



Mussels for Clean Water Initiative: Progress and Next Steps

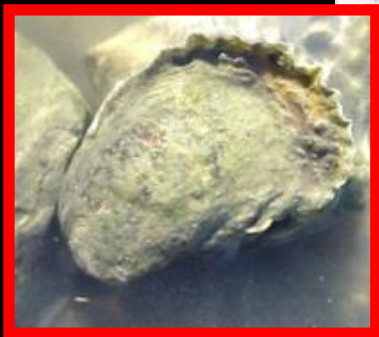
Danielle Kreeger

***Healthy Bivalves =
Healthy Watersheds***

>60 Bivalve Species

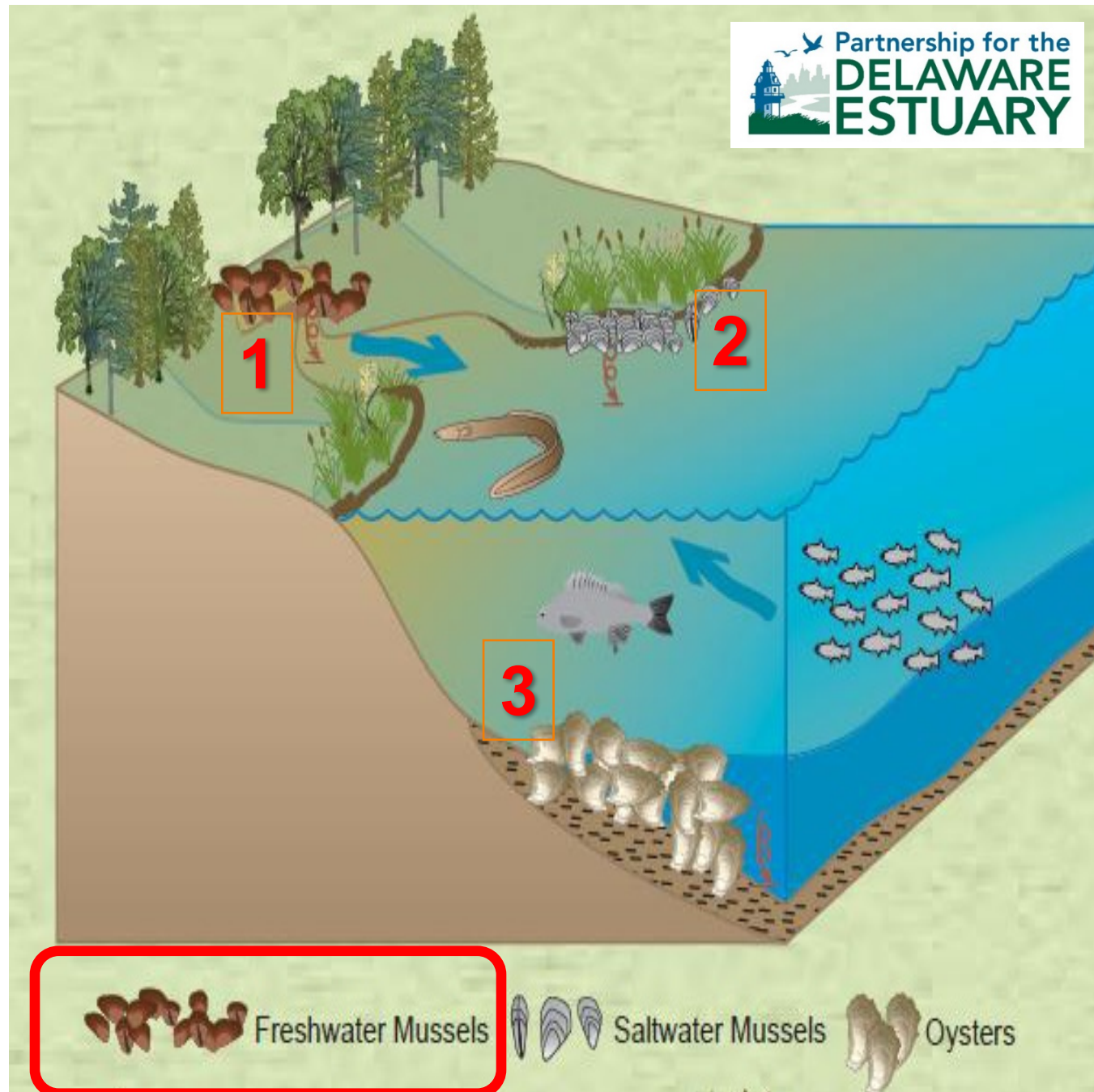


Delaware Basin
Chesapeake Basin

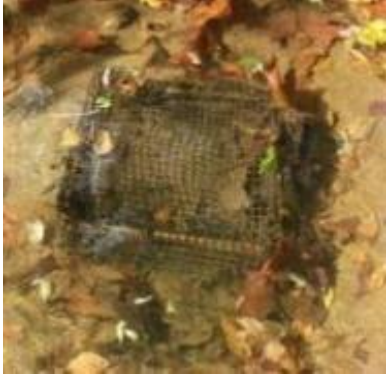


Headwaters to Ocean Shellfish Restoration

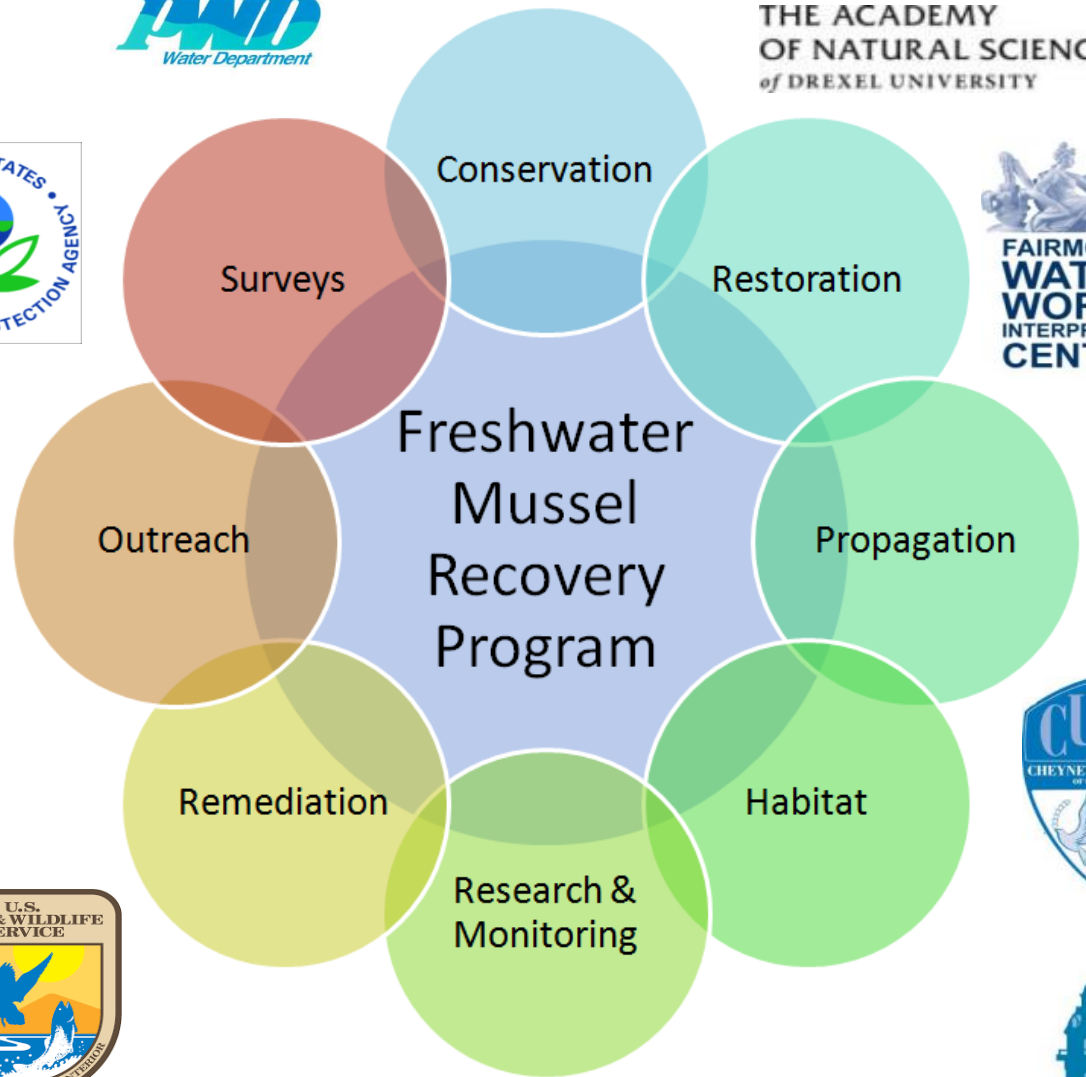
1. Non-tidal
2. Intertidal
3. Subtidal



Freshwater Mussel Recovery Program (FMRP)



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OF NATURAL SCIENCES
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Surveys

Determine current population status

Identify areas for Conservation

Identify areas for Restoration

Identify broodstock sources for propagation



Surveys – Tidewater Muckets (*Leptodea ochracea*)



July 19, 2018
Delaware River

Sept. 23, 2019
Delaware River

Surveys – Tidewater Mucklets (*Leptodea ochracea*)

