

# Marshes and Climate Change on Cape Cod



Chequessett Neck Dike, Herring River, Wellfleet, MA (*Cape Cod Times*)

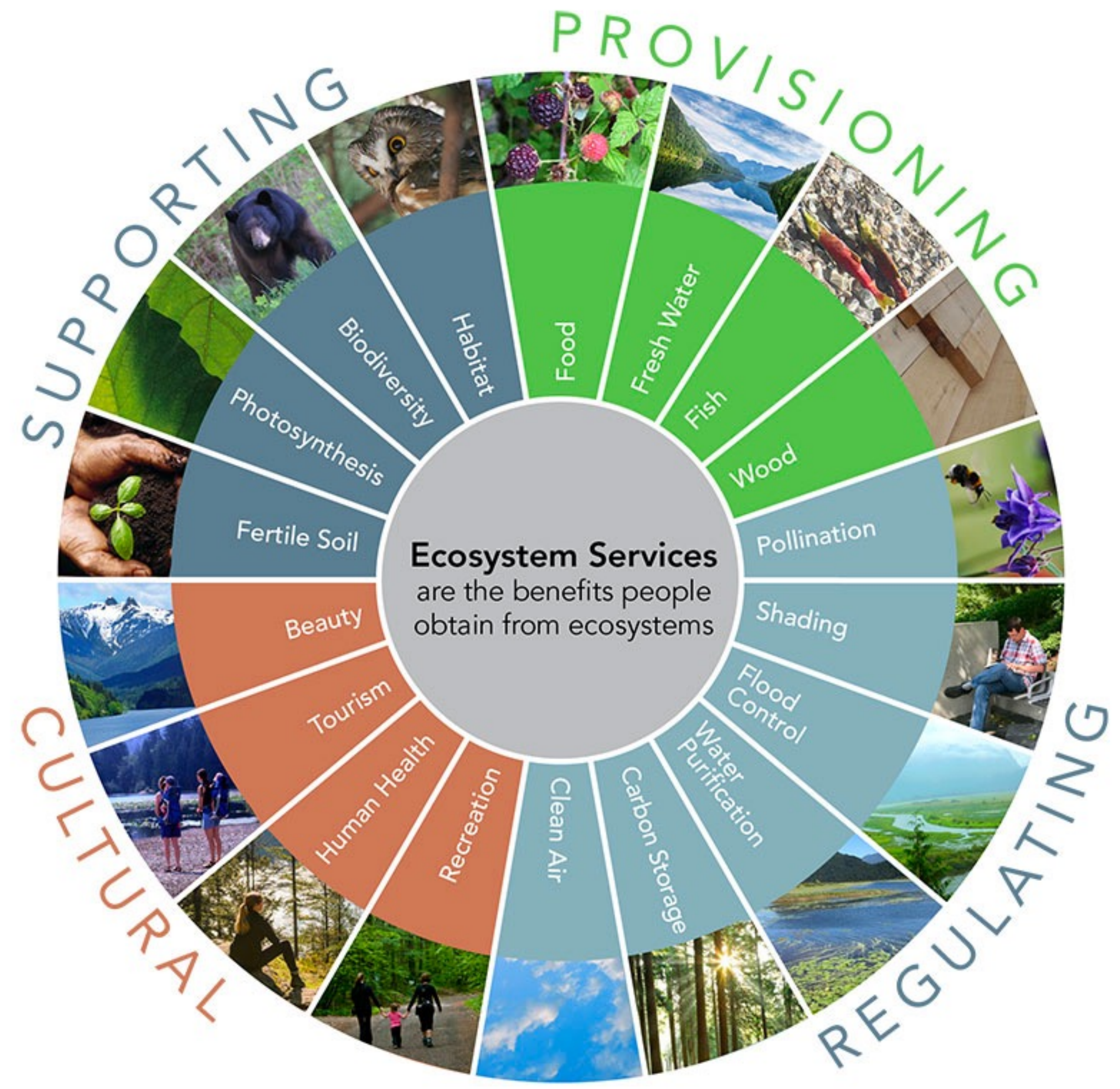
**Katie Castagno, Ph.D.**

Orleans Water and Climate Change Panel

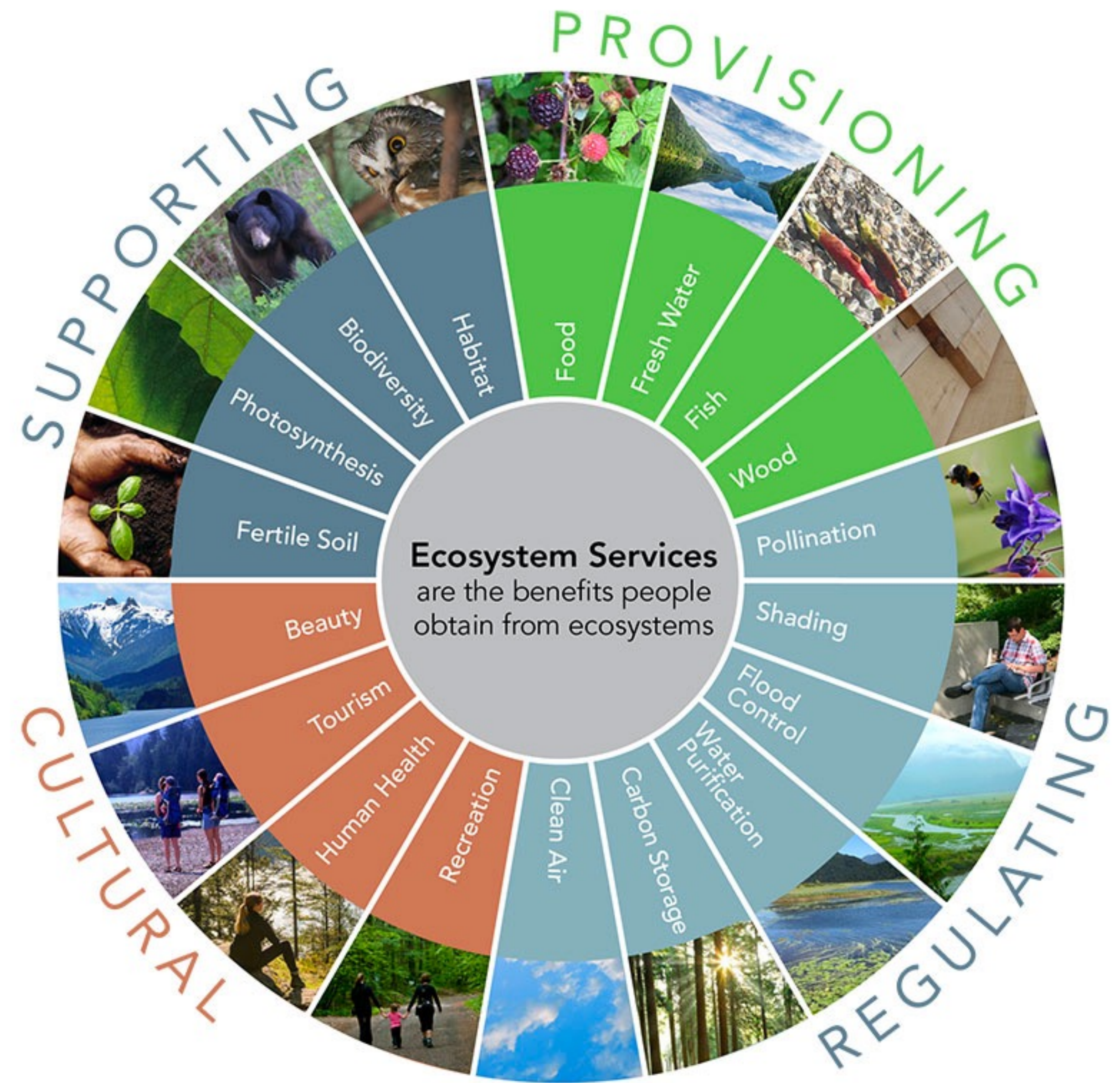
14 June 2024



# Salt marshes provide valuable ecosystem services



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# Salt marshes have experienced centuries of *natural* alteration



Pre-Sandy (May 21, 2009)

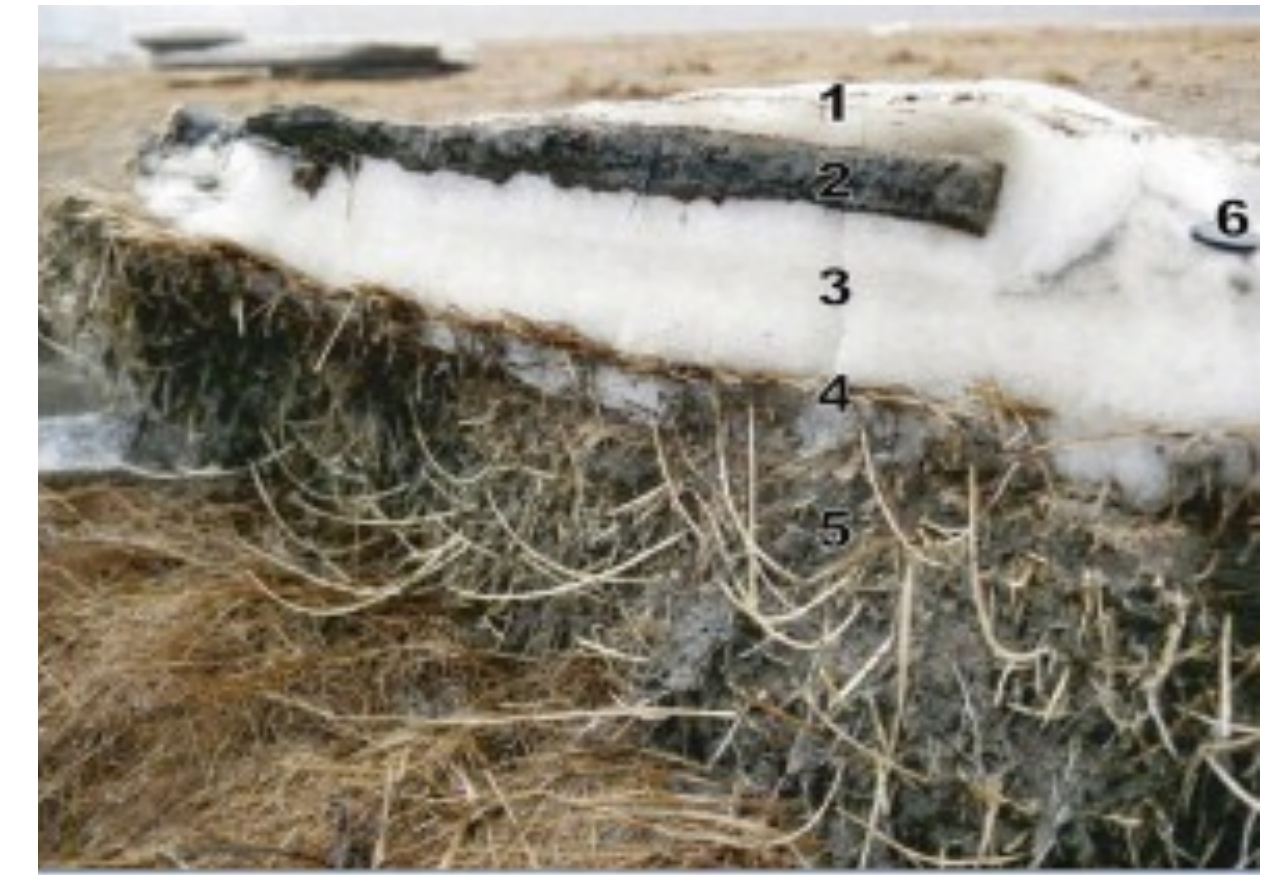


Post-Sandy (November 6, 2012)

Sopkin *et al.* (2014)



Fagherazzi *et al.* (2014)



Argow *et al.* (2011)



# Salt marshes have experienced centuries of *human* alteration

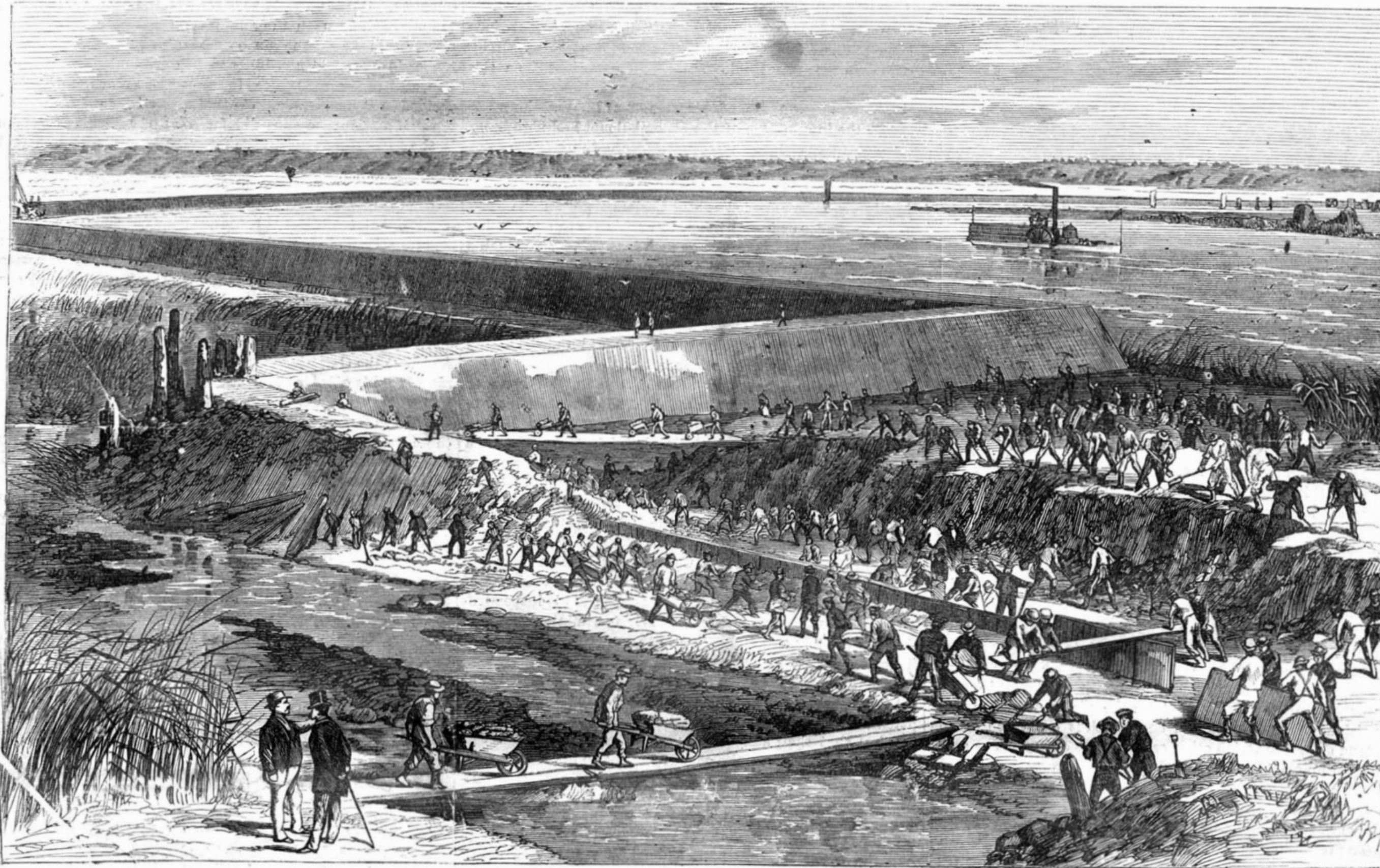
## SCIENTIFIC AMERICAN

A WEEKLY JOURNAL OF PRACTICAL INFORMATION, ART, SCIENCE, MECHANICS, CHEMISTRY, AND MANUFACTURES

Vol. XIX,--No. 5. }  
[NEW SERIES.] }

NEW YORK, JULY 29, 1868.

{ \$3 per Annum. }  
[IN ADVANCE.] }



DIKING AND DRAINING THE NEW JERSEY MEADOWS.

Scientific American (1868)

