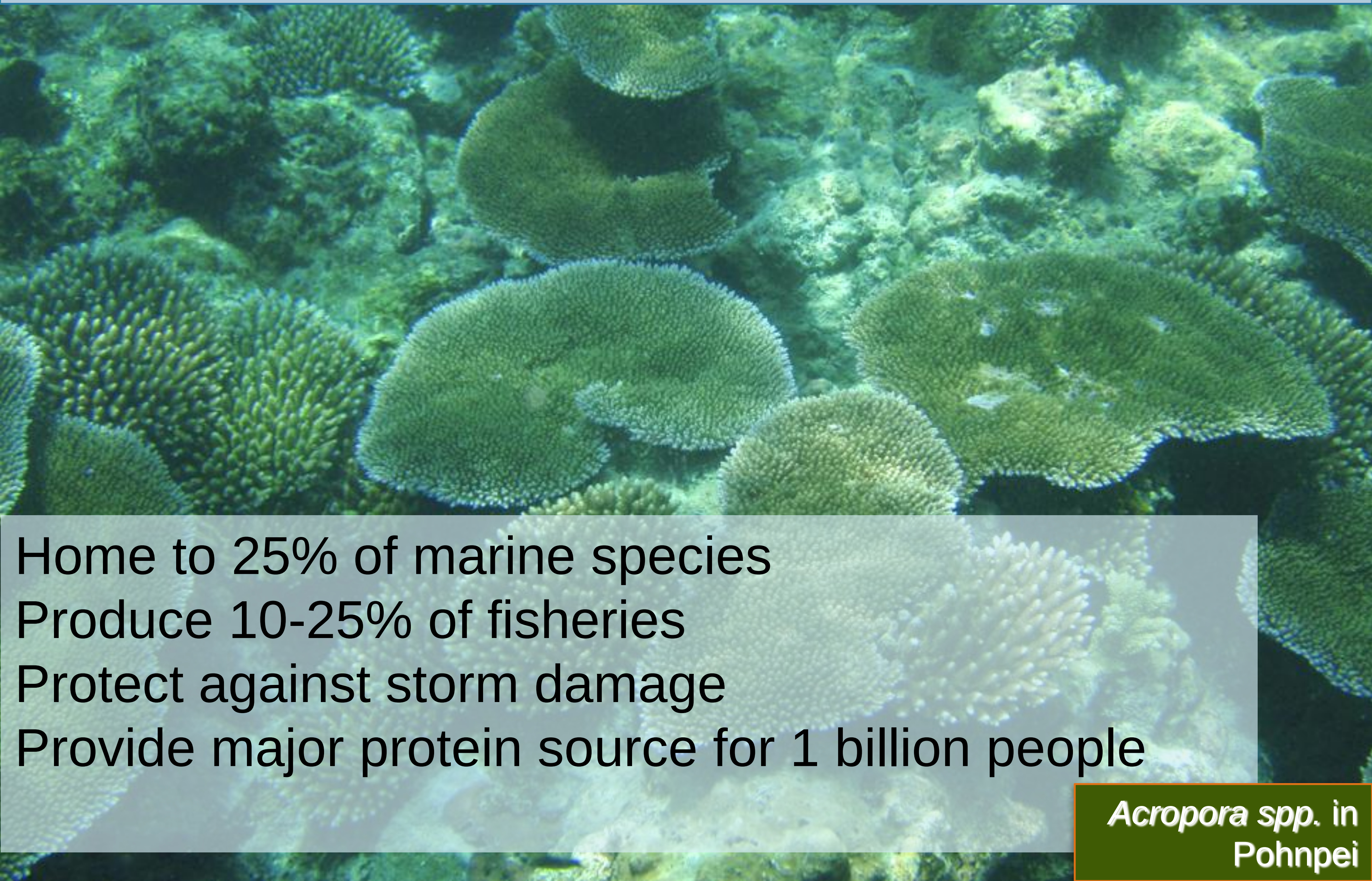
Reef building corals are ecosystem architects



Home to 25% of marine species

Produce 10-25% of fisheries

Protect against storm damage

Provide major protein source for 1 billion people

Acropora spp. in Pohnpei

Funafuti atoll in Tuvalu

Enormous cultural heritage and value

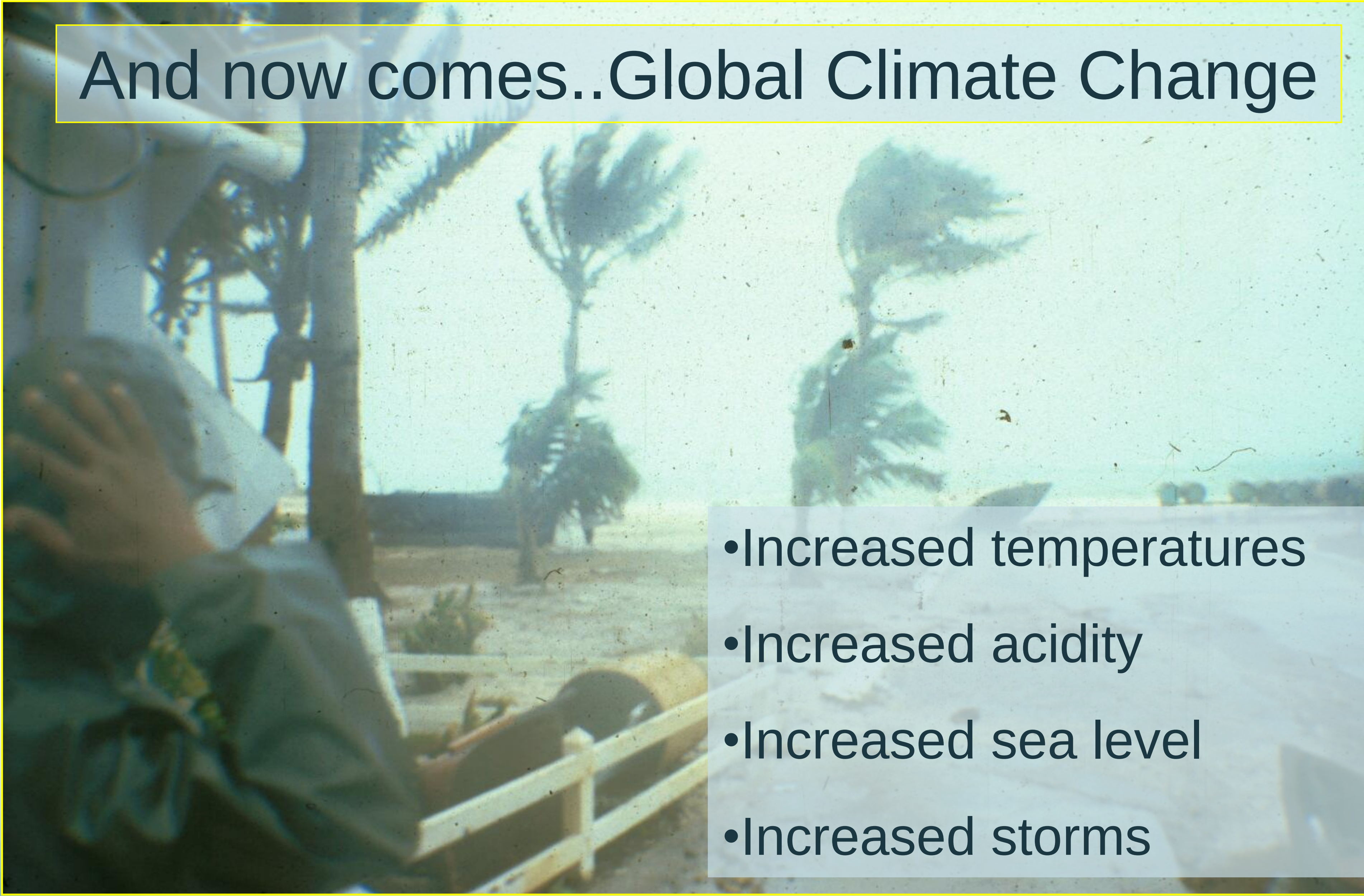
Village fishing in Bali

But reef ecosystems experience local stress

Example coral reefs depend on good land use
Ngerikill Bay, Airai State – Republic of Palau

- 25-30% of the world's coral reefs are severely degraded by local impacts from land and by over-harvesting.

And now comes..Global Climate Change



- Increased temperatures
- Increased acidity
- Increased sea level
- Increased storms

What 3100 Coral Scientists would like every Pacific Island leader to know about Corals and Climate Change

The Scientific Consensus Statement on Corals and Climate Change

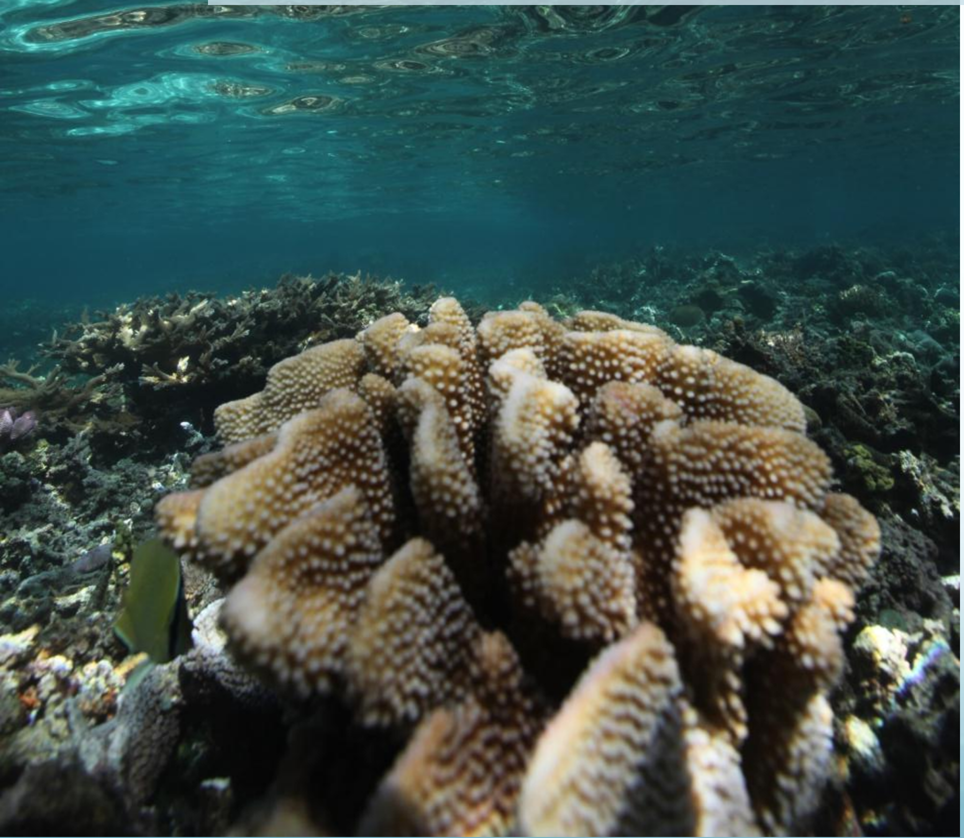
Written by a team of leading coral scientists over a two year period.

In consultation with Pacific leaders.

Signed by over 3100 coral scientists from around the world since July 2012.

Changes already observed in the last century:

- The surface of the world's oceans has warmed 0.7 ° C, resulting in unprecedented coral bleaching and mortality.
- The acidity of the ocean surface has increased 22%, due to increased CO_2.
- Sea level has risen on average by at least 18 cm.



By the end of this century: CO_2 emissions at the current rate will

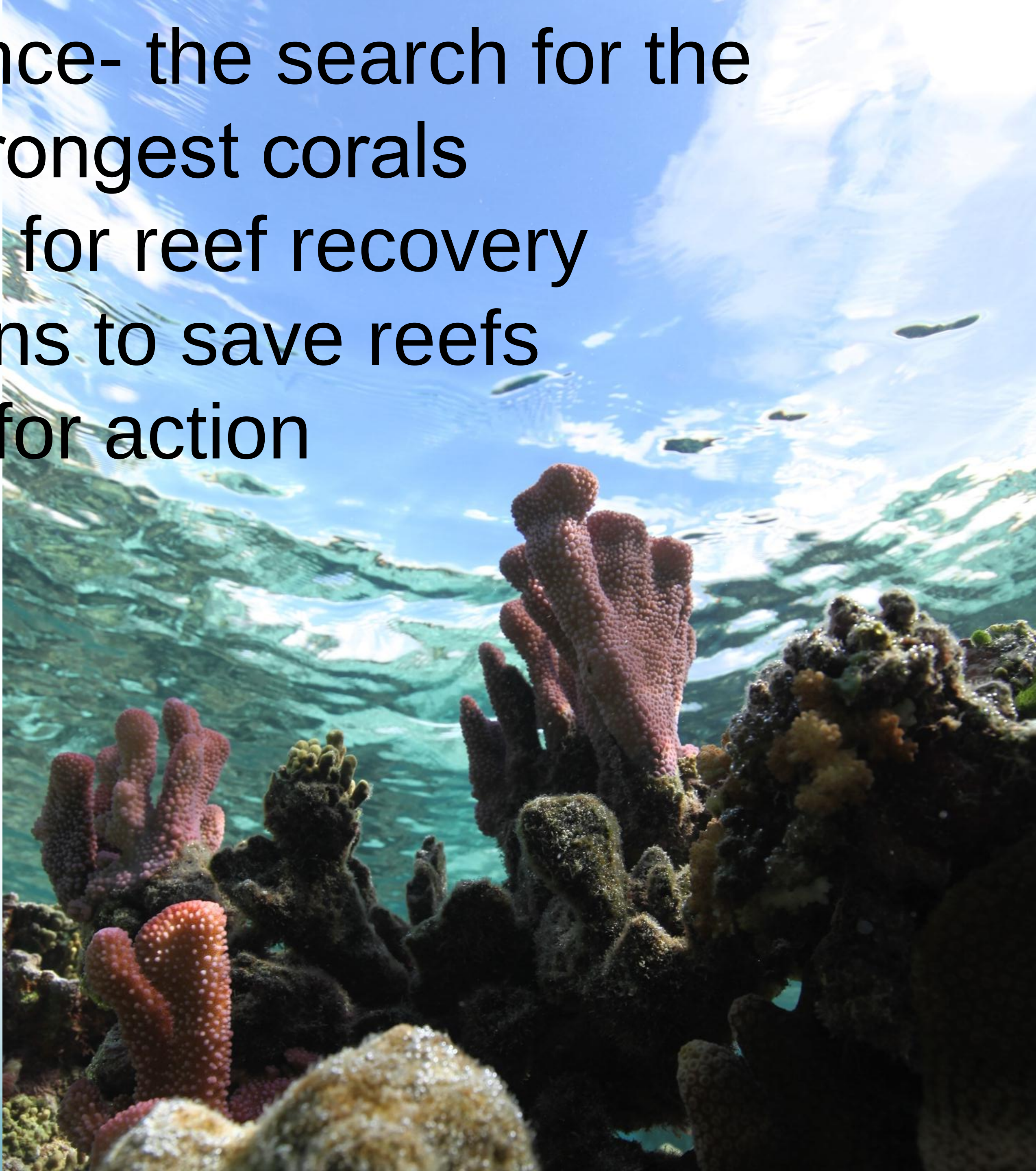
- warm sea surface temperatures by at least 2-3 ° C,
- raise sea-level by as much as 1.7 meters,
- double ocean acidity,
- and increase storm frequency and/or intensity.
- This combined change in temperature and ocean chemistry has not occurred since the last reef crisis 55 million years ago.

