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The reef fisheries of Pulau Banggi, Sabah: A preliminary profile and assessment of ecological and socio-economic sustainability

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Abstract

The recent creation of the Tun Mustapha Park (TMP) in the northern waters of Sabah, Malaysia has brought up the need for understanding the coral reef fisheries system in Pulau Banggi, for which there has been no previous documentation. This study draws upon field data collected in June and August 2004 to accomplish two things, namely, to build a profile of the ecological and socio-economic aspects of Pulau Banggi's reef fisheries, and undertake a preliminary assessment of the status of these fisheries. This research is important because it provides information that will help managers develop policies for the long-term ecological and socio-economic sustainability of Pulau Banggi's reef fisheries.

Keywords: Reef fisheries; Banggi; Sabah; Sustainable reef fisheries and livelihoods

1. Introduction

Most of the world's coral reefs occur in developing countries where the role of reef fisheries is crucial in providing food, income, and livelihood to millions of coastal dwellers. Increased competition for fisheries resources has resulted in overfishing and destructive fishing methods in many Southeast Asian reefs (McManus, 1997), making it unlikely that the region's reef fisheries resources will survive without active management (Ablan et al., 2002). However, reef fisheries generally exist in data poor conditions which hamper sustainable management.

Sabah's reef fisheries landings have decreased since peaking in the 1980s (Cabanban and Biusing, 1999). Destructive fishing methods have damaged reef habitat throughout Sabah (Pilcher and Cabanban, 2000), contributing to the decline of reef resources. In 2001 Sabah Parks[1] proposed the establishment of Tun Mustapha Park in north Sabah, including Pulau[2] Banggi, with the

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[1] Sabah Parks is the State agency responsible for the management of terrestrial and marine parks in Sabah.
[2] Pulau means island in Malay.

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Fig. 1. Map of Malaysia showing Banggi off the northern edge of Sabah. Map source: Atlas—Xpeditions@nationalgeographic.com (http://www.nationalgeographic.com/xpeditions/atlas/).

aim of alleviating overexploitation of the region's fisheries and conserving the rich biodiversity found within its coastal environment. The Sabah State Government's approval of TMP in 2003 brought up the need for understanding coastal resource uses within TMP.[3]

In this paper we investigate the reef fisheries of Pulau Banggi, one of the most important resources within TMP. We use fishery survey and interview data collected on site in 2004 to first provide an ecological and socio-economic characterization, followed by a preliminary assessment of Banggi's reef fisheries. This study aims to contribute towards identifying policies for the sustainable management of reef fisheries within the TMP. Insights derived here can also be applied on a broader scale to other reef fisheries in the region, many of which share similar characteristics and problems as the reef fisheries of Banggi.

[3] Although approved, the Tun Mustapha Park has not yet been officially gazetted as of July 2005. It still has to go through a parliamentary process before receiving final gazettement status.

2. Background

2.1. Study site and fishing grounds

Pulau Banggi (7.14′N, 117.10′E) is situated off the northern tip of Sabah, East Malaysia (Fig. 1), and is bounded by the South China Sea to the west, and the Sulu Sea to the east. Banggi is the biggest island in Malaysia, covering a total area of 700 km^2, with a coastline of 420 km (Anonymous, 2003). The nearest mainland town is Kudat, which is 26 km away and across the Banggi Channel.

Our study site was southern Banggi, and covered the villages of Karakit, the administrative centre of the island, Singgahmata, Perpaduan, and Maliangin Besar. The main fishing ground studied was the Maliangin area, immediately south of Banggi (Fig. 2). This is one of the three main fishing areas in Banggi, the others being Kuambang and Sibogo in the east, and Balambangan in the west. Maliangin is a traditional fishing zone where commercial fleets such as trawlers and

