Analysis of shifts within northwestern Montana lakes based on water clarity, temperature, and chemistry

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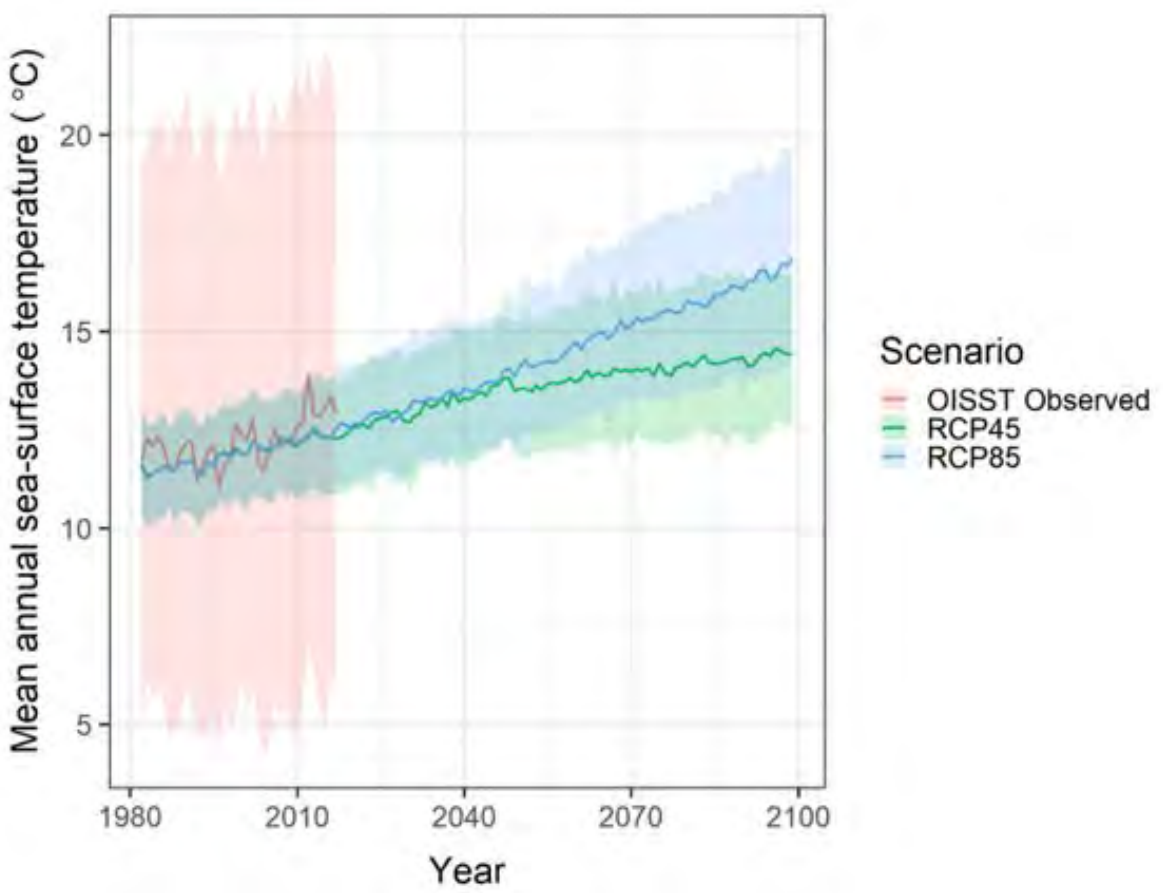
SUNY ONEONTA

Whitefish Lake INSTITUTE

BIOLOGICAL FIELD STATION

Global Climate Change



- Northwest Atlantic Large Marine Ecosystem

Global Climate Change

- Climate change heavily studied in marine environments
  - Less studies in freshwater environments
- Important to examine how lakes are changing locally and regionally.

Background

NORTHWEST MONTANA LAKES NETWORK

- Northwest Montana Lakes Network (NMLN)
  - Montana Fish, Wildlife, and Parks
  - Whitefish Lake Institute
- 41 lakes in Flathead Valley
- Seasonal and long-term changes
  - Secchi disk depth, temperature, water chemistry
  - Within (locally) or across (regionally) lakes

Methods

Data Collection

- Secchi disk depth & temperature data
  - Citizen science volunteers
  - 1 lake, twice a month
  - Online data submission (WQI form)
- Water chemistry parameters
  - TP, TPN (TN), Chlorophyll *a*
  - Whitefish Lake Institute staff
  - Once per summer
- 1992 - present

