REEF FISH ASSEMBLAGES IN ARTIFICIAL REEFS AT TUN SAKARAN MARINE PARK, SEMPORNA, SABAH

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UNIVERSITI MALAYSIA SABAH
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DECLARATION

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ABSTRACT

Tun Sakaran Marine Park (TSMP) is a Marine Protected Area (MPA) located in the heart of Malaysia's Coral Triangle – a region well-known for its outstanding marine biodiversity. Active coral reef restoration and rehabilitation efforts using the coral frame method have been in place by the park management authority since 2011. However, information on the reef fish assemblages on the artificial reefs are lacking. Thus, this study was carried out 1) to establish the diversity of the major groups of reef fish and non-major but endangered, threaten and protected (ETP) species in Malaysia (i.e., sharks and rays) in coral reef restoration sites 2) to estimate the abundance and biomass of four families of large indicator coral reef fishes (Serranidae, Labridae, Lethrinidae and Haemulidae) 3) to determine the correlation of hard coral cover on artificial reef towards the reef fish's diversity and abundance. Baited remote underwater video system (BRUVS), which captured approximately one-hour footage were annotated and analysed. Photos of corals on the artificial reef were analysed using Coral Point Count with Excel, CPCe (version 4.1) software to determine percentage of substrate type cover. Findings showed that species richness had a significant difference for both study sites ($p<0.05$) with a total of 105 species (26 families) and 102 species (25 families) at Site 1 and 2, respectively. There was a slight difference in the abundance between both sites where a total of 3,208 individuals were observed (1,209 in Site 1 and 1,999 in Site 2) where Caesionidae family was the highest abundance. In terms of species, Moon Wrasse, *Thalassoma lunare* was the most common species with highest count. The results indicated that fish swimming near the artificial reefs but not close enough to have direct contact with the structures (categorized as 'Ecological Type B fish'), was the dominating Type for both sites. Despite the artificial reefs on both sites being deployed at different locations and times, there were no significant differences ($p>0.05$) for reef fish diversity (Shannon-Weiner Diversity Index). Biomass of the Moon Wrasse recorded the highest in the artificial reefs since it has high abundance which is estimated 309.59g/m^3. A positive correlation is shown in Site 1 ($r=0.441$, $p=0.151$) conversely, a negative correlation shown in Site 2 ($r= -0.004$, $p=0.990$). The presence of elasmobranch particularly those listed as endangered, threatened, and protected (ETP) species, showed that the restored reef areas have created a sanctuary for these vulnerable species. This shows that the restored reefs are important sites for these species of rays. Despite this, it is concluded that active coral reef restoration and rehabilitation efforts are important in accelerating the re-colonization of the damaged coral reefs by coral reef inhabitants, particularly by juvenile coral reef fishes. Lessons learned from this study may help park managers to refine the technique of coral reef restoration and tailor-make coral frames based on the profile of the damaged reef.

