Oyster reef carbonate chemistry:
Implications for restoration

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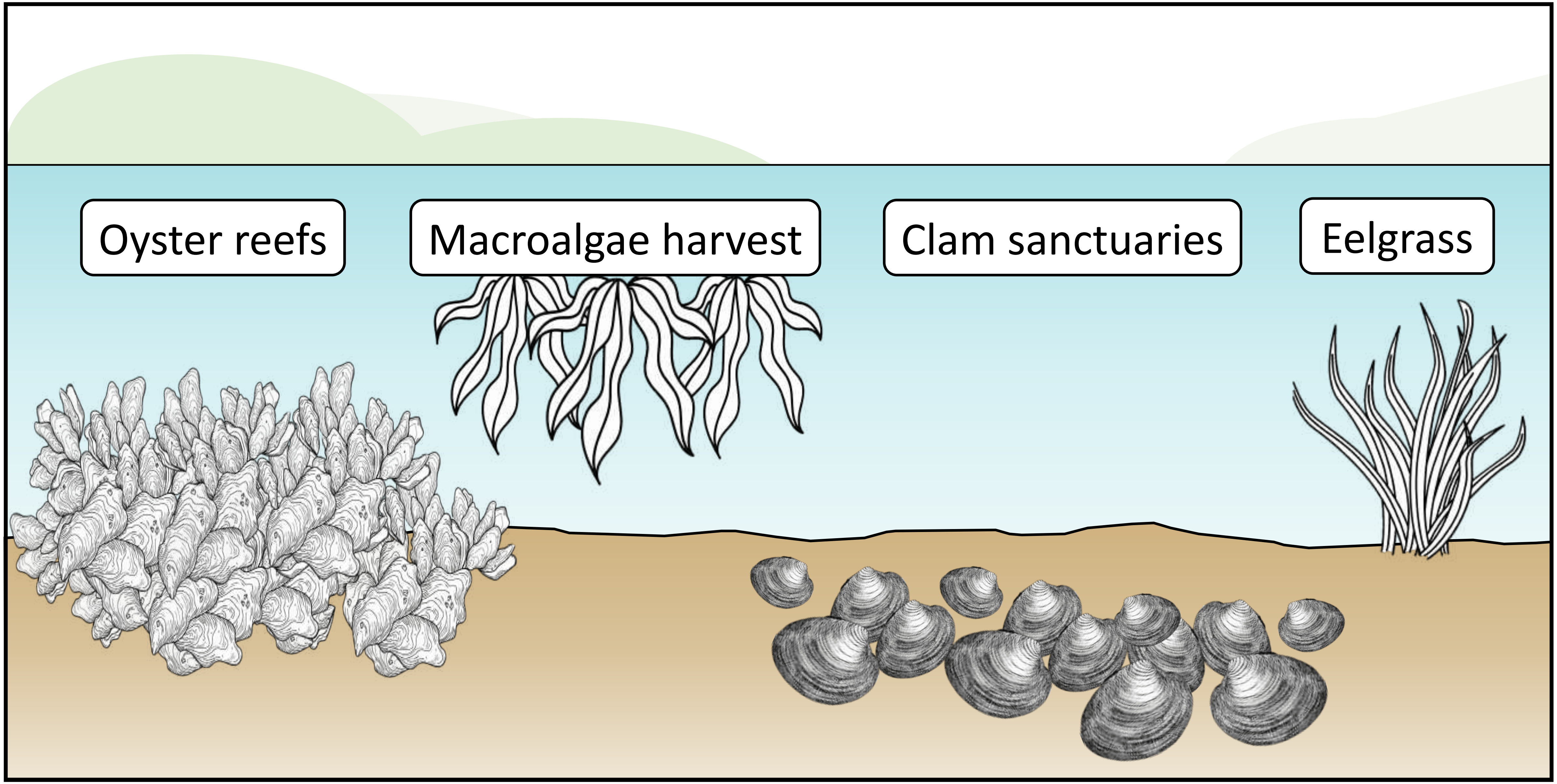
Photo: *Mike Doall;* ***Refs****:* Tomasetti et al., *in review*

