Working Towards a Sustainable Remediation of Georgica Pond

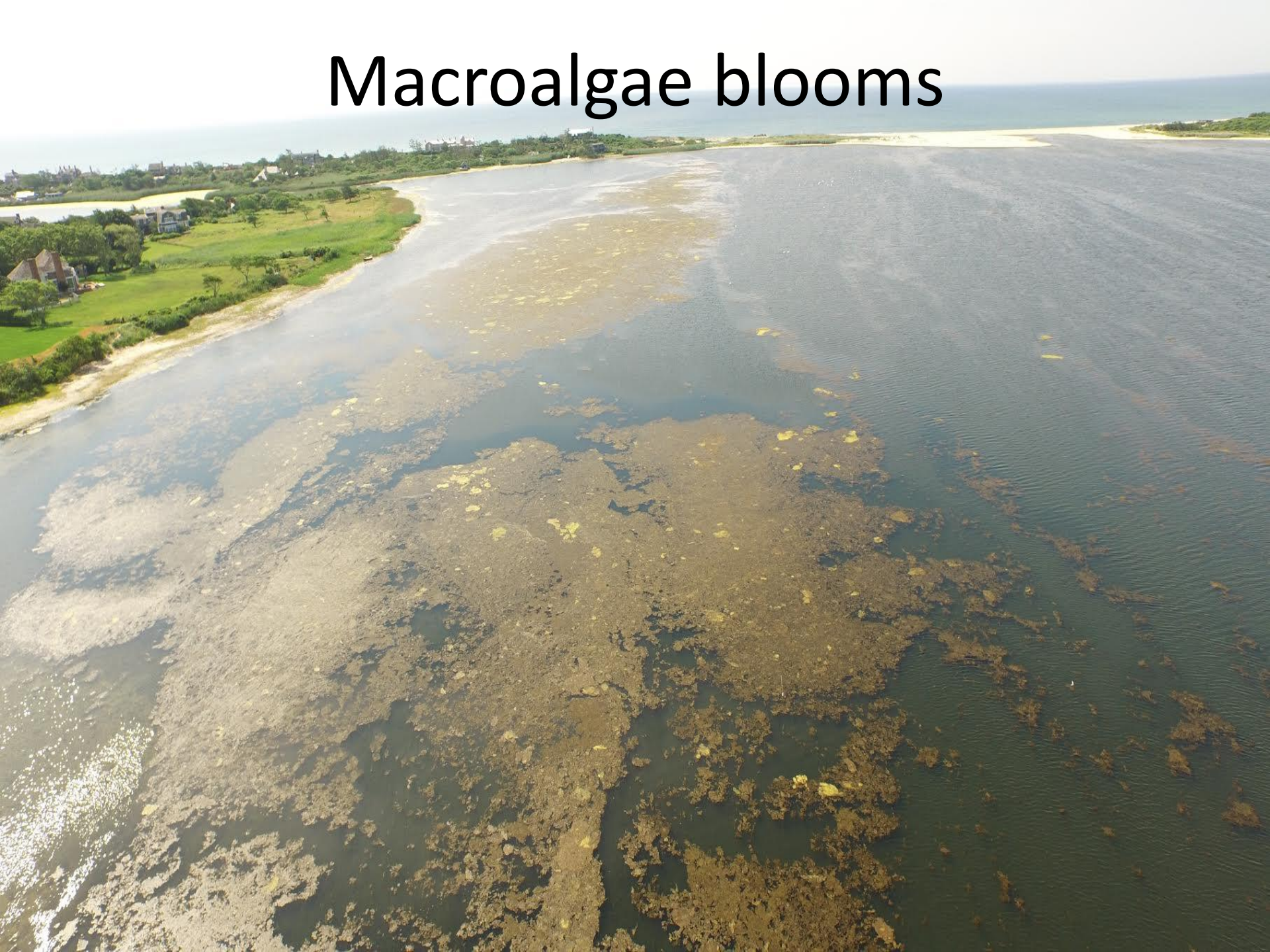
Christopher J. Gobler, PhD

Stony Brook University
School *of* Marine and Atmospheric Sciences

GOBLER LABORATORY

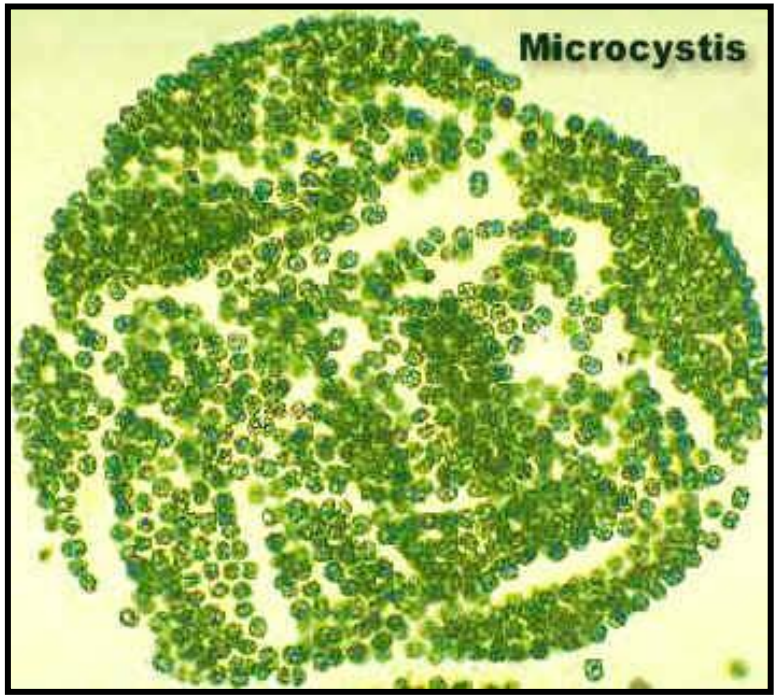
Why remediate Georgica Pond?

Macroalgae blooms

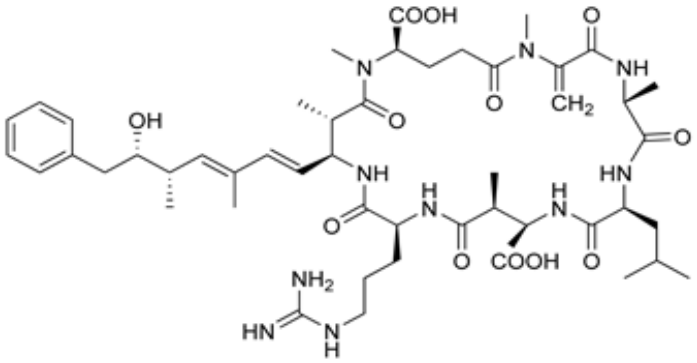


Blue-green algae blooms

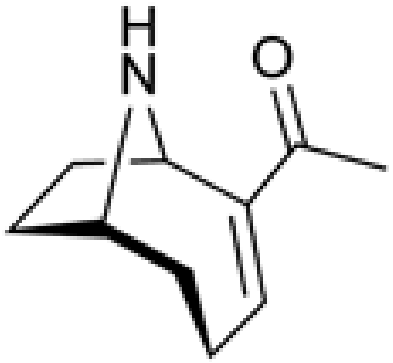
Blue-green algae and their toxins



Microcystin – gastrointestinal toxin



Anatoxin-a – neurotoxin



Low oxygen, death of wildlife






Why remediate Georgica Pond?

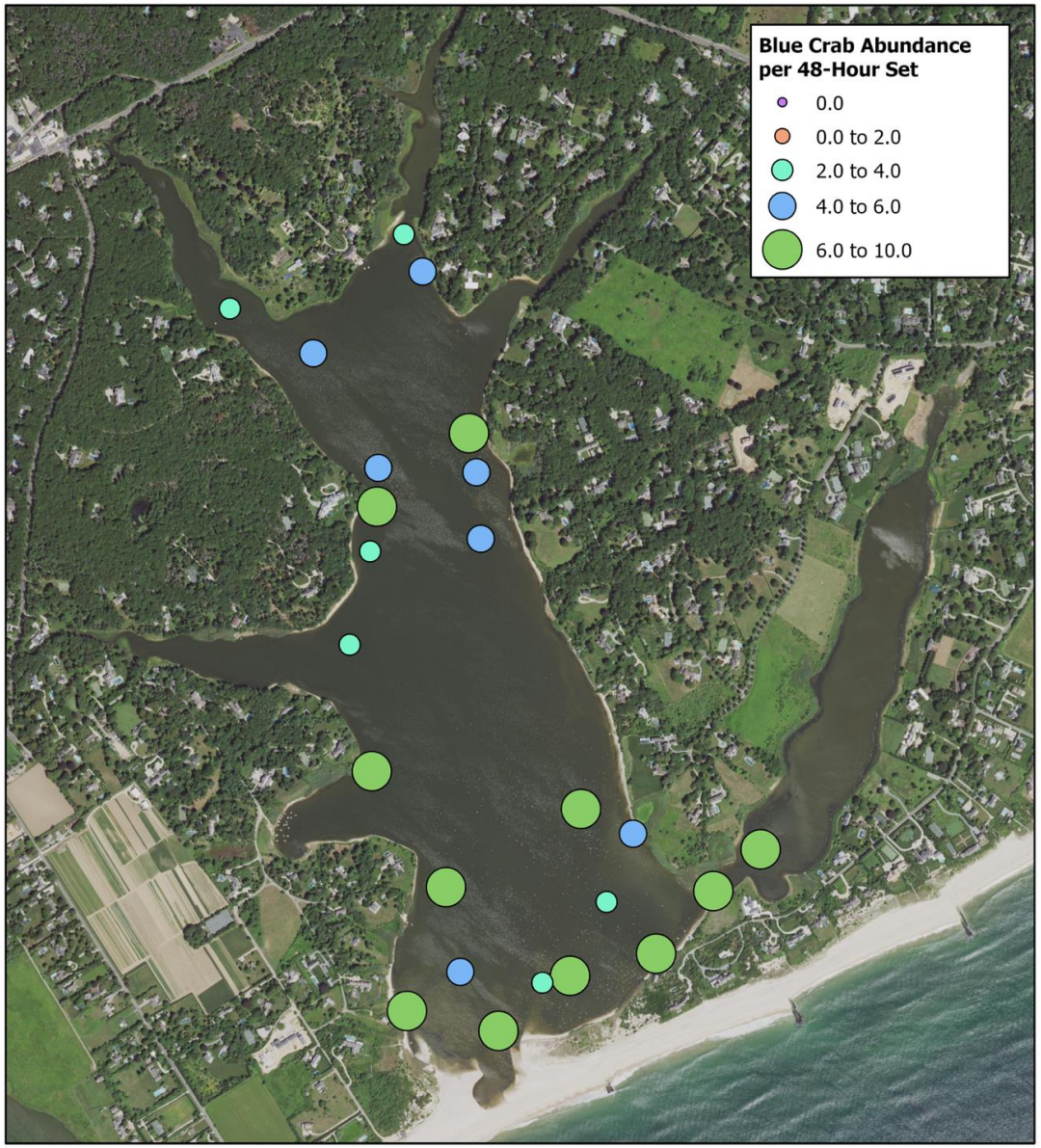
- Blooms of macroalgae
- Blooms of toxic blue green algae
- Hypoxia, anoxia
- Kills of fish, eels, birds, dogs
- Pathogenic bacteria

Overview

- Observations from 2021-2022
- Action to improve conditions

Blue crabs

Georgica Pond - Wainscott, NY
2021 - June - Blue Crab Abundance per 48 Hour Set



Spatial Reference:
NAD 1983 2011 StatePlane New York Long Isl FIPS 3104 Ft US

Imagery Source:
Esri, USDA Farm Service Agency (NAIP)

0 0.25 0.5 1 Km

N

This week on Georgica Pond




Real-time monitoring buoy

An investigation led by the Gobler Lab of Stony Brook University

Georgica Pond

Chart View | Table View | Site Information

GP_south
Site Id

40.934192
Latitude

-72.22572
Longitude

Georgica Pond Buoy - The Gobler Lab of Stony Brook University
Description

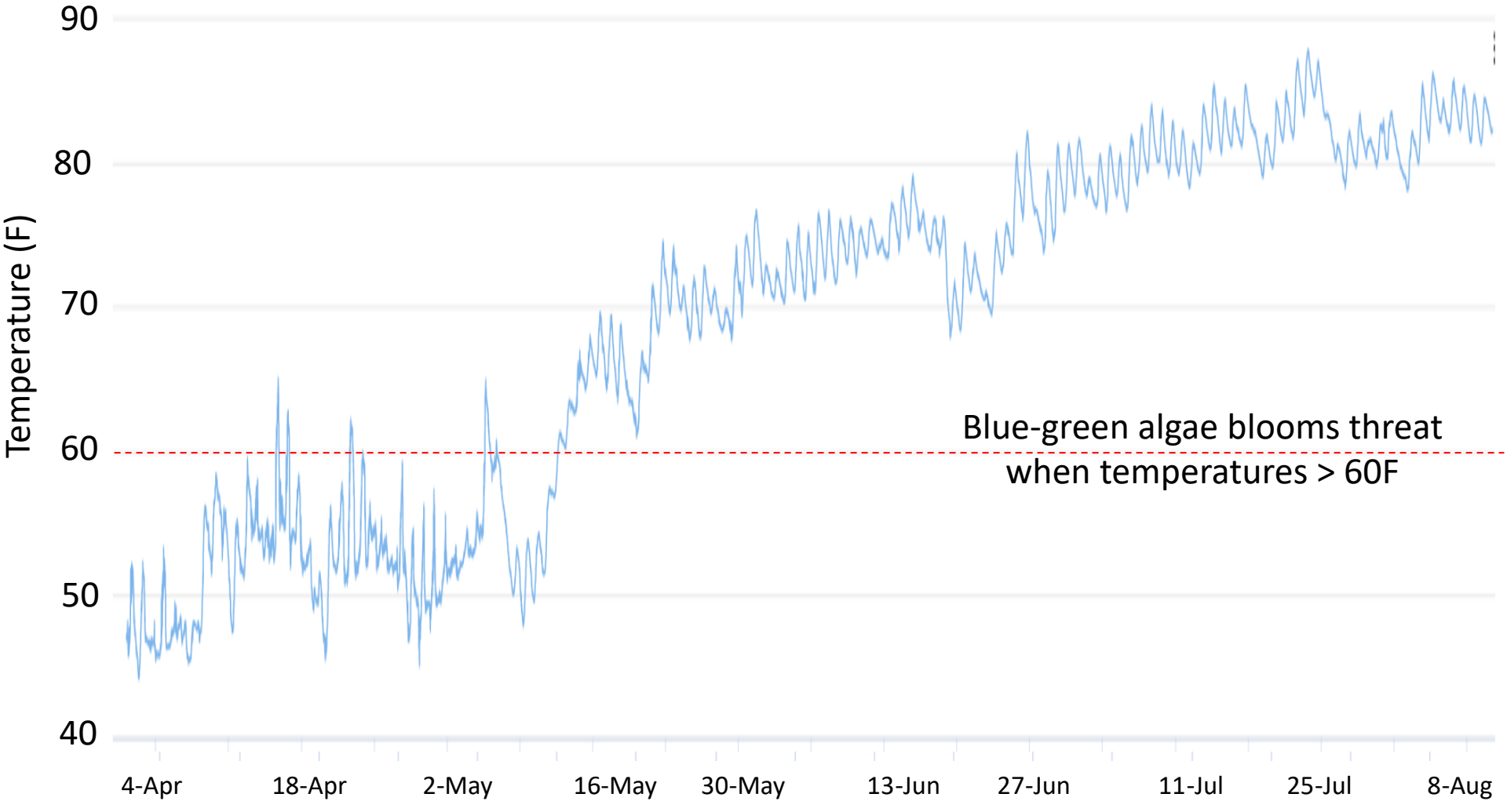
As part of The Georgica Pond Project, the Gobler laboratory has installed a water quality monitoring buoy in Georgica Pond. This device is making continuous, real-time measurements of key water quality indicators that are instantly telemetered to this web site.


An investigation led by the Gobler Lab of Stony Brook University
Georgica Pond
Chart View
Table View
Site Information
Parameters
Studies
Last Month
Last Day
Last Week
Last Month
Last Year
Custom range
Y-axis scaling
Min
Max
Clear
Blue-Green Algae (ug/L)
5
4
3
2
1
0

