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Title: From Marxan to Management: Ocean Zoning with stakeholders for the proposed Tun Mustapha Park in Sabah, Malaysia

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From Marxan to Management: Ocean Zoning with stakeholders for Tun Mustapha Park in Sabah, Malaysia

Abstract: Tun Mustapha Park (TMP) in Sabah, Malaysia was gazetted in May 2016 and is the first multiple use park in Malaysia where conservation, sustainable resource use and development co-occur within one management framework. We applied a systematic conservation planning tool, Marxan with Zones, and stakeholder consultation to design and revise the draft zoning plan. This process was facilitated by Sabah Parks, a government agency, and WWF-Malaysia, under the guidance of a TMP Steering Committee and with support from the University of Queensland. Four conservation and fishing zones, including no-take areas, were developed, each with representation and replication targets for key marine habitats and a range of socio-economic and community objectives. Here we report on how decision-support tools informed the reserve design process in three planning stages: prioritization, government review, and community consultation. Using marine habitat and species representation as a reporting metric, we describe how the zoning plan changed at each stage of the design process. We found that the changes made to the zoning plan by the government and stakeholders resulted in plans that compromised the achievement of conservation targets, because no-take areas were moved away from villages and the coastline, where unique habitats are located. Importantly, the design process highlights a number of lessons learned for future conservation zoning, which we believe will be useful as many other places around the world embark on similar zoning processes in the land and sea.

Keywords: Biodiversity, Coral Triangle Initiative, marine protected area, Marxan, representation, sustainable resource use, systematic conservation planning, Zoning.

Introduction

Marine ecosystems are threatened by human activities on land and in the sea (Halpern et al., 2015). Coupled with growing human populations and economies, the main threats include increasing overfishing (Jackson et al., 2001; Lotze et al., 2006; Worm et al., 2006, 2009), pollution (Syvitski et. al., 2005; Vitousek et.al., 1997), habitat modification and degradation (Burke et. al., 2011; Halpern et al., 2008, 2015). Further, climate change affects marine ecosystems through changes in sea level, aragonite concentrations and temperature (Hoegh-Guldberg et al., 2007; Hughes, 2003; Jackson et al., 2001). Marine protected areas (MPAs) are a key regional action that can help conserve marine biodiversity and sustain coastal resources (Edgar et al., 2014; Gaines et. al., 2010; Hughes et.al., 2010; Mumby & Harborne, 2010).

Given growing threats facing marine ecosystems, there is increasing incentive to establish MPAs. For example, the Convention on Biological Diversity aims to represent 10% of marine habitats in protected areas by 2020 (Convention on Biological Diversity, 2011). As protected areas often constrain resource users such as fishers, establishing different types of zones can accommodate multiple conflicting and incompatible uses of the ocean (Crowder et al., 2006; Yates, Schoeman, & Klein, 2015). Ocean zoning thus aims to regulate activities in time and space to achieve specific objectives for industries and biodiversity (Agardy, 2010).

There are many approaches that have been used to design zoning plans, ranging from stakeholder- to software-driven processes. For example, stakeholder groups were responsible for developing networks of coastal MPAs in California (Gleason et al., 2010; Klein et.al., 2008), and a national marine conservation strategy in the Marshall Islands (Baker et. al., 2011). In Papua New Guinea (Green et al., 2009), Australia (Fernandes et. al., 2005) and Indonesia (Grantham et al., 2013), spatial planning software helped identify priority areas for multiple human activities and biodiversity. Ideally, decision makers will utilize both stakeholder input and spatial planning software to identify zone placements to meet conservation and socio-economic objectives (Game et al., 2011). However, there is

limited guidance on how to best integrate stakeholder input and spatial planning software to design a zoning plan for multiple uses. Few published examples exist that describe the challenges and opportunities for integrated approaches. Accessing lessons learnt from projects that pioneered such approaches remains a challenge. As an increasing number of nations embark on ocean zoning processes to conserve biodiversity and manage growing economic activities, such guidance is urgently required to support effective decisions.

In this paper we describe the approach used to develop a zoning plan for Tun Mustapha Park (TMP) in Sabah, Malaysian Borneo, where the planning tool Marxan with Zones (Watts et al., 2009) was integrated with stakeholder consultation. Stakeholders included representatives from the government, academia, non-governmental organizations, and community members affected by TMP. One of the primary objectives of the plan was to meet basic representation targets for key marine habitats and species within TMP. We show how the representation of key marine habitats and species changed in each of three stages of the design process, as well as how evenly habitats and species are represented across each zone. We hope that lessons learned from our TMP experience can guide decisions about how to zone for conservation and human-uses elsewhere. In particular, we believe this study will be useful across the Coral Triangle, where an increasing number of zoning plans are underway, as the policy context and data limitations are similar.

Study Area

TMP is located in the northern region of Sabah. Prior to gazettement, the region had no effective formal natural resource management plans, and laws regulating its resource use were not fully enforced. To address this, the Sabah Government approved the intention to gazette TMP in 2003, with the gazettement finalized in May 2016. During this period, TMP became part of two major initiatives: the Sulu Sulawesi Marine Ecoregion Programme and the Coral Triangle Initiative for Coral Reefs, Fisheries and Food Security (CTI-CFF). The CTI-CFF is a regional multi-lateral collaboration to manage coral reef resources. TMP is among the top priority sites within the region that will help fulfill multiple goals of the CTI-CFF

(Beger et al., 2015). It is globally significant for its marine life, with a rich diversity of coral reef, mangrove, and seagrass habitats as well as several threatened species, including dugong (Dugong dugon), otters (Lutra perspicillata), humpback whales (Megaptera novaeangliae), and sea turtles (Chelonia mydas, Eretmochelys imbricata, Lepidochelys olivacea) (Conservation Plan for the Sulu-Sulawesi Marine Ecoregion, 2003). TMP is home to over 187,000 people living in three administrative districts (Kudat, Pitas, Kota Marudu), almost half of which depend on marine resources for their livelihood and wellbeing (Department of Statistics Malaysia & Department of Statistic Malaysia, 2010; PE Research, 2011). Fishing is a primary economic activity in the region, contributing 22% of total marine fisheries production in Sabah in 2008 (PE Research, 2011). Although trawl and purse seine fisheries are the largest fisheries in the region, the live reef fish trade, long line and small scale artisanal fisheries are significant for local livelihoods. As such, the habitats and marine life are threatened by a suite of human activities, including overfishing, destructive fishing, unsustainable coastal land-uses, and illegal harvest of sea turtles/eggs (Jumin et. al., 2013).

We categorized TMP into four ecological regions based on geographic location, ocean currents and wind regimes that influence the development of coral reef ecosystems, and report our results according to these regions (Figure 1). The planning area is 1.02 million hectares, which includes areas three miles from the mainland and two miles from the islands within TMP. We excluded an area of approximately 560 hectares adjacent to Kudat Town due to heavy degradation and industrial development including regional port and ferry terminals, and a landing jetty.

Methods: Zoning Process

In 2003, the Sabah State Government approved the intention to gazette and zone the area for multiple uses, including conservation and fishing. The Sabah State Government has three objectives for TMP: 1) eradicate poverty; 2) develop economic activities that are environmentally sustainable; and 3) conserve habitats and threatened species. In 2011, an Interim Steering Committee (henceforth “the Committee”) was established to manage and

guide the development of an integrated management plan for TMP. The Committee contains stakeholders representing the region's interests and is chaired by the Ministry of Tourism, Culture, and Environment. There are six technical working groups focused on different aspects of management, including a zoning working group, which facilitated all stages of the planning process described in this paper via review, feedback and endorsement of the final draft to the Committee. Stakeholder outreach was focused on these three objectives, with emphasis on how a well-designed multiple use MPA can achieve TMP's three objectives.

Prior to this zoning effort, two major marine zones existed within the proposed boundary of TMP: a commercial fishing zone (>3nm from mainland and >1nm from the islands) and a traditional fishing zone (< 3nm from mainland and <1 nm from islands). Both zones were insufficient in protecting key habitats such as mangroves and coral reefs, and existing laws were not fully enforced, which meant there was killing of endangered species and overfishing. Potential new zone types were developed consultatively with key stakeholders from Sabah Parks, Department of Fisheries Sabah, Universiti Malaysia Sabah, Land & Survey Department, Sabah Forestry Department, Persatuan Pemilik Kapal Nelayan Kudat (Kudat Fishing Boat Owners Association), and other non-governmental organisations (NGOs) (Weeks et al., 2014). The new zone types for TMP were determined to be: 1) Preservation Zone which prohibits all extractive activities; 2) Community Use Zone which allows non-destructive small scale and traditional fishing activities, and encourages the nearby communities to take part in the management of their own resources; 3) Multiple Use Zone which allows non-destructive and small scale fishing activities as well as other sustainable development activities, such as tourism and recreation; and 4) Commercial Fishing Zone which allows large scale extractive fishing practices. Certain types of commercial fishing activities such as long line (rawai) and recreational fishing are also allowed in the Multiple Use Zones but are not allowed in the Community Use zone.