ABSTRAK

HIMPUNAN IKAN TERUMBU KARANG PADA TUKUN TIRUAN DI TAMAN MARIN TUN SAKARAN SEMPORNA, SABAH

Taman Marin Tun Sakaran (TMTS) ialah Kawasan Perlindungan Marin yang terletak di tengah-tengah Segitiga Terumbu Karang Malaysia - sebuah wilayah yang terkenal dengan biodiversiti marin yang luar biasa. Usaha pemulihan dan pemeliharaan terumbu karang secara aktif menggunakan kaedah rangka karang telah dilaksanakan oleh pihak berkuasa pengurusan Taman sejak 2011. Bagaimanapun, maklumat mengenai himpunan ikan terumbu di terumbu tiruan adalah kurang. Oleh itu, kajian ini dijalankan 1) untuk mengenal pasti kepelbagaian kumpulan utama ikan terumbu dan spesies bukan utama tetapi terancam, diancam kepupusan dan dilindungi (ETP) di Malaysia (iaitu, jerung dan pari) di tapak pemulihan terumbu karang 2) untuk menganggarkan kelimpahan dan biojisim empat keluarga ikan terumbu karang penunjuk besar (Serranidae, Labridae, Lethrinidae dan Haemulidae) 3) untuk menentukan korelasi litupan karang keras pada tukun tiruan terhadap kepelbagaian dan kelimpahan ikan karang. Sistem video bawah air berumpan (BRUVS), yang merakam kira-kira satu jam rakaman telah diberi penjelasan dan dianalisis. Foto karang di terumbu tiruan dianalisis menggunakan perisian Coral Point Count dengan Excel, CPCe (versi 4.1) untuk menentukan peratusan litupan jenis substrat. Dapatan kajian menunjukkan bahawa kekayaan spesies mempunyai perbezaan yang signifikan bagi kedua-dua tapak kajian ($p<0.05$) dengan jumlah 105 spesies (26 famili) dan 102 spesies (25 famili) masing-masing di Tapak 1 dan 2. Terdapat sedikit perbezaan dalam kelimpahan antara kedua-dua tapak di mana sejumlah 3,208 individu telah diperhatikan (1,209 di Tapak 1 dan 1,999 di Tapak 2) di mana Famili Caesionidae merekodkan jumlah terbanyak. Manakala bagi spesies ikan pula, Moon Wrasse, Thalassoma lunare adalah spesies yang paling banyak jumlahnya. Keputusan menunjukkan bahawa ikan yang berenang berhampiran tukun tiruan tetapi tidak cukup dekat untuk mempunyai hubungan langsung dengan struktur (dikategorikan sebagai 'ikan Jenis Ekologi B'), adalah jenis yang mendominasi bagi kedua-dua tapak kajian. Walaupun tukun tiruan di kedua-dua tapak ditempatkan di lokasi dan masa yang berbeza, tidak terdapat perbezaan yang ketara ($p>0.05$) untuk kepelbagaian ikan terumbu (Indeks Kepelbagaian Shannon-Weiner). Ikan jenis Moon Wrasse mencatatkan biojisim yang tertinggi di kawasan tukun tiruan disebabkan ia mempunyai kelimpahan yang tinggi iaitu dianggarkan sebanyak 309.59g/m^3. Kolerasi positif ditunjukkan dalam Tapak 1 ($r=0.441$, $p=0.151$) sebaliknya, korelasi negatif ditunjukkan dalam Tapak 2 ($r=-0.004$, $p=0.990$). Kehadiran elasmobranch terutamanya yang disenaraikan sebagai spesies terancam, dan dilindungi, menunjukkan bahawa kawasan terumbu yang dipulihkan telah mewujudkan tempat perlindungan bagi spesies ini. Ini menunjukkan bahawa terumbu yang dipulihkan adalah tapak penting untuk spesies terancam dan dilindungi ini. Walaubagaimanapun, disimpulkan bahawa usaha pemulihan dan pemeliharaan terumbu karang yang aktif adalah penting dalam mempercepatkan pertumbuhan semula terumbu karang yang rosak oleh hidupan terumbu karang, khususnya oleh ikan terumbu karang juvana. Pengajaran yang diperoleh daripada kajian ini boleh membantu pengurus taman untuk memperhalusi teknik pemulihan terumbu karang dan menyesuaikan tukun tiruan berdasarkan profil terumbu yang rosak.

