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Reef Currents: When the Next El Nino

Will 2014-2015 be the Next Big El Niño? If so, What Might it Mean for Coral Reefs?

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As of June 2014, the US National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental Prediction (NCEP) has issued an El Niño Watch. There is a greater than 70% chance that an El Niño will develop by late 2014 (Fig. 1). The present consensus forecast calls for a weak-to-moderate event. Additionally, you can see areas likely to bleach up to four months in advance using NOAA Coral Reef Watch's current Seasonal Coral Bleaching Thermal Stress Outlook. Currently, the highest bleaching likelihood can be seen in Guam and the Marianas Islands, the equatorial Pacific around Kiribati, and the eastern tropical Pacific (Fig. 2).

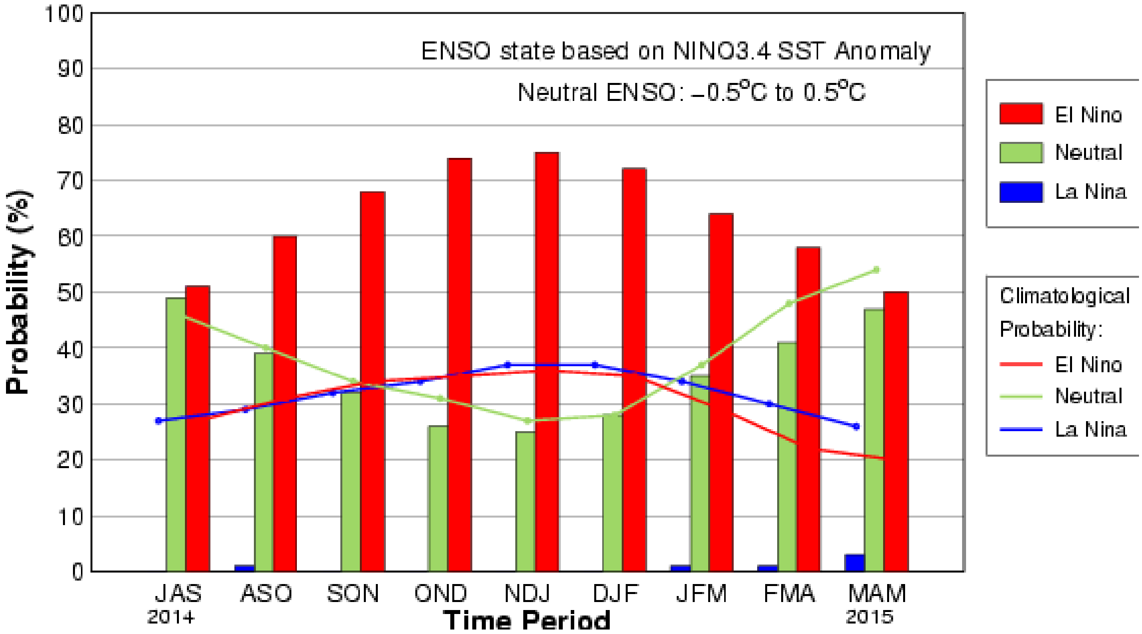


Figure 1: The probability of an El Niño (and La Niña) developing through early 2015 (as of mid-July 2014) from http://iri.columbia.edu/our-expertise/climate/forecasts/enso/. The three lines represent the climatological (i.e., normally expected) likelihood of El Niño, La Niña, or neutral conditions during each month of the year. The bars indicate the likelihood of these three conditions during 2014-2015 based on an analysis of various climate models.

1997-1999 ENSO and Patterns of Coral Bleaching

While each El Niño event follows a different spatial and temporal pattern, the following is a brief overview of the pattern and timing of thermal stress that resulted in widespread severe coral bleaching during 1997-1999. Past reports have estimated that over 15% of the world's coral reefs were effectively lost during the 1997-1999 period (Wilkinson 2000). NOAA Coral Reef Watch satellite-based observations show widespread prolonged high temperatures that caused the coral bleaching and mortality. Some indices rank the 1997-1998 El Niño as the largest on record. It was followed immediately by a strong La Niña (1998-1999). La Niña frequently causes bleaching by warming many areas that are cooled or unchanged during an El Niño (see [Eakin et al. 2009](#)). The 1997-1999 period was unique as both parts of the El Niño-Southern Oscillation (ENSO) system occurred consecutively with no neutral year between.

