Using Citizen Science to Inform the Role of Invasive Mussels on HABs in New York

Victoria Field

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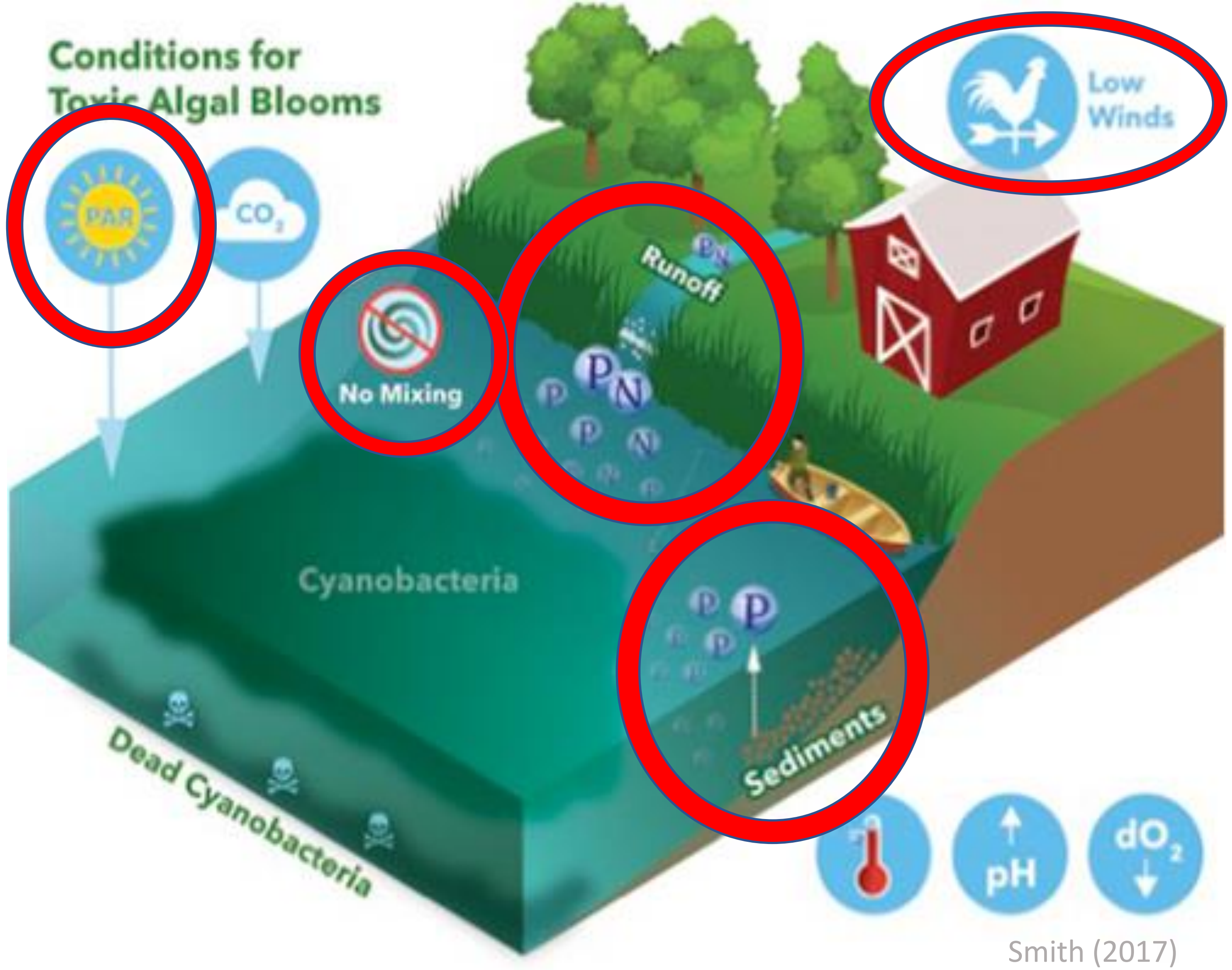
Skaneateles Lake

Credit: Matt Champlin

Overview

- Preliminary results of data collected by the Citizen’s Statewide Assessment Program (CSLAP) in low nutrient lakes show that the presence of dreissenid mussels positively influences total phosphorus (TP)-microcystin relationship
- Understanding the role dreissenids play in HAB formation is imperative for lake and HAB management
- Citizen science can help inform the role of dreissenids by incorporating dreissenid monitoring methods into existing network of long-term water quality monitoring program

Established factors in HAB formation



Smith (2017)

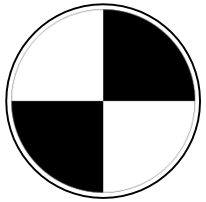
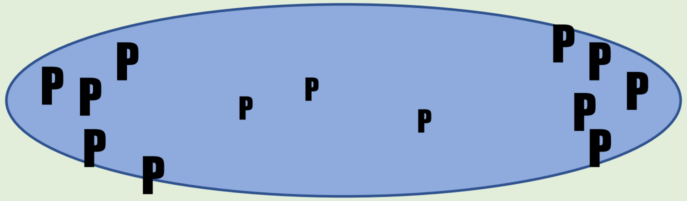
Dreissenid mussels are a biological factor in HAB formation

- First introduced to Great Lakes region in 1986
  (Hebert et al. 1989)
- “Ecosystem engineers”
  (Coleman and Williams 2002)
- Mussels selectively reject toxin-producing species
  (Vanderploeg et al. 2001)
- Invaded low-nutrient lakes have higher microcystin concentrations
  (Sarnelle et al. 2010)

Credit: NCRCD

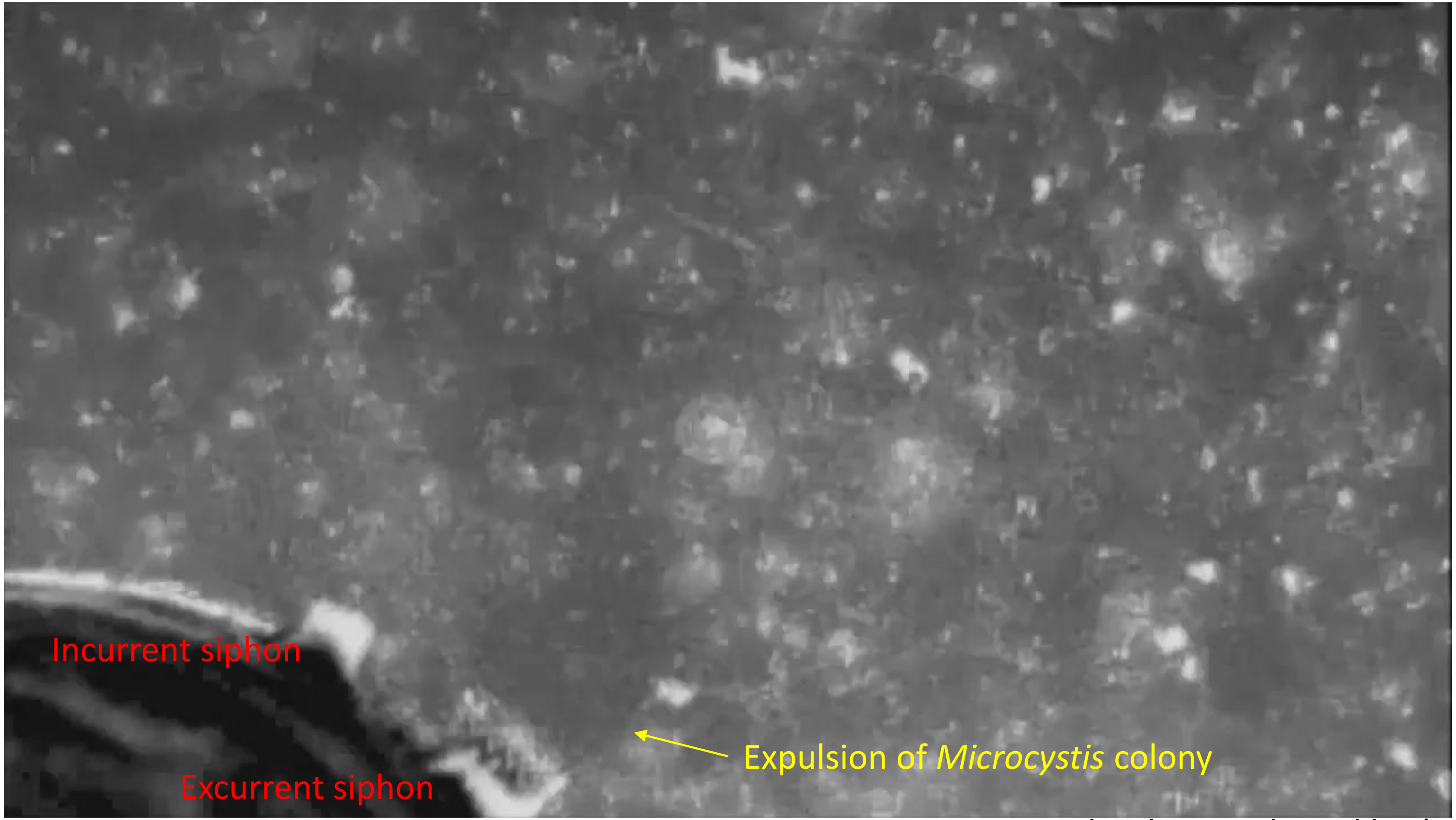

Joe Bryska / Winnipeg Free Press Files

Dreissenids alter physical, biochemical, and biological environment

CLEARANCE RATES		High filtration rates (increased water clarity)
NUTRIENT STOICHIOMETRY		Generally thought to decrease N:P ratio
SELECTIVE FILTRATION		Selectively reject: toxin-producing species and large colonies of phytoplankton
NUTRIENT DISTRIBUTION		External phosphorus input retained in the nearshore benthos ("Nearshore Phosphorus Shunt")

