

Basics of Coral Reefs & Climate Change

Section 2: Rising Temperatures, Mass Coral Bleaching, & Bleaching Weather

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NOAA Coral Reef Watch

Guam – August 2009





outline

Global Bleaching History

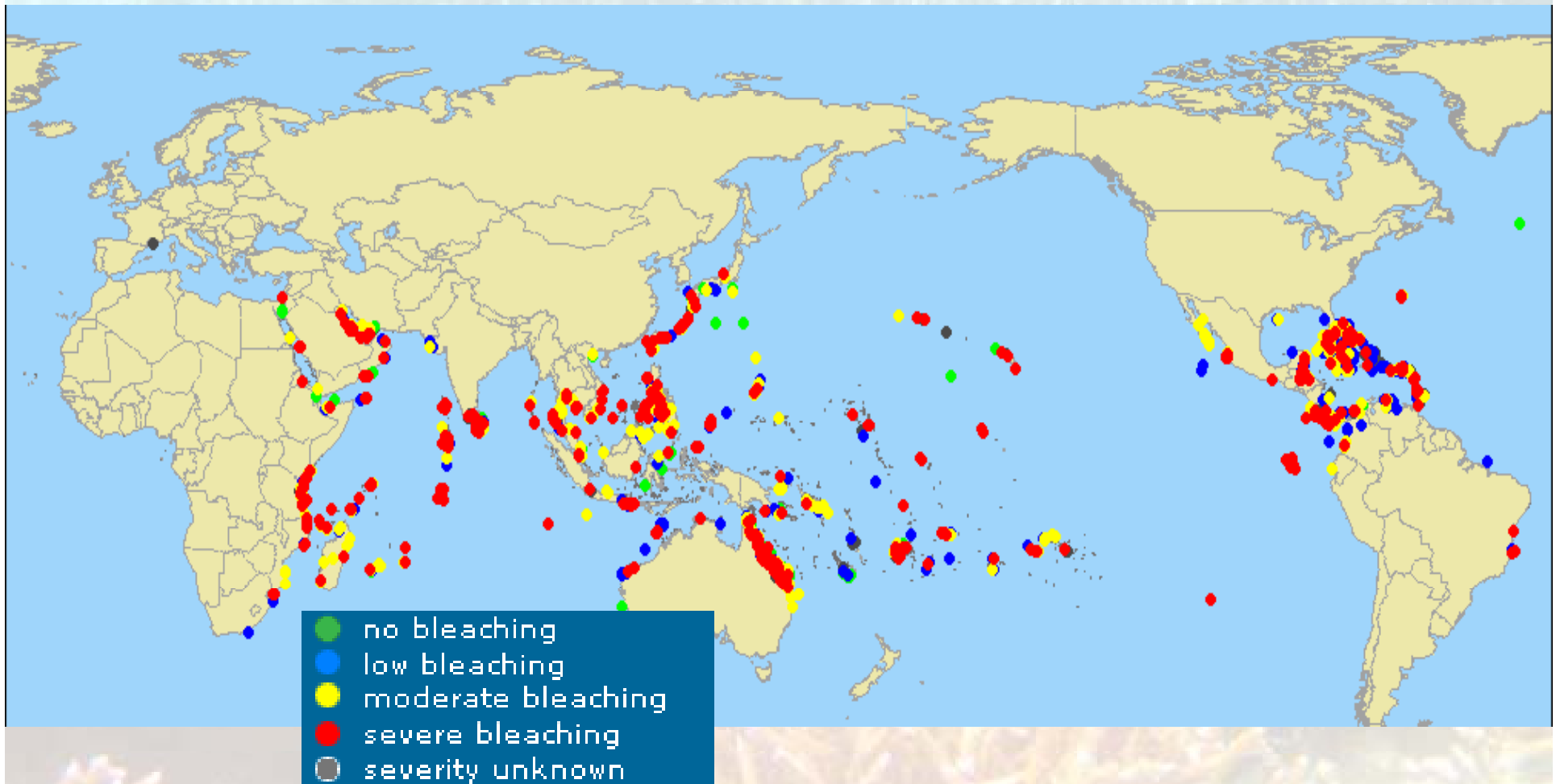
Patterns of SST Change

Causes of Mass Bleaching

Bleaching Weather

Global Bleaching History

Global bleaching reports to 2009 (ReefBase)



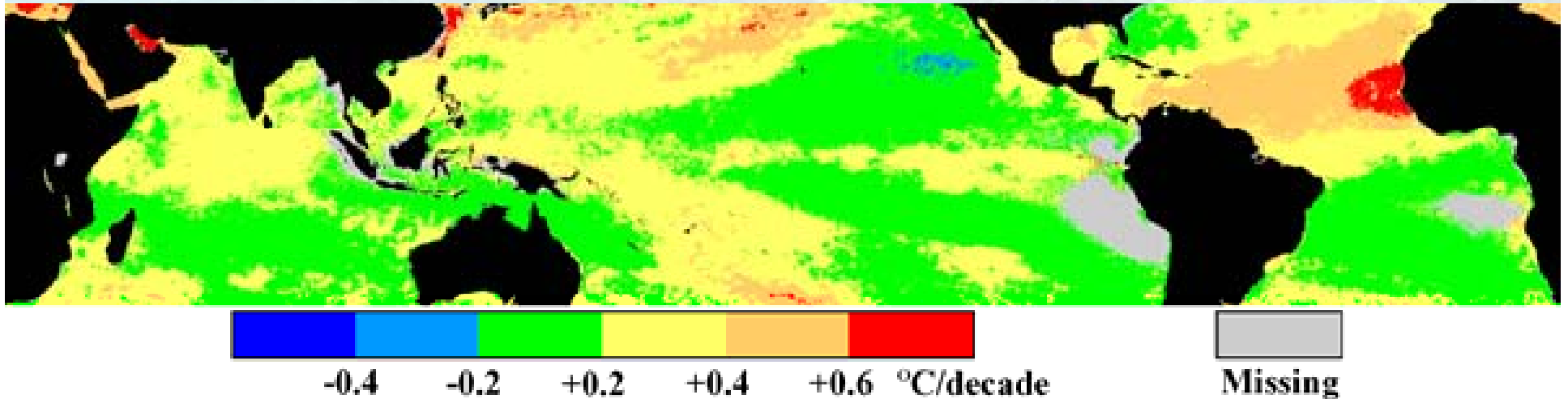
Bleaching has happened around the world, and continues to increase.

