

# Water Quality Monitoring and Lake Ecosystem Modeling:

an integrated approach to assess cyanobacterial blooms



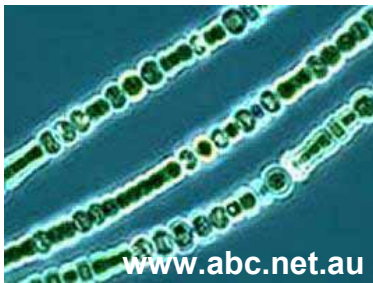


# Outline

- **What are cyanobacteria?**
- **Environmental adaptations**
- **Potentially harmful algal bloom**
- **Study designs and objectives**
- **Specific strategies**
- **Method**
  - Field experiments
  - Modeling
- **Results**
  - Field measurements
  - Simulations
- **Planned activities and synthesis**



# What are cyanobacteria?



- Very ancient organisms: 3G years
- Bacteria with algae properties: photosynthetic pigments: chl a
- Also known as blue-green algae
- Many different forms: single cells, filaments, colonies



# [ Environmental adaptations ]

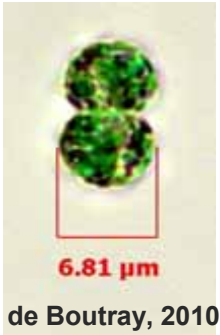


- Able to convert gaseous nitrogen ( $N_2$ ) to ammonium ( $NH_4^+$ )
- Gas vesicles to control buoyancy
- Can use different wavelength (500-650 nm)



**Phycocyanin & phycoerythrin pigments**

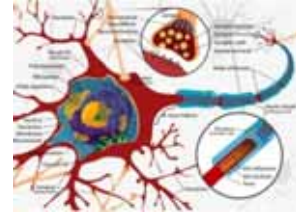
# Potentially harmful algal bloom



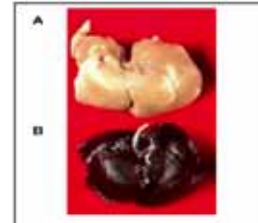
fracking-lawsuit.com



=



+



+



cartoonstock.com

myroadtomedicalschool.blogspot.com



promociel.com



sushifaq.com

## Consequences

- Threat to sources of drinking water
- Produce foul odours
- Harmful for aquatic communities
- Limit recreational and economical activities in water bodies



# Study design and objectives

- **3 general types of surface-water-quality studies (Averett & Schroder, 1994) :**
  - **Reconnaissance studies: assess the occurrence, distribution, and concentration of cyanobacteria and associated toxins**
  - **Monitoring studies: evaluate the potential for human health risks associated with cyanobacterial toxins**
  - **Interpretive studies: assess the processes that affect the spatial and temporal distribution and abundance of cyanobacteria and/or toxins**





# Specific strategies



## ■ Goal

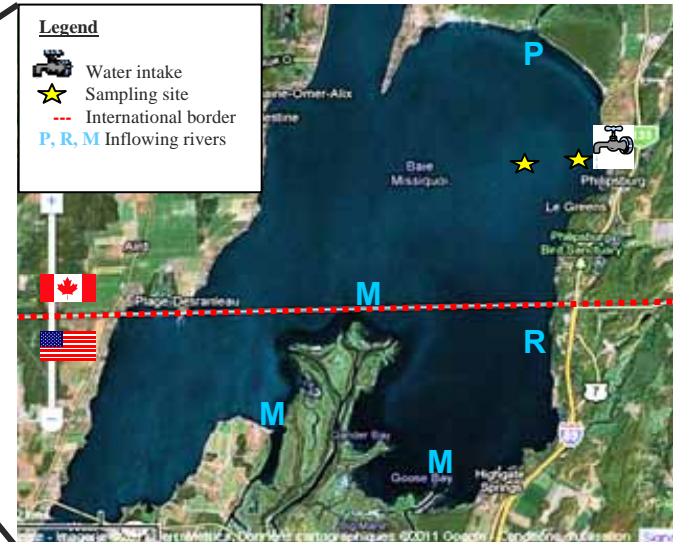
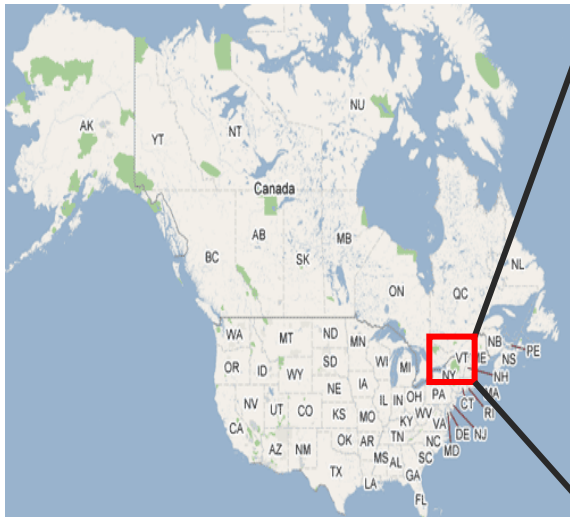
- Evaluate the risk of exceeding drinking water quality criteria ( $\leq 1 \mu\text{g/L}$  for microcystin-LR)
- Gain a deeper understanding of the physical, chemical and biological determinants of cyanobacteria blooms to assist with lake management decisions

