

# Basics of Coral Reefs & Climate Change

## Section 3: Delving Deeper into Bleaching Physiology

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NOAA Coral Reef Watch

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The background of the slide is an underwater photograph of a coral reef. The water is clear and blue. In the foreground, there are large, flat, white coral structures. Behind them, there are dense, branching coral structures that appear to be bleached, showing a yellowish-brown color. A small, striped fish is visible swimming near the bottom left.

outline

Light and Temperature in Coral Bleaching

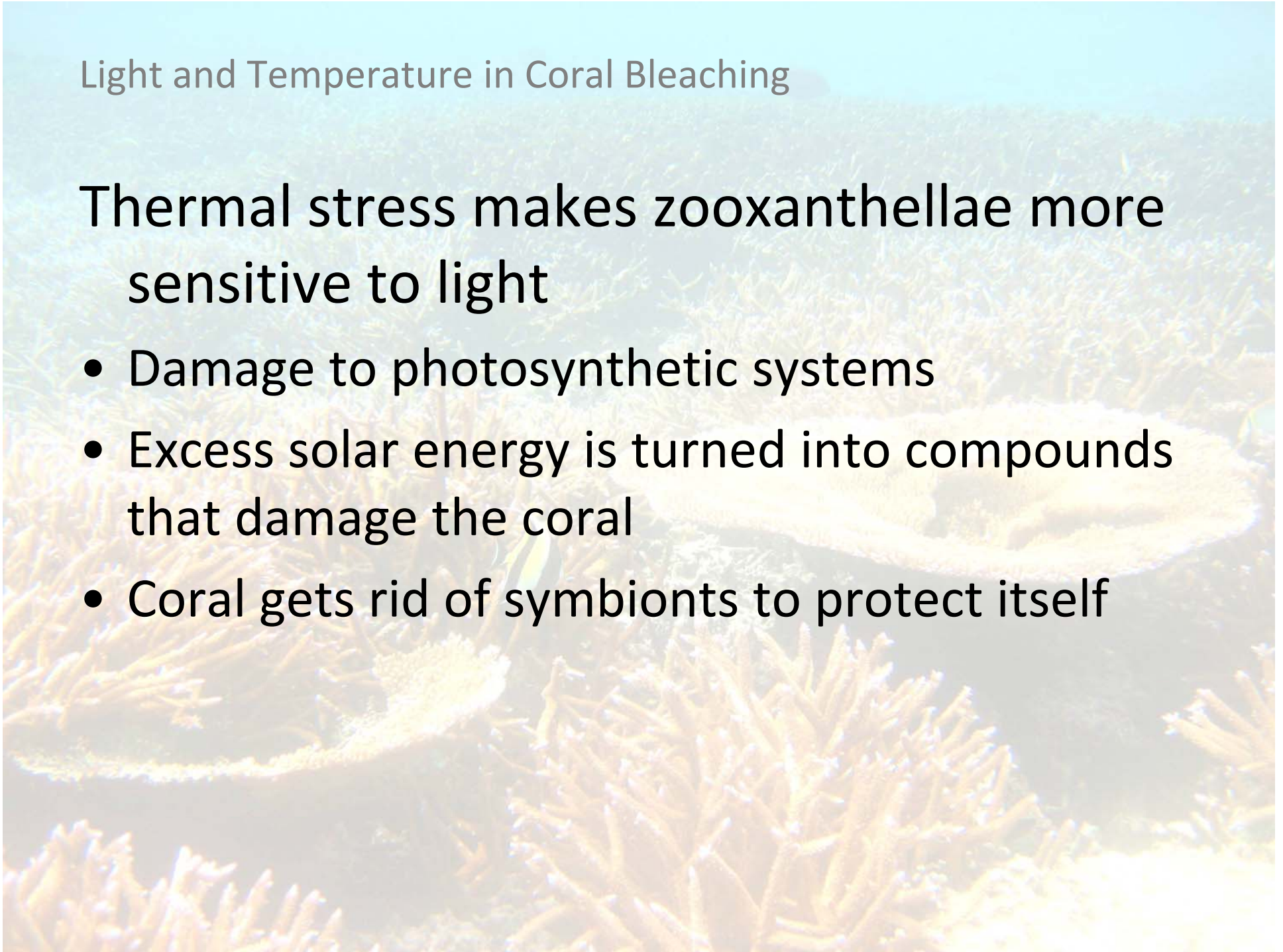
Can Coral Reefs Survive Bleaching?

Can Corals Adapt to Climate Change?

