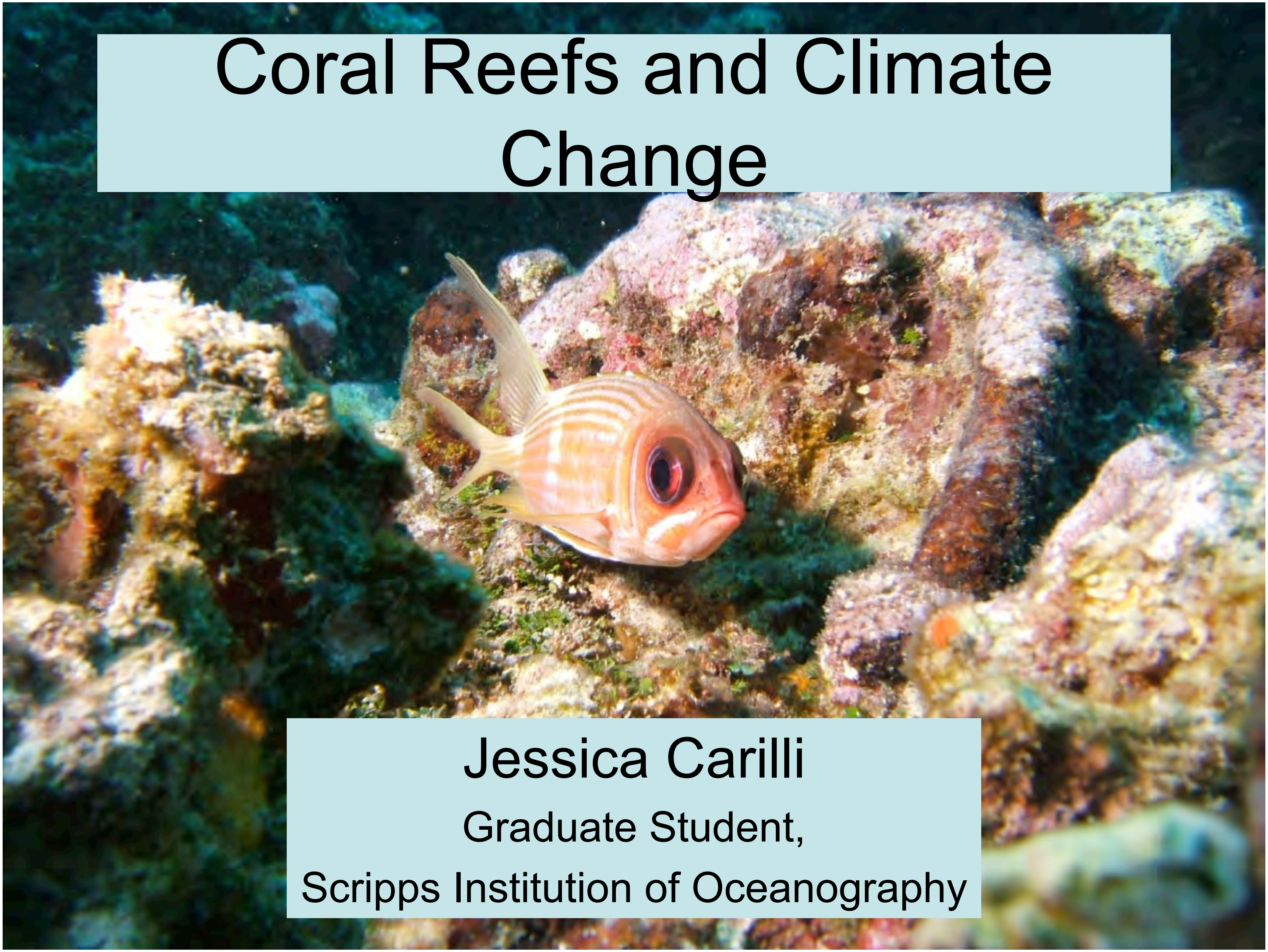
Coral Reefs and Climate Change



Jessica Carilli

Graduate Student,

Scripps Institution of Oceanography

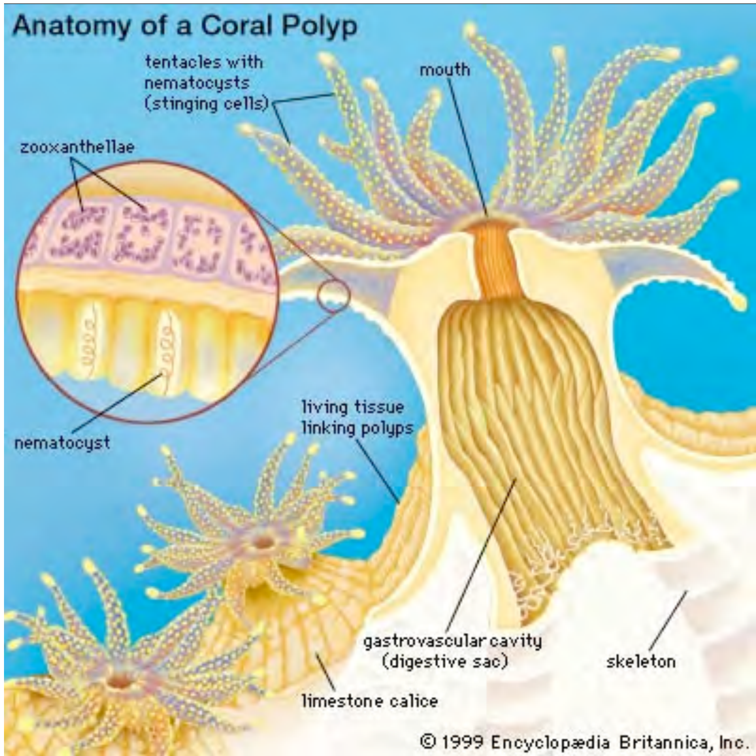
Outline

- What are corals?
- How are corals useful for climate reconstructions?
- How is climate change affecting corals?
- What else is killing off reefs?

