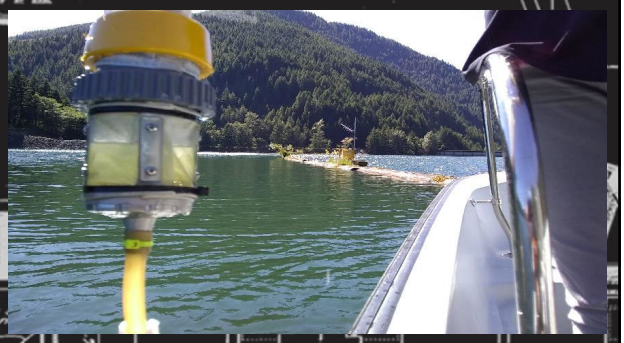
DO DAM OPERATIONS AFFECT CYANOTOXINS IN DETROIT LAKE?



Norm Buccola - Portland District USACE
Theo Dreher - Oregon State University
Kurt Carpenter – USGS Oregon Water Science Center

March 8, 2024
CyanoHabs meeting
Oregon State University, Corvallis Oregon

U.S. ARMY
US Army Corps of Engineers

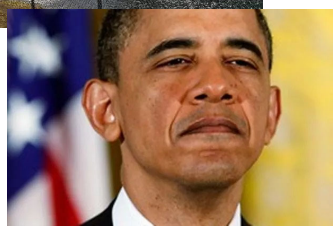
1

BACKGROUND AND HISTORY

U.S. ARMY

- 1955 Detroit Dam Construction Completed
- 2007 USACE begins operational temperature management (spillway and regulating outlet)
- 2015 EPA Cyanotoxin criteria established for recreational and drinking waters
- May 2018 HAB Event; USACE pauses spillway operations
- 2019 Seismic IRRM begins (reduced max lake)
- 2020 North Santiam and McKenzie Wildfires

But, 2019-Present:
No significant HAB events



WHY?
What happened in 2018?
What has happened since?

2

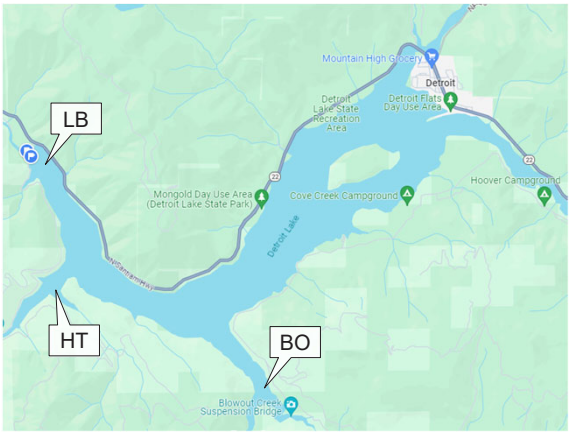
PROJECT GOALS AND FOUNDATIONAL DATA

Key Questions:

- Why the shift in algal assemblage? - Theo, Kurt
- What role does dam operations play in HAB formation? – Norm

Datasets (2011-2022):

- USACE/USGS: continuous monitors
  dam operations, hydrology, water temperature
- City of Salem: Boat-based sampling (3 locations)
  phytoplankton, toxins, nutrients
- USDA/USFS: met station near Mongold S.P.
  i.e., wind speed, wind direction



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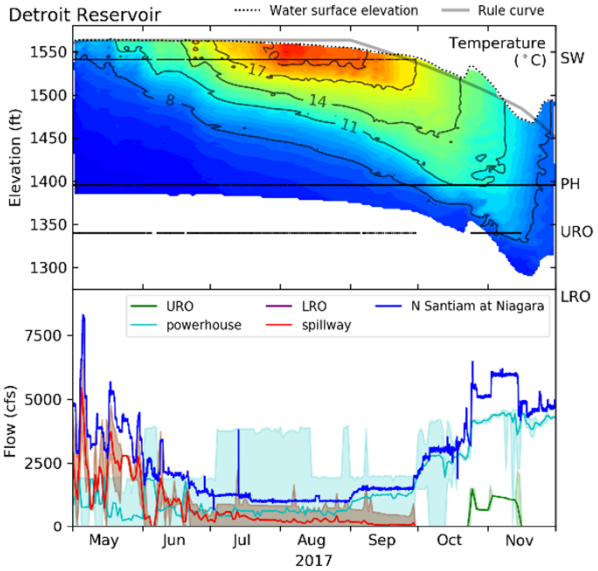
DATA PROCESSING