Shinnecock Bay, Long Island NY - 2011

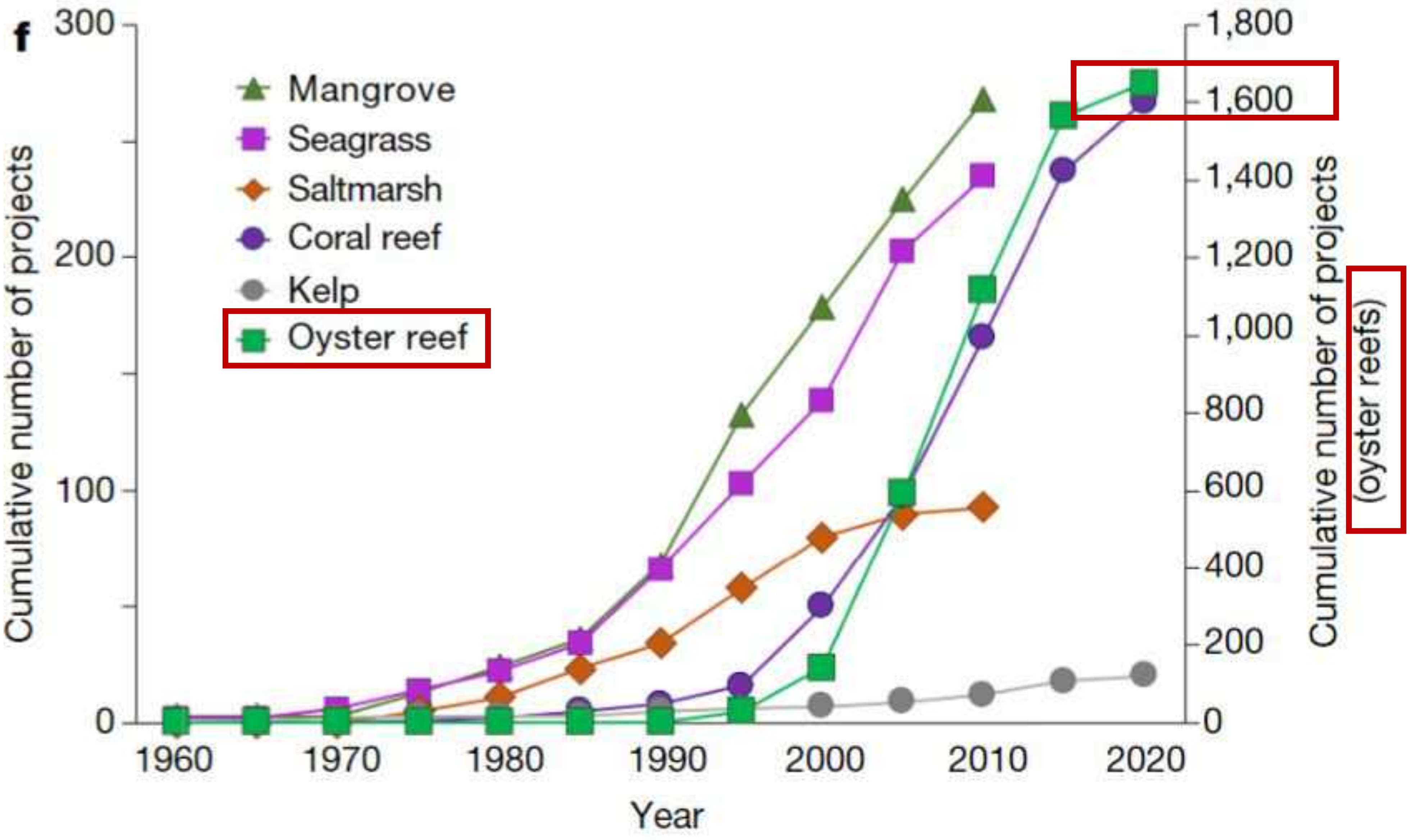
Photo: *shinnecockbay.org*

Shinnecock Bay Restoration Program - 2012



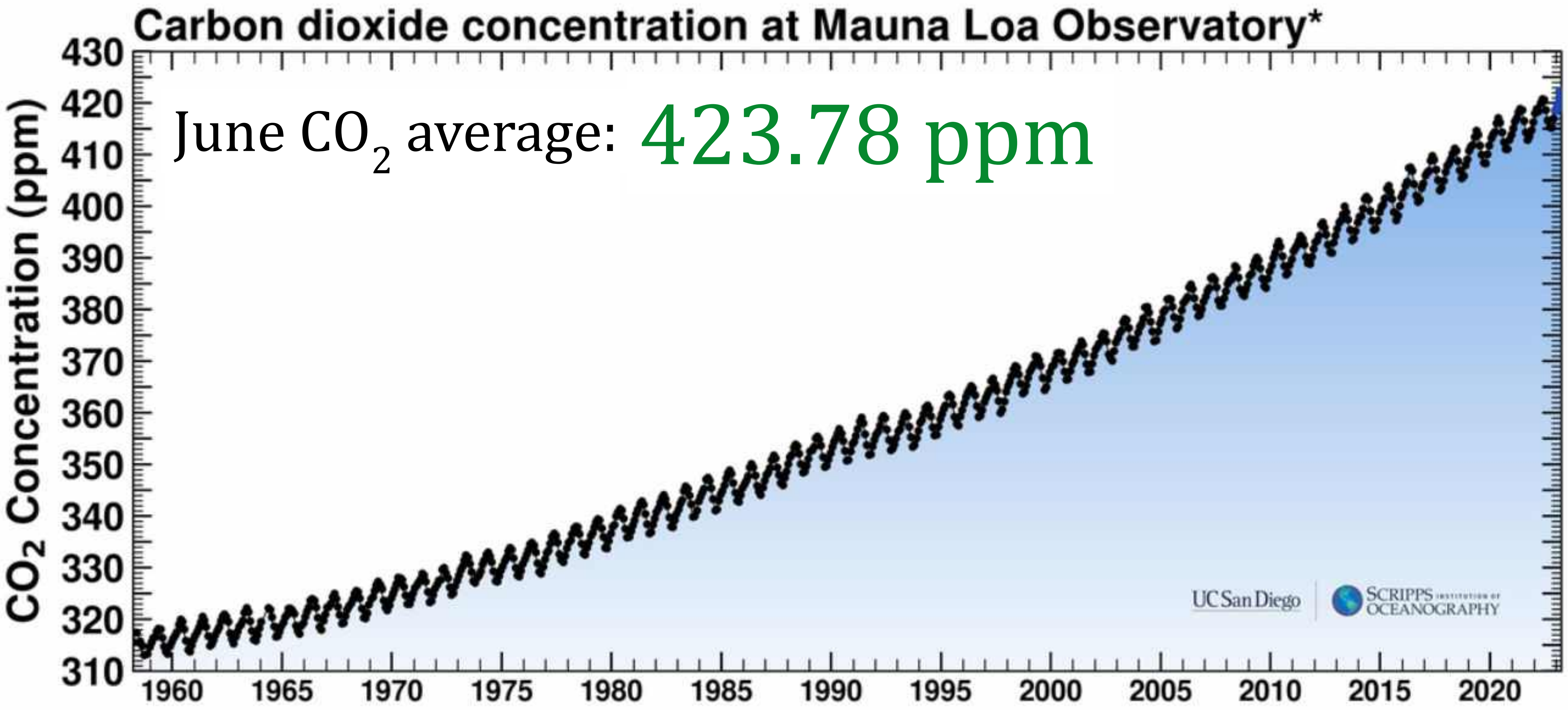
Refs: Gobler et al., *Front. Mar. Sci*, 2022