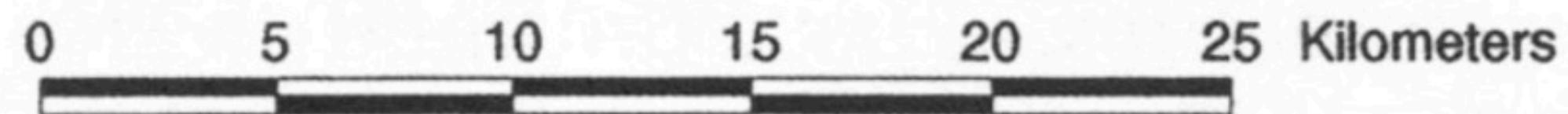
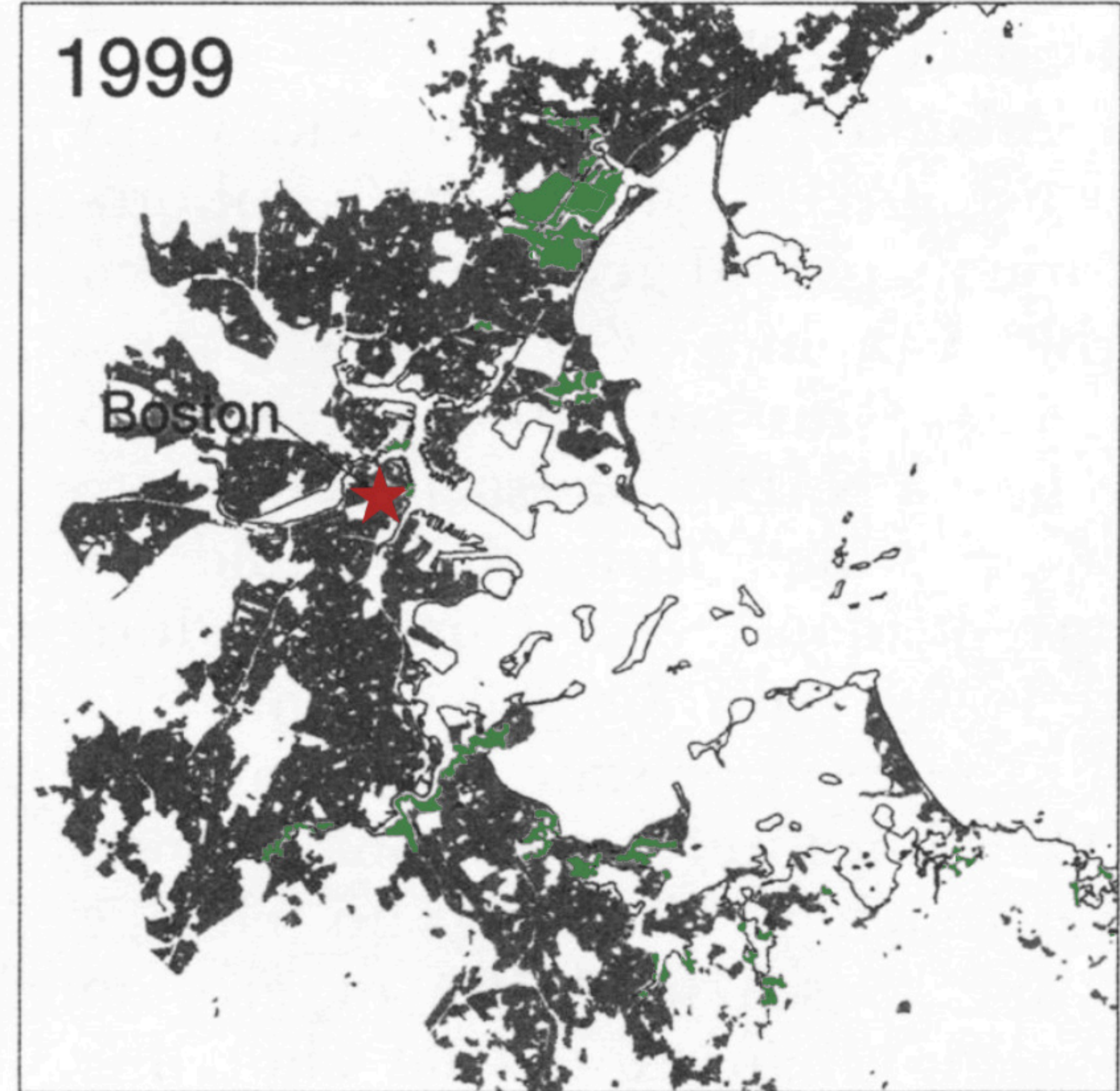
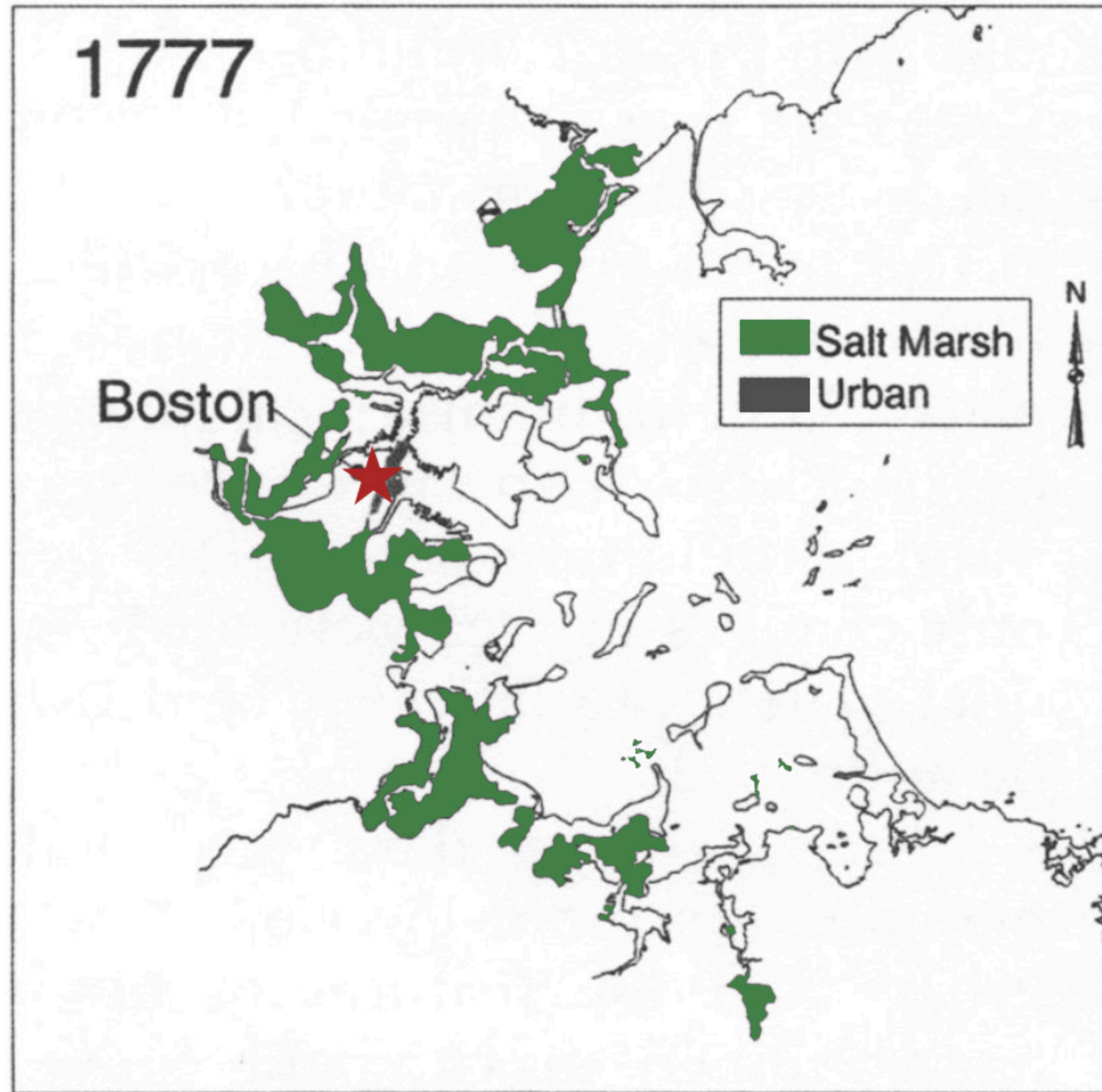
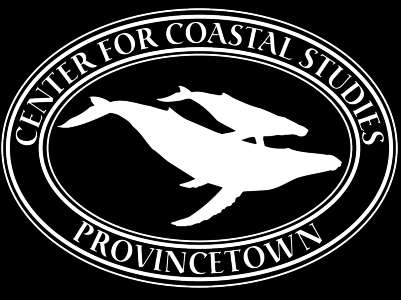
DE Mosquito Control Section (~1930)



George Dexter (~1900)



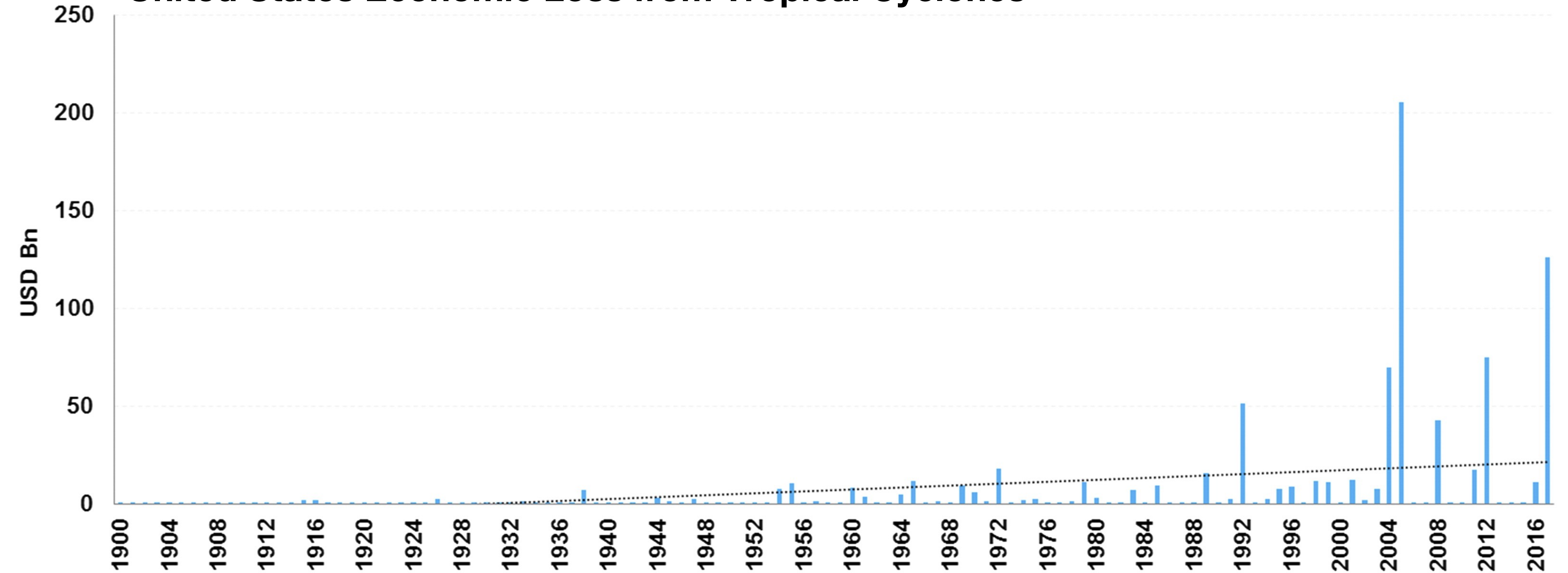
# Marshes have been lost at an alarming rate



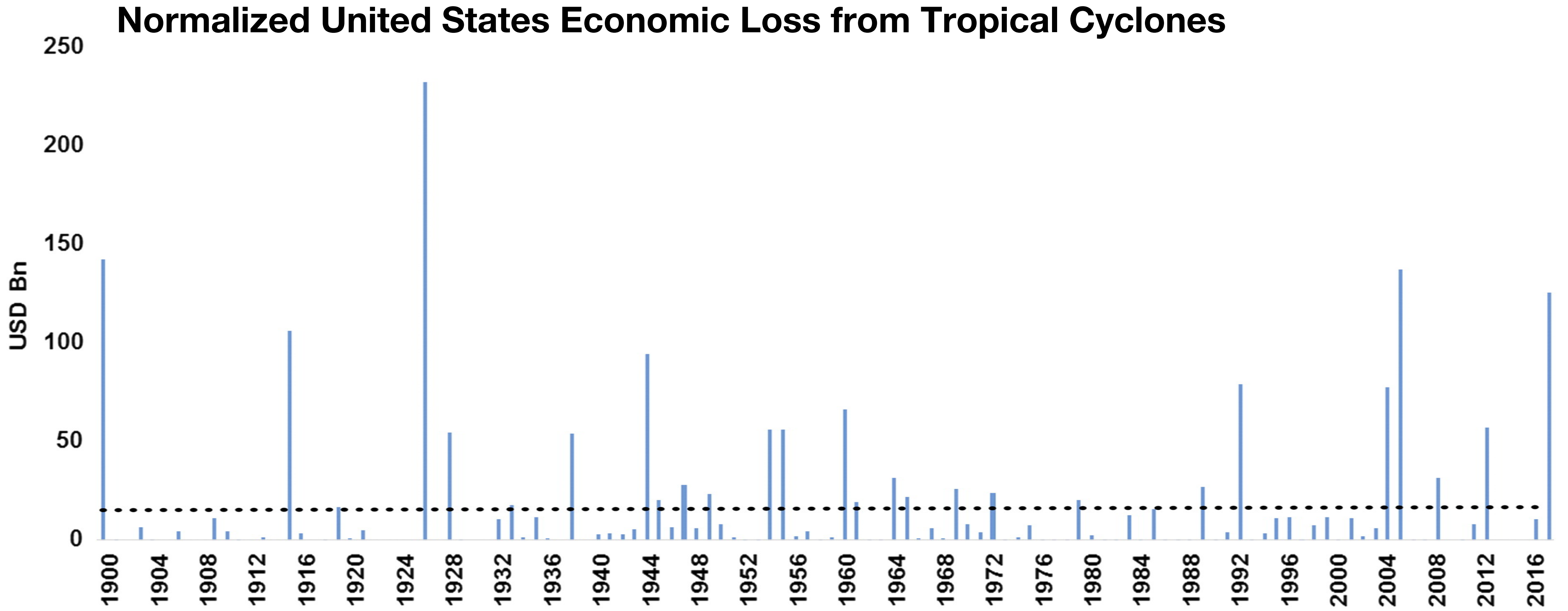
Bromberg and Bertness (2005)

# Coastal communities are growing more vulnerable to storm impacts

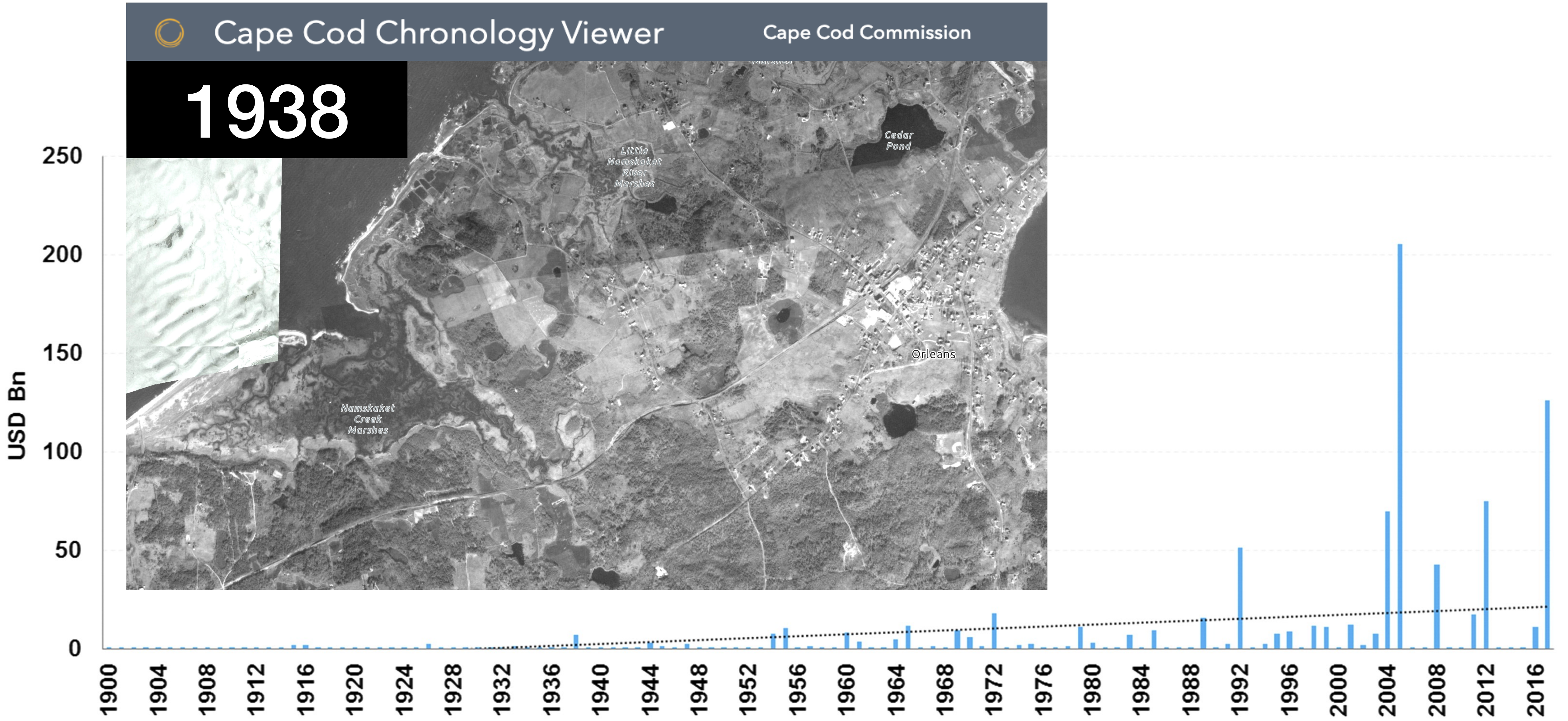
## United States Economic Loss from Tropical Cyclones



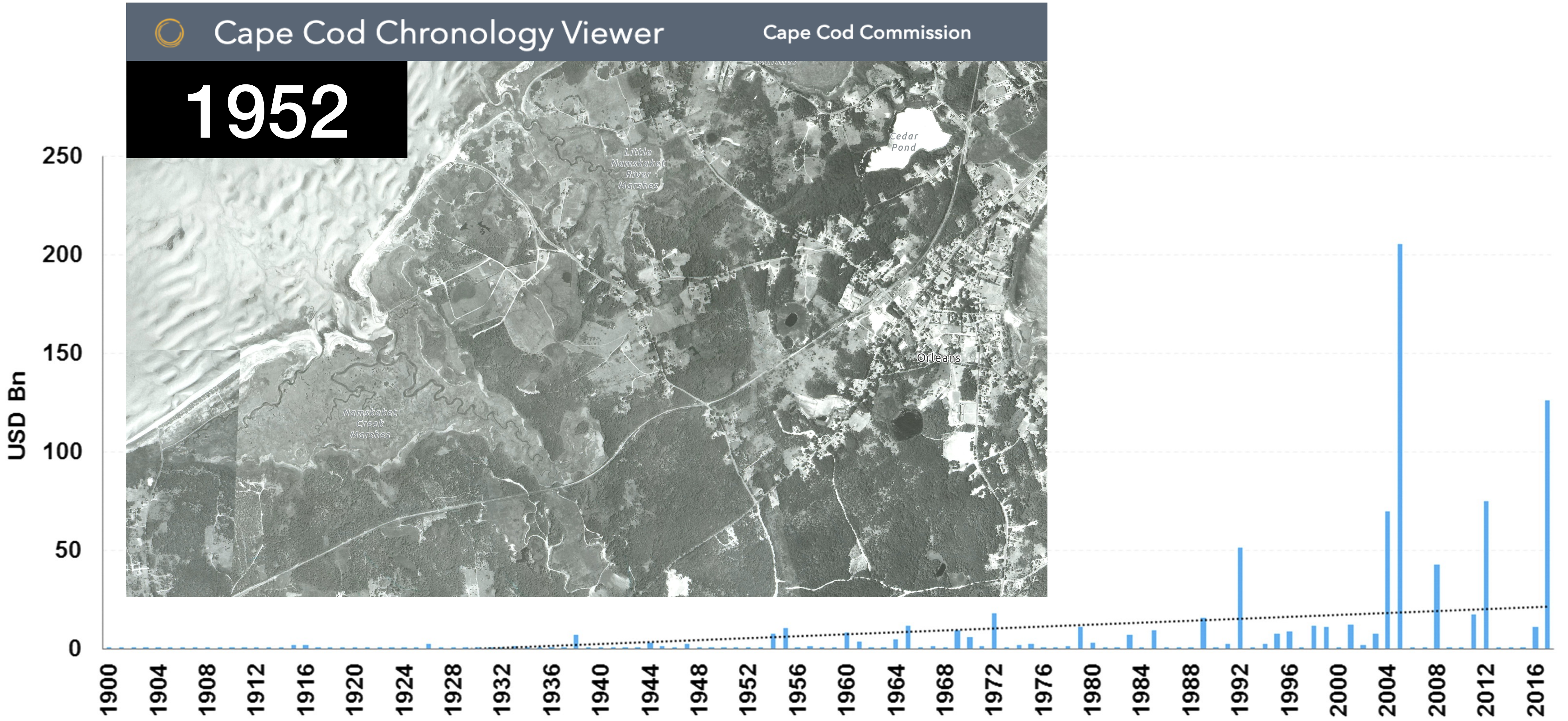
# Coastal communities are growing more vulnerable to storm impacts



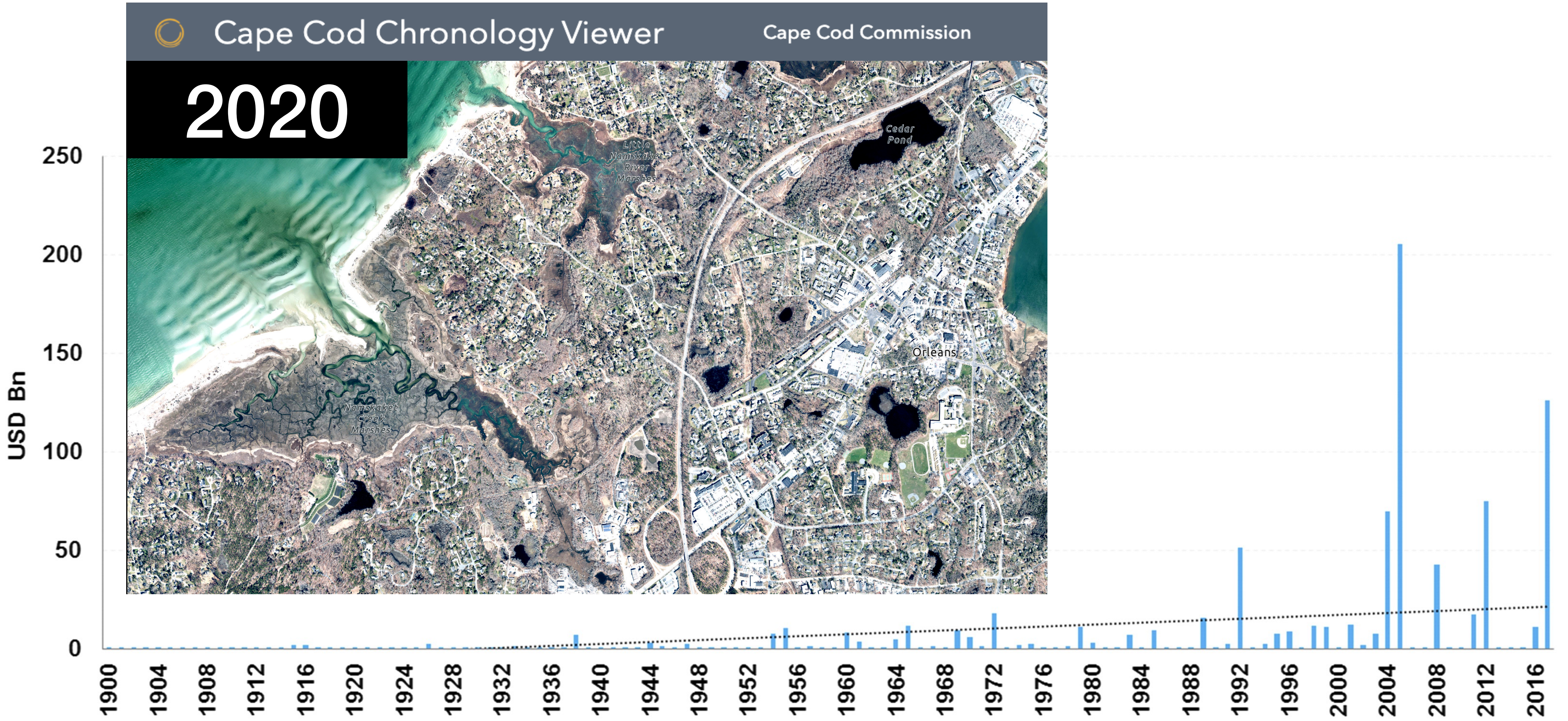
# Wealth is concentrated along vulnerable coastlines



