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

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New York Citizens Advisory Committee

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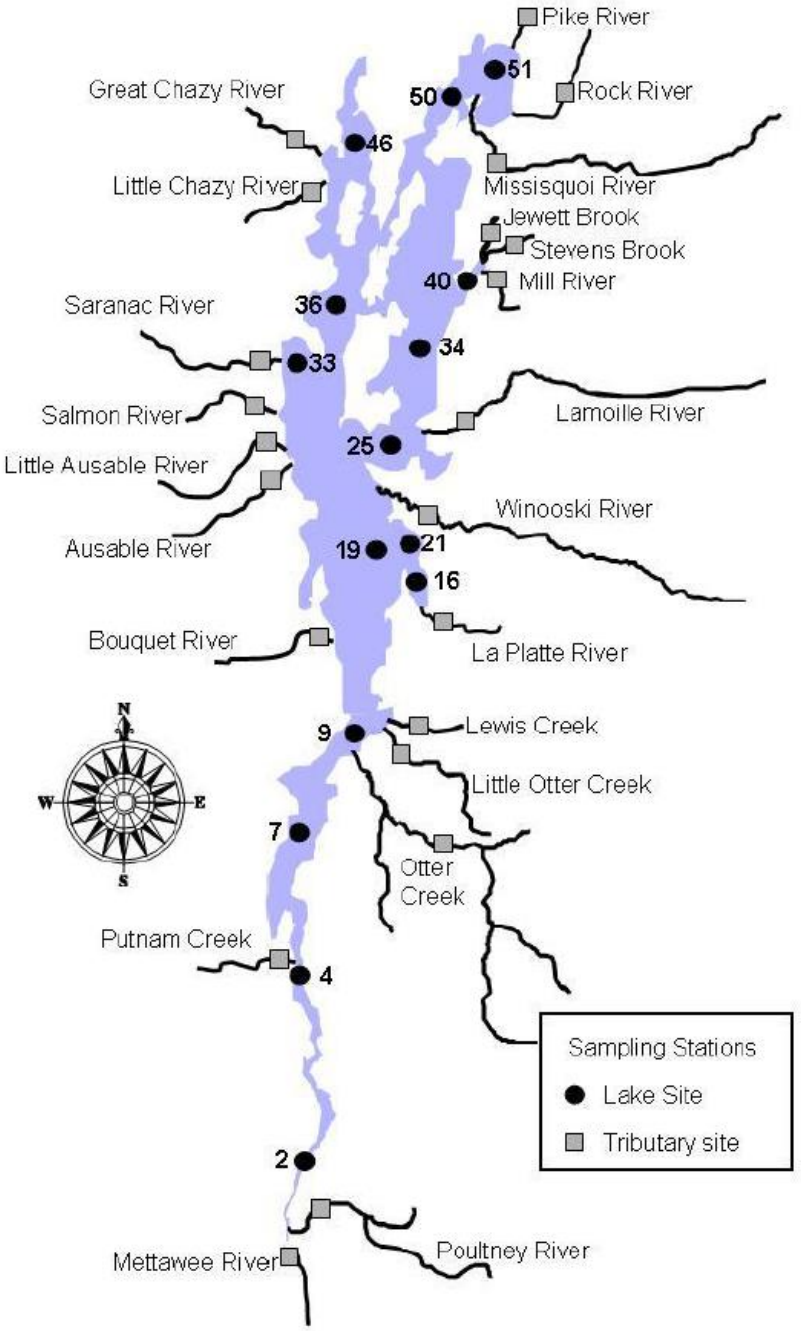
Lake Champlain long-term monitoring program

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

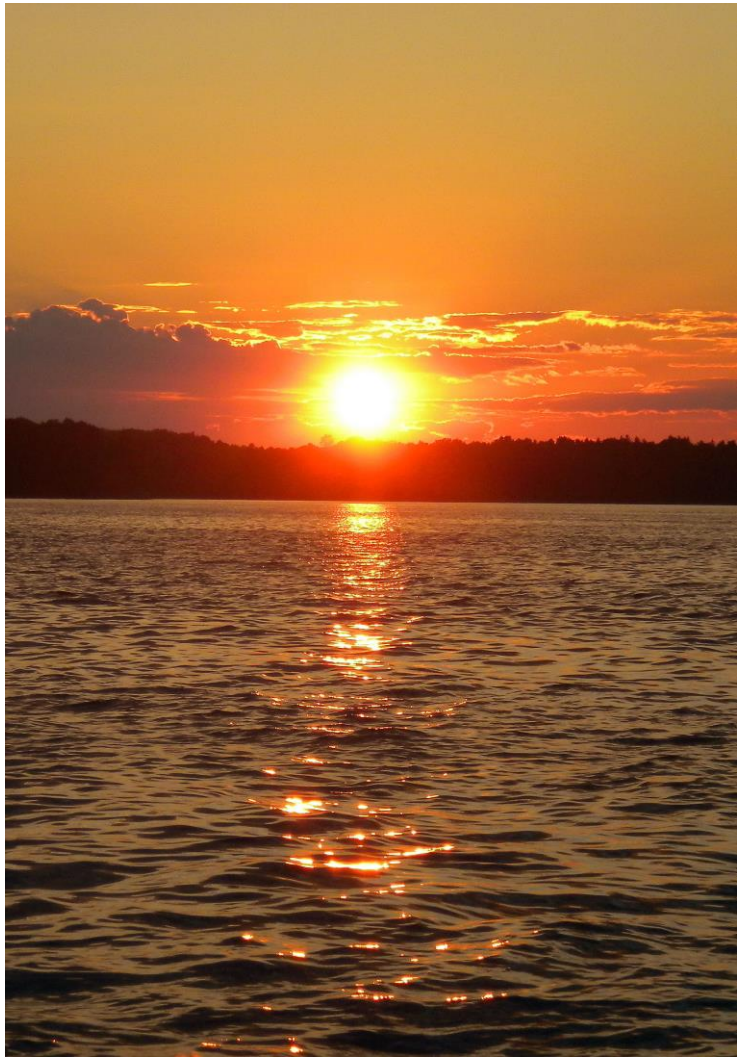
- Thermocline depth
- Water temperature
- Secchi depth