Oyster reef restoration



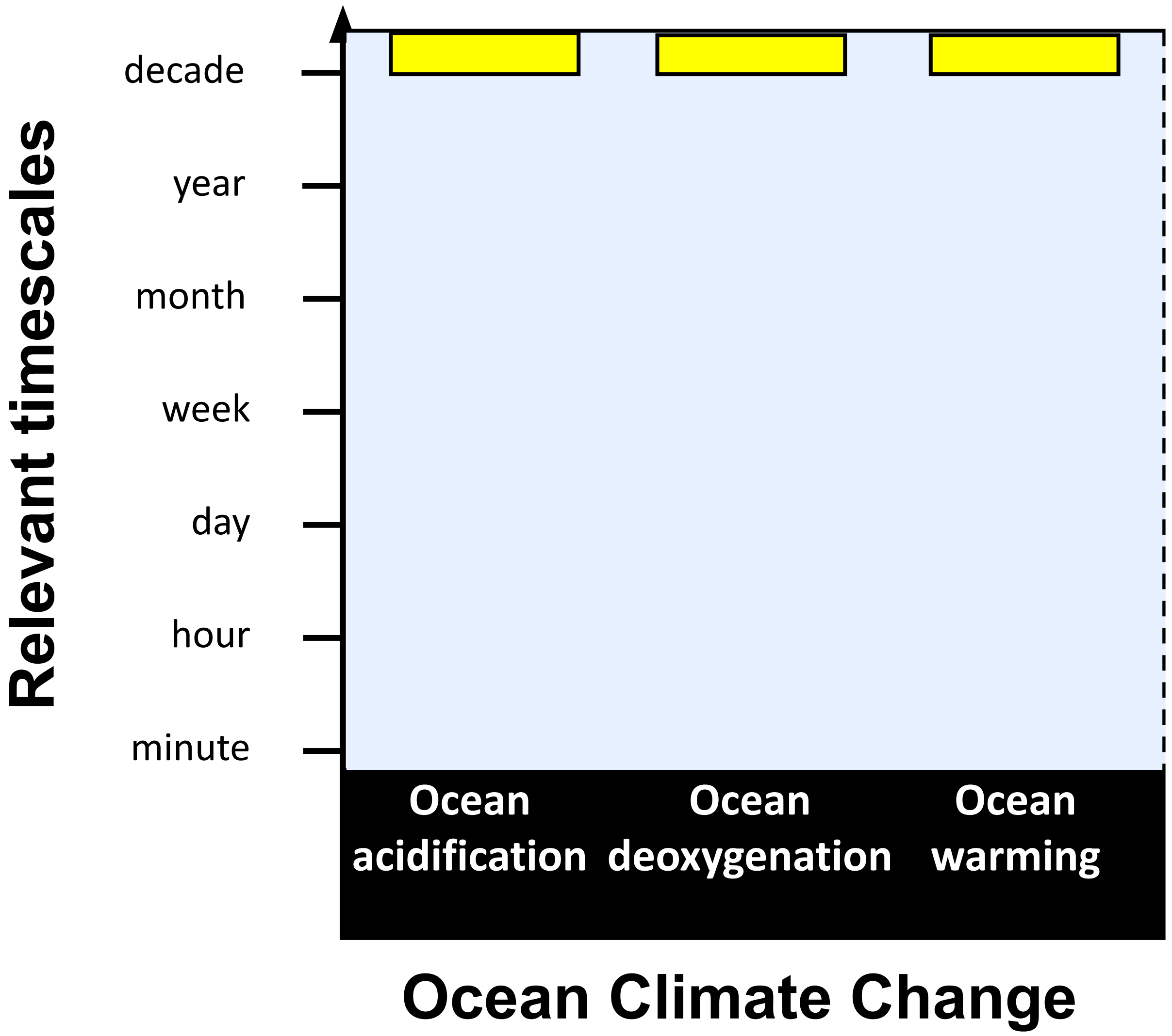
Refs: Duarte et al., *Nature*, 2020

Restoration interventions and climate change



Refs: https://keelingcurve.ucsd.edu/

Relevant timescales of ocean and coastal change



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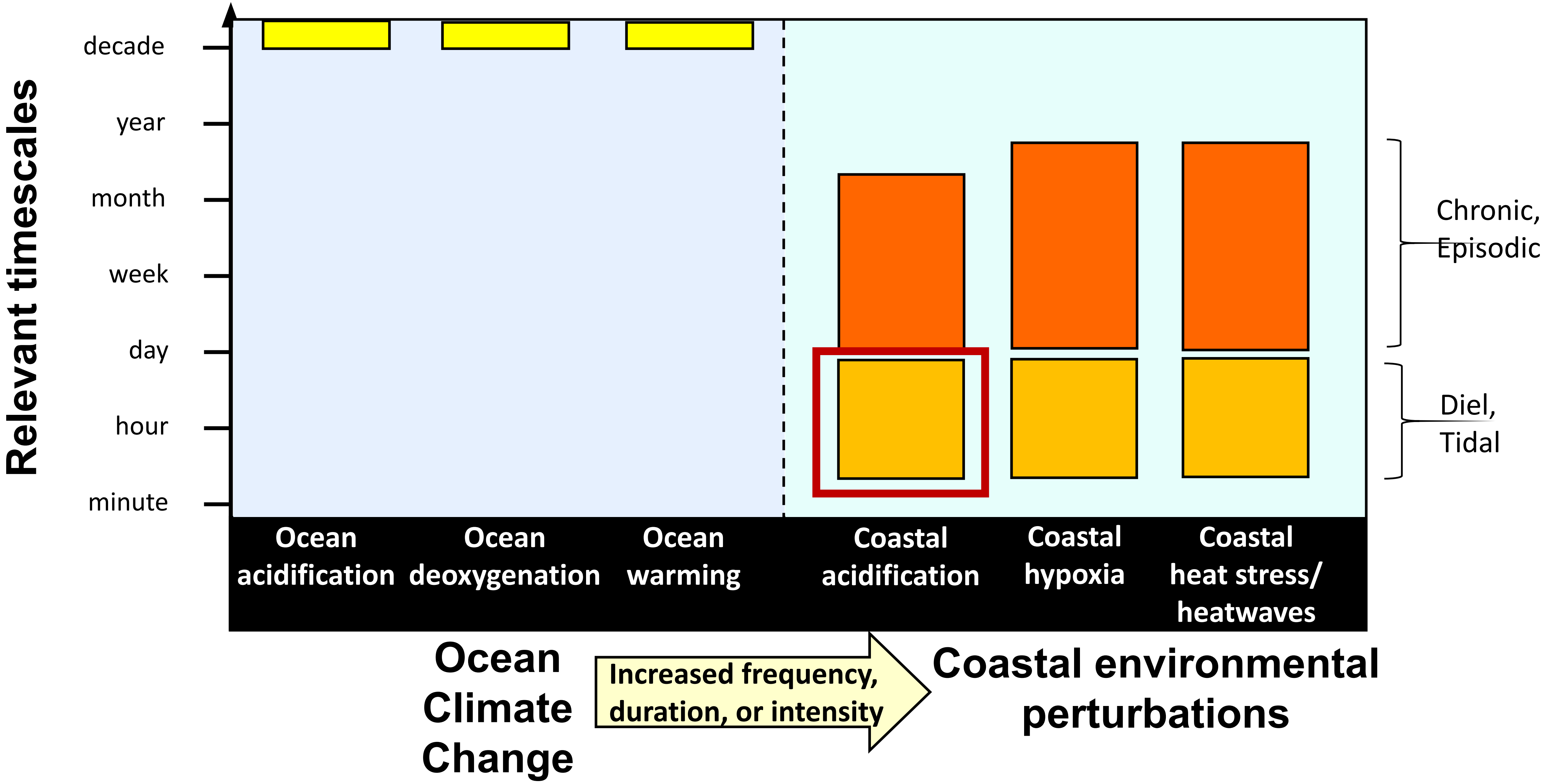
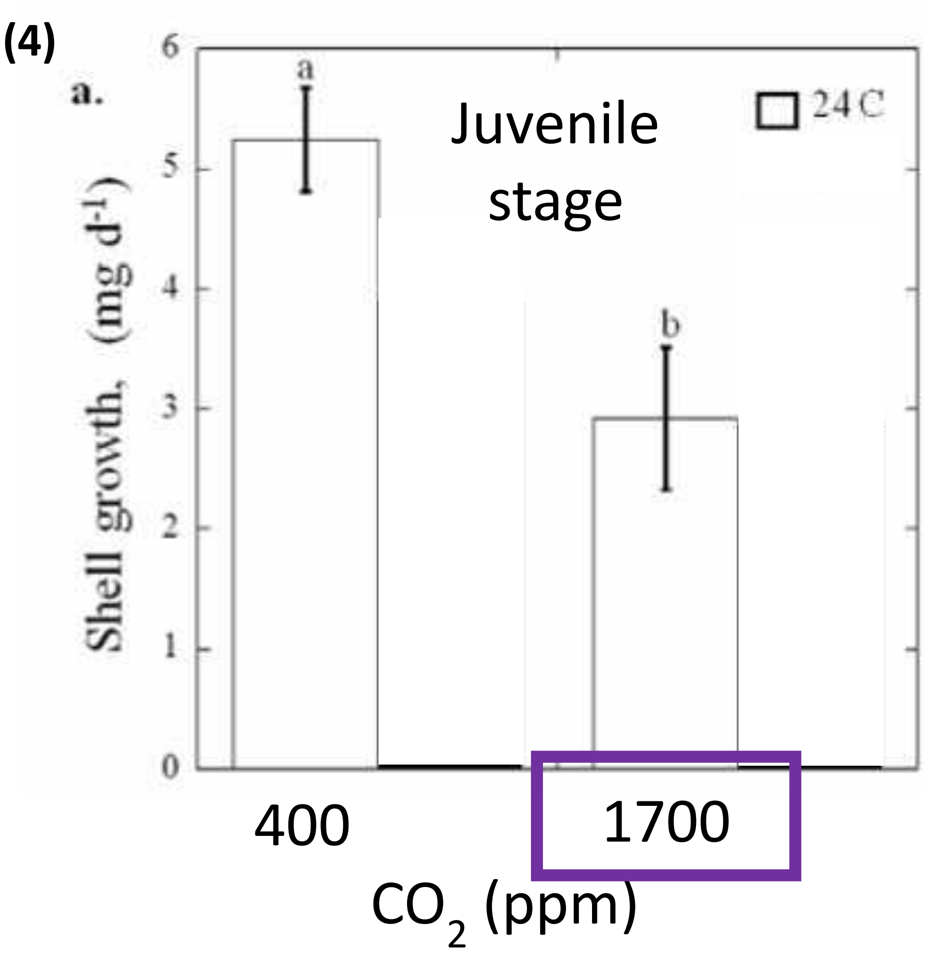


Acidification and oysters

- Both **chronic** and **diel-cycling** acidification can negatively impact oyster growth and calcification across larval and juvenile stages[1-8].

