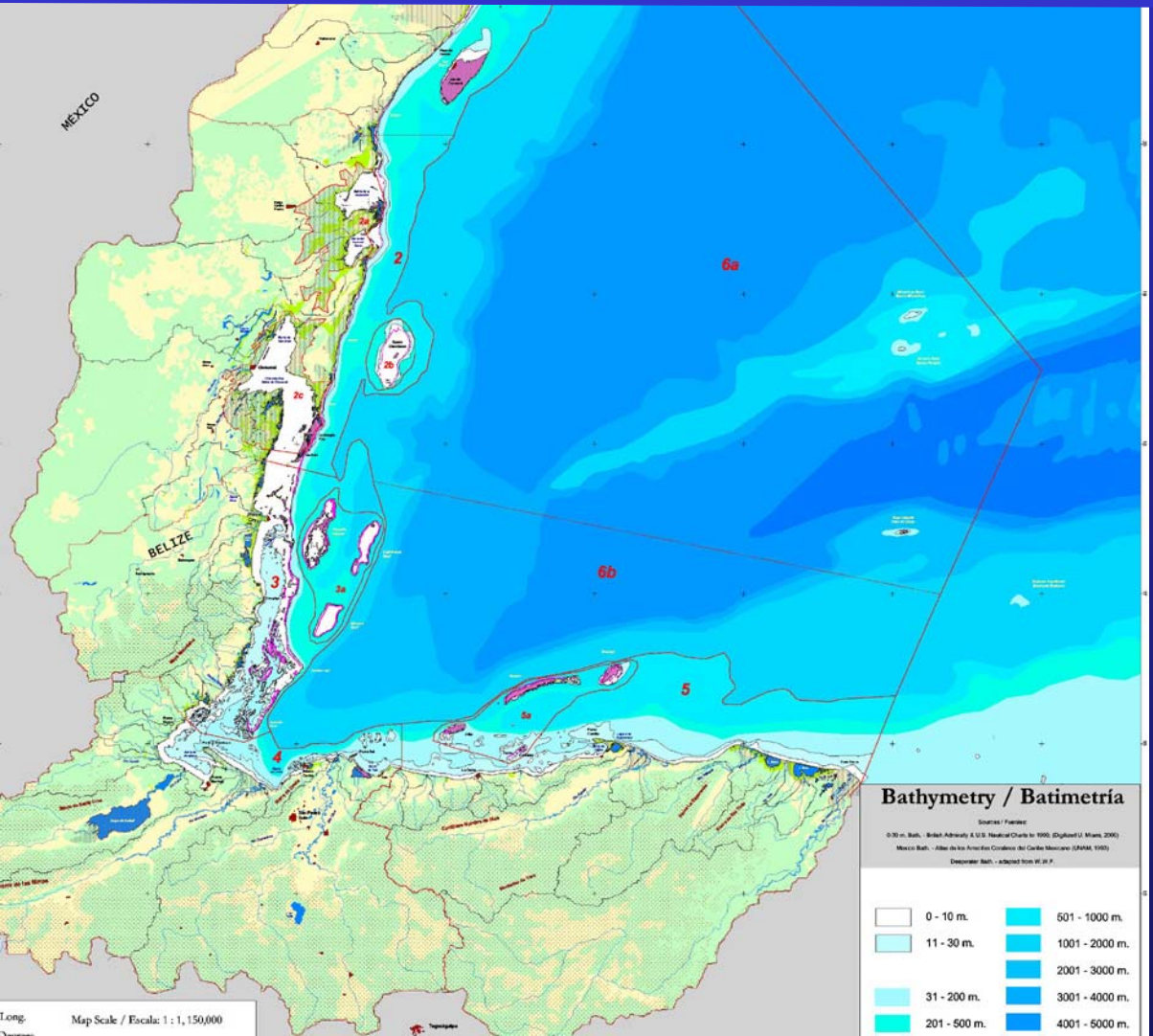
Large-scale Assessments of Bleaching and Potential Mitigation Strategies in the Mesoamerican Reef



Melanie McField
World Wildlife Fund
Mesoamerican Reef

Talk Outline

- Environmental conditions and coral response during and after the 1995 bleaching in Belize
- 1998 Bleaching Event: studies on various scales
- Potential Mitigation and Conservation Strategies: search for resiliency

1995 Bleaching Study Sites

McField, M.
Bul. Mar. Sci.
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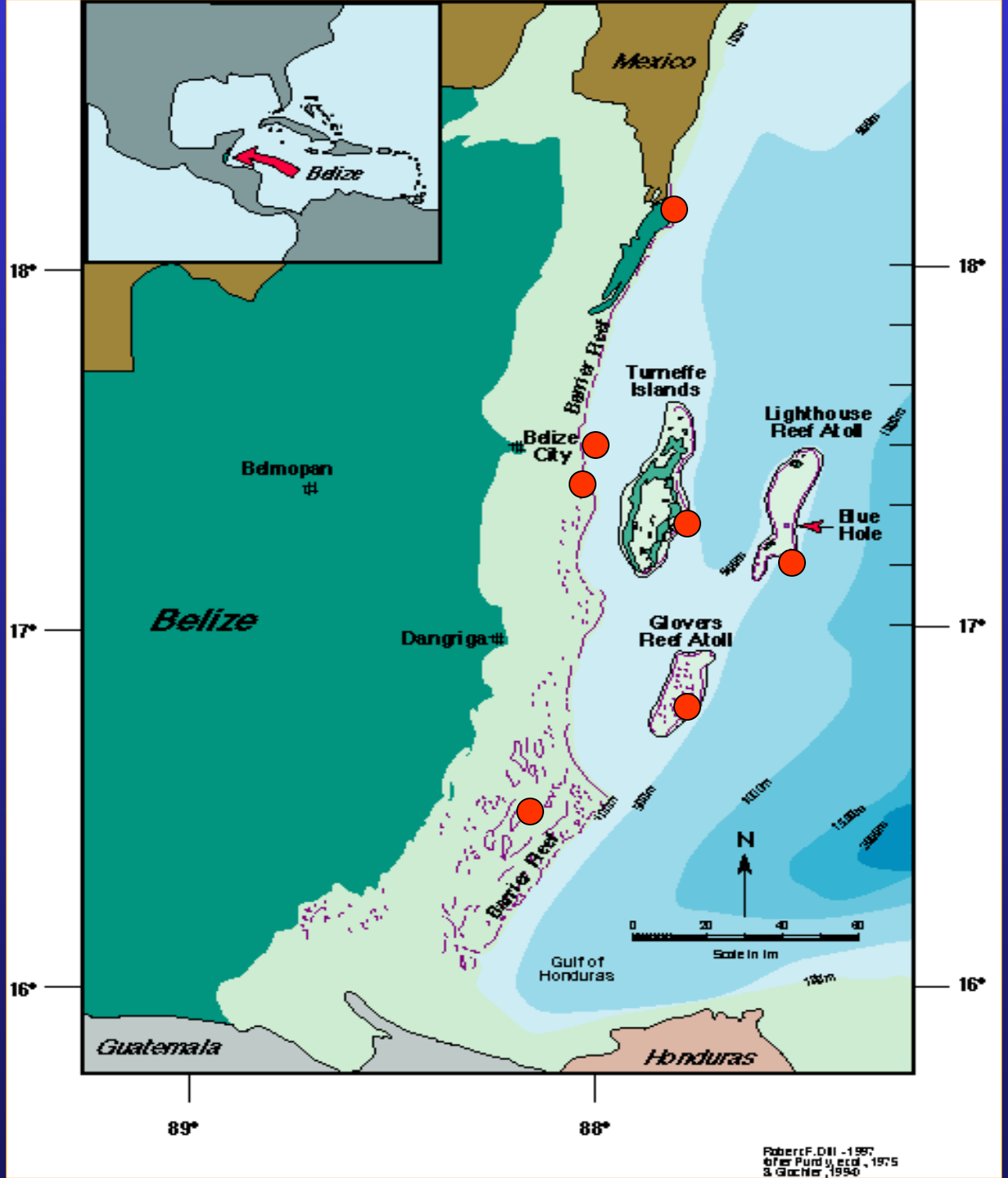
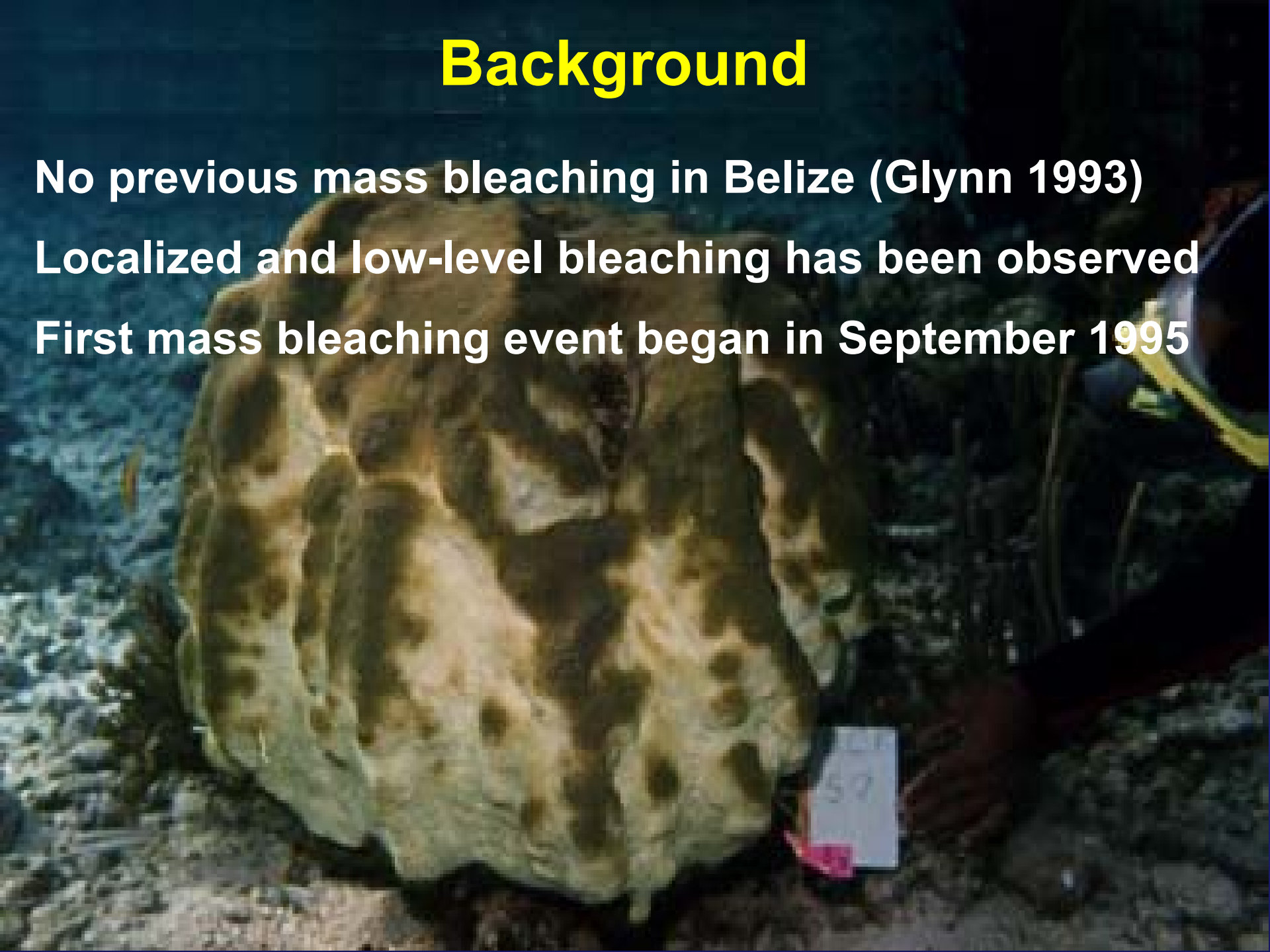