- Notable Variables:
  - **SurfT**: Max water temperature [ºC]
  - **ThermD**: Thermocline Depth[1] [m]
  - **SpillD**: Depth to spillway crest [m]
  - **SpillQ**: Release from Spillway [m^3/s]
  - **Qdif**: Lake Inflow - Outflow [m^3/s] (storage)
  - **ua**: wind velocity [m/s]
  - **wdc**: categorical wind direction [e.g., N, NNW
  - **t_n**: Total Nitrogen [mg/L]
  - **Log10DolBv :** Dolichospermum spp. [$\mu m^3/ml$
  - **cyl**: Cylindrospermopsin concentration [ppb]
  - **mc**: Microcystin concentration [ppb]
- Weekly averaging
- Removal of outliers



[1]"thermo.depth" function in rLakeAnalyzer (Winslow and others, 2019)
Winslow L, Read J, Woolway R, Brentrup J, Leach T, Zwart J, Albers S, Collinge D (2019). rLakeAnalyzer: Lake Physics Tools. R package version 1.11.4.1, <https://CRAN.R-project.org/package=rLakeAnalyzer>.

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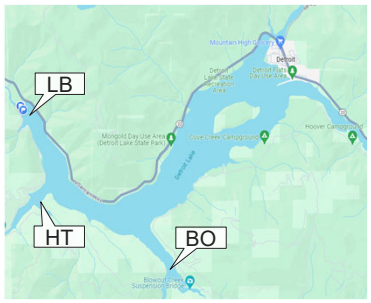
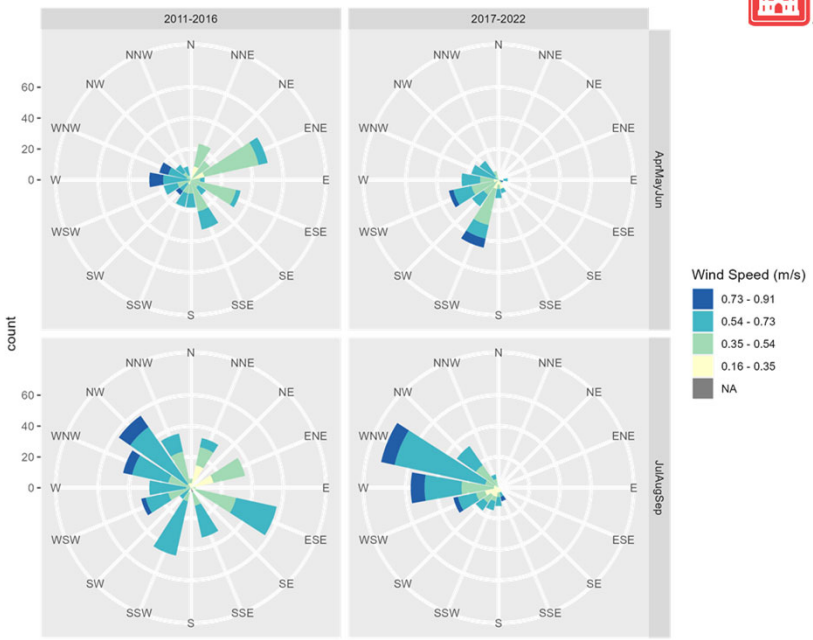
WIND

