Increased Mercury in Lake Champlain Fish Maybe Linked to Extreme Climatic Events

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National Atmospheric Deposition Program Scientific Symposium

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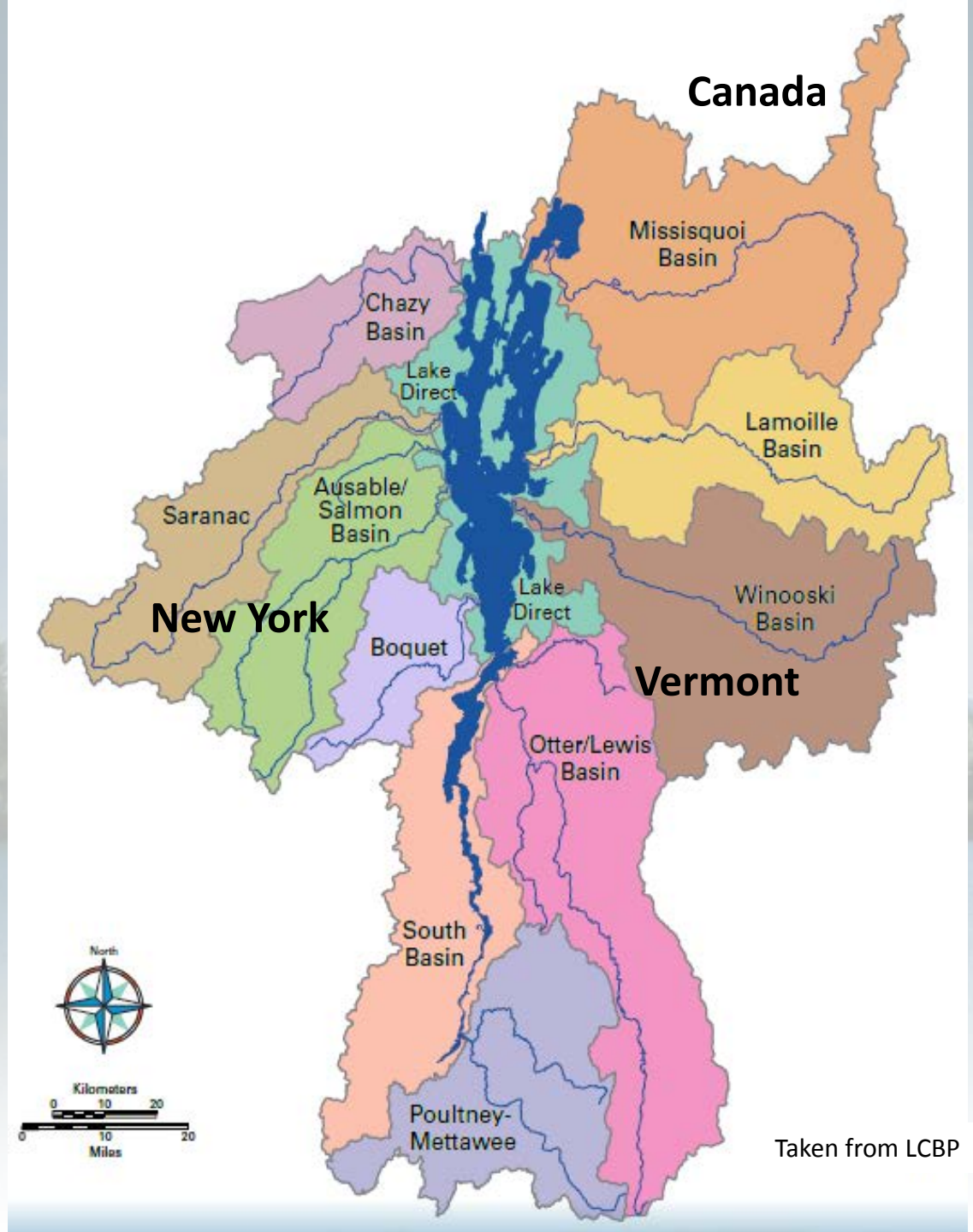
Lake Champlain Watershed

- Length: 193 km
- Max Depth: 122m
- Lake Area: 1127 km^2
- Volume: 25.8 km^3
- Land:Lake Surface Area: 19:1
- Retention Time: 2-36 months



Taken from LCBP

Project Outline

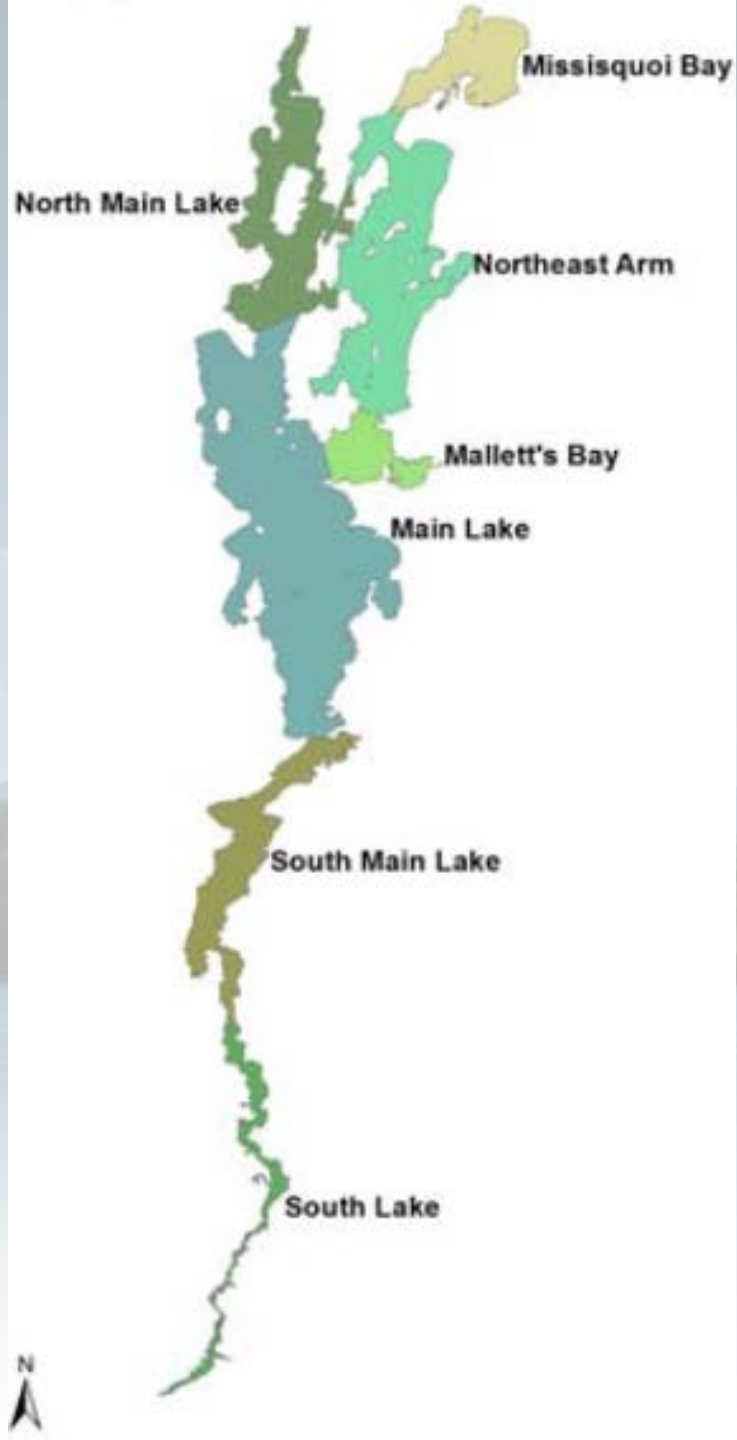
Re-analysis of fish Hg ~5 years to inform consumption advisories

Five fish species

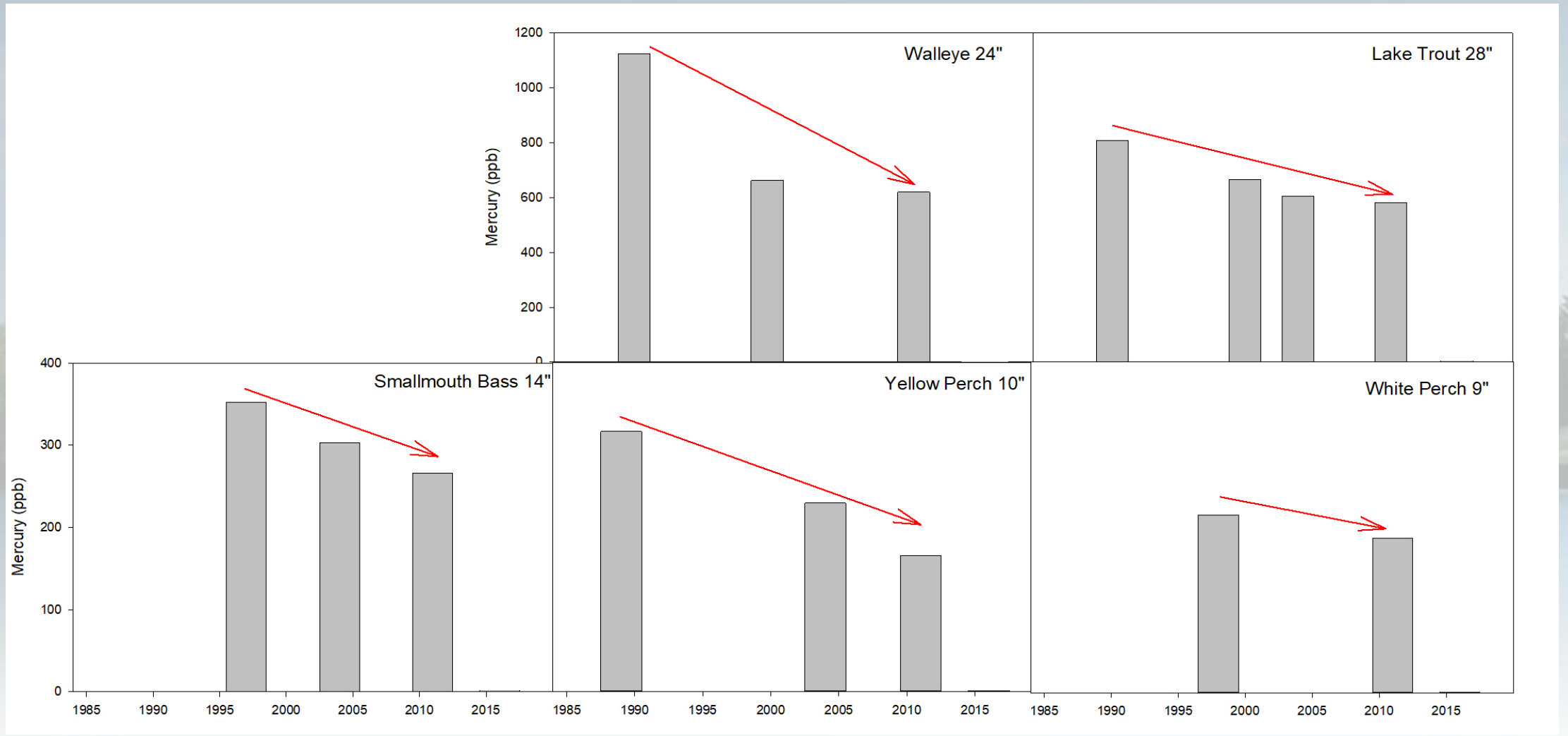
- Smallmouth Bass
- Yellow Perch
- White Perch
- Walleye
- Lake Trout