## Light and Temperature in Coral Bleaching

Thermal stress makes zooxanthellae more sensitive to light

- Damage to photosynthetic systems
- Excess solar energy is turned into compounds that damage the coral
- Coral gets rid of symbionts to protect itself



## Light and Temperature in Coral Bleaching

Normal sunny days: mid-day damage to  
zooxanthellae photosynthesis system

Fully repaired by the end of the day

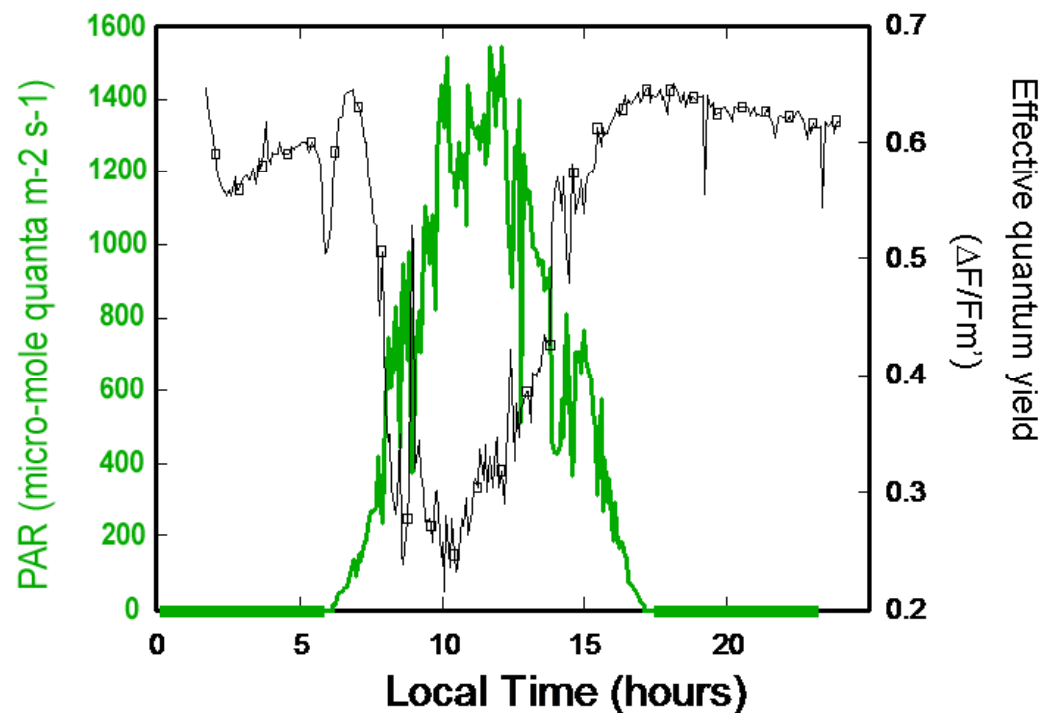
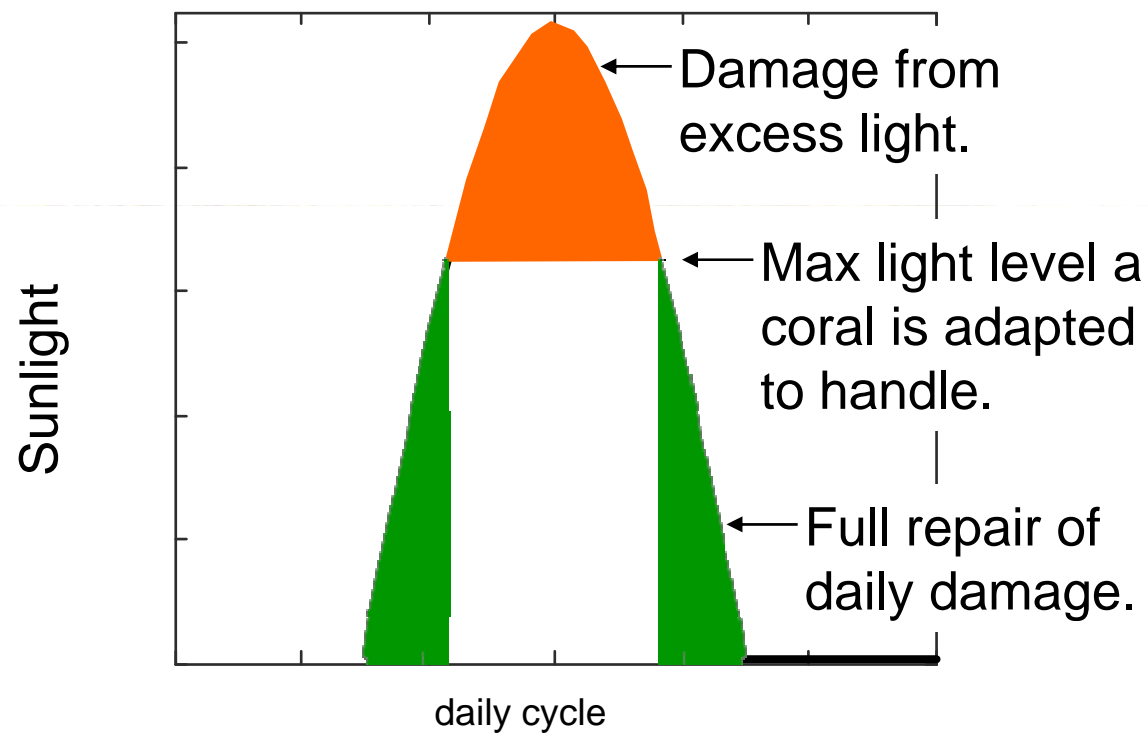


