Working Towards a Sustainable Remediation of Georgica Pond

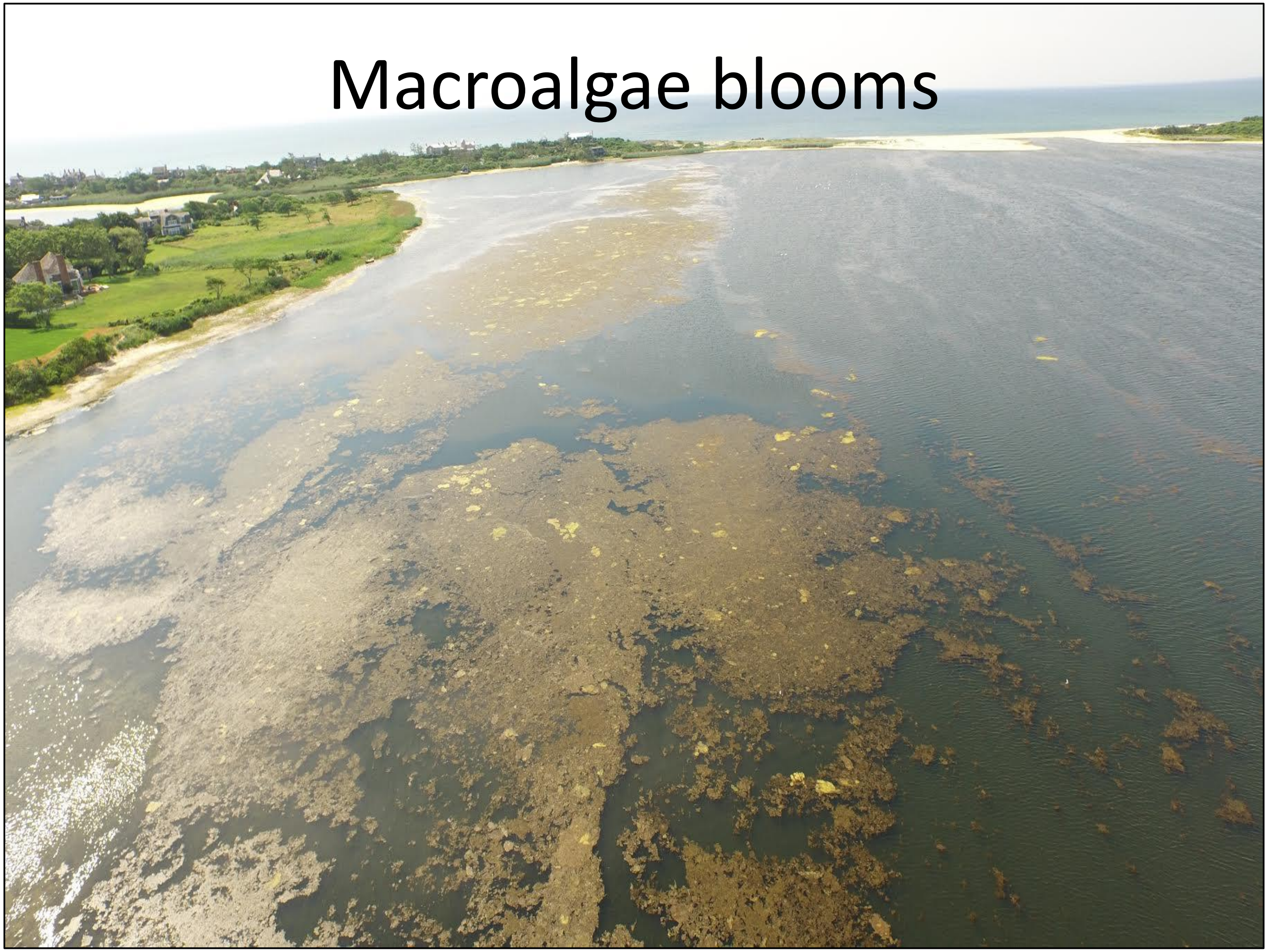
Chris Gobler, PhD

Stony Brook University
School *of* Marine and Atmospheric Sciences

GOBLER LABORATORY

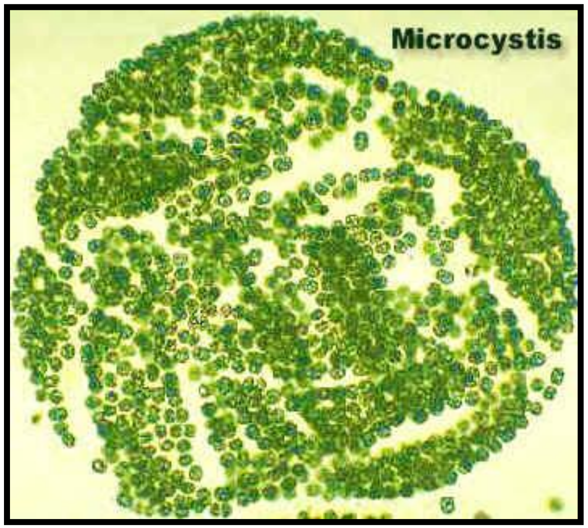

Why remediate Georgica Pond?

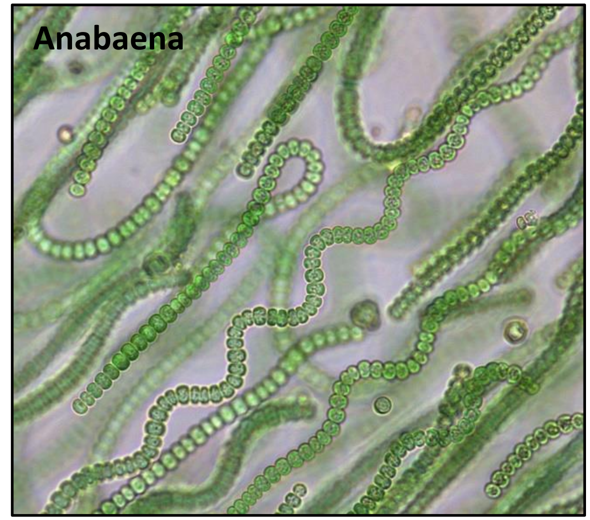
Macroalgae blooms



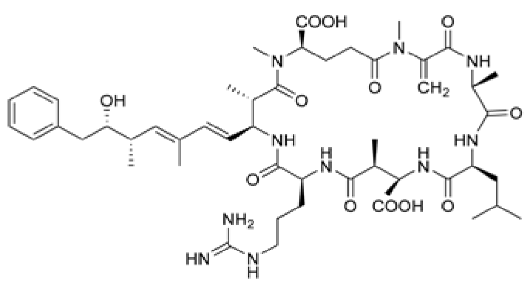
Blue-green algae blooms

Blue-green algae and their toxins

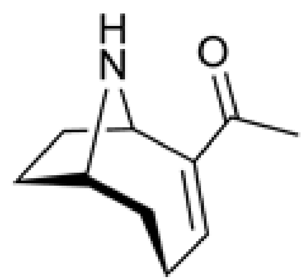




Microcystin – gastrointestinal toxin



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

- Status as of 2021
- Long-term trends
- Action to improve conditions

Real-time monitoring buoy, rebuilt in 2020

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

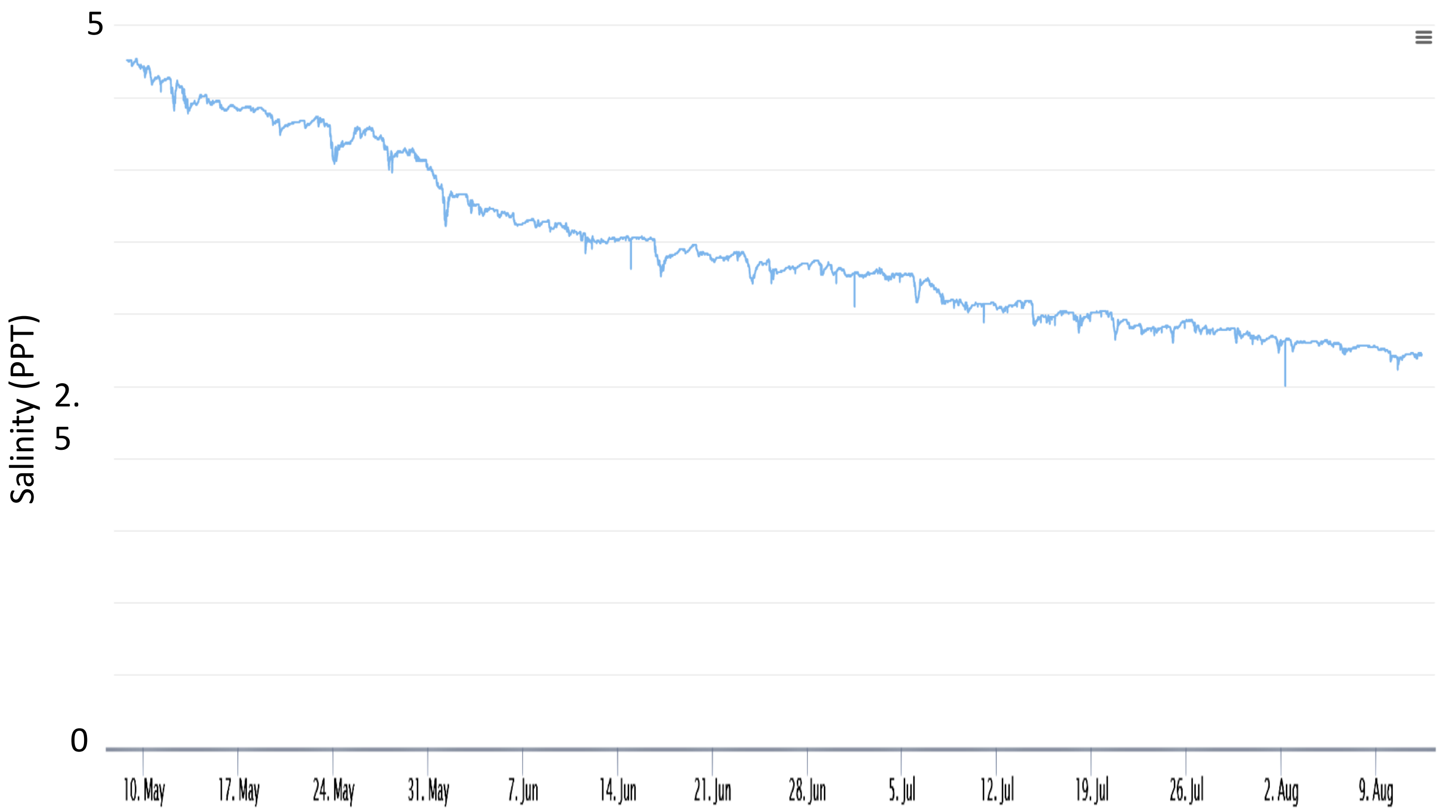
Georgica Pond Buoy - The Gobler Lab of Stony Brook University
Description

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.

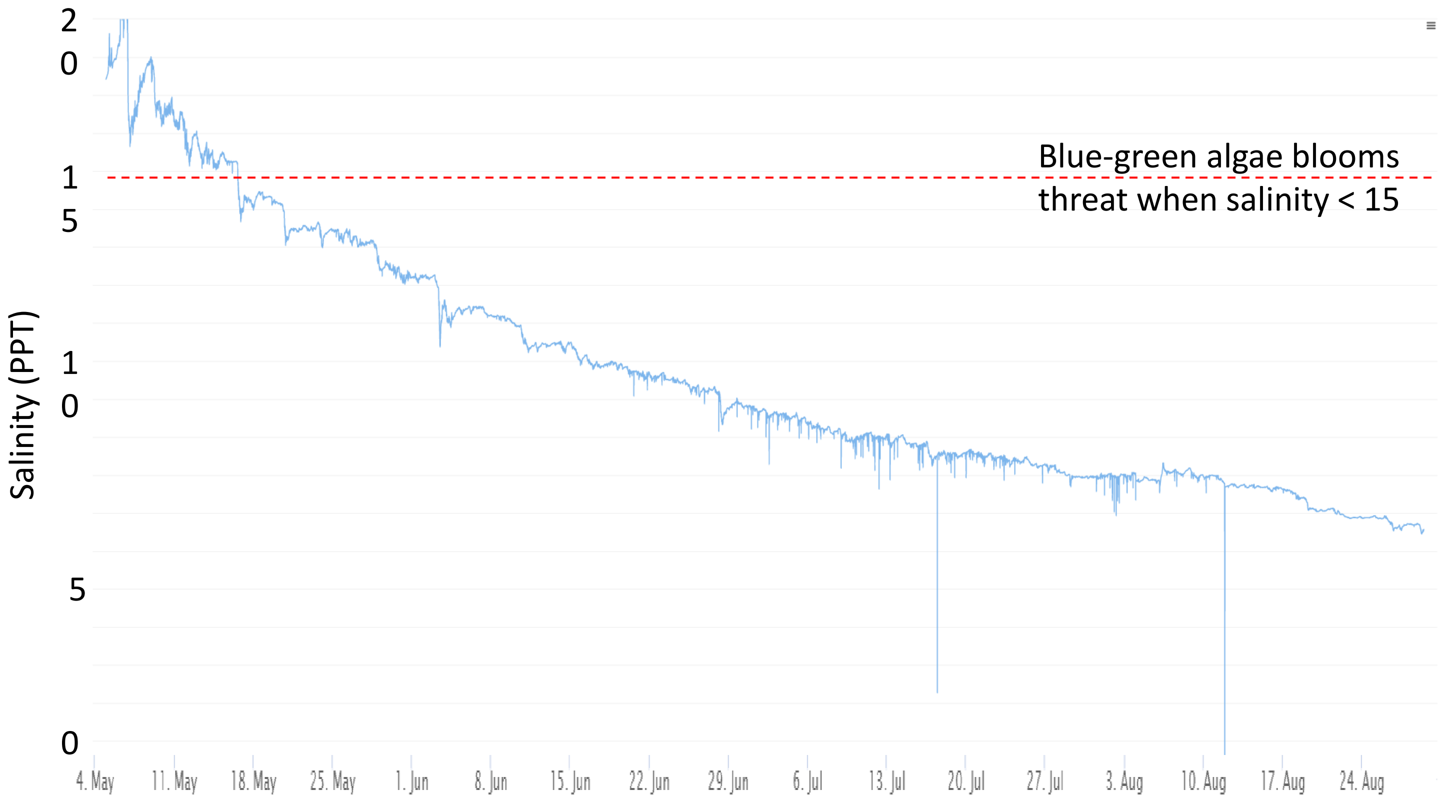

An investigation led by the Gobler Lab of Stony Brook University
Georgica Pond
Chart View
Table View
Site Information
Parameters
Studies
Last Month
Y-axis scaling
Min
Max
Clear
Last Day
Last Week
Last Month
Last Year
Custom range
Blue-Green Algae (ug/L)
5
4
3
2
1
0

