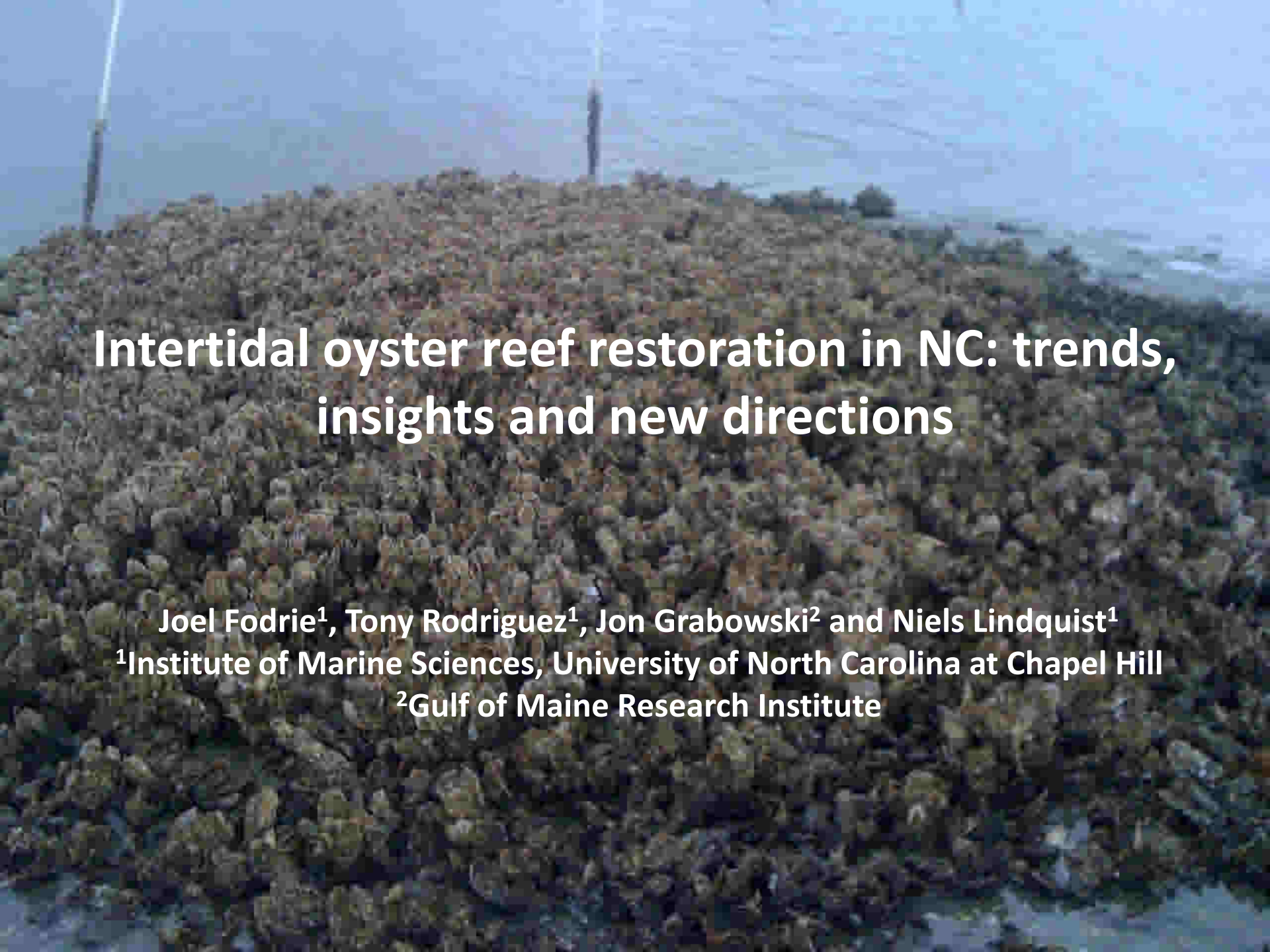

Intertidal oyster reef restoration in NC: trends, insights and new directions

Joel Fodrie[1], Tony Rodriguez[1], Jon Grabowski[2] and Niels Lindquist[1]
[1]Institute of Marine Sciences, University of North Carolina at Chapel Hill
[2]Gulf of Maine Research Institute

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Talk Outline

- A historical perspective on (North Carolina) intertidal oyster reefs
- Intertidal reef restoration in the 1990s
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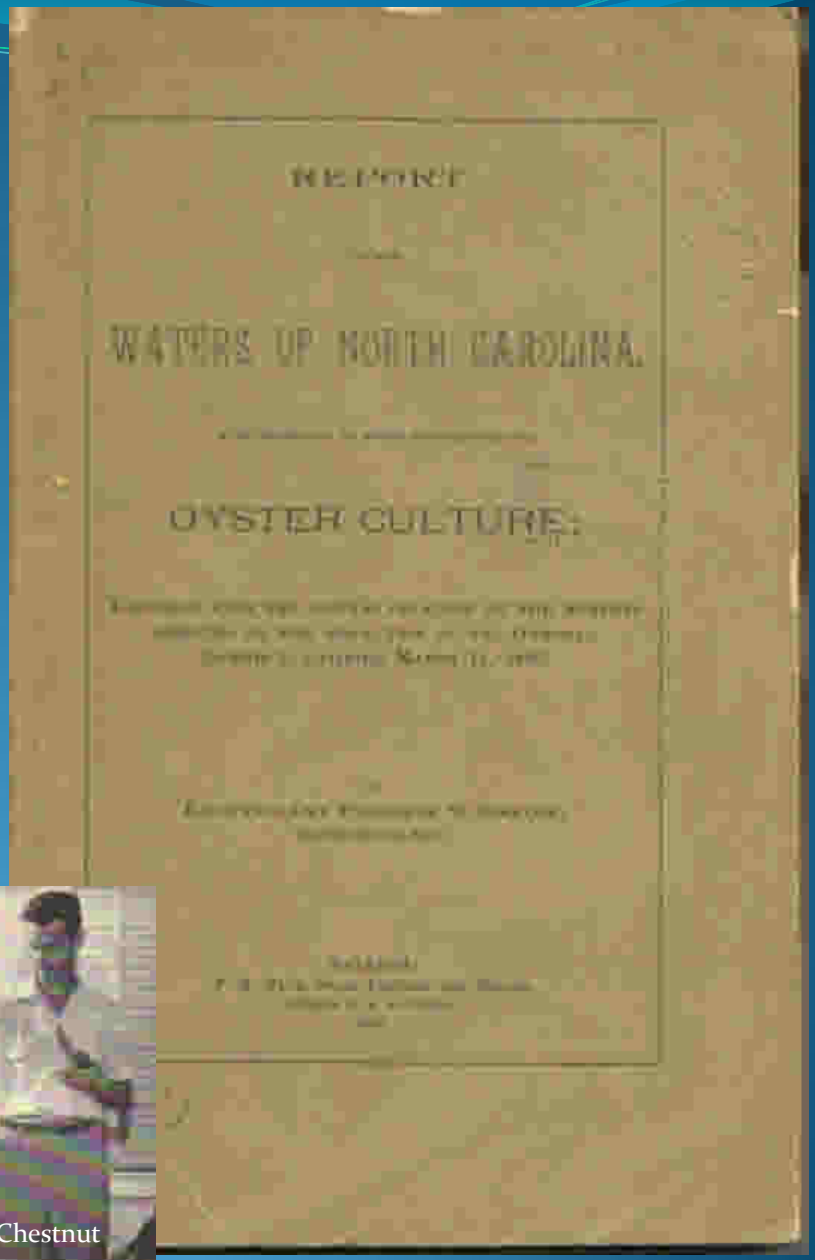
A historical perspective on North Carolina oyster reefs

- **Winslow 1886 (151 pgs)**
- **Grave 1904 (195 pgs)**
- **Coker 1907 (74 pgs)**

- ***"A most conspicuous feature of [Newport] river is the oyster reefs…a source of no little inconvenience to the navigation of the river"***

- **Focus on potential for oyster culture, searching for "*scientific basis for the artificial establishment of new oyster beds*"**

- ***"[The most] useful purpose served by the oyster of [an intertidal] reef is to be found in the supply of spawn, which are furnished to the beds in deeper waters"***