image from Roberto Iglesias, UNAM

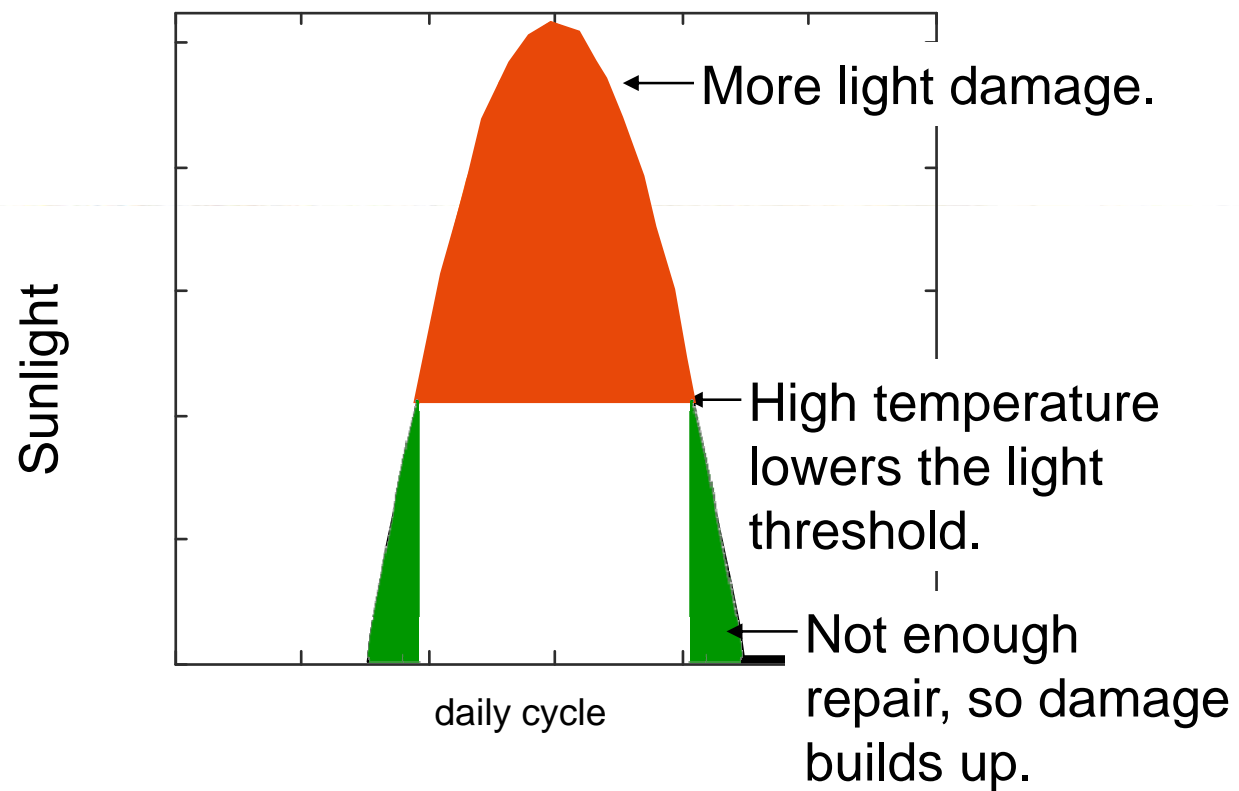
# Light and Temperature in Coral Bleaching