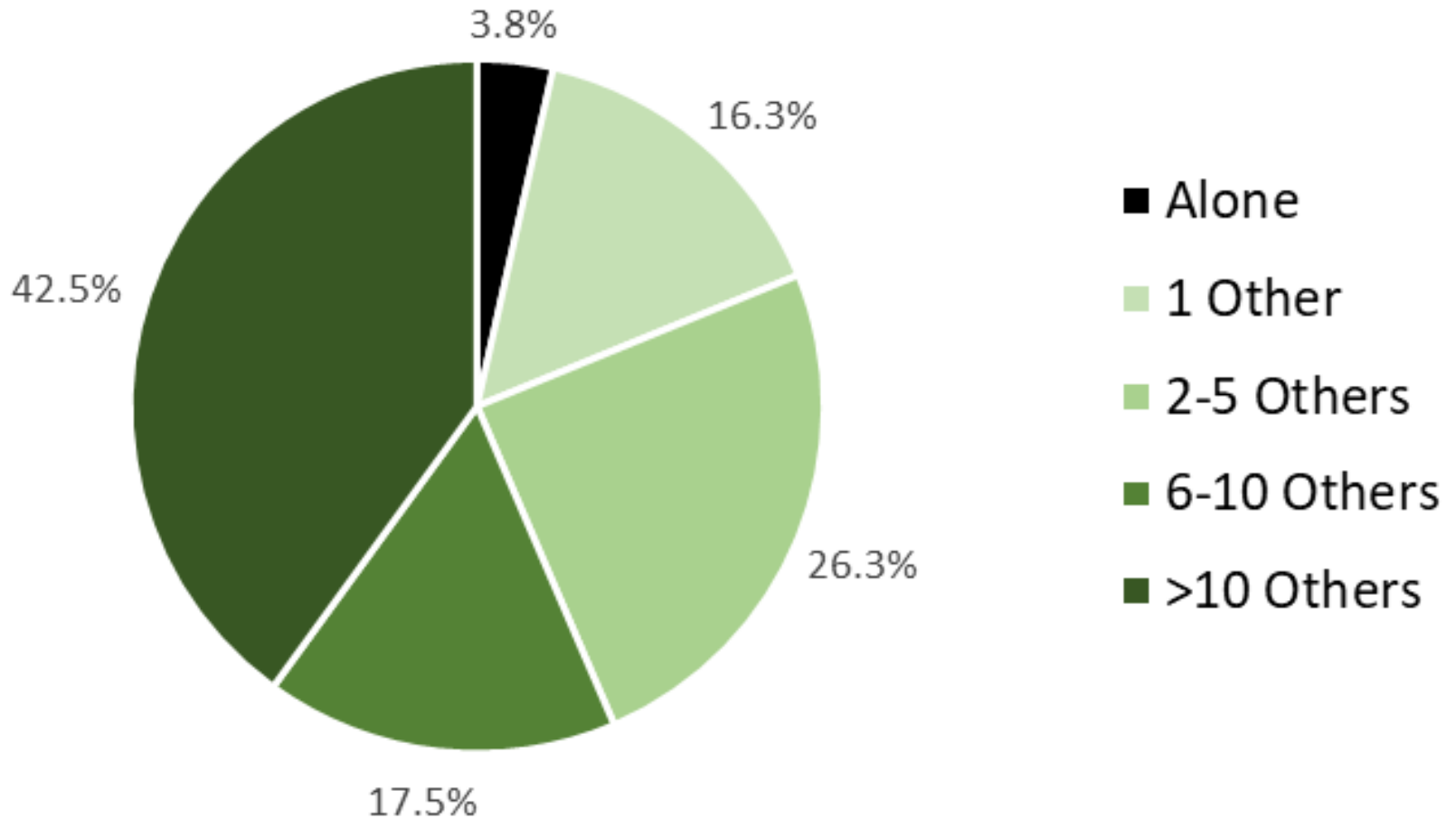


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OF NATURAL SCIENCES**
of DREXEL UNIVERSITY



Surveys – Tidewater Mucketts (*Leptodea ochracea*)