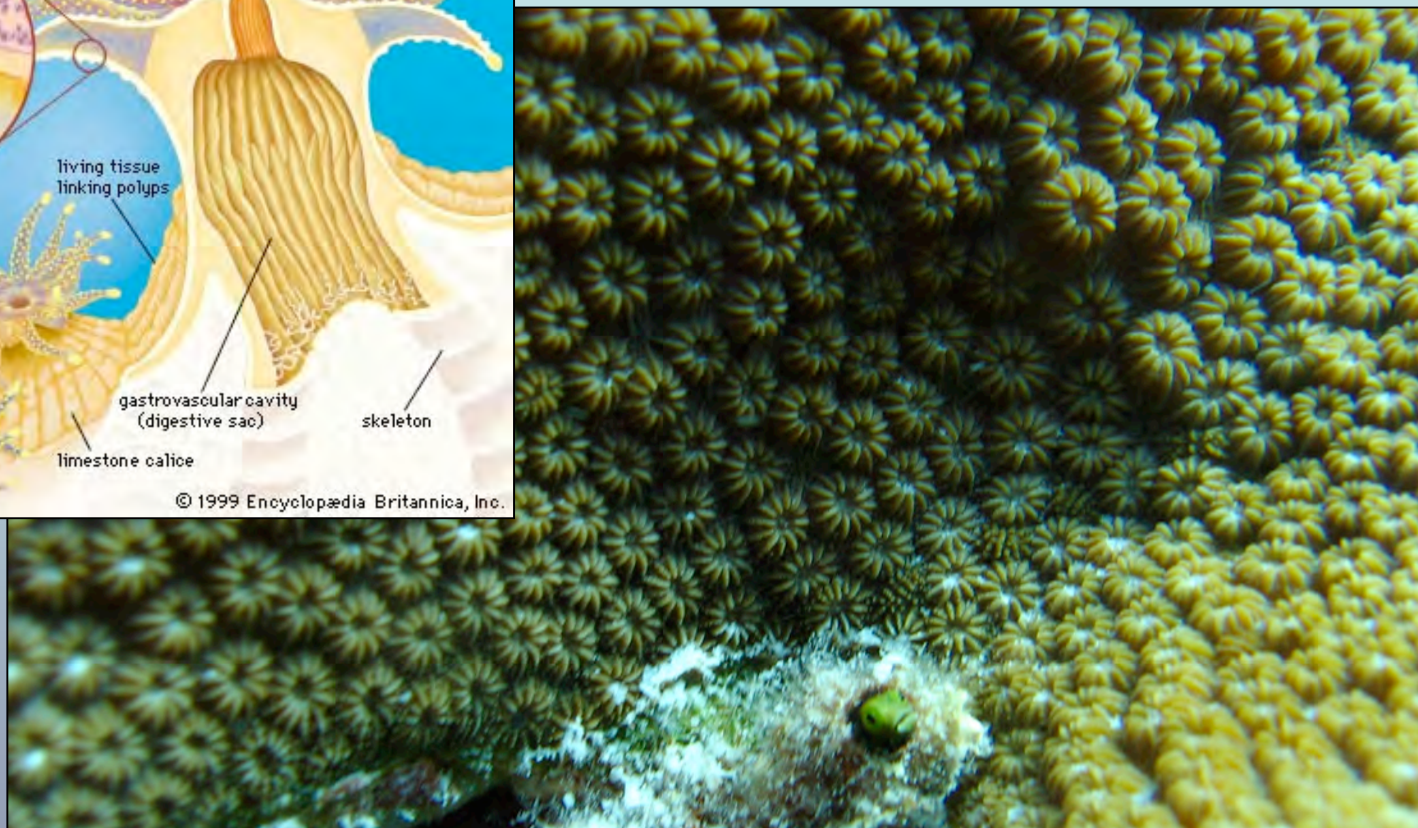
Rainforests of the Sea

Photos by Konrad Hughen

Coral



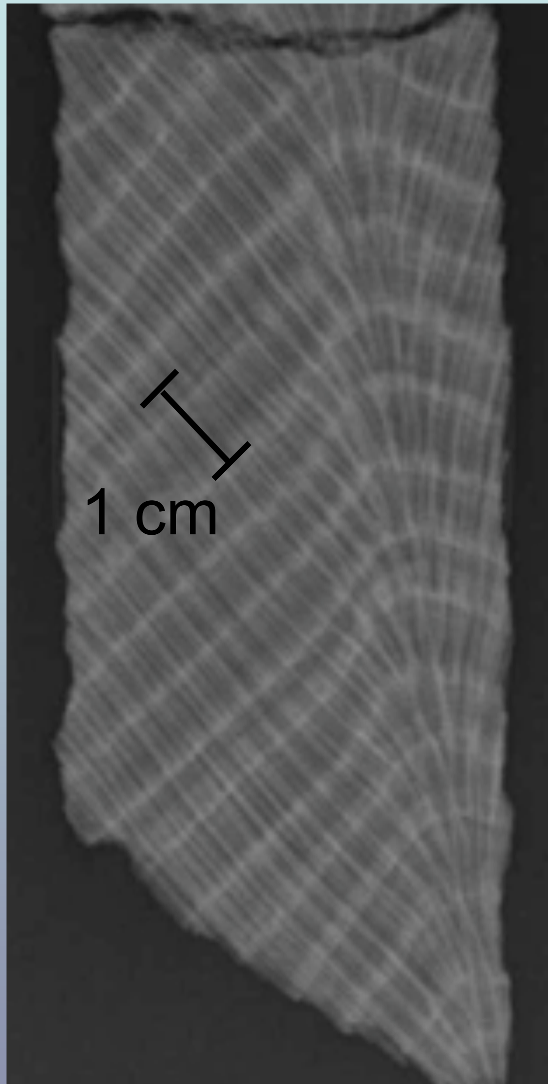
Anatomy of a Coral Polyp
tentacles with nematocysts (stinging cells)
mouth
zooxanthellae
nematocyst
living tissue linking polyps
gastrovascular cavity (digestive sac)
skeleton
limestone calice
© 1999 Encyclopædia Britannica, Inc.