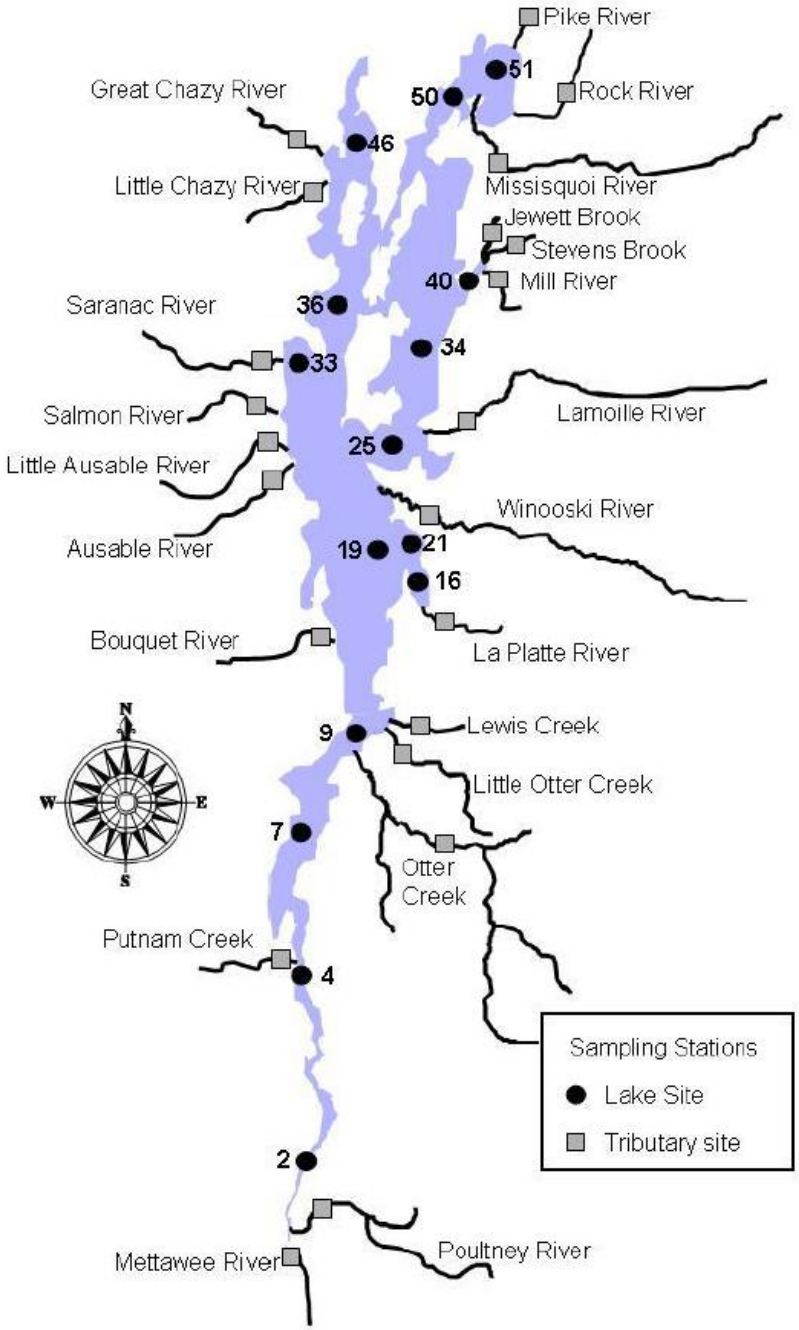
Biological measurements

- 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

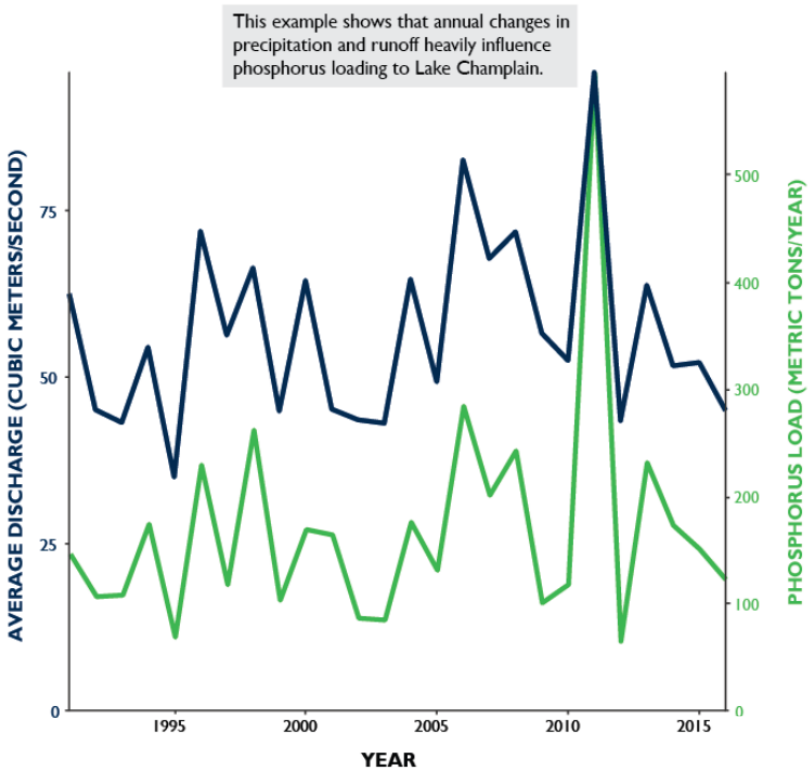
Analyzed

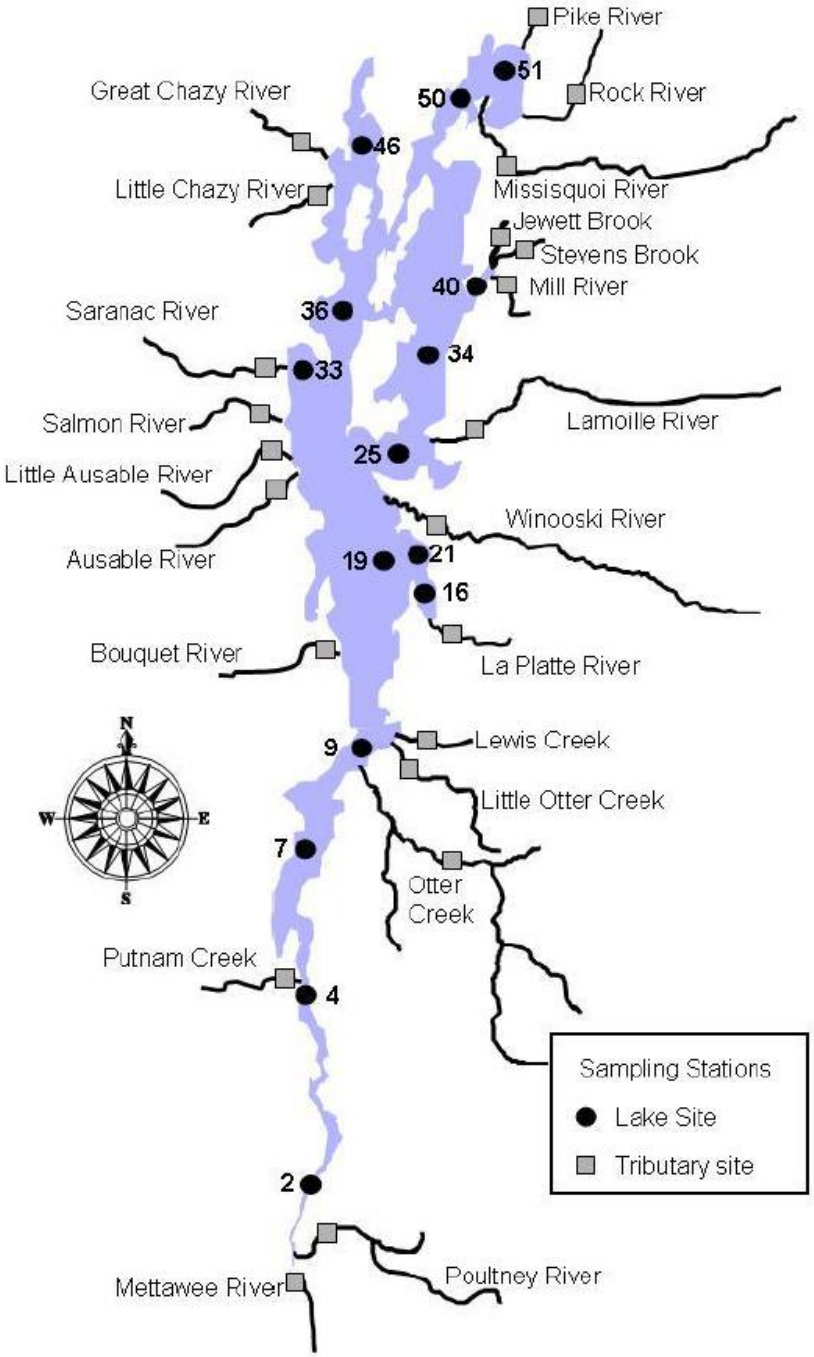
- Total and dissolved phosphorus
- Total nitrogen
- Chloride
- Suspended sediment