- Predominant wind is ~NW:
  - Pushing surface water toward arms (BO, HT sites)
- Non-prevailing wind is ~E
  - Pushing surface water toward arms (LB site)
  - Occurs more in summer
  - *Decreased after 2017*





CYANOTOXINS: BEFORE / AFTER 2017

Annual Maximums
Split by W/E wind

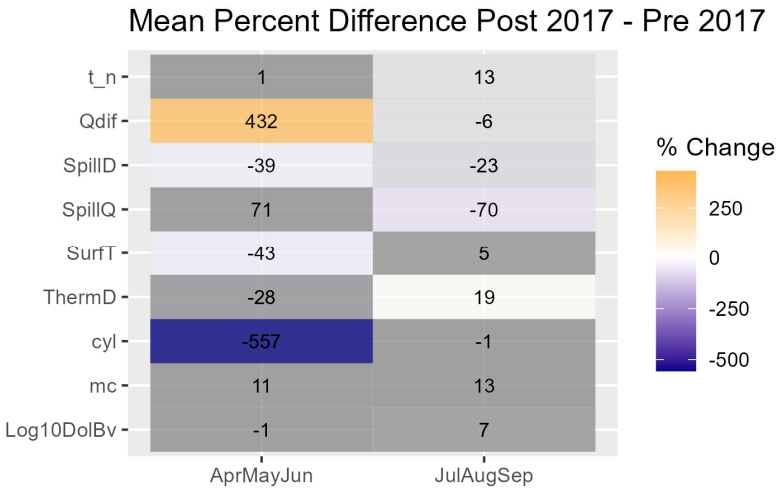
1. Low **LB cyl** values
2. High **cyl** in 2017:
   – E wind, high **DoIBv**
3. High **mc** in 2018
   – W wind

BEFORE / AFTER 2017*

colored values statistically different**

1. Most variables had bigger changes in AprMayJun
2. *Decreases*:
   cyl
   SpillD, **SurfT, ThermD**
   SpillQ (summer),
   Qdif (summer)

3. *Increase*:
   Qdif (spring storage),
   SpillQ (spring),
   mc



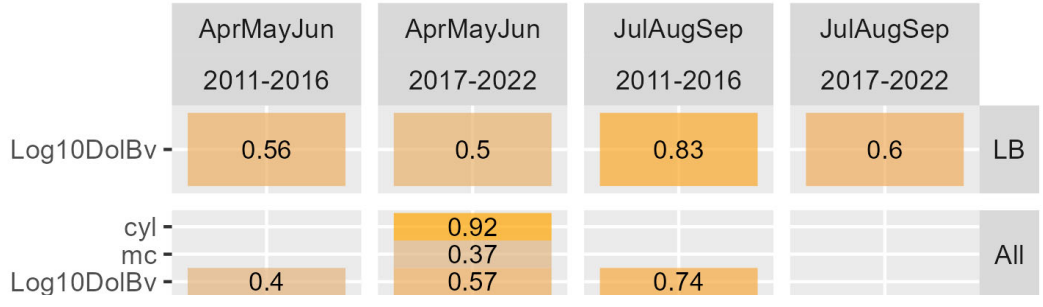
*2017 chosen for the year through trial and error due to the high number of good models developed variables before and after this year.
**wilcox.test function in R performs Wilcoxon Rank Sum test of significant difference between two vectors

STATISTICAL MODEL DEVELOPMENT

Random Forest[2] Models developed across:

- Sites:
  - LB (Log Boom)
  - All (Log Boom, Blowout Arm, Heater Arm)
- Before/After 2017
- Season (only AprMayJun timeframes produced good models)

