

Tools to Measure the Water Quality Benefits Provided by Oysters and Other Bivalves

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Aquaculture Growers Forum

- November, 29 2023 -

What is an Eastern oyster?

- Marine bivalve
 - Canada through Gulf Coast
 - Found on reefs and farms



Oysters and Water Quality Benefits

- Suspension feeders
- Oysters are a tool in the nutrient mitigation toolbox
- 85% decrease in oyster reefs in the past 130 years
(Beck et al. 2011)





Scale of water quality benefits provided by oyster farms are not well understood.

Ecosystem Service Value

- Chesapeake Bay TMDL (Maryland and Virginia)

The screenshot displays the RIBITS (Regulatory In-lieu Fee and Bank Information Tracking System) web application. At the top, there is a header with the RIBITS logo (a green frog) and the system name. Below the header, a navigation bar includes links for 'Log In', 'Home', 'Help Desk', 'Webservices', 'NPS Projects', and 'NPS Project'. The main content area is divided into several sections:

- News Article:** A red 'Bay News' button is positioned over an image of oysters. The article title is '1st-Time Trad Oyster Invest' (partially visible). The byline reads 'By Bay Bulletin / May 12, 2020'. The article text begins with 'It may be the future of offsetting nu building and an oyster farming ope'.
- TRACKING:** A sidebar menu with radio buttons for 'Mitigation' (selected), 'WQT', and 'Both'.
- MENU:** A sidebar menu with links for 'Mitigation', 'Banks & Sites', 'ILF Programs', 'Umbrella Instruments', 'NRDA Projects', 'BLM Projects/Programs', 'Public Notices', 'Knowledge', 'Related Resources', 'Credit Classifications', and 'Bank & ILF Establishment'.
- Project Details:** A section titled 'Oyster Company of Virginia - Potomac' with the following information:
 - Chair: WQT
 - Instrument signed by:
 - Source: Non-point Source
 - Category: NPS
 - State: Virginia
 - Permit No.: Bay-001
 - Status/Date: Approved 12/08/2021
 - Project HUC: 02070011
- Google Map:** A small map window showing a satellite view of a coastal area.

- Bioextraction vs. Filtration



How can we use science to improve local water quality in the Mid-Atlantic and help farmers' bottom line?

Estimate how much “stuff” oysters filter from the water column: annually, seasonally, and daily.

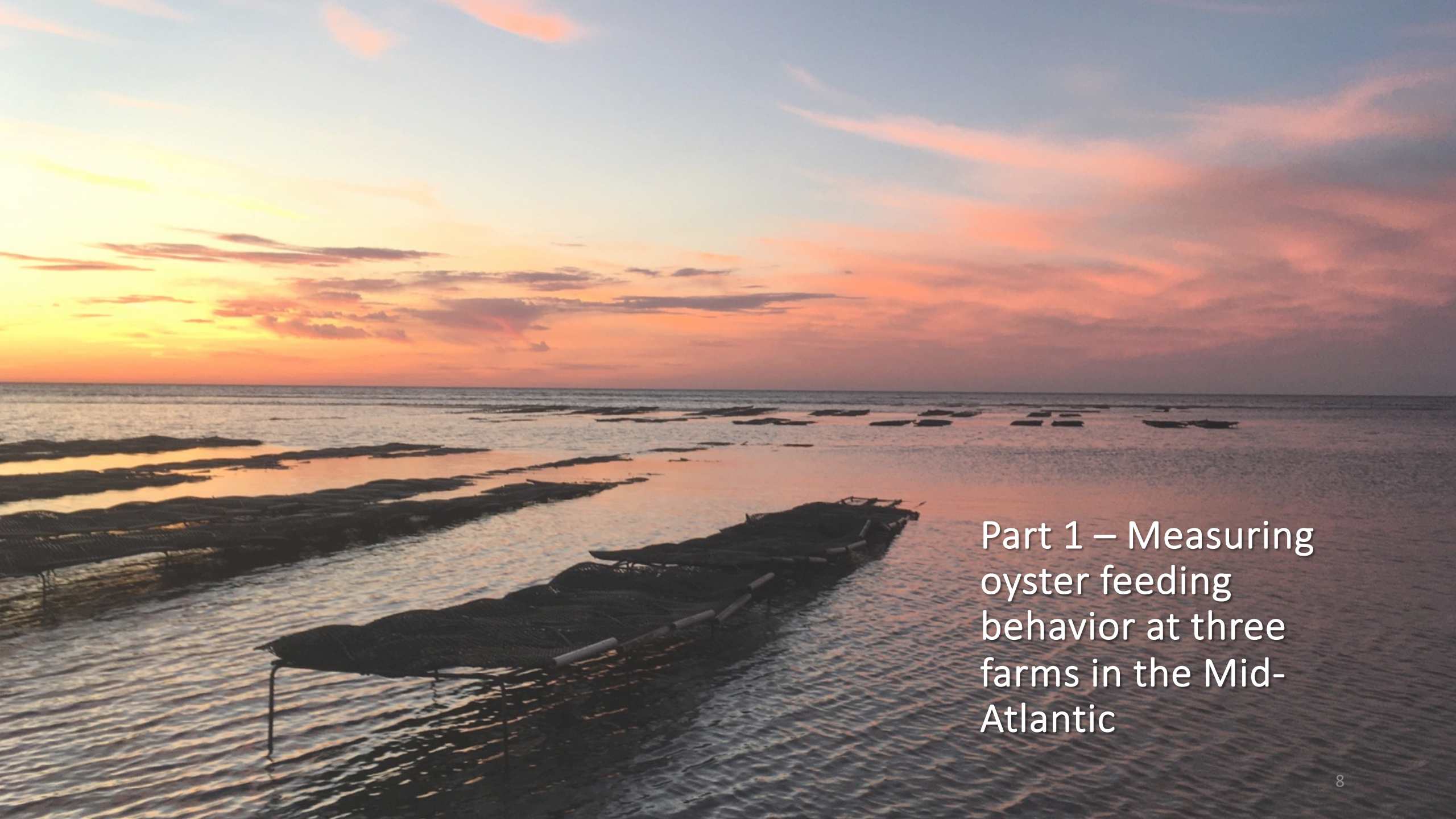
Presentation Overview

Part 1 – Measuring seasonal water quality improvement at **three oyster farms** in the mid-Atlantic.

