



# Submerged aquatic vegetation and coastal acidification

Highlights from recent research

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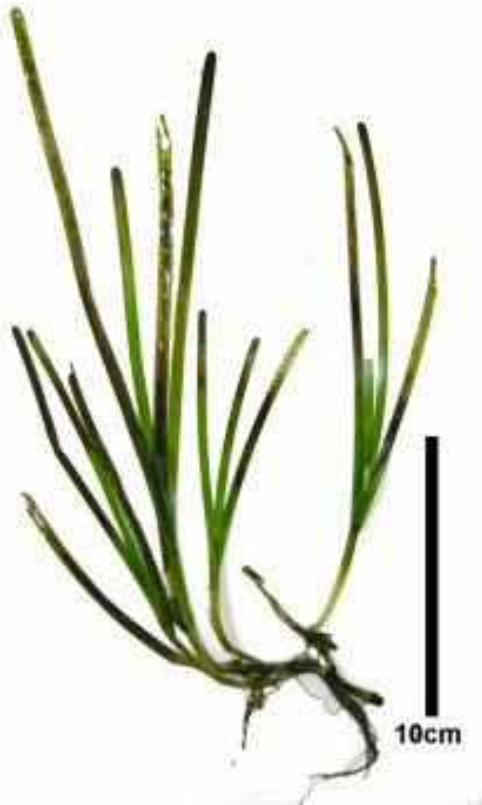
Cassie Gurbisz, St. Mary's College of Maryland

MACAN Coastal & Ocean Acidification Workshop

11 September 2023

# Seagrass

Brackish –  
full seawater  
*Zostera marina*

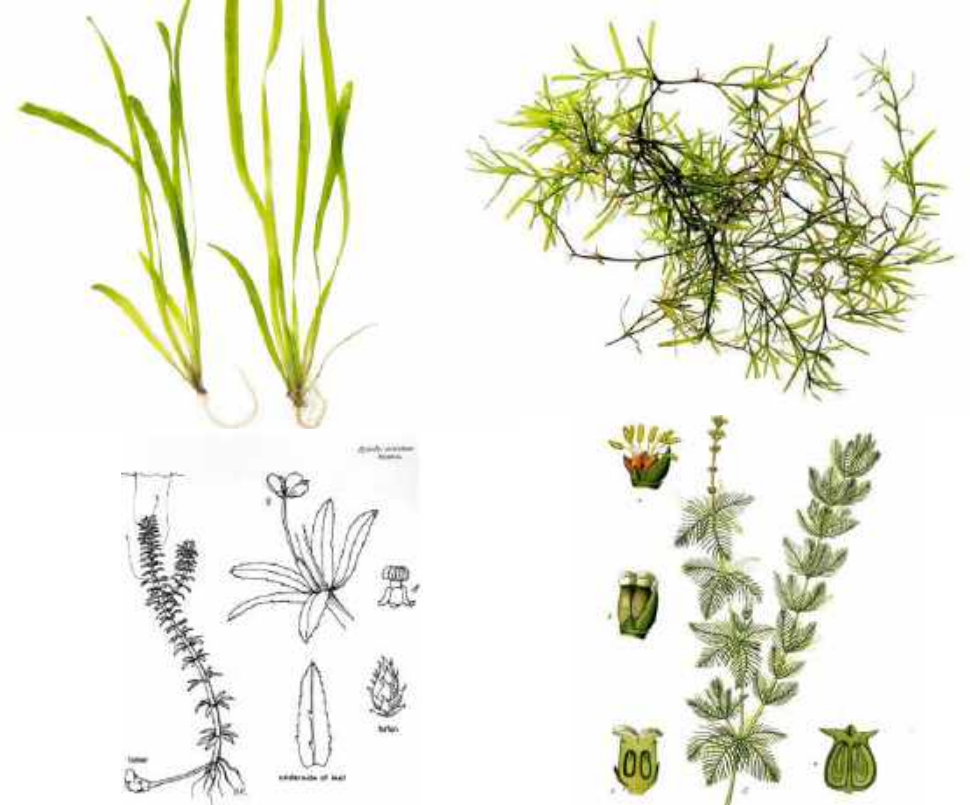


# Estuarine submerged aquatic vegetation (SAV)

Brackish  
*Ruppia maritima*  
*Potamogeton* spp.  
*Stuckenia pectinata*



Fresh  
*Vallisneria americana*  
*Hydrilla verticillata*  
*Ceratophyllum demersum*  
*Myriophyllum spicatum*  
*Elodea canadensis*  
*Najas* spp.



(not a comprehensive list)

How do increasing CO<sub>2</sub> and temperature affect SAV?

How does SAV affect carbonate chemistry?

Can SAV mitigate the negative effects of acidification?

Locally  
System-scale

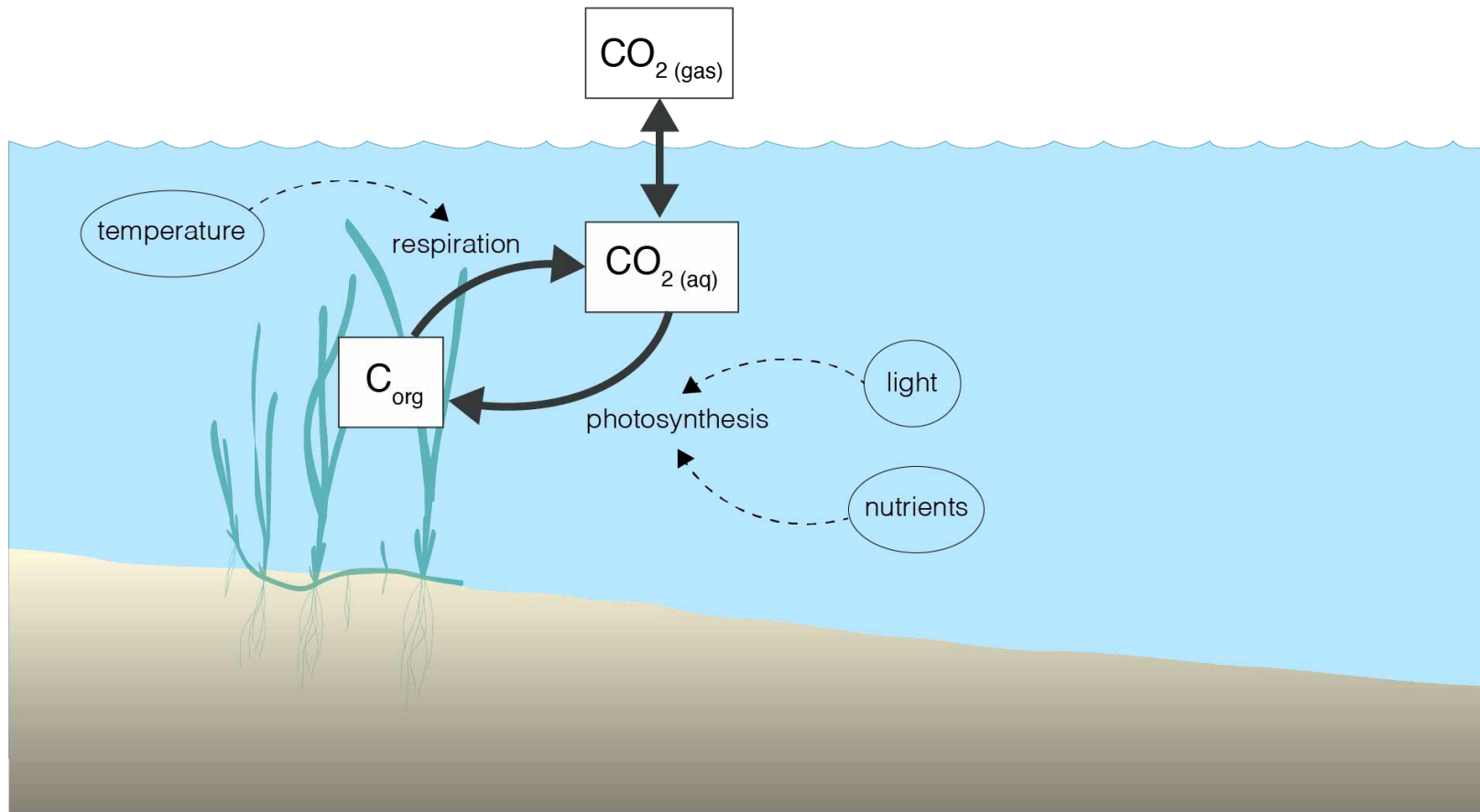
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# Light, temperature, nutrients, and CO<sub>2</sub> control SAV carbon balance



How do increasing CO<sub>2</sub> and temperature affect SAV?

