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DISCLAIMER

Every attempt has been made to attribute the expert opinions and comments in this report and to clearly distinguish them from the advice of the Science Advisory Board to the International Joint Commission. While these views are important and relevant for the report, they do not necessarily represent the views of the board or the International Joint Commission.

2.1 INTRODUCTION

Under the Great Lakes Water Quality Agreement, the Science Advisory Board (SAB) was established to provide scientific advice to the International Joint Commission (IJC) and the Great Lakes Water Quality Board (WQB) and is responsible for developing recommendations on all matters related to research and the development of scientific knowledge pertinent to Great Lakes water quality. Such a broad mandate requires a multi-disciplinary approach and accordingly, members are appointed from each country by the IJC with expertise in the natural, physical and social sciences. Within the broad mandate of the board, there are several processes that determine what is to be done and which of the myriad problems or scientific issues are most salient in terms of water quality, and for consensus building to support SAB recommendations.

Major activities of the SAB are largely tied to the IJC's biennial cycle. Development of board priorities by the IJC is based on consultation with its boards at the beginning of each biennial cycle and with the public during the biennial Public Forum. The Commission assigns a lead role to each of the advisory groups, according to whether the question is one of policy, science or research. A sole priority topic was initially assigned to the SAB for the 1999-2001 biennial cycle titled *Methodology for Assessing Community Health in Areas of Concern* , building on the previous work of the board in human and community health (1992 workshop in Ann Arbor, Michigan titled *Our Community, Our Health* , IJC 1994) . Throughout the past decade, as a result of

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significant investments by the United States and Canadian governments in Great Lakes environmental health research, there has been a new appreciation of the injury to human health from exposures to persistent toxic substances, particularly from the consumption of Great Lakes fish. Of particular concern are the irreversible changes in fetal developmental

processes as a result of maternal consumption of Great Lakes fish prior to and during pregnancy. The challenge for researchers, managers and policy makers is to determine the relevance of the effects identified by the scientific studies and the extent of injury occurring in critical subpopulations in communities, particularly in Areas of Concern (AOCs).

During the preparation of its Tenth Biennial Report on Great Lakes Water Quality, and in assessing the threat to human health from persistent toxic substances during its review of Annex 12, the IJC noted its serious concerns about this injury to human health from exposures to contaminants in Great Lakes fish. Generally, the policy response of governments is to issue fish consumption advisories. As stated in the report, this can only be considered an interim solution pending restoration of the chemical integrity of the ecosystem. Further, Commissioners requested additional advice on the adequacy of the advisories during the 1999-2001 biennial cycle and thus an additional human health related assignment was referred to the board.

A third major activity of the SAB, the review of Annex 1 of the Great Lakes Water Quality Agreement, evolved from the preliminary assessment of Lake Michigan Mass Balance data, by the SAB's Work Group on Parties Implementation. The original intent of this activity, to compare Lake Michigan Mass Balance data with Annex 1 Specific Objectives, led the work group to address broader issues related to the current relevance of Annex 1 to the Agreement, and its usefulness as a framework for reporting the status of Great Lakes water quality. The Commission accepted the advice of the board to fund further study, and in September 2000, this initiative began.

Several other important scientific issues were identified by the board and addressed with the assistance of student teams from Clemson University on the review of the State of the Lakes Ecosystem Conference (*SOLEC*), and from the University of Guelph of the review of *Nonpoint Sources of Pollution from Land-use Activities* .

The SAB also collaborated with the International Air Quality Advisory Board (IAQAB) on *Atmospheric Deposition Modeling to Develop Control Strategies* ; with the Water Quality Board on the *Review of the Great Lakes Binational Toxics Strategy;* and with the Council of Great Lakes Research Managers on the *Application of a Methodological Framework and a Proposed Process for Agreement Institutions in Addressing Emerging Issues in Great Lakes.*

The board completed a thorough review of its own internal processes for fulfilling its role under the Agreement, and developed *Procedural Guidelines* encompassing its administrative processes and work planning, the conduct of board workshops and the preparation of the Biennial Report on the Priorities and Progress under the Great Lakes Water Quality Agreement.

During this biennial reporting cycle, the SAB held two public meetings: at the IJC Biennial Meeting in Milwaukee, Wisconsin, held September 1999

(#115) and during the IJC status assessment of the Niagara River AOC, held in Niagara Falls in November 2000 (#120). Both meetings reflect the ongoing practice of the board to encourage public involvement and interaction with the board.

Given the ease of electronic communication with the Internet, there are greater opportunities than ever for interested citizens to be aware of their Great Lakes science heritage and to benefit from its discoveries in terms of societal change. Scientific knowledge, however exciting, is necessary but not sufficient as a sole basis for actions, as it must be applied wisely by decision makers, and their actions must receive public support, in order for progress under the Agreement to be sustained. Great Lakes citizens are encouraged to follow the board activities and advice by visiting their web site at the IJC home page at http://www.ijc.org/rel/boards/sab/index.html or to contact the board secretary Mr. Peter Boyer at boyerp@ijc.windsor.org for further information.

Finally, the board would like to acknowledge the efforts of all of the non-board contributors to the report, many of whom participated as invited experts at board meetings, industry tours, workshops and work group meetings. They include: Annette Ashizawa, Seth Ausubel, Thomas Baldini, Thomas Barnard, Michael Basile, Judy Beck, Mary Lynn Becker, Matthew Becker, Ryan Bodanyi, Ken Bondy, Barry Boyer, Jim Brophy, Jean Burton, Tanya Cabala, Michael Campana, Richard Carrier, Alice Chamberlin, Mathew Child, Theo Colborn, George Costaris, James Cowden, Joseph DePinto, Krista Devine, Jim Drummond, Abdel El-Shaarawi, Rose Ellison, Thomas Emery, Rick Esterline, John Eyles, Sharon Fedman, Ralph Ferguson, Joel Fisher, Irene Gauthier, Matt Hare, Lucy Harrison, Jim Hartnett, Maureen Healey, John Heatley, Allen Heimann, Henry Henderson, Adam Hess, Paul Horvatin, Robert Huggett, Irene Ilia, John Jackson, Lin Kaatz Chary, Neil Kagan, Rimas Kalinauskas, Wilfried

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2.2 HEALTH

2.2.1 Methodologies for Community Health Assessment: Measuring Injury to Health

Scientific, Diplomatic and Political Responses to Great Lakes Pollution

For more than 90 years, the International Joint Commission has been assisting the United States and Canadian governments in preventing and resolving potential disputes concerning the use of the boundary waters between the two countries, from coast to coast, under the Boundary Waters Treaty of 1909. Because the International Joint Commission is a diplomatic organization that undertakes its work by examining issues that are under dispute, it is not only a political, but also a scientific organization. Many of its responsibilities concern water use, diversions, allocations and other aspects of water quantity. But in the past 40 years, there has been a growing emphasis on water quality, particularly through the studies leading up to and subsequent to the signing of the 1972 Great Lakes Water Quality Agreement by the United States and Canada. The Agreement itself was both a political and scientific response to the widespread reports of deteriorating water quality in the Great Lakes basin.

At the core of the water quality aspects of the Boundary Waters Treaty is an agreement that the two governments would not pollute the boundary waters to the injury of health or property on the other side. However, in the preamble to the Great Lakes Water Quality Agreement there is an acknowledgment by the governments that this has happened and that the boundary waters in the Great Lakes basin have been polluted to the injury of health and property on the other side.

Initial priorities and programs were oriented to documenting and controlling eutrophication and developing and implementing common water quality objectives. But in the 1960s and through the 1970s, Great Lakes scientists began reporting observations of gross effects of persistent toxic substances on the reproduction and development of avian wildlife and ranch mink. These observations influenced the renegotiation of the 1978 Agreement. In the 29 years since the signing of the original Agreement, there have been enormous advances in documenting this injury to many species and taxa of wildlife and in formally demonstrating the causal links to specific pollutants. It has, however, proven more elusive to document the injury to human health from exposures to pollutants. Initial cohorts were established in the 1970s to investigate exposures from consumption of Great Lakes fish and the first cohort to examine possible effects on infant development from maternal

consumption of Great Lakes fish contaminated with persistent toxic substances (Fein et al. 1983) was established in 1980. By the end of the 1980s, there was such a remarkable concordance between the developmental effects that had been observed in wildlife and those seen in studies of infants that it lead to the successful formulation of the unifying hypothesis of endocrine disruptors as a mechanistic explanatory principle linking effects on reproductive, developmental, neurological, endocrine and immune processes (Colborn and Clement, 1992).

These scientific findings were politically influential in both countries. In the late 1980s, Health Canada instituted its Great Lakes Health Effects Program, and in the early 1990s, the United States, through the amendments to the Clean Water Act, mandated the Agency for Toxic Substances and Disease Registry (ATSDR) to fund epidemiological research through the Critical Programs Act. The ATSDR studies confirmed that fish consumption is the major pathway of exposure to persistent toxic substances, such as dioxin, polychlorinated biphenyls and mercury, and identified at-risk populations, including Native Americans and other minorities, sport anglers, the elderly, males and females of reproductive age, and fetuses and infants of mothers consuming contaminated Great Lakes fish (Johnson et al. 1999). In human studies, increasing levels of sport fish consumption have been associated with difficulties in conception for Michigan sport fish anglers (Courval 1999). ATSDR has funded research and other community-based studies have the ability to influence policy and public health practice, thereby

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directly enhancing the health status of vulnerable communities through identifying at risk groups consuming Great Lakes sport fish and by disseminating outreach materials alerting the public about safe fish consumption.

Community Health and Areas of Concern

In the mid-1980s, the IJC expressed concern about the recurrent reports from the governments of locations around the Great Lakes where water quality was out of compliance with water quality objectives, and particularly in relation to pollution by persistent toxic substances. These locations became known as Areas of Concern (AOC) and were intended for special programs to restore water quality through the development and implementation of Remedial Action Plans.

Health Canada, through its Great Lakes Health Effects Program, undertook a research project to investigate whether the incidence rates of diseases were different in the 17 Canadian AOCs compared with the rest of Ontario and to generate hypotheses about whether these differences might be related to

exposures from local sources of pollutants. The data and statistics in the reports were compiled from a national databases kept by Statistics Canada for selected health endpoints that might be related to pollution and included mortality, morbidity as hospitalization, congenital anomalies and birth weights. There was considerable nervousness within Health Canada about releasing the 17 reports after comments were received from the local medical officers of health and from officials in Environment Canada and in the Ontario Ministry of Environment. But in November 1999, the reports were released to the public, just before the Great Lakes Health Effects Program was terminated on March 31, 2000.

Partly as a result of the availability of the Health Canada reports, the International Joint Commission directed the SAB to examine methodologies for assessing whether human health effects of pollution are occurring in communities in the Great Lakes basin. The SAB's Work Group on Ecosystem Health developed a workplan for a *Workshop on Methodologies for Community Health Assessment for Areas of Concern* , which was held on October 4 and 5, 2000 in Windsor, Ontario. The primary concerns to the members of the work group were reliable interpretations of the health data and statistics for the Health Canada reports, and the apparent absence of any comparable data for the AOCs in the United States.

The Workplan

• Review the 17 Great Lakes Health Effects reports to prepare a synthesis of the health status within the communities in the Canadian AOCs, with particular regard to the health status in Windsor.

• Examine the processes being employed in these communities to respond to this new information, with a focus on the response in Windsor.

• Inquire whether comparable U.S. data can be obtained.

• Examine how to obtain data on more subtle quality-of-life indicators within the AOC communities, including such health endpoints as thyroid dysfunction, diabetes and immune dysfunction.

• Obtain indirect evidence from monitoring the incidence of endocrine effects on wildlife populations that are geographically distributed close to AOCs.

• Investigate the possible links between the incidence of disease and exposures to pollutants.

• Investigate the associated societal costs.

Several past activities had been undertaken by the IJC and the governments to gain understanding of the Great Lakes health issues at the community level. In 1992, the Work Group on Ecosystem Health held a workshop titled *Our Community, Our Health: Dialogue Between Science and Community* .

In 1995, Health Canada published two documents titled *Investigating Human Community Exposure to Contaminants in the Environment* and *A Community Handbook.* In 1999, the Great Lakes Science Advisory Board held a *Meeting to Assess Scientific Issues in Relation to the Effects of Persistent Toxic Substances in Relation to Lakewide Management Plans* , and identified the need to assemble epidemiological evidence related to the effects on human communities. Much of the work undertaken has traditionally related to the incidence of cancer. With the recent publication of several papers documenting the experimental induction of a variety of effects from prenatal exposures to low doses of endocrine disruptors, there is now a priority need for communities to investigate whether these subtle effects are occurring among individuals within their communities.

Community health and injury to health from exposures to pollutants connote environmental epidemiology. Epidemiology has been undergoing a period of intellectual crisis and reassessment (Susser and Susser, 1996a, b; Pearce 1996). The crisis has been precipitated by the limits of the methodology for detecting significant relationships between the incidences of disease and exposures to putative risk factors. The reassessment has been prompted by a recognition of the need to reconnect the science of

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epidemiology with the practice of public health in its ongoing attempts to intervene effectively with large scale increases in the incidences of certain diseases of uncertain etiology. In the quest for making definitive causal statements relating disease incidences to specific factors, to determine whether preventive interventions are feasible, there has been a recognition of the need to develop an *eco-epidemiological* approach by integrating molecular epidemiology, with its orientation toward mechanistic hypotheses, with individual and population epidemiology, and to cast these in a social, economic and political context (Susser and Susser, 1996b). There are particular challenges of applying this new approach to environmental epidemiology, with all the attendant difficulties of measuring, estimating or inferring exposures (Pekkanen and Pearce, 2001). The International Joint Commission, comprised of the dual attributes of politics and science, first applied an *eco-epidemiological* methodology to several Great Lakes case histories in 1989, at its first *Cause-Effect Linkages Workshop* (Fox 1991).

Within the Great Lakes basin, the political context of the implementation of the Great Lakes Water Quality Agreement has not changed significantly since the early 1980s when the shift to the political right resulted in a general withdrawal of environmental issues from the political agenda of both countries. The consilience of results of so many epidemiological studies, together with the extensive surveys of the concentrations of persistent toxic

substances in the Great Lakes environment, and the research on the mechanistic processes, has created a strong dynamic tension with the maintenance of these existing policies formulated more than 20 years ago. The workshop was structured to explore this consilience and lay out the diversity of evidence and implications of not implementing the restoration provisions of the Agreement. The papers from the *Workshop on Methodologies for Community Health Assessment for Areas of Concern* are being prepared for publication in the journal of the National Institute of Environmental Health Sciences, *Environmental Health Perspectives.*

One of the critical health endpoints from exposures of communities to toxic substances concerns the effects on neurological development. In his keynote address at the *Workshop on Methodologies for Community Health Assessment for Areas of Concern* , Ted Schettler, (Schettler et al. 1999) of the Greater Boston Physicians for Social Responsibility, elaborated the evidence of the unique vulnerability of the developing brain to environmental agents, such as organochlorine compounds and metals, at exposure levels that have no lasting effect in the adult. This has been known for a long time, since there are even biblical prohibitions against drinking alcohol because of the long-lasting damage to brain development and function caused by prenatal alcohol exposure. Where registries have been established, the collection of health information on behavioural, learning and developmental effects has been significantly enhanced.

Recommendation

The SAB recommends the following to the IJC.

• Recommend that the Parties establish prospective and retrospective registries of neurological deficits to identify subpopulations at risk from exposures to developmental toxicants.

Health Effects in Canadian Areas of Concern:
17 Health Canada Reports

The 17 Health Canada reports on health data and statistics for diseases and conditions that might be related to pollution in the communities in the Canadian AOCs, represent an enormous database that potentially could contribute to the formulation of statements that could provide a rational basis for remedial action plans to restore environmental quality under the Great Lakes Water Quality Agreement and under the Canada - United States Air Quality Agreement. The reports with the data and statistics can be found at http://www.hc-sc.gc.ca/ehp/ehd/bch/bioregional/healthdata.htm. Before the reports can be utilized for this or any other purpose, such as selecting community health indicators, they needed to be interpreted. The objective of the IJC *Workshop on Methodologies for Community Health Assessment for Areas of Concern* was to focus on methodologies. The secondary objective was to provide detailed descriptions of the community health status within AOCs. The following is a brief review of the methodology that Health Canada used to compile the reports and of the methodologies used to

interpret the database. Health Canada detailed the methods used in the study under the following headings: Assigning Standard Geographic Codes; Selecting Health Outcomes; and Gathering and Analyzing the Data.

Assigning Standard Geographic Codes

Each of the 17 AOCs was described using Standard Geographic Codes that contain provincial, Census Division and Census Sub-Division information, and that coincide with the Canadian process for collection of human health data. Each of the 17 reports contained detailed background information on: the study area and its population; methods used in the study for assigning Standard Geographic Codes; and gathering associated health data. The population within each area in 1991 was determined and compared, as a percentage, with the Ontario provincial population, which was 10,104,317. Data for the incidence rates for diseases and disorders for the populations in all the AOCs were age standardized by gender and comparisons made with the incidence rates for the rest of Ontario.

Selecting Health Outcomes

Health Canada selected approximately 70 categories of health endpoints, using the International Classification of Diseases (ICD 1992). Because this project was undertaken by the former Great Lakes Health Effects Program under the mandate of the Great Lakes Water Quality Agreement, there was an orientation toward selecting diseases and disorders on the basis that they might plausibly be linked to exposures to contaminants in the Great Lakes environment based on references in the published literature. Appendix I. contains the selected health outcomes based on the Ninth Edition of the International Classification of Disease (1992).

Gathering and Analyzing the Data

Population census data for the years 1986 and 1991 were accessed from the Demography Division of Statistics Canada to calculate mortality and morbidity rates on an age-specific and gender-specific basis. Mortality data were provided to Health Canada's Center for Disease Control by Statistics Canada and included information on the cause of death, reported by ICD code, the last location of residence based on the Census Sub-Division, and the sex and age of the deceased. Hospital separations data were supplied by the Canadian Institutes for Health Information, and included data on sex, age and residence, and the ICD code for the diagnosis for the main cause of

hospitalization. Health Canada warned about some of the pitfalls of using hospital separations data and these concerns included multiple visits or transfers between or within hospitals. They also exclude visits to clinics, doctor's offices and outpatient departments. Similarly, there may have been difficulties in transforming residence information, based on a postal code or an Ontario Residence Code, into a Census Sub-Division. Further, these data for Ontario do not include Ontario residents who were hospitalized in another province.

These pitfalls were addressed in the Health Canada reports in analyzing the data and statistics. For example, in using the hospital separations data, Health Canada referred to morbidity rates rather than incidence rates. The data were initially analyzed using 19 age groups, but for simplification of reporting were combined into five age categories: all ages; 0-24 years; 25-44 years; 45-74 years; and more than 75 years. The age adjusted mortality and morbidity rates were compared with the rates for the rest of Ontario and ratios calculated comparing the local rates with the provincial rates. In the 17 reports, Health Canada included numerous references to aid in the interpretation of the data and statistics. In addition, several of the reports of the former Great Lakes Health Effects Program of Health Canada (1995, 1997, 1998) proved invaluable in the interpretation of the 17 reports on the health data and statistics particularly in relation to possible causal factors, including occupational exposures to chemicals and lifestyle factors such as alcohol and smoking.

The interpretation of the reports has proved to be a challenge, even for those with advanced degrees in public health. The challenges can be divided into: those associated with the diversity of health outcomes selected; useful ways of aggregating the endpoints into categories; and interpretation of the tables into comprehensible displays and narratives. In the interpretation of the reports, the following three approaches have been taken by the Work Group on Ecosystem Health and its contractors:

a. **mapping** of the distribution of the statistical significance of the ratio of the incidence rate for a particular health endpoint compared with the rate in the rest of Ontario;

b. **extended narrative** of the elevated incidences of diseases or conditions within a population in a specific Area of Concern and comparisons with other locations with similar population size and racial profile; and

c. **statistical analyses** to rank Areas of Concern on the basis of the aggregated severity of incidences of diseases and conditions and to select indices of environmental health.

Mapping

Based on the Health Canada data and statistics, Dr. John Eyles of McMaster University prepared maps of the distribution of incidence rates for some of the diseases and conditions compared with the rest of the Ontario. He concluded that the Health Canada findings present a complex picture of health outcomes in the Canadian AOCs. In some respects, he felt, such a complex picture presents a scientific maze for policy makers in the IJC and in the federal and provincial bodies. There is so much that is potentially significant that it may be difficult to know where to concentrate finite and limited resources. While mapping the Health Canada statistical data provides a useful and user-friendly lens on the issues, there do remain methodological issues connected with the critical data and well documented as a series of caveats in the Health Canada reports themselves. Further, while the rates are usually standardized to the provincial population, this may not be the best comparator for a binational body like the IJC. It is of central importance to Ontario-based policy makers in public health and environmental regulation. And while the identification of statistical significance is important, such an approach may indicate issues of low incidence or even low public health relevance, given current knowledge and priorities.