Arnott and Vanni (1996); Hecky et al. (2004); Karatayev et al. (2015)

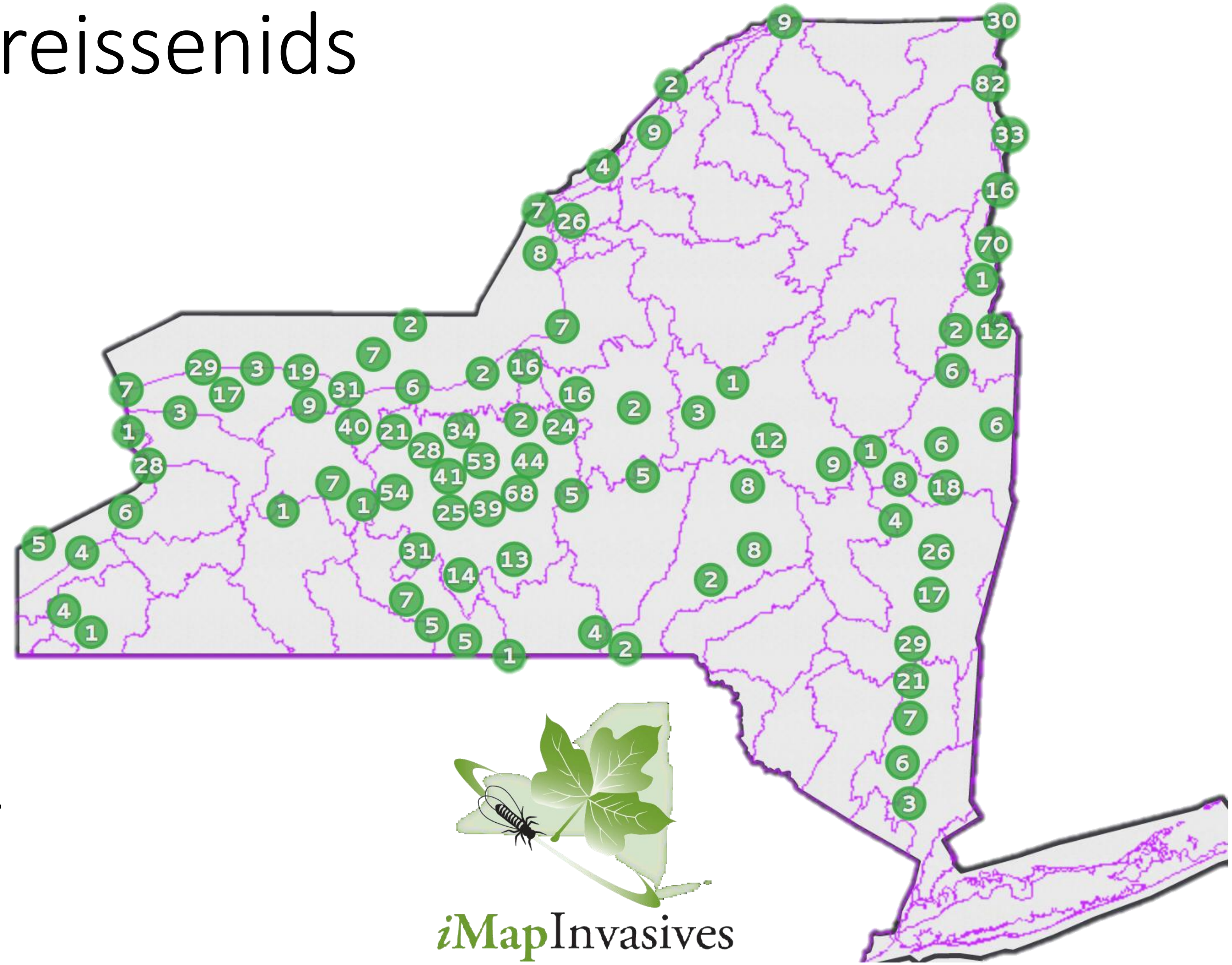
Zebra mussels selectively reject toxin-producing species like *Microcystis aeruginosa*



Vanderploeg and Strickler (2013)

Monitoring for dreissenids

- iMapInvasives
  (nyimapinvasives.org/about)
  - Documenting and sharing invasive species observation, survey, assessment and treatment data
  - Early detection and rapid response efforts though
  - Data analysis and summaries available for public access



Why are HABs becoming more prevalent in low-nutrient lakes?

Is there a dreissenid connection?

Criteria for lake selection

- Looked at CSLAP database **~240 lakes**
- Selected lakes that were mesotrophic and oligotrophic **n=140 lakes**
- **Selected lakes enrolled from 2012-2017** n=72 (Finger Lakes not included)
- Selected lakes in invaded watersheds **n=27**
- Presence/absence data on zebra mussels, no quagga mussels reported yet

Invaded Lakes

Cazenovia Lake
Craine Lake
DeRuyter Reservoir
Eaton Brook Reservoir
Glen Lake
Hatch Lake
Silver Lake
Tuscarora Lake
Upper Little York Lake