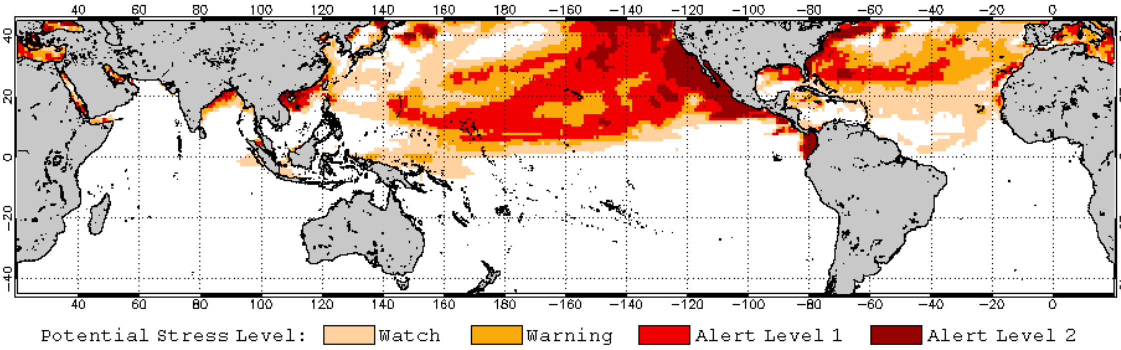


Figure 2: Map of areas where 60% or more of the model ensemble members are predicting thermal stress at each of NOAA Coral Reef Watch's alert levels through October 2014 (as of mid-July 2014).

In short, the tropical oceans experienced thermal stress sufficient for coral bleaching with impacts covering a 14-month period (May 1997-June 1998, Fig 3-6). Reefs in the central Pacific and eastern tropical Pacific were exposed to thermal stress during the early phase of the El Niño. Thermal stress developed on the Great Barrier Reef and across the islands of the south Pacific during February-April 1998 and the Indian Ocean during March-June 1998. Thermal stress in the Gulf of Mexico and the Caribbean, commonly seen in the second year of an El Niño, peaked in July-October 1998. The mid-1998 onset of La Niña conditions resulted in thermal stress in the northwestern Pacific Ocean from July-October 1998.

