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ABSTRACT

Malthusian overfishing occurs when socio-economic conditions drive small scale fishers to overexploit and destroy their coastal fisheries resources, resulting in declining yields and deepening poverty. The coastal communities of Pulau Banggi, Sabah, Malaysia, are economically under-developed, and dependent on the island's reef fisheries for livelihood. Population growth, international market demand, and the arrival of illegal fishers have all increased pressure on reef fisheries resources, leading to perceived declines in catch rates over the past 20 years. Characteristics of Malthusian overfishing are evident in Pulau Banggi, although not at a magnitude comparable with other more heavily exploited artisanal fisheries in the Philippines. It appears that Banggi's reef fisheries are at an early stage of Malthusian overfishing, and this is therefore a critical time for addressing and mitigating drivers of overfishing to prevent inevitable and further decline of Banggi's reef fisheries.

Keywords: reef fisheries, Banggi, Sabah, Malthusian overfishing

1. INTRODUCTION

The concept of Malthusian overfishing was introduced by Pauly et al. (1989) to describe the overexploitation of tropical coastal fisheries being carried out by poor fishers in an effort to maintain their incomes and source of animal protein. This form of overfishing remains particularly prevalent in the developing nations of Southeast Asia, where it has taken a firm foothold in the region's numerous small-scale, artisanal fisheries (Pauly, 1997; McManus, 1997).

Malthusian overfishing captures the socio-economic environment in which fishing occurs, pointing to poverty, population growth, and the lack of alternative livelihoods as the main factors driving the overexploitation of fisheries resources in Southeast Asia (Pauly and Chua, 1988; Pauly et al., 1989), and by extension, other developing countries. Overfishing, including habitat damaging fishing practices, is further exacerbated by the ineffective management, if any, of many tropical small-scale fisheries (Pauly, 1997).

Identifying whether a fishery is experiencing Malthusian overfishing is important because it can provide an impetus for implementing precautionary management measures that can help direct the course towards ecologically and socio-economically sustainable fisheries. This study investigates whether the reef fisheries of Pulau[1] Banggi in Sabah, Malaysia, which have not been actively managed before, have reached a state of Malthusian overfishing. We first characterize Banggi's reef fisheries in terms of their key fishery and

[1] Pulau is the Malay word for island.

socio-economic variables. We then qualitatively compare these characteristics to criteria pertaining to Malthusian overfishing as outlined in Pauly (1993), and end with some suggested actions needed to alleviate or mitigate this form of overfishing in Banggi.

2. BACKGROUND

Study site

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 (Anon., 2003). The nearest mainland town is Kudat, which is about 30 km across the Banggi Channel.

This study focuses on southern Banggi, with the research base located in Karakit, the administrative centre and main entry point to the island. Together with the adjoining villages of Singgahmata and Perpaduan, Karakit comprises the population centre and main socio-economic hub of southern Banggi.

Reef fisheries of Banggi

In this study, reef fisheries refer to the capture of both demersal reef fish, as well as reef-associated and coastal species such as scombrids and carangids. A detailed description of Banggi's reef fisheries can be found in Teh et al., (2005). Briefly, the reef fisheries of Banggi are small-scale, artisanal, and can be considered open access with virtually no

regulation in place. Although daily marine patrols by the army serve to reduce the occurrence of destructive fishing practices, blast and cyanide fishing are still common practices at the study site (Koh et al., 2002; Daw et al. 2002).

Fishing is done with traditional gears, with hook and line and gillnets being the two most important fishing gears in terms of landings (Teh et al., 2005). Other fishing methods include the use of traps, jigs, spears or spear guns, and explosives and cyanide. Fishing seasons are influenced by the severity of monsoon winds. The windy southwest (SW) monsoon period starting around June and lasting until September is considered the low fishing season. A second low fishing period occurs roughly between December and February, when there are strong northeast (NE) monsoon winds. Peak fishing season occurs from March until May, during the beginning of the SW monsoon when weather is the calmest.

