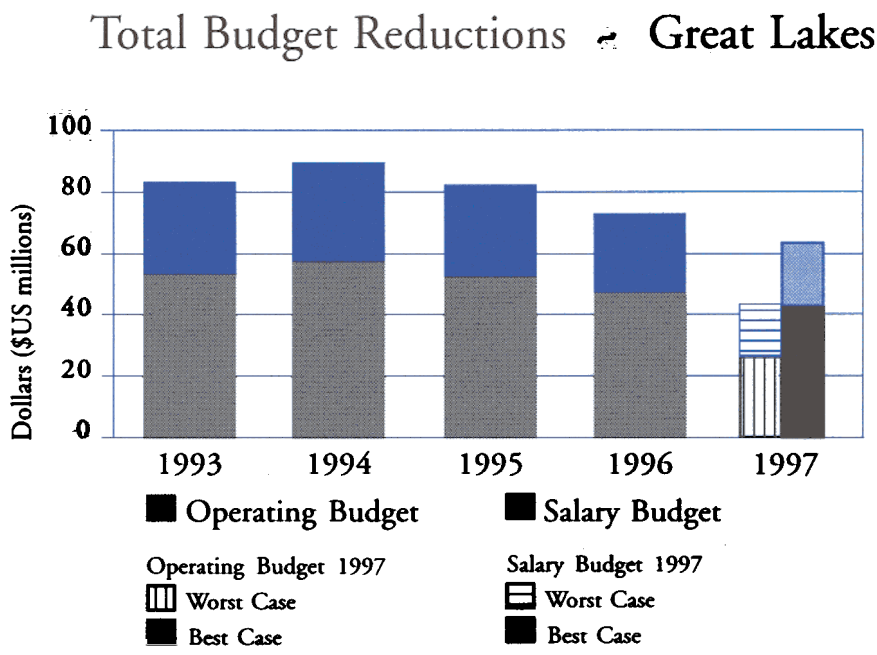


Figure 5 **Results of Research Budget Questionnaire: Total Budget Reductions - Great Lakes**

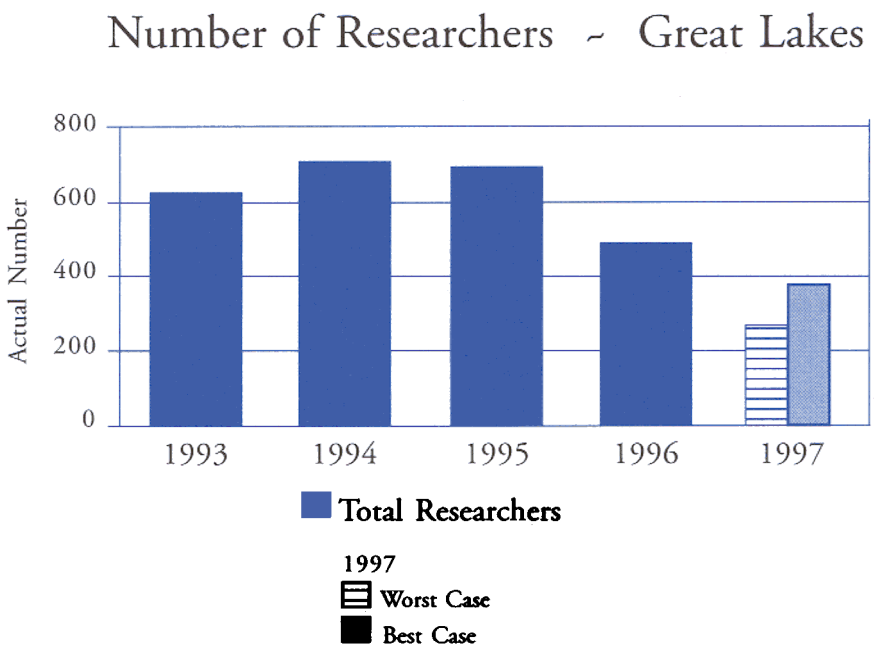


Figure 6 **Results of Research Budget Questionnaire: Number of Researchers - Great Lakes**

"It is often noted that it takes ten years to train and develop effective researchers. This assumes that the accumulated experience represented by established researchers will be available for inter-generational transfer and mentoring."

similar level of expertise. It is often noted that it takes ten years to train and develop effective researchers. This assumes that the accumulated experience represented by established researchers will be available for inter-generational transfer and mentoring. In addition, the ability to conduct research is affected not only by the expertise of the investigators but also by the achievement of a "critical mass" of researchers at key institutions.

Impacts

The largest impacts appear to be in the area of mass transfer of pollutants and load reduction models (Table 9). Eighty-five percent of respondents that conduct or fund research in these areas reported that they would experience a decrease in funding for these activities. These reductions would potentially impact the ability to meet research commitments for **remedial action plans** (RAPs) and **lakewide management plans** (LaMPs), dredging, surveillance and monitoring, persistent toxic substances, nonpoint sources, contaminated sediment, airborne toxic substances and contaminated groundwater. Another large impact would be in funding for research on ecotoxicology. Sixty-seven percent of respondents reported that they expected a decrease for this work. This would potentially impact the development of water quality objectives and indicators for rehabilitation of the Great Lakes ecosystem from adverse effects of persistent toxic substances. Other areas of research for which respondents reported budget reductions included the effects of climate change on the water quality, wildlife and habitat of the Great Lakes and the application of the ecosystem approach to fisheries management. The areas targeted for these deep cuts are critical for supporting the type of decisionmaking that led to successes described below.

The Council has compiled four case studies that demonstrate how research budget cuts affect various aspects of the Agreement.

Lake Ecosystem Objectives

The Agreement as amended in 1987 contains commitments by the Parties to develop lake ecosystem objectives as part of the binational effort to restore and maintain the chemical, physical and biological integrity of the waters of the Great Lakes basin ecosystem. The Parties developed and included in the 1987 amendments a Lake Superior ecosystem objective:

> "The Lake should be maintained as a balanced and stable oligotrophic ecosystem with lake trout as the top aquatic predator of a cold-water community and the *Pontoporeia hoyi* as a key organism in the food chain."

The Agreement calls for additional ecosystem objectives to be developed for the rest of the boundary waters of the Great Lakes system as the state of knowledge permits. Research is the vehicle to provide the knowledge required to establish such objectives.

Two of the research categories (see Table 9) that have been heavily impacted by reductions in Great Lakes research funding are:

(h) ecotoxicity and toxicity effects of pollutants for development of water quality objectives; and

(i) impact of water quality and non-native species introductions on fish and wildlife populations and habitats.

Six out of nine programs that indicated that they funded or conducted research in category (h) reported a decrease of funding in this area, while 10 out of 15 programs reported a decrease in funding for category (i). Research in these two categories is the principal means of advancing the "state of knowledge" for lake ecosystem objectives. Without continued funding in these areas, the Council believes that the Parties' obligations under this part of the Agreement will not be met.

Ecosystem Approach

The first guiding principle of Annex 2 of the Agreement is:

> "Remedial Action Plans and Lakewide Management Plans shall embody a systematic and comprehensive ecosystem approach to restoring and protecting beneficial uses in Areas of Concern or in open lake waters."

Research categories in Annex 17 that guide and support this approach are: (b) load reduction models, (c) delivery of pollutants by tributaries, (e) contaminated sediments, (f) pollutant exchange, (g) aquatic effects of varying lake levels and (i) impacts on fish and wildlife populations. All of these areas are targeted for some reductions in funding, and two, (b) and (i) have been identified as heavily impacted. Four important federal research laboratories involved in the biological component of the Great Lakes ecosystem (two in Ann Arbor, Michigan, one in Burlington, Ontario and one in Sault Ste. Marie, Ontario) were in imminent danger because they had been: 1) slated for closure, 2) severely cut back so as to question their effectiveness or 3) given a one-year extension while additional budget cuts are considered.

Table 9 **Breakdown of Survey Responses by Annex 17 Category**

Categories	Total Number of Research Programs Responding to each Category (N=31)	Total Number of Research Programs Reporting Reductions (out of total responding)	%	Agreement Annexes Affected
(a) mass transfer of pollutants between ecosystem components	16	14	87.5	13: Nonpoint Sources 14: Contaminated Sediments 15: Airborne Toxic Substances 16: Contaminated Groundwater
(b) load reduction models for pollutants	11	9	81.8	2: RAPs and LaMPs 11: Surveillance and Monitoring 12: Persistent Toxic Substances 13: Nonpoint Sources
(c) physical and transformational processes of pollutants by tributaries	6	4	66.7	
(d) cause-effect inter-relationships of productivity and ecotoxicity	10	4	40.0	11: Surveillance and Monitoring 12: Persistent Toxic Substances 13: Nonpoint Sources 15: Airborne Toxic Substances
(e) relationship of contaminated sediments on ecosystem health	11	6	54.5	2: RAPs and LaMPs 12: Persistent Toxic Substances 14: Contaminated Sediments
(f) pollutant exchanges between Areas of Concern and the open lakes	8	3	37.5	2: RAPs and LaMPs 3: Control of Phosphorus 12: Persistent Toxic Substances 14: Contaminated Sediments
(g) aquatic effects of varying lake levels (including wetlands)	6	3	50.0	2: RAPs and LaMPs 11: Surveillance and Monitoring 12: Persistent Toxic Substances 13: Nonpoint Sources 15: Airborne Toxic Substances 16: Contaminated Groundwater
(h) ecotoxicity and toxicity effects of pollutants for water quality objectives	9	6	66.7	1: Specific Objectives
(i) impact of water quality and the introduction of non-native species on fish and wildlife populations and habitats	15	10	66.7	1 & Article IV: Specific Objectives 2: RAPs and LaMPs 11: Surveillance and Monitoring 12: Persistent Toxic Substances
(j) control technologies for treatment (effluents, emissions, waste disposal)	8	5	62.5	2: RAPs and LaMPs 3: Control of Phosphorus 12: Persistent Toxic Substances 15: Airborne Toxic Substances 16: Contaminated Groundwater
(k) action levels for multimedia exposures and interactive effects of chemicals	2	1	50.0	1: Specific Objectives 12: Persistent Toxic Substances
(l) population-based studies to determine effects of toxic substances on human health	4	3	75.0	
(m) other (non-Agreement issues)	13	10	76.9	Examples: Ecosystem Approach to Fisheries Management; Ecotoxicology Management Tool Development; Climate Change; Long Range Transport of Pollutants.

These reductions included complete termination or phase out of programs directly applicable to the Agreement. For example, the **National Biological Service**'s (NBS) Great Lakes Science Center in Ann Arbor conducts research on fish population dynamics, the effects of physical habitat alterations on fish community structure and function and the effects of persistent toxic substances on reproduction and growth of fish. This laboratory's analytical program was targeted for elimination and its fish health program was to be phased out. Instead, the NBS became the **Biological Resources Division** (BRD) of the U.S. Geological Survey and these programs continue to support Agreement-related work.

The elimination of the Canada **Department of Fisheries and Ocean**'s (DFO) research program for the Upper Great Lakes in spring 1997 undermined management's efforts to restore native fish species, achieve sustainable fish populations and restore habitats. The loss of this expertise and research capability also calls into question the commitment to an ecosystem approach and support for RAPs and LaMPs. In fact, given the state of knowledge in these areas, continued research is the only alternative if a systematic and comprehensive approach is to be taken. Also, substantial cuts to Great Lakes programs of Canada DFO and the **Ontario Ministry of Natural Resources** (OMNR) will radically curtail the science under category (i) that is vital if targets for fish and wildlife populations are to be set and met. Further, such research cuts will undermine the sustainability of the $2-4 billion sport fishing economy in the Great Lakes basin.

The potential elimination of three fish contaminant programs would leave the Parties and jurisdictions without the ability to assess status and trends of contaminant body burdens in Great Lakes fish. These programs are the **Ontario Ministry of the Environment and Energy**'s (OMEE) sport fish contaminant monitoring program, BRD's cooperative program for fish contaminant trends and DFO's program for contaminants in top predators and forage fish. The combined effects of these cuts would be a weakening of the Parties' ability to assess the state of the lakes. This will ultimately erode IJC's ability to evaluate progress under the Agreement.

The proposed termination of the BRD Great Lakes Science Center's analytical chemistry facility and the major reductions at DFO's Great Lakes Laboratory for Fisheries and Aquatic Sciences also put in jeopardy the Great Lakes fish tissue specimen bank. This sample archive has been used effectively by many cooperators for retrospective monitoring of new and emerging problems as specified in Annex 12. Currently, BRD is cooperating with several universities in the identification of toxaphene-like compounds using the specimen bank. The U.S. EPA-BRD cooperative fish contaminant monitoring program under Annex 11 has detected a substantial increase in toxaphene-like compounds in Lake Superior lake trout.

Beneficial Uses and RAPs

To be effective and efficient, actions restoring and maintaining beneficial uses in **Areas of Concern** (AOC) must be based on an understanding of causes and predicted results. Adequate research and monitoring are essential to define problems, establish cause-and-effect relationships, evaluate options, select remedial and preventive actions and document effectiveness. Yet the categories of (a) mass transfer of pollutants and (b) load reduction models are the two that are experiencing some of the heaviest cuts. Fourteen out of 16 programs funding or conducting research in (a) were experiencing a decrease and 9 of 11 programs in category (b) were seeing funding reductions. However, such research and monitoring are the foundation of ecosystem-based management and, in the end, have proven to save money for both the public and private sectors. For example, in Collingwood Harbour, the only AOC to have all of its beneficial uses successfully restored, research from category (b) was used to save $9.4 million resulting in a win-win situation for the environment and economy (Table 10). Unnecessary expenditures were avoided and existing facilities were optimized. In Lower Green Bay and the Fox River, research from categories (a) and (b) is used to save tens of millions of dollars by selecting specific contaminated sediment hot-spots for remediation that will contribute to the removal of fish consumption advisories. In fact, all successful RAPs have strong research programs as part of the foundation for implementing locally-designed ecosystem approaches for restoring beneficial uses. Indeed, research for RAPs has proven to save money while achieving positive ecosystem results (Table 10). If research programs are eliminated or substantially reduced for RAPs, this will result in a lack of use restoration in most AOCs, which is required for delisting; an uncoupling of management efforts from the scientific method in AOCs; and a stagnation of the Stage 2 RAP process of identifying remedial and preventive actions.

Drinking Water, Beach Closings and Combined Sewer Overflows

Two use impairments that are directly related to human health are restrictions on drinking water consumption and the closing of beaches for swimming. These use impairments also result in economic impacts. In spring 1993, drinking water contaminated by a parasitic protozoan, *Cryptosporidium*, caused illness in 400,000 Milwaukee, Wisconsin residents and contributed to the deaths of about 100 people. This one incident is estimated to have cost

"In fact, all successful RAPs have strong research programs as part of the foundation for implementing locally-designed ecosystem approaches for restoring beneficial uses."

Table 10 **Examples of How Research Has Moved Remedial Action Plan Processes Forward and Achieved Cost- and Ecosystem-Effective Results**

RAP	Example of Contribution from Research
Collingwood Harbour (Ontario)	Research in load reduction models was used to optimize phosphorus removal at the Collingwood sewage treatment plant. This resulted in restoring impaired beneficial uses (cultural eutrophication) and resulted in a $9.4 million cost savings, representing a win-win situation for the environment and economy.
Green Bay (Wisconsin)	Research on mass transfer of pollutants and load reduction models identified the most cost- and ecosystem-effective strategy for remediation of contaminated sediment "hot spots." This resulted in progress in use restoration and savings of over $10 million, representing a win-win situation for the environment and economy.
Hamilton Harbour (Ontario)	Applied research on the relationship between loss of habitat and the structure and function of the Hamilton Harbour ecosystem has enabled the leveraging of $19 million from public and private partners to test and implement habitat rehabilitation techniques. This project will: rehabilitate 250 hectares of marsh in Cootes Paradise; enhance the pike spawning marsh in Grindstone Creek; improve the littoral habitat in Hamilton Harbour; rehabilitate the littoral fish community; and provide nesting and loafing sites for colonial waterbirds.
Black River (Ohio)	Research on the cause-and-effect relationship between PAH-contaminated sediments and liver tumors in the brown bullhead population led to agreement on a settlement with USS-KOBE Steel Company to remove over 38,230 m^3 of PAH-contaminated sediments from the river and upland disposal of dredged sediments in a secure landfill on company property.
Nipigon River (Ontario)	Research on the role of water level fluctuations in restoring the fishery resulted in agreement on and implementation of the Nipigon River Water Management Plan. This will benefit the upstream spawning success of walleye and brook trout previously affected by water level fluctuations resulting from hydro-electric power generation.

Milwaukee over $50 million. The Great Lakes Environmental Research Laboratory of the **National Oceanic and Atmospheric Administration** (NOAA) undertook a study of nearshore hydrodynamics to determine how contaminated water could be prevented from entering the water intake. This research and comparison study convinced Milwaukee to relocate its intake to minimize the problem. Recent concerns with the Collingwood, Ontario water supply suggest that this was not an isolated incident. Closings of beaches in Lake St. Clair and Lake Erie in summer 1995 resulted in the loss of millions of tourism dollars. Major causes of these threats to human health and economic well-being are combined sewer overflows (CSOs), urban runoff and failing septic tanks and tile fields. CSOs and urban runoff, in turn, are driven by meteorological and hydrological events that are still not well understood.

