COUNCIL OF GREAT LAKES RESEARCH MANAGERS
1997-1999 PRIORITIES REPORT

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November 5, 1999

COUNCIL OF GREAT LAKES RESEARCH MANAGERS 1997-1999 PRIORITIES REPORT

1. INTRODUCTION

The Council of Great Lakes Research Managers (the Council) is the International Joint Commission's (IJC) principal advisor on research programs and research needs. The Council undertook a number of activities in the 1997-99 biennial cycle, in accordance with identified priorities from the Commission. In addition, the Council scoped out a number of issues that will form the basis of future work by the Council, and advice to the IJC, and also supported some significant research activities.

1.1. *Council Priorities*

The Great Lakes-St. Lawrence Research Inventory continues to be the most frequently accessed area on the IJC's web site, often recording 500 hits per month. This venue coupled with increased conference exhibits at Great Lakes events has generated considerable exposure and greater inventory use by both the science community and the general public, use which is expected to continue in an upward trend.

Modeling Summit sessions were held at two major Great Lakes conferences. The first was held at the State of the Lakes Ecosystem Conference 1998 (SOLEC'98) in Buffalo, New York, and focused on the linkages amongst ecosystem components. The second was held at the International Association for Great Lakes Research 1999 (IAGLR'99) in Cleveland, Ohio and centered on the application of models to Lake Erie management issues.

As a founding member of the Task Team responsible for establishing the Great Lakes Communicator Network, the Council held an inaugural workshop in March 1999 in Ann Arbor, Michigan. The event was very successful and attended by communicators, managers, and scientists to develop a strategy for communicating research needs, gaps, and priorities using media, education, technology, and resource-sharing mechanisms.

1.2. *Scoping Activities*

At its 27th meeting in Niagara Falls, Ontario, in an effort to prioritize our efforts and better advise/serve the Commissioners, the Council defined an activity called "scoping" whereby the Council would evaluate the current state of knowledge and research needs, gaps and priorities for issues/problems facing the region and evaluate their relevance to the IJC. During the 1997-1999 Priority Cycle this scoping activity was directed at seven IJC priority areas: sediment, indicators implementation, Lake Erie, commercial aquaculture, biodiversity and habitat, persistent toxic substances and endocrine disrupters, and Remedial Action Plan (RAP) and Lakewide Management Plan (LaMP) research. These are discussed more fully below.

The scoping of the biodiversity and habitat issue in particular, generated numerous recommendations from experts in support of preservation and enhancement. Additionally, a survey of 136 Great Lakes agencies and institutions was undertaken in June 1998 to gain a better understanding of organizational roles, responsibilities, and goals with a view to ensuring preservation of critical habitats, enhancing an ecosystem/ ecoregional management approach, developing effective legislation, and coordinating biodiversity research.

1.3. *Research Support Activities*

In addition to the Research Inventory, the Council's research support activities were targeted at research vessel coordination and the development of a formal relationship and joint initiatives with the International Association for Great Lakes Research (IAGLR). Research vessel coordination workshops were held in March 1998 and in February 1999, premised on previously generated recommendations. Topics explored included communication and information sharing, institutional information requirements, and program development/coordination.

Two motions of significance involving joint initiatives with IAGLR were passed at the Council's 30th meeting in Montreal. The first involved an annual donation of $1,000 used to conduct a survey of emerging research needs, and the second was aimed at engaging heads of major research laboratories/agencies in presenting their research activities, priorities, and future directions at each annual IAGLR conference.

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2. COUNCIL PRIORITIES

2.1. *Research Inventory*

The Council of Great Lakes Research Managers, in an effort to promote interjurisdictional and interdisciplinary planning and coordination of research related to the implementation of the Great Lakes Water Quality Agreement, initiated this compilation of current research activities in the Great Lakes-St. Lawrence River basin. The Great Lakes-St. Lawrence Research Inventory continues to be produced by the Council every year as part of the continuing priority for improving the effectiveness and awareness of research throughout the Great Lakes region.

2.1.1. 1997 Inventory

When compared to the 1996 inventory, fewer projects and dollars of research were represented in the Inventory for this year (290 projects and $39 million U.S. dollars). Part of the reason is a real decrease in research funding. However, another reason for the decline is that many managers and researchers are overworked and are continually being asked to do more with less, including managers who complete the project descriptions for the Inventory. Note that improvements were made by the addition of an update capability which allowed changes to project descriptions on-line without having to re-enter the entire project. Also, the mailing list was refined to avoid duplicate mailings.

2.1.2. 1998 Inventory

The total number of projects entries increased to 436 representing a value of $67,219,112 US plus $ 6,489,145 Cdn. Forty-seven distinct agencies and organizations from both the U.S. and Canada had research projects listed in the inventory. Many of these agencies are further represented by branches, regions, and districts. Submitting agencies included government agencies, universities, Sea Grant extensions, Ontario conservation authorities, and associations.

A number of modifications were made to the 1998 Inventory following suggestions from the Council to increase the use of the Inventory for managing research and assessing information. These changes included more extensive searching capabilities, whereby it is now possible to search the inventory using ten different categories such as inventory titles, submitters, submitting agencies, keywords, investigators, scope,

scale, type, state/province, and basin. The Research Inventory search page can be found at http://www.ijc.org/php/publications/html/ri99home.html(.)

Two new sections were added to the request form to provide information for the Great Lakes Panel on Aquatic Nuisance Species and monitoring and research for the Lake Ontario Lakewide Management Plan (LaMP) Work Group. This survey is an efficient means of developing the Panel's inventory of aquatic nuisance species research relevant to the Great Lakes basin. The Great Lakes Panel anticipates that this research information will assist with future efforts to prevent further aquatic nuisance species introductions. The second addition to the form requests additional information details on monitoring and research relevant to Lake Ontario. Information regarding relevancy of research to beneficial use impairments, contaminant loadings or concentrations, and monitoring details such as media type, intensity, and monitoring region, will be used to guide future updates to LaMP documents.

Projects were accepted for the 1998 Research Inventory until March 15, 1999 at which time the 1998 database was closed and finalized.

2.1.3. 1999 Inventory

A request for new submissions and update forms was sent out in early May of 1999 for inclusion in the 1999 Research Inventory database. Presently there are 316 projects in the 1999 Research Inventory with a value of $21,835,302 U.S. plus $5,661,200 Cdn.

The Council's Research Inventories continue to be the most highly accessed publications on the IJC's web site, often recording more than 500 hits per month. An exhibit of the Research inventory was featured at the 1999 IAGLR conference in Cleveland, Ohio and will also be on display at the 1999 IJC's Biennial Forum in September. Through these events, increased use of the Research Inventory by the science community and the public is expected.

2.2. *Modeling Summit*

Council activities under this priority consisted of two sessions held at major Great Lakes conferences during the priority cycle: SOLEC'98 and IAGLR'99. The title of the SOLEC'98 session was: "Connecting Ecosystem Objectives and Indicators through Modeling" and the IAGLR'99 session was called: "Great Lakes Modeling Summit: Focus on Lake Erie". A stand-alone report is planned for this priority, but a brief description and summary of the sessions is provided here.

2.2.1. SOLEC Modeling Summit, October 23, 1998

At SOLEC'98 held during October 1998 in Buffalo, New York, the Council hosted a modeling session focussing on connecting ecosystem objectives and indicators. This session presented two examples of how LaMP workgroups can use models to make a theoretical connection and validate the selection of an indicator of a given ecosystem objective that they have "set".

The Council defined the following terms for use during the workshop:

Environmental Indicator: A measurable feature or one derivable from measurements which singly or in combination provides managerially and scientifically useful evidence of environmental and ecosystem quality, or reliable evidence of trends in quality.

Ecosystem Objective: A statement of a goal or desired outcome for a water body that describes in qualitative terms a target which management efforts are attempting to achieve.

Modeling: The exercise of representing a part of the ecosystem symbolically, either as a diagram or as a set of mathematical equations. Simple or conceptual models can be described in a drawing with boxes and arrows. Complex mathematical models are usually computer programs with mathematical and/or statistical descriptions of the system being modeled.

The achievement of an ecosystem objective is tracked by the selection and reporting of one or more indicators that quantitatively monitor ecosystem response. A good indicator of ecosystem health and integrity integrates a wide range of environmental factors (or stressors) into a single attribute that reflects the response of the system to those stressors. Ecosystem models that relate the response of an ecosystem to the cumulative impact of multiple stressors can provide the theoretical basis for indicator selection and application.