Future Impacts on coral reefs:

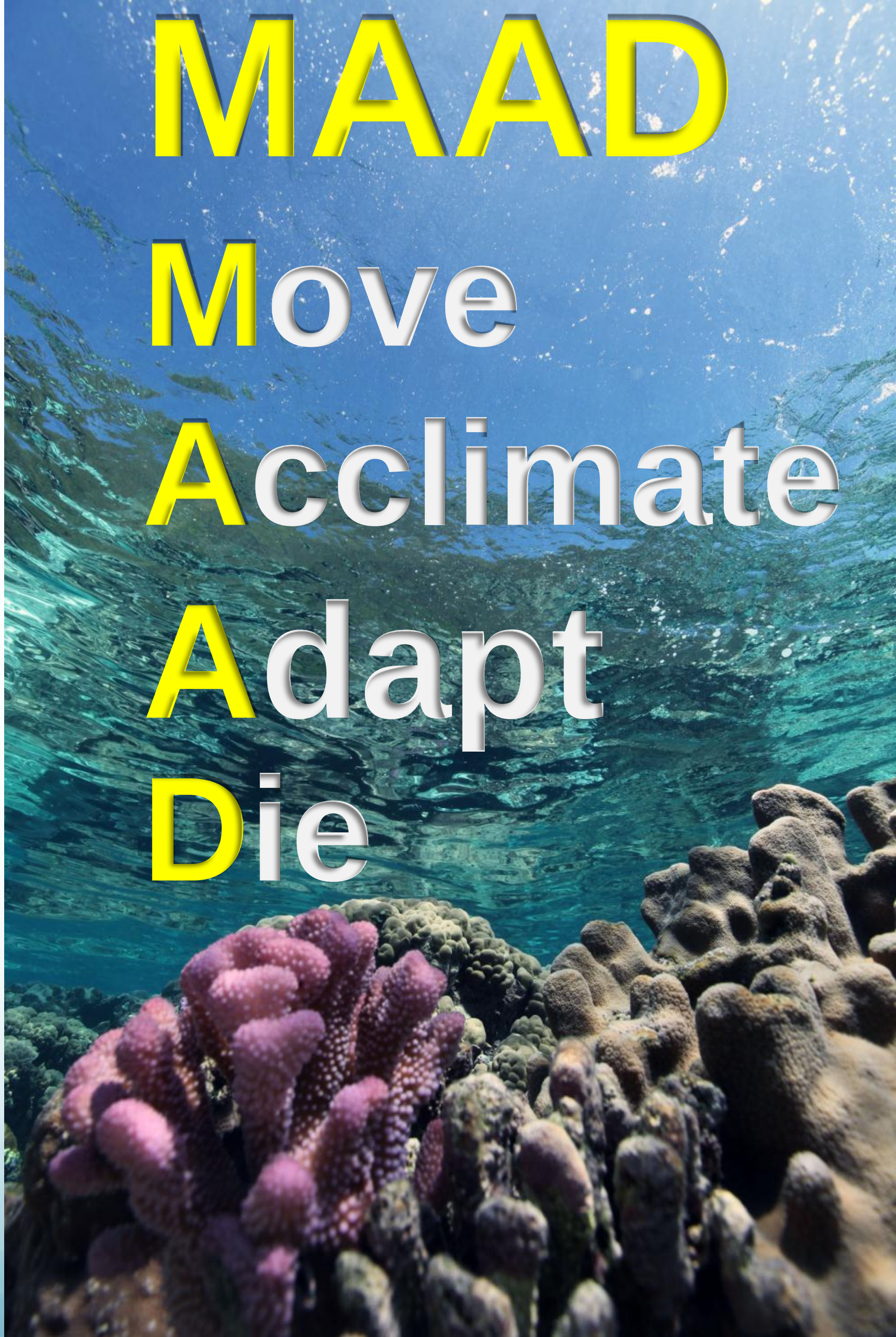
- Most corals will face water temperatures above their current tolerance.
- Most reefs will experience higher acidification, impairing calcification of corals and reef growth.
- Rising sea levels will be accompanied by disruption of human communities, sedimentation impacts and increased wave damage.

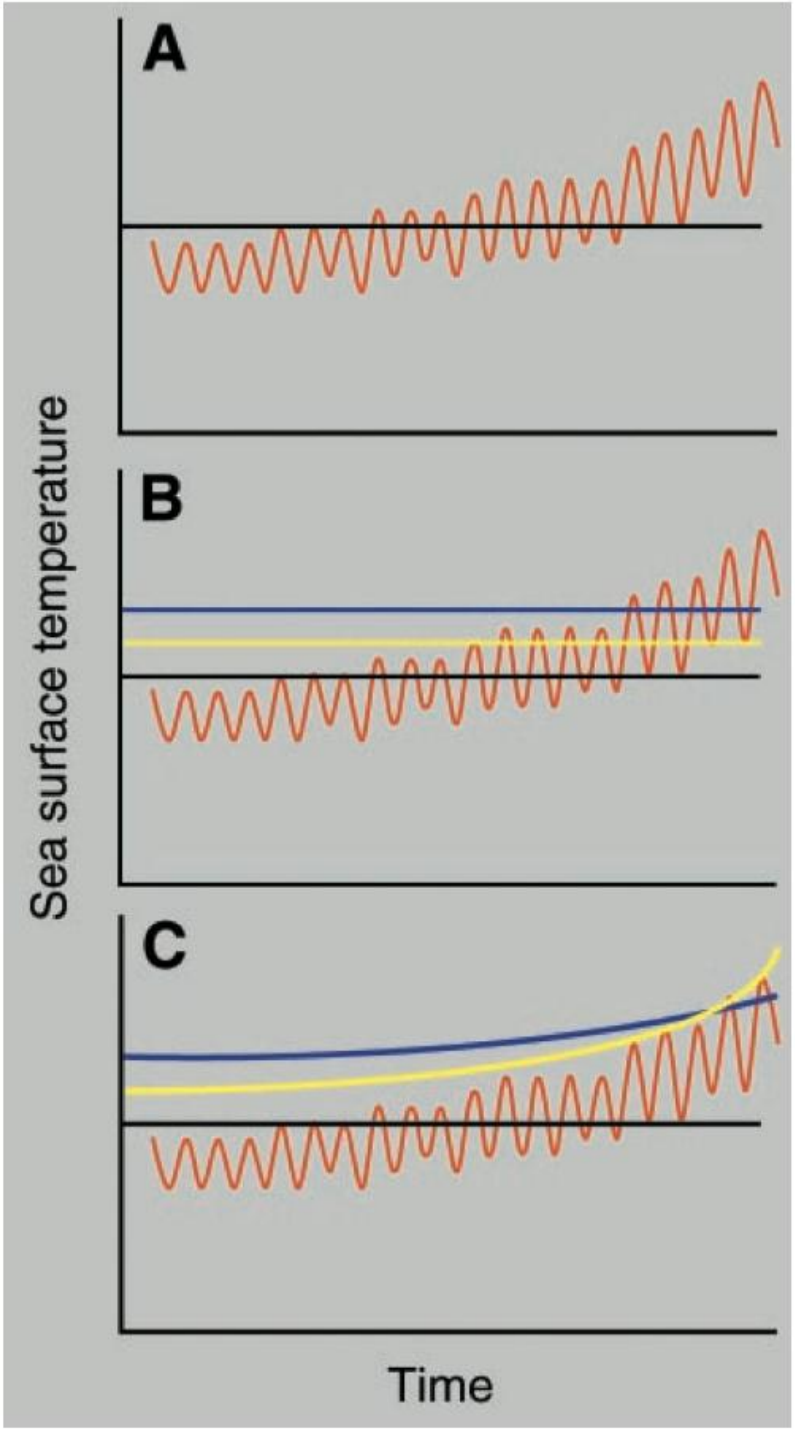
- Together, this combination of climate stressors represents an unprecedented challenge for the future of coral reefs and to the services they provide to people.

- New science- the search for the world's strongest corals
- New tools for reef recovery
- Five actions to save reefs
- Time line for action



Species have four ways to respond to significant environmental shifts



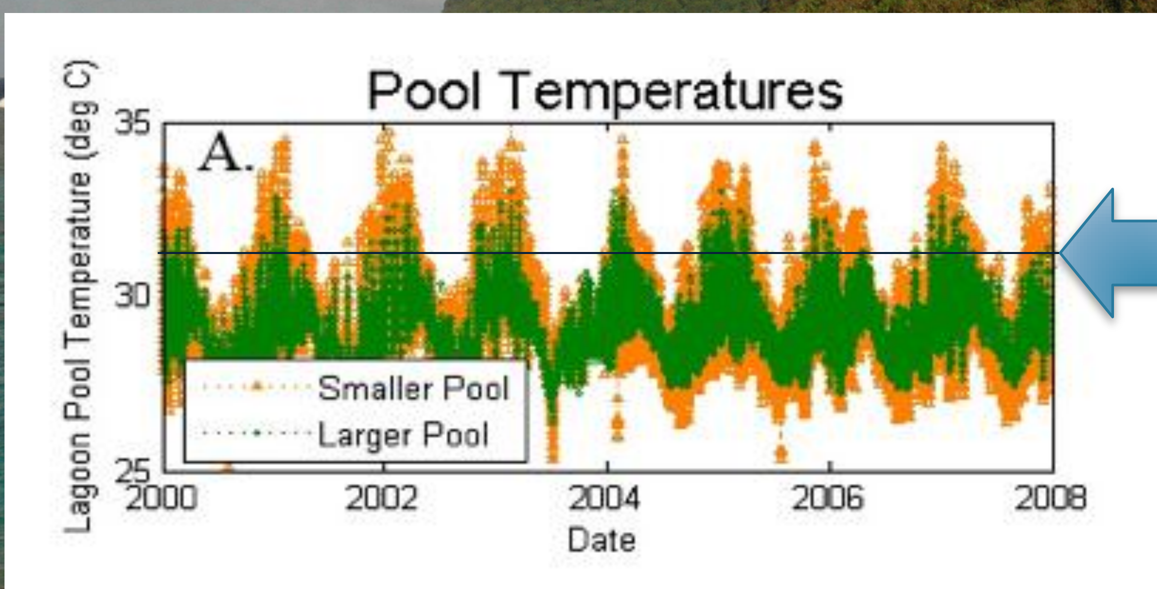


Hughes et al. 2003.

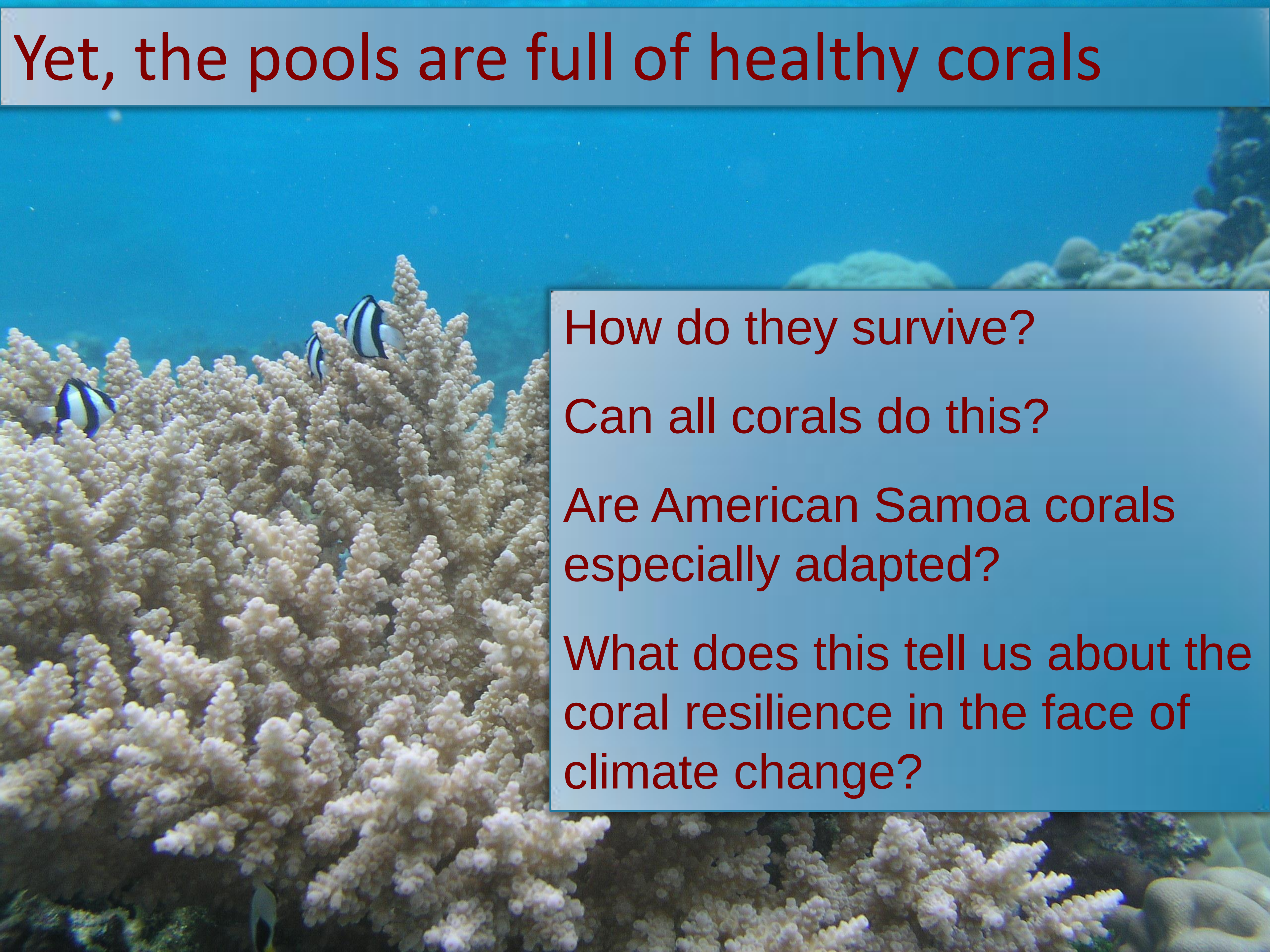
Coral reaction if heat tolerance is constant (A), variable between species (B) or changing over time (C) compared to globally increased temperature

But some reefs start off stronger than others

Back reef pools in American Samoa reach coral bleaching temperatures every summer



Yet, the pools are full of healthy corals



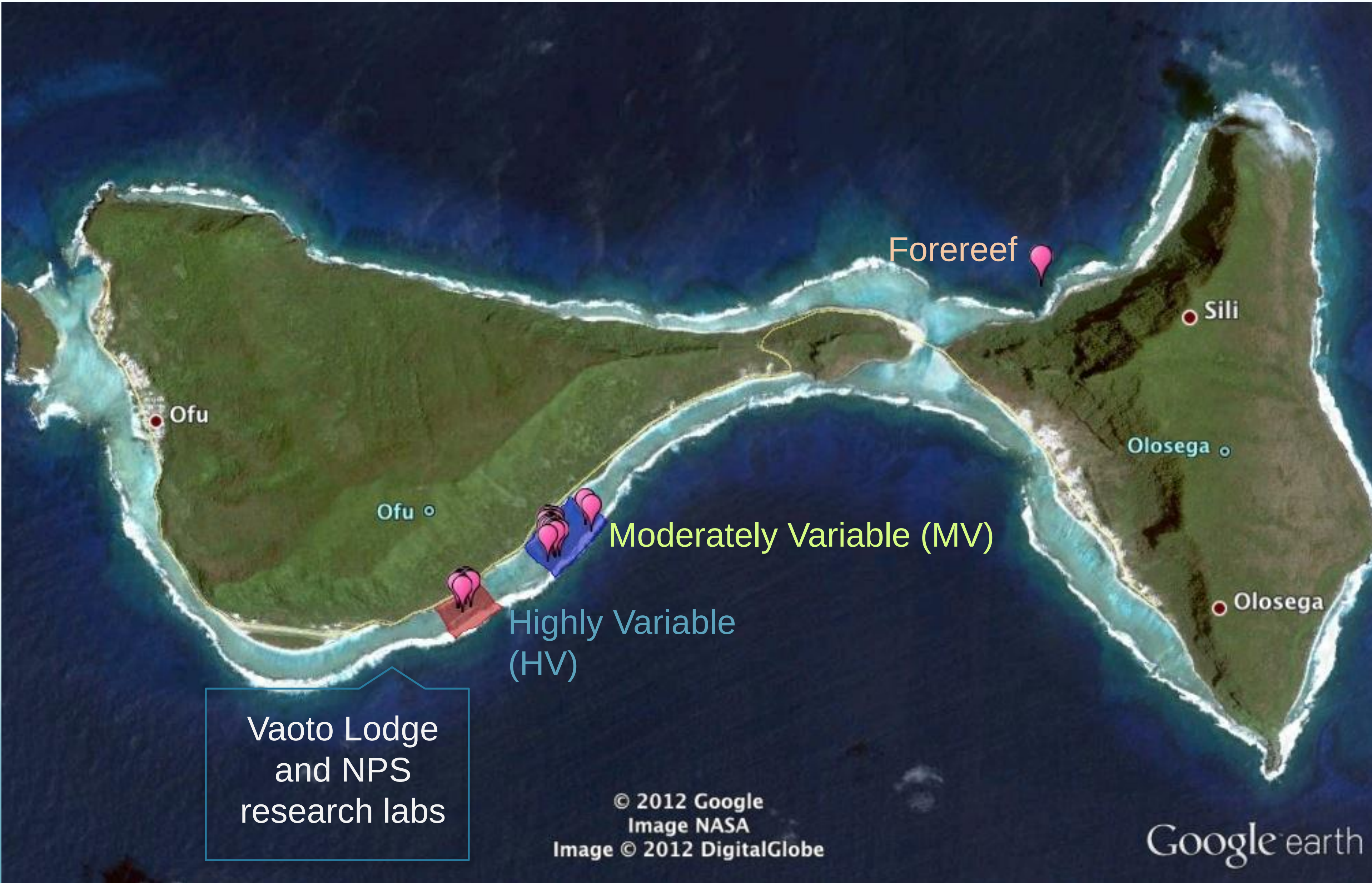
How do they survive?

