Coral Bleaching by Claire Starling

Coral reefs are remarkable aquatic structures that play a central role in the lives of many different species. Coral reefs can act as a vital source of food or shelter to many different kinds of marine life. They are a source of revenue for different human industries, such as fishing and tourism and provide security for human life with shoreline protection and pharmaceutical compounds. Coral reefs are extremely diverse and complex, yet with the increase of ocean acidification and higher sea surface temperatures due to climate change, their very existence becomes more and more threatened every day. As the temperature and pH of the ocean continues to change, the occurrence of coral bleaching has become a global phenomenon and ultimately destructive to the livelihood of the reefs. While this naturally causes a disruption within the ecosystem of the reefs, the real impact of coral bleaching events affects humans themselves with a slew of harmful and devastating effects.

Coral bleaching events often occur as a result of increased sea surface temperatures and ocean acidification. According to Marshall et al., "sea temperature increases of 1-2ºC above the long term average maximum are all that are required to trigger mass bleaching" (16). Along with increased temperatures, changes in oceanic pH affects a coral's ability to form their carbonate frame and therefore their ability to build reefs. Considering this issue from a biological perspective, this bleaching phenomenon causes a disruption within the natural order of the coral reefs. When they are healthy and thriving, coral reefs maintain a symbiotic relationship with microscopic algae known as zooxanthellae. The photosynthetic algae live within the coral's tissues. According to a recent study by an international team of scientists including researchers from Princeton University, this relationship began more than 210 million years ago ("When Corals Meet Algae"). This mutualistic relationship is vital to the coral's overall health. The algae

provide coral reefs with nutrients that are produced through the process of photosynthesis. These nutrients are the coral's primary food source. Along with the nutrients from photosynthesis, the algae provide energy for the corals and increase their rate of growth. Algae also provide the corals with their natural color and pigmentation. Corals in turn provide the algae a safe environment and habitat for them to live in. Corals also emit waste products in the form of ammonium, which the algae consume as a nutrient ("When Corals Meet Algae"). Both species rely on this relationship for the necessary components of life. However, this relationship can become stressed under certain conditions. Increased sea surface temperatures causes a strain on the relationship and in response, the algae is dispelled from the coral's tissues, resulting in coral bleaching. According to Leslie Roberts, "It is called bleaching because without the brown algae, the denuded corals are white" (1228). When the algae are not present, the corals are unable to feed themselves and become more susceptible to disease. Although coral reefs can recover from a bleaching event under the right conditions, the corals that survive are likely to have decreased growth and reproductive rates. The decline in growth and reproduction rates becomes extremely harmful for the coral reef population as coral bleaching events continue to occur on a global scale.

The frequency and severity of coral bleaching events has increased drastically since the early 1980s. The first major bleaching event occurred in 1998, affecting many different reefs throughout the Indian Ocean, including Australia's Great Barrier Reef. Before this occurrence, coral bleaching events were considered to happen on smaller, more localized levels caused by local stressors. The event of 1997-98 distinguished mass coral bleaching from localized events by the global extent of its impacts across reefs, attributing to mass mortalities of corals to many reef regions, in total destroying an estimated 16 percent of the world's reefs (Marshall 14).

Despite the severity and range of the 1998 event, it marked only the beginning of mass bleaching. The second global bleaching event occurred in May 2010 around reef sites in South East Asia. This event showed similar patterns of bleaching and mortality as the previous global incident, affecting a variety of different coral reefs areas. The third and most recent global event began in 2014 and is still affecting corals reefs today in 2017. Bleaching began in the north Pacific in summer 2014 and expanded to the south Pacific and Indian oceans in 2015 (NOAA). Areas that are feeling this global effect of intense and lasting coral bleaching include the Hawaiian Islands, Haiti, the Dominican Republic and Puerto Rico. As coral bleaching continues to spread and affect corals on a larger, global scale, coral reef populations continue to degrade and die at rapid rates. As of April 2017, this ongoing global coral bleaching event continues to be the longest, most widespread, and most damaging on record ("Global Coral Bleaching").