Starting from a couple of hypothetical ecosystem objectives (e.g., elimination of fish consumption advisories, absence of blue-green algal blooms, sustainable walleye population, etc.), an appropriate model was used to demonstrate the connection with each example to an indicator. One presentation used a mass balance/bioaccumulation model for Lake Ontario to demonstrate the quantitative relationship between a potential indicator, the concentration of PCBs in lake trout, and a potential action of the Lake Ontario LaMP, the reduction of PCB loading to the lake. In the other demonstration, an analysis of lakewide estimates of seasonal production and consumption by all pelagic trophic groups was presented. This analysis suggested that

there was not enough production by alewife to support the energy demands of the salmonid community in Lake Ontario. Accordingly, a 50% reduction in salmonid stocking was recommended and subsequently implemented with the predicted effect of restoring the balance between piscivorous fish and their prey. After the presentation of these examples, the participants were asked to suggest their own favorite ecosystem objective and then "work" their way through how a model framework might help in the selection and theoretical justification of an indicator/s for that objective.

An examples was worked through to illustrate the process to the participants.

EXAMPLE:

Using control of phosphorus in Lake Erie as an example, the ecosystem objectives (from the GLWQA, Annex 3) are:

1. Restoration of year-round aerobic conditions in the bottom waters of the Central Basin of Lake Erie; and
2. Substantial reduction in the present levels of algal biomass to a level below that of a nuisance condition in Lake Erie.

Mathematical models of algal growth and oxygen depletion in Lake Erie were developed to determine the quantitative relationship among the indicators phosphorus loading, summer average chlorophyll ***a*** and late-summer/early-fall hypolimnetic oxygen concentrations. The models then established a quantitative relationship between stressors and indicators as they related to the two ecosystem objectives, thus permitting the development of target phosphorus loadings for achieving those objectives. With the invasion of the zebra mussel in Lake Erie, new, more specific ecosystem objectives may be necessary.

RESULTS:

Key Questions: The following key questions were addressed at the workshop: 1. What ecosystem objectives are you interested in addressing? 2. For each ecosystem objective identified in 1. above, suggest an indicator. What data would need to be collected to allow reporting of that indicator? 3. Have you heard of a model or modeling approach that you wish to know more about? 4. What case studies can be described which have ecosystem objectives, indicators and models already in place?

Participant Perspectives: The participants were interested in knowing why models were needed to interpret indicators. Two examples were presented to show that indicators cannot be used in the absence of understanding. Models are successful in

providing that understanding when the response variables are selected to coincide with the desired outcomes.

Session Outcomes: Models should be constructed in a way that allows new species to be handled. We have good models of various parts of the ecosystem, but we need to work on the linkages. For example, we need better linkages 1. among air, land and water; 2. between near-shore and offshore; and 3. between the upper and lower food chains in lakes. If these linkages can be achieved, models can help sort out competing multiple outcomes.

Next Steps: Models cost only 1 to 1.5% of what control actions cost. We need to better sell modeling as part of the tools of Great Lakes management. The suggested approach is to:

1. Provide examples of successful modeling in support of indicators;
2. Show how indicators can be misinterpreted in the absence of models;
3. Show how models can resolve conflicts among indicators;
4. Show how models can predict when indicators are likely to respond; and
5. Show how managers can be involved in defining desired outcomes for lakes.

2.2.2. IAGLR Modeling Summit (May 27-28, 1999)

The Summit was a continuing effort to bring modelers together with resource managers to discuss the application of models to management issues. This year, the focus was on Lake Erie. The Lake Erie at the Millennium Issues Workshop, held at the University of Windsor in November 1998, had identified 71 Lake Erie management issues that were grouped into six broad categories:

1. Eutrophication/Primary production
2. Exotic Species/Nuisance Aquatic Species
3. Upper Food Web Exploitation
4. Ecosystem Stability
5. Habitat Structure and Function
6. Contaminants

The Lake Erie Summit was held at Case Western Reserve University in Cleveland, Ohio. Invitees were each asked to prepare a 7-8 page white paper describing a model that would address as many of these issue categories as possible. The goal was to achieve a quantitative/predictive capability for the Lake Erie ecosystem. In other words, the Council was trying to assess the potential for models to help implement the "Ecosystem Approach to Management" for Lake Erie. In order to meet this challenge, each model, at a minimum, was to include the following state variables:

- nutrient concentrations
- total algal biomass
- blue-green algal biomass
- walleye biomass
- fish body burdens of bioaccumulative chemicals (*e.g.*, PCBs)
- zebra mussel biomass
- richness and evenness of the fish community trophic levels between algae and top predator fish

Further, the model should indicate which stressors control these variables and whether or not they were susceptible to management actions. The invitees were asked to state explicitly their perception of the management problem being addressed. Two groups of panelists provided comments and answered questions at the Summit.

Also, the white papers were to include modeling assumptions, data/monitoring/research needs, relevant space and time scales, and other constraints needed for describing the model. The white papers are available on the Web at: http://www.ijc.org/php/publications/html/modsum/index.html

RESULTS

Several areas of agreement were reached among the participating modelers:

1. Primary productivity must be better understood (ie. the bacterial component has been neglected);
2. Spatial gradients in Lake Erie are too important to ignore (ie. west to east and nearshore/offshore);
3. Better calibrations of models are needed (ie. verification should be conducted under radically different conditions;
4. Modeling approaches are complimentary (ie. duplication of effort is healthy for complex topics);
5. Current monitoring programs are not sufficient to support even the most modest of modeling projects (ie. there is no long-term commitment to monitoring);
6. Carbon budgets need to be refined to better account for zebra mussel impacts and the role of bacterial activity; and
7. odels themselves are principally pedagogic, and it is the experience and insight gained from building them, not precise model predictions, that outfit the scientist for helping managers.

There are still areas of disagreement among modelers:

1. What is the appropriate level of aggregation? (ie. Can we lump state variables across space and time?);
2. Uncertainty of the appropriate degree of emphasis on the lower foodchain vs. the upper foodchain (ie. time and space scales);
3. Uncertainty in the linkages across the foodchain (ie. zooplankton); and
4. Are zebra mussels limited by vertical transport of particulate matter?

The panelists also had points of agreement:

1. Diversity of approaches is good, but there is confusion on which way to proceed.
2. The benefits of modeling vs. the price tag needs to be articulated and resolved.
3. There is utility in having both predictive and diagnostic models.

Both the modelers and the panelists agreed that future plans should be made to hold a session in which modelers and managers collaborate to implement a solution to some pressing management problem.

The Council recommends:

Sufficient monitoring programs and coordinated research programs are essential to the development of modeling projects which can provide assistance to managers in addressing pressing management issues.

2.3. *Communication of Research Needs, Gaps, and Priorities*

The Council discussed the importance of this issue and announced this effort in our address to the Commissioners in Niagara Falls. The Council is also one of the founding members of the Task Team to establish the Great Lakes Communicator Network. The goal was to develop and convene a Great Lakes Communicator's Network to address Great Lakes regional communications needs. The objectives of the inaugural workshop were to:

- Identify common issues and resources.
- Collaborate or develop partnerships on communications activities to develop more effective messages to be sure we are speaking with one voice when complex issues are discussed.
- Address educational awareness and product/program needs.
- Increase the effectiveness of Great Lakes communication efforts by sharing information on media projects, technology trends and traditional communications.

- Engage broader Great Lakes public in magnifying and expanding Great Lakes communication messages. Held in Ann Arbor, March 1999, approximately 40 agency communicators and resource managers/scientists exchanged perspectives on needs and actions.

A Great Lakes Communicators Listserve was established in March 1999, under the lead of the Great Lakes Commission. At the May 1999 IAGLR conference, the Great Lakes Communicators Network sponsored an interactive session featuring four panelists from a variety of backgrounds. Panelists shared their views on the challenges faced by media members and scientists when they interact on the reporting of a scientific issue. Session attendees had the opportunity to participate in lively discussion, and a follow up session for IJC Biennial Forum will be held in Milwaukee.