# Increased CO<sub>2</sub> can increase SAV production

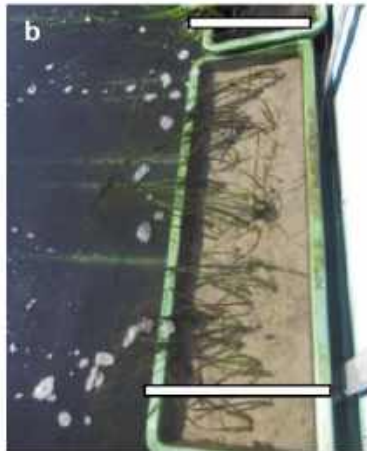
Mesocosm experiment with *Zostera marina* (eelgrass) from Chesapeake Bay:

- **Adding CO<sub>2</sub> increased eelgrass biomass production**

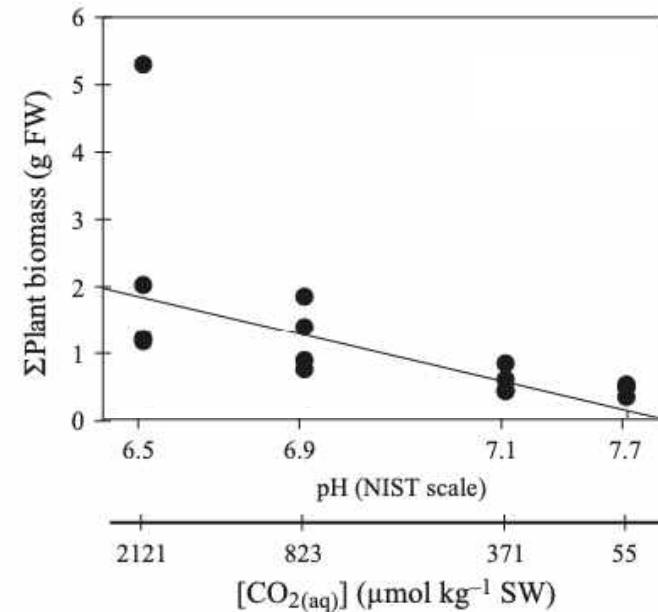
CO<sub>2</sub> added pH 6.5



Ambient CO<sub>2</sub> and pH

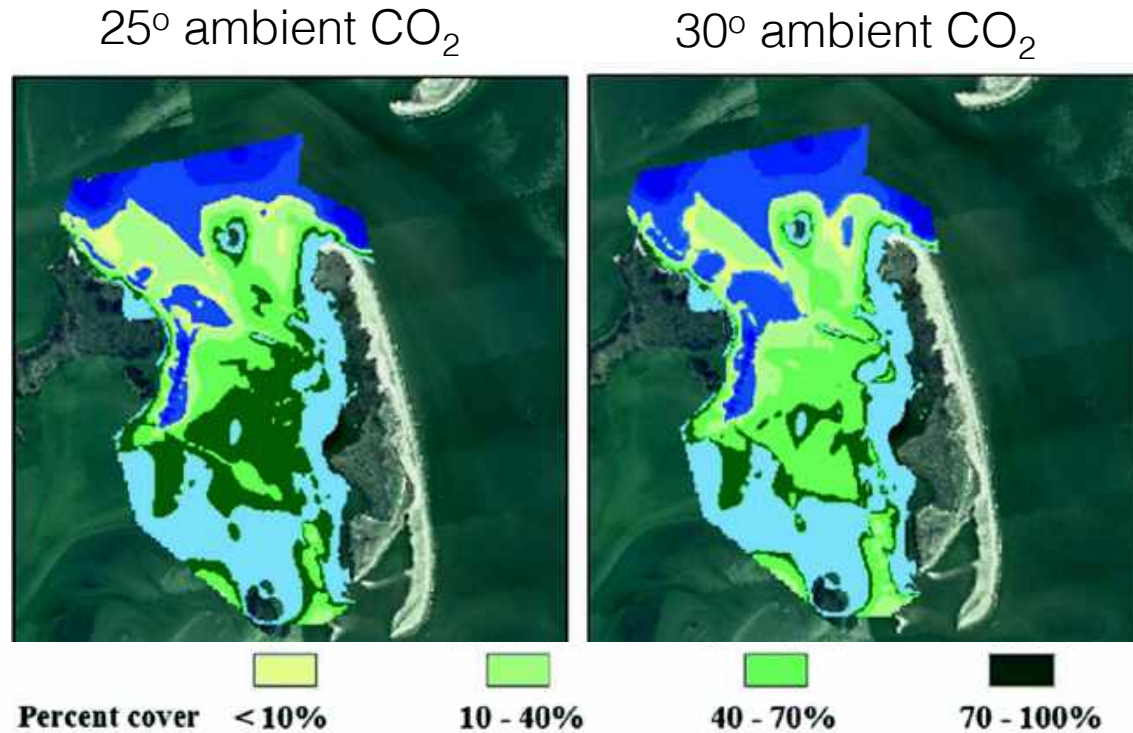


Higher CO<sub>2</sub> → greater eelgrass biomass



[Zimmerman et al. 2017 MEPS](#)

# Increased CO<sub>2</sub> can even offset SAV loss due to temperature stress

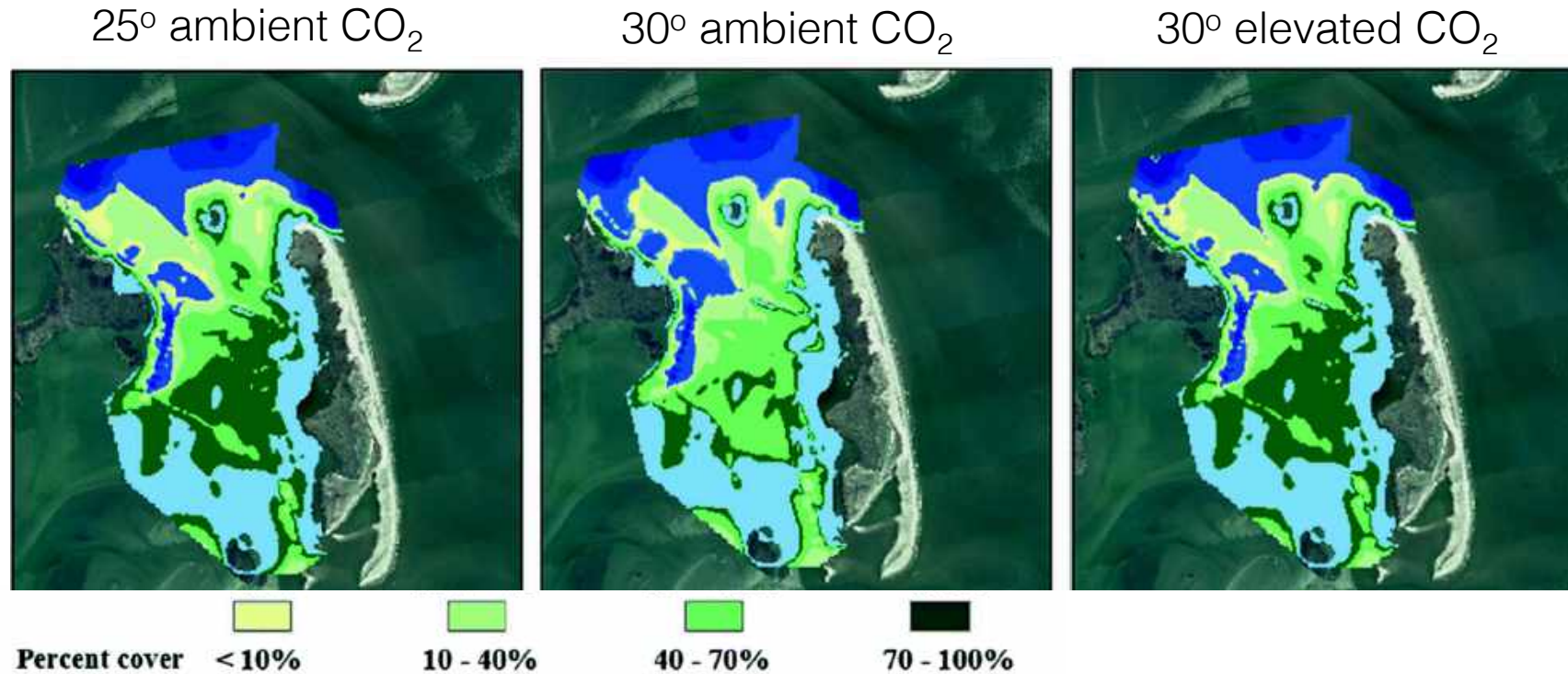


Modeling study with *Zostera marina* in Chesapeake Bay:

- **Eelgrass abundance decreased when temperature increased**

[Zimmerman et al. 2015 L&O](#)