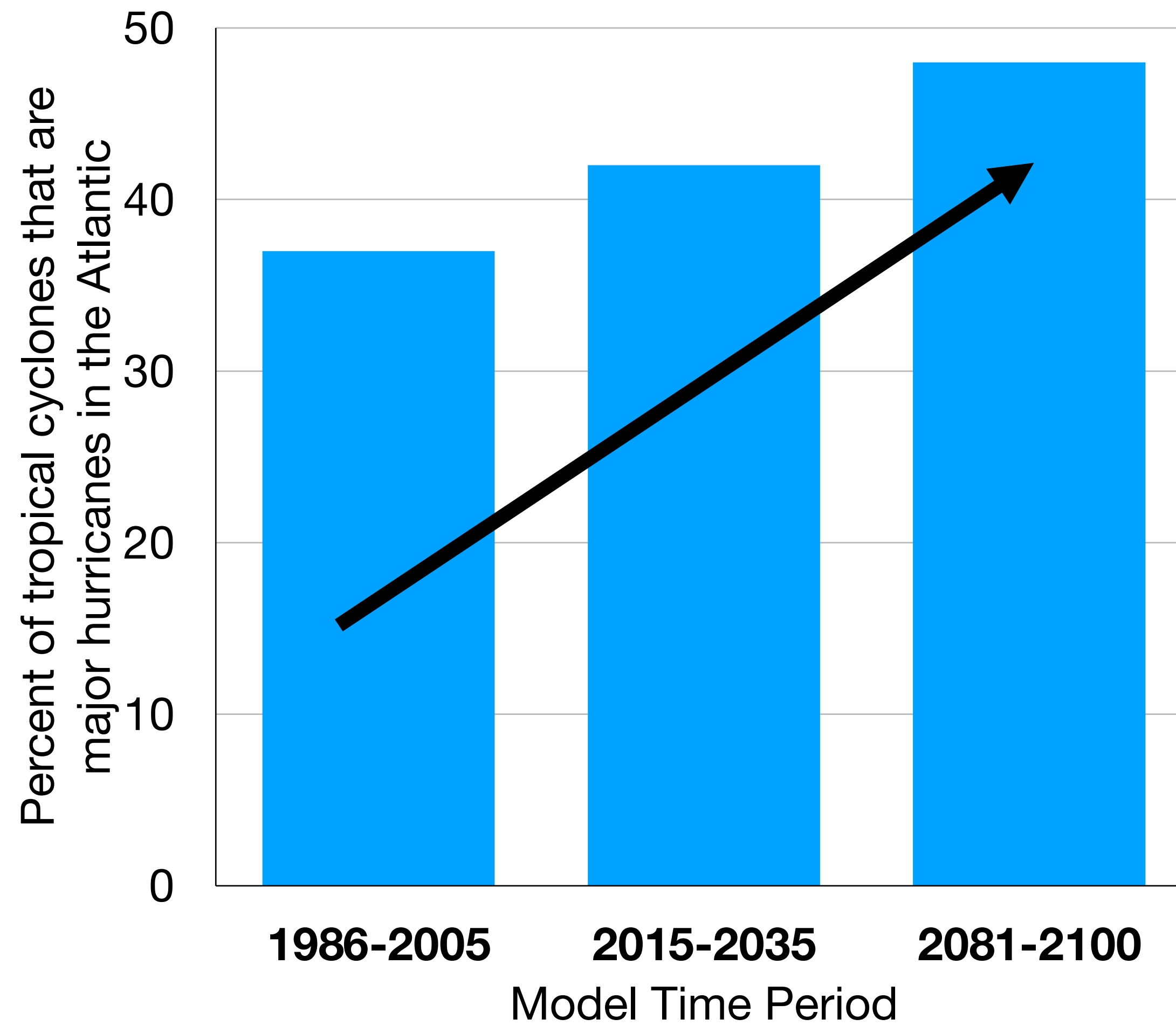
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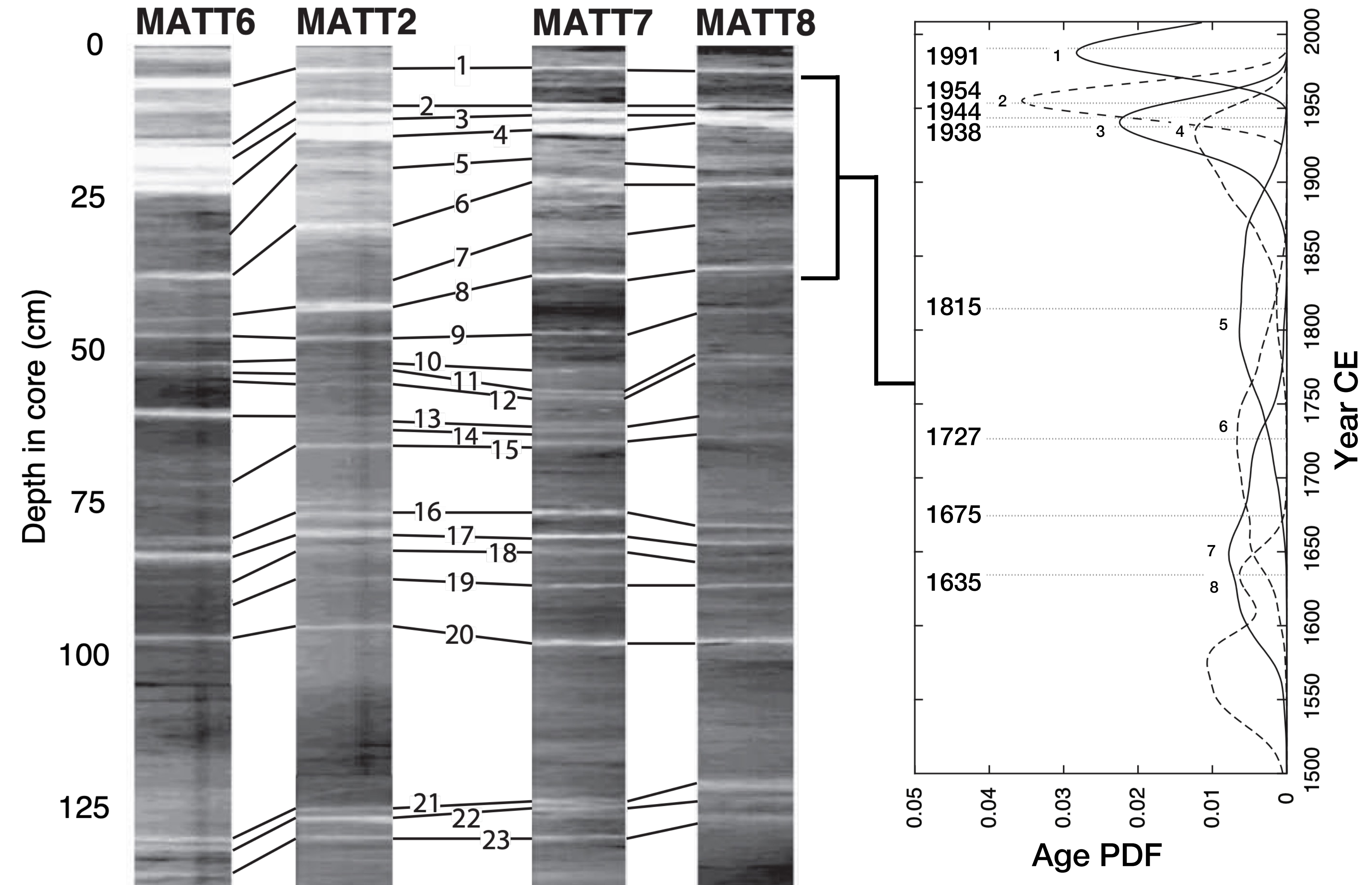
# Wealth is concentrated along vulnerable coastlines



# Intense hurricanes are estimated to increase in frequency



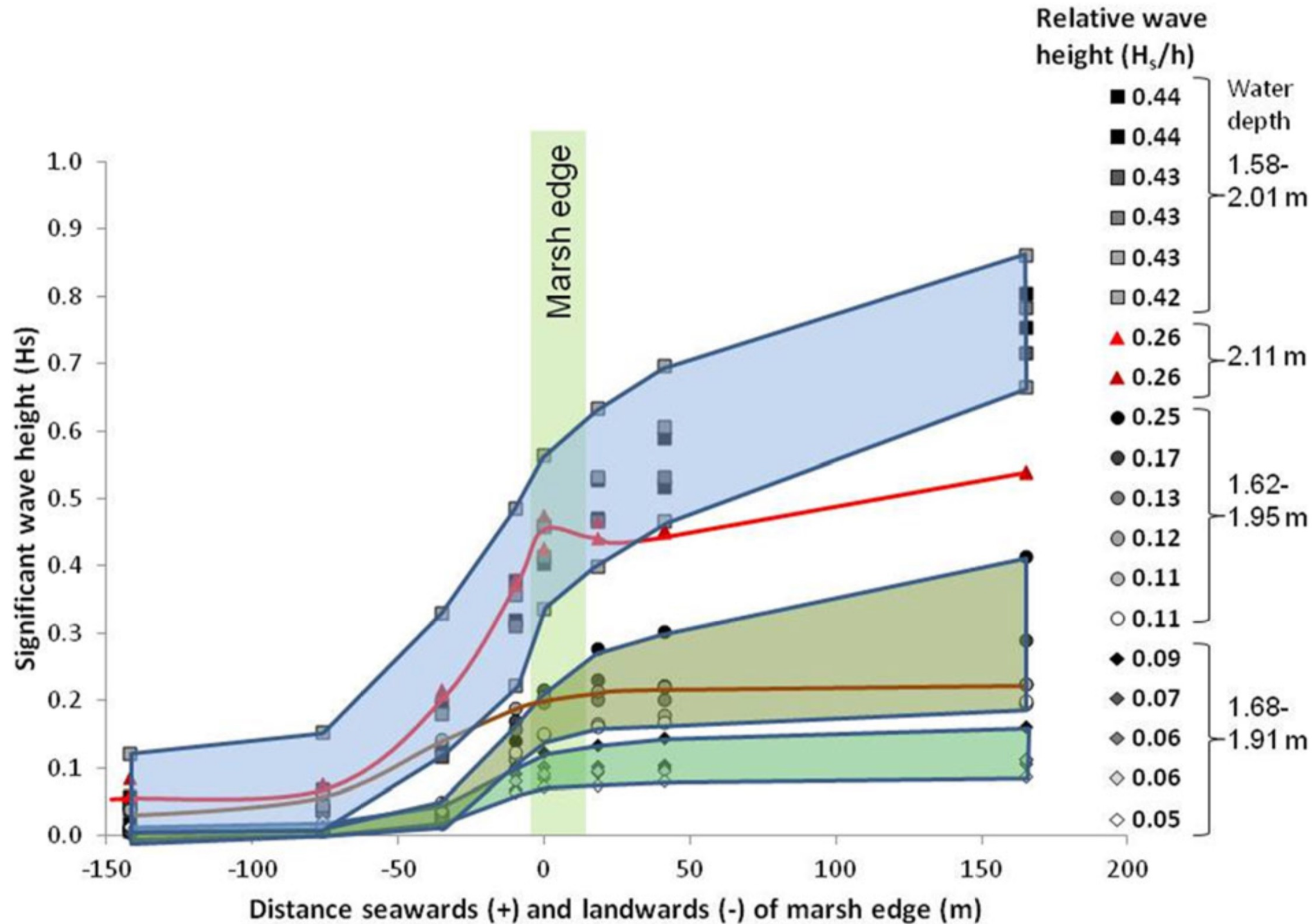
# Storms have impacted salt marshes for thousands of years