Background



No previous mass bleaching in Belize (Glynn 1993)

Localized and low-level bleaching has been observed

First mass bleaching event began in September 1995

Goals

To examine the environmental conditions coincident with this event

To determine the extent of bleaching throughout the reef system

To record interspecific variability in response to bleaching

Environmental Conditions

Hypothesis

Elevated temperature and solar radiation (UV) are suspected agents

Observations

Summer water temperatures were significantly higher in 1995 than in 1993 or 1994.

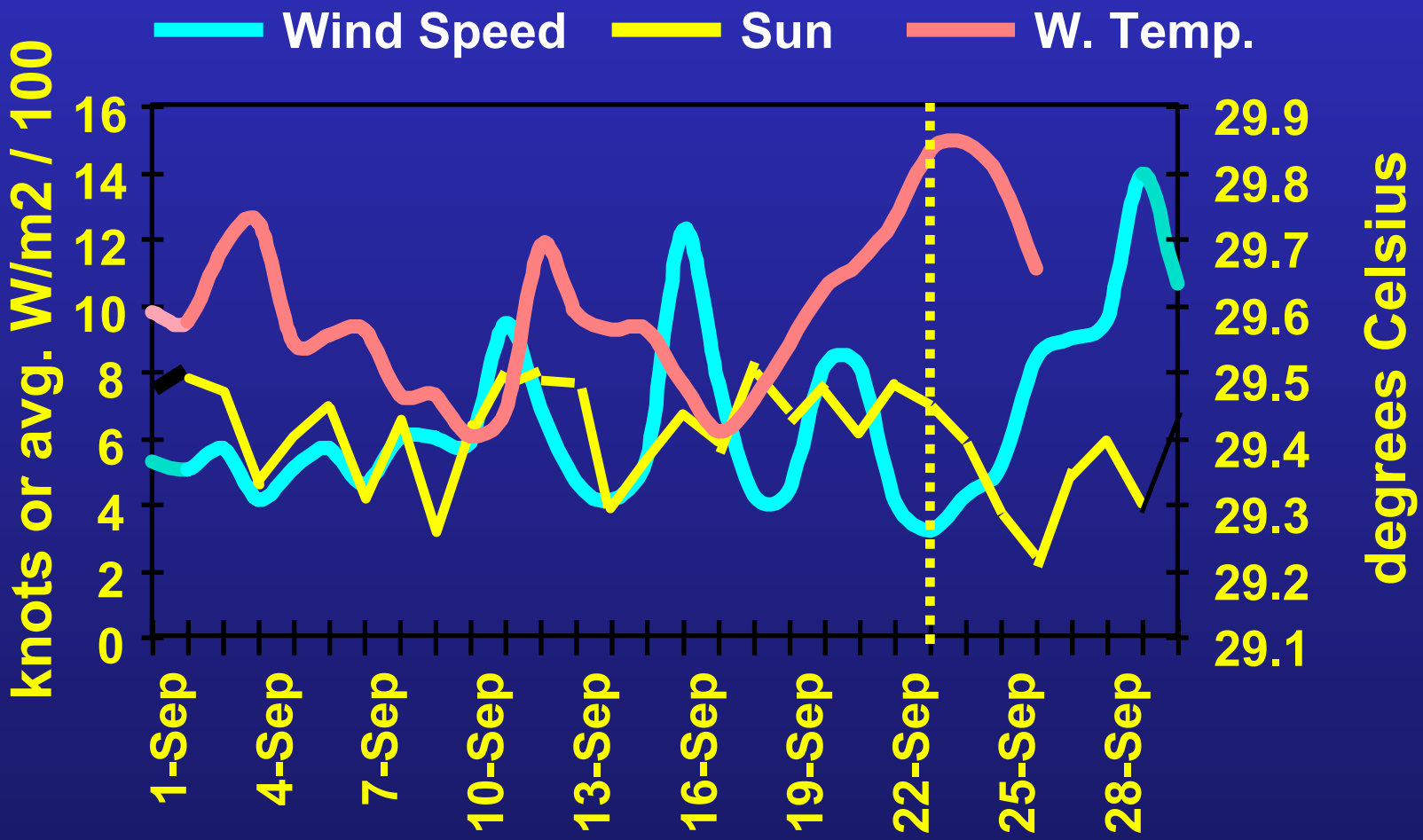
Satellite-based SST concur that 1995 was exceptionally warm in the W. Caribbean.

No *in situ* measurements of irradiance-at-depth are available. Surface solar irradiance and wind speed are used as a proxy.

Surface radiation was sig. higher in Sept. 1995 than in 1993.

