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DETERMINATION OF FISHERY AND SOCIO-ECONOMIC EFFECTS OF SIMCA ON LOCAL FISHING COMMUNITIES AND EVALUATION OF THE EFFECTS OF RESERVE PROTECTION ON REEF FISH SIZE AND ABUNDANCE

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This publication was prepared by Chung Fung Chen, Lydia Teh, Louise Teh, Felicity Kuek, Gan Sze Hoon and Leony Sikim with funding from the United States Agency for International Development's Coral Triangle Support Partnership (CTSP).

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Front cover photo: Small-scale fishermen at Sugud (top), School of rabbitfish in the well-protected reef, Lankayan Island (bottom). © Chung Fung Chen/ WWF-Canon

CONTENTS

ACKNOWLEDGEMENTS V

EXECUTIVE SUMMARY 1

ABBREVIATIONS 3

1. 0 BACKGROUND 4

1.1 ENHANCEMENT OF FISH BIOMASS 4
1.2 SIMCA ESTABLISHMENT 5
1.3 FISHING ACTIVITIES IN AND AROUND SIMCA 6
1.4 REEF FISH ABUNDANCE IN SIMCA 6

2. 0 OBJECTIVES 7

3.0 STUDY 1: FISHERIES AND SOCIO-ECONOMIC IMPACT OF SIMCA 8

3.1 SECTION 1: VILLAGE INTERVIEW 8
3.1.1 Background 8
3.1.2 Method 8
3.1.3 Data analysis 9
3.1.4 Results 10
3.1.4.1 Demographics of fishing villages 10
3.1.4.2 Catch per unit effort (CPUE) 11
3.1.4.3 Type and size of fish caught 12
3.1.4.4 Fishing grounds 12
3.1.4.5 Income 13
3.1.4.6 Perceptions about MPAs 14
3.1.5 Discussion 14
3.2 SECTION 2: AT SEA INTERVIEWS 15
3.2.1 Background 15
3.2.2 Method 16
3.2.3 Results 16
3.2.3.1 Demographics of respondents 17
3.2.3.2 Gear and catch 17
3.2.3.3 Spatial Use (Fishing grounds) 19
3.2.3.4 Catch per unit effort 20
3.2.3.5 Income 21
3.2.3.6 Reasons for fishing in SIMCA 22
3.2.3.7 Perception of MPAs 23
3.2.4 Discussion 23
3.3 SUMMARY AND CONCLUSION 24

4.0 STUDY 2: REEF FISH BIOMASS SURVEY 26

4.1 BACKGROUND 26

4.2 METHOD 26

4.2.1 Site selection 26

4.2.2 Fish biomass estimation 29

4.2.3 Data analysis 29

4.3 RESULTS 29

4.4 DISCUSSION AND CONCLUSION 36

5.0 REFERENCES 38

APPENDIX 1: VILLAGE INTERVIEWS QUESTIONNAIRE 40

APPENDIX 2: AT SEA INTERVIEWS QUESTIONNAIRE 47

APPENDIX 3: LIST OF TABLES 52

APPENDIX 4: LIST OF FIGURES 53

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EXECUTIVE SUMMARY

The establishment of no-take marine reserves puts a stop to fishing within a bounded area. By doing so, it affects fishing communities who depend on these fisheries resources for food and income, and also affects the ecology and abundance of marine organisms found within and nearby the reserve. The Sugud Islands Marine Conservation Area (SIMCA) is a no-take marine reserve that was established in Sabah, Malaysia, in 2001; however, its socio-economic and ecological impacts are not known. There are therefore two objectives to this project: 1) socio-economic - determine whether the establishment of SIMCA has affected the fish catch and fishing income of fishermen in the surrounding area; and 2) ecological - assess whether reef fish biomass and diversity are higher within SIMCA relative to outside the reserve.

The socio-economic study consists of two sections, both of which involved semi-structured interviews with fishermen that were carried out in 2010 and 2012. Section 1 involved undertaking a temporal comparison of fishermen's fishing effort, catch, and income before and after SIMCA establishment in order to identify potential socio-economic effects of SIMCA. We targeted fishermen who lived closest to SIMCA, which were villages along the Sugud coastline, as we assumed that these were the communities most likely to be affected by the marine reserve. Surprisingly however, we found that the establishment of SIMCA appeared to have had minimal impact on these fishermen, as the SIMCA area was not a frequented fishing ground for these fishermen in the past or present time.

