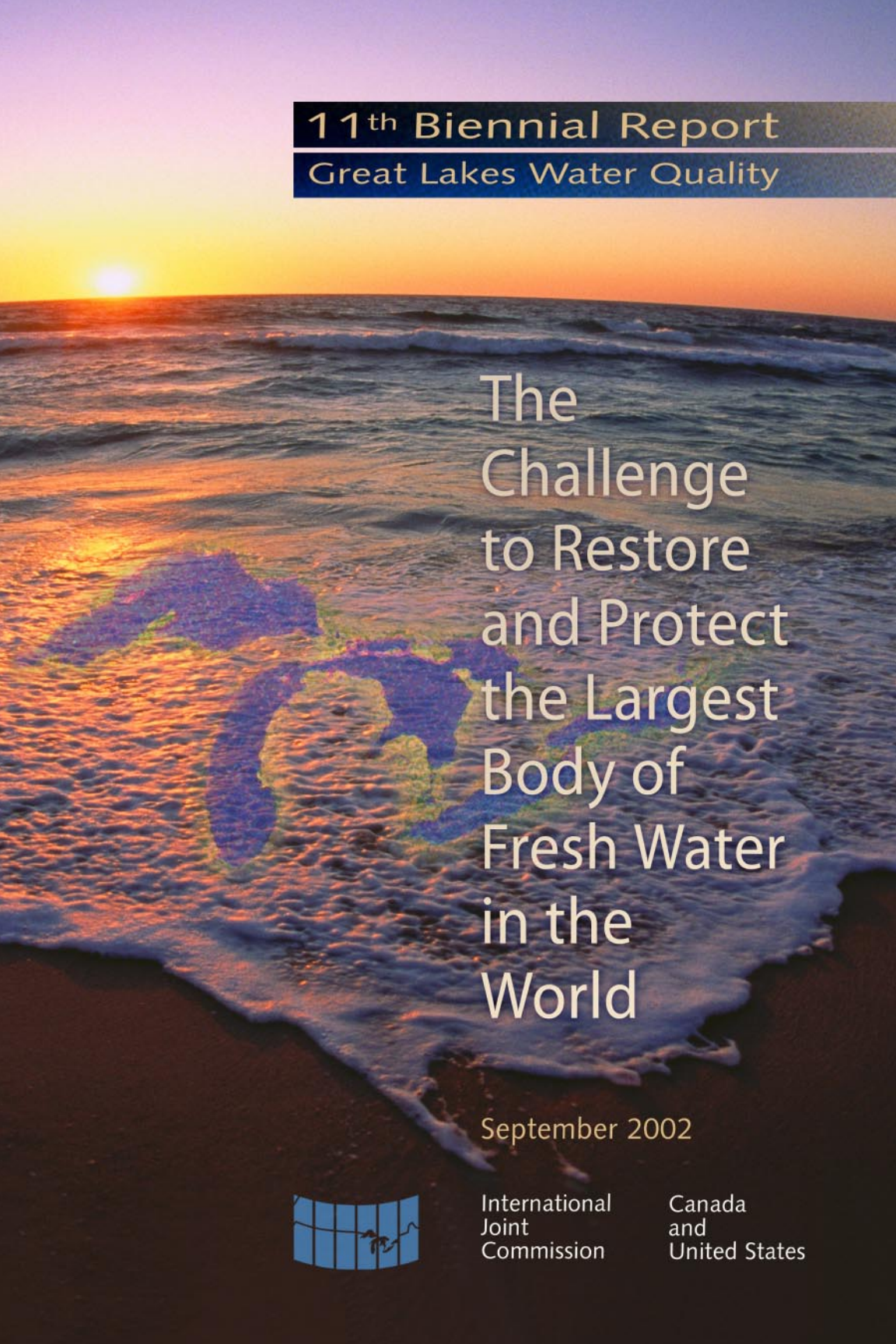
11th Biennial Report
Great Lakes Water Quality



The Challenge to Restore and Protect the Largest Body of Fresh Water in the World

September 2002

International Joint Commission

Canada and United States

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Eleventh Biennial Report

Prepared pursuant to the Great Lakes Water Quality Agreement of 1978 for submission to the Governments of the United States and Canada and the State and Provincial Governments of the Great Lakes Basin

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Eleventh Biennial Report on Great Lakes Water Quality

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The Great Lakes: Toward the Restoration of a Natural Wonder

None of the world's fresh water resources can rival the Great Lakes. Truly natural wonders of planet earth, their waters and ecosystems are precious to the lives of millions of people who live on and near their shores. They also are critical to the economies of both Canada and the United States. To protect and restore this unparalleled asset, Canada and the United States in 1972 created the Great Lakes Water Quality Agreement. Farsighted and futuristic, the Agreement provides an example to the world of how two countries can forge a commitment to restore the integrity of shared bodies of water. We have made progress on that commitment but, with regret, we declare again, as we did in 2000, that the power of the vision captured in the Agreement has generated neither enough action nor full recovery.

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. Yet that integrity continues to be compromised. Pollution endangers human health, and restricts the fish we can safely eat. Habitat continues to be destroyed or spoiled, and the rich diversity of our native fish and wildlife remains threatened. The International Joint Commission urges a balanced but more aggressive approach to restoring and protecting this magnificent asset.

In this report the Commission primarily addresses actions to restore chemical and biological integrity — sediment remediation and preventing the introduction of alien invasive species — as well as methods to assess progress in restoration. In its next biennial report, its *Twelfth Biennial Report*, the Commission will address in greater detail the Parties' progress in restoring the physical integrity of the waters of the Great Lakes ecosystem — including the challenges of intensified land use, the effects of dredging, wetlands losses and climate change.

Our knowledge of the effects of persistent toxic chemicals on ecosystem health, including humans, has increased enormously. A growing body of evidence shows that toxic pollutants in the Great Lakes basin pose serious risks to our children and to us. Solid studies substantiate harm to both mental and reproductive functions in fetuses and adults. On many previous occasions, the IJC has alerted the governments to the links between ecosystem health, including that of humans, and contamination of the Great Lakes. This *Eleventh Biennial Report* emphasizes these links. The United States and Canada must invest in measuring and controlling sources of toxic substances, including atmospheric inputs, contaminated groundwater, and urban and agricultural runoff. We strongly urge actions to stop the cycling of contaminants from sediment to people, fish, and wildlife, and to end known injury to ecosystem health.

This report also takes special note of the harm caused by alien species introduced to the Great Lakes basin ecosystems. Often brought to the Great Lakes in ballast tanks from ocean-going ships, booming populations of invaders such as the zebra mussel have already done very serious harm, at great economic cost, to parts of the Great Lakes ecosystem. Although some progress to restrict invasions has been made, the threat of unintentional introductions, such as Asian carp entering the Great Lakes, continues. Present regulations and programs do not prevent new and irreversible injury posed by alien invasive species.

The economic and health benefits of investments to restore and maintain the Great Lakes are compelling. Governments and citizens must measure and recognize these benefits and boldly take the necessary action. The majesty of these Great Lakes should inspire us all to respect and value what the early explorers once called “sweetwater seas.”

During the IJC's October 2001 Public Forum on Great Lakes - St. Lawrence River Water Quality held in Montréal, Québec, the Parties (the governments of the United States and Canada) addressed the steps they were taking to ensure safety and security of the Great Lakes water resources and infrastructure.

The events of September 11, 2001, have increased the governments' focus on the fundamental security of the Great Lakes water resources from terrorist threats. The Commission recognizes that responsibility for the safety and security of Great Lakes water and water infrastructure systems rests primarily with the governments of the United States and Canada. However, within the scope of its responsibilities, the Commission is prepared to assist the governments in protecting the Great Lakes water resources. The binational arrangements that exist under the Boundary Waters Treaty and the Great Lakes Water Quality Agreement serve as models of cooperation that could inform future binational actions to address security-related issues.

Priority Challenges and Recommendations

In this first section, the International Joint Commission focuses on three priority themes.

The first chapter focuses on the development and use of reliable ways to measure spacial and temporal trends in the levels and effects of pollutants, and on using those **indicators** to help convey both the current quality of the Great Lakes ecosystem and the trends in that quality.

The second chapter focuses on the **restoration of the chemical integrity** of damaged ecosystems in the Great Lakes basin, and particularly on preventing toxic chemicals from continuing to move from contaminated sediment into the wildlife and fish in the ecosystem and, all too often, into human tissues. The chapter points to an urgent need for programs to remediate contaminated sediment, an urgency heightened by the growing evidence of harm from these contaminants to human health.

The third chapter focuses on **alien invasive species**. These species can significantly and irreversibly damage the biological integrity of the Great Lakes, while imposing large fiscal burdens on those who must respond to their damaging effects.

Chapter 1

The State of the Great Lakes

The Great Lakes are a good source of treatable drinking water, but the public cannot always safely swim at all Great Lakes beaches or safely eat many of the fish from the Great Lakes. Although it is vitally important for policy makers and the public to be able to track changes in such facets of environmental quality, finding ways to report on them in a coherent and understandable manner has been difficult. In this chapter, the Commission offers its first overview of how specific "indicators" in the environment can be used as signals to inform and guide policy and progress toward the restoration of the Great Lakes.

Despite the considerable accomplishments of the State of the Lakes Ecosystem Conference (SOLEC), the current level of investment in indicators, particularly for the related monitoring, must be increased to support indicator development, measurement and reporting.

Introduction

Indicators can be thought of as pieces of evidence that provide information on matters of broader concern. A legendary environmental indicator was "the canary in the coal mine." Miners, or so the story goes, would bring a caged canary into a coal mine. If the canary stopped singing, and in fact had perished, it would serve as an early warning that harmful gases were building toward a level unsafe for miners.

Technically, an indicator can be defined as a value that reflects the condition of an environmental function or service that extends beyond the measurement itself. Consistent use of indicators over time provides the means to assess progress toward an objective.[1] An ideal indicator of environmental quality in the Great Lakes region would show whether the parameter being measured is improving or deteriorating over time (temporal trends) and whether there are differences between geographic areas or entire lake basins (spatial trends). When an established target or end point for an indicator is defined, the indicator can also show how close we are to achieving the goal and the broader set of conditions it reflects. For example, measurements of a given contaminant – say, mercury – in the tissues of a species of fish could be used to establish whether levels of that contaminant were increasing, decreasing or stable. (Indicators need not be living things. The condition of an abiotic, or non-living component of the environment, such as water quality, can also serve as an indicator.)

A good indicator is more than a measurement of one factor. Taken together, a set of indicators can be used to better understand the complexity of the Great Lakes, help guide policies, programs and decision making, and inform the public of progress in restoring the ecosystem.

The International Joint Commission is responsible for evaluating progress in meeting the objectives of the Great Lakes Water Quality Agreement. The Parties to the Agreement (governments of the United States and Canada) must also report on their progress in meeting the objectives of the Agreement. Reporting on a set of indicators that meets the Parties' needs while satisfying the Commission's requirements avoids duplication of reporting. It can also foster better collaboration between the Commission and the Parties. The Parties use the indicator framework of the State of the Lakes Ecosystem Conference (SOLEC) as an important mechanism to report progress on environmental quality.

Desired Outcomes

In 1996, the Commission's Indicators for Evaluation Task Force developed a framework of nine desired outcomes to evaluate the Parties' progress under the Agreement. These outcomes were derived in part from the beneficial uses listed in Annex 2 of the Agreement. The Indicators Implementation Task Force subsequently examined the feasibility of using indicators to monitor progress, focusing on three desired outcomes: Drinkability, Fishability and Swimmability.

In its *Tenth Biennial Report*, the Commission recommended to the Parties that they report on these three desired outcomes at the SOLEC 2000 meeting. The Commission was pleased to see that such a report was made at that 2000 meeting and commends the Parties for their responsiveness. The approach used by the SOLEC organizers is virtually the same as that recommended by the Indicators Implementation Task Force in terms of indicator definition and supporting measurements. These three desired outcomes particularly interest the public because they correspond to their most direct use of the lakes.

Indicators of ecosystem quality were assessed on a five-grade scale ranging from "good", "mixed improving", "mixed", "mixed deteriorating" and "poor". The assessments were based on the SOLEC authors' best professional judgement.[2]

Desired Outcome: Drinkability

Definition:

"Treated drinking water is safe for human consumption; human activities do not result in application of consumption restrictions."[3]

SOLEC Assessment

SOLEC's overall subjective assessment of Drinkability of waters in the Great Lakes ecosystem is "Good", the highest rating under the SOLEC scale. This assessment is described in the SOLEC report as, "The state of the ecosystem component is presently meeting ecosystem objectives or otherwise is in acceptable condition."

Basis for SOLEC Assessment

Data were collected from 22 cities that obtain their drinking water from Great Lakes surface water.[4] SOLEC presented summary results on five key factors: turbidity, organic matter, pathogens, chemical contaminants, and taste and odor, which are the stated measurements for this indicator.[5]

Commission Assessment

The Commission concurs with the subjective assessment of "Good" for the surface water of the Great Lakes as a source of treatable drinking water. It also recognizes the heightened concern regarding the safety of drinking water from all sources following tragic events arising from outbreaks of cryptosporidium and *E.coli*.[6] In this regard, the Commission is pleased that the SOLEC organizers are expanding data collection to include cities that depend on groundwater and tributaries as sources for drinking water.

Indicator Challenges

As an indicator, the condition of raw water going into a treatment plant reflects the local water conditions as well as the overall state of the Great Lakes. Raw water quality also may influence the cost and extent of treatment required in order to meet drinking water standards.

The challenge of applying indicators to the desired outcome of Drinkability is to develop a uniform reporting format in each country and undertake quantitative assessments of the information gathered. This situation is improving as more water treatment plants report results based on standard protocols and implement electronic data storage. Considerable effort will be required to report on temporal and spatial trends of the quality of the raw water.

The above SOLEC indicator focused on surface water. The public is interested in the quality of their tap water. This can be adversely affected by the quality of the source water (surface or ground water), the quality of the treatment process and the quality of the distribution systems, which in some communities are aging.

Desired Outcome: Fishability (fish that are safe to eat)

Definition:

"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 inputs of persistent toxic substances."[7]

SOLEC Assessment

SOLEC's overall subjective assessment of its indicator Chemical Contaminants in Edible Fish Tissue is "Mixed, Improving." This assessment is described in the SOLEC report as, "The ecosystem component displays both good and degraded features, but overall, conditions are improving toward an acceptable state."[8]

Basis for SOLEC Assessment

SOLEC reported on the results of a study that applied a uniform set of health standards to historical data on polychlorinated biphenyls (PCBs) in coho salmon in the Great Lakes.[9] The results show a slight decline in PCBs over time. Because of the risks they present and their persistence, PCBs are a frequent basis for health-based fish consumption advisories in the Great Lakes basin, and coho salmon is a popular sport fish.

The indicator for the desired outcome of Fishability is based on the concentration of persistent toxic substances that bioaccumulate in the food chain and can harm the health of humans who eat contaminated fish. Under SOLEC, this is measured by using fish contaminant data and a standardized fish advisory protocol. The Indicators Implementation Task Force concluded that indicators for the desired outcome of Fishability could be measured using trends in the chemical contaminants PCBs, DDT and mercury in selected species of fish, such as walleye, lake trout, coho salmon, smelt and alewife.[10] The Task Force also concluded that trends could be measured by the number of added, altered or lifted advisories where changes in advisories reflected changes in fish tissue concentrations, although not in cases where changes were made based on contaminant concentrations at which advisories were issued.

Commission Assessment

There continue to be restrictions on consumption of sport fish from the Great Lakes, and the desired outcome of Fishability has not been achieved for sport or subsistence fishers. All eight Great Lakes states and the province of Ontario continue to have fish consumption advisories. The analysis of PCBs in coho salmon using a uniform advisory is a good initial effort that provides information over both space and time. However, as recognized by the Parties, a single contaminant in a single species of fish is not sufficient for a thorough assessment of this desired outcome.

