EVIDENCE THAT SOME REEFS ON THE FRT ARE BEGINNING TO DISSOLVE- HETEROTROPHY LOOKS TO BE THE CAUSE

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Global Biogeochemical Cycles

RESEARCH ARTICLE

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Key Points:

- Seasonal reversal in the sign of NCP drives positive feedback on NCC in the summer and negative feedback in the winter
- Seasonal net dissolution in waters supersaturated with respect to aragonite
- Net loss of reefal substrate due to ocean acidification is already occurring

Dynamics of carbonate chemistry, production, and calcification of the Florida Reef Tract (2009–2010): Evidence for seasonal dissolution

Nancy Muehllehner[1], Chris Langdon[1], Alyson Venti[1], and David Kadko[2]

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Abstract Ocean acidification is projected to lower the Ω_{ar} of reefal waters by 0.3–0.4 units by the end of

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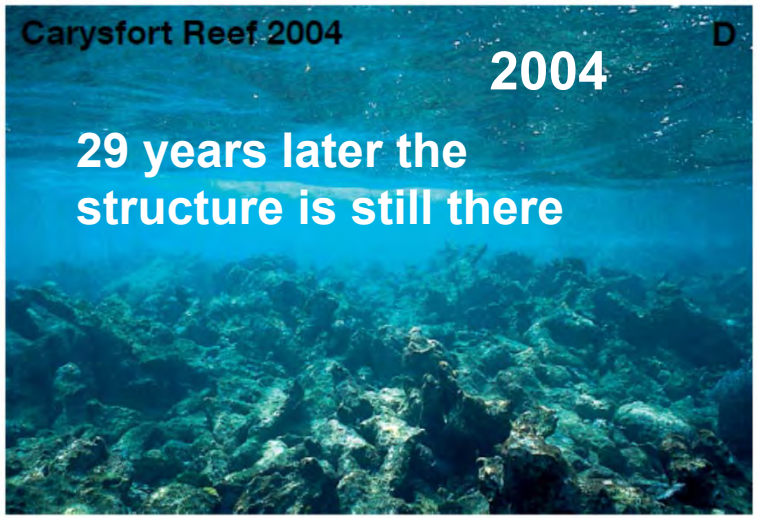
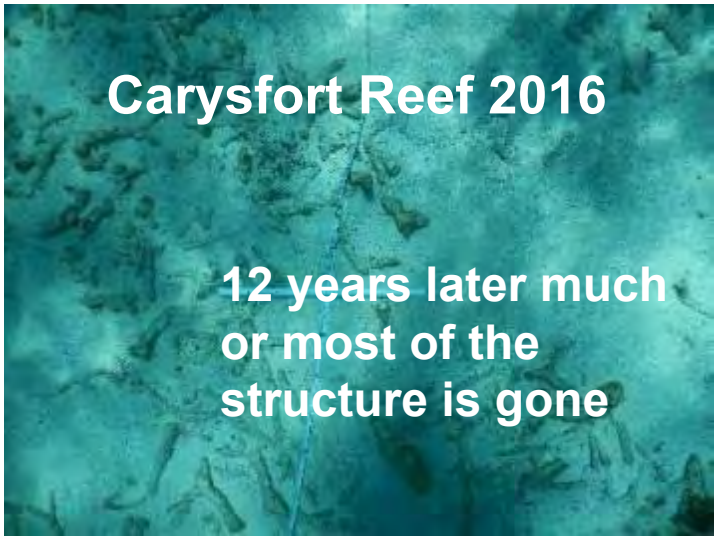
Take home messages

- Evidence of seasonal dissolution across wide areas of the FRT even though the waters are supersaturated
- Greatest rates of dissolution were observed in the upper Keys
- Best predictor of when and where dissolution occurs is respiration (heterotrophy)

Loss of reef structure could be a game changer





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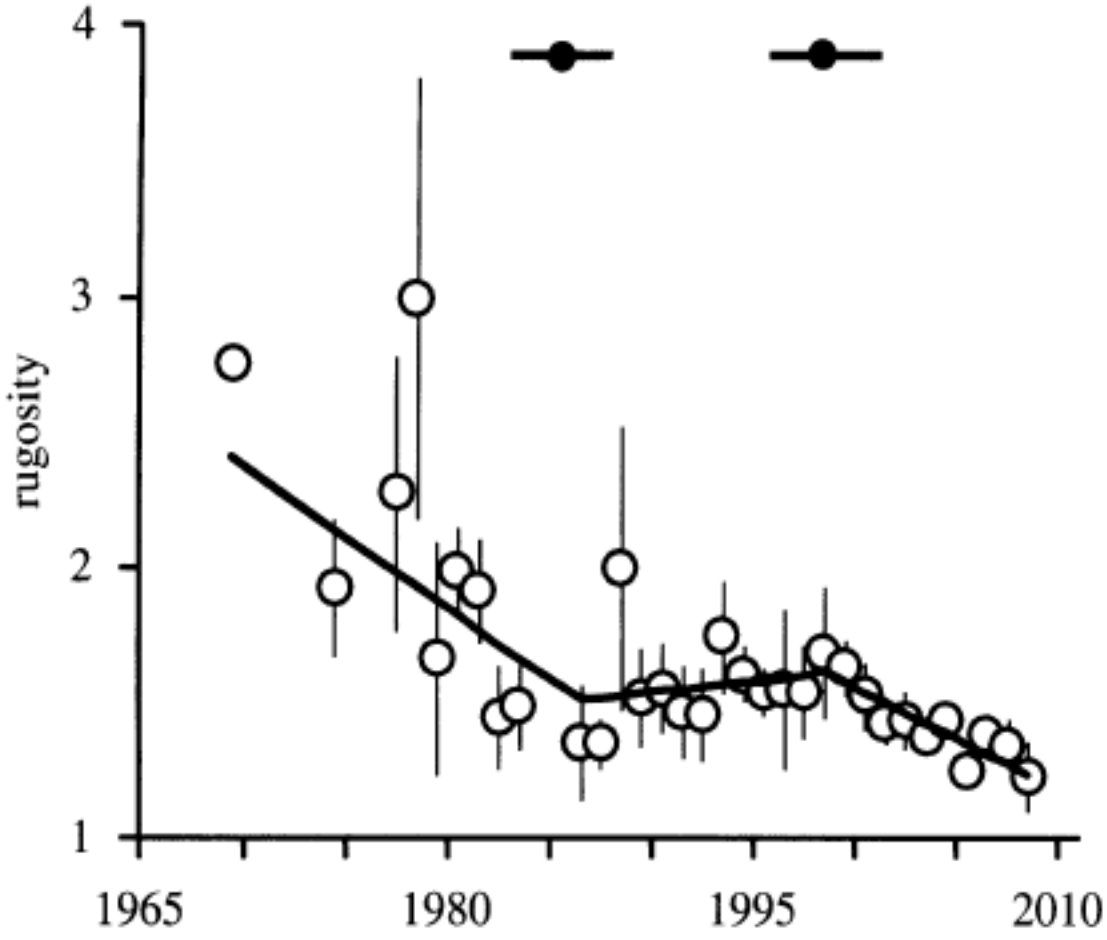
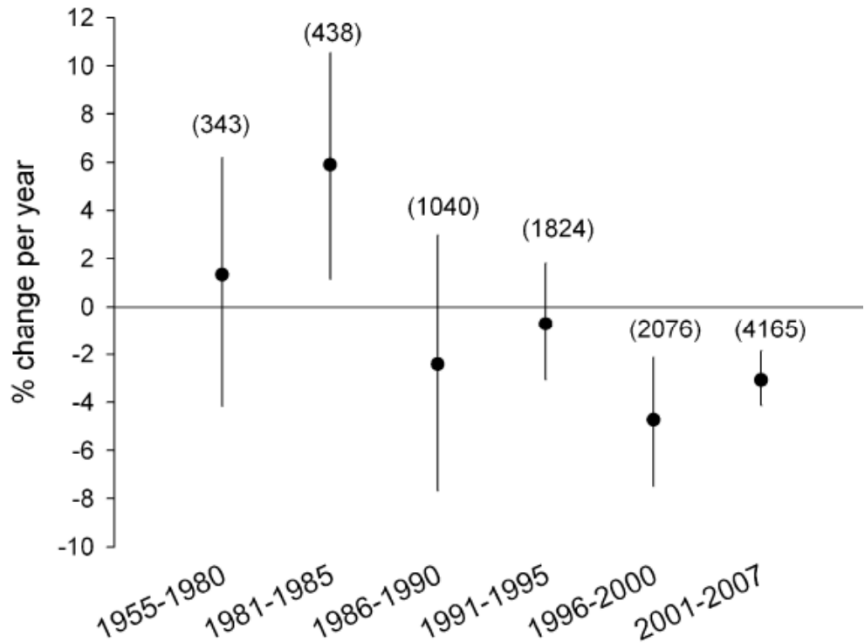
Region-wide decline in structural complexity of Caribbean reef



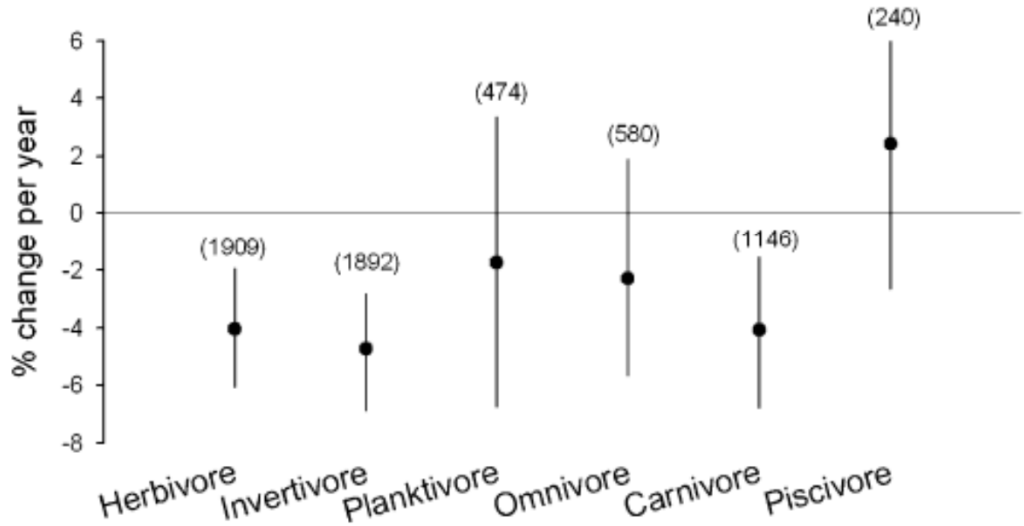
Alvarez-Fillip et al 2009

Recent Region-wide Declines in Caribbean Reef Fish Abundance

Declines began in 1980s when reef habitat was observed to begin its decline



All trophic groups and fished and non-fished species declining pointing to general habitat degradation as the cause