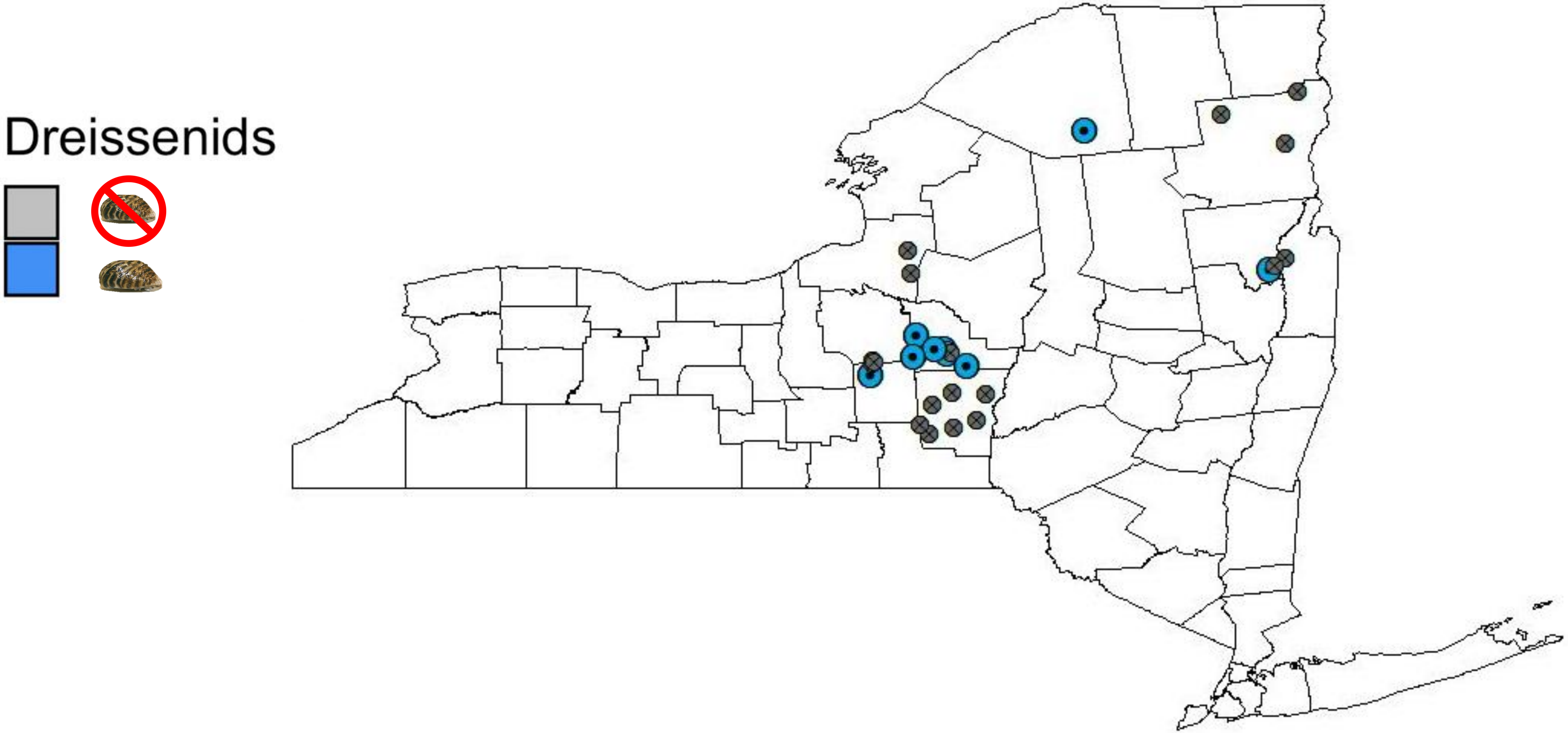
n=9

Uninvaded Lakes

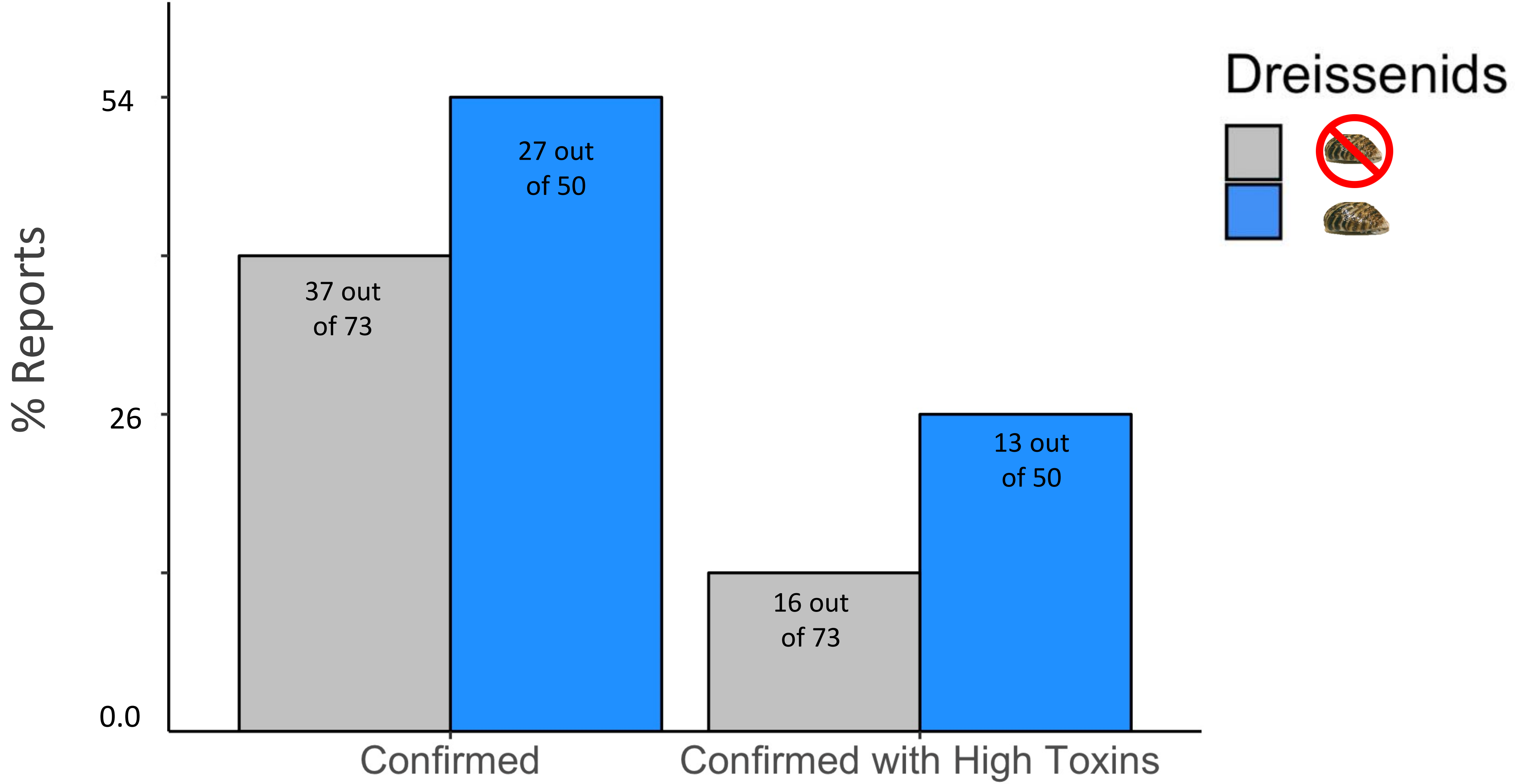
Augur Lake
Bradley Brook Reservoir
Chenango Lake
Crooked Lake
Echo Lake
Geneganslet Lake
Guilford Lake
Hadlock Pond
Kasoag Lake
Lincoln Pond
Panther Lake
Petonia Lake
Lake Placid
Plymouth Reservoir
Song Lake
Lake Sunnyside
Tully Lake
Warn Lake

n=18

Geographic distribution of study lakes (n=27)



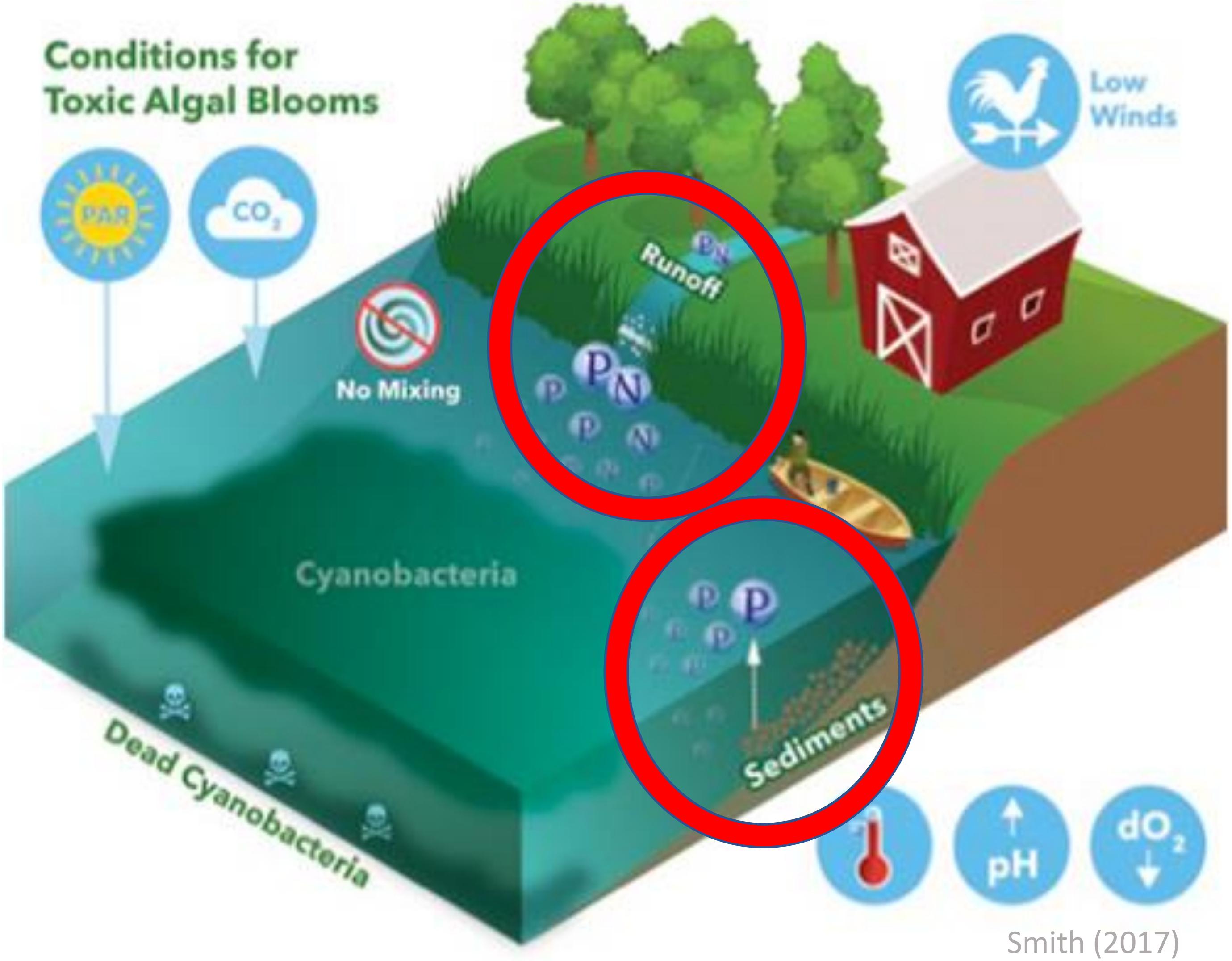
Frequency of HAB Reports in CSLAP monitoring 2012-2017