The Indicators Implementation Task Force report states that trends detected in fish contaminants could be corroborated by long-term trends of contaminants in fish-eating wildlife species, such as otters, snapping turtles and bald eagles as well as herring gull eggs. Bald eagles had PCB levels that were stable or declining in the last decade, but no trends are apparent for the entire Great Lakes.[11] Real declines in the levels of PCBs over the last 20 years are evident from studies of Great Lakes biota, including herring gull eggs, lake trout, coho salmon and bald eagles.

Commission-sponsored studies using several data sets for PCBs in herring gull eggs, and a data set for PCBs in coho salmon, show continuing decline in contaminant levels, but at dramatically slower rates than was observed in the period immediately following controls on manufacturing and point sources (1978-1980), and the rapid declines for the period of 1983-1989. The presence of a plateau effect is possible but unknown. Recent trends for PCB levels in lake trout also show a weak or very slow decline, which also could indicate a plateau, but there is no solid statistical evidence of such. The recent trends for PCBs in bald eagles are unclear because of huge data scatter, but only some pollutants, notably DDE and oxychlorodane show continuing declines in the bald eagle in all Great Lakes locations.[12]

Indicator Challenges

The eight Great Lake states and the province of Ontario have jurisdiction over sampling, measurement and analytical protocols and issue their own advisories. Individually, each jurisdiction has compiled a great deal of information on fish consumption advisories in the Great Lakes.

However, this information is not readily comparable or compatible for analysis.

Using changes in fish consumption advisories as a measure for this indicator would be effective if there were a uniform protocol for advisories in all jurisdictions and the rationale behind any changes to the advisories were clearly stated when issued. Given the number of jurisdictions involved, devising such a uniform advisory is not an easy task.

As outlined later in this *Eleventh Biennial Report*, studies show injury to human health. This is particularly so in fetuses and young children, and at lower levels of exposure to contaminants in fish than had previously been encountered. Exposure varies by type of fish, the parts of fish consumed and frequency of consumption. Without major new initiatives to reduce the sources of contaminants and ongoing human exposure, the desired outcome of Fishability will not likely be achieved in the foreseeable future.

Desired Outcome: Swimmability

Definition:

"No public bathing beaches closed as a result of human activities or conversely, all beaches are open and available for public swimming."[13]

SOLEC Assessment

SOLEC's overall subjective assessment of its indicator *E.coli* and Fecal Coliform in Recreational Waters is "Mixed." This assessment is described in the SOLEC report as, "The state of the ecosystem component has some features that are in good condition and some features that are degraded, perhaps differing between lake basins."[14]

Basis for SOLEC Assessment

The Indicators Implementation Task Force and SOLEC proponents concur that this indicator can be based on measurements of *E.coli* levels in water

and on the number of beaches closed.[15] The SOLEC report presented data for 1998 and 1999 beach closings in the U.S. and for 1998 beach closings in Canada. Additional data were presented at the SOLEC 2000 conference on the weekly *E.coli* readings at numerous Chicago beaches during the summer of 2000 and eastern Toronto beaches during the summer of 1999.

Commission Assessment

The Commission finds that it is not always safe to swim at certain locations in the Great Lakes and there is a limited ability to define progress.

Indicator Challenges

Beaches are sampled by local jurisdictions. The challenge is to ensure uniformity of sampling and reporting methods.

The U.S. beach survey data are compiled in a series for 1981 to 1994, and can be found online at www.epa.gov/glnpo/beach. Data also are available up to the year 2000, with gaps for 1995 and 1997. Currently, although data for Canadian Great Lakes beach closings exist, they are not centralized nor

made available basin-wide, and therefore, do not enable an overall understanding of the status in the Great Lakes. Efforts are now underway to establish a Canadian data compilation system that could be updated directly by local public health officials. To meaningfully use this indicator, the

jurisdictions involved need to follow a standard testing protocol and employ a statistically valid sample of beaches so the overall trend for the desired outcome of Swimmability can be assessed.

The SOLEC Process

The Commission's analysis of the three desired outcomes provides some insights into the Parties' overall indicator-based process. The Commission recognizes that the Parties, through the SOLEC process, continue to work on the development of new indicators. While the SOLEC 2001 report discussed 33 of the 80 indicators it has selected, many of those indicators were supported by very limited data, thereby reducing their utility. Despite this shortcoming, the SOLEC organizers are working to expand the list of indicators for the SOLEC 2002 conference with a focus on biological integrity. They are also emphasizing the development of indicators to measure society's response to environmental pressures, such as participation in recycling programs or reducing vehicle usage. The Commission applauds these initiatives but cautions that an expanded set of indicators will only be useful if supporting data and information are available. A balance must be struck between the resources to expand the number of indicators and the effort required to adequately monitor and compile information on those indicators already being used. Fishability, Swimmability and Drinkability should receive the highest priority. Monitoring is fundamental to the success of the indicator development and reporting process.

The SOLEC organizers are considering the development of indices that would combine related information to better communicate aspects of the state of the lakes. The smog index and the UV index, often reported in newspapers and in media weather forecasts, are examples of how this kind of tool can be used. However, the process of combining information to create overall indices results in the loss of detail. To ensure that detailed information is still accessible to the Commission and others, the Parties need to provide access to the data that support the indices. With today's technology, a database management system with improved inter-jurisdictional compatibility could go a long way toward providing access to such data.

In Canada there is a proposal under consideration to create a Canadian Information System for the Environment, which would be a coordinated,

cooperative network or "distributed system."[16] It would include all levels of government and numerous private sector and academic organizations. In a parallel initiative, the National Round Table on the Environment and the Economy, in cooperation with Statistics Canada, is creating and testing a set of sustainable development indicators. Linking these initiatives to the Parties' indicators work would benefit the SOLEC process as would the creation of linkages between databases in Canada and the U.S. for Great Lakes data.

The governments recognize that more effective and more efficient coordination of monitoring efforts among the various jurisdictions and agencies could be achieved. A dialogue about the development of a basin-wide monitoring inventory has begun in earnest. The purpose of this dialogue is to create the incentives to coordinate monitoring programs and to discuss ways of improving binational arrangements.

SOLEC organizers do not maintain original data, or copies of underlying supporting data. The data reside with the cooperating agency or organization. The indicator reports are prepared by the experts in the subject matter who have access to the underlying data. SOLEC organizers are encouraged to further investigate more satisfactory solutions to providing the underlying data to secondary users, including the public. We cannot overstate the enormous task of organizing a broad diversity of data and information from an array of organizations into a system that is accessible to and usable by a variety of audiences. Efforts must be made to provide adequate funds and staff for this critical activity.

Conclusion

The Parties responded quickly to the Commission's request to report on the three desired outcomes of Drinkability, Fishability and Swimmability. They brought together the available information on these indicators and reported their findings at SOLEC 2000. The Commission continues to be encouraged by the work of the Parties through SOLEC, and by their ongoing efforts to develop a set of indicators that will help decision-making for the Great Lakes and record the progress being made. Expanding indicator development and reporting on additional desired outcomes will require reliable data

and accessible information. The Parties, however, are limited by the data available to them from monitoring programs, by the difficulty of compiling meaningful information from disparate data sets and the need to adequately fund action on these three core indicators. The Parties' must increase support for the indicator process so that investments in restoration and protection can be better focused and progress toward restoration may be more completely and clearly conveyed to the public.

Recommendations

1. **Develop reliable data and accessible information to support indicators for the three desired outcomes of Drinkability, Swimmability and Fishability (fish that are safe to eat). This action should have priority status in the indicator process.**

2. **Expand indicator development and reporting on additional desired outcomes only where resources are sufficient to access scientifically valid and reliable data.**

3. **Improve public information and decision-making by:**
   - **increasing funding, technology and staff for monitoring, surveillance and information management to support the SOLEC indicator reporting**
   - **making the findings from indicators and their supporting databases generally available to decision-makers and the public, and**
   - **coordinating the databases in both Canada and the U.S. and linking significant Great Lakes databases.**

Chapter 2

Toward Chemical Integrity: The Challenge of Contaminated Sediment and Human Health Impacts

The 1987 Protocol to the Great Lakes Water Quality Agreement formalized the concept of Remedial Action Plans for restoring beneficial uses in Areas of Concern. More than a decade of compelling research documents subtle but serious injuries to the health of basin residents from exposure to persistent toxic substances. Yet Great Lakes ecosystem restoration continues to be delayed and public health continues to be injured.

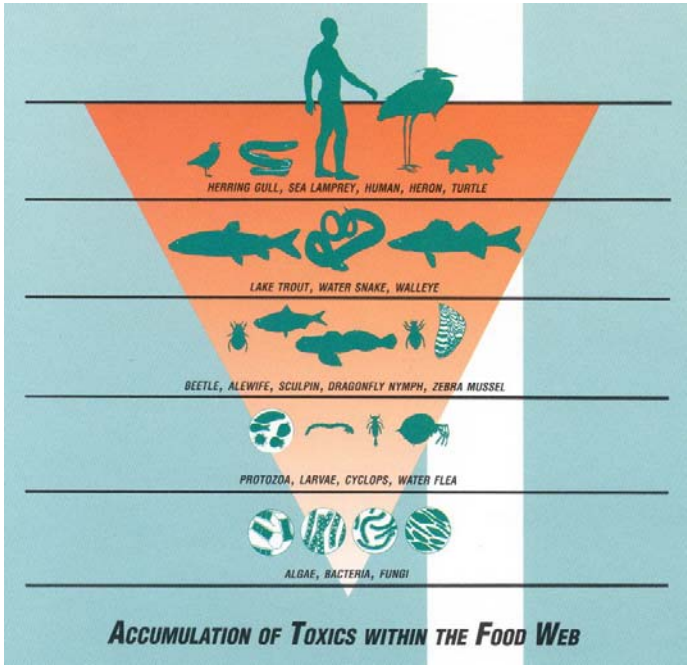
Introduction

For people in the region, the Great Lakes have long been an abundant source of food, in the form of fish. In 1990, the International Joint Commission concluded there was a risk of injury from persistent toxic pollutants that had found their way through the ecosystem into the tissues of fish. Based on a growing volume of research, the Commission expressed particular concern about the effects of these substances on children who had been exposed in the womb, and as infants, to residues of toxic pollutants.

"**When available data on fish, birds, reptiles and small mammals are considered along with this human research, the Commission must conclude that there is a threat to the health of our children emanating from our exposure to persistent toxic substances, even at very low ambient levels** ... The mounting evidence cannot be denied. Governments must emphasize development and implementation of a comprehensive, binational program to lessen the use of, and human exposure to, persistent

toxic substances found in the Great Lakes environment. These chemicals appear to be causing serious and fundamental physiological and other impacts on animal populations in the Great Lakes basin, and undoubtedly elsewhere. The dangers posed to the ecosystem, including humans, by the continuing use and release of persistent toxic contaminants are severe."[1]

The Commission's 1990 conclusion, based on the earliest findings of harm to the health of children of mothers consuming large quantities of Lake Michigan fish, underscored the fact that scientific studies of the effects of persistent toxic substances on wildlife could predict effects on humans. Those studies had accumulated over the course of 30 years, and consistently showed that exposure to toxic substances in an ecosystem's food chain likely leads to adverse health effects in fish, reptiles, birds and mammals.



Studies continue. Today, a convincing body of scientific research clearly links human exposure to toxic substances in the Great Lakes to serious injury to health. These investigations include both epidemiological and experimental research studies, undertaken by Canada's former Great Lakes Health Effects Program and, in the U.S., by the Agency for Toxic Substances and Disease Registry.

While human exposure to persistent toxic substances in the aquatic environment is an obvious concern, some preliminary data now suggest that simply living near contaminated sites and/or in the geographic boundaries of an Area of Concern may also result in increased rates of illness and mortality beyond those experienced by the general population elsewhere in that state or province.[2] More study clearly is required before this possibility can be confirmed. However, the Commission is concerned about this broader exposure and is engaged in cooperative efforts with its boards, the Agency for Toxic Substances and Disease Registry, and Health Canada to further its understanding and will report with more certainty in the future.

Systemic Health Effects in At-risk Populations Exposed to Polychlorinated Biphenyls[3]

Vulnerable Populations	Health Effects		Neuro-logical	Endocrine	Immune
	Reproductive	Developmental			
Reproductive Age Females	Mendola et al. 1997: Buck et al. 2000	Not Applicable	Not Found	Gerhard et al. 1998; Koopman-Esseboom et al. 1994	Not Found
Reproductive Age Males	Courval et al. 1999	Not Applicable	Fischbein et al. 1979	Persky et al. (In press)	Not Found
Fetus/ Infant/ Child	Not Applicable	Fein et al. 1984; Taylor et al. 1989; Jacobson et al. 1985,1990,1996; Patandin et al. 1998	Jacobson et al. 1984, 1985, 1990, 1996; Rogan et al.1986; Lonky et al. 1996; Stewart et al. 2000	Koopman-Esseboom et al. 1994; Osius et al. 1999	Smith 1984; Weisglas-Kuperus et al. 1995, Dewailly et al. 1993; 2000
Native American	Not Found	Not Found	Dellinger et al. 1997	Dellinger et al. 1997; Tarvis et al. 1997	Dewailly et al. 1993, 2000
Sport Anglers	Mendola et al. 1997: Courval et al. 1997	Not Applicable	Schantz et al. 2001	Persky et al. (In press)	Not Found

Systemic Health Effects to Animals and Humans from Exposure to Persistent Toxic Substances

Persistent Toxic Substance	Reproductive		Developmental		Systemic Health Effects				Immune	
					Neurological		Endocrine			
	ANIMAL	HUMAN	ANIMAL	HUMAN	ANIMAL	HUMAN	ANIMAL	HUMAN	ANIMAL	HUMAN
Dioxins (2,3,7,8-TCDD)	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Mercury	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Poly-chlorinated Biphenyl	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔

Other relevant findings from this decade of research include:

- **numerous health effects observed in animals have been reported in humans**
- **concentrations of toxic polychlorinated biphenyls (PCBs), in the waters of all Great Lakes are approximately 100 times higher than the Great Lakes Initiative criteria for the protection of human health.**[4]
- **the most significant known human exposure to toxins from the lakes comes from consuming contaminated Great Lakes fish**
- **the people at higher risk include sport and subsistence fish anglers, some ethnic populations, pregnant women, fetuses, nursing infants, young children, the elderly and the urban poor**[5]
- **there are effects on the reproductive function, such as conception rates and changes in the menstrual cycle**

Cleaning herring, Isle Royale, Lake Superior

- **maternal consumption of contaminated fish leads to exposure of the developing embryo and fetus and results in irreversible neuro-behavioral and developmental deficits after birth; consuming contaminated fish also affects neurological functioning**
- **over five million people eat Great Lakes sport fish.[6] Among these are the high risk populations noted above.**

In addition to injury to health, there are also economic and social impacts. The total economic cost to society for dealing with the health effects from exposure to contaminants has only begun to be estimated. At present, almost all of those costs are borne by individuals, families and non-federal institutions. Other costs include declining property values, and impacts on the tourism and recreation industries. Because navigational dredging can stir up or re-suspend contaminated sediment, economic harm can result in the form of added costs to, or restrictions on, the shipping industry. The inability to accurately estimate such costs under-represents the true harm to society from the continuing presence of contaminants and undermines the needed sense of urgency for action.

In short, we now know that injury is occurring. We believe that agencies' political leaders and managers are obligated to act decisively to protect their citizens from further injury.

Policy Response

The Great Lakes Water Quality Agreement has two purposes, *"to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem."* Some restoration has been achieved by maintaining common water quality standards. By the late 1960s, for example, Lake Erie had become known, infamously, as a "dying" lake. Choked with algae, and with large and growing deoxygenated zones, the lake was rapidly moving through an aging process called eutrophication caused by an overload of nutrients. In the early 1980s, regulations in both Canada and the U.S. to control the nutrient phosphorus successfully restored the lake from the worst effects of eutrophication. Vigilance is essential, however, since phosphorous concentrations in Lake Erie are again on the rise (See section 3, Further Matters of Importance).

