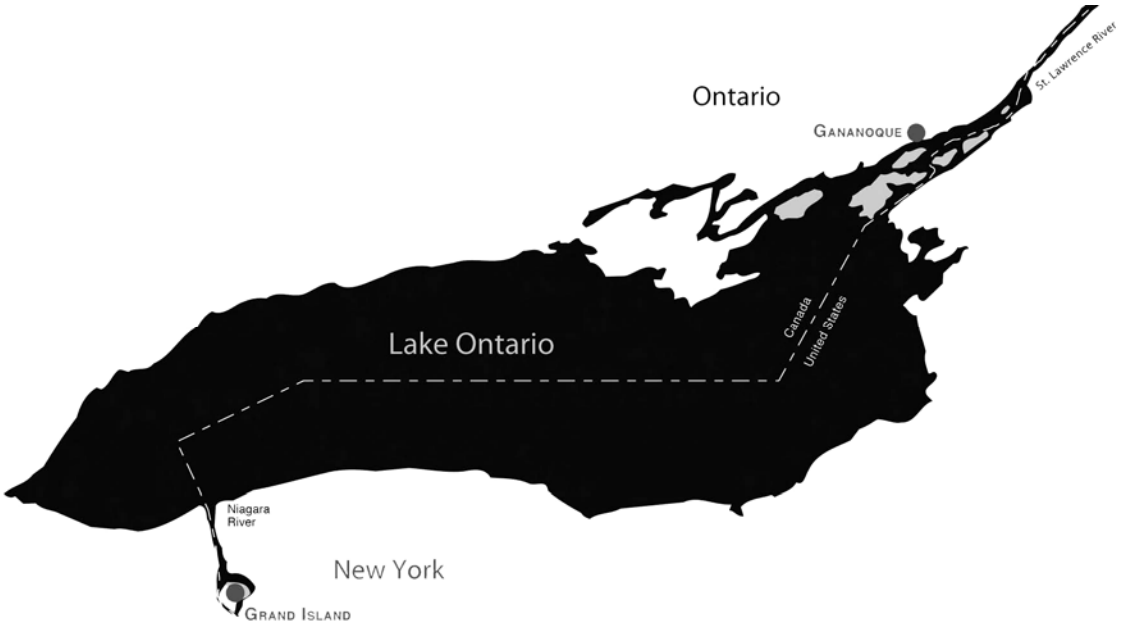
Information Needs for Lake Ontario: The Great Lakes Regional Research and Information Network Search Conferences



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This publication is part of a series of reports resulting from investigations dealing with public issues in the management of wildlife, fish, and other natural resources. The Human Dimensions Research Unit (HDRU) in the Department of Natural Resources at Cornell University studies the social and economic values of wildlife, fish, and other natural resources and the application of such information in management planning and policy. A list of HDRU publications may be obtained by writing to the Human Dimensions Research Unit, Department of Natural Resources, Fernow Hall, Cornell University, Ithaca, NY 14853, or by accessing our World Wide Web site at: http://www.dnr.cornell.edu/hdru.

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Notice

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Executive Summary

The Lake Ontario node of the Great Lakes Regional Research and Information Network (GLRRIN) contracted with the Human Dimensions Research Unit (HDRU) at Cornell University to design and facilitate two modified search conferences to engage diverse stakeholders in the identification of research and information needs for Lake Ontario. The search conferences took place in Grand Island, New York, and Gananoque, Ontario. Both search conferences were conducted between March 31 and April 4, 2008.

Participants developed a list of research and information needs through a series of sessions:

Initially, participants worked together to document a "shared history" by identifying key ecological, economic, political, and sociocultural trends and events in the history of Lake Ontario and depicting these events on a timeline. Most of the events depicted occurred after 1900, although the history of native peoples began well before that time. Three primary periods were evident during the last 60 years: (1) a period of system deterioration (beginning in the 1950s); (2) a period of system recovery (beginning in the 1970s); and (3) the present day (beginning in the 1990s).

In the next stage, participants worked in small and large groups to develop a list of traits they would like Lake Ontario to have in an "ideal future." Related traits were grouped into categories that were meaningful to participants. The categories of traits identified at the two search conferences were similar, but not identical. They included ecosystem health, water quality and quantity, fisheries, sustainable development, governance ("approaches" to decision-making and management), habitat, and invasive species.

After the ideal future of Lake Ontario was characterized, participants identified the traits they expected Lake Ontario to have in the "likely future" – the future they expected if current trends continue without intervention. The discussions were wide-ranging, but often illustrated either the differences between the ideal future and the likely future or the uncertainty associated with the likely future.

The principal product of the search conferences was a list of information needs to assist future decision-making about Lake Ontario. These information needs were developed based on the prior discussions of the ideal and likely futures of the lake. The principal questions guiding these discussions were: (1) What aspects of the likely future of Lake Ontario are uncertain? What information could help make the likely future more certain?; (2) In what cases does a mismatch between the ideal and likely futures exist? What information could help determine how to make the ideal future more likely?; and (3) In what cases does a disagreement exist about the ideal future? What additional information could be used to help resolve that disagreement?

After an extensive list of information needs was developed, each participant identified his or her highest priorities amongst these needs. We synthesized the highest priority information needs into the following list of questions in six topic areas:

Water

- What existing and emerging contaminants are present, at what levels, and originating from what sources?
- How do stormwater, wastewater, and runoff influence nutrient loadings and water quality, and how can they best be managed?
- How much water is available in the system? To what uses is it being put? How are lake levels influenced by water supply and usage?

Stressors

- What invasive species are present or expected in Lake Ontario? What impacts are they having? How are they introduced and spread throughout the system? What methods are most effective for controlling them?
- What impacts is climate change having on Lake Ontario? What impacts will it have in the future?

Fisheries

- How is the fish community (and interactions within the fish community) in Lake Ontario changing? How is it influenced by invasive species, climate change, and shifting land use patterns around the lake?
- What are the benefits and costs of dam removal and mitigation on Lake Ontario tributaries?
- How can interest in restoring native fish species to the lake be balanced against interest in maintaining current recreational fishing opportunities?
- How viable are recreational and commercial fishing in Lake Ontario?

People

- How is the distribution of people changing in the Lake Ontario basin? What impacts do these changes have?
- What are people's awareness, knowledge, attitudes, and opinions regarding key Lake Ontario concerns?
- How is the economy changing within the Lake Ontario basin? How are sources and uses of energy changing? What influences do these changes have on Lake Ontario?

Information and Analysis

- How can important sources of information and data be made more readily available?
- How can models of processes related to Lake Ontario be improved? How can regional habitat models be improved? How can models of links between human activities and the lake ecosystem be improved?

Decision-Making and Management

- How can responsibilities regarding the management of Lake Ontario be clarified?
- What are the best procedures for developing management plans for Lake Ontario?
- How can communication between decision makers and the public be improved?
- How can commitment to management plans be built?

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Background

The Great Lakes Regional Research and Information Network (GLRRIN) is a multi-agency, bi-national network in the Great Lakes region formed to aid the development of a regional research and information strategy by supporting and complementing the efforts of other agencies and organizations. One of GLRRIN's objectives is to involve:

> *a broad range of Great Lakes stakeholders (users, general public, managers, and research scientists) to identify and prioritize critical resource management problems and the associated research and information needs necessary for practical solutions and to develop a strategy and network to facilitate, and enhance the value of, Great Lakes research, education and outreach.*

Each of the five Great Lakes has a 4-person coordinating committee to lead GLRRIN efforts for that lake. The Lake Ontario coordinating committee, through the New York Sea Grant Institute, contracted with the Human Dimensions Research Unit (HDRU) at Cornell University to design and facilitate two modified search conferences to engage diverse stakeholders in the identification of research and information needs for the lake. Both search conferences were conducted between March 31 and April 4, 2008.

Search conferences are a methodology used for participatory planning in which participants define a desired future and identify actions to help achieve that future (Emery and Purser 1996, Schusler and Decker 2001). Search conferences depend on diverse representation of affected stakeholders, democratic procedures, and consideration of all viewpoints to ensure that the output of the conferences is relevant to all those involved.

Typically, a search conference is used to: (a) develop a common understanding of the system or situation of interest; (b) determine what participants would like that system to be like in the future (ideal future); (c) determine what that system will be like without intervention (likely future); and (d) identify actions to help make the ideal future more likely. In this case, rather than identifying management actions, the search conferences used participants' perspectives on the ideal and likely future of Lake Ontario to identify research or information needs.

The search conferences were designed to answer the following question:

> *What is the ideal future of Lake Ontario, considering both human needs and desires and lake ecology, and what information is needed to realize that vision?*

The principal sessions of the search conference included:

- **Opening Presentation.** A brief slide presentation was given to broadly characterize the Lake Ontario system and establish boundaries on the discussion to follow.
- **Shared History.** Participants worked together to identify key ecological, economic, political, and sociocultural trends and events in the history of Lake Ontario.

- **Ideal Future.** Participants worked in small and large groups to develop a list of traits they would like Lake Ontario to have in an "ideal future." Related traits were grouped into categories that were meaningful to participants.
- **Likely Future.** Participants identified the traits they expected Lake Ontario to have in the future if current trends continue without intervention.
- **Information Needs.** Considering both the ideal and likely future discussions, participants developed lists of "information needs" for future decision-making about Lake Ontario. The principal questions guiding these discussions were: (1) What aspects of the likely future of Lake Ontario are uncertain? What information could help make the likely future more certain?; (2) In what cases does a mismatch between the ideal and likely futures exist? What information could help determine how to make the ideal future more likely?; and (3) In what cases does a disagreement exist about the ideal future? What additional information could be used to help resolve that disagreement?
- **Prioritization.** Each participant identified his or her 5 highest priorities for information needs.