Leptodea ochracea Incidence in Quadrats

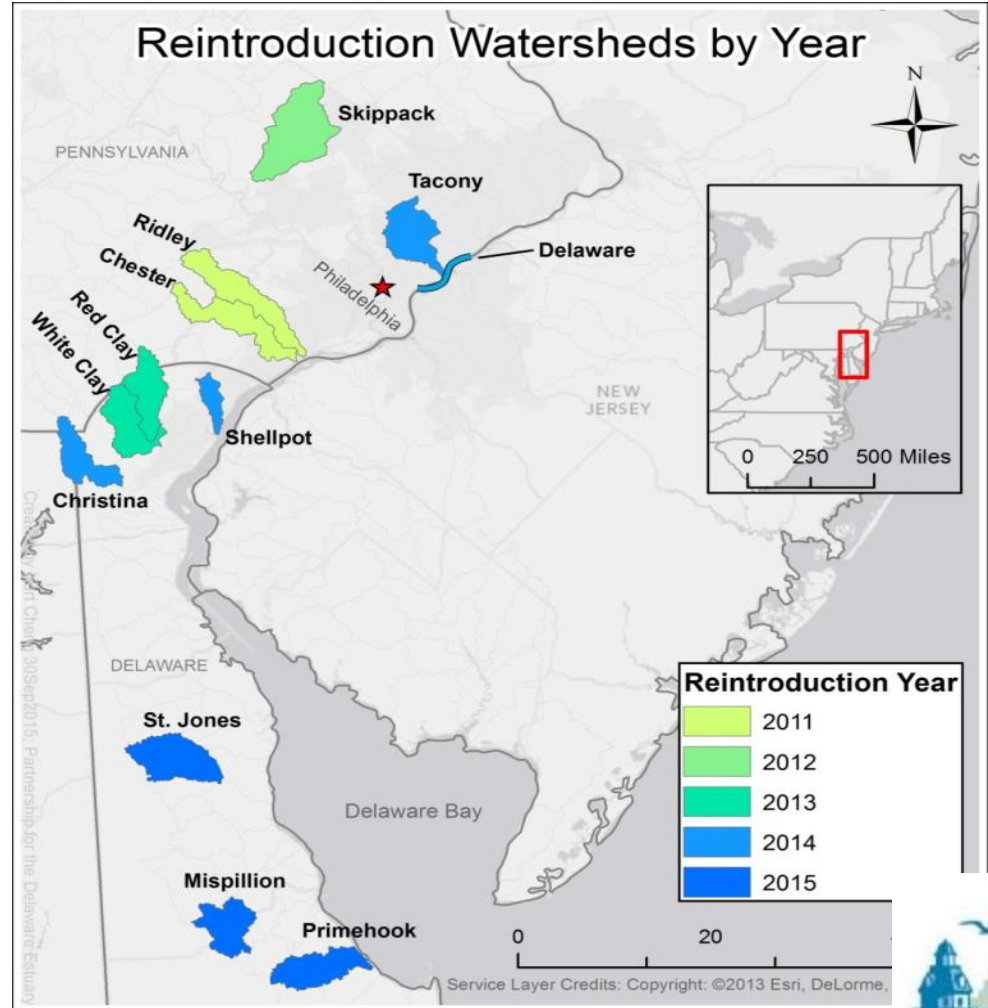


Restoration Via Reintroduction

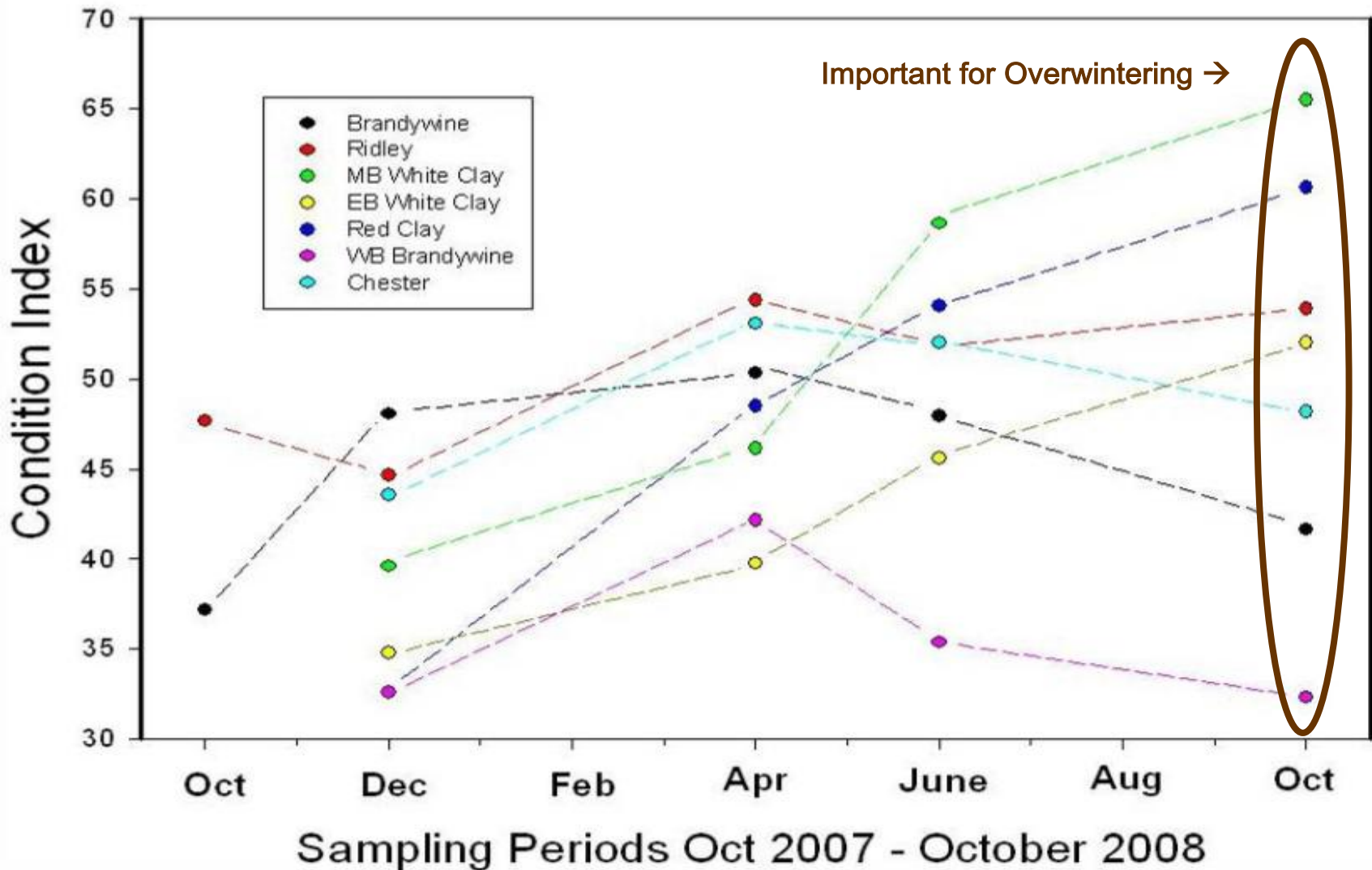
Utterbackiana implicata



Elliptio complanata



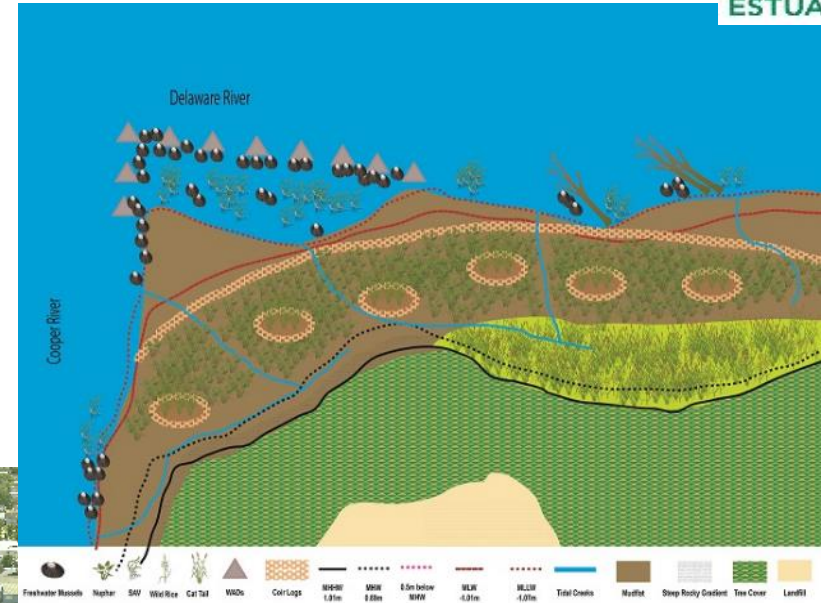
Condition Index Over 1 Year



Restoration via Habitat Enhancement



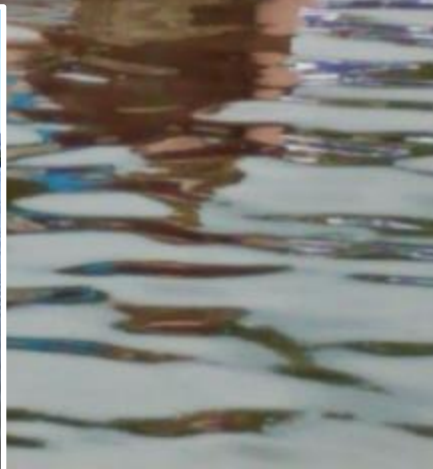
Urban Living Shorelines Include Mussel Beds



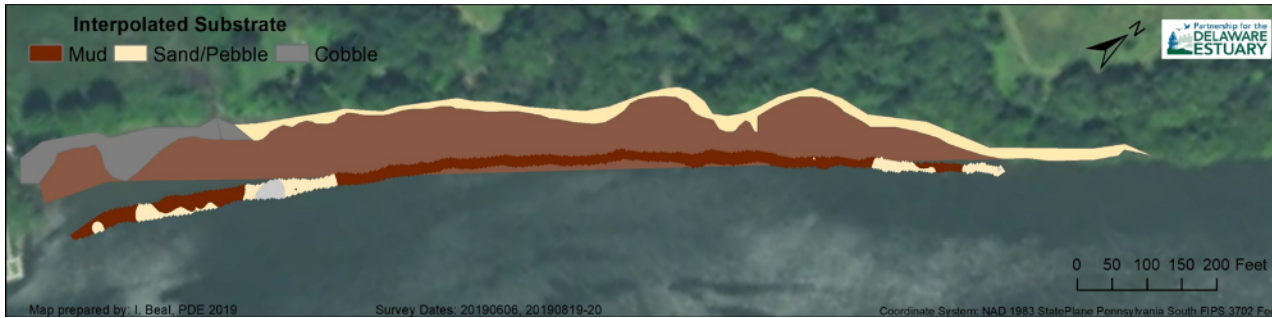
North Camden, NJ
South Camden, NJ
Schuylkill River, PA
Delaware River, PA
Wilmington, DE

Surveys – Candidate Living Shoreline Sites

August 19, 2019
Bartrams Gardens
Tidal Schuylkill River

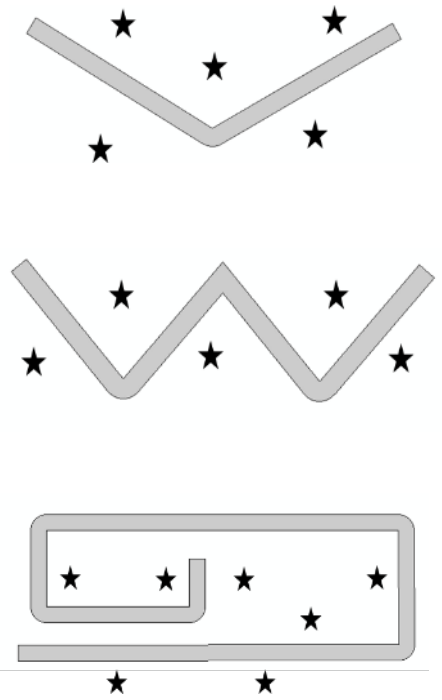


Bartram Gardens Living Shoreline

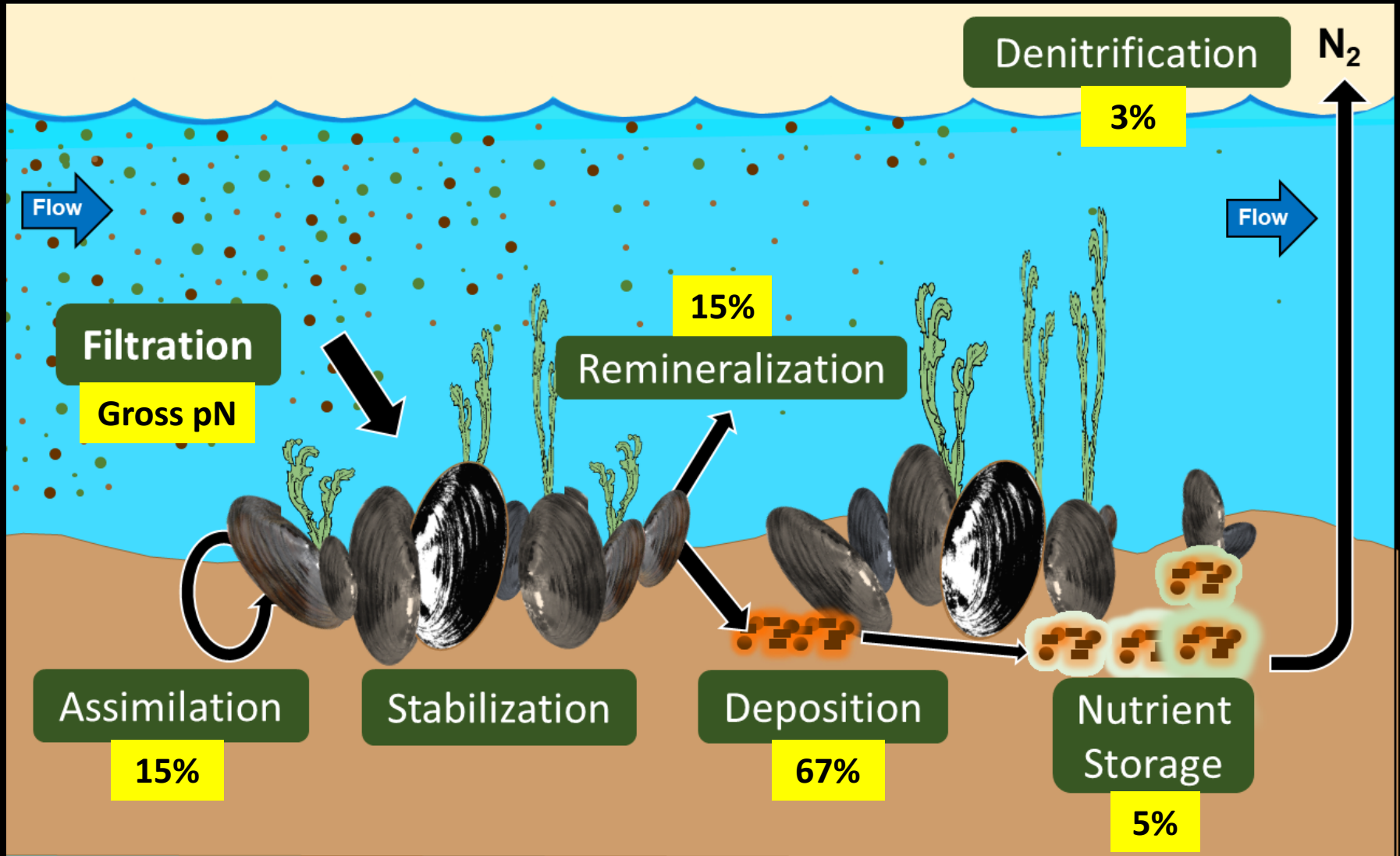


Pilot Installations in 2020

Mussel Pens



Research: Gross versus Net?