In the case of persistent toxic substances, product bans and source controls led to dramatic declines of such substances as PCBs and DDT in wildlife from the high levels of the early 1970s. Yet problems remain because a legacy of contaminants continue to enter food chains. Although contaminants enter the lakes from leaking hazardous waste sites, and also from the atmosphere, polluted sediment is the largest source of contaminants to the Great Lakes food chain.[7] This contaminated sediment amounts to an ongoing source of pollution, steadily releasing residues of pollutants that might have been discharged into the ecosystem years or decades ago. Cleaning up the contaminated sediment remains a major challenge.

Experience shows that progress can be made in remediating contaminated sediment. Notable examples of successful remediation include the Niagara River, the St. Lawrence River at Massena, New York, and Waukegan Harbor in Illinois. Other progress has been achieved in the U.S. under the Superfund Program. In Canada, Thunder Bay serves as an example. These successes demonstrate that knowledge and experience are available in the region to successfully address this problem.

Yet failures to address the magnitude of the problem and to allocate adequate resources blunt progress. The Commission continues to find that, after more than 15 years of planning and incremental activity, restoring the Great Lakes through remedial actions remains elusive and difficult.[8] Time frames of 10 to 20 years from problem identification to remediation of contaminated sediment are not unusual. Clearly, much more needs to be done, and much more quickly.

The Great Lakes Water Quality Agreement of the U.S. and Canada identifies severely degraded geographic areas within the Great Lakes basin. To date, 43 Areas of Concern (AOCs) have been identified. The Agreement envisioned that a Remedial Action Plan (RAP) would be developed for each of these problem areas, including considerable local public participation. Lessons resulting from more than a decade of experience with this work illustrate many difficulties in

developing and adopting a strategic approach to Great Lakes restoration. These difficulties include:

- **failure to link priority work to the need to prevent injury to human health**
- **lack of government accountability**
- **inadequate planning for many sites**
- **loss of focus on restoration of beneficial uses, particularly for those sites where there is no dedicated coordinator for RAP implementation and where community groups are expected by some agencies to lead RAP implementation**
- **lack of delisting targets identifying when beneficial uses will be recognized as restored**
- **limited tracking of the effectiveness of implementation actions in terms of removing beneficial use impairments**
- **inadequate funding for many sites that have completed plans**
- **not identifying responsible parties or requiring them to participate**
- **limited pre- and post-remediation monitoring to document environmental, human health and economic benefits**
- **lack of leadership for RAP implementation plans**
- **lack of a dedicated RAP Coordinator**
- **protracted planning efforts that diminish public participation in the decision-making process; and**
- **delays caused by lack of agreement on clean-up levels.**

Many of the issues discussed in this chapter were noted in recent reports by the Canadian Commissioner of the Environment and Sustainable Development and the U.S. General Accounting Office. These reports contain useful recommendations for more rapid implementation of programs called for under the Agreement.[9] The Commission will be issuing a report evaluating unmet challenges in the Areas of Concern in the fall of 2002.

Scale of the Restoration Challenge

Vast deposits of pollutants lie within contaminated sediment, threatening for decades to come the health of Great Lakes fish and wildlife and humans. Remediating contamination remains a major challenge requiring significant up-front investments.

Contaminated sediment often does not lie in stable, easily identified and relatively easy-to-cleanup "hot spots". Sediment containing contaminants are often poorly controlled, unstable systems containing large volumes of moderately contaminated material.[10] Contaminated sediment in Areas of Concern may be viewed as only a local problem. If they disperse, however, the contaminants can also affect the offshore regions and open waters of the Great Lakes, making remediation extremely difficult, and their toxic effects remain. Polluters responsible for the original contamination often no longer exist. Where polluters do exist, litigation often prolongs remediation. The Parties must take action more swiftly to prevent the inevitable and irreversible dispersal of contaminants.

Since existing programs have been insufficient for clean-up, governments must allocate adequate funds to clean up contaminated sediment and remove the threat to human health before sediment is too dispersed to remediate. In those cases where perpetrators can be found, some means must follow by which they pay for the problems they have caused. The Commission strongly recommends that the Parties develop strategies for prioritizing sites for remediation, and move forthrightly ahead.

To date, the magnitude of the contaminated sediment problem in Areas of Concern and its relationship to contamination of open lake waters remains poorly quantified. Sediment contaminated with PCBs and mercury is of particular concern.[11] Natural degradation of highly chlorinated PCBs is limited and occurs very slowly.[12]

Preliminary estimates of PCBs in the sediment of lakes Superior, Michigan and Ontario are 3,300 kg, 87,000 kg and 115,000 kg, respectively.[13] The Lake Michigan estimate does not include the quantities in Green Bay, which have been calculated separately at 68,000 kg. Large quantities of contaminated sediment at sites such as the Fox River and Lower Green Bay can also serve

as indirect sources of PCBs –molecules of PCBs can be transferred first to water, then into the air (volatilized) and back into the open lake by prevailing winds.[14] The relative significance of PCB loads contributed by the atmospheric pathway varies for each lake basin. Estimates for Lake Michigan indicate that 3,200 kg per year reach the lake through the air.[15]

Since signing the Great Lakes Water Quality Agreement, governments have taken action to curb chemical inputs, particularly from industrial point sources discharging directly to the lakes. The lakes responded, and several chemicals in fish and wildlife declined. Less aggressive action has been taken to cut atmospheric emissions, and for some lakes, the inputs of substances such as mercury and PCBs are dominated by atmospheric deposition. The amount associated with sediment, however, remains the singular largest pool requiring attention, to prevent further harm to humans, fish and wildlife. For example, in Lake Michigan the amount of PCB in sediment is two to three orders of magnitude greater than the annual inputs from air and tributaries, respectively.

Clam shell dredge operating at Michigan City, Indiana, on Lake Michigan

Sediment remediation remains a large-scale, high-cost problem requiring a strategic long-term solution. While the magnitude of the problem is greater in the United States than in Canada, using the most modest estimates, it would cost billions of dollars for thorough remediation.

Large-scale remediation efforts signal a commitment to protect the health of present and future generations and to restore the integrity of the Great Lakes. Reducing the body burdens of persistent toxic substances in fish populations will achieve the goal of protecting human health from this consumption pathway and will assist in the recovery of fish and wildlife populations. Based on positive restoration results in areas such as Gill Creek (a tributary of the Niagara River), Black River and Waukegan Harbor, remedial actions can be expected to stimulate improvements in ecosystem health in comparable Areas of Concern.

In Wisconsin, the Lower Fox River offers an example of the scale of the budgetary and management challenge being met at one Area of Concern. Achievement of a current goal to remove 5.5 million cubic meters of sediment, along with approximately 30,000 kilograms of PCBs, within the planned time frame of five to seven years is an ambitious undertaking requiring removal at a rate of close to one million cubic meters per year.[16] This may not be the end of the process.

Across the Areas of Concern lie an estimated 95 million cubic meters of material thought to be chemically contaminated at some level. Even if further biological testing shows that only a small percentage of this total must be removed, cleanup actions would still require a very large long-term commitment of time and resources. While source control and natural attenuation (or natural recovery) may be helpful in some situations, large-scale problems clearly require large-scale investments.

The Need for a Restoration Strategy

The Commission acknowledges that the Parties manage contaminated sediment within the domestic programs for each country, and not on a binational basis as recommended in the Commission's 2000 *Tenth Biennial Report*.[17] This management choice need not affect progress under the Agreement. The effectiveness of binational coordination relies upon the close level of cooperation that has been the hallmark of the relationship between the two countries since signing the Boundary Waters Treaty. However, a shared strategy and commitment to cleaning up this ecosystem becomes even more important when it depends on unilateral actions. For example, cleanup on one side of the international boundary may be less effective if the other side is not engaged in similar cleanup efforts and employing mutually acceptable time frames and standards.

The resources required to sustain cleanup activities and binational commitments are seldom sufficient when they are provided on an *ad hoc* basis, particularly when funding is based on established programs that serve other goals as well as contribute to progress under the Agreement. Because many national and regional priorities compete for scarce resources, a clearly stated government commitment to remediate contaminated sediment is critical if the agencies are to obtain sufficient funds to restore the Great Lakes.

The Commission is convinced that the Great Lakes region cannot hope to successfully receive support as a national priority without a publicly accepted, comprehensive plan for restoring the Great Lakes through remedial efforts, particularly sediment cleanup. The recently released U.S. Great Lakes Strategy and the newly signed Canada-Ontario Agreement could form the basis for the development of more effective strategies, and in particular, for building public and political support to sustain long-term restoration.[18]

The U.S. Great Lakes Strategy was developed cooperatively by the U.S. Policy Committee, a forum of senior-level representatives from Federal, State, and Tribal natural resource management agencies and environmental protection agencies. It is the culmination of a three-year effort, which included an extensive public comment process. The Strategy articulates a shared, long-range vision for the Great Lakes.

- **The Great Lakes basin is a healthy natural environment for wildlife and people.**
- **All Great Lakes beaches are open for swimming.**
- **All Great Lakes fish are safe to eat.**
- **The Great Lakes are protected as a safe source of drinking water.**

The U.S. Policy Committee will use the Strategy to guide protection and restoration activities over the next several years. The Commission commends the United States and the jurisdictions for arriving at a consensus on the long-range vision and specific goals, and will monitor the implementation of the Strategy. In particular, the Commission looks to the United States and the U.S. jurisdictions to find the resources to ensure Remedial Action Plan implementation is closely coordinated and directed to the restoration of beneficial uses.

With respect to sediment, the U.S. Great Lakes Strategy 2002 includes the following key objectives.

Accelerate the pace of contaminated sediment remediation, working to overcome barriers to progress identified at each site. Bring together complementary federal and state authorities, and/or government and private resources to address the contaminated sediment problem and its source, so that:

1. **Beginning in 2002, initiate three remedial action starts each year.**
2. **Beginning in 2004, complete three sediment remedial actions per year until all known sites in the basin are addressed.**
3. **Complete the cleanup of all known sites in the basin by 2025.**

The Commission also commends Canada and Ontario for achieving consensus on a vision for the Great Lakes under the new Canada Ontario Agreement Respecting the Great Lakes Basin Ecosystem (COA). The vision is to achieve a "healthy, prosperous and sustainable Great Lakes Basin Ecosystem for present and future generations." COA specifies results and commitments to achieve those results over the next five years. The Commission will monitor the implementation of the agreement and looks forward to reviewing the biennial reports on progress. The Commission particularly looks to Canada and Ontario to find the resources to ensure that Remedial Action

Plan implementation is closely coordinated and directed to the restoration of beneficial uses.

With respect to sediment, the Commission notes with interest that COA states that "Canada and Ontario will address the continuing sources of pollution to Areas of Concern by achieving ... management strategies for contaminated sediment."

The Commission is encouraged by the willingness of the Parties and jurisdictions of each country to reach a consensus on their respective program areas to restore and maintain the Great Lakes basin ecosystem. The Commission gives credit to the state of Michigan for the new investment of $25 million under the Clean Michigan Initiative for sediment remediation, and is encouraged by the pending U.S. Congress allocation of $50 million for sediment remediation. The Commission credits Ontario for its announcement of $50 million over five years as a contribution under the Canada Ontario Agreement and Canada for $30 million under the Sustainability Fund. The Commission looks forward to reports of progress on sediment remediation and the cleanup of Areas of Concern, both of which are priorities under U.S. Great Lakes Strategy and the Canada Ontario Agreement.

For both countries, and for our shared resource overall, it will be essential to set priorities for remediation and develop a strategic plan. Criteria need to be selected and applied to each Area of Concern to identify relative needs. Some relevant criteria related to sediment management include:

- **volume of contaminated sediment: an estimate of the amount of material exposing human, fish and wildlife populations to persistent toxic substances at levels causing injury and harm**
- **severity of contamination: concentrations of ecologically active contaminants in the sediment**
- **potential for sediment transport: whether the Area of Concern serves as a source of persistent toxic substances to the open lake waters, and**
- **potential to cause harm in the waters of the other country: the extent to which one side of the boundary waters is being polluted to the injury of health or property on the other.**

Additional criteria could be developed to create a framework for setting priorities. This framework could also improve the likelihood that all problem areas are eventually addressed, or further advanced with additional funding or support.

In the United States, funds have been authorized at the federal level for a variety of purposes that could be helpful to the cleanup of the Great Lakes. For example, funding for the control of sea lamprey has focused on the Great Lakes, but most programs, such as the Superfund program, have addressed issues on a national scale, with no directed funding for the Great Lakes.

In Canada, specific funding programs can be approved by cabinet and dedicated toward well defined priorities, such as the Great Lakes Sustainability Fund. The Commission is convinced that a more strategic, national approach should be initiated at the federal level in both the United States and Canada to authorize sufficient funds to permit an aggressive effort to clean up and restore the Areas of Concern in a reasonable time. This approach has been used in other specific regions of the United States. Most recently, Congress authorized $7.8 billion to carry out restoration of the Everglades in the state of Florida.

Without question, the restoration of the Great Lakes basin ecosystem is a matter of national and strategic importance for both countries. But restoration of water quality cannot occur as long as very large quantities of contaminated sediment present an ongoing source of exposure to humans in the Great Lakes. The Commission is convinced that the importance of restoring and maintaining the health of this vital resource is fundamental to our collective security in the 21st century and beyond. The Commission strongly supports a national commitment through specific legislation or specific funding programs to address remediation of Areas of Concern and to achieve the overall purpose of restoration as set out in the Agreement.

Annex 12 of the Agreement specifies the commitment to virtually eliminate the input of persistent toxic substances in order to protect human health and to ensure continued productivity of living aquatic resources and human use thereof. The goal of virtual elimination of persistent toxic substances cannot be achieved without control of all inputs, including those from contaminated sediment.

Conclusion

Contaminated sediment is the greatest source of persistent toxic substances to the waters of the Great Lakes basin, and represents a significant pathway of human exposure to these contaminants. At present, no single program in either country is sufficient to address the scope and cost of cleaning up contaminated sediment in the Areas of Concern. Also, there is no consistent binational approach to setting priorities. Existing plans and current funding levels are not adequate to restore beneficial uses within the Areas of Concern or to restore the chemical and biological integrity of the waters of the Great Lakes basin ecosystem. Decision-makers need to establish the case for restoration funding. Without adequate funding and increased efforts to develop successful strategies, any progress to restore the Great Lakes and to protect human health will continue at a slow incremental pace, much as it has over the past decade.

Recommendations

1. **Define explicitly the extent of sediment contamination and the goals for restoration so that remediation needs may be understood and publicly supported.**

2. **Set priorities and a schedule for contaminated sediment remediation based on the potential for benefits to ecosystem and human health.**

3. **Develop a long-term strategy for the remediation of contaminated sediment; ensure that it is adequately funded; and report on progress.**

4. **Provide dedicated U.S. and Canadian funding and programs focused on contaminated sediment remediation of Areas of Concern in the Great Lakes.**

5. **Strengthen leadership for Remedial Action Plan implementation with the focus on the restoration of beneficial uses.**

Chapter 3

Toward Biological Integrity: The Challenge of Alien Invasive Species

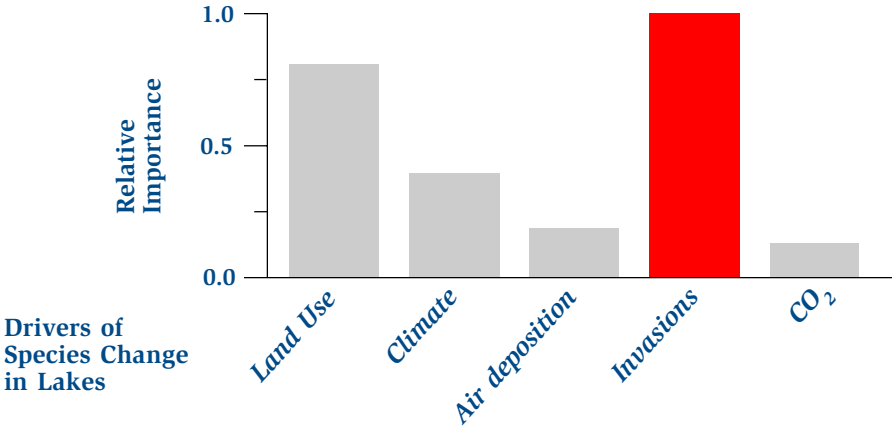
Despite more than a decade of national attention and regional action, the introduction and spread of aquatic alien invasive species continue to impair the biological integrity of the Great Lakes-St. Lawrence River basin ecosystem.

