REEF ENCOUNTER
The News Journal of the International Society for Reef Studies
Reef Currents: Global Coral Bleaching

REEF CURRENTS

General articles and overviews of reef science and management

Global Coral Bleaching 2014-2017

Status and an Appeal for Observations

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In 2014 we wrote in *Reef Encounter* about the prospect for a 2014-15 El Niño (Eakin et al. 2014). While that El Niño never fully formed, it helped set off the ongoing multi-year global coral bleaching event. A subsequent 2015-16 strong El Niño formed, spreading and worsening the bleaching, and has already caused bleaching in some areas two years in a row. As of April 2016, the current global coral bleaching event is the longest ever recorded. While it generally has not been as severe as the bleaching in 1998, it has affected more reefs than any previous global bleaching event and been worse in some locales (e.g., Great Barrier Reef, Kiribati), and thermal stress during this event has caused mass bleaching in several reefs that never bleached before.

Climatic History of the Global Bleaching Event

In June 2014 the US National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental Prediction (NCEP) issued an El Niño Watch, indicating a greater than 70% chance that a weak-to-moderate El Niño would develop by late 2014. While the ocean warmed for several months, the atmosphere never fully engaged in formation of this event, and the warming dissipated without an El Niño being declared. However, warming resumed early in 2015 - this time with full engagement of the atmosphere. In March 2015, NOAA issued an El Niño Advisory, indicating that El Niño conditions had finally been observed and were expected to continue. Starting in 2013 and coincident with these events, an unusually warm patch of water appeared in the eastern North Pacific. Nicknamed "The Blob", it was most likely caused by a record-strength anomalously strong high-pressure ridge in the atmosphere over the region (Bond et al. 2015). This anomaly increased already warm ocean temperatures impacting marine life in much of the eastern North Pacific until late 2015 when the strengthening El Niño caused it to dissipate.

As of April 2016, NOAA's El Niño Advisory remains in effect, but the warming in the central to eastern tropical Pacific has begun to dissipate, following the usual chronology of an El Niño. Importantly for some reefs, such as in Micronesia and Palau, a La Niña Watch is in effect as the forecast estimates a >70% chance of a La Niña forming later this year.

2014: Initiation of the Global Bleaching Event

The current global coral bleaching event began in June 2014, with initial bleaching in Guam and the Commonwealth of the Northern Mariana Islands (CNMI, Heron et al. 2016a) – an area not normally linked to warming during an El Niño (Figure 1). Warming in Guam and the CNMI lasted until October 2014. Regions of anomalously warm water

then expanded until they merged with the southwestward extension of "The Blob", encompassing parts of the Hawaiian archipelago, where the most severe bleaching was seen at Lisianski Atoll in the Papahānaumokuākea Marine National Monument. Thermal stress and bleaching extended into the Main Hawaiian Islands where major bleaching was seen along windward Oahu, especially Kāne'ohe Bay (Bahr et al. 2015). This was only the second widespread bleaching ever seen in the main islands of Hawai'i (Jokiel and Brown 2004). Also, in September 2014, severe bleaching was documented in both southeastern Florida and the Florida Keys. In November, sustained high water temperatures in the Republic of the Marshall Islands resulted in their most severe bleaching on record (Fellenius 2014). NOAA Coral Reef Watch's 5-km Degree Heating Week values (Liu et al. 2014) exceeded 8 °C-weeks (categorized as Alert Level 2 thermal stress, associated with widespread coral bleaching and significant mortality) in many of these areas.