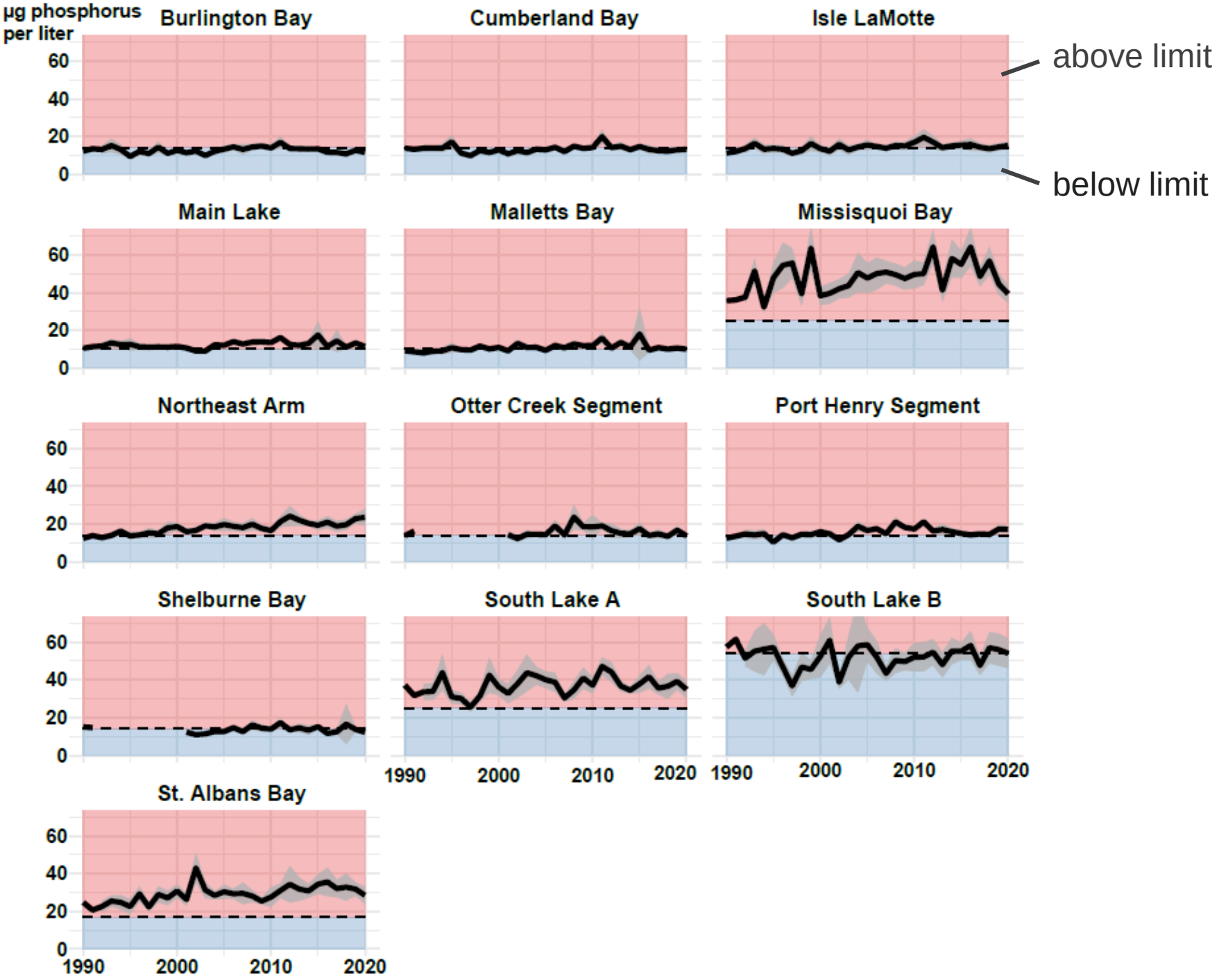
Determined

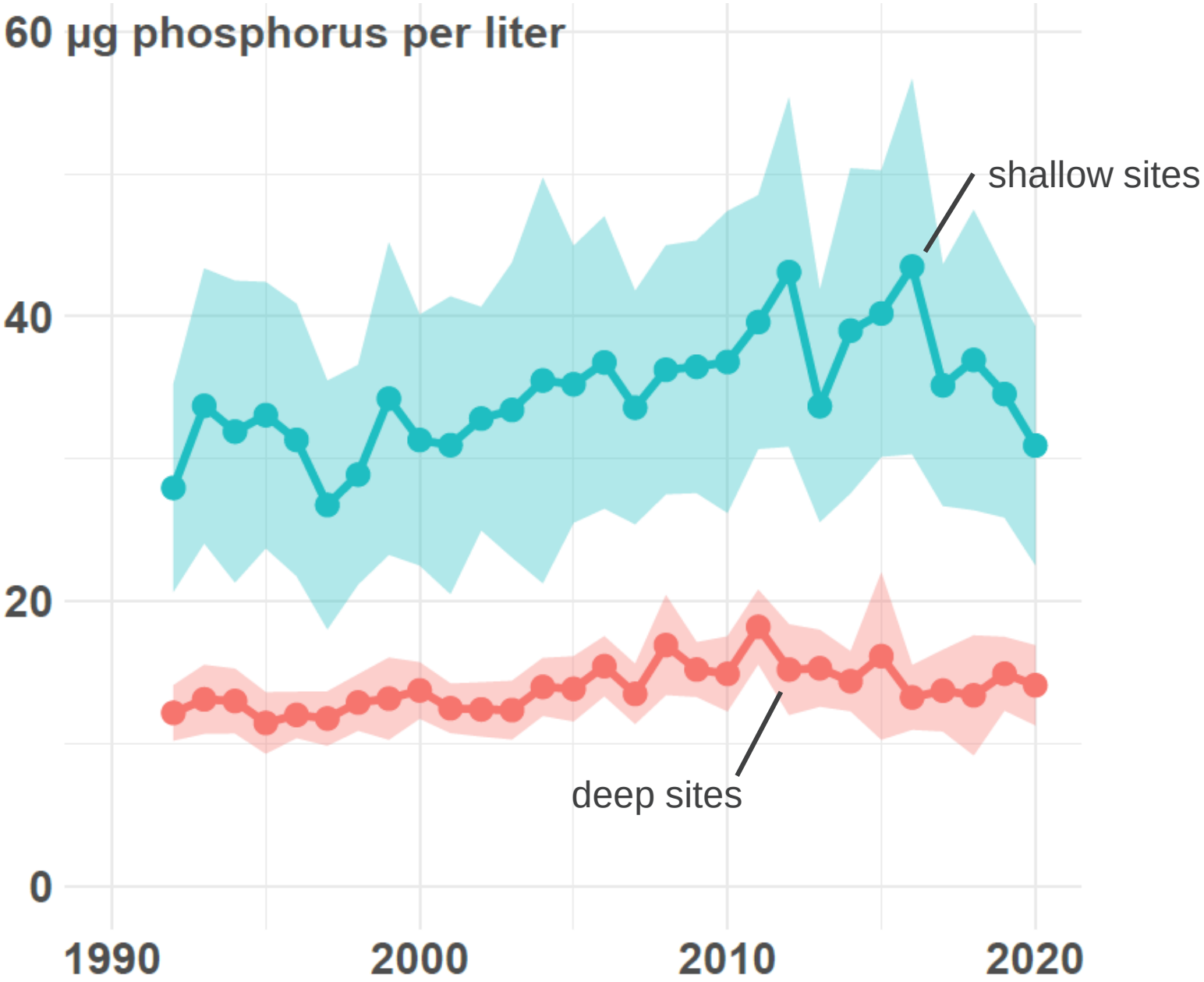
- Concentration
- Load
- Trends

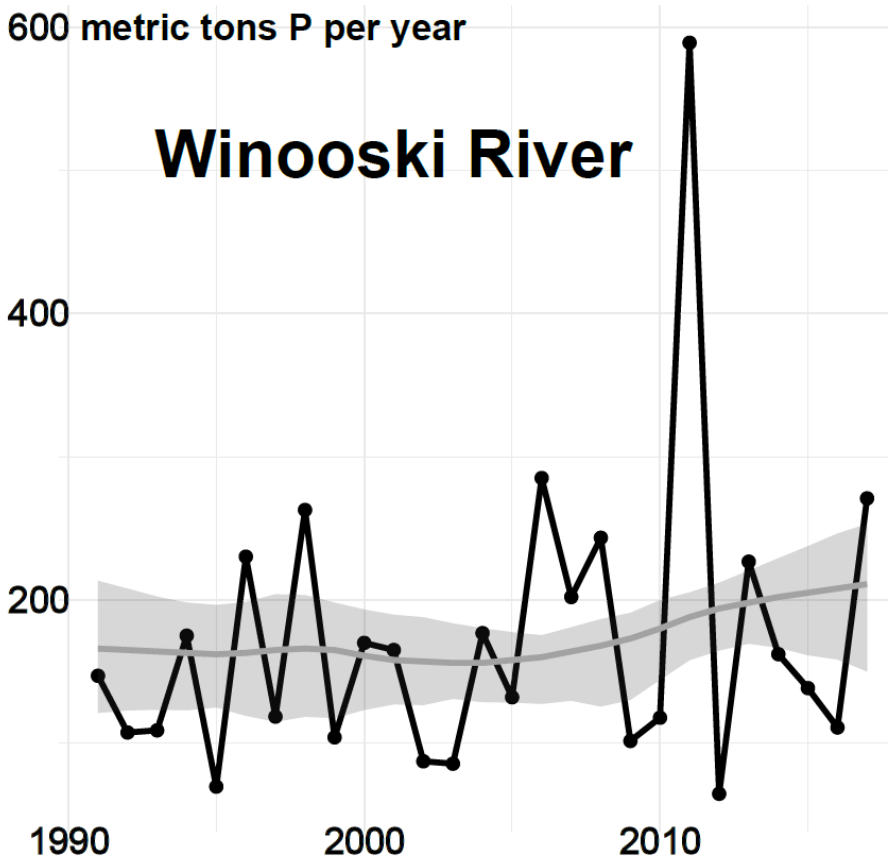
- **18 tributaries**
- **Long-term monitoring program samples**
- **WRTDS model to predict concentration -> load**
- **Reduce influence of annual flow variability**
- **Probability of trend**