Immediate federal action to mandate improved ballast water management procedures can reduce but not eliminate the biological and economic threat to the Great Lakes-St. Lawrence River basin ecosystem from the further introduction and spread of alien invasive species.

Introduction: An Ecologically Damaging and Economically Costly Problem

Since the 1980s, the International Joint Commission has issued alerts about the threat of aquatic alien invasive species to the Great Lakes-St. Lawrence River basin ecosystem and economy.[1] Yet despite more than a decade of international attention and regional action, this "biological pollution" continues at both great ecological and economic cost.

Most citizens of Canada and the United States are probably familiar with the havoc some alien invasive species have wreaked. The chestnut blight and Dutch Elm disease, gypsy moths, Norway rats and kudzu, and, in the Great Lakes basin, purple loosestrife, sea lampreys and zebra mussels are well known examples of ecologically and economically harmful species



Causes of Biodiversity Change in the Great Lakes during the 21st Century

The introduction and spread of aquatic invasive species is expected to be one of the leading causes of biotic change in lake ecosystems during the 21st century. All of the Great Lakes are experiencing such impacts from zebra mussels, sea lamprey, round gobey, and the spiny waterflea. Sala et al., 2000.

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imported either accidentally or purposely from other continents to North America. In each of these cases, damage occurred because native species and ecosystems were not capable of resisting infection, infestation, predation or competition from the alien species. In some cases, damage has been extraordinarily severe. The chestnut blight, for instance, eventually wiped out virtually all American chestnut trees across nine million acres; sea lampreys devastated populations of lake trout and other fish species in the Great Lakes.[2]

Invasive Species

Examples of invasive species: sea lamprey, asian carp, zebra mussel, purple loosestrife.

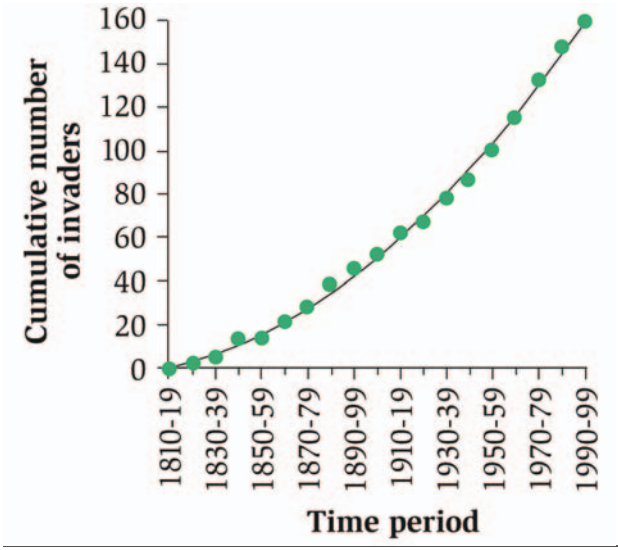
Researchers widely believe that the costs of biological pollution from alien invasive species are both massive and rising, with costs to native ecosystems, natural resources, fisheries and agriculture estimated in one study to reach $137 billion per year in the United States alone, including but not restricted to aquatic species.[3] In contrast, 1992's Hurricane Andrew, the single most expensive natural disaster in United States history, cost insurers only a small fraction of that amount, about $16 billion (or $20 billion in 2002 dollars).[4] This suggests the true costs of biological pollution in the U.S. alone equal multiple Hurricane Andrews every year.

In the Great Lakes, costs for treatment and control of zebra mussels alone reach several billion dollars annually.[5] The Great Lakes Fishery Commission reports that sea lamprey control, assessment and research cost $13.5 million in 2001.

The damage is at least as much environmental as economic. Since biological pollution's effects are often irreversible, any future introductions of alien invasive species could permanently harm the biological and ecological diversity of the Great Lakes, the world's largest surface freshwater ecosystem. Yet, despite some efforts to reduce the potential for future introductions of harmful alien species, the threat remains. This serious problem continues at least in part because individuals or businesses responsible for introducing alien invasive species have never borne any significant part of the often extremely high costs. The high costs instead have been transferred to government resource agencies and the taxpayers who support them, to private and public utilities, and to industrial and private users of natural resources.

Current rules and practices are not solving the problem

Today, the Great Lakes - St. Lawrence River basin ecosystem is home to more than 160 non-indigenous fish, invertebrates, plants, parasites, algae and pathogens.[6] Additionally, many introduced species have likely gone unnoticed.[7] The number of recorded introductions of alien invasive species increased throughout the 20th century, from 40 in the first half to 76 during the latter half. And despite increasing awareness of the risks, the 1990s saw no discernable improvement. In the 1990s, 15 alien species found their way into the ecosystem, a number of introductions essentially unchanged from the 1980s (15), the 1970s (17), and the 1960s (15).[8]



Great Lakes Invasions

The number of recorded introductions of alien invasive species from all sources continued to increase throught the 20th century. Riccardi 2001.

Nonindigenous Animals Established in the Great Lakes Drainage Basin Since the mid-1980s

Common Name	Year of Discovery	Endemic Region	Mode of Transfer	Probable Donor Region
Ruffe	1986	Ponto-Caspian	Ballast water	Danube River
Zebra mussel	1988	Ponto-Caspian	Ballast water	Baltic Sea
Quagga mussel	1989	Ponto-Caspian	Ballast water	Black Sea
Rudd	1989	Eurasia	Bait release	---
Round goby	1990	Ponto-Caspian	Ballast water	Black Sea
Tubenose goby	1990	Ponto-Caspian	Ballast water	Black Sea
New Zealand mudsnail	1991	New Zealand	Ballast water	Baltic Sea
Blueback herring	1995	Atlantic N.A.	Canal	Atlantic N.A.
Echinogammarus (amphipod)	1994	Ponto-Caspian	Ballast water	Baltic Sea
Acineta noticrae (ciliate)	1997	Eurasia	Ballast water	Black Sea
Cercopagis (waterflea)	1998	Ponto-Caspian	Ballast water	Baltic Sea
Daphnia lumholtzi	1999	Africa, Asia, Aust	Boat?	Ohio Reservoirs
Schizopera borutzkyi	1999	Ponto-Caspian	Ballast water	Danube River
Heteropsyllus nr. nunni	1999	Atlantic N.A.	?	Atlantic N.A.

Ricciardi and MacIsaac 2000.

A number of sources, or vectors, can transmit alien invasive species into the ecosystem including aquaculture, canals and diversions, baitfish disposal, intentional introductions, recreational boating, and ship fouling.[9] The most significant vector is ballast water – the water, entrained solids and sediment and, all too often, living species, taken in and discharged by ocean-going ships.[10] Some regulations and guidelines are now in place to attempt to control alien species introduction from ballast water exchange from ships moving into the Great Lakes through the St. Lawrence. Yet, as we achieve better control of ballast water, other vectors must be seriously addressed to stop the invasion of species such as the Asian carp.

Both the Canadian Auditor General's Office and the U.S. General Accounting Office will be releasing in the fall of 2002 their analysis of the governments' action to address the ongoing and destructive invasions of aliens species. In developing its findings, the Commission has worked closely with the two organizations.

Discharge of Ship Ballast Water

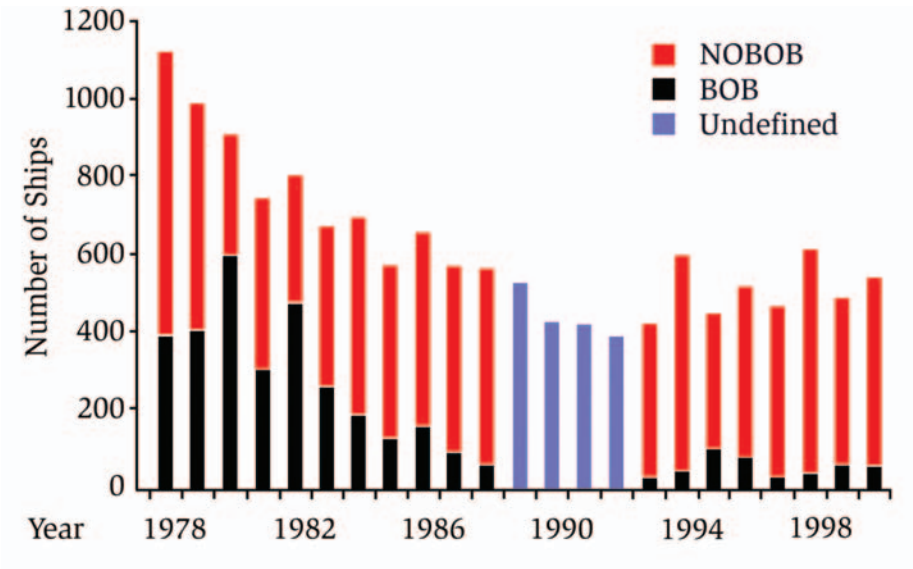
Ballast water is used to stabilize ships and maintain trim. Some transoceanic ships may carry up to 150 million liters of ballast water. Biota can be loaded with ballast water and discharged during routine ballast operations.

In 1993 the U.S. Coast Guard issued regulations requiring ships bound for the Great Lakes from beyond 200 miles off the U.S. coast to take steps to reduce risks from alien invasive species in ballast water. Ships now are required to exchange ballast water on the high seas, retain the water on board, discharge to an

approved reception facility, use an environmentally sound alternative (which could include such steps as treating the water), or under extraordinary conditions, exchange ballast water within an alternate area. Canada is currently drafting regulations.

Compliance with these regulations and guidelines has been nearly 100 percent.[11] Yet this high level of compliance alone is far from 100 percent effective. Research published in 1999 showed that a population of at least one alien invasive species, *Ceropagis pengoi* (a waterflea), found its way into Lake Ontario, apparently transferred by ballast water, even after the ballast water exchange regulations were put in place.

One major flaw in the process appears to be that ships declaring "no ballast on board" (NOBOBs) are exempt from the regulations, even though these ships can harbor alien invasive species in residues of previously discharged ballast water and therefore represent a serious, continuing biological pollution risk to the ecosystem.



Great Lakes Inbound Ships

NOBOB ships, currently exempt from regulations requiring ballast water exchange at sea, make up about 70 percent of the ships entering the Great Lakes system.
Colautti et al 2002.

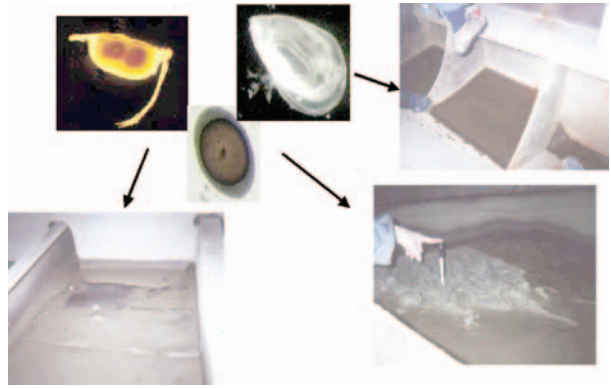
Ballast Water Exchange: A Complex Problem

Ballast water exchange may appear to be a simple matter of filling and emptying a tank, but it is much more complicated and can pose safety and structural risks for the ship and further risks to the crew. The volume of some large ballast tanks could fill a typical high school gymnasium, and the structural loads and effects of ballast water on the operation of a ship are by no means trivial. The weight of huge volumes of cargo, fuel and ballast water, in many different loading conditions must be considered when conducting ballast water exchange. The ship's structural integrity can be damaged if these weights are not properly balanced. Other safety concerns associated with ballasting include ship stability, maneuverability, forward visibility and potential hazards to the crew. In addition, the amount of time necessary to complete a ballast water exchange may be considerable for ocean-going ships – from 15 to 41 hours. Currently, two methods of exchange are recognized, a sequential method of filling and emptying tanks and a flow-through method. However, because the size and structure of ships vary widely, there is no universally acceptable solution. Class Societies, such as Lloyd's Register, Det Norske Veritas and the American Bureau of Shipping, have examined the effects of ballast water exchange on ship structures and maneuverability. These examinations clearly highlight the importance of a ship-specific analysis of structure and operating conditions to ensure that all risks are accounted for in a ballast management plan.

Prompted by International Maritime Organization (IMO) actions in 1997 to publish guidelines for ballast water management, Lloyd's Register commenced a two-part study to investigate the effects of ballast water exchange on ship structure and operations and to develop safe approaches for ballast water exchange.[12] *This study, carried out by naval architects under the direction of their principal surveyor, used 26 ships of various types, configurations and sizes. The study serves as an important reference or guide for IMO Administrations [the 162 member states of the IMO] who intend to develop ballast water management policies. Regarding the seriousness of the ballast water management issue, they concluded:*

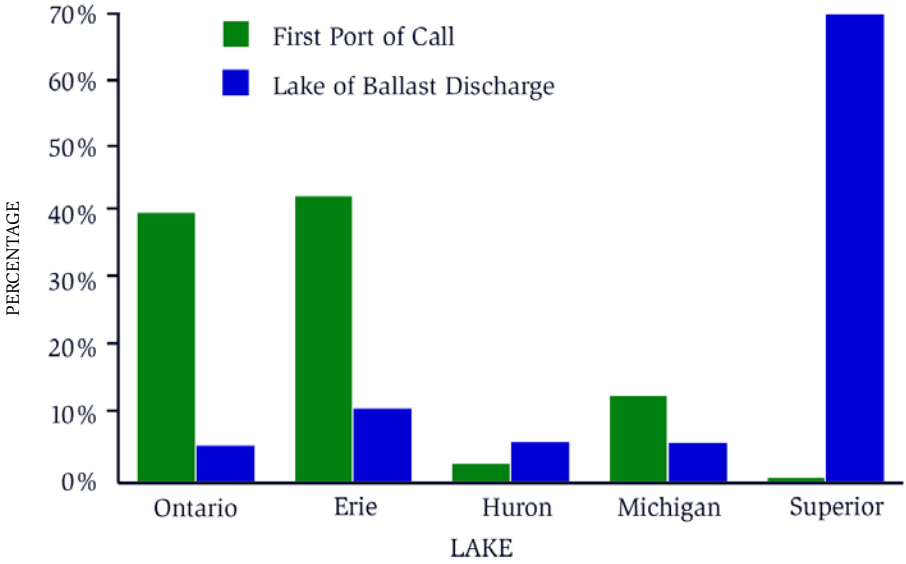
> *"The [IMO] Administrations' inability to multilaterally agree and define clearly the acceptable methods, procedures, and criteria for ballast water management indicates that the problem is not an easy one to solve. However, lack of decision making in the short-term could have long-term consequences for all parties concerned."*

According to U.S. Coast Guard data, NOBOBs represent over 70 percent (74 percent in 1999, 72.1 percent in 2000 and 68.5 percent in 2001) of incoming ships to the Great Lakes - St. Lawrence River system. These NOBOB ships are fully loaded with cargo and as a result their ballast tanks contain minimal (generally less than 3 percent) residual untreated ballast water and sediment. Yet even these small residues can be contaminated with alien invasive species. Both a Transport Canada study and a more recent study presented at the 11th International Conference on Aquatic Invasive Species in 2002 reported finding live organisms in virtually all ships that reported as NOBOB.[13] Clearly, current ballast water regulations are not sufficient to eliminate the risk these vessels pose.



