We didn’t plan to talk about it, but since you asked... Here’s some information on the health of the world’s coral reefs.
What is coral?

- What most people picture when they think of coral is actually just the limestone base of a living system.

- This structure is covered by polyps.
  - The polyps are small tentacled invertebrates that continuously build on to the base structure.
  - Polyps are colorless but act as the hosts to symbiotic single-celled algae that generate the colors of coral reefs and produce sugars that serve as nutrients to the polyps.
  - Since the algae produce the sugars through photosynthesis, coral reefs generally flourish in clear shallow waters.
The waving cilia of coral polyps create fluid motions that transport nutrients.
Why care about coral reefs?

- Reefs support more species per unit area than any other marine ecosystem, including about 4,000 documented species of fish, and 800 species of hard corals.
- $\approx 50\%$ of all federally-managed fisheries species depend on coral reefs for part of their life cycle.
- Coral reefs buffer adjacent shorelines from wave action and prevent erosion, property damage and loss of life.
Reef destruction

- The main concern surrounding coral reef health is a phenomenon called “bleaching”.
- When algae are lost from the polyps, coral loses its color. This occurs when the membrane that binds polyps together weakens and the algae cells are released.
  - Since their food source is gone, bleached polyps can eventually die, leaving behind only the limestone skeleton.
A wonderful image of bleached coral.
(Photo courtesy E.C. Peters)
Several causes of bleaching have been suggested:

- Excess exposure to UV light (caused by loss of ozone in the upper atmosphere)
- High levels of water pollution near reefs.
- Over-fishing

But the most important cause seems to be increased water temperature.

Tests indicate that bleaching can be induced in coral after several weeks of exposure to temperatures 1 to 2 °C above normal summer-time highs.

- The several week time period shrinks to 2 days if the temperature rise is 3 to 4 °C above normal.

Water temperatures above 30 °C will trigger a bleaching event.
Causes of water temperature rise include:

- Thermal pollution
- Natural fluctuations (Ex. El Niño.)
- Global warming
  - Some people have taken bleaching as evidence of an impact of global warming. However, some marine biologists think that it is too soon to come to that conclusion, at least based on the data on that currently exist.
Warmer ocean waters are thought to be a greater threat to reefs than local environmental insults.

Here are data showing a sudden jump in damage stemming from the 1997-1998 El Niño - La Niña event.

<table>
<thead>
<tr>
<th>Region</th>
<th>Pre- 1998 destruction</th>
<th>Occurred in 1998</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arabia</td>
<td>2%</td>
<td>33%</td>
</tr>
<tr>
<td>Indian Ocean, overall</td>
<td>13%</td>
<td>46%</td>
</tr>
<tr>
<td>Australia, Papua New Guinea</td>
<td>1%</td>
<td>3%</td>
</tr>
<tr>
<td>South, East Asia</td>
<td>16%</td>
<td>18%</td>
</tr>
<tr>
<td>Pacific Ocean. Overall</td>
<td>4%</td>
<td>5%</td>
</tr>
<tr>
<td>Caribbean</td>
<td>21%</td>
<td>1%</td>
</tr>
<tr>
<td>Global total</td>
<td>11%</td>
<td>16%</td>
</tr>
</tbody>
</table>
El Niño changes water temperature in the equatorial Pacific. During normal years (top figure) upwelling induced by the east to west surface winds along the equator keeps the surface waters of the central Pacific cool (blue-gray).

During El Niño, the easterly surface winds weaken and retreat to the eastern Pacific, allowing the central Pacific to warm.
Recovery

Most reefs recover from bleaching after a few months. In fact, reefs off the Florida Keys go through “bleaching seasons” almost every summer and recover by fall.

There are indications that each recovery takes a little longer. And, in many cases, reefs have not recovered when high temperature exposure was prolonged and/or repeated.

Example: in 1983 El Niño was particularly harsh and extended, and half the coral colonies off the west coast of Panama died and have not recovered.

Some reefs have recovered from the 1997-1998 El Niño, but it will take them decades to return to their prior state.
Rising levels of CO$_2$ from natural and anthropogenic sources have been absorbed by the oceans

- Oceans absorb about $\frac{1}{4}$ of the CO$_2$ produced by human activity.
- Rising CO$_2$ since the industrial revolution as lowered the pH of the world's oceans from about 8.2 to 8.1.

**CONTRAST** Calcifying organisms, such as these sea urchins grown in seawater acidified with 400 ppm CO$_2$ (left)—the current level in the ocean—produce spines that are truncated by dissolution when reared in seawater acidified with 2,850 ppm CO$_2$ (right), an extreme level for lab tests. Numbered scale in centimeters.
Other Info:

- One theory explaining the weakening of polyps is that high temperatures boosts the rate of algal photosynthesis, thus increasing $O_2$ production. $O_2$ can be toxic to the polyps at high levels.

- Bleaching can have other causes. Oil spills and hurricanes have been responsible for bleaching episodes.
  - Example: The barrier reef off the north coast of Jamaica was destroyed by a hurricane about 20 years ago, and is slowly recovering.

- Coral reefs have other enemies, too. The crown-of-thorns starfish is a notorious destroyer of coral in Australian reefs. One hypothesis is that the numbers of starfish have increased because pollution has decreased the population of predators that feed on the starfish.
The World Heritage committee is threatening to list Australia’s Great Barrier Reef as “in danger”.

This would be an embarrassment to the Australian government which established a 344,440 square kilometer Great Barrier Reef Marine Park in 1975.

The reef’s coral cover shrunk by half between 1985 and 2012, despite the fact that the reef is well managed.
A study in 2000 estimated that 27% of all coral reefs were effectively lost.

A total of 58% may be lost by 2030 if action is not taken.

The major threats include:
- Pollution
- Over-fishing
- Habitat-destruction
- Dredging
- Vessels and anchors
- Disease outbreaks
- Global climate change
Darwin’s paradox asks how productive and diverse ecosystems like coral reefs thrive in the marine equivalent of a desert.

Recent research shows that coral reef sponges are part of a highly efficient recycling pathway for dissolved organic matter, converting it rapidly into cellular detritus that is food for reef consumers.

\[ \text{millimoles of C m}^{-2} \text{ day}^{-1} \]
So, put on your mask and fins and go see a coral reef while you still can.

Remember to be kind to the coral; look but don’t touch.