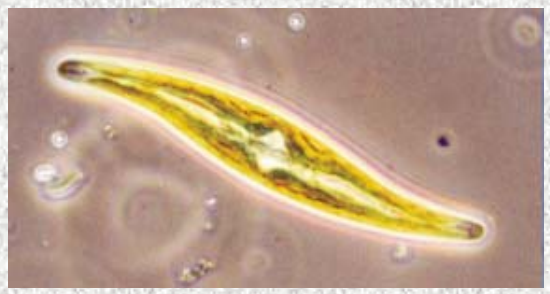


Phosphorus Loading and Related Impacts in Southern Cayuga Lake

Dave Matthews
Upstate Freshwater Institute
Syracuse, NY

Upstate Freshwater Institute (UFI)

- mission: advance freshwater research and protect the freshwater resources of New York State
- established in 1981
- not-for-profit [501(c)(3)]
- independent, with close professional ties to SU and CESF
- interdisciplinary research
- 270+ peer-reviewed manuscripts
- Systems studied: Onondaga Lake, Three Rivers System, Finger Lakes, NYC Reservoirs, Great Lakes, Lake Champlain

Symptoms of Excessive P Loading

- high levels of phytoplankton biomass
- blooms of nuisance cyanobacteria
- low transparency

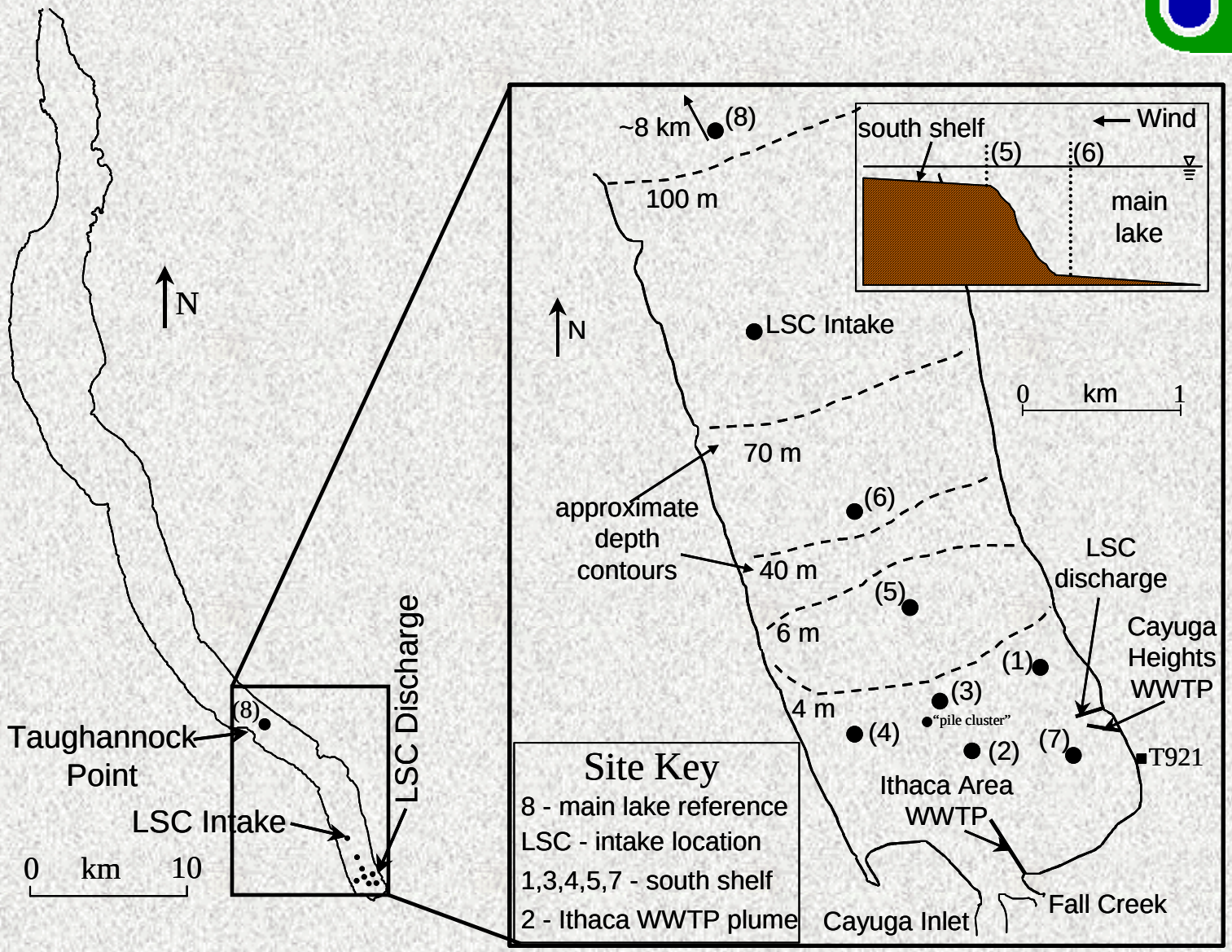
Common Metrics of Trophic State

- total P concentration - TP
- chlorophyll concentration - Chl
- Secchi disc transparency – SD