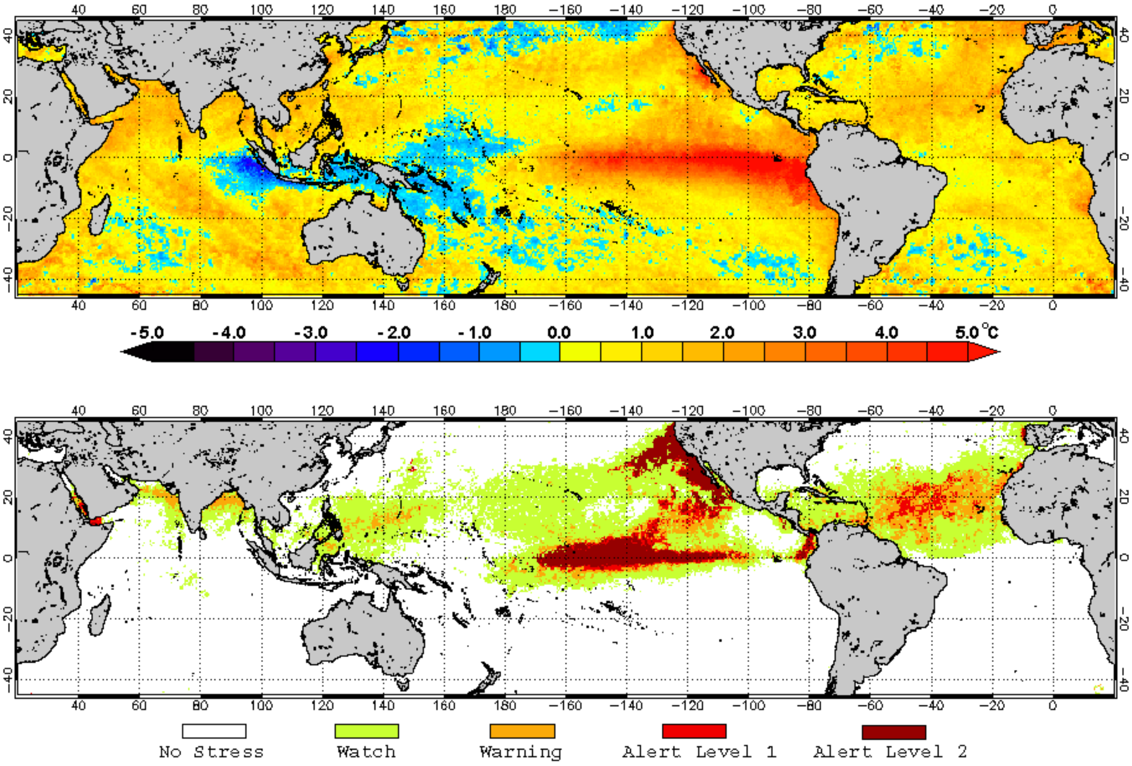
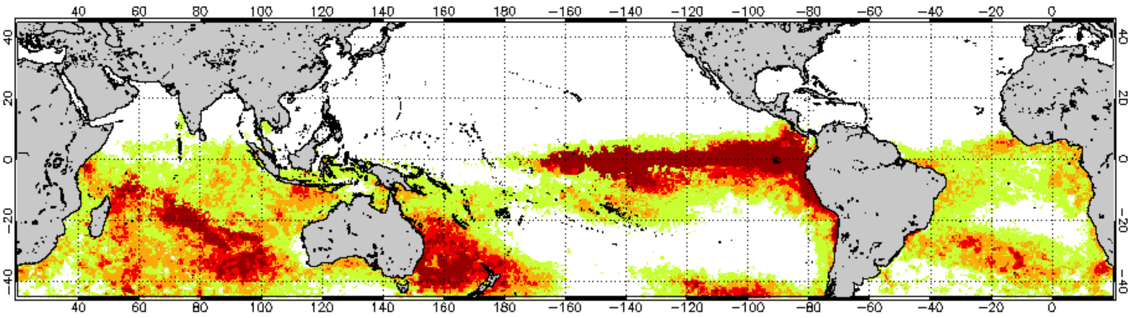
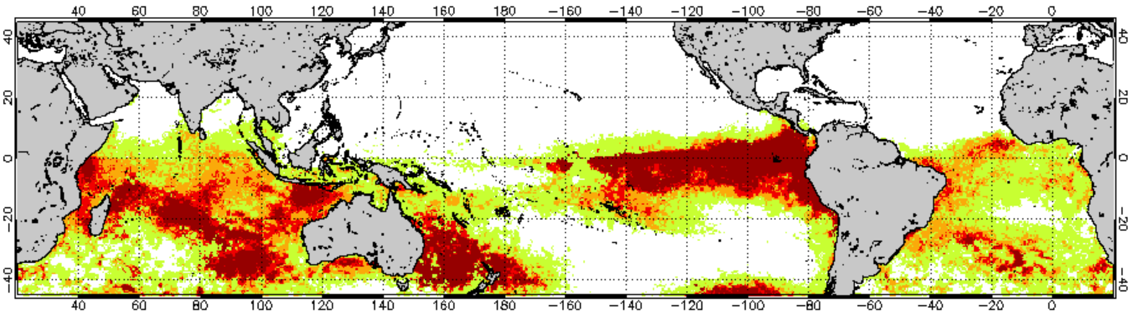


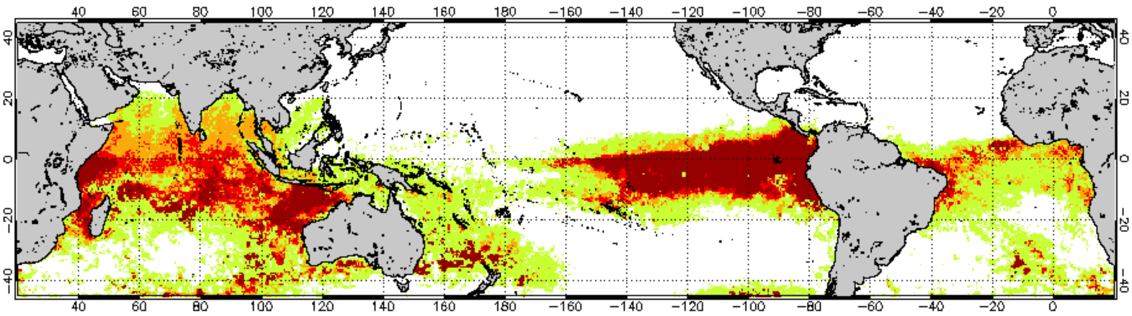
Figure 3: NOAA Coral Reef Watch 50 km satellite SST Anomaly (top) and Bleaching Alert Area (bottom) for October 1997.