A bloom of *Microcystis*, a toxic blue-green alga, extended from the western to the central basin of Lake Erie in late summer 1995. This portrays a new and ominous problem of particular concern because of the expenditures and effort to reduce phosphorus loading in the 1970s and 1980s. Furthermore, the zebra mussel became established and has actively filtered out most algae. The exact reasons for this bloom are uncertain. Did increased discharge of nutrients occur? Did the zebra mussel change the water quality and favor productivity of blue-green algae? Will this lead to more taste and odor problems in drinking water supplies? Research managers and decisionmakers will not know without the appropriate focussed research. In the meantime unnecessary funds might be expended on improper and futile control measures. A consortium of academics and federal and state agencies is moving toward collaborative research to address this blue-green algae problem. Research in categories (a) and (b), which have seen some of the heaviest impacts of budget reductions, is needed to identify cost-effective and practical solutions to these problems. Such work has been underway at the Great Lakes Environmental Research Laboratory in Ann Arbor and through research programs in Ontario, programs that have been targeted for reduction or termination.

Conclusions

Based on these survey results and concern raised at the Public Forum on the Future of Great Lakes Science held at IJC's Biennial Meeting in Duluth in 1995, the Council concludes that proposed reductions in research programs

will limit timely delivery on Parties' commitments as described in the Agreement and in the Boundary Waters Treaty.

Further, these reductions in research will weaken the Parties' ability to assess the state of the lakes and provide interpretive analysis in a management context. Agencies contributing data on status and trends of the Great Lakes rely heavily on results of research to assess the health of the lakes, identify emerging issues and establish future research needs for ecosystem-based management. In addition, a weakening of the Parties' ability to assess the state of the lakes will ultimately erode IJC's ability to evaluate progress under the Agreement.

As the Agreement has been in place for a quarter century, reflection on the requisite role of research and science in management is appropriate. Without a viable Great Lakes research program in place to address problems as they emerge or to resolve existing problems, the gains of the last 25 years will be lost.

Recommendations

The Council recommends the following.

- **The Parties, in cooperation with the jurisdictions, re-evaluate the direction, substance and mechanisms of proposed research program reductions in order to maintain the scientific foundation for management programs and to deliver on their commitments in the Agreement.**

- **IJC and the Parties take the view that investment in Great Lakes science results in substantial economic and ecosystem benefits.**

Immediate action on this recommendation is warranted.

In light of these findings, the Council proposes that it perform a more detailed and complete analysis of individual research projects through its Research Inventory. **The inventory has been updated and is accessible via the World Wide Web (http://www.ijc.org/boards/cglr/cglrreports.html).** Further, this analysis led to a series of meetings whose objectives were to find innovative solutions to the problems of reduced budgets and develop creative approaches to continued Great Lakes research. Reports on these activities are presented in Chapters 4.2.5 and 4.2.6 respectively.

"Without a viable Great Lakes research program in place to address problems as they emerge or to resolve existing problems, the gains of the last 25 years will be lost."

4.2.3 White Paper: Improving the Effectiveness of Great Lakes Research

Preamble

In October 1995, IJC asked the Council to take the lead in developing an approach to improving the effectiveness of research in the Great Lakes. This issue emerged from the results of the Public Forum on the Future of Great Lakes Science held at IJC's Biennial Meeting in Duluth, Minnesota in September 1995. The Council surveyed the Great Lakes research community to determine the magnitude of and areas impacted by research budget cuts and then involved researchers and research managers in identifying ways to ensure the continuation of needed research, but accomplish major cost savings. These savings not only will be realized by creating efficiencies in research programs, reducing overlap and setting priorities, but also by strengthening the link between research and management. Management actions not based on science or supported by research are often misguided and more costly than they should be. Management guided by research can help ensure achievement of ecosystem results and avoid many expensive wrong turns.

The Council believes that the quality of Great Lakes research is world class, especially in the area of application of an ecosystem approach to research of aquatic systems. An indication of this is the interest in research results from the Great Lakes throughout North America, Europe, Africa and Asia, and the requests for collaboration and technical assistance from all over the globe. The white paper was intended to encourage greater dialogue and to foster fruitful discussion on the issue of making this work more effective.

The focus of ecosystem research and management has inevitably been drawn from the open lake towards the nearshore. Much of each lake's productivity occurs in the nearshore zone or is initiated there. Past habitat alterations and losses have been concentrated in the nearshore and adjacent lands. Many of the impacts of exotic species (e.g. zebra mussels, purple loosestrife) are most evident in the nearshore. RAPs have played a significant role in promoting this shift from offshore to nearshore and from a largely chemical view to a broader ecosystem perspective. The LaMP effort should continue the process of integrating offshore, nearshore and watershed information.

The 1996 Great Lakes - St. Lawrence River Research Inventory currently contains 408 research projects and programs representing $71 million (U.S.) in research funding. Nearshore and nearshore-related projects account for 22 percent of the total projects and 35 percent of the total funding. Of the total U.S. funding, 19 percent was devoted to nearshore work, while 60 percent of Canadian funding went to nearshore projects. The current emphasis of Canadian funding reflects recent reductions in spending for open lake programs.

"The Council believes that the quality of Great Lakes research is world class, especially in the area of application of an ecosystem approach to research of aquatic systems."

The Research Inventory was searched for projects with keywords relevant to SOLEC '96 topics. Although there was some overlap of topics, 24 projects were identified that dealt with coastal wetlands and 21 projects that addressed land use by the lakes. While there were many projects that assessed the impact of land use, there was only one that considered nearshore land use specifically.

Purpose

The Council notes that Great Lakes problems requiring research support are more complex now than in the past. Not only must researchers strive for better science to meet these challenges but, since long-term, sustaining solutions will be more costly, there is a need to engage members of the Great Lakes community in the identification of cost saving strategies to share information and facilities, and develop partnering approaches to the conduct of research. Also, the research community should be involved in setting research priorities so that areas for budget reduction will be identified logically and new approaches can be found for areas that receive no new funding. Further, the Council seeks to identify research that is most responsive to resource management goals.

Successes and Challenges

Over the past 30 years, the results of Great Lakes research have been applied to a variety of problems. Many of these efforts have been successful, although most still face a number of challenges. The Council perceives a utility in briefly cataloguing some of these successes in the hope that some common threads emerge. Also, the Council wishes to remind researchers and managers alike that it is rarely the case that an environmental problem is solved so completely that some level of follow-up monitoring and assessment is unnecessary.

Lake Erie

One of the greatest successes for ecosystem research and management is the recovery of Lake Erie. Focussed research identified the causes of eutrophication and oxygen depletion that were responsible for the lake being labelled "dead" by the media. Aquatic ecosystem modelling led to target phosphorus loads for Lake Erie. Research on nonpoint pollution identified the contributions to phosphorus loading from agriculture leading to promotion of best management practices. Engineers determined the treatment technology needed to reduce phosphorus in point sources. Also, research to reformulate laundry detergents reduced or eliminated the contribution from this source. When this binational effort was put into action, Lake Erie responded as predicted. Phosphorus concentrations in the lake declined dramatically, blue-green algal blooms were much less evident, and oxygen was depleted at a reduced rate, with no anoxia (absence of oxygen) being observed during 1994-96. The broad success of phosphorus control efforts in the Great Lakes influenced eutrophication management globally.

Yet challenges remain. The invasion of zebra mussels and other aquatic nuisance species has had repercussions on the upper trophic levels in the lake that have put additional strain on fish populations. Also, subsequent to the zebra mussel invasion, blue-green algal blooms have begun to recur in the Western Basin. This situation points out the need for a continued, viable research effort that can respond to new problems, help elucidate cause-and-effect relationships, and provide advice on lessons learned to other areas of North America and the world.

Remedial Action Plans

Another accomplishment has been the role of research in planning and implementation in the more successful RAPs such as Green Bay and Hamilton Harbour. For example, research has been targeted at the causes of impaired beneficial uses such as contaminated sediments, combined sewer overflows and inefficient treatment facilities. Environment Canada and **U.S. Environmental Protection Agency** (EPA) funded the evaluation of dozens of sediment treatment technologies including demonstrations at bench, pilot and full scale. These programs fostered the development of innovative technologies, and expanded the information base on technologies suitable for use in RAPs. Optimization of control systems for CSOs incorporating collection, storage and treatment components is another fruitful area of research that benefits urban AOCs. Satellite treatment systems are expected to be significantly more cost effective than other options and, if proven feasible, could create potential savings of several hundred million dollars for municipalities with CSO problems.

The challenge that remains is to strengthen the link between research and management for all areas of the Great Lakes. The challenge for the Great Lakes research and development community is to maintain the momentum in the development of cost-efficient remediation technologies that was started with programs such as the Assessment and Remediation of Contaminated Sediments and the Great Lakes Cleanup Fund. Complete remedial actions have been implemented at only a handful of AOCs, and the scale of problems, such as in-place sediment contamination and overloaded sewers, can overwhelm the resources of many RAPs. Further development of several remediation technologies is necessary to optimize their performance and bring them to full-scale capability.

Nipigon Bay

Nipigon Bay on Lake Superior has been subjected to a variety of stresses over the last century, including eutrophi-cation, atmospheric loading of contaminants, alteration of physical habitat, point source discharges and exploitation of forests and fisheries. Since the inception of commercial fishing, walleye and lake sturgeon have been extirpated (complete eradicated) and the abundance of other important species has declined significantly. To address these and other problems, a partnership among the research community, resource management agencies, industry and the public was formed through the Nipigon Bay RAP to:

1. identify the multiple stresses acting upon the Nipigon Bay ecosystem;
2. establish objectives for remediation;
3. prioritize contaminant stresses for reduction;
4. rehabilitate affected habitat;
5. effect change in water management and resource exploitation practices; and
6. track and assess progress in the restoration of beneficial uses.

Although not all stresses on Nipigon Bay have been relieved, the initial results are encouraging and the abundance of two fish species dependent on this ecosystem has increased. The marriage of science, management and remediation in this effort has provided relief from multiple stresses in a logical process that benefited the entire ecosystem.

Project Quinte

A multi-agency research program, Project Quinte, has tracked a succession of ecosystem changes since 1972 in the Bay of Quinte AOC. The long-term, diverse, multi-trophic research studies, spanning nutrients to fish, have had two major impacts. First, the project has provided a unique, continuous record of a Great Lakes ecosystem responding to phosphorus controls under the Agreement and later to increases in the abundance of the major fish predator, walleye. Now, the ecosystem-wide impacts of the on-going zebra mussel invasion are being assessed. This work has produced significant insights into the dynamics of a large, productive bay. Second, the project provided the basis for the RAP process, beginning in 1985. Existing project data were used to produce the Stage I report. The data and the accumulated experience and expertise of the research team were applied to the identification and evaluation of remedial options in Stage II. Much of the information was synthesized into models allowing alternative options to be evaluated objectively and communicated to decisionmakers. The Bay of Quinte RAP would have been severely hampered if the pool of data and expertise represented by Project Quinte had not existed.

"The Bay of Quinte RAP would have been severely hampered if the pool of data and expertise represented by Project Quinte had not existed . . . In recent years, the emphasis has shifted to RAP implementation while research budgets and staffs have been overburdened by a widening array of problems as a result of cuts from government downsizing efforts."

In recent years, the emphasis has shifted to RAP implementation while research budgets and staffs have been overburdened by a widening array of problems as a result of cuts from government downsizing efforts. As a result, the research contribution is reduced and many ecosystem management issues are unresolved. The core Project Quinte assessment studies, which underpinned all past management advice, are barely being sustained. For example, a unique effort to develop a watershed-wide system for phosphorus load quotas and allocation is faltering for lack of research input and resources.

Ecosystem Approach

The evolution of an ecosystem approach through RAPs and LaMPs has broadened the concept of environmental assessment to encompass habitat loss and degradation, the still-growing problems of exotics, and the need to understand productivity in relation to biodiversity. It has increased awareness that actions can no longer be taken "in a vacuum." However, a big challenge that confronts the Great Lakes research community is the quantitative understanding of the effects of multiple stressors (e.g. nutrient loads, persistent toxic chemical loads, flow events and exotics invasions) taken in concert on multiple response end-points (e.g. fish production, water quality, algal growth and bioaccumulation). Major tasks that still need to be completed include: 1) defining the goals and indicators of ecosystem-based management with biodiversity and ecological sustainability being high priorities; 2) developing biologically-based habitat supply goals and management actions thereby directing restoration and creation efforts; 3) coming to grips with anticipatory policies for preventing and managing exotic species; and 4) establishing nutrient load quotas and allocations on a local basis within each basin, securing past successes against population growth and harmonized with socioeconomic development policies.

Persistent Toxic Substance Reduction

Research has played a profound role in developing compelling arguments for toxic substance reduction in the Great Lakes. For example, early in the 1980s, toxaphene was discovered in the tissues of lake trout obtained from Lake Siskiwit on Isle Royale, in Lake Superior. This lake is 60 feet above the level of Lake Superior and has no direct land-based inputs. The only source of toxaphene was from the atmosphere. It was suspected that the origin was from cotton fields in the southern U.S. As a result of this research, a ban on the use of toxaphene in the United States was issued in the mid-1980s.

The Green Bay Mass Balance Study, with the combination of modelling and data collection, was the first formal documentation of the system-wide impacts of resuspension of historically contaminated bottom sediments (i.e. high PCB levels in fish in the bay as a direct result of resuspension events in the Fox River). This study represents the use of state-of-the-art toxic substance mass balance models to quantify the relationship between loadings and concentration of toxic chemicals in water, sediments and biota of the Great Lakes.

Another example is the development of uniform water quality standards for the Great Lakes states. Recent research was brought together to establish new methodologies for water quality criteria for aquatic life, wildlife, and procedures for limiting bioaccumulative chemicals. These methods formed the basis of the Great Lakes Initiative, which became a formal regulation in 1995. The challenge that remains is to implement these new controls and verify the ecosystem improvements that occur through sound monitoring and assessment programs.

Human Health

Great Lakes human health effects research has reported an association between the consumption of contaminated Great Lakes fish and body burdens of persistent toxic substances. Neurobehavioural and developmental effects have been observed in newborn infants of mothers who consumed Great Lakes fish. Recent efforts have harmonized the methodological and analytical protocols across these and other studies. This will allow a basin-wide analysis and evaluation of health effects potentially associated with the consumption of contaminated Great Lakes fish.

Budget Cuts and Research Trends

In response, the Council sees three courses of action: 1) request more money, 2) attempt to do more with less, or 3) do something different and innovative. The first option is to argue to have the funding for Great Lakes research restored to the 1994 level. In the current fiscal climate, more resources are unlikely, and even if an argument could persuade legislators to restore funding this year, the vulnerability to research budget cuts would continue in future years. The second option would threaten the continued quality of Great Lakes research. The third option recognizes the reality of shrinking research dollars and attempts to compensate by improving the efficiency of how research is conducted. However, it also emphasizes new directions for research. There must be a balance between focussed investigation and innovative science. It is this option that the Council wishes to pursue with resource managers, researchers and research managers.

Advice from Forum on the Future of Great Lakes Science

Participants at the Forum on the Future of Great Lakes Science commented that the forum was a good mechanism to share information on budget and program cuts and their potential impacts, and to elevate the concern for the loss of "intellectual capital" (i.e. experienced scientists and researchers) required to meet the commitments under the Boundary Waters Treaty, the Agreement, the Great Lakes Fishery Convention and the Great Lakes Charter. In addition, there were suggestions for actions or activities to compensate for program restraint measures in the Great Lakes basin. In general, these suggested actions and activities can be grouped into the following categories:

- clarify and reach agreement on priorities;
- plan cooperatively;
- share responsibilities in delivery of programs;
- share capital resources;
- build partnerships and cooperatives for better science;
- develop new approaches to science and management issues (i.e. adaptive management); and
- communicate value and benefits of science and research.

Improvements can be made in each of these areas to achieve better value. These actions and activities are not comprehensive or perfect, but are intended as practical steps that can be taken immediately to ensure that the important research and scientific programs survive to provide the necessary foundation for management. The rate of change in environmental and resource issues and programs is accelerating. Therefore, decisionmakers in research, science and management must be willing to change. The suggestions are intended to better manage program constraints, pool resources, form partnerships, target priorities and still improve effectiveness.

Charge to Audience

Using the seven action items listed, participants at the SOLEC roundtable and IAGLR '97 conference were asked:

- to identify where the principle was currently put into practice (i.e. where has it been used successfully?) and where the potential exists for application in the Great Lakes community (i.e. how can we transfer this experience across the Great Lakes basin?).

- ascertain the mechanism for action on each item and define the role of the Council, the **Great Lakes Fishery Commission** (GLFC) and the Great Lakes Commission, as well as other Great Lakes organizations and individual researchers in delivering improvements in the effectiveness of Great Lakes research.

- determine whether there are any proactive steps that can be taken to strengthen the position of Great Lakes research for the future.

The responses are discussed in Chapters 4.2.5 and 4.2.6.

4.2.4 Summary of Public Meeting, November 5, 1996

In accordance with IJC's guidelines for public meetings, the Council prepared and circulated a news release to the media in the Detroit-Windsor area and mailed flyers to nearby universities, non-government organizations and local government agencies. The Council invited public views on four questions that are relevant to the priority, improving the effectiveness of Great Lakes research.

- How can the Great Lakes research community combine efforts and develop cost-saving strategies to continue its world-class work, despite recent budget and staffing cutbacks in Canada and the United States?