Cut opened in spring, closed since May 1st

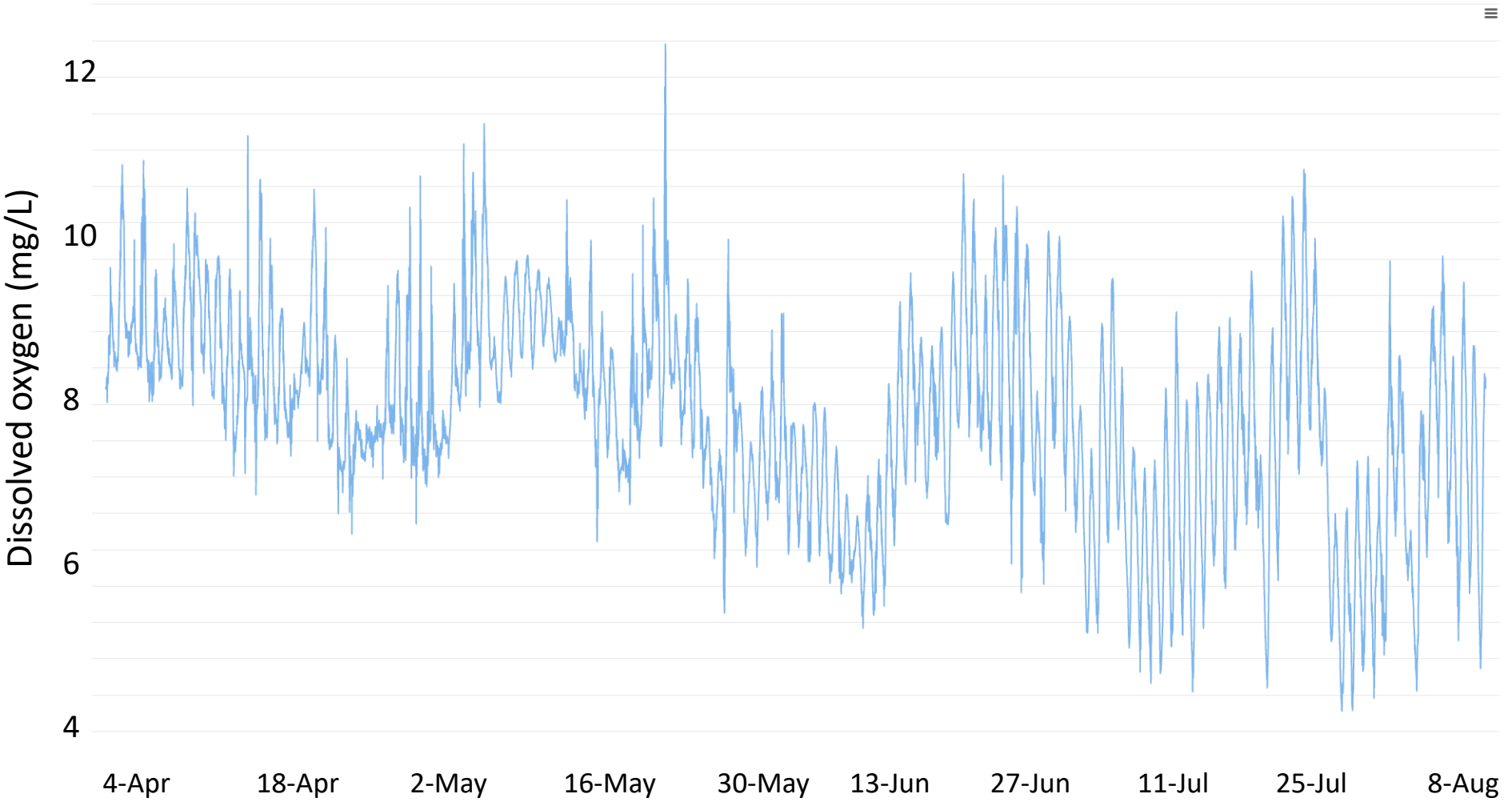
Salinity, 2022

Temperature, 2022

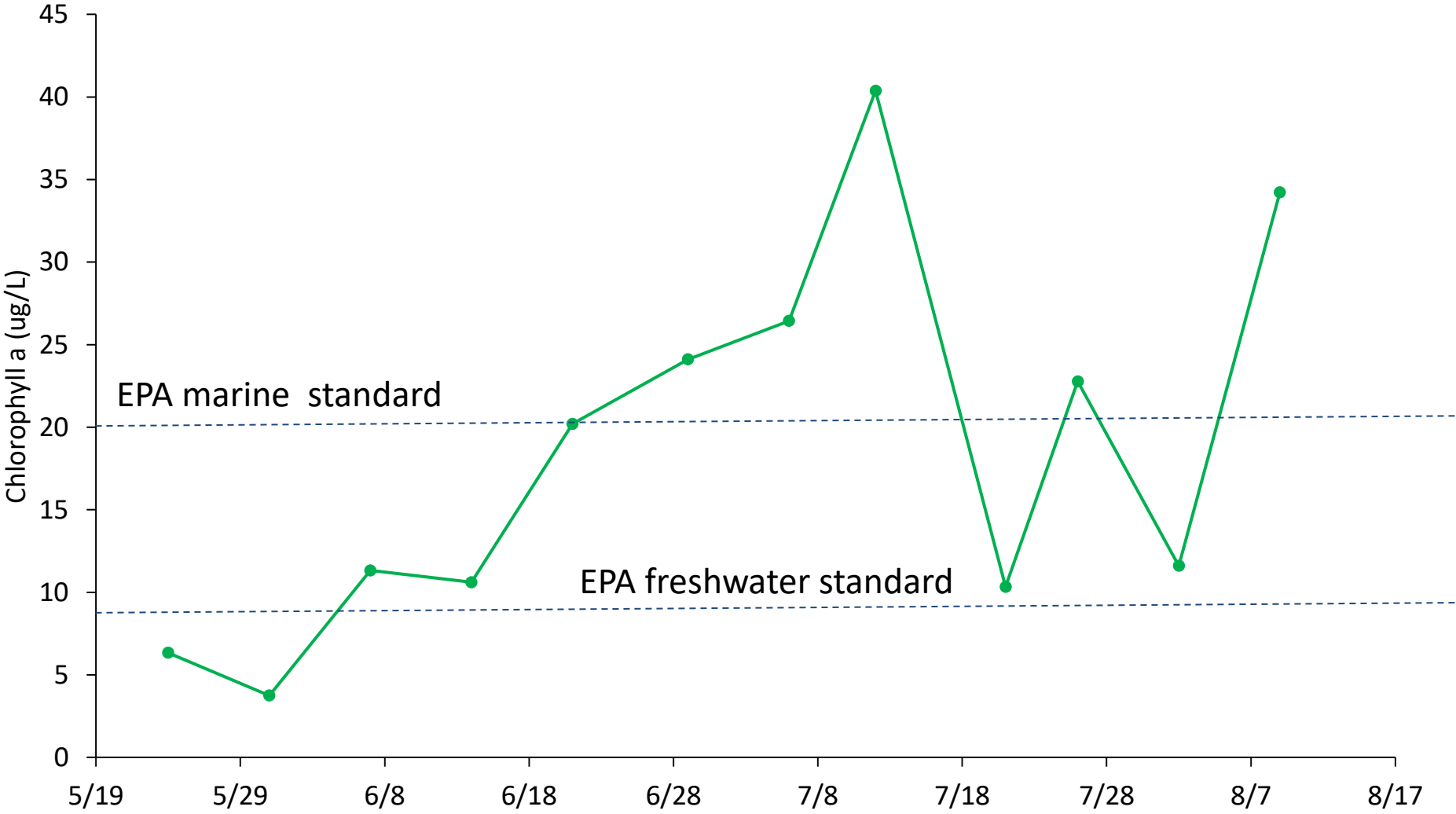


Dissolved oxygen, 2022

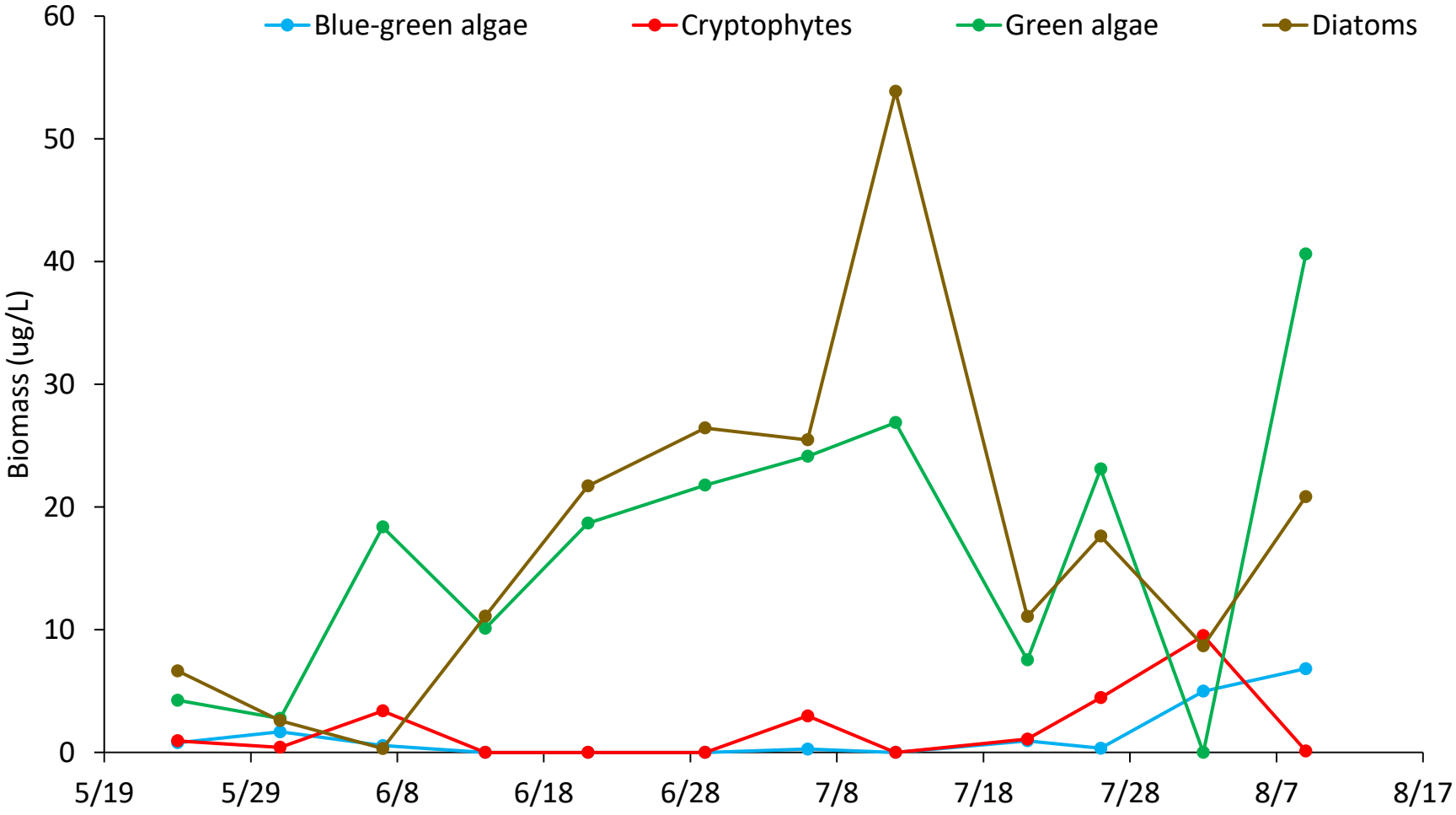
NYSDEC minimum standard = 3mg/L



Chlorophyll *a*, 2022

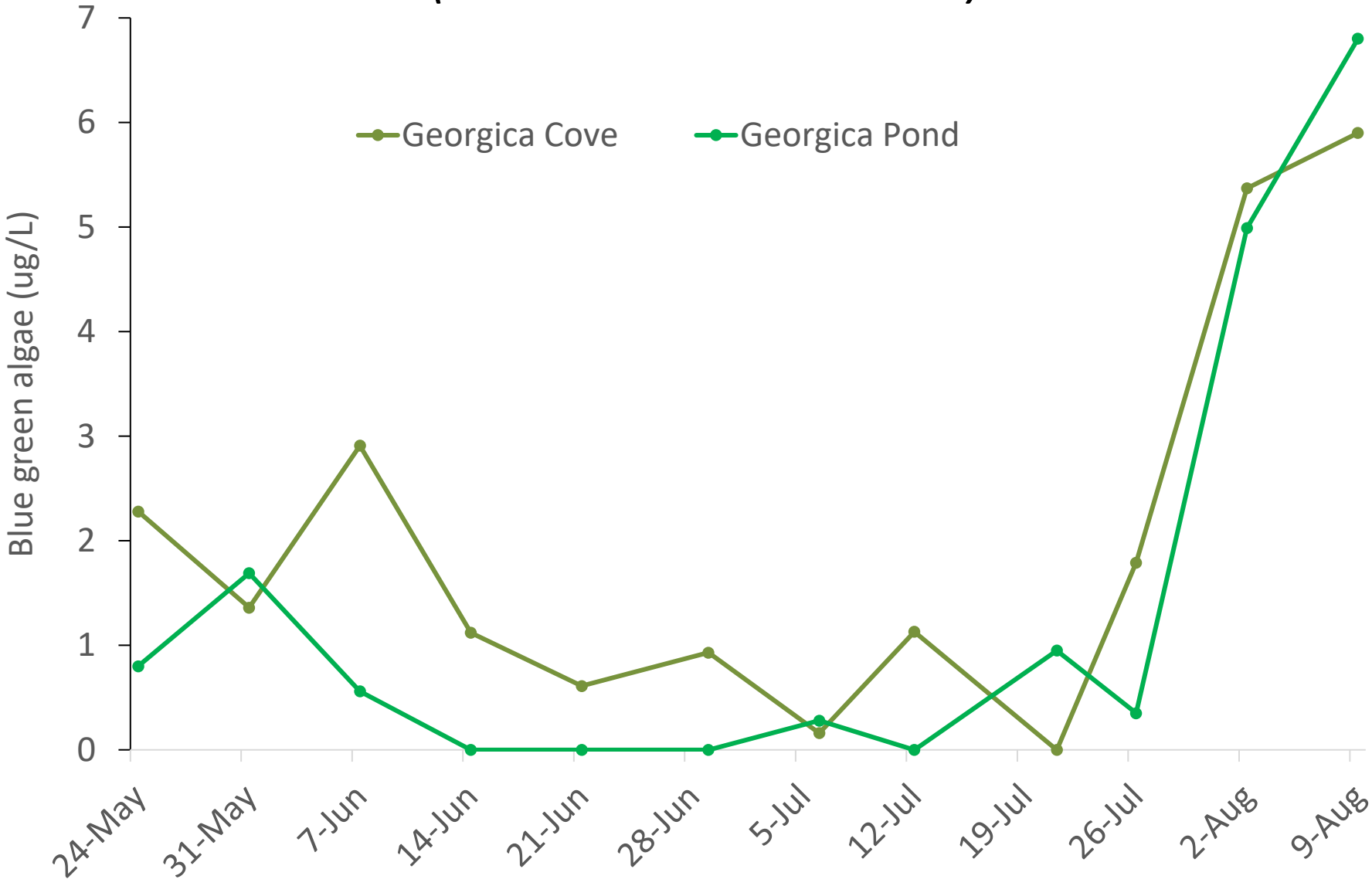


Algae communities, 2022



Blue-green algae, 2022

(NYSDEC standard = 25)

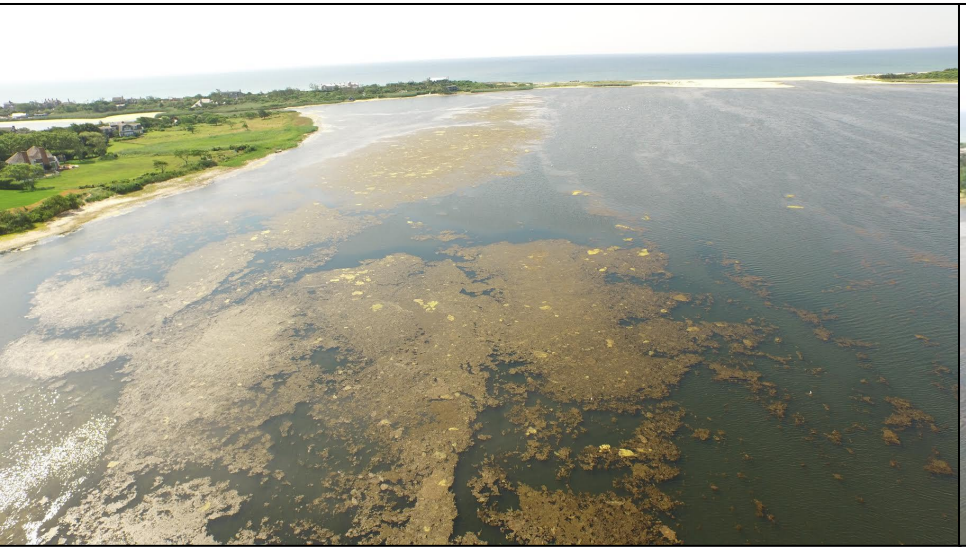


Pond weed in Georgica Pond

It’s pond weed…

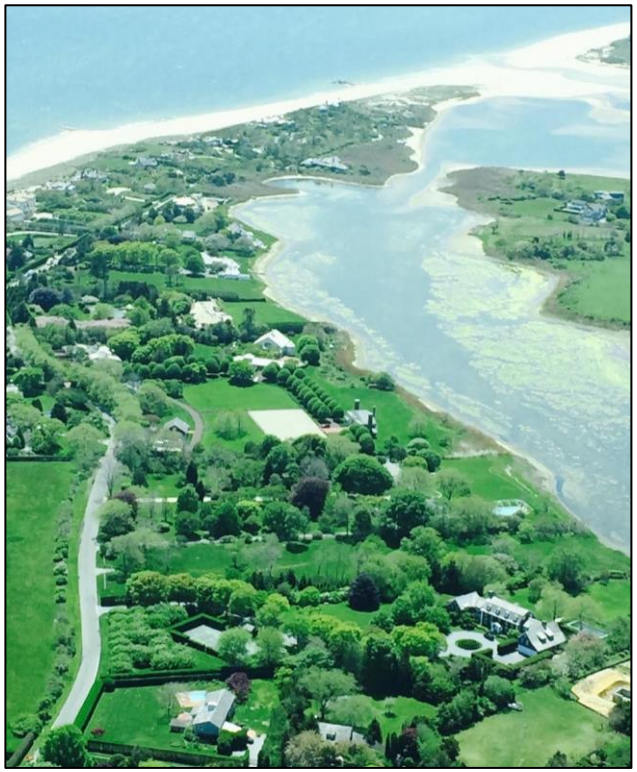
Pond weed on this week's fly over

Macroalgae bloom, 2015



The macroalgae – blue green algae hypothesis

June → July → August



Hunting the eagle killer: A cyanobacterial neurotoxin causes vacuolar myelinopathy

Breinlinger *et al.*, *Science* **371**, eaax9050 (2021) 26 March 2021

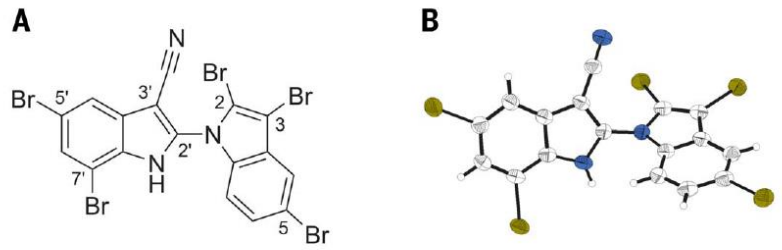
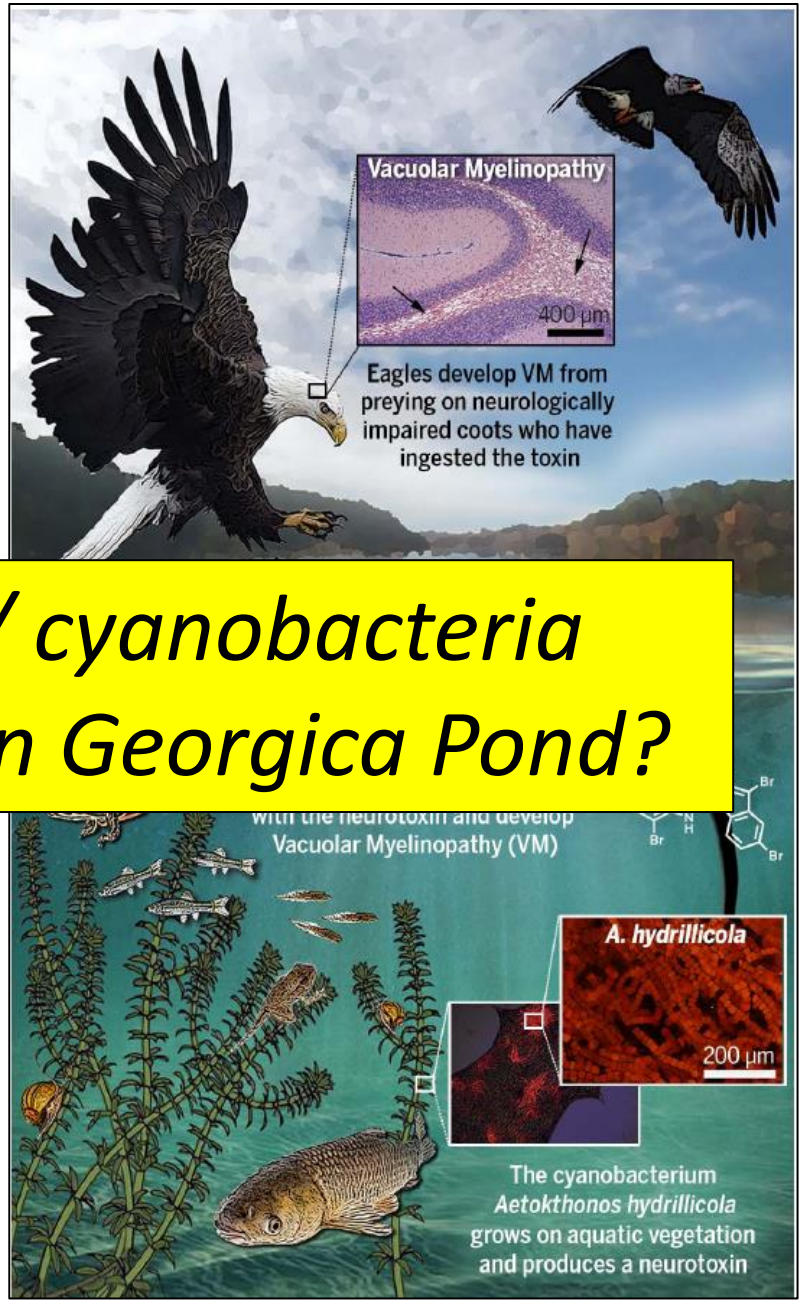


Fig. 3. AETX is a pentabrominated biindole alkaloid. (**A** and **B**) Structure (A) and x-ray crystallography structure (B) of AETX.



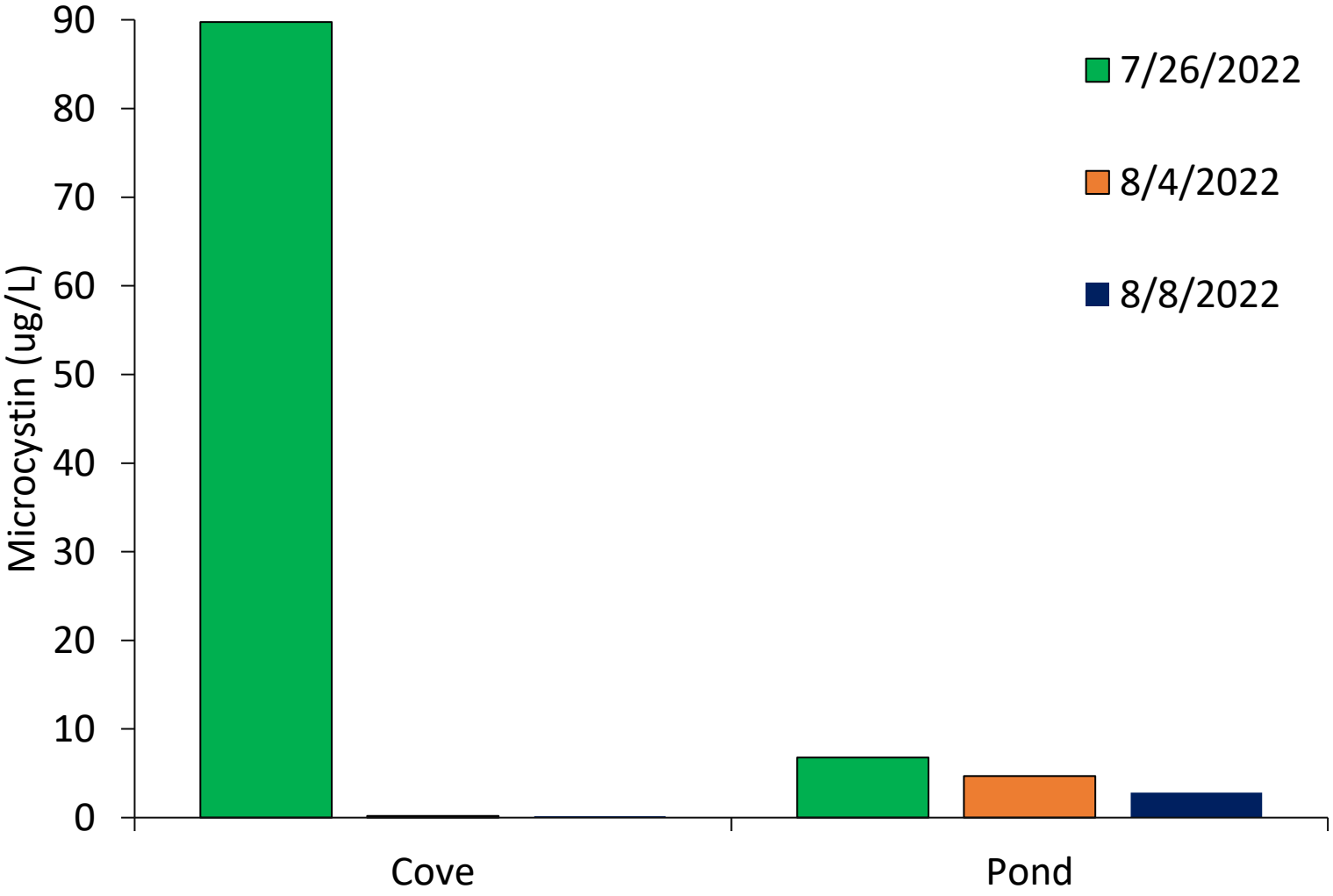
- *Are blue-green algae / cyanobacteria growing on pond weed in Georgica Pond?*

- Neurotoxin from cyanobacteria enters aquatic food web as birds and fish consume the pond weed.

- Bald eagles consuming prey with neurotoxins expire from vacuolar myelinopathy.

Blue Green Algae on Sago Pond Weed in Georgica Pond

Microcystin on pond weed



Georgica Pond macrophytes

Excessive nutrient loading in Pond

Macroalgae bloom

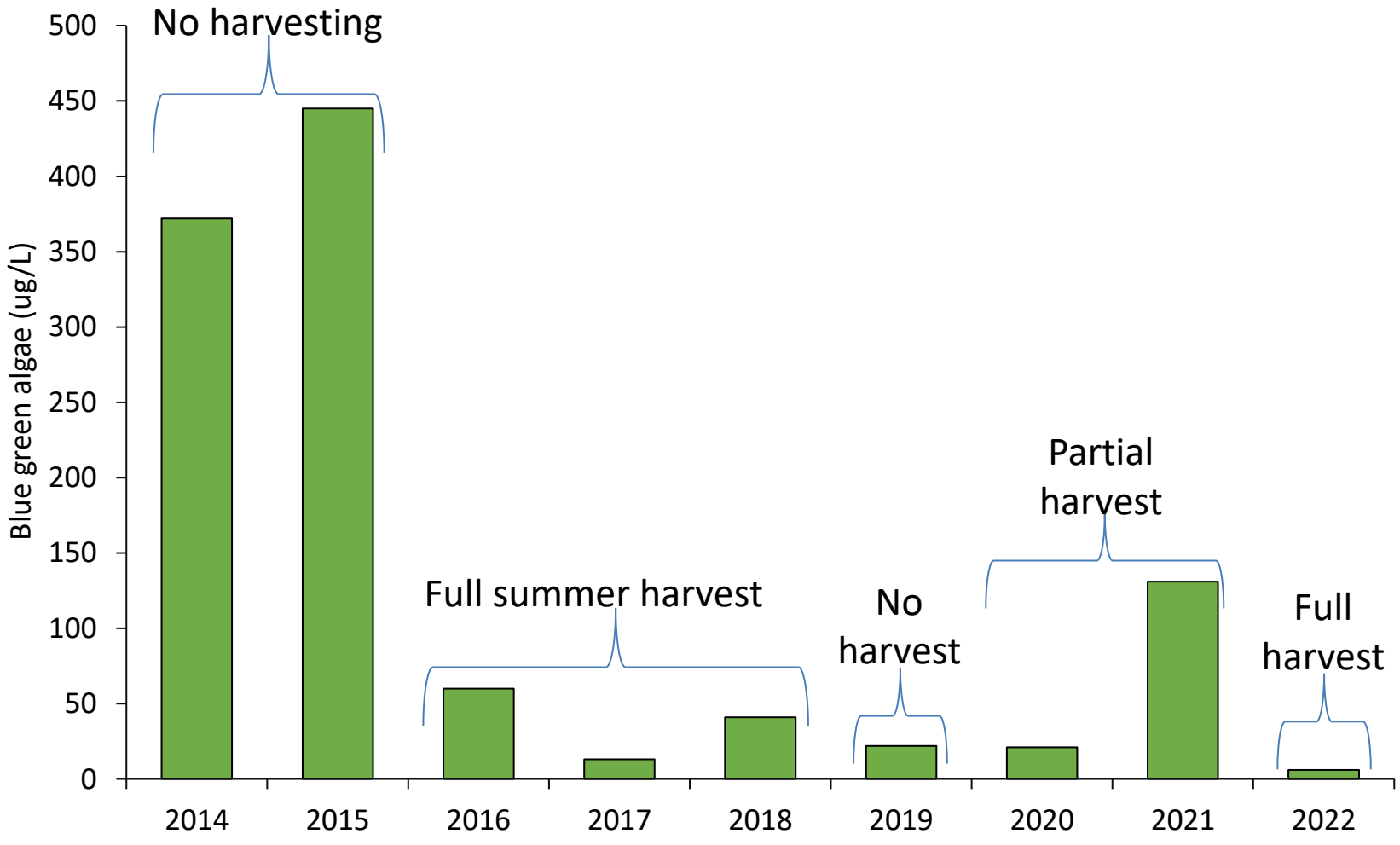
Collapsing macroalgae releases nutrients, toxic blue-green algae

Blue-green algae use released nutrients; hypoxia

Aquatic weed harvester:

Began in 2016; Current NYSDEC permit 2021 - 2026

History of blue-green algae and harvesting



Bioextraction: macroalgal harvest, summer 2021

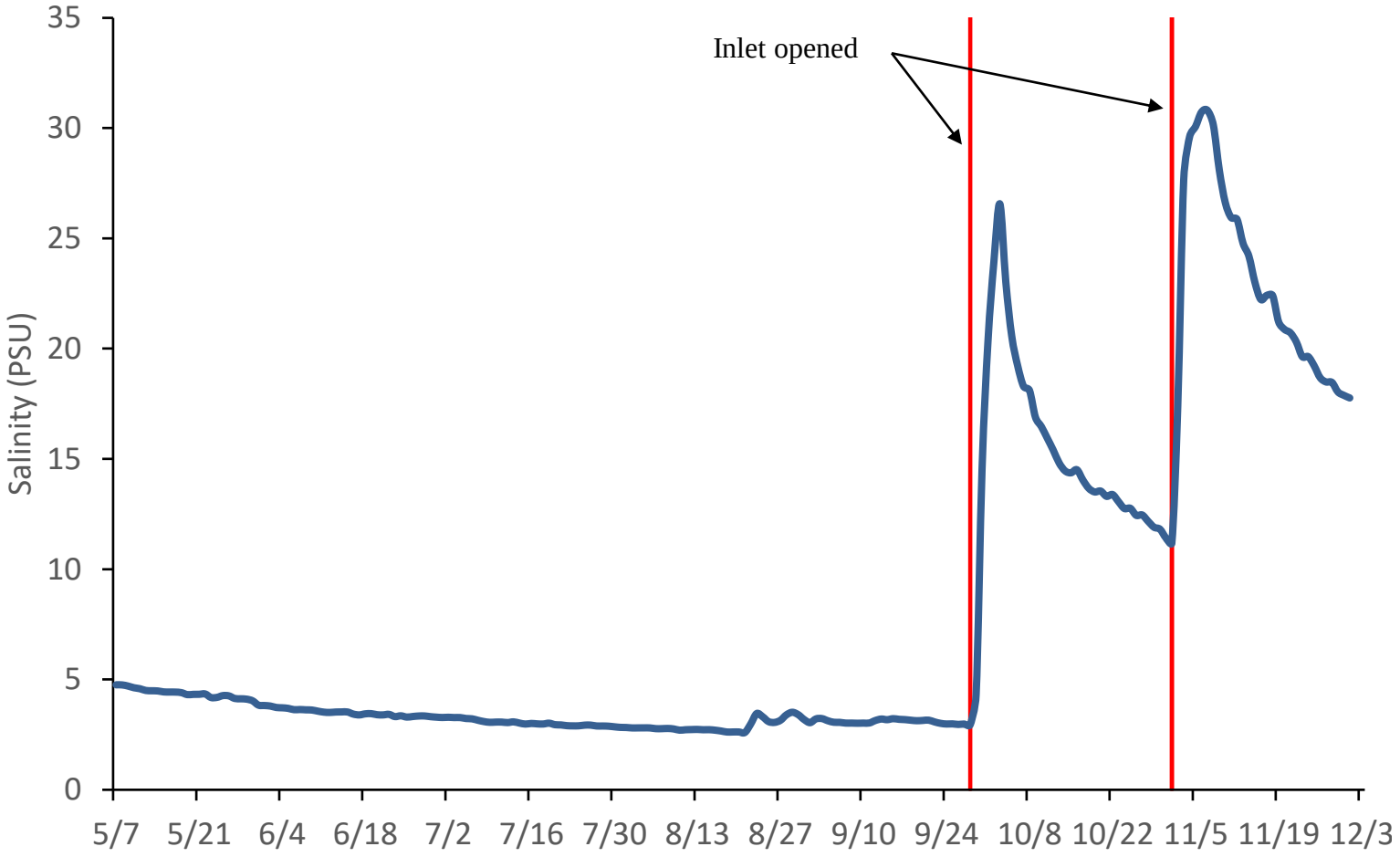
- **50,540 lbs removed**
- Up to 10% of summer N and P load