Nevertheless, the fact that fishermen are frequently observed fishing inside and close to SIMCA indicates that there may be some perceived socio-economic benefits from fishing here. Section 2 of the socio-economic study therefore aimed to investigate who these fishermen were, and what factors motivated them to encroach into, or fish near SIMCA in the present time. Our results indicated that the majority of these fishing vessels were commercial operations. It appears that market demand for commercially valuable species, such as shrimp and groupers, is the main factor driving these commercial operations to fish near SIMCA. Yet, only a minority of fishermen appeared to perceive direct benefits from SIMCA, in the form of increased catch or income.

Reef fish biomass was compared by underwater visual censuses (UVC) at reefs with difference level of protections. Three levels of protections were defined in this study: Level 1 as (100%) fully protected reefs with zero fishing mortality; Level 2 as (50%) semi-protected reefs and Level 3 as (0%) non-protected reefs. Total of 12 patch reefs and 72 transects were surveys from July 2010 to November 2011. We found that total reef fish biomass was significantly higher inside the reserve, with highest abundance recorded at sites with full protection. The abundance counts of commercially targeted species such as groupers (Serranidae) and snappers (Lutjanidae) were highest in well protected reefs. In addition, species richness was also higher at well protected reefs. For example there was total of 15 species of Serranidae recorded in this study, 14 species were recorded at fully protected reefs whereby only 5 species were recorded at non-protected reefs. Out of 14 grouper species in the protected reefs, seven are commercially important species. These included *Plectropomus leopardus*, *Plectropomus oligacanthus, Plectropomus maculatus, Epinephelus coioide* and*, Cromileptes altivelis* (Barramundi).

Overall, we found that the creation of SIMCA may have produced ecological benefits by increasing the total biomass of commercially important fish species within the reserve. The biomass gradient decrease across the distance may suggest density dependent emigration from the center of reserve (Level 1 and 2) to outside of the reserve (Level 3). Reef fishes that allowed to growth larger are potentially serves as spawning-stock that provided a source of recruitment to replenish areas outside of reserve. However, the socio-economic impacts of SIMCA are less conclusive. On the one hand, most fishermen who fish in the vicinity of SIMCA do not perceive differences in fish catch or earnings compared to other fishing grounds. Yet, the continual presence of fishing vessels within or just outside SIMCA suggests that fishing is better in the vicinity of SIMCA, at least for commercial operations. SIMCA was not created for socio-economic objectives; nevertheless, our study shows that the socio-economic impacts of a no-take zone cannot be ignored, as it influences fishermen's fishing behaviour and ultimately, the integrity of an MPA. Thus, from a management perspective, our findings reinforce the importance of 1) assessing and monitoring the spatial use patterns of fishermen, including gathering spatially explicit information on fish catch-, effort, and earnings; and 2) engaging fishermen's opinions on where to locate no-take zones, *prior* to the establishment of MPA boundaries. Although SIMCA was created for biodiversity protection and recreation purposes, the management implications of this study are just as applicable to multi-use marine protected areas, which are increasingly being used as tools for fulfilling multiple biodiversity, sustainable fisheries, and poverty alleviation goals, particularly in the Coral Triangle.

ABBREVIATIONS

ANOVA	Analysis of variance
cm	Centimetre
Cmap	Marine electronic chart produce by C-Map
CPUE	Catch per unit effort
g	Gram
ha	Hectare
Hrs/day	Hours per day
HP	Horse power
IUCN	International Union for Conservation of Nature
kg	Kilogram
m^2	Meter square
Max	Maximum
Min	Minumum
MPA	Marine Protected Area
n	Sample size
nm	Nautical mile
RM	Ringgit Malaysia
SD	Standard deviation
SIMCA	Sugud Islands Marine Conservation Area
Std. Error	Standard error
UVC	Underwater visual censuses
WWF	World Wide Fund for Nature
WWF-US	World Wildlife Fund United States
%	Percent

1. 0 BACKGROUND

No-take marine reserves are defined as areas where fishing is not allowed, and have been used as management tools for marine conservation, fisheries, and recreational activities around the world (Halpern, 2003). By removing fishing pressure, no-take reserves can serve as refuges where populations of exploited species can recover (Gell and Roberts, 2003), and also provide protection for habitats with important ecological functions, such as spawning aggregation sites for reef fishes (Lavieren, 2009). However, using marine reserves for fisheries management is controversial because few empirical studies have been carried out on the effectiveness of marine reserves for fisheries sustainability (Sale et al., 2005).