Written questionnaires were completed by participants immediately before and after the search conference as part of an evaluation.

Two one-and-a-half day search conferences were conducted in order to facilitate attendance by as many individuals as possible. The first search conference was conducted on March 31 and April 1, 2008, in Grand Island, New York. Thirty-three individuals attended. The second search conference was conducted on April 3 and 4, 2008, in Gananoque, Ontario. Thirty-eight individuals attended. Participants at each search conference included a mix of representatives of government (federal, tribal, provincial, state, and local), academia, non-governmental organizations, and business owners or associations.

This report includes a summary of discussions that took place at the search conferences.

Shared History

During this session, participants depicted important events (ecological, political, economic, and sociocultural) in the history of Lake Ontario. Events were depicted on a timeline composed of a series of newsprint sheets posted along one wall of the conference center. Events were added by individuals, and then reviewed by the entire group in a discussion led by the HDRU facilitator. No attempts were made to verify the dates of events, and on the occasions when disagreements surfaced, they were noted but not necessarily resolved.

The events described at each of the search conferences are depicted in Table 1 using wording as close to the original wording as possible. Within each time period, events are organized into categories identified following the search conference: (1) ecosystem (biophysical characteristics of Lake Ontario and its basin, habitat characteristics, and relationships between species); (2) populations (sizes of populations of key species); (3) political (treaties, laws, regulations, or management institutions); (4) management (approaches to managing Lake Ontario or its components); (5) research – efforts to gather information about Lake Ontario; (6) economics

(economic activity associated with Lake Ontario or human actions that could influence economic activity); and (7) social (changes in human populations, behaviors, or attitudes).

Most of the events depicted in the timeline occurred after 1900, although the history of native peoples began well before that time. Three primary periods were evident during the last 60 years: (1) a period of resource decline (beginning in the 1950s); (2) a period of resource recovery (beginning in the 1970s); and (3) the present day (beginning in the 1990s).

Table 1. Shared history of Lake Ontario.

Time Period	Gananoque	Grand Island
40,000 years ago	**Ecosystem:** • Ice Time	
12,000 years ago	**Ecosystem:** • Fracture of the Frontenac Ice Tongue by the St. Lawrence Fault – "When the River Roared."	
10,000 years ago	**Social:** • Aboriginal people move to Great Lakes after the collapse of Southern Nation due to climate change.	
8,000 years ago	**Ecosystem:** • Land rebounds from removal of ice sheets – "Flaming Head" Pizro Effect. **Populations:** • Woodland caribou, wood bison, fish plentiful.	
600	**Social:** • Large cities and town established. Syracuse (Onondaga City) population of 60,000. (London, England 45,000 at that time). All interconnecting land occupied by aboriginal people. "Hidden Treaty" between nations.	

1200	**Social:** • Confederacy established.	
1200-1900	**Populations:** • Sea lamprey observed (1835). • Atlantic salmon natural reproduction lost (c. 1860). • Alewife appear (1860). • Present in large numbers (1870). • Atlantic salmon extinct (c. 1899). • Intact deepwater cisco complex supporting native predators. • Native lake trout populations. • No Pacific salmonids (rainbow trout??) • Carp introduced. **Political:** • Two Indian Acts – one giving title of St. Lawrence to Mohawks of Akwesasne and one giving title to Canada (1867). **Management:** • Wilmot Creek Atlantic salmon hatchery (1862).	**Ecosystem:** • Wetland loss. **Populations:** • Loss of Atlantic salmon. • Decline of lake sturgeon. • Invasion of sea lamprey and alewife (1872). • Common carp established in wetlands. **Management:** • Caledonia fish hatchery.

1200-1900 (continued)	**Economic:**
	• Mill/dams increase (c. 1800)
	• Majority of all tributaries dammed.
	• Deforestation and population settlement in 1850s at eastern end of lake.
	• Canal construction allowing invasive species introduction.
	  o Rideau
	  o Oswego
	  o Long Sault
	  o Welland
	  o Erie
	• "Barley Years" (1860-70).
	• Commercial fishing increases – pound nets used.
	• Logging industry using Lake Ontario and St. Lawrence for transport.
	
	Social:
	• Europeans arrive (c. 1600).
	• Time of death and dying for aboriginal people (1600-1700).
	• Church at Akwesasne established (1673).
	• War of 1812 in which Haudenosaunee sided with both U.S. and Canada (1812).
	• Beauharnois Control Structure contested by Mohawks (1834).
		Economic:
		• Building of dams on tributaries.
		• Deforestation of watershed.
		• Building of Welland and Erie Canals (1825).
		• Barley years (huge increase in agriculture) (1860-1870)
		• Eastman Kodak plan started in Rochester (1888?).
		
		Social:
		• Europeans arrive (c. 1600)
		• Change in energy sources from local to distant – loss of social capital and financial capital leading to local community disempowerment.

1900s	**Populations:** • Rainbow trout introduced. • Brown trout introduced. **Political:** • International Joint Commission gets started (Boundary Waters Treaty). • Indian Advancement Act (1900). **Management:** • Whitefish stocking/hatcheries (unsuccessful). **Economic:** • Paper plant at Akwesasne – mercury in river.	**Populations:** • Atlantic salmon extinct. • Introduction of rainbow trout. **Political:** • Boundary Waters Treaty (creates International Joint Commission). .
1910s	**Ecosystem:** • Widespread deforestation. o Change in hydrograph. o Erosion and sedimentation. o Lost Atlantic salmon habitat. **Research:** • Cape Vincent.	**Ecosystem:** • Habitat and wetland loss. **Populations:** • 1st cormorant breeding – Lake Superior (1913).

1910s (continued)	**Social:** • World War I. • Idea of St. Lawrence Seaway originated.	**Economic:** • Damming continues. • Last Erie Canal expansion. • Expansion of Welland Canal.

1920s	**Populations:**
	• Smelt invade.
	
	Economic:
	• Erie Barge Canal (1925).
	• Extensive commercial fishing.
	  o Sustained high harvests of:
	  ▪ Lake trout.
	  ▪ Herring.
	  ▪ Chubs.
	
	Research:
	• Great Lakes Environmental Research Laboratory (GLERL) established.
	
	Social:
	• Formation of angling and hunting organizations reflecting interest in conservation.
	• Brighton, ON – Rochester, NY sailing regattas reinforce common interests in lake.
		Populations:
		• Invasion of smelt (1920).
		• Lake trout in serious decline.
		
		Research:
		• Great Lakes Environmental Research Laboratory (GLERL) established in Muskegon.
		
		Social:
		• Invention of outboard motor.

1930s	**Economic:**
	• Increase in commercial fishing with:
	  o Technological improvements.
	  o Diesel engines and hydraulics.
	  o Net lifters.
	• Introduction of large scale mink farming in Great Lakes region.
		Ecosystem:
		• Continued habitat and wetland loss.
		• Habitat filled in for factories.
		• Low water levels – drought.
		
		Populations:
		• Blue pike decline.
		• Sturgeon decline continues.
		• Cormorant breeding on Lake Ontario.
		
		Economic:
		• Heyday of commercial fishing.

1940s	**Ecosystem:**
	• Mercury starts to increase.
	• Contamination of tributaries due to extensive industrial and agricultural pollution.
	• Nutrient loading increases.
	
	Management:
	• Registered trapline system for furbearers implemented in Ontario (1947).
	
	Research:
	• Ontario Ministry of Natural Resources Fisheries – research program established.
	
	Economic:
	• World War II.
	  o Increase in industry around Lake Ontario.
	• St. Lawrence Seaway construction (1947-1959).
	• Decline of commercial lake trout fishery.
	• Increase in whitefish commercial harvest.
	
	Social:
	• Large workforce returns from war.
	• Akwesasne folk drinking (my grandparents).
	  o Water taken straight from St. Lawrence River.
	  o Eating fish 3 to 5 times a week.
		Research:
		• Ontario Ministry of Natural Resources Great Lakes research program initiated.
		
		Economic:
		• World War II leading to increases in industry and pollution.
		• Development of modern organic chemistry.
		• Start of dioxin era.
		• “Better living through chemistry.”

1950s	**Populations:** • Lake trout extirpated. • Deepwater sculpin (extirpated?). • American eel recruitment blocked (1950-1975). • Cladophora. **Political:** • Convention on Great Lakes Fisheries, which led to the establishment of the Great Lakes Fishery Commission. • Conservation Authorities get started in Canada. **Management:** • First Lake Ontario water level plan – water levels become regulated. • TFM used for lamprey control. **Research:** • Glenora Fishery Research Laboratory established.	**Ecosystem:** • DDT found in birds eggs (1955). **Populations:** • Loss of blue pike. • Lake trout and corregonid collapse. **Political:** • Great Lakes Fisheries Commission established. **Management** • Water level regulation begins (1959). • Lampricide TFM first used. **Research:** • First meeting of the International Association of Great Lakes Research.

1950s (continued)	**Economics:** • Large scale industrial contaminants entering system (PCB, mercury). • Niagara River chemical industry loading of persistent contaminants into system. • Large scale use of DDT. • Opening of St. Lawrence Seaway. • Moses-Saunder Power Station (1955-1958) and Beauharnois Power station block eel passage and increase eel mortality in turbines. • Increased commercial shipping from overseas? **Social:** • Recreational boating increases.	**Economics:** • St. Lawrence Seaway opens. • Development of Moses/Saunders dam. • Agricultural intensification (mechanized agriculture). • Development of interstate highway system. • Tourism increases. • Development of fiberglass boats. **Social:** • GIs return from World War II. • Population growth accelerates – baby boomers. • Number of second homes increases.