# Increased CO<sub>2</sub> can even offset SAV loss due to temperature stress

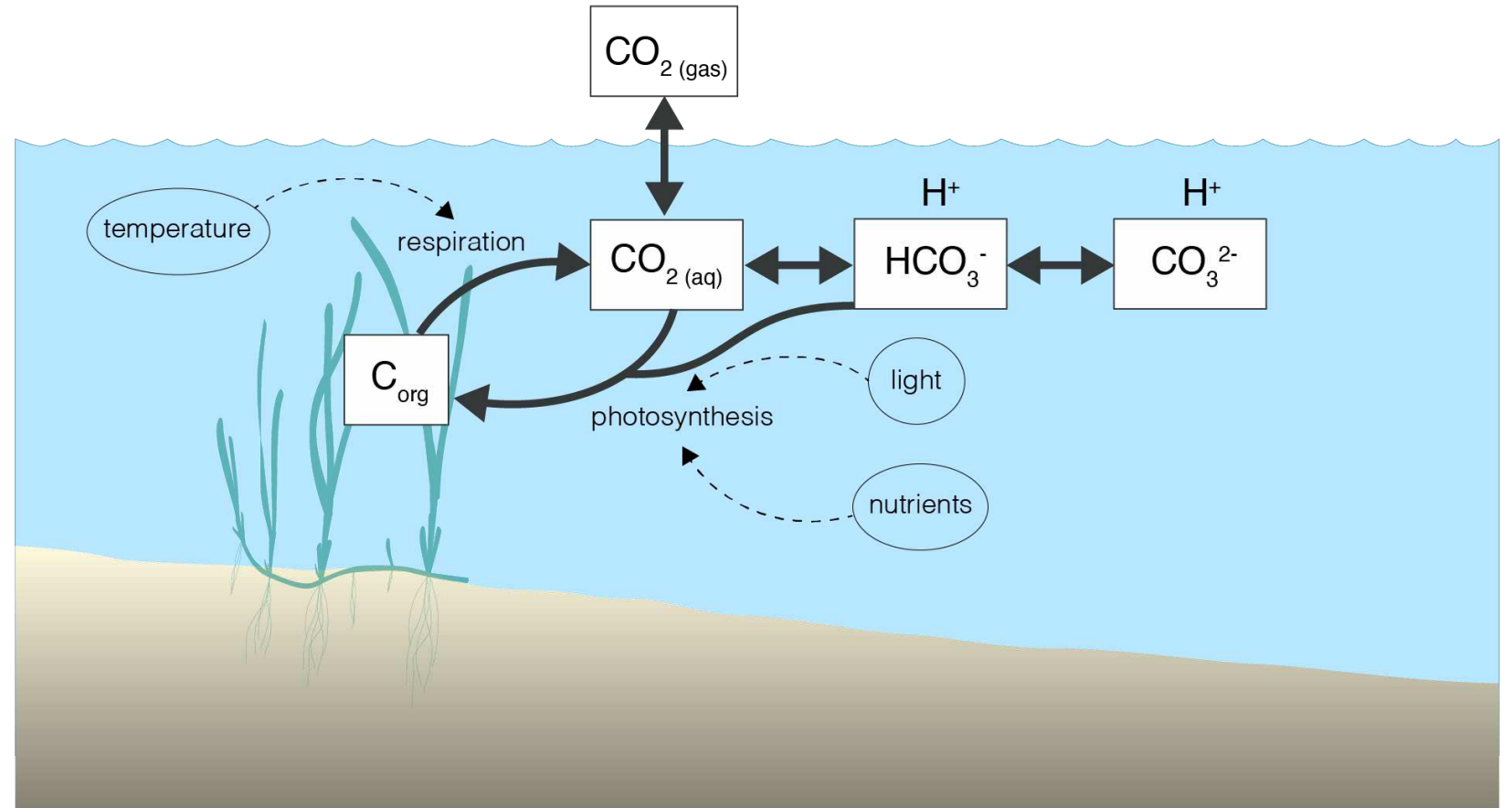


- but stayed the same when CO<sub>2</sub> also increased

[Zimmerman et al. 2015 L&O](#)

# CO<sub>2</sub> may not have a positive effect if the plant is not CO<sub>2</sub>-limited

- many SAV species can use bicarbonate as a carbon source
- something else could be limiting their growth.



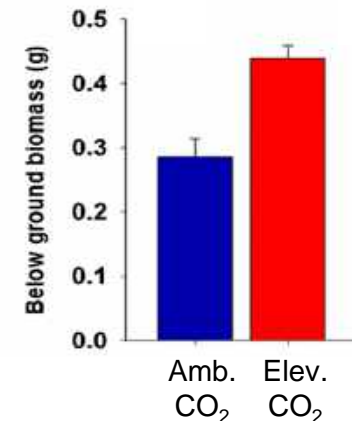
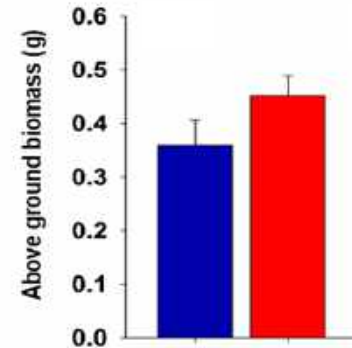
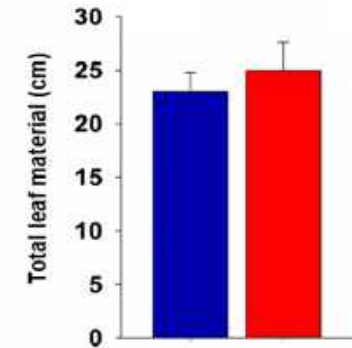
# CO<sub>2</sub> doesn't always have a positive effect...

Mesocosm experiment with *Halodule* and *Ruppia* from Gulf of Mexico:

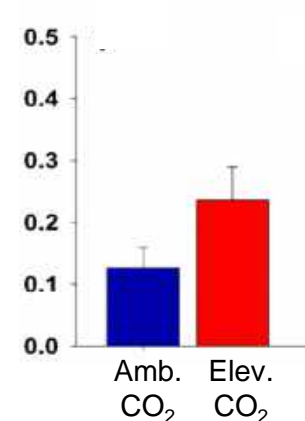
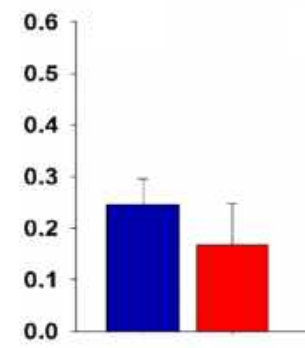
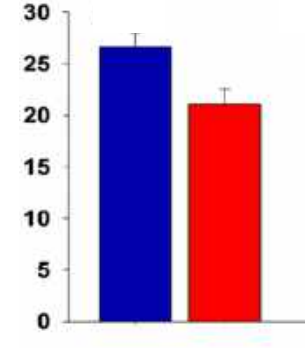
- no “statistically significant” CO<sub>2</sub> effect on SAV biomass because production was not C-limited

[Guerrero-Meseguer et al. 2020 Estuaries & Coasts](#)

*Halodule wrightii*



*Ruppia maritima*



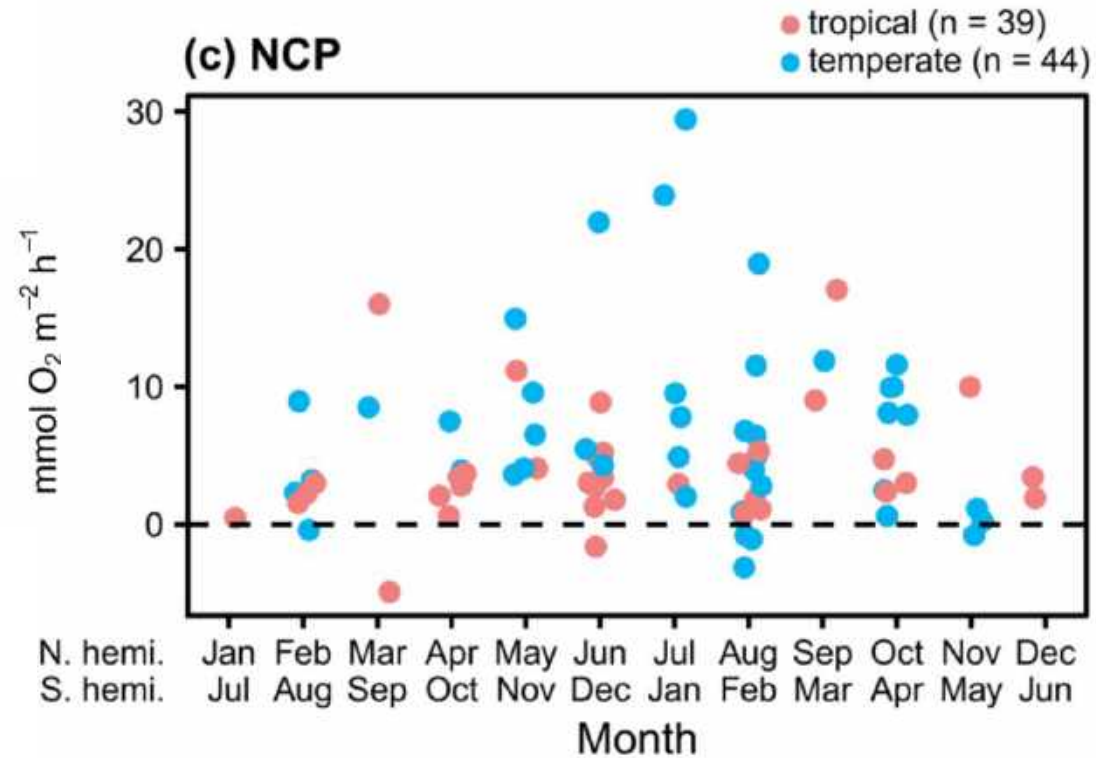
How do increasing CO<sub>2</sub> and temperature affect SAV?