Georgica Pond

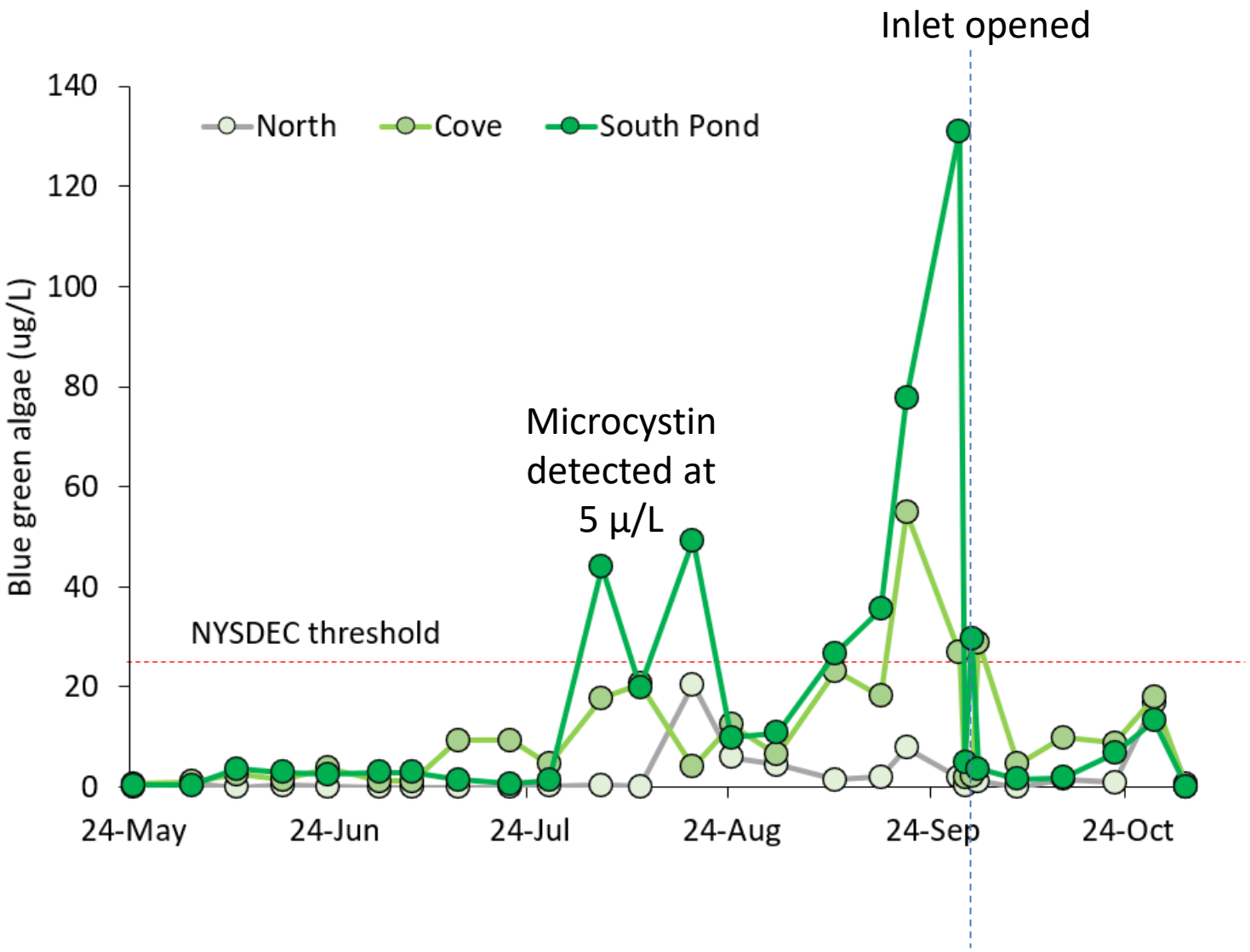
Inlet open

Inlet closed

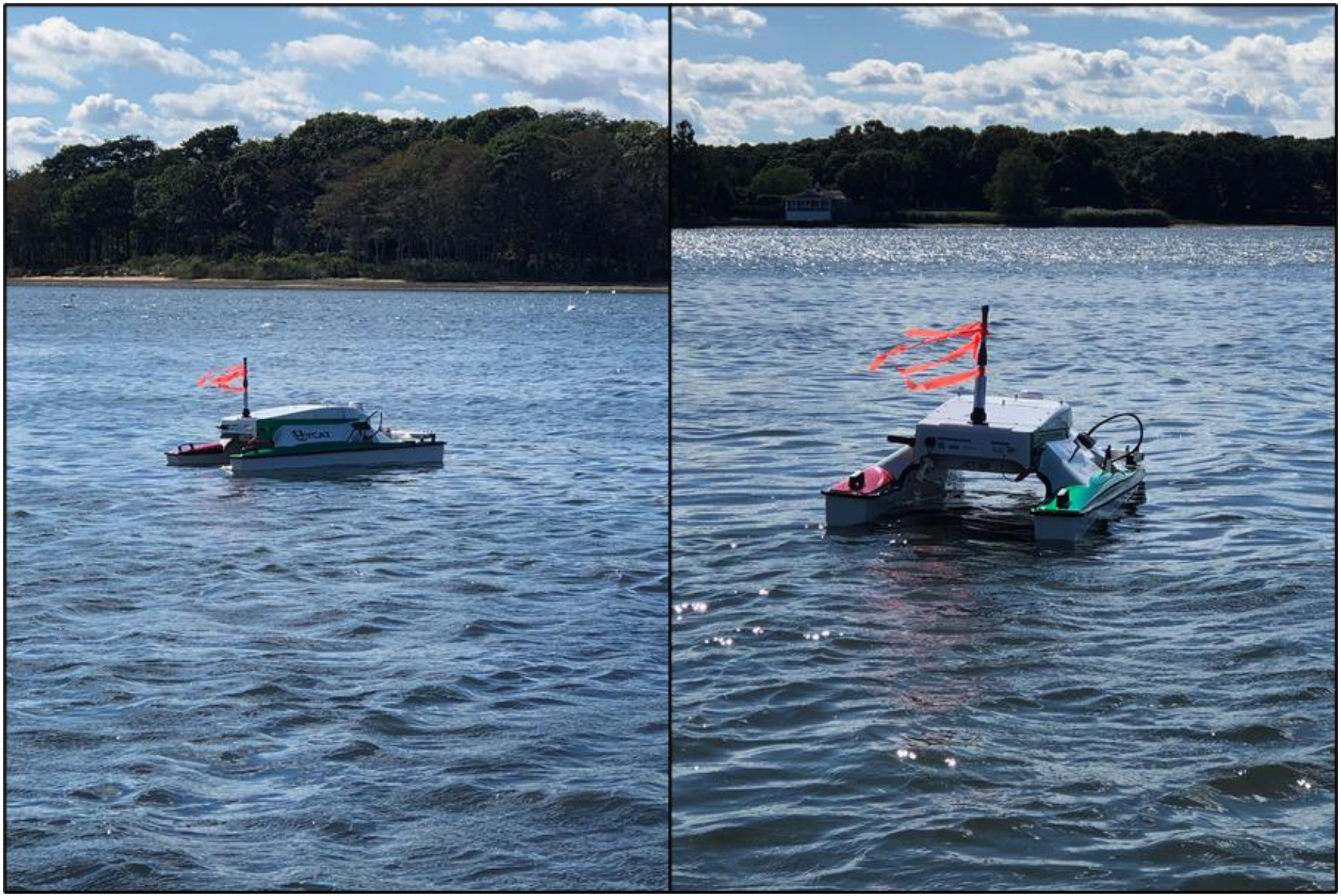
Georgica Pond salinity, 2021



Blue green algae, Georgica 2021

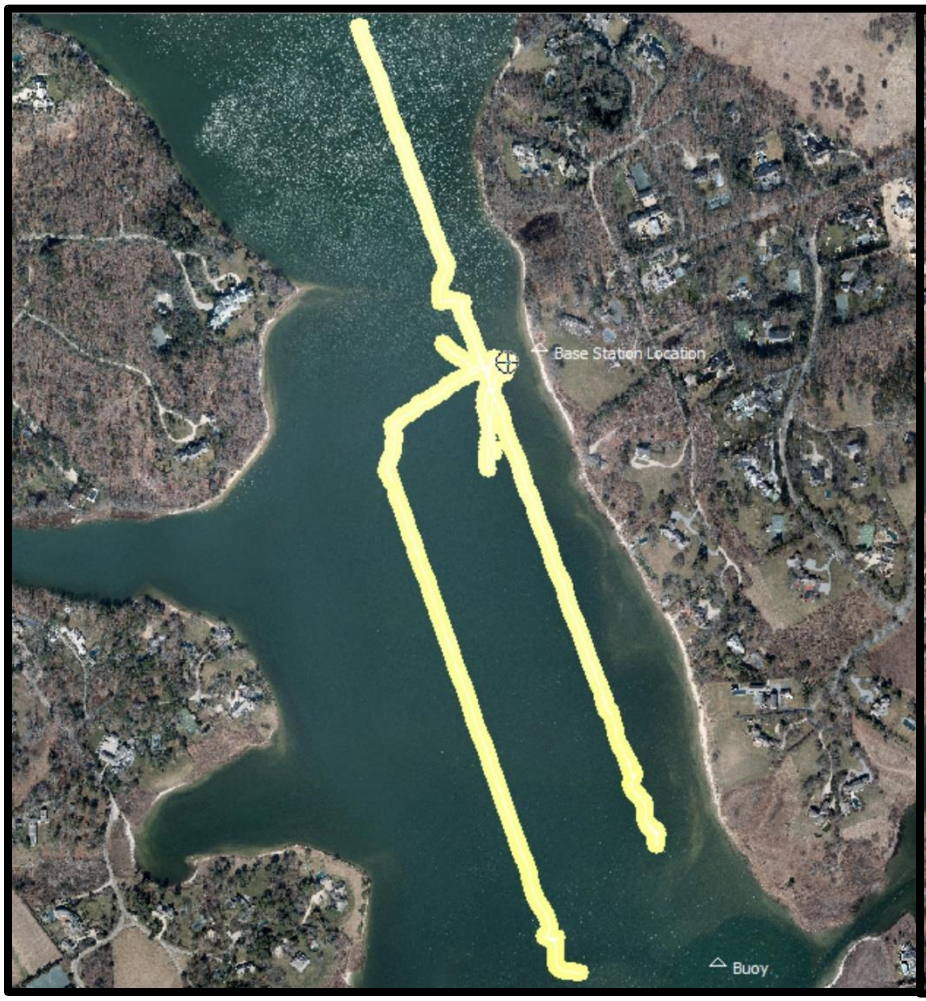


HYCAT autonomous surface vehicle



Salinity, before and after cut opening

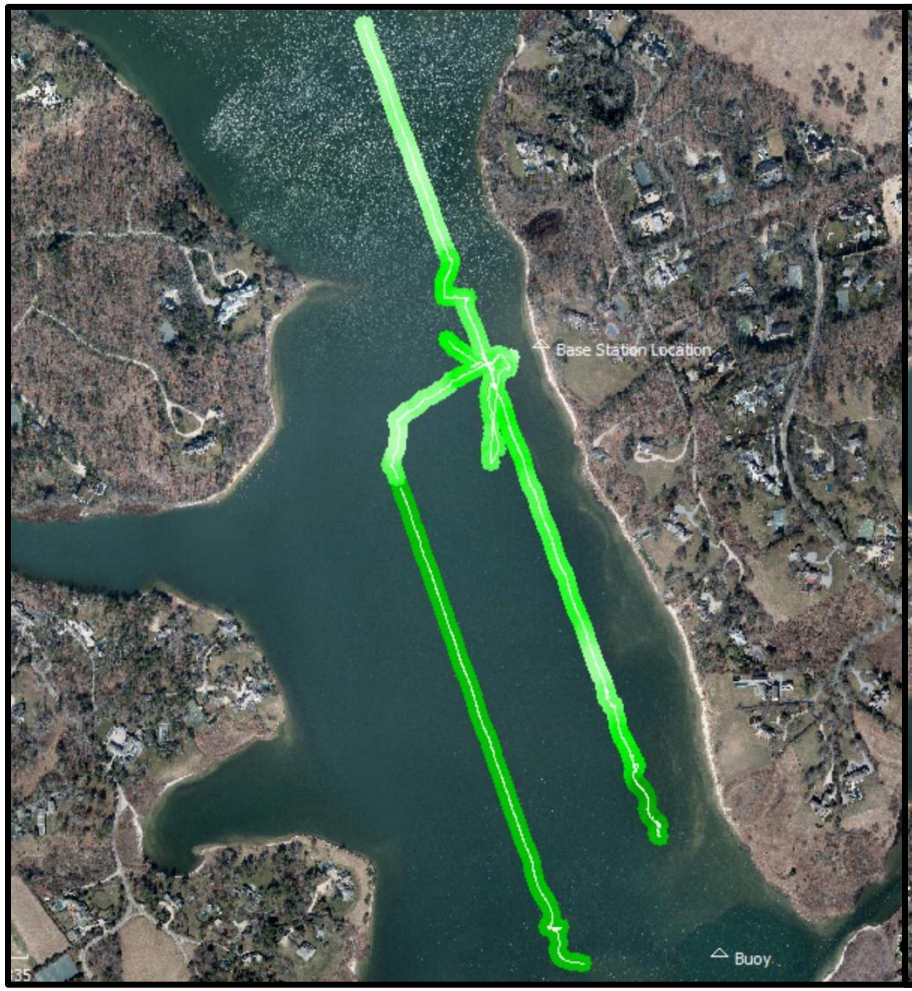
Salinity (PSU), 9/29/21



Salinity (PSU), 10/1/21

Blue-green algae before and after cut opening

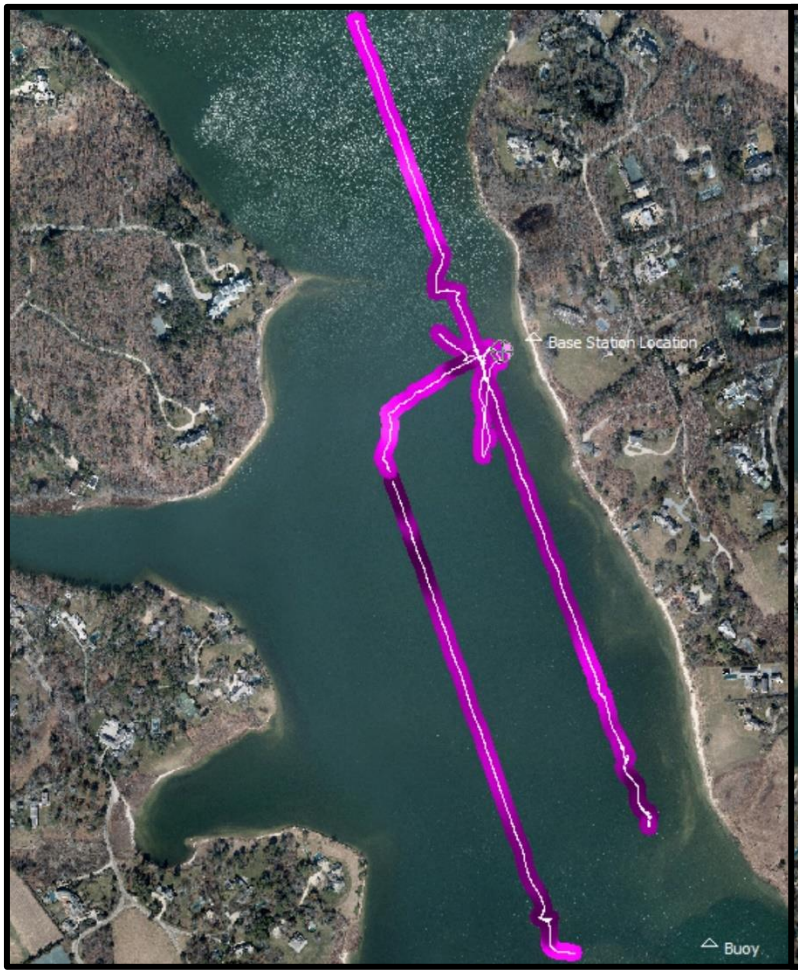
Blue-green algae (µg/L), 9/29/21



Blue-green algae (µg/L), 10/1/21

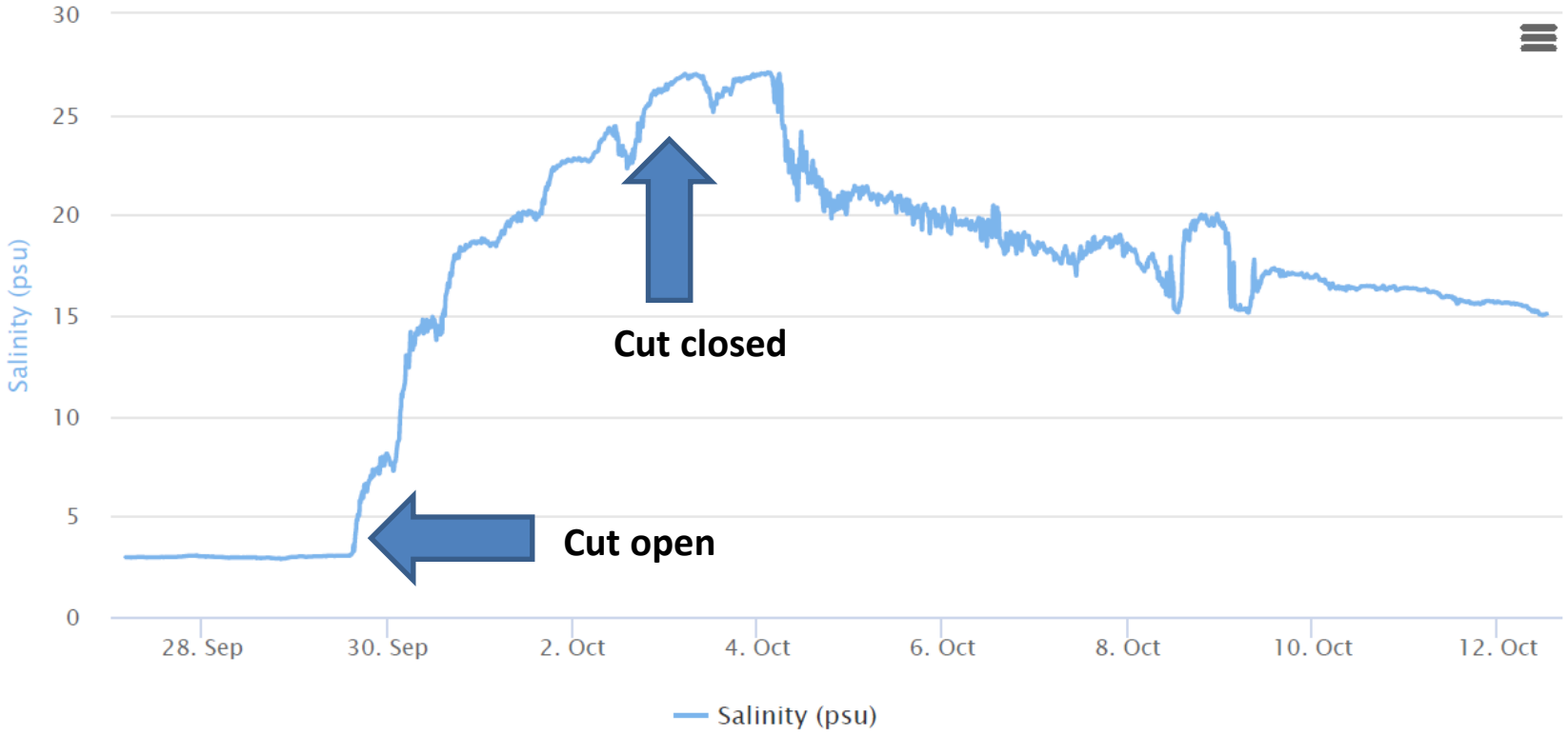
Dissolved oxygen before and after cut opening