1960s	**Ecosystem:**
	• Ecosystem shifts from river to lake ecosystem.
	• Two Mirex spills:
	  o Niagara.
	  o Oswego.
	• Lake Erie catches fire.	

1960s (continued)	**Populations:**
	• Massive alewife and smelt die-offs.
	• Wildlife declines from contaminants.
	• Pacific salmon introduced (1968)
	  o Initial effort at biocontrol of alewife (hypothesis only?)
	  o Later becomes economic engine.
	
	Research:
	• First Lake Ontario survey (c. 1964).
	
	Economics:
	• Large scale water use for power production.
	• Expanded commercial fishery for American Eel.
	
	Social:
	• Silent Spring (1962).
	• Bridge at Cornwall blocked in protest related to St. Lawrence Seaway (1963).
		Populations:
		• Alewives becoming abundant.
		• Deepwater sculpin starting to decline.
		• Lamprey abundance increase.
		• Lake Erie and Ontario full of fish (non-natives).
		• Fish numbers increase with eutrophication, but then decrease
		
		Political:
		• U.S. Endangered Species Act
		
		Management:
		• Water levels regulated.
		• Pacific salmonid stocking program.
		
		Research:
		• Canadian Wildlife Service – Bird contaminant monitoring.
		• Great Lakes Environmental Research Laboratory established in Ann Arbor.
		
		Economics:
		• Mirex manufacture.
		• Nuclear plant development.
		
		Social:
		• Silent Spring published.

1970s	**Populations:** • Early Mortality Syndrome (EMS) due to thiaminase deficiency affects Lake Trout recruitment. • Contaminant levels in wildlife populations begin to increase. • White perch population increases (Bay of Quinte). • Smelt decline (late 1970s). • Blue pike extinct. • Algal blooms off shore. **Political:** • Great Lakes Water Quality Agreement (focus on reducing eutrophication) (1972). • International Field Year for the Great Lakes – largest lakewide survey (1972). • Superfund started in U.S. • U.S. Clean Water Act. • Manufacturing regulations increase. • Use of "dirty dozen" organic pesticides starts to be banned/restricted/decreased. o DDT, PCBs, dieldrin…	**Ecosystem:** • Continued wetland and habitat loss. • Second period of real low water levels. • Cold winters 1976-77. **Populations:** • Massive alewife die-off. **Political:** • DDT ban. • Clean Water Act (1972).

1970s (continued)	**Management:**
	• Sea lamprey control.
	• Joint strategic plan for Great Lakes fisheries management developed.
	• Lake trout restoration efforts:
	  o Increase in stocking.
	  o Increase in adult stock.
	
	Research:
	• PLUARG (Pollution from Land Use Activities Reference Group) studies of pollution.
	• Long term monitoring begins.
	
	Economic:
	• Lake whitefish harvest peaks.
	• Eel harvest peaks.
	• Smelt commercial fishery peaks (c. 1970).
	
	Social:
	• Love Canal.
	• Akwesasne community told to stop eating fish from St. Lawrence River after community health study was conducted (1978).
		Management:
		• First Sea Lamprey treatments.
		• Lampricide TFM in use.
		• Presence of PCBs and mirex lead to trout and salmon stocking hiatus.
		
		Research:
		• Whole Lake Survey (1972?).
		• Whole lake models (circulation) begin to be developed.
		• Journal of Great Lakes Research published.
		• Canada Centre for Inland Waters established.
		
		Economic:
		• Pickering Generating Station (1971).
		
		Social:
		• Love Canal.

1980s	**Populations:** • Zebra/quagga mussel introduction (Dreissena). • Mitten crab introduced through ballast water (c. 1983). • Cormorant problem surfaces. • American eel begins to decline (late 1980s). **Political:** • Protocol of Great Lakes Water Quality Agreement – focus on toxics (1987). o Introduction of Areas of Concern, Remedial Action Plans, and Lakewide Management Plans. • U.S. Environmental Protection Agency and Environment Canada "take back" Great Lakes Water Quality Agreement. • International Joint Commission begins to lose voice of lakes. • Clean Up Fund – Canada (1987-88). • Acid rain legislation. • Water Quality Coordinating Committees formed in New York State.	**Ecosystem:** • Continued wetland and habitat loss. • Niagara River burns. • Target total phosphorous levels reached. • Extreme high water levels (1987). **Populations:** • Zebra mussels found. • Bythotrephes found (BC water flea). • Nuisance Cladophora growth near shore. • Decline of American eel begins (1985). **Political:** • 1987 Amendment to Great Lakes Water Quality Agreement of 1972 initiates Remedial Action Plans.

1980s (continued)	**Management:** • NYS Department of Environmental Conservation Salmon River Hatchery established. o Focus of management shifts to recreational fishing. • Zero discharge of chlorine considered by International Joint Commission. • Brownfields managed by leaving lands vacant. • CURB (Clean Up Rural Beaches) program established to improve private land use practices (Ministry of Environment). **Research:** • First ballast water study (c. 1984). • Herring gulls used as bioindicators.	**Management:** • Salmon River Hatchery built to release Pacific salmon into lake. • Ecosystem approach to management begins. • Great Lakes begins to be viewed as entire system. • Hamilton Harbour Remedial Action Plan process begins (1985). • Niagara River Toxic Management Plan instituted. • Conservation Authorities regulate shoreline (MNR policies) (1988-89). • Ontario Ministry of Natural Resources develops Ontario Wetland Evaluation System (OWES). **Research:** • Great Lakes Research Commission formed (1986). • First ballast water study (1986). **Economic:** • Just in time delivery global trading increases use of St. Lawrence Seaway. • Trend toward globalization. • Shift to unleaded fuel. • Sustainable development becomes focus. • Darlington nuclear generating station on line (1986).

1980s (continued)	**Social:** • Pacific salmon recreational fishery.	**Social:** • Increased recreational fishing for trout and salmon. • Lake Ontario becomes leading recreational sportfishery in New York State. • Echo boomers – baby boomers have babies. • Conspicuous consumption – "I need a lake house." • Interest in reuse and recycling.

1990s	**Ecosystem:**
	• Target total phosphorous levels reached.
	
	Populations:
	• Appearance of blueback herring (invasive species through canal system).
	• Algal blooms inshore.
	• Observed lake trout reproduction
	  o Decreased stocking of lake trout
	  o Decreased juvenile survival.
	• Appearance of Viral Hemorrhagic Septicemia Virus (VHSV)?
	• Decline of Diporeia (mid 1990s).
	
	Political:
	• Ontario provincial cutbacks (1995-96).
	• Managed Forests Tax Incentive Program (MFTIP) – private landowners get tax incentives to protect natural areas.
		Ecosystem:
		• Clear water.
		• Lots of bass.
		• 1999 – beginning of water level decline into next decade.
		
		Populations:
		• Diporeia in decline.
		• Round gobies appear.
		• Cormorants increase.
		• Blueback herring appear.
		
		Political:
		• Clean Water Act Amendments implemented (Stormwater Phase I & II).
		• Transfer of fish habitat responsibility from provinces to federal government.

1990s (continued)	**Management:** • Review/Revision Joint Strategic Plan for Management of Great Lakes Fisheries. • Lake Ontario Fish Community Objectives. • 50% reduction in chinook stocking (1993). • Licensing of hydro plants leads to greater base flows, which leads to increase in natural reproduction. • Ban of snagging. • Taste and odor of water used as indicators. • Watershed Plans and Report Cards initiated, which engage public in planning process.. • Declaration of provincial interest stops development on Lake Ontario from Burlington to Quinte. • Ontario Ministry of Natural Resources consultative planning process (Ontario Living Legacy).	**Research:** • First State of the Lake Ecosystem (SOLEC) meeting – binational body for development of indicators (1994). • Great Lakes coastal forecast system initiated (GLERL). • Improved computer modeling capabilities.

1990s (continued)	**Economic:** • Waterfront Trail opens – public access improves. • Increase in residential development on Lake Ontario. • Environmental Farm (Ontario) – risk assessment by coalition of farm groups (1992). **Social:** • Akwesasne/OKA Conflict.	**Social:** • World Wide Web/internet.
2000s	**Ecosystem:** • Lower Trent River – dioxins • Oswego Area of Concern delisted. • Walkerton – contamination of drinking water. **Populations:** • Walleye decrease in Bay of Quinte – then "stable" at lower level of abundance. • Collapse of whitefish. • Decline in adult lake trout abundance. • Deepwater sculpin observed. • Gobies increase. • Viral Hemorrhagic Septicemia Virus (VHSV) (2007) – affects both sides of border commercially. • Emergence of disease (e.g., botulism E) (associated with exotics? – round gobies). • Return of Cladophora.	**Populations:** • Round gobies appear. • Exponential increases in cormorant abundances. • Botulism outbreaks. • Viral Hemorrhagic Septicemia Virus (VHSV). Hemimysis found. • Fishhook water flea. • Cladophora nuisance growths. • Increased nuisance algae. • Loss of Diporeia.