Global Bleaching History

2005

- Strongest bleaching in the Caribbean
- Followed by disease outbreaks in some areas
- Happened during ENSO-neutral period
- Up to 50% coral mortality in one year

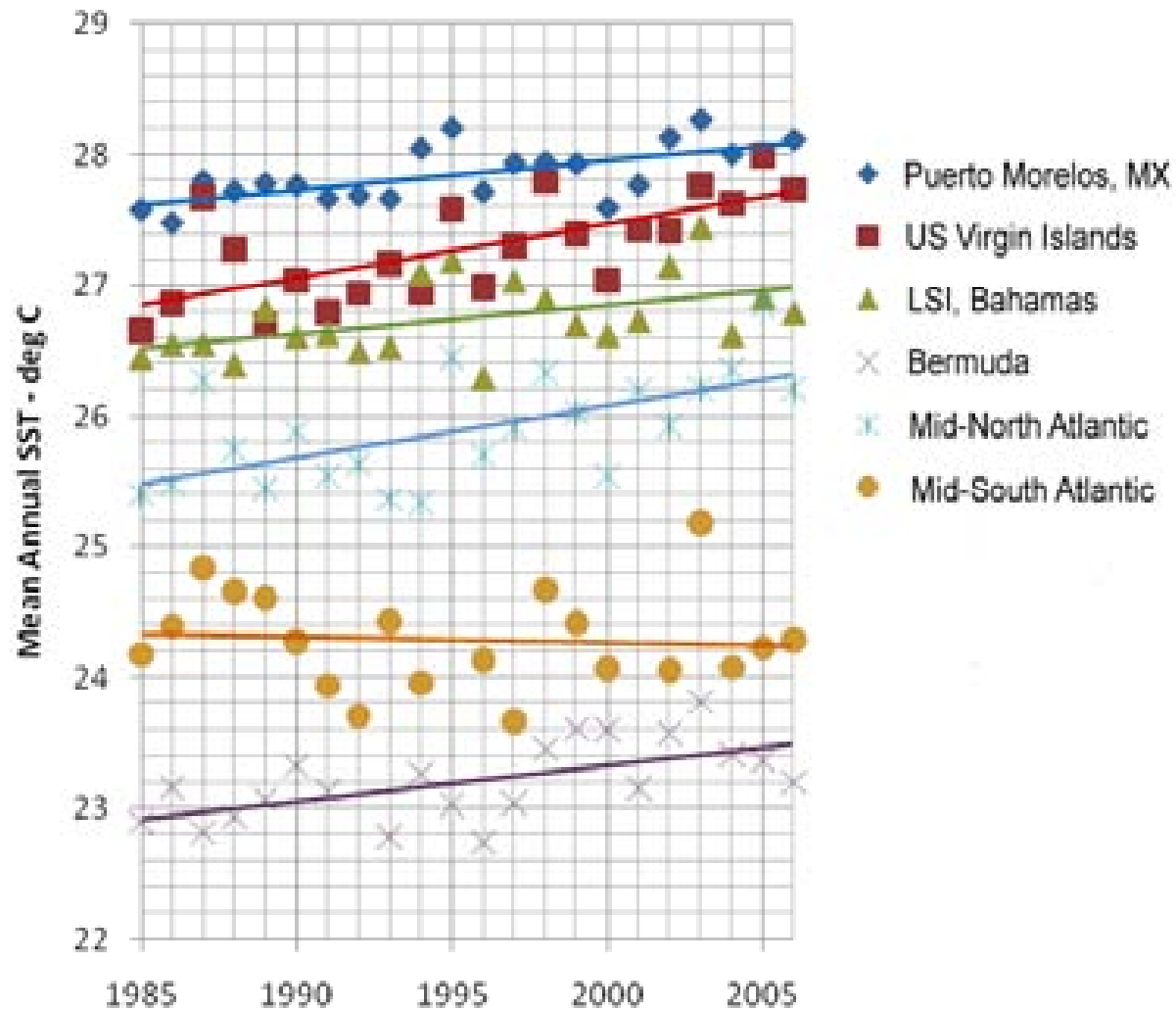
Patterns of Temperature Change



20 years of satellite data show global trends.
Some areas (e.g. SE Caribbean) are increasing
much faster than others (e.g. Coral Triangle).

Strong et al., "Implications for Our Coral Reefs in a Changing Climate over the Next Few Decades -- Hints from the past 22 years", 11th ICRS proceedings.
http://www.reefbase.org/resource_center/publication/icrs.aspx

Patterns of Temperature Change



Caribbean is
changing
very rapidly

Many reef
areas show
positive SST
trends

Future Temperature Changes

Global climate models predict that the oceans will continue to warm.

Some areas will increase faster than others.

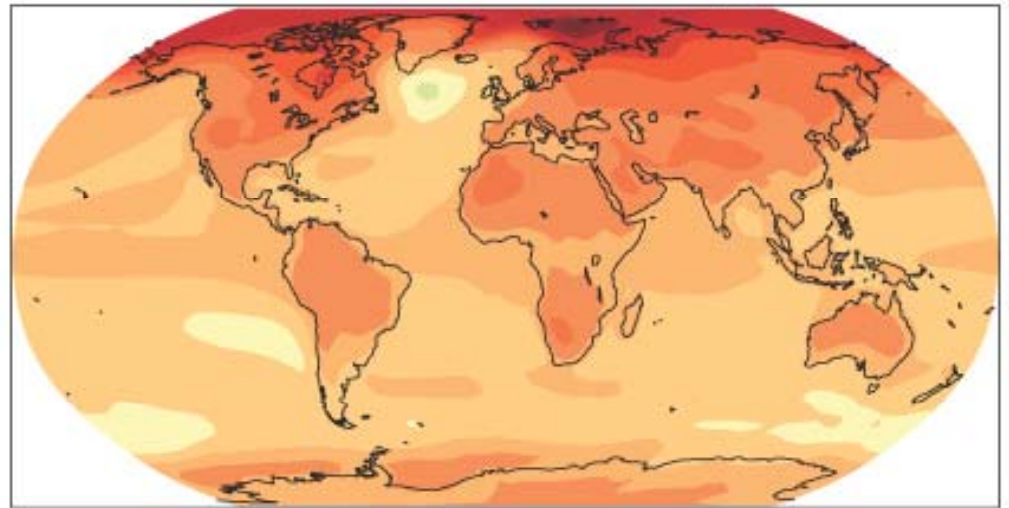
Rate of warming depends on CO₂ emissions.