The primary four design principles considered in the zoning process were protection of key habitats in no-take areas, replication, representation, and connectivity (Green et al., 2014;

147 Lee & Jumin, 2007). Specifically, the representation goal was to ensure all major habitats
148 were included within no-take zones and the replication goal was to ensure that each habitat
149 was protected in multiple individual no-take zones. The TMP zoning process was undertaken
150 in three stages: prioritization, review and consultation (Figure 2), each of which produced a
151 proposed zoning map. The entire process involved academics, government and NGOs, and
152 local communities. Here, we describe each stage of the process and evaluate how well each
153 resulting zoning plan achieved the outlined conservation and socio-economic goals for TMP.
154
155 Stage 1: Prioritization using Marxan with Zones
156 We used the systematic conservation planning software, Marxan with Zones (Watts et al.,
157 2009), to assist in the creation of multiple-use zoning plans for TMP to ensure a repeatable,
158 transparent and scientifically credible methodology (Klein et al., 2009).
159
160 We identified priority areas for three different zones: 1) Preservation; 2) Community use; and
161 3) Multiple use. We did not include a zone for commercial fishing activities (i.e., trawl and
162 purse seine gear). Rather, the commercial fishing zone was restricted to beyond 3 nautical
163 miles of land, which is the legal limit for commercial fishing activity in Sabah, Malaysia.
164 However, it is important to note that this legal limit is not currently strictly enforced, resulting
165 in commercial fishing occurring closer to shore; a problem that will be addressed when the
166 zoning plan is implemented.
167
168 For each zone, Marxan with Zones requires two basic types of information: 1) how much and
169 what type of features (e.g., habitat and distributions and fishing grounds) should be included
170 in each zone; and 2) the 'cost' for implementing the zone.
171
172 We targeted 15 conservation features (habitats and species) and two socioeconomic
173 features (fishing grounds and historical sites) in each of the four ecological regions for
174 inclusion in preservation and community use zones (Table 1) (Weeks et al., 2014). We set a
175 target for each feature in each zone to address the principle of replication, which helps

ensure the zoning plan is resilient to catastrophic events (Green et al., 2009; Green et al., 2014). A minimum of 30% representation of habitats and species were set in line with general recommendations from conservation science (Bohnsack et al., 2000; O'Leary et al., 2016). This figure is higher than the 20% target set for the broader Coral Triangle (White et al., 2014) but is justified by the prevailing threats of unsustainable fishing practices in the area such as dynamite and cyanide fishing. The Balambangan Island caves and historical sites were fixed as targets to protect their unique status (Lee & Jumin, 2007).

The coral reefs were divided into eight distinct types on the basis of a rapid morphological assessment of TMP's reef area, combining reef data from (Zulkafly et. al., 2011) and the World Conservation Monitoring Centre's global coral reef distribution data (http://data.unep-wcmc.org/datasets/1). Each reef type represents different reef assemblages based on the general influence of wind and ocean current exposure. Mangrove data were sourced from remotely sensed images (SPOT5, 2006). Turtle nesting and feeding grounds, dugong habitat, and important traditional fishing ground were mapped using data from a community survey conducted in 2006 -2007 by WWF-Malaysia and Sabah Parks (Jumin et. al., 2012). The survey team made up of WWF-Malaysia and Sabah Parks visited 58 villages, interviewed more than 500 respondents with a structured questionnaire, and conducted discussions and mapping with more than 1,500 local community members.

A large number of TMP's communities depend on fisheries for subsistence and livelihoods. Therefore, we aimed to minimize the impact of preservation zones on these communities. We developed a proxy of opportunity cost that was a function of distance from fishing villages (the closer to the village, the higher cost) and important fishing grounds (higher cost where important fishing grounds existed). Further, we targeted traditional fishing grounds in the Community Use and Multiple Use zones that allow traditional fishing. Distance from the village was used as the management cost for the Community Use zone, where the further away the area is from a village, the more costly will it be for the community to manage the area because it will require more resources to access. As a cost is required for each zone,

we defined the cost in the Multi-Use zones as the area of the planning unit; this essentially identifies the smallest area possible that achieves the conservation and socio-economic targets. We constrained Marxan with Zones to ensure that some of the Preservation zones were adjacent to Community Use zones so that communities could benefit from the spillover of adult fish from the Preservation zone.

Stage 2: Review and enforceability assessment by Sabah Parks

The Marxan with Zones planning stage produced several zoning solutions that met TMP's conservation and socioeconomic targets. As the analysis is done based on a grid of small planning units, the boundaries of the zones are jagged and cannot realistically be enforced. Thus, the best solution Marxan with Zones map (Figure 3a) was submitted to Sabah Parks to assess in terms of enforceability. Based on this map, Sabah Parks identified general areas for each zone, using the map as a guide to refine zone boundaries. This produced the first draft zoning plan that was endorsed by the Committee for stakeholder consultation (Figure 3b).

Stage 3: Stakeholder consultation

The stakeholder consultation was conducted by Sabah Parks, with support from WWF-Malaysia, Department of Fisheries Sabah and Universiti Malaysia Sabah. Facilitators with in-depth knowledge of TMP, its stakeholders and their languages conducted consultations for feedback on the draft zoning plan produced in Stage 2, targeting three main stakeholder groups: local coastal communities, the private sector, in particular commercial fishermen, and government agencies. Consultations were conducted in two steps, taking accessibility and efficiency of information dissemination into consideration, and the role of the stakeholders in decision making as well as their influence in the process. The first step involved: i) discussions with district officers, ii) briefing during District Offices Development Committee meetings (Pitas and Kota Marudu), iii) exhibition at the annual Kota Marudu Corn Festival, iii) pilot testing in Banggi Island where community leaders and members of the communities were invited to the district office of Banggi for presentations of the zoning

process, and iv) early ground surveys (Pitas, Kudat, Banggi, Matunggong). During the ground surveys, facilitators visited at least 134 coastal communities/villages and the commercial fishing group based in Kudat, to pre-inform community groups about the proposed plans, and to establish contact with village heads to assist with information dissemination for the second step.

The second step of the consultations involved the use of a semi-structured questionnaire as a tool to systematically capture stakeholder feedback on the draft zoning plan including direct input to the draft zoning map attached to the semi-structured questionnaire. This accumulated 1,017 respondents from the coastal villagers (72% of targeted respondents) and 18 respondents from the commercial fishing group (75% of targeted respondents).

Subsequent to the consultation with the coastal communities and the private sector, consultations with the district offices of Pitas, Kota Marudu, Kudat and the sub-district of Banggi were conducted, presenting the outcome of the previous consultations. Feedback from the stakeholders were incorporated into the draft zoning plan and when necessary, follow-up consultations with specific stakeholders were undertaken to reach a consensus on their input to the zoning plan. The consultations resulted in a third zoning plan (Figure 3c).

Evaluation of zoning maps produced in each planning stage

For each stage of the zoning process, we calculated the amount of each conservation feature represented in each zone by region (Figure 4). We also used an additional metric to illustrate how evenly the habitats were represented within each zone. This metric is a modification of the Gini coefficient (Barr et al., 2011), widely used in economics as a measure of income equality. Here, we used it to quantify the evenness of habitat representation within each zone for each planning stage. We modified the coefficient so that a value of 1 indicates perfect evenness across conservation features, and values closer to 0 indicate uneven representation. We also capped the coefficient, so that 30% protection was

considered the maximum. For simplicity in the evaluation, we aggregated the coral reef types and report representation for coral reef habitat as a whole.

Results

The zoning plan resulting from Stage 1 (Marxan with Zones prioritization) achieved all conservation targets (Table 2). Stage 1 met the design principles for the preservation zones, representation of features and replication of features across regions. We found an even representation of features in the preservation zones, and an unequal representation of features in the other two zones (Table 2).

In Stage 2, Sabah Parks altered the zone boundaries. This process maintained the 30% habitat targets achieved for Region 1 and Region 2, but did not maintain the targets of 30% for coral reefs and seagrass in Region 3 and seagrass and turtle nesting in Region 4 (Figure 4). The Gini Coefficient indicated reduced evenness in representation of features in preservation zones across the park (Table 2). The draft zoning map from this stage produced large coastal preservation zones, particularly around Banggi Island, driven by the desire to protect important coastal habitats like seagrass and mangroves (Figure 3b).