Dissolved oxygen (mg/L), 9/29/21

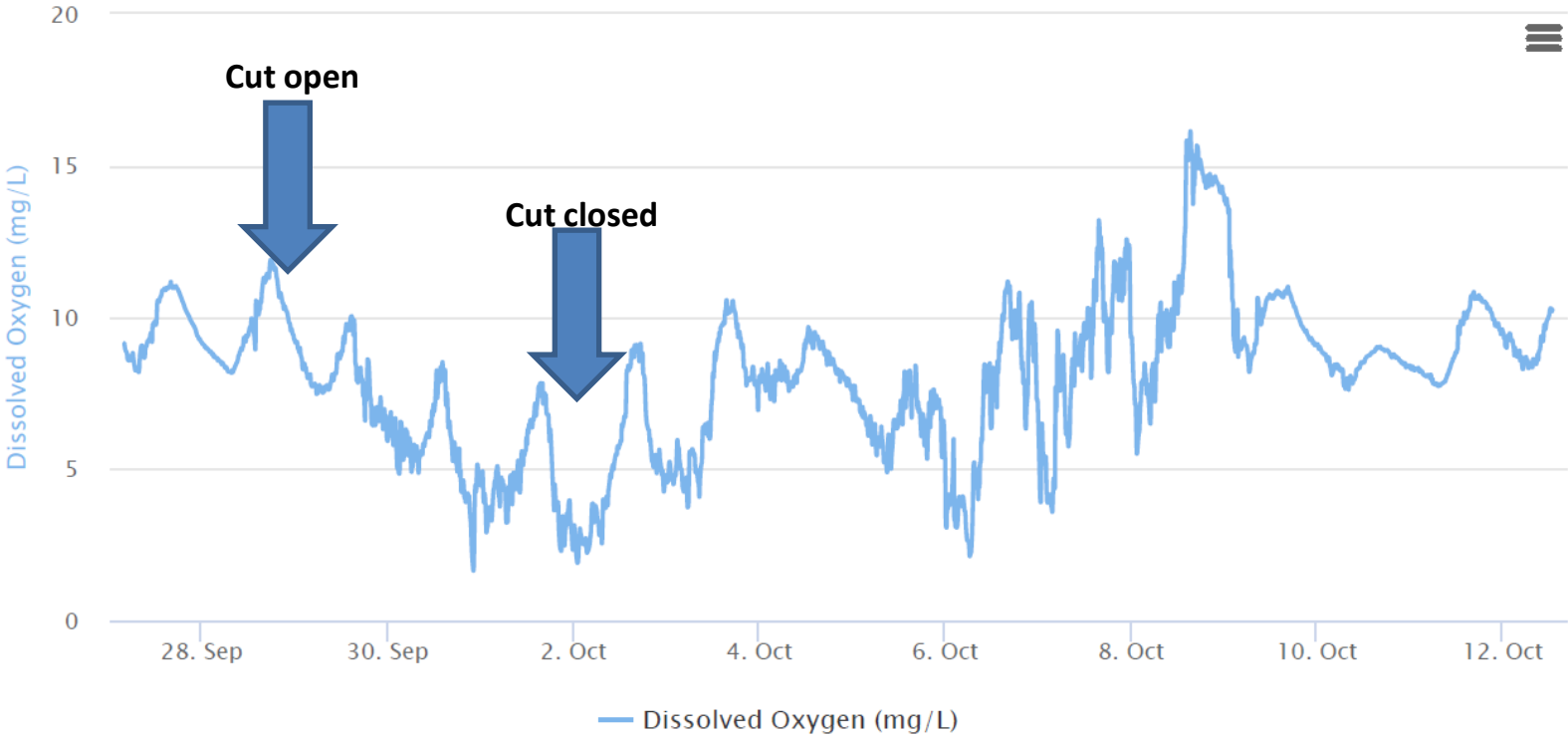


Dissolved oxygen (mg/L), 10/1/21

Salinity, 2021 cut opening

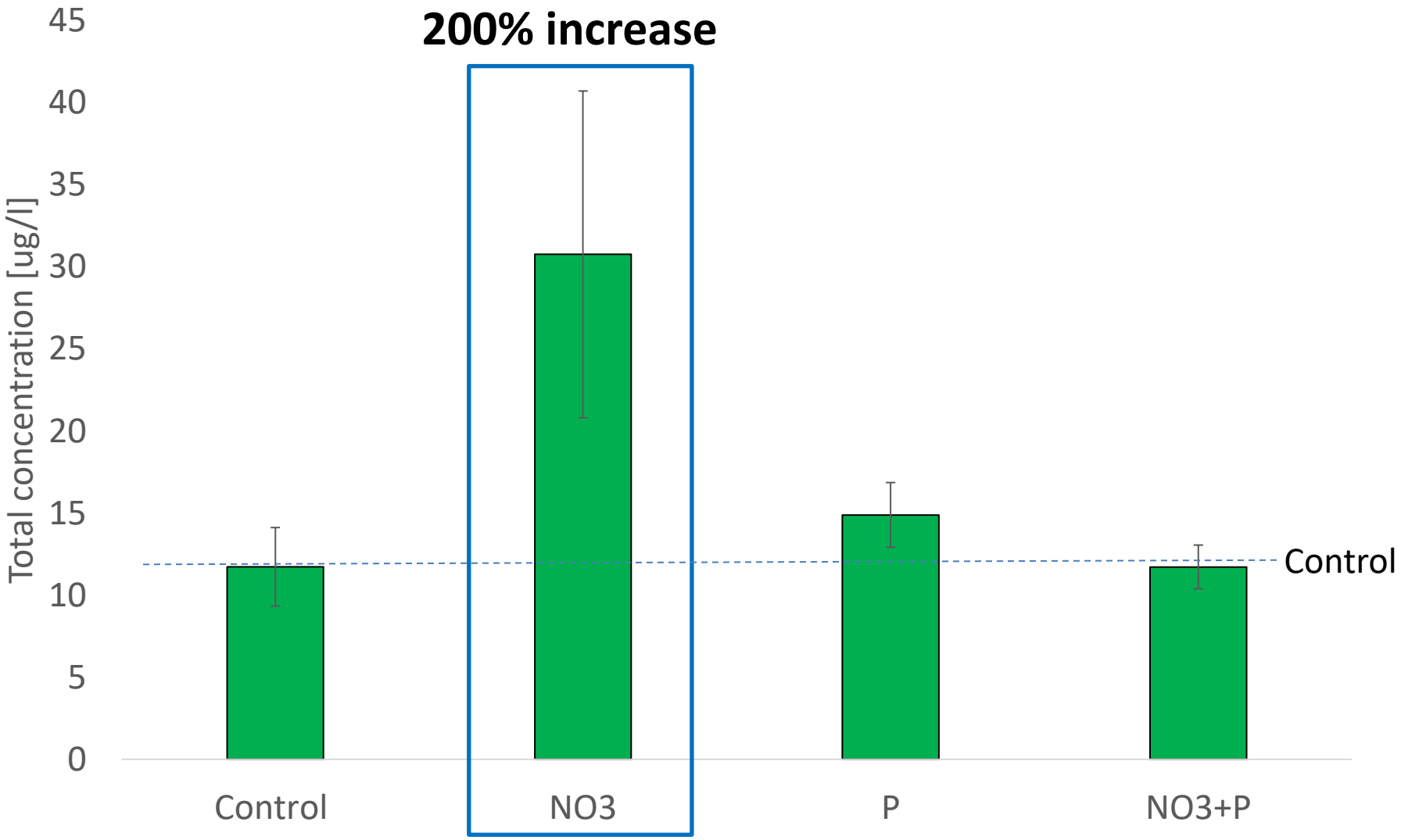


Dissolved oxygen, 2021 cut opening

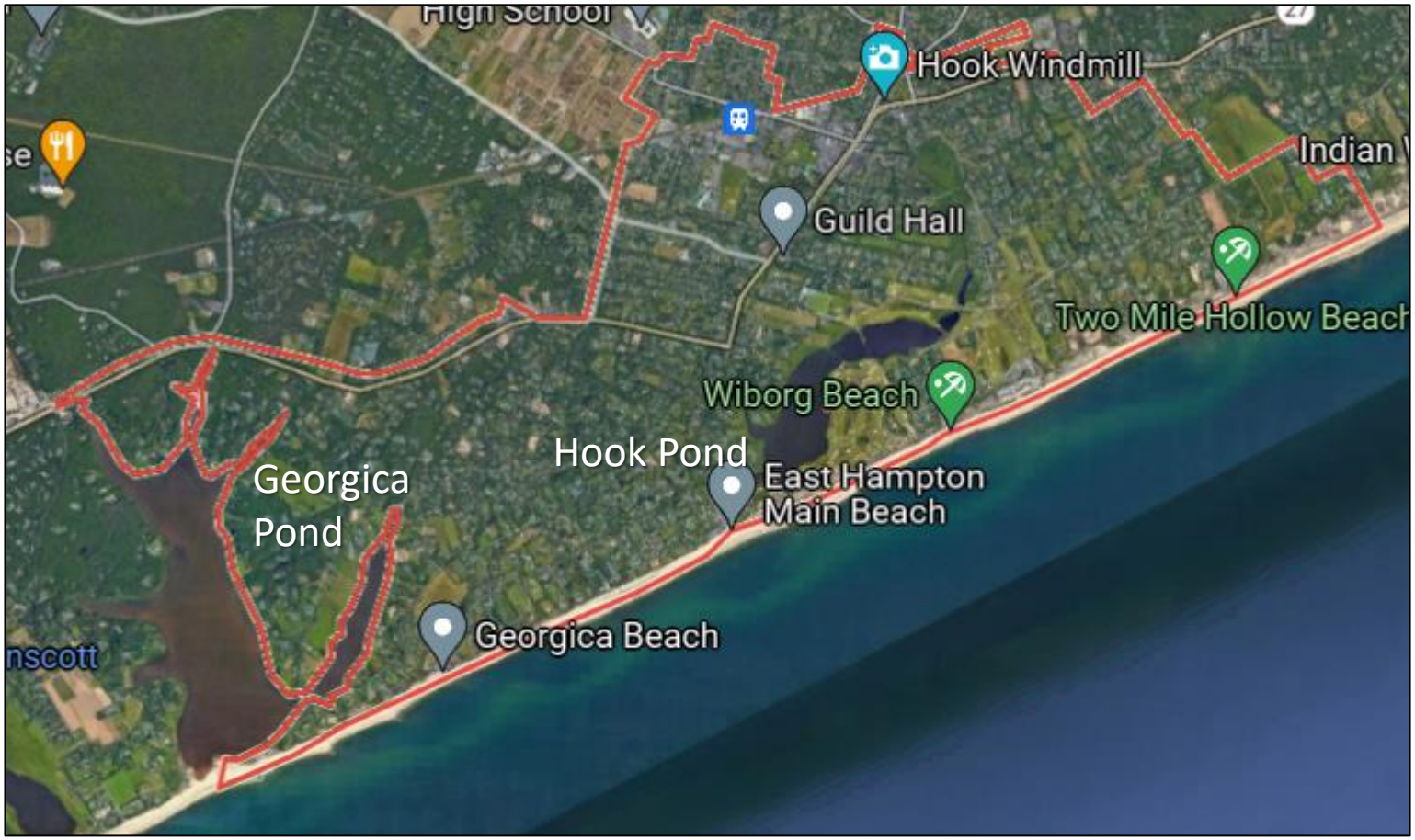


What is promoting algal blooms and low oxygen in Georgica Pond?

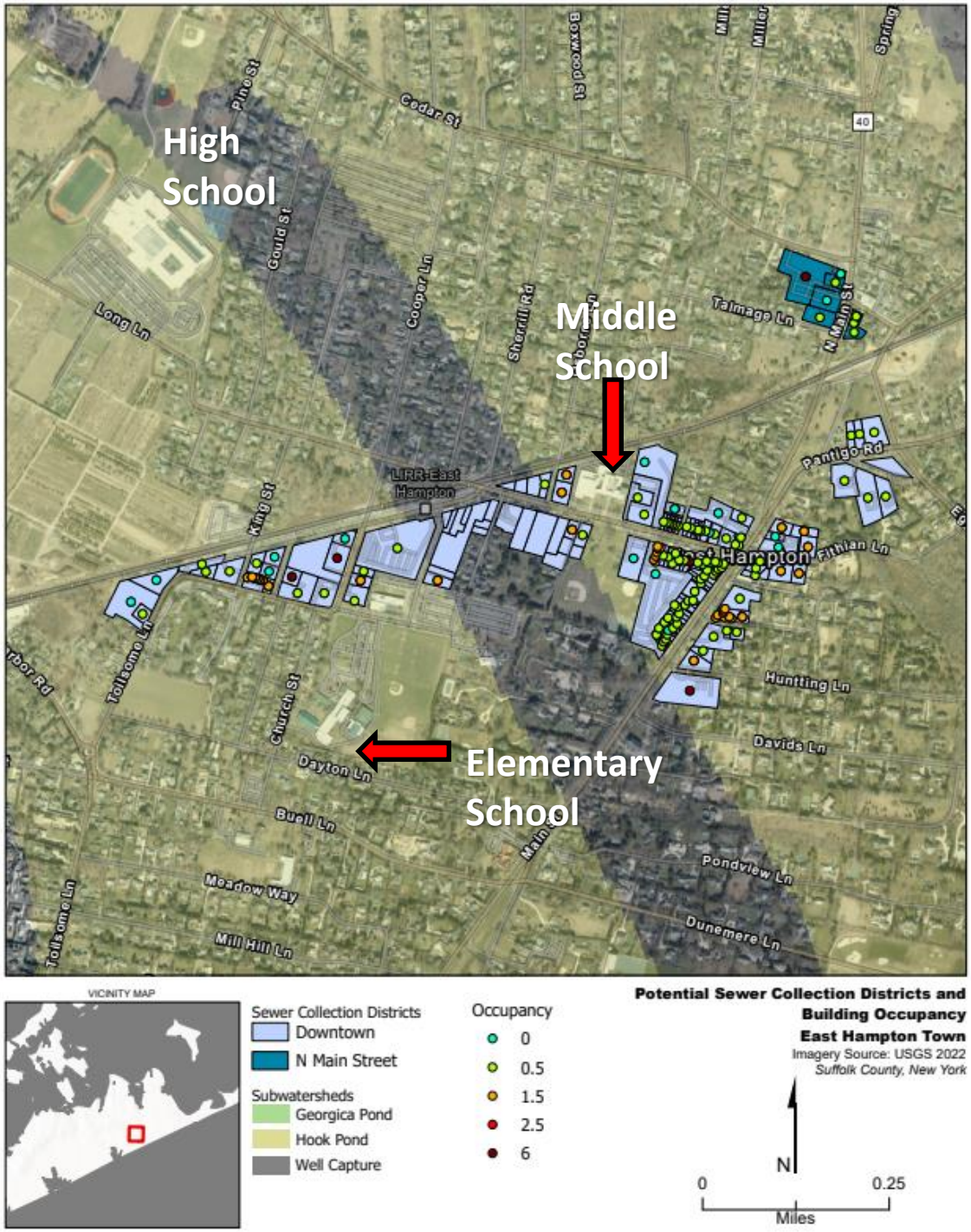
Nutrients controlling blue-green algae



East Hampton Village 2022 study

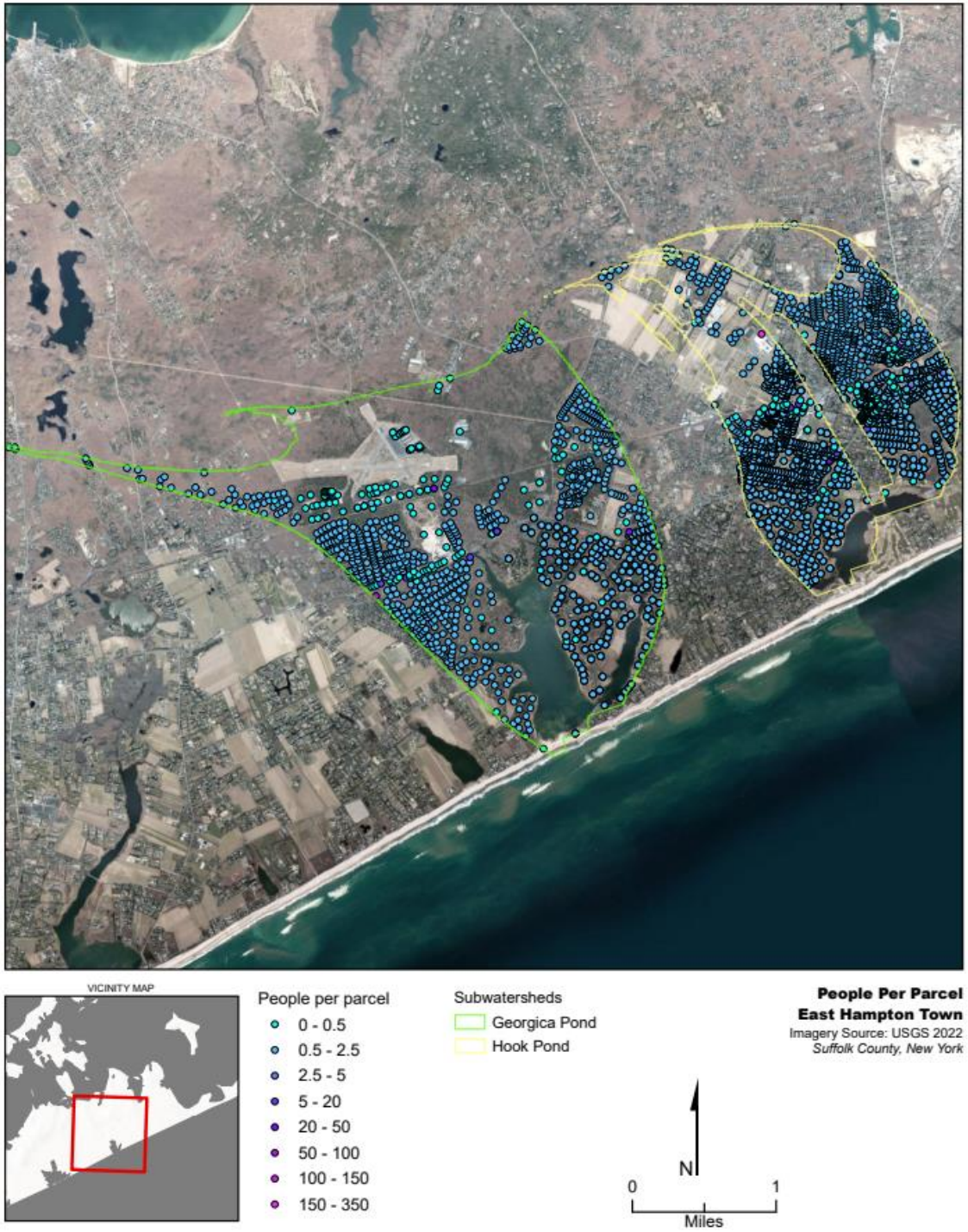


East Hampton Village sewer district study, 2022



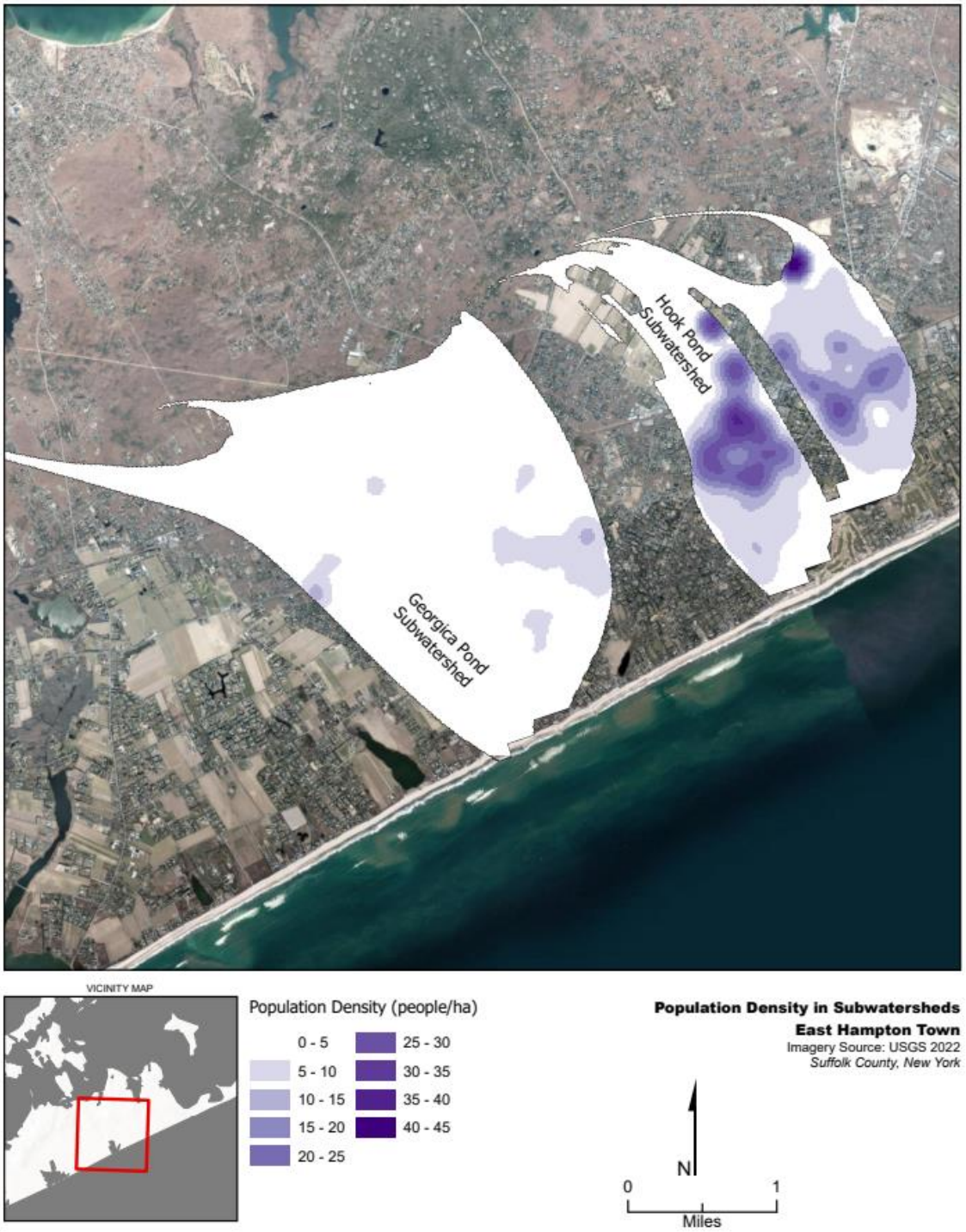
East Hampton Village sewer district study, 2022