1996-2007

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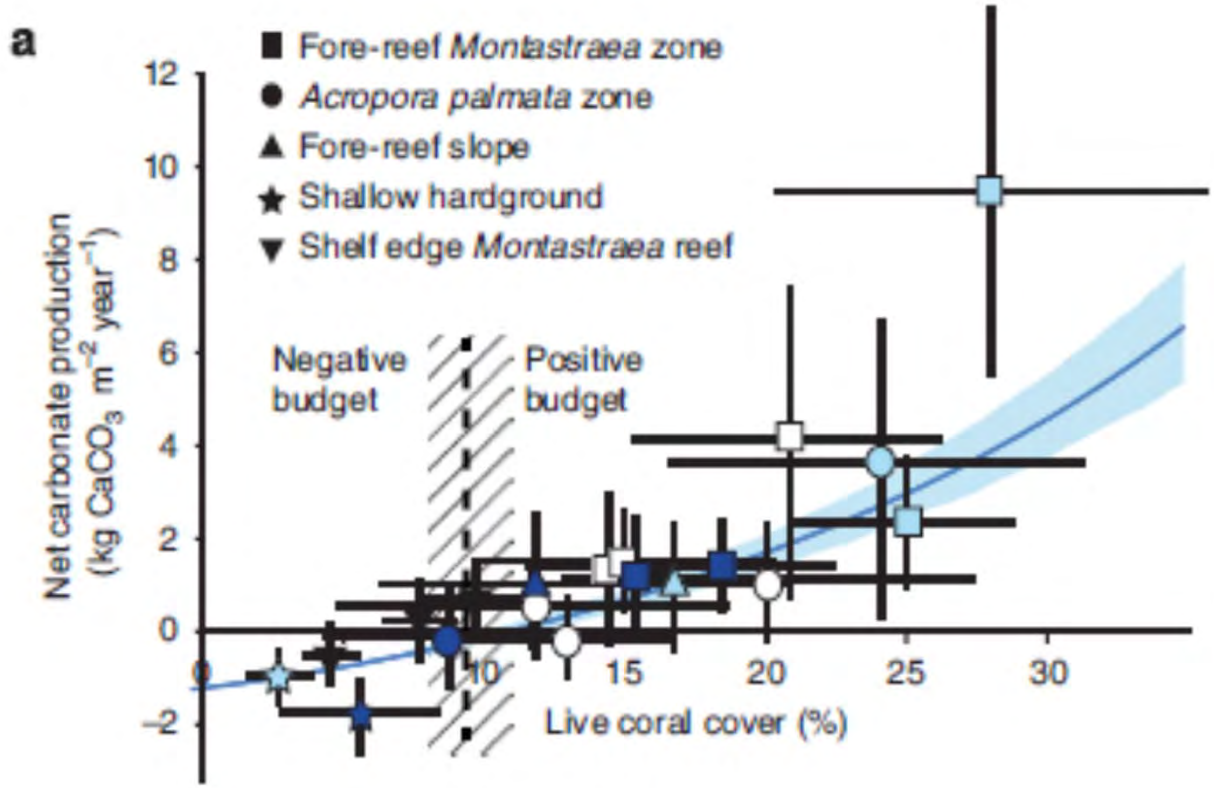
From Paddack et al., 2009

Are the reefs in Florida producing enough $CaCO_3$ to offset loses?



Perry et al 2013 using a census-based method found that carbonate budgets on Caribbean reefs become negative if coral cover < ~ 10%.

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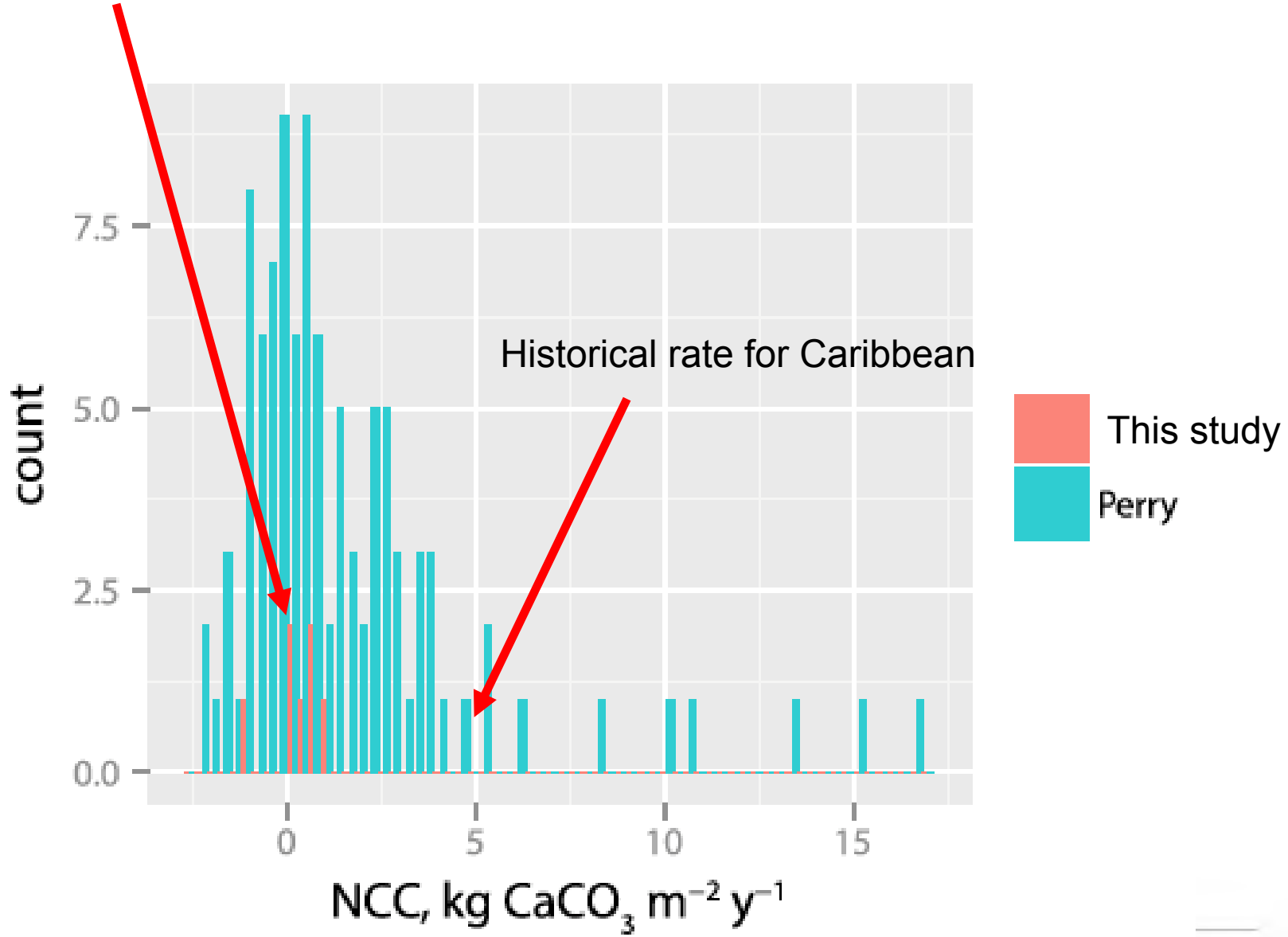
This study found that present day rates of calcification are 10-20% of historical rates but still positive (except in the upper Keys)



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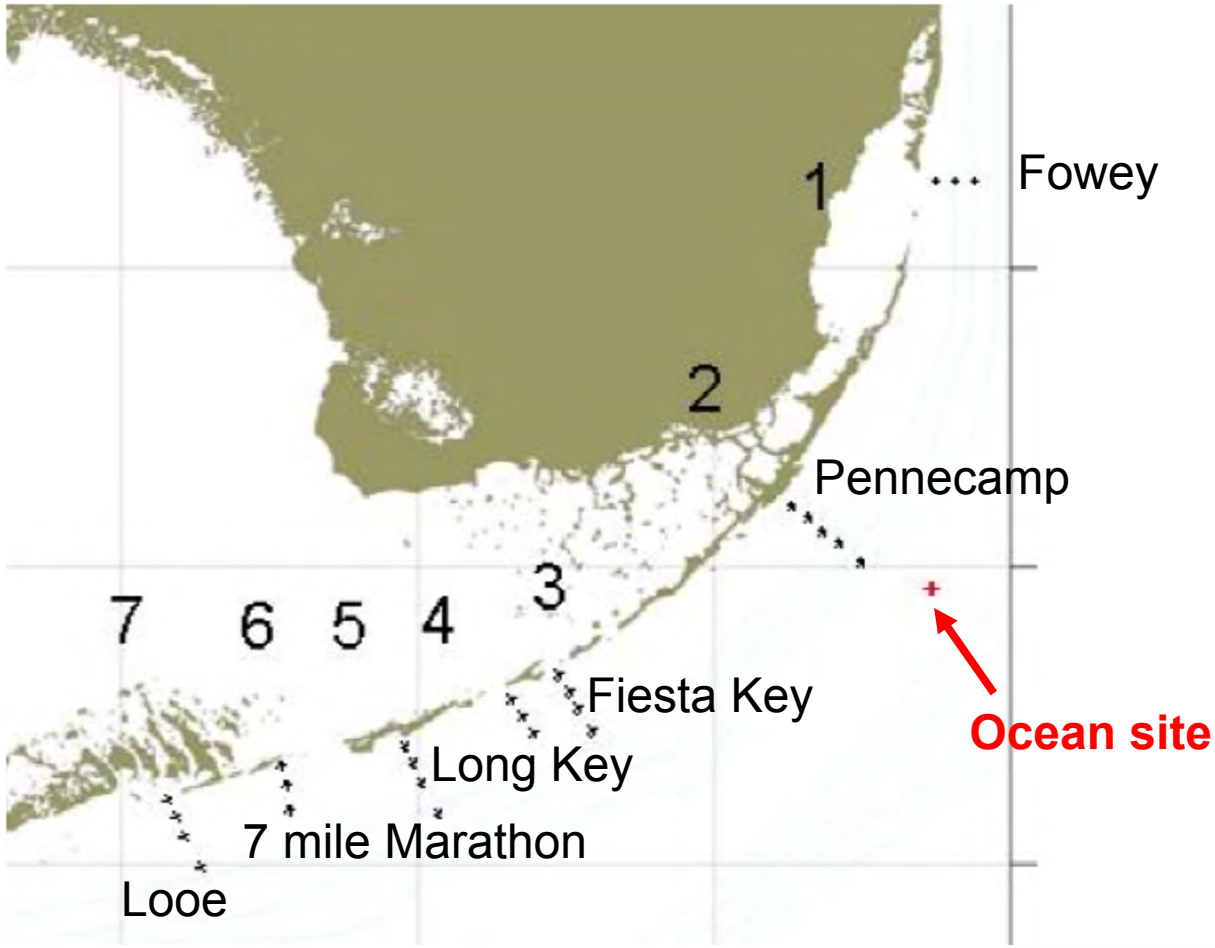
Muehllehner et al 2016

Water samples for carbonate chemistry were collected along seven transects traversing the FRT plus an offshore site for the ocean end-member