Dr. Eyles compared the standardized rates, for the selected health outcomes for the various AOCs, with the rates for the rest of the Ontario. Those outcomes in which the ratios of the standardized rates were statistically significantly above one, were identified, based on the argument that any *above average* deviation from the province is worthy of note. This technique identified, for example, the Detroit River Area of Concern for both men and women, and the Niagara River (women only) as worthy of further investigation, even at the ecological level. Thus, it may be worth doing some analysis of census data to see the associations between some health determinants and the identified health outcomes. In this way, it will be possible to account for, at the ecological level, some of the non-environmental determinants of health. Further work will enable a discussion of potential explanations of the associations between different health outcomes and environmental factors operating in the Canadian AOCs.

Extended Narrative: Focus on Windsor, Ontario

Marcia Valiante of the University of Windsor set the historic context of the bilateral concerns about transboundary air pollution at the Detroit River. Windsor and the outlying areas have had poor air quality as a palpable fact of life for the last 100 years. This region is also subject to greater incidences of certain health problems than other areas in Ontario. Investigating the link between these two facts is like assembling a jigsaw puzzle with many pieces missing and no picture to guide the task of assembling the available information about the state of the air in this region and comment on the relationship between local and transboundary sources.

Marcia Valiante noted that Windsor is uniquely located. It is a city of 200,000 residents (with another 100,000 in neighboring communities in Essex County), yet it has air quality that is generally worse than that of the largest cities in Canada. This is in large part because Windsor's air quality is closely linked to emissions from industry and transportation sources in Detroit and the rest of southeast Michigan, in the larger upwind context of the Great Lakes basin. But Windsor is not simply a faultless victim of another jurisdiction's neglect; local industry and transportation sources also contribute harmful emissions to the atmosphere.

She pointed out that air pollution is usually regulated on the basis of its health impacts due to direct inhalation. Standards in both the U.S. and Canada reflect this traditional concern with air emissions. More recently, other concerns have emerged. Studies have shown that there is a proportionately significant contribution from atmospheric deposition to the Great Lakes for certain persistent substances, such as PCBs and mercury, which may then build up in the environment to harmful levels. As well, many substances no longer emitted locally are still detected in the air and water due to atmospheric transport from distant sources. Finally, the atmosphere allows for the transformation of some substances into other compounds that can then have effects far downwind. This is the case with acid rain and smog. While understanding all of these interrelationships is important to a complete picture of air pollution's impacts, it is difficult to get that complete picture due to major information gaps.

Of the 17 Canadian AOCs, Windsor, Ontario seems to be the municipality ranked among the highest for incidences of diseases that might be related to pollution. Jim Brophy of the Occupational Health Clinics for Ontario Workers and Michael Gilbertson of the International Joint Commission used the Health Canada health data and statistics for the Detroit River Area of Concern to provide an extended narrative of the incidence rates of mortality and of cancer, of morbidity as hospitalizations, and of congenital anomalies. Mortality and morbidity rates from all causes were higher than in the rest of the province. Anomalously high rates of diseases included: various cancers; endocrine, nutritional, metabolic and immunity disorders; and

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diseases of the blood and blood-forming organs; nervous system and sense organs; circulatory and respiratory systems; digestive system; genitourinary system; skin and subcutaneous tissue; musculoskeletal system and connective tissues; congenital anomalies and infant mortality. These incidence rates for most diseases were much higher than those in Hamilton, another industrial municipality in southern Ontario, suggesting that, in addition to a variety of local sources of industrial pollution from automobile

manufacturing and use, there are transboundary sources of air and water pollution from Detroit that are potentially important causes of these health outcomes in the Windsor AOC. New United States and Canadian websites have been established that contain details of ongoing releases of toxic substances from industries and municipalities in Detroit and Windsor (http://www.scorecard.org and http://www.scorecard.org/pollutionwatch/ , respectively).

This pilot project by Health Canada would seem to be a useful preliminary method of integrating human health concerns and of priority setting for the administration of the Great Lakes Water Quality Agreement and the Canada - United States Air Quality Agreement. For the detailed community health profile for Windsor and the comparison with Hamilton, Ontario, see Appendix I.

Further Statistical Analyses

The availability of electronic versions of the Health Canada data (http://www.hc-sc.gc.ca/ehp/ehd/bch/bioregional/healthdata.htm) and the provision of significant funding by Environment Canada for the development of indicators provides an opportunity to further analyze these databases. For example, ranking, cluster analysis, correlational and principal component techniques could provide better descriptions of the disease profiles in the most polluted areas and selection of particular diseases that might most reliably be used to indicate the environmental health status in a community exposed to pollutants.

Responses from the Medical Officers of Health

After Health Canada had prepared reports on the health data and statistics for each of the 17 Canadian AOCs to generate hypotheses about the possible role of pollution on the incidence of mortality, morbidity and congenital anomalies, the respective report was sent to the local medical officers of health for information. The SAB then contracted with Dr. John Eyles to undertake a brief survey of the medical officers' responses to these reports. In every instance, the reports were referred to staff of the public health units, many of whom found the reports useful and who assisted in interpreting the reports.

There were, however, several concerns raised with Dr. Eyles about the reports. They were described as being too technical and dense and there were concerns expressed that, despite the following caveats, they might raise more questions than answers.

• They would have been more useful if the reports had contained an analysis and summary of the findings.

• Some of the populations in the AOCs were small and therefore provided limited statistical power for assessing the significance of the data.

• The use of hospitalization data may reflect the styles of practice at the facility rather than underlying health problems.

• The geographic boundaries of the AOC may not correspond to those of the public health unit and thus the reports were of limited value for their responsibilities.

The survey indicated that there may be a difference of opinion between the medical officers of health and the members of the public within a community about whether pollution is an important determinant of health. The diseases and risk factors that have been the traditional concerns of the medical officers of health include smoking, nutrition, heart disease, respiratory illness and cancer, and that environmental pollution tended not to be viewed as a factor affecting public health. The public, however, tends to view pollution as more important in determining diseases, especially in industrial settings, but this was viewed by some medical officers of health as a product of the media. Apart from cancer, respiratory disease, especially asthma, and the exacerbation of other disease conditions, such as heart disease and diabetes, the medical officers of health tended to be unclear about any connection between human health and pollution, while waiting for new evidence that could change their minds.

There were no plans on the part of the medical officers of health to release the reports to the general public in their Area of Concern. While most of the medical officers of health recognized that the statistical and epidemiological caveats had been addressed, they believed that the reports could amplify public concern over health problems in the AOCs, given the statistical significance of the presence of so many health endpoints. They believed that the populations in their AOC fared no better or

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worse than the other Ontario and Canadian populations, that public trust in all government institutions, including public health, is fragile, and that the reports could, when there is no solution, frighten the public.

Recommendations

The SAB recommends the following to the IJC.

• Recommend that the Parties establish institutional health structures at the local and regional level that can effectively investigate and respond to community health concerns that may be caused by chemical pollutants.

• Link human epidemiology to exposure data on air, water, sediments and biota in the preparation of future reports on Remedial Action Plans and Lakewide Management Plans.

Availability of Health Data in the United States

The Work Group on Ecosystem Health let two contracts to assess the availability of comparable health data for the eight Great Lakes states. One contract was with a student of Dr. David Carpenter at the State University of New York at Albany who collected information on the availability of health data in New York state. The second contract was with a student of Dr. Diane Henshel of the School of Public Health and Policy in Indiana University at Bloomington. The goals for these studies were to assess the availability of health data in the eight Great Lakes states: Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania and Wisconsin. The specific aims were to:

1. identify the status of the development of health databases (i.e. health registries) and the collection practices in each state and in the municipalities designated as an Area of Concern;

2. identify the accessibility of the public health databases relevant to exposures to pollutants;

3. characterize the quality of each database; and

4. identify the barriers to database access and information on database quality.

In order to quantify data accessibility, the state databases were ranked on several parameters that affect the usefulness of the public health databases for research purposes. Overall, the New York public health databases and registries stand out among the eight states for completeness and accessibility to researchers. The Illinois and Wisconsin databases rank just below that of New York, followed by the databases for Michigan and Pennsylvania. What registries exist for public health databases in Indiana are difficult to access. Databases for the Great Lakes region of Ohio are not accessible, although the public health databases for the rest of the state are available. The Minnesota registries do not present information at an individual level, and are therefore of minimal use to researchers trying to correlate data across multiple endpoints. In sum, there is too little consistency in the collection and availability of public health information across the eight Great Lakes states, making it more difficult for researchers to compare and use public health data on a region-wide basis.

In New York state, the Statewide Planning and Research Cooperative System records diagnoses by International Classification of Disease (ICD) code for all patients admitted to state-regulated hospital facilities. There are six AOCs in New York, and three, the Buffalo River, Niagara River and 18 Mile Creek, are contiguous in western New York and have similar

contaminants. These records can be utilized to compare the incidences of selected diseases reported in hospitalized patients who reside in zip codes that are within 15 miles of any of these sites to those of residents in the rest of New York state. Dr. Carpenter found significant elevations of disorders of the female genital tract, primarily due to endometriosis, and thyroid disease in women at all ages above 25 years, and significant elevations of diagnosis of ischemic heart disease and diseases of arteries, arterioles and capillaries in both men and women at some but not all age groups. The incidence of diabetes was significantly elevated in both men and women in the age range 25-44 years, but was significantly less in ages 55-74 years. Disease of the ovaries and testes were not different from the rest of New York. While many factors influence incidence of thyroid, genital and heart disease and diabetes, these results are consistent with the hypothesis that exposure to environmental contaminants through residence near polluted sites may be contributory.

There is a paradox between the need to access information on the health of individuals in order to operate a complex health care system with care that is accessible, efficient and of high quality and the need to protect the privacy of personal health care

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information. In Canada, there has been an impressive record of protecting the privacy of an individual's health information while making data available to *bona fide* health researchers. There are, however, bills both in the Federal Parliament of Canada and in the Ontario Provincial Legislature to introduce new legislation that may make access to and use of health data more complicated. Individual consent may be required to use information in new ways that had not been contemplated when the data was originally collected. Stronger requirements for obtaining these kinds of consent have been incorporated into legislation in the United States and in Europe.

Recommendations

In the preparation of evidence of injury to human health from exposures to pollutants at the boundary, in accordance with Article IV of the Boundary Waters Treaty, the SAB recommends the following to the IJC.

• Recommend that the Parties facilitate the access of researchers to health information, while not compromising the rights of individuals to privacy and confidentiality.

• Recommend that the Parties make representations, with respect to pending legislation on the privacy and confidentiality of health

information, to ensure that the capacity to monitor long term trends in pollutant-induced diseases and disorders is not jeopardized.

Biochemical Epidemiology

Glen Fox of the Canadian Wildlife Service, working at the biochemical and individual epizootiological levels, cited studies of Great Lakes wildlife species afflicted with thyroid and other endocrine disorders, metabolic diseases, altered immune function, reproductive impairment, developmental toxicity, genotoxicity or cancer, attributable to exposures to persistent organic pollutants, particularly PCBs, PCDDs and PAHs. The frequency and severity of these effects occurred in the most contaminated sites of Green Bay, Saginaw Bay, Lake Ontario, the St. Lawrence estuary, and, more recently, Lake Erie, some of which are Areas of Concern. Because these health impairments in wildlife resemble those observed with increased incidence in human subpopulations in one or more AOCs, wildlife could be used as a sentinel of the likely biochemical effects occurring in exposed human communities. These wildlife data were gathered as a result of academic research or research-based monitoring, rather than a formal effects monitoring program. While there are adequate long-term monitoring programs to document trends in concentrations of persistent toxic substances in the Great Lakes environment, there is no formal existing program for gathering long-term evidence for determining trends in the incidence and severity of their effects in wildlife. Such a program, using one or more sentinel wildlife species, would allow the Parties to the Great Lakes Water Quality Agreement to optimally use such information as a basis for decisions and policies regarding the effects of chemical exposures on human populations.

Recommendations

The SAB recommends the following to the IJC.

• Recommend that the Parties develop a coordinated binational monitoring program to determine the incidence of health effects in wildlife that have been attributed to exposures to persistent toxic substances.

Current human health and wildlife monitoring programs sometimes have levels of chemical analytical detection that are well above the concentrations at which biological effects occur.

• Recommend that the Parties monitor the chemical exposures of human and wildlife populations using limits of detection appropriate to the known toxicology of these substances.

Three papers explored the possibility of using the distribution of endocrine and immune diseases in human communities to identify small populations at high risk and indicate Areas of Concern. The requirements for diseases to serve this purpose include:

• agreement that the disease and markers can be employed as valid health indicators;

• the necessity that the disease have a short latency period in order to facilitate early detection;

• full clinical manifestation of the disease; and

• easy ascertainment from population-based investigations or from registries.

The first of these three papers was by Dr. Wilfried Karmaus concerning the use of thyroid disease. Although there is evidence that alterations in thyroid hormones are related to environmental exposures, thyroid disorders do not seem well suited to identify community exposures to thyroid active substances. While environmental exposures can produce effects within a short latency period, these are predominantly subclinical effects and may likely be undetected except in a special investigation. A few studies, occurring mainly in an occupational setting, have demonstrated a higher incidence of clinical thyroid diseases or related delays in neurological development in childhood, associated with environmental exposure. Thus, to identify potential health risks of thyroid active compounds in communities, epidemiological studies, including effect monitoring and human biomonitoring, are necessary. To overcome these limitations, Dr. Karmaus proposed the development of a network of exposed communities concerned about exposures. In addition to a representative national sampling, a network would provide assessments of exposures and health outcomes with different communities mutually serving as exposed and control groups. Residents of communities that participate in epidemiological studies are all too often subsequently neglected in the dissemination of information about the risks identified. Such a network could foster risk communication and prevention within communities where studies have been conducted.

The second paper, by Dr. Matthew Longnecker, concerned the etiology of diabetes within communities. The rates of both type 1 and type 2 diabetes mellitus have been increasing in the U.S. and elsewhere, and genetic factors account for less than half of the new cases. These observations suggest that environmental factors cause both type 1 and type 2 diabetes. Occupational exposures have been associated with increased risk of diabetes. In addition, recent data suggest that toxic substances in the environment, other than viruses or immunogenic dietary components, are associated with the occurrence of type 1 and type 2 diabetes. For type 1 diabetes, intake of nitrates, nitrites, and N-nitroso compounds have been associated with increased risk. Overall, however, the data were limited and inconsistent.

With respect to type 2 diabetes, data on arsenic and 2,3,7,8-tetrachlorodibenzo- *p* -dioxin (TCDD) in relation to risk were suggestive of an association but were inconclusive. The occupational data suggested that more data on exposure to N-nitroso compounds, arsenic, dioxins, talc, and straight oil machining fluids in relation to diabetes would be useful. Dr. Longnecker concluded that although environmental factors other than contaminants may account for the majority of type 1 and type 2 diabetes, the etiologic role of several contaminants and occupational exposures deserves further study.

The third paper, by Dr. Helen Tryphonas, Health Canada, concerned diseases of the immune system. Experimental animal studies indicate that environmental contaminants can have adverse effects on several organs and tissues of the immune system. Such effects are known to lead to increased host susceptibility to microbial infections and compromised immunosurveillance mechanisms that are normally instrumental in the elimination of neoplastic cells and the prevention of autoimmune diseases. Evaluation of the potential risks that environmental contaminants pose to the human immune system is currently accomplished via extrapolation of experimentally derived animal data to human. This process requires that uncertainty factors, such as interspecies differences and genetic variability, be taken into consideration. This process would be more manageable if data similar to that derived from experimental animals were available for human populations exposed to environmental contaminants. In view of the continuous exposure of humans to environmental contaminants there is, presently, a pressing need to improve the process of risk assessment by enlarging the human data base. To generate the much needed data, one must first identify a set of clinically relevant endpoints. Such endpoints, when adequately standardized, should be incorporated into the design of prospective epidemiologic studies.

While all three endpoints have potential to be used in these ways, there is still a need for developmental work and, if they are validated, make them operational.

Issues of Economic Costs of Disease and of Equity

The Work Group on Ecosystem Health had an interest in the direct and indirect economic costs of diseases that might be associated with exposures to pollution. In the field of economics there is extensive work being undertaken on this topic. Tom Muir of the Ontario Region of Environment Canada chose the following four candidate health outcomes for analysis: diabetes; Parkinson's disease; hypothyroidism; and deficits in IQ.

The methods used involve the examination of several lines of evidence, including empirical, methodological and theoretical.

First, the literature was reviewed to determine the evidence leading to the published concerns that exposures to environmental agents, particularly persistent toxic substances, are plausible risk factors to children, and the chosen effects or outcomes. Second, literature was reviewed to gauge and assess the extent to which approaches and methodology to measure such financial and economic costs and impacts, in general, are developed, and the extent to which case studies on our chosen outcomes have been undertaken. Where such methodologies and case studies existed, they were either cited, adapted, updated or expanded. Third, where no existing studies were found that evaluate or cost any of the selected effects, primary data sources were searched for, and where possible, estimates were made using the existing methodologies and/or economic theory. Throughout this exercise, efforts were made to develop estimates not only for Canada or the Canadian jurisdictions, but for the United States. In some cases, there are cost estimates for other countries, in the literature, and these are cited for comparison.

Based on these several lines of evidence, there are indications of an enormous cost burden for these diseases or conditions in the United States, Canada and elsewhere. Tom Muir reviewed actual social and economic costs, constructed estimates of some costs from pertinent sources, and provided several hypothetical examples that are consistent with published evidence. Many detailed costs are estimated, but these are fragmented, and missing in coverage and jurisdiction. Nonetheless, the cumulative costs identified are potentially very large and undoubtedly extend into the billions of dollars.

In the United States, environmental justice, concerned with equitable representation of all affected persons, particularly low-income people and persons of color, in environmental and environmental health decision-making, has become a prominent political issue. Dr. Rueben Warren of the Center for Disease Control and Prevention drew attention to the Presidential Executive Order 12898, on environmental justice, which encourages all federal agencies to ensure environmental justice in their policies, regulations and programmatic activities. People in communities across the country experience adverse living and health conditions due, in part, to the limited implementation of the Executive Order. Adverse health conditions associated with environmental toxins are a major problem expressed by environmental justice advocates and people living in close proximity to toxic and hazardous waste sites. They perceive a disproportionate burden of disease, dysfunction and premature death due to chemical contamination. They also believe that public health officials have not adequately responded to their health concerns. Dr. Warren discussed the history and current activities of the environmental justice movement and described human health threats posed by toxic and hazardous wastes. He reviewed strategies for collaboration between environmental justice advocates and public health

officials that, if implemented, should enhance the missions of both groups. More importantly, it is expected that through increased basic and applied research and public health advocacy and practice, the well-being and quality of life of low-income and people of color will improve.

Dr. Bernard Weiss of the School of Medicine and Dentistry at the University of Rochester, contrasted the ethical requirements for conducting experimental studies on drugs in humans with those for populations exposed to environmental contaminants. Drug testing in humans is governed by a body of principles whose main tenets have evolved over the past few decades. Three of these tenets provide the foundations for judging the ethical adequacy of such an experiment. One addresses the question of who receives the benefits of the research and who bears its burdens. A second requires that the research maximize the potential benefits to the subjects and minimize the risk of harm. The third concerns the source of guidelines for informed consent and requires that subjects enter into the research voluntarily and with adequate information. By contrast, unlike research conducted to evaluate drugs, those responsible for environmental exposures to potentially toxic chemicals neither survey those exposed for their consent, nor provide an appropriate calculus for measuring risks and benefits. Dr. Weiss concluded that a process of ethics assessment may need to be incorporated, as a new element, into risk characterization, especially for exposure to developmental neurotoxicants, where the risk-benefit incompatibility between different populations can be so striking.

Contrasting the Scientific Approach and the Public Health Approach

The Great Lakes Science Advisory Board noted that there has been a significant debate recently about decision making in relation to the protection of public health. Mr. Horace Krever headed a commission into a major public health disaster in Canada from the presence of HIV and hepatitis-C in the blood supply. The findings from the judicial investigation of the blood supply disaster may have important lessons for those involved in policy making under the Agreement. Specifically, pollution of the Great Lakes with persistent toxic substances may present several analogous situations.

Mr. Krever pointed out that a chief factor leading to the infection of so many people with a deadly virus was the influence of the traditional way of thinking of the scientists, when what was more appropriate was the method of the public health practitioners.