(4)



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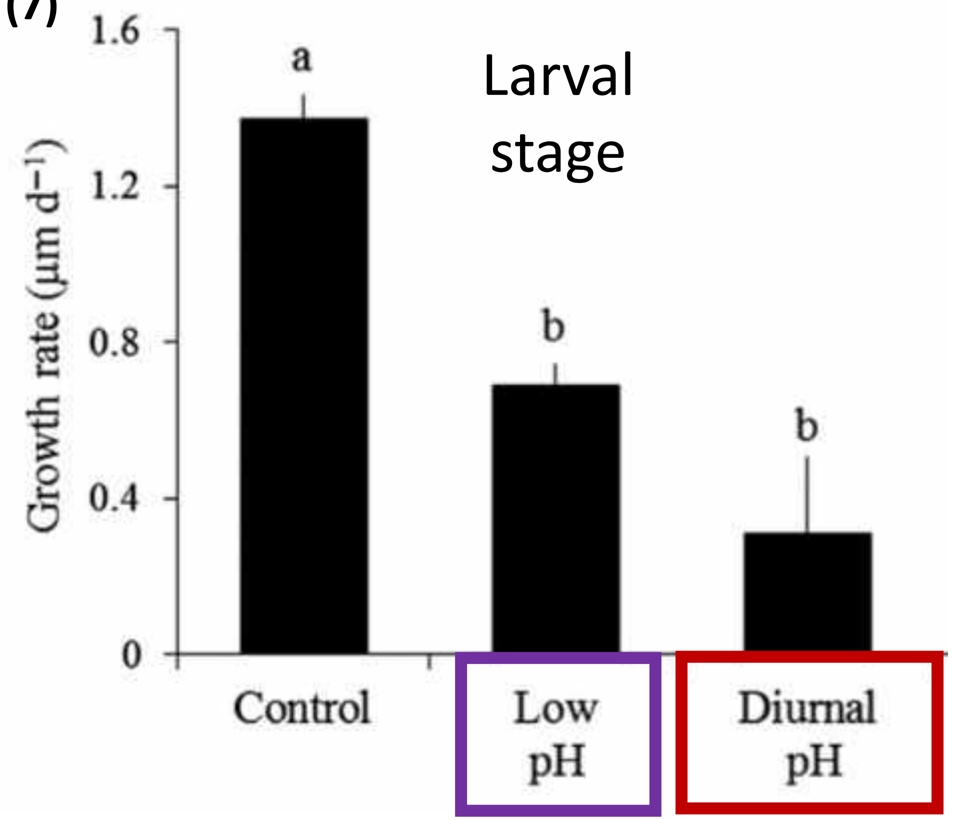


Refs: (1) Miller et al., 2009; (2) Ries et al., 2009; (3) Waldbusser et al., 2011; (4) Talmage and Gobler, 2011; (5) Beniash et al., 2010; (6) Gobler and Talmage, 2014; (7) Clark and Gobler, 2016; (8) Speights et al., 2017.

Oyster restoration and coastal acidification

Objectives:

- Characterize the carbonate system dynamics of oyster reef habitat relative to the background environment
- Identify the impacts (if any) on resident oysters

Refs: Tomasetti et al., *in review*

Methods: Ecological and environmental monitoring (2018-2021) + field experiments (2020, 2021).

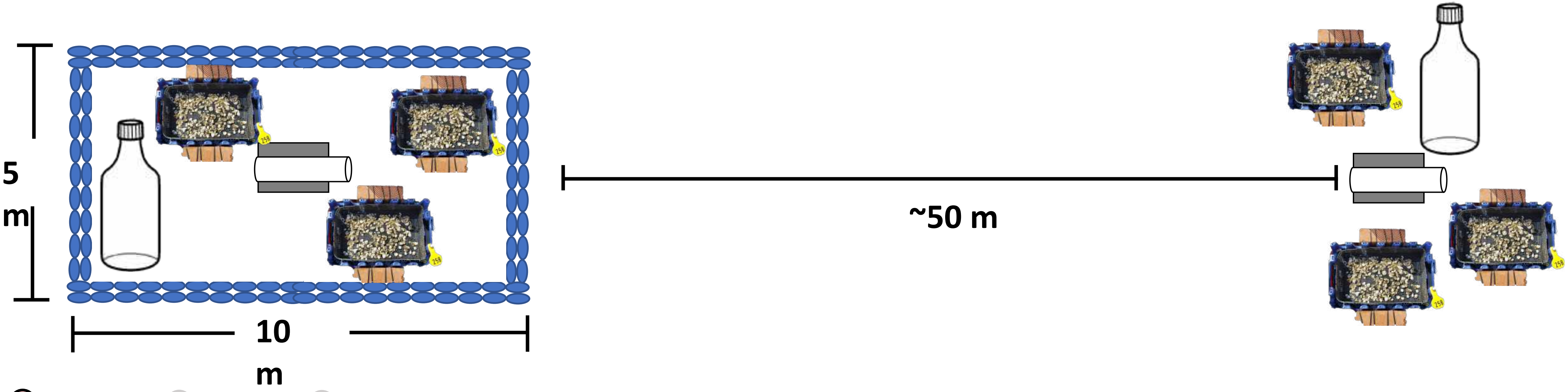
Ecological monitoring of reefs; high-frequency summer monitoring of pH