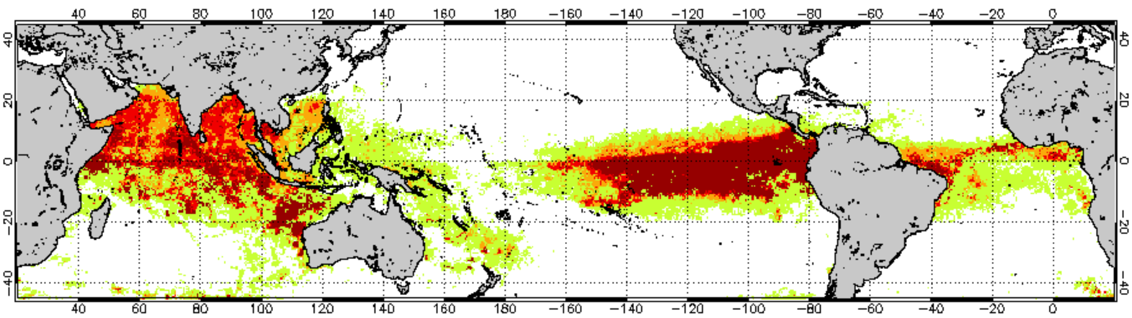
a) Feb 1998



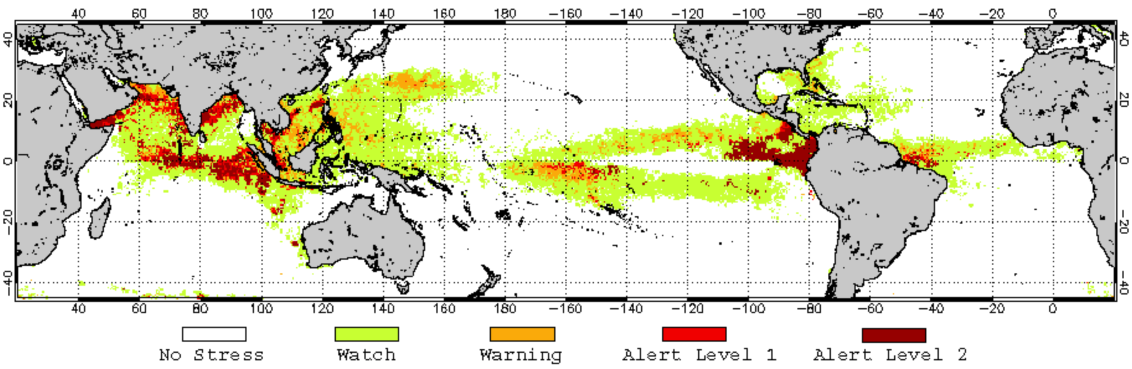
b) Mar 1998



c) Apr 1998



d) May 1998



e) June 1998

Figure 4: NOAA Coral Reef Watch 50 km satellite Bleaching Alert Area for February-June 1998 showing progression of the direct El Niño warming in the Pacific and Indian Oceans.

The following discussion uses the CRW 50 km SST Anomaly and Bleaching Alert Area products (Fig 3-5) to illustrate the events. The Bleaching Alert Area shows patterns of areas with accumulated thermal stress sufficient to cause coral bleaching. The patterns are a bit different, and more coral-focused, than those visible in the SST Anomaly data. More on these products can be found at: http://coralreefwatch.noaa.gov/satellite/index.php.

1997: The classical El Niño warming pattern formed by May 1997, with movement of the Pacific warm pool from the western tropical Pacific eastward to the South American coastline. Prolonged thermal stress with the potential to cause bleaching was seen along the equator, from Howland and Baker Islands east to the Galapagos and the Ecuadorian coastline, during the remainder of 1997 (Fig. 3). During this time, warming also proceeded northward along the South American coast to Panama. Additionally, warming was seen reaching northeast to Mexico, and some warming was seen along the Central American Coastline. Limited warming was seen in the Caribbean (Fig. 3).

1998: By early 1998, the classic El Niño pattern was fully developed, with broader areas of high temperature in the eastern Tropical Pacific and extending up the Central American coast past Costa Rica, including all of the eastern Tropical Pacific islands; high temperatures in these regions began to dissipate in June. Thermal stress also caused coral bleaching along the Great Barrier Reef in February-March (Fig. 4). Warming began in the eastern to central Indian Ocean in February, spreading to the eastern Indian Ocean and dissipating after May (Fig. 4).