Part 2 – Tools available for estimating water quality improvements generated by shellfish.

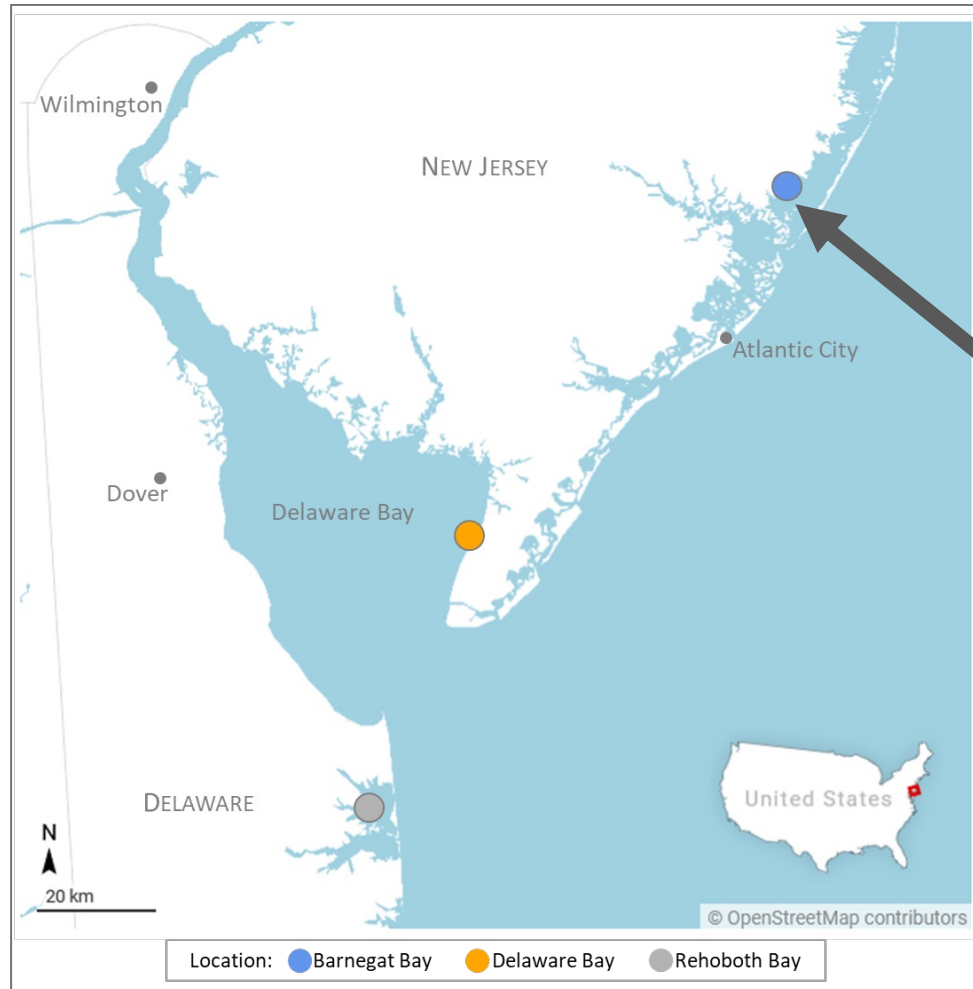
Part 3 – Next steps for the Rutgers Oyster Water Quality Benefits Calculator