## NORMAL TEMPERATURE CONDITIONS

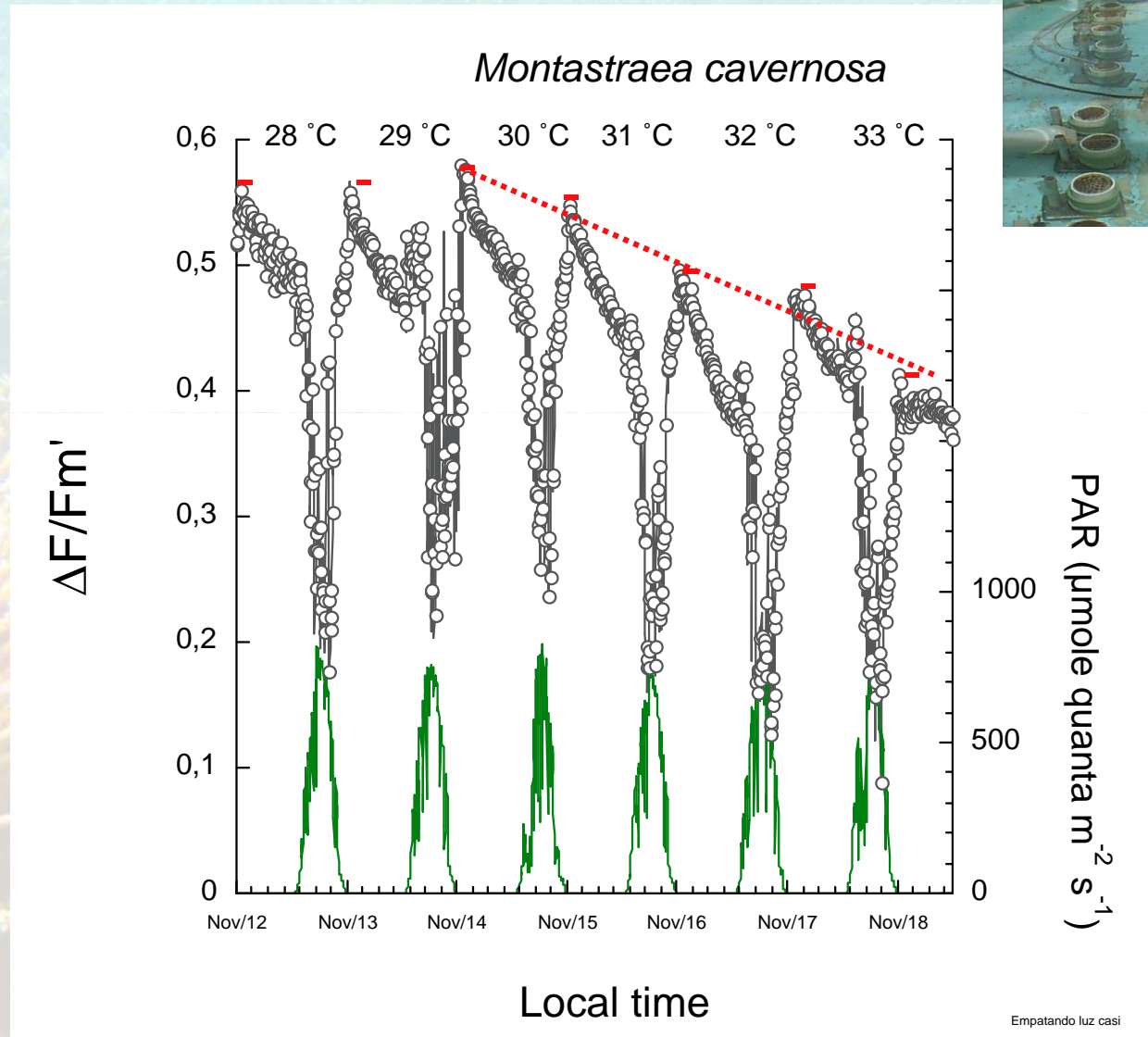


## Light and Temperature in Coral Bleaching

### STRESSFUL TEMPERATURE CONDITIONS



# Light and Temperature in Coral Bleaching



Roberto Iglesias, UNAM

## Light and Temperature in Coral Bleaching

If the absorbed light energy can't be used in photosynthesis, what happens to it?

- Extra energy converted into reactive oxygen species (“free radicals”)
- Cellular damage to zooxanthellae and to the coral host