Cut opened in spring, closed since March 31st

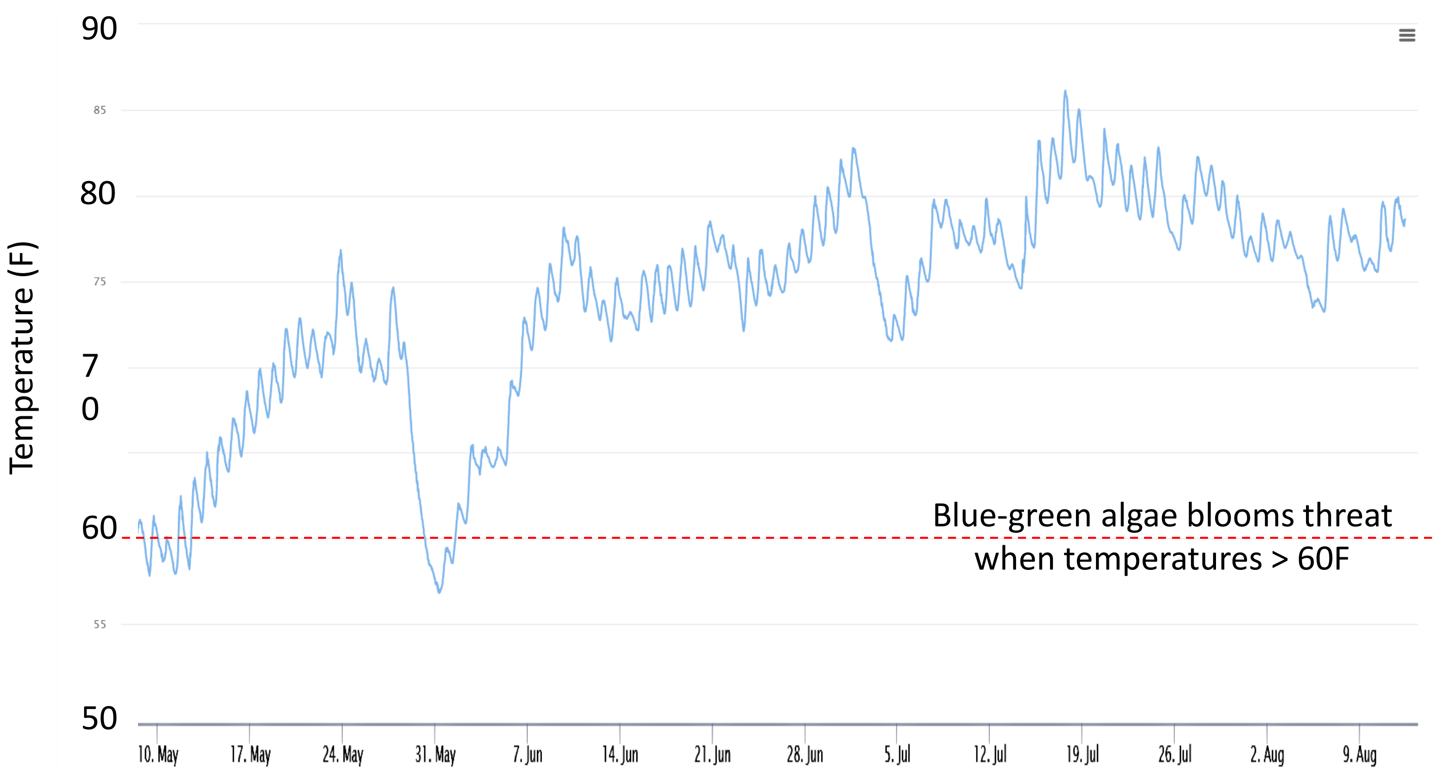
Salinity, 2021



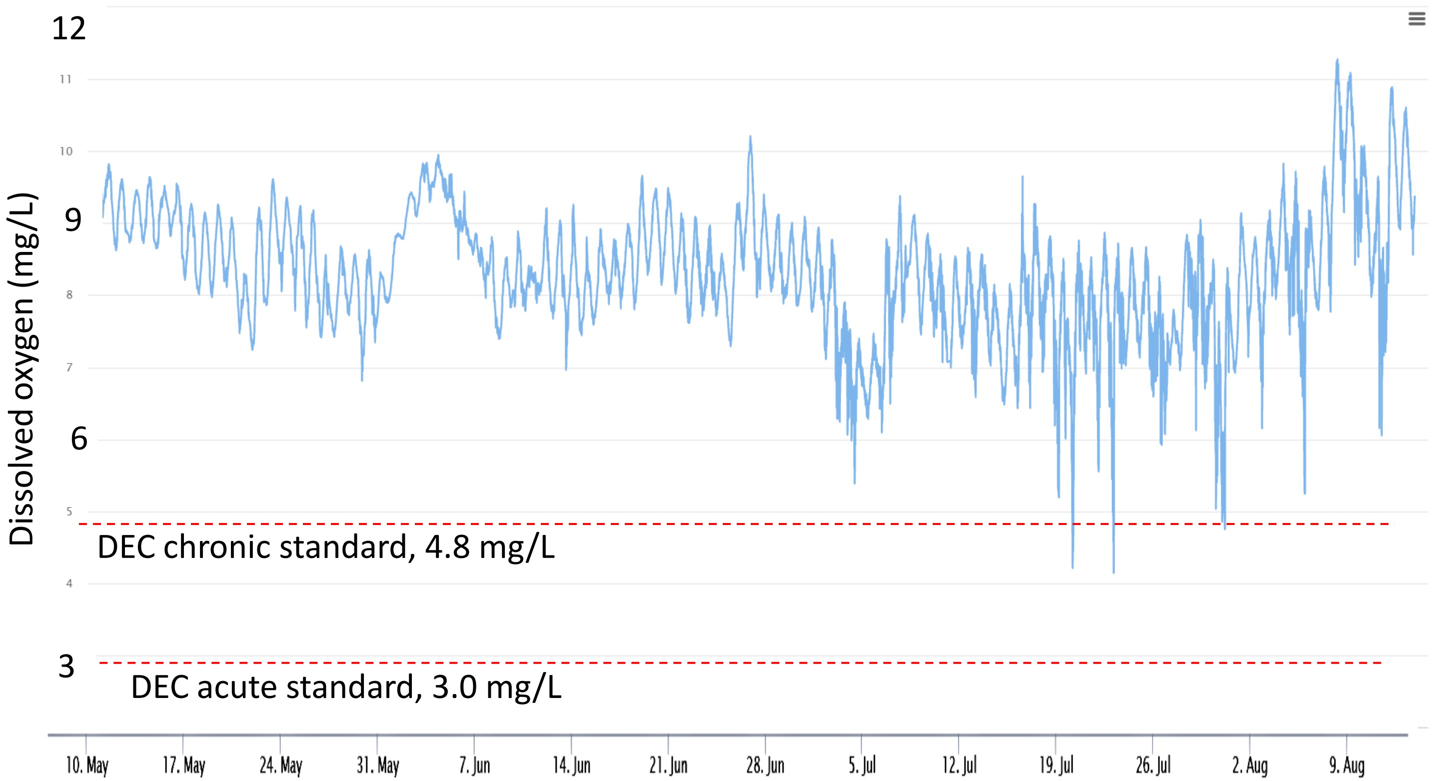
Salinity, 2020 – quite a contrast



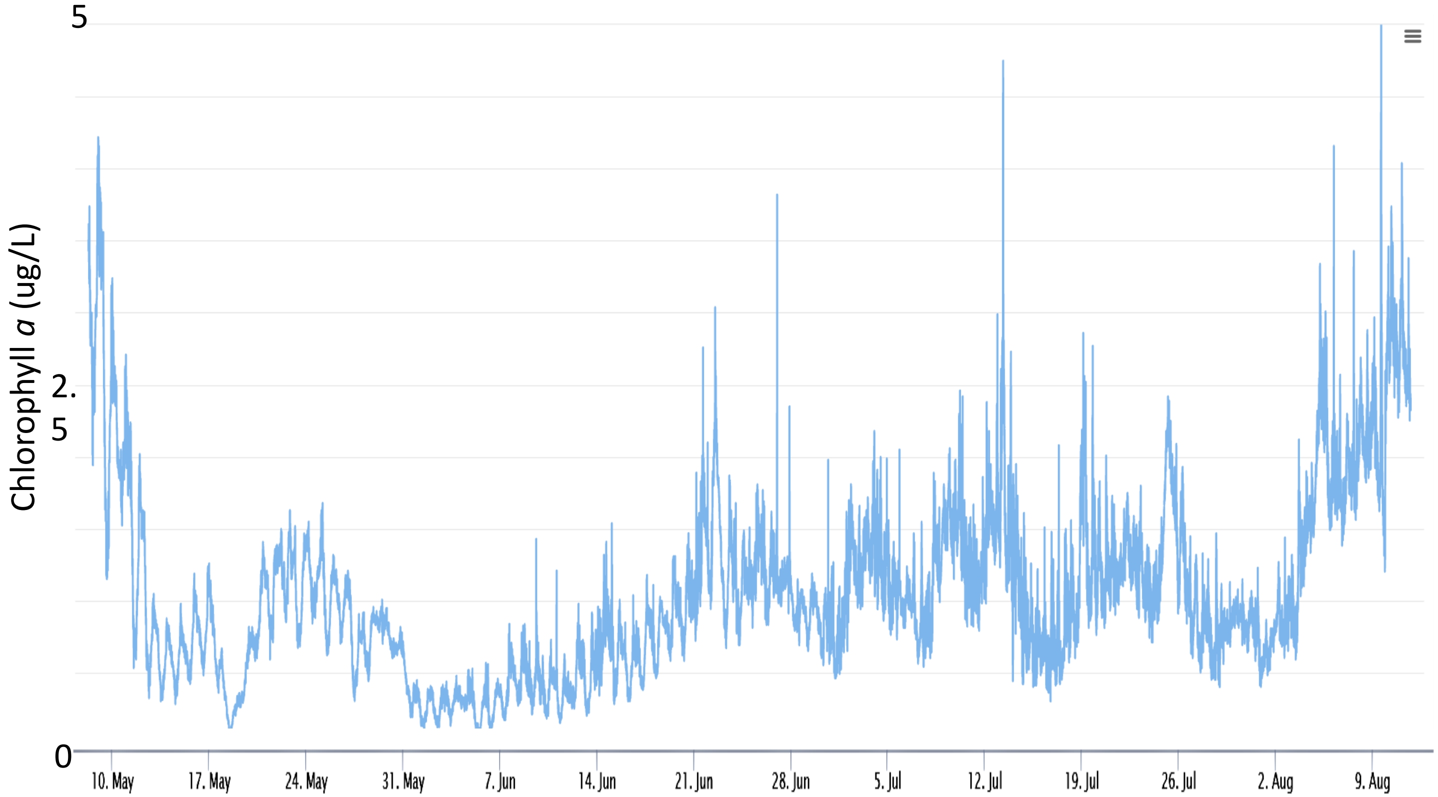
Temperature, 2021



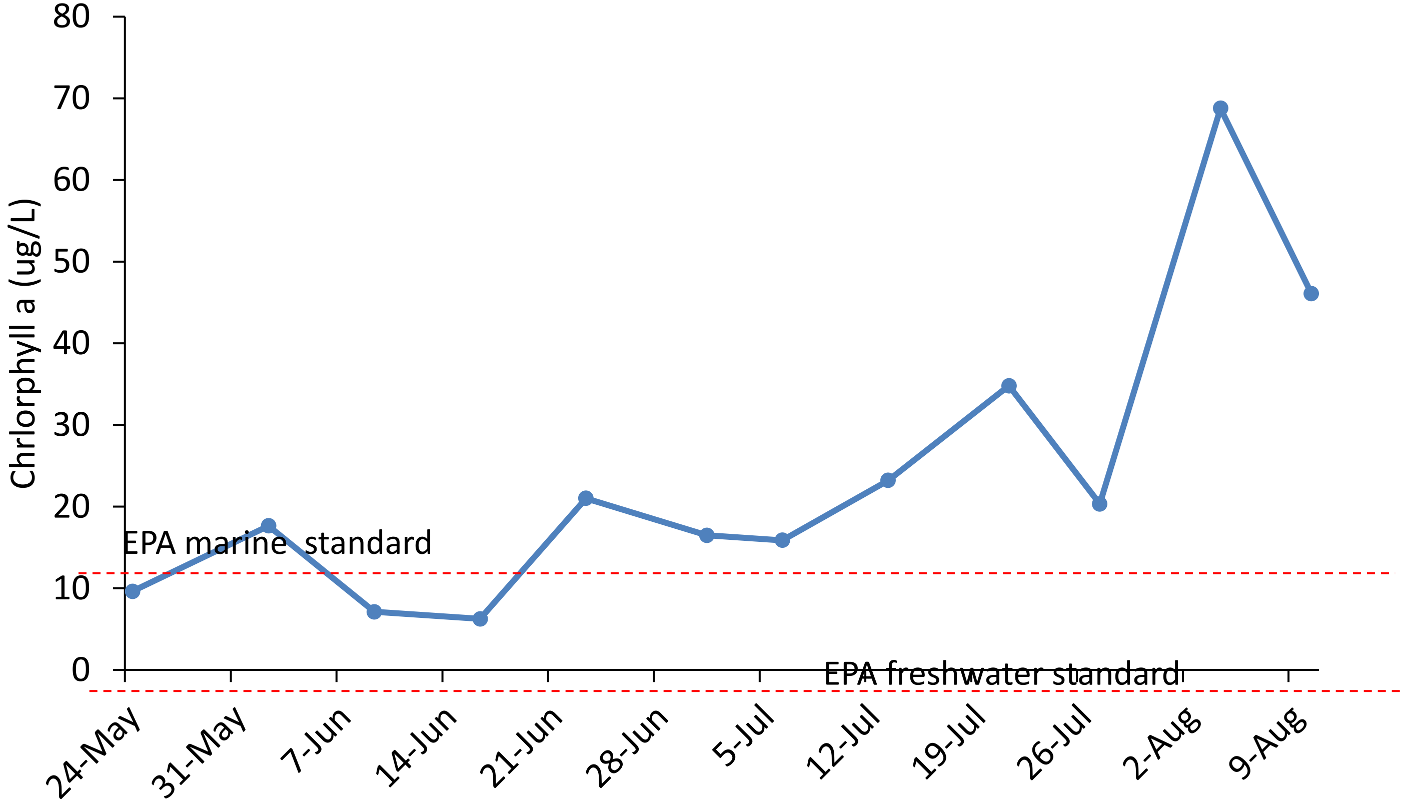
Dissolved oxygen, 2021



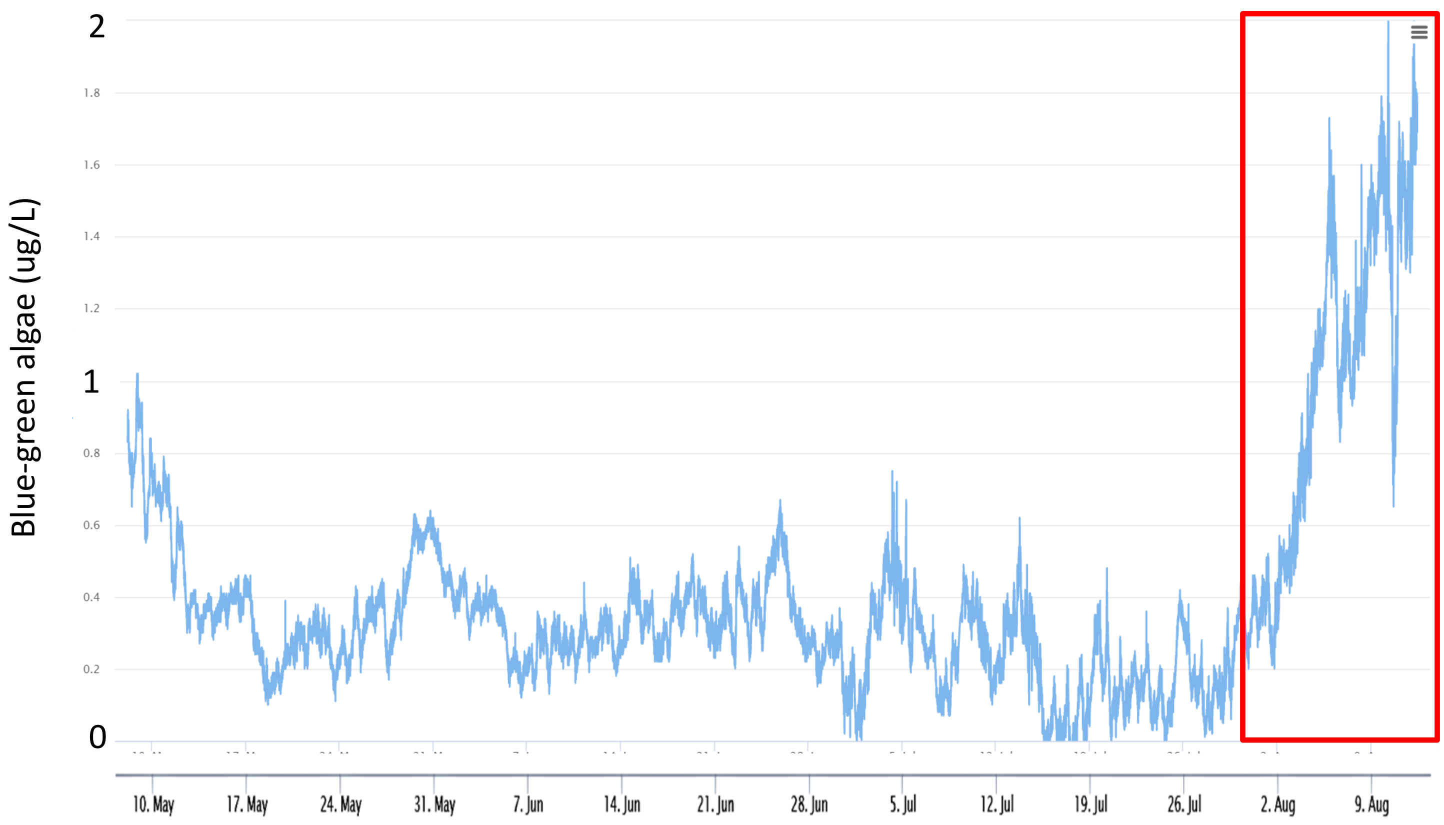
Chlorophyll *a*, 2021, buoy



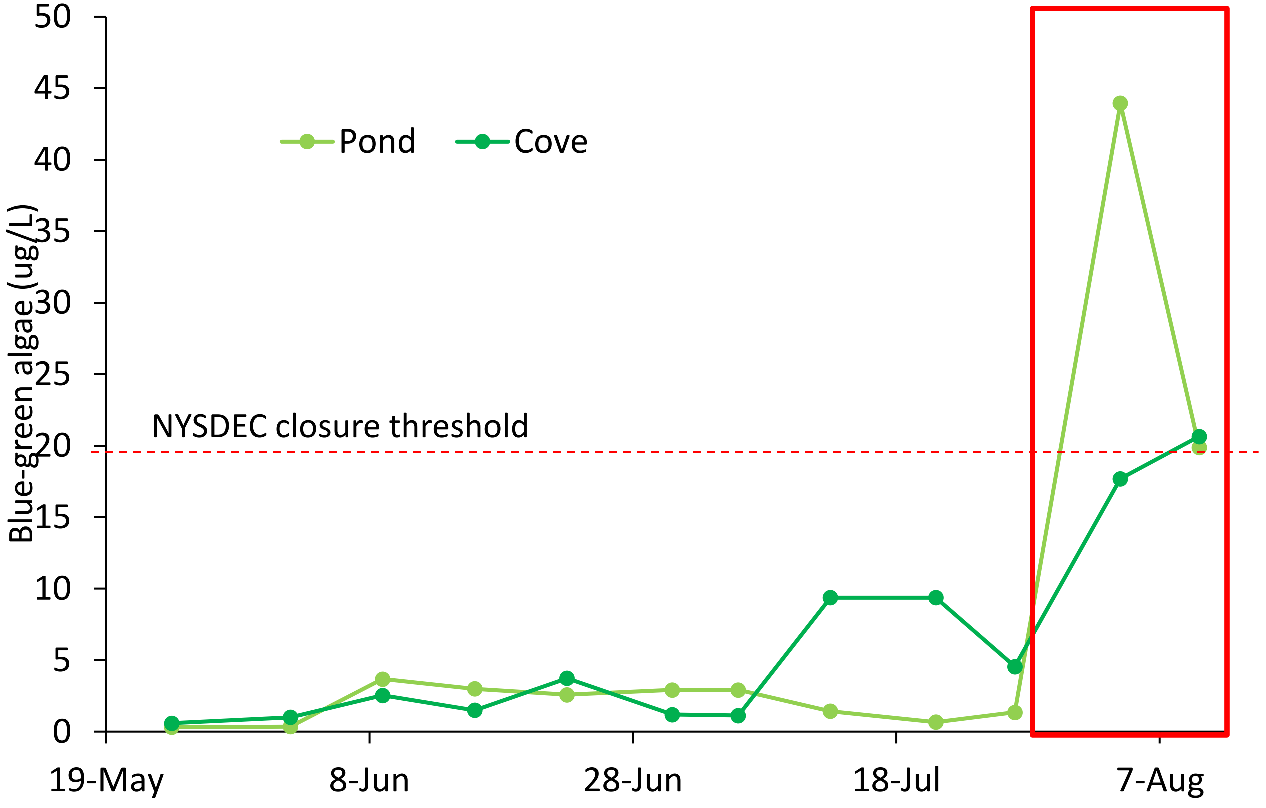
Chlorophyll *a*, extracted



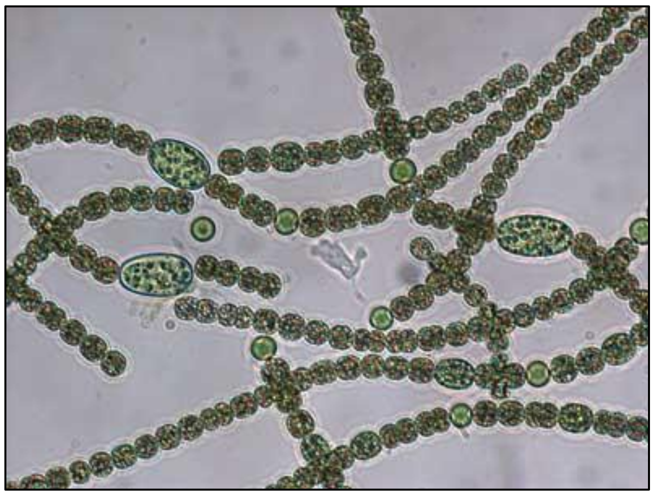
Blue green algae, 2021, buoy



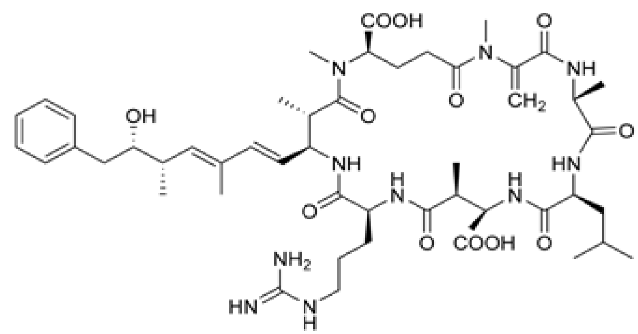
Blue-green algae, Fluoroprobe



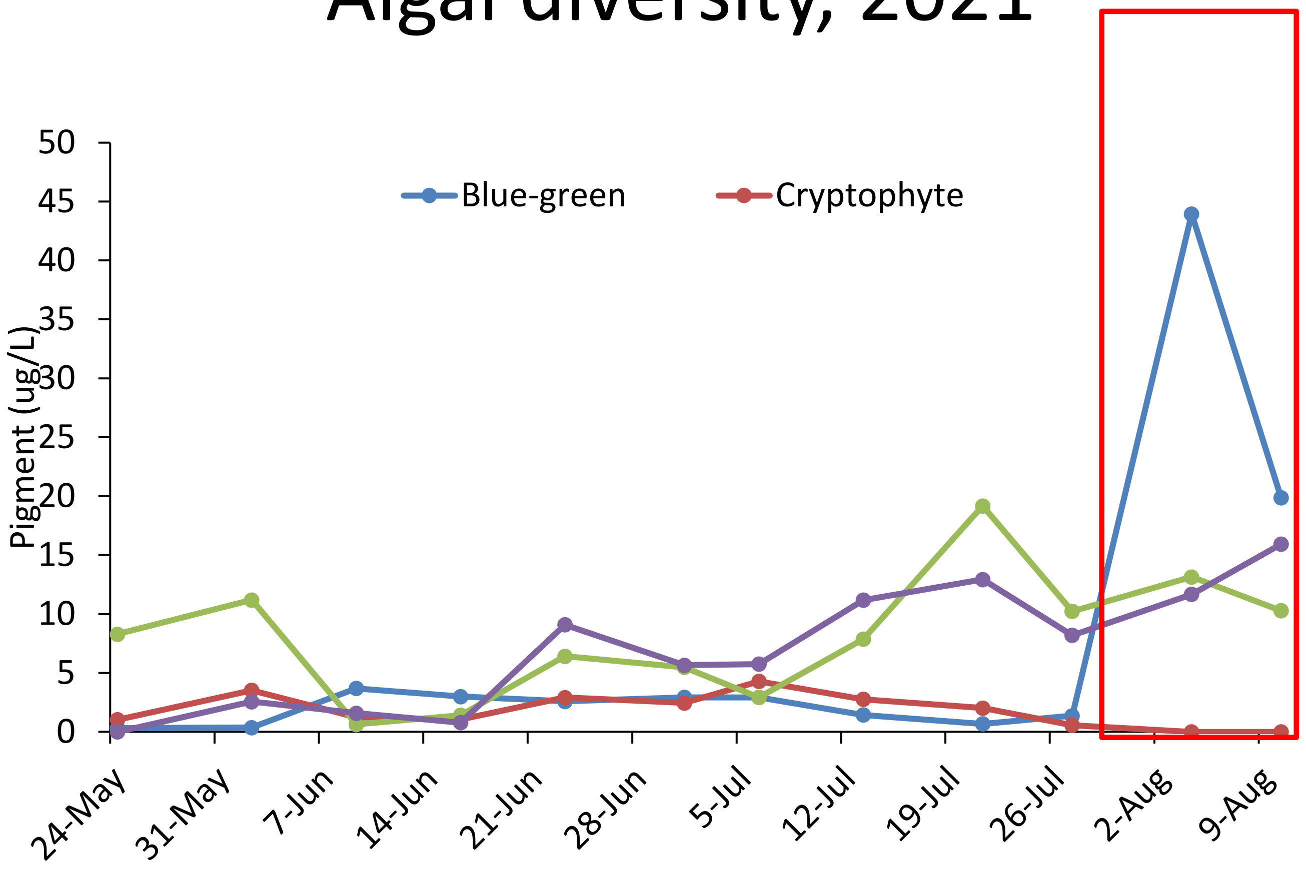
2021 bloom-former, *Dolichospermum*



Microcystin – 5µg/L, 8/9/21

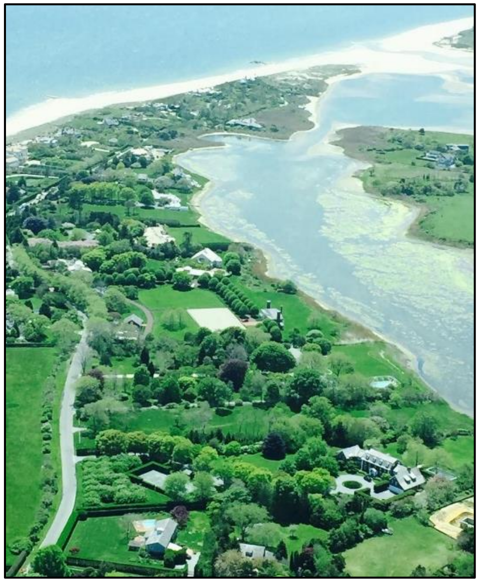


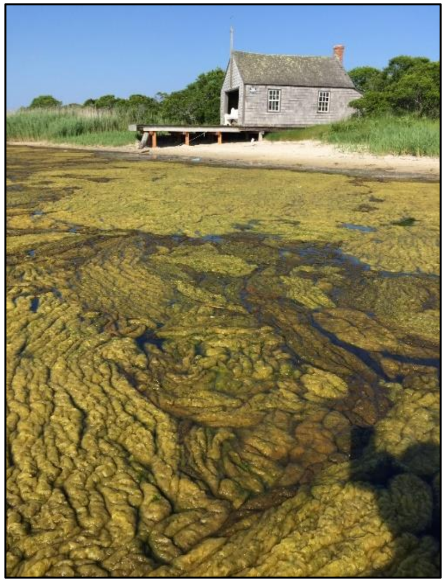
Algal diversity, 2021



