



# REEF CURRENTS

*General articles and overviews of reef science and management*

## Ding, Dong, The Witch is Dead (?)— Three Years of Global Coral Bleaching 2014-2017

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In 2016, we wrote in *Reef Encounter* about the ongoing Third Global Coral Bleaching Event, which was forecast to continue into 2017 ([Eakin et al. 2016](#)). As predicted, the 2015-16 strong El Niño formed, worsening the bleaching, and was followed by a La Niña event. Despite the end of the La Niña, high temperatures persisted into 2017. At least half of the world's coral reef areas bleached in two or all three years of the event, and many suffered the worst bleaching ever documented. As of June 2017, the three-year-long, Third Global Coral Bleaching Event has most likely ended (National Oceanic and Atmospheric Administration, [NOAA 2017](#)) but remains the longest, most widespread, and probably the most destructive ever recorded.

### Recap: Bleaching in 2014

In [June 2014](#) coral bleaching began in Guam and the Commonwealth of the Northern Mariana Islands (CNMI, [Heron et al. 2016](#)) and an El Niño was predicted to form, but never did. [Papahānaumokuākea Marine National Monument](#), the Main Hawaiian Islands ([DAR 2014](#), [Bahr et al. 2015](#)), southeastern Florida and the Florida Keys ([FRRP 2015a](#)) saw bleaching in August and September, while the Republic of the Marshall Islands (Fellenius 2014, [Eakin et al. 2016](#)) saw bleaching from September-November.

