# THE POTENTIAL OF SOUTH FLORIDA SEAGRASS MEADOWS AS 'NATURAL CLIMATE SOLUTIONS'


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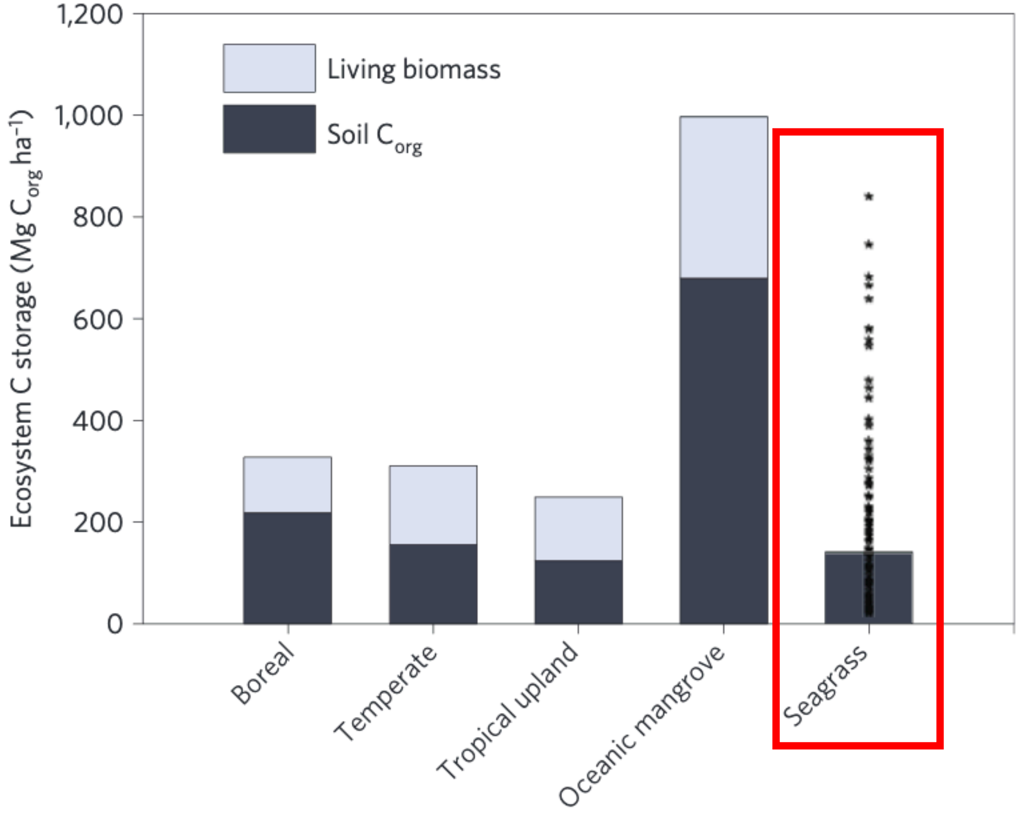
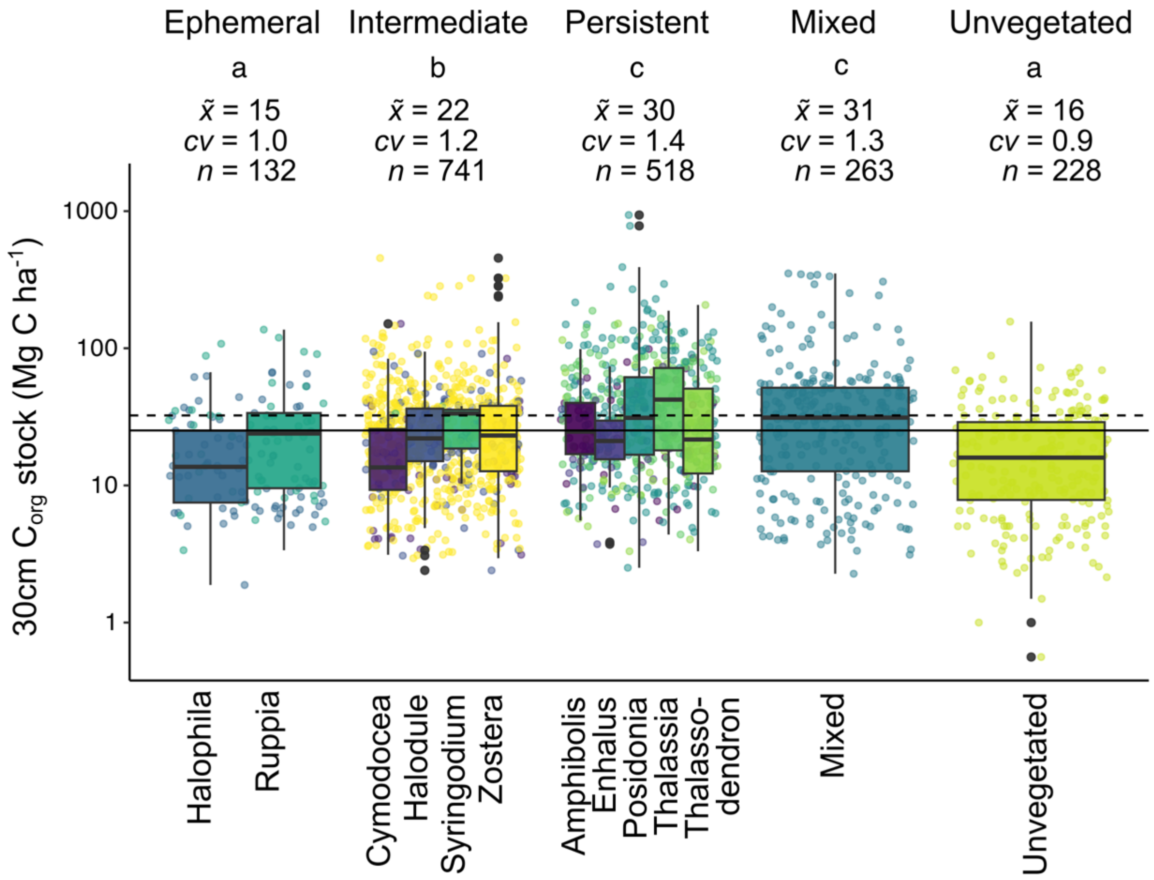
# Seagrass meadows as carbon sinks