The macroalgae – blue green algae connection, **2015**

June → July → August





Georgica Pond macroalgae

Excessive nutrient loading in Pond

Macroalgae bloom

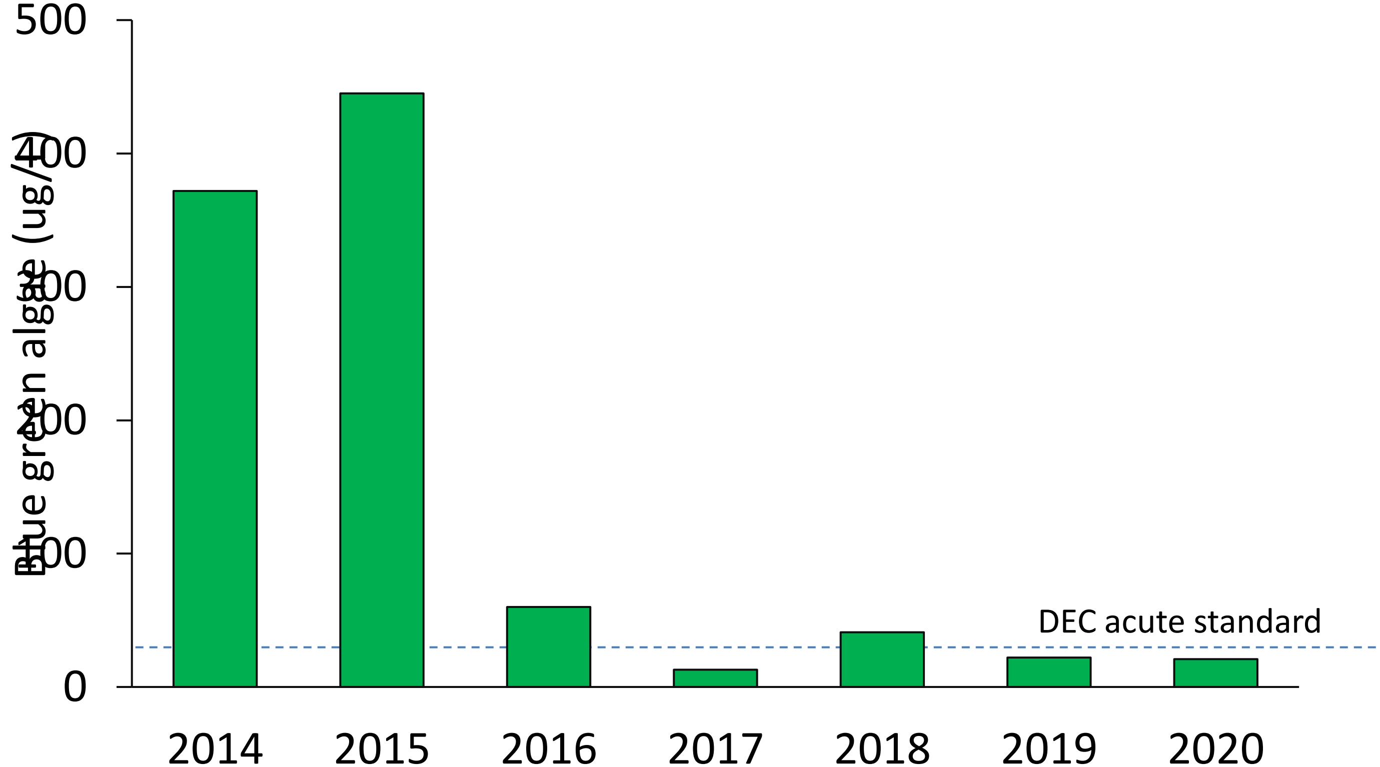
Collapsing macroalgal bloom regenerates nutrients

Blue-green algae use released nutrients; hypoxia

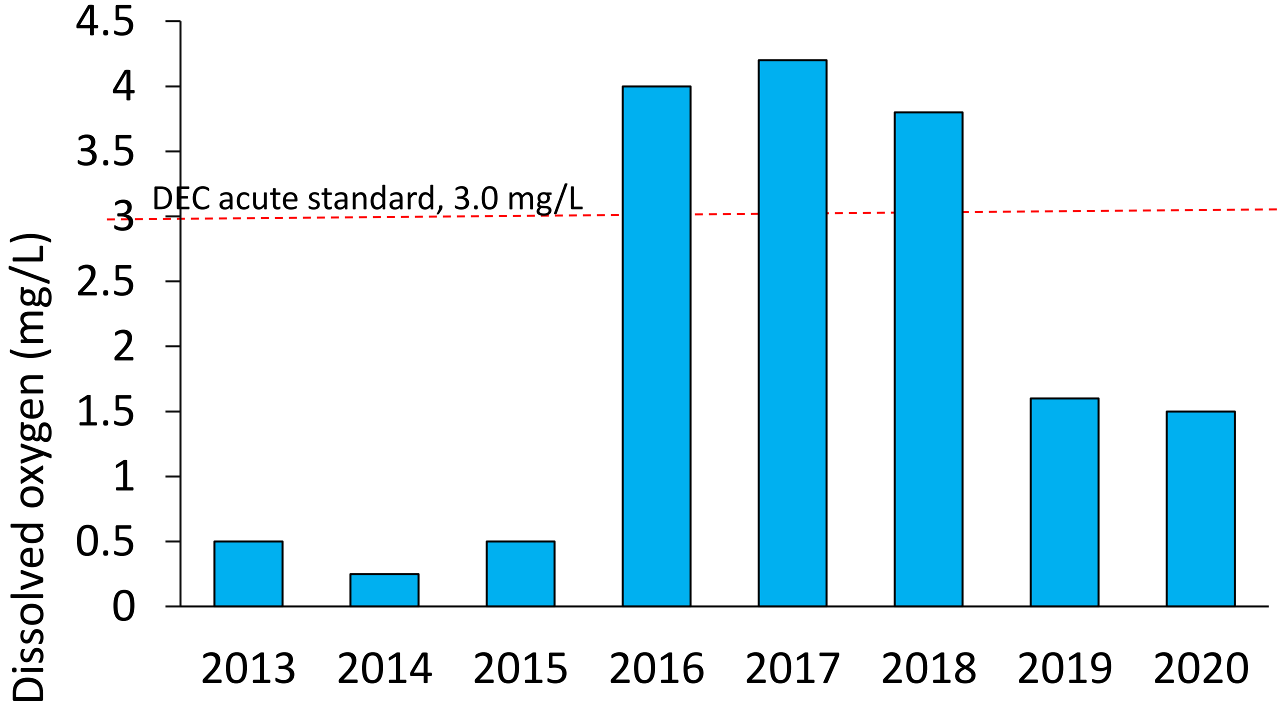
2016 - 2018: NYSDEC permitted harvesting of macroalgae funded by FoGP

FRIENDS OF
GEORGICA POND
FOUNDATION

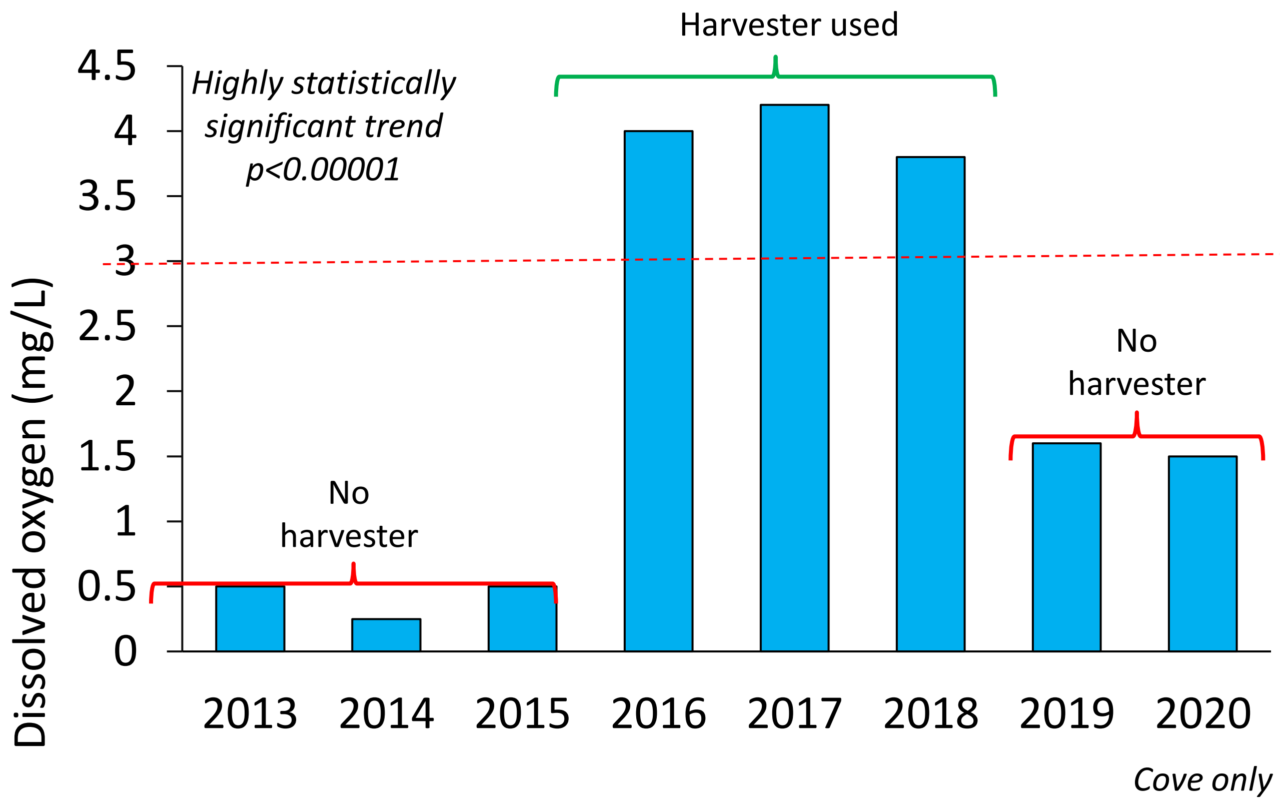
Blue-green algae blooms, 2014-2020



Summer dissolved oxygen minimum by year



Summer dissolved oxygen minimum by year



Five Year authorization for harvester granted by DEC, August 2021

Bioextraction by the harvester

	Lbs	lbs N	% summer N input
2016	55,740	501.66	13%
2017	26,480	238.32	6%
2018	93,140	838.26	15%
2020*	20,000	180	-
Total	**195,360**	**1,758**	