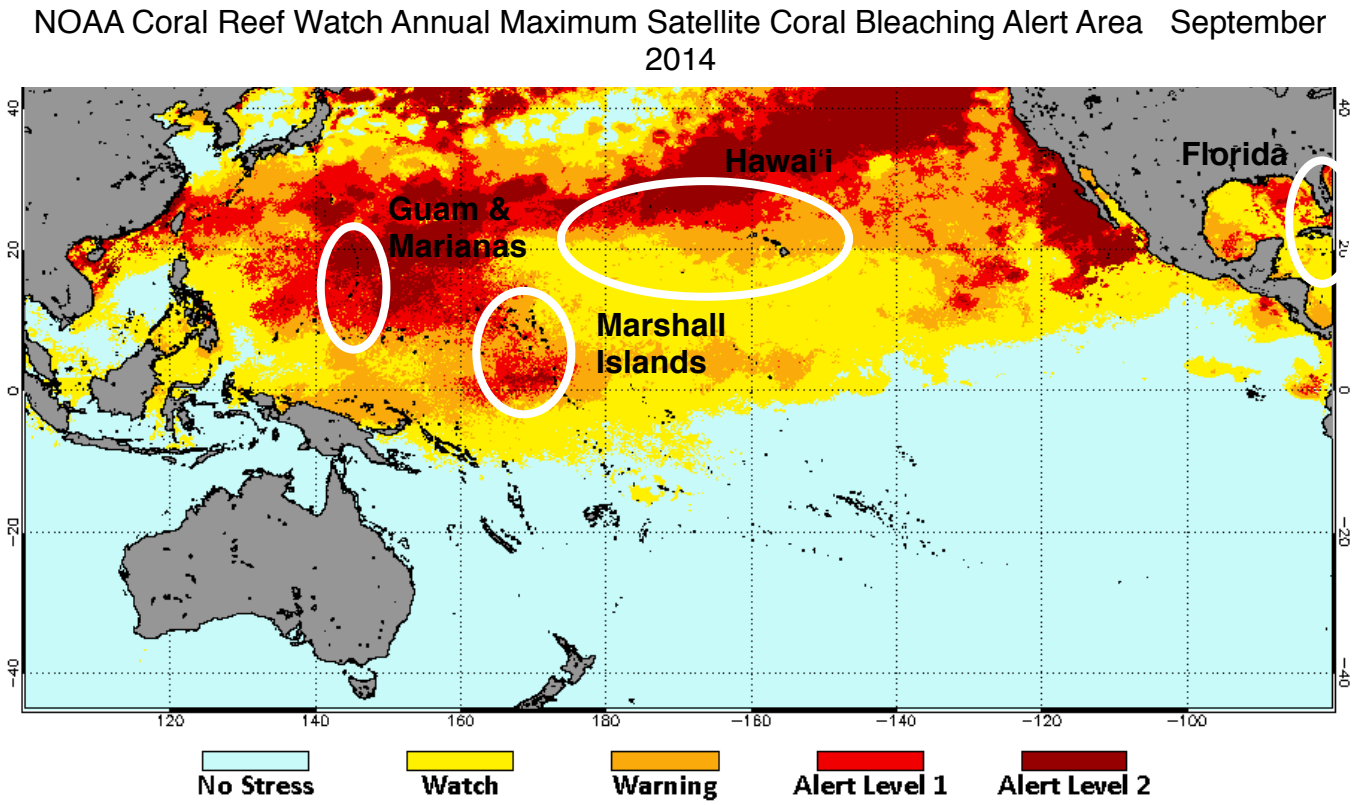


Figure 1. Coral Reef Watch Maximum Bleaching Alert Area map for September 2014. Marked are four areas exhibiting bleaching in the latter half of 2014. Alert Level 2 is associated with widespread coral bleaching and significant mortality.

January-June 2015: Bleaching Spreads

With the onset of austral summer, ocean temperatures started to rise and bleaching was reported in the Southern Hemisphere (Figure 2). Moderate levels of thermal stress and bleaching were reported in eastern Papua New Guinea and the Solomon Islands early in 2015, and subsequently in northern Fiji. The Samoas, especially American Samoa, reported the worst bleaching ever seen (Figure 3). Moderate levels of thermal stress were seen in the Indian Ocean in the first half of 2015 with reports of moderate bleaching in the Chagos Archipelago, the Maldives, western Indonesia, and the southern Red Sea. It is interesting to note that this pattern of bleaching in the South Pacific and Indian Ocean is most commonly observed during the second year of an El Niño, as in 1998 and 2010. However, most of the 2015 bleaching occurred before the 2015-16 El Niño conditions developed, raising the suspicion that this bleaching was associated with either the aborted 2014-15 El Niño or an oceanographic precursor of 2015-16 record-strength El Niño.