How does SAV affect carbonate chemistry?

Can SAV mitigate the negative effects of acidification?

Locally  
System-scale

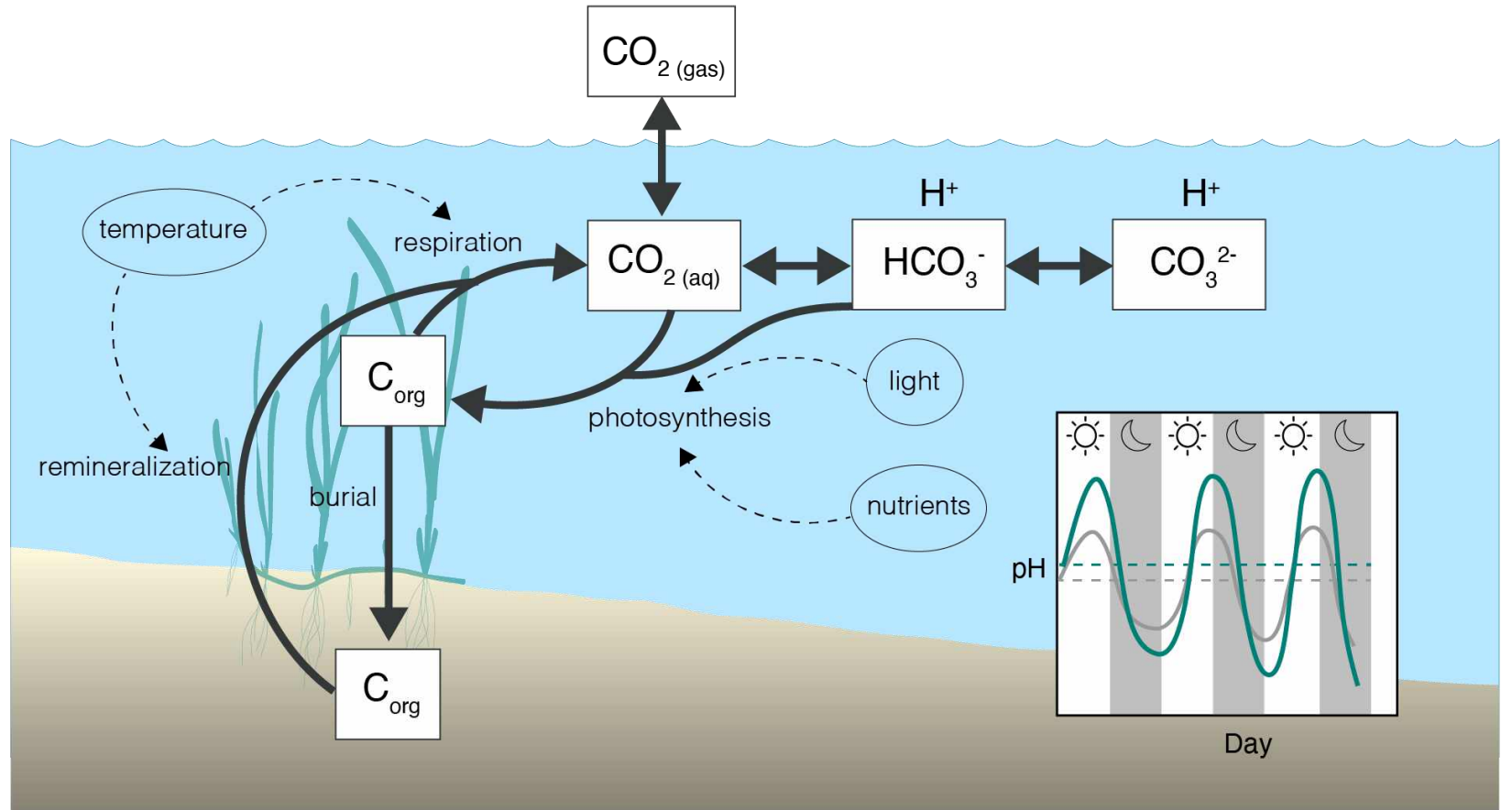
# SAV systems are very productive



Ward et al. 2022

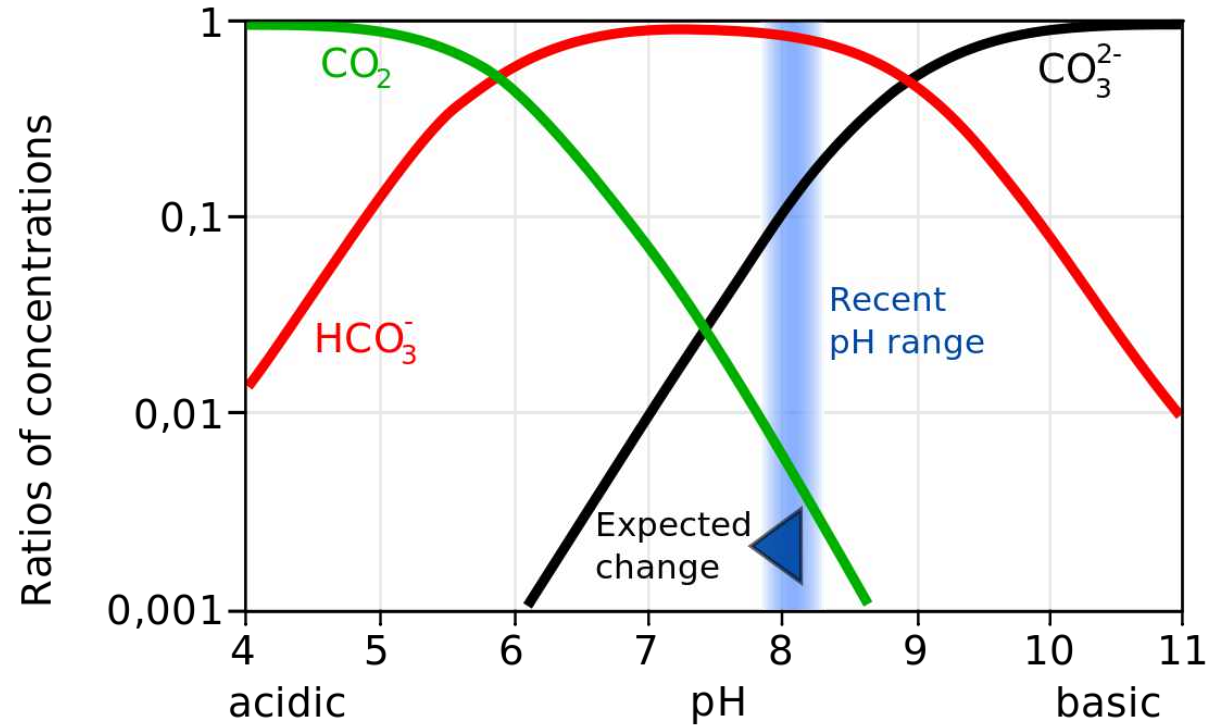
How does SAV affect carbonate chemistry?

**SAV draws down  $\text{CO}_2$  and  $\text{HCO}_3^-$ , which increases pH and  $\text{CaCO}_3^{2-}$  saturation**



How do increasing  $\text{CO}_2$  and temperature affect SAV?

