PHYSIOLOGY OF CORALS AND THEIR ZOOXANTHELLAE

(what we do and don't know!)

Bill Fitt + many others

1. Introduction: 1987 Bleaching Event

2. Seasonal Sampling of Corals

3. Cold kill (2010)

4. How does sub-clade of *Symbiodinium* (zooxanthellae) factor in?

1. 1987 Bleaching event

Bleaching
- what happens?
- what are the effects
- how fast does it recover

But…no controls!

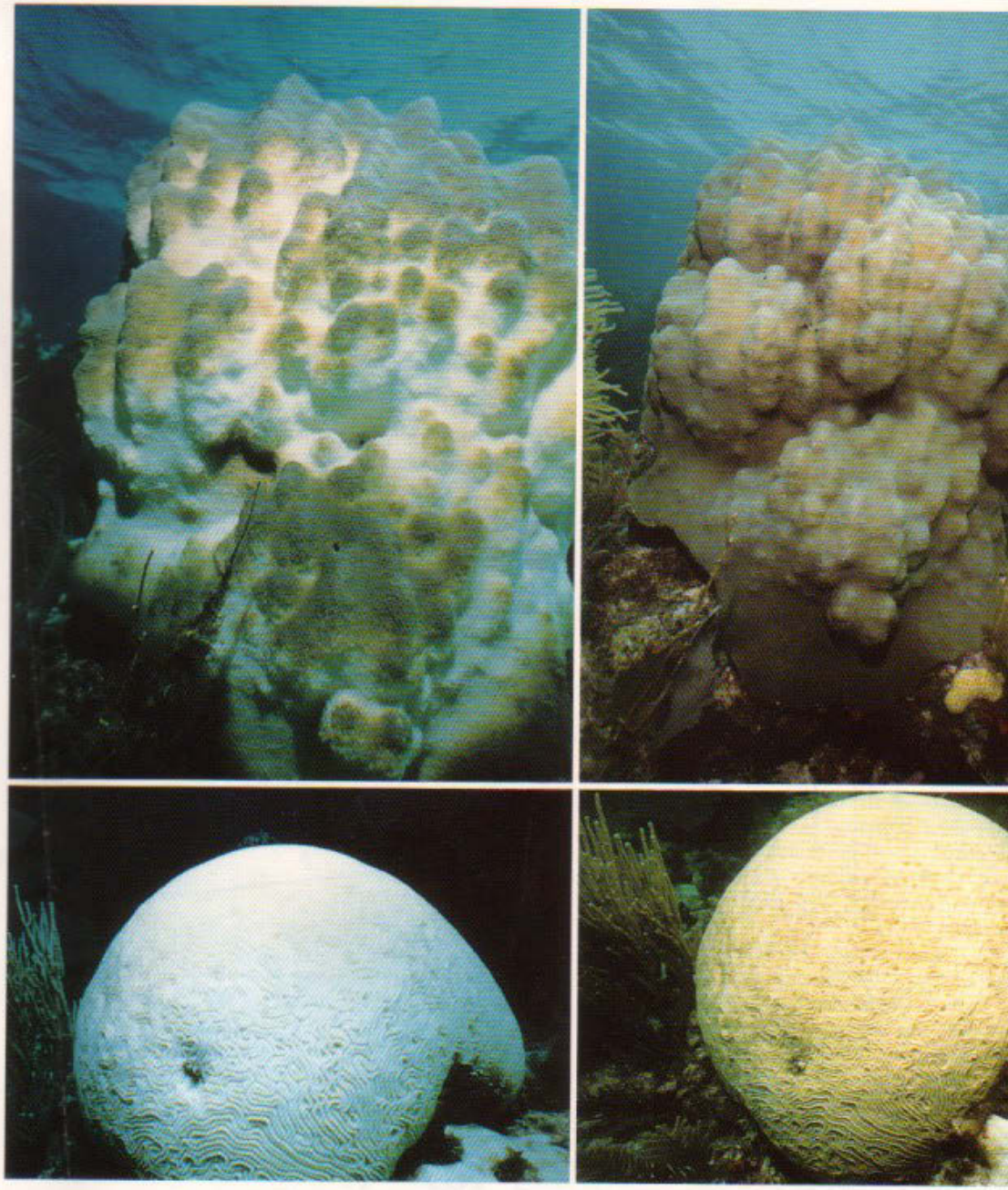
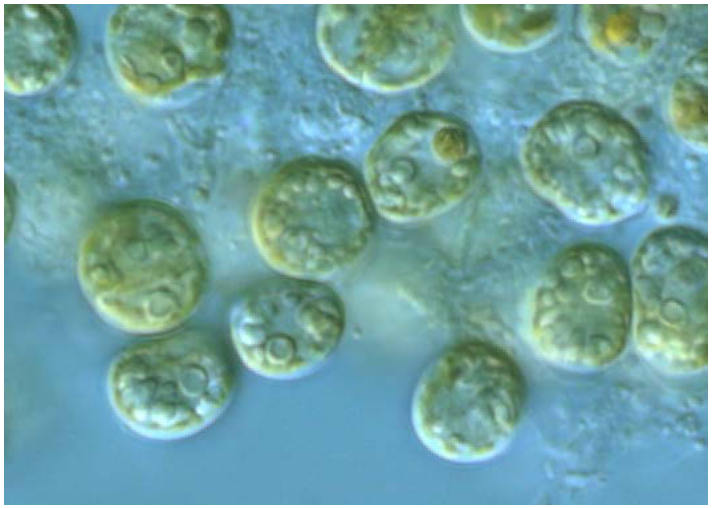


Fig. 1. *Montastrea annularis* (above) and *Diploria labyrinthiformis* (below) on Grecian Rocks Reef in the Key Largo National Ma during the "bleaching event", October of 1987 (left), and after recovery of normal coloration in August of 1990 (right)

2. Seasonal analyses



Zooxanthellae (densities and type)

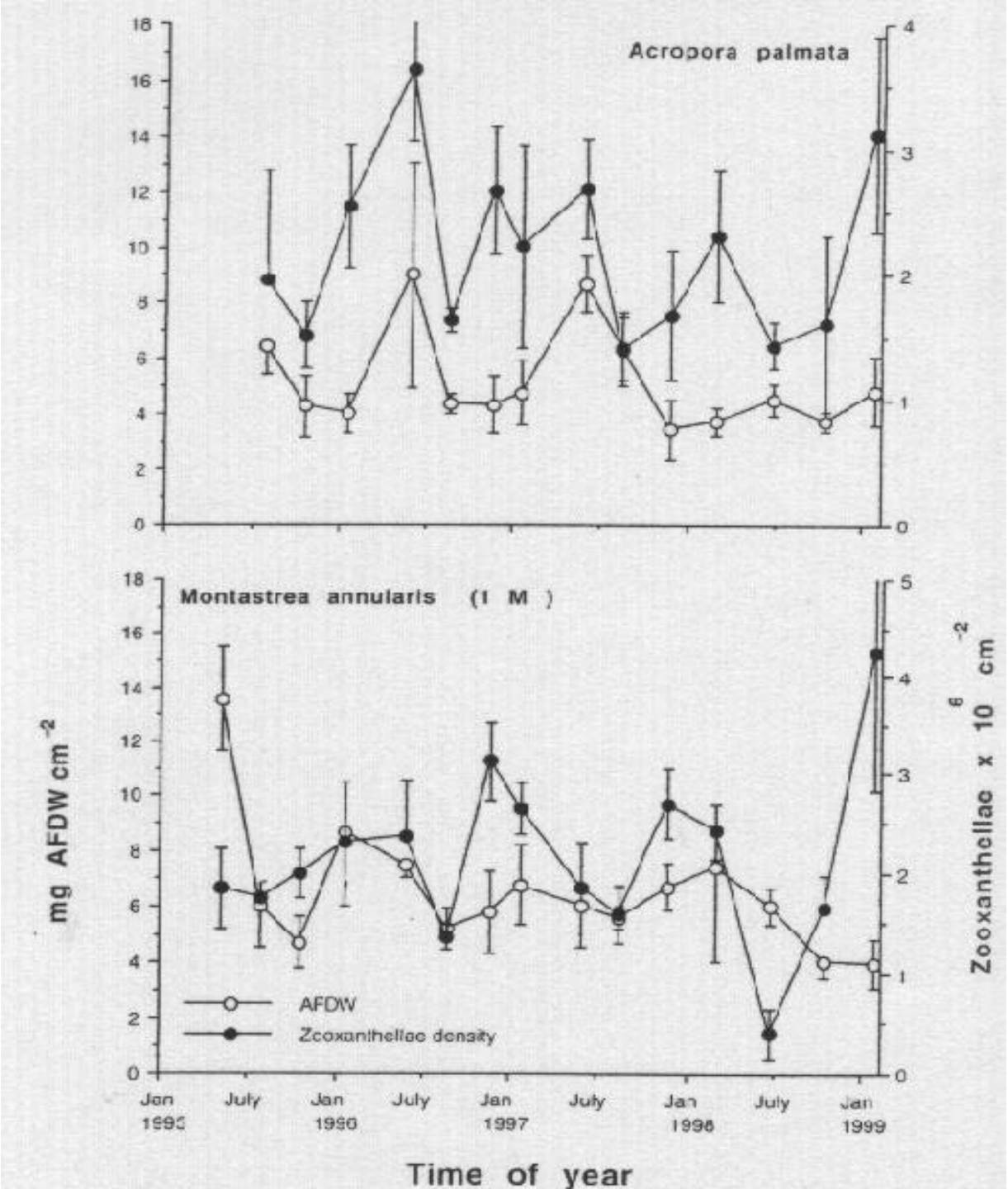
Biomass of host tissue (ash-free dry weight)