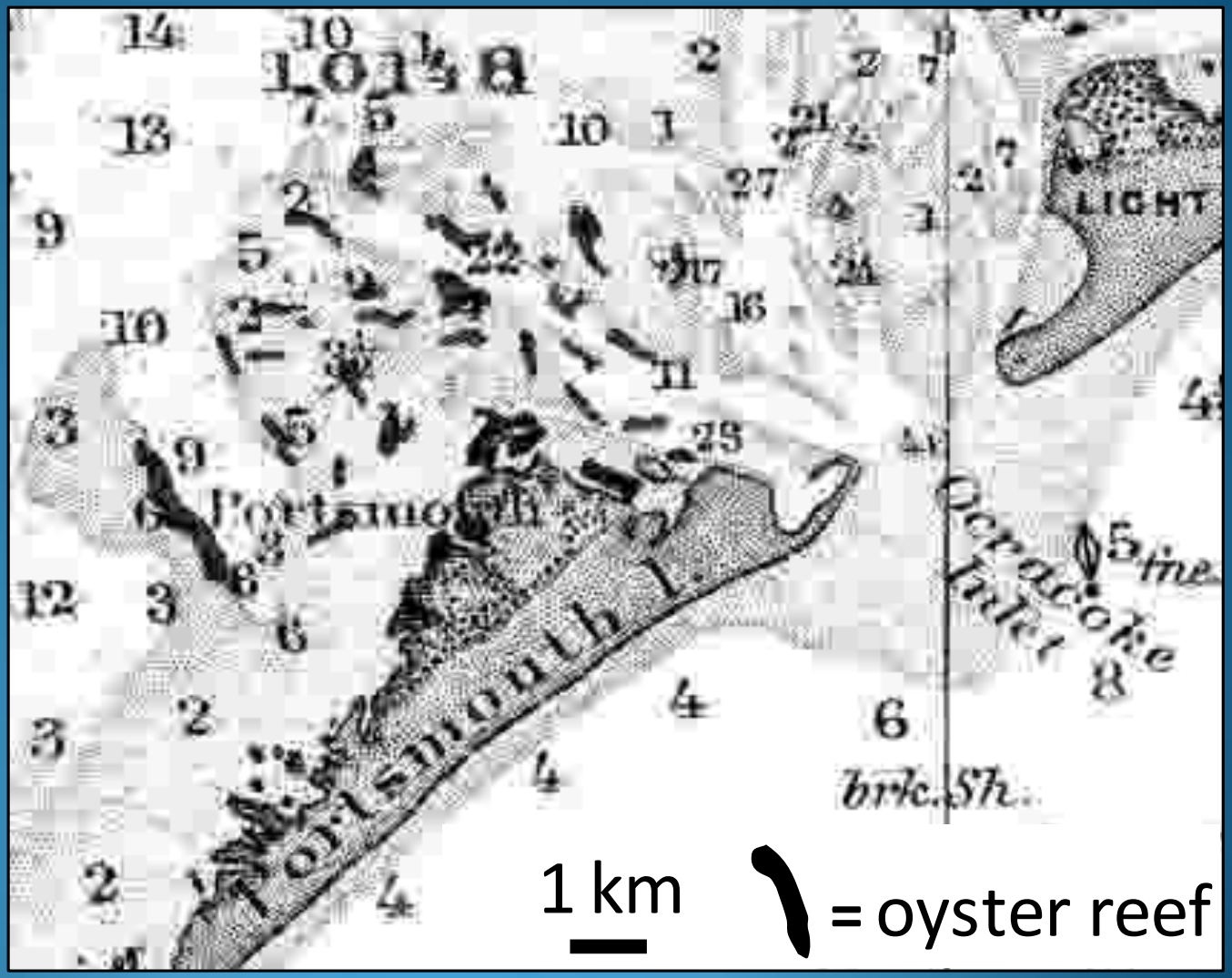
A. Chestnut

A historical perspective on North Carolina oyster reefs

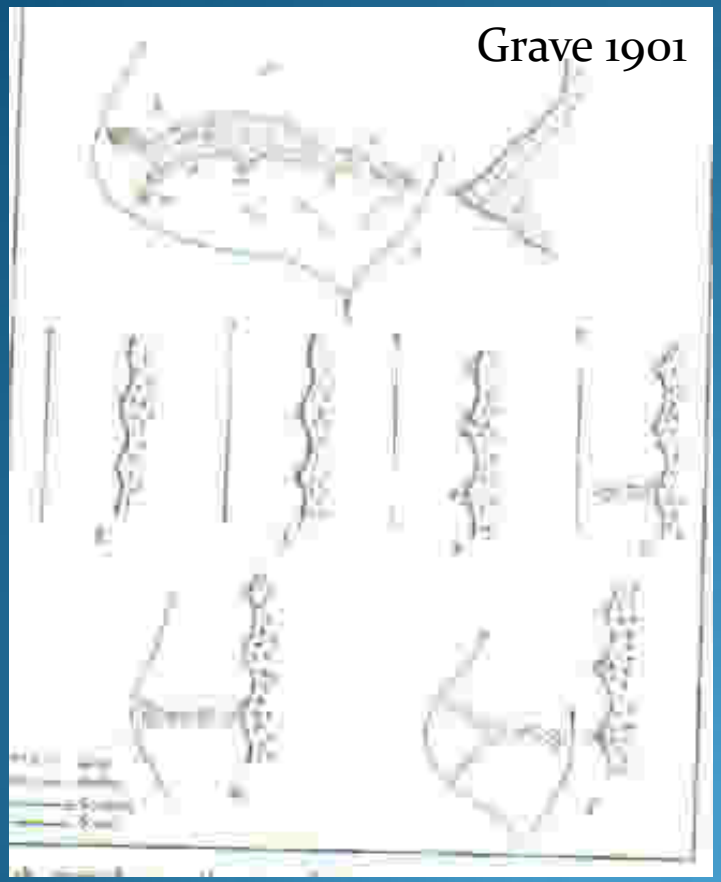
Intertidal oyster

Subtidal oyster

Winslow 1886



Lessons we have learned, maybe some we've forgotten



Vs.

- **Instructions for living shorelines:**
  - **Reefs are groins, not sills…**

Restoring intertidal reefs using derelict fishing gear

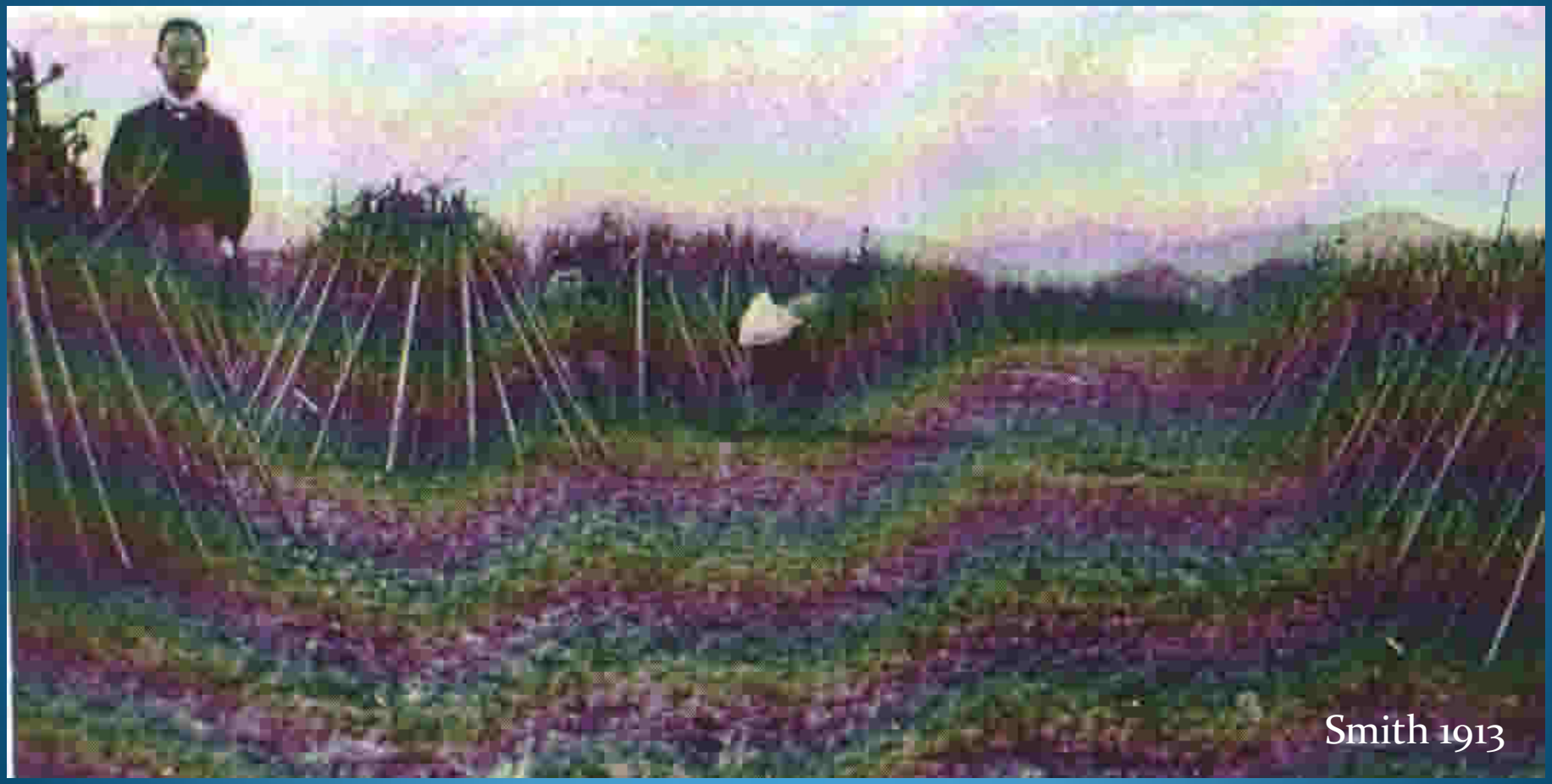
- 2011 (APNEP funded) : working with DMF to refurbish and deploy 200 crab pots as substrate for intertidal oyster reefs