The primary fishing ground studied is the Maliangin area, immediately south of Karakit (Fig. 1). This is one of four main fishing areas in Banggi, the others being Kuambang and Sibogo in the east, and Balambangan in the west. The Maliangin fishing ground is characterized by shallow reefs 3 to 5 m in depth near shore, and deeper patch reefs of 15-30 m depth further offshore. Different fishing gears operate at spatially distinct locations (Fig.1). Hook and line fishers tend to concentrate around a small offshore island called Maliangin Besar, whereas gillnet fishers fish at more dispersed locations around the coast and other offshore islands.

There is an active live reef fish trade (LRFT) operating in southern Banggi. This involves the capture of live fish, of which coral grouper (*Plectropomus* spp.) is the primary target. Live fish caught in the Maliangin area are sold to a holding cage in Perpaduan village, and these are eventually sold to Kudat, the centre of the LRFT in Sabah (Daw et al., 2002; Biusing, 2001). Due to the high economic value of live coral grouper, these fish are intensely targeted by fishers during the SW monsoon months, during which their catches peak.

Coastal communities of Banggi

The current population of Banggi is estimated at between 18,000 (Biusing, 2001) and 20,000 (Institut Penyelidikan Marin Borneo, 2003), with around 1,100 inhabitants in the vicinity of the study site (Teh et al., 2005). There are around 90 fishers in the main fishing villages in proximity to Karakit, i.e., Singgahmata, Perpaduan, Patanunam, and Maliangin Besar (Teh, 2006). In Kobong and Lumais, two other villages whose fishers frequent the Maliangin fishing grounds, there are approximately 40 to 50 fishers.

Banggi remains relatively under-developed, and coastal households are considerably below the Sabah monthly poverty line income of RM 633, or approximately USD 167 (IPMB, 2003). Fishing, on which these communities continue to depend heavily on for food and income, accounts for about 70% of the island's economic activity (IPMB, 2003).

The population growth rate in Banggi is approximately 4.4% (IPMB, 2003) per year, which is substantially higher than the 2003 national rate of 1.6 % (Anon., 2004). North

Sabah's proximity to the Philippine border has attracted many illegal immigrants to Kudat and Banggi , many of whom are fishers, and thus increase the pressure on coastal fisheries resources. In fact, illegal transient fishers are estimated to make up 28% of the total fisher population in the Sulu-Sulawesi Marine Ecoregion (SSME) area of Sabah, which consists of the northern and eastern parts of Sabah that are bounded by the Sulu and Sulawesi Seas (including Banggi). In 1999, roughly 17% of Banggi's residents were believed to be illegal immigrants (Fisher, 2000).

3. METHODS

Field work to collect primary data was conducted by the first author in 2004 and 2005. The first field season lasted six weeks during the SW monsoon windy period in June and August 2004. The second field season was another six weeks in March and April 2005.

Fishery data

Fishery data was collected for the hook and line and gillnet fisheries, which, according to the two main fish buyers in southern Banggi, accounted for the majority of fish captured for sale in Banggi. These data were collected by monitoring catch landings and surveying fishing grounds. Surveys of the Maliangin fishing grounds 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. Fishers were randomly stopped and the following was recorded: a) gear type; b) quantity

of fish caught (weight was estimated by a boat operator, who is also an experienced fisher); c) number of hours fished; and d) species caught.

Fish landings during the first sampling season were recorded at the two main fish buyers' sites at Karakit and Singgahmata from June 16th to July 6th, and from August 7th to August 27th, 2004. This data collection period corresponded to the low fishing season, and was considered representative of the catch and effort for that particular time period as no extraordinary events occurred to indicate otherwise. Gillnet fishers landed their catch at the Karakit site between 8:30 to 11:00 p.m. The landing site was continuously monitored during these times, and all catches that were landed were recorded. Hook and line catches were landed more sporadically at the Singgahmata site. Therefore, sampling at this site was more opportunistic. The majority of sampled hook and line catches during 2004 was taken during the fishing grounds surveys.

During the second sampling season, catch landings were recorded from March 6th to April 12th, 2005. This was supposed to represent the calm weather period, but the continuation of strong NE winds might have caused catches to be lower than normal. Receipts covering parts of mid April-May 2005 (typically the peak season) were kindly supplied by the two main fish traders.

