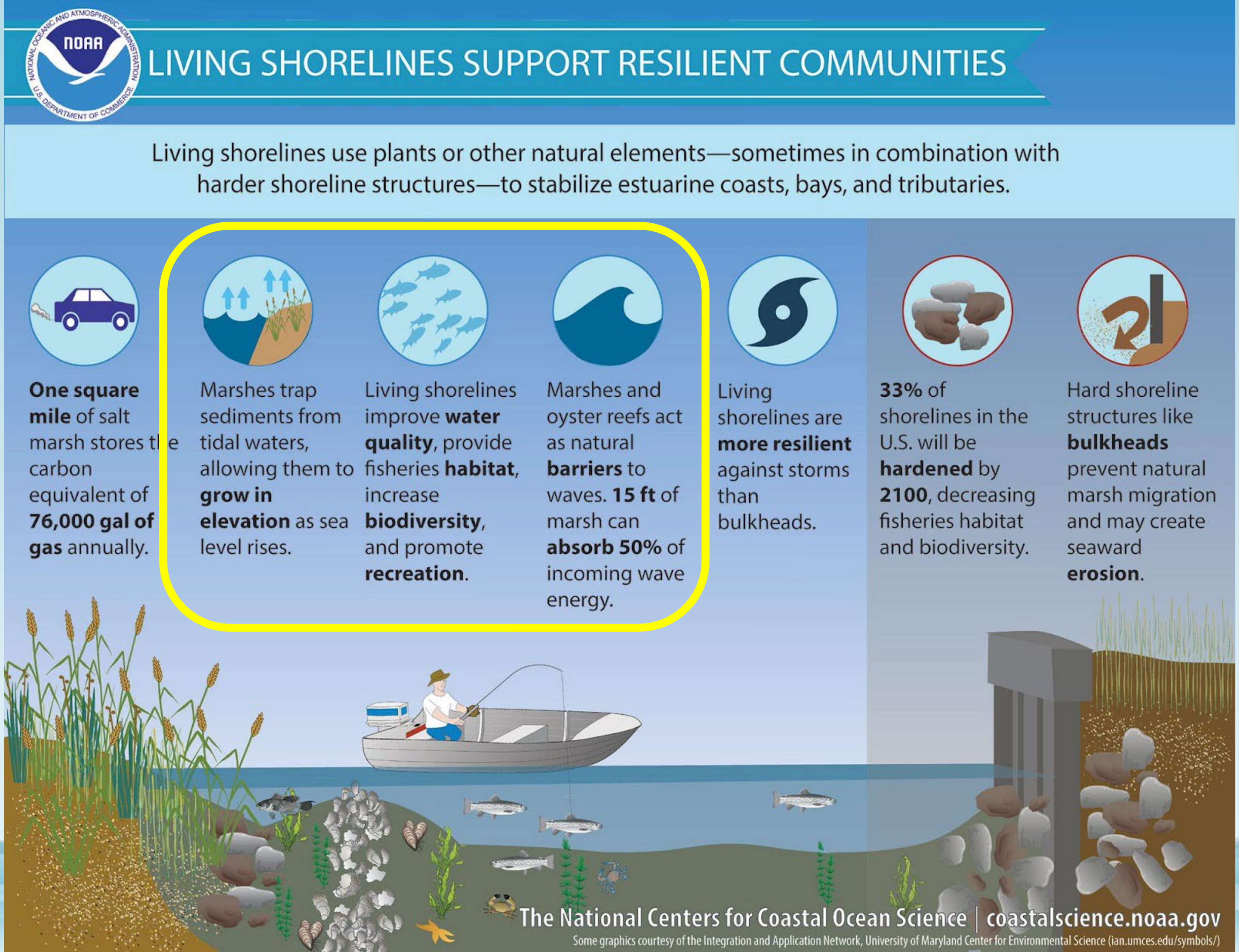
Coastal Resilience Pilot Project:

Oyster Castle® Reef, Salt Marsh Health and Sea Level Rise

DR. JEN KARBERG
SENIOR RESEARCH ECOLOGIST
NANTUCKET CONSERVATION FOUNDATION

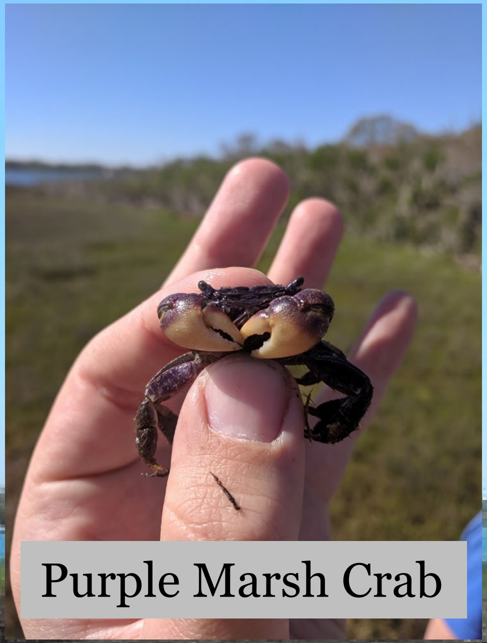
JKARBERG@NANTUCKETCONSERVATION.ORG



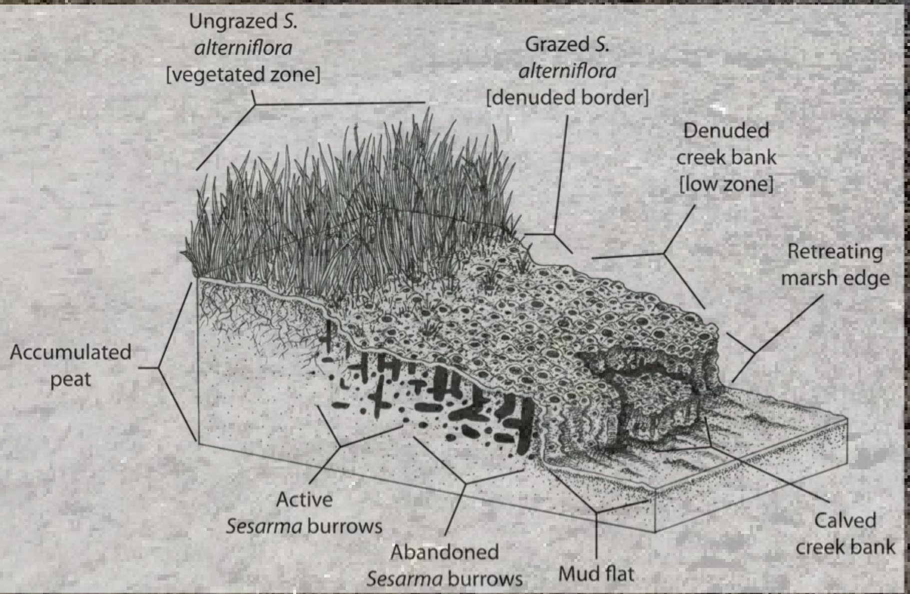
NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE
LIVING SHORELINES SUPPORT RESILIENT COMMUNITIES
Living shorelines use plants or other natural elements—sometimes in combination with harder shoreline structures—to stabilize estuarine coasts, bays, and tributaries.
One square mile of salt marsh stores the carbon equivalent of **76,000 gal of gas** annually.
Marshes trap sediments from tidal waters, allowing them to **grow in elevation** as sea level rises.
Living shorelines improve **water quality**, provide fisheries **habitat**, increase **biodiversity**, and promote **recreation**.
Marshes and oyster reefs act as natural **barriers** to waves. **15 ft** of marsh can **absorb 50%** of incoming wave energy.
Living shorelines are **more resilient** against storms than bulkheads.
33% of shorelines in the U.S. will be **hardened** by **2100**, decreasing fisheries habitat and biodiversity.
Hard shoreline structures like **bulkheads** prevent natural marsh migration and may create seaward **erosion**.
The National Centers for Coastal Ocean Science | coastalscience.noaa.gov
Some graphics courtesy of the Integration and Application Network, University of Maryland Center for Environmental Science (ian.umces.edu/symbols/)

Medouie Creek Oyster Project
Site Overview
Medouie Creek Wetland Complex
Oyster Reef
Proposed Site
Reference
Monitoring Site
Polpis Harbor

Salt marsh Dieback and Erosion

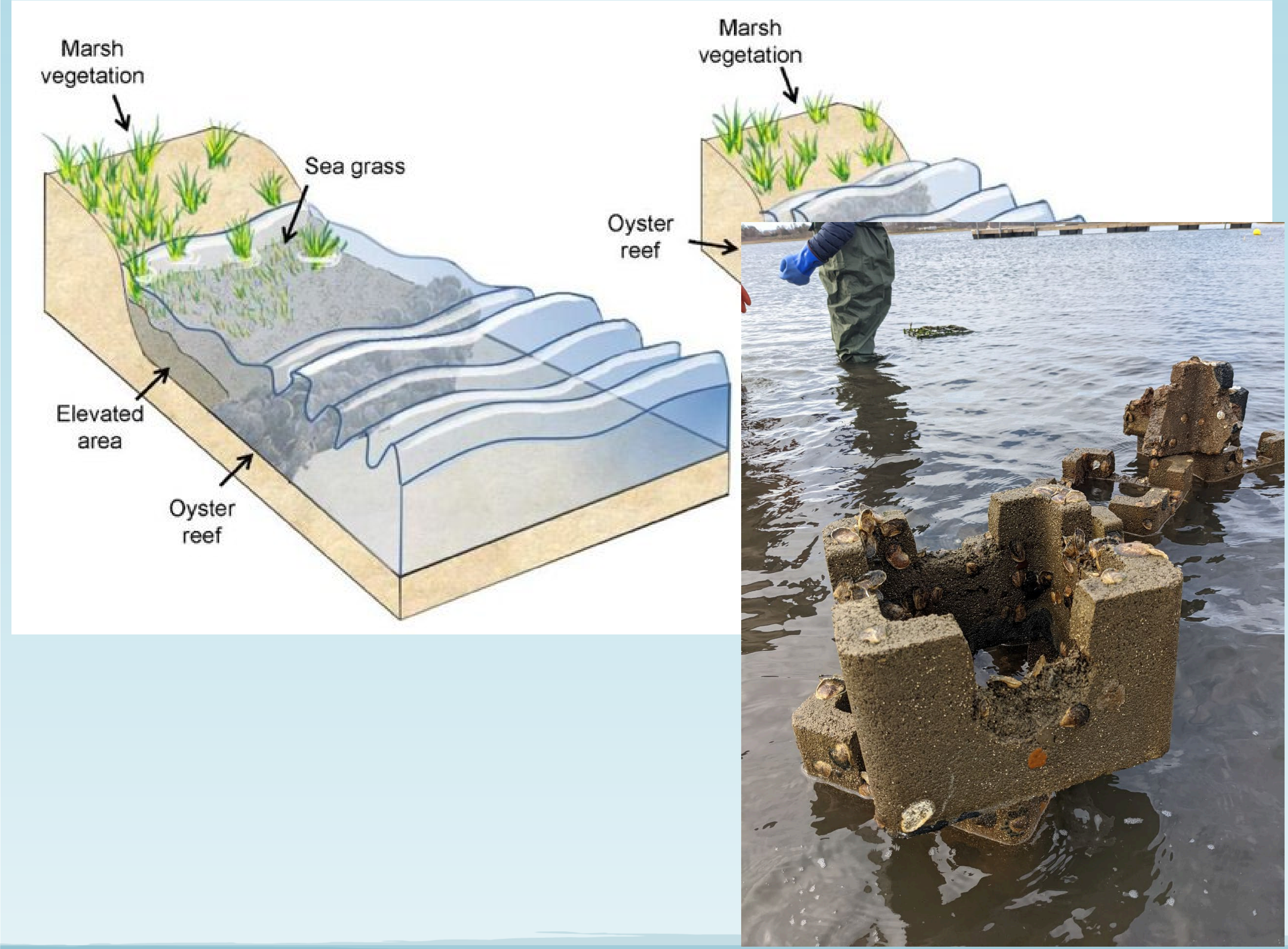


- 2019: Crab removal research
- 2020: Con’t crab removal, Spartina outplanting
- 2021 – 2026/7 : continue crab removal research as the marsh stabilizes.