IPCC 2007

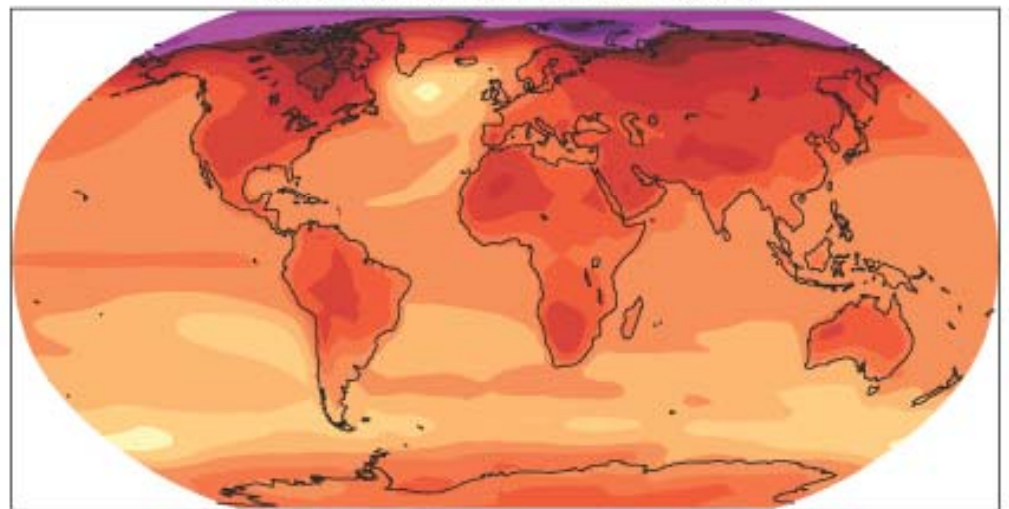
<http://www.ipcc.ch/ipccreports/ar4-wg1.htm>

Surface temperature change by 2100

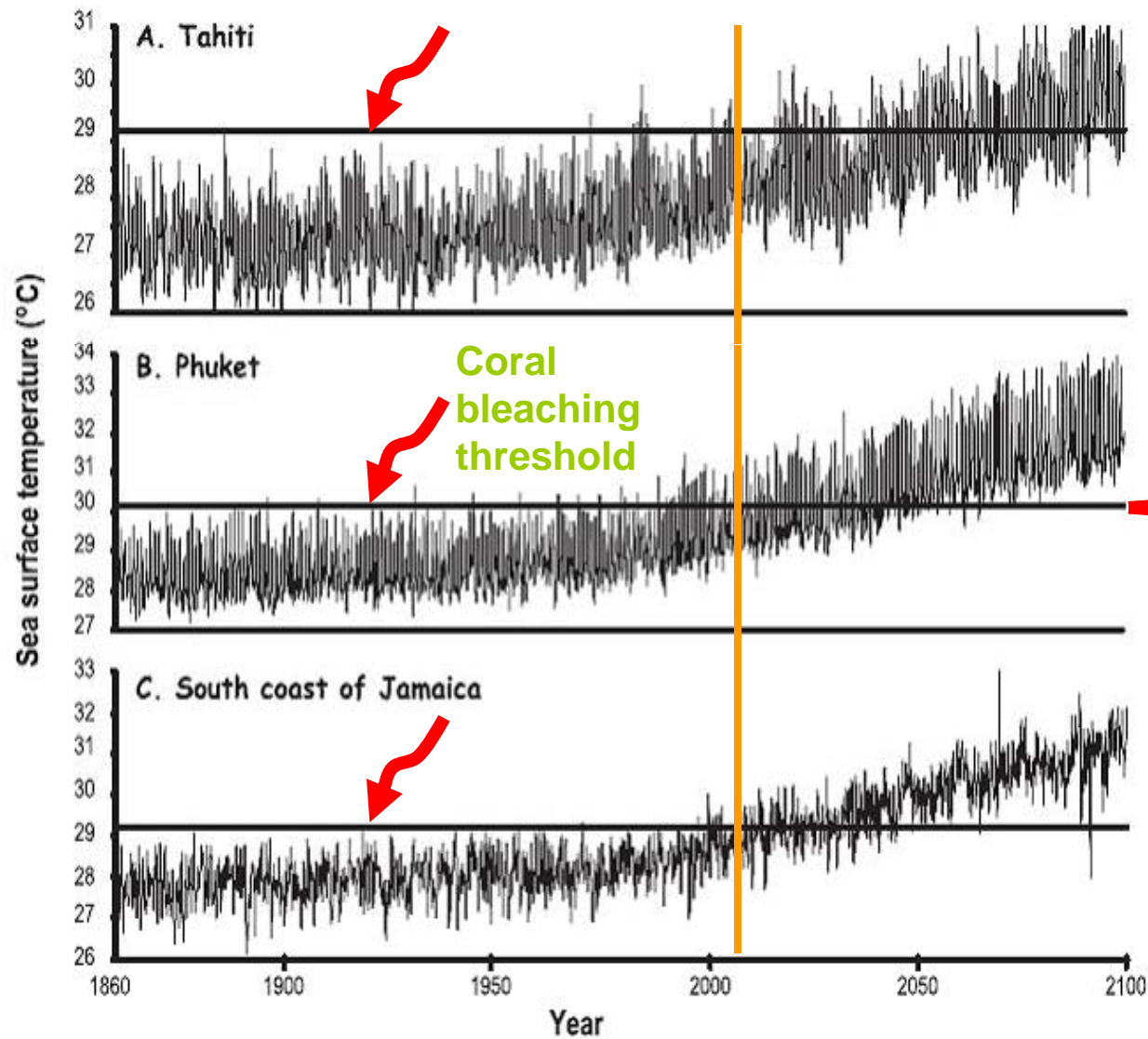
Lower Emissions Scenario (B1)



High Emissions Scenario (A1B)