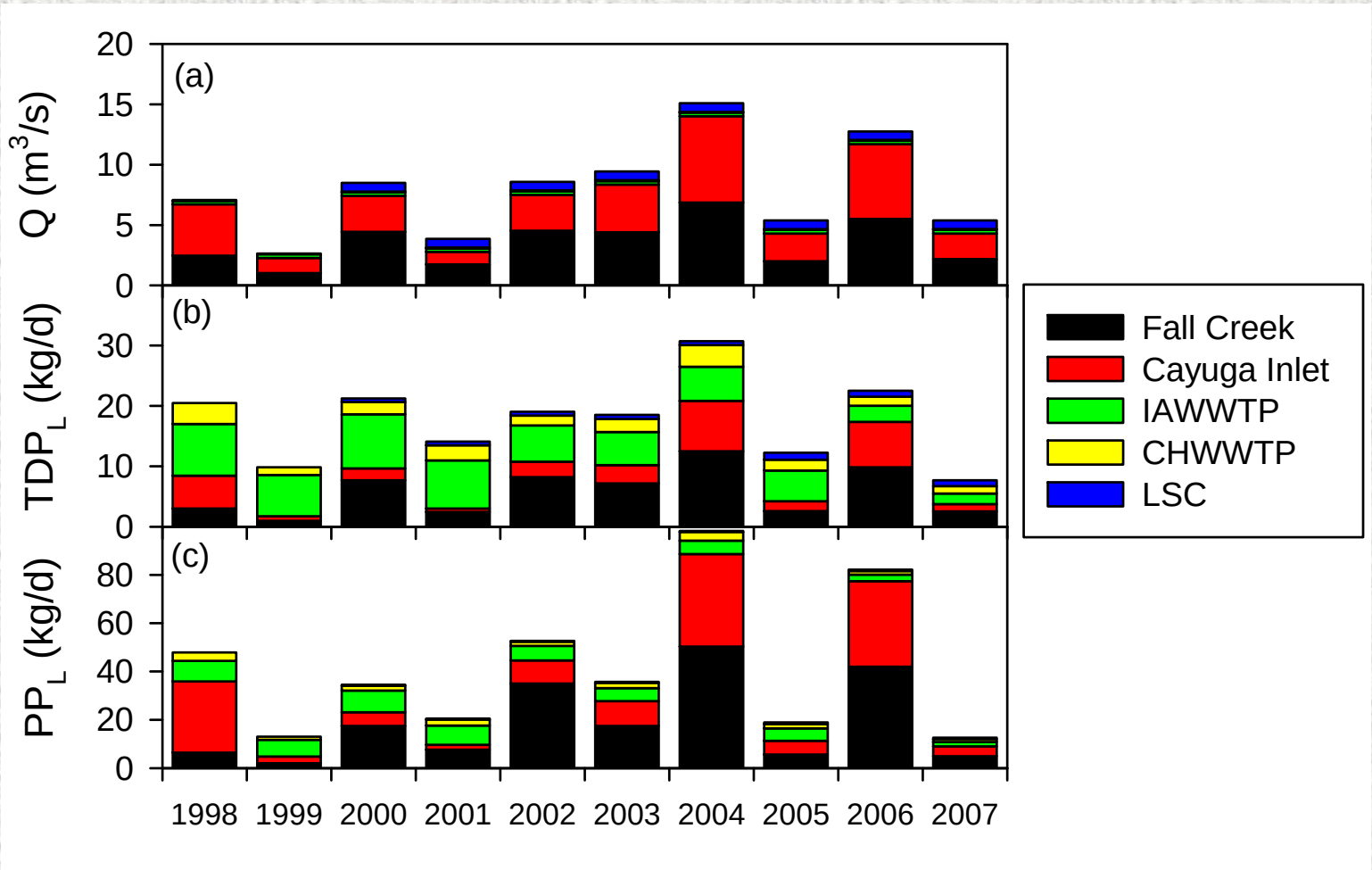
Contributing Data Sets

- Cornell University-Lake Source Cooling (LSC)
  - bi-weekly, April-October, 9 sites in southern Cayuga Lake,1998-2007
  - phosphorus, chlorophyll, Secchi disc
- Upstate Freshwater Institute
  - phosphorus measurements in Cayuga Inlet and Fall Creek
  - synoptic surveys of the Finger Lakes in 1996, 2004
- Community Science Institute
  - Fall Creek phosphorus measurements during high flows
- Ithaca Area and Cayuga Heights WWTP
  - phosphorus loading information

Cayuga Lake: LSC Monitoring Sites

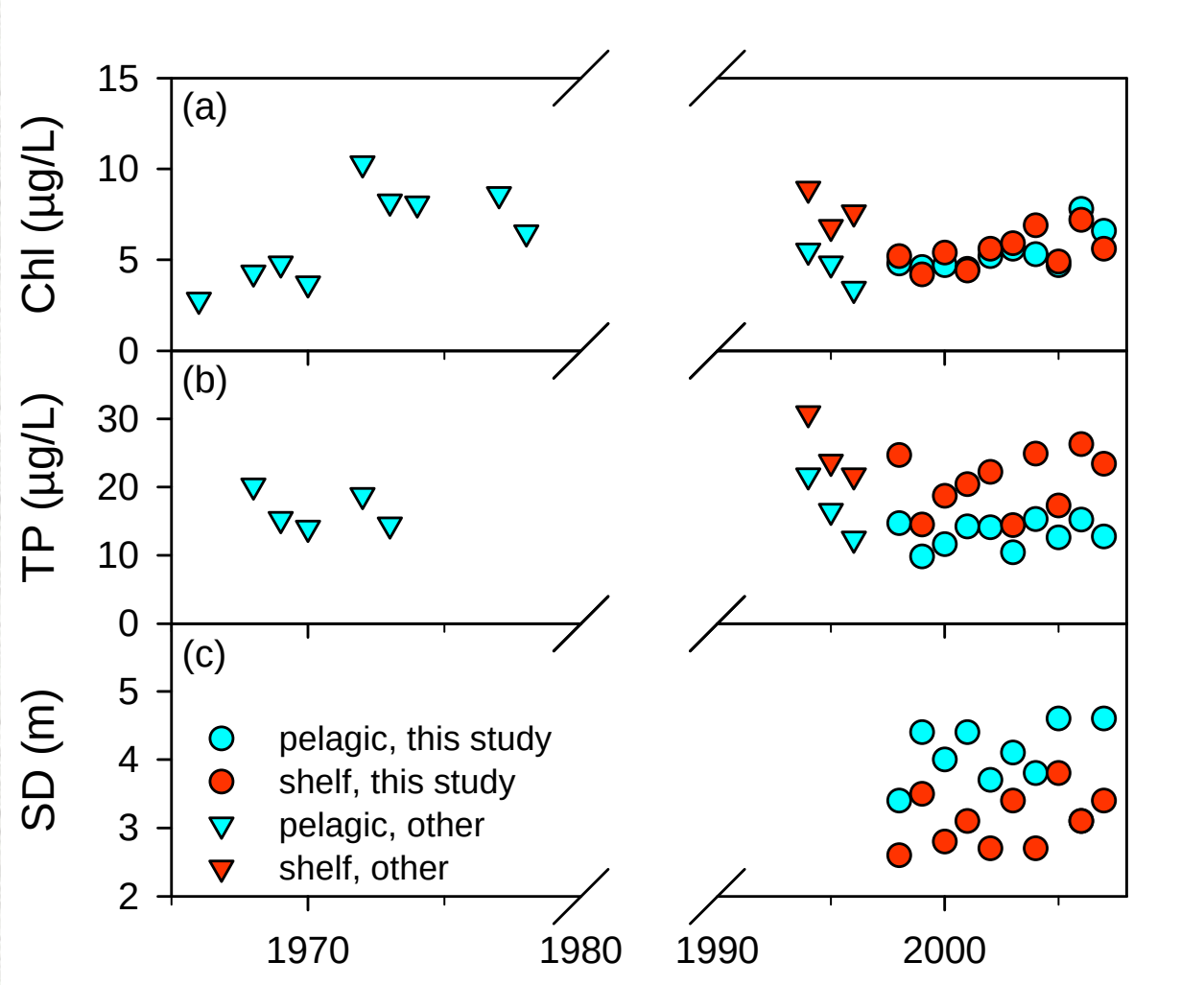


Partitioning Flows and Phosphorus Loads to Southern Cayuga Lake



- tributary inputs dominant during high runoff years (2004, 2006)
- 50% reduction in Ithaca Area WWTP load beginning in 2006