CSLAP variables to assess

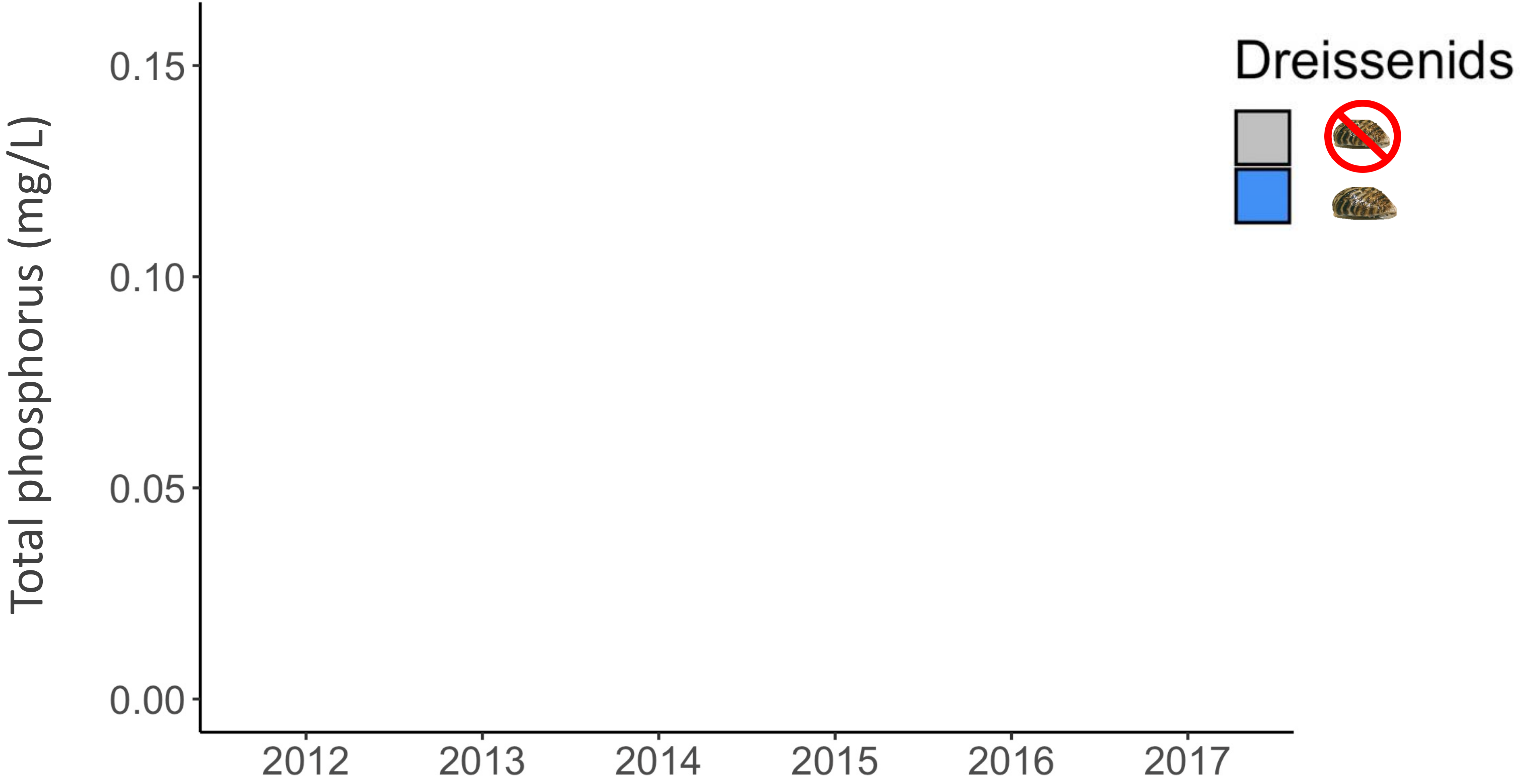
Parameter	**Importance**
PHOSPHORUS	Limiting nutrient in freshwater. Important for growth of aquatic plants and phytoplankton.
SECCHI DEPTH	Estimator of water quality. Inversely related to chlorophyll *a.*
TRUE COLOR	Estimation of dissolved organic matter (DOM). Affects water clarity and light penetration
TP/MICROCYSTIN CORRELATION	Informs the degree of the relationship between total phosphorus and the toxin microcystin.

Known: Increased phosphorus contributes to bloom formation

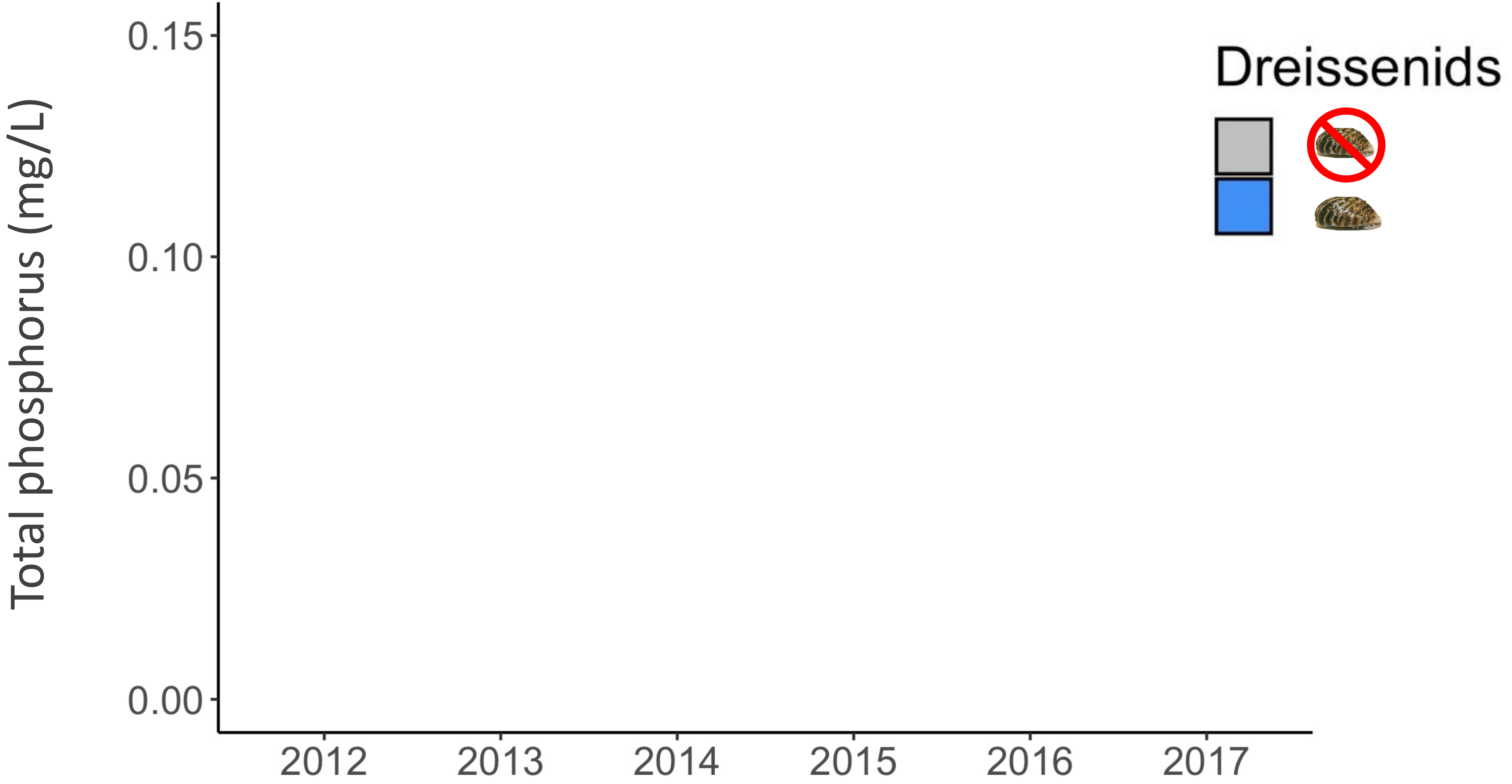


Smith (2017)