But also chl a/zoox, chl a/cm2, and fluorescence

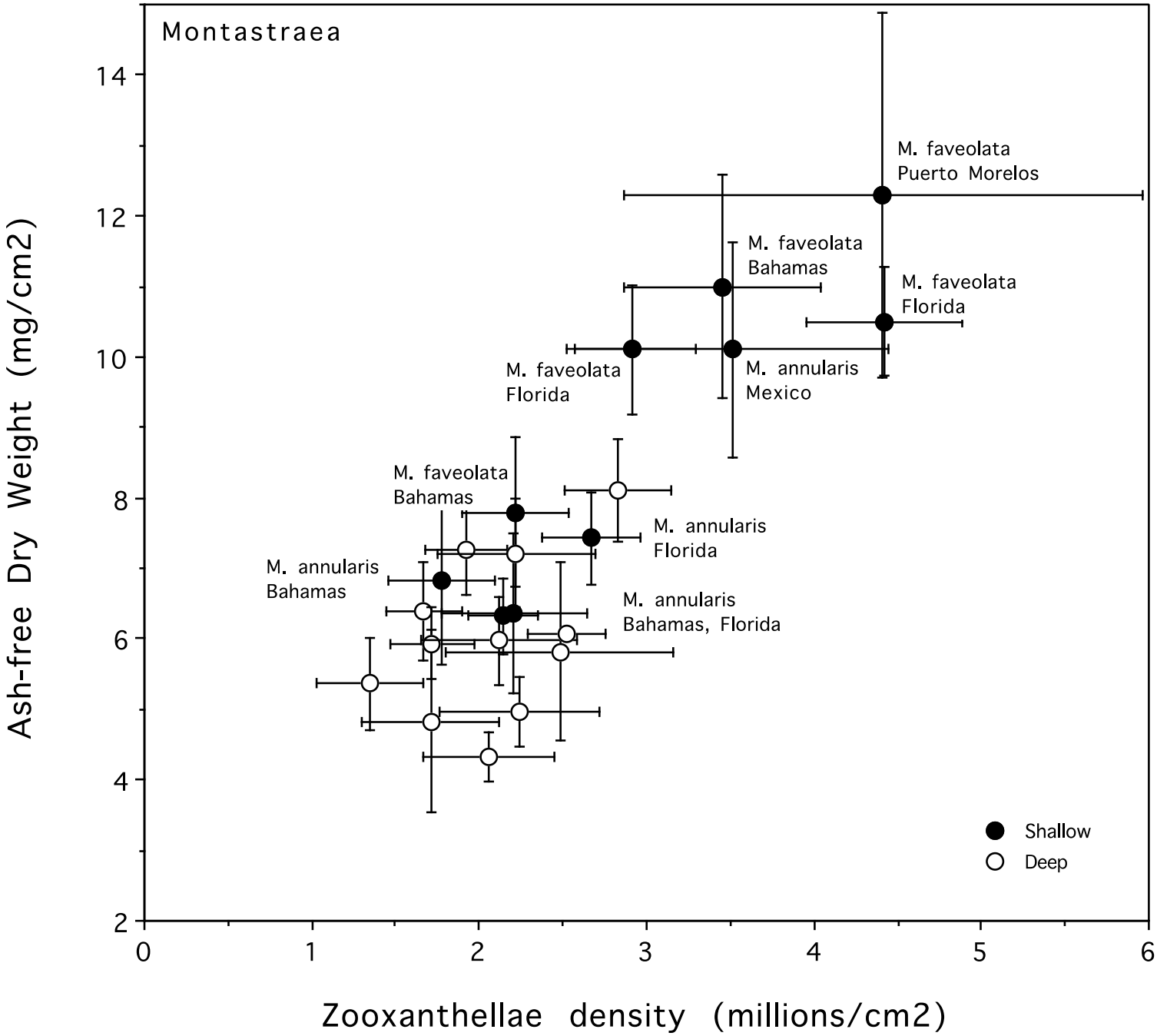
Functional relationship?

Zooxanthellae drive host tissue Biomass

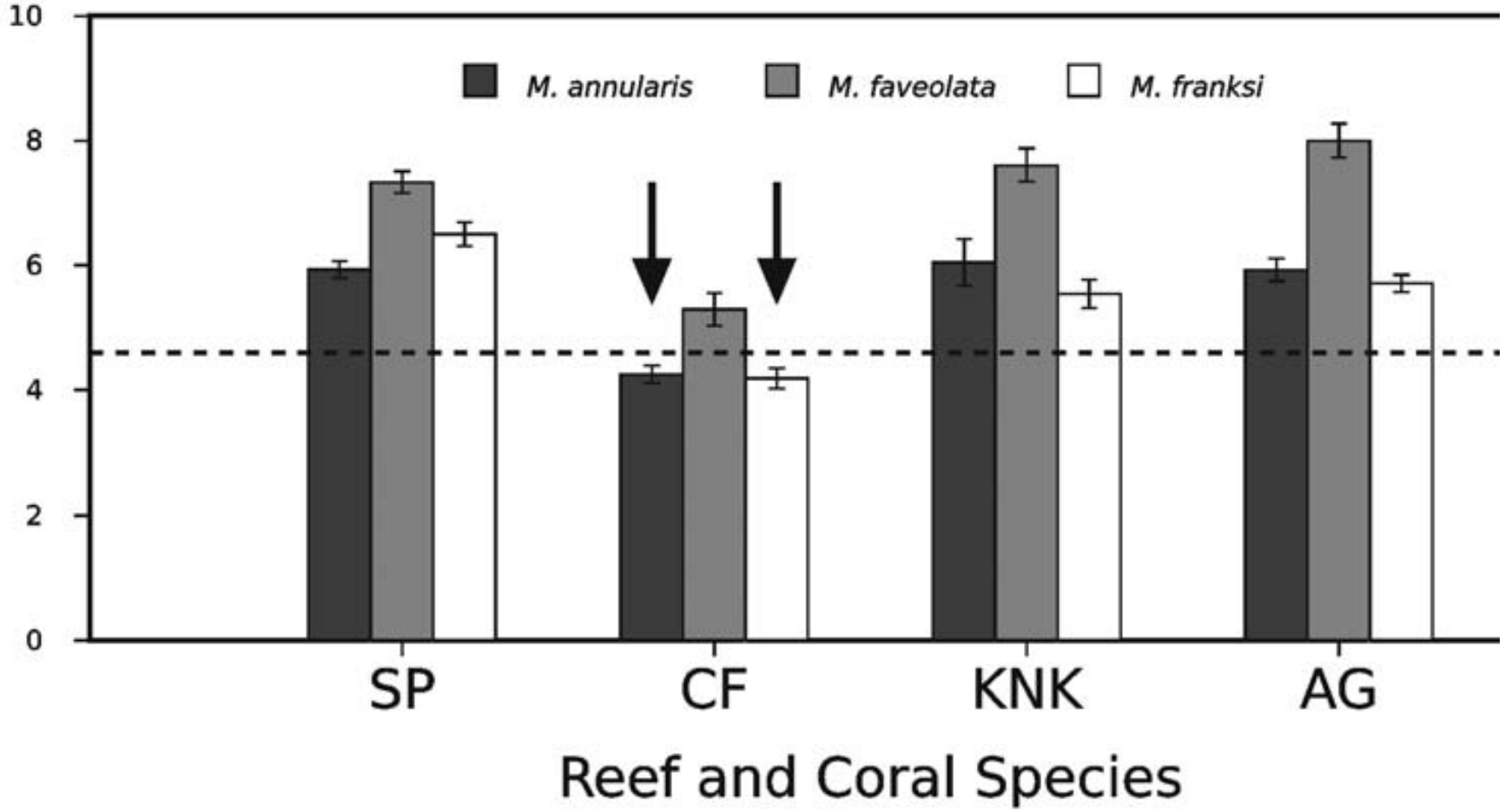
(photosythesis, translocate most of it!)