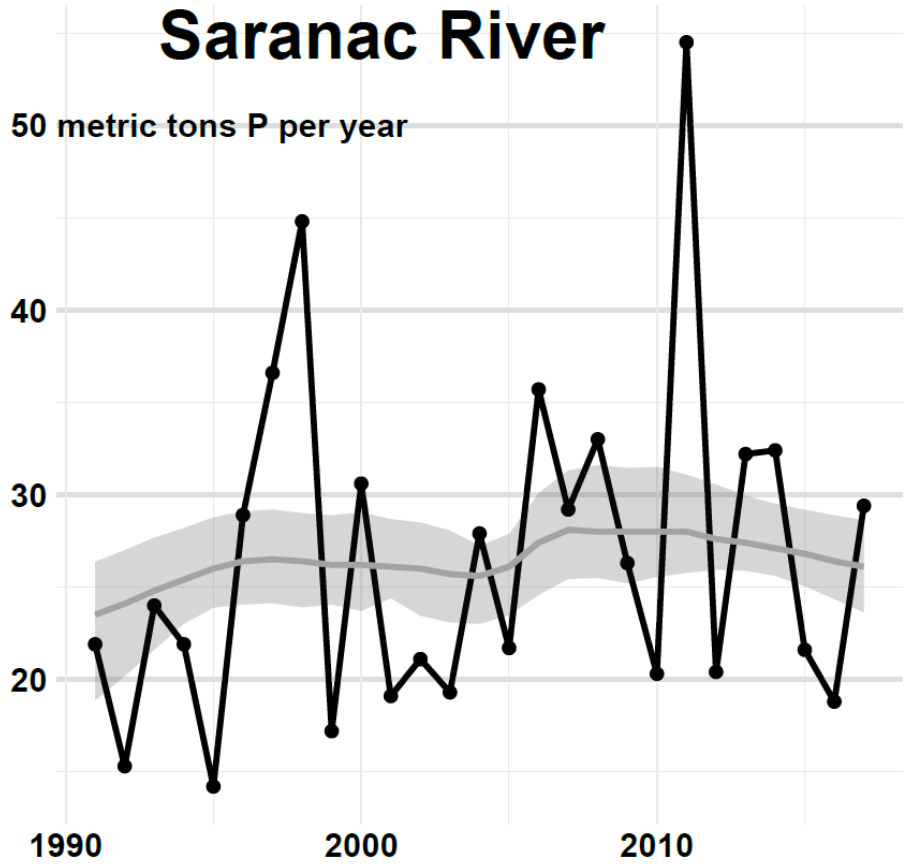


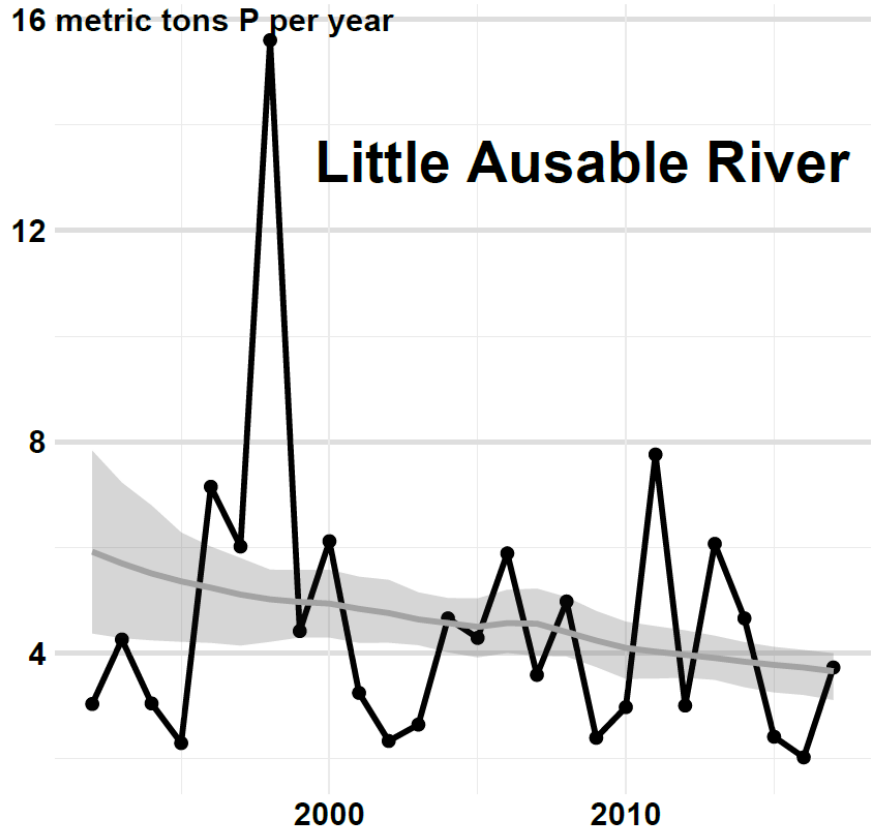


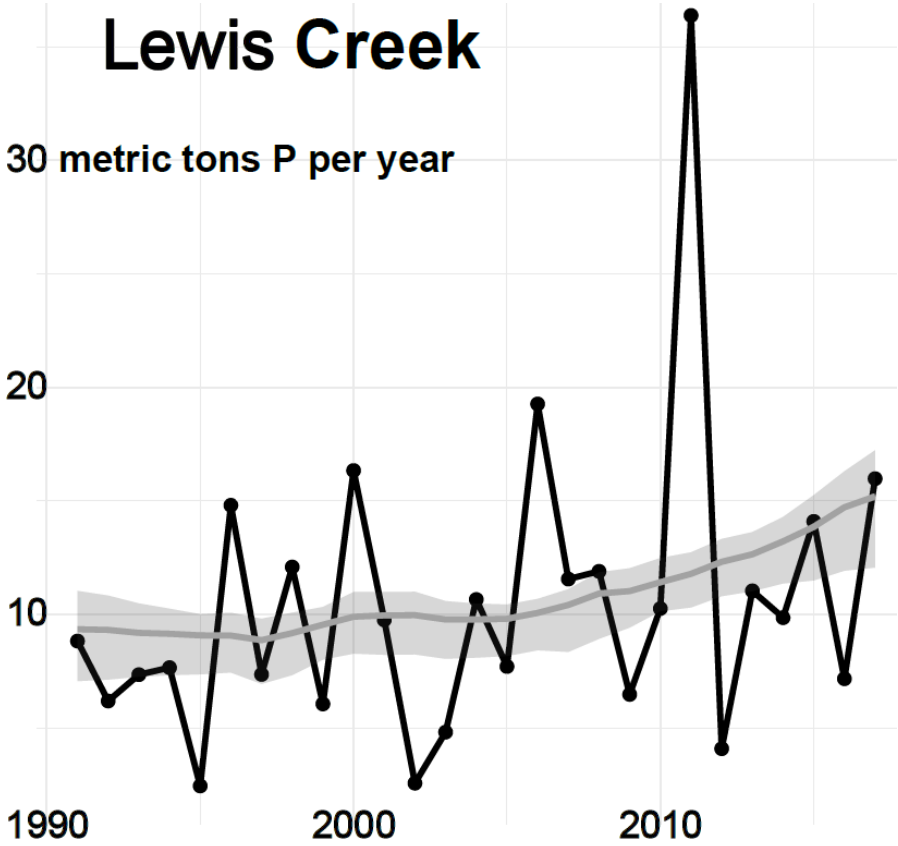

µg phosphorus per liter
Burlington Bay
Cumberland Bay
Isle LaMotte
Main Lake
Malletts Bay
Missisquoi Bay
Northeast Arm
Otter Creek Segment
Port Henry Segment
Shelburne Bay
South Lake A
South Lake B
St. Albans Bay
0
20
40
60
1990
2000
2010
2020
above limit
below limit

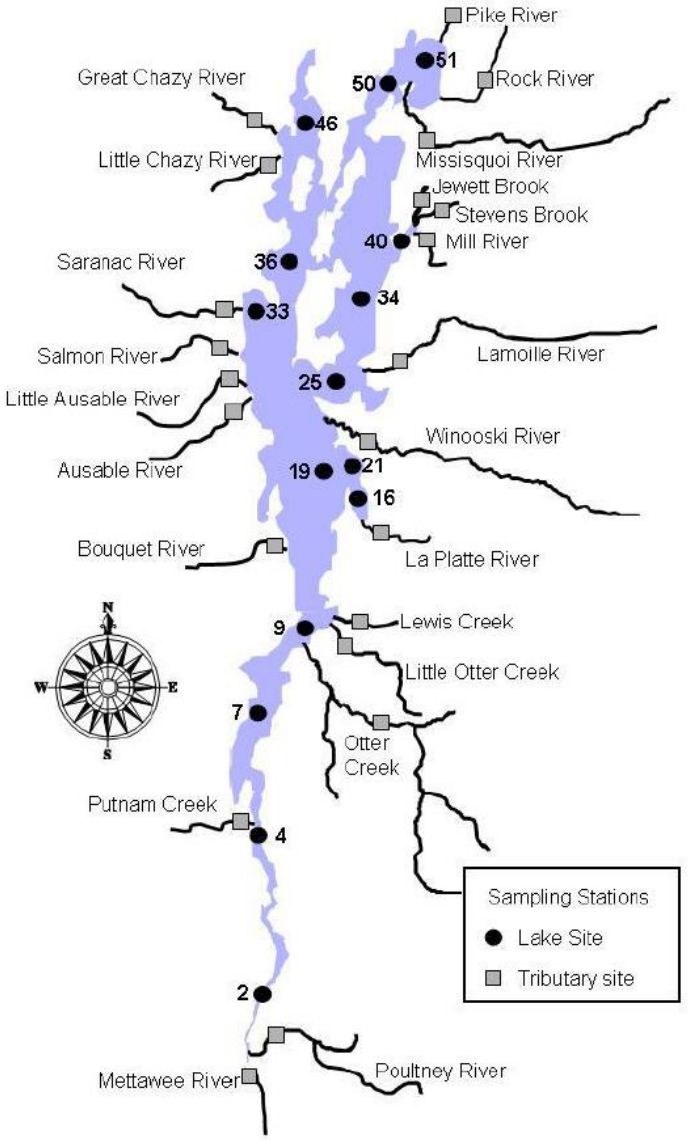

60 µg phosphorus per liter
40
20
0
1990
2000
2010
2020
shallow sites
deep sites

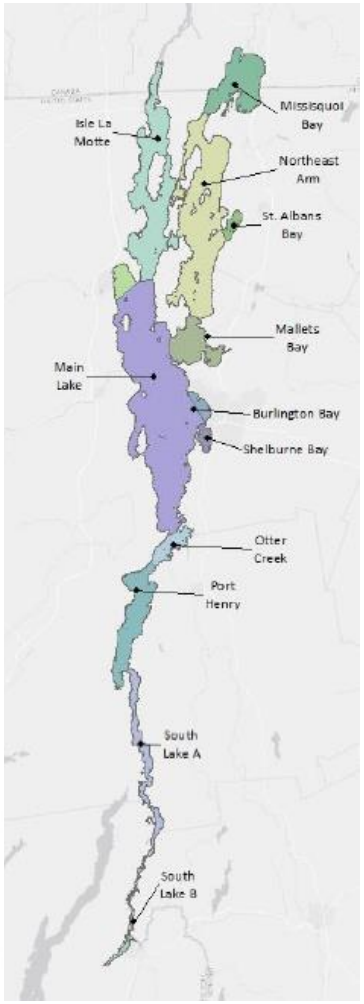

600 metric tons P per year
Winooski River
400
200
1990
2000
2010


Saranac River
50 metric tons P per year
40
30
20
1990
2000
2010


16 metric tons P per year
Little Ausable River
12
8
4
2000
2010


Lewis Creek
30 metric tons P per year
20
10
1990
2000
2010

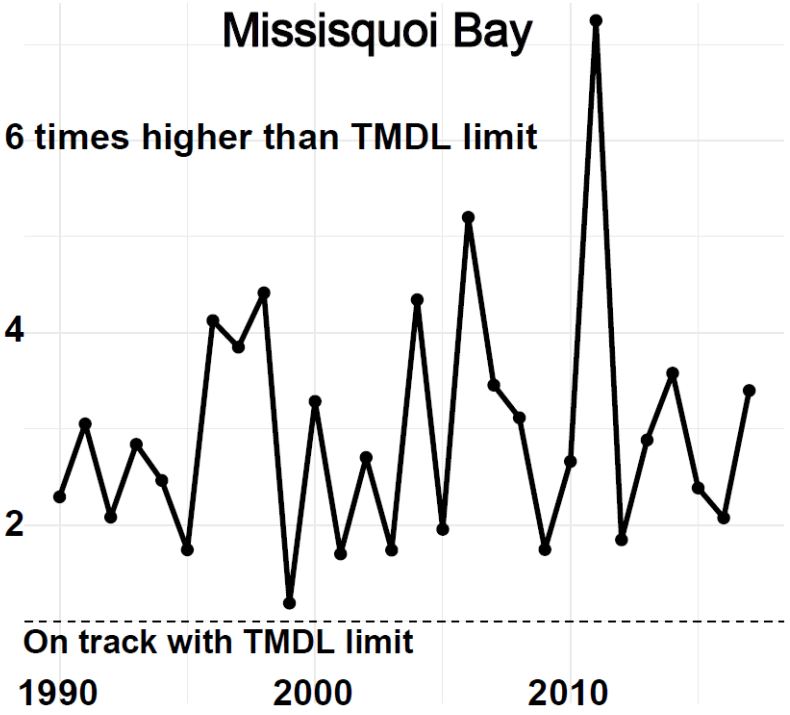


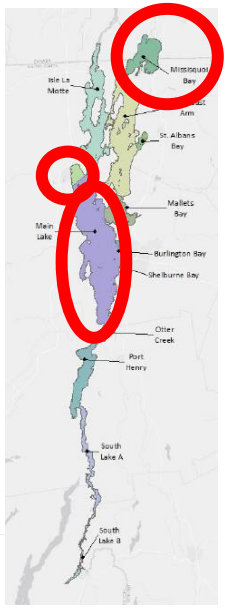


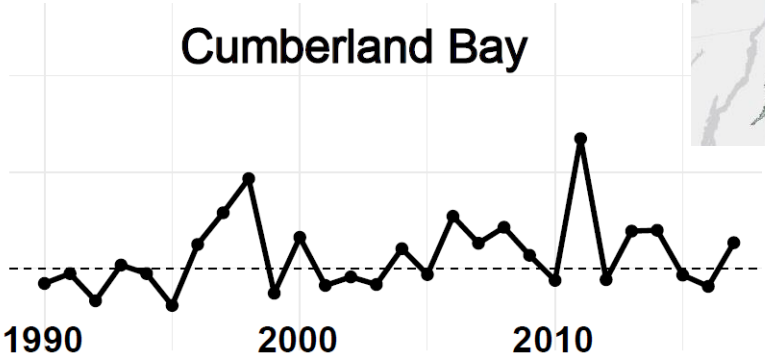
Long-term monitoring: 22 tributaries

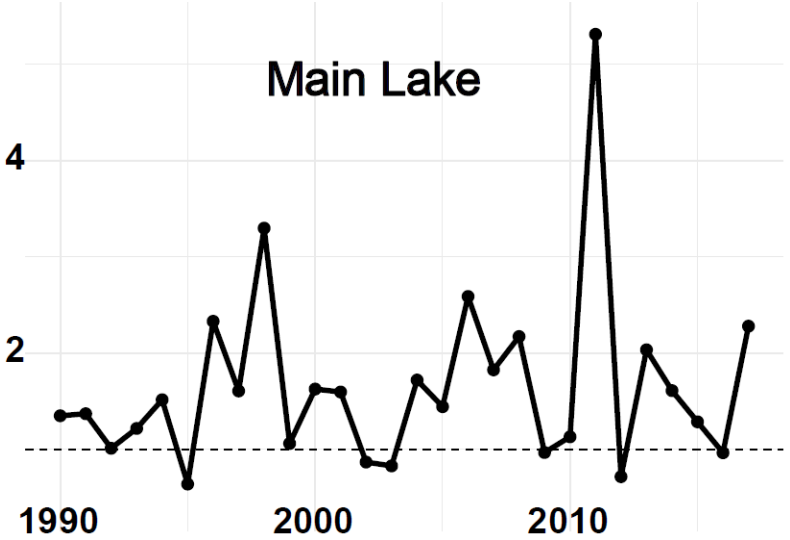
TMDL for phosphorus: 13 lake segments

How can we track progress?


