



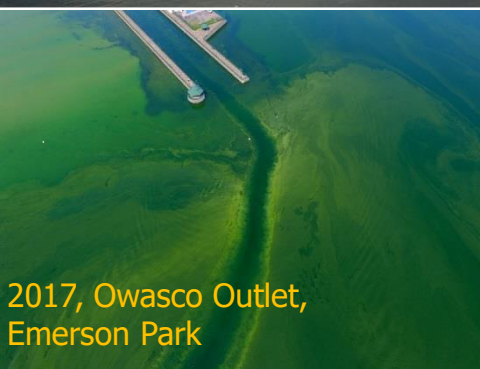
# WQ Status of Owasco Lake – 2020

## Bob Brower Scientific Symposium

March 6, 2021



2017, Burtis Pt, Owasco Lake



2017, Owasco Outlet, Emerson Park



Owasco Lake looking South

**John D Halfman**

Environmental Studies Program  
Department of Geoscience  
Finger Lakes Institute  
Hobart & William Smith Colleges

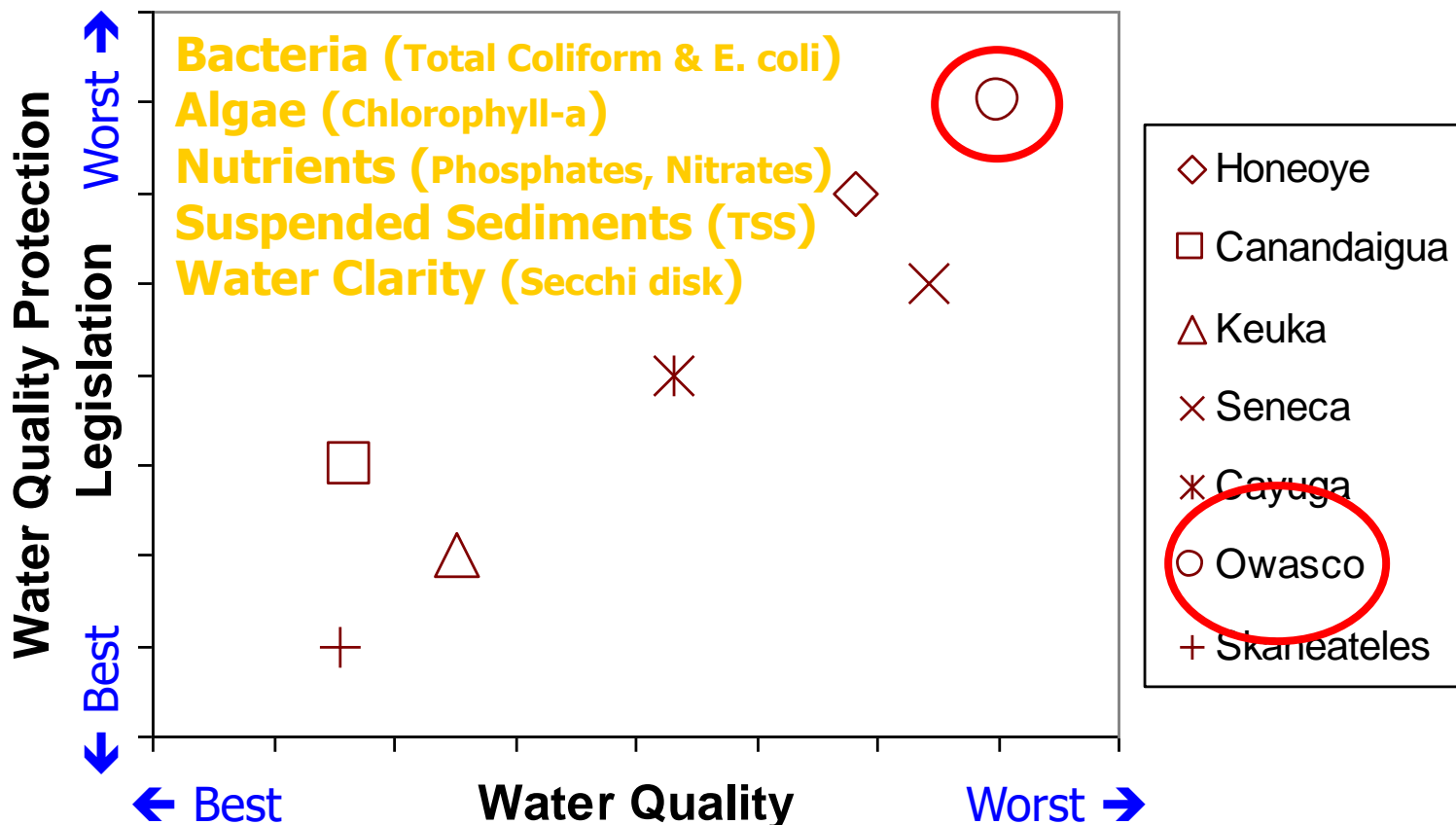


2017, NE Corner, Owasco Lake

# Background: 2005 Water Quality & Its Protection



## Finger Lake Water Quality





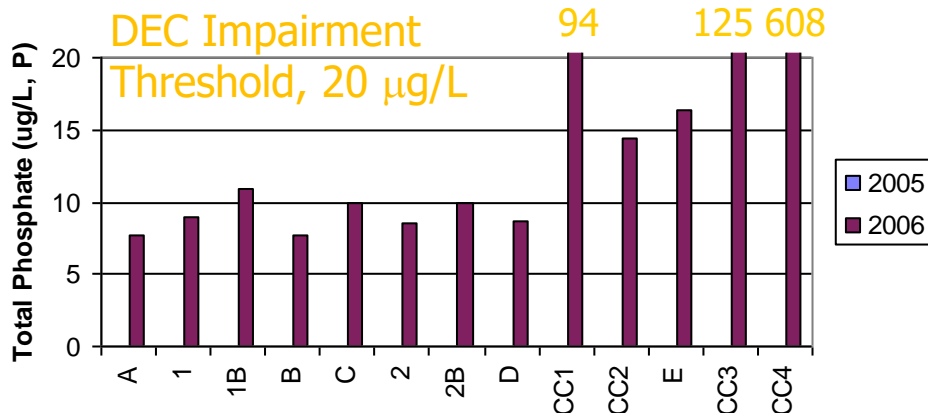
# Owasco Lake

## Total Phosphates

2006 Fred L. Emerson Foundation Funds  
2007 NYS Funds – Senator Nozzolio

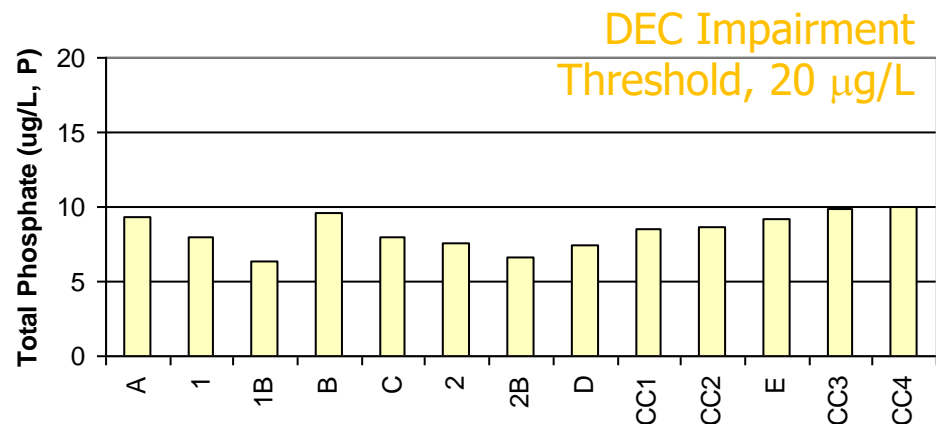
**2006**

**Total Phosphate  
Annual Averages**



**2007**

**Total Phosphate  
Annual Averages**



# Ecological Health? Nutrient Cycle

Streams, Rain

Dissolved Nutrients

Plankton

Outlet

Bacterial  
Decomposition

Fish (Lake Trout)  
&  
Other Organisms

Dead Organic Matter

Sediments

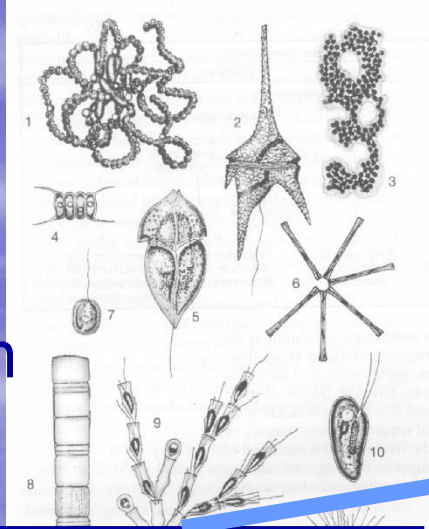


Figure 21-4 Selected phytoplankton. (1) cyanobacterium cluster: *Anabaena flos-aquae*, (2) dinoflagellate: *Ceratium hirundinella*, (3) cyanobacterium colony: *Microcystis flos-aquae*, (4) green algae colony: *Scenedesmus quadricauda*, (5) dinoflagellate: *Gymnodinium helveticum*, (6) diatom: *Asterionella formosa*, (7) chrysophyte: *Chrysococcus rufescens*, (8) filamentous diatom: *Aulacoseira islandica*, (9) chrysophyte: *Chrysococcus rufescens*, (10) cryptomonad: *Cryptomonas parvula*, (11) alga (desmid): *Pediastrum boryanum*, (12) *Chlamydomonas caudata*. Not to scale.



Lake Trout (*Salvelinus namaycush*)





# Human Impact: Nutrient Cycle

Agricultural Fertilizers  
Animal Feedlots  
Wastewater Nutrients  
On-Site Systems

Streams, Rain

Dissolved Nutrients

Plankton

Algae Scum  
Weeds

**Cyanobacteria**

Outlet

Bacterial  
Decomposition

Eutrophication  
Anoxia?

Rotten Egg Smell

Zebra/Quagga  
Mussel Impact

Fish (Lake Trout)  
&  
Other Organisms

Dead Organic  
Matter

CAFO, Human &  
Soil Particulate  
Organic Matter

Sediments

"Bottom Up" Approach



# 2020: A Busy Year

## COVID Issues – No Students

Monthly Lake Surveys  
Stream Segment Analyses  
Buoy Deployment  
Dockside Instrumentation



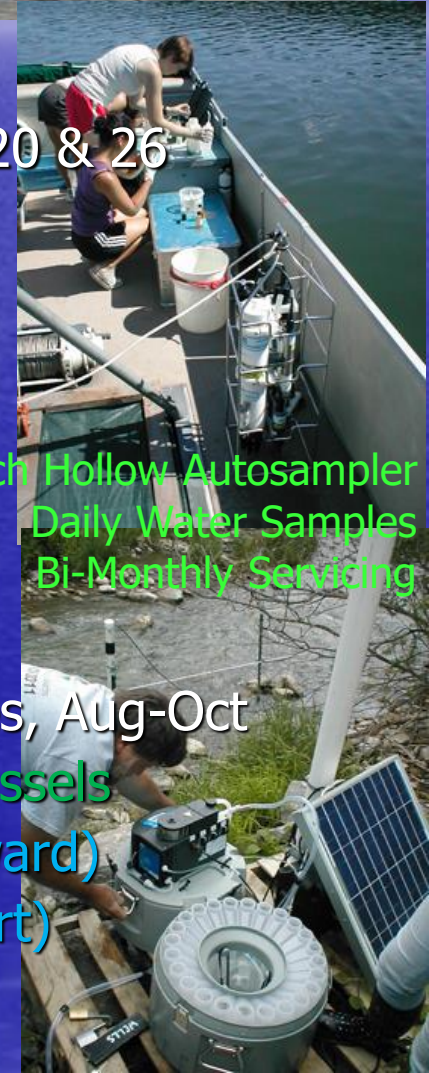
### • Lake & Stream Monitoring

- Lake, Dutch Hollow Brook, Owasco Inlet & Fire Lane 20 & 26
  - Lakes: Monthly Surveys, May – Oct, Two Sites
  - Streams: Four Surveys, May-June, Nine Sites
- Lake WQ, Nutrient Sources & Phosphorus Budget
- Event/Base Flow @ Dutch Hollow Brook, Apr - Nov
- Cayuga County Support

### • Offshore Buoy & Dockside Sensor Arrays

- Deployment WQ & Air Monitoring Buoy, May - Nov
- Weather, Water Temperature & Photos at 4 Dock Sites, Aug-Oct
- Mesocosms, Nutrients in Sediments, Macrophytes, Mussels
- Fred L. Emerson Foundation Support (1<sup>st</sup> of 3 year award)
- Spectral Information of Cyanobacteria (County Support)

Dutch Hollow Autosampler  
Daily Water Samples  
Bi-Monthly Servicing





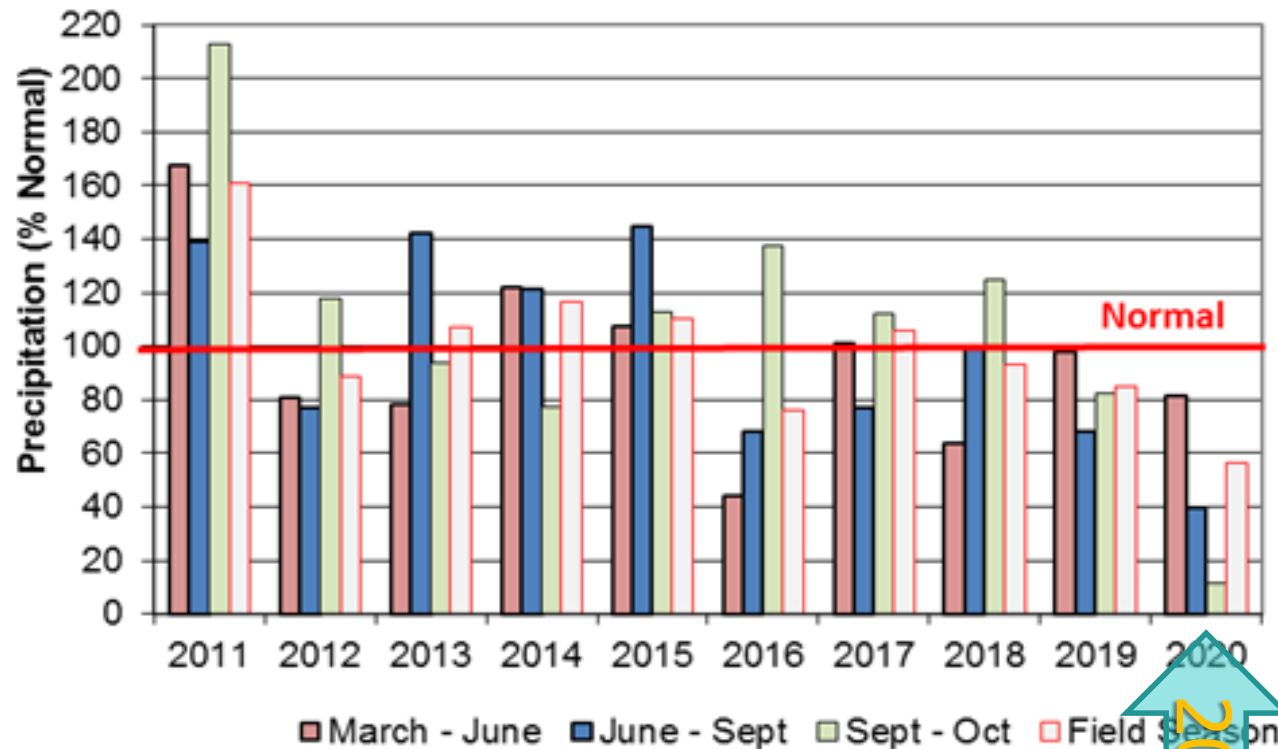
# Rainfall in 2020: A Very "Dry" Year

## Impact on Water Quality?



When Wet...