Wind speeds were sig. lower in September 1995 than in 1993.

Environmental Conditions
September 1995



Data source: Belize Meteorological Office and CMRC / PCRF

Benthic Survey Method

The weighted-bar swimming transect method (WBST) was developed in this study.

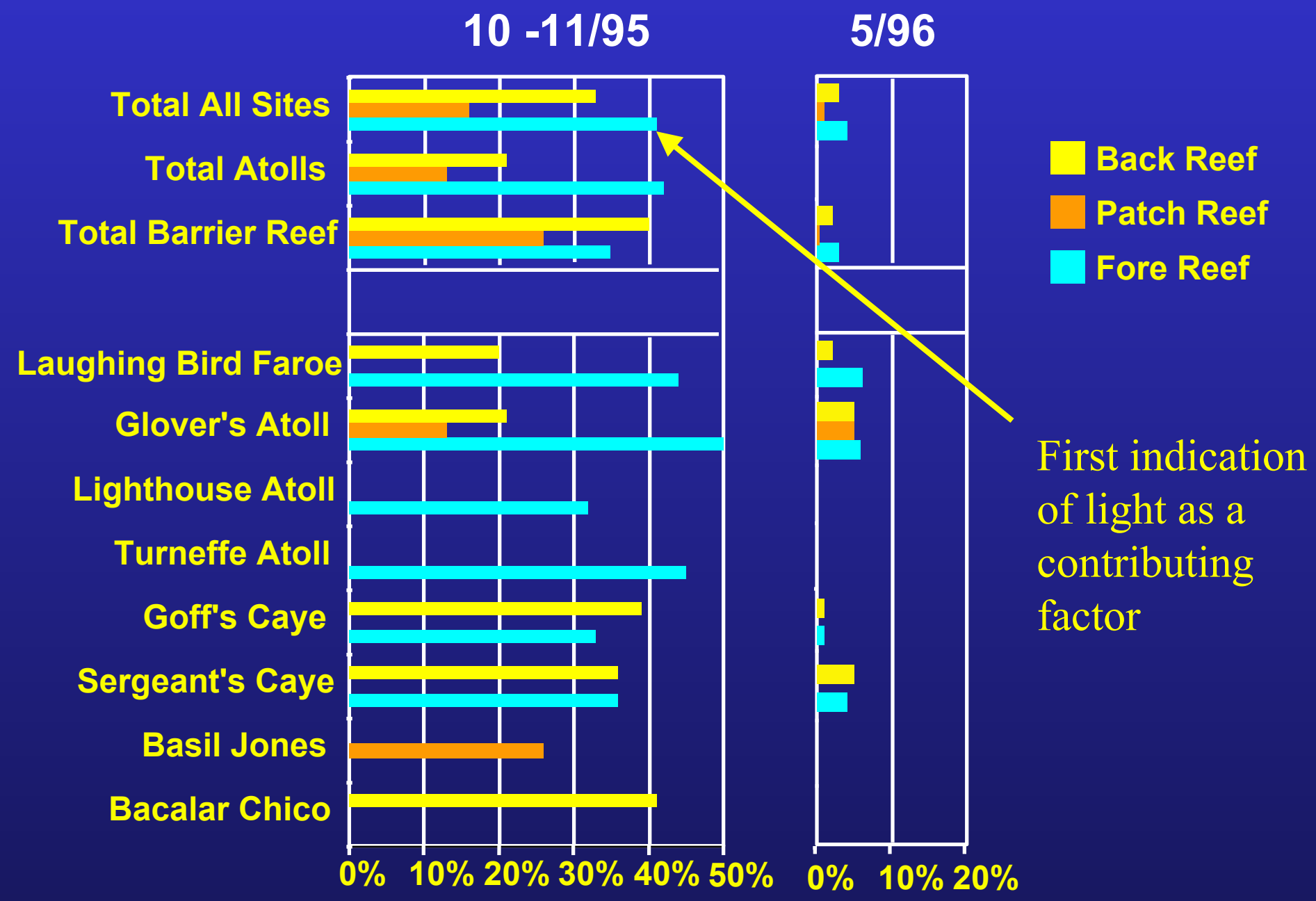
Observers swim on a compass bearing or depth contour and drop a one meter bar every three kick-cycles.

Bars have five marks which define the sample areas.

A ranking of coral condition is given for any coral found in the sample area, with up to five records per bar drop.

rapid, quantitative, user-friendly method

Percent White-Bleached



Hypothesis

Bleaching varies by symbiont clade (which appears controlled primarily by light)

Clades, as identified by Baker and Rowan (1997)

Species with known polymorphisms and those with N < 15 were excluded

Percent bleached with different symbiont clades

Clade "C"

Species	% blchd	N
M. cavernosa	21	101
P. furcata	27	57
P. divaricata	13	34
P. porites	34	298
S. siderea	42	235
D. clivosa	14	43
M. ferox	24	21
Agaricia spp.	33	577
A. tenuifolia	39	347
Mean	**27**	
Std. Dev.	**10.4**	

Clade "B"

Species	%blchd	N
C. natans	0	41
D. strigosa	8	324
E. fastigiata	13	16
M. meandrites	3	39
M. mirabilis	4	47
F. fragum	25	167
Mean	**8.8**	
Std. Dev.	**9.1**	

Corals with Clade "C" symbionts experience higher levels of bleaching Than those with Clade "B" symbionts.

P = 0.005 (approximate randomization test; 10,000 trials)

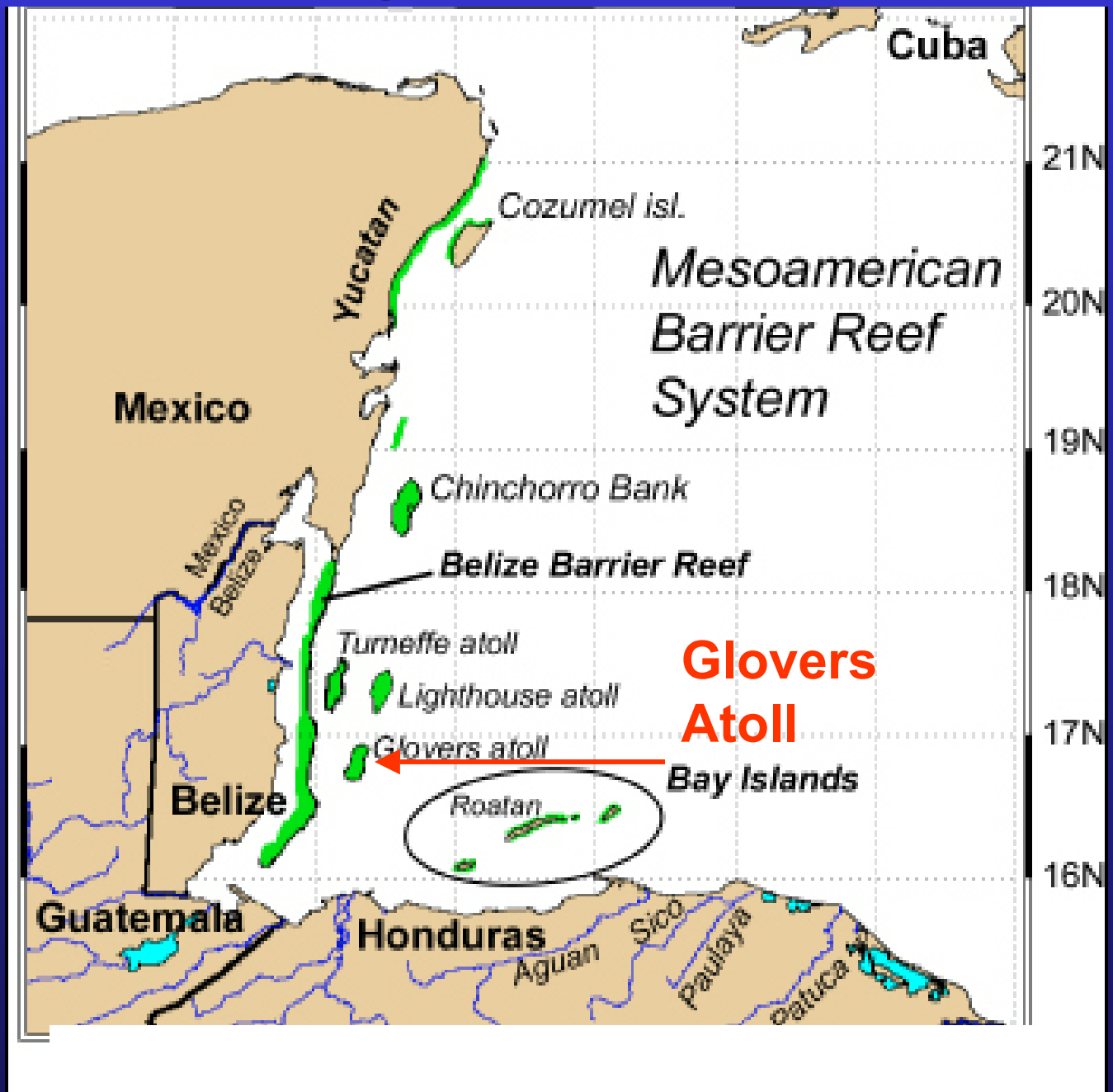
Summary

Corals hosting clade “C” symbiont are more affected by bleaching than those with clade “B”