Long-term Variations in Chl, TP, and Secchi Disc Transparency

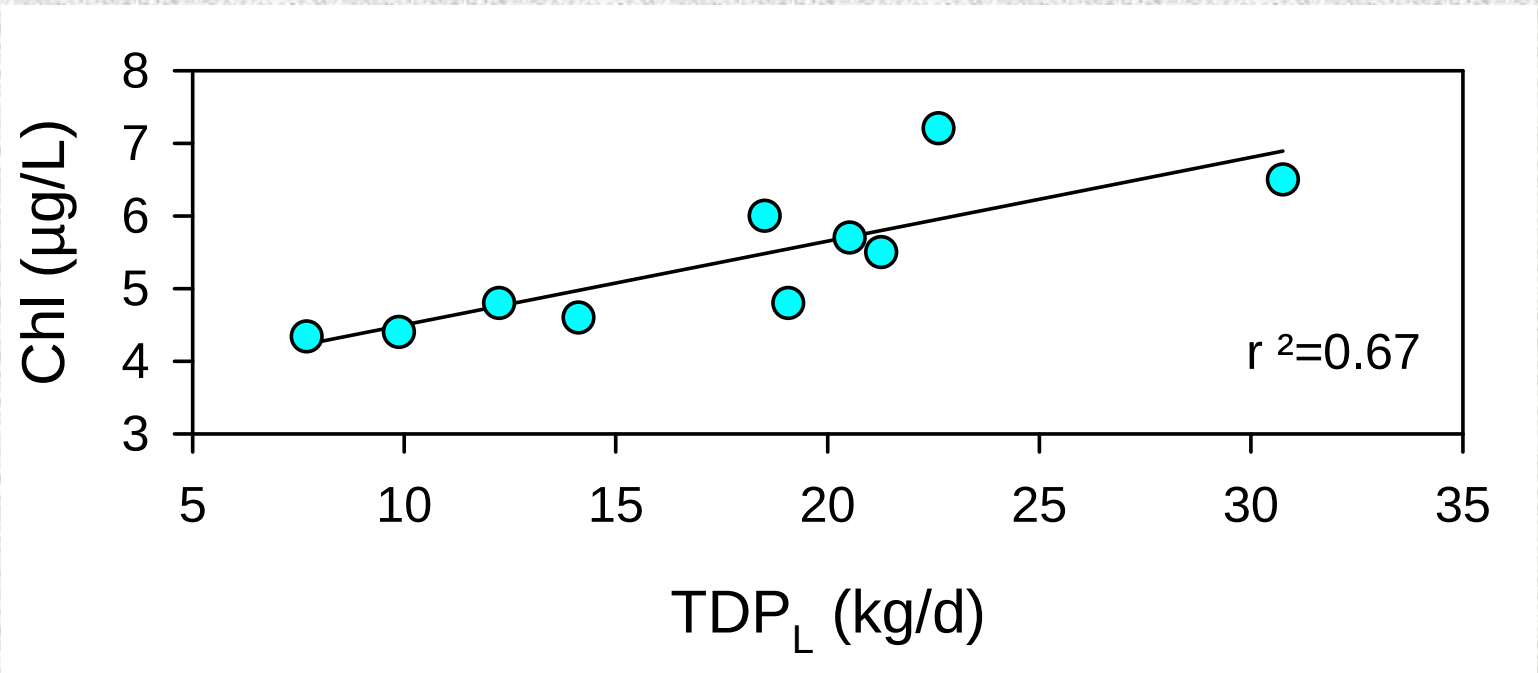


- Chl levels similar on the shelf and in the main lake
- TP levels higher on the shelf than in the main lake
- clarity lower on the shelf than in the main lake

- disconnect between Chl and TP/clarity caused by inorganic particles

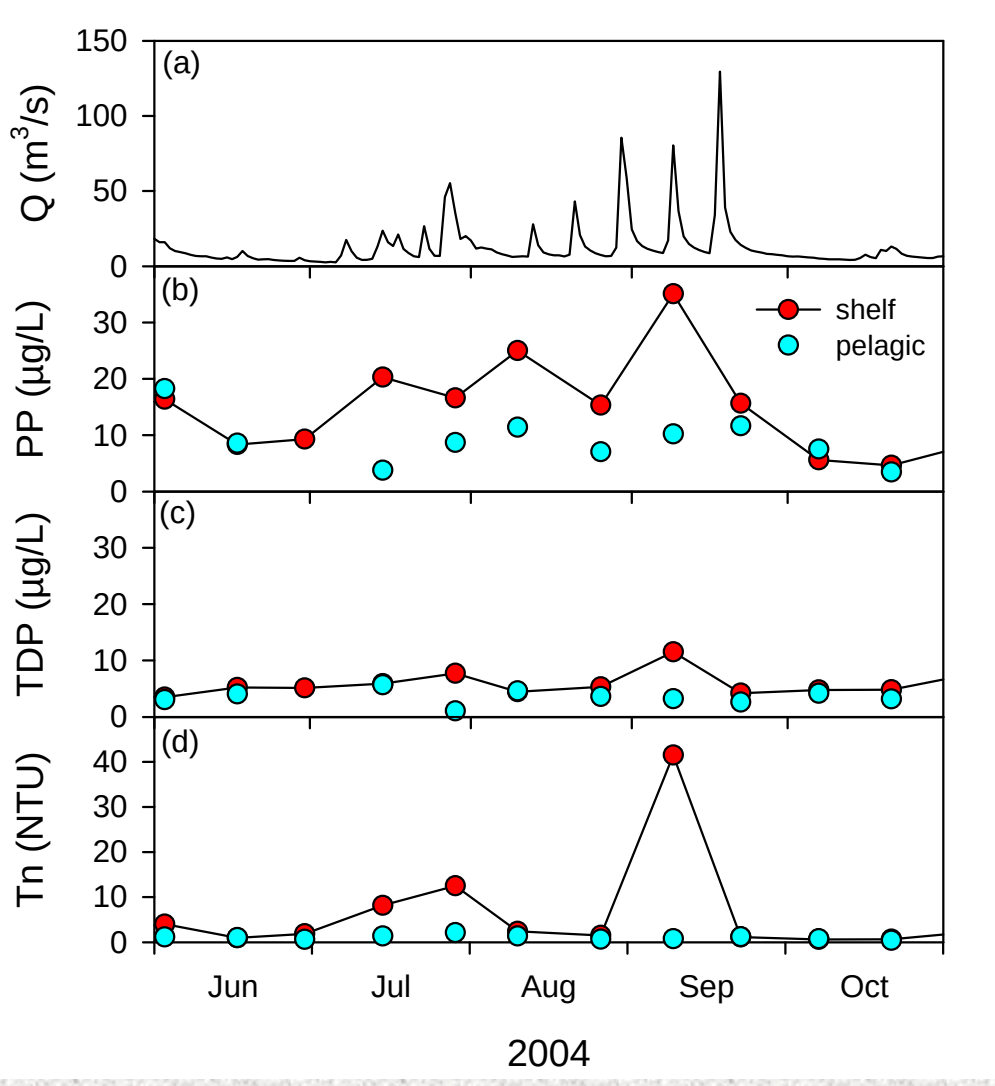
Evaluation of the Relationship Between TDP Loading and Chlorophyll Levels

annual average values for 10 years (1998-2007)