Good model threshold: Nash Sutcliffe > 0.36

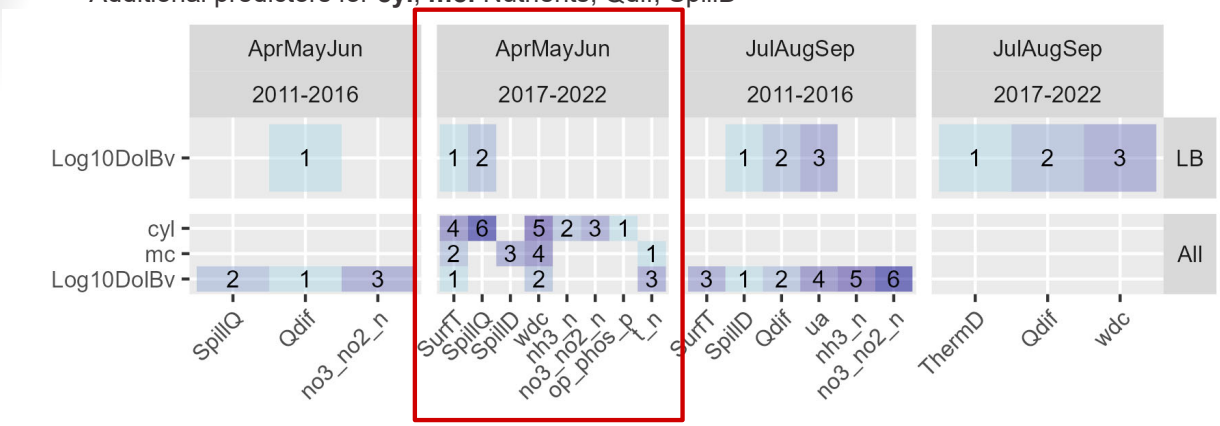


[2]A. Liaw and M. Wiener (2002). Classification and Regression by randomForest. R News 2(3),18--22.

STATISTICAL MODEL DEVELOPMENT

Random Forest[2] Model Variable Importance:

- **cyl, mc** predicted well only 2017-2022
- Focusing on AprMayJun:
  - Top predictor variables for **LB, DoIBv**: SurfT, SpillQ, ThermD, SpillD, wind
  - Additional predictors for **cyl**, **mc:** Nutrients, Qdif, SpillD

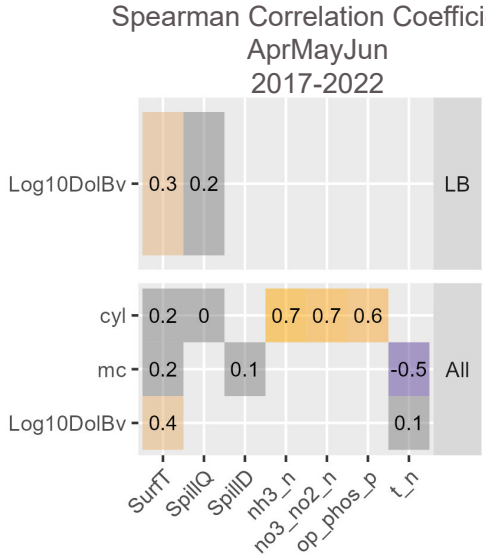


[2]A. Liaw and M. Wiener (2002). Classification and Regression by randomForest. R News 2(3),18--22.

STATISTICAL MODEL DEVELOPMENT

Since 2017:

- Higher **cyl** associated with higher nutrients
- Higher **mc** associated with lower nitrogen



Note: grey values <0.3

CONCLUSIONS

Goal is to decrease *Dolichospermum* and algal toxins

1. Role of flow, storage, and nutrients is important and complex
2. Spillway flow and depth from surface elevation to spillway crest are the only operational "knobs"
   - No clear direct relationship with *Dolichospermum* biovolume or toxins
   - May have importance during specific conditions (i.e., wind, refill timing)
3. Nutrients, SurfT, Wind are best predictors for MC and Cylindro toxins
4. East wind events may result in higher CyanoHAB biovolume near dam
   - Suggest avoiding spillway flow during warm spring with East wind

Note: grey values <0.3

COMMENTS OR QUESTIONS?