1 cm


Coral Reef


Redwood Forest
www.mass.gov

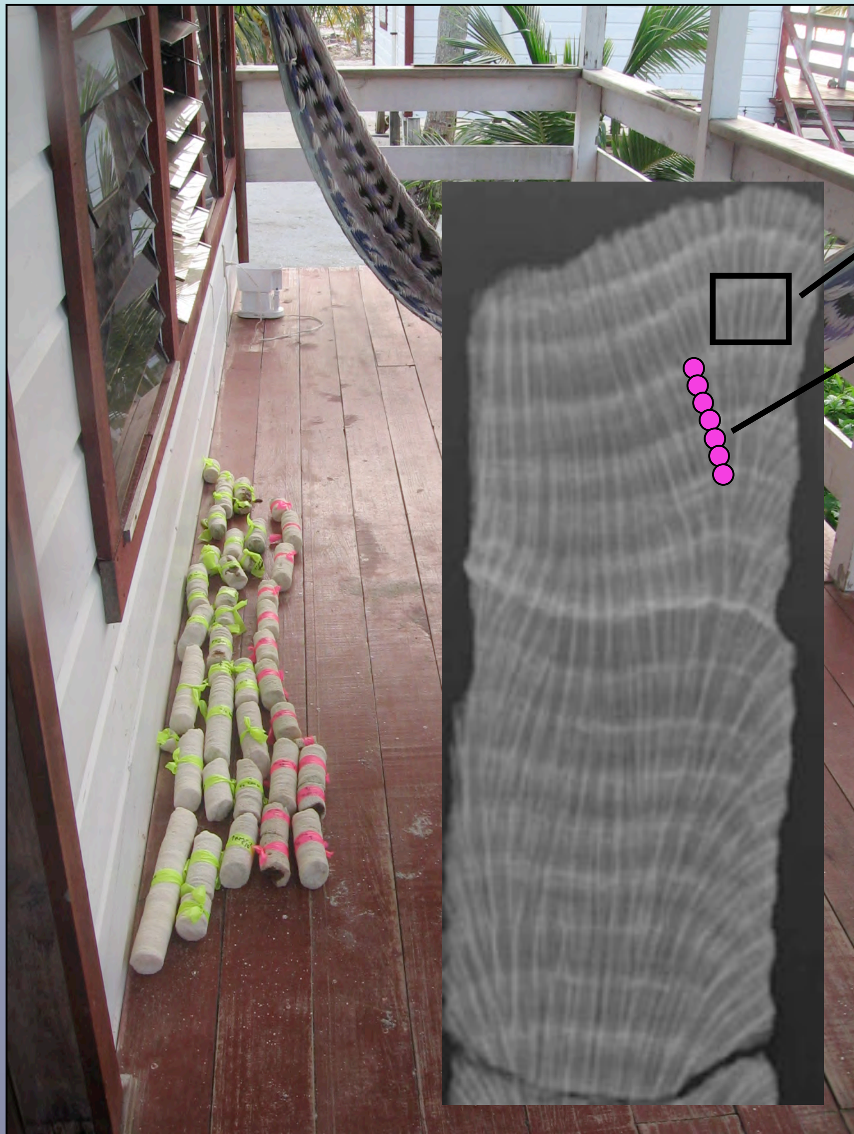


Coral Rings

Tree Rings

http://web.utk.edu/~grissino/images/ashland_hemlock2.jpg

A Wonderful Climate Archive