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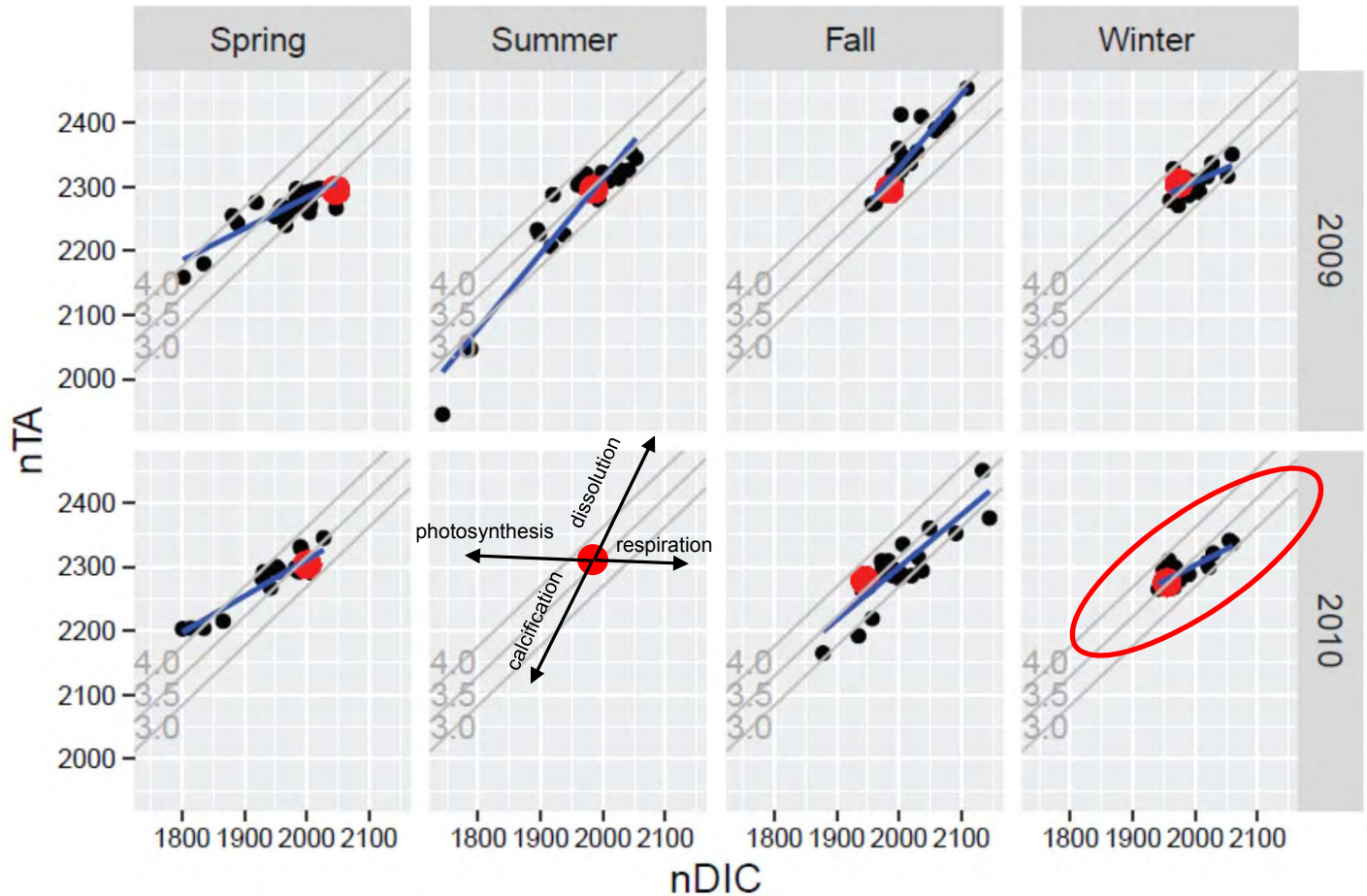
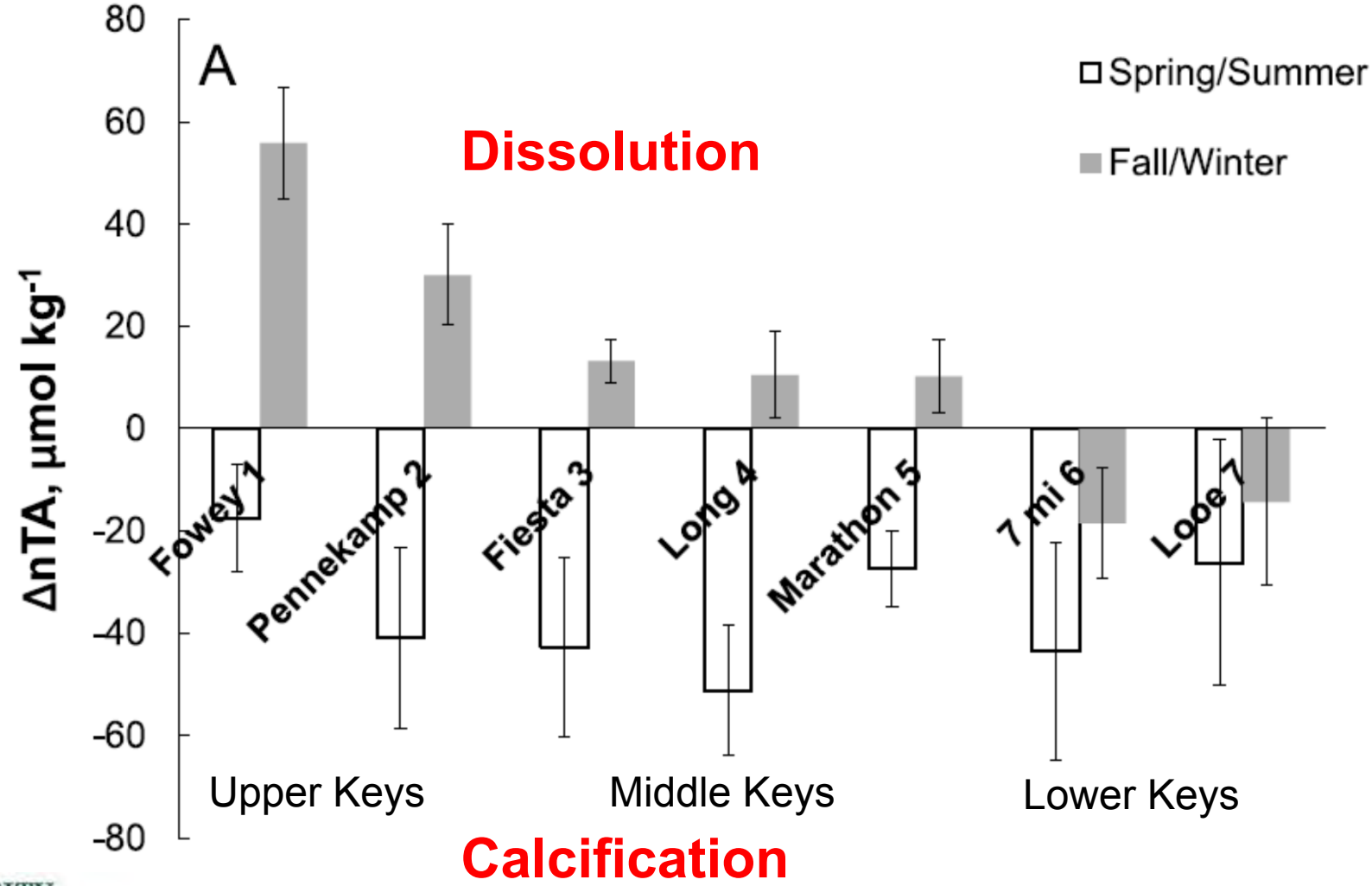
Data revealed a chemical fingerprint for dissolution and respiration of organic matter



Dissolution and respiration

Red circle represents the ocean source water

+ΔnTA throughout the upper and middle Keys during the fall and winter



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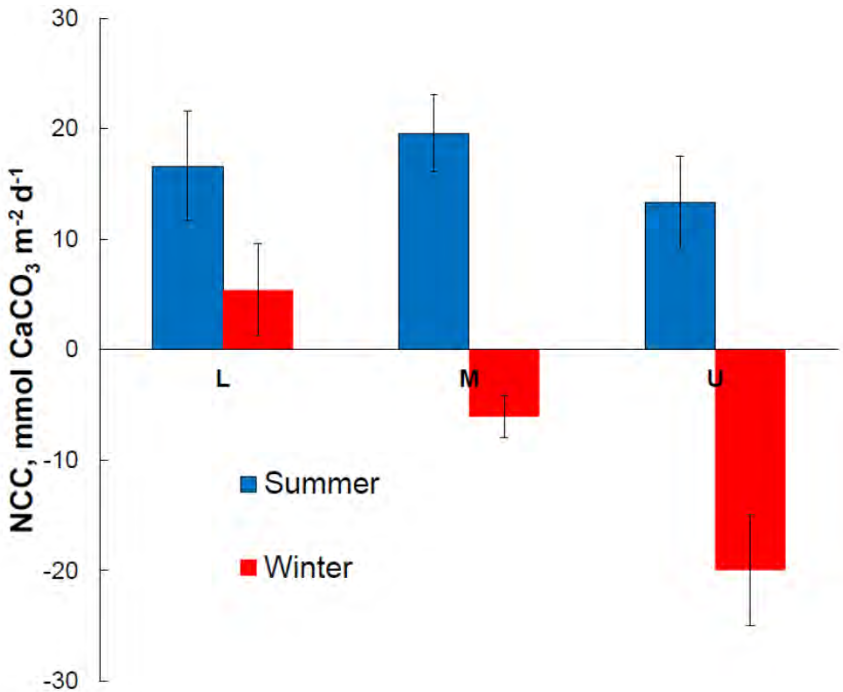
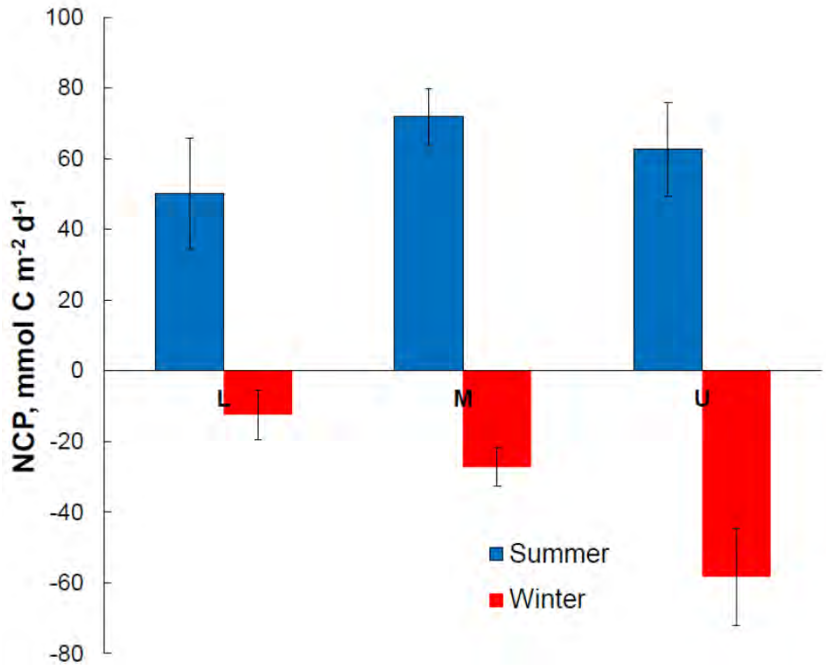
Seasonal and spatial trends in NCC and NCP aggregated by location (lower, middle or upper Keys)