Interviews

Semi-structured interviews were conducted in villages where fishers were known to frequent the Maliangin fishing ground. During these interviews, questions pertaining to

catch, effort, target species, historical trends, and fishing knowledge 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, and the number of respondents varied for each question. When reporting these interview data, the number of total respondents to specific questions is indicated in brackets.

In 2004, 20 fishers, 2 fish traders, and 3 village leaders were interviewed. These interviews were conducted in Malay, and took place in the villages of Karakit, Perpaduan, Singgahmata, Maliangin Besar, and Lok Tohog. Two expert interviews were also conducted with fisheries officers in the Kota Kinabalu and Kudat Department of Fisheries branches. In addition, a participatory approach (Reason, 1994), in which the researchers joined in fishing trips and reef gleaning activities, was undertaken as a means of furthering knowledge about local fishing practices. During 2005, a total of 30 additional interviews were conducted with fishers in the villages of Perpaduan, Maliangin Besar, Kobong, Lumais, and Patanunam. Altogether, the number of interviews in 2004 and 2005 represented roughly 30 to 40% of the total fisher population in these villages.

Malthusian Overfishing

Pauly (1993) listed a set of characteristics which typically indicate the presence of Malthusian overfishing in a fishery. These features include:

1) An increasing number of fishers;
2) Decrease in catch and income per fisher;

3) Evidence of biological and ecological overfishing;
4) Economic overfishing;
5) Breakdown of traditional management strategies;
6) Non-enforcement of management regulations;
7) Entry of new fishers with no fishing tradition;
8) Increasing or common use of destructive gears;
9) Women increasingly generating the bulk of family income.

- *Modified from Pauly (1993).*

We assess whether the above criteria are met for the reef fisheries of Pulau Banggi. Based on our assessment, we come to a conclusion of whether or not Malthusian overfishing is occurring in Banggi.

4. RESULTS & ANALYSIS

Catch composition

The species composition for both hook and line and gillnet fisheries varied seasonally, but consisted mainly of carnivorous fish throughout the year (Teh, 2006). The main families caught by using hook and line during all three sampling seasons were the groupers (Serranidae), emperors (Lethrinidae), snappers (Lutjanidae), tunas and mackerels (Scombridae), and trevallies (Carangidae). The average proportion of each main fish group in the catch, over all sampling periods, is given in Table 1. The two main target species for the hook and line fishery were coral grouper (*Plectropomus* spp.) and

Spanish mackerel (*Scomberomoros commerson*), which were caught during the SW and NE monsoon periods, respectively. During the coral grouper season in June/August 2004, coral groupers were caught in 28% of sampled catches. During March to May 2005, which corresponded to the end of the Spanish mackerel season, Spanish mackerel were present in 28% of all recorded catches as well.

Gillnet landings consisted mainly of trevallies (Carangidae), demersal reef fish (Lethrinidae, Lutjanidae, and Haemulidae), and tunas and mackerels (Scombridae). There were no specific target species for the gillnet fishery, although trevallies and Spanish mackerel were preferred for their higher price per unit weight. The average proportion of each group in the catch, over all sampling periods, is given in Table 1.

When compared to other artisanal reef fisheries in Southeast Asia in terms of fishery characteristics, Banggi appears to be in relatively good shape. The species composition of both hook and line and gillnet landings comprises mainly of higher trophic level, carnivorous fish. This is in contrast to overfished coral reef ecosystems where top predatory species have been removed, and fishery catches consist of mostly herbivorous or planktivorous species (McManus, 2000).

Catch quantity

Mean catch for the hook and line fishery was lowest in June and August 2004 at 7.1±7.6 $kg \cdot fisher^{-1} \cdot day^{-1}$, and increased by up to 63% during the subsequent two sampling periods (Table 2). It should be noted that only non-zero catches were included for analysis in all

seasons. This is because it was not possible to record zero catches for the gillnet landings, while zero catches for the hook and line fishery were not recorded consistently. Mean gillnet catches were also lowest in June and August 2004 at 14.8 ± 12.7 kg·fisher^{-1}·day^{-1}, and increased by up to 27% during the two ensuing sampling periods (Table 2).

