



Saving Our Oceans Through Coral Restoration

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Saving our oceans from the devastating impacts of human choices is possible through coral restoration. Often it can be difficult to know how to aid our oceans in recovery, yet several restoration opportunities exist. While scientists work diligently to help coral reefs recover, societal knowledge and influence is the key to true change.

Loss of Coral Reefs

Humans contribute approximately 40 billion pounds of carbon dioxide to our atmosphere each year through routine activities (Block, 2017). Since the Industrial Revolution, our earth has

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warmed by 0.7 degrees Celsius due to the amount of carbon dioxide released (Riebeek, 2010). It is estimated that over the next 80 years warming will increase by 2-6 degrees celsius, impacting life on land and life within our oceans (Riebeek, 2010). Approximately 93% of the carbon dioxide put into the atmosphere is absorbed by our oceans, allowing earth’s temperatures to remain stable. Without a healthy ocean, stability will be compromised, resulting in weather pattern changes and a loss of biodiversity among both plants and animals (Block, 2017).

Coral reefs occupy less than 1% of our oceans, but house more than 25% of our ocean’s fishes (NOAA’s Coral Reef Conservation Program, 2016). They require specific water temperatures in order to survive, exhibiting coral bleaching when ocean temperatures rise above their thresholds. A symbiotic relationship exists between corals and zooxanthellae, a type of algae. This gives corals with their vibrant colors and provides organic material that corals use for growth (US Department of Commerce, National Oceanic and Atmospheric Administration, 2013). During coral bleaching the algae is expelled by the coral, causing the coral tissues to become white. Frequently leading to coral death when the stress is extended, corals are unable to recover the algae to the coral’s tissues.



Restoration Opportunities

Humans need to understand how we alter our earth and how coral restoration efforts can benefit our oceans. Both proactive and reactive measures are possible in support of coral restoration. Proactive avenues include Marine Protected Areas (MPAs) and educating the public, which require varying levels of community and government support (Gunderson, 2007; Rinkevich, 2008; Yeemin, Sutthacheep, & Pettongma, 2006). Reactive conservation is working to fix an immediate problem, rather than preemptively working to protect a species or ecosystem. This avenue is more common for restoring ecosystems rather than specific species. There are several techniques utilized for reactive conservation with corals, including silviculture, artificial reefs, and alternative management strategies. While each opportunity has its benefits and drawbacks, there are a variety of approaches to coral restoration.



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Marine Protected Areas

MPAs are marine areas being preserved and protected against human harm in regards to animal, shell, and substrate collection. Even so, there are MPAs that allow for collection upon specific circumstances and needs of the ecosystem being conserved. There is the question of whether or not MPAs actually benefit the intended species, area, or ecosystem. While MPAs are a good effort in restoring damaged ecosystems, there isn't evidence to support MPAs actually benefiting intended organisms (Rinkevich, 2008). Often MPAs are not beneficial because they are inadequately managed, therefore making their purpose moot (Rinkevich, 2008). If the restrictions of MPAs were effectively enforced and respected by humans, their benefit would be greater (International Coral Reef Initiative, 2017; World Wildlife Fund, 2017). This would ultimately preserve the coral reefs and other species that live within them. Respecting the restrictions of MPAs requires support from local and national governments, as well as from the local people. Human disrespect for the environment is often unintentional, as it is a lack of knowledge about the needs of an ecosystem.



Educating the Public

There is a prevailing disconnect between the scientific community and the general public. This can be seen in areas where locals are seemingly unaware of conservation efforts necessary in their communities. Typically, columnists and officials promote scientific findings through the negative and uninspiring lens of species loss and habitat fragmentation

(Gunderson, 2007). This leads the public to a sense of hopelessness and inability to impact conservation efforts (Gunderson, 2007). Once the public is inspired, coral restoration efforts can achieve remarkable success with the aid of public involvement. A great example is a coral reef restoration project in Thailand was executed off of Kham Island (Yeemin et al., 2006). Youth took direct action by transplanting coral fragments with a success rate of over 90% (Yeemin et al., 2006). Thailand's coral restoration efforts demonstrated youth's active voice and important role in how our earth is treated (Yeemin et al., 2006). Ultimately, some researchers argue that local involvement is a key component in effective coral restoration and their reef ecosystems (Yeemin et al., 2006).

