# Climate change and coral reefs

**Simon Donner**

**Department of Geography**

**University of British Columbia**

a place of mind

THE UNIVERSITY OF BRITISH COLUMBIA

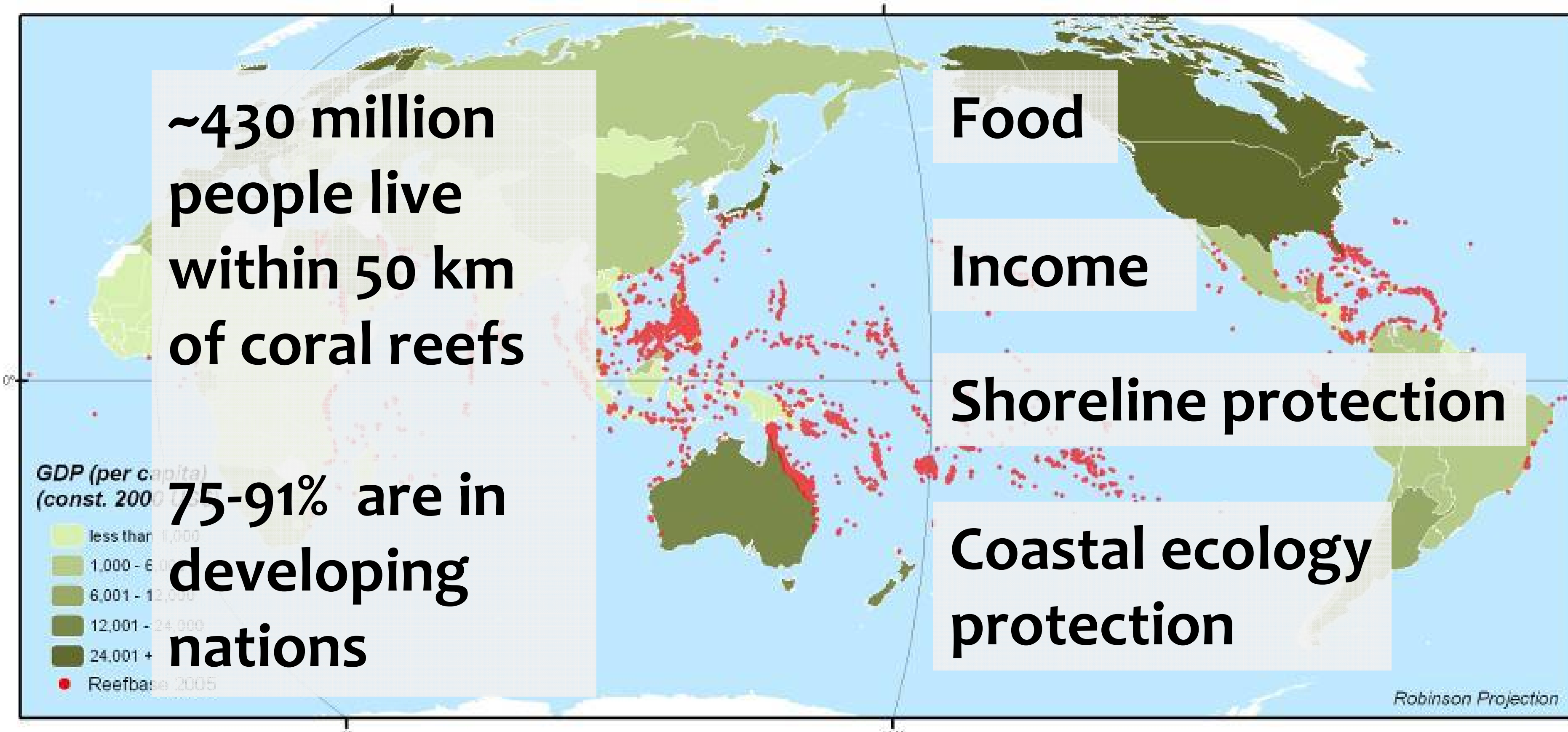
Scleractinia (hard corals) are sedentary animals, related to jellyfish and anemones, that secrete calcium carbonate skeletons.

Corals and other reef organisms derive energy from symbiotic dinoflagellates “zooxanthallae” that live in the animal’s tissue.

*WWF Coral Bleaching guide*


Disney
ON ICE
PRODUCED BY FELD ENTERTAINMENT
Disney · PIXAR
FINDING
NEMO

# Millions of people depend on reefs




~430 million people live within 50 km of coral reefs

75-91% are in developing nations

Food

Income

Shoreline protection

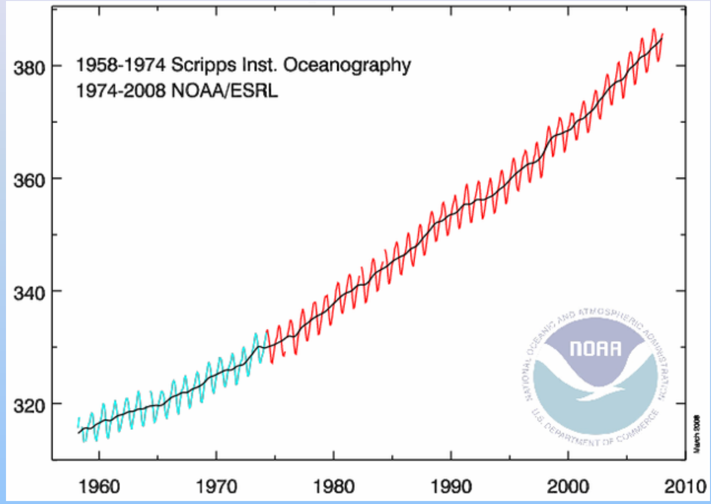
Coastal ecology protection

*Donner and Potere, 2007*

# The canaries in the climatic coal mine

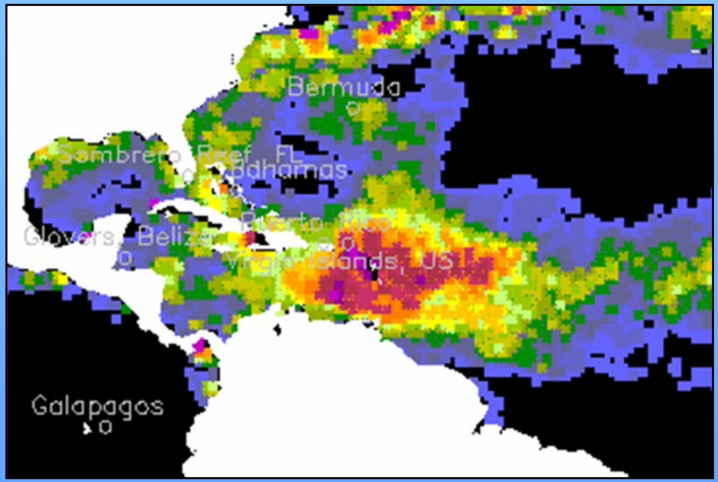
1. Rising $CO_2$ levels

(incremental change over time)