Seasonal Precipitation @ Ithaca Airport  
2011-2020



2020 was Dry  
~56% of Normal

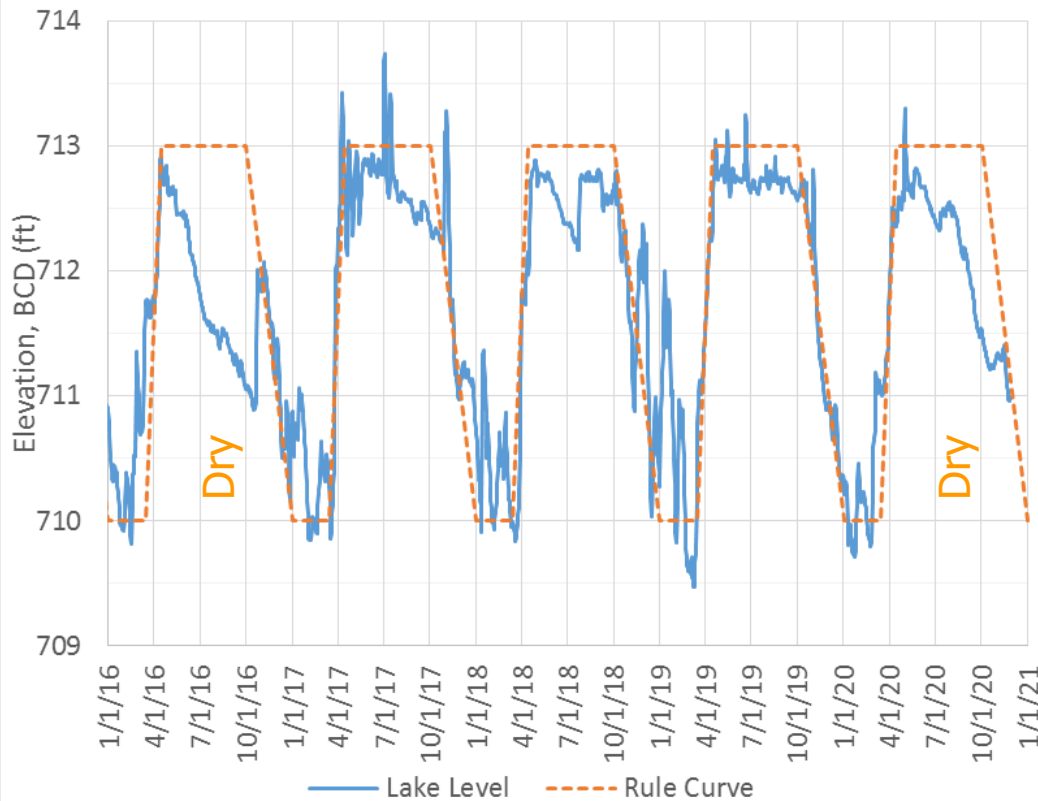
Wet 2011, '13 & '15  
Dry 2012, '16 & '18

Correlation to Nutrient  
and Sediment Loads,  
Water Quality in Lake?

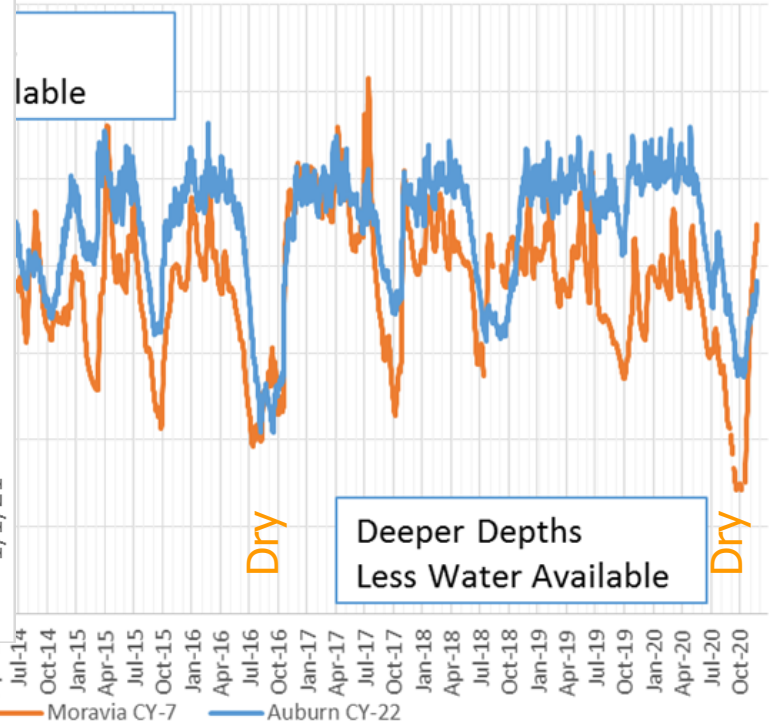
2020

# Dry Conditions Impacted Lake Levels & GW Water Tables

Owasco Lake Levels



tershed Groundwater Depths  
tion from Mean Depth





# Stream Monitoring for Nutrients

## Dutch Hollow Brook & Owasco Inlet

Total 9 Sites, including Fire Lane 20 & 26

- **Stream Segment Analysis**

- Water Grab Samples

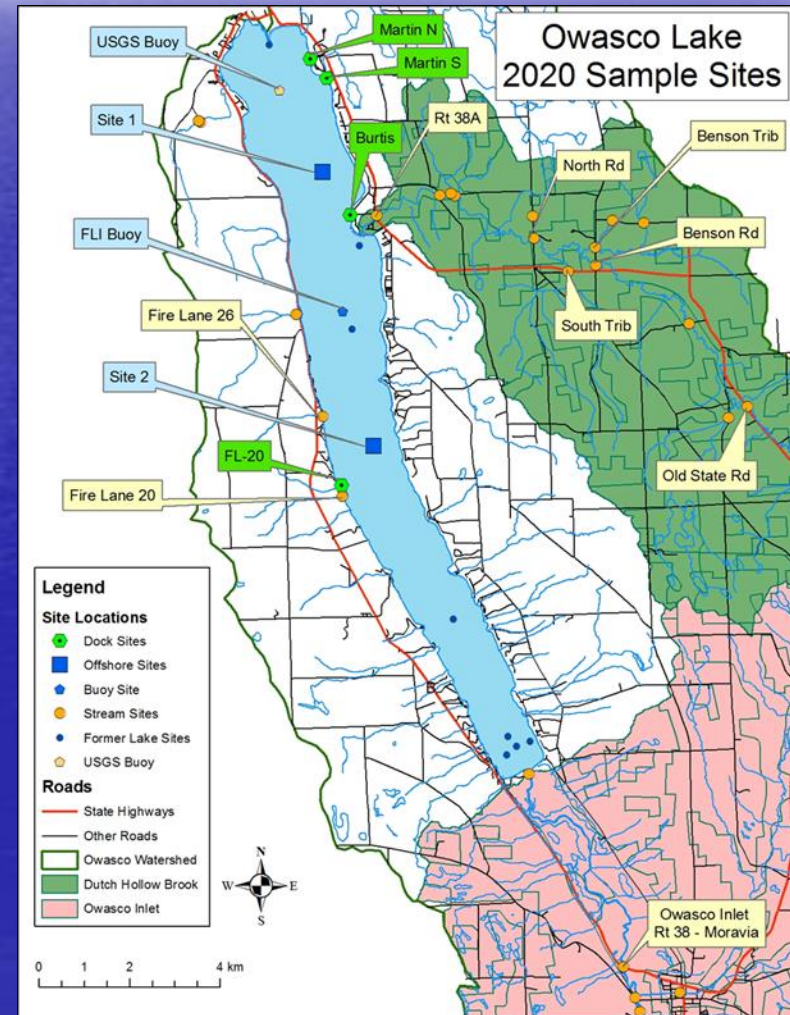
- **Discharge**

- **On-Site Analyses**

- DO, pH, Alkalinity
- Conductivity
- Temperature

- **Lab Analyses**

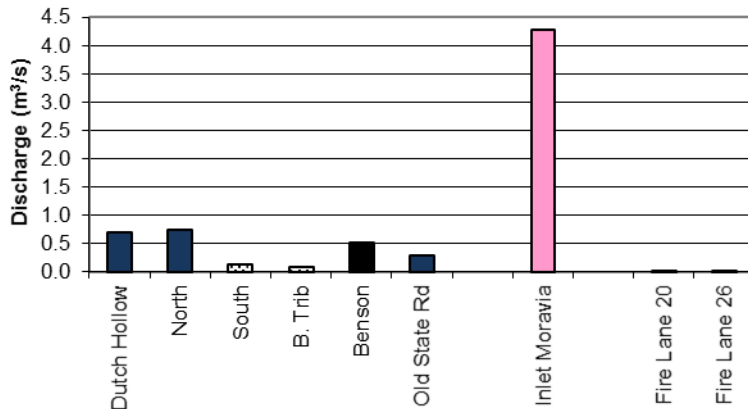
- Total Phosphate
- SR Phosphate
- Nitrates
- Total Suspended Solids
- **Dissolved Silica**



# Stream Discharge, Q

Dry

2020 Stream Discharge  
Annual Average Flow



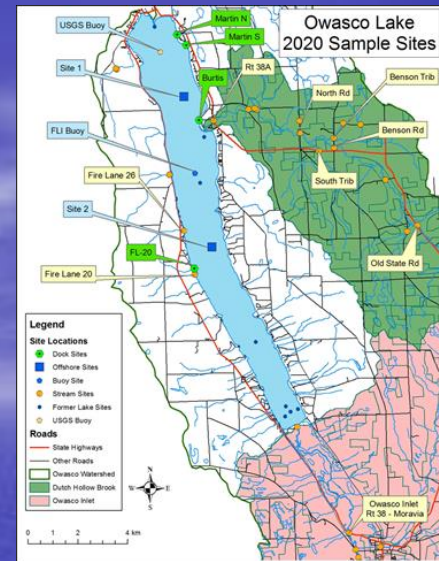
Low Flows in 2020

Comparison:

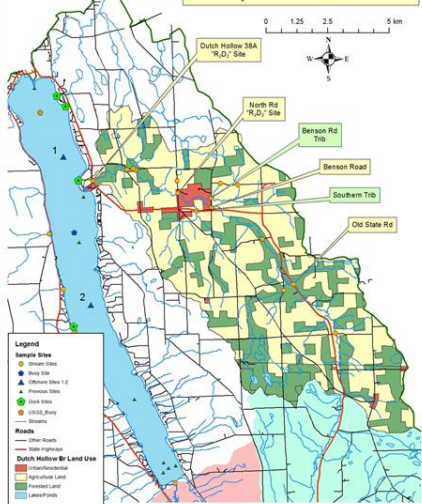
High Flow in 2011 - Wet

Low Flow in 2012 - Dry

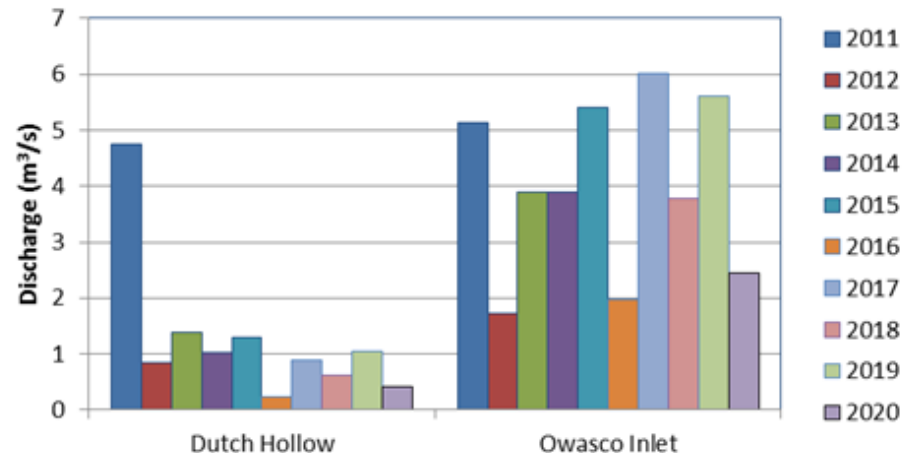
Q Proportional to Basin Areas



Dutch Hollow Brook Watershed  
Sample Sites & Land Use



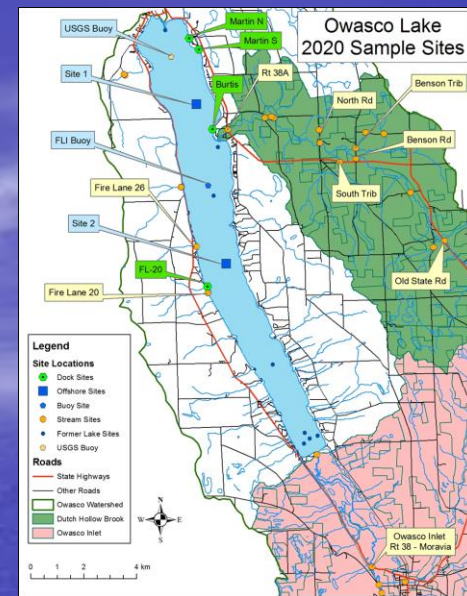
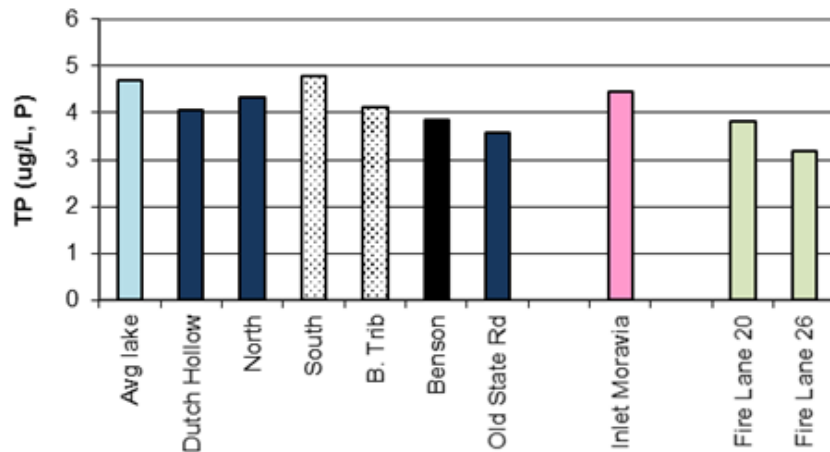
April - October Mean Daily Discharge





