State Of The Strait

Monitoring For Sound Management

A Binational Conference on the Detroit River Ecosystem

Convened December 2004 by Great Lakes Institute for Environmental Research, University of Windsor, The Greater Detroit American Heritage River Initiative of Metropolitan Affairs Coalition, The Detroit River Canadian Cleanup, The Detroit River International Wildlife Refuge, The Detroit Water and Sewerage Department, and other organizations.

Cover photos: photos left and center (upper and lower): Recreational fishing in the Huron-Erie Corridor (lower center photo by Kurt Byers, Michigan Sea Grant Extension, courtesy of United States Environmental Protection Agency, Great Lakes National Program Office; other photos courtesy of OMNR); upper right: Scientist sampling water, benthic invertebrates and sediment in Lake Erie (photo courtesy of Environment Canada and University of Windsor); lower right: Longear sunfish (*Lepomis megalotis*) (photo courtesy of Nicolas Lapointe)

STATE OF THE STRAIT

MONITORING FOR SOUND MANAGEMENT

2004 Conference Proceedings

Edited by:

Rachael Eedy, University of Windsor
John Hartig, U.S. Fish and Wildlife Service
Charlie Bristol, Bristol Technical Services, Inc.
Melanie Coulter, Detroit River Canadian Cleanup
Tracy Mabee, University of Windsor
Jan Ciborowski, University of Windsor

Based on a binational conference convened by
The Great Lakes Institute for Environmental Research, University of Windsor, Greater Detroit American Heritage River Initiative of Metropolitan Affairs Coalition Detroit River Canadian Cleanup, Detroit River International Wildlife Refuge, Detroit Water and Sewerage Department, and other organizations.

Suggested citation: Eedy, R., J. Hartig, C. Bristol, M. Coulter, T. Mabee and J. Ciborowski eds. (2005). *State of the Strait: Monitoring for Sound Management*. Great Lakes Institute for Environmental Research, Occasional Publication No. 4, University of Windsor, Windsor, Ontario.

6.4. Monitoring In Support of Modeling

Ken G. Drouillard, Great Lakes Institute for Environmental Research, University of Windsor, Windsor, Ontario

Introduction

Management areas such as the Detroit River Area of Concern (AOC) are host to numerous ongoing environmental monitoring programs. Locating, accessing, compiling, integrating, and interpreting diverse, multiagency-generated datasets can be an immense task, with many pitfalls. Use of a modeling framework can help to meet these challenges and prioritize actions for remediation. Calibrated management models provide the framework to interpret data collected from different studies and at different times or spatial scales. Such models need extensive data both for calibration and for setting starting points. However, a properly calibrated model can be used to evaluate many different management scenarios, which can help guide important decisions. The model can also tell us if the current sampling strategy is adequate to detect ecosystem recovery once remediation has been started. Therefore, we should be sure that monitoring programs are compatible with a model's design.

The Detroit River Modeling and Management Framework (DRMMF) was developed and partially calibrated during 1999–2002 by the Great Lakes Institute for Environmental Research (GLIER), under the guidance of the Detroit River Canadian Cleanup and with funds and in-kind support from agencies including: Environment Canada, Ministry of the Environment (MOE), the City of Windsor, Essex Region Conservation Authority (ERCA), Citizens Environmental Alliance (CEA), U.S. Environmental Protection Agency, U.S. Army Corps of Engineers (USACOE), and National Oceanic and Atmospheric Administration (NOAA). The DRMMF consists of a series of sub-models (linked water hydraulic and sediment transport models; food web bioaccumulation model) and an on-line electronic database – Data Retrieval, Archival and Management System (DREAMS). Uses of the DRMMF include 1) predicting dispersion and pollutant concentrations in water; 2) establishing time-integrated loadings of critical contaminants from the Detroit River to Lake Erie; 3) predicting areas of sediment deposition and erosion; and 4) predicting bioaccumulation and toxic effects of critical pollutants such as PCBs and mercury in fishes.

These applications have provided insights into management priorities necessary to achieve RAP goals. Among the DRMMF conclusions were:

1) Elevated PCB concentrations in sport fish exceeding "No Consumption" advisory triggers are a result of contaminated sediments, primarily in the lower U.S. portion of the Detroit River.

2) Sport-fish consumption advisories, based on the most stringent criteria of 50 ug/kg total PCB, will continue to persist in the Detroit River even in the absence of contaminated sediments due to background PCB concentrations in water from Lake St. Clair.

