

Coral Reefs and Ocean Acidification

Effects of an Unsustainable Energy System



A talk by Dr. Ken Caldeira,
of the Carnegie Institution for Science

6pm Tuesday, Aug. 2
ACES at Hallam Lake
100 Puppy Smith St., Aspen

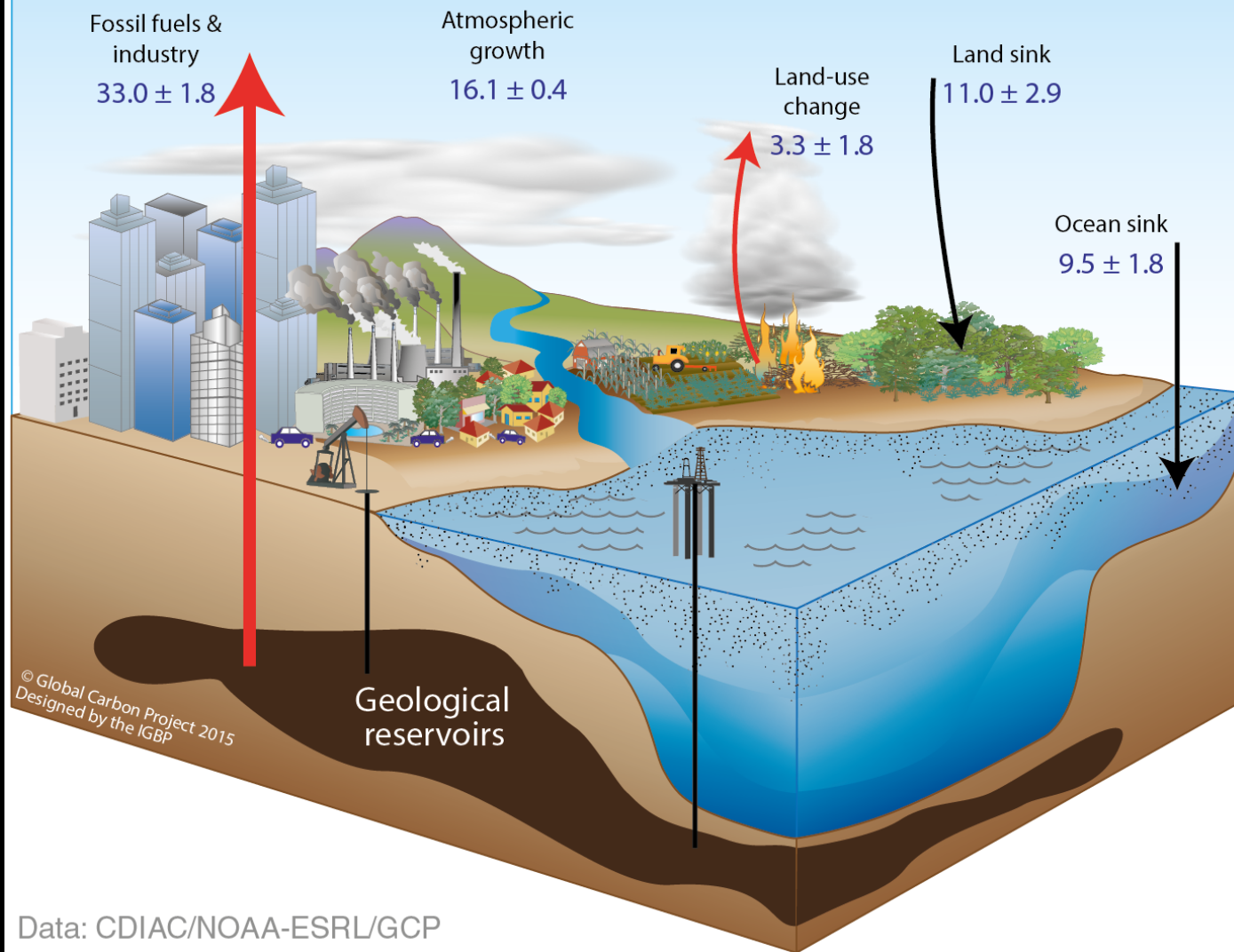
Free Public Lecture
Wine and cheese reception to follow





Global carbon dioxide budget (gigatonnes of carbon dioxide per year)

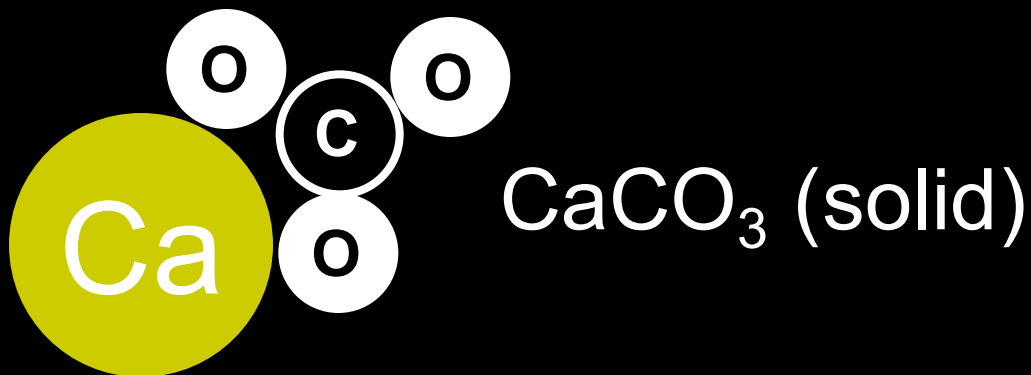
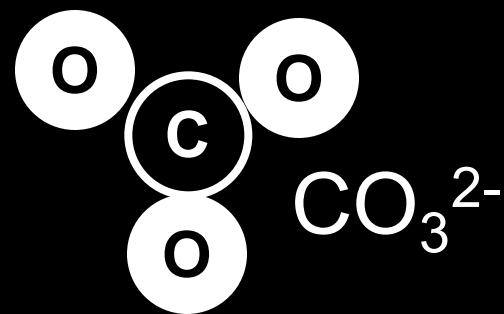
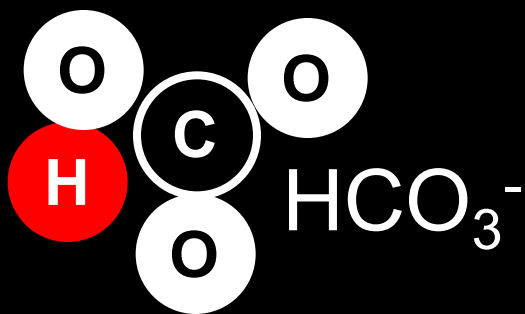
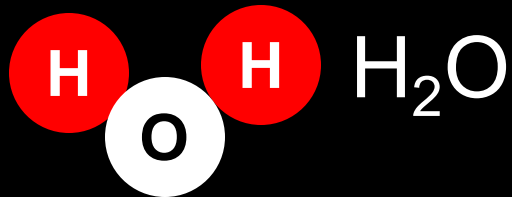
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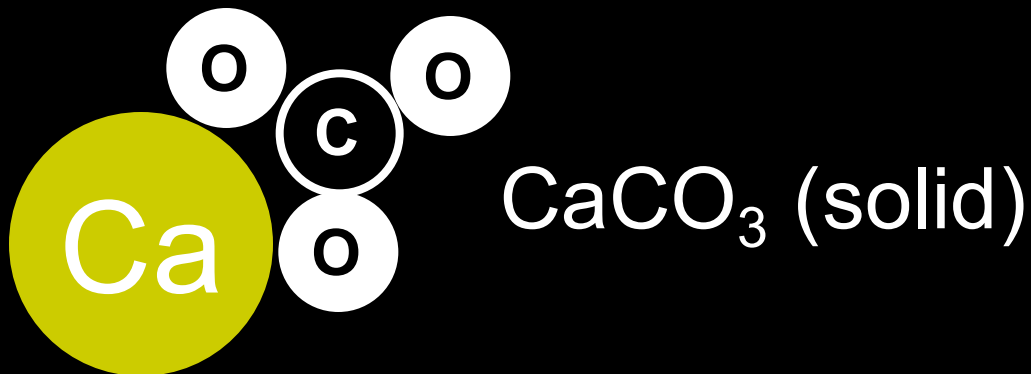
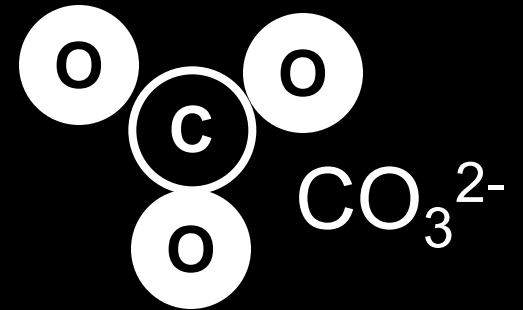
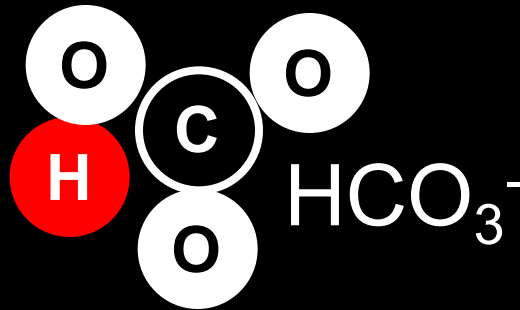
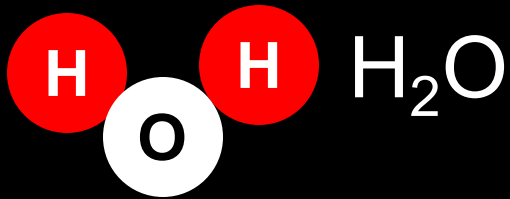
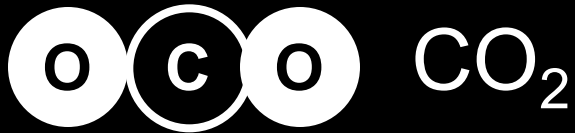
Data: CDIAC/NOAA-ESRL/GCP

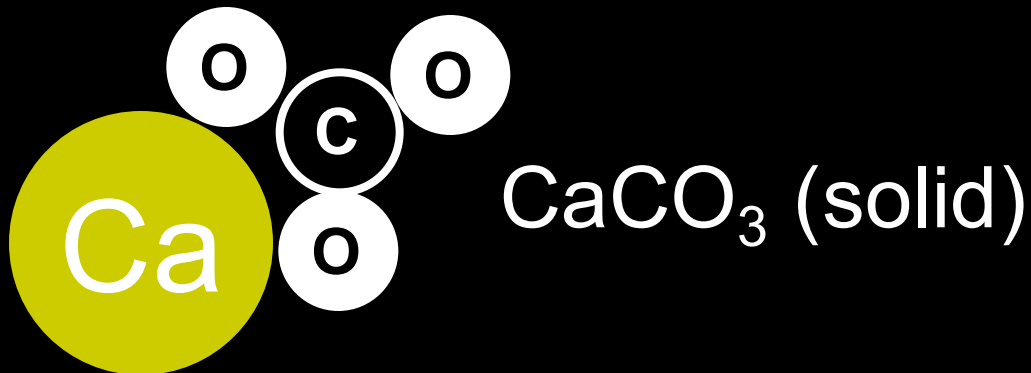
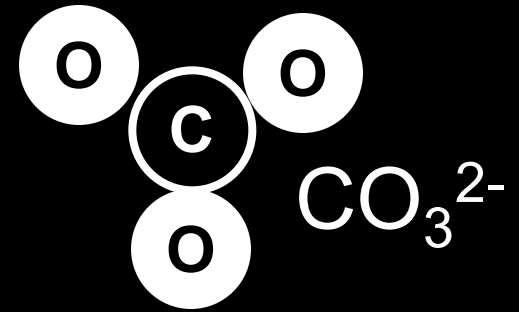
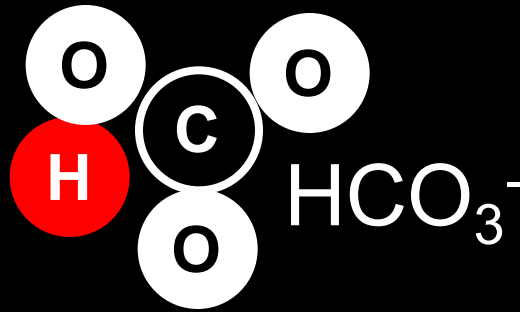
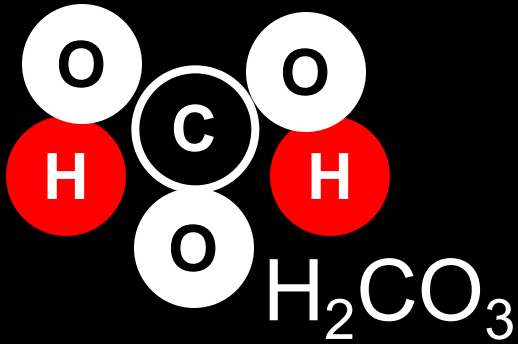
Source: [CDIAC](#); [NOAA-ESRL](#); [Le Quéré et al 2015](#); [Global Carbon Budget 2015](#)

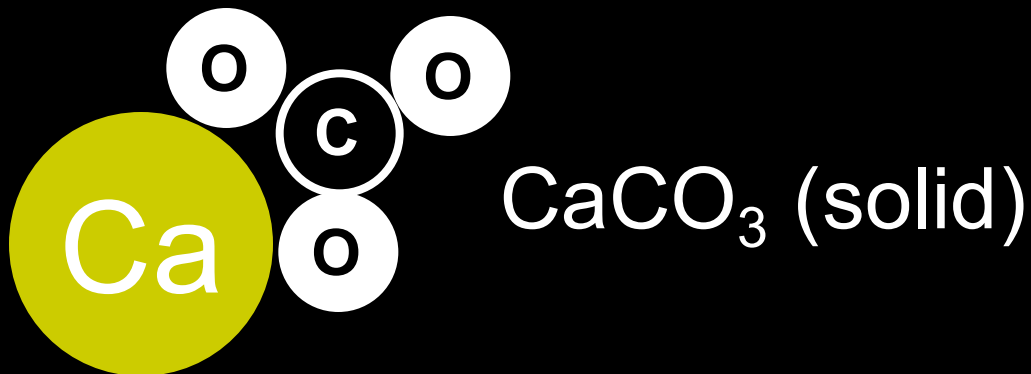
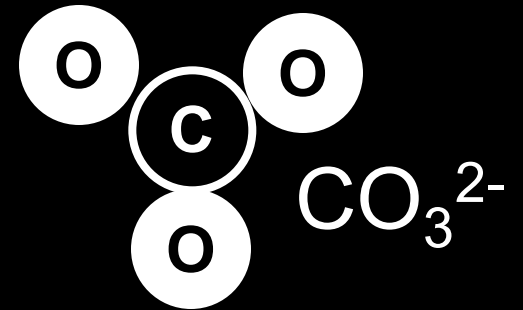
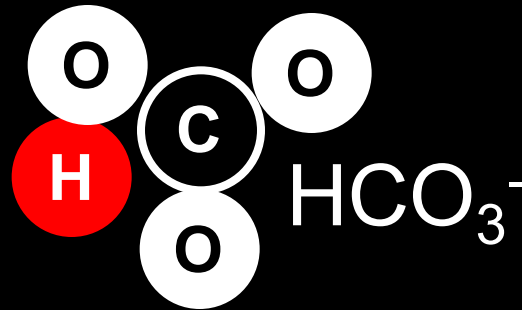
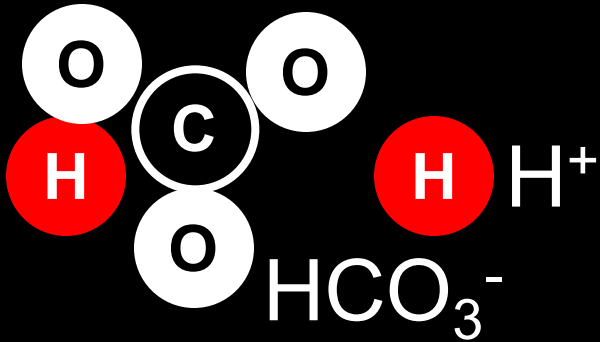
Ocean carbonate chemistry