### Recap: Bleaching in 2015

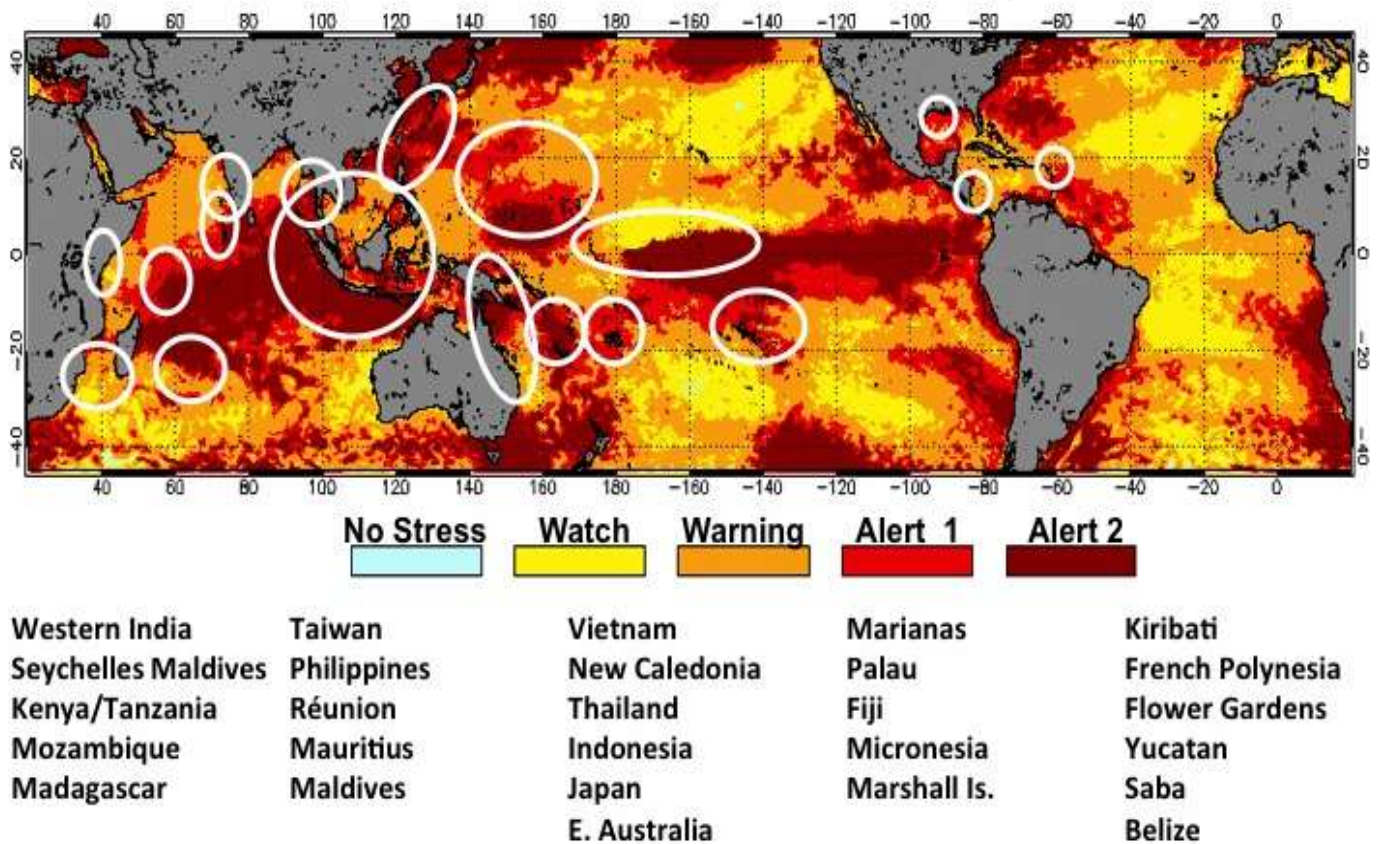
Bleaching worsened as heat stress moved into the southern hemisphere in late 2014/early 2015, striking in the South Pacific, large areas of the Indian Ocean, and parts of Southeast Asia – including severe localized bleaching in Dongsha Atoll in June 2015 ([DeCarlo et al. 2017](#)). With the onset of the 2015-16 El Niño, the heat stress focused on the central and eastern Tropical Pacific. The heat stress spread northward, causing the worst bleaching on record in the Main Hawaiian Islands in October 2015 ([TNC 2015](#), [Eakin et al. 2016](#), [Kramer et al. 2016](#), [Rodgers et al. 2017](#), [Rosinski et al. 2017](#)). In the Atlantic, September-October brought moderate to severe coral bleaching (and disease) and low to moderate mortality to Florida's coral reefs for the second year in a row ([FRRP 2015b](#), [FRRP 2016a](#)); bleaching at varying severities and scales was then reported from multiple locations across the eastern and western Caribbean through October. As of October 2015, with widespread bleaching in each of the Indian, Pacific, and Atlantic basins, [NOAA declared that the Third Global Coral Bleaching Event was underway](#). By the end of 2015, 41% of global coral reefs had been exposed to heat stress of 4°C-weeks or more (measured by NOAA Coral Reef Watch's Daily Global 5km Degree Heating Week version 3 - DHW) and almost all of the world's reefs had exceeded their normal warm-season temperatures.

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## NOAA Coral Reef Watch Maximum Satellite Coral Bleaching Alert Area 2016



**Figure 1.** NOAA Coral Reef Watch Maximum Bleaching Alert Area map for January-December 2016. Severe coral bleaching was reported in all areas circled in white on map and listed below the map. Data from Coral Reef Watch Daily Global 5km Coral Bleaching Heat Stress Monitoring Product Suite version 3 (Liu et al. 2017)