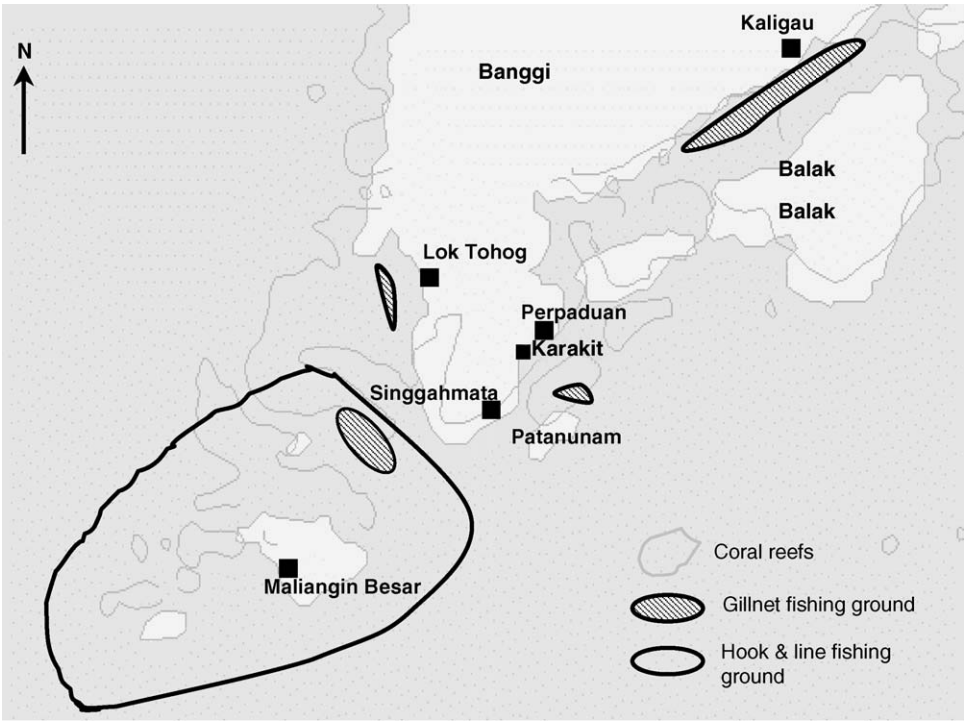

Fig. 2. Map of southern Banggi fishing grounds. Map source: Reefbase online GIS (http://www.reefbase.org). Modified using Microsoft PowerPoint.

purse seiners are prohibited from fishing.[4] It is characterized by shallow reefs 3–5 m in depth near shore, and deeper patch reefs of 15–25 m depth further offshore. Although fishing practices tend to vary by village, the general trends observed in the Maliangin area are common to other parts of Banggi, and can be used to broadly characterize the entire island's reef fisheries.

2.2. Fishing community

The current population of Banggi is approximately 20,000 (IPMB, 2003), with around 1076 inhabitants in the vicinity of the study site (Kisal, personal communication). In the past two decades, an influx of migrants from the southern Philippines has come to Banggi in search of a marginally better life. Nevertheless, Banggi remains relatively undeveloped, and coastal households are considerably below the Sabah poverty line (IPMB, 2003). These communities continue to depend heavily on marine resources for their livelihood, with fishing accounting for 70% of the island's economic activity (IPMB, 2003). There are 1195 licensed fishers on the entire island of Banggi (Kudat Fisheries Department, unpublished data), but this should only be taken as a lower reference point as many local fishers do not own licenses due to the lack of Fisheries Department personnel presence on the island. There are approximately 69 fishers in the study site (Kisal, personal communication).

2.3. Banggi's reef fisheries

The reef fisheries of Pulau Banggi can be classified as artisanal, which for the purposes of this paper is characterized as being small scale, using low technology fishing gear and small fishing vessels operating on fishing grounds close to shore. Banggi's reef fisheries can also be considered open access, in that there

[4] The Malaysia Fisheries Comprehensive Licensing Policy designates the area within five nautical miles of the shoreline as a traditional fishing zone.

are no active spatial input or output controls. The only regulation pertains to a ban on bomb fishing (Fisheries Regulation Prohibition of Methods of Fishing, 1980) which is not always effectively enforced by the Malaysian Marine Police.[5]

Hook and line and gillnet are two of the most important fishing methods in Banggi (Cooke, 2003). Hand lines are used with a single baited hook or with a series of 8–10 fabric lures attached to the main line with small hooks. Gillnet fishers use monofilament nets that are approximately 20 m in length, and 1.5 m in height, with mesh sizes ranging from 6.35 to 12.7 cm. Fishers tend to use smaller mesh sizes under windy conditions, as larger mesh sizes get tangled more easily. Other fishing gears include squid jigs, spear guns, bombs, and cyanide. Reef gleaning on the exposed reef flat occurs during extreme low tides. The majority of local fishers use pump boats,[6] although a small number operate outboard engine fiberglass boats that are provided as part of a poverty alleviation scheme administered by the Sabah Fisheries Development and Fishermen Corporation since 1996.