Bottom Sample Total Phosphorus

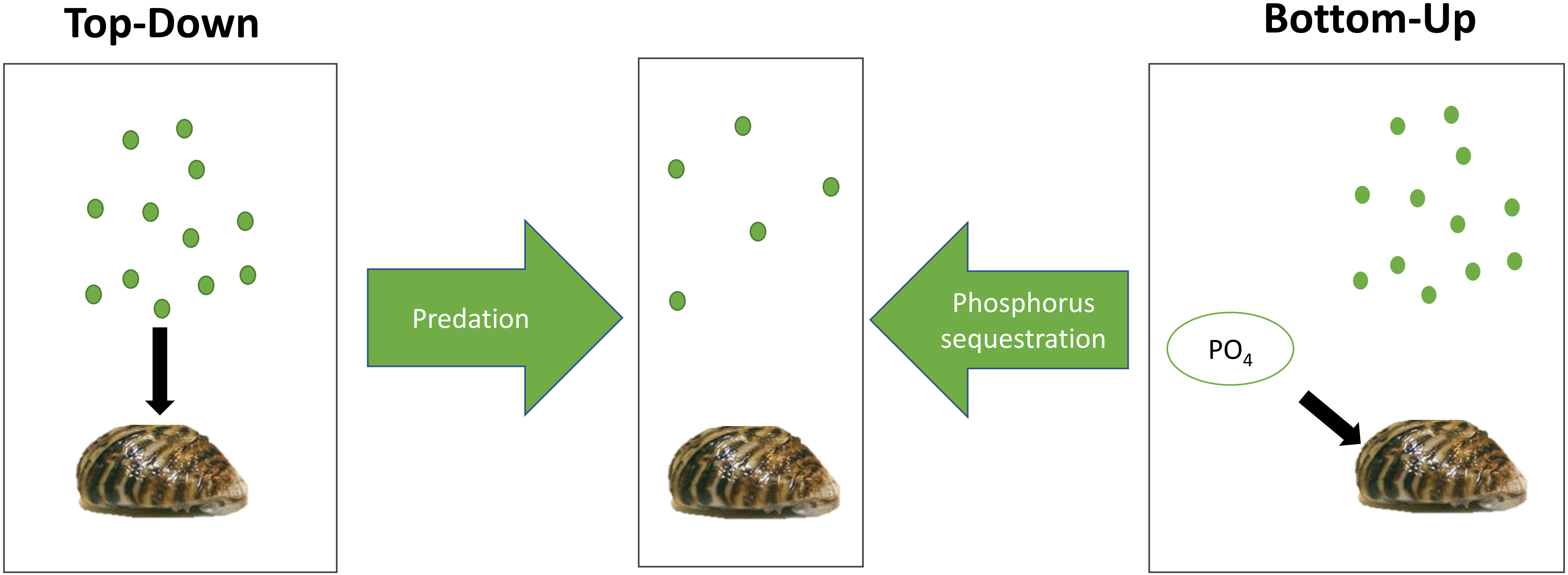


Open Water Total Phosphorus

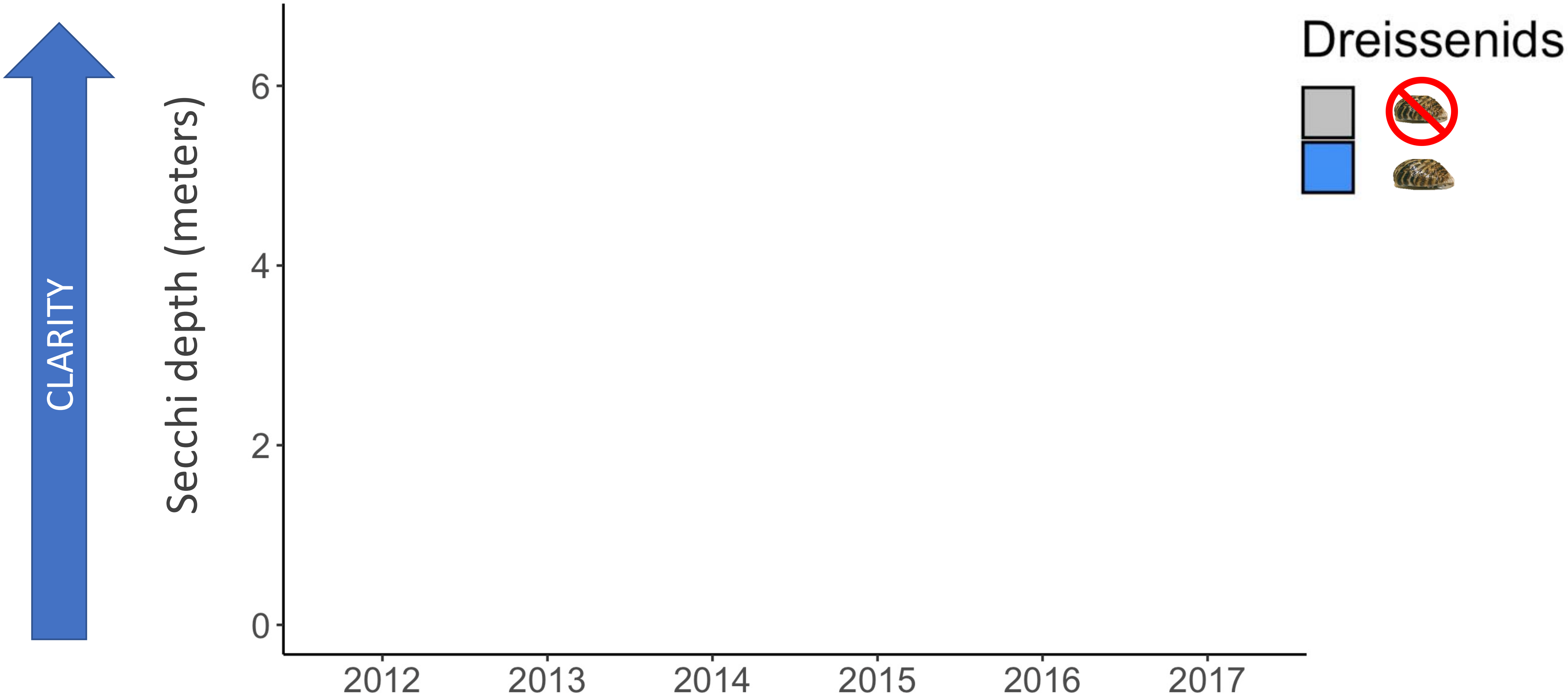


Parameter	**Mixed Effects Model Result**
PHOSPHORUS	**No significant difference** between invaded and uninvaded lakes
SECCHI DEPTH	
TRUE COLOR	
TP/MICROCYSTIN CORRELATION	