Seven Lake Segments

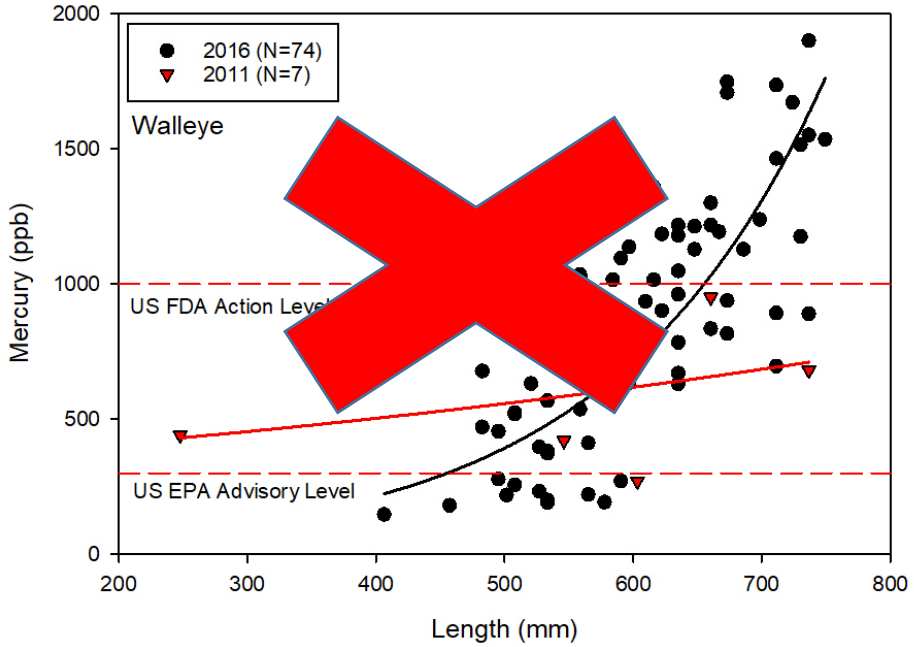
600+ THg measurements

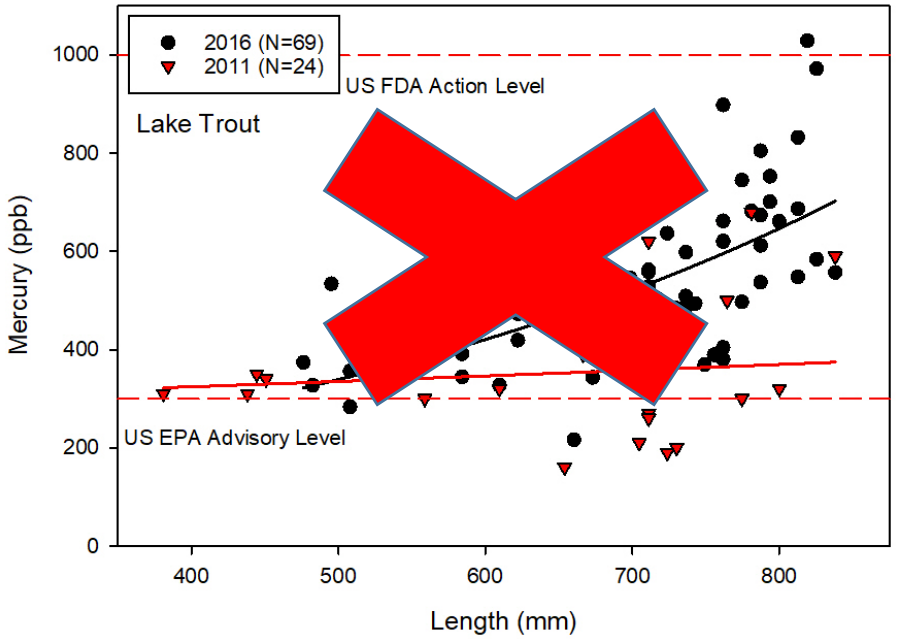


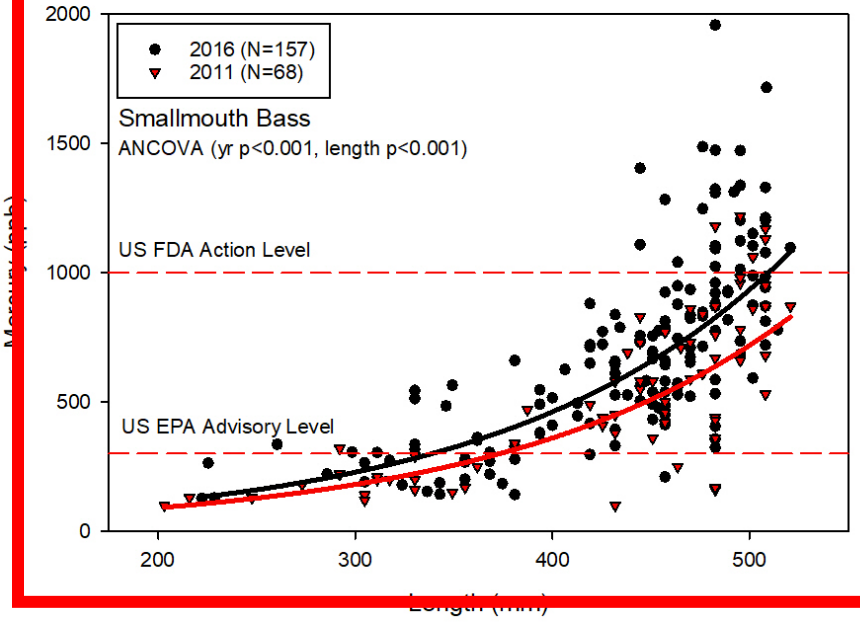
2011 Study – Lake-wide Mercury Decreasing For >2 Decades

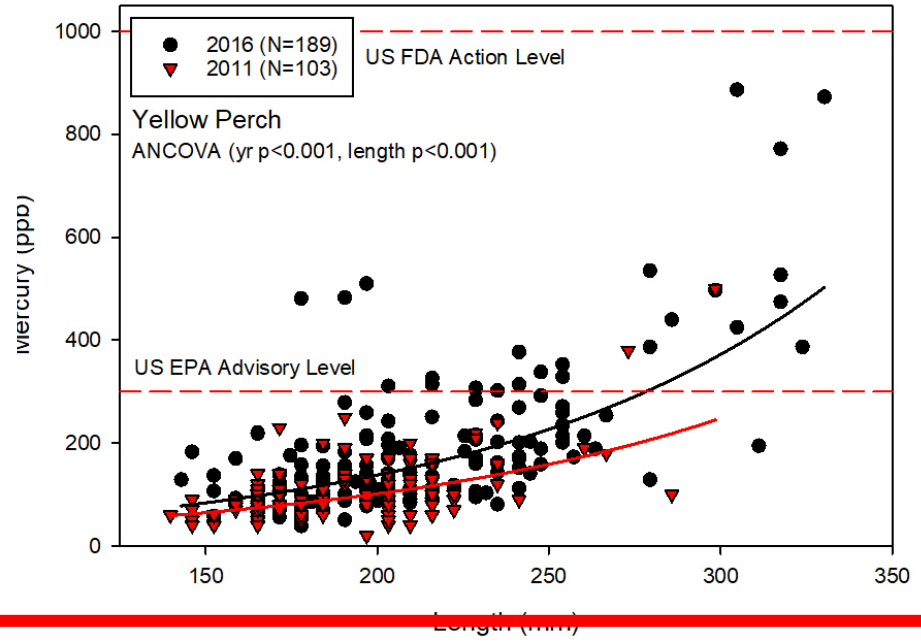


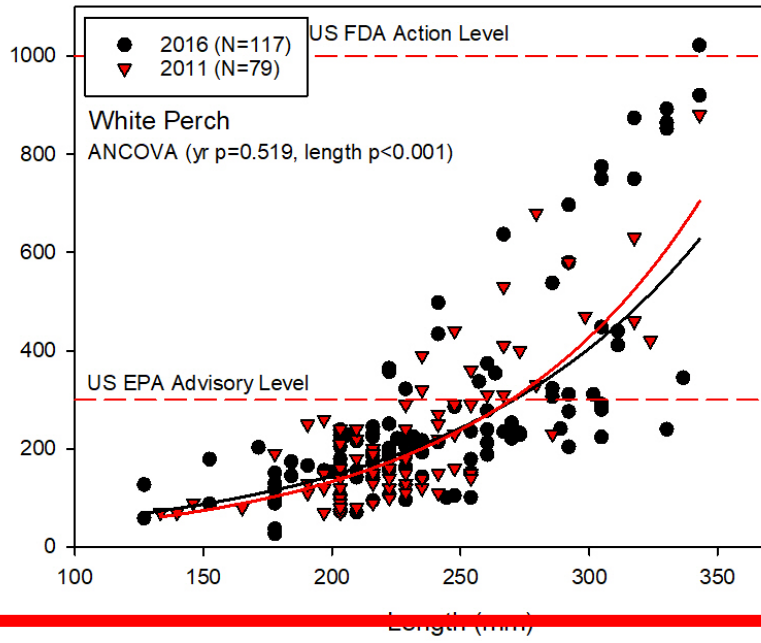
2016 Study - M

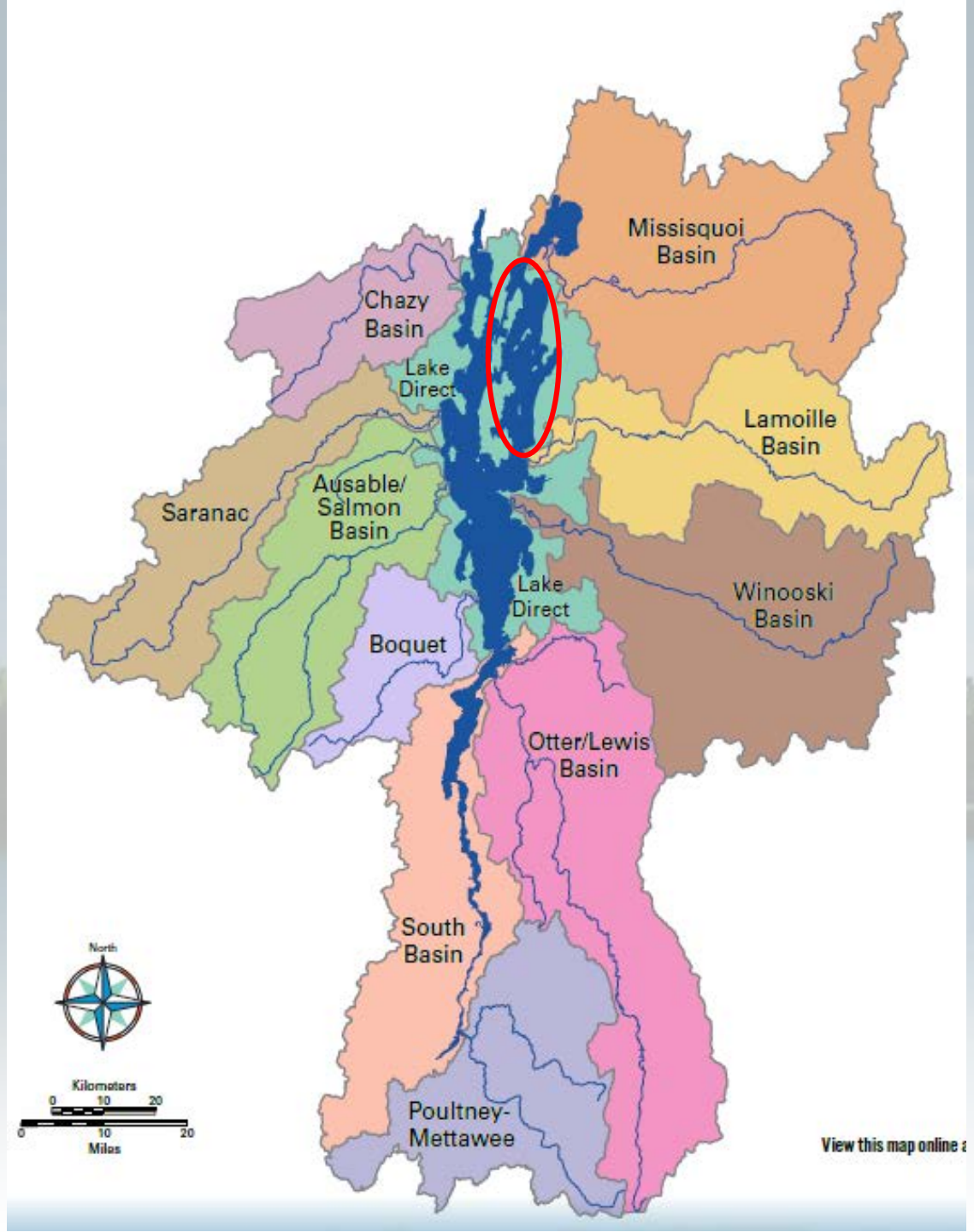

2016 (N=74)
2011 (N=7)
Walleye
US FDA Action Level
US EPA Advisory Level
Mercury (ppb)
Length (mm)