- Rationale:
  - Get oysters up in water column (in flow)
  - Away from predators
  - 3-dimensional habitat for fishes

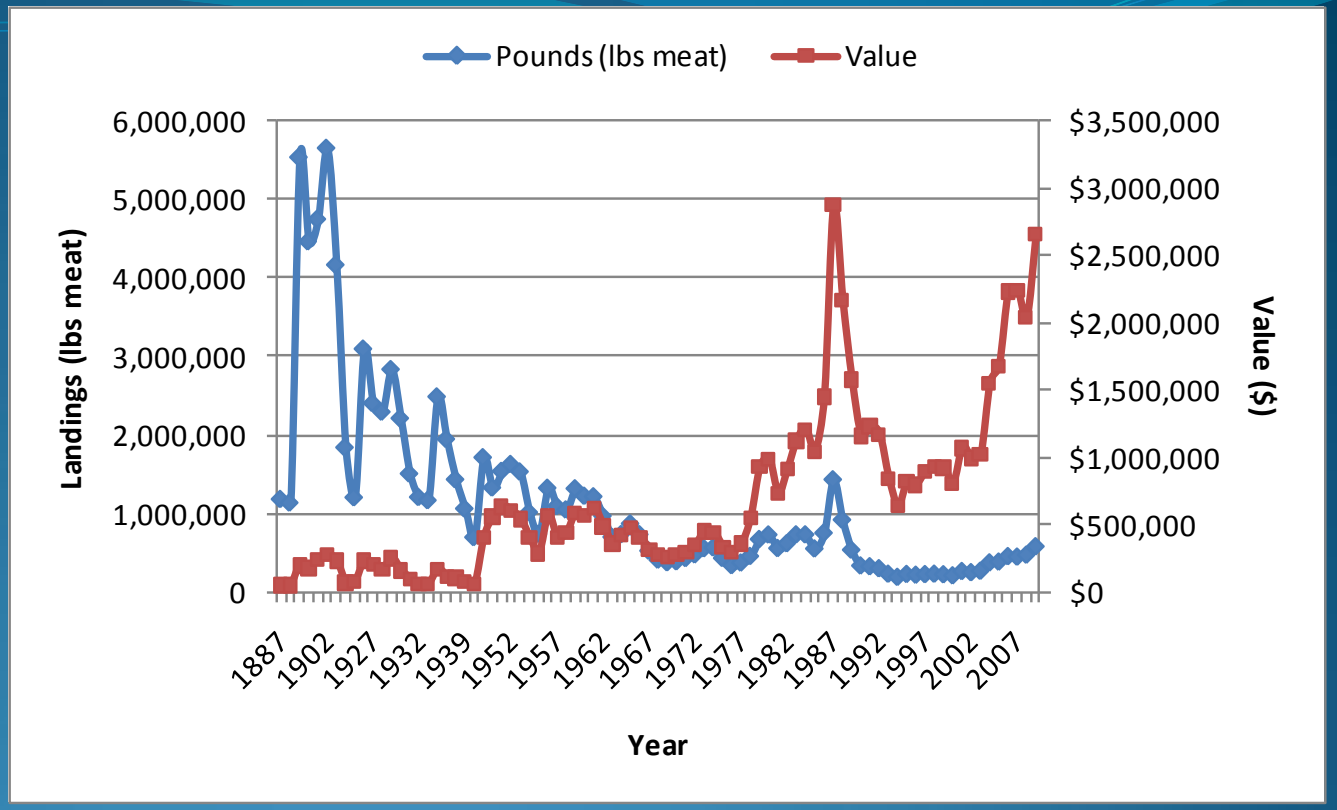
- Determine fishery and ecosystem benefits

Actually, not really a new idea…

- Japanese aquaculture since the 1800s…
- Winslow 1889



Long-term North Carolina oyster harvests



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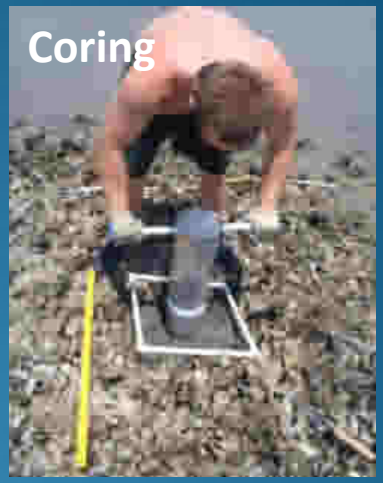
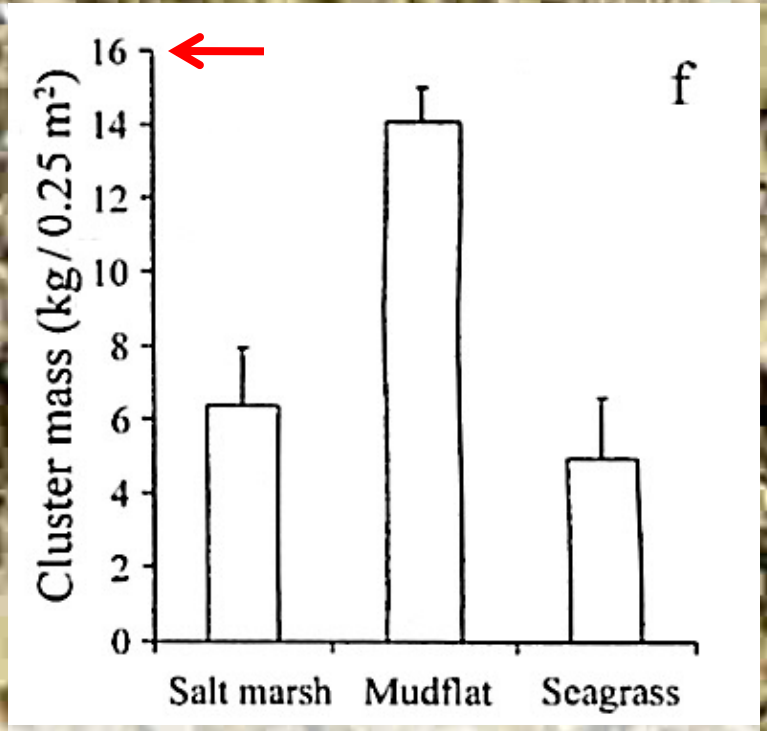
NC intertidal reef restoration in the 1990s

Intertidal reef restoration in the 1990s

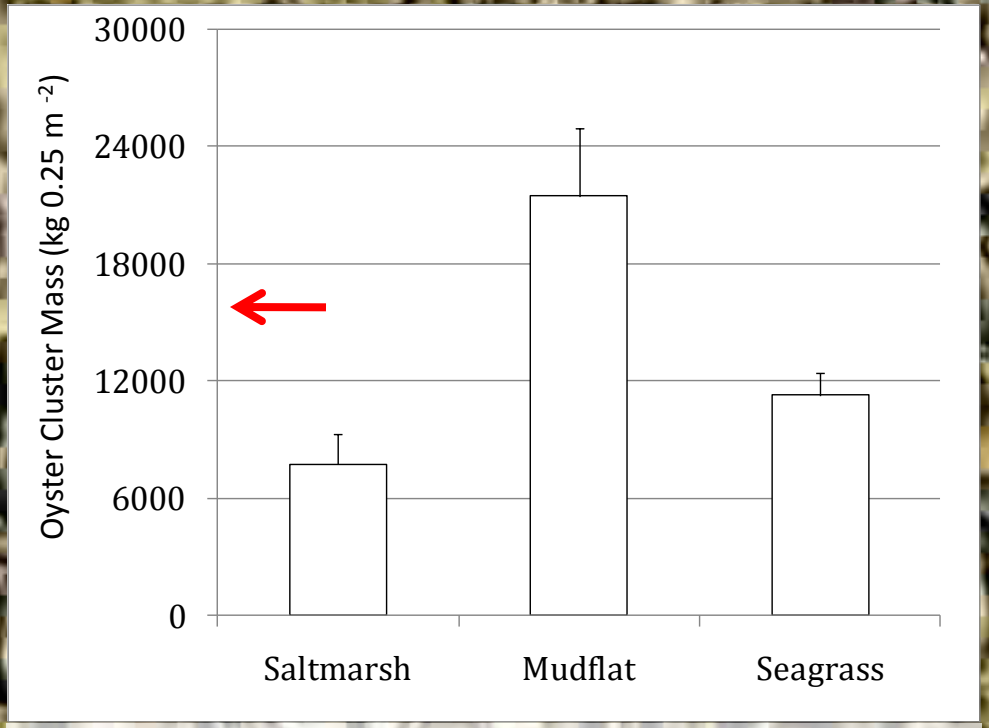
- Constructed in 1997
- Middle Marsh – Rachel Carson NERRS
- Initially 3 * 5 * 0.33 m (5 m^3)
  Immediately collapsed to ~1.67 m^3
- 3 landscape settings
  - -Mudflat
  - -Saltmarsh
  - -Saltmarsh-Seagrass
- Sampling
  - -June & December Coring
  - -Summer/Fall trap sampling
  - -Summer/Fall gillnetting
- 1998-2001, revisited in 2010