Known: Dreissenid mussels decrease chlorophyll *a* concentrations

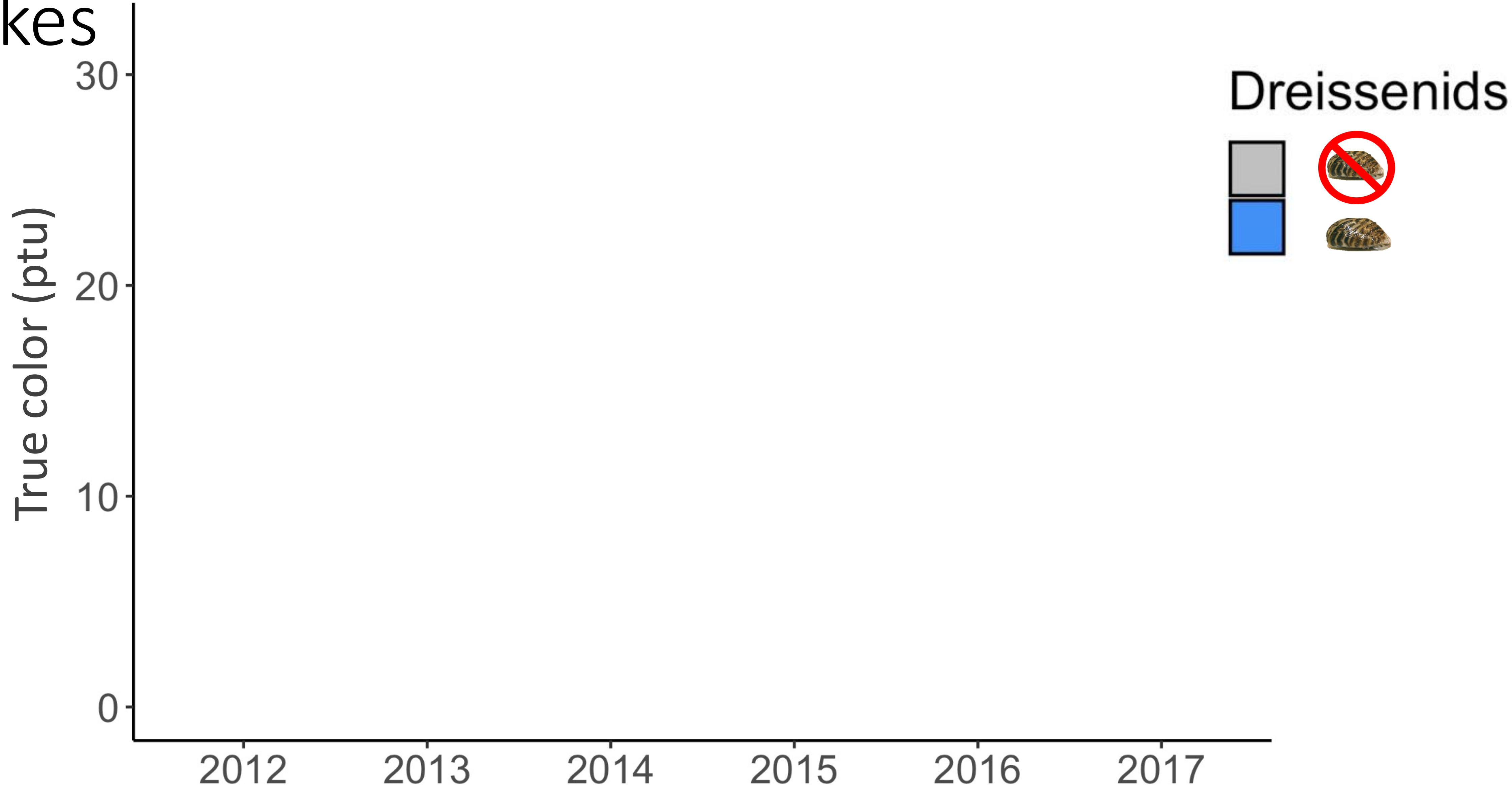


Secchi Depth



Parameter	Mixed Effects Model Result
PHOSPHORUS	**No significant difference** between invaded and uninvaded lakes
SECCHI DEPTH	**No significant difference** between invaded and uninvaded lakes
TRUE COLOR	
TP/MICROCYSTIN CORRELATION	

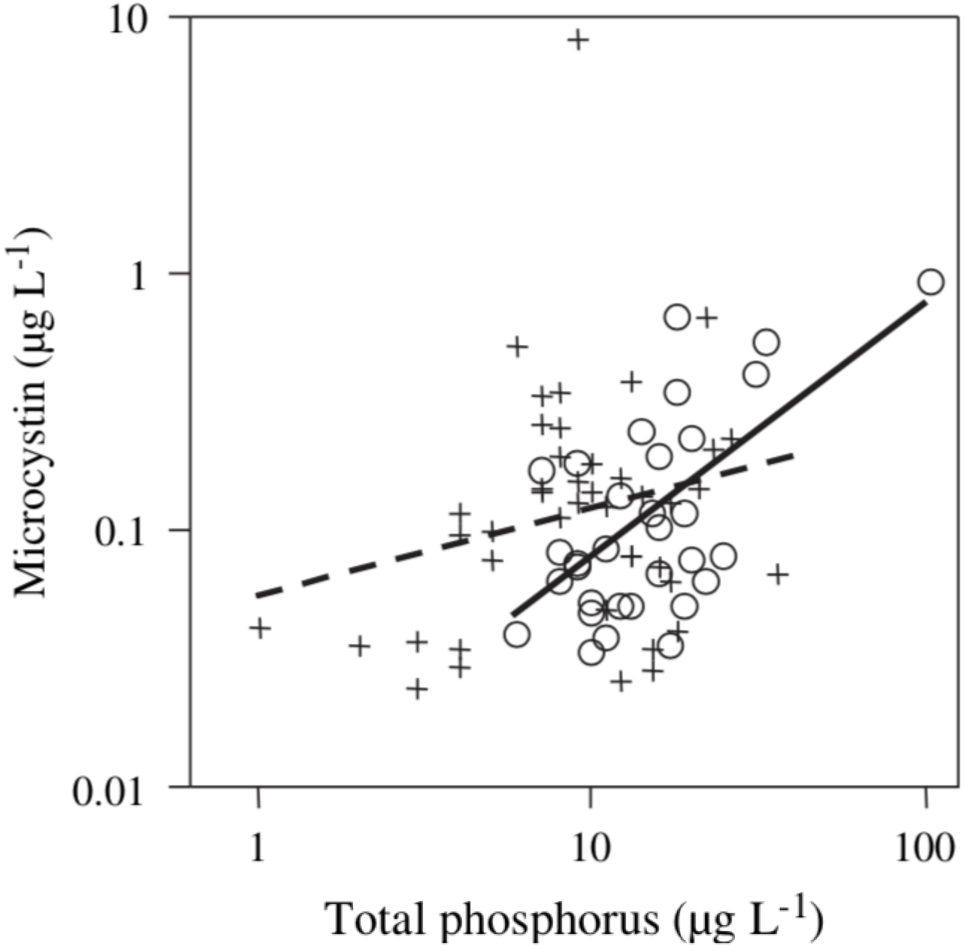
True color (DOM) is greater in uninvaded lakes



Parameter	Mixed Effects Model Result
PHOSPHORUS	**No significant difference** between invaded and uninvaded lakes
SECCHI DEPTH	**No significant difference** between invaded and uninvaded lakes
TRUE COLOR	**Significant difference** between invaded and uninvaded lakes True color lower in invaded lakes (*p*=0.0002)
TP/MICROCYSTIN CORRELATION	

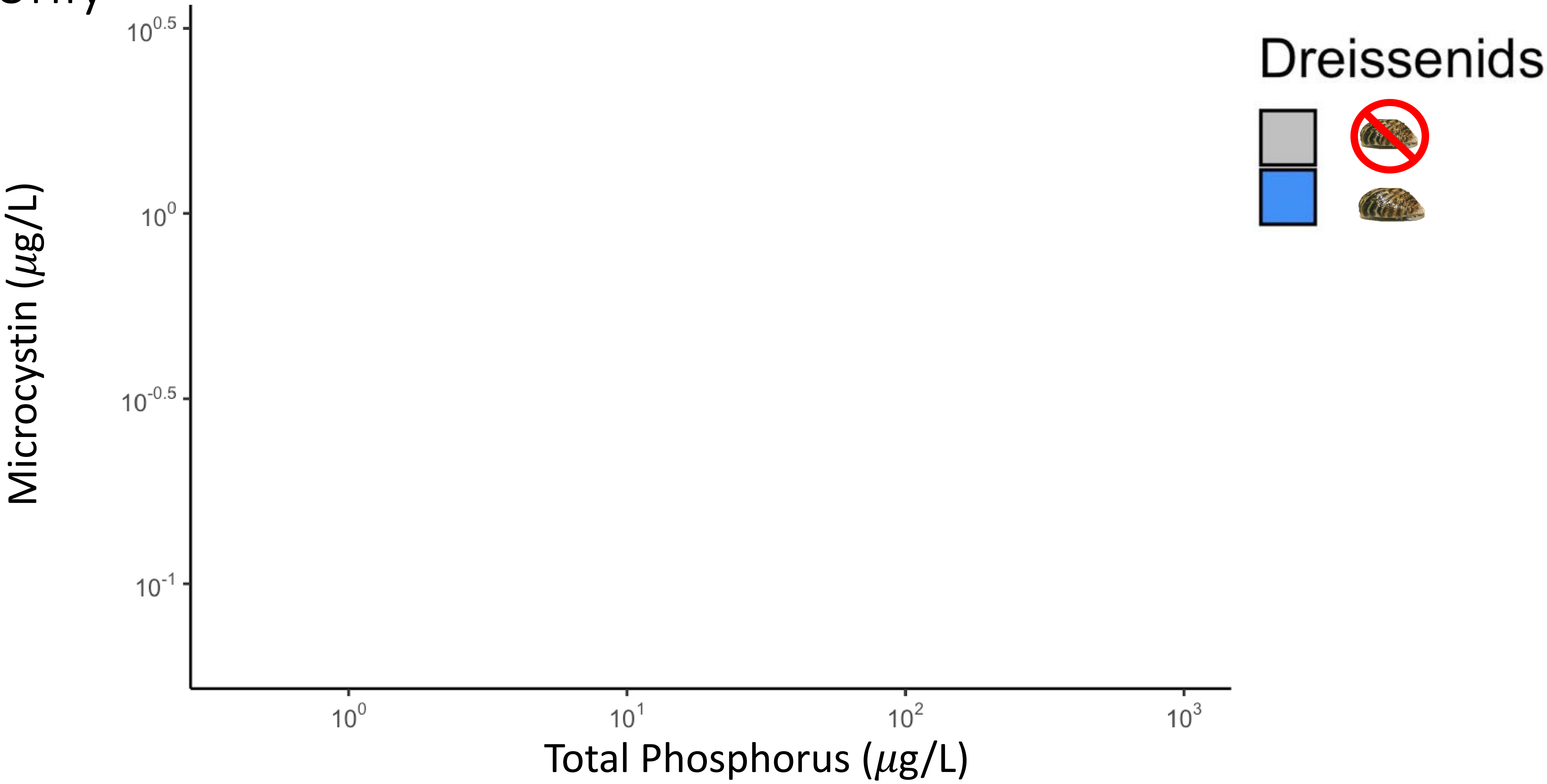
How do expected correlations differ between invaded and uninvaded lakes?