Invasions via NOBOB Shipping

Transit of a NOBOB Steel Carrier *The yellow arrows indicate the path of a NOBOB ship on an inbound trip, showing points where the ship unloads steel and takes on Great Lakes water as ballast (stability). The blue arrow indicates the final inbound leg of the trip on the Great Lakes. The ship is now empty of cargo and fully loaded with Great Lakes ballast water. Taking on ballast water on the lower lakes provides an environment for cysts or eggs of invasive species remaining in residual ballast water and sediment to hatch.*



NOBOB Ships on the Great Lakes

The Great Lakes receive ballast water discharged from ships transiting the system. Fully loaded ships carrying only residual ballast water (NOBOBs) unload cargo and take on ballast water for stability and trim. When these ships take on new cargo, they discharge ballast water to attain stability. Lake Superior has increasingly become more important as the initial site of ballast water discharged to the lakes from ships transiting the system.

In addition to the U.S. regulations requiring ships bound for the Great Lakes to exchange ballast water in the open ocean, Canada and the U.S. also have voluntary guidelines designed to minimize the uptake and release of harmful aquatic organisms, pathogens, and sediment in ballast water.[14] The guidelines suggest precautionary practices to avoid the uptake of ballast water in areas near sewage outfalls, in areas with known outbreaks or infestations, near dredging operations and where tidal flushing is poor, and suggest avoiding shallow water, turbid water, and darkness, when benthic (bottom-dwelling) organisms may be up in the water column. The guidelines provide advice on the timely and routine cleaning of sediment from ballast tanks and include recommendations to avoid unnecessary discharge of ballast water, to retain or minimize release of improperly exchanged ballast and, where applicable, to discharge to appropriate reception facilities. Some guidelines also address anchor-chain washing and removal of hull fouling. The guidelines also recommend maintaining ship ballast water

management records and plans and providing training in ballast water and sediment management for ships' personnel.

Making such ballast water management practices mandatory for all ships capable of carrying ballast water, including NOBOBs, into the Great Lakes - St. Lawrence River basin could greatly reduce, though not eliminate, the threat of introduction of alien invasive species in the Great Lakes. Along these lines, agencies have made some progress. For example, the St. Lawrence Seaway Development Corporation (SLSDC) in the U.S. and the St. Lawrence Seaway Management Corporation (SLSMC) of Canada jointly administer the Seaway Regulations and Rules. The SLSDC, in agreement with the SLSMC, has amended its regulations to require compliance with Great Lakes shipping industry codes for ballast water management practices for a ship to gain permission to transit the seaway.[15] While this step is encouraging, the amendments appear to lack sufficient means to measure compliance and support enforcement. The SLSDC and SLSMC have indicated they will assess the effectiveness of this action after the 2002 seaway navigation season.

Improved mandatory ballast water management practices could use procedures approved by the Coast Guard, or a classification society authorized to act on its behalf, to ensure that the best practices are incorporated for each vessel's particular operational constraints. Owners and operators of ships could also be required to address other possible pathways for unintentional transfer of alien invasive species not connected to ballast systems, such as hull fouling, biofilms and anchor chains. And customers for shipping could be encouraged to contract with owners and operators of shipping lines that apply best management practices.

Substantial Gaps in Knowledge Remain

While the salinity of the ballast water is used to determine if it has been exchanged, there is no accepted standard to evaluate how effective current ballast water exchange operations actually are at reducing entrained or accumulated sediment, and its associated organisms. Because ballast tanks containing residual water and sediment have been found to harbor viable organisms,[16] a protocol (a wash out dye study) for testing the effectiveness of ballast water exchange would help ensure that alien

invasive species are not released when a ship mixes ballast water with local water and discharges it during routine operations. Also lacking are agreed-upon discharge standards for ballast water treatment, describing numerical targets for the percent of viable organisms removed, including an acceptable number, type or stage of development for a wide range of organisms. Such standards are necessary to assess the effectiveness of alternative treatment technologies (including biocides) or the effectiveness of any technical modifications for improved ballast water exchange (the installation of ejectors). These protocols and standards would lay the basic foundation for an effective ballast water management program. In support of developing these needed protocols and standards, the U.S. Aquatic Nuisance Species Task Force has recently approved research priorities recommended by its Ballast Water and Shipping Committee. Among its top priorities, the committee pointed to the need for public funding for research to develop methods to measure effectiveness of ballast water exchange procedures and to develop alternative technologies.

Research on developing and testing alternative technologies that could remove or kill alien invasive species, such as filtration, UV radiation, ozonation, biocides, heat and deoxygenation is lagging in the absence of standards and regulations.[17] Paradoxically, the new mandatory ballast exchange requirements in the United States may also be delaying important research into new technologies. To test these new technologies, mandatory ballast water exchange requirements sometimes must be waived, but the current review process for such requests tends to take a long time.

In addition, the lack of assurances that investments to develop, test and implement new technologies will be protected from future rule changes contributes to delays in innovation. Inadequate funding to meet critical research and development needs, identified by numerous national and regional level panels, agencies, task forces and commissions, has delayed progress. Finally, the long-term and slow-moving nature of federal legislation and rulemaking, combined with the need for binational and international harmonization, has further delayed progress in developing and implementing new technologies to prevent immediately the introduction and spread of alien invasive species.

Economic Incentives Could Help

The conspicuous lack of government incentives contributes to the problem. The European port management community has pointed the way toward innovative incentives with its "green ship" awards. These awards offer reduced port fees for ships exceeding established management practices for all ship wastes, emissions, and discharges, including ballast water. Requiring mandatory compliance with existing voluntary guidelines would establish a minimum acceptable level of performance, but a system of awards and economic incentives could encourage shippers to exceed the minimum levels of performance by continuously improving ballast management practices using innovative approaches. (Economic incentives also have been called for by other Great Lakes - St. Lawrence River organizations, such as the binational Great Lakes Panel on Aquatic Nuisance Species in its March 2001 policy statement on ballast water management.)

The future threat of liability for the damages from biological pollution may be a powerful economic incentive. Insurance companies have been slow to recognize that their exposure could be substantial. Because there are a limited number of carriers, customers, and ports of origin and destination, and because such biological analytic techniques such as DNA analysis are advancing rapidly, the prospect of assigning liabilities for damages is increasing. Marine insurers would be wise to consider incorporating the risk of entry of alien invasive species into their insurance policies and premiums.

For governments and regulatory agencies, economic incentives warrant further investigation as to feasibility and enforcement.

Progress from Governments

Governments are making some progress toward addressing the threat of alien invasive species with incremental advances in legislation, rulemaking and international agreements, such as those proposed for the year 2003 by the International Maritime Organization.[18] Recently, the U.S. Coast Guard published an advance notice of proposed rulemaking and a request for comment on the development of a ballast water treatment goal and interim

ballast water treatment standard.[19] Both of these actions are essential to determine whether alternative ballast water management methods are environmentally sound and at least as effective as ballast water exchange. However, such measures are focused on long-term actions and solutions and are developing at a frustratingly slow pace, despite repeated calls for immediate, urgent action from the Great Lakes community.[20]

Our Future Hangs in the Ballast

Photo of highway billboard developed by citizen group, Protect the Great Lakes, communicates its concerns about aquatic invasive species.

Reflecting the need to act now, some U.S. states have attempted to pass legislation concerning alien invasive species in the Great Lakes. Only the state of Michigan has successfully enacted such legislation. A private member's bill in Ontario was not passed. These local initiatives, including the recent action by the St. Lawrence Seaway Management and Development Corporations noted previously, illustrate the need for greater federal leadership, particularly between the U.S. and Canada, who control the entrance to the freshwater ecosystem of the Great Lakes.

Even though the state and provincial jurisdictions are taking or attempting to take unilateral action, the two nations need to take action because this is a matter of inter-state and international commerce and environmental quality.

Historically, Great Lakes - St. Lawrence River regional concerns have driven the creation of laws and programs to prevent the introduction and spread of biological pollution, including, in the U.S., the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, and the National Invasive Species Act (NISA) of 1996.[21]

The pending re-authorization of NISA is an opportunity to bolster action, strengthen research and improve binational harmonization. Therefore, it is not surprising that the region's sense of the biological and economic urgency of this problem should ***again*** drive the call for federal action to implement immediate steps to address the continuing threat of alien invasive species in the basin.

The *Tenth Biennial Report* recommended that a reference be given to the Commission to develop binational standards and the most appropriate methods for implementing those standards. Our reasons for requesting that reference persist. Both the Canadian and United States governments responded that progress was being made and that the technical aspects of the issue were best left to existing bodies such as the Ballast Water and Shipping Committee of the Aquatic Nuisance Species Task Force.

The Commission notes the position of the Parties but remains concerned that the pace of progress is much too slow while the risks to the lakes remain high. In recognition that the gateway to the freshwater ecosystem of the Great Lakes is a binational waterway, the coordinating and harmonizing role of the International Joint Commission is particularly relevant. The Commission stands willing to assist the Parties, pursuant to their request. Action must be taken quickly to stop this ongoing threat to the economy and the biological integrity of the Great Lakes.

Conclusion

The introduction and spread of alien invasive species are continuing to impair the biological integrity and threaten the many water-dependent economic sectors of the Great Lakes basin. The costs for treatment and control are massive, rising, and largely borne by local communities, utilities and industry rather than those who create the problem.

Current regulations, guidelines, and practices in place are not sufficient to prevent further alien invasive species introduction and spread. Specifically, current regulations exempting ships declaring no ballast on board (NOBOB) do nothing to minimize the threat they pose. The Great Lake region's sense of the biological and economic urgency of the problem drives the call for more federal leadership and immediate steps to prevent further introduction and spread of alien invasive species.

Immediate federal action to make mandatory ballast water management practices, including the requirement for NOBOB participation in the program, can reduce the biologic and economic threat from the introduction and spread of alien invasive species. The time to act is *now*.

Recommendations

The Governments need to take more aggressive steps to end the invasion of alien species and we urge the following:

1. **Immediately make existing voluntary guidelines for ballast water management practices mandatory and provide for measures of enforcement and compliance for all ships capable of carrying ballast water, including those currently not carrying ballast water.**
2. **Develop uniform protocols for performance testing of ballast water:**
    - **develop best practices and any improvements for ballast management operations**
    - **establish by the end of 2003 enforceable interim biological standards**

- concurrently, establish biological standards for ballast water discharges from all ships and for new technologies for ballast water treatment.

3. Ensure all ships built after a certain date have a treatment technology incorporated in their construction as a condition for entry into the Great Lakes.

4. Design and implement economic incentives to encourage shippers to continuously improve (ISO 14000) Ballast Management Practices.

5. Fund research recommended by expert regional, national and binational panels, task forces and committees, especially focused on:

   - research (including research for biological standards, criteria and indicators) for ballast water treatment necessary to drive technology, product development, and ship design
   - research to develop alternative technologies including biocides to achieve new standards and criteria for the elimination of Alien Invasive Species in ballast water
   - research and technology development to reduce entrained and accumulated sediment in ship ballast water and tanks, and
   - research to develop analytical tools and procedures to permit the identification of new invasive species and to link these species to their possible points of origin and vessels of introduction.

6. Issue the Commission a reference to coordinate and harmonize binational efforts for action to stop this ongoing threat to the economy and the biological integrity of the Great Lakes.

Further Matters of Importance

This section of the *Eleventh Biennial Report on Great Lakes Water Quality* results from a commitment by the International Joint Commission to systematically review progress under specified annexes of the *Great Lakes Water Quality Agreement*. This report covers:

- **Annex 1 (Specific Objectives)**
- **Annex 2 (Areas of Concern)**
- **Annex 3 (Phosphorus)**
- **Annex 7 (Dredging)**
- **Annex 8 (Discharge from Onshore and Offshore Facilities)**
- **Annex 10 (Hazardous Polluting Substances)**
- **Annex 12 (Persistent Toxic Substances)**
- **Annex 15 (Airborne Toxic Substances)**
- **Annex 16 (Groundwater) and**
- **Annex 17 (Research).**

The format for this section differs from the main body of the *Eleventh Biennial Report*. On these topics, the Commission offers its observations while not recommending detailed solutions. With this approach, observations highlight a common understanding of a problem and recognize that a problem or issue could be addressed in a number of ways, not necessarily limited to current program emphases.

The topic of Annex 1 (Specific Objectives) illustrates this approach. There are a number of actions that could be taken by the governments of the United States and Canada to address deficiencies in Annex 1; many are well known and understood by senior officials and managers. The issue of record, however, is that Annex 1 is essential to the Agreement as a basis to quantitatively assess progress and, as such, it needs updating.

The Commission is hopeful that this approach will facilitate an ongoing dialogue with and between the two governments by placing greater focus on the issues and providing flexibility in the choice of workable solutions.

The Commission will be initiating such a dialogue at the earliest opportunity and has already begun discussions with representatives of Environment Canada and U.S. EPA on several of these topics.

Finally, the *Eleventh Biennial Report* reviews several issues arising from its Public Forum on Great Lakes-St. Lawrence Water Quality, held October 19-20, 2001 in Montréal, Québec, including: the Lake Superior Binational Program, risk and potential impact of nuclear facilities on the Great Lakes, unmonitored chemicals, and water use.

Section 1: Specific Objectives (Annex 1)

Observation

Because Specific Objectives listed in Annex 1 of the *Great Lakes Water Quality Agreement* have not been updated for more than 20 years, they have only limited relevance today to the goals of restoring and maintaining the chemical or biological integrity of the Great Lakes basin ecosystem. Revisions to Annex 1 are required if the Parties to the Agreement are to meet their responsibilities for, accountability to, and reporting on the adequacy of their efforts to protect the Great Lakes. The Parties recent work to develop indicators of Great Lakes environmental quality may enhance the development of new Specific Objectives.

Discussion

Annex 1 puts forth a series of Specific Objectives, intended to provide a basis for judging progress toward achievement of the Agreement's purpose, including numerical targets. Nevertheless, knowledge has advanced to such a degree since then that the Specific Objectives developed nearly a quarter century ago are now out of date and of only limited value.

In particular, our understanding of the nature of the risk posed by contaminants, cause-and-effect relationships, and factors that affect human and ecosystem health have improved considerably, with no corresponding update

to the Objectives. For example, we have learned that some chemicals are unsafe at levels far lower than previously thought, rendering inadequate the target levels stated in the Objectives. Specific Objectives should be able to drive management actions, but the outdated Objectives cannot properly serve this function. Furthermore, surveillance and monitoring data are not available to adequately evaluate the attainment of the Agreement's Objectives.

Many of the Objectives in Annex 1 no longer conform to revised or updated objectives of the Parties. Regulatory agencies no longer monitor many Annex 1 contaminants including aldrin/dieldrin, endrin, heptachlor/heptachlor epoxide, methoxychlor, and pharmaceuticals (see also Section 13). At the same time many other compounds, including polynuclear aromatic hydrocarbons, chlorobenzenes, and octachlorostyrene, have emerged as serious potential health risks, but these are not included among the Objectives.

Many of the lakes' contaminants are not routinely monitored in water, often because the available data show that concentrations are so low, and the standard deviation so large, that routine monitoring serves no scientifically valid purpose. The Parties need to develop a new approach to objectives and monitoring programs, such as the continued development and use of indicators of ecosystem health that focus not only on concentrations of substances, but on ecological and human health effects, as highlighted in Chapter 1.

Through its Great Lakes Science Advisory Board, the Commission investigated whether Annex 1 is still relevant, if revisions are necessary, if there is a role for ecological indicators, and how achievement of Specific Objectives could be judged. The Commission concluded that in principal Annex 1 and the Specific Objectives are still relevant because tangible evidence, including achievement of stated targets, is necessary to demonstrate progress toward achieving the Agreement's purpose. The Objectives need revision so they can provide direction to determine what is required to restore beneficial uses and maintain ecosystem quality.

In signing the Agreement, the Parties committed to, "consult ... at least once every two years ..." regarding Annex 1. The only substantive discussion by the Parties to date was initiated in 1999 and then terminated with no further action. As part of their next review, the Parties have the opportunity to explore the role of indicators and their relationship to the Specific Objectives.

Objectives are of little use without surveillance and monitoring data. Despite the Parties' commitment in Annex 11 (Surveillance and Monitoring), "to provide definitive information [regarding] ... non-achievement of the Objectives ...," present programs are not geared to developing such data. A commitment to Annex 11 will be necessary to support revisions to Annex 1 and subsequent revision of the Objectives.