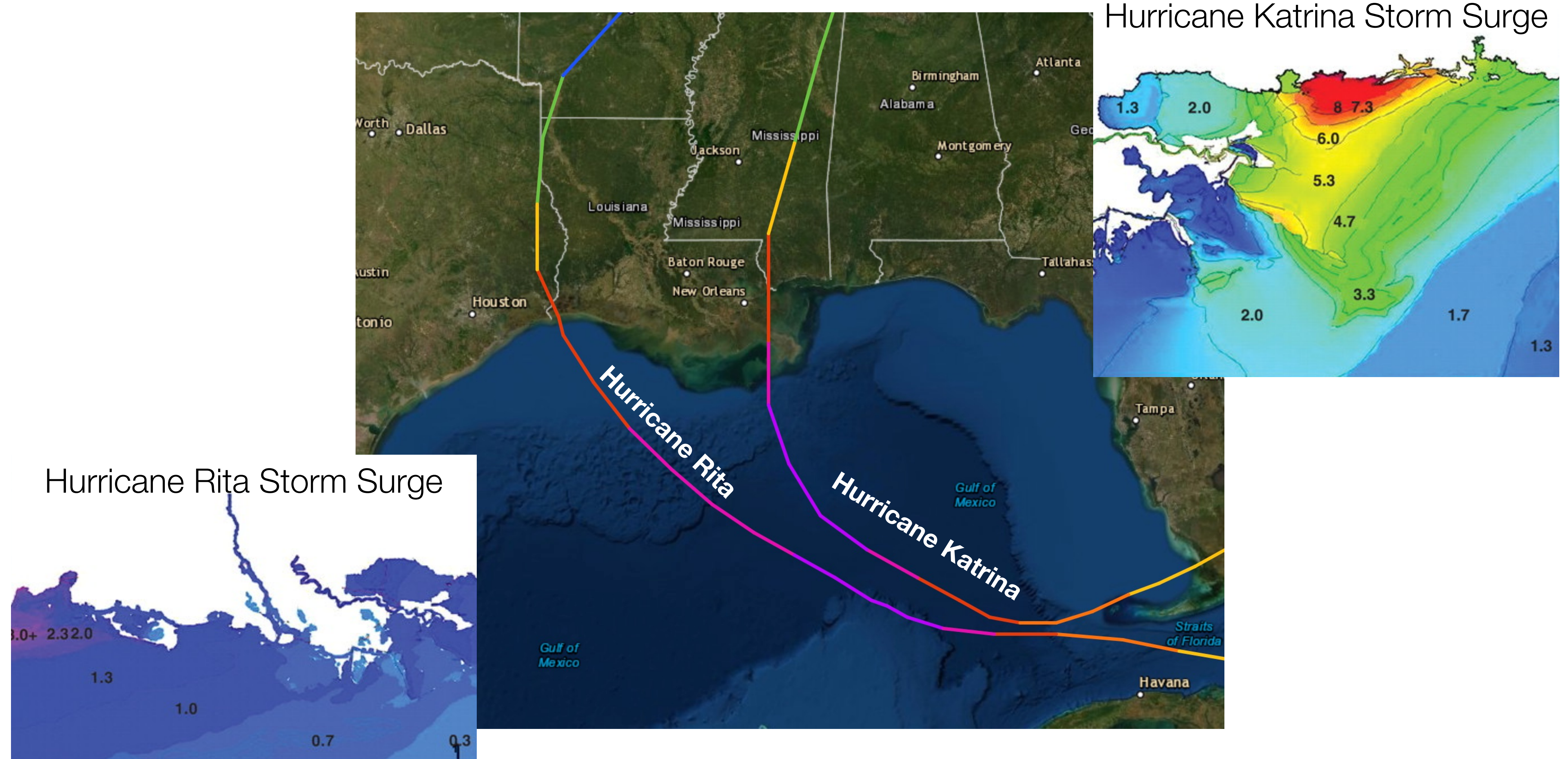
Castagno et al. (2021), *JCR*



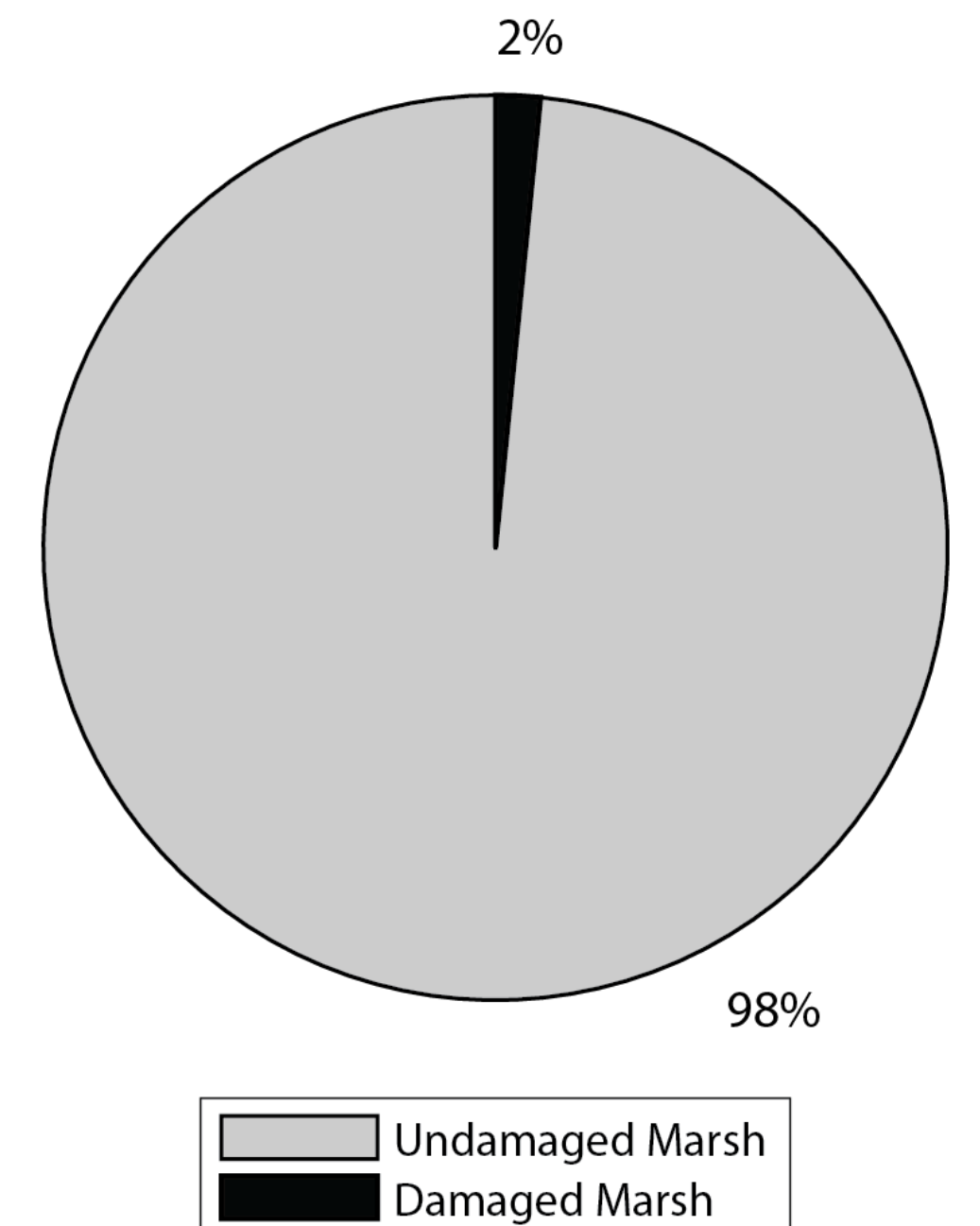
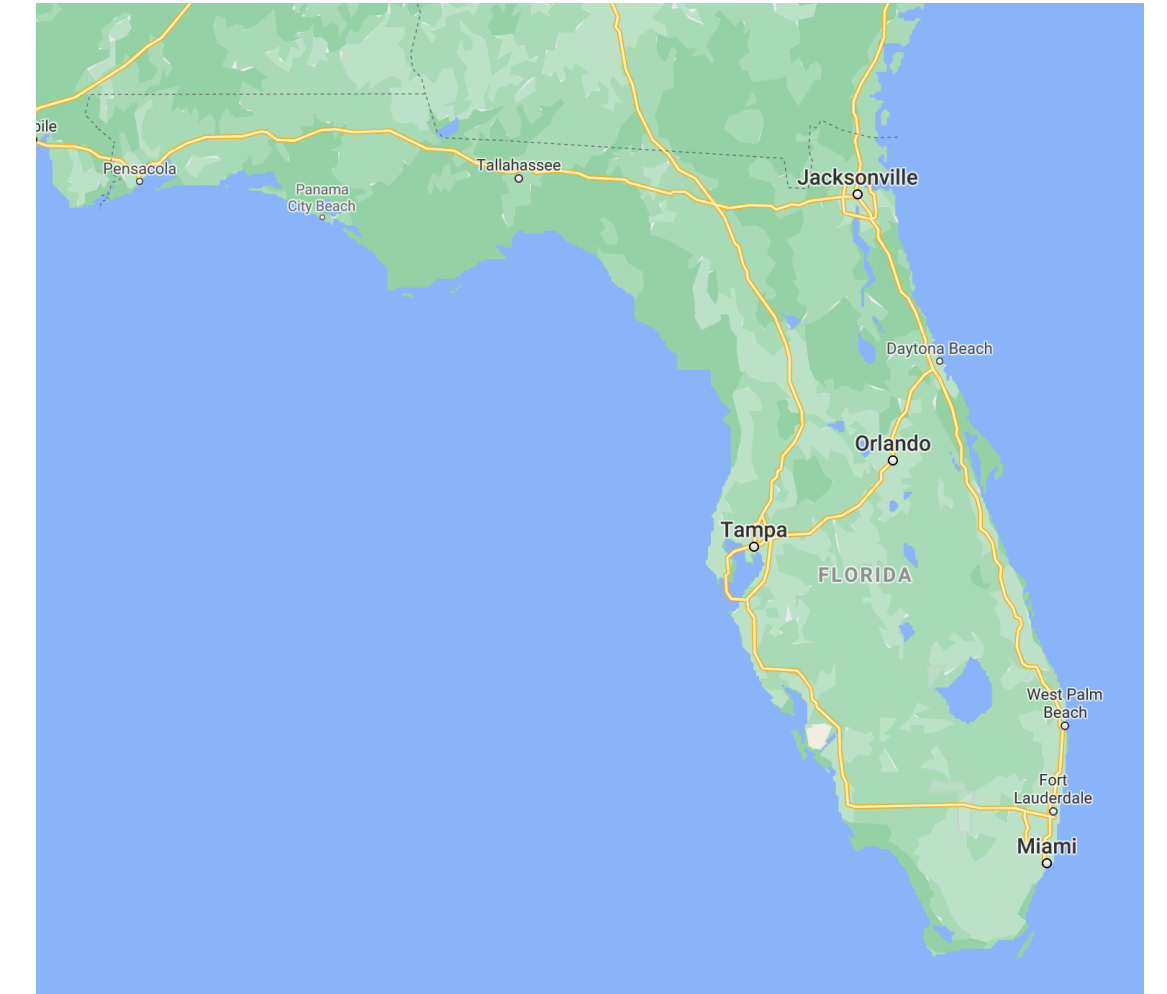
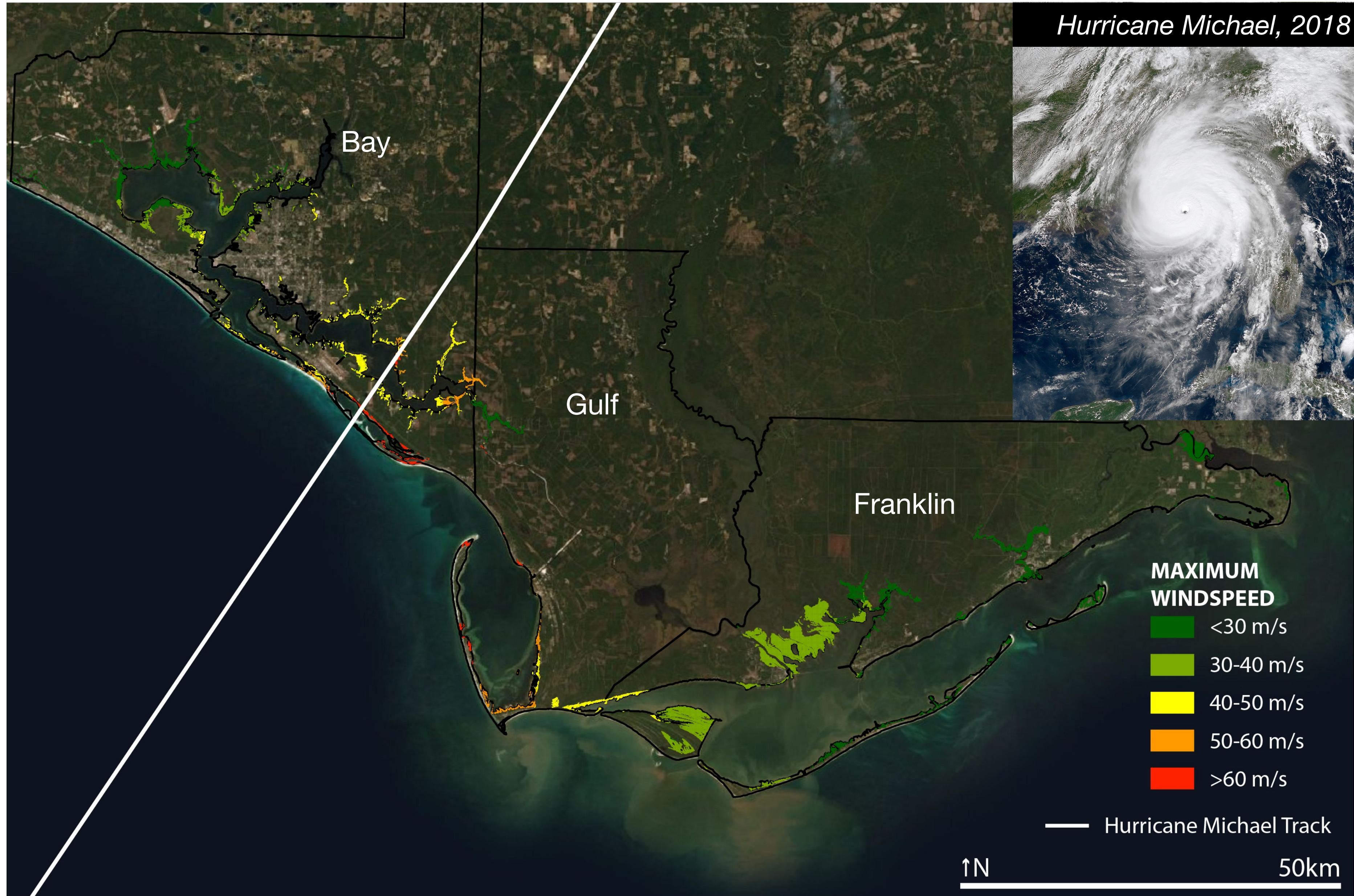
# Salt marshes contribute to coastal resilience as storm buffers



# Salt marshes contribute to coastal resilience as storm buffers



# Salt marshes are largely resistant to storm damage



Castagno et al. (2021), *Scientific Reports*

# Damaged marshes are less resilient to storm impacts



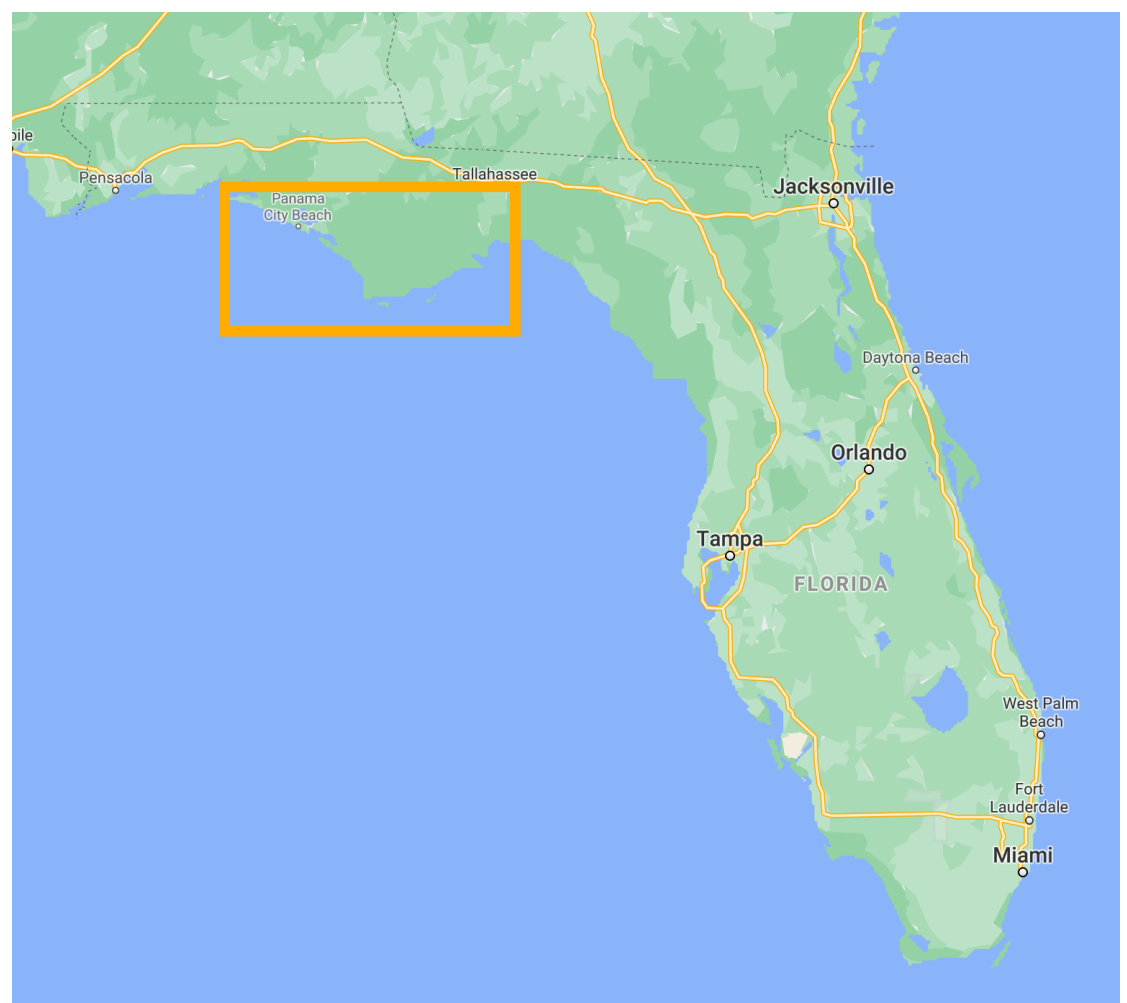
deposition



fallen trees



vegetation loss



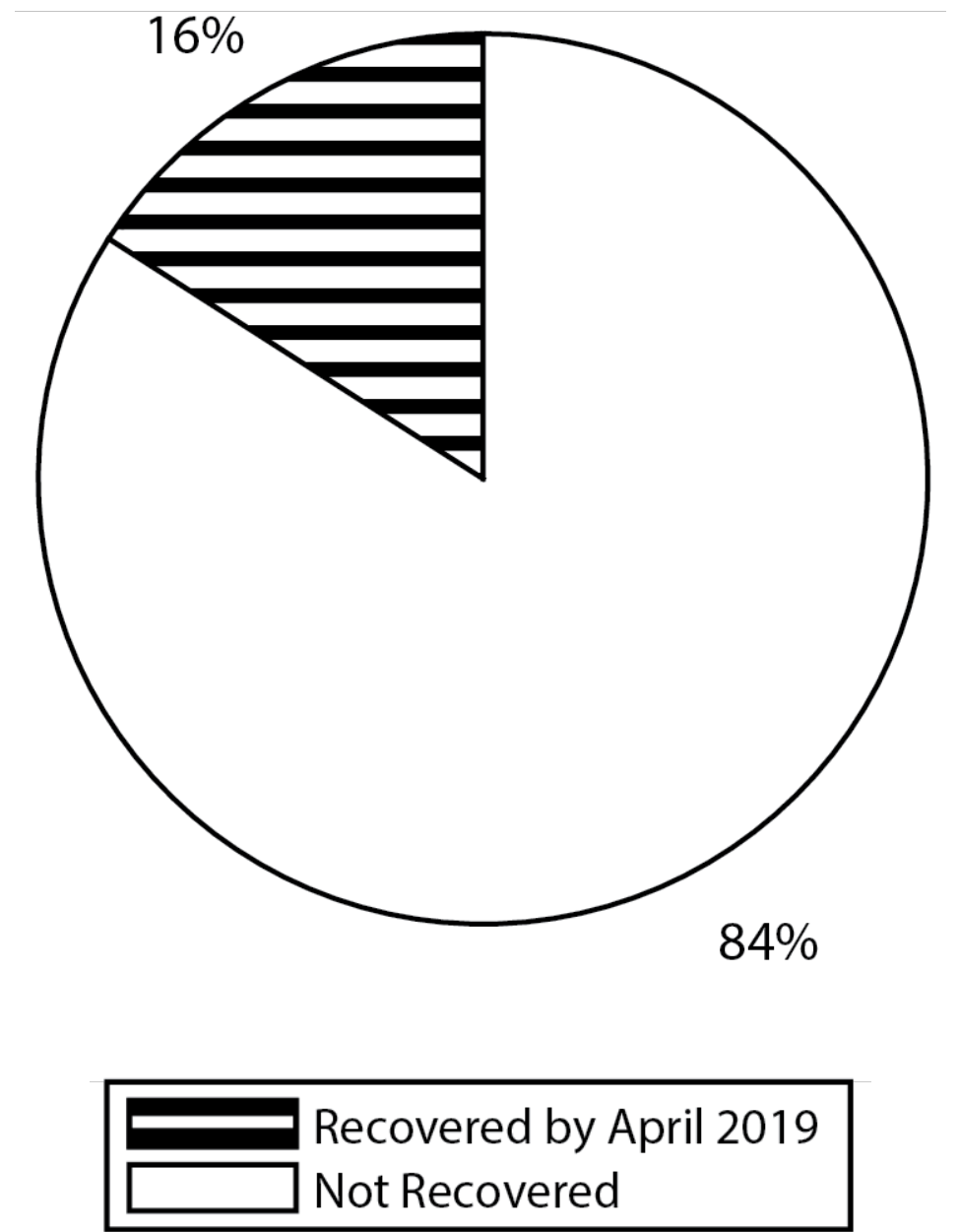
conversion to open water



debris

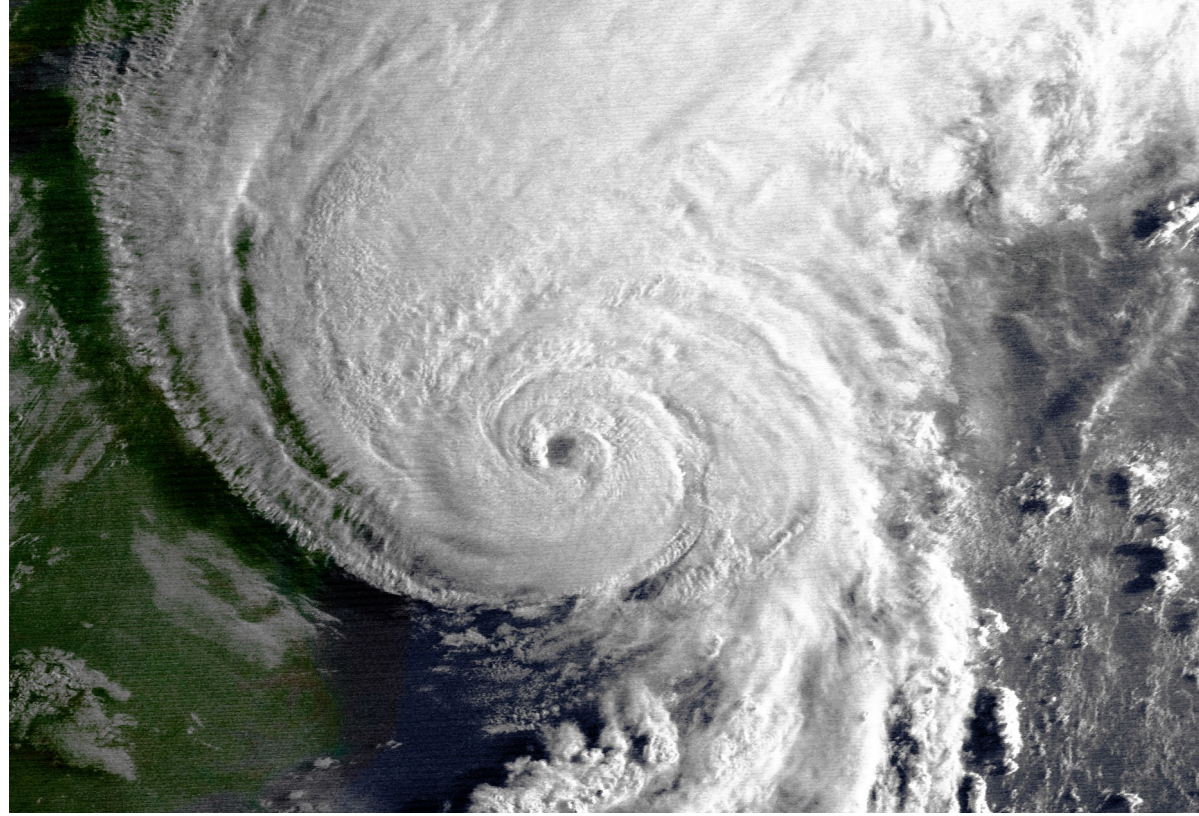


lateral erosion



Castagno et al. (2021), *Scientific Reports*

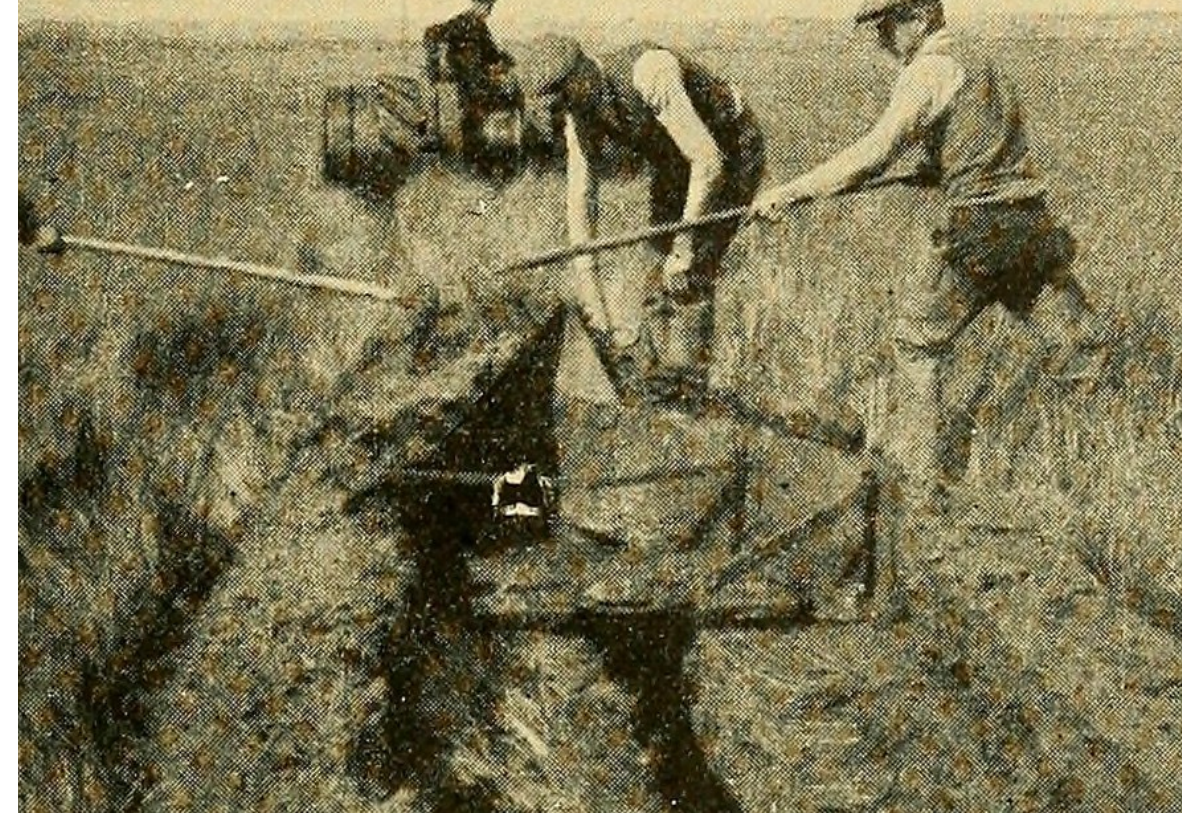
# Salt marshes face many other threats (a non-exhaustive list)