2000s (continued)	**Political:** • Great Lakes Sustainable Water Resources Agreement. • Species at Risk Act (SARA). • Ontario Endangered Species Act. • Dombind ban • Establishment of Ontario Regulation 97/06. o Allows Conservation Authorities to regulate development. • Ontario Nutrient Management Act. • Ontario Clean Water Act. • Source Water Protection. • Smart Growth Plan. • Greenbelt/Oak Ridge Moraine – protect many tributaries headwaters. • Agricultural Environmental Management (NYS) **Management:** • Atlantic salmon reintroduction. • Cormorant control programs. • Ontario American eel fishery closed. • NY Ocean and Great Lakes Ecosystem Conservation Council – ecosystem-based management initiatives. • Ecosystem-based management. • Blue Flag Program introduction – international safe swimming standards. Aboriginal traditional knowledge included in various acts – after numerous wins in court cases.	**Political:** • Ontario Endangered Species Act. • Species at Risk Act (SARA). • Progress of compact. • Bush fires IJC chair (2007). **Management:** • U.S. mandatory ballast water exchange (2000). • Transport Canada – strict ballast water regulations (previously voluntary measures, but now mandatory) (2006-07). • Relocation program for Canada geese.

2000s (continued)	**Economic:** • Late 2000s – increased corn production.	**Research:** • SWOOP – new source of imagery for tracking changes in land use over time. • Great Lakes Observing System (GLOS). • International Joint Commission water levels study. **Economic:** • Increased sewage treatment plant addition of secondary treatment around basin. • Increased "green" energy (wind, biofuels). • Live fire proposal (2006). **Social:** • "An Inconvenient Truth" recognition of global climate effects. • Lake Ontario Water Keeper – greater awareness of environmental problems. • Immigration into region.
Future?		• With global warming should stockings move to more warm water fish? • "Age boom" – increased aging population? • Bass fishing – catch and release out of season?

Ideal Future

In this session, participants identified traits (ecological, political, economic, and sociocultural) that they would like Lake Ontario to have in an "ideal future." Discussions originally took place in small groups of 5 to 10 participants. After each small group had developed a list of "ideal future" traits, the groups reconvened and worked together to identify categories into which these traits could be organized. These categories were then used to organize discussions for the remainder of the search conferences. In Gananoque, the categories of traits were:

- Ecosystem Health
- Water Quality and Quantity
- Fisheries
- Sustainable Development
- Governance

In Grand Island, the categories were:

- Habitat/Invasives/Water Quality
- Fisheries
- Sustainable Development
- Approaches (i.e., how decisions are made and actions carried out)

Although each search conference developed its list of categories independently, the categorization systems had many similarities.

A description of the ideal future traits developed at each search conference follows. Although broad agreement existed on the desirability of many traits, other traits were valued by some participants, but not others. No attempt was made to resolve these inconsistencies during the search conferences.

Gananoque

Ecosystem Health

In an ideal future, the Lake Ontario ecosystem would be functional and healthy, characterized by ecological integrity. The number and severity of ecological upheavals would be reduced. Food webs would be stable.

Contaminants would be reduced or eliminated in the lake and its tributaries. Fish consumption advisories would no longer be needed.

The aquatic ecosystem would be characterized by a diverse and stable set of native and naturalized species (including lake sturgeon, Atlantic salmon, American eel, lake trout, and deepwater cisco). The prey base would be diverse. Improved connectivity of tributary fish habitat (through dam removal) would increase fish spawning in streams. Aquatic bird communities would be healthy and diverse.

The number of invasive species would be reduced, and the introduction of new invasive species would be prevented. Limiting shipping to vessels restricted to the Great Lakes would facilitate this end. Cladophora blooms would be eliminated.

Lake temperatures would have stabilized. No anoxic zones would appear in the summer.

Natural landscape processes would be maintained around the lake through reforestation, the creation of more natural spaces, a naturalized shoreline with vegetative buffers, the development of natural corridors to link habitat, and the improvement of wetland habitat. All land and water use would be sustainable.

Thermal pollution would be eliminated.

Water Quality and Quantity

In an ideal future, a binational agreement would be reached both regarding pollution control around Lake Ontario and regarding water use and withdrawals from the lake.

Levels of resistant pesticides, heavy metals, and other contaminants in the lake would be declining. Non-point source pollution inputs would have decreased. Contaminated sediments would be dredged. Water would be safe for both drinking and swimming. Contaminants in fish would have decreased. Advisories about swimming and fish consumption would not be needed. Algal blooms would be reduced.

Concerns about water levels would have been addressed. Large scale commercial diversions of water would not occur. Water levels would exhibit more natural variation.

Fisheries

In an ideal future, Lake Ontario would be characterized by a healthy and sustainable fishery that would meet the needs of both recreational and commercial users and contribute to the economy. Diverse fishing opportunities would be available. Fish from the lake would have low enough contaminants to be edible. The fishery would include species such as lake trout, Atlantic salmon, American eel, lake herring, and lake sturgeon. Recreational anglers would have the opportunity to catch trophy lake trout and Atlantic salmon. Sea lampreys would be suppressed. The zooplankton community would be balanced.

Sustainable Development

In an ideal future, Lake Ontario would be characterized by a sustainable, strong, and innovative economy in which growth was managed, industry was non-polluting, and a local supply of renewable energy was available (including increased use of water for hydroelectric power).

Tourism would be an important component of the economy. Urban development would be managed to reduce sprawl.

Access to the lake and the lake's edge would contribute to a high quality of life. The water would be clean enough for people to swim into it. Other recreational uses would include boating, scuba diving, camping, and hiking. Water taxis/ferries would transport people around the lake.

Communities around the lake would be characterized by beautiful buildings, the availability of places for community gatherings, and a strong cultural heritage. Communities and neighborhoods would be walkable.

Residents would be more aware of how their actions affect Lake Ontario and more willing to act to benefit the lake. Landowners would be engaged in sustainable land use practices and would be recognized for the ecological goods and services they provide. Less regulation of landowners and marine-related businesses would be needed.

Governance

In an ideal future, Lake Ontario would be managed using an adaptive, ecological approach.

Management and governance would be more closely coordinated across all relevant jurisdictions – U.S., Canada, native peoples, provinces, states, and local government. Communication and cooperation between stakeholders would be improved.

Agencies, scientists, key stakeholders, and the public in general would be aware of and engaged in management and governance. The management of Lake Ontario would be a success story for others to emulate.

Decisions would be made on the basis of sound information. An improved understanding of socioeconomic factors that influence Lake Ontario would be achieved. Long-term monitoring of ecological and socioeconomic variables would be maintained, and the data from this monitoring would be readily accessible.

Funding would be readily available for research, resource protection, and management.

Grand Island

Habitat/Invasives/Water Quality

In an ideal future, the quality of water in and around Lake Ontario would be significantly improved. Chemical contaminants (including "new" contaminants, such as pharmaceuticals) would be reduced or eliminated. Wastewater treatment would be improved and concentrated

sewer overflows would be eliminated. The east basin of the lake would be mesotrophic and the main lake would be oligotrophic.

Bacterial contamination and excessive algal growth would be eliminated. Lake water would be suitable for drinking and swimming without advisories. Sediment would be safe to walk on. Both fish and waterfowl would be safe to eat. Increases in swimming and water-based recreation would occur.

The number and populations of invasive species would be reduced, and the introduction of new invasive species would be prevented. Botulism and fish diseases (such as viral hemorrhagic septicemia virus) would be eliminated.

Aquatic habitat would be restored. Gravel shoals would be returned to tributaries. Wetlands would be restored. Lands revealed by lower water levels would be protected. Habitat for native fish species would be increased while habitat for sea lamprey would be decreased.

Fisheries

In an ideal future, Lake Ontario would be characterized by healthy and diverse fish and wildlife communities. Consensus did not exist about the composition of the fish community, with search conference participants variously prioritizing native and naturalized species (American eel, Atlantic salmon, lake trout, lake herring, and other coregonids), warm water species, and Pacific Salmon. Fish stocking would not be necessary. Alewives would be reduced in number. Sea lamprey numbers would be low enough that they would not need to be controlled. Cormorants would be reduced.

Food webs would be stable. Aquatic and coastal habitats would be diverse.

Both sport and commercial fisheries would be viable. Diverse fishing opportunities would be available, and the use of these opportunities by anglers would increase. Contaminant levels in fish would be low enough that fish could be eaten without fish consumption advisories.

Sustainable Development

In an ideal future, economic development around Lake Ontario would be sustainable, balanced, and cleaner. Population growth would be reduced. The lake basin would be energy neutral relying on a new generation of alternative energy sources. Industry would be non-polluting. Urban growth would be controlled. Water exports would be limited.

The economy would rely more heavily on eco-tourism and recreation – fishing, swimming, boating, etc.

Harbors would be dredged so that they were usable.

Lake shorelines would be attractive and healthy. Fewer obtrusive shoreline structures would be evident. Shorelines would contain more trees, vegetation, and park areas. Natural coastal processes would be protected.

Shoreline communities would be pleasant places to visit with museums, parks, festivals, and other recreational opportunities.

Approaches

In an ideal future, management of Lake Ontario would focus on larger scale watersheds and ecosystems. Management decision-making and actions would be coordinated across political boundaries with minimal duplication of effort.

Management would be proactive. Decisions about climate change, alternative energy policy, and other topics would identify and respond to problems in advance, rather than waiting for these problems to appear.

The information needed for making decisions about the lake would be available. A consistent commitment of funding would lead to long-term monitoring and data sets. A better understanding of human-lake interactions would exist. Increased knowledge would exist of practices that decrease unintentional introductions of invasive species. Information would be shared between stakeholders.

Public outreach would increase. Residents and local officials would be educated about and engaged in decisions related to Lake Ontario. Interest in the lake and the opportunities it provides would increase.

More and better funding and incentives for land acquisition and management of private lands would exist.