- Could explain intra-colony variability in polymorphic species and depth variability Fore reef being more affected that back reef

- Another indication that light in an important factor (since light controls clade zonation)

II. 1998 Bleaching: studies on various scales



Glovers Reef Atoll: BABA Project

(blondes against brown algae)

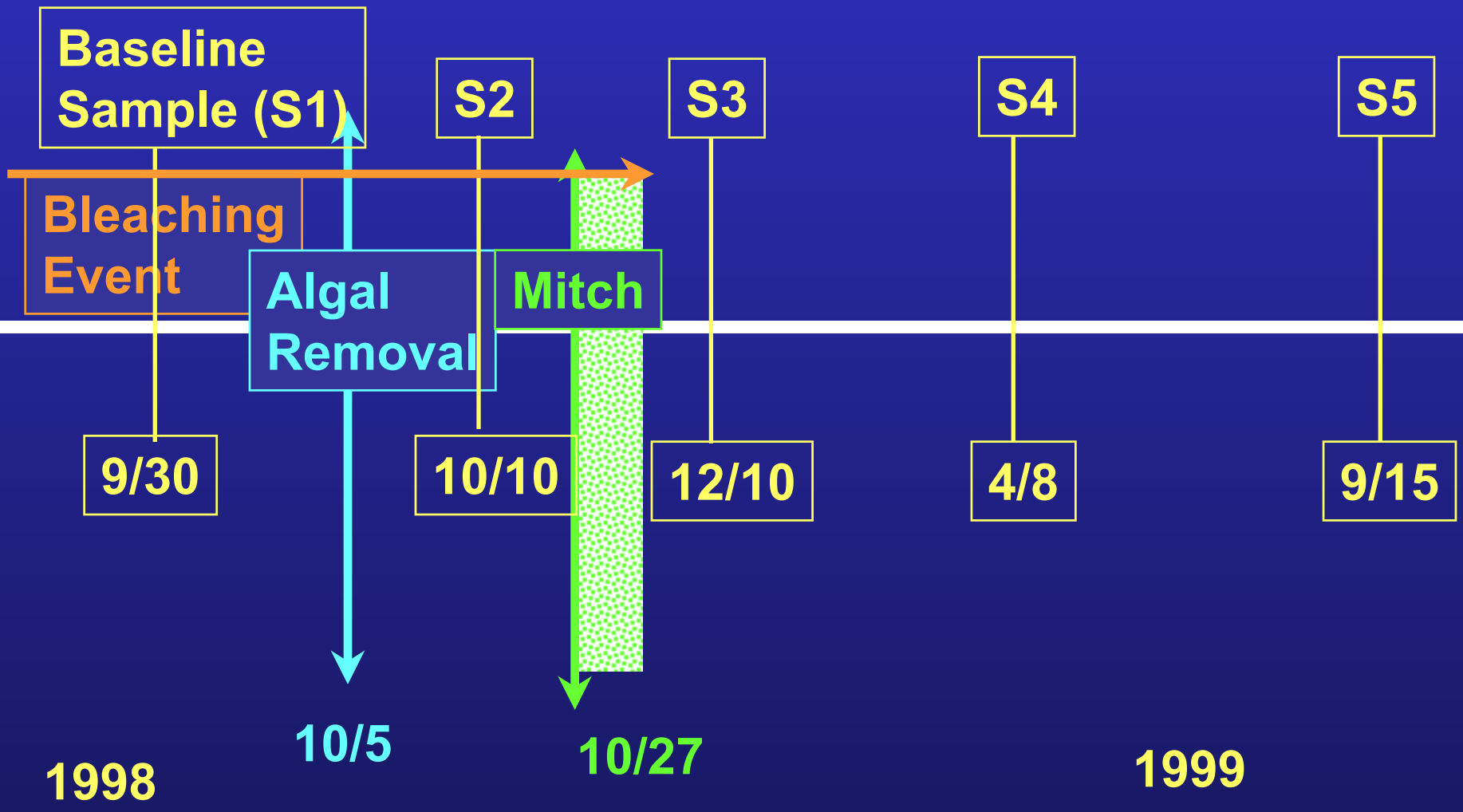
Testing dual effects of algal reduction and MPAs

Patch reefs overgrown with tall macroalgae
(80% cover vs 20% in ’70s)

Hedge clippers cut canopy
Wire brushes scrape holdfasts

8 man-hrs per reef (224 hrs)
1 ton removed per patch reef (8 tons)

Time-line of Events



Glovers Recruitment Study: Goals

To determine if our algal reduction experiment affected the percent bleached or the mortality of coral recruits (as observed in Australia)

To measure the impact of the natural disturbances (coral bleaching and hurricane) on coral recruit populations

Recruitment: Field Methods

6 patch reefs in WZ

3 experimentally cleared - 3 control

Twenty four 50 x 50 cm quadrats per per patch reef

36 m^2 surveyed in each sampling period

Results

Number of Bleached Recruits in Experimental and Control Reefs in 1998

Control (56.7% bleached) vs Experimental (68.3% bleached)

Chi-2	# bleached	# Normal	Total	P-value
Control	314	246	560	0.000
Experimental	522	224	746	
Total	836	470	1306	

Same analysis in 1999 – not significant (6.7% bleached)

Results

Recruit Density (number / m2) in Oct. 98 and Sept. 99

	1998 mean (st dev)	1999 mean (stdev)
Control	31.1 (8.6)	18.5 (5.0)
Experimental	41.4 (13.7)	15.8 (4.3)
Total	36.3 (11.7)	17.1 (4.4)

2-way ANOVA

	Time	Treatment	Interaction
P value:	0.005	ns	ns

Conclusion

- The algal removal had a significant effect on initial bleaching, but not on 1999 bleaching, or the density reduction between 1998 and 1999