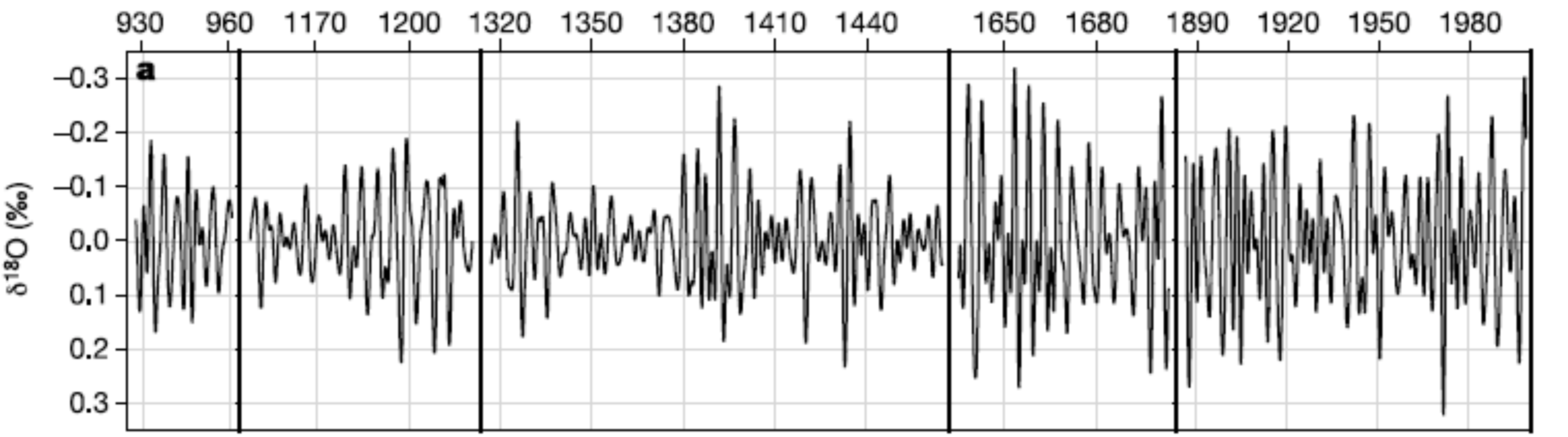


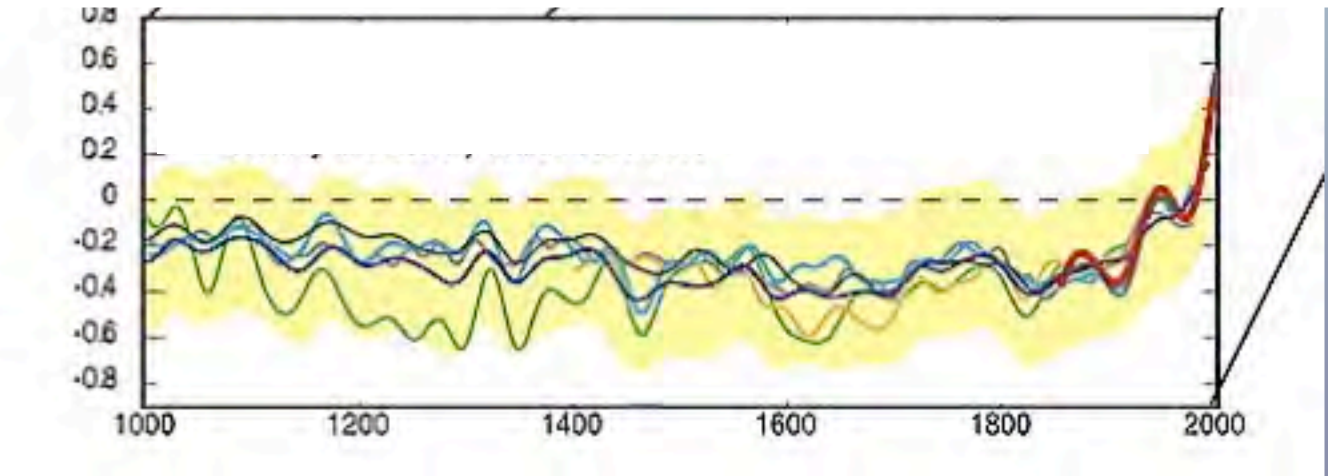
Annual Growth

Monthly (or less)
*Temperature
*Salinity
Oxygen isotopes, Sr/Ca
*Water Quality
Nitrogen isotopes,
Metals

(Also, past sea levels)