Can all corals do this?

Are American Samoa corals especially adapted?

What does this tell us about the coral resilience in the face of climate change?

Ofu, American Samoa



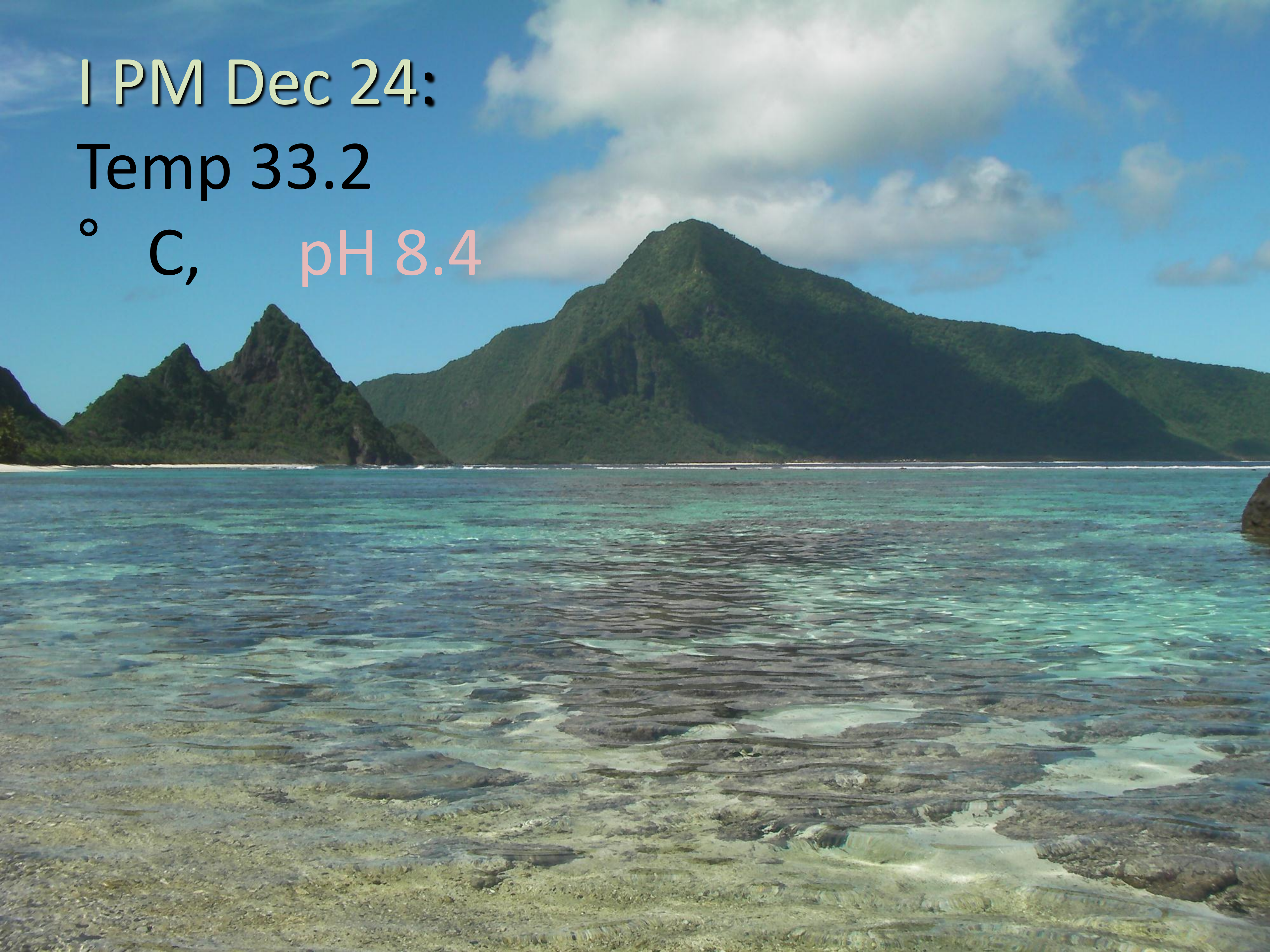
Collaboration with the Territorial Government of American Samoa, the US National Park Service, Stanford University

Dan Barshis
Carlo Caruso
Lupita Ruiz Jones
Rachael Bay
Nikki Traylor Knowles


A day on Ofu
Dawn Dec 24:
Temp 28,5
° C, pH 8.1

I PM Dec 24:

Temp 33.2 °C, pH 8.4



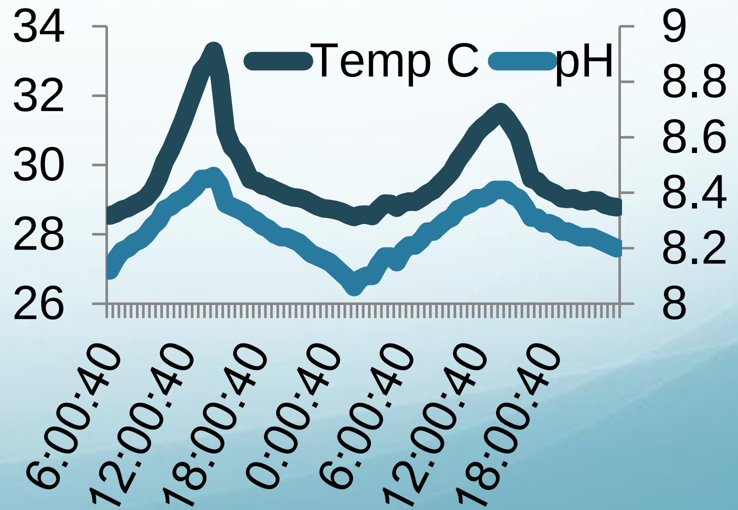
6 PM Dec 24:

Temp 29.5 °C, pH 8.3

---

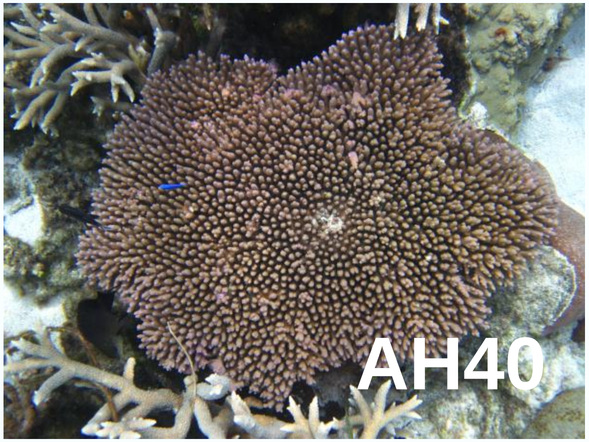
12 AM Dec 25:

Temp 28 °C, pH 8.0

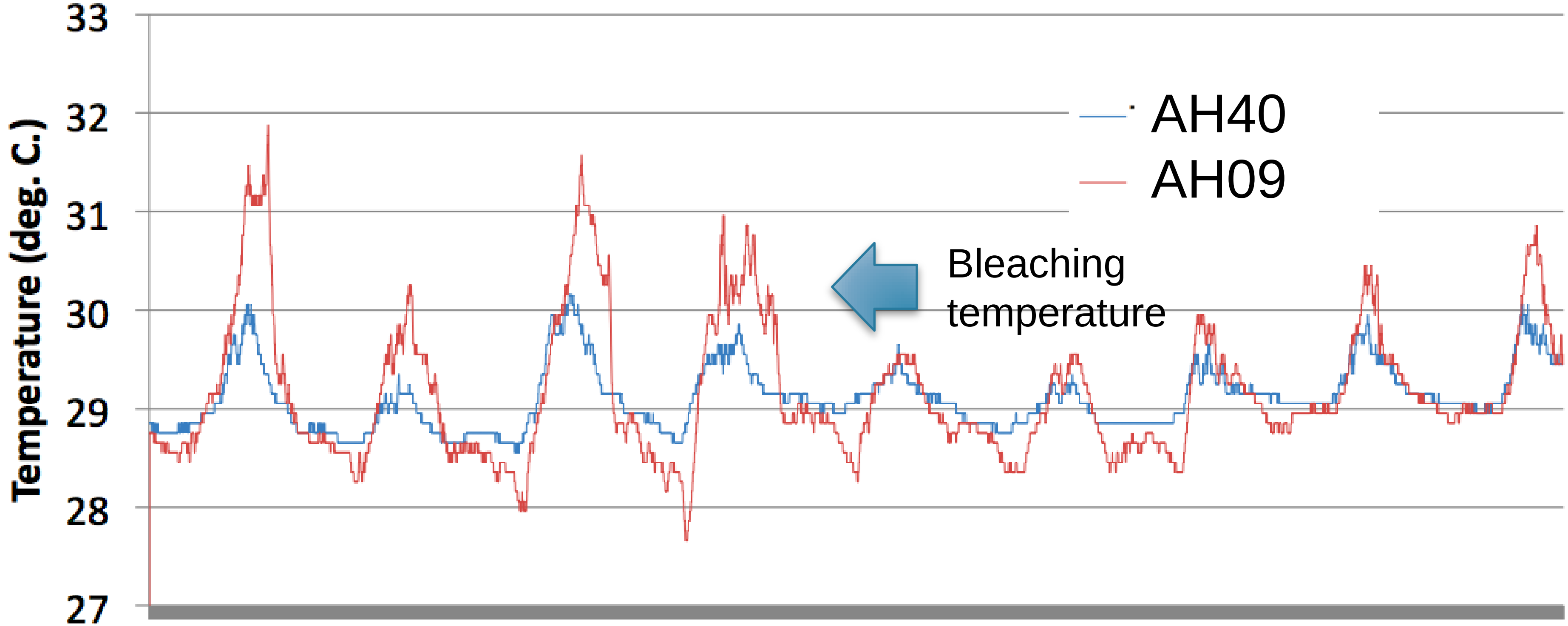


Mapping corals and monitoring environments in the Ofu lagoon

We map and follow individual coral colonies over time.



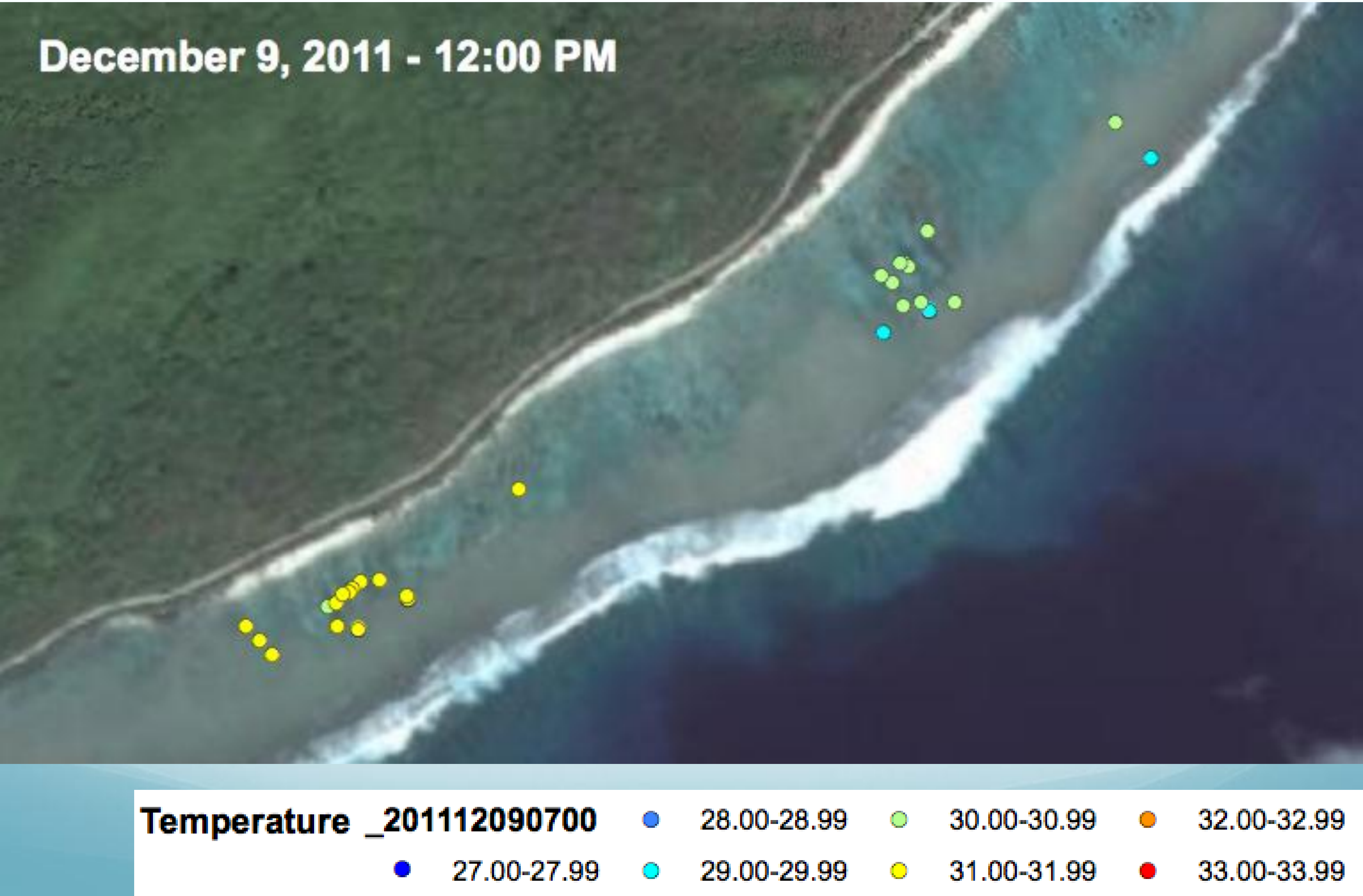
Recording the secret lives of corals with reef temperature loggers