Methods

Statistical Analysis

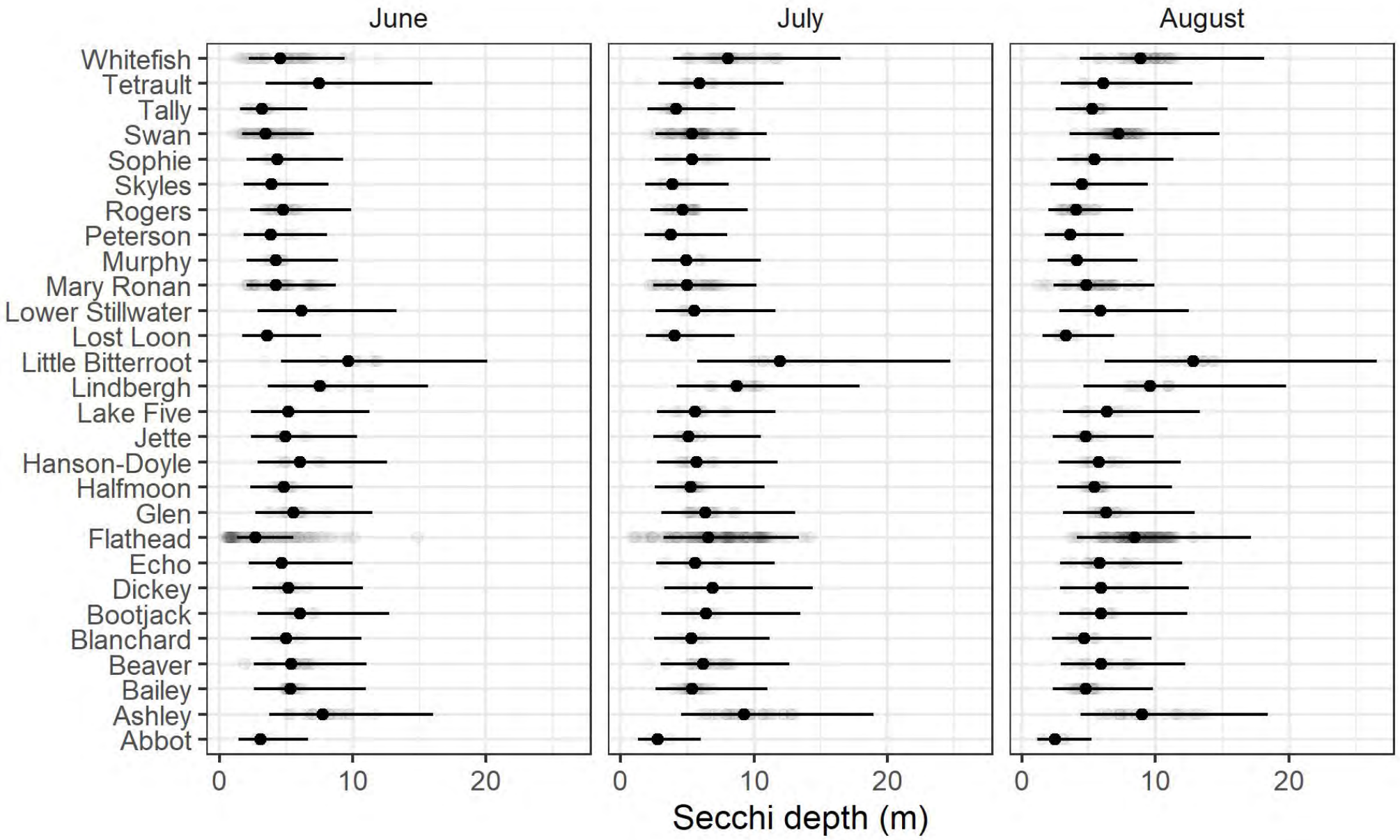
- Rstudio®
- Filtered data
  - Secchi depth & temperature: June, July, August
  - Water chemistry (total phosphorus, total nitrogen, chl *a*): July & August
  - Lakes w/ 5+ years of data
- Year (continuous), Month (categorical), and lake (categorical) explanatory variables
- Water quality parameters dependent variables