Summary of Suggested Next Steps for Action, based on the March 1999 workshop

Media:

- Create a mechanism to share media lists (i.e., a list of which Great Lakes communicators deal with which audiences).
- Create a Great Lakes Tip Sheet (Possibly a listserve through GLIN (The Great Lakes Information Network)).
- Pursue a media corner on GLIN to feature news on Great Lakes agencies. Reporters (and others) could visit this site to get a good sense of what's going on in the region, what upcoming events they should be covering, and different perspectives on a specific issue (e.g., the Lake Champlain controversy or Great Lakes diversions) from various agencies.

Education:

- Great Lakes Commission via GLIN and the Center for Great Lakes Environmental Education will work together to determine needs and define responsibility regarding development of an education website that could include an educational material list of items to be ordered or a resource list of on-line activities.
- Send the Council's education material to the Center for Great Lakes Environmental Education for distribution to teachers who call.
- Talk directly to teachers via the GLIN listserve set up for educators.
- Host summit of teachers to identify their educational needs.

Progress, look into the potential to:

- Survey teachers during the already planned teachers workshop during the Great Lakes Student Summit in Buffalo, New York, May 13-14, 1999 and
- Use the information gained through the survey to create a workshop for teachers.

Technology

- Develop Communications Network listserve: com.net on GLINProgress.
- Develop a Multiserver search function on GLIN NetMeeting or other Internet conferencing
- Review of clearinghouse proposal for the Great Lakes Environmental Education CenterVirtual Press Room on GLIN

Sharing Resources

- Organize IAGLR panel discussion Progress on Communicating Science to the Media. This was completed and a mix of reporters and seasoned scientific communicators.
- Decide how often the Network should meet in terms of a conference
- Discuss future funding avenues

The Council suggested a number of potential subcommittees such as the following; Conferences/workshops; Electronic/web resources; Educational materials; Media outreach; Marketing; and Publications.

2.4. *Biodiversity and Habitat*

The Council conducted two activities with regard to this priority in the 1997-1999 Priorities Cycle. One was a "scoping" of the topic to identify research needs, gaps and priorities (See section III for a general description of scoping activities). The other activity was a survey of Great Lakes agencies and institutions regarding their goals for biodiversity and habitat. These activities are summarized below.

2.4.1. Scoping of the Biodiversity and Habitat Priority

The Council used the following sources of information to "scope" this priority: Great Lakes scientists; Government/private research programs; scientific literature; and the World Wide Web.

In general, the "scoping" resulted in this overview:

Biodiversity started as species cataloguing and has more recently emphasis has been placed on species assemblages and associated habitat. There are an extensive number of biodiversity and habitat initiatives underway. These initiatives range from well-funded, technically complex primary research, to regional surveys that depend largely on volunteer help from interested naturalists. Emphasis appears to be on large, showy, rare species and less emphasis has been placed on species such as non-vascular plants, insects, near shore crustaceans, algae, and microbes. An emerging issue for this topic is: How much, and what kind of habitat conservation is required to maximize biodiversity?

There are numerous examples of existing and on-going biodiversity and habitat programs including the following: atlases, biodiversity investment areas, the Ecological Monitoring and Assessment Network, the Aquatic Communities Classification System, the Great Lakes Fishery Commission's Fish Biodiversity Project, and the Great Lakes Fauna/biodiversity CD's from the University of Guelph.

Through "scoping" this priority the Council outlined in their recommendations the need to:

1. Clearly identify objectives for biodiversity and habitat initiatives;
2. Encourage and support the more recent ecoregional or ecosystem approach to habitat and biodiversity preservation;
3. Promote efforts on smaller organisms such as non-vascular plants, microbes, algae, insects, and crustaceans. In aquatic ecosystems these data are especially needed for near- shore habitats;
4. Support initiatives to link the various biodiversity/habitat programs so that the large quantity of data can be used in the most effective manner; and
5. Encourage the training of systematists to increase available expertise.

2.4.2. Survey of Biodiversity and Habitat Goals in the Great Lakes

This study was designed as a continuation of the initial "scoping" of the Biodiversity/Habitat Issues for the Great Lakes. Members of the Council wanted to develop a better understanding of the number and types of organizations involved in the preservation and enhancement of biodiversity and the relevant habitat issues and goals in the Great Lakes. To do this, the Council developed and distributed a survey. The survey's intent was to gain a better understanding of biodiversity and habitat goals of agencies working in the Great Lakes region and included:

- collecting information on which agencies were involved in gathering information on the current biodiversity research as well as habitat issues;

- defining what role these agencies were playing and whether it was a fundamental part of their organizational make up;
- defining what the agencies habitat goals are; and
- evaluating how the agencies were encouraging biodiversity when involved in habitat restoration or enhancement.

The survey was designed as primarily a yes/no response and choosing from a list of options as well as providing space for additions or comments. Respondents were also asked to provide any relevant documents or additional information as an attachment. A four page survey consisting of 17 questions was mailed to 136 agencies on June 26, 1998. Of these, 51 were Canadian and 85 were U.S. agencies. Due to the variety of organizations surveyed, not all survey questions were applicable to all surveyed organizations.

Agencies were chosen following an extensive search of the World Wide Web for organizations whose web pages had information about biodiversity as well as from an existing mailing list. Agencies surveyed included museums, colleges, universities, environmental and conservation organizations, foundations, funding agencies, government agencies, and research organizations.

The agencies chosen were a mere fraction of the numerous agencies and organizations involved in biodiversity and habitat in the Great Lakes-St. Lawrence area and as a result the agencies surveyed can not be viewed as a comprehensive list. A comprehensive literature search was also conducted on the World Wide Web in conjunction with the agency search to compile a reference bibliography of reports and current information available regarding biodiversity.

The Survey Results

The Council received 47 responses which represented approximately 35% of the 136 surveys requested. These include six responses from agencies that did not complete the survey as biodiversity was not within their scope or goals of their organization. These uncompleted surveys were not included in analysis (Table 1).

Table 1. Types of respondents to the biodiversity survey.

Category	Number of Respondents
Universities	10
Colleges	1
Environmental/Conservation Organizations	9
Research Organizations	3

Corporations	2
Government Agencies	12

- Twenty-two of the agencies (26/42=62%) responded that they do have goals, policy objectives or a mandate regarding biodiversity goals.
- 24% of the respondents indicated that they were mandated by legislation for biodiversity. The Clean Water Act was another legislation mentioned by respondents.
- The majority of respondents use an ecosystem approach. 15 respondents use the ecosystem approach as compared to 5 that use ecoregion and 4 that use landscape approaches exclusively (Table 2). A number of other organizations use a combination of more than one approach.

Table 2. Types of approaches used by various organization.

Approach	**Respondents**
Ecosystem	15
Ecoregion	5
Landscape	4
Species or habitat type specific	3
Ecosystem and Ecoregion	1
Ecosystem and species or habitat	4
Ecosystem/Ecoregion and species or habitat type specific	2
Landscape and species of habitat	1
Ecosystem and landscape	1
Combination of ecosystem, ecoregion, landscape and species or habitat type specific	2
No response	4

- 37 respondents indicated that they were involved in more than one means of providing information on biodiversity programs.
- 23 respondents were involved in habitat restoration projects, population management or stocking programs.
- restoration of wetlands (23 responses), nearshore lakes (15 responses) and offshore lakes (14 responses) were the top three habitat types involved in restoration or protection.
- 23 respondents use native species of flora and fauna for habitat restoration, population management and stocking programs, whereas 8 respondents use non-native sources, 12 use local sources, 3 use out of province/state sources,

and 8 respondents use historical listings of pre-existing flora and fauna. Five respondents use all five options for projects.

- 20 respondents have implemented monitoring programs for habitat restoration projects.
- 7 respondents are involved in the propagation of native sources of plants or seed.
- 15 respondents maintain a database of sightings or rare, threatened or endangered species.
- 18 respondents contribute information to larger databases such as Canada's Natural Heritage Information Centre or the U.S. National Wetlands Inventory.
- 30 respondents indicated that they were aware of the United Nations Convention on Biological Diversity (UNEP 1992).
- 32 respondents indicated that they were aware of Canada's National Biodiversity Strategy and/or National Biological Survey in the U.S. and 13 respondents are involved in implementing part of these Biodiversity strategies
- 20 respondents apply for funding from agencies that outline specific biodiversity goals or requirements as part of their approval.
- 18 respondents indicated that these funding agency requirements influence project design regarding biodiversity.
- 15 respondents indicated that they work in partnership with other organizations with differing goals regarding biodiversity.
- 22 respondents indicated that they use at least one of the technologies such as GIS, GPS, satellite imagery, maintenance of an electronic database to gain a better understanding of biodiversity.

