Lessons learned from three decades of water quality monitoring on Lake Champlain

Matthew Vaughan, PhD
Lake Champlain Basin Program
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New York Citizens Advisory Committee
mvaughan@lcbp.org
Lake Champlain long-term monitoring program

How is the lake’s water quality? Is it changing?
**Chemical measurements**
- Alkalinity
- Aluminum
- Calcium
- **Chloride**
- Chlorophyll
- Conductivity
- Dissolved organic carbon
- Dissolved oxygen
- Dissolved phosphorus
- Dissolved silica
- Iron
- Magnesium
- pH
- Potassium
- Sodium
- Total nitrogen
- Total phosphorus
- Total suspended solids

**Physical measurements**
- Thermocline depth
- Water temperature
- Secchi depth

**Biological measurements**
- Net phytoplankton density, biovolume, and community composition
- Net zooplankton density, biovolume, and community composition

**Calculated metrics**
- Molar ratio TN:TP
- Hypolimnetic DO depletion (June 1 – Sept 1)
In-lake analyses

- 25 parameters
- 110,000 observations
- 600,000 sonde measurements
- Grouping, stats, trends
Tributary analyses

71,000 measurements

Analyzed

- Total and dissolved phosphorus
- Total nitrogen
- Chloride
- Suspended sediment

Determined

- Concentration
- Load
- Trends
- 18 tributaries
- Long-term monitoring program samples
- WRTDS model to predict concentration -> load
- Reduce influence of annual flow variability
- Probability of trend

This example shows that annual changes in precipitation and runoff heavily influence phosphorus loading to Lake Champlain.
Long-term monitoring: 22 tributaries
TMDL for phosphorus: 13 lake segments
How can we track progress?
Missisquoi Bay

6 times higher than TMDL limit

On track with TMDL limit

1990  2000  2010

Cumberland Bay

1990  2000  2010

Main Lake

1990  2000  2010
Phosphorus takeaways

In the lake:
• No trends for most lake segments
• Increased lake-wide until recent decreases

Tributary loading:
• Highly variable
• Loading remains too high to meet water quality goals
• No trends in 10 out of 18 tributaries
• Decreasing trends in three rivers, variable timeframes
• Increasing trends in five rivers, variable timeframes
Flow-normalized total nitrogen yield

Metric tons nitrogen per km² per year

1990  2000  2010  2020
Nitrogen takeaways

In the lake
- Decreased lake-wide
- Trends at deep sites have shifted in the past decade

Tributaries:
- Pike River
- Trends for 14 out of 18 tributaries
- From 2004 - 2017:
  - Six rivers decreased
  - Two rivers increased
  - Ten rivers had no trend
Natural log of molar TN:TP

Redfield ratio

shallow sites

deep sites

Redfield ratio

1990  2000  2010  2020
20 mg chloride per liter

- shallow sites
- deep sites
Chloride takeaways

**In the lake**
- Well below EPA thresholds
- May be nearing double background concentration
- **Changing**, with increases in the past decade

**Tributary loading**
- **Increasing trends** for 16 out of 18 tributaries
- Two rivers show full record decreases
Suspended sediment takeaways

**Tributary loading**
- The model did not predict loads well for several tributaries
- **Increasing trends** for 5 out of 18 tributaries, all in Vermont / Quebec
- Some increases have recently slowed or stopped
- **Recent decreasing trends** in Little Ausable and Little Chazy
Next steps

- Publish in-lake results, update tributary results
- State of the Lake report
- Real-time *in situ* monitoring
Questions?

mvaughan@lcbp.org