Salt Marsh Dieback Research

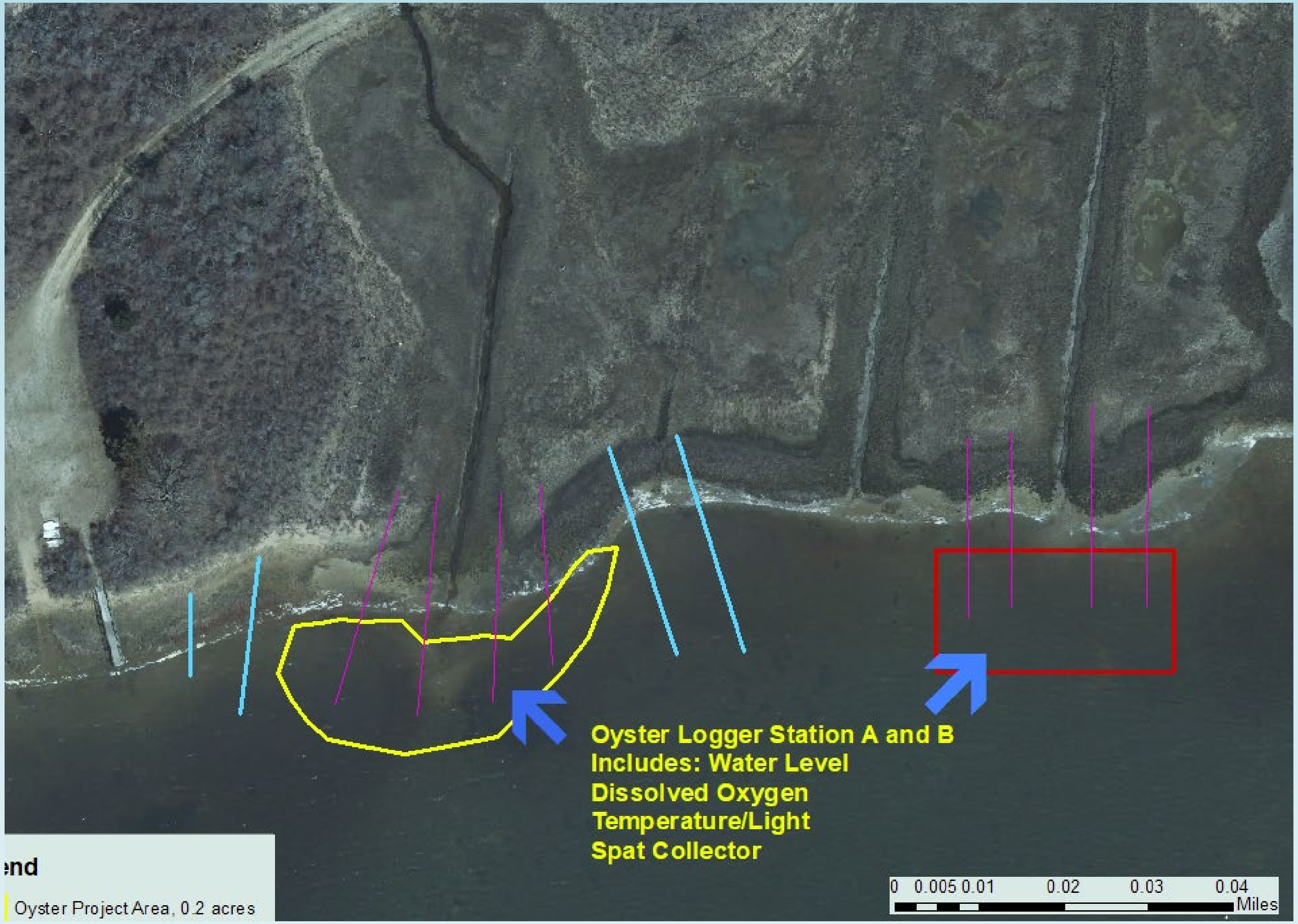
- Crab Control + Spartina alterniflora planting = high success………
- But, it’s still a 5 year process

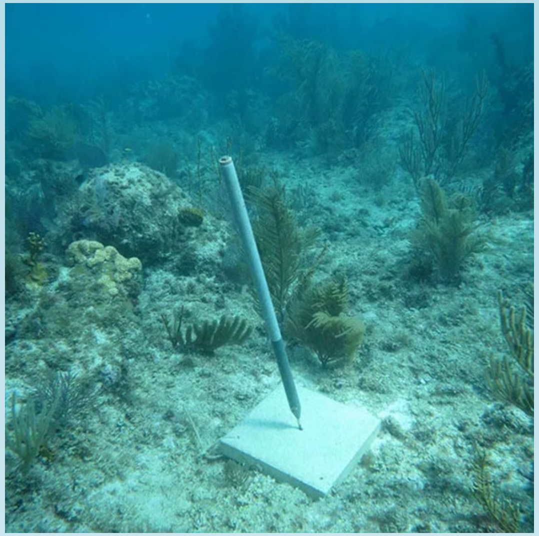


Intertidal Oyster Reef

- Wave reduction (height and force)
- Erosion reduction
- Sediment accumulation
- Marsh migration sea-ward?

Environmental Impacts/Monitoring





Prior Restoration Site Conditions

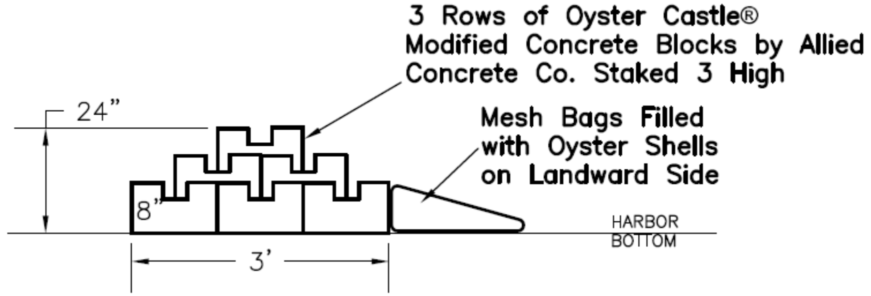
Water Depth

- Mean 2.89ft
- Water drops below 0.8ft for 30min ever 3-4 months.

Salinity: 19-35ppt over 15 years.

No submerged aquatic veg

Spat Collectors = no oyster spat in 2020



CROSS–SECTION VIEW OF TYPICAL OYSTER CASTLE REEF
Scale: 1"=2'

Permitting and Funding

- The FIRST intertidal oyster reef in Massachusetts
- Permitting extensive and longer than anticipated (~18-20 months)
- ACOE, Chapter 91, CZM, DMF, ENF, MEAP, Local Wetland Regs

- Funding ~$200k over 5 years
- Nantucket Shellfish Association
- MA In-Lieu Fee Program, administered by MA Dept of Fish and Game

Required FIVE years monitoring and mitigation
Reports to MA In-Lieu Fee and ACOE

Hopefully facilitate permitting of additional projects

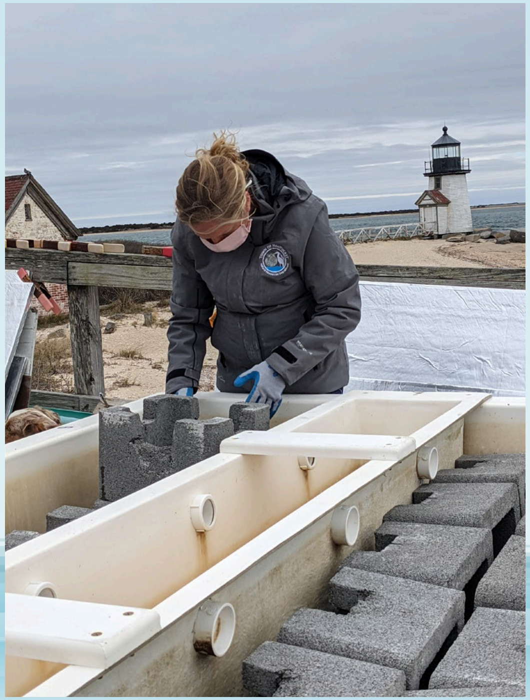

ANDERSON'S STILLWATER MOORINGS
150


DYER

Thank you and Questions

Jen Karberg: jkarberg@nantucketconservation.org

Town of Nantucket, Natural Resources Dept and Shellfish Hatchery
Allied Concrete
MA In Lieu Fee Program
Linda Loring Nature Foundation, Massachusetts Nantucket Audubon, Nantucket Shellfish Association, Maria Mitchell Association, ACKlimate, Nantucket Land Council, and Champoux Landscape

Quantifying Impacts of Floating Oyster Aquaculture on Nitrogen Cycling in Southeastern Massachusetts Embayments

May 18, 2022

Presentation by Micheline Selim Labrie

EPA-SNEP Virtual Symposium

Outline

1. Problem statement: potential use of floating oyster aquaculture as a nitrogen removal tool in nitrogen enriched estuaries of southeastern MA
2. Research questions
   a) What is the spatial distribution of oyster biodeposits across receiving sediments?
   b) Do oysters enhance sediment denitrification?
3. Summary
   a) mass balance of the oyster aquaculture nitrogen cycle
   b) nitrogen removal versus cost

(www.sms.si.edu)