2. Rising temperatures

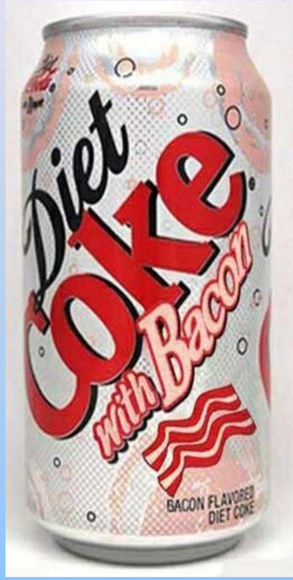
(more frequent extremes)



# 1. Ocean 'acidification' and coral reefs

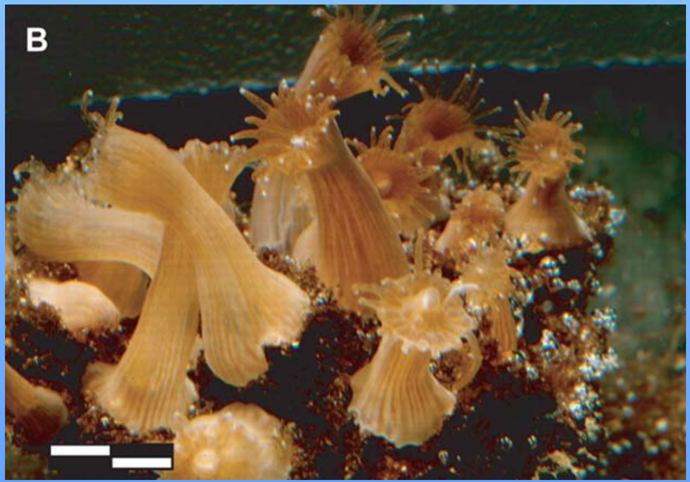
Roughly 1/3rd of the $CO_2$ we emit is absorbed by the oceans

This additional $CO_2$ dissolution alters the "carbonate" ion ($CO_3^{2-}$, $HCO_3^-$ , $H_2CO_3^{2-}$) balance.


This causes:

- Lower pH
- reduced skeletal growth in corals and coralline algae
- increased dissolution



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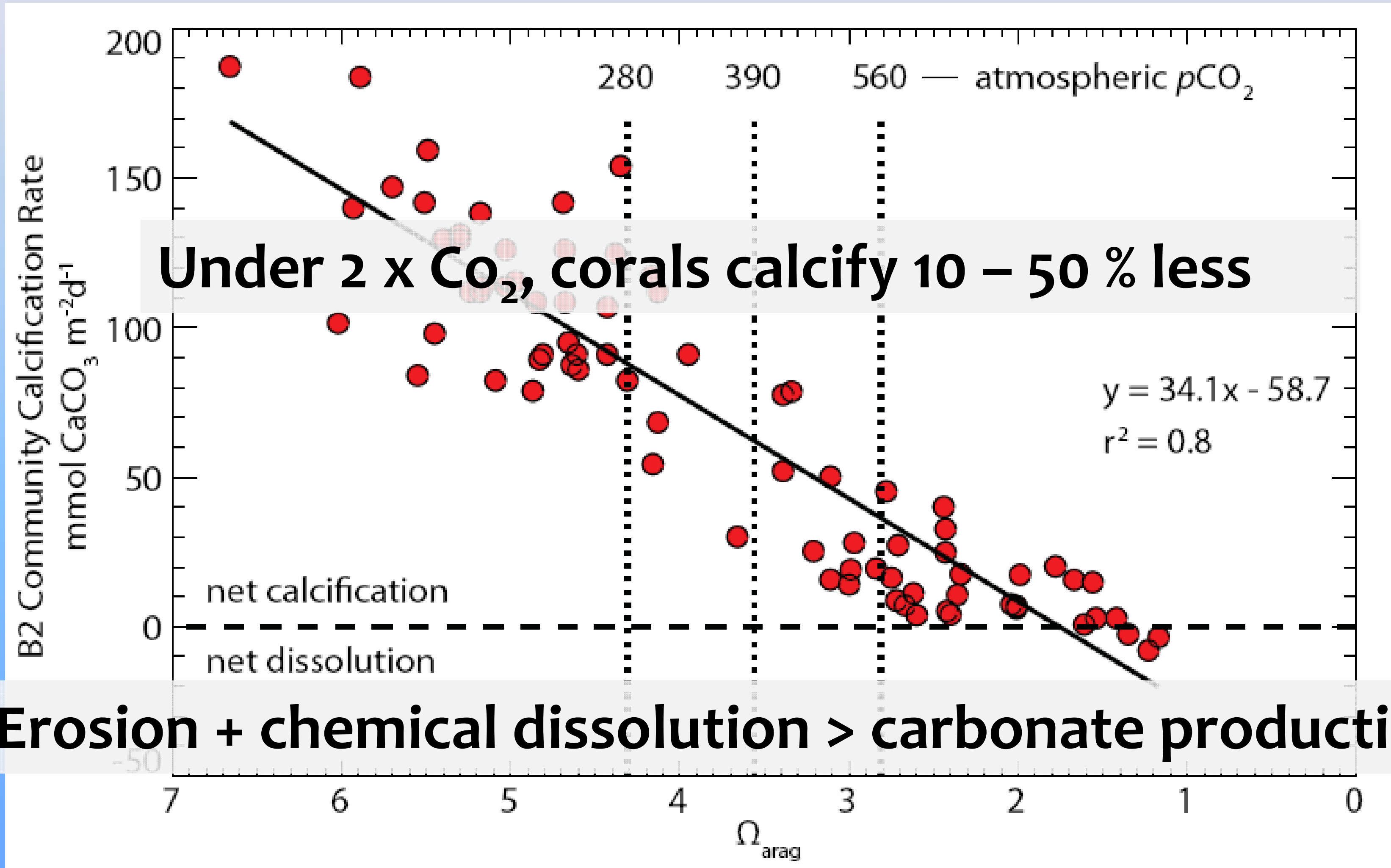