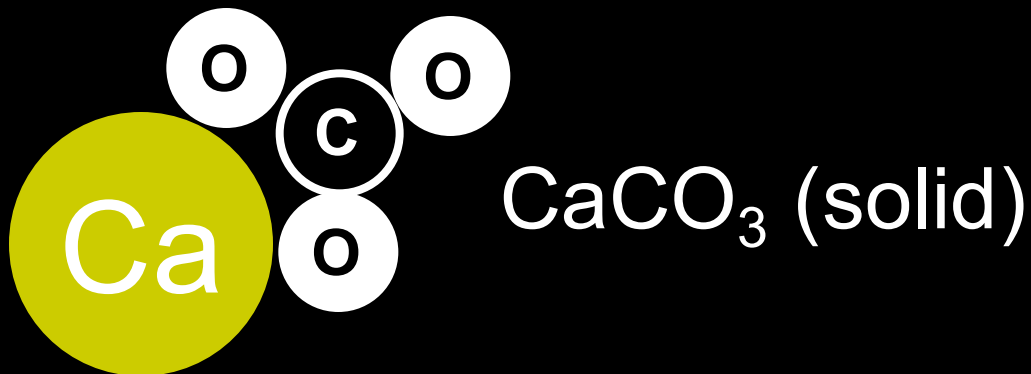
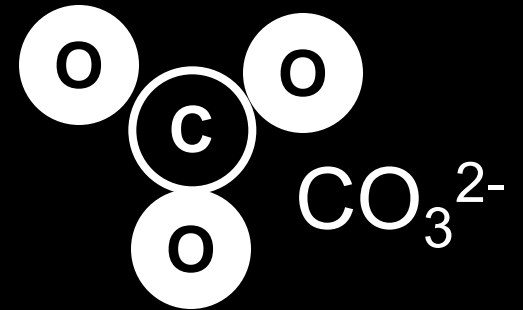
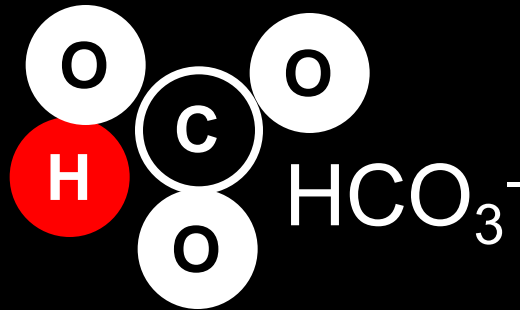
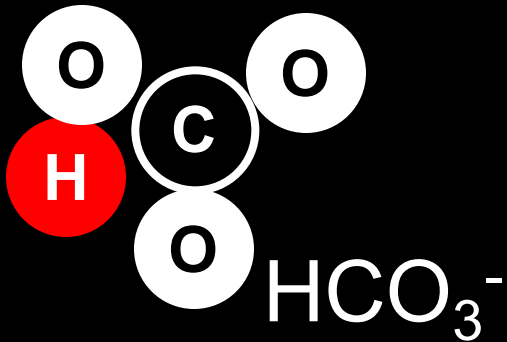


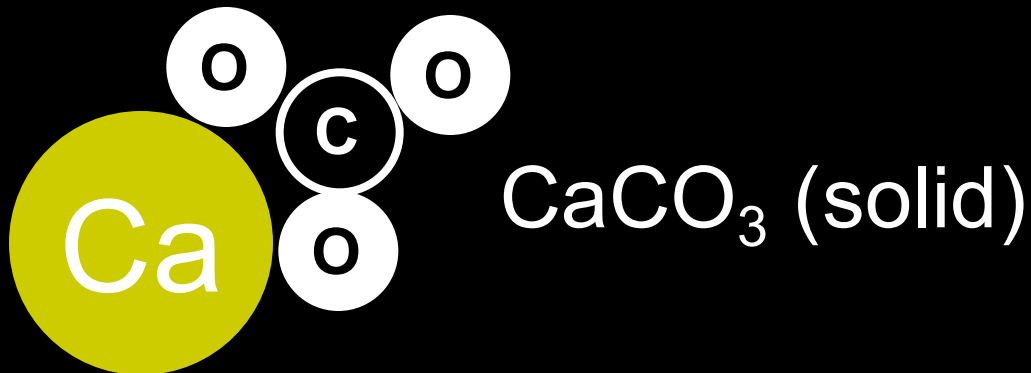
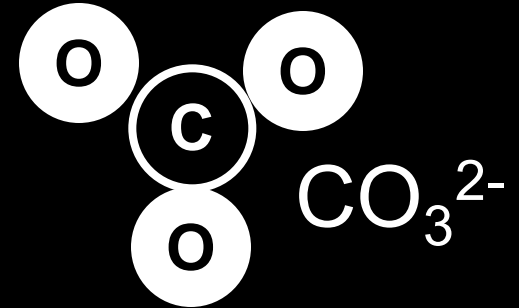
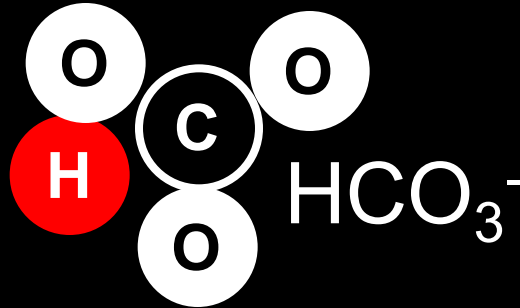
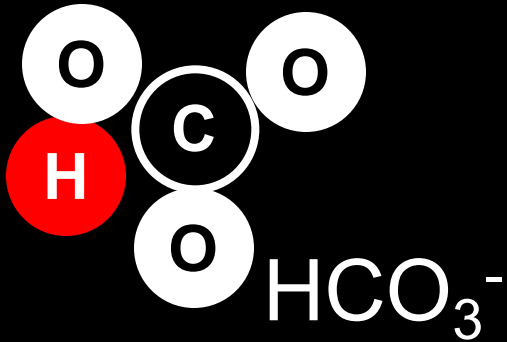
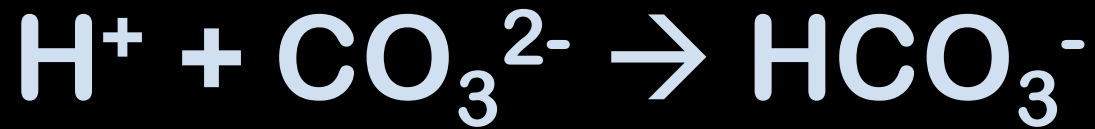
Addition of CO₂

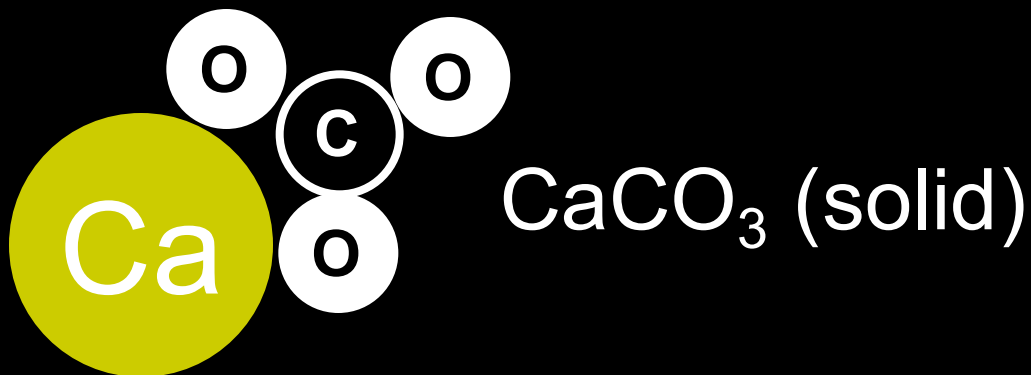
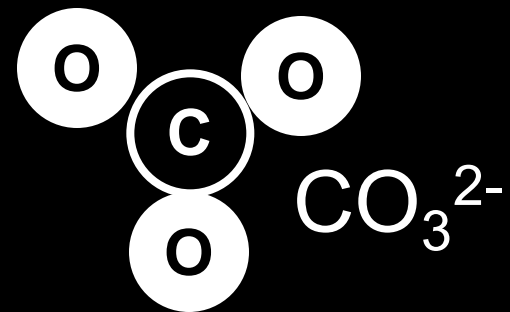
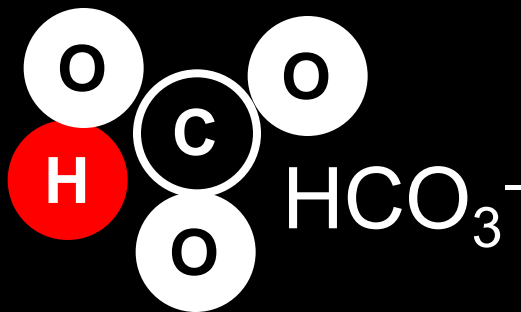
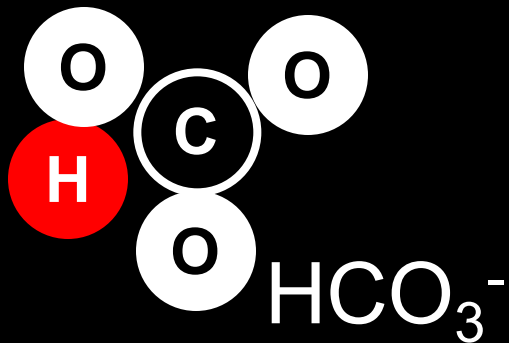
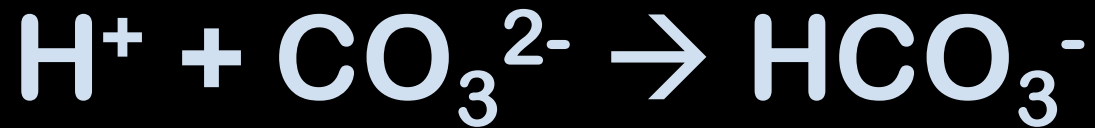


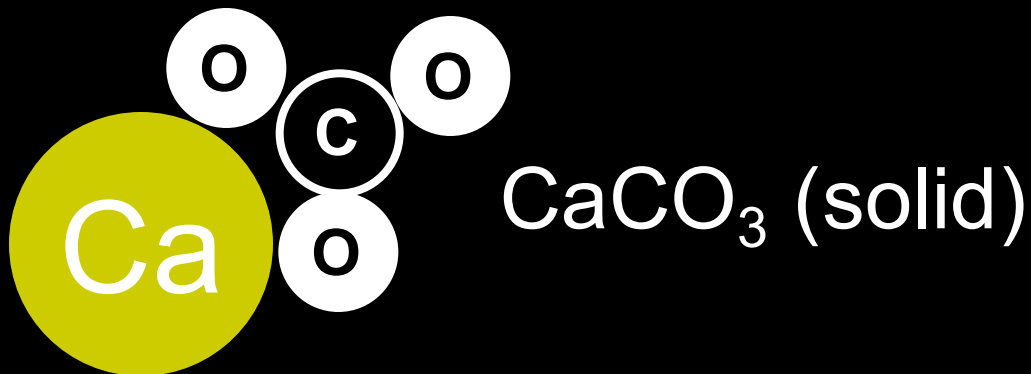
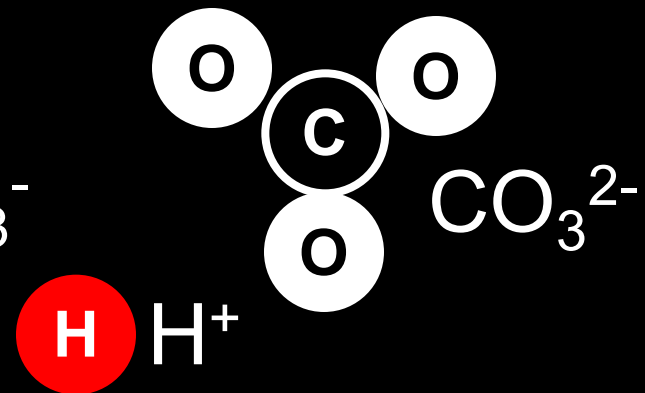
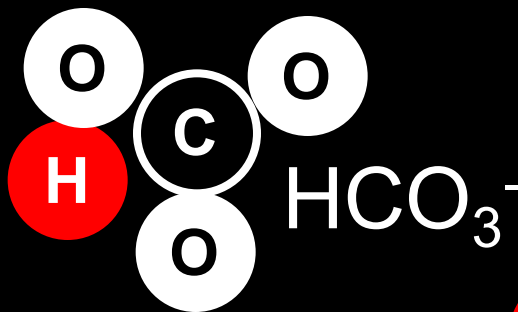
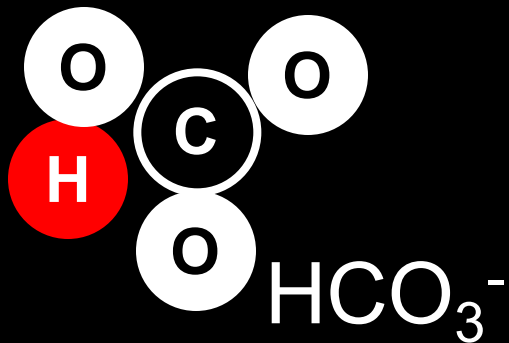
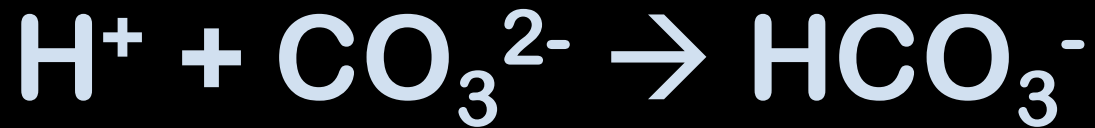


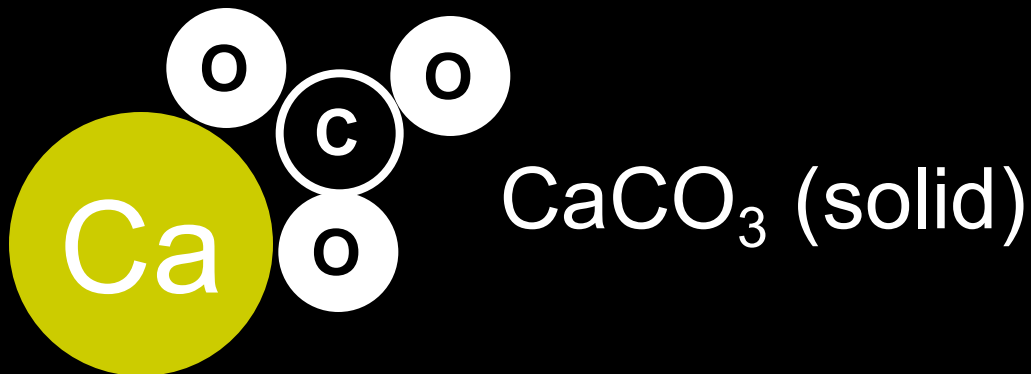
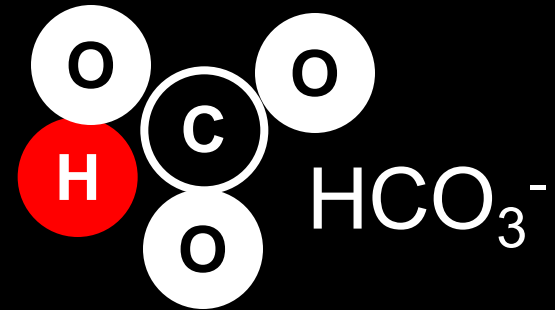
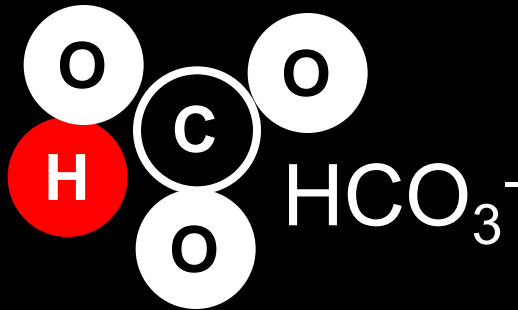
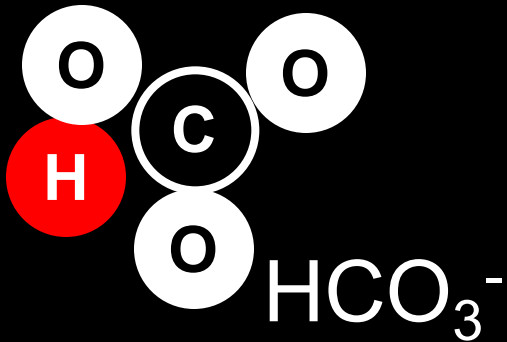
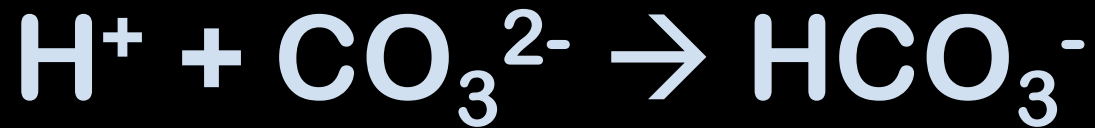


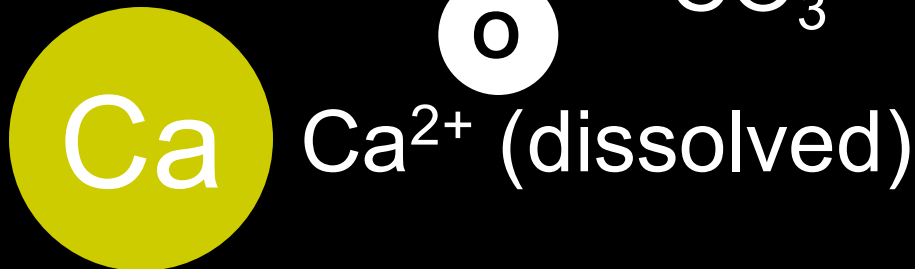
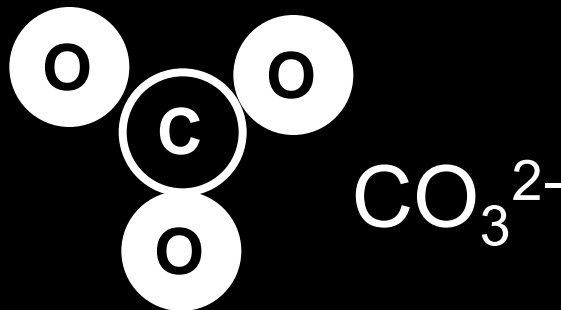
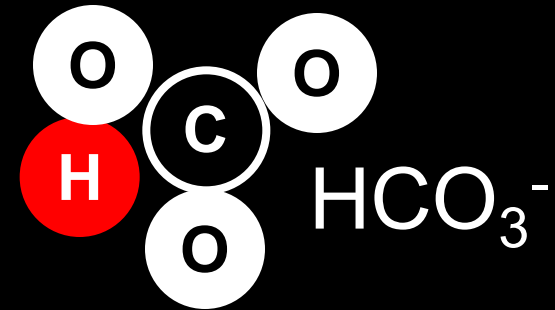
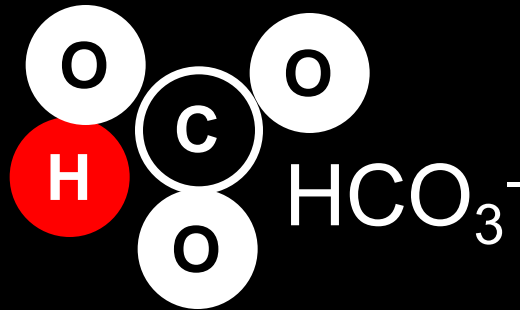
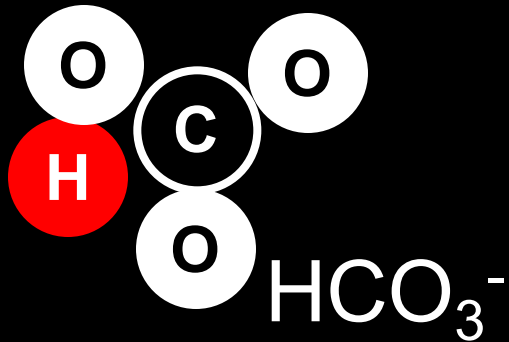