Reef evolution

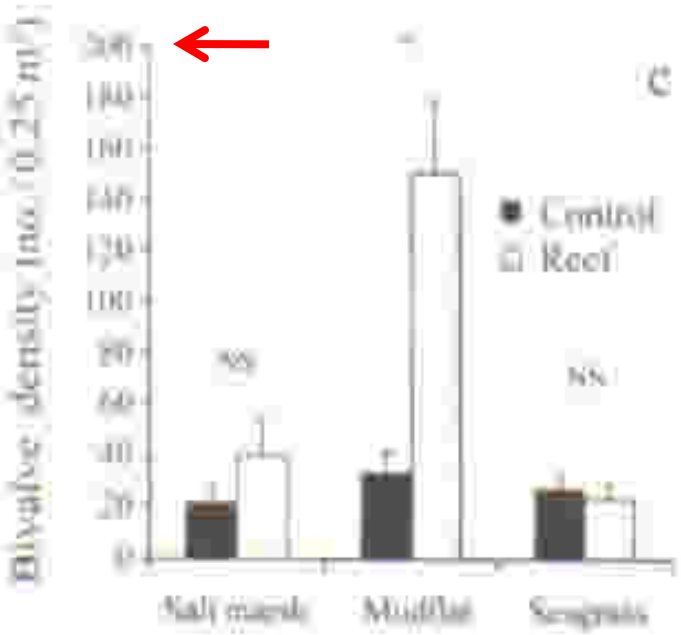


3 years: Grabowski et al. 2005

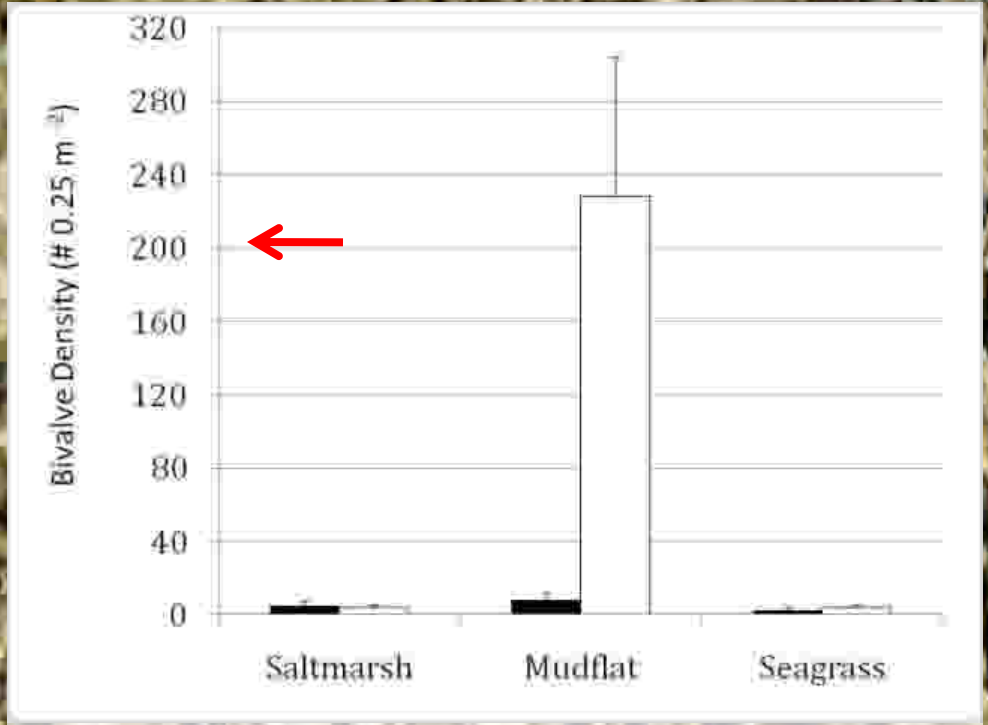


13 years: current study

Reef evolution



3 years

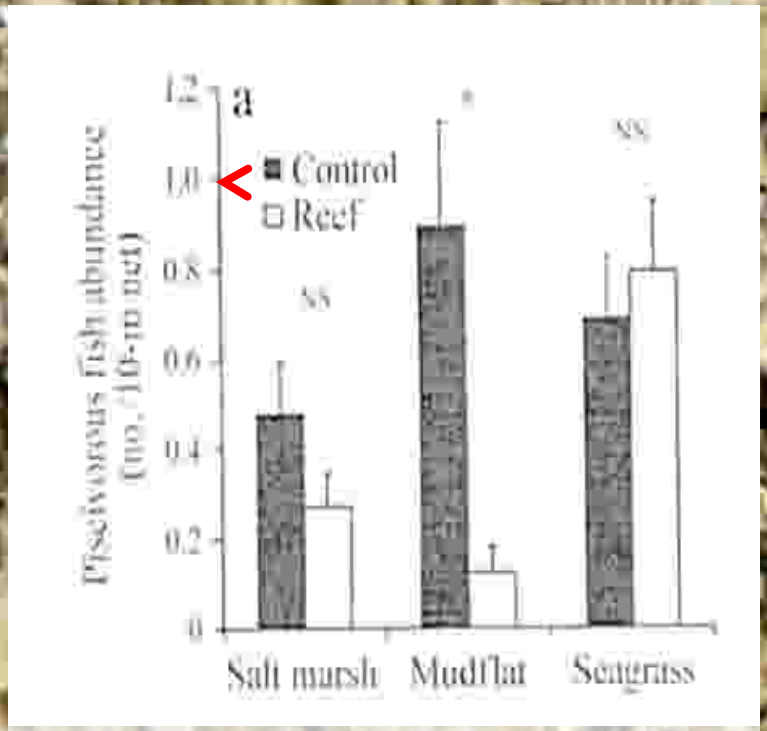


13 years

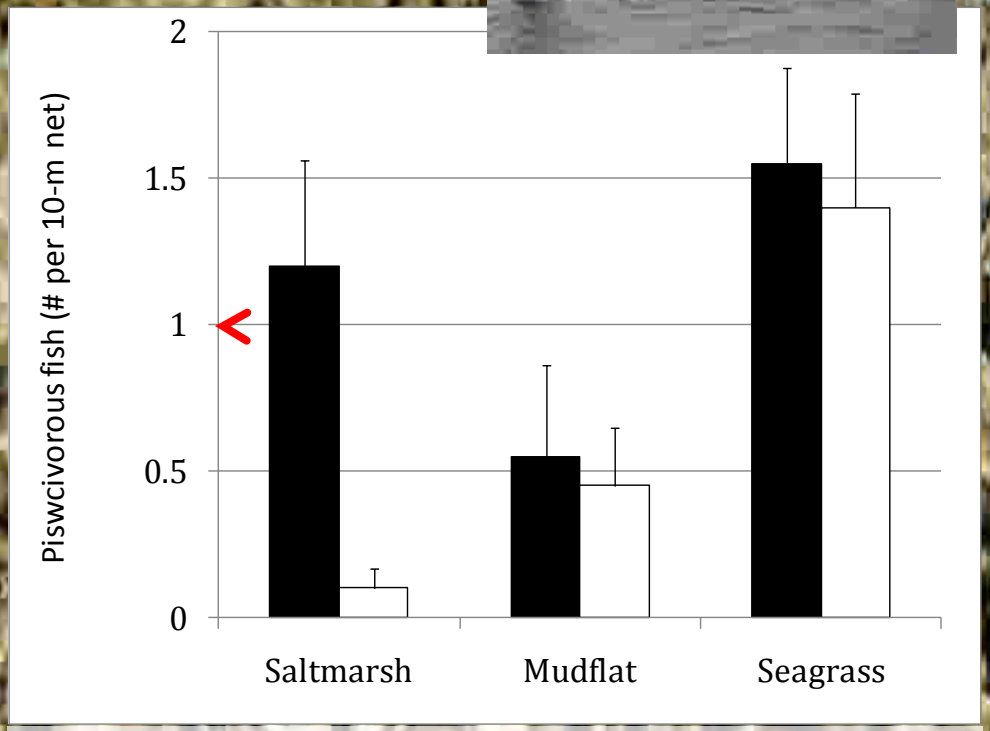
Function of reefs within the larger estuarine ecosystem

