

LCRC Workshop April 9, 2005 – Research Priorities for Cyanobacteria and Nutrient Dynamics in the Missisquoi Bay and Watershed

Participants: Tom Manley, Doug Facey, Bob Genter, Isabelle Beaudin, Aubert Michaud, Martin Mimeault, Chantal D'Auteuil, Andre Lavoie, Chandra Madramooto, Alexei Voinov, Suzanne Levine, and Mary Watzin

Background

Cyanobacteria currently dominate in the phytoplankton of Missisquoi Bay but did not do so prior to the 1990s. Currently, bloom conditions from July through September can be described as noxious and toxin concentrations exceed levels suggested for the protection of human health, severely limiting use of the bay for drinking water supply and recreation.

The reasons for the dominance of cyanobacteria in Missisquoi Bay are not clear. High phosphorus concentrations support high densities of algae, but do not necessarily mean dominance by cyanobacteria. Other hypotheses for the recent dominance of cyanobacteria might include competition for nitrogen or carbon, global climate change, increases in average summer water temperature, the presence of herbicides in the water that may selectively act on eukaryotic algae, or changes in the food web structure that may have reduced grazing pressures on the algae.

The increase in phosphorus, nitrogen, and sediment in the bay are clearly related to activities in the Missisquoi watershed. Although Vermont and Quebec have agreed to in-lake water quality criteria for Missisquoi Bay and the overall loadings reduction necessary to achieve them, realistic subwatershed allocations have not been evaluated, nor has there been an overall assessment of the most effective combination of practices to achieve the reductions that are necessary.

It also seems clear that there is not enough information on sediment phosphorus concentration, or sedimentation and resuspension rates in order to reliably estimate the magnitude of internal loading in the Bay. An understanding of internal loading is critical to estimating response times to nutrient reductions in the watershed. As plans continue to be considered for causeway removal, and as we consider best ways to predict zones of cyanobacteria accumulation and the export of phosphorus and toxic cyanobacteria from the bay, there is also an urgent need to better understand the hydrodynamics of Missisquoi Bay and connected segments of the northern lake.

The group present identified six most critical research questions:

- Why is cyanobacteria dominant in the bay?
- What is triggering toxin production by the dominant species?
- What are realistic and achievable load allocations for the subwatersheds in the Missisquoi River basin?
- What is the most efficient way to reduction phosphorus in Missisquoi Bay (considering both the watershed and in-lake options that might be feasible)

- What is the contribution of the internal phosphorus load to available phosphorus in the overlying water column?
- What are the predominant water flow patterns in Missisquoi Bay and what are the hydrodynamic connections to the northeast arm and Alburg passage?

The group also noted that both modeling and field studies would be necessary and important parts of a comprehensive research agenda. The following pages outline a potential hierarchy of models that could support our work.

A Hierarchy of Models to Support Research on Algal Blooms and Cyanobacteria

The following hierarchy of models links the hyper-eutrophic conditions in Missisquoi Bay, which lead to excessive concentrations of algae and dangerously high counts of toxic cyanobacteria, to watershed sources of nutrients.