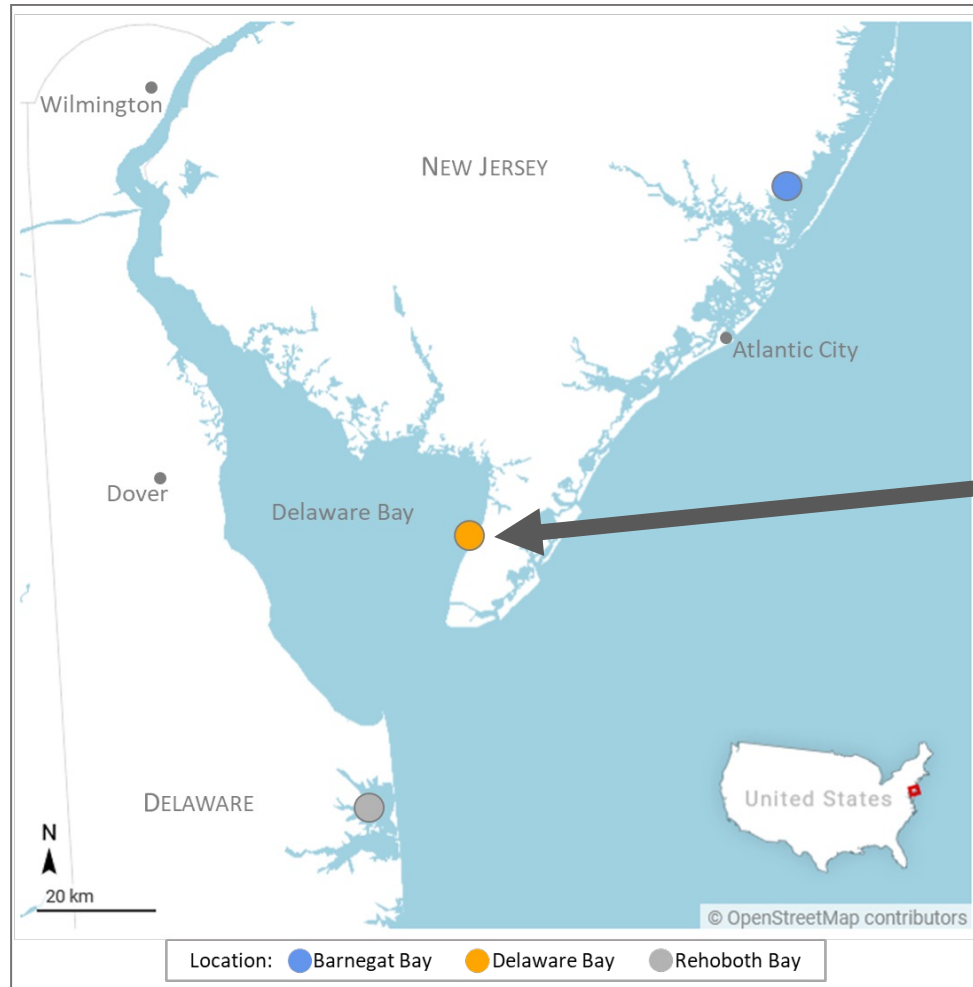


Part 1 – Measuring
oyster feeding
behavior at three
farms in the Mid-
Atlantic

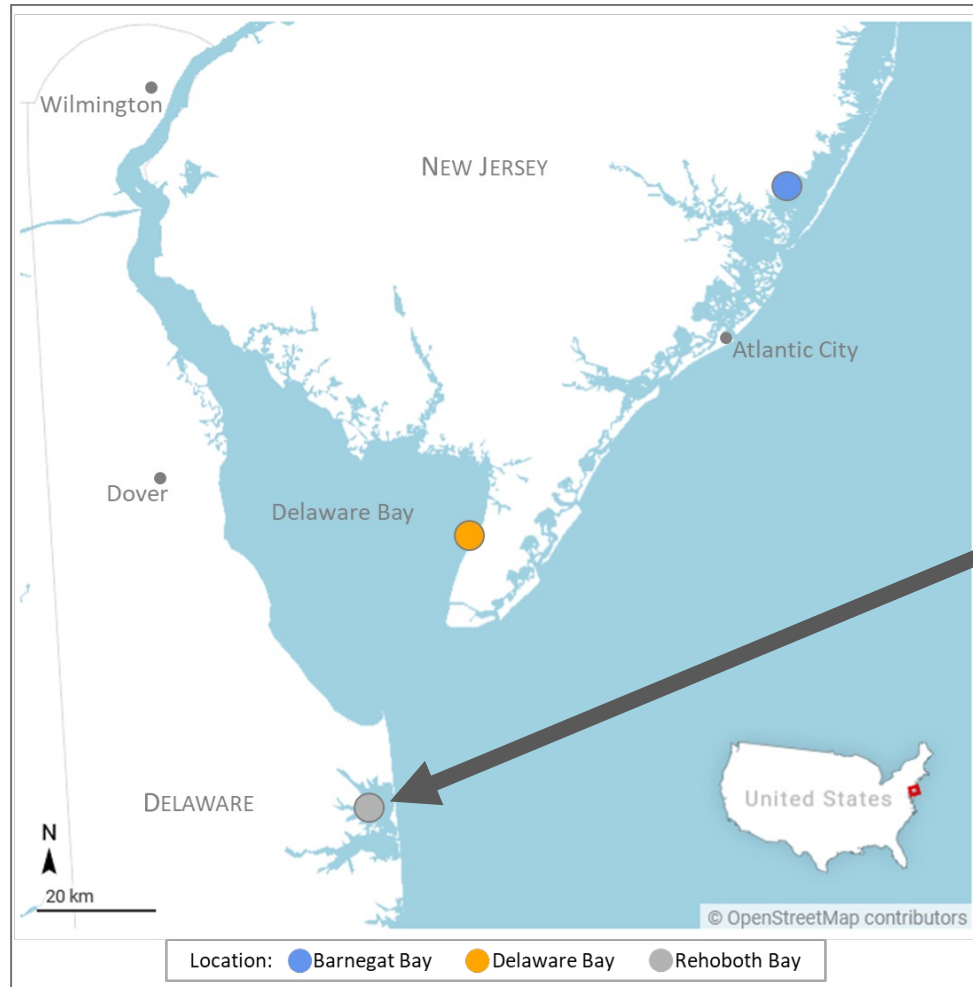
Farm Locations