A coral bleaching event is damaging to not only the corals themselves, but also to the delicate and complex ecosystem of species that live within the reefs. In their natural and healthy form, coral reefs maintain a great responsibility for many different kinds of marine life. Coral reefs support more species per unit area than any other marine environment, including about 4,000 species of fish, 800 species of hard corals, and hundreds of other species ("Importance of Coral Reefs"). Although many different forms of marine life rely directly on support from coral reefs, climate change and coral bleaching events threaten their ability to host such a wide variety of organisms every day. One group of species in particular that is dramatically affected by coral bleaching are coral reef fishes. Coral bleaching negatively affects coral reef fishes in a variety of different ways. Climate induced coral bleaching can lead to effects on individual performance, trophic linkages, recruitment dynamics, population connectivity, and other ecosystem processes (Munday et al. 261). While these effects are damaging and disruptive among reef fishes species,

the most harmful effect of coral bleaching is the loss of marine diversity and the change within the fish community. Bleaching causes a serious problem for these species, as they are dependent on coral reefs. As continued bleaching causes damage and mortality to the corals, reef fish species experience a dramatic drop in population. Larval reef fishes are quite delicate when it comes to environmental conditions. Effects of climate change on the number of larvae produced, or their growth, survival and dispersal patterns, could have significant consequences for adult populations (Munday et al. 263). This change in the structure and population of reef fishes is in turn destructive to other aspects of the reef ecosystem.

Coral reef fishes play an important role in the health and vitality of coral reefs. Reef fishes are the central predators among reefs. Their existence alone structures surrounding communities and keeps the quantity of smaller species in check. Without their presence, there would be no balance or organization among the coral reef ecosystem. Although it seems as though the corals primarily provide for the coral reef fishes, the fishes themselves are a necessary component to the coral's livelihood. In fact, some reef fish species even protect the corals themselves. Grazing herbivorous fishes prevent the growth of macroalgae that might otherwise smother corals (Munday et al. 263). The relationship between the coral and the organisms that it hosts is essential for both species to thrive. Unfortunately, if coral bleaching continues to occur, both species will suffer and eventually die out.

Although coral bleaching has an adverse effect on many different kinds of marine life and corals themselves, the real impact that bleaching has is on humans and human society. From an anthropological perspective, coral reefs play a huge role in the daily lives of many people, and because of that, coral bleaching has an especially harmful effect on human societies. One aspect in particular that coral bleaching affects greatly is the tourism industry. Tourism is the fastest

growing economic sector associated with coral reefs and generates billions of dollars for countries associated with them (Hoegh-Guldberg 839). Sadly, when coral bleaching occurs the reefs lose their color and overall vitality. As a result, the corals lose their aesthetic appeal that is vital to reef tourism. Damaged and dying corals are not in high demand and therefore do not produce as much money. In fact, coral bleaching and coral mortality is contributing to a huge loss of revenue. For example, the cost of losing 58% of the world's coral reefs has been estimated as $90 billion in lost tourism alone (Hoegh-Guldberg 840). The subsequent loss of revenue from reduced tourist activity can in turn threaten the lives of local communities that rely on tourism specifically for a source of income. Beyond that, the disappearance of coral reefs will ultimately result in economic hardship for the tourism industry altogether.

