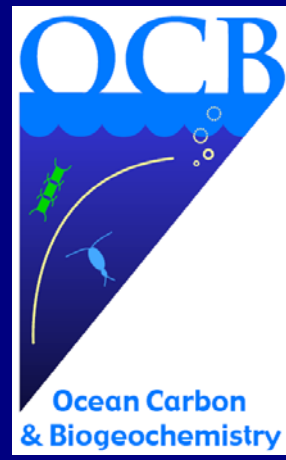
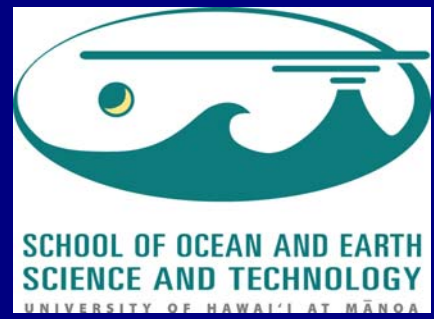
Ocean acidification impacts on coral reefs: changes in community structure

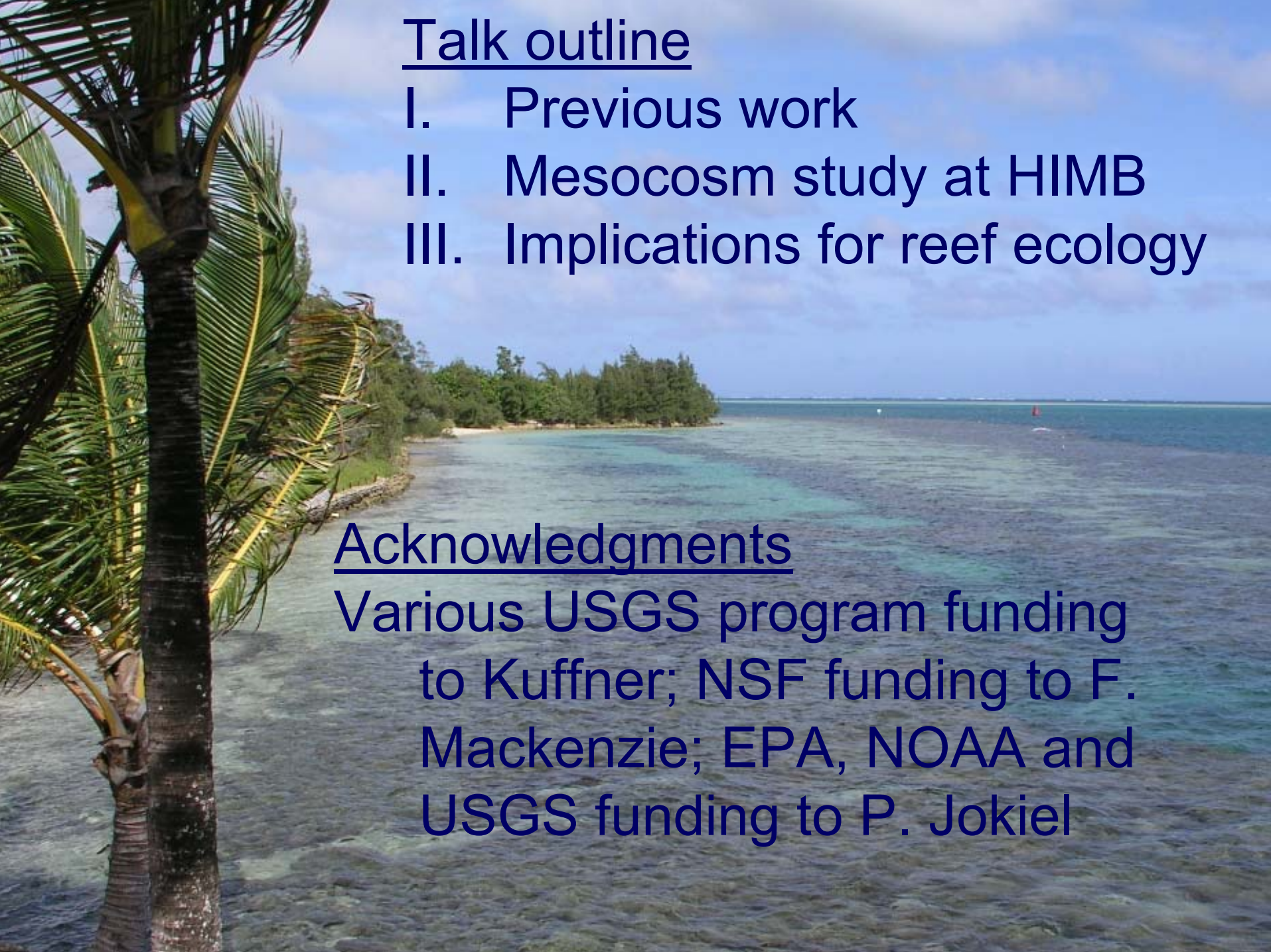
Ilsa Kuffner, Andreas Andersson, Paul Jokiel, Ku'ulei Rodgers & Fred Mackenzie



USGS
science for a changing world

Florida Integrated Science Center
St. Petersburg, Florida





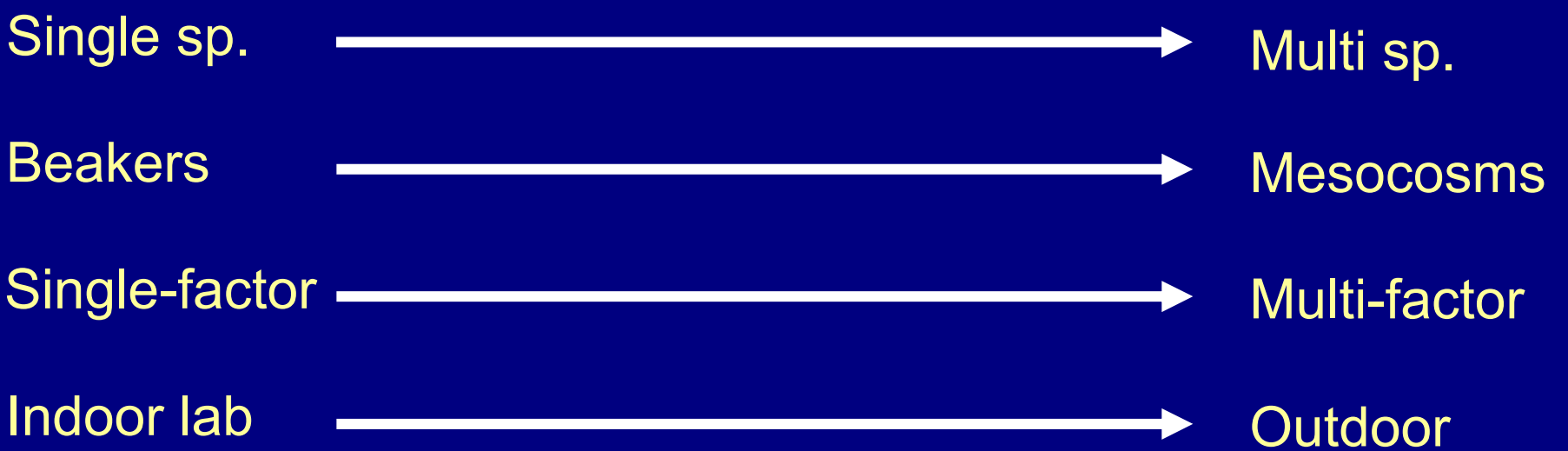
Talk outline

I. Previous work
II. Mesocosm study at HIMB
III. Implications for reef ecology

Acknowledgments

Various USGS program funding to Kuffner; NSF funding to F. Mackenzie; EPA, NOAA and USGS funding to P. Jokiel