Estimated CPUE for June/August 2004, which was the sampling period with lowest recorded catches, was still substantially higher than CPUE recorded at two artisanal reef fisheries that were considered to be overexploited- Semporna in southeast Sabah and Malalison Island in the Philippines (Table 3). This implies that southern Banggi's reef fisheries might not be overfished to the same extent as the other two locations.

Profitability of fishing

Profitability, which is defined here as the ratio between net income (i.e. the net return from fishing after deducting all fishing related costs) and gross revenue, was estimated for the hook and line and gillnet fisheries for each sampling season (Table 4). It is noted that real labour cost was set at zero in this analysis because of the lack of alternative employment opportunities on Pulau Banggi; therefore it was considered reasonable to assume that the opportunity cost of labour was zero.

Profitability for both hook and line and gillnet fisheries was lowest during the June/August 2004 sampling period, at 33% and 49%, respectively (Table 4). The profitability of hook and line fishing was lower than gillnet in all seasons. However, hook and line profitability in April and May could potentially surpass that of gillnet by

approximately 10% (from 62% to 74%), if revenue from coral grouper sales were included (Teh, 2006).[2] The biggest gap between gear incomes occurred during the windy SW monsoon period in 2004, when fishing by gillnet yielded 16% higher profitability than by hook and line.

The above analysis indicates that fishing still appears to be a profitable activity in southern Banggi. Consequently, criteria (4) Economic overfishing, does not seem to apply to Banggi's reef fisheries. However, this analysis might be an overly optimistic outlook of the real economic situation. A key contributor to the high profitability is that opportunity cost of labour is assumed to be zero. In absolute terms, fishers are still very poor, with net income levels below the poverty line (IPMB, 2003). It is not clear whether individual real income levels have decreased, since fishers indicate that decreased catches have been offset by higher fish prices. Nevertheless, fishers often face financial difficulties during the low fishing season (Cooke, 2003; Teh, 2006), but due to the lack of alternative employment, fishers will likely continue to fish until the last fish is caught, virtually. This behaviour is inherently linked to the issue of discounting, wherein poverty and uncertainty result in too much weight being put on receiving benefits from marine ecosystems now rather than in the future (Sumaila, 2005), thus resulting in extreme overexploitation.

[2] Receipts in April-May 2005 did not include potential coral grouper sales, which would have been sold to a separate live fish operation.

Historical trends

Eleven out of 22 fishers indicated that individual catch rates had declined by three to four times since the 1980s. Notably, 67% (18 out of 27) of fishers pointed out that noticeable decrease in catch rates occurred only since 2000. According to fisher interview data, catch rates of coral grouper (*Plectropomus* spp.) by hook and line appeared to have declined by 12 times since the 1970s, while catch rates by trap declined by 6 times since the 1980s (Fig. 2). At the same time, prices of coral grouper increased as catch rates decreased (Fig.2). Fishers also reported that the capture of two premium LRFT species, the humphead wrasse (*Cheilinus undulatus*) and humpback grouper (*Cromileptes altivelis*) were extremely rare in the Maliangin area now. Underwater visual surveys support this claim (Koh, 2002; Harding, 2001).

With the exception of the two previously mentioned live reef species, fishers reported no change in the type of species caught now, compared to before; thus large scale ecosystem overfishing does not appear to have occurred. However, captured fish were considered to be smaller now (65% of respondents, n=17), a potential sign of growth overfishing. In addition, fishers said that they now have to travel to reefs further offshore in order to catch fish, whereas they used to fish directly from shore. The trends described above suggest that criteria (2): Decrease in catch per fisher, and (3): Evidence of biological and ecological overfishing, are applicable to Banggi's reef fisheries.

The fishers attributed the temporal decline in catch rates to an overall increase in fishing effort, as the number of fishers around southern Banggi had increased substantially from

before. This satisfies criteria (1): An increasing number of fishers; the continuing trend of new fishers arriving in Banggi over the last 20 years also satisfies criteria (7): Entry of new fishers with no fishing tradition, to a certain extent. It is unlikely that all the new fishers who arrived in Banggi lacked prior fishing tradition, as many of them were fishers from fishing communities in southern Philippine islands such as Balabac, Tawi-Tawi, and Cagayan de Sulu (Cooke, 2003).