In Stage 3, stakeholder consultation process produced a result that reflects the general preference of stakeholders to have more area assigned to community use, and less for preservation. No 30% targets were achieved in Regions 1, 2 and 3. In these regions, some features still achieved some inclusion in preservation areas (corals, dugong), but in Region 3 only 6% of corals were represented, and none of the estuary, mangrove and seagrass features (Figure 4). On the other hand, the 30% targets for coral reefs and turtle habitat were achieved for Region 4 (Figure 4). Stakeholders' preference to have preservation zones located away from their villages contributed to the lack of coastal habitats in the preservation zone. In some cases, stakeholders recommended relocation of a preservation zone to areas that do not contain conservation features or important habitats. Some governmental decisions made during this process also contributed to the target shortfall, including i)

291 excluding coastal land area and mangrove forest reserves from the TMP boundary, and ii)
292 amending the outer boundary of TMP in some regions (Figure 3c). This development
293 equates to a change in management objectives during the process, where stakeholders
294 decided that some nearshore habitats could not be represented given their socio-economic
295 and political needs.
296
297 Changing conservation objectives to accommodate economic and political realities is
298 common (Goldsmith et. al., 2016; Gormley et. al., 2015; Sale et al., 2014), but it does
299 compromise management outcomes and the livelihoods of people who depend on
300 sustainable resource use. For example, many important fisheries species that are well
301 protected on coral reefs require nursery habitat in seagrasses and mangroves (Olds et. al.,
302 2012) which remain unprotected.
303
304 The biggest change was evident in Region 3. After the stakeholder process, the coastal
305 boundary of TMP was significantly altered, moving the park boundary in some areas to 500
306 meters away from the coastline and reducing the total area of the park. Additionally, coastal
307 habitats like mangroves, seagrass and turtle nesting areas were excluded from the TMP. As
308 in Region 3, mangroves are also not represented within TMP in Region 4, however some
309 mangrove areas are protected by forestry management regulations (Boon & Beger, 2016).
310 The changes in the park and zone boundaries reduced the Gini coefficient for the
311 preservation zone, but increased it slightly for the community use zone (Table 2).
312
313 **Discussion**
314 The establishment of TMP as a multiple use park under IUCN Category VI (Protected Area
315 with Sustainable Use of Natural Resources) is the first of its kind to be established in
316 Malaysia and the first under the Coral Triangle Initiative (Beger et al., 2015; Weeks et al.,
317 2014). We applaud this achievement and believe TMP makes substantial strides towards
318 the protection of biodiversity and the ecosystem services it provides to the local
319 communities. The planning process began with the intention to gazette TMP approved by

the Sabah State Government in 2003. The process on which we report spanned over a decade and included the establishment of a management plan and the design of the TMP zoning plan. However, it was not a perfect planning process and we focus the discussion on the challenges and lessons learned. Our aim is to assist other integrated planning processes within the Coral Triangle, and more broadly around the world, to establish marine protected areas.

Our evaluation shows that the conservation targets were substantially compromised in Stage 3 of the planning process, during the stakeholder consultations, when areas near the coastline were excluded from the park and the outer boundary of the park was reduced. These modifications reflect the concerns of the stakeholders, including local communities, government agencies, and industries (e.g., commercial fishing), who thought that they would not have access to natural resources once the zones were established. These concerns are, in part, due to the perception that the law under which TMP was established (Sabah Parks Enactment 1984) is strictly focused on protecting biodiversity and does not allow for extractive activities, such as fishing. This perception arose because most parks in Sabah established under this law are “no-take” state parks (established as IUCN category II) that only allow for non-extractive recreational activities. However, as demonstrated with TMP, special provisions under the law can be made to allow for the establishment of multiple use parks (IUCN category VI). Educating stakeholders on the benefits of no-take areas to fisheries and food security, as well as clear communication of the special provisions of law, may have prevented some of the comprising changes in Stage 3.

The reduction of the park’s outer boundary in Stage 3 reflects concerns of government agencies. In Sabah, different government agencies have jurisdiction over different habitats that are important for marine biodiversity (e.g., mangroves, estuaries, turtle nesting areas). The Park Enactment law does not allow for collaborative management, and the sole mandate of management belongs to the Sabah Parks Board of Trustees for a period of 99 years (Thandauthapany, 2008). The lack of regulatory support for collaborative management

contributed to the doubts of other government agencies that TMP can be successfully managed by multiple agencies. Consequently, government agencies preferred to maintain the current management practices. For example, the Forestry Department requested that mangrove forest reserves remain under their management, and the District Offices requested some coastal area excluded from TMP boundary for development purposes (Binson, 2014). Excluding these areas may impact the effectiveness of TMP in marine resource management and biodiversity conservation. Notably, most mangrove areas that are important for fish breeding will remain as mangrove forest reserves under the management of the Forestry Department which does not regulate fishing activities, while turtle nesting beaches will remain as state land under the management of the Land Office and will be subject to development. Overall, the exclusions reduced the total area gazetted under the TMP from the proposed 1.2 million ha to 898,762 ha (Warta Kerajaan Negeri Sabah, 2014).

If stakeholders were involved earlier in the planning process, we believe the resulting zoning plan would have better protected biodiversity. Collective decision-making on critical issues such as the park boundary, conservation objectives, features to be protected and their conservation targets, and the types of zones is a crucial step in conservation planning and the success of conservation plans (Carwardine et. al., 2009; Margules & Pressey, 2000; Watts et al., 2009). Although the benefits of involving stakeholders at the beginning of the planning process are well known (Beger et. al., 2004; Crawford et. al., 2006; Fernandes et. al., 2005; Gaymer et al., 2014; Pollnac & Crawford, 2000), inadequate resources delayed the consultation process until funding from the USAID Coral Triangle Support Partnership (CTSP) could be secured in 2010, enabling a focused and structured effort to push for the zoning and designing of TMP. This effort commenced with the establishment of the TMP Interim Steering Committee in January 2011.

The delay led to other, not yet mentioned, challenging negotiations during stakeholder consultation in Stage 3. Several government agencies requested that new areas for commercial fisheries, aquaculture and socio-economic development be identified.

Stakeholders in the trawl fishery were concerned that the exclusion of trawl fishing from multiple-use zones would make their fishery unprofitable. Many of the trawl operators have to service significant loans taken out to buy boats and gear and which they feel they will not be able to repay with spatial restrictions on their fishing effort (Barrett et al., 2011; Cinner, 2011; Cinner et. al., 2009; Mcnally et. al., 2011). In line with institutional and legal support, adequate funding of the process over multiple years is vital to maintain momentum, and to achieve stakeholder buy-in throughout the process.

Important hurdles tackled during the TMP planning process arose from realities and perceptions of the legislations relevant to Malaysian marine parks. The Sabah Parks Enactment is perceived to be a strong legislation that do not allow for multiple use and collaboratively managed park. We found that a legal framework that allows for the implementation of a conservation planning process geared towards multiple use and collaboratively managed park will ensure commitment by and foster confidence from the stakeholders to be part of the process.

A decision support tool such as Marxan with Zones is useful as it translates the planning goals into spatial maps and provides several different zoning options for consideration by stakeholders. In the TMP process, only one zoning map was given to Sabah Parks (Stage 2) for consideration. The decision to use only best option produced by the Marxan with Zones analysis was due to the desire to keep communications with stakeholders simple, rapid and less technical. However, this was a mistake and we learnt that a number of different zoning plans should have been submitted to demonstrate that there are many ways to achieve the desired goals (Game et al., 2011; Linke, Watts, Stewart, & Possingham, 2011).

The use of a planning tool and the associated internal learning processes of the implementing agencies were a novel step for Malaysian national parks planning. Many MPAs around the world are planned without the use of decision support tools. Although

there are many valid planning approaches, decision support tools ensure that resulting plans achieve goals efficiently (Klein et al., 2008). Further, they find places that are required to achieve goals, places that are never needed to achieve goals, and provide stakeholders with alternatives for achieving their goals. Marxan with Zones was used out of the desire by Sabah Parks and WWF-Malaysia to have a decision support tool that is transparent, repeatable and can directly identify areas required for different management types (zones) (Game et al., 2011; Watts et al., 2009). Marxan with Zone produces multiple options for decision making – informed selection of alternate area for the zones that can serve to guide an iterative decision process in stakeholder consultations. However, due to the need to rapidly reach a large number of stakeholders, the approach used in TMP was to focus on the best solution produced by Marxan with Zones, which did allow direct stakeholder input into the Marxan design. While this approach is flawed, the use of Marxan with Zone enabled the zoning team to assess whether conservation targets has been achieved and provide recommendations where critical areas needed to be included in the zoning plan.

The use of Marxan with Zones was challenging because it is new to most people involved in the zoning process. WWF and Sabah Parks staff spent a great deal of time learning and understanding how to use the software. Although the software itself is relatively simple to use, it requires a sophisticated understanding of the principles of systematic conservation planning as well as spatial analyst skills. We learned that understanding the basic guiding principles to systematic conservation planning and the socio-economic benefits of MPAs is perhaps more fundamental compared to understanding the mechanics of a decision support tool, as such technical expertise can be sourced externally. This type of education requires long-term commitment; education that would ideally start in university environmental programmes.

Future planning processes would benefit from having social implications, like poverty traps, explicitly considered in planning tools. For instance, social equity is important to consider to trade off conservation, cost and equity outcomes in reserve design (Agardy, 2003; Barrett et

al., 2011; Halpern et al., 2013). While poverty traps were not explicitly considered in the tools used for the TMP planning process, the process has helped to start discussions between fishermen and the government. These discussions have brought the issue of poverty traps to the government's attention, who is seeking solutions, although inadequate funding hinders implementation (e.g., trawler buy-back).