Experimental OA work on coral reef organisms

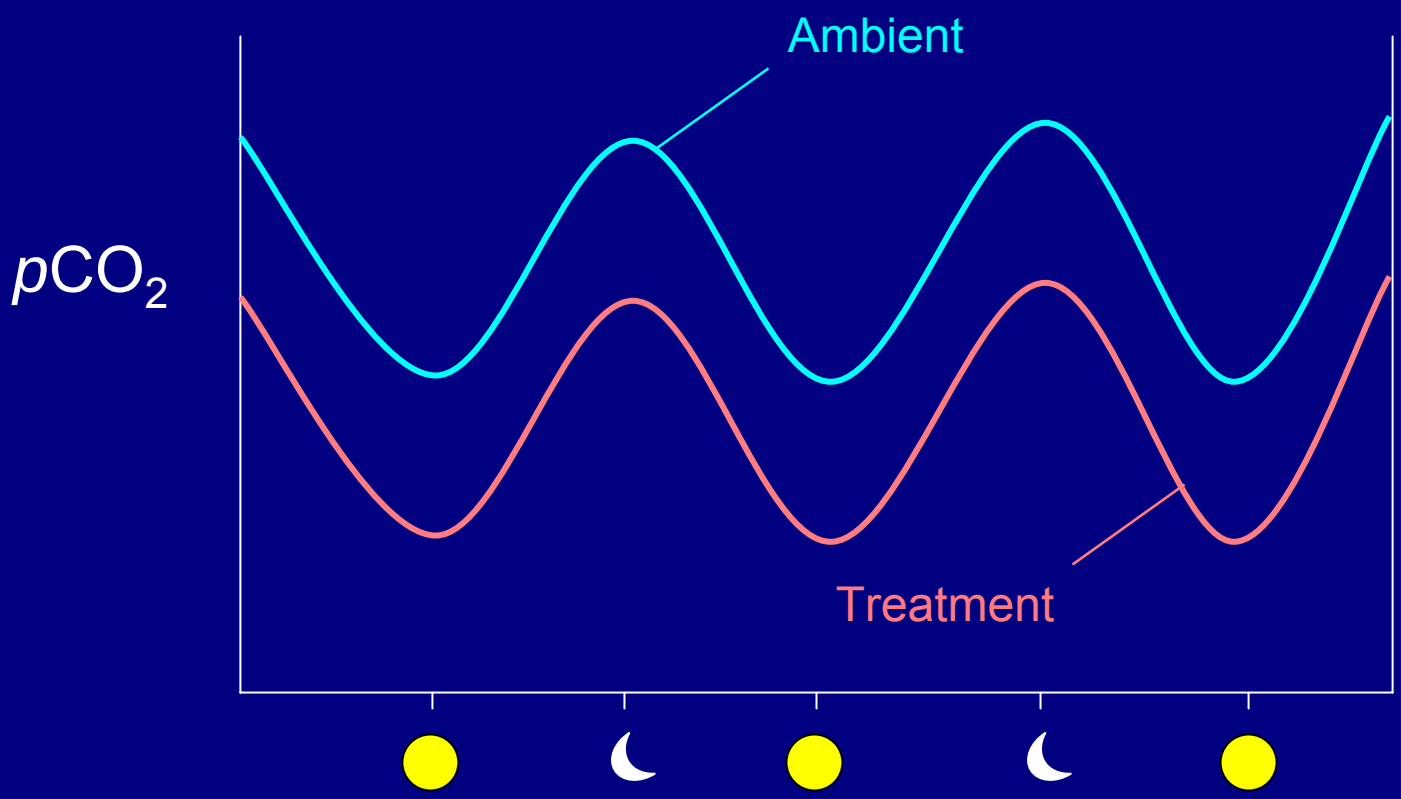


Hawaii Institute of Marine Biology
Coconut Island, Kaneohe Bay, HI

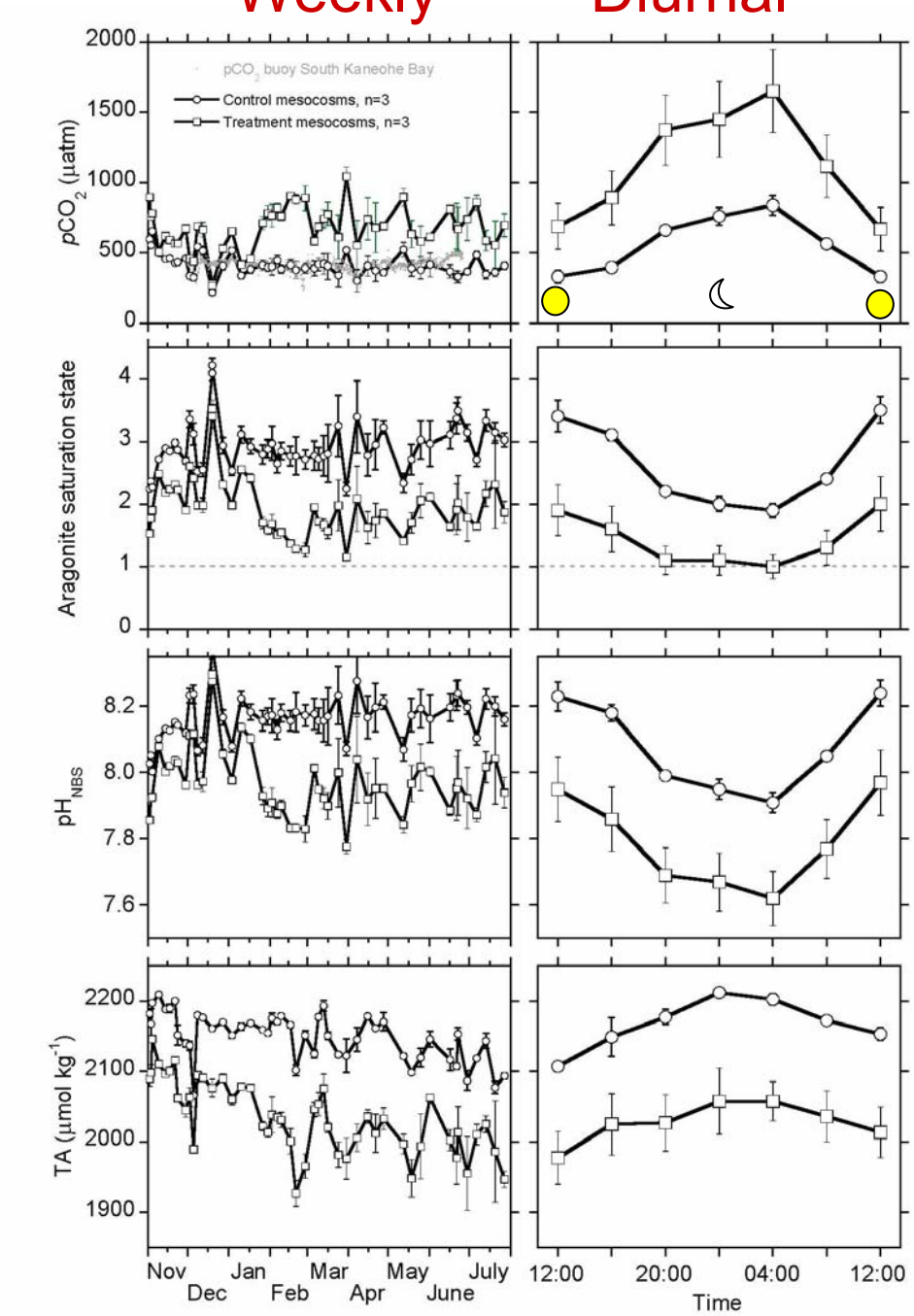
- Large-capacity open seawater system
- Surrounded by active reef flat community


T
C
1 m
T
C
T
C

Our approach:

