Climate Change and Coral Disease: More than a cough or sniffle

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Outline

- Disease, defined
- The coral organism: aspects pertaining to resilience and climate change
- Predicted responses to climate change: empirical evidence
- Tips for field assessment and diagnosis
- Name That Disease!

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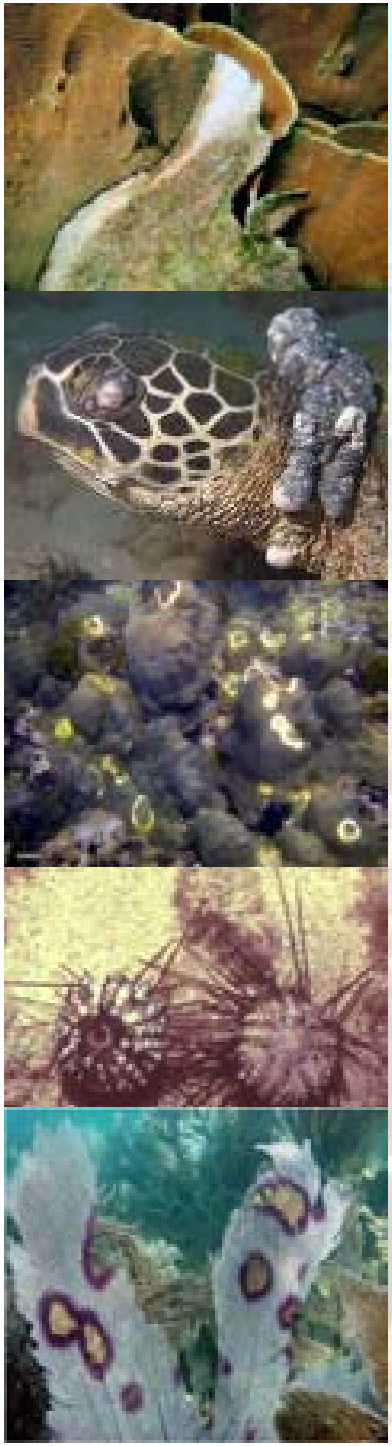


Disease = any impairment (interruption, cessation, proliferation or other disorder) of vital body functions, systems or organs (Stedman 2000).

It can be caused by:

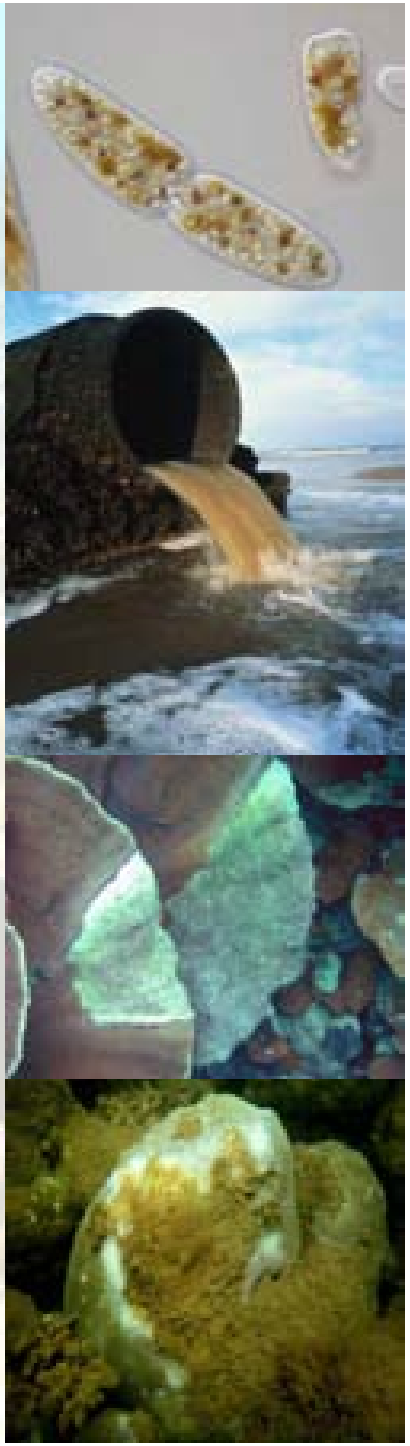
- Either ***biotic*** agents (bacteria, protist, virus, congenital defect)

  or ***abiotic*** agents (toxin, environmental stress, pollutant)

It can be either:

- ***infectious*** (transmissible)

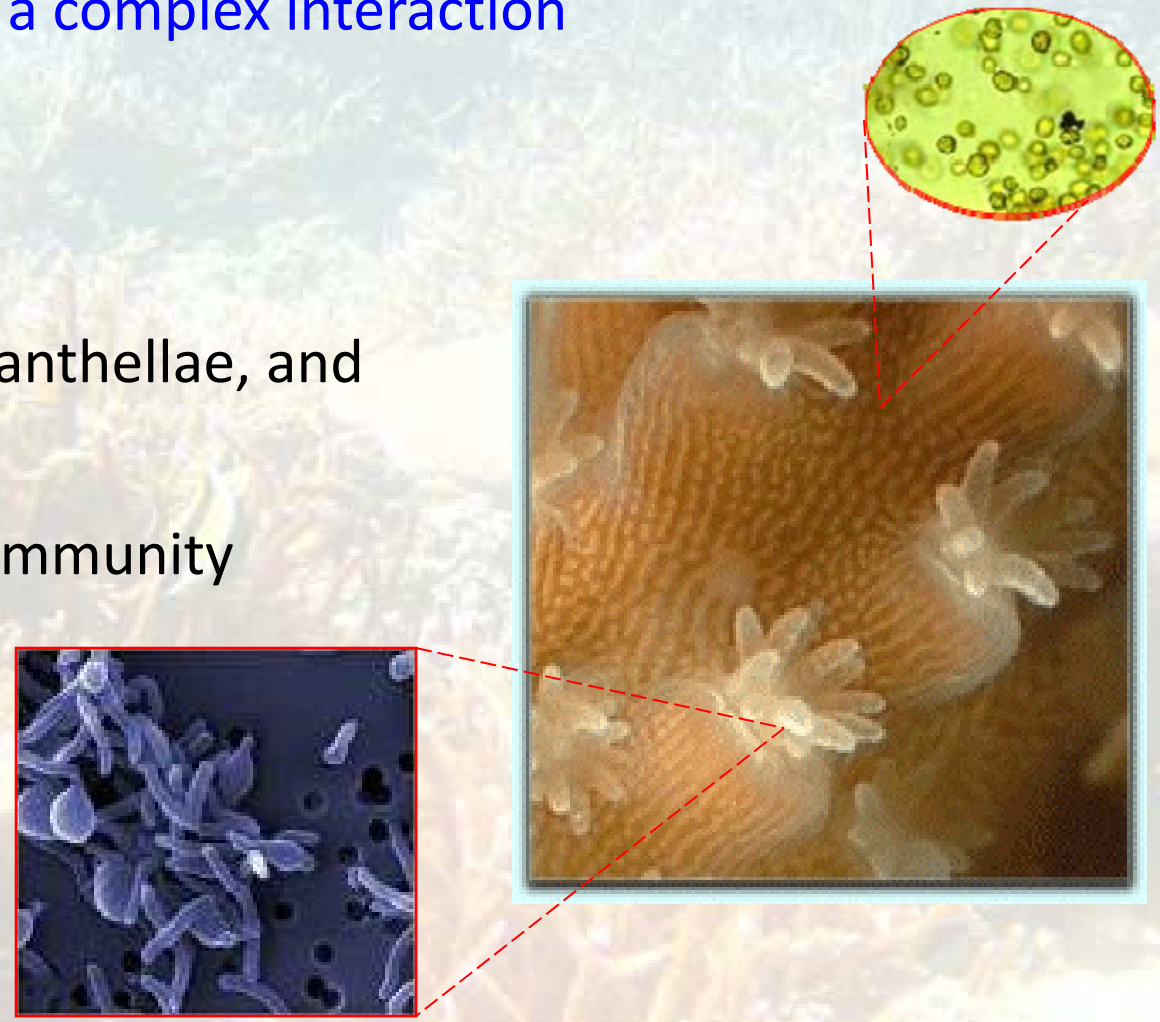
  or ***non-infectious***



The coral organism: Aspects pertaining to disease and resilience

Corals are holobionts: a complex interaction between the

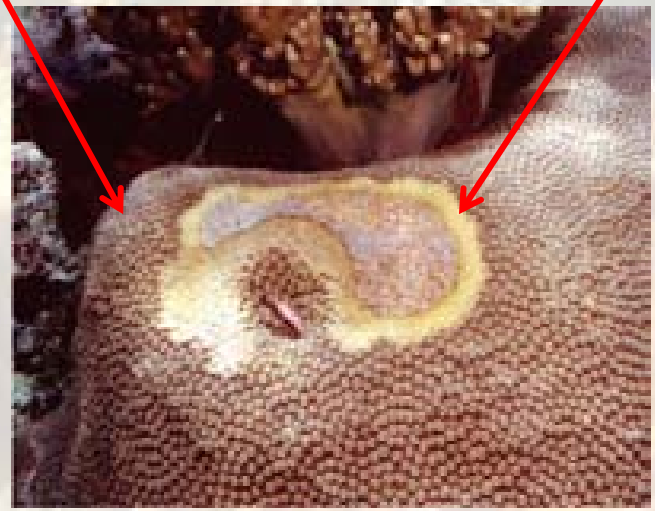
- coral polyp,
- endosymbiotic zooxanthellae, and
- surface microbial community



→*Disease can attack any or all of these components & may affect them differentially*. Cervino *et al.* (2008):