Future Temperature Changes



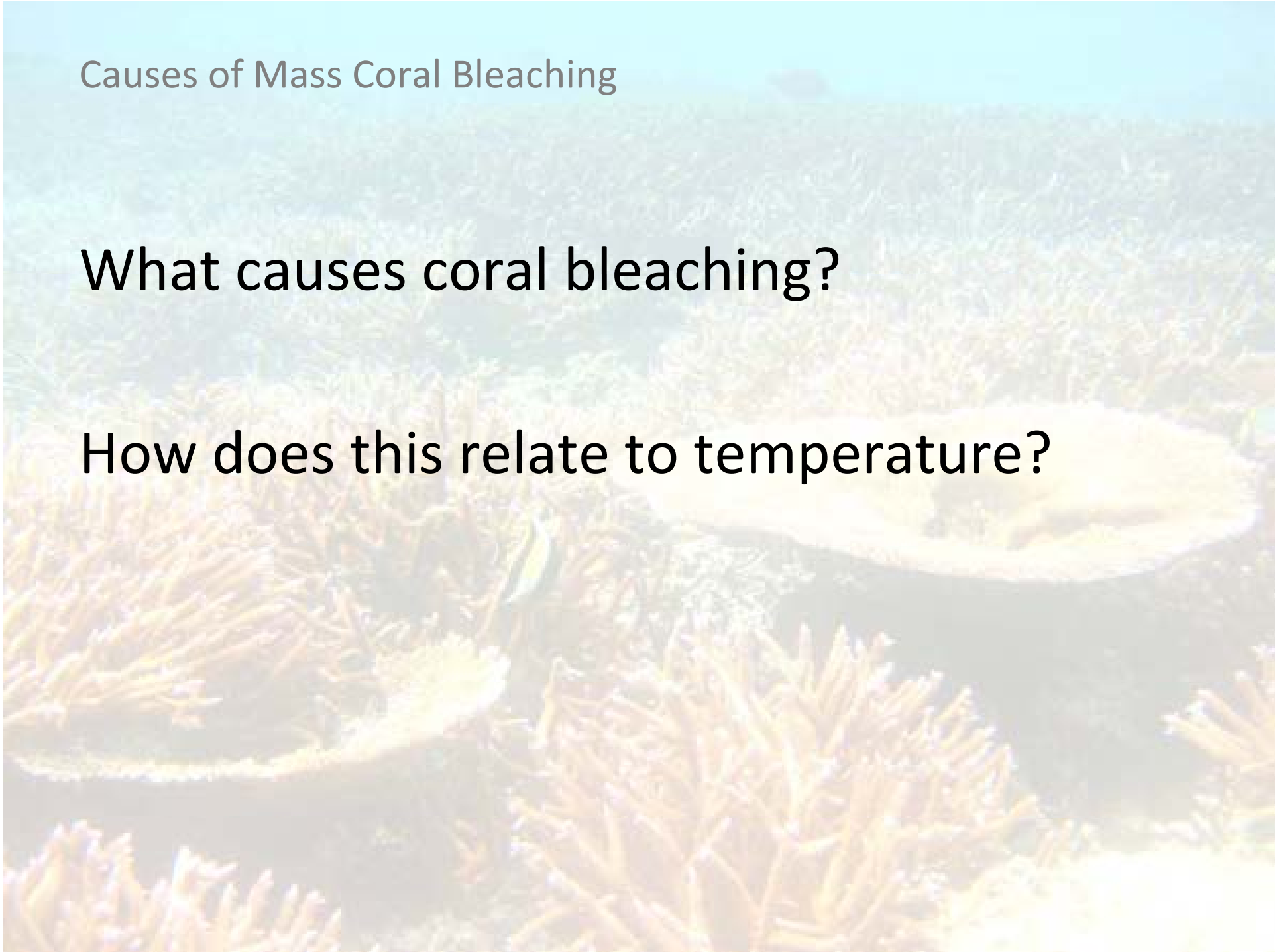
Hoegh-Guldberg (1999)



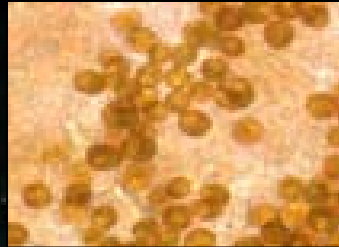
Causes of Mass Coral Bleaching

What causes coral bleaching?

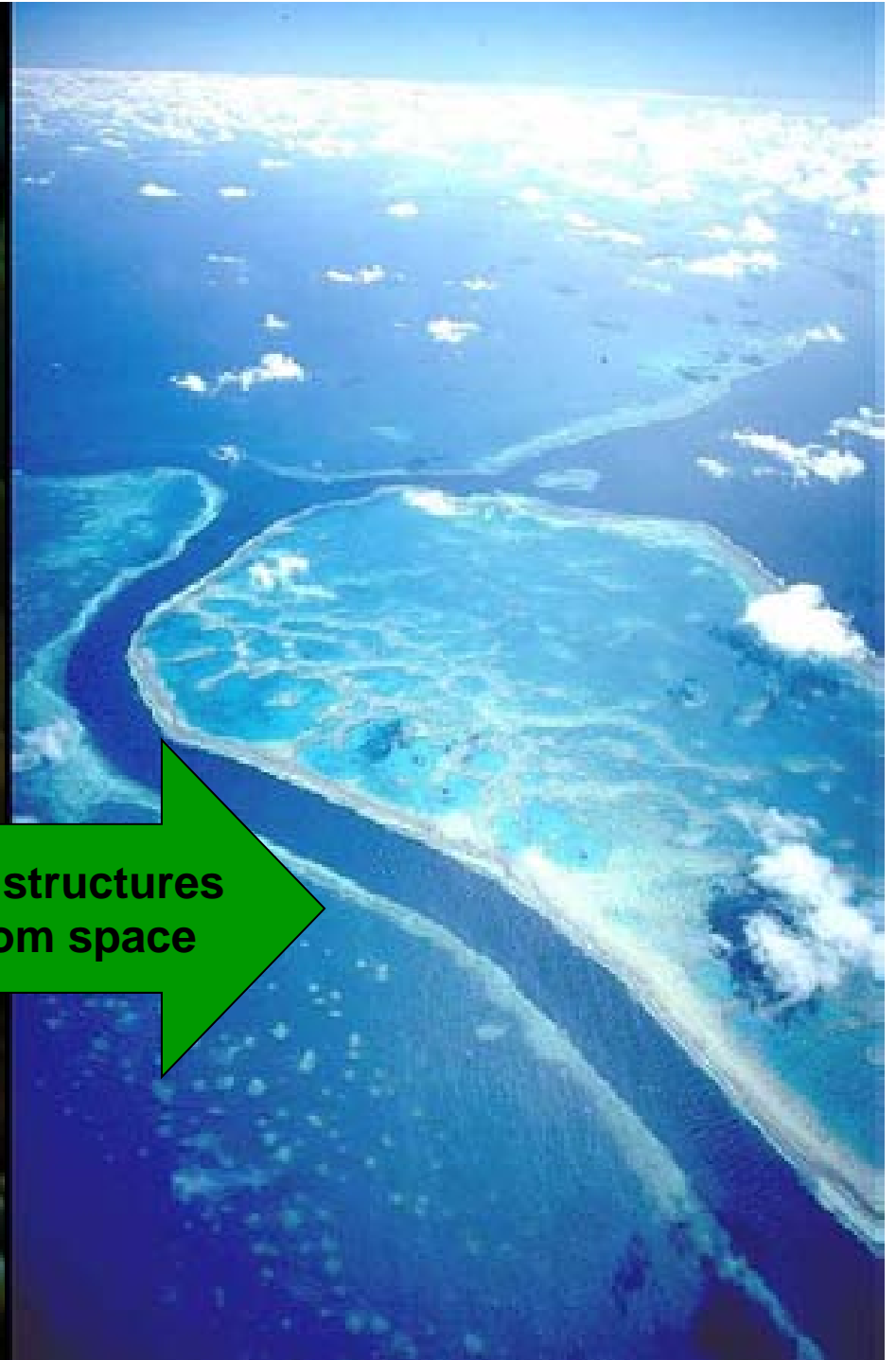
How does this relate to temperature?