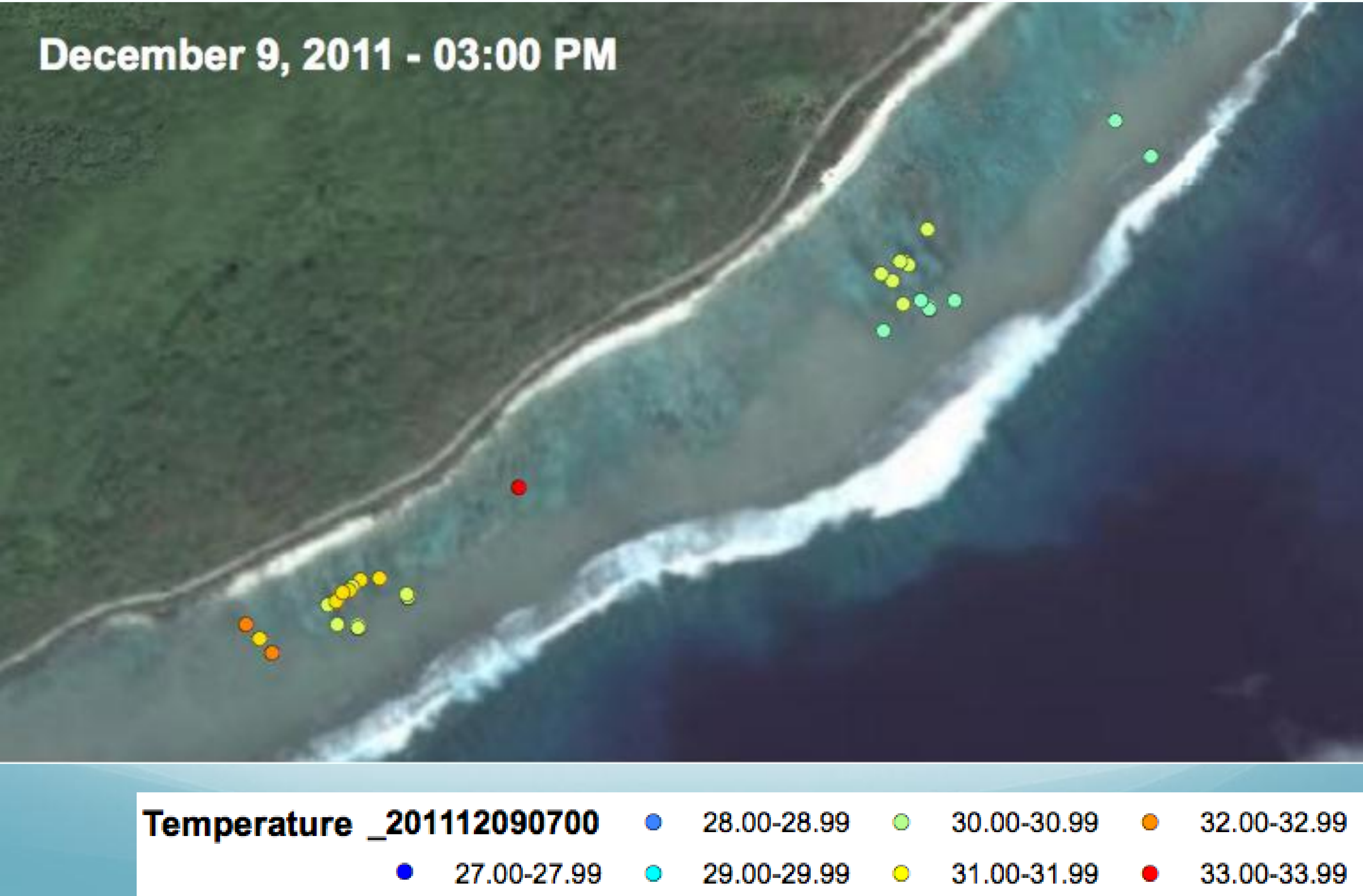


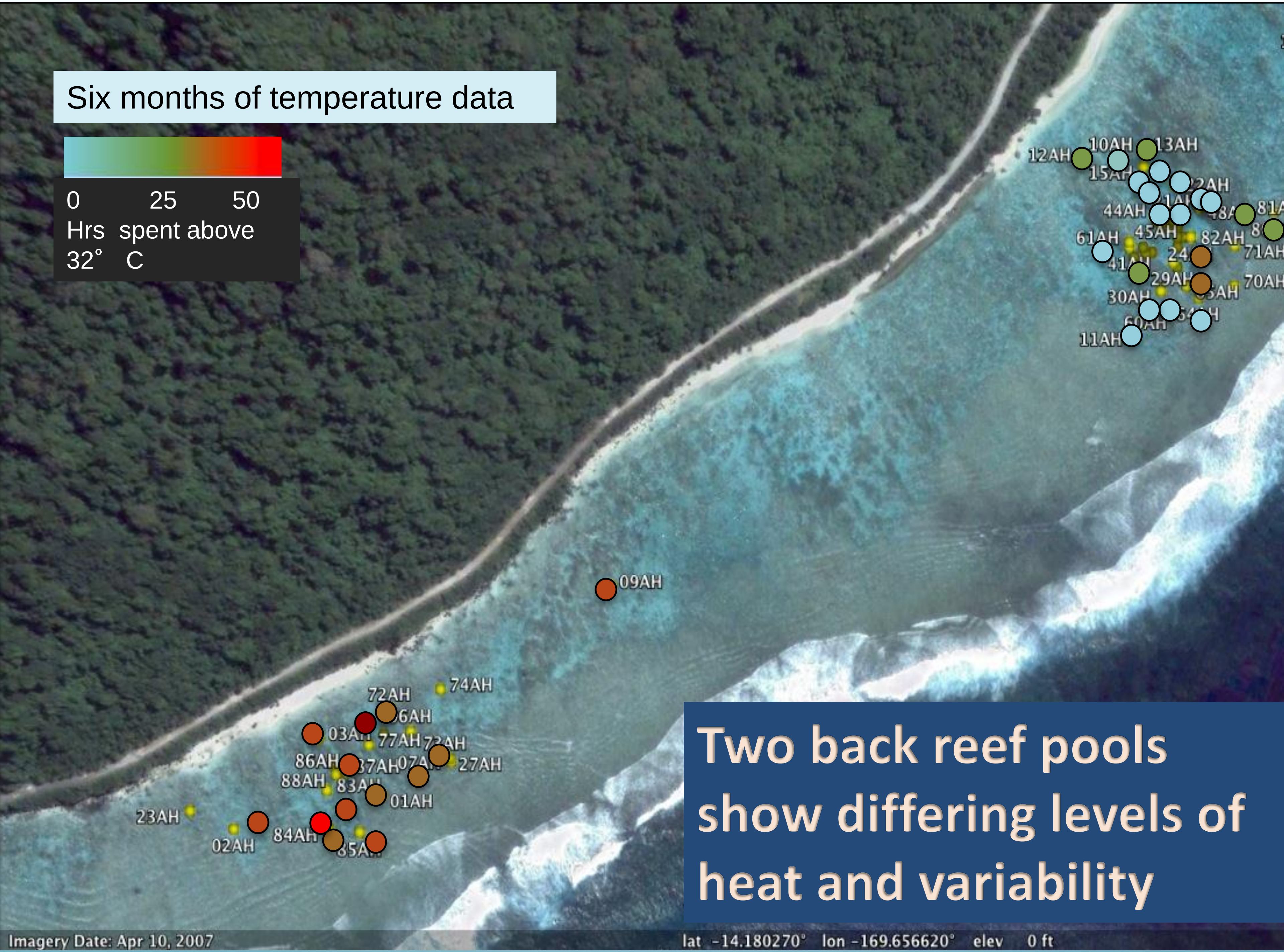
Temperature maps from the Ofu lagoon

Temperature _201112090700

- 27.00-27.99
- 28.00-28.99
- 29.00-29.99
- 30.00-30.99
- 31.00-31.99
- 32.00-32.99
- 33.00-33.99


December 9, 2011 - 12:00 PM
Temperature _201112090700
28.00-28.99
30.00-30.99
32.00-32.99
27.00-27.99
29.00-29.99
31.00-31.99
33.00-33.99

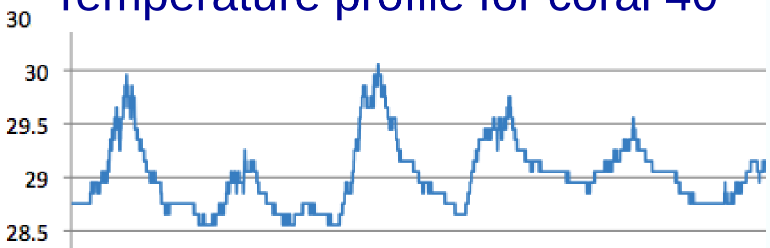

December 9, 2011 - 03:00 PM
Temperature _201112090700
28.00-28.99
30.00-30.99
32.00-32.99
27.00-27.99
29.00-29.99
31.00-31.99
33.00-33.99


Six months of temperature data
0 25 50
Hrs spent above
32° C
Two back reef pools show differing levels of heat and variability
12AH
10AH
13AH
15AH
44AH
61AH
45AH
82AH
71AH
70AH
29AH
30AH
11AH
09AH
72AH
74AH
77AH
27AH
86AH
88AH
01AH
23AH
02AH
84AH
Imagery Date: Apr 10, 2007
lat -14.180270° lon -169.656620° elev 0 ft

Ofu research on environmental stress and coral response:

- ❖Stress tests
- ❖Coral maps and microclimates
- ❖Transplants
- ❖Complete gene sequences

Temperature profile for coral 40



Transcriptome for coral 40

Coral AH40 at home

Colony 40 transplanted from large to small pools

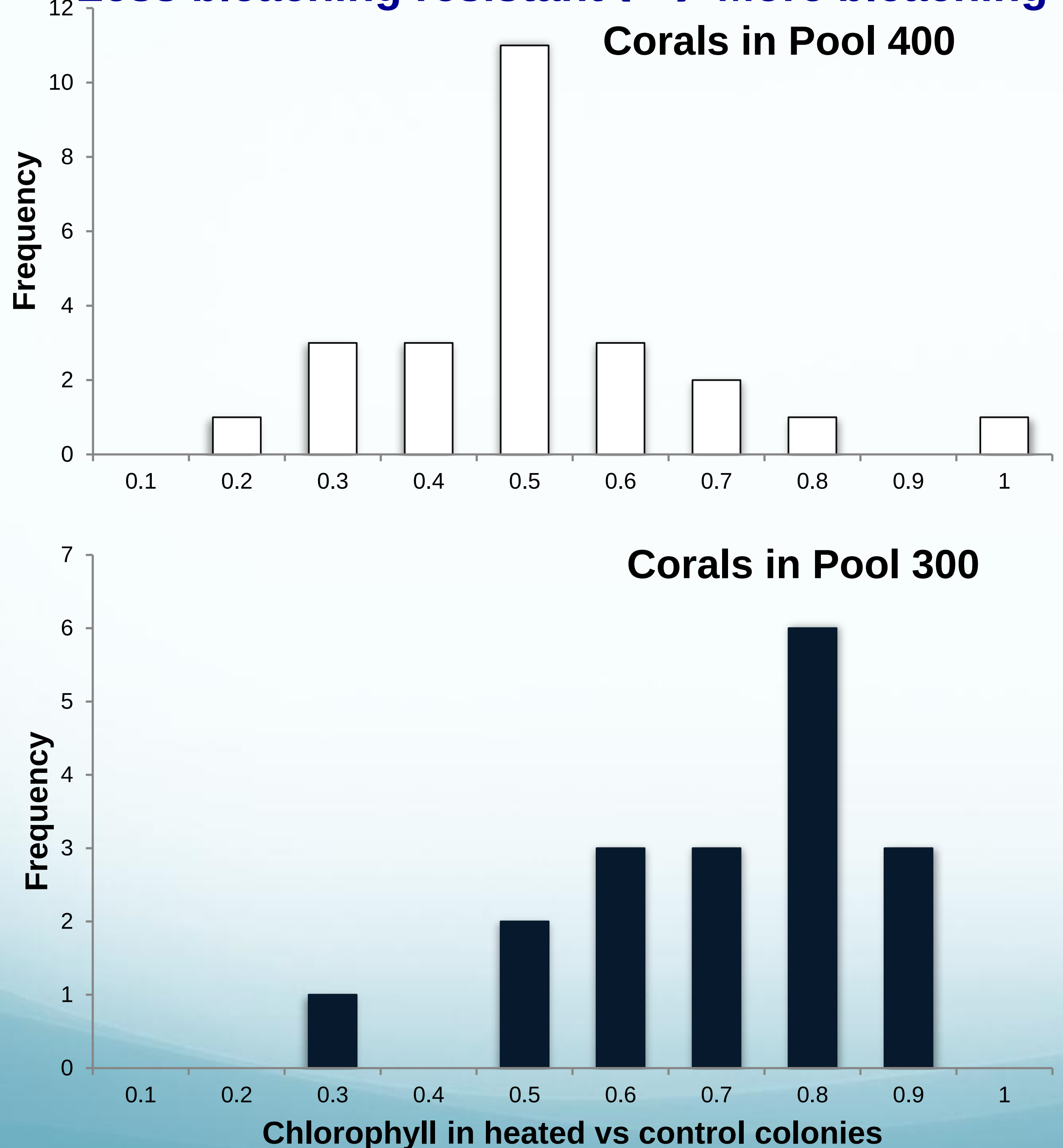
Four coral stress tanks at Ofu – testing coral resistance to high temperature

Stress tank results: Some corals bleach (lose color, lose chlorophyll)

Coral from the cooler Pool 400

Same species from the warmer Pool 300 does not bleach.

Less bleaching resistant← → More bleaching resistant

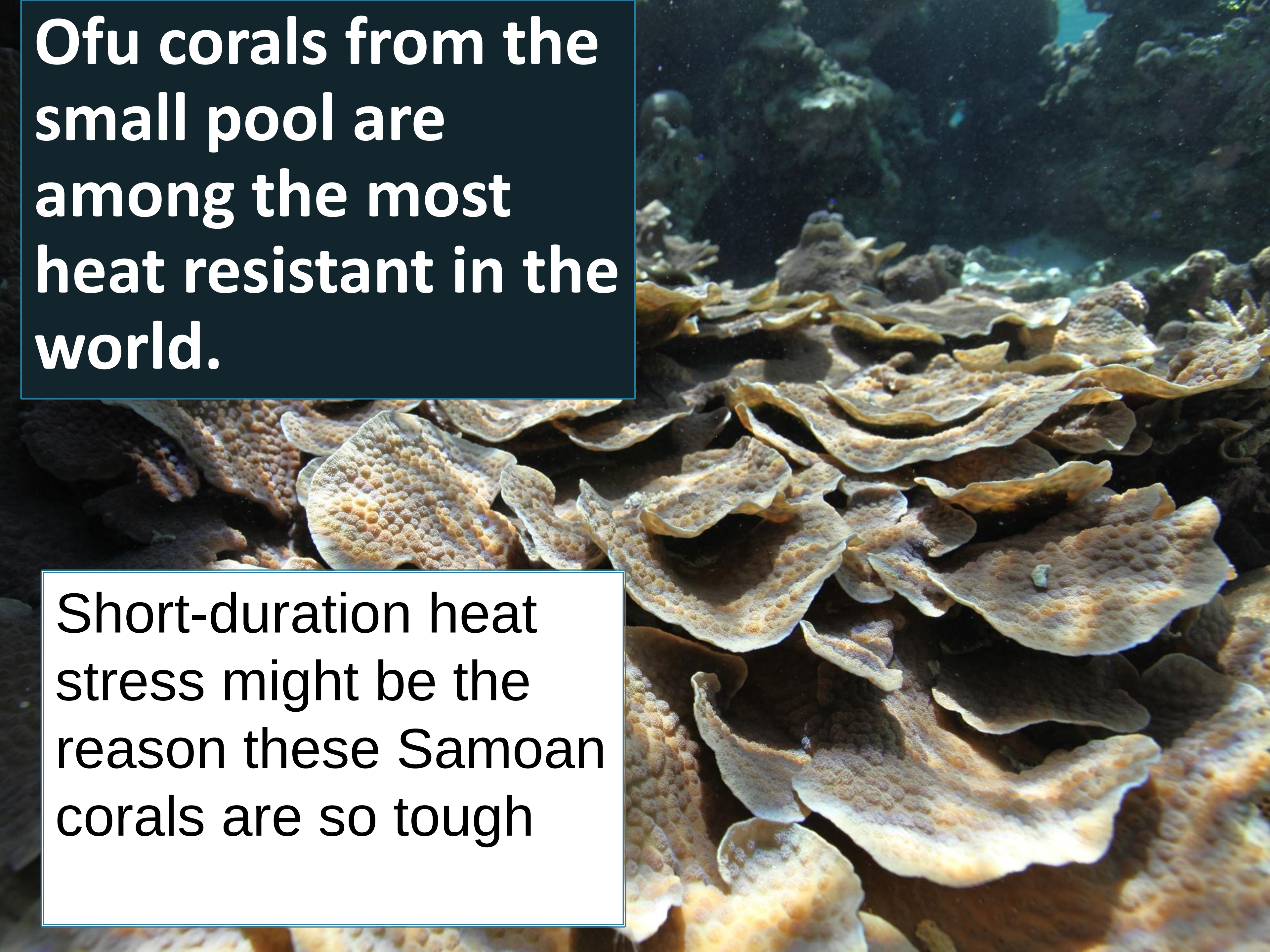


We test corals with a bleaching index: 1 = highly bleaching resistant

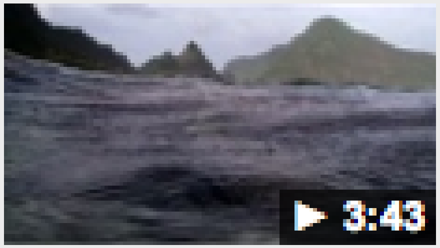
Data for *Acropora hyacinthus*

Ofu corals from the small pool are among the most heat resistant in the world.