- **Fish utilization**

Reef evolution: fish utilization

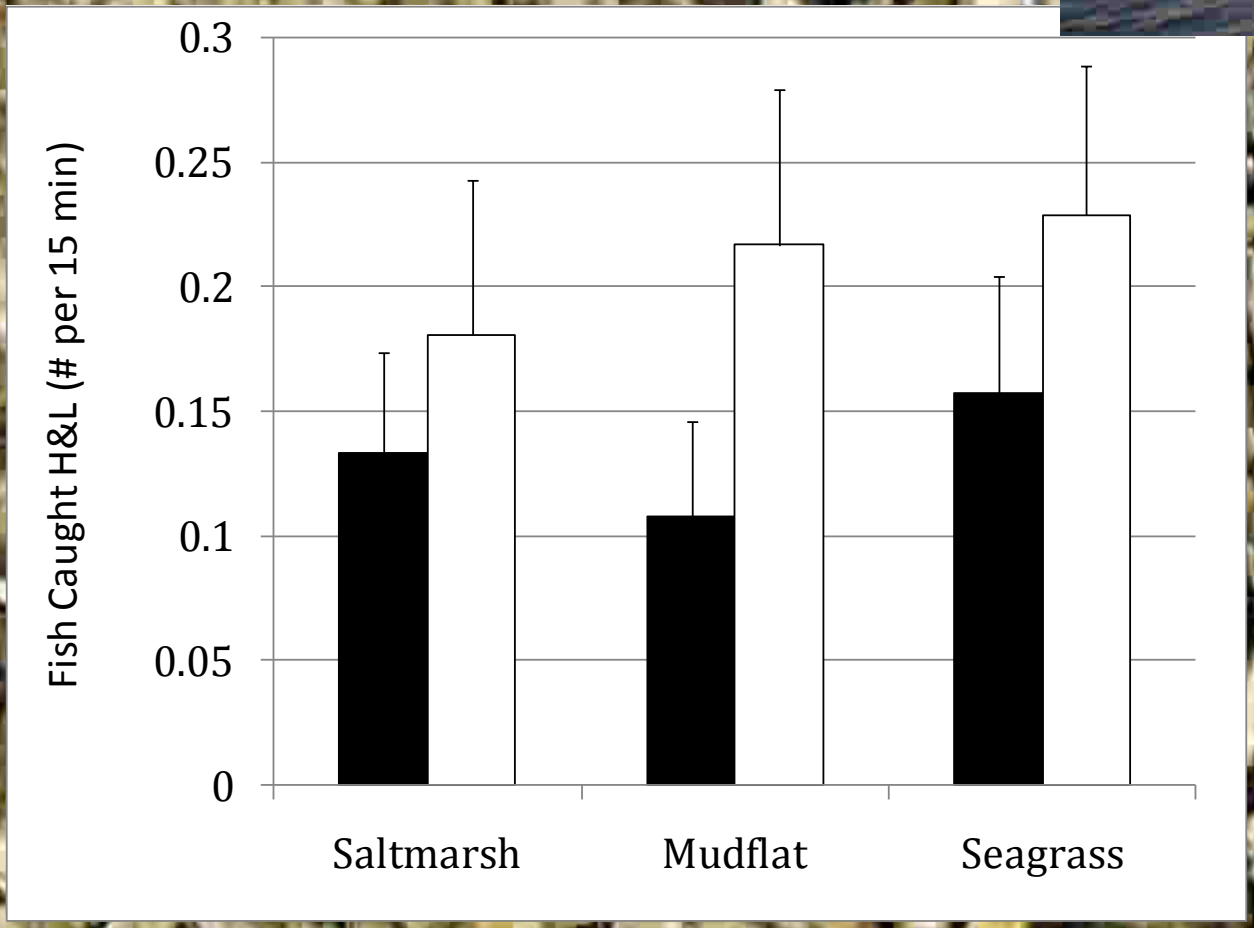


3 years

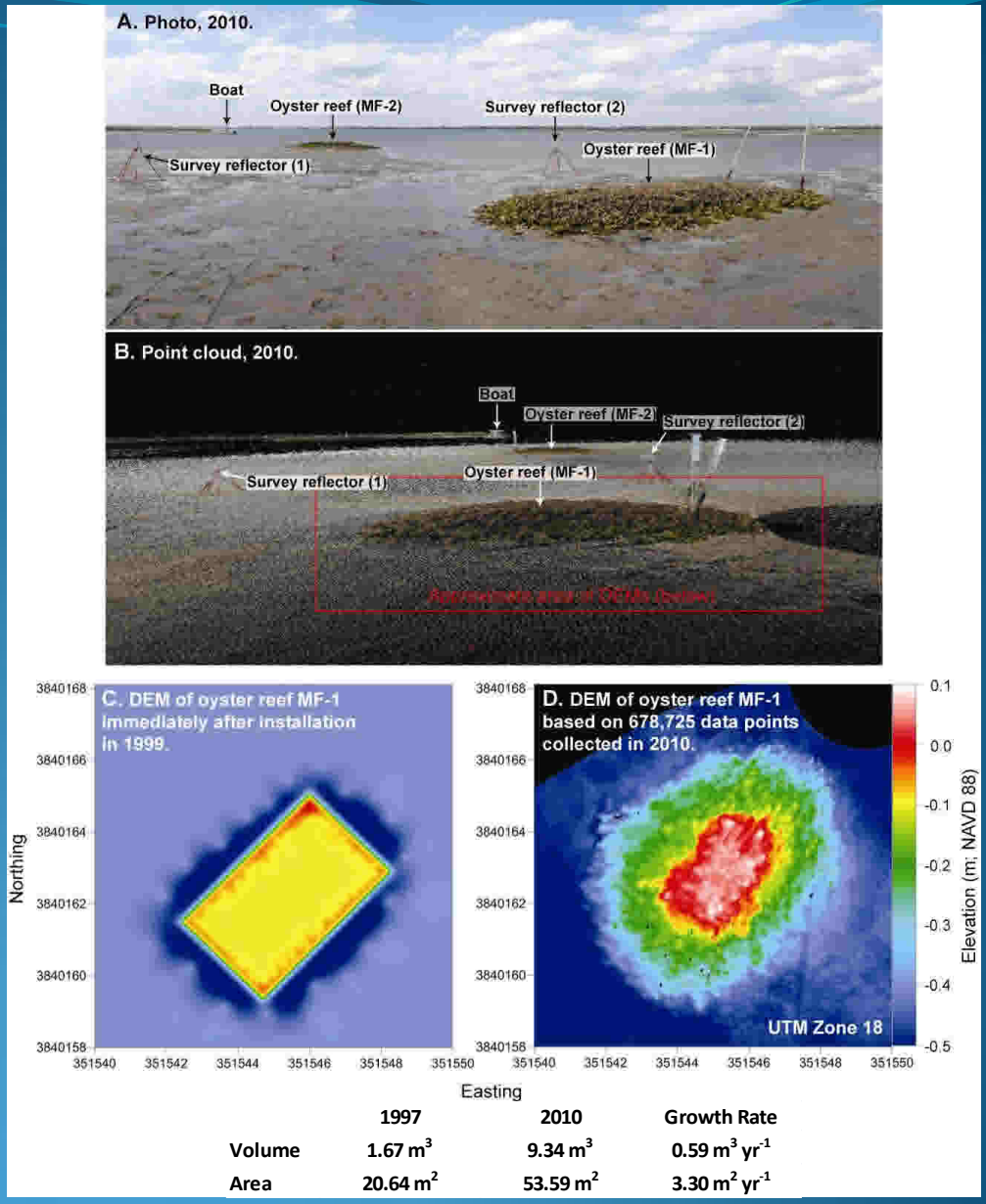


13 years

Ecosystem services: fish utilization

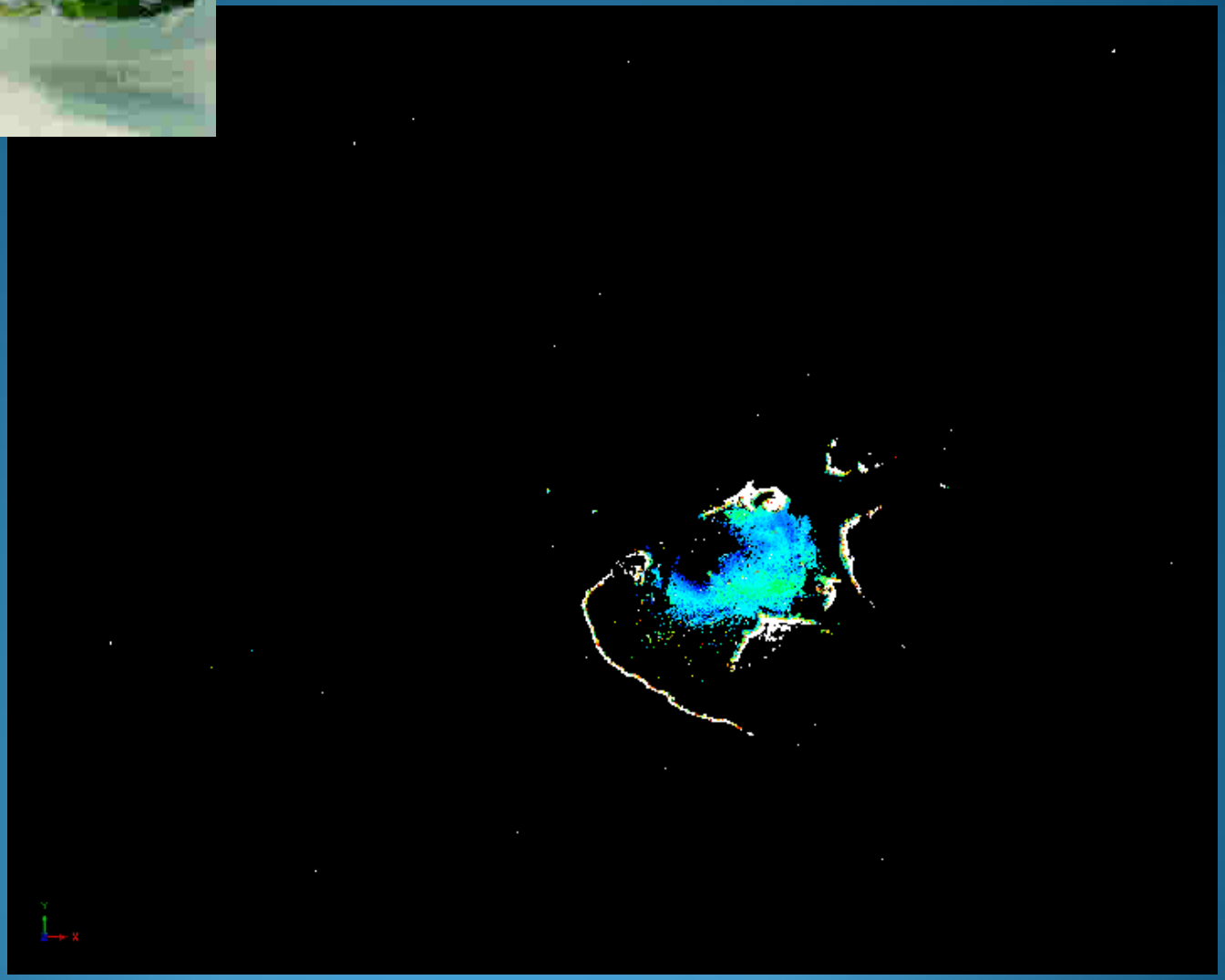


Laser scanning and surveying reefs



	1997	2010	Growth Rate
Volume	1.67 m^3	9.34 m^3	0.59 $m^3\ yr^{-1}$
Area	20.64 m^2	53.59 m^2	3.30 $m^2\ yr^{-1}$

Laser scanning and surveying reefs



Reef evolution after 13 years – a look through the reefs

- SM and SG reefs have not grown (possibly net loss)
- No obvious new "living" shell