- strong relationship between TDP loading and phytoplankton biomass
- however, the shallow slope indicates little “bang for the buck”

Impacts of Runoff Events on Southern Cayuga Lake, 2004



- fixed-frequency sampling program captured one major runoff event
- major increases in PP and turbidity on the shelf during early September storm
- the main lake was unaffected

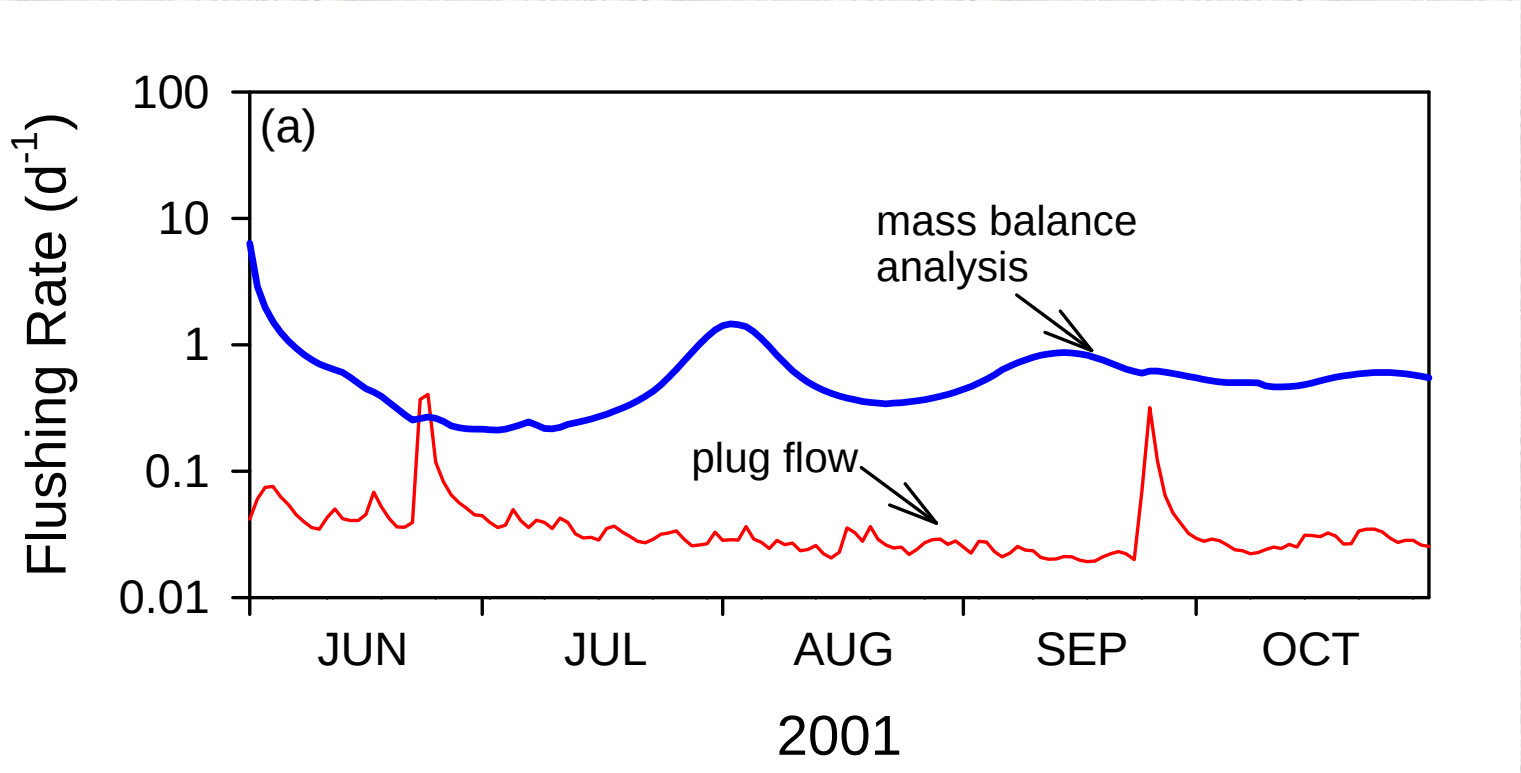
Turbid Plumes Entering Cayuga Lake

Cayuga Inlet and Fall Creek

Taughannock Creek