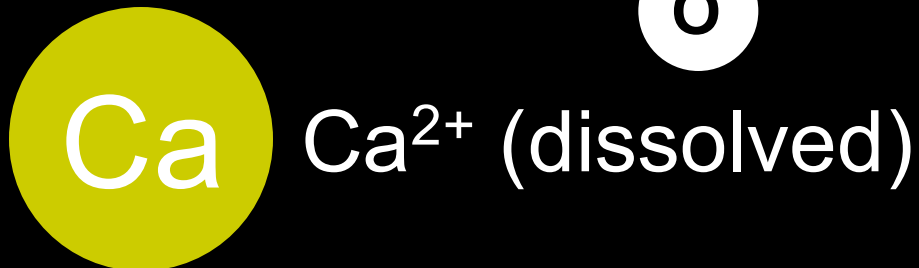
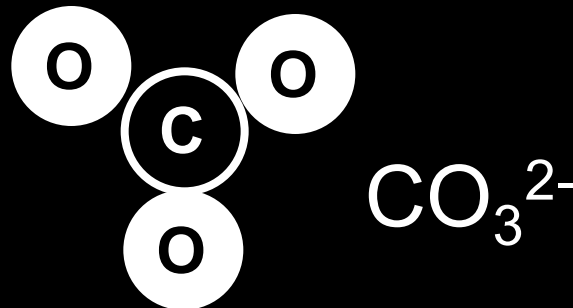
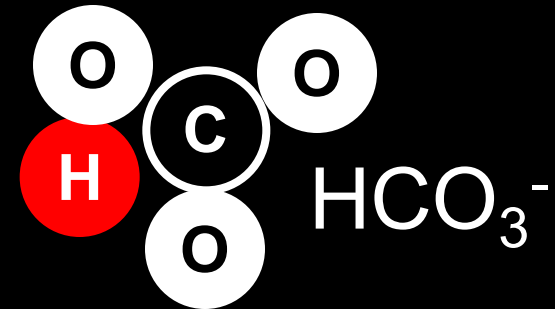
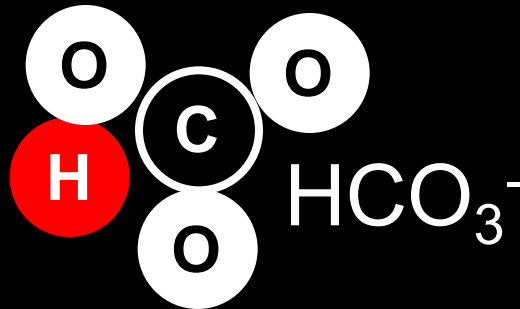
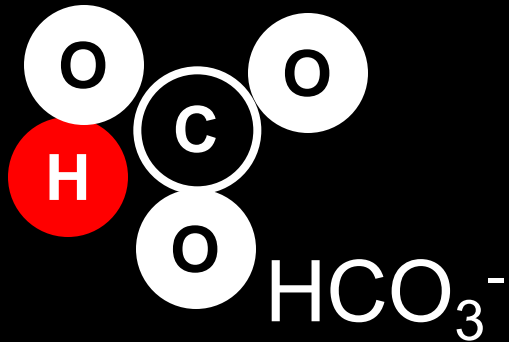


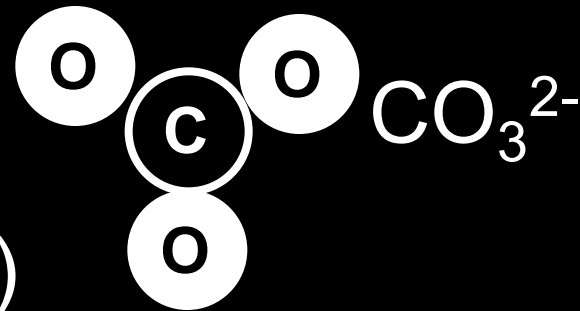
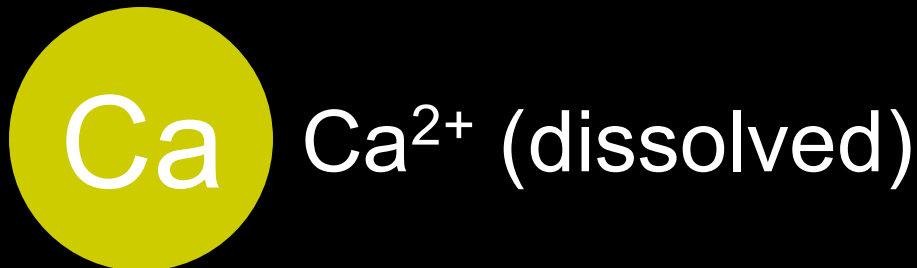
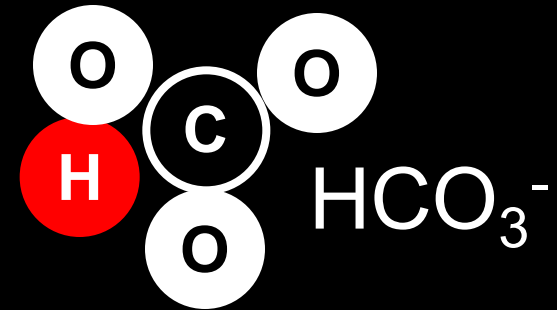
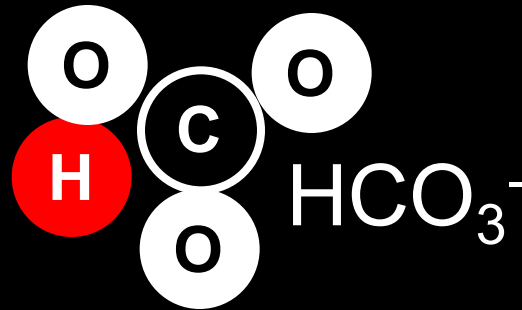
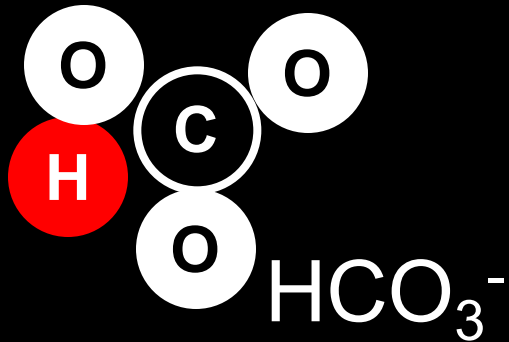


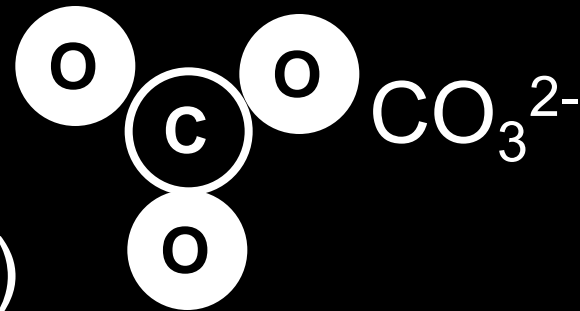
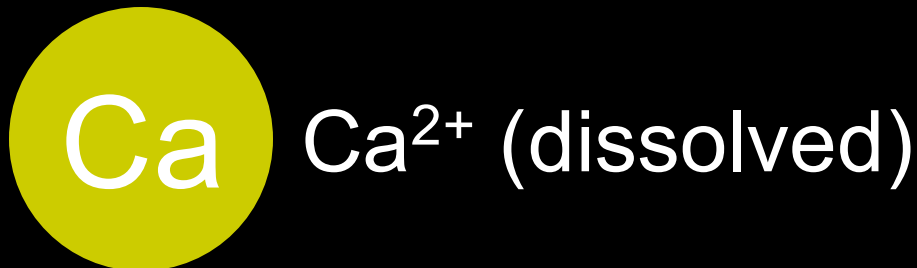
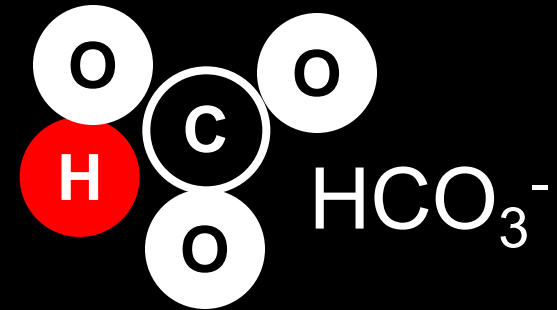
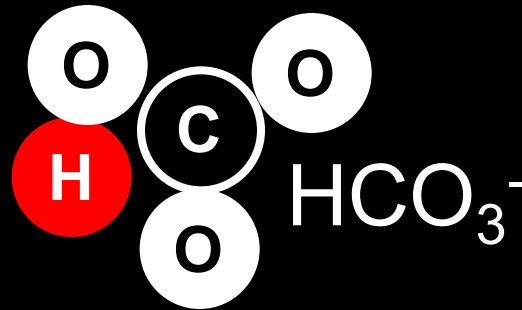
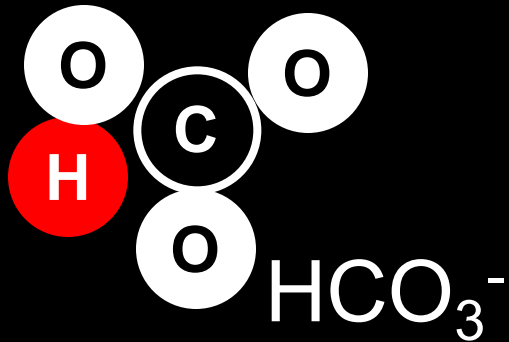










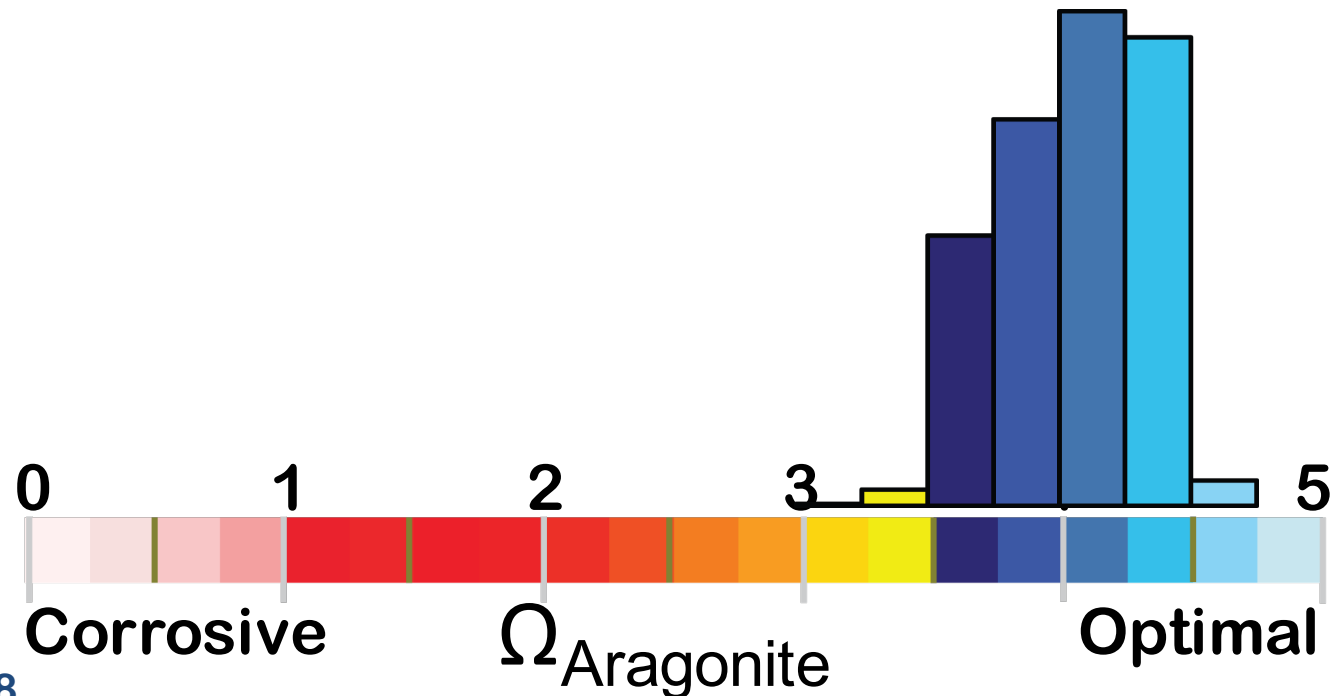
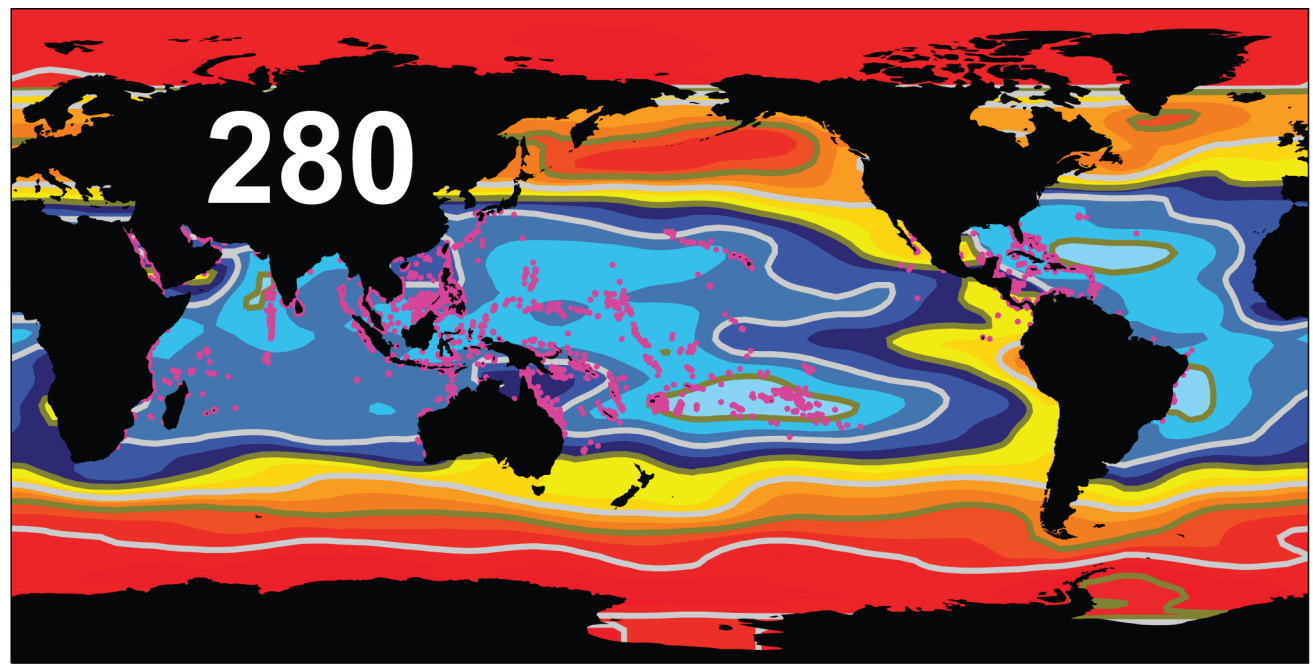


Distribution of corals and ocean acidification

Carbon
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Coral reef
distribution,