Flux

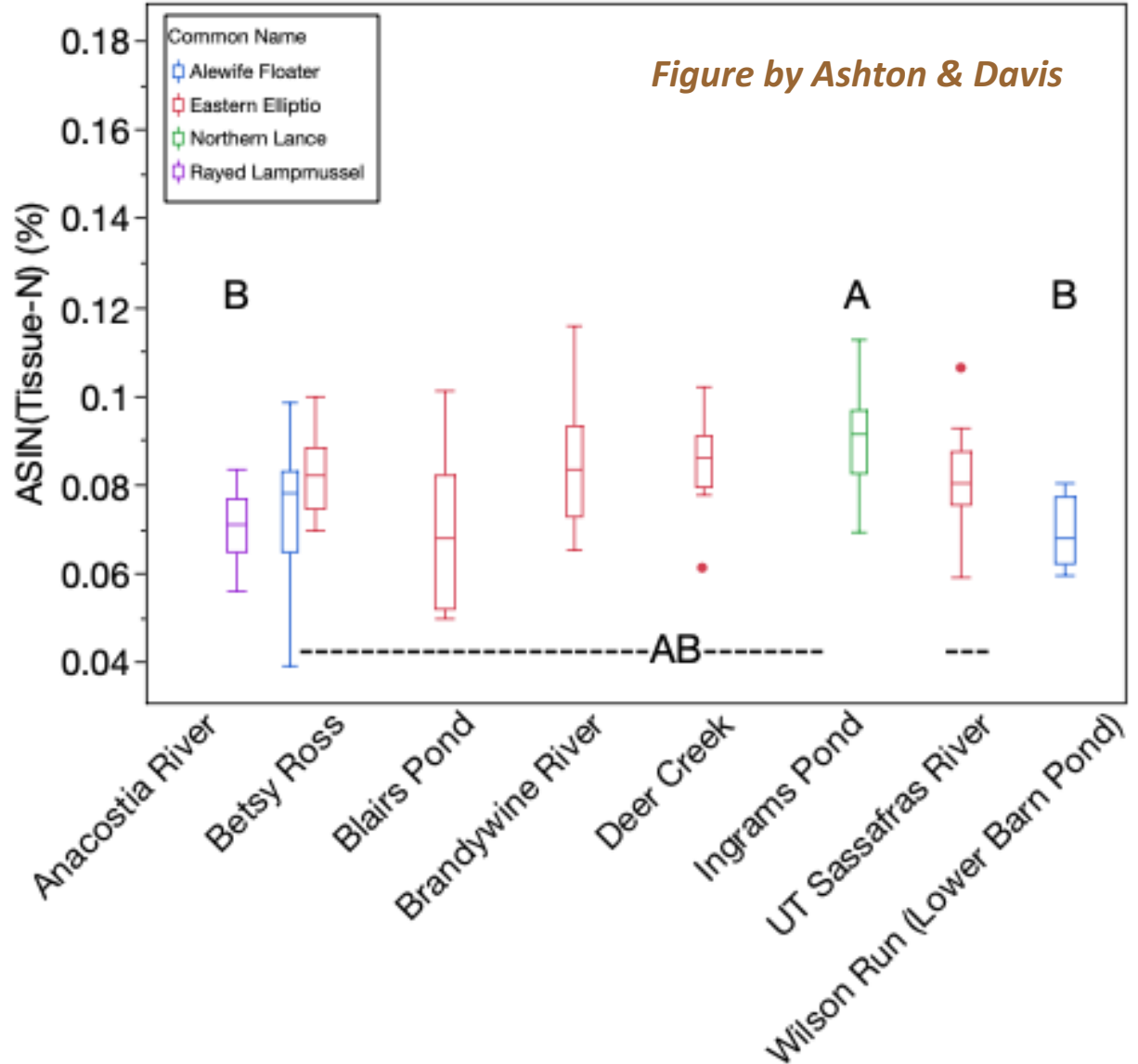
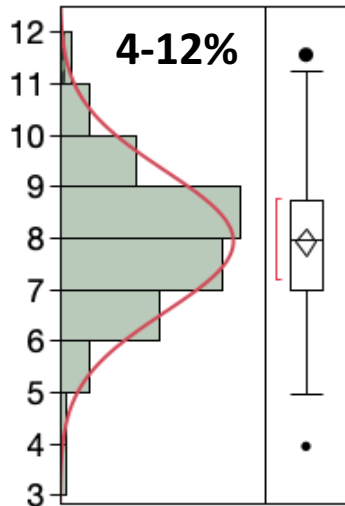
Research – Nitrogen Removal Rates



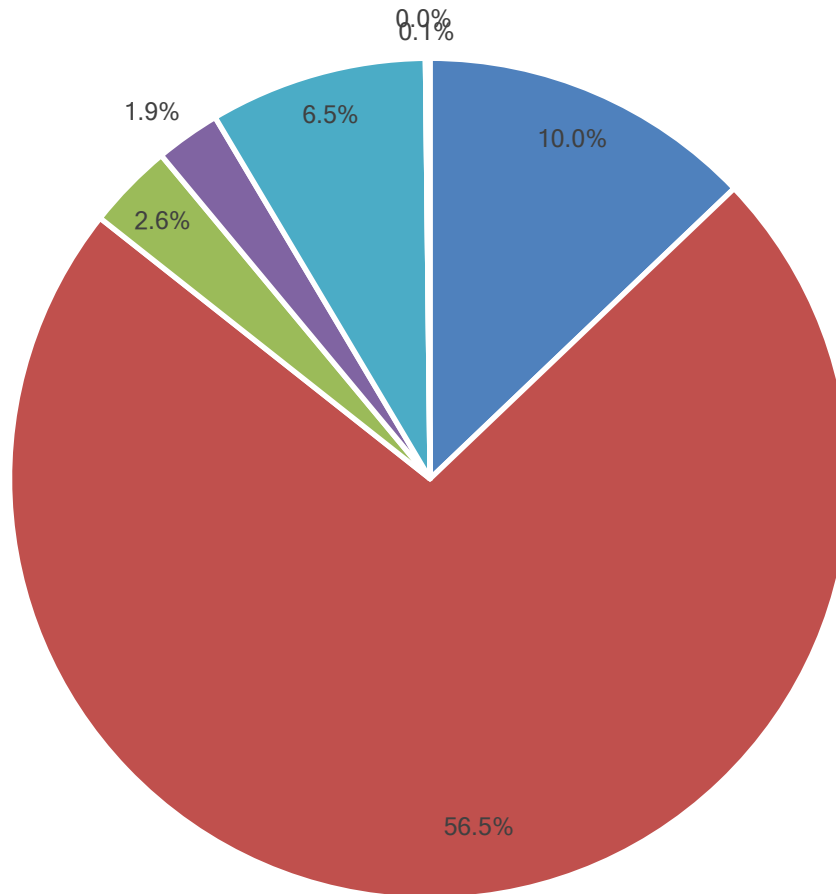
N in Mussel Tissues and Shells

In Progress by

Matt Ashton, MD DNR
Megan Davis, MD DNR
Matt Gray, Univ of MD
Danielle Kreeger, PDE