There is a strong spatial distinction according to gear type (Fig. 2). Hook and line fishers operate during the day in the Maliangin area, while gillnet fishers set their nets in the evening around Maliangin, Lok Tohog, Patanunam, and Balak Balak. Sometimes they will travel to further reefs in the north east of Banggi. Due to the relatively protected nature of their fishing grounds, gillnet fishers are able to go out fishing more often during the windy season, when most hook and line fishers are stuck on land.

The fishing year revolves around distinct weather patterns and target species. The peak fishing period occurs between March and May, when the prevailing north-easterly winds transition to a south-westerly direction, bringing calm seas. June to September corresponds to the low fishing season, when strong southwest monsoon winds often prevent fishers from going out to sea.

[5] The first author heard four bombs go off in a span of only 3 days. As well, non-governmental groups doing underwater visual surveys in the area also reported hearing frequent blasts.

[6] Pumpboats are wooden boats powered by a modified 7 or 8 hp water pump engine. They were first introduced from the southern Philippines in the 1990s, and became popular due to their low fuel consumption.

Hook and line fishers rotate between two target species in a year. From April to September they use baited hooks or traps to target coral grouper (*Plectropomus* spp.) for the live reef fish trade (LRFT). They then switch to Spanish mackerel (*Scomberomorous commerson*), which is caught by trolling or using live bait from a stationary boat, from October to February or March. Starting in November until February, many fishers also target cuttlefish, which is caught with a trident like spear. Other target species include invertebrates such as scallops (Pectinidae), abalone (Haliotidae), sea cucumber (Holothuroidea), and squid (Cephalopoda).

2.4. Markets and prices

Banggi's fishers provide a supply of fresh fish to the domestic village market. After setting aside fish for family consumption,[7] fishers sell their catch to one of three local fish buyers in the Karakit area, who then sell to the villagers. These fish traders transport their excess or more expensive fish to Kudat, where they have established permanent relationships with wholesale fish traders. LRFT species caught in the Maliangin area are kept in a holding pen in Perpaduan village. Daw et al. (2002) provide a detailed study of the Kudat/Banggi LRFT.

Fishers receive only RM 1.5–RM 1.7/kg[8] for most species of demersal reef fish. Spanish mackerel and trevallies are higher priced at RM 4 and RM 5.5/kg, respectively, while cuttlefish fetch RM 4.5/kg. In contrast, live leopard coral groupers (*Plectropomus leopardus*) are worth RM 42/kg, with the price of less expensive *Plectropomus* species ranging from RM 10 to RM 30/kg. As such, there is a strong economic incentive for fishers to target coral groupers, resulting in negative consequences on the fish stock.

3. Methodology

Quantitative fishery data was collected for the hook and line and gillnet fisheries because these two gears

[7] According to interviewed fishers, this normally ranges from 2 to 3 kg per day.

[8] Currency exchange rate on 23 February 2005 is 1 USD = RM 3.8.

account for the majority of fish captured for sale.[9] Methods used to collect these data included fishing ground surveys and monitoring catch landings. Fishing ground surveys were conducted three times a week when weather permitted, between 7:30 to 11:00 a.m., when it was most likely that fishers would have caught some fish, and before they started to head back to land. We randomly stopped fishers and recorded the following: (a) gear type; (b) quantity of fish caught; (c) number of hours fished; and (d) species caught.