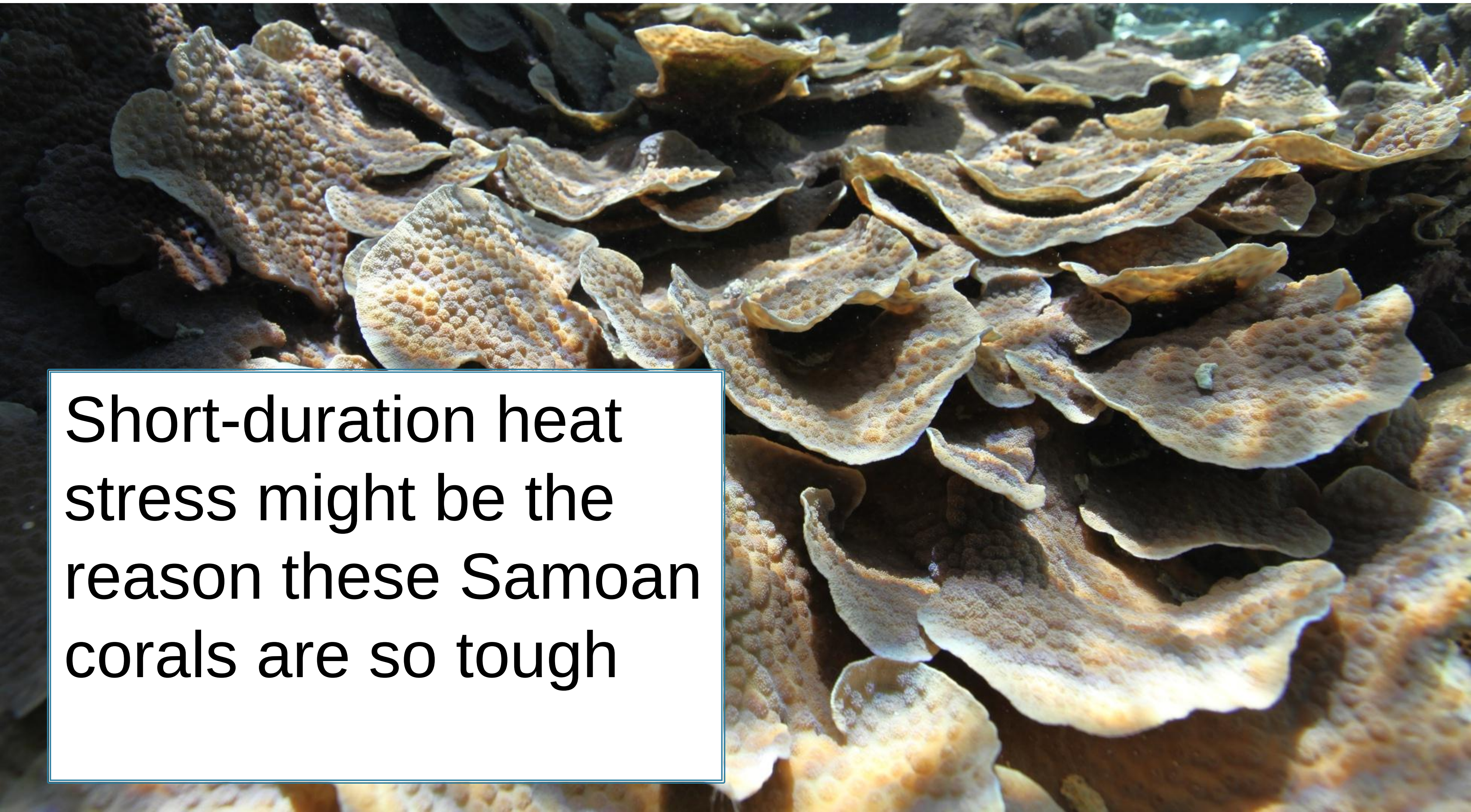
Short-duration heat stress might be the reason these Samoan corals are so tough



Tough! Football and Coral in American Samoa - YouTube



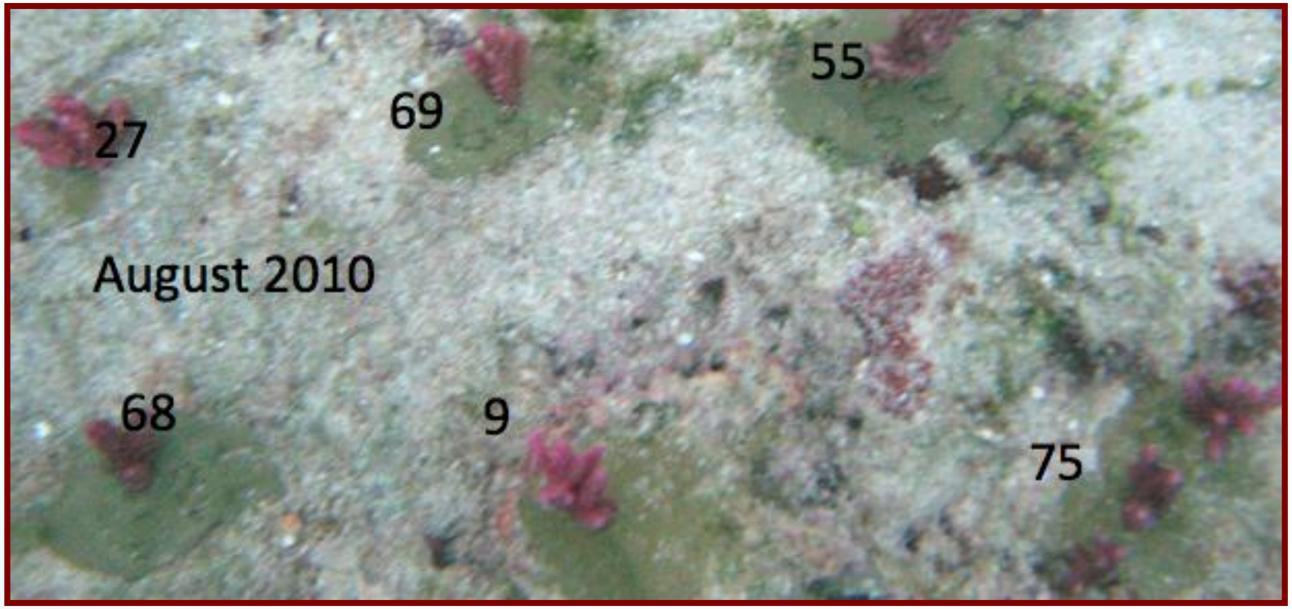
www.youtube.com/watch?v...
Aug 24, 2010 - 4 min - Uploaded by Microdocs
The **corals** of **American Samoa** are **tough**! Hidden in sun baked lagoons, these **corals** are in training for **...**

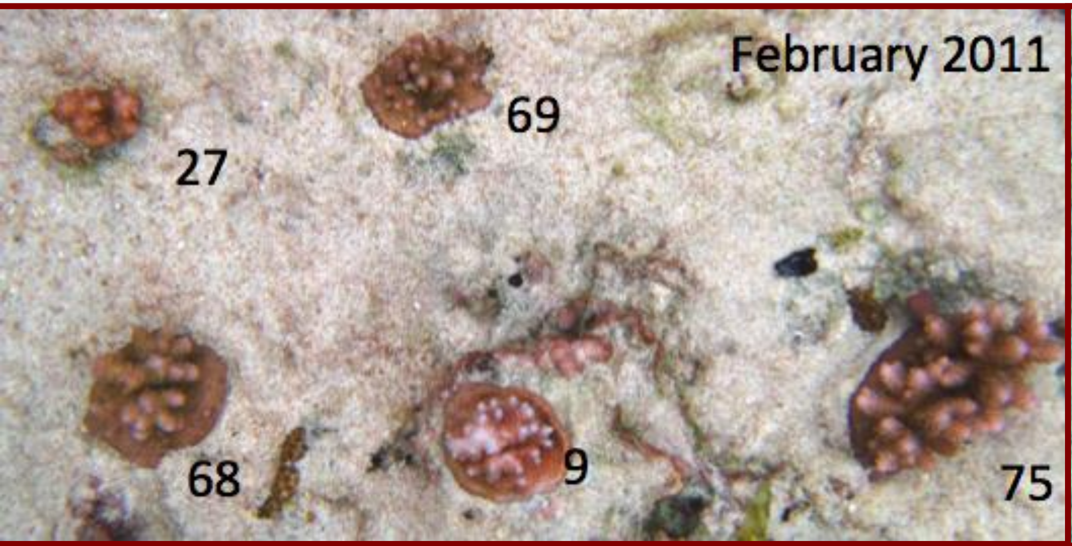


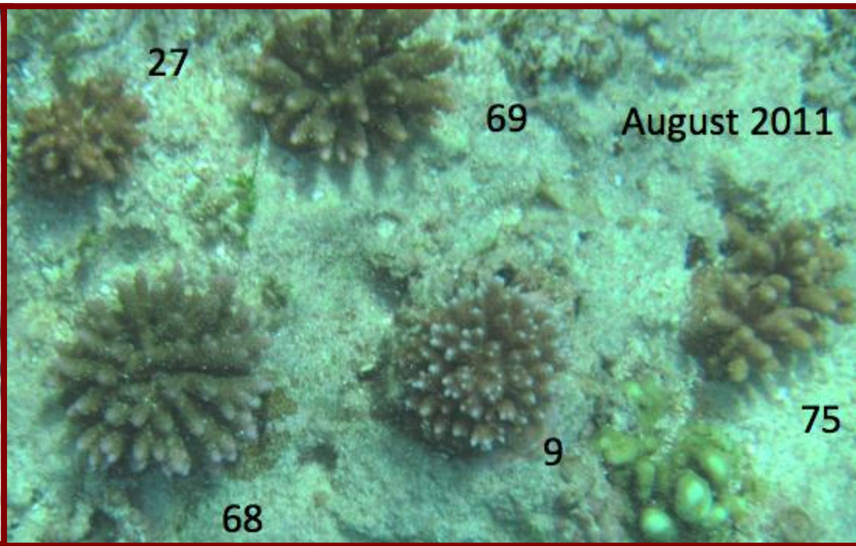
Short-duration heat stress might be the reason these Samoan corals are so tough

Can corals acquire heat resistance?

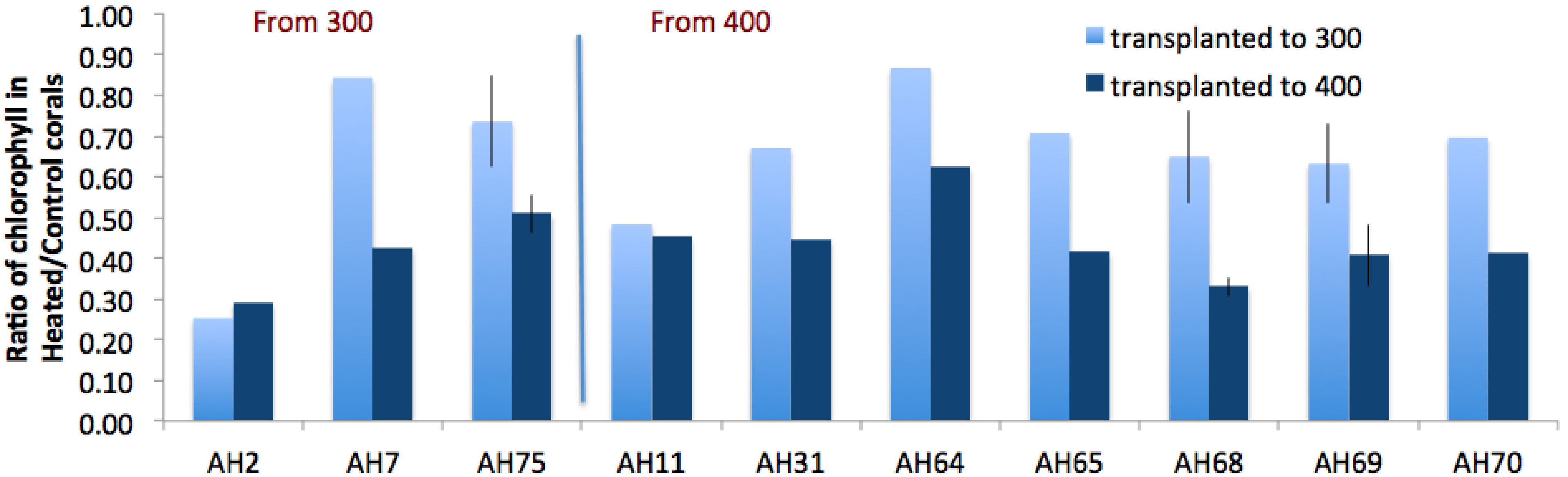
Colonies of *A. hyacinthus* reciprocally transplanted between pools.





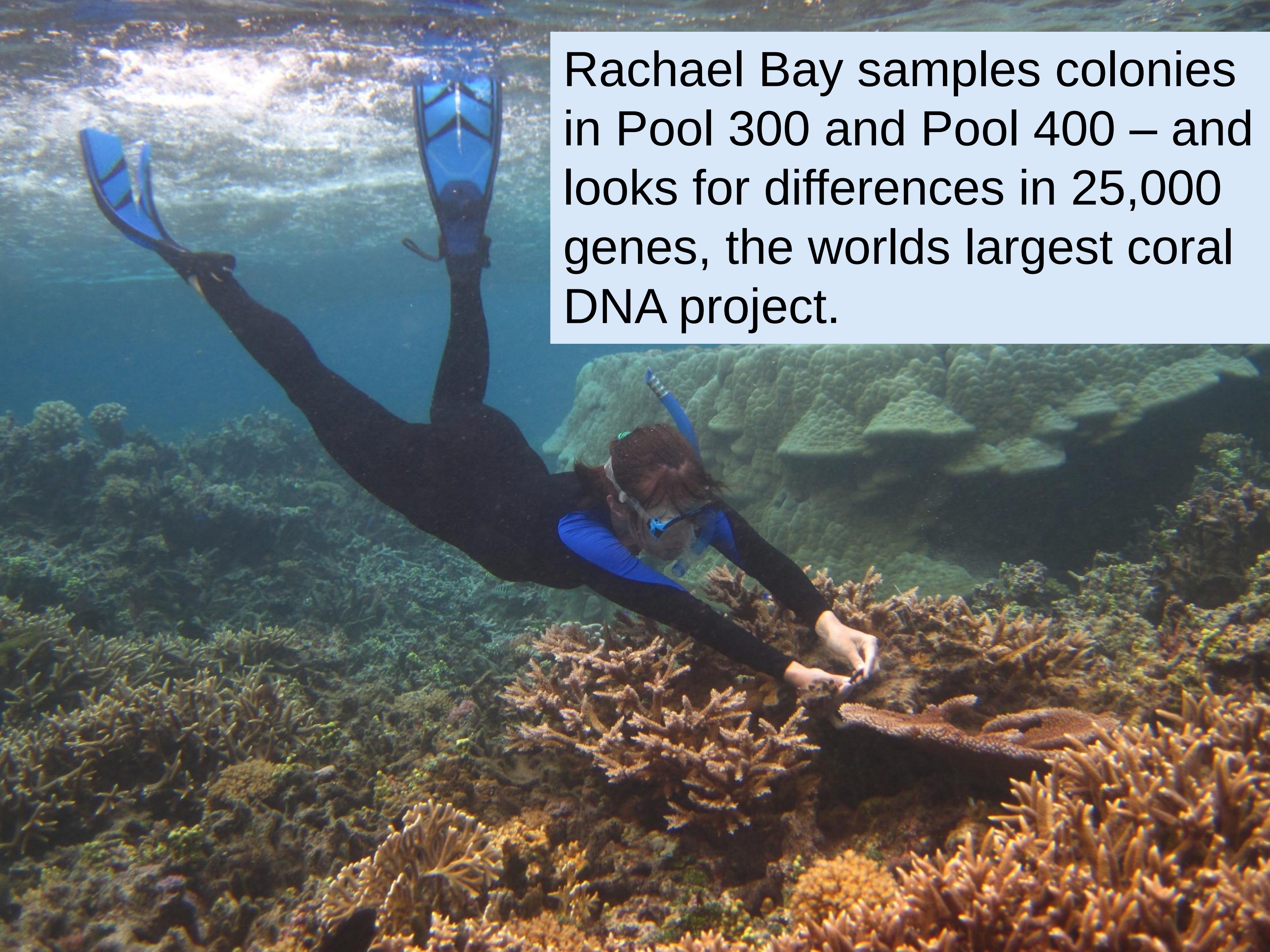


Corals acquire bleaching resistance when grown in Pool 300



Each set of bars is from a colony: Light blue is bleaching resistance when it is living in Pool 300. Dark blue is resistance when it is living in Pool 400.

