LAKE CHAMPLAIN RESEARCH CONSORTIUM

MIDDLEBURY COLLEGE
GEOLOGY DEPARTMENT
MIDDLEBURY, VT 05753
(802) 443-3114
LCRC@MIDDLEBURY.EDU

BASIN PRIORITIZATION MEETING

Bishop Booth Conference Center
19 November 1999

8:00-8:45	coffee and pastries
8:50-9:10	WELCOME - Tom Manley, *Middlebury College*
9:15-9:35	DATA MANAGEMENT - Bill Howland, *LCBP*
9:40-10:00	ATMOSPHERICS - Ning Gao, *Plattsburgh State University*
10:05-10:25	TOXICS - Al McIntosh, *University of Vermon*t
10:30-10:50	LAND-USE - Kate Joyce, *Plattsburgh State University*
10:55-11:15	CULTURAL - Phil Huffman, *consultant* and Anne Drost, *Atlantic Center for the Environment*
11:20-11:40	SOCIAL - Richard Kujawa, *St. Michael's College*
11:40-12:30	lunch
12:35-12:55	HYDRODYNAMICS & SEDIMENT RESUSPENSION - Ken Hunkins, LDEO
1:00-1:20	NUTRIENTS & LOWER FOOD WEB - Suzanne Levine, University of Vermont
1:25-1:45	MIDDLE FOOD WEB & EXOTICS - Tim Mihuc, LCRI
1:50-2:10	FISHERIES - Ellen Marsden, *University of Vermont*
2:15-2:35	WILDLIFE & BIODIVERSITY - Dave Tilton, *USFWS*
2:40-3:00	ECOSYSTEM HEALTH - Mary Watzin, *University of Vermont*
3:05-3:35	afternoon break, voting on interdisciplinary priorities
3:40-5:00	TOP INTERDISCIPLINARY RESEARCH PROGRAMS
5:00	*adjourned*

DATA MANAGEMENT

Based on interviews, email and telephone conversations with LCRC participants regarding data management interests in the Lake Champlain Basin, several research priorities were identified during the fall of 1999. These priorities are phrased as the following five specific research questions that may best be considered as the essential steps of a single research agenda.

William G. Howland - Lake Champlain Basin Program

1. *<u>What is the extent of data sharing desired</u> by those involved in research and monitoring in the Lake Champlain Basin?*

A primary data management research priority is to determine the extent of data sharing that is desired or needed by those involved in research and monitoring efforts in the Lake Champlain Basin. The answer to this question will largely determine the scope of cooperative data management needed by the research community and will allow the least onerous data protocols to be designed.

Effective collaboration among researchers of different specializations is emerging as one over-arching research priority in the Lake Champlain Basin and will increase the cross-disciplinary sharing of data. Also, as generations of research emerge, reliance on both the results *and* the data of earlier research is an essential component of research design. Because funding for research and monitoring in the Basin will increasingly reflect this collaboration priority, investigators need to determine what degree of data sharing they desire in advancing their research programs.

2. <u>What are the most acceptable data format standards</u> for project data that may in the future be conveyed by participants to a Basin data repository?

An important data management research priority is the review of current project data tabulation and formatting practices used for research and monitoring in the Basin. This effort should also seek to recognize common data formatting capacities and opportunities for data handling that broaden the usefulness of data. One or more widely acceptable data formats should be recommended as the common standard for shared data.

Data that is to be shared must be readable. Of the several data formats presently in use in the Basin, some are readable by commonly used software and others require special data-processing software that is not widely available in the community. For example, not all water quality or aquatic biology data gathered in the Basin are rendered in EPA's Water Quality Storage and Retrieval System (STORET) or Ocean Data Evaluation System (ODES), even though those standards are designed to facilitate data sharing. And New York, Vermont and Quebec geographical location data are commonly obtained and reported in different coordinate reference systems, although more universal systems are available and coordinate transformations are no longer difficult.

3. <u>What are the most acceptable metadata standards</u> for project data that may in the future be conveyed by participants to a Basin repository?

An important data management research priority is the review of current metadata practices used in the Basin, including the documentation protocols that have been developed by other cooperative research efforts and established by various government agencies. This effort should also seek to recognize the minimum essential metadata requirements and recommend protocols that facilitate data exchange and use among the research and monitoring community.

Information about project data is an essential part of any data set. *Metadata* (data *about* the research data) describes the research methods, instrumentation and standards that generated the project data and includes the quality assurance & quality control protocols that were applied. Metadata also includes more fundamental project parameters such as research design, location of sampling or measurement, identity of the investigator and how the data are archived and documented. This type of essential information establishes the usefulness of project data both for the original research and for subsequent projects that attempt to use the data.

4. *<u>What are the most acceptable data sharing protocols</u> that will assist researchers desiring to use shared data, while also meeting the special needs of those generating the data?*

An important data management research priority is a determination of suitable protocols for the sharing of research and monitoring data. Some data, predominately that supported with public funds, is potentially in

the public domain from the time it is generated, while other data will be provided only at the courtesy of the researcher.

Increasingly in research and monitoring, the primary data generated in research retain their significance as a resource far beyond the immediate results of the study. As examples, data describing indigenous species diversity in Lake Champlain generated prior to the invasion of zebra mussels could be of heightened interest to future researchers examining the ecological impact of this species. Similarly, data from a study of underwater shipwrecks prior to the invasion of zebra mussels could be of particular value to researchers in years following the encrustation of some wrecks.

At some appropriate point in the course of any research project, the sharing of research results with the broader research community is essential; so too in most cases, is the sharing of the data generated by the study. Researchers normally have a professional need to delay the sharing of data until appropriate quality control and quality assurance requirements are concluded. Because research results are normally presented to the public in peer-reviewed journal articles, which are virtually required of many researchers, there may be a legitimate professional need to limit the sharing of some data prior to publication.

Protocols that present researchers with workable options for the various degrees and stages of data sharing, and that clearly establish the ethical and professional guidelines for the collaborative use of a colleague's data should be articulated in this effort.