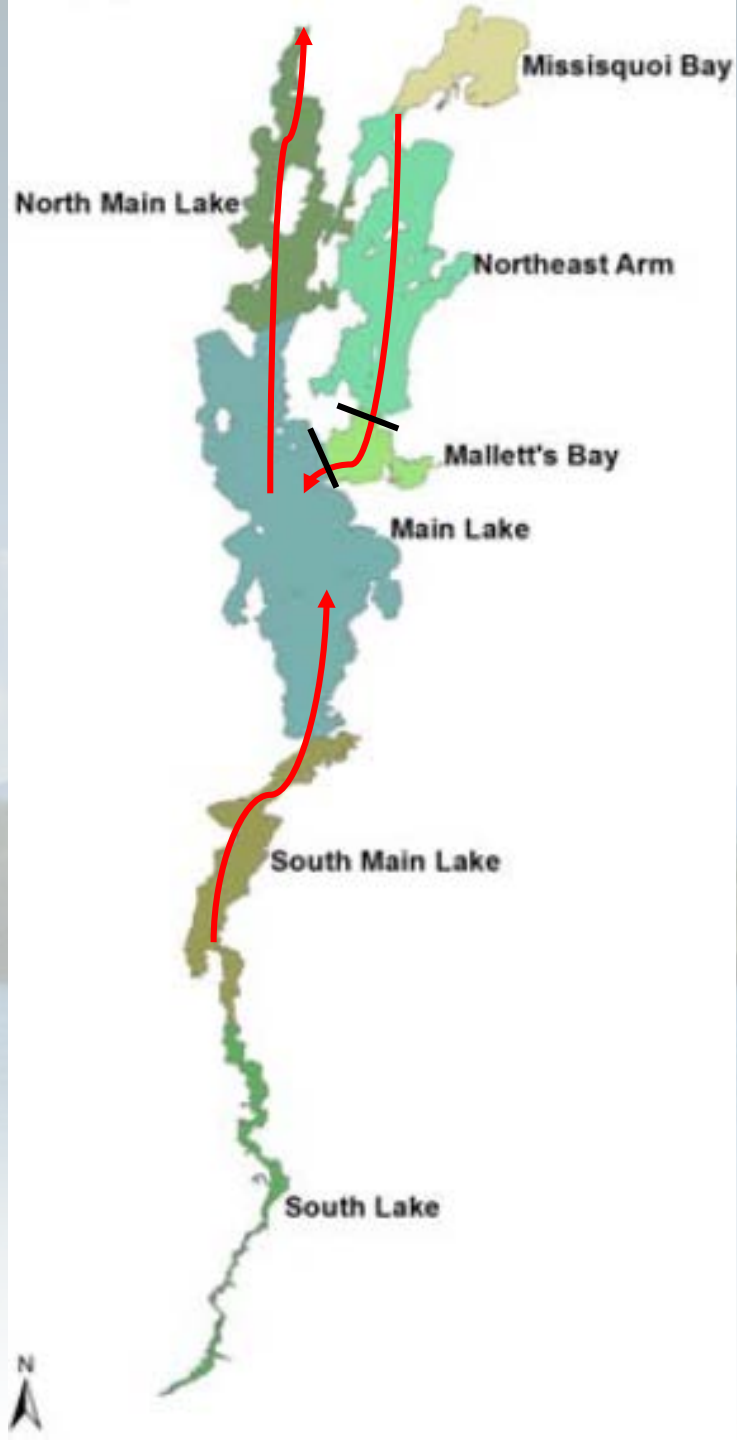

2016 (N=69)
2011 (N=24)
US FDA Action Level
Lake Trout
US EPA Advisory Level
Mercury (ppb)
Length (mm)


2016 (N=157)
2011 (N=68)
Smallmouth Bass
ANCOVA (yr p<0.001, length p<0.001)
US FDA Action Level
US EPA Advisory Level

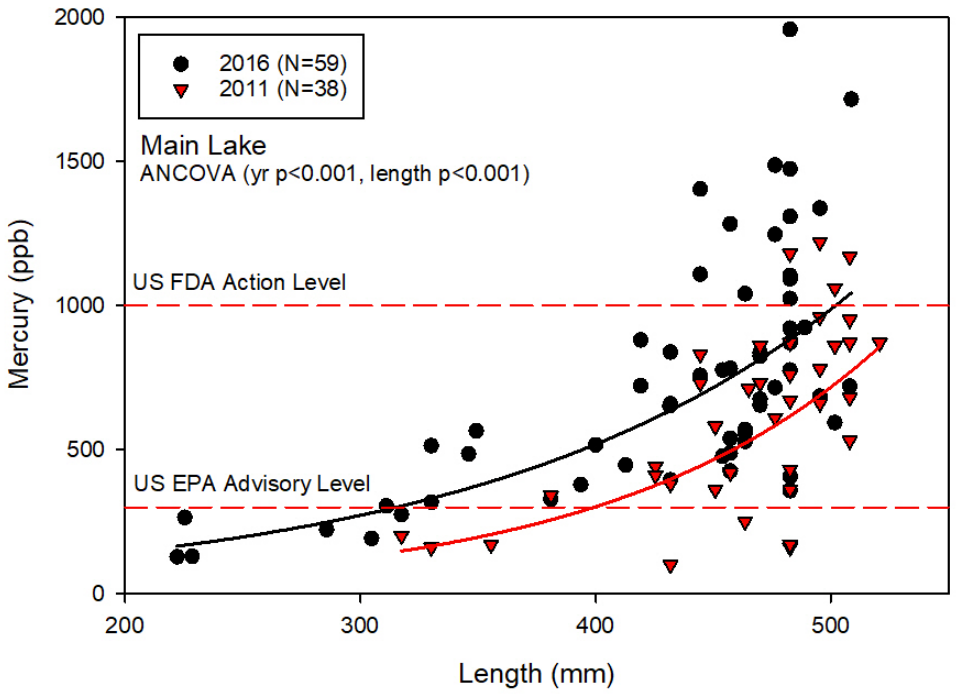

2016 (N=189)
2011 (N=103)
US FDA Action Level
Yellow Perch
ANCOVA (yr p<0.001, length p<0.001)
US EPA Advisory Level

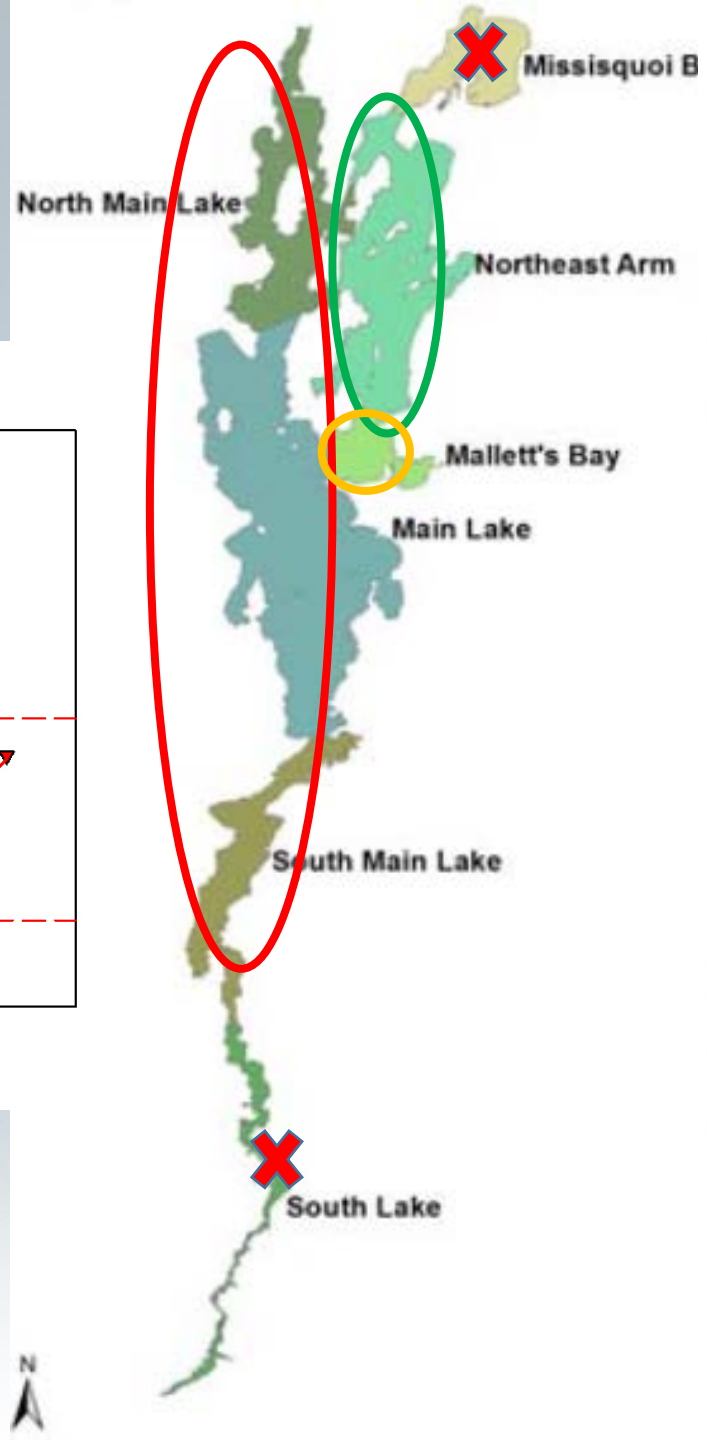

2016 (N=117)
2011 (N=79)
US FDA Action Level
White Perch
ANCOVA (yr p=0.519, length p<0.001)
US EPA Advisory Level

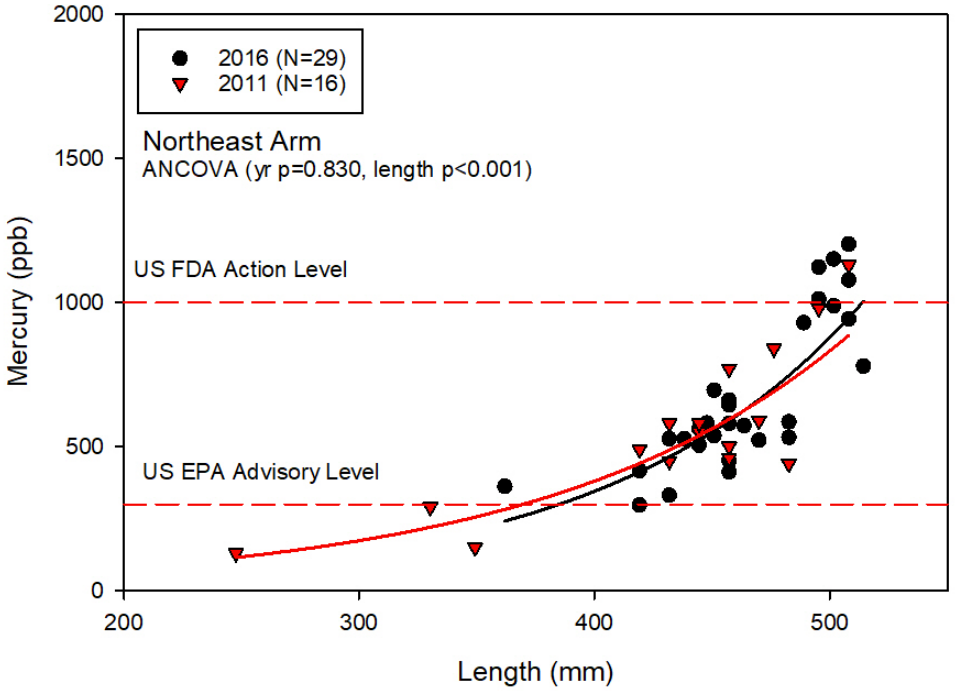

Missisquoi Basin
Chazy Basin
Lake Direct
Lamoille Basin
Saranac
Ausable/ Salmon Basin
Lake Direct
Winooski Basin
Boquet
Otter/Lewis Basin
South Basin
Poultney-Mettawee
North
Kilometers
0 10 20
0 10 20
Miles
View this map online