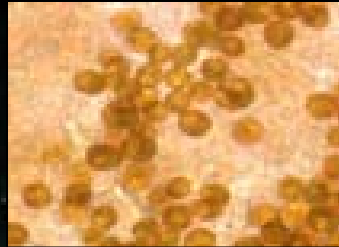
**Corals live in
symbiosis with
zooxanthellae**



**Biological structures
visible from space**



**Corals live in
symbiosis with
zooxanthellae**



Stress
*(high temperatures,
disease, pollution)*



Causes of Mass Coral Bleaching

Many local-scale stressors can cause bleaching:

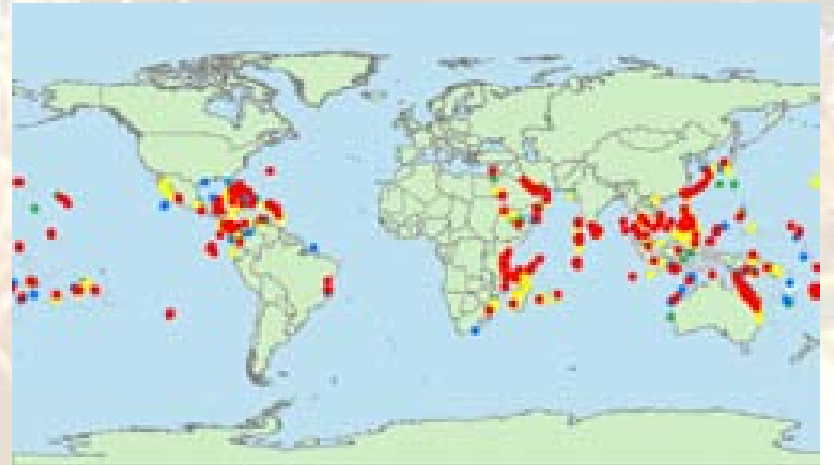
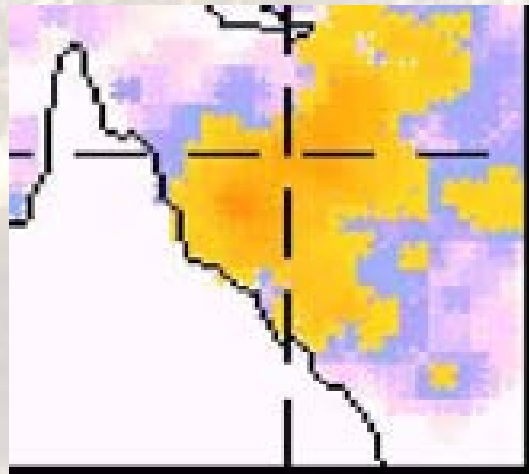
- Flood plumes
- Pollutants
- Disease
- Sedimentation
- Destructive fishing practices



Causes of Mass Coral Bleaching

Only one thing causes bleaching at a regional or global scale

TEMPERATURE



Causes of Mass Coral Bleaching

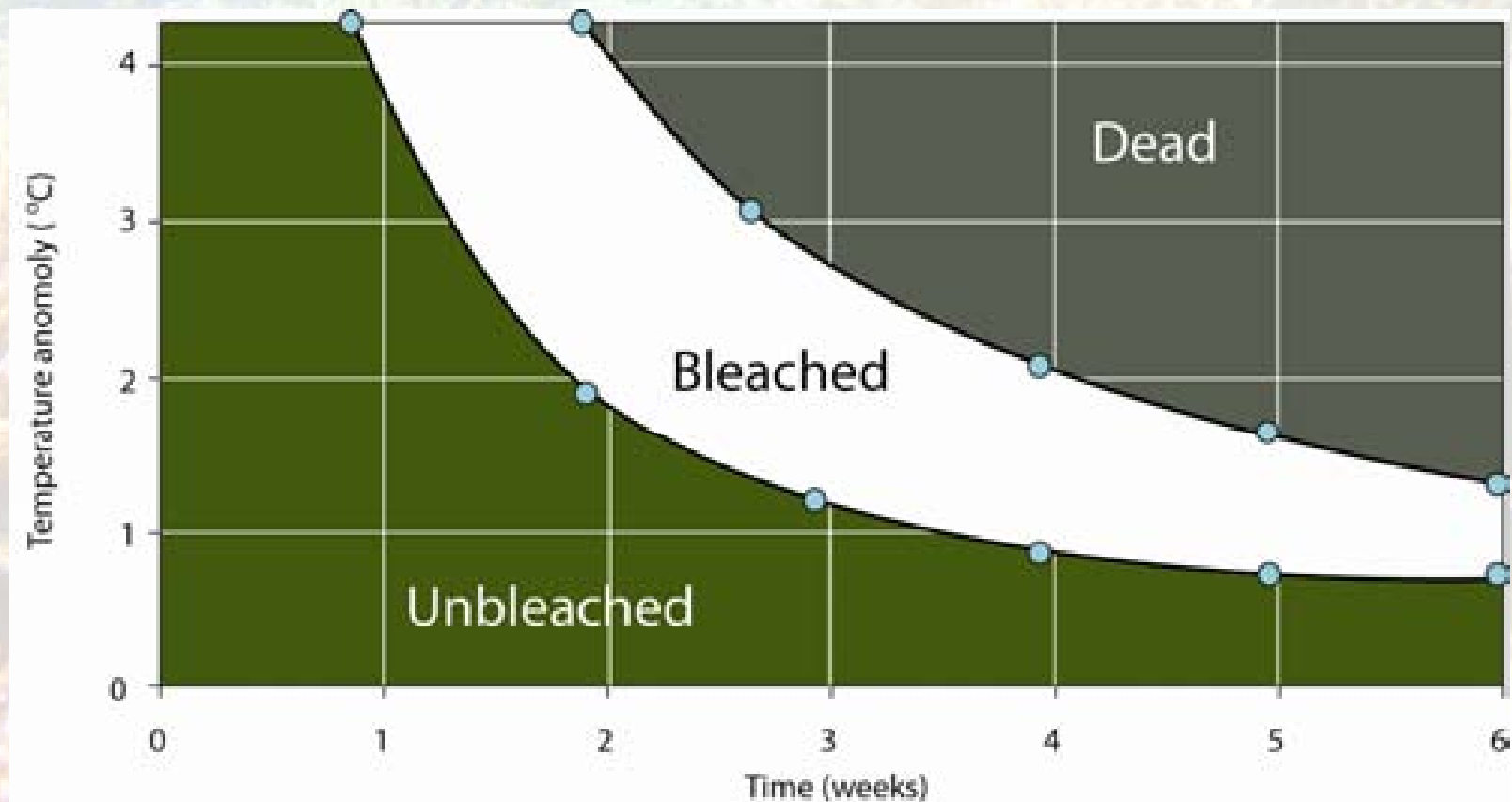
Bleaching Threshold Temperature

- 1°C above the average temperature for the warmest month
- Above the threshold → thermal stress

Location	Threshold
Galapagos	27.5°C
Oahu, Hawaii	28.0
Florida Keys	30.3
Apo Reef, Philippines	30.9
Gulf of Oman	33.5

Causes of Mass Coral Bleaching

Relationship between intensity and duration of temperature stress



Causes of Mass Coral Bleaching

What are the consequences?