Methods

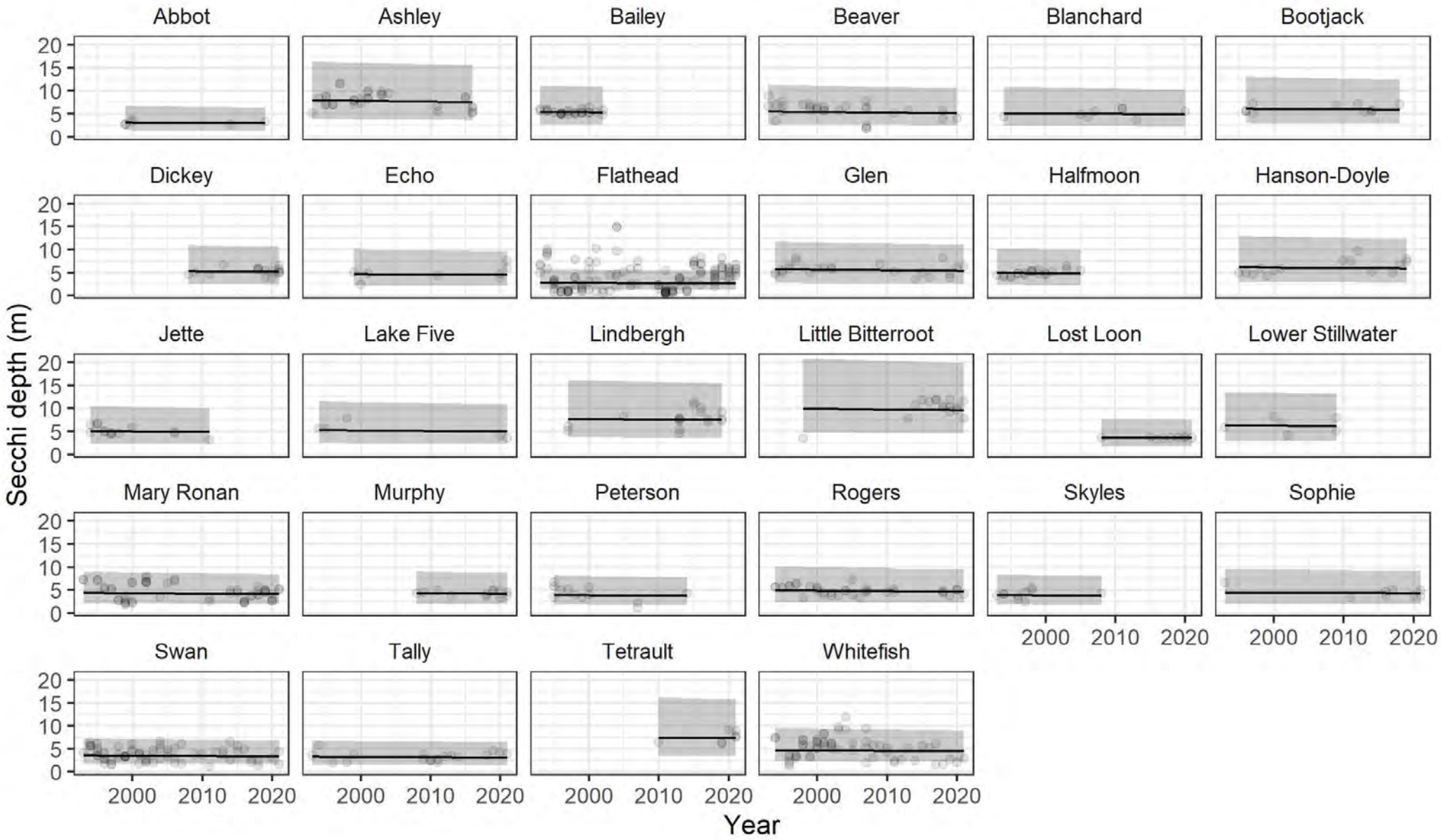
Statistical Analysis

- Log-transformed dependent variables & standardized year
- Fixed effects models
  - Various combinations of year, month, lake
  - Model selection using Akaike Information Criterion (AIC)
- Refit best model with random effect of lake
- Analysis of deviance
  - Statistical significance of fixed effects
- Plotted predictions of best model against observed data

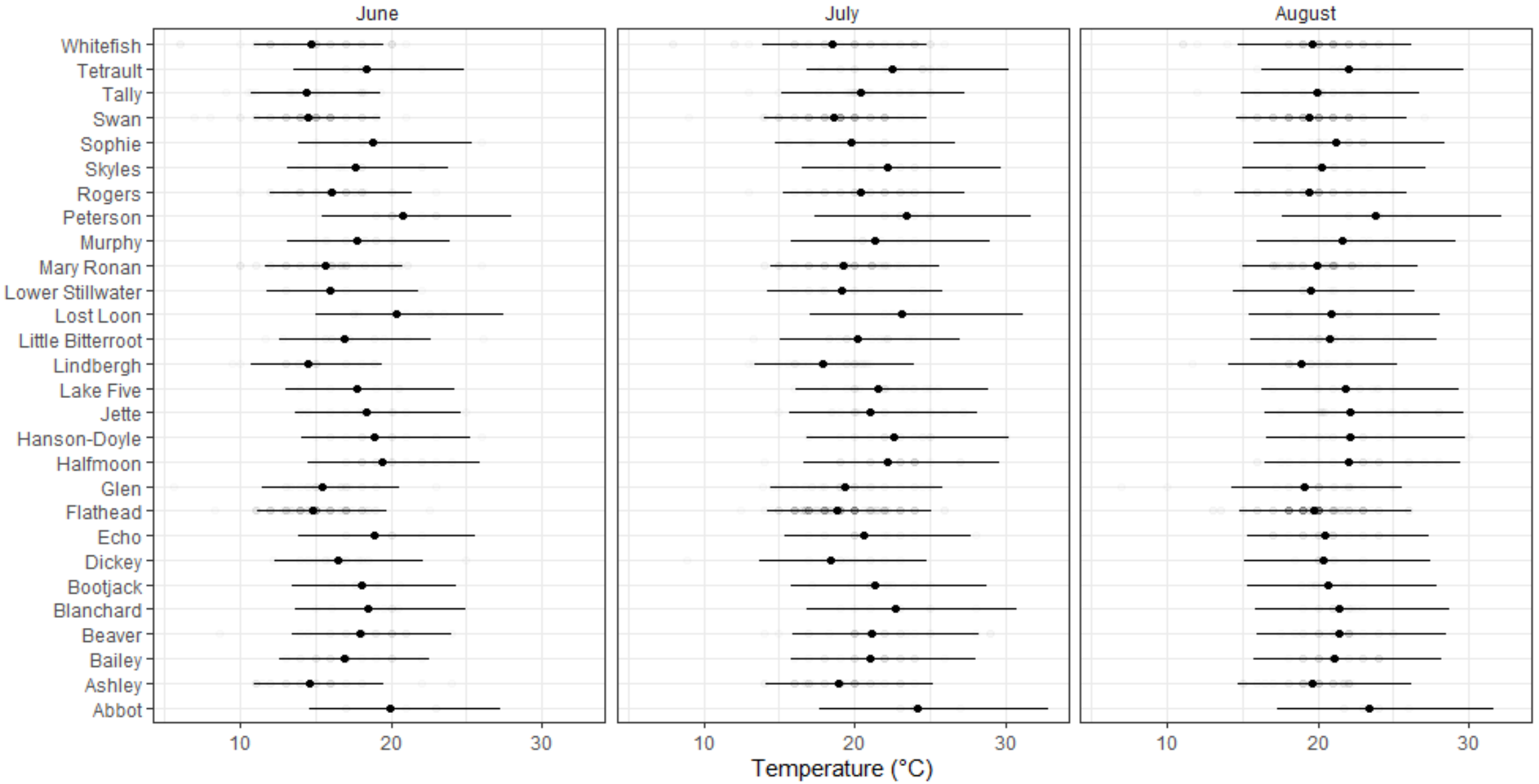
Secchi disk depth increased from June to August (2006)