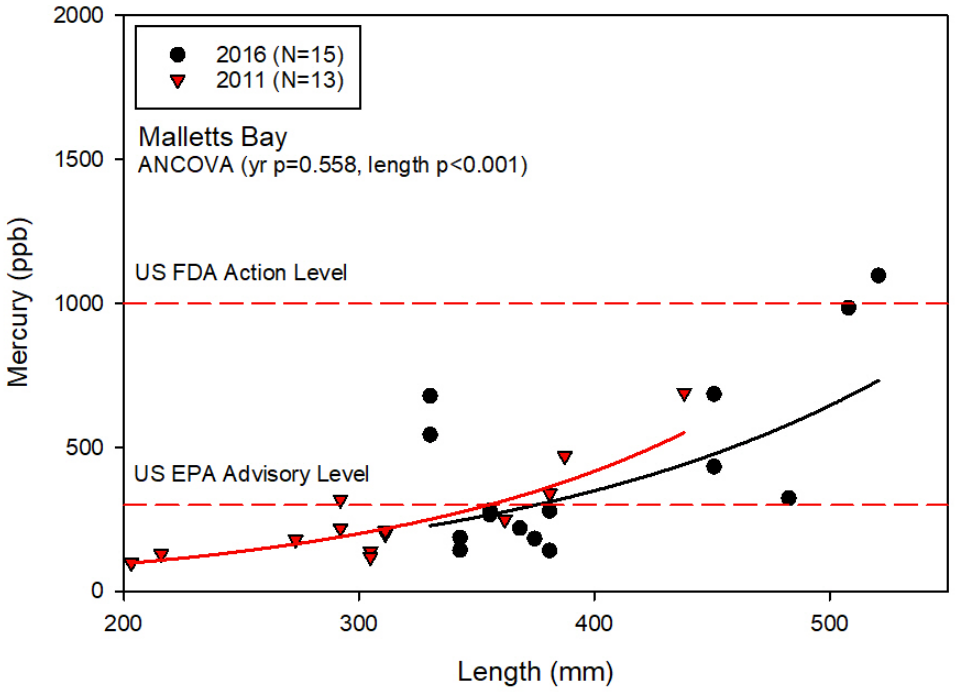

Missisquoi Bay
North Main Lake
Northeast Arm
Mallett's Bay
Main Lake
South Main Lake
South Lake
N

