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Executive Summary

Lake Champlain Sediment Toxics Assessment Program

An Assessment of Sediment-Associated Contaminants in Lake Champlain - Phase I

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LAKE CHAMPLAIN SEDIMENT TOXICS ASSESSMENT PROGRAM
An Assessment of Sediment-Associated Contaminants in Lake Champlain
Phase I

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EXECUTIVE SUMMARY

This report presents the findings of a two-year assessment of sediment-associated toxic contaminants in Lake Champlain. The study was undertaken for the following reasons: (1) there is little recent information concerning levels of persistent toxic substances present in Lake Champlain sediments; (2) the presence of these substances in the lake has been confirmed by elevated levels of mercury and PCBs in certain sport fish; (3) sediment-associated toxic contaminants not only represent a continuing threat to the benthic community but also may re-enter the water column and, hence, the food web; and (4) there is ample evidence from the Great Lakes and elsewhere that sediments often act as repositories for persistent contaminants.

Initial Survey

Because there is little information on the distribution of toxic substances in Lake Champlain, it was necessary to undertake an initial survey to locate areas suitable for further study. Replicate grab samples of surface sediments were collected in June, 1991, at 30 sites lake-wide and analyzed for the following contaminants: (1)trace metals: aluminum (Al); arsenic (As); cadmium (Cd); chromium (Cr); copper (Cu); iron (Fe); lead (Pb); manganese (Mn); mercury (Hg); nickel (Ni); silver (Ag); and zinc (Zn); and (2) trace organics: polychlorinated biphenyls (PCBs)/chlorinated hydrocarbon pesticides (DDT, etc.); polycyclic aromatic hydrocarbons (PAHs); and dioxins and furans (at three locations).

In an attempt to determine which sites contained concentrations of contaminants above established levels of concern, we used the following guidelines from the National Oceanic and Atmospheric Administration (NOAA): the ER-L (a 10% level of concern at which biological effects are likely to be limited in extent) and the ER-M (a 50% level of concern at which

biological effects are likely to be widespread). Because NOAA's guidelines contain data from marine environments, we also used values for fresh waters established by the Province of Ontario.

Among the general findings of the initial survey were the following:

Trace Metals

1. Certain commonly found contaminants, such as cadmium, occurred at generally low levels lake-wide.

2. Some substances, such as arsenic, chromium and silver, exceeded guidelines at a few specific locations, with arsenic particularly elevated in Malletts Bay; chromium, in St. Albans Bay; and silver, in Inner Burlington Harbor.

3. Others, such as lead and zinc, exceeded NOAA’s ER-L at a number of sites, particularly in the northern half of the lake, while the ER-M for lead was violated in Cumberland Bay (Wilcox dock)* and Inner Burlington Harbor sediments.

4. Modestly elevated levels of mercury were found in sediments at many sites, including those in the deep lake. It will be important to evaluate the contribution of this extensive pool of mercury to the lake-wide burden.

5. Sediments at some sites are contaminated by a number of substances; for example, Inner Burlington Harbor sediments contain elevated concentrations of lead, mercury and silver. Concentrations of most trace metals were similar to those reported in the Great Lakes.

Trace Organics

1. In general, levels of PCBs, pesticides and PAI-Is in surface sediments lake-wide do not appear to be greatly enhanced.

2. Elevated concentrations of both PCBs and PAHs were noted in both Cumberland Bay (near Wilcox dock) and in Inner Burlington Harbor; levels of PCBs in surface sediments in a small area adjacent to the Wilcox dock were the highest found in the lake.

3. Surface sediments at three sites** (Inner Burlington Harbor, Cumberland Bay (Wilcox dock), and below the IPCO discharge) were analyzed for dioxins and furans; concentrations were the highest near the Wilcox dock, intermediate below the [PC0 discharge and lowest in Inner Burlington Harbor sediments.

* While values from most sites are based on an average of five replicates, data from the Wilcox dock in Cumberland Bay and additional samples in Inner Burlington Harbor are based on a single sample.