Coral Records of El Niño





From Cobb et al., 2003, Nature and IPCC

Bleaching

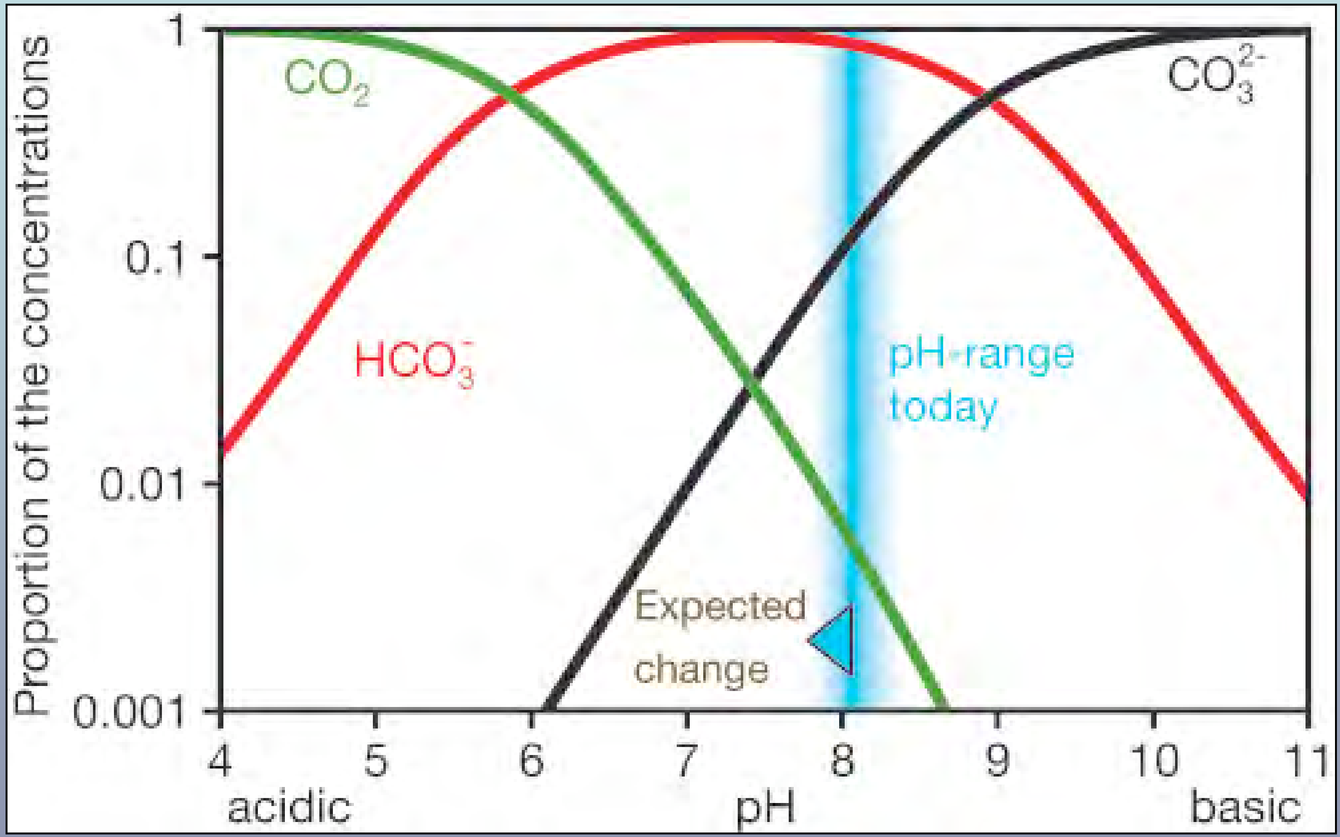
Noaa.gov

uq.edu.au

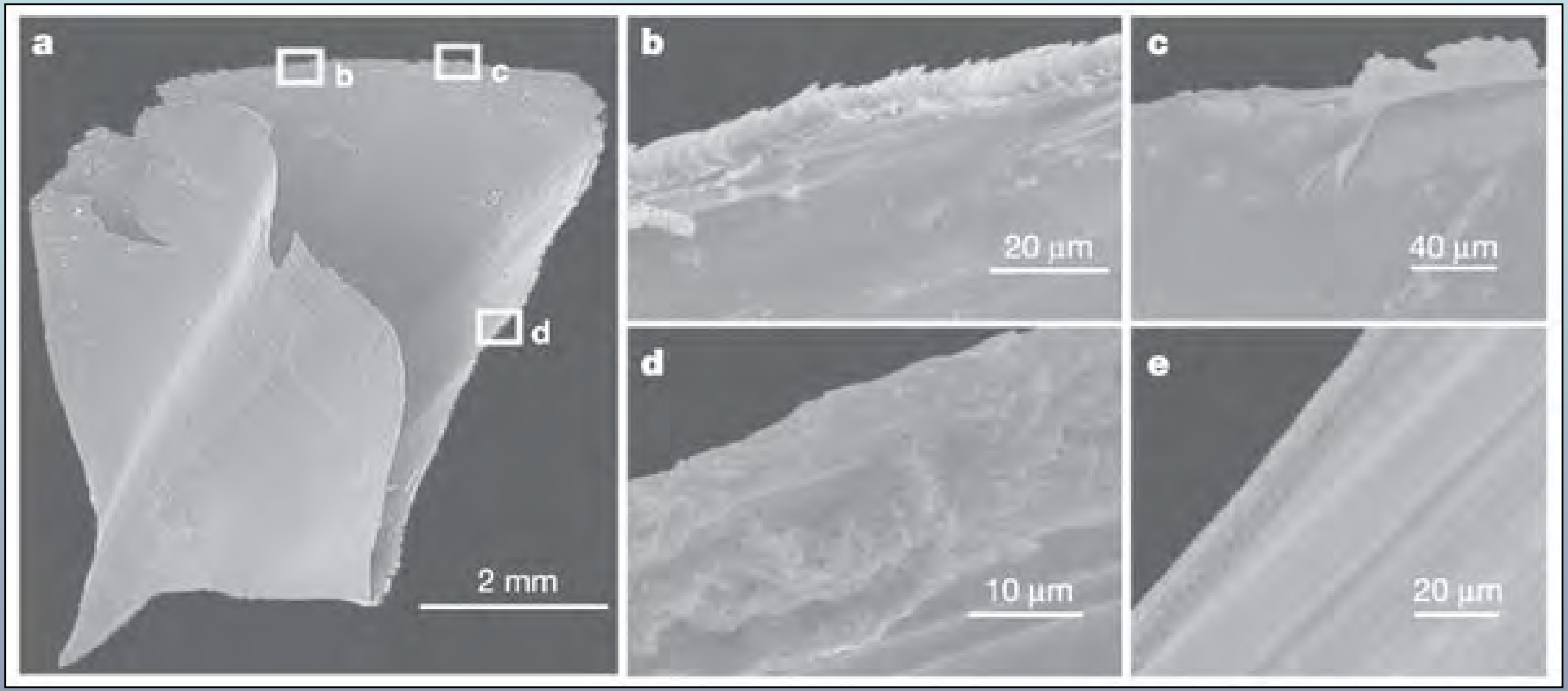
Why Can’t Corals Relocate Poleward?