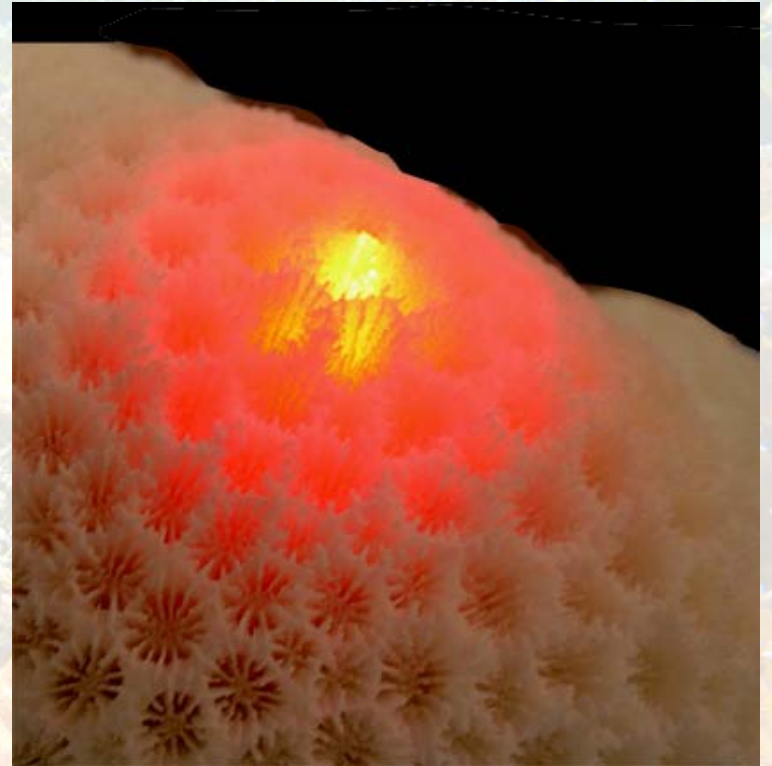
## Light and Temperature in Coral Bleaching

### Bleached coral enhances light

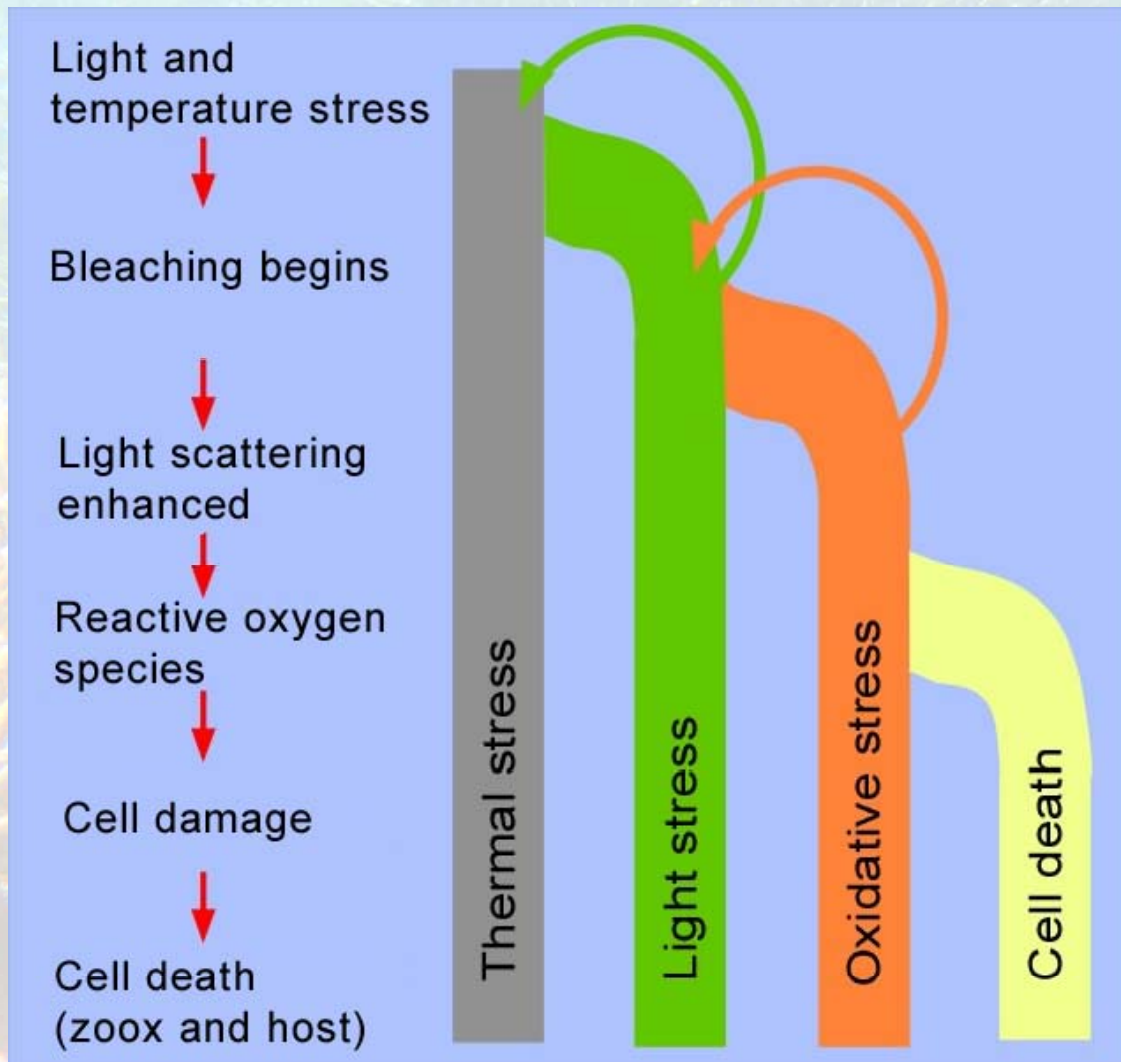
Normal conditions: coral skeleton scatters light to enhance the light field for the zooxanthellae