The survey expanded upon the findings from the scoping exercise which revealed the vastness of the topic of biodiversity and habitat. A broad spectrum of organizations including universities, museums, government agencies, and grassroots environmental nongovernment organizations are involved in various aspects of biodiversity and habitat issues in the Great Lakes-St. Lawrence area and a majority (62%) have biodiversity goals, policy objectives or mandates. There is also a variety in the efforts undertaken to assess biodiversity including cataloguing, database maintenance, research and volunteer-run species. All of these efforts contribute to the current knowledge and understanding of biodiversity and habitat in the Great Lakes-St. Lawrence area.

The Council identified a number of preliminary recommendations from the survey results which will help to increase the knowledge, understanding, and preservation of biodiversity and habitat since the protection of critical habitats is of utmost importance to preserving biodiversity.

- Develop ecosystem or ecoregional management approaches that protect and enhance critical habitats large enough to sustain viable, genetically diverse populations.
- Develop legislation and policies effective in stopping or slowing the introduction of non-native species.
- An oversight committee or organization both within the U.S. and Canada and between countries should be developed to provide a coordinated body for assimilation of the extensive amount of research, databases, atlases, cataloguing, etc. on biodiversity.
- Develop an approach to coordinate university research regarding biodiversity.
- Encourage an ecosystem or ecoregion approach to biodiversity and habitat restoration projects.
- Promote efforts to document information on small organisms such as non-vascular plants, microbes, algae, insects, and crustaceans. In aquatic systems these data are especially needed for near shore habitats.
- Encourage the coordination of US and Canadian biodiversity initiatives such as cataloguing by museums.
- Encourage the use of native species of flora and fauna when performing habitat restoration or enhancement projects.
- Encourage economically viable projects which promote the use and production of native species of flora and fauna.
- Coordinate programs with similar mandates such as fisheries or wetlands.
- Develop electronic means to share information and coordinate databases, cataloguing and research..
- Encourage the rehabilitation and enhancement of habitats such as golf courses, graveyards, corporate property, urban backyards, schoolyards, etc. to increase biodiversity.

From these preliminary findings and preliminary recommendations the Council developed two recommendations to the IJC.

The Council recommends that:

There is a critical need to develop ecosystem or ecoregional management approaches that protect and enhance critical habitats.

There is a need for U.S. and Canadian coordination for assimilation of biodiversity and habitat research, databases, atlases, cataloguing and other ongoing programs.

November 5, 1999

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3. SCOPING ACTIVITIES

At its 27th meeting in Niagara Falls, Ontario, the Council defined an activity called "scoping" which was conducted at each of the Council's subsequent meetings. Below is the text of a resolution passed unanimously at that meeting:

The CGLRM will identify and prioritize the science needs and research activities needed to address IJC Biennial Priorities.

The Council will use the Research Inventory and other sources of information to determine the current level of scientific knowledge on each priority and identify gaps in our knowledge and rank research needs to fill the gaps (scoping).

The Council will report this information and any new priorities identified during the process to the Commission for transmittal to the Parties.

The six topics in this section (as well as Biodiversity and Habitat in Section 2, above) were "scoped" by the Council during the 1997-1999 Priority Cycle. A summary of the results of each effort is included below.

3.1. ***Sediment Priority***

There is a consensus among diverse sectors in the Great Lakes Basin (e.g., government, industry, non-governmental organizations, RAP groups) that contaminated sediment is an important element leading to many of the impairments to beneficial uses of the Great Lakes. All 42 Great Lakes Areas of Concern have contaminated sediment based on application of chemical guidelines. This universal obstacle to environmental recovery in Areas of Concern can potentially pose a challenge to restoring 11 of the 14 beneficial use impairments identified in the GLWQA (SedPAC 1997).

For RAPs, sediment management decisions need to be made bearing in mind the relationship between contaminated sediment and restoration of beneficial uses. This goes far beyond setting a numerical chemical cleanup criteria, as these are not based on the need to fully restore beneficial uses. The ultimate success of sediment management activities will be judged upon restoration of beneficial uses (e.g.,

elimination of fish consumption advisories, restoration of fish and wildlife populations, restoration of benthos).

Bioassessment frameworks have evolved substantially recently, and in many cases, large data sets have the required elements for developing a sediment management strategy. Equally important to the collection of data, however, is that sufficient attention be placed on thorough and comprehensive interpretation of the data. By employing scientifically sound methods of data interpretation, the information from an intensive sediment assessment can finally be integrated to make a decision to intervene (i.e., remediate contaminated sediment) or pursue source control and natural recovery as the preferred remedial option.

Research into ecologically meaningful data interpretation tools would advance sediment management decision-making by RAP practitioners. In addition to researching data interpretation tools, the Sediment Priority Action Committee (SedPAC) recognizes that the IJC can offer more assistance in the efforts to overcome obstacles to sediment management.

The Council supports SedPAC's findings that there are currently few, if any, simple or proven methods to predict recovery of use impairments based on sediment cleanup. More research is needed to quantify the relationships between contaminated sediment and known use impairments. The concept of ecological benefit forecasting (i.e., predicting ecological benefits and restoration of beneficial uses) is an important management need which, if accomplished, would be a substantial step forward.

Finally, deciding when to intervene is embedded with multiple elements. Data interpretation tools and techniques are a central element in developing the sediment management strategy. Other aspects involve what is and is not known about linking sediment clean up to ecological recovery and restoration of beneficial uses, as well as economic benefits that may accrue from effective management of contaminated sediment.

Existing studies that assess the economic benefits of remediating contaminated aquatic sediment are few. Most of the quantitative work to date has focused on the economics of navigational dredging and disposal. Further, given the lack of biophysical documentation that links sediment cleanup with beneficial use restoration, it is difficult to generate economic benefit estimates with any degree of rigor. Case studies using a range of economic valuation methods, applied to sites where sediment cleanup is complete, underway or proposed, is needed. These case studies will help identify the nature and extent of potential benefit types, and which valuation methodologies are best suited for the local characteristics of the remediation site.

Perhaps most importantly, economic valuation can help legitimize the need to expedite sediment management decision-making in the Great Lakes basin.

The Council concurs with SedPAC in the following recommendations regarding contaminated sediment:

- **The Commission recommends to the Parties and Jurisdictions that they develop and reach agreement on methods or programs to predict and measure successful ecological recovery in Areas of Concern (e.g., ecological benefit forecasting, monitoring and surveillance programs to measure use restoration); and**
- **The Commission recommends to the Parties and Jurisdictions that they establish procedures for consistent data collection and interpretation across Areas of Concern, recognizing the importance of site specificity in applying methodologies and tools.**

3.2. *Indicators Priority Implementation*

The emphasis for the Indicators Priority is on demonstrating feasibility of implementing indicators for the nine desired outcomes that were previously identified. The Indicators Implementation Task Force (IITF) has been sharing their metadata findings with SOLEC, and the two initatives are collaborating towards reporting on indicators. IITF has been examining indicators and measurements to track 9 desired outcomes of the water quality agreement (such as swimmability, fish edibility, drinkability). SOLEC has been considering ecosystem type indicators in regions or on a basin-wide perspective. Relationships between IITF indicators and those of SOLEC are now being catalogued.

Ecosystem objectives (equivalent to desired outcomes) are also being developed by LaMP (Lakewide Management Plans) and SOLEC is interacting with LaMPs. Currently, there is a list of several indicators under each of the nine outcomes. The IITF is also interested in the question of how to integrate data from different regions.

The Council formed a subcommittee to "scope" the indicator priority. Here are the results of the effort:

Current Status: There has been more than 25 years of work under the GLWQA. There has been more than 10 years of debate and discussion on indicators.

