Detection of fine scale water temperature trends through long-term continuous monitoring in Shiraho Reef, Okinawa, Japan

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As part of a long-term monitoring effort, water temperature and other oceanographic parameters have been measured at different locations within and just offshore of Shiraho Reef in Okinawa, Japan using various standalone sensors. As observations from as far back as 2010 have been collected, examination of the trends over different seasons and years provide a unique look at how regional and local factors have affected water temperatures in the site. The reef is located in an area frequented by typhoons during the summer and autumn seasons, which can potentially cause damage but have also been associated with cooling mechanisms that mitigate against thermally stressful conditions. In 2016, massive coral bleaching occurred in Sekisei Lagoon, the largest coral reef area in Japan, which is located in the Yaeyama Islands and is in the same general vicinity as Shiraho Reef.

By examining trends in the data during typhoon passages over different years, it was found that for some passages, abrupt downshifts in water temperature of 1 deg C or more were generated in certain parts of the reef. Such downshifts appeared to be related to the track of the passing typhoon and were unrelated to the height of the waves just offshore of the reef. In particular, typhoons which passed south of the Yaeyama Islands on a southeast to northwest trajectory generated the highest significant wave heights but the observed water temperature trends were relatively unremarkable. Some typhoons which also passed close (within 300 km) but had other types of tracks generated more notable temperature downshifts, with the largest downshift magnitudes observed for Typhoon 2015-15 (Goni), which passed within 50 km of Shiraho Reef, but along a track on the opposite side of Ishigaki Island in which the reef is located. There is also some indication that intense typhoons located relatively far away may cause peculiar downshift patterns, as was observed for Typhoon 2014-19 (Vongfong), which was more than 300 km away to the east at its closest location to Shiraho Reef. As the frequency and intensity of typhoons have been projected to increase, further examination of the data trends during typhoon passages may help to more accurately characterize how hydrodynamic conditions within the reef can be influenced.

The long-term observations also covered the period of the massive bleaching in summer 2016. Comparison of water temperature trends for this year and those in the same period for the years 2014 to 2018 show that 2016 indeed stood out in terms of how frequently temperature measurements of 31 deg C or higher were recorded in the different parts of the reef. However, there were also years when particular locations within the reef were also subjected to elevated temperatures in a similar degree to the 2016 conditions. And while water depth has a large influence, there may be other factors or reef features that may be causing the observed trends. In addition to these fine scale trends, the data set also records other important features, such as the longer term cooling effects caused by typhoon passages and their yearly variations, and also cooling episodes not associated with typhoons but which may be linked to other types of regional circulation features.

By further examination of the long-term trends in the temperature data, a better understanding of factors driving them may be obtained, leading to more accurate projections of future scenarios and how to possibly mitigate against thermally stressful conditions. Simultaneous long-term observations at different locations at the reef scale are still not common, particularly for a site as dynamically active as Shiraho

Reef. Careful examination of the field data obtained may help us gain a better understanding of how the combination of local features and regional scale factors drive the hydrodynamic and thermal characteristics of the reef, which in turn affect the local coral reef ecosystem.

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