Gross versus Net Nutrient Removal



■ Recycled as Ammonia

■ Recycled via Feces

■ Recycled via
Tissues/Gametes

■ Lost as Feces
Dentrification

■ Lost as Feces Burial

■ Lost as Tissue Burial

10,000 mussel seed over 30 years -> 729 pounds net N removal

Mussel Outreach: Clean Water Benefits



March Mussel Madness

Lincoln Financial Field, 3/21/19



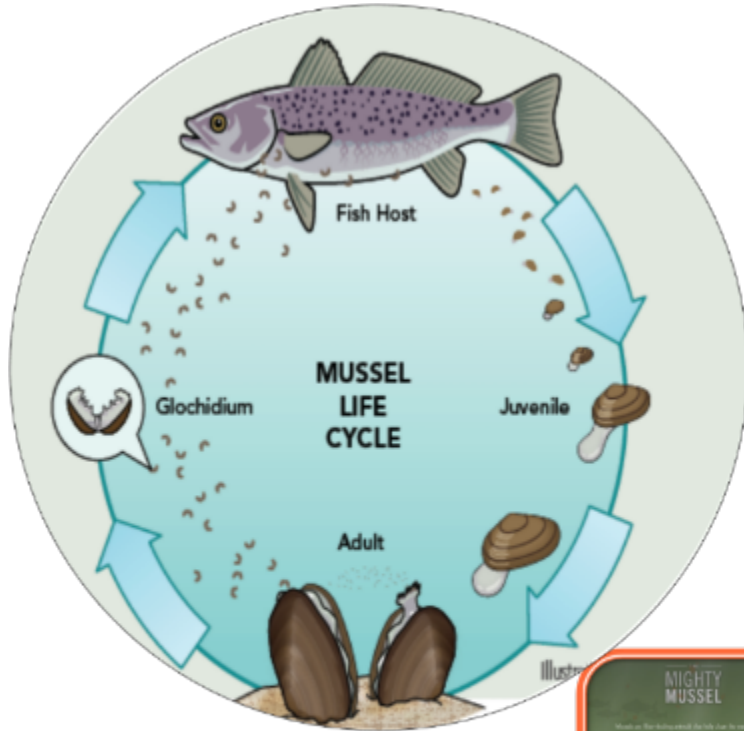
River Fest

Philly and Camden, 9/7/19



Bottleneck = Mussel Supply

Mussel Propagation Research & Outreach

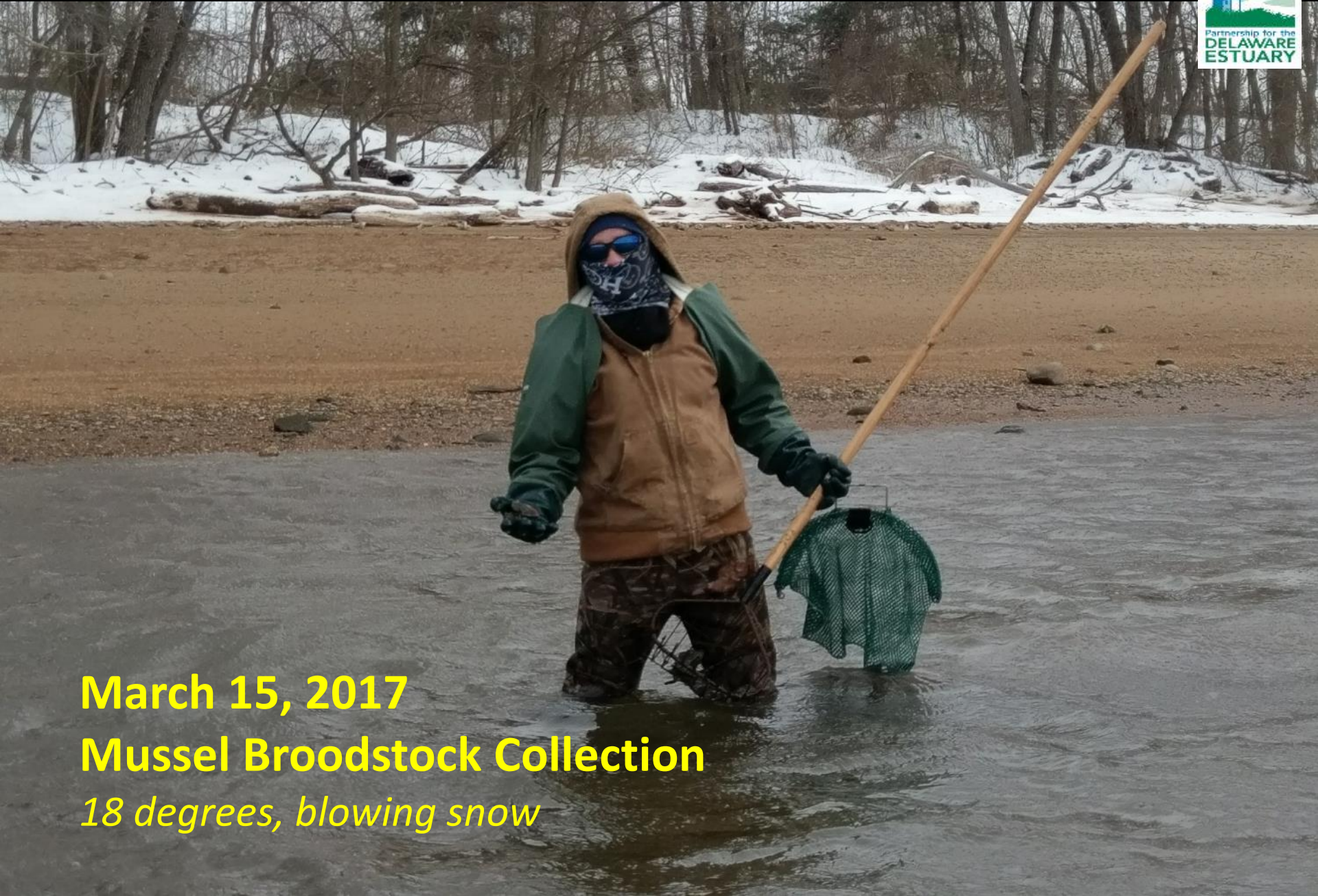


Demonstration
Hatchery at
Fairmount
Water Works



<http://www.mightymussel.com/>

Propagation

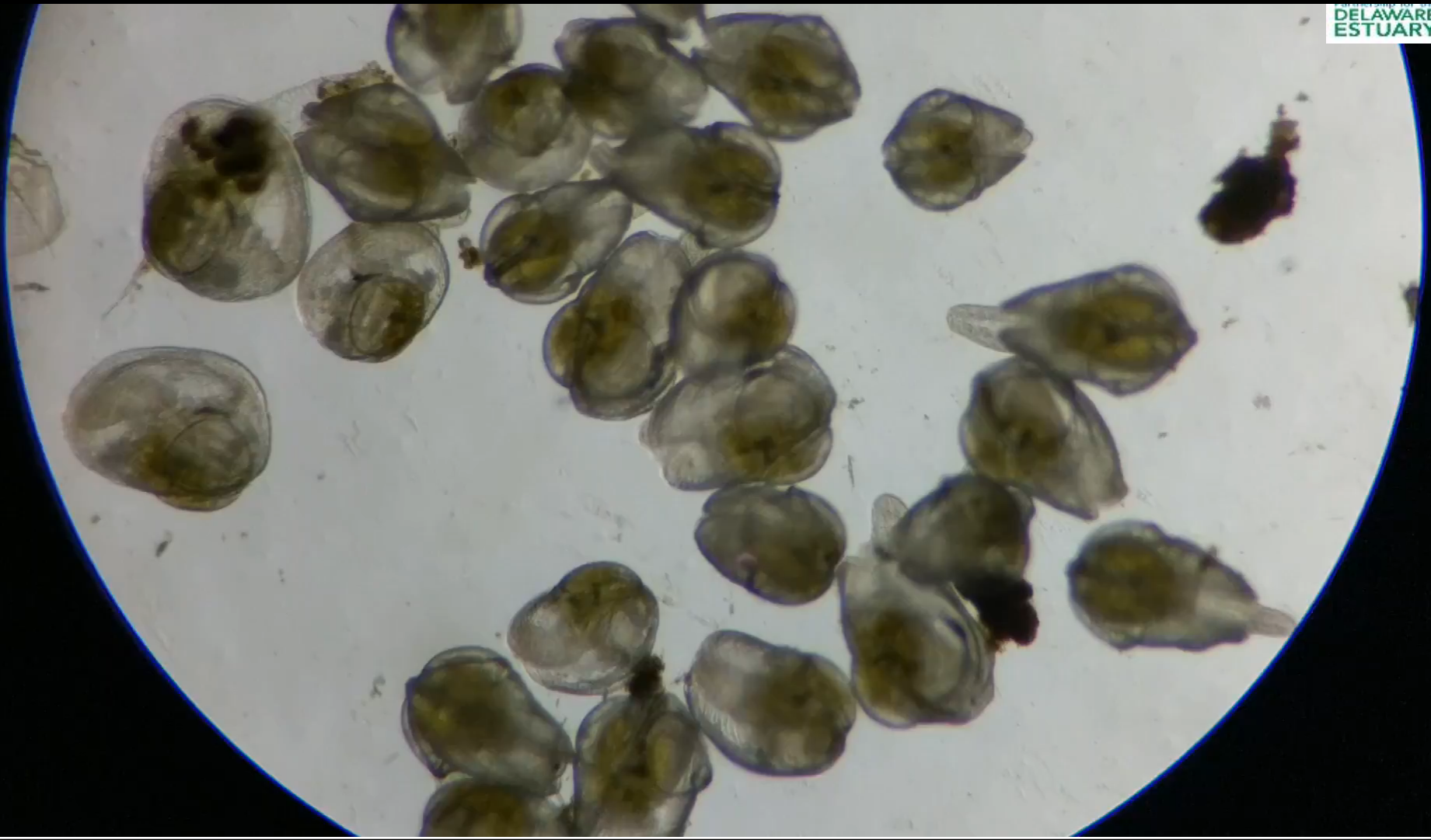


March 15, 2017

Mussel Broodstock Collection

18 degrees, blowing snow

Propagation – Juvenile Alewife Floaters



Pond Rearing Trials



Mussels in Floating Baskets

Pond Rearing Trials

Partnership for the
**DELAWARE
ESTUARY**



July 20, 2017
Juvenile Mussels

Pond Rearing Trials

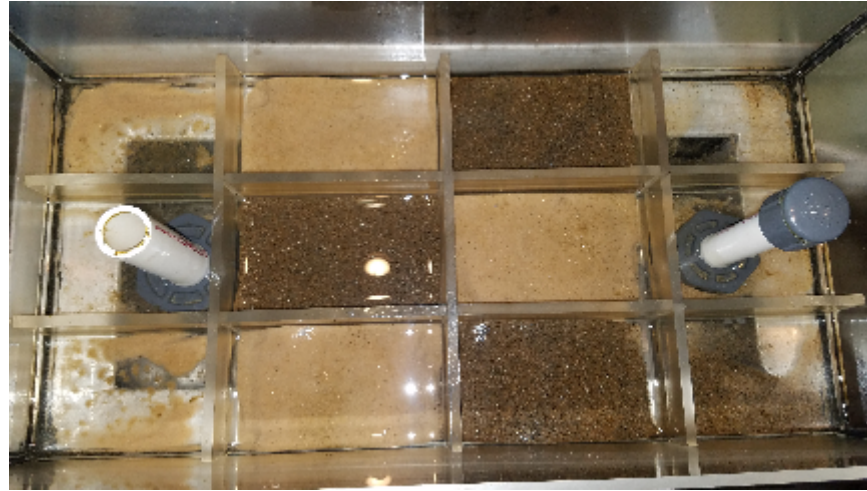


Sept. 9, 2017

5-Month Old Juveniles Compared to Old Adults

Mussel Propagation & Restoration

With PWD
FWW Hatchery



**New
Culture
Systems**

5 Species in 2019:

Elliptio complanata

Ligumia nasuta

Utterbackiana

implicata

Lampsilis cariosa

Leptodea ochracea



Mussel Propagation & Restoration

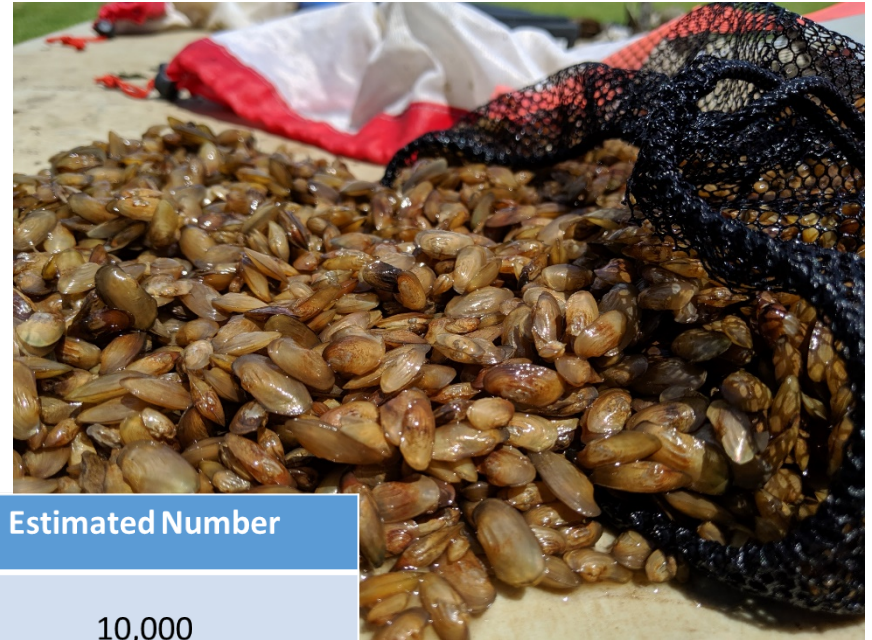
With USFWS

Harrison Lake NFH

2 Species in 2019:

Ligumia nasuta

Utterbackiana implicata




Date Received	Species	Size	Estimated Number
May 9, 2019	UTIM	500 um	10,000
May 9, 2019	LINA	500 um	20,000
May 24, 2019	UTIM	1 mm	1,800
May 24, 2019	LINA	1 mm	1,200
July 24, 2019	UTIM	5-15 mm	38,000
July 24, 2019	LINA	5-15 mm	17,000

Mussel Rearing – 2017 Progeny



Growth Comparisons in Ponds

Site	Basket #	Deployed #	Start SL (mm)		End SL (mm)		Trial Days	Daily Growth (mm)	Survival (%)
			Mean ± SEM	N	Mean ± SEM	N			
Seaport Museum	1	100	32.1 ± 0.74	100	50.7 ± 1.2	43	67	0.28	43
Green Lane Reservoir							0.10	79	
Green Lane Reservoir							0.06	91	
Green Lane Reservoir							0.09	100	
Green Lane Reservoir							0.09	99	
Green Lane Reservoir							0.09	98	
Green Lane Reservoir							0.09	97	