5. ***What data management mechanisms will best address the need for accession, retention and distribution of data by those involved in research and monitoring in the Lake Champlain Basin?***

A primary data management research priority is to determine what mechanisms exist or should be developed to implement Basin-wide data management at the level that is desired by participants in research and monitoring. Several models exist in the Basin, such as the GIS protocols developed for the Lake Champlain Basin Program by the *Vermont Center for Geographic Information* (VCGI) and the Data Library of the *Vermont Forest Ecosystem Monitoring* (EforEM) program.

In determining the best mechanism for Lake Champlain data management, the following design parameters should be addressed:

- The emphasis in designing a data management program for the Basin must be on effectiveness and ease of use by researchers who desire access to data.
- The reliability of data handling, long-term storage and ease of access should be robust.
- The metadata standards must be efficient and effective, so that data documentation is not an obstacle for researcher participation, and the utility of data is maximized.
- The need of participating funding agencies to bring data generated through their programs to the public should be accommodated where possible in the design.
- The requisite protection of research data in the sensitive period prior to publication should be accommodated in data management program design.
- The data management mechanism must be designed to persist with the active support of an agency or organization, so that it functions continuously and effectively for the long term.
- Periodic informational workshops and effective web-based resources for the research and monitoring community should be a component of the data management program.

Ning Gao Plattsburgh State University

Contributing Authors:
Tim Scherbatskoy, UVM, VT
Rich Poirot, DEC, VT
Tom Holsen, Clarkson University, NY
Philip Hopke, Clarkson University, NY
Tom Manley, Middlebury College, VT
John Lehman, University of Michigan, MI

Other Division Representatives Consulted:
Al McIntosh, UVM, VT (Toxics)
Bill Howland (A. Donlon and B. Gruessner), LCBP, VT (Data Management)
Tim Mihuc, PSU, NY (Middle Food Web)
Suzanne Levine, UVM, VT (Lower Food Web)

For the research priorities within the atmospheric division:

1) *To establish a long term monitoring site on the shore of Lake Champlain to directly measure atmospheric deposition into the Lake.*
Even though different air monitoring activities have been conducted for the last few years, such as the AIRMoN, NADP and Hg program at Underhill, none have directly measured direct atmospheric deposition of air pollutants, both gaseous and particulate species, into Lake Champlain. To fill in the gap in our current understanding of atmospheric depositions, this sampling site is proposed. An MICB sampler could be set up at an on-shore location that employs a surrogate water surface. The samples collected weekly can be analyzed for ionic species, including NH_3 (NH_4^+), and trace elements. Analytical instruments are ICP-MS and ion chromatography. The most desirable approach is to have a denuder and filter pack sampler co-located so the direct deposition can be correlated to air-borne particulate and gaseous species concentrations. This new monitoring activity will provide very useful but yet currently unavailable data for modeling purpose, such as the MB modeling proposed above, and for a better understanding of the different systems in the Lake.

2) *To conduct modeling which can determine source-receptor relationship for the Lake Champlain Basin.*
Such studies utilize several multivariate analysis models and air trajectory-based models that incorporate chemical and meteorological data to identify contributing sources to the atmospheric pollutants detected in the Basin. The work would include source apportionment that can provide information on source profiles and source contributions. Such information is very important to various regulatory agencies, such as DEC, EPA, and NOAA and other researchers. There have been some preliminary studies that have identified up to 10 different contributing sources to air pollutants collected at Underhill, VT. The proposal is to continue and expand the modeling to include more chemical species and more data from other monitoring sites.
Program status: SOME ON-GOING STUDIES, not yet funded.

3) *To continue air monitoring through AIRMoN at Underhill, VT for wet and dry deposition.*
The Atmospheric Integrated Research Monitoring Network, funded by NOAA, has been monitoring wet deposition on an event basis and dry deposition on an integrated weekly basis at the VMC (Vermont Monitoring Cooperative) monitoring station in Underhill since Jan 1993. Its value is in providing chemical data for major ions in individual storms (essential for source identification) and in providing dry deposition data for sulfur and nitrogen compounds (essential for determining the total acid loading). Data are important to NOAA, acid rain scientists, source identification modelers and others. Results have been most recently published in Scherbatskoy et al. (1999), and show that dry deposition of acid compounds is significant in this region, and that dominant sources of this are to our west and south.
Program status: UNCERTAIN due to changes in funding.

4) *To continue the weather station on Colchester Reef that provides meteorological data for atmospheric and hydrodynamic modeling.*
Meteorological monitoring has been conducted at Colchester Reef on Lake Champlain since August 1995, providing continuous data on wind (speed and direction), temperature (air and water), solar radiation (400-1100 nm), relative humidity, and barometric pressure. Data are reported by the National Weather service several time daily, and are archived by the VMC. This station was developed with support from the VMC and Lake Champlain Basin Program to provide data for atmospheric modeling and recreational

information. These data are one of the NWS's most popular data products. Support for the maintenance of this station is now from NOAA.

Program status: UNCERTAIN due to changes in funding.

5) *To continue Hg program at Underhill, VT and tributaries.*

Mercury in precipitation (event), vapor and aerosol (24-hour samples every 6 days) forms have been monitored at the VMC monitoring station in Underhill since Dec 1992, making this the longest continuous mercury monitoring program in the world. This work has been funded by EPA and NOAA, and carried out in conjunction with Jerry Keeler of the University of Michigan. In addition to monitoring, this program has also studied factors controlling the transport and fate of mercury within the forested watershed. The data have shown that atmospheric concentration and deposition rate have not changed during this period. These data are important for assessing the mercury loading and long term trends in this region, and are used in assessments by the VT Air Pollution Control Division (VT DEC), NESCAUM, and EPA Region I. Monitoring results have been most recently published in Scherbatskoy et al. (1999) and there are several manuscripts related to ecological processing of mercury ready for journal submission.

Program status: UNCERTAIN due to changes in funding.