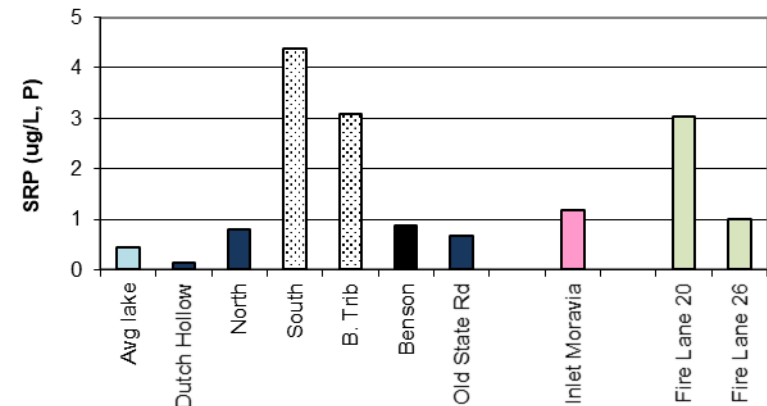
# Nutrient Concentrations

**2020 Total Phosphate  
Annual Average Concentration**

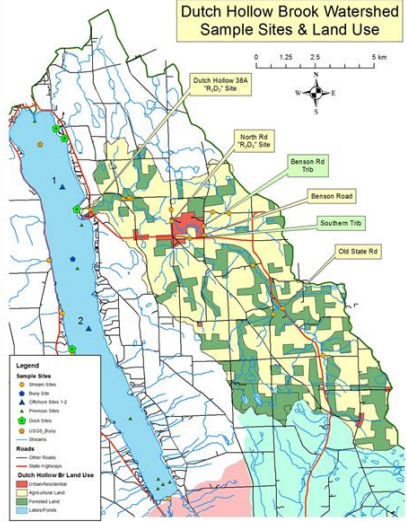


-Slightly Smaller TP & SRP Conc.

**2020 Dissolved Phosphate  
Annual Average Concentration**

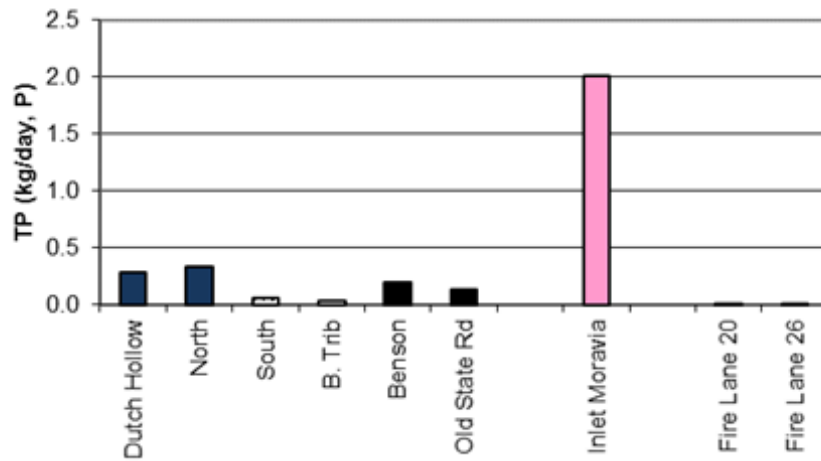


**Dutch Hollow Brook Watershed  
Sample Sites & Land Use**

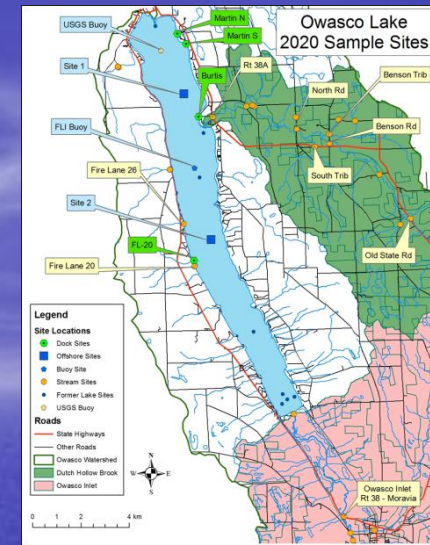


# Nutrient Fluxes

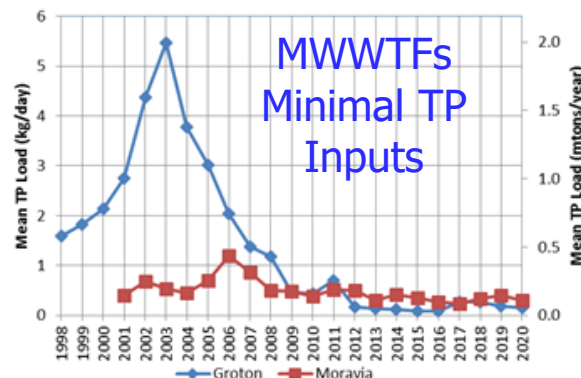
**2020 Total Phosphate  
Annual Average Flux**



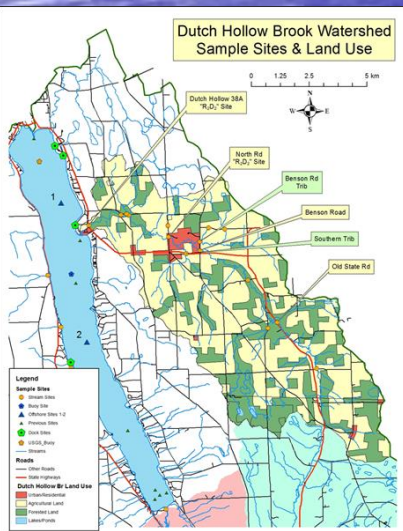
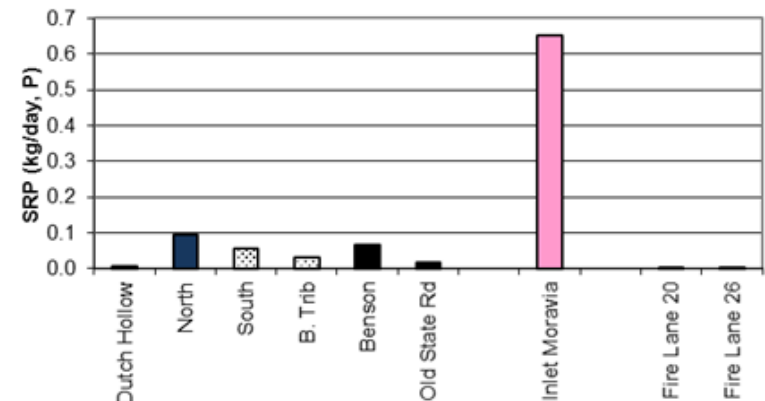
Flux = Concentration x Discharge  
 Fluxes Decreased in 2020  
 Both Q & Concentration Decreased



**Wastewater Treatment Facility  
TP Effluent**



**2020 Soluble Reactive Phosphate  
Annual Average Flux**

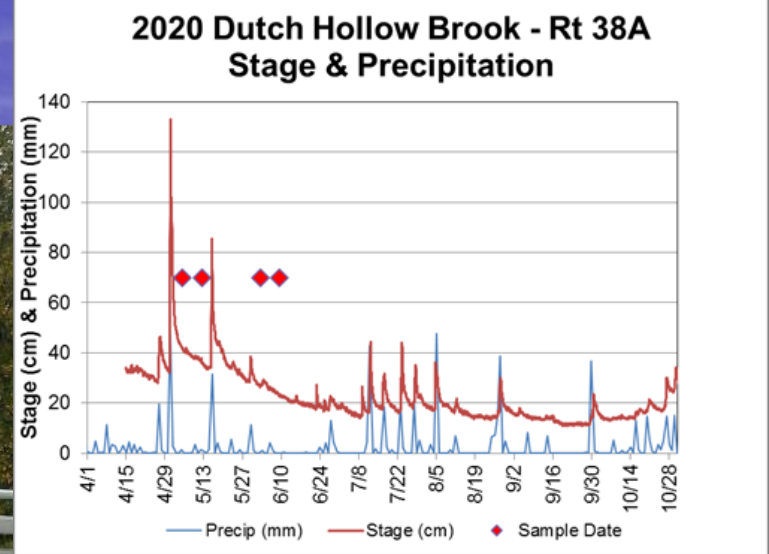




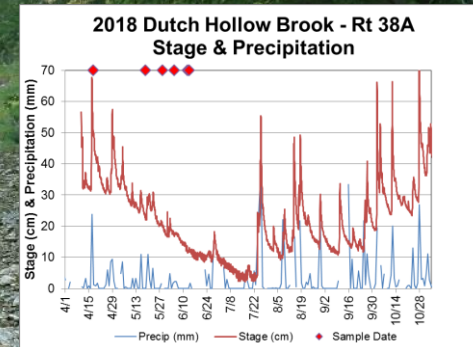
# Dutch Hollow – Daily Samples

## Event vs. Base Flow

Dutch Hollow Rainfall Event



Dutch Hollow Base Flow



Variability on  
Different Time  
Scales



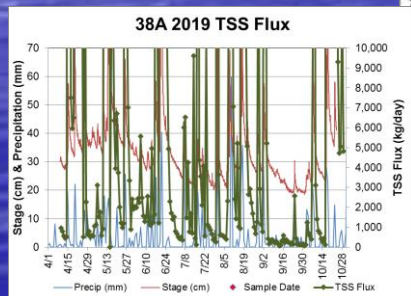
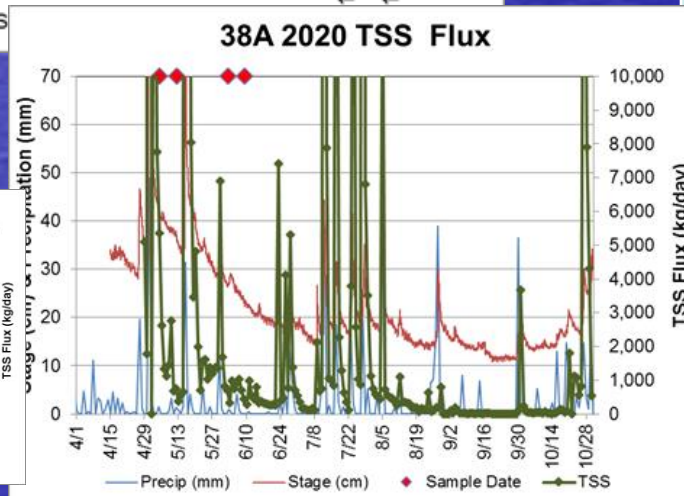
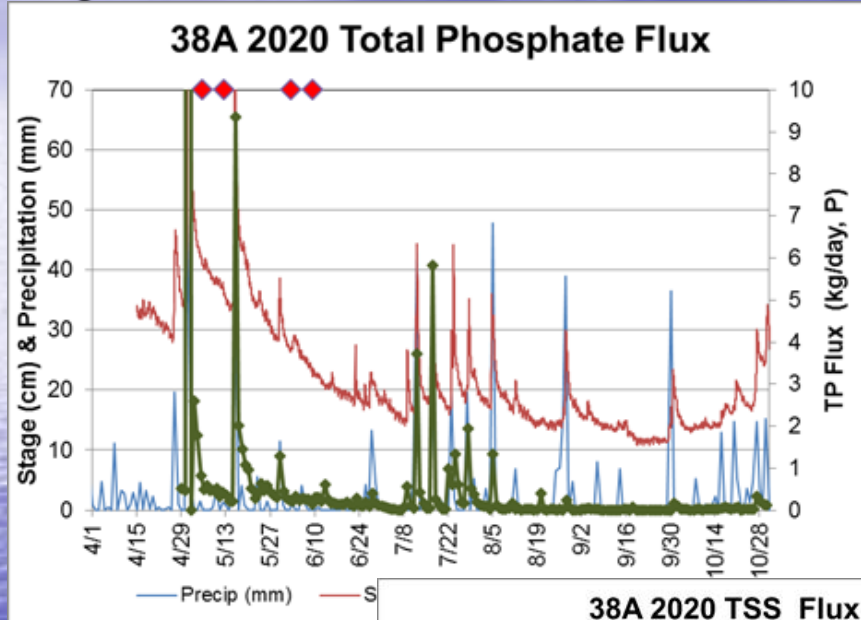
# Dutch Hollow Event vs. Base Flow

## April - October

"R<sub>2</sub>D<sub>2</sub>"-Sampler  
Daily Samples  
Bi-Monthly Servicing



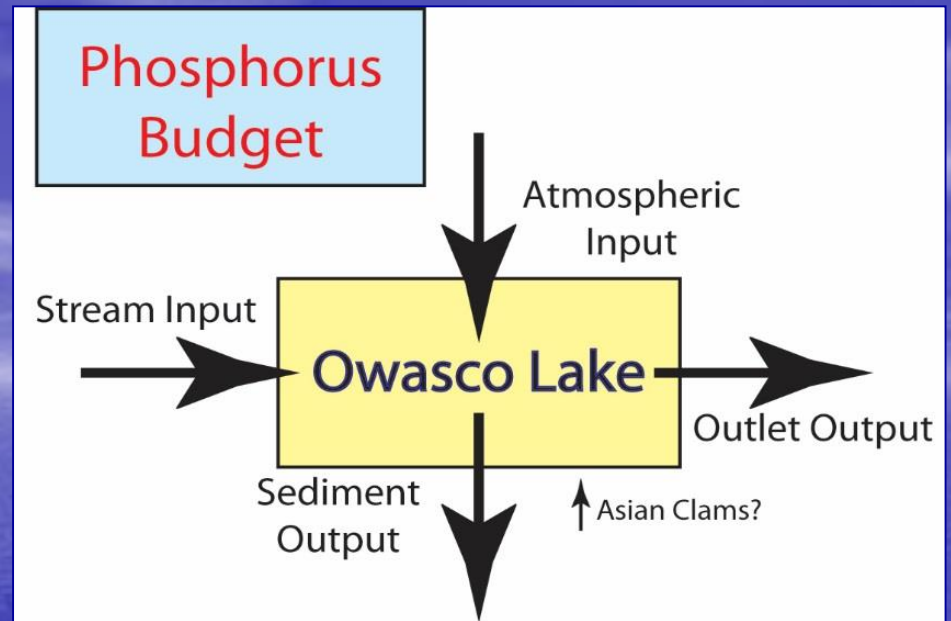
Small TSS Flux  
Small TP Flux



Year	TSS kg/day (Event %)	TP kg/day (Event %)
2011	8,730 (99)	2.7 (90)
2012	2,410 (95)	1.9 (59)
2013	7,550 (98)	4.4 (90)
2014	14,600 (99)	3.5 (74)
2015	36,600 (99)	3.7 (99)
2016	7,500 (99)	1.4 (97)
2017	14,800 (99)	2.2 (92)
2018	3,300 (97)	2.1 (91)
2019	25,000 (99)	2.4 (97)
2020	8,500 (99)	1.0 (93)



# Phosphorus Budget Past 10 Years



## Before 2016

Inputs > Outputs

## 2016 & After

Are Remediation Efforts  
Working?