Frequent carbonate chemistry sampling

Field experiments with juvenile oysters

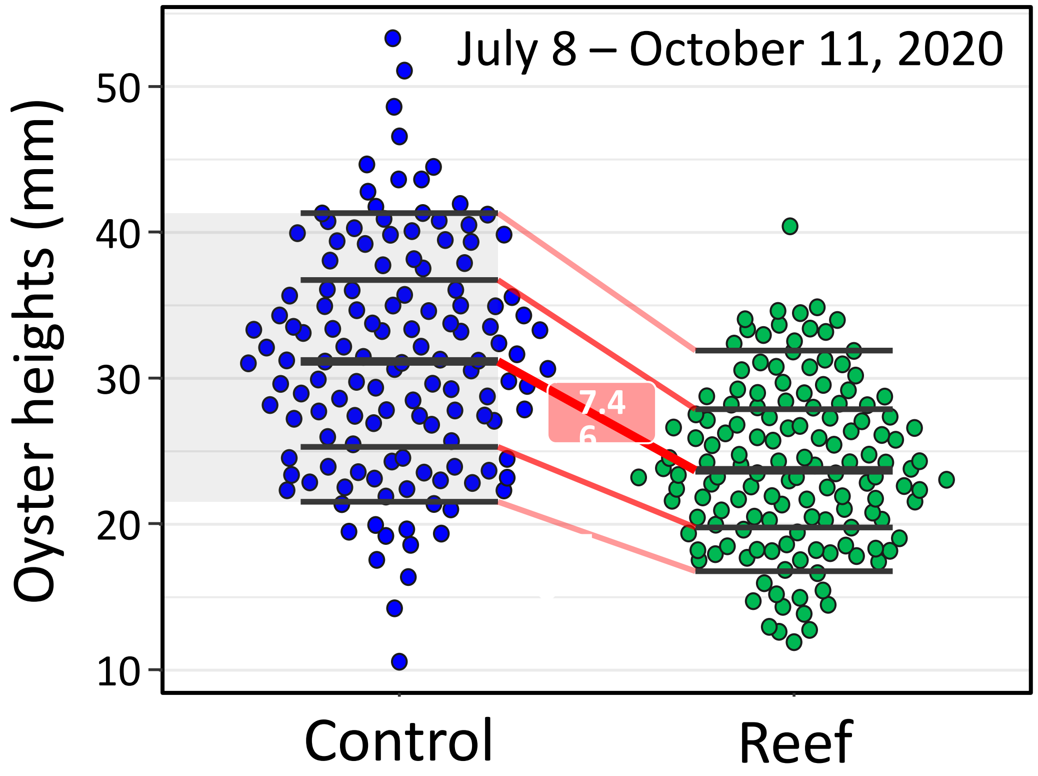
Refs: Tomasetti et al., *in review*

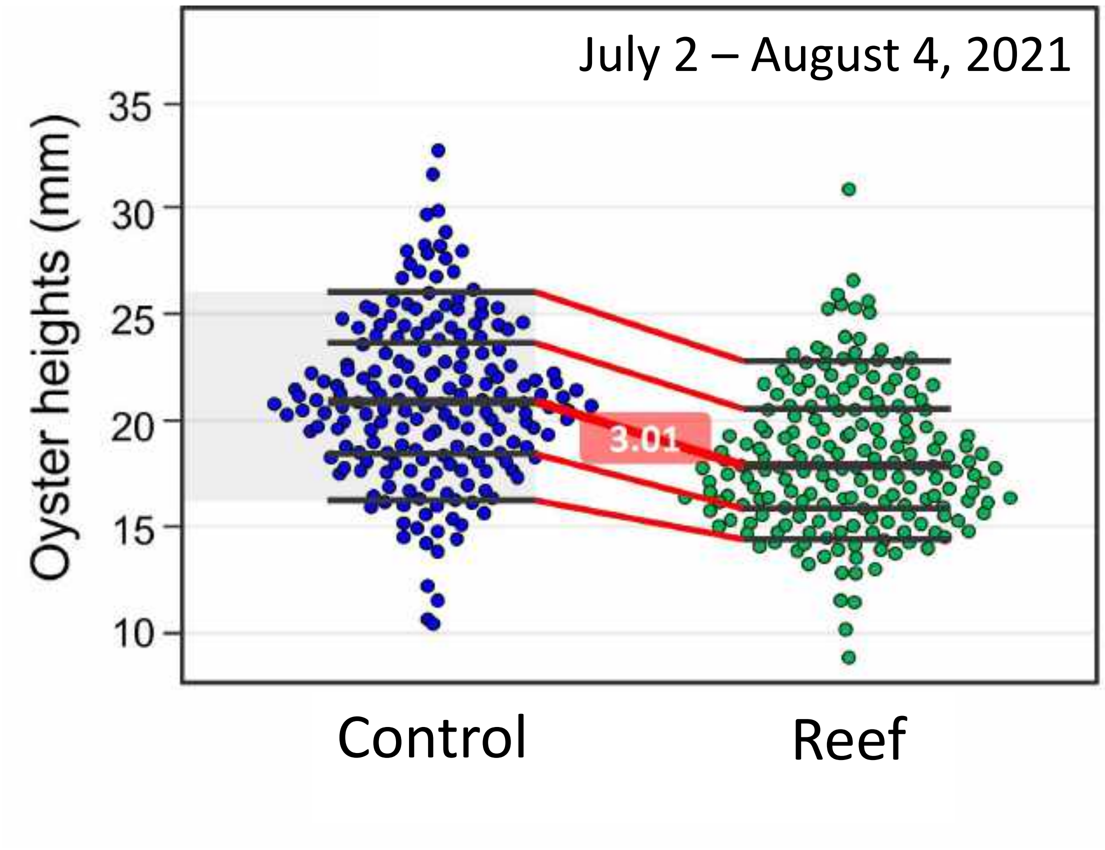
Methods: Using constructed oyster reefs of Shinnecock Bay



Refs: **Tomasetti** et al., *in review*

Results: reduced shell growth of juvenile oysters

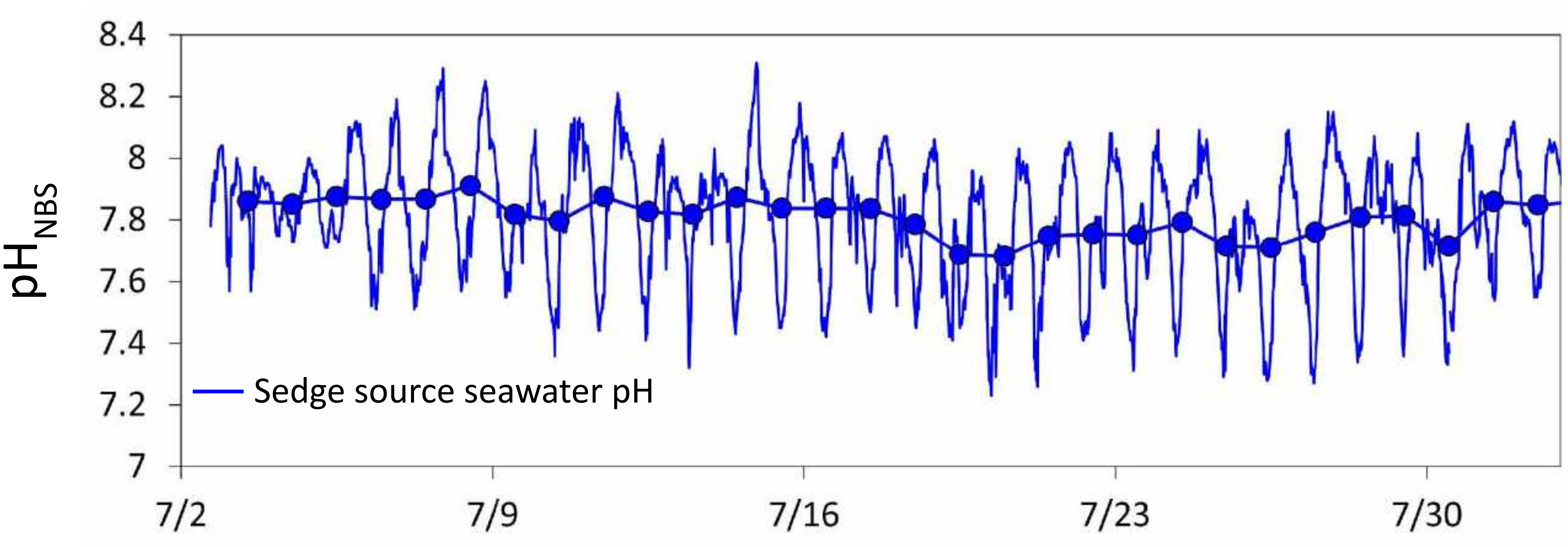




Refs: Tomasetti et al., *in review*

Results: Source seawater pH

- The background environment exhibited large daily fluctuations in pH associated with photosynthesis/respiration over a diel cycle