3) The large reservoir of contaminated sediments in the U.S. reaches of the lower Detroit River is subject to resuspension during periodic scouring of the river bottom during

storms. This occurs approximately every 20 years.

Thus, the model suggests that sediment contamination patterns in the river do not simply reflect legacy loadings from historical emissions, but rather continue to be replenished from locally active sources and by mobilization/redistribution of contaminated particles throughout the basin.

Clearly, the next steps in applying the DRMMF model should be to compile measured loadings data, predicting chemical mass balance and the spatial distribution of water and sediment contamination, and to validate model predictions by conducting carefully planned surveys of water, sediment, and biota contamination. Figure 1 summarizes the needs for model input and validation and identifies associated information gaps. The following sections summarize the major on-going monitoring programs, their adequacy in satisfying DRMMF model input needs for each sub-model, and suggested improvements that would allow better integration into the management framework.

Water Quality Sub-Model

The water quality sub-model predicts flow using a hydraulic model (USACOE-CH3D model) adapted to the Detroit River using bathymetry data collected by NOAA in 2000, and base flow and storm event frequency data derived from analysis of water level gauge information (NOAA, Department of Fisheries and Oceans). Optimization of the hydraulic model parameters resulted in a predictions that usually were within 10% of measured flow rates (DRMMF 2003).

We still know too little about chemical loadings from upstream sources, tributaries, and outfalls to be able to predict pollutant dispersion and spatial gradients in the water. Programs that can monitor upstream loadings of toxins such as PCBs, mercury, and dioxins include: Environment Canada's Corridor Monitoring Program (2000–2004), City of Windsor's Biomonitoring Program (1998–2004), and COA (Canada-Ontario Agreement) Biomonitoring Program (2002–2003). Each program regularly provides fixed-station, water quality data at the Detroit River headwaters. This data can be used to validate overall changes in water concentrations, but it is too coarse to test for cross-channel variation in water quality. To support DRMMF needs for an upstream loadings estimate, we require synoptic sampling across an upstream transect that considers near shore areas and centre-channel locations selected on the basis of flow distribution.

In-stream contaminant loading estimates could be supplied by federal and state/provincial tributary sampling programs, and by industrial Permit Compliance Monitoring Programs. Recent reviews of existing monitoring databases conducted by the Lake Erie LaMP (Lakewide Management Plan) Sources and Loadings Committee concluded that the effluent and tributary monitoring data available for many trace contaminants, including PCBs, are not of suitable quality to compute loads (Painter 2003). At a minimum, DRMMF input needs and mass balance calculations could be accomplished by establishing synoptic tributary sampling and tracking temporal loading changes that occur as a result of storm events. Additional data sets supplied by City of Windsor's municipal effluent monitoring program and Detroit Water and Sewerage Department's effluent monitoring should be incorporated to account for loadings from these closely monitored sources. Critical validation data sets should include additional transect sampling of water quality along mid-stream and downstream reaches of the Detroit River (e.g., reimplementation of the Upper Great Lakes Connecting Channel Study design). We should consider re-evaluating industrial effluent monitoring programs to ensure the use of standardized analytical methods that are sensitive enough to detect background contaminant levels. Laboratory accreditation should be considered if such programs are to be seriously considered for integration into a mass balance assessment.

Sediment Quality Sub-Model

The USACOE CH3D hydraulic model permits one to track the distribution and fate of contaminated particles originating from different input locations. The particles may settle within the river or they may be exported to Lake Erie. Model input requirements are similar to the water quality sub-model, in that contaminated particle loadings from upstream sources, tributaries, and effluents must be made available. Therefore, monitoring designs proposed to meet water loads requirements should include particle sampling, characterization (size distribution and organic matter content), and chemical analysis in their design. Environment Canada's Corridor Monitoring Program presently combines filtered particles and dissolved phase extracts prior to chemical analysis. It is recommended that the proposed transect studies separately analyze particulate and dissolved fractions to capitalize on the DRMMF model's ability to contrast chemical distribution and export via particle settling from that of water export by advective flow.