Green Lane Reservoir							0.09	97	
Longwood-1							0.06	49	
Longwood-1							0.07	55	
Longwood-1							0.07	47	
Longwood-2							0.08	52	
Longwood-2							0.08	25	
Longwood-2							0.07	33	
Van Sciver Lake							0.09	59	
Van Sciver Lake							0.10		
Van Sciver Lake							0.11		
Winterthur-1							0.07	87	
Winterthur-1							0.06	81	
Winterthur-1							nd	nd	
Winterthur-2	1	1000	17.9 ± 0.32	100	36.0 ± 0.89	20	321	0.06	8
Winterthur-2	2	1000	18.9 ± 0.25	100	42.7 ± 0.90	20	321	0.07	32
Winterthur-2	3	1000	18.7 ± 0.30	100	35.9 ± 1.1	20	321	0.05	18

Mussel Rearing – 2017 Progeny



Growth Comparisons in Streams

Site	Silo #	Day 0		Day 113		Day 205		Mean Growth Rate (mm/day)		
		SL (mm)		SL (mm)		SL (mm)		Winter	Spring	Overall
		Mean ± SEM	N	Mean ± SEM	N	Mean ± SEM	N			
Ridley Creek	1	21.9 ± 0.91	25	22.2 ± 0.94	24	28.2 ± 1.17	16	0.003	0.07	0.03
Ridley Creek	2	24.3 ± 1.28	25	24.8 ± 1.29	25	29.3 ± 1.32	24	0.004	0.05	0.02
Ridley Creek	3	24.3 ± 1.29	25	24.9 ± 1.27	24	29.8 ± 1.44	19	0.01	0.05	0.03
Ridley Creek	4	22.1 ± 0.97	25	22.6 ± 0.97	25	30.0 ± 0.92	23	0.004	0.08	0.04
Skippack Creek	1	25.0 ± 0.90	25	25.4 ± 0.90	25	29.6 ± 0.86	24	0.003	0.05	0.02
Skippack Creek	2	26.2 ± 1.04	25	27.0 ± 0.93	24	30.6 ± 0.98	22	0.007	0.04	0.02
Skippack Creek	3	24.1 ± 1.03	25	23.9 ± 1.02	25	27.7 ± 1.06	25	0.000	0.04	0.02
Skippack Creek	4	25.5 ± 1.04	25	25.7 ± 1.05	25	29.0 ± 1.01	24	0.002	0.04	0.02
Tacony Creek	1	26.7 ± 0.84	25	27.9 ± 0.74	25	28.2 ± 0.98	17	0.01	0.003	0.01
Tacony Creek	2	24.3 ± 1.04	25	25.0 ± 0.97	24	28.3 ± 0.88	22	0.006	0.04	0.02
Tacony Creek	3	22.4 ± 0.80	25	22.4 ± 1.13	13	nd	nd	4 x 10 ⁻⁵	nd	nd
Tacony Creek	4	22.4 ± 0.84	25	22.6 ± 0.84	25	22.7 ± 0.80	24	0.002	0.001	0.002



Mussel Rearing – 2019 Progeny



Growth Comparisons



Currently:

Longwood Gardens
Green Lane Reservoir
Van Sciver Lake
Independence Seaport Museum

Outcomes:

- Reservoirs doing better
- Species growth is similar

Surplus Seed:

- Mussels in Classroom
- Mussel Gardening



MuCWI Strategy (contingent on partners and \$\$)

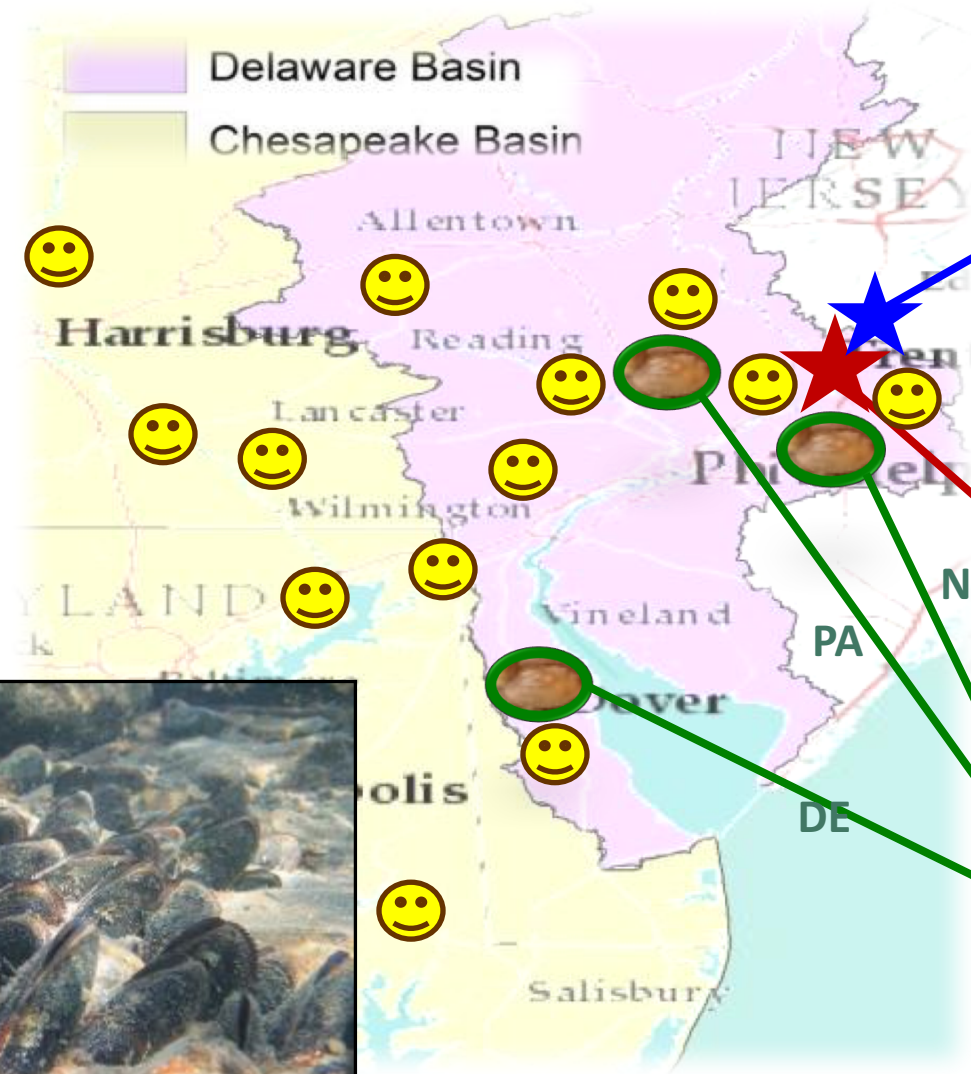


Exhibit Hatchery
(FWWIC, 2017)



Production Hatchery
(2023)