Missisquoi Bay
6 times higher than TMDL limit
4
2
On track with TMDL limit
1990
2000
2010


Missisquoi Bay
Isle La Motte
St Albans Bay
Mallets Bay
Main Lake
Burlington Bay
Shelburne Bay
Otter Creek
Port Henry
South Lake A
South Lake B


Cumberland Bay
1990
2000
2010


Main Lake
4
2
1990
2000
2010

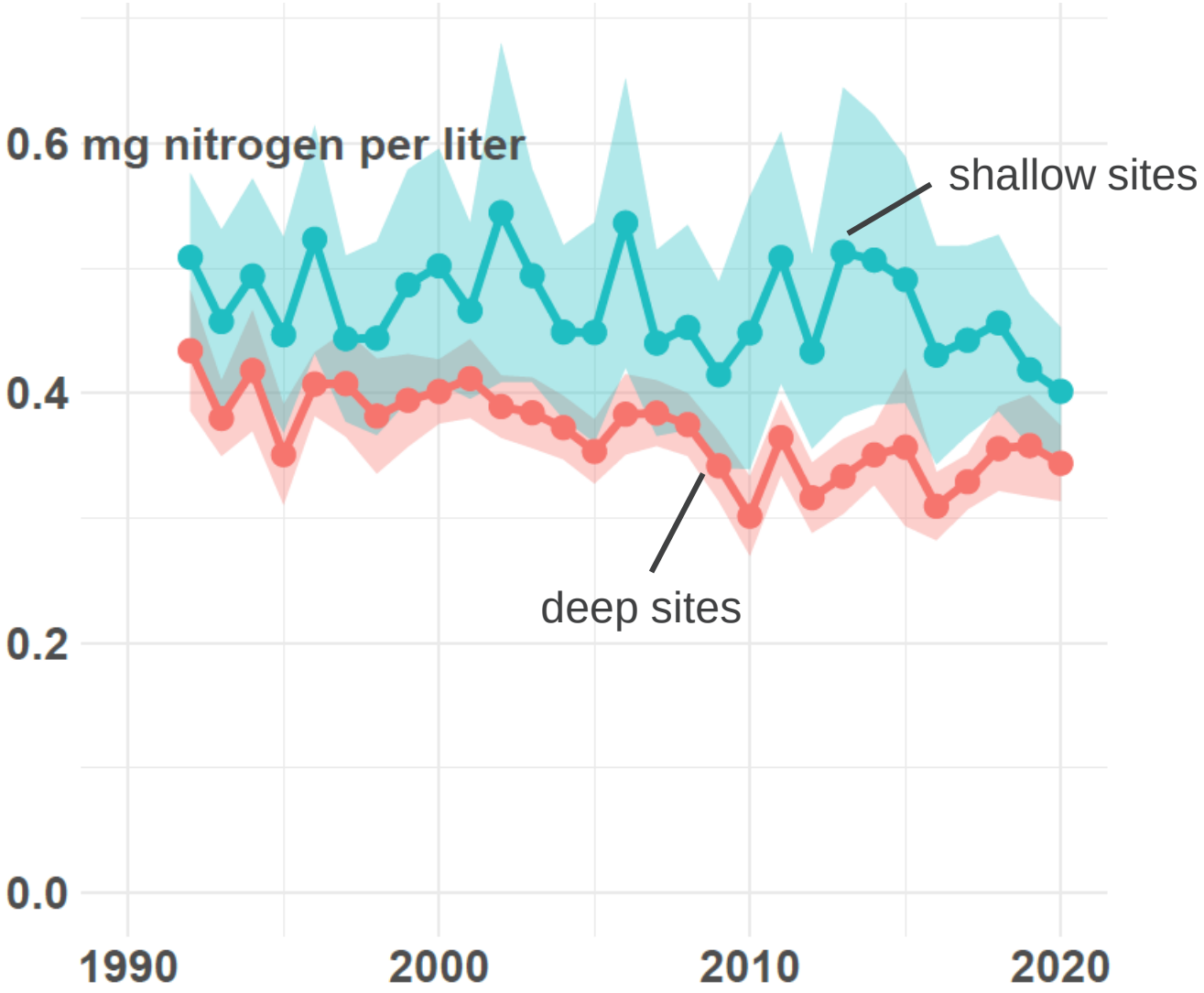
Phosphorus takeaways

In the lake:

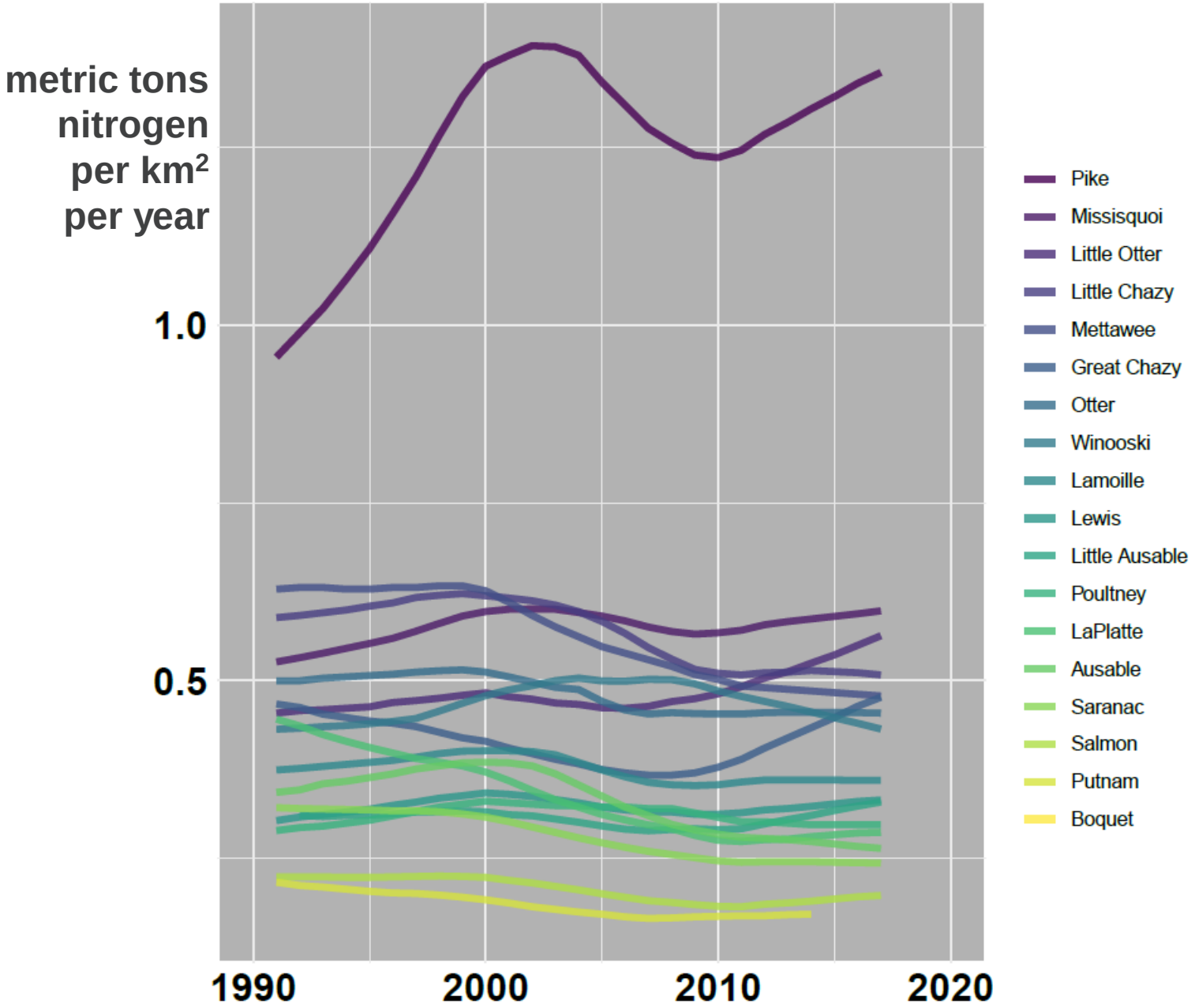
- **No trends** for most lake segments
- Increased lake-wide until recent decreases

Tributary loading:

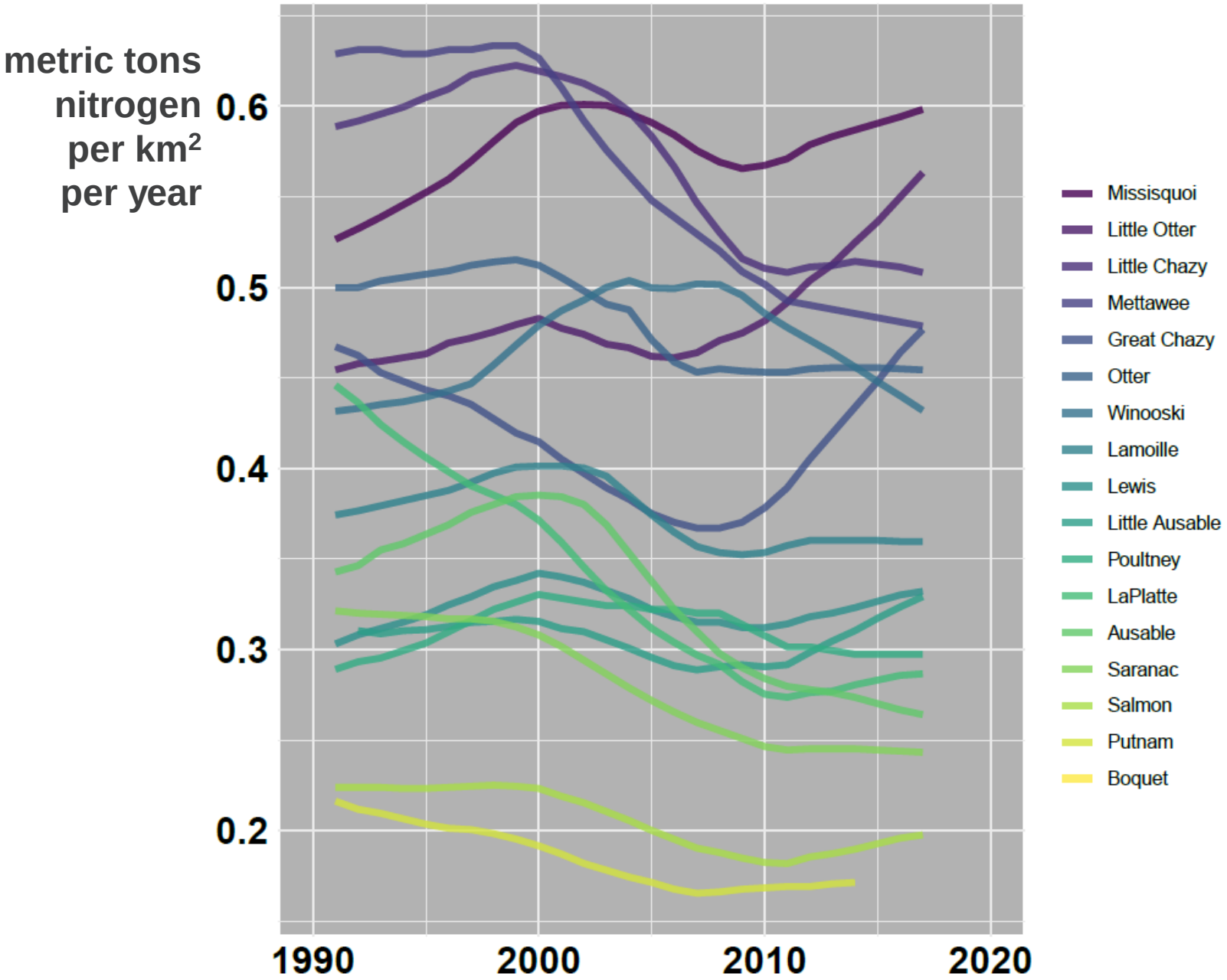
- Highly **variable**
- Loading remains **too high** to meet water quality goals
- **No trends** in 10 out of 18 tributaries
- **Decreasing trends** in three rivers, variable timeframes
- **Increasing trends** in five rivers, variable timeframes


0.6 mg nitrogen per liter
0.4
0.2
0.0
1990
2000
2010
2020
shallow sites
deep sites