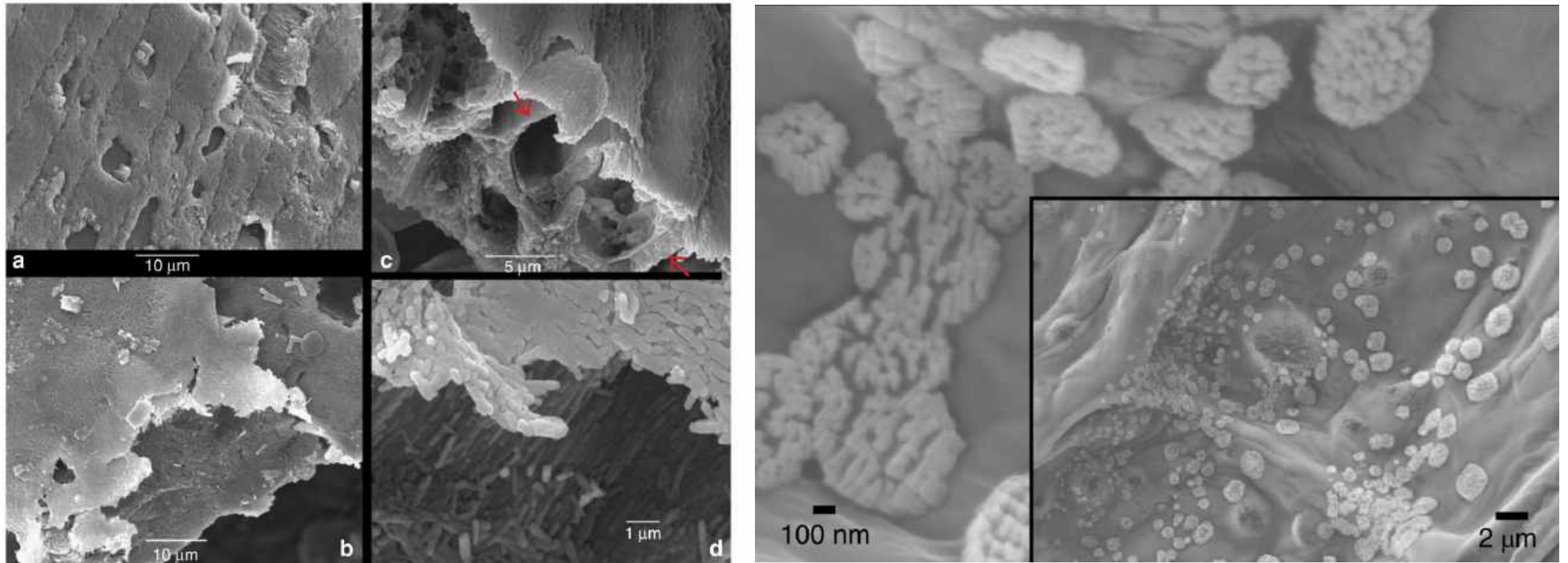
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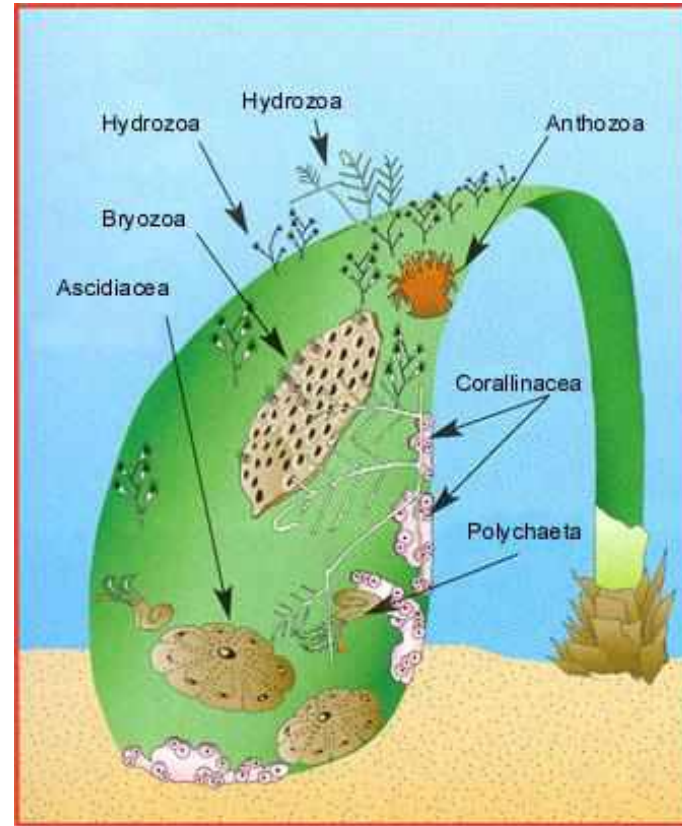
# Sometimes, $\text{CaCO}_3$ can even precipitate on the surface of and within SAV leaves

Carbonate deposits on *Thalassia testudinum* (Bahamas) and *Vallisneria americana* (Chesapeake Bay)

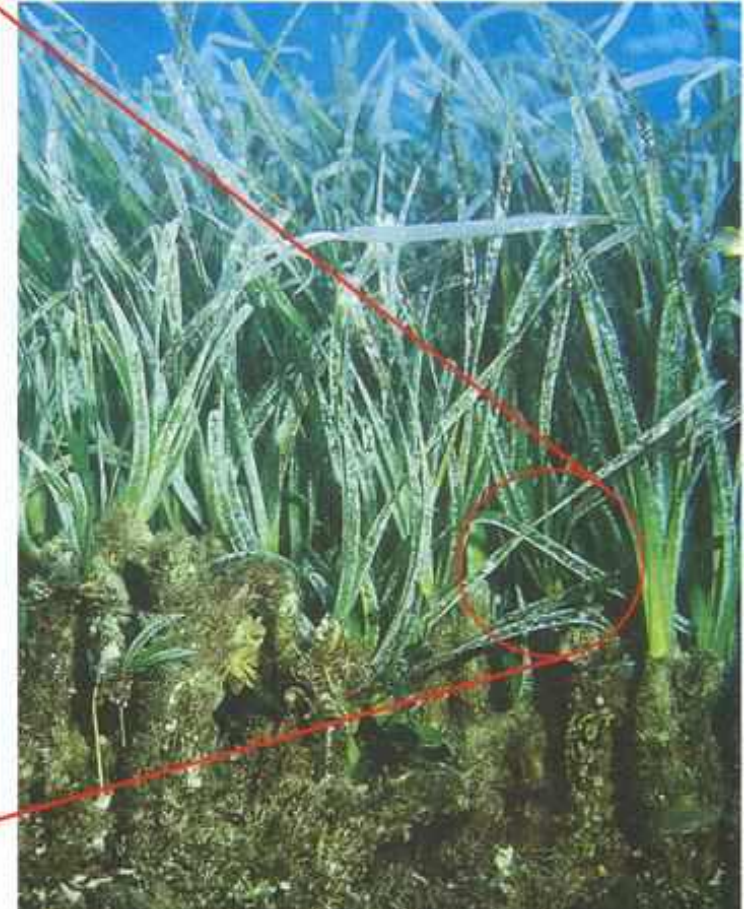


How does SAV affect carbonate chemistry?

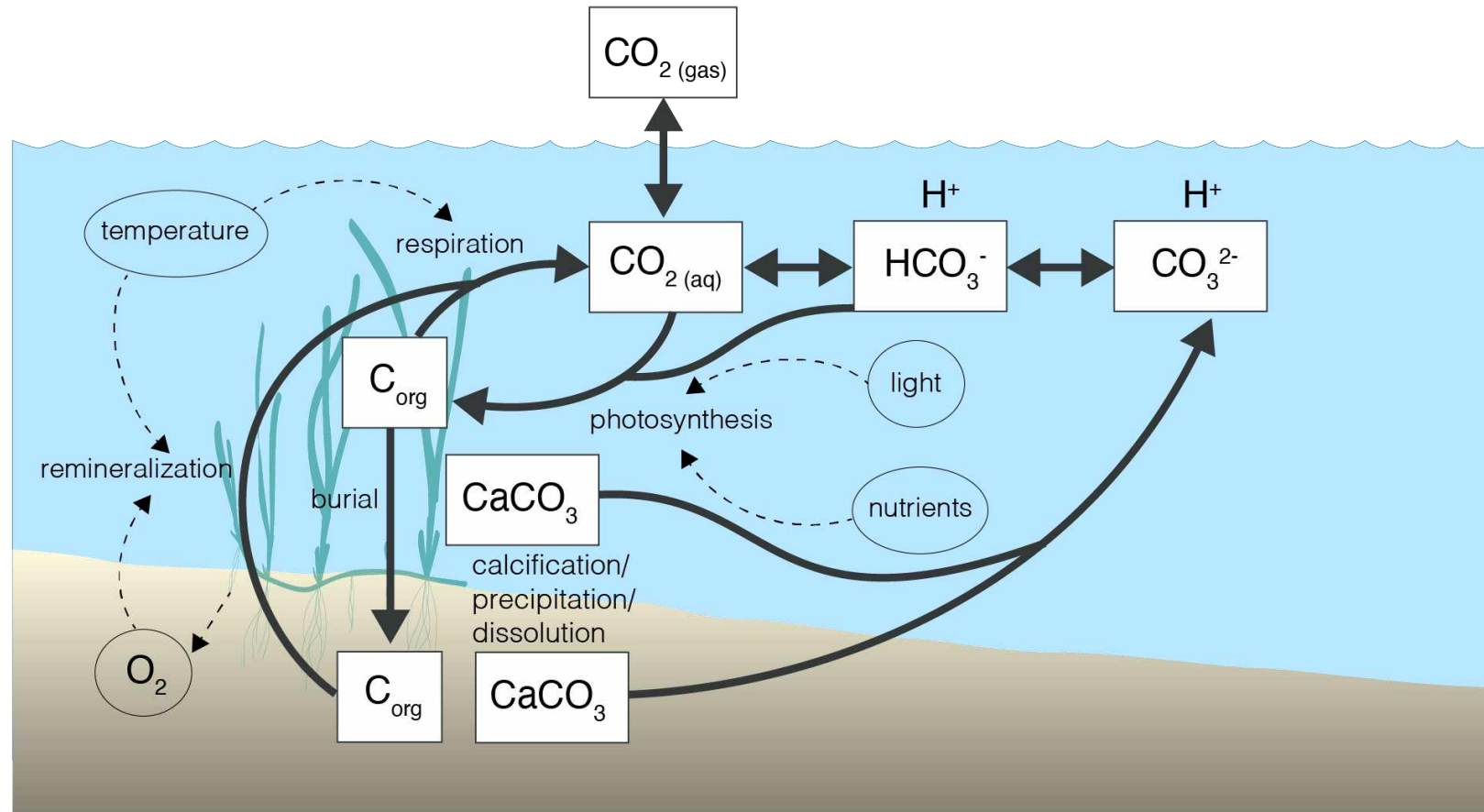
# SAV beds are also habitat for many calcifying organisms