Near Equilibrium

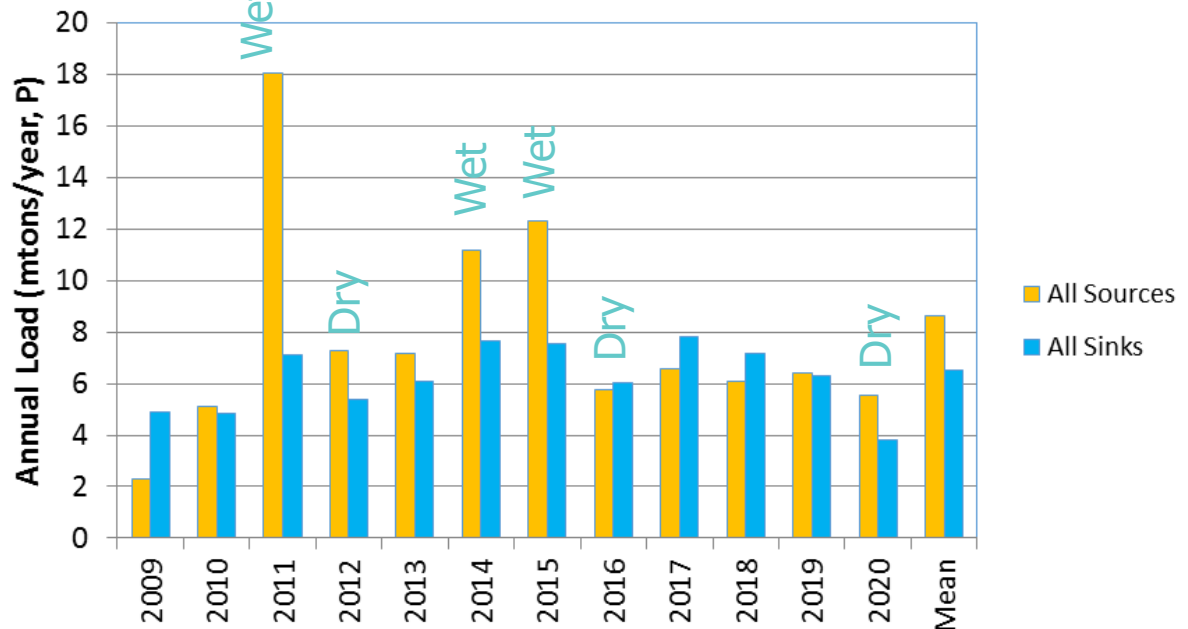
'16, '17, '18 & '19

2020 Inputs Low

Outputs Lower

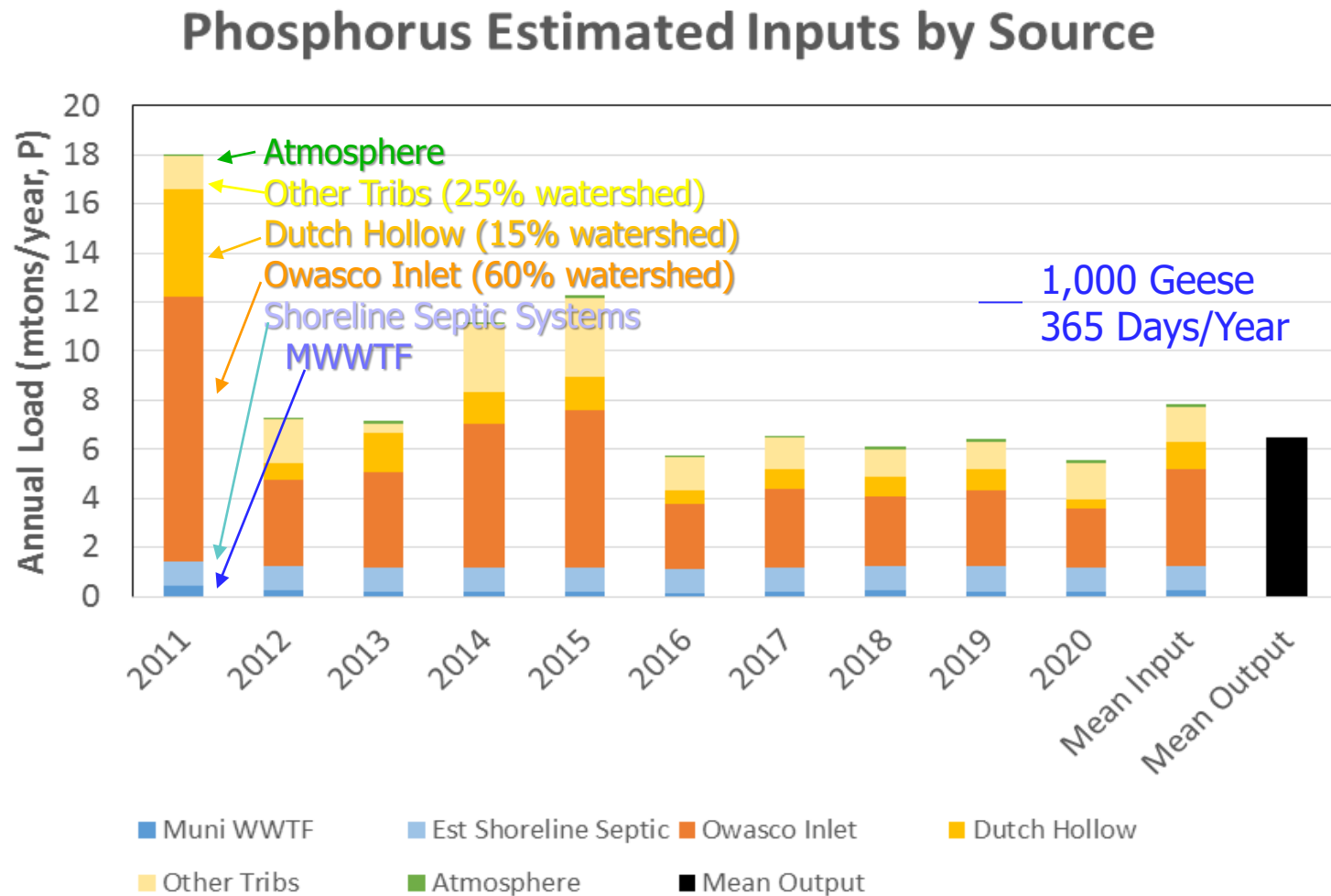
Decreased Flow & Conc.

## Phosphorus Estimated Inputs and Outputs



# Loads by Source, Varies

## Majority From Rain Events





# How to Curtail Degradation?

- Implement 'Revised' Rules & Regulations!
- Implement Recommendations in 9E Plan
- Reduce Nutrient & Sediment Sources
  - Stricter Regulations for Lakeshore Septics?
    - Connect to MWWTFs?
  - Roadside Ditches & Drainage Tile
    - More Reductions Required
    - Especially if Collect Drain Tile Effluent from Farm Fields
      - Source SRP
  - Agricultural
    - BMPs to Curtail Runoff Event Impact
      - Buffer Strips
    - Responsible Manure Spreading
      - Perhaps Waste Water Treatment?
    - Remove P from Animal Wastes before Spreading
- Bioreactors
  - Removes & Recovers P



Owasco Inlet Turbidity Plume

Veness Bk Turbidity



Joe Leonardi, by permission



# Lake Monitoring

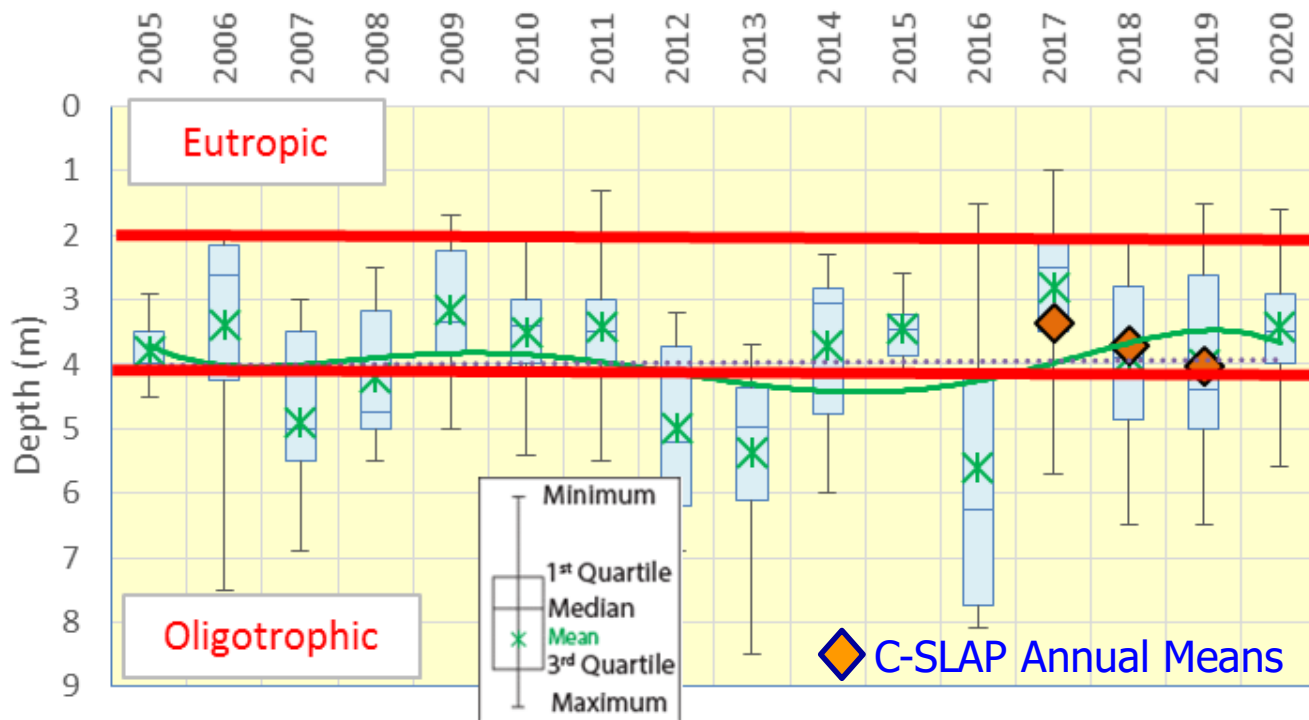
- **Sites 1 & 2**
  - Representative of Open Lake
- **CTD Casts**
  - Temperature & Conductivity
  - DO & pH
  - PAR, Fluorescence & Turbidity
- **Secchi Depth & Plankton Tows**
- **Spectral Signature of Water**
- **Surface & Bottom Water**
  - DO, pH, Conductivity, Temperature
  - Total Phosphate, Soluble Reactive Phosphate, Nitrates, Chlorophyll, Total Suspended Solids, (Dissolved Silica)





# Secchi Depths

Owasco Lake Annual Secchi Depths

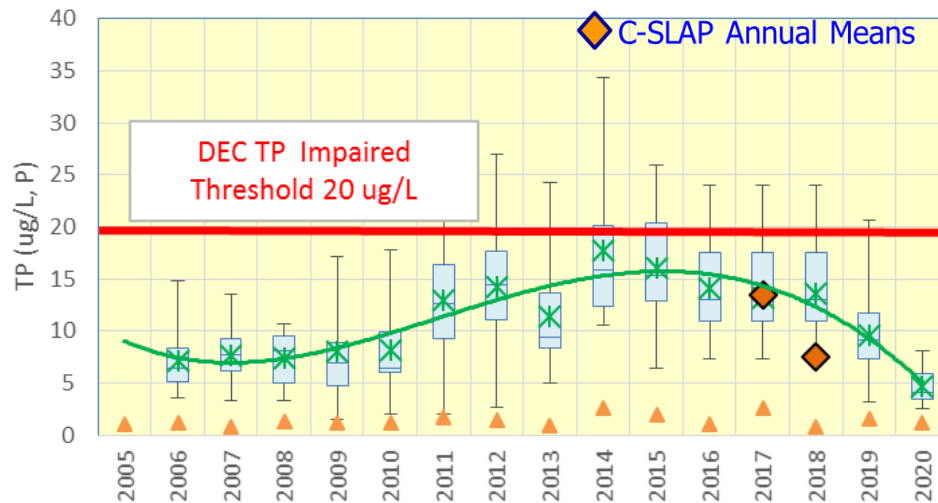


Water Quality Improvement?  
Reverses 2017 Decline

# Phosphate & Chlorophyll Concentrations



Owasco Annual Surface Total Phosphate



Decline in TP since 2016:-

Phosphate → 4.7  $\mu\text{g/L}$

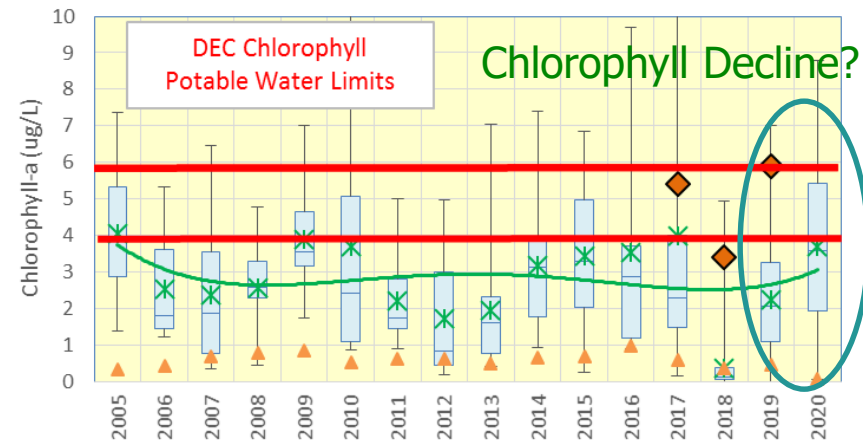
Similar:-

P:N Ratio → 1:2,300 (mass)

P: Limiting Nutrient

Dry Year

Owasco Annual Surface Chlorophyll-a



Trophic Status (Improved Slightly)