**Under 2 x $Co_2$, corals calcify 10 – 50 % less**

**Erosion + chemical dissolution > carbonate production**

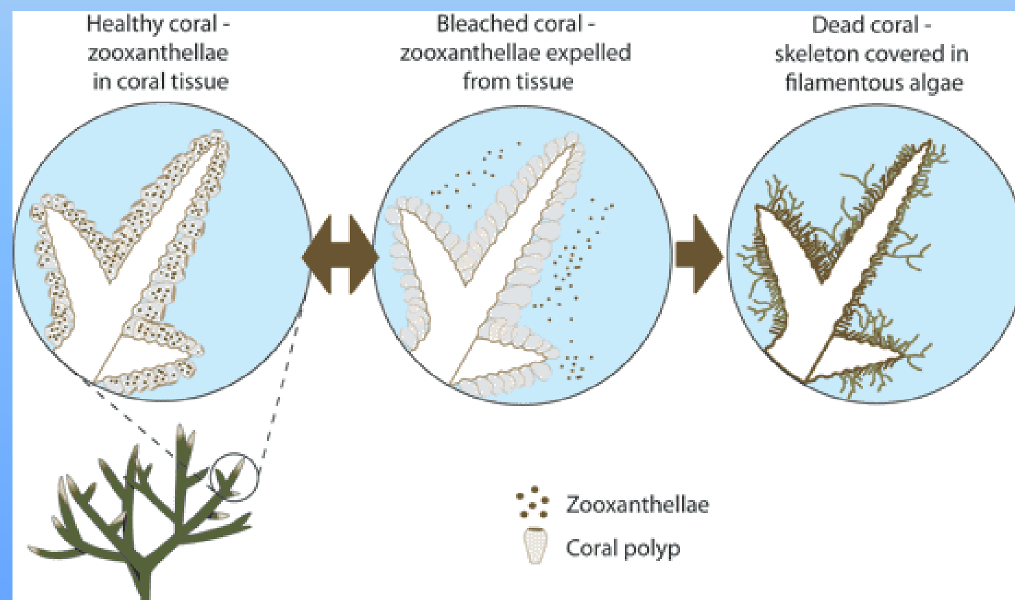
*Kleypas and Yates (2009) from C. Langdon data*

# 2. Mass coral "bleaching"

Corals and zooxanthallae are accustomed to a narrow range of environmental conditions (salinity, temperature, pH).

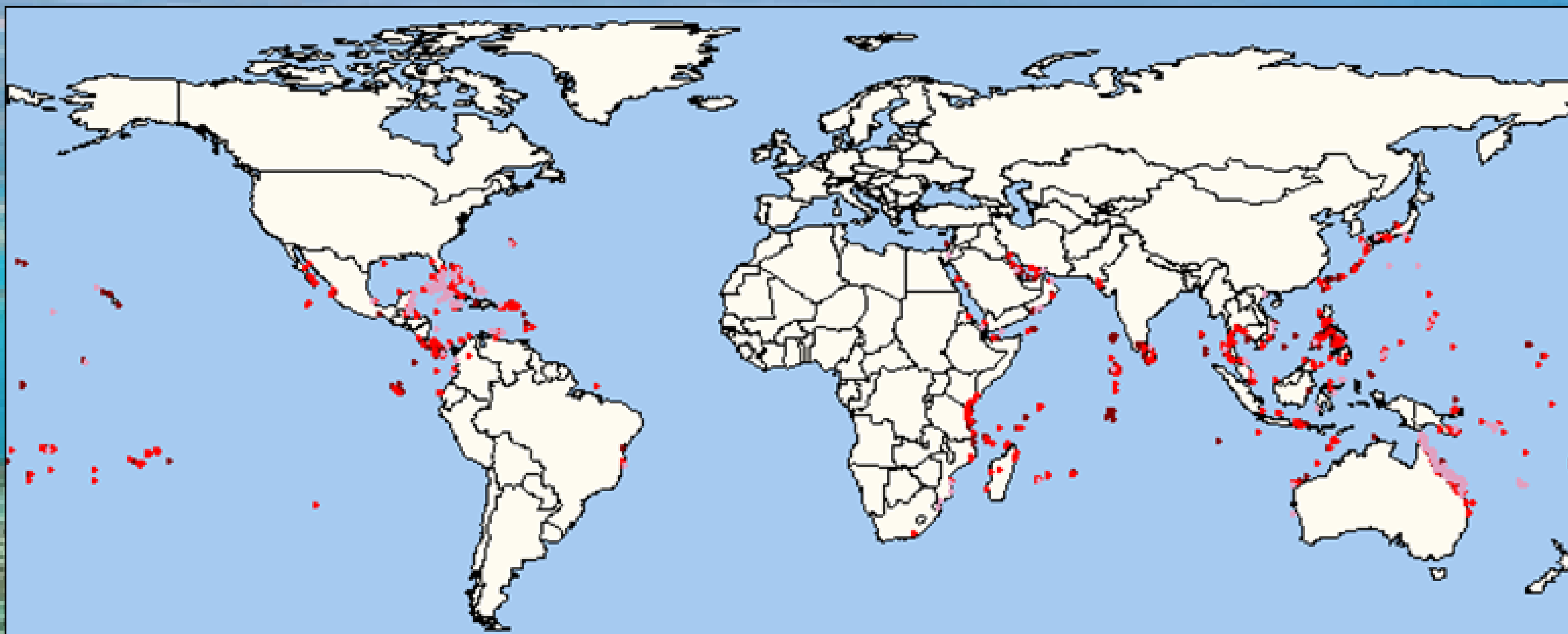
When stressed – the environmental conditions change – the symbiosis can break down.

**+ 1-2 $^oC$**




*GBRMPA, Coral Watch*

# Mass coral bleaching events since the 1980s



Commonly observed effects include:

i.coral morality and declines in coral cover

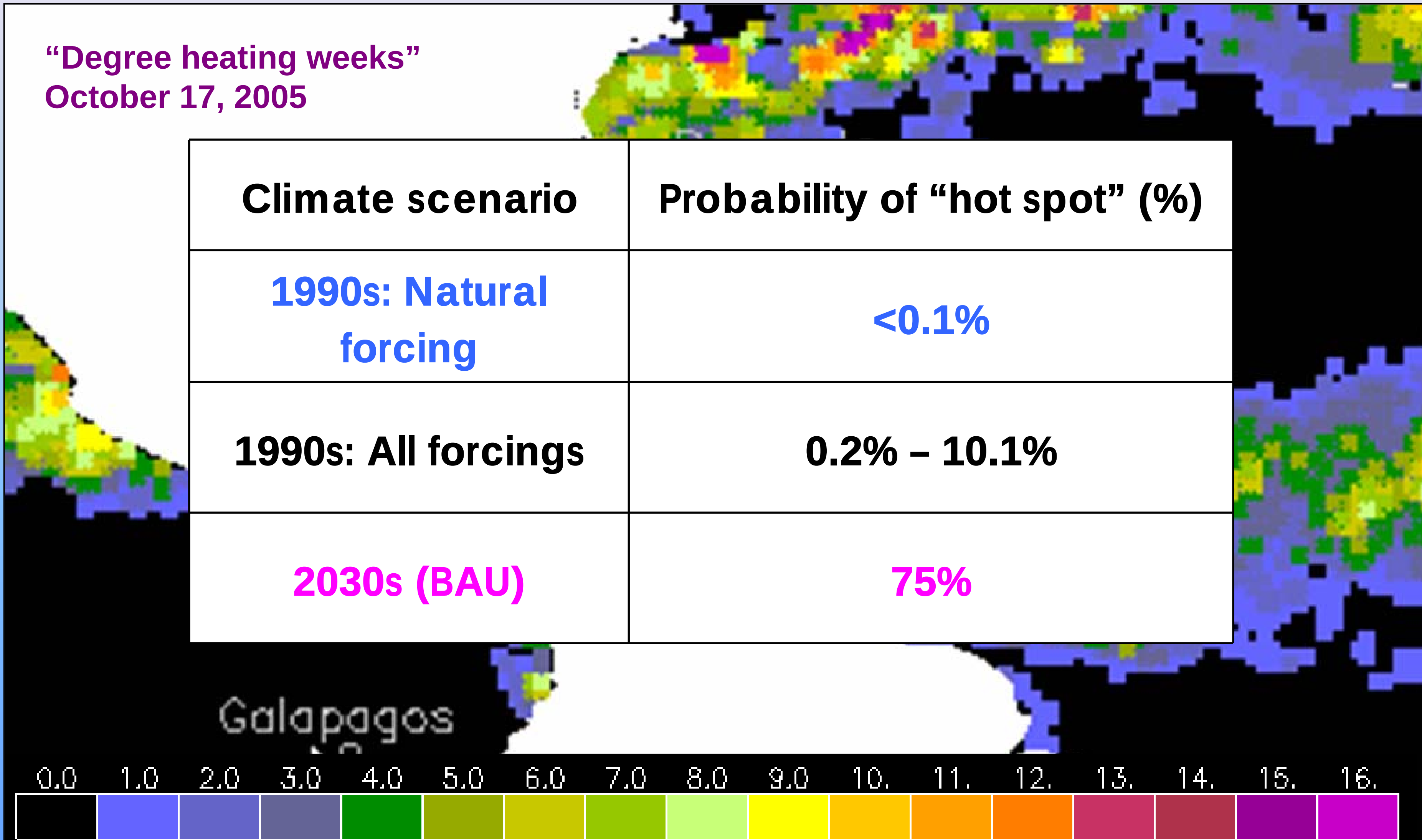
ii. reduced productivity and fecundity in surviving corals

iii. susceptibility to coral disease

iv. community shifts in corals and other reef-dwelling organisms

Great Barrier Reef

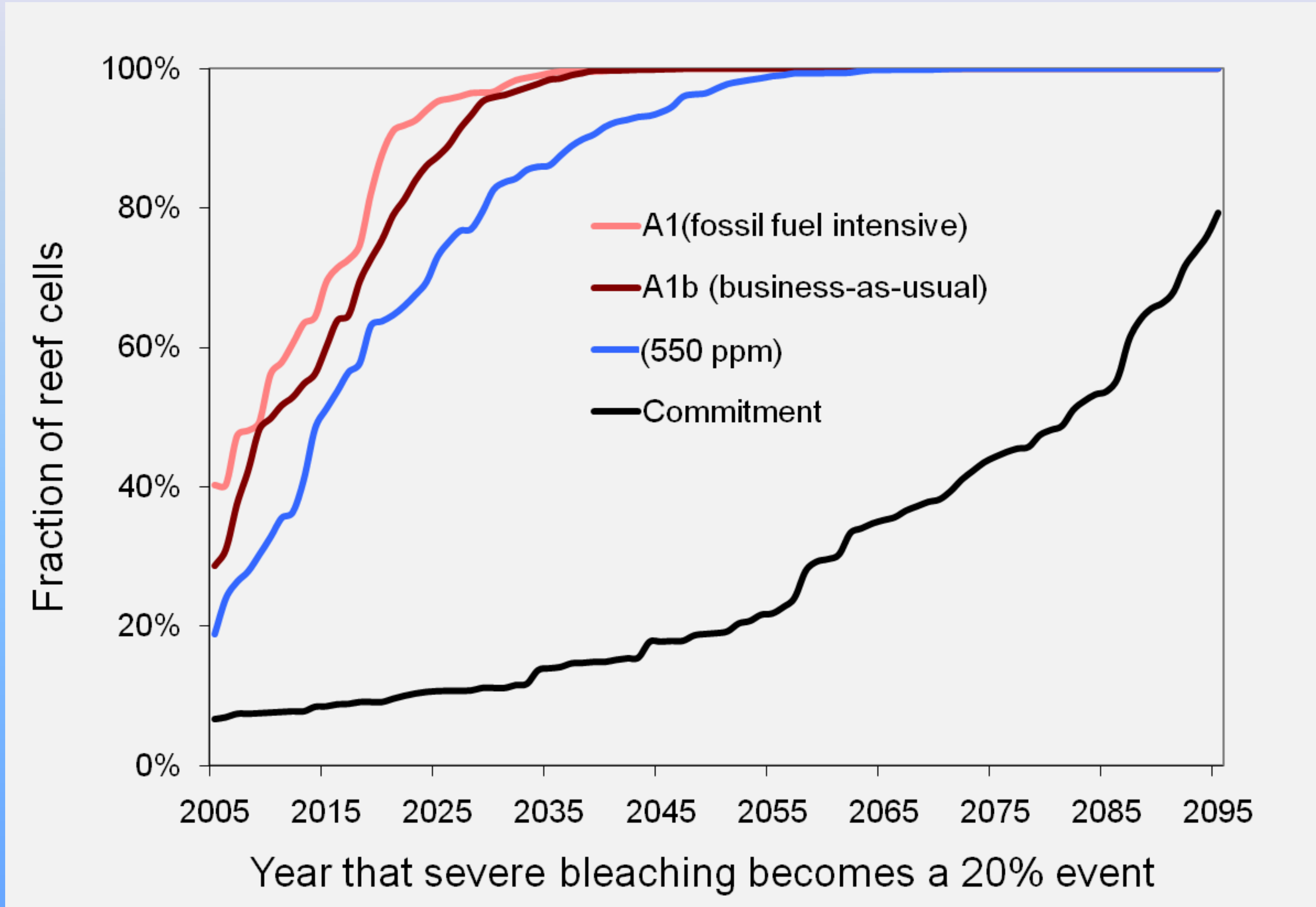
# Example: 2005 Caribbean event




| Climate scenario | Probability of "hot spot" (%) |
|---|---|
| 1990s: Natural forcing | <0.1% |
| 1990s: All forcings | 0.2% – 10.1% |
| 2030s (BAU) | 75% |

