Matthew Chan
BIO376 – Professor Bailey McMeans

Current management strategies ineffective in rehabilitating coral reef ecosystems

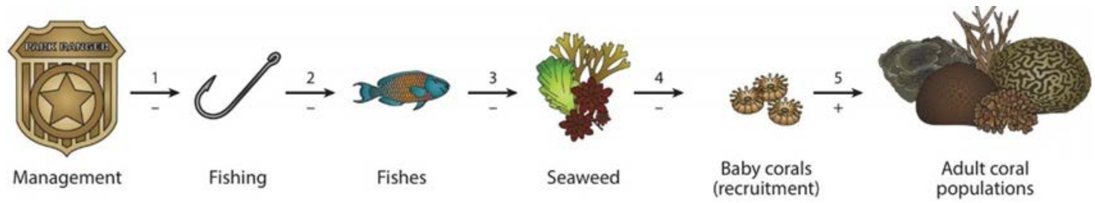

Figure 1 Hypothetical management strategy that can be used to increase resilience of coral populations. Plus and minus symbols indicate the effect one step would normally have on the other. Management strategies decreasing fishing would increase herbivorous fish abundance, in turn decreasing abundance of algae, a coral competitor. This will lead to increased coral recruitment, increasing coral abundance. From Bruno et al. 2019.

Coral reefs are among the most endangered ecosystems on the planet, currently in precipitous global decline. The loss of coral cover can have a large effect on marine ecosystems, as coral reefs are a habitat for a diverse array of marine species and provide a multitude of ecosystem services. Coral reefs are being lost due to a number of reasons, including disease, overfishing, pollution and climate change (Alvarez-Filip et al. 2013). In the past 30 years, over 50% of global coral reefs are estimated to have been lost, while anthropogenic loss has happened as far back as the 17th century (Green et al. 2008). To combat coral reef losses, governments have enacted policies in an attempt to protect coral ecosystems and increase coral cover, but they have not always been successful.

The most common type of coral reef management is managed-resilience, which entails the enactment of policies and initiatives designed to help return the ecosystem to pre-disturbance conditions (Bruno et al. 2013). This involves controlling possible local coral stressors that have been thought to negatively impact coral communities, such as fishing or microalgae cover, to provide beneficial conditions for coral recruitment and coral growth (Bruno et al. 2013). Increased abundance of herbivorous fish has been thought to have positive impacts on coral abundance, while microalgae serve as competitors to coral species, so altering these factors hypothetically should help coral reefs (Bruno et al. 2013). Figure 1 (Bruno et al. 2013) below shows how a managed-resilience strategy could hypothetically lead to increased coral resilience. However, while scientists, non-governmental organizations, and government have all agreed on the value of managed-resilience intervention, there is not much proof that these policies have been effective.

Toth et al. (2014) examined coral ecosystems from 1998-2011 in the Florida Keys that were designated as "no-take" zones where fishing has been banned, looking at the prevalence of the species *Orbicella annularis*, commonly known as the boulder star coral. Compared to similar sites in the Florida Keys where fishing was permitted, the creation of no-take zones did not improve *Orbicella annularis* cover; in fact, *Orbicella annularis* was slightly lower in the no-take zones compared to regular sites (Toth et al. 2014). The authors maintain there is no evidence that no-take zones were actually responsible for the decline of *Orbicella annularis* cover, meaning they will not actively harm coral resilience (Toth et al. 2014). This suggests that while fishing bans may increase the abundance of herbivorous fish, they do not necessarily have an effect on coral cover.

Similarly, Harris et al. (2014) studied coral ecosystems on the Seychelles Bank 10 years after a 1998 bleaching event. In 1998, 45% of the coral cover across the western Indian Ocean (WIO) was lost, including 75-90% mortality in the inner Seychelles (Harris et al. 2014). After the mass coral loss, various management and protection strategies were enacted, but the authors found that 10 years after, the diversity, density and surface area of juvenile and adult corals in the inner Seychelles remained extremely low (Harris et al. 2014). This suggests that despite environmental protection, the mass losses of 1998 had ravaged the ecosystem to the extent that a recovery was impossible (Harris et al. 2014). In addition, other stressors, including competition from microalgae, have made it difficult for juvenile corals grow at these sites, suggesting recruitment failure is a significant reason for the botched recovery (Harris et al. 2014).