Smallmouth Bass

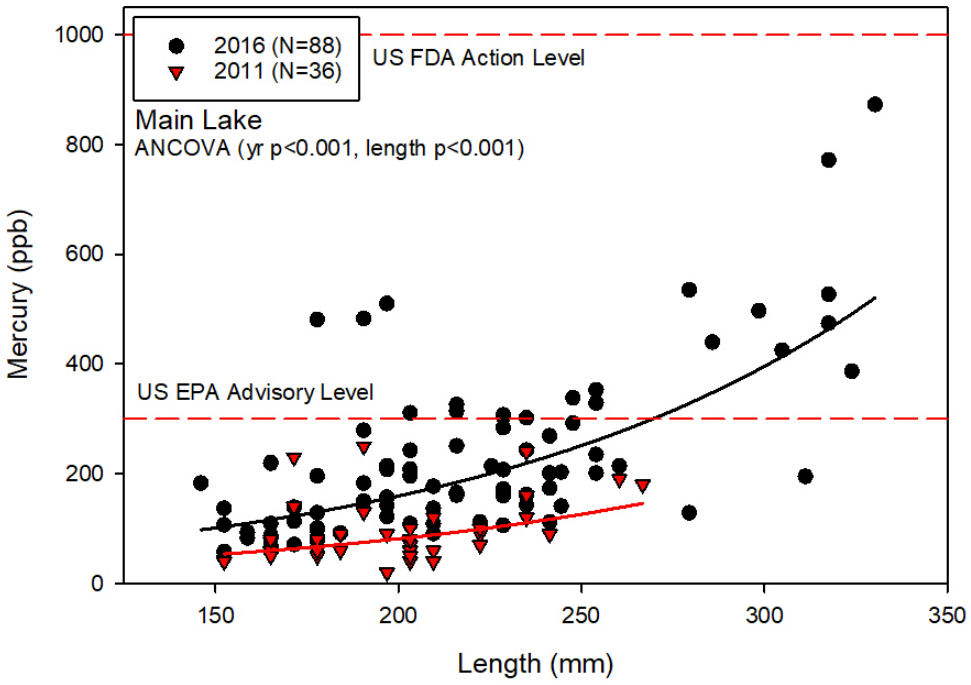


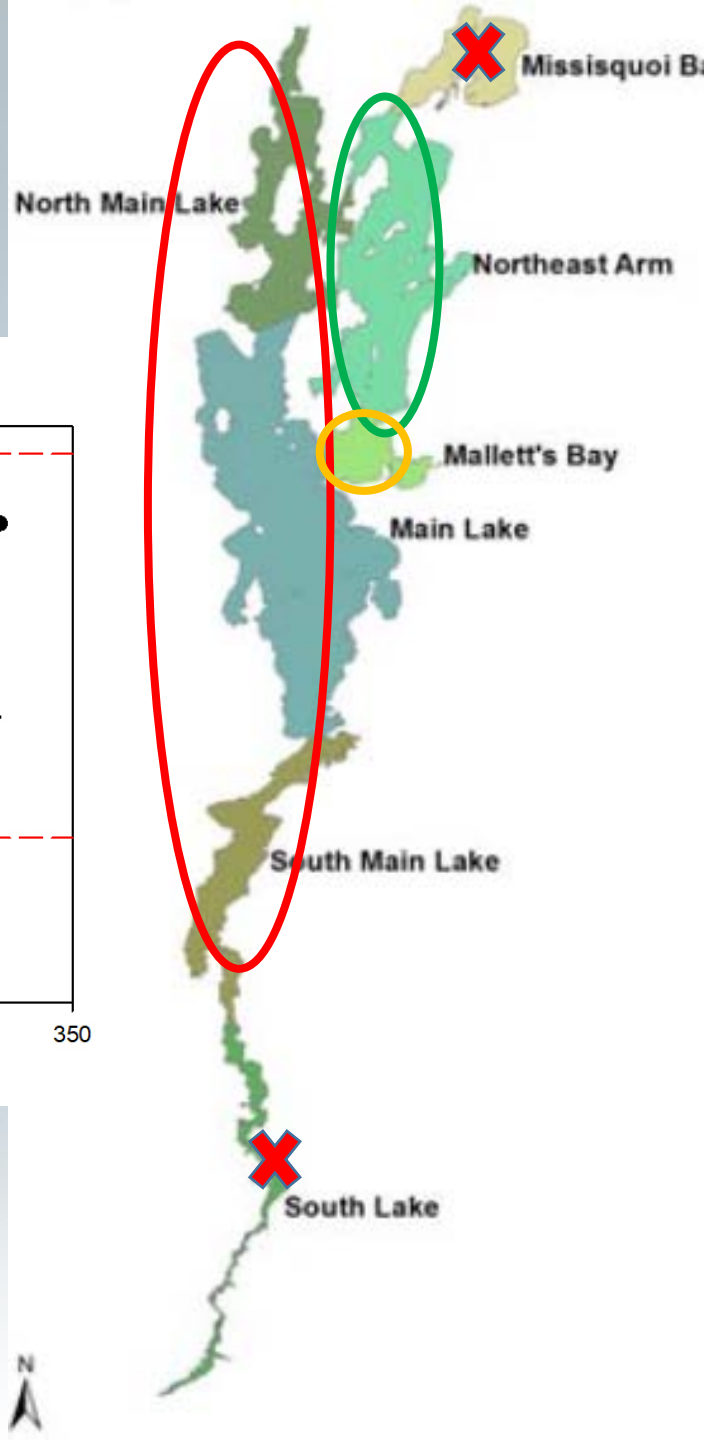


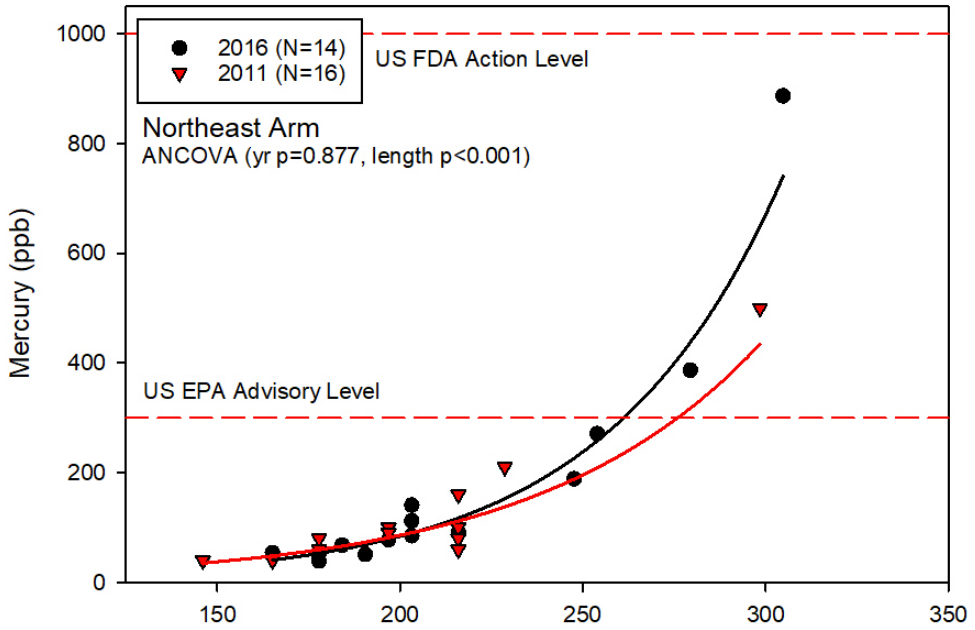


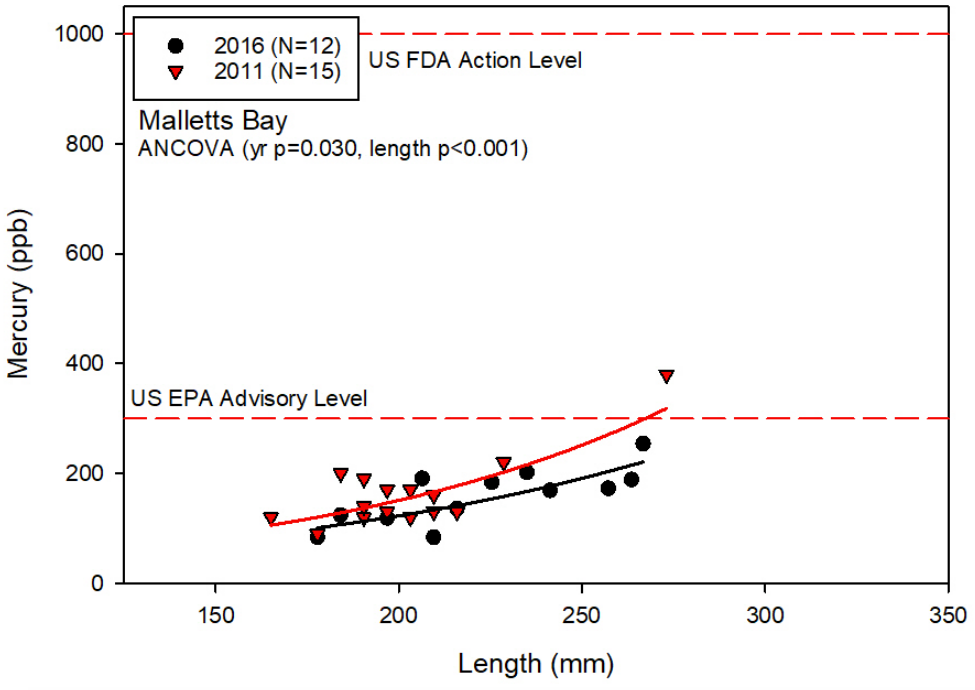


Yellow Perch

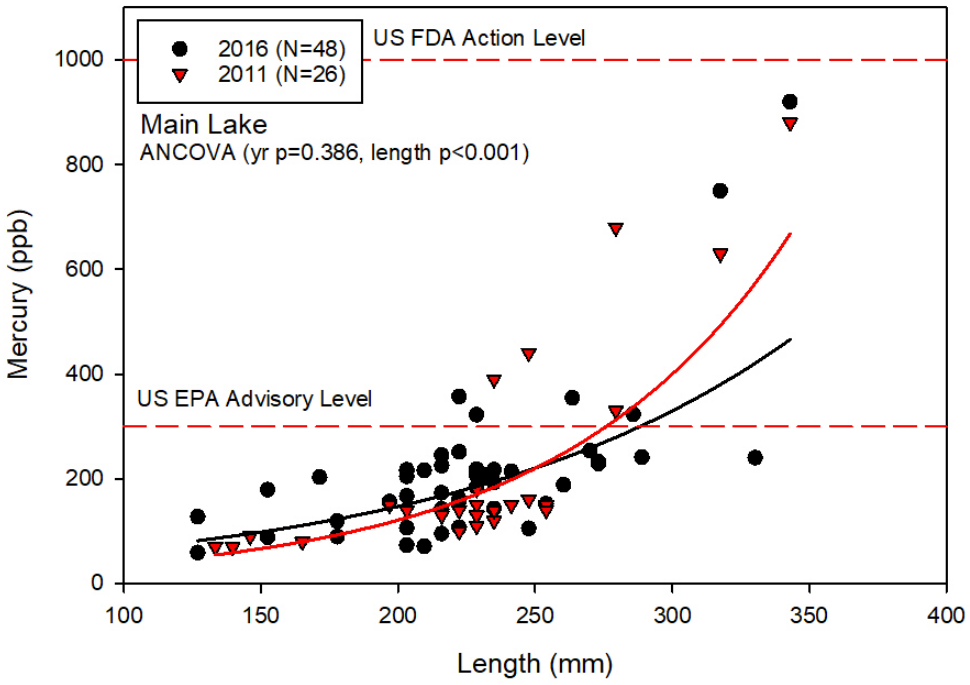


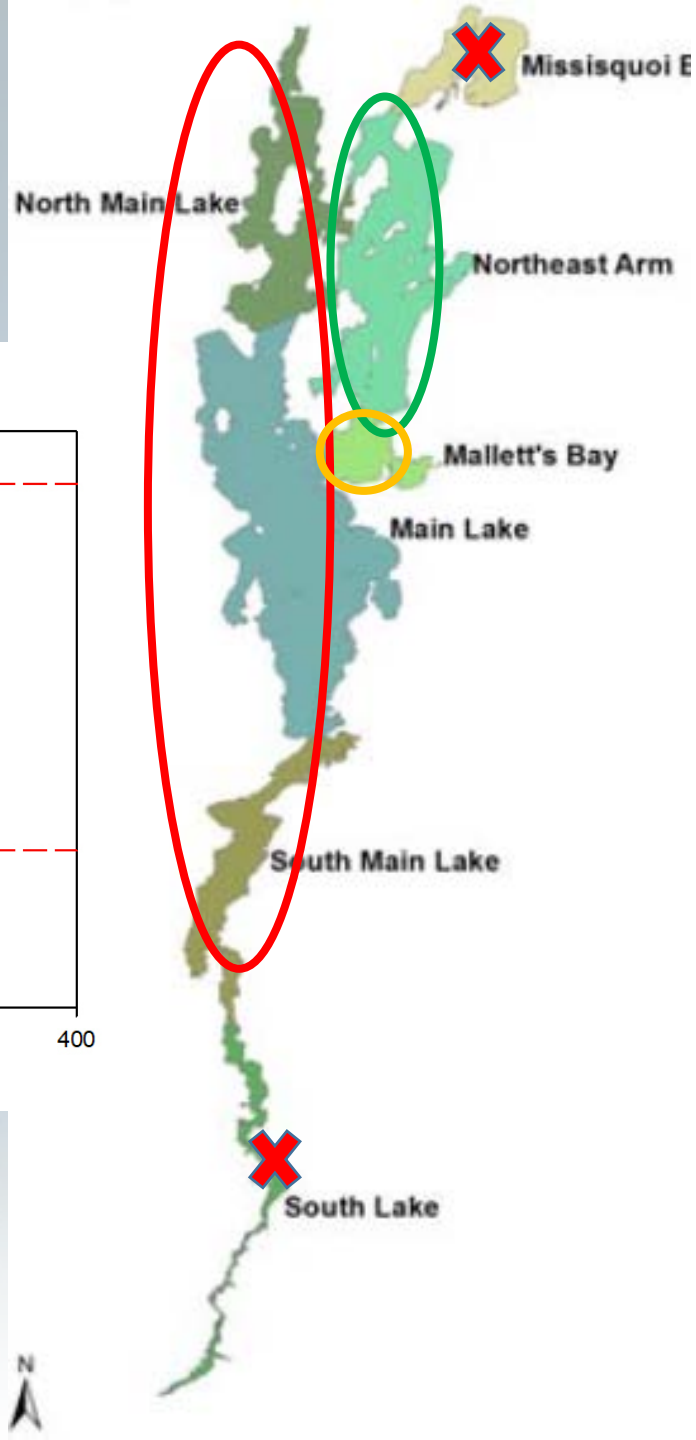


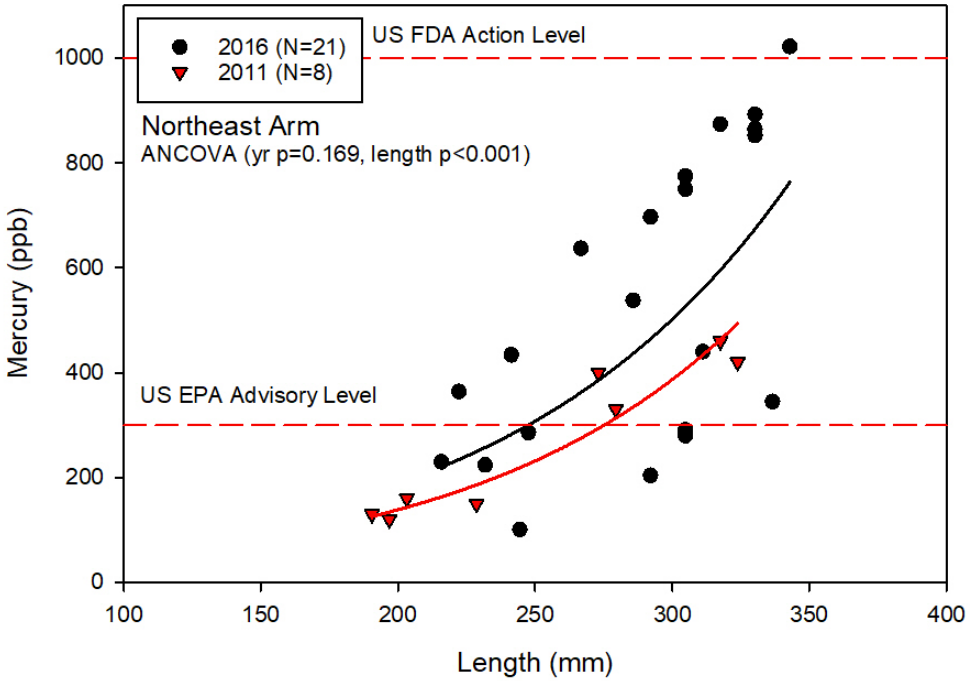


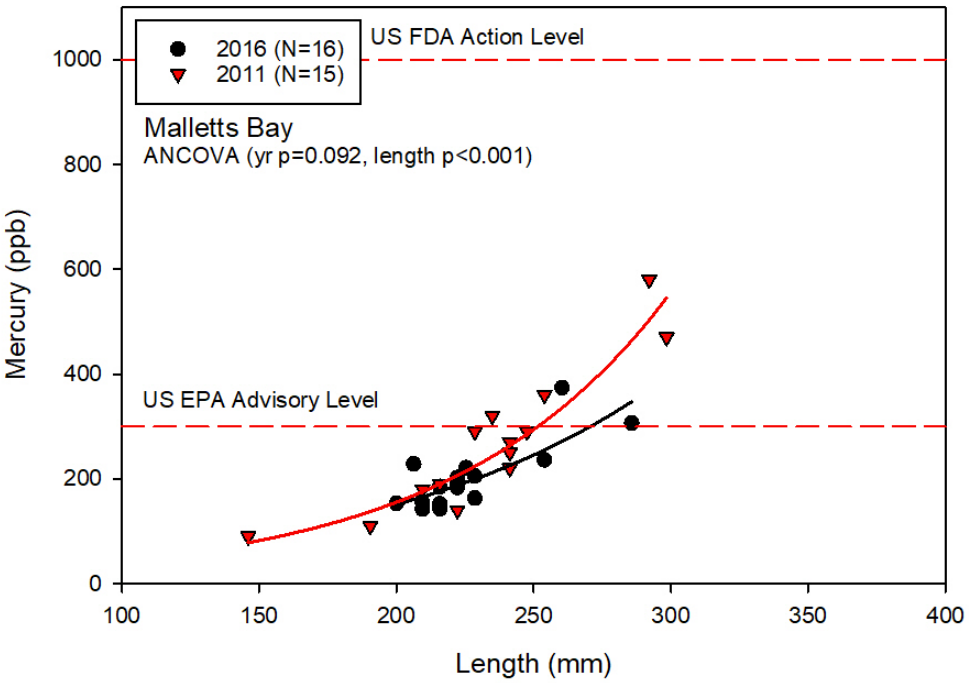


White Perch


2016 (N=48)
2011 (N=26)
US FDA Action Level
Main Lake
ANCOVA (yr p=0.386, length p<0.001)
US EPA Advisory Level
Mercury (ppb)
Length (mm)


Missisquoi B
North Main Lake
Northeast Arm
Mallett's Bay
Main Lake
South Main Lake
South Lake
N


2016 (N=21)
2011 (N=8)
US FDA Action Level
Northeast Arm
ANCOVA (yr p=0.169, length p<0.001)
US EPA Advisory Level
Mercury (ppb)
Length (mm)


2016 (N=16)
2011 (N=15)
US FDA Action Level
Malletts Bay
ANCOVA (yr p=0.092, length p<0.001)
US EPA Advisory Level
Mercury (ppb)
Length (mm)

Fish Mercury Trend 2011 to 2016

Lake Segment	Smallmouth Bass	Yellow Perch	White Perch
Lake-wide	↑ p<0.001	↑ p<0.001	≈ p=0.52
Main Lake Proper	↑ p<0.001	↑ p<0.001	≈ p=0.39
Northeast Arm	≈ p=0.83	≈ p=0.88	≈ p=0.17
Malletts Bay	≈ p=0.58	↓ p=0.030	↓ p=0.09