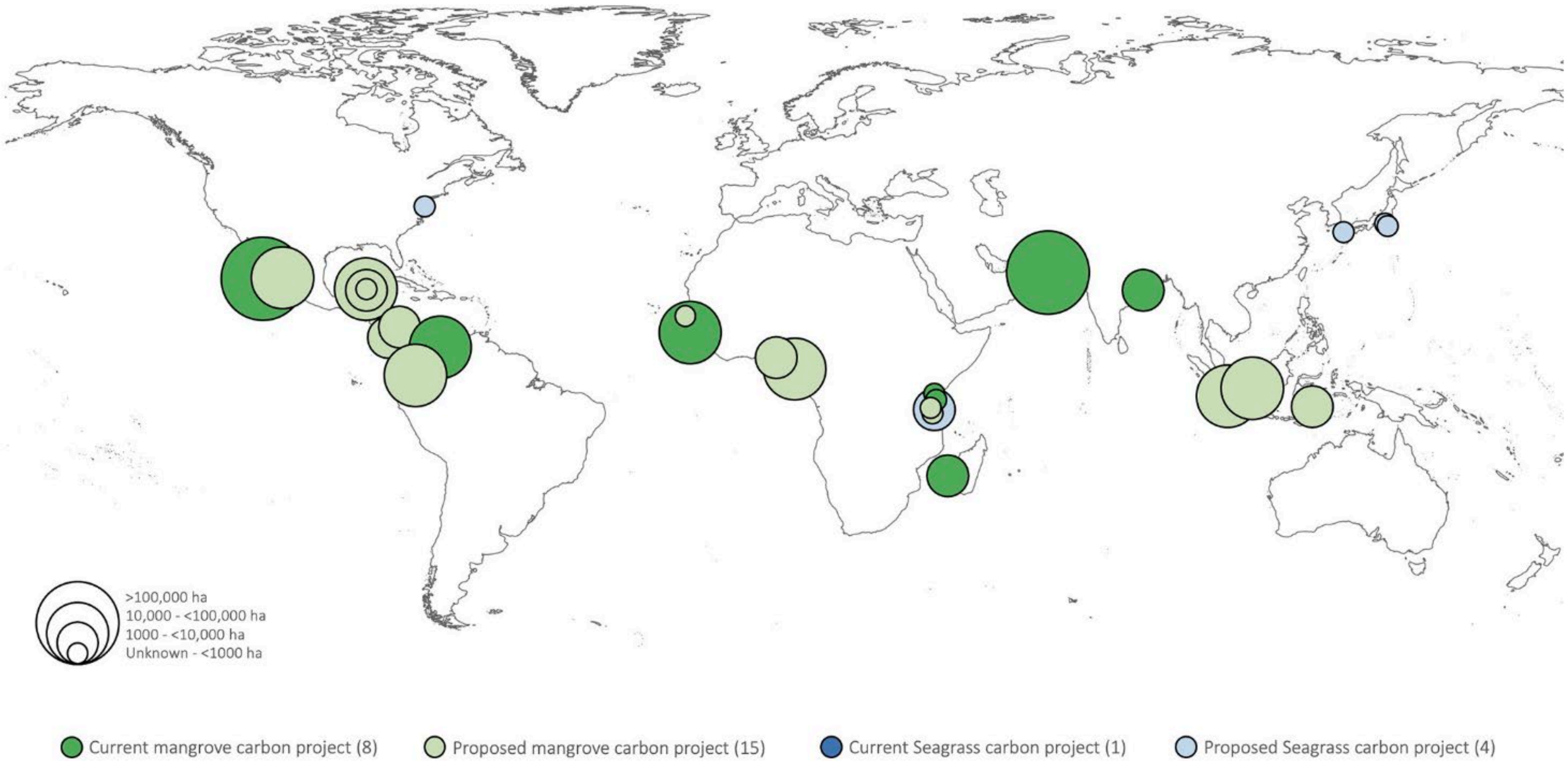



Fourqurean et al. 2012
*Nat Geosci*




Krause et al. 2025
*Nat Comms*

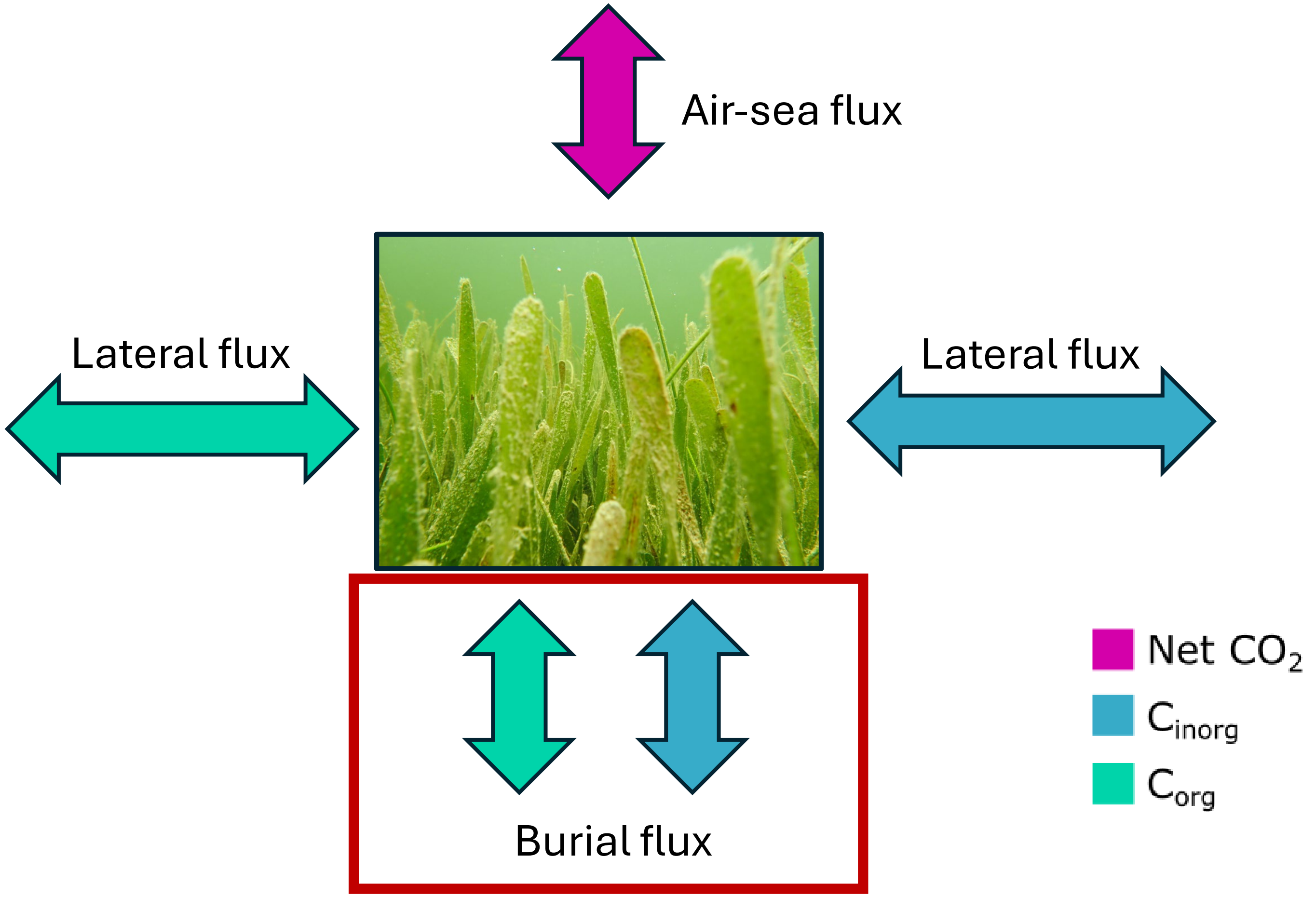
# Habitat restoration and protection for blue carbon