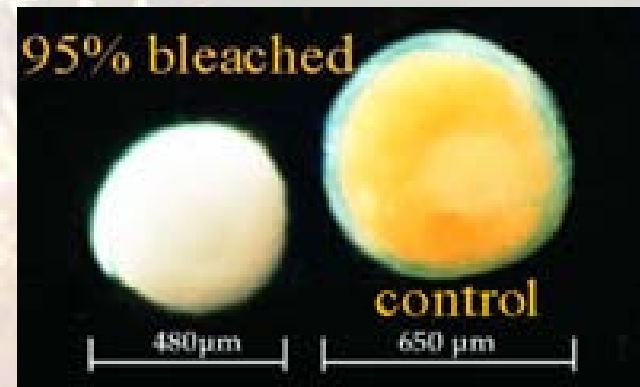
Lethal Effects:

- Cell damage
- Loss of autotrophy
- Starvation
- Death



Sub lethal effects:

- Reduced energy input
- Less calcification and growth
- Less reproductive output
- Less resistance to disease and competitors

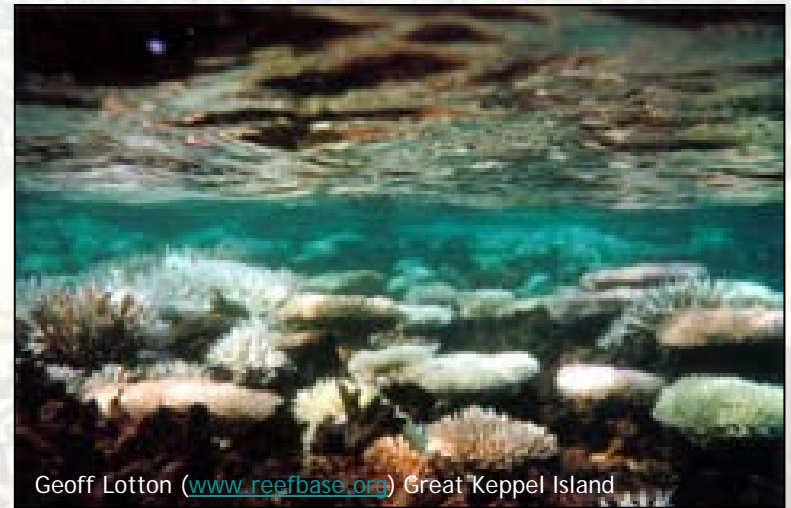


Courtesy of K. Michalek-Wagner

Bleaching Weather

“Bleaching Weather”

- Lack of clouds
- Little to no wind
- Weak currents



Bleaching Weather

1. Lack of clouds

- Solar energy raises water temperature.
- Clouds block the sun's influence from a particular water region.
- High insolation also influences corals physiologically and can lead to bleaching.



Ralph F. Kresge/NOAA

Bleaching Weather

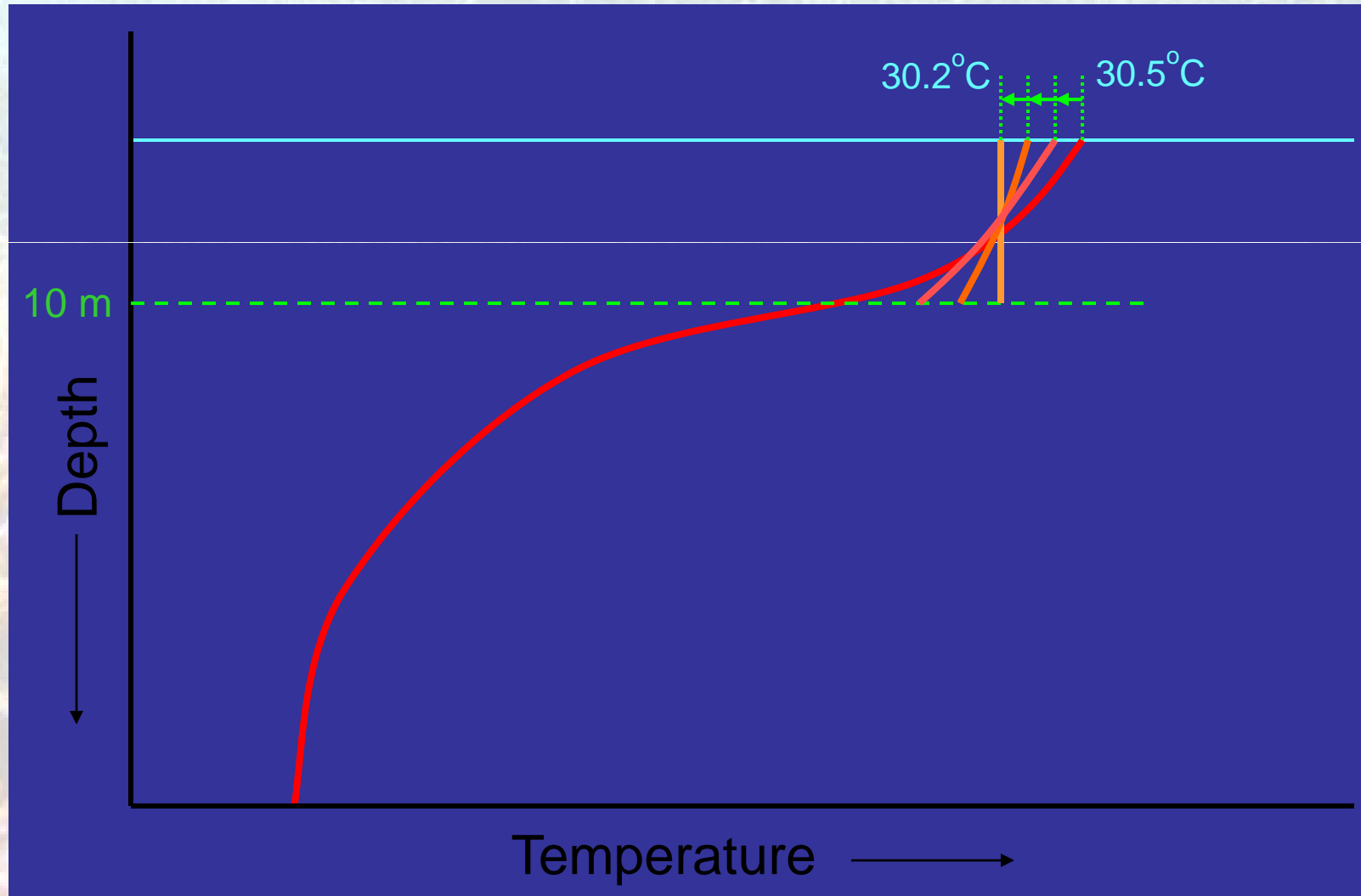
2. Little to no wind

- Wind causes mixing near the sea-surface and roughness of the surface.
- Low winds induce stratification and decrease the reflection of solar radiation.