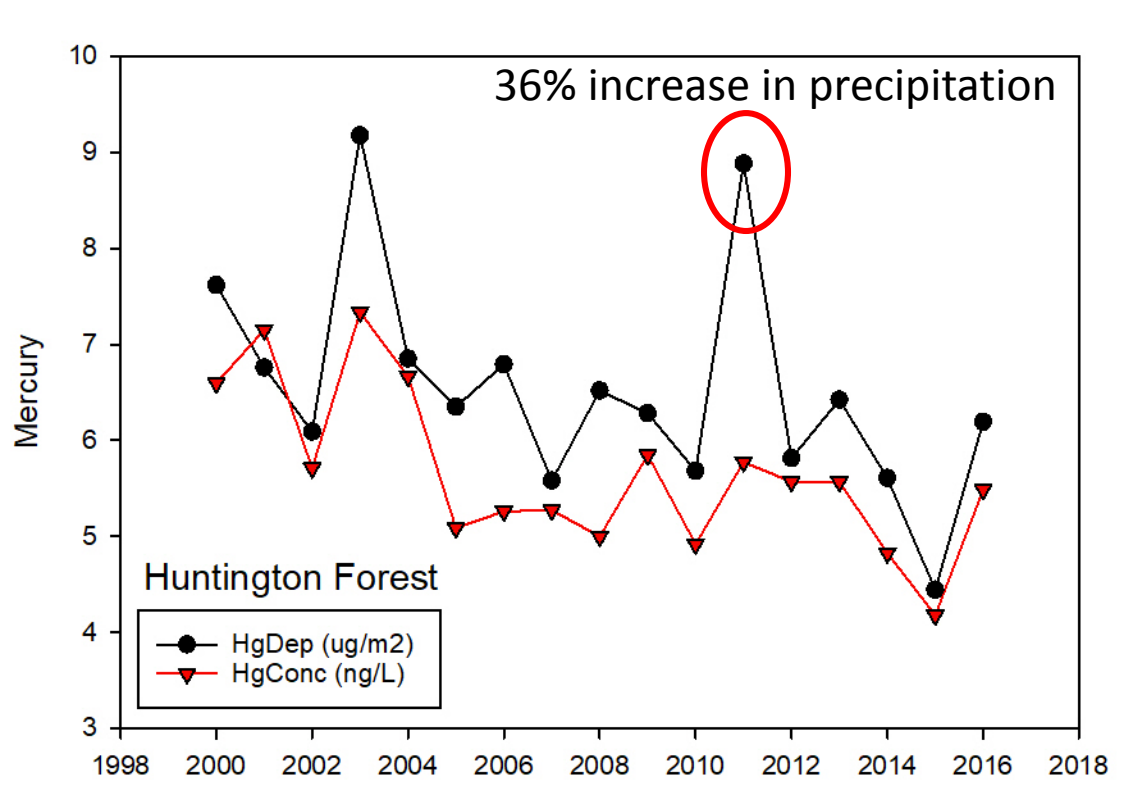
Main Questions

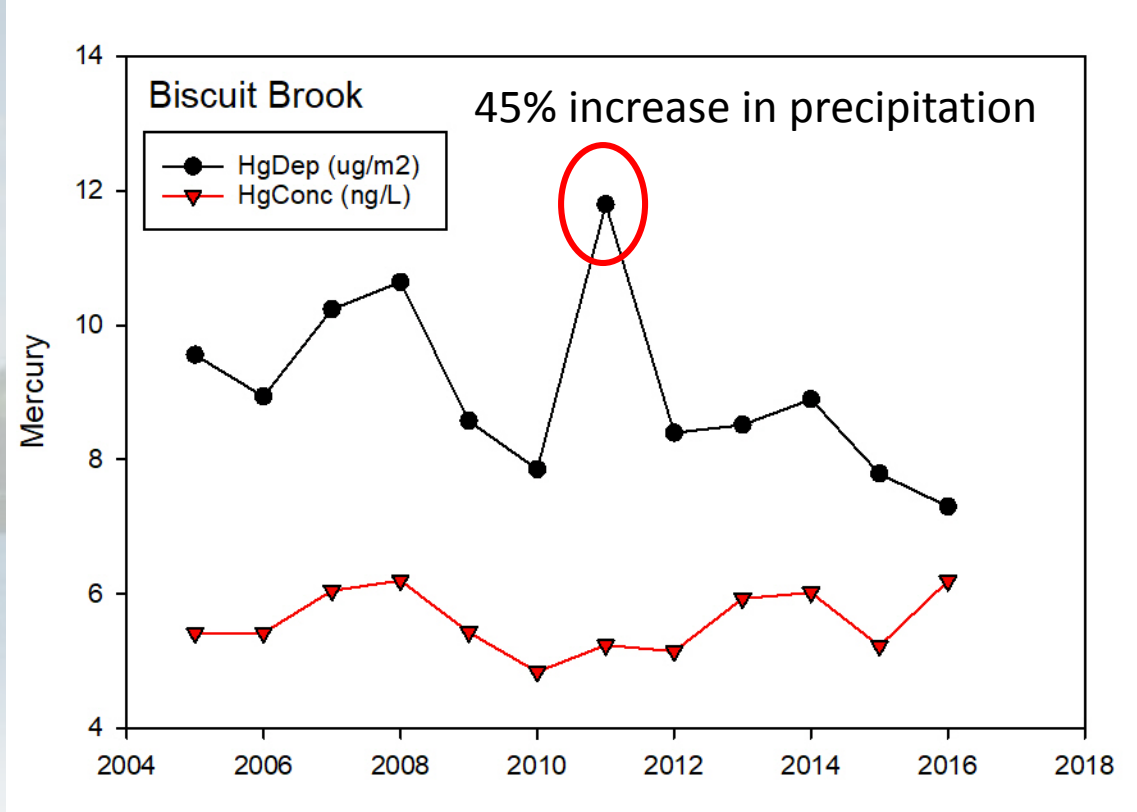
What caused the mercury spike in the Main Lake segments?

What differences between lake segments cause the conflicting trends?

What Caused the Spike in Mercury?

Atmospheric Deposition?





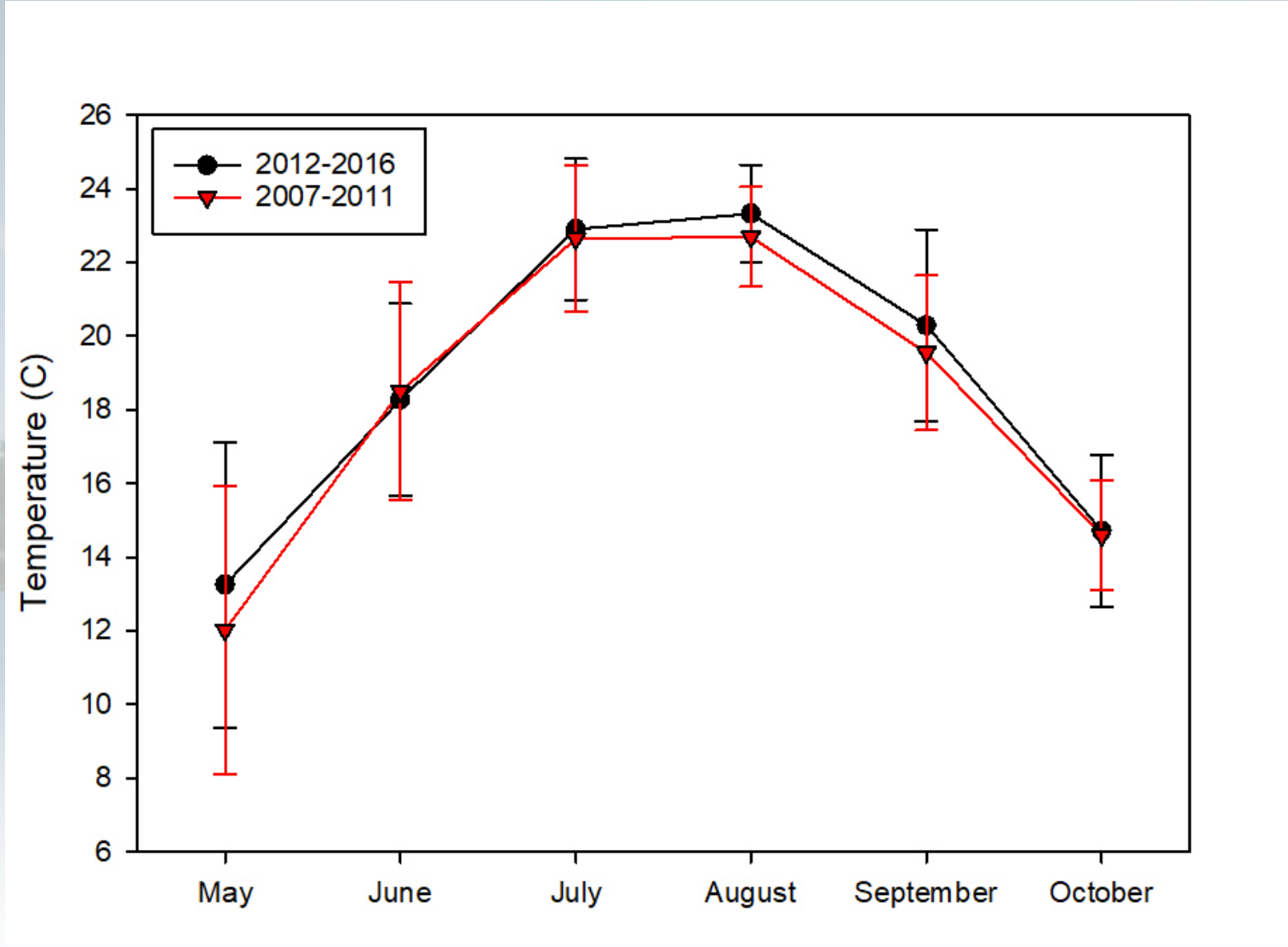
What Caused the Spike in Mercury?

Atmospheric Deposition-NO

Lake Temperature?

Surface temp increased 0.5C between studies

- Main Lake Segments 0.1-0.8C
- Northeast Arm 0.7C
- Malletts Bay 0.6C



What Caused the Spike in Mercury?

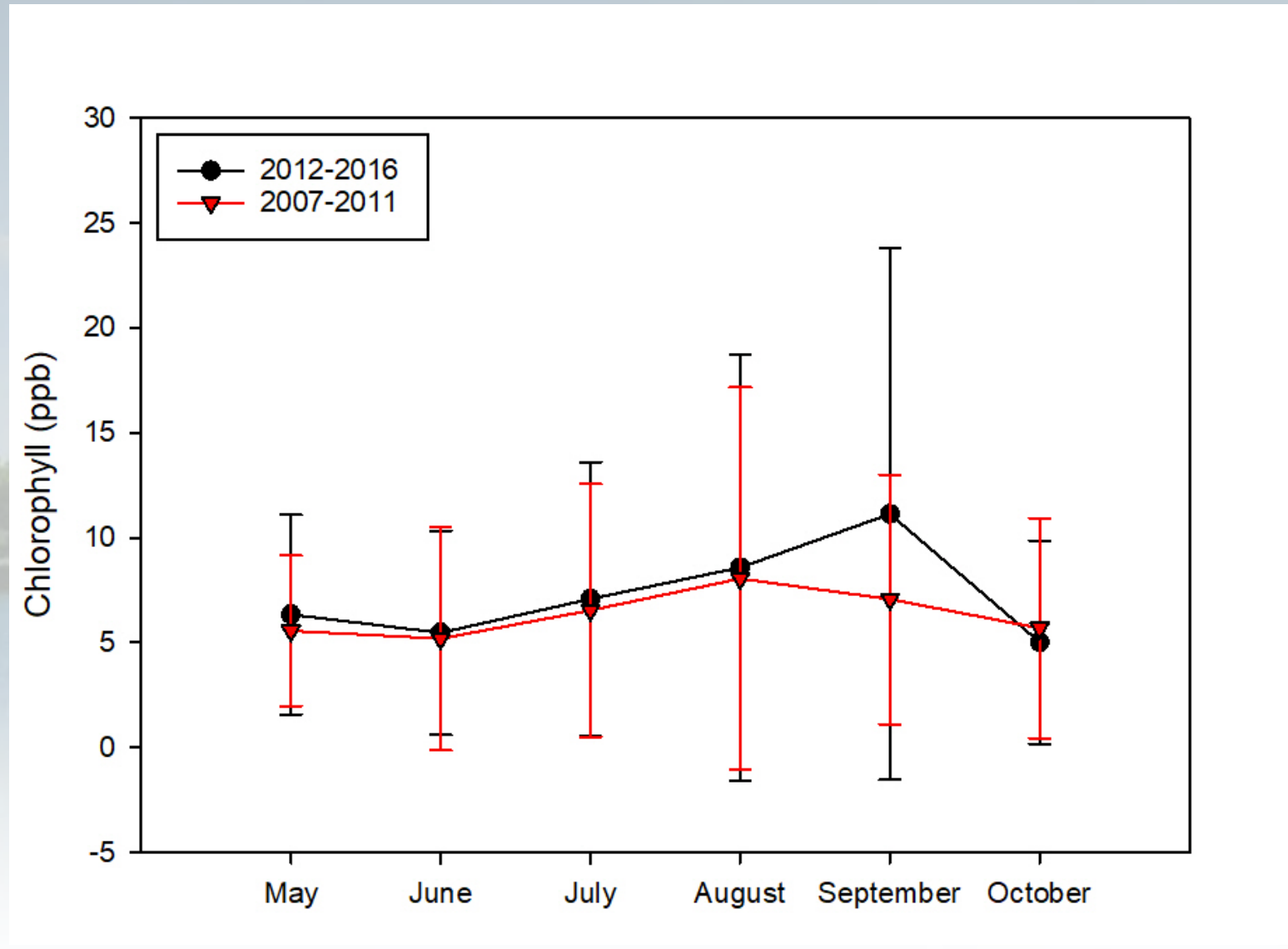
Atmospheric Deposition-NO

Lake Temperature-NO

Primary productivity?