Likely Future

For this session, participants organized themselves into groups with each group working on one of the four or five topic areas (based on categories of traits) identified during the "ideal future" session. Each group generated a list of traits they expected Lake Ontario to have in the "likely future" – the future if current trends continued without intervention. The lists of traits were reviewed (and in some cases supplemented with additional traits) after the groups reconvened.

The likely future traits identified were as follows:

Gananoque

Ecosystem Health

(1) Invasive Species
- More brackish species will invade.
- Loss of native species.
- Homogenization of lake community.
- New disease pathogens.
- Lakers only shipping?
    - Considered unlikely that shipping will be restricted to only those ships that transport exclusively on the lake (to reduce invasive species introductions), but expect technological solutions will help to address the problem.

(2) Climate Change
- More warm water species.
- More storms.
- More floods.
- Increased sedimentation.
- Increased algal blooms.
- Cold water species will suffer.
- Demands for water will increase.

(2) Long-term Records
- Predict lack of centralized data.
- Predict improvement in data available.
- Concern over fate of data collection programs owing to funding uncertainty. (Government does not take long-term view and monitoring funds are not a priority for politicians. Creating partnerships may help to address this problem.)

(3) Habitat Management
- No net gain or loss of wetlands.
- Quality of habitat will diminish.
- Increased fragmentation of basin habitat.

(4) Contaminants
- Old contaminants will decline, but new ones will increase. (Thousands of unmeasured chemicals are in system.)

(5) Shoreline Naturalization
- Shoreline largely developed already.
- In Ontario, buffers would likely need to be 100 m to be effective. These buffers can still be developed.

(6) Wind Power
- Negative impacts on migratory birds and bats expected.

Water Quality and Quantity

(1) Quantity (levels, inflows/outflows)
- Reduction in water levels due to climate change.

- Upper lakes having less water to send to lower lakes.
- More shoreline (affecting private properties and boaters).
- Effects of changes on vegetation.
- Decreased groundwater quantity.
- Decreased hydropower generation.
- Effect of current and past legislation will be visible.
- Effect on commercial navigation and recreational boating.
- Changes in economic activities (marinas close/change).
- Decreased wetlands and biodiversity.
- Sources of drinking water in jeopardy? Cost of extending intakes.
- Effects on lake temperature.
- Intake/discharge structures modification needed.
- Dredging?
- Diversion legislation will be necessary.

(2) Quality

- Slow decrease in presence of traditional toxic compounds (due to sediment deposition and atmospheric conditions).
- Continued limits on fish consumption.
- Introduction of "new" toxics (pharmaceuticals).
- Decline in point source discharges.
- Decrease in agricultural non-point sources?
- Increase in nearshore impacts due to urbanization (and sprawl).
- Continuance of high algae (in Toronto waterfront).
- Increased monitoring and research on water quality because of decreased acceptance of problems by public.
- Quality decrease due to quantity decrease.
- If dredging increases then quality will decrease as contaminants are released.
- Increased water treatment costs due to more stringent limits on toxic compounds.

Fisheries

(1) Coldwater (Off-shore) Fisheries

- Increase in gobies.
- Decrease in alewife.
- Decrease in size and abundance of chinook and coho.
- Continued low abundance of lake trout.
- Continued low abundance of lake herring.
- No deepwater herring.
- American eels – gone.
- Atlantic salmon and brown and rainbow trout future uncertain.
- Increase in sea lamprey habitat (following dam removal and failure).
- Sea lamprey populations will depend on sea lamprey control.
- New species will appear.

(2) Tributaries
- Increase in water fluctuations.
- Increase in water temperatures.
- Will remain fragmented.

(3) Nearshore (Coolwater and Warmwater) Fisheries
- Increase in gobies.
- Decrease in walleye – varying with magnitude and frequency of year classes.
- Decrease in Esocid species (pike and musky family) because of global warming and water fluctuations.
- Increase in warmwater species (bass, bullhead, and panfish).
- Lake sturgeon will exist at low levels.
- New species will appear.
- Stabilized cormorant populations (with goby as prey).

(4) Commercial Fishery
- U.S. commercial fishery will remain small (using hook and line).
- Canadian commercial fishery will see a decline in high value species with potential growth in warmwater species.

(5) Recreational Fishery (general decline in anglers)
- Decrease in off shore angling.
- Increase in warmwater (bass) angling.
- Uncertainty about coolwater species
- Uncertainty about migratory species
- Uncertainty about impacts of fish disease

Sustainable Development

- General trend to turn away from the lake, but local trend to take back the lake.
- Commuting along the lake edge.
- Need to make a living.
- Trend in economy and regulatory requirements will drive some business owners out of business. Difficult for small business to survive. Sustainability of marina industry is threatened by residential development.
- Different users want access to the lake – public/private and commercial/residential conflicts.
- Population increase in Golden Horseshoe. Migration north because of drought.
- Brownfield development will occur.
- Sprawl along the lake edge.
- Intensification of land use within the watersheds, i.e. agriculture.
- Loss of wetlands because of regulations (no more dredging). Will need watershed management to prevent siltation and destruction of fish spawning and staging areas.
- Trends towards water heritage and community celebrations.
- People want access and vistas.
- Trend towards waterfront community renaissance and restoration – increased tourism. Three-season not four-season tourism.

- Water quality affecting beach water quality and use of lake. Increase in various kinds of pollutants.
- Will management of growth occur? Some sporadic examples.
- Need Lake Ontario shoreline growth management strategy.
- Transportation for commuters stuck in car mentality.
- No more ferries on the lake.
- Binational discussions must move forward regarding water quantity.
- Donation to developers or land trusts of waterfront properties as landowners feel tax pressure.
- Planning acts are reflecting what people want.
- Disparate municipal priorities, focuses, and rules.
- "Dirty" industries are dying of own accord but leave behind a brownfield mess to clean up.
- Windmill farms in upstate New York will cause problems with noise, birds, and visual.
- Trend for "renewable energy" is increasing but demand is increasing also. We need to manage demand.
- Trend that shipping traffic is up but loads are smaller leading to increased invasives.
- Must look at connection within basin and up into watersheds.
- Economic impacts of water traffic, water access, boating and ancillary businesses. Impacts on small communities.

Governance

- Failure to implement adaptive management.
- Continued conflicts within and among agencies.
- Continued management facing uncertainty.
- Lack of leadership and lack of ownership.
- Current negative trends in governance to continue.
- Continued lack of transparency and accountability.

Grand Island

Habitat/Water Quality/Invasives

(1) Habitat

- Nearshore habitat quantity will decrease because of water level changes, watershed development, and eutrophication.
- Nearshore habitat quality will decrease.
- Offshore habitat quantity will decrease because of warming (global climate change), circulation, and hypolimnion.
- Offshore habitat quality will decrease.

(2) Water Quality

- Global climate change leading to:

- Severe storms.
- Higher runoff.
- Nutrients/sedimentation.
- Waste treatment capacity exceeded – sewer overflows.
- Blue-green algae blooms increase.

(3) Invasive Species

Current policy will decrease number of invasives?
Zebra mussels – waterfowl – botulism will increase.
Gobies will transform benthos.

Fisheries

- Same species mix.
- More invasive species and disease.
- Consumption advisories will continue.
- Algae blooms will continue because of oxygen problems.
- Recreational angling will decline.
- Diminished commercial fisheries?
- No American eel.
- No natural (native) fishery – sustained by stocking only.
- Unknown food web impacts.
- Decline in spawning habitat/nursery.

Sustainable Development

- Continued consumption – a tragedy of the commons.
- Sprawl without growth – urbanization, increased immigration, or same old-same old.
- Short term growth without long term vision.
- Self limiting situation – no oil, no energy, no water.
- Diminished water quality.
- Water sold to highest bidder.
- Population growth unchecked – increased immigration due to water availability.
- Easier to move resource to people (water south) than people to resource.
- Increased pressure on land.
- Loss of land stewards – "Farmland is my retirement. Farming is not viable so let's build condos!" Death from a thousand paper cuts.
- Ontario is growing at huge rate in Hamilton and Toronto.
- May lead to opportunities in transportation (increased sail shipping).
- Land prices drive out commercial interests.
- Huge shift in how we transport things.
- Back to walkable cities? Requires changes in laws. More community-based neighborhoods. Will become cost/time prohibitive to commute. But mass transit must be better than driving.
- Enter into crisis mode solutions that work in 20 years but are not applicable in 40 years.
- People will learn to adapt. To what? Will the 2 hour commute be the norm?

Approaches

Ideal Approach to Management: Decide policy at various specified scales first, then evaluate, allocate and manage. This approach would require:

- An iterative process (with feedbacks).
- A human ecosystem approach.
- Adaptive management with social learning – communicated broadly.
- A precautionary approach to deal w/uncertainty.

Current Approach to Management: Numerous watershed planning approaches that are participating in management with piecemeal levels of implementation, if at all.
Inconsistencies between ideal and actual create following problems:

- Conflicts among stakeholders without resolution.
- Spotty collaborations that are successful.
- Not all stakeholders aware and knowledgeable.
- Not all stakeholders with "voice" and resources (public education, political education).
- Not enough economic and social data.
- Inconsistent scale of ecological, social, and economic data.
- Lack of clear institutional roles and responsibilities, redundancies, and home rule paradigm.
- Current communication (or lack of) is not sufficient and is often competitive, not collaborative.

Information Needs

Small groups for each topic area worked to identify key information needs using the following questions:

- What aspects of the likely future of Lake Ontario are uncertain? What information could help make the likely future more certain?
- In what cases does a mismatch between the ideal and likely futures exist? What information could help determine how to make the ideal future more likely?
- In what cases does a disagreement exist about the ideal future? What additional information could be used to help resolve that disagreement?