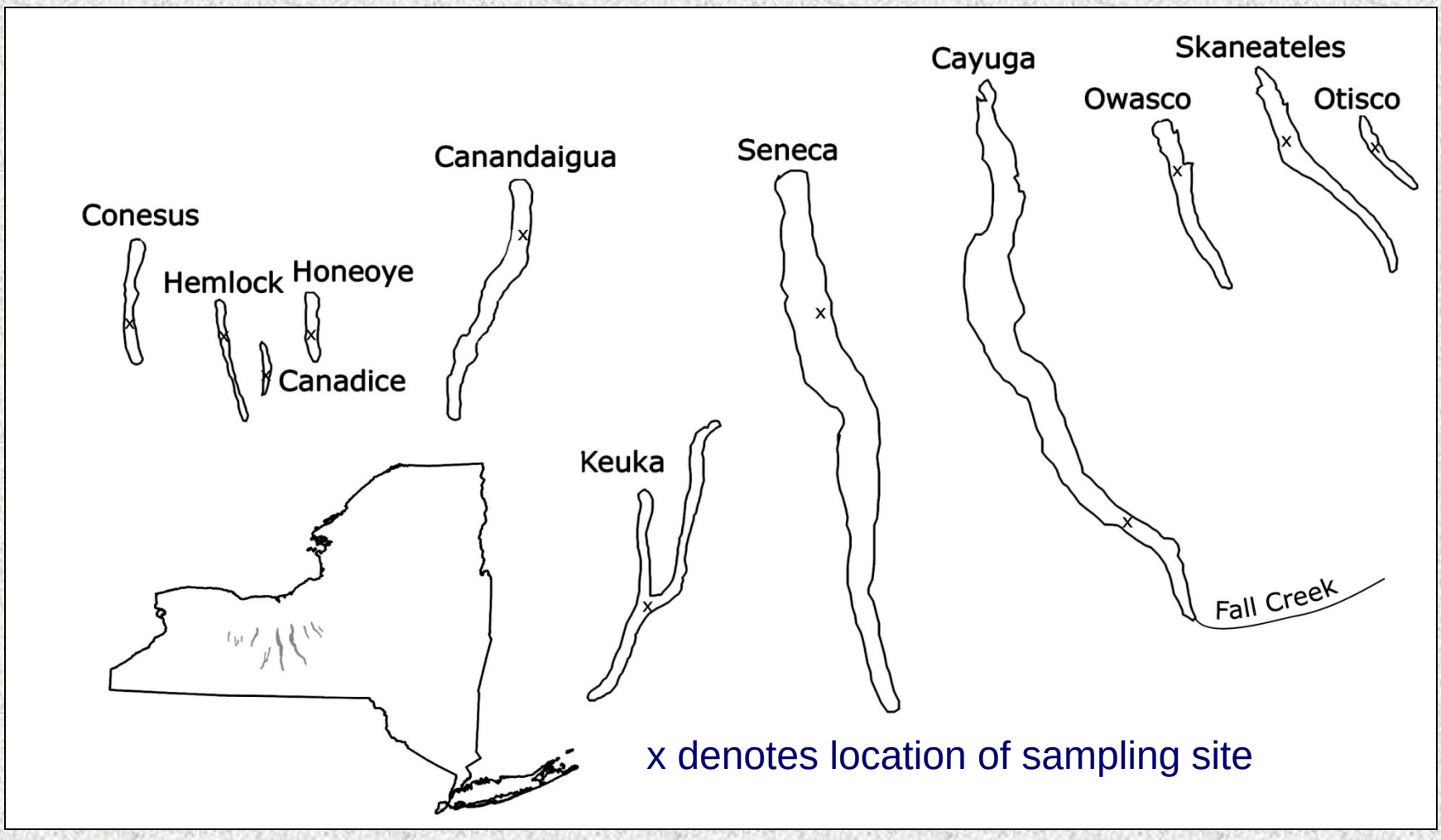
Photos by Bill Hecht

Flushing Rate of the Southern Shelf of Cayuga Lake



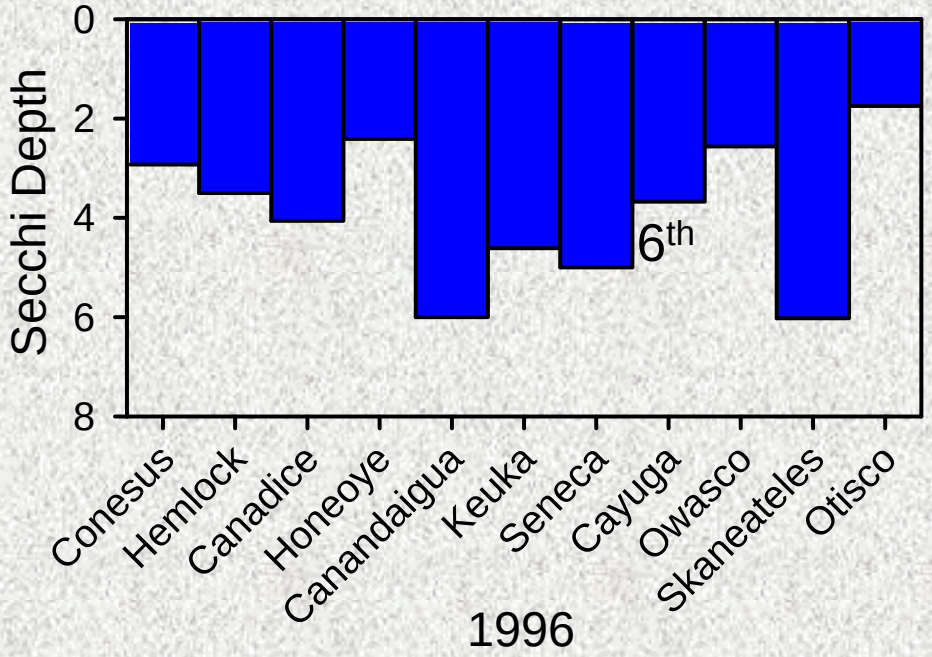
- the southern shelf of Cayuga Lake flushes rapidly, about once per day during the summer months
- this is mostly due to exchange with the main lake
- explains modest water quality differences between the shelf and main lake

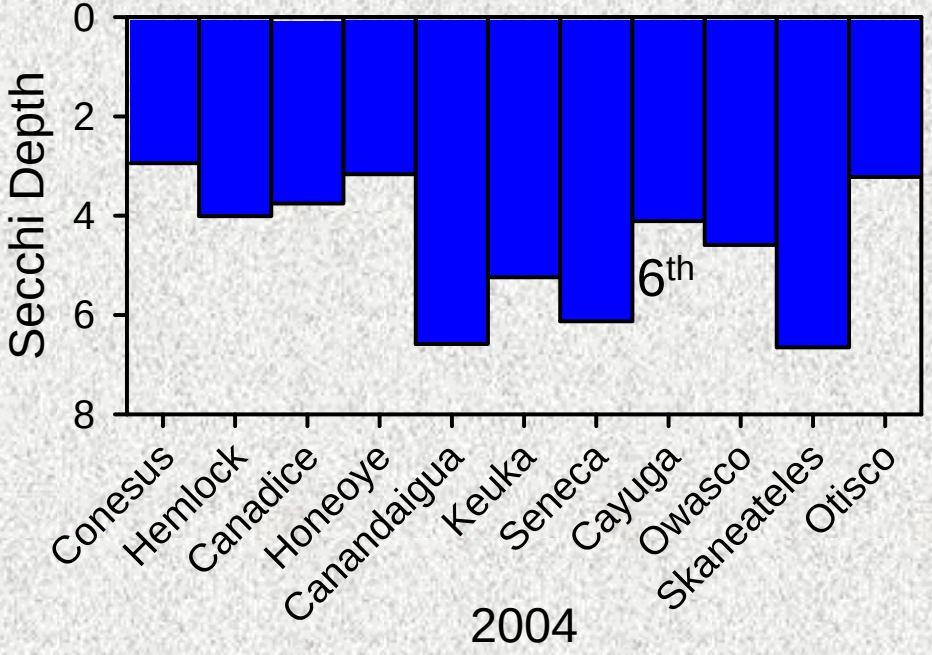
Selected Limnological Features, Cayuga Lake and other Finger Lakes



