Annela Tchouadep • March 17, 2020

Coral Bleaching: What is it and can anything be done about it?

Coral bleaching is one of the major issues that coral reefs are facing and it has yet to be solved

The corals that build reefs are colorful hermatypic organisms found in waters that are hit by a lot of sunlight (Spalding et al., 2001). They are referred to as hermatypic because of their ability to build reefs, unlike their ahermatypic counterparts. These hermatypic corals live in colonies and collectively deposit a calcium carbonate skeleton (Spalding et al., 2001). It is these calcium carbonate skeletons that build and grow the infamous structures known as coral reefs.

Their ahermatypic counterparts might not be able to produce reefs but on the other hand, they are pretty much found everywhere, whereas hermatypic corals are restricted to rocks in shallow waters in the tropics (Spalding et al., 2001). The reason being is, they have a symbiotic relationship with photosynthetic algae known as zooxanthellae that require sufficient light to efficiently photosynthesize (Pearse and Muscatine, 1971). Furthermore, corals are usually found on rocks because they need a hard substrate to attach to (Spalding et al., 2001). Despite the corals being heterotrophic, they have autotrophic organisms that reside within their cells and tissues, which makes this symbiosis quite interesting. These algae serve as the corals' nutrient supply by providing them with the excess products of their photosynthetic activity after they met their own metabolic requirements and in return, they have unlimited access to the nitrogen and phosphorus-rich waste products of their host, which tends to be limiting in the waters they live in (Dubinsky and Joel. 2014).

Without the zooxanthellae, corals would not be able to build the reefs they are so well-known for and those reefs would no longer be able to provide their various ecosystem services from habitat to fish nursery (Berkelmans and Oppen, 2016). Furthermore, without the organic compounds zooxanthellae provide them with, the corals will eventually starve to death. Unfortunately, this is not a hypothetical scenario but a very real issue that corals face and is known as coral bleaching.

Coral bleaching is the massive expulsion of zooxanthellae from the endodermal tissues of the corals they reside in, which results in the coral turning white (Hoegh-Guldberg and Smith, 1989). The causes or mechanism that triggers coral bleaching is still poorly understood. According to Hoegh-Guldberg and Smith, several researchers have performed experiments where corals were deprived of light, starved, and exposed to water temperatures beyond their tolerance range (1989). All experiments resulted in coral bleaching, hence making it difficult to mechanistically explain how or why the zooxanthellae were expelled from the cells of their host. What is better understood is why the corals turn white after the loss of their zooxanthellae. Well, it turns out that the zooxanthellae's photosynthetic pigments are what provide hermatypic corals with their bright colors in the first place. Hence, the loss of zooxanthellae means no photosynthetic pigments and hence resulting in the coral's loss of pigmentation. Once the zooxanthellae are expelled, all that is left of the corals is their white calcium carbonate skeleton which is now exposed, hence explaining their white appearance or 'bleaching'.

If turning white was the only consequence of coral bleaching, then it wouldn't be that much of an issue. Unfortunately, the loss of their symbionts has much more drastic consequences which negatively impact the corals. Not only do corals lose their color once this phenomenon happens, but they also lose their source of organic carbon and their ability to deposit calcium carbonate (Goreau and Hayes, 1994). Goreau and Hayes studied mass bleaching events and noticed that the majority of them occurred after “extended periods of high temperature, low wind, low cloudiness, and low rainfall” (1994). However, just like others, they were unable to determine which of the above factors was the cause of the bleaching or whether it was a combination of more than one factor.

Unfortunately, according to Gleason and Wellington, the frequency of coral bleaching in the tropics has drastically increased over the past decade (1993). Gleason and Wellington attribute this to higher than average UV radiation intensities which are more heavily felt in the shallow, clear waters of the tropics where corals are found (1993). According to these authors, coral bleaching might be a self-perpetuating cycle where intense UV rays causes coral bleaching and hence prevent them from building reefs which serve as protection against UV rays, so without the reefs, UV rays further damage the corals and hence amplify the bleaching.

What makes bleaching such a serious threat is that no coral is able to survive on a long term-basis without zooxanthellae. In Panama, corals that went through a massive bleaching event were initially alive during the initial observations but after a few months, they were all dead (Glynn, 1983). They don't die immediately, but instead their growth slowly decreases and then they eventually die. The reason being is they are completely dependent on their photosynthetic symbionts for food. Although they are physically capable of obtaining their own food by capturing prey, the amount they obtain in doing so is simply not enough to sustain them, which is they need the zooxanthellae in the first place (Tremblay et al., 2013).

Although it seems very bleak, there is research suggesting that there could be a possible solution to this issue. That solution being artificial nutrient enrichment. What this consists of is adding inorganic nutrients locally to specific areas where corals are heavily concentrated. According to Wiedenmann et al., this should “accelerate proliferation of zooxanthellae” (2012). Hence, if there are more of them, then when some are ejected from their host, there are still enough left to pick up the slack. According to Wiedenmann et al., artificial nutrient enrichment would be most effective in regions where the concentration of inorganic nutrients is naturally low because if a particular area has sufficient nitrogen or phosphorus, then adding more won't make a difference (2012). However, before implementing it in real marine environments, it should be tested experimentally in a lab. For instance, corals could be placed in different water tanks with same amount of light and increase the amount of inorganic nutrients in one tank. Then the researchers can observe which corals were more severely impacted by coral bleaching. The reason why it is more prudent to test this in a lab first is because there could be adverse effects not just on the corals and the zooxanthellae, but on other organisms.

There are researchers who actually attempted the nutrient enrichment solution. They found that minor enrichment did not harm the coral and actually benefited the zooxanthellae who were in nutrient-limited waters (Bruno et al., 2003). However, moderate nutrient increases resulted in a substantial increase in the severity of coral diseases, due to the fact that the pathogens that infected them were able to thrive more due to the increase in nutrient supply (Bruno et al., 2003). Hence, this suggests that nutrient enrichment might not be the perfect solution, but could potentially worked if executed properly. The right amount of nutrients would have to be added and the effects on coral disease would have to be taken into consideration. Based on the results from Bruno and his colleagues, if the pathogens weren’t an issue, then this nutrient enrichment idea could become more than just a mere theory, but an actual plan that becomes implemented.

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