He noted that there are essential differences between the scientific approach and the public health approach. The former was characterized by a refusal to accept that the illness could be spread by blood until Koch's Postulates had been satisfied and this lead to lengthy and undue delays in introducing the screening of blood donors and the subsequent testing of blood donations. The absence of definitive proof of a link between AIDS and blood transfusion was consistently used as a justification for maintaining the *status quo* . Strong action to reduce the risk of AIDS should not have required conclusive evidence. If there was even a possibility of transmission of the virus via blood, there was, above all, a moral and legal obligation to protect the blood recipient. Where there is reasonable evidence of an impending threat of public health it is inappropriate to require proof of causation beyond a reasonable doubt before taking steps to avert the threat.

Mr. Krever noted that, in environmental matters, this precautionary principle has become part of a number of international treaties and declarations, including the Second and Third International Conference of the Protection of the North Sea concerning ocean dumping. The application of the precautionary principle is not problem free. First, on some occasions, it will turn out after the fact that precaution was, with the benefit of hindsight, not necessary, and moreover, was costly. The second problem relates to the application of cost-benefit analysis that should not be a deterrent in the application of the precautionary principle. Risk management is defective if it protects only the risk creators and permitters and not also the person suffering the harm when inevitably the risk accrues. For these circumstances, there should be no fault compensation for victims of the harm created by the risk. The compassion of the society can be judged by the measure it takes to reduce the impact of the tragedy on its members.

Mr. Krever concluded by posing several questions. What should we as a society do about polluters, and about pollution? Should we shut down the polluter's business and so create unemployment by making them undertake preventive measures that are so cost prohibitive that their businesses become unprofitable? Or do we simply warn consumers of the products poisoned by the pollution? More philosophically, what right do we have, as the current and very temporary trustees of the environment, to decide, even for apparently sound reasons, to permit the destruction of land and water?

Conclusions

Epidemiological data on incidences of mortality, morbidity as hospitalization, congenital anomalies and infant mortality are useful to detect gross differences in rates between communities that might be related to pollutants. On the basis of epidemiological data and statistics on health endpoints that might be related to exposures to pollutants, there are several Areas of Concern that have elevated incidences of diseases. Similarly, research on wildlife populations for exposure and disease has provided exposure and effects information that is directly relevant to research on human health.

Local health authorities have well developed institutional structures for preventing diseases caused by microbiological agents and for investigating and responding to disease outbreaks. In contrast, there is a generalized reluctance at all levels of government to detect and publicly acknowledge anomalous incidences of diseases and disorders within communities that may have been caused by chemical pollutants, and there seems to be an apparent aversion to establishing the necessary institutional health structures at the local and regional levels that can effectively investigate and respond to community health crises that may be caused by chemical pollutants.

There is growing evidence of an increase in learning, behavior and developmental problems in the North American population. Exposure to persistent pollutants may contribute to this situation by their actions on physiological functions, and in particular the neuro-endocrine axis. While these may not be readily apparent in the individual, they can have important effects on a population level. There is a priority to address these questions through:

• tracking, monitoring and surveillance using registries, hospitalization, school performance records, and use of pharmaceutical utilization data; and

• integration of data bases on exposure assessment, health, and academic and behavioral performance indicators.

Research Needs

The SAB has identified the following specific research needs concerning community health:

• to examine the subtle decrements in neurofunctional capacities, immunological, hormonal and reproductive functions in

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relation to exposures in adult and child populations;

• to determine whether subtle functional decrements in wildlife reduce survival, growth and population numbers of wildlife;

• to use the new information on the human genome to evaluate how genetic susceptibility explains human responses to environmental pollutants and help identify the more sensitive sub-populations that may need additional consideration in the development of regulations and regulatory actions;

• to investigate interrelations between exposure and the socio-economic environment with a view toward better policy making;

• to develop methodologies that will allow for better integration of information from exposure, health and social data sets, and to develop more effective means of applying animal experimentation and wildlife studies to humans; and

• to assess the impact of the biological effects resulting from chemical exposure on community well-being.

2.2.2 Protecting Human Health from Exposure to Contaminants in Great Lakes Fish

Introduction

Fish in the Great Lakes basin are contaminated with a variety of persistent toxic substances and this raises concerns about the suitability of fish as food. In the past 30 years, agencies responsible for public health and for fisheries have had to respond to the challenge of maintaining the recreational use of the Great Lakes fisheries resources while protecting public health from exposures to persistent toxic substances. Governments have responded to this challenge by publishing advisories on the consumption of Great Lakes fish. For example, in Ontario, there is a *Guide to Eating Ontario Sport Fish* , published and distributed annually to anglers, particularly through the Liquor Control Board of Ontario and outfitters selling fishing licenses. For the past decade, the Council of Great Lakes Governors has convened a Great Lakes Fish Advisory Task Force to develop a common protocol for an advisory for contaminants in fish across all the Great Lakes states. Fish consumption advisories have been based on the estimation of `safe' concentrations of each contaminant based on toxicological data. Toxicology experiments have traditionally been undertaken at high dosage concentrations, and the safe concentrations have been estimated by applying safety factors to the dosage at which there was no effect observed. It has been assumed that the public would be protected as long as the concentrations in the Great Lakes fish that were being consumed were below these concentrations. As the IJC pointed out in its Tenth Biennial Report on Great Lakes Water Quality, fish consumption advisories are not a guarantee of safety and for more than the past 30 years, fish advisories have generally become more restrictive as knowledge increased and more sensitive endpoints were reported from human health research.

Risk Assessment and Limitations

In 1983, the U.S. Environmental Protection Service introduced a formal risk assessment process that has been widely applied to the setting of `safe' concentrations for consumption of Great Lakes fish. The current advisories are based on a series of assumptions, including:

• the risk can be defined;

• the critical variables to be managed can be identified; and

• specific actions and techniques are available and effective for achieving management goals.

Most Great Lake jurisdictions include consideration of the species consumed, intervals of consumption, quantities consumed, cooking methods, location caught, size of fish and exposure of sensitive populations. There is, however, always a danger that current advisories do not reflect the latest research.

For example, in 1990, the endocrine disruptor hypothesis was proposed (Colborn and Clement, 1992; Colborn et al. 1993). The thesis is that structural and functional developmental processes, such as differentiation of the reproductive anatomy and of neurological and immunological processes, is under the control of a large variety of chemical messengers. These include, not only the traditional hormones from glands, but also various growth factors, interleukins and cellular receptors, collectively known, for the purposes of this hypothesis, as the endocrine system. The mechanism of control action of these chemical

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messengers is through interactions at receptor sites and turning specific genes on or off at predetermined periods of development. The products from these genes in turn affect other cellular processes, such as cell division or cellular differentiation. The concentrations at which these chemical messengers operate are at fractions of a trillionth of a gram.

Certain natural and man-made chemicals can interfere with the production, transport and metabolism of these chemical messengers, or they can mimic or block the chemical messengers at the receptor sites. These interferences with the endocrine system can result in irreversible alterations to a wide variety of developmental processes, including the reproductive anatomy (Gray et al. 1999), the neurological (Colborn et al. 1998) and immunological (Voccia et al. 1999; Colborn 1995; Porter et al. 1999) systems. These natural and man-made endocrine disruptors are at concentrations much higher than the concentrations of the chemical messengers that control developmental processes. They are not necessarily bound to carrier proteins that moderate the endocrine activity of the normal hormones. In traditional toxicology, the effect becomes more pronounced as the dose or concentration of the compound increases yielding a monotonic relationship. However, the dose-response relations with endocrine disruptors tend to be non-monotonic.

Though this is a well-established phenomenon in endocrinology, it has not been a general consideration in traditional toxicology. On October 10-12, 2000, at the request of the U.S. Environmental Protection Agency, the

National Toxicology Program and the National Institute of Environmental Health Sciences organized and conducted a scientific peer review meeting to evaluate reported low-dose effects and dose-response relationships for endocrine disrupting chemicals. The participants were from a variety of interests including industry and environmental non-government organizations. For this meeting, `low-dose effects' referred to biological changes that occur in the range of human exposures or at doses that are lower than those typically used in the U.S. EPA's standard testing paradigm for evaluating reproductive and developmental toxicity. The Statistics and Dose-Response Modeling Subpanel analyzed the data for 38 studies prior to the meeting and provided its analyses to the four other subpanels on: Bisphenol A; Estradiol and other estrogens; androgens and antiandrogens; biological factors; and study design.

Based upon presentations by the individual subpanels and general discussions during the plenary session, preliminary conclusions from this peer-review meeting include the following.

• Low-dose effects have been clearly demonstrated for estradiol and some estrogenic compounds. For example, low-dose findings for nonylphenol and the phytoestrogen genistein include effects on the immune system and on neurological structure.

• Effects of antiandrogenic compounds have been demonstrated for some endpoints and the dose-response curve appears linear to the lowest dose tested; however, it was noted that the available studies were not designed to evaluate low-dose effects as defined for this review.

Workshop participants identified areas for additional research that would clarify uncertainties about the occurrence of low-dose effects and better characterize those observed effects. These include using pharmacological and genetic approaches to determine mechanisms of action and to characterize dose-response relationships, characterizing response longevity from gestation through adulthood, evaluating long-term health outcomes, investigating the basis for immune system effects, and determining the impact of variations in endogenous hormone levels. The implications of these irreversible low-dose phenomena, particularly for community health, are far reaching and the main consideration is that very low concentrations of these substances cause endocrine disruption, and humans should not be exposed to them. The final report of the National Institute of Environmental Health Sciences' Endocrine Disruptor Low-Dose Peer Review has been released for public comment and is posted at

http://www.ntp-server.niehs.nih.gov/htdocs/liason/LowDosePeerFinalRpt.pdf.

There is a wide array of documented effects in humans, wildlife and in experimental animals in the laboratory. In several populations, there have been increased rates of testicular and prostate cancer, cryptorchidism and

hypospadias, and decreases in sperm quality (Toppari et al. 1996; Swan et al. 1997). Recent epidemiological studies have shown that women who ate Lake Ontario fish for seven years prior to pregnancy had shorter menstrual cycles (Mendola et al. 1997) and maternal consumption of Lake Ontario fish for three to six years was associated with a reduced biological capacity to reproduce (Buck et al. 2000). Similarly, an epidemiological study of anglers and their families found an association between the amount of sport-caught fish consumed by males and a delay in conception (Courval et al. 1999). Consumption of contaminated fish from the St. Lawrence River has been associated with a decline in short-term memory, attention and fine motor skills in adult fisherfolk (Mergler et al. 1997; 1999). Similar findings have recently been published that show the impact of PCBs and other fish-borne contaminants on intellectual functioning in older adults who ate more than 24 lbs. per year of sport fish caught in Lake Michigan (Schantz et al.

2001). There are many chemicals in Great Lakes fish that have been shown to be endocrine disruptors, including DDT and metabolites, PCBs and dioxins. More particularly, there are increasing Great Lakes concentrations of brominated organic flame retardants that are endocrine disruptors, such as polybrominated biphenyl ethers (Darnerud et al. 2001). In addition, there are many modern pesticides in use that are endocrine disruptors and to which the population in the Great Lakes basin is exposed.

Of particular concern are the effects on the developing brain. For example, in a cohort of infants established in 1980, maternal consumption of Lake Michigan fish prior to and during pregnancy was associated with the following effects associated with exposure *in utero* to PCBs: poorer performance in tests of visual recognition memory in infants (Jacobson et al. 1985); poorer verbal and numerical memory in four year old children (Jacobson et al. 1990); and a loss of more than six IQ points by the time the children had become 11 years old (Jacobson and Jacobson, 1996). Ten years later, the results were replicated in another cohort of infants established in 1990, some of whose mothers had eaten Lake Ontario fish prior to pregnancy (Lonky et al. 1996). The effects were most pronounced in infants who were most exposed to the higher chlorinated PCBs, and included an inability to habituate to unpleasant events (Stewart et al. 2000). Subsequent studies at six and at 12 months showed poorer performance in intelligence tests in those children with the highest PCB levels (Darvill et al. 2000). Though these neurological effects are statistically robust, there have been questions about whether they are biologically significant since the shift downwards in scores is within two standard deviations of the mean and thus not outside the lower 95 percent confidence limit for the population. Should these statistically significant losses be regarded as adverse biological effects?

It would seem that no community or civilization, and particularly one that is so highly dependent on the collection and processing of information, can afford the systematic loss of neurological functioning (Weiss 1997).

Studies of several different human populations exposed to PCBs before birth, suggest that prenatal exposure results in a reduction of overall IQ of six to eight points, and other studies show motor and sensory decrements upon pesticide exposures. While this may not be a sufficiently large decrement so as to greatly influence any single individual's lifetime productivity, on a population basis this may exert very important societal effects. Most human populations are never exposed to a single toxic substance, and indeed Great Lakes fish contain many different chemicals. However animal studies of single chemicals, such as PCBs, methyl mercury and persistent pesticides, alone or in combination, or animals being fed contaminated fish, all confirm alterations in brain function consistent with reduced intelligence, a shortened attention span and increased frustration.

The new information about endocrine disruptors poses several questions in relation to traditional risk assessment. Can `safe' concentrations of these compounds be determined from traditional toxicology testing at high doses? Did the application of traditional toxicological approaches to derive `safe' levels for compounds, that are now known to be endocrine disruptors, lead to injury to human health even in those who followed the fish consumption advisories? Where there is a possibility that injury may occur, is it essential, in the interest of public health and safety, that responsible parties be identified and empowered to take appropriate direct action to avoid, prevent or mitigate future harm? Might abrogation of this responsibility, by responsible parties in matters related to public health protection, result in findings of liability, negligence and even criminality by the courts or in official inquiries, such as the Krever Commission? Where the consequences are serious, would decision makers be held accountable for adopting policies, programs and practices that were not risk averse, and that promoted safety, instead of precaution? Are the scientific uncertainties of such a degree that the general public should be warned not to eat any fish from the Great Lakes or the St. Lawrence River, until remedial actions have reduced the concentrations to levels at which effects on the endocrine system and on developmental processes do not occur?

Risk Management

Fish consumption advisories have been described (Knuth 1995) as a "risk management tool designed to inform fish consumers about how to minimize exposures to chemical contaminants." Other risk management tools have been implemented in the past, including closure of commercial fisheries and the mid-1970s prohibition by New York state of the possession of certain sport fish from Lake Ontario. This last means was met with such flagrant violation of the law that the regulation was rescinded within months of proclamation. The objective in developing fish consumption advisories has been to give people enough information to make their own decisions about

how much Great Lakes fish to eat and their likely exposure to persistent toxic substances through consumption of fish.

The development and implementation of the risk management program for consumption of fish from the Great Lakes is based on the following premises:

• the principal route of human exposure to persistent toxic substances in the Great Lakes region is through the food chain;

• there is a significant body of scientific research related to understanding human health effects from eating Great Lakes fish;

• implementation of remedial work will lead to declines in the concentrations of persistent toxic substances in fish; and

• fish consumption advisories must be based on assessing risk based on the most sensitive end points and to the most sensitive subpopulations.

There is a significant body of evidence that, for example, neurological effects from prenatal exposure to PCBs may be the most sensitive endpoint, and women of child-bearing age and children may be the most sensitive subpopulations. For these reasons, risk management, in the form of fish consumption advisories, is not necessarily uniform for the entire population. Based on scientific research, risk managers might communicate different advice to different age groups ranging from unlimited fish consumption, to complete avoidance.

Risk Communication

The success of any risk management approach depends on effective risk communication. This, in turn, requires that there is not only agreement on a clear message to be communicated, but also appropriate methods for communicating that message. In the past, the states and provinces each issued fish consumption advisories applicable to the fish caught in their jurisdictions. Because of differences in the approaches used by the jurisdictions to calculate acceptable exposures, the resulting advice might differ between jurisdictions. In the mid-1980s, there was a growing concern that advice in some jurisdictions was less protective of the public and sensitive subpopulations and this lead to confusion for the general public. In an effort to address this inconsistency, the Council of Great Lakes Governors convened a Great Lakes Fish Advisory Task Force to develop a common protocol for an advisory for PCBs across all the Great Lakes states. However, this effort took nearly 10 years of scientific review and

negotiations before completion in 1995, and no other common advisories have been developed for any other persistent toxic substance.

There has been extensive social science research undertaken on the effectiveness of communication of the fish consumption advisories and much of this has been reviewed by Grondin and LaRue (http://www.hc-sc.gc.ca/ehp/ehd/catalogue/bch_pubs/great_lakes_part2.pdf). For example, early work among New York state anglers indicated that those who were older, more educated, higher income, male and white had a higher awareness of the advisories (Connelly et al. 1993). Overall knowledge on the adverse health effects of fish consumption was high, though knowledge of the recommendations in the advisories tended to be inaccurate. While dissemination of the information through brochures distributed with fishing licences is an effective means of communicating the message to certain groups, there are many subpopulations, such as women and certain ethnic groups, who were not being reached (Knuth 1995). Programs have been developed to communicate more effectively with these groups. A more recent survey has shown the scale of Great Lakes fish consumption (Tilden et al. 1997). In the eight Great Lakes states, about 4.7 million people eat Great Lakes fish, and women accounted for 44 percent of these Great Lakes fish consumers. This study confirmed the results from the previous work, that women tended to have a poor awareness of the advisories, suggesting the need for special risk communication strategies.

There are difficulties in obtaining similar statistics for Canadian angling in the Great Lakes, because no comparable random survey has been undertaken. There is one estimate from the mid-1980s that 37 percent of the general population of Ontario (about 10 million people) participated in sportfishing an average of five times per person per year (Usher et al. 1987). A survey by the Department of Fisheries and Oceans (1997) showed that there were 1,928,568 licenses issued in 1995, of which 1,342,567 were to Ontario residents. Instead of a random sampling approach to estimate the number of anglers in the province, Health Canada (1997), through its former Great Lakes Health Effects Program, undertook a Fish and Wildlife Nutrition Project as a series of surveys of anglers at the following five Great Lakes Areas of Concern: Metro Toronto; St. Clair River; Detroit River; Hamilton Harbour; and the Niagara River (http://www.hc-sc.gc.ca/ehp/ehd/catalogue/bch_pubs/monograph.pdf).

There is no specific requirement that the fish consumption advisories reflect current research results. While public and private efforts throughout the basin promote the consumption of Great Lakes fish, research undertaken in the past decade continues to raise serious public health questions about the harmful effects of exposures to persistent toxic substances. While these forces tend to minimize the risk detailed under current fish advisories, new research suggests that many of the current advisories are set at much too high a level, and do not adequately protect public health. If these questions escalate among the public into serious

concerns about health, there is the potential for widespread dissatisfaction with the fish consumption advisory approach. As understanding of the toxic effects of exposures to persistent toxic substances increases over time, a transparent and accountable process for updating the advisories with current scientific understanding of health effects is needed.

In the case of other highly exposed groups, such as ethnic and native subsistence consumers who choose to exceed or ignore the recommendations of the advisories, they assume a risk that is accordingly higher than would otherwise be the case if the advisory were to be followed. In order to reduce the risk to this group to within a no observable effects level assumed by the advisories, it is necessary to improve communication and understanding, sufficient to support a modification of behaviour that respects the advisory. Recent social research is only beginning to identify the important elements of a risk communication strategy to better convey information to support improved personal decision making.

Because of the serious public health implications already acknowledged from consuming Great Lakes fish, and the complex scientific issues related to the significance of new findings from the latest scientific research on human health effects, the SAB recommends that the task of reviewing and developing a uniform, protective advisory be undertaken on a scientific basis by a third party, with adequate human and financial resources provided by the governments to achieve a rigorous and credible result.

Recommendation

Accordingly, the SAB recommends the following to the IJC.

• **Recommend to the Parties that the U.S. National Academy of Sciences and the Royal Society of Canada convene a binational committee to develop a uniform and consistent protocol to protect human health from contaminants in Great Lakes fish.**

Given insufficient progress on this matter to date, the conduct of such a study should give consideration, but not necessarily be restricted to the following issues:

• the application of the latest health effects research in risk assessment calculations and the development of a process to include new findings;

• the use of a safety factor above and beyond the risk assessment calculation to ensure protection for the range of human responses to toxins, for potential synergistic effects of multiple toxic exposures, for effects not yet fully

quantified, and protection of subpopulations at greater risk than the target population, particularly children;

• the improvement of risk communication efforts, particularly to protect sensitive populations, for example, subsistence anglers; and

• the identification of risk communication challenges, including the key factors related to perception and awareness that affect changes in attitudes and fish consumption behaviour.

2.3 WATER QUALITY ASSESSMENT AND REPORTING

2.3.1 Review of Annex 1 of the Great Lakes Water Quality Agreement

Introduction

In fall 1999, the Work Group on Parties Implementation began work to obtain newly released data from U.S. EPA's Lake Michigan Mass Balance (LMMB) project and compare these data to Specific Objectives in Annex 1 of the Agreement.