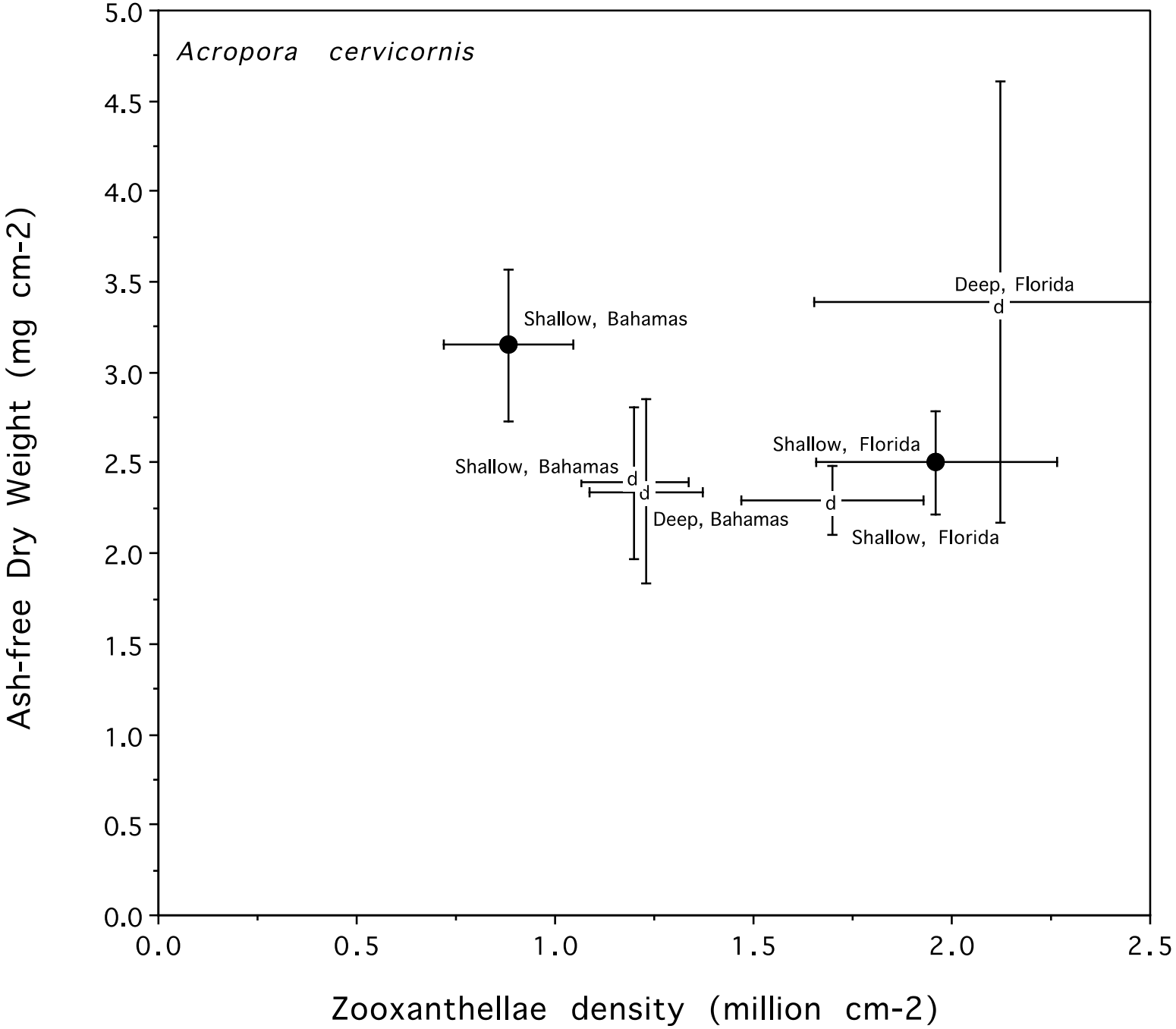


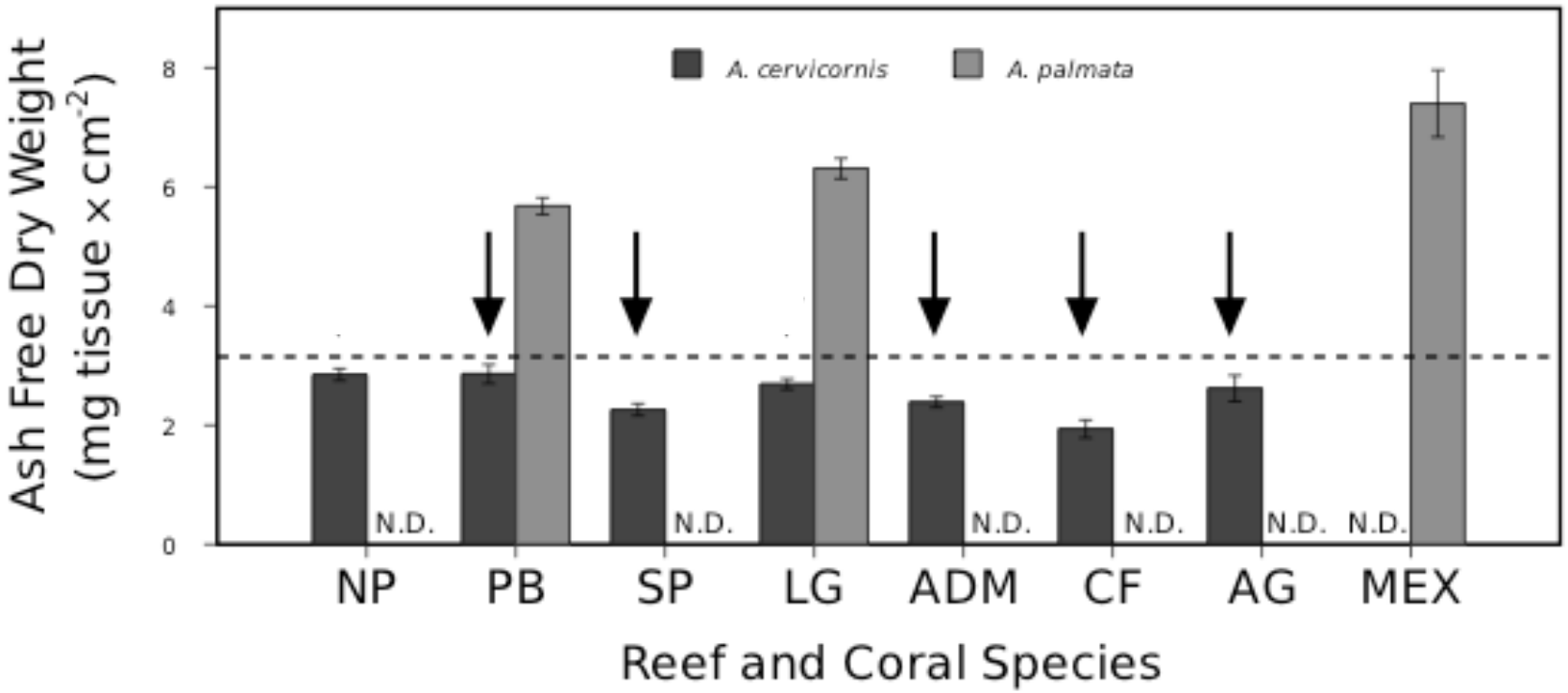
Death of reef corals


Montastraea
M. faveolata
Puerto Morelos
M. faveolata
Bahamas
M. faveolata
Florida
M. faveolata
Florida
M. annularis
Mexico
M. faveolata
Bahamas
M. annularis
Florida
M. annularis
Bahamas
M. annularis
Bahamas, Florida
Shallow
Deep
Ash-free Dry Weight (mg/cm2)
Zooxanthellae density (millions/cm2)
2
4
6
8
10
12
14
0
1
2
3
4
5
6

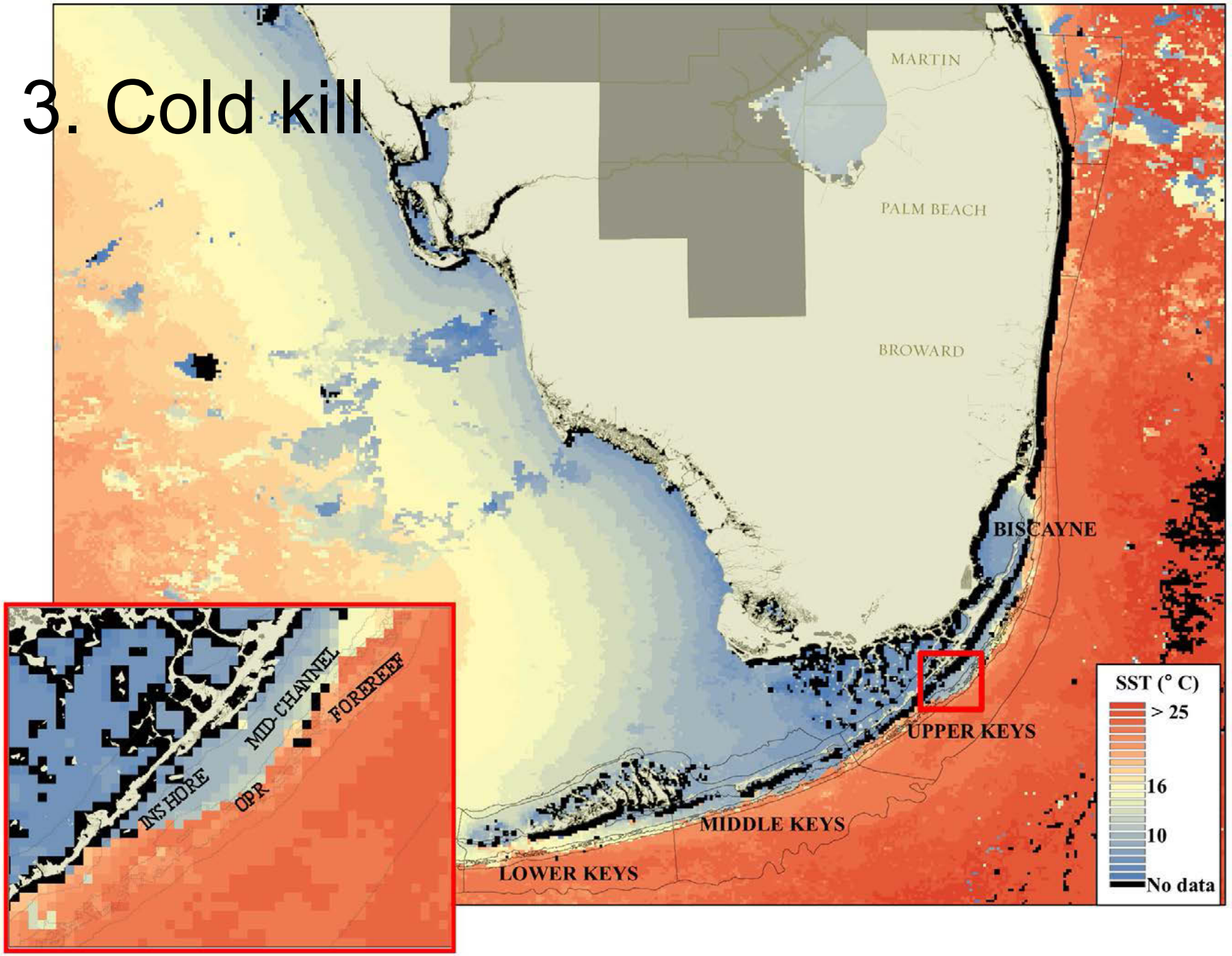
Tissue biomass of *Montastraea* spp.
In relation to colony mortality