Secchi Depths – 3.4 m Mesotrophic

Nitrate – 0.6 mg/L Oligotrophic

Total Phosphate – 4.7  $\mu\text{g/L}$  Oligotrophic

Chlorophyll a – 3.7  $\mu\text{g/L}$  Oligotrophic

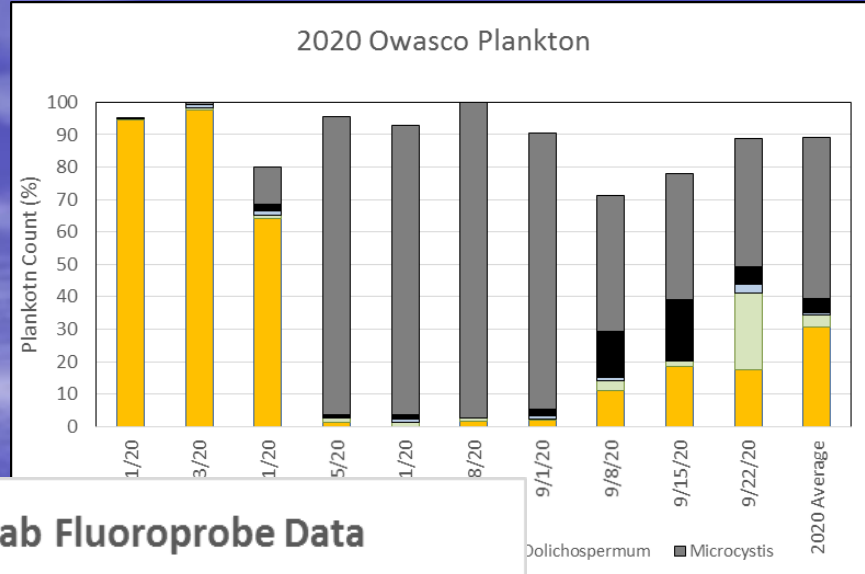
Oxygen – 50% Saturation Mesotrophic



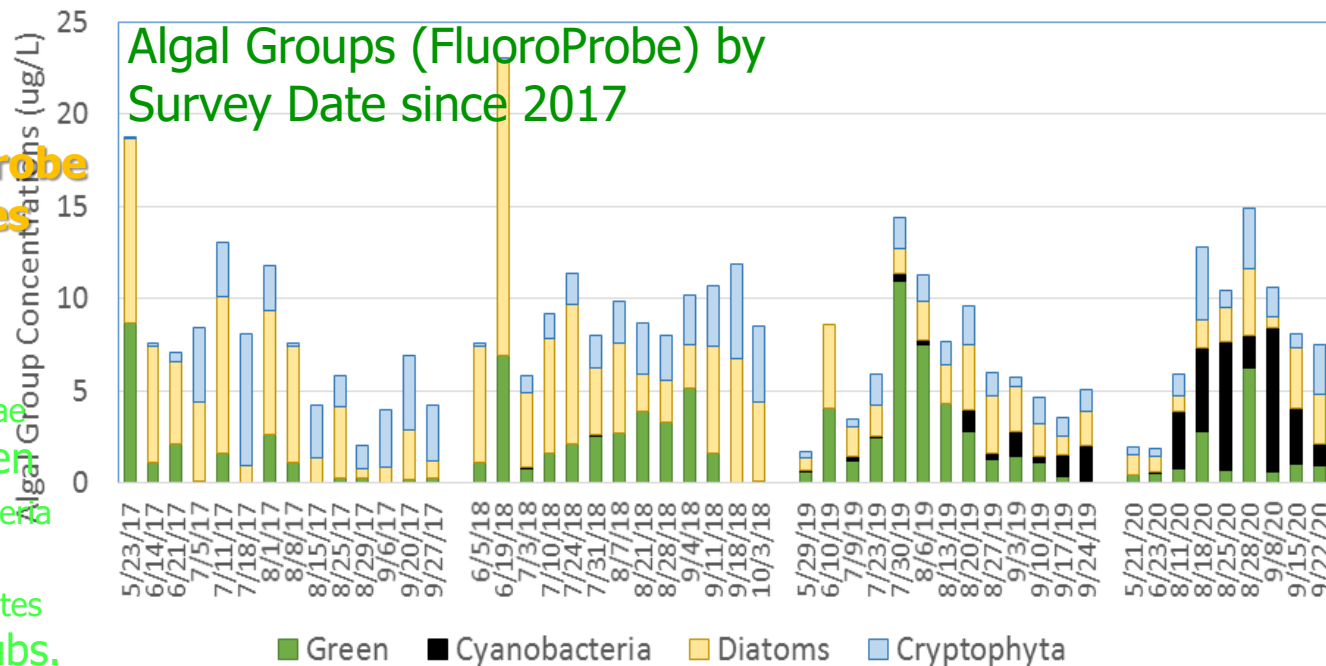
# Plankton

## Fluoroprobe & Plankton Tows

Plankton by Survey  
Date in 2020



2017 - 2020 Owasco Offshore Surface Grab Fluoroprobe Data



HABs  
Dominated  
August -  
November

Increase in  
BGA compared  
to previous  
years

HABs Float so  
Secchi &  
Influenced  
Surface Grabs

Increase in HABs in Surface Water in Open Lake compared to earlier years is **disturbing** ... Waves moved Nearshore HABs?

# Cyanobacteria

No 2020 BGA/HABs Conc. Data

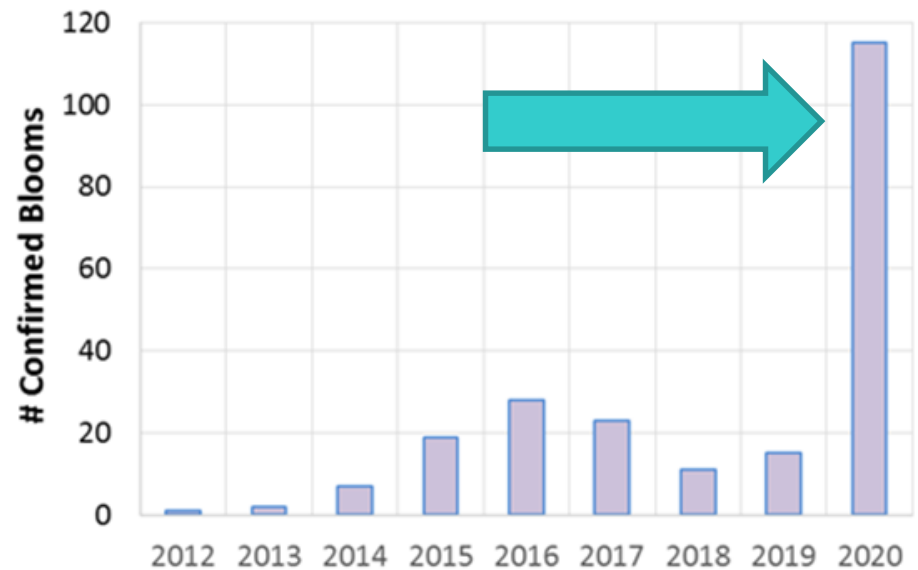


Data: DEC HABs Map Portal

Shoreline Large Values  
Northern Locations  
DOH/DEC Microcystin Limit:  
0.3 µg/L – Drinking  
20 µg/L – Swimming  
EPA 4 µg/L – Swimming

Significantly More HABs Events  
Minimal Nutrient Loads & Nutrients in Lake  
Perplexing! Better Monitoring Efforts?  
Alternative Nutrient Source?

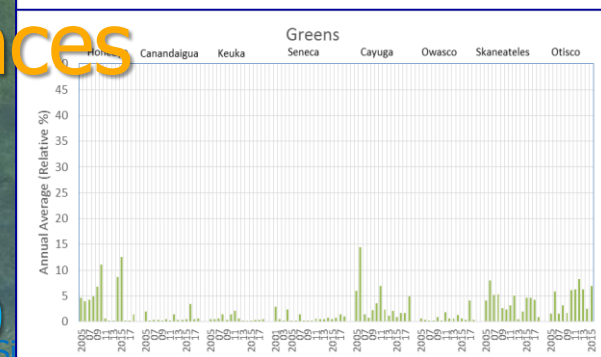
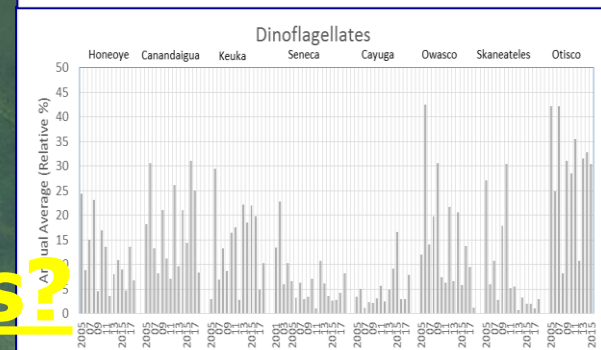
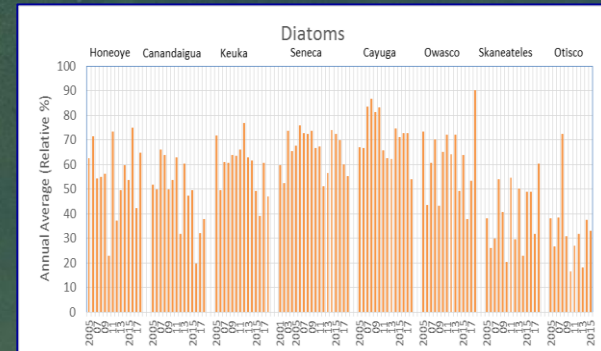
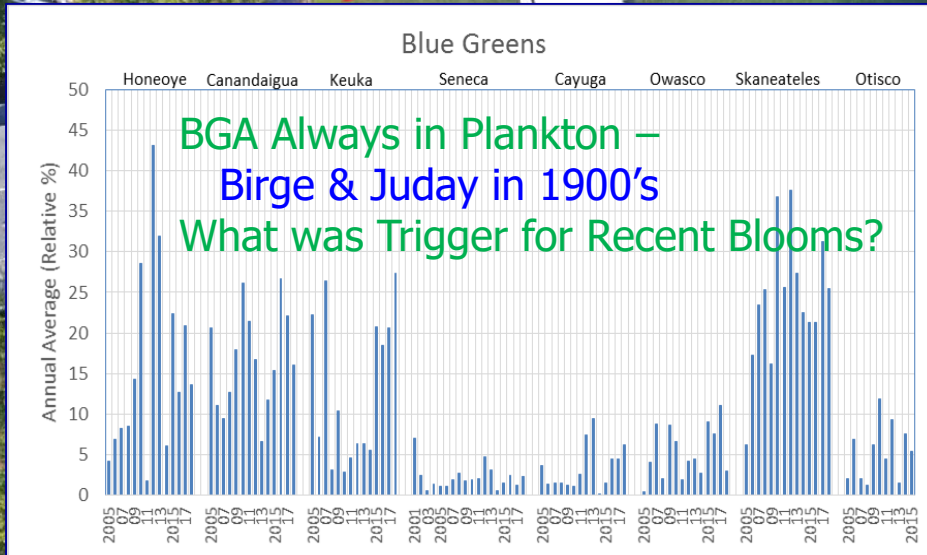
## Cyanobacteria Blooms - Owasco Lake



Winds shift from S to SSE  
Promoted more HABs Events?



# Cyanobacteria in Plankton?



Trigger for Recent Blooms?

HABs Environmental Preferences

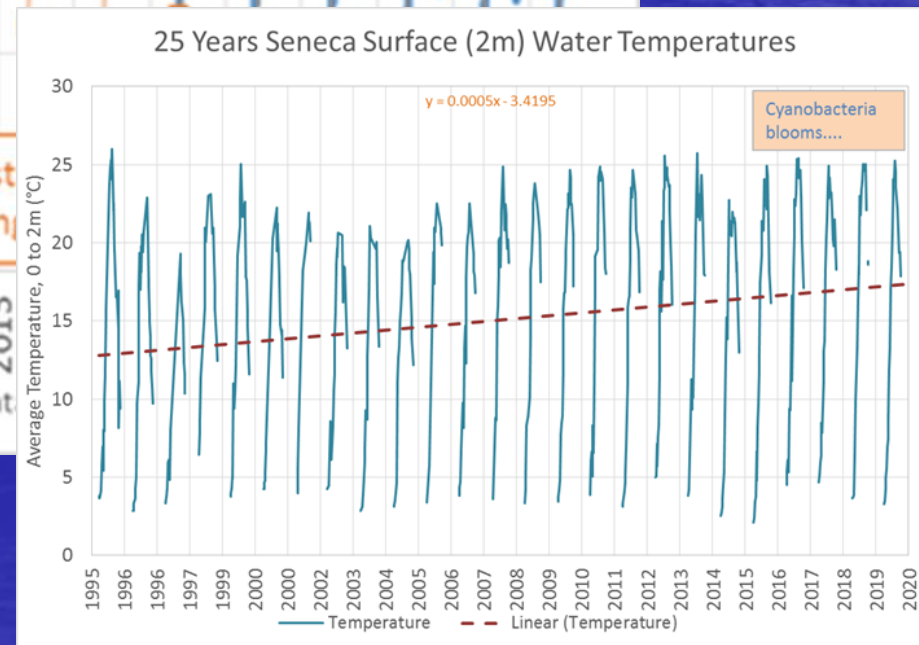
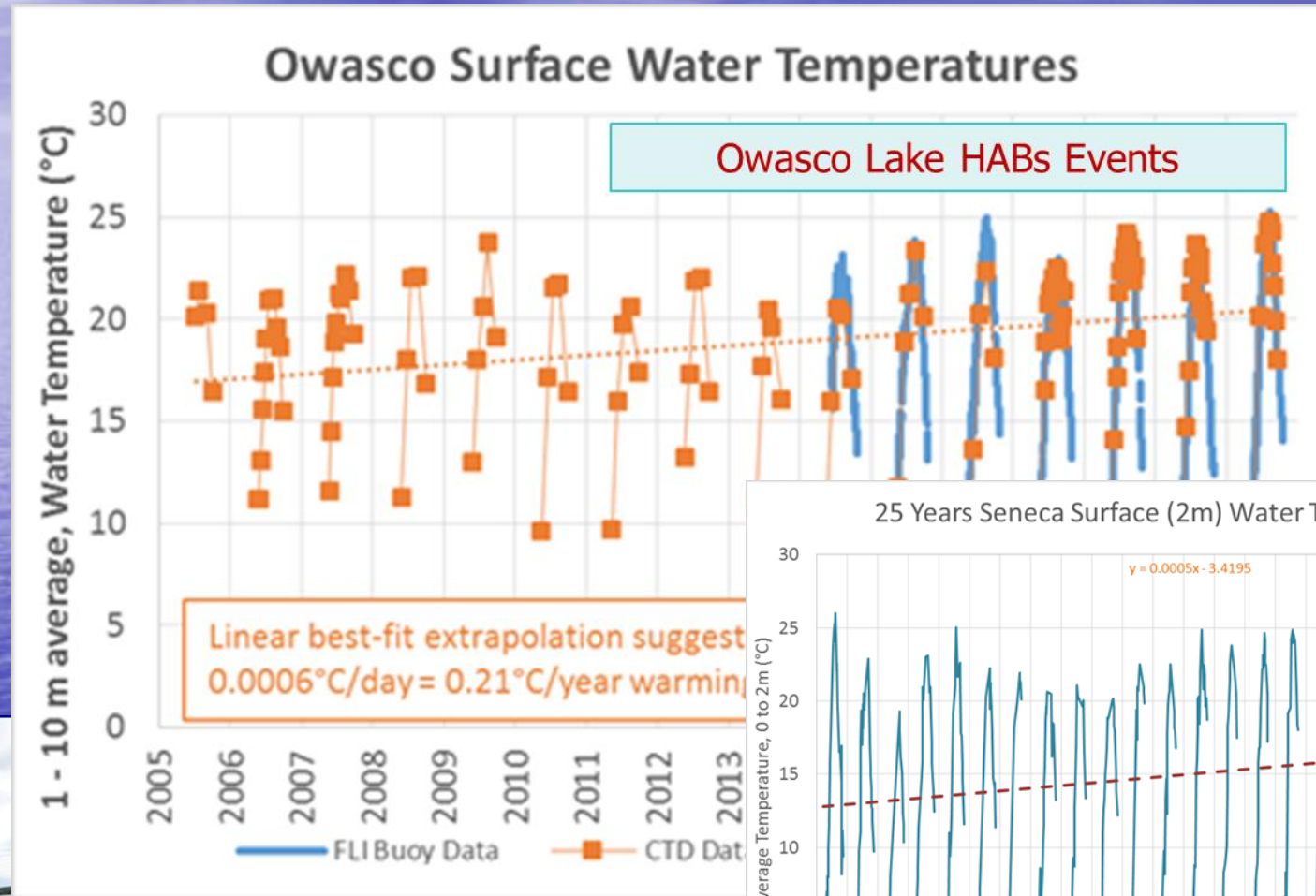
Warmer Water