## ■ Solution

- **Long-term water quality monitoring system coupled with one dimensional modeling**



# Methods: field experiments



- Real-time monitoring system: on-line 6600V2-4 multi-probe from YSI
  - 8 sensors: T, depth, cond., turb., pH, DO, chl a, phyco fluorescence
  - DWTP raw water: 2007-2010: continuous: 30 min or 1h
  - Water intake + pelagic zone: 2008 & 2010: punctual: 1/1-2 w
  - Microcystin concentration : 2008 & 2010
  - Taxonomic identification + counts: 2008 & 2010
  - Nutrients (TN, TP, NO<sub>x</sub>, o-PO<sub>4</sub>) : 2010
- } punctual water sampling



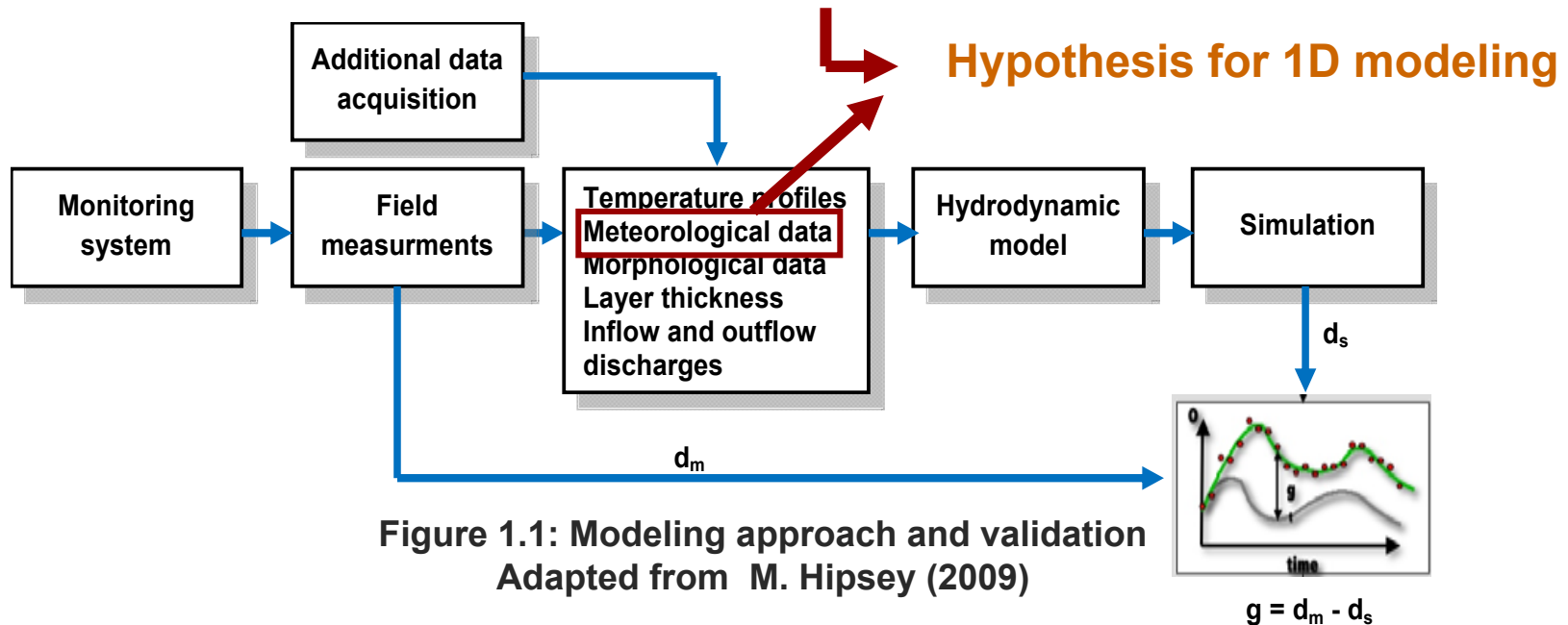




# Methods: modeling

## DYRESM-CAEDYM

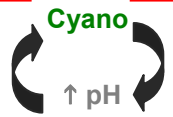
- Determinist model
- One dimensional
- Suitable for modeling shallow reservoir and lakes.
- Assumes that horizontal variations in the water are less important than vertical variations





[Chla] ≠ cyano → switch dominant species

T changes → dominant species change



# Results: field measurements

2008

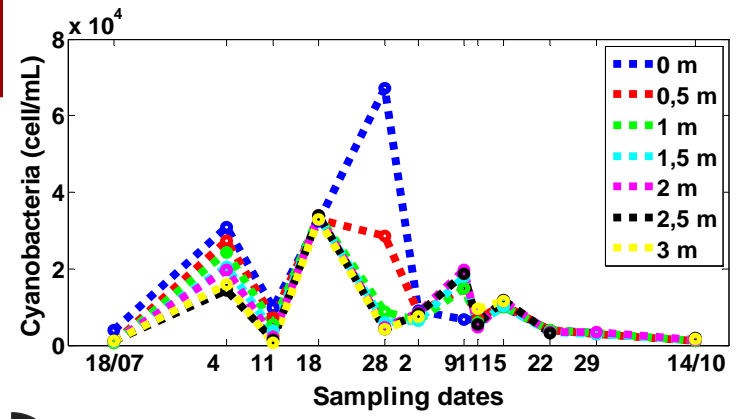
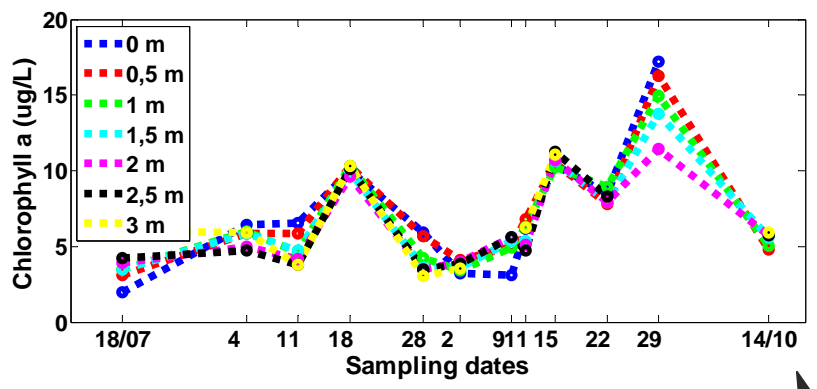