Farm Locations



Farm Locations



Farm Locations

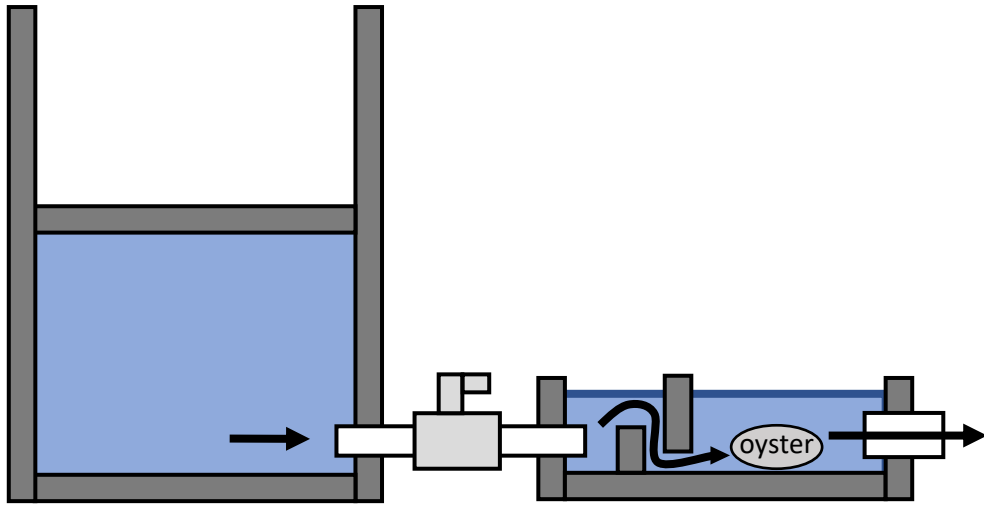


Barnegat Bay (n=3)

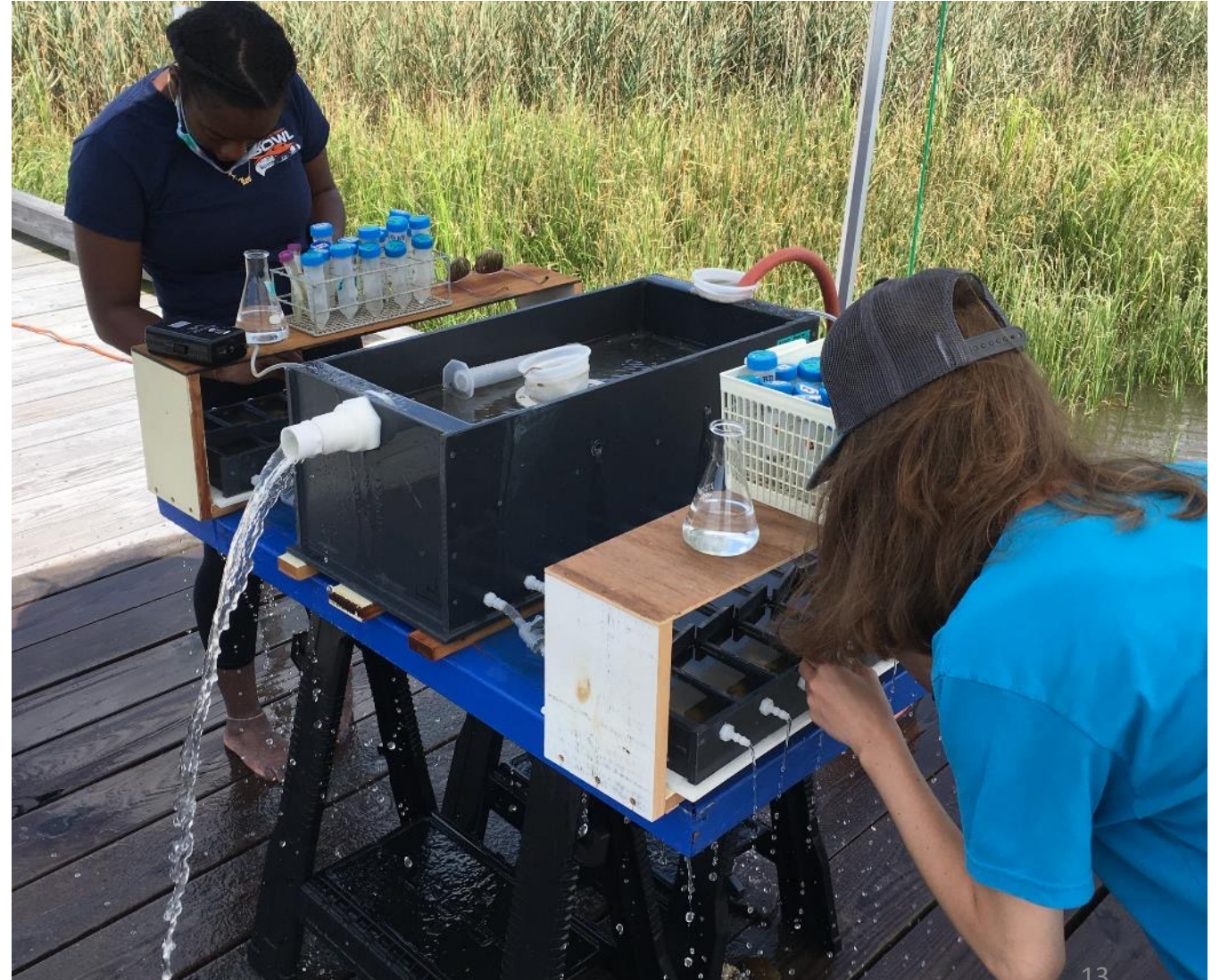
Delaware Bay (n=4)