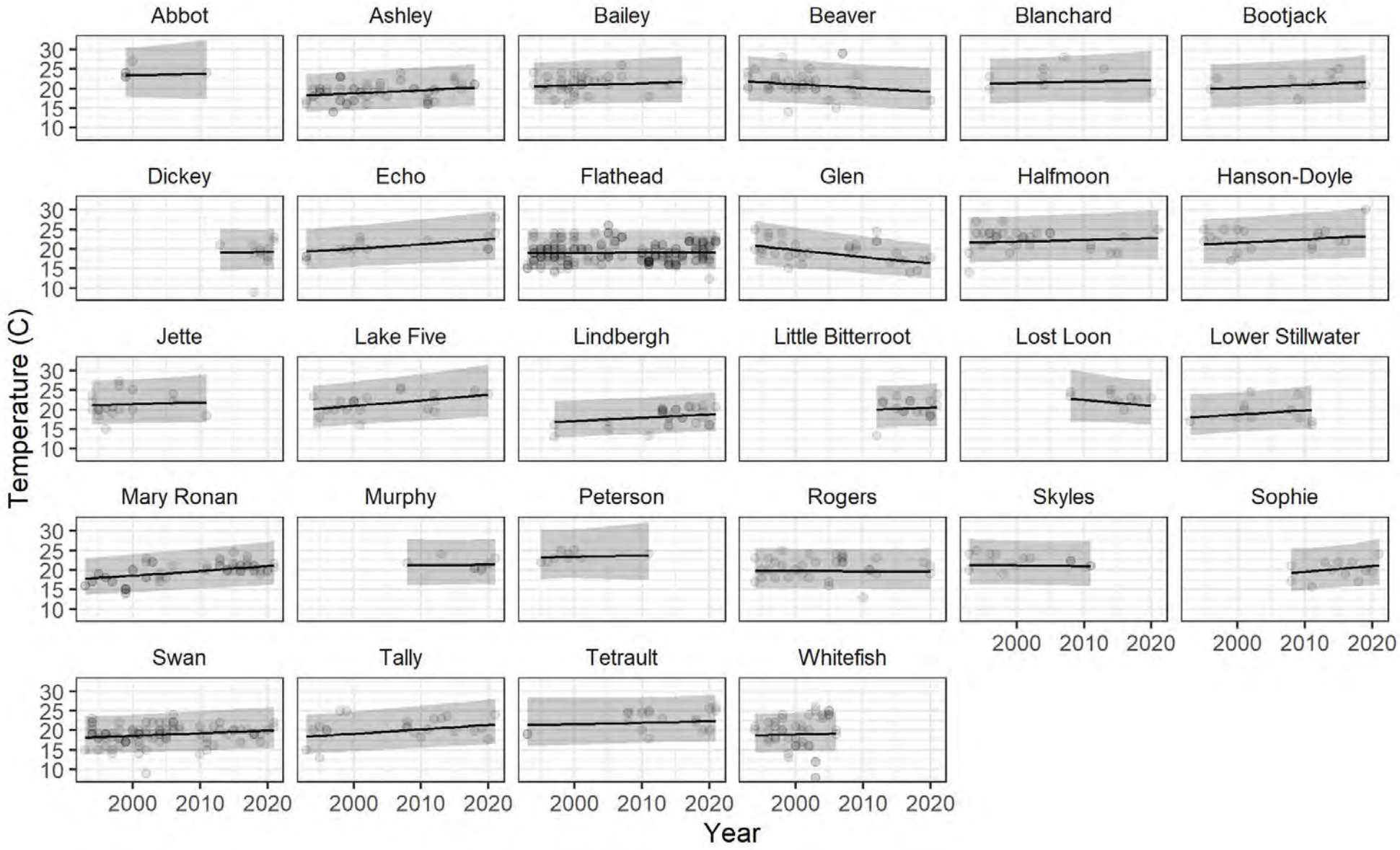
Secchi disk depth decreased across years, within lakes (June)