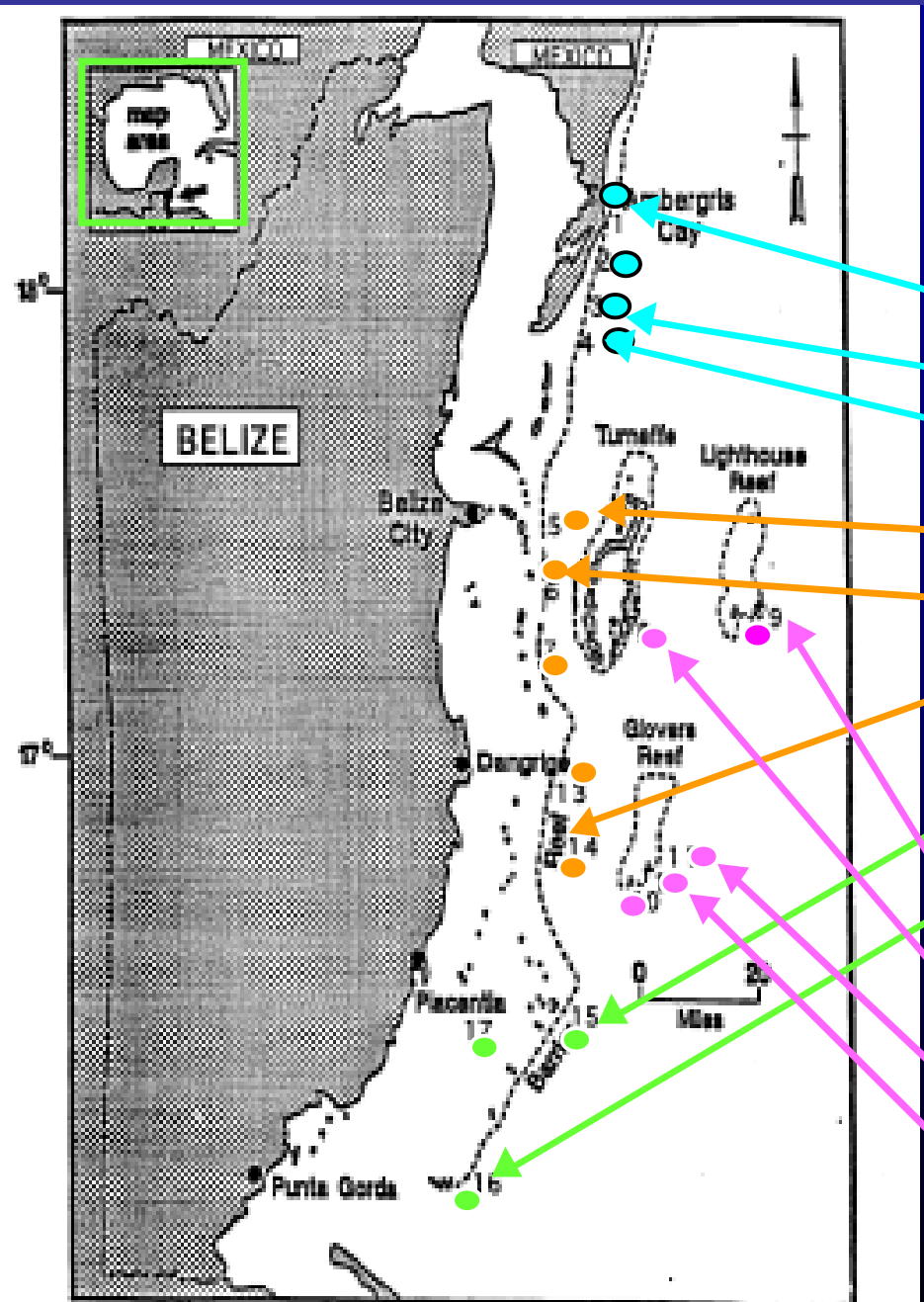
- Significant decline in recruit density (49%)
- between Sept. 1998 and 1999

- Bleaching is suspected as primary agent

- Few physical signs of hurricane damage in these
- sheltered patch reefs

- Similar to Results of Aronson in inner lagoon reef
- Differs from Mumby on Glovers fore reef

Effects of 1998 Bleaching on the Belize reef



Study Sites 97 vs 99

% decrease coral cover

Barrier Reef:

1. Bacalar Chico - 56%
2. Tackle Box - 37%
3. HolChan - 65%
4. Gallows - 37%
5. Goffs Caye - 40%
6. S. Water - 26%
7. Pompion - 41%
8. Nicholas - 85%

Atoll:

9. Half Moon - 31%
10. Calabash - 56%
11. Middle Caye - 56%
12. SpurNgroove - 53%

Sampling Methods

10 video transects per site

25m transects, swath width of 25cm

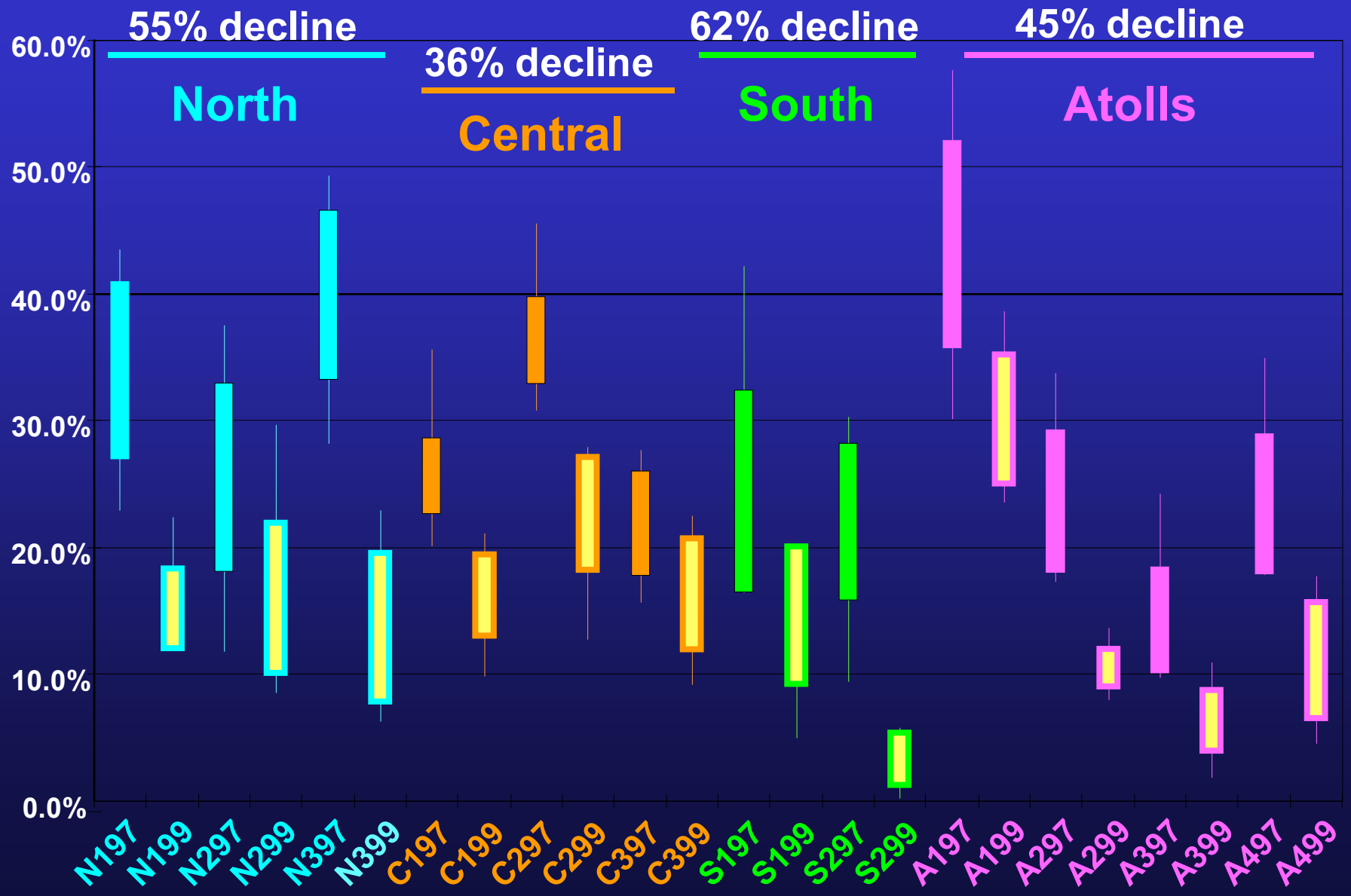
located along spurs (12 - 19m depth)

50 images per transect analyzed

10 random points per image

Point Count for Coral Reefs Software

Percent Coral Cover 1997 vs 1999 (+/- *s*; N=10)



Shannon - Wiener Diversity Index

before vs after disturbances (video transects)

	1997	1999
Mean (St Dev)	1.84 (0.12)	1.36 (0.28)

T-test significant ($P < 0.0000$)

Change in Coral Diversity by Region

	1997	1999
Northern Barrier Reef	1.93	1.38
Central Barrier Reef	1.87	1.65
Southern Barrier Reef	1.72	1.12
Atolls	1.82	1.32

Coral Species Abundance (97 to 99)

% change	Coral Species
-70.7%	Agaricia tenuifolia
-66.4%	Acropora cervicornis
-50.8%	Montastrea annularis complex
-4.3%	Porites astreoides
13.5%	Siderastrea siderea