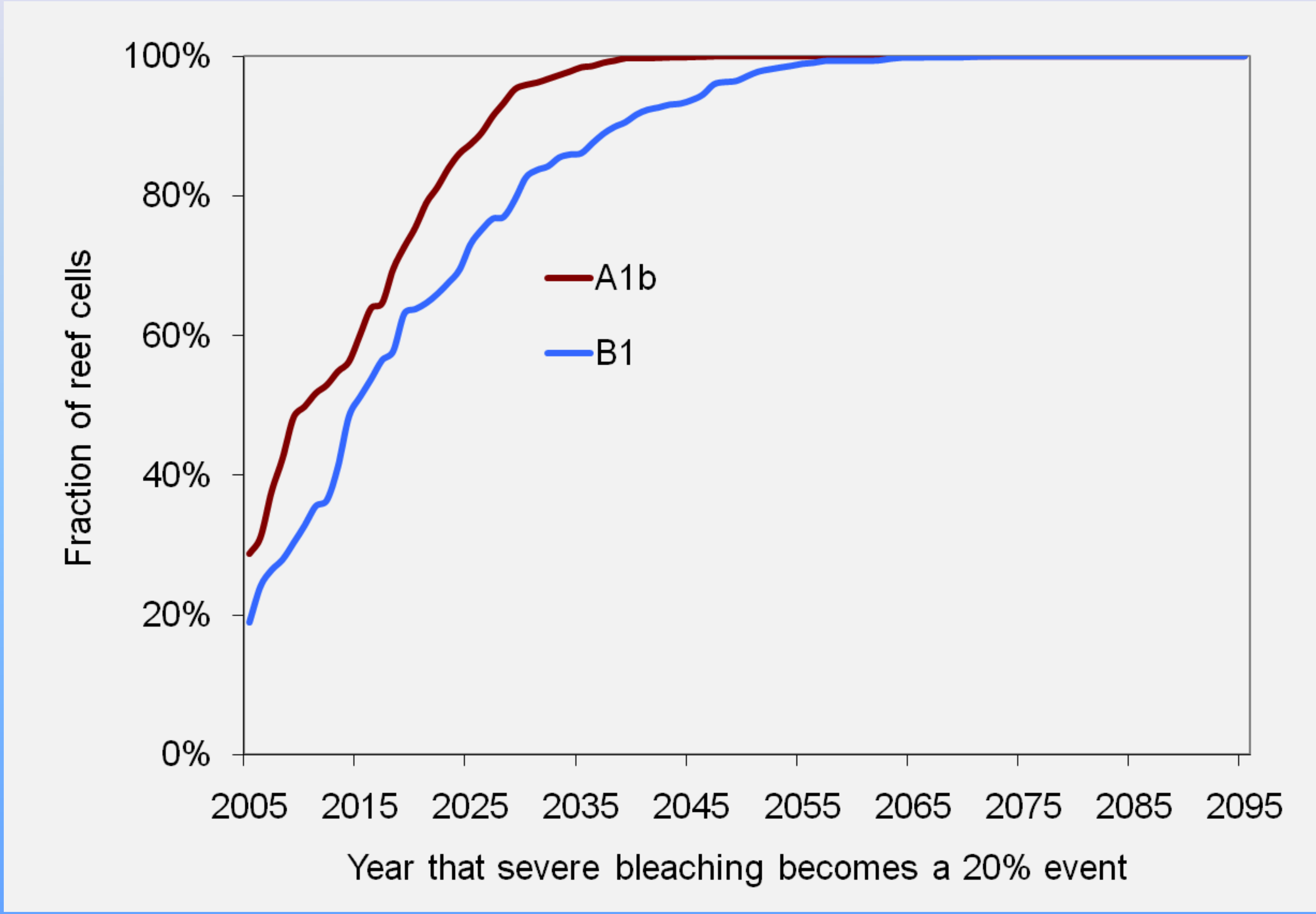
*Donner et al., 2007*

# Committed warming is a problem




*Donner. PLOS One*

# Can GHG mitigation make a difference?




*Donner. PLOS One*

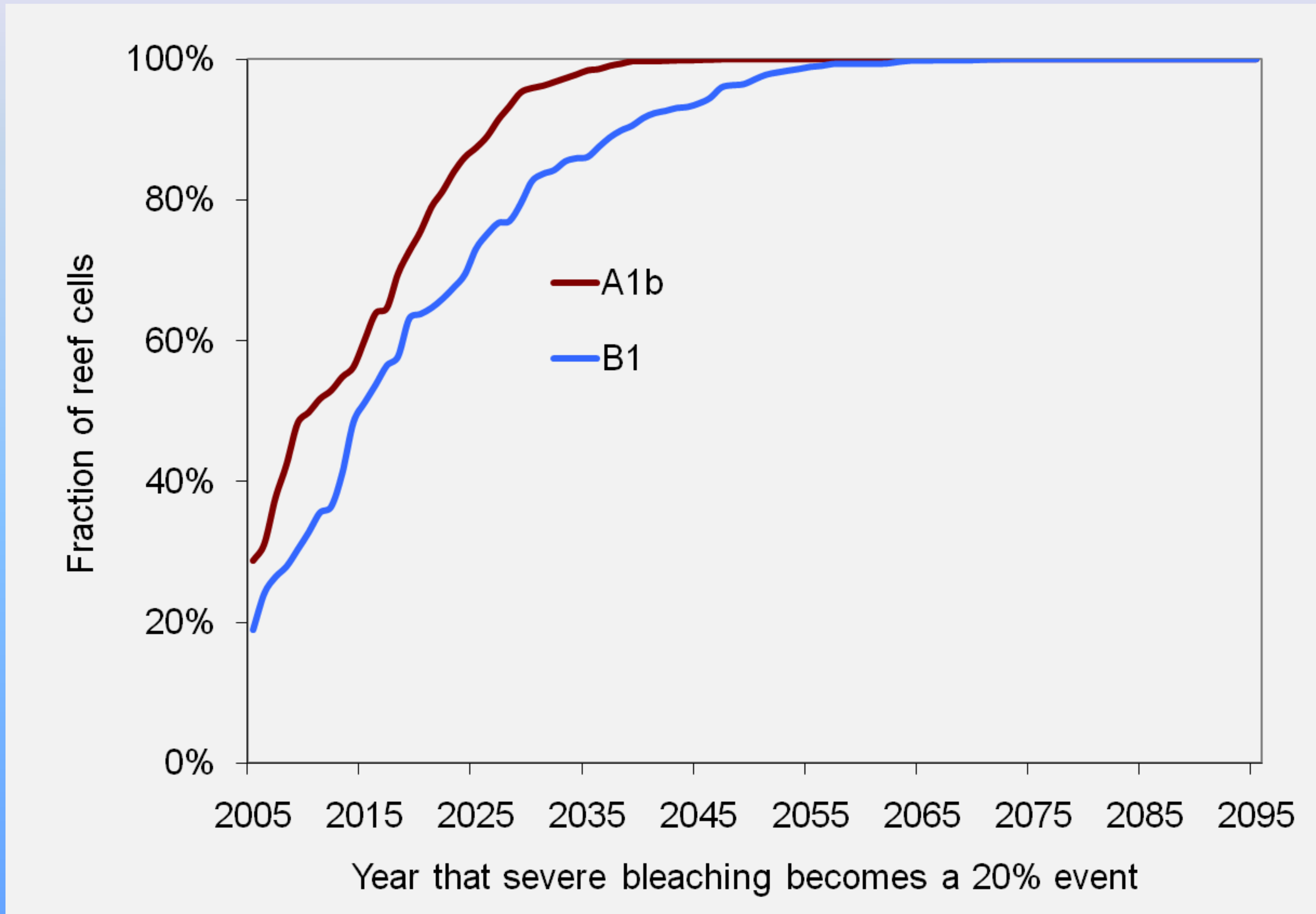
# Can corals and zooxanthallae adapt?