Gaps/Problems:

- no scientific/management consensus on some of the desired outcomes

- weak or inappropriate indicators for some desired outcomes
- local collection/storage/reporting of data ie., municipal or county level
- non-uniformity of data standards, methods, and coherence in spatial or temporal coverage

The Council identified the following research/data needs:

- **Critical Path Analysis for implementation ie, by the year 2000, how can some indicators actually be happening (costed-out, data acquisition questions answered, management responsibility assigned).**
- **Global literature review and evaluation of indicator theory.**
- **Research and Development of Ecosystem models to illustrate theory and the quantitative relationship of indicators.**
- **Research to identify specific species, chemicals and space/time coverage for indicators.**
- **Great Lakes centralized meta-data base (ie. Data on data: who, where, QA/QC, etc.**
- **Research and development on tools for use of indicator data such as GIS (geographic information systems) and relational databases. These should be made available to local users.**
- **Coordinated, binational monitoring program driven by indicators.**

3.3. *Lake Erie*

The Council first called for a Reference on Lake Erie at the April 1993 meeting in Atlanta. The request was based on the huge changes that were occurring in the ecosystem as the zebra mussel population expanded. This continues to be a priority area for the Council. In 1998 and 1999, the Council focused on:

- modeling efforts (previously discussed in the Modeling section);
- organizing two special meetings of regional experts to discuss phosphorus levels and loading; and
- supporting a major conference at the University of Windsor hosted by the Great Lakes Institute for Environmental Research and the University of Windsor, the Ohio Sea Grant College Program and Stone Laboratory at The Ohio State University, US EPA-Duluth, and National Water Research Institute of Canada.

Lake Erie Phosphorus Issue. In February 1998, the Lake Erie Committee of the Great Lakes Fishery Commission expressed grave concern over the drastic reduction in some important Lake Erie fish populations and requested that no further phosphorus loading reductions be made until managers had a better understanding of the impact. They also urged scientists on both sides of the border to focus research on

this important issue. The Council rapidly brought together a group of about 50 experts on phosphorus, zebra mussels, and the Lake Erie ecosystem to discuss the issues, share their most recent research results, and make recommendations regarding research needs. Kent State University hosted the first meeting of the group on April 23-24, 1998. The University of Buffalo hosted the second meeting on June 29-30, 1998.

The models developed in the 1970's to control phosphorus loading to Lake Erie in an effort to reduce algal production and decomposition rates (oxygen depletion rates in the hypolimnion of the central basin-eutrophication) recommended a loading target level of 11,000 metric tons/year. In the period from 1982 to 1993 - most recent period of good phosphorous loading data - the total phosphorus loading to Lake Erie has hovered around the target load, with annual loading varying from about 7500 metric tons/year to about 12,500 metric tons/year depending on hydrology-driven non-point sources. This range of phosphorus loading reduced chlorophyll *a* concentrations to target levels; however, with the invasion zebra mussels in 1988 further reductions in phytoplankton standing crop were observed. It was this further reduction in phytoplankton coupled with the decreases in walleye standing crops that led to the questioning of the appropriateness of the 11,000 metric tons/year target phosphorous loading. However, it is not at all clear that there is a quantitative relationship between increasing phosphorus loading and increasing fish production. It is quite possible that an increase in phosphorus load will only increase zebra mussel biomass. It was primarily this uncertainty that led to the deliberations of the phosphorus expert panel.

This issue was discussed at great length at both the Kent State University and University of Buffalo meetings by the panel of experts. The Council's conclusions and recommendations follow.

Conclusions

1. Lake Erie is probably still very productive in the western basin, but primary productivity in the eastern basin is more problematic. More importantly, productivity goes down as one moves from west to east within the Lake.
2. The smelt fishery in the eastern basin has all but collapsed.
3. The zebra mussel has changed the ecosystem and food webs to the extent that it is entirely unclear that adding phosphorus will produce the kind of plankton populations needed to support larger fish populations of target species.
4. Recent blooms of blue-green algae (including the toxin producer *Microcystis)* can cause taste and odor problems and are clearly associated with the selective filtering/feeding of zebra mussels and their alteration of phosphorus cycling in the western basin.
5. Dissolved reactive phosphorus levels near zebra mussel beds are high.

6. Adding phosphorus is more likely to cause increases in blue-green algae populations and taste and odor problems with public drinking water supplies than increased fish populations.
7. Hypothetically, we considered several scenarios for increasing phosphorus loadings. It was determined that it would be unreasonable to expect that relaxing point source controls could be expected to increase annual loading by more than 10-20%; given that the natural variability in loading over the last 10-15 years has been close to 50%, it is unlikely that relaxing point source controls will greatly affect productivity in the lake.
8. The suggestion to increase phosphorus loading during the spring at a time when diatoms would be produced was not practical, because at that time phytoplankton populations did not appear to be phosphorus limited.

Recommendations

1. **In view of the significant changes in the Lake Erie ecosystem that have occurred subsequent to the zebra mussel invasion, the group recommended that a new effort to quantify the relationship between phosphorus loading and lake productivity at all trophic levels was sorely needed.**
2. **Research to better understand lower trophic levels and the relationships between nutrients, phytoplankton and zooplankton, and zebra mussels is greatly needed.**
3. **Research to determine the relationship between nutrient loading and fish production is badly needed.**
4. **The research recommended in items 2-3, should be driven by and integrated by sophisticated ecosystem models. Only then can we achieve the quantitative relationship between phosphorus loading and walleye production that is necessary to address the question at hand.**
5. **All management agencies should be encouraged to maintain and reinvigorate their monitoring programs, including a statistically-significant yet cost-effective monitoring of phosphorus loading to the lake. It was observed that budget cuts have forced cutbacks in some monitoring programs to the point that it is no longer possible for the IJC to accurately estimate nutrient loading to Lake Erie.**
6. **At the Buffalo meeting, the group supported a plan to participate in the Lake Erie at the Millenium Program to better coordinate Lake Erie research and monitoring efforts.**

Lake Erie at the Millenium Conference. The Council helped to support a major conference at the University of Windsor on April 26-28, 1999. This conference was hosted by the Great Lakes Institute for Environmental Research and the University of

Windsor, the Ohio Sea Grant College Program and Stone Laboratory at The Ohio State University, US EPA-Duluth, and National Water Research Institute of Canada. The conference was attended by approximately 140 scientists and included sessions on:

- Physical Structure of Lake Erie;
- Lake Erie Loadings and Flux;
- Environmental Features;
- Open-Water Biotic Processes;
- Nearshore/Coastal Biotic Processes;
- Invaders; and
- Human-Related Concerns.

Each speaker summarized current knowledge on the topic, followed by a listing of research needs. A conference proceedings is being prepared by the University of Windsor. A series of 4-6 follow-up workshops on priority issues is planned. The first workshop, scheduled to occur during the fall of 1999, will focus on nutrients and the base of the food chain.

3.4. *Great Lakes Commercial Aquaculture*

Background: Great Lakes commercial aquaculture has been identified as an emerging issue. The wild harvest of fisheries has put tremendous pressure on natural populations worldwide, and in many instances has exhausted traditional fishing grounds and eliminated many species from the commercial catch. "By-catch", the incidental harvesting of unwanted species, is also a major concern. The United Nations estimates that nearly one-quarter of the protein in human diets derives from seafood. The underdeveloped world currently relies on seafood for nearly 50% of its protein requirements. The demand for seafood is predicted to continue to increase as the human population increases from roughly 5.8 billion today to an estimated 8 billion within the next 25 years. In order to meet this demand it is estimated that aquaculture will supply more than one half of the world's seafood by the year 2025. In the United States the seafood industry has an estimated annual sales of $40 billion (U.S.). 1998 consumption of seafood in the U.S. was approximately 16 lbs. per capita.

Aquaculture activities are growing rapidly. This is in part due to an increase in the demand for seafood as a "healthy" red meat substitute. The aquaculture industry grew 265% in United States from 1980-1995 and is projected to produce 1.26-2.2 billion lbs. annually in the United States by the year 2000. In 1995, the Canadian aquaculture industry was valued at $289 million (Cdn.). In Ontario, the industry generated $50 million in 1995 (~7 million lbs.), principally through the farming of rainbow trout. Ontario forecasters are predicting a tripling of production by the year 2000. However,

it is difficult to obtain accurate statistics on the industry in all states and provinces because no uniform accounting practices and regulations are in place. The majority of aquaculture operations are small (~$5000 per year), but the demand for larger facilities is growing rapidly. The industry provides opportunities for alternate aquatic businesses in some depressed regions and amongst some aboriginal communities associated with declining Great Lakes fisheries. Currently, very little infrastructure exists for this industry.