** Data for dioxin/furans are based on a single sample.

Intensive Survey

Based on the initial survey, the following sites were selected for more comprehensive assessment, including physical, chemical and biological evaluation: Outer Malletts Bay; the mouth of Ticonderoga Creek; north of the discharge of IPCO; the mouth of the Ausable River; Inner St. Albans Bay; Cumberland Bay (adjacent to the Wilcox dock); Inner Burlington Harbor; Missisquoi Bay; and a reference site north of Juniper Island.

Core samples taken at these nine sites during 1991 and 1992 revealed widely varying patterns of contaminant distribution. At some sites, such as Missisquoi Bay, patterns of trace element distribution over depth were similar to those seen in other lakes, with slightly elevated levels in upper sediment layers, followed by a rapid decrease with depth. At other locations, high

concentrations of a particular contaminant were limited to the uppermost layer of sediment, as was the case for arsenic in Outer Malletts Bay. Finally, very different patterns were noted at sites like Inner Burlington Harbor and near the Wilcox dock in Cumberland Bay. Here concentrations of several of the substances measured were high at the surface and increased over depth.

Patterns of contamination at these sites raise a practical concern when, and if, remedial actions are to be considered. It is obvious that, at some locations, unacceptably high concentrations of contaminants may be present only in deeper layers, raising the possibility that disturbance of the upper layers of sediments could lead to substantial resuspension of deeper, more contaminated, materials below. Such an outcome should be given careful consideration at sites such as Cumberland Bay (Wilcox dock), the mouth of Ticonderoga Creek and Inner Burlington Harbor. It is hoped that federal and state regulators will find the data in this report useful when considering what, if any, remedial steps are necessary at specific sites.

Levels of nutrients in Lake Champlain sediments indicate a trend of accelerated eutrophication during the 20th century, with total phosphorus levels approaching 2,000 /(.g/g in several parts of the lake.

Solid phase tests demonstrated acute toxicity in the cladoceran *Ceriodaphnia dubia* exposed to both Inner and Outer Malletts Bay sediments. Acute toxicity was also observed in porewater toxicity tests with *Ceriodaphnia dubia* for both inner and outer portions of the bay, and with *Daphnia magna* for the outer bay. Porewater exposures with Inner Burlington Harbor sediments also resulted in significant mortality (> 40%) to *D. magna*. Data from the remainder of the nine sites did not indicate acutely toxic responses. The only chronic impact noted in tests on larval midges was a significant delayed emergence when organisms were exposed to sediments from the Wilcox dock site in Cumberland Bay.

Additional evaluation of the accumulation of sediment-associated PCBs by the freshwater shrimp, *Mysis relicta*, a key part of the lake's food web, indicated that sediments play a significant role in the accumulation of PCBs by mysids. In the laboratory, organisms directly exposed to contaminated sediments and associated interstitial water accumulated significantly higher PCB levels than did those screened from sediments.

Conclusions

1. The initial survey of surface sediments provided an insight into the nature of toxic contaminants in Lake Champlain as follows:

* For several substances of historic concern, mercury and PCBs, the nature of the problem appears to be different, with mercury occurring at moderate concentrations in sediments at many stations, while PCBs appear to be more localized, particularly in the area of the Wilcox dock in Cumberland Bay.

* The toxic contaminant cadmium is not found in high concentrations at any of the locations examined in this study.

* Several other trace metals, including chromium, copper, and silver, occur at levels exceeding NOAA or Ontario guidelines at specific sites in the lake.

* Arsenic, lead, nickel and zinc are moderately elevated in sediments throughout much of the northern two-thirds of the lake, often being found at concentrations exceeding low-level guidelines.

* While most trace metals occur at levels similar to or below concentrations reported for Great Lakes sediments, nickel and arsenic are generally higher in Lake Champlain sediments.

* Additional grab samples revealed that several sites, including Cumberland Bay (near Wilcox dock) and Inner Burlington Harbor, are polluted by several different trace contaminants.

2. We have demonstrated that it is feasible to accurately date the majority of sediment cores from Lake Champlain using a combination of radiometric methods and pollen dating. We can reconstruct the history of contaminant input to Lake Champlain by studies of sediment cores.

