REEF ENHANCEMENT UNITS: THE FUTURE OF CORAL REEFS?

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Figure 2. REU in 2004 (left) vs. REU in 2014 (right) (2)

IMMEDIATE ACTION IS NEEDED TO PROTECT OUR CORAL REEFS

For decades, the Singapore southern islands have been impacted by **anthropogenic stressors** including land reclamation, large-scale coastal development, and recurrent dredging from ship lanes (4). As a consequence, Singapore's reefs have been largely degraded and are **under threat** (4). This document outlines the pros and cons of Reef Enhancement Units (REUs) as a type of Artificial Reef (AR) to restore coral reefs, and thereafter concludes with **potential policy-based action items.**

WHY ARE CORAL REEFS IMPORTANT?

Coral reefs are an important component of the marine environment. **Ecologically**, these reefs provide a habitat for Singapore's rich biodiversity and are the source of nitrogen and other essential nutrients in the the food chain (5). With respect to the **economy**, the Singaporean reefs have a value of $796 million largely due to their role in fisheries and tourism (6). **Historically**, these small islands were once home to the native Malay islanders and sea nomads before they resettled on the Singapore main island. In the last half-century, the negative anthropogenic impact on coral reefs has taken their toll - reduced coral cover by up to 20% and reduced depth limit of coral growth (4). Consequently, **we must act now** and employ effective conservation tools, such as REUs, to promote coral reef growth, thereby augmenting biodiversity.

ARTIFICIAL REEFS?

Artificial reefs (ARs) are **human-made structures** that are placed in marine environments in order to mimic the presence of a natural reef (1). There are many different types of ARs, from submerged shipwrecks, to concrete blocks, to reef enhancement units (REUs). In general, most ARs are used to **facilitate biological production** by providing a substrate for organisms to grow (2).

REEF ENHANCEMENT UNITS?

Reef Enhancement Units (REUs) are a **subtype of ARs** that are made of fibreglass with circular holes cut in the walls which allow coral larvae along with other organisms to settle and grow while allowing for water to flow through (3). This is a method used in Singapore's southern coast to **aid in the recovery** of sediment-affected coral reef areas (3).

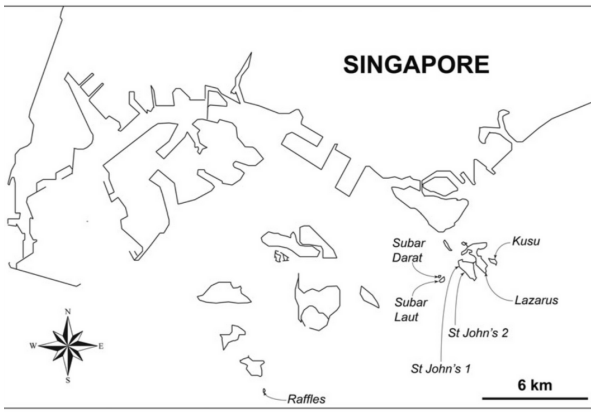

Figure 1. Map of REUs deployed on the southern Singapore islands (2)

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YES TO REUS

REUs are strong, lightweight, easy to deploy, and cost-effective (4). They are suitable for Singapore's shallow southern offshore islands as there is no need to use barges nor cranes for their deployment, limiting the disruption to the shallow marine environment (4). Once settled in their marine habitats, demonstrated in 2004-2014, overall **biodiversity almost doubled** on several REUs sites (4). On the REU interior, ray-finned fish used these structures as their **shelter** and to protect their eggs and on the exterior, markings revealed urchin grazing activity and growth of algal turf, hard corals, soft corals, and sponges (4). On top, crinoids rested to feed in the strong current.

NO TO REUS

REUs may not promote biodiversity as a whole, but simply **attract reef organisms** from other areas causing stocks to be redistributed rather than replenished (5). This increase in fish abundance in one congregated area may **promote fishing and exploitation** of reef species, counteracting its intended objective of restoring reefs and promoting biodiversity (5). Also, the changes in coral families, as well as other biota on REUs may have negative impacts on the ecosystem, as the natural interactions and relationships between different species may be disrupted by the loss or gain of certain species (4).

Image from coralreef.nus.edu.sg

Image from bbc.com

RECOMMENDATIONS & IMPLICATIONS

1. **Establish marine protected areas (MPAs) on the southern Singapore coast surrounding the natural coral reefs and REUs.**
   a. Implications: Honour this MPA as a no-take zone in order to prevent these areas from becoming fisher attraction areas that leads to further exploitation. This is dependent on the compliance of the fishers and the monitoring of these reefs.
2. **Appropriate monitoring using the Shannon Diversity Index to compare REUs versus natural reefs.**
   a. Implications: The Shannon index must be used to evaluate both the REUs deployed and surrounding natural reefs to ensure that these units are in fact increasing biodiversity. This will confirm or refute that the REUs are not acting as a substrate to lure species from natural corals.
3. **Long-term monitoring of reef sites.**
   a. Implications: Due to the long duration required for biological diversity to mature, particularly corals, continuous monitoring is required to evaluate both the progress and effectiveness of the AR in terms of the Shannon diversity index. This is contingent on funding resources.

Overall: Although REUs do not solve the root cause of reef destruction, if MPAs have been properly established with input from community stakeholders and follow-up with appropriate long-term monitoring, they are a viable technique to create new reefs and promote biodiversity. In doing so, it is possible for reefs and their associated biota to flourish again.

1. NOAA. (2020).
2. Ng, C. S. L., Toh, T. C., & Chou, L. M. (2017).
3. Tse-Lynn, L. (2002).
4. Carr, M. H. & Hixon, M. A. (1997)
5. Human impact on the reef. (n.d)
6. Chou L. M. (2006).