note showed striking similarity





NCC net community calcification
NCP net community production

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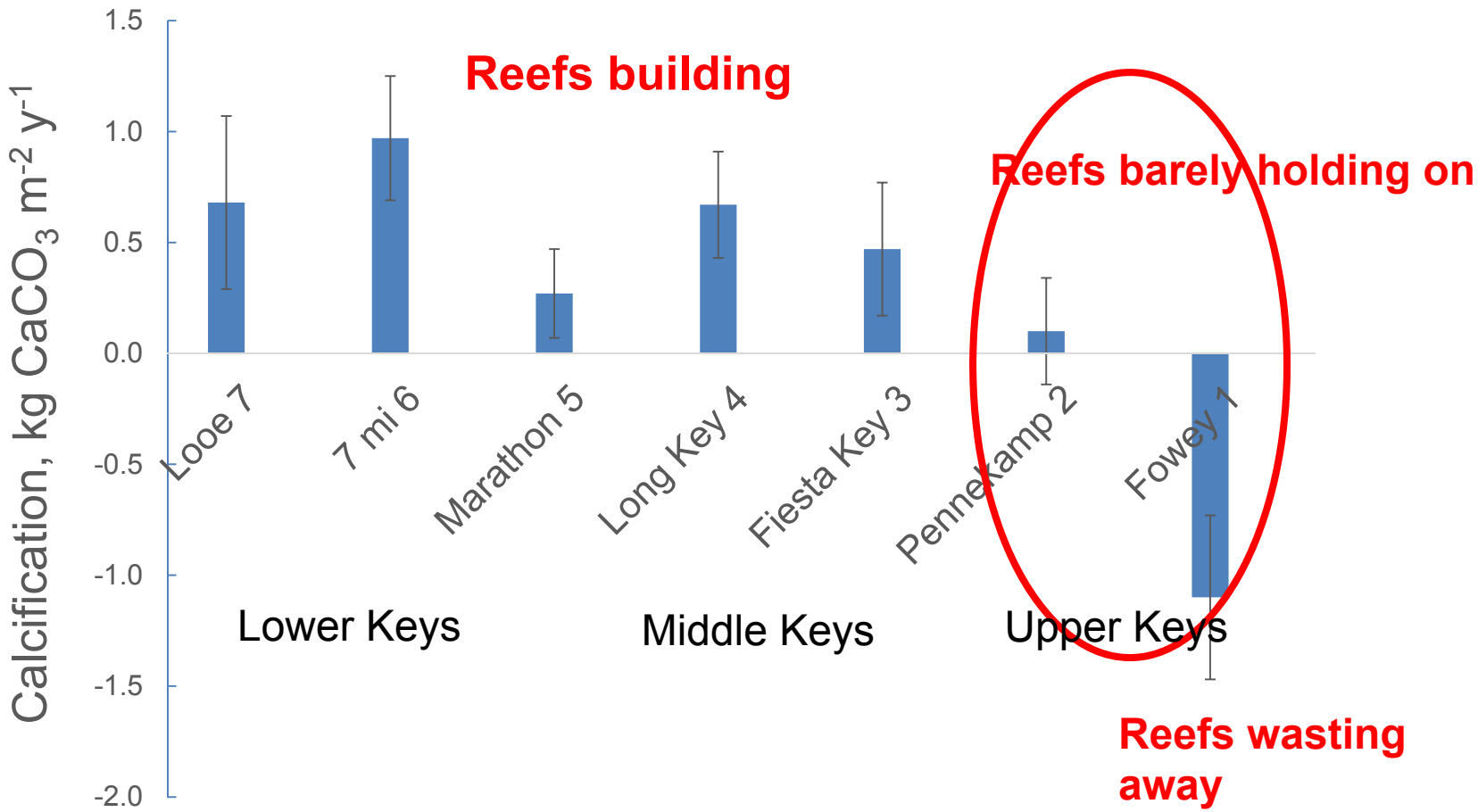
Reefs in the lower and middle Keys have positive $CaCO_3$ budgets but those in the upper Keys are barely holding on or are wasting away



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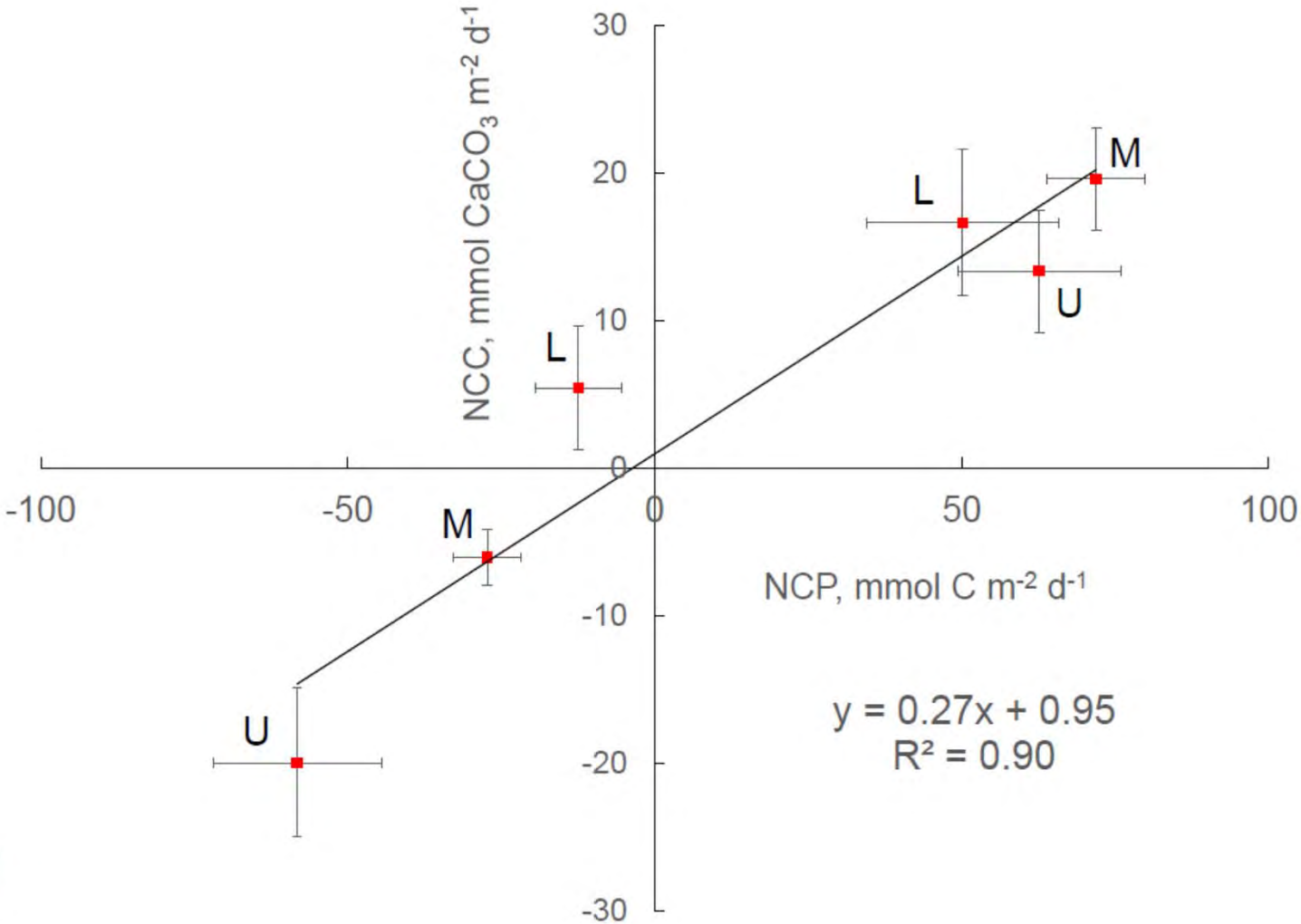
Muehllehner et al. 2016

Variability in NCP explained 90% of the variability in NCC
Heterotrophy best predictor of when, where and how much dissolution occurs



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Why hasn't this been observed before and why would the problem be greatest in the upper Keys?

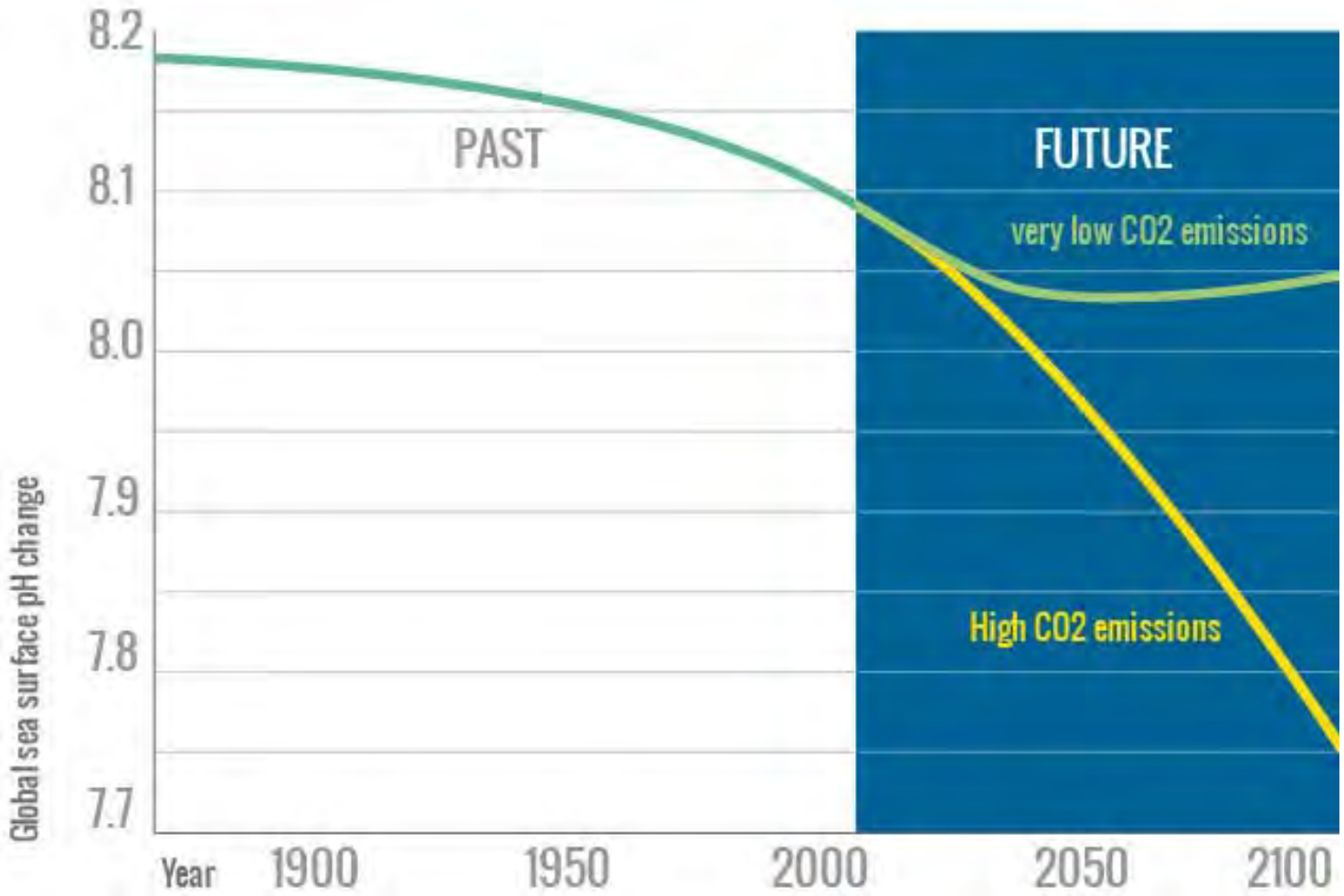
- pH of reef waters have declining due to ocean acidification
- May be it has only recently become low enough to cause dissolution
- Cultural acidification resulting from human inputs of nutrients to the coastal zone is increasingly being recognized as a threat that can lower pH by an additional 0.4-0.5 units over and above that caused by CO2 emissions and ocean uptake

Hypothesis

We haven't seen this before because:

1. pH is lower today and getting lower every year
2. Respiration in the sediments in some areas is pushing pH down by an additional 0.4-0.5 units