The list of needs generated by each small group was reviewed (and sometimes supplemented) by the entire set of participants.

Each participant at the search conferences identified the five information needs he or she believed were the highest priorities. Participants were categorized as representing: (1) government or academia; (2) conservation interests; or (3) commercial interests. (Participants had the option of choosing a different category if they did not agree with the category to which conference organizers had assigned them.) The "votes" for each information need were calculated as a percentage of the total possible votes – both among the entire set of participants and for government/academia, conservation, and commercial participants. Information needs

receiving at least one vote as a priority are listed in Tables 2 and 3. A complete list of information needs generated during the search conferences is provided in Appendix A.

Because the topic areas used to organized discussions overlapped somewhat, closely related information needs were sometimes generated by different groups. These closely related needs were merged in the table. A loose categorization of the information needs is provided.

We synthesized the highest priority information needs generated into the following list of questions in six topic areas:

Water

- What existing and emerging contaminants are present, at what levels, and originating from what sources?
- How do stormwater, wastewater, and runoff influence nutrient loadings and water quality, and how can they best be managed?
- How much water is available in the system? To what uses is it being put? How are lake levels influenced by water supply and usage?

Stressors

- What invasive species are present or expected in Lake Ontario? What impacts are they having? How are they introduced and spread throughout the system? What methods are most effective for controlling them?
- What impacts is climate change having on Lake Ontario? What impacts will it have in the future?

Fisheries

- How is the fish community (and interactions within the fish community) in Lake Ontario changing? How is it influenced by invasive species, climate change, and shifting land use patterns around the lake?
- What are the benefits and costs of dam removal and mitigation on Lake Ontario tributaries?
- How can interest in restoring native fish species to the lake be balanced against interest in maintaining current recreational fishing opportunities?
- How viable are recreational and commercial fishing in Lake Ontario?

People

- How is the distribution of people changing in the Lake Ontario basin? What impacts do these changes have?
- What are people's awareness, knowledge, attitudes, and opinions regarding key Lake Ontario concerns?
- How is the economy changing within the Lake Ontario basin? How are sources and uses of energy changing? What influences do these changes have on Lake Ontario?

Information and Analysis

- How can important sources of information and data be made more readily available?

- How can models of processes related to Lake Ontario be improved? How can regional habitat models be improved? How can models of links between human activities and the lake ecosystem be improved?

Decision-Making and Management

- How can responsibilities regarding the management of Lake Ontario be clarified?
- What are the best procedures for developing management plans for Lake Ontario?
- How can communication between decision makers and the public be improved?
- How can commitment to management plans be built?

Table 2. Priority information needs from Gananoque. Numbers indicate votes received for an information need (or category of needs) calculated as a percentage of all possible votes.

Information Need	Government/ Academia	Conservation	Commercial	Total
Decision-Making and Management	**19.5**	**10.0**	**22.5**	**21.9**
Clarify who is fundamentally responsible for the lake	9.8	5.0	10.0	9.2
How to develop a lakewide management plan	7.3	5.0	15.0	9.2
Agreement on metrics that reflect and evaluate governance	2.4	0.0	7.5	3.5
Fisheries	**15.7**	**20.0**	**22.5**	**18.2**
Understanding fish diets and effects of changes in prey fish populations (in relation to thiamine deficiency)	2.4	10.0	10.0	5.6
Potential restoration actions for restoring native fish	7.3	5.0	0.0	4.9
Predicting the benefits and costs (for migratory fish) of increased access to tributaries with dam removal and mitigation	0.0	5.0	2.5	1.4
Future of prey base/lower trophic levels production and ability to support target fish community	2.4	0.0	0.0	1.4
Integrated analysis and common understanding of future states in recreational fishery	1.2	0.0	2.5	1.4
Balance among top predator species	1.2	0.0	0.0	0.7
Future of gobies and influence on fish community	1.2	0.0	0.0	0.7

Table 2. (continued)

Information Need	Government/ Academia	Conservation	Commercial	Total
Fisheries (continued)				
Value and role of lake trout in recreational fishing	0.0	0.0	2.5	0.7
Future of Pacific salmon in recreational fishery and related ecosystem changes	0.0	0.0	2.5	0.7
Commercial fishery opportunities for western lake	0.0	0.0	2.5	0.7
Water (Quality)	**18.2**	**22.5**	**2.5**	**14.0**
Current nutrient loadings to lake	7.3	0.0	0.0	4.2
Emerging contaminants	4.9	7.5	0.0	3.5
Monitoring and maintenance of w/s siltation into coastal wetlands and into the lake	1.2	0.0	2.5	1.4
Information on stormwater quality and quantity	0.0	10.0	0.0	1.4
Combined quantitative estimate of CSO estimates to lake	2.4	0.0	0.0	1.4
Information for public understanding of water quality	1.2	0.0	0.0	0.7
On site wastewater treatment system inventory and impacts	1.2	0.0	0.0	0.7
Finer and better understanding of land use within the watersheds draining into the lake	0.0	5.0	0.0	0.7
Stressors (Invasive Species)	**8.5**	**10.0**	**15.0**	**10.5**
New invasions	3.7	5.0	10.0	5.6
Ecological-economic tradeoff models relating shipping to invasive species	1.2	0.0	5.0	2.1
Ballast monitoring/cargo/outside ships	2.4	0.0	0.0	1.4

Table 2. (continued)

Information Need	Government/ Academia	Conservation	Commercial	Total
Stressors (Invasive Species) (continued)				
Invasion routes	1.2	0.0	0.0	0.7
Control methods	0.0	5.0	0.0	0.7
Water (Levels)	**9.7**	**15.0**	**10.0**	**10.5**
Water management in terms of use and supplies	4.9	0.0	7.5	4.9
Effects of water withdrawals on flow regimes and water temperature	2.4	5.0	0.0	2.1
Understanding the relationship between watersheds (and land use) and the lake – including water taking and water flow	1.2	5.0	2.5	2.1
Develop a capacity model for Lake Ontario to inform lake policy	1.2	5.0	0.0	1.4
Stressors (Climate change)	**7.3**	**20.0**	**5.0**	**8.4**
Climate change effects	6.1	15.0	5.0	7.0
Effects of climate change on fish community	1.2	0.0	0.0	0.7
Need for long-term data on effects of climate change on fish community	0.0	5.0	0.0	0.7
People	**8.5**	**5.0**	**5.0**	**7.0**
Public level of knowledge about the life of the lakes	6.1	0.0	0.0	3.5
Survey of economic health of small businesses (including marinas) on the waterfront to support good economic policy	0.0	0.0	5.0	1.4
Shared vision (or lack thereof) for the lake	1.2	0.0	0.0	0.7
Inventory of heritage/community waterfront celebrations	1.2	0.0	0.0	0.7
Impact of wind power on bird and bat populations	0.0	5.0	0.0	0.7

Table 2. (continued)

Information Need	Government/ Academia	Conservation	Commercial	Total
Information and Analysis	**8.5**	**5.0**	**5.0**	**7.0**
Landscape models/analysis of habitat at a regional scale	4.9	5.0	2.5	4.2
Mechanism for sharing information	2.4	0.0	0.0	1.4
Sociopolitical analysis tied to watershed/lakewide management plans integrated with discussion of science in decision making process	1.2	0.0	0.0	0.7
Assimilated and synthesized net effectiveness of diverse environmental management action	0.0	0.0	2.5	0.7

Table 3. Priority information needs from Grand Island. Numbers indicate votes received for an information need (or category of needs) calculated as a percentage of all possible votes.

Information Need	Government/ Academia	Conservation	Commercial	Total
Decision-Making and Management	**23.2**	**25.8**	**28.0**	**24.5**
How to communicate and obtain commitment to Lake Ontario Biodiversity Conservation Strategy	3.8	8.6	4.0	5.1
Models of feedbacks between human systems and lake ecosystem	7.7	0.0	0.0	4.3
How to link data to decision making	2.6	8.6	4.0	4.3
Central virtual directory of Lake Ontario information and data	2.6	5.7	8.0	4.3
Digitization of historical and archival data	2.6	0.0	4.0	2.2
How to make information accessible	1.3	2.9	4.0	2.2
Natural science data	2.6	0.0	0.0	1.4
How to manage data	0.0	0.0	4.0	0.7
People	**27.0**	**17.2**	**20.0**	**23.1**
Impacts of renewable energy development	7.7	0.0	8.0	5.8
Lakewide models of community vulnerabilities from population shifts	3.8	5.7	0.0	3.6
Social data needs over time and space – opinions, attitudes, awareness, knowledge	2.6	5.7	0.0	2.9
How to respond to shrinking population	2.6	2.9	0.0	2.2
How to respond to growing population	2.6	2.9	0.0	2.2
How will the transition from oil-based energy occur?	3.8	0.0	0.0	2.2

Table 3. (continued)