Colony AH68 living in Pool 300 (left) and Pool 400 (right)



Rachael Bay samples colonies in Pool 300 and Pool 400 – and looks for differences in 25,000 genes, the worlds largest coral DNA project.

Ofu results tell us how corals deal with stress

Corals under stress → Turn on a set of stress genes → Recover

Pool 300 corals have stress genes turned on BEFORE stress → Recover from heat stress faster

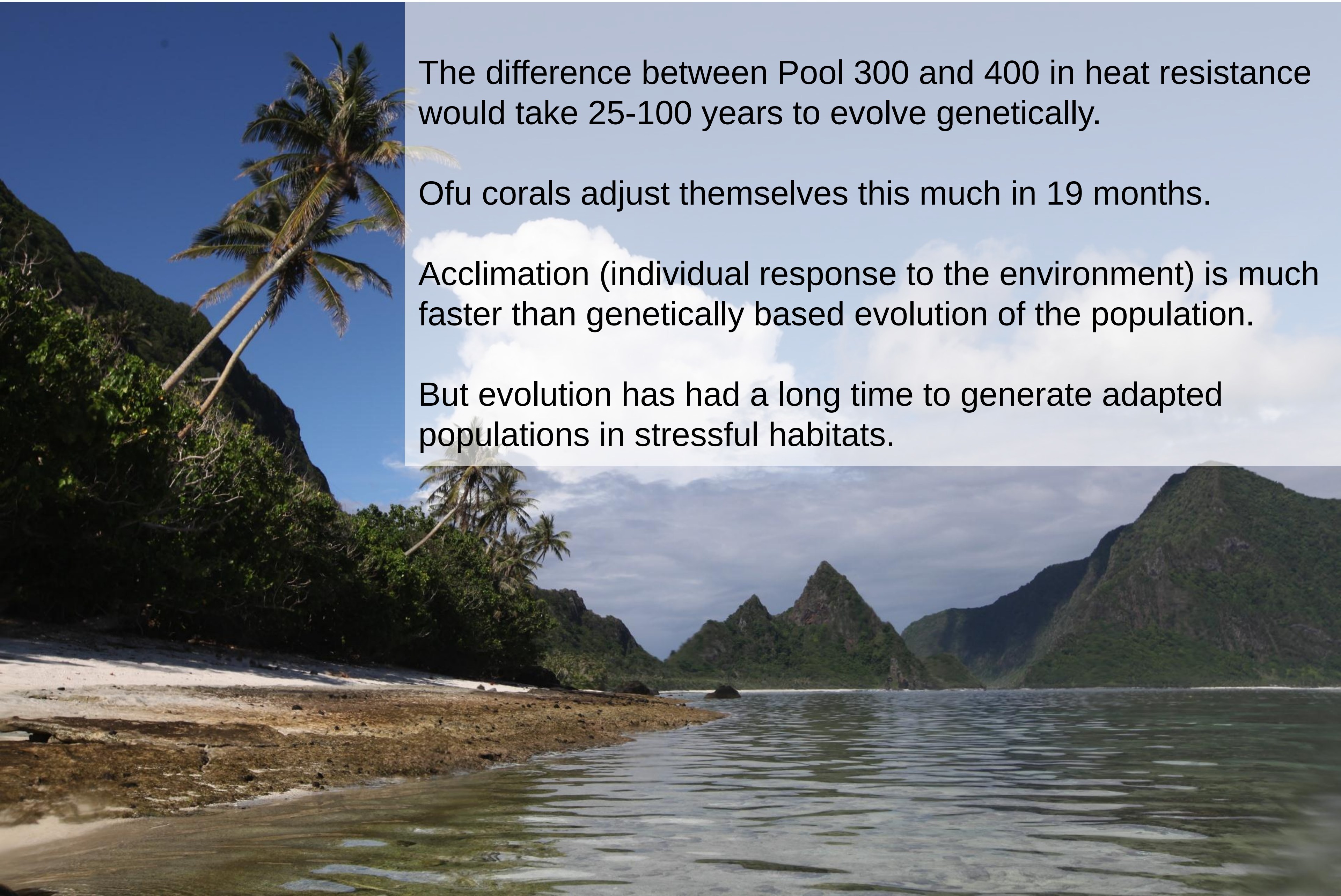
How fast can a coral change?

The difference between Pool 300 and 400 in heat resistance would take 25-100 years to evolve genetically.

Ofu corals adjust themselves this much in 19 months.

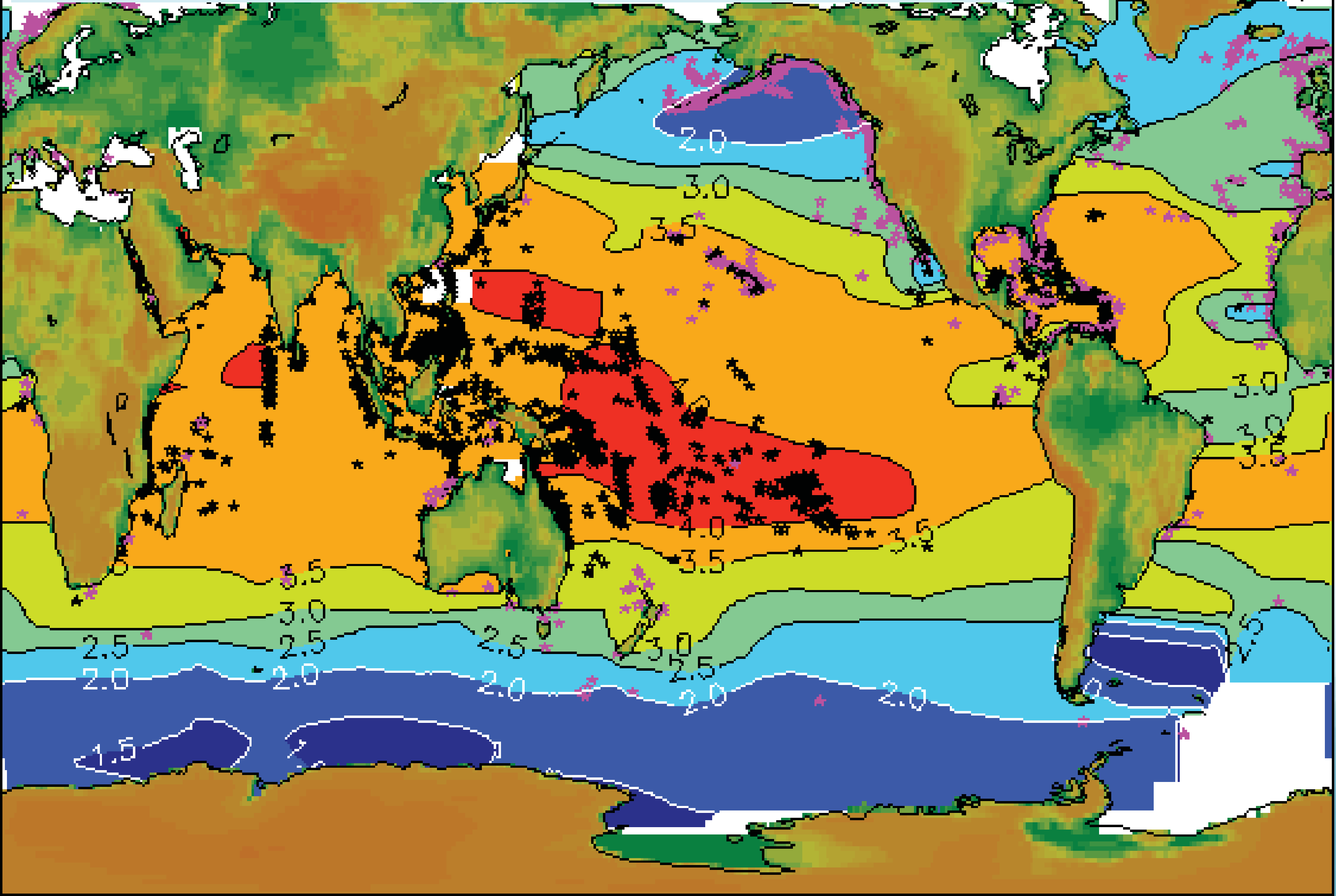
Acclimation (individual response to the environment) is much faster than genetically based evolution of the population.

But evolution has had a long time to generate adapted populations in stressful habitats.