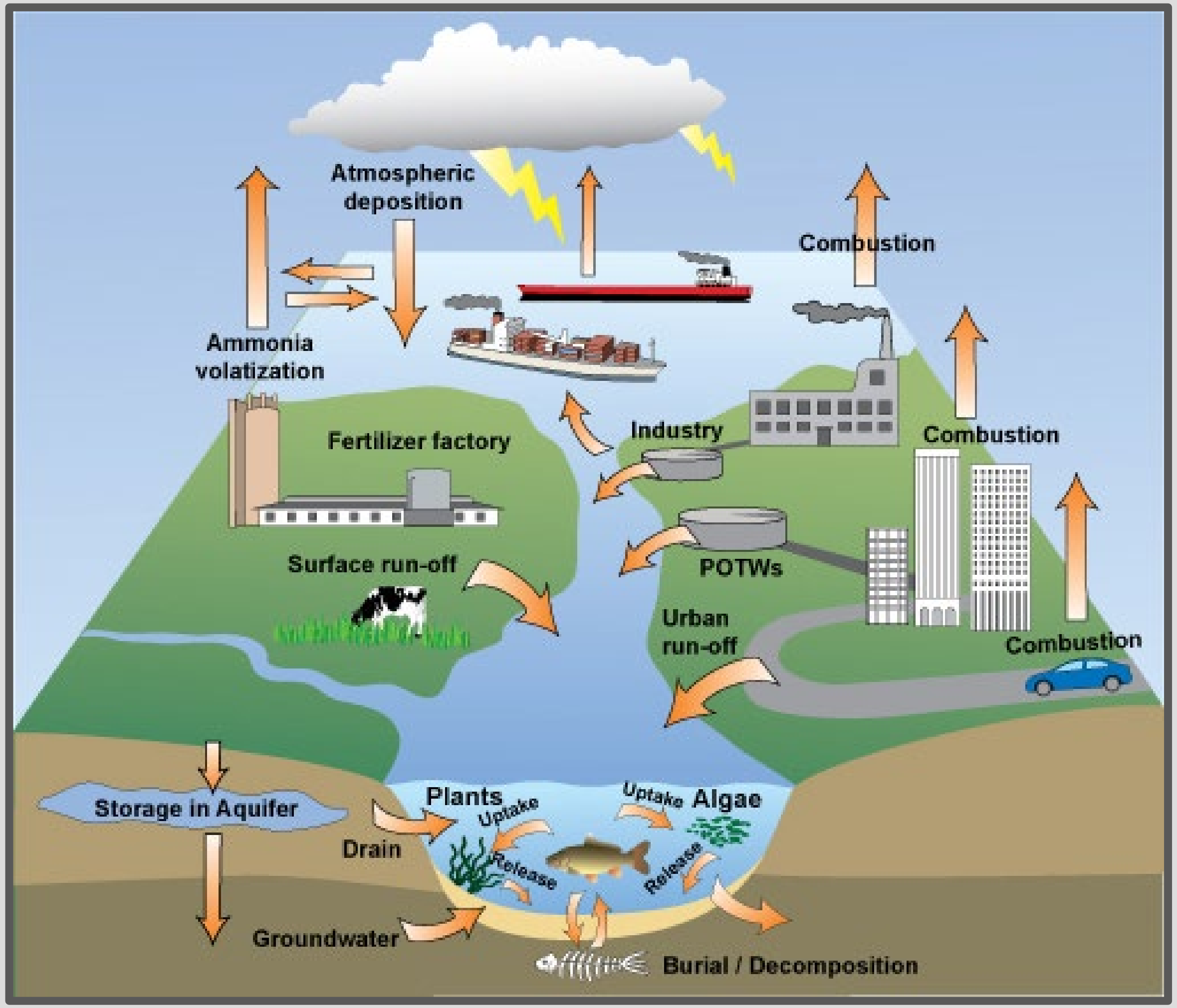
Estuaries worldwide degraded by anthropogenic nitrogen (N), primarily from watersheds

Approaches to nitrogen (N) reduction

1. Reduce/remove N at source

2. Reduce N in transit

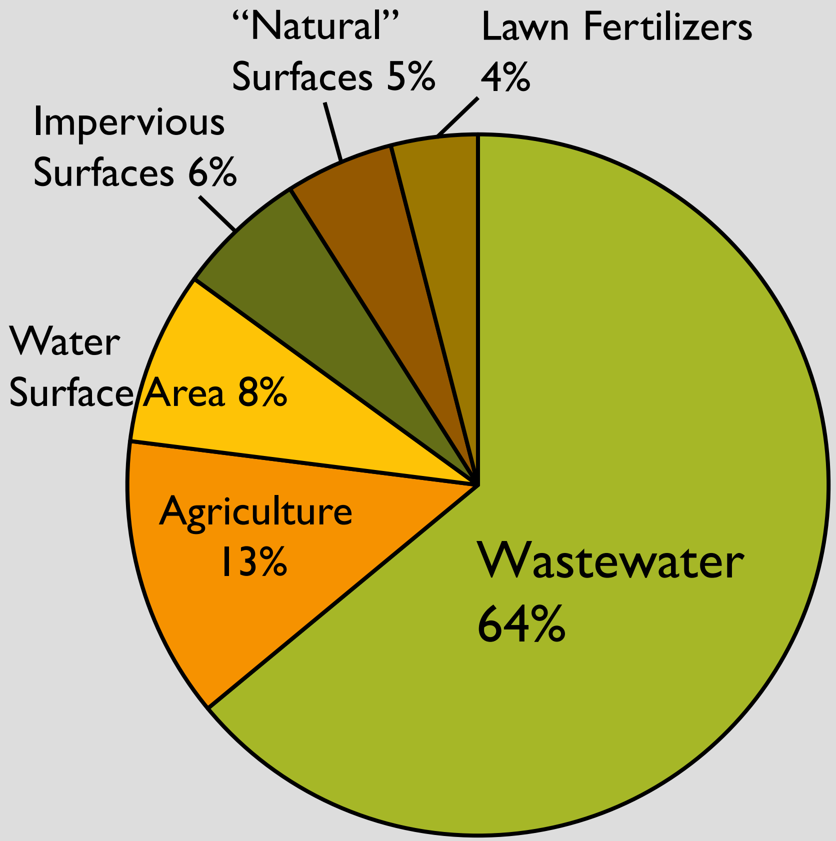
3. Reduce N in estuary



(Image: http://estuaryinfo.blogspot.com/)

MA water quality managers seeking cost-effective methods of decreasing total N concentrations in eutrophic estuaries

Need to quantify N removed by non-traditional methods to incorporate into TMDLs and WQM plans (Howes et al. 2006)

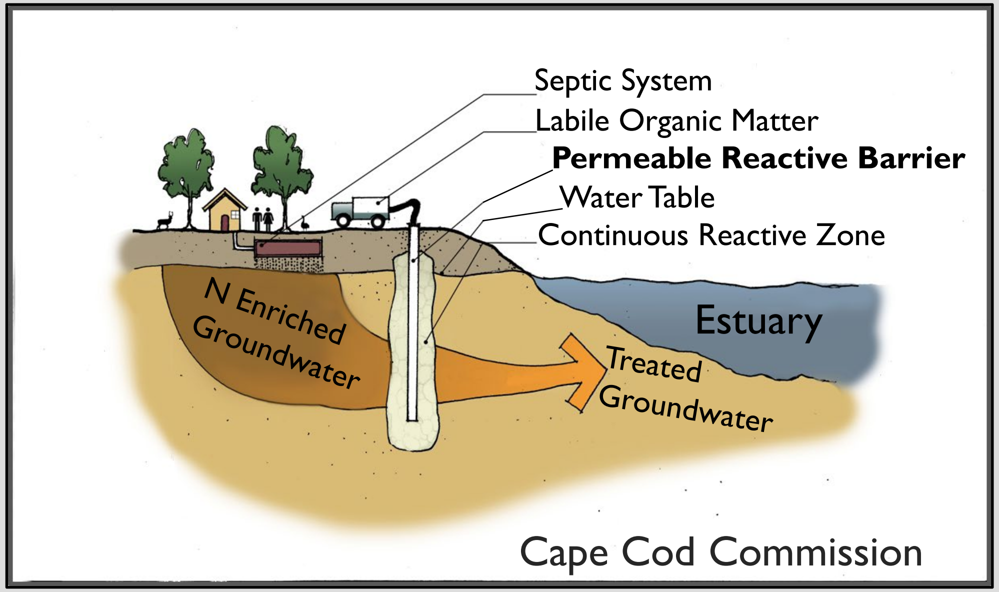


Land-use specific N load Westport Harbor: Westport River Estuary

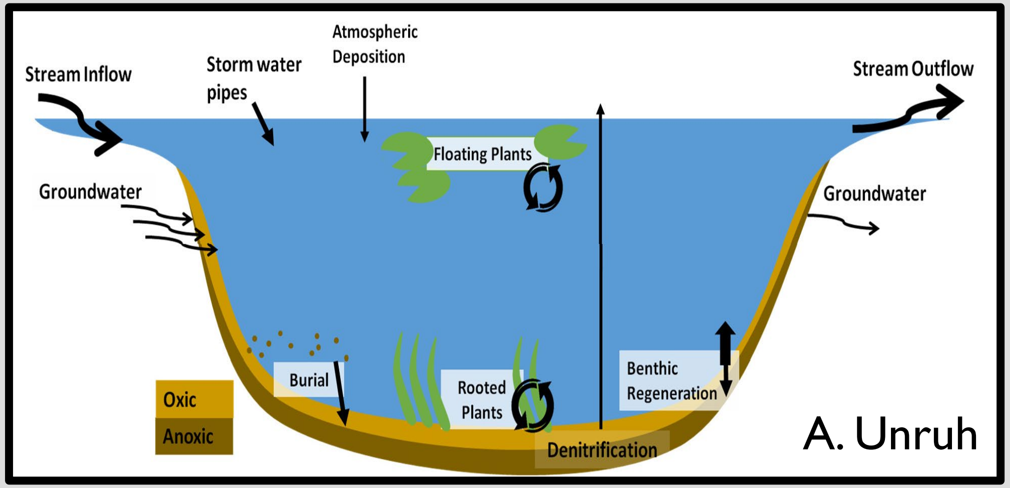
Next:
6 non-traditional N management technologies

Non-traditional N management technologies

1. Composting Toilet: N in composted material doesn't enter groundwater
2. Denitrifying Septic Systems promote denitrification in septic distribution field
3. PRBs promote denitrification in groundwater
4. Pond/wetland restoration
5. FTWs remove N via biological uptake and harvest
6. …



Permeable Reactive Barrier (PRB)



Freshwater Pond restoration

6. Floating oyster aquaculture (FOA)

Use of shellfish to reduce total nitrogen levels (needs 300 kg N yr reduction to meet TMDL; oyster aquaculture is targeting 75 kg N/yr removal)