There are two basic types of aquaculture: within-lake and land-based facilities. Within-lake facilities consist of pen or cage cultures and at present this practice is at a low level within the Great Lakes and, for the most part, is restricted to Canadian waters. These are generally open-mesh nylon bags suspended from frames. Cage culture sites are concentrated principally Lake Huron/Georgian Bay and Lake Ontario (Bay of Quinte) farming rainbow trout. There are approximately 10 cage culture sites in the Great Lakes-St. Lawrence with 6-12 cages per site yielding approximately 22 tonnes of fish per cage annually.

Within the U.S. there appear to no active cage culture operations within the Great Lakes basin, and there appears to be little enthusiasm for cage culture operations in U.S. waters from either the natural resource management community or commercial operators.

Land-based aquaculture facilities include recirculating aquaculture systems (RAS), pond aquaculture, raceways, aquaria, garden ponds, and bait fish culture. Many of the potential problems resulting from the flow-through aquaculture systems typically used in a large portion of the industry today would be largely eliminated by recirculating aquaculture technology wherein the water is recycled and reused. Consequently, RAS are seen as a much more "environmentally friendly" technology, and an increasing number of land-based operations are secure, indoor facilities that utilize recirculating systems. Current recirculating systems, however, are expensive and the technology is in its infancy in terms of development. An R&D effort to establish cost effective RAS technologies is needed.

ISSUES: A number of technological, economic, environmental, regulatory and health issues have arisen along with the rise in the aquaculture industry.

A major issue for the aquaculture industry is the regulations and guidelines that govern all phases of operations and best management practices including construction and termination. In many instances, the regulations in use are not designed with the aquaculture industry in mind, or they are lacking entirely. Environmental and regulatory issues surrounding aquaculture will need to receive more attention as the industry expands. Issues include: pond construction guidelines; well digging and

aquifer sustainability and protection; water consumption; effluent discharge, treatment and water quality impacts on surface waters and wetlands; waste management; predator control (largely birds); disease infection, control and prevention; accidental release of exotic and/or domesticated species into the wild gene pool or ecosystem; land use and natural habitat modification for pond or lagoon aquaculture; packaging, processing, transportation and food safety; and economic, operational or aesthetic conflicts with commercial fishing, cottagers, boaters, First Nations land claims, the shipping industry, etc.

Research, Policy and Planning Needs:

There is a need for uniform, thoughtful legislation that minimizes environmental impacts but does not over-regulate the industry. This must be based on sound scientific knowledge and research. Kathy Shwayder at Great Lakes Commission is developing draft legislative language that could be adapted in various jurisdictions to fit local needs and suggests a permit approach that takes into account the relative risk of the operation to environmental integrity.

There is also a need for more uniform, clearly defined Best Management Practices (BMP) in commercial aquaculture, including siting criteria and monitoring requirements. Anne Kapuscinski and Deborah Brister (UMN St. Paul) are developing a "Model Management Program for Private Aquaculture" for the Great Lakes Fishery Commission's Council of Lake Committees. This computer-based system is designed to be a user-friendly, interactive program that will address within-lake, land-based, and secured aquaculture systems. The system is a computer-based decision support tool with 2 tiers of decision making whereby a manager, farmer, or other user determines whether a target species appears on a "consideration list" and if so, the user assesses risks to genetic diversity and ecological integrity. If present, the user or manager considers risk management measures, or denies a permit for the operation.

From its initial scoping exercise, the Council identified a number of research needs for the practice, monitoring, and management of aquaculture within the Great Lakes basin:

- determination of the actual number and types of aquaculture facilities currently in existence;
- development of standardized monitoring protocols, including what is essential for management, what are the requirements of scale (temporal and spatial), what parameters (chemical and biological) are diagnostic of impacts on water quality, local biological communities, etc.;
- development of siting criteria;

- development of mass balance accounting protocols and models for assessing nutrient loading following examples from marine cage culture and recirculating systems;
- development of safe, effective certified and approved drugs, therapeutants, water treatment chemicals, and disease control agents for use in aquaculture;
- development of efficient feeds that are not derived from fish meal;
- development of cost-effective RAS (Recirculating Aquatic Systems) to minimize high water consumption and effluent discharge;
- refinement of net and pen culture technologies;
- assessment of the potential effects of drawdown on aquifers, streams, rivers; and the capacity of streams, rivers and aquifers to sustain aquaculture facilities;
- assessment of methods to minimize predation, particularly from birds, via predator friendly technologies;
- assessment of the potential impacts of thermal alteration of receiving waters by aquaculture effluent discharges;
- assessment of the potential impacts of modification of existing wetlands and littoral areas;
- development of requirements that importation of aquaculture species to the Great Lakes jurisdictions be subject to same consultative process as government importations and require similar controls to those used for soil and agricultural plants;
- establishment of a "clean list" of species eligible for private possession; and
- development of education and outreach tools in support of personal and industry responsibility and the implementation of best management practices.

3.5. *Review of Progress of Governments in the Control and Management of Persistent Toxic Substances and Endocrine Disruptors*

3.5.1. Persistent Toxic Substances (PTSs)

A. Findings in Humans

There is no evidence over the past five years of dramatic shifts in levels or types of bioaccumulating contaminants in tissues of residents of the Great Lakes basin. However, the levels of such contaminants in the tissues of people eating large amounts of Great Lakes fish continue to be several fold higher than in people who do not eat such fish. *SOLEC 1996*

Exposure

- At-risk populations continue to be exposed to PTSs. Some highly exposed groups have body burden levels 3-4 times higher than the background level (e.g., data from Schantz and coworkers on DDE, Hg, and PCBs).
- Fish consumption remains the major pathway for exposure to PTS in fish eaters. Levels of some contaminants in Great Lakes fish exceed state and federal guidelines. Contaminated sediments are also of concern.
- Sport fish eaters consume 2 to 3 times more fish than is estimated for the general population - FDA estimate is 6.5 grams/person-day, for example, Schantz and coworkers report that high-fish eaters consume over 32 lbs/yr; Anderson and coworkers indicate that fish eaters on average consume 55 meals/yr with some consuming twice this amount; and Kearney and coworkers found Lake Ontario fish eaters in Canada consumed approximately 21 g/day).
- The biological significance of these increases is uncertain. Preliminary evidence in humans of neurobehavioural effects has been reported by Jacobson et.al. and very recently by Mergler.

Demographics

- 4.7 million people consumed Great Lakes sport fish in 1994 / Fish is an essential component of diets of minority populations and Native Americans.
- Men consume more fish than women; men and women eat Great Lakes fish during most of their reproductive years.

Health Effects

- Reproductive function (e.g., delay in time to pregnancy and shortened menstrual cycles) may be disrupted by exposure to PTSs.
- Neurobehavioral and developmental deficits occur in newborns and continue through school-age children from in utero exposure to PTSs .
- Other systemic effects, e.g., self-reported liver disease and diabetes may be associated with elevated serum levels of PCBs.

Other Conclusions:

- Weight of evidence can be used in lieu of causality.
- Data are compelling: People are continuing to be exposed, and there are health consequences associated with these exposures.
- There is an immediate need to put science to service in implementing health intervention / health promotion strategies where necessary.
- Strategies should recognize the importance and benefits of fish consumption to particular populations. Risk and benefit analysis is essential for meaningful strategies.

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B. Environmental Trends

- Concentrations of some persistent toxic substances in the Great Lakes in air, water, and biota appear to have leveled off, or declined only slightly, in recent years.100 % of the Great Lakes waters continue to be under fishing advisories. PCBs are most commonly the focus of advisories issued in the basin, followed by dioxins, chlordane and mercury.

- The 1993 TRI data (USEPA Toxics Release Inventory data released in 1995) showed that all of the Great Lakes Basin states and counties had shown a decrease in releases of targeted chemicals between 1988 and 1993.
- USEPA's 33/50 Program was a nationwide voluntary effort aimed at reducing the releases and transfers of 17 targeted chemicals (including PCBs, Hg, Pb, and other heavy metals and organics) tracked under TRI, with a goal of 50% reduction by the end of 1995. The Program was successful, exhibiting 55.6% decrease from 1988, which is equivalent to a reduction of over 664 million lbs. In three areas of the basin (SE Chicago, NW Indiana, and SE Michigan), an average reduction of 62% was achieved.
- Up to 1997, Canada has reported substantial decreases in alkyl-lead (85%), octachloro-styrene (18%), dioxins and furans (66%), and benzo(a)pyrene (20%) primarily as a result of the ARET Program in the Great Lakes Basin.