Fishers blamed the relatively recent and noticeable decrease in catches to the increased frequency and number of purse seine fishing vessels encroaching on traditional near-shore fishing grounds.[3] These allegations coincide with the increase in licensed seine net vessels operating in Kudat since 1992 (A. Cabanban, unpubl. data). The apparent lack of enforcement of the traditional fishing zone regulation indicates that criteria (6): Non-enforcement of management regulations, applies to Banggi. Moreover, fishers also blamed blast and cyanide fishing for causing the decline in fish, indicating that criteria (8): Increasing or common use of destructive gears is applicable. Blast fishing is used to obtain bait fish for fishing and as feed for live fish kept in cages, while cyanide is used to stun and capture live fish.

Two criteria are not relevant to Banggi's reef fisheries. Firstly, (5): Breakdown in traditional management scheme is inapplicable since to our knowledge, there is no traditional fisheries management in Banggi. Yet, the fact that such a system does not exist could be one of the contributing factors for the presence of Malthusian overfishing.

[3] Under the Malaysian Fisheries Act 1985, the zone within five nautical miles from shore is reserved only for fishing using traditional gears.

Secondly, criteria (9): Women generating most of the family income, is not common in Banggi, where fishing, done mostly by men, is still the major source of household income. However, many Banggi youths who work in urban Malaysian towns and cities do constitute a source of non-fishing income to fishing households in Banggi. In this way, they indirectly subsidize fishers to continue fishing, much as women generating household income would do (Pauly, 1997).

In summary, our analysis shows that 6 out of 9 criteria for Malthusian overfishing criteria are applicable to Banggi's reef fisheries, although not at a magnitude comparable with other more heavily exploited artisanal fisheries (e.g. Bolinao in the Philippines: McManus, 1992). Taking into account the comparatively good catch rates and species composition recorded, Banggi's reef fisheries can be considered to be at an early stage of Malthusian overfishing.

Potential solutions for Malthusian overfishing?

Poverty has been identified as one of the main causes of fishing problems (Pauly and Chua, 1988). In Banggi, poverty is exacerbated and driven by the under-development of the island's economy, as well as by high internal population growth and migration. Efforts to limit or decrease fishing effort thus centre not only on fisheries management tools and policies, but must also encompass broad socio-economic policies (Sadovy, 2005). This implies that efforts to eliminate Malthusian overfishing fall within the larger context of integrated coastal zone management. A starting point for potential management policies would include, but not limited, to the following:

1) Development of suitable non-marine resource extractive industries, e.g. sustainable tourism or aquaculture (e.g. clam farming), and small scale agriculture. These would take place in conjunction with training programmes to provide fishers with the required skills;
2) Community organization and education to build local capacity, knowledge, and support for community managed fisheries and marine resources;
3) The establishment of a community managed no-take marine reserve within the current fishing grounds. This approach has proven successful for fish population recovery, potential fisheries enhancement, and tourism development in similar artisanal reef fisheries and communities (e.g. Russ et al., 2004). It will also serve to focus attention on the immediate need for limiting fishing effort;
4) Provision and development of infrastructure (e.g., roads, electricity, and sewage) and social (e.g. health and education) programmes;
5) Tighter enforcement of international border to control illegal immigration.

5. CONCLUDING REMARKS

This study suggests that Banggi's reef fisheries are in the early stages of Malthusian overfishing. This is, therefore, a critical time for policy makers to address drivers of overfishing, and to mitigate these issues to prevent further decline towards "wholesale resource destruction" (Pauly et al.,1989). In order to achieve this, the current drivers of poverty, namely, lack of alternative employment stemming from poor economic development and increase in the number of fishers, have to be addressed and rectified.

This implies that reef fisheries managers in Banggi will have to collaborate with a wide range of community, social, and political organizations in order to initiate the actions required for long-term sustainable reef fisheries.