Oyster Demonstration Project, Lonnie's Pond – Orleans, MA

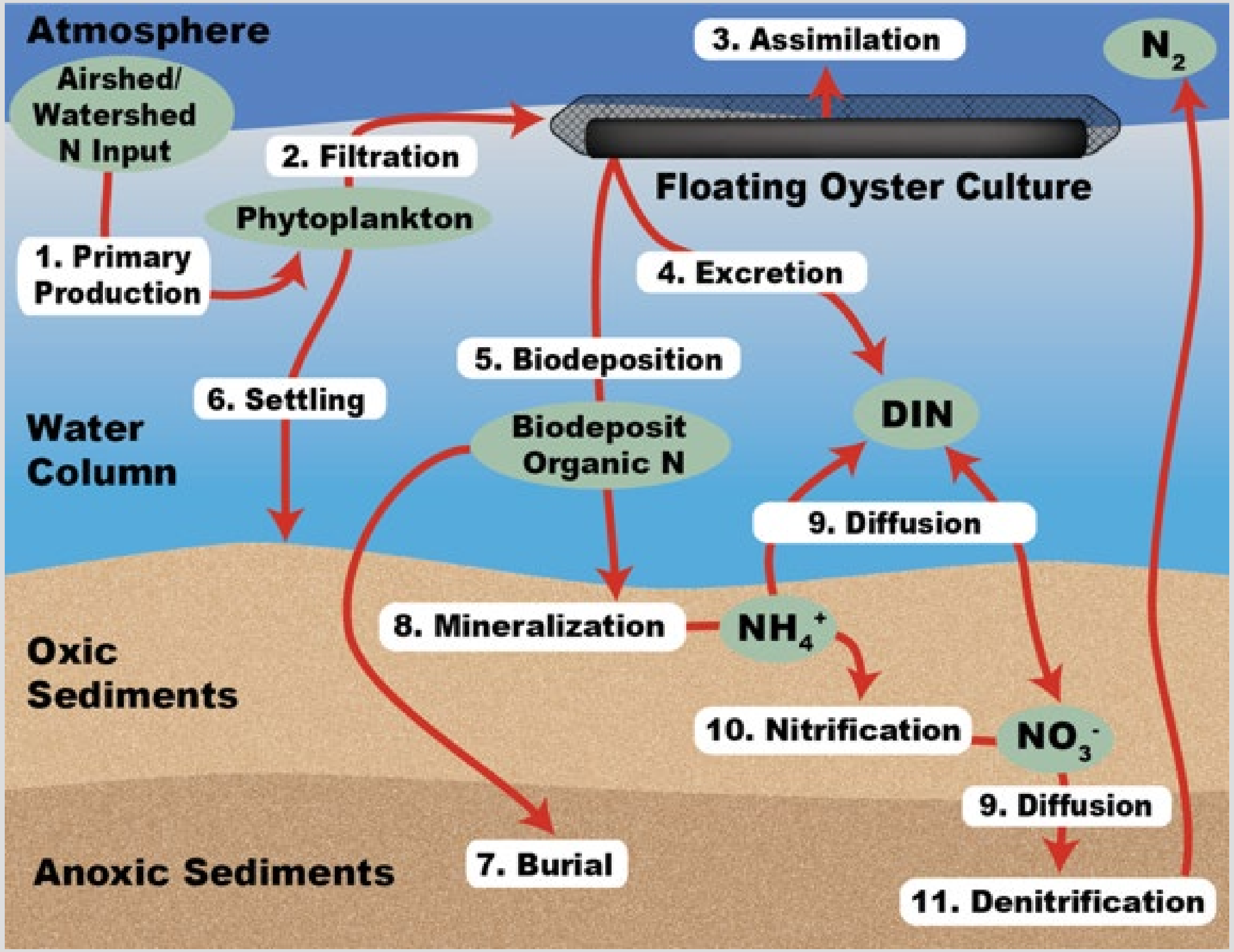
This approach is being used by Orleans, Falmouth, Mashpee, Barnstable, Wellfleet, Westport, Harwich, and Dennis, MA.

How does FOA impact N cycling in estuaries?

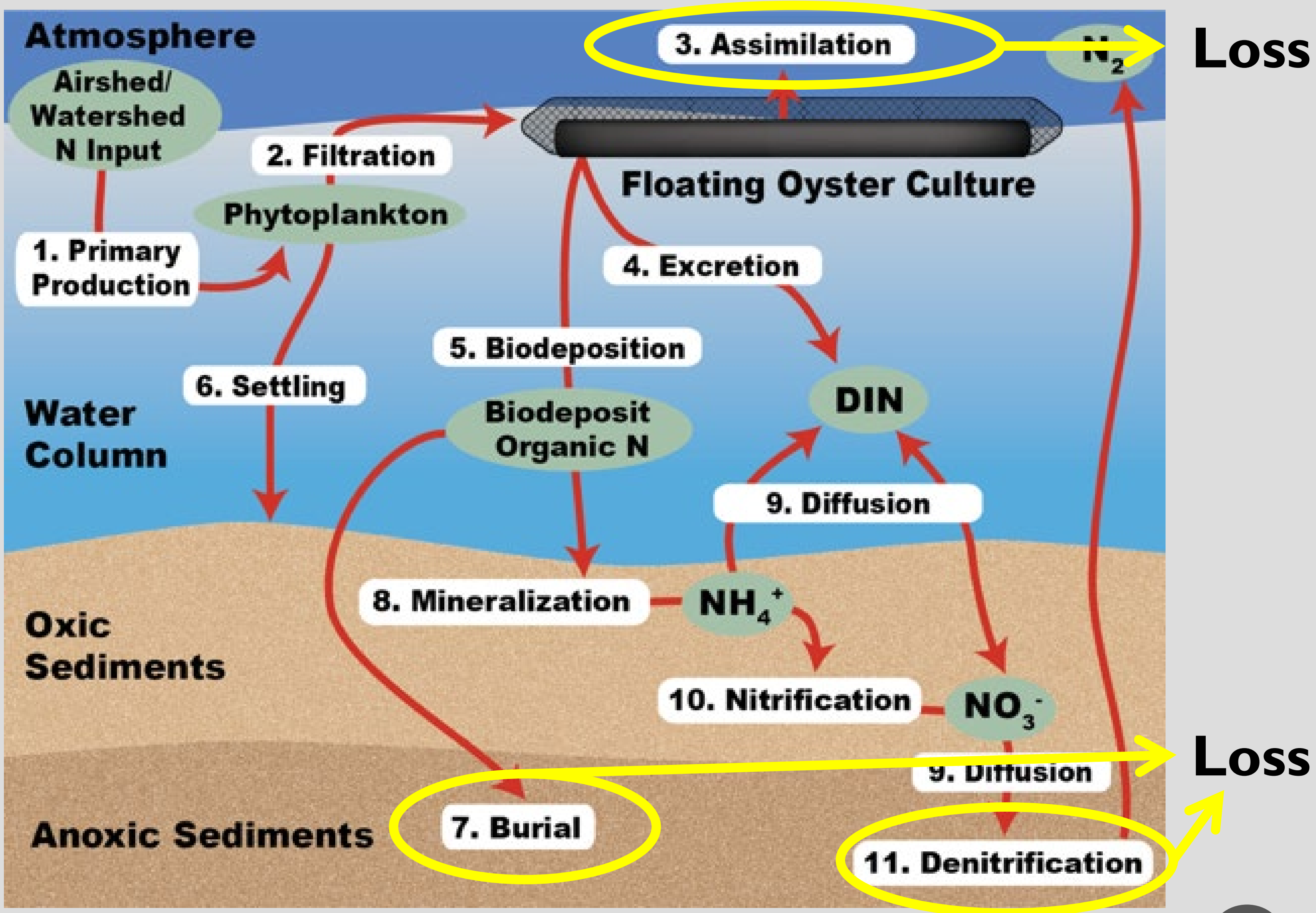
Increased water clarity

Oysters maintain high clearance rates, which produces pseudofeces

Nutrients assimilated as biomass or voided as dissolved N, feces, and pseudofeces (**biodeposits**)



FOA removes N via assimilation, enhanced denitrification, & burial, but the rate of N removal varies across estuaries

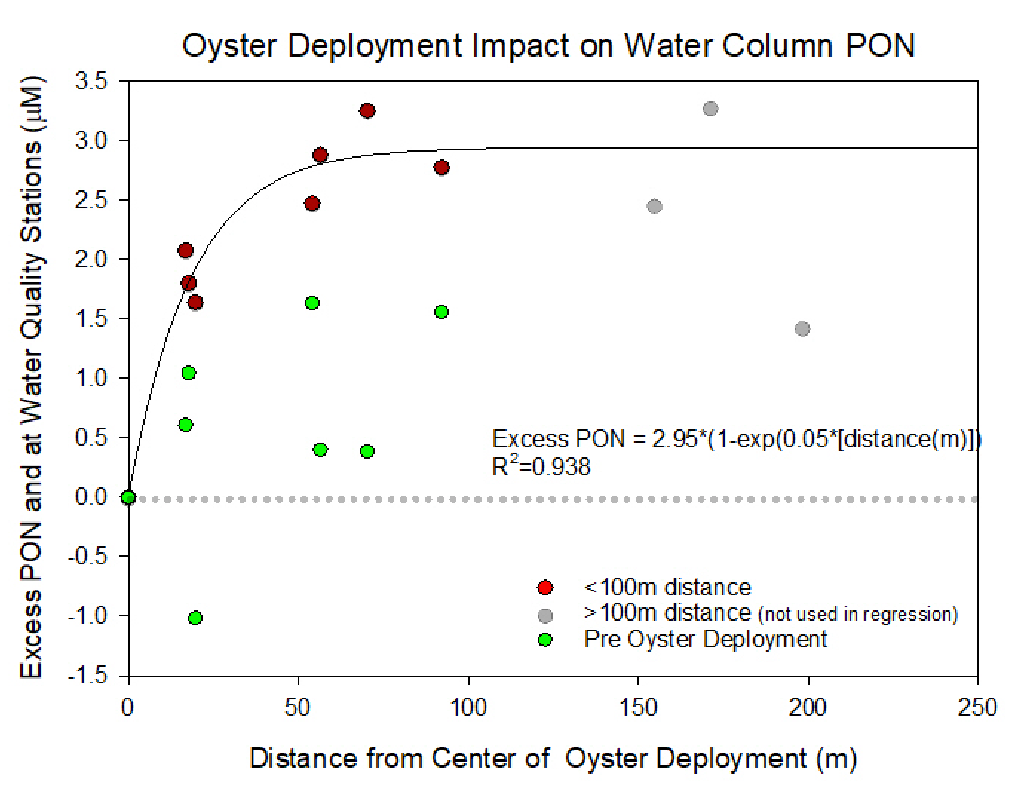


(Diagram adapted from Kellogg et al. 2013)