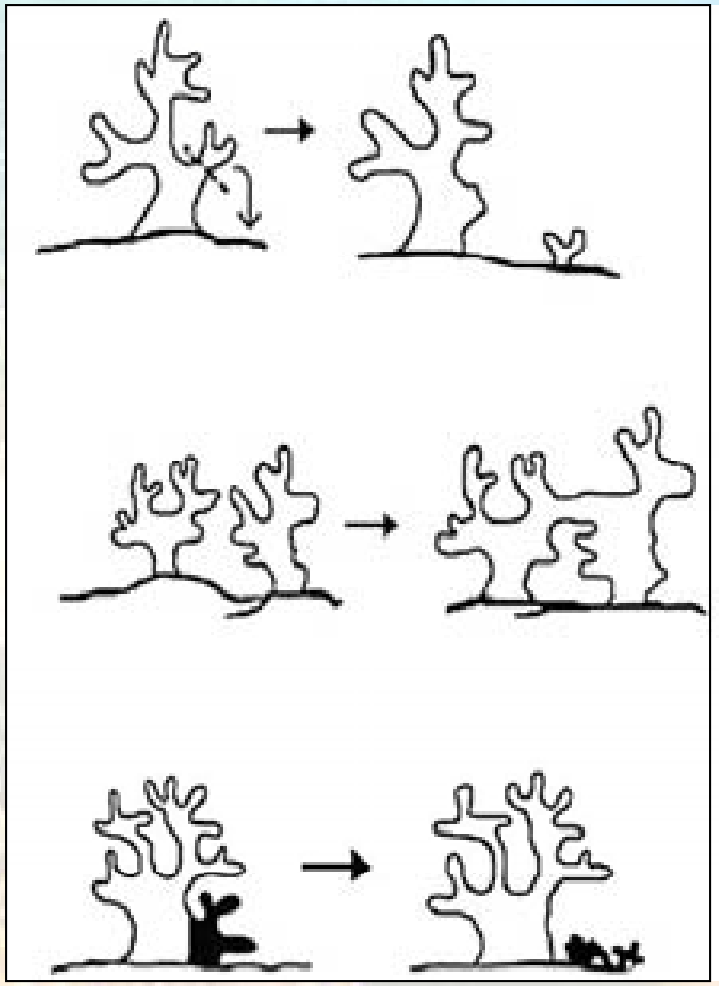
Normal zoox in healthy *Diploastrea*

Lysed zoox in YBD-infected *Fungia*



Corals are clonal and colonial:

- they fragment & grow by reproducing polyps
- they can fuse with each other
- they can partially die



→*Implications for recovery, reproduction:*

- they can resheet over dead skeleton; small reservoirs of tissue can be a recovery source

- they need a minimum size to reproduce; partial mortality may revert a colony to a pre-reproductive size

Corals are lower invertebrates: they have limited capacity for immunodefense

→No immune memory, as in vertebrates; reinfection possible (Sato et al. 2009):

Table 1. Comparison of BBD incidence between colonies with and without a history of BBD infection in the previous 12 months. (Data were collected during BBD outbreaks in an assemblage of *Montipora* species throughout 2007 and 2008. Incidence of BBD infections was tested between the non-infected assemblage and previously infected assemblage using a *G*-test with Yates' continuity correction.)

	2007		2008	
	not infected previously	infected previously	not infected previously	infected previously
population size (colonies)	559	16	685	50
BBD infections (colonies)	54	6	43	11
incidence	9.7%	37.5%	6.3%	22.0%
G_{Yates}	7.666		17.129	
d.f.	1		1	
p-value	<0.01		<0.001	

Corals live at or near their thermal threshold

→ *warmer water can tip the balance in a stressed coral*

→*bleached corals can recover, but may subsequently succumb to disease*

Muller et al. 2008:

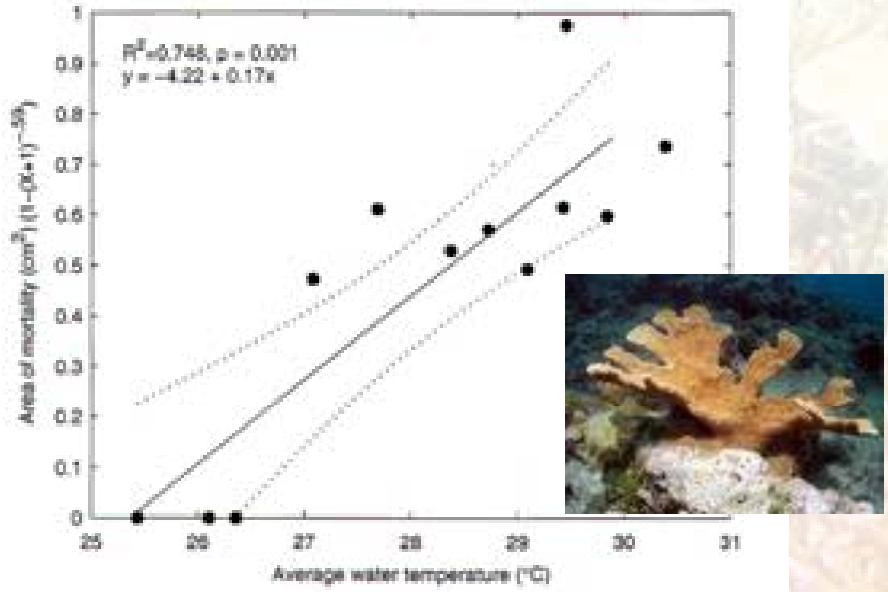


Fig. 4 Relationship between average area of disease-associated mortality and average water temperature for bleached colonies at Hawksnest Bay, St John in 2005. *Dotted lines* indicate 95% confidence limits

Whelan et al. 2007:
82% of *Colpophyllia natans* colonies started to recover post-bleaching, then died of White Plague

Are diseases on reefs increasing?

The evidence:

Harvell et al. (1999): Increase in reports of mass mortalities

- 1938-1975: 7 (fish, seal, seagrass, inverts)
- 1980-1997: 27 (bivalves, coral, seagrass, algae, dolphins, porpoises, seals, fish, urchins)

Sutherland et al. (2004):

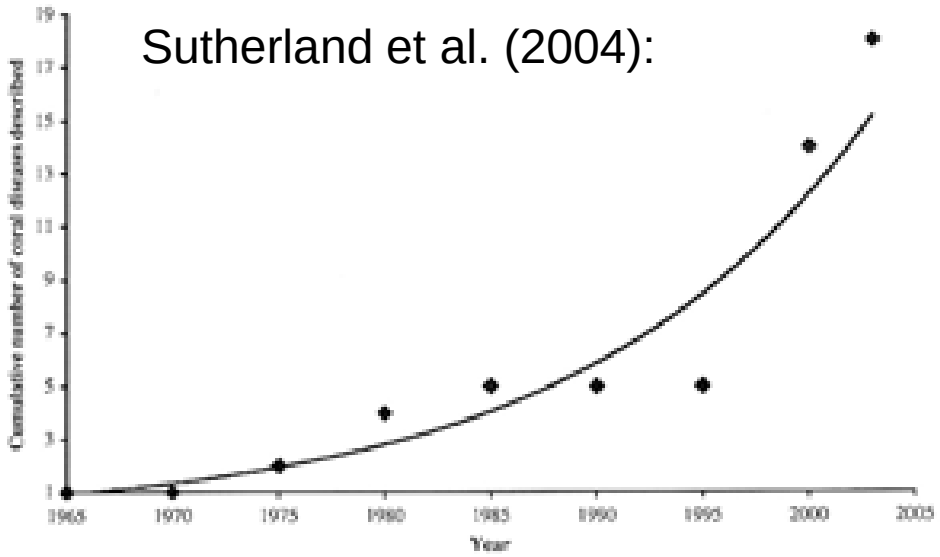


Figure 3 The cumulative increase in described coral diseases shows an exponential rise since 1965 (Sutherland et al. 2004).

-exponential increase in number of described coral diseases in the literature

→ But, is this due to better detection & observation?

How and why: Evidence for a role of climate change

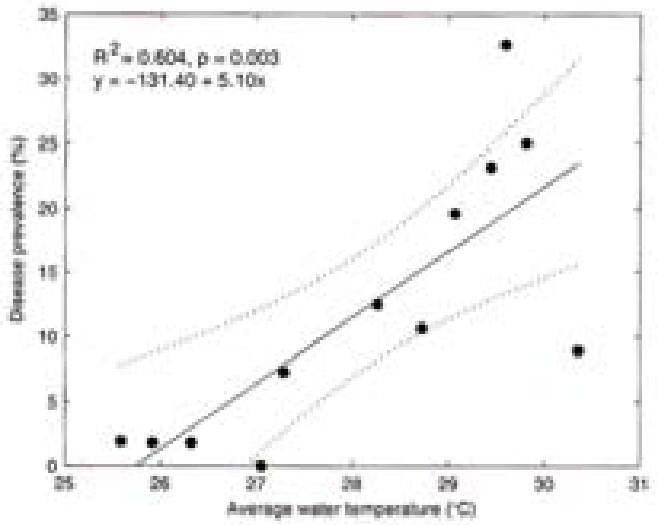
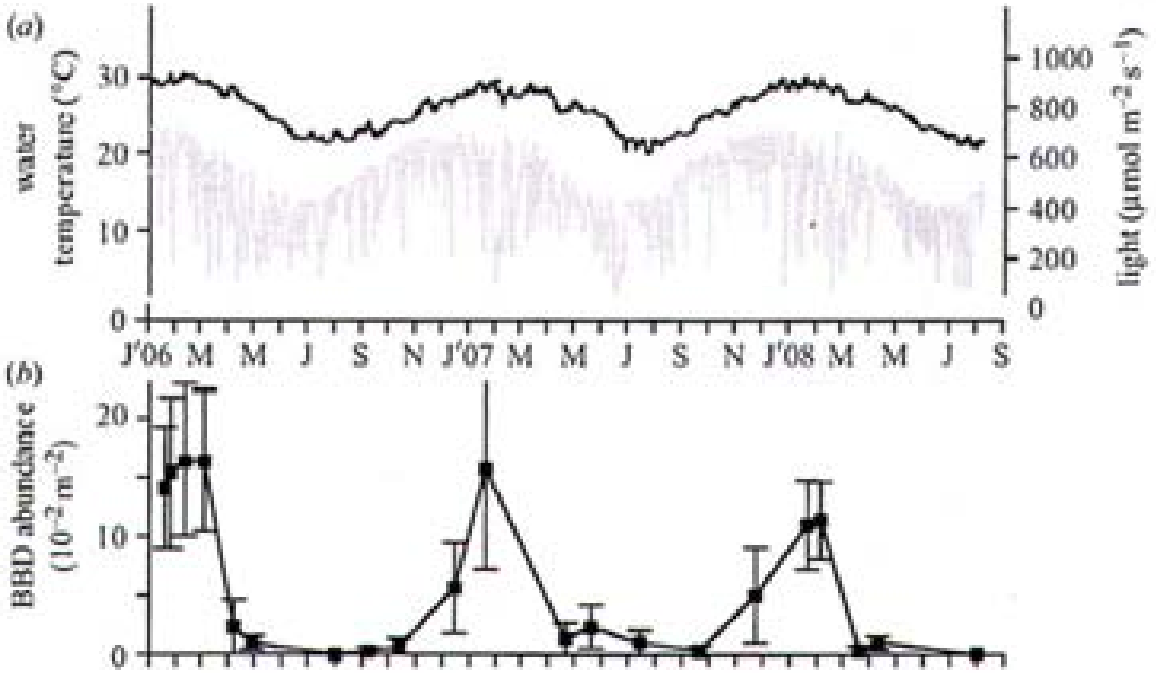