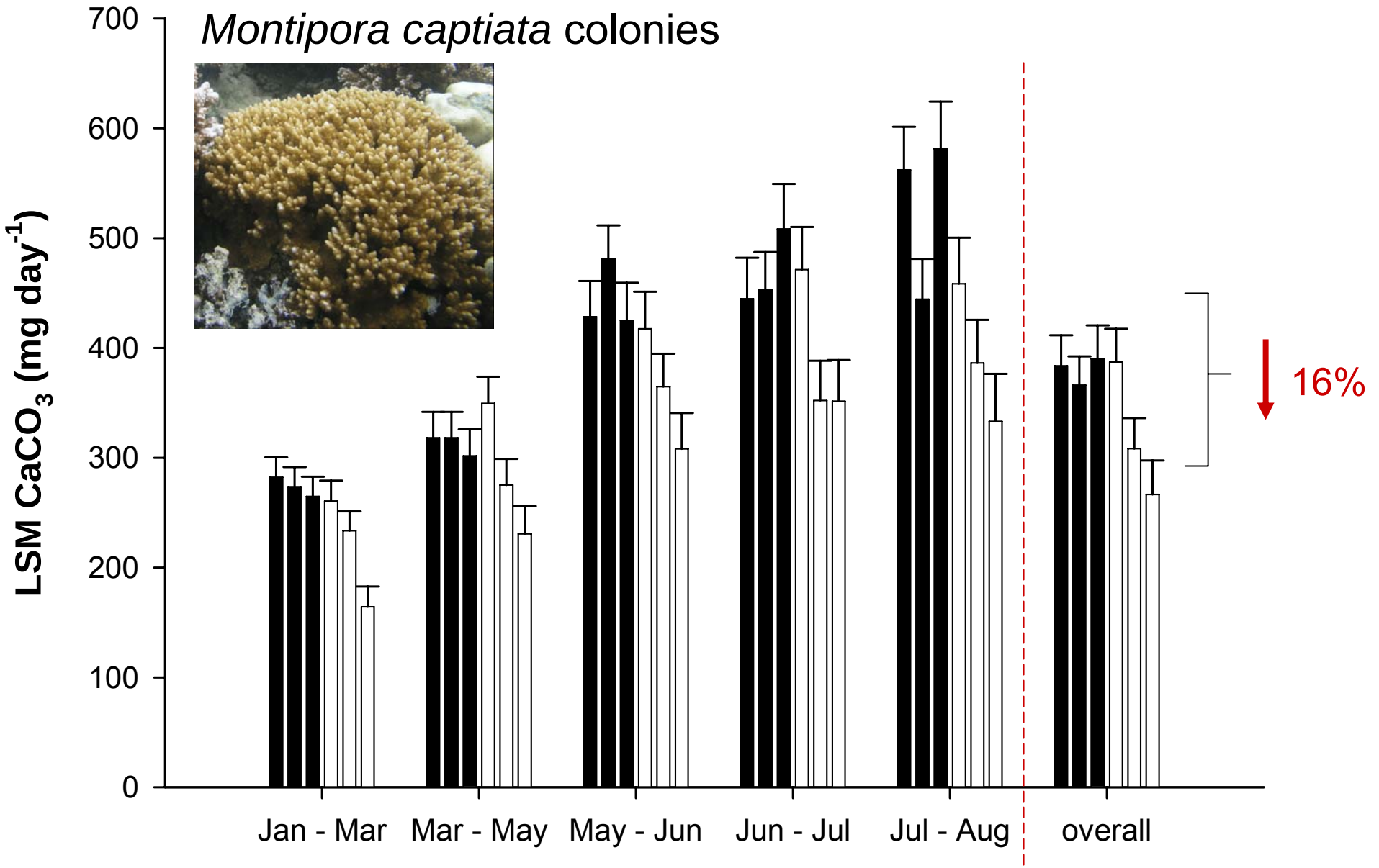


1. Realistic diurnal cycles (Agegian 1985, Suzuki 1995, Ohde & Van Woesik 1999)
2. Open system (natural larval recruitment)
3. Long-term (9 months)


Weekly
Diurnal
pCO2 buoy South Kaneohe Bay
Control mesocosms, n=3
Treatment mesocosms, n=3
pCO2 (µatm)
Aragonite saturation state
pHNBS
TA (µmol kg-1)
Nov
Dec
Jan
Feb
Mar
Apr
May
June
July
12:00
20:00
04:00
12:00
Time