- Water not as clear, less light
- Ocean is more acidic toward poles
- Potential lack of shallow space for growth

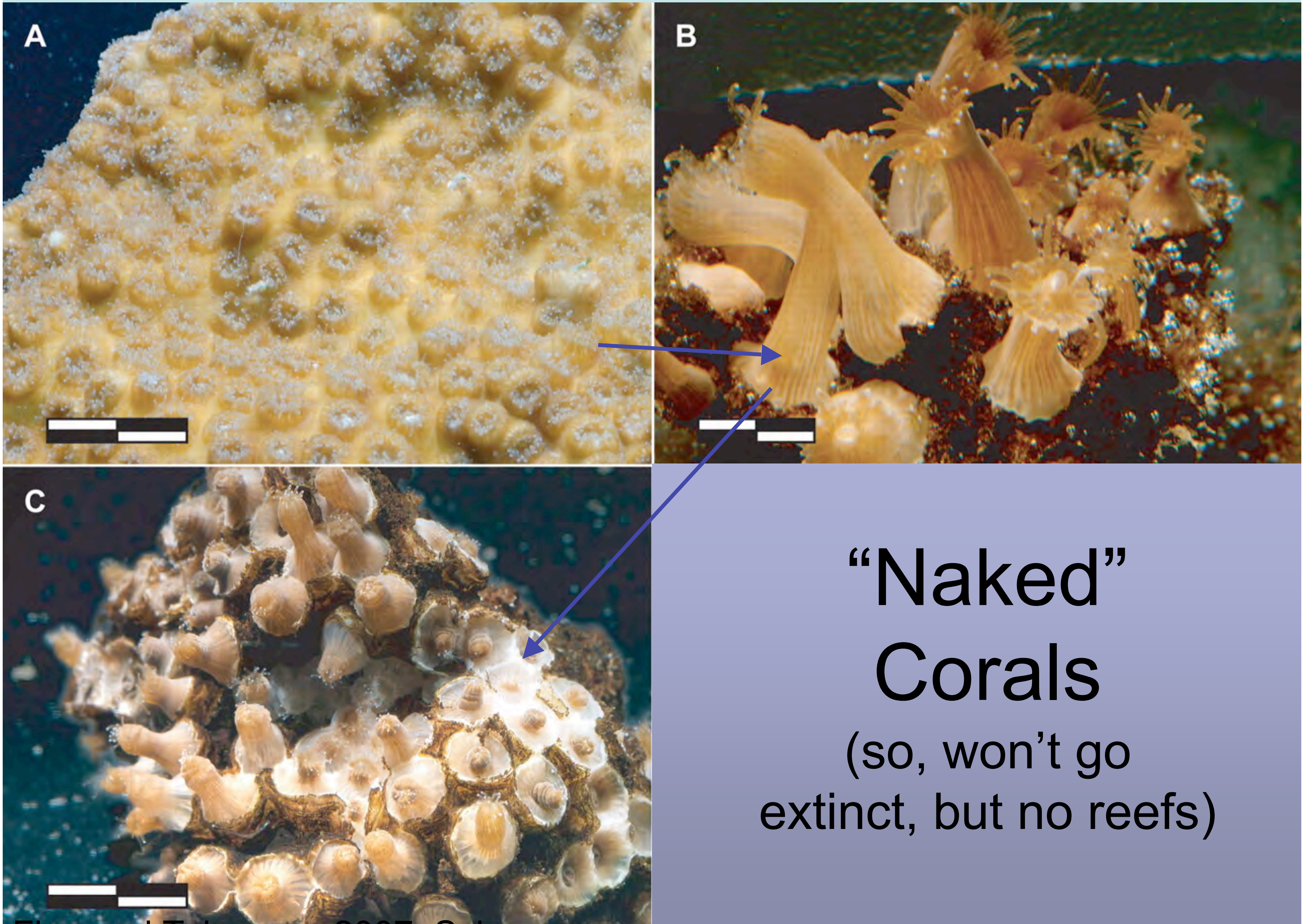
Ocean Acidification



Pteropod Shell Dissolving



From Orr et al., Nature, 2005



“Naked” Corals

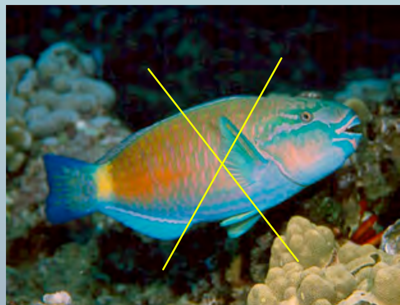
(so, won’t go extinct, but no reefs)