Review of the available data showed that only two of the compounds included in the LMMB project, mercury and trans-nonachlor (a component of chlordane), are comparable to Specific Objectives in Annex 1. More importantly, the data revealed that concentrations of these two compounds in the open lake water column are approximately three orders of magnitude below the Specific Objectives.

While this could be viewed as good news, discussion within the work group and during a meeting with U.S. EPA officials managing the LMMB led to the conclusion that the Specific Objectives might not be stringent enough. For example, it was noted that while open lake mercury concentrations are far below the mercury Specific Objective, "we still have problems with mercury," such as widespread fish consumption advisories. Therefore, the task evolved into an examination of the Specific Objectives themselves.

Specific Objectives were incorporated into the Great Lakes Water Quality Agreement in 1978 and reflect the science and understanding of chronic and

acute effects on human and aquatic ecosystem health prevalent at that time. Our understanding of cause and effect relationships, the nature of the threat posed by contaminants, and factors that impinge upon human and ecosystem health has improved considerably over the past quarter century. In addition, the information base about the environmental occurrences of these substances and programs in place for their regulation continue to evolve.

In keeping with the Commission's responsibility under Article VII of the Agreement, to tender "advice and recommendations to the Parties in connection with matters covered under the Annexes to th[e] Agreement" and to ensure that the Agreement remains strong and relevant, the work group decided to undertake a review of Annex 1.

A Proposal to the Commission

To secure the resources necessary to carry out this task, a white paper was presented to the IJC during its fall 2000 semi-annual meeting. The Commission subsequently allocated the resources.

The intent was to frame the issue as opposed to development of new or alternative Specific Objectives or other prescriptive solutions. To address the task, the work group commissioned the preparation of a background report and then convened a workshop where interested stakeholders could learn about the issue and share their opinions.

Background Report

Limno-Tech, Inc. of Ann Arbor, Michigan was chosen to prepare a background report, specifically to:

• compile the most current field data representative of open-lake conditions and compare those data with the Specific Objectives;

• compile current statutory, regulatory and policy values used by the United States and Canadian federal agencies, Great Lakes state agencies, and Ontario provincial government agencies to manage Great Lakes environmental quality and, where possible, compare those values with the Specific Objectives;

• summarize how each Great Lakes agency assesses compliance with its set of statutory, regulatory and policy values; and

• summarize the conceptual basis and rationale for the development and application of each set of values from the second task above.

The report, which is posted on the IJC's web site at **http://www.ijc.org/rel/agree/annex1/index.html** , was not intended to be a comprehensive review. Resource and time constraints were such that data were collected primarily from federal, state and provincial government sources. Data reviewed were limited to those reflecting the open waters of the lakes, though the Specific Objectives are not similarly limited in their

application. Only data generated within the last five years were included and did not necessarily represent comprehensive spatial coverage. All data were assumed to meet the quality assurance/quality control requirements of the programs within which they were generated. Despite these limitations, the report provided sufficient information to allow judgments to be made about the currency and relevance of Annex 1.

Key information from the report follows.

Comparison of Environmental Data to Specific Objectives

The goal of this screening-level study was to make general comparisons of whether the data are less than, equal to or greater than the Specific Objectives. The statistical and environmental significance of any differences noted were not evaluated.

Concentrations of most Annex 1 substances are apparently below their Specific Objectives in all the lakes, both in the open lake water column and in fish tissue. Differences of an order of magnitude or more are common, especially for water column data.

The most significant exceedances that occur are for the fish tissue objectives. PCBs exceed the fish tissue objective in all takes by multiples ranging from approximately four in Lake Superior to almost 18 in Lake Michigan. DDT and its metabolites slightly exceed the fish tissue objective in Lake Michigan and approach it in lakes Huron and Ontario. Mirex, with a Specific Objective of no detection in fish tissue, is detectable in at least some fish in all the lakes. Lake Ontario has the highest frequency of detection and also the highest concentrations detected. All other lakes are relatively low on both counts.

Other apparent exceedances occur for guthion and un-ionized ammonia in Lake Erie. The detection limit for readily available parathion data is above the Specific Objective in some lakes.

Comparison of Regulatory and Policy Values

with Specific Objectives

Regulatory and policy values (i.e. standards, criteria, guidelines) were reviewed for jurisdictions within the Great Lakes basin. Among the key findings are many inconsistencies both in terms of specific values and in terms of substances included. There are a number of Specific Objectives for which some or all of the jurisdictions examined have no comparable policy

value. Conversely, there are many substances for which policy values exist, but for which there are no Specific Objectives. The closest correspondence, in terms of substances included and numeric objectives is with the Ontario Provincial Water Quality Objectives promulgated in 1979.

Specific Objectives based on water concentrations are often lower than policy values intended to protect aquatic life. However, water concentration policy values intended for protection of human or wildlife consumers of aquatic organisms are almost always orders of magnitude below the Specific Objective. For example, the Specific Objective for aldrin/dieldrin in water is 0.001 g/L. Ontario Provincial Water Quality Objectives and U.S. EPA Great Lakes Water Quality Guidance values for protection of aquatic life are 0.001 and 0.056 g/L, respectively. However, the Water Quality Guidance value for protection of humans exposed through fish consumption is 0.0000065 g/L, almost three orders of magnitude below the Specific Objective.

Where there are regulatory or policy values to compare with the various fish tissue-based Specific Objectives, the Specific Objectives are not the lowest values in any instance. However, the discrepancies tend to be less than for water-based values, with very few even as large as an order of magnitude. For example, the Specific Objective for aldrin/dieldrin in edible fish tissue is 0.3 g/g (wet weight). The comparable policy values for the U.S. FDA (commercial fish sales) and the states of Michigan and Ohio (trigger levels for fish consumption advisories) are 0.3, 0.3 and 0.05 g/g, respectively.

Monitoring and Compliance Assessment

The effort to compare environmental data to the Specific Objectives focused primarily on data available from government agencies. Attempts were made to obtain data for comparison to 37 Specific Objectives (open lake water column and/or fish tissue) in each of the five lakes, a total of 185 comparisons. In 73 instances, 40 percent, data could not be obtained because no agency contacted does the appropriate monitoring. Monitoring programs at the state and local level tend to be aimed at nearshore areas, particularly Areas of Concern. Much effort is being directed by the various jurisdictions toward assessing fish tissue levels and the impacts of contaminated sediment in the Areas of Concern.

The effort to learn about how the jurisdictions judge compliance with their own regulatory or policy values was intended to provide insight into how achievement of the Specific Objectives might be determined, as required by Article IV of the Agreement. The finding was that none of the agencies contacted has a formal program in place to judge compliance with its policy values. There are some informal efforts undertaken by Environment Canada but there is no formal reporting. U.S. EPA does not presently systematically review open lake water quality data or compare the data to U.S. EPA Great Lakes Water Quality Guidance or other criteria. States and provinces similarly do not have formal programs for judging compliance with their regulatory or policy values.

Workshop

A workshop titled *Review of Annex 1 of the Great Lakes Water Quality Agreement* was held in Ann Arbor, Michigan on March 21, 2001. Approximately 40 attendees heard a series of presentations on the history of Annex 1, the background report, the science of standard setting and the science of compliance assessment. These presentations were followed by an `options panel' with representatives from the two Parties, industry and the environmental community. A plenary discussion followed. The panel and subsequent plenary discussion focused on the following questions:

• Is Annex 1 still relevant and useful? Why or why not?

• Should Annex 1 be revised? If so, how?

• Is there a role for ecological indicators (for example, SOLEC) in the Agreement?

• How should achievement of Specific Objectives be judged?

The following are significant highlights from the workshop. The full workshop transcript is posted on the IJC's web site at **http://www.ijc.org/rel/agree/annex1/index.html** .

History of Annex 1

Dr. Joel Fisher of the IJC's U.S. Section explained that Annex 1 was part of the original Agreement signed in 1972. It contained `final' objectives for eight substances and `interim' objectives for five substances or classes of substances. The objectives were based, at least in part, on criteria and objectives in place in other jurisdictions at the time. Most of the Specific Objectives currently in place were added when the Agreement was revised in 1978, taking advantage of extensive studies in both countries and elsewhere into contaminant effects culminating, for example, in the development of water quality criteria mandated by the 1972 U.S. Clean Water Act. The 1987 Protocol to the Agreement added the Supplement to Annex 1 but did not add or change any Specific Objectives.

Issues Raised by The Background Report

Wendy Larson, Limno-Tech, Inc., reported the findings in the background report as summarized above. Dr. Joseph DePinto, also of Limno-Tech, Inc., discussed some issues that arose during the study.

Variations between agencies in sampling and analytical protocols made it difficult to put all the data on a common footing to allow fair comparisons with the Specific Objectives. There was also variation in the way data were provided. Some agencies provided raw data and some provided averages. Handling of censored data (for example, non-detects) when computing averages also varied among agencies. The contractor noted internal inconsistencies for some substances that have both water and tissue Specific Objectives. That is, given current knowledge of bioaccumulation factors, the tissue concentrations are not consistent with what would be expected to occur in fish bioaccumulating the substance from water at the specified concentration.

When considering regulatory and policy values, Limno-Tech, Inc. noted that the Canadian Water Quality Guidelines cover 54 more substances than are included in the Specific Objectives. The U.S. EPA Great Lakes Water Quality Guidance covers 11 extra compounds. Those states that have chosen to implement the Great Lakes Water Quality Guidance's Tier 2 methodology potentially have policy values for hundreds of substances not included in Annex 1. It was also noted that unlike policy values from the various basin jurisdictions, the conceptual basis for the Specific Objectives is not always clear. For example, it is not always clear what is being protected and at what level.

The Science of Standard Setting

James Whitaker, EA Engineering, Science and Technology, reviewed the current approach to setting water quality policy values. He pointed out that there are three aspects to any value — magnitude, duration and frequency. To the extent the current Specific Objectives were based on early U.S. water quality criteria, they may incorporate this philosophy, but certainly not explicitly.

Mr. Whitaker said that careful consideration must be given, when setting water quality objectives, to the following issues.

• What is to be protected (e.g. species, designated uses, geographic range)?

• What level of protection is to be afforded?

• What is the true exposure to the substance?

• What data are available to support setting an objective?

The Science of Compliance Assessment

Article IV of the Agreement says, "The determination of the achievement of Specific Objectives shall be based on statistically valid sampling data." Dr. Abdel El-Shaarawi of Canada's National Water Research Institute illustrated through a series of examples why, when setting and judging achievement of water quality objectives, it is important to consider the statistical nature of the variables involved. He pointed out that `absolute' objectives, those stated as a single value not to be exceeded, present the most difficulty for judging achievement, though techniques do exist to do so if sufficient monitoring data are available.

The Options Panel and Plenary Discussion

A panel of experts from the Parties, industry and the environmental community was followed by a plenary discussion. The presentations and discussion elicited a wide range of ideas and suggestions. The following describes the range of ideas presented. Two points upon which there was very little disagreement were that the Specific Objectives are of little use because they are so out of date and that the situation should be remedied somehow.

Douglas Spry of Environment Canada made the important point that to be meaningful, the Specific Objectives need to drive management actions. During the plenary discussion this point was reinforced numerous times. He also made the equally important point that revision of Annex 1 will require political will and resources. Again, this point was validated during discussions. Among suggested options during his presentation were to:

• adopt new Specific Objectives from the existing pool of the Parties' current objectives (i.e. Canadian Water Quality Guidelines and U.S. EPA Great Lakes Water Quality Guidance);

• provide guidance in Annex 1 on use of the Parties' existing objectives, but do not incorporate them into the annex.; and

• revise and develop new objectives using the current science. During the discussion, several people made the point that this would be a very resource intensive task.

Paul Horvatin of U.S. EPA was clear that his agency has no formal position on revision of Annex 1. However, he pointed out that a new Annex 1 could be relevant and useful in a number of regulatory and environmental management contexts. He suggested an *action level* approach wherein Specific Objectives would be triggers for actions. For example, the Specific Objectives could be the most stringent of the various values in use in the basin. Apparent exceedances of the objectives would trigger binational consultation on what actions to take.

George Kuper of the Council of Great Lakes Industries stated that CGLI has reversed its earlier position and now favours revision of Annex 1. The focus of such revision should be on the *doable* with recognition that, in the context

of the virtual elimination of substances, "there is no such thing as zero." He stressed that insistence on the unattainable only leads to inaction. Among the suggestions he made were:

• Replace the current numerical Specific Objectives with a "directive to utilize the SOLEC indicators as the monitoring

protocol and outcome-based measures that define the specific objectives of the Agreement." There was much discussion of this concept. There was recognition that the SOLEC process is driving formulation of indicators and associated monitoring that could definitely fit into Annex 1. Some people involved with the process expressed the belief that it may be premature to use SOLEC indicators in this way. Mr. Horvatin said that he would resist putting the SOLEC indicators per se into the Agreement.

• Incorporate into the Supplement to Annex 1 the Commission's Virtual Elimination Task Force definition of virtual elimination, ". . . defined as achieving an absence of injury, and achieving the goals of restoring and maintaining ecosystem health."

• Revise Section 1(b) of the Supplement regarding detection levels to read, "Substances not detected and determined to be *absent* as specified in this paragraph will be treated as *zero* for purposes of data analysis and assessment of progress toward virtual elimination."

During subsequent discussion of the second and third points, it was suggested that something not detected in water, but detected in fish tissue, should not be considered virtually eliminated from the environment. However, it was also pointed out that virtual elimination in the Agreement refers to inputs, not presence. It was also pointed out that detection limits are always going lower, so a non-detect today might be a detect tomorrow. Thus, treating non-detects as zero may not be an unchangeable declaration of virtual elimination.

Neil Kagan of The National Wildlife Federation stated that "virtual elimination should be paramount in any discussion of Annex 1" and that, for persistent toxic substances, Specific Objectives should not replace virtual elimination. He said objectives of zero should be considered. Subsequent discussion of this concept pointed out the practical difficulty of judging achievement of such a standard. It was suggested that failure to detect the substance might be taken as a preliminary indication of achievement but that, as long as fish flesh concentrations were sufficient to warrant consumption advisories, achievement could not be declared even if the

substance could not be detected in water. It was also suggested that zero objectives could be useful driving activities to reduce concentrations in various media, such as fish flesh and sediments. Mr. Kagan suggested that new chemicals such as dioxins, alkyl phenols and *endocrine-disrupting* chemicals should be considered for inclusion in Annex 1 and that indicators for source loadings might also be considered.

Other significant points raised during the plenary discussion are as follows

• Being able to make credible judgments about the achievement of meaningful Specific Objectives for the Great Lakes may help highlight problem areas in the basin more clearly than is being done now. This could be useful when trying to obtain resources with which to address the problems.

• When striving for lofty goals like those in the Agreement, it is important to have something like Specific Objectives by which to judge progress.

• Because there are references to the Specific Objectives in several Agreement annexes, revision of Annex 1 may require revisions elsewhere. While this is a daunting prospect for some, it may ultimately lead to other needed improvements in the annexes.

• To date, judgments of the status of achievement of SOLEC indicators have not been based on large amounts of data or rigorous statistical or environmental criteria but, rather, on best professional judgments and peer review.

• Our scientific understanding of the Great Lakes is not at a point where we can understand how all stressors interact to affect the health of the Great Lakes. This makes any attempt at setting Specific Objectives, whether they are chemical-specific or ecological indicators, inherently *provisional* until our scientific understanding improves.

Findings and Recommendations

Answers to the questions posed to the workshop participants are a convenient framework within which to present the significant findings and recommendations from this review. Following are answers to those questions based on what was learned during the review. Recommendations are also presented.

1. Is Annex 1 still relevant and useful? Why or why not? Annex 1 and the Specific Objectives are still very relevant as concepts. In Article II of the Agreement, the Parties state that the purpose is "to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem." To work toward this purpose it is necessary to have targets or tangible evidence that progress is being made and successes are being achieved. Without this kind of feedback, it could become difficult to

sustain the level of effort that is called for to continue progress toward the purpose of the Agreement.

Annex 1 is not particularly useful as it exists now because the Specific Objectives are badly behind the times in terms of our understanding of the requirements for restoring and maintaining the ecosystem. The Specific Objectives drive no management actions. Almost no one is impressed to hear that current data indicate that most of the Specific Objectives are being met because it is far from certain that meeting them any longer represents a significant achievement in terms of the purpose of the Agreement. This is probably why monitoring programs have drifted away from the Specific Objectives. It simply makes no sense to devote resources to demonstrating achievement of an objective that is no longer meaningful in terms Great Lakes ecosystem protection. Annex 1 and/or the Specific Objectives are referred to throughout the Agreement (Articles I, IV, V, VI, VII and X and several annexes). To the extent the lack of utility of the present Specific Objectives carries over to those other parts of the Agreement, it could perhaps be argued that Annex 1 in its current state is actually worse than useless.

2. Should Annex 1 be revised? If so, how? The answer to the first part of the question is emphatically yes. Annex 1 could and should be one of the touchstones of the Agreement. Great Lakes managers should be able to refer to Annex 1 when deciding the directions or effectiveness of management actions taken for the benefit of the ecosystem. Revision of Annex 1 represents an opportunity to revitalize the Agreement and recommit to its purpose. It is a shame not to take advantage of such an opportunity.

There are two facets as to how any revision should be done. The first concerns logistics. This review is not the first time concerns have been raised publicly about Annex 1. Nevertheless, despite the Parties' commitment to "consult . . . at least once every two years . . ." regarding modification of Annex 1, little meaningful action has been taken. Based on the level of interest and expertise displayed at the workshop, the lack of progress is clearly not due to shortages in those areas. What is needed is a clear commitment by the Parties to start an open, accessible, transparent and inclusive effort to make Annex 1 a vital part of the Agreement that will help drive actions toward accomplishment of the Agreement's purpose. While the content of Annex 1 is ultimately a matter of agreement between the Parties, the best way to decide on that content is to actively engage all stakeholders in an open process that gathers all ideas and viewpoints before decisions are made. One example of a process framework that could be used to engage stakeholders regarding substantive revisions to Annex 1 is described in

Effective Collaborative Processes on Sustainable Development and Environmental Policy - The Boulder Principles, published by the Council of Great Lakes Industries. http://www.cgli.org/positions.html

The second facet of the question concerns what specific changes should be made to Annex 1. The options panel and plenary discussion illustrated there are many interesting and sometimes conflicting ideas about what should be done. A one-day workshop is clearly not adequate to come to any firm conclusions as to what would be most appropriate. Indeed, this was never the intent of the review. Nevertheless, it is clear that Annex 1 should be revised in a way that makes it a useful management tool and enhances reporting and public accountability. Moreover, any revision should ensure that Annex 1 is not only brought up to date, but that it will continue to remain current and relevant into the foreseeable future. Because the Agreement is between the Parties, it ultimately falls to them to define a process by which all the ideas can be aired and a best path for revision chosen.

Recommendation

The SAB recommends the following to the IJC.

• Recommend that the Parties initiate a transparent and inclusive process to revise Annex 1 to drive actions toward accomplishment of the Agreement's purpose.

3. Is there a role for ecological indicators, such as SOLEC, in the Agreement? Yes, there is a role for ecological and other indicators in Annex 1. Indeed, the Supplement already contains two lake ecosystem objectives that are rudimentary ecological indicators. The fact that something is called an `indicator' should not preclude its consideration as a Specific Objective. Any indicator that has a firm scientific basis, has an identifiable desirable level that is relevant to the purpose of the Agreement and can be measured, should be considered for inclusion as a Specific Objective. This does not mean all indicators meeting these criteria should become Specific Objectives or that all Specific Objectives should originate as indicators. Further, not all indicators need be designed to generate statistically valid data. It simply means that semantics should not preclude the addition of a Specific Objective that would be a useful addition to Annex 1.

4. How should achievement of Specific Objectives be judged? The first facet of the answer concerns monitoring. It is impossible to judge achievement of any Specific Objective without collection of appropriate environmental data. Current monitoring and surveillance activities are insufficient to allow such judgments for many of the Specific Objectives. As discussed above, this is at least partly because the existing Specific Objectives are of little use for indicating progress toward the purpose of the Agreement. Nevertheless, Annex 11 specifically calls for surveillance and monitoring activities "To provide definitive information on the location, severity, areal or volume extent, frequency and duration of non-achievement of the Objectives ..." With revised Specific Objectives should come a

renewed commitment to monitoring and surveillance programs that can realistically allow judgments as to achievement of those objectives. Such a commitment could probably be met by a combination of modifications to existing programs perhaps with modest additional activities. The specific requirements would obviously depend on the nature of any revisions to Annex 1.