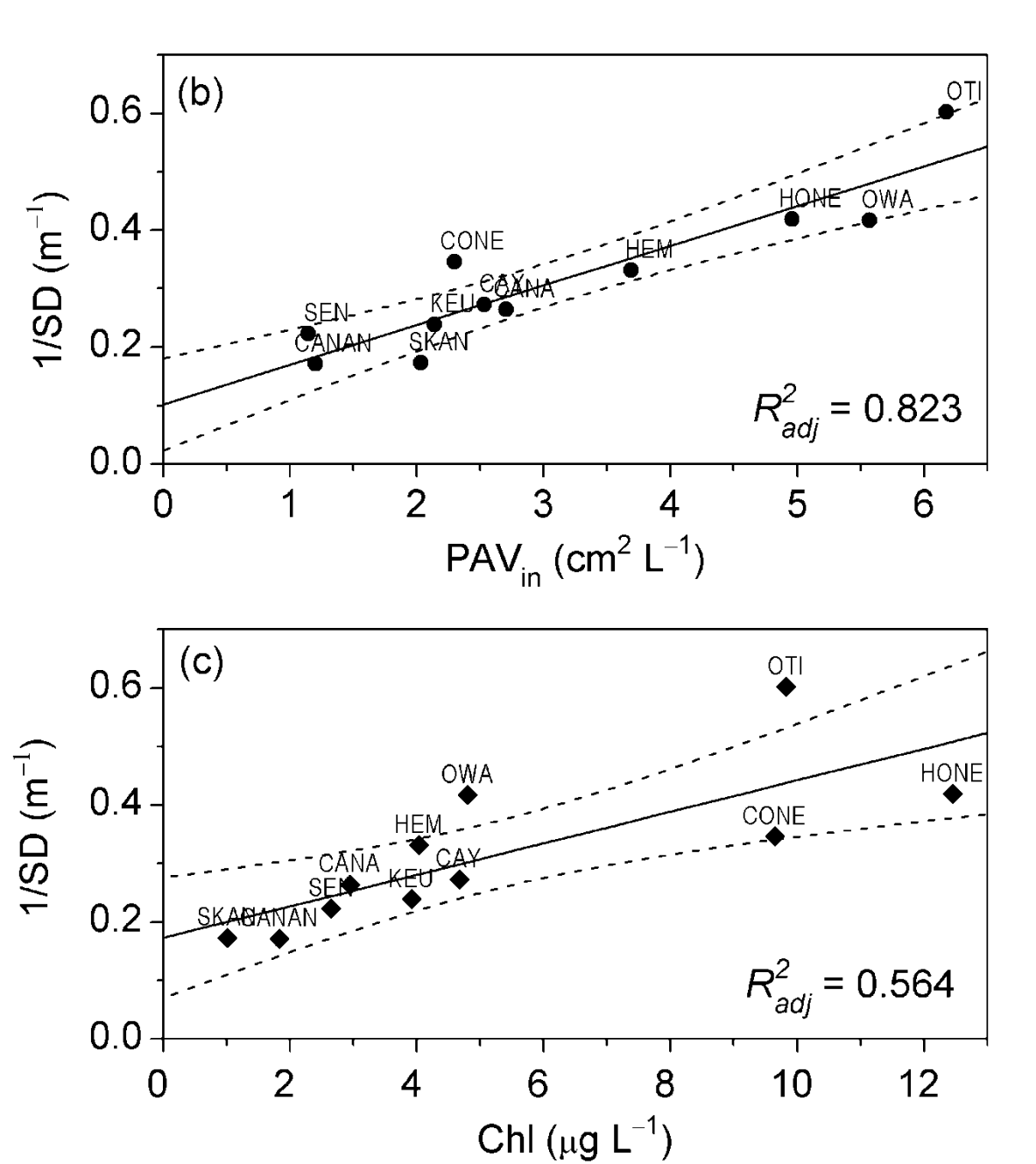
Finger Lakes – Wide Studies: Cayuga Lake Rankings, Secchi Disc

monthly monitoring





Regulation of Secchi Disc: Finger Lakes



Peng and Effler 2005

Summary

- phosphorus loading to southern Cayuga Lake is dominated by tributary inputs, particularly during high runoff years
- modest water quality benefits expected from a 50% decrease in phosphorus loading from Ithaca Area WWTP
- clarity on the southern shelf is regulated by terrigenous inorganic particles rather than phytoplankton
- the southern shelf flushes rapidly (once per day), which moderates water quality differences with the main lake
- differences in transparency among the Finger Lakes explained by concentrations of inorganic particles and phytoplankton

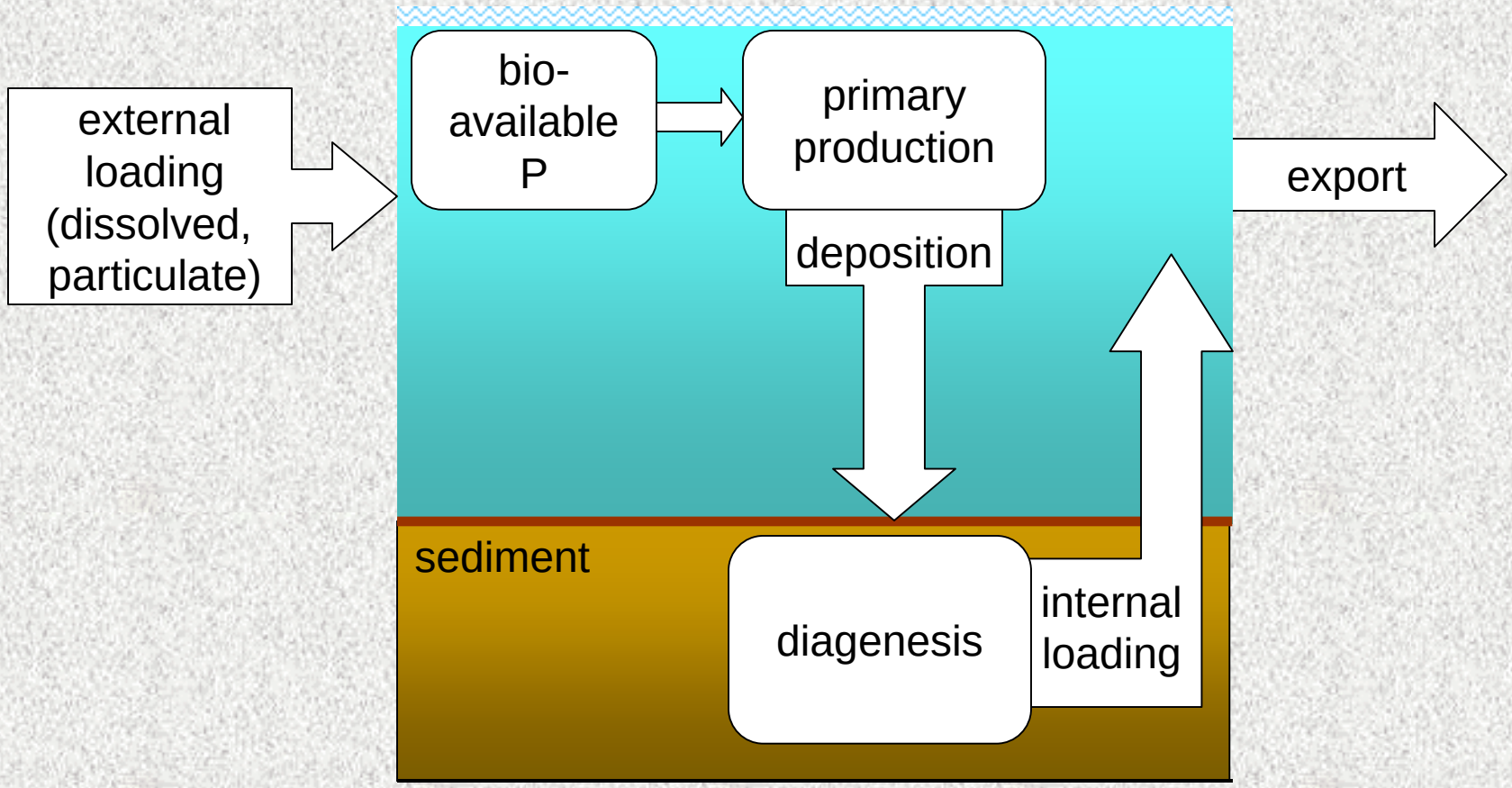
This study was funded by a FL-LOWPA Special Projects grant