Sunny Skies, Calm Conditions

Excess Nutrients (FLs Nutrient Poor)

Eight Eastern Finger Lakes (Halfman, Unpublished Data, Monthly, May-Oct, Mid-Lake S)

# Global Warming → Warmer Water



Surface Water Warming  
(0.2°C year)





# BGA: Sunny Skies & Calm Water Looks Sunny & Calm to me...



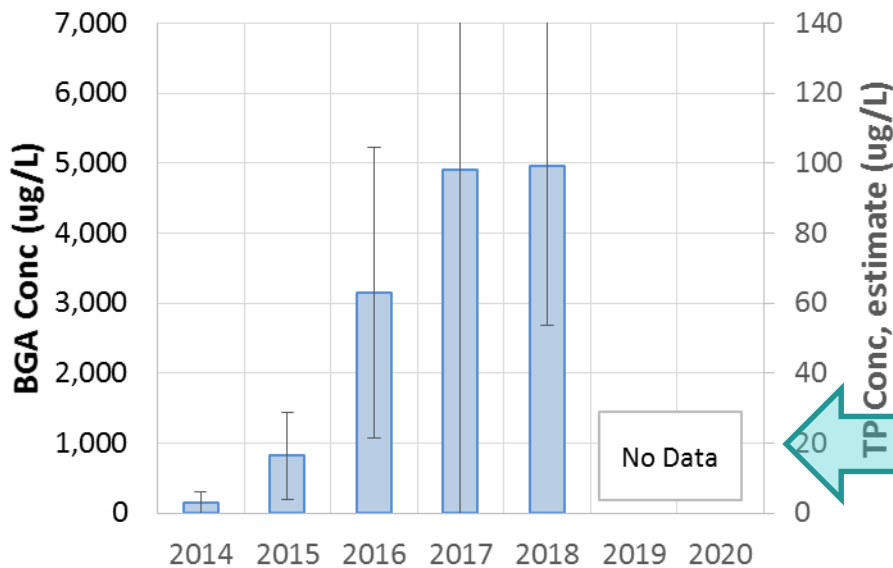
Sun → Photosynthesis → Buoyancy **BUT** blooms **NOT** every sunny and calm day  
Also Require Nutrients

Sept, 2018, Owasco Lake by Drone

# Nutrients?

## Water Column Nutrient Conc. Insufficient for Average BGA Bloom

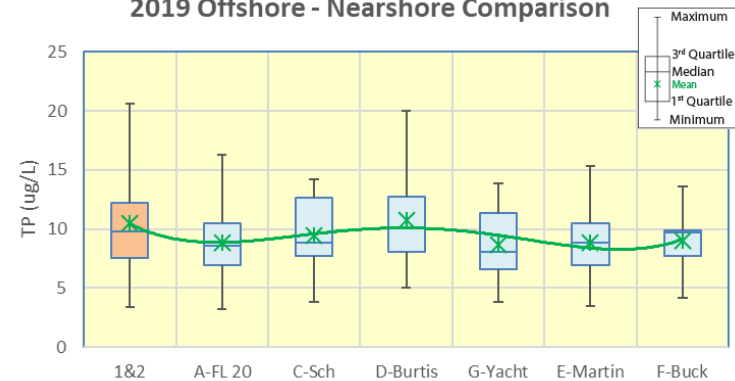
Annual Mean BGA Concentration



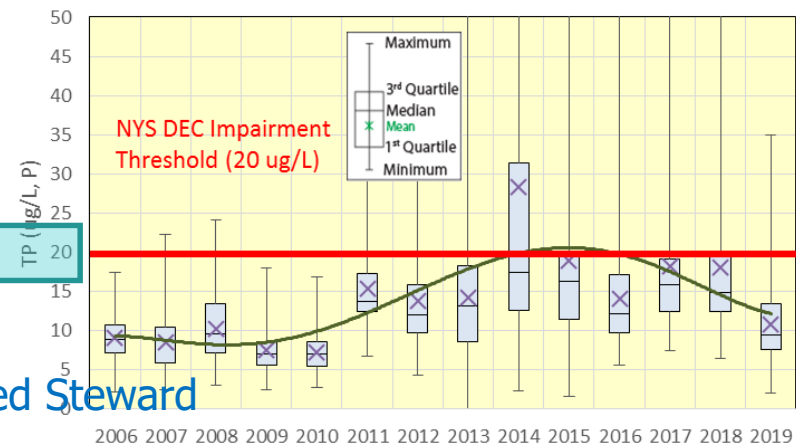
BGA Samples Collected by OWLA Volunteers & Watershed Steward

Analyses at SUNY ESF, Data Compiled by NYS-DEC

Total Phosphate  
2019 Offshore - Nearshore Comparison



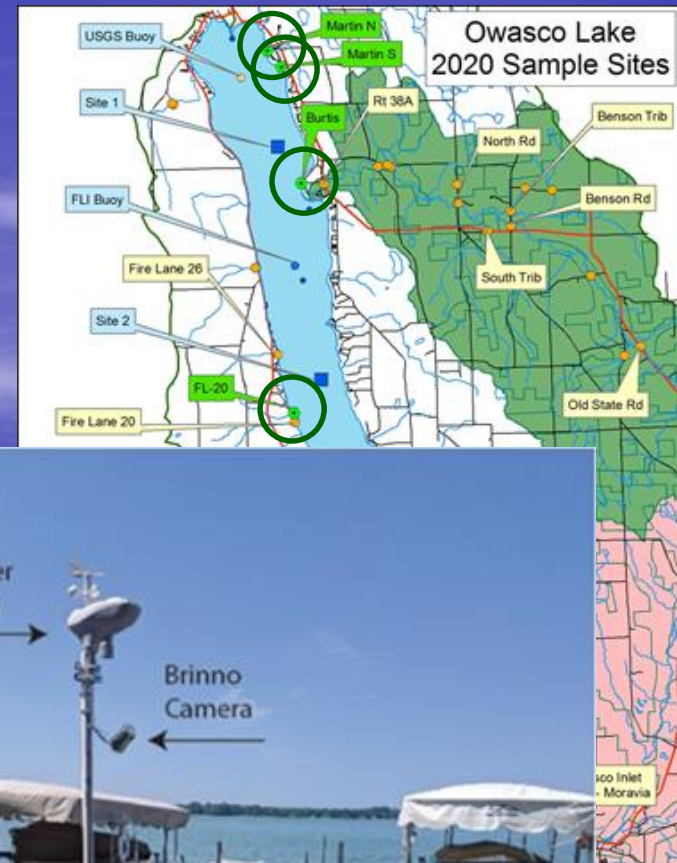
Seneca Annual Surface Total Phosphate





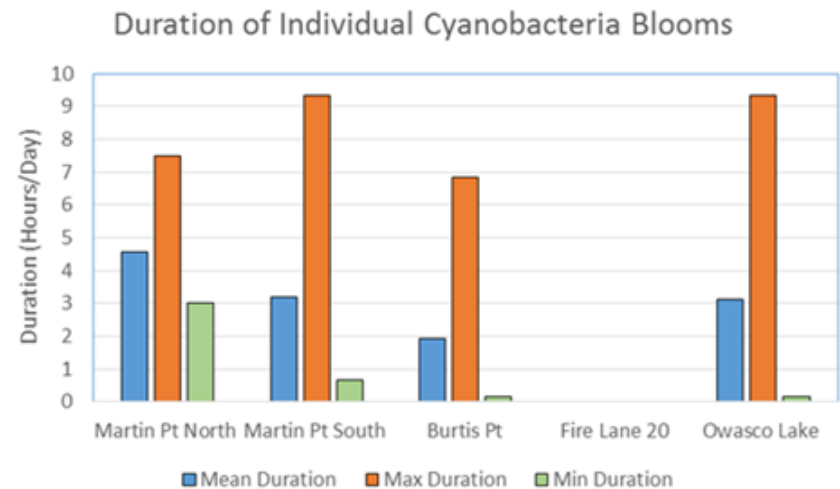
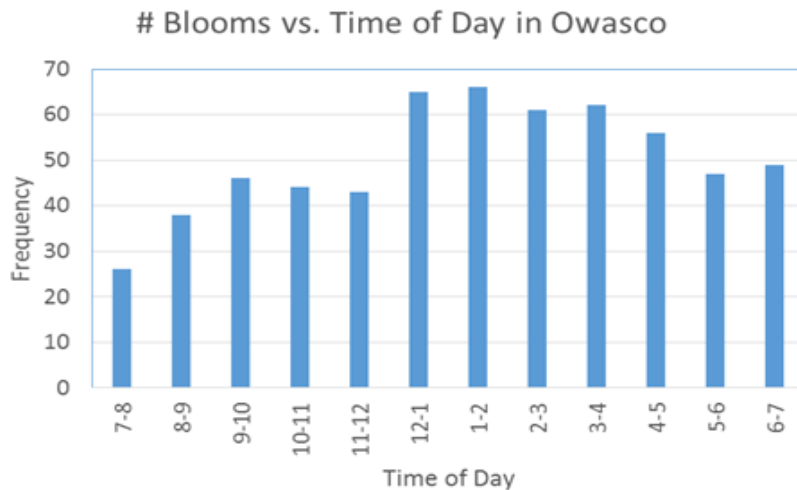
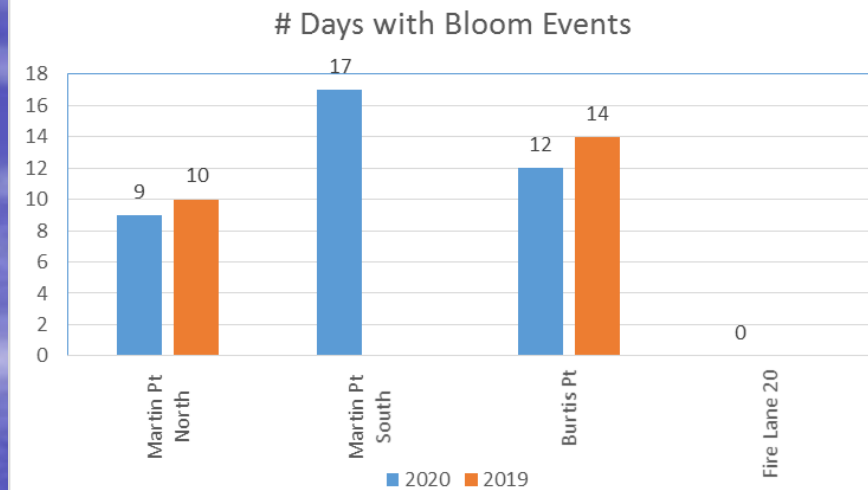
# Dock Monitoring Effort

- **Weather Station**
  - Wind Speed & Direction
  - Sunlight
- **Automatic Camera**
  - Confirm HABs Events
  - Clear/Turbid
- **Water Temperatures**
- **WQ Sonde**
  - Total Algae
  - HABs
  - Dissolved Oxygen
- **Mesocosm Analyses**
- **Sediment Organics, Macrophyte & Mussel Surveys**
- **Drone Surveys**
  - Not Done COVID Issues



# Brinno Cameras

- Time of Day
- # Blooms
- Duration



Alongshore Currents

TLC200 2019/09/05 16:10:04

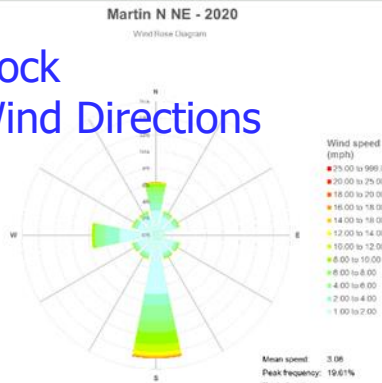
## Brinno Cameras

Faithfully Recorded 2x3 m area of Lake Surface  
 Detected BGA Blooms, Clear & Turbid Water,  
 Ducks ...  
 Detected 10x's more blooms than Volunteers

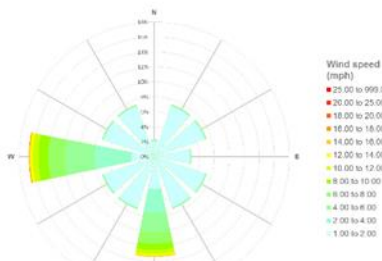


# Weather Stations

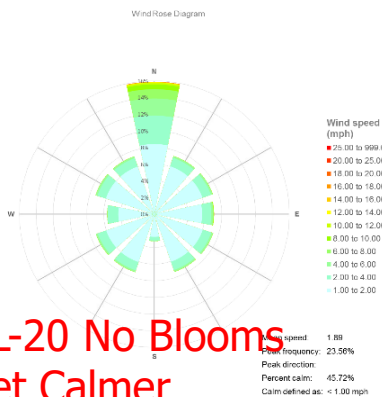
## Dock Wind Directions



## Martin S Most Blooms

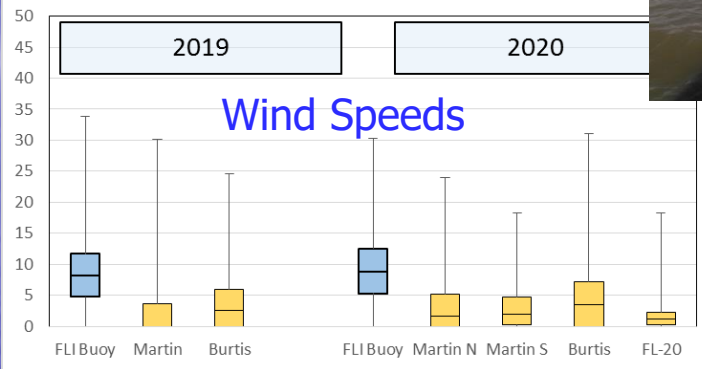


## FL-20 SW - 2020

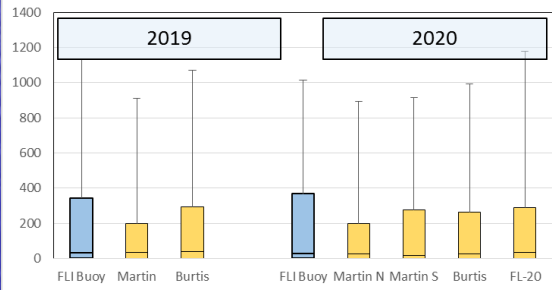


FL-20 No Blooms  
Yet Calmer

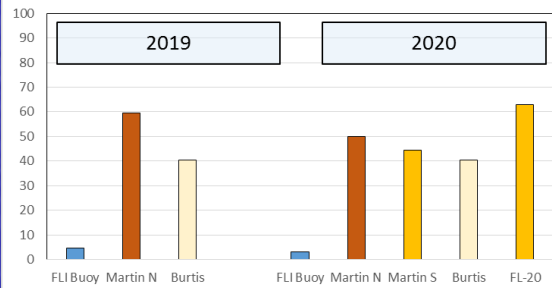
## Owasco Wind Speed (mph)