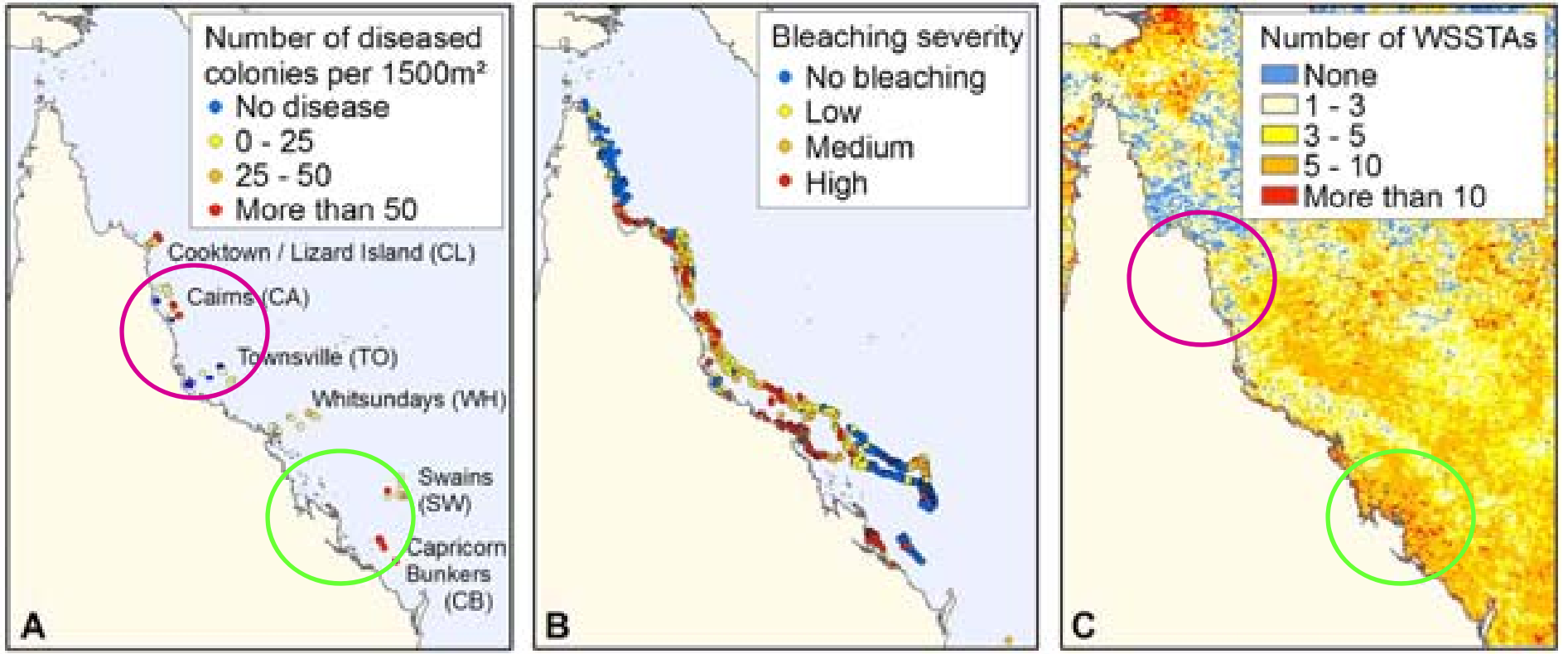
Fig. 2 Relationship between disease prevalence and average water temperature at Hawksnest Bay, St John in 2005. *Dotted lines* indicate 95% confidence limits

Muller et al. 2008: Strong relationship between disease & temperature in the Caribbean

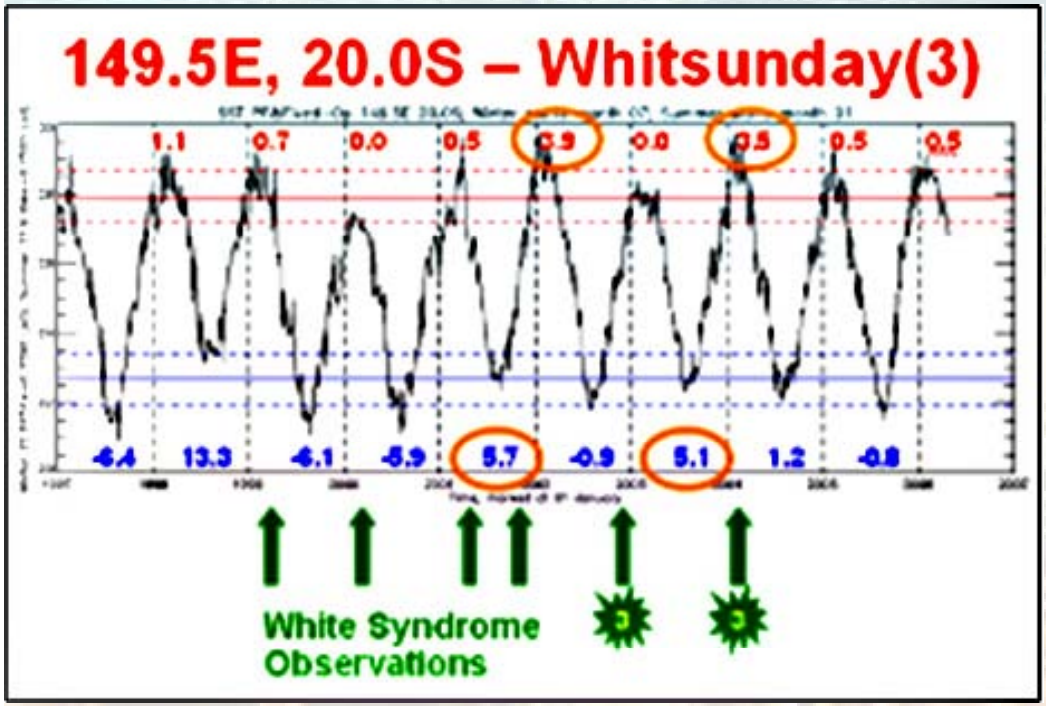
Sato et al. 2009: Black band disease seasonal outbreaks in the Indo-Pacific

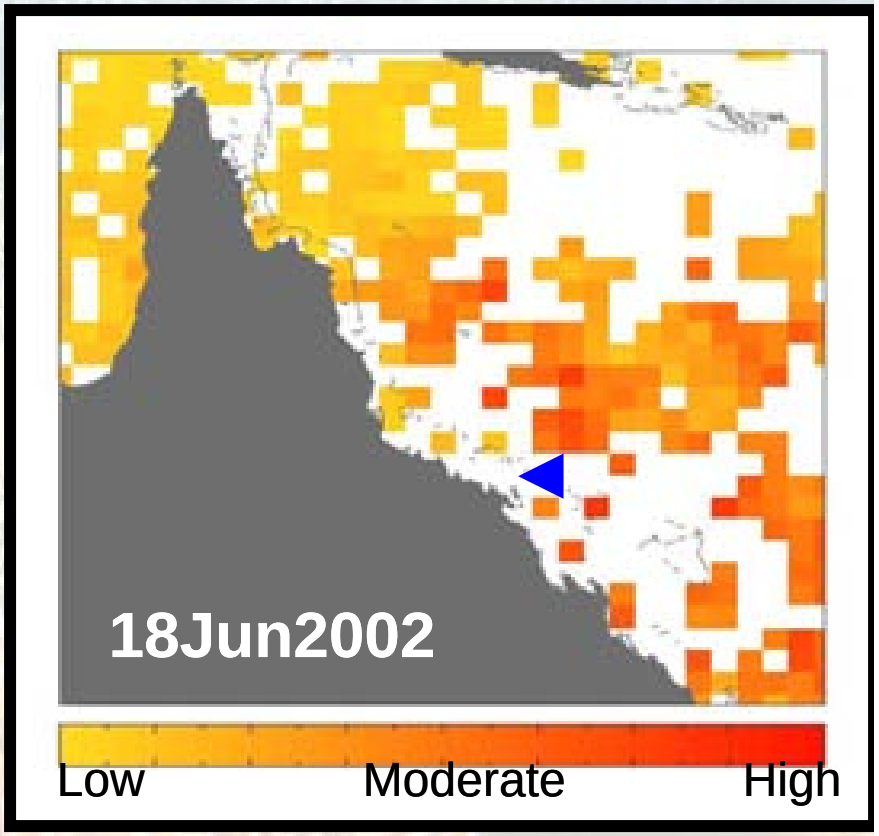


Bruno et al. 2007:
Thermal stress and coral cover drivers of disease patterns along the GBR:



Satellite-derived measure of the risk of White Syndrome outbreak (courtesy of Mark Eakin):

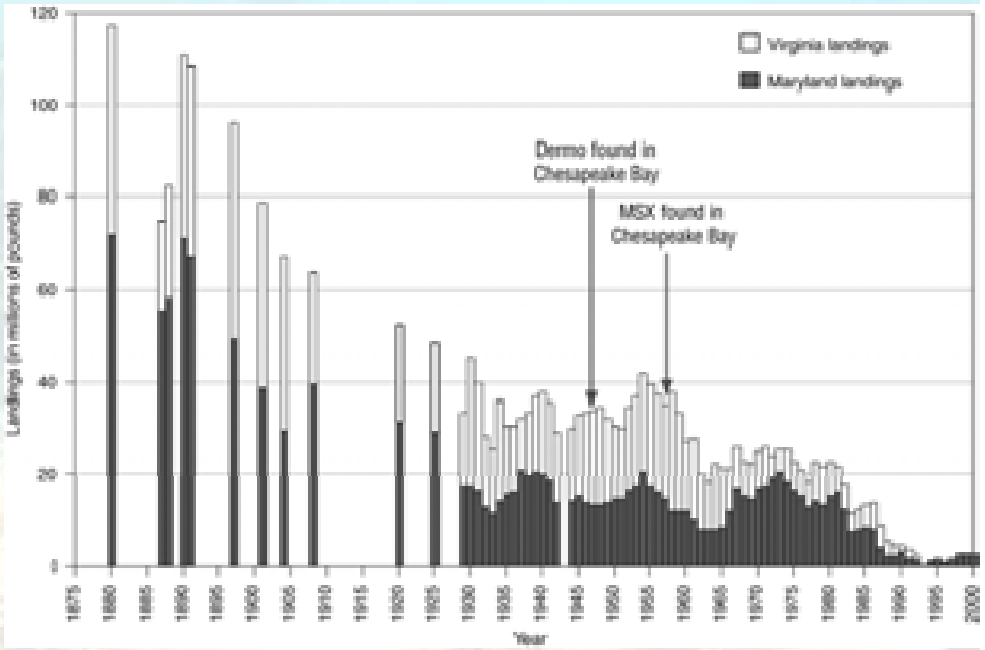




=warm winters AND summers
important drivers
=work by CoralReefWatch to predict outbreaks, based on SST satellite data