Differs from 1995

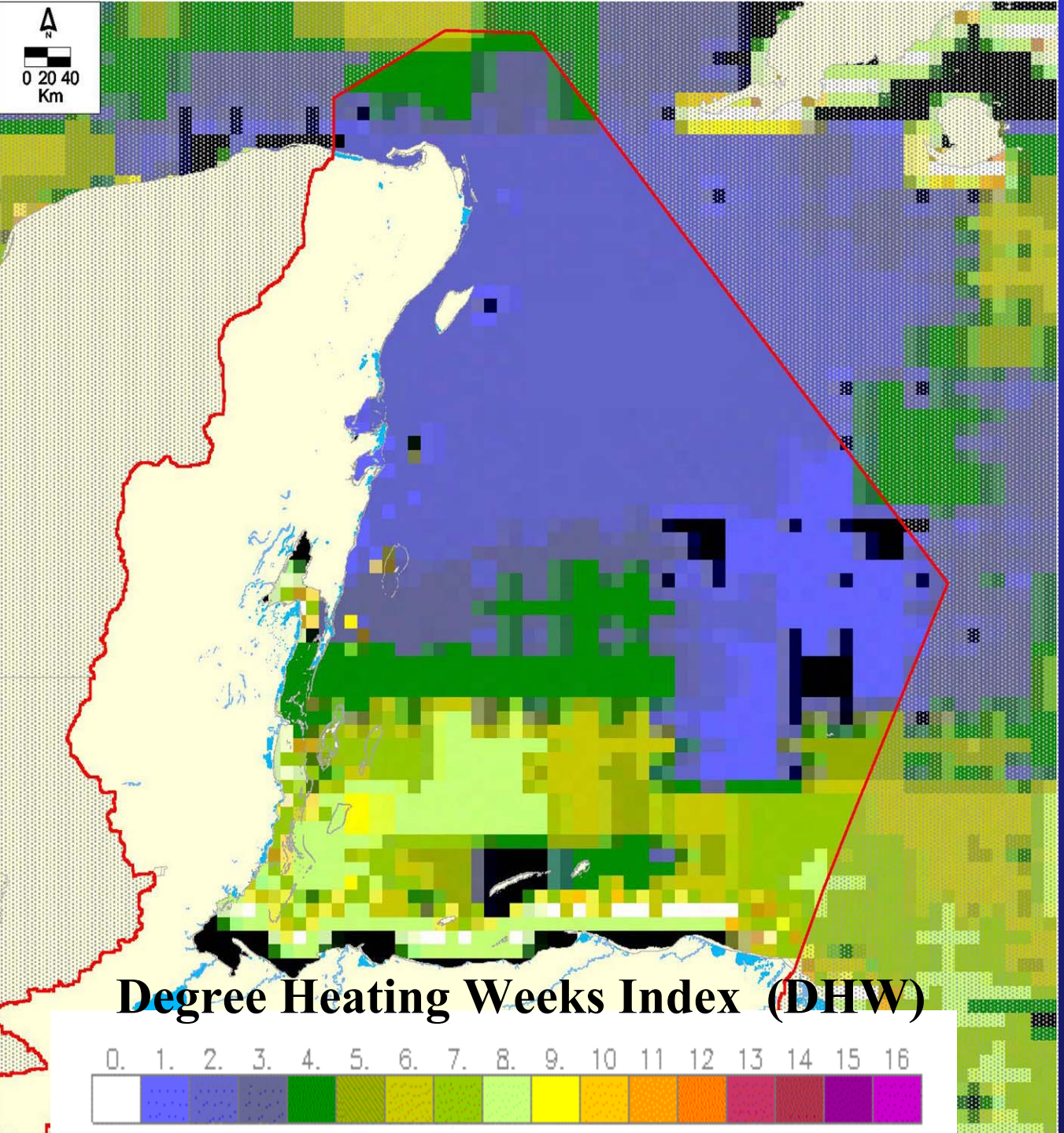
Few affected
By hurricane

Depth of study differs
Clade "C" vs "A"
Also
easily damaged
by hurricane

Impacts of Hurricane Mitch and 1998 bleaching (Kramer and Kramer, 2000; Report to WB)
Surveyed 157 sites – modified WBST method

- **Hurricane damage was highest along NE sides of the barrier and atolls in Belize.**
- **Bleaching resulted in extensive mortality throughout MAR: Most mortality in *A. tenufolia* and *M. complanata*. Recovery from bleaching has been slow, particularly for massive corals that are still pale/partly bleached 8 months after the peak.**
- **All depth reefs in Belize are suffering extensive damage from disease.**
- **Overall, the shallow reefs of the MAR (in particular Belize) have suffered catastrophic losses due to these two impacts (and subsequent disease).**

III. Potential Mitigation and Conservation Strategies: the search for resiliency



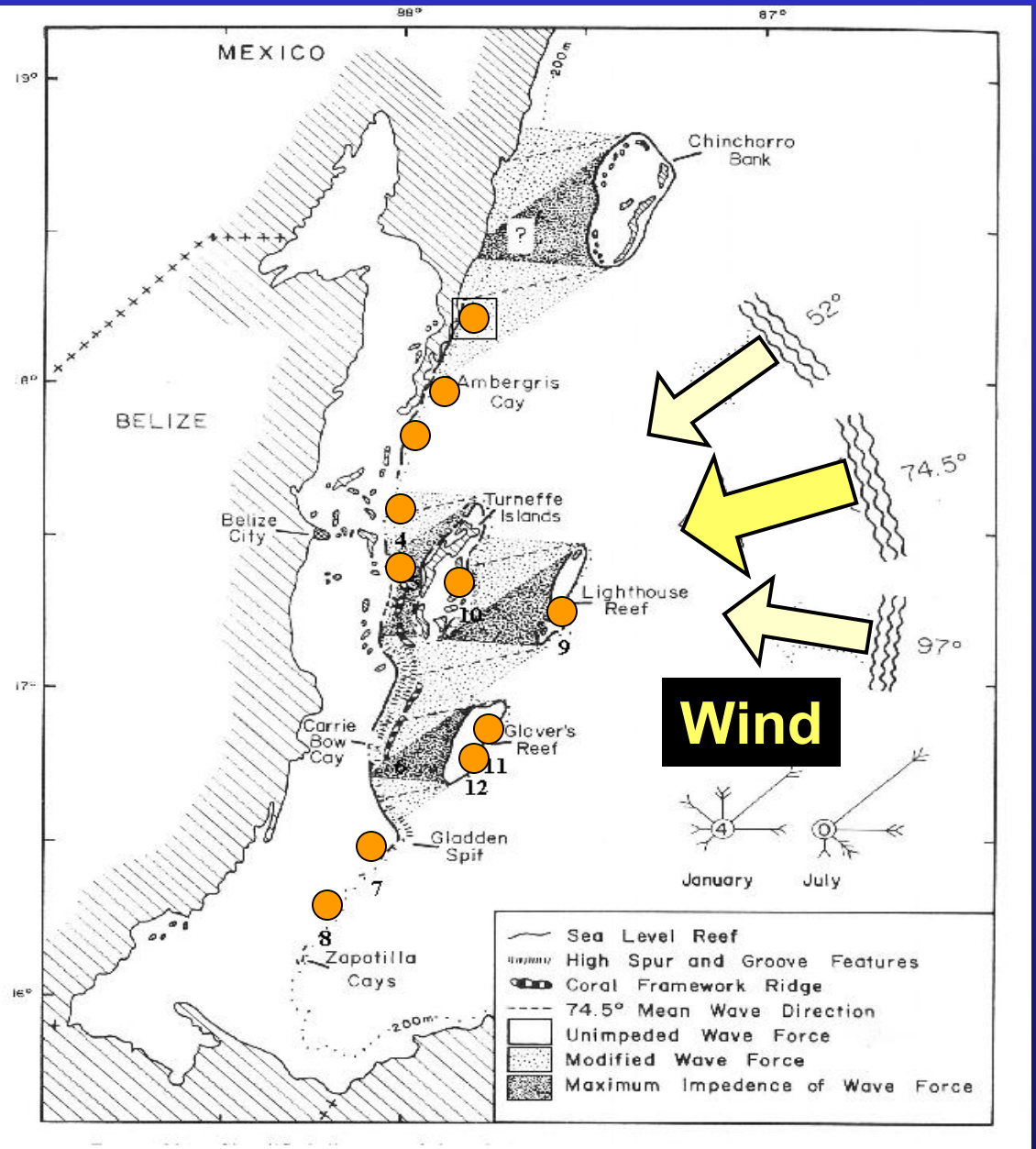
Degree Heating Weeks Index For the MAR

Summer 1998

One DHW is equivalent to one week of sea surface temperatures one degree Celsius warmer than the expected summer-time maximum.

