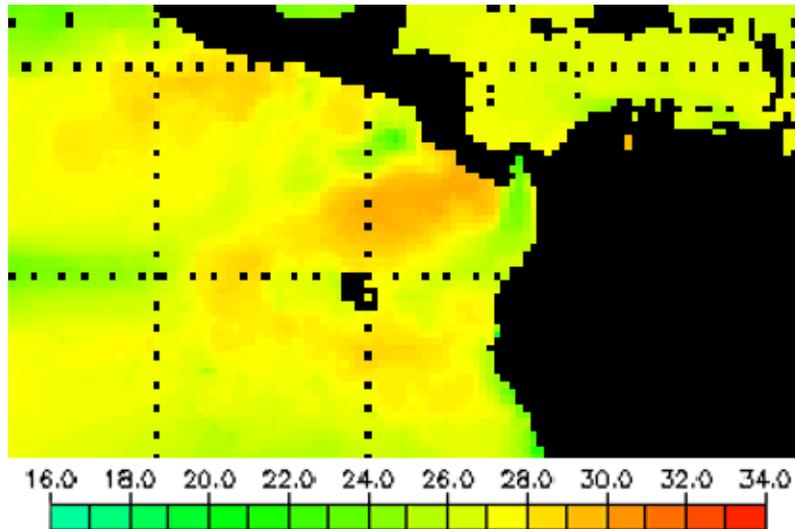
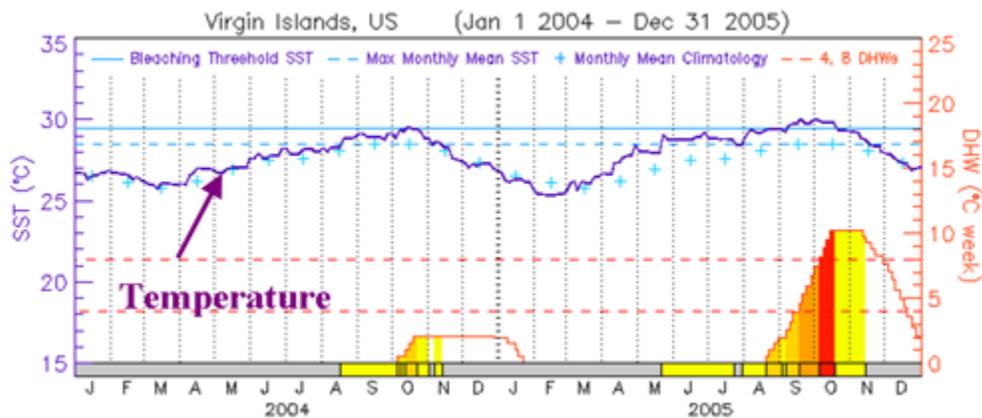


ANSWER SHEET

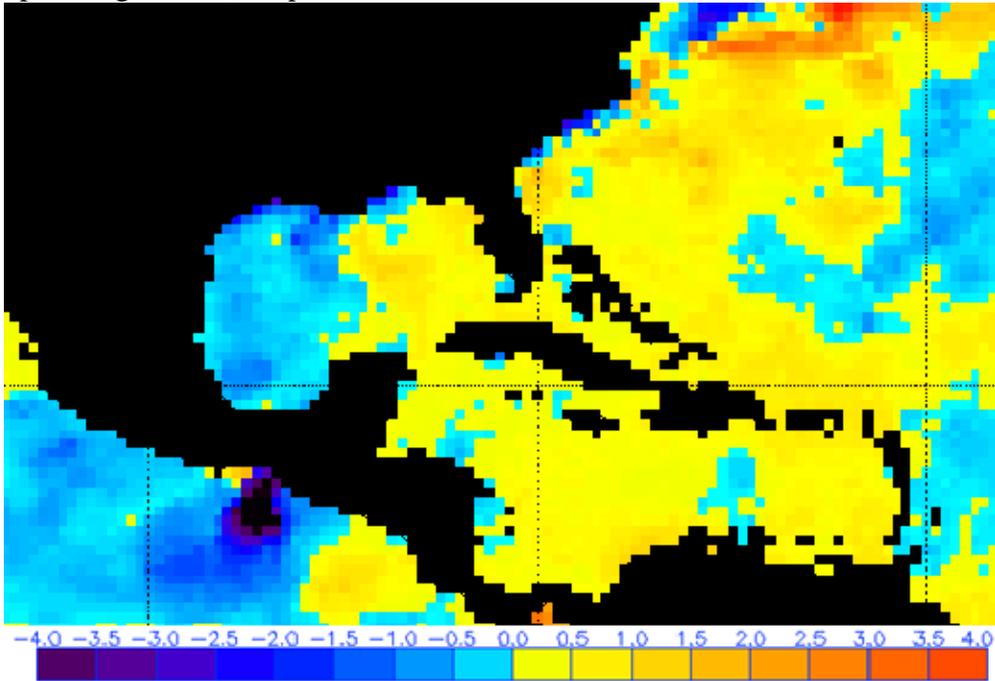
1. The pixels closest to the Galapagos are pale green to yellow, which indicates temperatures around 27°C.