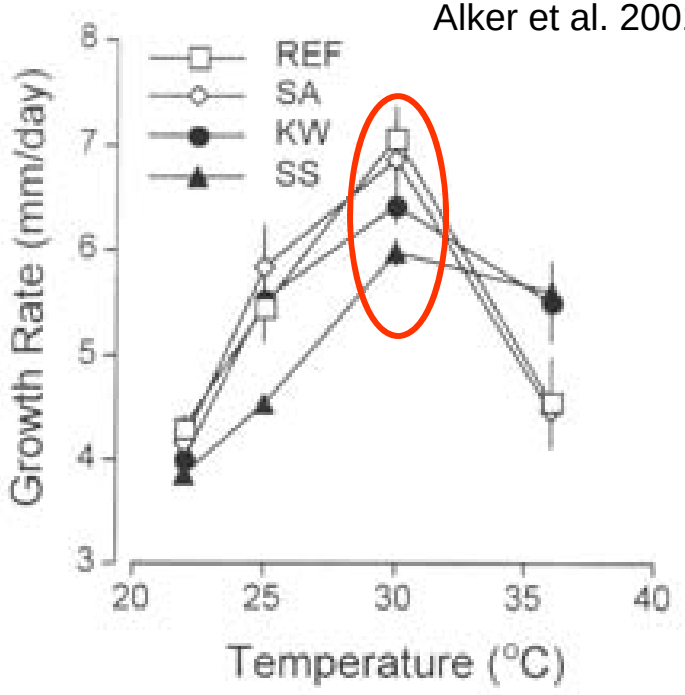
Altered environment may favor pathogens:

Increased pathogen range:
Perkinsus marinus (Dermo), *Haplosporidium* (MSX) in oysters. Northern range extension due to repeated introductions and warmer winters (Ford 1996)



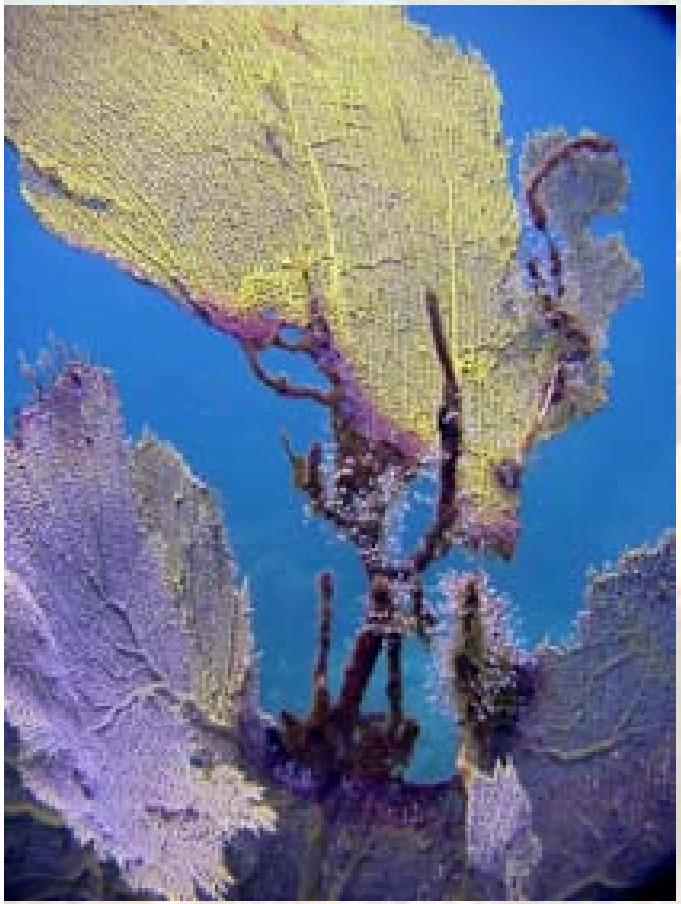
Chesapeake Bay Program & NMFS

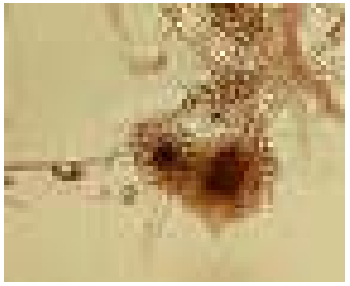
Alker et al. 2001



Increased pathogen virulence: *Aspergillus sydowii* (Aspergillosis in sea fans) grows faster at 30oC than at 25oC

decreased host resistance:
Gorgonia ventalina
antifungal activity less
effective at higher temps.



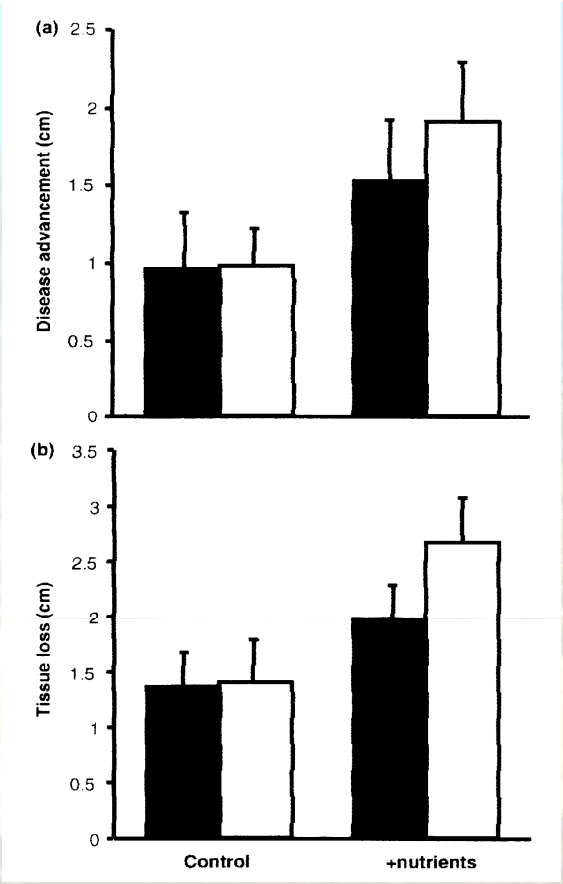


From: Alker et al. 2001

novel host-pathogen interactions:
Aspergillus = terrestrial
opportunistic fungus which
invaded reef ecosystems

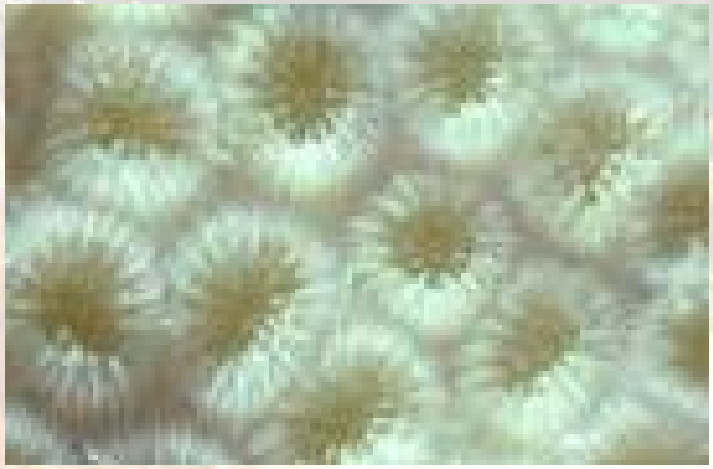
Nutrient loading & eutrophication:

Increased loads of N, P = faster progression of Yellow Band Disease in *Montastraea* spp. (Bruno et al. 2003)



Bleaching link:

bleaching caused by *Vibrio shiloi* in *Oculina patagonica* (Kushmaro et al. 1997), and by *Vibrio coralliilyticus* in *Pocillopora damicornis* (Ben-Haim, et al. 2003),with greater effects at higher temps.



In summary:

To date: early evidence for a disease-temp link is scarce, but compelling

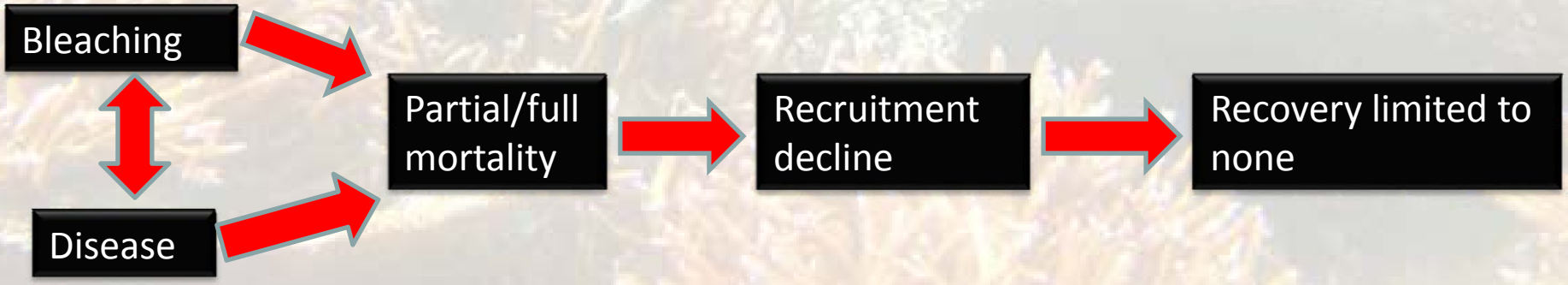
= more reports of diseases, outbreaks, mortality