6) *To continue NADP and UV-B monitoring program at Underhill, VT.*

Acid rain monitoring has been conducted at the VMC monitoring station in Underhill since June 1994 as part of the National Atmospheric Deposition Program. This site is funded by the USGS. Integrated weekly samples are analyzed and reported by the NADP program. The data are important in placing Vermont's acid deposition rate in perspective with the rest of the nation as well as providing data on loading of sulfur, nitrogen and other ions in the LC basin. Monitoring results have been most recently published in Scherbatskoy et al. (1999), and show that although sulfur concentrations in precipitation have declined recently, nitrogen and total acidity have not.

Program status: CONTINUING.

Continuous monitoring of UV-B exposures and related information has been conducted at the VMC monitoring station in Underhill since July 1996 as part of a national climatological network operated by the US DA. These data are used by public health and recreation managers, air quality specialists and biologists concerned with UV-B effects on foliage and aquatic life. The data are continuously posted on the USDA UBV-B Program's web site.

Program status: CONTINUING.

1. What is the importance of various sources of toxic substances?

Progress

… continued efforts by Scherbatskoy et al. to understand role of atmospheric Hg sources (monitoring of Hg in precipitation since 1992… longest of its kind in the world)

… work by Fuller et al. in Cumberland Bay and Main Lake to determine patterns of PCB occurrence; significant variability in congener patterns, depending on location

… analysis by Rowell et al. of the NYDEC of toxic constituents in urban runoff in 18 tributaries; found occasional PCBs, frequent PAHs and hits for pesticides DDT and chlordane in Burlington area

… new project on Burlington Bay measuring toxic pollutants at six storm drains discharging into the lake

Priorities

… continue analysis of atmospheric component of contaminant loading to the lake

… track down additional sources of PCBs identified by Fuller's work

… evaluate urban stormwater and other potential sources in urban/suburban areas

2. What processes control the fate of toxic substances in the basin?

Progress

… efforts by Scherbatskoy and Shanley to understand transport of Hg through upland watersheds

… assessment of Kammen et al. of relationship between drainage basin parameters and Hg fates in lakes

… evaluation by Watzin et al. of uptake of trace metals from Outer Mallets Bay sediments by zebra mussels

Priorities

… characterize movement of pesticides from non-agricultural uses through the ecosystem

… expand Scherbatskoy's assessement to southern upland catchment and evaluate transport of Hg from agricultural streams

… assess food web transport of Hg by linking food web and toxic substances research

… determine how toxic substances are remobilized and transported into different lake regions through resuspension processes

… continue research on effects of zebra mussels on contaminant dynamics

… foster collaboration between research on toxic substances, hydrodynamics and atmospherics

3. How important are existing sites in the lake where contamination has already been documented?

Progress

… Cumberland Bay assessment complete; cleanup in progress

… Tetra Tech Inc. performed followup work in 1997 in Inner Burlington Harbor; found generally lower levels of contaminants in sediements than previous study but substantial toxicity to *Hyallela* in sediement tests

… additional analysis of Inner Harbor sediements in 1996 yielded conflicting results, with trace metals higher than in 1993 and 1994

… analysis of mysids and rainbow smelt from Outer Malletts Bay for arsenic and nickel indicated no bioaccumulation of these elements

Priorities

… continue characterization and risk assessment of contaminated sites (e.g. is Inner Burlington Harbor cleansing itself after removal of treatment plant discharge?)

… assess sources, sinks and transformations of arsenic/nickel in Lamoille River basin related to possible risks to water consumers

… initiate program of bioassays to assess migration of previously sediment bound PCBs into biota in Cumberland Bay region

… perform screening to identify any new “hot spots” in the lake

4. What are the long-term impacts of toxic substances on the Lake Champlain ecosystem?

Progress

… Facey’s work on rock bass from north and south Inner Burlington Harbor to compare 1999 data on macrophage aggregates and liver parameters to 1992 data on same species

… Burlington Bat project will measure sublethal indicators of stress among fish and zooplankton collected from Inner Burlington Harbor

Priorities

… do toxicity tests in areas known to be historically contaminated indicate improving conditions?

… characterize contaminant patterns in fish and identify biomarkers that might be linked to sources

… identify indicators or biomarkers to detect unacceptable exposures of lake biota to toxic substances

… determine if levels of mercury and PCBs carried by walleye and trout are sufficiently high to cause sublethal effects, particularly on sensitive life stages

… assess chronic effects of existing point source discharges

5. What are the future issues?

Priorities

… conduct research into the effects of point source discharges that contain potential endocrine disrupting chemicals

… characterize wetlands and amphibian breeding areas around the lake in terms of pesticides and possible development-disrupting contaminants

… assess potential problems from surfacants and plasticizers known to be endocrine disrupters

… periodically evaluate biota at top of food web for signs of contaminat stress

… provide support for research on emerging issues

LAND USE

(unranked)

Economics

1. Economic benefit studies of a cleaner Lake (new recreational user surveys, contingent value studies, analysis of tourism trends and expenditure patterns, etc.).
2. Improved economic benefit analysis of the impact of recreational enhancements (Lake Champlain Bicycle Trail , Lake Champlain Paddlers Trail, proposed Heritage Corridor, historic sites and canal redevelopment).
3. Economic and socio-economic analysis of the costs associated with non-native nuisance aquatics in Lake Champlain and other invasive plant species in the watershed.
4. Annual or every-other year economic cost-benefit analysis and evaluative overview of Lake Champlain Basin Programs.
5. Methods for involving the public and incorporating local economic concerns.

Economics and Land Use

6. Ecotourism initiatives that build coalitions and planning initiatives to integrate sustainable tourism, environmental preservation and economic development.
7. Methods for enhancing farm and forest preservation.
8. Better technical and cost data on specific phosphorus producing activities, on particular phosphorus reduction techniques (including transferable P reduction credits), and a better understanding of who is paying for the cost of phosphorus reduction.
9. Impact of climate change on Lake Champlain.
10. South Lake issues such as environmental and economic impact of the paper mill, nuisance aquatic species control, and phosphorus reduction.

Land Use

11. Identification and ranking of ecosystems and properties for preservation of open space.
12. Facilitated workshops with local planning commissions and municipalities to envision improved local environmental planning.
13. Impact of "buildout" on phosphorus loadings to the Lake.
14. Nutrient loadings to the Lake from different agricultural BMPs.