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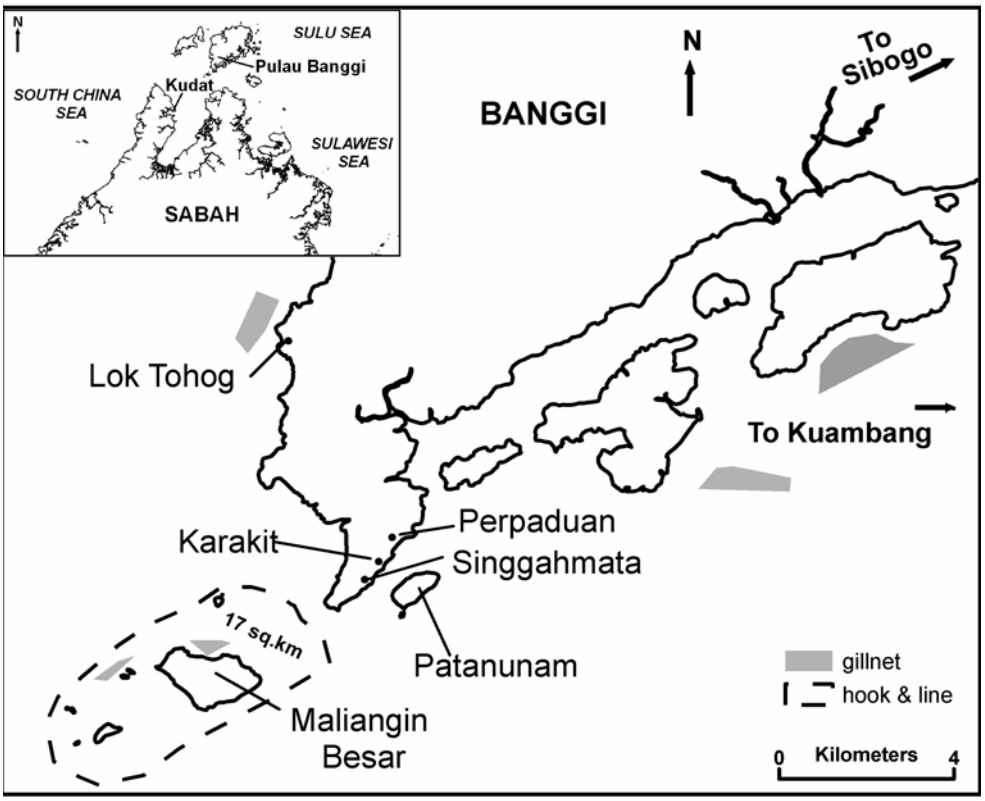
Figure Captions

Figure 1 Map showing southern Banggi fishing ground with inset map showing Pulau Banggi located off the north coast of Sabah.

Figure 2 Present and historic prices (unadjusted for inflation) and mean catch rates of coral groupers using hook and line and traps, as reported by fishers. Units are $kg \cdot day^{-1}$ for hook and line, and $kg \cdot week^{-1}$ for trap.

Figure1


N
SULU SEA
Pulau Banggi
Kudat
SOUTH CHINA SEA
SULAWESI SEA
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To Sibogo
Lok Tohog
To Kuambang
Perpaduan
Karakit
Singgahmata
17 sq.km
Patanunam
Maliangin Besar
gillnet
hook & line
0 Kilometers 4