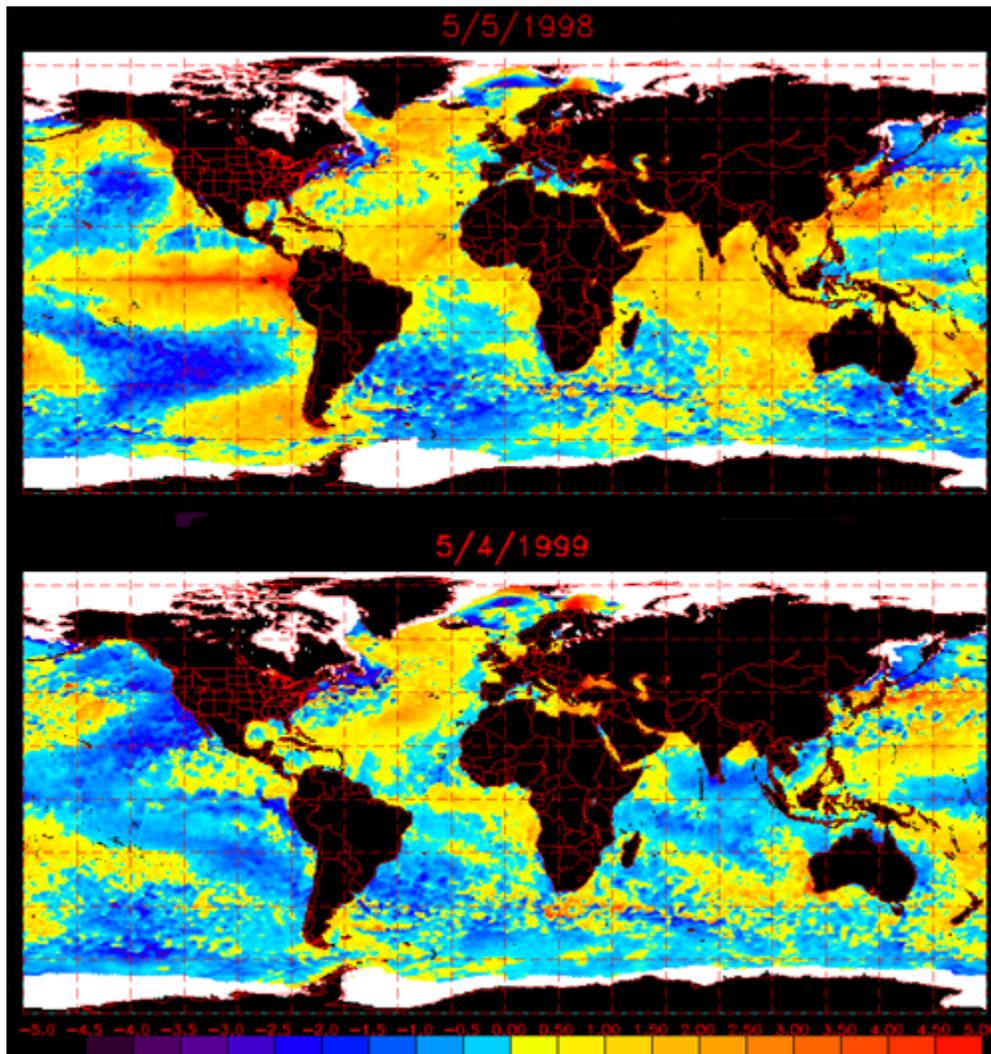
2. The summer of 2005 was consistently above average throughout the spring and summer, definitely warmer than 2004. In fact, there was significant coral bleaching in the US Virgin Islands in late summer 2005.