IPCC projected changes in surface ocean pH



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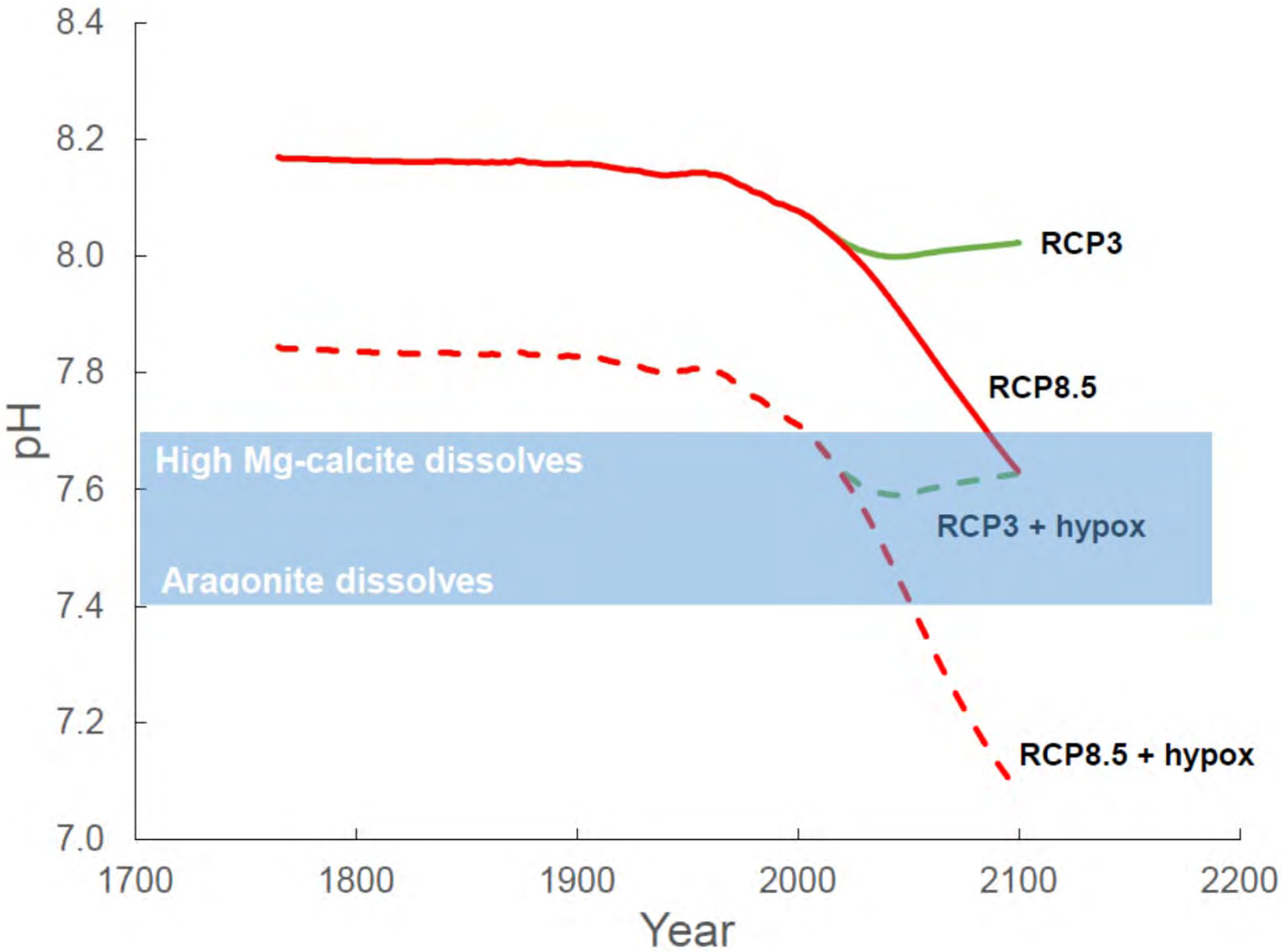
pH scenarios if hypoxia is factored in



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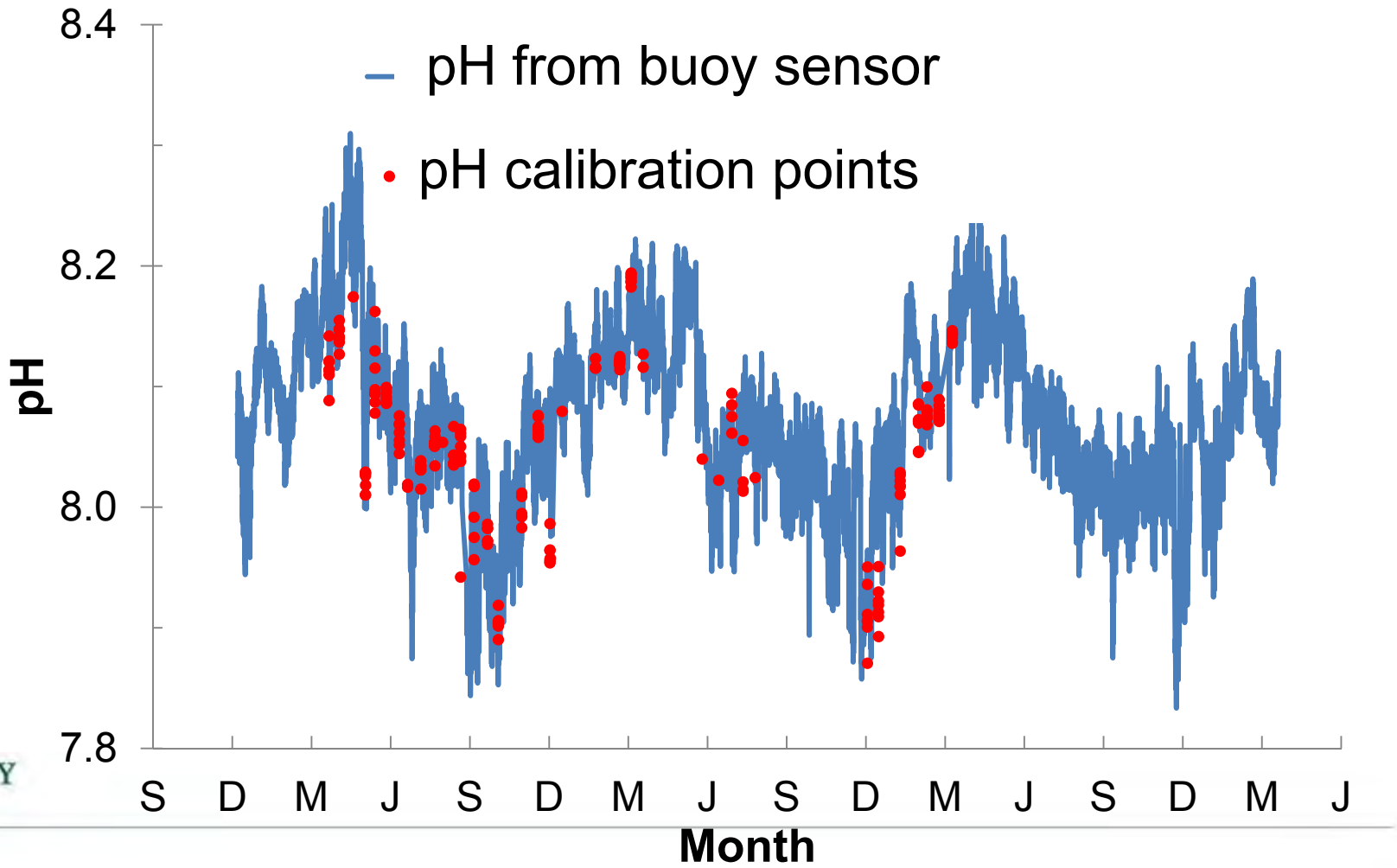
pH time series for mid Keys reef site 2012-2014

Biological activity causes pH to swing by 0.5 units

Swing would be greater in the upper Keys



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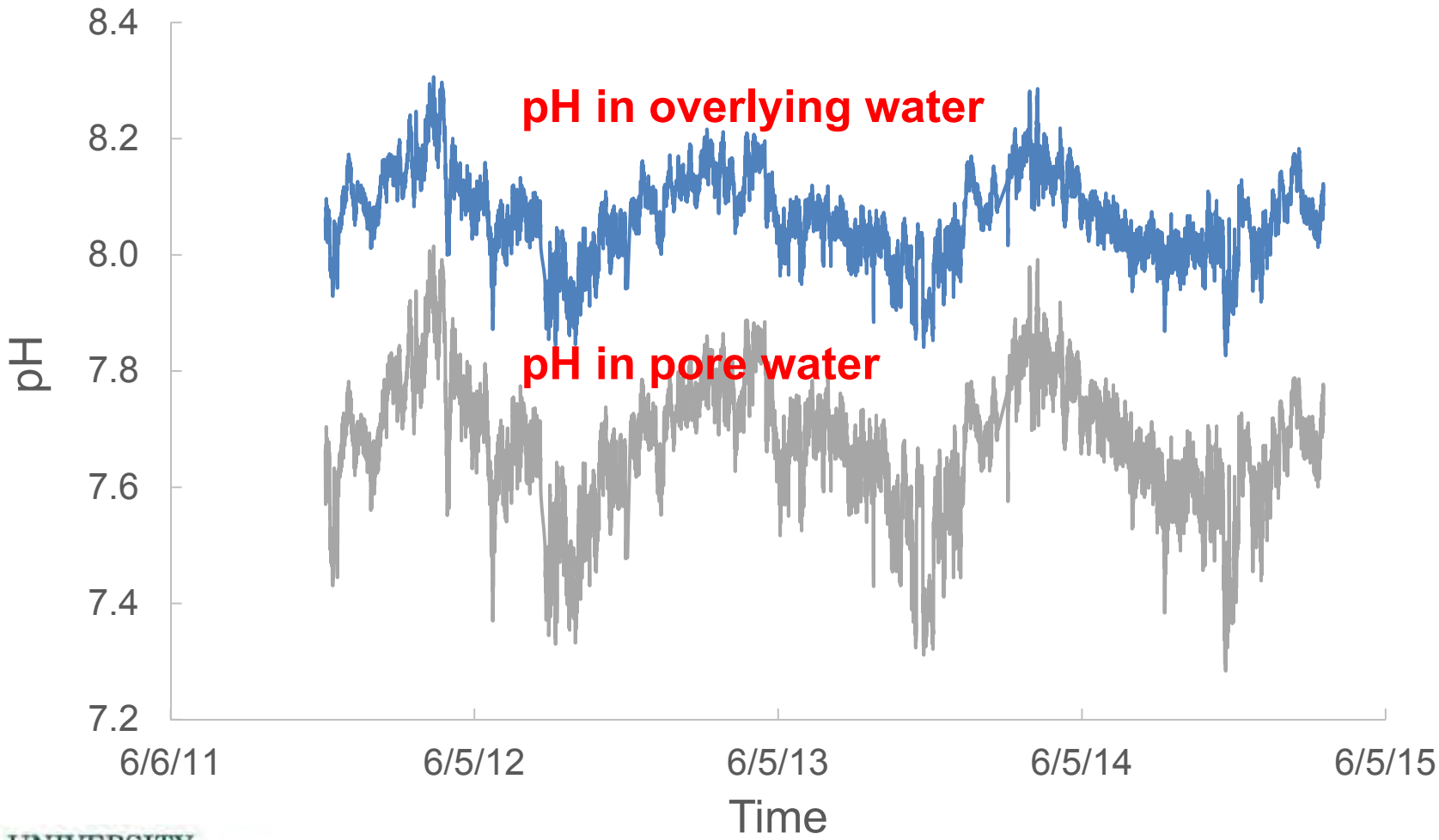
If respiration in the sediments is strong enough consume all of the oxygen then pH in the pore waters drops by 0.4-0.5 units