- How can it ensure a solid scientific foundation for management programs?

- What areas of research are most valuable to people developing and implementing RAPs for degraded areas around the basin, as well as LaMPs?

- How can these programs' research needs to be communicated more effectively?

Six people addressed the Council; some also provided written comments. For a summary of remarks as well as the discussion with Council members, **please see the Council's home page on the World Wide Web (http://www.ijc.org/boards/cglr/cglrmmtg.html)**. The following are several common threads gleaned from the public meeting.

1. The perceived conflict between science and management and the need to incorporate more science in management decisions. This would lead to better decisions and presumably make managers advocates for science.

2. The need for research partnerships. However, these partnerships must often be international in order to deal with the lakes and connecting channels. Barriers to these collaborative efforts must be removed, including access to baseline data critical for sound research.

3. Issues associated with long range transport of air pollutants have not been addressed adequately in research to date. These include air-water and air-land transfer and movement of pollutants from a variety of sources. The concept of an "airshed" may be a useful tool for evaluation.

4. RAPs depend on science for sound decision making. However, not all RAPs have sources of technical advice and some RAPs, such as the Detroit River RAP, do not use science as the primary rationale for decisions. This not only hurts the credibility of the plan itself but ultimately is detrimental to the viability of the research community whose advice and research is not used.

5. The Council should continue to champion adequate research, monitoring and assessment in order to achieve the spirit and intent of the Agreement. These provide the foundation for understanding how ecosystems function and how to manage the human component of interaction with the ecosystem.

4.2.5 SOLEC '96 Session: Council of Great Lakes Research Managers

As part of its strategy for addressing the priority on improving the effectiveness of Great Lakes research, the Council sought to engage researchers and managers in discussions that would lead to innovative approaches. The SOLEC '96 conference, held in Windsor, Ontario on November 6-8, 1996 by Environment Canada and U.S. EPA was an opportunity for such discussion. Since the theme of SOLEC '96 was the nearshore of the Great Lakes, the Council's white paper was modified to include information on research in the nearshore and distributed to all SOLEC attendees.

The Council facilitated a roundtable session on the topic of improving the effectiveness of Great Lakes research. Five "focus" questions were prepared and the discussion facilitated by Gail Krantzberg, OMEE and current president of the **International Association for Great Lakes Research** (IAGLR). Council members and researchers from government and university laboratories served as resource persons. The session also was summarized and the highlights reported to SOLEC by Dave Dolan, Secretary of the Council. Approximately 70 people attended, including researchers, research managers and interested members of the public. The "focus" questions and discussion are summarized below.

Question 1. **What kind of cost saving strategies, such as facility and information sharing and partnering approaches, will make Great Lakes research more effective and yet maintain its high quality?**

Some did not accept the premise that further cost savings could be gained from the Great Lakes research community. In many cases, research was already pared to bone. During the past five to ten years, the research budgets of many institutions have been nibbled away at until there is very little excess left. Many of the seven action points suggested in the Council's white paper (see Chapter 4.2.3) already have been carried out and further resources generated from such activity will not be great. Also, some duplication of effort is good in order to check and verify research results. The bottom line is that good decision making cannot be based on bad science.

Nevertheless, there are some strategies that could be followed to make research more efficient. For example, information accessibility could be improved to the benefit of all. All Great Lakes data should be systematically looked at with the aim of producing an information inventory. Existing data should be consolidated and made accessible by publication as a compact disc or at a web site. This would help avoid duplication of effort and allow researchers easy access to baseline data for future studies.

To get public support for research the value of research should be communicated to the general public. One way to accomplish this is to put a dollar value on research. Although this may be difficult, the public can relate to the results. This would require a cooperative binational strategy since it would involve many agencies in both countries.

The Great Lakes Fishery Commission has committees for each Great Lake. These are composed of fisheries managers around the lakes whose purpose is to make recommendations about the fish community. The committees rely heavily on research results concerning the fishery and the aquatic food chain. One strategy to improve research effectiveness would be to expand each committee's scope and involve them in the development of LaMPs. LaMPs also rely heavily on research but are focussed more on identification and control of critical pollutants in the lake and its watershed. Since decisions on the fishery are affected by decisions on managing critical pollutants, the overall efficiency of research supporting these two efforts would be improved if they were better coordinated.

Other strategies include multi-agency assaults on Great Lakes problems with more partnering/sharing among all levels of government including municipal agencies and educational institutions including secondary schools. The latter can participate in student training and volunteer monitoring programs. Also, better agency-university links need to be established. For example, agencies could advertise research vessel activities so that university researchers can take advantage of gaps in schedules.

Question 2. **What research is necessary to help achieve nearshore resource management goals?**

Nearshore resource management goals vary from lake to lake and region to region but they have wording such as "achieve a balanced, self-sustaining biotic community." Specific objectives might include:

- restore impaired beneficial uses;
- control exotics;
- exhibit no net habitat loss; and
- restore/maintain native fish.

In order to achieve such goals and objectives, a research approach to nearshore management is needed, including research in four areas: watershed system dynamics, nearshore environmental dynamics, integration of watershed and nearshore, and ecosystem indicators. Also, effort is needed to communicate research results. Among the points raised in discussion, the nearshore area is heavily influenced by associated watershed activities. Therefore, watershed system dynamics must be understood, including answers to such questions as:

- what are important environmental processes taking place within the watershed (e.g. atmospheric deposition, erosion, agricultural runoff and tributary linkages)?; and

- what are important socioeconomic processes within the watershed (e.g. land use, land use decisionmaking processes and population shifts)?

In short, a watershed approach must be applied to understand the influences on the nearshore.

Nearshore and open lake processes are very different. The most important difference that influences nearshore environmental dynamics is scale. Different environmental processes are dominant in the nearshore because of the smaller scale. While the long-term average may be adequate to describe a process in the open lake, episodic events in the nearshore drive the system. This highly dynamic situation results in intensive data needs for study of nearshore processes. In turn, these data needs require generation of information at the necessary time and space scales. Because of the potential expense the most efficient long-term sampling schemes must be identified. Nearshore monitoring can be improved by mathematical models. Therefore, better predictive capability in the nearshore is needed.

Watershed and nearshore dynamics need to be integrated at all levels. Research and long-term ecosystem investigations in the nearshore should include the relevant watershed(s). Monitoring should also be integrated both among laboratories and across media. Inventories and mapping of resources should be conducted including both watersheds and the nearshore. Mathematical models should include interactions between the two regions. There is often too much focus on individual problems and not enough synthesis.

Because of the complexity of the nearshore, multiple indicators are needed that can be related to specific ecosystem goals. When these indicators are identified and developed, they can be observed for trends and rate of change (i.e. are indicators moving toward or away from an established goal?). However, for the proper development of indicators, statistical analysis is needed to assure their validity and to correctly interpret trends.

Significant effort should be devoted to communicating research findings and needs. It is important to first identify the audience and then explain simply the benefits of continued research (i.e. What's in it for me?). Benefits include increased support for technical assistance and educational efforts, not at the expense of basic research but as a spin-off. Above all, research results have to be transferred to management and the public in a form that will be useful to them. Ambient monitoring programs are always at risk from political, arbitrary and uncoordinated budget cuts because only a small fraction of decisionmakers understand the utility of long-term, uninterrupted ambient data.

Question 3. **What research areas are most useful to RAP and LaMP coordinators, and how can the research needs of these programs be communicated more effectively?**

The research needs of RAPs, LaMPs and resource managers are often poorly defined, partly due to a communication breakdown between those developing plans and the research community. One proven effective way to overcome this is to have researchers directly involved in the development of RAPs and LaMPs. Also, RAPs and LaMPs should invite broader agency involvement (e.g. Sea Grant, Canadian Wildlife Service, U.S. Fish and Wildlife Service, Public Works Canada and the U.S. Army Corps of Engineers).

Better communication also is needed with potential advocates for RAP-related research and potential funding sources. Relevant research and results need to be communicated in plain language beyond the RAP/LaMP coordinators to the advisory councils and the public. These should be thought of as end-users for the research and can be strong advocates if kept informed. Also, RAPs and LaMPs need to identify and communicate research needs for potential funding sources. For example, resources may be needed to adapt and apply research tools on a site-specific basis. Finally, RAPs and LaMPs must complement each other. Research needs are similar, often differing by just a matter of scale. For example, a mathematical model of contaminant fate and transport for Lake Erie may have applicability to AOCs around the lake if adjustments are made for the size of the water body.

A partial list of research areas that were identified based on their applicability to one or more RAP or LaMP includes:

- research on technology for contaminated sediments remediation;
- effective methods for habitat restoration;
- methods to reduce loads and impacts from non-point sources;
- identification of biological community structure and the dynamics of ecological stresses for predictions about the likely result of remedial actions;
- socioeconomic analysis of remedial options;
- cause-effect relationships between remedial actions and restoration of impaired uses;
- quantitative targets to serve as indicators of restoration;
- data to monitor progress in the restoration of beneficial uses (argue that monitoring with guidance of a hypothesis *is* research); and
- establishment and use of standard pollutant loading protocols (include supplemental information such as quality assurance/quality control, flow rates, relevant water chemistry).

Whatever research needs are identified for a RAP or LaMP, a process to complete the work is required. This involves finding the expertise in the research community as well as the necessary funding. One suggestion to ensure future financial resources is to establish RAP endowment funds (for research and data collection) similar to the Great Lakes Protection Fund. Also, since many of the research needs are not unique, an expert system could be developed to help RAPs and LaMPs identify and prioritize research needs (i.e. share a common heuristic knowledge base). Finally, since LaMPs depend on RAPs, good coordination is needed between them, including the identification and implementation of needed research. This is a good opportunity for cost savings, because it could reduce duplication and achieve multiple objectives.

Question 4. **How can multiple disciplines and research institutions be best combined to achieve "critical mass" to address complex research topics?**

Complex research topics, such as tracking pesticide fate and transport or understanding nearshore physical/ecological processes, require multiple disciplines and research institutions. Although much basic research can be conducted by individual researchers and laboratories, applied research that is responsive to management needs must be holistic, coordinated and multi-institutional projects (e.g. the International Field Year for the Great Lakes or the Green Bay Mass Balance). The complexity of the Great Lakes system warrants the combined efforts of researchers and institutions.

Achieving critical mass for a complex research topic means assembling a team of researchers that represents the major disciplines required for the study without leaving gaps or excessive duplication. Necessary prerequisites are:

- need for cooperative planning at the beginning of a project;
- need for research managers and researchers to formulate integrating questions;
- need for a commitment to long-term research funding for multi-discipline research;

- establish a mechanism that allows groups to form for specific problems and gets agencies to commit funding;
- implement post-proposal coordination/cooperation by asking proposers to refine/amalgamate their proposals (e.g. Great Lakes Agricultural Profile Project (Great Lakes Protection Fund), Great Lakes University Research Fund project on Lake Erie);
- investigate the possibility of matching funding from governments, industry, foundations and NGOs;
- explore partnerships; and
- eliminate cross-border funding barriers.

Several areas regarding data and information should be improved in order to support this effort. There is a need to establish a basin-wide, geo-referenced database of researchers, expertise, institutions and study areas as a means to facilitate project coordination. Information and databases should be shared; a sense of trust should be fostered. Public data should be available free of charge and ways of accessing data widely publicized (e.g. training, user manuals). The "good will" factor should be an aspect of mobilizing and sharing multiple data sets. New technology for information management should be used to reach a wider audience and make the overall process of obtaining data easier. If information from private sources is confidential, then it should be kept separate from publicly available data.

One way to use the data base to improve coordination is to cross-reference the Council's inventory by funding agency and use it to generate interagency cooperation. In conjunction with this, the Council could organize a biennial, binational Great Lakes research managers workshop with the following objectives: share priorities (exchange information on current and future projects and look for possible synergies; eliminate overlap; develop partnerships; and explore ways to share equipment and staff. Such a workshop should be organized and attended by managers and researchers and should provide ample opportunities for communication, networking and coordination.

When discussing complex research, there needs to be a balance with exploratory research that is often best done by individual researchers or small teams. It is important that adequate funding and mechanisms for autonomous, not necessarily problem-solving, basic research be kept available so that the ability to identify new problems is retained.

Question 5. **If research funding must be reduced in certain areas, how can the Great Lakes research community be involved to ensure that reductions will be achieved logically and that vital components do not go unfunded?**

This question is related to Question 4 in two ways. If a clear set of research directions has been identified, including basic and exploratory research, then reductions could be carried out logically. Also, if critical mass has been established for some complex research topics, then these projects have to be allowed to finish before reductions are considered. It is necessary to include the academic community in these decisions.

"When discussing (funding of) complex research, there needs to be a balance with exploratory research that is often best done by individual researchers or small teams."

When reductions have occurred, it is possible to manage them so as to have the least impact. For example, human resources and institutional knowledge should be preserved above all else. This could be achieved by cooperative training and rotation of staff among labs and by mentoring of younger scientists. Vital components of research programs in the nearshore are often field work and the data and information associated with it. Coordinated planning of monitoring can ensure that this area is impacted as little as possible. Also, it is possible that existing data may have utility for purposes other than those for which they were collected. When new data are not available, it may be feasible to connect researchers with existing data (i.e. data mining).

A culture and paradigm shift must occur to recognize science as part of policy and to incorporate advice from the result of scientific study into the decisionmaking process. One way to convince decisionmakers and the public that this shift is needed is to document and market the relevance of research and the return on investment (i.e. quantify the value of research). Once done, it is still necessary to rally support for research. An important part of this is communication to the public (e.g. web pages, laboratory brochures) in order to help the public understand the *real* issues and research needs and the value of good science in support of them.

The above suggestions to reduce the impacts of research budget cuts require constant attention by researchers and managers. A good way to focus this effort is through an annual meeting, such as the IAGLR Conference where a regular session on recommendations, priorities, resource sharing and partnerships could be held and easily reach the target audience. Such a session was held at the IAGLR '97 Conference in Buffalo, New York and was of immediate value in the face of documented research cuts (see Chapter 4.2.6).

The common threads from the discussion at the SOLEC '96 session included:

- the research community should market the value of their research in terms relevant to the general public;
- research and monitoring in the face of budget cuts requires a long-term, integrated approach;

- innovative funding alternatives must be sought, such as partnerships, where barriers are removed including cross-border funding obstacles;
- better data integration and availability are needed to foster cooperative research efforts;
- sampling and field work require advanced coordination, especially in complex research efforts;
- all affected groups should be involved in research decisionmaking, particularly the academic community; and
- there is a communication barrier between some RAP teams and researchers. Researchers should participate as members of RAP teams and have an equal voice.

4.2.6 IAGLR Plenary Session, June 4, 1997

As part of its strategy for addressing the priority on improving the effectiveness of Great Lakes research, the Council engaged researchers and managers in discussions at the IAGLR '97 Conference held in Buffalo, New York and sponsored by Buffalo State College and the State University of New York (SUNY) at Buffalo. The approximately 70-80 attendees reflected a variety of interests including physics, chemistry, biology, engineering and policy. The Council's white paper, Improving the Effectiveness of Great Lakes Research, served as the basis for discussion.

At the conference, the Council facilitated a plenary session entitled Improving the Effectiveness of Great Lakes Research. Dr. Joe DePinto (SUNY Buffalo) presented a summary of the results of the SOLEC '96 session on research. During an interactive discussion, four panelists summarized how their agencies were managing this topic.

Presentations

Mike Quigley (NOAA) discussed the IAGLR '97 plenary session, Sharing and Leveraging Scarce Resources — Great Lakes Science Partnerships through the 90s and Beyond. At that plenary, panelists discussed partnerships and shared resources on a national level. One example of a formal partnership in the U.S. is the Sea Grant program. There is an active university grant program for each of the Great Lakes states and the process places added value on partnerships among grantees. The Consortium for Oceanographic Research and Education, a coalition of agencies and universities, has been formed to speak with one voice regarding resource needs for research and education in ocean programs. Examples of partnerships in Canada include the **Canada-Ontario Agreement** (COA), the **Upper Lakes Environmental Research Network** and the **Great Lakes Cleanup Fund**. The University-National Oceanographic Laboratory System coordinates oceanographic ship schedules and research facilities.

Mr. Quigley also described the Great Lakes Research Vessel Coordination Workshop held in Detroit on March 11-12, 1997. Seeing the need for a similar coordinating body in the Great Lakes, NOAA and other agencies and universities convened the workshop, which brought together Great Lakes research vessel operators and managers. One result was an Internet-based coordination system and an inventory of research vessels. Currently, there are about 60 vessels and their capabilities and characteristics will be listed. To continue saving money by exchanging equipment, current plans call for a workshop every year. As the resource decline continues, accountability for efficient use of remaining resources is increased and coordination of vessel use demonstrates this concern.

". . . major resource cuts to the Great Lakes science program at DFO: a 40 percent reduction of staff, a 70 percent reduction of operating funds and loss of one research vessel, the R/V Lauzier."

Harvey Shear (Environment Canada) noted that as a result of a program review by Environment Canada, their program experienced a 30 percent reduction in people and budgets nationally. Ontario Region programs in support of the Agreement, such as surveillance and monitoring, the **National Water Research Institute** and the **National Wildlife Research Centre** suffered somewhat less than this. Some programs have been restored by internal reallocation, but cuts at the provincial level also necessitate a reassessment of the partnering through COA.