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

Forbes

EDITORS' PICK | Aug 9, 2021, 10:31am EDT | 7,441 views

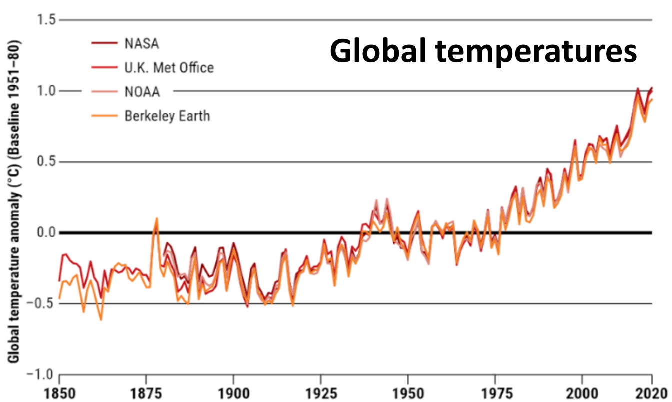
‘Code Red For Humanity’: Humans Driving ‘Unprecedented’

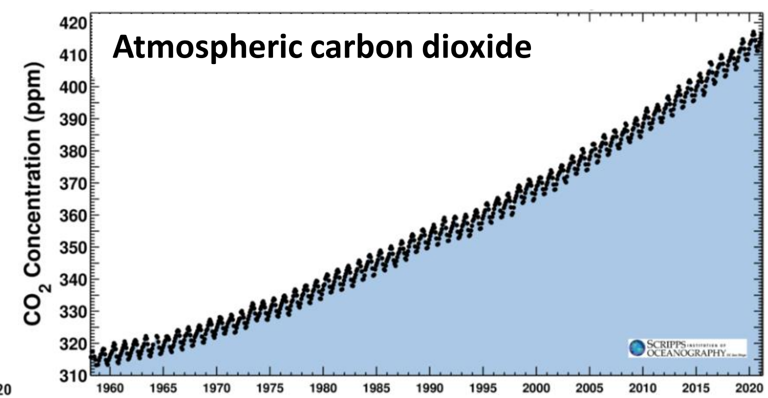
CLIMATE

Blooms Like It Hot

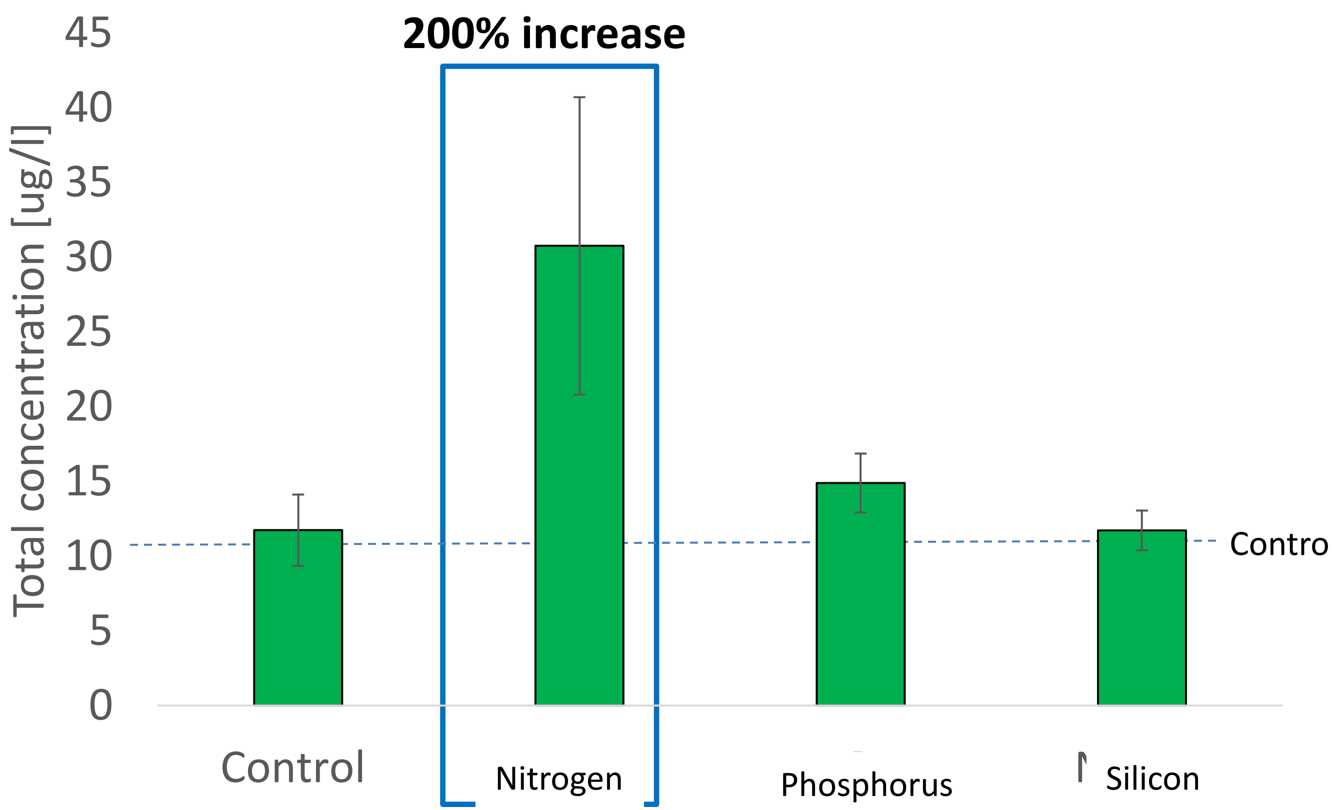
Hans W. Paerl[1] and Jef Huisman[2]

A link exists between global warming and the worldwide proliferation of harmful cyanobacterial blooms.