Initiation of the 2015-16 El Niño resulted in high thermal stress in the eastern tropical Pacific, with observations of bleaching in Panamá, and expected but unconfirmed bleaching in the northern Galápagos Islands. Mid-2015 also brought thermal stress to Kiribati, especially the Line Islands, where thermal stress reached the highest levels ever recorded, and killed at least 80% of the corals there (K. Cobb, pers. comm).

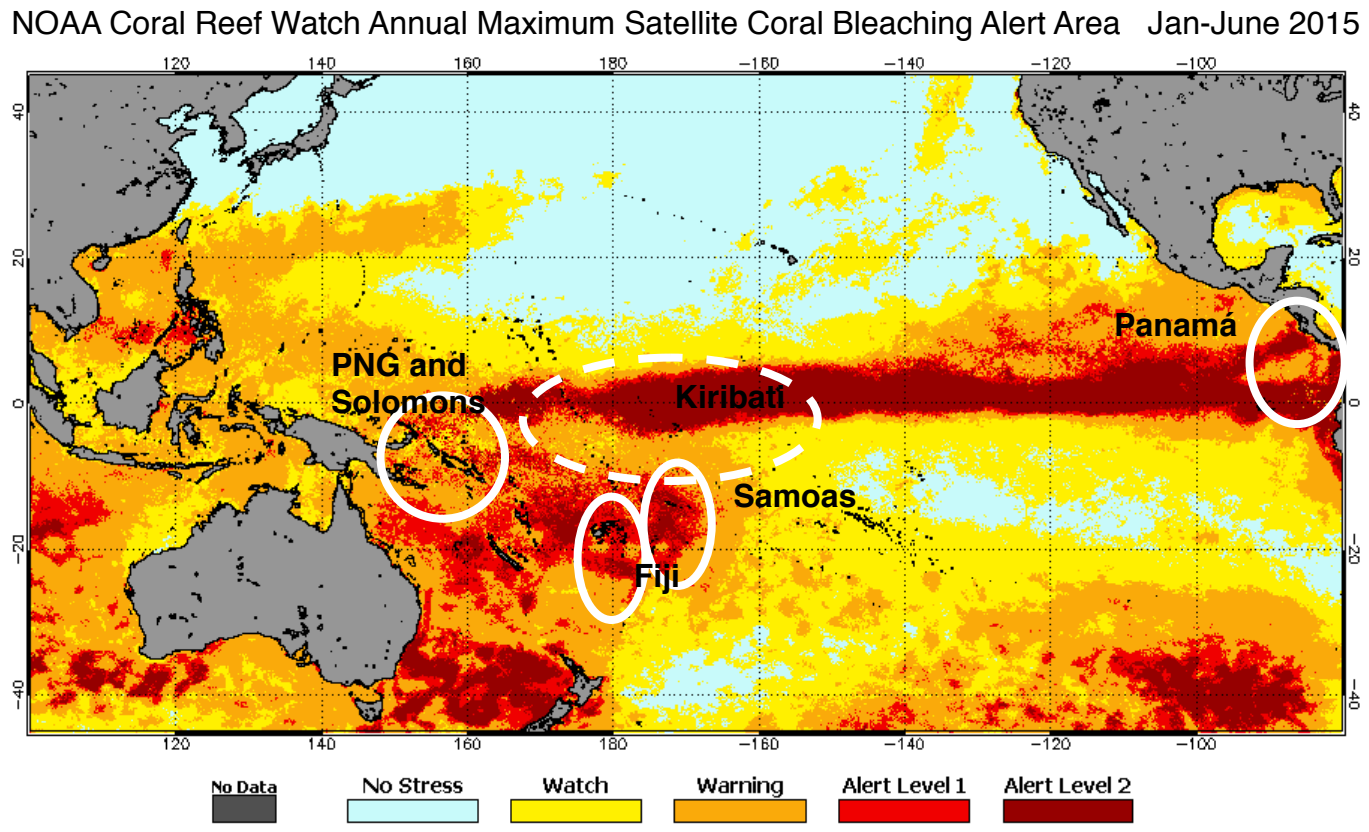


Figure 2. Coral Reef Watch Maximum Bleaching Alert Area map for January-June 2015. Marked are six areas exhibiting bleaching in the first half of 2015.