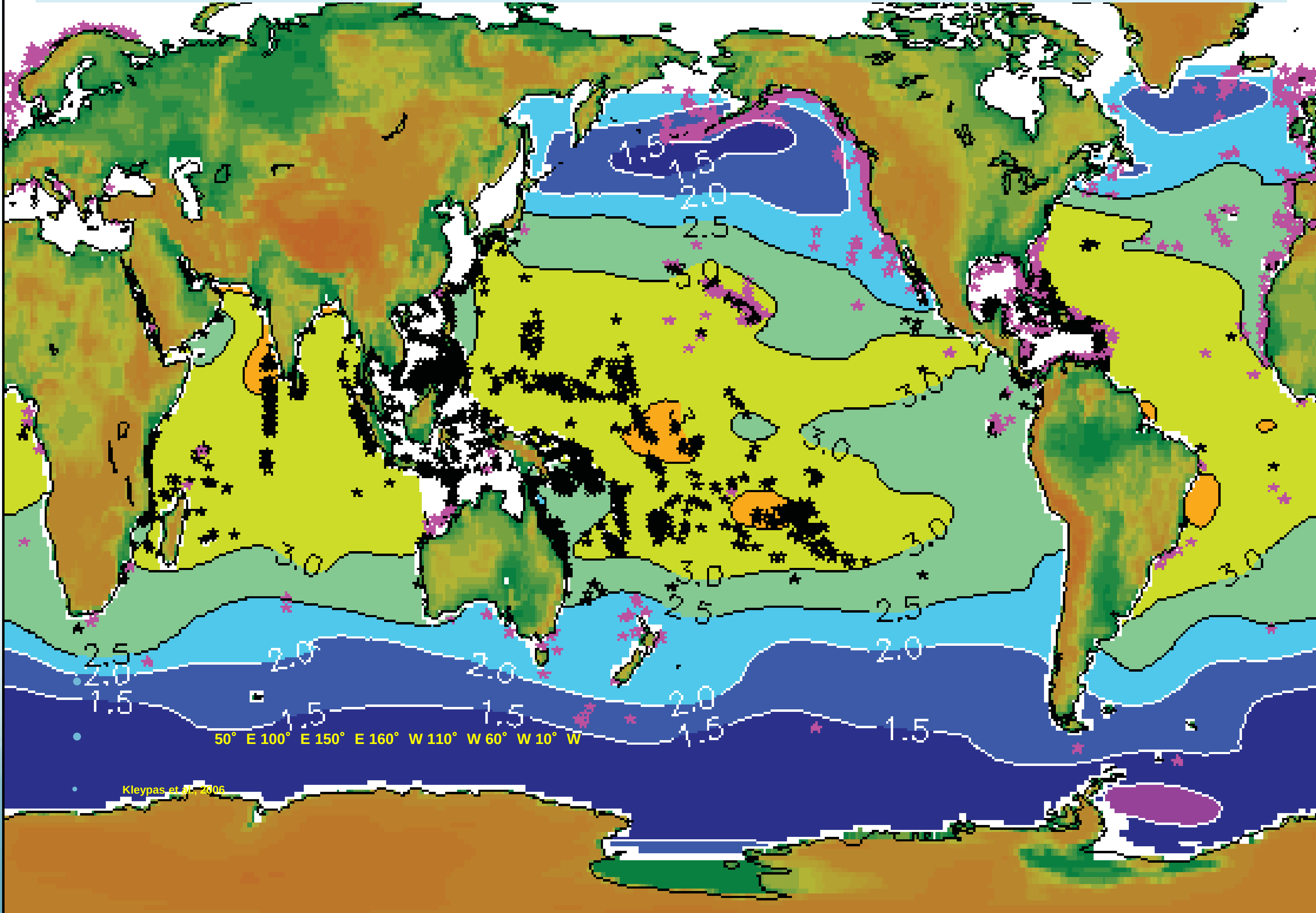


The other part of ocean climate change: acidification

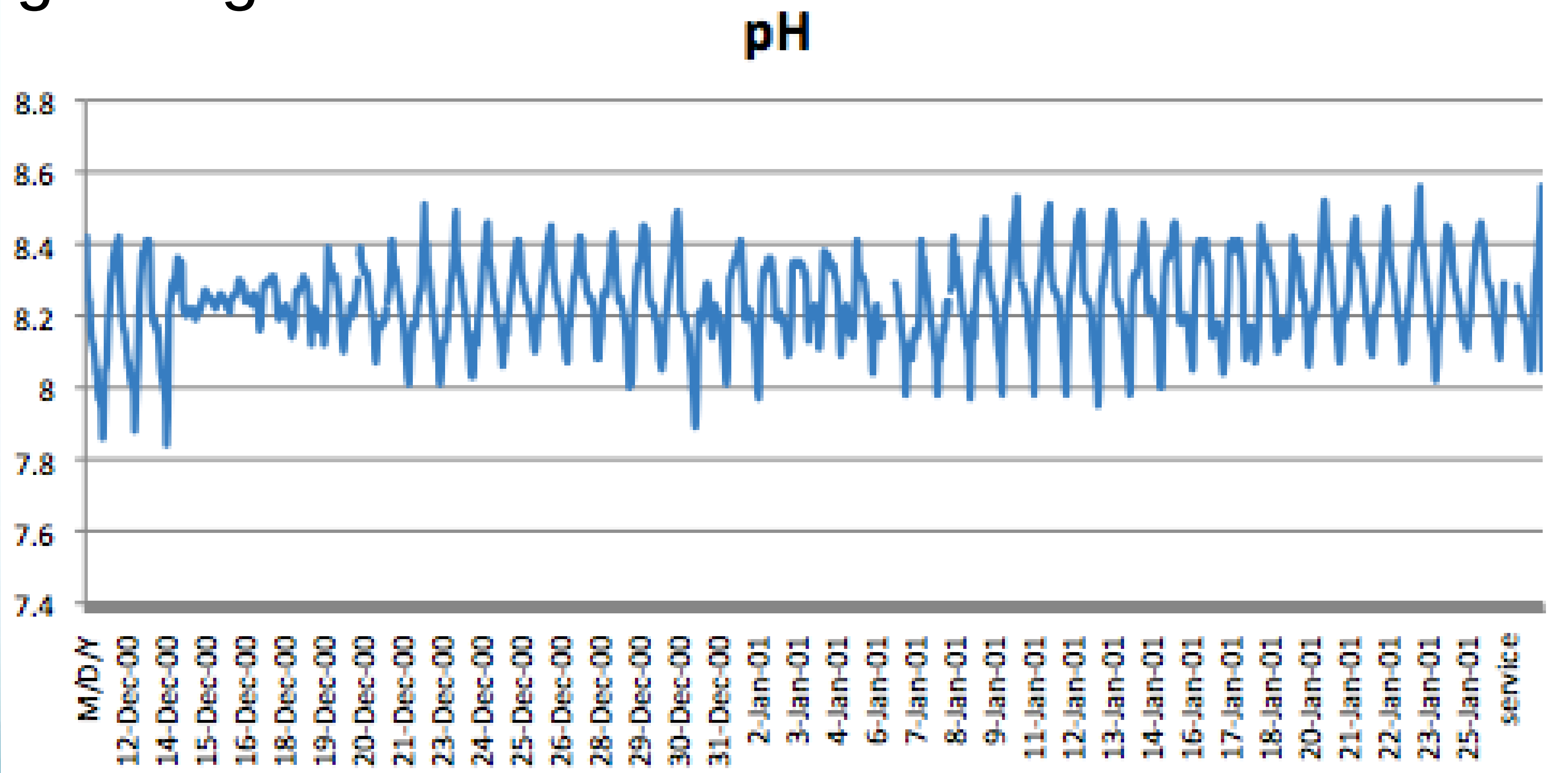
Aragonite Saturation Levels 1995



Predicted Aragonite Saturation Levels in 2040

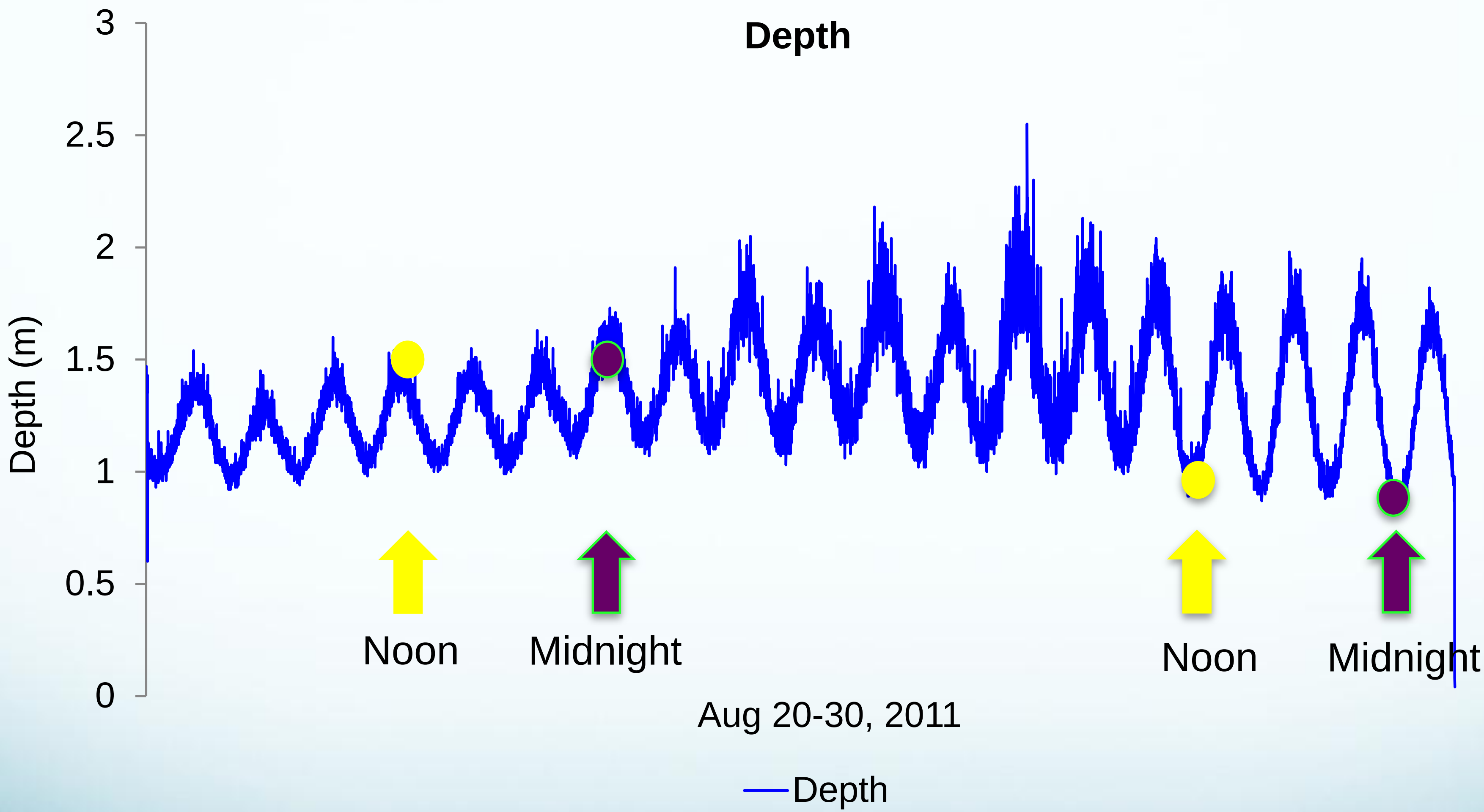


Another surprise from Ofu. pH values vary widely throughout the day in lagoons with fast growing corals



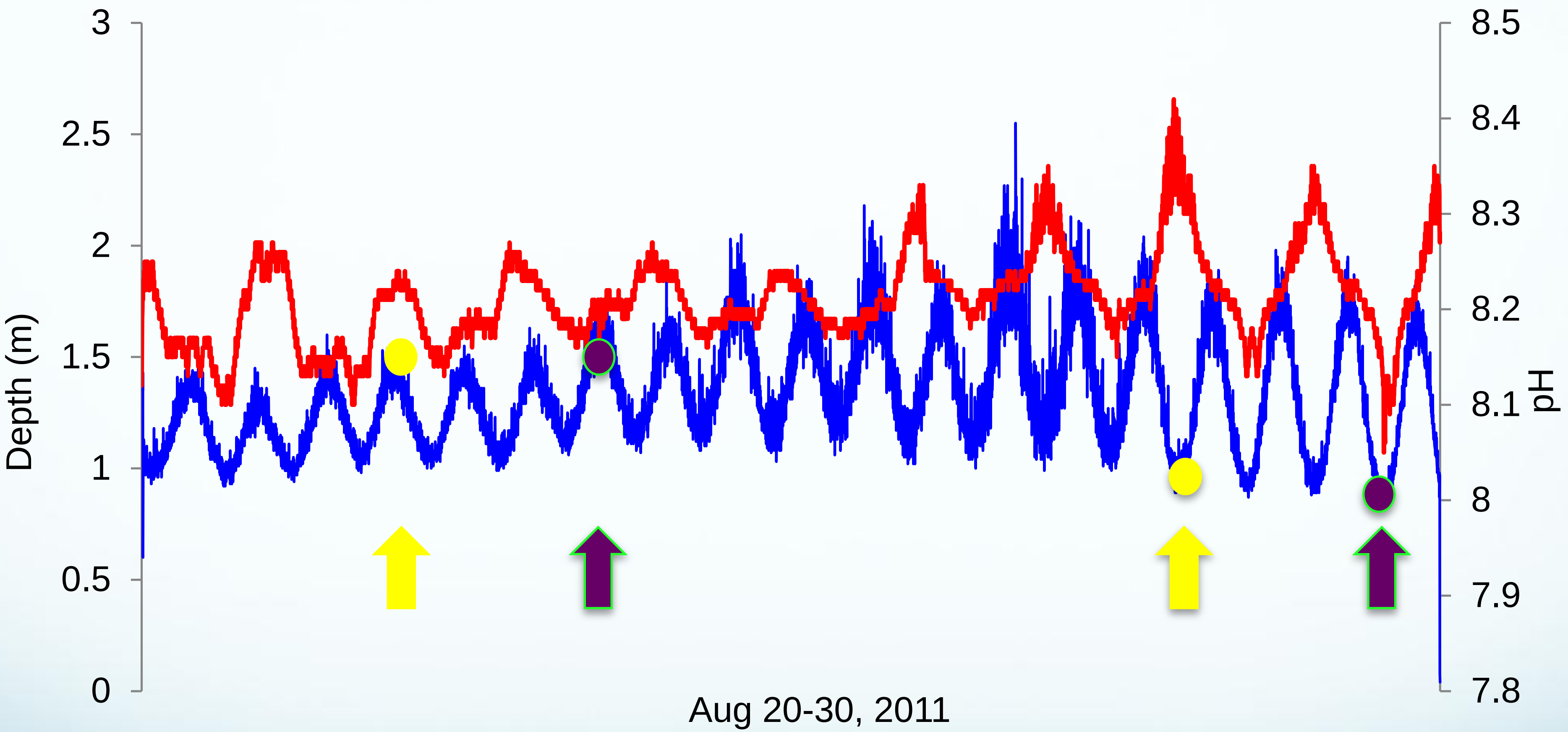
Corals can live in a variety of pH environments

Tide changes in Ofu lagoon



Data from NPS, DataSonde

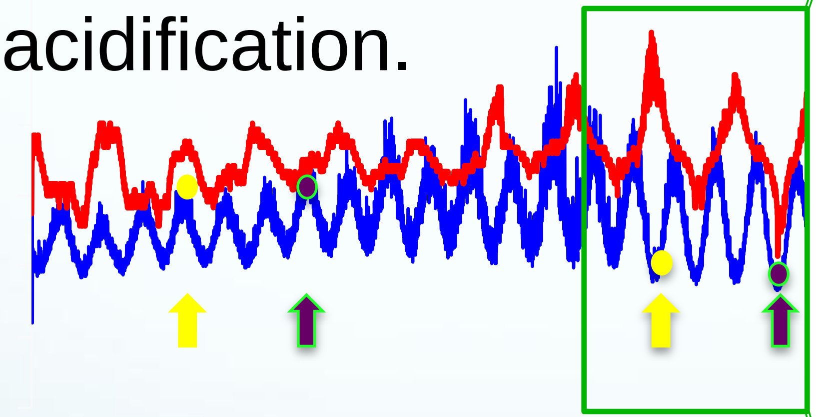
pH also changes with the tide



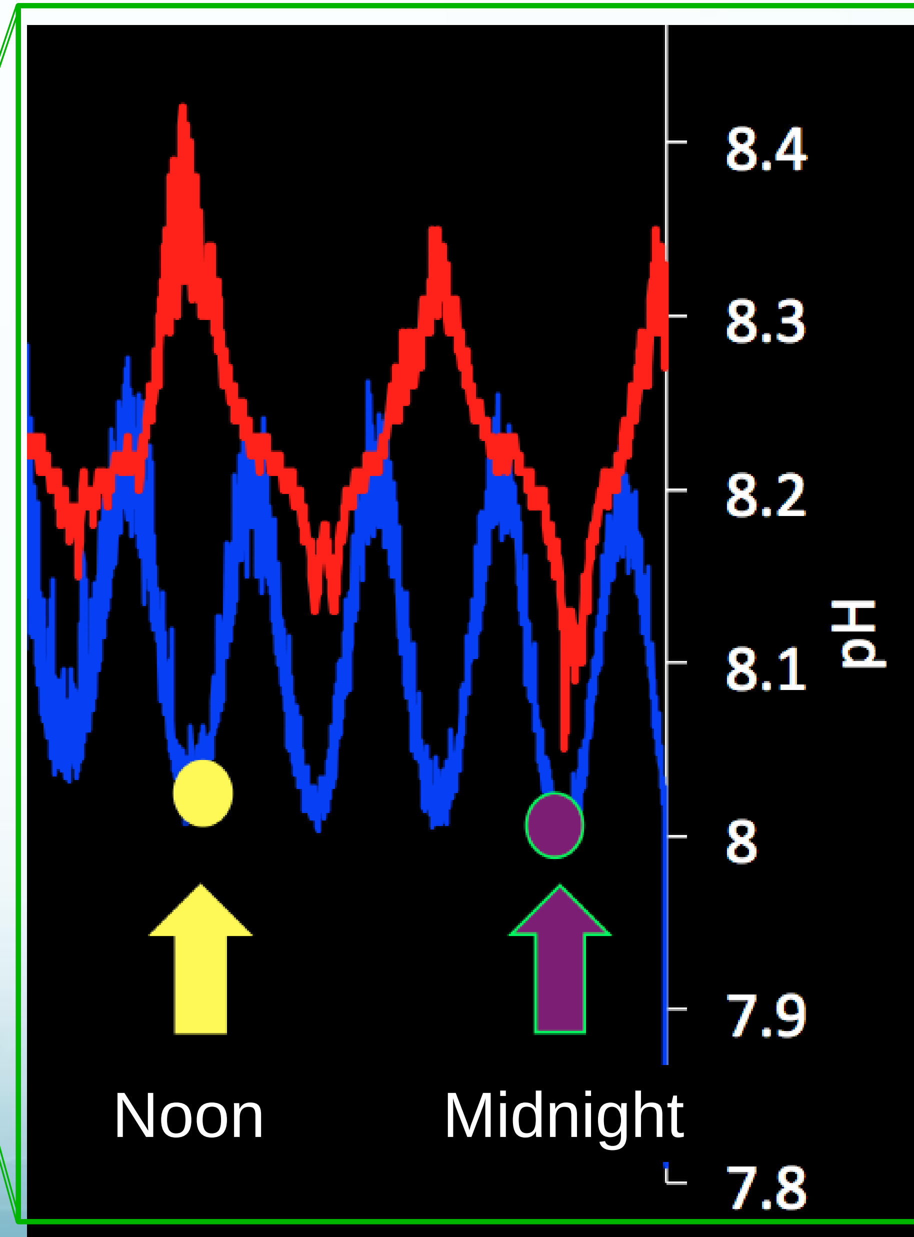
Data from NPS DataSonde

pH is high during the day but low at night

Photosynthesis during the day used up CO_2 and raises pH. This reverses ocean acidification.

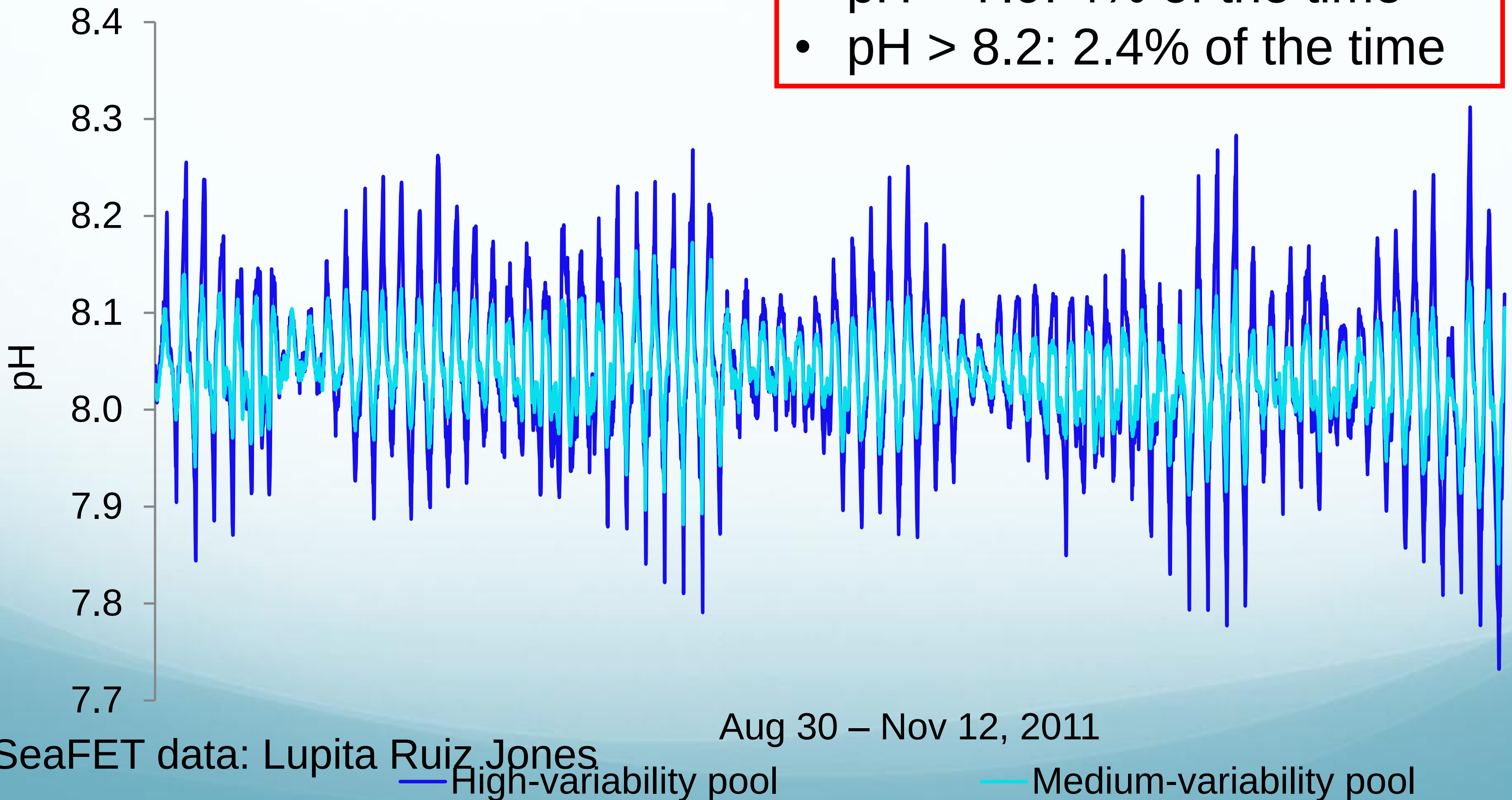


But the pH falls dramatically at night when CO_2 is produced by the reef



Pool 300 has many low pH periods at night – but corals growth faster there. Do noontimes with high pH make up for acidification effects? Experiments ongoing