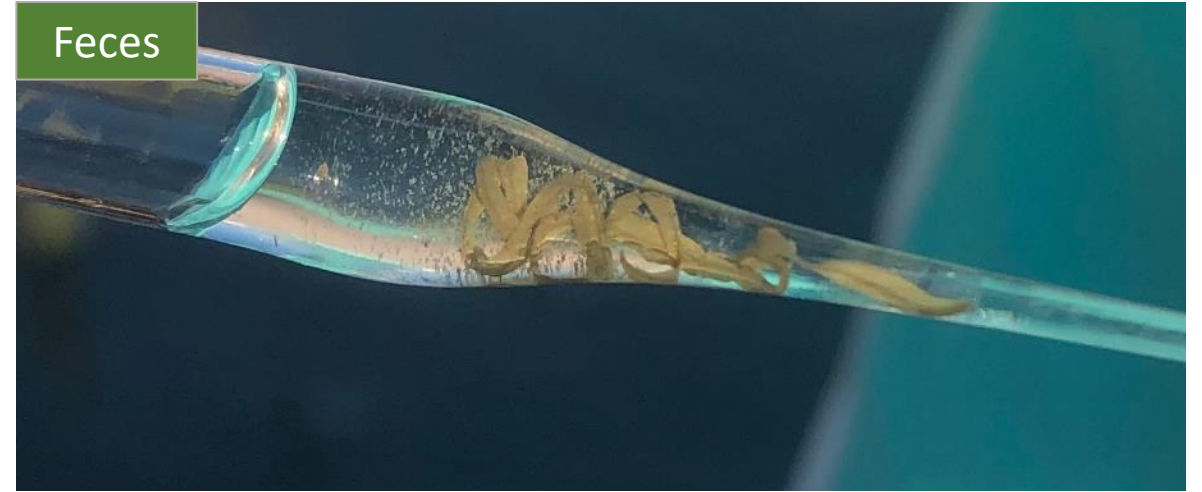
Rehoboth Bay (n=4)

Oyster Farm Methods



Galimany et al. 2018





Iglesias et al. 1998

Key Environmental Parameters

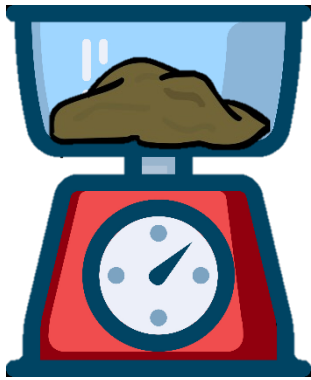
- Water Temperature (Temp)
- Salinity
- Total Particulate Matter (TPM)
- Organic Content of TPM (WC.Org)





Measuring time it takes oysters to digest food.

Key Physiological Parameters



Filtration Rate

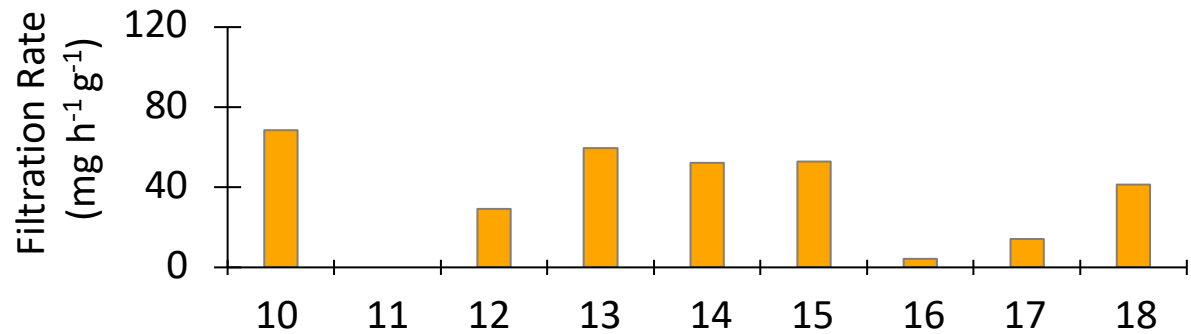
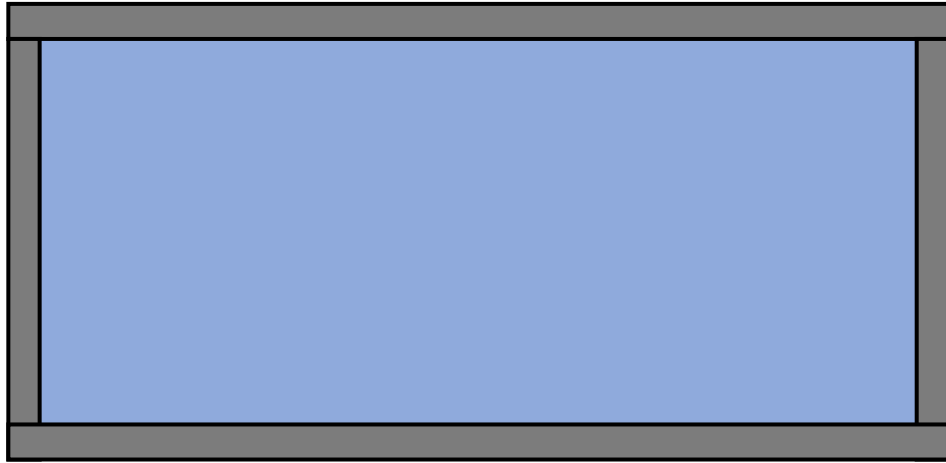
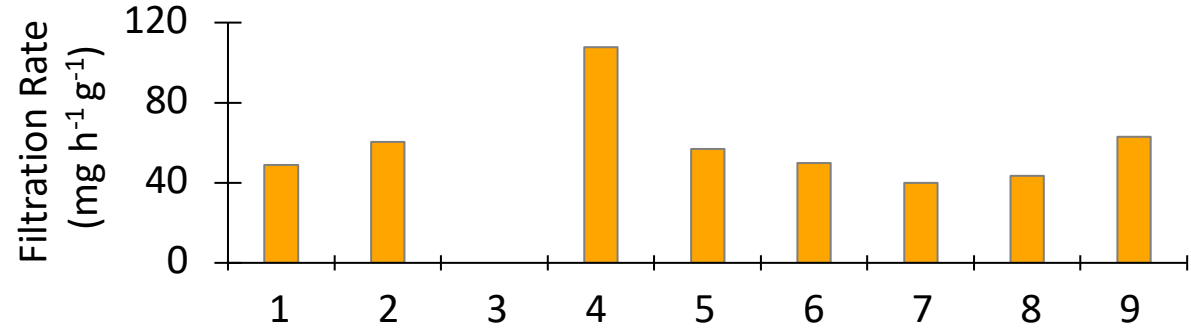
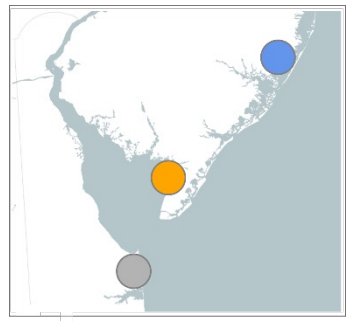