Zoning the ocean is just one of many interventions used to manage natural resources. There are many other effective tools that can be used both in isolation or in conjunction with ocean zoning, including various fisheries management regimes (e.g., quotas, gear restrictions) (Costello et al., 2016; Day & Dobbs, 2013; Hilborn, 2016). The designing of TMP's zoning plan described in this paper is part of the overall initiative to develop an integrated management plan for TMP. We hope that the lessons from this zoning process will provide guidance for implementation of similar initiatives in Malaysia and elsewhere, as ecosystem approaches to resource management become more important regionally and globally. Collaborative planning processes that involve representative stakeholders in all phases of the planning process will help lead to outcomes that foster the protection of biodiversity and security of livelihoods for many generations to come.

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Biographical Sketches

Robecca Jumin's interest is in conservation planning, especially in the integration of science and human dimension in marine conservation and resource management. Augustine Binson specialized in Park management, ensuring good governance and management system is in place for Tun Mustapha Park. Jennifer McGowan's research interest is in conservation planning focused on developing and integrating novel methods for mobile marine species conservation into spatial decision-support tools. Sikula Magupin is a GIS specialist with WWF-Malaysia; his research interest is in coastal management and spatial conservation planning. Maria Beger's research interest is in spatial conservation planning, environmental management and ecology, combining empirical and theoretical approaches. Christopher Brown's research interest is in the conservation of marine ecosystems and sustainable management of fisheries. Hugh Possingham is Chief Scientist of The Nature Conservancy and a Professor at The University of Queensland. Carissa Klein's primary research interest is in supporting marine conservation decisions, especially in tropical ecosystems.

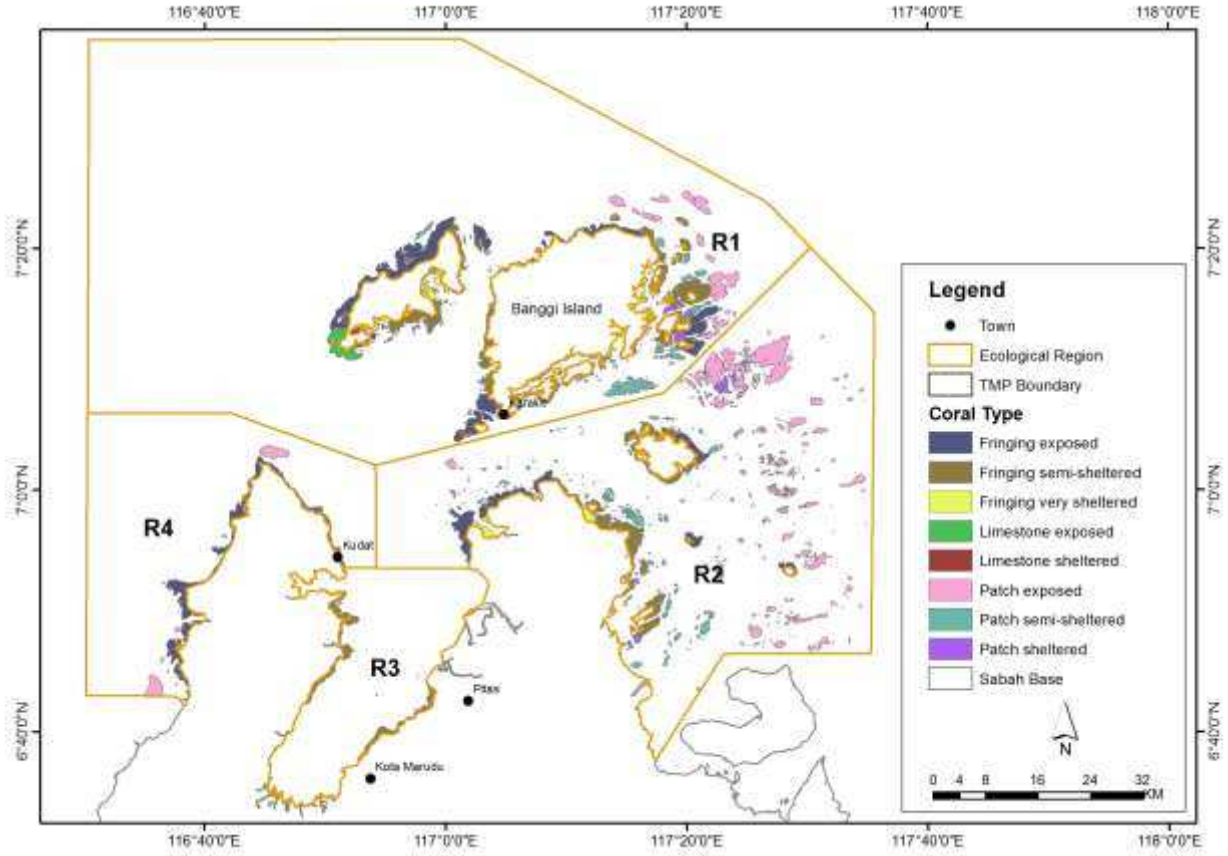


Figure 1: Reef classification and ecological regions within Tun Mustapha Park (TMP).

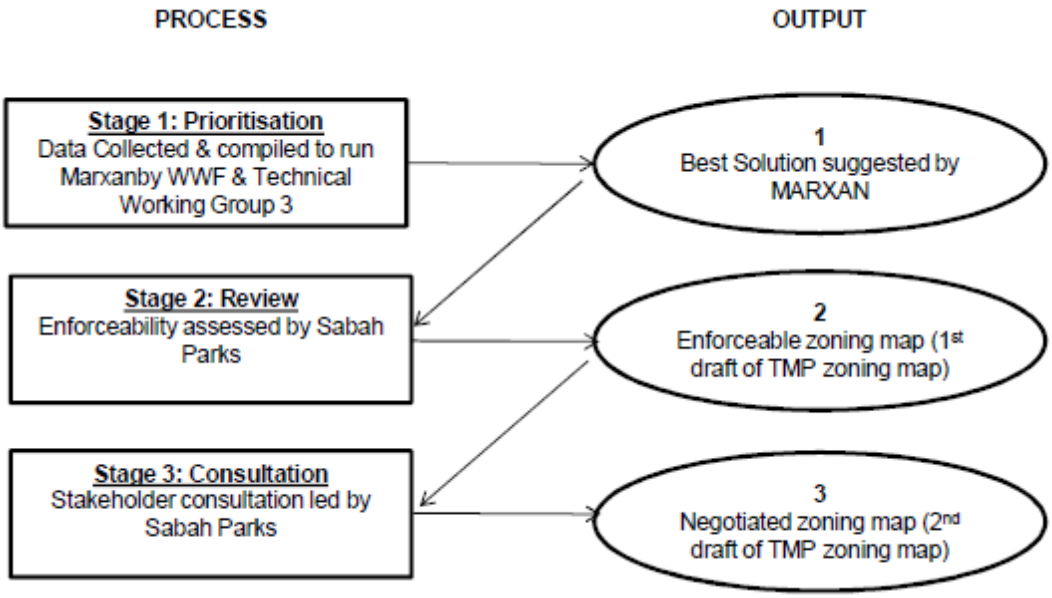
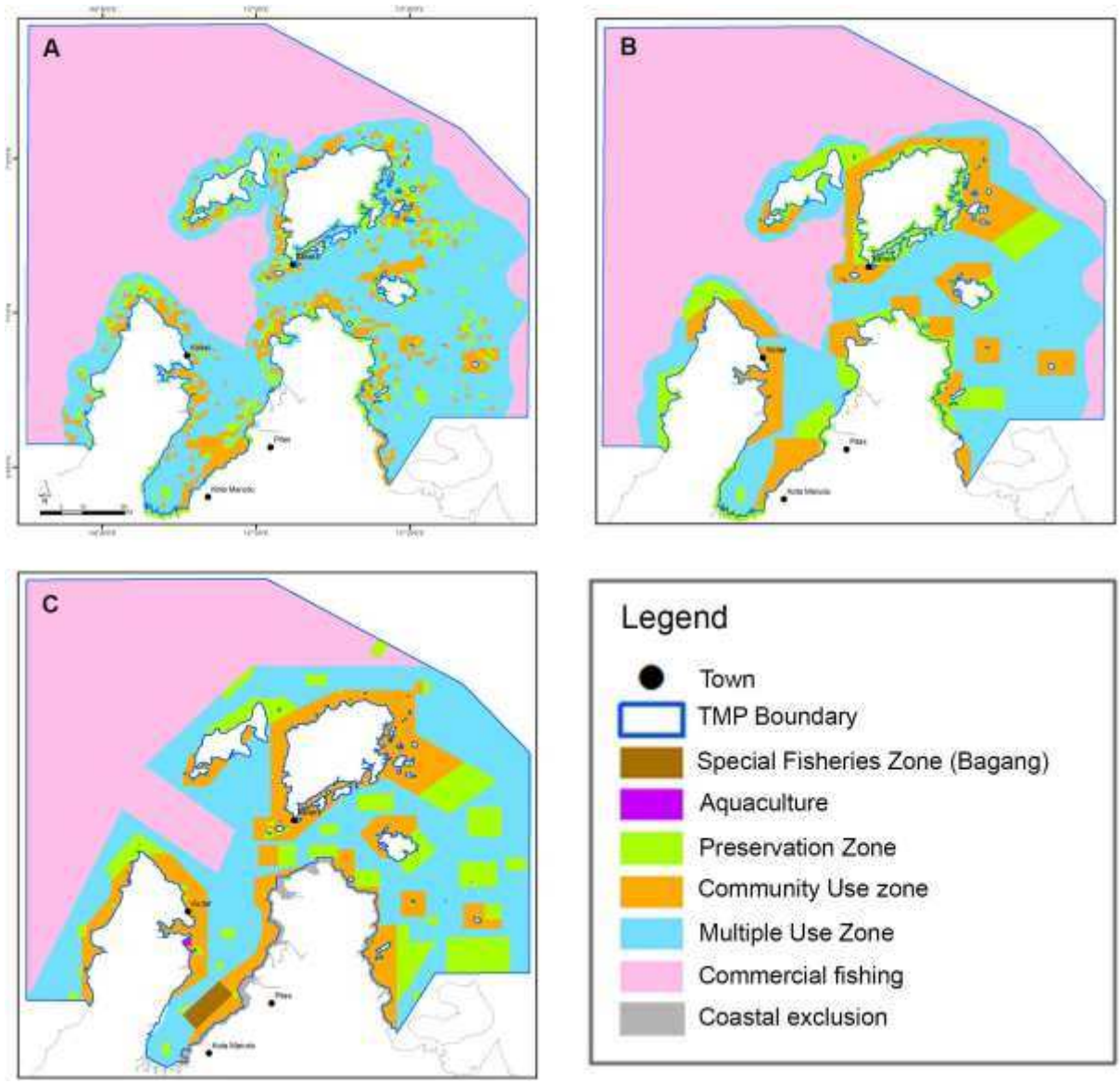