Some possible mechanisms for adaptation*:

1. "Flexibility of symbiosis" (Baker, Berkelmens and Van Oppen)
2. "Heterotrophic" plasticity (Grottoli et al.)
3. Changes in community composition (McClanahan, Loya, etc.)
4. Managing for resilience (e.g. protecting high variability reefs)

* measures that reduce the system to external stress

# Adaptation may provide time for mitigation



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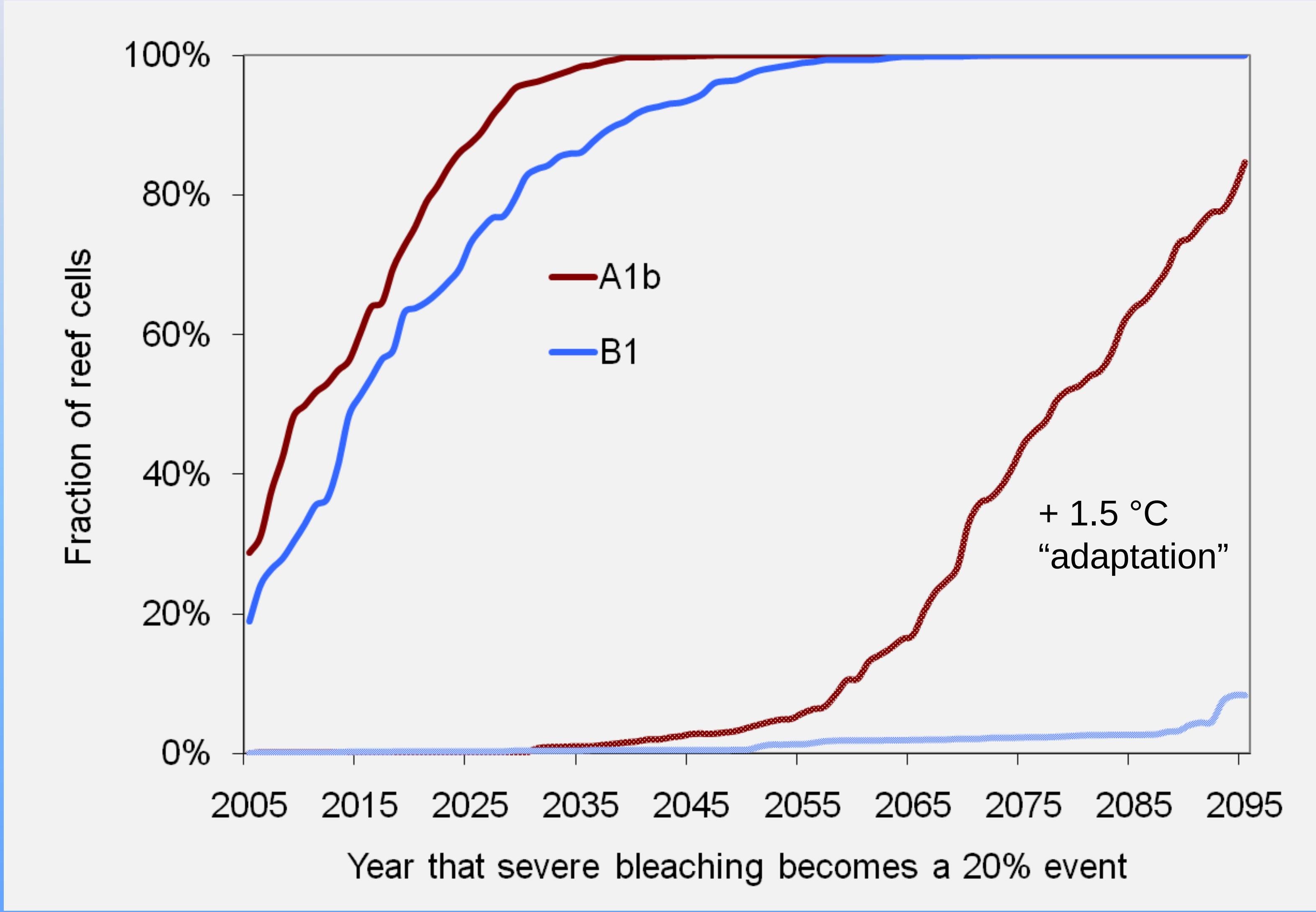
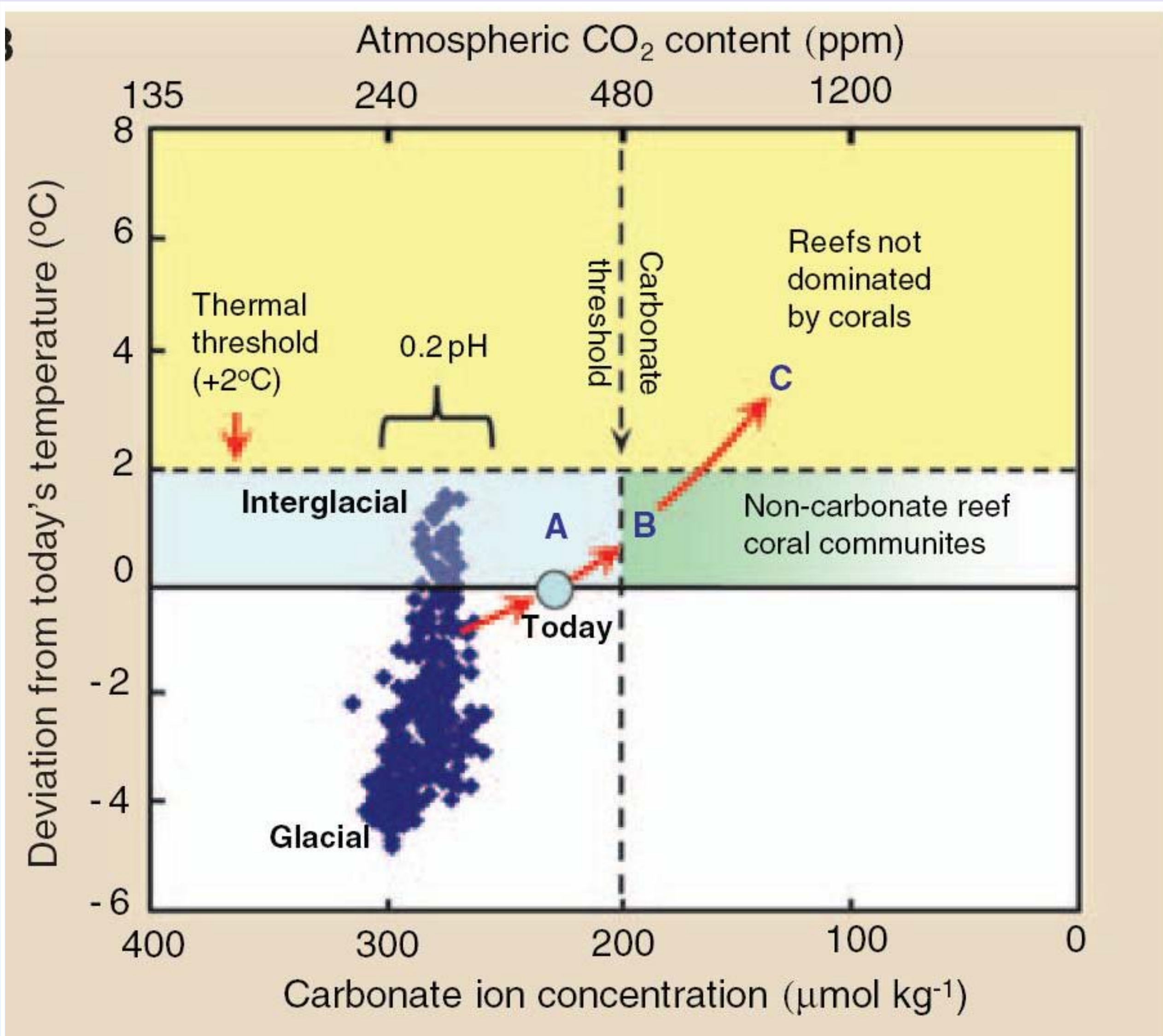