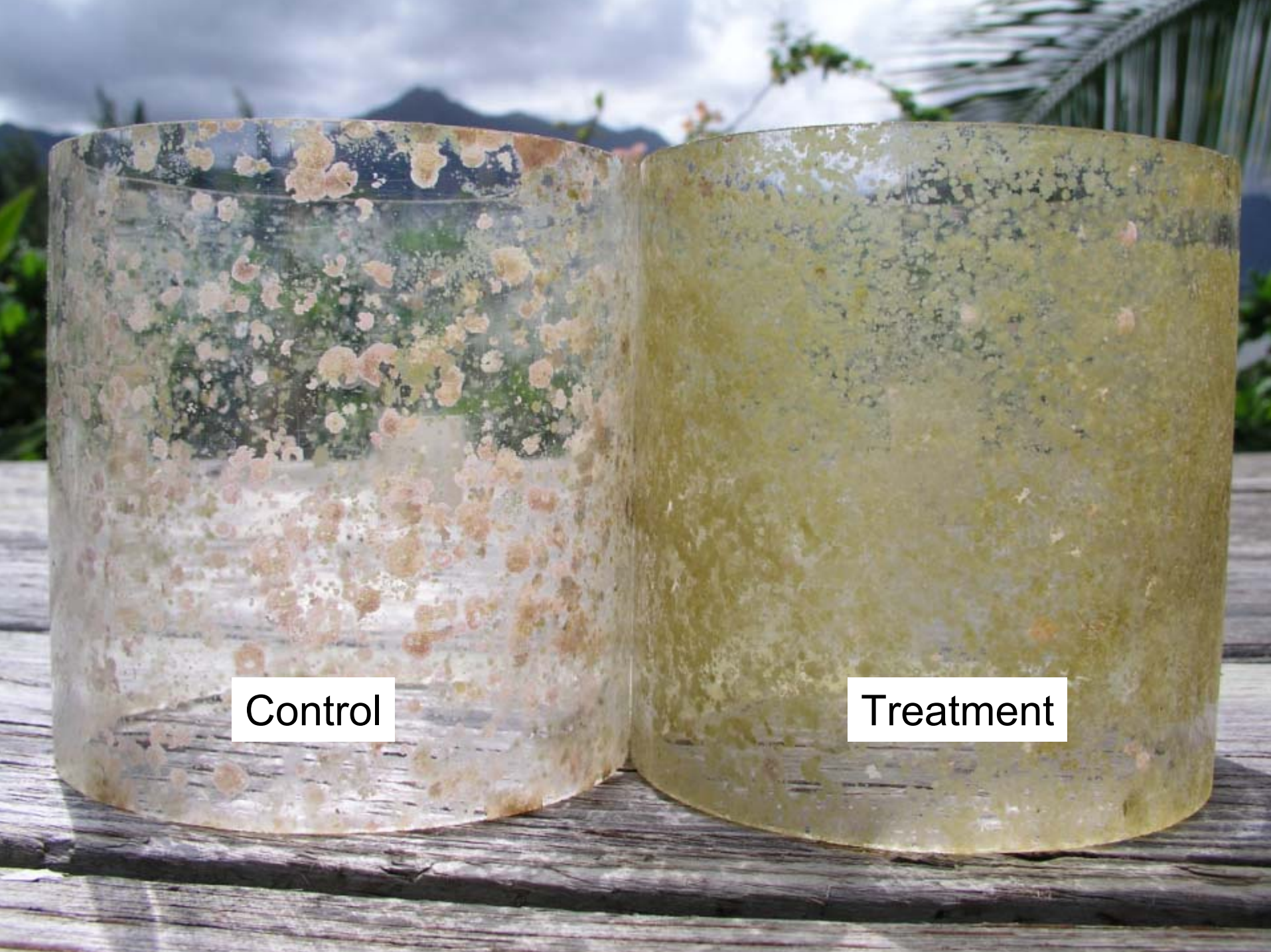
Montipora capitata

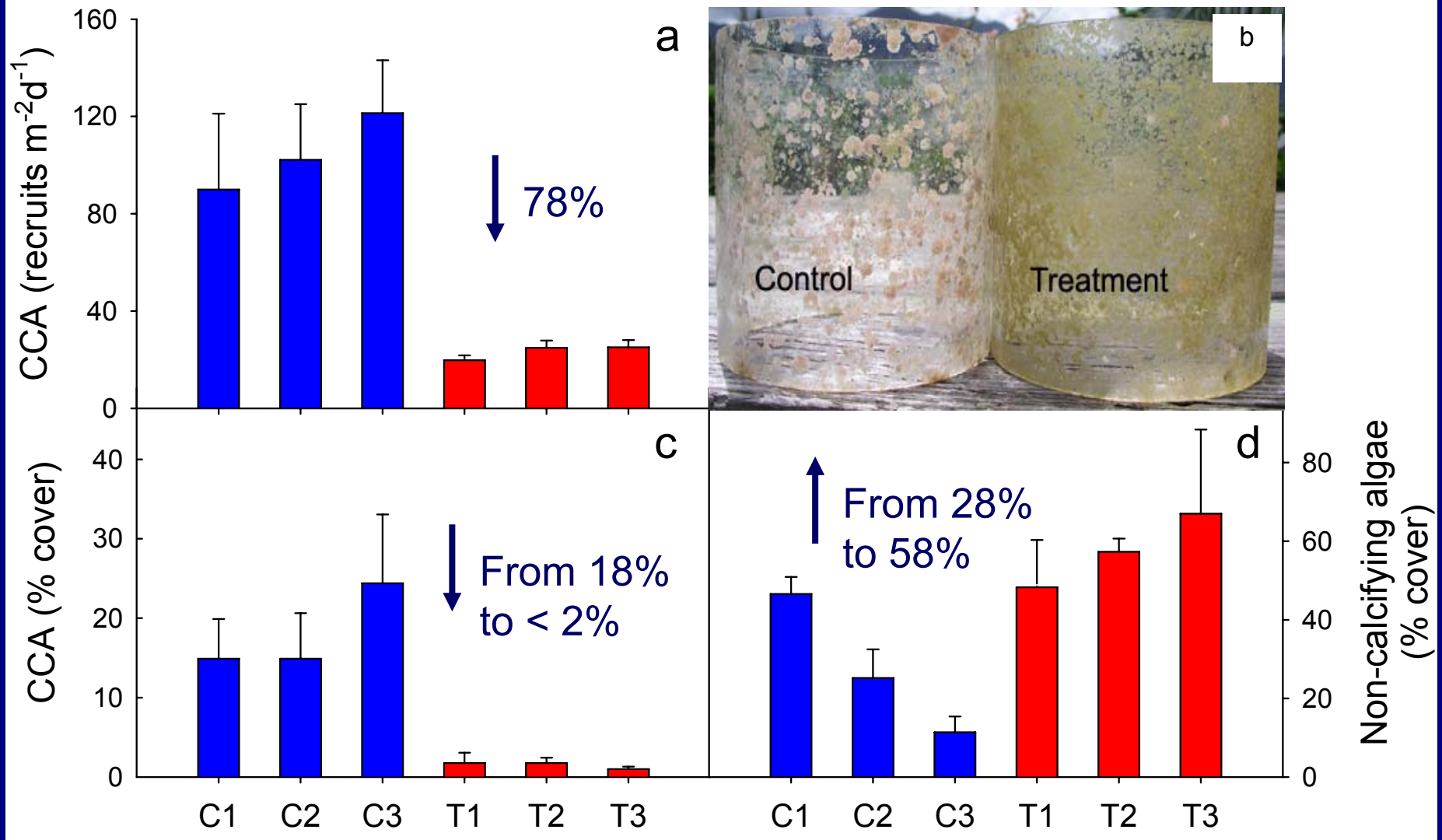
Measured calcification rates (buoyant weight) and linear extension



did not “acclimate” to treatment; saw increase in calcification rates during summer

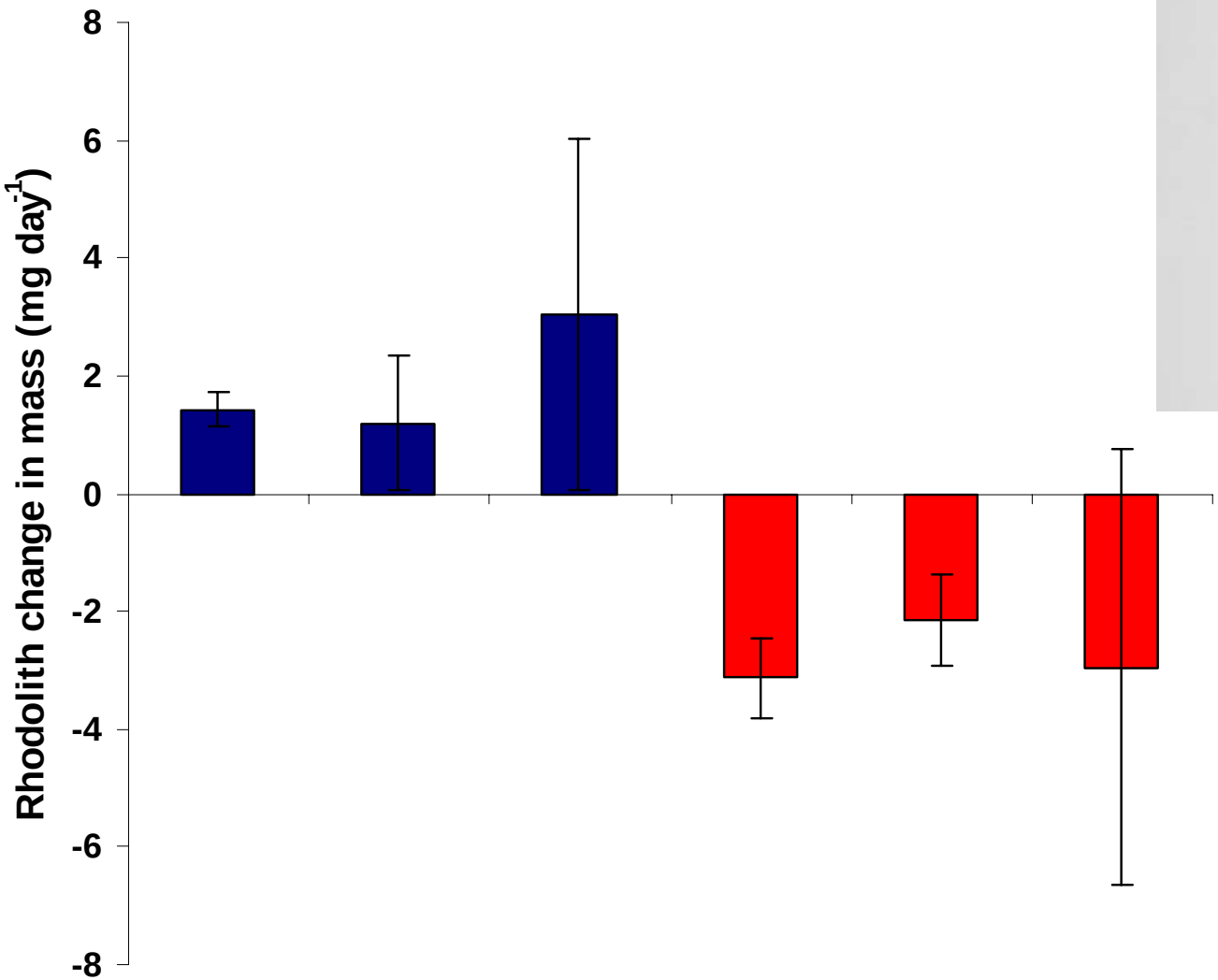
H_1: Communities developing in tanks simulating ocean acidification would be different than control tanks