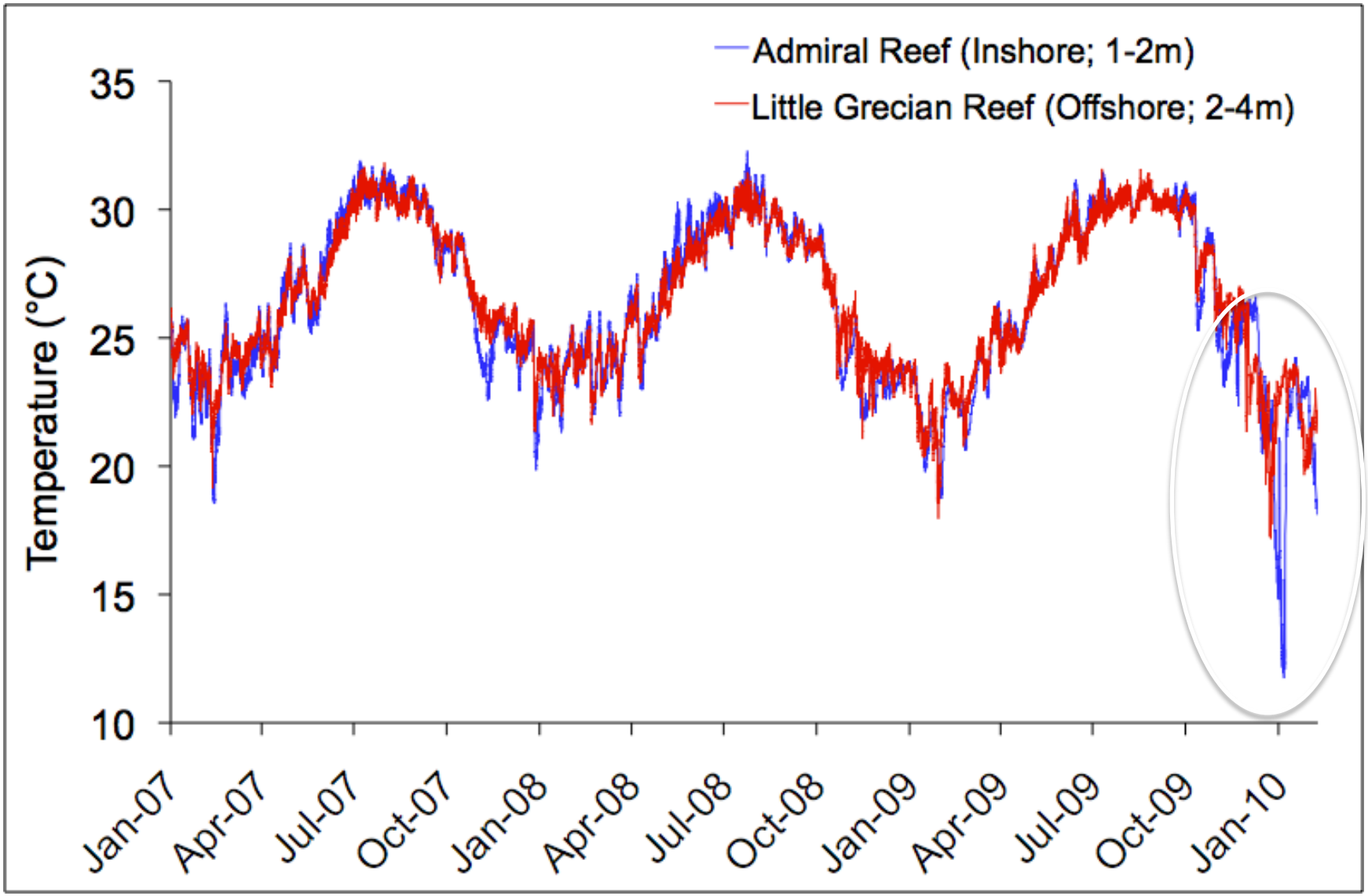


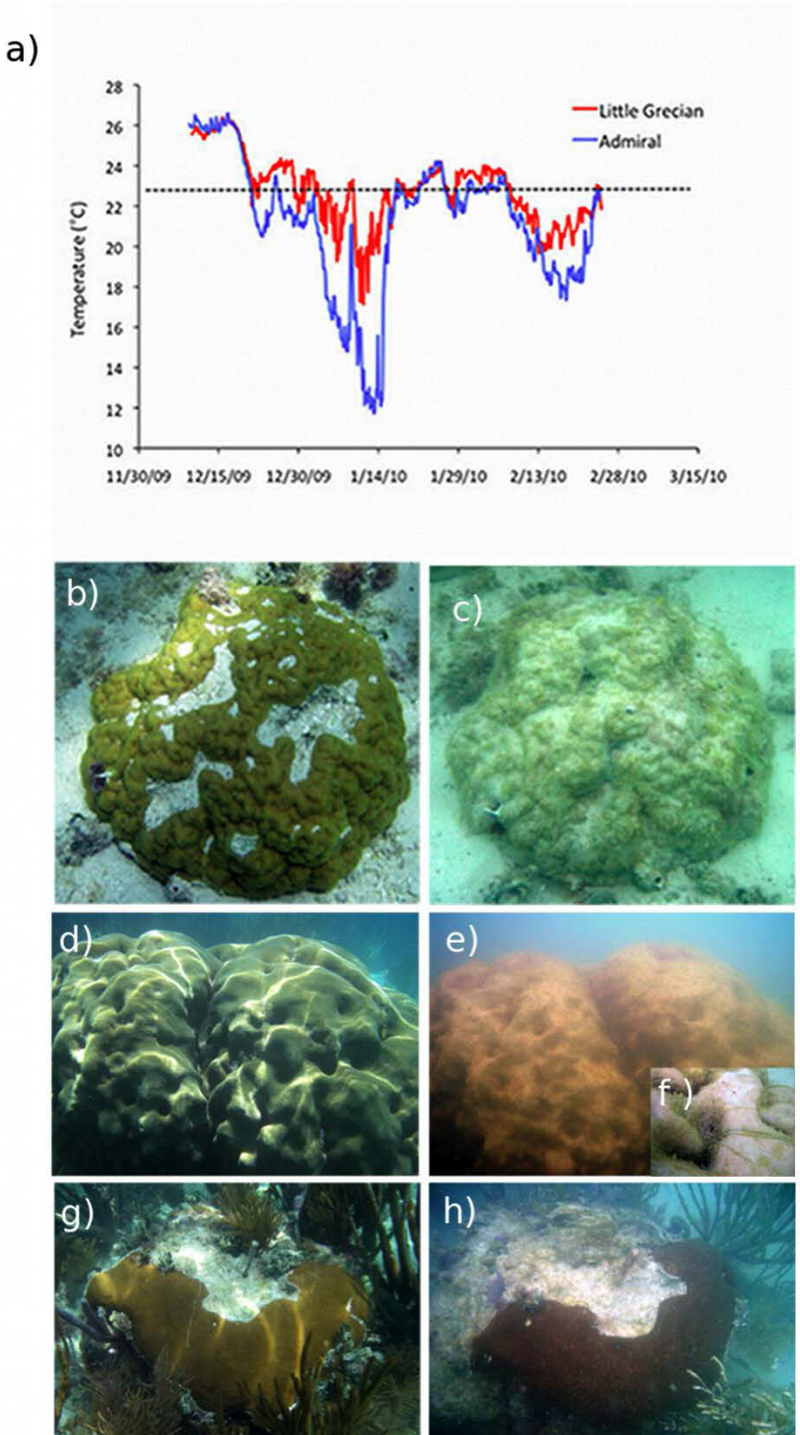

Acropora cervicornis
Ash-free Dry Weight (mg cm-2)
Zooxanthellae density (million cm-2)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Shallow, Bahamas
Deep, Florida
d
Shallow, Bahamas
d
d
Deep, Bahamas
Shallow, Florida
d
Shallow, Florida

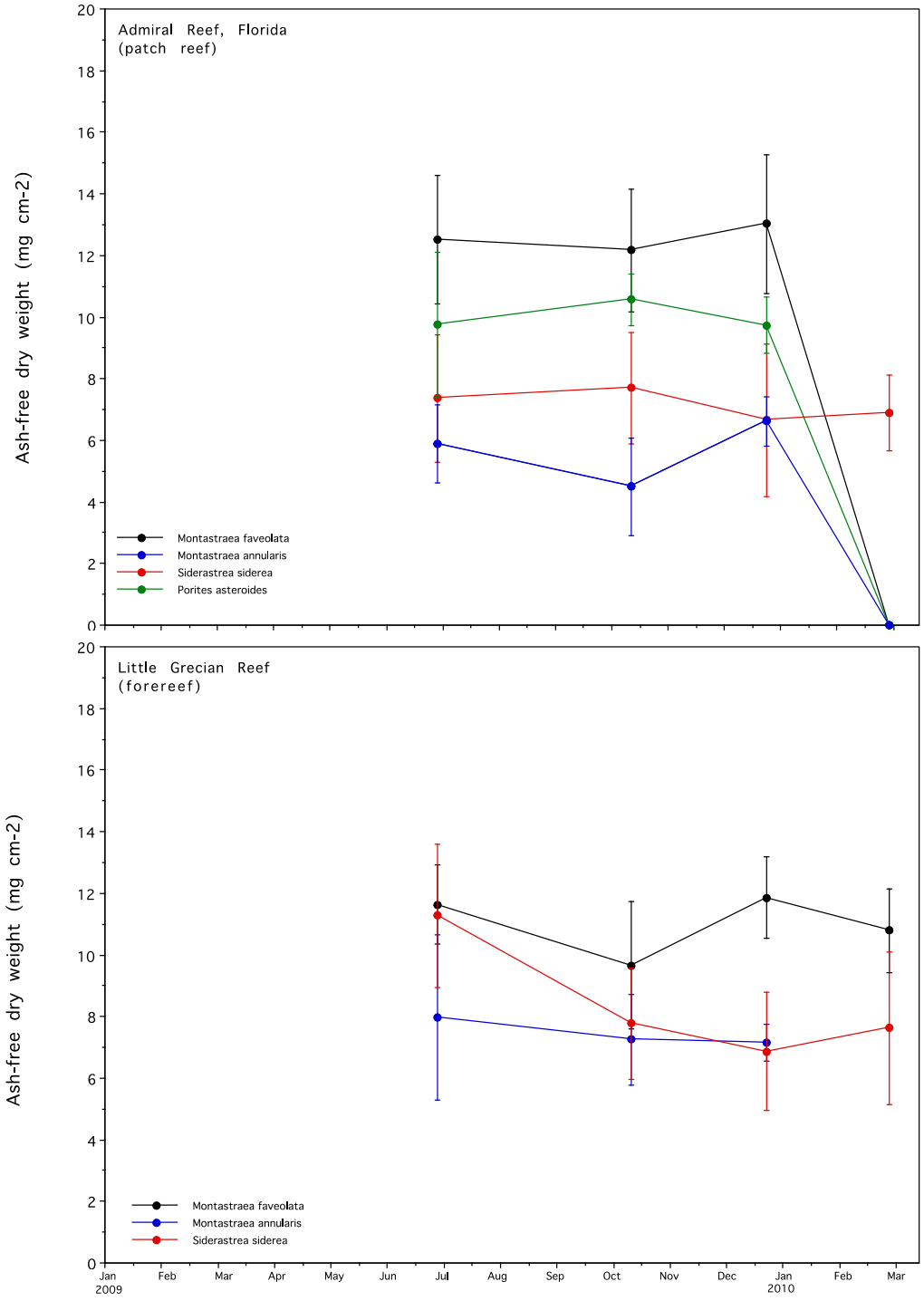

Ash Free Dry Weight
(mg tissue x cm-2)
A. cervicornis
A. palmata
0
2
4
6
8
N.D.
NP
PB
SP
LG
ADM
CF
AG
MEX
Reef and Coral Species