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LIST OF ABBREVIATIONS

CPCe	-	Coral Point Count with Excel Extension Programme
g/m^3	-	gram per metre cubic
indi. $/m^3$	-	individual per metre cubic
JASP	-	Jeffrey's Amazing Statistical
km	-	kilometre
m	-	metre
PVC	-	Polyvinyl Chloride
cm	-	centimetre
CTI	-	Coral Triangle Initiative
SSME	-	Sulu-Sulawesi Marine Ecoregion
MPA	-	Marine Protected Area
SEA	-	Southeast Asia
TSMP	-	Tun Sakaran Marine Park
IUCN	-	International Union for Conservation of Nature
BRUVS	-	Baited Remote Underwater Video System

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Coral reef ecosystems are important in various ecological, aesthetic, economic, and cultural functions (Maragos, et al., 1996). It protects shoreline, which acts as the first line of defence against erosion by reducing the force of wave and the production of sediment (Elliff & Silva, 2017). Energy from ocean wave could be dispersed by reef crests of fringing reefs which act as breakwaters (Gallop, et al., 2014; Rogers, et al., 2016). Coral reefs provide critical ecosystem services, including fisheries, coastal protection, and tourist income, to millions of people (de Groot, et al., 2012; Barbier, 2017; Woodhead, et al., 2019).

One of the most diverse coral ecosystems in the world are located at the Coral Triangle Initiatives (CTI) area. CTI area has diverse coral reefs which home to 605 zooxanthellate coral species (66% are common to all ecoregions) that is equivalent to 76% of the world's total coral species (Veron, et al., 2009). CTI area also has the richest area for reef fishes Islands which contains 52% of Indo-Pacific reef fishes (37% of reef fishes of the world). This area includes eastern Indonesia, Sabah (Malaysia), Philippines, Papua New Guinea, and the Solomon Island (Allen, 2008). In the heart of CTI area, located the Tun Sakaran Marine Park (TSMP) Semporna, Sabah, which is a recently gazetted (in 2004) Marine Protected Area (MPA) in Malaysia. Coral and fish diversity in TSMP have been documented as the highest in Malaysia (SIP, 2001).

However, coral reef faces a significant threat from anthropogenic factors such as overfishing, global climate change, coral disease, sedimentation, extensive coastal development, the introduction of invasive species and the release of pollutants (Hughes, et al., 2003; Hoegh-Guldberg, et al., 2017). In TSMP, the park also faces challenges on its coral reefs. The Semporna Island Project (SIP, 2001) reported that unsustainable fishing practices occurred long before the TSMP was gazetted. More recent unpublished internal reports by Sabah Parks (SP, 2017, 2018), documented the threats to the coral reef ecosystem in the TSMP from 'natural' phenomena, namely bleaching (in 2017) and mass Crown of Thorn starfish outbreak (in 2018) that damaged the park's coral reefs. Despite this, the most recent report of the annual survey on the health of coral reefs by Reef Check Malaysia (RCM) showed that 25% of the natural reefs within TSMP were in excellent condition, 33% were in good condition, and 25% were in fair condition while the remaining 17% were in poor condition (Reef Check Malaysia, 2018).

In TSMP aside from gazetting the area as a protected area, coral reef restoration is also practiced. The coral frame method which adopts the techniques and technology of Seamarc Ptv. Ltd. from the Maldives has been used here since 2011. This strategy is to repair damaged coral reef based on a small scale, of which is then expected to eventually make a significant difference, versus a big-scale restoration program, which is not only difficult but expensive and time-consuming (Wood & Ng, 2014).

To measure the success of this coral frame as an artificial reef, this study has focus on to get more information on commercially important and indicator coral reef fish (based on Reef Check). Thus, this study was initiated to evaluate the effectiveness of coral frame as a method in coral reef restoration project by determining the population structure of commercially important species and indicator coral reef fish around the coral frames.

1.2 Research Problem

Since the beginning of these coral reef restoration efforts, monitoring of the 'recovery' phases on the population structure of coral reef fish has been minimal, and done to monitor the coral fragment on the structure are intact. Thus, this study was initiated to evaluate the effectiveness of the Tun Sakaran Marine Park coral restoration programme.

1.3 Research Questions

a) What is the diversity of reef fish at coral reef restoration sites at Tun Sakaran Marine Park?
b) What is the abundance and biomass of the large indicator coral reef fishes (Serranidae, Labridae, Lethrinidae and Haemulidae) on coral frame?
c) Is there any significant relationship between hard coral cover (on coral frames) and the biodiversity and abundance of reef fishes?