= manipulative studies to examine mechanisms

Disease impacts predicted to rise with rising temps

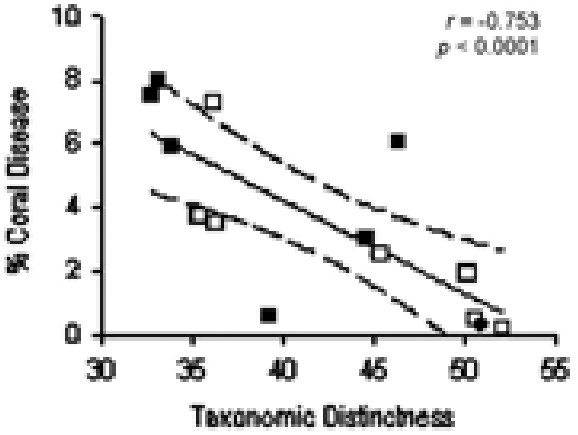
= more frequent and severe outbreaks

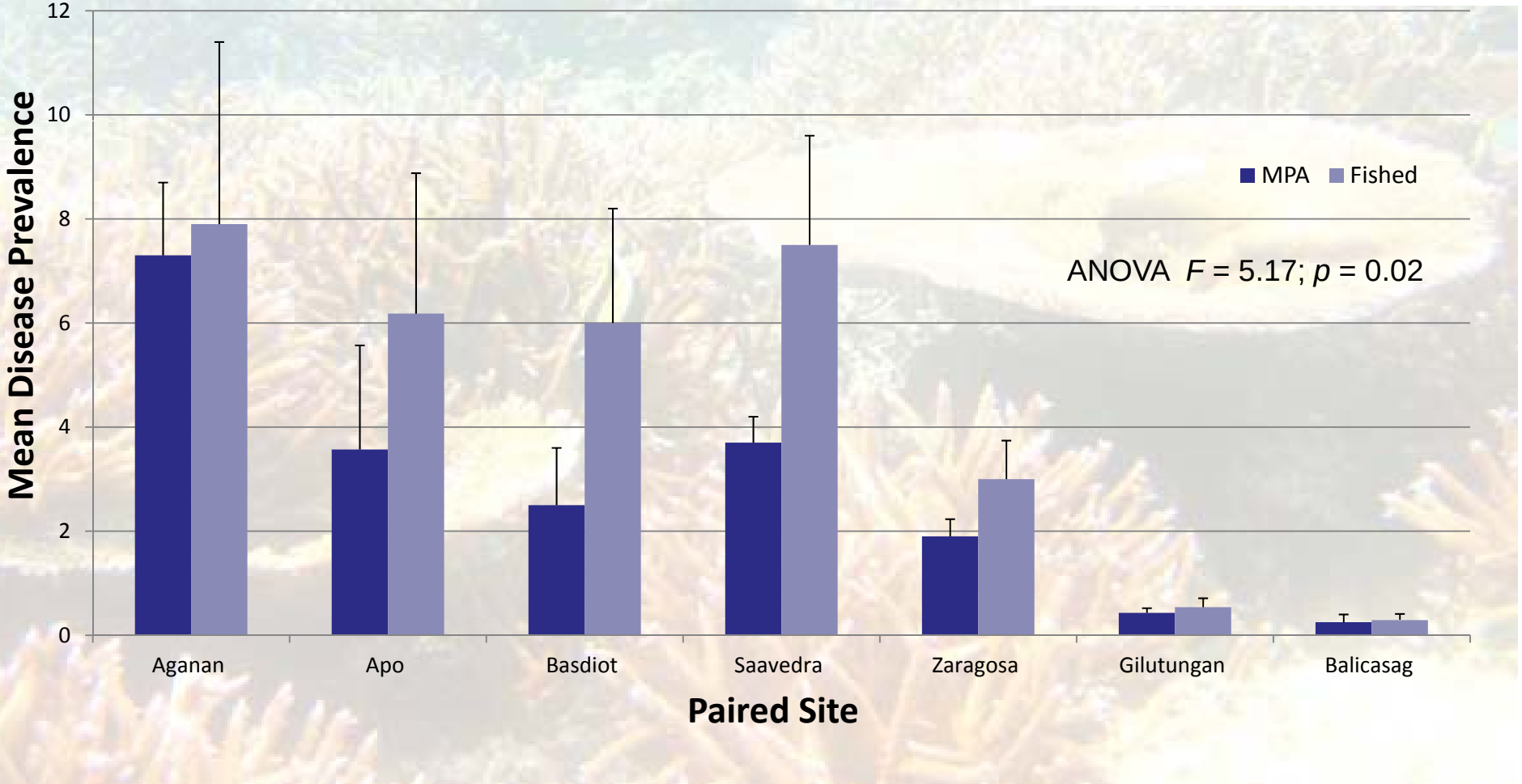
= loss of resilience:



But: evidence that MPAs help!!

Raymundo, Halford, Maypa, Kerr (in review): Disease prevalence lower within MPAs, linked to fish functional diversity





When is it a Disease?

Four broad categories of signs of ill-health:

1. Tissue Loss
2. Discolour-ation
3. Growth Anomalies
4. Compro-mised Health

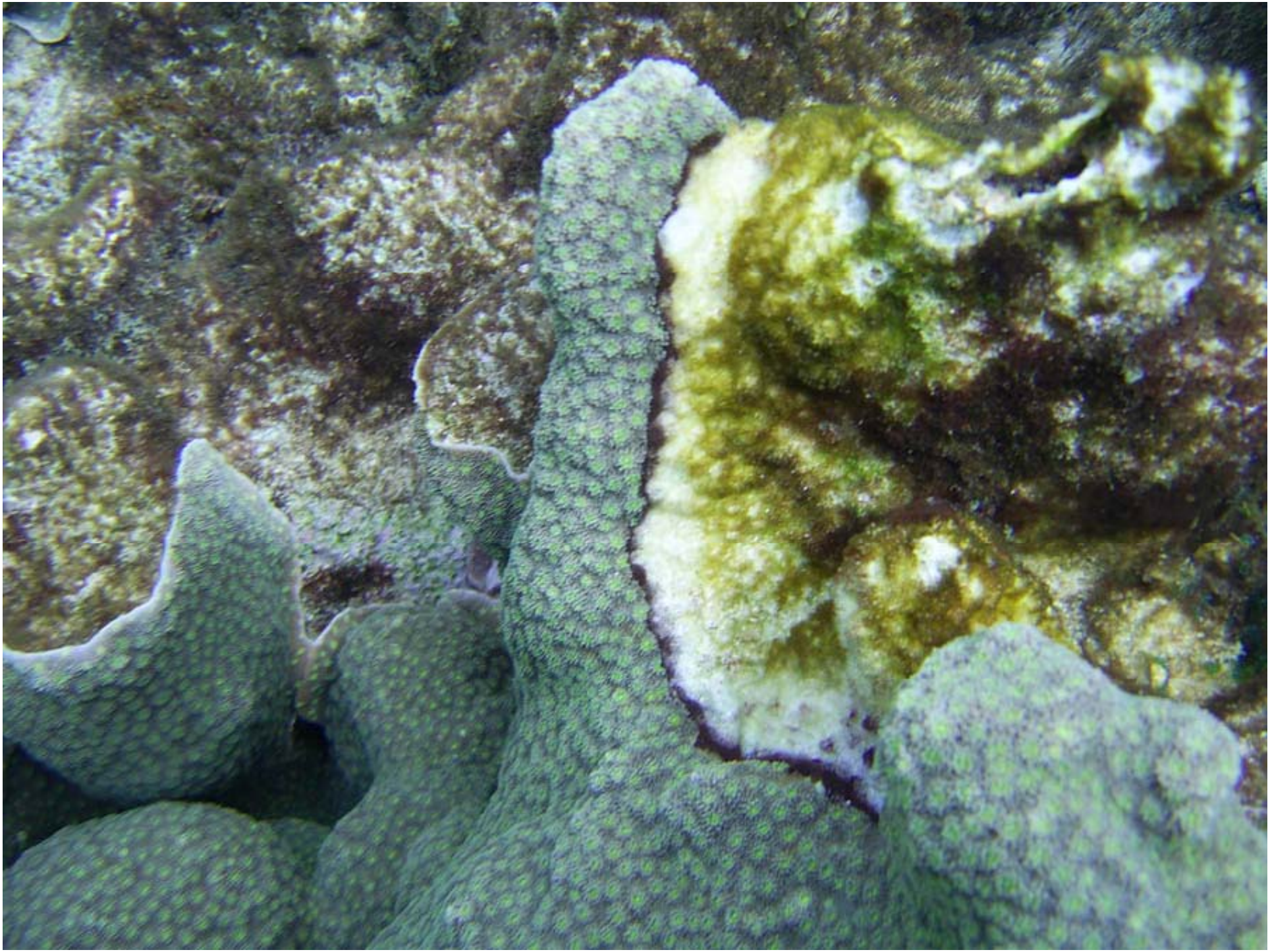




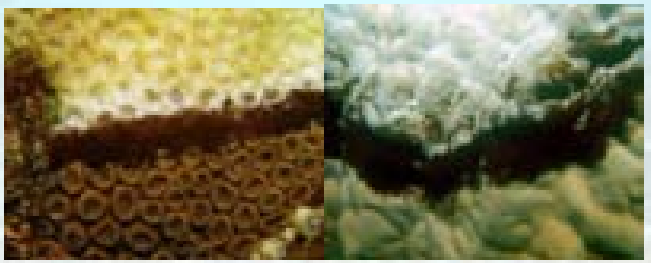


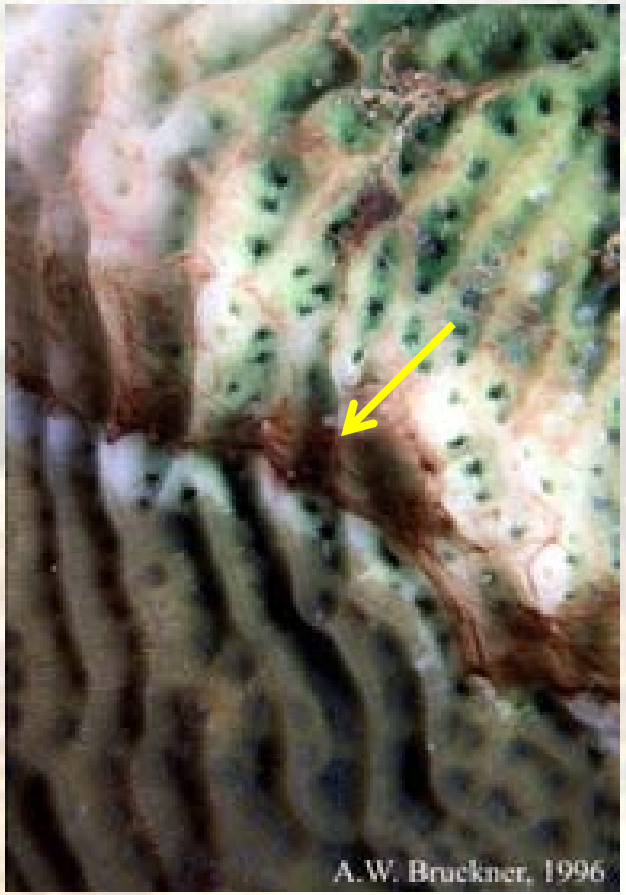

Appendix 3
Indo-Pacific Coral Health – Decision Tree

NAME THAT DISEASE !!