Bleaching: more light reaching the skeleton, more scattering, more enhancement of the light field

Past a tipping-point, the bleaching makes the cause of bleaching worse



## Light and Temperature in Coral Bleaching



Severe stress  
may directly  
cause cell  
death.

Starvation from  
chronic  
bleaching may  
occur in the  
long term.

## Can Coral Reefs Survive Bleaching?

### Resistance to bleaching

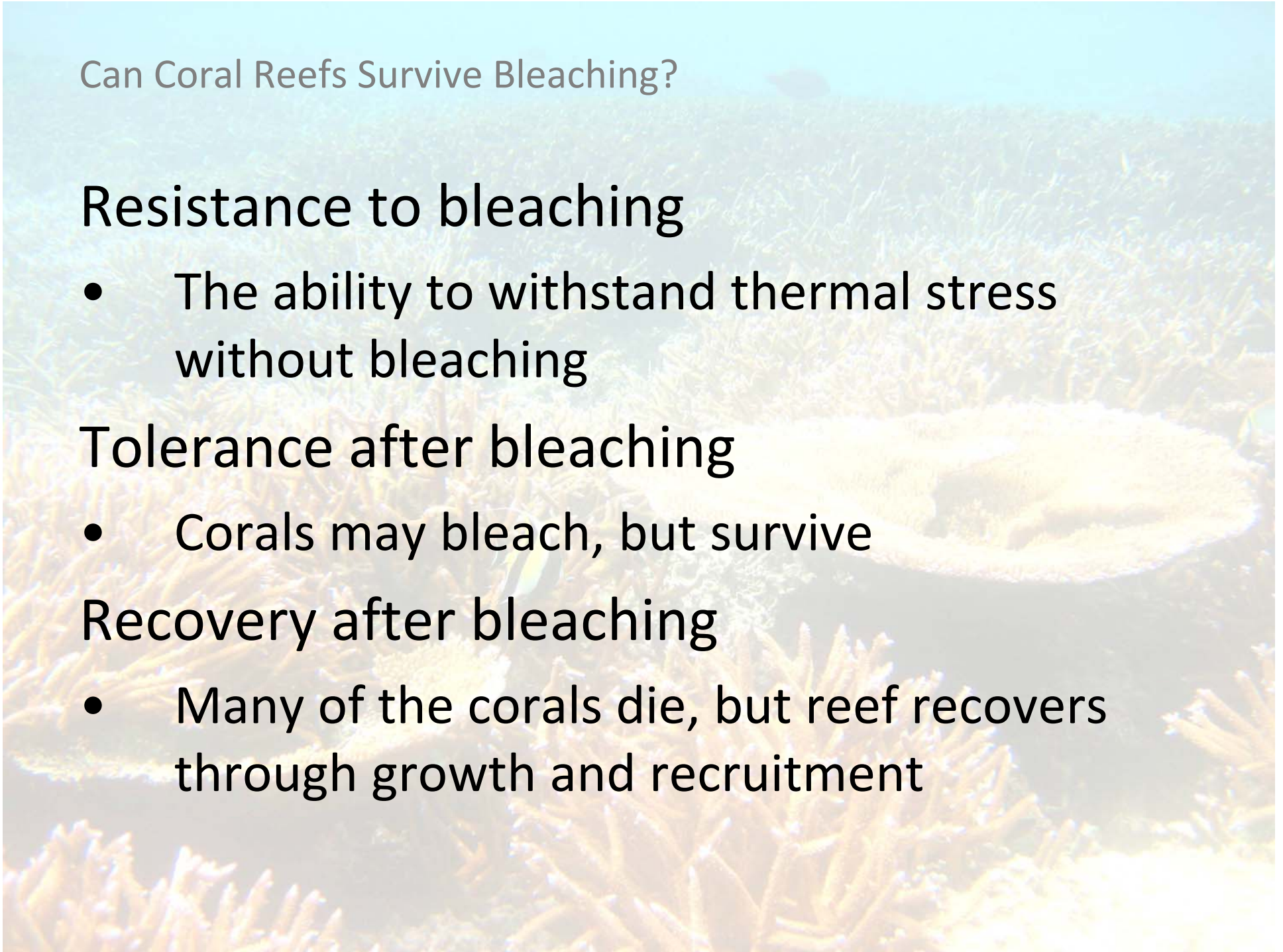
- The ability to withstand thermal stress without bleaching