Lonnie's pond year1-3 water quality related oyster effects

Oysters removed significant amounts of PON and Chlorophyll-*a* and increased water clarity as water flowed through the deployment area

Given the short time that any parcel of water is in contact with the oysters, the large quantifiable reductions in all particulate groups is clear evidence of the ability of these types of oyster deployments to improve water quality even in N-enriched waters

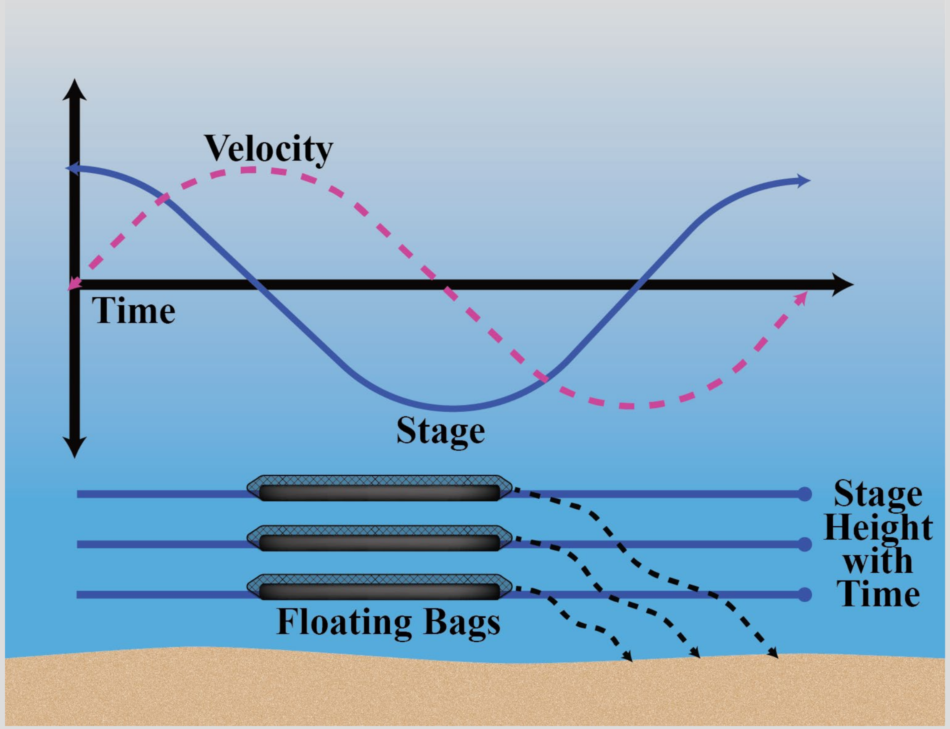


Mixed layer average concentrations of PON in excess of that observed in the deployment area prior to and following oyster deployment

Note the concentrations of excess PON within 100m of oyster deployment increase exponentially with distance only after oysters were deployed

QUESTION ONE: What is the spatial distribution of biodeposits across receiving sediments?

The model incorporates measurements of **(1)** biodeposit settling rate, **(2)** wind and tidally driven currents, **(3)** tidal range, and **(4)** depth of the oyster deployment area.

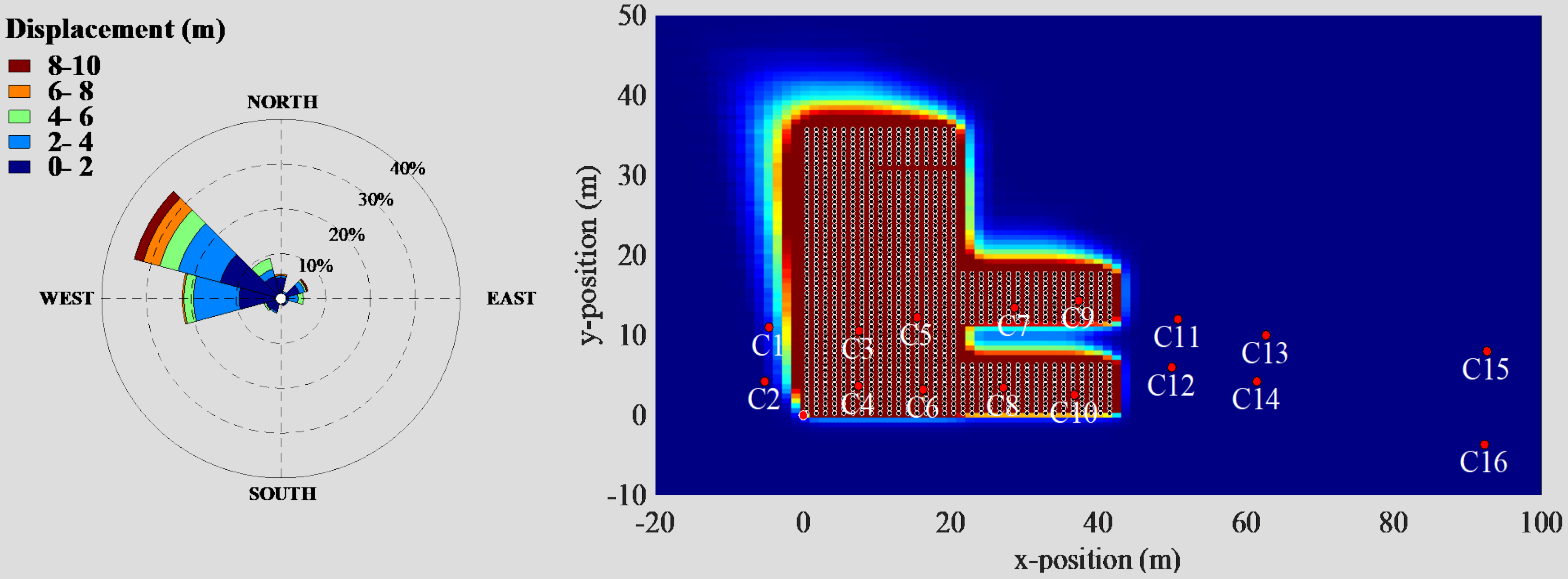


Analytical equation using time dependent velocity and stage height, and a mean biodeposit settling rate describes horizontal biodeposit displacement

$$x_{displacement}(x,t) = \frac{h(t)}{v_{settling}} \times u(z,t),$$

$$y_{displacement}(y,t) = \frac{h(t)}{v_{settling}} \times v(z,t),$$

Lonnie's pond biodeposit displacements

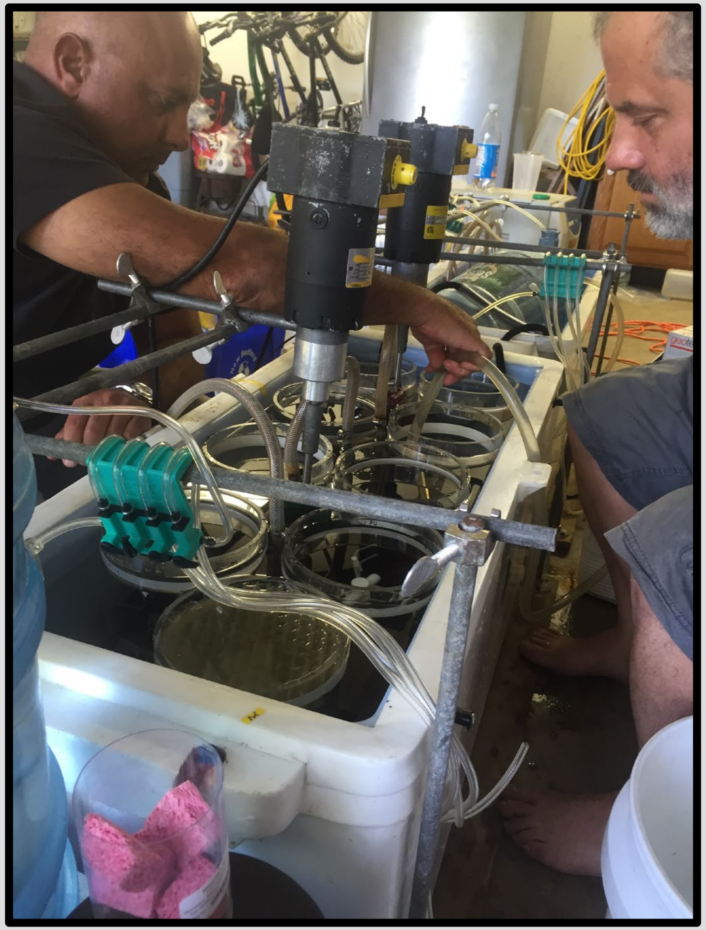


- The numerical model predicted that most of the biodeposits settle to sediments directly below the oyster bags
- Heat maps indicate the extension of the biodeposition area beyond the footprint of the floating oyster bags

QUESTION TWO: Does floating oyster aquaculture enhance sediment denitrification?

Time-series measurements of core headspace water for dissolved organic N, nitrite + nitrate, ammonium, and N_2

Determine change in N_2/Ar gas concentrations with isotope ratio mass spectrometer to determine denitrification (IRMS; Altabet lab)