Project partners:

- Tompkins County
- City of Ithaca
- Cayuga Lake Watershed Network

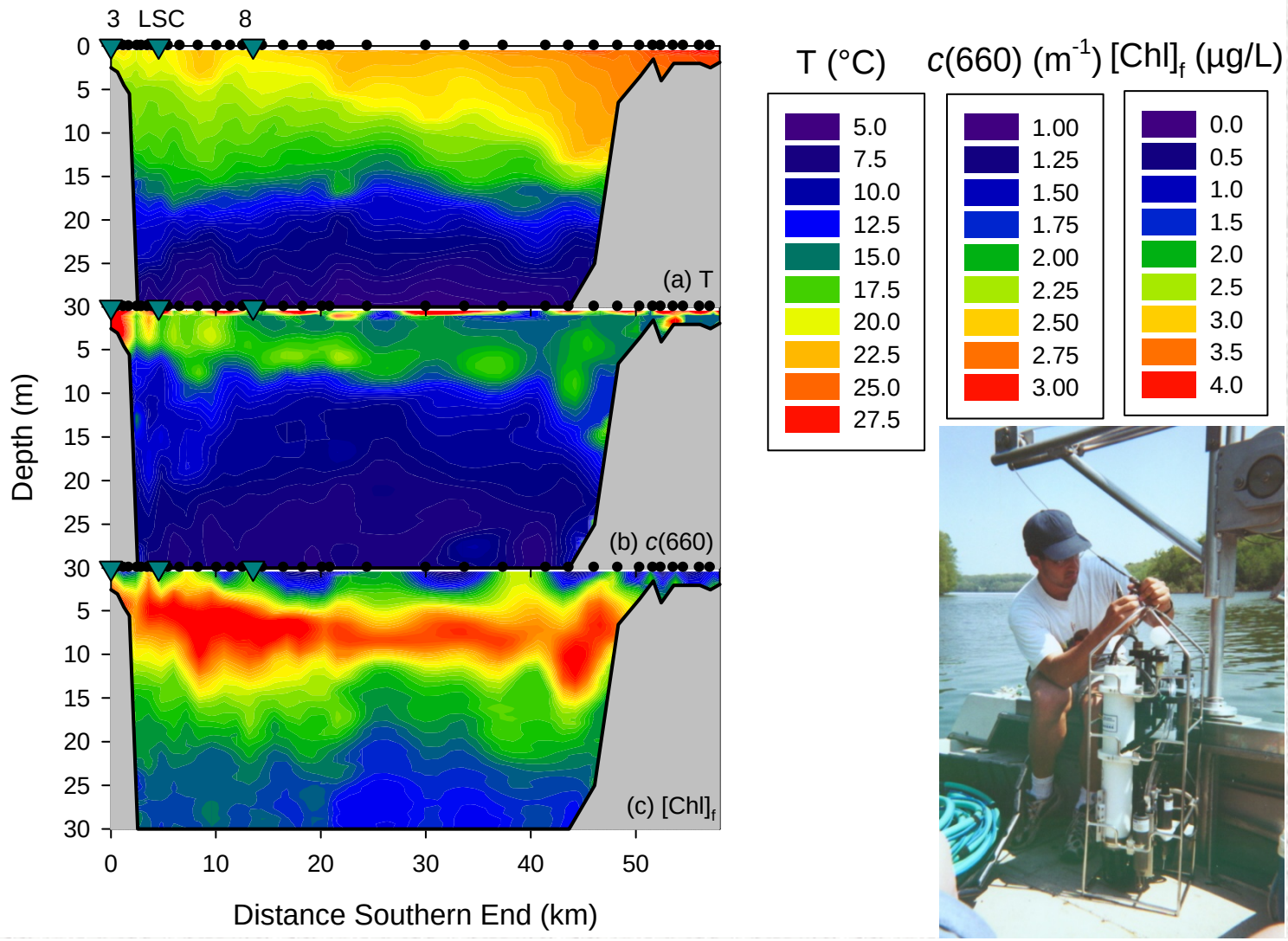
Questions?

Phosphorus Cycling in Lakes



total phosphorus (TP) = total dissolved P (TDP) + particulate P (PP)