### Tolerance after bleaching

- Corals may bleach, but survive

### Recovery after bleaching

- Many of the corals die, but reef recovers through growth and recruitment



## Can Coral Reefs Survive Bleaching?

Where mortality is relatively low, reefs may recover within months to years (mainly through growth)

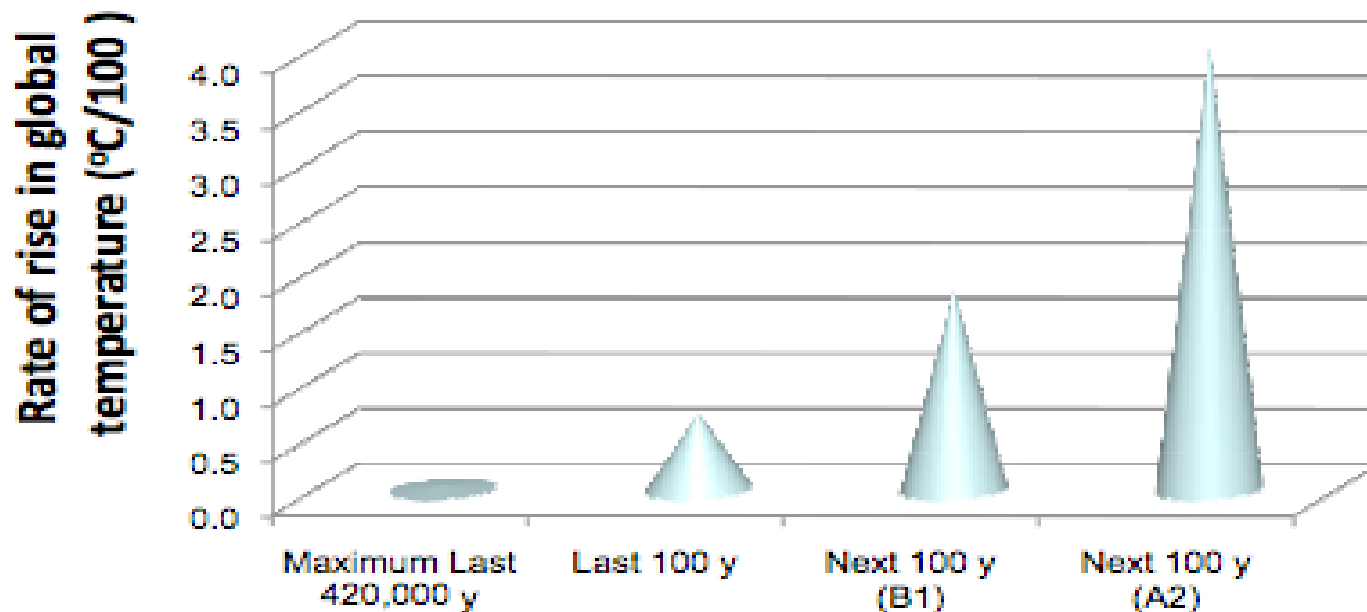
Where mortality is high, reefs may take decades to recover (mainly through recruitment)



## Can Corals Adapt to Climate Change?

Temperatures are changing at a very fast rate. Corals may not be able to adapt fast enough to keep up.

### B. Rate of change in global temperature

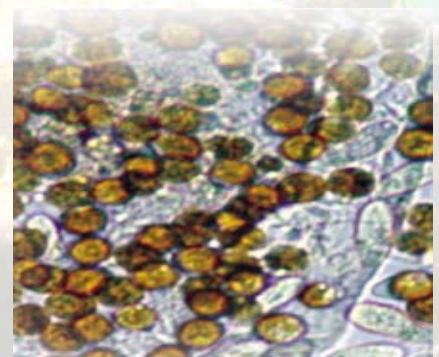
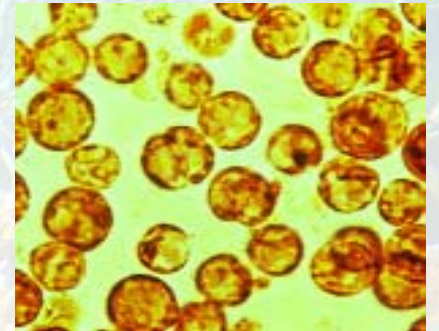


## Can Corals Adapt to Climate Change?

Evidence of shuffling and switching of zooxanthellae after bleaching.