The second facet involves the statistical nature of the Specific Objectives and the data used to judge achievement. The Annex 11 language cited above in combination with the Article II requirement that judgments of achievement be based on statistically valid sampling data, lay out the basic requirements fairly well. Discussions at the workshop demonstrated that techniques do exist or could be developed to facilitate statistically sound judgments. Monitoring programs put in place to judge achievement of Specific Objectives clearly should take advantage of advances in statistics to make such judgments more credible. Designing

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and implementing monitoring and surveillance programs as part of a collaborative process presents an excellent opportunity to harmonize such programs and eliminate many of the inconsistencies and other problems noted.

Recommendation

The SAB recommends the following to the IJC.

• Recommend that the Parties, in conjunction with revisions to Annex 1, design and implement binationally harmonized monitoring and surveillance that will allow statistically credible judgments regarding achievement of the Specific Objectives.

2.3.2 Review of the Agreement

In its 1995-97 priorities report, pages 32 - 33, the Science Advisory Board reported that the rapid transformation of Great Lakes basin governance poses a challenge for the continuing relevance of the Agreement and its institutions. The governments themselves acknowledged that "the environmental challenges faced collectively by our people have grown in size and complexity, requiring strengthened collaborative action." The board identified a number of reports that, collectively, "represent a cogent analysis of the institutional opportunities and challenges facing the United States and Canada in the joint management and protection of the Great Lakes. Their analyses suggest that 25 years of binational experience is sufficient for

undertaking institutional reform ... to support continued progress under the Agreement ..." The board noted that, "Following release of the IJC's next [Ninth] biennial report, Article X of the Agreement calls on the Parties `to conduct a comprehensive review of the operation and effectiveness of this Agreement'." The board then recommended the following to the IJC and continues to do so.

Recommendation

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

The board further noted that any "decision as to whether the Agreement needs to be modified should not be predetermined, but should be an objective outcome of the review process."

The board notes that, since its advice four years ago, although a review of the Agreement was initiated through the Parties' Binational Executive Committee, that review was terminated in early 2000 and that no updating of the Agreement has taken place since 1987. The board's review of Annex 1 of the Agreement, discussed elsewhere in this chapter, clearly points out the need to revise that annex, and reviews of other components of the Agreement would likely lead to similar conclusions. The board's advice provided in 1997 remains valid today.

The board reiterates its previous recommendation the IJC that they encourage the Parties to conduct a review of the adequacy of the Agreement.

2.3.3 Nonpoint Sources of Pollution from Land-use Activities

Introduction

Annex 13 of the Agreement "delineates programs and measures for the abatement and reduction of non-point sources of pollution from land-use activities." It calls on the Parties, in conjunction with state and provincial governments, to identify land-based activities contributing to water quality problems described in Remedial Action Plans (RAPs) and Lakewide Management Plans (LaMPs) and to develop and implement watershed management plans. In this section, the board provides advice

regarding the mitigation of pollution from nonpoint sources.

Over the past several years, the Parties Implementation Work Group has been studying the role of nonpoint source (NPS) pollution in Great Lakes water quality and the efforts of the Parties to control and prevent that pollution. As part of its 1997-99 Priorities Report, the work group presented the findings of a workshop held to commemorate the 20 th anniversary of the final report of the Commission's Pollution from Land Use Activities Reference Group (PLUARG). That report concluded that NPS pollution remains a significant challenge in the Great Lakes basin, particularly in light of the intensification of agricultural practices and the rapid urbanization of many parts of the basin. In its priorities report, the board therefore recommended that the IJC urge the Parties to continue action and vigilance in the control of NPS pollution. In addition, the board emphasized the need for special attention to urbanizing areas.

In this current cycle, the work group continued its investigations into this important area. As part of this effort, it commissioned three reports by senior undergraduate environmental science students at the University of Guelph, Ontario. The first of these reports (Cakmakci et al. 2001) assessed the current state of agricultural NPS pollution control and identified emerging trends and research gaps in that domain. The second report (Fata et al. 2001) made a parallel assessment of urban NPS pollution and its control. The third report (Beyba et al. 2001) compared the pollutant sources, water quality, and management practices of two similar basins, the Grand River in Ontario and the Maumee River in Ohio.

The findings of these studies bore striking similarities, even though their subject material varied widely. The most important of these was the conclusion that nonpoint sources remain a significant source of pollution to the Great Lakes. Although total soil erosion in the United States dropped 42 percent between 1982 and 1997 (Uri and Lewis, 1999), pollution from land-based activities continues to impose substantial costs, particularly in the Great Lakes basin with its rapid urbanization and intensive water use. The current research reveals a large number of traditional and innovative management practices that have clearly been shown to reduce soil erosion and associated pollutant transport. Technical control of NPS pollution is feasible, practical and cost-effective. The study concluded that the barriers to NPS control are not technical.

Current research also suggests that the principal roots of the problem are not regulatory, although there is certainly room for improvement, particularly in the control of discharges from intensive confined animal feeding operations. In both urban and rural environments, even control programs with the best of intentions will fail if resources are not available for effective enforcement. Numerous studies have demonstrated that effective control of NPS pollution demands site-specific assessment techniques and remedial measures. Because NPS pollution arises over a large land area, its control demands an understanding of the physical, chemical and biological characteristics of the

land surface. In some cases, this means tailoring control measures to conditions at the field level within a farm or in a particular residential lot.

It is clearly not feasible to develop environmental management plans at a scale of meters. Yet it is equally clear that generic solutions are unenforceable and not necessarily cost effective. One solution is to prioritize areas and solutions based on hydrology, climate and precipitation patterns, specific pollutants and existing treatment facilities, and concentrate planning and management activities on those areas. Geographic information systems and remote sensing data may be helpful in establishing management priorities and, if linked to predictive computer simulation models, in developing the most effective management strategies.

Some of the literature indicates that public education programs can be helpful in increasing the proportion of landowners that adopt NPS controls, but that the legal language of laws and policies makes the programs inaccessible to many members of the public. It is equally clear, however, that bottom up, landowner-driven strategies have in many cases been more effective than traditional public education approaches. Social marketing strategies in particular do not dictate a preferred approach but, rather, build NPS control programs from the needs and desires of the target audience. Social marketing approaches are based on comprehensive research and evaluation of local environmental, economic, and social conditions emphasizing once again the need for site-specific solutions.

This need for site-specific approaches may underlie much of the management challenge of NPS pollution. In particular, the current research suggests that control of NPS pollution has been hampered by:

• insufficient persuasive evidence of the effectiveness of best management practices;

• lack of performance standards;

• inadequate financial incentives for clean-up; and

• inadequate institutional arrangements.

The following paragraphs summarize current thinking on each of these topics.

Insufficient Persuasive Evidence of the Effectiveness

of Best Management Practices

Consistent with the findings presented in the board's 1997-99 priorities report, the current research underscores the need for much better information on NPS loadings of pollutants with and without best management practices in place. This type of information exemplified in inventories such as the National Pollutant Release Inventory in Canada and the Toxics Release Inventory in the United States currently forms the cornerstone of point source pollution control. Yet fundamental information about the quantities of pollutants contributed by individual NPS control practices to receiving waters, the nature and magnitude of associated impacts, and the costs of control (and lack of control) is almost entirely lacking in the NPS domain. Although research is conducted in this area, little seems to find its way into public outreach or extension activities. Furthermore, much of the available information comes from U.S. systems; very little agricultural or urban NPS loading or control information specific to Canada was apparent in the current literature search. In part this may be a function of the Parties' differing communication strategies. Generally speaking, information on NPS pollutants and control strategies is more easily available, in a wider range of formats, in the United States relative to Canada. For example, the (U.S.) National Stormwater Best Management Practice Database provides a comprehensive, user-friendly guide to storm water control. By contrast, Canadian information was much more limited and much more difficult to access.

Recommendation

The SAB recommends the following to the IJC.

• Recommend that the Parties quantify pollutant loadings to receiving waters by individual nonpoint source control practices; the nature and magnitude of associated impacts; and the costs of control (and lack of control) of nonpoint source pollution.

A second, related consideration is the almost complete absence of strategies to evaluate the effectiveness of urban and agricultural NPS programs, despite the many millions of dollars that have been spent on them by governments and private landowners. Methodologies for such assessment, commonly termed program evaluation, are widely available in the social science literature and indeed are required by many major granting agencies, such as the Canadian International Development Agency and U.S. Agency for International Development. Program evaluation is widely used in government, and many agencies have formal program evaluation offices. Formal program evaluation normally assesses:

• program inputs, including human and financial resources;

• program activities;

• program participants;

• reactions attributable to the program; and

• measurable outcomes, including changes in knowledge, attitudes and skills in addition to biophysical changes, such as pollution reductions.

Without program evaluation, it is difficult for governments and non-government organizations to develop persuasive evidence that any one type of program or best management practice is superior to another. For example, in the Maumee River, as with other Areas of Concern, the purpose of the RAP is to establish strategies to identify and address pollution problems. Although the RAP may coordinate remedial actions, it does not have the authority to impose responsibility for achieving results, nor does it have a means of measuring the success of individual measures. So although the RAP team may recommend NPS control strategies, they cannot guarantee that those strategies will be implemented, nor can they promise or measure any particular level of performance. Landowners within the RAP area may therefore be reluctant to risk significant expenditure on control measures whose performance is not proven, and progress on NPS controls may be slowed.

In contrast, most point source controls are regularly and closely scrutinized to ensure cost-effectiveness, in part because of the need for accountability to owners and directors (or to the public, in the case of a public utility) for each expenditure. It is therefore often possible for the discharger to state that an expenditure of X dollars will result in an estimated Y percent pollutant reduction. This information is powerful and persuasive evidence that proposed expenditures will have the desired environmen

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tal impact.

Recommendation

The SAB recommends the following to the IJC.

• Recommend that the Parties adopt systematic methods to evaluate nonpoint source pollution control programs.

Lack of Performance Standards

A second major obstacle to implementation of NPS controls is the absence of performance targets for the land surface and for individual management practices. Although available, ambient water quality guidelines are of little help, especially in view of the dearth of loading information described above, in establishing targets for nutrient concentrations, metals, pesticides,

solvents, microorganisms and similar constituents on the land or in treated effluent from best management practices. Some jurisdictions, for instance Pennsylvania, have attempted to set regulatory performance criteria for nutrient management practices (see, for example, Beegle et al. 2000). However such approaches are rare.

Instead, local ordinances often specify the type of required treatment (e.g. a storm water retention pond) but not the expected level of performance (e.g. expected percent removal of a given pollutant) of that device. There is now considerable evidence indicating that the performance of even the most common urban and agricultural best management practices varies widely depending on age, maintenance history and local conditions. Furthermore, it is increasingly evident that, although the percentage of impervious land surface is a good predictor of urban water quality impairment, planning ordinances rarely if ever impose restrictions on this factor. In the absence of such performance benchmarks, it is difficult for enforcement staff to assess the adequacy of existing management practices in urban or rural settings.

Landowners may be aware that NPS pollution should be controlled and that certain practices are desirable, but they may be reluctant to proceed with implementation because of uncertainty as to the necessary scope and cost of work. Program evaluation would provide evidence of the cost-effectiveness of preferred management approaches, and thus remove a barrier to implementation of NPS controls.

Recommendation

The SAB recommends the following to the IJC.

• Recommend that the Parties develop performance standards for nonpoint source pollution control technologies, including standards for the land surface.

Economic Considerations

Many studies have demonstrated that economic considerations are critical in the implementation of NPS controls. The current research reveals a lack of detailed information on farm- or lot-level economic forces, and the factors that encourage, or discourage, the landowner from adopting best management practices. It is, however, apparent that, in many cases, existing regulatory structures in fact work to separate landowners from the true costs of their behaviour. For example, existing Right-to -Farm legislation in both countries exempts agricultural operations from most environmental regulations.

Inappropriate land management techniques can create significant costs for downstream users, but these costs are largely invisible to the landowner from whose lands pollution or eroded sediment arises. For example, soil lost from agricultural lands is the major source of suspended sediment pollution in the Maumee River. These sediments must be dredged yearly and confined as

contaminated soil by the U.S. Army Corps of Engineers, at an estimated annual cost of $3 million (U.S.). Currently, these funds come from public coffers, but other approaches may be necessary. In particular, there is considerable potential for application of economic instruments in the control of NPS pollution. At present, such instruments are limited to grants and subsidies, particularly in the agricultural sector. Additional opportunities may exist, not all of which have implications for trade

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agreements. Examples might include compensated conservation easements (in which a farmer grants limited use or retirement of land in exchange for compensation), performance bonds (that can be repaid on demonstration of satisfactory performance), and grants and subsidies for land stewardship and habitat restoration. Such instruments are already common throughout the Organization for Economic Cooperation and Development countries (OECD 1999), including Canada and the United States.

Site-specific measures such as so-called prescription agriculture (in which global positioning systems are used in combination with frequent soil testing to determine optimal fertilizer application rates within a field) offer a means of minimizing fertilizer use and associated costs, and therefore implicitly provide financial incentives for NPS control. Prescription agriculture technology is potentially costly, however, and may require financial subsidies in addition to the savings realized in fertilizer use.

Recommendation

The SAB recommends the following to the IJC.

• Recommend that the Parties extend the use of economic incentives for the control of pollution from nonpoint sources.

A more subtle economic consideration is the under pricing of water throughout most of the Great Lakes basin. The literature suggests that many jurisdictions set water prices at approximately two-thirds to three-quarters of the true cost of delivering water and sewerage services. Some estimates place current prices at half their real cost. This situation differs markedly from other regions in the world, which have much higher water prices and much lower per capita use. In terms of NPS controls, the implications of excessive water use and low water costs are clear — more water use means faster deterioration of water infrastructure, higher energy costs and greater potential for erosion and pollutant transport.

Also, no jurisdiction attaches a price to the water itself, whether surface or ground water, even in situations where local scarcity of that water proves

that it is a limited and valuable resource. Moreover, at a time when residents of the Great Lakes basin worry that other regions may propose exports of Great Lakes water, that water is still available at zero price as if basin waters were an inexhaustible and unlimited resource.

Recommendation

The SAB recommends the following to the IJC.

• Recommend that the Parties adopt full-cost pricing of water and sewerage services, incorporating a scarcity value of the water and including provisions for infrastructure maintenance, upgrading and replacement.

Inadequate Institutional Arrangements

Possibly the most dramatic and consistent finding arising from the current research is that current institutional arrangements may in themselves create significant obstacles to the control of NPS pollution. Problems with institutional arrangements stem from three sources:

• lack of communication and coordination among levels of government in the control of natural resource stewardship, land use planning and control of NPS pollution;

• lack of integration of planning policies with environmental protection policies; and

• lack of collaborative multi-stakeholder approaches to planning, management and research.

To a large extent, current institutional arrangements derive from the government structures and attitudes of the 1970s and 1980s, which were generally based on political boundaries, divided along environmental media lines, and emphasized information dissemination over collaboration.

It is increasingly clear that such arrangements fail to foster the communication necessary for control of NPS pollution. For example, although NPS controls are most effective if based on site-specific assessments, there is also a need for regional coordination of land use planning, including NPS management practices. Most jurisdictions have found this difficult.

For example, the Maumee River watershed crosses the border between Ohio and Indiana, thus dividing responsibility for water quality between the two jurisdictions. Although the RAP structure provides a framework for coordination of activities in the area, the Maumee Area of Concern does not include the full watershed area, so upstream pollution sources are excluded from RAP deliberations.

By contrast, water management decisions in the Grand River basin are overseen by a single agency, the Grand River Conservation Authority (GRCA). This arrangement is facilitated by the fact that the entire Grand River watershed falls within the province of Ontario. GRCA has spent 25 years developing close working relationships with basin municipalities, all of whom are represented on its technical committees, and include federal and provincial resource management agencies, local non-governmental organizations and the public. Through this framework, GRCA has created an exemplary watershed-based partnership for management of the river basin, and was recently recognized with the 2000 Theiss River Prize as the best water management agency in the world. Among its other achievements, GRCA has succeeded in establishing a sense of team and shared vision within the watershed, which finds practical expression in collaborative research and funding of major planning and management initiatives.

The current research supports the notion that water management, including NPS control, is best conducted on a watershed basis. Although the RAP and LaMP programs are intended to be community based, in practice RAP public advisory committees are often separated from the technical work of the RAP, and may in any case be disproportionately small relative to agency representation. The comparison of the Grand and Maumee management systems conducted in the current research suggests that the successful programs in the Grand River watershed are not initiated by a government body, but rather by citizen groups in other words, bottom up rather than top down.

GRCA's technical committees have responsibility for point and nonpoint source pollution abatement and for maintaining the river's beneficial uses. Most have membership drawn from across stakeholder groups, who jointly and collaboratively analyze basin data, propose and evaluate remedial actions, oversee monitoring and communicate results to the community. The structure of the Maumee RAP is also effective for identifying problems and initiating the necessary programs, but is less effective in terms of ongoing adaptive management, monitoring and follow-up, perhaps because it lacks the basin-wide endorsement present in GRCA.

The watershed management structure employed in the Grand River also addresses the problem of linkage between the land use planning function and environmental protection. In most jurisdictions, including Ontario, these are separate systems and coordination between them is often weak or lacking. In Ontario, the Planning Act provides for local decision making with provincial oversight but, in practice, oversight occurs only at the level of a dispute resolution tribunal, the Ontario Municipal Board. Legislative reforms

proposed by the Sewell Commission in the early 1990s (Sewell et al. 1993) would have introduced formal linkages between the Planning Act and environmental legislation. Those reforms were, however, overturned when the current Conservative government of Premier Mike Harris took office in 1995.

GRCA's collaborative watershed management structure successfully integrates land use planning and environmental management at both local and regional scales. Through its committee structure, individual municipalities and private citizens participate in basin-wide planning and management discussions. A basin-wide hydrologic/water quality model, the Grand River Simulation Model, provides a means of evaluating alternative management strategies, and serves as the basis for discussions about regional priorities. While individuals represent local interests and conditions, regional coordination is provided through round-table discussions. The committee structure, which is based around standing committees and long-term membership, also provides an informal forum for exchange of technical information and advice.

Elsewhere in the world, notably in Australia, innovative institutional arrangements now underlie water management on a watershed basis. Most models incorporate a single lead agency, often at arm's length from, but with participation by, regulatory agencies. Like GRCA, their role is to provide basin-wide oversight of planning, resource management and extraction, pollution prevention and abatement activities, and related matters. Often, water allocation is overseen by the watershed agency, which is also responsible for designating responsibilities, timetables and costs among basin stakeholders. Other key responsibilities include monitoring, often involving a substantial volunteer component coordinated with community representatives, schools and retirees, and communications regarding watershed quality and activities. Examples of innovative management institutions include the Great Artesian Basin Consultative Council, Lake Eyre Basin Coordination Group, Murray-Darling Basin Commission (all Australian) and the California State Water Resources Control Board's system of regional, but not watershed-based

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quality control boards.

Recommendation

The SAB recommends the following to the IJC.

• Recommend that the Parties review current institutional arrangements for water and watershed management, and explore the feasibility of collaborative, multi-stakeholder regional or watershed-based institutional structures.

The preceding discussion has focused on NPS pollution at the local and regional scales. However, the NPS issue is national and international in scale, and actions at the local and regional levels cannot be taken in isolation of these broader dimensions. The dictum to "think globally, but act locally" clearly pertains.

As noted in the introduction to this NPS discussion, the board had previously concluded that NPS pollution remains a significant challenge in the Great Lakes basin. The PLUARG study was completed a quarter century ago, but we, as a society, are only now beginning to appreciate the depth and breadth of its findings, in light of the rapidly changing agricultural and urban land-use patterns and practices. The PLUARG study was timely in the 1970s, as well as ahead of its time. Perhaps we should each read or re-read the PLUARG report and its substantial supporting documentation. Annex 13 of the Agreement remains relevant and, indeed, control and mitigation of NPS pollution is key to restoration and protection of our Great Lakes.

2.3.4 Evaluation of SOLEC Indicators Relative to the GLWQA

For more than a decade, there has been significant efforts by the Parties and the IJC to develop indicators in relation to the Great Lakes Water Quality Agreement, and it is, perhaps, appropriate at this time to reflect on the purpose of indicators and to evaluate whether these efforts are producing the needed results. In 1996, the IJC published a report titled *Indicators to Evaluate Progress under the Great Lakes Water Quality Agreement* (International Joint Commission 1996). The definition of an indicator was that it "provides a clue to a matter of larger significance or makes perceptible a trend or phenomenon that is not immediately detectable." This definition accords with those used internationally in relation to indicator organisms as "an organism whose characteristics are used as an index of attributes too difficult, inconvenient, or expensive to measure for other species or environmental conditions of interest" (Landres et al. 1988, cited in Ewins et al. 2001). All measurements are not necessarily indicators though some measurements could be used as indicators. For a measurement to become an indicator it must fulfil the following circumstances and criteria.

• There must be a trend or phenomenon that is not immediately detectable.

• There must be a matter of larger significance for which the index provides a clue.

• The measurement must be able to be transformed into a reliable index.