Figure2

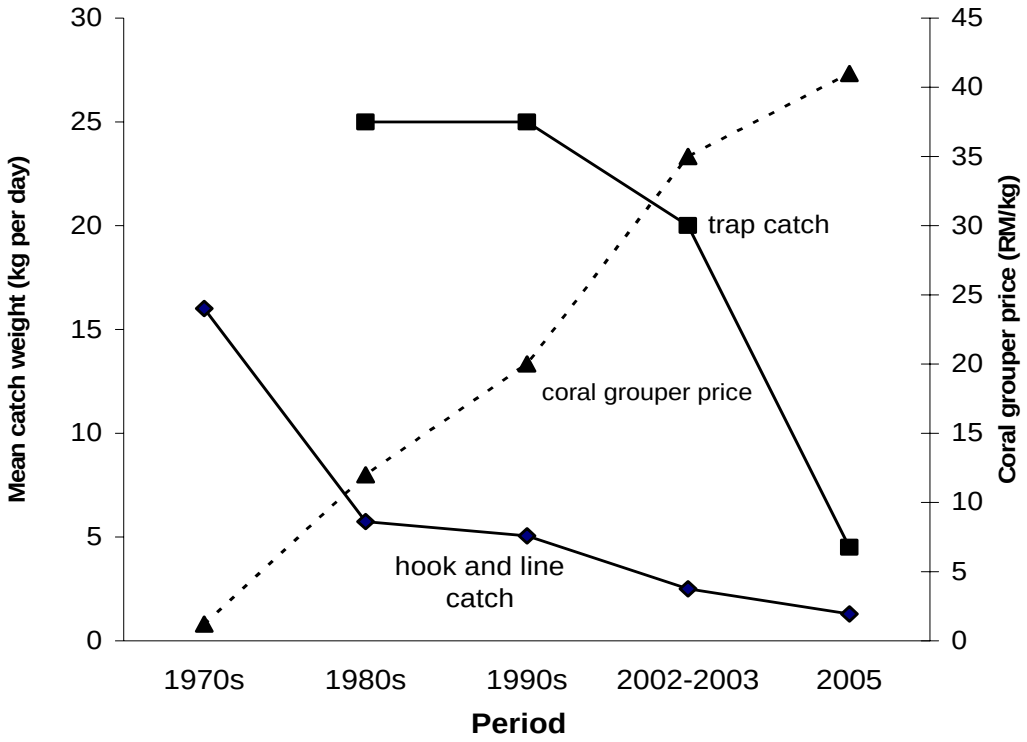
30
25
20
15
10
5
0
45
40
35
30
25
20
15
10
5
0
Mean catch weight (kg per day)
Coral grouper price (RM/kg)
trap catch
coral grouper price
hook and line
catch
1970s
1980s
1990s
2002-2003
2005
Period

Table 1 Catch composition (%) by major fish families/groups

GEAR	MAJOR FISH FAMILIES / GROUPS		
	Demersal reef fish	Carangidae	Scombridae
Hook and line	51	26	18
Gillnet	36	38	12

Table 2 Daily catch weights (Mean ± S.D. and median ($kg \cdot day^{-1}$)) for hook and line and gillnet fisheries in 3 sampling seasons.

Gear	**June/Aug 2004**		**March/April 2005**		**April/May 2005**	
	Mean	Median	Mean	Median	Mean	Median
Hook and Line	7.1±7.6	4.1	11.2±9.5	6.8	11.6±12.2	8.8
Gillnet	14.8±12.7	11.5	16.4±14.8	11.0	18.8±24.0	11.0

Table 3 Comparison of mean CPUE (kg·fisher·hr^{-1}) by site.

Gear	South Banggi	Semporna*	Malalison Island**
Hook and line	1.43	0.38	0.67
Gillnet (set)	3.85	0.63	0.43

*Source: Semporna Islands Project (http://www.mcsuk.org/semporna/resource/19.htm)

**Source: Amar et al. (1996).

Table 4 Estimation of net monthly income (RM)* and profitability for hook and line (HL) and gillnet (GN) fishers.**

Season/ Gear	**June/Aug 2004**		**March/April 2005**		**April/May 2005**	
	HL	GN	HL	GN	HL	GN
Gross daily revenue	17.62	33.57	26.26	42.95	29.98	43.27
Gross monthly revenue	281.92	671.40	525.20	1030.80	719.52	1038.48
Variable costs	171.79	320.00	214.74	357.65	257.68	357.65
Net revenue	110.13	351.40	310.46	673.15	461.84	680.83
Depreciation costs	16.25	24.58	16.25	24.58	16.25	24.58
Net monthly income	93.88	326.82	294.21	648.57	445.59	656.25
Profitability *	0.33	0.49	0.56	0.63	0.62	0.63

* The exchange rate on June 13, 2006 is 1USD = 3.68 RM

** Assumptions for these estimates can be found in Teh (2006), Appendix IV.