CULTURAL

Prepared by a working group of cultural resources experts from New York, Vermont, and Quebec
Philip B. Huffman and Anne Drost, co-chairs

TOP 5 PRIORITIES:

1. ***Continue the systematic lake bottom survey to complete the inventory of Lake Champlain shipwrecks.***
There has been significant public/private partnership in this survey, which has been underway since 1996. The project is systematically surveying the entire bottom of Lake Champlain, creating an inventory of submerged cultural resources and a data set for Middlebury College's ongoing analysis of hydrodynamics and bottom geology. Lake Champlain Maritime Museum is leading the survey. Given the significant investment of time and money thus far and the accelerating threat from zebra mussel encrustation, it is critical to complete the survey as expeditiously as possible.

2. ***Continue research of "Zebra Mussels, Shipwrecks and the Environment".***
This new study was initiated in 1999 through a partnership between the University of Vermont and the Lake Champlain Maritime Museum. It focuses on determining what actual impact zebra mussel encrustration is having on the Lake's cultural resources, with implications far beyond the immediate area. The initial phase was 100% privately funded, but significant public funds are needed to continue the study in 2000.

3. ***Complete a comprehensive inventory of the Basin's land-based cultural resources.***
Much work has been done by the Lake Champlain Basin Program, Lake Champlain Byways and others in recent years to develop thorough databases of the region's cultural resources. However, additional research is needed in such areas as updating and completing Vermont's and New York's Historic Register Surveys, identifying sites potentially eligible for the National Register of Historic Places, and consolidating comprehensive cultural resource data from the two states and Quebec. Ideally, this region-wide information should be digitized and linked with GIS mapping capability, and made broadly available for use in education and interpretation, heritage tourism and promotion, and cultural resource preservation and management.

4. ***Conduct a cultural landscape study of the Champlain-Richelieu Valley.***
To date, much of the research on cultural resources has treated cultural sites in the region in isolation, both from each other and from the surrounding landscape. In contrast, a cultural landscape approach emphasizes a more integrated perspective, focusing on the inter-relationships between people and place, between people and their environment. It examines the patterns and character of the region, and how they evolved over time. A multi-disciplinary analysis, it provides a layering of history, including the first inhabitants - the Abenaki and Iroquois Nations - early exploration, military history, industrial development, land use (agriculture, forestry, etc.), and settlement patterns. It synthesizes information on physical evidence as well as social, economic and philosophic/spiritual aspects of the experience of the region and thus can fill in gaps on natural and cultural resources from more site-specific analyses. GIS mapping provides an effective tool to depict these relationships of time, place, and resources. Once compiled and documented, such information can have several uses - for instance, as a tool for education and interpretation, a planning tool for smart growth management that addresses urban sprawl issues, and a platform from which to develop private stewardship initiatives.

5. ***Research mechanisms through which cultural/historic sites can receive greater economic benefit from heritage tourism.***
Much attention has been given to the potential economic benefit that cultural heritage tourism offers to the Lake Champlain region (e.g., the 1996 tourism study conducted by MarketReach Inc. and the recently completed economic impact analysis incorporated in the National Park Service's *Champlain Valley Heritage Corridor Project Report*), and current initiatives are pursuing strategies to realize that potential (notably Lake Champlain Byways and Lake Champlain Bikeways). However, thus far only limited attention has been focused on determining how to ensure that the region's cultural and historic sites—which provide the magnet for heritage tourism—benefit from increased tourism to the same degree as other amenities (lodgings, restaurants, gift shops, etc.). Such direct economic benefit to the sites is essential if they are to be able to respond successfully to the increased preservation and management challenges that increased visitation will undoubtedly create. Research is needed of the pros and cons of different mechanisms that could help increase site revenues (e.g., increased admissions fees, encouraging

memberships/contributions from visitors, corporate sponsorship, grants from rooms/meals tax receipts), and of additional collaborative marketing strategies that will benefit small sites as well as large throughout the region.

OTHER IMPORTANT RESEARCH NEEDS (NOT NECESSARILY IN ORDER OF PRIORITY):

Evaluate carrying capacity for cultural sites/resources: Promoting increased heritage tourism for its economic benefits raises concerns for the long-term integrity of cultural sites. Overuse may degrade the sites and, in turn, diminish tourism potential. Carrying capacity measures the limits of use a resource is capable of sustaining. It is both an objective and subjective analysis - measuring physical impacts as well as human perceptions. Such research is needed to assist in determining management options that will ensure that the relationship among visitors, host communities and cultural preservation remains positive. Research could focus initially on the Underwater Preserves in Lake Champlain and the sites associated with the Paddler's Trail to develop a model for measuring carrying capacity that can be applied to other sites around the Basin and in other regions.

Research best planning/management practices for important current cultural issues (including historic bridges, post offices, downtowns, and the impact of truck traffic on cultural resources), and prepare a guide of best management practices for cultural sites (particularly those in private ownership) similar to what has been done for agriculture through the Lake Champlain Basin Program.

Do a comparative analysis of heritage preservation legislation and incentives (e.g., tax credits) in Vermont, New York and Quebec to help streamline the system and learn about best approaches. Underwater cultural resource legislation could be an initial priority since all the resources are publicly owned. Also, attention should be given to mechanisms that encourage stewardship of privately owned cultural resources and combat urban sprawl. The analysis could be expanded to include analysis of innovative approaches from other regions.

Conduct research that will help communities to better understand and appreciate their maritime heritage. For instance, continue and expand the study on historic landings that has been started by the Lake Champlain Basin Program, and integrate other maritime heritage resources such as lighthouses, canal piers, and shipbuilding. *(note—this could be a sub-component of cultural landscape research).*

Evaluate programs related to Lake Champlain's historic shipwrecks*:* Vermont and New York have balanced protection vs. public access to historic shipwrecks through the Underwater Historic Preserves and educational programs. What is the value of these programs? How can they be enhanced to better address public interest and State responsibility?

SOCIAL SCIENCE

Prepared by Richard Kujawa, Ph.D., Associate Professor of Geography, Saint Michael's College
for the LCRC Plenary Meeting November 1999.