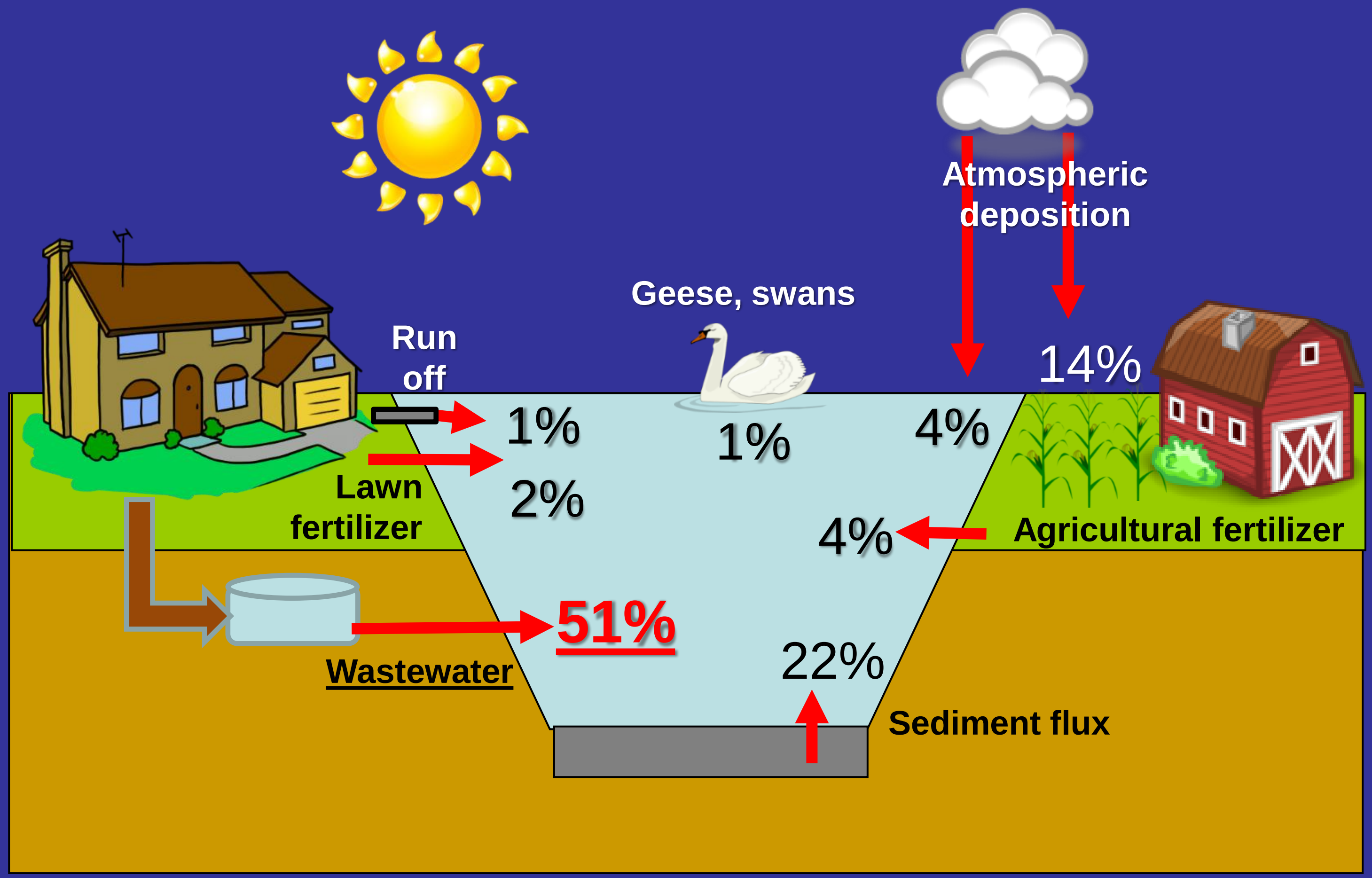


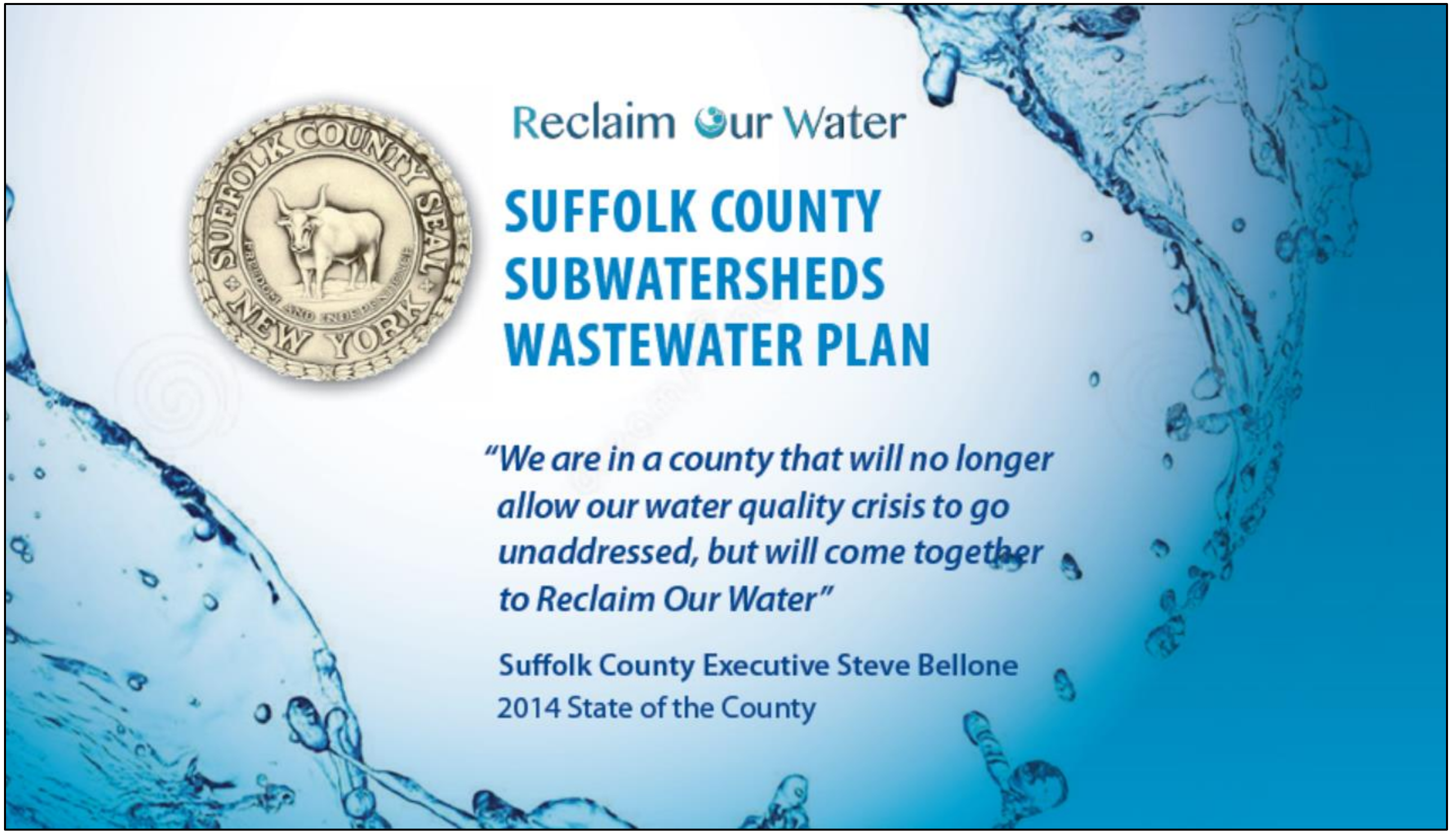


Nutrients controlling blue-green algae



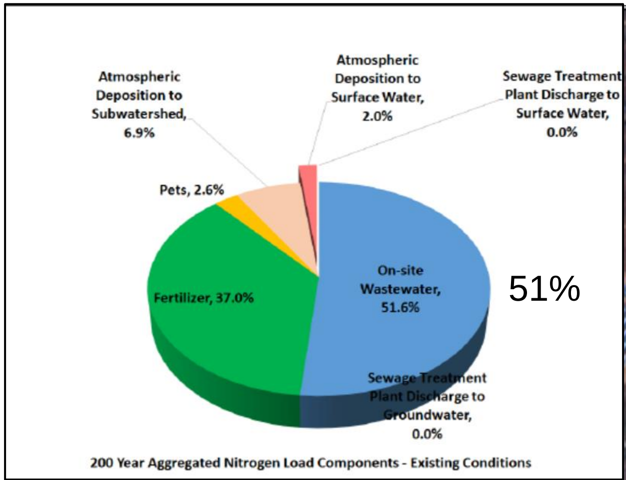
Nitrogen loading model





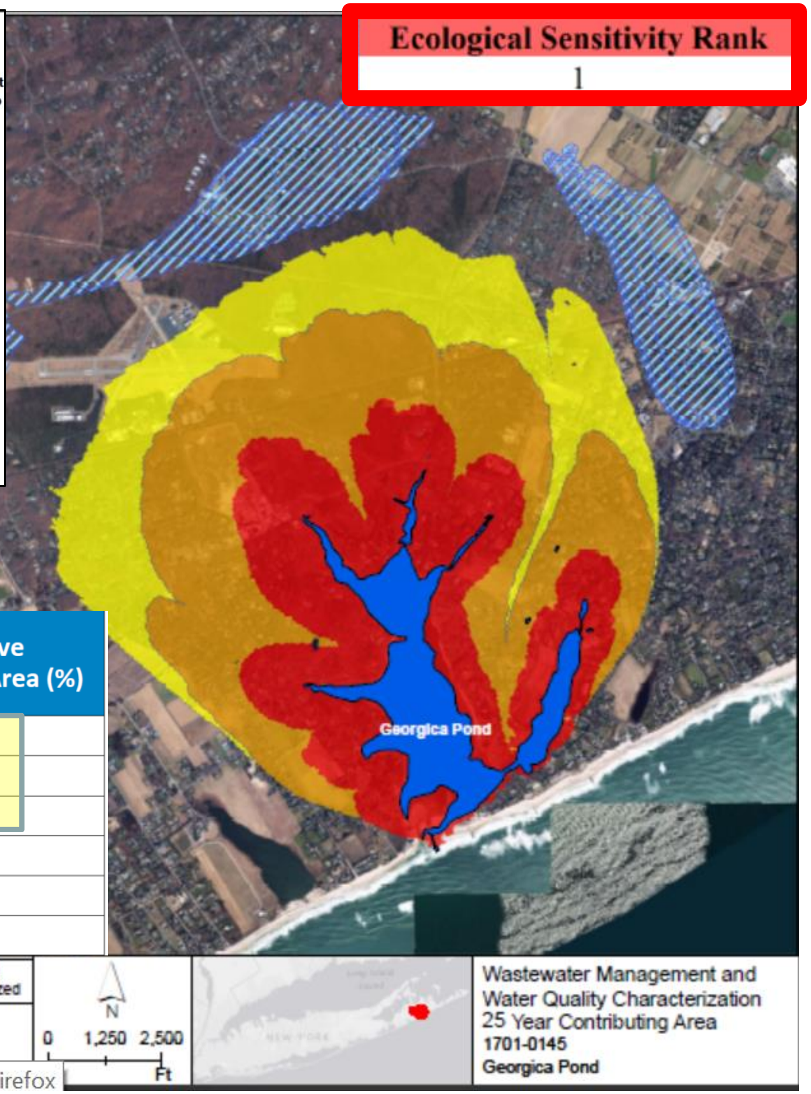
Adopted, summer 2020

Ecological Sensitivity Rank
1



51%

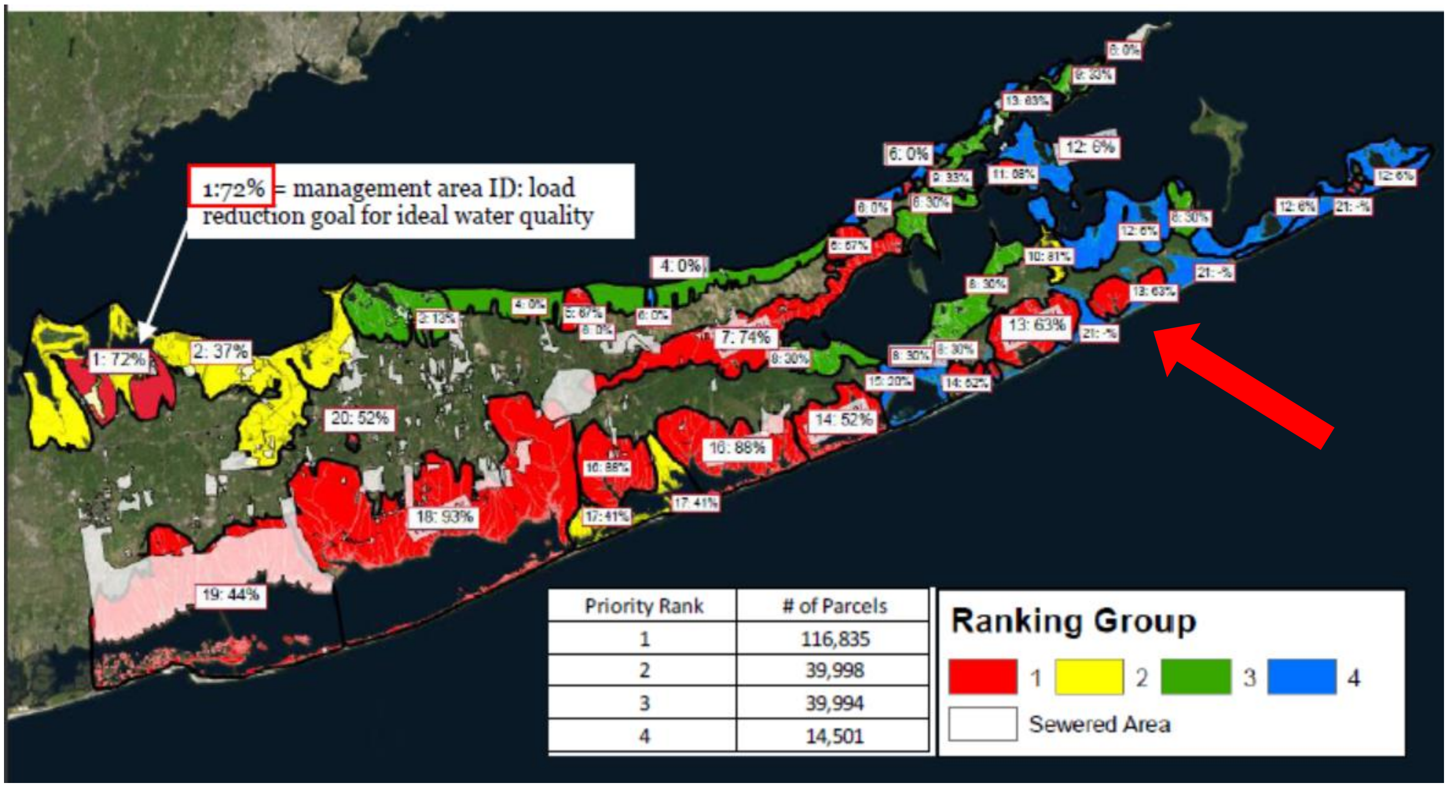
Travel Time Interval (Years)	Contributing Area (%)	Cumulative Contributing Area (%)
0 to 2	30.2%	30.2%
2 to 10	34.3%	64.5%
10 to 25	16.3%	80.8%
25 to 50	15.8%	96.6%
50 to 100	2.9%	99.5%
100 to 200	0.5%	100%



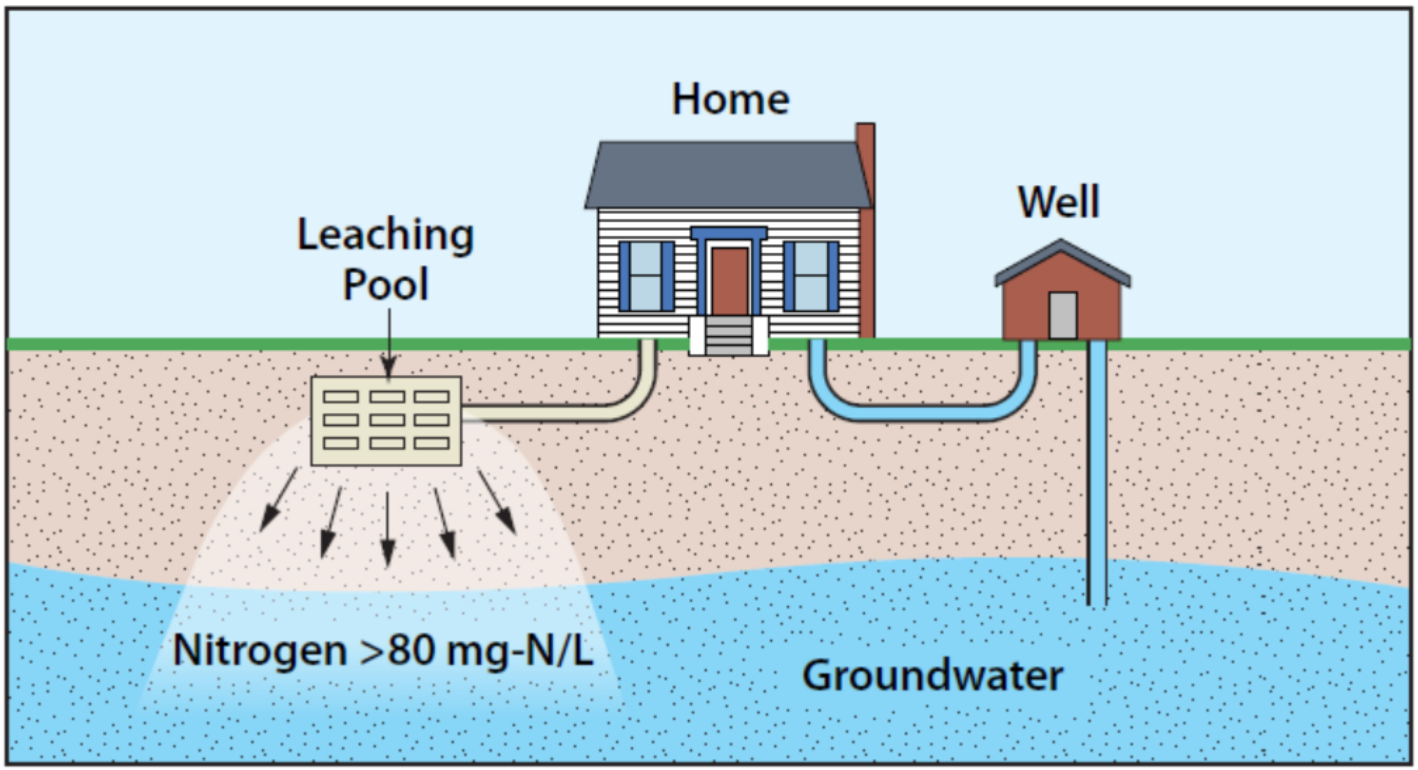
Suffolk County Subwatershed Nitrogen reductions for Georgica Pond

Approach	N reduction recommended
Gobler mass balance, cut open two months	90%
Gobler mass balance, cut open ten months	60%
Suffolk County, final recommendation	<u>**63%**</u>

Georgica Pond is priority #1 for nitrogen load reductions; one of the highest N reductions required



Long Island household wastewater system

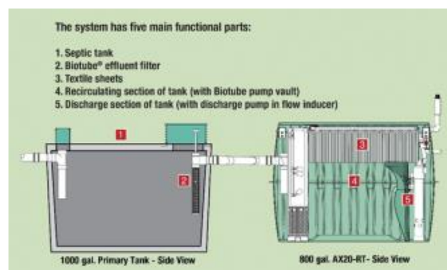


PROVISIONALLY APPROVED systems: Reduce N below 19 mg/L

Hydro-Action

Fuji Clean System

Norweco Hydrokinetic



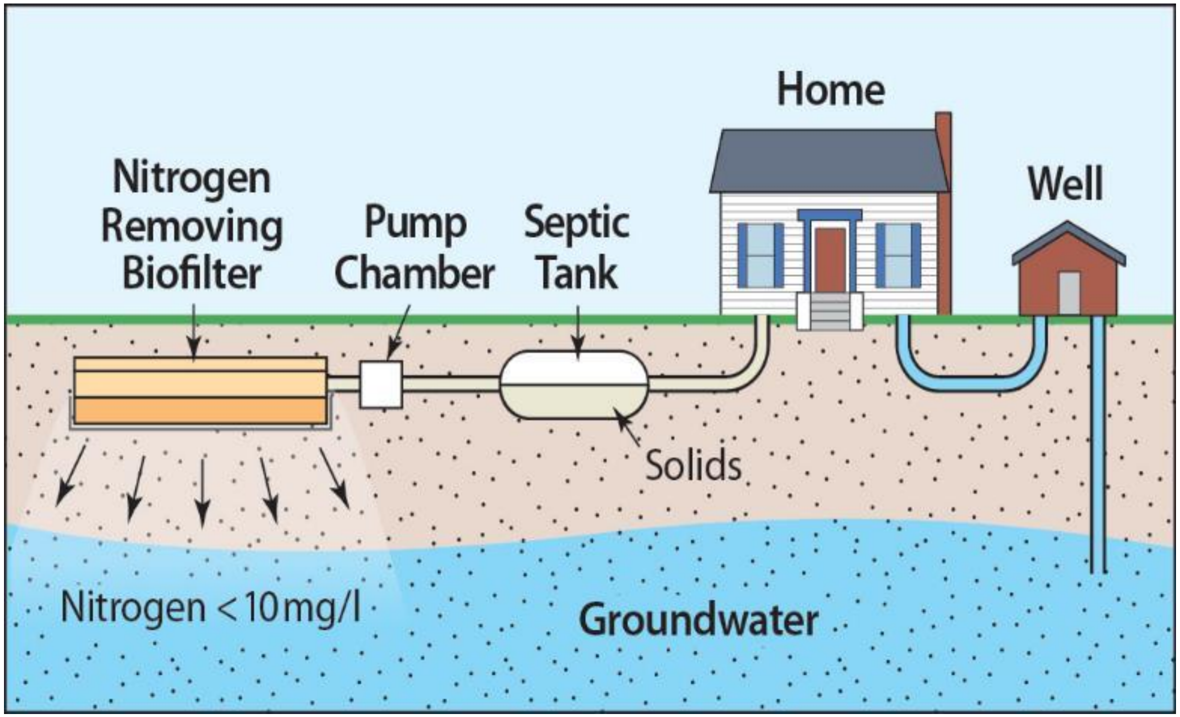
Orenco Advantex AX-RT

Norweco Singlair TNT

The New York State Center for Clean Water Technology: Innovating solutions to protect our most vital resource

Director, Dr. Chris Gobler

Nitrogen Removing Biofilters (NRB)



Ecological Engineering 161 (2021) 106157

Contents lists available at ScienceDirect

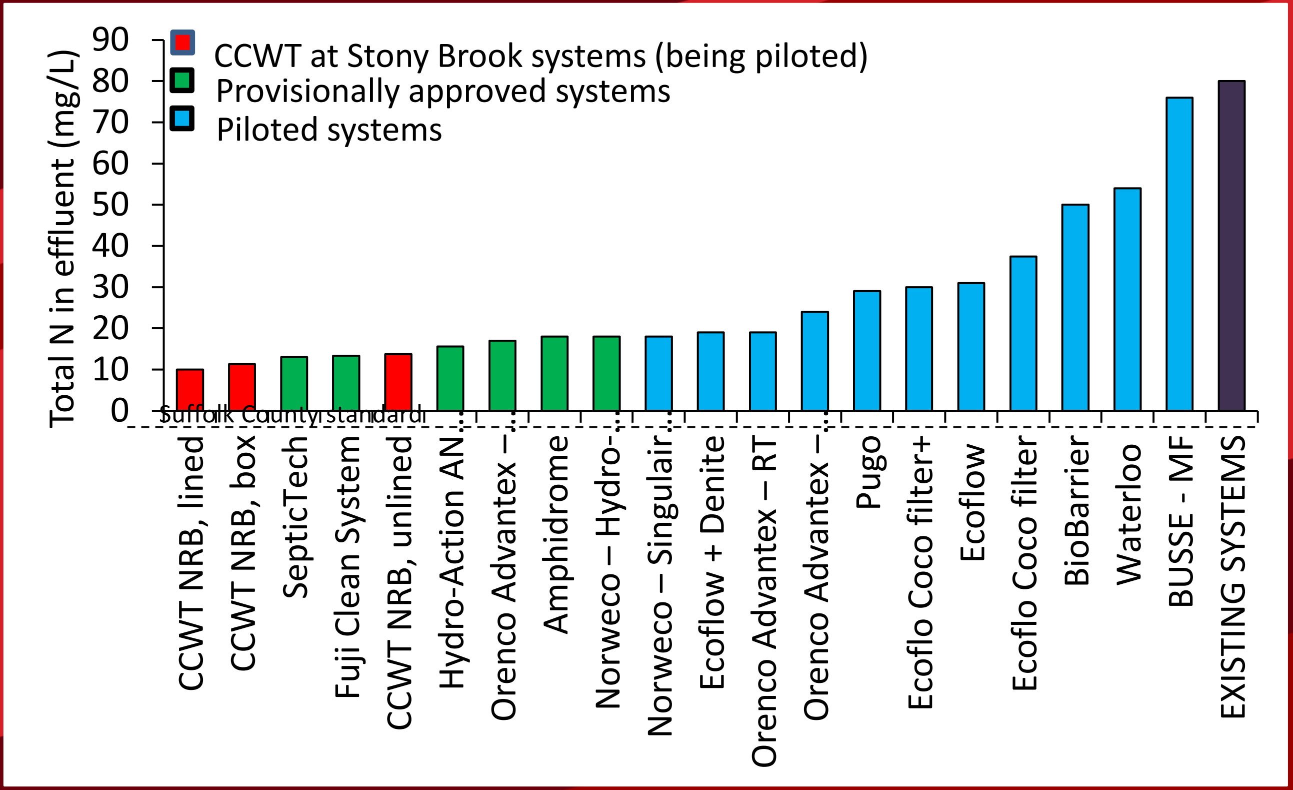
Ecological Engineering

journal homepage: www.elsevier.com/locate/ecoleng

Removing 80%–90% of nitrogen and organic contaminants with three distinct passive, lignocellulose-based on-site septic systems receiving municipal and residential wastewater

Christopher J. Gobler[a,b,*], Stuart Waugh[a], Caitlin Asato[a], Patricia M. Clyde[a,b], Samantha C. Nyer[a,b], Molly Graffam[a,b], Bruce Brownawell[b], Arjun K. Venkatesan[a,c], Jennifer A. Goleski[b], Roy E. Price[a,b], Xinwei Mao[a,c], Frank M. Russo[a,c], George Heufelder[d], Harold W. Walker[a,1]