## Owasco Solar Intensity (watts/m<sup>2</sup>)



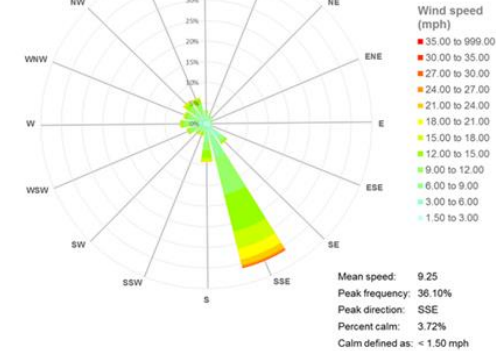
## Owasco % Calm Conditions (<1.5 mph)



## FLI Buoy Owasco Lake - 2020

5/21 - 10/25

## Open Lake Wind Direction



## HABs Events

After Rainfall / Wind Event  
Next Sunny, Calm Day

## Nearshore Winds\*\*\*

- (1) Decrease in Speed
- (2) Altered Directions

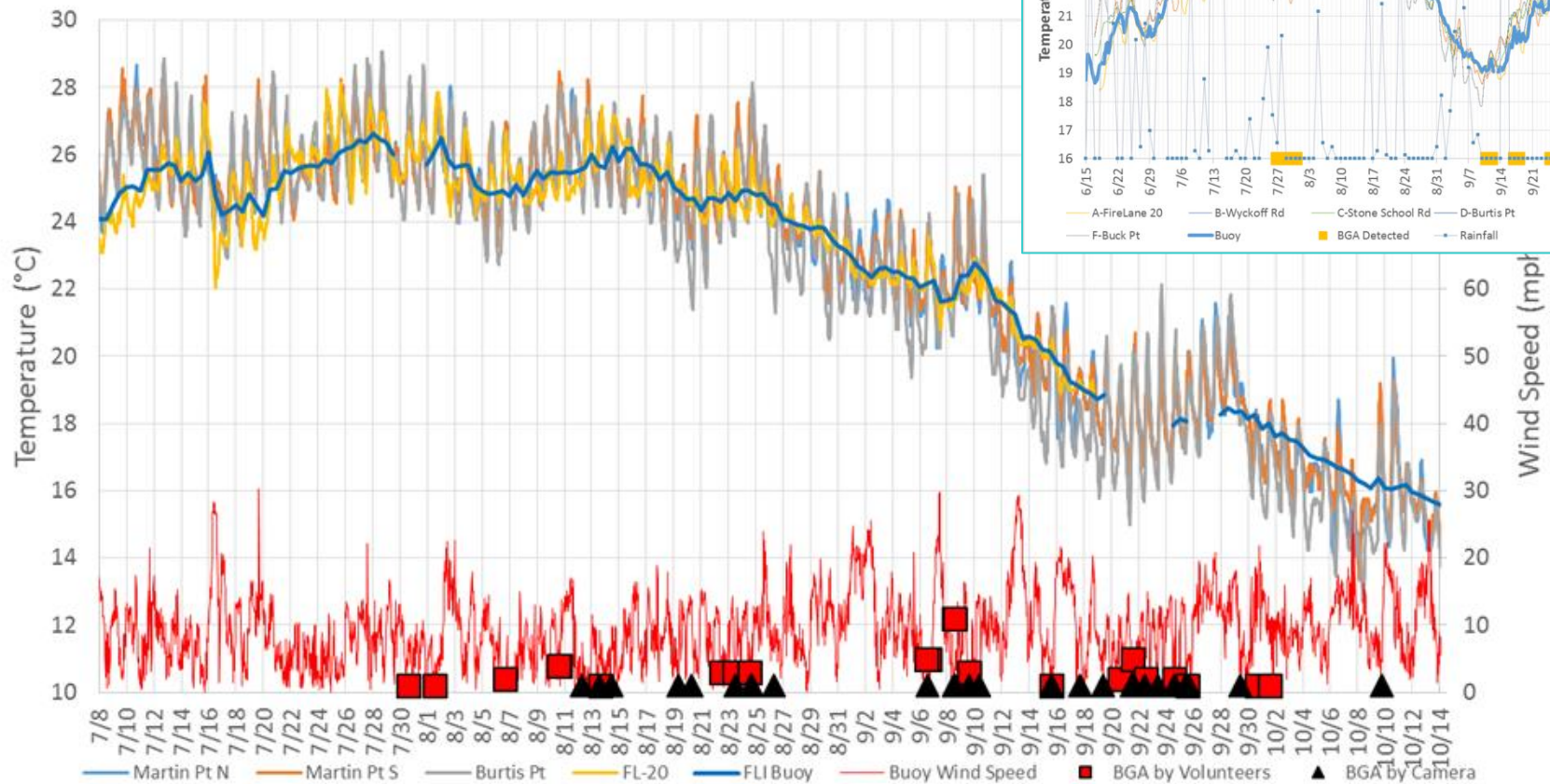
## \*\*\*Reason for

Bloom in One Area  
BUT Not Others?

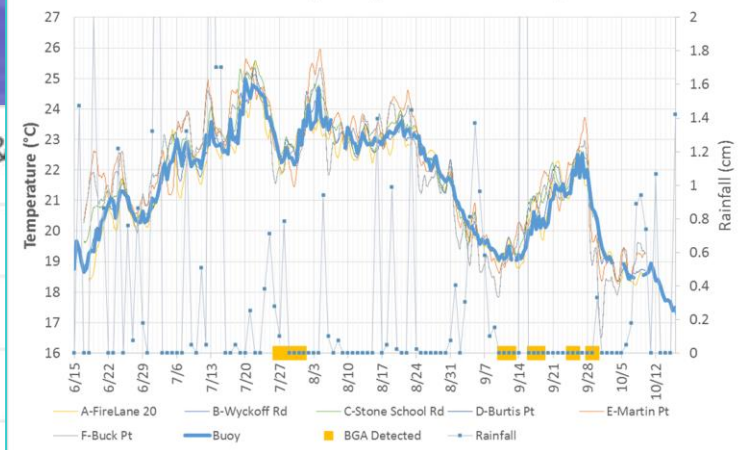
Why More HABs in 2020?  
Nutrients?

# Bloom Triggers – Nearshore/Shoreline Water Temperature

Owasco Docks & FLI Buoy (1 m) Temperatures (°C) &



2017 Owasco Lake Daily Average Surface Water Temperatures



BGA After Temperature Dips? → Nutrient Source?

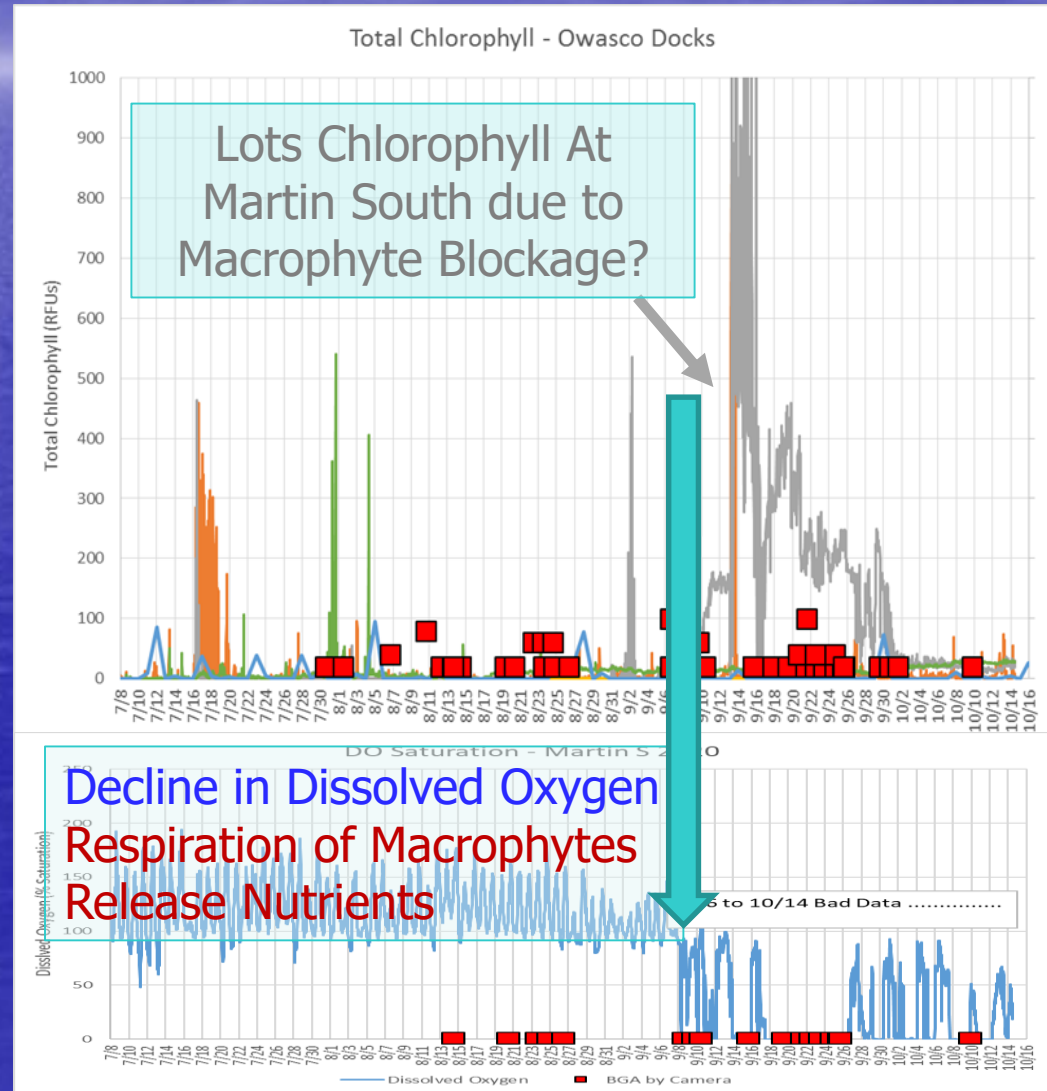


# WQ Sondes

## Total Algae



*In-Situ Aqua Troll 600*



HABs Nutrient Source?  
 Lots Benthic Algae  
 Esp. Nearshore  
 Esp. Extensive Shelf

# WQ Sondes

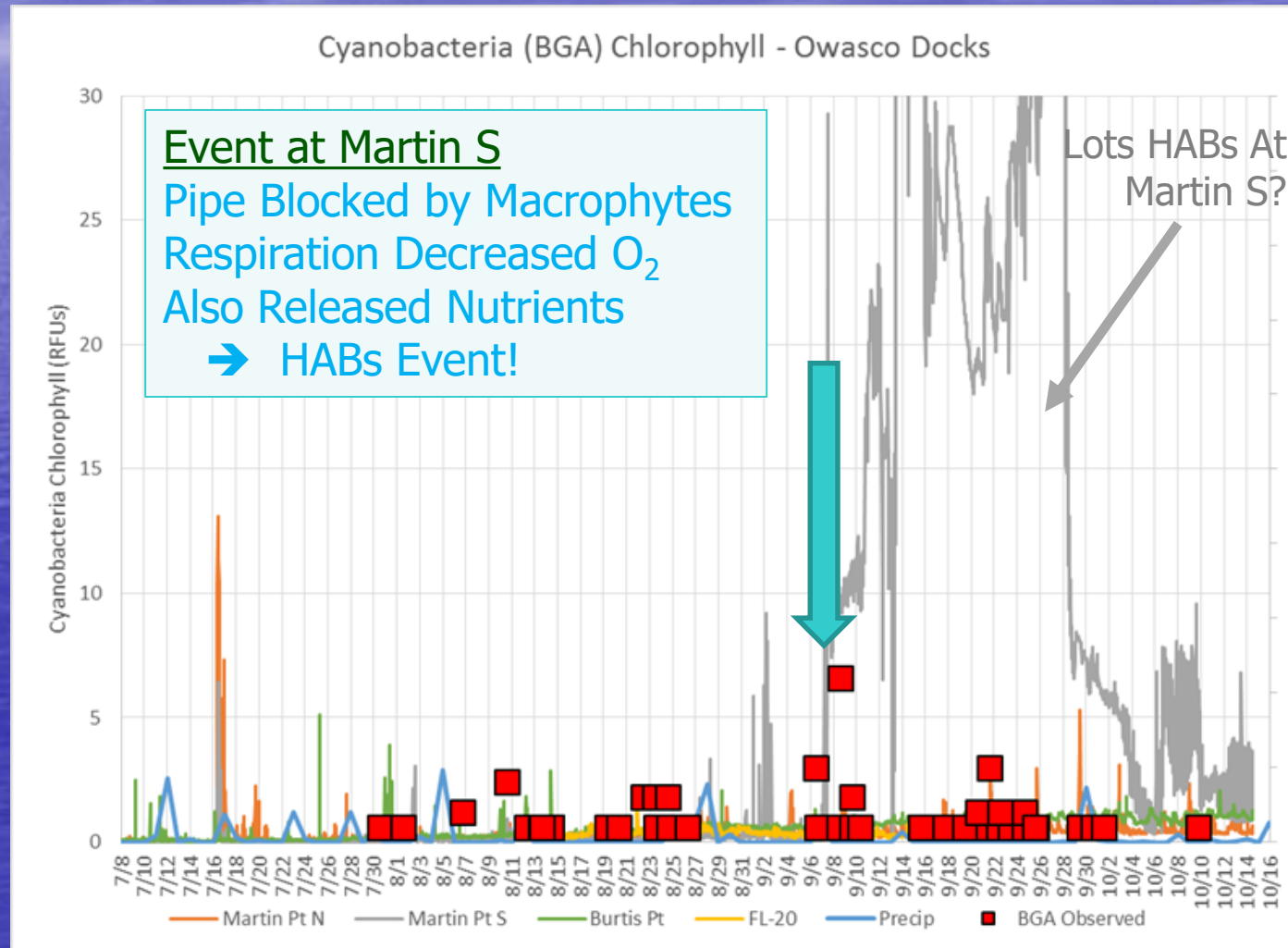
## HABs



*In-Situ Aqua Troll 600*



HABs Nutrient Source?  
Respiration of  
Benthic Organics  
Lots in Nearshore  
Esp. Extensive Shelf