Clearance Rate

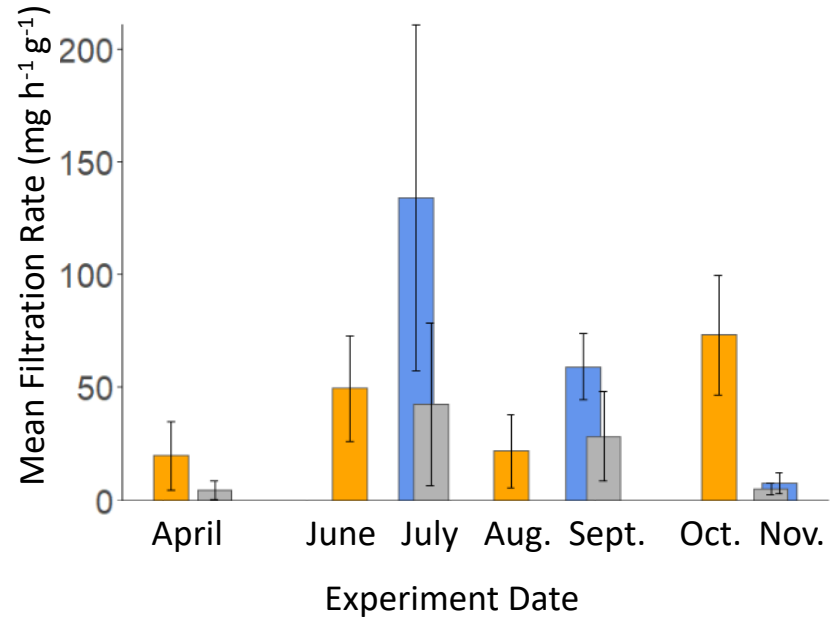
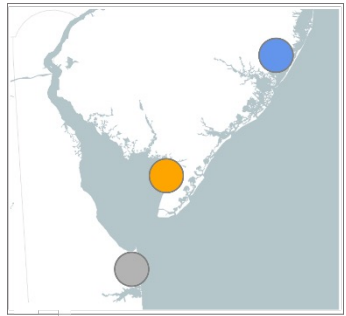


Biodeposit Rate

Delaware Bay Oysters - Filtration Rate

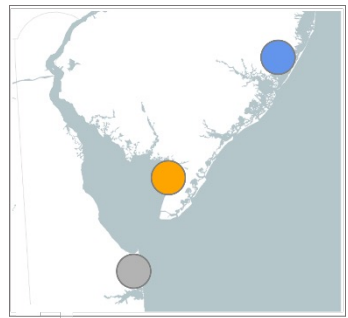


Results - Filtration Physiology



Location: ● Barnegat Bay ● Delaware Bay ● Rehoboth Bay

What was the estimated water quality impact of these farms?

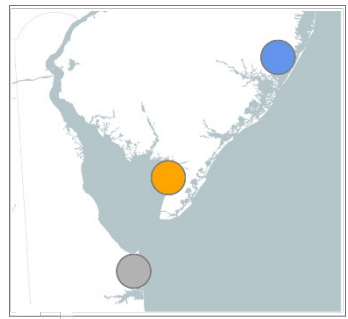


Farm Location	Number of Olympic Sized Pools Cleared (10 ⁹ L per yr)	Particles Filtered (tons per year)	Mass of Deposited Pseudofeces (tons per year)
Barnegat Bay	2.4	78.9	62.1
Delaware Bay	0.8	43.8	36.4
Rehoboth Bay	1.2	32.5	20.2

*water quality benefits estimated for a full calendar year

*last column is not total biomass production

How do these oysters compare to the often sited “an oyster can filter up to 50 gallons per day” stat?



Farm Location	Spring (gal day ⁻¹)	Summer (gal day ⁻¹)	Fall (gal day ⁻¹)
Barnegat Bay	----	16.8 (34.1)	3.5 (9.5)
Delaware Bay	5.7 (17.2)	3.4 (10.3)	4.3 (7.7)
Rehoboth Bay	1.8 (4.0)	9.4 (28.2)	3.2 (7.3)

*values reported as the mean and (maximum) volume of water cleared by individual oysters at each farm location and during each season



Part 2 – Tools for
estimating water
quality benefits
provided by shellfish

Existing Calculators – *The Farm Model*

Mussels ▾

Mussels

Clams

Cockles

IMTA

RUN THE FARM MODEL

Farm layout

Farm width	<input type="text" value="20"/>	m
Farm length	<input type="text" value="300"/>	m
Farm depth	<input type="text" value="10"/>	m
N° sections	<input type="text" value="3"/>	
Section volume	<input type="text" value="20000"/>	m3
Total animals	<input type="text" value="3000000"/>	ind
<input type="checkbox"/> Bottom culture		