Epiphytic growth on *Posidonia oceanica*  
adapted from Hofrichter, 2001



# SAV can also alter sediment biogeochemistry in ways that affect pH and CO<sub>2</sub>



How does SAV affect carbonate chemistry?

Ongoing study: SAV effects on DIC and alkalinity fluxes in Chesapeake Bay



Can SAV mitigate the negative effects of acidification?

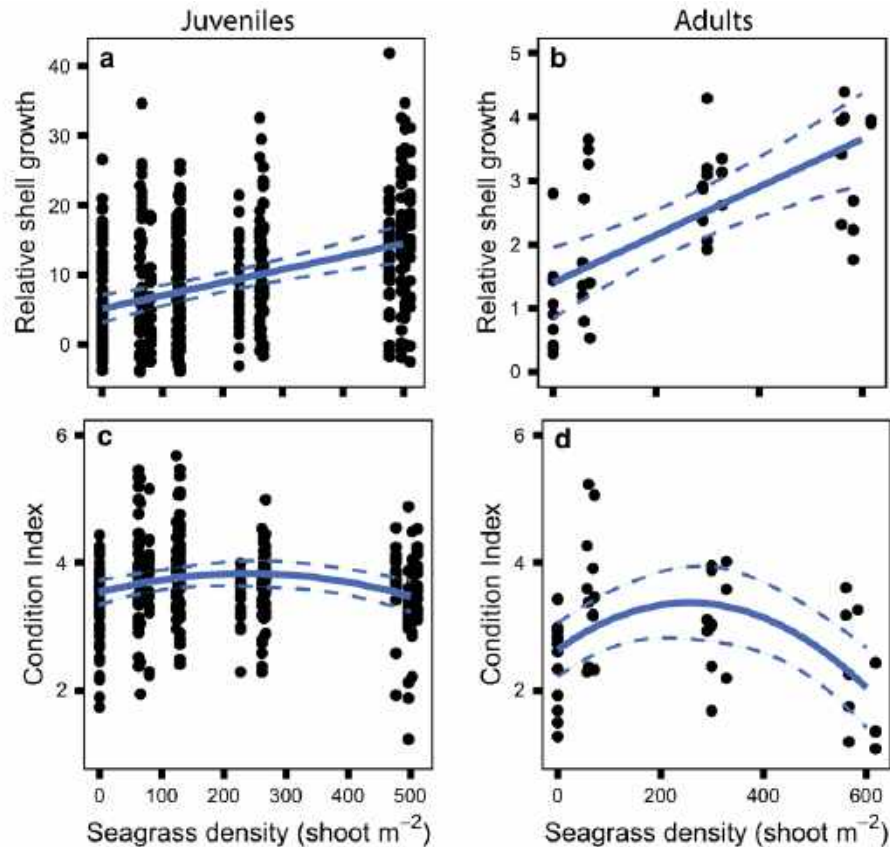
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System-scale

# Locally increased pH and $\text{CaCO}_3^{2-}$ saturation can enhance bivalve growth

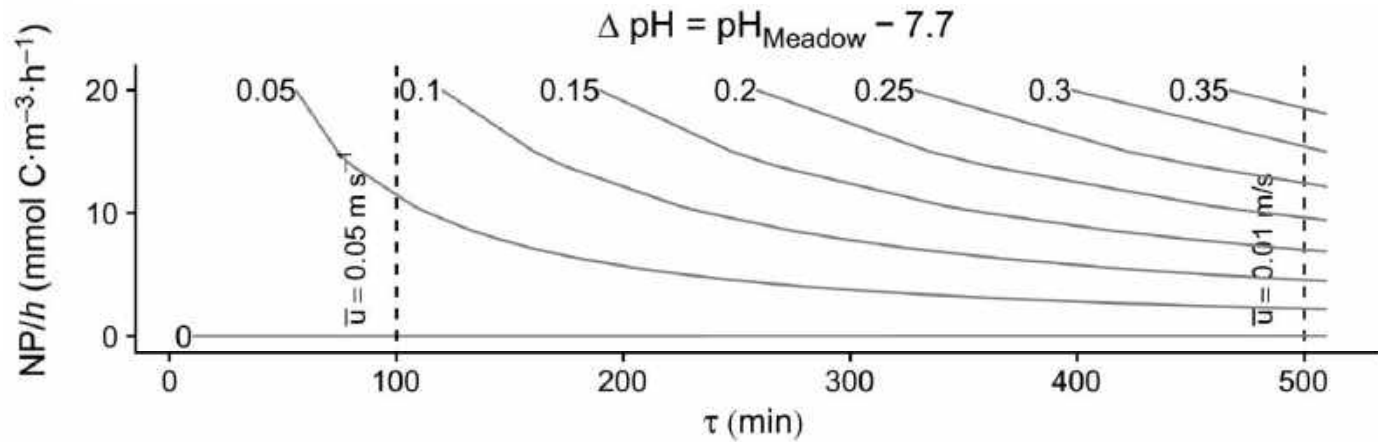


Mesocosm experiment with *Zostera marina* and *Crassostrea gigas*:

**Seagrass increased pH and oyster shell growth.**

[Ricart et al. 2021 \*Oecologia\*](#)

# SAV effect on carbonate chemistry depends on hydrodynamics and SAV production rates



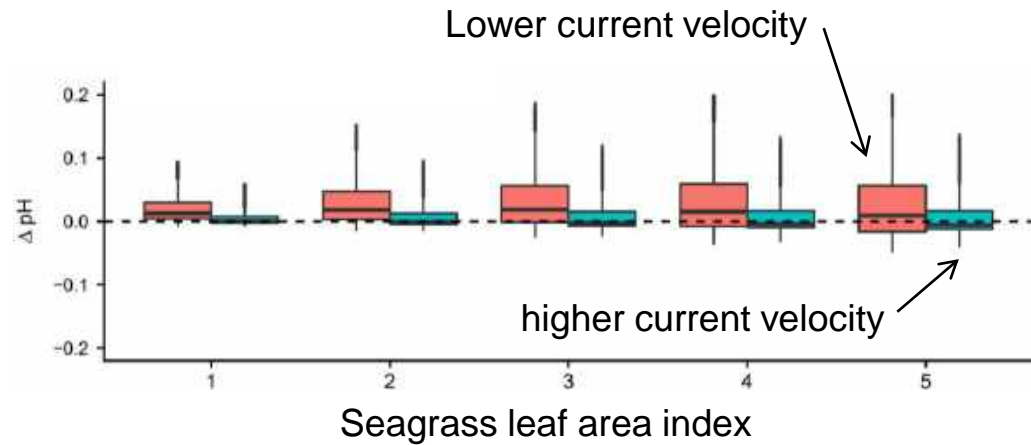
Modeling study parameterized for *Zostera marina* in Tomales Bay, CA:

Greatest effects on pH associated with longer **water residence time** within seagrass meadow and **greater plant production rates**

[Koweeck et al. 2018 Ecological Applications](#)

Can SAV mitigate the negative effects of acidification?