Increased storminess



Sea-level rise



Marsh ditching/drainage



Tidal restrictions



Construction



Crab herbivory (*Sesarma*)

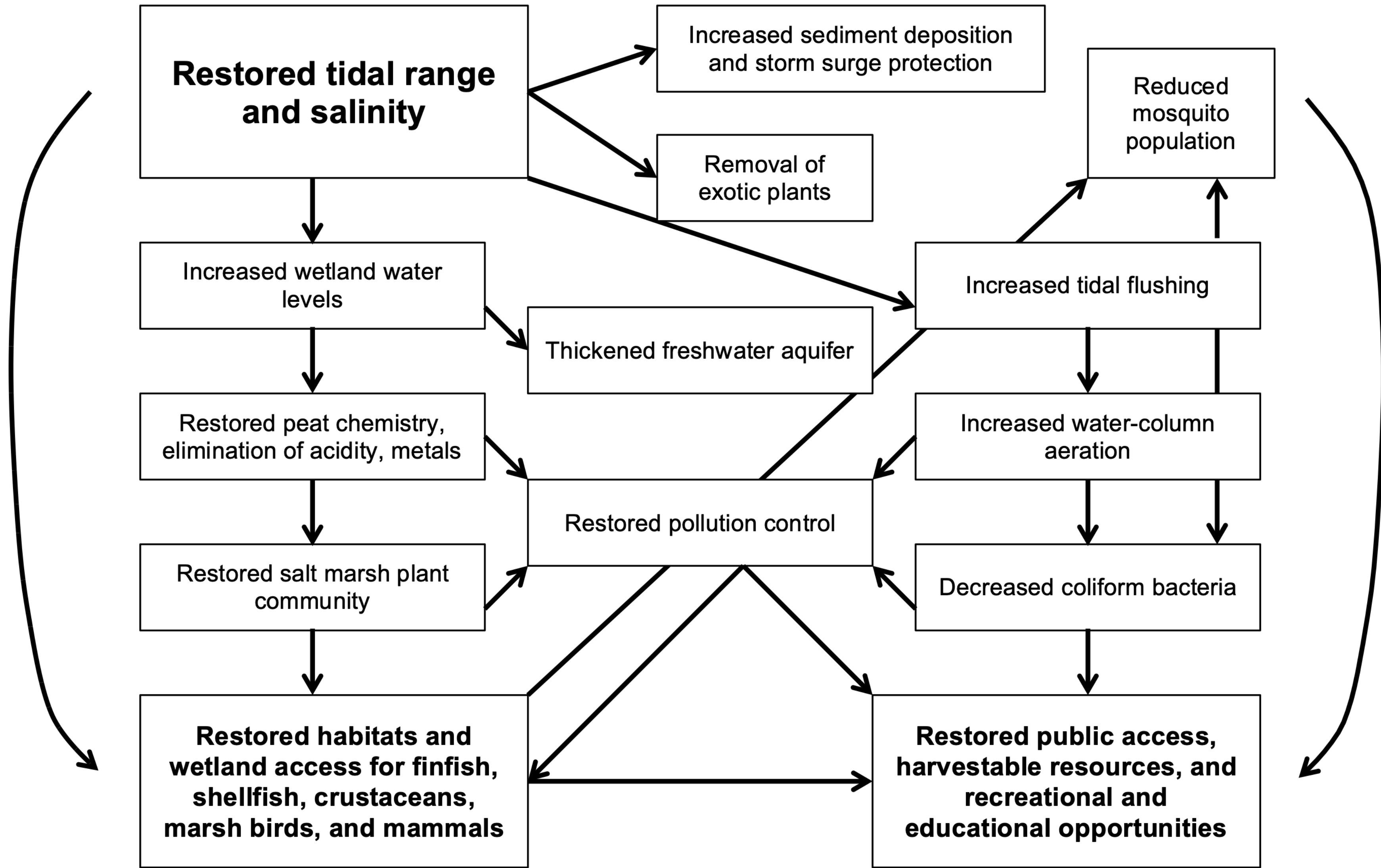
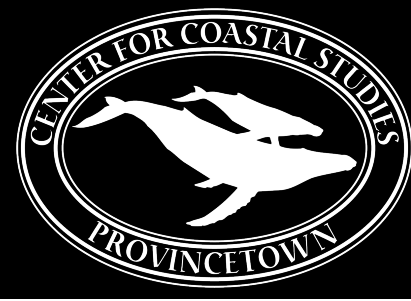


Invasive species (*Phragmites*)

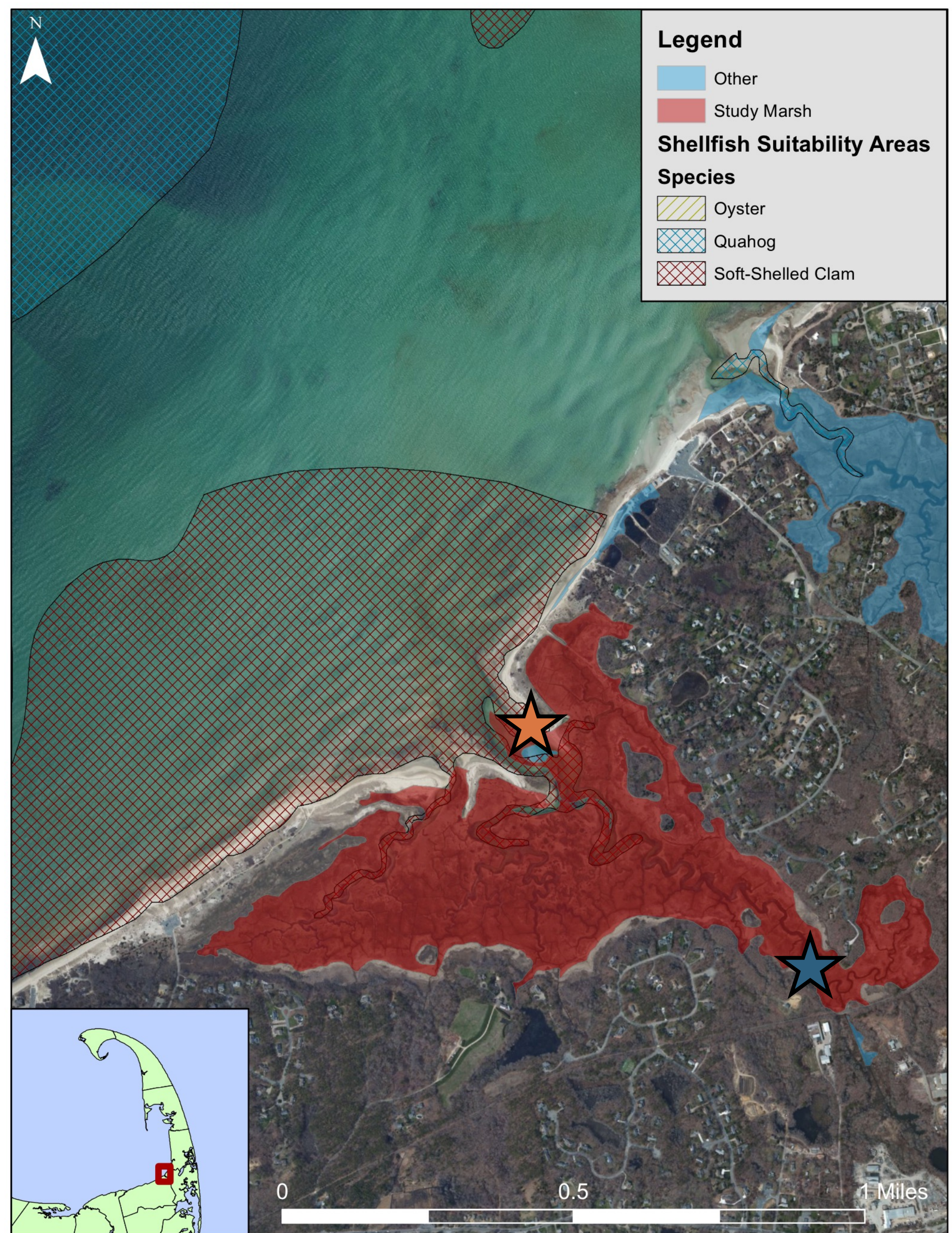


Pollution and runoff

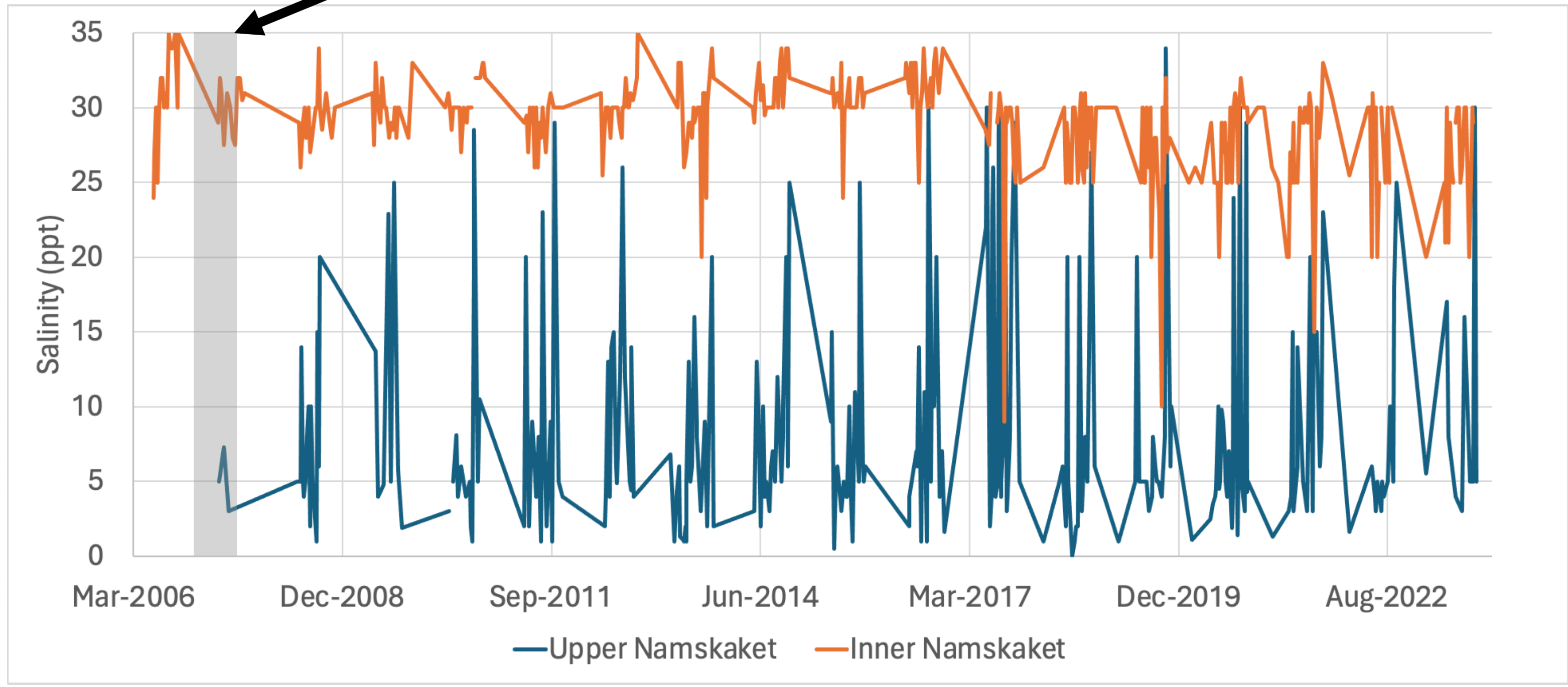
# Salt marsh restoration seeks to restore ecosystem services



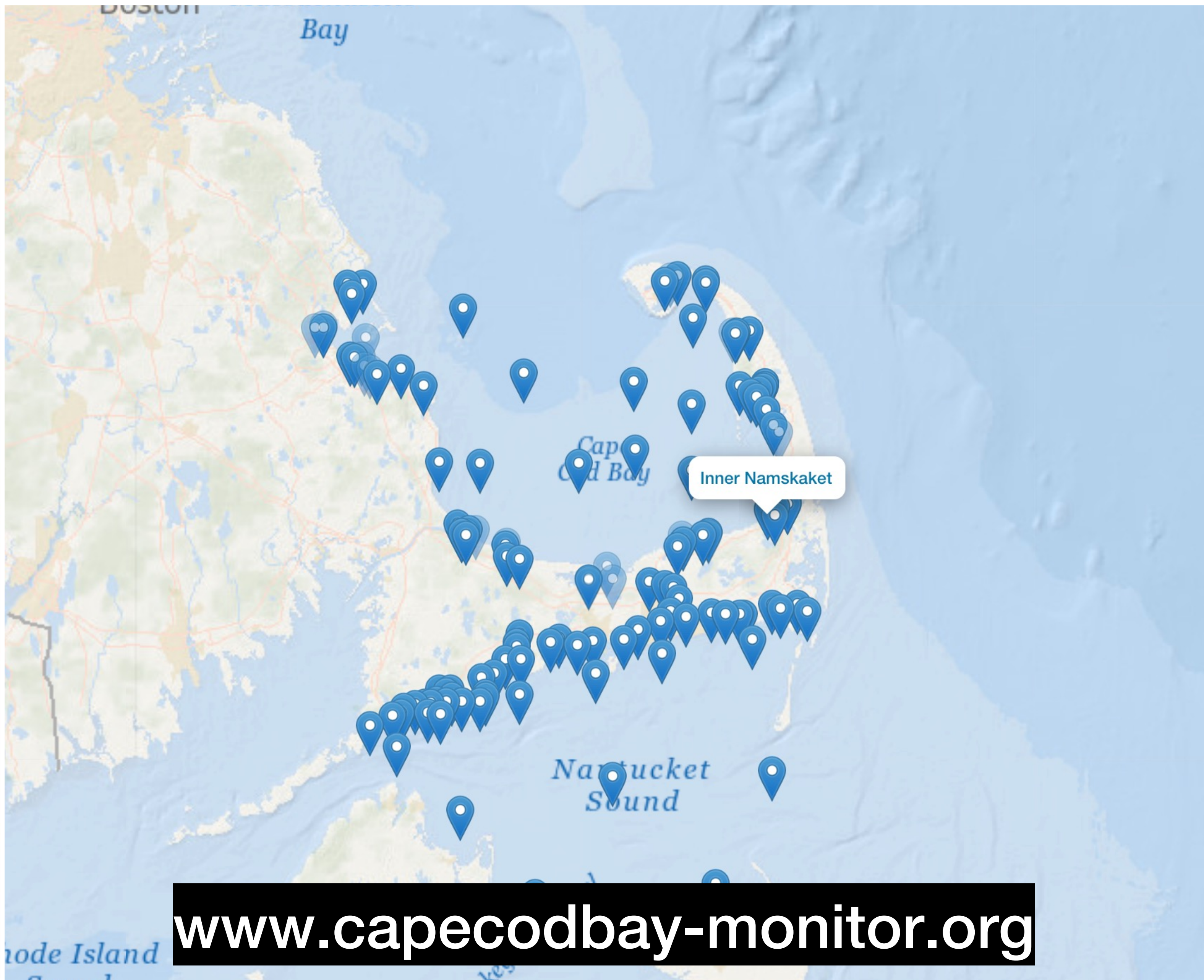
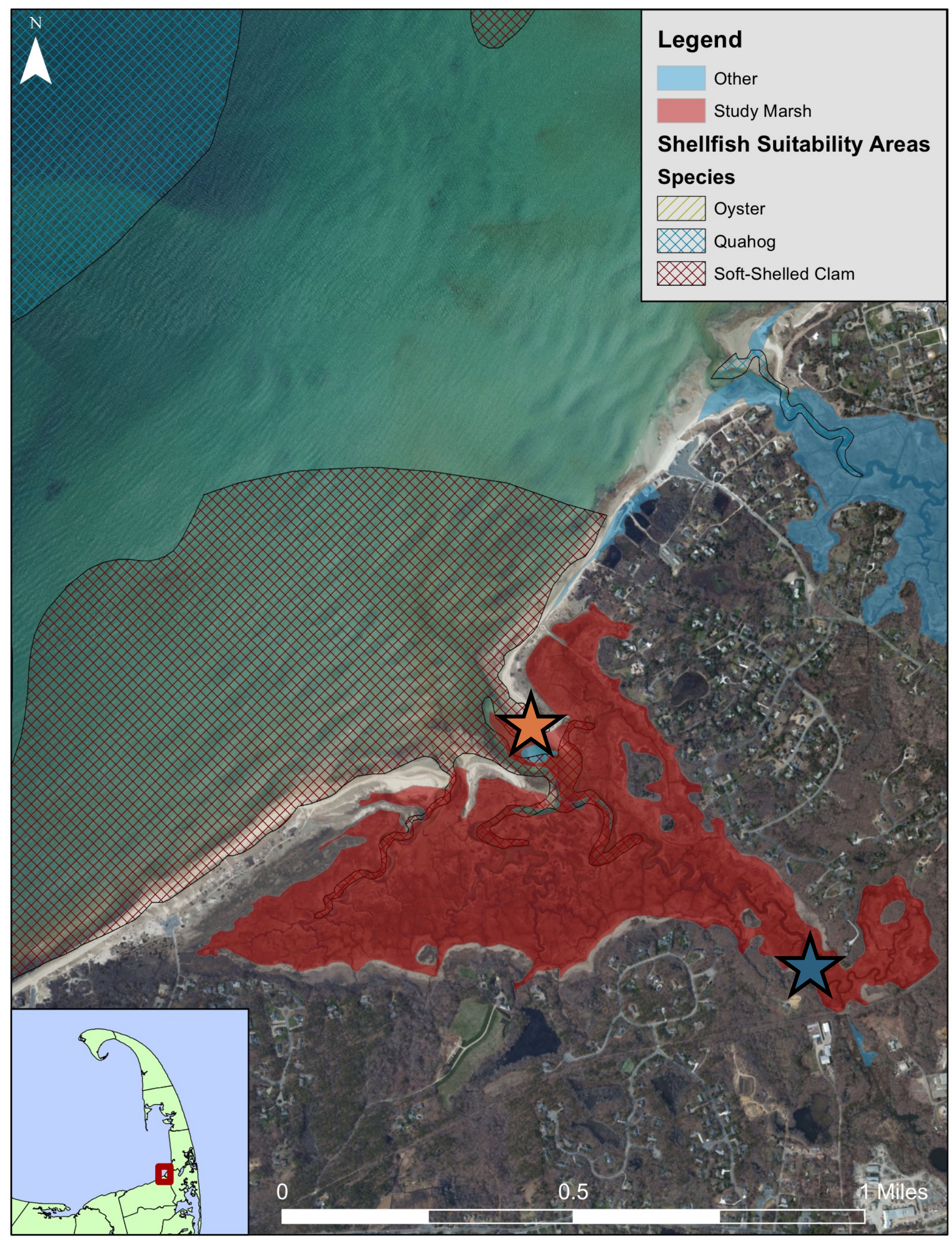
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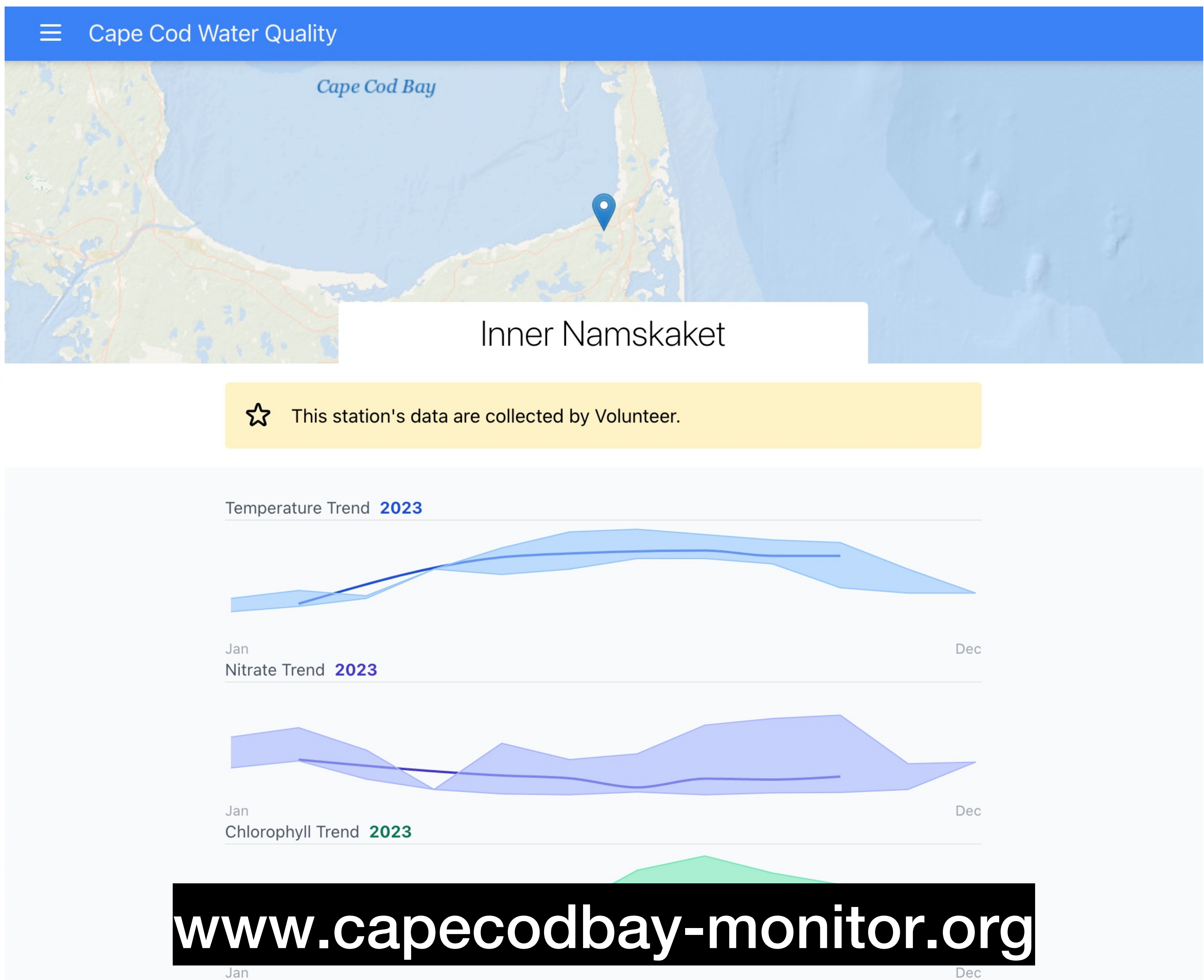
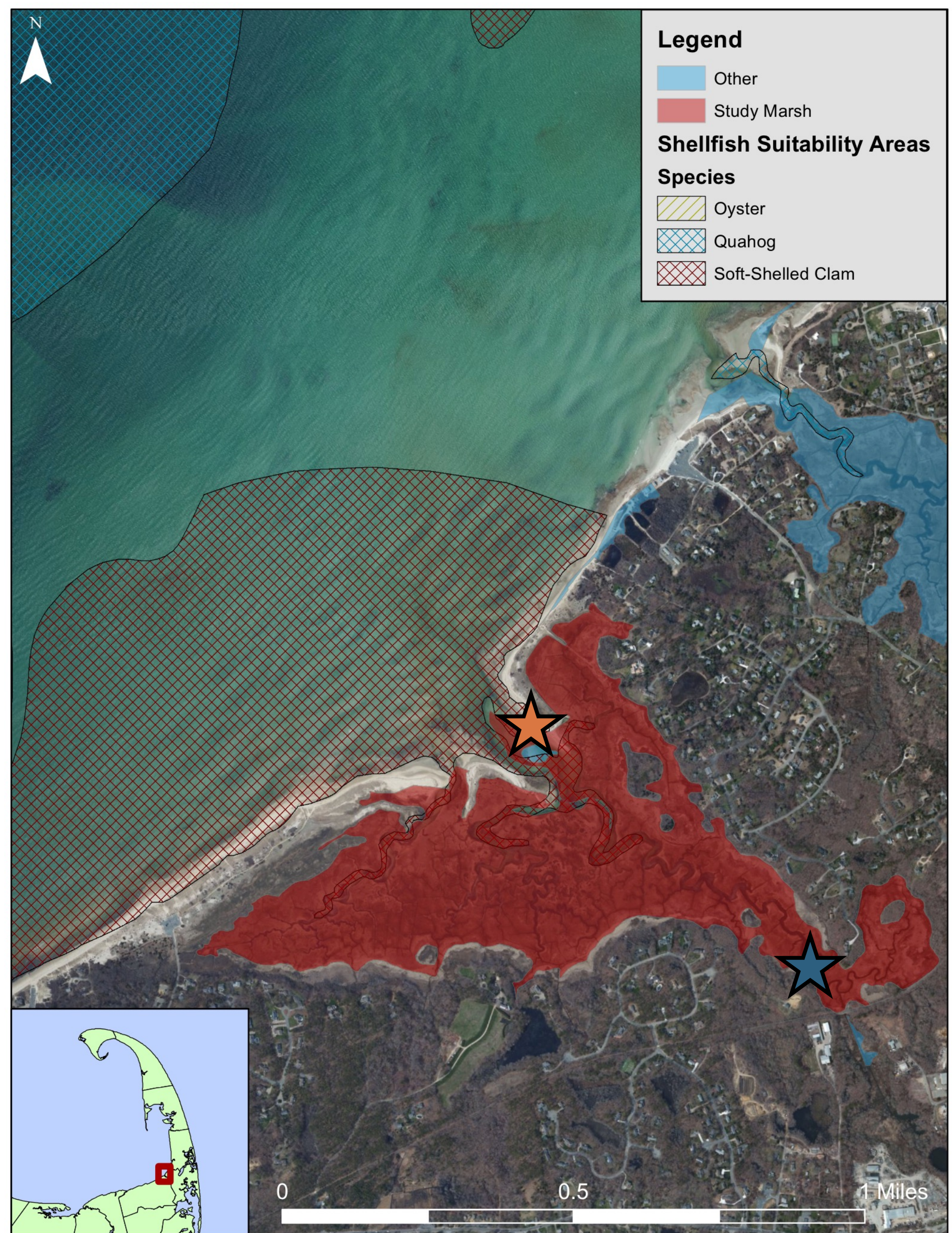
1-ft culvert replaced by two larger, side-by-side box culverts