Establishment of marine protected areas (MPAs) without prior socio-economic study will always incur questions about whether the reserve will benefit local communities and previous users of the protected area. No-take marine reserves or strict MPAs establishment often results in fishermen losing access to their fishing grounds, forcing movement to new or less favourable fishing areas (Carr, 2000). Thus, MPAs typically reduce the total area that fishermen can fish freely. In Kenya, McClanahan & Mangi (2000) found a 35% decrease in total fish catch with the creation of Mombasa Marine Park, as fishermen lost nearly 65% of their fishing area after the reserve was created. In addition, MPA creation can also indirectly shift and concentrate fishing activity to a few selected fishing sites outside the reserve, thereby increasing exploitation rates at these sites to unsustainable levels.

1.1 Enhancement of fish biomass

Well-managed marine reserves are expected to reduce fishing pressure and have better potential to maintain and enhance fishery catches and increase sustainability (Gell and Robert, 2003). In no-take reserves, fish are theorized to grow larger and more fecund, thereby sustaining the population within reserves and supplementing the surrounding area (Sale et al., 2005). The supplements are through the export of pelagic larvae and eggs out of the reserve (Russ and Alcala, 1996; Crowder et al., 2000; Gell and Roberts, 2003), and by net migration of juveniles, sub-adults or adults across the reserve borders (Roberts, 1997; Gell & Roberts, 2003, Goñi et al., 2008). Both processes positively impact the fish stock within and outside the reserves. Several studies have been conducted in the past decade on fishery benefits of marine protected areas, showing greater fish biomass inside the reserves (e.g., Polunin and Roberts, 1993). One documented example of spillover was at Apo Island, Philippines, a no-take reserve that has been protected for more than 18 years. Surveys done by Russ et al. (2004) and Alcala et al. (2004) indicated an enhancement of fish biomass at the surrounding reserve. The species richness and biomass of many fish families were also reported to be higher at reserves where protective regulations are effectively enforced (Jennings et al., 1996).

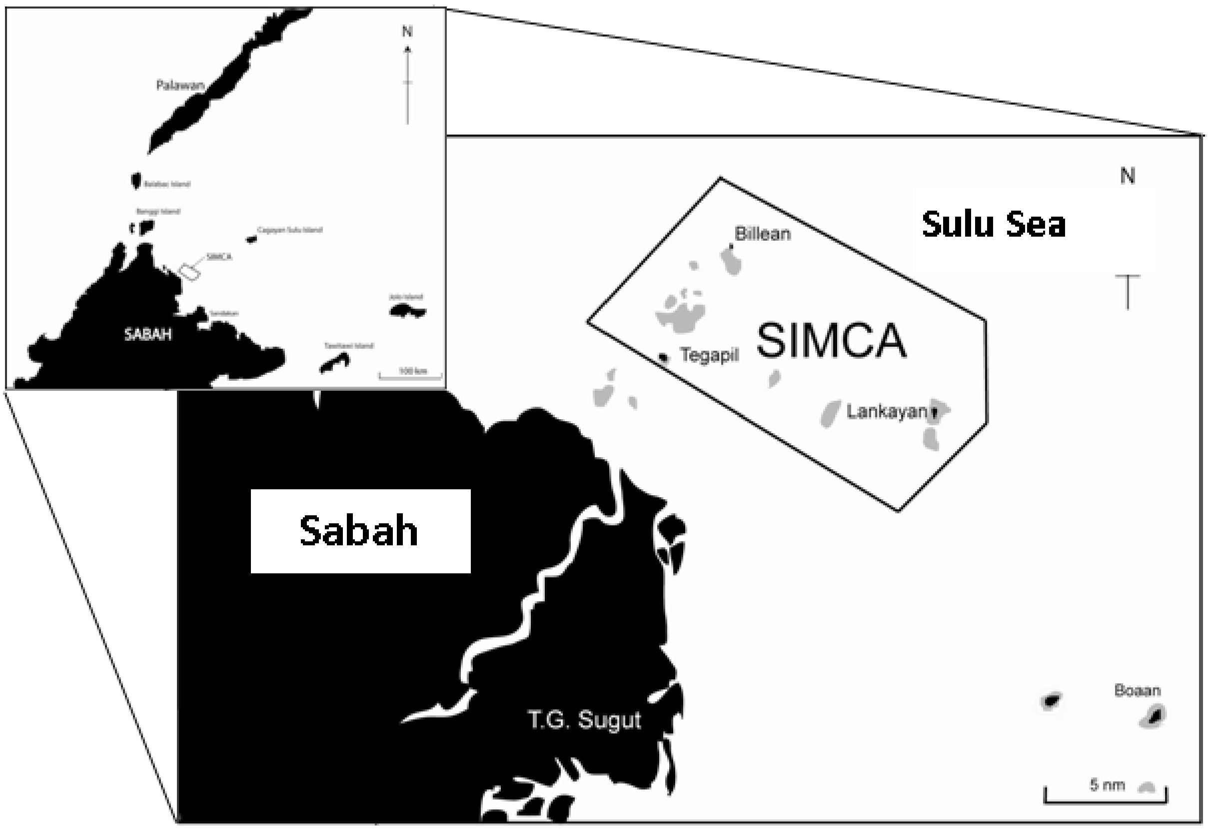
However, not all fish species will benefit from reserve protection, particularly the more mobile or migratory species (Halpern et al., 2010). Protection from reserves will most likely benefit the sedentary species (e.g. groupers) inside the reserves (Gell and Roberts, 2003; Halpern, 2003; McClanahan and Mangi, 2000), while the abundance of highly vagile fish are not likely to increase (McClanahan and Mangi, 2000). Enhancement of fish populations could extend from several meters to kilometers from the reserve. The scales of spill over vary across species and ecosystem (Gell & Robert, 2003).