0-5cm

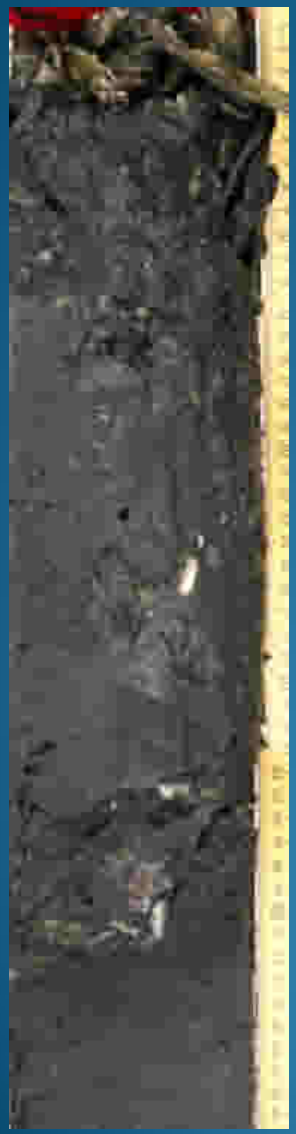
5-10cm

10-15cm

15-20cm

Reef evolution after 13 years – a look through the reefs

- Even with some compaction, reefs now >50 cm tall (3.5 cm yr^{-1})
- Outplanted shell versus new 'living' shell easy to distinguish



15-20cm

20-25cm

40-45cm

45-50cm

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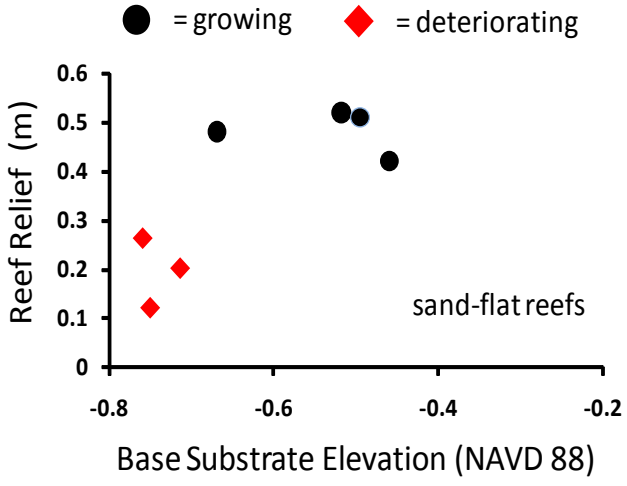
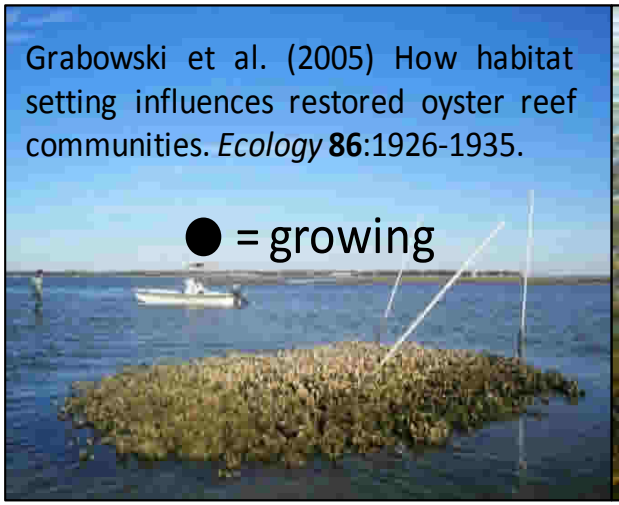
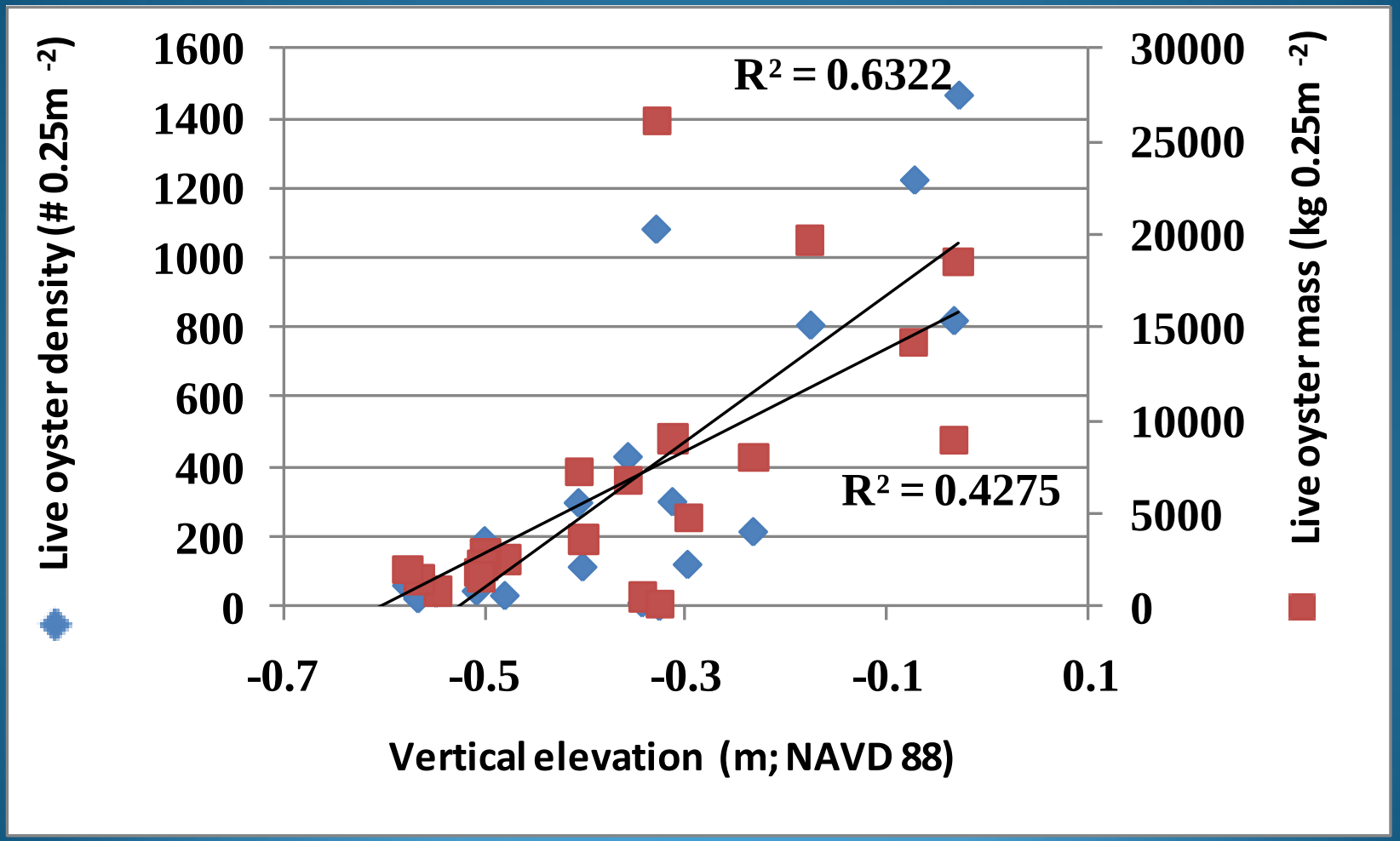
Reef evolution after 13 years: a depth-related twist on NC intertidal reefs