Another business that is greatly affected by corals and coral bleaching is the fishing industry. Fisheries involved with coral reefs produce a substantial amount of money for countries with coral reef coastlines. Annually, fisheries in coral reef ecosystems yield at least six million metric tons of fish catches worldwide (Hoegh-Guldberg 839). Although the fishing industry is productive and thriving, commercial fisheries face issues like any other businesses. Overfishing is a common problem in the fishing industry and considered a profound threat to coral reefs. However, instances of coral bleaching prove to be just as, if not, more harmful to fishers and fish communities, especially when considering how it will affect the industry in the future. Anthropogenic stress associated with coral bleaching events can lead to excessive amounts of coral coverage loss. When this happens, coral reefs take part in what is referred to as a phase shift. A phase shift occurs when coral reefs shift to unusually low levels of coral cover, associated with persistent states of high cover of fleshy macroalgae (Mcmanus 264). The result of a phase shift can lead to a change in the structure and organization of the reef-associated fish

assemblage. This can drive large shifts in fish communities, resulting in reduced catches for fisheries that are targeting specific reef fishes. Reduced catches will also result in reduced revenue. Along with this reduction in resource and revenue affecting the fishers, human communities that rely heavily on tropical reef fisheries as a food source will suffer as well.

Coral bleaching affects many aspects of human life beyond the industry level. Corals provide humans with a great amount of protection, specifically shoreline protection. According to a recent report, "Coral reefs provide substantial protection against wave energy, lessening the impact of sea level rise and intense storm surges for 7 million people in the U.S. alone" (Valentine). Since the reef crest is the shallowest portion of the reef, this is where a wave hits first. Once a wave crashes upon the reef crest, it disperses a large amount of the wave's energy on its own. The entire reef itself also manages to reduce the wave's overall height. Without coral reefs, humans would most likely be more susceptible to higher number of damaging storms and floods. However, coral bleaching makes a coral's job much harder to do. When coral bleaching occurs, the coral becomes weaker and physically degraded, rendering it less productive. As their growth rates decrease, bleached corals cannot provide the same amount of protection as they could before when they were healthy. This proves to be an issue for human communities that depend on the coral as their primary source of protection. Without the coral's ability to reduce the amount of energy and force in a wave, human communities are left weakened and incapable of minimizing the wave's strong effect on their own. As a result, damage and erosion along the shoreline will increase rapidly.

Coral reefs not only provide humans with terrestrial protection, but they also provide protection in a medicinal form as pharmaceutical compounds. These diverse and miraculous marine structures have recently become the solution to many of life's problems, as scientists

have developed many different medical treatments from different aspects of corals. For example, Secosteroids, an enzyme used by corals to protect themselves from disease, is used to treat asthma, arthritis and other inflammatory disorders (Levins). Other kinds of corals can be used as a treatment for some forms of cancer, including melanoma and some types of tumors. The use of corals in medicine does not stop there either. With continued research on corals, scientists will have a better understanding of their anti-viral, anti-tumor and antibacterial properties, and there will be more medical discoveries made. However, the issue again comes back to climate change and the damaging effect it has on coral reefs. Microbial communities, where many new drugs could likely be found, are especially susceptible to these changes, and some are already beginning to decline or migrate (Levins). This can lead to damage of precious corals and their medicinal properties. This can have an adverse but less visible effect on humans, at least at first. With the destruction of coral reefs comes the destruction of medicinal opportunities and discoveries. As a society, humans may very well be killing the very thing that could save their lives one day.

It is easy to see that coral reefs are extremely vital structures that play an important role in many different aspects of life. For marine species, corals provide shelter and protection to a diverse ecosystem of many organisms. Corals also provide humans with a similar idea of protection, whether it be physical protection such as shoreline protection, or protection to their health with the coral's medicinal properties. On top of that, corals provide an aesthetic value for humans, as well as revenue for different industries. Continued coral bleaching events, however, have threatened to destroy the coral reefs themselves and all that they provide for both marine life and human life. Although certain marine life depends directly on corals, humans would suffer the greatest from their disappearance. Without coral reefs, humans would lose billions of

dollars in both the fishing and tourism industries, as well as increased damage to human societies due to a lack of shoreline protection and medicinal discoveries. This problem is trending toward becoming a reality with continued patterns of global bleaching. If humans do not take action to try to save coral reef populations, they will be forced to see just how different their lives would be without them.

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