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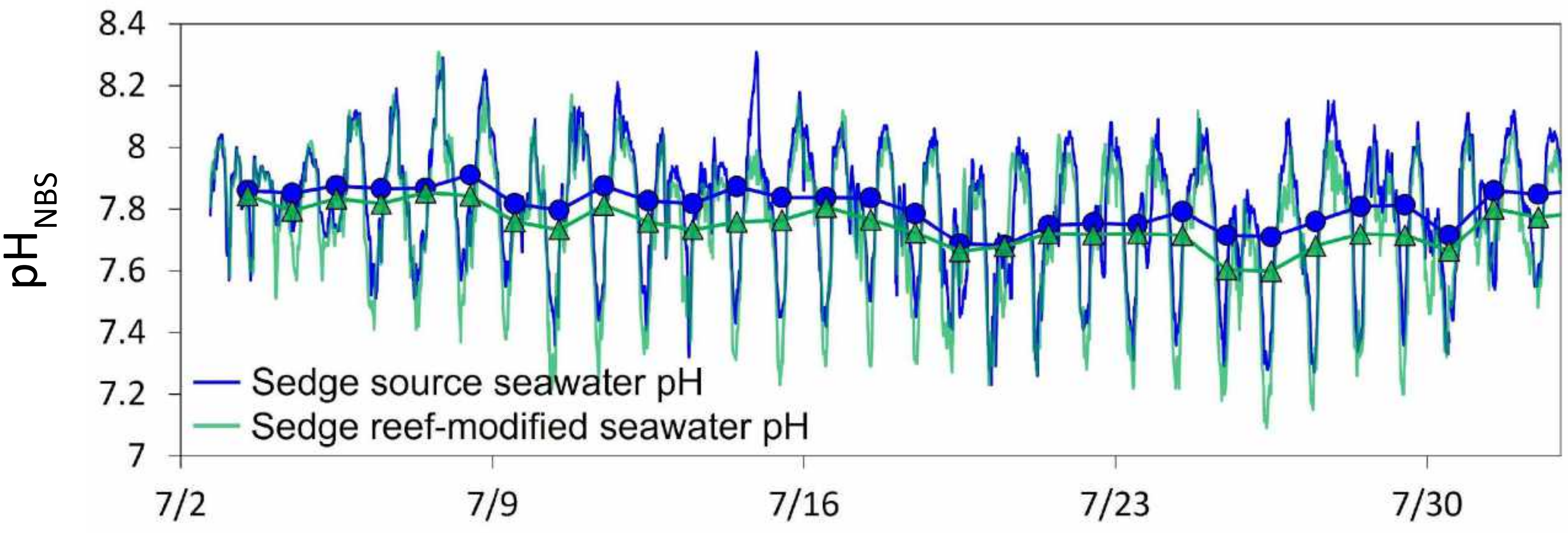
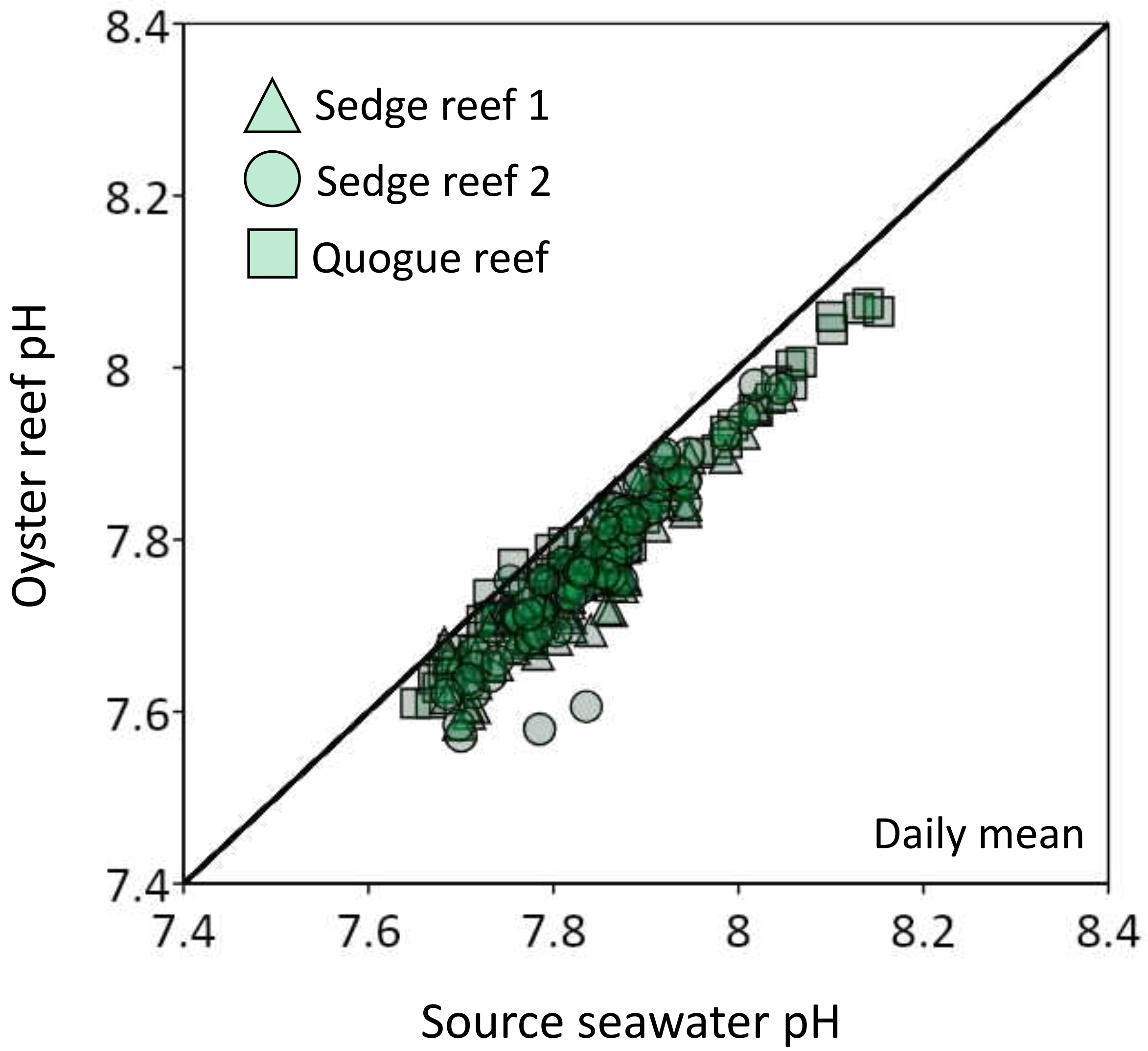
Results: Reef influence on daily pH means and minima

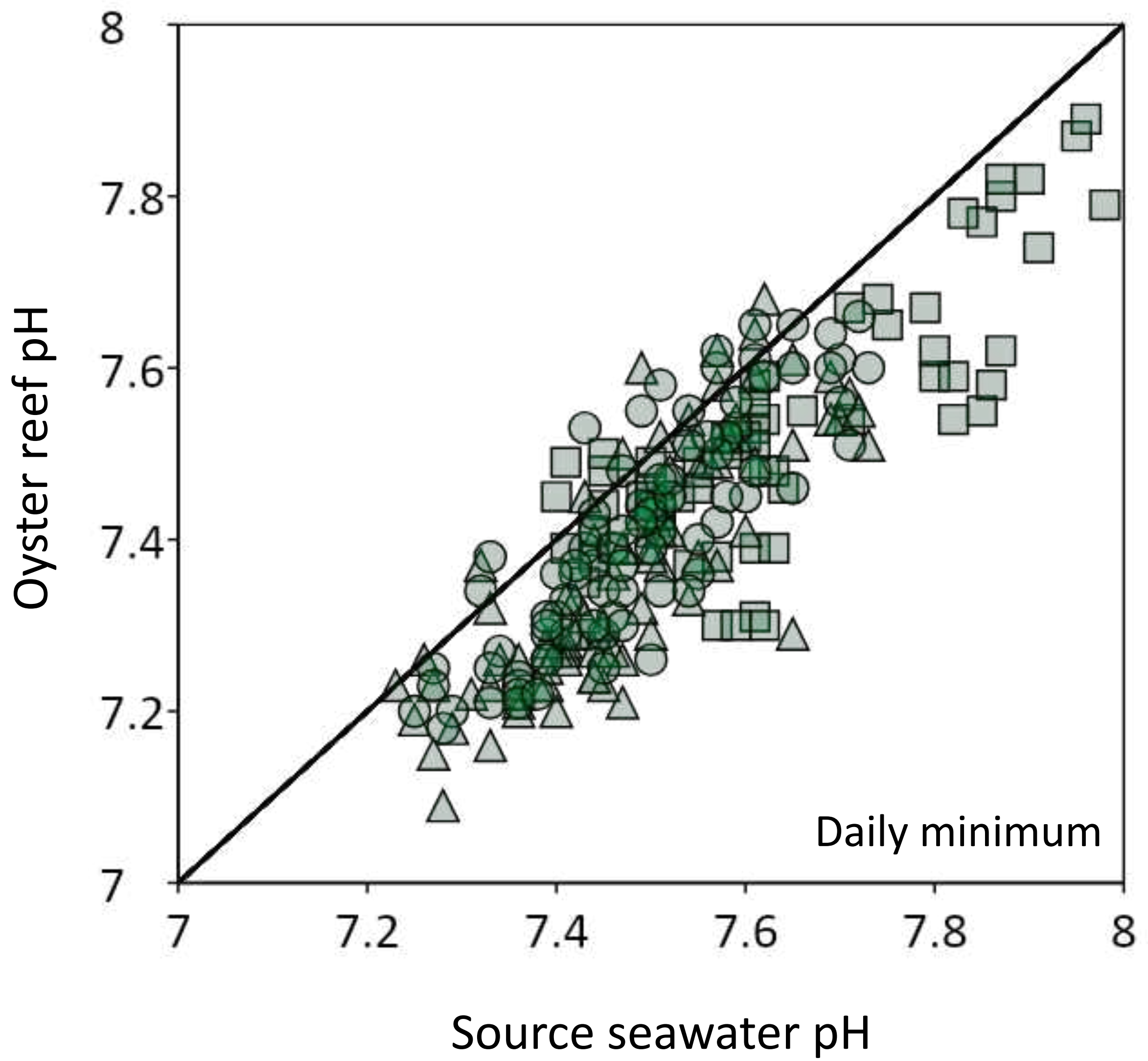
- The oyster reef community modified waters in ways that generally reduced the daily pH means and minima