Chlorophyll increased 0.9 ppb between studies

- Main Lake Segments 0.4-0.5 ppb
- Northeast Arm 1.2 ppb
- Malletts Bay 0.4 ppb



What Caused the Spike in Mercury?

Atmospheric Deposition-NO

Lake Temperature-NO

Primary productivity-NO

pH?

- Mean pH ~8, rarely <7

What Caused the Spike in Mercury?

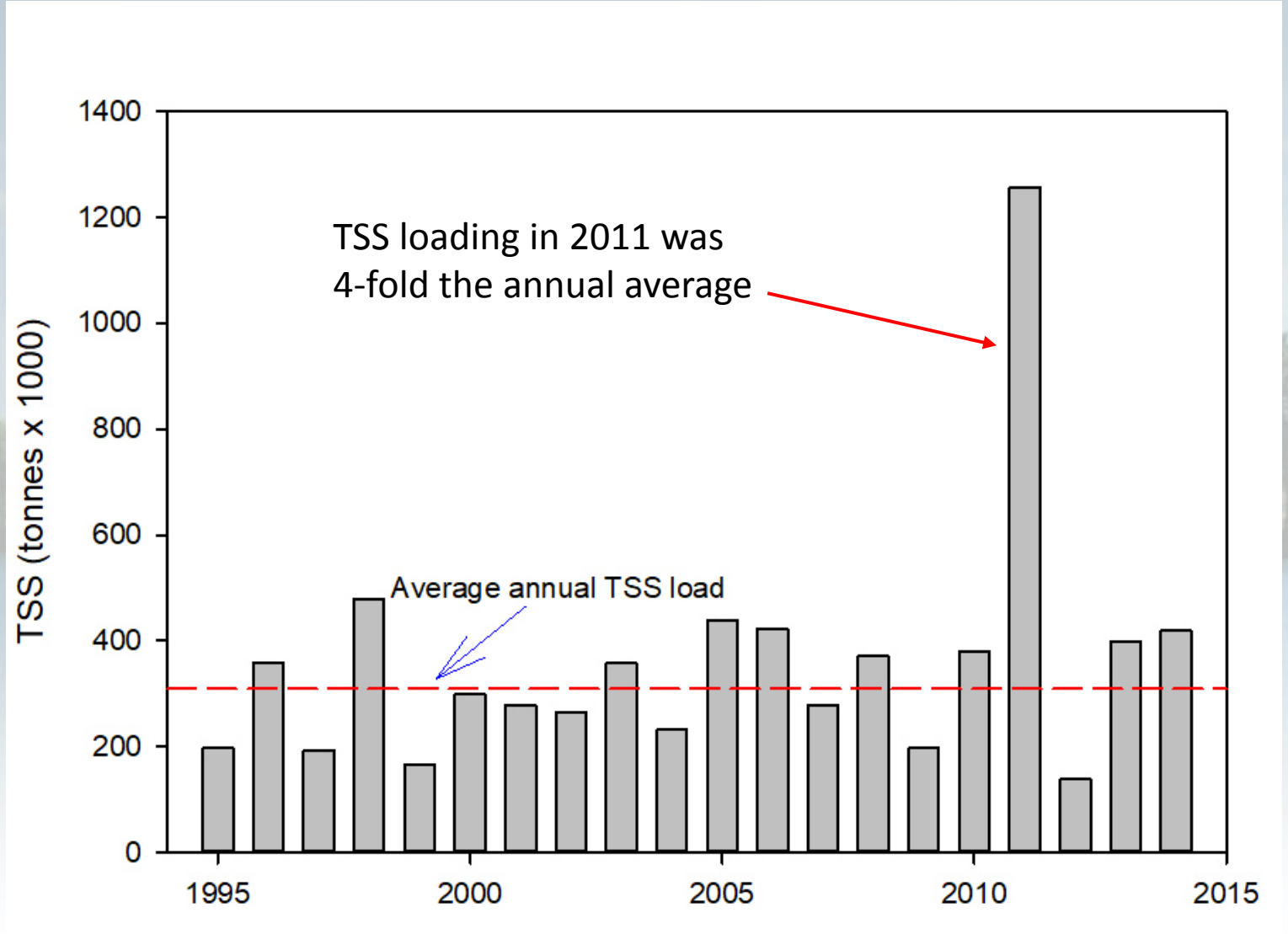
Atmospheric Deposition-NO

Lake Temperature-NO

Primary productivity-NO

pH-NO

Stream Loading?



What Caused the Spike in Mercury?

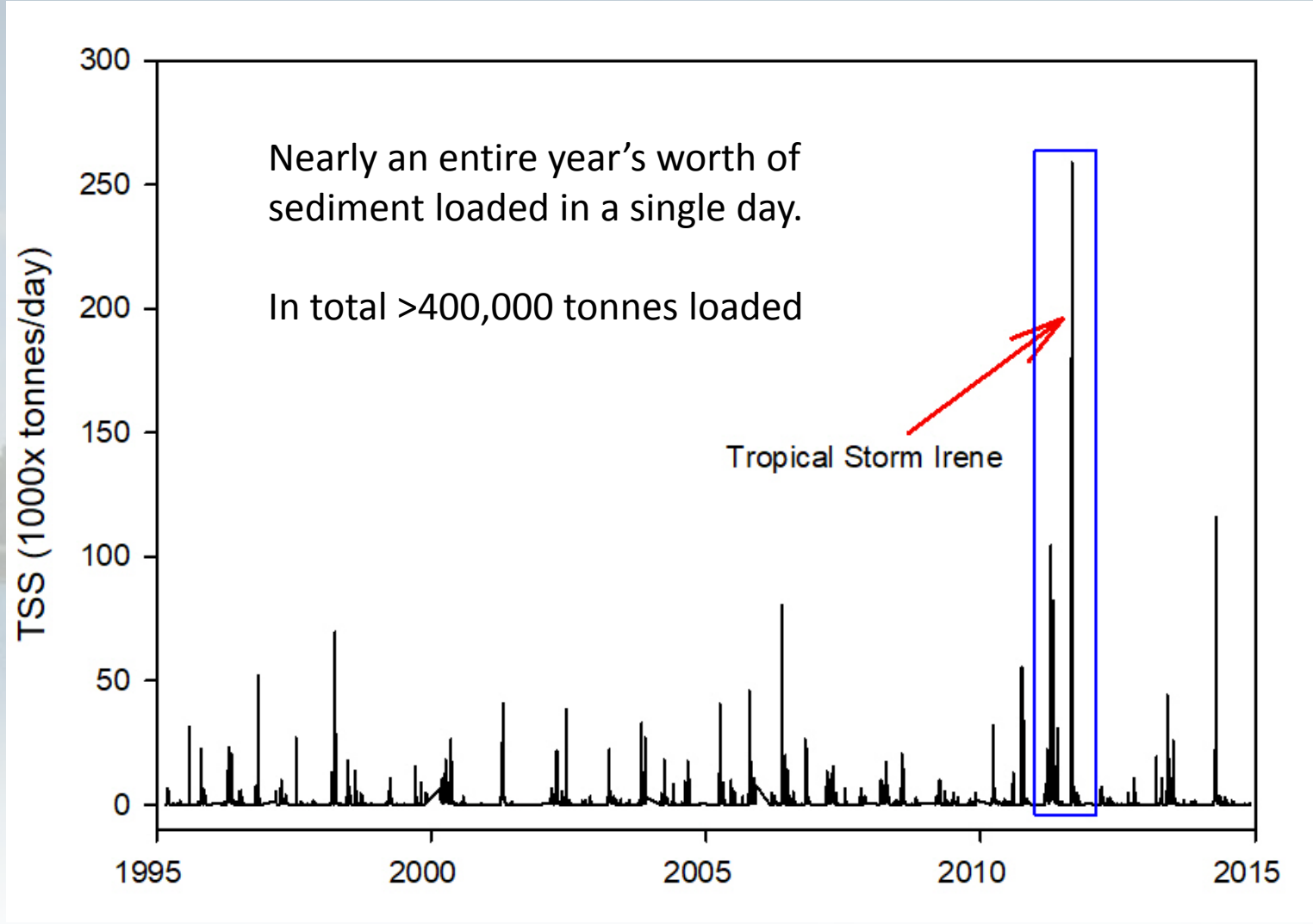
Atmospheric Deposition-NO

Lake Temperature-NO

Primary productivity-NO

pH-NO

Stream Loading?



What Caused the Spike in Mercury?