### Bleaching in 2016

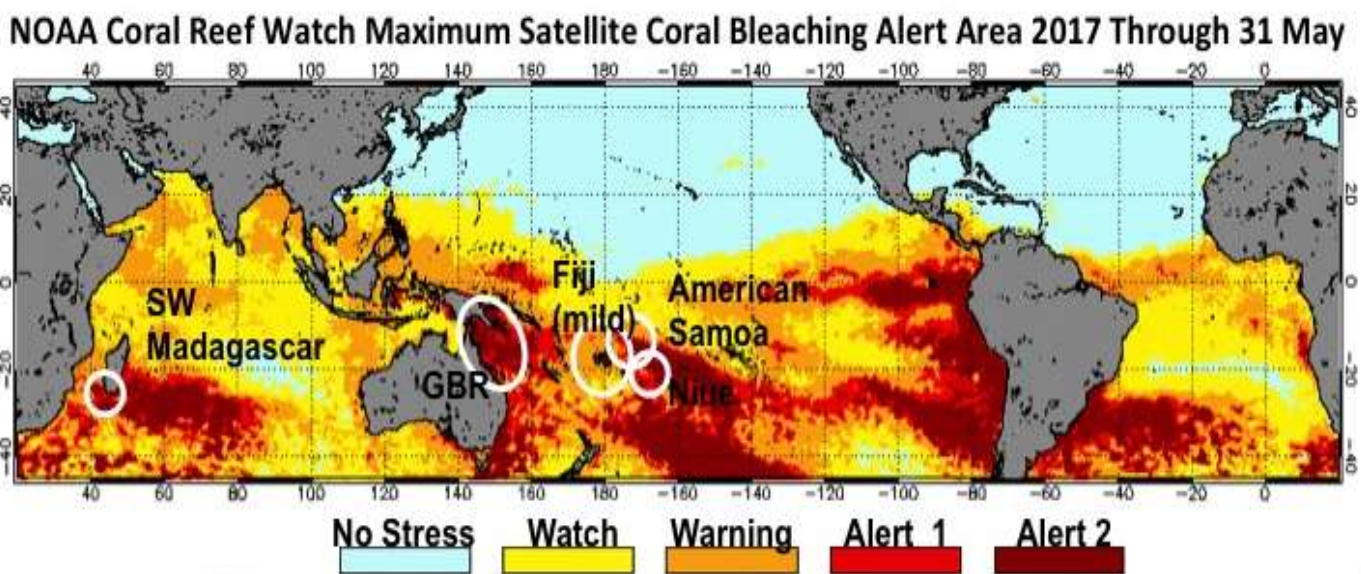
As the El Niño continued to strengthen, heat stress and bleaching returned to the Southern Hemisphere. Heat stress in 2016 was much more widespread than in 2015, encompassing 51% of global coral reefs (as measured by CRW’s DHW). Even more important was the severity. The El Niño resulted in continuous heat stress in the Central Pacific from April 2015 to May 2016. The [Northern Line Islands](#) heat stress values were the highest Coral Reef Watch has ever documented (DHW > 25°C-weeks) and caused the worst bleaching-related mortality ever reported. By May 2016, this included 80% of total coral cover dead and an additional 15% bleached in Kiritimati ([Harvey 2016](#)), as well as 98% total coral cover dead at [Jarvis Island with substantial reduction to reef structural complexity \(investigation into the mechanism of this rapid erosion is underway\)](#). Severe heat stress in Fiji’s lagoons caused sudden and widespread coral death in February just weeks before Cyclone Winston cooled ocean temperatures. Bleaching in New Caledonia in March caused wide swaths of lagoon corals, especially *Acropora*, to fluoresce in [multi-colored pastels](#). The first major bleaching ever documented on the Northern and Far Northern sectors of the Great Barrier Reef (GBR) peaked in March ([Hughes et al. 2017](#)). This was the worst bleaching ever seen in the GBR resulting in 29% mortality of shallow-water corals across the entire reef ([GBRMMPA 2017](#)). Coral bleaching started in the Western Indian Ocean in January and peaked by May ([CORDIO-EA](#)), with bleaching in the Seychelles ranging from 69-99% resulting in a subsequent 50% reduction in hard coral cover (SIF 2017). Bleaching in Southeast Asia caused Thailand in May to close many of its coral reefs to recreational diving activities ([AFP 2016](#)). Bleaching in Guam, especially Tumon Bay, returned for the fourth year in a row.

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In the boreal summer, bleaching returned to the Northern Hemisphere, with extensive (over 90%) bleaching observed in the largest coral reef in the Ryukyu Islands, Japan starting in July, resulting in 70% mortality ([Harvey 2017](#)). The heat stress then brought bleaching back to the western Atlantic, Gulf of Mexico, and Caribbean from September through November, with the western Caribbean hit hardest. Florida suffered only mild to moderate bleaching in summer 2016 but was struck by another round of coral disease, including the loss of 95% of pillar coral (*Dendrogyra cylindrus*) across the state ([FRRP 2016b](#)). October brought the worst bleaching ever to the Flower Garden Banks, while patchy bleaching was reported from the eastern Caribbean. Moderate to severe bleaching (generally more severe than in 2015) also was reported in parts of the Mesoamerican Barrier Reef in October and November, with deeper reefs being impacted more so than shallow. The year culminated in a return of bleaching to the Republic of the Marshall Islands by November 2016. Figure 1 shows the total extent of heat stress in 2016 and regions with confirmed coral bleaching reports.