Control
Treatment

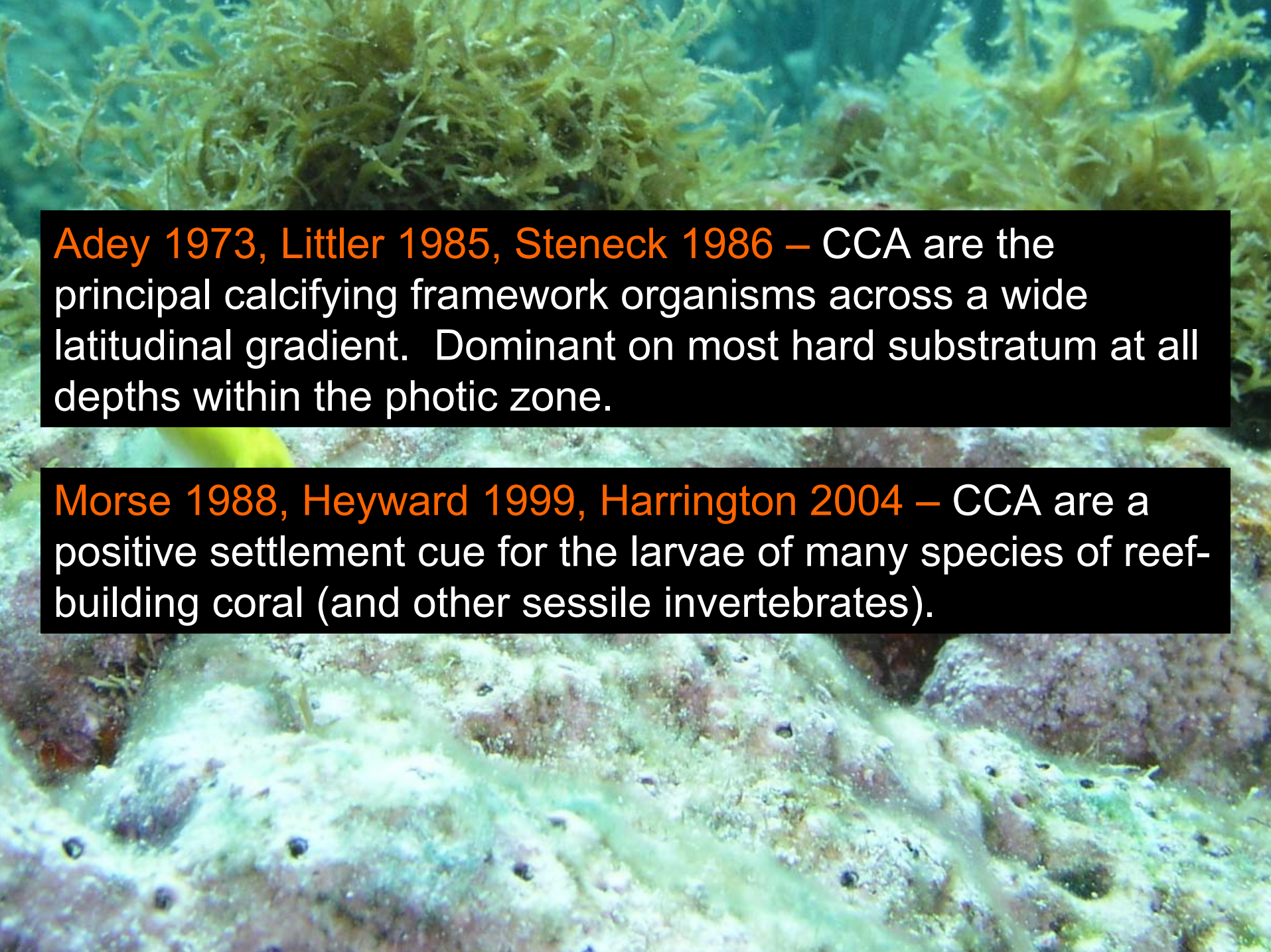


Blue = control Red = OA treatment

“Rhodoliths”: free-living accretions of coralline algae



(Rhodoliths were introduced to the tanks)



Adey 1973, Littler 1985, Steneck 1986 – CCA are the principal calcifying framework organisms across a wide latitudinal gradient. Dominant on most hard substratum at all depths within the photic zone.

Morse 1988, Heyward 1999, Harrington 2004 – CCA are a positive settlement cue for the larvae of many species of reef-building coral (and other sessile invertebrates).

Life cycle of a coral

Coral “slick”

Egg-sperm bundle

≈ 72 hours

Planula larva

“Brooders”