Focus on Mercury

- Fish consumption advisories for human health have been issued in 38 states and Ontario and Quebec due to mercury.
- There was an 82% decline in mercury use in the USA from 1980-1995 due to bans in paints and pesticides, phaseouts in batteries, and reductions in industrial uses.
- Mercury emissions were also curtailed under the US federal Clean Air Act amendments. Eight Great Lake states have implemented numerous programs to reduce mercury. In 1996, the US chlor-alkali sector voluntarily committed to reduce emissions and use of mercury by 50% during the next decade.
- Canada and the US included mercury in the Binational Toxics Strategy signed in 1997.

Focus on PCBs

- Although banned or tightly restricted, all 5 Great Lakes, as well as numerous inland lakes and rivers, have fish consumption advisories as a result of PCB contamination.
- In the US, 12 major utility companies have accelerated their voluntary phasedown of electric equipment which contain PCBs.
- USEPA and many states are working to remove sediments contaminated with PCBs from Great Lakes rivers and embayments.
- In Ontario, 46% of high level PCBs have been decommissioned in Ontario. 30% of high level PCB wastes and 20% of low level PCB wastes have been destroyed.
- Measurable levels of PCBs can be found in the tissues of all residents of the Great Lakes Basin (majority of monitoring is in blood and breast milk).

Focus on Pesticides.

- In US Great Lakes basin counties, the overall use of pesticides has decreased by almost 10 million lbs. from 1994-1995. Annual pesticide usage now stands at 57 million lbs.
- There is increasing concern about possible endocrine disrupting properties associated with some pesticides.
- A USEPA Great Lakes Basin Pesticide Report was made available in 1998.
- In 1996, Canada and Ontario confirmed zero use and availability of five priority substances (aldrin/dieldrin, chlordane, DDT, toxaphene, and mirex).

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3.5.2. Endocrine Disruptors

Background: A major issue in toxicology today is potential endocrine disruption. The current view is that a number of environmental chemicals and/or natural products may mimic, block, or alter hormonal activity in offspring and thus pose a hazard to normal development. Canada and the US have both initiated action to address scientific and regulatory issues related to endocrine disruptors.

US Activities: As a result of growing concerns regarding the presence of endocrine disruptors in food, water, and the environment, and the 1996 passage of the Food Quality Protection Act (FQPA) and the amendments to the Safe Drinking Water Act, USEPA was required to develop a screening and testing program. Specifically, EPA was required to:

- develop a screening program and testing program by August, 1998,
- implement the program by August, 1999, and;
- report to Congress on the program's progress by August 2000.

To implement this plan, USEPA formed the Endocrine Disruptor Screening and Testing Advisory Committee (EDSTAC) in 1996 and charged this committee with

providing advice on how to design an appropriate screening and testing program. The EDSTAC was composed of scientists and representatives from USEPA, other federal agencies, state agencies, industry, water providers, worker protection and labor organizations, national environmental groups, environmental justice groups, public health groups, and research scientists. The committee was organized into work groups, and as of July 16, 1998, the draft document developed by the EDSTAC committee had been accepted by the full committee and delivered to USEPA on September 1.

Summary of recommendations:

1. The universe of chemicals (+ 87,000) considered for screening and testing should include:
    - all chemicals currently listed on the TSCA inventory (~75,500).
    - all active ingredients (approximately 900) and approximately 2,500 inert ingredients used to formulate over 20,000 pesticide products.
    - approximately 8,000 chemicals regulated by the FDA, including 5,000 ingredients in cosmetics and 3,000 food additives.
    - naturally occurring non-steroidal estrogens (NONEs) and other naturally occurring or environmentally degraded chemicals.
    - nutritional supplements (currently not regulated therefore difficult to estimate the number).
2. The screening and testing program should be implemented in a phased manner. This means the chemicals which are determined to be a high priority should be screened and, if necessary, tested prior to those which are determined to be a lower priority.

The proposed 2-tier battery follows.

Tier 1 was designed to detect chemical substances or mixtures capable of interacting with estrogen, androgen, or thyroid hormone systems. The recommended battery includes three *in vitro*assays, three *in vivo* mammalian assays, and two *in vivo* nonmammalian assays (Table 4).

Table 4. Proposed Tier 1 Assays.

In Vitro	• Estrogen Receptor (ER) Binding/Transcriptional Activation Assay • Androgen Receptor (AR) Binding/Transcriptional Activation Assay • Steroidogenesis Assay with Minced Testis
In Vivo	• Rodent 3-day Uterotrophic Assay (Subcutaneous) • Rodent 20-day Pubertal Female Assay with Thyroid • Rodent 5-7-day Hershberger Assay

- Frog Metamorphosis Assay
- Fish Gonadal Recrudescence Assay

Alternate assays for possible inclusion:

In Vitro
- Placental Aromatase Assay

In Vivo
- Modified Rodent 3-day Uterotrophic Assay (Intraperitoneal)
- Rodent 14-day Intact Adult Male Assay With Thyroid
- Rodent 20-day Thyroid/Pubertal Male Assay

Tier 2 was designed to characterize the nature, likelihood, and dose-response relationship of endocrine disruption of estrogen, androgen, and thyroid in humans and wildlife. These tests are longer term studies designed to encompass critical life stages and processes, a broad range of doses, and administration by a relevant route of exposure. A more comprehensive profile of biological consequences of chemical exposure can be identified and related to the dose of exposure which caused them. Tests will usually encompass 2 generations since effects associated with endocrine disruption may be latent and not manifested until later in life or may not appear until the reproductive period is reached (Table 5).

Table 5. Proposed Tier 2 tests.

Mammalian Tests	• Two-generation Mammalian Reproductive Toxicity Study; or • A Less Comprehensive Test (when appropriate): Alternative Mammalian Reproductive Test; or One-Generation Test
Multigeneration Tests in Other Taxa	• Avian Reproduction (with bobwhite quail and mallard) • Fish Life Cycle (fathead minnow) • Mysid Life Cycle (Americamysis) • Amphibian Development and Reproduction (*Xenopus)*

Canadian Activities: Health Canada works with Environment Canada on an inter-departmental committee on endocrine disruptors. The committee coordinates research activities and provides support for policy initiatives required to address endocrine disrupting substances currently in the environment, found in food, consumer products or drugs, or as pesticides, or those that may enter into commerce in the future.

Health Canada has an endocrine disruptor committee that addresses research, regulatory, and policy issues.

Health Canada also participates in international activities under the OECD Working Group on Endocrine Disruptor Testing and Assessment and the WHO/IPCS Steering Committee for the Global Assessment of Endocrine Disruptors.

An increase in research funding will be directed to endocrine disruptors and their implications for health and the environment in 1999.

In assessing the risk of a persistent toxic substance or possible endocrine disruptor in the Great Lakes, it is necessary to consider both exposure potential and effects potential. Ideally, we have a good quantitative understanding of the entire pathway from source to transport and fate to bioaccumulation to effects (either human or ecological). Therefore, it is strongly recommended that health risk research be coordinated so as to develop this linkage between source and effects through the exposure pathway. Agencies responsible for environmental fate and exposure research should continue to closely coordinate with those responsible for health effects research. Indeed, the development of programs of coordinated, synoptic studies of specific contaminants of concern in specific ecosystems is the best way to develop this linkage.

The Council recommends that:

There is an immediate need to put science to service in implementing health intervention / health promotion strategies where necessary.

All strategies should recognize the importance and benefits of fish consumption to particular populations.

3.6. *RAP and LaMP Research Needs*

Purpose: A primary function of the Council of Great Lakes Research Managers is to advise the International Joint Commission on research needs related to the implementation of the Great Lakes Water Quality Agreement. The purpose of this white paper is to help determine the research needs associated with development and implementation of Remedial Action Plans (RAPs) under Annex 2 of the Agreement, and to begin a process of building a common understanding of the priorities.