Friess et al. 2022
*PLOS Climate*

# The role of carbonates in blue carbon

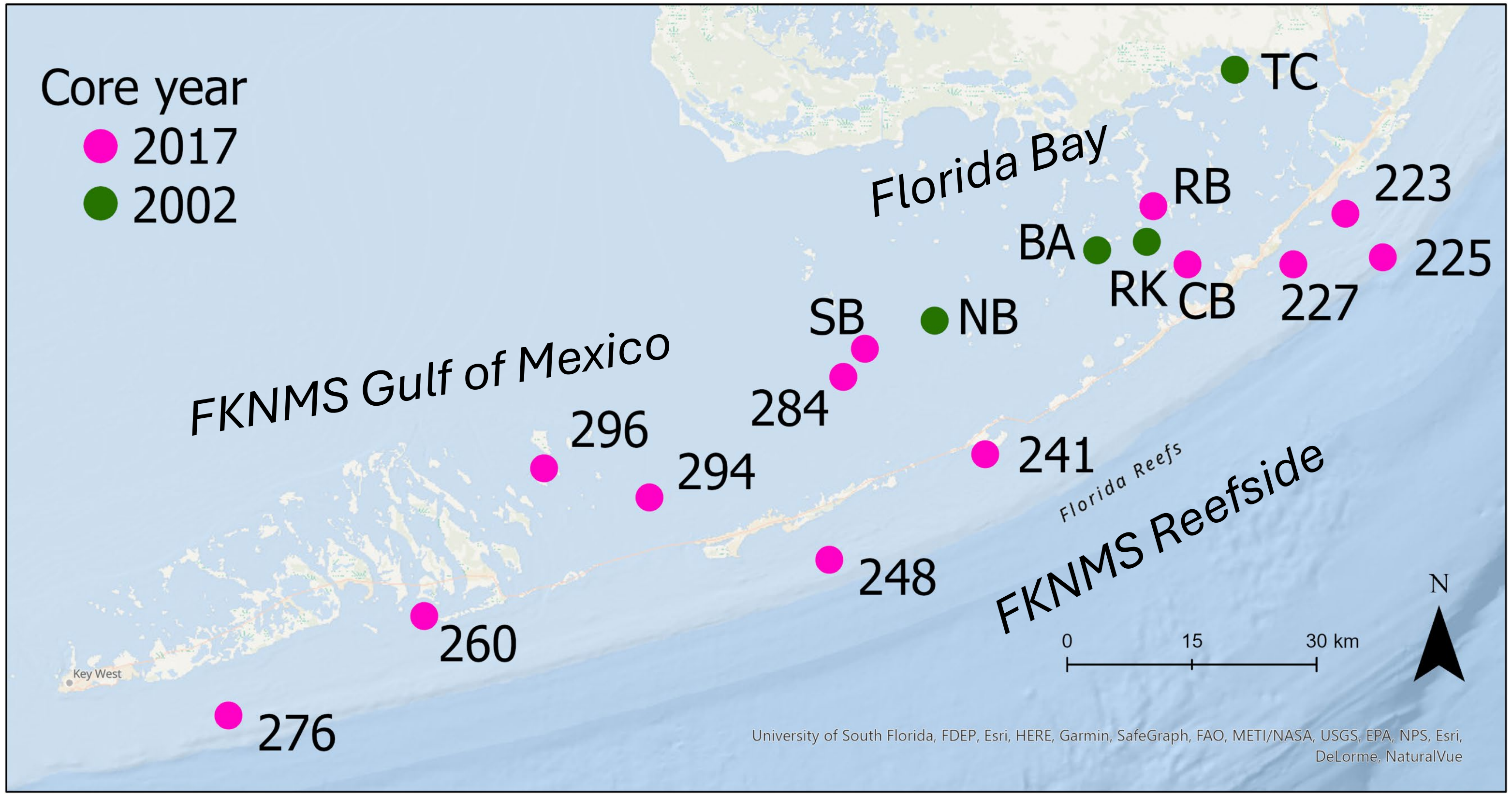
- Carbon balance in seagrass meadows depends on fluxes of $C_{inorg}$ and $C_{org}$ (Howard et al. 2018)
- Carbonate formation releases ~0.6 mol $CO_2$ per mol of $CaCO_3$
- Carbonate dissolution captures ~0.6 mol $CO_2$ per mol of $CaCO_3$
- Provenance of $C_{inorg}$ and $C_{org}$ determine net carbon balance of seagrass meadow
- Globally, seagrasses likely sites of $CaCO_3$ dissolution and import, enhancing C sink function (Saderne et. al 2019; Fakhraee et al. 2023)