With the rapid onset of La Niña conditions in July 1998, warming was observed in the western Pacific Ocean, north of the equator (Fig. 5). August-September saw warming in the South China Sea, Philippines, Palau, and the Ryukyu Islands, which spread southeastward through Palau and Micronesia before finally dissipating in November.

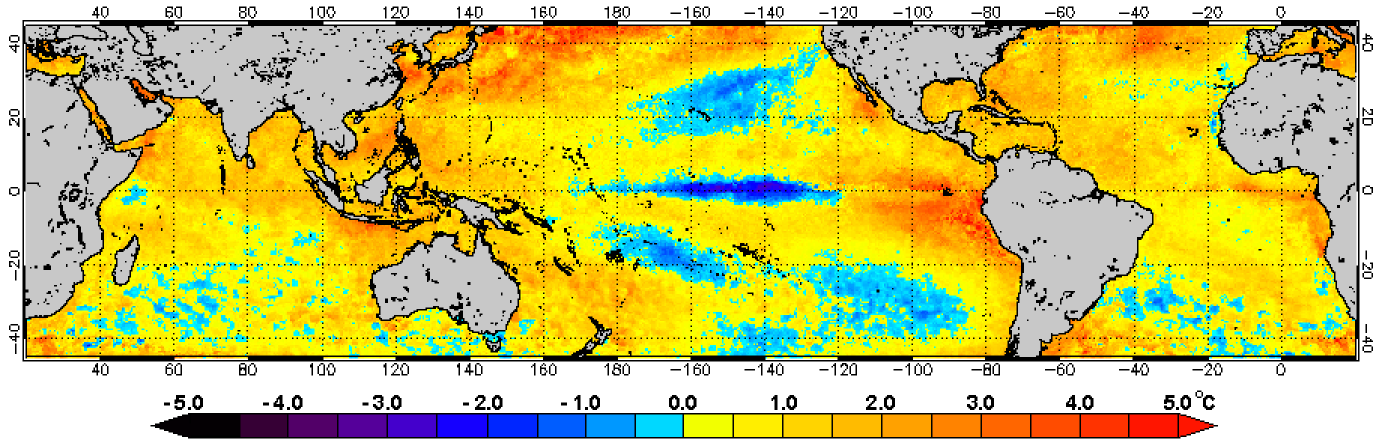


Figure 5: NOAA Coral Reef Watch 50 km satellite SST Anomaly for July 1998.

Thermal stress in the Western Atlantic/Gulf of Mexico/Caribbean is most commonly seen in the summer-fall (warm) season in the year after the onset of an El Niño (Fig. 6). This results from atmospheric teleconnections whereby warming and wind changes in the Pacific cause large-scale changes in the atmospheric wave and jet stream. These atmospheric disturbances cause warming downstream in the Caribbean. While strong El Niño events regularly result in bleaching in the Caribbean, some mild to moderate El Niños contribute to bleaching in this region as well. Warming sufficient to cause bleaching started to develop in July 1998 in Atlantic regions and peaked in the Gulf of Mexico in August and in the Caribbean Sea in October (Fig. 7).

1999: By 1999, the worst of the thermal stress was over, from a coral bleaching perspective, but only after major losses of coral reefs worldwide in 1998. Some warming was seen along the Great Barrier Reef in early 1999 but was much weaker than the prior year. Conditions were rather quiescent until August, when warming of the western North Pacific led to low bleaching levels of thermal stress that reached down to the Mariana Islands. Warming was again seen in the Caribbean in August-September 1999 but to a lesser extent than in 1998.

Each El Niño is different and spatial patterns of warming in the Pacific Ocean can change bleaching in the Indian Ocean and Caribbean Sea. However, bleaching patterns during the weak 2009-2010 El Niño were quite similar to those seen in 1997-1998, only less severe. While the patterns above probably will not be repeated precisely in 2014-2015, the events of 1997-1998 can serve as a guide to likely impacts on coral reefs if this El Niño does develop. We will be watching conditions over the coming months and encourage you to follow El Niño forecasts and observations from organizations such as NOAA/NCEP, as well as NOAA Coral Reef Watch for developments on coral reefs.