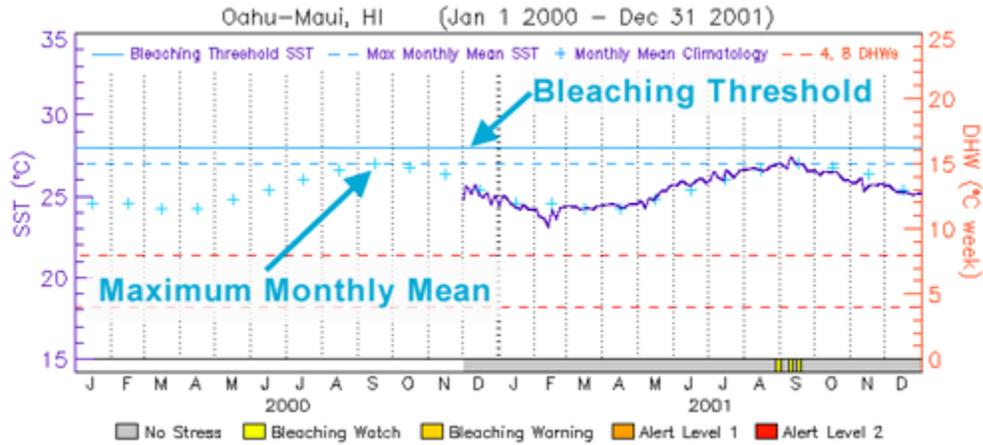
3. Areas in yellow to orange are above the long-term mean for November 1st in that area. Parts of the Gulf Stream current, east of the US coastline, are the furthest above the mean—but all of the central Caribbean and eastern Gulf of Mexico are above average. The western Gulf of Mexico is cooler than the mean. In addition, there is a small area off the Mexican west coast that is more than 3.5°C below the mean—this is probably an upwelling of cold, deep water.