To deal with these cuts priorities have been set, such as ecosystem objectives in support of LaMPs and reports on indicators. The result is targeted, mission-oriented research and the linking of science to policy. This may limit scientific freedom because researchers may not have as much flexibility. Research managers are working to establish the right blend of basic research versus targeted research so that researchers will still have some freedom to pursue interesting avenues.

Another approach is an expanded effort to rely on university research, including efforts that synthesize the work of previous researchers and moves away from narrowly defined projects. The concept of "mining" data sets from previous work that may still contain relevant information to establish baselines needs to be furthered with university researchers. It is difficult to convince some university departments that such projects have merit. There is also the need to market research through such events as SOLEC to reach decisionmakers. Researchers should avoid jargon so that their results are understood by the interested public.

Vic Cairns (Department of Fisheries and Oceans) summarized the major resource cuts to their Great Lakes science program: a 40 percent reduction of staff, a 70 percent reduction of operating funds and loss of one research vessel, the R/V *Lauzier*. In response, a new research paradigm for Great Lakes science was identified. Table 11 compares the old ways of doing science with future needs.

Table 11 **Old Paradigm vs. New Paradigm**

OLD PARADIGM	NEW PARADIGM
Focus on problem identification	Science more focussed on solutions (focus on common goal)
Tend not to look beyond internal capability to solve problems	Expand horizons to include other scientists to solve problems (lend or borrow expertise, training, incentives, flexibility in budgets)
Sense of responsibility for complete solutions sometimes constrained by mandate, capability and interest (someone else's problem)	More sharing of responsibility and mandate (empowerment of local agents, universities for problem solving), e.g. RAPs
Reactive science — issues already here (lamprey)	Should be more proactive, e.g. risk assessment for new invaders
Variety of science initiatives, including some curiosity driven science, could be afforded	Strictly bounded by resources. Pragmatic and focussed with almost no opportunity for "want to know" effects (less distinction between academia and government for same funds)
Detailed examination of complex issues encouraged	Movement toward indicators of individual and community health, habitat quality.
Planning model (planning, doing, evaluating) 10:80:10	As resources decline and partnerships (and data) increase, much more emphasis on planning and synthesis and less on doing 40:20:40. Change in expertise needed?
High level of resource intervention (habitat restoration)	Conservation and prevention vs. rehabilitation.
Science funded almost entirely from government	Government monies used to lever outside resources. Science priority increasingly reflects third party priorities. Becoming more difficult to fund long-term (20-year) ecosystem studies, forcing science community into short-term studies. Need to find way to weave short-term priorities into long-term programs
Science priority planning tends to be internalized	Research priorities need to be defined by much larger community (e.g. LaMPs), role for more active involvement from Council, IJC and GLFC in science priorities.

DFO has taken eight steps toward establishing the new paradigm.

1. Emphasis has moved from activities to science products that are more focussed on client needs.

2. Discussions have been initiated with OMNR to establish a formal mutual priority setting process.

3. Initial steps have been taken to develop partnerships with universities and other governments through the Upper Lakes University Research Network (for example, listing research priorities, identifying who is doing what, collaborating on calls for proposals).

4. More reliance has been placed on collaborative partnerships with university researchers, including support for more graduate students and post-doctoral

fellowships. Projects are usually client driven and supported and focussed on needed questions.

5. Research staff are seconded (assigned) to work with fisheries habitat resource managers to better understand what the operations-people need from science.

6. Collaborative agreement has been reached with OMNR to assign an expert to work with DFO staff to solve a mutual problem, improving the lower trophic model to fit the Lake Erie Ecosystem Model.

7. Internal collaboration is slowly increasing. People and equipment are borrowed internally to meet peak demands, for example, fish health biologists to conduct habitat surveys.

8. Operational partnerships have been established with outside agencies (such as the Metro Toronto Region and the Hamilton Region Conservation Authorities) where specialised equipment and trained staff are shared in return for similar favors.

DFO has identified five important issues that need to be resolved in the near future.

1. **Science planning**. Because of lack of communication, some important issues (exotics, habitat management) and programs in support of the Agreement and COA are scrambling for funding. A mechanism is needed for setting priorities and more communication among agencies.

2. **Information on fish stocks to assess status and predict response to environmental change**. Long-term monitoring is required for an appropriate suite of environmental indicators, as is more information about fish stocks on the upper lakes. To ensure data homogeneity among lakes, a basic suite of information for all lakes will be recommended and relevant monitoring parameters carefully selected.

3. **Science based guidance for fisheries managers** will help them understand how chemical contaminants and multiple or even single alterations to phosphorus, exotics, habitat, fish stocking and exploitation affect fish stocks, water quality, and ecosystem stability and influence resource management.

4. **Exotic species management**. Since control is difficult, prevention is the top priority. A risk assessment framework is required to evaluate potential damage and influence decisionmakers.

5. **Science based guidance for habitat management** is required to quantify and assess impacts of habitat alterations on fish communities and to link habitat alterations and fish production. Science results must be transferred into prevention and enhancement activities, not regulation.

The ORD strategic plan includes the creation of four "mega-labs" around the country organized around risk and representing movement away from stressors towards an ecosystem approach.

Steve Lozano (U.S. EPA) noted that his agency also is going through a paradigm shift. On the national level, U.S. EPA's **Office of Research and Development** (ORD) has an expanded grants and fellowship program with $100 million going to extramural investigator-initiated grants in 1997. The ORD strategic plan includes the creation of four "mega-labs" around the country organized around risk and representing movement away from stressors towards an ecosystem approach. One of the national programs is EMAP II (**Environmental Monitoring and Assessment Program**) emphasizing indicator development, integrated assessment and information management. The latter includes public data access via the Internet. **Regional EMAP** (REMAP) makes approximately $2 million per year available to U.S. EPA regions for EMAP-like projects such as the St. Louis River sediment project. The Mid-Continent Ecology Division, located in Duluth, Minnesota, is currently adding post-doctoral positions through the ORD fellowship program. The Ecology Branch is working on Lake Superior to establish long-term monitoring at 45- and 100-metre sites and to track transfer of material through trophic levels from watersheds.

U.S. EPA is involved with several partnerships at both the national and Great Lakes level. Nationally, U.S. EPA partners with universities and other agencies through the EMAP program. The Lake Michigan Mass Balance Study is a good example of partnering that includes several agencies and universities. Smaller projects include the St. Louis River REMAP project which uses an EMAP design to test sediment in the AOC and the Lake Superior Forage Fish Assessment. U.S. EPA can now enter into a cooperative research agreement that allows for sharing of equipment and expertise including the use of U.S. EPA boats by universities.

Discussion

Following on the idea of seconding (temporarily assigning) researchers to universities and other agencies, the suggestion was made that researchers could be seconded to communities (e.g. by researchers joining RAP teams). This would permit easier identification of RAP research needs as well as adapting work from other areas to meet individual RAP requirements. This kind of coordination already occurs for some RAPs. How can this arrangement be fostered for all RAPs? One common RAP research need is the development of relevant, credible indicators of progress in remediation efforts. However, indicators may be misleading because there is often not enough information to make indicators useful.

The extremely broad **Requests for Proposals** (RFPs) that universities respond to currently are in opposition to the suggestion that agencies conduct targeted, mission-oriented research. The suggestion was made that the Agreement annexes are clear about research needs and these could be used to target RFPs. Research managers who create RFPs would respond to pressure to focus their research direction. Currently, managers are not getting the message on the value of research; they need constant reminders. Researchers should work with program managers to develop research agendas.

It may be dangerous for IAGLR to presume that more research has to be done with less resources. When Great Lakes research is compared to other government programs, the budgets appear tiny and the results substantial. However, the lack of resources may be because the marketing of the benefits of Great Lakes research has not been done. Planning needs to be devoted to this. Also, money is available to support research if searched for, but that should not stop efforts to make research more efficient.

One way that IAGLR and the Council could help improve research planning would be to sponsor a workshop with those involved in the Lake Ontario LaMP and researchers at the next IAGLR meeting. One theme of IAGLR '98, to be held at McMaster University in Hamilton, Ontario, is the state of Lake Ontario.

The need for more synthesis of existing information is not new, but there are barriers to conducting such projects, including lack of academic credit and lack of project funding. One solution is to reserve a certain amount of funding for synthesis projects. Also, if the synthesis included socioeconomic concerns and was media friendly, then marketing of the results would be easier. However, training would be needed to accomplish this. An example is a course taught to engineers and lawyers where each experienced the other's discipline.

The example of the Wildlife Habitat Council was brought up as a potential industrial partner. This is a group of individuals, conservation organizations and corporations (including over 100 industries) established to help large landholders manage their unused lands in an ecologically sensitive manner for the benefit of wildlife. In the Great Lakes, the St. Clair River Waterways for Wildlife Project includes as partners Detroit Edison, Terra International, Ontario Hydro, Environment Canada and the Joyce Foundation.

Five common threads were identified in this plenary session.

1. Mechanisms for establishing partnerships exist and are in use in many areas of Great Lakes research. These need to be used more frequently and in more creative ways.

2. Targeted, solution-oriented research needs must be given higher priority by program managers. This includes continued and expanded use of graduate students and post-doctoral fellows to conduct issue-driven research. University departments should be urged to accept projects that are applied in nature or are syntheses of previous work as valid academic endeavours. Agencies should set aside funding for such work.

3. The benefits of Great Lakes research need to be better marketed, including addressing the socioeconomic implications of projects as well as effectively communicating with the news media. This will require additional skill acquisition by researchers.

4. Better planning of research projects is important. RFPs should not be developed in a vacuum but with the full participation of the research community. The Council and IAGLR could work together to convene a workshop bringing together researchers and Lake Ontario LaMP planners.

5. Suggestions for improving the effectiveness of RAP-related research include:

   - second (assign) researchers to RAP teams, thus eliminating communication barriers that some RAPs are facing; and

   - increase effort on indicator research, an area that many RAPs rely on for goal and target setting. Research from other AOCs can be adapted to RAPs that may not have had the benefit of a focussed research project initially. An example is the Green Bay Mass Balance Study where models developed are applicable to several other AOCs.

4.2.7 Conclusions and Recommendations

Under the priority, improving the effectiveness of Great Lakes research, the Council surveyed Great Lakes researchers to ascertain the magnitude of budget cuts and their impact on research programs in support of the Agreement. IJC used the results in its Eighth Biennial Report on Great Lakes Water Quality. In addition, the Council engaged the research community in discussion to identify mechanisms to increase effectiveness. The Council used three venues with different formats to reach audiences essential to address the topic.

- At the public meeting, researchers and interested members of the public presented their concerns and suggestions.

- A roundtable at SOLEC '96 engaged managers and others through five "focus" questions.

- A plenary session at IAGLR '97 engaged researchers through a panel and discussion.

The Council reached a reasonable cross-section of the Great Lakes research community. Judging from the number of suggestions received and the attendance at these events, especially the SOLEC and IAGLR sessions, the interest of researchers, managers and the public is strong. As described in this chapter, mechanisms are in place that, if fully used, could help make Great Lakes research more effective. Highlighted below are recommendations derived from these sessions.

Research partnerships currently exist both in the Great Lakes and at the national level. Innovative use of this mechanism should continue, especially for federal-provincial partnerships in Canada and federal-state partnerships in the U.S. However, research on the lakes and connecting channels is often international in nature and barriers to partnerships of this nature should be removed. Barriers include access to data and equipment and cross-border funding. To increase the effectiveness of Great Lakes research, the Council recommends the following.

- **The use of existing partnership mechanisms continue and new mechanisms for establishing research partnerships be crafted with special emphasis on the formation of international partnerships.**

One partnership mechanism that has been in existence since the signing of the original Agreement is university-government cooperation. In both countries there has been a recent, renewed emphasis on cooperative research projects that utilize graduate students and post-doctoral fellows. This can be an efficient mechanism as long as the projects result in targeted, mission-oriented research. Some of these projects should represent syntheses of previous work. University departments should be willing to give academic credit for synthesis projects. The Council recommends the following.

- **Government agencies collaborate with universities on focussed, client-driven research projects that will result in an improved scientific basis for management decisions.**

Much of the research conducted in the Great Lakes basin currently is done in support of RAPs and LaMPs. These plans depend on good science for sound decisionmaking. Yet not all of these efforts, especially RAPs, have the benefit of this research, because of communications barriers between researchers and some RAP teams. This hinders both the identification of RAP research needs and implementation of research results. The Council recommends the following.

- **Researchers be actively involved in the decisionmaking processes of RAPs and LaMPs through membership on RAP and LaMP teams and advisory councils. In addition, research results must be incorporated in all RAP and LaMP reports to strengthen research management linkages.**

A recurring theme in all of the events that the Council held was "marketing" the benefits of Great Lakes research. The Council's white paper (Chapter 4.2.3) includes examples of successful applications of research and attempts to initiate marketing efforts. However, scientists not trained in this area find it difficult to deal effectively with the public and the news media. The Council recommends the following.

- **IJC, as a priority for the 1997-99 biennial cycle, address the effective communication of research results.**

An important initiative being conducted by NOAA and other agencies and universities is the Great Lakes Research Vessel Coordination Workshop and associated vessel inventory. A major expense of lake research is ship time. This effort to coordinate and optimize the use of research vessels is a major step towards improving the effectiveness of research. The Council recommends the following.

- **Coordination of Great Lakes research vessels continue and IJC sponsor future vessel coordination workshops.**

Research planning has often been under-emphasized in the past. Managers have tended to establish research priorities in a vacuum and wrote broadly scoped RFPs. With the reality of reduced budgets, planning is more important than ever before and researchers should have a voice in establishing RFPs that will lead to focussed research. The Council recommends the following.

- **To establish research priorities, government agencies share the responsibility with both scientists who are familiar with Great Lakes research needs and also users of research results.**

The size and complexity of the Great Lakes system is such that one funding agency cannot hope to cover all aspects of a given research problem. Agencies need a way to leverage their research resources by combining funds with other agencies in collaborative studies. Examples of such projects include the Green Bay Mass Balance Study and the Lake Michigan Mass Balance Study. These studies are not binational, however. What is needed for Lake Ontario or Lake Erie is a study that is both binational and lakewide (e.g. International Field Year for the Great Lakes). The Council recommends the following.

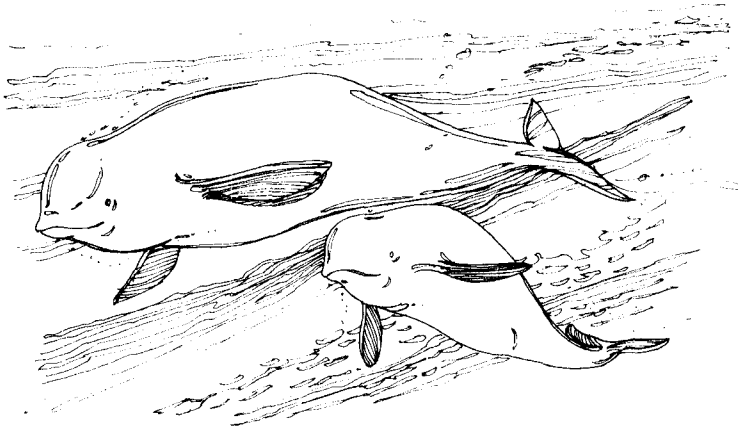
- **Government agencies support the concept of a lakewide, binational, coordinated, multi-institutional project that would cover all aspects of a given problem domain in a given system.**

4.3 STATUS OF THE GREAT LAKES - ST. LAWRENCE RIVER RESEARCH INVENTORY

In the fall of 1995, the Council began to re-design the Research Inventory and to make it accessible through the **Great Lakes Information Network** (GLIN). The objective in improving the inventory and making it more timely and accessible is to promote the transfer of information on research programs to Great Lakes basin policymakers, resource managers and the public. The project description form was revised to make it easier to complete, improve the quality of information, and facilitate its adaptation into an electronic form available through GLIN; and the data base was revised to make it easier to search. These changes were implemented for the 1996 version of the Research Inventory.

In January 1996, the revised project description forms were mailed to approximately 1,000 addressees known to conduct relevant research on the Great Lakes and St. Lawrence River. Included were instructions on how to access and complete the electronic form or to submit a hard copy, either of which would result in exactly the same information being entered in the data base. Mandatory items have been designated on both versions of the form. The requirement to submit mandatory information has improved the integrity of the data base.

The 1996 Great Lakes - St. Lawrence River Research Inventory currently contains 432 research projects and programs, representing approximately $71 million (U.S.) in research funding. **It is available on the Internet at http://www.ijc.org/cglrm/ri96home.html(.)** New search capabilities have been added including keyword, agency and principal investigator. The research categories have been made more relevant. The 1997 inventory is currently being assembled and should be accessible in the fall.