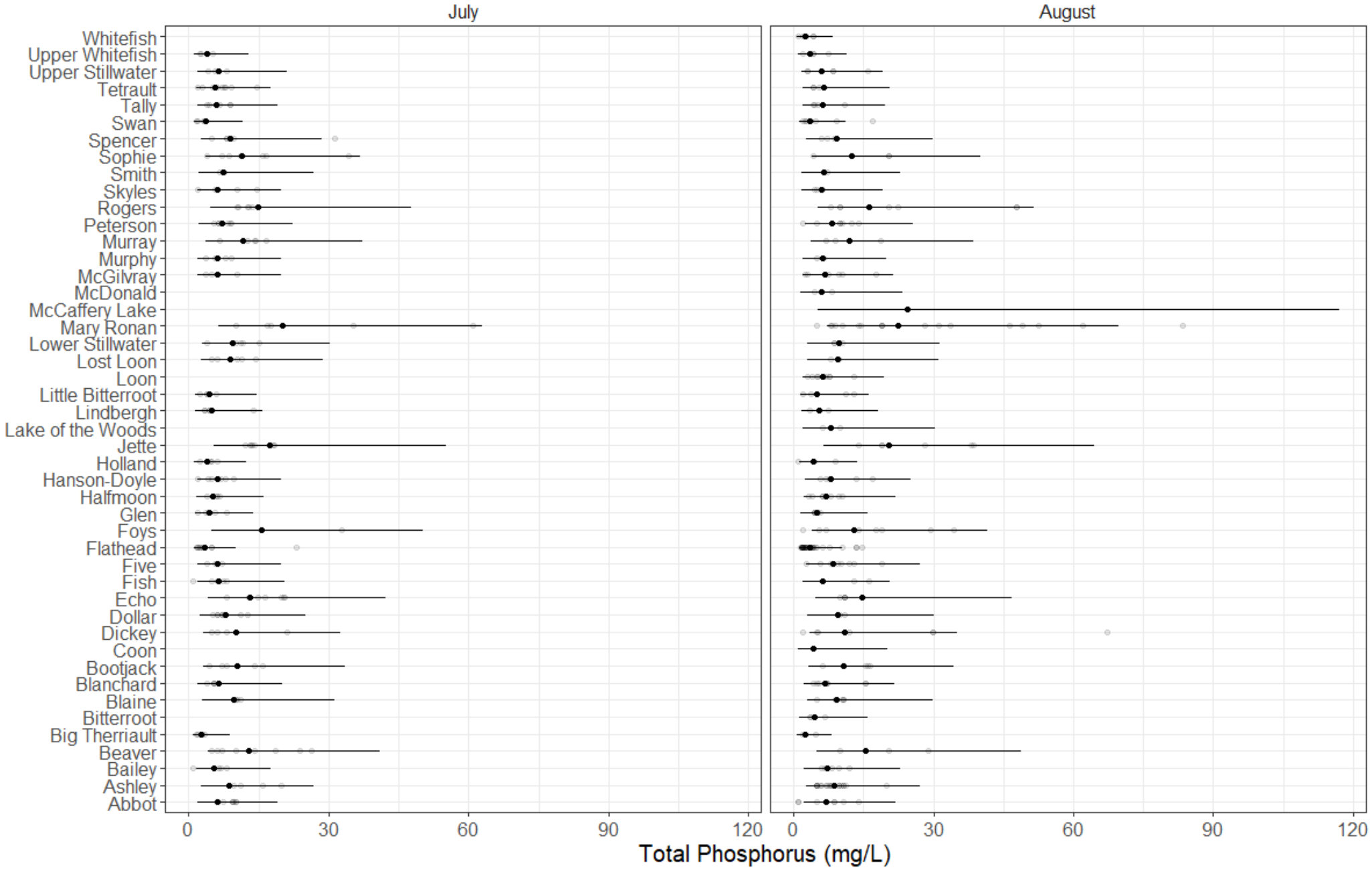
Temperature peaked in July (2006)



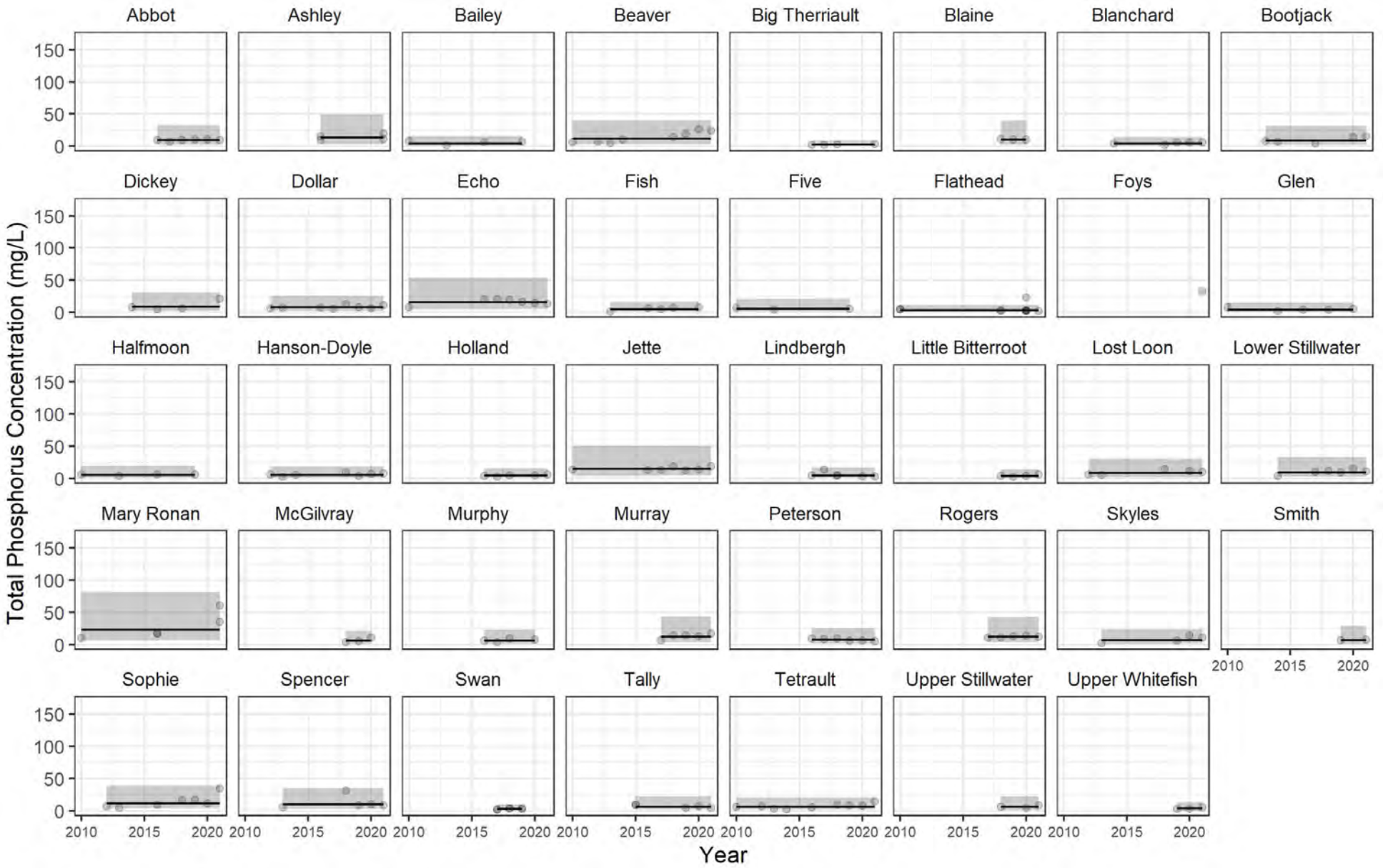
Temperature increased across years within lakes (June)