Figure 2: Iterative planning process for Tun Mustapha Park (TMP) showing the three stages of planning.



694

695 Figure 3: The evolution of the zoning plan through each stage of the of planning process,:
696 A) prioritization: best solution map from Marxan with Zones results, B) review: draft zoning
697 plan endorsed by TMP Interim Steering Committee, and C) consultation: revised zoning plan
698 for TMP incorporating feedback from the stakeholder consultation.

699

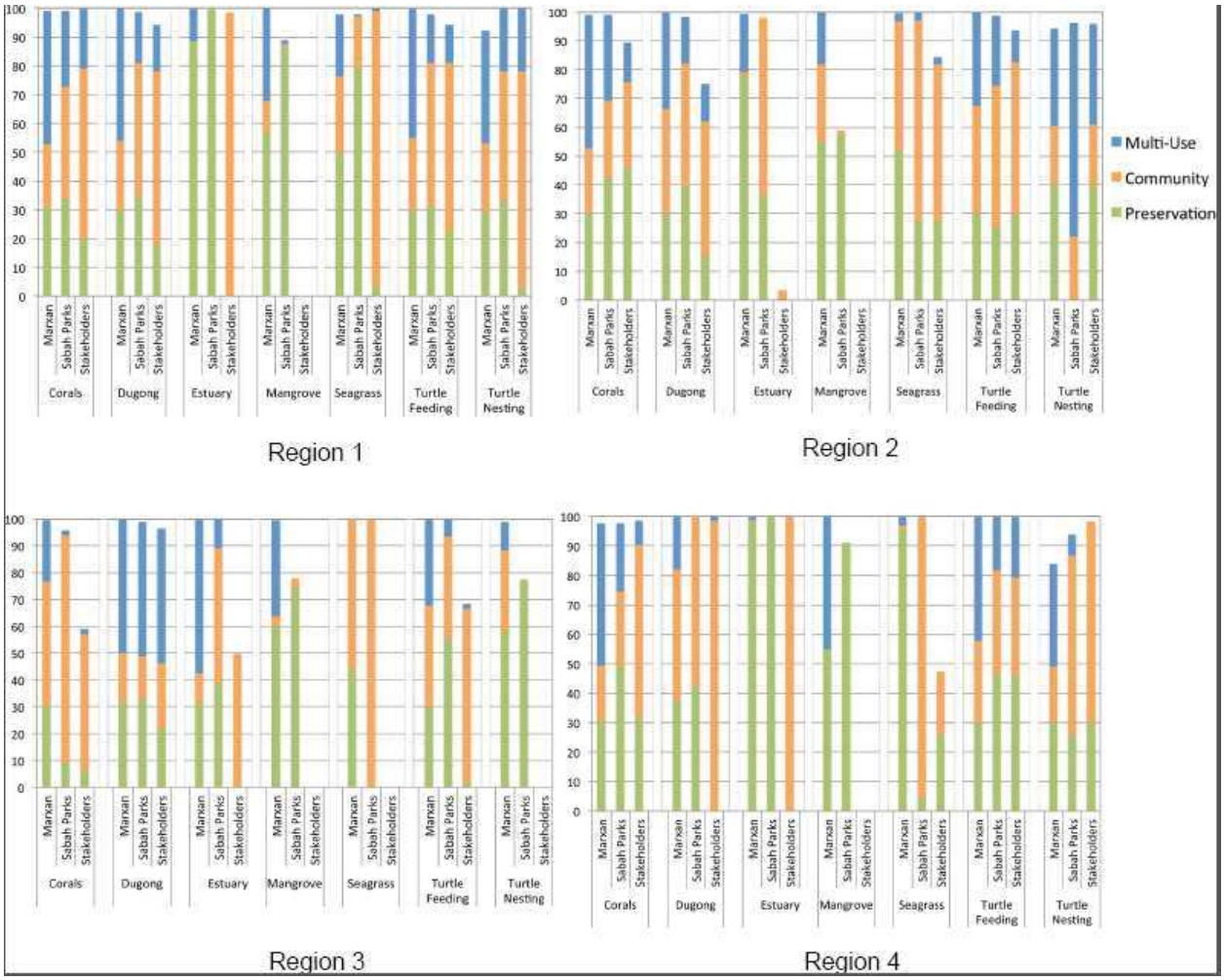


Figure 4: Conservation features by region allocated to each zone across planning stages. Target for preservation zone (green) was 30% per feature.

709 Table 1: Representation targets for each conservation and socioeconomic feature for each
710 zone. A target for each feature was set in each of within each of the four ecological regions
711 shown in Figure 2.

Features		Targets for Zones in Each Ecological Region		
		Preservation	Community Use	Multi-Use
Traditional / Small Scale Fishing Ground		No target set	30%	70%
Coral reefs	Fringing reef exposed Fringing semi-sheltered Fringing very sheltered Patch reef exposed Patch reef semi-sheltered Patch reef sheltered) Limestone reef exposed Limestone reef sheltered	30%	30%	
Dugong habitat		30%		
Estuary		30%		
Mangroves		30%		
Seagrass		30%		
Turtle feeding areas		30%		
Turtle nesting areas		30%		
Balambangan limestone caves		Locked in		
Historical sites		Locked in		

712

713

714

715 Table 2: Summary of the modified Gini coefficient for the 3 stages of TMP zoning process,
716 showing habitat representation within each zones (High value indicates a more even
717 habitat/feature representation).
718

Zoning Stages	Zones		
	Preservation	Community Use	Multiple Use
Marxan (Best)	1	0.57	0.63
Sabah Parks	0.72	0.54	0.3
Stakeholder	0.36	0.64	0.27