Fig 1: Depth profile of chlorophyll a

Fig 2: Depth profile of cyanobacteria

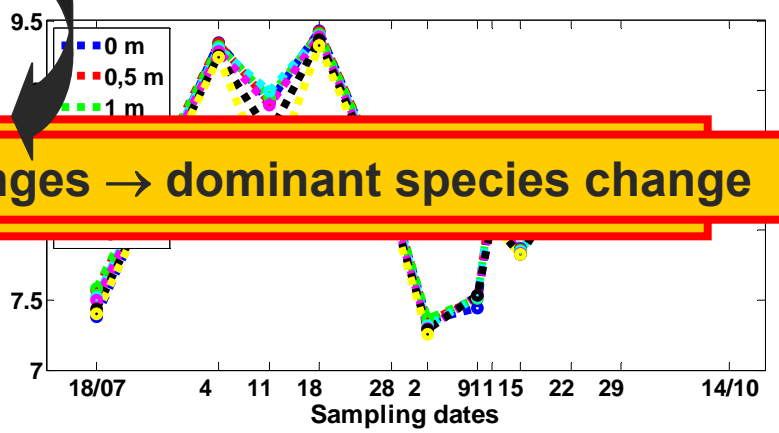
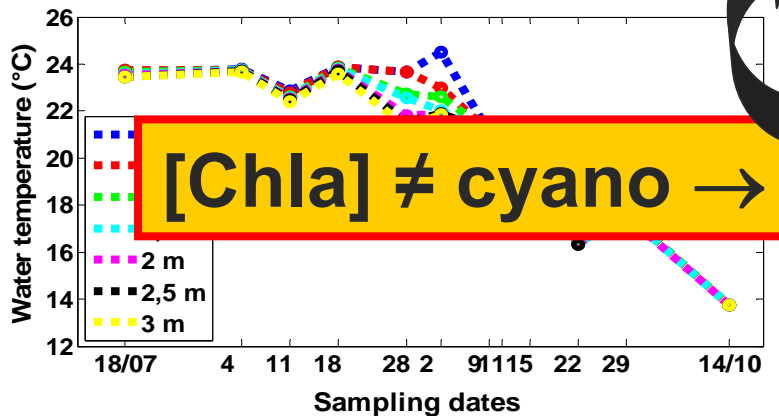


Fig 3: Depth profile of water temperature

Fig 4: Depth profile of pH

[Chla] ≠ cyano → switch dominant species      T changes → dominant species change



# Results: field measurements

**2010**

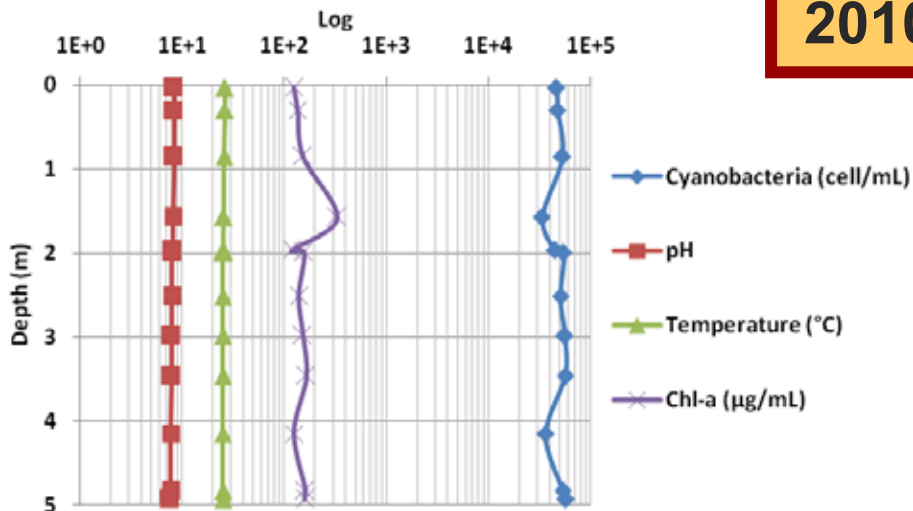


Fig 5: Depth profile of cyanobacteria density, pH, temperature and chl-a concentration in the middle of the bay, on July 20th 2010