People per parcel

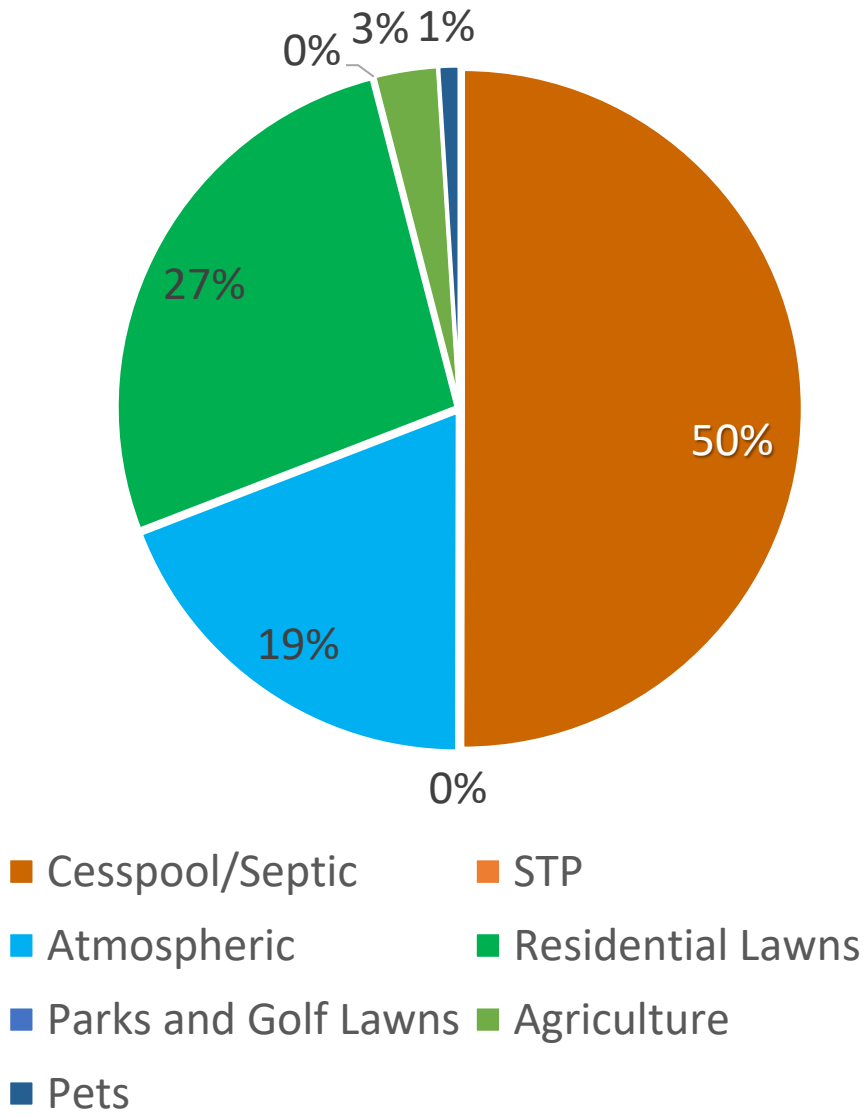


East Hampton Village sewer district study, 2022

People per parcel

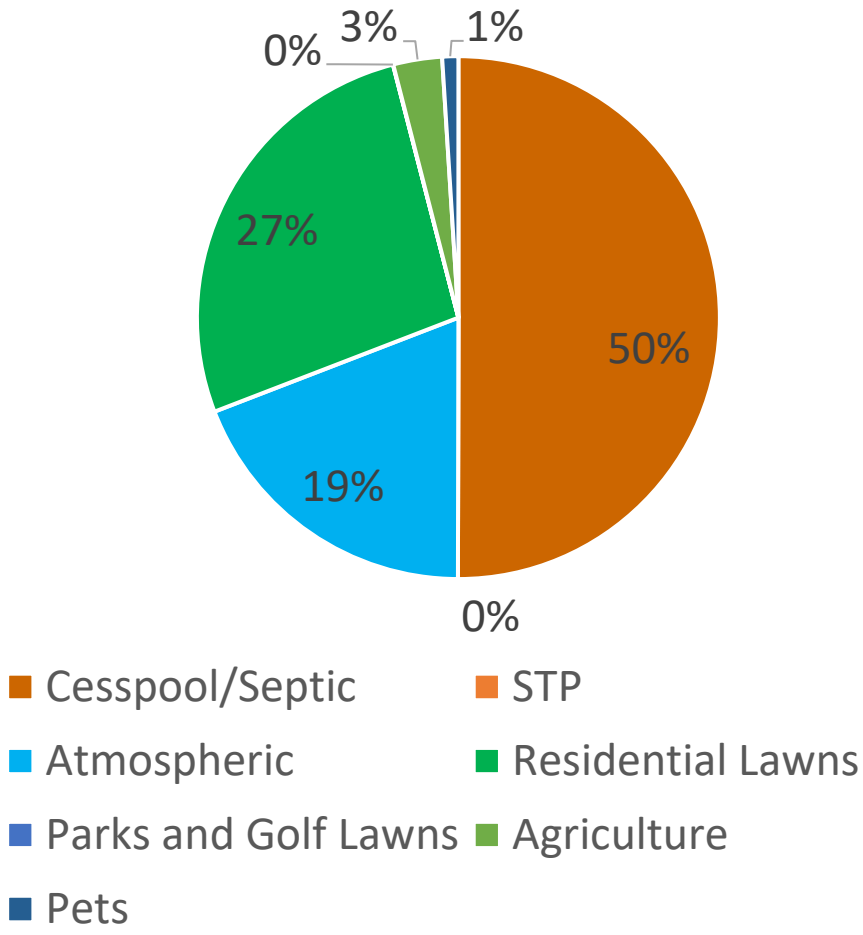


Georgica Pond, nitrogen sources

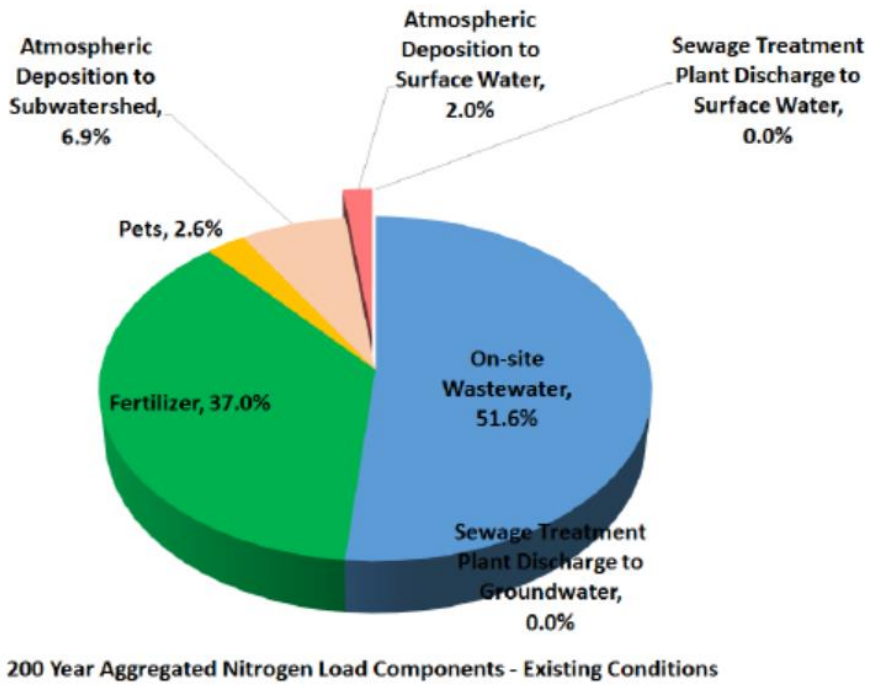


East Hampton Village study vs Suffolk County study

East Hampton Village study

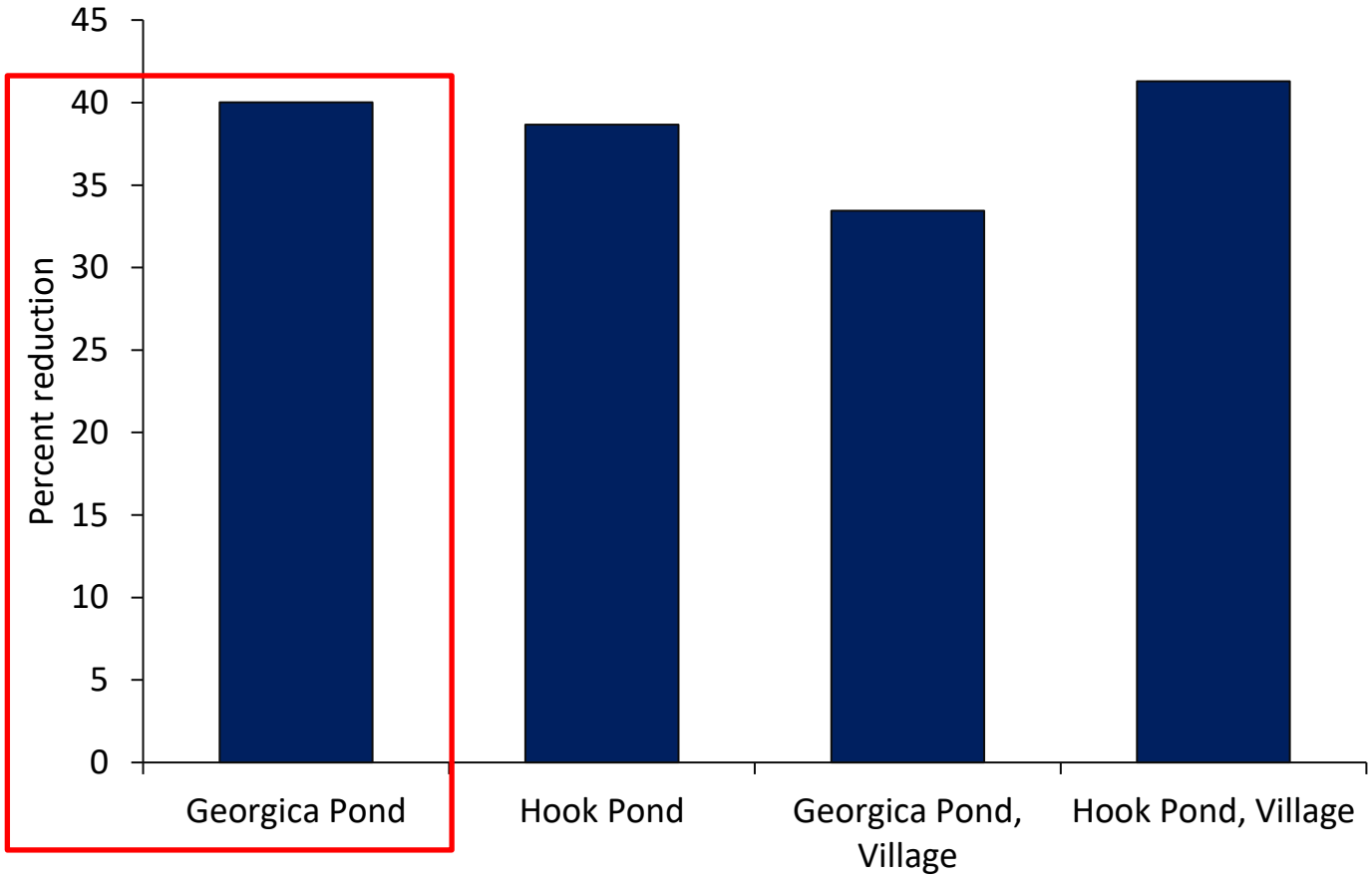


Suffolk County study

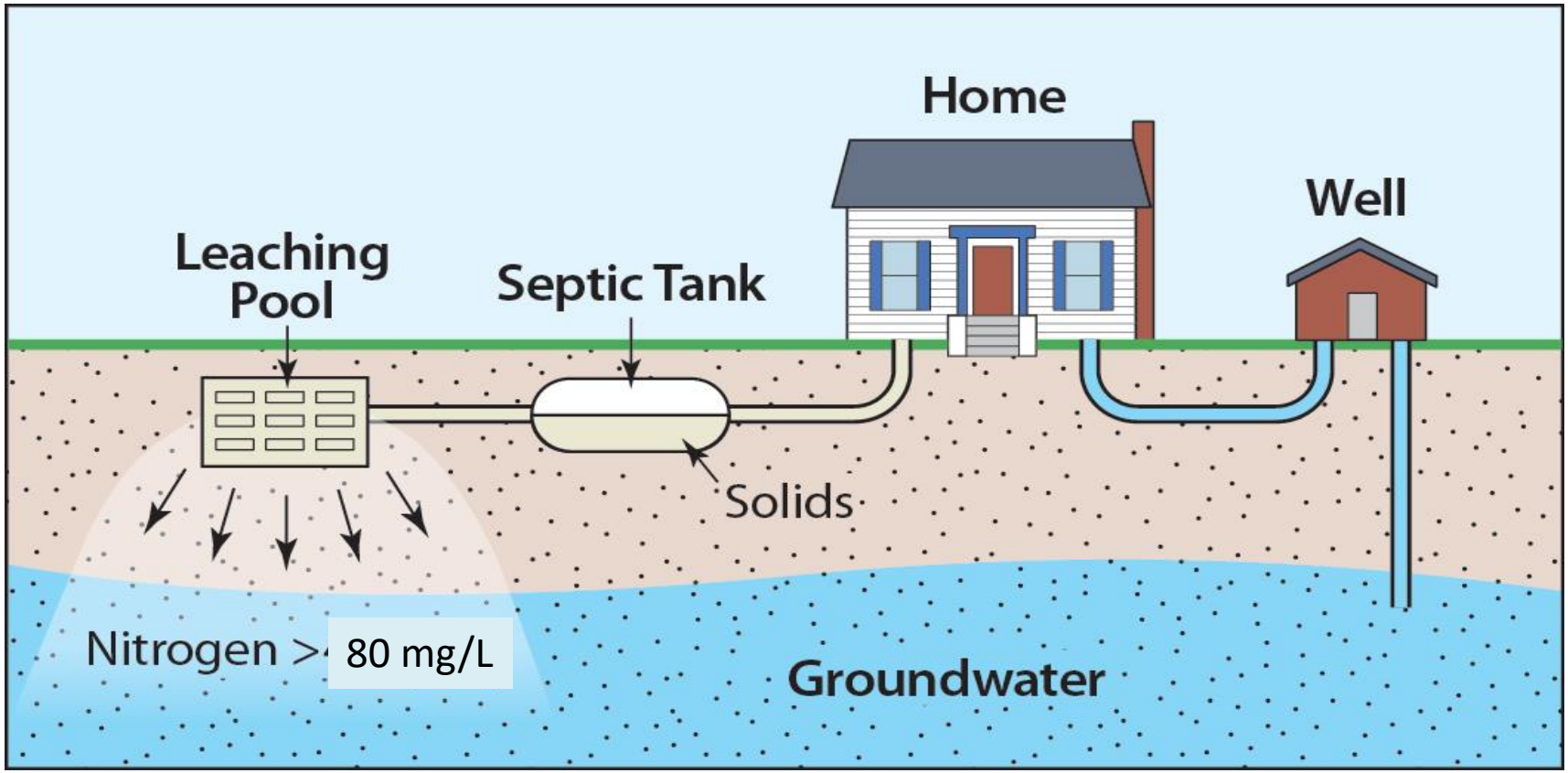


200 Year Aggregated Nitrogen Load Components - Existing Conditions

Nitrogen load reduction from septic upgrades



Suffolk County wastewater systems



SUFFOLK COUNTY SUBWATERSHEDS WASTEWATER PLAN

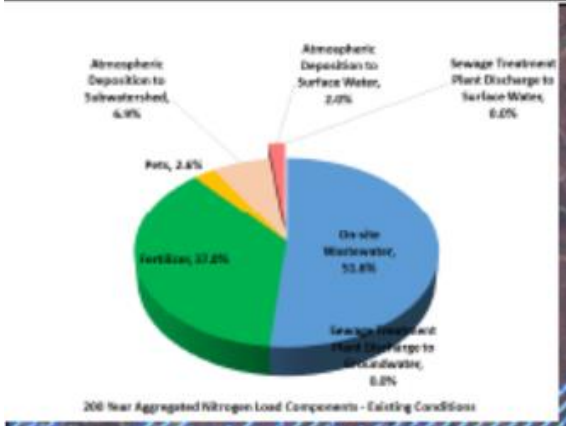
JUNE 2020

FROM WORST TO FIRST!

Reclaim Our Water

This presentation was prepared with funding provided by the New York State Department of Environmental Conservation as part of the Long Island Nitrogen Action Plan and by New York State Department of State under the Environmental Protection Fund

Ecological Sensitivity Rank
1



Travel Time Interval (Years)	Contributing Area (%)	Cumulative Contributing Area (%)
0 to 2	30.2%	30.2%
2 to 10	34.3%	64.5%
10 to 25	16.3%	80.8%
25 to 50	15.8%	96.6%
50 to 100	2.9%	99.5%
100 to 200	0.5%	100%

Georgica Pond

Management Area/Nitrogen Reduction Goal

13 63%

Travel Time (Years)
0 to 2
2 to 10
10 to 25
25 to 50

Subwatershed is Poorly Characterized
Waterbody
Sewered Area
Well Contribut

N
0 1,250 2,500
Ft

Firefox

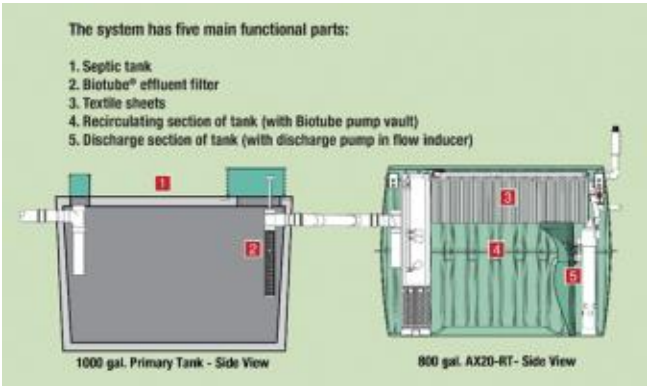
Wastewater Management and Water Quality Characterization
25 Year Contributing Area
1701-0145
Georgica Pond

Provisionally approved low N septic systems (<19 mg N/L)

Hydro-Action

Fuji Clean System

Norweco Hydrokinetic



Orenco Advantex AX-RT

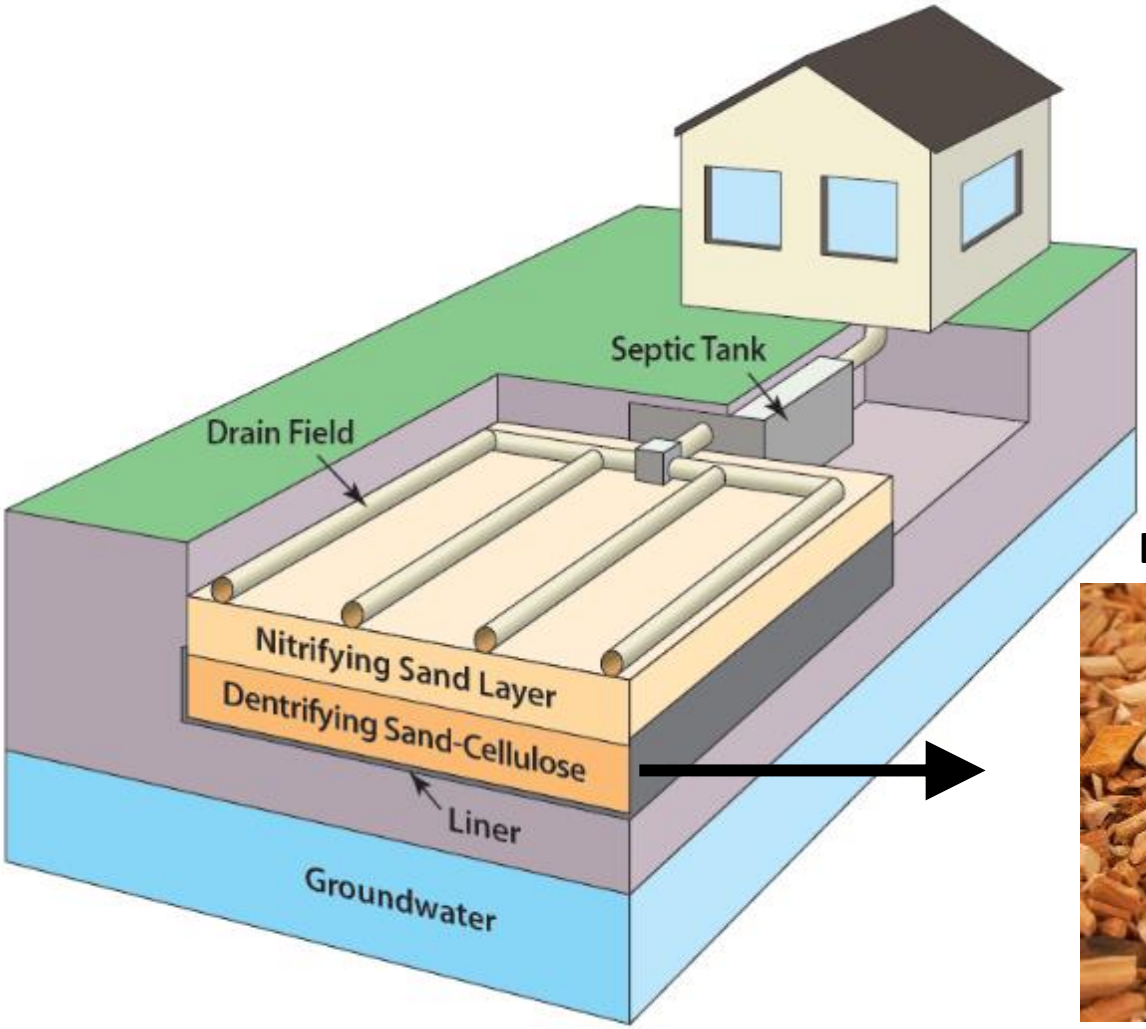
Norweco Singlair TNT

Stony Brook University

The New York State Center for Clean Water Technology:

Harnessing science to engineer clean water for the protection of public health and the environment in New York and beyond.

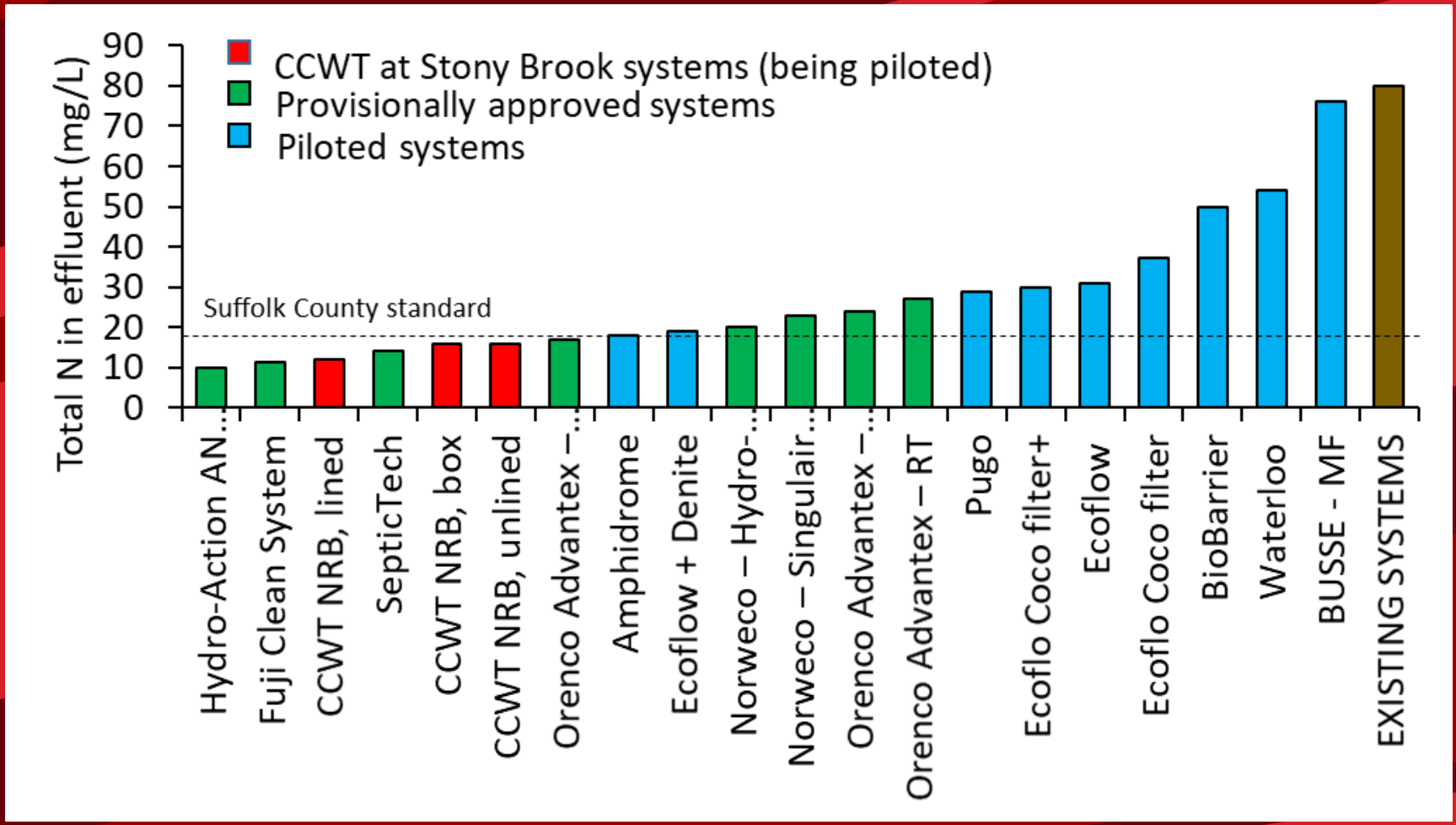
Nitrogen Removing Biofilters (NRB)



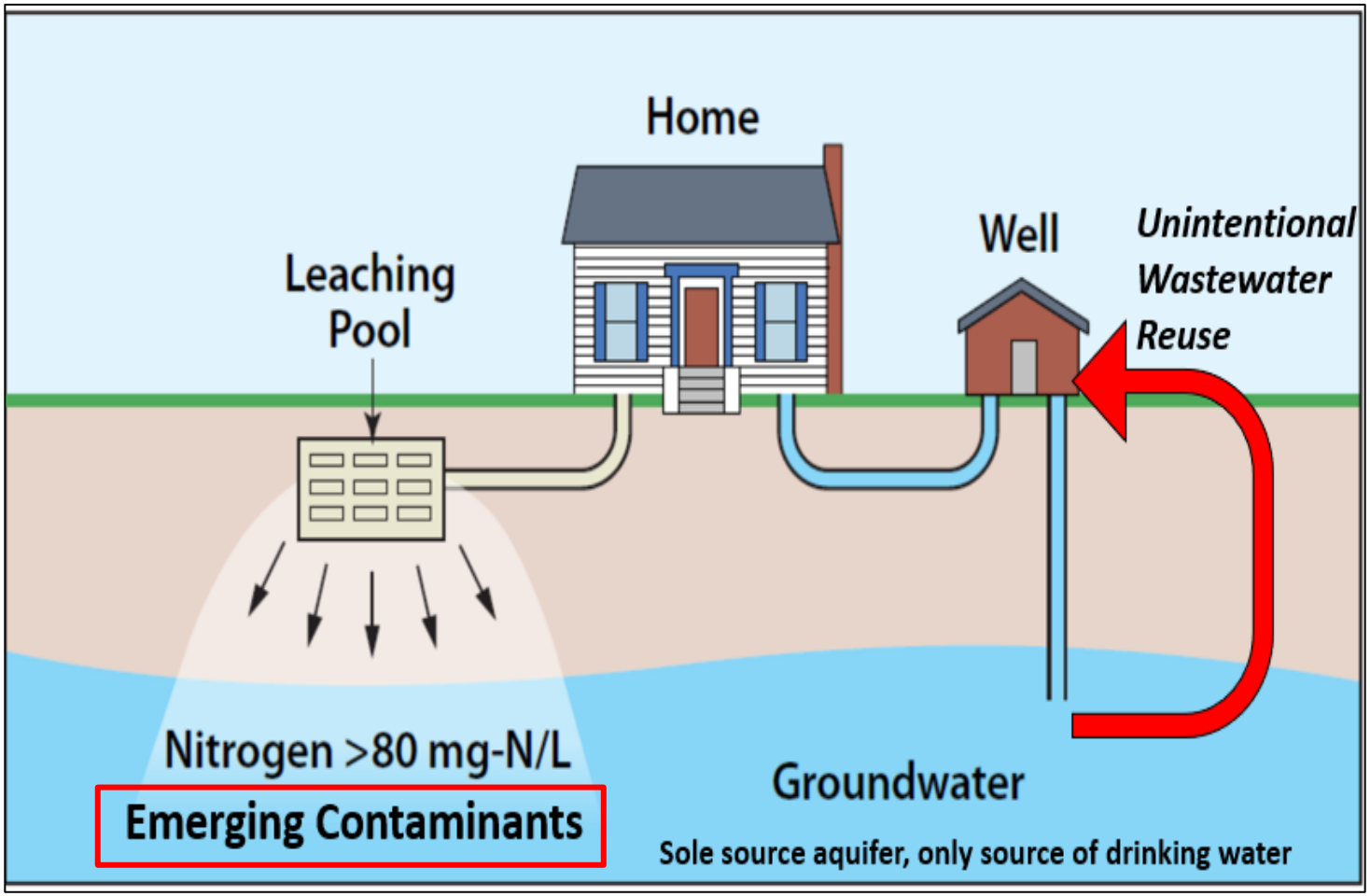
Lignocellulose = wood, chips

Carbon source to promote denitrification

Comparison of I/A performance in Suffolk County



Wastewater contains more than nitrogen



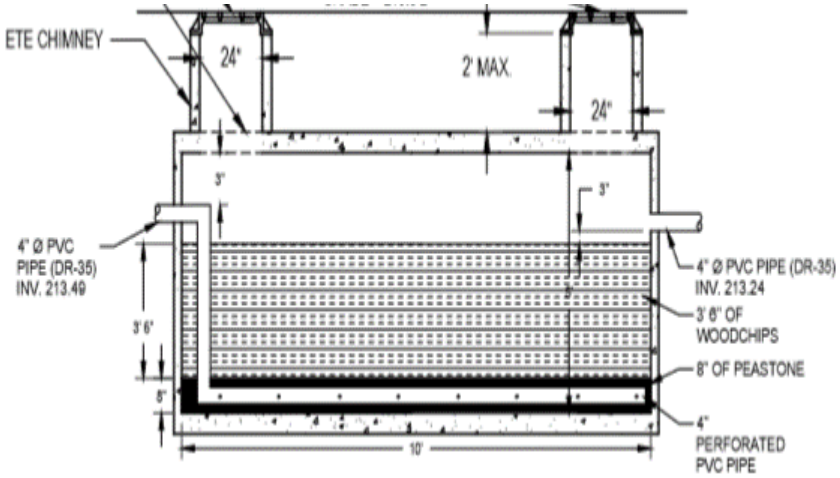
50 – 100% removal of two dozen drugs, pharmaceuticals, personal care products by NRBs in Suffolk County

Compound	Use	Removal (%)
Acetaminophen	NSAID	94 – 100
Caffeine	stimulant	99 – 100
Paraxanthine	human metabolite of caffeine	98 – 99
DEET	mosquito repellant	82 – 96
Nicotine	stimulant	92 – 97
Cotinine	human metabolite of nicotine	86 – 98
Sulfamethoxazole	antibiotic	85 – 97
Diphenhydramine	antihistamine	97 – 95
Trimethoprim	antibiotic	87 – 90
Ciprofloxacin	antibiotic	64 – 78
Atenolol	beta blocker	88 – 97
Metoprolol	beta blocker	85 – 90
Diltiazem	calcium channel blocker	76 – 90
Carbamazepine	anticonvulsant	51 -60
Ketoprofen	NSAID	68 – 74
TCEP	flame retardant	60 – 70
Salbutamol	bronchiodialator	50 – 78
Ranitidine	anti-acid	82 – 100
Diclofenac	NSAID	76
Propranolol	beta blocker	98 – 100
Venlafaxine	antibiotic	98
Fluoxetine	antidepressant (SSRI)	64 – 66
Lamotrigine	anticonvulsant	82
Primidone	anticonvulsant	58

Data courtesy of Dr. Tricia Clyde

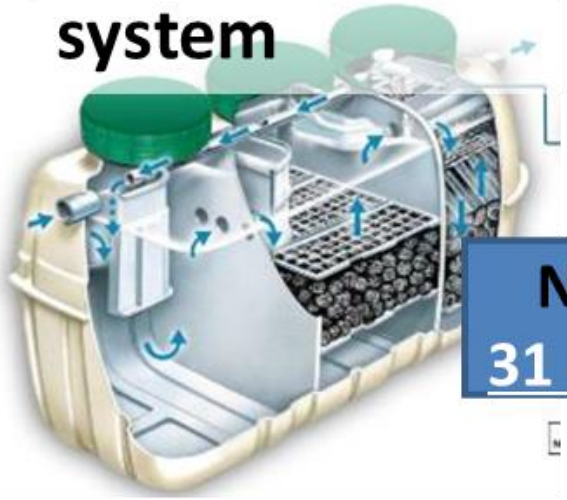
WOOD-CHIP BOX NITROGEN POLISHING UNITS

- Add-on unit ***for any approved low N septic system*** to reduce final effluent below **19mg/L**.
- Suffolk County incentive programs allow these units to be **installed at no cost**.
- CCWT have units that are ‘shovel ready’ for any installation.