Information Need	Government/ Academia	Conservation	Commercial	Total
People (continued)				
Economic data needs over time and space – economic impacts, costs/benefits, nonmarket benefits	2.6	0.0	0.0	1.4
Public acceptance of management actions and mitigation related to energy development	0.0	0.0	8.0	1.4
What will be the level of population growth and ensuing development?	0.0	0.0	4.0	0.7
Census information at more than ten-year intervals	1.3	0.0	0.0	0.7
Stressors (Climate change)	**18.1**	**28.7**	**12.0**	**19.5**
Effects of climate change on fisheries	9.0	11.4	0.0	8.0
Effects on lake levels	2.6	2.9	4.0	2.9
Effects on storm events	2.6	5.7	0.0	2.9
Effects on fish communities, algal growth, power production, and turnover timing	1.3	0.0	8.0	2.2
Models of effects on lake levels, temperature, circulation, thermal bars, etc.	1.3	2.9	0.0	1.4
General effects	1.3	2.9	0.0	1.4
Location of flood plains	0.0	2.9	0.0	0.7
Stressors (Invasive Species)	**14.0**	**17.2**	**28.0**	**17.3**
Number, impacts, and mechanics of spread and introduction	3.8	5.7	12.0	5.8
Exotic species and disease and their impacts	5.1	2.9	8.0	5.1
Develop good documentation of current impacts of exotic species	3.8	0.0	4.0	2.9

Table 3. (continued)

Information Need	Government/ Academia	Conservation	Commercial	Total
Stressors (Invasive Species) (continued)				
Interbasin transfer – mechanisms and tools to start	0.0	5.7	0.0	1.4
Predict impacts and likely future invaders	1.3	0.0	4.0	1.4
Effectiveness of numeric discharge standards	0.0	2.9	0.0	0.7
Fisheries	**12.8**	**5.8**	**12.0**	**10.7**
How to protect habitat while considering migratory fish, near shore land management, water levels, and identification of priority areas	3.8	2.9	8.0	4.3
Can we restore native fish communities and still maintain recreational benefits?	5.1	2.9	0.0	3.6
How to manage tributaries considering restoration, dam/barrier mitigation, and access	2.6	0.0	0.0	1.4
Are native fish communities going to be acceptable to recreational users	1.3	0.0	4.0	1.4
Water (Quality)	**5.2**	**2.9**	**0.0**	**3.5**
Effects of human population on water quality	2.6	0.0	0.0	1.4
Better land use change models	1.3	0.0	0.0	0.7
Emerging chemical contaminants – sources and effects	1.3	0.0	0.0	0.7
How to restore natural processes in relation to sediment cycle	0.0	2.9	0.0	0.7

Table 3. (continued)

Information Need	Government/ Academia	Conservation	Commercial	Total
Water (Levels)	**0.0**	**2.9**	**0.0**	**0.7**
How to manage for water levels	0.0	2.9	0.0	0.7

Search Conference Evaluation

Evaluation data were collected through the pre- and post-workshop questionnaires. Two primary types of data were collected:

- The importance of various concerns related to Lake Ontario (Table 4); and
- Evaluation of the *products* of the search conferences (Table 5) and the *process* used to produce those products (Table 6).

Participants at the search conferences had a wide range of concerns about the lake (Table 4). The most important of these concerns prior to the search conferences were:

- Invasive species;
- Contaminants and nutrients in the lake water (and their effects on fish);
- Lack of information and data about the lake;
- Lack of political attention to the lake;
- Lake levels and water withdrawals; and
- Fish and wildlife habitat.

Tables 5 and 6 present summaries of participants' evaluation of the search conferences. In general, satisfaction with both the process used and the products produced at the search conferences were high. As reflected by the evaluation data, the most significant concern about the search conferences was the fact that some key types of stakeholders were not present.

Table 4. Mean strength of search conference participants' concerns about Lake Ontario (ranked in order of importance before search conferences).

Concern	Mean Importance[1]	
	Pre-test	Post-test
Invasive species	3.90	3.81
Contaminants in water	3.63	3.57
Lack of continuous, long-term data sets	3.61	3.64
Insufficient political attention to Lake Ontario	3.57	3.63
Lake levels	3.57	3.63
Nutrients in water	3.56	3.54
Contaminants in fish	3.55	3.50
Loss of critical wildlife habitat	3.52	3.43
Water withdrawals	3.52	3.54
Loss of critical fish habitat	3.51	3.58
Success of agriculture	3.37	3.47
Urban sprawl	3.32	3.42
Concern about economic development in general	3.28	3.40
Success of community development	3.23	3.44
Success of tourism industry	3.22	3.25
VHS (Viral Hemorrhagic Septicemia Virus)	3.17	3.06
Trout and salmon stocking rates	3.17	2.87
Protection of shoreline access	3.15	3.21
Status of Atlantic salmon	3.12	3.22
Lack of socioeconomic information	3.12	3.37
Reintroduction of deep water forage species	3.10	2.98
Avian botulism	3.09	2.96
Status of American eels	3.07	3.10
Cormorants	2.97	2.54
Insufficient promotion of Lake Ontario resources	2.93	3.08
Status of steelhead	2.87	2.60
Success of electric power generation	2.86	3.13
Success of marinas	2.71	2.62
Success of bait fish industry	2.67	2.47

(Continued on next page.)

[1] Ranked on scale of 1-4 (1 = not at all important; 4 = very important).

Table 4. (continued)

Concern	Mean Importance	
	Pre-test	Post-test
Success of charter boat industry	2.65	2.65
Success of commercial navigation	2.58	2.79
Success of commercial fisheries	2.53	2.56
Conflicts between tributary and lake angler interests	2.45	2.24
Success of fishing gear or equipment sales industry	2.36	2.27
Conflicts between sailboats, power boats, and jetskis	2.12	1.94

Table 5. Evaluation of *process* used during search conferences

Evaluative Criteria	Mean Agreement[2]
Receptivity	
Search conference participants were not willing to consider all viewpoints about Lake Ontario.	1.53 (4.47)
All participants in the search conference were treated in the same way.	4.75
Voice	
Participants were given an equal opportunity to voice their concerns at the search conference.	4.50
Participants were given an equal opportunity to "have their say" at this search conference.	4.63
Satisfied with Process	
I am not satisfied with how the list of information needs was generated.	1.68 (4.32)
Fair Process	
The process used to develop a list of information needs was fair.	4.23
Time	
The benefits of the search conference were worth the time spent on it.	4.21
Cost	
Considering the products of the search conference, too much money was spent on it.	1.82 (4.18)
Influence	
All participants had a real influence on the list of information needs generated during the search conference.	4.17
Participants' Knowledge	
Most search conference participants were knowledgeable about Lake Ontario.	4.32
Search conference participants did not seem to understand all important Lake Ontario issues.	2.19 (3.81)
Representation	
All important stakeholders were represented at the search conference.	2.89
Some key stakeholders were not present at the search conference.	3.67 (2.33)

[2] Responses indicate level of agreement with each statement on a scale of 1-5 (1= strongly disagree; 5 = strongly agree). For negative statements (e.g., "search conferences participants were not willing to consider all viewpoints…"), values included in parentheses have been rescaled (1=5, 2=4, etc.) so that they can be compared to positive statements.

Table 6. Evaluation of *products* produced during search conferences.

Evaluative Criteria	Mean Agreement[3]
Information Needs	
The search conference did not produce a useful list of information needs.	1.49 (4.51)
Commitment	
I am proud to have contributed to this search conference.	4.31
Understanding of Others	
The search conference increased my understanding of other stakeholders' perspectives.	4.30
Interest Satisfaction	
The list of information needs developed at the search conference reflected my interests well.	4.15
Knowledge	
The search conference built my understanding of Lake Ontario issues.	4.13
Relationships	
The relationship between participants improved during the search conference.	3.98
Search conference participants will be better able to work with each other in the future.	4.02
I feel more connected to other participants after attending this search conference.	4.19
Common Vision	
At the end of the search conference, participants did not agree with each other about Lake Ontario information needs.	2.02 (3.98)
This search conference helped build a common vision among participants about key information needs for Lake Ontario.	4.08

[3] Responses indicate level of agreement with each statement on a scale of 1-5 (1= strongly disagree; 5 = strongly agree). For negative statements (e.g., "the search conference did *not* produce a useful list of information needs…"), values included in parentheses have been rescaled (1=5, 2=4, etc.) so that they can be compared to positive statements.

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Appendix A
Complete List of Information Needs

Gananoque

Ecosystem Health

(1) Invasive species and shifting ranges
- New invasions?
- Invasion routes?
- Unknown biology of species?

Information needs:
- Legislation regulating shipping
- Research on disease pathogens
- Control methods
- Ballast monitoring/cargo/outside ships
- Potential sources of invasive species (e.g., Baltic sea)
- Dirty list, proactive research
- Impacts of aquarium trade (live fish)

(2) Climate change
- Effects – rate and degree?

Information needs:
- Refine predictive climate change models

(3) Lakers only shipping
- Economic costs vs. ecological costs of lakers only shipping? (Restricting trade to lakers only would reduce invasive species, reduce trade from outside of Great Lakes, increase local trade, and increase local industry.)

Information needs:
- Ecological-economic trade-off models: shipping trade vs. invasives
- Costs and benefits of increased local trade vs. increased local industry

(4) Long-term data records
- Government priorities for long-term data records?

Information needs:
- How to increase partnerships between government and academic scientists and increase pressure on policy people and politicians
- Influence of researchers' job-related incentives on long-term data records

(5) Habitat management, relating to:
- Wetlands
- Habitat fragmentation

Information needs:
- Landscape models/analysis at a regional scale
- Net changes in wetland regions/areas
- Net change in fragmentation

(6) Contaminants
- Emerging chemicals (thousands of unmeasured chemicals)?

Information needs:

- Analytic techniques
- How to monitor thousands of chemicals

(7) Wind power

Information needs:

- Impact on bird and bat populations?
- New wind technology?