Article IV of the Agreement requires the use of statistically valid data to determine achievement of Specific Objectives. The Agreement, however, provides little guidance on the treatment of surveillance and monitoring data used to judge achievement. Yet, such considerations are critical in the design of both sampling and data analysis programs. For example, it is unclear whether the intention of a particular Objective is to assess average conditions, maximums or minimums, or values typical of a given geographic area or depth. Ideally, the Parties should state Objectives in such a way that intended statistical methods, and thus, considerations, such as spatial and temporal monitoring frequency, are clear.

Section 2: Public Involvement and Experience Sharing in Areas of Concern (Annex 2)

Observation

Public involvement during the implementation phase of Remedial Action Plans enables community engagement and participation in remediation. Although new models of community collaboration are being developed and applied, the fiscal restraints of governments have reduced funding to some local committees, which has particularly affected the ability of community groups to enhance their expertise through the sharing of experiences. The Commission's 2001 Biennial Forum provided an example of the value of exchanging lessons learned about community-based restoration. It also showed that it can be valuable for participants in Areas of Concern in the Great Lakes to interact with their counterparts to the east in Quebec, who are facing similar challenges downstream in the St. Lawrence River.

Discussion

Public involvement and education facilitates a positive change in the culture and values of people, businesses and organizations in Areas of Concern. It is a long-range change toward better awareness and improved stewardship at the individual level. By changing the culture and values of those living in the community, a new set of sustainable behaviors can emerge. This can be one of the most subtle but powerful effects of broad public participation.

The Commission believes an active and engaged group of local citizens is critical to making progress in implementing a Remedial Action Plan and maintaining the viability of the process.[1] For this to emerge, communities need to mobilize leaders who can focus actions and activities toward a shared vision and common goals. Local advisory committees provide a mechanism for concerned citizens to become informed and, at the same time, provide government agencies a structured approach to consultation. Bringing together representatives from different committees for the transfer of information among Areas of Concern enables the cross-fertilization of ideas and approaches. It also provides a mechanism for the governments to work with them on shared topics such as new strategies.

During the 2001 Public Forum, the Commission heard that funding reductions for some local public committees both in Canada and the United States were purportedly impeding the ability of the public to play its role in the remediation of Areas of Concern. Some public committees in Areas of Concern are fully supported; others are not. The Commission recognizes that funding is not the only determinant of effective public involvement. For example, the groups need to have a legitimate role that is respected, and the planning horizon needs to be sufficiently tight to maintain momentum. Funding is required, however, to enable community members to interact across the basin so that they may share successes, challenges and solutions for sustaining community capacity through the period of Remedial Action Plan implementation.

A workshop held at the 2001 Public Forum enabled several Great Lakes and St. Lawrence River communities to learn about each other's programs and progress. Representatives from various groups could benefit from continued discussions on issues of mutual interest.

Section 3: Phosphorus (Annex 3)

Observation

Calculations suggest that limits on external phosphorus loads are generally being achieved and that known phosphorus sources were not the cause of increased phosphorus concentration levels in Lake Erie during the 1990s. Despite this, the concentrations of phosphorus in Lake Erie exceed limits, and suggest that eutrophication (excessive nutrient enrichment) is occurring. The Parties must invest in new basic research, monitoring and information sharing if they are to achieve the binational goal for the management of phosphorus under Annex 3 for Lake Erie. **As reported in newspapers of late, the discovery of a "dead zone" in Lake Erie is puzzling scientists, with causes currently undetermined.**

Discussion

Twenty-five years ago, numerous scientific studies conducted by the Commission's Pollution From Land Use Activities Reference Group resulted in the Parties adopting policies and programs to manage phosphorus for each lake basin through a variety of point and nonpoint source control measures. This linkage of science and policy resulted in programs to reduce phosphorus loads to the Great Lakes based on reduction targets as set out in Annex 3. The achievement of a target load for each lake is currently represented by a specific outcome: concentrations of phosphorus in the open waters. For lakes Superior, Huron, Michigan and Ontario, concentrations indicate that progress has been sustained.[1] In the case of Lake Erie, however, open water concentrations of phosphorus often exceed the guideline, indicating that phosphorus is being released into the lake by sources or processes not fully understood.

Better information, derived from monitoring programs that can confirm the sources and loadings of phosphorus to the lake, could lead to improved policy decisions. As municipal wastewater discharges appear to decrease in importance due to technological improvements and infrastructure upgrades, reduced water quality monitoring efforts associated with this sector are

often perceived as justified. However, increased effort in point source and tributary monitoring may be warranted to account for the tremendous changes that have occurred in the basin over the last 25 years, particularly as a result of urbanization and the increase in pavement and other practices that create land that is impervious to water.[2] The impact of large point sources, such as Detroit's sewage treatment plant, is difficult to assess because suitable phosphorus loading data are not readily accessible for independent or binational interpretation. Although municipal sources may not provide the greatest contribution to the total phosphorus inputs to the lake, their impact can be significant, since the phosphorus they discharge is in a form that is more readily utilized by living things than is the predominant form transported to the lakes from nonpoint sources.

Tributaries are large sources of total phosphorus to the lake; however, because some forms of phosphorus are not readily bioavailable, good data are needed to distinguish phosphorus species and their relative contribution to increasing concentrations in the open waters. Current tributary monitoring efforts do not provide such loading estimates. Some streams are sampled no more than monthly and others have not been regularly sampled since 2000. The number of unmonitored streams is increasing, adding additional uncertainty in determining the primary sources of phosphorus to the lake.

Major tributaries to Lake Erie, such as the Maumee River, have achieved notable decreases in suspended sediment discharges and reductions in phosphorus loads as a result of improved agricultural practices.[3] However, these tributaries are still very large sources of phosphorus with year-to-year loads varying with the frequency and intensity of flooding. For example, phosphorus stored in the sediment of tributaries can build up during dry or average rainfall years and can serve as a substantial load to the lake during a single flood event. Such major events could become common in the Great Lakes as a result of climate change, adding a further management challenge to achieving target loads. The Commission is evaluating the potential impacts of climate change based on different predictive models, and will report on this during the next few years and in its *Twelfth Biennial Report*.

Scientifically, the phosphorus cycle is well understood. However, detailed information to assess options to manage phosphorus effectively in Lake Erie

has not been available.[4] Because of the level of uncertainty, scientific knowledge based on the past should not be assumed to be adequate to serve as a basis for decision-making for the future. New investment in basic research, monitoring, and information sharing for Lake Erie needs to include improved long-term monitoring of point and nonpoint sources and tributaries, calculation of the rate of inter-basin transfer of nutrients, and development of better tools for making predictions.

Section 4: Dredging (Annex 7)

Observation

The Great Lakes Dredging Team, a U.S. committee created in 1996 by Department of Transportation, Maritime Administration, is a strong advocate for research and development related to dredging technologies, sediment management and related environmental impacts. Canadians participate, but only in an *ad hoc* manner. Full Canadian membership on the Great Lakes Dredging Team would enhance binational cooperation and oversight of the environmental consequences of navigational dredging. Current information technology resources can satisfy the Annex 7 requirement to maintain a register of significant dredging projects.

Discussion

Specific studies assigned to the Subcommittee on Dredging under Annex 7 were completed during the 1980s and 1990s, and consequently, the annex no longer reflects current organizational relationships and activities.

The Great Lakes Dredging Team promotes uniform environmental regulation of the management of dredged material in the U.S. where there is currently some variation between the states. It is already a strong advocate for research and development related to dredging technologies, sediment management and environmental impacts.

If the Great Lakes Dredging Team had full representation from both U.S. and Canadian agencies, this organization could fill the role of a standing

subcommittee on dredging called for in Annex 7. The team could be recognized in future updates to Annex 7 of the *Great Lakes Water Quality Agreement*. Additional work by the Parties and/or the Commission to follow up on past recommendations or to investigate new concerns involving dredging could then be carried out by the team on an as-needed basis.

In addition to recognizing the value of the Great Lakes Dredging Team, the Parties could consider modifying the Annex 7 requirement calling for the maintenance of a formal register of significant dredging projects. The last register of Great Lakes dredging projects was published for the Great Lakes Water Quality Board in 1990. That report contained data on approximately 95 percent of all dredging activities in the Great Lakes basin from 1980 through 1984. Now that the governments have made more recent information available on the Internet, it appears unnecessary to publish an updated register. Use of the Internet could be extended so that all the data needed to conduct an environmental assessment of dredging projects could be easily accessed electronically.

Section 5: Discharges from Onshore and Offshore Facilities, including offshore and directional drilling (Annex 8)

Observation

Considerable public controversy has arisen over potential environmental risks from U.S. and Canadian offshore and directional oil and natural gas drilling in the Great Lakes. To date, there have been few reported problems. However, this matter does relate to Annex 8 of the *Great Lakes Water Quality Agreement*. (In the U.S., Congress has authorized a comprehensive U.S. review of oil and gas drilling practices in the Great Lakes basin.)

Discussion

Annex 8 includes definitions and principles as well as programs and measures to prevent discharges of oil and other substances into the Great Lakes system from drill rigs, pipelines, wells and other on or offshore facilities.

Jurisdictional Policies

Canadian Federal Government
Generally speaking, drilling in the Great Lakes falls within provincial jurisdiction.

U.S. Federal Government
The U.S. Environmental Protection Agency and the U.S. Army Corps of Engineers in a 1982 joint report concluded that the development of natural gas from beneath the U.S. portion of Lake Erie can be done safely as long as current regulations governing the activity are strictly followed.

In November 2001, however, President Bush signed into law a two-year ban on any new drilling operations in the U.S. portion of the Great Lakes. The law also calls for a comprehensive study by the U.S. Army Corps of Engineers on all potential environmental impacts that drilling operations could have on the Great Lakes. This study has not yet been funded.

Actions taken by state and provincial governments with respect to drilling are shown in the table below.

State/ Province	Offshore Drilling	Directional Drilling	Comments
Michigan	Banned	Banned	Michigan has been leasing bottomlands since the 1940s. In 1979, the first well was drilled beneath the Great Lakes. There were 6 producing gas wells and 1 oil well.
New York	Under 2 year federal moratorium	Under 2 year federal moratorium	New York allows leasing but no drilling has been undertaken.
Ohio	Under 2 year federal moratorium	Under 2 year federal moratorium	Governor Bob Taft has stated that he will not support any move to allow drilling in Ohio's section of Lake Erie.
Pennsylvania	Under 2 year federal moratorium	Under 2 year federal moratorium	Pennsylvania signed the original Great Lakes Governor's memorandum of understanding in 1985 to disallow any offshore oil drilling in Lake Erie.
Ontario	Permitted (gas only)	Permitted	2,500 offshore gas wells have been drilled in Lake Erie since 1913. Ontario does not support the banning of environmentally sound directional drilling under the bed of the Great Lakes.
The following jurisdictions have little, or no offshore oil and gas potential or drilling targets			
Indiana	Under 2 year federal moratorium	Under 2 year federal moratorium	Drilling permits subject to review by Indiana Natural Resources Commission.
Illinois	"	"	No drilling is pending beneath Lake Michigan and no potential targets are identified.
Minnesota	"	"	Has no oil or gas production therefore no statute related to directional drilling.
Wisconsin	"	"	Has no oil or gas production therefore no statute related to directional drilling.
Quebec	Not applicable	Not applicable	

Other Stakeholders

The International Association of Great Lakes and St. Lawrence Mayors passed a resolution calling for a moratorium on Great Lakes oil and gas exploration, development and extraction.

The Chippewa Ottawa Resources Authority passed a resolution stating its unqualified opposition to any oil drilling activities to exploit oil deposits under the Great Lakes.

Section 6: Hazardous Polluting Substances (Annex 10)

Observation

Up-to-date lists of hazardous pollutants, now readily available by electronic means, can fill the need to provide a continually updated inventory as called for under Annex 10 of the *Great Lakes Water Quality Agreement*.

Discussion

Annex 10 was first included in the revised Agreement of 1978 to provide information regarding hazardous polluting substances. The annex has two appendices, a list of known hazardous polluting substances and a list of potential hazardous pollutants. The annex requires that the two lists be maintained and continually revised in light of growing scientific knowledge. When the Agreement was updated in 1987, a short paragraph was added to Annex 10 directing that the practices and procedures consistent with the general principals of the Agreement be applied to those substances categorized as marine pollutants by the International Maritime Organization.

However, no chemical has been added to either list since 1978 and more current information is now readily available through other sources.

The purpose of Annex 10 was explained in the Commission's 1992 *Sixth Biennial Report on Great Lakes Water Quality*. At that time the Commission recognized that information called for from the United States was available to the U.S. Environmental Protection Agency and to the state environmental agencies, but that the Canadian information was not readily available to the two Canadian departments holding responsibilities under the Environmental Contaminants Act. This problem occurred because data held by Statistics Canada and Revenue Canada were, by Canadian law, confidential and inaccessible to any other federal departments. The Commission recommended that the governments initiate the development of a continually updated inventory to identify chemical compounds used, manufactured, processed or imported in the Great Lakes basin. Additionally, the Commission expressed concern about the availability of information to Canadian regulatory agencies and recommended that the situation be corrected.

Since that time, problems with access to critical data about hazardous polluting substances that were needed to protect the public health and welfare have been corrected. In 1988, the First Report of Canada under the 1987 Protocol to the Agreement noted that the original intent of Annex 10 had been met by Canada through the promulgation of the Transportation of Dangerous Goods Act, Canadian Environmental Protection Act and legislation in Ontario. The government of Canada reported that the lists in Annex 10 were being superseded by new mechanisms and determined that a review of Annex 10 was necessary.

While the need for a continually updated inventory of all hazardous or potentially hazardous substances used, manufactured, processed or imported in the Great Lakes basin still exists, the Commission finds that new technology providing continually updated hazardous material lists by electronic means over the Internet has eliminated the need to publish printed lists as required by the Agreement.

Section 7: Persistent Toxic Substances (Annex 12)

Observation

Numerous programs in the United States and Canada, including the Great Lakes Binational Toxics Strategy, Remedial Action Plans (RAPs), and Lakewide Management Plans (LaMPs), and clean air and clean water legislation contribute to reducing and eliminating the input of persistent toxic substances to the Great Lakes from various sources. Improved coordination among these programs would enhance progress toward virtual elimination of persistent toxic substances.

Discussion

Persistent toxic substances reach the Great Lakes from airborne, land and aquatic sources. Through Annex 12, the Parties to the *Great Lakes Water Quality Agreement* in cooperation with the Great Lakes states and provincial jurisdictions committed themselves to virtually eliminate the input of persistent toxic substances. Because this complex endeavor poses many challenges, the Parties broke the issue into more manageable components, adding Annexes 13-17 to the Agreement in 1987. These annexes focus on specific sources of contaminants – nonpoint sources, contaminated sediment, atmospheric transport and groundwater – as well as associated research needs. Annex 2, also added in 1987, provides for greater public participation as another means to help achieve virtual elimination.

The Parties and jurisdictions have undertaken numerous initiatives in support of all these annexes, including those that promote pollution prevention over reduction and control. Because considerable progress has been made, the Great Lakes ecosystem today is much improved. Nevertheless, after more than two decades, virtual elimination is not yet realized for any compounds with the possible exception of octochlorostyrene releases. The case of PCBs illustrates the point. Despite the Parties' commitment a quarter century ago to ban their manufacture, remove them from use, and

dispose of or destroy stockpiles, PCBs remain in use and continue to enter the environment from landfills, storage yards and other pathways for transport worldwide via the atmosphere. While the Parties continue to make progress, including the removal of one million pounds of PCBs from Waukegan Harbor, large amounts of sediment heavily contaminated with PCBs still need to be cleaned up, since their presence constitutes an active source of contaminant cycling in the Great Lakes basin ecosystem.