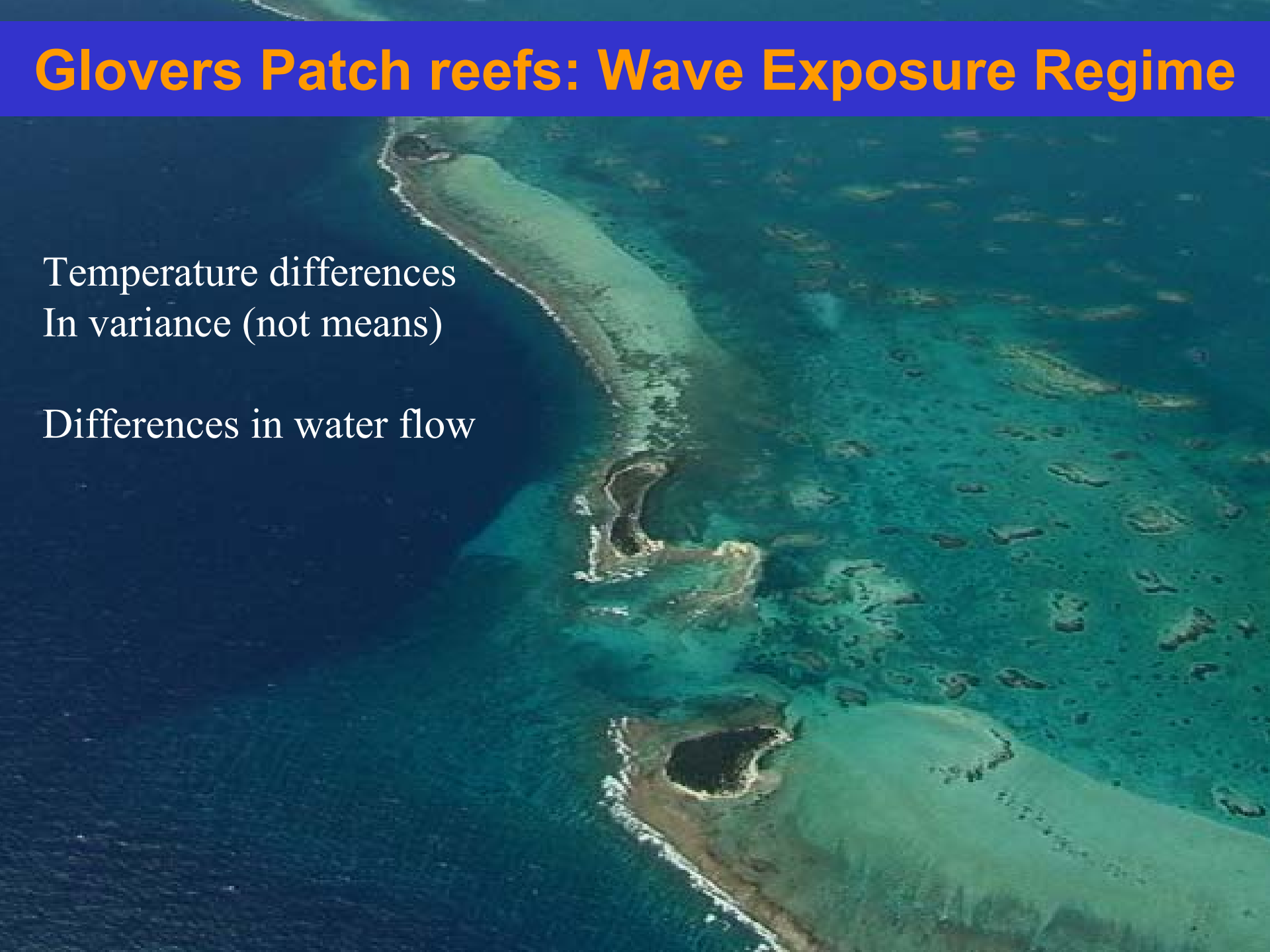
Belize: Wave Exposure Regime

Pros and Cons of Exposure



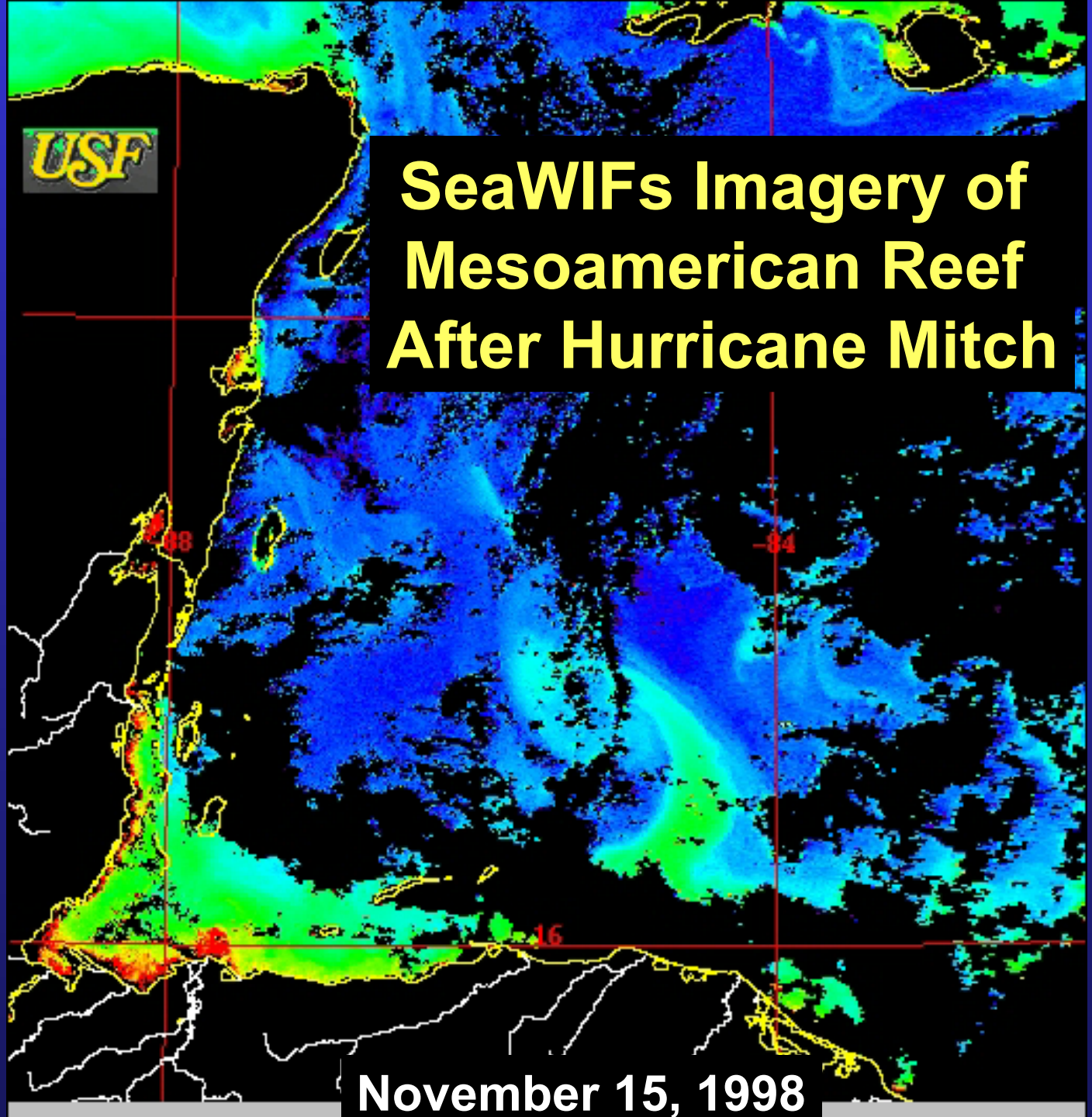
Adapted from Burke (1982)