Howard et al. 2018 *L&O*

# Study sites

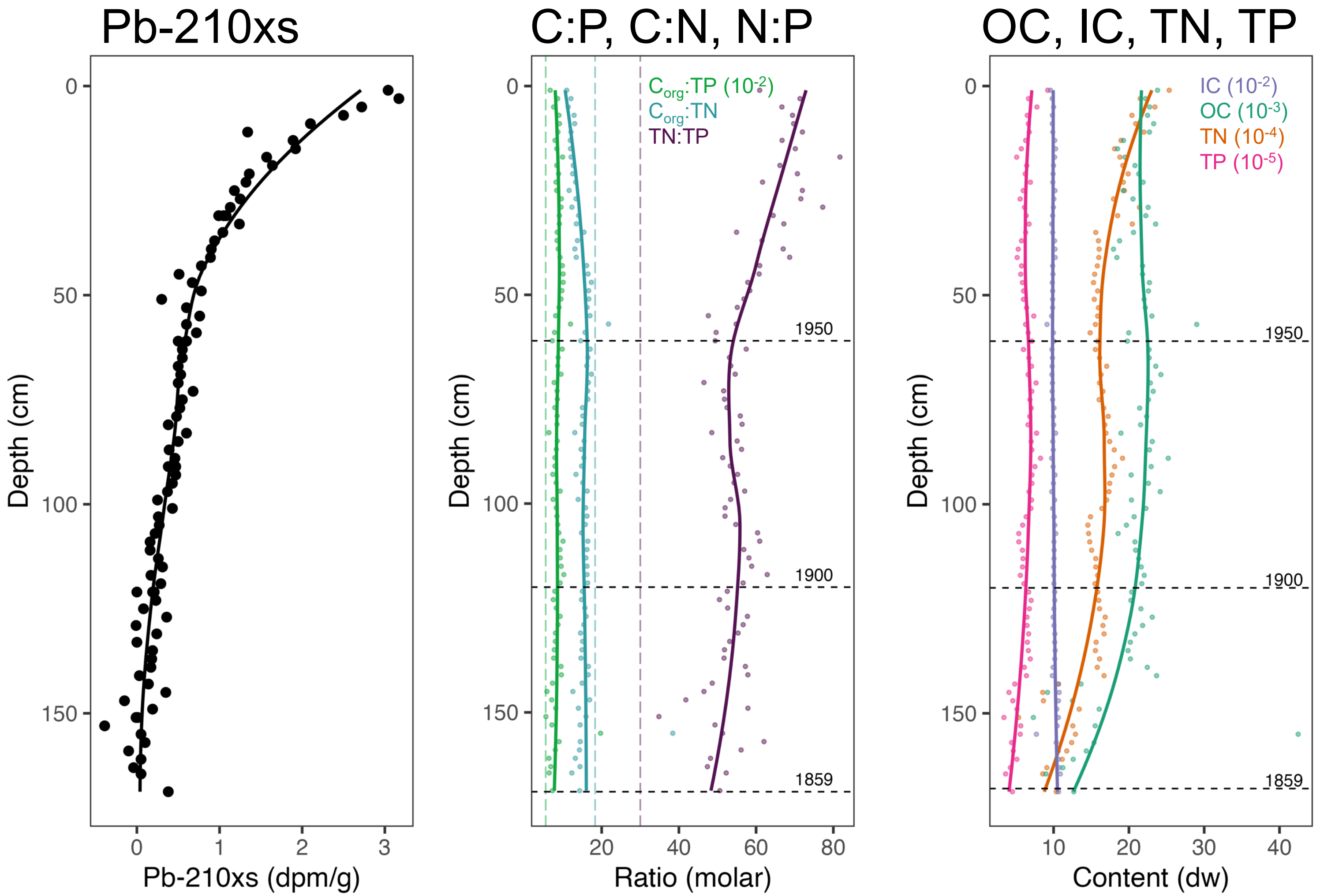
- South Florida seascape a microcosm representative of seagrass habitats across Caribbean region
- Florida Bay sites (TC, RB, CB, RK, BA, NB, SB) on shallow mudbanks, high salinity
- FKNMS Reefside (223-276) on coarse carbonate sand in backreef
- FKNMS GoM (284-296) nutrient-rich, productive Syringodium + calcareous green algae