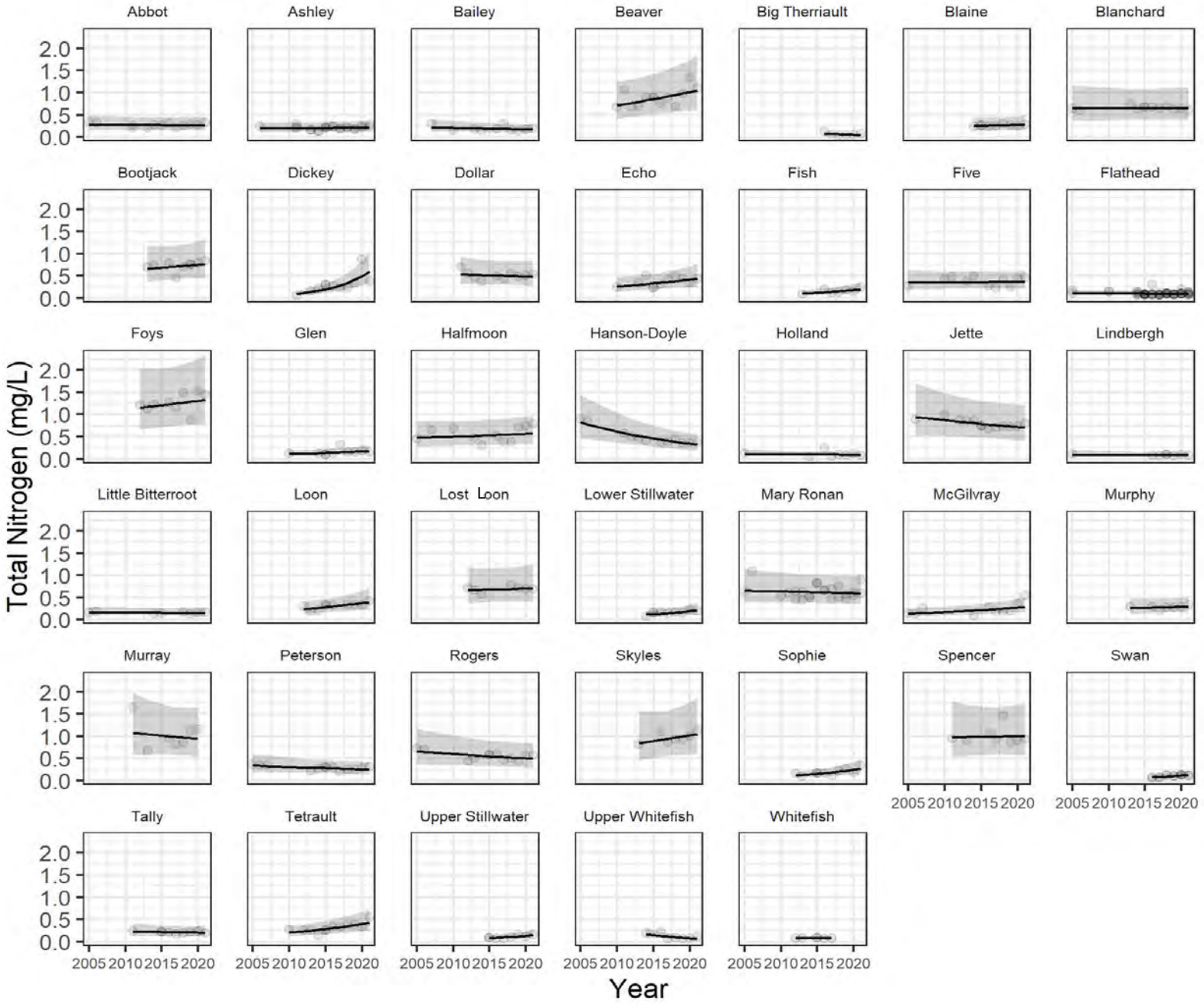
Total phosphorus concentrations higher in August (2013)