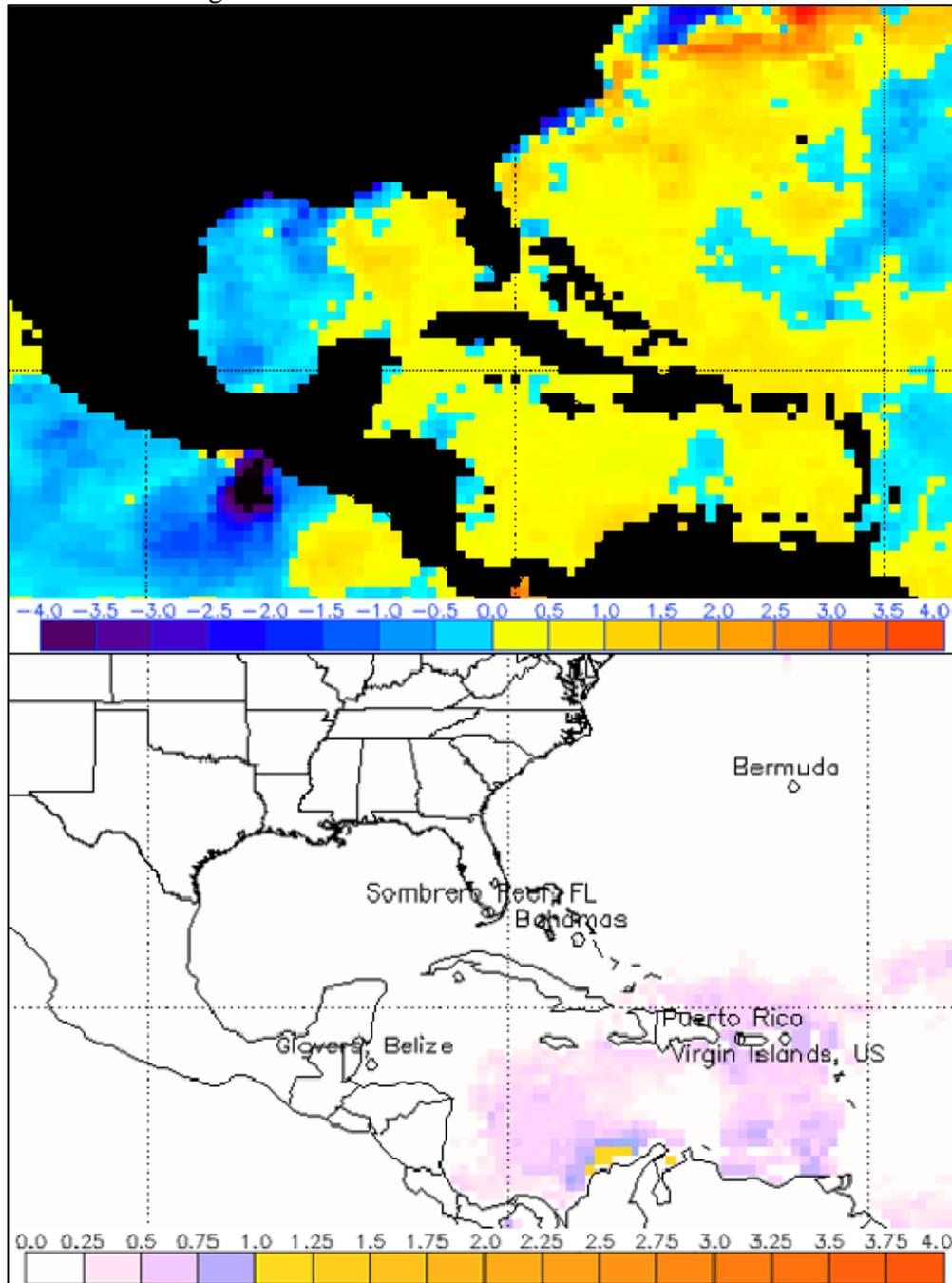
4. Almost everywhere that was warmer than the mean in May 1998 was cooler than the mean in May 1999. This is especially evident along the equator in the Pacific: a huge warm anomaly that was present in 1998 has switched to cooler-than-average one year later. The anomalous warmth in the equatorial Pacific is characteristic of an El Niño period; in fact, 1998 was one of the strongest El Niños on record. This pattern causes many areas of the world's tropical oceans to be warmer than average. By 1999, the equatorial Pacific had switched to being cooler than average—characteristic of La Niña. This pattern causes many other areas to be cooler than normal also, but it does lead to above-average temperatures in some areas of the tropics. This period caused the worst global episode of coral bleaching. It is estimated that 16% of the world's coral reefs were killed during this 1998 El Niño/1999 La Niña.



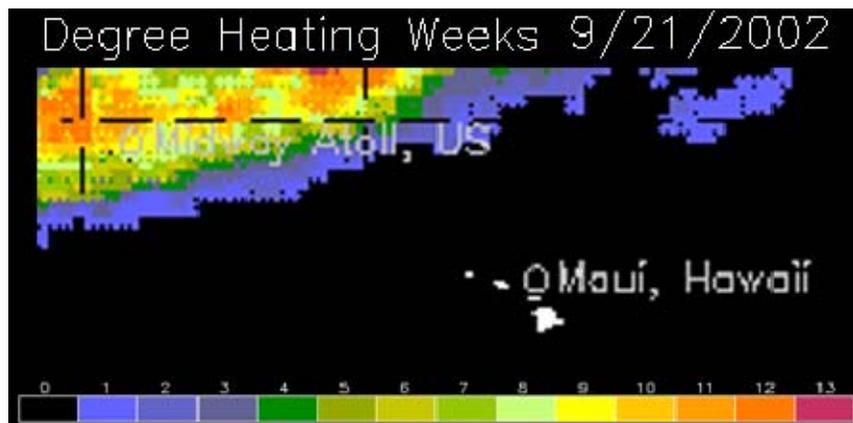
5. The warmest month for the Oahu-Maui pixel, on average, is September. The mean for September is 27°C, so that is the maximum monthly mean (MMM). Note that the MMM is also depicted as a dashed light-blue line. The bleaching threshold temperature is 1°C above the MMM; so for the Oahu-Maui Virtual Station, the bleaching threshold is 28°C (shown as the solid light-blue line).