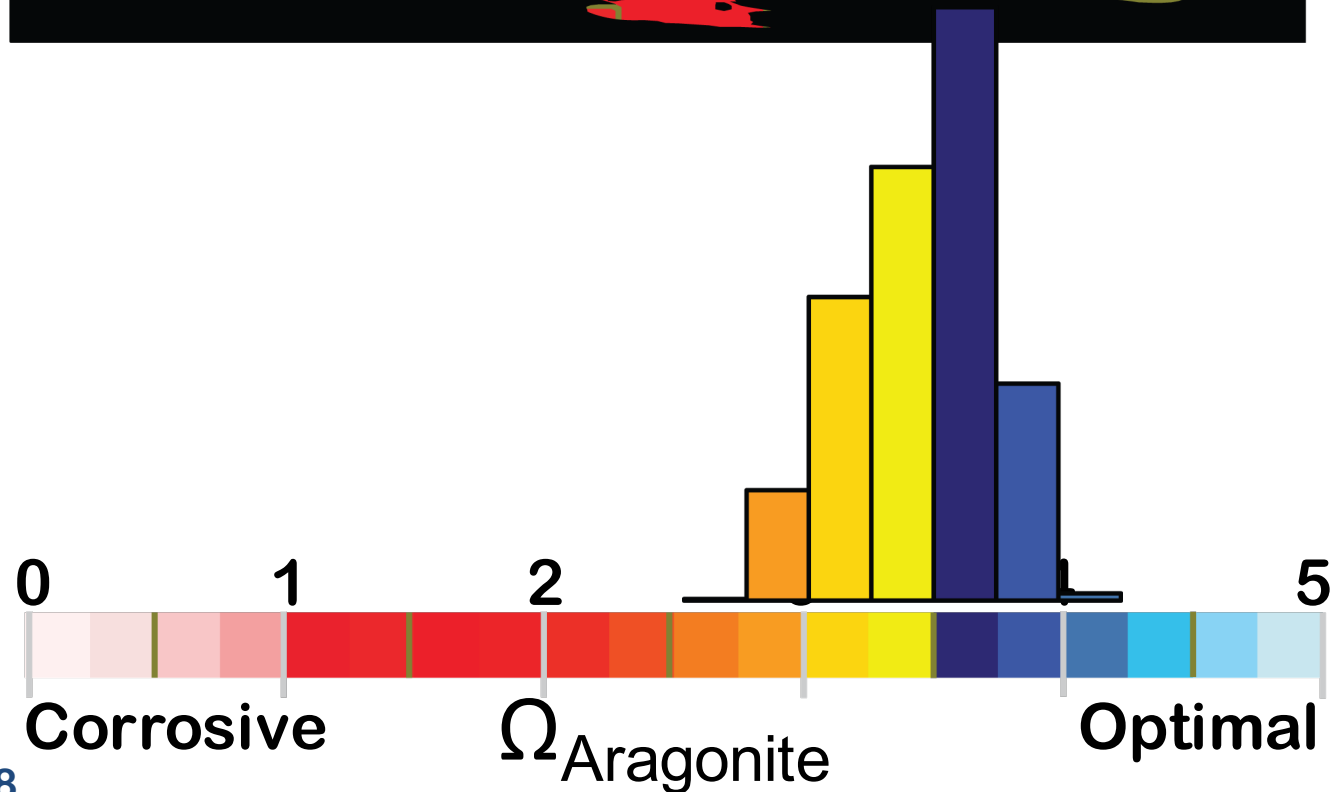
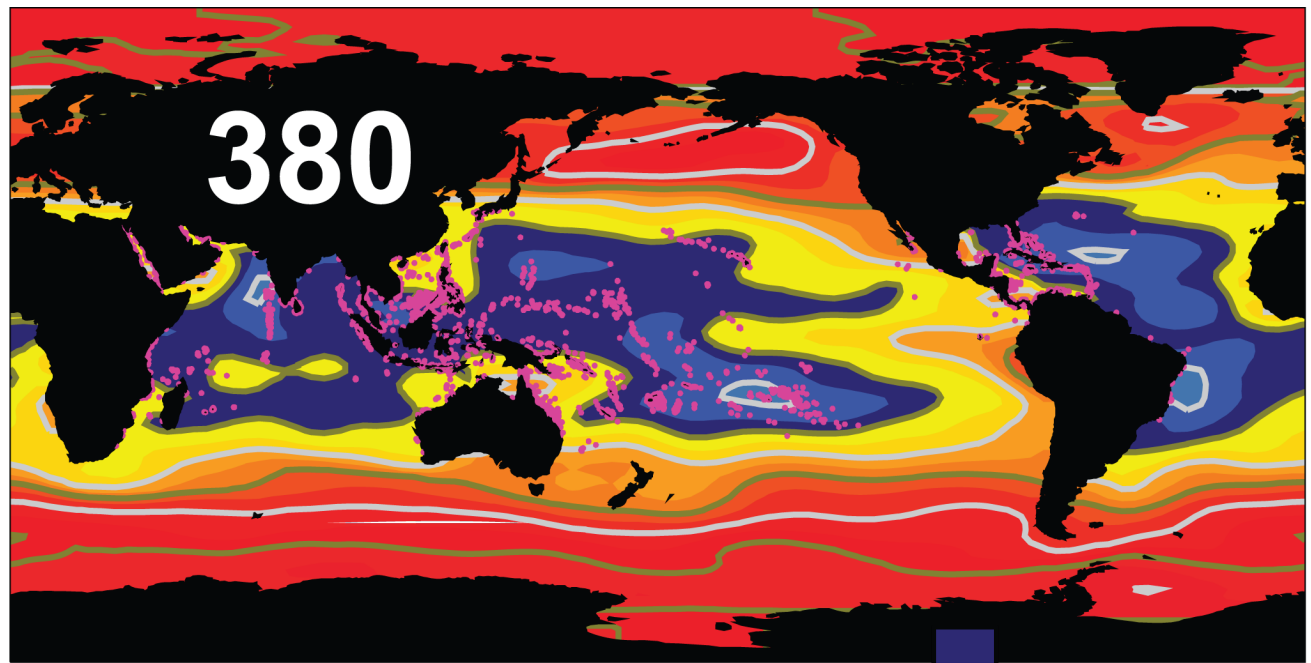
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conditions
helping
drive reef
formation