- pH < 7.9: 4% of the time
- pH > 8.2: 2.4% of the time



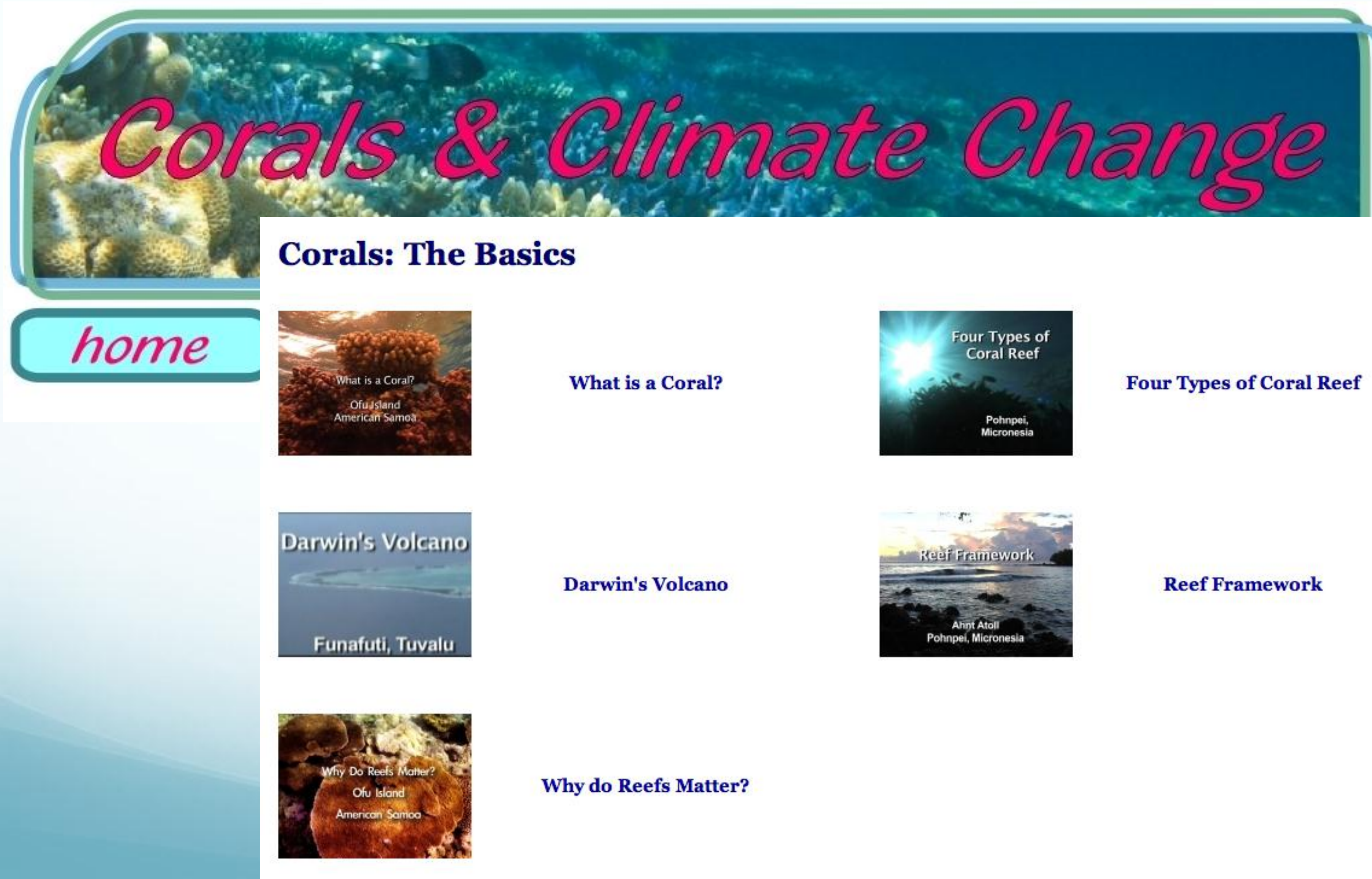
SeaFET data: Lupita Ruiz Jones

How fast do corals acquire heat tolerance? Experiments on Ofu next month are designed to answer this.

What is the relationship between shading and acclimation?

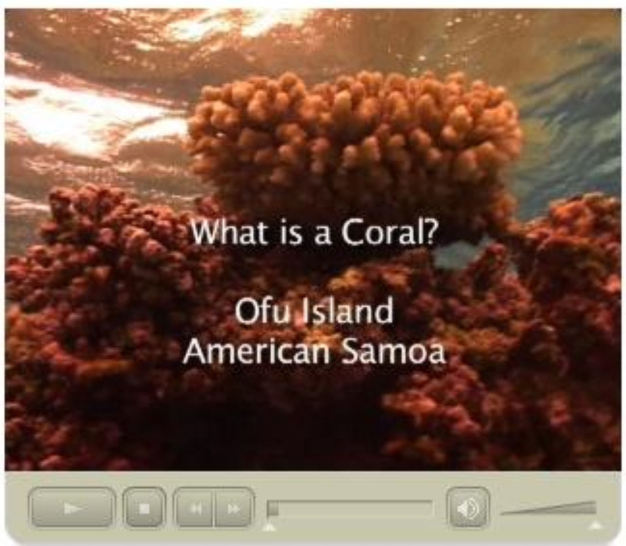
New coral reef resilience web site:
http://corals.stanford.edu

New coral reef resilience web site: http://corals.stanford.edu/



New coral reef resilience web site: http://corals.stanford.edu/

Corals: The Basics



Coral reefs can be seen from space, but they are made by one of the world's simplest animals.

What is a Coral?

Summary

- Coral polyps are tiny animals that build protective calcium carbonate skeletons.
- Coral polyps create the basic structure of coral reefs with the help of single-celled algae.

Coral reefs can be seen from space, but they are made by one of the world's simplest animals - some no bigger than the head of a pin. They are able do this because of their symbiotic relation with single-celled algae.

Tiny reef builders

Every coral, from small free-living individuals to huge colonies, has the same basic body plan:

- Coral polyp – the living animal, basically a sack with a stomach and a mouth surrounded by retractable, stinging tentacles. These tentacles are used to catch food.
- Corallite - a hard calcium carbonate shell that protects the polyp.

How will the world's strongest corals survive?

Tools for reef protection

Reef nations can not solve global climate change themselves. But reefs will be threatened until climate change ends.

A primary conclusion is that dedicated and consistent effort should be mounted to reduce climate change through reduction in CO_2 and other greenhouse gas emissions throughout the world. This is simply the only long term, comprehensive solution to the problems of climate change.

Corals and climate consensus statement

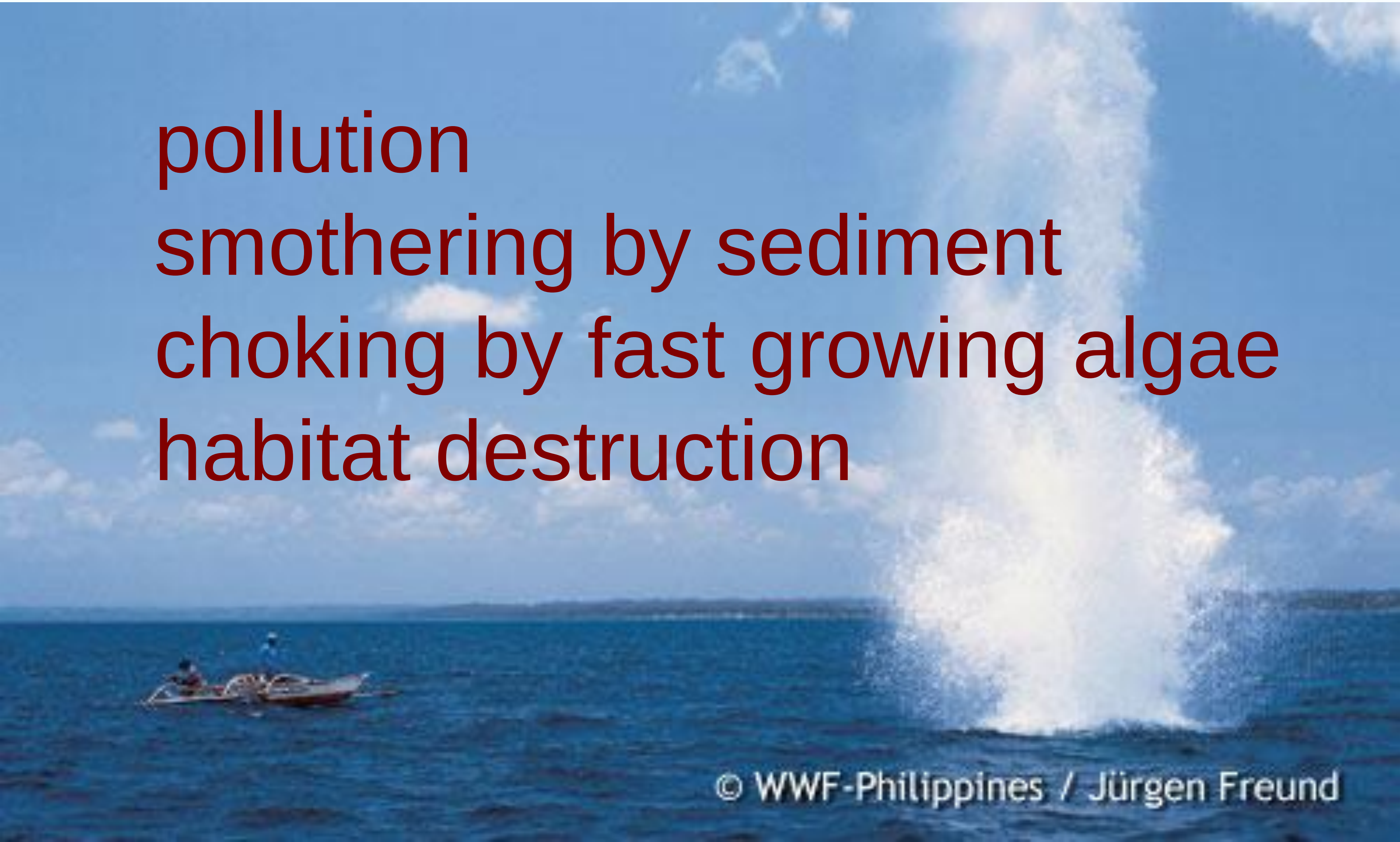
What have we learned from Ofu about coral resilience?

1. Corals can live in highly variable conditions
2. Healthy corals can adjust themselves to higher temperatures
3. Healthy lagoon reefs might control local pH
4. Local stressors reduce coral growth and limit their adaptive responses
5. Protecting the strongest corals may buy time

Protecting corals can help them resist climate change.

Not even the strongest corals can survive

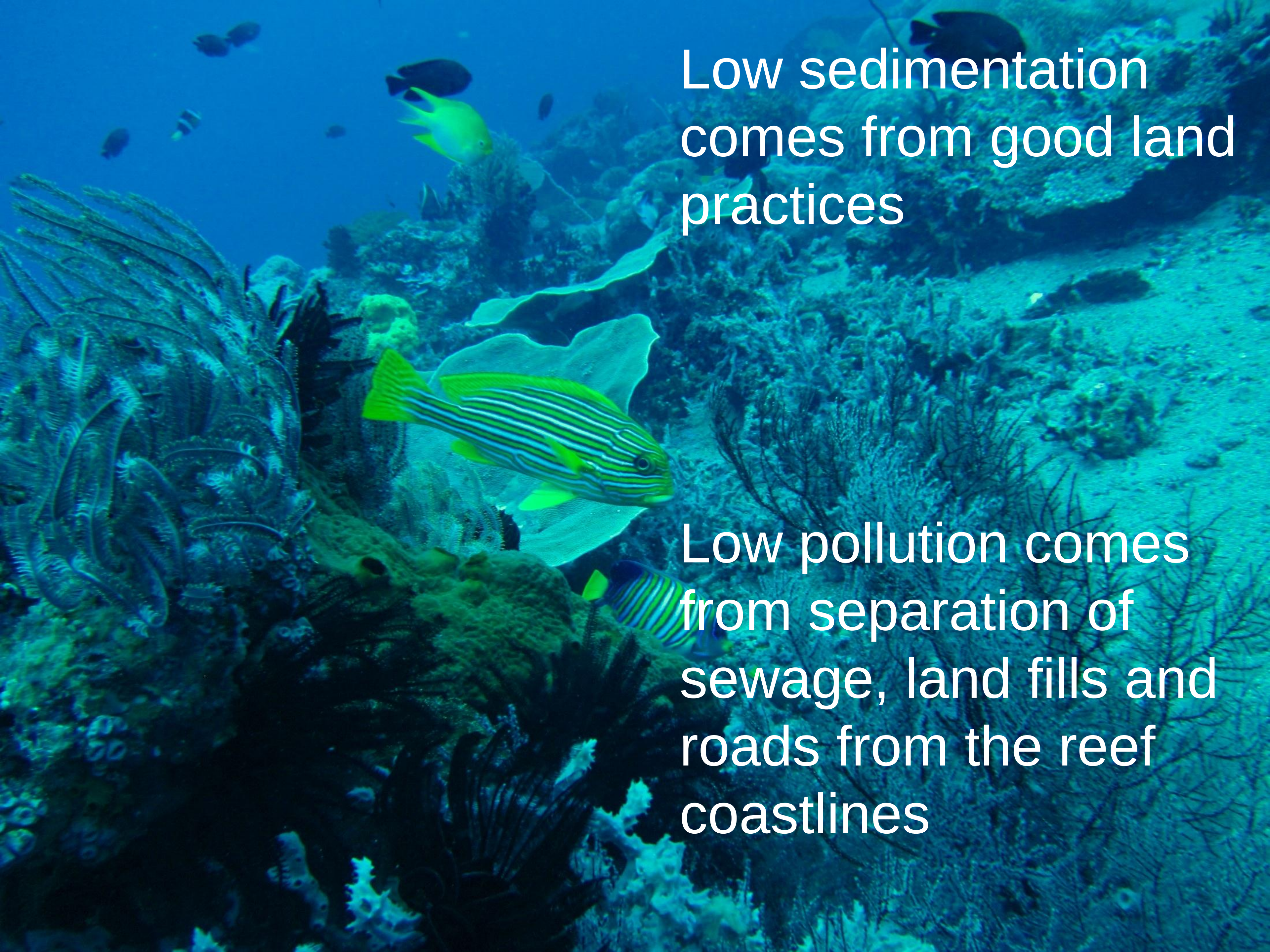
pollution
smothering by sediment
choking by fast growing algae
habitat destruction



Tools for coral reef protection

Protect some areas from overfishing

Large reef fish in the Philippines live only in marine reserves such as Apo Island



Low sedimentation comes from good land practices

Low pollution comes from separation of sewage, land fills and roads from the reef coastlines

What to do locally

1. Fight poverty and overpopulation
2. Rebuild fish stocks
3. Stop/reduce runoff and pollutants coming from land
4. Stop/reduce destruction of coral reef habitats
5. Identify and protect the most resilient reefs
6. Take advantage of the global market drivers of sustainable habitat use such as tourism and fishing
7. Change incentive systems to promote sustainability
8. Use aquaculture without increasing pollution and runoff

Corals and climate change consensus statement

Five paths to future reefs

1. Protect one part of the reef from any fishing
2. Make sure streams and rivers run clear when it rains
3. Remove pig farms and other pollution from the shoreline
4. Keep mangrove forests and estuaries as intact as possible
5. Plan farms, roads and houses so that they do not increase erosion.


Climate change will alter coral reef communities and the way people can use them.
Healthy reefs now support human communities now and are the best way to assure reefs for the future.