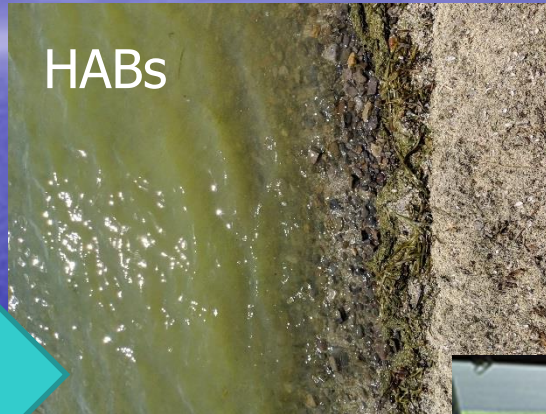




# 100 steps South of Burtis Site Spotty Shoreline Bloom



Rotting Weeds



Fluoroprobe

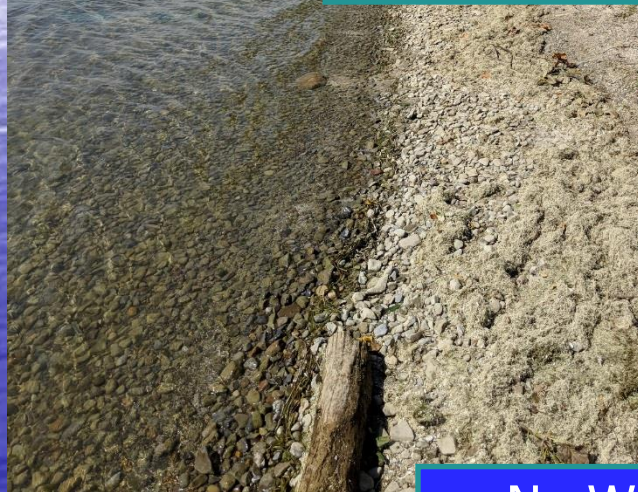
Green: 0 ug/L

Cyano: 497.4

Diatoms: 0

Crypto: 1.1

**Total: 498.5**



No Weeds



Decay Organics  
in Sediments

No HABs

Cyanobacteria were found only where rotten weeds lined the shoreline.

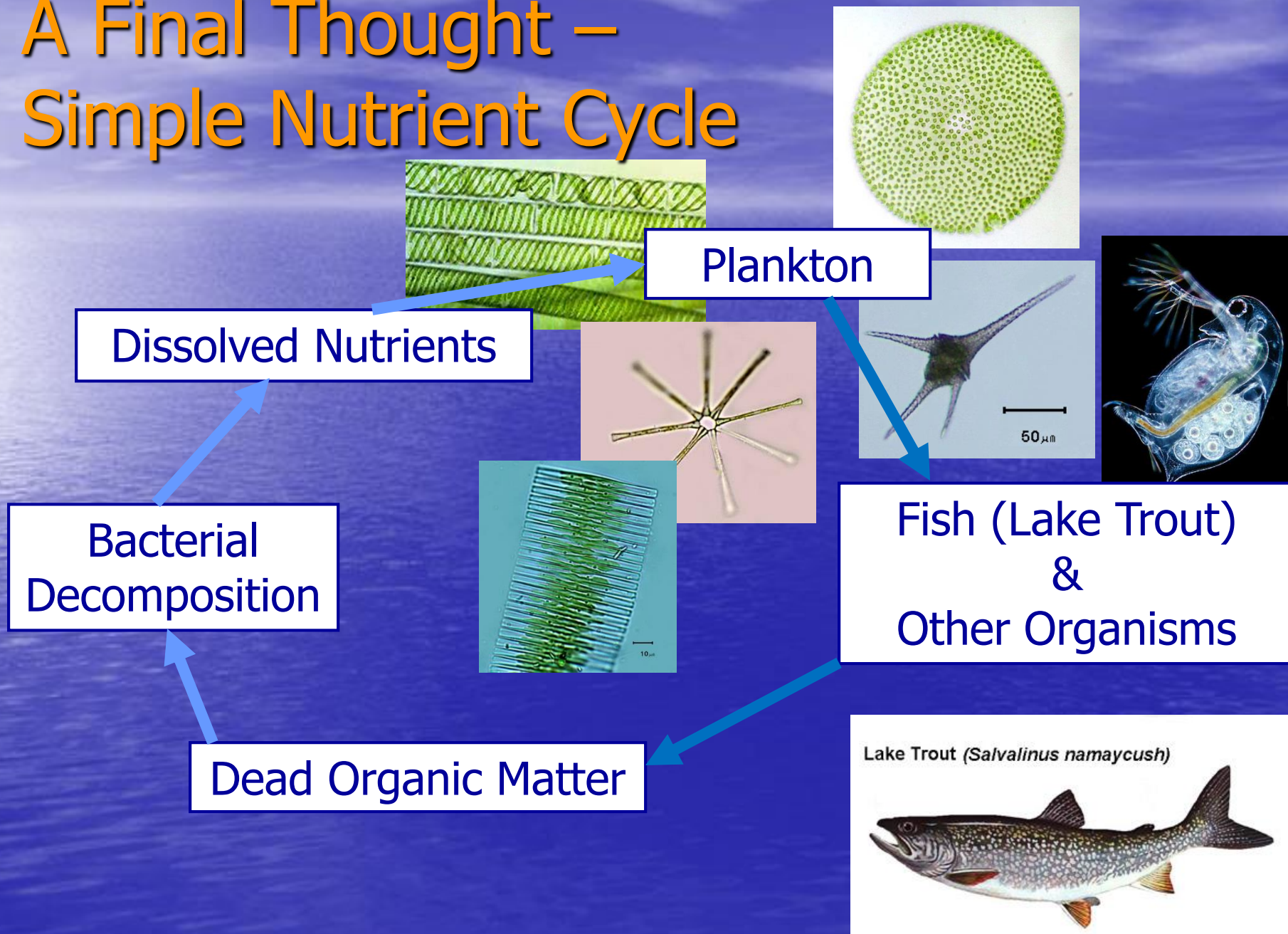


# HABs Remediation

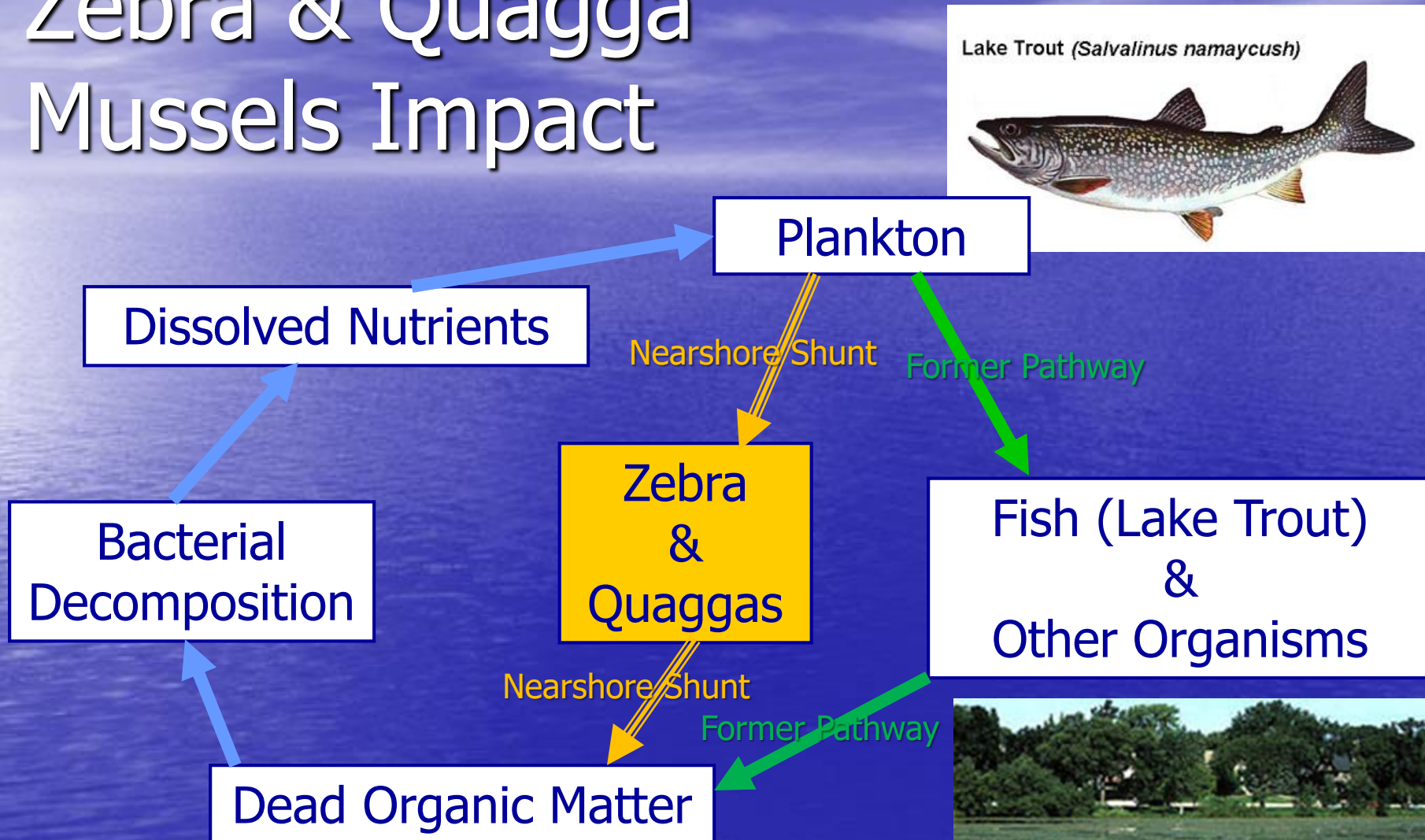
- Nearshore Bubblers, Ultrasonic Sound, Mats?
- **NEVER** use Herbicides
  - Owasco is Water Supply for over 45,000 People
- Remove/Harvest Nearshore Organic Matter
  - Macrophytes
  - BGA Blooms
  - If NOT Harvested, When Die
    - Bacterial Decomposition
    - Releases Nutrients to Nearshore Area
  - Zebra/Quagga Mussels & Asian Clams
- **Reduce Nutrient Loading to Lake!**



# A Final Thought – Simple Nutrient Cycle



# Zebra & Quagga Mussels Impact



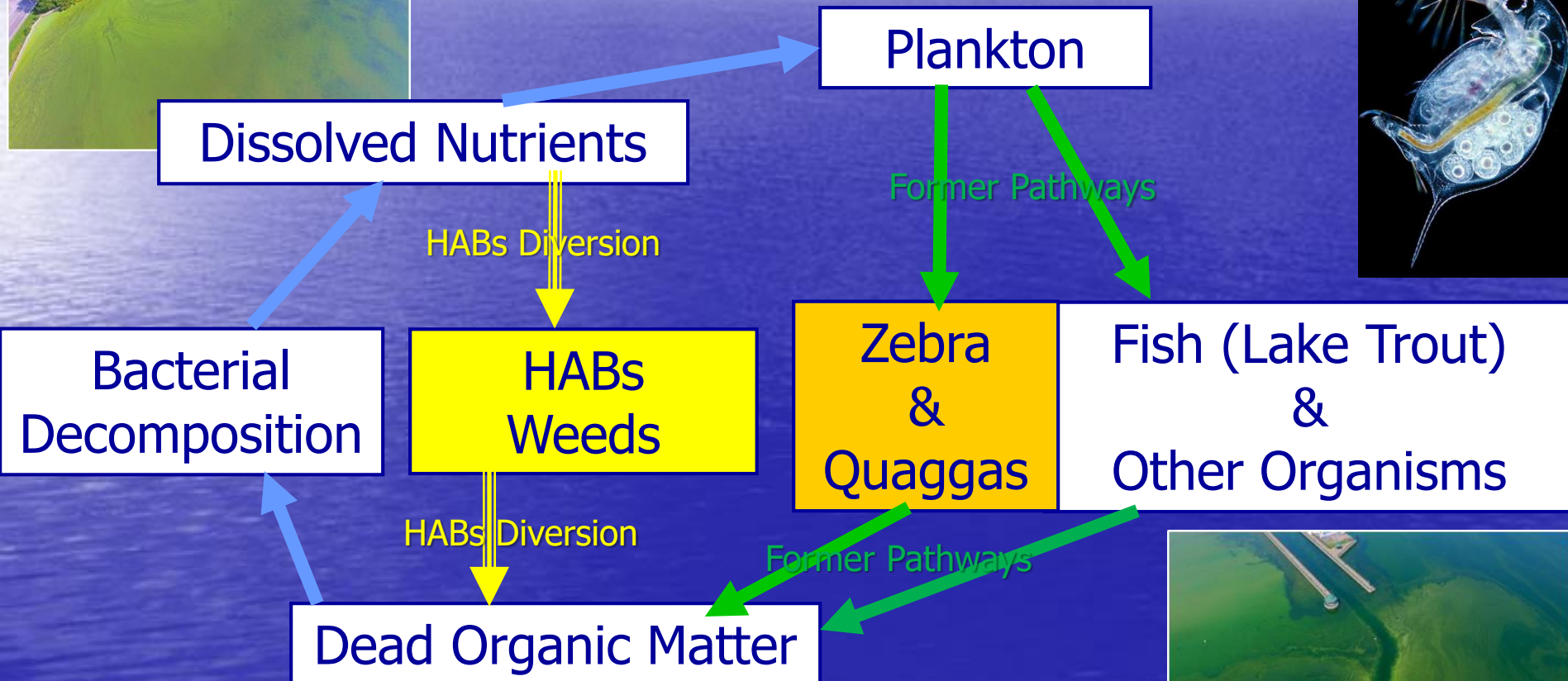
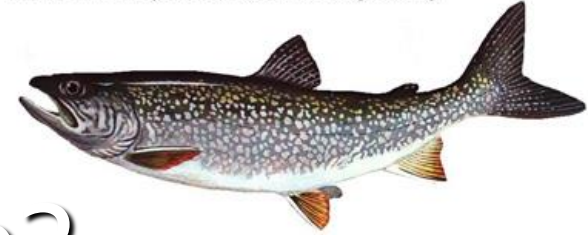
**Concentrates Organics/Nutrients to Nearshore Regions!**



# HABs

## Positive Feedback Loop?

Lake Trout (*Salvelinus namaycush*)



Concentrates HABs Events to Nearshore Regions!



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# Questions