Bleaching Weather

Temperature Profile with Wind Mixing



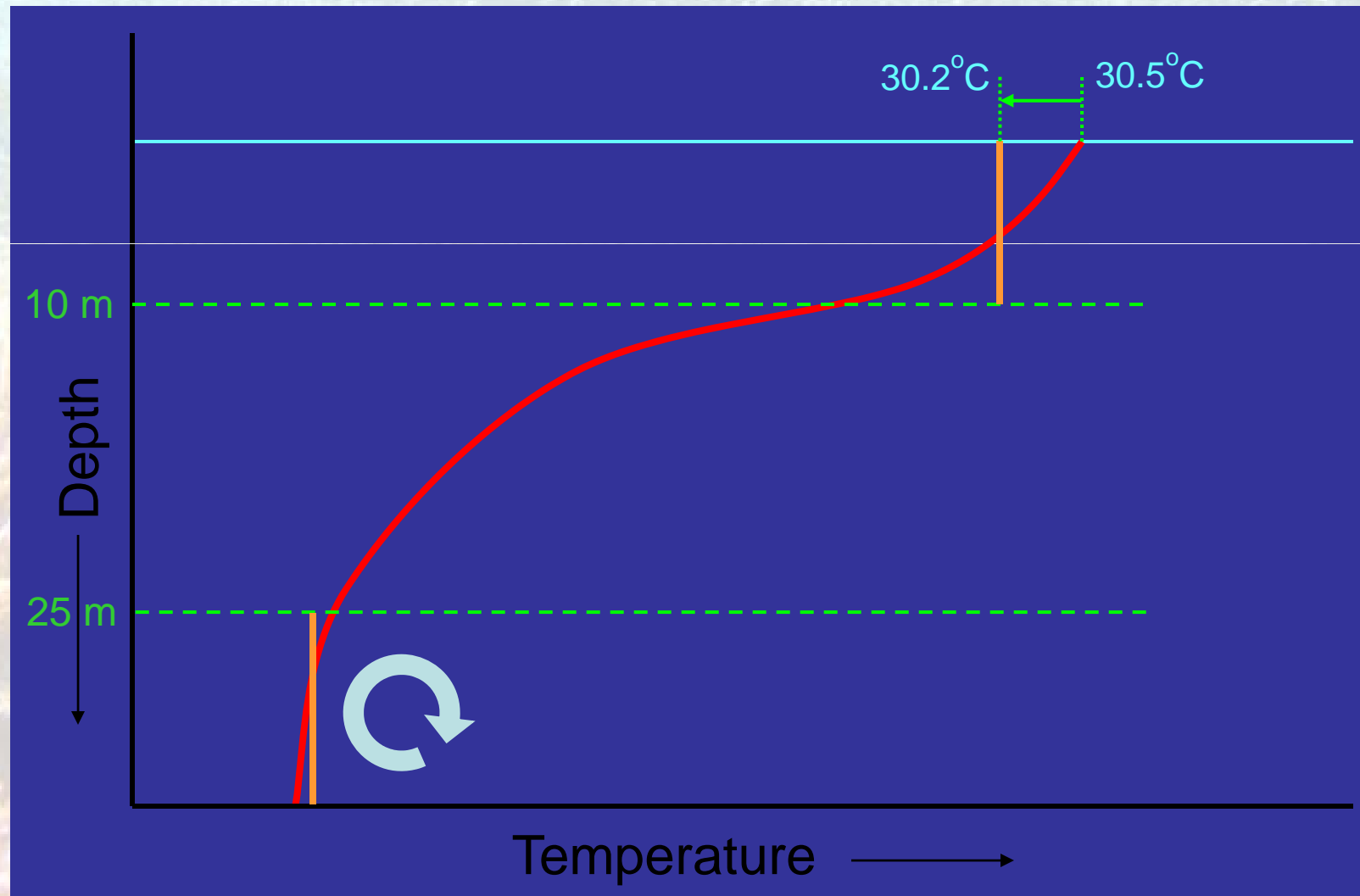
3. Weak currents

- Currents interact with the substrate, and friction induces mixing at the bottom of the water column.
- Oceanic currents are generally consistent in their magnitude and direction (e.g., East Australian Current).
- Local scale currents change rapidly (e.g., tidal currents).
- Models can predict currents.