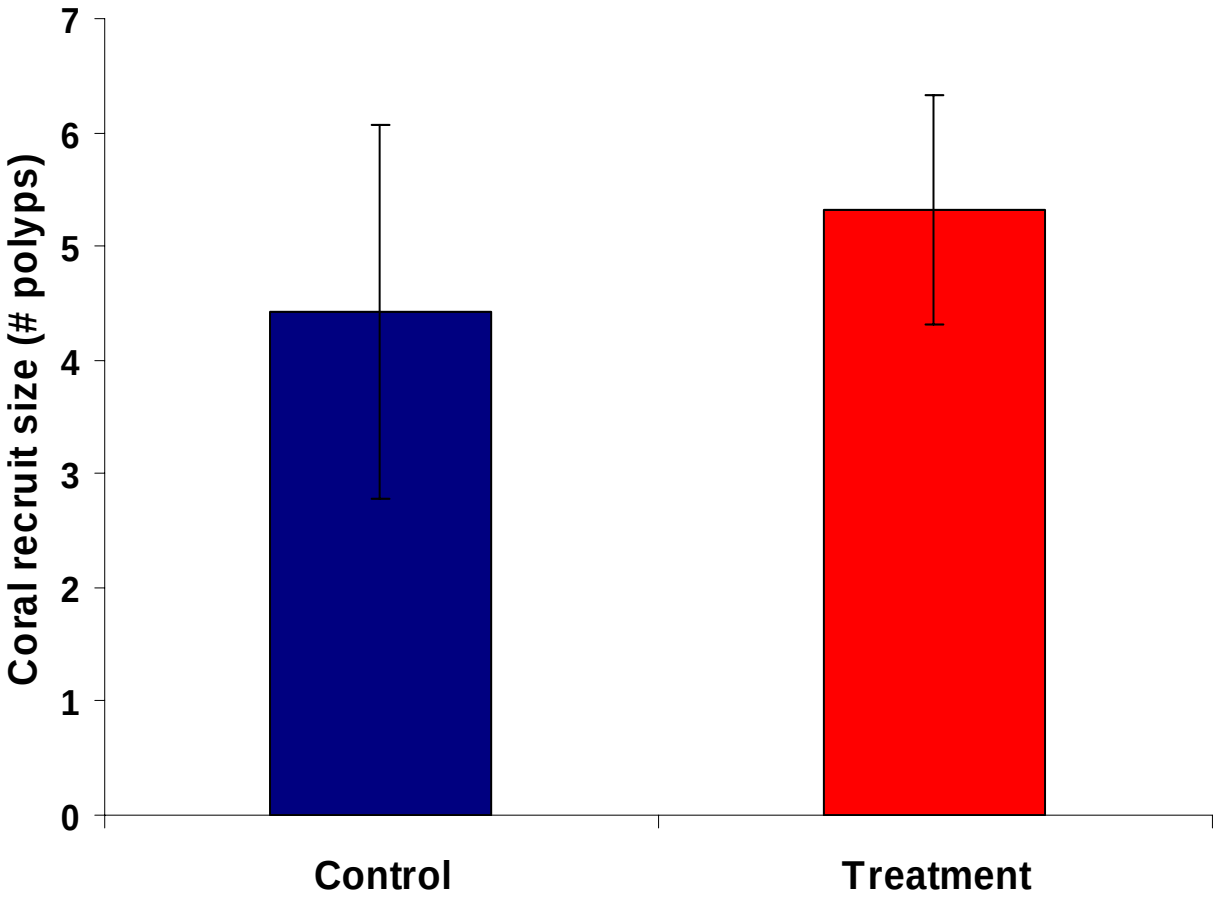
Larval search pattern

Adult coral

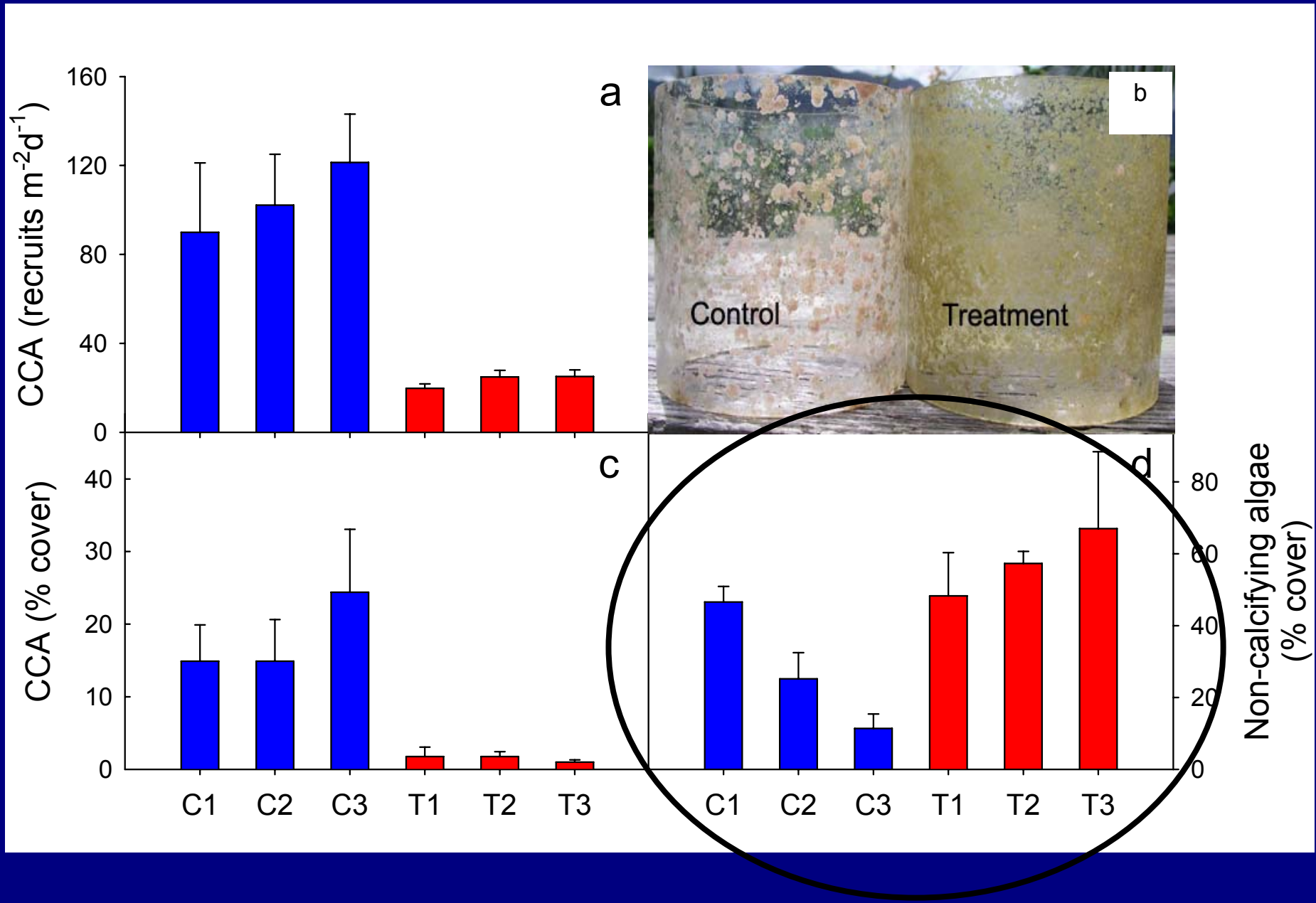
CCA

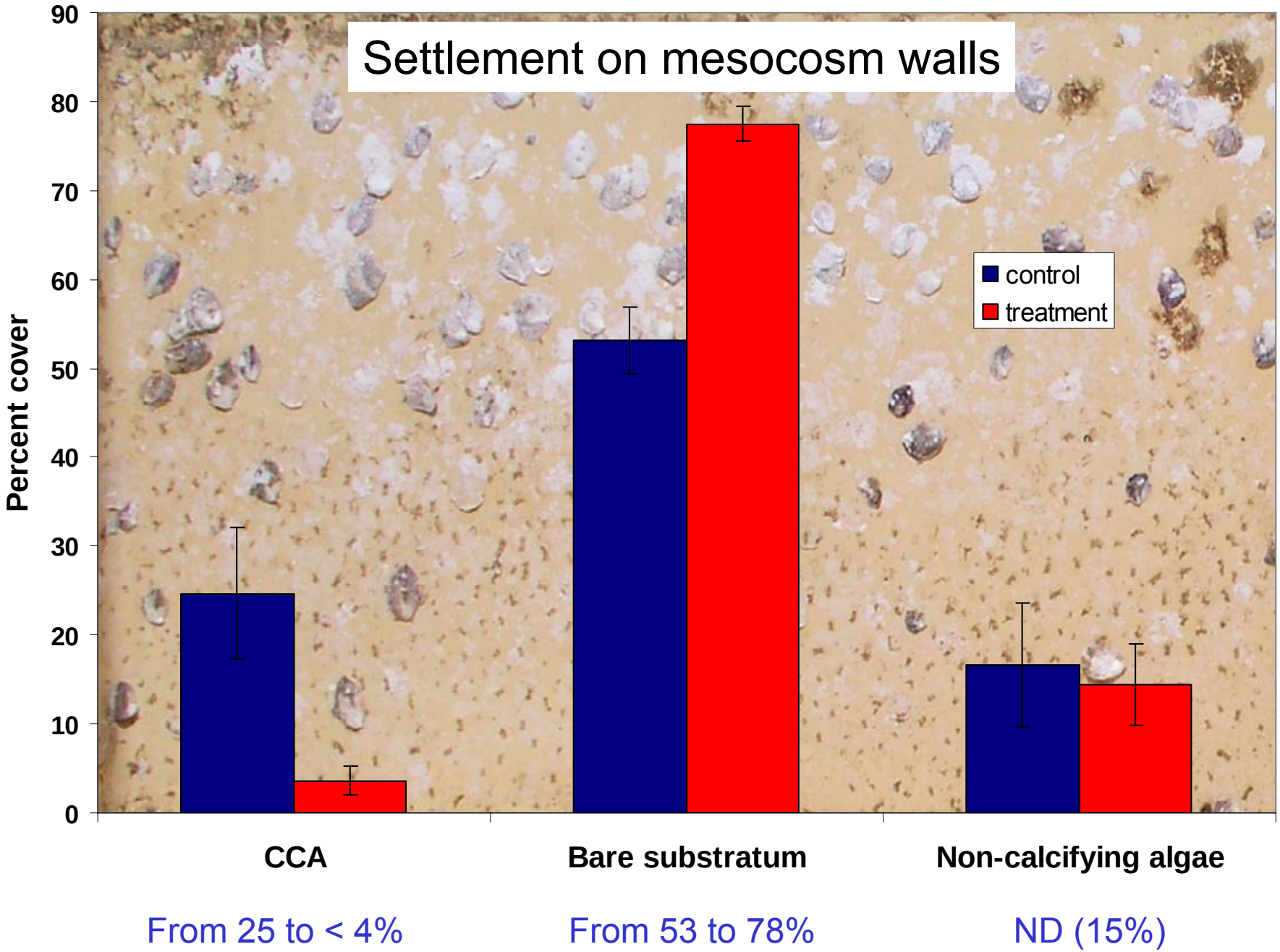
Coral recruit

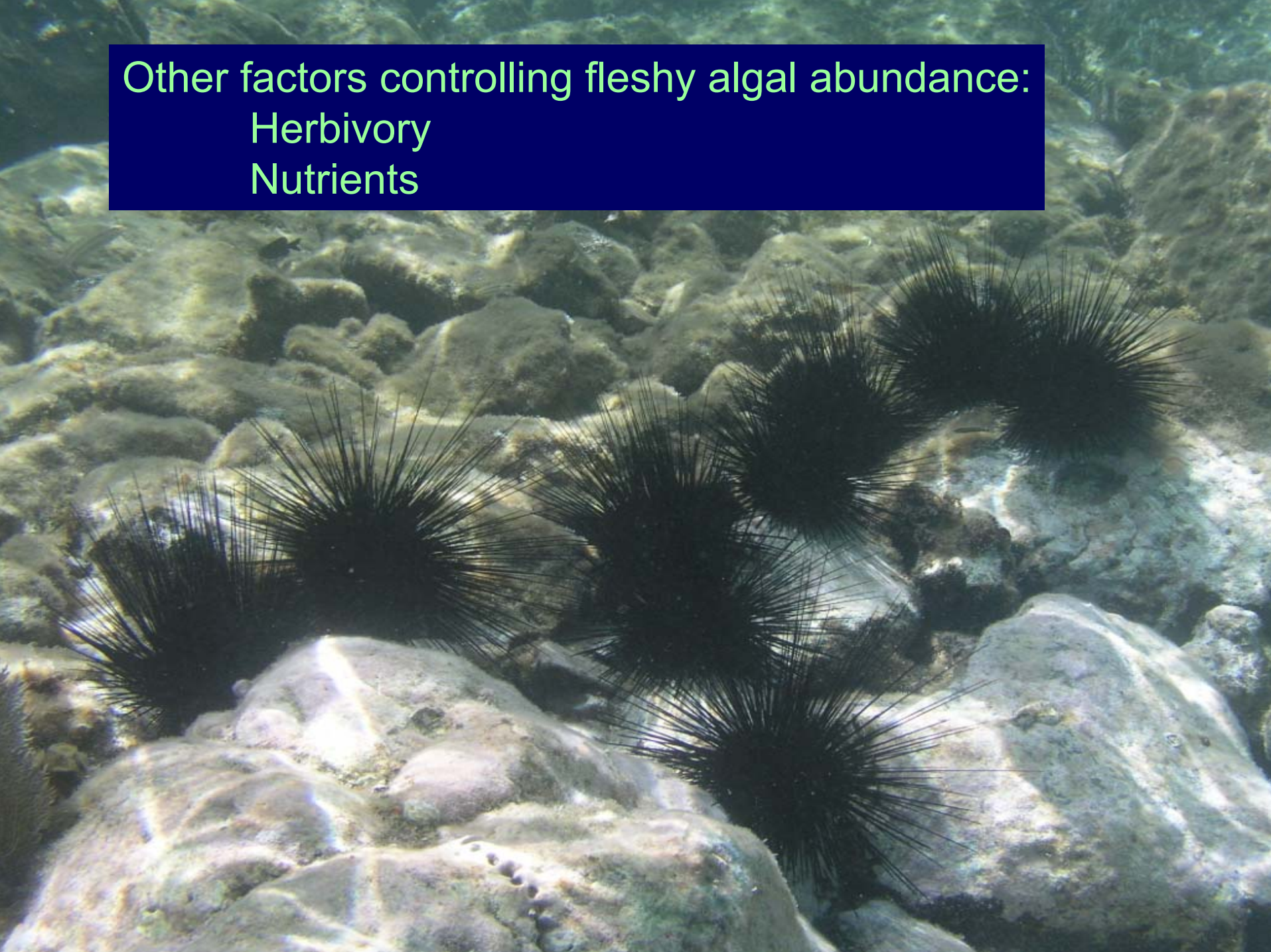
Pocillopora damicornis recruitment