Atmospheric Deposition-NO

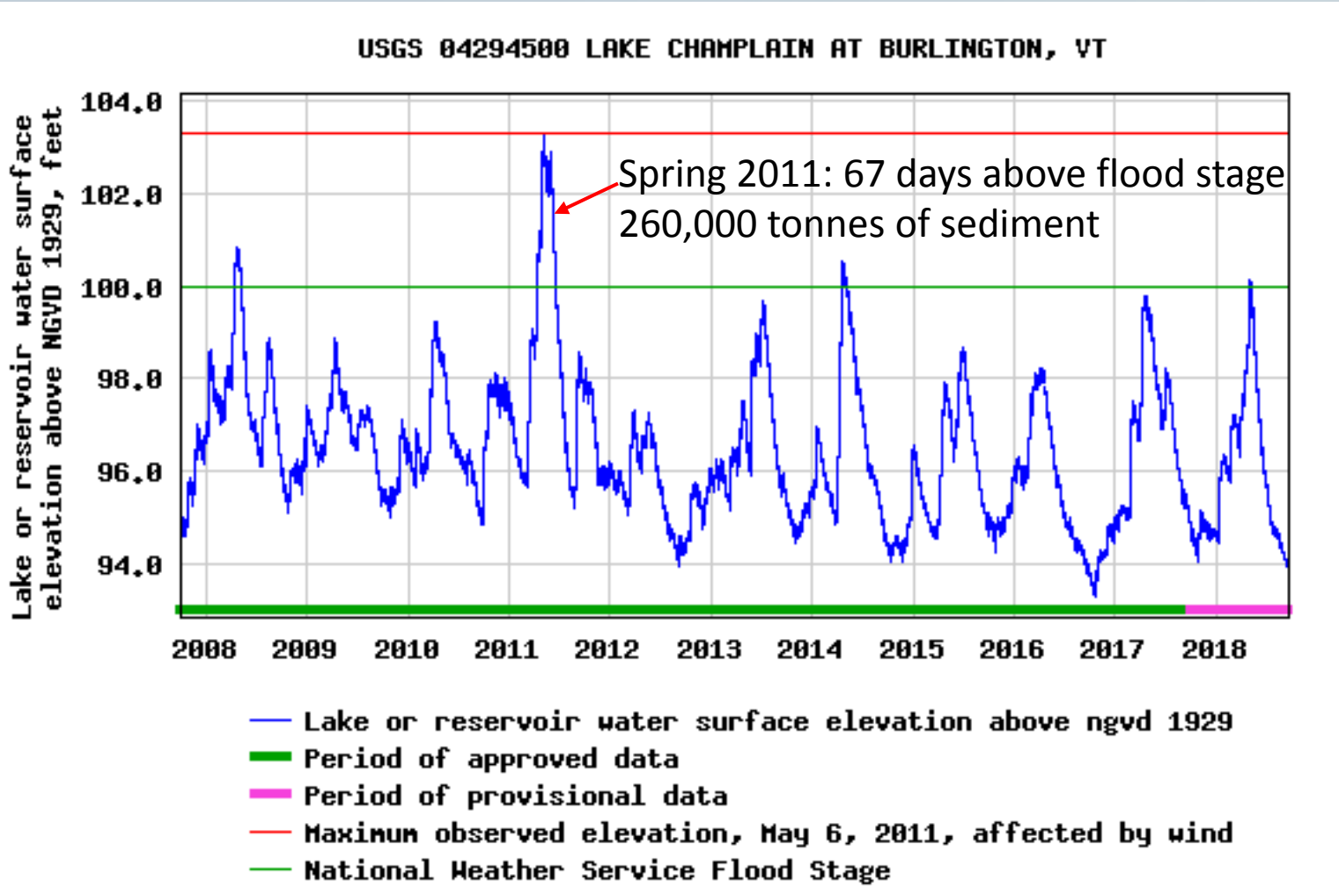
Lake Temperature-NO

Primary productivity-NO

pH-NO

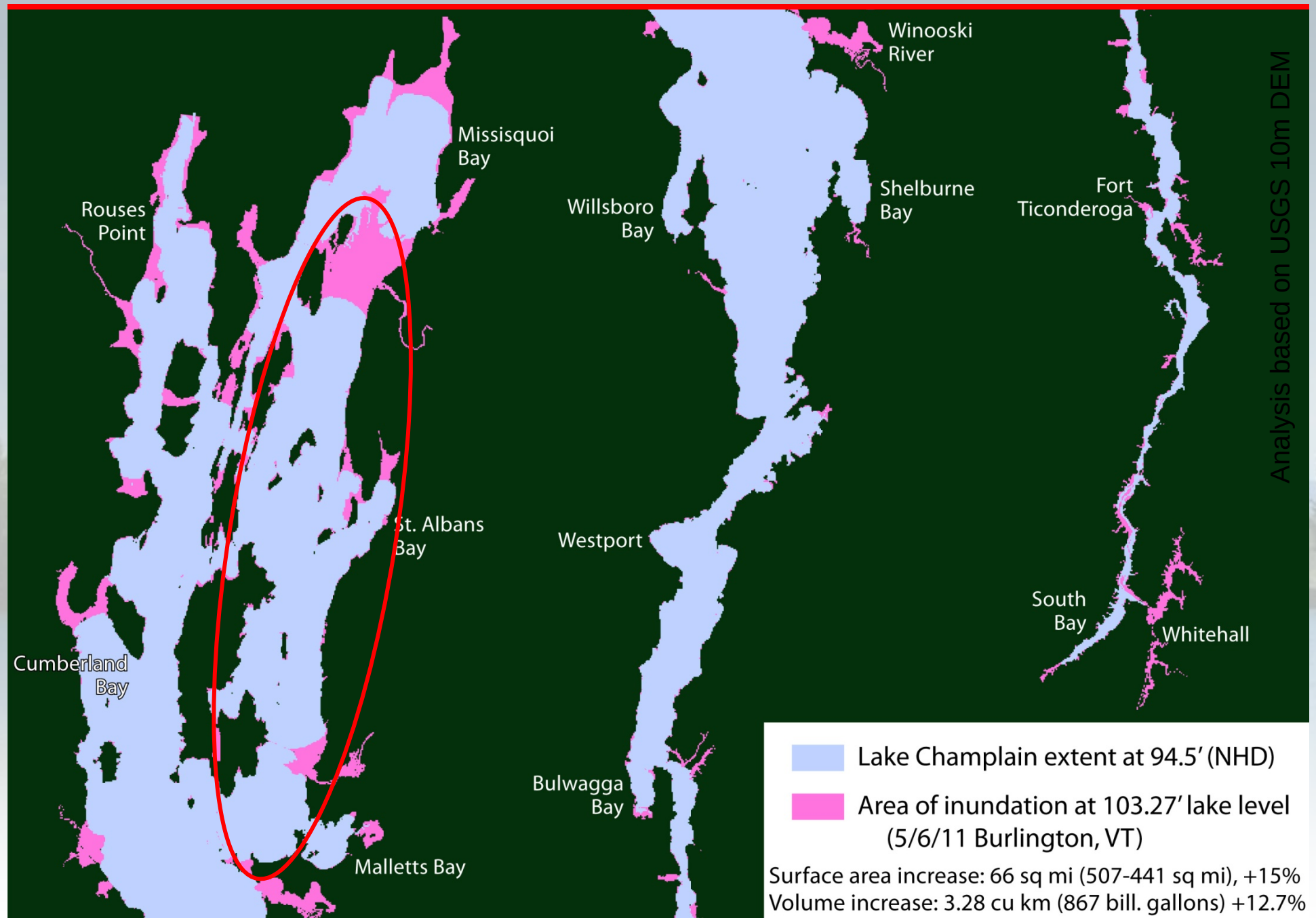
Stream Loading-Maybe

Flooding?



Taken from LCBP “The Floods of 2011 – A Quick View”

May 2011 Lake Champlain Flood



What Caused the Spike in Mercury?

Atmospheric Deposition-NO

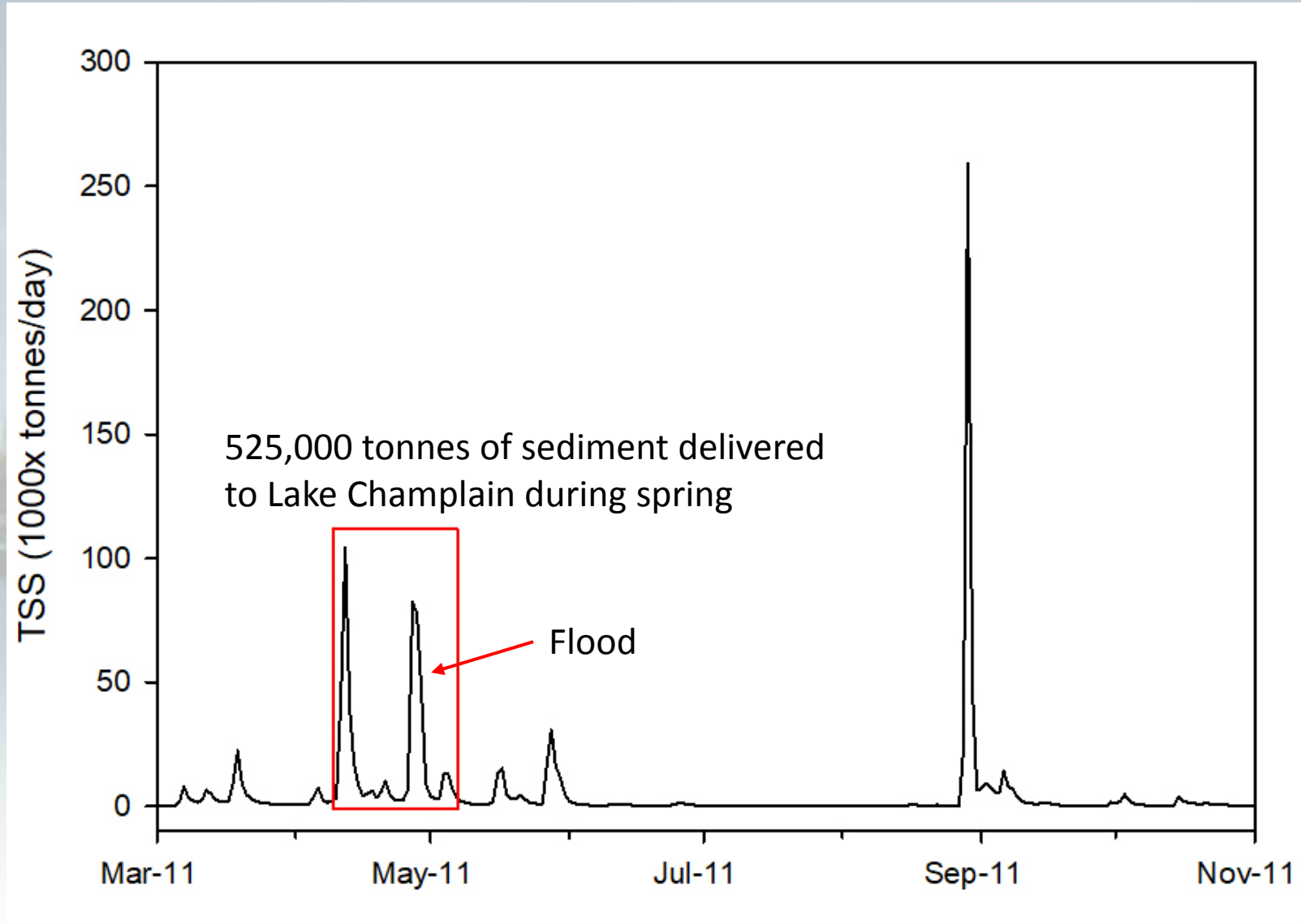
Lake Temperature-NO

Primary productivity-NO

pH-NO

Stream Loading-Maybe

Flooding-Maybe



Main Questions

What caused the mercury spike in the Main Lake segmen

Sediment loading in 2011 may have caused the i

Analyze sediment cores from Main Lake, Nort

Assess mercury in lower trophic levels of benti

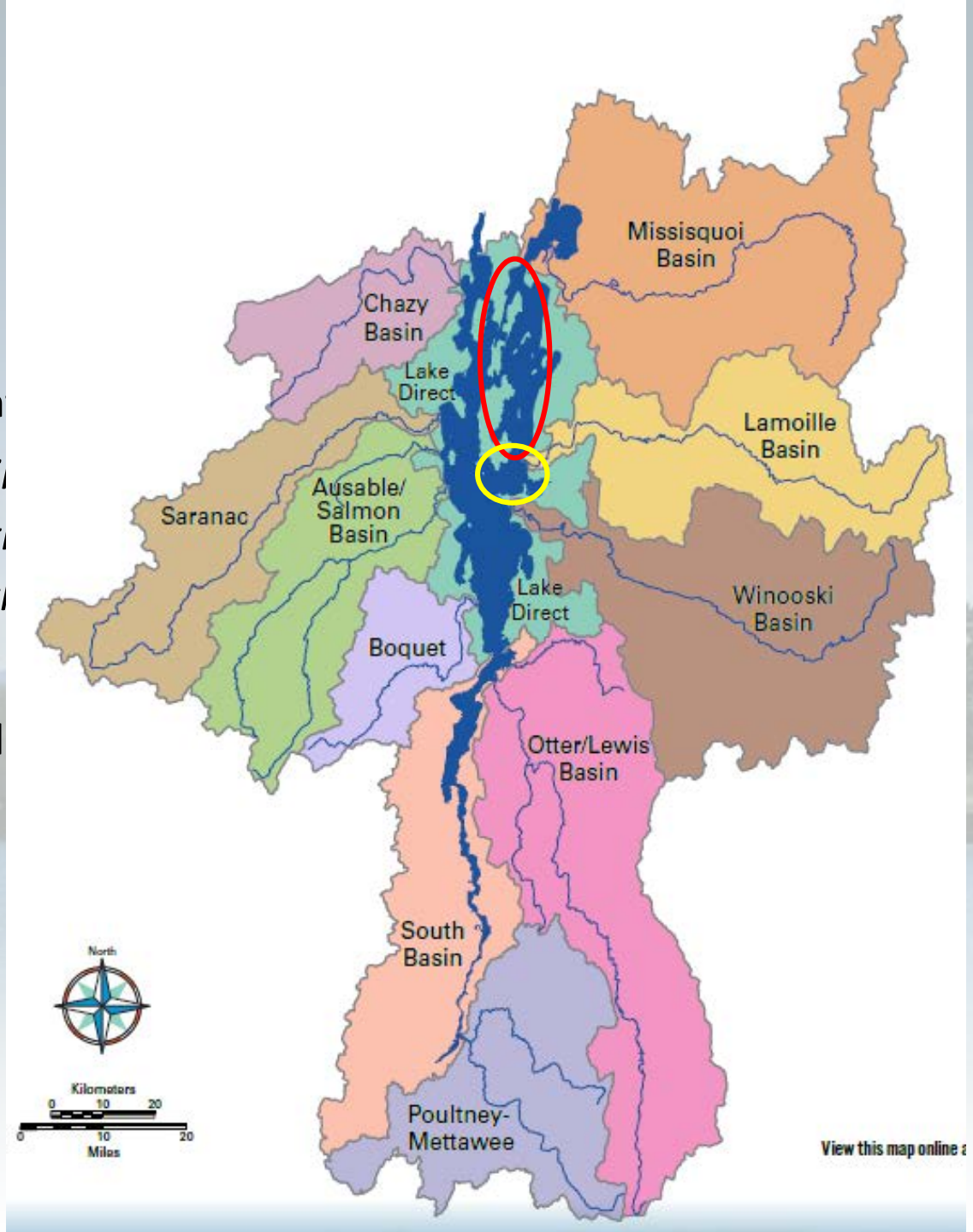
What differences between lake segments cause the confl

Less sediment loading to the Northeast Arm

Restricted circulation in Malletts Bay could

be impacting food web dynamics,

methylation rates…..



Broader Impact

Extreme disturbance events maybe increasing mercury in biota

- Need for more case studies
  - How quickly does mercury increase?
  - Length of increase?
  - Impact on fish consumption advisories?

Funding provided by the Lake Champlain Basin Program

QUESTIONS?