Status Report on Ngederrak and Lighthouse Reefs

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PICRC Technical Report 19-09

June 2019
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Synopsis

The reefs of Ngederrak and Lighthouse were devastated by Typhoon Bopha, reducing the cover of coral from around 70% to virtually zero at the end of 2012. We reveal that corals at Lighthouse are showing prolific recovery and, after a delayed start, have already returned to 60% cover and increasing rapidly. Recovery is slower at nearby southern Ngederrak but now increasing at a rapid rate, having doubled from 15% to 30% cover in the last year alone. Reefs at the north end of Ngederrak are still showing little signs of recovery. It is unknown why northern Ngederrak is struggling to recover but it likely has a natural explanation, possibly because the reefs have received fewer larval corals (these patterns are highly variable) or because the higher level of shelter from waves does not favour such rapid coral growth. Lighthouse Reef is now one of the best-recovered reefs from Typhoon Bopha and it would be prudent to monitor for outbreaks of crown-of-thorns starfish and eradicate if necessary.

The reefs of Ngederrak and Lighthouse were severely impacted by the 1998 coral bleaching event (Bruno et al. 2001). Prior to the bleaching, branching corals dominated the reefs and their death resulted in colony collapse and the creation of extensive rubble fields. Unfortunately, rubble rolls around the reef and provides an unstable substrate for new corals to attach to (Fig. 1). This can delay recovery significantly.

Fig. 1. Reef dominated by rubble which provides a poor substrate for corals to recruit to. Photo taken at Lukes Reef, 2018.
Fig. 2. Trends in coral cover and herbivorous fishes at Ngederrak and Lighthouse Reefs
By 2006, much of the rubble had consolidated, becoming quite stable. Surveys at Ngederrak South documented only modest levels of herbivorous fish (Fig. 2) at this time. However, by 2008 coral recovery began in earnest at all three sites and the reef soon became dominated by branching corals once again. By the beginning of 2012 coral cover exceeded 60% which is extremely high (Fig. 2). In short, recovery was variable (Golbuu et al. 2007) and it took around 10 years for the reefs to recover from the mass bleaching event of 1998.

In late 2012, Typhoon Bopha damaged reefs along the east side of Palau (Guezo et al. 2015). Coral cover dropped to virtually zero at Ngederrak and Lighthouse reefs and was replaced by a bloom of the red seaweed, *Liagora* (Fig. 3; Roff et al. 2015). In 2013, coral larvae chose not to settle on these reefs, likely on account of the bloom of toxic seaweed – they settled elsewhere where the reefs were not damaged (e.g., short drop-off) (Doropoulos et al. 2014).

The bloom of seaweed also prevented herbivorous fishes from feeding properly and allowed another seaweed – *Lobophora* – to develop under the safety of the *Liagora* canopy (Fig. 4). *Lobophora* is a carpeting or encrusting seaweed that corals avoid when they can. When the *Liagora* died off around six months after the typhoon, it appeared that the *Lobophora* had become sufficiently well established that it was able to continue growing over the reef. Corals avoid settling near *Lobophora* which releases toxic chemicals (Evensen et al. 2019). As a result new corals avoided settling on Ngederrak and Lighthouse reefs for at least three years (Doropoulos et al. 2016). At this point, we wondered when coral recovery would take place.

Our monitoring of these reefs continued and is now showing a clear pattern (Fig. 2).
We make the following conclusions.

1) Areas dominated by rubble after Typhoon Bopha are still showing no recovery (Fig. 5). It might take several more years for the rubble to stabilise as it did eventually after the 1998 bleaching.

Fig. 5. Areas of rubble still failing to show recovery even at Lighthouse Reef
2) Recovery is limited at the north end of Ngederrak with coral cover only just reaching 10% and relatively little sign of new corals in the population.

Ngederrak North 2019: Still little recovery after 6 years

3) Last year we noted that there has been prolific recruitment of new corals (lots of small colonies) and predicted recovery to take off over the next few years. Monitoring of recruitment on tiles has also increased in 2016 and 2017 compared to 2013-2015, now reaching >3 per 5 cm × 5 cm tile. This has proven to be the case and recovery has accelerated at the south end of Ngederrak with coral cover doubling from around 15% to 30% within a single year.

Ngederrak South 2018 Many young corals
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<th align="center">Southern Ngederrak in 2019. Excellent recovery, including plate corals</th>
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![Image of coral reef]
Recovery is in full swing at Lighthouse Reef with corals doubling in cover from 30% in 2018 to 60% in 2019. The reef spurs are dominated by table corals, which can grow rapidly.

Overall, the level of recovery at Lighthouse Reef is profound, particularly given the limited levels of settlement over the last few years. Our results tell us that some reefs in Palau have surprisingly high resilience and can bounce back even when showing some troubling symptoms. It is unclear why recovery shows such a clear latitudinal pattern, being greater at the southern end of the Ngederrak/Lighthouse reef complex. It is likely to have a natural cause and might occur because the environmental conditions – involving higher wave exposure in the south – favour coral growth or a chance event such that the supply of coral larvae on coastal currents was greatest at the
southern end. Alternatively there is some evidence that larval supply might be lower in the northern area of Ngederrak and/or that the reef habitat quality is poorer. Further research will investigate this question further. There is, however, little cause for alarm.

Historically, corals at Lighthouse Reef have had a high risk of disturbance by the crown-of-thorns starfish (CoTS). This might be because of the elevated nutrients at the site which help starfish larvae survive. While we saw no evidence of outbreaks at present, the rapid rise of table corals could facilitate an outbreak of CoTS. We advise that periodic monitoring of Lighthouse be carried out and starfish eradicated if their numbers become noticeable. The latest techniques use an injection of vinegar to kill the starfish. Action to protect Lighthouse in this way might be warranted given that it is currently one of the best-recovered reefs from typhoons.

One of the interesting natural processes we are now seeing is that the rise of high coral cover is reducing the density of surgeonfish. This is likely because there are large patches of reef that have so much coral that they cannot find enough dead substrated on which to scrape for detritus. These sorts of trends are natural and are important because negative trends in fish density do not have to indicate too much fishing (though they usually do for predatory fishes and even herbivores unless the coral cover is increasing dramatically).

References