➢**Relationship between base substrate elevation and reef vertical relief (r^2 = 0.67). *Middle*: View of an accreting sand flat oyster reef. *Right*: View of a deteriorating reef located on a slightly deeper sand flat – note low relief and high level of biofouling.**

Reef evolution after 13 years: a depth-related twist on NC intertidal reefs



A depth-related twist on NC intertidal reefs: a depth/salinity gradient (Beaufort Waterfront)

- Credit to N. Lindquist

A depth-related twist on NC intertidal reefs: a depth/salinity gradient (Core Creek)

Potential culprits for reef demise below threshold depth

- **Vertical limits in the distribution of oyster predators and bioeroders**

Potential culprits for reef demise below threshold depth: a boring problem???

➢Credit to N. Lindquist

Potential culprits for reef demise below threshold depth

- As well as oyster disease and fouling organisms

Complex synergisms between oyster enemies

82.0 ± 1.1 mm (μ ± SE)

\+

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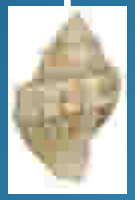

45.4 ± 0.1 mm (μ ± SE)

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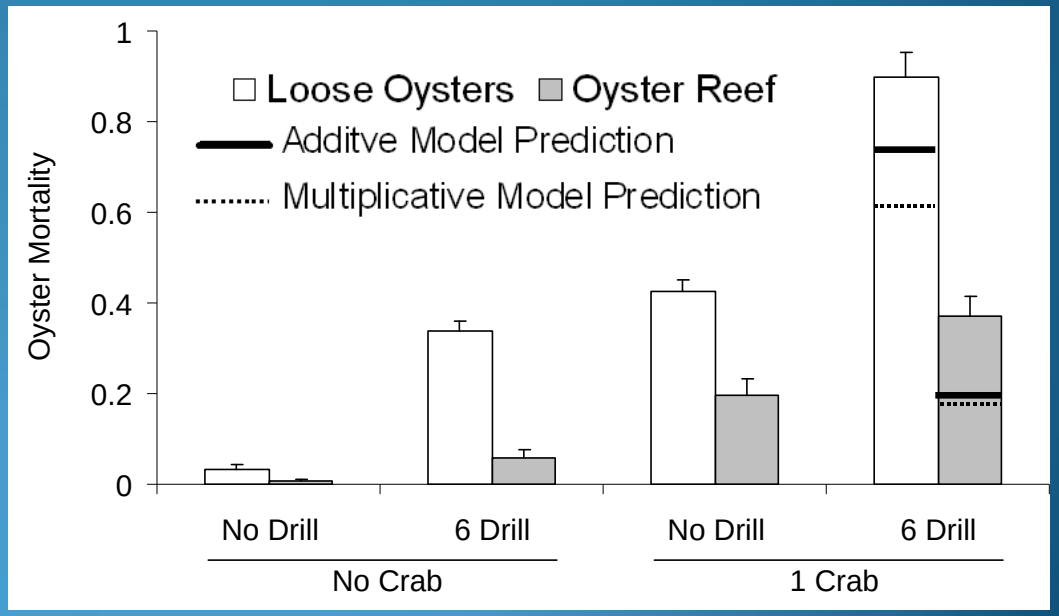
\–

66.0 ± 0.7 mm (μ ± SE)



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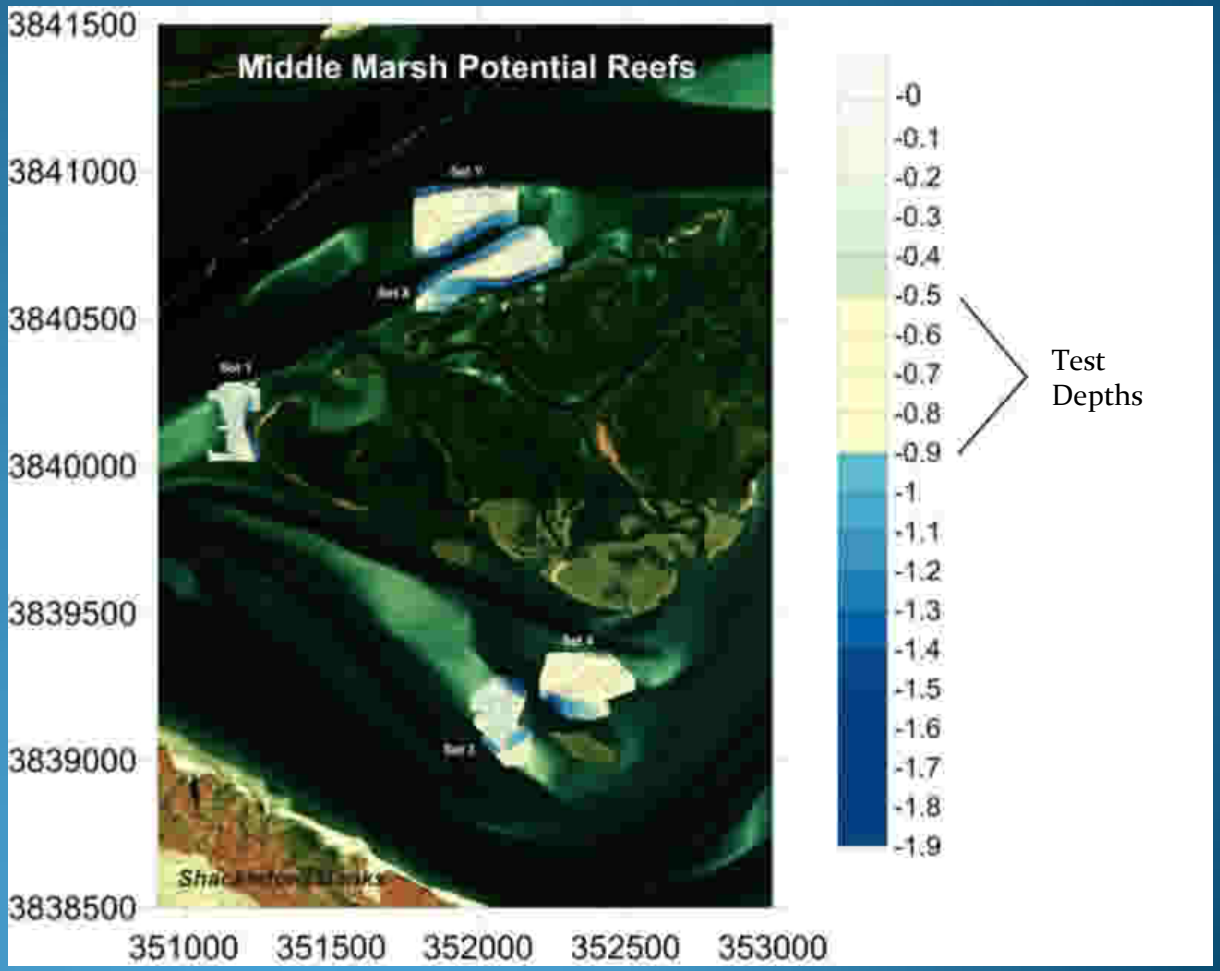
Ongoing restoration