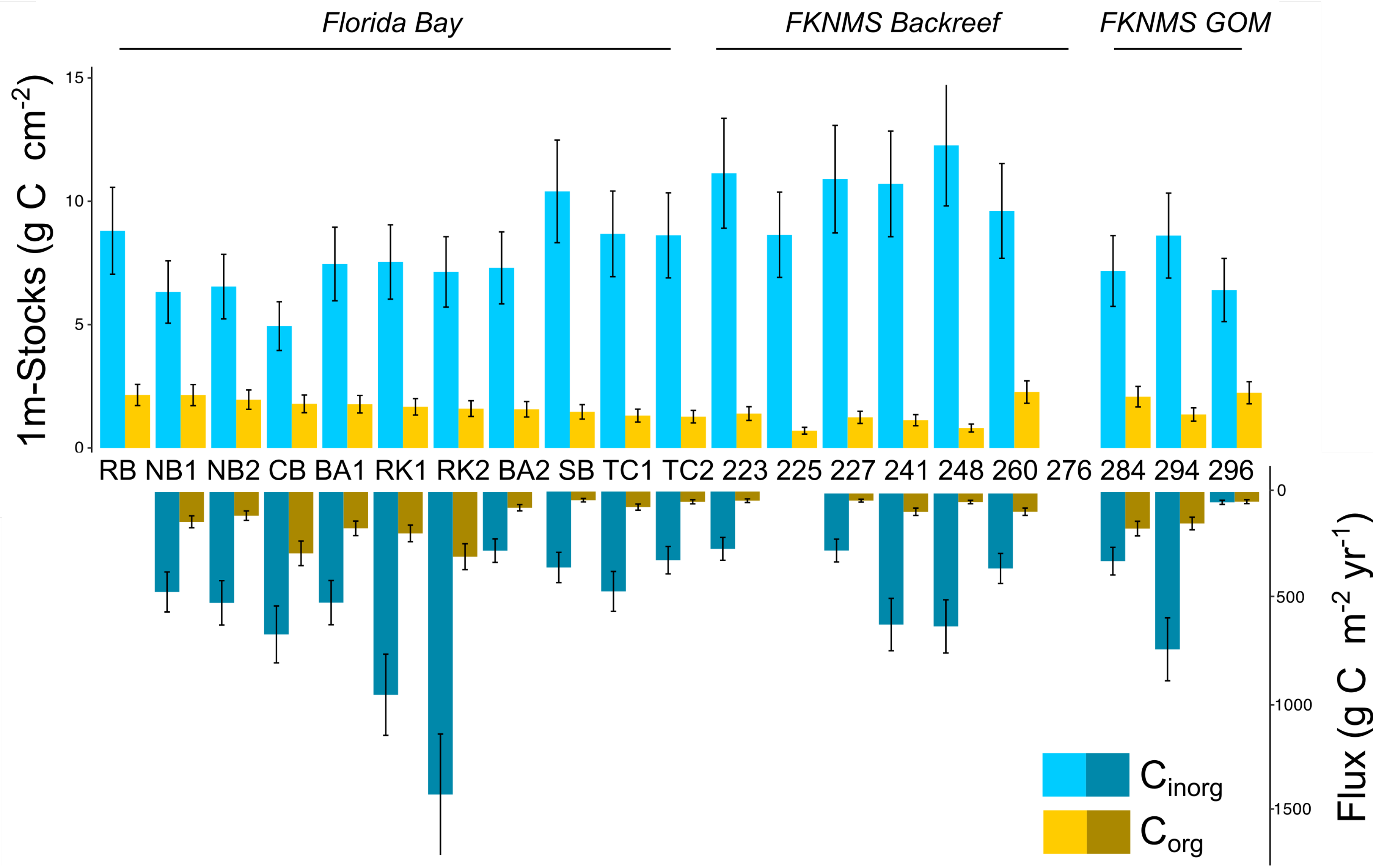
# Methodological approach

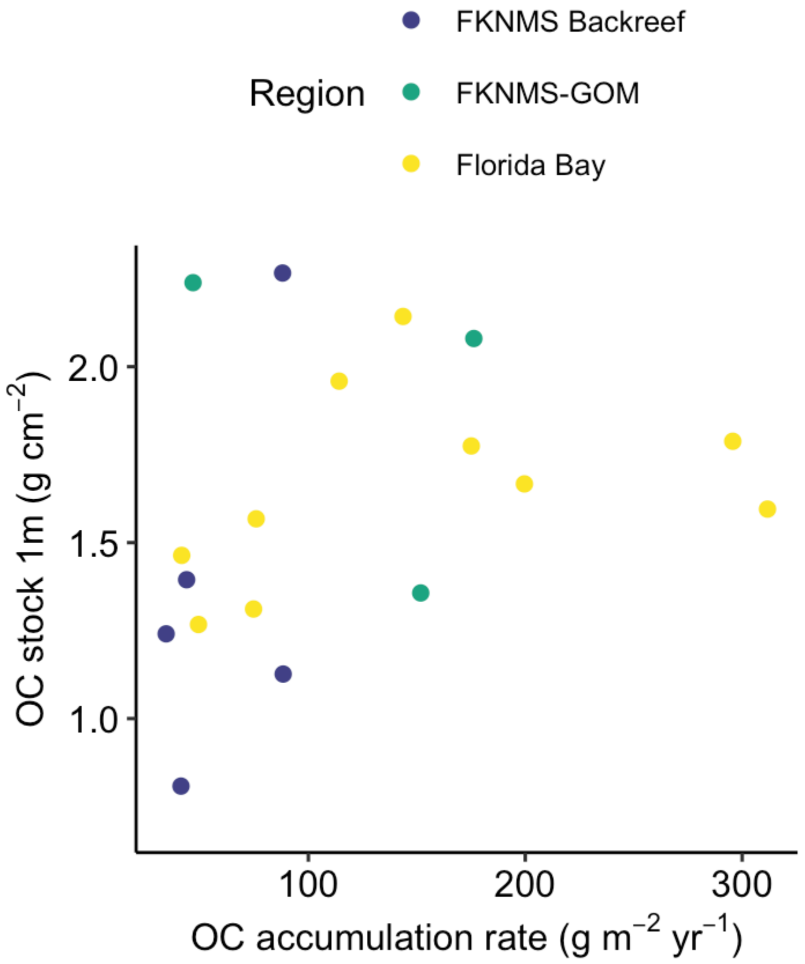
Example: Russel Key core profiles

- Downcore distribution of $\%C_{org}$, $\%C_{inorg}$, %N, %P, DBD, $\delta^{13}C$
- $^{210}$Pb-dating using CF:CS models
- Burial fluxes estimated using full inventory
- For this talk, stocks are normalized to 1m, although at some sites bedrock was reached < 1m



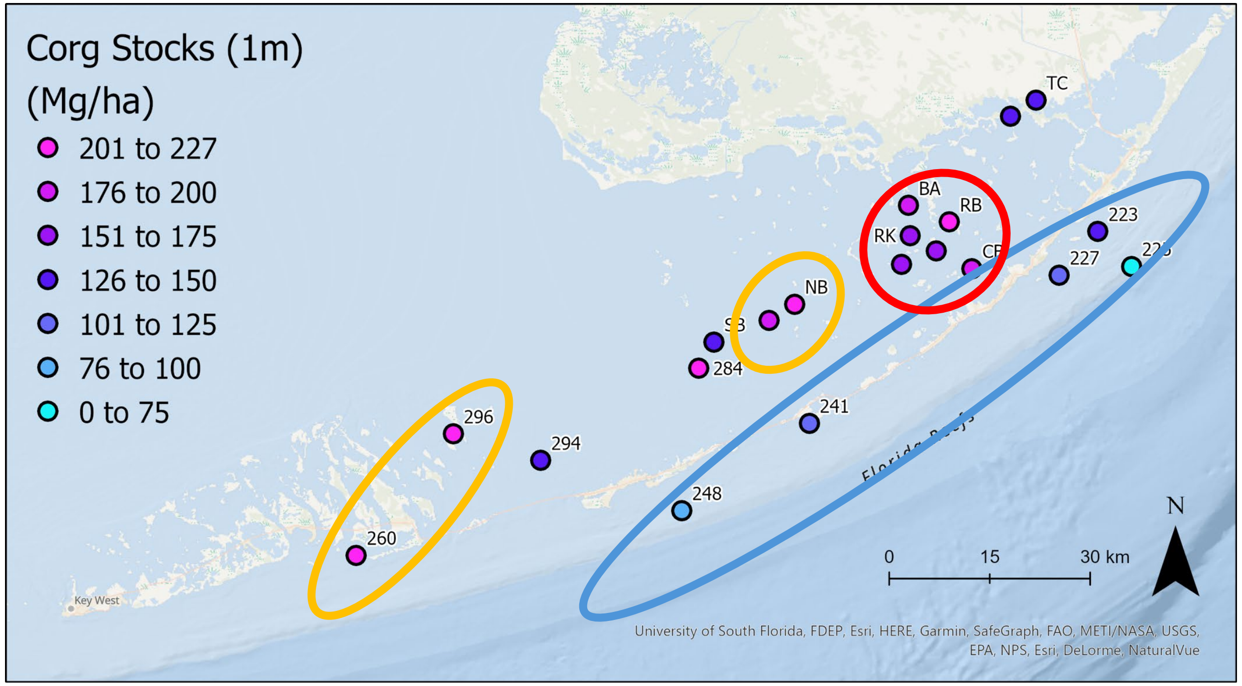
# We found large variability in carbon stocks and burial fluxes