In prior biennial reports, the Commission has presented assessments and advice on the achievement of virtual elimination. The Commission advised the Parties to develop a comprehensive virtual elimination strategy. Subsequent to the Commission's call, the Parties signed the collaborative Great Lakes Binational Toxics Strategy in 1997.

From 1999 to 2001 the Great Lakes Water Quality Board progress review work group on the Binational Toxics Strategy evaluated the Binational Toxics Strategy.

According to the Board's assessment, the Strategy:

- contributes to the development, assembly, and expanded use of information, and provides coordination for collaborative sharing of this information among various jurisdictions
- helps engage industry, trade and professional associations, and others in voluntary action to achieve reductions beyond regulatory requirements.

Among the Strategy's weaknesses are:

- problems with organization, including coordination and oversight of Strategy activities. The roles of various groups involved in this effort need to be defined and confirmed
- the work appears to be bilateral rather than binational
- the Strategy's web site is seriously outdated, with the notable absence of Canadian information sources
- some key reports lack adequate information, including which information inventories are being used, and how top sources for certain Level I substances were identified. Some are not linked to the Strategy's web site or are not publicly available. The Strategy's progress reports in

some cases lack quantitative baseline and current-year information, present incomplete information, or lack Canadian information

- The Strategy could be used to greater advantage if its profile were raised and its opportunities actively promoted.

The voluntary nature of the Strategy is both an asset and a liability. On the one hand, it facilitates stakeholder opportunities and participation in activities beyond regulatory requirements. On the other hand, the Strategy is only one of many initiatives competing for time and resources, and mandatory regulatory programs tend to take precedence over voluntary initiatives such as the Strategy.

The Binational Toxics Strategy is not a comprehensive strategy for virtual elimination. Rather, it is one initiative in a panoply of programs that address various components of the issue. While the Strategy encourages stakeholder opportunities and voluntary participation, its influence on other programs is unclear.

The role of the Strategy in fulfilling the Parties' commitments under the Agreement is uncertain, particularly in its relationship with Remedial Action Plans and Lakewide Management Plans.

The Parties should explicitly state whether the Strategy relies on Annex 2 requirements as a mechanism to deliver on selected goals, especially in regard to contaminated sediment and atmospheric transport. Further — could the Strategy offer leadership with regard to implementing Remedial Action Plans and Lakewide Management Plans?

Despite improvements to the Binational Toxics Strategy itself, the Commission sees a clear need for better coordination and effective linkages across program areas to resolve the persistent toxic substances issue and to fulfill the Parties' commitments under the Agreement.

Section 8: Airborne Toxic Substances (Annex 15)

Observation

The sources of a majority of airborne toxic substances remain unmeasured and, in some cases, unidentified. This hinders the ability of the two governments to reduce atmospheric deposition of toxic substances. Resolving this problem will require an extension of monitoring activities beyond the current International Atmospheric Deposition Network.

Discussion

Two past biennial reports have noted that emission inventories needed to support the objectives of Annex 15 are inadequate. Currently, only mercury, dioxin and cadmium inventories are adequate for source-receptor modeling on a broad binational geographic scale. Inventories of most of the 11 Critical Pollutants are marginal.[1] Those for the balance of the Critical Pollutants and Level II Binational Toxic Strategy contaminants range from inadequate to largely non-existent. Existing data on point sources, such as factory and power plant smokestacks, need enhancement and assurance of quality. Other sources, such as burn barrels (barrels used for the open burning of rubbish), which can produce dioxin, require initial analysis. The governments are making some gains with pollution prevention initiatives to reduce emissions of toxic substances. Nevertheless, the focus and achievement of such programs could be sharpened and measured by improved knowledge of the dominant sources and their pathways.

Loadings of PCBs to Lake Michigan from unmeasured and often unknown sources are far greater than those that can be attributed to regulated point sources. While we know that hundreds of kilograms of PCBs enter the lake each year via the atmosphere, only about 30 kg per year can be attributed to regulated sources. Urban air plumes originating in Chicago and Gary, particularly in the summer, contain significant amounts of persistent toxic substances, such as PCBs, from various nonpoint sources, which can

include transformer storage yards, landfills and brownfield industrial sites. These observations could well apply to other urban areas throughout the Great Lakes basin.

A number of techniques have been shown capable of estimating emissions from some of these sources. Applying such techniques to Critical Pollutants throughout the Great Lakes basin would provide important information to support more effective management actions.

To determine concentrations of several persistent toxic substances in the air, the governments use the binational Great Lakes Integrated Atmospheric Deposition Network of five master stations, one per lake basin, and 14 satellite stations. Studies focusing on Lake Michigan show that regional concentrations and loadings estimated from these data alone do not accurately represent actual deposition to that lake basin. For example, PCB concentrations at the Sleeping Bear Dunes master station were shown to be substantially lower than samples taken at another point on the eastern shore or adjacent to Chicago. Variations in concentrations across the basin were very pronounced. Similar determinations for the other lakes for this and other contaminants also would likely be inaccurate. Sampling at a number of other locales in the lake basins, including over water, and the development of better estimation tools are necessary to improve these regional deposition estimates and to develop and implement effective management programs and policies.

Section 9: Pollution from Contaminated Ground Water (Annex 16)

Observation

Millions of basin residents rely on groundwater for basic water supplies,[1] yet there is a serious lack of information on groundwater quantity and quality in the Great Lakes basin. Given the threat of contaminated groundwater to human health, as illustrated by the recent Walkerton, Ontario tragedy, and to the health of the Great Lakes basin ecosystem,[2] there is a critical need for more information on groundwater quality and quantity.

Groundwater issues were recently highlighted by the Commission in its 2000 report, *Protection of the Waters of the Great Lakes*.

Discussion

Groundwater contaminants of concern[3]:

Pathogens (bacteria/viruses)

Nutrients (nitrate)

Pesticides (triazines, DDT/DDE, Mirex)

Chlorinated solvents (trichloroethylene)

Petroleum products (BTEX, MTBE)[4]

De-icing compounds (road salt, glycol).

In the 1987 amendment to the *Great Lakes Water Quality Agreement*, the Parties agreed to identify sources of contaminated groundwater affecting the Great Lakes, map hydrogeological conditions, develop standardized approaches for sampling and analysis to support Remedial Action Plans and Lakewide Management Plans, control groundwater contamination, and report progress to the Commission biennially beginning in 1988.

Contaminated groundwater is polluting surface water due to direct, ground to surface withdrawals by people and through passage of contaminated water into tributaries to the Great Lakes or directly into the Great Lakes. Many Areas of Concern, such as the Maumee and Niagara rivers, are contaminated by groundwater and require serious attention to ensure restoration of beneficial uses.[5]

Citizens of the basin have expressed considerable concern about the potential impact of large scale, intensive livestock farming on the quality and safety of groundwater and surface water. Article VI, Section 1(e)(ii) of the Agreement, calls for "measures for the abatement and control of pollution from animal husbandry operations, including encouragement to appropriate agencies to adopt policies and regulations regarding utilization of animal waste, and site selection and disposal of liquid and solid wastes, and to strengthen educational and technical assistance program to enable farmers to establish waste utilization, handling and disposal systems."

The methods and approach to mapping hydrogeological units are well developed. Nevertheless, there is a lack of such mapping, and far more detailed information about groundwater and the use of groundwater in the basin is needed. Data on withdrawals varies in quality, and data on consumption are extremely limited.

State, provincial and local government attention to the monitoring and regulation of groundwater withdrawals is especially warranted when climate change models are considered.[6] Protection of groundwater recharge areas is the most efficient and cost-effective way to preserve groundwater quality.[7]

Because groundwater and surface water frequently interact, and it is impossible to distinguish between them in some instances, governments could be proactive and apply the precautionary principle (err on the side of caution) with respect to removals and use of groundwater in the basin. Land conservation programs within the 2002 U.S. Farm Bill offer incentives to protect water bodies from pollution.

Recently announced initiatives and new funding for groundwater monitoring and protection are welcome.[8] Additionally, progress by governments in controlling the 26 most egregious sources of surface water contamination from contaminated groundwater along the Niagara River is commendable.[9]

Until new and proven technologies can be applied, these efforts will need to be sustained. More remediation sites will need to be added to ensure that the intent of Annex 16 is achieved.

Section 10: Research and Development (Annex 17)

Observation

Since there is no mechanism in the *Great Lakes Water Quality Agreement* to set priorities and implement research programs as delineated in Annex 17, the designation by the Parties of lead agencies with the authority and resources to support Annex 17 would allow for an organized, binational approach to more comprehensively meet the annex requirements.

Discussion

Annex 17 does not place priorities on the research it delineates to support the needs of the Agreement. The Annex requires the Parties to the Agreement to conduct research in coordination with state and provincial governments, but it does not identify lead agencies with responsibilities for binational coordination. Workshops and conferences sponsored by agencies throughout the Great Lakes basin foster collaboration, but there is no effort specifically targeted at Annex 17 goals.

In order to measure the level of research activity in support of the Agreement, the Commission's Council of Great Lakes Research Managers established a Research Inventory to assist research managers and serve as a networking tool. The Research Inventory can be used to discern the level of support directed toward various fields of research, which can be useful in determining future research agendas. Areas that have less measured activity than others can be identified, leading to a constructive debate over whether support should be increased.

The Commission recognizes that its collection of project data published on the Internet confronts many challenges including accessibility, comparability and the inability to ensure full participation by all Great Lakes researchers. Consequently, the results of the inventory are not viewed as a precise measure, but rather as a general indicator of activity.

When Research Inventory data from 1993 were compared to current data, trends in areas of emphasis in Annex 17 indicated increasing support for the goals listed in subparagraphs (d), (g), (h) and (l). A relatively high degree of emphasis continues to be placed on studies related to the impact of water quality and of alien invasive species on native fish and wildlife populations and habitats. Data from the inventory, however, indicate that two areas of Annex 17 continue to receive little emphasis in the basin: subparagraph (b) Development of Load Reduction Models in the Great Lakes and subparagraph (k) Development of Action Levels for Contamination that Incorporate Multi-Media Exposures and the Interactive Effects of Chemicals. It is possible that this research is being undertaken within or outside the Great Lakes and is not captured by the Research Inventory. Therefore, this issue merits further investigation.

In order to properly support all goals set in Annex 17, a more proactive approach to research management is needed. It will not be possible to manage priorities in research and development effectively without a binational mechanism in place to implement and support related research programs.

Section 11: Lake Superior Binational Program

Observation

The Parties have documented significant reductions in the in-basin emissions of dioxin and the in-basin discharge, emission, and disposal of mercury between 1990 and 1999. However, recent reductions in funding for the Lake Superior Binational Program, their program to restore and protect Lake Superior, may hinder their ability to address impaired beneficial uses due to other stressors. For example, during the past five years, the U.S. Environmental Protection Agency's contributions to the Binational Program have been reduced from $2 million per year to $480,000. This reduction has occurred during the transition from information gathering and goal setting to the more challenging stage of implementing required actions, which will require more, not less, funding than the planning stage. Environment Canada funding for the Stakeholder Forum[1] has remained at approximately $50,000 for the past three years. Trends for the Program itself were not available.

Discussion

In 1990, the International Joint Commission recommended that Lake Superior be designated a demonstration area where "no point source discharge of any persistent toxic substance will be permitted." As part of their response, the Parties announced in 1991 a Broader Program in addition to the Zero Discharge Demonstration Program. The stated goal of the Zero Discharge Demonstration Program is to achieve zero discharge and zero emissions of certain persistent, bioaccumulative toxic substances, while the Broader Program focuses on the entire ecosystem of Lake Superior.[2]

Significant funding reductions for Lake Superior activities have occurred during the past five years, with the current U.S. Environmental Protection Agency funding substantially less than five years ago. Current funding may not be able to support both aspects of the binational program. The Commission previously expressed concern regarding a lack of information necessary to assess the progress and effectiveness of the Zero Discharge Demonstra-

tion Program.[3] Because available funds for the Lake Superior Binational Program have been substantially reduced, the zero discharge program may be in jeopardy, and the potential capacity of the Lake Superior Binational Program may not be fully realized.

Previous achievements of the Stakeholder Forum have demonstrated that it is a necessary component of the governments' initiative to develop and implement a Lakewide Management Plan for Lake Superior. Tracking progress toward the goal of virtual elimination of all critical pollutants from all sources, as envisioned by the Commission in 1990, is still needed and beneficial. The Zero Discharge Demonstration Program was specifically designed to address this need. The Governments' Lakewide Management Plan 2000 report outlines significant progress toward the control of in-basin sources for mercury and dioxin. Although there is the goal of 33 percent destruction of accessible and in-use PCBs by 2000, no complete inventory exists for PCBs in the U.S. portion of the Lake Superior basin.[4] More recently, the Lake Superior Binational Forum has identified a need to more effectively deal with potentially increased loadings of new sources of contaminants previously targeted for virtual elimination.

Section 12: Nuclear Issues

Observation

Because of energy requirements, both countries have extended the licenses of nuclear reactors beyond their original design lifetime. This could create problems of structural stability as well as renew ongoing concerns about nuclear waste handling, and add to the more recent security concerns. On the other hand, increases in the number of fossil fuel plants to replace lost nuclear power can increase emissions of airborne hazardous substances.

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Discussion

In its 1997 report to the Commission, the then Nuclear Task Force noted that beginning in 2003, and continuing for the next several years, numerous nuclear reactors at nuclear power plants were scheduled for decommissioning. These reactors were reaching the end of their 40 year design life as well as the time limit on their operating licenses.[1] Since 2000, this situation has changed considerably -- with a new emphasis on energy self-sufficiency, utilities have requested that the nuclear licensing authorities in both countries extend licensing periods.

A "fast track" review process had been established in the United States by the U.S. Nuclear Regulatory Commission to address the extended licensing issue. Atomic Energy of Canada is using a process that authorizes license extension one to two years at a time.

Radiation ages metals and causes metallurgical fatigue. Members of the public have raised the issue that extending the operating license of a reactor beyond its original design lifetime could lead to safety problems from reactor structural stability. The U.S. Nuclear Regulatory Commission's studies show that many of the aging mechanisms that cause radiation damage to metals take place within the original license period for the reactor, and they have stated that it does not expect additional metal aging to be a problem in reactors granted license extensions.[2]

All environmental requirements for nuclear reactor facilities call for sufficient on-site storage for high-level wastes, primarily fuel rods.[3] At virtually all nuclear power plants, spent fuel rods continue to accumulate in storage facilities originally intended to be only temporary. The on-going actions by the U.S. government to develop storage facilities in Nevada may mitigate this situation. Under the license renewal guidelines, the on-site storage problem is exempted from consideration in license applications. However, the possibility of radioactive waste discharges to the Great Lakes from breaching of the sites must be considered in the application for license renewal and extension. The issue of security at nuclear power plants has also been raised.

Despite the above very real concerns, nuclear power can eliminate the need for fossil fuel generation and the increase in airborne contaminants that would result. For example, in the United States from 1990-1995, "21 states achieved a 16.4% increase in nuclear generation" and "avoided 480,000 tons (non-metric) of sulfur dioxide emissions." In 1998, "nuclear power plants avoided 100 million metric tons of carbon dioxide."[4] If instead of nuclear-generated energy in the Great Lakes, coal/fossil fuels had been the alternative for energy production, the amount of green house gases emitted would have seriously exacerbated air quality degradation.

Section 13: Unmonitored Chemicals

Observation

The Commission is concerned that the number of chemicals being monitored to establish the chemical integrity of the Great Lakes ecosystem is inadequate for that purpose.

Of particular concern are many unmonitored chemicals, especially pharmaceuticals, flame retardants, and high-volume chemicals, such as a new generation of biodegradable pesticides, which have the ability to dissolve in both water and fat and therefore often show unusual patterns of bioaccumulation and environmental degradation. The mix of chemicals, and potential to cause unknown harm in combination, adds further concern. Most of the environmental consequences of these chemicals, usually found at low concentrations, are unknown.