Longitudinal and Vertical Patterns - August 1996, 40 sites

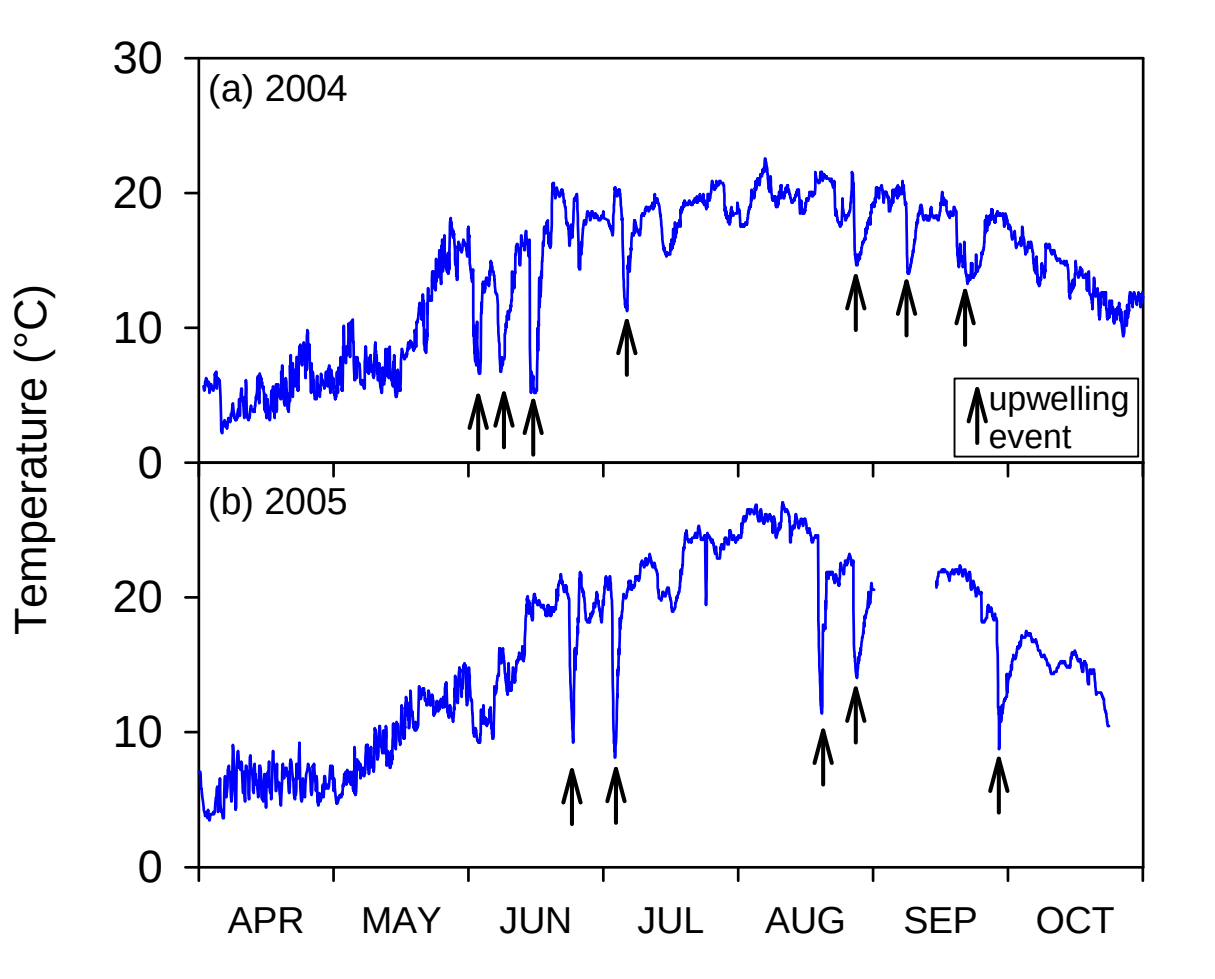


Outline

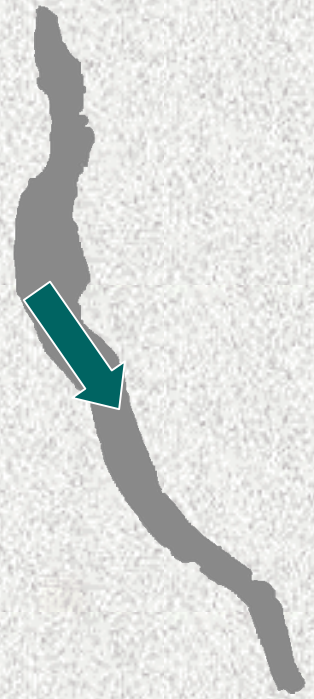
1. Brief introduction to UFI
2. Phosphorus cycling in lakes
3. Contributing data sets
4. Results
   - Partitioning of phosphorus loads
   - Long-term variations in water quality
   - Impact of runoff events on water quality
   - Flushing rate of southern Cayuga Lake
   - Longitudinal patterns
   - Synoptic surveys of the Finger Lakes
5. Summary
6. Questions

Bill Hecht

Flushing of the Shelf Enhanced by Upwelling Events



- upwelling is promoted by strong sustained winds along the long axis of the lake



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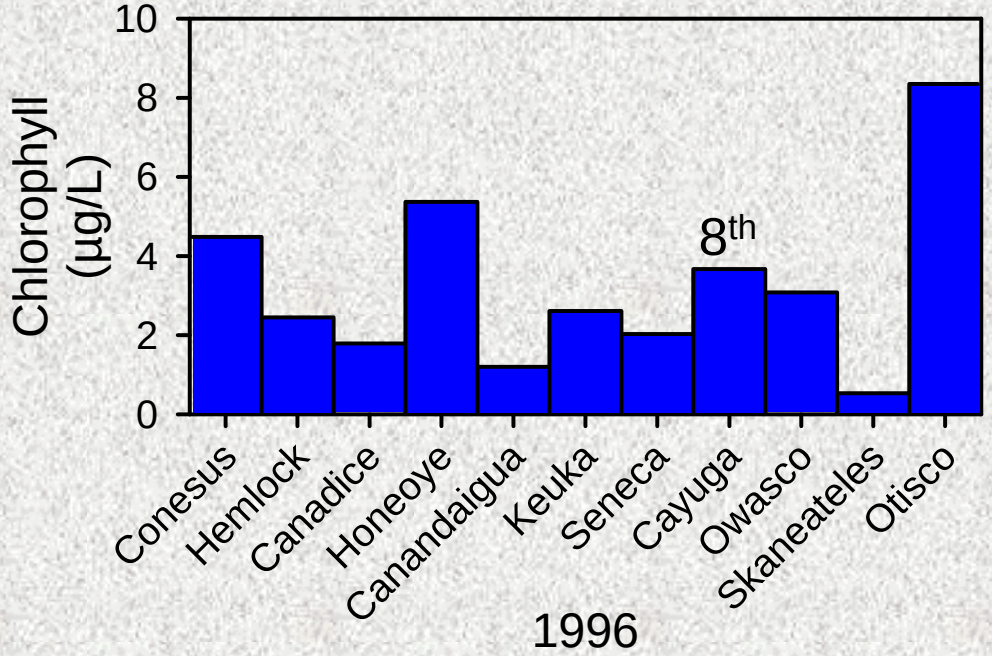

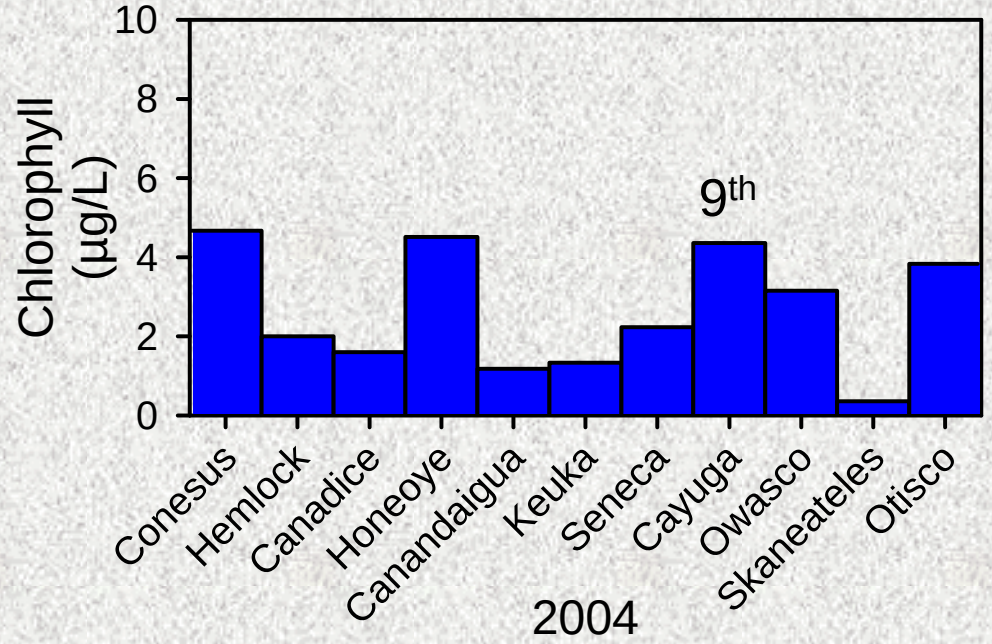

Program of Measurements

Field

temperature
conductivity
fluorescence
beam attenuation
irradiance
    scalar
    downwelling
    upwelling
dissolved oxygen
Secchi disc transparency

April-October, bi-weekly, 9 sites, 1998-2007

Lab

total phosphorus
soluble reactive phosphorus
total dissolved phosphorus
turbidity
acidified turbidity
total dissolved nitrogen
ammonia nitrogen
nitrate and nitrite nitrogen
chlorophyll a
chloride
fecal coliform