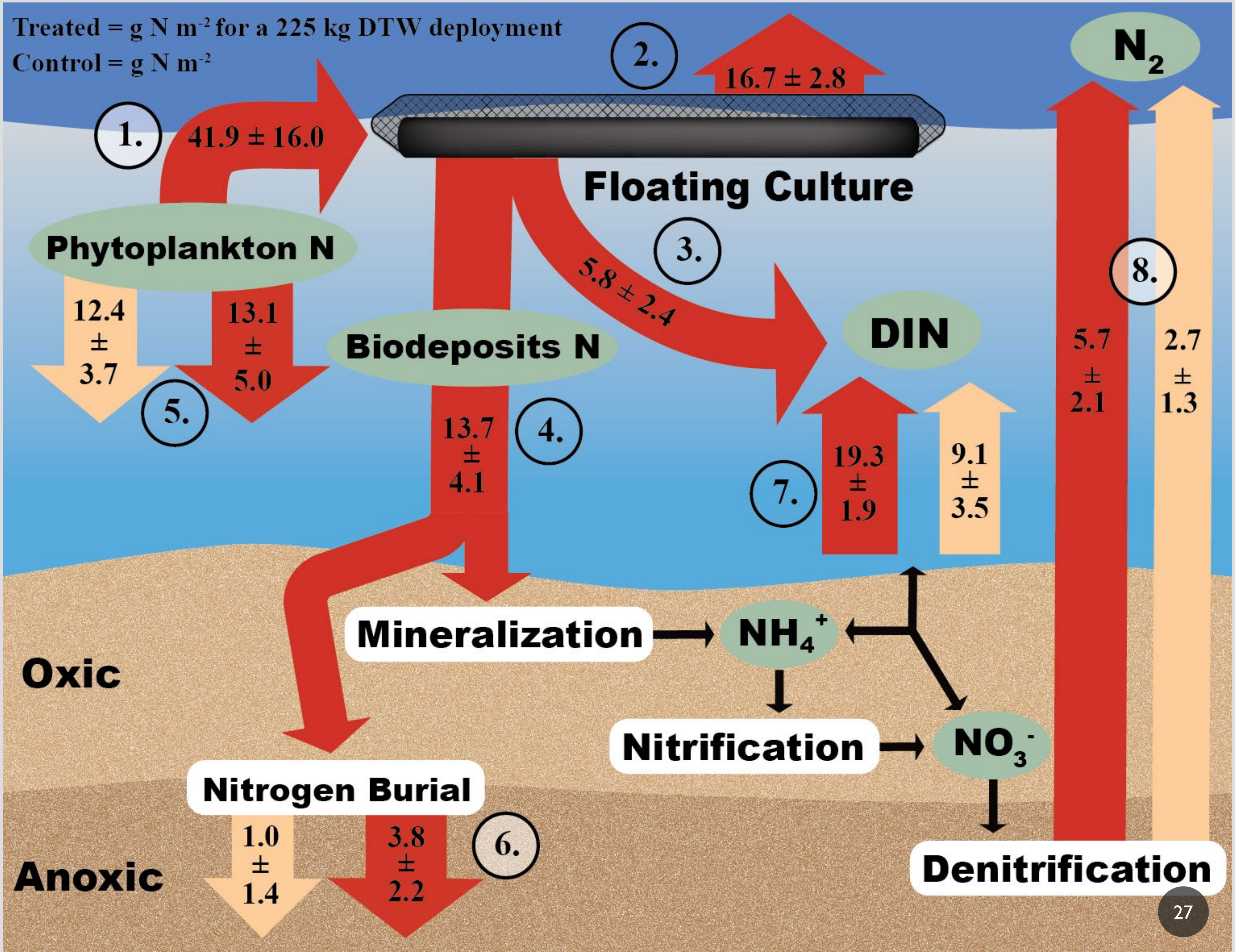


Mean ± SD denitrification rates for cores collected within the biodeposit area (treated) and outside the biodeposit area (control)

Project Year	Date	Treated	Control	Enhancement	*p* value
		mmol m^{-2} day^{-1}			
Year 1	Aug '16	3.0 ± 1.1	1.7 ± 0.3	69%	**0.038**
	Oct '16	2.8 ± 1.1	1.7 ± 0.7	62%	**0.097**
	Apr '17	2.7 ± 1.7	0.9 ± 0.3	202%	**0.052**
Year 2	Jun '17	1.3 ± 0.4	0.3 ± 0.4	343%	**0.002**
	Aug '17	2.1 ± 0.9	1.6 ± 0.8	29%*	0.372
	Sep '17	0.7 ± 0.9	0.2 ± 0.1	236%*	0.300
	Oct '17	1.5 ± 0.9	0.7 ± 0.4	107%	**0.056**
Year 3	Jul '18	3.3 ± 2.5	1.2 ± 0.4	186%	**0.066**
	Oct '18	0.5 ± 0.3	0.2 ± 0.3	196%	**0.051**
	Apr '19	1.8 ± 1.2	0.3 ± 0.5	450%	**0.010**

* Surface sediments were sulfidic

Range of enhancement = 62% to 450%



Treated = g N m-2 for a 225 kg DTW deployment
Control = g N m-2
1.
41.9 ± 16.0
2.
16.7 ± 2.8
N2
Floating Culture
Phytoplankton N
3.
5.8 ± 2.4
8.
12.4 ± 3.7
13.1 ± 5.0
Biodeposits N
DIN
5.7 ± 2.1
2.7 ± 1.3
5.
13.7 ± 4.1
4.
19.3 ± 1.9
9.1 ± 3.5
7.
Mineralization
NH4+
Oxic
Nitrification
NO3-
Nitrogen Burial
1.0 ± 1.4
3.8 ± 2.2
6.
Anoxic
Denitrification

Lonnie’s Pond 2020 nitrogen removal

Total nitrogen removal from Lonnie's Pond associated with the 2020 deployment to date was **109 kg N**

15.5 kg N removal via denitrification

The target removal is 75 kg N/yr from oyster harvest

93.1 kg N was removed via oyster harvest

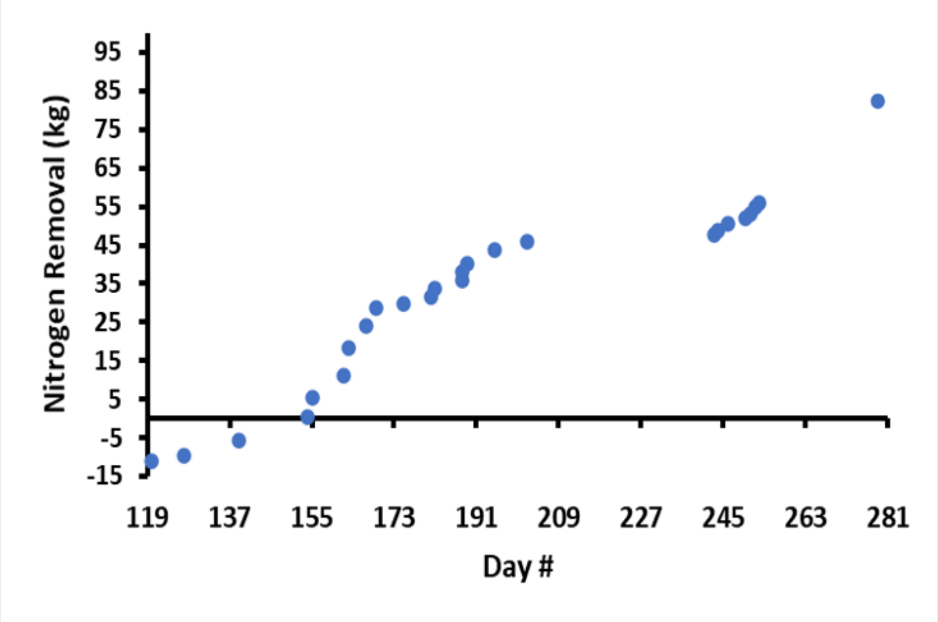
Cost of remediation method:

$270 per kg N/yr (full compliance monitoring)

$107 per kg N/yr (reduced monitoring)

Oyster economic value:

$7.06/kg oysters (MA DMF Annual Report)



Conclusions

1. What is the spatial distribution of biodeposits across receiving sediments?

   Simple model can be used in systems with low probability of biodeposit erosion

2. Does floating oyster aquaculture enhance sediment denitrification?

   Yes, denitrification is enhanced in sediments affected by oyster biodeposition. The level of enhancement depends on biodeposition rate and oxygen availability

4. What are the main pathways of nitrogen removal associated with floating oyster culture?

Assimilation/harvest (64%), enhanced denitrification (22%), & burial (14%)

109 kg N removed/year

Cost as low as $107 per kg N/year

Acknowledgments

We would like to thank the United States Environmental Protection Agency Southeast New England Program and the Town of Orleans for supporting this work

We gratefully acknowledge Science Wares Inc. and Ward Aquafarms for maintaining the oyster arrays and their assistance determining oyster survival and growth and D.R. Schlezinger, J. Benson, S. Horvet, A. Unruh, N. Uline, and E. Ells of the Coastal Systems Program at SMAST-UMD.

SNEP

Southeast New England Program

REBUILDING THE MASSACHUSETTS COASTAL PINE BARRENS

ALIGNING RESTORATION, CONSERVATION AND MANAGEMENT

Sharl Heller
Massachusetts Coastal Pine Barrens Partnership
USDA Landscape Scale Restoration Grant

MASSACHUSETTS COASTAL PINE BARRENS PARTNERSHIP

One of 52 partnerships in the Regional Conservation Partnership Network.

The **Massachusetts Coastal Pine Barrens Partnership** is a community united in protecting, restoring, managing, linking, celebrating and recreating within the unique environmental resources of the Massachusetts Coastal Pine Barrens.

Pine Barrens Partnership Steering Committee

Heather McElroy, Natural Resources Specialist, Cape Cod Commission

Eric Walberg, Senior Program Leader, Climate Services, Manomet, Inc.

Tim Simmons, Simmons Stewardship and Conservation Ecology

Paul Gregory, Management Forester, DCR

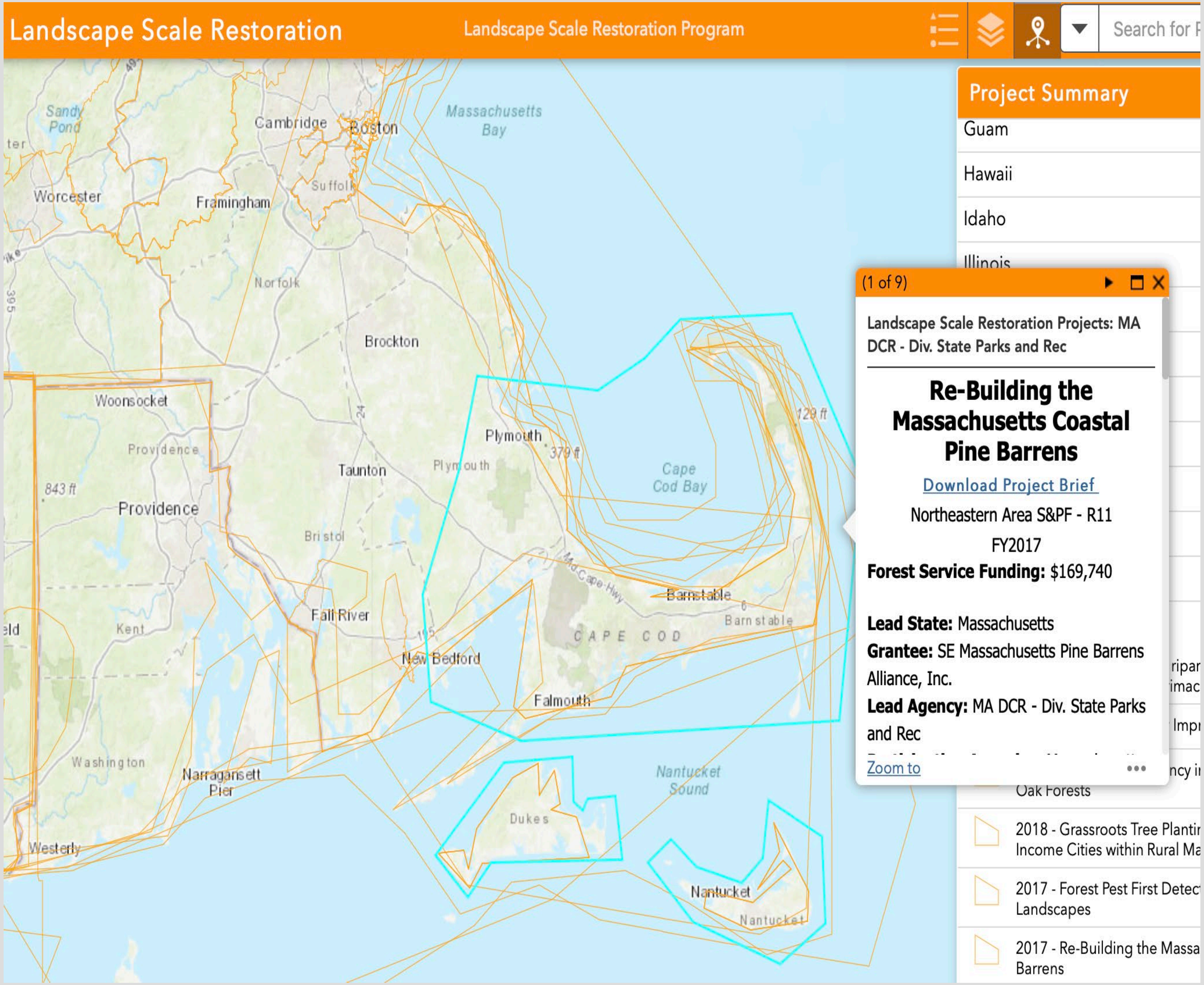
James Rassman, DCR Stewardship Coordinator Waquoit Bay National Estuarine Research Reserve