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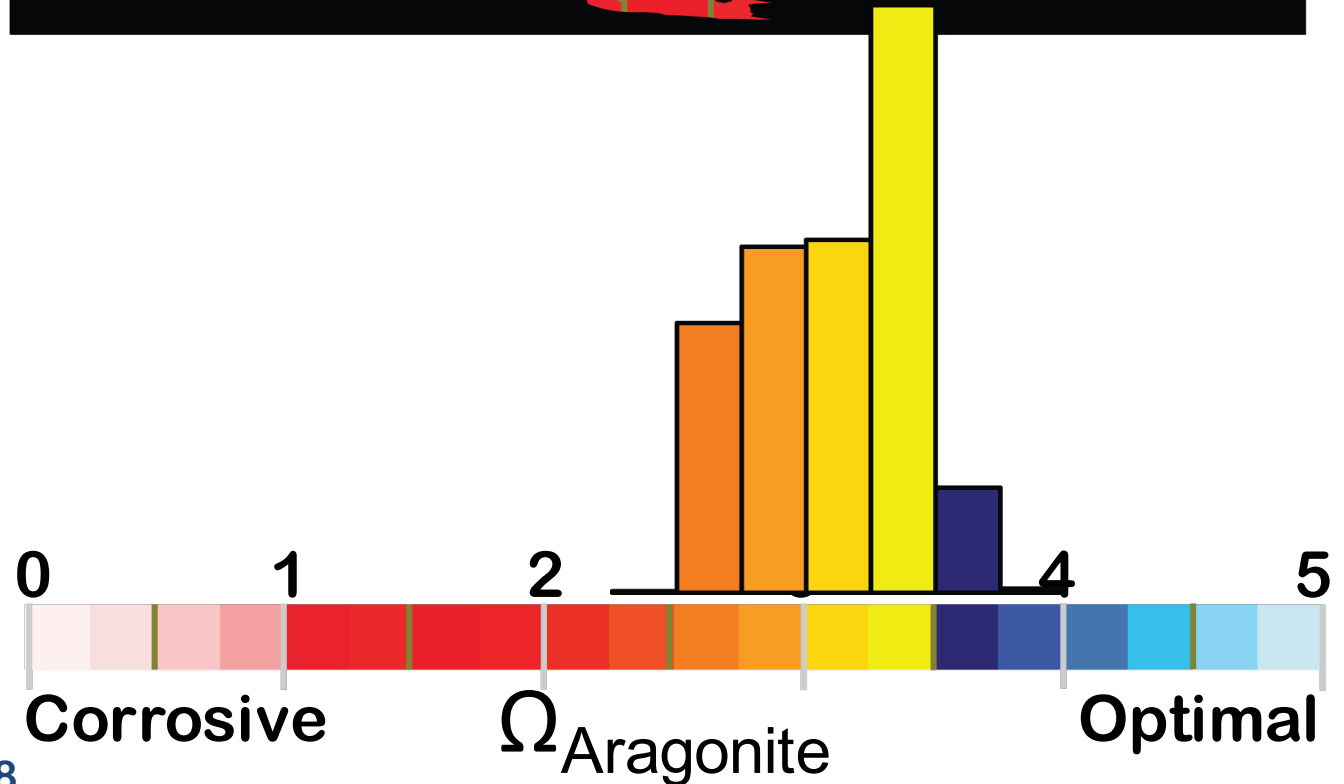
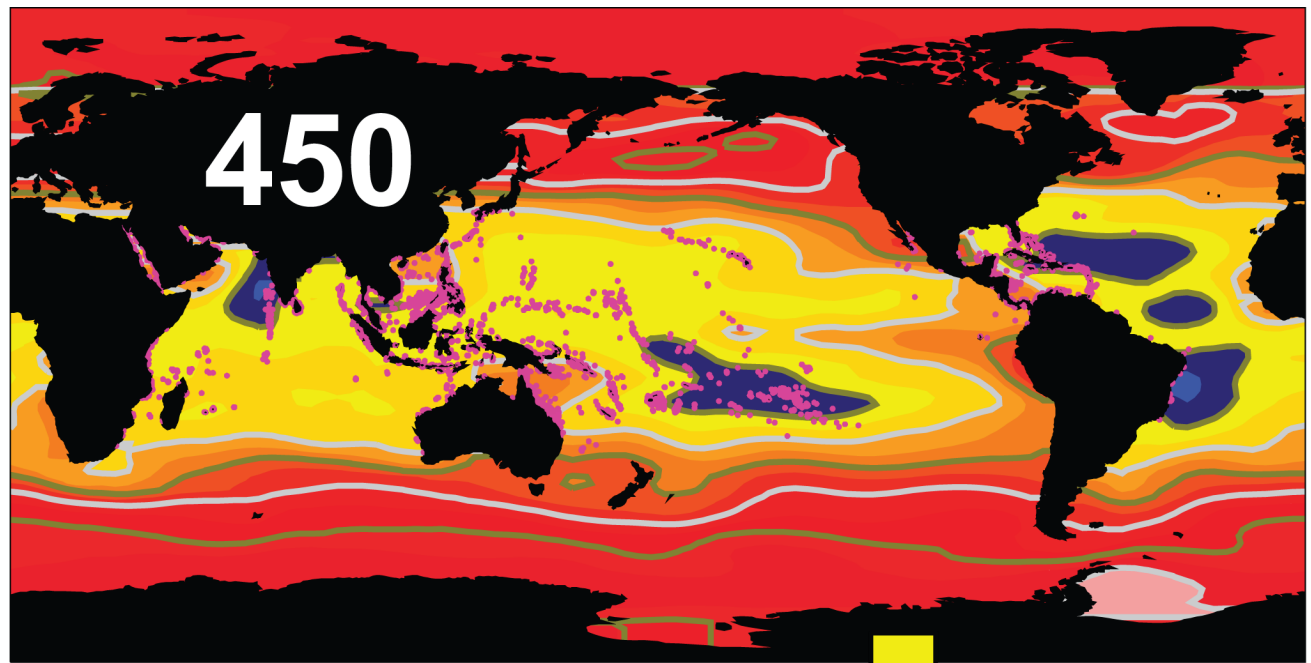
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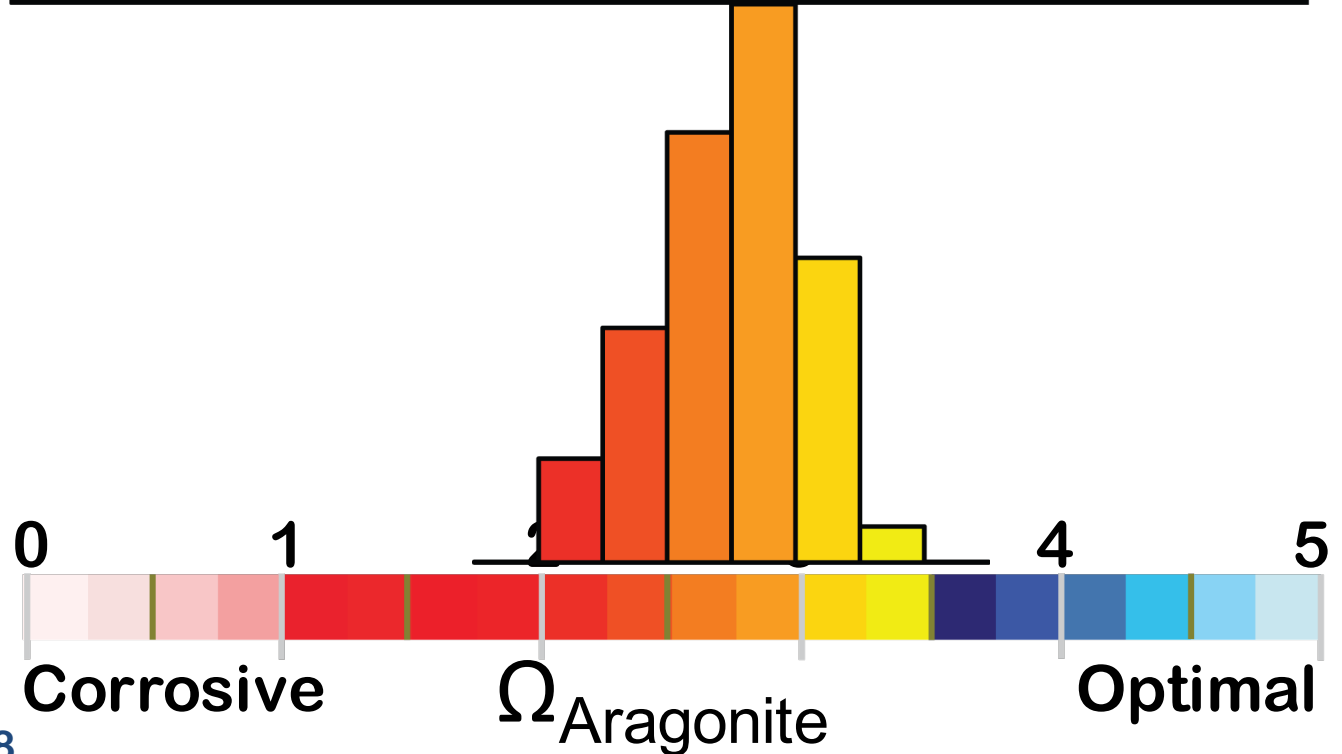
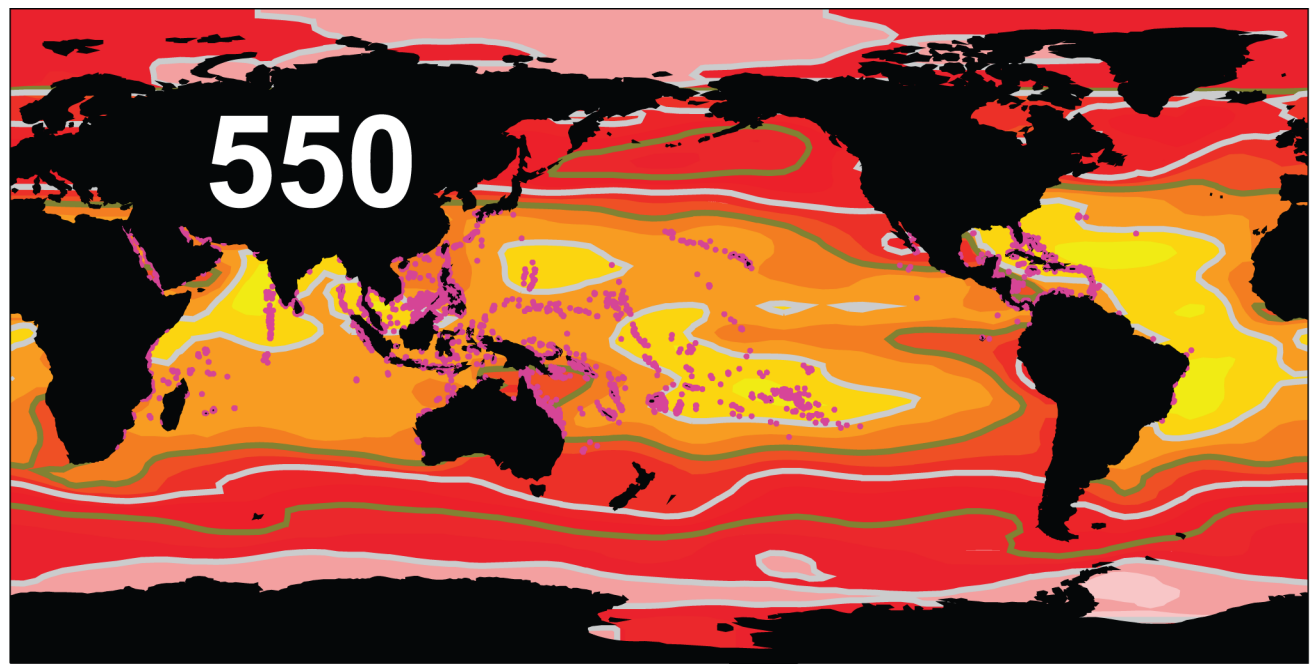
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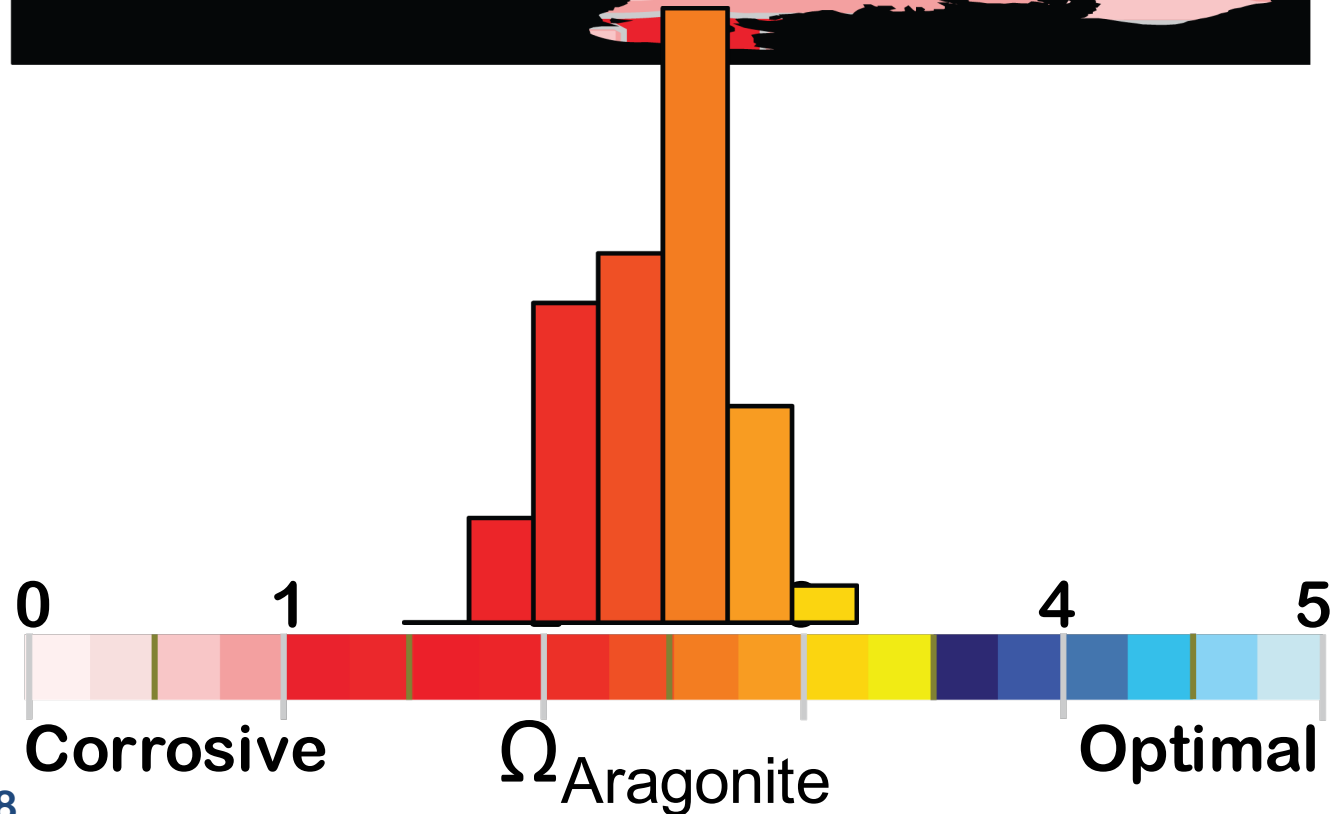
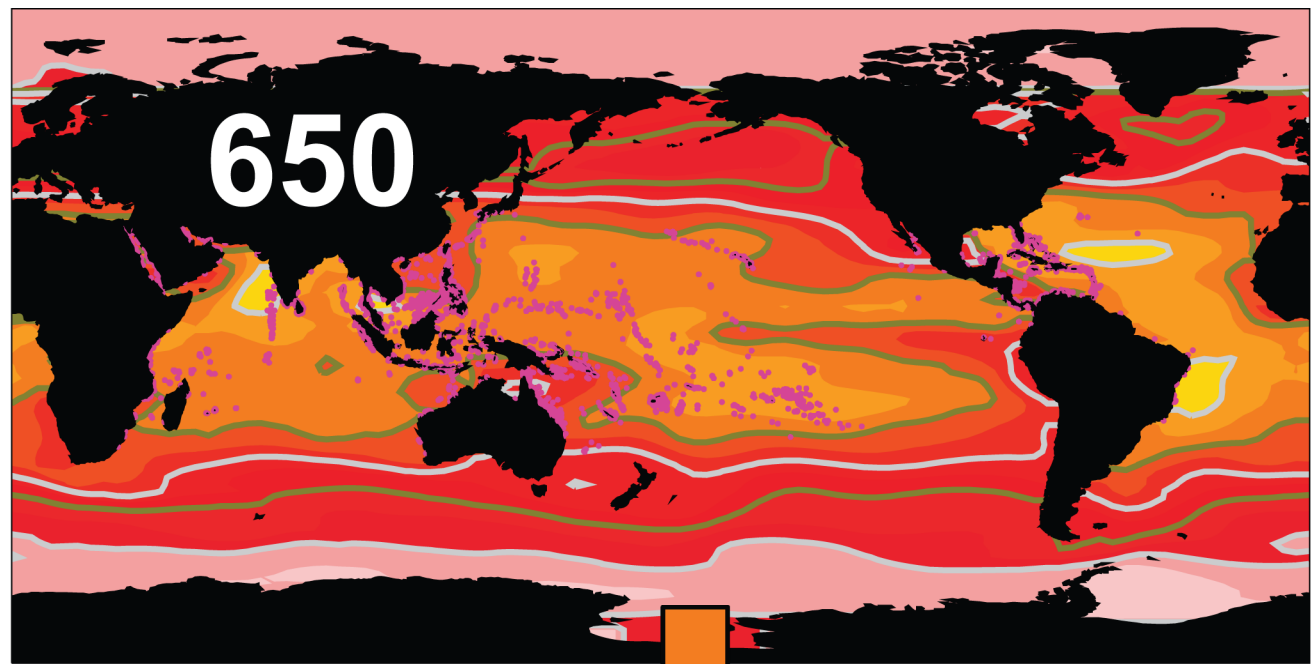
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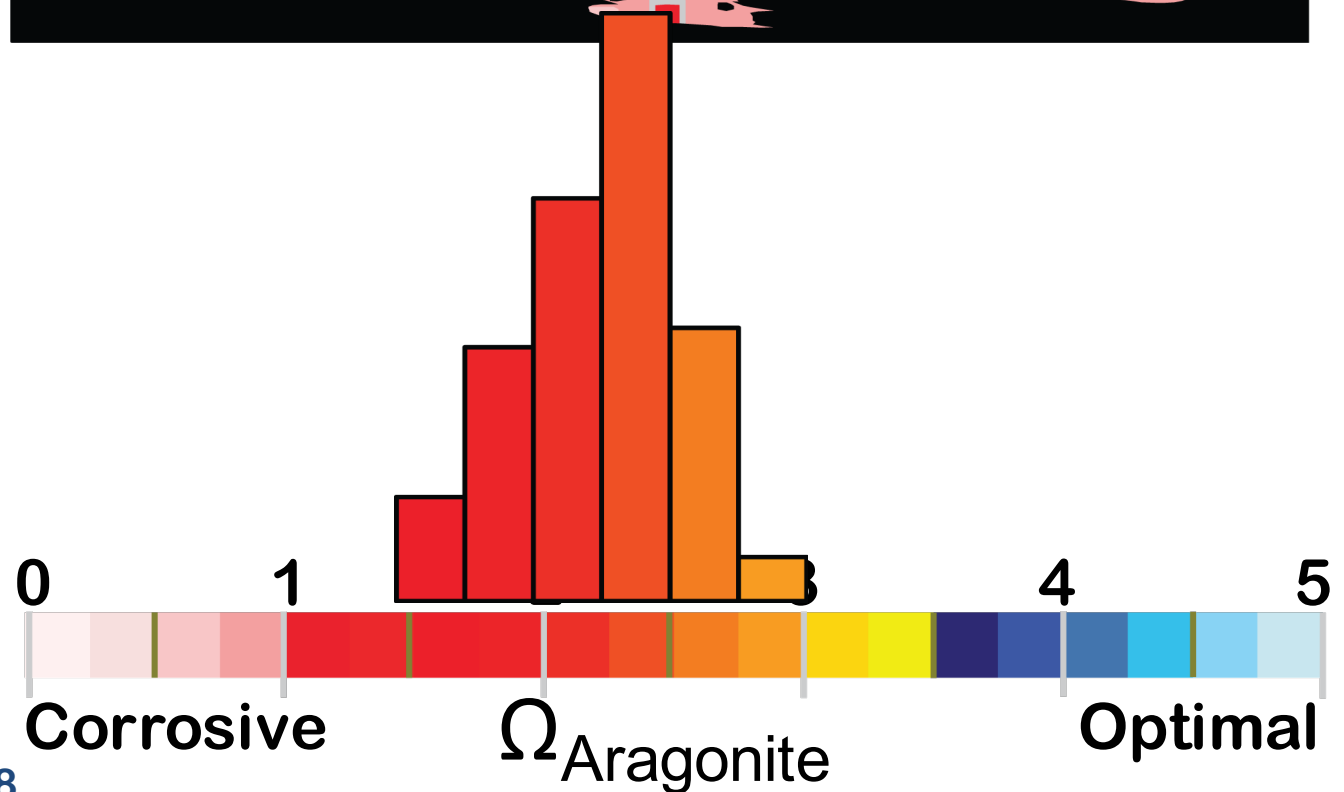
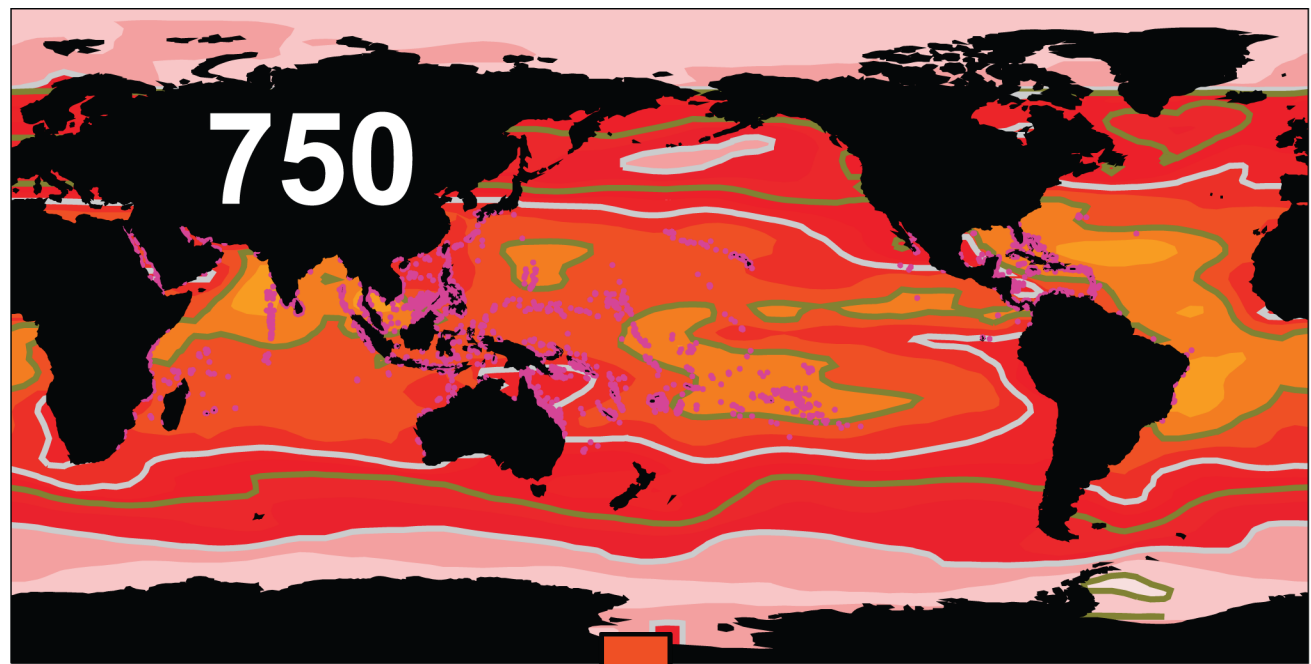
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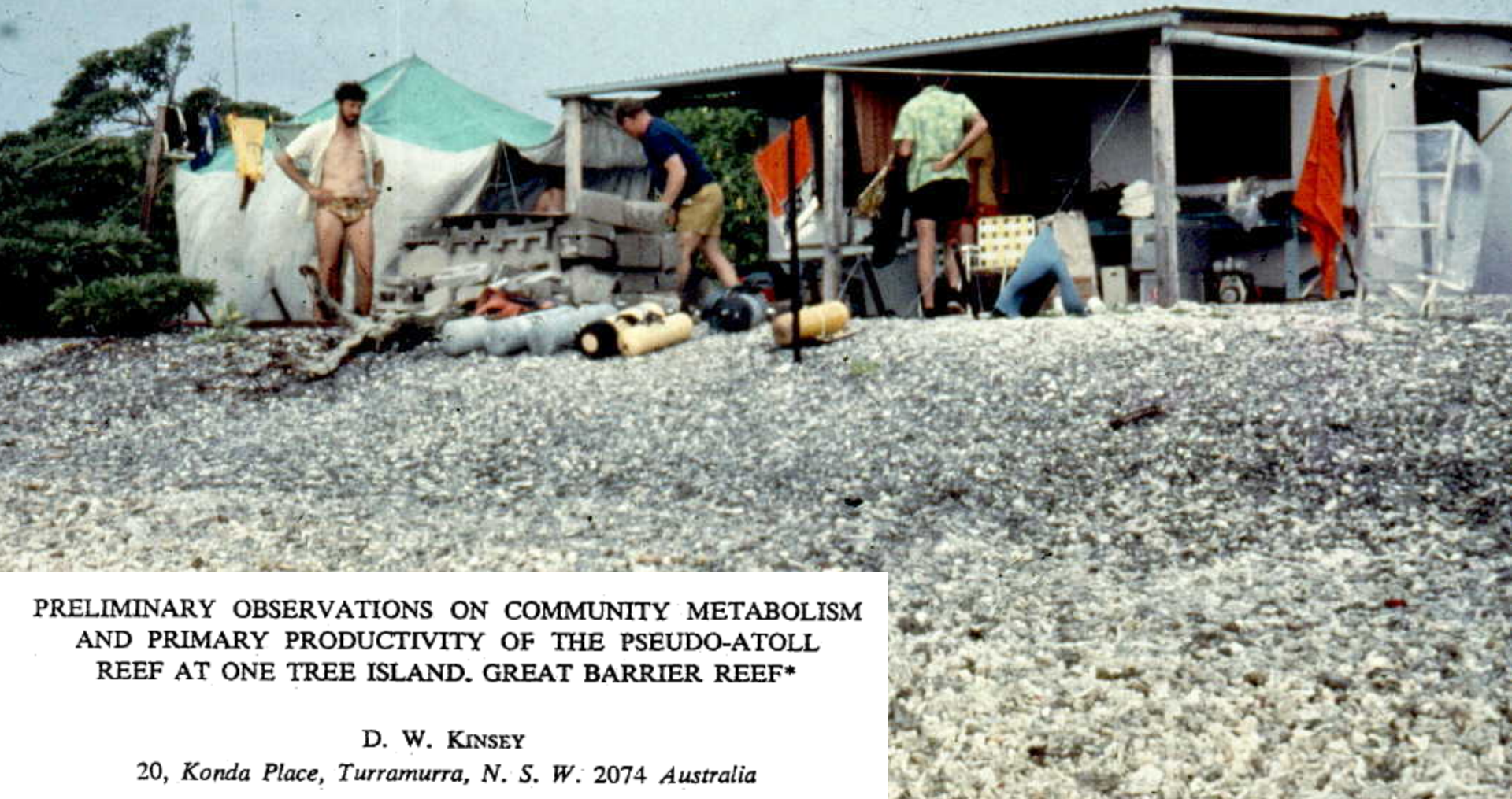
Carbon
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Kinsey expeditions to the Great Barrier Reef (late 1960s to early 1980s)



PRELIMINARY OBSERVATIONS ON COMMUNITY METABOLISM
AND PRIMARY PRODUCTIVITY OF THE PSEUDO-ATOLL
REEF AT ONE TREE ISLAND. GREAT BARRIER REEF*