Comparison of I/A performance in Suffolk County



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

Science of the Total Environment 771 (2021) 144806

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

ELSEVIER

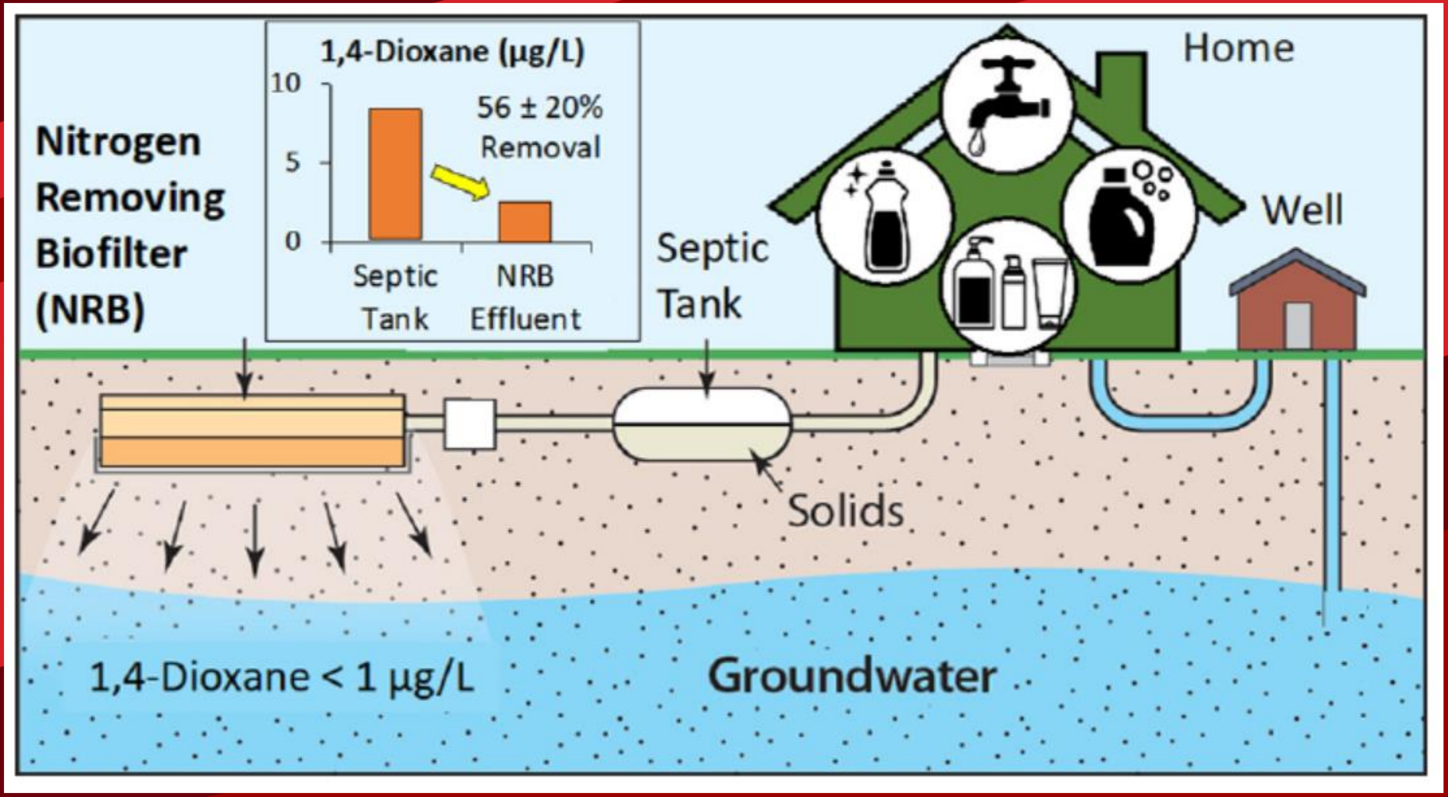
Removal of 1,4-dioxane during on-site wastewater treatment using nitrogen removing biofilters

Cheng-Shiuan Lee[a], Caitlin Asato[a], Mian Wang[a,c], Xinwei Mao[a,c], Christopher J. Gobler[a,b], Arjun K. Venkatesan[a,b,c,*]

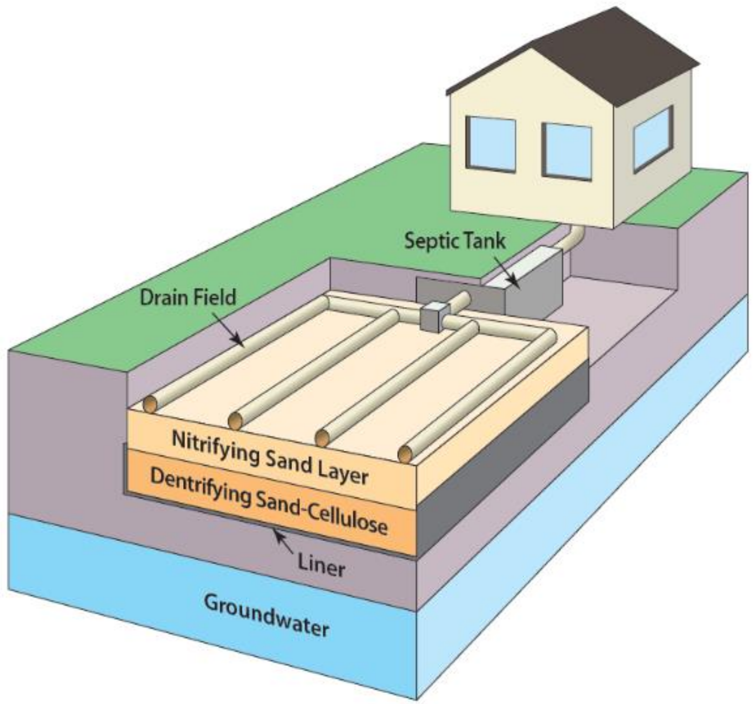
- 1,4-dioxane is listed as probable carcinogen by US EPA

- Not removed by most water treatment approaches

NRBs remove ~60% of 1, 4-dioxane down below the NYS drinking water standard of 1 ppb

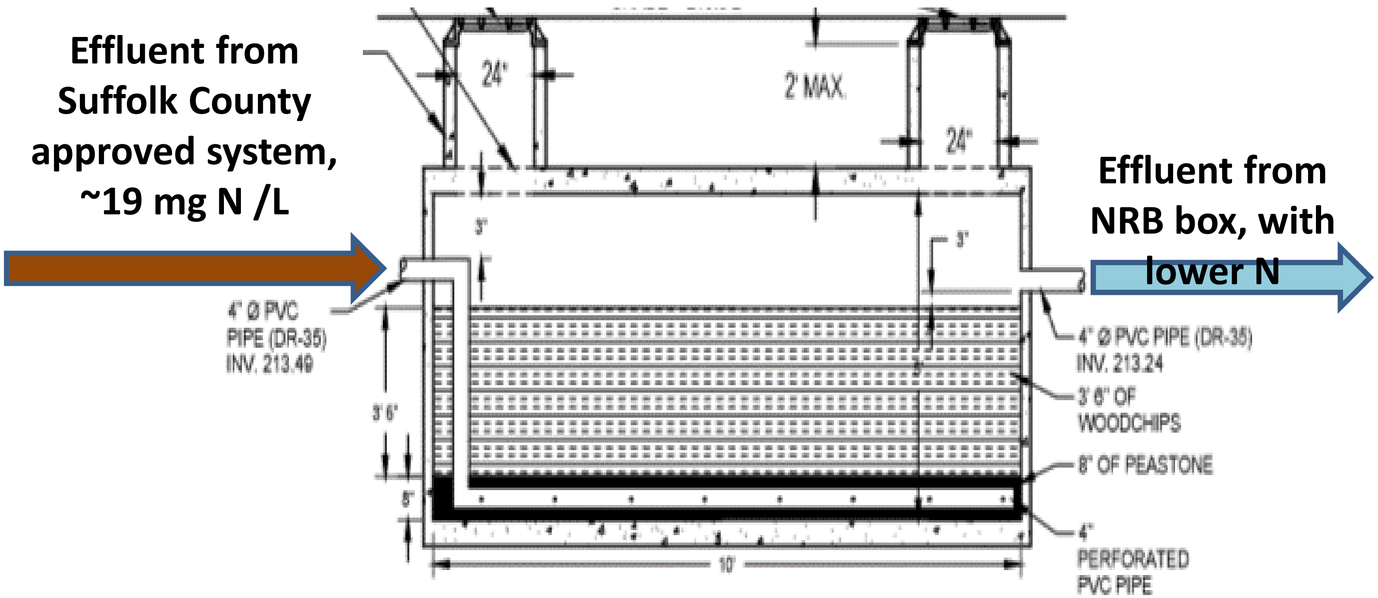


Nitrogen Removing Biofilters (NRB)



- NRB installations ~$25K (in range of other systems; covered by grants).
- In final 'piloting stage' of approval process.
- Provisional approval in Suffolk County expected in **2022**

Woodchip boxes as 'polishing units' for I/A systems across Suffolk County, ***available now***, full price covered grant

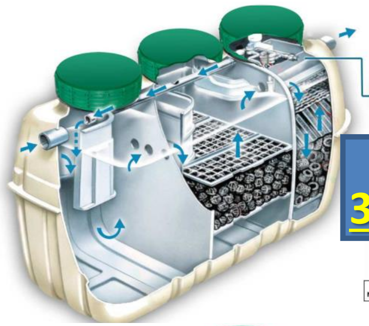


Designed by Dr. Stuart Waugh and Frank Russo, P.E.

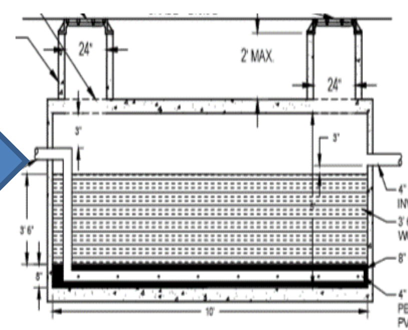
Improving the performance of Fuji Clean CEN 5 with CCWT WCB polishing units on Georgica Pond

Fuji Clean CEN 5

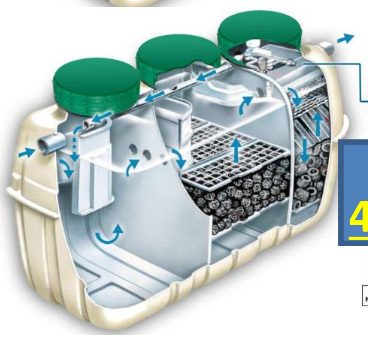
CCWT Woodchip Box



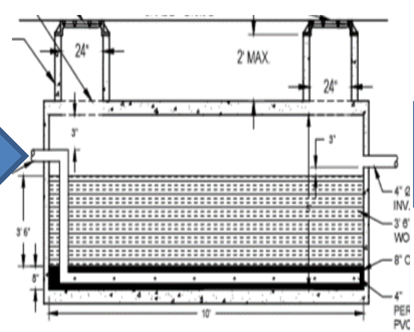
Nitrate:
38 mg-N L^{-1}



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



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



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

How do we know how well on-site septic systems are performing?

How variable is their performance?

What drives that variance?

U.S. ENVIRONMENTAL PROTECTION AGENCY

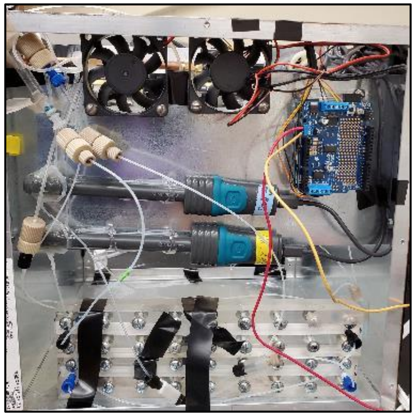
NEWS RELEASE

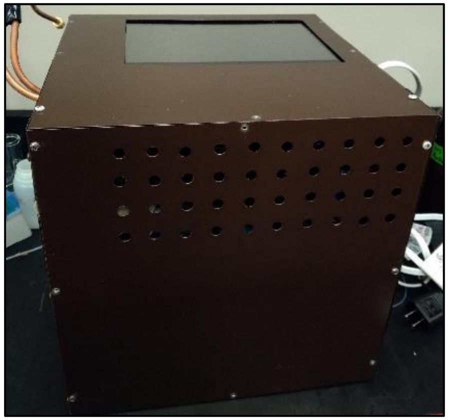
WWW.EPA.GOV/NEWSROOM

EPA at 50

Progress for a Stronger Future

Long Island Scientist Wins EPA Advanced Septic System Nitrogen Sensor Challenge



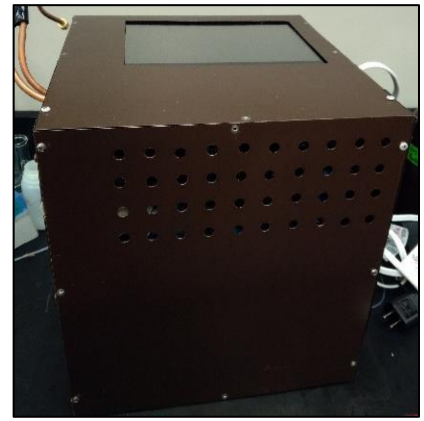


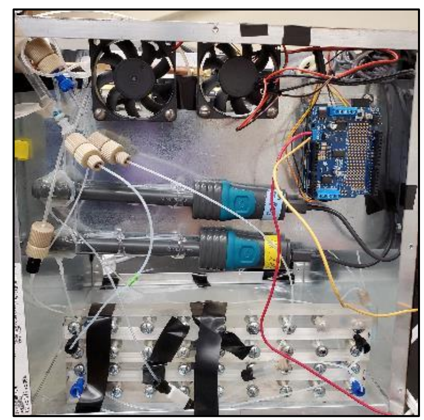
- Dr. Qing Zhu, member of the Center for Clean Water Technology and his nitrogen sensor

- **<u>Autonomously quantifies nitrate and ammonium in a single unit</u>**

CCWT Nitrogen Sensor

- Patent pending, filed by SBU.
- Won the US EPA sensor challenge.
- Received ISO 14034 ETV certification by the International Organization for Standardization after passing six-month performance test.
- Start-up company being formed to fill orders from municipalities.
- Sensors assures optimal performance of any advanced septic system.



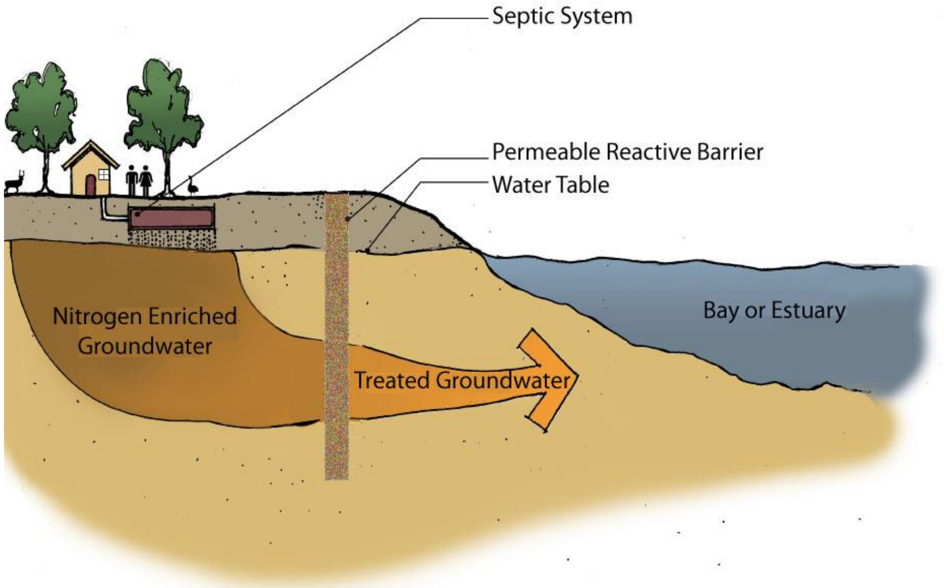


CCWT is ideally positioned to help Friends of Georgica Pond upgrade septic systems

- Access to cutting edge technology that ***maximally reduces nitrogen and other contaminants.***
- Access to cutting edge technology that can ***assess system performance in real-time.***
- University-level science to assure the ***most protective solution*** on a home-by-home basis.
- Collaboration the University's Geospatial Center to assure a ***whole-ecosystem approach.***

NYS
CENTER FOR
CLEAN WATER
TECHNOLOGY

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.

PRB can be complex and expensive to install

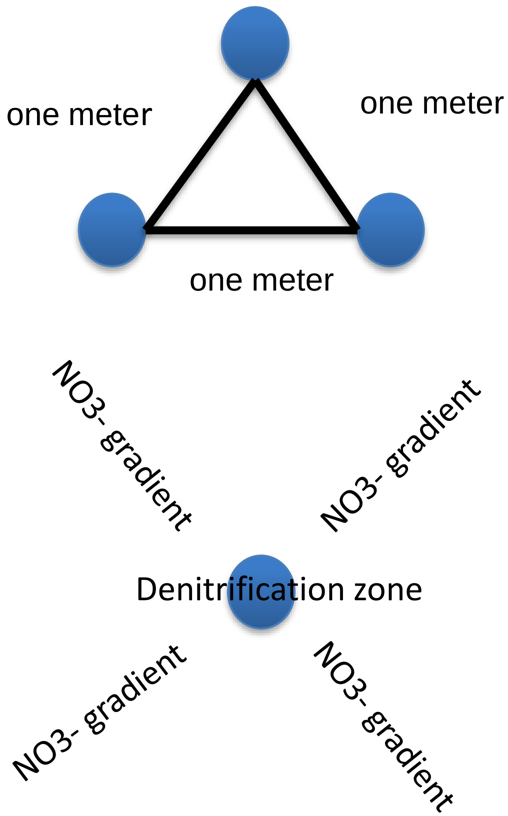
Deep trenching with heavy equipment in tandem with dewatering of groundwater is a logistical and financial challenge.