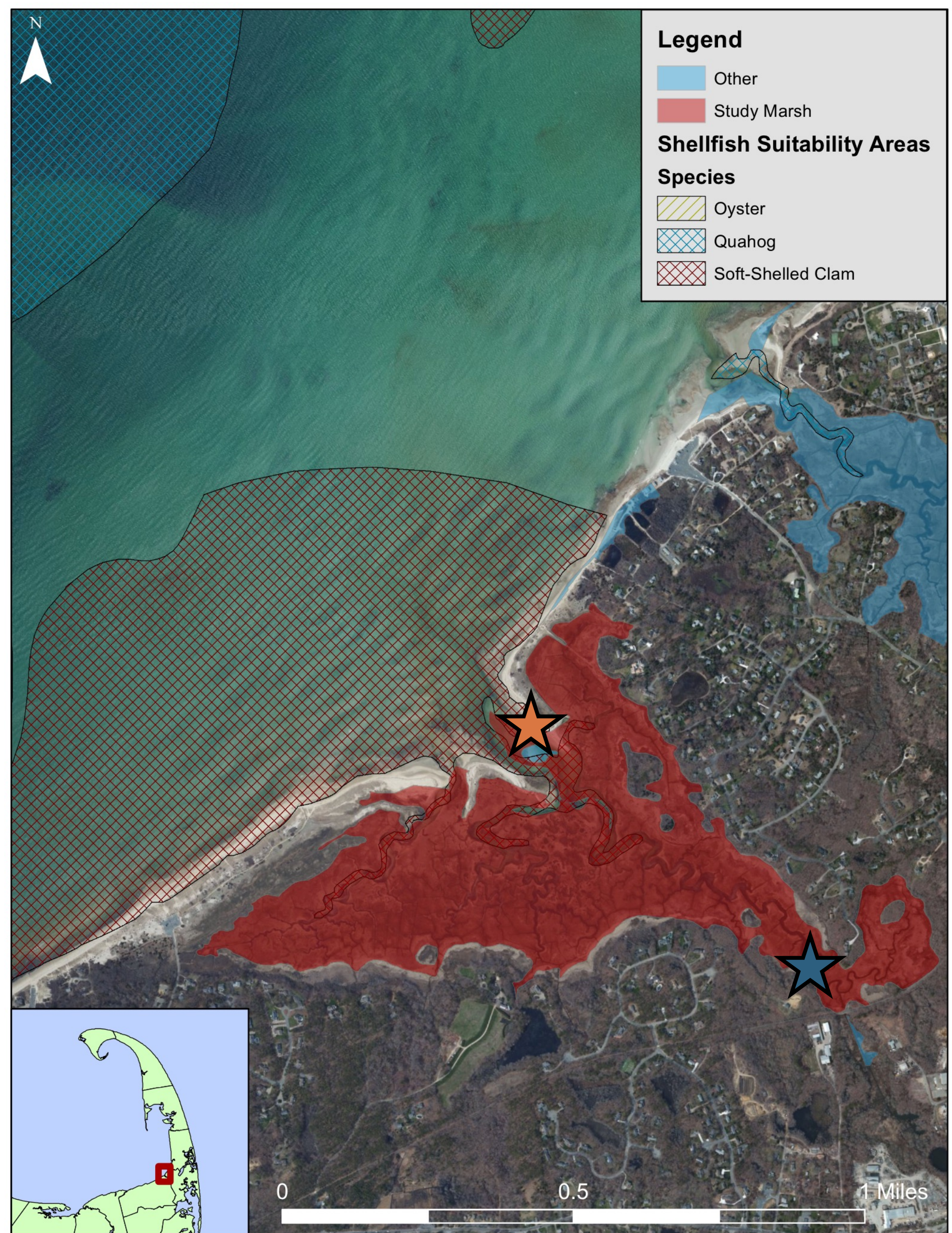
# Resources available from CCS



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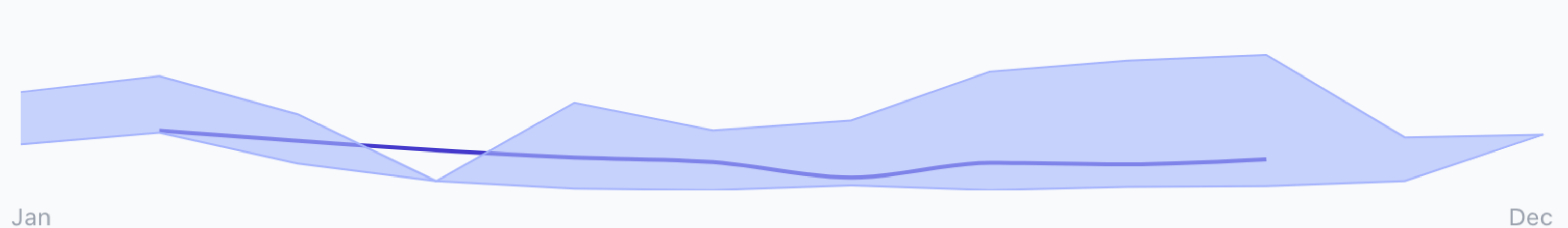
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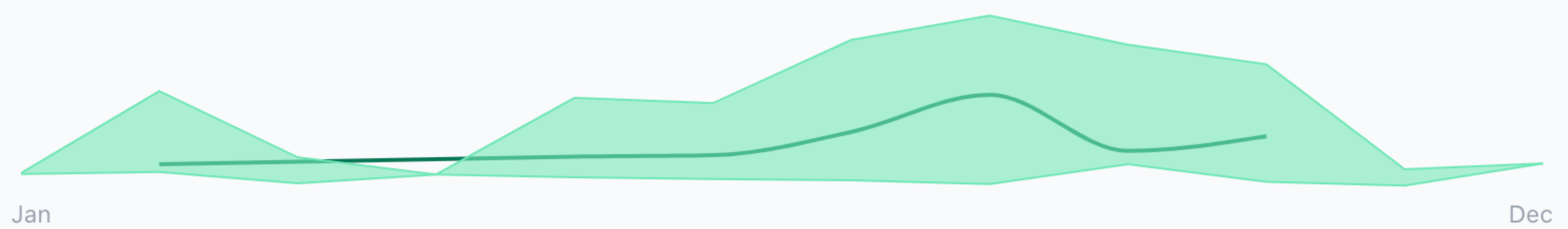
Temperature Trend 2023



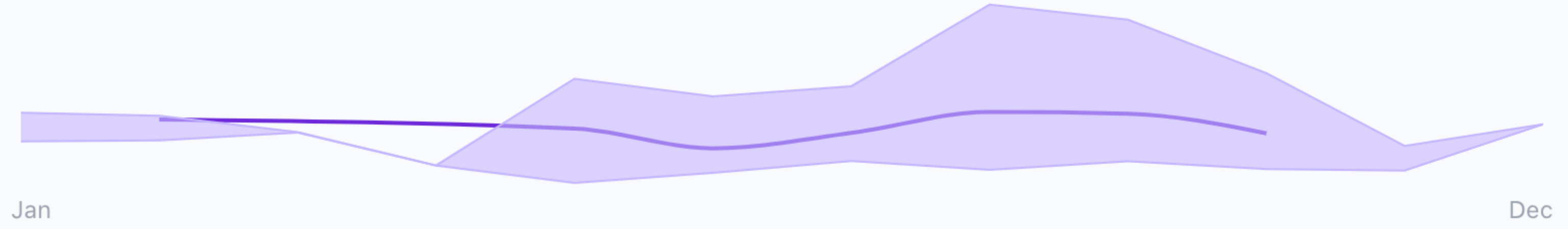
Nitrate Trend 2023



Chlorophyll Trend 2023

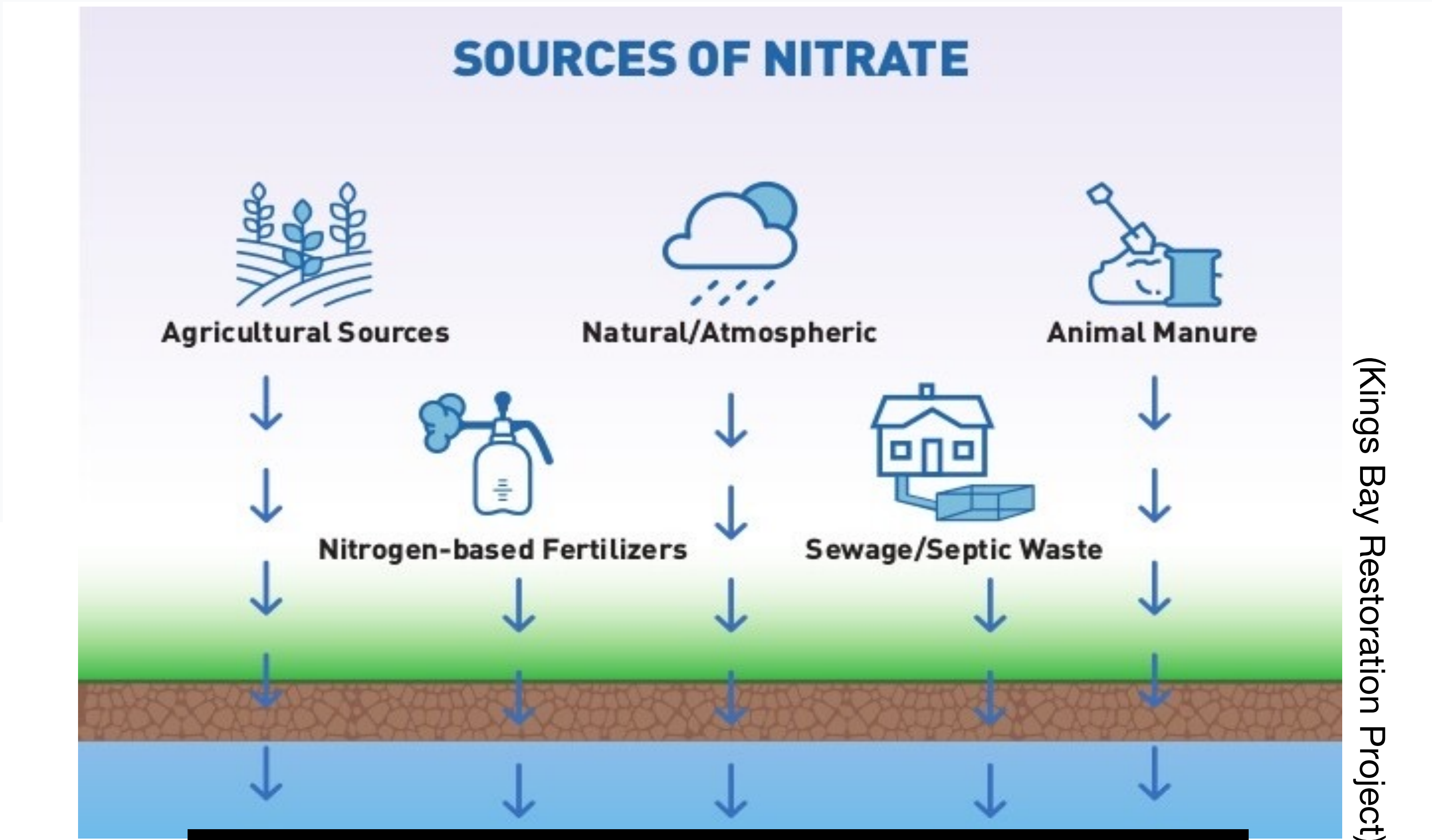
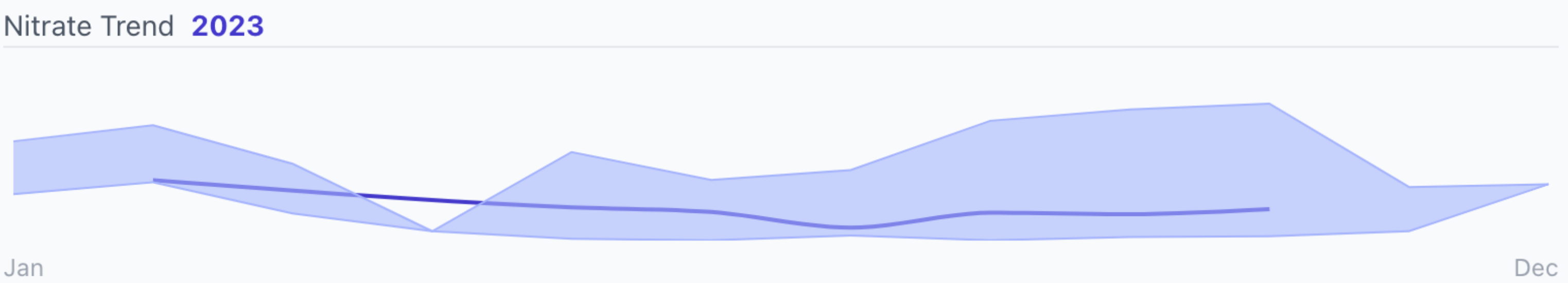
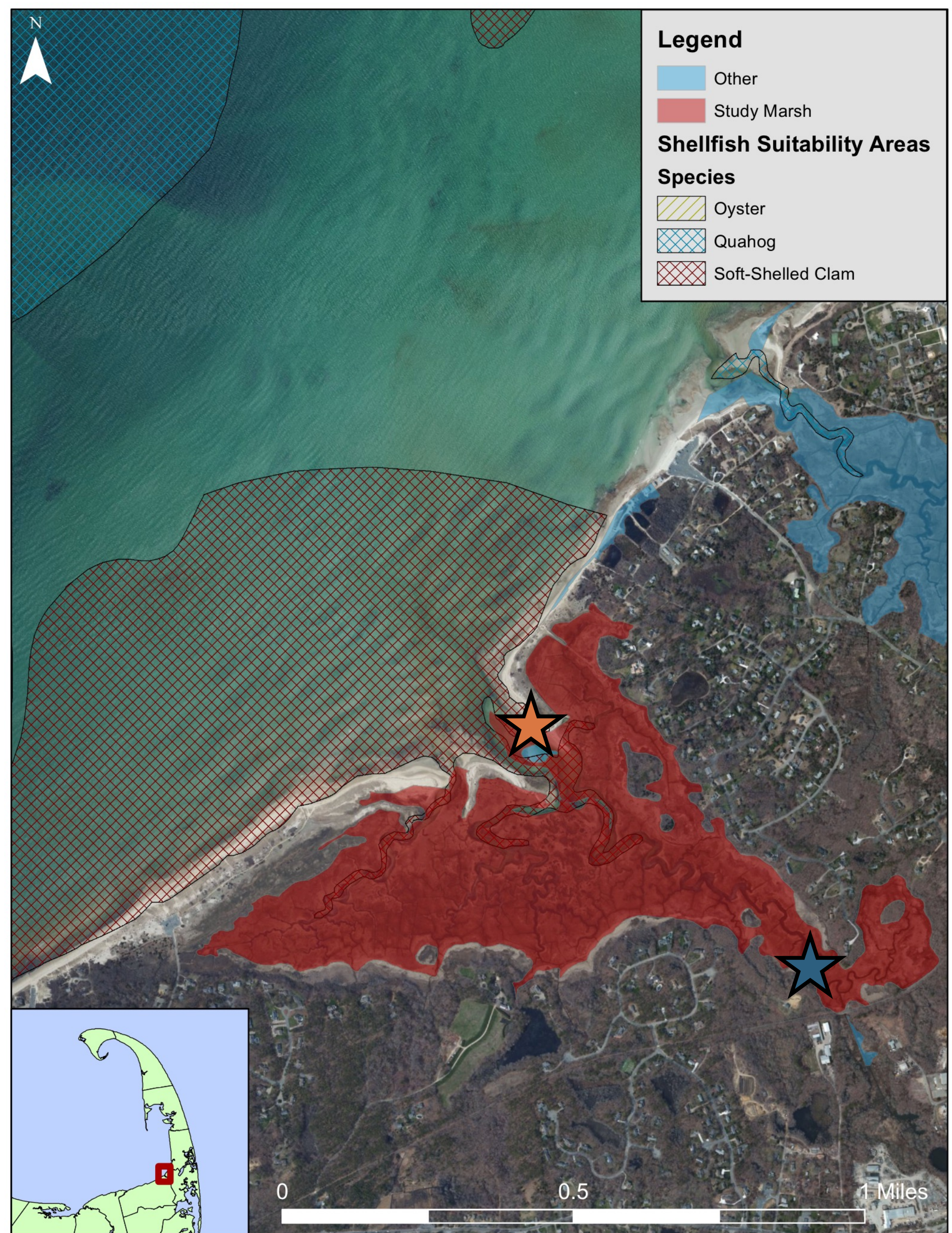