Refs: Tomasetti et al., *in review*

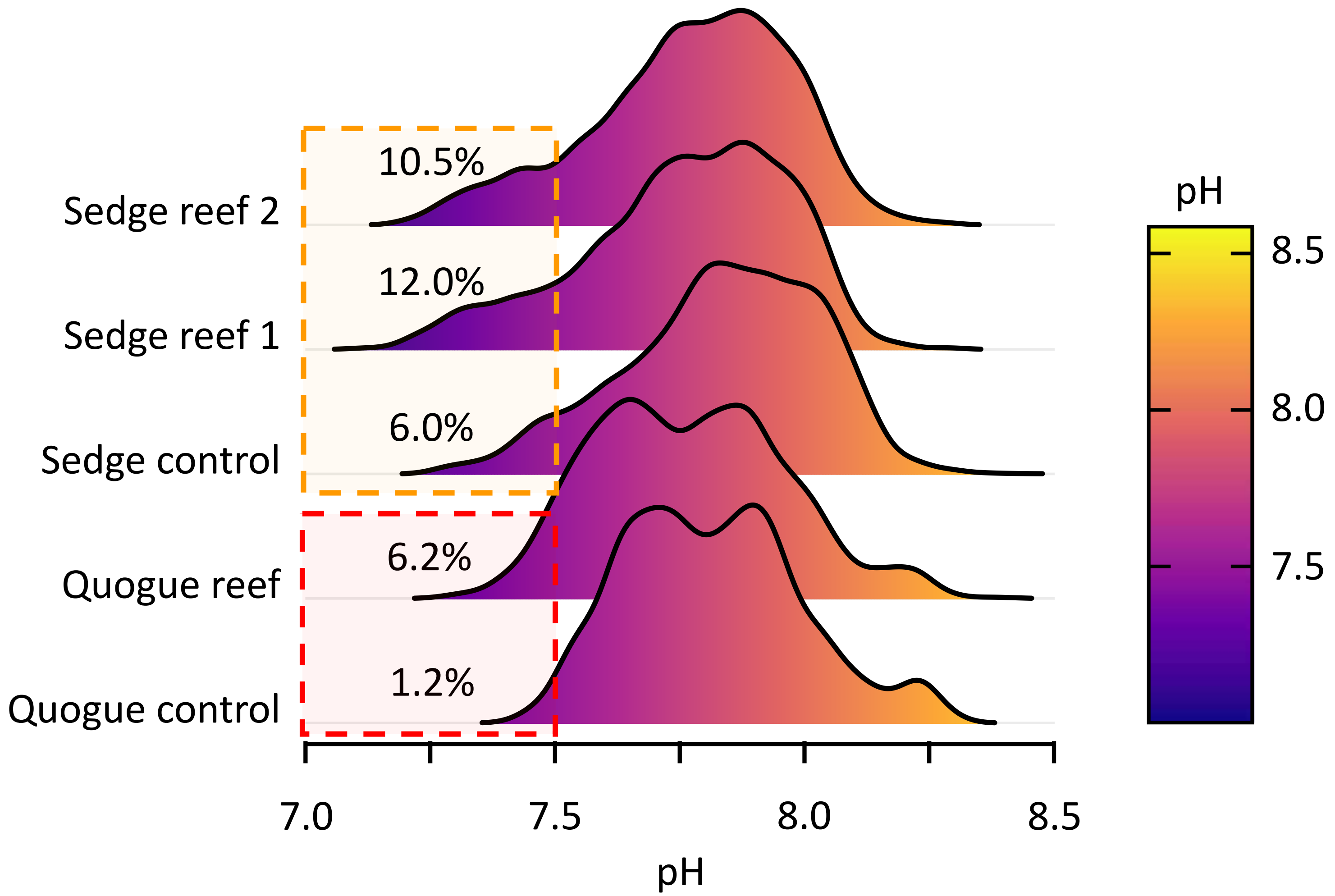
Results: Daily mean pH and daily minimum pH





Refs: Tomasetti et al., *in review*

Results: Longer durations of unfavorable pH in reefs



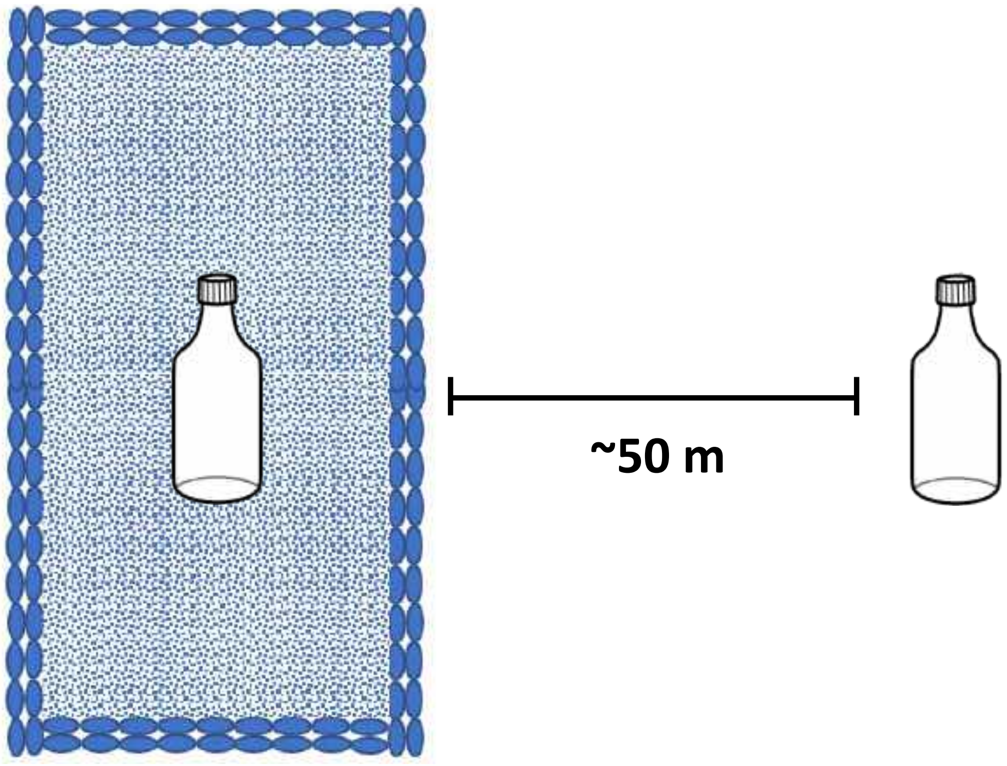
Refs: Tomasetti et al., *in review*

Effects of reef community processes on the carbonate system

Total alkalinity (TA):

The excess in bases relative to acids

$$TA = [HCO_3^{-}] + 2[CO_3^{-}] + [HPO_4^{2-}] + [OH^{-}] + 2[PO_4^{3-}] + \ldots [NH_3] – [H^{+}] - [H_3PO_4] - \ldots [HNO_2]$$



Dissolved inorganic carbon (DIC):