Though indicators are not mentioned in the preamble or in the articles to the Great Lakes Water Quality Agreement, there are several references in the annexes. There are, however, throughout the preamble and the articles, phenomena and matters of a larger significance that are not immediately detectable and for which indicators are required to provide a clue. For example, the Parties concluded in the preamble that "the best means to preserve the aquatic ecosystem and achieve water quality throughout the Great Lakes System is by adopting common objectives, developing and implementing cooperative programs and other measures . . ." Both the preserving of the aquatic ecosystem and the achievement of water quality throughout the Great Lakes system are matters of larger significance and phenomena that are not immediately detectable. For the Parties to report on trends in progress in the attainment of these matters of larger significance, there has been a need, since the signing of the original agreement in 1972, to select indicators and to implement long-term programs to measure their status.

The 1987 Protocol to the Agreement added a supplement to Annex 1 that provides for the establishment of lake ecosystem objectives and designated two species, the lake trout (*Salvelinus namaycush*) and *Pontoporeia hoyi,* (now identified as *Diporeia hoyi*), as indicators of oligotrophic conditions for Lake Superior. Since then, other lake ecosystem objectives have not been added by the Parties, although the SAB has recommended several species for adoption (IJC 1991), including the bald eagle *(Haliaeetus leucocephalus)* , double crested cormorant *(Phalacrocorax auritus),* mink *(Mustela vison)* and otter *(Lutra canadensis).*

The SAB also recommended that the lake trout objective be further developed to measure exposure to persistent toxic substances by determining the incidence of embryo mortality, fry survival and developmental anomalies in samples of fish eggs (IJC 1991).

SOLEC is one of several reporting mechanisms available to the Parties under the Agreement, which has the potential to be particularly important as a basis for future reporting on the state of the lakes through the use of indicators. The SOLEC process, generally, also provides an excellent opportunity for Great Lakes scientific and policy communities to consult binationally and to achieve consensus on critical aspects of Agreement implementation. The adoption of a suite of 80 indicators in 1999, based on SOLEC categories of open and nearshore waters, coastal wetlands, nearshore terrestrial, human health, land use, societal and unbounded categories, represented a major transition from ad hoc reporting efforts of the past to a unified reporting method for the future. Yet despite these attributes, SOLEC reporting does

not fully satisfy the reporting responsibilities of the Parties under the Agreement, (Environment Canada and U.S. EPA, 2000) and therefore it remains insufficient as a sole basis for evaluating progress under the Agreement by the IJC. Recent IJC efforts of the IETF (Indicators for Evaluation Task Force) and the IITF (Indicators Implementation Task Force) proposed an evaluative framework based on desired outcomes, such as fishability, drinkability and swimmibility (IJC 1996; 2000) and the IITF concluded that continued involvement of the IJC is necessary over the next decade in order to further develop and apply indicators that measure Agreement progress.

In order to assess the suitability of current SOLEC indicators for IJC evaluative purposes, the Work Group on Ecosystem Health received assistance from four graduate students (John Heatley, Sandra Knuteson, Amy Roe, Rick Sherrard) at Clemson University, who undertook research during spring 2000 to determine the extent to which the suite of 80 indicators fulfilled reporting requirements under the Agreement.

The SAB developed a set of criteria for judging the suitability of candidate organisms to serve as indicators of ecosystem quality (IJC 1985). These criteria were to:

• have a broad distribution in the system;

• be easily collected and measured in terms of biomass;

• be indigenous and maintain itself through natural reproduction;

• interact directly with many components of its ecosystem;

• have available historical, preferably quantified information pertaining to its abundance;

• have well documented and quantified niche dimensions expressed in terms of metabolic and behaviourial responses;

• exhibit a gradual response to a variety of human induced stresses;

• serve as a diagnostic tool for specific stresses of many sorts;

• respond to stresses in a manner that is both identifiable and quantifiable;

• be a suitable species for laboratory investigations;

• be generally recognized as important to humans; and

• serve to indicate aspects of ecosystem quality other than those represented by presently accepted parameters.

The graduate students developed a method of ranking each of the 80 SOLEC indicators based upon a set of 12 questions, 11 of which were related directly

to the SAB criteria and a 12 th on the merit of the indicator and its ability to adequately assess the ecosystem (Table 1). A score of one to five points was assigned to each of the 11 questions related to Ecosystem Health and up to 10 points were assigned for the question on merit, based on the current state of development and future potential of development for the indicator. Each student independently ranked each of the indicators, then a group consensus was reached to assign a final score to each indicator.

Based on these criteria and the indicator information provided in recent SOLEC reports (Environment Canada and U.S. EPA, 1999; 2000), SOLEC indicators classified as excellent, good and moderate, if fully developed, were considered sufficient for meeting the need for ecosystem indicators under the Agreement.

Final scores were assigned to each indicator and were ranked as either excellent (51-70 points), good (40-50 points), moderate (30-39 points) or poor (less than 30 points) (Table 2). Excellent indicators are deemed to adequately represent ecosystem health and all but one were ready to be used in the field. Good and moderate indicators are meritorious, but need more information to establish endpoints before they are ready for use. Indicators ranked as poor were not viewed as adequate to represent ecosystem health and/or lacked merit as an indicator, and did not receive further consideration by the researchers. Ten of the indicators received a classification of excellent. Seventeen of the indicators received a classification of good. Twenty-one of the indicators

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received a classification of moderate. The other 32 indicators were classified as poor. None of the SOLEC indicators related to its categories of Land Use or Societal indicators were developed enough to be useful and were all classified as poor.

Table 1 SOLEC Evaluative Framework

Developed by Clemson University Researchers

Criteria Group Criterion Question(s) to be asked

Specificity to Gradual Response Does it give a gradual response to different induced stresses (dose/

Toxic Substances response relationship)?

Diagnostic Tool Can it serve as a diagnostic tool specific for many different stresses?

Quantification Is the response identifiable and quantifiable?

Placement Great Lakes Basin Is it basin wide, whole lake, limited area (AOC specific)?

Distribution

Indigenous Is it indigenous to the Great Lakes basin with a naturally reproducing population?

Ecosystem Are there key interactions with components of the ecosystems, for

Interactions example, keystone species?

Specific Niche Does it have a specific niche that can be expressed in metabolic and behavioural response terms?

Ease and Cost in Ease of Collection Are there standard methods? Is it quick and easy, cost efficient, taking few

Measurement resources?

Historical Records Are there previous data to study historical trends, current abundance?

Suitability for Will the indicators be suitable for lab studies?

Lab studies

Social Relevance / Social Relevance Is it important to public perception?

Public Perception

Future Relevance Merit Will it adequately assess the ecosystem?

Table 2 Ranking of Indicators Deemed as Excellent, Good and Moderate in Fulfilling Reporting Requirements under the Agreement

SOLEC No. SOLEC Indicator Name Ranking

E X C E L L E N T

4179 Geographic patterns and trends in human disease incidence 70

4503 Deformities/eroded finds/lesions/tumors (DELT) in fish 58

8135 Contaminants affecting productivity of bald eagles 57

101 Deformities/eroded fins/lesions/tumors (DELT) in fish 56

115 Contaminants in colonial nesting waterbirds 55

93 Lake trout and scud 54

113 Contaminants in recreational fish 53

9000 Acid rain 52

111 Phosphorous concentrations and loadings 51

8 Salmon and trout 51

G O O D

17 Preyfish populations 50

4860 Nitrates and total phosphorous into coastal wetlands 49

114 Contaminants in young-of-the-year spottail shiners 47

9 Walleye and *Hexagenia* 47

4176 Air quality 46

8150 Breeding bird diversity and abundance 46

4175 Drinking water quality 45

109 Phytoplankton populations 44

4083 Chemical contaminants in fish tissue 43

72 Fish entrainment 43

8134 Nearshore plant and wildlife problem species 42

8147 Contaminants affecting the American otter 42

4178 Radionuclides 42

4501 Coastal wetland invertebrate community health 42

4502 Coastal wetland fish community health 42

4088 Chemical contaminant intake from air, water, soil and food 41

4506 Contaminants in snapping turtle eggs 40

M O D E R A T E

4861 Water level fluctuations 39

117 Atmospheric deposition of toxic chemicals 38

9001 Atmospheric visibility; prevention of significant deterioration 38

7059 Wastewater pollutant loading 38

4081 Fecal pollution levels of nearshore recreational waters 38

4177 Chemical contaminants in human tissue 38

116 Zooplankton populations as indicators of ecosystem health 38

8161 Threatened species 38

118 Toxic chemical concentrations in offshore waters 36

6 Aquatic habitat 36

120 Contaminant exchanges between air to water, and water to sediment 35

4513 Presence, abundance and expansion of invasive plants 35

4510 Coastal wetland area by type 33

119 Concentrations of contaminants in sediment cores 32

4507 Wetland-dependent bird diversity and abundance 32

18 Sea lamprey 31

4511 Gain in restored coastal wetland area by type 31

8137 Nearshore species diversity and stability 31

104 Benthos diversity and abundance 31

4504 Amphibian diversity and abundance 30

4857 Global warming; first emergence of water lilies in coastal wetlands 30

A second review of the SOLEC indicators and their applicability to IJC objectives, desired outcomes and the annexes of the Great Lakes Water Quality Agreement was included as Appendix 2 in the SOLEC 2000 Draft for Discussion. This review of applicability to IJC related priorities only determined if any applicability to the IJC priority was met by the indicator, and not the adequacy of the indicator to actually achieve these objectives. A number of gaps were identified regarding IJC priorities. SOLEC indicators were not identified for the following IJC priorities: Great Lakes Water Quality Agreement, annexes 4 through 10, and 16; the desired outcome of economic viability; and the beneficial use impairments of tainting of fish and wildlife, beach closings, and agricultural and industrial costs. SOLEC indicators did not adequately cover the following IJC priorities: desired outcomes for dredging, swimability/drinkability and excess phosphorous); and the beneficial use impairments of dredging, fish and wildlife consumption, tumors, drinking water and aesthetics. No attempt has been made by SOLEC to evaluate the adequacy of the SOLEC indicators relevant to any of the IJC priorities evaluated, such as RAPs, LaMPs, the Great Lakes Water Quality Agreement, desired outcomes or IJC objectives. Therefore, the needs of the IJC and the responsibility of the Parties for reporting under the Agreement have not been evaluated for the SOLEC indicators.

Recommendations

The SAB recommends the following to the IJC.

• Evaluate the utility of SOLEC indicators to fulfill the reporting requirements under the Great Lakes Water Quality Agreement.

• Increase the IJC's emphasis on its role to assess the state of the lakes and evaluate progress under the Great Lakes Water Quality Agreement, now that a framework for indicators and reporting has been developed.

2.3.5 Remedial Action Plan Assessment:

Site Visits to the Niagara River and

St. Lawrence Areas of Concern

The IJC adopted a status review process for AOCs in 1996, and since that time, three reviews have been completed (IJC 1997a; 1999a,b) and two are

currently underway. The SAB has assisted the Commission with the scientific aspects of its reviews and by conducted site visits, holding public meetings and providing advice to the Commission. During the 1999-2001 biennial cycle, the board met in the Niagara River and St. Lawrence Areas of Concern.

Niagara River

The SAB meeting in Niagara Falls, New York was held on November 29-30, 2000, and comprised technical presentations from representatives of the government agencies cooperating under the Niagara River Toxics Management Plan, a tour of the hazardous waste sites on the U.S. side and a public meeting involving invited scientific presentations and interested citizens. The meeting was held in association with the U.S. EPA and New York Department of Environmental Conservation open house for the public and media on remediation of U.S. Niagara River hazardous waste sites. The following comments and conclusions were reached by the board and submitted to the Commission.

1. The Niagara River Area of Concern was designated primarily on the basis of concerns about the input of toxic chemicals to the Niagara River, particularly related to the operation of hazardous waste sites on the U.S. side. Chemical manufacturing involving chlorine started in the 1890s and wastes have been released to the Niagara River and deposited in chemical land fill sites throughout the 20 th century. The toxicological situation became particularly acute by the 1940s with subsequent extirpations of fish and wildlife species. These concerns became extremely serious with the realization that chemicals, such as PCBs, Mirex and dioxins from the Niagara region can not only influence all of Lake Ontario and the St. Lawrence River, but can also impinge on the Gulf of St. Lawrence and the Atlantic Ocean.

2. While very serious efforts are underway at each individual waste site to contain movement of chemicals from the sites, the larger reality of the immense geographical and temporal scale of the problem needs to be recognized and acknowledged. For example, approximately 80,000 tons of waste, some of which is hazardous material, is contained at the Hyde Park dump. By pumping and treating water infiltrating the site, about eight pounds of chemicals are removed and treated daily. Nevertheless, U.S. EPA, NYDEC and industry should be commended for their management efforts in containing toxic wastes onsite.

3. The monitoring and surveillance programs under the Niagara River Toxics Management Plan are models for binational cooperation and success. The results of remedial efforts and waste containment activities are reflected in dramatic reductions in ambient levels of pollutants both in the river and in biota. The effectiveness of monitoring programs strongly support the value of applying this approach for the other connecting channels.

4. The containment of the wastes, the reduction of contaminant inputs to the river, and the relocation of homes and citizens has resulted in a noticeable lack of public outrage and concern, in contrast to the early days of citizen activism in the region. While these actions appear to be have been successful, a comment at the board's public meeting reminded officials that such measures do not comprise remediation or cleanup, and commit government and industry to long term, high cost solutions for this legacy, in perpetuity. There was some apprehension expressed whether this commitment would be sustained in the face of high cumulative costs of containment and the absence of immediately affected citizens to demand action.

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5. The importance of dense non aqueous phase liquids (DNAPL) in fractured rock aquifers is well understood scientifically, however this knowledge is only beginning to be applied in terms of operational practices. Since it is difficult to locate the DNAPL in fractures and even more difficult to access it, pump and treat technology is not very effective for removal. The primary intention of pump and treat technology is to reverse the hydraulic gradient at a contaminated site, however, small amounts of contaminants DNAPL will be removed with the water and is treated before it can be discharged. Over the long term, DNAPL could become increasingly significant as an ongoing source requiring treatment as more soluble wastes within the site are removed with groundwater. Also, given the limited access of the groundwater to the DNAPL in fractures of rock, the effectiveness of maintaining an inward hydraulic gradient on DNAPL movement is difficult to predict. In addition, as time goes on and the more accessible DNAPL sources are reduced, concentrations in the water will be reduced and more water will have to be pumped to remove a given amount of contaminants. There appears to be very limited applied research into alternatives to pump and treat technologies in the Niagara region involving local hydrogeological expertise at nearby universities or involving institutions such as the U.S. Geological Survey. The Niagara region offers an opportunity to better develop the science and engineering of DNAPL treatment and this improved understanding is needed to address the future challenges of site remediation.

6. Because of the severity of the problems, the Parties chose to manage toxic substance problems using the respective regulatory frameworks in each country and binationally under the auspices of the Niagara River Toxics Management Plan (NRTMP). The NRTMP comprises the Niagara Declaration of Intent, a four party agreement that provides for an annually updated workplan aimed at reducing concentrations of chemicals in the river. While the NRTMP is essentially a subactivity within the Niagara River RAP, RAP efforts in both countries have played a limited or marginal role in

addressing problems of toxic substances. For example, in Canada, most RAP concerns are related to the Welland River. At best, the development of the RAP has poor binational coordination, is not managed binationally using an ecosystem approach, and does not appear to be a high priority of the senior governments. There is a need to have more binational linkages between the NRTMP, RAPs and Lake Ontario LaMP. It could also be warranted, to encompass the research and monitoring activities occurring in the St. Lawrence River and the Gulf of St. Lawrence, with reference to previous comments numbers 1 and 2.

7. For the short term, the crisis of hazardous waste management appears to be manageable through containment at individual priority waste sites. But issues related to other sources to the Niagara River, including, for example, upstream inputs, non priority waste sites, contaminated sediments, and other nonpoint sources, continue to have an impact on beneficial uses and will necessitate ongoing fish consumption advisories for the foreseeable future. For example, there are more advisories, and the advisories are more restrictive in the Lower Niagara River than in the Upper Niagara River. By 2003, current approaches related to source track down are scheduled to be completed in terms of the 26 priority sites identified by U.S. EPA. For further reductions, it may become necessary to better account for other sources, sinks and pathways, especially as they relate to Lake Ontario so that best management decisions and measures can be adopted.

8. There is limited flow of information related to the Niagara region, particularly to support a transfer of waste site management technology throughout the Great Lakes basin, and there is a need for an increased role for the Great Lakes National Program Office of U.S. EPA to facilitate greater awareness between the EPA regions and in those AOCs with similar, but admittedly smaller scale problems. The mayor of Niagara Falls highlighted this issue in terms of increasing the profile of the environmental accomplishments in the area and showcasing them as learning experiences for others.

9. The waste management approach through containment has resulted in extensive areas of restricted, grassed, open space that may exist within the town for decades, even centuries. From a land-use perspective, such areas will continue to have a severe economic and social impact on the city as long as they are unusable. Addressing the legal, design and environmental impediments to be overcome in order for these areas to be used for beneficial purposes, such as open public space, in the long term, need to be considered.

St. Lawrence River

In the 1997-1999 Priority report (IJC 2000), the SAB recommended the Commission conduct a status assessment review of progress of the Cornwall/Massena AOC following receipt of the Stage 2 RAPs. The SAB met in Cornwall on May 23-24, 2001 and toured three industrial sites undergoing remediation on the U.S. side. Board comments are as follows.

1. Overall, the board is impressed with the progress being achieved at the three U.S. industrial sites, GM, Reynolds and

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ALCOA. These efforts are significant and contrast with the lack of any remedial action on the Canadian side of the St. Lawrence AOC.

2. Despite this progress, at the GM site, concerns were expressed at the long delay prior to the removal of the most contaminated material from the site. It appeared, to those board members present, that a step-wise, strategic approach, with priorities based on protecting public health, might have resulted in earlier and more effective action. It is recommended that following validation and discussion of these concerns with the company, the decision-making process used in the GM project should be subject to an independent management review, with a view to improved accountability and streamlining of the regulatory system.

3. Consideration of the impact and significance of volatilization of PCBs was apparently not required by regulators in determining the remedial measures for the Reynolds site. Volatilization at this site is further increased by the use of an air curtain, an efficient method of stripping PCBs from water, employed to contain the sediments resuspended during the dredging operation. Volatilization of PCBs is known to be important and has been addressed at other AOCs, for example, in the design and implementation of the dredging plan for the Grand Calumet River. It could be quantified through a modeling study using current scientific methods. Such a study would allow decision makers and evaluators to assess the magnitude of releases and consequent risk to public health arising from the open handling of PCB contaminated material against the cost and feasibility of mitigative measures. Without this information, it is open to debate whether the most cost effective results are being achieved under the existing work plan, and the impact to Canada cannot be quantified. The rationale for selection of an air curtain by the company and the U.S. EPA in the dredging project, and the lessons to be learned for future remediation projects should be examined.

4. Current monitoring efforts, particularly biomonitoring, would appear to be insufficient to allow adequate project management and post-evaluative assessment and would benefit from a plan, technical review and public release of the results.

5. The foregoing comments pertain primarily to the capability of governments to carry out their oversight, management and decision-making responsibilities in a manner that applies the best science and technology available to assist them in achieving their environmental goals of

remediation. Governments should be encouraged to improve peer-review processes or to use outside human resources when necessary, in order that knowledge and expertise are available that ensures the highest standard of cleanup is prescribed and approved.

2.3.6 The Use of Atmospheric Modeling in Policy Development and Using Models to Develop Air Toxics Reduction Strategies

The capability and utility of atmospheric models as a basis for policy and regulatory decision making toward the further control of emissions of persistent toxic chemicals was addressed through the collaborative efforts of the Delta Institute, the IJC's International Air Quality Advisory Board and the Science Advisory Board at a series of two workshops held in July and November 2000.

The substantive findings and recommendations to the IJC from both events are found under the chapter four of the this report and prepared by the IAQAB.

The first workshop identified the capacities of models as scientific tools to contribute knowledge and understanding of the processes and fate of atmospheric sources of persistent toxic chemicals, particularly in the linkage of proximate and more distant sources to receptor regions, such as the Great Lakes. While the need to further acquaint the policy-making community on the application of models was evident, it was made clear that such physical models would be applied together with other models, such as risk analysis and socio-economic impact assessments in formulating policy.

The second workshop considered the application of various models to a determination of sources and extent of contamination of the Lake Michigan basin by selected persistent toxic substances, with reference to parallel modeling efforts in other parts of the world. A preliminary identification of significant areal emission sources, particularly of PCBs, was offered and recommendations for further source identification, ambient monitoring and modeling activities were also developed. The Delta Institute also tabled a preliminary strategy for reducing air toxics deposition to Lake Michigan based largely on data and information from the Lake Michigan Mass Balance Program of the U.S. Environmental Protection Agency.