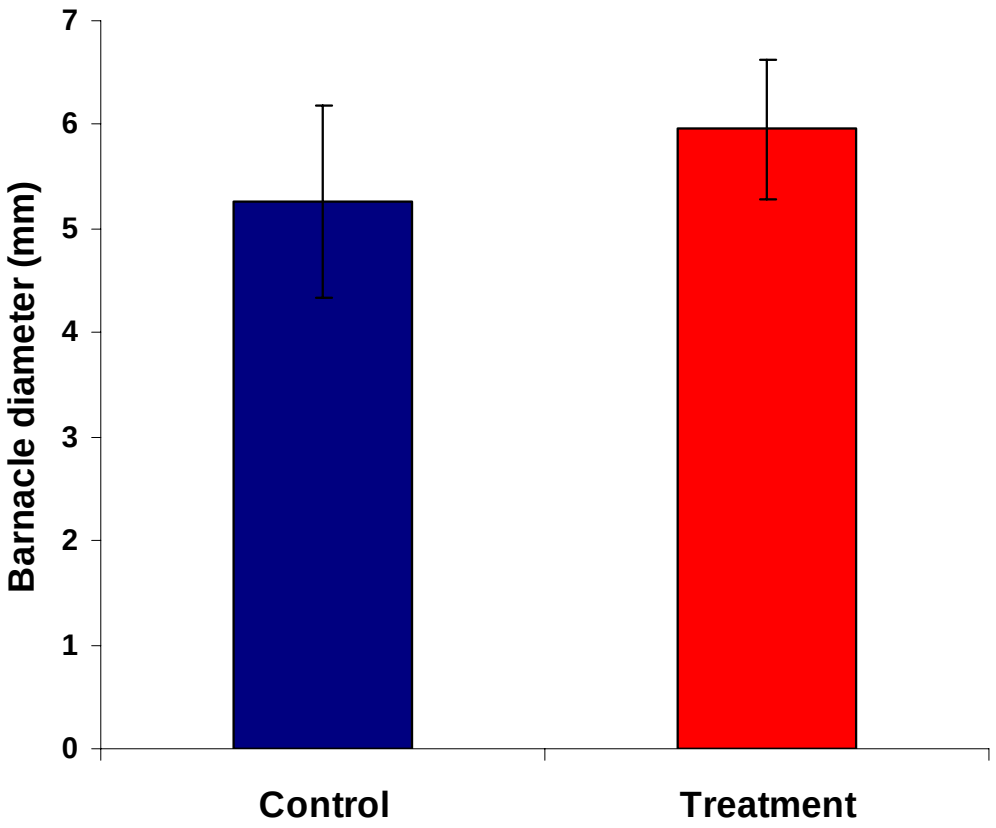
(Tanks were seeded with adult colonies)

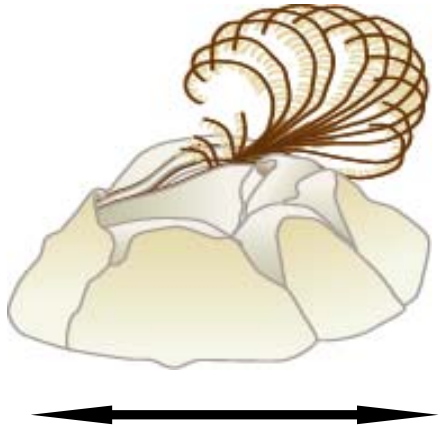

a
b
c
d
CCA (recruits m-2d-1)
160
120
80
40
0
Control
Treatment
CCA (% cover)
40
30
20
10
0
Non-calcifying algae (% cover)
80
60
40
20
0
C1
C2
C3
T1
T2
T3