**Figure 2.** NOAA Coral Reef Watch Maximum Bleaching Alert Area map for January-May 2017, with coral reef areas with reports of bleaching circled in white. Data from Coral Reef Watch Daily Global 5km Coral Bleaching Heat Stress Monitoring Product Suite version 3 (Liu et al. 2017)

### Bleaching in the First Half of 2017

Mild coral bleaching started in Fiji in January 2017, but stormy conditions cooled the water, averting severe thermal stress and bleaching. However, severe bleaching was reported in Niue in February and by March, bleaching returned to American Samoa and Samoa. This time, bleaching was much more extensive bleaching on the outer reefs than in 2015. The first-ever consecutive bleaching was confirmed on the GBR in March ([Hughes and Kerry 2017](#)). This time, the Northern (again) and Central sectors were most impacted in what would have been the worst bleaching of the GBR, if not for the mortality from 2016. Heat stress was limited in the Indian Ocean, with the only pocket of moderate bleaching reported from southwestern Madagascar in April ([CORDIO-EA](#)). Reports indicate that bleaching elsewhere in the Indian Ocean has been mild. Figure 2 shows the total extent of heat stress in 2017 and regions with confirmed bleaching reports.

As of September 2017, NOAA's El Niño-Southern Oscillation Alert System has issued a [La Niña Watch](#), with a 55-60% chance of La Niña formation during late 2017. [NOAA Coral Reef Watch's Four-Month Coral Bleaching Heat Stress Outlook](#) indicates that bleaching is much less likely in most of the Northern Hemisphere this summer (Figure 3). However, the Outlook through December 2017 does indicate a potential for significant bleaching and potential coral mortality in the western Pacific Ocean (from the Guam through Micronesia); in the eastern portion of the Papahānaumokuākea Marine National Monument; and in the Caribbean Sea. We anticipate a similar level of risk to the rest of the western Atlantic and Caribbean after August and through the end of the year. While more coral

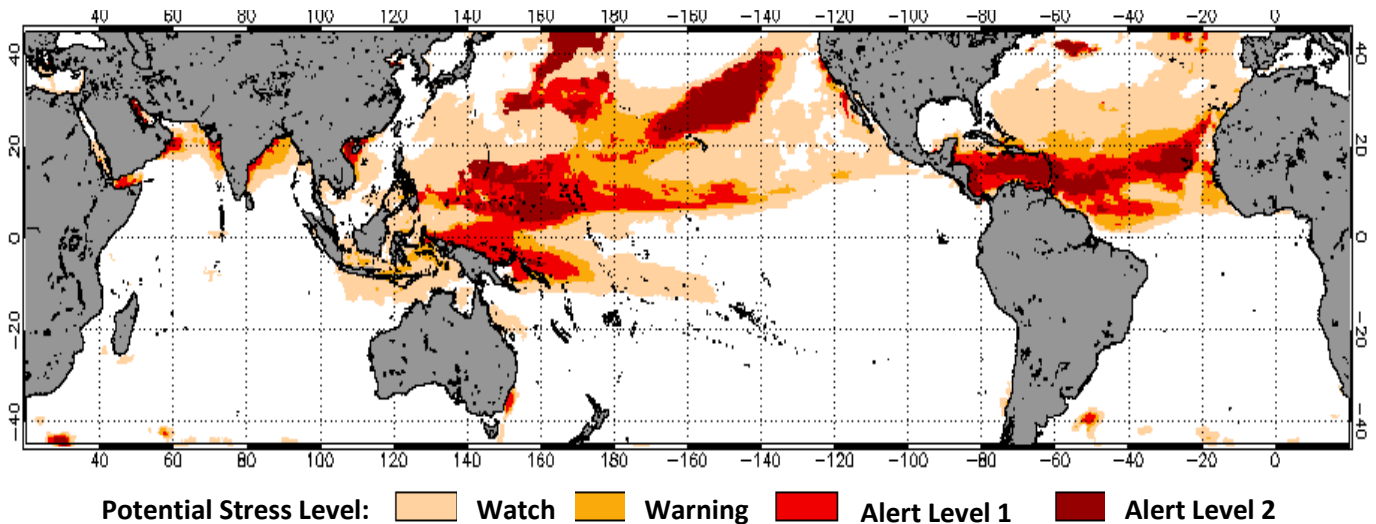
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bleaching may still occur in 2017, the absence of widespread coral bleaching in the Indian Ocean appears to signal that the three-year-long global event has ended.