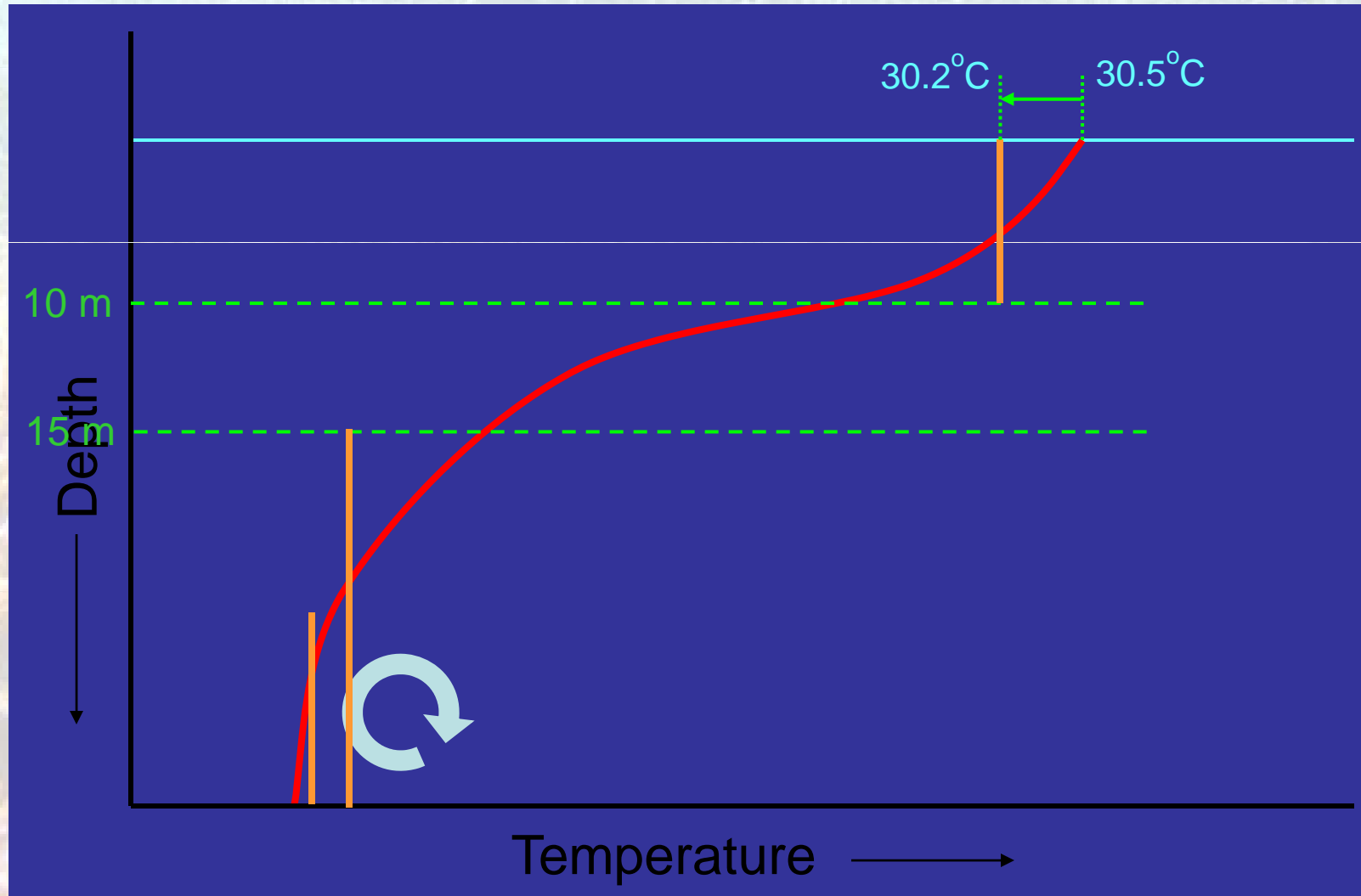
Bleaching Weather

Temperature Profile with Currents Mixing



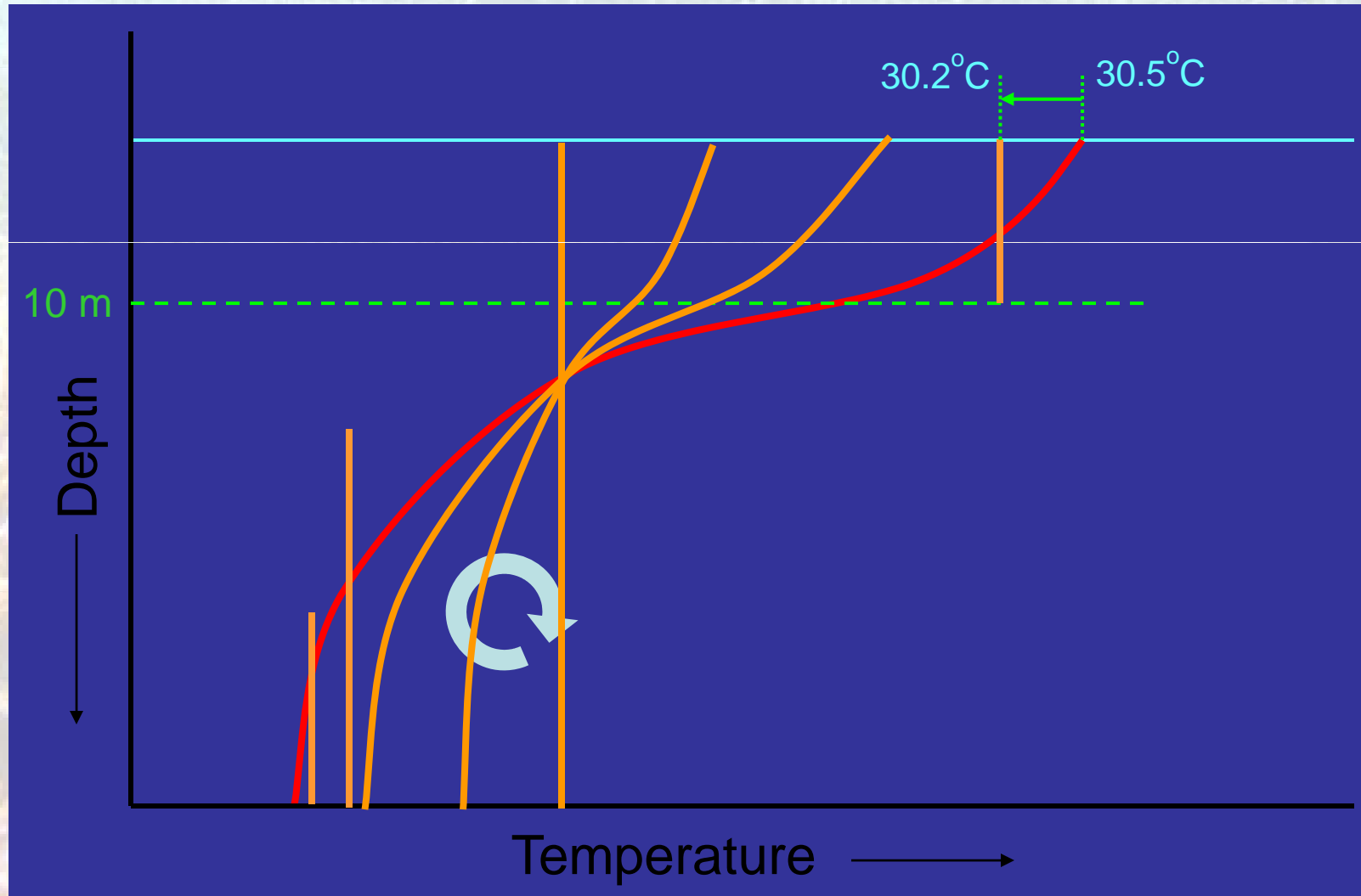
Bleaching Weather

Temperature Profile with Currents Mixing



Bleaching Weather

Temperature Profile with Currents Mixing



Summary

- The oceans will continue to warm, making bleaching more likely.
- Mass bleaching occurs when the water temperature stays above the bleaching threshold.
- Sunny skies, light wind, and weak currents set up bleaching weather.