Validation dataset needs for the sediment quality sub-model are largely met through Environment Canada's sediment trap monitoring program (Marvin et al. 2002) and comprehensive river-wide surveys of sediment contamination conducted in 1999 (DRMMF 2003) and partially replicated in 2004 (GLIER, COA, and Great Lakes Sustainability Fund). The UGLCCS recommended that comprehensive river-wide sediments surveys be repeated every five years to track ecosystem recovery over time. Since sediment deposits can be mobile in dynamic, event-driven systems such as the Detroit River, we recommend that future sediment surveys use a stratified random sampling design.

The DRMMF sediment sub-model predicts that storms can resuspend large quantities of contaminated sediments and contribute to excess contaminated particle loadings to Lake Erie. Monitoring programs should be aware of such events and be prepared to re-characterize sediment quality at pre-defined depositional areas following such storms.

Bioaccumulation Sub-Model

The bioaccumulation sub-model uses a steady state bioenergetics based food web model calibrated and implemented in Lake Erie and Lake St. Clair (DRMMF 2003) to predict bioaccumulation and trophic transfer of PCBs and mercury in sport fish. Model inputs include average water and sediment contaminant concentrations within 11 model zones encompassing the entire Detroit River. The bioaccumulation model is computationally uncoupled from the hydraulic and sediment sub-models, although linkage may be possible once data have been collected to estimate loading requirements and to validate hydraulic/sediment sub-model predictions of contaminant dispersion.

Validation data sets used to evaluate the bioaccumulation sub-models performance were obtained from GLIER food web surveys conducted in 2000 and 2002 at four Detroit River locations. Additional data sets that would be useful to the model include sport fishing monitoring programs of the MOE and the Michigan Department of Natural Resources, and the MOE young-of-the-year spottail shiner monitoring program. Overall, the bioaccumulation sub-model adequately predicted PCB concentrations in most species analyzed. More than 90% of measured data were within a factor of ten. Bias in model predictions was most notable for large organisms (> 100 g) perhaps due to failure of the model to accurately account for fish movements. Given long-range movements of some consumed species such as walleye (*Sander vitreus*), expansion of the model to a Huron-Erie corridor scale may be necessary. Such an approach would also be supported by long-term fish biomonitoring programs in western Lake Erie and Lake St. Clair as conducted by DFO and U.S. Geological Survey.

Conclusion

Remedial action plans are charged with implementing efficient strategies to restore beneficial uses. A major challenge to this process is finding the cause-effect linkages between chemical loadings, environmental concentrations, and biological effects. It is unlikely that such linkages or effective management targets can be established by simply compiling data from existing monitoring programs and conducting statistical or weight-of-evidence assessment approaches. Management models, such as the DRMMF, have the potential to establish scientifically defensible linkages among key system or ecological processes. Coordination of monitoring programs to satisfy DRMMF needs and to permit integrated assessment of the Detroit River RAP will require that: 1) managers, monitoring agencies, and modelers are made fully aware of the types of data being collected; 2) where possible, modelers have a chance to influence sampling designs; 3) existing monitoring data be compiled, made readily available, and evaluated in a timely manner to identify/address data gaps; and 4) data are collected with appropriate QA/QC (quality assurance/quality control) and are cross compatible between studies.

References

Dolan, D. (2003). "*Appendix 4: Trends in annual point source PCB loads to the Detroit River, 1986-1998." Evaluating Ecosystem Results of PCB Control Measures Within the Detroit River-Western Lake Erie Basin*, T.M. Heidtke, J. Hartig and B. Yu, eds., U.S. Environmental Protection Agency, EPA-905-R-03-001, Chicago, Illinois.

Great Lakes Institute for Environmental Research. (2003). *Detroit River Modeling and Management Framework Interpretive Report*, Occasional Publication No. 5, University of Windsor, Windsor, Ontario.

Marvin, C., M. Alaee, S. Painter, M. Charlton, P. Kauss, T. Kolic, K. MacPherson, D. Takeuchi and E. Reiner. (2002). "Persistent Organic Pollutants in Detroit River Suspended Sediments: Polychlorinated Dibenzo-p-dioxins, and Dibenzofurans, Dioxin-like Polychlorinated Biphenyls and Polychlorinated Naphthalenes." *Chemosphere*, 49, 111-120.

Painter, S. (2003). "Appendix 3: Lake Erie Lakewide Management Plan Perspective on PCB Sources and Loadings." *Evaluating Ecosystem Results of PCB Control Measures Within the Detroit River-Western Lake Erie Basin*, T.M. Heidtke, J. Hartig and B. Yu, eds., U.S. Environmental Protection Agency, EPA-905-R-03-001, Chicago, Illinois.