Artificial Reefs

Artificial reefs are uncommonly documented and have benefits that spread ecosystem-wide. Creating an artificial reef requires fiberglass pieces to be placed into the ecosystem, creating opportunities for new corals to establish (Ng, Toh, & Chou., 2016). This endeavor is successful, with over 100 species demonstrating a positive increase in population size over 10 years (Ng, Toh, & Chou., 2016). Because fiberglass pieces are plastics, how will they affect the ecosystem post coral establishment. With this consideration and a lack of research on these artificial reefs, hesitation towards this approach is understandable.

Ng, Toh, & Chou (2016) utilize a method adding plastics to our oceans, allowing for potential toxins to be leached into our environment.



With toxins in our oceans, the organisms that live within it are more likely to ingest such toxins. As the individuals ingest toxins throughout their lifespan, a process known as bioaccumulation, the overall health of the individual decreases (Environmental Protection Agency, 2002). When individuals affected by bioaccumulation are consumed by organisms higher on the food chain, the consumers become affected by biomagnification. Biomagnification is where the amount of a toxin within an individual is a higher concentration further up the food chain (Environmental Protection Agency, 2002). As scientists, we should be looking for methods that help restore ecosystems without adding more toxins to the environment.

Restoring Fish Populations

Another reactive approach, restoring fish populations to increase corals have more potential for success in regards to reef ecosystems. The removal of apex predators from ecosystems creates imbalances which allows the populations of lower level species to overpopulate (Heithaus et al., 2008). To reduce populations of lower level species to healthy numbers, top predator populations need to be restored (Heithaus et al., 2008). Prohibiting overfishing of apex predators is necessary for reef recovery as these species are the least able to recover (Dulvy & Kindsvater, 2015). Prohibiting the use of equipment and fishing practices can be ineffective (Rinkevich, 2008). These measures are taxing and not well managed by the associated governments (Rinkevich, 2008). Dulvy & Kindsvater (2015) work to restore corals and reef ecosystems with the use of fish population restoration. However, it has not been shown to be as effective as creating an artificial reef (Dulvy & Kindsvater, 2015). Further research is needed to determine if restored populations will

continue living in an environment being restored. A concern is that restored populations with either die-off quickly or relocate to a location with acceptable resources already intact.



Silviculture

Through silviculture, small pieces of coral are clipped and farmed (in situ, ex situ, or both) (Epstein, Bak, & Rinkevich, 2001; Epstein, Bak, & Rinkevich, 2003; Shafir, Rijn, & Rinkevich, 2006). After, they are returned to the damaged reef to live, continue reproducing, and provide resources to other species (Epstein, Bak, & Rinkevich, 2001; Epstein, Bak, & Rinkevich, 2003; Shafir, Rijn, & Rinkevich, 2006). One consideration is whether to focus on sexually or asexually reproducing species. Rinkevich (2000) tested fragments of two *Acropora* subspecies and found that asexually reproducing *Acropora digitifera* performed better than sexually reproducing *Acropora hyacinthus*. Similarly, asexually reproducing *Acropora spp.* performed greater than sexually reproducing *Acropora spp.* (Boch & Morse, 2012). Important factors to consider beyond coral itself are water speed and quality, which affect coral material. One approach is treating reefs similarly to forests, where dead areas are evaluated and restored based on ecosystem needs (Epstein et al., 2003). This requires ecosystem evaluation prior to transplantation.

Technique adaptability (the ability for a technique to be used across genres) is important in restoring corals through silviculture. *Stylophora pistillata* and *Acropora spp.* are utilized in multiple studies each, with *Pocillopora damicornis* appearing once (Boch & Morse, 2012; Epstein et al., 2001; Rinkevich, 2000; Shafir et al., 2006). *Acropora spp.* is most commonly utilized in coral restoration and appears to have the highest success rates. A lack of success among *S. pistillata* and *P. damicornis*, demonstrates the need for easily modifiable techniques across genres (Boch & Morse, 2012; Epstein et al., 2001; Rinkevich, 2000; Shafir et al., 2006). To restore entire coral ecosystems, research of restoration efforts of other coral species beyond *Acropora spp.* are vital.

Looking Forward



Proactive coral restoration poses greater promise for future environmental health compared to more common reactive efforts. Each restoration technique requires an understanding of the effort required to benefit the health, growth, and success of our corals. Coral restoration efforts allow for healthier reef ecosystems and oceans, and scientists need our help to advocate for our ocean. After inspiring ocean advocates, we can build on the knowledge of local environments, then expand upon it to the entire ocean. After creating reef advocates, we should promote reef-friendly changes in human habits and focus on restoring reefs as an ecosystem. These ecosystem-focused restoration techniques should involve restoration of several species within our reefs, including fish that live within them.



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