Fish landings were recorded at the two main fish buyers' sites from 16 June to 6 July, and from 7 August to 27 August 2004. Both data collection periods corresponded to the low fishing season, and are considered representative of the catch and effort for that particular time period as no extraordinary events occurred to indicate otherwise. As such, preliminary estimates of catch and effort can be considered conservative; sampling of peak season catches is planned for 2005. Gillnet fishers landed their catch at the Karakit site between 8:30 to 11:00 p.m. The first author waited at the landing site during those times and recorded all the catches that were landed during that time frame. Hook and line catches were landed more sporadically at the Singgahmata site. Therefore, sampling at this site was done opportunistically, that is, whenever the first author happened to be around when fishermen landed their catch. The majority of hook and line catches presented in this paper were sampled during the fishing grounds survey.

Semi-structured interviews were conducted in June 2004 with 20 fishers (i.e. approximately 29% of the fisher population in our study area), 2 fish traders, and 3 village leaders. The first author and her assistant conducted all the interviews in Malay. Prepared questions pertaining to catch, effort, target species, historical trends, and perceptions on the future of fishing in Banggi were asked. Fishers were given a lot of breadth in answering the questions, and those who brought up new topics or elaborated on certain questions were allowed to do so. As such, not all interviews followed the same questionnaire format. Depending on fishers' willingness to continue, interviews lasted between 15 min and 1 h.

Fishers were chosen opportunistically; the first author and her assistant went house to house and interviewed any fisher who was at home and willing to speak. We did not encounter any refusals, and in general all interviewees were open and cooperative in answering the questions. Additional information was gathered through informal interviews conducted whenever the opportunity arose to speak to fishers or villagers about reef resource use. Due to the limited sample size, the information gathered from interviews is presented qualitatively in this paper.

[9] Based on information from the two main fish buyers in southern Banggi.

4. Results

4.1. Catches and effort

Hook and line catches are highly variable; recorded catches ranged from 0 to 30 kg fisher^{-1} trip^{-1}, with a mean of 6.29 kg (S.D. = 7.47) fisher^{-1} trip^{-1} (Table 1). Similarly, gillnet catches are also highly variable, with recorded catches ranging from a low of 1 kg to a high of 37 kg fisher^{-1} trip^{-1}, and a mean of 11.54 kg (S.D. = 8.81) fisher^{-1} trip^{-1} (Table 1). Among the gears, the highest catches were obtained using longline, which ranged from 10 to 120 kg. Traps can yield on average 3–4 kg of fish from being submerged for 3 days.

In the low fishing season, hook and line fishers typically fish for 6 h a day during permissible weather. Due to the strong winds during this period, they generally go for fishing only 3–4 days in a week. An average of 11 (ranging from 8 to 23) fishing boats were recorded at the fishing ground during each survey trip. Fishers from other parts of Sabah make multi-day fishing trips to the Maliangin area as well, some of them coming all the way from Semporna, an island group approximately 340 km away. During field surveys, up to three outside fishing boats were observed in the span of 1 week. The soak time (i.e. the duration that the net is in the water) for gillnets is approximately 2–3 h. As gillnet fishing grounds are more sheltered, fishers are usually able to fish at least five times a week. There are an estimated eight gillnet fishers operating in this area, all of whom reside in the village of Kaligau.

4.2. Catch composition

Eighty and eighty one identifiable species were recorded in the hook and line and gillnet catches,

Table 1
Mean CPUE and catch recorded during sample period June and August 2004

Gear	Mean CPUE (kg h^{-1})	Standard deviation	Mean catch per trip (kg trip^{-1})	Standard deviation	Sample size
Hook and line	1.26	1.49	6.29	7.47	69
Gillnet	3.85	2.94	11.54	8.81	80

respectively. The most frequently caught families by hook and line are Serranidae (36%), Lethrinidae (17%), and Nemipteridae (10%). Besides demersal reef fish, pelagic fish such as carangids and scombrids are also regularly caught by hook and line (Fig. 3). Carangidae is the dominant family (57%) in gillnet catches in terms of weight (Fig. 4), with yellowtail scad (*Atule mate*) and trevallies accounting for 24 and 23% of these carangids, respectively. Demersal reef fish belonging to the Haemulidae, Lethrinidae, and Lutjanidae families make up another 32% of the catch.