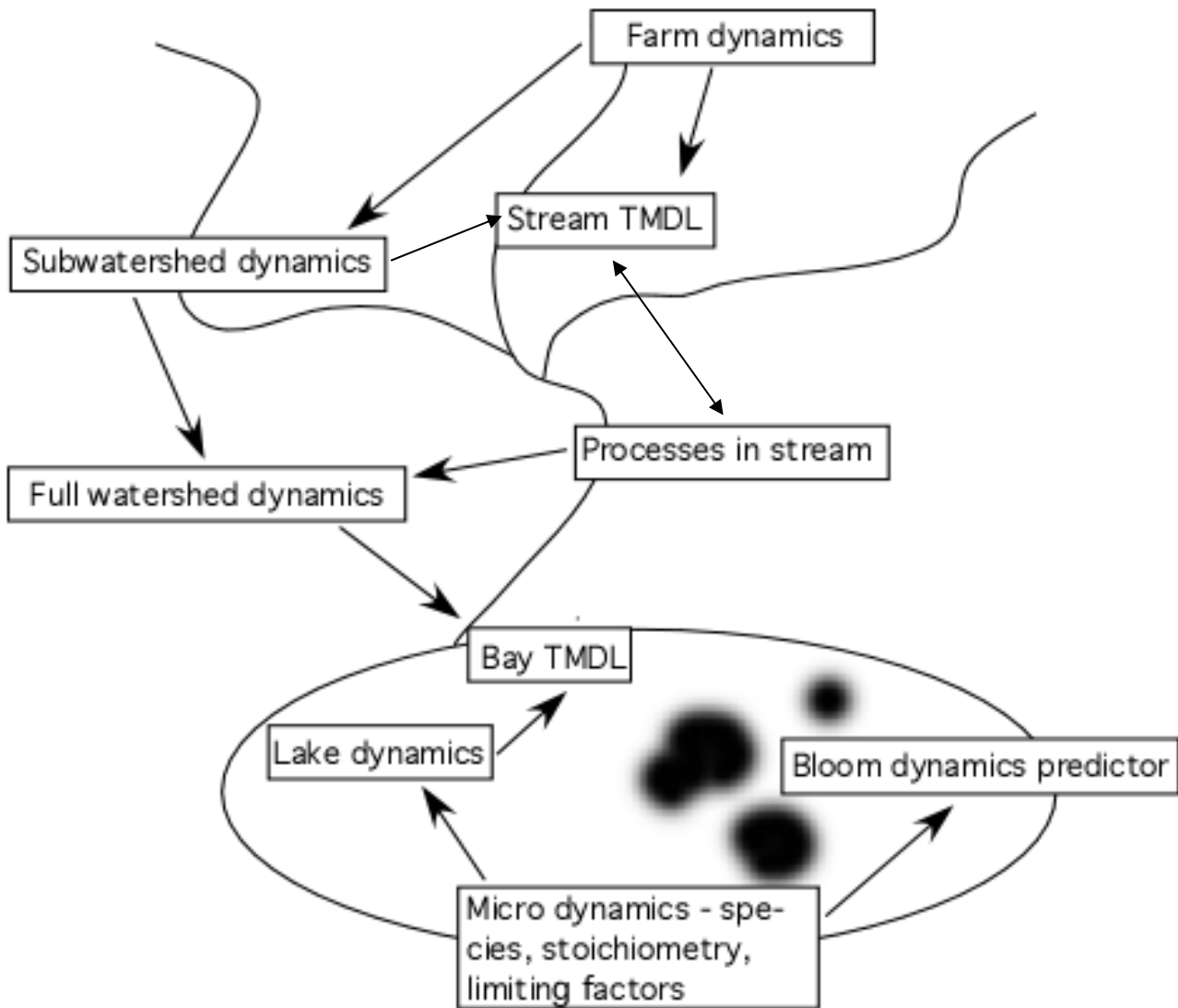


Fig.1. Arrows show the dependencies between various modules, and the flow of information in the overall research.

Microdynamics (MicroDyn) – a detailed model of algae growth, allowing for multiple limiting factors and several algal species. The goal is to test the possible response of algal communities to various changes in physical (climate, circulation) and trophic (abundance of nutrients, CO₂, grazing pressure, etc.) conditions.

Bloom dynamics predictor (BDP) – a linked hydrodynamics and algae growth model to understand the likelihood of cyanobacterial scum formation, and the spatial distribution of patches under varying climatic and nutrient enrichment conditions.

Lake Dynamics (LD) – a compartmental Lake model to understand lake dynamics as a whole, including trophic interactions, sediments, aggregated hydrodynamics, climatic and watershed forcings.

Bay TMDL – based on watershed and lake dynamics, verify or propose meaningful TMDLs

Farm Dynamics (FD) – Cassell-Watzin type of model that generates N/P output from each farm and field.

Subwatershed Dynamics (SD) – the Pike SWAT type of modeling for subwatersheds and hydrologic units.

Stream Dynamics (RD) – a model of a stream reach, accounting for nutrients uptake, release, bank erosion, sedimentation, etc.

The farm dynamics (FD), stream dynamics (RD) and subwatershed dynamics (SD) models must be tightly linked together in a mass-balance approach.

Full Watershed Dynamics (WD) – a spatial model of the full watershed that connects all the land uses, point and non-point sources, and processes in streams and rivers, and that provides input for the lake processes.

Module	Spatial res.	Time step	Input from	Output to	Who (starting point)
MicroDyn	Local	1 hour		BD	Suzanne Mary Alexey
BD	Distributed 10m	1 day	MicroDyn	LD	Tom Andre
LD	Compartmental	1 day	MicroDyn BD	TMDL	Mary Suzanne Tom Alexey
FD	Local	1 year		SD	Mary Al
SD	Distributed 10-30 m	1 hour/ 1day	FD	WD	Aubert Julie
RD	Local	1 day		WD	
WD	Distributed 1 km	1 day	RD, SD	TMDL	Alexey Aubert Mary
Str. TMDL			FD, SD		
Bay TMDL			LD, WD		All