Figure 3. Photo composite of before, during, and after bleaching at Airport Reef, Tutuila, American Samoa (image courtesy of R. Vevers, XL Catlin Seaview Survey).

July-December 2015: Global Bleaching

With the 2015-16 El Niño in full swing, thermal stress intensified in the central to eastern Pacific (Figure 4). Reports from the Phoenix and Line Islands of Kiribati indicated bleaching and mortality of corals were well underway. A warm water mass, most likely related to warm El Niño waters off the Americas, spread to the Hawaiian archipelago from the southeast, resulting in widespread bleaching in the main islands of Hawai'i, with the most severe bleaching seen along shores of Hawai'i Island and Maui Nui. This was the worst bleaching ever seen in the main Hawaiian Islands and their first documented instance of back-to-back bleaching.

Unlike 2014, thermal stress and bleaching were widespread in the northern Caribbean, along with some bleaching in other parts of the basin. Bleaching of varying severity was reported in Florida, Cuba (northern and southern coasts), the Bahamas, Turks & Caicos, the Cayman Islands, parts of the Dominican Republic, Haiti, and Bonaire. Southeastern Florida and the Florida Keys not only saw a second year of bleaching, but southeastern Florida saw a severe outbreak of a white disease resulting in high levels of mortality. As of October 2015, with widespread bleaching in each of the Indian, Pacific, and Atlantic basins, NOAA declared that the third documented global coral bleaching event was underway. This followed confirmed global bleaching in 1998 (Wilkinson 2000) and 2010 (Heron et al. 2016b). Of note, this actually may have been the fourth global event, as widespread, possibly global bleaching was seen in 1983 in association with the 1982-83 El Niño (Coffroth et al. 1990).

By the end of 2015 32% of coral reefs worldwide had been exposed to thermal stress of 4 °C-weeks or more and almost all of the world's reefs had exceeded their normal warm-season temperatures.