- Shift towards less diversity and energetic tradeoffs (lower growth)
- No evidence that the switch is permanent.

No evidence that bleaching is an adaptation response.



What are the consequences if reefs don't cope?

## Environmental impacts

- Loss of coral
- Changes in reef community
- Loss of biodiversity

## Economic impacts

- Decreased tourism appeal
- “Flow-on” effects - fisheries

## Loss of ecosystem services

- Subsistence
- Recreational opportunities
- Cultural significance
- Shoreline protection



Is there Hope?? -- YES!

This reef in Palau was devastated by bleaching in 1998.

Ten years later, the reef is covered with healthy corals.

**If conditions are right,**  
reefs can recover:

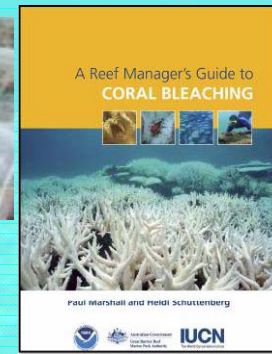
- clean water
- low fishing pressure
- many grazing fish
- low nutrients
- source of larvae

Video from Peter Mumby, University of Exeter

Is there Hope?? -- YES!

## **Local managers can:**

- **Reduce bleaching**
  - Reduce light stress
  - Cool reefs, increase mixing
- **Increase survival**
  - Improve water quality
  - Reduce disease prevalence
- **Aid recovery**
  - Coral fragmentation
  - Encourage recruitment
  - Protect ecosystem functions (herbivory)



Is there Hope?? -- YES!



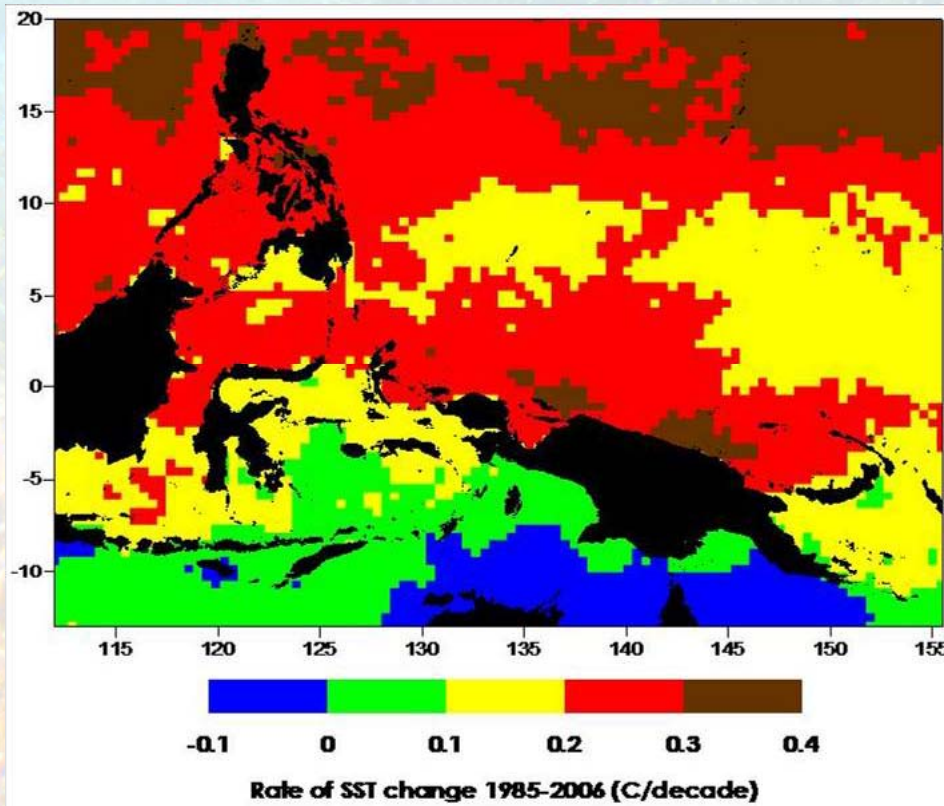
After bleaching and death of some corals....

Sensitive coral species are killed....

The corals that remain are the ones that can tolerate higher temperatures.

Result? Less diversity, but the reef ecosystem develops bleaching resistance.

Is there Hope?? -- YES!



Some places are heating more slowly than others

These regions may act as natural refuges where coral reefs may survive.