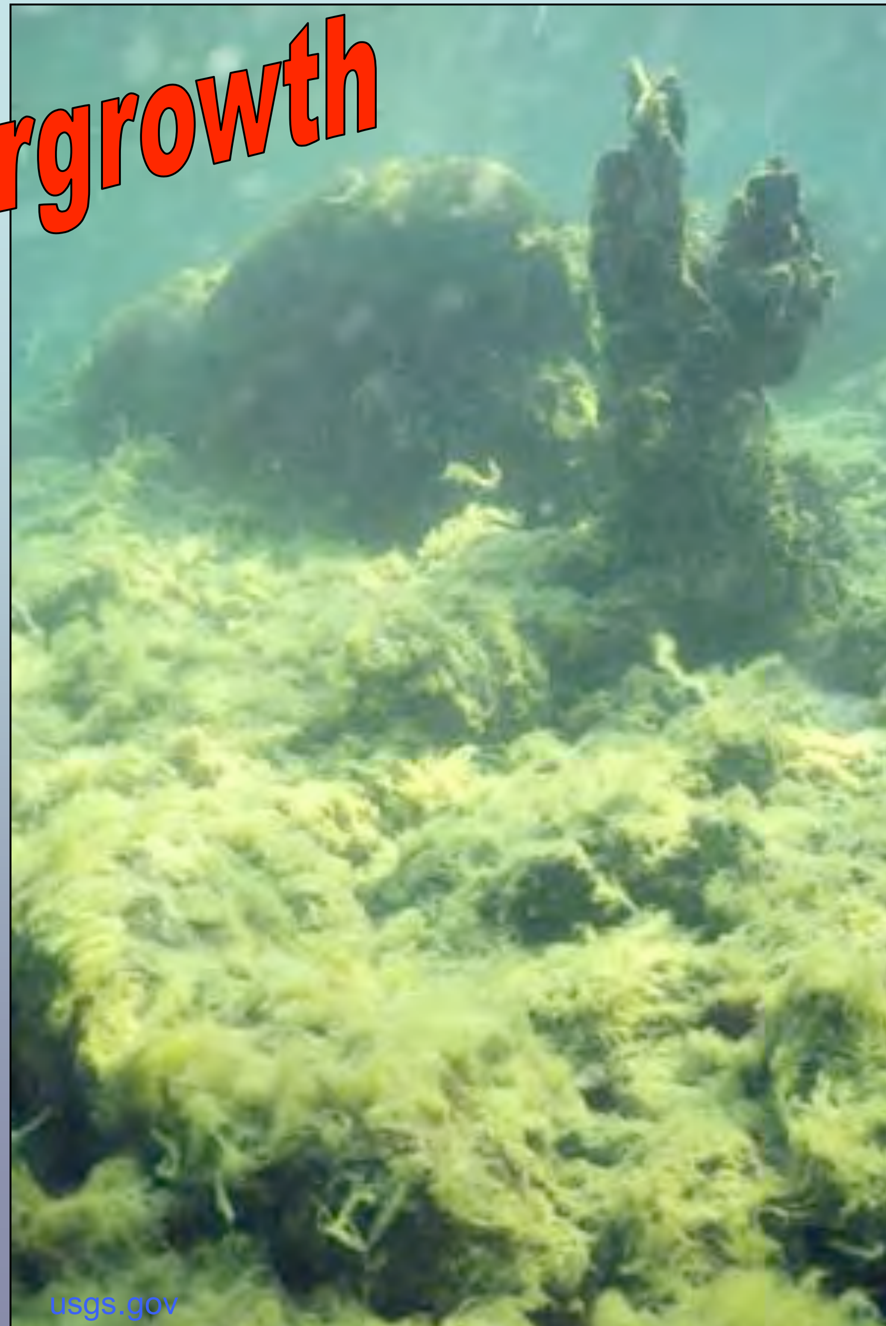
Fine and Tchernov, 2007, Science


Even dead coral is better than nothing.
What happens with Ocean Acidification?

Physical Damage

Algae Overgrowth





Disease

Sedimentation

What Can We Do?

- Decrease emissions
- Support good agricultural practices (organic fruits)
- Buy sustainable seafood
- Support local conservation
- **Spread the word!**

Notes for “Coral Reefs and Climate Change” talk by Jessica Carilli

Slide 3: Coral Reefs are often referred to as rainforests of the sea because they are so high in biodiversity and they occur in tropical waters.