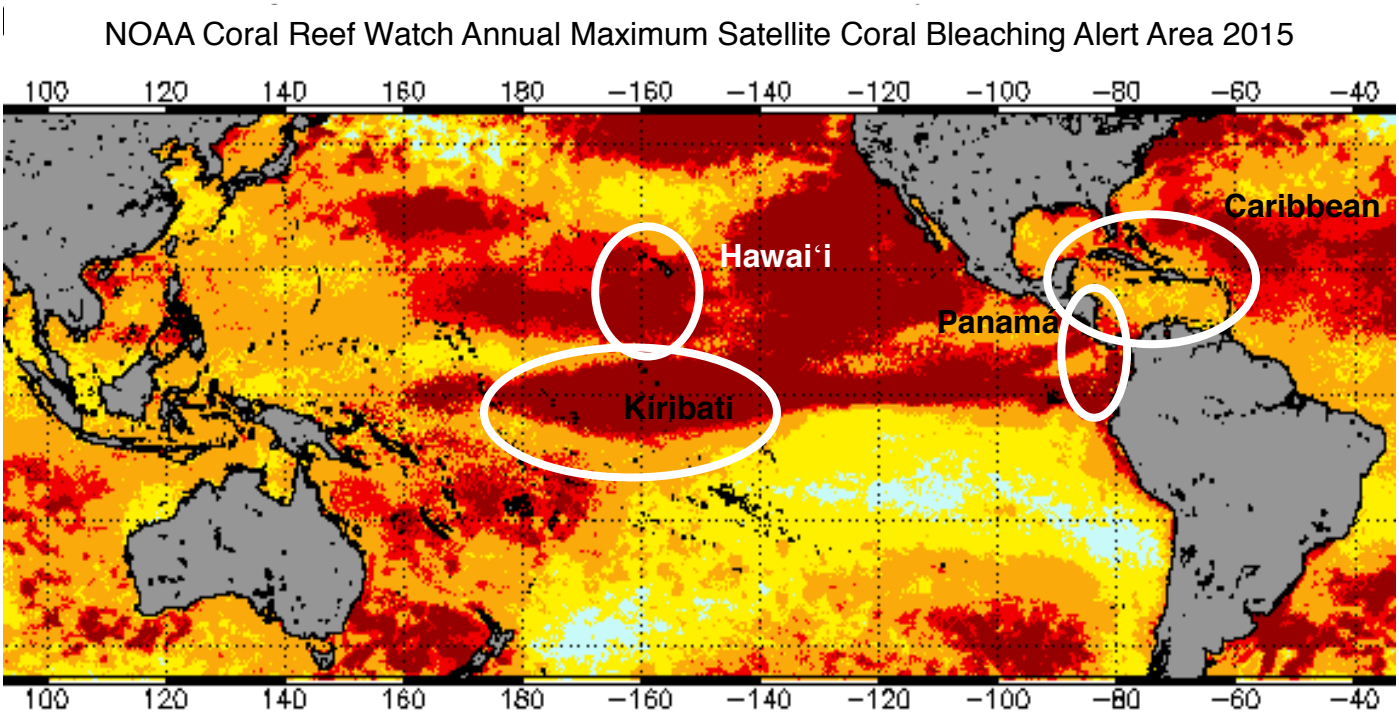
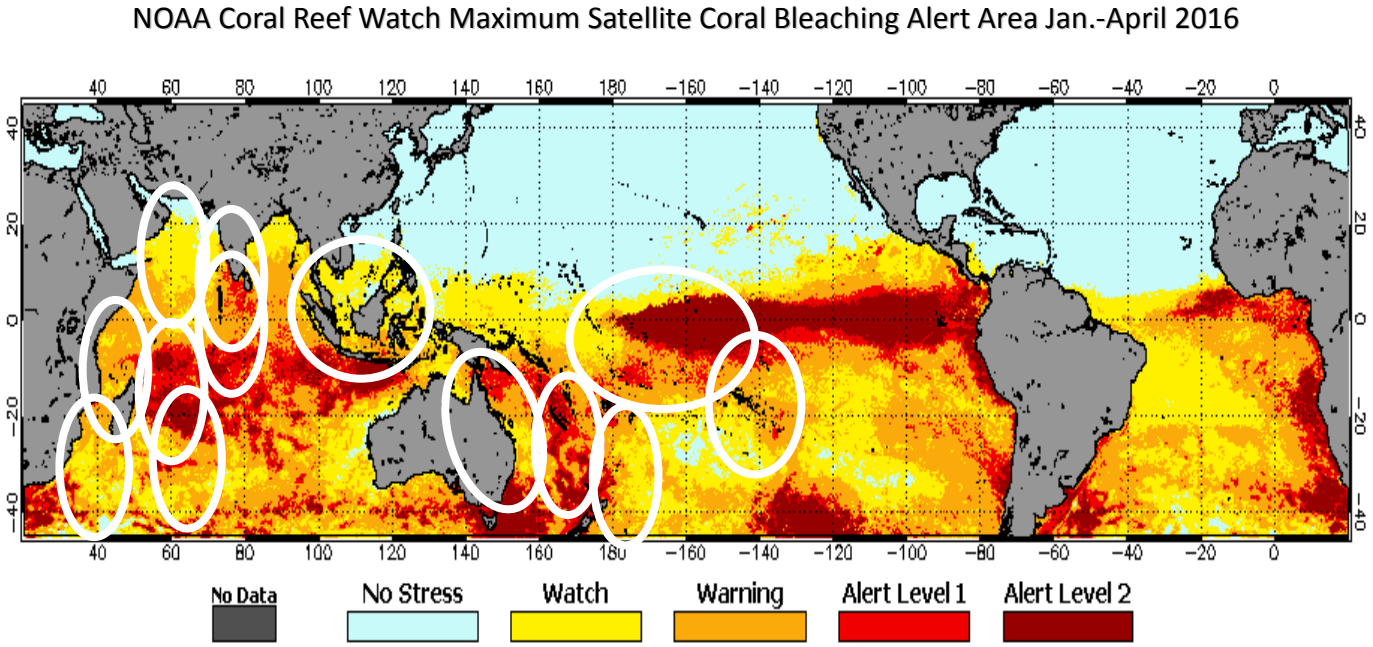


Figure 4. Coral Reef Watch Maximum Bleaching Alert Area map for 2015. Marked are five areas exhibiting bleaching in the latter half of 2015.

