HYDRODYNAMICS

1. What are the currents and circulation within Lake Champlain and how do they vary with space and time? What forces drive the generation and govern the decay of the variable water flow?

In this context, circulation implies not only the observation of water flow 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 (I year) in order 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 it is 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, correlations 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 develop predictive modeling capabilities so that management issues can be investigated and potential solutions discussed. Examples include the impact of an accidental 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 structure within the main lake have been collected in recent years. The data describe sluggish circulation under winter ice cover and extremely energetic currents during summer stratification. The data has been used for early verification of hydrodynamic models, but much remains to be learned using both numerical 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, we have 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 the research 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 sediments can be distributed to?

Deep-sediment-penetration seismic surveys can be used to assess sediment thickness, and coring and element analysis can determine accumulation rates and sediment age. We need data describing the bottom stresses necessary to suspend the sediments and the frequency of their occurrence. Resuspension by surface wave action is important in the embayments, so wave action should 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's Point), 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 in particulate 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 entering the lake from various tributaries have distinct differences, reflecting upstream 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 hydrodynamics. Our current understanding of sediment sources and transport processes within the basin is not adequate to determine the ultimate fate of these materials. From a management perspective, it may be easiest to reduce loading of some pollutants and toxins through better management of sediment loading.

5. What are the key factors that lead to high lake levels? Can we develop a 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 to be quantified and areas of major ground water inflow delineated. Are ground water recharge areas identifiable by bathymetric features such as pockmarks in unconsolidated sediments? Future lake-level variations may be impacted by global climate change and effects of the various climate change models on lake-levels need to be investigated. Improved hydrologic modeling of the drainage bas