THE DEVELOPMENT OF NEW CONCRETE ARTIFICIAL REEF CULVERT-PROKA IN SARAWAK WATERS, MALAYSIAN BORNEO

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ABSTRACT

Coral reefs are essential aquatic marine ecosystems that provide food and shelter for a wide range of marine organisms, including fish. However, the decline of natural coral reefs makes the current natural artificial reefs insufficient for supporting marine biodiversity. Existing design and construction approaches for artificial reefs are often associated with high development costs, with the construction phase subsequently requiring a considerable amount of time to complete. This study proposes a new structural design and construction of artificial reefs units, which were deployed at selected Department of Fisheries Malaysia (DoFM) areas in Sarawak. The results indicate that, one year after deployment, the Culvert-PROKA artificial reef structures remain stable and intact on the seabed. Furthermore, a comparative study between reef and non-reef sites was conducted to evaluate fish aggregation and biodiversity. This study has shown that the new design effectively enhances, restores, and protects marine resources. Moreover, the comparison of actual construction costs and time requirements between previous artificial reef designs and the Culvert-PROKA system reveals that the new design significantly reduces both financial expenditure and implementation time, thereby confirming its effectiveness as a more efficient and practical solution. Overall, the author emphasizes on the potential of the newly developed artificial reef design as a cost-effective and efficient solution, as evidenced by the comparative evaluation of actual costs and time requirements. This suggests that the design is highly adaptable and can be applied by other areas in Malaysia or other countries.

Keyword: *Coral Reef, Coral Propagation, Culvert, Artificial Reef*

INTRODUCTION

The development of artificial reefs (AR) in Malaysia, particularly in Sarawak, has progressed rapidly with the deployment of large-scale concrete reef structures since the mid-2000s (Duwin, 2021). The primary objectives of AR production, as highlighted by Ahmad and Virgilia (2014), are to enhance coastal fishery resources, establish new marine habitats, support the economic sustainability of coastal fishing communities, and facilitate the growth of recreational fisheries.

Artificial reefs have been produced in various sizes, shapes, and materials. However, most AR produced in Malaysia incur relatively high costs, particularly for concrete-based structures such as reef balls, which typically range from approximately RM400 to RM480 per unit for manufacturing and may exceed RM800 per unit when transportation and deployment costs are included (Reef Ball Foundation, 2004).

Given the vastness of Sarawak's waters, it is crucial to diversify the design of artificial reefs to further increase fish populations in the region, particularly by identifying suitable deployment zones in coastal waters which are typically located between approximately 4.8 km and 8 km from the shoreline (≈2.6–4.3 nautical miles), where artificial reefs are widely used in Malaysia for fisheries enhancement and protection of inshore resources (International Collective in Support of Fishworkers [ICSF], 2017). In addition, AR placement within traditional fishing zones (<5 nautical miles) plays an important role in supporting artisanal fisheries and preventing encroachment by commercial trawlers (Zainudin, 2016).

The revenue generated from AR deployment programs will help address the challenges of dwindling fishery resources and improve the income of local fishermen, ultimately benefiting the community (Ali *et al*., 2015). The new culvert-PROKA ('*Propagasi Karang'*) AR design stands out due to the following factors:

i. The construction components are more cost-effective compared to existing AR used worldwide.
ii. The custom interlocking system reduces production time while maintaining the strength of the reef structure.
iii. The culvert-PROKA AR design offers a two-in-one package, combining coral propagation and fish aggregation, with coral propagation contributing to the reef's maturity (Barton *et al*., 2015).

This research was initiated by a researcher from the Sarawak Marine Fisheries Department (SMFD) Kuching, Sarawak who made observations and eventually conducted a joint venture with Sarawak Consolidated Industries Berhad (SCIB), based in Kuching, Sarawak. The main purpose of this collaboration is to jointly contribute to the production of a new design AR and to achieve more cost-effective AR production. The culvert products from SCIB were found to be suitable for AR production, where the company has many culverts that could be recycled for this purpose.

MATERIAL AND METHOD

The research framework is illustrated in Figure 1, beginning with case studies and design development, followed by site surveys, structure deployment, and post-deployment observations.

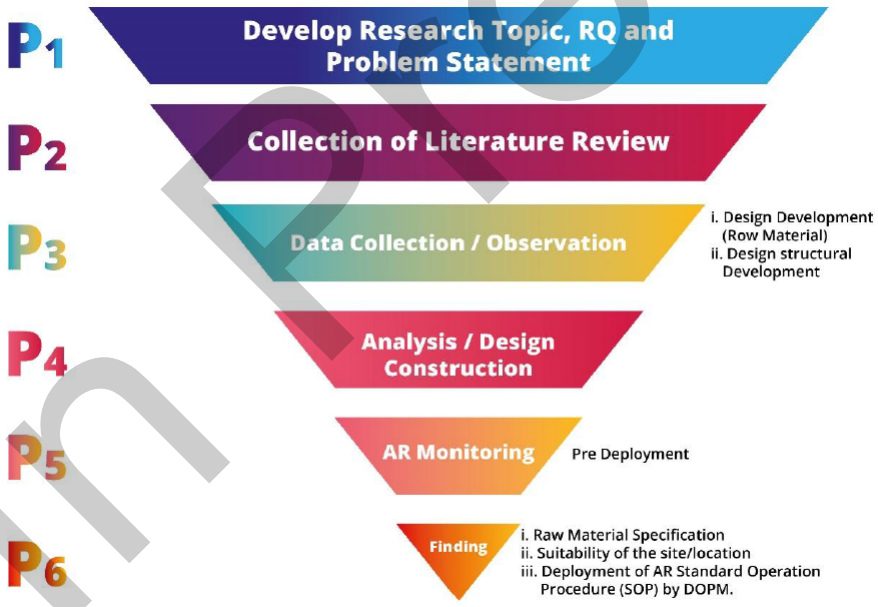

Figure 1: The Research Framework

(a) Project Location

A team from the Sarawak Marine Fisheries Department (SMFD), in collaboration with the Fisheries Research Institute (FRI), Bintawa, conducted a site survey to assess the suitability of the AR deployment area (Ahmad *et al*., 2018). The survey