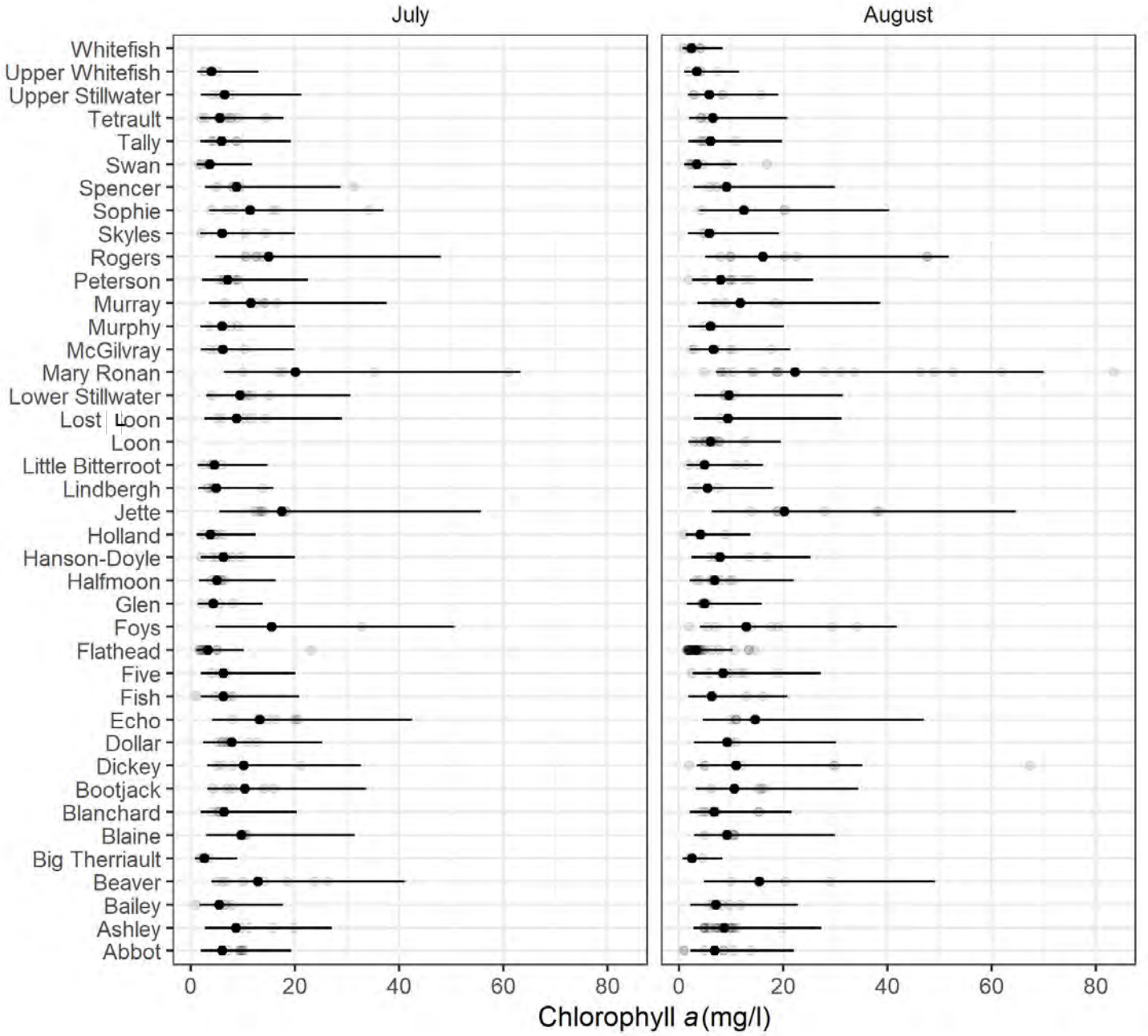
Total phosphorus concentrations increased across years, consistently among lakes (July)