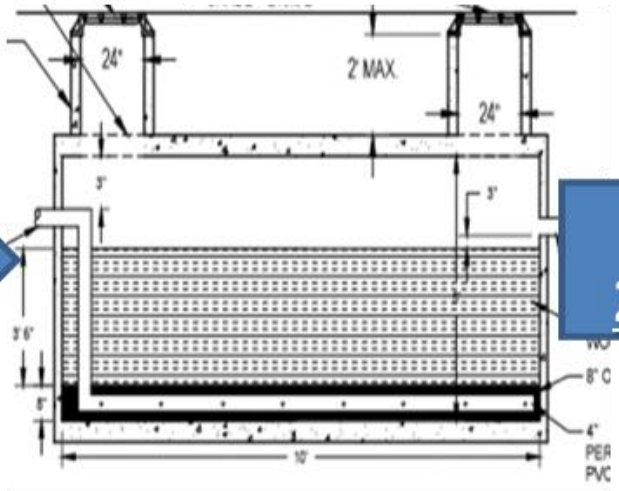
Performance of woodchip box in Wainscott

Approved I/A system



Nitrate: 31 mg-N L^{-1}

CCWT Woodchip Box



Nitrate: 2 mg-N L^{-1}

Five new installs pending…

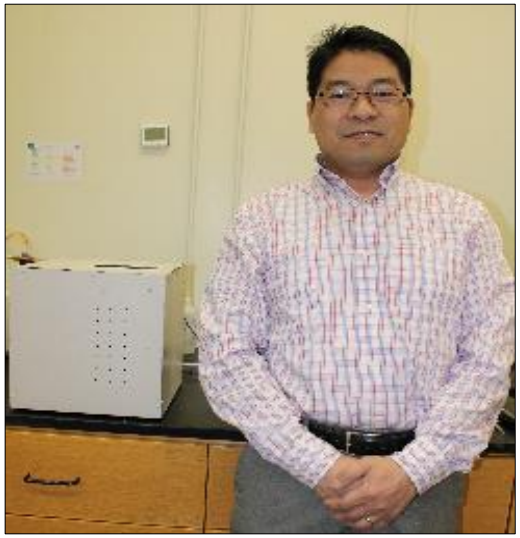
U.S. ENVIRONMENTAL PROTECTION AGENCY

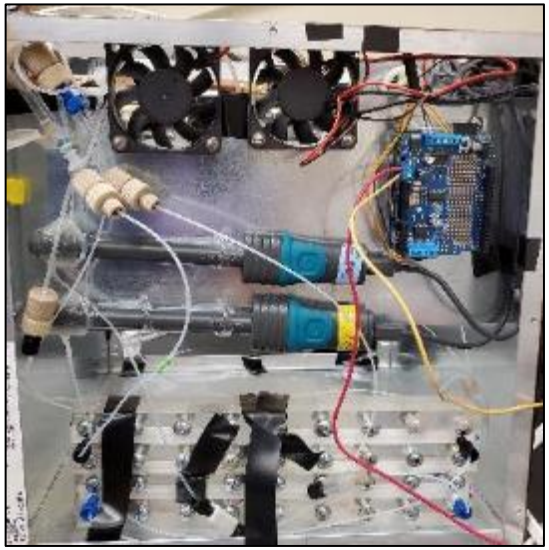
NEWS RELEASE

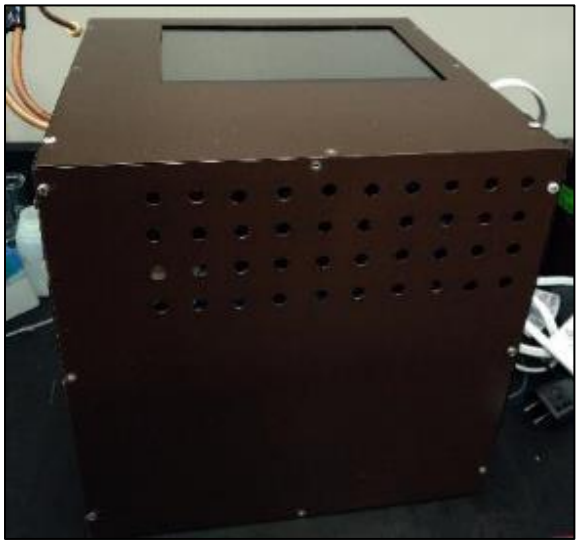
WWW.EPA.GOV/NEWSROOM

EPA at 50 Progress for a Stronger Future

Long Island Scientist Wins EPA Advanced Septic System Nitrogen Sensor Challenge







- Dr. Qing Zhu, member of the Center for Clean Water Technology and his nitrogen sensor

- **<u>Quantifies nitrate and ammonium in a single unit</u>** for < $1,500; provisional patent

Nitrogen Sensor Technology Validation

Won EPA's "Low-Cost Nitrogen Sensor Challenge"
Nobody else even finished

Test Sponsors

EPA · The Nature Conservancy

The prize:

1. **$50,000**
2. **Six-month ISO 14034 technology certification by International Organization for Standardization**
3. **200 Unit Commercial Order to Suffolk County**

NSF Certified Test Facilities

BARNSTABLE COUNTY DEPARTMENT OF HEALTH AND ENVIRONMENT

MASSTC The Massachusetts Alternative Septic System Test Center

Verification Results

n=135	NH_4	NO_3/NO_2
R^2	0.997	.986
% Recovery	98.8%	93.5%
Rel.Std.Dev.	3.3%	2.4%

Independent Test Oversight

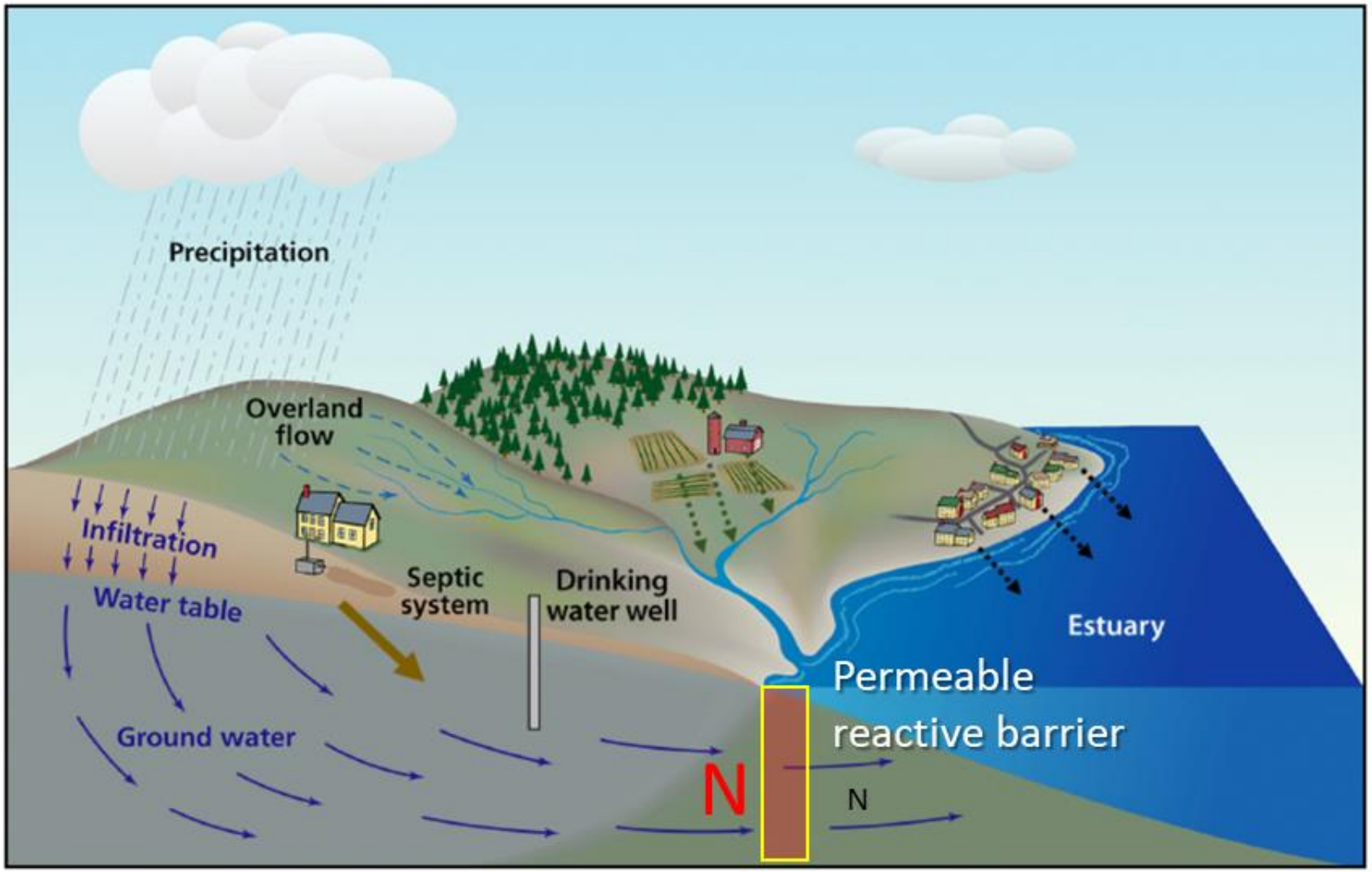
BATTELLE · VerifiGlobal

Verified Water

You can't manage what you don't measure

- Purchases of nitrogen sensor from municipalities and communities in Massachusetts and NY.
- Freshwater and sewage treatment plant adaptations in progress.
- Patent filings in US, Europe, Japan, Korea, Australia, Canada, News Zealand.

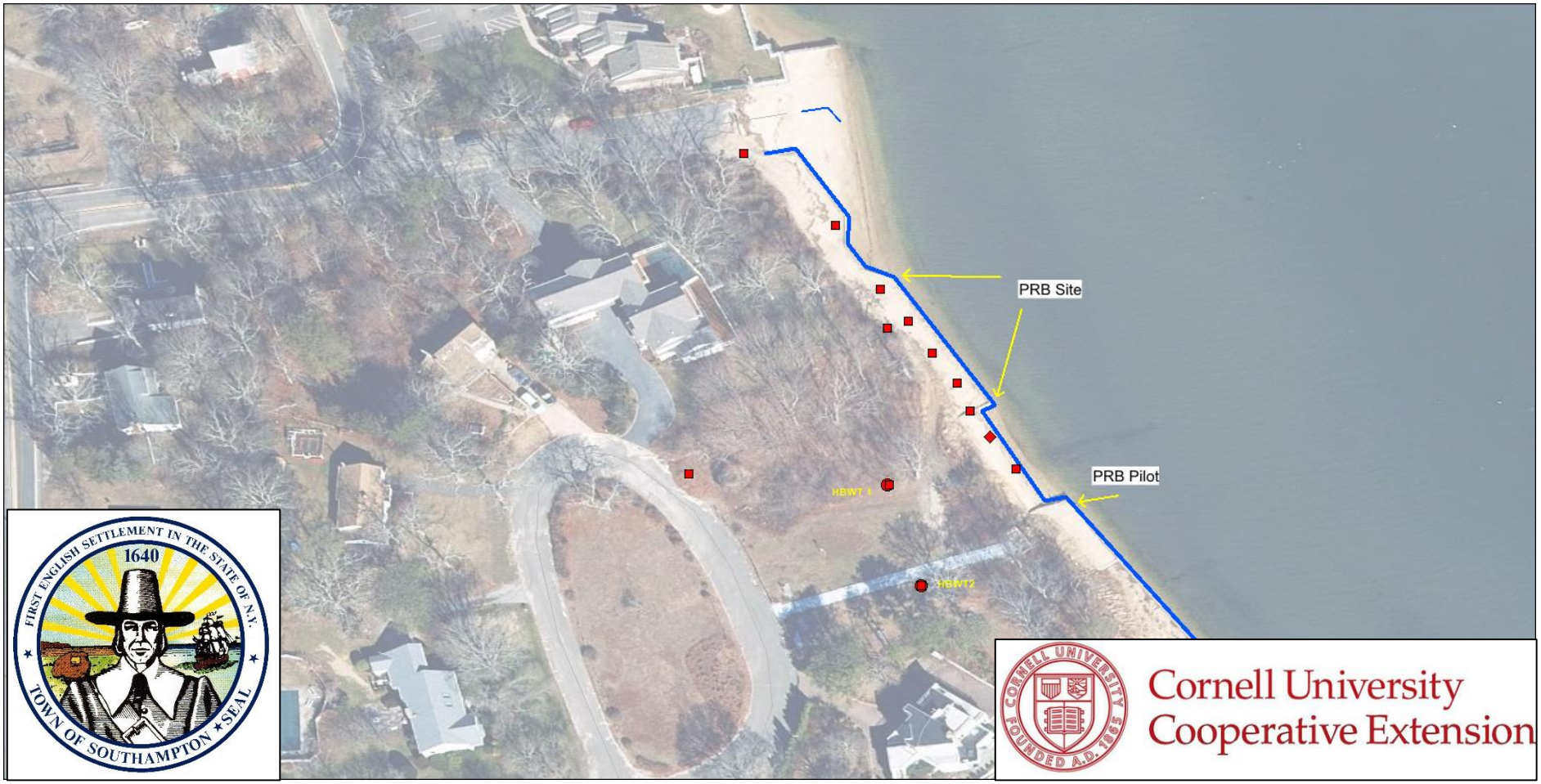
Permeable reactive barriers



- It will take decades to upgrade hundreds of thousands septic systems on Long Island and for legacy contamination to flush out of the aquifer.
- PRBs allow for the removal of legacy N before entering ecosystems or well heads.

Hampton Bays Bulkhead PRB installation (100 ft), 2020

Funded by Town of Southampton CPF fund

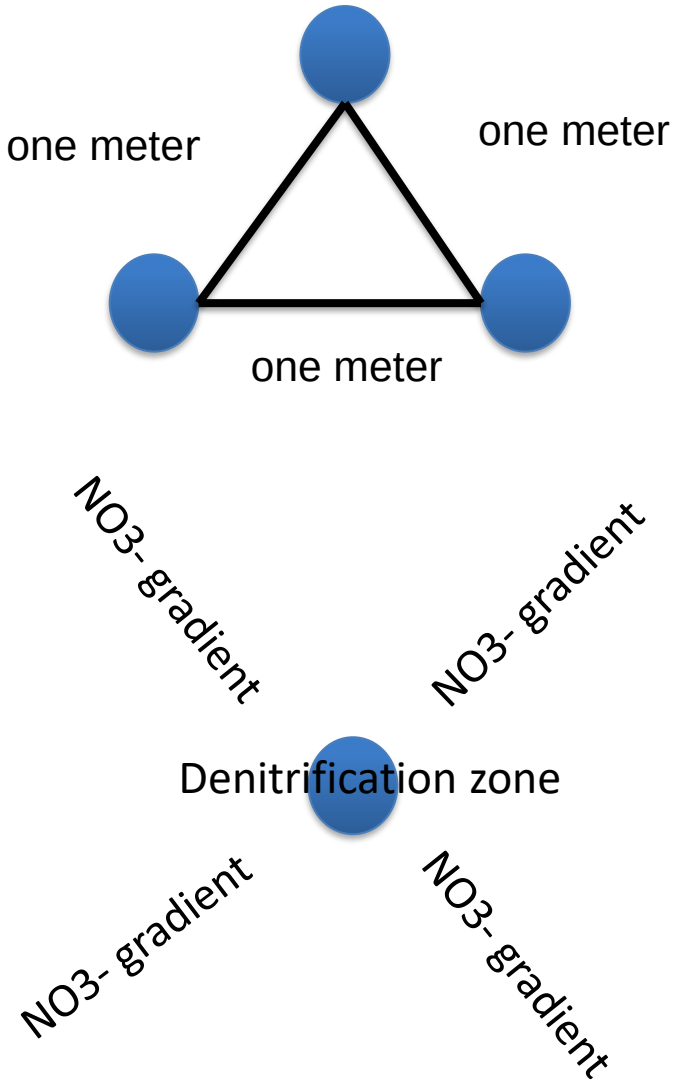


PRB can be complex and expensive to install

Deep trenching with heavy equipment in tandem with dewatering of groundwater is a logistical and financial challenge.

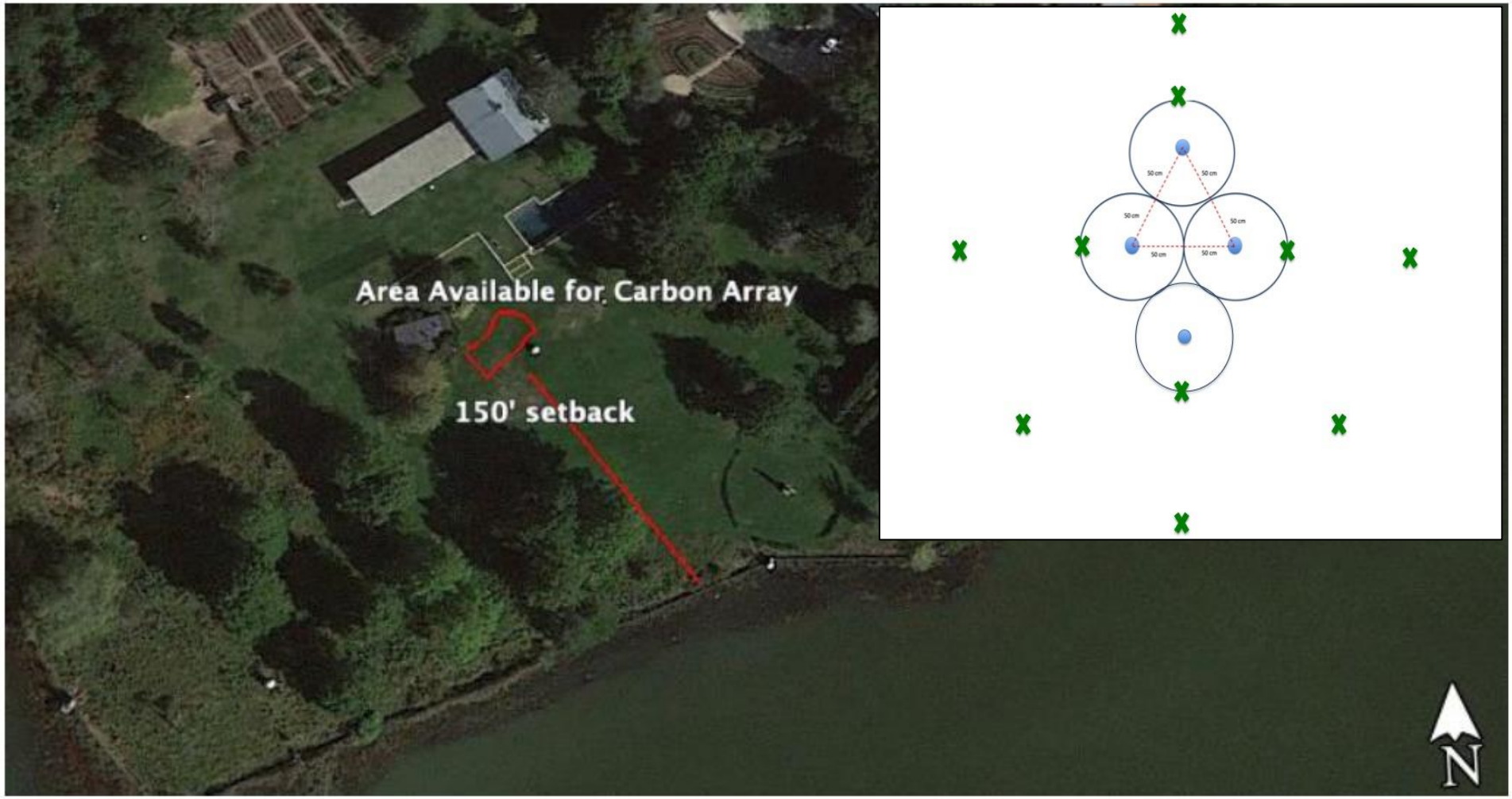
Carbon array barrier

- 2¾” holes,15” deep, filled with woodchips
- Installed with Geoprobe = smaller, faster, simpler, less expensive.
- Denitrification in ‘reactive rod’ creates nitrate gradient away from rod drawing more nitrate towards it.
- Carbon diffuses outwards creating enhanced zone of denitrification.
- Size, concentrations, and configuration optimized via lab experiments