PRBs are not always suitable solutions for shorelines

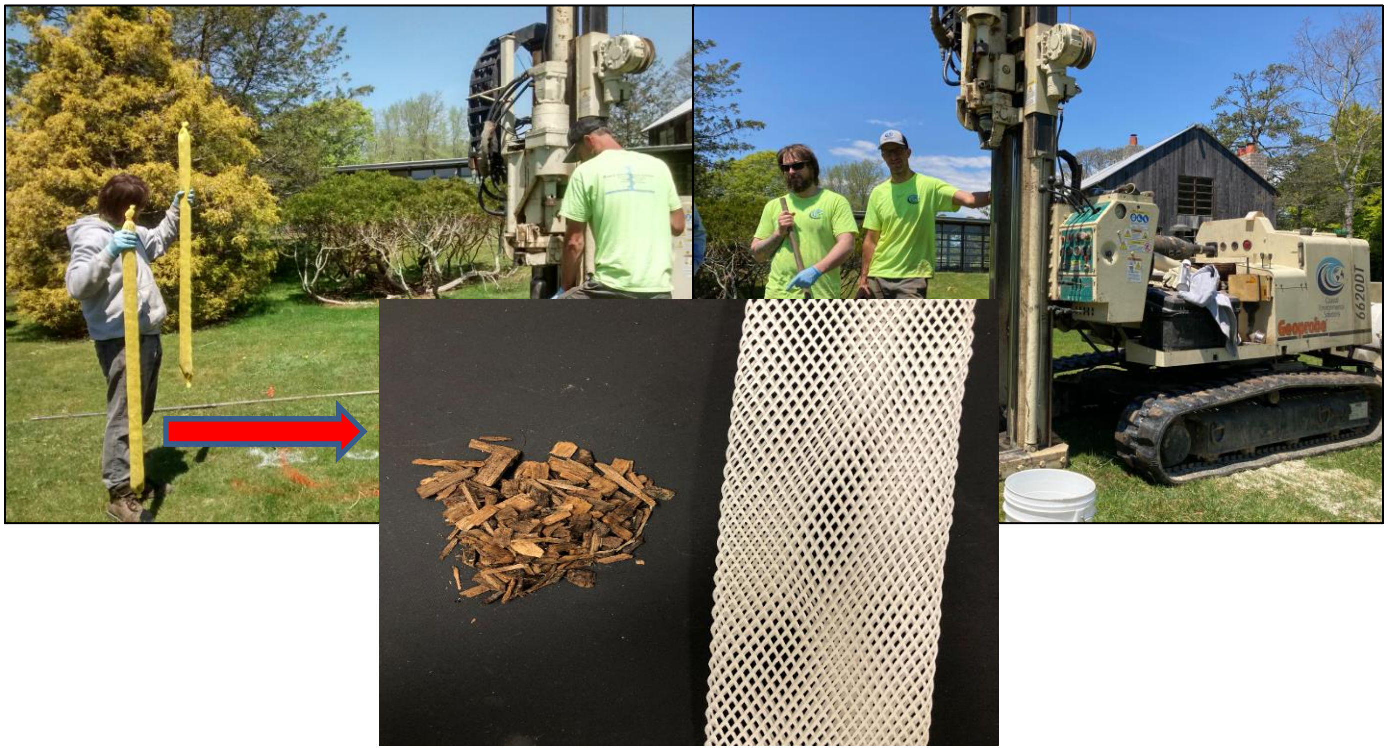
- Complex and expensive to install
- Lower nitrogen conditions
- Dominance of ammonium
- Slow groundwater flow
- Sub-oxic conditions

Solution: The carbon array

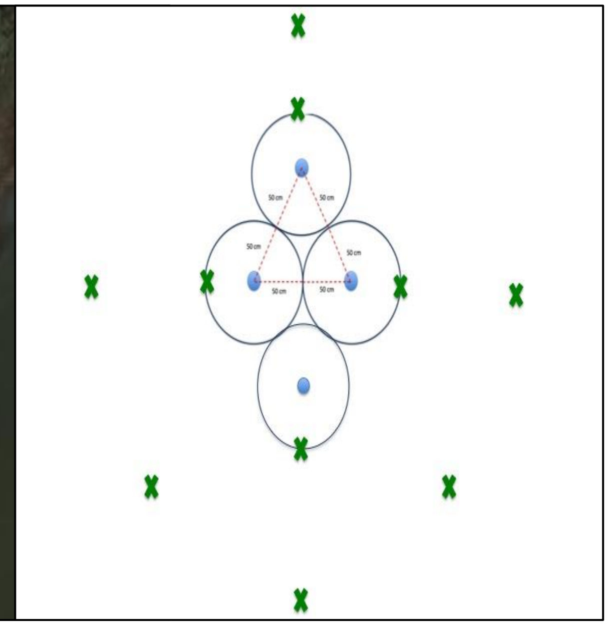
- 2¾” holes,15” deep, filled with woodchips
- Installed with Geoprobe = ***smaller, faster, simpler, less expensive.***
- Denitrification in ‘***reactive rod***’ creates nitrate gradient away from rod drawing more nitrate towards it.
- ***Carbon diffuses outwards*** creating enhanced zone of denitrification.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



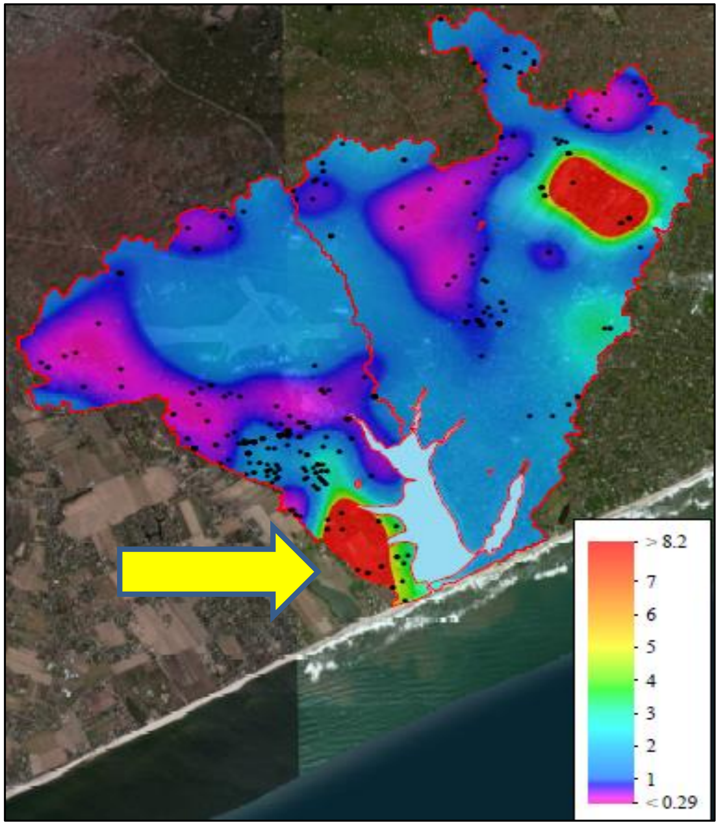
Ease of carbon array installation



Carbon array installation, Georgica Pond, May 2021; *analyses in progress*



Other carbon array opportunities?

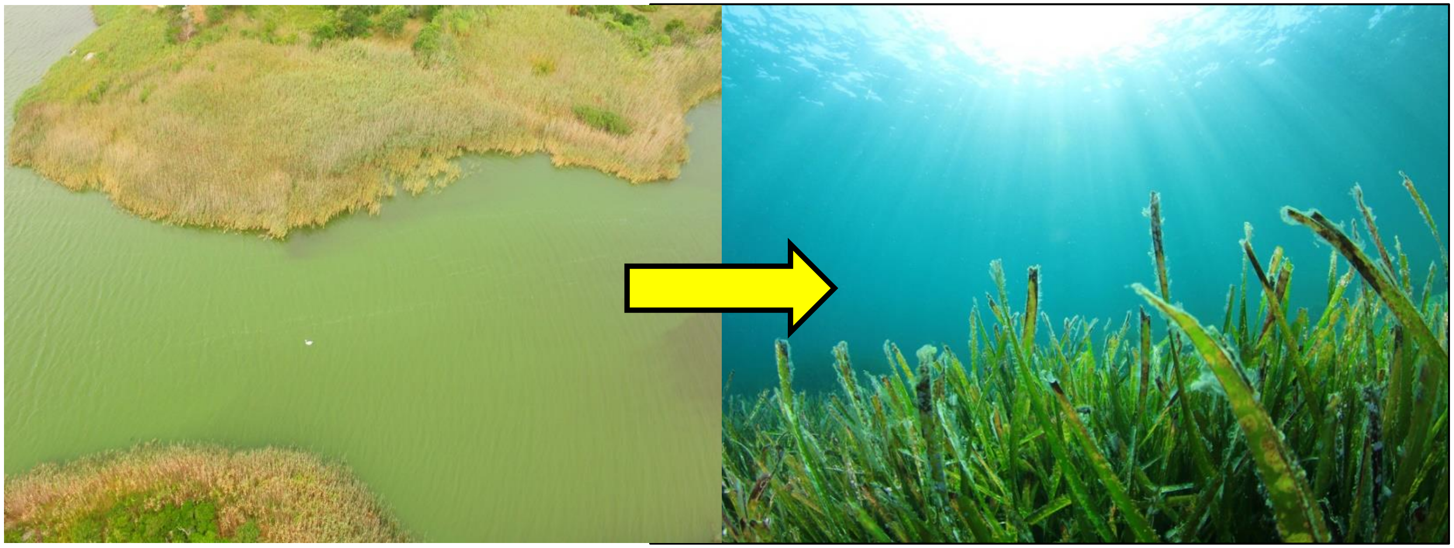



OYSTERS!

Oysters are ‘Ecosystem Engineers’

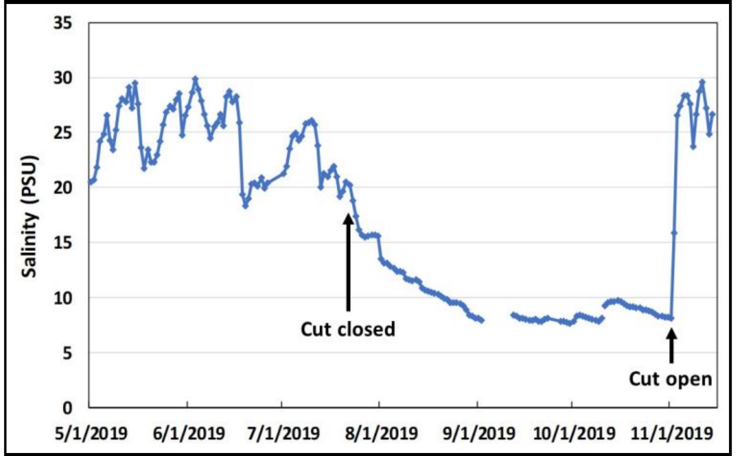
Oysters are filter feeders, and when abundant can:

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



Georgica Pond may provide an ideal habitat for oyster restoration

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



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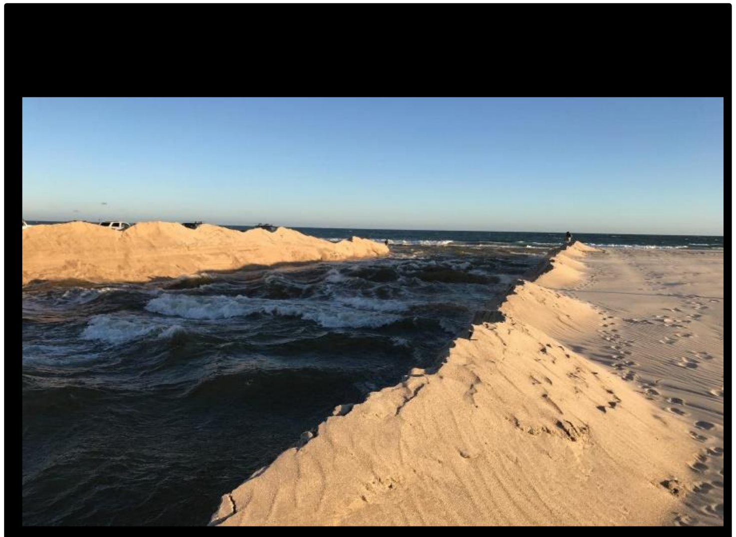
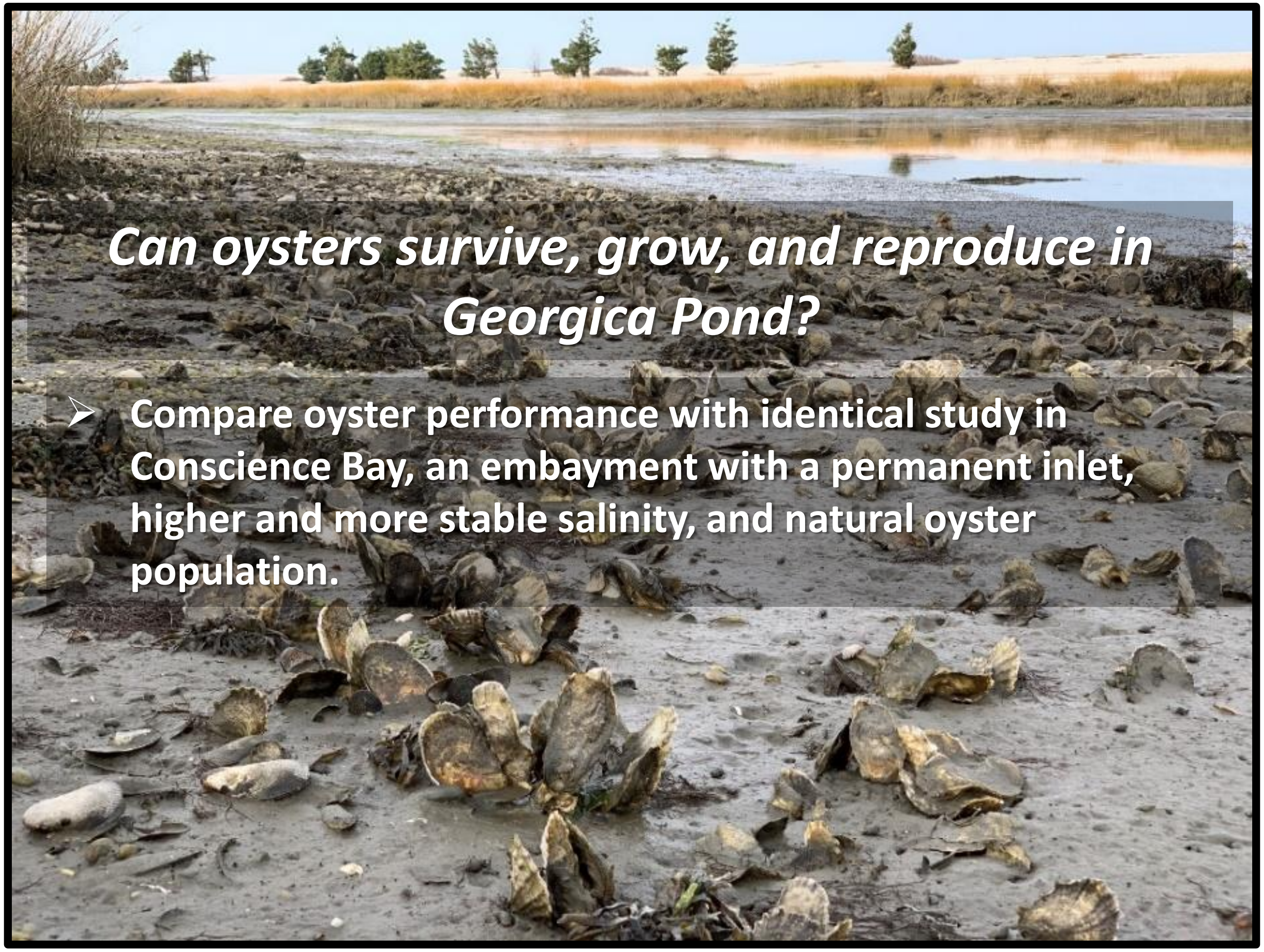


Georgica Pond may provide an ideal habitat for oyster restoration

- ➢ 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?

- **Compare oyster performance with identical study in Conscience Bay, an embayment with a permanent inlet, higher and more stable salinity, and natural oyster population.**

Phase 1 of Study

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

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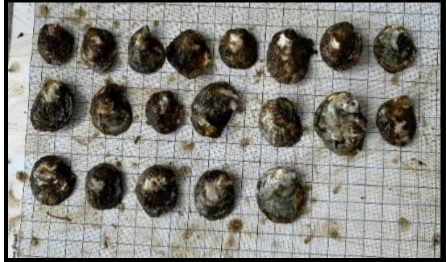
- Deployed two size/age classes of oysters in cages



2019 year-class "zero-year olds"

2018 year-class "one-year olds"

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  - *Focus on water quality*

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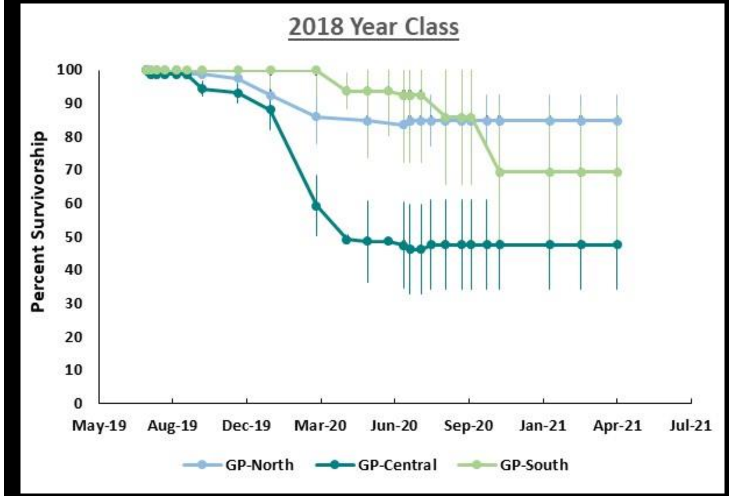
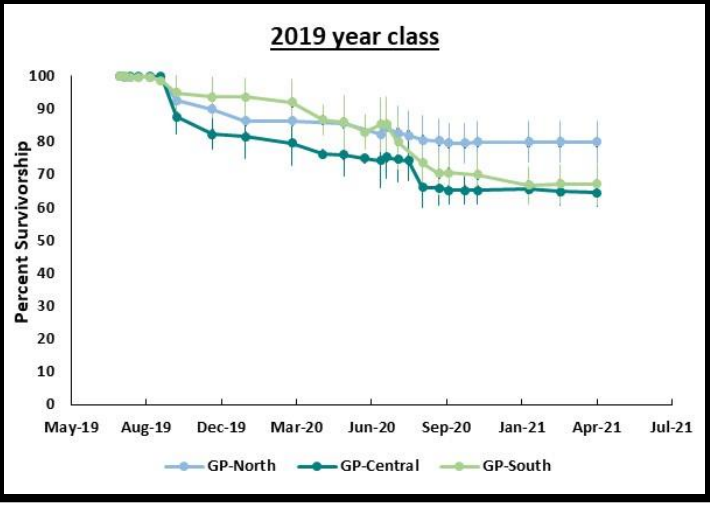
- Established three study sites accessible from shore
- Deployed two size/age classes of oysters in cages
  - *Predators excluded*
  - *Focus on water quality*
- Monitored growth, survivorship, disease, and reproduction to present (~two years)