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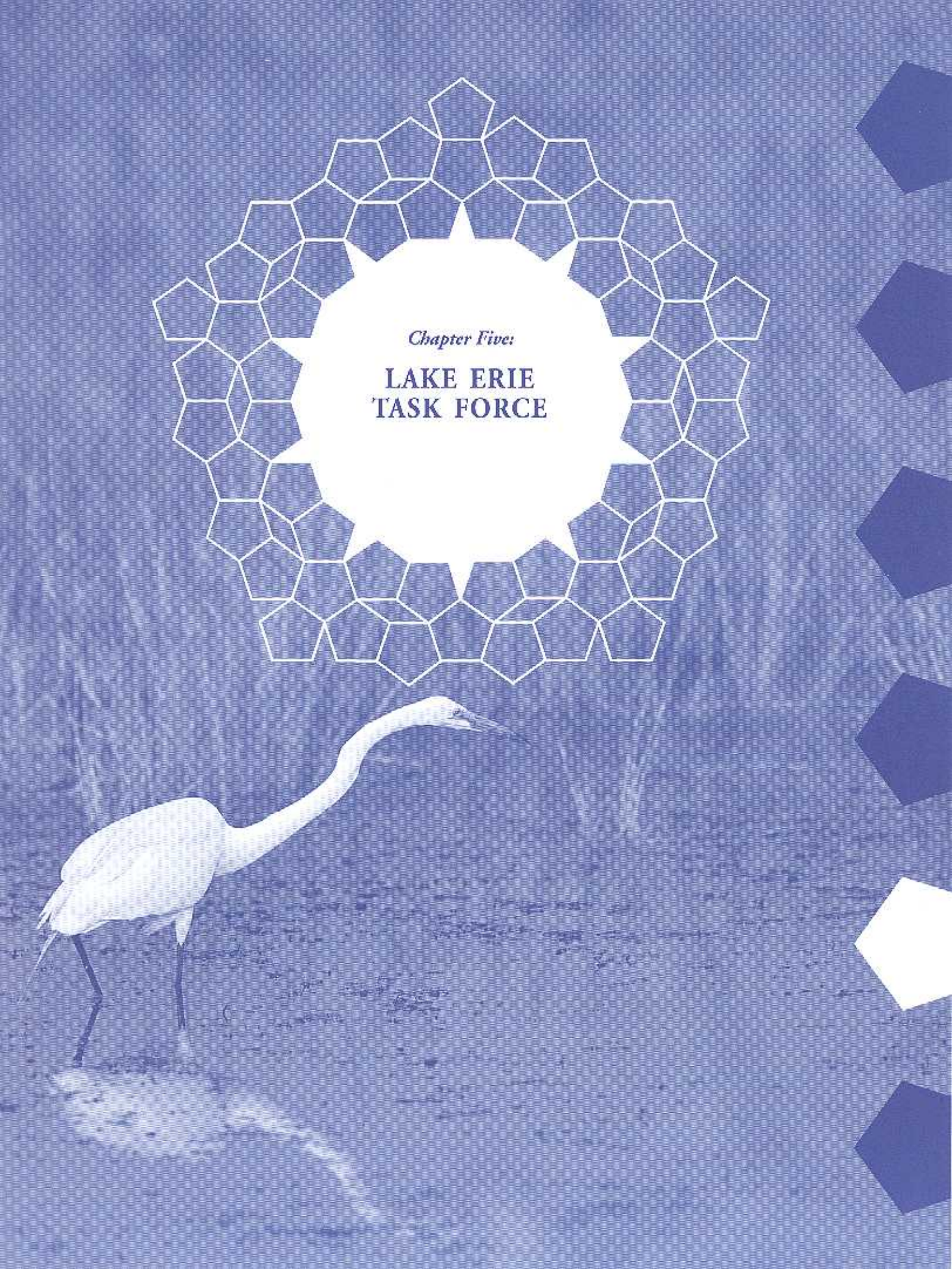


Chapter Five:

LAKE ERIE TASK FORCE

CHAPTER FIVE *Contents*

5.1 THE 1995-1997 PRIORITY

5.1.1 Background

In 1993, the **International Joint Commission** (IJC) established the Lake Erie Steering Committee, later called the **Lake Erie Task Force**, to advise it on the impact of various stressors affecting the health of Lake Erie. In particular, the Task Force focussed its efforts on the adverse effects of stressors on the benthic and fish communities and reported to IJC at its 1995 biennial meeting in Duluth, Minnesota.

In spring 1994, the Task Force convened a telephone conference with modelling and ecosystem experts. They concluded that it was appropriate and possible at this time to initiate development of an ecosystem model for Lake Erie. They also agreed that this was the best approach to gain an understanding of the significant ecological changes occurring in the lake and evaluate the impact of these changes on management decisions affecting the **Great Lakes Water Quality Agreement**.

In June 1994, the Task Force hosted a modelling "pre-workshop" involving researchers, modellers and managers with an interest in the ecological changes occurring in Lake Erie. Results from this pre-workshop encouraged the Task Force to pursue development of an ecosystem model for the lake. Workshop participants confirmed the need for a Lake Erie model and identified key elements of an approach to model development, including:

- a comprehensive review of existing models, focussing on their scope, linkages and data gaps; and
- development of a stress/response model for zebra mussels to test critical questions and linkages among the various components of the ecosystem.

Participants also recognized the benefit of IJC taking a coordination or leadership role in model development. They stressed the need for involvement from those who would ultimately use the model, including Lake Erie managers within **Environment Canada**, the **United States Environmental Protection Agency** (U.S. EPA), state and provincial resource management and environmental control agencies, and others.

In December 1994, the Task Force distributed a "request for proposals" to modellers in the United States and Canada. In January 1995, after evaluating a number of proposals in an open and competitive process, the Task Force initiated the Lake Erie Ecological Modelling Project (LEEMP) by contracting with a binational consulting team consisting of LURA Group from Toronto, Ontario and Dr. Joseph Koonce and Dr. Ana Locci from Case Western Reserve University in Cleveland, Ohio.

5.1.2 Purpose of LEEMP

The purpose of LEEMP was to:

- develop a comprehensive model to enhance understanding of changes taking place in the Lake Erie ecosystem;
- provide a tool to assist Lake Erie resource managers; and
- assist IJC to evaluate progress under the Agreement.

5.2 TRANSFER TO THE PARTIES

The Task Force co-chairs, late in 1995, met with representatives of Environment Canada and U.S. EPA — two agencies that would be key users of the model and are leading the Lake Erie LaMP (lakewide management plan) process. Specifically, meetings were held with senior representatives from each agency in December 1995, with the Lake Erie LaMP Work Group in January 1996, and with the LaMP Work Group co-chairs in January 1997. To summarize:

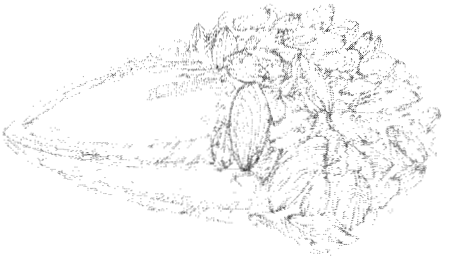
- the binational Lake Erie Committee of the Great Lakes Fishery Commission will use and enhance the existing model, which has already been modified to allow a separate focus on the Eastern Basin of Lake Erie, to examine fisheries issues; and
- the Lake Erie LaMP Work Group has created a modelling subcommittee that is using and enhancing this model and others to assist in the development of the Lake Erie LaMP.

Throughout, the Task Force regularly shared its experience in developing LEEMP with agencies involved in the Lake Erie LaMP. This interaction occurred primarily through involvement by LaMP participants in the LEEMP Core Advisory Group, in model development workshops and in working with and testing the model. In fact, the Core Advisory Group provided the Task Force with a list of priority urgent issues that could be addressed by developing the Lake Erie Ecological Model (LEEM) (Appendix). This approach, with its emphasis on sound technical modelling coupled with an interactive, collaborative process for model development, provides an effective blueprint for future model development. The experience in developing a model together with an advisory group, the learning that occurred regarding the uses of the model, the compromise in model resolution and heuristics of model use were all positive. The transfer of the model to the LaMP occurred through the involvement of LaMP participants in the entire process. The Task Force created a much larger nucleus of people working together on ecosystem issues and has crossed boundaries among agencies, offices, communities and disciplines.

5.3 FUNDING FOR ONGOING MODEL DEVELOPMENT

Dr. Koonce, the model's principal investigator, received a substantial U.S. EPA research grant to pursue further model development. The grant, totalling approximately $250,000 (U.S.), is for an overall project entitled "Modelling and Multiobjective Risk Decision Tools for Assessment and Management of Great Lakes Ecosystems" and will enable continued expansion of the Lake Erie model to address issues such as habitat, hydrology and climate change.

In addition, this funding will enable further development of the model to meet the specific needs of the Beneficial Use Impairment Subcommittee under the Lake Erie LaMP. In particular, the Subcommittee has expressed interest in using the model to examine issues such as the effect of water transparency on predator-prey relations, habitat complexity effects, winter die-off of clupeids and in-lake concentrations of phosphorus.



"This approach, with its emphasis on sound technical modelling coupled with an interactive, collaborative process for model development, provides an effective blueprint for future model development."

5.4 LESSONS LEARNED IN DEVELOPING LEEMP

5.4.1 Background

Integrated modelling of living system/environs complexes (e.g. the Lake Erie ecosystem) is one of the more promising ways to marshal decision support tools so the Parties may fulfill their agreement "to make a maximum effort to develop programs, practices and technology necessary for a better understanding of the Great Lakes Basin Ecosystem." The Lake Erie Task Force concluded that the most recent iteration of its model warranted a place in the suite of models of several logical types, such as graphic landscape models, word models, process-function models, mass balance models, community models, population models and watershed models, which must be interlinked in order to ascertain where understanding of the Lake Erie ecosystem is "robust" and where important gaps lie. However, integration of such models for enabling explorations of ecosystem integrity, type and scale, requires that there be a legitimate unified approach.

The Lake Erie Task Force accepted as fact that the ecospheric complex is fully interrelated, an unseamed whole in which everything is connected to everything else. The reason for doing ecological research is to find which connections are stronger and more significant, given certain criteria, than others. The goal in developing predictive models, such as LEEM, is not to show that everything is connected, but to show which minimal number of measurable connections may be used as a reasonable surrogate for the whole system, in this case Lake Erie. Models of any type are abstract and, hopefully, realistic. They are, however, models of reality and are not themselves reality.

"The goal in developing predictive models, such as LEEM, is not to show that everything is connected, but to show which minimal number of measurable connections may be used as a reasonable surrogate for the whole system, in this case Lake Erie."

5.4.2 Lessons

Through its work on LEEMP during the past two biennial cycles, the Task Force developed considerable insight regarding the effort to develop a comprehensive, ecosystem model for Lake Erie. Several key lessons learned are summarized below.

No one model can adequately address all the issues and problems associated with the dynamic Lake Erie ecosystem. By definition, ecosystems, such as Lake Erie, involve many complex, interactive processes and components that are in a constant state of change. Capturing all of these processes and components in any one model, while ensuring model outputs are realistic, certain and verifiable for users, is extremely challenging. In the Task Force's view, emphasis in the future should be placed on exploring ways of facilitating interface and possibly integration among complementary Lake Erie modelling initiatives. In fact, the ultimate Lake Erie ecosystem model may be a large comprehensive model capable of being the interface among numerous smaller models, each dealing with a specific component of the ecosystem.

The Lake Erie Task Force believes it successfully accomplished its goals. It developed an ecosystem model that has been deemed useful and will be used by the Lake Erie LaMP and the Lake Erie Committee of the Great Lakes Fishery Commission. The Task Force had an impact on the LaMP process, which now includes a modelling subcommittee. Furthermore, Dr. Koonce received additional funding from U.S. EPA to allow further model development. Therefore, the results of IJC efforts will not sit on the shelf — they will be used — and the Parties themselves are continuing the development and improvement of the work initiated by IJC.

"Therefore, the results of IJC efforts will not sit on the shelf — they will be used — and the Parties themselves are continuing the development and improvement of the work initiated by IJC."

The process by which a model is developed is at least as important as the technical capabilities of the model itself. From the outset of LEEMP, the Task Force pursued a collaborative, inclusive approach to model development. The Task Force believed that the constituency of over 60 Lake Erie modellers, researchers and managers, which had been actively involved in the model's development, testing and use, was one of LEEMP's greatest strengths and accomplishments.

Criteria for closure are essential to model design. All models are simplifications of real systems and are thus incorrect at some level of detail. Establishing criteria for closure provides a way of judging model adequacy. Nothing in the testing of the LEEM prototype indicated that it was inappropriate to address the range of problems for which it was designed. The initial problem focus included questions about the interaction of reductions in nutrient loading, invasion of zebra mussels, contaminants and fish management policies in causing the decline of important Lake Erie fisheries. However, review and testing of the prototype was not limited to those involved with its initial design. By opening the evaluation of the prototype to a wider audience, much was learned about model weaknesses and the implication of those weaknesses to use of the model for the intended purposes. At the same time, broader review resulted in new perspectives on problem definition for the model. It is important to recognize that model development is, and should be, an iterative process. Within this context, criteria for closure are needed for each iteration of a model to enable the model development process to move forward.

Strong project management is a prerequisite for success, particularly with multi-faceted projects spanning one or more years in duration. During its work, the Task Force met regularly to review progress, address and resolve issues and provide direction to its contractor/principal investigator. The Task Force also believed that its diverse mix of members — with unique ideas, perspectives and areas of expertise — also contributed to successful completion of work.

5.5 CONCLUSIONS

The Task Force, in its view, achieved both of its overall goals.

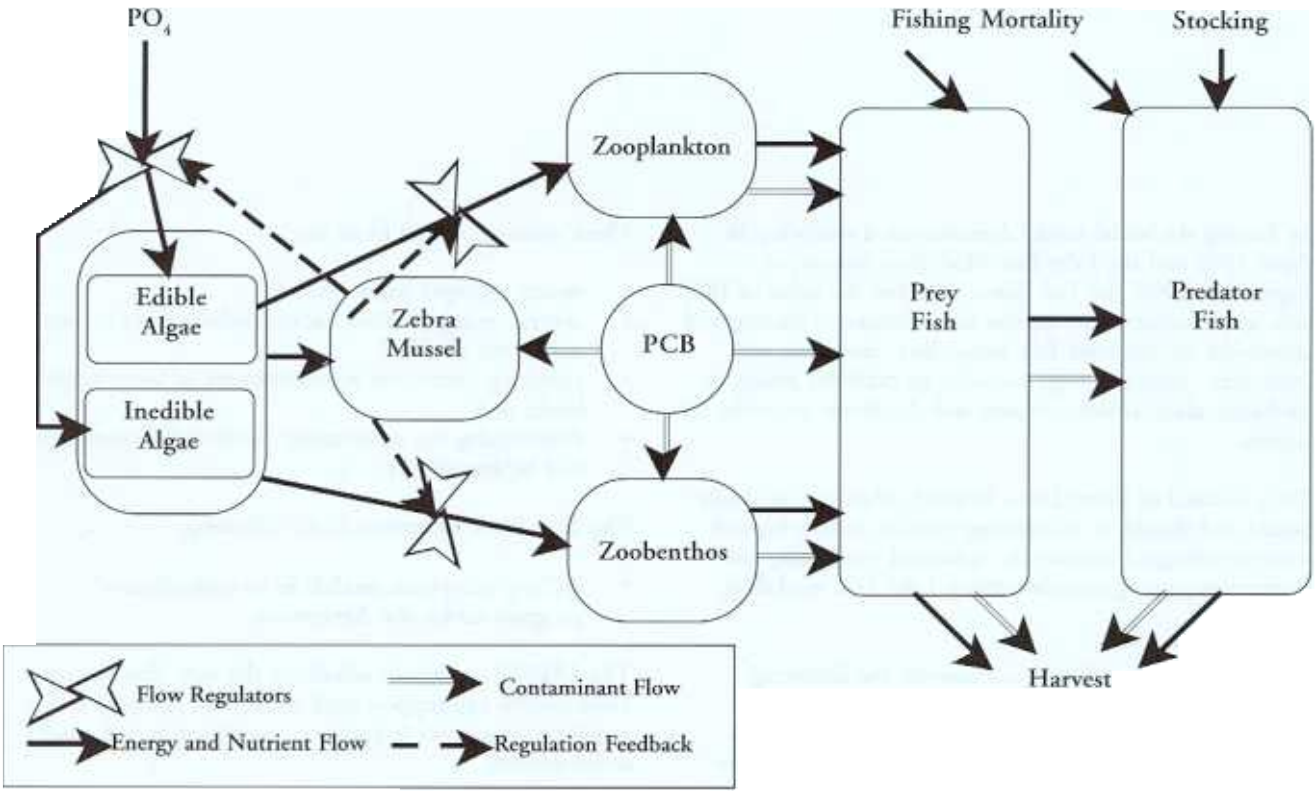
Model Modification and Improvement

By starting an iterative correction process for the Lake Erie Ecological Model, the prototype was further tested, developed and improved. This was accomplished through a series of interactive demonstrations, testing exercises and workshops, culminating in the development of a second iteration of the model (Figure 7). At this stage in its development, the model remains a prototype. Further evaluation and testing is needed to move from prototype to application of the model to the Lake Erie condition. It is important to note that even a fully evaluated and tested version will not be able to address all the ecological issues confronting management of Lake Erie. However, testing and evaluation of the prototype to date indicates that LEEM will have primarily heuristic value in addressing the range of problems for which it was originally designed — to illustrate interactions among the key stresses affecting the Lake Erie ecosystem: the zebra mussel invasion, contaminant loading, the fisheries and declining nutrient loading.

Sustainable Model Development: Framework and Infrastructure

A strong foundation for future model development was developed by securing additional substantial funding for further model development. Dr. Koonce received a substantial U.S. EPA research grant to pursue further model development. In addition, in the Task Force's view, transfer of its experience in developing LEEMP to the Lake Erie LaMP has occurred through the involvement of LaMP participants in the process. Furthermore, the Lake Erie LaMP Work Group has created a modelling subcommittee that will use LEEM and other models. The Lake Erie Committee of the Great Lakes Fishery Commission will use the Eastern Basin version of LEEM to evaluate a variety of fishery, contaminant and nutrient issues.