Policy Anlaysis

* Is the research and planning process for Lake Champlain a model for others?
* The articulation between the natural/physical science communities, policy and planning communities, and stakeholders and the general public. (this might include comparative studies at various geographical scales and across state and international boundaries)
* Examine institutional arrangements (including legal, political jurisdiction, and administrative/organizational frameworks) this might include an exploration of cross jurisdictional issues between local government and state/regional authorities as they relate to defining and addressing land-use development patterns and protection of the lake.
* Comprehensive assessment of the efficacy of research funding both in terms of creating scientific/technical knowledge and the timeliness and relevance of those insights into the policy making process.
* Examine the Lake Champlain research and policy community as an organizational environment.
* Examining the relationships (both positive and negative) between concepts of property (e.g., private property and autonomy; public property and collective goods) and concepts of ecology and watersheds where processes (e.g., ecological, economic, political) move across land-tenure boundaries.
* Examine economic development instruments to assess their adherence to principles of sustainable development.

Recreation/Environmental Perception

* Examine water-based recreation in social-psychological terms
* Explore valuation of the environment by the public, stakeholder groups, and scientific community.
* Explore creation and recreation of cultural landscapes at various geographic scales (one potential focus here would be on the definition and self-definition of communities in various regions of the basin)

Public Involvement/Stakeholder Research

* Examine local, regional and basin-wide policy environments to expose central issues of conflict and identify potential for consensus
* Examine historic and contemporary social and political movements for sustainable (and not so sustainable) development
* Conduct meta-analysis of the public/stakeholder involvement practices of economic development and environmental/land use planning entities..

HYDRODYNAMICS & SEDIMENT RESUSPENSION

James Saylor, NOAA/GLERL and
Ken Hunkins, Lamont-Doherty Earth Observatory

1. What are the currents and circulation within Lake Champlain and how do they vary with space and time? What forces drive the generation andgovern the decay of the variable water flow?
In this context, circulation implies not only the observation of waterflow in the main lake basins, but also the exchange between the various embayments and the almost 'closed bays' with the central lake.Observations of temperature and currents should be continuous and of high enough frequency to resolve the pertinent physics, and long term (l year) inorder to better understand seasonal and inter-annual variations. Our ability to observe currents with free drifter technology should also be investigated. If feasible, use of this Lagrangian (water-parcel-tracking) technology should be utilized in hydrodynamics experiments.

Satellite imagery should also be utilized whenever and wherever possible. Surface temperature data would reveal the extent of upwelling, whether itis full or not, while SeaWifs imagery can provide data on chlorophyll distribution. We need to seriously explore working with satellite data specialists for clues to the interpretations of lake physics and nutrient and biological distributions.

Because atmospheric forcing is the main force driving currents,correlation between observed winds and currents must always be examined. Installation of a new meteorological station on Diamond Island would be beneficial, while continuation of recording at the station on Colchester Reef is essential. Additional lake level gaging stations would also benefit attempts at realistic lake hydrodynamics simulation.

2. The long-term goal of the hydrodynamics program is to developpredictive modeling capabilities so that management issues can be investigated and potential solutions discussed. Examples include the impact of anaccidental release of toxic materials into the lake, or the optimization of effluent and potable water intake pipes within close proximity of each other. What needs must be met to achieve these modeling goals?
Considerable data describing currents and water temperature structurewithin the main lake have been collected in recent years. The data describe sluggish circulation under winter ice cover and extremely energeticcurrents during summer stratification. The data has been used for earlyverification of hydrodynamic models, but much remains to be learned using bothnumerical and conceptual methods. Nonlinear internal waves, surges, and bores need more complete examination, as does effects of ice cover. Interactions between the deep basin and the shallow north and south reaches of the lake require rigorous description, as do water mass exchanges with the lake's sub-basins. These research models can provide useful feed back to observational programs to identify research needs, but a fully3-dimensional applications model is also needed to study linkages of hydrodynamics with sediment and chemical/biological distributions.

3. As more detailed morphology of the lake bottom has been gathered, wehave learned that specific regions (in some cases at depths greater than 200ft) have long term histories (101,000 years) of bottom erosion. While new regions of erosion are being documented each year via side-scan sonar surveys, little is known about the length of time this sediment remains suspended in the water column, the distance it may be transported, or preferential deposition sites. An example of the importance of theresearch is the observed concentration of heavy metals near the center node of the first-mode longitudinal seiche. What research needs to be accomplished to document the spatial extent these erosion sites, as well as the net deposition areas within the lake where potentially toxic laden sedimentscan be distributed to?
Deep-sediment-penetration seismic surveys can be used to assess sediment thickness, and coring and element analysis can determine accumulationrates and sediment age. We need data describing the bottom stresses necessaryto suspend the sediments and the frequency of their occurrence. Resuspension by surface wave action is important in the embayments, so wave actionshould be measured in addition to currents, temperature, and water transparency. Sediment transport models coupled with wind wave, sediment resuspension,and circulation models will prove useful for this characterization.. For example, recent evidence shows that sediment supplied to the southern part of the main lake is not evenly distributed (Port Henry to Thompson'sPoint), but rather it concentrates in eastern Lake Champlain.

Recent studies of basin morphology using side-scan sonar recordings would prove valuable in improving lake charts of bathymetry and structure.Modern depth sounding with multi-beam instruments can add to the

information already gathered. High priority should be given to efforts to incorporate this knowledge in charting information.

4. What are the sources of sediment to Lake Champlain? What are the dominant forms of the sediment? What are the principal sediment transport processes?

Much of the phosphorus and mercury entering Lake Champlain is inparticulate form. Insights from simulated runoff plot studies suggest a rapid reorganization of soluble P in runoff (sorption on suspended sediments). Biologic availability of particulate-P in runoff water has been shown to vary from 30% to 90%. We can hypothesize that sediment-P loads enteringthe lake from various tributaries have distinct differences, reflectingupstream biophysics characteristics and agricultural production systems. When looking at sediment-P, should we "keep an eye" on its relative availability, from upstream down to the lake bottom? Comprehension of the internal P-loading issue would likely benefit from an interdisciplinary perspective on sediment-P (a biochemical characterization) and sediment hyrodynamics. Our current understanding of sediment sources and transport processes within the basin is not adequate to determine the ultimate fateof these materials. From a management perspective, it may be easiest toreduce loading of some pollutants and toxins through better management ofsediment loading.