Glovers Patch reefs: Wave Exposure Regime



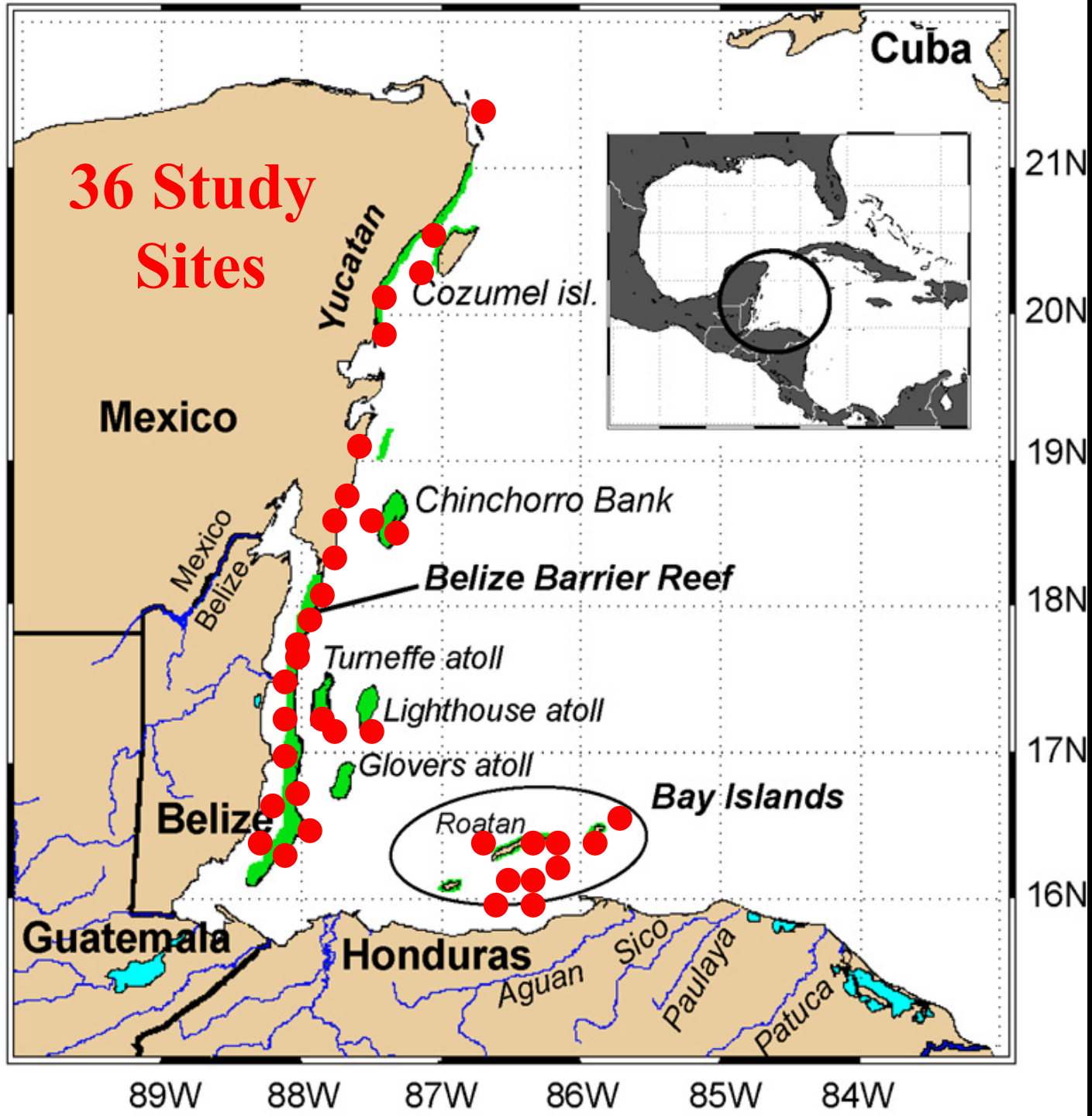
Temperature differences
In variance (not means)

Differences in water flow


USF
SeaWIFs Imagery of
Mesoamerican Reef
After Hurricane Mitch
-88
-84
16
November 15, 1998

Mesoamerican Reef Survey

Amigos de Sian Ka'an, Belize Audubon, Coastal Zone Management Institute, DIGEPESCA, Honduran Coral Reef Fund, SEMARNAP, WWF



Parameters studied

coral health

benthic cover

coral diversity

coral recruitment

sea urchin abundance

General Findings

Latitudinal trends N to S:

↑ coral diversity

↓ coral cover & juveniles

Coral cover not recovering (Bz)

Urchins/fish herbivory assist

Longer timeframe for recovery?

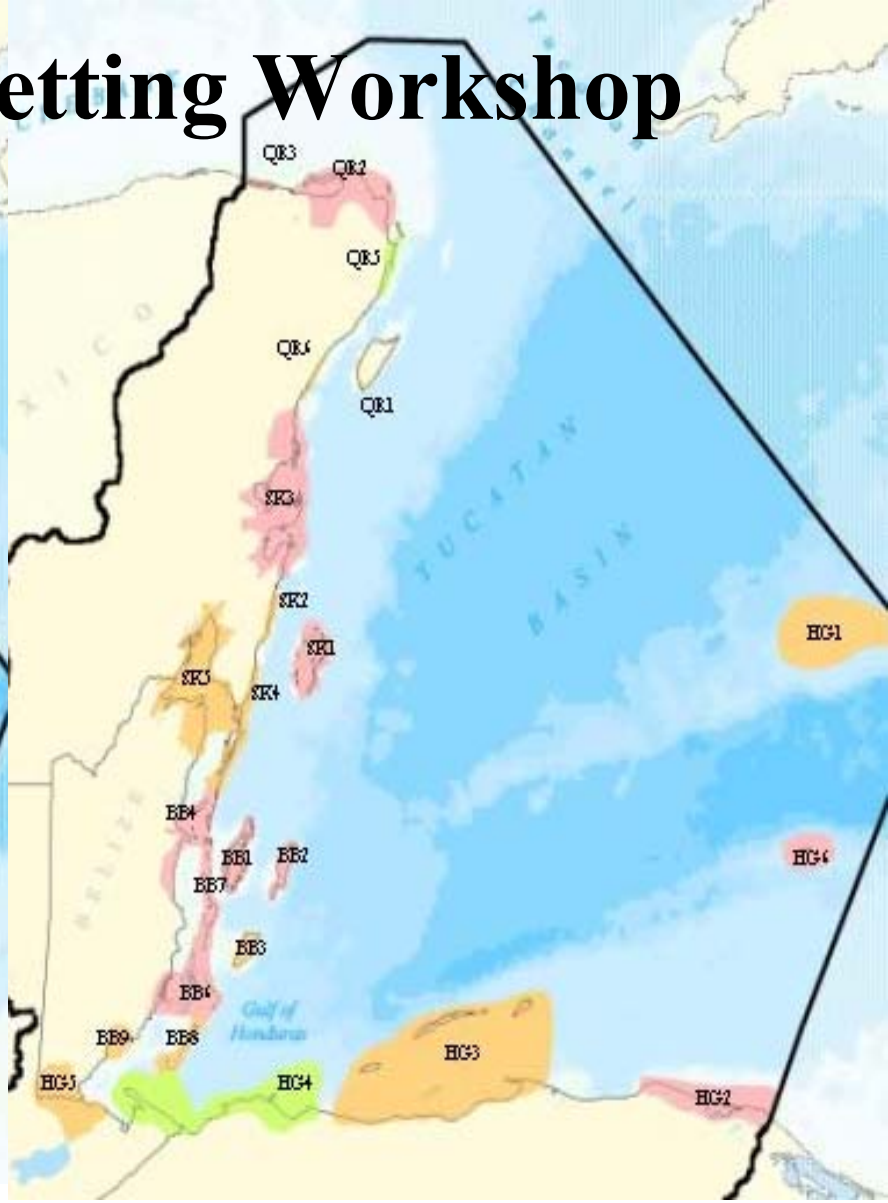
Immediate focus: Honduras

High in impacts & value

High diversity areas

Resiliency within MPA network

Results of Priority-setting Workshop



Biodiversity Values

● Highest ● High ● Priority

Persistence Value

● High ● Medium ● Low

BY PHILIP A. KRAMER AND
PATRICIA RICHARDS KRAMER
EDITED BY MELANIE McFIELD

ECOREGIONAL CONSERVATION PLANNING

for the Mesoamerican Caribbean Reef

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