Phase 1 Results

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

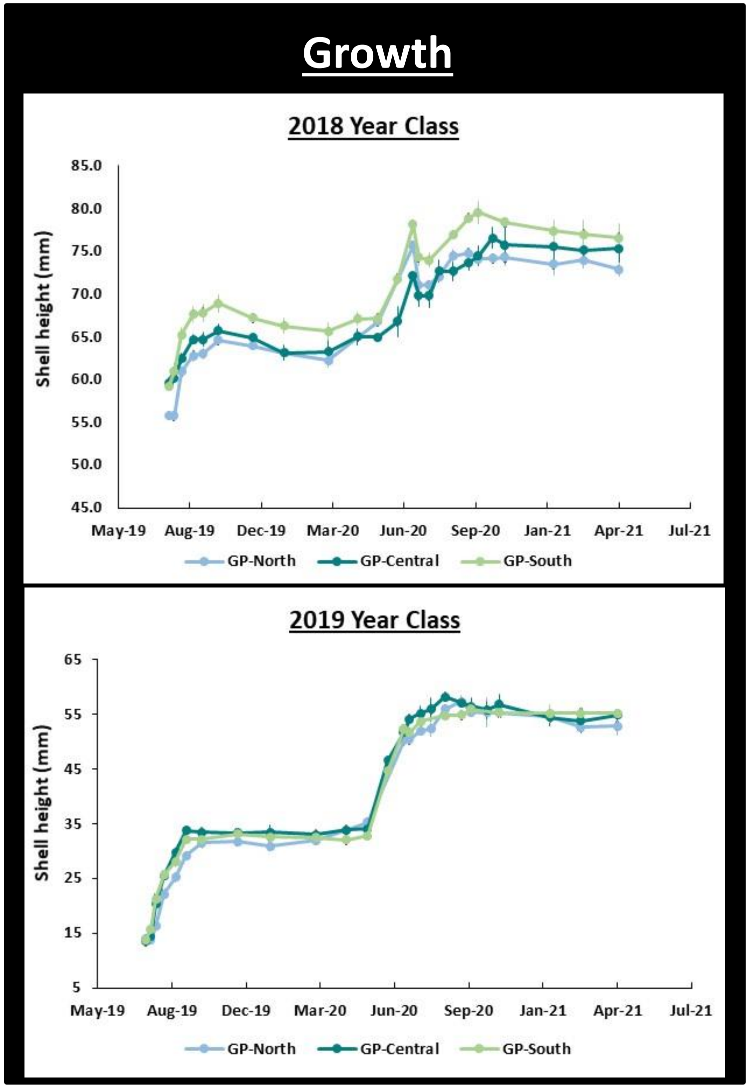
Survivorship





Phase 1 Results

- High survivorship of both size classes across all sites in Georgica Pond after one year
- Strong growth during warmer months



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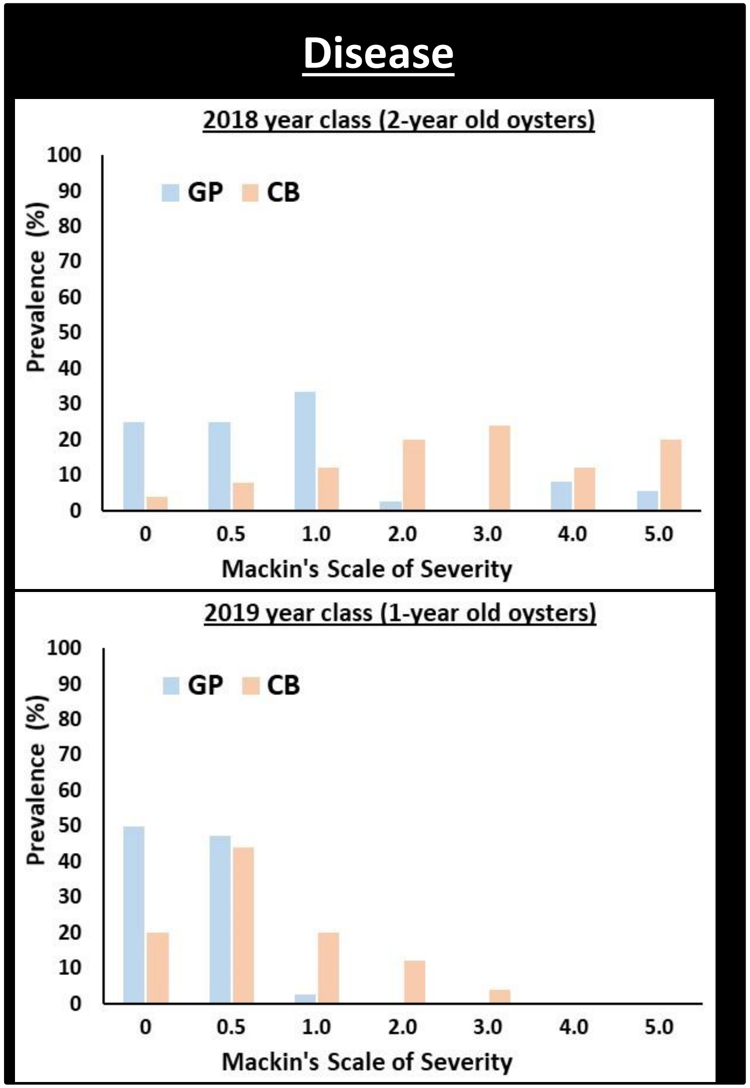
- High survivorship of both size classes across all sites in Georgica Pond after one year
- Strong growth during warmer months
- Oysters were reproductive in second summer (one-year-olds)
- Lower prevalence and intensity of disease (Dermo) in Georgica Pond than in Conscience Bay after one year; Lower salinities are a disease refuge.



Phase 2 of Study

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

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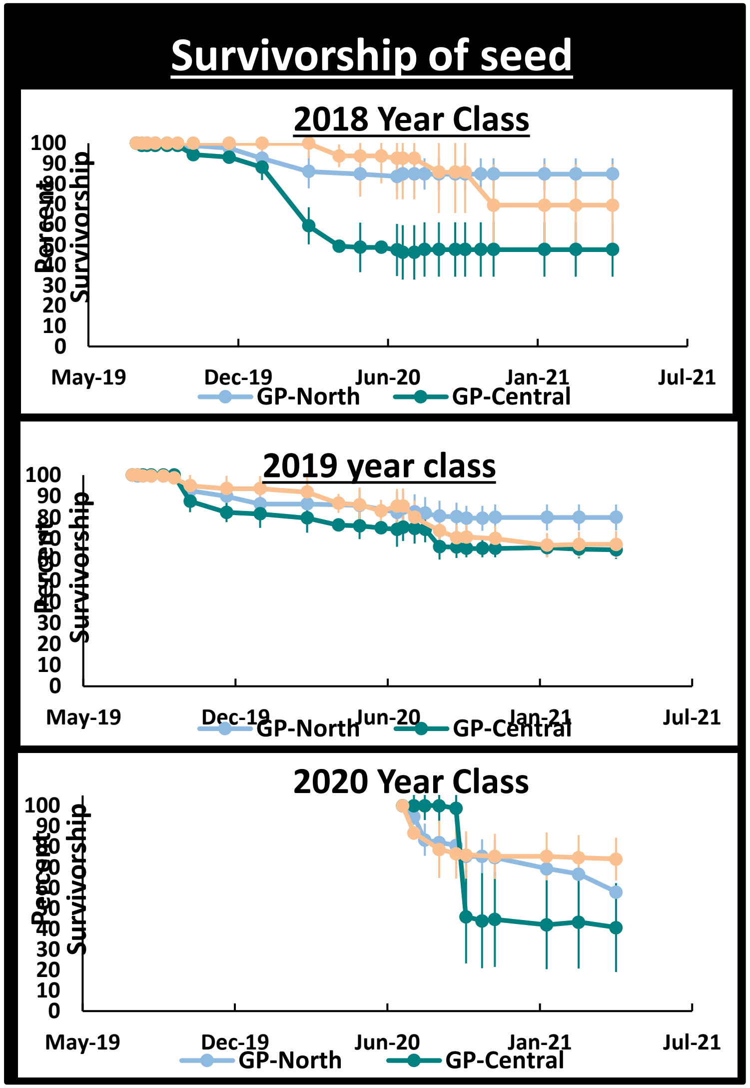
- Commenced in Summer 2020
- Added new cohort of oyster seed to cages
  - Smallest size added
- Added spat on shell
  - More natural oyster set
  - Exposed to predators
  - Packaged in mesh bags following techniques used for reef restoration

Phase 2 Results

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



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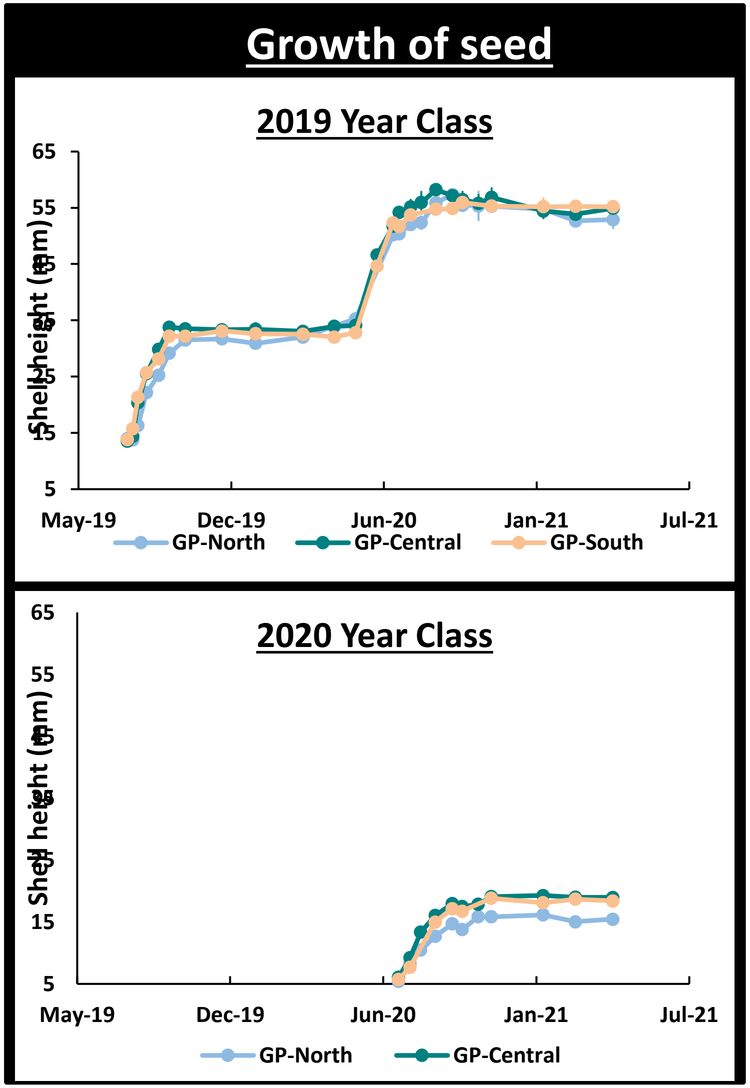
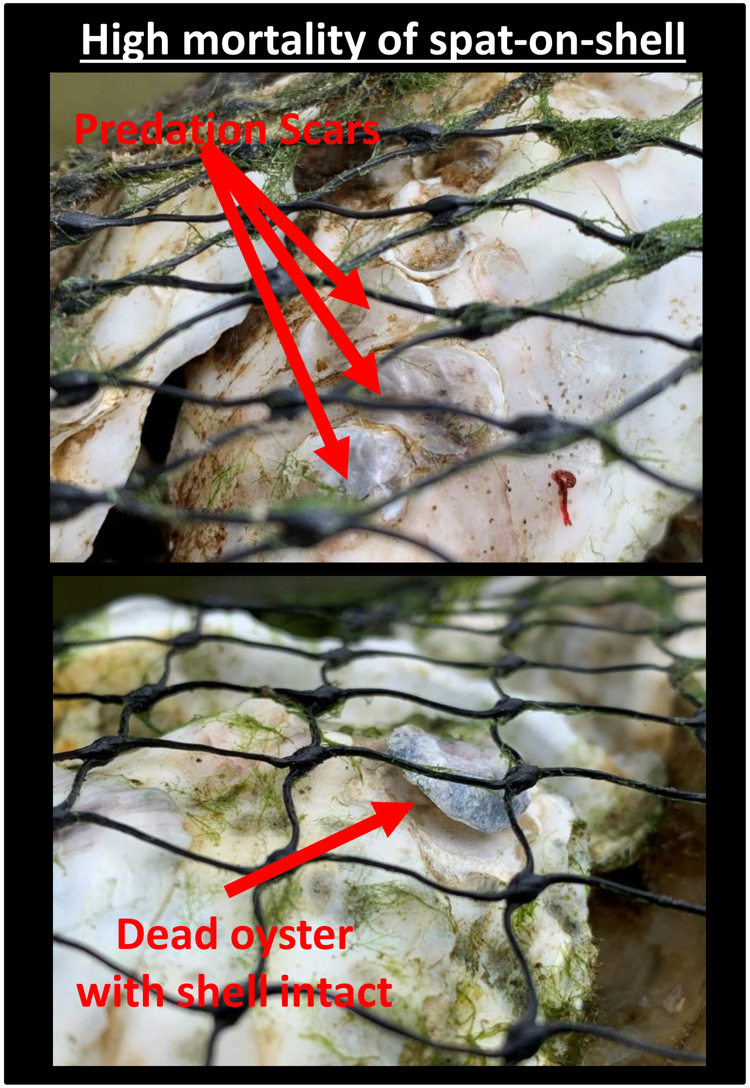
- Higher mortality of 2020 year class. Smaller seed more sensitive.
- 2020 year class grew less than 2019 year class during first year after deployment. May also reflect smaller starting size.



Phase 2 Results

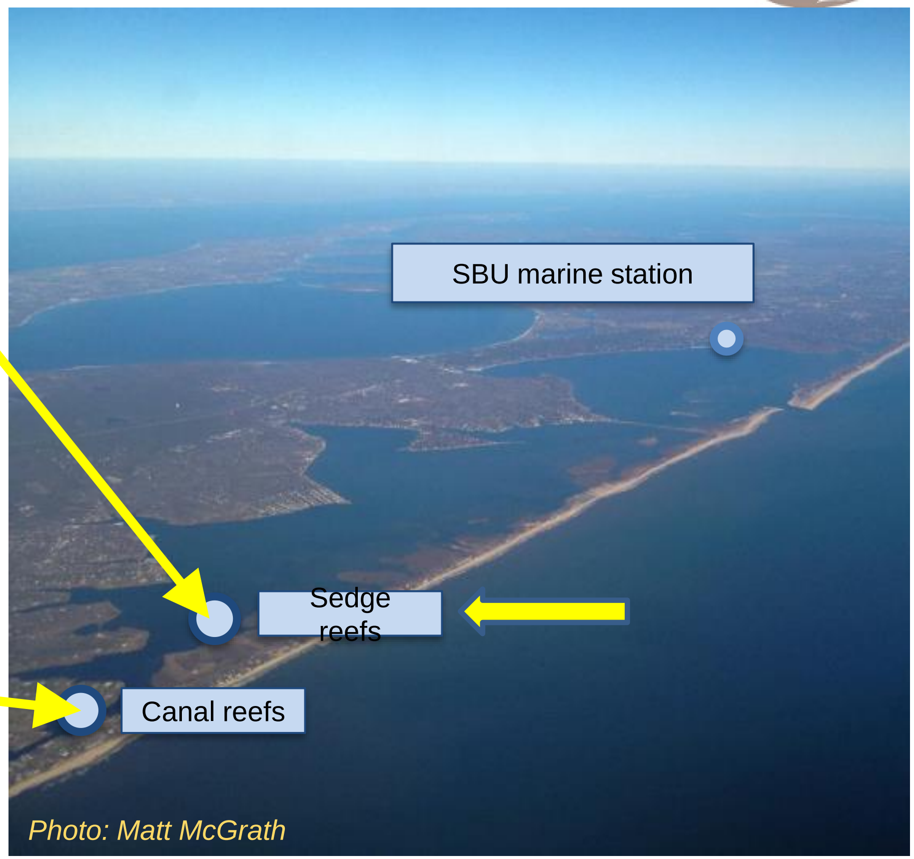
- Higher mortality of 2020 year class. Smaller seed more sensitive.
- 2020 year class grew less than 2019 year class during first year after deployment. May also reflect smaller starting size.
- High mortality of oyster spat-on-shell. May be due to low salinity when deployed, and/or blue crab predation



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.

First eight NYSDEC permitted oyster reefs in NYS constructed across western Shinnecock Bay, 2017 - 2021



Sedge reef, November 2020

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.
- Most of the nitrogen entering Georgica Pond comes from wastewater.
- Accelerating the removal of nitrogen from wastewater is the central long-term solution.
- Oysters and bioextraction via the harvester are effective short-term solutions.

<u>Acknowledgements:</u>

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

Thank you to the Gobler Laboratory crew: Michael Doall, Kevin Shaffer, Brooke Morrell, Jennifer Goleski, Mark Lusty, 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