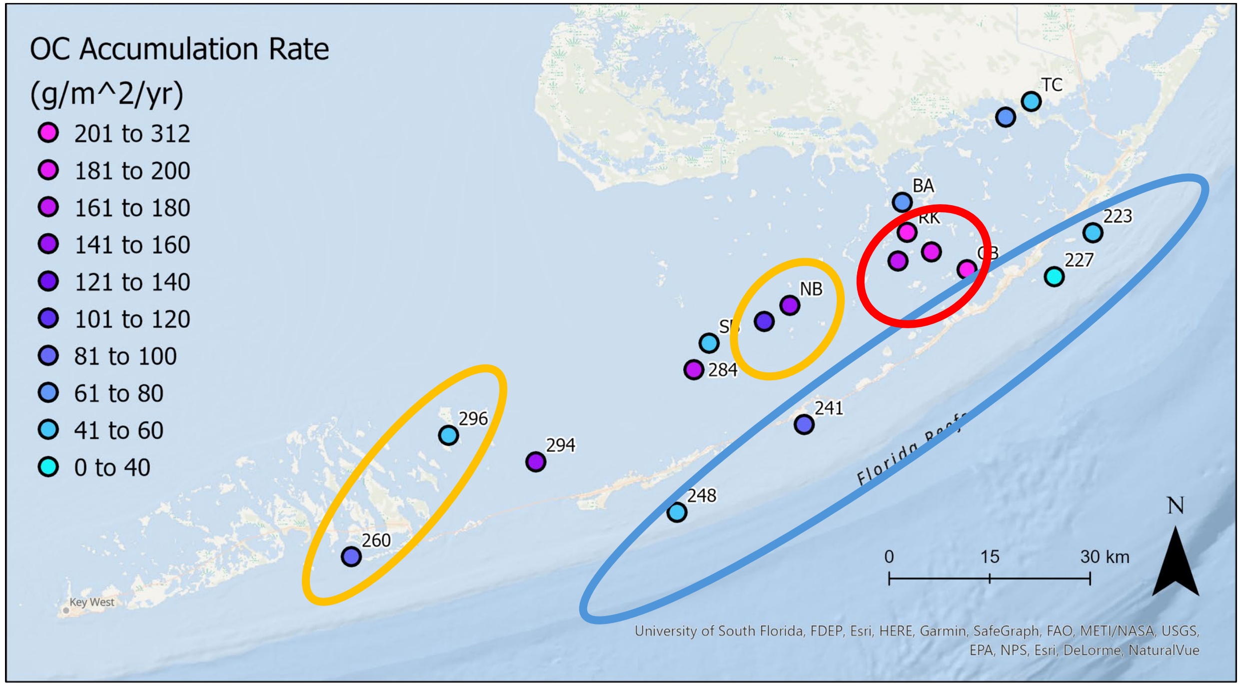


# High stocks = high fluxes?

- Backreef seagrass meadows have low $C_{org}$ stocks and low $C_{org}$ burial rates
- Central Florida Bay sites have high $C_{org}$ stocks and high $C_{org}$ burial rates
- But several sites have high $C_{org}$ stocks but low $C_{org}$ burial rates
- Overall, hotspots for $C_{org}$ stocks can be decoupled from hotspots from $C_{org}$ burial