Black Band Disease





→Dark, filamentous band (needs a hand lens or dissecting scope)

→Band can look either black or brick red; same cyanobacterium involved

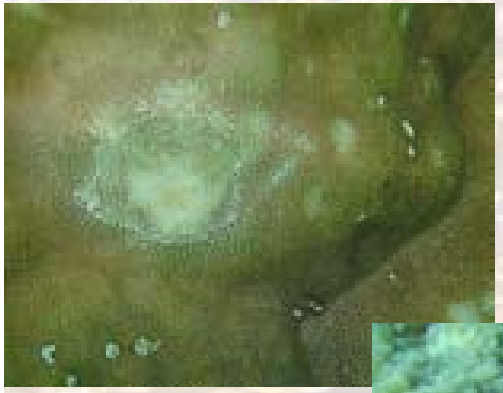
Brown Band Disease

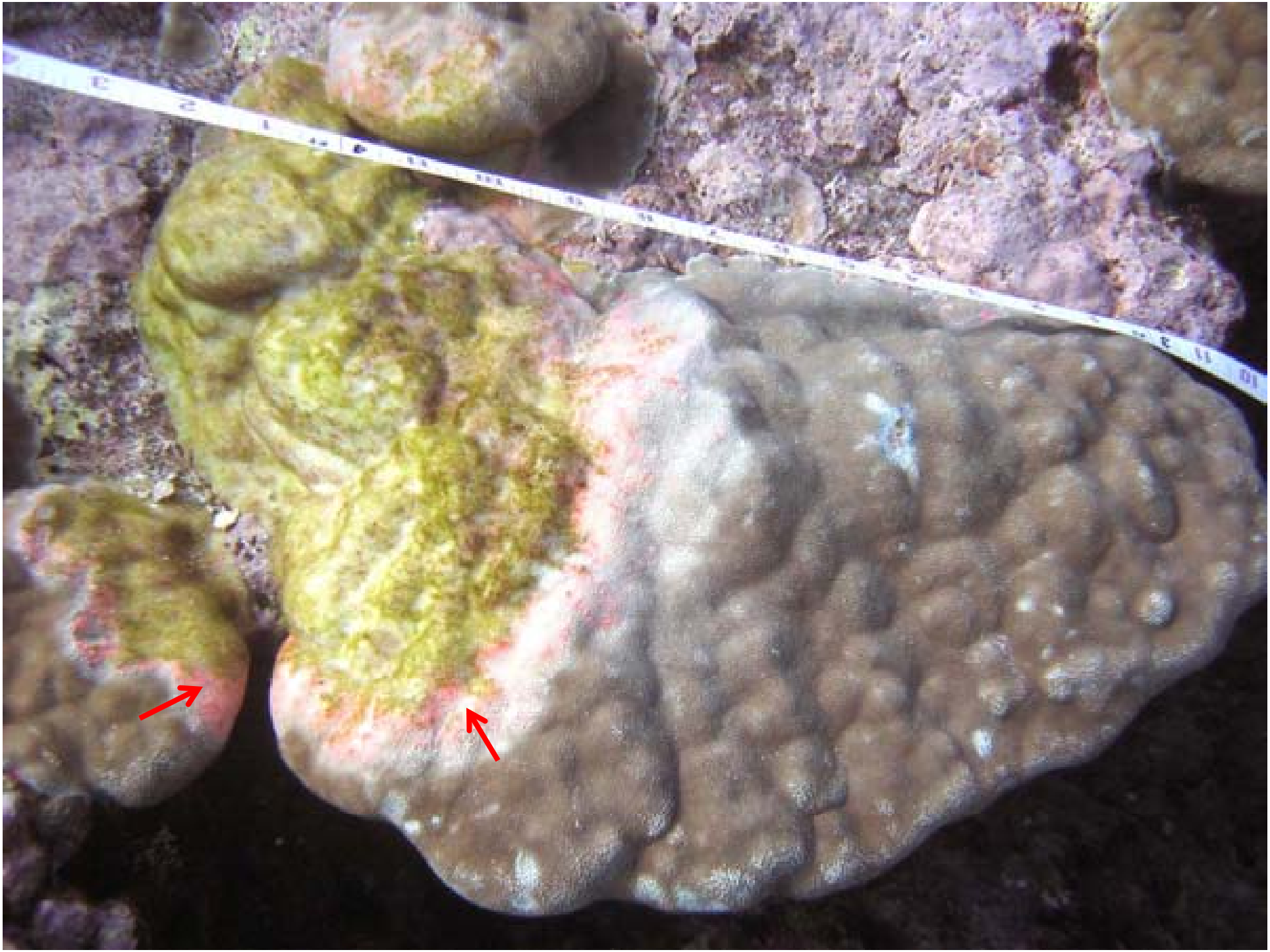
→Clusters of ciliates feeding on coral tissue, leaving stark, white skeleton

→Visible with hand lens as hair-like clusters

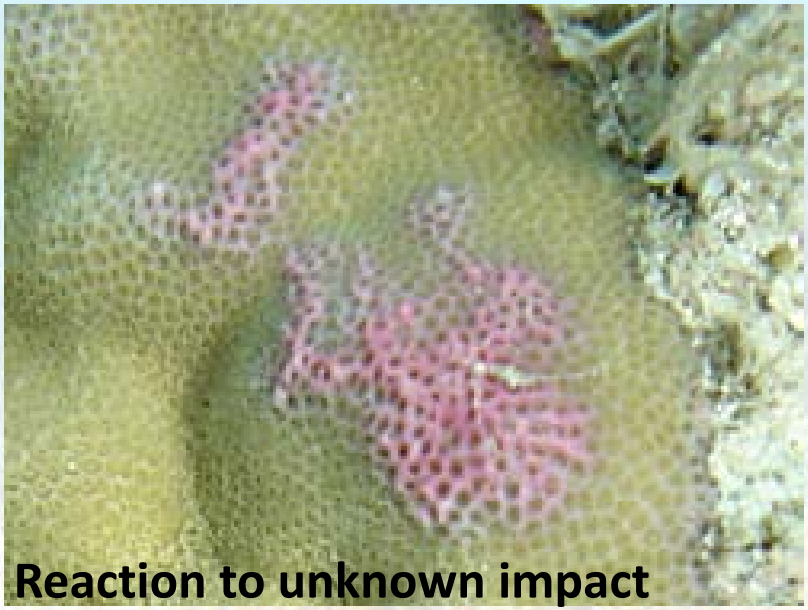
White syndrome

→ Possibly several diseases
→ Rapid, progressive tissue loss in an irregular pattern, diffuse border
→ The most difficult to assess underwater; looks like predation, bleaching. May spread between colonies:



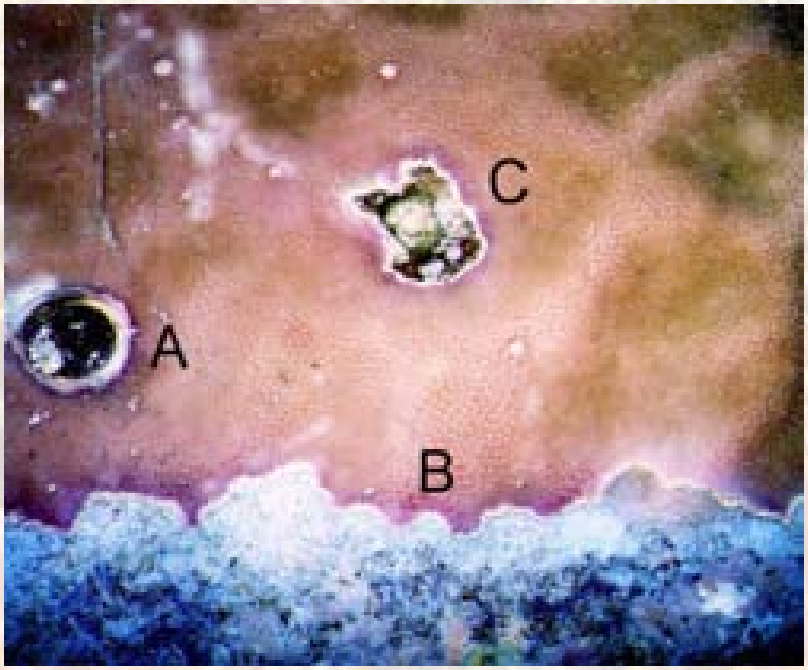


Pigmentation Response



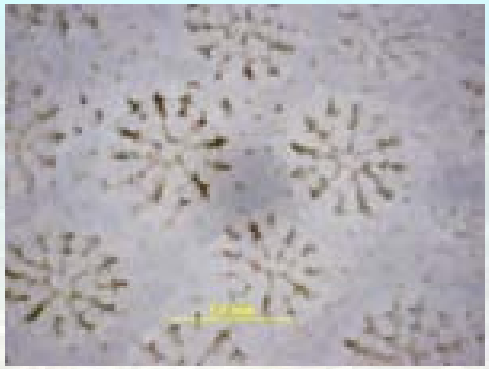
Reaction to unknown impact

Algal abrasion

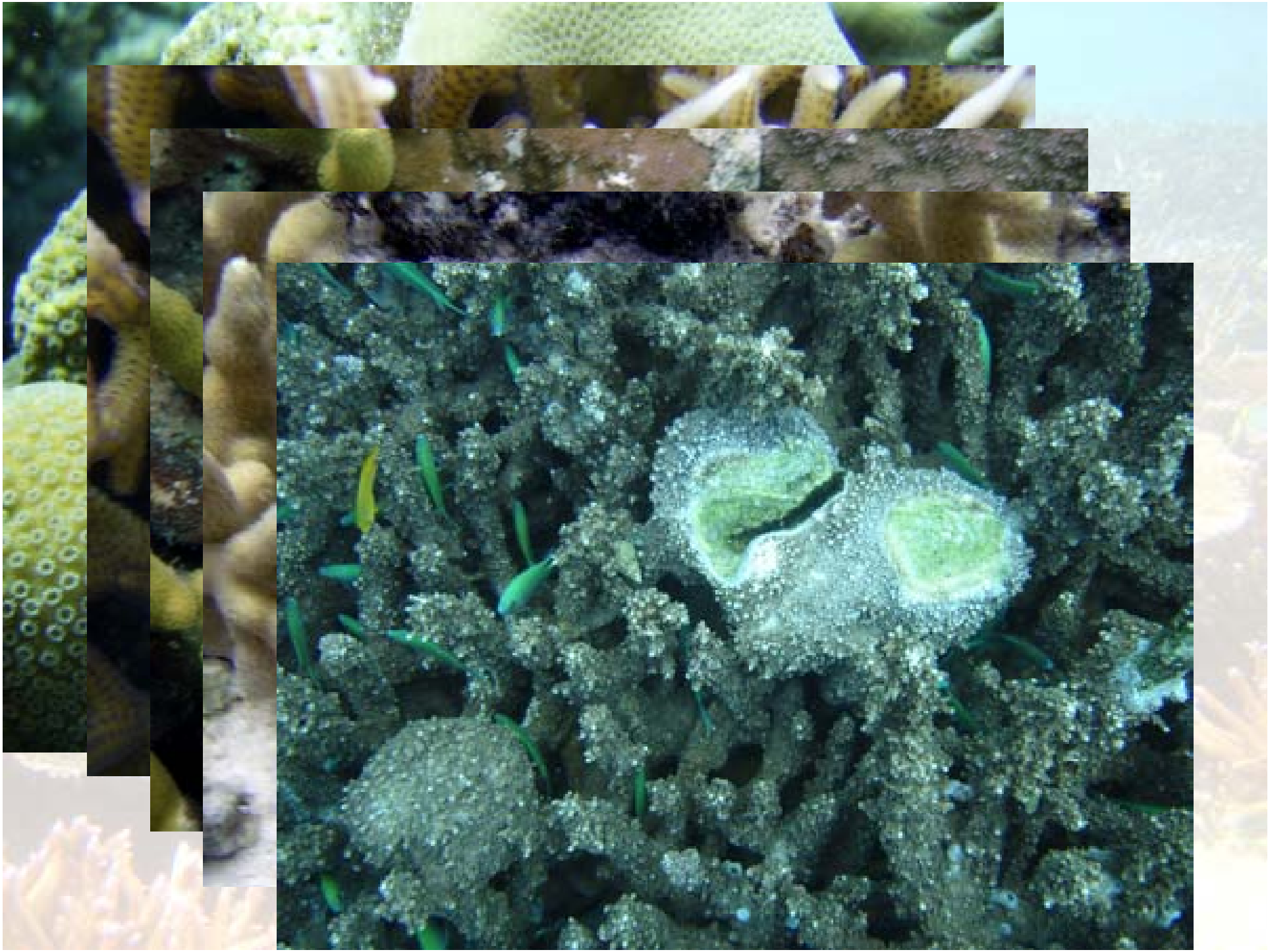


Reaction to boring organism, tissue preferred by fish predator

Growth anomalies



→ Abnormal growth form within a colony
→ Distinctly different surface texture, corallite density/size/structure
→ May have different pigmentation or appear bleached



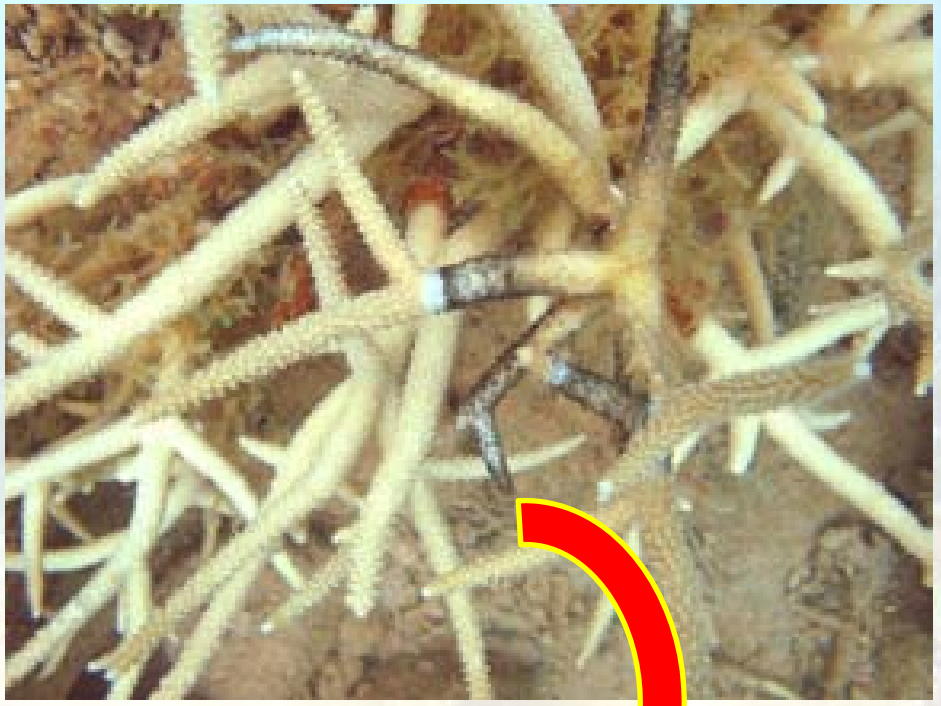
Bleaching

→ Note pattern of discoloration:
- Usually same position on multiple colonies
- Tissue still present

***Porites rus,* Tumon Bay, August 2008**

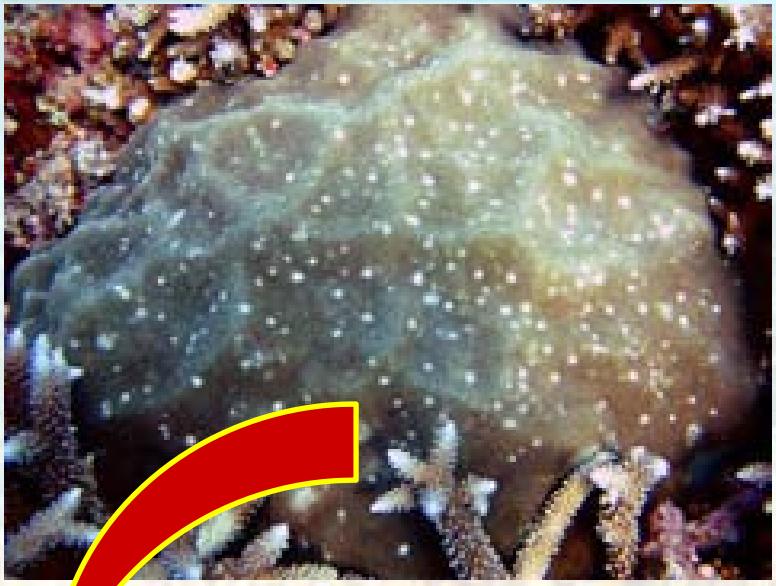
Same colony, November 2008:
- **Note recovery and resilience**

Skeletal Eroding Band



→Excavating ciliate that bores into skeleton
→May form a band or a diffuse patch
→Gives skeleton a fuzzy appearance