1.4 Aims

The aim of this study is to assess the efficacy of the coral frame techniques as a strategy to rehabilitate coral reef that were damaged primarily by unsustainable fishing activities before the establishment of the MPA. This study also aims to assess the effect of the hard coral cover (planted on the coral frame) on the recruitment of indicator, commercially important coral reef fish and endangered, threaten and protected (ETP) species.

1.5 Significant of the Study

The finding from this study will be important knowledge for the marine park management (especially Sabah Parks) or other related agencies that involved in coral restoration programmes, in evaluating the success of coral frames as an option for artificial reef in improving fisheries stock in the wild. This understanding could help park managers in planning and managing the suitable techniques in coral reef restoration programmes inside of the marine parks in the future.

1.6 Objectives

a) To establish the biodiversity of the major groups of reef fishes, including endangered, threatened, and protected (ETP) elasmobranch species in the Tun Sakaran Marine Park coral reef restoration sites.
b) To estimate the abundance and biomass of four families of large indicator coral reef fishes (Serranidae, Labridae, Lethrinidae and Haemulidae).
c) To determine the correlation of hard coral cover on artificial reef towards the reef fish's diversity and abundance.

1.7 Hypothesis

It is hypothesized that the use of coral frames as an approach to enhance damaged coral reef areas within the Tun Sakaran Marine Park (TSMP) had the positive effects in rebuilding the coral reef fish population. The coral frames are attracting not just coral reef fishes to the rehabilitated waters, but other non-reef fishes such as economically important food fish, carangids and endangered, threaten and protected (ETP) species.

CHAPTER 2

LITERATURE REVIEW

2.1 Marine Protected Area

Marine Protected Area (MPA) is a strategic tool for the conservation of marine life. IUCN define a protected area as “A geographical space, recognised, dedicated, and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values” (Day et al., 2012) which includes terrestrial protected area and marine protected area.

Marine Protected Area (MPA) consists of a portion of marine and coastal habitat that has been designated as a protected area by the owner or manager. MPAs include marine parks, nature reserves and locally managed marine areas that protect reefs, seagrass beds, shipwrecks, archaeological sites, tidal lagoons, mudflats, saltmarshes, mangroves, rock platforms, underwater areas on the coast and the seabed in deep water, as well as open water (the water column). Each MPA has limits and a statement of permitted and prohibited uses. The steward (public or private) empowers a designated agency to administer the area within the MPA boundaries for the purposes for which the MPA was established (Salm et al., 2000). According to Salm et al. (2000), an MPA can be designated (multiple uses) for one or more reasons: (1) it is the best example of an important ecosystem or habitat type; (2) it is necessary for the sustainability of the fisheries, e.g. through no-fishing zones; (3) it has high biodiversity; (4) it is a site of intense biological activity; (5) it is a natural wonder or a tourist attraction; (6) it provides critical habitat for particular species or groups of species; (7) it has particular cultural values (such as historical, religious, or recreational sites); (9) it protects the shoreline from storms, and (10) it facilitates the necessary research or determination of the natural ground state.

The world needs more areas to be protected and manage as protected area as it brings significant benefit towards the protection of biodiversity. Based on UNEP-WCMC and IUCN (2022), as of November 2022, the numbers of protected areas around the world are 285,520 which covered land areas of 21,312,474km^2 and ocean area of 29,581,883 km^2. There are total of 267,072 Protected areas which include the terrestrial and inland waters protected area and 18,448 areas are established as marine protected area. This comprises of 15% and 8.16% of the world's land and ocean area respectively that have been established as protected areas. If the other effective area-based conservation measures (OCEMs) were included into the statistic which has 827 number of that comprises of OCEMs number of 632 terrestrial and inland waters OECMs and 195 number of marine OECMs, then the area covered were larger. Based on data total of 16.64% of land and 7.74% of marine areas are now protected.