Flow-normalized total nitrogen yield



Flow-normalized total nitrogen yield



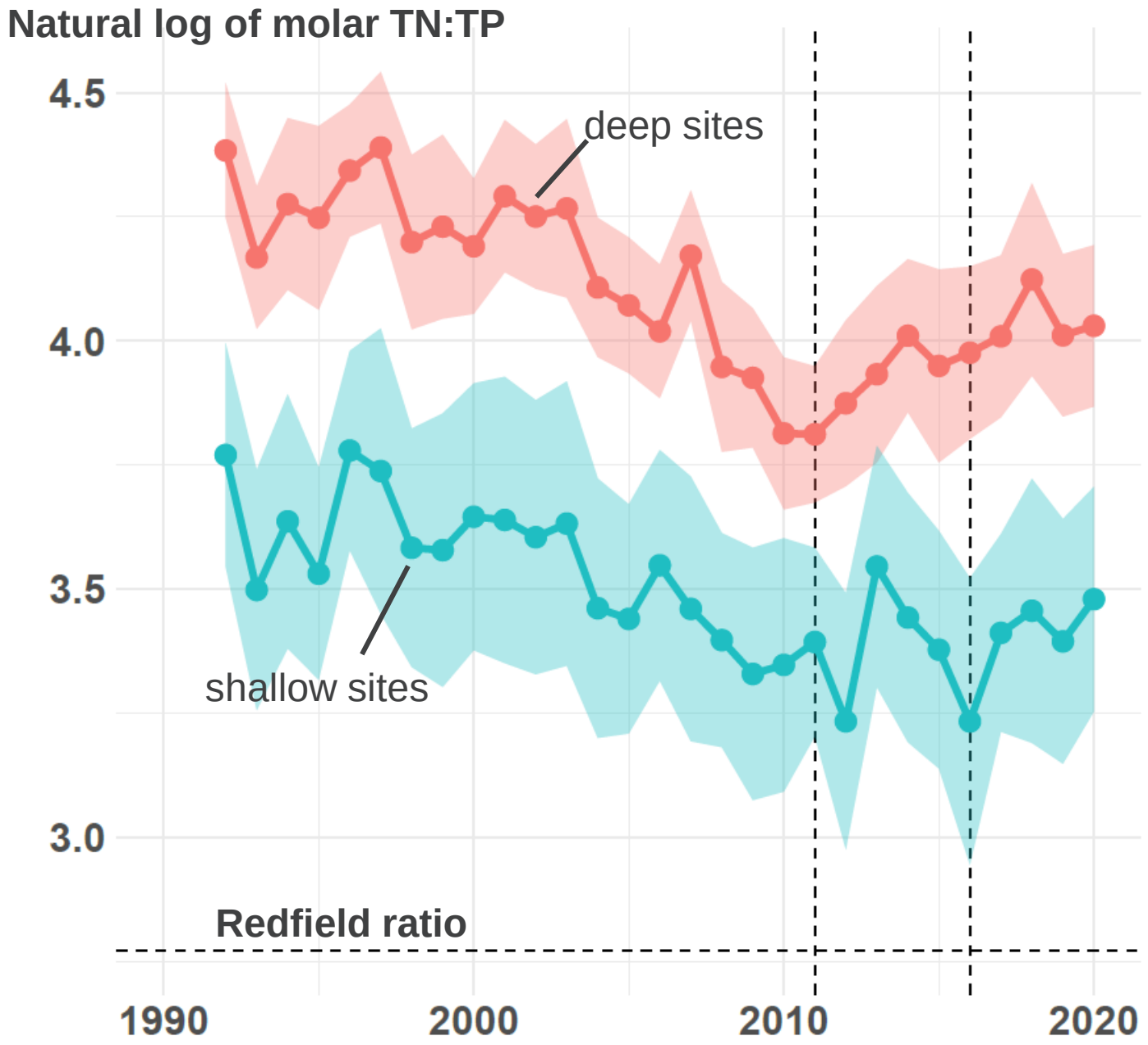
Nitrogen takeaways

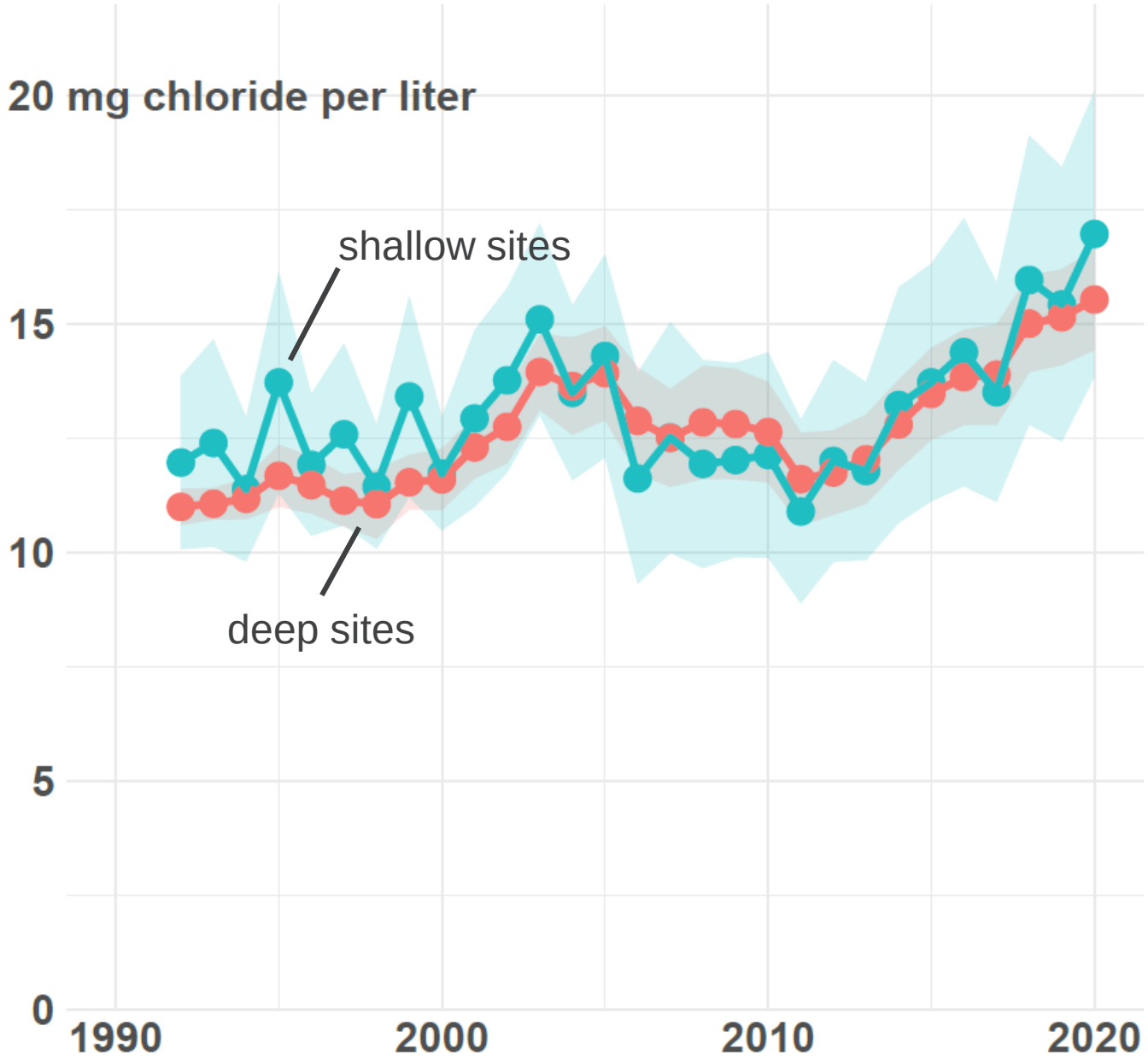
In the lake

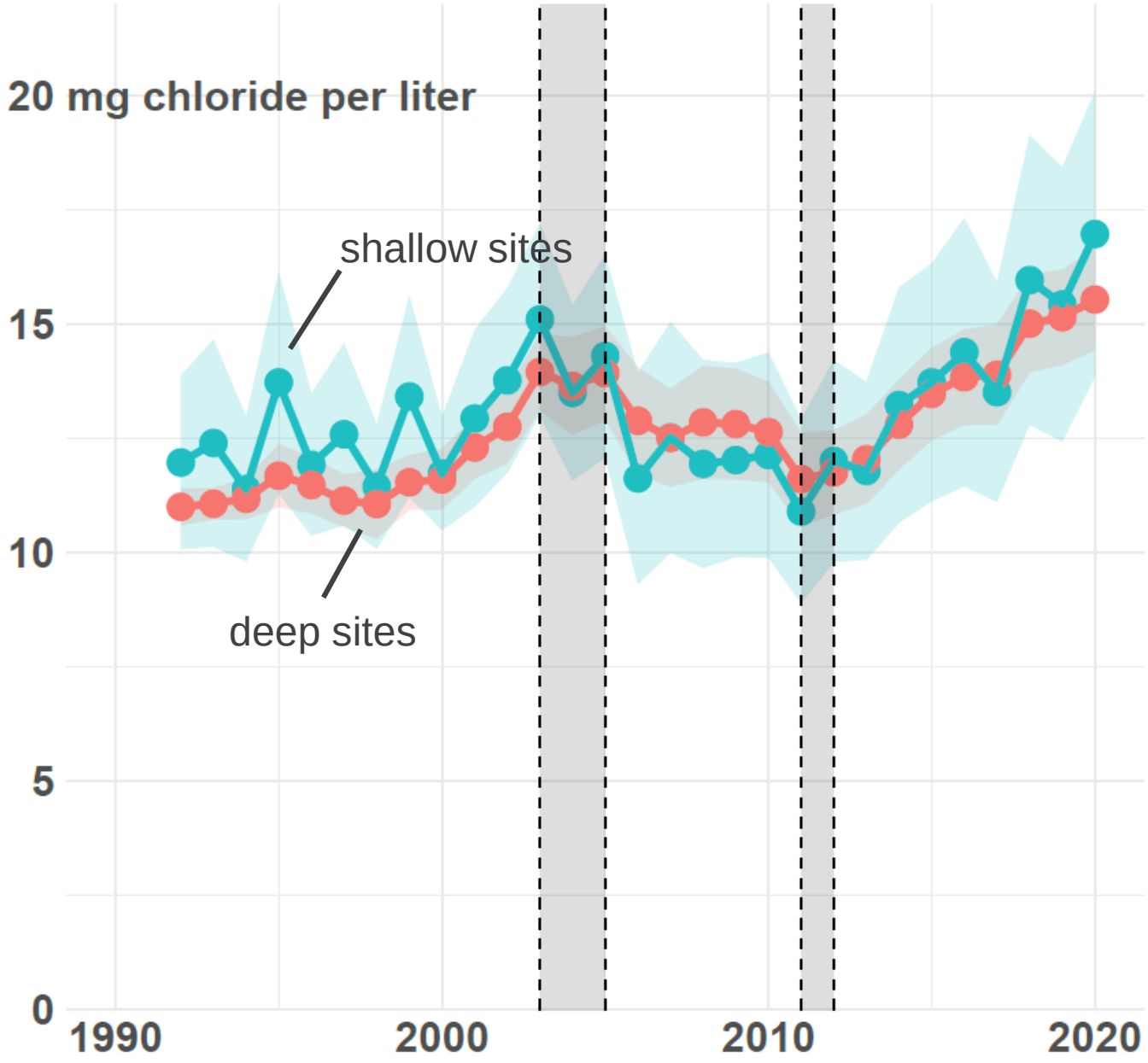
- Decreased lake-wide
- Trends at deep sites have shifted in the past decade

Tributaries:

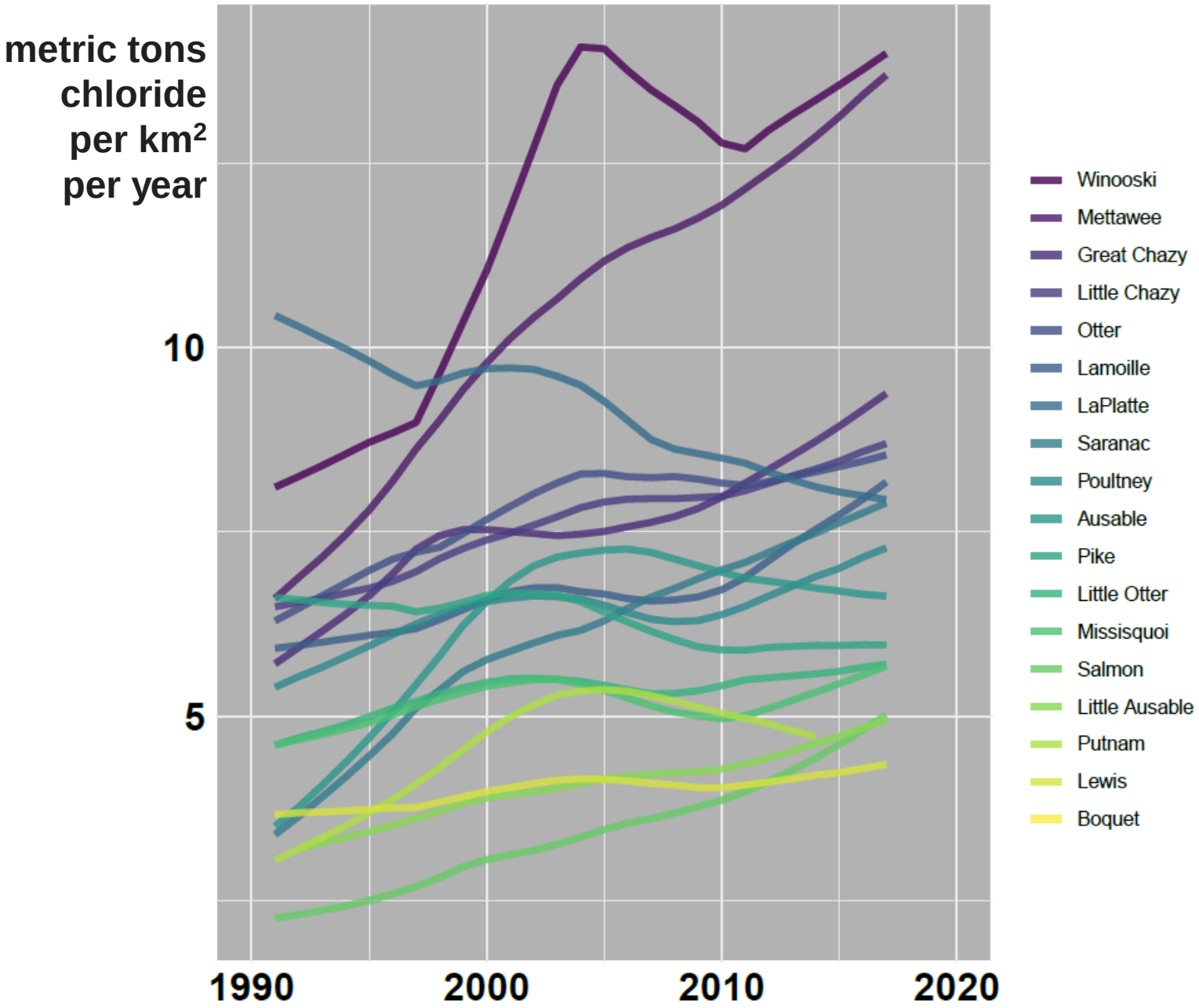
- Pike River
- **Trends** for 14 out of 18 tributaries
- From 2004 - 2017:
  - **Six** rivers **decreased**
  - **Two** rivers **increased**
  - **Ten** rivers had **no trend**


Natural log of molar TN:TP
4.5
4.0
3.5
3.0
deep sites
shallow sites
Redfield ratio
1990
2000
2010
2020