1.2 SIMCA Establishment

The Sugud Islands Marine Conservation Area (SIMCA) was officially created in 2001 as a Category II conservation area under the IUCN Protected Area Management Category. This designation specifies that SIMCA is to be protected and managed to preserve its natural conditions and to provide recreational opportunities. The primary users of SIMCA are divers and snorkelers, while a no fishing regulation is strictly enforced. SIMCA comprises a total area of 46,317 hectares, and includes the islands of Lankayan, Billean and Tegaipil (Figure 1). Reef Guardian is a non-profit organisation that conducts conservation, enforcement, and other management activities within SIMCA.

SIMCA is located in the Sulu Sea, at the western end of the biodiversity rich Coral Triangle. The reefs around Lankayan Island have received some form of informal protection since 1996, when the Lankayan Island Dive Resort was established on the island. However, protection from fishing provided by the resort was restricted to a radius of approximately 4 km radius around Lankayan Island. Since 2005, enforcement has been fully enforced by the Reef Guardian team to control the intrusion of fishing vessels within SIMCA.

Figure 1: *The Sugud Islands Marine Conservation Area*



SIMCA was formed in 2001 and conservation work undertaken by Reef Guardian began in 2004. The enforcement team was formed in 2005 and sea patrol activities have since been conducted at least twice a week to control the intrusion of fishing vessels within SIMCA. Enforcement work has been assisted by a land-based radar tracking system that enables the Reef Guardian team to monitor fishing intruders day and night. Information from the radar tracking system is recorded on an hourly basis and it enables the team to detect possible illegal fishing activities at a specific area and time.

During day-light hours, fishing boats fish in areas adjacent to SIMCA. However, intrusions into SIMCA boundaries still occur, especially at night time. Night enforcement has been limited because there is a lack of night time assistance from armed forces, and risks for night sea patrols are high. Despite Reef Guardian's enforcement activities, fishing inside SIMCA still occurs occasionally, when fishermen attempt to trawl or fish inside the SIMCA border. This may indicate that fish catches appear to be comparatively higher in or near SIMCA.