Discussion

The U.S. Environmental Protection Agency uses a list of 129 Priority Pollutants as part of its regulations under the U.S. Toxic Substances Control Act. Other lists of toxic substances address the contents of waste repositories, notably the CERCLA Priority List of Hazardous Substances, which contains 275 trackable pollutants.[1] There are also numerous Canadian toxic

substances lists, including the Canadian Water Quality Guidelines for the Protection of Aquatic Life,[2] which lists 180 chemical substances, and other sources from which to make selections of additional chemicals to monitor for the purposes of establishing the chemical integrity of Great Lakes.

Yet the number of chemicals actually monitored, often as few as 30, is a very small subset of the total, with more intensive monitoring occurring in special cases (*e.g.* monitoring for heavy metals, pesticide residue screening) at infrequent intervals or one-time special efforts. There are also questions about how to select the chemicals to be monitored, and which additional chemicals to select. Questions surround the available methods for monitoring at low environmental concentrations on a mass production basis, and the availability of infrastructure to accommodate the monitoring (laboratories, vessels, sampling facilities, etc).

Several groups of unmonitored chemicals have caused specific concerns among citizens and scientists, including pharmaceuticals, flame retardants, and high-volume chemicals. A landmark study by the United States Geological Survey has recently documented the distribution and levels of some of these chemicals in water bodies, mainly in rivers of the United States.[3] None of the chemicals in this study has a Specific Objective in Annex 1 of the Great Lakes Water Quality Agreement. Also, many of these chemicals do not fit into the category in Annex 1 of nondegradable, bioaccumulative and persistent. They are persistent, but usually biodegradable and not all of them are bioaccumulative. The mechanisms and rates of biodegradability often depend on specific environmental conditions, which are sometimes present, and sometimes not. Studies at sewage treatment plants have shown the need for special adaptations to ensure removal of these materials from treated wastewaters.[4]

Pharmaceuticals include antibiotics, growth hormones, contraceptive drugs, veterinary products, and pesticides for animals and household pets.[5] Some of these chemicals have known endocrine disruption properties;[6] others confer antibiotic resistance to certain bacteria.[7] Some have high-volume use in agriculture and medicine. Recent attention has been paid to pharmaceutical residues in drinking water supplies.[8]

Many flame retardants are brominated organic compounds similar in structure to PCBs, and can have even greater toxicity than their chlorinated counterparts. Some have been appearing in waters and biota of the Great Lakes system where they have not been previously documented.[9]

There is also a new generation of biodegradable pesticides that have solubility both in water and adipose (fatty) tissue. Atrazine, a widely used pesticide, is one example. Because of their high volume usage, these pesticides may pose new kinds of challenges in terms of their environmental toxicology and effects.

Most of the environmental consequences of these chemicals, usually found at low concentrations, are unknown. Also, these chemicals are rarely found alone, and the mix of chemicals adds further concern.

Section 14: Water Use in the Great Lakes Basin and Annex 2001

Observation

In its 2000 report to governments on *Protection of the Waters of the Great Lakes*, the Commission noted that water quality and quantity are inextricably linked.[1]

The Commission continues to be concerned about the risk to the Great Lakes from factors such as future consumption, small-scale removals, diversions, and climate change. The Commission has made recommendations to governments regarding water use in the basin and has been given a reference to report in early 2003 on progress made by basin jurisdictions in this regard.

In December 2001, the government of Canada passed amendments to the International Boundary Waters Treaty Act to better implement the Boundary Waters Treaty by prohibiting the bulk removal of boundary

waters from the water basins in which they are located and requiring persons to obtain licenses from the Minister of Foreign Affairs for water-related projects that affect the natural level or flow of waters on the United States side of the border. Regulations envisioned in the amendments have not yet been issued, and the amendments are not yet in force.

Discussion

Under Annex 2001, the governors and premiers agreed to a number of commitments including:

1) preparing a new set of binding agreements as may be necessary within three years of the effective date of the Annex (June 2001)

2) developing a broad-based public participation program to ensure ongoing public input in the preparation and implementation of the binding agreements

3) establishing a decision-making standard for reviewing new proposals to withdraw water from the Great Lakes basin for diversions and major consumptive uses as well as proposals to increase existing water withdrawals

4) developing a decision support system to implement the Great Lakes Charter and Annex 2001 to ensure availability of the best information on water uses in the basin, including the role of groundwater

5) developing guidelines for the implementation of mutually agreed upon measures to promote the efficient use and conservation of water

6) developing a mechanism by which individual and cumulative impacts of water withdrawals will be assessed, and

7) identifying and implementing effective mechanisms for decision-making and dispute resolution.

Pending final approval of the agreements mentioned above, the governors of the Great Lakes states will notify and consult with the premiers of Ontario and Québec on all proposals subject to the U.S. Water Resources Development Act of 1986, amended in 2000.

The Commission is pleased to note that work is proceeding apace on a number of these commitments. In particular, under the guidance of the Great Lakes Commission, the water use database for basin jurisdictions is being updated and improved and the decision support system is being developed. A high-level state and provincial task force, chartered by the governors and premiers, is developing standards to be used in assessment of the impact of proposed withdrawals and consumptive uses and to develop the institutional structure needed to support the process.

The development of the new decision-making standard will be based on the following principles: preventing or minimizing water loss from the basin through return flow and implementation of feasible water conservation measures; no significant adverse individual or cumulative impacts to the quantity or quality of the waters and water-dependent natural resources of the basin; an improvement to the waters and water-dependent natural resources of the Great Lakes basin; and compliance with the applicable state, provincial, federal and international laws and treaties.

Signed this Twelfth Day of September 2002 as the Eleventh Biennial Report of the International Joint Commission

Pursuant to the Great Lakes Water Quality Agreement of 1978

Dennis L. Schornack
Chair, United States Section

Herb Gray
Chair, Canadian Section

Robert Gourd
Commissioner

Dr. Jack P. Blaney
Commissioner

Notes

Notes for Chapter 1

1 SOLEC, 2001
2 SOLEC, 2001
3 IITF, 2000
4 SOLEC, 2001
5 SOLEC, 2001
6 Milwaukee, 1993; Walkerton, 2000
7 IITF, 2000
8 SOLEC, 2001
9 SOLEC, 2001
10 IITF, 2000
11 SOL IJC, 2002 - in preparation EC, 200l, p 53
12 IJC, 2002 - in preparation
13 IITF, 2000
14 SOLEC, 2001
15 IITF, 2000; SOLEC, 2001
16 www.ec.gc.ca/cise

Notes for Chapter 2

1 IJC, Fifth Biennial Report, Part II, p 15-16
2 Carpenter *et al.*, 2001
3 Ashizawa *et al.*, 2001
4 Anderson *et al*, 1999
5 National Wildlife Federation. www.nwf.org/watersheds/index.html .
6 Tilden *et al.*, 1997
7 USEPA 2001
8 IJC, Detroit River, 1997; IJC, Hamilton Harbour, 1999; IJC, St. Marys River, 1999; IJC 2002
9 U.S. General Accounting Office, 2002 and Commission of the Environment and Sustainable Development, 2001
10 Nuclear Regulatory Commission, 2000
11 Rice, 1995; Bemis and Seegal, 1999; Schantz *et al.*, 2001
12 Nuclear Regulatory Commission, 2000
13 Golden *et al.*, 1999
14 Stratus Consulting Inc., 1999
15 Hornbuckle, 2002
16 Wisconsin DNR and U.S. EPA, 2001
17 United States, 2001 and Government of Canada, 2001
18 U.S. EPA, 200l; Governments of Canada and Ontario, 2002

Notes for Chapter 3

1 Initial efforts by the Commission to address its concerns for AIS led to the 1990 IJC-Great Lakes Fishery Commission joint report, *Exotic Species*

and the Shipping Industry. More recently, the IJC commented on the continuing threat of AIS to the Great Lakes in its *Tenth Biennial Report* (IJC, 2000); and in a joint letter with the Great Lakes Fishery Commission (IJC-GLFC, 2001). Its Great Lakes Water Quality Board (2001) also issued a white paper on the subject.

2 For a general discussion see: Jewell, Susan. 2000. A United Defense Against Invasive Species. Endangered Species Bulletin vol. XXV No. 5. Available online at: endangered.fws.gov/esb/2000/09-10/08-10.pdf

3 Pimentel *et al.*, 2000.

4 Although widely quoted, key original source appears to be Property Claims Service of the Insurance Services Office Inc. See: http://www.iso.com/docs/pres273.htm

5 Ruiz *et al.*, 1997

6 Ricciardi, 2001

7 Ricciardi, 2001, Tamburri *et al.*, 2002

8 Ricciardi, 2001

9 Tamburri *et al.*, 2002; Johnston and Carlton, 1996

10 Berg *et al.*, 2002; MacIssac *et al.*, 2002

11 Gerrity, 2002

12 Karaminas *et al.*, 2001

13 Aquatic Sciences, 1996. QUESTION: How to handle 2002 Alexandria Conference Reference — are there proceedings?

14 U.S. 33 CFR part 151; Canadian TP 13617E *Guidelines for the Control of Ballast Water Discharge from Ships in Waters under Canadian Jurisdiction*

15 U.S. Government, 2002, Federal Register 67 FR 39: 8885-8888

16 Aquatic Sciences, 1996

17 Cangelosi *et al.*, 2001

18 International Convention for Control and Management of Ships' Ballast Water and Sediments; www.imo.org

19 U.S. Government, 2002, Federal Register 67 FR 42:9632-9638

20 Council of Great Lakes Fishery Agencies, 2001; Nalbone 2001

21 The purpose of the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 is to prevent the unintentional introduction of nonindigenous aquatic species and prevent and controls aquatic nuisance species dispersal in the waters of the United States. NISA legislation prevents biological invasions of the nation's waters and controls the spread of species within the United States.

Notes for Section 2

1 *Beacons of Light*, IJC, 1998

Notes for Section 3

1 SOLEC, 2001, p 38-39

2 GLSAB, Priorities 1997-99, p 33

3 Baker *et al.*, 1998

4 GLSAB, Priorities 1999-2001, p 59

Note for Section 8

1 **The Critical 11**: Dieldrin, benzo(a)pyrene, DDT and metabolites, hexachlorobenzene, alkylated lead, mercury and compounds, mirex, PCBs, dioxin (2,3,7,8), furan, and toxaphene. Chlordane, cadmium, arsenic, and octachlorostyrene were subsequent additions to the Critical 11.

Notes for Section 9

1 IJC, 2000
2 Grannemann and Weaver, 1999; Grannemann *et al.*, 2000; CGLRM, 2001
3 IJC, 1993
4 GAO, 2001
5 GLSAB, 2000; Becker, 2001
6 Piggott, 2001
7 Hall, 2001
8 OMNR, 2001; Sharpe, 2001
9 U.S. EPA/NYSDEC, 2000

Notes for Section 11

1 A binational partnership of 24 stakeholders who advise the governments of the U.S., Canada, and Great Lakes states and province of the basin. Members are a cross section including business, environment, industry and academia.
2 U.S. EPA and Environment Canada, 1999
3 IJC, 2000
4 U.S. EPA and Environment Canada, 2000

Notes for Section 12

1 IJC, 1997
2 www.nrc.gov. See section on operating reactor licensing and renewal
3 Code of Federal Regulations
4 Nuclear Energy Institute, 2002

Notes for Section 13

1 Agency for Toxic Substances and Disease Registry, 2001
2 Environment Canada, 2002
3 www.usgs.gov/regional/emc
4 Heberer, T. *et al.*, 2001; Skakkebaek, N.E., 2001; Stephany, R.W., 2001
5 Science News, 2000, 2001, 2002; Skakkebaek, N.W., 2001; Stephany, R.W., 2001
6 Zhou, T. *et al.*, 2001
7 TK from IJC
8 Heberer, T. *et al.*, 2001
9 Manchester-Neesvig, J.B. *et al.*, 2001

Note for Section 14

1 IJC, 2000

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- Province of Ontario guidance on dredging and sediment management: http://www.ene.gov.on.ca/envision/gp/B1-3.pdf
- Canadian Council of Ministers sediment criteria: http://www.ec.gc.ca/ceqg-rcqe/sediment.htm
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- U.S. EPA Consolidated List of Lists: http://www.epa.gov/swercepp/ds-epds.htm
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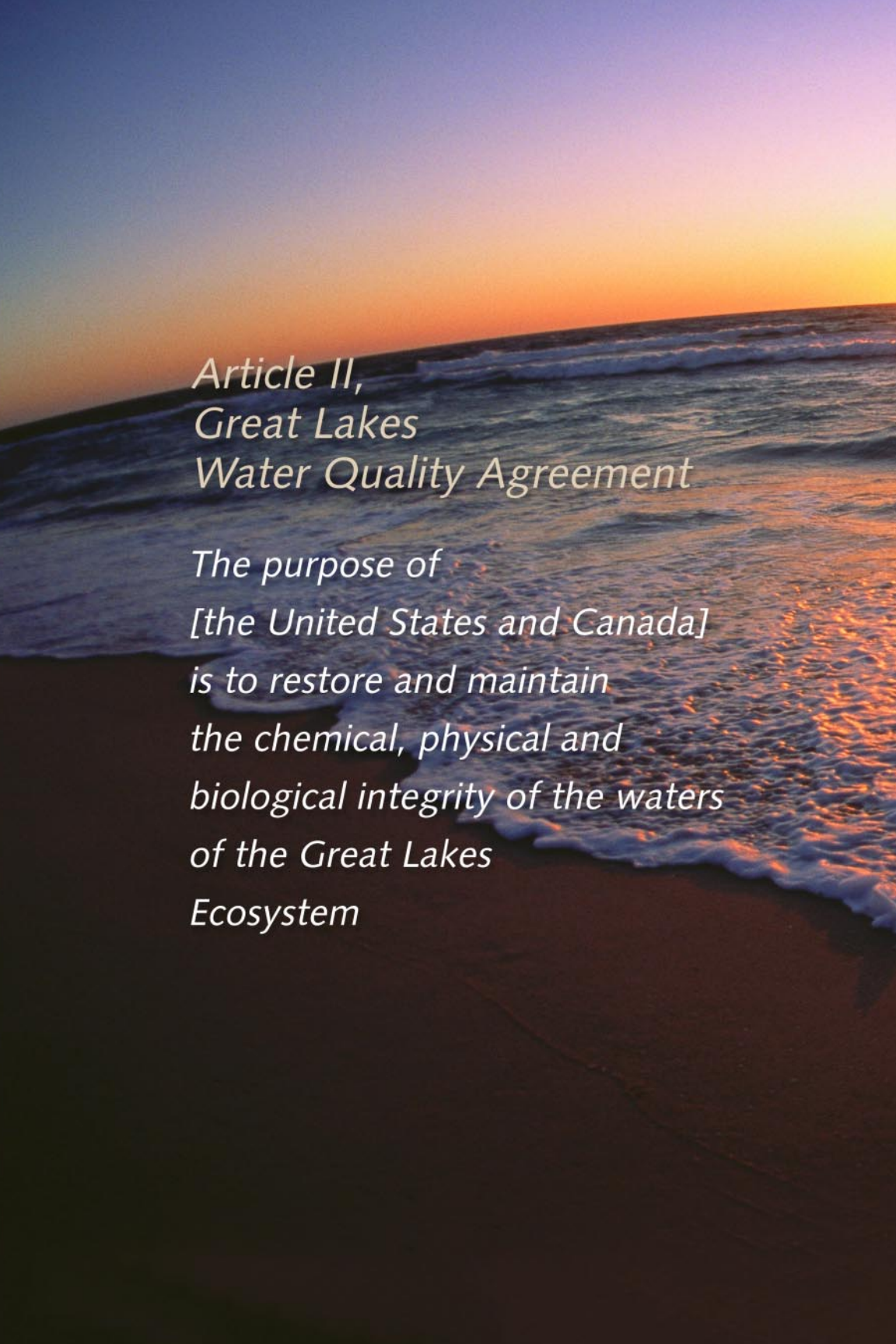

Article II,
Great Lakes
Water Quality Agreement

The purpose of
[the United States and Canada]
is to restore and maintain
the chemical, physical and
biological integrity of the waters
of the Great Lakes
Ecosystem