# Sometimes the effect is not strong enough to mitigate acidification

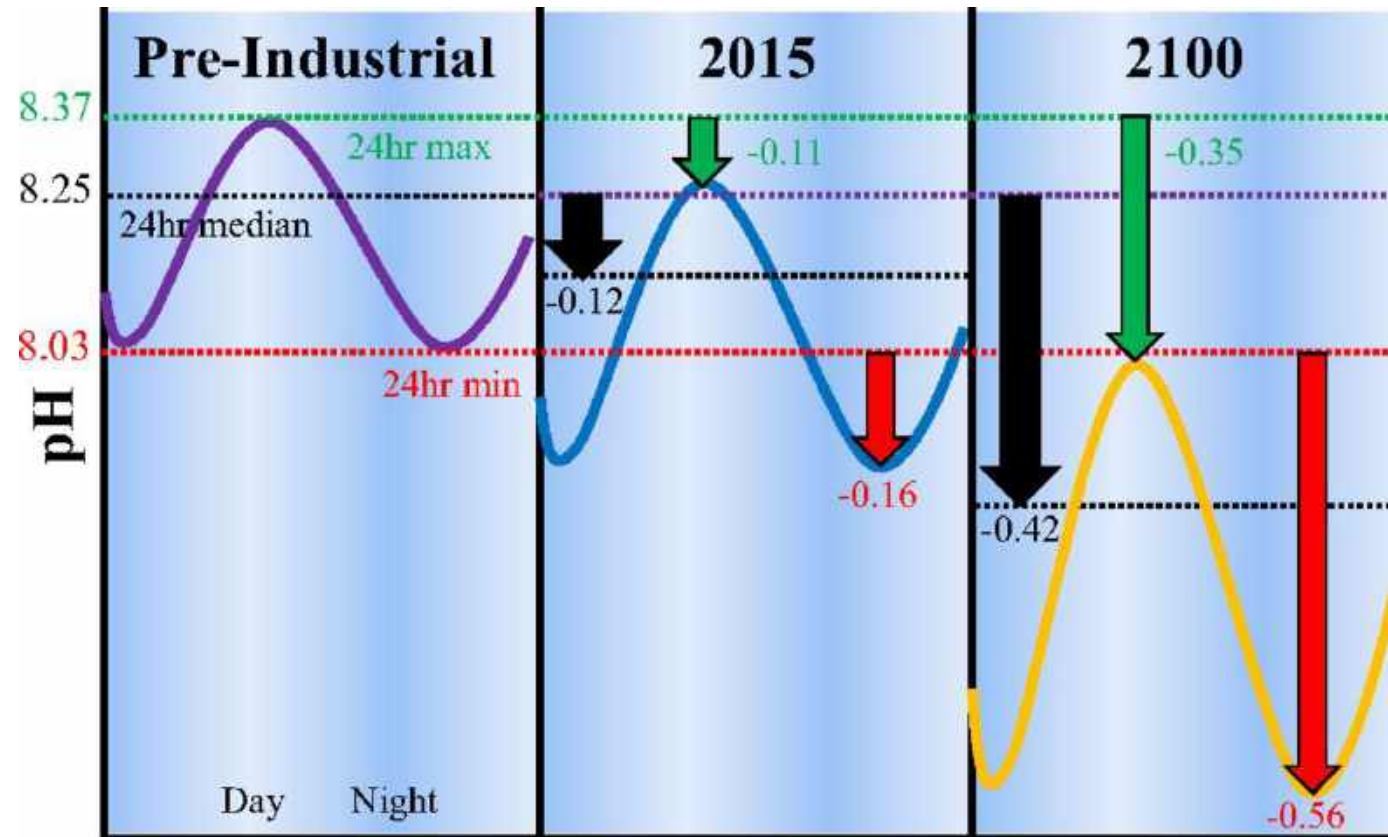


Modeling study parameterized for *Zostera marina* in Tomales Bay, CA:

**Small effect on pH due to low water residence time in seagrass meadow**

[Koweeck et al. 2018 Ecological Applications](#)

# SAV effects on pH are becoming more extreme due to decreased buffering capacity

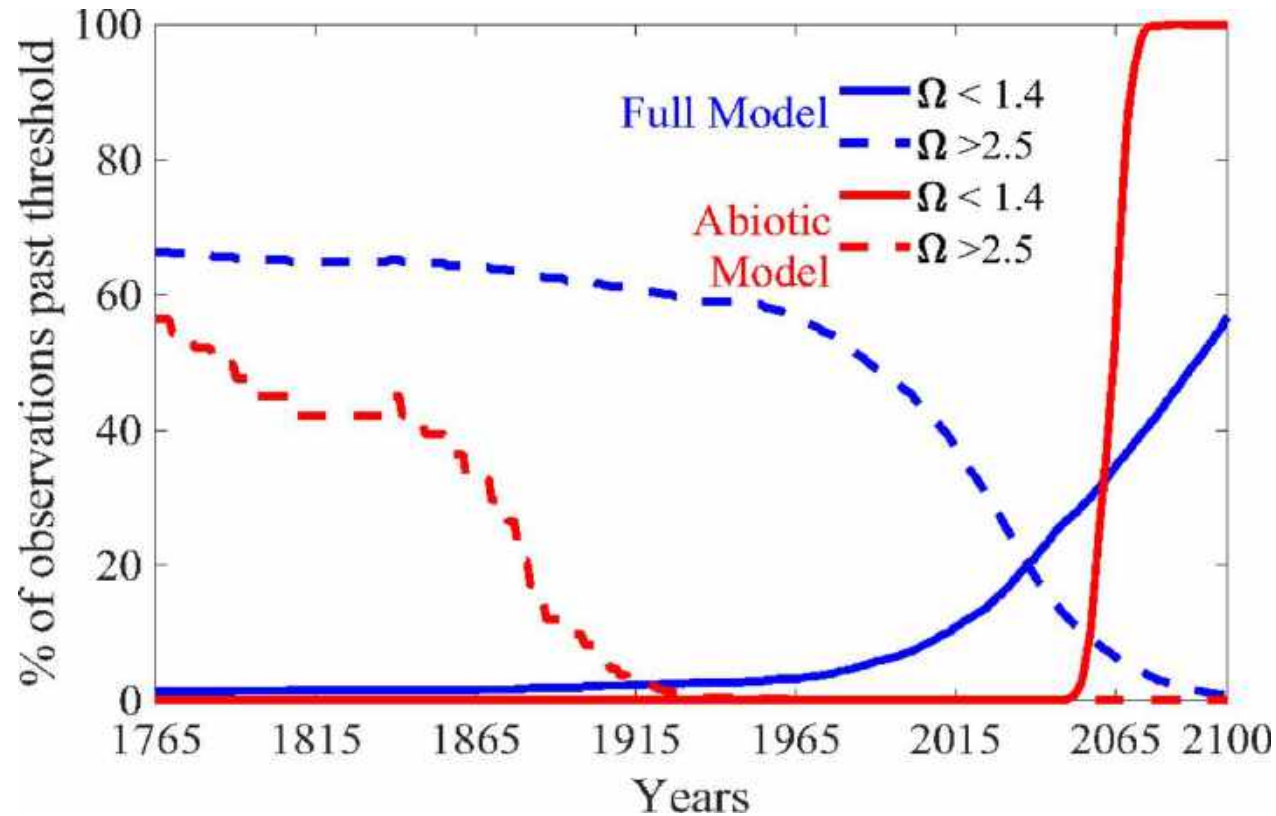


Increasing CO<sub>2</sub> leads to overall decrease in pH and increase in pH range

[Pacella et al. 2018 PNAS](#)

Can SAV mitigate the negative effects of acidification?

# SAV effects on pH are becoming more extreme due to decreased buffering capacity



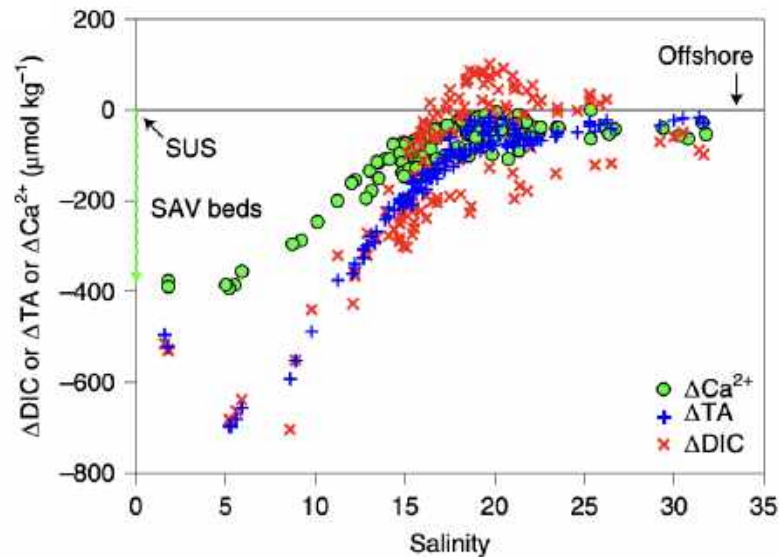
Modeling study with *Zostera marina* in Puget Sound:

- **More exposure to both favorable and harmful  $\Omega_{\text{aragonite}}$  values for larval bivalves in seagrass**
- **More variable “carbonate weather”**