Turbidity Trend 2023



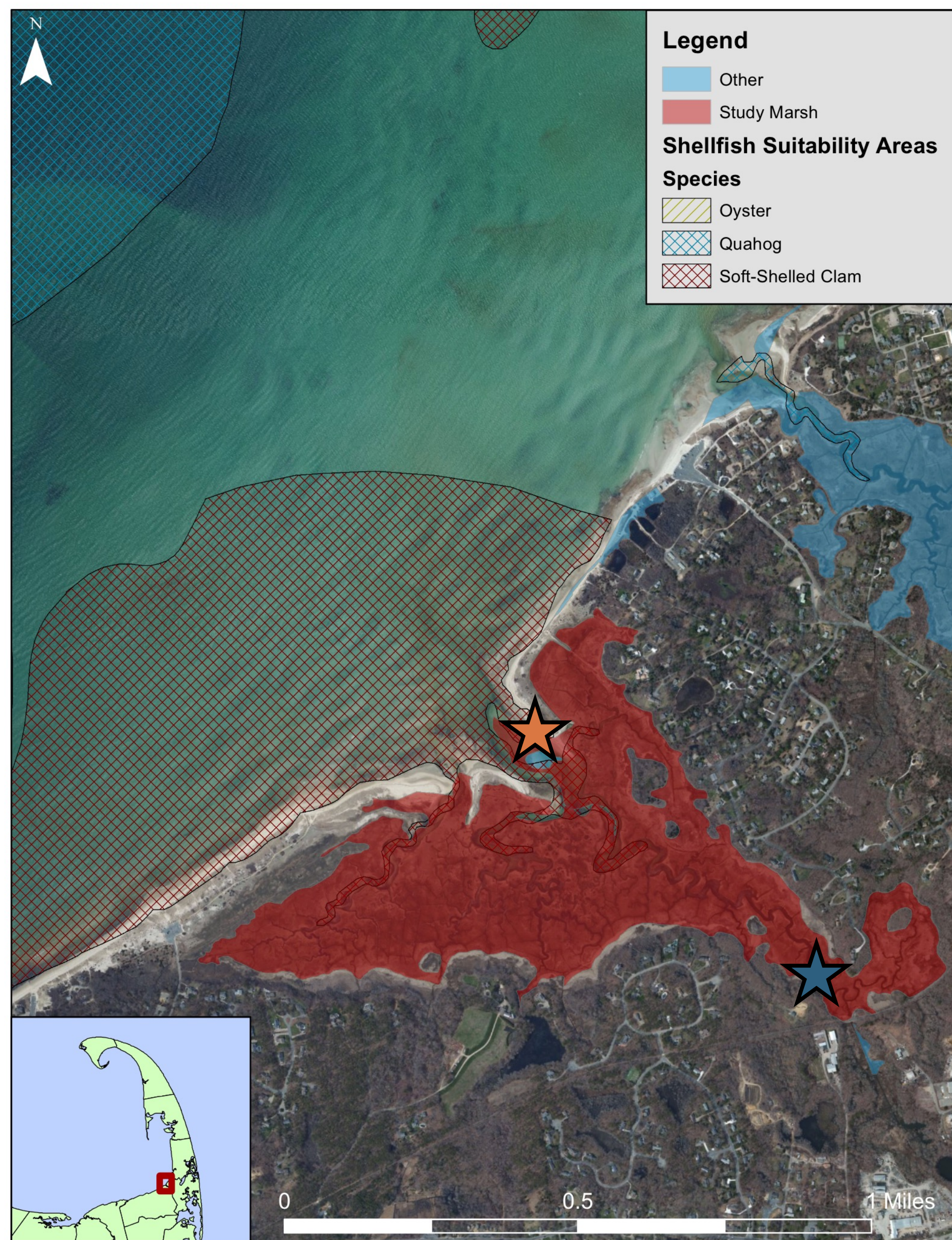
[www.capecodbay-monitor.org](http://www.capecodbay-monitor.org)

# Resources available from CCS

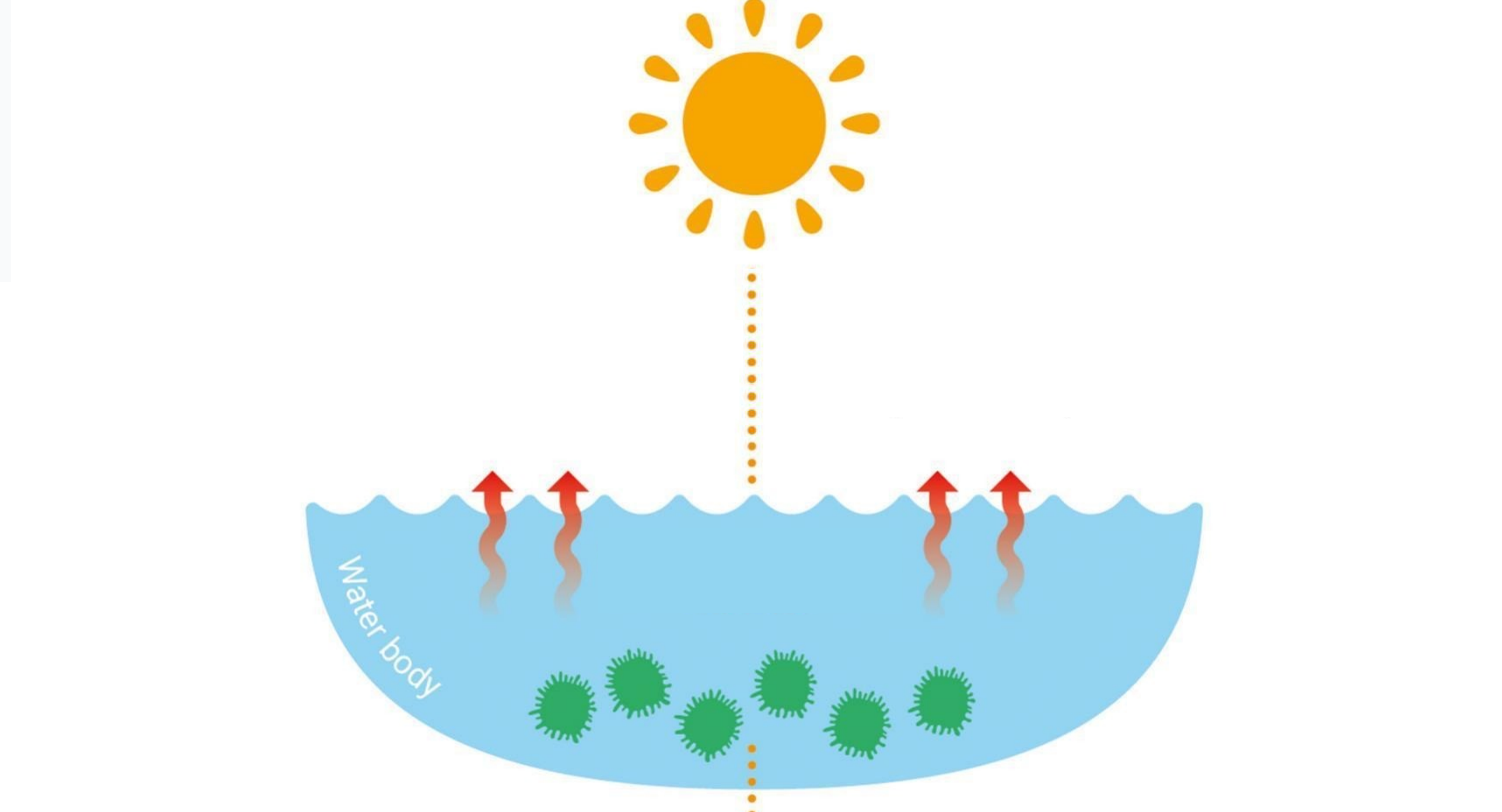


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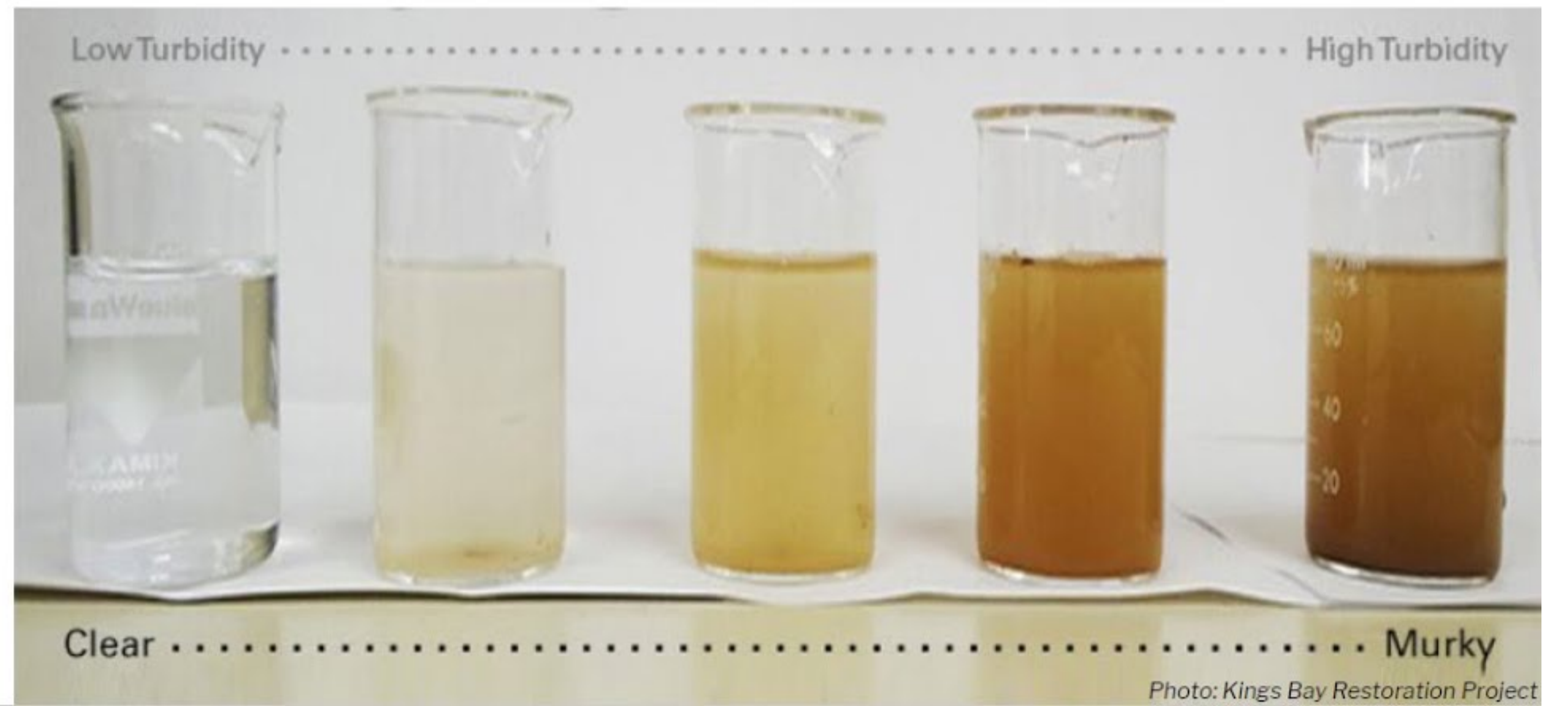
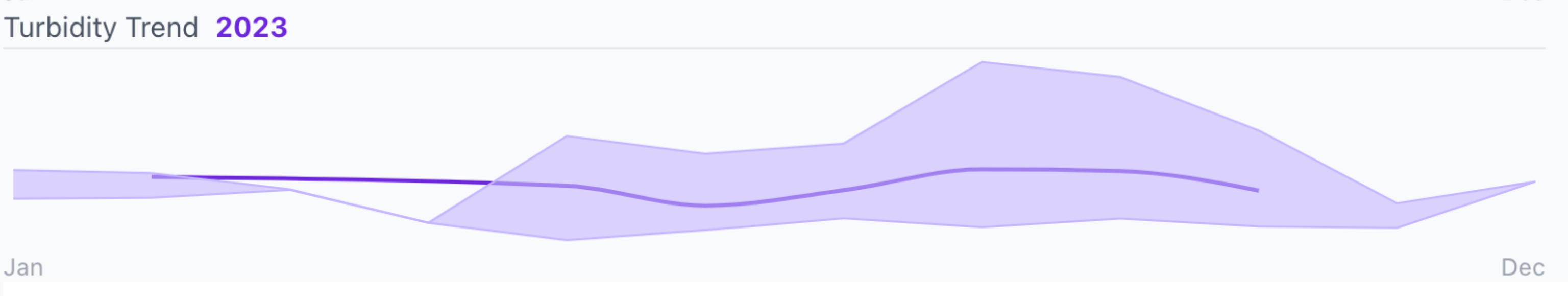
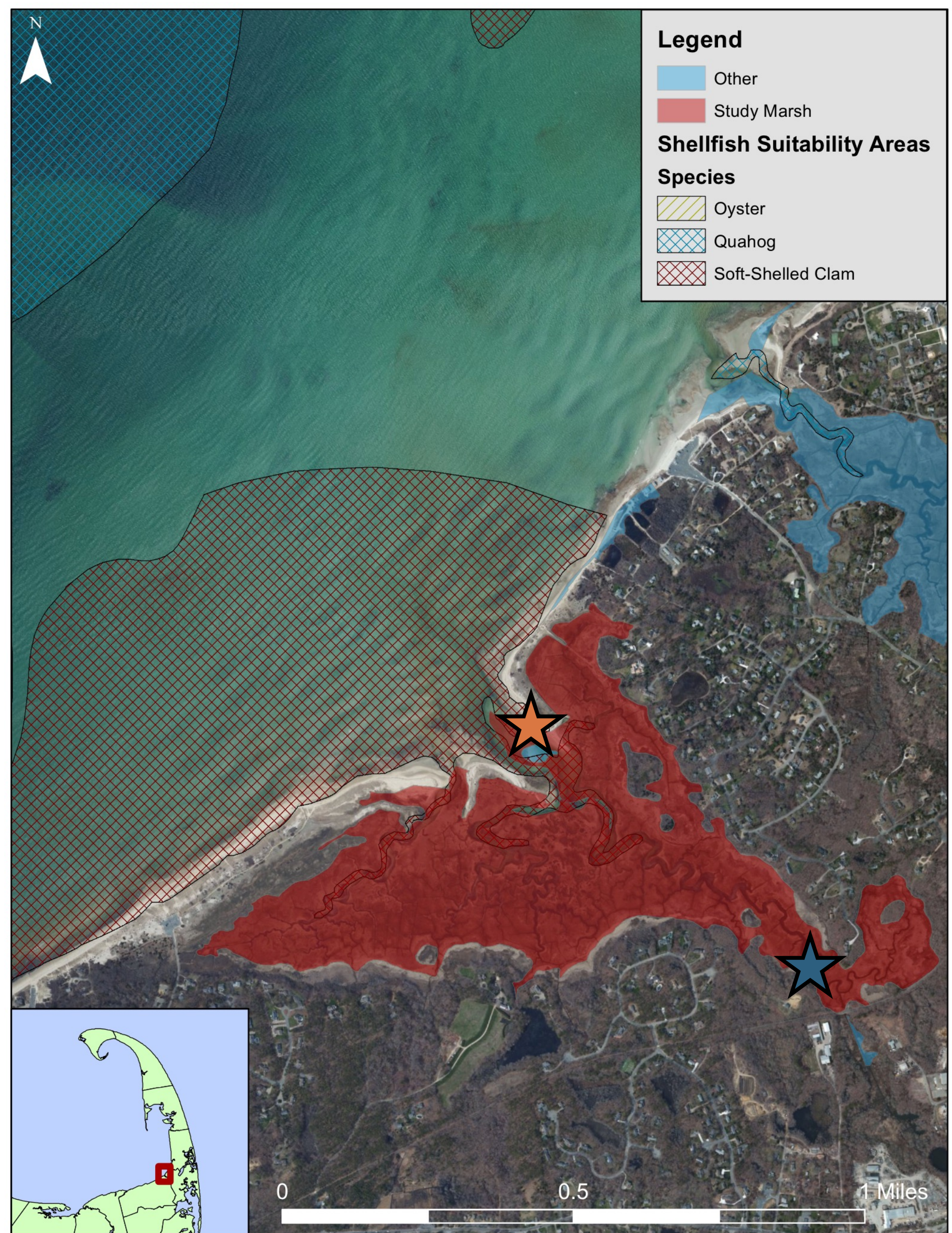


Chlorophyll Trend **2023**



(Girgibo et al., 2023)

# Resources available from CCS




[www.capecodbay-monitor.org](http://www.capecodbay-monitor.org)

# Resources available from CCS




[www.stormtides.org](http://www.stormtides.org)


### Storm Tide Pathways

Predicted Total Water Level  ?



Choose Tide Gauge:

Select Town

Total Water Level Slider  ?







Settings  ?

Partners, Sponsors & Supporters Information







### Map Legend

Water Depth:

	< 0.5 ft.
	0.5-1 ft.
	1-2 ft.
	2-3 ft.
	3-4 ft.
	> 4 ft.

NWS Flooding Categories (MLLW ft): ?