Figure 7 **Revised Structure, Lake Erie Ecological Model, 1996**



Finally, in the Task Force's view, the LEEMP process made a substantial contribution to the use of models and modelling applications to enhance understanding and decision-making about Lake Erie. Key benefits and accomplishments include:

- **active involvement of more than 60 Lake Erie managers, researchers and modellers in model development;**
- **information sharing regarding models, modelling applications and issues confronting Lake Erie; and**
- **development of a prototype that, with additional evaluation, testing and improvement, can be used and applied heuristically to assist:**

  Managers **- in exploring alternative management options, hypotheses and scenarios; clarifying issues and problems; and communicating and justifying management preferences; and**

  Scientists **- in screening hypotheses and identifying research priorities.**

5.6 RECOMMENDATIONS

In hosting the initial model demonstration workshop in April 1995 and the Lake Erie Modelling Summit in September 1996, the Task Force observed the value of IJC's role in providing opportunities for information sharing and discussion among Lake Erie researchers, modellers and managers. Both meetings provided an excellent setting to exchange ideas, review progress and determine priorities for action.

IJC's Council of Great Lakes Research Managers is ideally suited and should, as an ongoing priority, serially explore various ecological avenues for enhanced interfacing and integration among complementary Lake Erie modelling efforts.

Therefore, the Task Force recommends the following.

- **IJC mandate its Council of Great Lakes Research Managers to provide a regular forum for Lake Erie modellers, researchers and managers to share information, discuss progress and explore potential linkages among complementary Lake Erie modelling initiatives.**

These meetings would focus on:

- testing multiple basin versions;
- experimenting to allow various habitat types to overlap within the model(s);
- exploring alternative representations of lower trophic levels; and
- determining the relationship between fish recruitment and habitat supply.

The Task Force recommends the following.

- **IJC use ecosystem models in its evaluation of progress under the Agreement.**

The LEEMP experience reinforces the view that management models can support such evaluation, but only if this provision of support is *explicitly* considered during model development.

"The Task Force recommends the following.

- ***IJC mandate its Council of Great Lakes Research Managers to provide a regular forum for Lake Erie modellers, researchers and managers to share information, discuss progress and explore potential linkages among complementary Lake Erie modelling initiatives."***

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5.9 APPENDIX: CORE ADVISORY GROUP — PRIORITY MANAGEMENT ISSUES

I. Changes in fish species composition (abundance) likely to occur with various combinations of fish management, nutrient loading and mussel effects. Fish species include walleye, yellow perch, ruffe, trout perch, white perch, white bass, emerald shiners, spottail shiners, lake herring, lake whitefish, smelt, gizzard shad, alewife, burbot, smallmouth bass, drum, sturgeon, round goby, coho salmon, chinook salmon, brown trout, lake trout, rainbow trout, sea lamprey.

1. Can we sustain significant production and harvest of smelt with current mussel and phosphorus regimes?
2. Is the current decline of walleye, yellow perch and smelt due to lower phosphorus loadings and mussel invasion?
3. Would yellow perch and other species' harvest increase if phosphorus loads increase?
4. What would be the effect of reducing the predation effects of walleye and lake trout on smelt and yellow perch harvest?
5. What, if any, is the interaction between sustainable harvest of yellow perch and sustainable harvest of walleye?
6. What is the impact of ruffe invasion on yellow perch and young-of-year classes of walleye?
7. What is the impact of reduced sea lamprey controls on salmonids, coregonine, burbot and smelt?

II. Changes in contaminant body burdens with same factors (as in #I) as well as changes in contaminant loadings (PCB, DDT, mercury and atrazine).

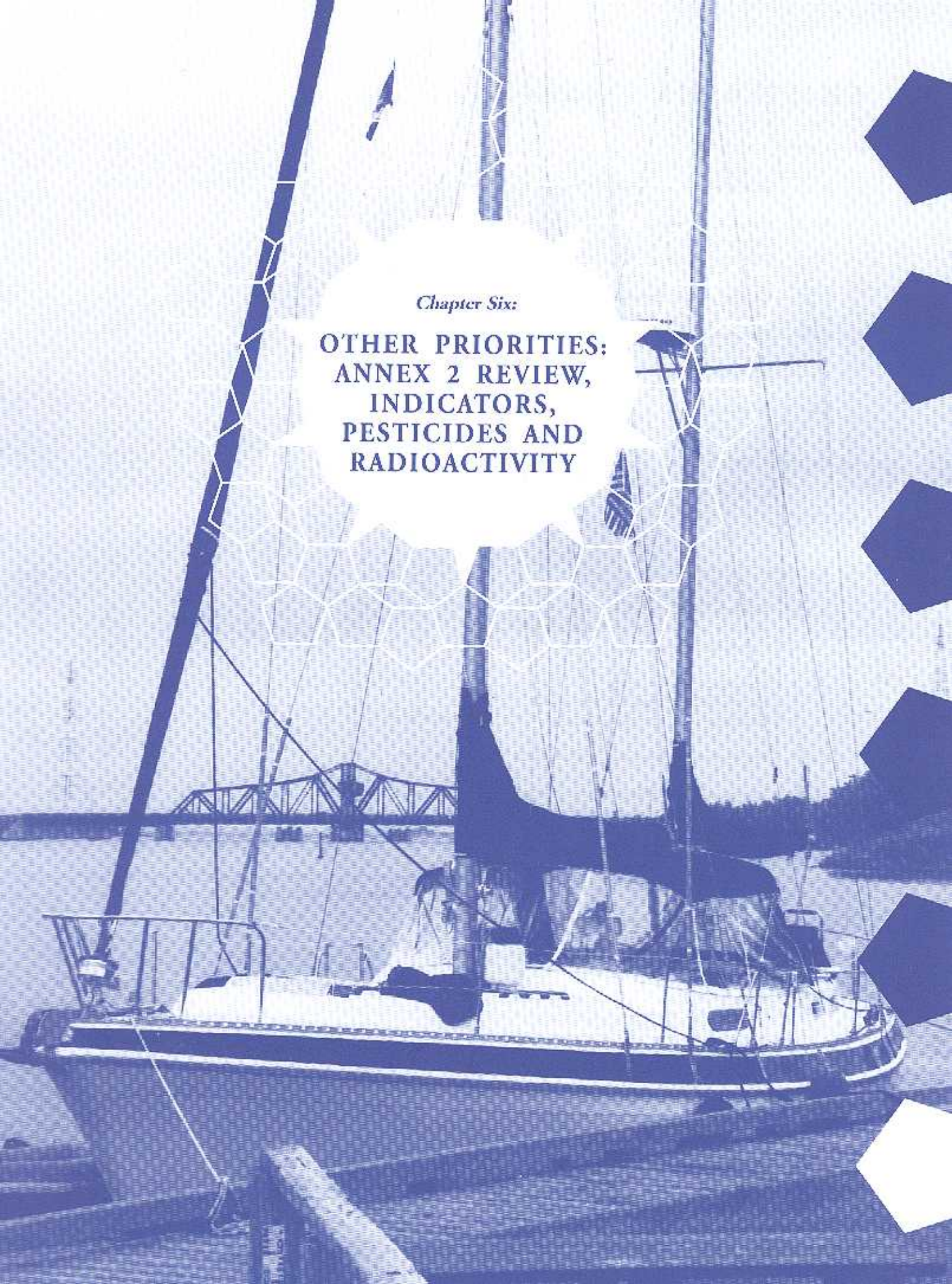
1. Should changes in body burdens be expected as a result of decreased phosphorus?
2. Latency of response of body burdens to changes in phosphorus or mussels? (complete list of species, as relevant)
3. Do concentrations of contaminants in various species show consistent ratios or divergent ratios?

III. Current mussel biomass status and effect of nutrient loading on mussel biomass.

1. Do mussels increase primary production?
2. What are the net effects of mussels on primary, secondary and benthic production and latency of those interactions
3. What are the consequences of system changing from pelagic to benthic as a result of mussels?

IV. Interaction of community structure changes including vegetation, fish populations, nutrient loading (including silica) and water quality.

1. What are the impacts of atrazine on food web, energy transfer changes in vegetation, plankton, and algae?
2. What are the effects of silica or other secondary nutrient limitations on food web dynamics and fish community structure? (edible/inedible - spatial distribution of productivity)
3. What is the effect of fish harvest on water quality parameters of specific interest?
4. What is relationship between walleye abundance and distribution with water quality (transparency)?



Chapter Six:

OTHER PRIORITIES: ANNEX 2 REVIEW, INDICATORS, PESTICIDES AND RADIOACTIVITY

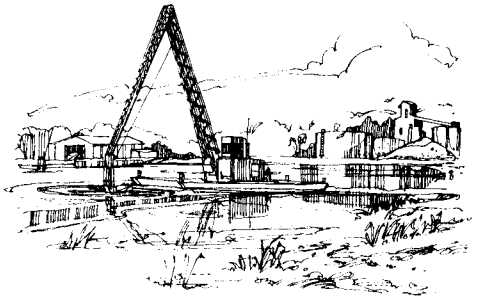
CHAPTER SIX *Contents*

6.1 ANNEX 2 REVIEW

6.1.1 Special Report on Areas of Concern

Dramatic changes in funding levels for **Area of Concern** (AOC) planning and implementation activities have occurred within the last few years. Reductions in funding have resulted in layoffs or reduced staffing levels, reduced agency support for public consultation activities and the need or desire to forge private/public partnerships and innovative approaches to addressing the unmet requirements of AOC restoration. Because of these issues and the **International Joint Commission's** (IJC) role in assisting implementation of **remedial action plans** (RAPs), IJC is preparing a special report dealing with restoration activities in AOCs.

Despite funding limitations, there are numerous success stories regarding AOCs. The special report is focussing on several of these and promoting the concept of certain AOC efforts serving as "lighthouses" to guide other RAP efforts in positive directions. Sharing information and successful techniques among various AOCs has become even more important as financial resources become more scarce.



Despite funding limitations, there are numerous success stories regarding AOCs.

6.1.2 Status Assessments

In April 1996, IJC adopted a new approach to carrying out its activities under Annex 2 of the **Great Lakes Water Quality Agreement**. In order to more effectively fulfill its roles of reviewing progress and assisting in implementing the Agreement, it is proactively evaluating progress under Annex 2, rather than waiting for RAPs and **lakewide management plans** (LaMPs) to be submitted for review and comment. This evaluation activity, or status assessment, is being undertaken for selected AOCs and, in the case of LaMPs, selected open lake waters.

Since status assessments focus on a subset of AOCs and open lake waters, site selection criteria are utilized to maximize the benefits of the activity. The site selection process considers:

- sites that have the potential to export persistent toxic substances;
- binational sites;
- sites with a high level of planning or remedial activity; and
- sites with noteworthy institutional arrangements.

Detroit River AOC

The need for effective working partnerships in the Detroit River AOC was apparent to IJC prior to the formal initiation of the status assessment. Accordingly, in June 1996, IJC in cooperation with the **Canadian Consulate General** in Detroit and the **Southeast Michigan Council of Governments** sponsored a Partnerships for Progress (Becker and Kirschner, 1996) workshop in Detroit, Michigan. A summary of the workshop is provided in Chapter 6.4.

The status assessment was begun in November 1996. IJC will present its findings and recommendations in a separate report, scheduled for release in fall 1997.

Hamilton Harbour AOC

IJC began the status assessment for Hamilton Harbour on May 22, 1997. The initial site visit involved a tour of the AOC and attendance at the annual meeting of the **Bay Area Restoration Council** (BARC). IJC's **Science Advisory**

Board (SAB) assisted in this status assessment by examining scientific issues related to the remediation effort. A summary of SAB's review is provided in its chapter of this report.

Preliminary observations from the Hamilton Harbour site visit show this AOC restoration effort is especially effective at consulting the public regarding restoration activities and involving local elected officials. BARC also has gained local corporate support for various implementation activities. BARC is hopeful that this type of financial support will allow it to better cope with cutbacks in agency support.

6.1.3 Conference on Creative Funding

On July 23-25, 1996, IJC in cooperation with The Keland Endowment Fund of The Johnson Foundation convened a conference on Funding Strategies for Restoration of Areas of Concern in the Great Lakes Basin (IJC 1996a). The conference brought together 40 agency and community representatives including: provincial, state, federal and tribal government officials; nongovernmental organizations; public advisory group members; and IJC personnel involved in developing, implementing and monitoring restoration activities in AOCs throughout the Great Lakes basin. The principal purpose of the conference was to evaluate opportunities for successful alternative funding of remedial action planning and implementation efforts. Presentations ranged from a professional fundraiser to an explanation of tribal partnering with environmentalists and farmers. Numerous strategies for funding activities and coping with government funding cutbacks were detailed in presentations and facilitated discussion. Strategies include:

- developing partnerships with key stakeholders to facilitate implementation activities;
- establishing a trust fund to provide restoration funding at the local level;
- implementing remediation in an incremental fashion as funding permits;
- communicating funding needs to government agencies and elected officials;
- attracting interest from local corporations and businesses by demonstrating the benefits of restoration;
- using mechanisms such as affinity credit cards and environmental license plates to fund remedial activities;
- publicizing remedial success stories in order to gain additional public and political support;
- undertaking a concerted effort to interest and involve units of local government;
- developing an award system to encourage and expand participation by representatives of all sectors of the community;
- cultivating media interest and support;
- establishing not-for-profit status in order to encourage contributions; and
- considering economic and community/social aspects of potential activities in order to attract a broad array of partners.

"Through consideration of these and other strategies, it is apparent that few, if any, AOC efforts are near their full potential in regard to maximizing local financial support for restoration efforts."

Through consideration of these and other strategies, it is apparent that few, if any, AOC efforts are near their full potential in regard to maximizing local financial support for restoration efforts. While certain capacity-building exercises are underway, the ability of local volunteer groups or local government to accept funding responsibility from state, provincial or federal government remains uncertain. Accordingly, as resources allow, IJC will continue assisting in capacity-building initiatives for RAP personnel and advisory groups.

6.1.4 Partnerships for Progress Workshop

On June 5, 1996, the Canadian consulate general in Detroit, the Southeast Michigan Council of Governments and IJC conducted a workshop regarding the utility of partnerships in Detroit, Michigan. The primary purpose of the workshop was to highlight successful partnerships so that the potential utility of a Detroit River AOC partnership could be examined.

Presentations regarding partnerships were made by the Canadian consul general, the mayors of Detroit, Michigan and Windsor, Ontario, representatives of the Waterfront Regeneration Trust, the Northwest Michigan Resource Conservation and Development Council, BASF Corporation, and the city of Wyandotte, Michigan.

Examples of partnerships and concepts that were discussed include:

- the partnership between BASF Corporation, Wyandotte and the state of Michigan resulting in the redevelopment of an industrial site into a recreational area including a nine-hole golf course;
- a partnership between Detroit and the National Wildlife Federation to develop a polychlorinated biphenyls and mercury minimization program;
- the Grand Traverse Bay watershed initiative that has a total of 130 partners and centres on the concern for water quality and quality of life;

- formation of the Ashtabula Partnership allowed individual agencies to have a vision beyond that of each individual agency's mandate;
- the Waterfront Regeneration Trust's use of a readily identifiable logo helping to spark corporate sponsorship; and
- adoption of a partnership agreement tends to unify diverse groups around a common goal.

6.1.5 Lakewide Management Plans

Lakewide Management Plans (LaMPs) for the open waters of lakes Erie, Michigan, Ontario and Superior are currently under development. The goal of LaMPs is to restore beneficial uses in open waters of each lake. Implementation of LaMPs is to result in reduced loadings of critical pollutants.

The Stage 1 (problem identification) LaMP for Lake Superior was submitted to IJC for review and comment in September 1995. IJC and individual reviewers conducted a review meeting in February 1996 with representatives of the Parties, jurisdictions and the Lake Superior Forum. In November 1996, IJC transmitted its comments to the Parties and jurisdictions (IJC 1996b).

The major issues addressed include:

- few data are presented linking exposure to specific critical pollutants to human health threats;
- significant data gaps related to loadings of critical pollutants suggest that the initial scoping of environmental problems should have taken a more systematic and comprehensive ecosystem approach; and
- little information was presented regarding atmospheric loadings, therefore additional attention should be devoted to the atmospheric loadings of critical pollutants to the Lake Superior basin and sources of critical pollutants outside the Great Lakes basin.

IJC has initiated efforts to assist the Parties in filling data gaps related to atmospheric loadings and to the human health threat posed by critical pollutants. IJC assistance has been in the form of a February 26, 1997 workshop, Understanding the Air Deposition Pathway and Examining a Potential Approach Toward the Virtual Elimination of Dioxin, and a September 19, 1997 workshop on human health and aquatic life concerns.

Major discussion topics at the February 1997 workshop include:

- identifying major sources of dioxin;
- atmospheric transport of toxic chemicals within and to the Great Lakes basin determined from Canadian observations;
- an outline of U.S. EPA and Environment Canada initiatives; and
- economically constructive methods of virtually eliminating the entry of dioxin into the Great Lakes.

A principal focus of the workshop was discussion regarding sources and possible pollution prevention efforts related to "dioxin," which designates (for this discussion) the 210 polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans. As noted above, IJC's review of the Lake Superior Stage 1 LaMP noted that significant data gaps related to sources and loadings of critical pollutants exist. Potential means of achieving virtual elimination of dioxin in the Great Lakes basin were outlined and discussed at the workshop.