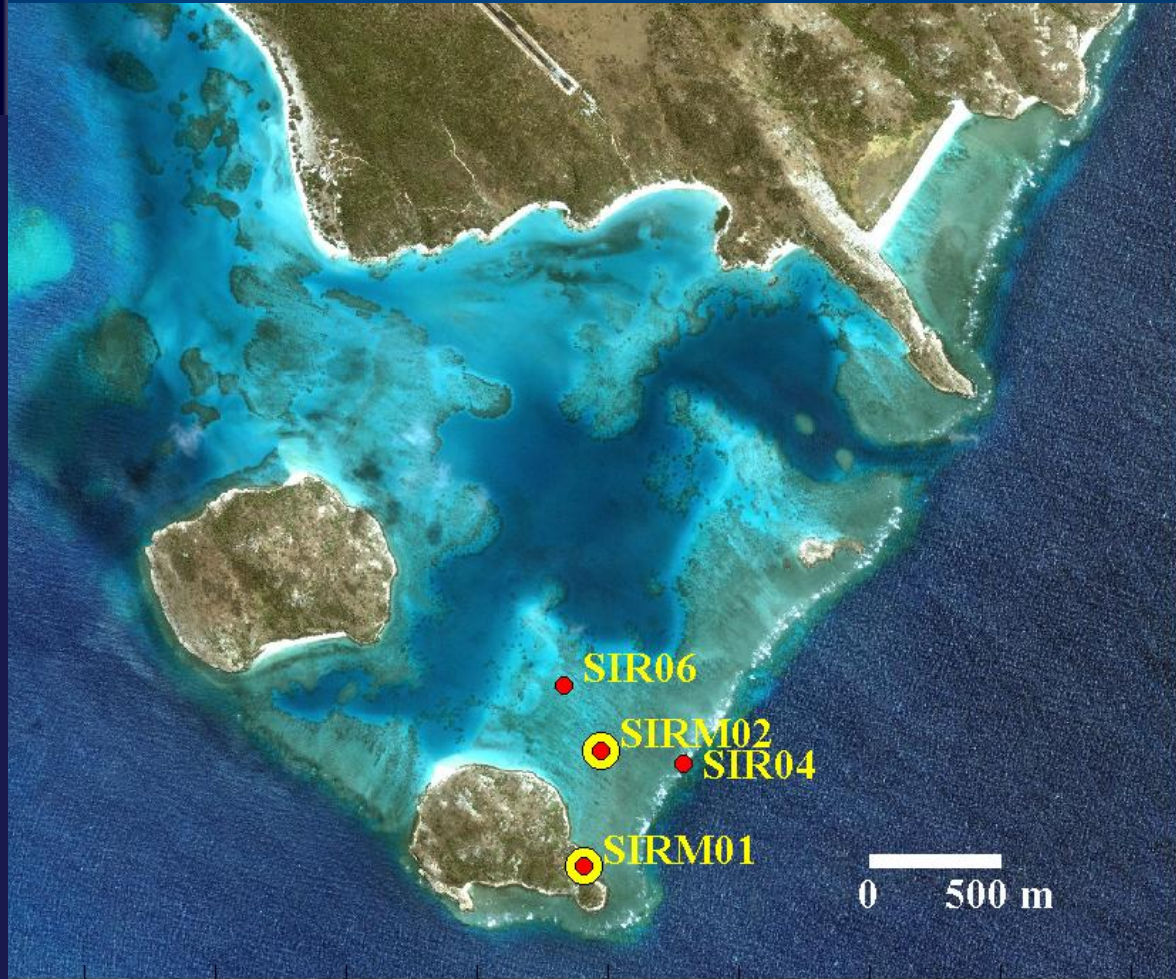
D. W. KINSEY

20, Konda Place, Turramurra, N. S. W. 2074 Australia



Lizard Island Expeditions

September 2008
November 2009





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**Geochimica et
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Acta**

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Community calcification in Lizard Island, Great Barrier Reef: A 33 year perspective

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Abstract

Measurements of community calcification (G_{net}) were made during September 2008 and October 2009 on a reef flat in Lizard Island, Great Barrier Reef, Australia, 33 years after the first measurements were made there by the LIMEX expedition in 1975. In 2008 and 2009 we measured $G_{\text{net}} = 61 \pm 12$ and 54 ± 13 mmol $\text{CaCO}_3 \text{ m}^{-2} \cdot \text{day}^{-1}$, respectively. These rates are 27–49% lower than those measured during the same season in 1975–76. These rates agree well with those estimated from the measured temperature and degree of aragonite saturation using a reef calcification rate equation developed from obser-

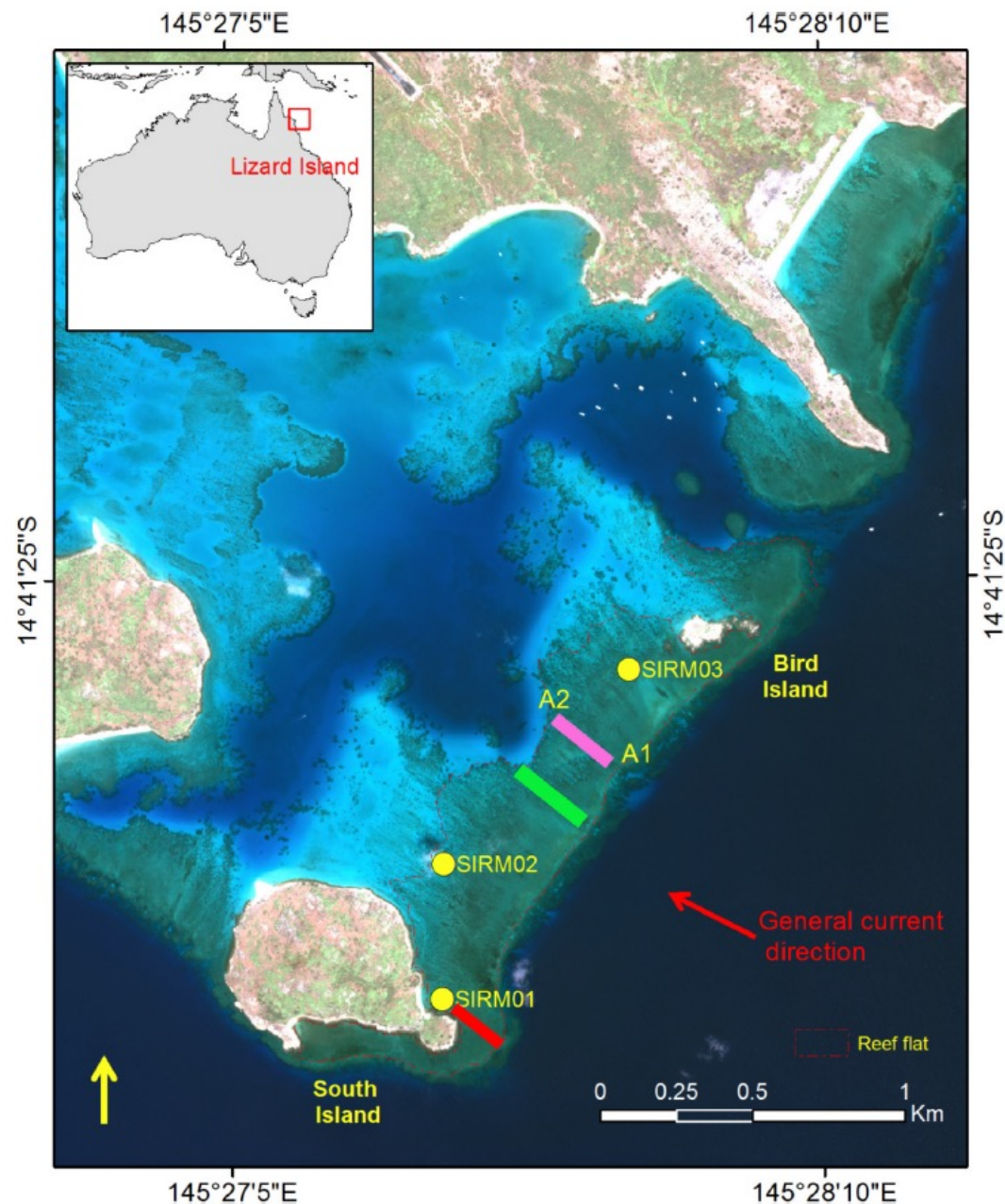
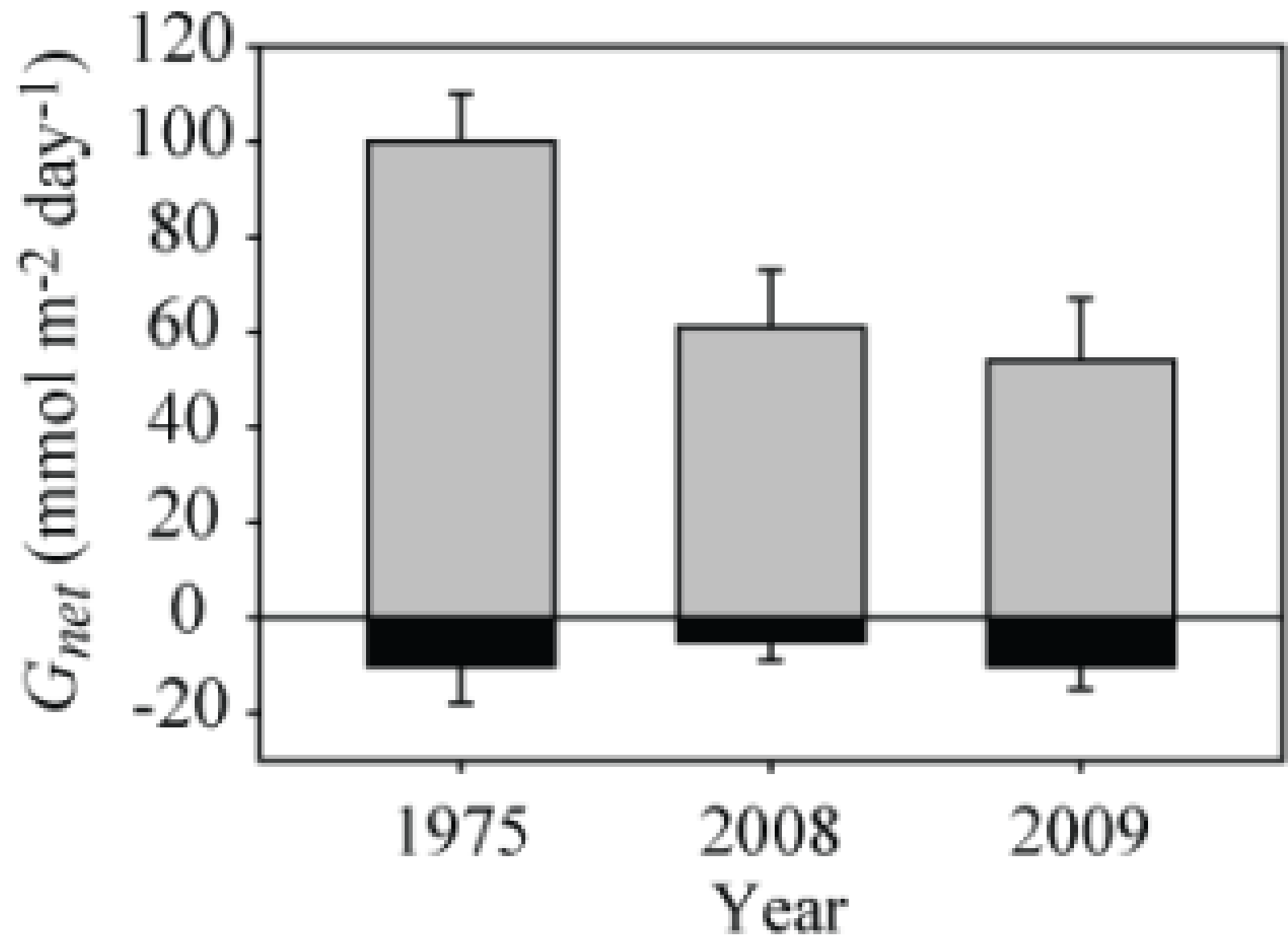


Fig. 2. Location map and aerial photo of Lizard Island and South Island reef flat study site. During 1975–76 transect measurements were made along lines A1 and A2 (LIMER 1975, 1976). In this study G_{net} was measured at SIRM01 (2008–09), SIRM02 (2008) and SIRM03 (2009). Benthic community surveys were conducted along the red line and green line, which is also in the region of the reef surveyed by Pichon and Morrissey in 1979 (1981). The red dashed line outlines the reef flat as defined by the IKONOS image classification. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)



Net Coral Skeletal Growth Rate Measured at Lizard Island



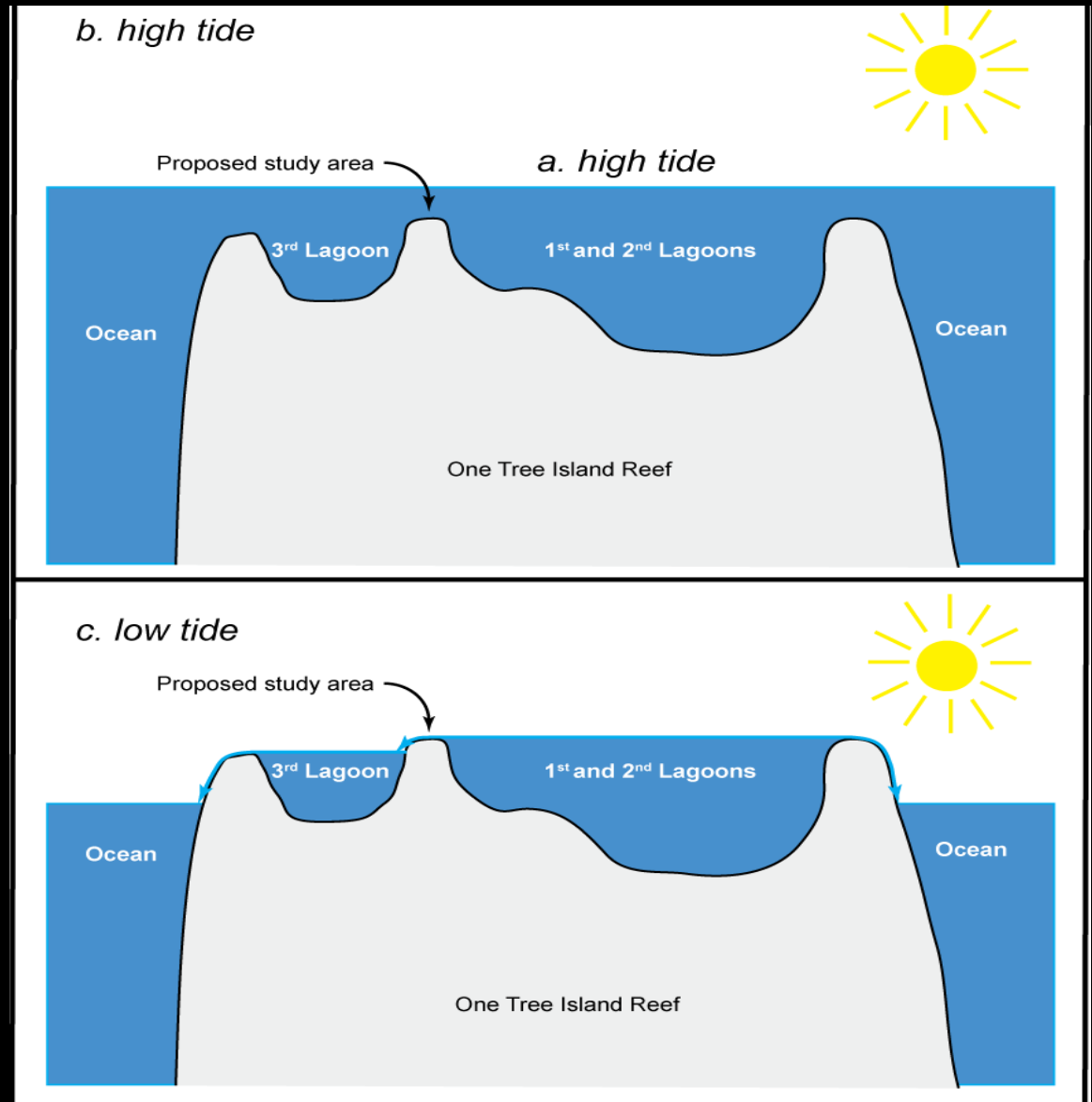


One Tree Island Expedition December 2009



Water ponds at different levels in different lagoons at low tide.

Some flow over sills.



Carbon turnover rates in the One Tree Island reef: A 40-year perspective

J. Silverman,¹ D. I. Kline,² L. Johnson,³ T. Rivlin,⁴ K. Schneider,⁶ J. Erez,⁵ B. Lazar,⁵
and K. Caldeira⁶

Received 2 February 2012; revised 21 June 2012; accepted 21 June 2012; published 18 August 2012.

[1] During November–December 2009 community rates of gross photosynthesis (P_g), respiration (R) and net calcification (G_{net}) were estimated from low-tide slack water measurements of dissolved oxygen, dissolved inorganic carbon and total alkalinity at the historical station DK13 One Tree Island reef, Great Barrier Reef, Australia. Compared to measurements made during the 1960s–1970s at DK13 in the same season, P_g increased from 833 to 914 mmol O₂·m⁻²·d⁻¹ and $P_g:R$ increased from 1.14 to 1.30, indicating that the reef has become more autotrophic. In contrast, G_{net} decreased from 133 mmol C·m⁻²·d⁻¹ to 74 ± 24 mmol C·m⁻²·d⁻¹. This decrease stems primarily from the threefold increase in nighttime CaCO₃ dissolution from -2.5 mmol·m⁻²·h⁻¹ to -7.5 mmol·m⁻²·h⁻¹. Comparison of the benthic community survey results from DK13 and its vicinity conducted during this study and in studies from the 1970s, 1980s and 1990s suggest that there have been no significant changes in the live coral coverage during the past 40 years. The reduced G_{net} most likely reflects the almost threefold increase in dissolution rates, possibly resulting from increased bioerosion due to changes in the biota (e.g., sea cucumbers, boring organisms) and/or from greater chemical dissolution produced by changing abiotic conditions over the past 40 years associated with climate change, such as increased temperatures and ocean acidification. However, at this stage of research on One Tree Island the effects of these changes are not entirely understood.

Citation: Silverman, J., D. I. Kline, L. Johnson, T. Rivlin, K. Schneider, J. Erez, B. Lazar, and K. Caldeira (2012), Carbon turnover rates in the One Tree Island reef: A 40-year perspective, *J. Geophys. Res.*, 117, G03023, doi:10.1029/2012JG001974.