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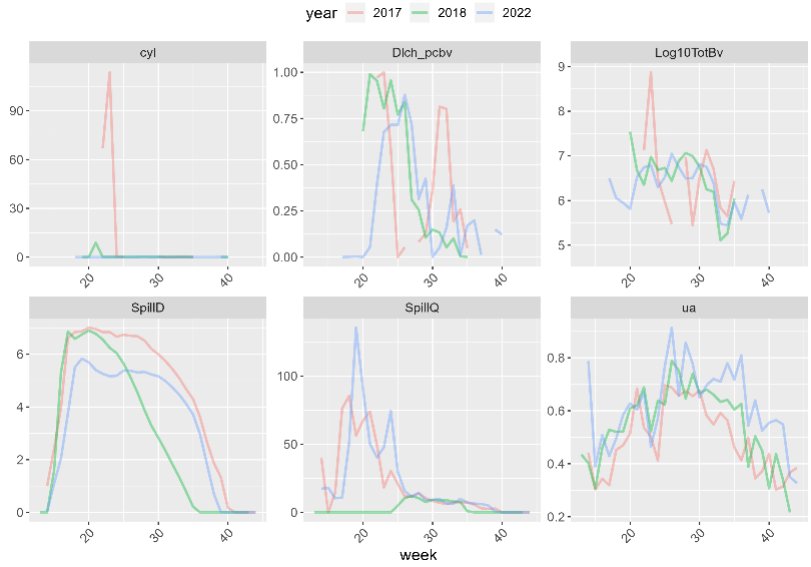
WHAT HAPPENED IN 2017 AND 2018?



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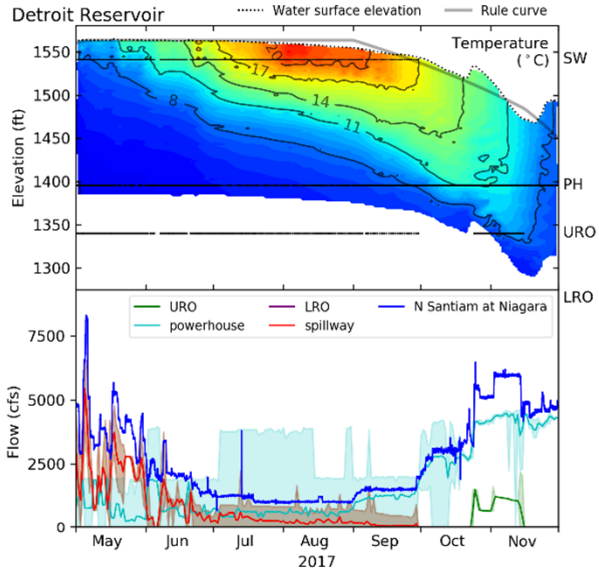
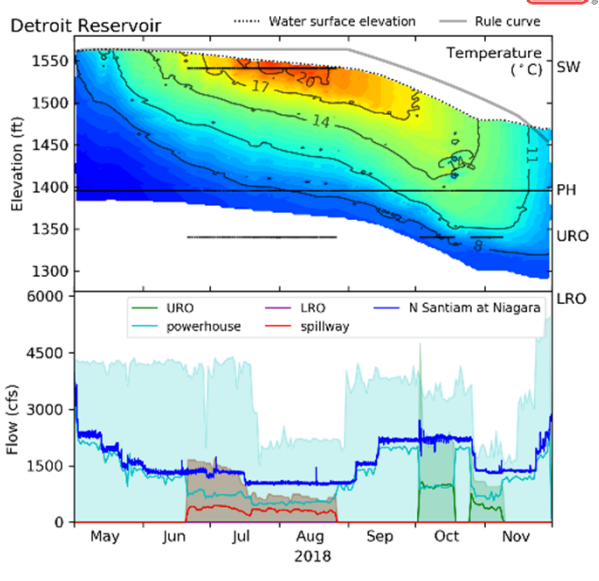
2017 AND 2018





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