Settlement on mesocosm walls
Percent cover
90
80
70
60
50
40
30
20
10
0
control
treatment
CCA
Bare substratum
Non-calcifying algae
From 25 to < 4%
From 53 to 78%
ND (15%)


Other factors controlling fleshy algal abundance:
Herbivory
Nutrients

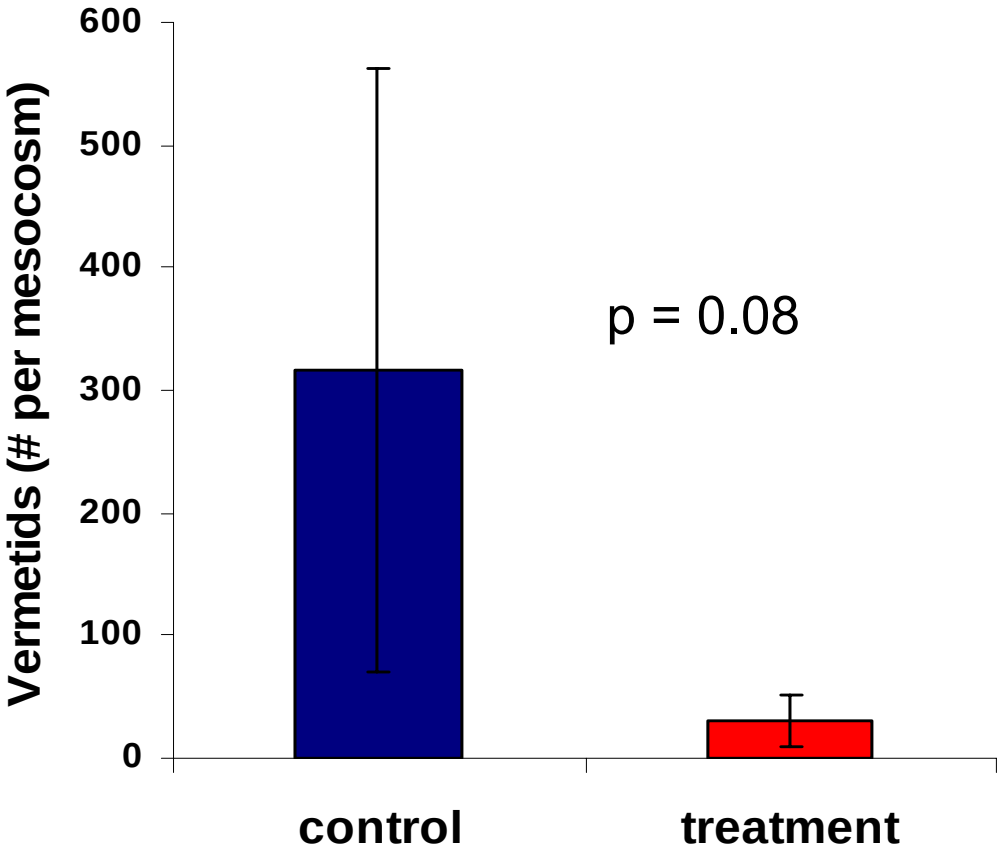
Balanus sp. (barnacle) recruitment

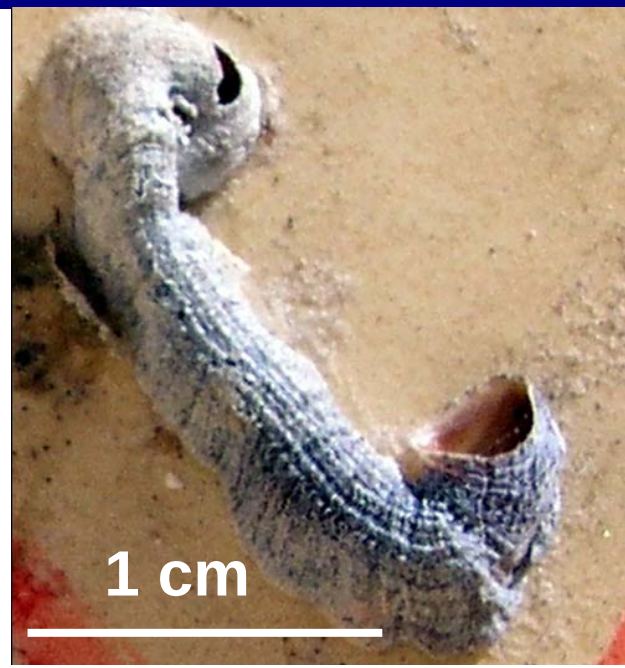




Barnacles secrete low Mg-calcite (Mackenzie et al. 1983 review)

Vermetid recruitment (c.f. *Dendropoma* sp.)



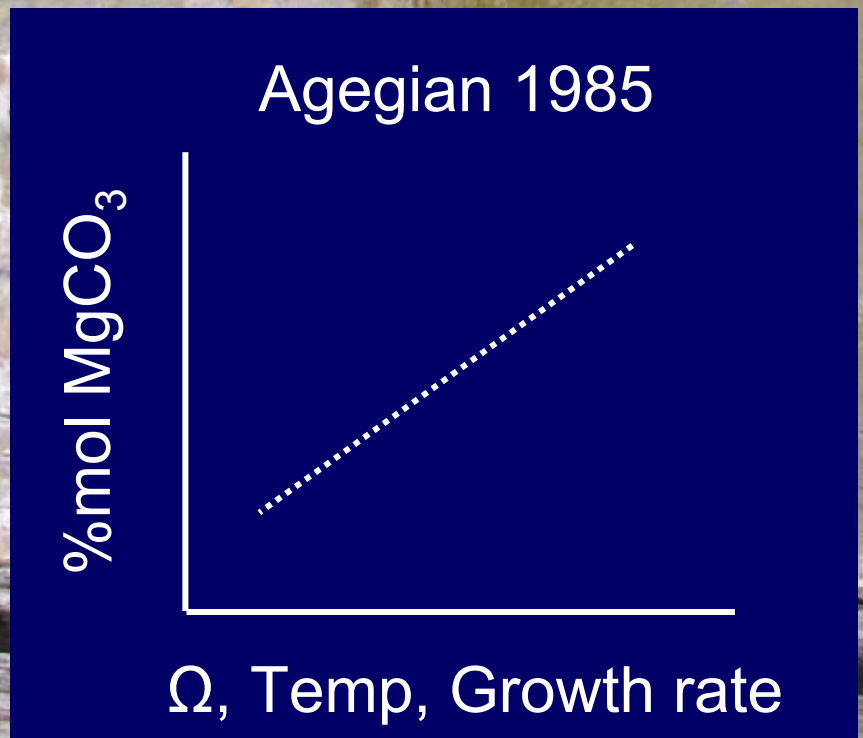


Most gastropods secrete aragonite (Chave, 1954)

Vermetids + CCA =
Bermuda's "boiler reefs"

XRD analysis: surprisingly no difference!

13.6 ± 0.4 mol% $MgCO_3$



Main points to ponder:

OA effects on ecological processes, including recruitment and competition for space, could be substantial, at least for the ubiquitous CCA.

Will changes to community structure resulting from OA (and other stressors, e.g., high temperature) affect reef accretion rates to a greater degree than sub-lethal effects on calcification rates?

Clues to changes to community structure might lie in the carbonate mineral phase deposited by different taxa. However, can organisms change the mineral phase they deposit?

We need to account for the replacement of calcifying organisms with those that do not calcify when predicting future reef accretion rates.