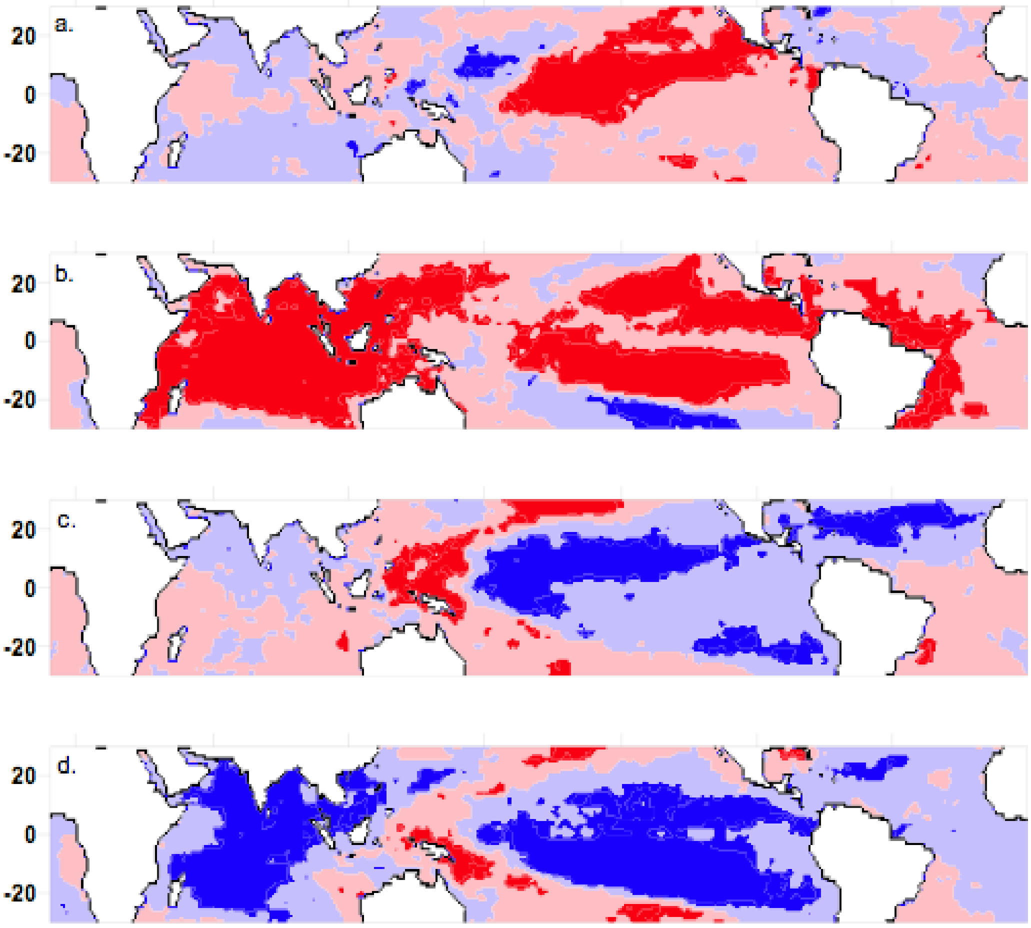
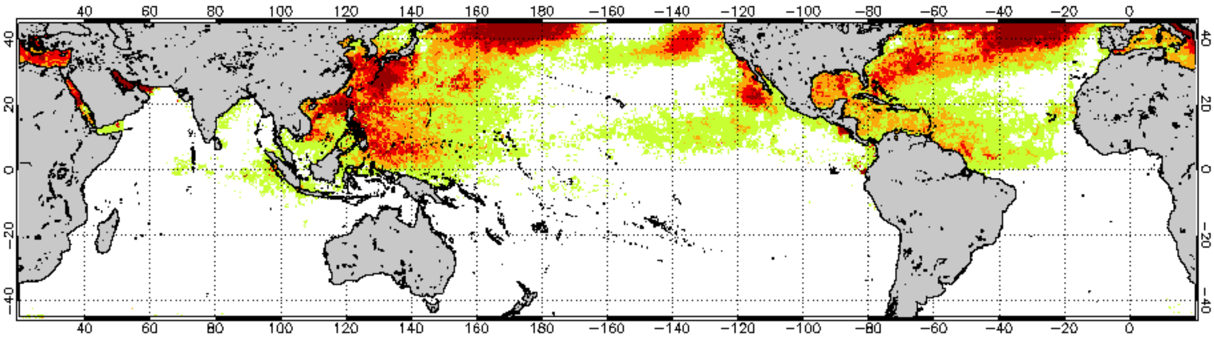


Figure 6: Significantly (at 5% level) warmer *(red)* or cooler *(blue)* annual maximum SST difference during: (a) the onset year of an El Niño, (b) the year after onset of an El Niño, (c) the onset year of a La Niña, and (d) the year after onset of a La Niña. Figures represent average values calculated for 20 El Niño events and 20 La Niña events, and tested for significant differences from 20 ENSO-neutral years. The groups of years were identified from Southern Oscillation Index (SOI) updated by the Australian Bureau of Meteorology (from Eakin *et al.* 2009).