Articulation of RAP Needs

In recent years, there have been three separate attempts to articulate the needs of RAPs, both in general terms and specifically related to research. As part of a Workshop on Research, Assessment, and Analysis at the 1996 SOLEC, a breakout session was conducted with the principal theme of "Improving the Effectiveness of Great Lakes Research." Breakout groups were instructed to participate in subgroups that addressed questions relating to the overall Great Lakes research arena. One of the subgroups consisting of about 10 individuals addressed the area of RAPs and LaMPs.

While this is a small subgroup of respondents and therefore does not constitute basin-wide consensus, some insightful findings were revealed.

From the discussions, two general types of RAP/LaMP research needs emerged. 1.) Research to support the development of technologies for remediation, mitigation or restoration. Particular research requirements would depend dependent on the specific types of degradation, such as sediment and habitat.

A second class of research needs surrounded benefits forcasting. This consists of methods and data that enable RAP practitioners to evaluate and predict future conditions in response to remediation scenarios. These types of analytical tools were identified by category of study (e.g. ecology, socio-economic).

The consideration of monitoring and surveillance within the context of research was also highlighted.

The articulation of RAP needs has also been conducted by the IJC Sediment Priority Action Committee (SedPAC), who prepared a white paper on the "Overcoming Obstacles to Sediment Remediation in the Great Lakes Basin" (IJC, 1997). Contaminated sediment is a major factor limiting the implementation of many RAPs and the ability to restore beneficial uses. The paper identified the following six obstacles to sediment remediation in Great lakes Areas of Concern:

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

To overcome these obstacles, research needs surround the creation of innovative funding formulas, policy and legislative flexibility, science-based data interpretation tools, private sector incentives, technology, and public awareness, consultation and engagement.

The most recent articulation of RAP needs was presented by the IJC in a paper entitled "Beacons of Light: Special Report on Successful Strategies Toward Restoration in Areas of Concern under the Great Lakes Water Quality Agreement" (IJC 1998). This paper identified the following seven major obstacles to implementation of RAPs:

- lack of planning for implementation of "big ticket" remedial measures;

- reductions in government support with no associated increase in local capacity;
- failure to set priorities within and between AOCs;
- public participation;
- information transfer; and
- failure to quantify benefits of remediation, particularly regarding human health.

Analysis of RAP Needs

Using the above, recent efforts to articulate the needs of RAPs, one possible way of analyzing these needs is by grouping them according to their root cause. The causes of these needs might be considered as three major categories of limitations:

- process limitations;
- funding/resource limitations; and
- science/research limitations.

These categories are artificial, and not exclusive, but may enable us to discriminate science/research-limited needs from those limited by other factors. While some needs may be due to a single limitation, most are probably limited by two or all three to a degree. In an effort to examine the RAP needs systematically, the RAP needs have been matched with limitations on the attached matrix (Table 3).

This cursory analysis suggests that the majority of RAP needs are either process or funding limited. While science/research appears to be the primary limitation for only a few RAP needs, it is a contributing limitation for more than half.

Table 3. Analysis of Great Lakes RAP Needs

RAP Need	Limitations		
	Process	Funds	Science
Remediation technologies		++	+
Evaluation & predictive tools		+	+
Regulatory/policy changes	++		+
Monitoring data & information		++	+
Decision-making framework	+		+
Corporate involvement	+	++	
Public support	++	+	+
Planning for hi-cost features	++		
Information transfer	++		
Benefit quantification		+	++

Legend: primary limitation ++, contributing limitation +

November 5, 1999

COUNCIL OF GREAT LAKES RESEARCH MANAGERS 1997-1999 PRIORITIES REPORT

4. RESEARCH SUPPORT ACTIVITIES

4.1. *Research Vessel Coordination*

The Second Annual Great Lakes Research Vessel Coordination Workshop was held in Ann Arbor on March 3-4, 1998. The workshop focused on several of the 37 recommendations made concerning research vessels at the first workshop. Three important areas were:

1. **Communication and Information Sharing**
   Information about the research vessels and their schedule are made available to managers and operators via the Internet. This has been received very enthusiastically by boat captains and has already saved money.
2. **Institutional Information Requirement**
   There is a real need to establish lake committees so that coordination can occur in smaller, workable units. This would also encourage memorandums of understanding and interagency agreements to allow efficient partnering. It was also suggested that an IJC committee could focus on research vessel coordination.
3. **Program Development and Coordination**
   The 1998 Science Vessel Inventory provides the State of the Fleet. There are 62 vessels over 30 feet in length counting U.S. and Canadian boats including the Coast Guard. The average age of the boats is 30 years and the average length is 50 feet.

Based on this inventory, the conclusion was that the fleet is not adequate to meet Great Lakes science needs. The Great Lakes fleet should be compared to the coastal marine fleet on the east coast, for example, where the equipment is much newer and larger, even though the Great Lakes area is a tougher environment to work in and has a much longer coastline. In fact, there is only one vessel, the U.S. EPA's Lake Guardian that is capable of year round work on the lakes in most conditions. Because of this, data gaps occur during periods when most boats cannot work, i.e. November through March. This message should get out to a broader audience. Funding for

further coordination is needed and support for a Great Lakes Protection Fund proposal is required. For example, an effort should be made to organize the web pages that different vessels may already have. One possibility is that a boat's schedule may be available to others so that ship time can be efficiently used.

The Third Annual Workshop on Great Lakes Science Vessel Coordination was held in Windsor on February 17-18, 1999. This year, the keynote address was given by the Canadian Cochair of the Council, Harvey Shear. The University-National Oceanographic Laboratory System (UNOLS) system (http://www.gso.uri.edu/unols/unols.html) for marine research laboratories was described at the workshop. There are three full-time equivalent staff devoted to schedule coordination. Only the University of Michigan boat, the Laurentian, is part of this system. The Council recommends that a UNOLS type system should be used to coordinate Great Lakes Research Vessels. The potential benefits of coordination on the basin level are enormous.

The Council recommends that:

A system like the University-National Oceanographic Laboratory System (UNOLS) should be used to help coordinate and maximize/optimize use of Great Lakes Research Vessels.

4.2. *Joint Initiatives with IAGLR*

1. New Research Priorities. Session Chairs at the Annual IAGLR Conference have been asked to help identify research needs that come out of their sessions. The following motion was passed unanimously at the Council's 30th Meeting in Montreal:

   "The Council will donate annually to IAGLR $1,000.00 which will be used to conduct a survey of emerging research needs which will be compiled and summarized and published as a Commentary and Editorial in the Journal of Great Lakes Research (JGLR).

2. Agency Presentations on Research Needs. Another motion that was passed is for heads of major research laboratories to present their current research needs at the Annual IAGLR Conference each year. This should be of interest to government funders and organizations including some groups which cannot fund directly but can partner, such as U.S. Geological Survey. The following motion was made and passed unanimously:

"Hold a session annually at IAGLR where funding agencies would present their funding or collaboration possibilities to the audience".

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5. CONCLUSIONS

Scoping of the Aquaculture Priority revealed many questions and research needs. However, it is clear that the actual number and types of aquaculture facilities currently in existence needs to be determined and that there is an urgent need for uniform, thoughtful legislation, operational guidelines and best management practices that minimize environmental impacts but do not over-regulate the industry. There is also a need for research and development of environmentally-friendly recirculating system technologies that can grow food with minimal impacts on natural waters and environmental quality.

The Modeling Summit continues to be an effective way to bring together modelers and resource managers to discuss how ecosystem modeling can aid in accomplishing the goals of RAPs, LaMPs and indicator selection and development. The Council is pleased to convene the summit at various venues including SOLEC and IAGLR and notes that its objective of identifying research needs, gaps and priorities is furthered by the regular scheduling of these events. Future summits may continue to be held on a lake specific basis or be organized around other themes such as a session in which modelers and managers collaborate to implement a solution to some pressing management problem.

Biodiversity in the Great Lakes basin is affected by the activities of a tremendous number of organizations and programs. However, there is no single agency or group that has the responsibility and authority to protect biodiversity. There is a critical need to develop ecosystem or ecoregional management approaches that protect and enhance critical habitats large enough to sustain viable, genetically diverse populations. Further, an oversight committee or organization both within the U.S. and Canada and between countries should be developed to provide a coordinated body for assimilation of the extensive amount of research, databases, atlases, cataloguing and other ongoing programs on biodiversity.

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