Mary Griffin, Regional Director Southeast, Cape and Islands, Massachusetts Audubon Society

Massachusetts Coastal Pine Barrens

- Includes 34 towns
- Over 615,000 acres, ~ 492,000 acres of Pine Barrens habitat
- 2nd largest of the 3 remaining coastal pine barrens ecoregions in the world
- Globally rare habitat
- 40 natural communities
- 200 state listed species

USDA Forest Service Landscape Scale Restoration (LSR) Grant



LSR Grant: Rebuilding the Massachusetts Coastal Pine Barrens

Habitat Restoration

Regional Conservation Planning

Education

Branding – “to make coastal pine barrens a household term”

Habitat Restoration

Tidmarsh Farms

- Restore, two former sandpits to a sandplain natural community, Mass Audubon Tidmarsh Farms.
- Remove dense invasive plants on 10-acre site; replant with pine barrens shrubs.
- Volunteer program for mapping invasive species.
- Created geo-database to track treatment and success of treatment/removal.

Habitat Restoration

Town of Plymouth, Town Forest

Restore pitch pine-white pine community with the removal of diseased red pine in the Town Forest, Plymouth.

Regional Conservation Vision Map Planning

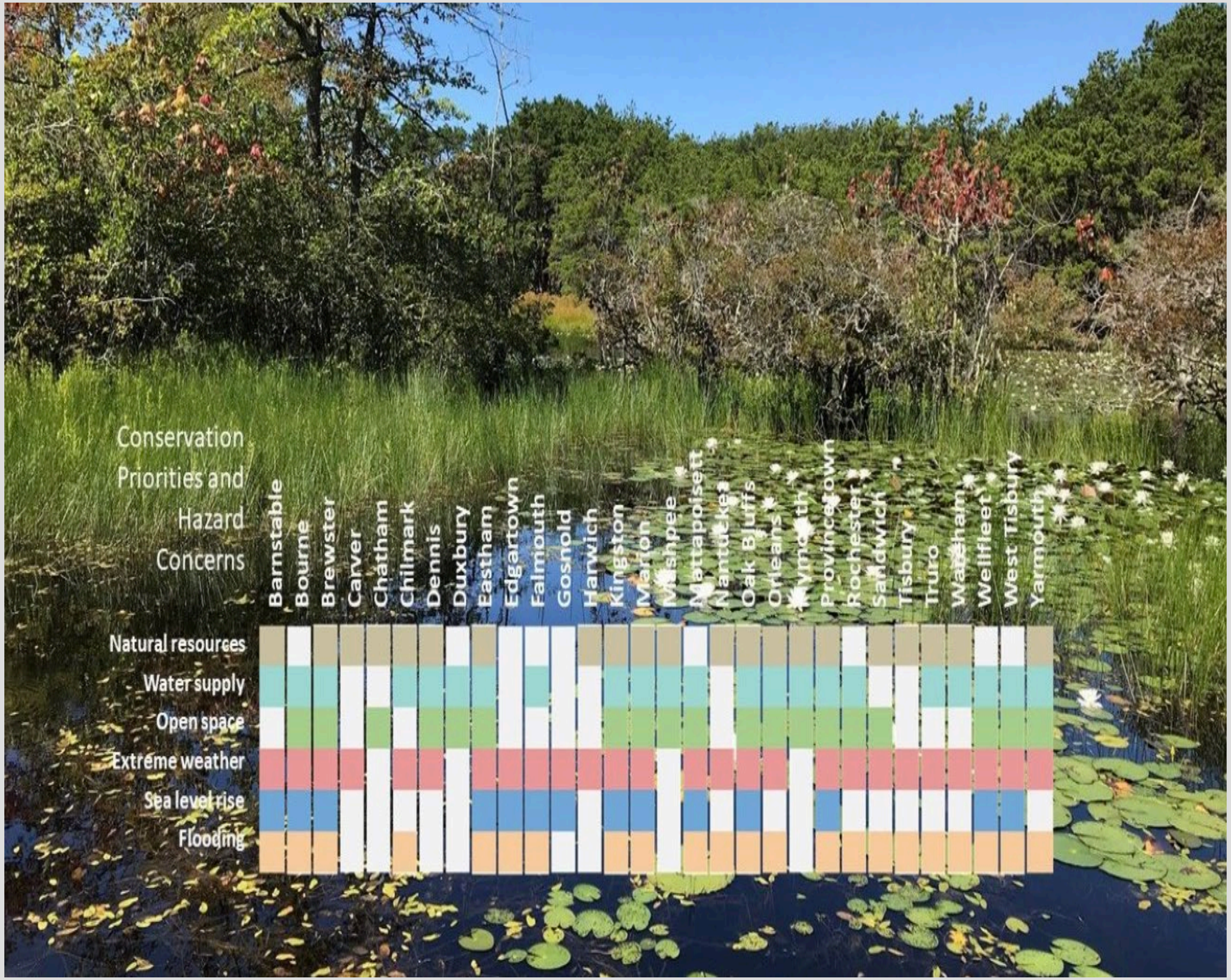
Project goals:

- Creation of a conservation vision map that can serve as a regional standard.
- Linkage of biodiversity support and climate change resiliency.
- Develop green infrastructure map for the ecoregion.
- Publish booklet of results derived from the green infrastructure mapping process.
- Incorporate habitat protection & management into Cape Cod Commission's regional planning activities, including the Regional Policy Plan.
- Create a Coastal Pine Barrens Conservation Vision Online Story Map.

Regional Conservation Vision Map Planning

The Partnership began the definition of a vision map with a comparative review of 30 towns' Open Space and Recreation Plans, Hazard Mitigation Plans, Local Comprehensive Plans, and Municipal Vulnerability Preparedness Reports.

--Alyssa Young
TerraCorps Service Member 2018



Regional Conservation Planning

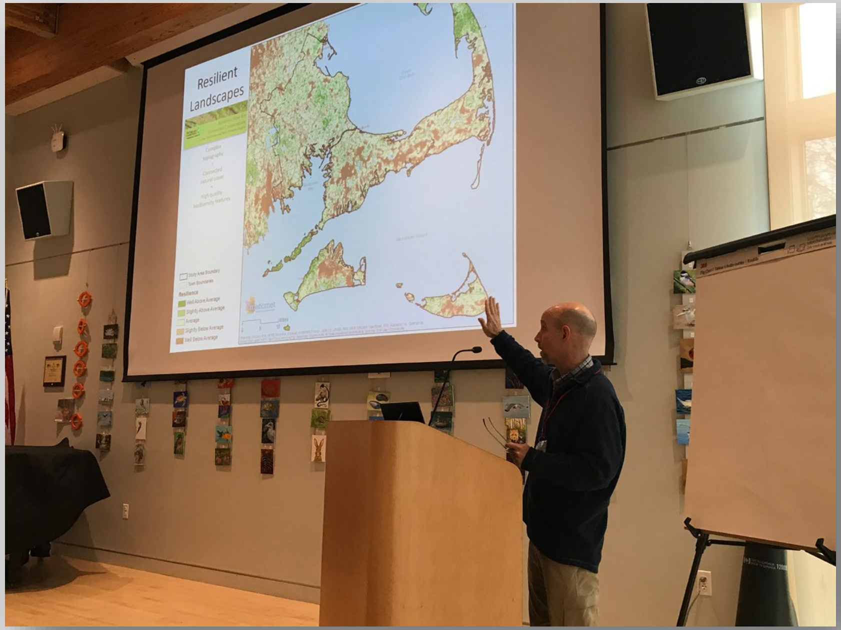
Creation of a conservation vision map that can serve as are regional standard.

- Hosted 4 stakeholder workshops at different locations throughout the ecoregion.

- Engaged conservation staff from 15 towns, 19 conservation organizations, and several state and federal agencies.

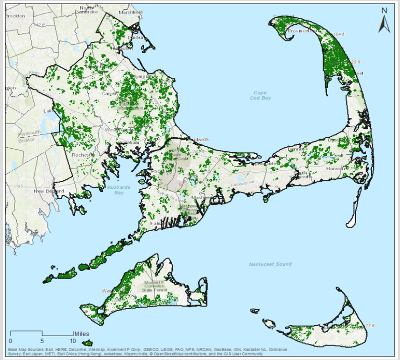
- 90 Stakeholders participated in the workshops.

- Gathered local information and suggestions for data layers to include in the final Green Infrastructure map.