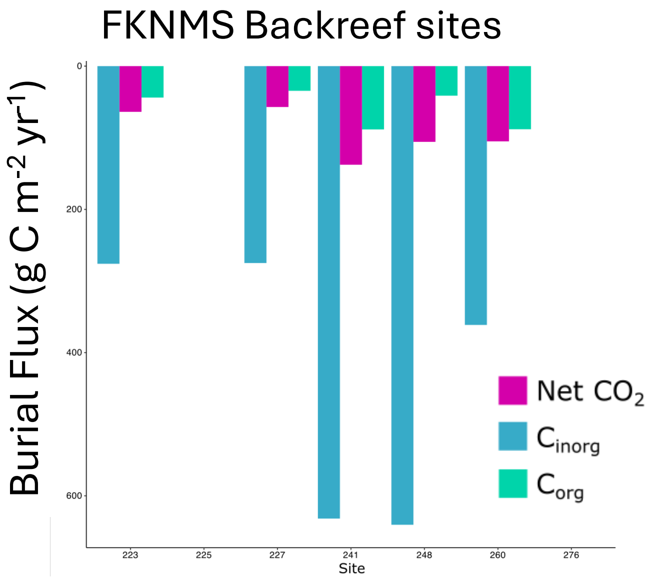


# Inorganic carbon flux likely enhances blue carbon in FKNMS

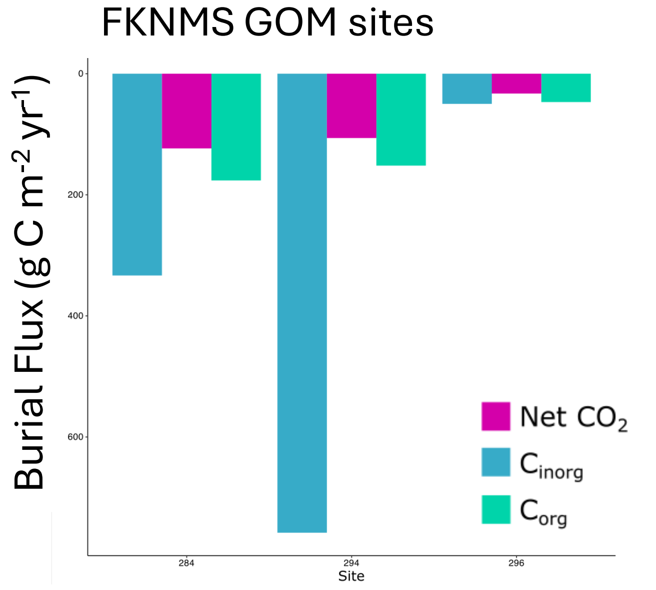
## FKNMS Backreef

- $C_{org}$ ~ 70% autochthonous (Fourqurean et al. 2023)
- $C_{inorg}$ largely allochthonous production
- Likely net $CaCO_3$ dissolution in seagrass root zone (Fakhraee et al. 2023, Mazarrasa et al. 2015)
- Net fluxes ~ -50 – -150 g C m$^2$ yr$^{-1}$




## FKNMS GoM/Backcountry

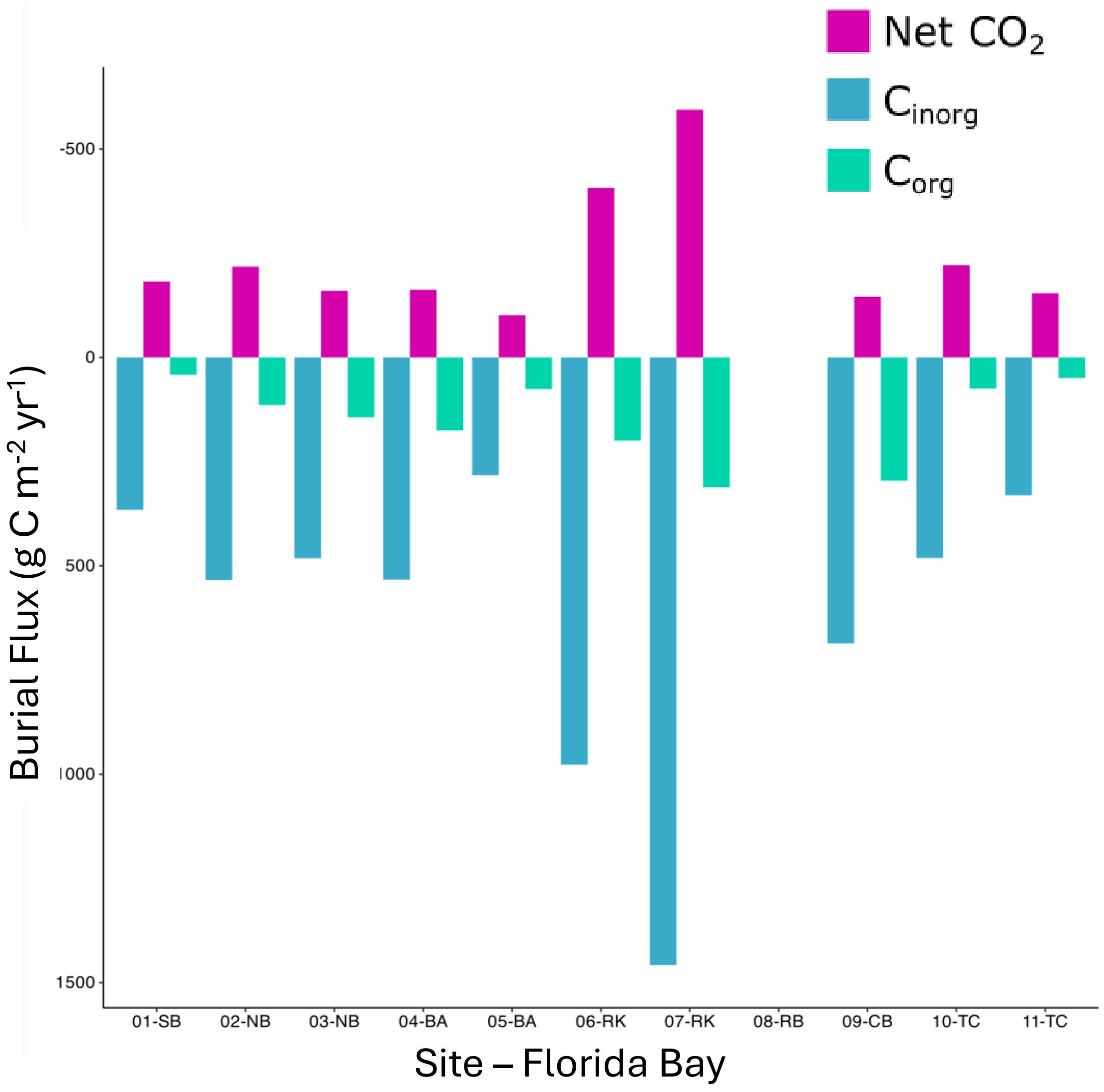
- $C_{org}$ ~ 70% autochthonous (Fourqurean et al. 2023)
- $C_{inorg}$ partly allochthonous, but local production from calcareous green algae and other organisms
- Net fluxes ~ -30 – -150 g C m$^2$ yr$^{-1}$