The Science Advisory Board concurs with the findings of the IAQAB, and endorses their recommendations (found in Chapter 4) arising from these two activities.

2.4. EMERGING ISSUES IN GREAT LAKES SCIENCE,

RESEARCH AND POLICY

2.4.1 Application of a Methodological Framework and a Proposed Process for Agreement Institutions in Addressing Emerging Issues in Great Lakes Science, Research and Policy

Since its last report, several academic and governmental initiatives related to the identification and assessment of emerging issues, and in particular the role of science, have taken place (Munn 1999; Munn et al. 1999; Victor et al. 2000). The improved understanding of phenomenon, such as the geochemical cycling of contaminants, the increased capabilities of monitoring and detection of biological effects of pollutants, and the widespread development and use of sophisticated models at global, regional and local scales, has improved the value and relevancy of forecasts for policy development. The recognition of emerging issues provides an opportunity for policy and decision makers to identify salient topics for further research in areas that may be unproven, not well understood, or related to social and economic trends that are difficult to quantify. More fundamentally, knowledge of emerging issues can result in proactive policies and actions that avoid potential problems before they occur, and is thus linked to the cornerstone of environmental policy and pollution prevention.

In Chapter 1 of the *1997-99 Priorities and Progress under the Great Lakes Water Quality Agreement* (http://www.ijc.org/php/publications/html/pr9799.html), the Science Advisory Board's Work Group on Emerging Issues indicated that it intended to apply a more methodological approach to the assessment of emerging issues. It identified the work of the U.S. EPA Science Advisory Board as one approach meriting attention. A current review of best practices commissioned by the Ontario MOE recommended that a modified version of the U.S. EPA methodology be adapted for use by the ministry. In the report, Victor *et al.* noted that there is "no single example of a thoroughly successful

emerging issues procedure or process in use by an environmental agency anywhere in the world" (Victor et al. 2000).

In order to apply the U.S. EPA methodology, the SAB work group collaborated with the Emerging Issues Committee of the Council of Great Lakes Research Managers to identify a range of issues based on expert judgement and assessed them using the standard values and criteria weights. The assessment methodology is a ranking procedure based on five criteria related to impact and one criterion based on probability. The score for each criteria is assigned an initial value within a range of one to five and then the score is adjusted according to an assigned weight. These are: novelty - 10; scope - 7; severity - 10; visibility - 5; timing - 5; and probability - .5. Since probability assesses the likelihood that an issue will need to be addressed, it is an integrative and predictive criterion, highly dependent on the five impact criteria. Probability values were estimated in percentage terms, based on how likely it is that the specific emerging issue will occur. For example, 100 percent probability has an effect equal to the highest rating of a novel issue, one that has never been seen before. The work group found these values and criteria weights to be appropriate to apply the methodology to Great Lakes emerging issues, however, it recognizes that they could also be adjusted to emphasize different attributes, to reflect other priorities, or if one simply disagreed with the original proposed weighting.

With this scheme, an issue with the highest priority is one that is entirely novel, severely affects essentially everyone, is publically visible, apt to be felt soon, and is highly probable to emerge. The first five criteria characterize an issue assuming it develops as foreseen, while the final criterion reflects the extent to which the issue will develop and needs to be addressed within a relevant future time frame.

A methodological approach to the assessment of emerging issues also provides for further analysis of the results. For example, by assessing impact scores against probability scores it is possible to identify four tiers of concern: high impact/high probability - major issues to be addressed immediately; high impact/low probability - surprise issues requiring no regret policies; low impact/high probability - preparation needed for appropriate response; low impact/low probability - not urgent, watch and wait.

In applying this assessment methodology, the work group and the Council of Great Lakes Research Managers identified the following 18 emerging issues.

- **New or Unmonitored Contaminants**

in Wastewater, Including Pharmaceuticals

Chemicals specifically listed in the Great Lakes Water Quality Agreement and its appendices constitute only a part of the greater discharge of substances into Great Lakes waters. Little attention has been given to several, more diverse groups of substances, including pharmaceutical agents and the bio-active ingredients in a wide array of personal care products.

• Emergence of New Pathogens

New infectious type agents are referred to as `emerging pathogens' and are treated as separate issue from emerging contaminants, such as the chemical and pharmaceutical compounds, discussed above. Pathogens in Great Lakes waters that have been identified over the past decade, typically as a result of outbreaks, include *Cryptosporidia* , *Giardia, Cyclospora* and *Escherichia coli* . A pathogen that is always of potential concern is cholera, which is ever-present in waters elsewhere in the world and has been shown to be spread by the release of ships' ballast water.

• Groundwater

Wise management of water resources in the Great Lakes requires an understanding that groundwater is a large component of the Great Lakes water budget. Decisions that affect the quantity or quality of groundwater discharge to tributary streams and coastal wetlands also affect the quantity and quality of water in the Great Lakes and the health of the Great Lakes ecosystem.

• Invasive Species

Currently there are more than 160 nonindigenous species in the Great Lakes, with more discovered each year. Numerous studies have documented the serious environmental and economic consequences associated with alien invasive species becoming established. Many vectors for transporting alien invasive species have been identified, however the discharge of ballast water from ships entering the Great Lakes from other regions of the world is seen to pose the biggest threat.

• Biotechnology: Engineered Risks of Bioengineered Species

What are the ecological risks to plants and fish from releasing genetically modified organisms into the Great Lakes basin?

• Globalization of Trade and Environmental Issues

The importance of economy and environment linkages and the direct and indirect impacts of increased economic activity on the environment are serious concerns so that competitive advantage does not result in diminished environmental quality. For Great Lakes industry, what are these issues, and what is their potential to impinge on Great lakes water quality?

• Biodiversity Decline

This has generally been defined as a global and a regional conservation issue. For the Great Lakes, there is insufficient data available to determine the significance of species loss to the biological integrity of the waters. Once this can be defined, a strategy to restore and protect native species needs to developed.

• Integrated Monitoring and Observing System

An automated system based on remote sensing and satellite communication, coupled with models to derive the state of the lakes and trends over time, is needed for the critical pollutants.

• Nutrient Targets

Phosphorous continues to be a major source of concern in the Great Lakes, with implications for fisheries and non point management efforts. Are new targets needed under Annex 3, and how should they be derived?

• Ecological and Socioeconomic Issues of Water Level Changes

Significant fluctuations of Great Lakes water levels has occurred and will continue in the future. How might these changes affect water quality, both directly and indirectly? Direct effects could include increased concentration of persistent toxic substances, for example, while an indirect effect could include more navigational dredging involving contaminated sediments.

• Biological Integrity

What is the scientific definition of biological integrity and what policy actions are necessary to achieve it?

• Population Growth Impacts on the Great Lakes

Growth in population and economic activity, along with climate change, may lead to water shortages in some regions of North America. What are the implications for the Great Lakes region? What are the implications for the Great Lakes from the negative impacts of sprawl, increased vehicular use, solid waste management and agribusiness?

• Improved Resource Evaluation

Current techniques to value non-monetary benefits to protect and restore natural resources are limited. How can the decision making process better take into account development decisions to protect human and ecosystem health?

• Climate Change

Increasing reliability of global circulation models makes it increasingly possible to identify local climate change factors and impacts. What will these be, based on the latest research?

• Toxics and Toxins

This topic includes all aspects of biological and chemical pollutants, such as unmeasured or unevaluated chemicals, human health impacts and trends in critical pollutants.

• Air Quality

What are the implications for the lakes of eventual nuclear power plant closings? What are the implications of ongoing long range sources for RAPs and LaMPs?

• Synergistic and Additive Effects of Toxic Mixtures

The Great Lakes Water Quality Agreement delineates research needed to support its goals in Annex 17. Research to develop action levels for contamination that incorporate multi-media exposures and the interactive effects of chemicals was identified as a priority issue for the Parties to the Agreement.

The results provided an overall ranking based on the submission of individual assessments, thus providing a basis for possible consensus or further discussion. Because the exercise tested the veracity of the methodology and there was only a small number of participants involved, the actual ranking of the issues was deemed to be less important than the process used for eliciting them. Therefore, the work group does not intend to apply the results or make recommendations based upon them at this time.

As noted in the SAB's 1997-99 report, a major strength of future research and analysis is to provide a methodological framework to assess information and influence decisions and actions, especially research agendas. The U.S. EPA methodology comprises one approach that demonstrated merit and has potential for use in other exercises of this kind in the future. In applying the methodology however, the importance of a process to ensure involvement of a sufficient number of informed participants was viewed as essential to obtaining robust results. Recent reviews of emerging issue processes in other agencies and internationally identified the need to adopt both a formal procedure and process to benefit from the visionary capabilities of a societies' most innovative and creative members. The work group believes

that the current approach is insufficient to meet the needs of the IJC in fulfilling its alerting role in advising the Parties.

Recommendations

Accordingly, the SAB recommends the following to the IJC.

• Direct a specific group to be responsible for organizing and managing a workshop to identify trends and emerging issues under the Great Lakes Water Quality Agreement at the beginning of each biennial cycle, report on the outcome of their work at the IJC biennial Public Forum, and consider the information when developing work plans for priority activities during each next biennial cycle.

• Direct the advisory institutions of the IJC, according to their roles relative to the science, research and policy relevance

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of an issue, to take a lead role in assessing those issues related to their mandate.

• Direct the advisory institutions to provide a regular report on emerging issues to the IJC, as part of their biennial reporting process under the Agreement.

While the proposed workshop is not envisioned to be large or extensive, it would require some resources on a biennial basis. It is envisioned that the workshop would be attended by invited experts along with board, council and task force members, and would need to focus on at least four major elements in order to provide a comprehensive approach:

• new effects on humans, fish and wildlife related to water quality;

• new chemical agents;

• new sources of pollution; and

• new policy approaches to current problems.

Public interest in emerging issues is also valuable and should be encouraged. Currently the work group maintains a presence through the IJC web site and welcomes public advice through response to its survey questionnaire.

2.4.2 Green Chemistry

In the 1993-95 report from the SAB, the green chemistry approach to less polluting synthesis of chemicals was described. In particular, the ways in which such approaches can minimize waste generation or reduce the toxicity of waste streams were highlighted. Over the last five years there has been development in the scope of green chemistry or cleaner production technologies. Major national or regional awards and research grants for green chemistry are established or proposed in U.S. and Europe. The U.S. Presidential Green Chemistry Challenge is one of the earliest initiatives of this nature (http://www.epa.gov/opptintr/greenchemistry). Companies that have developed new, less-polluting processes or products are showing that progress can be made using green chemistry approaches and leaders in industry and academia are receiving recognition through such awards.

Equally important, broader principles (see Table 3) and longer-term goals of green chemistry (Collins 2001; Smaglik 2000) have been articulated. These include approaches to more benign reagents and synthetic pathways, but also go further, raising fundamental questions around molecular synthesis and the concepts of `single product' manufacturing philosophies, with concomitant by-products and impurities. New approaches to industrial design, the next industrial revolution (McDonough and Braungart, 1998), while in their infancy, provide even higher goals for a green chemistry philosophy, separating biological recycling and technical recycling streams and creating new manufacturing challenges.

The U.S. EPA Office of Pollution Prevention is showing leadership in promoting green chemistry and it appears to be gaining ground within industry and academic institutions. In Canada, while there may be specific developments that fit the concept, there is little visibility of a green chemistry icon within industry, academia or government. For example, in Canada, a significant initiative is currently underway to provide increased partnerships with industry to strengthen innovation by strategically assisting and investing in research and development opportunities while at the same time increasing the research capacity of Canadian universities and government laboratories and institutions through a global strategy for Canadian science and technology. More effective coordination of this program with Environment Canada under a green chemistry banner would serve industry, which has to meet environmental and business competitive goals from its own research and also represent a classic environment and economy linkage, with broader societal benefits.
What are the prospects for research and development in the Great Lakes basin for green chemistry and what opportunities exist for a binational initiative involving academia, government and industry? What opportunities exist for the Parties to promote green chemistry and encourage collaborative approaches that could link the new frontiers of basic chemistry with the relevant environmental challenges of society and industry, particularly in the Great Lakes region? The board concludes that a more proactive approach is appropriate, given the potential benefits of new more benign technologies.

Recommendation

Accordingly, the SAB recommends the following to the IJC.

• Recommend that the Parties promote and coordinate research efforts and visibility of green chemistry priorities within their programs, and on a binational level, promote the innovation and adoption of new technologies in the emerging field of green chemistry to Great Lakes industry.

2.4.3 Integrated Observation and Monitoring Network

The need for development of regional coastal observing systems has been recommended by a number of recent reports, including the NOAA Strategic Plan, the National Ocean Partnership Program and the U.S. Coastal-Global Ocean Observing System program.

The Science Advisory Board also suggested in the 1997-99 priorities report that the development of a Coastal Observing System is of fundamental importance for the Great Lakes region. The board argued that the past decade has seen a rapid development of new sensor capabilities, data management, data transmission and data visualization technologies. *In situ* instrumentation is now available with high temporal measurement frequency, as are remote telemetry capabilities, either via hard wire (e.g. fiber optic) or cellular telephone links, and a variety of measurement capabilities, including *in situ* biomonitoring.

The next logical step is to hold a workshop designed to review capabilities and produce a plan for the Great Lakes region. A similar plan has been offered by the oceanic community. The workshop will consist of invited experts from around the world on available and developing *in situ* measuring platforms, sensors, telecommunications, and visualization and modeling needs. The proposed sessions include: User Community Needs, Navigation and Communication, Environmental Sensing and Interpretation, Data Transmission, Management and Visualization, and Status of Stationary and Mobile Underwater Platforms.

The Workshop is scheduled for September 18 - 21, 2001 at the Massachusetts Institute of Technology, Boston, Massachusetts and is cosponsored by MIT and Wisconsin Sea Grants, the IJC, the NOAA Great Lakes Environmental Research Laboratory and the NOAA Office of

Atmospheric and Oceanic Research. The anticipated product will be a blueprint for deploying an *in situ* Great Lakes Observation System.

2.5 ACTIVITIES AND MEETINGS OF THE SCIENCE ADVISORY BOARD

FOR THE 1999-2001 BIENNIAL CYCLE

116 December 1-2, 1999 Windsor, Ontario

117 February 24-25, 2000 Windsor, Ontario

118 May 4-5, 2000 Windsor, Ontario

119 October 4-5, 2000 Windsor, Ontario

The Work Group on Ecosystem Health held a workshop on Methodologies for Community Health Assessment in Areas of Concern.

120 November 29-30, 2000 Niagara Falls, New York

Held a Niagara Status Assessment, open house and public forum as well as a tour of a waste facility and some industrial sites.

121 February 22-23, 2001 Windsor, Ontario

March 21, 2001 The Work Group on Parties Implementation held a workshop on a Review of Annex 1 of the Great Lakes Water Quality Agreement.

122 May 23-24, 2001 Cornwall, Ontario

Tour of four industrial sites in Massena, New York.

123 September 13, 2001 Montréal, Québec

In association with 2001 biennial Public Forum.

2.6 SCIENCE ADVISORY BOARD AND WORK GROUP MEMBERSHIP 1999-2001

Dr. Anders Andren âå

Sea Grant Institute

University of Wisconsin - Madison

Madison, Wisconsin

Dr. William Bowerman âã

Department of Environmental Toxicology,

Clemson University,

Pendleton, South Carolina

Dr. John Carey âã

National Water Research Institute

Burlington, Ontario

Dr. David Carpenter, M.D. âã

Environmental Health and Toxicology

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Rensselaer, New York

Dr. Donald Dewees âä

Department of Economics

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Dr. Michael Donahue *(U.S. Co-chairman* â *)*

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Ann Arbor, Michigan

Dr. Michel Fournier âã

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Mr. Henry Lickers âä

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National Health and

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U.S. Environmental Protection Agency

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Sunnybrook Health Science Centre

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Mr. Tony Wagner

(Canadian Co-chairman åå *)*

(resigned April 2000)

Guelph, Ontario

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Dr. H. Kay Austin *(Liaison* â *)*

(from September 2000)

International Joint Commission

United States Section

Washington, D.C.

Mr. Bruce Bandurski *(Liaison* â *)*

(to September 2000)

International Joint Commission

United States Section

Washington, D.C.

Mr. Peter Boyer *(Secretary* âä *)*

International Joint Commission

Great Lakes Regional Office
Windsor, Ontario

Dr. Marty Bratzel *(Secretary* å *)*

(from September 2000)

International Joint Commission

Great Lakes Regional Office

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Ms. Ann MacKenzie *(Liaison* â *)*

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Mr. Geoffrey Thornburn *(Liaison* â *)*

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â Science Advisory Board

ã Workgroup on Ecosystem Health

ä Workgroup on Emerging Issues

å Workgroup on Parties Implementation

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Appendix I. List of Health Outcomes Selected by Health Canada on the Basis That They Might Be Linked To Pollution.

(http://www.hc-sc.gc.ca/ehp/ehd/bch/bioregional/healthdata.htm)

ICD*-9 Category ICD-9:# Disease or Condition

All Causes

Category II All Malignant Neoplasms

140-149 Malignant Neoplasm of Lip, Oral Cavity and Pharynx

146-148 Malignant Neoplasm of the Pharynx

150-159 Malignant Neoplasm of Digestive Organs and Peritoneum

150 Malignant Neoplasm of Oesophagus

151 Malignant Neoplasm of Stomach

153-154 Malignant Neoplasm of Colon and Rectum
155 Malignant Neoplasm of Liver and Introhepatic Bile Ducts

156 Malignant Neoplasm of Gallbladder and Extrahepatic Bile Ducts

157 Malignant Neoplasm of the Pancreas

160-165 Malignant Neoplasm of Respiratory and Intrathoracic Organs

162 Malignant Neoplasm of the Trachea, Bronchus and Lung

170-175 Malignant Neoplasm of Bone, Connective Tissue, Skin and Breast

172 Malignant Melanoma of Skin

174 Malignant Neoplasm of Female Breast

179-189 Malignant Neoplasm of Genitourinary Organs

183 Malignant Neoplasm of Ovary and Other Uterine Adnexa

185 Malignant Neoplasm of the Prostate

186 Malignant Neoplasm of Testis

188 Malignant Neoplasm of the Bladder

189 Malignant Neoplasm of Kidney, Other and Unspecified Urinary Organs

190-199 Malignant Neoplasm of Other and Unspecified Sites

193 Malignant Neoplasm of Thyroid Gland

200-208 Malignant Neoplasm of Lymphatic and Haematopoietic Tissue

200-202 Non-Hodgkin's Lymphoma

201 Hodgkin's Disease

204-208 Leukaemia

Category III 240-246 Disorders of Thyroid Gland

250-259 Diseases of Other Endocrine Glands

250 Diabetes Mellitus

255 Ovarian Dysfunction

257 Testicular Dysfunction

270-279 Other Metabolic Disorders and Immunity Disorders

Category IV 280-289 Diseases of Blood and Blood-Forming Organs

Category VI 330-337 Hereditary and Degenerative Diseases of the Central Nervous System

332 Parkinson's Disease

340-349 Other Disorders of the Central Nervous System

340 Multiple Sclerosis

343 Infantile Cerebral Palsy

350-359 Disorders of the Peripheral Nervous System

359 Muscular Dystrophies and Other Myopathies

360-379 Disorders of the Eye and Adnexa

369 Blindness and Low Vision

380-389 Diseases of the Ear and Mastoid Process

Category VII 401-405 Hypertensive Disease

410-414 Ischemic Heart Disease

415-417 Diseases of Pulmonary Circulation

420-429 Other Forms of Heart Disease

440-448 Diseases of Arteries, Arterioles and Capillaries

440 Atherosclerosis

Category VIII 460-466 Acute Respiratory Infections

470-478 Other Diseases of the Upper Respiratory Tract

470-487 Pneumonia and Influenza

490-496 Chronic Obstructive Pulmonary Disease and Allied Conditions

491 Chronic Bronchitis

492 Emphysema

493 Asthma

500-537 Pneumoconiosis and Other Lung Diseases due to External Agents

Category IX 530-537 Diseases of Oesophagus, Stomach and Duodenum

555-558 Noninfective Enteritis and Colitis

560-569 Other Diseases of Intestines and Peritoneum

570-579 Other Diseases of Digestive System

Category X 580-589 Nephritis, Nephrotic Syndrome and Nephrosis

590-599 Other Diseases of Urinary System

600-608 Diseases of Male Genital Organs

606 Infertility, Male

610-611 Disorders of the Breast

617-629 Other Disorders of Female Genital Tract

617 Endometriosis

628 Infertility Female

Category XI 630-639 Pregnancy with Abortive Outcome

634 Spontaneous Abortion

640-648 Complications mainly related to Pregnancy

642 Hypertension Complicating Pregnancy, Childbirth and the Puerperium

644 Early of Threatened Labour

680-686 Infections of Skin and Subcutaneous Tissue

690-698 Other Inflammatory Conditions of Skin and Subcutaneous Tissue

700-709 Other Diseases of Skin and Subcutaneous Tissue

Category XII 710-719 Arthropathies and Related Disorders

720-724 Dorsopathies

725-729 Rheumatism, excluding the Back

730-739 Osteopathies, Chondropathies and Acquired Musculoskeletal Deformities

Category XII All Anomalies

740.0-742.9 Central Nervous System Anomalies

740.0-740.2 Anencephalus and Similar Anomalies

741.0-741.9 Spina Bifida

742.1-742.2 Microcephalus and Brain Reduction

742.3 Congenital Hydrocephalus

743.0-743.9 Eye Anomalies

745.0-746.9 Congenital Heart Defects

745.4 Ventricular Septal Defect

745.5 Atrial Septal Defect

747.1-747.9 Circulatory System Anomalies

747.3 Pulmonary Artery Anomalies

748.0-748.9 Respiratory System Anomalies

749.0-749.2 Cleft Lip and/or Palate

750.1-751.9 Digestive System Anomalies

752.6 Hypospadias, Epispadias

753.0-753.9 Urinary System Anomalies

753 Renal Agenesis and Dysgenesis

754.5-754.7 Clubfoot

755.0-755.1 Polydactyly, Syndactyly

755.2-755.3 Limb Reduction Anomalies

758 Down Syndrome

Category XIV 760-779 Certain Conditions Originating in the Perinatal Period

* The Ninth Edition of the International Classification of Disease (1992).