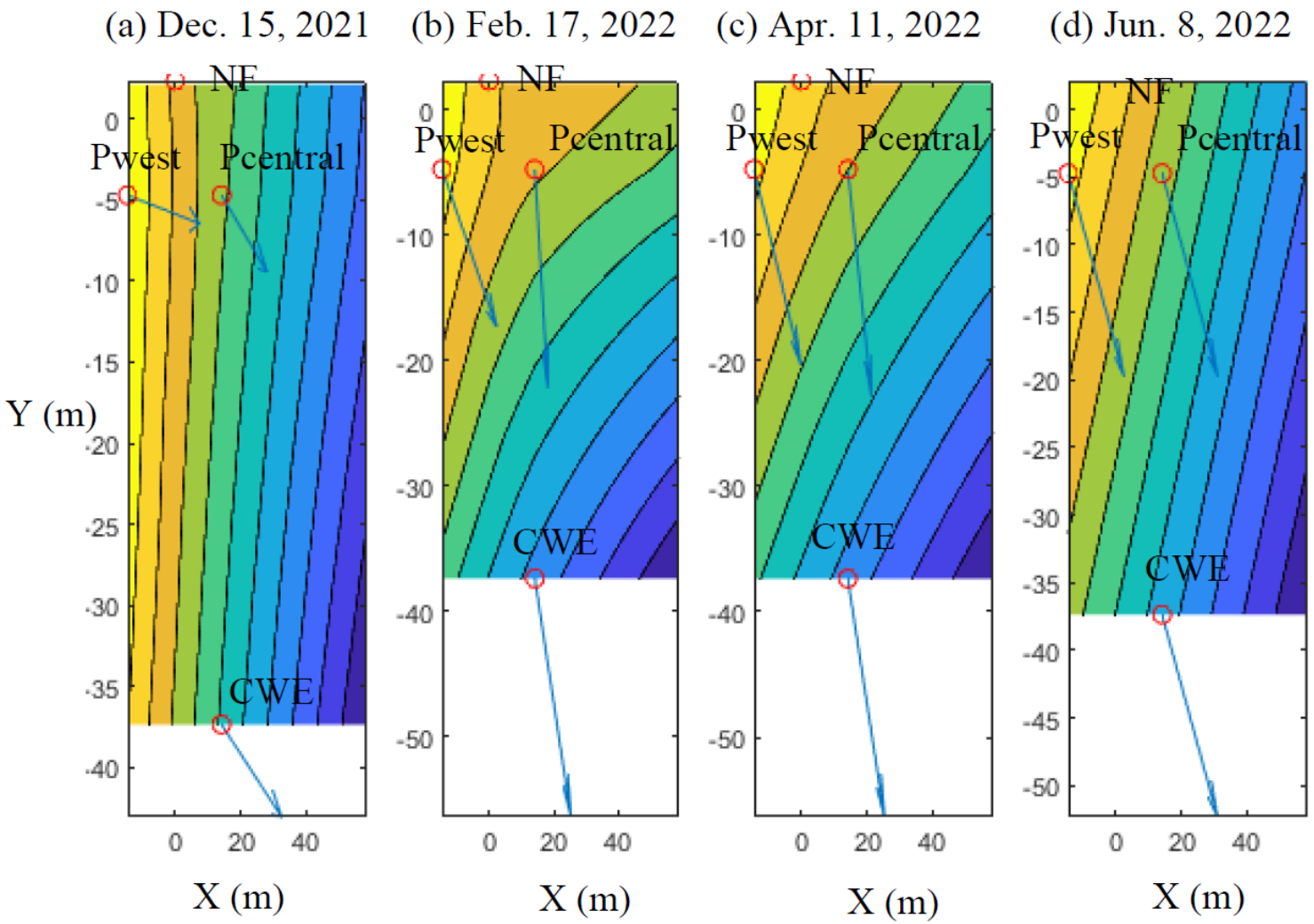


Simplicity of carbon array installation

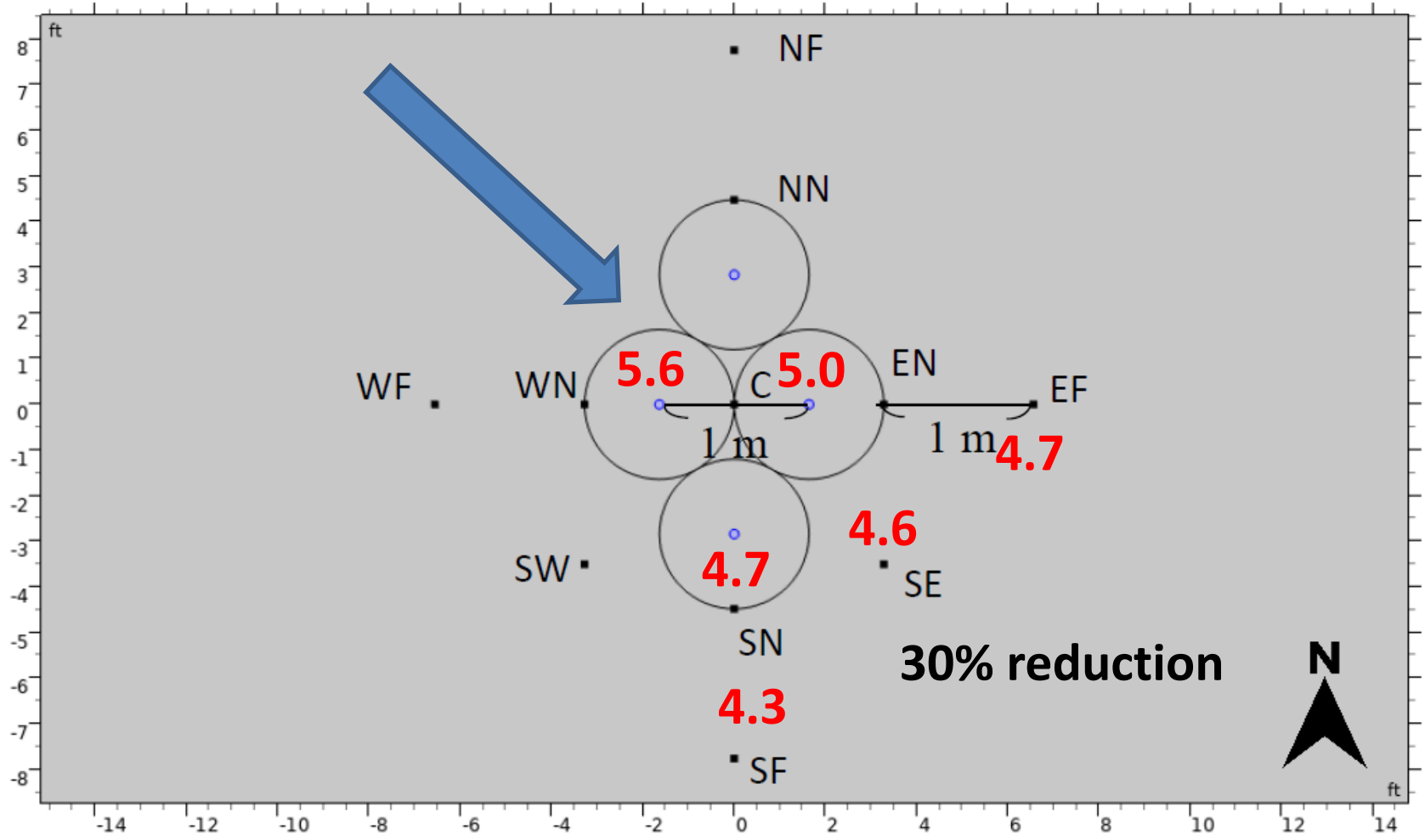
Carbon array installation at The Creeks



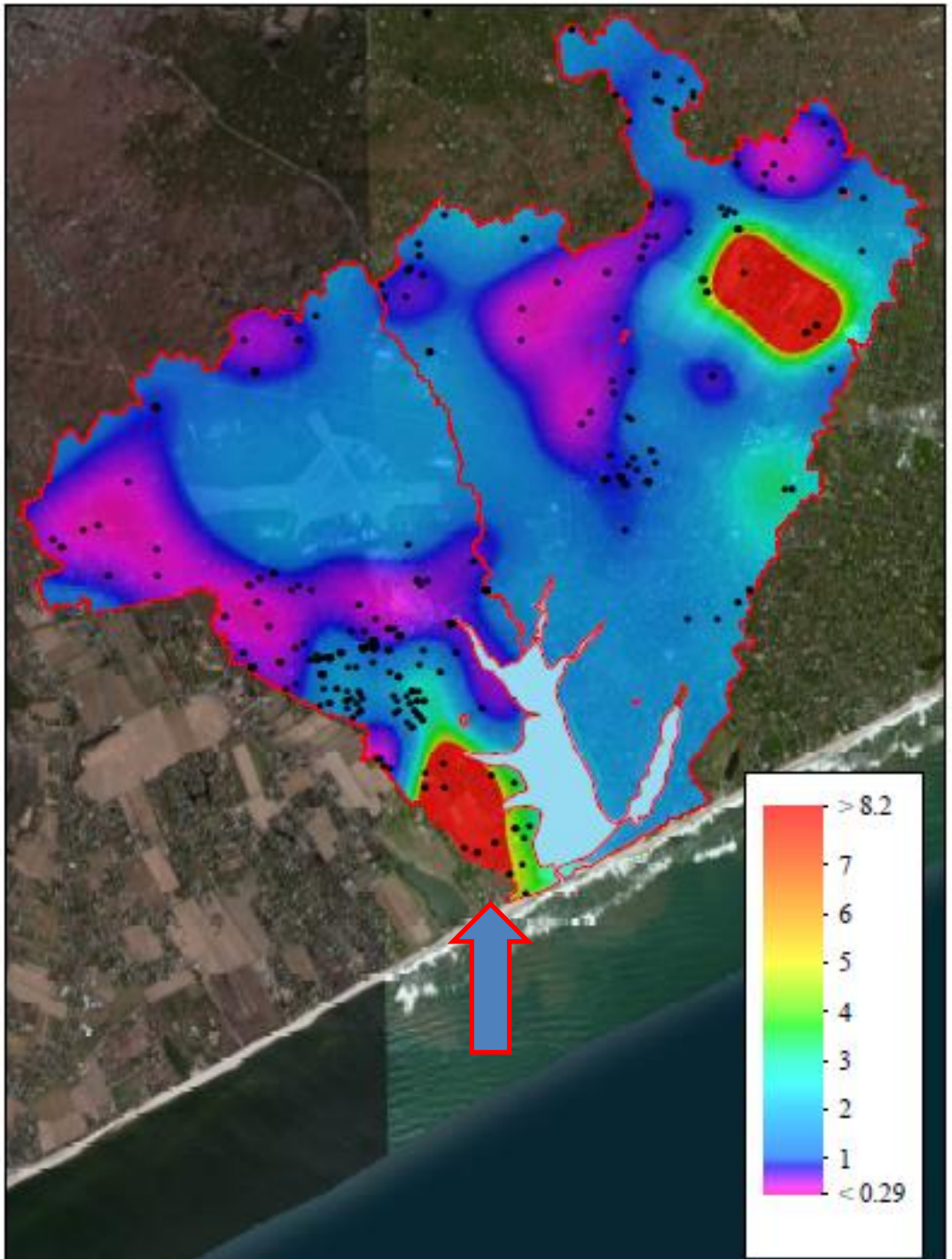
Seasonal groundwater flow



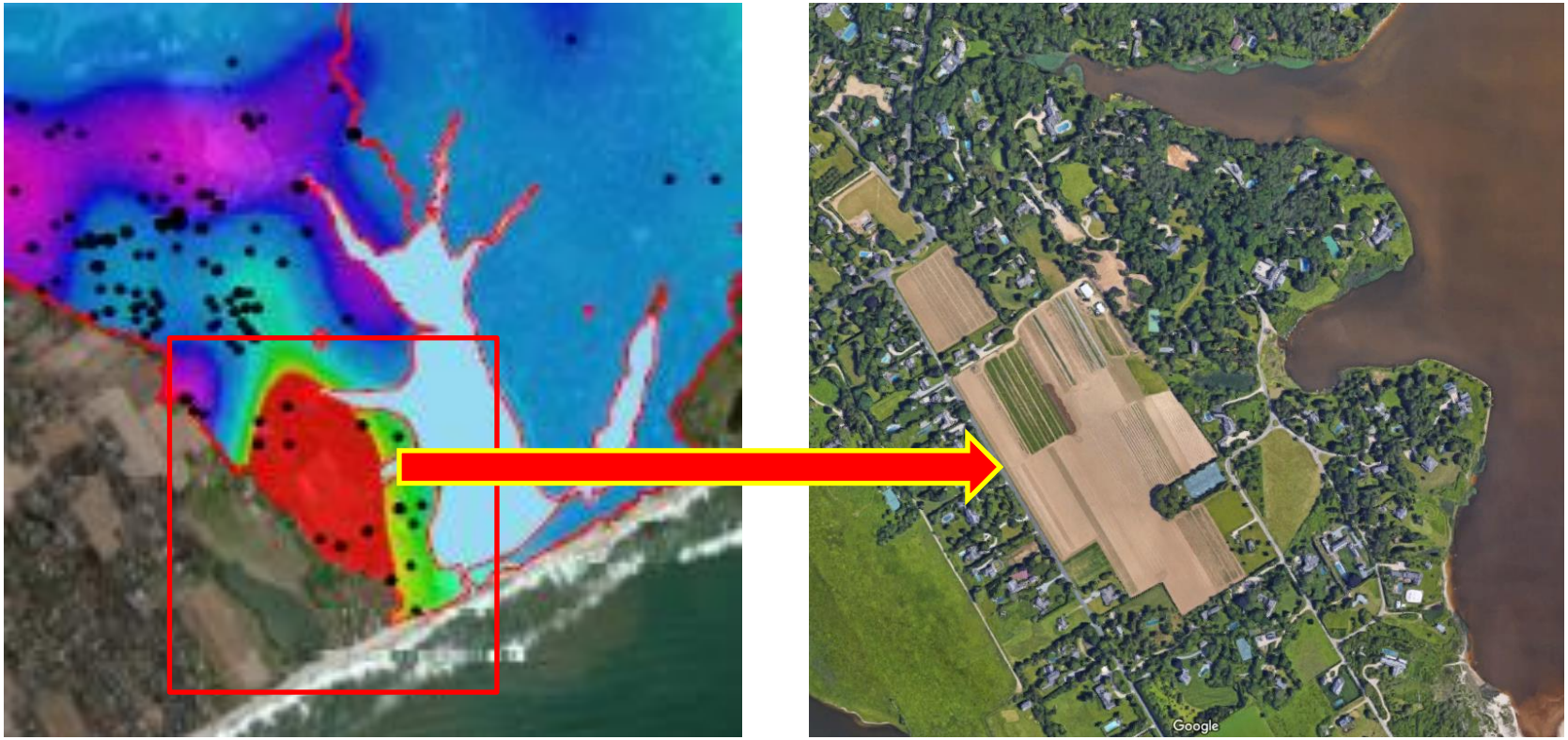
Nitrate concentrations (mg/L)



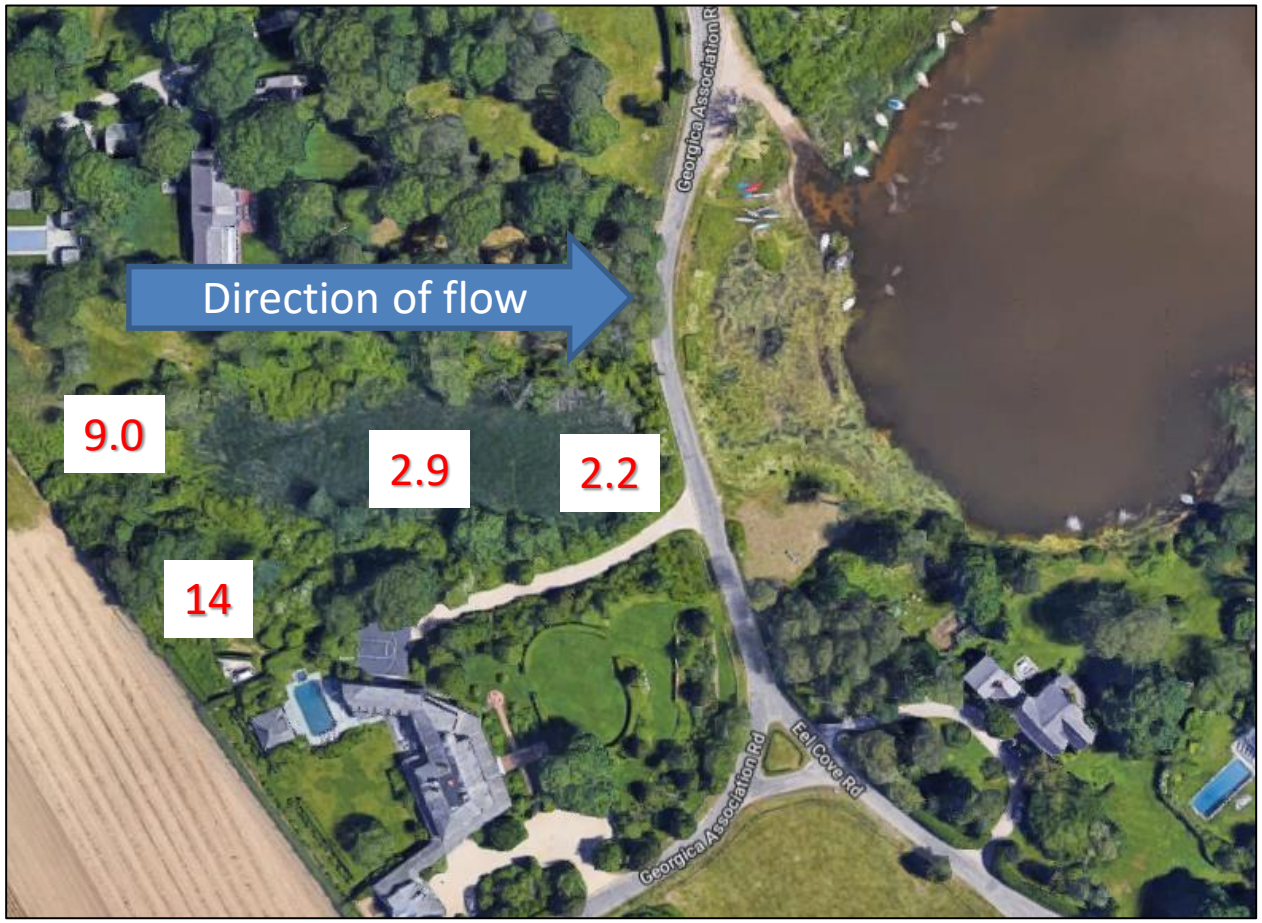
Nitrate levels in groundwater across Georgica Pond watershed



High nitrate plume



Eel Cove groundwater investigation
- *nitrate values in mg/L*



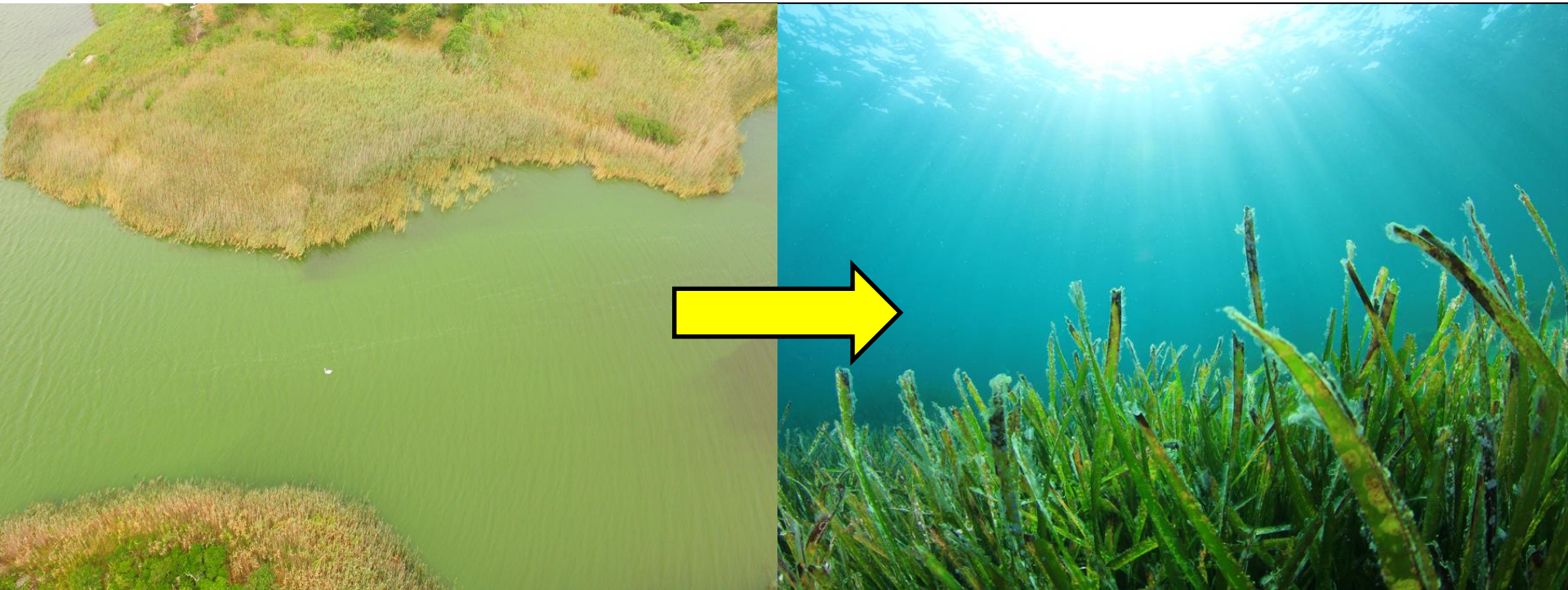
Collecting data to design of column array or barrier

OYSTERS in Georgica Pond

Oysters are ‘Ecosystem Engineers’

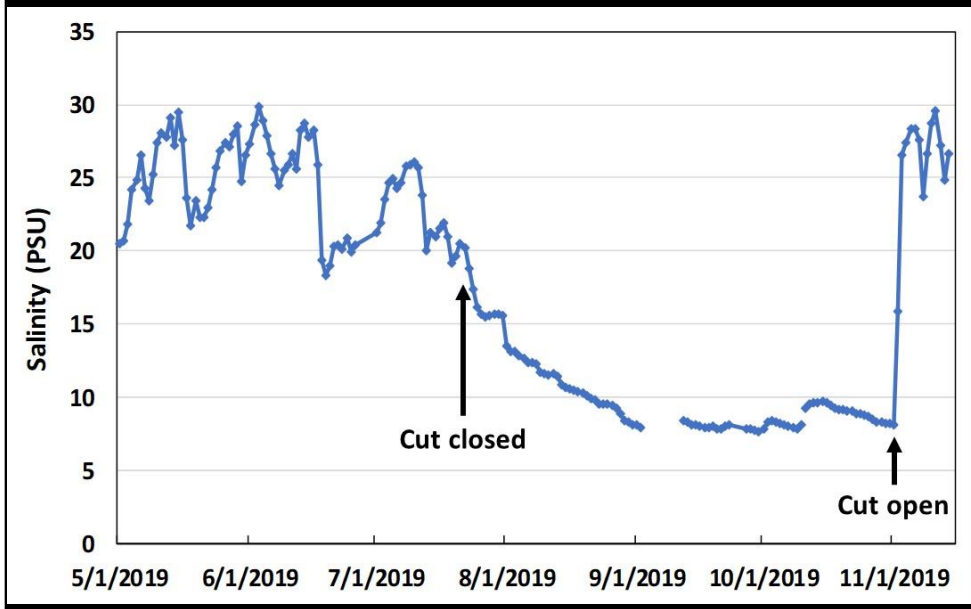
Oysters are filter feeders, and when abundant can:

- Control phytoplankton abundance
- Reduce harmful algal blooms
- Improve water clarity



Georgica Pond may provide an ideal habitat for oyster restoration

- Oysters thrive in brackish waters
  - Low salinities provide a disease refuge



Georgica Pond may provide an ideal habitat for oyster restoration

- Oysters thrive in brackish waters
  - Low salinities provide a disease refuge
- Restricted circulation with ocean may result in high retention of larvae

Georgica Pond may provide an ideal habitat for oyster restoration

- Oysters thrive in brackish waters
  - Low salinities provide a disease refuge
- Restricted circulation with ocean may result in high retention of larvae
- Nearby and very similar Mecox Bay has most robust oyster population on Long Island's South Shore


Can oysters survive, grow, and reproduce in Georgica Pond?