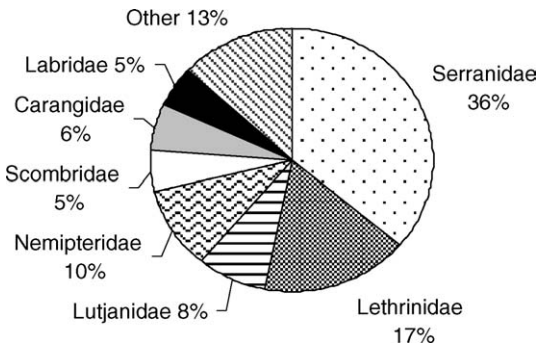

Fig. 3. Composition of hook and line catch by frequency of occurrence and family.

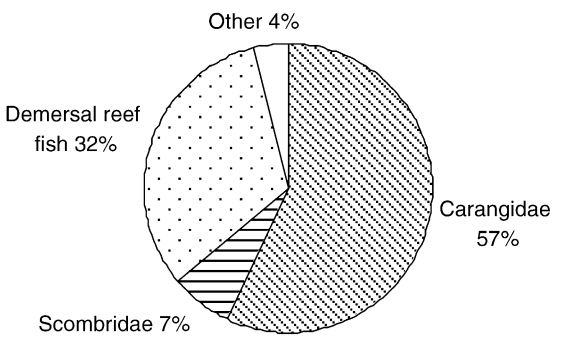

Fig. 4. Composition of gillnet catch by weight and family.

Due to the limited times other gears were observed and recorded, their catch composition can only be described qualitatively in this paper. Longline catches consisted of large sized coral groupers, aerolate grouper (*Epinephelus aerolatus*), pink ear emperor (*Lethrinus lentjan*), and Spanish flag snapper (*Lutjanus carponotatus*). Sweetlips (Haemulidae), fusiliers (Caesionidae), and unicornfish (*Naso* spp.) were named as the most commonly trapped fish. For the spear fishery, unicornfish (*Naso* spp.), ribboned sweetlips (*Plectorhinchus polytaenia*), blue spotted ray (*Taeniura lymma*), and lobster (*Panulirus* spp.) were observed among the species caught.

4.3. Catch revenue

The average daily revenue for hook and line and gillnet fishers was calculated based on their daily catch, and is presented in Table 2. These estimates show that hook and line fishers are substantially worse off because they are more susceptible to lost fishing days as a result of adverse weather conditions. However, hook and line requires less capital investment in gear than gillnet. Therefore, there may not be a significant difference in net income if fishing costs are deducted (Table 3).

With the exception of one case, all sampled hook and line fishers who attained daily revenue higher than the mean of RM 17.60 had caught a coral grouper. The value of coral grouper accounted for 43–100% of the revenue earned by these fishers (Fig. 5).

Table 2
Estimated average fishing revenue (RM) during low fishing season (June–September)

Gear	Average daily revenue (RM)	Average number of fishing days per week	Estimated average monthly revenue (RM)
Hook and line	17.60	3.5	247
Gillnet	33.60	5	672

Table 3
Comparison of mean CPUE (kg h^{-1}) by site

Gear	South Banggi	Semporna[a]
Hook and line	1.26	0.375
Gillnet	3.85	0.625

[a] Data from Semporna Islands Project (http://www.mcsuk.org/semporna/resource/19.htm).

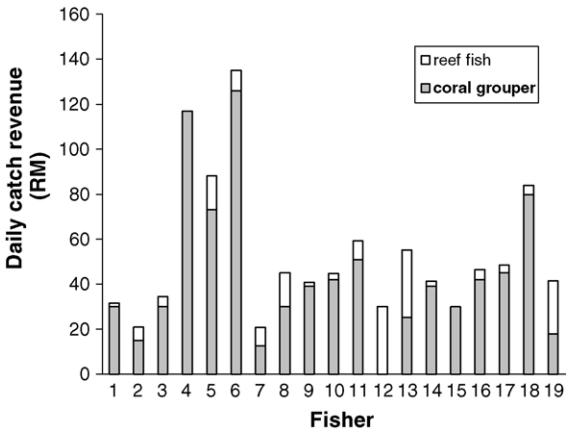

Fig. 5. Breakdown of daily revenue from hook and line of 19 fishers, showing the proportion due to the capture of coral grouper and of other reef fish, in June and August 2004.