5. What are the key factors that lead to high lake levels? Can we developa predictive model for lake level forecasting? What are the gaps in current data collection?

Recent high and low water events on Lake Champlain have caught authorities and lake shore residents off guard and caused extensive property damage. Flow data from the several new stream gauges installed on lake inlets in 1989-90 need to be incorporated into numerical lake level prediction schemes. The role played by ground water recharge to the lake basin needs quantified and areas of major ground water inflow delineated. Are ground water recharge areas identifiable by bathymetric features such aspockmarks in unconsolidated sediments? Future lake level variations may be impacted by global climate change and effects of the various climate change modelson lake levels need to be investigated. Improved hydrologic modeling of the drainage basin is necessary to make full use of these simulations.

NUTRIENTS & LOWER FOOD WEB

Rapporter: Suzanne N. Levine, UVM

The following listings are based on email exchanges within the focus group "Nutrients and the Lower Foodweb". Nutrient specialists were much better represented within this group than those concerned with foodwebs or phytoplankton, and watershed specialists were better represented than those who work within lakes. Because of this uneven representation and the great importance of both topics to water quality, I have decided (with group approval) to present separate lists for the two foci. The lists overlap due to the importance of nutrients to productivity and lower foodweb structure (which, of course, is the reason why we manage nutrients).

The ordering of the priorities given below is only roughly according to perceived importance, with one exception: many group members felt that especially high priority should be given to assessment of nutrient runoff from urban/suburban areas, and plans for managing these urban sources. Study of nitrogen dynamics in the lake and in runoff was the second most mentioned priority in our discussions. There was general concurrence within the group that ranking would be counterproductive.

It is our hope that these lists function not just as input to the Lake Champlain Management Conference, but will spark collaborations among Basin researchers that may involve seeking funding from a diversity of sources (foundations, state agencies, NSF, etc.). This is, of course, the only way that more than one or two of the priorities can be addressed.

Nutrient Related Priorities

1. Urban and suburban nutrient inputs to Lake Champlain are growing. To manage runoff from urban/suburban areas, we need to know the relative importance and magnitudes of the various possible sources of P and N. Sources requiring investigation include lawn fertilizers, pet manure, streambank erosion caused by hydrologic changes, soil erosion at construction (and other disturbed) sites, commercial wastes, and dust and grime running off impervious surfaces. Recent work in Wisconsin might serve as a model (and source of information) for research in our region.

   An assessment of the impact of P addition to city drinking water (to prevent pipe corrosion; about 500 µg P/L) should be made. While P is removed at the municipal treatment plant, some does not return to the plant (e.g., lawn watering will add this P to the landscape). We might look into alternatives to $ZnPO_4$ as an anti-corrosion agent.

2. There is continued concern regarding how effective the non-point source management practices that are in use (agricultural BMPs mostly) have been in reducing P and N loads delivered to streams. Fertilization of fields has resulted in P and N storage on the landscape. We should know the extent to which this has occurred and understand how storage might affect later runoff loads. We need to know about the sustainability of our short-term fixes, and whether changing agricultural practices (e.g., larger farms) require altered approaches.

   Researchers working in watersheds would like to have clear targets for nutrient reductions based on work done in the lake indicating what is needed.

3. Nitrogen loading to the lake and its internal cycling needs to receive more attention, given that the algae in the lake appear to be N as well as P limited at times, and given the importance of N availability in determining whether blue green algae are present.

   N data have been collected by the monitoring program which might be used to assess the amount of N retention in the lake. We may want to expand the monitoring program to measure ammonium and nitrate concentrations as well as total N.

   It would also be worthwhile to assess the impact that our P reduction practices in the watershed have had on N runoff.

N inputs to the Basin have been increased by the nitric acid in acid rain. We should determine by how much. Is this source substantial relative to agricultural and natural sources? *(There is some interest in the Atmospherics group in pursuing this question.)*

4. We need to know more about internal sources of nutrients in the lake, and how they compare in magnitude with nutrients entering in tributaries. Some analysis is now possible given our regular tributary monitoring and the recent study of sediment fluxes by HydroQual and the Univ. Maryland. However we need to know more about the relationship between flux rates and various environmental factors. Bioturbation appears to play a role in enhancing nutrient fluxes from sediments, and macrophytes are capable of using the nutrients around their roots, thus bringing them to the sediment surface. These factors could be important in shallow regions of the lake (e.g., St. Albans Bay).

   Lake Champlain's large and persistent seiche may be important in bringing nutrient from deep waters to the epilimnion during summer stratification. A cooperative study between physical limnologists (who would measure water exchange) and biogeochemists (who would measure N and P concentrations at different depths) could be very productive.

5. We should know more about the bioavailability of the different forms of N and P coming off the land and entering the lake. Not all forms are equally available; in particular, particulate forms may sediment without contributing to algal productivity. Dissolved organic nutrients may also be only sparingly available. This goal might be achieved through a combination of more detailed N chemistry (measuring ammonium and nitrate), bioassays for P availability, and occasional fractionations of dissolved P through ultrafiltration (which separates molecules by molecular size). The last would indicate how much dissolved P is present as large organic molecules versus phosphate (the standard assay for phosphate overestimates its presence by cleaving phosphate from organic substances; this overestimation was as much as 10 fold during the recent LaPlatte River study of Hoffmann et al.).

6. Monitoring programs for nutrient chemistry in the lake should continue, as they permit assessment of the effectiveness of nutrient reduction programs, warn of major changes in lake functioning, and provide information needed to understand and predict algal dynamics. The database should be available to all researchers.