In general, significant increases in metals of primarily anthropogenic origin occurred during the early-to-mid 1800's, generally reached maximum concentrations about 1960 and then decreased, probably in response to regulatory changes and altered industrial use, to the present.

Coring done at nine sites during an intensive survey has revealed different patterns of contamination in lake sediments.

* At several sites, like Missisquoi Bay, elevated concentrations of contaminants occur in the upper layers of cores; decreases to background levels are noted with increasing depth.

* In some instances, contaminant concentrations in the upper sediment layers are very high, as is the case for arsenic in Outer Malletts Bay.

* At a few sites where sources of contaminants are historic, levels actually increase in lower layers, reaching concentrations which, in several instances, exceed severe effects levels.

* Among the trace organics, high levels of PAHs are encountered in cores for Inner Burlington Harbor, Cumberland Bay near Wilcox dock, and at the mouth of Ticonderoga Creek.

* PCB concentrations are unusually high throughout the core from Cumberland Bay (Wilcox dock).

* A trend of increasing nutrient levels during the 20th century is observed in Lake Champlain sediments, likely reflecting advanced eutrophication of the lake caused by increased nutrient inputs from various sources.

3. Biological responses include the following:

* Acute effects were noted during toxicity tests on sediments from Inner Burlington Harbor and Inner and Outer Malletts Bay, while chronic effects were noted only at the Cumberland Bay site.

* The freshwater shrimp *Mysis relicto* accumulated significant levels of PCBs when allowed to come into contact with contaminated sediments.

Future Directions

Clearly, several sites and issues merit more attention:

* **CUMBERLAND BAY**: levels of several toxic contaminants are very high throughout the sediment column near the Wilcox dock in Cumberland Bay.

  The following questions are critical: (1) Where did the contaminants come from? Are there only historic sources involved? **(2)** Are the contaminants moving off-site and entering the circulation of the broad lake? **(3)** Is there sub-surface sediment contamination at other points in Cumberland Bay? and **(4)** What is the extent of ecological impact at the site? Given the level of pollution present, attention to this site is warranted.

* **INNER BURLINGTON HARBOR:** we have documented the presence of elevated levels of several toxic contaminants in the sediments of Inner Burlington Harbor.

Key questions remain: (1) What portion of the Inner Harbor is contaminated and what is the spatial (horizontal and vertical) distribution of contaminants in the sediments? **(2)** Are contaminants present in Harbor sediments carried by currents into the Main Lake? **(3)** How serious are the ecological effects of the pollution of Inner Harbor sediments? and **(4)** Is the pollution sufficiently serious to warrant remedial actions? We hope to provide answers to these questions during the second phase of the project.

* **OUTER MALLETTS BAY:** nickel, arsenic and manganese occur at high levels in sediments of Outer Malletts Bay and, to a lesser extent, Inner Malletts Bay.

While significant positive results have been obtained during toxicity tests with sediments taken from these sites, **several key issues remain unresolved: (1)** How do these contaminants enter the bay? **(2)** What, if any, effects are the high levels of metals having on the health of the Outer Malletts Bay ecosystem? and **(3)** If it is determined that the contaminants present threaten human health or the environment, what strategies exist for managing the problem? On-going work should help address these issues.

* **IN ADDITION TO THESE SITE-SPECIFIC CONCERNS, THERE ARE SEVERAL LAKE-WIDE ISSUES:**

* The elevated levels of several contaminants at the Juniper Island site, suggest that contaminants may be transported rapidly throughout the lake following introduction. Collaborative work with scientists assessing the hydrology of the lake to determine how contaminants are moving through the lake should be undertaken. It will also be critical to better understand how contaminants like mercury and PCBs are entering Lake Champlain.

* The modestly elevated levels of mercury found in sediments at many sites in Lake Champlain may represent a significant source to the food web. It will be important to

determine whether or not a sizeable fraction of this sediment burden is converted into bioavailable forms and subsequently enters the food web.

* While concentrations of several sediment-associated contaminants exceed guidelines for sediment quality, only a few areas have produced positive results during toxicity tests. A broader array of biological approaches will be used to better define the level of hazard present at sites like Inner Burlington Harbor and Outer Malletts Bay.