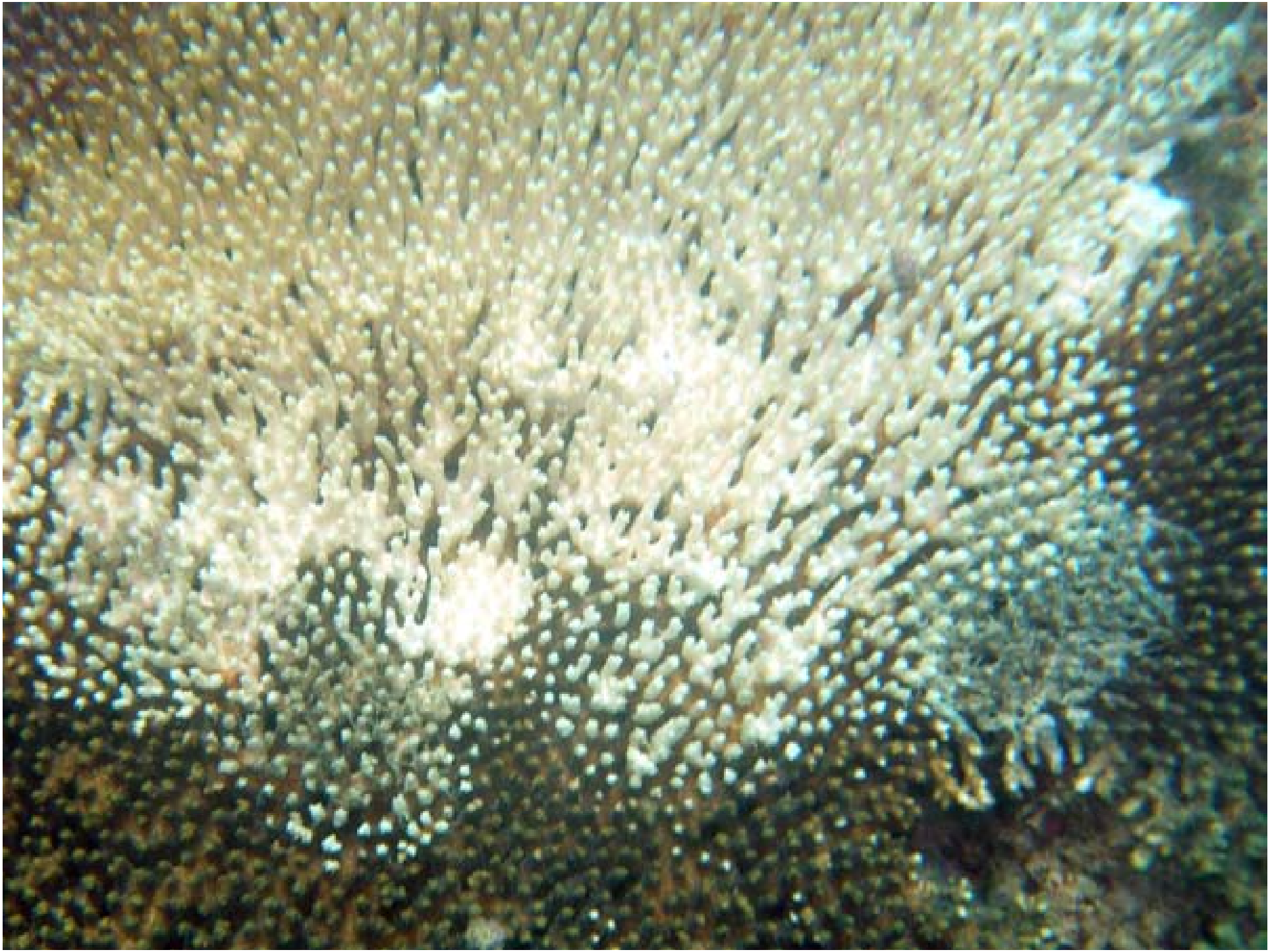
Ulcerative White Spots



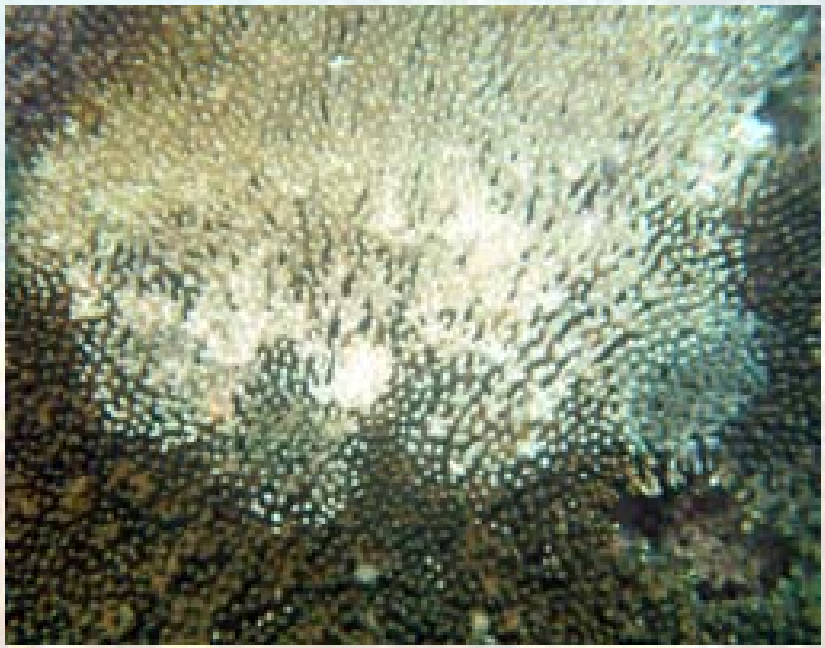
→small, discrete, lesions, scattered or clustered

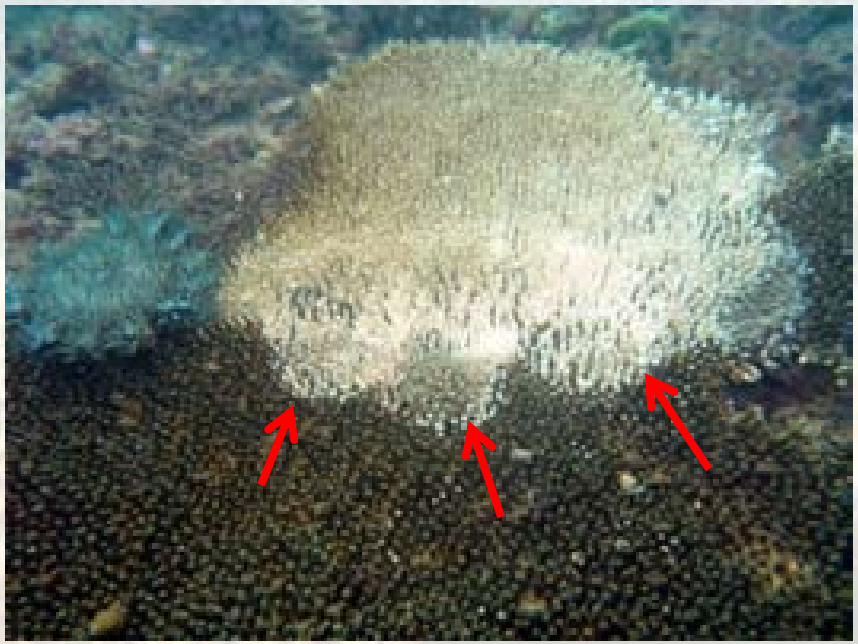
→new ones with bleached tissue

→either recovery, or progression to tissue loss



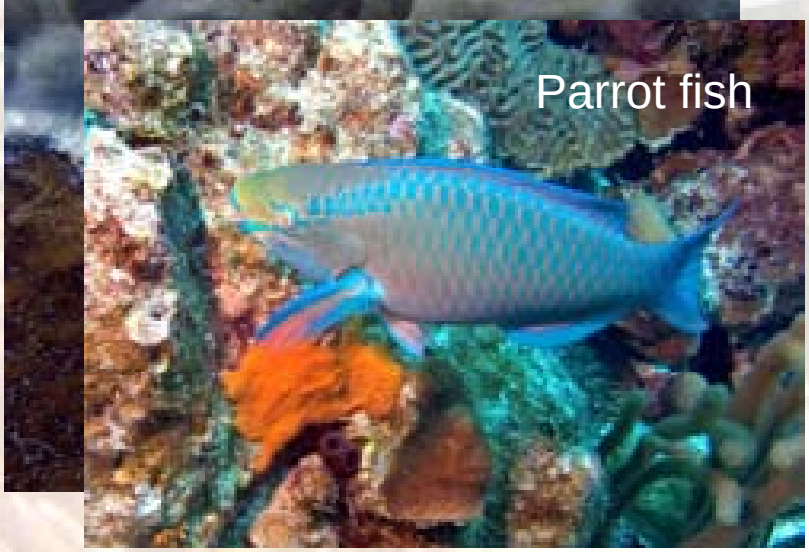
Crown-Of-Thorns predation

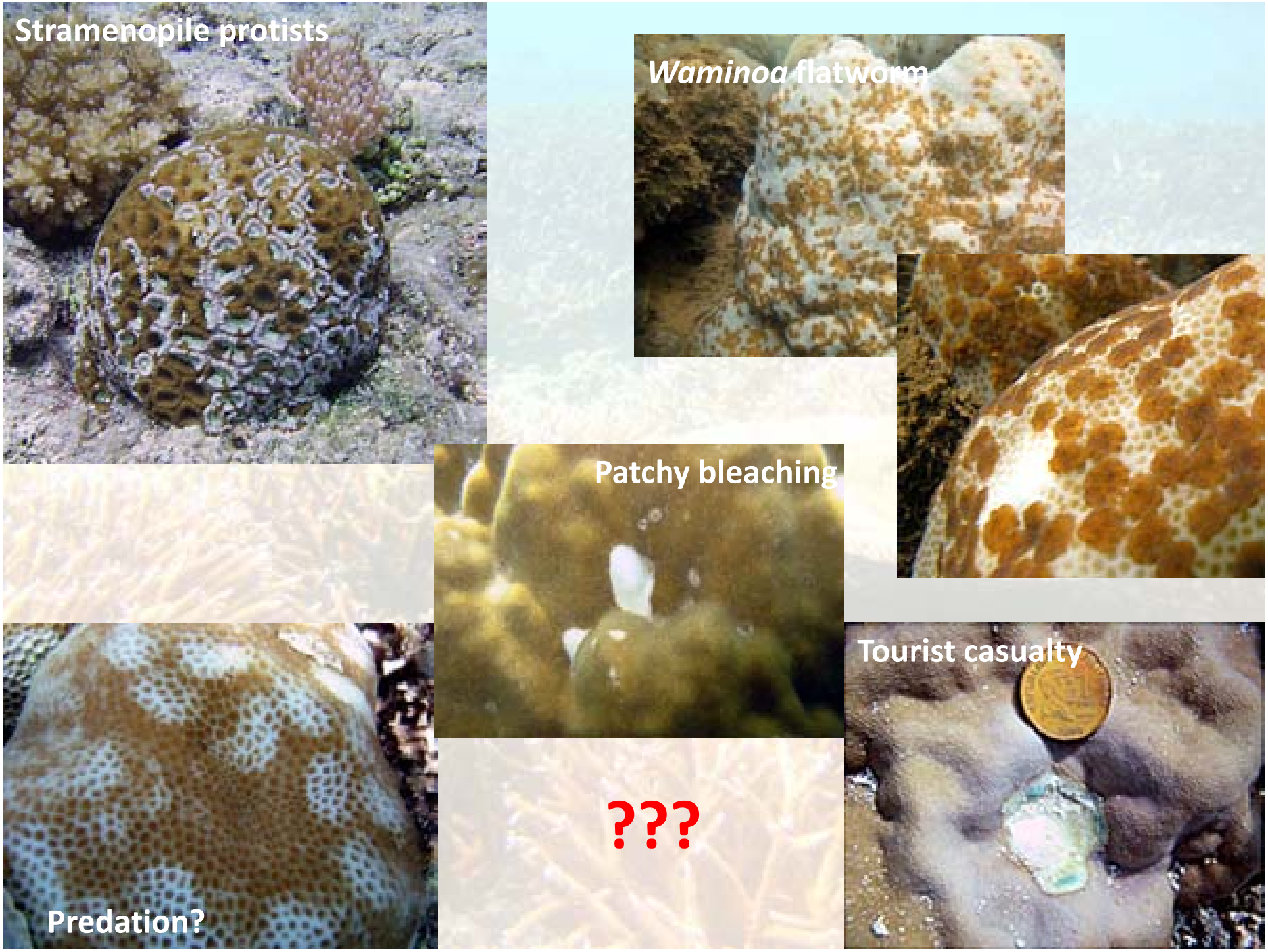




→sudden tissue loss, often large colony areas
→scalloped edges

Other predators: NAME THAT PREDATOR!!




Stramenopile protists
Waminoa flatworm
Patchy bleaching
???
Tourist casualty
Predation?

Acknowledgements

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