Five classes of dioxin sources (medical waste incinerators, municipal waste incinerators, cement kilns that burn hazardous waste, iron sintering plants and pulp and paper mills) were evaluated and the following issues addressed:

- identifying appropriate changes in production technology that would prevent dioxin formation;
- estimating the cost of substituting these technologies for existing dioxin-generating technologies; and
- evaluating impact on the regional economy.

Commoner et al. (1996) documented that these five classes of dioxin sources account for nearly 90 percent of the dioxin entering the Great Lakes and addressed the above issues for each class of dioxin sources in Zeroing Out Dioxin In The Great Lakes: Within Our Reach. As an example of remedial measure evaluation for LaMPs, Table 12 outlines the scenario of an intensive recycling system for the incineration of municipal solid waste in the Great Lakes region.

As noted in Table 12, the evaluation of substituting an intensive recycling system for the present incineration of municipal solid waste predicts savings of over $500 million (U.S.) annually in the Great Lakes region, while reducing dioxin emissions from a major source to zero. As LaMPs

". . . the evaluation of substituting an intensive recycling system for the present incineration of municipal solid waste predicts savings of over $500 million (U.S.) annually in the Great Lakes region, while reducing dioxin emissions from a major source to zero."

Table 12 **Summary of Direct Economic Impact of Substituting an Intensive Recycling System for the Incineration of Municipal Solid Waste in the Great Lakes Region**

COST/ REVENUE CATEGORY	COST IMPACT OF CHANGE IN FIRST YEAR OF INTENSIVE RECYCLING SYSTEM ($millions)
Net revenues from additional recycled materials*	+462
Avoided incinerator tip fees	+675
Additional collection costs	-206
Additional education costs	-88
Incinerator debt retirement costs	-307
Total Net Revenue	+536

* The midpoints of the estimates for public and private facilities are averaged to generate this value.

Source: Presentation by Dr. Barry Commoner on February 26, 1997 in Chicago, Illinois.

Production of dioxin from iron sintering plants is a recently raised concern in the Great Lakes basin.

progress further into Stage 3 (selection of remedial measures), it will be important to analyze benefits of alternatives, such as recycling, as a cost-effective means of decreasing the dioxin load to a lake.

Production of dioxin from iron sintering plants is a recently raised concern in the Great Lakes basin. As of the February 1997 workshop, no known measurements of dioxin emissions from iron sintering plants in the basin had been made. Commoner et al. (1996) suggest that iron sintering plants account for 21 percent of the total atmospheric deposition of dioxin in Lake Michigan. Emissions from iron sintering plants in the Great Lakes basin were measured in June 1997. Still, little is known regarding this source of dioxin emissions and an evaluation of remedial measures to reduce resultant loading to Lake Michigan or other lakes would be difficult to accomplish at this time. The measurement of dioxin emissions and evaluation of remedial measures are important, particularly for the Lake Michigan LaMP effort. Newly measured sources of dioxin, such as iron sintering plants, represent a significant opportunity for the Parties and jurisdictions to pursue pollution prevention rather than control options to reduce dioxin loading.

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6.2 INDICATORS

"Are the Great Lakes getting better? Can we swim there, drink the water and eat the fish? What data and information do we need to evaluate progress towards these and other goals? How do we know when the goals have been reached? These are challenging questions, but managers, legislators and interested citizens must frequently come to terms with them."

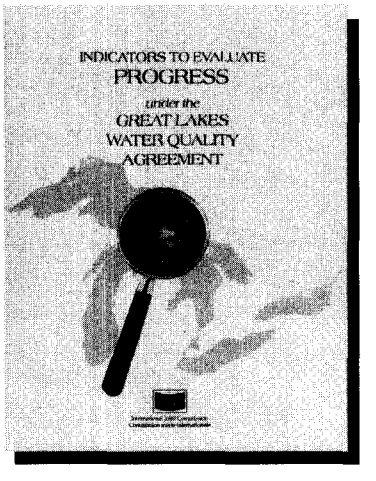
— M.P. Bratzel, Jr. in "Focus" March/April 1996

In 1993, the **International Joint Commission** (IJC) established an **Indicators for Evaluation Task Force** to identify indicators to evaluate progress under the **Great Lakes Water Quality Agreement**. In its final report, *Indicators to Evaluate Progress under the Great Lakes Water Quality Agreement,* the Task Force provided a framework the IJC could use to fulfil its obligation to evaluate Agreement progress and develop advice to governments. The framework consists of nine carefully defined desired outcomes (Table 13). Associated with each desired outcome are indicators chosen, based on several criteria with special relevance to the Agreement, scientific completeness and public understandability. The desired outcomes incorporate the 14 beneficial uses listed in Annex 2 of the Agreement.

IJC adopted the Task Force's report and will use the nine desired outcomes as one of the organizing principles for its Ninth Biennial Report. In addition, the next State of the Great Lakes Ecosystem Conference (SOLEC '98) organized by **U.S. Environmental Protection Agency** and **Environment Canada** will focus on the use of indicators.

To examine applicability of the proposed indicators and implement the recommendations of the Task Force, IJC, in 1997, created an **Indicators Implementation Task Force**. This new task force, composed of academics and government personnel, has begun a pilot study in cooperation with government agencies to inventory and assess cost, availability, format and quality of historical data for the proposed indicators. This pilot study focussed on two desired outcomes — "fishability" and "virtual elimination of inputs of persistent toxic substances" for lakes Erie and Superior. IJC requested the federal governments to assist in identifying and providing the needed data. After completion of the pilot study in 1997, the Task Force will make recommendations regarding implementation, compilation, assessment and evaluation of the remaining desired outcomes and their associated indicators for all the Great Lakes.

IJC likely will make indicators one of its priorities for the 1997-99 biennial cycle and use indicators to evaluate the Parties' progress under the Agreement. Although IJC will work cooperatively with government and the SOLEC initiative, it will maintain its independence to review and assess progress. Eventually, all nine desired outcomes will be addressed on each of the Great Lakes to determine their overall quality, trends and progress toward achieving the Parties' purpose in the Agreement, "to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem."



Copies of *Indicators to Evaluate Progress Under the Great Lakes Water Quality Agreement* may be obtained from the Commission's Windsor, Ottawa or Washington offices, or via Internet on the IJC's home page: http://www.ijc.org(.)

Table 13 Desired Outcomes for the Great Lakes Basin Ecosystem

1. **Fishability.** There shall be no restrictions on the human consumption of fish in the waters of the Great Lakes basin ecosystem as a result of anthropogenic (human) inputs of persistent toxic substances.

2. **Swimmability.** No public bathing beaches closed as a result of human activities or, conversely, all beaches are open and available for public swimming.

3. **Drinkability.** Treated drinking water is safe for human consumption; human activities do not result in application of consumption restrictions.

4. **Healthy Human Populations.** Human populations in the Great Lakes basin are healthy and free from acute illness associated with locally high levels of contaminants, or chronic illness associated with long-term exposure to low levels of contaminants.

5. **Economic Viability.** A regional economy that is viable, sustainable and provides adequate sustenance and dignity for the human population of the basin.

6. **Biological Community Integrity and Diversity.** Maintenance of the ability of biological communities to function normally in the absence of severe environment stress (ecosystem health) and to cope with changes in environmental conditions which impose stress, *i.e.* to be able to maintain their processes of self-organization on an ongoing basis (ecological integrity). Maintenance of the diversity of biological communities, species and genetic variation within species.

7. **Virtual Elimination of Inputs of Persistent Toxic Substances.** Virtual elimination of inputs of persistent toxic substances to the Great Lakes system.

8. **Absence of Excess Phosphorus.** Absence of excess phosphorus entering the water as a result of human activity.

9. **Physical Environment Integrity.** Land development and use compatible with maintaining aquatic habitat of a quantity and quality necessary and sufficient to sustain an endemic assemblage of fish and wildlife populations.

6.3 PESTICIDE USAGE

Building upon previous IJC activities that documented the extent of rowcrop pesticide usage (pages 48-50, 1993-95 priorities report), a series of workshops was held assessing the feasibility of partnerships to reduce the delivery of row crop pesticides to the Great Lakes.

A preliminary workshop and public consultation were conducted August 8, 1996 in Madison, Wisconsin. Considerable support was expressed regarding government/industry partnerships that could directly assist interested farmers in employing conservation and application practices that would result in smaller amounts of herbicides entering the lakes.

Programs that allow farmers to self-assess environmental risks on their particular farms have been adopted throughout the Great Lakes basin. These may provide a suitable model for public/private partnerships to use in addressing the obstacle of pesticide loss from agricultural fields. The use of effective buffer strips and conservation tillage can reduce the loss of herbicides from an agricultural field by 65-90 percent. Their widespread application could result in a considerable loading reduction of compounds such as atrazine. Economic evaluations that display a benefit or cost to a farmer using a particular tillage system are now complete. These were presented at a workshop held August 21, 1997 in Toledo, Ohio. Findings have been presented to IJC in a separate report.

"Considerable support was expressed regarding government/ industry partnerships that could directly assist interested farmers in employing conservation and application practices that would result in smaller amounts of herbicides entering the lakes."

6.4 RADIOACTIVITY

6.4.1 Nuclear Task Force Mandate

In 1995 IJC authorized a Nuclear Task Force to review, assess and report on the state of radioactivity in the Great Lakes and to carry out other activities IJC might direct. IJC requested the Task Force to complete its review and assessment by 1997 and recommend additional projects based in part on three criteria:

- the Task Force's findings, based on work performed in preparing its status report, would substantiate a priority list of nuclear problems requiring analysis and remediation;
- concerns of IJC Commissioners; and
- problems brought to the Task Force's attention in the course of its work.

The Task Force determined that an inventory of radionuclides for the Great Lakes was essential to address the state of radioactivity in the lakes, so undertook to produce such an inventory. Key material in the inventory report is summarized below. The full report is in the final stages of preparation.

What Is an Inventory of Radionuclides?

An inventory of radionuclides attempts to quantify and organize information on the sources, levels, distributions, receptors and repositories of radioactivity. It is numerical, but not theoretical modelling, part of a material balance study of radioactive substances found in the Great Lakes basin. An inventory is a natural starting point to evaluate many radioactivity issues. It organizes information on what exists and where. Without an inventory, basic risk assessment analysis cannot be performed, nor can the aspects of sources, distributions and pathways of radionuclides requiring special attention be determined.

The Agreement contains a specific objective for radioactivity. In the 25 years of the Agreement's existence, neither the objective nor the subject of radioactivity drew much IJC attention. With the impending decommissioning of nuclear power plants, the growing problems of nuclear waste and the signing of a Comprehensive Test Ban Treaty on September 24, 1996, posing a plutonium disposal problem, general concerns about the effects of radioactivity on humans and ecosystems have made the subject of radioactivity very timely. The Agreement also espouses an ecosystem approach, which

the Task Force used to place in perspective the extent to which radionuclides may be environmental factors in the dynamics of Great Lakes ecosystems.

Historical Perspective

From 1945 to 1963, radioactive fallout from the atmospheric testing of nuclear weapons was the main source of artificial radioactivity to the Great Lakes. Following the Limited Test Ban Treaty in 1963, atmospheric testing continued sporadically through 1980. During the 30-year period of the treaty, the decay of residual nuclear debris from atmospheric testing has reduced nuclear fallout sufficiently to make it a secondary source of artificial radioactivity to the lakes.

Starting in 1962 with the commissioning of the Big Rock Point nuclear power plant, reactors in the basin added new sources of artificial radioactivity to the lakes. The number of nuclear power plant facilities increased rapidly until 1974, then more slowly until 1993. There are currently 19 nuclear power plants in, and with emissions to, the basin. Two other nuclear power plants operate in Great Lakes states near the basin, but their emissions enter other watershed and airshed regions. Decommissioning of reactors may begin as early as 2000 with expiration of the license for Big Rock Point.

Other large sources of radioactivity in the basin include a tritium (^{3}H) removal plant at Darlington (Lake Ontario), uranium mine and mill tailings entering the Serpent River region (North Channel), uranium refining and conversion at Blind River (North Channel) and Port Hope, Ontario, and weapons facilities and auxiliary operations at Ashtabula, Ohio. Not all of these facilities are currently operating but they remain sources of radioactivity to the basin.

The March/April 1997 issue of FOCUS newsletter, with a lead article about decommissioning nuclear reactors, is available by request to the IJC's Great Lakes Regional Office or can be read at the IJC's website, http:// www.ijc.org(.)

Previous IJC reports have reviewed radioactivity in the Great Lakes basin, specifically those of the Water Quality Board in 1977, 1978, 1979, 1983 and 1987. Those reports discussed the routinely studied radionuclides: ^{3}H, strontium (^{90}Sr), cesium (^{137}Cs), radium (^{226}Ra), uranium (^{238}U) and iodine (^{131}I); and α, β, and γ radiation and a few occasionally reported nuclides: antimony (^{125}Sb), cobalt (^{60}Co) and thorium (^{232}Th). The reported parameters can help assess the effects of radioactivity on the Great Lakes, but are inadequate to address such issues as ecosystem impacts of radioactivity, technology and resource needs for nuclear waste disposal, the decommissioning of nuclear reactors and interactions of toxic chemicals and radiation.

6.4.2 Sources of Radioactivity

Sources of radioactivity include natural background radiation from cosmogenic and terrestrial origin, residual debris from weapons testing in fallout, atmospheric deposition of nuclides emitted in gaseous discharges from various facilities, liquid emissions from various facilities, and many smaller sources that require identification. Facilities include nuclear power plants, mining and milling operations, refining, conversion and fuel fabrication and reprocessing operations, and tritium recovery operations. Smaller sources include research reactors and laboratories, hospital nuclear medicine departments and industrial operations. These are discussed in the Task Force's report, along with comments on data acquisition and analysis procedures. The material below focusses on emissions from nuclear power plants and secondary sources.

Emissions from Nuclear Power Plants

Table 14 presents information on licensed nuclear power plants in the Great Lakes basin. There are heavy water reactors (HWR) and two kinds of light water reactors (LWR), the pressurized water reactor (PWR) and boiling water reactor (BWR). U.S. facilities are all LWR systems and Canadian facilities all HWR systems. The names describe the reactor cooling and moderating systems used. A fourth type of reactor at university and hospital research laboratories is the gas cooled reactor, which is not used for electric power production. Under development is a fast breeder reactor (FBR). The Fermi 1 nuclear power plant had a FBR system but was decommissioned following an accident.

The relative quantities of radionuclides produced depend on the reactor type, including the technology and materials of construction, the amount of electricity generated, and the processes used to handle effluents and waste products. **United Nations Scientific Committee on the Effects of Atomic Radiation** (UNSCEAR) documents present nuclear power plant data in a format based on reactor type and power production. UNSCEAR applies a special averaging technique, normalization, which puts nuclide production in a reactor on a unit energy basis averaged over all reactors worldwide of the given type. The Task Force calculated normalization of the data but did not find it useful.

Table 14 **NUCLEAR POWER PLANT REACTORS IN THE GREAT LAKES BASIN[a]**

Reactor	Start-Up (Year)	Net Electrical	Reactor Type[b] Power MW(e)	License Expiration (Year)
United States				
Big Rock Point	1962	70	BWR	2000
Nine Mile Point 1	1969	625	BWR	2009
R.E. Ginna	1970	420	PWR	2009
Point Beach 1	1970	497	PWR	2010
Palisades	1971	700	PWR	2007
Point Beach 2	1972	497	PWR	2013
Zion 1,2	1973	2 x 1050	PWR	2013
D.C. Cook 1	1975	1050	PWR	2014
Kewaunee	1974	520	PWR	2013
J.A. Fitzpatrick	1975	800	BWR	2014
Davis-Besse 1	1977	910	PWR	2017
D.C. Cook 2	1978	1050	PWR	2017
Fermi 2	1985	1090	BWR	2025
Perry	1986	1205	BWR	2026
Nine Mile Point 2	1987	1070	BWR	2026
Canada				
Douglas Point [c]	1966	220	HWR	1996
Pickering A	1971/1973	4 x 508	HWR	1996
Pickering B	1983/1984	4 x 508	HWR	1996
Bruce A	1976/1979	4 x 750	HWR	1996
Bruce B	1984/1987	4 x 840	HWR	1996
Darlington A	1990/1993	4 x 850	HWR	1996

a. Sources of data: U.S. Nuclear Regulatory Commission, Information Digest, 1995 edition; Tracy and Ahier (1995), "Radionuclides in the Great Lakes Basin;" UNSCEAR 1977, 1982, 1988; Reporter, AECB Newsletter, Spring 1996. See the Task Force's report for full citations.

b. BWR: boiling water reactor; PWR: pressurized water reactor; HWR: heavy water reactor

c. No longer operating but not yet decommissioned.

Atmospheric emission data from nuclear power plants in the basin show varying degrees of completeness, specificity and descriptive information. All power plants report particulate matter, ^{3}H, total β-emissions excluding ^{3}H, and ^{131}I. Some plants report "total noble gases," α and γ radiation, and others list specific noble gas radionuclides (e.g. ^{41}Ar, ^{85}Kr, ^{133}Xe, ^{135}Xe) and other radionuclides of iodine (e.g. ^{133}I, ^{134}I, ^{135}I). The measurement of xenon nuclides depends on their energy spectrum; those emitting γ radiation of less than 1 MeV (1 million electron volts) might not be reported. Canadian HWR plants generally report fewer radionuclides. Canadian regulation is based on the consideration of the effect of all radionuclides migrating through all pathways to humans. While reporting of many nuclides may not be required, sometimes power plant authorities do collect this information but without any consistency or regularity.