Slide 4: Coral reefs are built by corals; these are colonies of tiny anemone-like animals that produce a skeleton. Over time they grow outwards by adding onto their existing skeleton.
This is a close-up of a coral colony with the tentacles closed. At night most corals open their tentacles to feed. However, they receive most of their food from the photosynthesis of symbiotic algae that live in the coral tissue. The algae are the reason the corals are colorful.

Slide 5: Coral Reefs are also similar to forests because of the 3-d complexity that they create. Corals are like the trees in the forest, which provide habitat for other organisms. Without corals, there would be no reefs.

Slide 6: Corals are similar to trees in another way--they have annual growth rings that we can see in x-rays of slices of coral skeleton. On the right is a slice through a tree trunk, where annual growth bands can be seen by eye. On the left is an x-ray of a slice of coral skeleton. Brighter, higher-density bands are built in the summer. This allows us to measure how much the coral grew in past years, counting back from when it was collected, so we know how healthy the coral was in the past. At the same time, we can measure the chemistry of the skeleton to tell us something about past environmental conditions: water temperature, pollutants, etc.

Slide 7: Corals are a wonderful archive because they are so easily dated. Some other climate archives, like lake sediments or ocean sediments, don’t always have annual layers and can be stirred up later, so it’s more difficult to date them. This slide shows some of the measurements that can be made on coral skeleton samples.

Slide 8: The bottom panel on this slide shows global temperature over the past 1000 years, from the latest IPCC report. Recent warming is evident. The top panel is a record of El Nino strength over the past ~1000 years, which was computed by measuring water temperature records contained in coral skeletons from the middle of the Pacific Ocean. This record indicates that El Nino hasn’t gotten noticeably stronger with the recent warming, which is a potential fear associated with climate change.

Slide 9: Now to switch into how corals are affected by climate, not just how they passively record it: bleaching is the most obvious impact. When water temperatures reach a certain threshold, the symbiosis between coral host and symbiotic algae breaks down, and the algae are ejected. This results in loss of color, so the coral tissue is left clear, hence the term bleaching. The problem with bleaching is that, as stated before, corals get most of their food from the photosynthesis of these symbiotic algae. Without them, corals can starve to death.

Slide 10: Some people wonder why corals can't just move towards the poles if water temperature at the current locations gets too warm. Here are some of the reasons.

Slide 11: Another potential problem associated with climate change is ocean acidification. This plot shows the relative abundances of carbon dioxide, bicarbonate ion, and carbonate ion at different pH levels. These species are in balance with each other at the present ocean pH of about 8.2 . Adding more carbon dioxide to the atmosphere and ultimately the ocean means that this balance will be shifted, pH will drop and there will be less carbonate ion in the water. This will make it more difficult for calcifying organisms to build their shells and skeletons, and dead corals and shells may dissolve away.

Slide 12: This is an image of a pteropod shell dissolving under acidified conditions. Pteropods are made of the same mineral—aragonite—as corals. It's a more open architecture crystal structure of calcium carbonate with is particularly susceptible to dissolving at low pH.

Slide 13: These images are from a study in a laboratory looking at what would happen to corals (a) under severely acidified conditions. The pH was changed to 5 (which is not realistic for the ocean), and the corals did not die. Instead, they morphed into skeleton-less solitary anemone-like organisms (b). After a few months, the pH was returned to normal, and the corals started to grow back into a colony and started to regain their skeleton (c). This indicates that corals will not go extinct from ocean acidification, but they may cease to fill the important role of reef builders.

Slide 14: This is a picture of a dead reef, which still retains some of its 3-d structure, and therefore is still providing habitat, such as for this squirrel fish. With ocean acidification, reefs like this may start to dissolve, further removing precious habitat.

Slide 15: Other problems that coral reefs face include physical destruction from tourists walking on the reef, or anchor damage.

Slide 16: Macroalgal (not the symbiotic algae) overgrowth is another important problem. This can occur from overfishing plant-eating fish, which will then not keep algal growth in check. Increased addition of nutrients, such as from sewage or fertilizer runoff, can also stimulate excessive algal growth. Algae compete with corals for space, and can shade them and prevent larvae from settling. They may also fuel the growth of harmful bacteria which can kill corals.

Slide 17: Coral disease is becoming more and more common. This is an image of a brain coral with black band disease in the Caribbean. Diseases may thrive in warmer waters, and may be caused by bacteria feeding on excess sugars from macroalgae.

Slide 18: Sedimentation is another problem for coral reefs. This image shows soil running off of an agricultural area in Hawaii. Sediment can smother corals, and also often has attached pollutants such as heavy metals which can poison corals.

Slide 19: With all of these threats to coral reefs, there are still things we can each do to prevent loss of reefs. While climate change and ocean acidification are global problems, some of the other impacts are more local and therefore easier to tackle. There is also evidence that corals without these other local impacts are more able to withstand warming temperatures. Some of the things we can each do from afar are to support sustainable fisheries and organic agriculture with our dollars. This will help stimulate growth in these reef-friendly practices. When visiting countries with coral reefs, it is important to support local conservation efforts: make sure the dive operators tell everyone not to touch the corals. If there is a collection for funds to install dive buoys, make a donation, stay in a lodge that has a septic tank, don’t eat lobster or conch out of season or undersize, don’t eat overharvested reef fish, etc.