This economic reliance on coral grouper is a cause for concern, as its life history makes it intrinsically vulnerable to exploitation. The depletion of the coral grouper stock might lead to economic hardships for those hook and line fishers whose sole income source is from fishing.

5. Discussion and conclusion

The emerging picture of Banggi's reef fisheries is that it has not yet reached the depleted state characterized by other South East Asian fisheries (e.g., Talaue-McManus and Kesner, 1995). CPUE estimates obtained in this study are substantially higher than those documented for the heavily exploited artisanal reef fisheries of Semporna, a similar reef fishery in south eastern Sabah (Table 2). The catch composition for both hook and line and gillnet is still dominated by high trophic level predatory fish (Figs. 3 and 4), indicating that the global phenomenon of "fishing down marine food webs" (Pauly et al., 1998) is currently not applicable here. Furthermore, the presence of outside fishers at Maliangin suggests that fish stocks here are relatively abundant compared to other areas of Sabah. Strong south-west monsoon winds may restrict excessive exploitation by reducing fishing effort from June to September. This seasonal weather pattern indirectly acts to conserve fish stocks, as noted also by Alcala and Luchavez (1982) about the Apo Island fisheries.

On the other hand, it is also apparent that the open access nature of Banggi's reef fisheries has led to Malthusian overfishing (Pauly et al., 1989). Anecdotal evidence suggests that the number of fishers has risen markedly in the past 10–15 years, corresponding to a two to four times decrease in individual catch (various fishers, personal communication). At the same time, dynamite and cyanide fishing, hallmarks of Malthusian overfishing, occur on a regular basis in Banggi (Koh et al., 2002; Daw et al., 2002). Biological overfishing is likely applicable to LRFT species such as the humphead wrasse (*Cheilinus undulatus*) and humpback grouper (*Cromileptes altivelis*), whose populations are severely depleted in Banggi (Oakley et al., 1999). Fishers attest to the rarity of capturing these species, making the present coral grouper fishery a cause of concern due to the species' vulnerable life history.

At this point, it is not possible to determine conclusively what the current status of Banggi's coral reef fisheries is. Although Banggi's reefs appear productive enough to meet the needs of the present population, our overall impression is that the continuation of current exploitation rates will lead to an overfished resource in the long-term. Fishing effort is influenced by a broader realm of socio-economic drivers which have to be explicitly considered when pursuing further assessment.[10] While fisheries' productivity has not yet declined to a critical level, the opportunity should be taken by fisheries managers to initiate precautionary policies which will conserve reef resources while enabling sustainable use in the long-term.

In the absence of any data, this study serves as an important starting point for understanding the dynam-

[10] These drivers and their potential impact on fishing effort are summarized in Appendix A.

ics of Banggi's reef fisheries. Future work includes: (i) expanding sampling locations and incorporating seasonal catch and fish size data to further assess exploitation status; (ii) using Ecopath with Ecosim (Pauly et al., 2000) ecosystem modeling software to undertake preliminary exploration of the biological and socio-economic impact of different management strategies;[11] (iii) identifying best policy option(s) which will balance the need for conserving reef fisheries resources with the need to derive economic benefits from the ecosystem.

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Appendix A

Drivers of fishing activity in southern Banggi

Driver	Impact on fishing activity	Pathway
Population dynamics	Increase	Influx of migrants from neighbouring islands
	Maintain/decrease	Youths leaving for urban centres
Economic incentives	Increase	High monetary incentives from LRFT
Subsidies	Increase	Decrease cost of fishing
Culture	Maintain/increase	Cultural connection to fishing lifestyle; low conservation ethic[a]
Seasonal weather	Decrease	South-west monsoon winds prevent fishing

[a] *Source*: Fisher (2000).

[11] The intent is to find out whether the model will produce representative and useable results, and if not, what information needs have to be satisfied in order for more sophisticated modeling to be undertaken in the future.

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