Emissions from Secondary Sources in the Great Lakes Basin

Sources not associated with releases from nuclear fuel cycle activities are designated as secondary sources. This does not imply that such sources of radioactivity or their emissions are secondary in importance. These are either military or

For most radionuclides emissions are a few megabecquerels per year, although a few can reach gigabecquerel per year levels. These are insignificant compared to the tera- and petabecquerel levels released from nuclear reactors.

civilian (e.g. hospitals, industrial and commercial users and universities) or activities that release a naturally occurring radioactive material from an otherwise trapped matrix (technological enhancement), provided that the technological enhancement did not result from an activity associated with the nuclear fuel cycle. Although emissions from a single source may be negligible, the large number of such sources in the basin may make their combined effect significant. The Task Force's report addresses open sources of radionuclides that may eventually be released to the atmosphere or to sewer systems draining into the lakes. Excluded are an even larger category of sealed source uses, which would not be expected to release radionuclides to the air or water. Sealed sources could become a problem only if disposed of indiscriminately in municipal landfills.

All users of radioisotopes must obtain a license from the national regulator, the Atomic Energy Control Board (AECB) in Canada or the Nuclear Regulatory Commission (NRC) in the U.S. Regular reporting of measured or estimated emissions is a condition of maintaining the licence. This information is available from the regulators, but not usually in a convenient or machine-readable format. The Task Force obtained information from most of the Canadian users but not the larger number of U.S. users. Although incomplete, these data indicate the magnitude of the emissions. A crude estimate of total secondary emissions to the basin can be obtained by considering the ratio of the total population in the basin to that on the Canadian side.

The Task Force inquiry on secondary sources emphasized research reactors at universities and industrial sites and the use of radioisotopes in hospitals, research facilities and medical facilities other than hospitals. The Canadian data, obtained with the cooperation of AECB, came through questionnaires asking licensees to estimate their emissions. Responses were obtained from 85 percent of the licensees, which was assumed to include virtually all those with significant emissions. The greatest users of radionuclides are nuclear medicine departments of hospitals, which administer radioisotopes to patients for diagnostic purposes. Lesser amounts of radionuclides are used for research or industrial purposes. About 75 percent of the radioisotopes administered to patients are assumed to be excreted to sewers.

The Task Force's report summarizes the results for secondary Canadian users of radioisotopes for 1993, 1994 and 1995. For most radionuclides emissions are a few megabecquerels per year, although a few can reach gigabecquerel per year levels. These are insignificant compared to the tera- and petabecquerel levels released from nuclear reactors. Furthermore radionuclides from secondary sources all have half lives significantly less than one year and therefore do not accumulate from year to year. (Note: Becquerel is a measure of the rate of decay of a radioactive substance; mega = 10^6, giga = 10^9, tera = 10^{12} and peta = 10^{15})

6.4.3 Environmental Monitoring Data from Nuclear Facilities

The Task Force collected and examined environmental monitoring data provided by the operators of the major nuclear facilities in the basin. Virtually all radionuclide activities or concentrations were reported as the lower limit of detection. This does not necessarily mean that various radionuclides were absent from the environment, nor that their environmental impacts were insignificant. Rather, it means that the radionuclides could not be detected by the instrumentation and procedures used.

Rather than reproducing the results from all station reports, the Task Force report presents three typical examples to illustrate the general significance and the limitations of these results:

- artificial radionuclides in shoreline sediment, fish and surface waters near the Nine Mile Point nuclear station (Oswego County, New York) during 1994;
- environmental monitoring results from the Donald G. Cook nuclear plant operated by the Indiana Michigan Power Company; and
- radionuclides in Lake Ontario fish in the vicinity of the Pickering nuclear generating station during 1988.

Although the Task Force examined a significant quantity of environmental data collected by nuclear facility operators, the analysis of open water data was constrained by the limited number of lakewide monitoring surveys conducted in the past, making environmental and biological assessments difficult to perform. IJC previously recommended (in 1987) that radionuclide monitoring be conducted in the open waters of the Great Lakes every five years in a manner similar to the surveys conducted by the National Water Research Institute, Environment Canada, between 1973 and 1983. The last open water surveillance program, in 1990 by Environment Canada, was limited to Lake Ontario. Its scope was to ensure that nuclear facilities and other sources of radioactive contamination were controlled in a manner that met the broad objectives of the Lake Ontario Toxics Management Plan and the Agreement.

6.4.4 Inventories for Biological Compartments

One of the most difficult components of an inventory is assessing the radionuclide content of biota. Organisms are continuously exposed to radiation and radioactivity, but the extent to which they act as repositories for radioactive isotopes of various elements involves a complex set of metabolic and physiological processes that has not been intensively studied for purposes of establishing an inventory. Most of the research entails use of radioactive versions of selected elements or compounds (tracers) that are important in the physiological functioning of various species in order to understand the pathways and mechanisms of those physiological processes and functions. Almost none of the studies extended the data from tracer studies to establish biological compartmental inventories of radionuclides.

Because most radionuclides entering the Great Lakes move to sediments as their final repositories, the need to study biological compartments and establish radionuclide inventories for biota must necessarily emphasize those nuclides that have known physiological functions because of their stable element versions, and those which can become available to biota through natural physical, chemical, geological and biological processes which modify their movement and reaction patterns. Still, it is very difficult to detect those elements in the water column unless very large water samples (300 litres) are taken. The major exceptions are tritium and isotopes of strontium and rubidium. The Task Force reviewed considerable data on physiological and metabolic behaviour in lake biota of various elements and realized that for the Great Lakes, the production of an inventory for radionuclides in biological compartments meant addressing several generic problems related to the lakes, their biota and the nature of available data. The Task Force report addresses individual elements and nuclides with respect to bioaccumulation and biomagnification factors for freshwater biota. The work emphasizes studies with stable nuclides, but some data derived from radionuclides appear, mainly cesium and potassium.

6.4.5 Conclusions

The Task Force's key conclusions, based on inventory work to date, are presented below.

Adequacy Of Monitoring

1. Monitoring meets the needs of the relevant atomic energy acts in the U.S. and Canada but is not designed to look at environmental cycling of radionuclides.

2. Quality assurance protocols are also designed for compliance monitoring. Therefore, it is not possible to tell if nuclear plant monitoring is satisfactory to meet the goals and objectives of the Agreement.

The information base used to assemble the inventories, notably emissions data from nuclear facilities and monitoring data off site of the facility but keyed to its activities, has many problems. The Task Force reviewed monitoring protocols (i.e. directives, instrumentation, sampling plans, chemical analysis techniques, station and monitoring site locations, quality assurance considerations, data reporting and statistical analysis procedures) and found the following.

- The primary goal of all monitoring is to show that a given nuclear facility complies with the environmental requirements of its license. In turn, the environmental requirements in the license are dictated by the atomic energy legislation of each country. The Task Force concluded that the current state of monitoring is that of compliance.

- The atomic energy legislation of each country prescribes a maximum annual allowable human exposure to radiation as the basis for setting environmental monitoring requirements for each individual radionuclide. Dose assessment models translate this exposure criterion into allowable discharges of specific radionuclides and types of energy.

- The dose assessment models used to derive allowable discharges have a very limited relationship to the cycling of radionuclides for development of an inventory. The models make assumptions about the distribution of the activity of a given nuclide in different environmental compartments and the fraction of that nuclide's activity that is taken up by biota, assimilated and retained as opposed to taken up and then released, excreted or otherwise removed. The models also make specific assumptions about the transfer of radioactivity from retained nuclides in other biological compartments and the movements of nuclides through various foodwebs. This includes direct uptake by humans through drinking water or through intermediate uptake and bioaccumulation through food species.

- When monitoring environmental media, a particular characteristic of radionuclide measurements is that the lower limit of detection for a given sample depends on the time lapse between collection and analysis. This arises because the radioactivity in the sample continues to decay after sample collection and all measured activities must be corrected back to the time of collection. Thus the reported lower limits of detection may vary considerably from one laboratory to another, or even for measurements carried out in the same laboratory at different times after collection. For this reason it is not practical to use reported lower limits of detection to derive an upper bound for radionuclide inventories in the Great Lakes, or in any environmental compartment within the lakes.

Need for Reassessment of Environmental Monitoring of Nuclear Facilities to Support the Agreement

The comments in the four bullets above are generic and address specific data problems associated with individual facilities in each country. This led the Task Force to conclude the following.

3. There is a strong need for a comprehensive review of all monitoring activities at nuclear facilities with a view toward making monitoring more accommodating to the needs of the Agreement.

4. Since there are policy and fiscal implications to any likely expansion or adjustment of monitoring efforts, the Task Force calls upon the relevant atomic energy and environmental agencies in each country to explore in detail the kinds of monitoring needed and changes to current protocols.

Reporting

The Task Force concludes the following.

5. There are significant differences in the scope of data reporting and analysis of U.S. states and Canadian nuclear power plant emissions.

6. The monitoring for toxic chemicals used in large quantities at nuclear power plants needs to be included in analyses of their impact on the Great Lakes ecosystem.

7. The monitoring of radionuclides does not include identification of radioactive forms of toxic chemicals.

8. The details of U.S. data reporting are greater and more helpful for the purpose of ecosystem impact analysis than is Canadian reporting, but U.S. data come in mixed formats which make them difficult to organize.

9. U.S. facilities historically have aggregated their data on an annual basis, but the contract to continue this aggregation has apparently been discontinued as a cost savings measure.

10. Current biological monitoring and reporting is neither consistent nor adequate for lakewide assessments.

11. Developing inventories for specific isotopes in biological compartments was difficult because no common reporting format is used to produce/present biological data.

Conclusions 5 - 11 describe problems associated with using specific data from individual nuclear facilities and associated monitoring sites. The conclusions address the scope of data collection, the completeness of such collection from specific sites and facilities, the methods of data reporting and aggregation, and the problems of handling data from variable formats. In addressing these specific data issues, the Task Force noted the following important considerations.

The details of U.S. data reporting are greater and more helpful for the purpose of ecosystem impact analysis than is Canadian reporting, but U.S. data come in mixed formats which make them difficult to organize.

- Since all Canadian nuclear power plant facilities belong to one corporate entity, Canadian data are quite uniform in their scope, reporting and formats. U.S. nuclear power plant facilities, however, belong to 15 different corporate entities. Thus, while U.S. facilities report data that meet requirements set by NRC, these data often vary in scope, reporting and formats.

- To bring some semblance of order to the data from U.S. nuclear power plants, NRC had previously contracted with the Brookhaven National Laboratories to produce an annual document which assembled in a standardized format emissions data from these plants. These reports often appeared three years after the individual facilities reported their emissions for a given year and usually reflected the varying timetables and lag times in the submission of data from U.S. facilities. The termination of the Brookhaven contract in 1996 without a new contractual effort represents a serious reporting setback for those groups interested in the radionuclide emissions from U.S. nuclear power facilities.

- U.S. reporting tends to include a far greater number of radionuclides than Canadian reporting, although the Task Force could not always judge whether the more extensive reporting by U.S. sources is more comprehensive and useful than Canadian reporting. U.S. data often report nuclides at extremely low levels, basically levels of detection. The uncertainties in the reported data may call into question the information value of reporting selected radionuclides in certain emissions at levels of detection. On the other hand, the aggregated reporting of these radionuclides at trace levels reveals much about the performance of nuclear reactors and allows for a better understanding of the relationship between a particular reactor technology and the generation of its nuclear waste products.

- Biological data have multiple problems, ranging from sample descriptions to variable lower limits of nuclide detection. The latter problem is particularly troubling because, for many nuclides, the lower limit changes

with every sample even when methodology and instrumentation do not change. This situation arises because of the need to back calculate and correct nuclide data to the original time of sampling. Radioactivity continues to decay in a sample after collection and through the period of storage, analysis and reporting. To place all measurements on a common basis, the nuclide levels must be corrected to those at the time of sample collection.

- The large-scale use of nonradioactive toxic chemicals at nuclear power plants is often overlooked in establishing toxic substance inventories and monitoring activities. Among the chemical problems are those related to weed control on roadways and fence areas in a facility and at its perimeter, calling for considerable use of herbicides and pesticides. Cooling towers require antifouling and water softening agents and a variety chemicals to maintain heat transfer surfaces at their highest heat exchange capacities. The corrosion and fouling of piping and cooling system components, including water intakes, has led to widespread use of anti-corrosion and fouling control agents. Zebra mussel problems have led to increased use of chlorine as a decontaminating agent. How these chemicals behave in contact with radioactivity is not assessed in any monitoring work.

Harmonization of Monitoring and Data Reporting

The Task Force concludes the following.

12. There is a need to harmonize the approaches used in the U.S. and Canada with respect to the scope of monitoring, the nuclides reported and the reporting of biological data. International cooperation among the nuclear agencies of both countries would accomplish much of this harmonization.

Biological Transfer Factors for Lake Systems

The Task Force concludes the following.

13. There is a special issue of the reporting of nuclear data that applies specifically to the Great Lakes. It has the serious possibility of rendering incorrect all dose assessment factors used in establishing the transfer of radionuclides from biota to humans in the region of interest. The issue relates to the transfer factors which estimate biotic uptake of radionuclides. These factors traditionally have been derived from work done in rivers and oceans, rather than fresh water lakes. The Task Force is concerned that the factors derived from riverine and oceanic systems are inappropriate for use in the Great Lakes.

In developing the inventory for radionuclides, the Task Force noted that the bioaccumulation, biomagnification and transfer factors used to describe the cycling of

There is a special issue of the reporting of nuclear data that applies specifically to the Great Lakes. It has the serious possibility of rendering incorrect all dose assessment factors used in establishing the transfer of radionuclides from biota to humans in the region of interest. The issue relates to the transfer factors which estimate biotic uptake of radionuclides.

radionuclides and their transfer along exposure pathways to biota, including humans, came from the long history of work done in marine, estuarine and river environments. This work stemmed from interests in the deposition of radionuclides in the oceans and the transport of nuclides down rivers and estuaries from discharges to the oceans. The comparable studies for lakes were virtually nonexistent. Yet for the Great Lakes, the need for transfer factors that describe lake environments is critical.

To what extent can riverine, estuarine or oceanic data be used to infer lake situations for the cycling and transfer of radionuclides in environmental compartments? Where no data exist, it is the obvious approach. But why use marine data when lake data exist that can be used to develop the appropriate factors? The Task Force undertook such analysis after discovering the nuclear sciences literature was not extensive in its coverage of lake situations. To those who believe that the oceanic work, excellent as it was, should be used for the Great Lakes without confirmation, the Task Force cites two examples: nuclides of silver, specifically ^{110,110m}Ag, and nuclides of lanthanide elements (rare earths). These nuclides appear in the effluents of nuclear power plants from the Great Lakes.

Silver, in the presence of chloride (the main anionic constituent of estuaries and oceans) forms silver chloride, a compound with such a low water solubility that it is a basis for the quantitative analysis of silver. To reverse the solubility requires a large quantity of either ammonia or cyanide ion, such levels in environment being toxic in their own right. Because of nitrogen limitations of marine and estuarine environments, ammonia would not be present in these environments unless a specific pollutant source were present or an unusual algal species dominated plankton production. In lakes and rivers, however, where chloride is low and nitrogen is rarely limited, the presence of silver nuclides in soluble ionic form is expected. Only soluble silver is subject to biouptake, and biouptake factors for silver in fresh water systems are as high as 100,000. However, factors for silver do not exist for river biota, and thus the marine factors are used.

Rare earth elements have unusual biological uptake. Freshwater organisms can often selectively accumulate these elements and, except for yttrium, cerium, lanthanum and, in a few instances europium, usually only the even atomic numbered elements accumulate in freshwater biota. Thus it is not correct to assume that all lanthanides accumulate and to use the marine factors which rarely discriminate among lanthanides, but rather use cerium and lanthanum as surrogates for all the elements in this group.

Nuclides of Concern

Based on its studies, the Task Force concludes the following.

14. There are isotopes which merit separate studies and further reporting because of use and discharge patterns; physical, chemical and biological properties; and the special monitoring needs of lakes as opposed to estuaries, oceans and rivers. These include ^{3}H, ^{14}C, ^{129}I, isotopes of plutonium and ^{226}Ra.

15. Other nuclides could be a potential concern in special situations: $^{99,99m}Tc$, ^{32}P, ^{51}Cr, $^{134,137}Cs$, $^{141,144}Ce$, $^{89,90}Sr$, $^{125,131}I$ and ^{60}Co.

The isotopes listed in conclusion 14 are those that have exceptionally long half lives, arise from both natural (cosmogenic and primordial) sources and some aspect of the nuclear fuel cycle, and present long term toxicological and ecological problems. Except for ^{14}C and ^{129}I, the isotopes are routinely monitored in the Great Lakes. The isotopes listed in conclusion 15 occur often in the discharges of sources other than nuclear power plants as well as in some cases in various components of the nuclear fuel cycle. Under conditions of large scale emission or abundance they merit special monitoring studies.

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GREAT LAKES WATER QUALITY AGREEMENT
Twenty-fifth Anniversary
1972–1997
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