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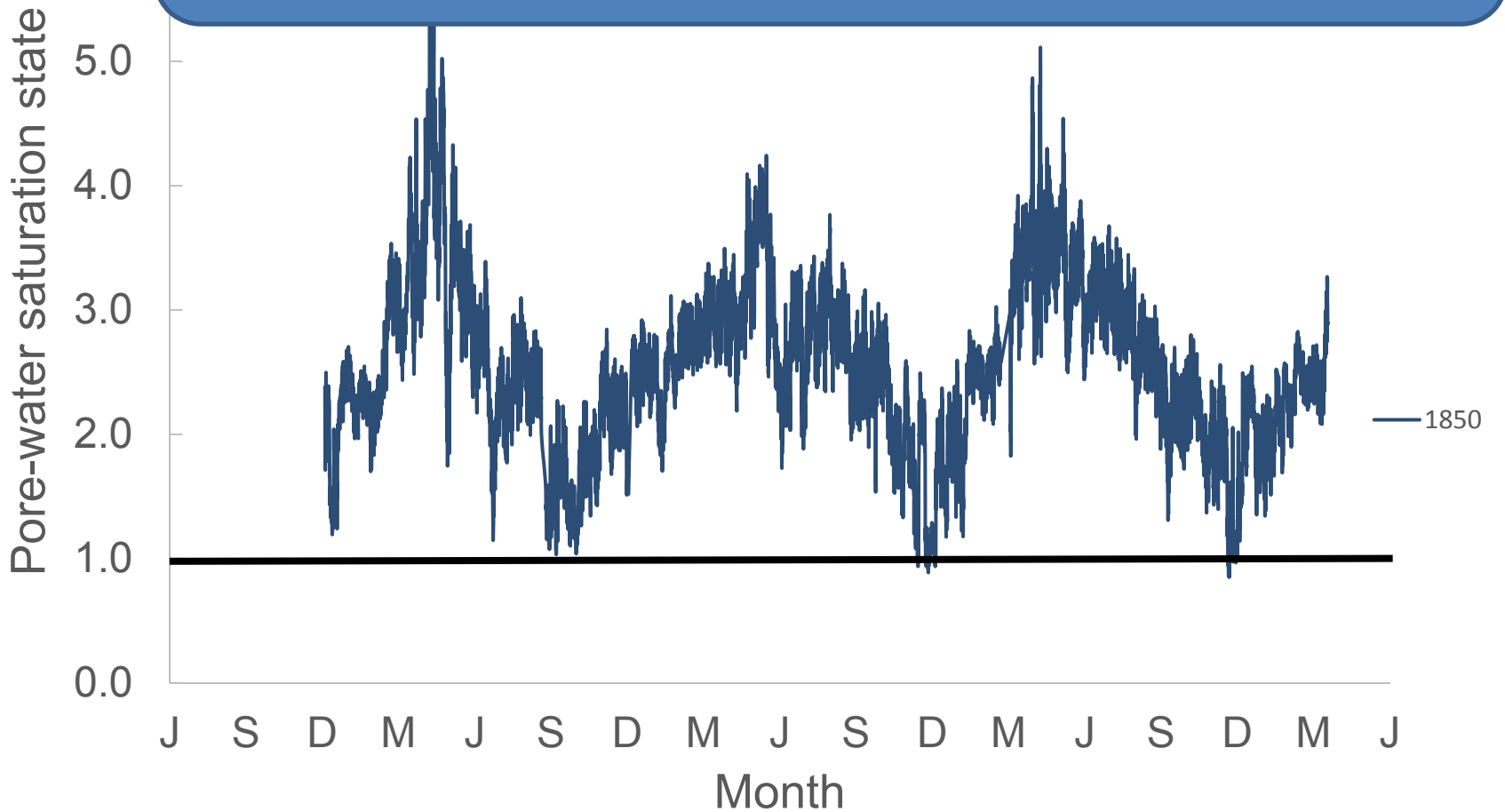
Drupp et al 2016 measured ΔpH in reef pore water to be -0.4 to -0.5 units

Pore-water Ω_{ar} 1850
Few days of dissolution



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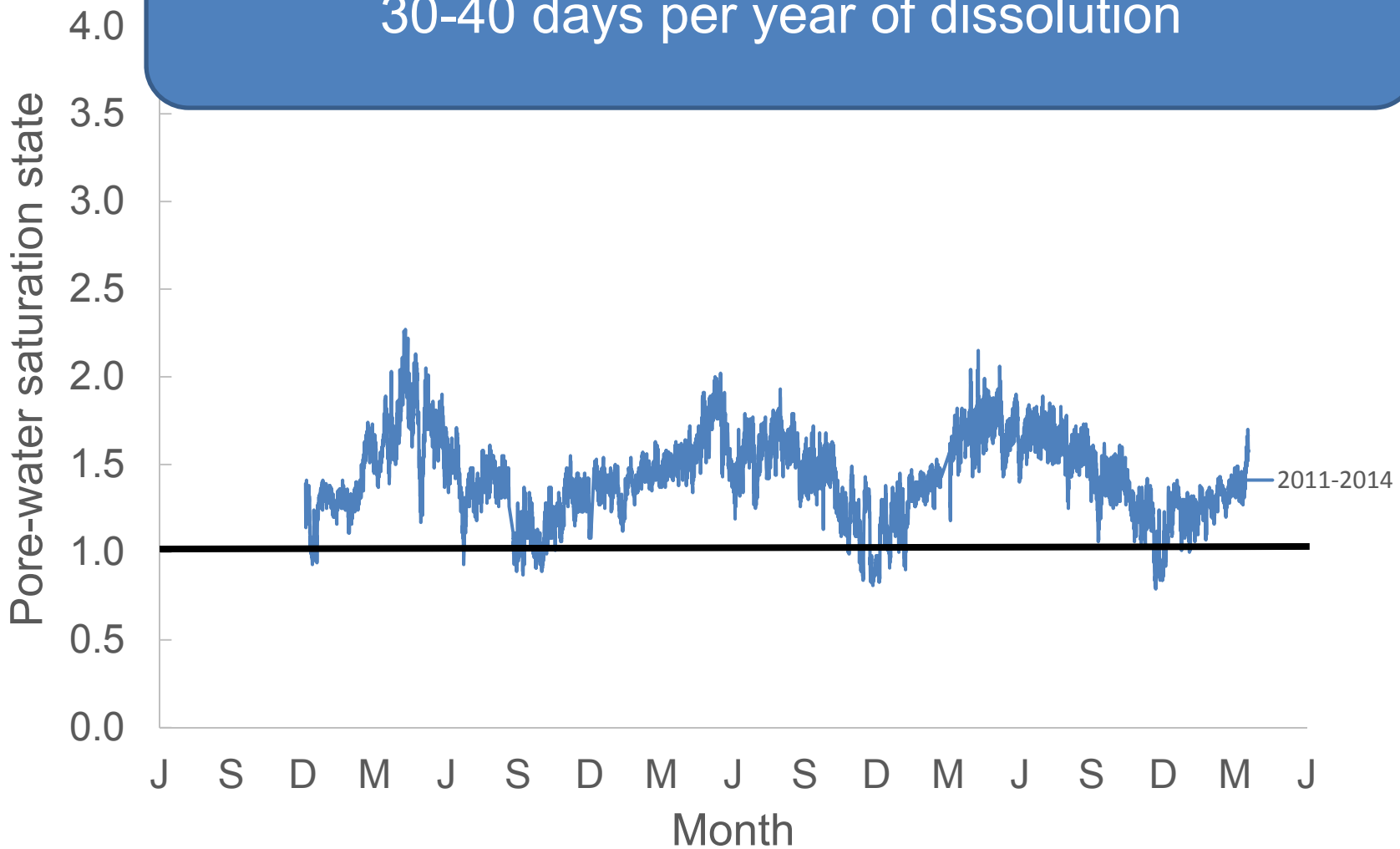
Pore-water Ω_{ar} present day
30-40 days per year of dissolution



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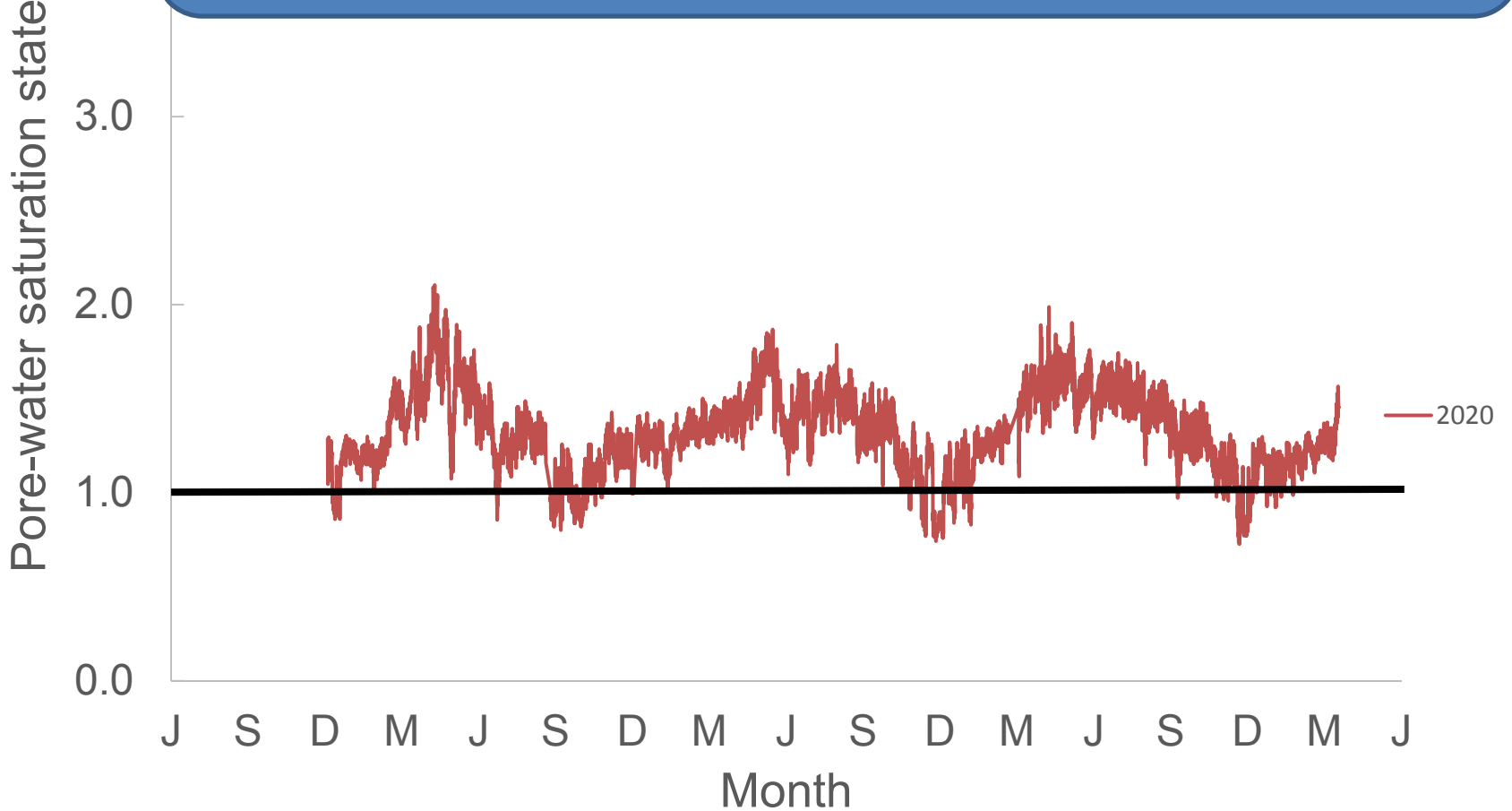
Pore-water Ω_{ar} 2020
Age-progressed assuming RCP8.5