Pond Grow-Out

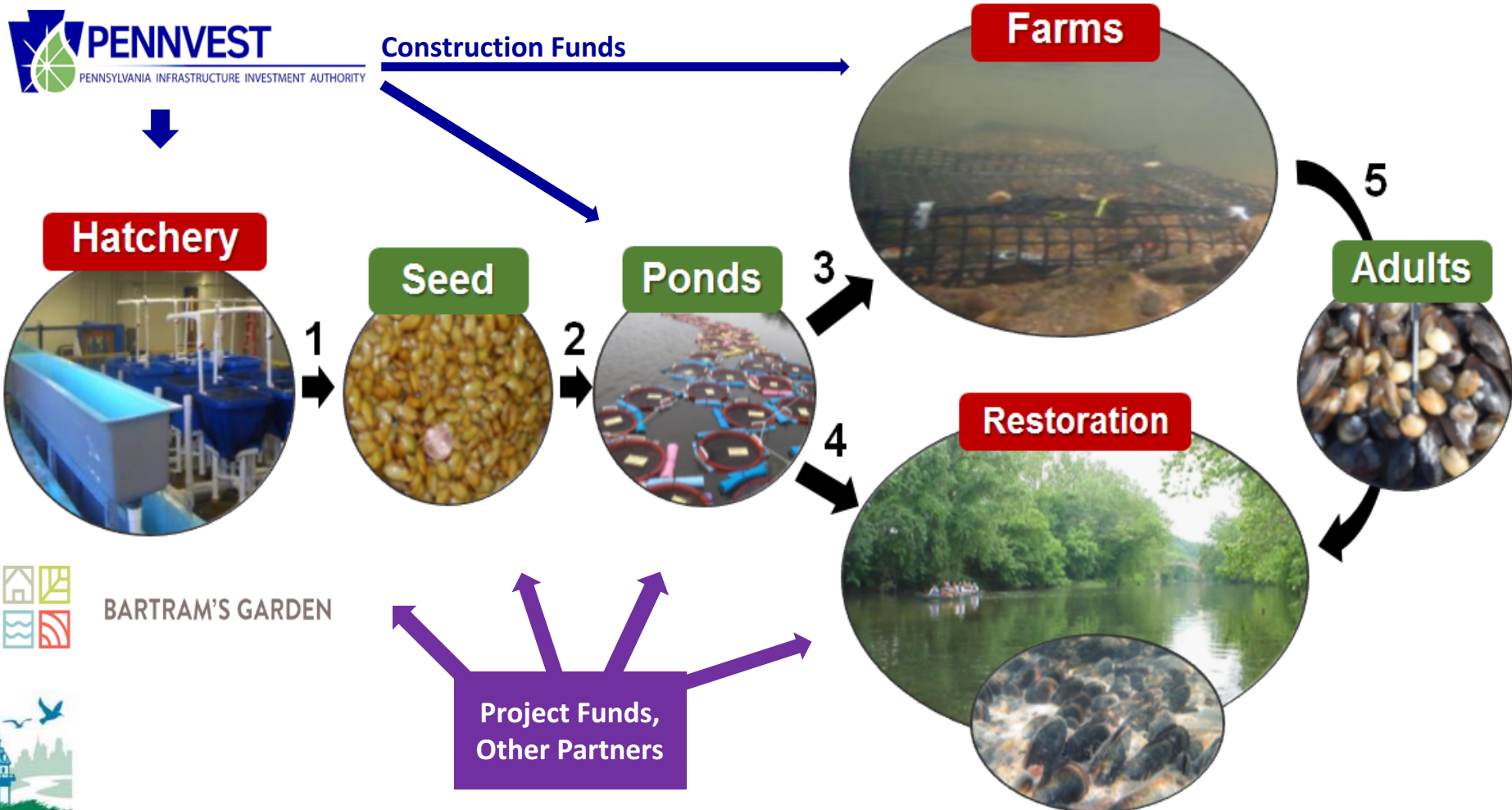


**Restoration
Targets**



THE MUSSELS FOR CLEAN WATER INITIATIVE OF THE DELAWARE AND SUSQUEHANNA RIVERS

WATER QUALITY ENHANCEMENT BY BEDS OF FRESHWATER MUSSELS



BARTRAM'S GARDEN



Partnership for the
DELAWARE
ESTUARY

AGREEMENTS

2019

TECH GROUP

2020

TECH GROUP,
DESIGN RFP

LEASE

Q1

LEASE AGREEMENT

Q2

DESIGN

Q3

Q4

2021

Mussels for Clean Water

2019-2022

4 Year Plan

BREAK
GROUND

Q4

Q3

Q2

Q1

2022

CONSTRUCTION

CONSTR. FIRM,
CONTRACT

CONSTR.
RFP

FINALIZE DESIGN

Q1

Q2

Q3

Q4

FINISH

2023

CONSTRUCTION

ORDER EQUIPMENT

INSTALL EQUIPMENT

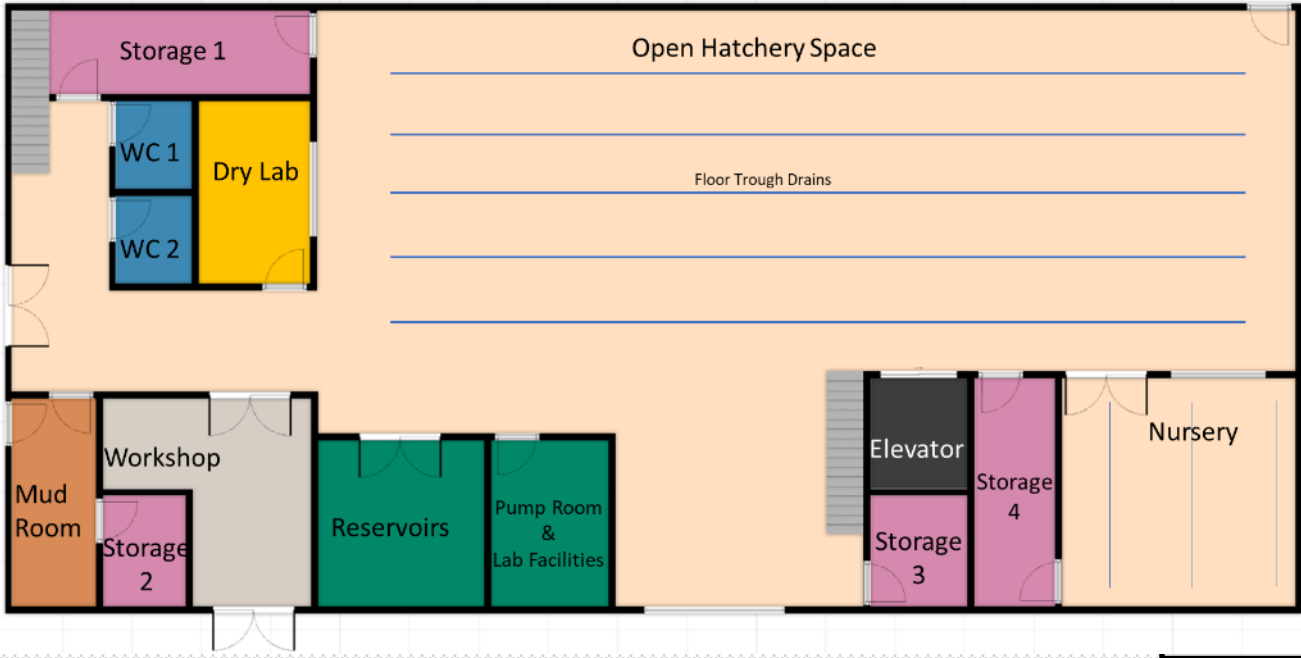
OCCUPANCY
& TESTING



The Production Hatchery

Downstairs

Potential Addition
(contingent on additional funding)



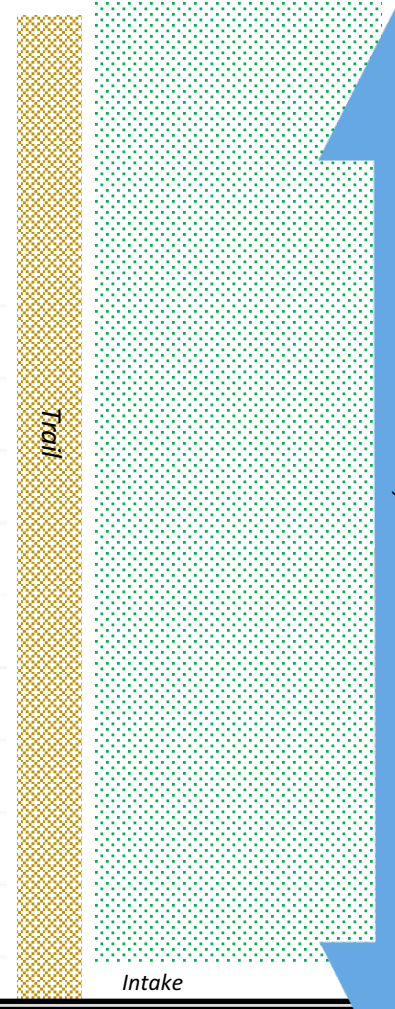
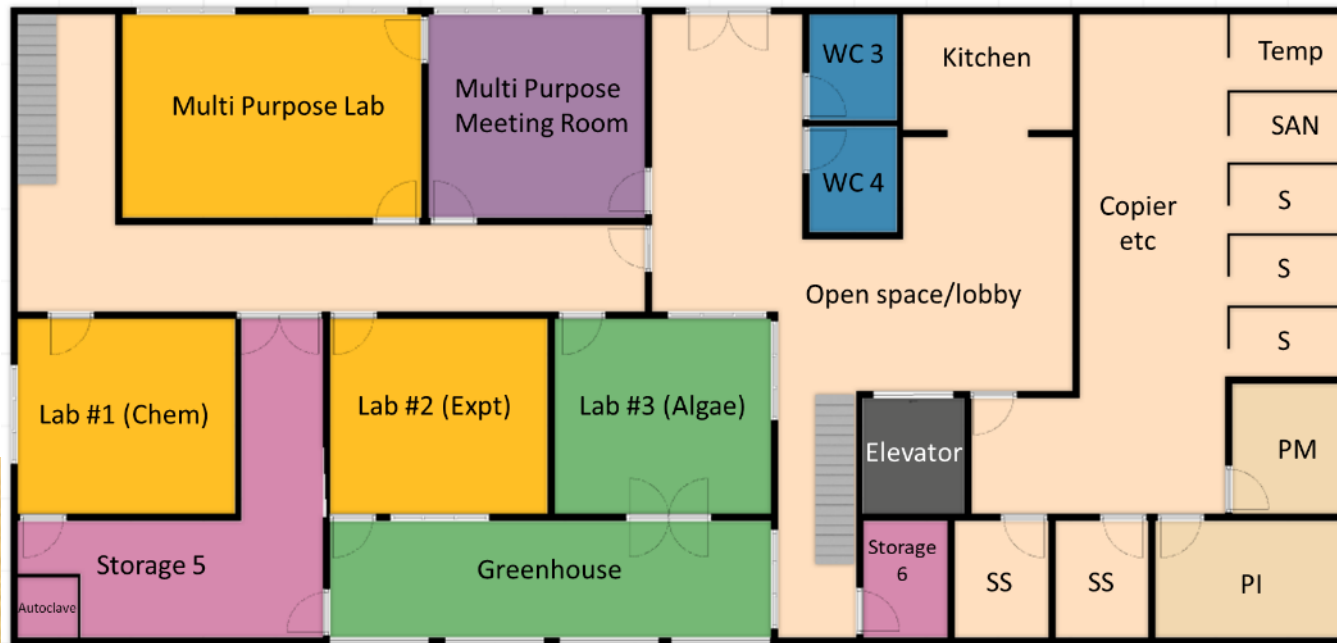
56th Street