1.3 Fishing activities in and around SIMCA

Prior to the establishment of SIMCA, the reefs surrounding the three islands were fishing grounds for small and large-scale commercial fishermen. Nearly 40 – 50% of fishing boats checked from 2006 to 2009 were fish or shrimp trawlers (SIMCA, 2009), with drift net fishing following as the second most commonly used fishing practice. Additionally, compressor fishing, spear-fishing, sodium cyanide fishing and dynamite fishing have been recorded around SIMCA. Illegal fishing normally takes place at night, when fishermen encroach on reefs inside SIMCA. In 2006, three dynamite fishing operations were apprehended north of Lankayan (SIMCA, 2006). Prior to the establishment of SIMCA, the area was reportedly used by small-scale fishermen from Boaan Island (Philippines). These fishermen came by small pump boats, and used hook and line to target pelagic fishes such as mackerel (Minda, pers. comm.)

Sea patrol activities conducted since 2005 recorded that 51% of commercial fishing boats were registered from Sandakan District, 29% from Kudat, and 12% from Berhala (SIMCA, 2005). Fishing boats from Kudat mostly fished using hook and line, and also used compressors in tandem with fish spears. These fishing operations also use sodium cyanide to target valuable reef fishes such as groupers, humphead wrasse and some snapper species. Additionally, sea gypsies (*Bajau Laut*) have been around SIMCA prior to its formation, and continue to encroach into SIMCA areas, especially near Billean and Tegaipil Islands to collect marine invertebrates such as giant clams and sea cucumbers. The majority of *Bajau Laut* use gill nets to target sharks, rays, and pelagic fishes. All their catches are normally salted and dried on boats.

1.4 Reef fish abundance in SIMCA

SIMCA lies on a shallow continental shelf, and the three islands are enclosed by fringing reef flats that are 50 m to 1 km wide. The islands are also surrounded by many small (~0.5 ha) to large (~400 ha) patch reefs (Chung, unpublished data). The total area of reefs is estimated to range from 3,300 ha – 4,400 ha. Hard coral cover is moderate, ranging from 30% – 60% (SIMCA, 2008).

About 445 species from 72 families of fishes have been recorded around SIMCA (Chung, unpublished data), and include 33 species of groupers, 18 species of snappers, and 10 species of sweetlips. Fish abundance surveys conducted since 2005 indicate that reefs around SIMCA have a high abundance of planktivores such as fusiliers. The population of groupers in SIMCA is comparatively higher compared to other non-reserve areas (Teh et al., 2008). However, there have been no comparative surveys done before and after the formation of SIMCA. Consequently, the fishery and ecological effects of SIMCA are not known.

2. 0 OBJECTIVES

The objectives of this project are to:

1. Determine the fishery and socio-economic effects of SIMCA on local fishing communities.
2. Evaluate the effects of reserve protection on reef fish biomass and abundance (density).

The first part of the project aims to evaluate the fisheries impact of SIMCA from the perspective of fishermen who regularly fish near SIMCA. The survey is divided into 2 sections; Section 1 targets fishing communities situated along the Sugud mainland, which are the villages closest to SIMCA. Section 2 targets fishermen found fishing around SIMCA, who do not live within the immediate vicinity of the marine reserve.

The second part of the project aims to test the hypothesis that SIMCA will lead to an increase in the biomass and density of fishes across a distance gradient from Lankayan Island. We utilize underwater visual surveys to evaluate whether there is possible spill-over of fish populations from inside to outside the reserve.

3.0 Study 1: Fisheries and socio-economic impact of SIMCA

3.1 Section 1: Village interview

3.1.1 Background

Prior to the establishment of SIMCA, the waters around Billean, Tegaipil, and Lankayan islands were actively fished fishing grounds. However, little is documented about the fishermen and type of fishing activity that took place in this area pre-SIMCA establishment. As a result, the objective of this study is to determine how the creation of SIMCA has affected the socio-economic condition and fishing activities of fishermen who used to fish in the SIMCA area. The specific research questions are as follows:

a. Have fishermen's spatial movement been affected by the creation of SIMCA?
b. How has catch per unit effort (CPUE) changed since the establishment of SIMCA?
c. Have sizes of fish caught and catch composition changed since the creation of SIMCA?
d. Have fishermen's revenues been affected by the creation of SIMCA?

3.1.2 Method

We hypothesized that communities along the Sugud coastline, which is the nearest settlement to SIMCA, were the main users of these fishing grounds prior to the establishment of the marine reserve. Thus, three villages along the Sugud coastline were chosen for the survey: Kampung Memahat, Kampung Terusan Sugud and Kampung Keniogan (Figure 2). Table 1 shows the general description of the villages.