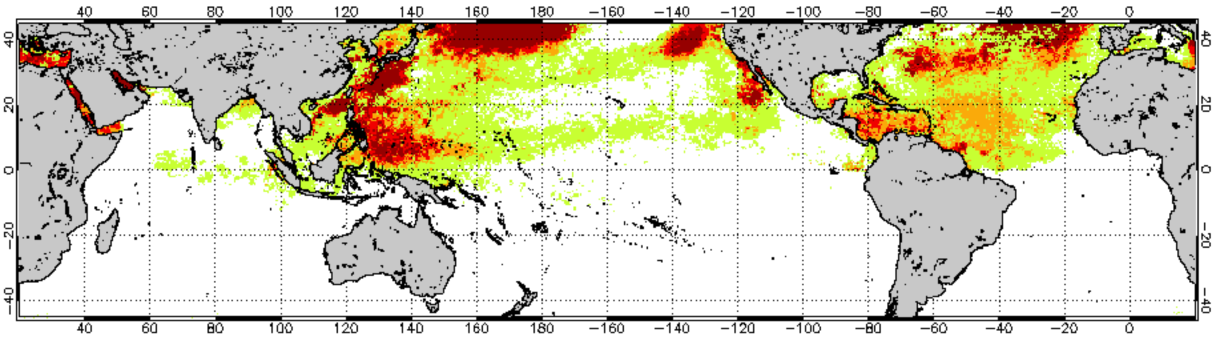
References:

Eakin CM, Lough JM, Heron SF (2009) Climate variability and change: monitoring data and evidence for increased coral bleaching stress. In: vanOppen MJH, Lough JM (eds) Coral Bleaching, Ecological Studies 205: 41-67, Springer-Verlag, Berlin Heidelberg.
Wilkinson, C (2000) Status of Coral Reefs of the World: 2000. Australian Institute of Marine Science, Townsville, Australia.

a) August 1998



b) September 1998



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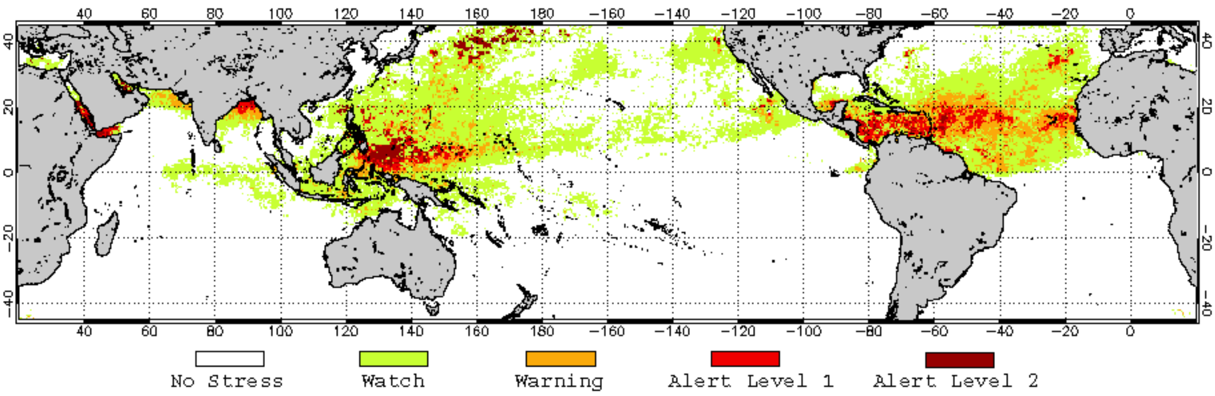

Figure 7: NOAA Coral Reef Watch 50 km satellite Bleaching Alert Area for August-October 1998 showing progression of the teleconnected El Niño warming in the Gulf of Mexico, Caribbean, and western Atlantic.

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