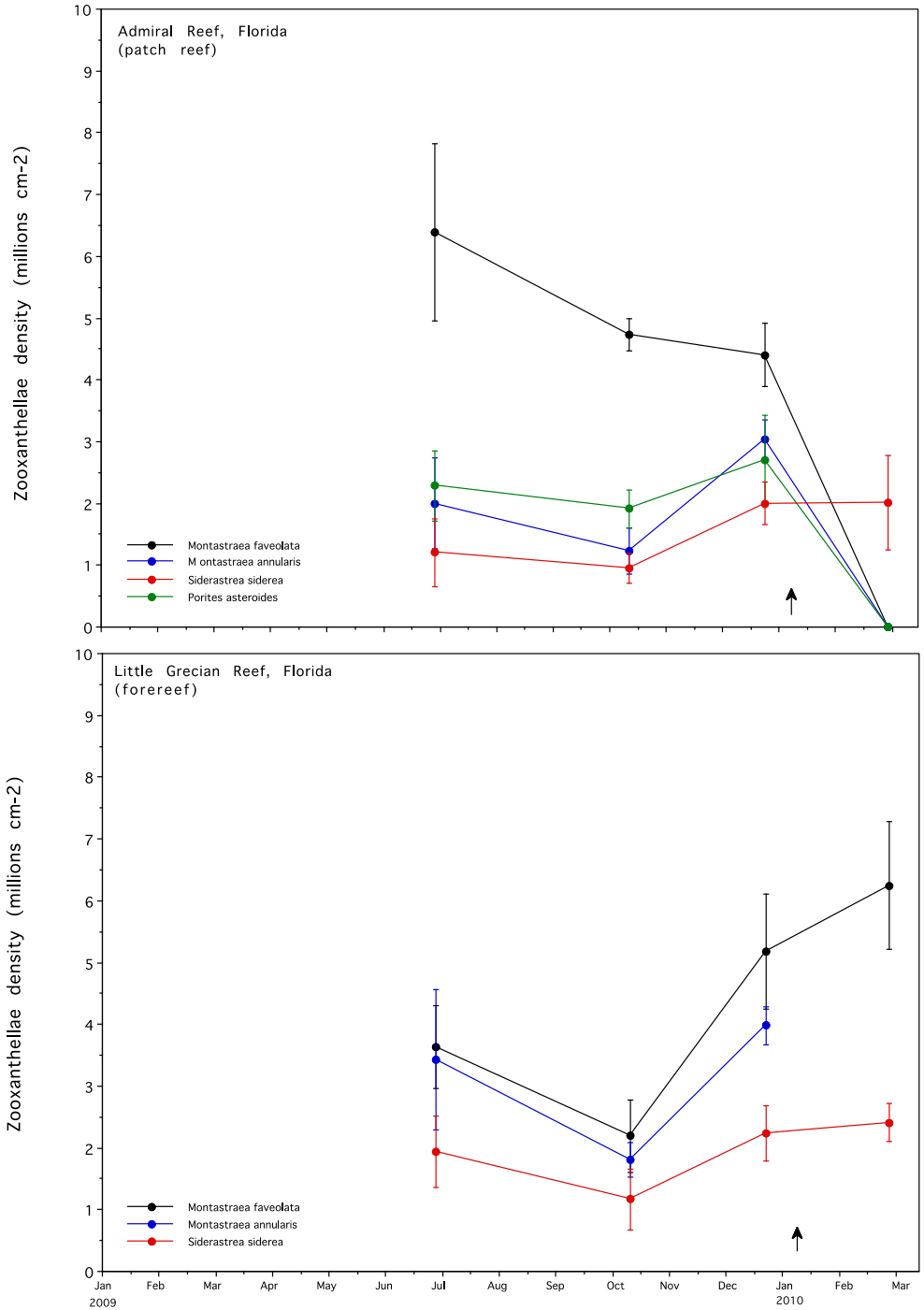
3. Cold kill

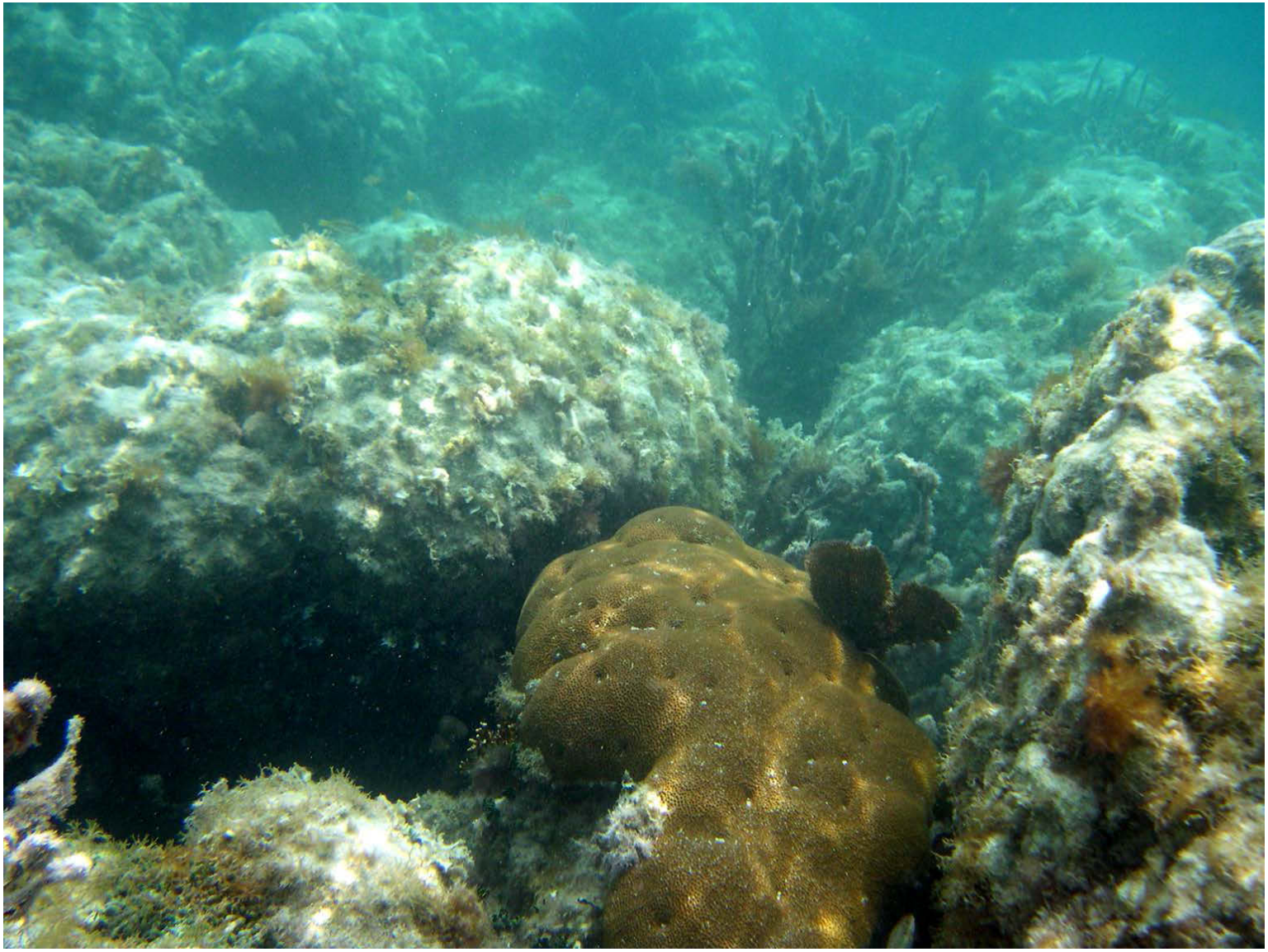

MARTIN
PALM BEACH
BROWARD
BISCAYNE
UPPER KEYS
MIDDLE KEYS
LOWER KEYS
SST (° C)
> 25
16
10
No data
INSHORE
MID-CHANNEL
FOREREEF
OPR


Admiral Reef (Inshore; 1-2m)
Little Grecian Reef (Offshore; 2-4m)
Temperature (°C)
35
30
25
20
15
10
Jan-07
Apr-07
Jul-07
Oct-07
Jan-08
Apr-08
Jul-08
Oct-08
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10


a)
Little Grecian
Admiral
Temperature (°C)
28
26
24
22
20
18
16
14
12
10
11/30/09
12/15/09
12/30/09
1/14/10
1/29/10
2/13/10
2/28/10
3/15/10
b)
c)
d)
e)
f)
g)
h)


Admiral Reef, Florida
(patch reef)
Ash-free dry weight (mg cm-2)
Montastraea faveolata
Montastraea annularis
Siderastrea siderea
Porites asteroides
Little Grecian Reef
(forereef)
Ash-free dry weight (mg cm-2)
Montastraea faveolata
Montastraea annularis
Siderastrea siderea
0
2
4
6
8
10
12
14
16
18
20
Jan
2009
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
2010
Feb
Mar