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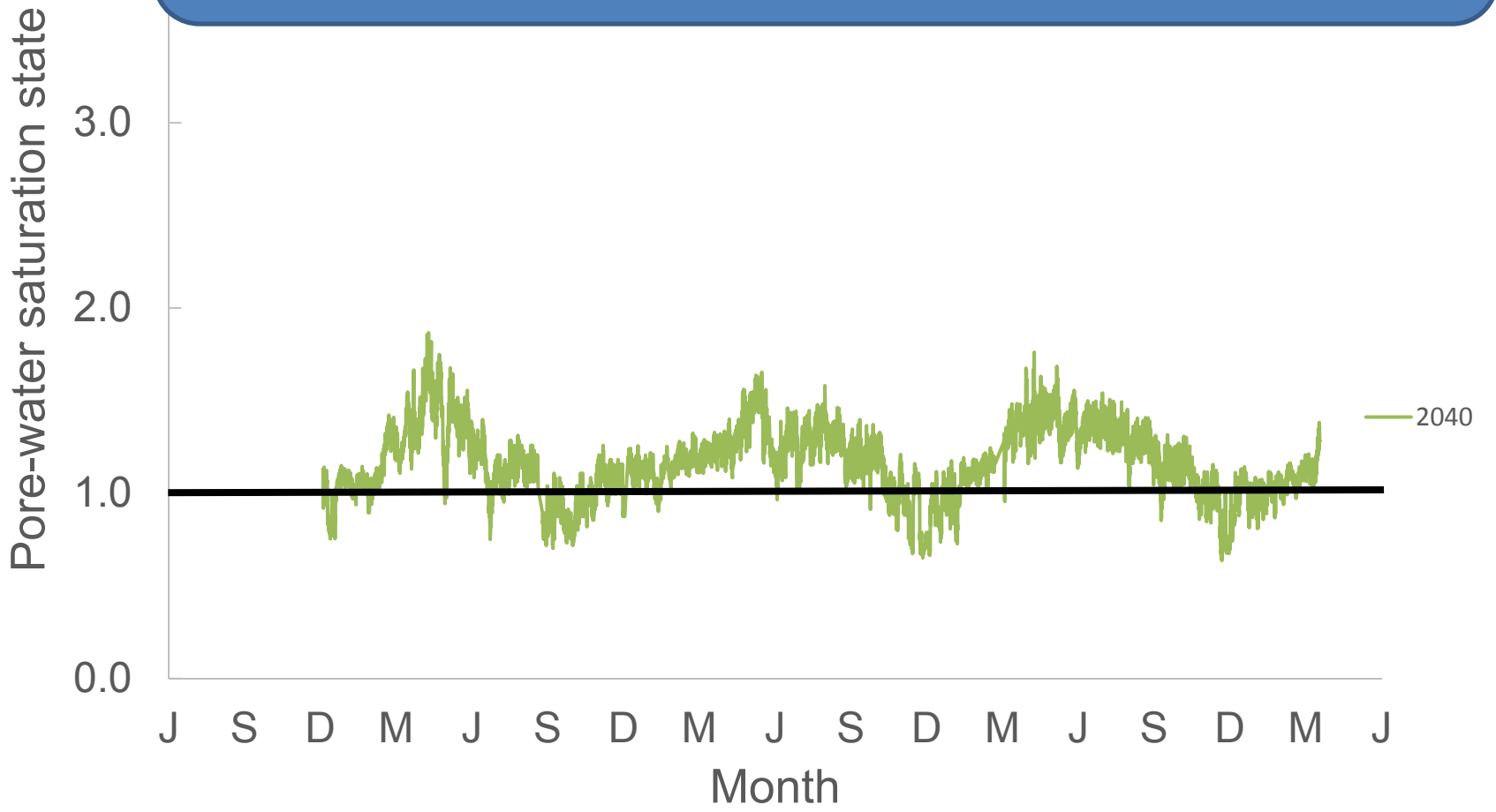
Pore-water Ω_{ar} 2040
Age-progressed assuming RCP8.5



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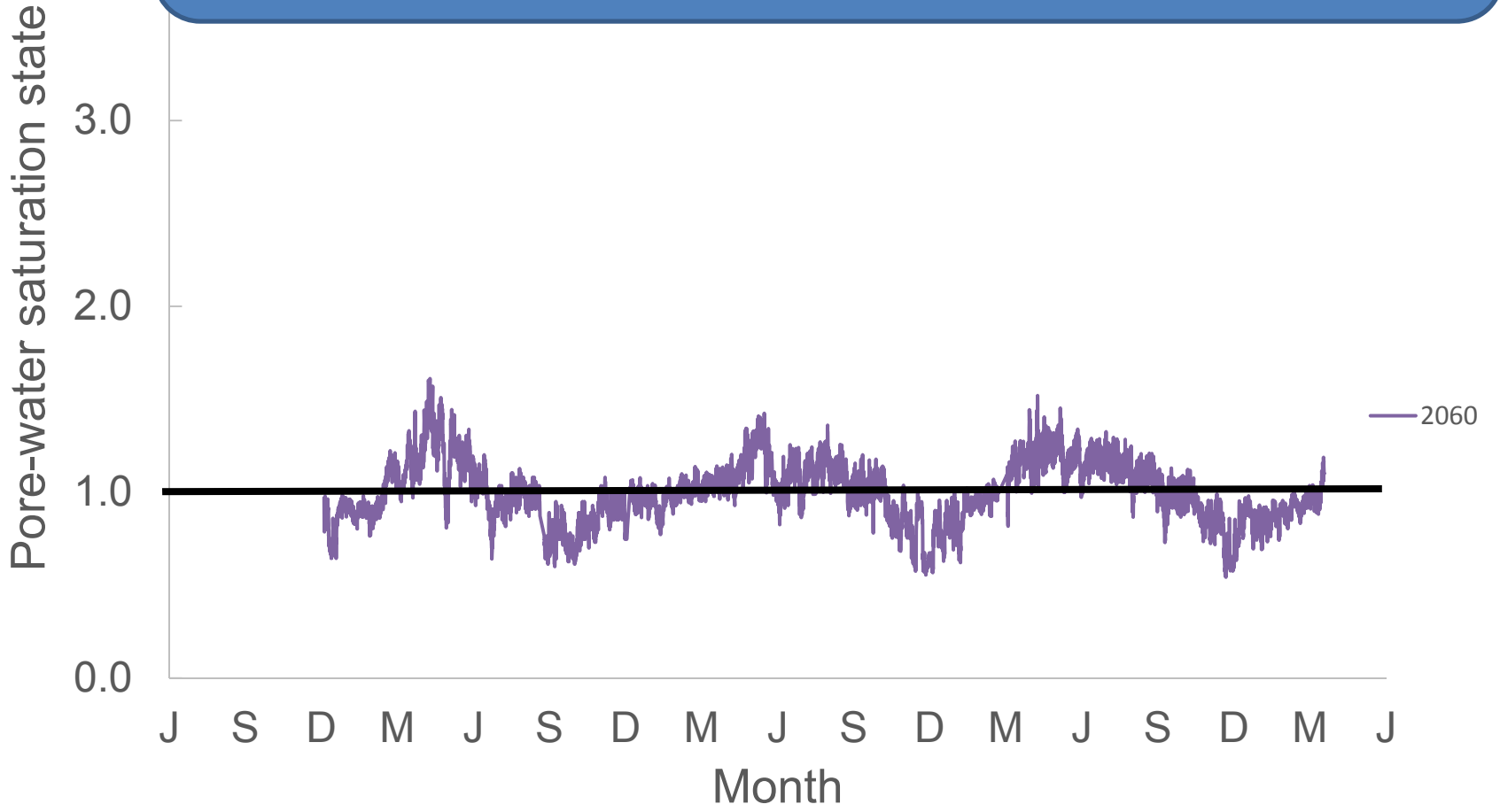
Pore-water Ω_{ar} 2060
Age-progressed assuming RCP8.5



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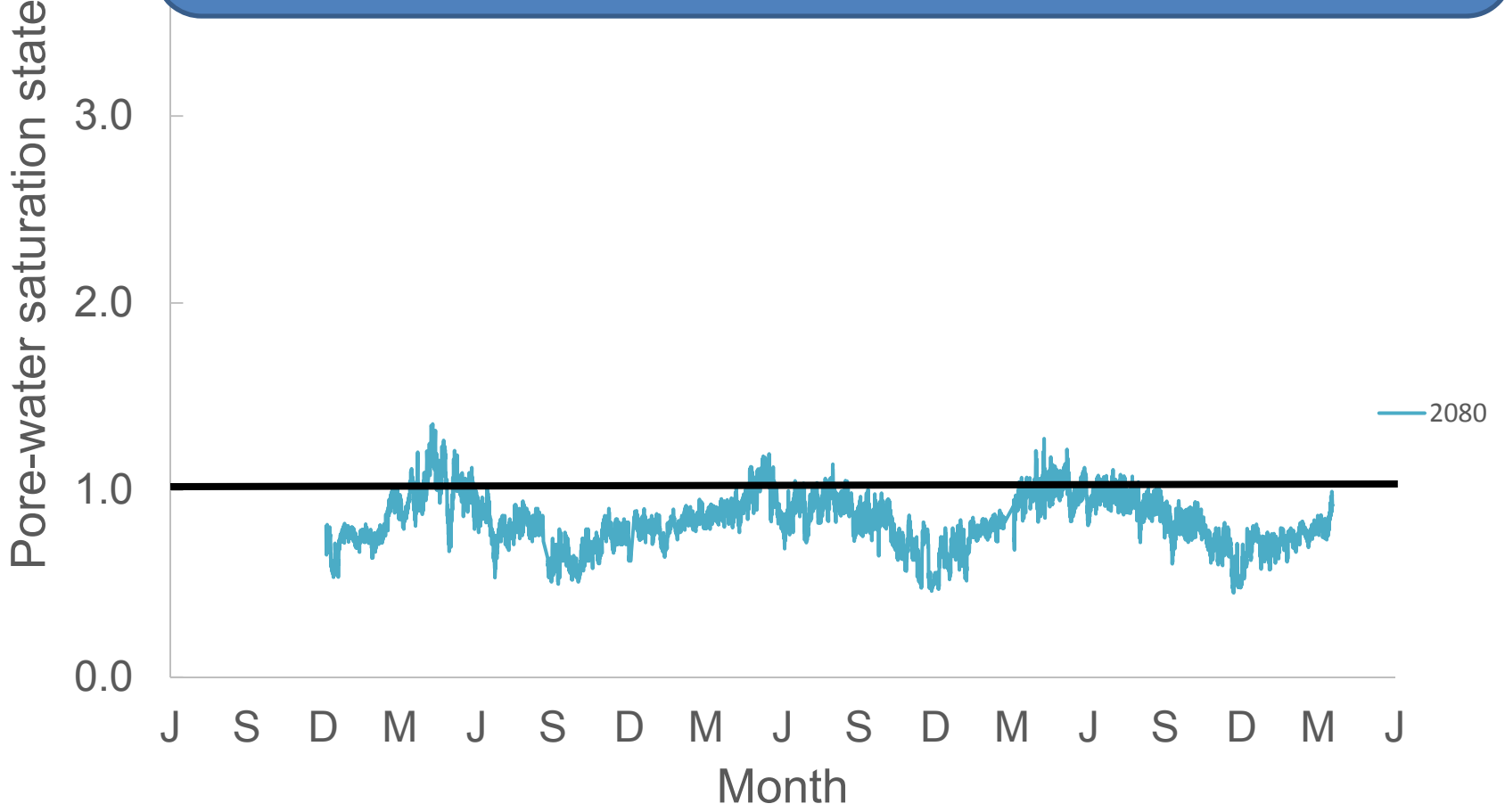
Pore-water Ω_{ar} 2080
Age-progressed assuming RCP8.5