Lower Food Web

1. It would be useful to have a long-term record of the trophic state of Lake Champlain to better appreciate how much the lake has changed in recent decades (if it has really changed) and to have a baseline against which to gauge the effectiveness of our management efforts. This baseline might also elucidate changes in the foodweb related to biological invasions and other disturbances. Coring in some of the more impacted regions of the lake (St. Albans Bay, Missisquoi Bay, South lake) and perhaps in the Main lake as well, would provide this record. We could look first at the stable isotope record, which would indicate whether gross changes in productivity have occurred. If this is productive, the C, P, N and Si chemistry of the sediment layers could be examined, along with an assessment of changes in diatom and chrysophyte species (these have preservable structures and include indicators of trophic status). Dating of the core(s) would, of course, be necessary as well. Some Lake Champlain folklore might be confirmed or put to rest through this exercise (e.g., that St. Albans Bay was once much less productive, that diatoms once dominated throughout the year and now dominate only in spring, etc.).

   Several people were enthusiastic about this proposal and expressed interest in participating.

2. We need to know more about controls on algal biomass, productivity and species composition in the lake. In particular we need to know whether diatoms have declined (if indeed they have) due to silica depletion during the summer, and whether blue green algae are becoming more abundant due to occasional episodes of N limitation (some blue green algae fix nitrogen and are favored by N shortages that affect other species).

Information in this arena might be used to determine optimal P and N levels for achieving the algal levels and grazing relationships desired for the lake (to attain water clarity, a productive fishery and high biological diversity).

It must be understood that light (which is affected by mixing depth) and grazing also affect phytoplankton biomass and composition and may at times be more important than nutrients.

3. There is concern about toxic blue green algae among the public. Some would like to see a monitoring program that would allow for public alerts when blue green levels are high. Farmers are concerned about blue greens in ponds used to water cows. In general, it would be worthwhile to learn more about the factors favoring blue green algae and the conditions that lead to the production of these toxic substances. Blue green algae are common in many Vermont lakes, not just Lake Champlain.

4. Continued monitoring of phytoplankton communities in the lake is critical. A data base needs to be established that is open to all researchers and to the public. Basin researchers have been frustrated with their inability to access data gathered by monitoring programs during the past decade and note that this is preventing assessment of the impacts of recent stresses, such as zebra mussel invasion. The NY Biological Survey (which holds the early data) should be encouraged to publish its findings and open up its data files to other researchers. The NY DEC, which continues to sample, is behind in analyzing samples and would appreciate help from others in the Basin in completing the phytoplankton counts. These data would be available.

5. Lake Champlain's microbial foodweb (the part of the foodweb involving bacteria, protozoa and zooplankton) is very active during the summer (Levine et al. 1999). A substantial amount of the energy and nutrients reaching zooplankton and subsequently fish passes through this foodchain. We should know more about the lake's microbial foodweb and how zebra mussels, which feed largely on bacteria and small algae, are affecting it.

Studies involving the relative impact of introduced species.

Define the role of zebra mussels in the ecosystem-
Are the introduced species becoming the "dominant" group that will "fuel" the lake ecosystem.

Assess the global perspective about the distribution of adult zebra mussels throughout the lake.

Projects that 'monitor' for input of new exotics-
Monitor zooplankton, macroinvertebrate, fish, plant populations in the lake

Exotic impacts on native species-
Native reestablishment following pest control.

Effect of zebra mussels on habitat of benthic-spawning fishes.

Ecological effects of alewives in Lake Champlain-
Food web dynamics and fisheries restoration in the Lake Champlain basin.

Research on the weevil (Euhrychiopsis lecontei) as a bio-control for Eurasian watermilfoil-

Exotic species distribution and colonization – metapopulation dynamics

Spread of exotic species- *(requires monitoring)*
Identify habitats most likely for invasion.

Dynamics of calcium and zebra mussel development and survival –
Facilitate predictions on potential colonization of zebra mussels into the Lake Champlain basin.

Feasibility study for dispersal barriers-
Champlain Canal and Richelieu River/Chambly Canal.

What is the Lake Champlain - Richelieu River continuum?
Given the fact that the Richelieu River is directly linked with the St.Lawrence River, what are the possibilities of introducing new species via this route?

How does diversity change along the Lake and the River?

What are the mechanisms structuring and maintaining (or not) the diversity along the Lake Champlain-Richelieu River basin?

Food web linkages

Linkages between the middle and lower foodwebs-
Bottom-up effects

Zebra mussel effects

Linkages between middle and upper food webs-
Top-down effects

Energy flow pathways

Understand the planktonic food web-
Impact of zebra mussels on nutrient and energy flow

Plankton community dynamics (including zebra mussel veligers)

Quantify smelt densities and their feeding rates *(requires monitoring)*

Estimate secondary productivity in Lake Champlain *(requires monitoring)*

Benthic-Pelagic Coupling

Energy flow patterns between benthic and pelagic food webs

Effect of zebra mussels on benthic and pelagic food webs

Impact of ZM on phytoplankton productivity in Lake Champlain. *(link with the phosphorus issue)*

Interaction studies

The interaction between zebra mussels and other benthic organisms

Smelt-zooplankton interactions

Zebra mussel-phytoplankton interactions
Potential relationship of zebra mussels to blue-green algae blooms in Lake Champlain

(no rankings)

What contribution does walleye stocking make to the adult population?
Develop long-term fry/fingerling marks

Conduct bioenergetics modeling to establish yearling equivalencies for stocking

Evaluate stocking effectiveness and recruitment

How should we sample walleye?
Develop sampling strategies to estimate population within 25% of actual value

Data needed to regulate stocking, harvest

Are smelt populations different among basins?
Use genetic analysis, comparison of population dynamics, or track movement between basins

Discrete populations may require predator management to be independent among basins

What level of predation can smelt sustain in Lake Champlain?
Use modeling and literature review

Optimize stocking levels to prevent collapse of smelt population(s)

Are lake trout naturally reproducing, and if not, why not?
Do stocked lake trout spawn in appropriate habitat?

Is spawning is successful in producing fry?

What factors limit natural recruitment?

What management actions will improve natural recruitment?

WILDLIFE & BIODIVERSITY

Stars represent the importance placed on each priority during the meeting held on Weds.

☆☆☆☆ Development of appropriate economic and planning incentives and guidance needed to support the continuance of rural-based occupations and open spaces.

☆☆ Evaluate economic costs of sprawl vs. benefits of conservation.