Admiral Reef, Florida
(patch reef)
Zooxanthellae density (millions cm-2)
Montastraea faveolata
M ontastraea annularis
Siderastrea siderea
Porites asteroides
Little Grecian Reef, Florida
(forereef)
Zooxanthellae density (millions cm-2)
Montastraea faveolata
Montastraea annularis
Siderastrea siderea
Jan
2009
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
2010
Feb
Mar



Admiral Reef 2008 = 24% coral coverage*

2010 < 1% coral coverage

*CREMP

4. Zooxanthellae

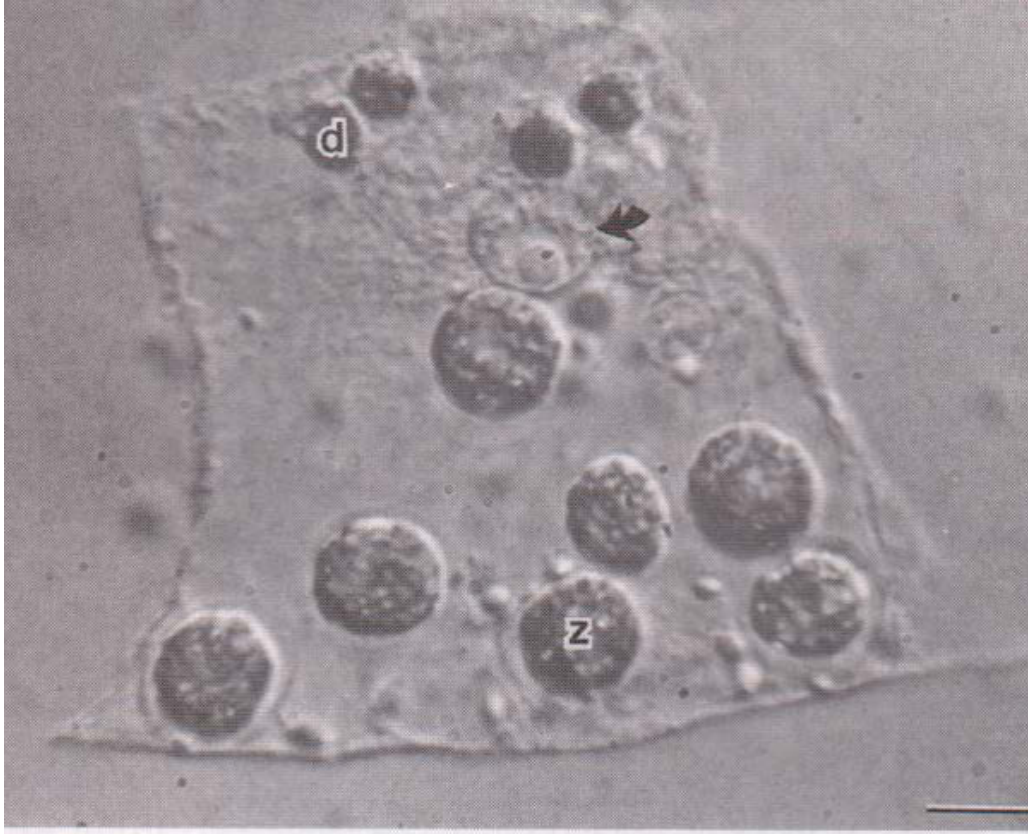
Where are zooxanthellae
= *Symbiodinium*
found:

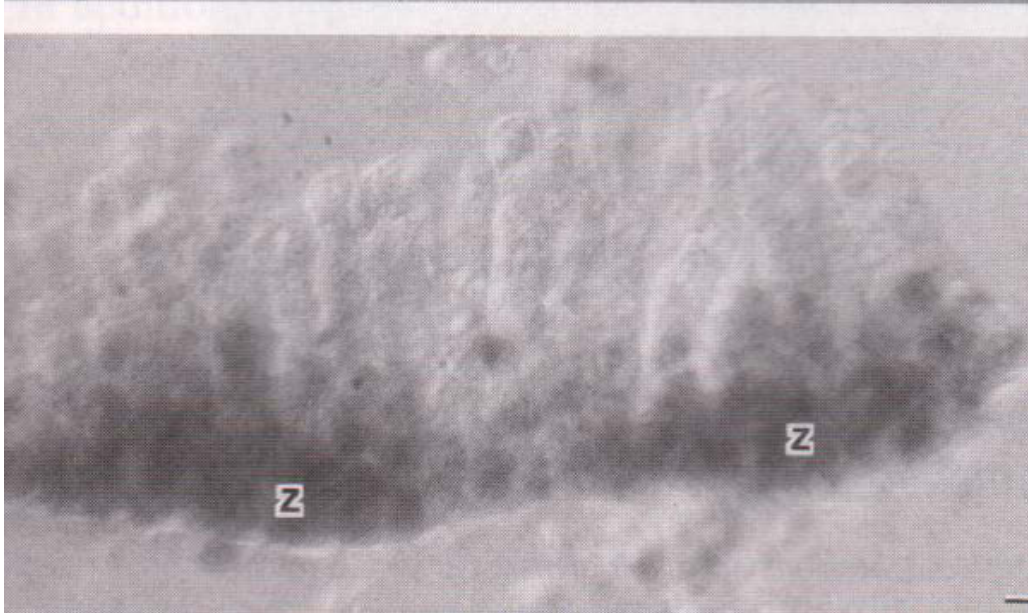
Inside of gastrodermal cells
in cnidarians