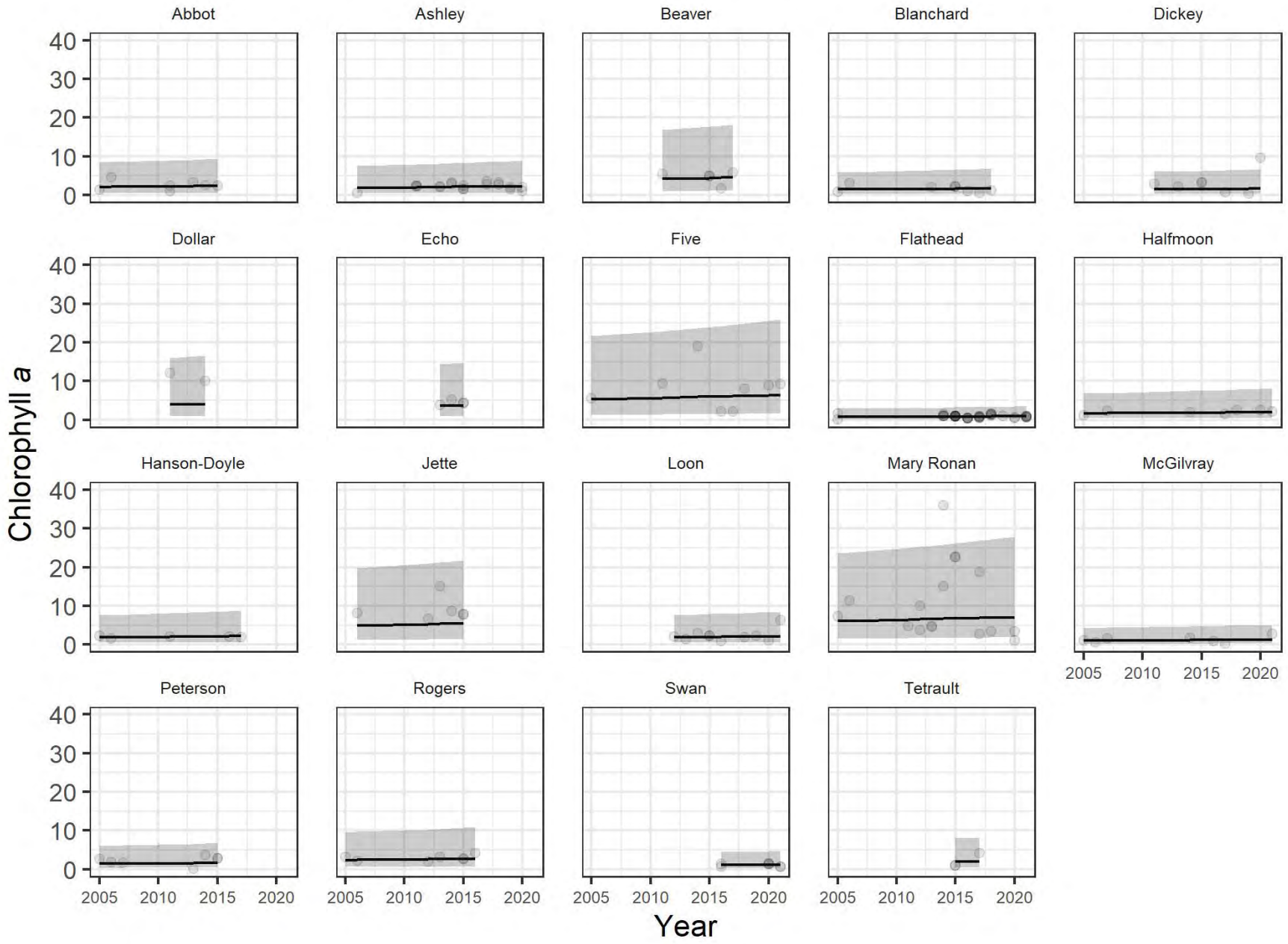
Total nitrogen concentrations varied across years, among lakes



Chlorophyll *a* concentrations greater in July (2013)



Chlorophyll *a* increased across years (July)



Summary of Observations Across Years

- Water clarity ⬇
- Temperature ⬆
- Total phosphorus ⬆
- Total nitrogen ↕
- Chlorophyll *a* ⬆

- Most variables vary seasonally and yearly across the region

Interpretation of Observations

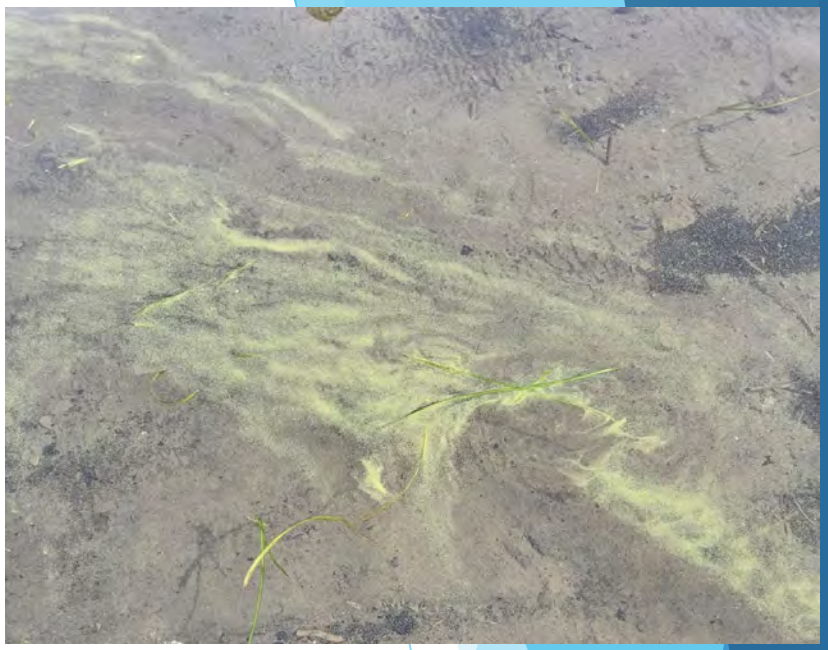
- Water clarity ⬇
- Temperature ⬆
- Total phosphorus ⬆
- Chlorophyll *a* ⬆

Indicators of eutrophication

- Reflects findings of other studies and observations

Interpretation of findings

- Eutrophication
  - Nutrients
  - Warm water temperature
  - Phytoplankton
- Consequences
  - Increased risk of harmful algal blooms (HABs)
  - Decrease in biodiversity



Acknowledgements

- Citizen Science volunteers & WLI staff
- Mike Koopal (WLI) and Cynthia Ingelfinger (Whitefish Legacy Partners)
- Dan Stich (SUNY Oneonta)

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