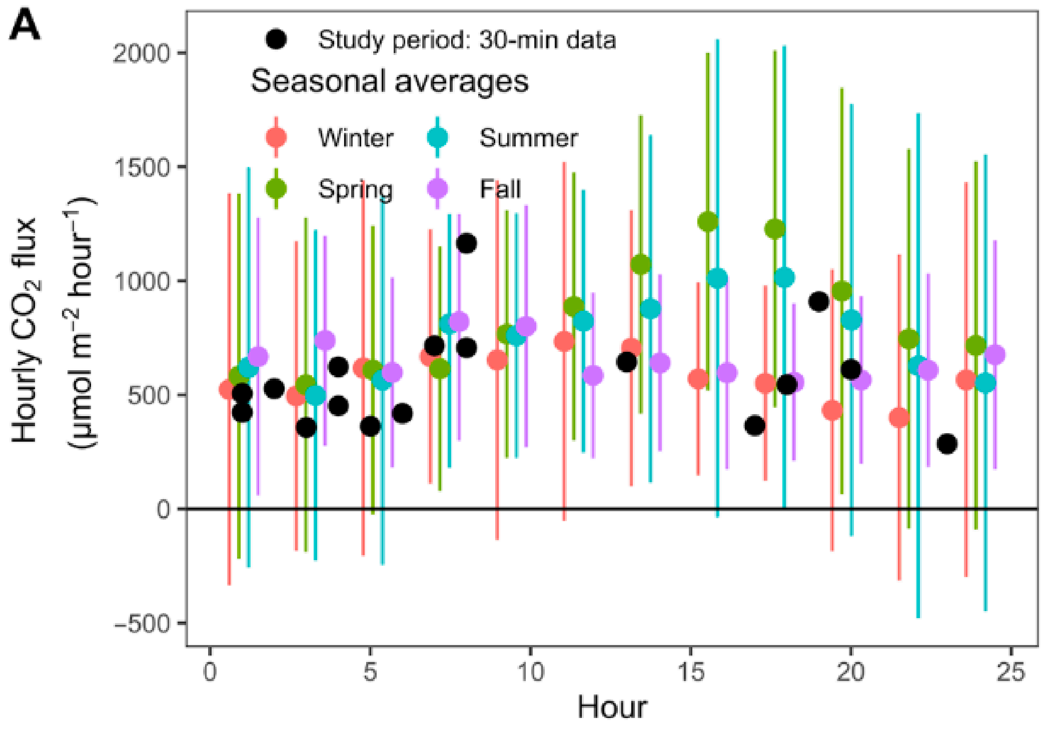
# Carbonate production likely offsets blue carbon in FL Bay

**FKNMS Florida Bay**

- $C_{org}$ ~ 90% autochthonous (Howard et al. 2021)
- $C_{inorg}$ mostly autochthonous, hydrodynamically very isolated basins
- Likely net calcifying (Yates & Halley 2006)
- Carbonate production potentially offsets blue carbon burial all Florida Bay sites
- Net fluxes ~ 50 – 550 g C $m^2$ $yr^{-1}$



# Air-sea $CO_2$ flux data confirm Bob Allen seagrass net source




van Dam et al. 2021
*Sci Adv*

- Air-sea C flux estimates from eddy covariance (van Dam et al. 2021) are comparable to sediment burial flux for site BA
- Suggests basin at Bob Allen has little lateral exchange over past ~ 150 years
- Suggests net carbonate production indeed offsets blue carbon burial in certain conditions (van Dam et al. 2021)

| **C Flux (g C m$^{-2}$ yr$^{-1}$)** | **Sites** | **Method** |
|---|---|---|
| 73 ± 69 | BA | Eddy covariance flux |
| 220 ± 46<br><br>120 ± 26 | SB, BA, TC, CB, RK, RB, NM<br>BA | $C_{org}$, $C_{inorg}$ burial rates ($^{210}$Pb & burial concentration) |

# Conclusions

1. Not all seagrass meadows suitable conservation targets for blue carbon (but may provide many other benefits!)
2. FKNMS backreef seagrass meadows may not play large role in carbon sequestration
3. Florida Bay seagrass meadows may store and bury $C_{org}$, but $C_{inorg}$ cycling likely offsets carbon sink capacity
4. Protection of FKNMS backcountry meadows with high $C_{org}$ stocks may provide climate benefit
5. But restoration of such meadows may not yield much due to low carbon burial rates
6. Sites for seagrass restoration in south Florida should target conditions where high burial fluxes are likely

# Next steps

- Measure more air-sea CO2 fluxes directly: We have a second eddy covariance tower installed at Rabbit Key
- Investigate reactivity of buried $C_{org}$ – how likely will it be remineralized and returned to the atmosphere when seagrass is lost?
- Link carbon stocks and burial rates to seagrass meadow and environmental factors – what site characteristics support seagrass conservation for blue carbon?

# THANK YOU FOR YOUR ATTENTION


## Acknowledgements

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## References:


**Fourqurean**, J. W. *et al.* Seagrass ecosystems as a globally significant carbon stock. *Nature Geoscience* **5**, 505-509 (2012)

**Krause**, J. R. *et al.* Global seagrass carbon stock variability and emissions from seagrass loss. *Nature Commun* **16** (2025).

**Friess**, D. A., Howard, J., Huxham, M., Macreadie, P. I. & Ross, F. Capitalizing on the global financial interest in blue carbon. *PLOS Climate* **1**, e0000061 (2022).

**Saderne**, V. *et al.* Role of carbonate burial in Blue Carbon budgets. *Nat Commun* **10**, 1106 (2019). Fakhraee, M., Planavsky, N. J. & Reinhard, C. T. Ocean alkalinity enhancement through restoration of blue carbon ecosystems. *Nature Sustainability* (2023).

**Fourqurean**, J. W. *et al.* Seagrass Abundance Predicts Surficial Soil Organic Carbon Stocks Across the Range of Thalassia testudinum in the Western North Atlantic. *Estuaries and Coasts* (2023).

**Mazarrasa**, I. *et al.* Seagrass meadows as a globally significant carbonate reservoir. *Biogeosciences* **12**, 4993-5003 (2015).

**Howard**, J. L., Creed, J. C., Aguiar, M. V. P. & Fourqurean, J. W. CO 2 released by carbonate sediment production in some coastal areas may offset the benefits of seagrass “Blue Carbon” storage. Limnology and Oceanography 63, 160-172 (2018).

**Howard**, J. L. *et al.* Decomposition Rates of Surficial and Buried Organic Matter and the Lability of Soil Carbon Stocks Across a Large Tropical Seagrass Landscape. *Estuaries and Coasts* **44**, 846-866 (2021).

**Yates**, K. K. & Halley, R. B. Diurnal variation in rates of calcification and carbonate sediment dissolution in Florida Bay. *Estuaries and Coasts* **29**, 24-39 (2006).

**Van Dam**, B. R. *et al.* Calcification-driven CO2 emissions exceed “Blue Carbon” sequestration in a carbonate seagrass meadow. *Science Advances* **7** (2021).