SCIENCE CENTER

The Production Hatchery

Upstairs

Potential Addition
(contingent on additional funding)

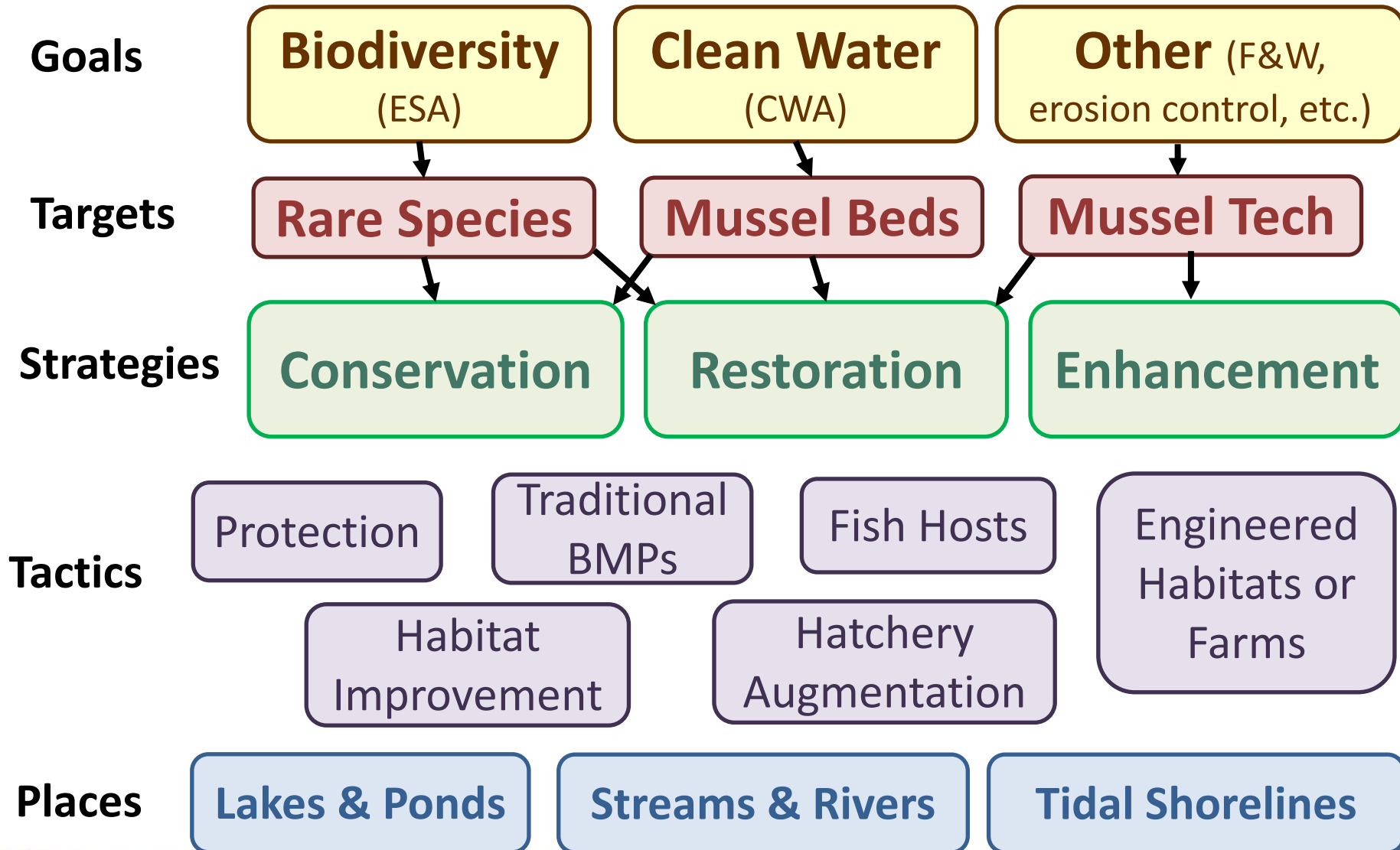


Parking

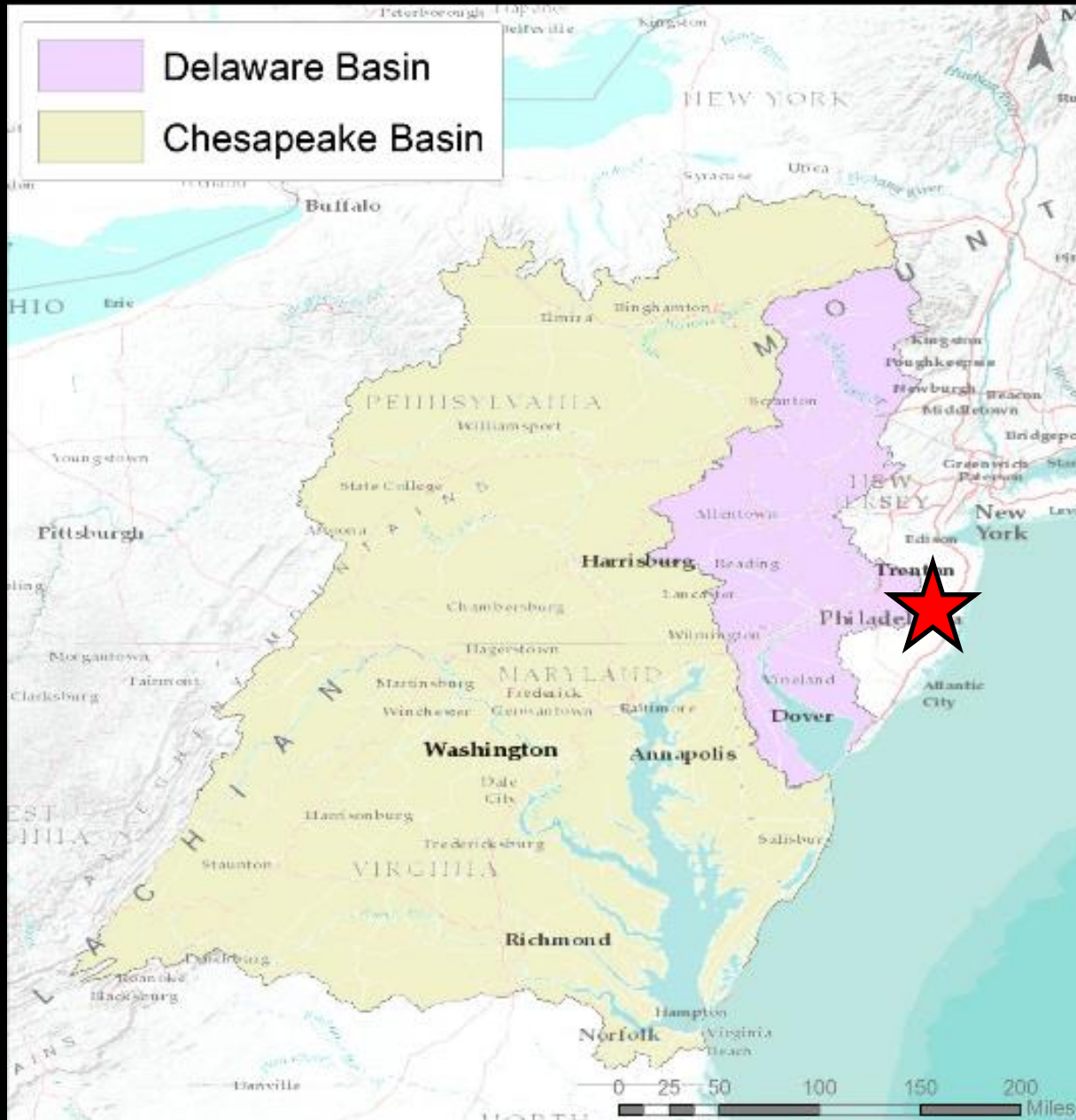
56th Street

Production Hatchery

Lots of Management Options



Let's Collaborate!





Partnership for the
**DELAWARE
ESTUARY**

Thank You!

Danielle Kreeger, Ph.D.

Science Director

(302) 655-990, x104 | DelawareEstuary.org

*Connecting people, science, and nature
for a healthy Delaware River and Bay*

For More Info:

Mussels for Clean Water Initiative

<http://www.delawareestuary.org/science-and-research/mussels-clean-water-initiative-mucwi/>