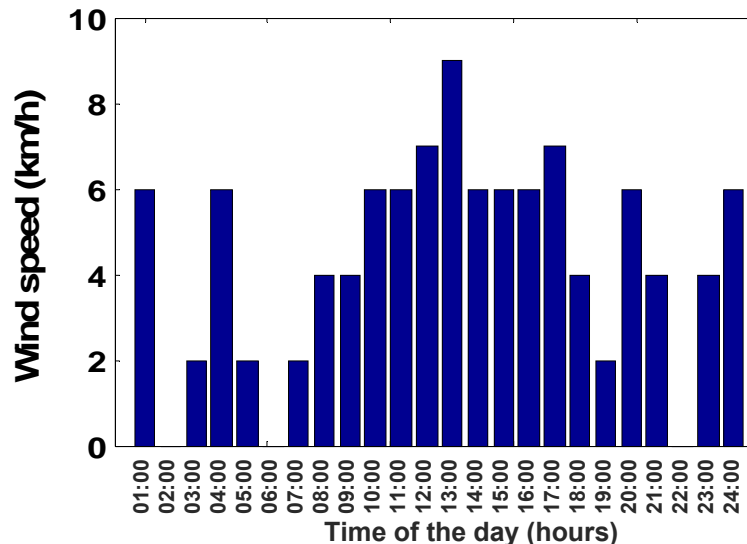


Fig 6: Mean hourly wind speed on July 20th 2010 at the weather station of Frelighsburg.

Parameters	07-17-10	07-18-10	07-19-10	07-20-10
Rain (mm)	1.6	0.2	12.6	0
Speed of maximum guts (km/h)	43	32	< 31	< 31

Table 1: Total rain and speed of maximum guts, from July 17th to 20th 2010

**↑[Cyanobacteria] + homogenous density profiles = high risk at DWTP**

# [ Results: simulations ]

Undergoing...

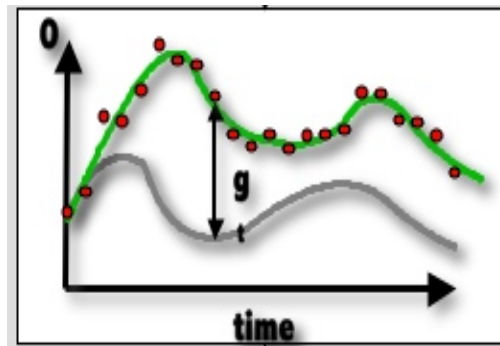


Adapted from : [blog.port-to-port.com](http://blog.port-to-port.com) et [zazzle.com](http://zazzle.com)



# Planned activities

- Proceed with simulation
- Compare simulation and real data
- Test different case scenario to predict cyanobacteria dynamic



M. Hipsey (2009)





# Synthesis



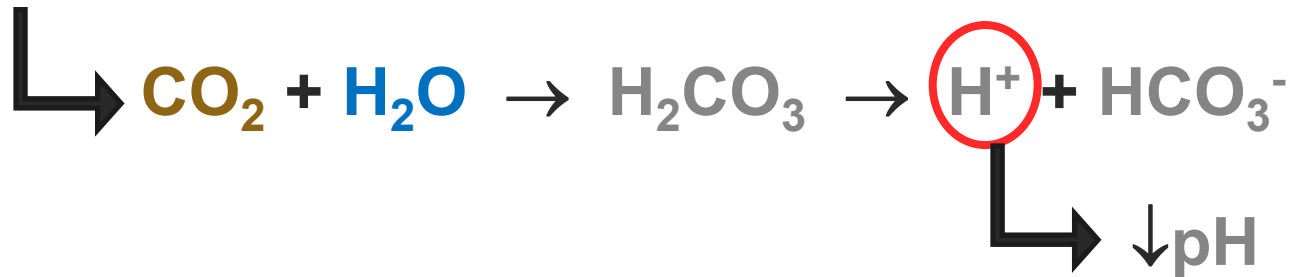
care2.com

- Real-time monitoring system is useful to better understand the spatial **distribution** and the **dynamic** of cyanobacteria
- Detect **high risk** situations
- Globally, most countries have experienced or routinely experience cyanobacterial presence in surface waters (CODD, 2005)
- Long-term **monitoring programs** → \$\$\$ → ∅ **developing** countries



# Photosynthesis vs Respiration

## ■ Photosynthesis



## ■ Respiration





# [ Fluorescent probe ]

## ■ Chl a

- Light emission: 470 nm
- Emission of pigments: **680 nm**
- Range of light absorption (probe): 650-700 nm

Phyc. Readings  $\neq$   $\rightarrow$   $\uparrow$  [Chl a]

## ■ Phycocyanin

- Light excitation: 590 nm
- Emission of pigments: 660 nm
- Range of light absorption (probe): 640-**680 nm**