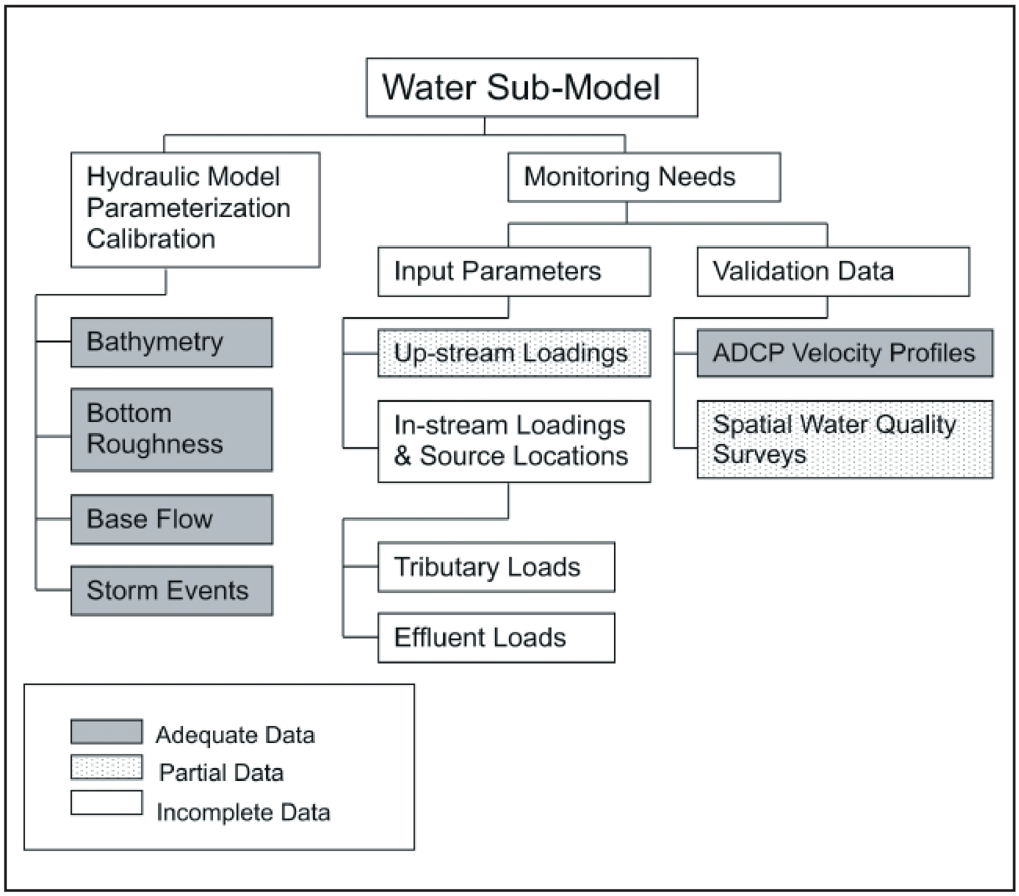

Figure 1. DRMMF water quality sub-model components and data requirements.