Likewise, van Woesik et al. (2014) also examined the Florida Keys to see whether the poor recovery of coral communities was due to low coral recruitment. The authors examined whether coral recruitment was affected by levels of protection (van Woesik et al. 2014). While they found that coral recruitment was indeed higher at sites where a fishing ban was imposed, recruitment was present across the board, suggesting that coral recruitment may not necessarily be a problem (van Woesik et al. 2014). However, the adult taxa currently present in these ecosystems did not match those that were successfully recruited in this experiment (van Woesik et al. 2014). This suggests that environmental conditions may be unfavorable to the long-term growth and survival of some species, so they fail to contribute to full reef recovery (van Woesik et al. 2014). While environmental protections are creating favorable conditions for many species to settle in these ecosystems, competition may be inhibiting all of them from thriving, thus making recovery incomplete.

Well-meaning environmental protections have actually created favorable conditions for some coral species, but they have tended to be “weedy” species, as described by Green et al. (2008). The authors examined coral reef communities in the Caribbean, specifically comparing the historical and present abundance of *Porites astreoides*, commonly known as the mustard hill coral (Green et al. 2008). They discovered that despite overall decreases in cover for all coral species, relative abundance of *Porites astreoides* has actually increased (Green et al. 2008). In addition, the *Porites astreoides* present in the reefs were small in size, indicating that they are relatively new recruits to the sampled sites (Green et al. 2008). Green et al. (2008) suggest that this indicates how “weedy” corals are dominating these ecosystems, and that they colonize and grow quickly, before being suddenly replaced by a new species. It has become difficult for a species to establish itself for the long term in these reefs, leading to a high turnover rate in the species present. This could have a significant impact on the survival of other marine species that rely on specific coral species for their habitat, or the ability of coral reefs to provide reliable ecosystem services.

As shown by the above studies, current management and protection strategies, while well-intentioned, are mostly ineffective at rehabilitating coral reef ecosystems. Even in cases where imposing “no-take” zones, banning fishing, and decreasing the abundance of competitive algae have made the site more viable for coral species in general, weed-like species are the ones benefiting and outcompeting the native species that are supposed to be there. It is clear that a simple, "one size fits all" solution such as imposing areas of conservation will not work.

One possible way of trying to rehabilitate coral reef ecosystems is to attempt managed-resilience on a much more specific, case by case basis. As shown by Green et al. (2008), weedy species can take advantage of conservation areas and outcompete native species, rendering the entire rehabilitation effort moot. Therefore, managed-resilience must take a more active approach in creating conservation areas, including the removal of competitive weed species that may pose just as much harm to native species as traditional factors such as competitive algae or fishing. Some may not understand why weedy species are necessarily are problem, as they may think they are just another coral species, and if there is any coral present, the problem has been solved. However, it is not just whether corals are present, but whether the right coral species are present in the habitat, as different species obviously provide different services to the ecosystem and its inhabitant species.

To do this, research should be done to compare present coral communities to historical communities at individual sites, similar to Green et al. (2008), to determine which species are native and which species are invasive. Native species for each individual reef ecosystem should be actively recruited, while all invasive species should be removed. Ecosystems must then be continuously monitored to ensure invasive species do not return as competitors, at least not until recruited native populations are able to establish themselves as the dominant species.

In addition, further research should examine factors that can impact coral reef ecosystem health. Currently, factors such as fishing, algae abundance, and factors associated with anthropogenic climate change are generally considered the most important ones, with little attention paid to others. As demonstrated, a less considered factor like competitive weedy corals can also be an important factor. These factors can vary between individual sites, so each protected area must be examined for other possible local factors that could have an impact on coral health, positive or negative.

Despite the possibility that local, case by case management strategies may be more effective, it is also true that such efforts will be significantly more costly than a broad approach, thus making it economically unfeasible. Therefore, if there is a lack of funding, costly local management strategies should be directed towards the most endangered communities, whereas other communities may have to receive a broad approach.

However, it may be possible that any sort of local management strategy will turn out to be ineffective simply because the effects of anthropogenic climate change are overwhelming any positive impacts of local management. True coral reef rehabilitation, in terms of returning communities to the historical state they were naturally in may just not be possible. In that case, the aforementioned management strategies should still be attempted in order to rehabilitate coral reef communities as best as possible. If these strategies can result in modest rehabilitation of coral reef communities, or at least slow the present decline of coral reef ecosystems, it would be a worthwhile research and conservation opportunity.

References

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