# Coral reefs in a doubled CO2 world




# Take home messages

1. "Committed" warming and rise in $CO_2$ are serious threat to the function of coral reef ecosystems.

2. Thermal adaptation *could* postpone forecast by 50-70 years, but is not a panacea.

3. In that case, stabilizing $CO_2$ at 550 ppm is the absolute outer limit for preventing "dangerously" frequent bleaching and . The lower limit is on the order of 370 ppm.

4. Coral reefs are an example of why there is no point arguing between managing for resilience (adaptation) and reducing GHG emissions (mitigation).

5. There's an increased focus on understanding of reef resilience may be improved by examining on regions with high SST variability.

# Resources

**NOAA Coral Reef Watch:** coralreefwatch.noaa.gov/

**Great Barrier Reef MPA:** www.gbrmpa.gov.au/

**Stanford “micro-docs”:** www.stanford.edu/group/microdocs/

**OA policy summary:** www.ocean-acidification.net/

**Climate shifts:** www.climateshifts.org

**Maribo:** simondonner.blogspot.com

# 2009 / 2010 “Central Pacific” El Nino event

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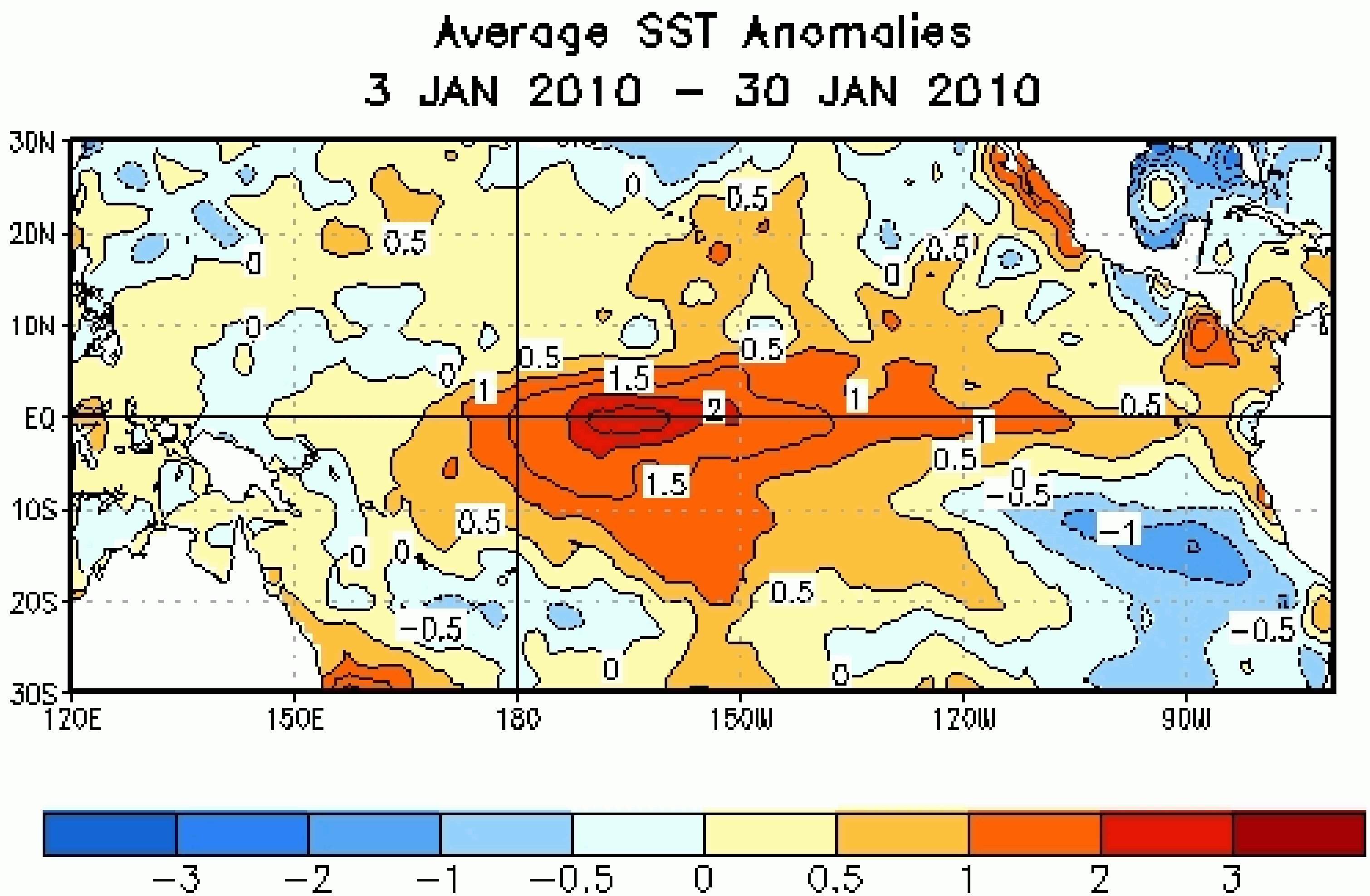
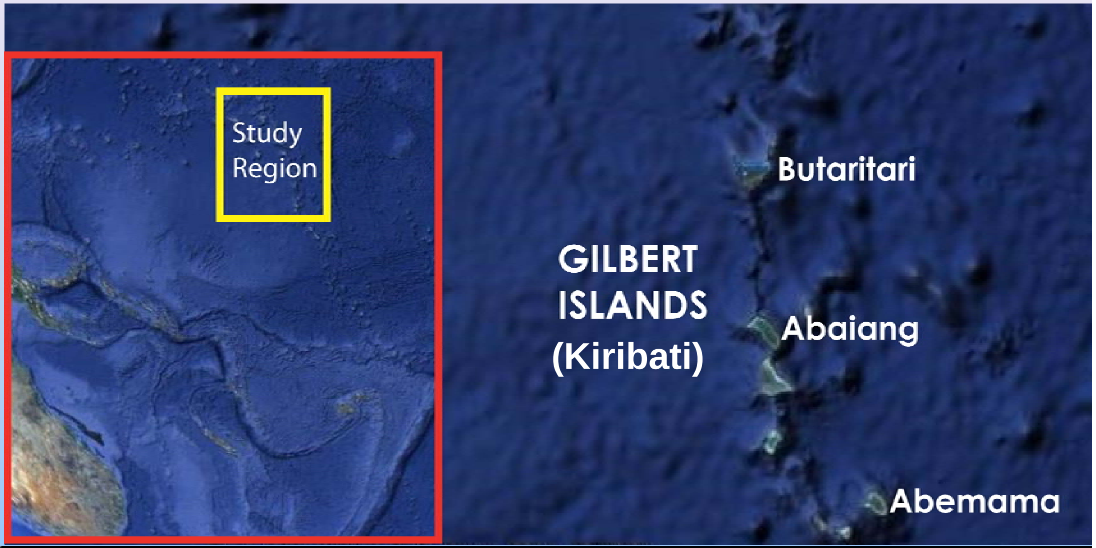


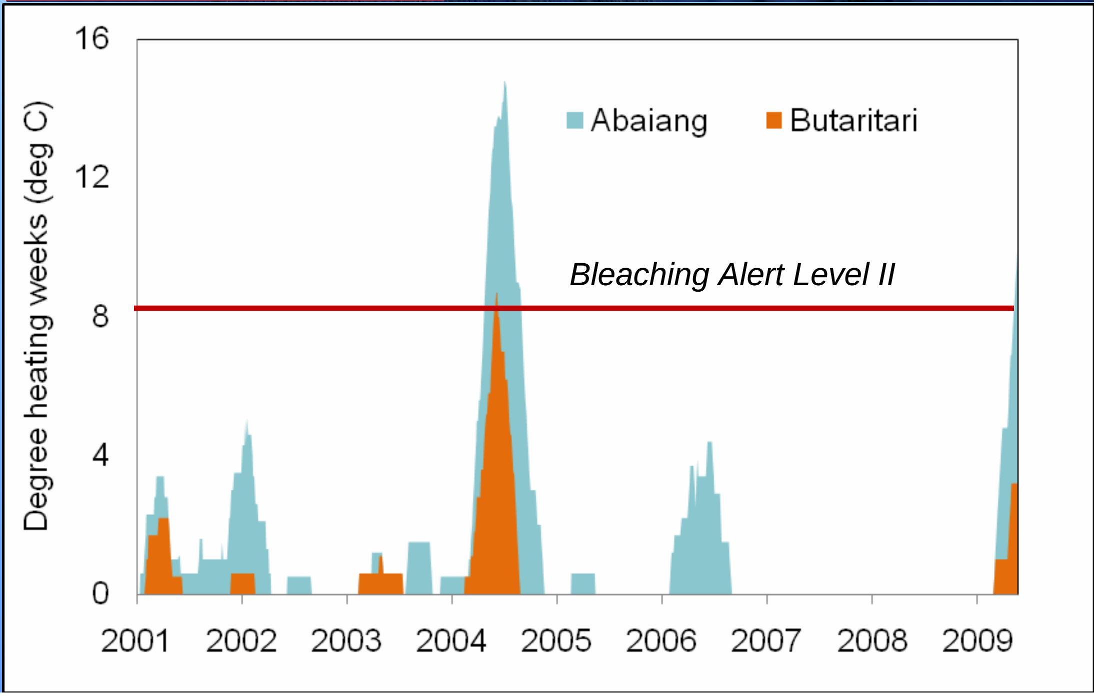

Figure 1. Average sea surface temperature (SST) anomalies (°C) for the four-week period 3 January 2010 – 30 January 2010. Anomalies are computed with respect to the 1971-2000 base period weekly means (Xue et al. 2003, *J. Climate*, **16**, 1601-1612).

# Bleaching in a high variability region

The central equatorial Pacific may be a natural model for the effect of frequent thermal stress on coral reefs

We hope to learn about the factors that confer bleaching resistance or resilience by conducting coral surveys and coral core analysis across the gradient(s) of historical temperature variability.




*Donner and Vieux (in prep)*