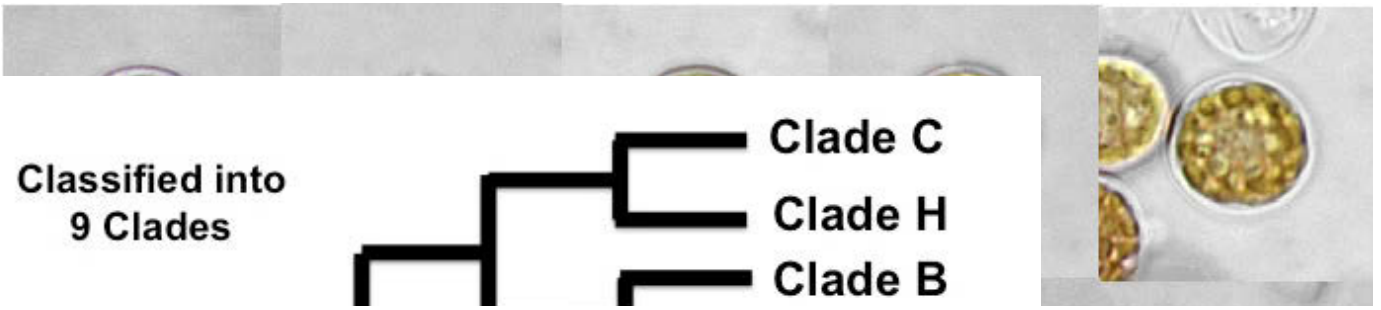
Coelenteron-

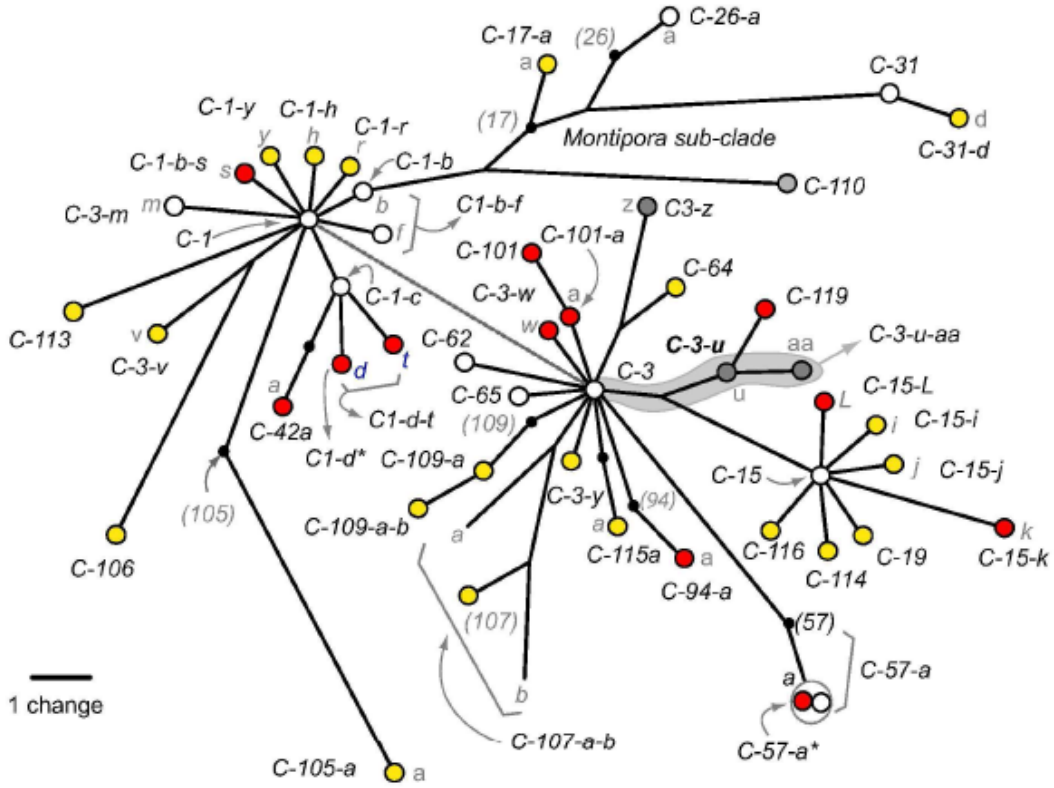
Gastrodermal-
Cells

Mesoglea-

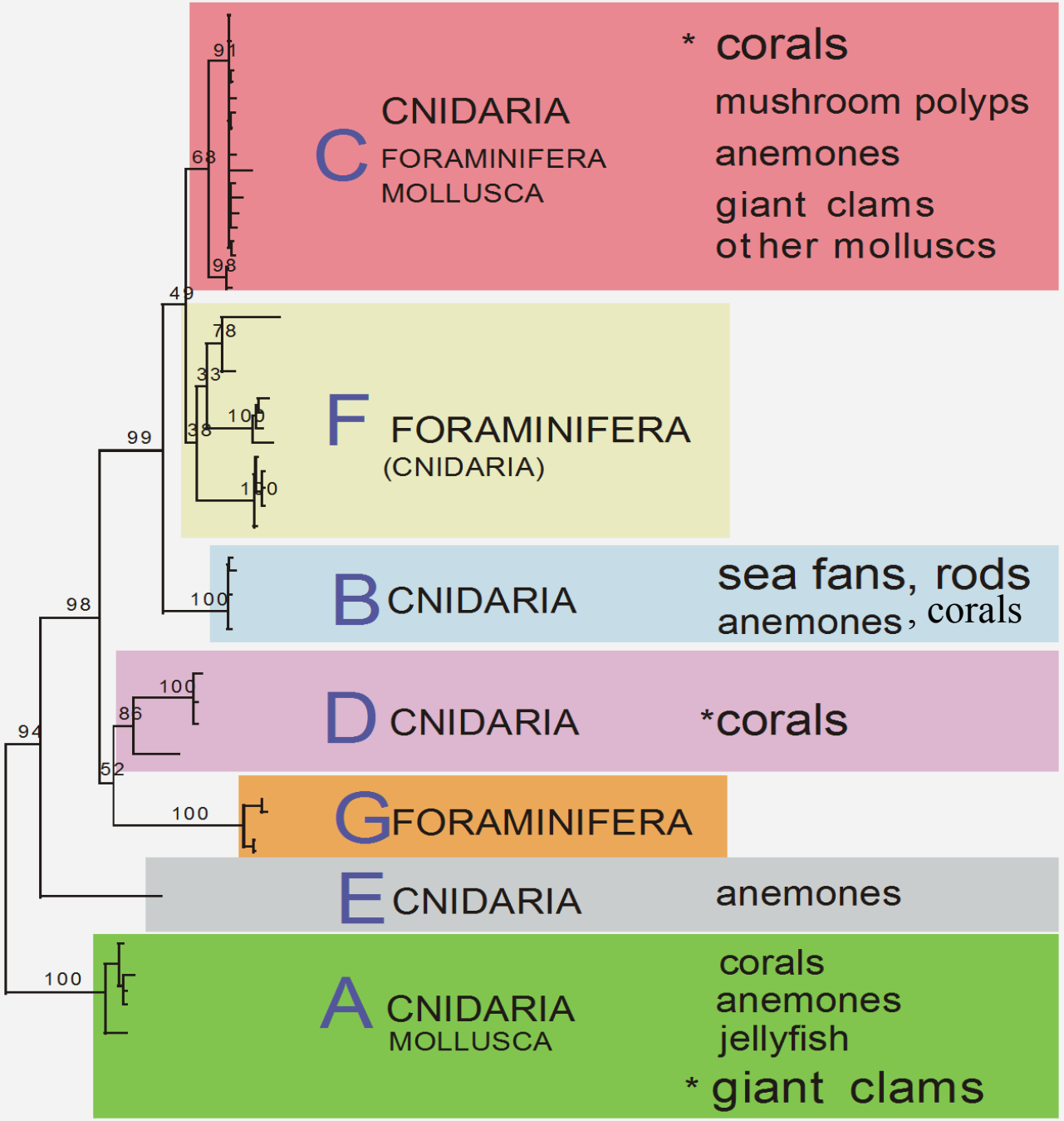


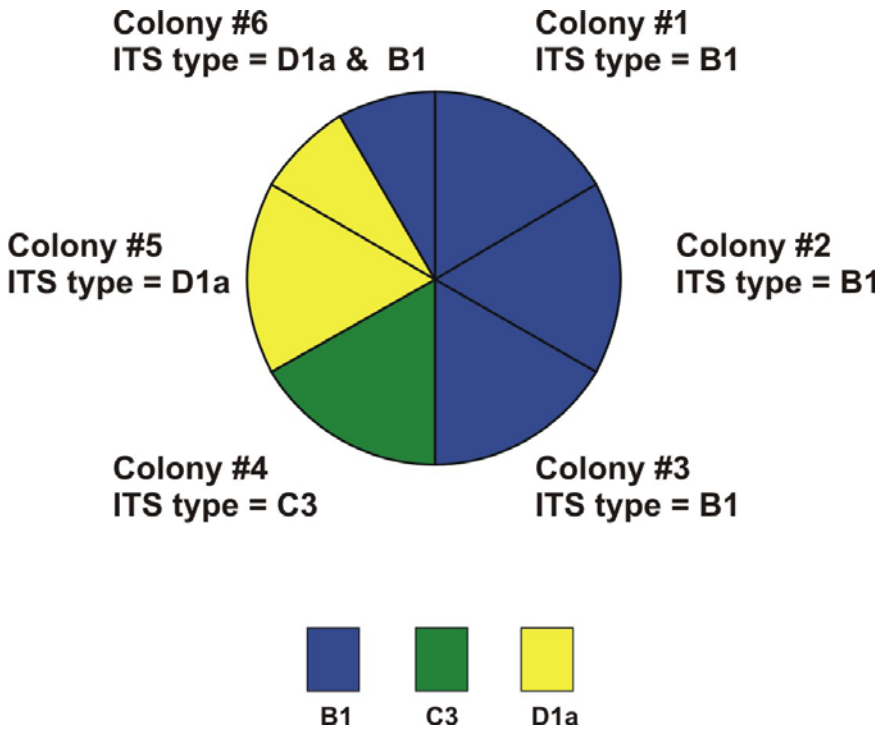






LaJeunesse, TC et al


C
CNIDARIA
FORAMINIFERA
MOLLUSCA
* corals
mushroom polyps
anemones
giant clams
other molluscs
F FORAMINIFERA
(CNIDARIA)
B CNIDARIA
sea fans, rods
anemones, corals
D CNIDARIA
*corals
G FORAMINIFERA
E CNIDARIA
anemones
A CNIDARIA
MOLLUSCA
corals
anemones
jellyfish
* giant clams
91
68
98
49
78
33
100
38
100
99
100
98
100
86
94
52
100
100



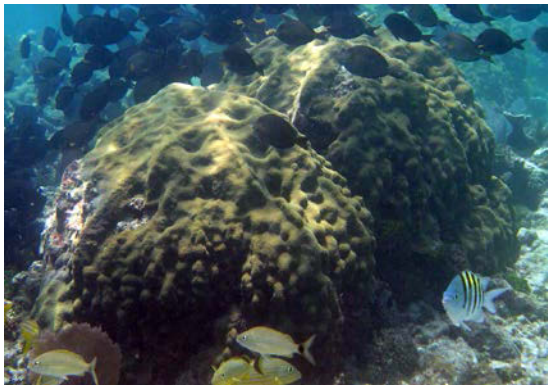
6 colonies / coral species / reef / season