- Expect microcystin to correlate with total phosphorus
- Rate might differ between invaded and uninvaded lakes



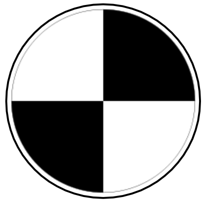
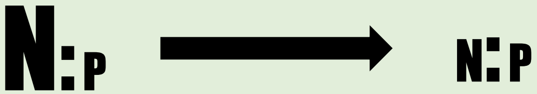
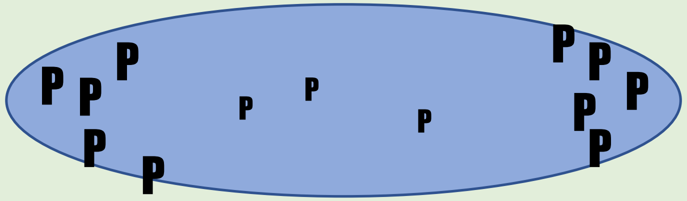
Sarnelle et al. (2010)

Microcystin weakly correlated with TP in invaded lakes only



Parameter	Mixed Effects Model Result
PHOSPHORUS	**No significant difference** between invaded and uninvaded lakes
SECCHI DEPTH	**No significant difference** between invaded and uninvaded lakes
TRUE COLOR	**Significant difference** between invaded and uninvaded lakes True color lower in invaded lakes (p=0.0002)
TP/MICROCYSTIN CORRELATION	**Significant** *only* in invaded lakes (p=0.002)

Dreissenids alter physical, biochemical, and biological environment

CLEARANCE RATES		No difference in clarity, but there is a difference in true color
NUTRIENT STOICHIOMETRY		No differences in TP concentrations
SELECTIVE FILTRATION		Evidence of stronger relationship between TP and microcystin
NUTRIENT DISTRIBUTION		Spatial distribution not yet assessed

Arnott and Vanni (1996); Hecky et al. (2004); Karatayev et al. (2015)

Zebra Mussel
(*Dreissenia polymorpha)*

Quagga Mussel
(*Dreissenia rostriformis bugensis)*

Sits flat on ventral side

Triangular in shape

Color patterns vary

Will not sit flat/topples over

Rounder in shape

Dark concentric rings on shell

Paler in color near hinge

Credit: USGS

Citizen science can be used to monitor for dreissenids

- iMapInvasives
- CSLAP
- Add dreissenid parameter
  - Passive monitoring for presence/absence
  - Active sampling to estimate mussel abundance


Credit: NYSDEC

Proposed methods for dreissenid data collection

Tully Lake *Chris Kruth*

Song Lake* *Tarki Heath*

Crooked Lake *Seth Aldrich*

Owasco Lake* *Michele Bartlett*

Honeoye Lake* *Terry and Dorothy Gronwall*

DeRuyter Reservoir* *Kathy Sherlock*

Proposed protocol

Early Spring
- Place 5 bricks in your lake
- Bricks can be tied off underneath docks

Retrieval
- Every 4 weeks, take one brick out
- Check for presence of dreissenid mussels

Counting
- Count number of zebra and quagga mussels
- Using known surface area of brick, estimate mussel density (mussels/m^2)

Takeaways

- Zebra and quagga mussel alter the physical, biological, and chemical characteristics of the systems they invade
- Redistribution of nutrients and increased water clarity by dreissenids might impact HAB formation
- For these lakes:
    - Invaded lakes did not have differences in TP and Secchi depth
    - Invaded lakes had lower true color and a TP/microcystin relationship
- Monitoring by citizen scientists can help by
    - Preventing mussel establishment
    - Informing extent of invasion

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Chris Kruth (Tully Lake)

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Seth Aldrich (Crooked Lake)

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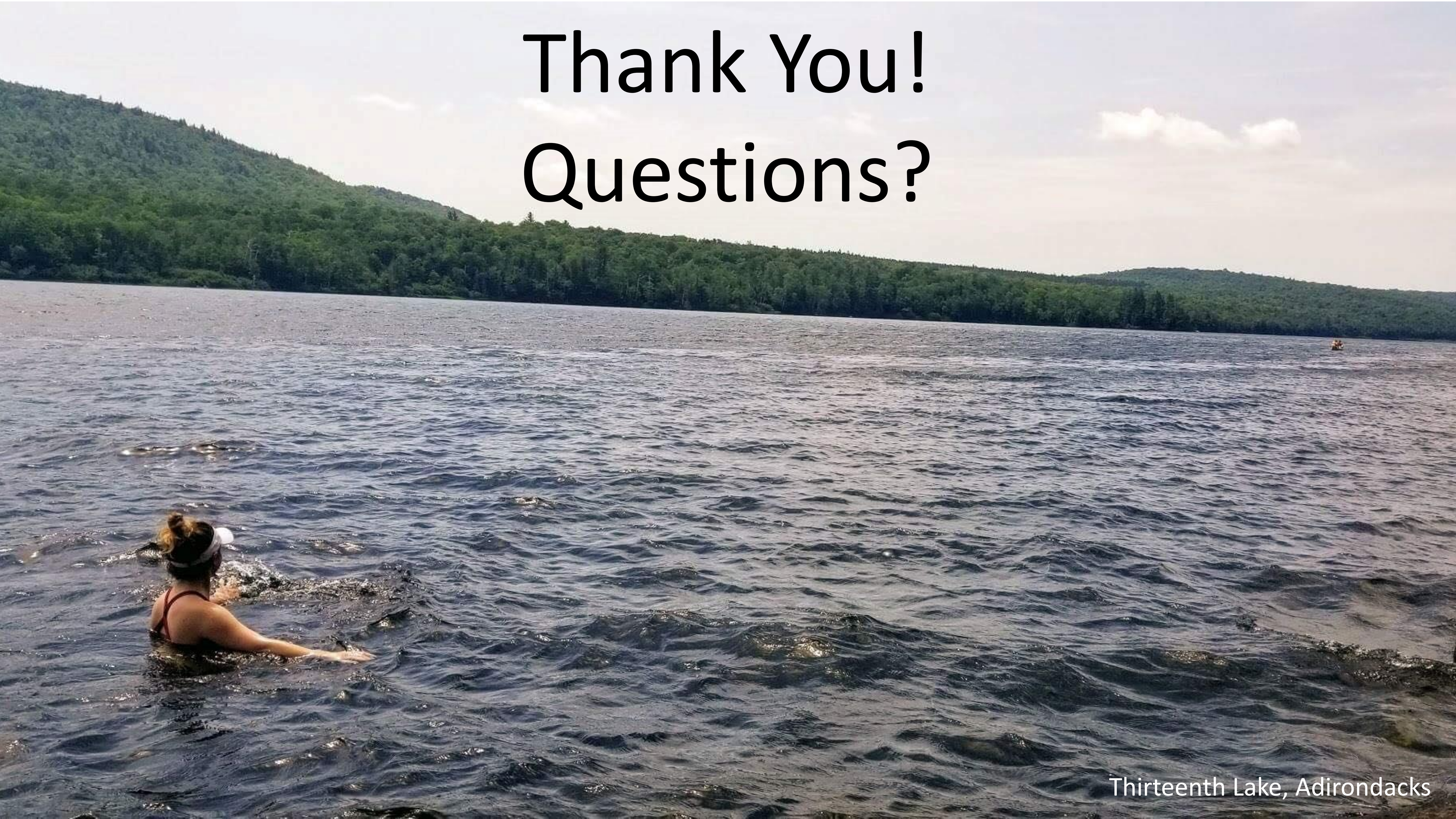
ESF

State University of New York College of
Environmental Science and Forestry

Thank You!
Questions?



Thirteenth Lake, Adirondacks

Phosphorus

Why it's important Phosphorus is usually the limiting nutrient in freshwater systems

How it's measured Open water samples (~1.5 meters from surface) and deep samples (~1.5 from bottom) are analyzed using spectrophotometry (total phosphorus=dissolved+suspended)

Trophic assessment Eutrophic: (> .020 mg/L) Oligotrophic: (< .010 mg/L)

Chlorophyll *a*

Why it's important Chlorophyll *a* is a photosynthetic pigment found in plants and phytoplankton. It is indicative of primary productivity

How it's measured Open water samples are organically extracted and analyzed via spectrophotometer

Trophic assessment Eutrophic: (> 8.0 μg/L) Oligotrophic: (< 2.0 μg/L)

Water clarity

Why it’s important Secchi depth is closely related to algal and macrophyte productivity. Water clarity is also important for public perception

How it’s measured Computed as the average of the depth at which the Secchi disk disappears from sight from the lake surface and the depth at which the disk reappears, both measured to the nearest 0.1 meter.