### 2017 Sep 12 NOAA Coral Reef Watch 60% Probability Coral Bleaching Thermal Stress for Sep-Dec Experimental, v4.0 CFSv2-based, 28 to 112 Ensemble Members



**Figure 3.** Map of areas where 60% or more of the model ensemble members were predicting heat stress at each of NOAA Coral Reef Watch's bleaching heat stress alert levels through December 2017 (as of 12 September 2017). Data from Coral Reef Watch Four-Month Coral Bleaching Heat Stress Outlook version 4 (Liu et al. 2017)

### Documenting the 2014-2017 Global Bleaching Event

With the Third Global Coral Bleaching Event apparently coming to a close, NOAA Coral Reef Watch is now working in earnest to collate reports on the global extent of this event. We are planning a follow-on global summary paper similar to our 2005 Caribbean Bleaching Event paper (Eakin et al. 2010). We truly appreciate all reports we have received so far, many of which contributed to this brief review of the global event. Please assist us further by continuing to report coral bleaching and disease observations to your existing regional programs such as the Global Coral Reef Monitoring Network nodes, ReefCheck, CORDIO-EA, AGRR, etc. Also, please send a brief email to [coralreefwatch@noaa.gov](mailto:coralreefwatch@noaa.gov) to let us know where you submitted them. If you aren't involved in one of these [monitoring programs](#), please submit your reports directly to the Coral Reef Watch [Report Bleaching](#) web page. Coral Reef Watch needs both bleaching and non-bleaching observations to document the spatial extent and timing of the event and to continue to improve its satellite and climate model-based products. Contributing your observations ensures that your site's data are considered in global analyses; gives context to how bleaching patterns at your sites compare with global patterns; and provides access to the latest global coral bleaching data analyses to communicate climate impacts to decision makers. All contributors will have the opportunity to co-author peer-reviewed publication(s) on global and/or regional bleaching.

A special issue or portion of an issue of the ISRS journal *Coral Reefs* will focus on this event. This will be an opportunity for you to publish more detailed studies on coral health, bleaching, disease, and mortality in your country or region associated with the Third Global Coral Bleaching Event.

Since our last update ([Eakin et al. 2016](#)), filmmakers at Exposure Labs completed an 89-minute documentary on their efforts to capture time-lapse imagery of coral bleaching during the Third Global Coral Bleaching Event. The film includes many of your contributions to their global call for bleaching reports and part was shot at the 13<sup>th</sup> International Coral Reef Symposium in Honolulu, Hawaii. The resulting film, [Chasing Coral](#), premiered on Netflix on July 14, 2017 (see the two more detailed articles about the film on pages 46 - 50).

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## Final Thoughts

With the end of the Third Global Coral Bleaching Event, it is more essential than ever that coral reef ecosystem scientists, managers, and other stakeholders, including the public, work together to increase our collective knowledge as we continue toward a future with a changed climate. While continuing and expanding efforts to reduce local stressors, we all must work to address the cause of global warming through reducing atmospheric carbon dioxide concentrations and emissions.

## Acknowledgements:

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Coral Bleaching at Heron Island, Great Barrier Reef, Australia (Photo credit - courtesy of The Ocean Agency / XL Catlin Seaview Survey / Richard Vevers ).