Shellfish cultivation

Species	<input type="text" value="Mussels"/>	▾
Cultivation period	<input type="text" value="180"/>	days
Density (first box)	<input type="text" value="50"/>	ind. m-3
Density (middle box)	<input type="text" value="50"/>	ind. m-3
Density (last box)	<input type="text" value="50"/>	ind. m-3
<input checked="" type="checkbox"/> Use shellfish		
<input checked="" type="checkbox"/> Use population		

Environment

Water temperature	<input type="text" value="10"/>	oC
Current speed	<input type="text" value="0.05"/>	m s-1
Chlorophyll a	<input type="text" value="5.5"/>	ug L-1
POM	<input type="text" value="5"/>	mg L-1
TPM	<input type="text" value="50"/>	mg L-1
Dissolved oxygen	<input type="text" value="9.02"/>	mg L-1
ASSETS score	<input type="text" value="Good"/>	

Harvestable biomass

First box	<input type="text" value="-"/>	tons
Middle box	<input type="text" value="-"/>	tons
Last box	<input type="text" value="-"/>	tons
Total harvest (TPP)	<input type="text" value="-"/>	tons
Biomass ratio (APP)	<input type="text" value="-"/>	

Harvestable animals

Adults (first box)	<input type="text" value="-"/>	ind
Adults (middle box)	<input type="text" value="-"/>	ind
Adults (last box)	<input type="text" value="-"/>	ind
Adults (total)	<input type="text" value="-"/>	ind
Individuals (ratio)	<input type="text" value="-"/>	%

Environment

Chl a (first box)	<input type="text" value="-"/>	ug L-1
Chl a (middle box)	<input type="text" value="-"/>	ug L-1
Chl a (last box)	<input type="text" value="-"/>	ug L-1
Chl a (average)	<input type="text" value="-"/>	ug L-1
Chl a reduction	<input type="text" value="-"/>	%
D.O. (minimum)	<input type="text" value="-"/>	mg L-1
D.O. (reduction)	<input type="text" value="-"/>	%
ASSETS score	<input type="text" value="-"/>	

Simulate now

Open a model

Please select... ▾



Save model

Existing Calculators – *University of Florida*

Florida Clam Farm Environmental Benefits Calculator

Enter county where your clam farm is located:

Brevard

Enter your **annual** clam farm production:

Number of littleneck (1" or greater) clams harvested

Number of buttons (7/8") clams harvested

Pounds of pasta (5/8") clams harvested
(calculator will convert to numbers)

Calculate

*estimates nitrogen removal and carbon sequestration of clams

*should be used as "a starting point" for understanding potential ecosystem benefits of clams

Existing Calculators – *The Nature Conservancy and NOAA*

Delaware Bay, NJ

To use the calculator, first select a bay location from our database. If using your own site, select the closest site within our database to load oyster mass formula and fish benefits data.

Select site

Reset data

BAY PROPERTIES ?

Bay Volume

12668400

1000m³

Residence Time

8

days

Temperature

22.18

°C

Current Reef Area

11471

ha

CURRENT OYSTER PROPERTIES ?

Mean Oyster Length

(< 76mm)

51.98

mm

Mean Oyster Length

(≥ 76mm)

86.7

mm

Mean Oyster Density

(< 76mm)

13.14

ind/m²

Mean Oyster Density

(≥ 76mm)

2.36

ind/m²

GOALS ?

Estuary Filtration Percent



50

%

Mean Oyster Length

Mean Oyster Length

An estimated **12%** of the bay is currently filtered by oysters. To increase the filtration of the bay to **50%** will require **0 ha (0 ac)** of restored habitat.

Filtration

Fish Production

ESTUARY FILTRATION ?



Estuary filter volume
66.0 B L/h

Historic filtration
24.0 B L/h (36%)