In 2010, world governments reaffirmed their commitment to expanding protected and protected areas by agreeing to conserve 17% of the world's terrestrial and inland water ecosystems and 10% of its coastal waters and oceans by 2020 in achieving target 11 of the Aichi Biodiversity Targets. The target clearly stated that by 2020, systems of protected areas that are effectively managed, ecologically representative, well-connected, and comprise at least 17% of terrestrial and inland water, 10% of coastal and marine areas, and particularly areas of particular importance for biodiversity and ecosystem services, will be preserved and integrated into larger landscapes and seascapes. However, looking at the current coverage of world protected areas, both terrestrial and marine protected areas have not achieved the target set before 2020. Even though there are increase in the protected areas for the past 30 years since 1990 (Figure 2.1) and additional of few OCEMs into the database but still it did not reach the target set.

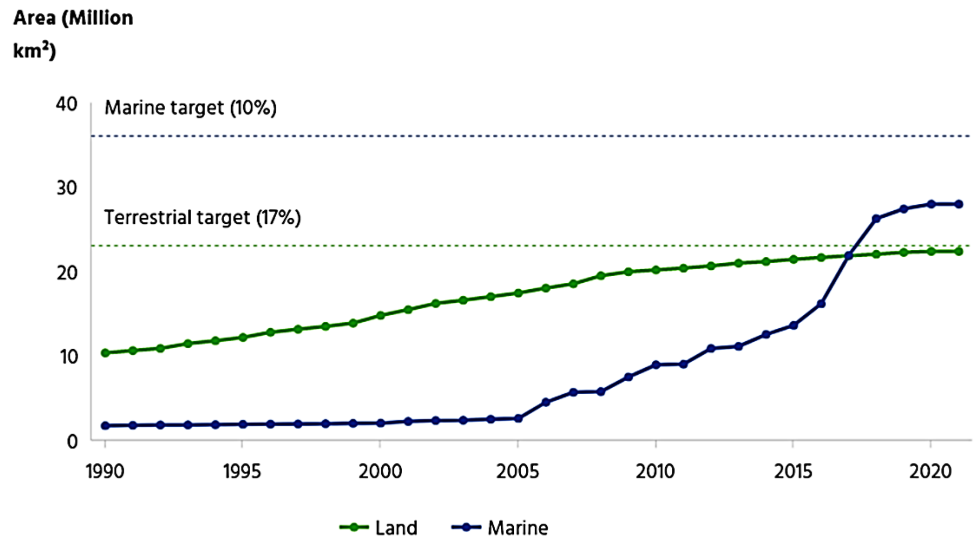

Figure 2.1 : Change in protected area and other effective area-based conservation measures (OECMs) in the world.
Source : UNEP-WCMC and IUCN (2021)

Nonetheless, Convention on Biological Diversity are still committed in preserving the world diversity. The Biodiversity Strategic Plan 2011-2020 set the context for short and medium-term actions by outlining an agreed long-term vision for biodiversity up to 2050, entitled Living in harmony with nature. Post-2020 global biodiversity framework has been plant as a roadmap toward the vision. (Secretariat of the Convention on Biological Diversity, 2020)

2.1.1 Benefits of Marine Protected Area

Throughout the world, many countries had adopted Marine Protected Area (MPA) as a tool for conservation. MPA have proven to be effective management tools for improving fish populations. Benefits of having MPA are endless. Several studies have shown that MPAs increase fish biomass and produce larger fish (Chung et al., 2012; Abesamis et al., 2014; Russ et al., 2015). These include halting and possibly reversing the global and local decline in fish populations and production by safeguarding essential breeding, nursery and feeding habits (OECD, 2017). A study has shown that MPA could improve the population of fish as it protects the crucial habitats for breeding (Davies et al., 2021). Another important impact of marine reserves is the