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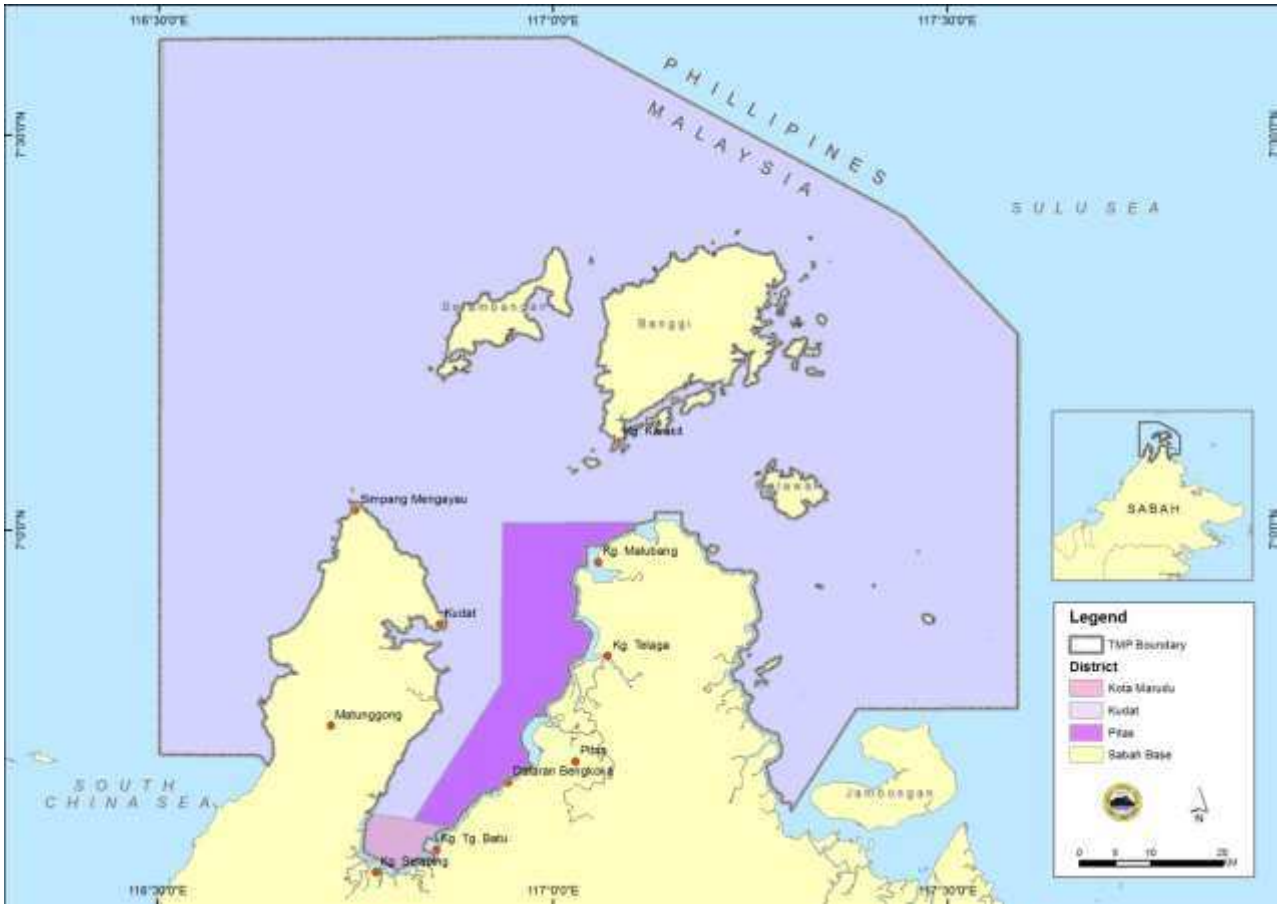
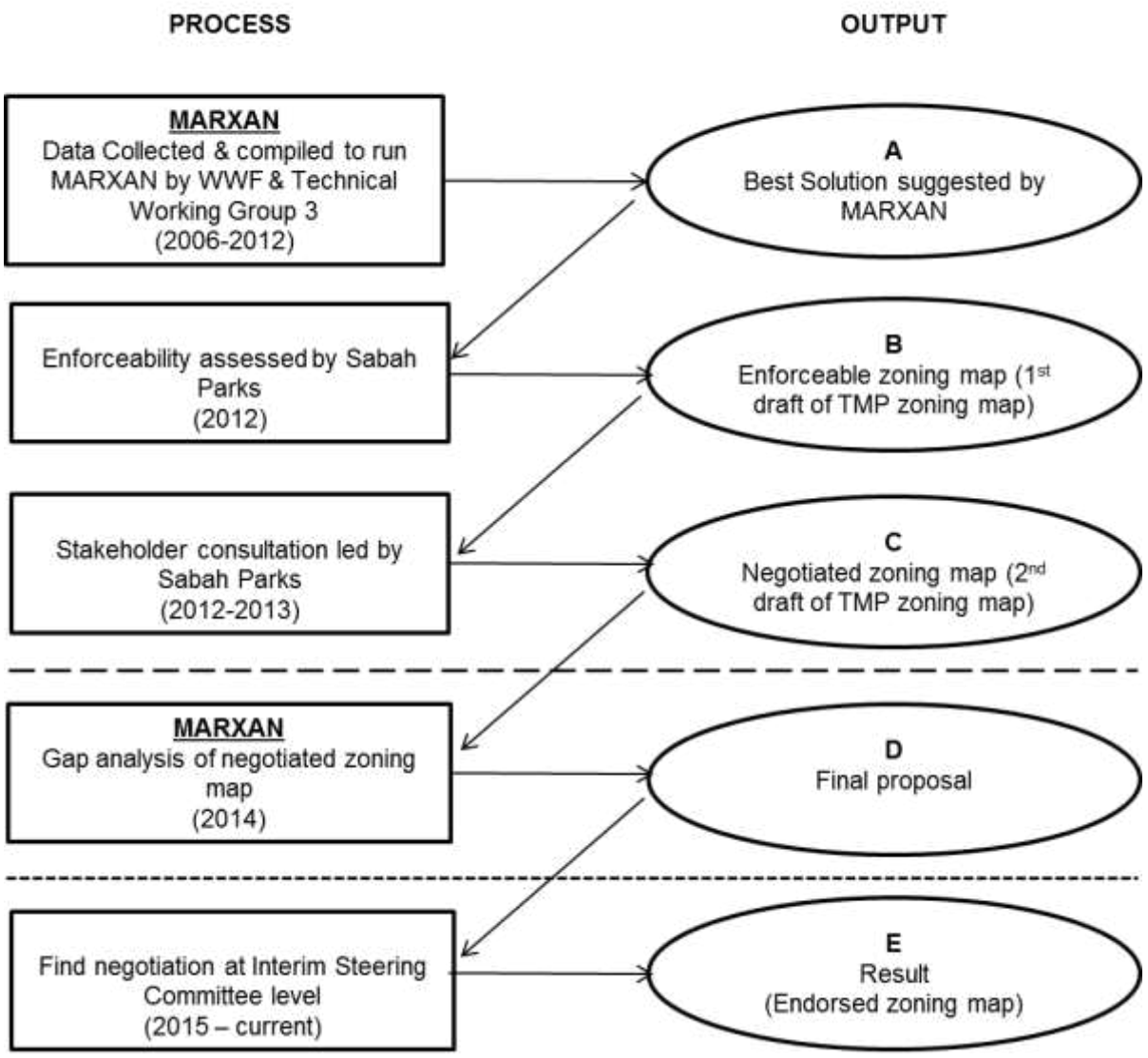
Appendices

Appendix 1: Map of the Proposed Tun Mustapha Park



Appendix 2: Diagram of full iterative planning process for Tun Mustapha Park (TMP) including two additional stages after the completion of the stakeholder consultation.



Appendix 3: Accounting for the different stages of Zoning Process

A) Accounting for Marxan Best Solution

Region 1	**Preservation Zone**	**Community Zone**	**Multi-Use**
Dugong	30.1	23.9	46.0
Estuary	88.6	0.0	11.4
Fishing	18.5	30.0	51.5
Fringing exposed	30.3	23.5	46.2
Fringing semi-sheltered	30.1	27.4	42.1
Fringing very sheltered	29.9	14.1	55.6
Limestone exposed	33.1	34.0	32.4
Limestone sheltered	56.9	38.0	1.2
Mangrove	57.0	10.5	32.4
Patch exposed	28.4	5.7	60.6
Patch semi-sheltered	30.0	15.5	54.5
Patch sheltered	31.2	49.8	18.8
Seagrass	49.7	26.6	21.6
Turtle Feeding	30.0	25.2	44.7
Turtle Nesting	29.0	24.2	39.1

Region 2	**Preservation Zone**	**Community Zone**	**Multi-Use**
Dugong	30.1	36.2	33.8
Estuary	77.9	1.3	20.1
Fishing	13.2	30.0	56.7
Fringing exposed	30.2	51.9	17.8
Fringing semi-sheltered	30.0	30.7	39.2
Fringing very sheltered	36.4	14.9	48.6
Limestone exposed	na	na	na
Limestone sheltered	na	na	na

Mangrove	54.9	27.2	17.8
Patch exposed	29.4	11.9	56.7
Patch semi-sheltered	30.0	14.3	55.5
Patch sheltered	31.8	6.8	61.3
Seagrass	52.2	44.6	2.8
TurtleFeeding	30.0	37.4	32.5
TurtleNesting	40.1	20.4	33.7
Region 3	**Preservation Zone**	**Community Zone**	**Multi-Use**
Dugong	31.7	18.4	49.9
Estuary	30.8	11.6	57.6
Fishing	14.2	30.0	55.7
Fringing exposed	na	na	na
Fringing semi-sheltered	30.0	46.8	22.7
Fringing very sheltered	34.6	36.4	27.8
Limestone exposed	na	na	na
Limestone sheltered	na	na	na
Mangrove	60.3	3.8	35.8
Patch exposed	na	na	na
Patch semi-sheltered	60.5	26.1	13.1
Patch sheltered	na	na	na
Seagrass	43.9	56.1	0.0
Turtle Feeding	30.0	37.8	32.2
Turtle Nesting	57.7	30.6	10.6

Region 4	**Preservation Zone**	**Community Zone**	**Multi-Use**
Dugong	37.3	44.8	18.0
Estuary	98.9	0.0	0.9
Fishing	17.6	30.0	52.4

Fringing exposed	30.3	14.9	54.6
Fringing semi-sheltered	30.7	25.3	31.6
Fringing very sheltered	na	na	na
Limestone exposed	na	na	na
Limestone sheltered	na	na	na
Mangrove	55.2	0	44.7
Patch exposed	30.8	26.1	39.4
Patch semi-sheltered	54.5	0.4	44.9
Patch sheltered	na	na	na
Seagrass	95.7	1.3	3.1
Turtle Feeding	30.0	27.6	42.3
Turtle Nesting	30.3	18.8	34.7