Total amount of inorganic carbon

$$DIC = [CO_2] + [HCO_3^{-}] + [H_2CO_3] + [CO_3^{2-}]$$

Refs: Tomasetti et al., *in review*

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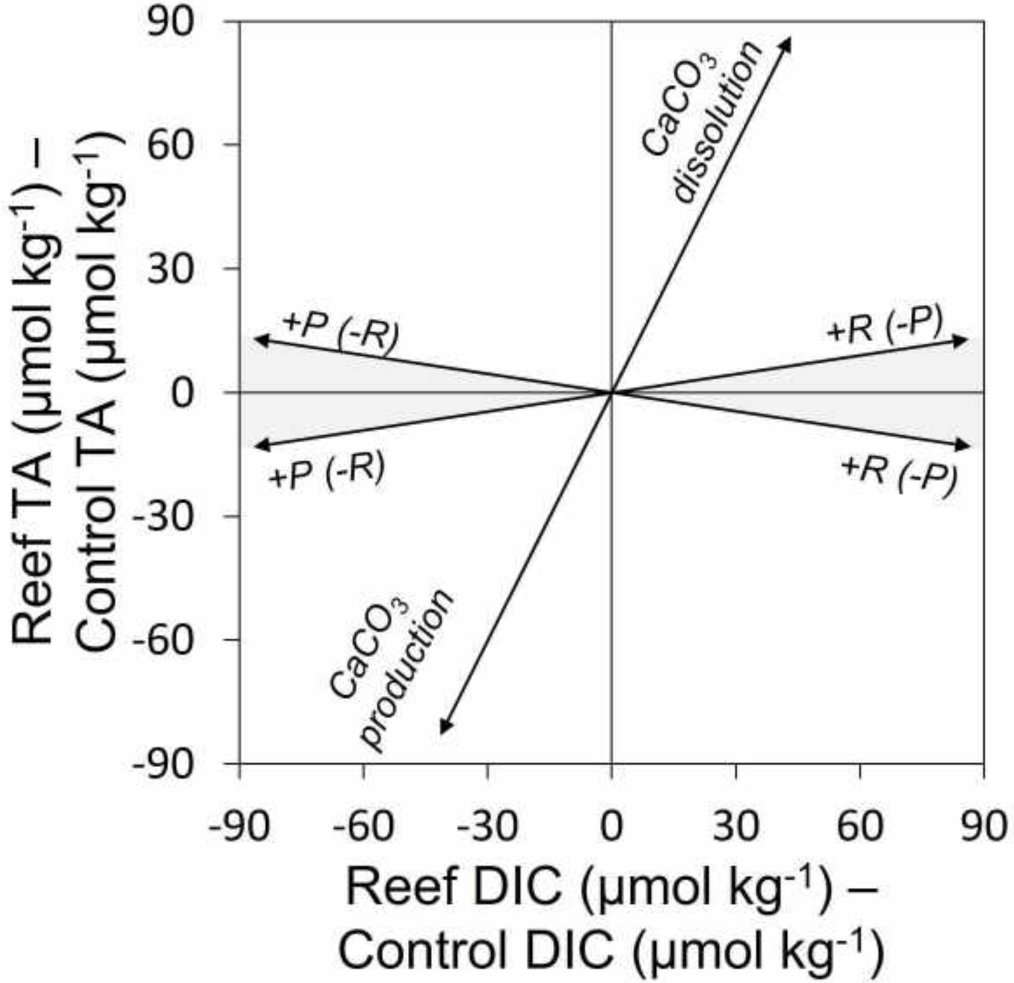

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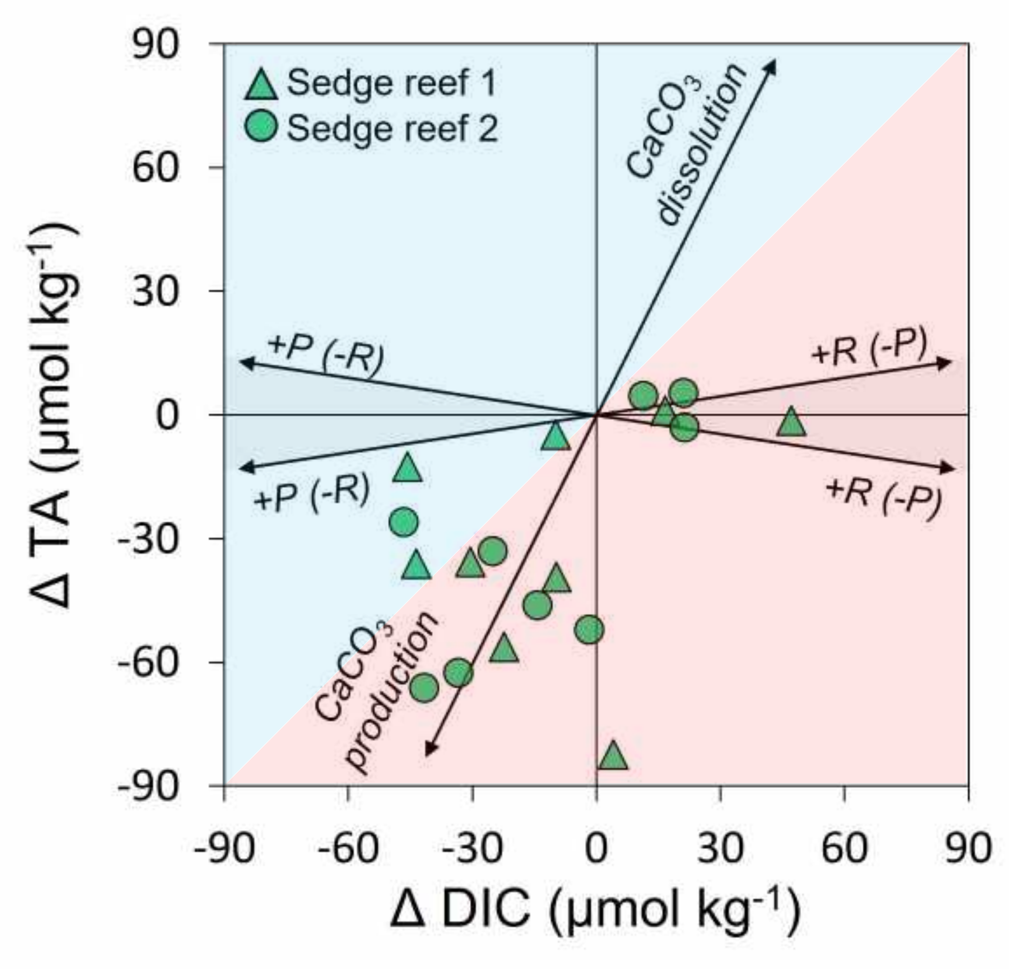
Results: Reef-modified water was depleted in TA

- Majority of reef TA anomalies were negative

- Many datapoints clustered around the $CaCO_3$ production vector



- Reduced pH in reefs was associated with enhanced calcification and respiration

- Temporarily increased pH in reefs was primarily associated with enhanced production

Refs: Tomasetti et al., *in review*

Summary

- Community calcification and respiration processes **generate CO_2** and can lead to decreased pH and decreased Ω in oyster reef habitat.

- These oyster reef community processes, when occurring in locations already subject to impairment, can increase oyster vulnerability to acidification.

- Oyster restoration practitioners: consider pre-existing carbonate chemistry during site selection!

Refs: Tomasetti et al., *in review*

A note on oyster reefs and mCDR

Are oyster reefs **CO_2** **sinks** or **sources**?

-2 mol TA
-2 mol DIC

+1 mol DIC

CALCIFICATION: $Ca^{2+} + 2HCO_3^- \square CaCO_3 + CO_2 + H_2O$ (**NET: -2 TA, -1 DIC**)

+1 mol DIC

RESPIRATION: $CH_2O + O_2 \square CO_2 + H_2O$ (**NET: +1 DIC**)

*In some cases, **organic** C burial may offset CO_2 production from calcification/respiration to ultimately make oyster reefs C-neutral or even C-sinks (Fodrie et al., 2017).

Thank you!

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Stony Brook University School of Marine and Atmospheric Sciences

SHINNECOCK BAY RESTORATION PROGRAM

STRIDE

Scientists from Stony Brook University

Bob Maze,
Laurie Landeau