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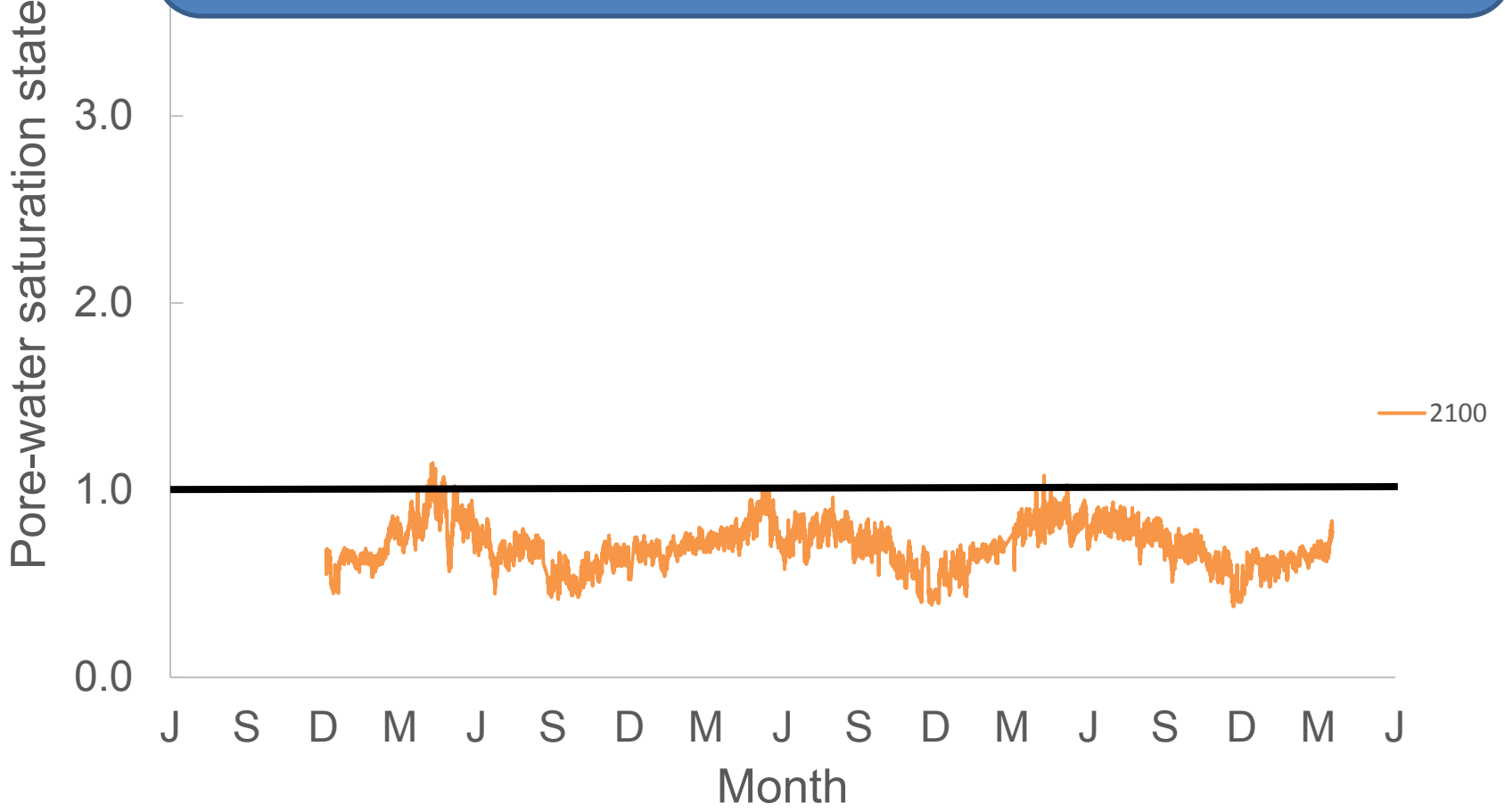
Pore-water Ω_{ar} 2100
Age-progressed assuming RCP8.5



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Conclusions

- Normal biological activity is causing pH in the water to swing from 8.2 in summer to 7.85 in winter – but this alone wouldn't account for dissolution
- Breakdown of organic matter which can lower the pH in the pore waters by 0.4-0.5 pH units is necessary to explain the patterns in dissolution we are seeing

Implications

- **This a game changer** – restoration efforts will ultimately fail if there is no reef framework to attach the corals to
- Breakdown of organic matter in the sediments seems to account for the dissolution in the upper Keys
- If we could reduce the supply of organic matter to the sediments we might be able to reduce or eliminate dissolution for many years

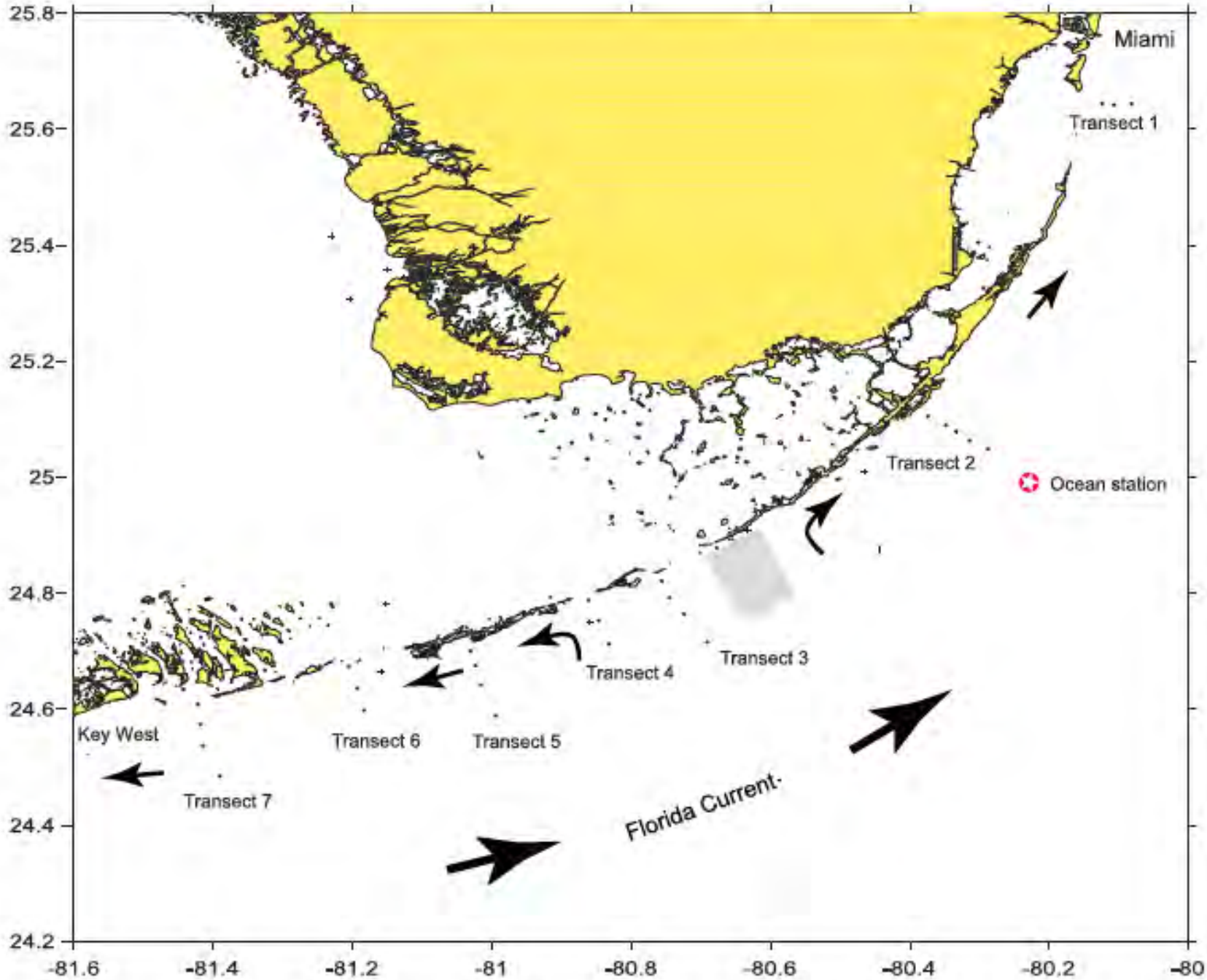
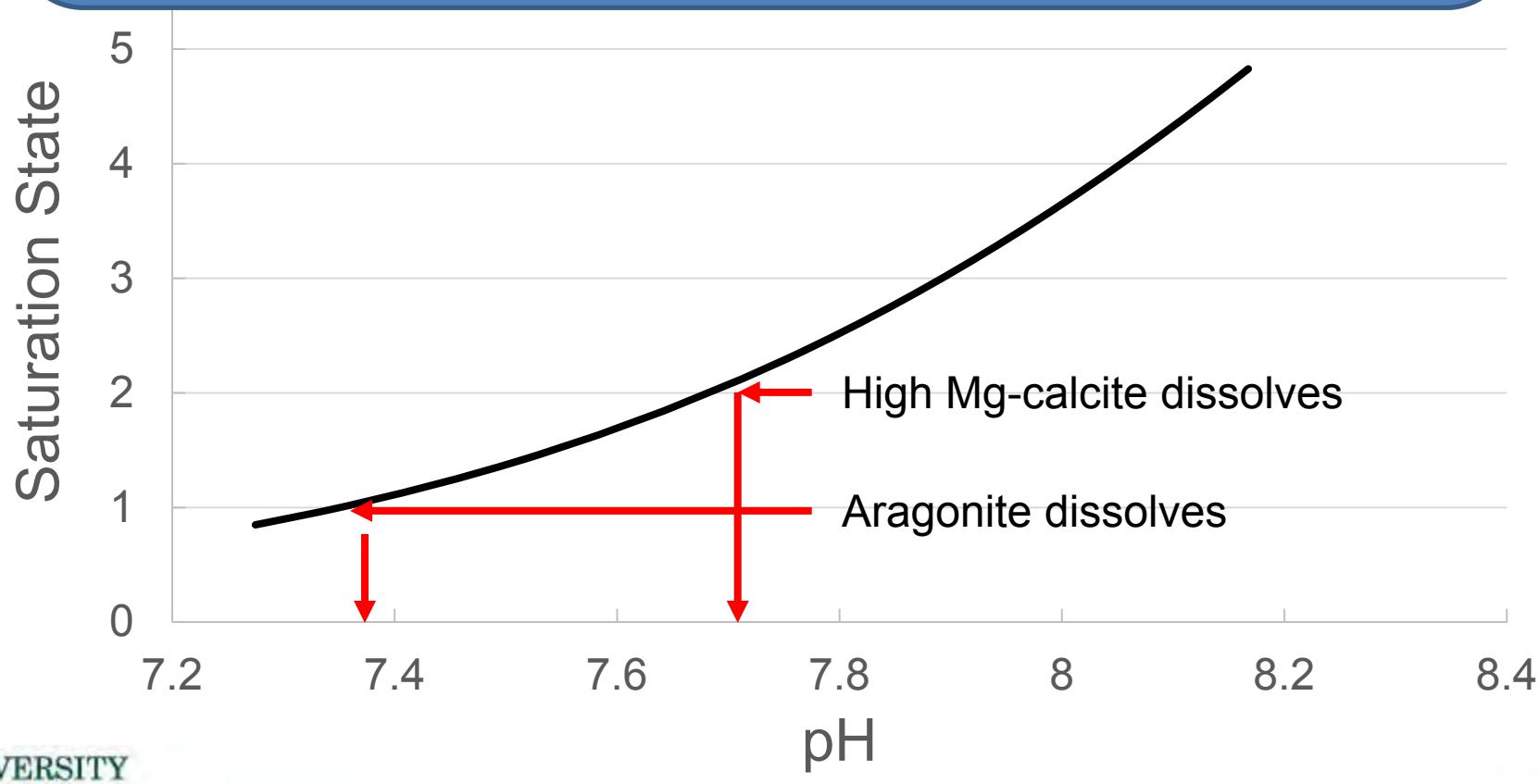


Figure 1. Map of the study area showing the locations of the stations making up the seven transects. The location

Decreasing pH makes it more difficult for organisms to form limestone shells and skeletons and when saturation state falls below 1-2 they actually start to dissolve



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