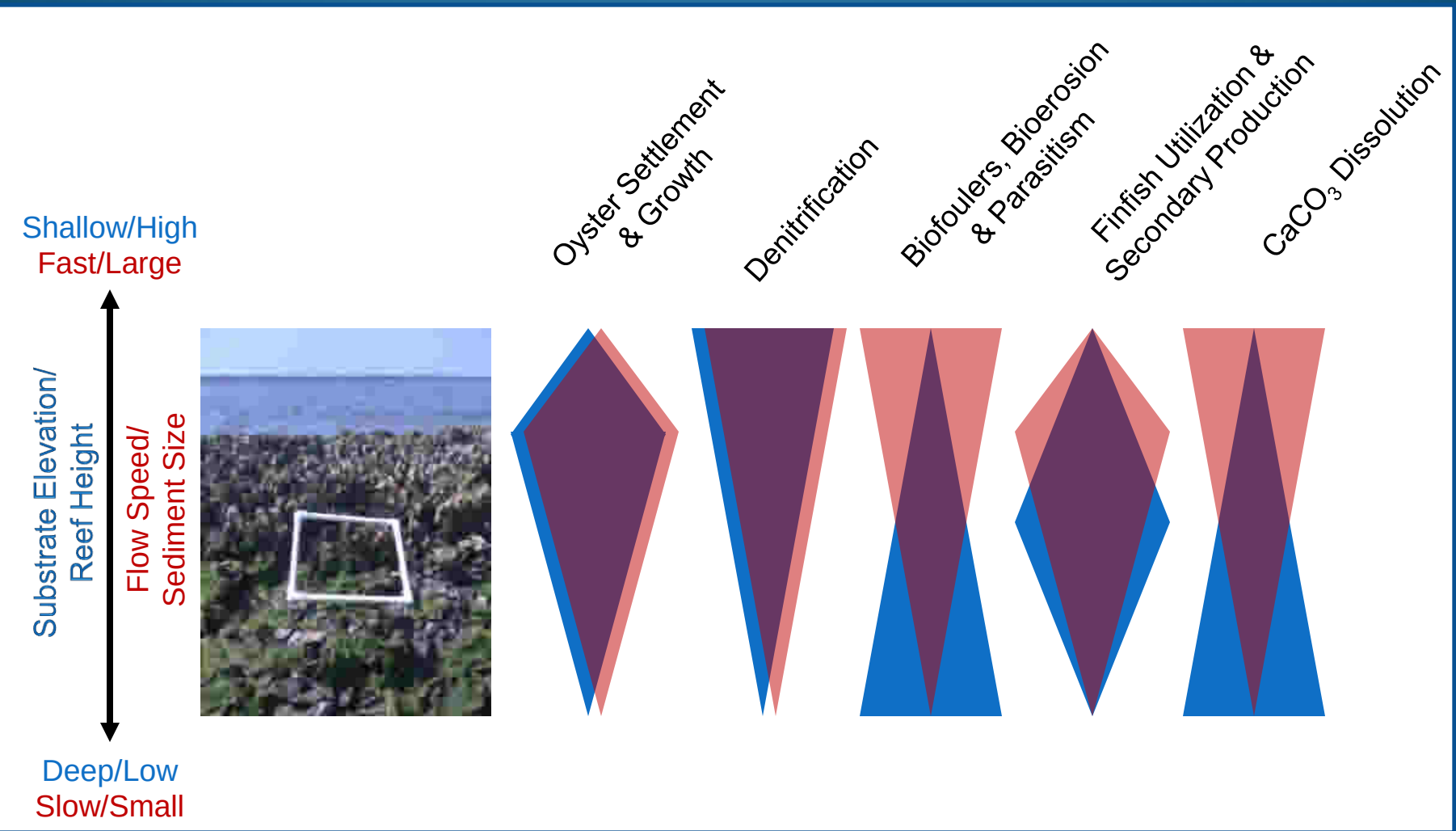
- 2011 restoration at Middle Marsh (APNEP funded)
- 60 (3 * 5 * 0.1m) and 600 (10 * 15 * 0.1m) bushel reefs
- Measuring : oyster density, settlement and growth . Associated ecosystem services: biogeochemcial cycling, water quality, biodiversity maintenance

Future restoration

- 2011 restoration at Middle Marsh
- 60 (3 * 5 * 0.1m) and 600 (10 * 15 * 0.1m) bushel reefs
- 4 depths:
  - -0.5m,
  - -0.6m,
  - -0.75m
  - and -0.9m NAVD 88
- Climate change effects
  - sea-level
  - ocean acidification



Future restoration – how do ecosystem services scale with location in the intertidal



Restoration guidelines taken from the rocky intertidal

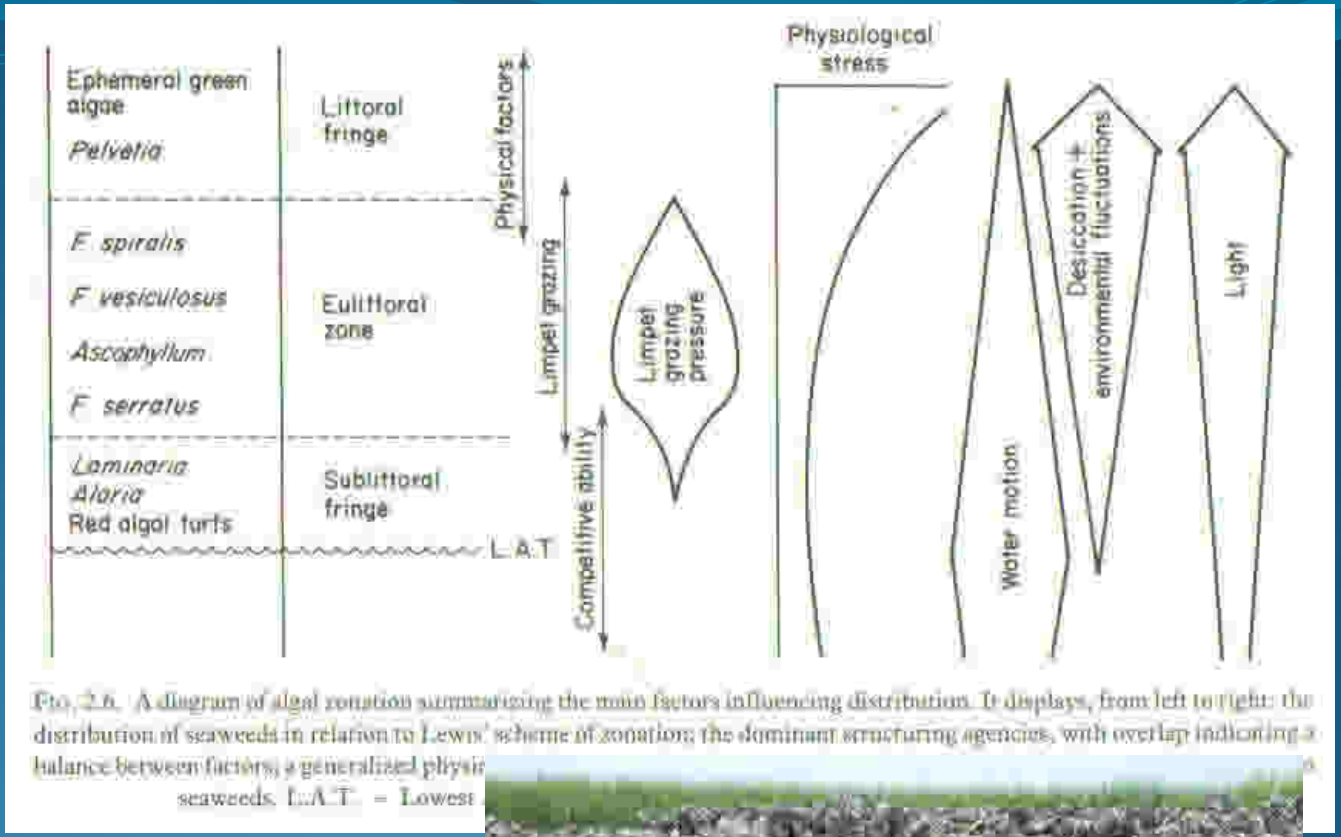


FIG. 2.6. A diagram of algal zonation summarizing the main factors influencing distribution. It displays, from left to right: the distribution of seaweeds in relation to Lewis' scheme of zonation; the dominant structuring agencies, with overlap indicating a balance between factors; a generalized physi
seaweeds. L.A.T. = Lowest

- Lower limit set by biotic stressors (enemies)
- Upper limit set by physical limits
- Competition for space alters morphology

Conclusions

- Intertidal reefs formerly a huge ecosystem component: restoring them presents unique challenges

- Restored intertidal reef success
  - -effects of landscape
  - -also, potential fine-scale, threshold effects of depth

- Rocky intertidal paradigm (vertical zonation) appropriate for intertidal reefs

- Still revisiting concepts known to naturalists/scientists a century ago


Thank You!