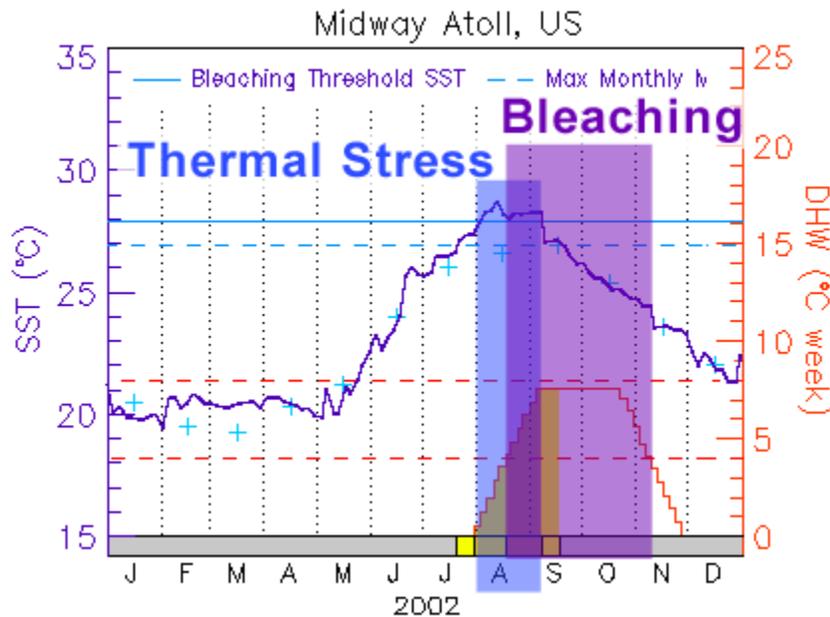
6. The areas that are most above normal in the anomaly image (i.e. the northern Gulf Stream) are not warm enough to be above the maximum monthly mean. In fact, there are almost no HotSpots north of 20 degrees latitude—not surprising, as autumn is progressing in the northern hemisphere. The only HotSpots are found in the southern and eastern Caribbean Sea. The highest HotSpots are just off the northern coast of Colombia—a few pixels in this region have HotSpots greater than 1°C, meaning that they are above the bleaching threshold.



7. The DHWs were highest at the northern end of the Northwest Hawaiian Island chain, reaching a maximum of around 11 or 12 °C-weeks near Midway Atoll. The values then decreased sharply as you move south and east, and disappeared altogether before you're halfway to the Main Hawaiian Islands. In areas around Midway where the DHWs were above 8 °C-weeks, you would predict widespread bleaching and some coral mortality. South and east of there, a zone where DHWs were between 4 and 8 °C-weeks should have seen significant bleaching, especially in sensitive species. Areas in the blue colors, less than 4 °C-weeks, may have experienced mild bleaching. NOAA monitoring cruises surveyed for bleaching just after this 2002 thermal stress; they reported the first mass bleaching in the Northwest Hawaiian Islands, with a gradient of bleaching that was highest in the far northwest ([Kenyon et al., 2006](#)).



8. By looking at the graph and at the text data file, we can see when the temperature first crossed the bleaching threshold: July 30th, 2002. In the data file, you can determine this date because it's the day when DHWs are greater than zero, and the HotSpot also goes above one. On the graph, you can see when the SST trace crosses the bleaching threshold (solid light-blue line). The thermal stress ended on September 7th, 2002. In the data file, you can see when this happens because the HotSpot goes back below one and the DHWs are no longer increasing. On the graph, you can look for the date when the SST crosses back below the bleaching threshold. You expect to see significant bleaching when DHWs are greater than 4 °C-weeks. At this Virtual Station, DHWs remained above 4 °C-weeks from August 16th through November 4th, so we can expect that bleaching occurred during this time period.



9. In the US Virgin Islands, a **Bleaching Alert Level 2** was issued, for DHWs over 8 °C-weeks. Widespread bleaching and some coral mortality would be predicted for this Virtual Station. For the Bermuda Virtual Station, the highest alert was a **Bleaching Warning**. That means that DHWs never got above 4 °C-weeks, and significant bleaching was not expected. In fact, bleaching was very severe in the Virgin Islands during 2005, with 40% mortality in some locations. Bermuda saw little to no bleaching during that same period, due to much lower levels of thermal stress there.