B) Accounting for Sabah **Parks**

Region 1	**Preservation Zone**	**Community Zone**	**Multi-Use**
Dugong	34.6	46.4	17.8
Estuary	100.0	0.0	0.0
Fishing	29.4	42.2	27.7
Fringing exposed	51.1	35.6	13.3
Fringing semi-sheltered	31.1	48.5	20.1
Fringing very sheltered	80.4	4.4	15.0
Limestone exposed	2.5	89.1	7.8
Limestone sheltered	76.4	19.9	0.0
Mangroves	86.9	0.7	1.4
Patch exposed	0.0	25.3	69.5
Patch semi-sheltered	4.1	38.4	57.4
Patch sheltered	8.9	80.5	10.6

Seagrass	79.3	17.8	0.7
Turtle Feeding	31.4	49.6	16.8
Turtle Nesting	33.3	44.7	22.0

Region 2	**Preservation Zone**	**Community Zone**	**Multi-Use**
Dugong	39.3	43.0	16.0
Estuary	36.2	61.7	0.0
Fishing	20.5	31.5	46.8
Fringing exposed	39.9	59.6	0.5
Fringing semi-sheltered	50.9	35.3	13.7
Fringing very sheltered	39.9	60.0	0.0
Mangroves	57.4	1.4	0.0
Limestone exposed	na	na	na
Limestone sheltered	na	na	na
Patch exposed	39.7	9.5	48.7
Patch semi-sheltered	27.8	26.2	45.8
Patch sheltered	79.9	8.7	11.4
Seagrass	27.2	69.8	2.7
Turtle Feeding	25.5	48.9	24.2
Turtle Nesting	0.0	22.0	73.9

Region 3	**Preservation Zone**	**Community Zone**	**Multi-Use**
Dugong	32.6	16.0	50.3
Estuary	38.8	50.4	10.9
Fishing	24.5	36.0	38.9
Fringing exposed	na	na	na

Fringing semi-sheltered	9.5	88.5	1.8
Fringing very sheltered	0.0	4.2	0.0
Limestone exposed	na	na	na
Limestone sheltered	na	na	na
Mangrove	74.4	3.5	0.0
Patch exposed	na	na	na
Patch semi-sheltered	18.0	82.0	0.0
Patch sheltered	na	na	na
Seagrass	0.0	100.0	0.0
Turtle Feeding	55.4	37.6	6.7
Turtle Nesting	77.0	0.1	0.0

Region 4	**Preservation Zone**	**Community Zone**	**Multi-Use**
Dugong	42.1	57.9	0.0
Estuary	99.9	0.0	0.0
Fishing	25.3	37.7	37.0
Fringing exposed	53.5	29.7	16.4
Fringing semi-sheltered	14.6	62.7	9.9
Fringing very sheltered	na	na	na
Limestone exposed	na	na	na
Limestone sheltered	na	na	na
Mangrove	91.0	0.03	0.0
Patch exposed	49.2	0.0	47.3
Patch semi-sheltered	99.4	0.4	0.0
Patch sheltered	na	na	na
Seagrass	4.2	95.5	0.0
Turtle Feeding	46.1	35.7	18.1
Turtle Nesting	25.5	61.2	7.3

C) Accounting for Stakeholders

Region 1	**Preservation Zone**	**Community Zone**	**Multi-Use**
Dugong	17.8	60.3	16.0
Estuary	0.0	98.6	0.0
Fishing	15.7	59.3	21.5
Fringing exposed	41.5	47.7	10.7
Fringing semi-sheltered	4.8	74.7	20.1
Fringing very sheltered	0.0	83.7	15.0
Limestone exposed	0.0	91.6	7.8
Limestone sheltered	0.0	95.8	0.0
Mangrove	0	0	0
Patch exposed	3.9	32.9	63.2
Patch semi-sheltered	43.6	39.4	17.0
Patch sheltered	0.0	89.4	10.6
Seagrass	3.5	95.8	0.7
Turtle Feeding	21.7	59.4	13.1
Turtle Nesting	2.9	75.1	22.0

Region 2	Preservation Zone	Community Zone	Multi-Use
Dugong	15.6	46.5	12.9
Estuary	0.0	3.6	0
Fishing	31.7	36.8	28.8
Fringing exposed	16.3	59.8	0.3
Fringing semi-sheltered	11.4	59.8	8.8
Fringing very sheltered	0	23.6	0
Mangrove	0	0	0
Patch exposed	73.1	6.8	20.1
Patch semi-sheltered	58.6	17.7	23.9

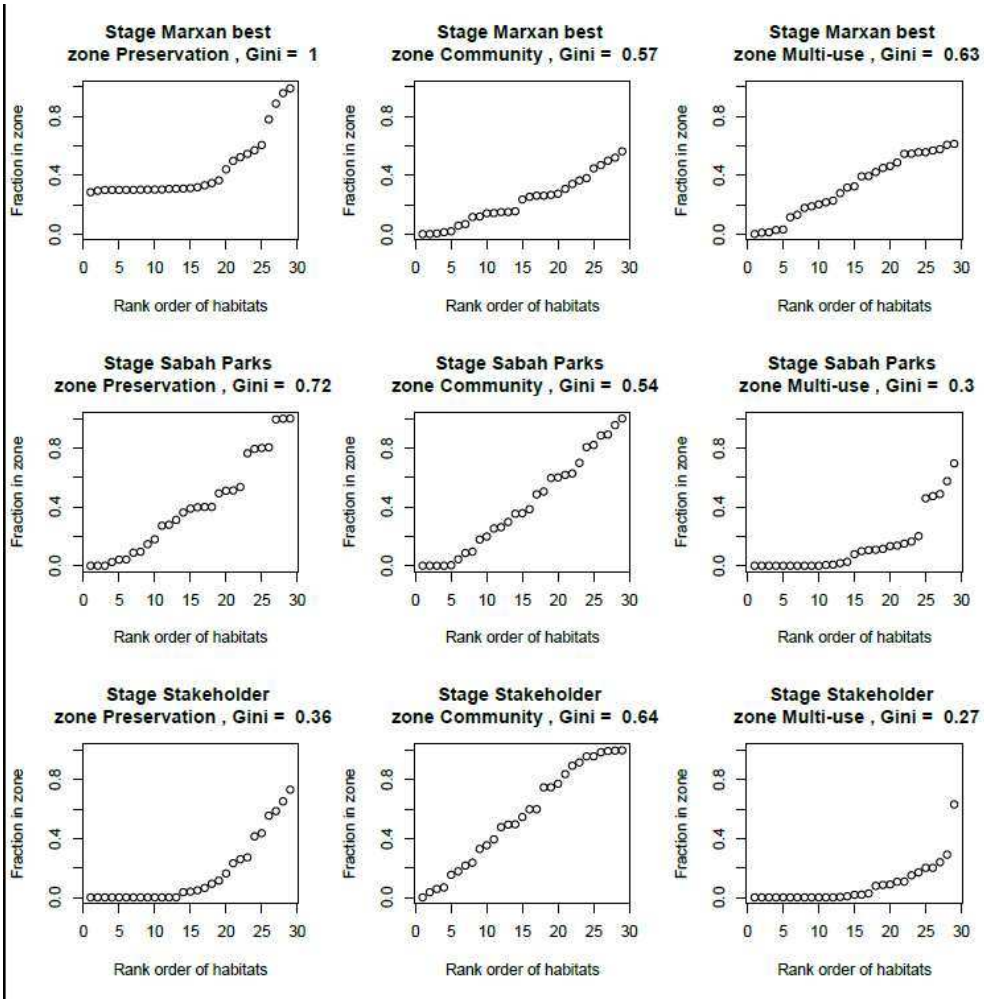
Patch sheltered	55.5	35.4	8.5
Seagrass	27.2	54.5	2.7
Turtle Feeding	29.5	53.0	11.3
Turtle Nesting	38.8	22.0	35.1

Region 3	**Preservation Zone**	**Community Zone**	**Multi-Use**
Dugong	21.6	24.5	50.3
Estuary	0	49.6	0
Fishing	2.7	37.6	34.2
Fringing exposed	na	na	na
Fringing semi-sheltered	6.5	49.5	1.9
Fringing very sheltered	0	99.3	0
Limestone exposed	na	na	na
Limestone sheltered	na	na	na
Mangrove	0	0	0
Patch exposed	na	na	na
Patch semi-sheltered	0	15.3	0
Patch sheltered	na	na	na
Seagrass	0	0.0	0
Turtle Feeding	1.5	65.0	1.7
Turtle Nesting	0	0	0

Region 4	**Preservation Zone**	**Community Zone**	**Multi-Use**
Dugong	0	98.6	1.4
Estuary	0	99.7	0
Fishing	22.1	49.8	28.1
Fringing exposed	23.2	74.8	1.8
Fringing semi-sheltered	9.3	77.2	

Fringing very sheltered	na	na	na
Limestone exposed	na	na	na
Limestone sheltered	na	na	na
Mangrove	0	0	0
Patch exposed	65.2	5.7	29.1
Patch semi-sheltered	0	99.9	0
Patch sheltered	na	na	na
Seagrass	25.9	21.6	0
Turtle Feeding	46.0	33.1	20.8
Turtle Nesting	30.4	67.9	0