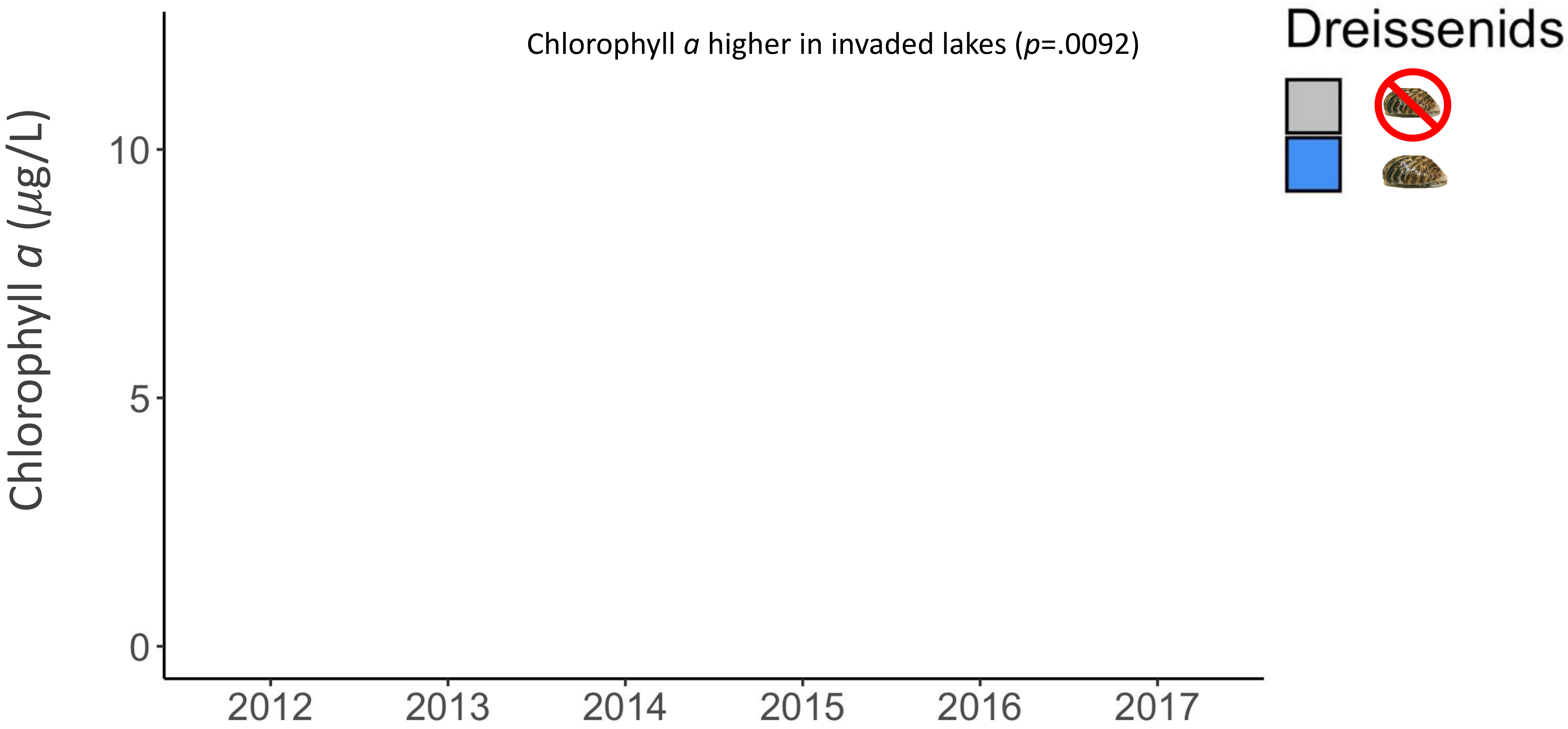
Trophic assessment Eutrophic: (< 2 meters) Oligotrophic: (> 5 meters)

True Color

Why it's important True color gives an estimation of dissolved organic carbon by not including suspended particles like algae and sediment

How it's measured Color samples are visually compared to a scaled set of standards created from a platinum-cobalt solution

Chlorophyll *a*



DON'T MOVE A MUSSEL

CLEAN · DRAIN · DRY

Toxicant

- Niclosamide
- Potassium Chloride
- Copper Compounds
- *Pseudomonas fluorescens*

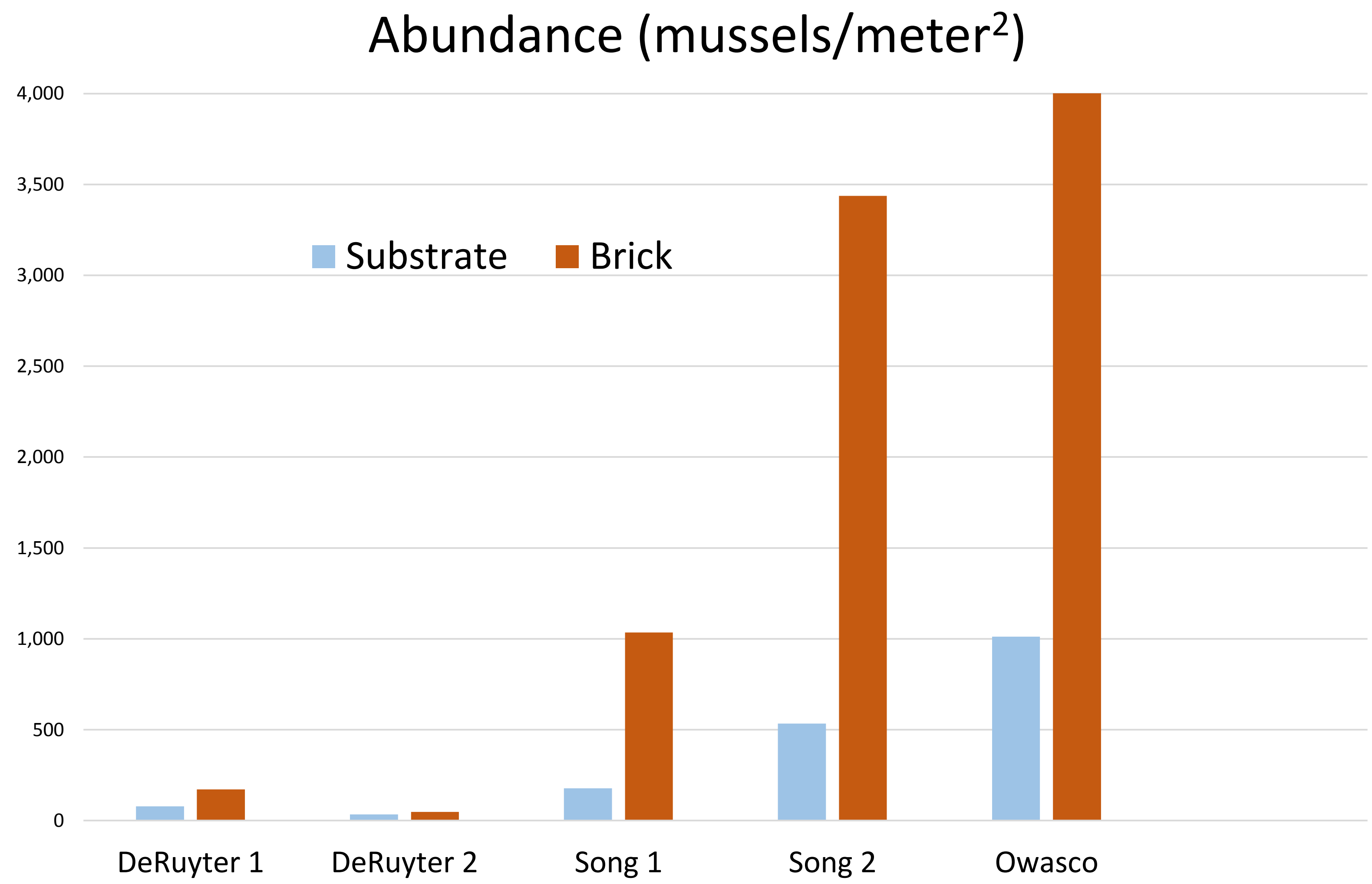
Physical

- Benthic mats
- Water drawdowns
- Manual removal

Other

- Biological
  - Predation
- Carbon Dioxide

Summer 2018 Results



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Karatayev, A. Y., Burlakova, L. E. & Padilla, D. K. Zebra versus quagga mussels: a review of their spread, population dynamics, and ecosystem impacts. *Hydrobiologia* **746**, 97–112 (2015).

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