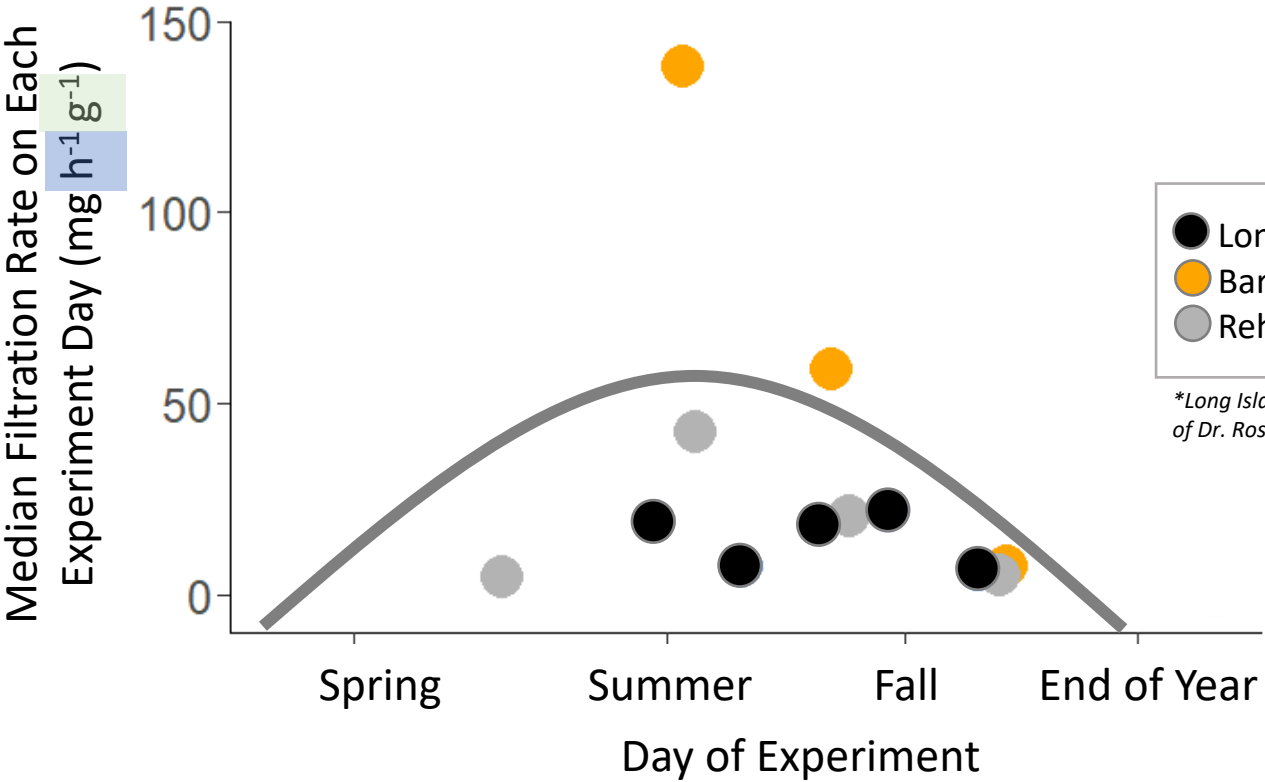
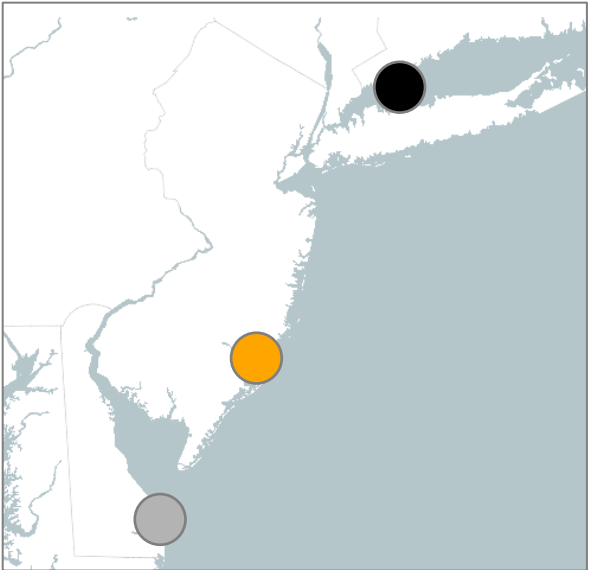
Current filtration
7.6 B L/h (12%)

Goal data, including estuary filtration goals and fish production, is not shown until at least one goal oyster length and density is entered. All calculations are estimates only, based on an extensive literature review.

Ecoregion
Virginian

Oyster mass to Length formula
Bushek unpublished data
 $0.00003 * \text{Length}^{2.4503}$

Rutgers Oyster Eco-Serve Calculator - Methods



Milligrams of “stuff” an oyster filters **per hour** per gram of try tissue weight



each day for all the oysters on a given farm



Part 3 – Next Steps

- Gather input on, and publish, the calculator
- Develop calculator 2.0



ACKNOWLEDGEMENTS



Existing Calculators

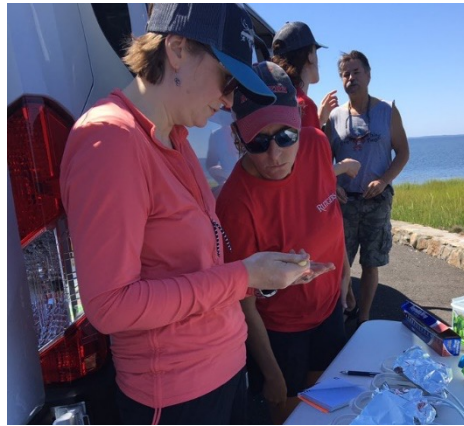
- The Farm Model - <http://www.farmscale.org/>
- University of Florida - <https://shellfish.ifas.ufl.edu/farm-benefits-calculator/> (and background information here: <https://shellfish.ifas.ufl.edu/environmental-benefits/>)
- The Nature Conservancy and NOAA - <https://oceanwealth.org/tools/oyster-calculator/>

Research and Calculator Team

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- Laura Steeves
- Lisa Calvo
- Julie Rose
- Gary Taghon

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Dr. Sarah Borsetti
Elizabeth Bouchard
Iris Burt
Taylor Dolan
Jaime Haggard
Ari Horgan
Emma Huntzinger
Rebecca Lucero
Grace Jackson
Emily Manuel
Joe Nichols
Joey O'Brien
Chris Roan
Miranda Rosen
Gab Rosenthal
Ailey Sheehan
Patty Woodruff
Zhenwei Wang
Dan Zeng



Collaborators and Funders

Collaborators

- Farmers:
 - Shaughn Juckett and Brian Harman
 - Marc Zitter
 - Mark Casey and Brent Hott
- Research Space:
 - Tracey Vance of West Bay Water Front Community
 - Sam Ratcliff of Rutgers Cape Shore Lab
 - Danica and Jeff Stetler of Boat World Marina
- Research Vessel:
 - NJDEP and the crew of R/V James W. Joseph
- Colleagues:
 - Rutgers' DMCS and the Haskin Shellfish Research Lab
 - Partnership for the Delaware Estuary
 - Dr. Danielle Kreeger, Kurt Cheng, and Leah Morgan
 - NOAA Northeast Fisheries Science Center
 - Genevieve Barnatchez and Dr. Shannon Meseck

Funders



Grant No.
1633557



Thank you!!

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