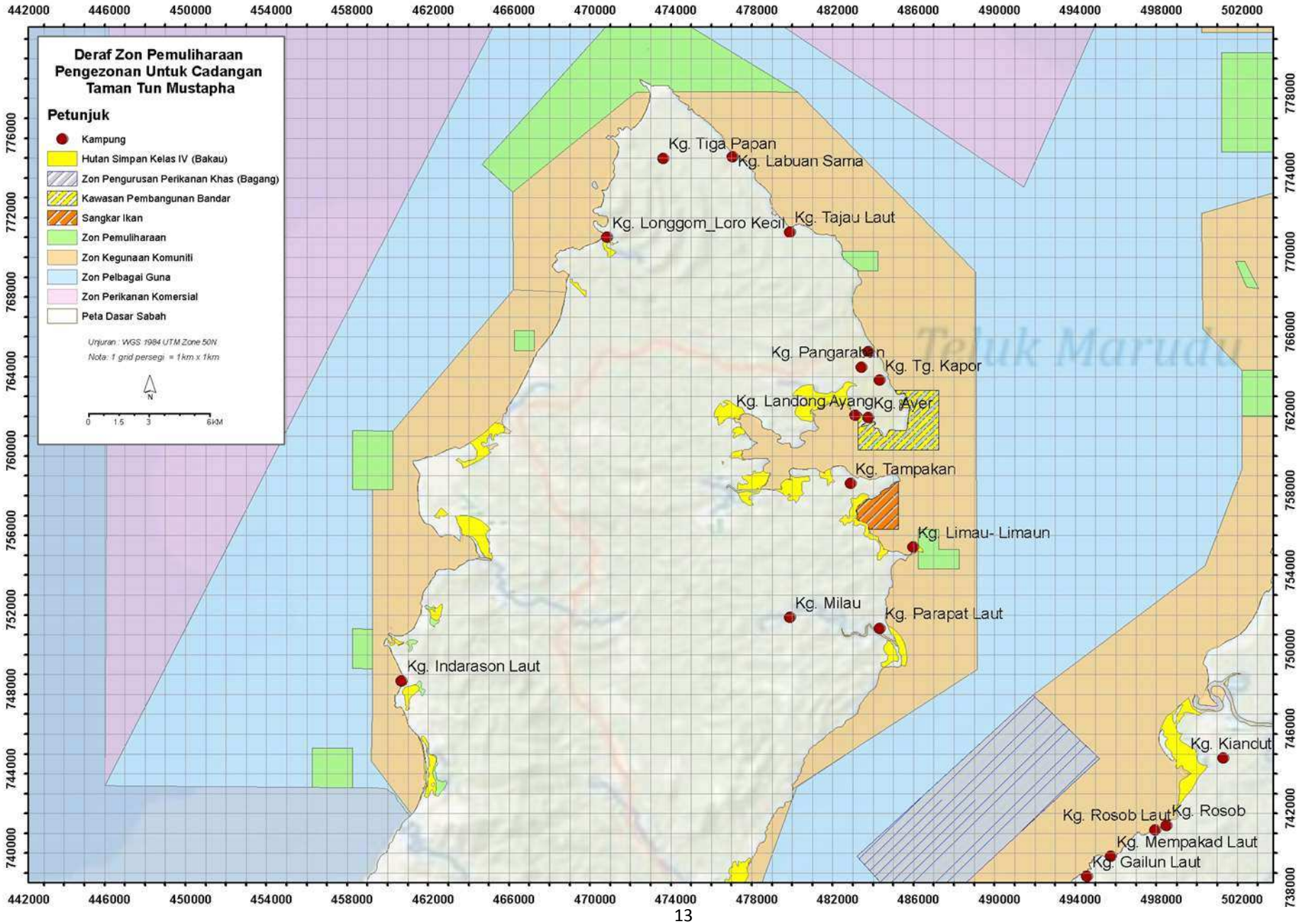
Appendix 4: Habitat representation within each zones at each zoning process calculated using a modified Gini coefficient (High value indicates a more even habitat/feature representation)



Appendix 5 : Feedback and Questionnaire Form

FEEDBACK FORM OF PUBLIC CONSULTATION IN PROPOSED TUN MUSTAPHA PARK

RESPONDENT INFORMATION
Name:_____ Contact No.:_____
Village :_____ 1.2 Age : _____ years old
1.3 Gender : □ Men □ Woman
1.4. Race : □ Sungai □ Suluk □ Bajau □ Dusun Bonggi □ KDM Rungus □ Ubian □ Others_____
Nationality : □ Malaysian □ Permanent Resident □ Non Malaysian □ Others_____
Education Level : □ None □ High School □ Primary School □ Others_____
Occupation : □ Small-scale fisherman □ Head of Village □ PJKKK □ Commercial Fisherman □ Farmers □ Others_____
Number of children in school :_____
1.9 Salary Estimations : □ Less than RM 200 □ RM 200 – RM 500 □RM 500 – RM 1 000 □ More than RM 1 000
1.10 Are you on of a member in any clubs/ organisation? □ JKKK □ Fisherman Association □ Traders Association □ Politics Organisation □ Others_____
1.11 What are the fisheries activities you usually do? □ Quick Fishing □ Hook & Line/ Net □ Taking sea cucumbers □ Others_____


Deraf Zon Pemuliharaan Pengezonan Untuk Cadangan Taman Tun Mustapha
Petunjuk
Kampung
Hutan Simpan Kelas IV (Bakau)
Zon Pengurusan Perikanan Khas (Bagang)
Kawasan Pembangunan Bandar
Sangkar Ikan
Zon Pemuliharaan
Zon Kegunaan Komuniti
Zon Pelbagai Guna
Zon Perikanan Komersial
Peta Dasar Sabah
Unjuran : WGS 1984 UTM Zone 50N
Nota: 1 grid persegi = 1km x 1km
N
0 1.5 3 6KM
Kg. Tiga Papan
Kg. Labuan Sama
Kg. Longgom_Loro Kecil
Kg. Tajau Laut
Kg. Pangaralan
Kg. Tg. Kapor
Kg. Landong Ayang
Kg. Ayer
Kg. Tampakan
Kg. Limau- Limaun
Kg. Milau
Kg. Parapat Laut
Kg. Indarason Laut
Kg. Kiandut
Kg. Rosob Laut
Kg. Rosob
Kg. Mempakad Laut
Kg. Gailun Laut
Teluk Marudu
442000 446000 450000 454000 458000 462000 466000 470000 474000 478000 482000 486000 490000 494000 498000 502000
776000 774000 772000 770000 768000 766000 764000 762000 760000 758000 756000 754000 752000 750000 748000 746000 744000 742000 740000 738000

ZONING PLAN

Instruction: Based on the *Map of TMP Zoning Plan*, provide your idea on the zoning and the suggested activities as follow;

*YOU ALSO CAN PROVIDE COMMENTS BY MARKING ON THE MAP ABOVE.

2.1	AREA Based on zones;	Mark (/)					REMARKS
		TOTALLY AGREE	AGREE	NOT SURE	NOT AGREE	TOTALLY NOT AGREE	
2.1.1	Commercial Fishing Zone						
2.1.2	Community Use Zone						
2.1.3	Multi-Use Zone						
2.1.4	Conservation Zone (*Tabungan Ikan*)						

2.1.5 Opinion and Other Suggestion on the AREA based on zones

_____

2.2	AREA Based on zones;	Mark (/)					REMARKS
		TOTALLY AGREE	AGREE	NOT SURE	NOT AGREE	TOTALLY NOT AGREE	
2.2.1	Commercial Fishing Zone						
2.2.2	Community Use Zone						
2.2.3	Multi-Use Zone						
2.2.4	Conservation Zone (*Tabungan Ikan*)						

2.2.5 Opinion and Other Suggestion on the ACTIVITIES in Proposed Tun Mustapha Park

_____

3.0	General Knowledge on Proposed Tun Mustapha Park					
No.	**QUESTION; Are you agree on the following subjects?**	**Mark (/)**				
		TOTALLY AGREE	**AGREE**	**NOT SURE**	**NOT AGREE**	**TOTALLY NOT AGREE**
3.1	Objectives of Tun Mustapha Park gazettement.					
3.2	Below is the concept of gazettement: *" Multi-Use Park that practices co-management and communities will be involved in the management"*					
3.3	Participation by communities in management of natural resources in the Community Use Zone.					
3.4	Collaborations with government agencies involved in management of Tun Mustapha Park.					

4.0 What is your hope upon TMP Zoning Plan?

	Mark (/)
Purse Seine and Trawlers will only operating in Commercial Fishing Zone.	
Fishermens will not lose their rights and still can catch fish in the area.	
Fish bombing and cyanide activities abolished.	
Other source of income will be introduced. (E.g: Tourism)	
Others (Please state)_____	

Are you agree with the suggestion by our State Government to gazette Tun Mustapha Park?
□ Agree □ Not sure □ Disagree
Explain _____

6.0 Does the delivered information in this public consultation are understandable?
□ Yes □ Not sure □ No
Explain _____

7.0 Other Suggestion
_____

- THANKS FOR YOUR PARTICIPATION-