20 mg chloride per liter
shallow sites
deep sites
15
10
5
0
1990
2000
2010
2020


20 mg chloride per liter
shallow sites
deep sites
15
10
5
0
1990
2000
2010
2020

Flow-normalized chloride yield



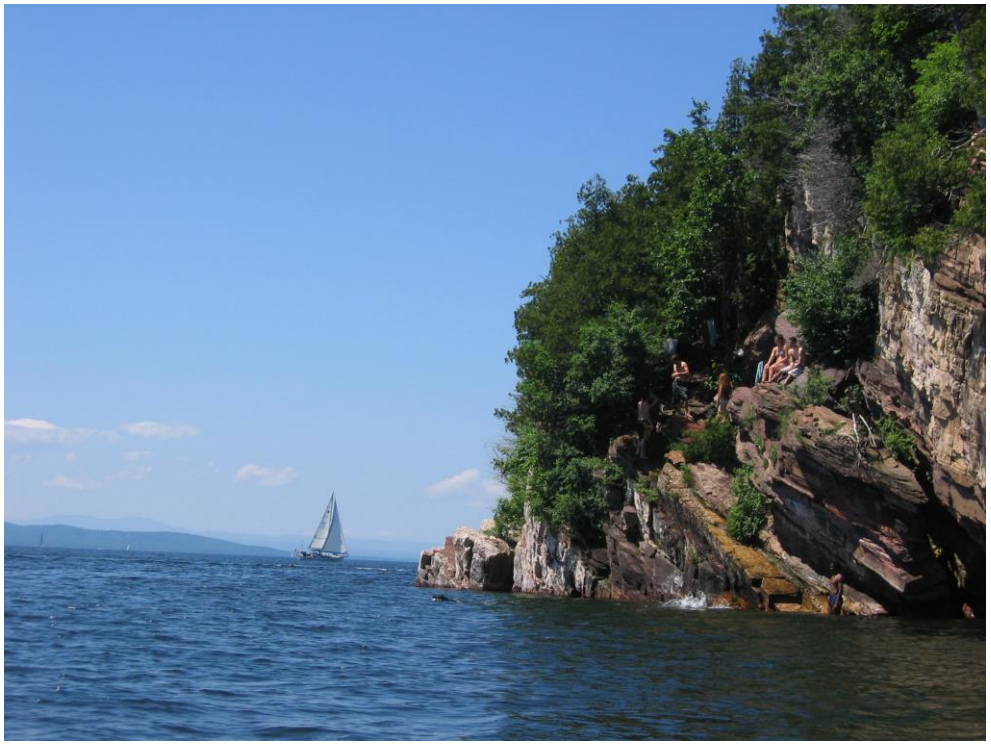
Chloride takeaways

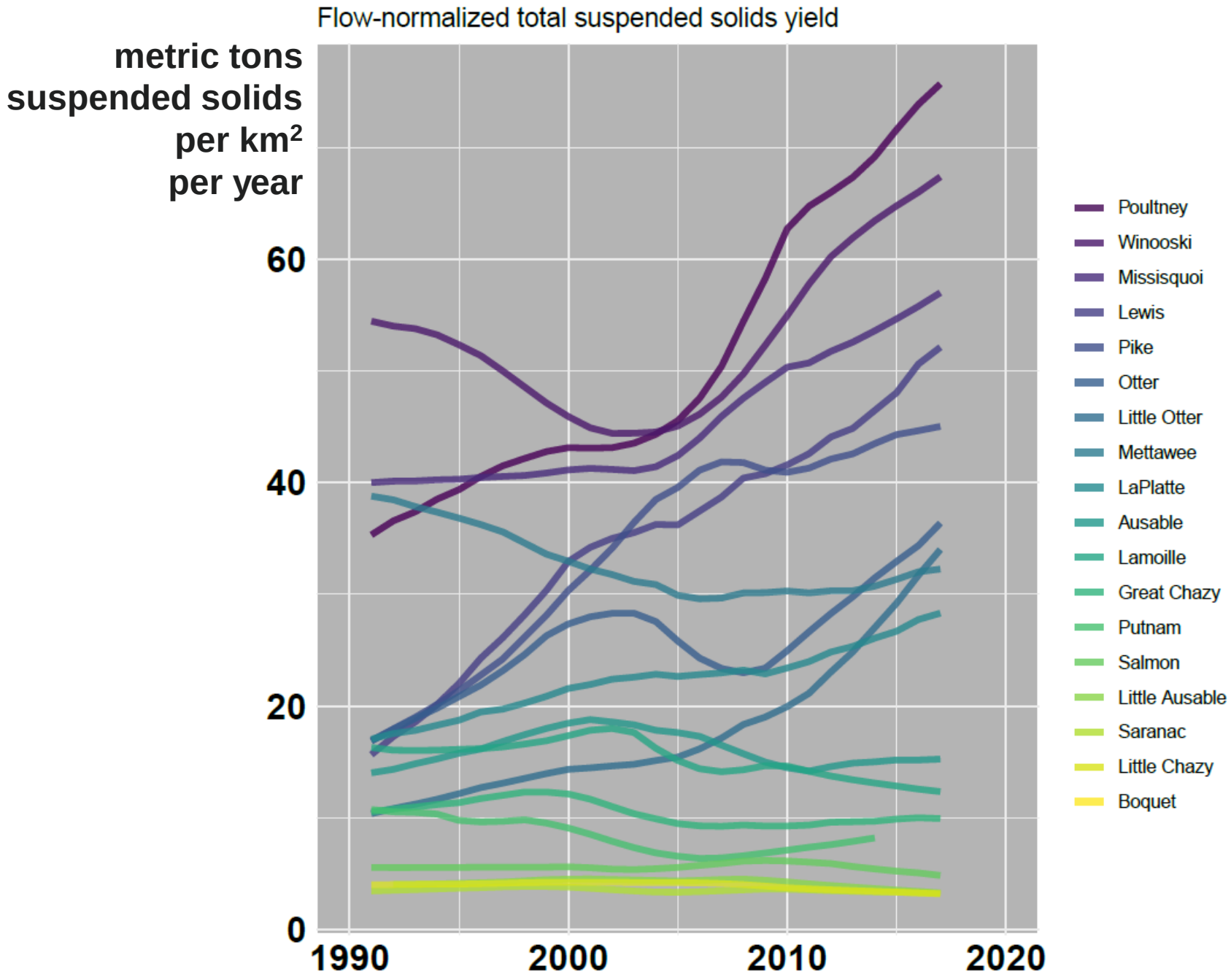
In the lake

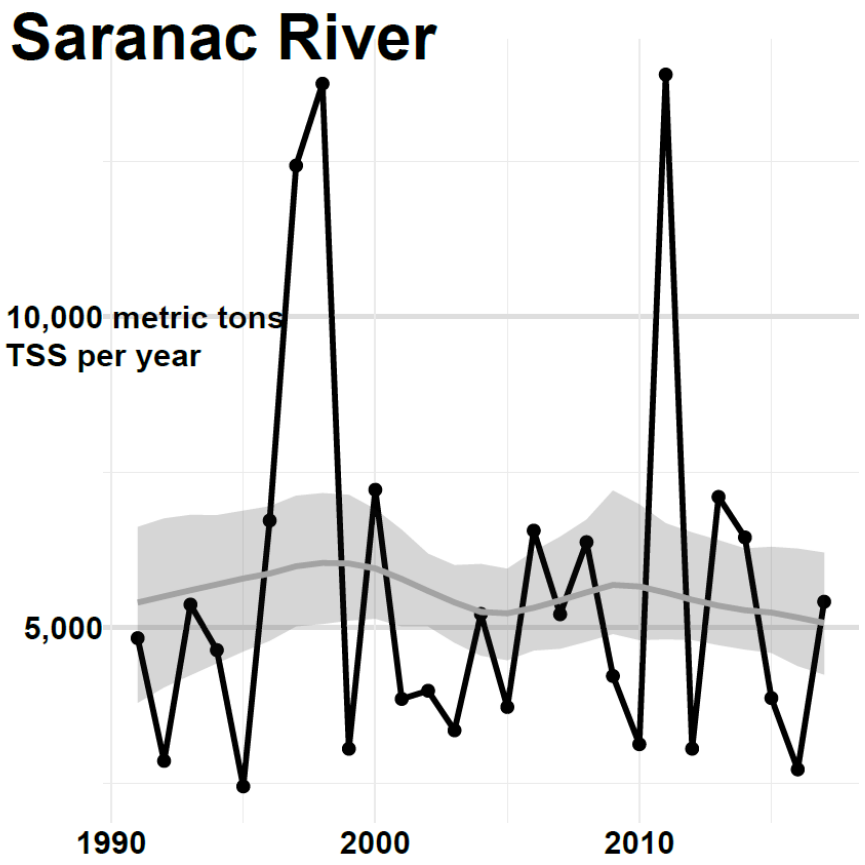
- Well below EPA thresholds
- May be nearing double background concentration
- **Changing**, with increases in the past decade

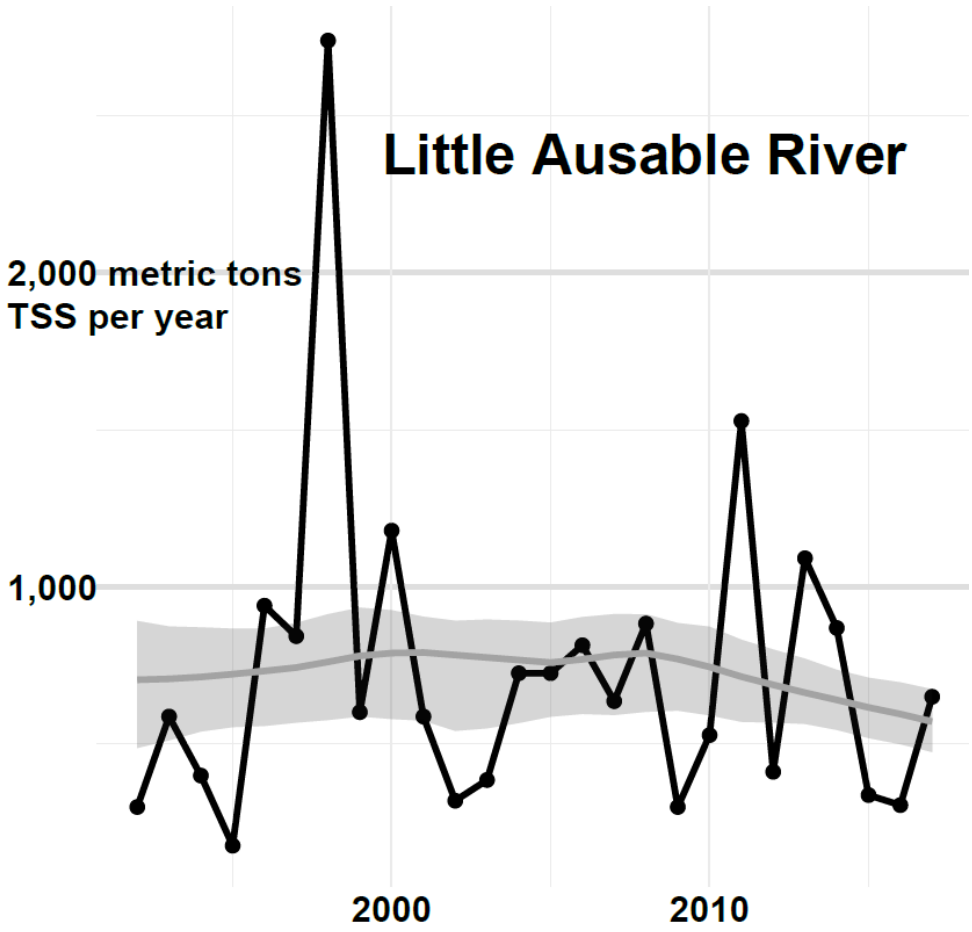
Tributary loading

- **Increasing trends** for 16 out of 18 tributaries
- Two rivers show full record **decreases**




Flow-normalized total suspended solids yield
metric tons suspended solids per km² per year
60
40
20
0
1990
2000
2010
2020
Poultney
Winooski
Missisquoi
Lewis
Pike
Otter
Little Otter
Mettawee
LaPlatte
Ausable
Lamoille
Great Chazy
Putnam
Salmon
Little Ausable
Saranac
Little Chazy
Boquet


Saranac River
10,000 metric tons
TSS per year
5,000
1990
2000
2010


Little Ausable River
2,000 metric tons
TSS per year
1,000
2000
2010

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?

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Lake Champlain tributary loading report (2019): bit.ly/2wDAQ17

Lake Champlain Basin Program

NE IW PCC