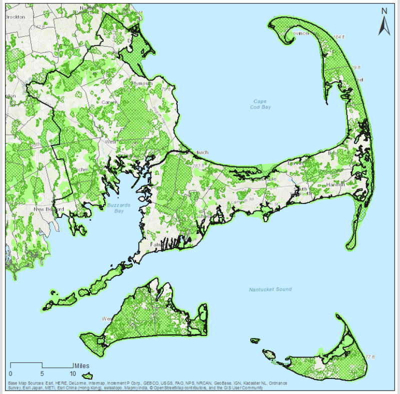


Green Infrastructure Network Components…

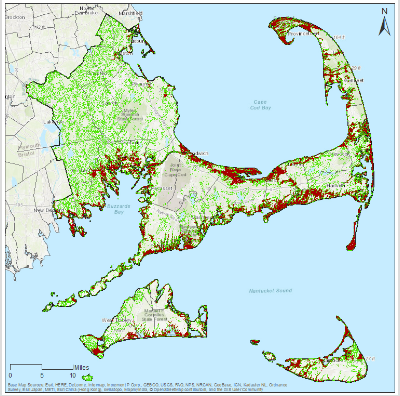
Areas of Above Average Resilience

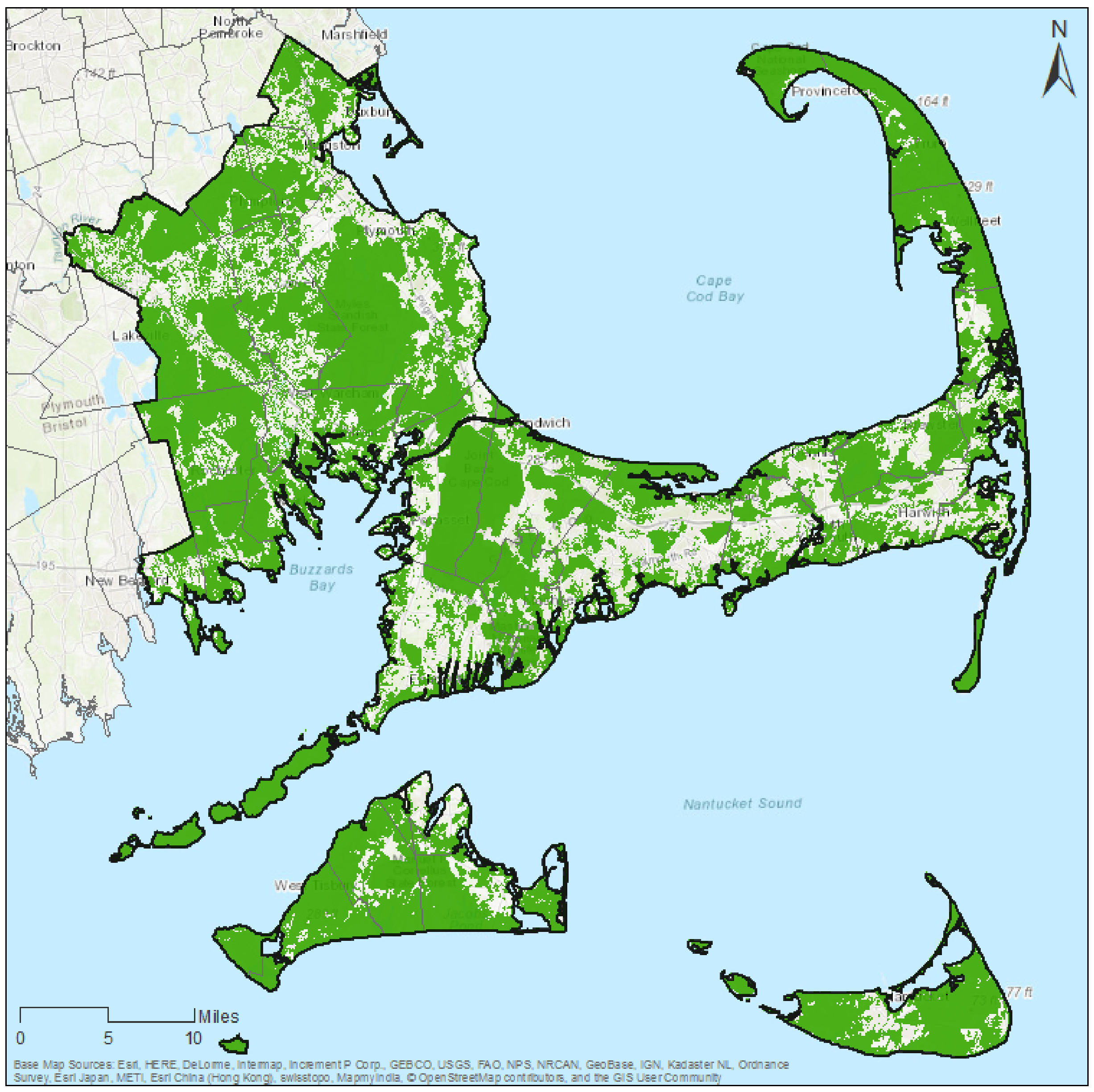


BioMap2 Core & Critical Natural Landscape



Areas within 100ft of Surface Waters, Wetlands, and Flood Zones; Areas </= 4m elevation (vulnerable to sea level rise)

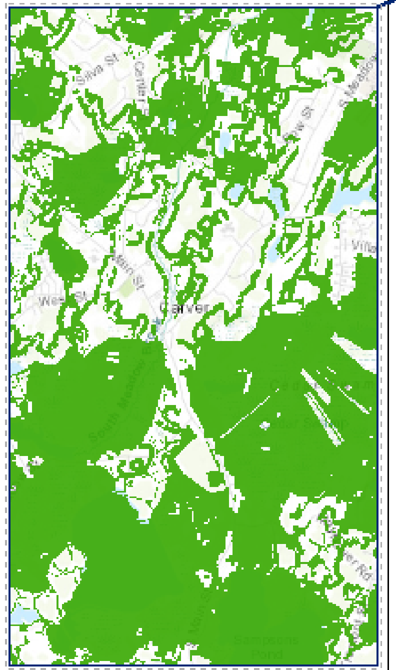


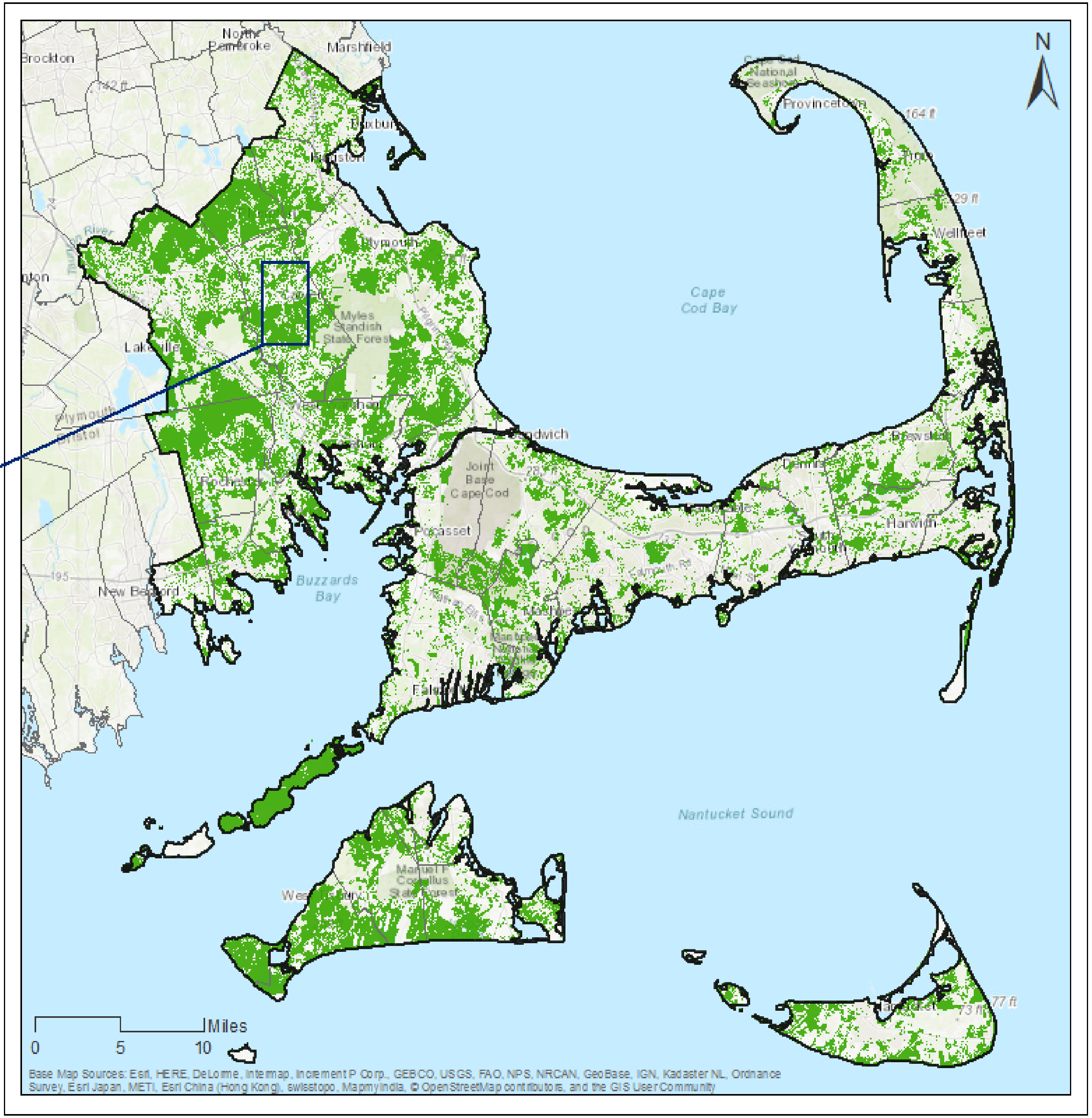


Undeveloped & Unpr
Green Infrastruct

53% of the GI Network
is currently undeveloped &
unprotected.

This represents **39%** of the
study area
(~ 243,000 acres).





243,000 acres in play
—unprotected and undevelop

Undeveloped & Unprotected Green Infrastructure Topo Map

Story Map

https://bit.ly/3MnykRS

A Cape Cod Commissio...

Conserving the Massachusetts Coastal Pine Barrens

Pine Barrens Overview

Natural riches! Despite centuries of development, the Southeastern Massachusetts region has retained much of its original natural splendor. Forty unique, globally rare natural communities and nearly 200 state and federally listed species can be found here, within the Massachusetts Coastal Pine Barrens ecoregion.

This 'story map' celebrates those riches, the biological wealth of the pine barrens ecoregion, and tells the story of one effort to cooperatively identify the most critical and sensitive of the region's remaining open spaces in order to preserve and protect the integrity of these irreplaceable places.

Education

- Provide online and printed editions of *A Guide to the Natural Communities of Massachusetts.*
- Offer citizen science programs.
- Post informational videos on social media of state and local restoration and management efforts.
- Establish a Pine Barrens Nature and Climate Research and Education Center.


SOUTHEASTERN MASSACHUSETTS
SEMPBA
PINE BARRENS ALLIANCE

Branding – “to make Coastal Pine Barrens a household term”

- Place interpretive panels at selected Massachusetts Department of Conservation and Recreation sites in SE Mass.

Branding – “to make Coastal Pine Barrens a household term”

- Install signs along roadways, “Entering the Coastal Pine Barrens”


TOGETHER
WE CAN PROTECT OUR
COASTAL PINE BARRENS