Develop effective education strategies for promotion of conservation planning on a landscape scale.

☆☆ Endangered and threatened species monitoring and management, primarily avian species.

Monitor and evaluate population trends of neotropical migrant landbirds.

Creation of a comprehensive vertibrate habitat use database.

☆☆☆ Identification of critical core habitat and corridors essential for maintenance and enhancement of biodiversity.

☆☆☆☆ Gathering data on the natural history, population dynamics, and habitat needs of rare, threatened and endangered amphibian and reptile species that are unique to the Lake Champlain basin.

☆☆ Investigate amphibian malformity levels and potential causes and the effects of malformities on amphibian populations over the long term.

☆☆ Research the former distribution and composition of clayplain forests as a step toward restoration.

☆☆ Research into the effects of acid rain and the mercury deposition on Lake Champlain basin biodiversity.

☆☆ Identify status and trends of seasonal wetlands and protection strategies for maintaining their biological diversity.

☆☆☆ Investigate the value of riparian corridors for wildlife habitat, and evaluate the effectiveness of present protection measures.

☆☆☆ Research the ecological effects of invasive species found in the Lake Champlain basin and develop effective education strategies.

First Priority

Most group participants agreed that these first three research priorities are linked and should be addressed in a coordinated manner. The Lake Champlain Basin Program recently released an RFP for the development of ecological indicators. This study should make substantial progress on this issue, however, much of the basic research necessary to define appropriate levels of the indicators that may ultimately be selected has not been conducted.

How can the Lake Champlain Basin Program's management goals be translated into a reference condition for Lake Champlain? Is there agreement among the people of the Lake Champlain Basin as to what they want their lake to look like?

These questions could be answered through a combination of sociological research into human values in Basin communities and scientific research and interpretation of what ecological conditions are necessary to provide these values. Although *Opportunities for Action,* the comprehensive management plan for Lake Champlain, includes explicit management goals, social surveys and focus groups might provide additional information on what the people in Lake Champlain Basin communities value.

What are appropriate measures of the ecological quality or integrity of Lake Champlain? Are there ecosystem measures that can be used to tell us whether Lake Champlain is healthy or not?

Research is needed to identify appropriate indicators of ecosystem health. There are a variety of approaches that have been taken to develop indicators in the Great Lakes and other water bodies. Some these may apply here. Much additional basic information on reference community composition and the tolerances of organisms to anthropogenic stresses is needed.

How can ecological indicators be linked to management actions in order to evaluate the success of the Lake Champlain Basin Program?

Ecological indicators must be linked to management actions in order to evaluate whether our management plan is achieving its goals. A hierarchy of indicators could be developed to accomplish this goal.

Other Priorities

How are phosphorus concentrations linked to the composition of the aquatic community in Lake Champlain? Are the in-lake phosphorus criteria appropriate for the biological community we want in Lake Champlain?

Additional research on trophic transfer and trophic dynamics in Lake Champlain are needed to answer these questions. A model that links all the trophic levels in the lake could be used to explore the implications of various phosphorus concentrations for upper levels of the food web would be a valuable management tool.

The bottom-up food web project provided much information on N and P limitation in the lake. However, it is still not clear what phosphorus concentrations are appropriate to support healthy aquatic communities in the lake. Presumably, the nutrient and food web groups also see research in this area as a priority.

Additional research is needed on the effects of zebra mussels on phosphorus and trophic dynamics in Lake Champlain.

Recent outbreaks of Cyanobacteria in the lake may be related to zebra mussels in that zebra mussels appear to select against ingestion of blue-green algae. Additional research on the ways that zebra mussels are altering the lake ecosystem as a whole are warranted. It is reasonable to expect that food webs will be substantially different now that zebra mussels are firmly established in the lake.

Data on biological, chemical, and physical anthropogenic changes are scattered and patchy. What techniques can best evaluate the degree of impairment of the Lake Champlain ecosystem?

Managers and researchers in the Great Lakes have explored a variety of habitat assessment approaches to quantify impairment. Some are based on long term data sets and some are based on "best professional judgment" and other more qualitative approaches. Research is needed to explore the best options for the Lake Champlain Basin.

Additional data should be collected on the natural history, population dynamics, and habitat needs of species or groups that are not well studied.

Because no baseline data exist on groups such as amphibians and reptiles in the basin, it is difficult to evaluate changes in their populations from either human impacts or other disturbances. For example, the lack of data on amphibians in the basin makes it even more difficult to interpret recent observations of abnormalities.

A strong biological monitoring program will be necessary to help interpret long term trends in species composition of the lake and its watershed.

Data Management	➢	needs to start up, no IRP (yet)
Atmospherics	1.	mass balance modeling direct deposition into lake
Toxics	2.	endocrine disruptors
	3.	Hg
	4.	bio-indicators
Land Use (& Economics)	➢	willingness to participate
Cultural	5.	shipwreck survey
	6.	zebra mussel effects on shipwrecks
	7.	cultural landscape
Social	8.	community-led problem solving, starting with the public perceptions, going slower, less fighting
Hydrodynamics	9.	ecosystem analysis of the Cumberland Bay region
Nutrients &	10.	top/down bottom up
Lower Food Web	11.	seiche mining of nutrients
	12.	acid rain
Middle Food Web & Exotics	13.	a whole basin integrated food web model w/ basic structure, the energy flow, trophic dynamics, controlling factors & impact of exotics
Fisheries	14.	impacts of changes in the ecosystem (particularly physical habitat changes) on fishes
	15.	effect of flow, hydrodynamic characteristics of lake on larval fishes, survival on year classes
	16.	modeling of nutrient and food web dynamics in relation to fish survival and growth
Wildlife & Biodiversity	17.	development of appropriate economic and planning incentives and guidance needed to support the continuance of rural-based occupations and open spaces
	18.	investigate the value of riparian corridors for wildlife habitat
Ecosystem Health	19.	link hydrodynamics to water quality to aquatic communities
	20.	link water quality to recreational use and enjoyment, economic vitality
	21.	link exotic species to ecosystem health, cultural resources, and recreational use and enjoyment