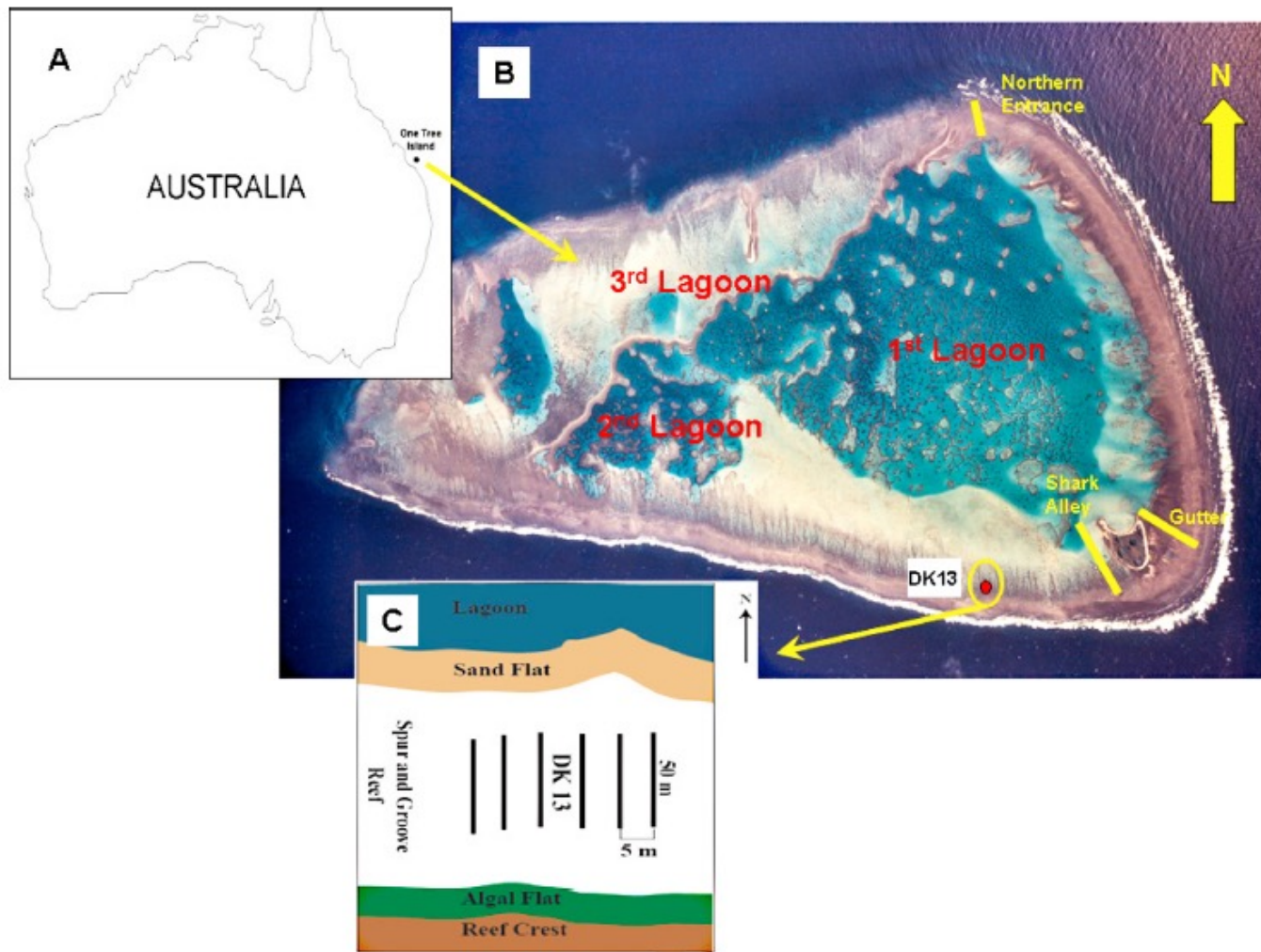


Figure 1. (a) Australian coast line and location of One Tree Island. (b) Aerial photo of One Tree Reef with sampling station DK 13 indicated by solid red circle on the southern rim of the reef. One Tree Island is on the inner southeast rim of the reef. The spur-and-groove zone of the reef in which the sampling station DK13 is located is indicated by the yellow ellipse. The areas known as The Gutter and Shark Alley are slightly lower than the rest of the reef, and water flows through them to the open water throughout most of the low-tide period. (c) Layout of benthic survey transects in the vicinity of DK13.

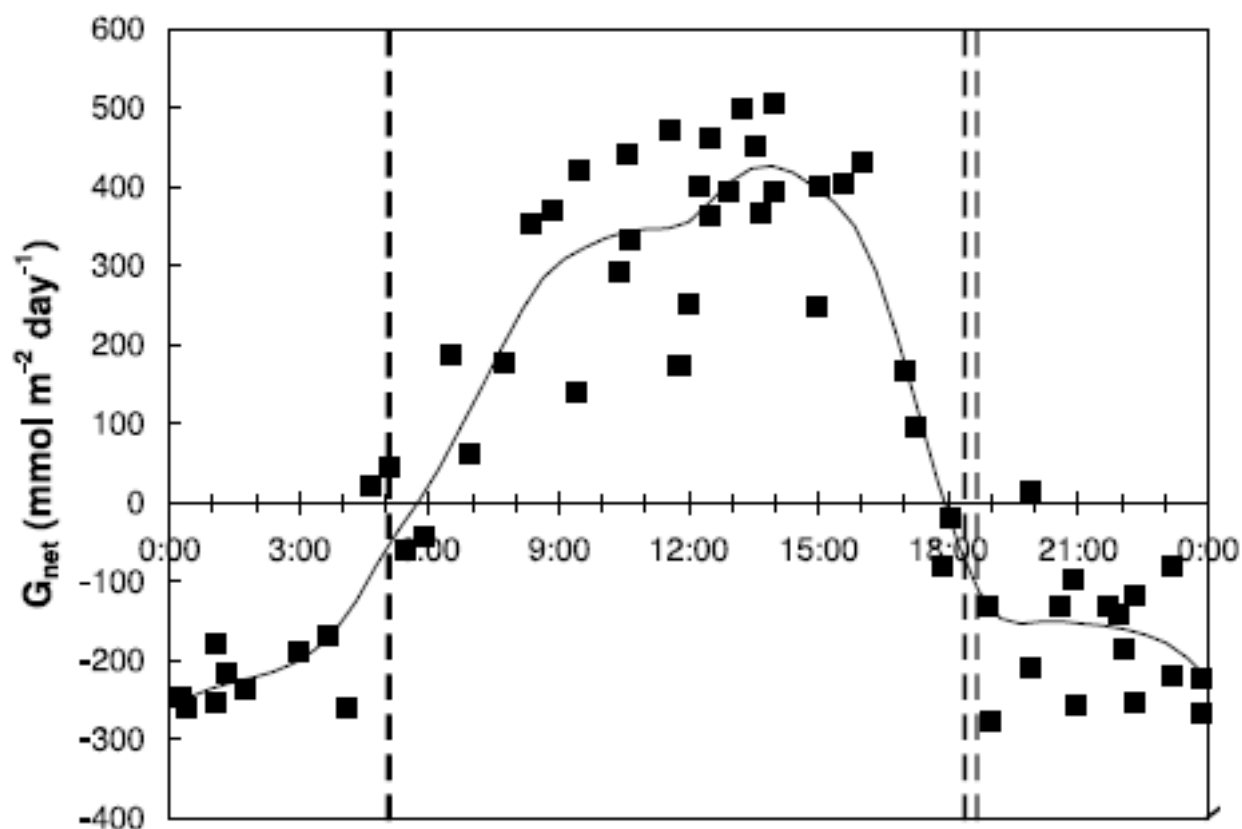


Figure 11. Standard day compilation of all G_{net} slack water values measured at DK13 during 11/20/2009–12/15/2009 (gray markers). The black line is the cubic spline fit to the G_{net} values calculated using the csaps.m Matlab function with a smoothing parameter of $P = 0.99996$. The vertical dashed black lines indicate the range of the sunrise and sunset times during 11/20/2009–12/15/2009 at One Tree Island.