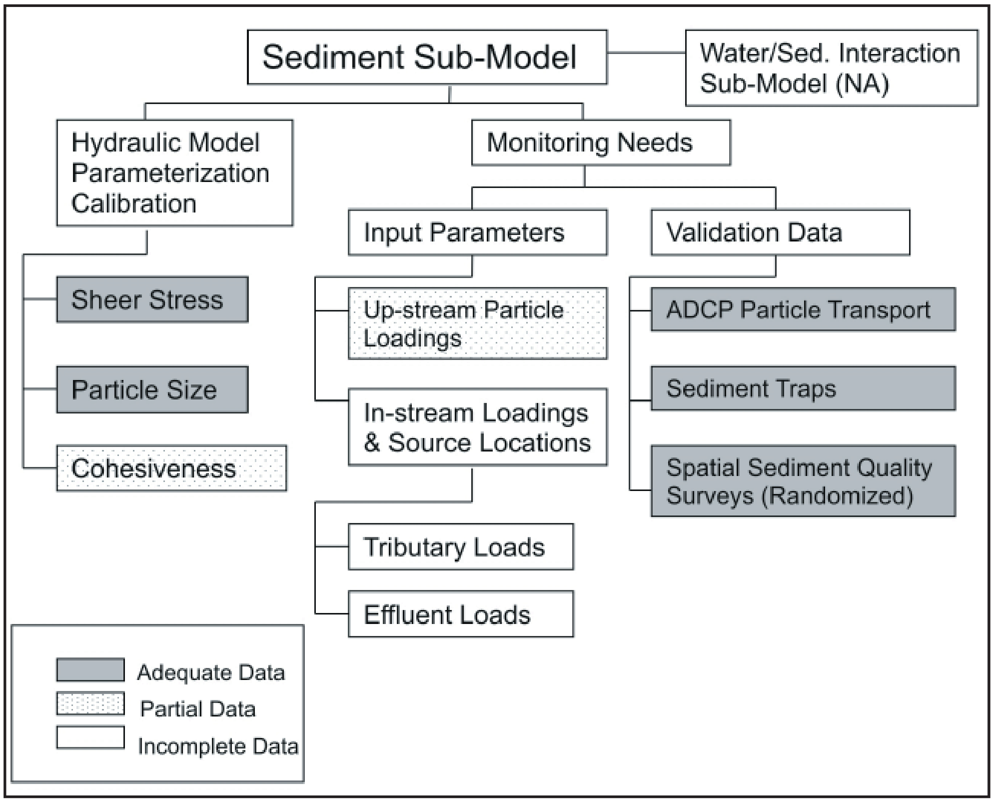

Figure 2. DRMMF sediment quality sub-model components and data requirements.

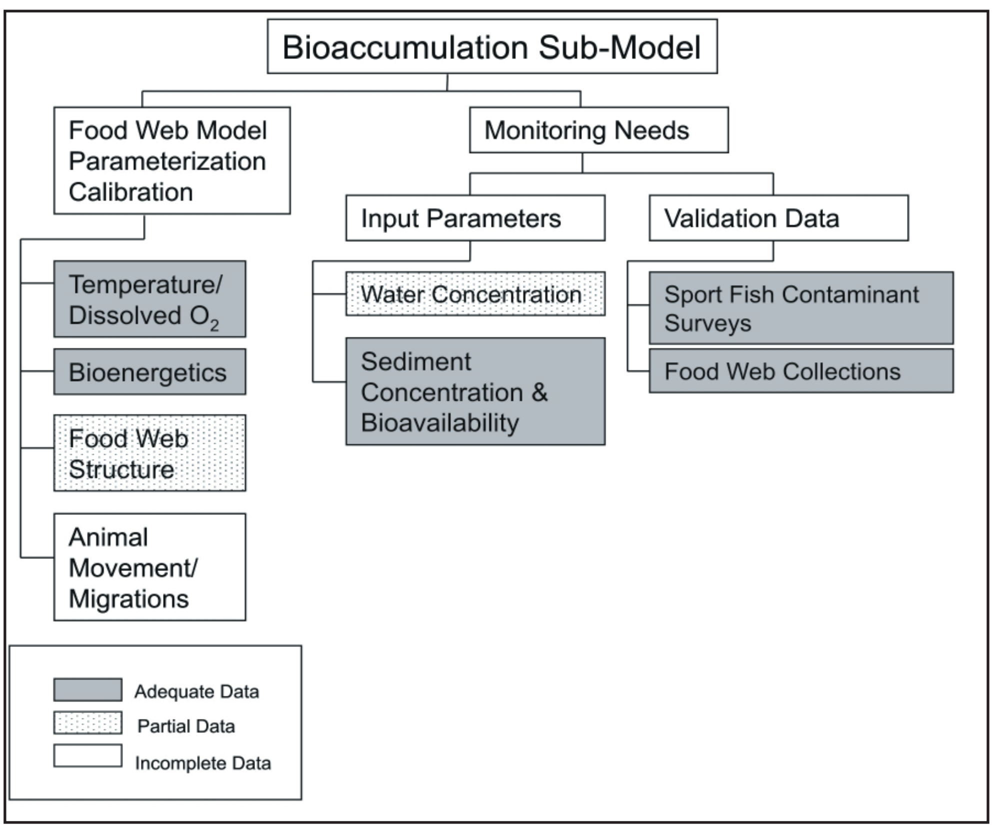

Figure 3. DRMMF bioaccumulation sub-model components and data requirements.