Appendix II. Mortality, Morbidity and Congenital Anomalies Rates (1986-1992)

in the Windsor Area of Concern

Introduction

In November 1999, Health Canada (1998) released a set of reports on the health status of 17 sub-populations on the Canadian side of the Great Lakes. These 17 sub-populations lived in Areas of Concern (AOCs) designated as such under the Great Lakes Water Quality Agreement. One of these areas is the Detroit River, and, as part of its Great Lakes Health Effects Program, Health Canada compiled data and statistics on the health of the community residing in the following municipalities: Windsor; Amherstburg; Tecumseh, Sandwich West; Essex, Belle River; St.Clair Beach, Anderton, Malden, Colchester North, Sandwich South, Rochester and Maidstone. For the purposes of this report, the selected municipalities are referred to as the Windsor AOC.

The reports are valuable sources of data on the incidences of diseases and their statistical significance for each of the 17 AOCs compared with the rest of the province of Ontario. Data were selected by Health Canada on diseases that might be linked to exposures to contaminants in the environment. The reports provide quantitative data as a resource to professionals to investigate the health status of communities within the AOC and compare incidence rates with the rates in the rest of the population in Ontario. No attempt was made to explain causal relationships between exposures to contaminants and any specific health outcome. The objective was to provide a basis for forming hypotheses that could be further investigated.

Windsor residents are exposed to a variety of contaminants from a variety of sources. In addition to occupational exposures of the workforce to a variety of products during manufacturing, residents are exposed to a variety of pollutants discharged to the waters and emitted to the atmosphere in Windsor and Detroit, Michigan.

Congenital Anomalies and Infant Mortality

One of the health outcomes of particular interest to potential parents is the health of their newborn child. The Windsor AOC had 13,196 females born between 1986 and 1992. 779 of these had some kind of anomaly diagnosed within the first year. This was 25 percent higher than the rest of Ontario and included: 13 females born without brains, anencephalus, at a rate three times higher than the rest of Ontario; 149 girls born with heart defects, 56 percent higher; 95 with clubfoot, 69 percent higher; and 10 with reductions in the length of their limbs, 2.24 times higher. 93 girls died within the first year at a rate 24 percent higher than the provincial rate.

Similarly, there were 13,950 boys born between 1986 and 1992, and of this group, 885 had anomalies, 13 percent higher than the provincial rate; 24 had water on the brain, congenital hydrocephalus, at a rate 88 percent higher than the provincial rate; 172 had congenital heart defects, 65 percent higher; and

89 had clubfoot, 36 percent higher. 97 boys died within the first year at a rate that was comparable to the rest of Ontario.

From a statistical standpoint, it is impossible to determine whether the infants who died had a significantly elevated incidence of anomalies, but the table in the Health Canada report warns about or flags several conditions, including anomalies of the nervous system and heart, renal and urinary systems, circulatory and respiratory systems, and Down syndrome.

Mortality Rates and Morbidity Incidence, Based on Hospitalization Records, 1986-1992

The rate at which people die or go to the hospital can be taken as an indication of the overall health of the community. People in the Windsor AOC died at a significantly higher rate, males - 8 percent higher and females - 5 percent higher, than in the rest of Ontario. This increased mortality occurred significantly among people who were over 45 years old and for both males, 14 percent higher and females, 10 percent higher. The number of cases of people in the Windsor AOC hospitalized for all causes was about 15 percent higher for females and 21 percent higher in males than in the rest of Ontario.

In terms of infectious diseases, the people of the Windsor AOC had lower rates of mortality. Males tended, however, to have a higher incidence of morbidity from intestinal infectious diseases, 11 percent higher than provincial rate, particularly among those under 25 years old, 14 percent higher, and females had a 53 percent higher incidence of morbidity from viral hepatitis, particularly among females between 45 and 75 years of age, 73 percent higher.

In recent years there has been a growing appreciation of the effects of environmental contaminants on the functioning of the endocrine and immune systems. While the incidences of mortality from this class of diseases in the Windsor AOC tended to be non-statistically above the provincial rates, the morbidity was of particular concern. For example, there were 314 cases of thyroid disease in females, representing a 24 percent increase over the provincial rate. In contrast to all the other 16 AOCs, the onset of the increased incidence of thyroid disease in females occurred in the Windsor AOC between birth and 24 years of age and this increase was more than two fold of the provincial rate. Further, there were elevated rates for thyroid disease in Windsor women occurring in all age categories, suggesting the possible presence of thyroid active agents in the Detroit/Windsor environment. Interference with thyroid function has recently been implicated

in the structural and functional development of the fetal and infant brain with consequences for learning and behaviour.

Similarly, there are increased incidences of morbidity for diseases of other endocrine glands in both males, 41 percent, and females, 41 percent, over the provincial rate. In contrast to Hamilton and Toronto that had rates of diabetes 30-40 percent lower than the provincial rates, the rates in the Windsor AOC were 44 percent higher for males and 41 percent higher for females. In common with other relatively polluted locations, such as Thunder Bay, Sault Ste Marie, Spanish River and Niagara Falls, the onset of the increase in the incidence, 58 percent for males and 41 percent for females, in the Windsor AOC occurred between birth and 24 years old. These data indicated that there may be environmental pollutants that interfere with the functioning of the pancreas.

Similarly, in contrast to Hamilton and Toronto that had rates of ovarian dysfunction related to diseases of the endocrine system well below the provincial rate, the rate in the Windsor AOC was more than twice, 2.12 times, the provincial rate and comparable with the rates at Thunder Bay, 2.19 times, and Sault Ste Marie, 2.34 times, though not as high as at Spanish River, 5.84 times. There was an early onset of the hospitalization of women for ovarian dysfunction in the Windsor AOC and the increased incidence began in the group under 25 years of age.

In terms of morbidity as hospitalization from disorders of the metabolic and immune systems, both males and females had incidence rates that were more than 40 percent higher than the rest of the province. In males, the increased incidence, 30 percent higher, occurred among those under 25 years old. In males and females over 45 years old, the morbidity rate as hospitalization was respectively 47 percent higher and 61 percent higher, and rose for those over 75 years old to 60 percent and 94 percent. 46 females died of these disorders at a rate that was 33 percent higher than the rest of the province. The rate of mortality among females between 45 and 74 years old was 86 percent higher than the rest of the province.

The population in the Windsor AOC tended to have higher morbidity rates for diseases of the blood and blood-forming organs compared with the rest of Ontario. Males had a 29 percent higher incidence rate and the corresponding figure for females was 13 percent higher (See also section 4 below for mortality and morbidity from cancer of the lymphatic and hematopoietic systems). Among males between birth and 24 years old, the incidence was 68 percent higher than males of the corresponding age in the rest of Ontario. Males over 45 years old had rates that were 15 percent higher and among females over 75 the rate was 10 percent higher than the corresponding provincial rates.

There were several disorders of the nervous system and sense organs that exhibit significantly higher incidence rates in the Windsor AOC than in the rest of the province. The rate of hereditary and degenerative diseases of the central nervous system in

both males and females was about 15 percent higher than the incidence rate for the rest of Ontario. For both males and females between 25 and 44 years old, the rate rose to 44 percent and 54 percent respectively above the provincial rate. Similarly, for other disorders of the central nervous system, the morbidity incidence rate was higher for males, 31 percent, and females, 21 percent, and rose to 54 percent above the provincial rate among women between 25 to 44 years old and to 40 percent above the provincial rate among men between 45 and 75 years old. The mortality rate for males between 25 and 44 years old was more than twofold, 231 percent higher than the provincial rate for disorders of the central nervous system. Disorders of the peripheral nervous system, such as muscular dystrophies and other myopathies, were about 45 percent higher than the provincial rates in both males and females, and among those between 25 and 44 years old the rate above the provincial rate rose to 99 percent higher for males and 81 percent for females. The rate of disorders of the eye was 21 percent higher among males and 11 percent higher than the provincial rate among those between 45 and 74 years old.

There are several diseases of the circulatory system for which the population in the Windsor AOC had a significantly higher incidence of mortality and morbidity than in the rest of the province. Of particular concern was the rate of mortality for hypertensive disease in males that was 56 percent higher, and mortality from diseases of the arteries, particularly atherosclerosis that was more than two times higher than in the rest of the province for males, 2.23 times, and for females, 2.45 times. Other disorders of the circulatory system for which there was a higher morbidity than in the rest of the province include: hypertensive disease, about 40 percent higher, and ischaemic and other heart diseases, about 20 percent higher.

In terms of the incidence of diseases of the respiratory system, the community had more than a two fold increase over the rest of the province for mortality from chronic bronchitis in males (See also section 4 below for mortality and morbidity from cancer of the respiratory and intrathoracic organs). Elevated incidences of morbidity for other disorders of the respiratory system included: respiratory infections; pneumonia and influenza; chronic obstructive pulmonary disease, particularly, including chronic bronchitis, 77 percent higher, and asthma, 9 percent higher, in females. The number of cases of hospitalization for asthma between birth and 24 years of age between 1986 and 1992 was 1637 for males, 490 per 100,000 population, and 1239 for females, 380 per 100,000 population.

Among the diseases of the digestive system, mortality in males and females was about 40 percent higher than the provincial rate for diseases of the oesophagus, stomach and duodenum. Significantly elevated rates of morbidity over the provincial rates were evident for: diseases of the oesophagus, stomach and duodenum, 30 percent higher for males and 60 percent higher for females; noninfective enteritis and colitis, 70 percent higher for males and 46 percent for females; and other diseases of the intestines and peritoneum, 23 percent higher for males and 33 percent for females; and digestive system, 16 percent for males and 20 percent for females. Of particular concern was the increased rates compared with the rest of the province for these diseases among young males and females between birth and 24 years of age with rates about 70 percent higher than in the rest of the province (See also section 4 below for mortality and morbidity from cancer of the digestive organs and peritoneum).

Several of the rates of the incidences of morbidity from diseases of the genitourinary system in the population were elevated (See also section 4 below for mortality and morbidity from cancer of the genitourinary organs). There was more than a 60 percent increased incidence rate of diseases of the urinary system in both males and females and increased incidences occur in all age classes. Morbidity from disorders of the breast was increased in both males, 44 percent, and females, 30 percent. Morbidity as hospitalization cases for diseases of the male genital system was elevated 40 percent and for infertility was 55 percent higher than the rate in the rest of the province and elevated incidence rates occur in all age classes. Similarly, morbidity from disorders of the female genital tract was elevated 14 percent. Morbidity from cases of hospitalization for females between 25 and 44 years old was elevated for endometriosis, 9 percent higher, and for infertility, 13 percent higher, compared with rates in the rest of the province.

There was a significantly elevated incidence of morbidity from inflammatory conditions and other diseases of the skin and subcutaneous tissues in both males and females and in all age classes. The incidences in males and females between birth and 24 years old were, respectively, about 60 percent and 30 percent higher than the rest of the province, but rose to about twice the provincial rate in 25 to 44 years of age.

The rates of morbidity as hospitalization cases for diseases of the musculoskeletal and connective systems in the population of the Windsor AOC were significantly elevated for the following: arthropathies and related diseases, 12 percent for males and 11 percent for females; dorsopathies, 26 percent for males and 21 percent for females; rheumatism, excluding the back, twofold increase for males and 88 percent increase for females; and osteopathies, chondropathies and acquired musculoskeletal deformities, 27 percent for males and 30 percent for females. These elevated incidence rates tended to occur in all age classes up to 75

years old. Five females between 45 and 74 died of diseases classified as osteopathies, chondropathies and acquired musculoskeletal deformities resulting in incidence rates more than threefold, 361 percent higher than the provincial rate.

Cancer Mortality and Morbidity

The following is a description of the cancer mortality and morbidity based on the health data and statistics for the period 1986-1992. In the intervening years, the incidence of cancer in the Windsor AOC may have increased. The incidence of selected cancers in the population was 4,275 cases for males and 3,941 for females. The incidence rate for males was seven percent above the rate for the rest of the province. Among males and females between 45 and 74 years old, the elevated incidence rates of cancer morbidity were, respectively, 10 percent and 5 percent higher than the provincial rates

The incidence rate for mortality from cancer of the lip, oral cavity and pharynx among people who were between 45 to 75 years old was 54 percent higher for males and more than twofold higher for females.

Among the class of cancers of the digestive organs and peritoneum, there was a 10 percent higher incidence rate of mortality among males and 16 percent higher among those between 45 and 74 years of age than in the rest of Ontario. Much of this increased rate of mortality from cancer in males was attributable to cancer of the stomach, colon and rectum. Of particular concern, however, was the increased rate of mortality from pancreatic cancer among both males, 49 percent higher, and females, 57 percent higher, particularly for those between the ages of 45 to 74. This significantly elevated mortality among this age group from pancreatic cancer was reflected in increased morbidity rates in males, 33 percent higher, and females, 40 percent higher. In women, this increased morbidity rate from pancreatic cancer, 43 percent higher, persisted for those in the Windsor AOC for those over 75 years of age.

There were increased incidence rates for morbidity and mortality from cancers of the respiratory and intrathoracic organs for both males and females. The mortality and morbidity rates were elevated, respectively, by 17 percent and 19 percent in males and by 12 percent and 16 percent in females. Among males between 25 and 45 years of age, the rate of morbidity was 77 percent higher and the mortality was more than twice the provincial rate. Elevated incidence rates of morbidity from lung cancer were evident for males, 20 percent, and females, 17 percent, between 45 and 74 years of age.

In terms of cancers of the genitourinary organs, including the ovary, prostate, testis, bladder, kidney and other urinary organs, a statistically significant increase in morbidity was evident for bladder cancer in males, 19 percent higher, between 45 and 74 years of age. Mortality rates for males

and females from all cancers of the genitourinary organs tended to be elevated even though they did not reach statistical significance.

There were three kinds of cancers of the lymphatic and hematopoietic (blood forming) system: Non-Hodgkin's lymphoma, Hodgkin's lymphoma and leukemia. There was more than a twofold higher, 226 percent, incidence rate for mortality from Hodgkin's disease in females and twofold elevated rates, though they were not statistically significant, occurred in all age categories. The rates of morbidity from leukemia was significantly elevated in both males, 33 percent higher, and females, 44 percent higher, between 45 and 74 years of age compared with the rest of the province.

Comparison With Hamilton, Ontario

Health Canada selected these health outcomes based on the plausibility that the outcome could occur as a result of exposure to environmental contaminants. Hamilton is another municipality with heavy manufacturing in southern Ontario, is designated as an Area of Concern, and might represent a useful comparison with the health data and statistics for the Windsor AOC.

The overall rates of congenital anomalies in the Hamilton population were 20-30 percent lower than the Ontario provincial rates and thus the rates for males in Hamilton were 35 percent lower than in the Windsor area and 53 percent lower for girls. Such contrasts might indicate the presence of contaminants in the Windsor environment that might be increasing the rates of congenital anomalies.

There was a marked contrast between Windsor and Hamilton in terms of the morbidity as hospitalization in relation to diseases

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of the endocrine, nutritional, metabolic and immune systems. The Windsor population experienced higher incidence rates than the provincial rates for diseases of the thyroid, diabetes, ovarian dysfunction and for metabolic and immunity disorders, whereas the Hamilton population exhibited much lower incidence rates. While the increased mortality rates for endocrine and immune diseases in the Windsor population may not be statistically significant compared with the rest of the province, they contrasted with the rates in the Hamilton population that were significantly lower than the provincial rates. There was a similar marked contrast between these two Areas of Concern in terms of the incidence rates for diseases of the blood and blood-forming organs.

In terms of the diseases of the nervous systems and sense organs, the population in the Windsor AOC showed markedly elevated incidence rates

for diseases of the central and peripheral nervous systems and disorders of the eye in both males and females. In contrast, Hamilton had an increased rate only for diseases of the peripheral nervous system in females and for infantile cerebral palsy in females.

The incidence rates for certain circulatory diseases was the only category for which Hamilton had comparable disease incidence rates. For example, there were higher rates of atherosclerosis in Hamilton versus Windsor males, respectively 91 percent versus 61 percent higher than the provincial rate, and comparable rates in females, 63 percent versus 66 percent higher than the provincial rate. There were also possible concerns about the slightly elevated incidence rates for ischaemic heart disease compared with the provincial rates in Hamilton males, 1 percent higher, and females, 3 percent higher, and for pulmonary circulation in females, 12 percent higher. But these contrast with the markedly elevated incidence rates in Windsor for males and females for hypertensive disease, respectively 41 percent and 36 percent higher; ischaemic heart disease, 18 percent and 36 percent higher; diseases of the pulmonary circulation in males, 18 percent higher; other forms of heart disease in males and females, 14 percent and 23 percent higher; and diseases of the arteries, arterioles and capillaries, 29 percent and 27 percent higher. These contrasts in the measures of morbidity from circulatory diseases in the Hamilton and Windsor populations are reflected in the mortality rates in the respective communities.

There was a similar marked contrast between the incidence rates for Hamilton versus Windsor for the respiratory systems in both males and females. Rates in Hamilton for acute respiratory infections and other diseases of the upper respiratory tract, pneumonia and influenza and for chronic obstructive pulmonary diseases, including chronic bronchitis, emphysema and asthma, were markedly below the provincial rates in contrast to those in Windsor that were significantly elevated.

Similar contrasts in incidence rates between the two Areas of Concern were evident for morbidity as hospitalization for diseases of the digestive and genitourinary systems and for inflammatory and other conditions of the skin and subcutaneous tissues and for diseases of the musculoskeletal and connective systems.

Similar contrasts between Windsor and Hamilton were evident for the cancer morbidity and mortality rates. In Hamilton, there were no categories of cancer for which there was an elevated incidence rate for morbidity that was statistically significantly. However, there were several, such as the morbidity rate for cancer of the colon and rectum, prostate, and female genitourinary organs that were significantly lower than the provincial rates. In Windsor, there were significantly elevated rates of morbidity from cancer of the pancreas and of the intrathoracic organs in males and females, and of the bladder and of leukemia in males. Females had significantly lower rates of cancer of the oesophagus and melanoma of the skin.

Similarly, mortality from cancer was elevated in the Windsor population compared with the Hamilton population. In the Hamilton data base, there was a significantly elevated incidence of cancers that were unspecified in both males and females making direct comparison difficult. Mortality in males in Windsor was significantly elevated for cancers of the lip, oral cavity and pharynx, and for cancer of the colon and rectum. Mortality from pancreatic cancer was significantly elevated in males and females in the Windsor area. While males in Hamilton died from cancers of the intrathoracic organs at an elevated rate, 6 percent higher, compared with the rest of the province, the mortality rates in Windsor tended to be 10 percent higher and the rate for females became statistically significant compared to the rate in the rest of the province.

Conclusion and Recommendation

Based on the health data and statistics for those health outcomes that might be related to exposures to environmental contaminants, the population living in the Windsor Area of Concern experienced the following: a higher incidence of cancer; a higher rate of hospitalization for a variety of diseases; and their infants had a higher incidence of congenital anomalies than the rest of the province. Because no specific causes of these increased incidence rates of these health conditions have been identified in the

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Windsor Area of Concern, as a precaution, every measure should be taken to reduce exposures to environmental contaminants whether the exposure route is from occupation, water, air or food, or from dust.