	Major: 15ft and above
	Moderate: 13ft to 14ft
	Minor: 11.5 to 13ft
	Nuisance: 10ft to 11.5ft

# Resources available from CCS



### Storm Tide Pathways

Predicted Total Water Level

Total Water Level Slider

21ft  
20ft  
19ft  
18ft  
17ft  
16ft  
15ft  
14ft  
13ft  
12ft  
**11ft**  
10ft

Settings

Partners, Sponsors & Supporters Information

[www.stormtides.org](http://www.stormtides.org)



### Map Legend

**Water Depth:**

- < 0.5 ft.
- 0.5-1 ft.
- 1-2 ft.
- 2-3 ft.
- 3-4 ft.
- > 4 ft.

**NWS Flooding Categories (MLLW ft):**

- Major: 16ft and above
- Moderate: 14.5ft to 16ft
- Minor: 13ft to 14.5ft
- Nuisance: 12ft to 13ft

# Resources available from CCS



### Storm Tide Pathways



Predicted Total Water Level

Total Water Level Slider

21ft  
20ft  
19ft  
18ft  
17ft  
16ft  
15ft  
14ft  
**13ft**  
12ft  
11ft  
10ft

Settings

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### Storm Tide Pathways

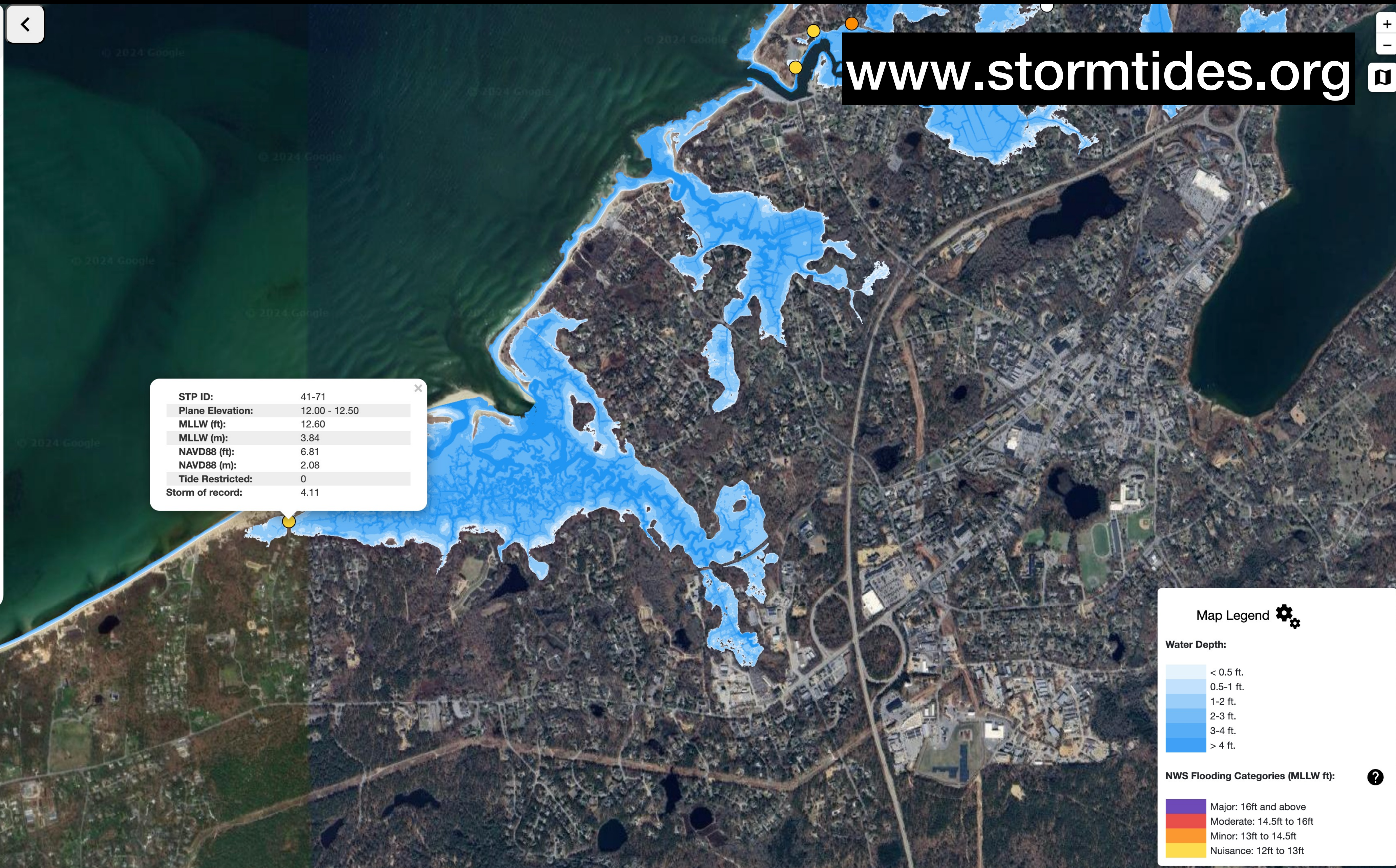
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Total Water Level Slider

21ft  
20ft  
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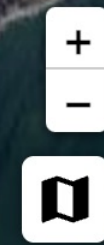
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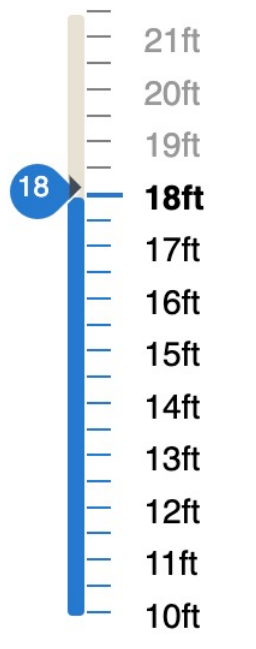


## Storm Tide Pathways



Predicted Total Water Level  

Total Water Level Slider  



Settings  


Partners, Sponsors & Supporters Information







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### Storm Tide Pathways

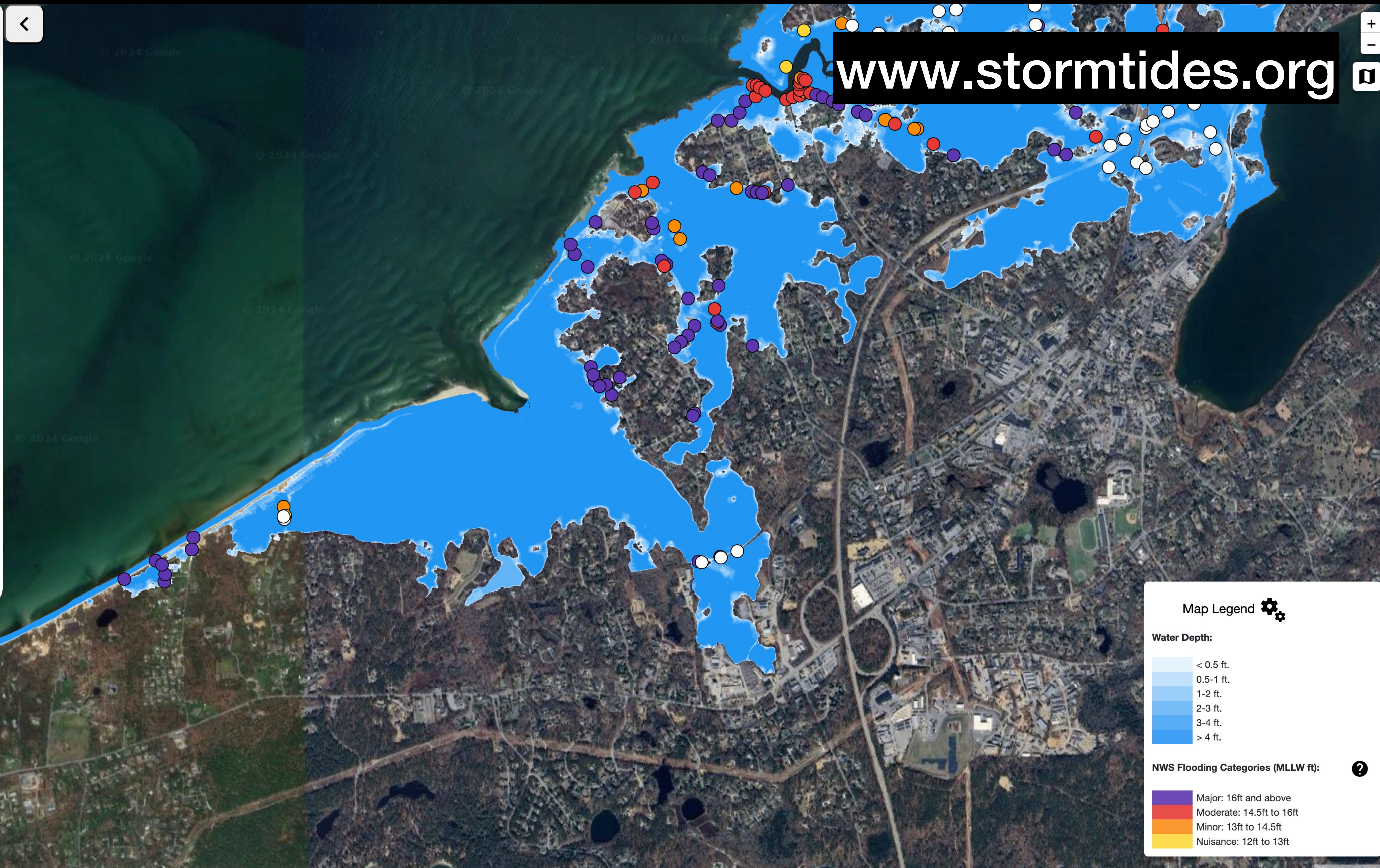
Predicted Total Water Level ?

Total Water Level Slider ?

21ft  
20ft  
19ft  
18ft  
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16ft  
15ft  
14ft  
13ft  
12ft  
11ft  
10ft

Settings ?

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A brief interlude...



# Coastal Erosion Viewer

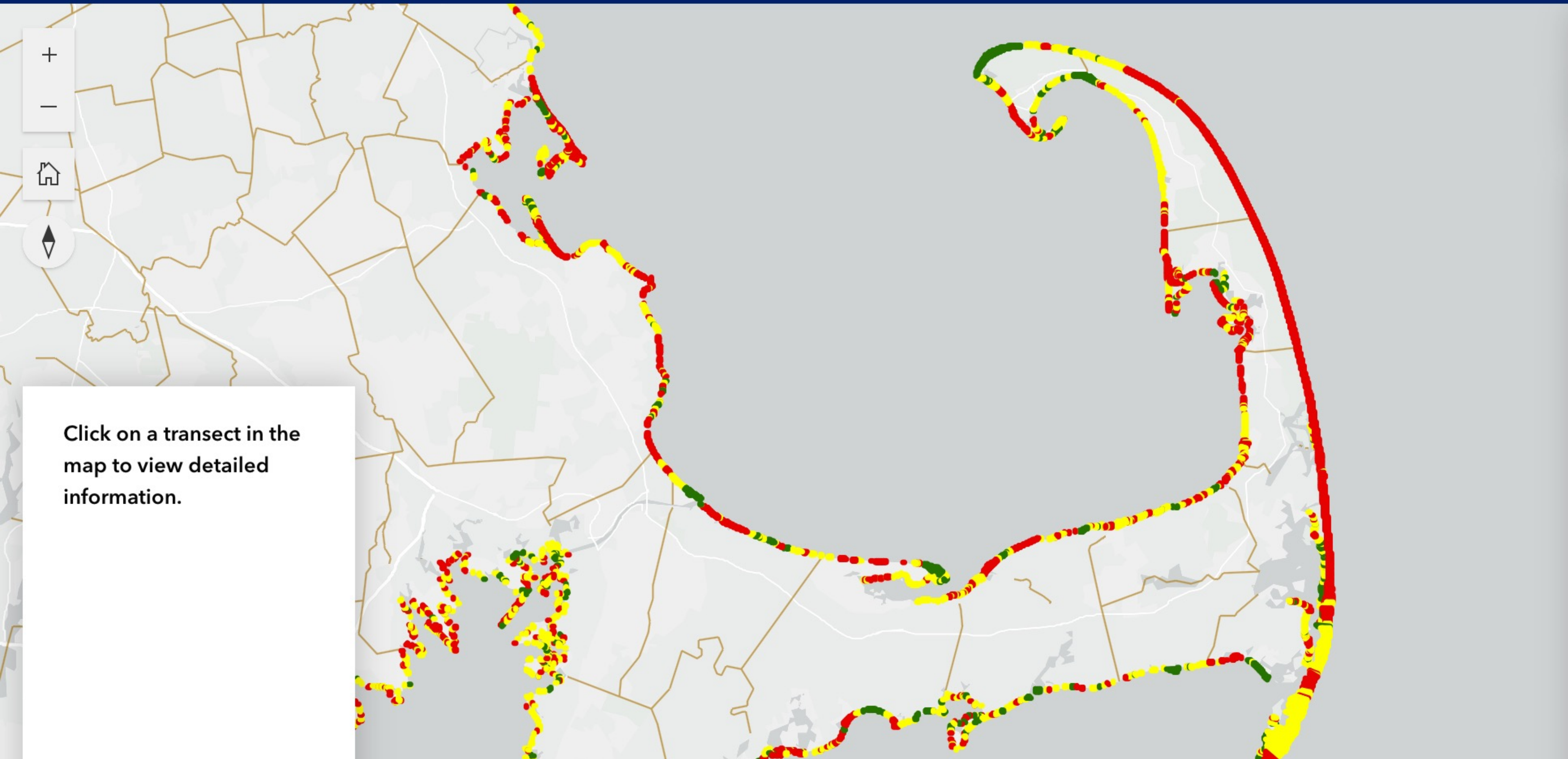
Introduction

Data Interpretation

Short-Term Rates

**Long-Term Rates**

Contact






Click magnifying glass to search by address or place



Search Transect ID



### Long-Term change transects (1840s-2018)

-  Accreting
-  Eroding
-  No Statistical Change

Zoom in to view mean high water shorelines (1844-2018)

Click on a transect in the map to view detailed information.

[mass.gov/info-details/massachusetts-shoreline-change-project](https://mass.gov/info-details/massachusetts-shoreline-change-project)

A brief interlude...



# Coastal Erosion Viewer

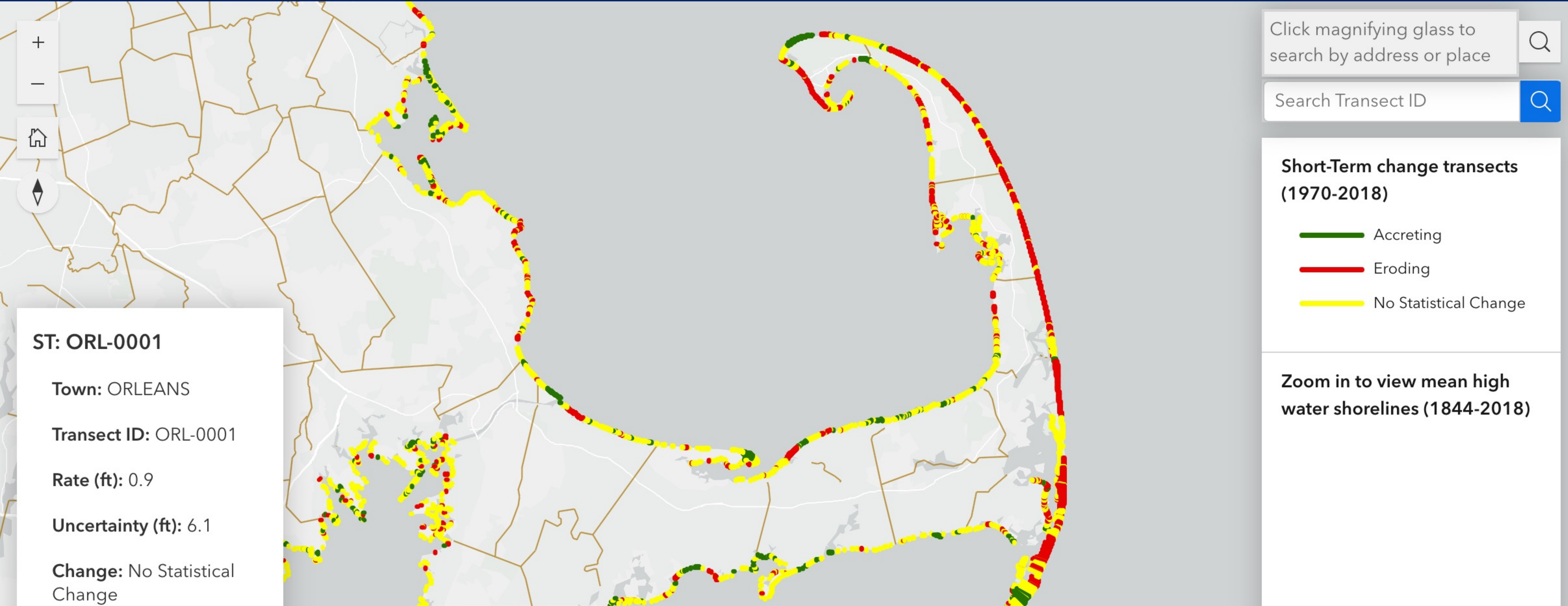
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Data Interpretation

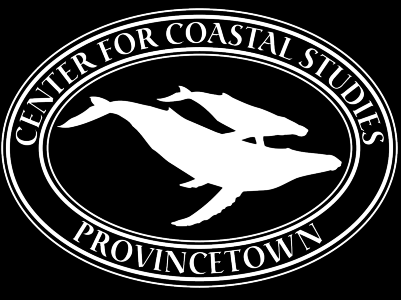
Short-Term Rates

Long-Term Rates

Contact



[mass.gov/info-details/massachusetts-shoreline-change-project](https://mass.gov/info-details/massachusetts-shoreline-change-project)



A brief interlude...



# Coastal Erosion Viewer

Introduction

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Long-Term Rates

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Click magnifying glass to search by address or place

Search Transect ID

**LT: ORL-0001**

Town: ORLEANS

Transect ID: ORL-0001

Rate (ft): -2.5

Uncertainty (ft): 1.1

Change: Eroding



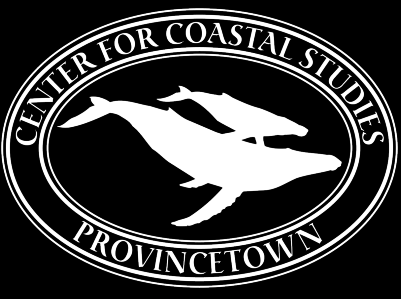
**Long-Term change transects (1840s-2018)**

- Accreting (Green line)
- Eroding (Red line)
- No Statistical Change (Yellow line)

**Mean High Water Shorelines (1844-2018)**

- 2018 (Dark purple line)
- 2013 - 2014 (Purple line)
- 2010 - 2012 (Light purple line)
- 2007 - 2009 (Blue-purple line)
- 2000 - 2001 (Blue line)

[mass.gov/info-details/massachusetts-shoreline-change-project](https://mass.gov/info-details/massachusetts-shoreline-change-project)



# Resources available from CCS



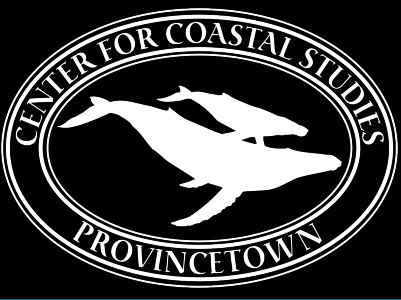
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[www.mapthatcapecod.com](http://www.mapthatcapecod.com)

## Outer Cape Shoreline Management

### Data Portal

Use this public portal to explore and download regional shoreline management data for the Outer Cape, discover geo-applications, and engage in our collaborative effort to better understand and manage our shared shoreline.



# Resources available from CCS

[www.mapthatcapecod.com](http://www.mapthatcapecod.com)



Legend

- Long Term Rates (FT/YR)**
- Rate of Change (ft/yr)
- < -10
  - 10 to -5
  - 5 to -2.5
  - 2.5 to 0
  - 0 to 2.5
  - 2.5 to 5
  - 5 to 10
  - 10

- CCS LittoralCells NullPoints**
- Area\_Type
- Sink Area
  - Source Area

- CCS LittoralCells**
- SubType
- Eroding
  - Accreting
  - Outer Cape
  - Mixed

- Wellfleet Harbor Generalized Net Sediment Transport Direction**
-

# Key takeaways

- Salt marshes are key ecosystems in the face of climate change and key players in climate resilience
- Research, monitoring, and baseline data are key to assess changes and success
- Many resources exist to assess your neighborhood