Water Quality and Quantity

- Current nutrient loadings to lake
  - Protocols (standardized)
  - Make binational
- Combined quantitative estimate of CSO estimates to lake
- Stormwater quality/quantity info
- Improved "sewershed" mapping
- Information for public understanding of lake (e.g., cyanobacteria)
- Emerging contaminants
  - Financial support for addressing
  - Increase in extent spatially and temporally
  - Development of methods for addressing
  - Year round or seasonal
- Impact of quantity on quality for various contaminants
- Role of atmospheric deposition
- Water use (household) under permit requirements
- On site wastewater treatment system inventory & impacts
- Model for mitigation in terms of water quantity and water temperature
- Water management in terms of water use and supply
  - Information transfer to conservation authorities (dam management)
- Better regional models and data for climate change
- Develop a capacity model for Lake Ontario to inform lake policy (growth)
- Understanding the relationship between watersheds (and land use) and the Lake (% drainage areas on both sides of lake)
  - Including water taking, water flow
- Monitoring of coastal wetlands and classification
- Monitoring and maintenance of w/s siltation into coastal wetlands and into the lake

Fisheries

(1) Future of Migratory Fish (Atlantic salmon, rainbow trout)

- Effects of water withdrawals (e.g. bottled water) on flow regimes and water temperature
- Effects of climate change on flow regimes and water temperature
- Effects of flow regimes and water temperature on reproduction, recruitment, and survival
- Predicting the benefits and costs of increased access to tributaries with dam removal and mitigation

    - Reproductive habitat inventory
    - Sea lamprey control, invasive species, and disease
- Understanding the interaction between salmon and trout in streams
    - Reproduction/spawning/juvenile survival

(2) Diet/forage – thiamine deficiency

- Understanding fish diets and effects of changes in prey fish populations
    - Role and status of gobies
    - Role and status of round whitefish
    - Role of lake herring
    - Role of juvenile lake whitefish
    - Role of deepwater cisco
- Nutrient/thiamine value of alternative prey species – why do these values vary within populations? Among species?

(3) Future of the prey base/lower trophic levels production and ability to support target fishery/fish community

- Future of production in the offshore
- Balance among top predator species
- Role of lake trout

(4) Future of gobies – lake, tributaries

- Nutrient/thiamine value of gobies
- Role/effect of gobies in tributaries
    - Predator effect
- Density/distribution of gobies in the lake
    - Egg production (negative)
    - As food (positive)

(5) Recreational fisheries

- Value/role of lake trout
- Future for Pacific salmon and related ecosystem changes
- Value/role of Atlantic salmon
- Integrated analysis/common understanding of future states

(6) Development of management objectives

- What to value – nearshore vs. offshore fisheries

(7) Commercial fisheries

- Interest in and role of recreational target species
- Contaminant levels and quality of fish
- Need for fishery independent assessments
- Commercial fishery opportunities for western lake
- Local markets

(8) Species at risk

- Potential for increasing density of native species in face of invasives and ecological change
- Potential restoration actions (stocking, genetics, disease, biodiversity)
    - American eel
    - Lake sturgeon
    - Deep water cisco

    - Lake trout
    - Atlantic salmon

(9) Effects of climate change on fish community

- Predicting physical changes in habitat
- Predicting effects on production/recruitment and communities
- Need for long-term data sets

Sustainable Development

- A public policy for public access and use to the waterfront
    - Need a comprehensive list of all regulations and policies on lake
- Survey about public perception of the lake and lake issues
- Survey of economic health of small businesses (including marinas) on the waterfront to support good economic policy
- Census data to assess population growth (including seasonal vs. permanent) – where are they coming from?
- Finer, better understanding of land use within the watersheds draining into lake
- Inventory of heritage/community waterfront celebrations
    - Economic valuations, i.e. waterfront festivals, river walks, CHRS??
- Transportation model and economic research to support changes in current transportation needs (highways, waterways)
- Intermunicipality information sharing regarding land use planning
- Shared vision (or lack of)
    - Reactionary, not foresight
    - Control external impacts on the lake (human inputs)
    - IDEAL – how to develop a lake management plan
- Mechanism for sharing information
- Uncertainty about renewable energy policies – need clear direction
- Understanding demand and new uses pressure
- Human impact on the lake?
    - Understand our impacts now!

Governance

(1) Assimilated and synthesized net effectiveness of diverse environmental management actions

- Improved mechanism to move past the existing management regime
- Need some concrete guideposts
- Who? How? How effective is management to make decisions on future management?

(2) Sociopolitical analysis tied to watershed/lakewide management plans integrated with discussion of science in decision making processes

(3) What is the public's level of knowledge about the life of the lakes?

- Necessary for effective communication of social costs of remediation/protection/sustainability and building capacity of stakeholders/public

(4) Clarify who is fundamentally responsible for the lake

- But no one wants to be responsible (watchdog or auditor)

- Need to understand power/responsibility/authority/jurisdiction
- Integration of work efforts – project management?
- Organizational chart won't improve situation of Great Lakes governance
    - It's about understanding power
    - Building capacity
    - Integrating work efforts to avoid reinventing

(5) Need a strategy for effectively sharing information for decision making
(6) Need agreement on metrics that reflect and evaluate governance

- And agreement on science mechanisms to inform decision-making
- Comes back to who is a accountable for the lakes
- Evaluate governance on a basin-wide basis – put all of feet in the fire equally
- Role of jurisdictional scan to look outside the basin for tools and ideas (possible technique)

Grand Island

Habitat/Invasives/Water Quality

<u>Habitat</u>
(1) Management of exposed bottom lands
(2) Ownership of exposed bottom lands
(3) Water level management
(4) Managing lands to protect lake habitat while considering:

- Migratory fish
- Nearshore land management
- Water levels
- Identification of priority areas

(5) Tributaries

- Dam/barrier mitigation
- Potential restoration and access

(6) Restoring natural processes

- Sediment cycle

(7) Lake Ontario Biodiversity Conservation Strategy

- How to communicate and obtain commitment to strategy

<u>Invasives</u>
(1) Invasives

- What is expected from invasive species?
- How many species?
- Impacts of species?
- Mechanics of spread and introduction?

(2) Ballast water regulations and policies

- How effective are numeric discharge standards?
- When will these standards be implemented?

- What will the U.S. standard be?
- How effective are standards for limiting viruses?

(3) Other information needs

- How to screen for invasive species
- How to promote rapid response to invasives
- What are the risks of invasive species
- What accounts for interbasin transfer?
    - Critical linkages
    - Tools to stop transfer

Water quality

(1) Emerging chemical contaminants

- Where are the chemicals from?
- What affects the inputs of these chemicals and what effects do they have?

(2) Global climate change

- Circulation and flow with global climate change
- Effects on water temperature
    - Point source (discharges)
    - Upwelling
    - Stratification – thermal bars
    - Stability
    - Mixing
- Effects on storm events
    - Frequency
    - Duration
    - Volume

(3) General information needs

- Long-term data
- Monitoring and models
- Management of data
- Linkage of data to decision making

Fisheries

(1) Exotic species and disease

- Exotic species and disease and their impacts?
- Develop good documentation of current impacts of exotic species?
- Predict impacts and likely future invaders

(2) Climate change

- Effects of climate change?
- Predict ecosystem impacts of likely climate scenarios

(3) Energy development

- Impacts of renewable energy development?
    - Dams
    - Windmills

    - Turbines
    - Nuclear
- What will public acceptance of management actions be? Will mitigation be accepted?
- Identify cumulative impacts of energy development without mitigation.
- What differences will between the U.S. and Canada regarding energy development?

(4) Human population growth

- What will be the level of population growth and ensuing development?

(5) Fish communities

- Can we restore native fish community and still maintain recreational benefits?
- Are native fish communities going to be acceptable to recreational users?
- How much harvest should be allowed?
- What should other management regulations be (seasons, size limits, etc.)?

Sustainable Development

(1) Global climate change

- Effects on lake levels?
    - Impacts on transport
    - Impacts on habitat
    - Impacts on marinas and dredging
    - Better models with case specific predictions – holistic, quantify uncertainty
    - Models for lake level, temperature, circulation (including upwelling), thermal bars, etc.
    - Where are the flood plains?
- Effects of warming temperatures on fish communities, algal growth, power production, and turnover timing
- Effects of increased carbon dioxide
- Expected changes in precipitation patterns (e.g., more severe weather)

(2) How will the transition from oil-based energy occur (change in transport, industry, communities)?

(3) What will the effects of invasive species be?

(4) Human population shifts

- How to respond to shrinking population
- How to respond to growing population
- Need for census at more than ten-year intervals
- Better land use change models
- Effects of human population on water quality
- How to plan for sustainability and stick to plan
- Whether ecosystem-based management and adaptive plans can be used?
- Awareness of community vulnerabilities
    - Need lakewide models
- Models for long term sustainable community development

(5) What new technology will be developed?

(6) Planning

- Should planning be directed toward growth or sustainability?

- How do plan for the uncertainties associated with climate change?

Approaches

(1) Social data needs (over time and space)
- Opinions, attitudes, awareness, knowledge

(2) Economic data needs (over time and space)
- Economic impacts
- Costs/benefits
- Nonmarket benefits (ecosystem services)

(3) Central virtual directory of Lake Ontario information and data
- Who has what?
- Scale of information and data
- What is being done with the information?

(4) Specific spatial data over time at useful resolution and consistent in both nations

(5) Natural science data

(6) How to make information accessible

(7) Models of feedbacks between human systems and lake ecosystem
- Projections of change over time (economic, social, and biophysical)
- Projections of climate change over time and impacts on economic, social, and biophysical variables

(8) Digitization of historical archival data

Appendix B
Participant List

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