Broadcast Spawning Corals

Acropora palmata

Acropora cervicornis

Siderastrea siderea

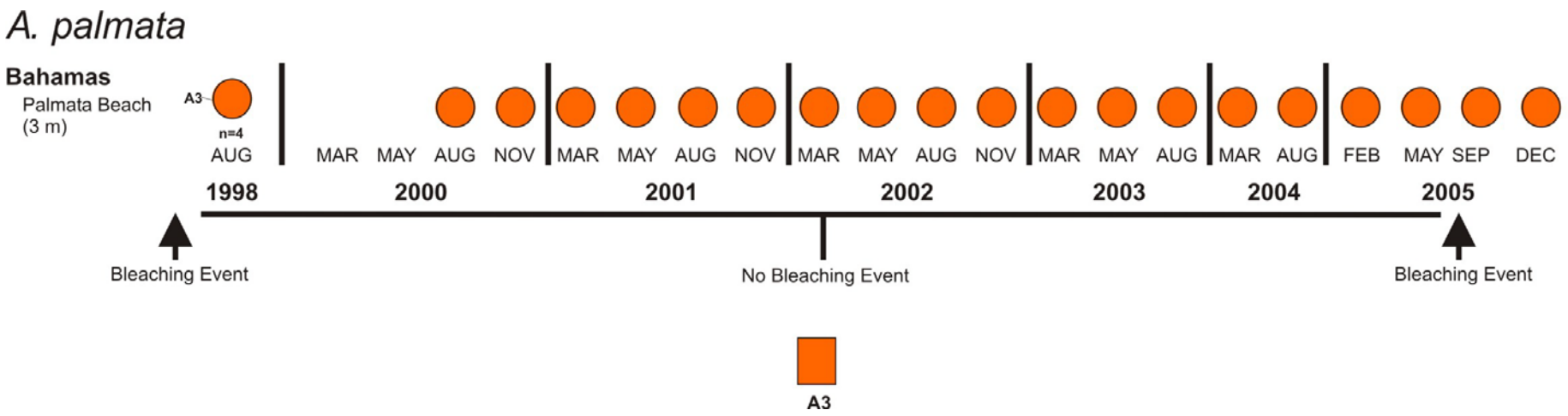


Montastrea faveolata

Montastrea annularis

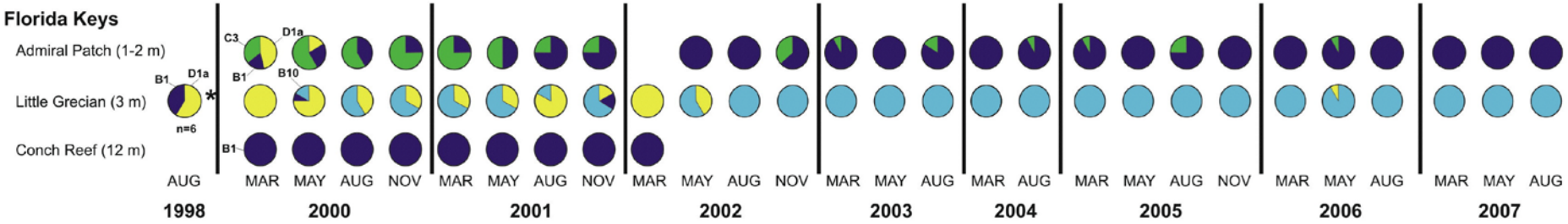
Montastrea franksi

Acropora palmata

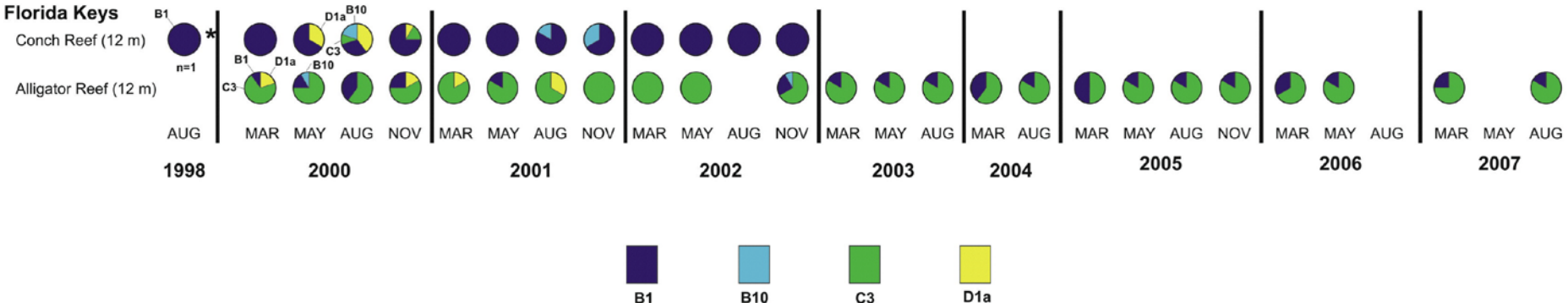


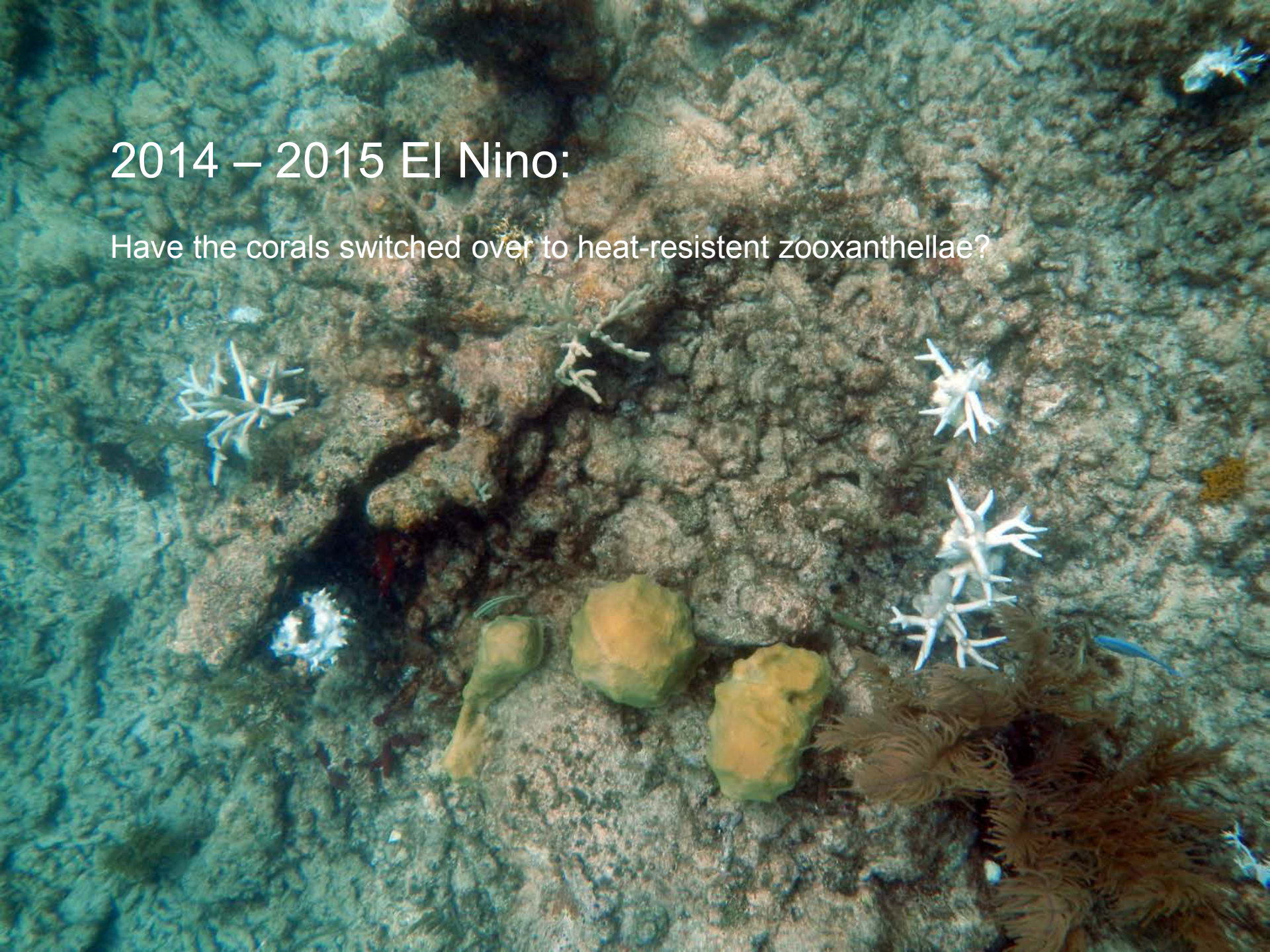
Thornhill et al. (2006)

(A) *M. annularis*



(B) *M. franksi*

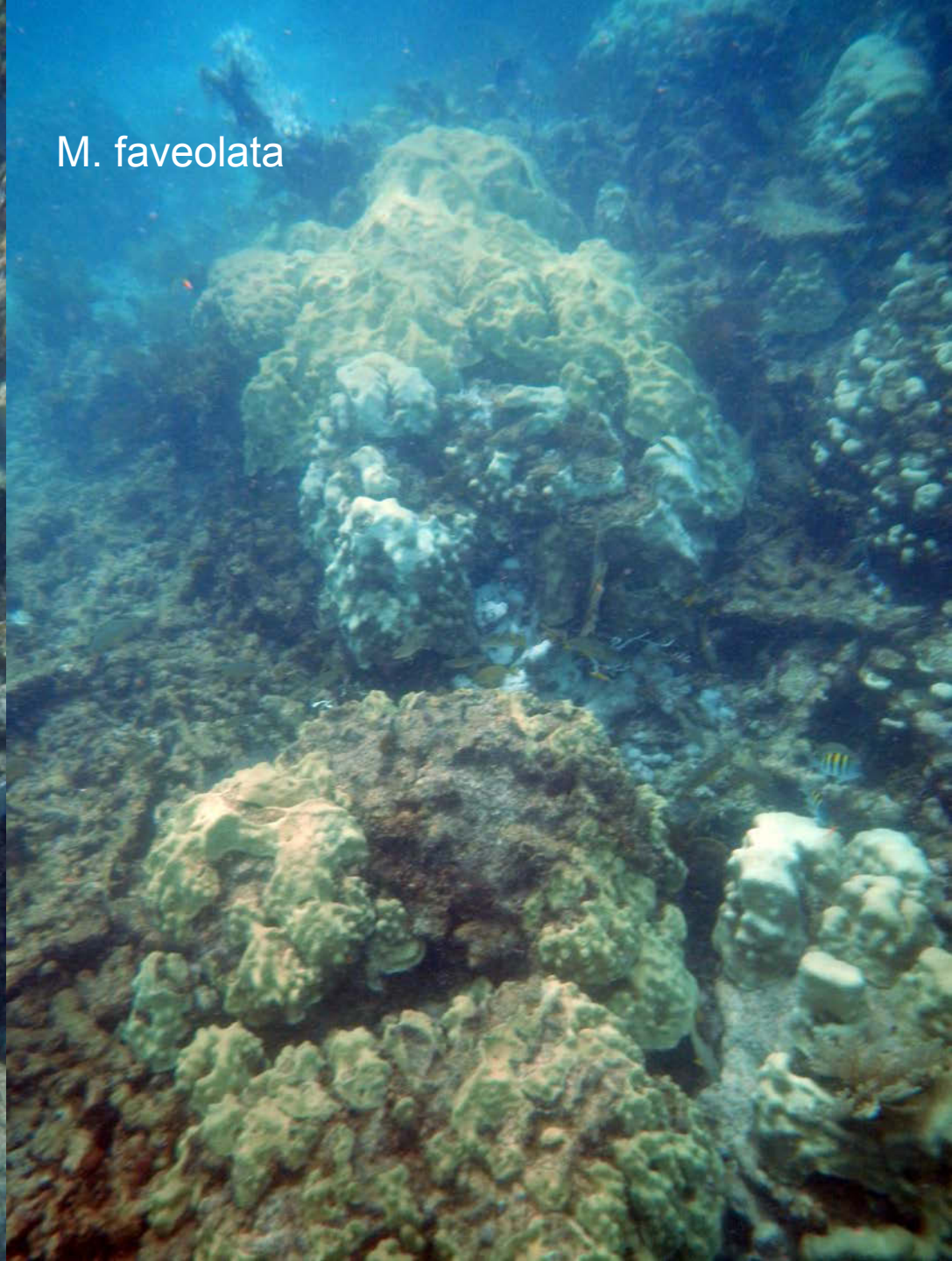




2014 – 2015 El Nino:

Have the corals switched over to heat-resistent zooxanthellae?


M. annularis


M. faveolata

2015 Jun 2 NOAA 60% Probability Coral Bleaching Thermal Stress for Jun–Sep 2015

Experimental, v3.0, CFSv2–based, 28–member Ensemble Forecast