2016: Global Bleaching Continues

The El Niño continued to strengthen, becoming one of the strongest ever witnessed by the end of 2015. With the return of the austral summer, thermal stress and bleaching returned to the Southern Hemisphere. As of this writing, bleaching has been reported from as far west as Tanzania to as far east as French Polynesia, with severe bleaching in the Far Northern Great Barrier Reef, New Caledonia, and Fiji. Bleaching in the GBR has been the worst ever



Oman	**Western India**	**Thailand**	**Kiribati**
Kenya	**Maldives**	**Indonesia**	**French Polynesia**
Seychelles	**Réunion**	**Great Barrier Reef**	
Tanzania	**Mauritius**	**New Caledonia**	
Mozambique	**Madagascar**	**Fiji**	

Figure 5. Coral Reef Watch Maximum Bleaching Alert Area map for January-April 2016. List of marked areas with reports of severe bleaching.

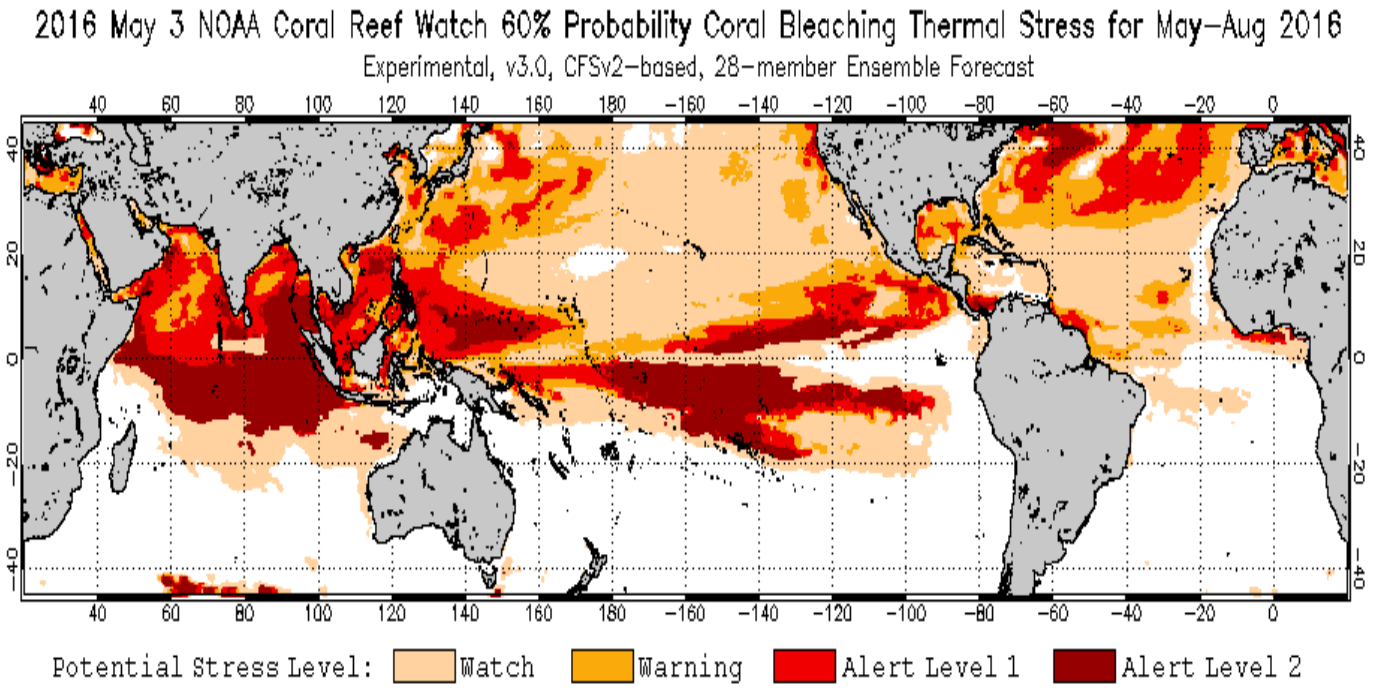


Figure 6. Map of areas where 60% or more of the model ensemble members are predicting thermal stress at each of NOAA Coral Reef Watch's bleaching thermal stress alert levels through August 2016 (as of 3 May 2016).

documented, affecting over 93% of the reefs with severe bleaching in 95% of the reefs in the northern 1/3 of the GBR, formerly the healthiest part of the GBR (De'ath et al 2012). Far worse is the bleaching in Kiribati. Surveys in March and April revealed over 80% of corals dead and 15% bleached, leaving few untouched (J. Baum, pers. comm. and in Harvey 2015).

