

Reconstructing the nutrient history of Biscayne National Park using phosphorus recorded in coral skeleton

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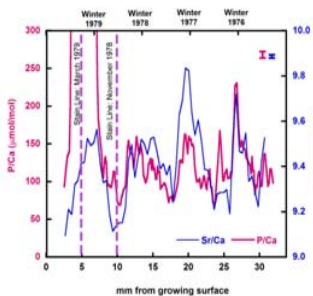
I. INTRODUCTION

- Coral reefs shelter thousands of marine species and are important for tourism. However, coral growth rates have been on the decline globally for the past century.
- The Florida Keys is the 3rd largest reef in the world; there, the decline may be linked to climate change, pollution, ship grounding, urban runoff, and coastal eutrophication.¹
- Coastal eutrophication is caused by anthropogenic nutrient input (NO₃⁻, PO₄³⁻).
- As they calcify, corals record ambient seawater chemistry in their annually banded CaCO₃ skeleton.

• Skeletal P/Ca of various corals has recently been shown to track variations in seasonal nutrient upwelling.^{2,3}

• Corals incorporate more skeletal P as [PO₄³⁻] increases in the surrounding water.

• The incorporation mechanism for skeletal P is uncertain. Both organic and inorganic P have been suggested to be present; anionic substitution (PO₄³⁻ for CO₃²⁻) may occur, while coral polyps may also organically incorporate P into the skeleton during calcification.²



In this coral taken from the Gulf of Panama, Sr/Ca peaks indicate cooler temperatures due to upwelling; P/Ca peaks occur in-phase with Sr/Ca. (LaVigne et al., 2008)

III. LOCATION

Biscayne National Park, Florida

• Southeast of Miami, Florida, and east of Everglades National Park.

• Subject to runoff from a large urban area as well as agricultural areas.

• The area experiences large seasonal temperature variation but no significant coastal upwelling.



(Hudson et al., 1994)

IV. QUESTIONS

(Q1) Could skeletal P incorporation be affected by changes in seawater temperature as well as [PO₄³⁻] in seawater?

(Q2) In a low-nutrient environment, does P/Ca in *M. faveolata* record only dissolved phosphate?

(Q3) Were periods of coral decline in BNP through the last century a result of elevated nutrient input from early urban development (i.e. eutrophication)?

(Q4) Can a pre-anthropogenic baseline for seawater PO₄³⁻ in Biscayne NP be determined?



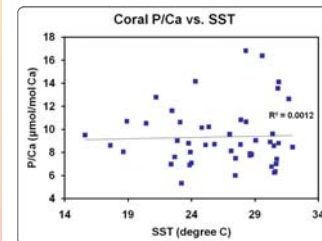
V. METHOD

• Eight discrete time windows over the last century were identified in the core using the coral's annual density bands.

• Powdered samples were drilled along the coral's growth axis at ~1mm resolution.

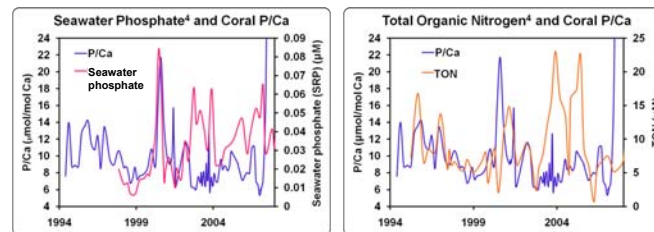
• Powders (~1 mg) were dissolved in acid and solutions were then analyzed using solution-phase ICP-MS.³

VI. RESULTS



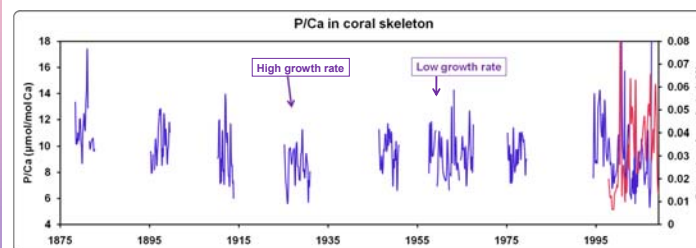
(Q1) P/Ca AND TEMPERATURE

- P/Ca values were regressed against a 15-year seasonal record of local sea surface temperature (SST) supplied by SERC⁴.
- No correlation between P/Ca and SST exists.
- This suggests that P/Ca is dependent on nutrient enrichment rather than SST.



(Q2) MODERN RECORD

- P/Ca tracks general trends in seawater phosphate as well as a peak in 2000.
- However, low level P/Ca variability appears to be also related to changes in total organic nitrogen (TON). Five of seven peaks show as P/Ca peaks.
- This suggests that in this low-nutrient environment, the coral P/Ca responds to seawater phosphate above a certain threshold.
- The relationship between P/Ca and TON (dominated by PON) suggests that at low [PO₄³⁻] other factors such as feeding could affect skeletal P incorporation.



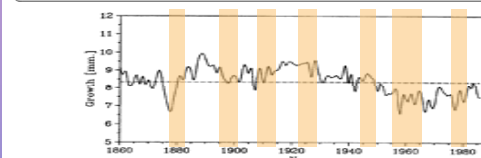
(Q3, Q4) LONG-TERM RECORD

• P/Ca values show very little long-term trend throughout the 120-year record. Periods of low growth rates (1956 to 1977) and periods of higher growth rates (1900 to 1930) have similar P/Ca values.

• [PO₄³⁻] in seawater has apparently remained at a relatively low and stable level (0.02 – 0.06 μM) since 1878.

• We conclude that nutrient loading did not cause the decline in coral growth rates in Biscayne National Park.

• The record does show subtle long-term trends in P/Ca; these trends, however, could be due to growth rate affecting incorporation of P into the coral skeleton.



Average growth rate for *Montastrea faveolata* in Biscayne Bay over the past century. The highlighted time periods are the windows analyzed. (Hudson et al., 1994)

VII. CONCLUSIONS

• P/Ca is NOT dependent on SST.

• In a low-nutrient environment, P/Ca is dependent on the concentrations of a number of different nutrients, possibly because of feeding.

• In such a setting, P/Ca tracks large peaks (>~0.06 μM) in seawater [PO₄³⁻].

• Seawater PO₄³⁻ in Biscayne National Park has remained relatively stable for the past 120 years.

• Eutrophication as a result of high levels of PO₄³⁻ due to development of nearby urban centers (such as Miami) has not been the cause of coral growth rate decline.

• Changes in growth rate may be due to large influxes of nitrates or climate change.

VIII. FUTURE WORK

• Why, at these low concentrations, does P/Ca track TON as well as phosphate? Does P/Ca incorporation vary in different environments?

• Can we mathematically model how phosphate and TON control P/Ca? What is the threshold for tracking phosphate?

• If nitrate played a big role in past eutrophication, how else might past runoff be investigated? What might other elements (Ba, Y) tell about runoff or productivity?

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References:

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