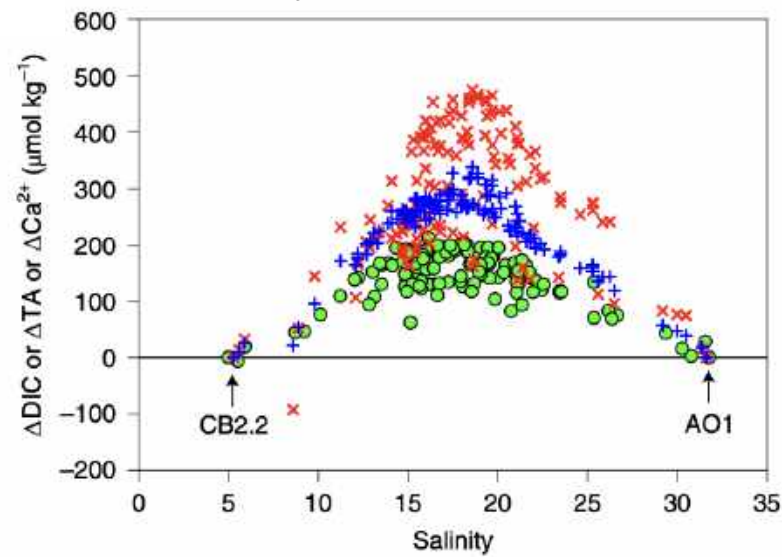
[Pacella et al. 2018 PNAS](#)

# Evidence for cross-scale effect on hypoxia-induced acidification

DIC, TA, and  $\text{Ca}^{2+}$  removal in upper bay



DIC, TA, and  $\text{Ca}^{2+}$  addition in mid bay

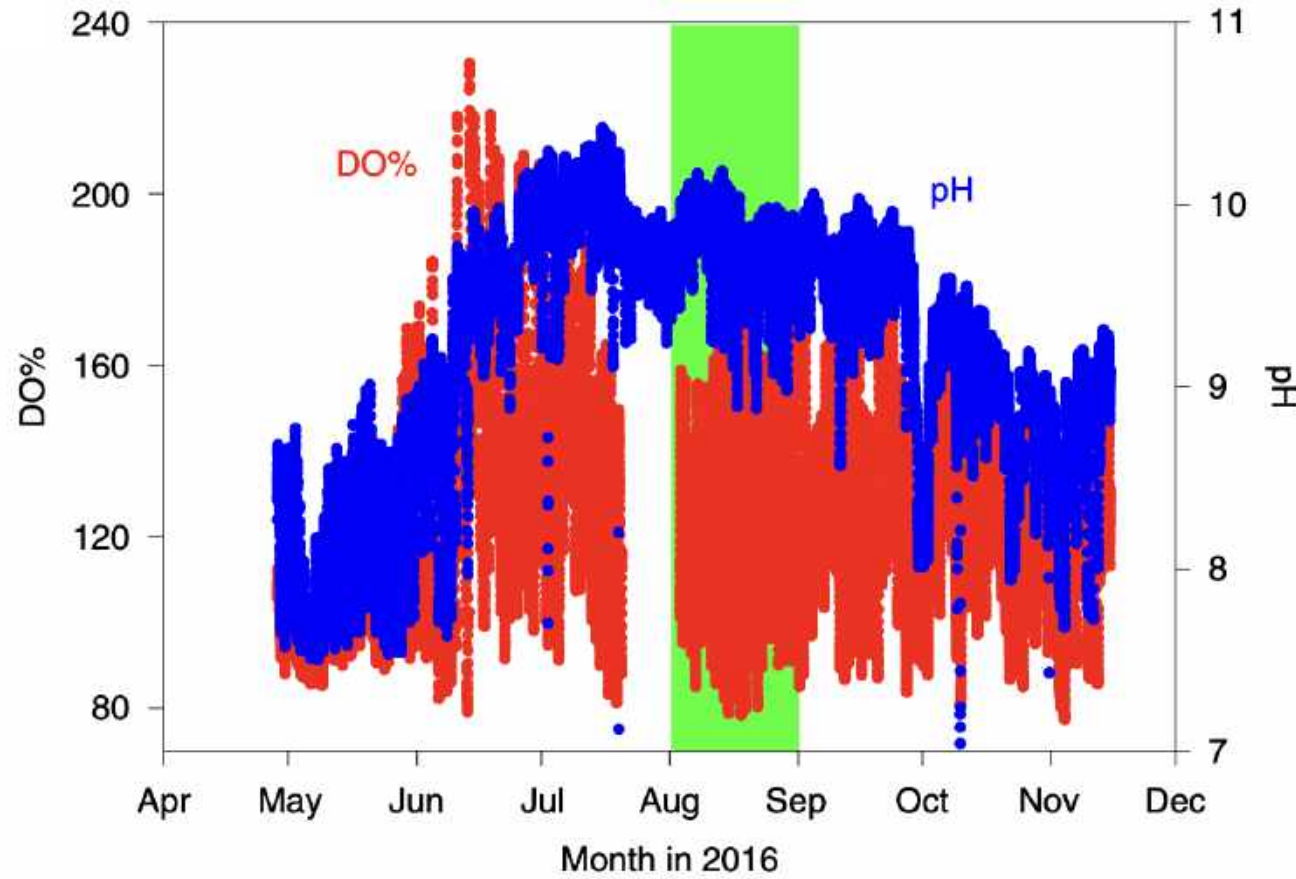


# Evidence for cross-scale effect on hypoxia-induced acidification



Can SAV mitigate the negative effects of acidification?

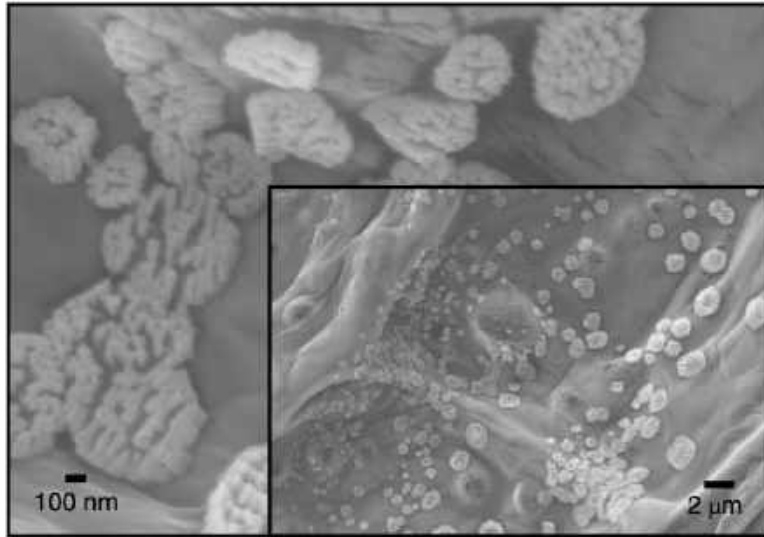
# Evidence for cross-scale effect on hypoxia-induced acidification



Very high pH during the summer!

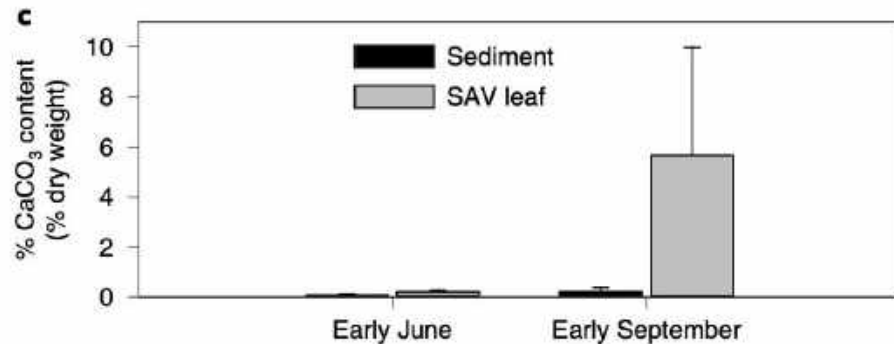
Huge SAV bed, long residence time

# Evidence for cross-scale effect on hypoxia-induced acidification



Field study in Chesapeake Bay:

- **SAV-driven pH increase caused CaCO<sub>3</sub> precipitation**
- **Advection and dissolution in mid-bay bottom water may have offset a portion of respiration-driven acidification**



How do increasing CO<sub>2</sub> and temperature affect SAV?

Sometimes SAV grows better, sometimes it doesn't

How does SAV affect carbonate chemistry?

SAV *can* increase pH and CaCO<sub>3</sub> saturation but it's complicated

Can SAV mitigate the negative effects of acidification?

Sometimes it mitigates acidification, sometimes it doesn't

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Can SAV mitigate the negative effects of acidification?

Sometimes it mitigates acidification, sometimes it doesn't

A close-up, low-angle shot of a dense field of tall, green grasses. The grasses are vibrant green and appear to be blowing in the wind, creating a sense of movement. The lighting is bright, highlighting the texture of the blades. In the center of the image, the words "Thank you!" are written in a large, white, sans-serif font.

**Thank you!**