An important question for Micronesia, Palau, and some other parts of the western Pacific Ocean, is whether a strong La Niña will follow this El Niño, as occurred in 1998. It is unfortunately too soon to tell. NOAA has issued a 70% chance of a moderate La Niña, but predictions of El Niño and La Niña issued before June are not highly reliable. NOAA Coral Reef Watch's Four Month Outlook indicates that more bleaching is likely in the northern Indian Ocean, parts of the Coral Triangle and Southeast Asia, and the central to eastern tropical Pacific during April-July (Figure 6). Also, the extended-range outlook and past El Niño patterns indicate bleaching will likely return to the Caribbean again this year. While still beyond the range of the seasonal models, bleaching has been seen in the Southern Hemisphere in the year after an El Niño, leaving open the possibility of this event continuing into 2017.

Documenting the 2014-(2017?) Global Bleaching Event

Unfortunately, two international programs that previously documented coral bleaching events are no longer serving this purpose. ReefBase has not added new bleaching observations since 2012 and few records in the database document the 2010 global bleaching. Also, since the retirement of its former coordinator, Clive Wilkinson, the Global Coral Reef Monitoring Network (GCRMN) has not actively maintained observations and reporting of bleaching worldwide. Fortunately, some regional GCRMN networks are still in place or are rebuilding, while other regional and global programs, like Reef Check, continue to coordinate coral reef monitoring.

To ensure that documentation of the ongoing bleaching event is as complete as possible, Coral Reef Watch plans to collate and report on the global extent of this event and we would be happy to work with any local or regional partners. Please continue any monitoring you are conducting and either report to your existing regional efforts or send them directly to us at Coral Reef Watch. Of note, we need both bleaching and non-bleaching observations to document the spatial extent and timing of the event, and to validate our satellite- and climate model-based products. Contributing data ensures that your site data are considered in global analyses; helps to understand how to better use the tools for your reefs; gives context to how bleaching patterns at your sites compare with global patterns; and provides access to the latest global 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.

Additionally, film-makers at Exposure Labs are developing a documentary on this bleaching event. They are in need of assistance capturing pictures and video of the bleaching in as many places as possible. They have issued an appeal for underwater photographers and videographers to help them in this project.

Acknowledgements:
Coral Reef Watch work is supported primarily by the NOAA Coral Reef Conservation Program and the NOAA National Environmental Satellite, Data, and Information Service's Center for Satellite Applications and Research. The contents in this manuscript are solely the opinions of the authors and do not constitute a statement of policy, decision, or position on behalf of NOAA or the U.S. Government.

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Challenges and opportunities in conducting mesophotic reef research

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Introduction

Mesophotic coral ecosystems (MCEs) are of growing interest because of the degradation of shallow coral ecosystems as a result of regional and global stressors, and the possibility that MCEs may be more protected by virtue of their depth. MCEs occur between depths of 30 to 150m, and are characterized by light-dependent zooxanthellate coral, octocorals, macroalgae and sponge communities (Hinderstein et al. 2010). Historically, MCEs have been poorly studied because of the logistical challenges associated with surveying this depth range (Pyle 2000; Hinderstein et al. 2010). Recent advances in technology are now making it possible to conduct research at these depths.

Much interest in MCEs has been driven by the deep-reef refugia hypothesis, first proposed by Glynn (1996) and based on decreased thermal stress with depth, but now expanded to other reef stressors. In short this states: many of the stressors causing damage to shallow reefs decline with depth, therefore allowing species threatened on shallow reefs to survive in deeper waters. These deep populations can then recolonize shallow reefs following