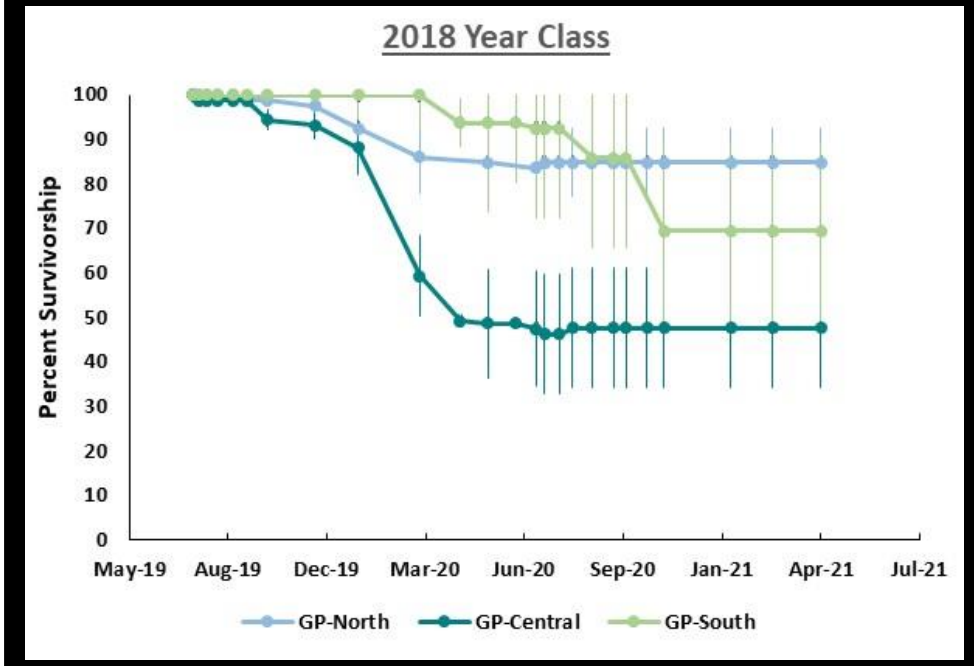
Phase 1 of Study

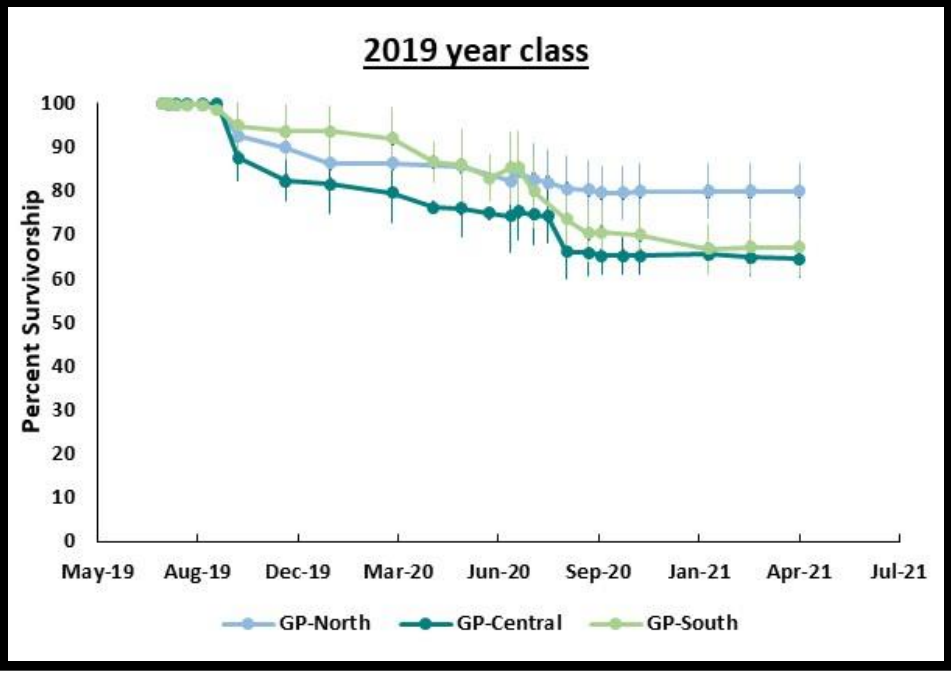
- Commenced in summer 2019
- Established 3 study sites accessible from shore

Phase 1 Results

- High survivorship of both size classes across all sites in Georgica Pond after one year

Survivorship

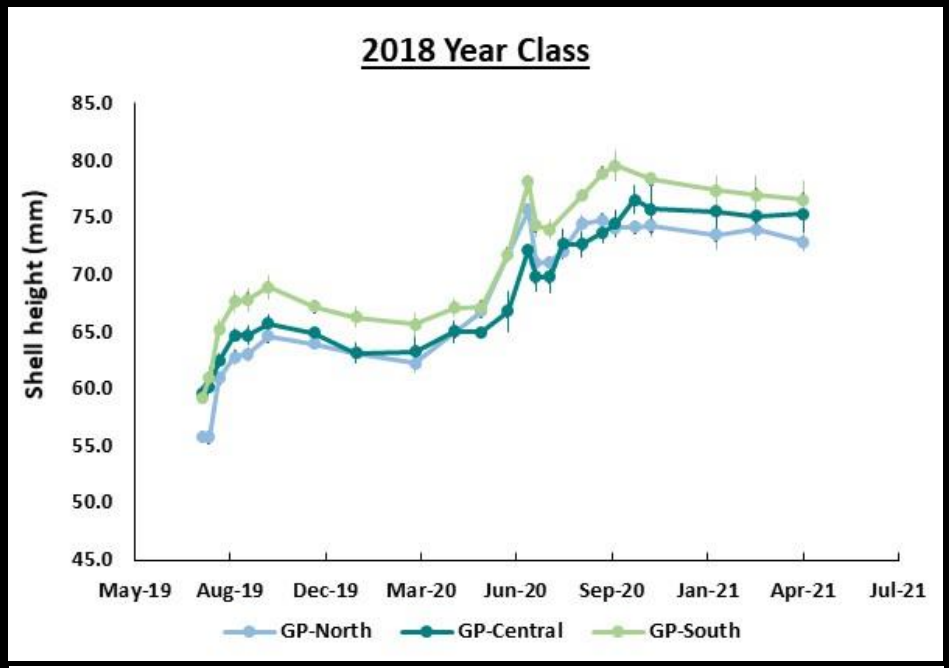


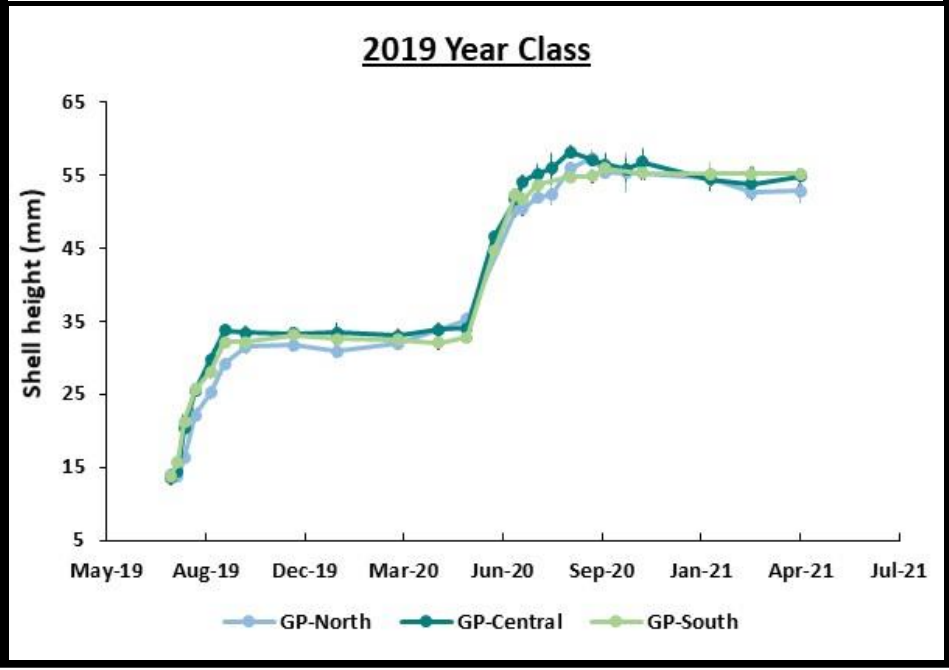


Phase 1 Results

- High survivorship of both size classes across all sites in Georgica Pond after one year
- Strong growth during warmer months
- Oysters were reproductive in second summer (one-year-olds)

Growth





Phase 2 of Study

- Commenced in Summer 2020
- Added new cohort of oyster seed to cages
  - Smallest size added

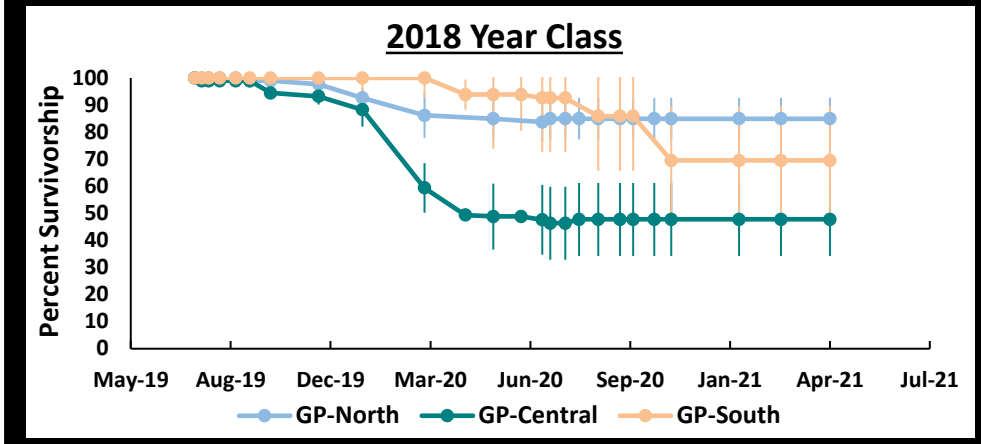
Phase 2 of Study

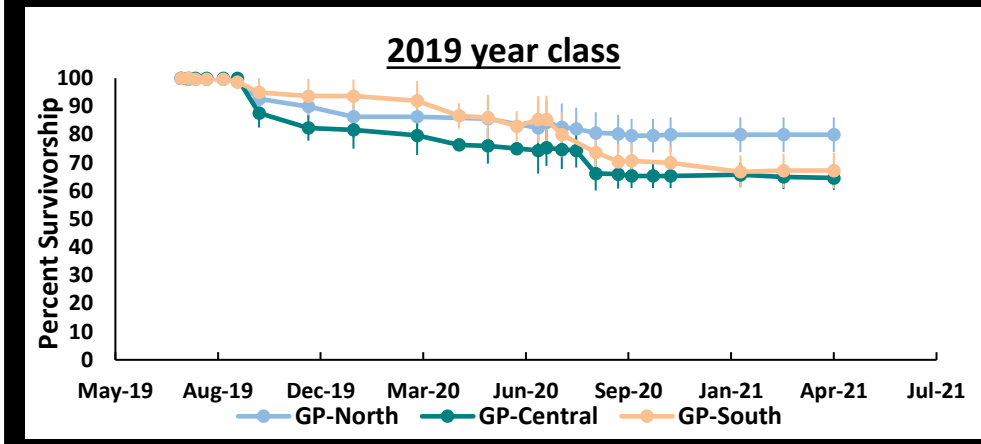
- Commenced in Summer 2020
- Added new cohort of oyster seed to cages
  - Smallest size added
- Added spat on shell
  - More natural oyster set
  - Exposed to predators
  - Packaged in mesh bags following techniques used for reef restoration

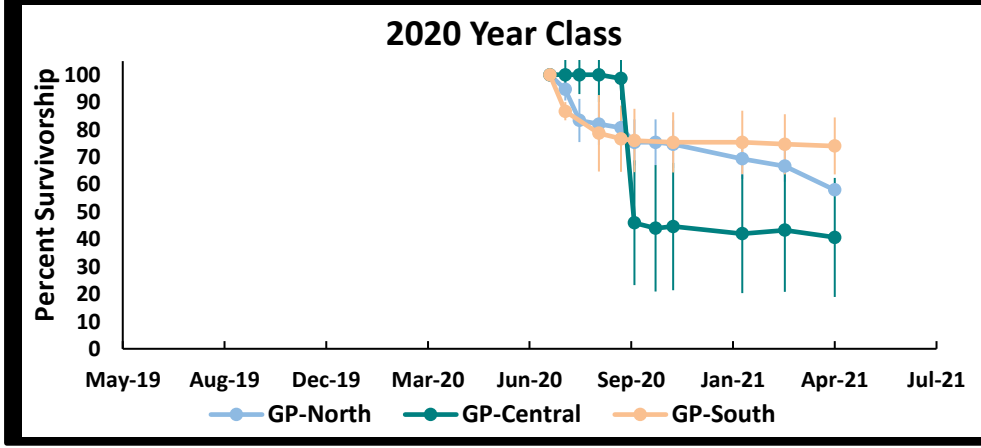
Phase 2 Results

- Higher mortality of 2020 year class. Smaller seed more sensitive.

Survivorship of seed







Phase 2 Results

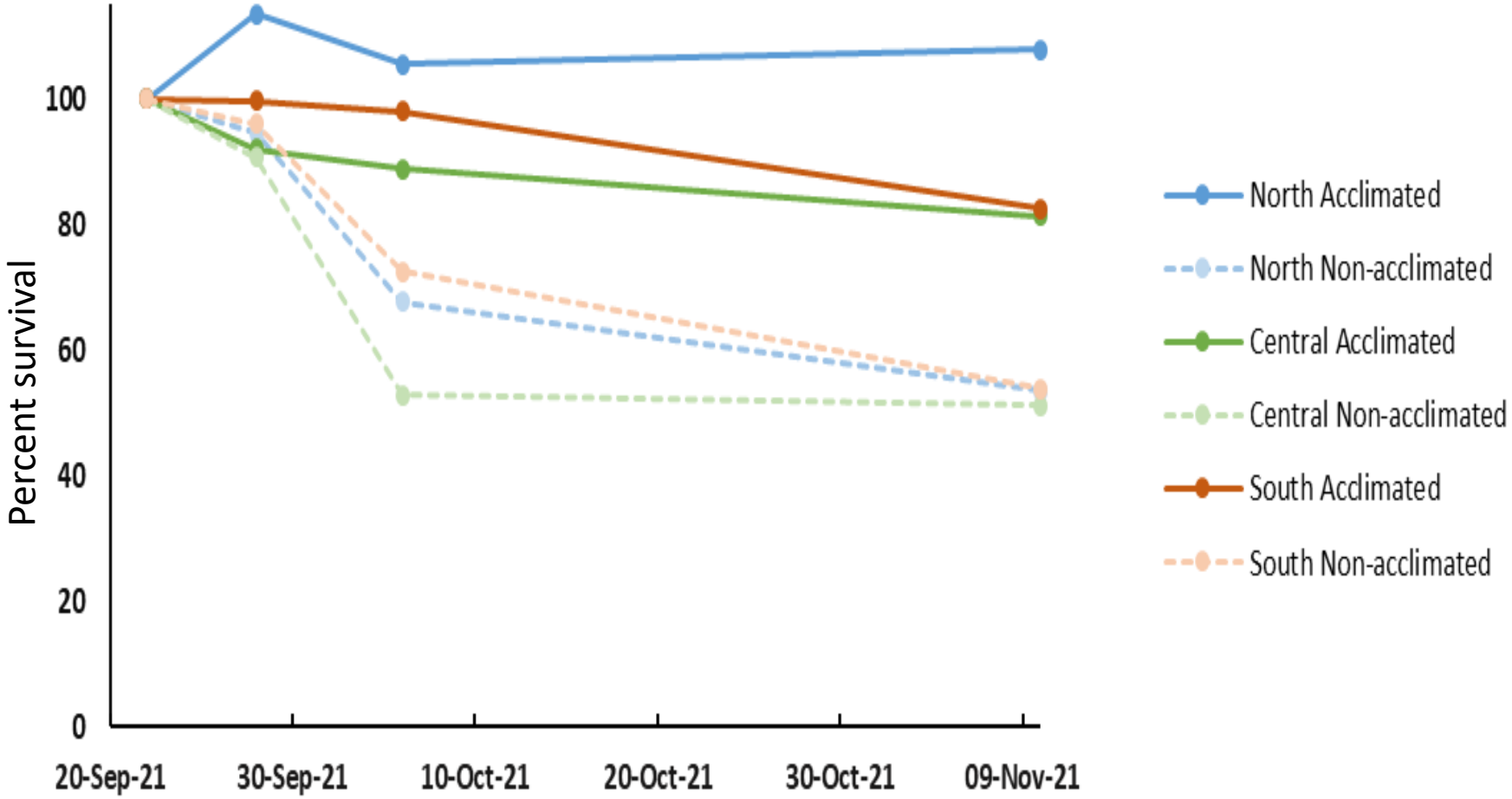
- Higher mortality of 2020 year class. Smaller seed more sensitive.
- 2020 year class grew less than 2019 year class during first year after deployment. May also reflect smaller starting size.
- Almost complete mortality of oyster spat-on-shell. May be due to low salinity when deployed, and/or blue crab predation

High mortality of spat-on-shell

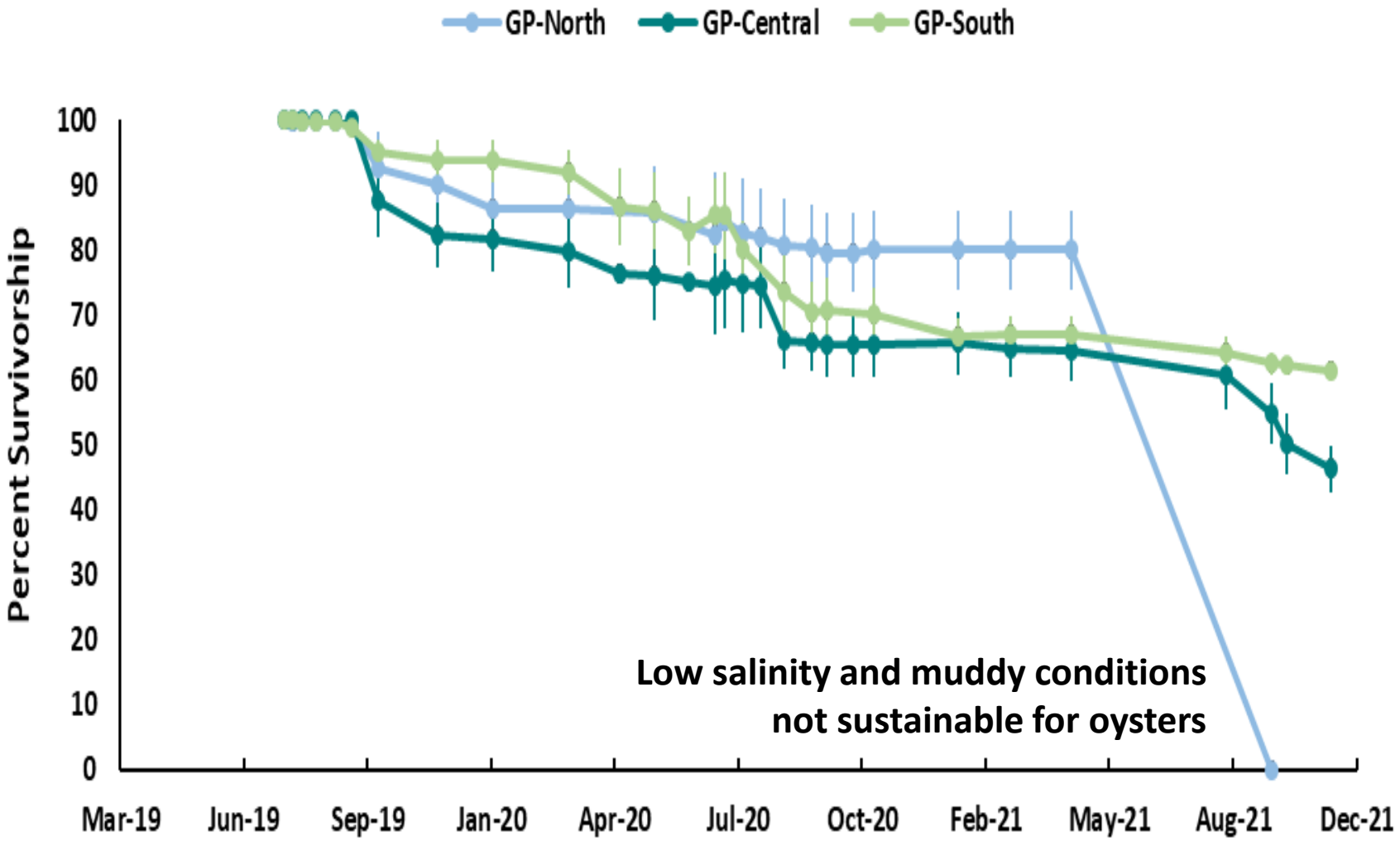
Phase 3 of Study

- Commenced in Summer 2021
- Produced spat-on-shell at the Southampton Marine Station
- Running experiments to test causes of spat mortality in 2020
- *To test salinity hypothesis:* Acclimating spat to low salinity and deploying acclimated and unacclimated spat into Georgica Pond when salinity is low before the cut is open. Also holding spat-on-shell at lab to deploy after cut is opened.
- *To test predation hypothesis:* Deploying spat-on-shell inside and outside of predator exclusion cages.

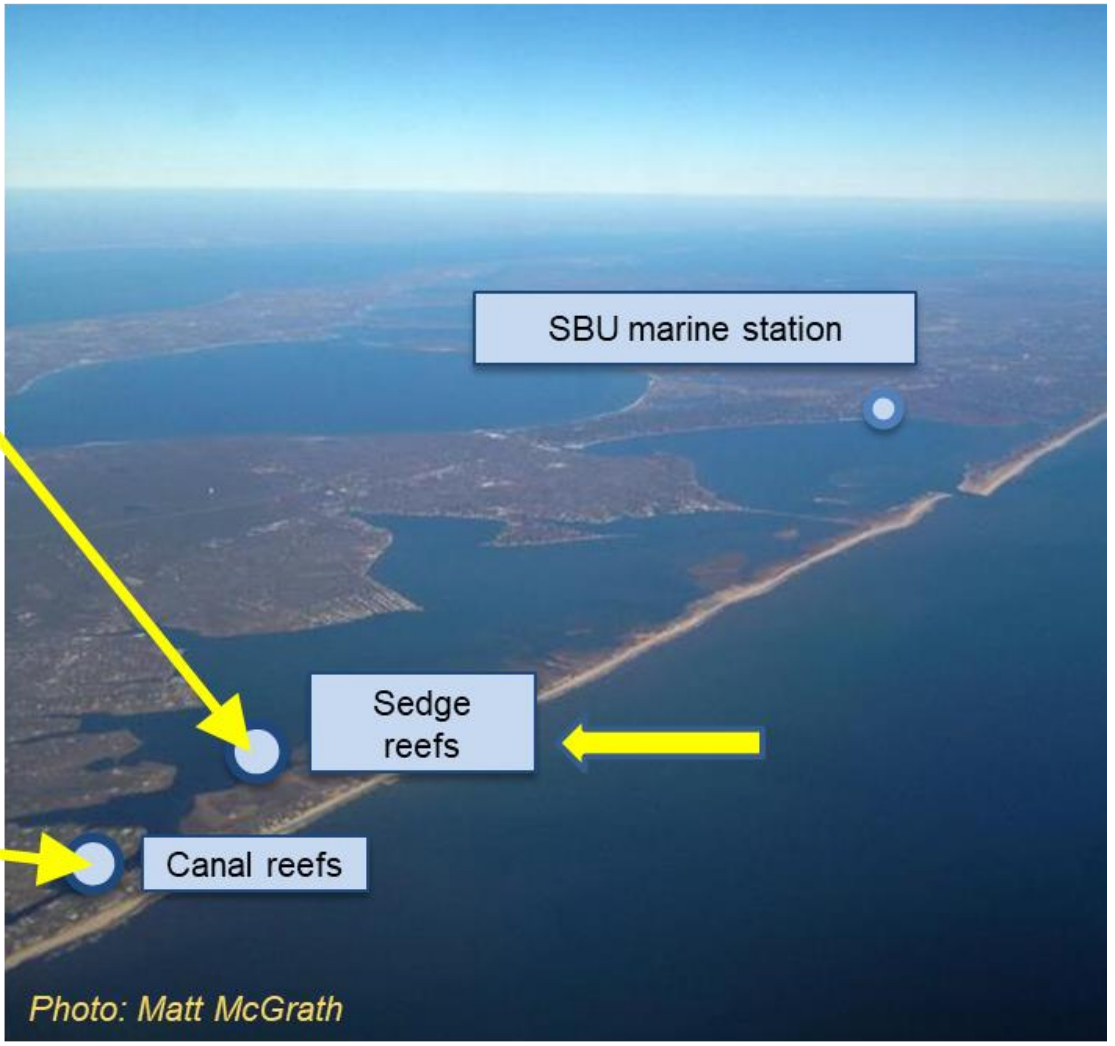
Oyster spat-on-shell survival



Oyster survival, three years



First eight NYSDEC permitted oyster reefs in NYS constructed across western Shinnecock Bay, 2017 - 2022



Oyster reef, Shinnecock Bay

Mesoscale oyster reefs

- Site surveys completed in spring
- Oysters spawned onto shell this summer
- Oysters being grown at elevated salinity
- Mesoreefs to be planted after the cut is opened to avoid salinity shock and assure proper depth

Conclusions:

- Georgica Pond suffers from algal blooms, blue-green algae, low oxygen, and fish kills.
- Harvesting macroalgae has been coincident with improved conditions.
- Algal blooms are promoted by excessive nitrogen.
- Suffolk County's 2020 Subwatersheds Study's findings closely match the 2015 and 2022 study of Georgica Pond by Stony Brook University
- Most of the nitrogen entering Georgica Pond comes from wastewater.
- Accelerating the removal of nitrogen from wastewater is the central long-term solution.
- Long-term, significantly improved water quality can occur in < 10 years if rapid action is taken now.
- Oysters can be part of long-term remediation.

Acknowledgements:

Sincere gratitude for:
The leadership of Sara Davison
The support from the Friends of Georgica Pond
The commitment of the East Hampton Town Trustees and Town of East Hampton

Thank you to Kevin Shaffer, Jennifer Goleski, Ann Marine Falmarulo, and others for field sampling, laboratory work, and data analysis support.

Thank you for your attention.

Stony Brook University
School *of* Marine and Atmospheric Sciences

GOBLER LABORATORY