Rate of net calcification 44% lower than in 1970's





**One Tree
Island
Expeditions
Nov 2011
Feb 2013
Sep/Oct 2014**





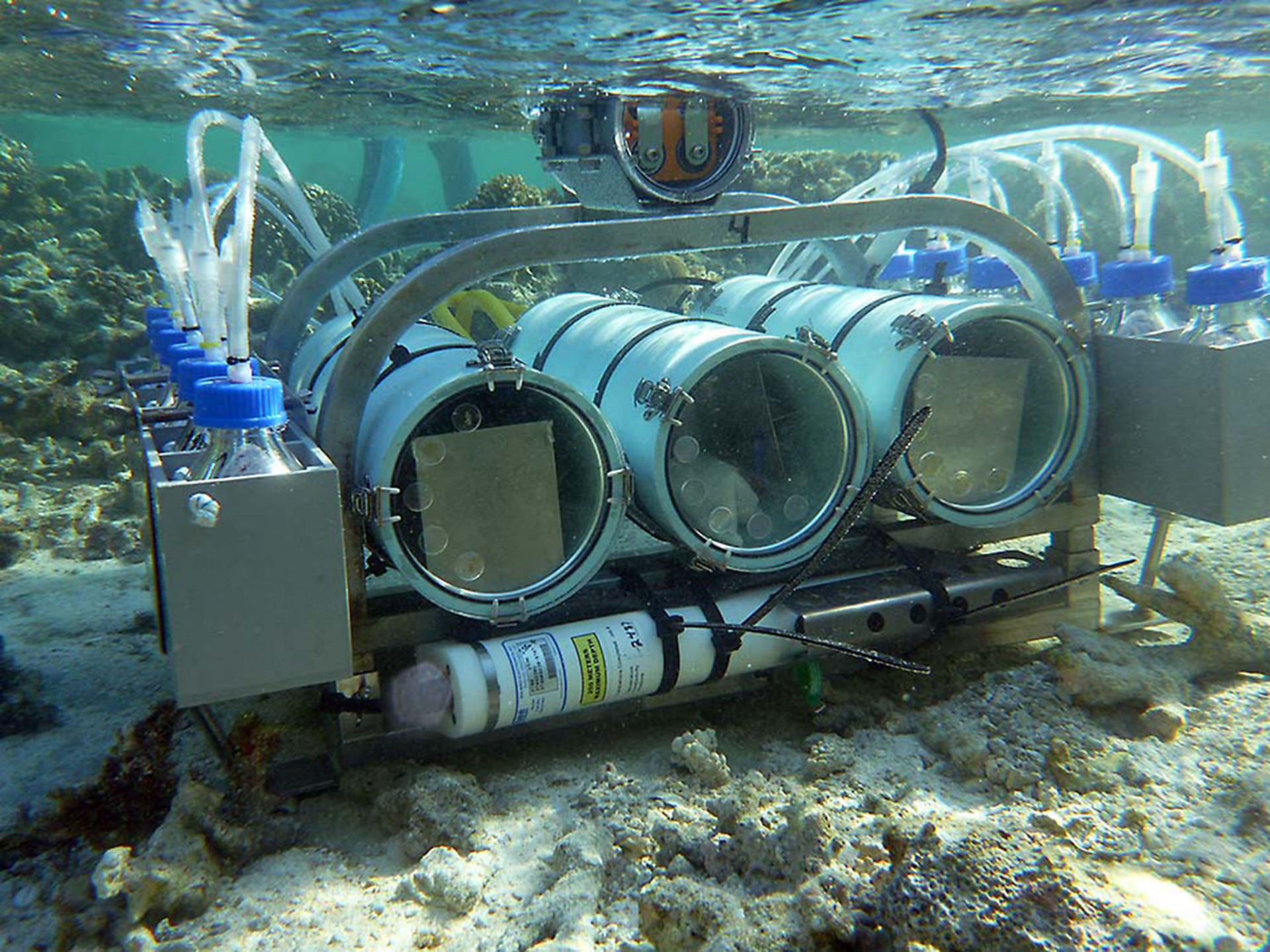
One Tree Island Research Station

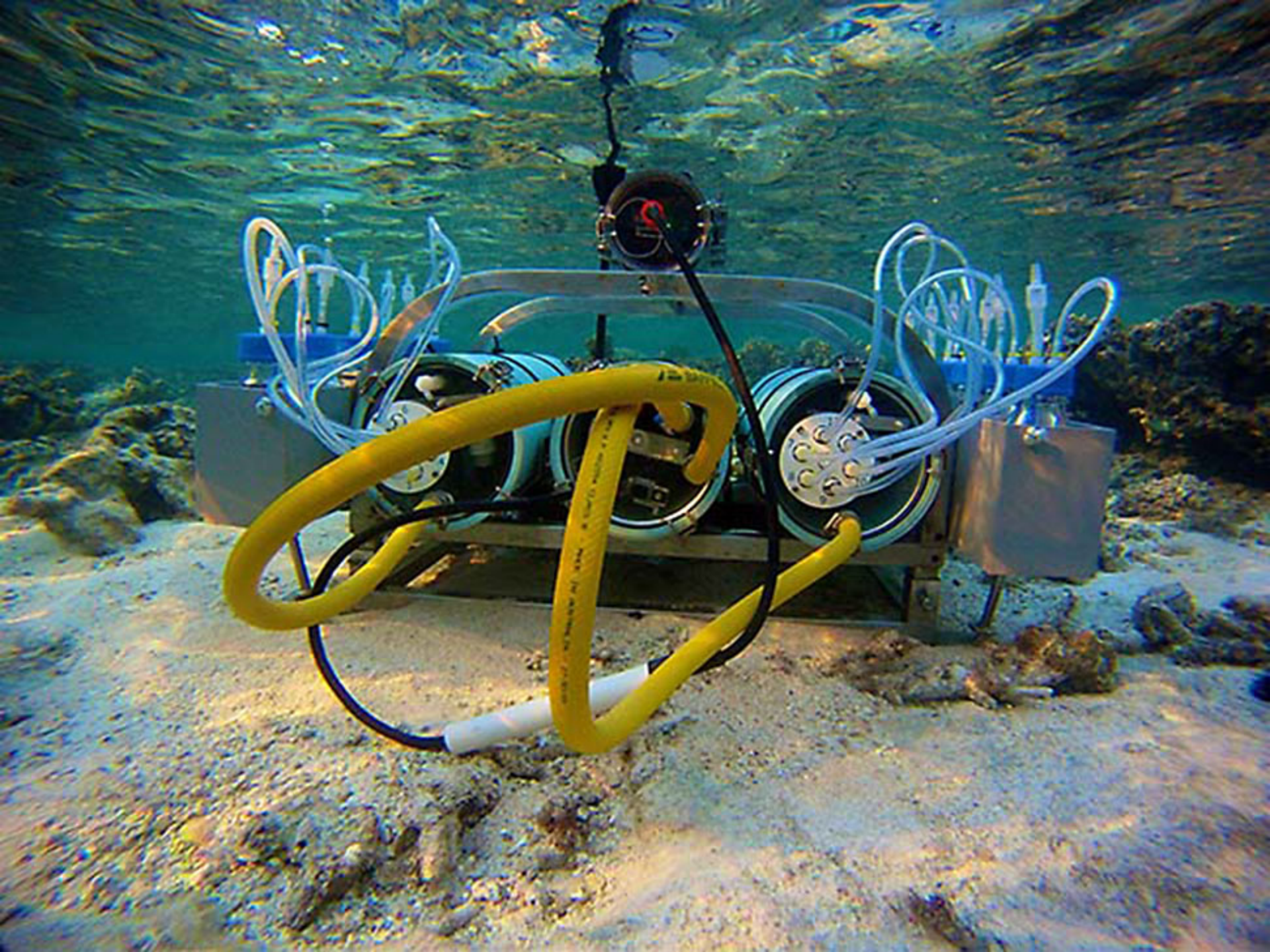


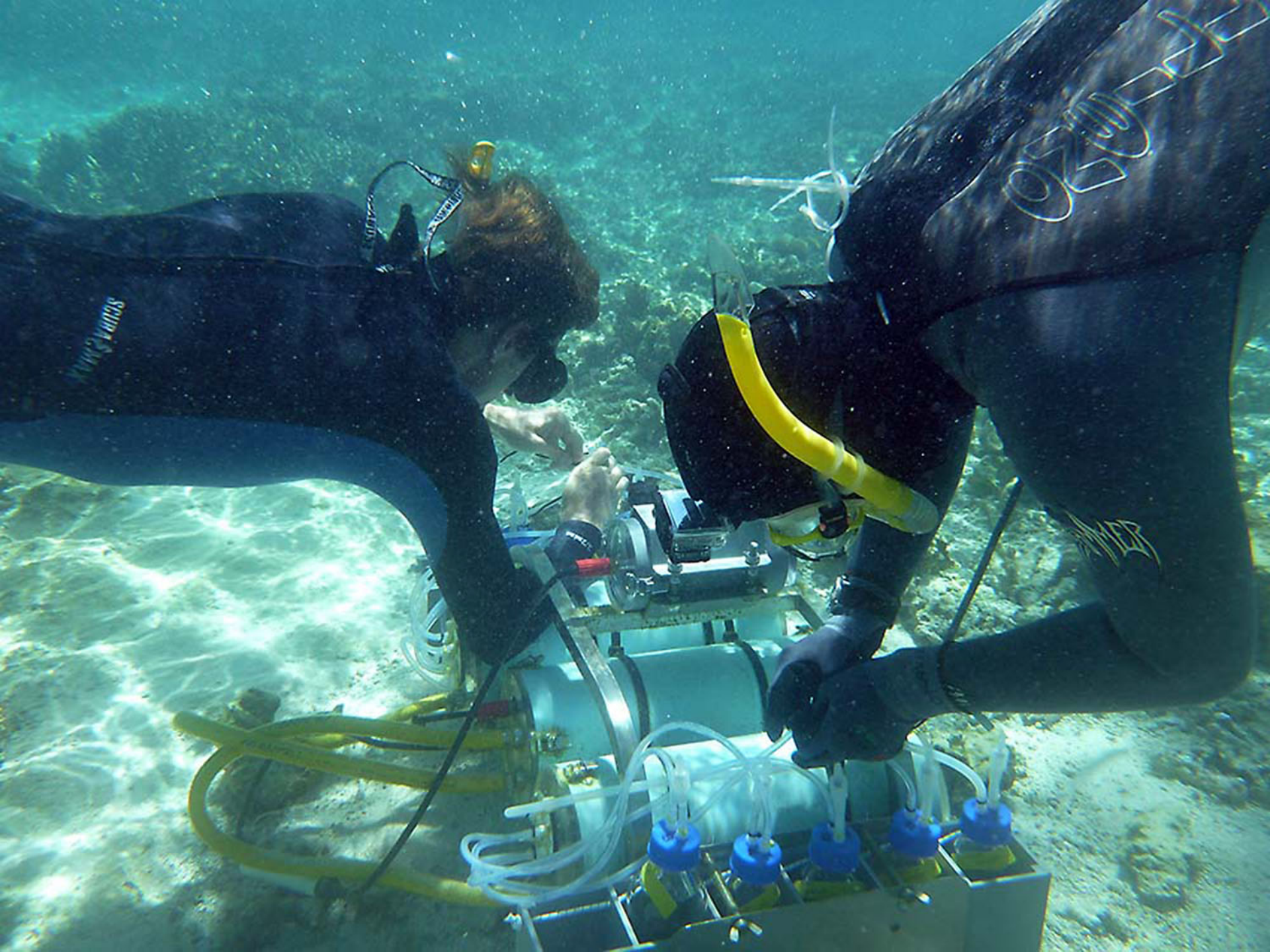




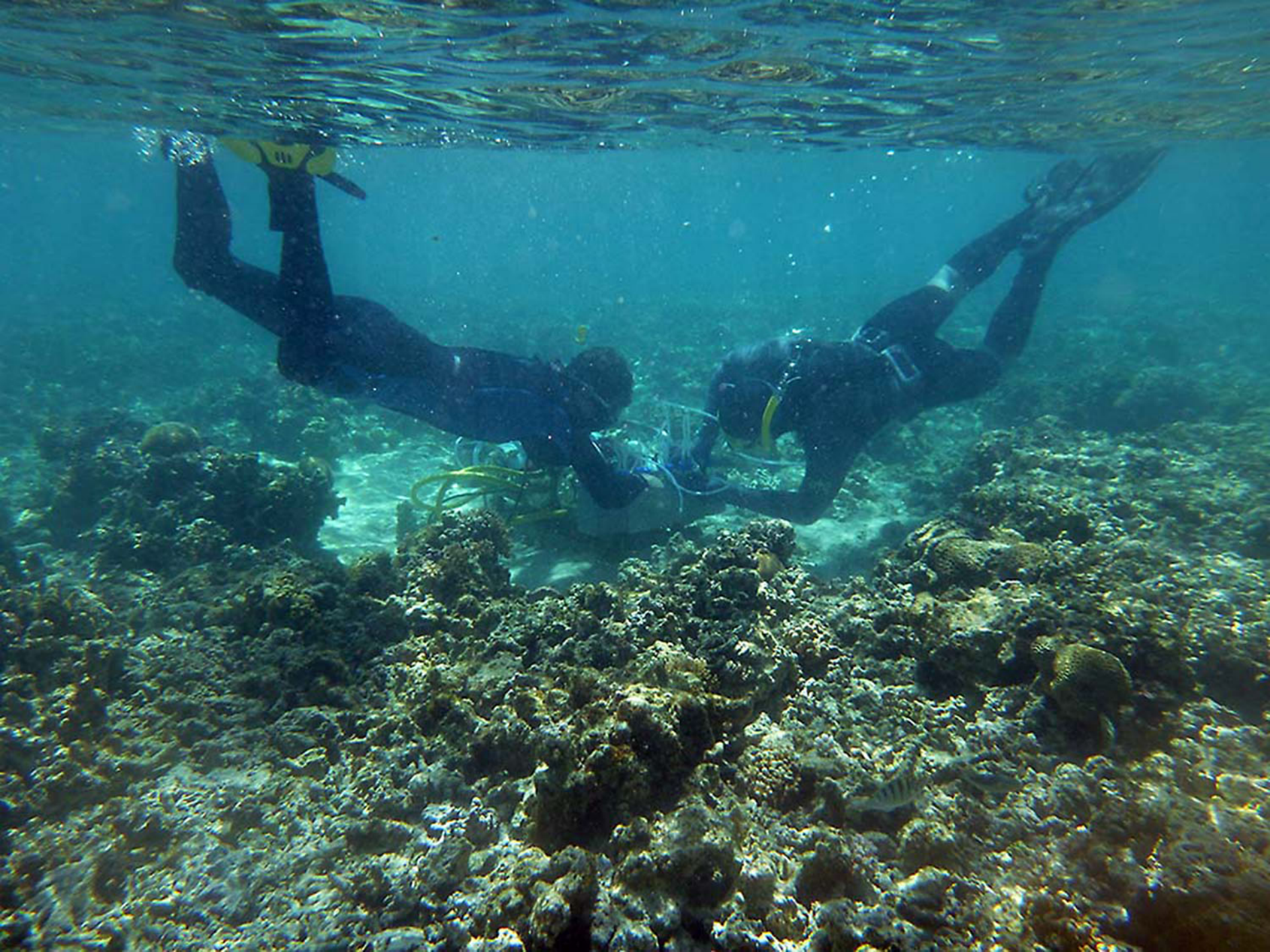


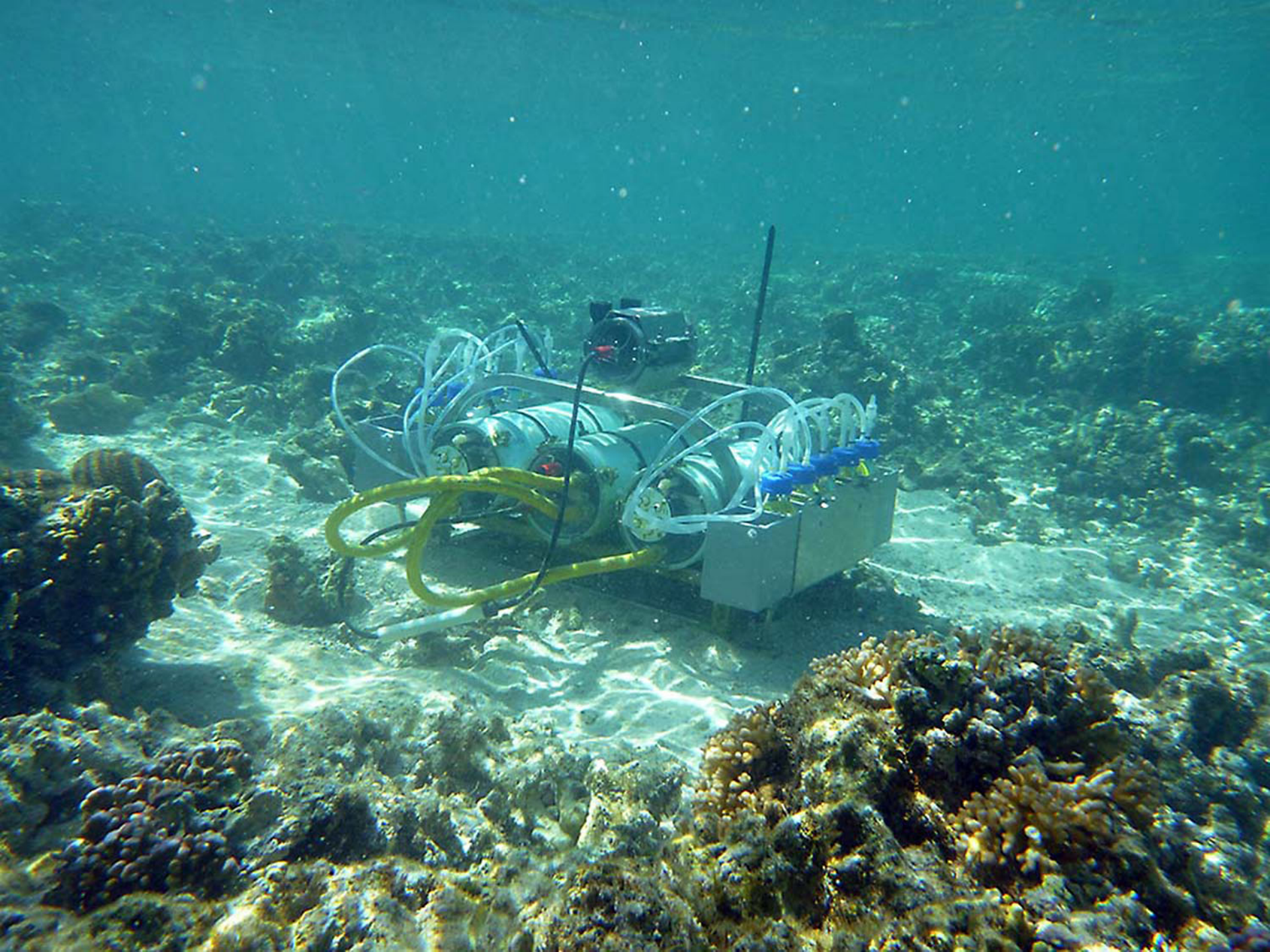








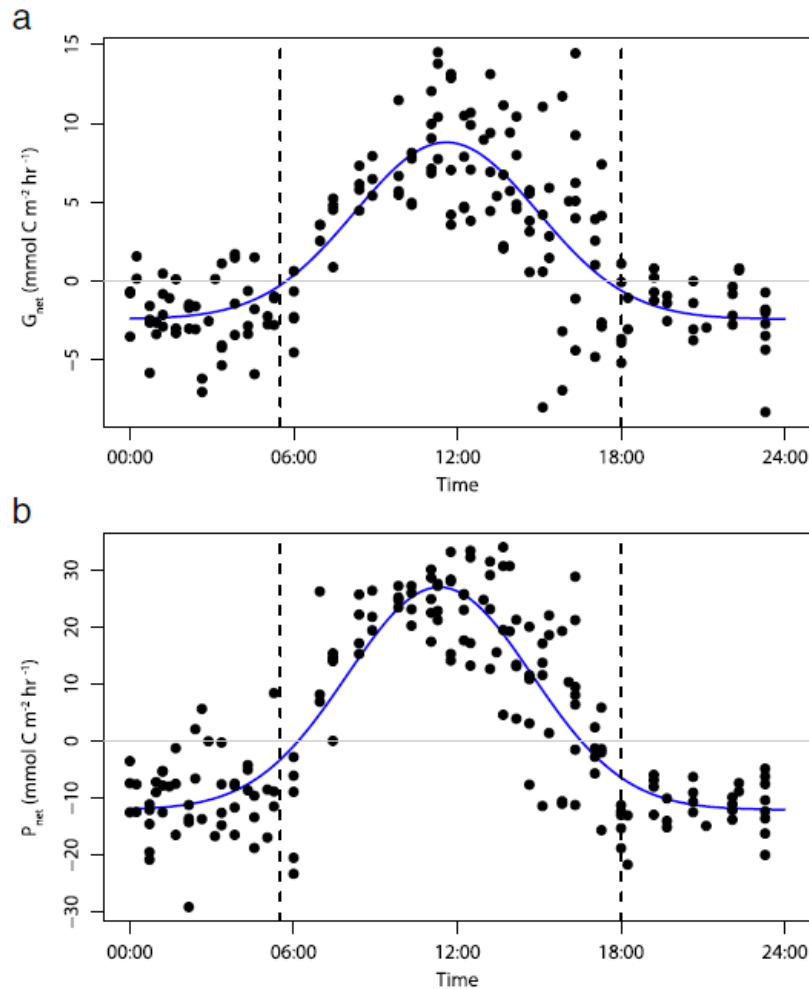










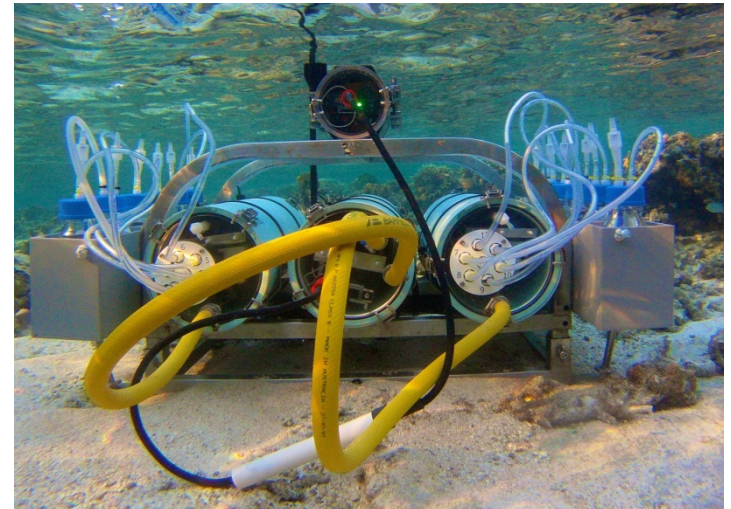
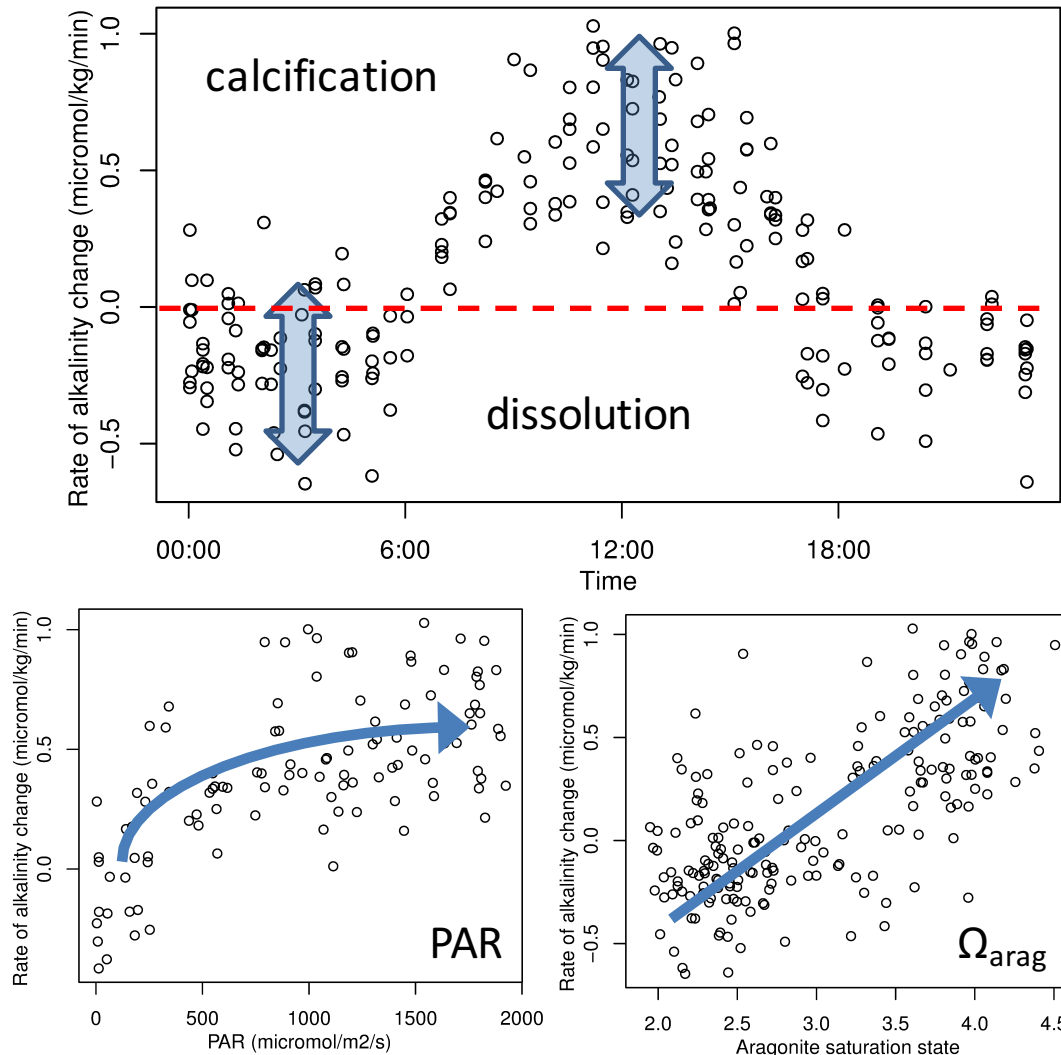


Net skeletal growth
(calcification)

Net photosynthesis
(net production)

Figure 1. Temporal cycles in community calcification (G_{net}) and production (P_{net}). (a) G_{net} (mmol C m⁻² hr⁻¹) and (b) P_{net} (mmol C m⁻² hr⁻¹) against time of day. Dashed lines indicate approximate daylight hours during the study period. Values outside the hourly mean ± 2 standard deviations of the mean are not shown.

Australian reef metabolism work



- Large dataset thanks to autosamplers and autotitrators
- Strong diel cycles in calcification/dissolution
- **Provisional conclusion:** Ω_{arag} can explain some of the variance in δA_T unaccounted for by T & PAR