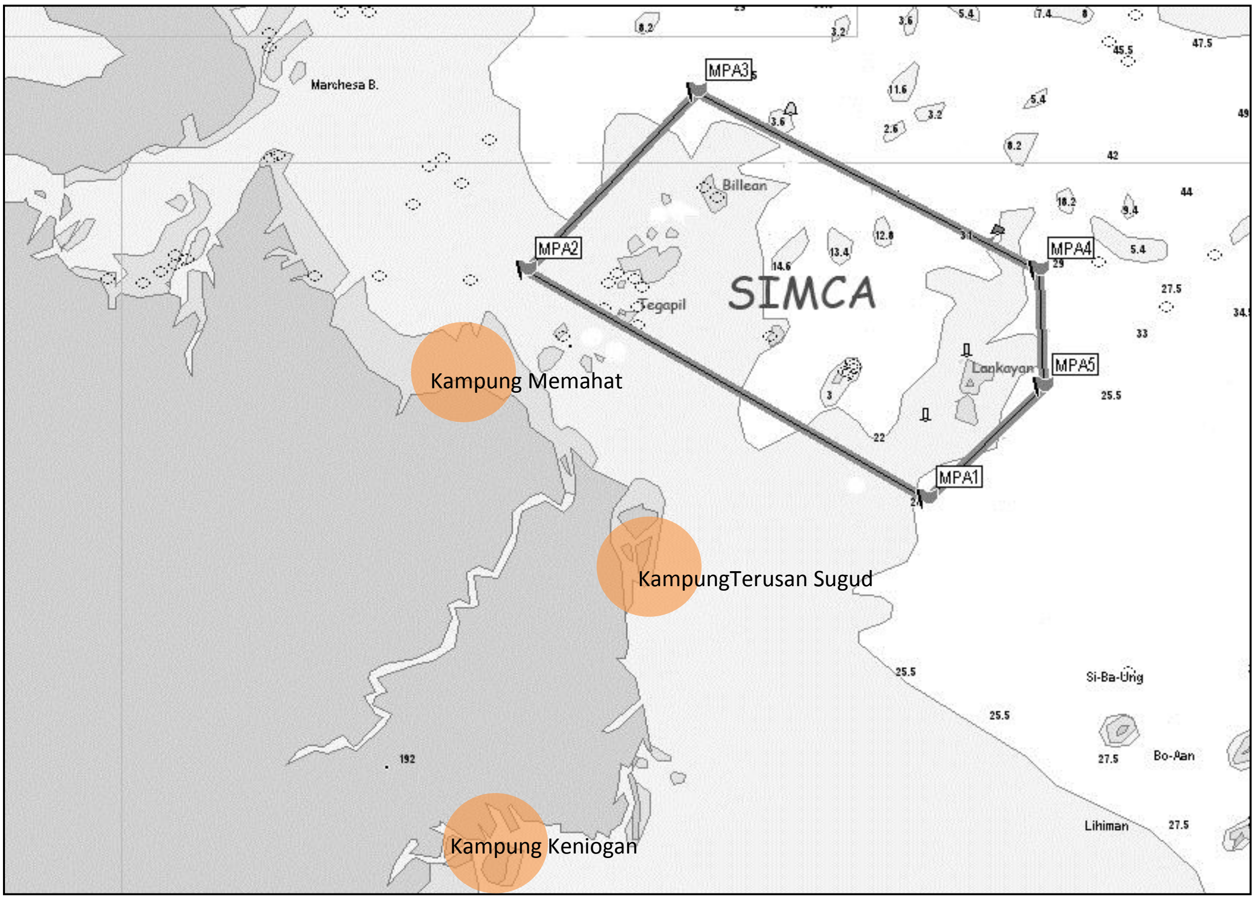
Interviews with fishermen were conducted to evaluate the temporal effects, if any, of SIMCA on their fishing activity and socio-economic conditions. The interviews were conducted one-on-one following a semi-structured format based on prepared questionnaires. We targeted small-scale fishermen who fished individually or in small groups using traditional fishing gears.

Table 1: General descriptions of selected fishing villages.

Village Name	General description
Kampung Memahat	▪ Village chief: Indanan bin Naing. ▪ Population: Nine families (five permanent families, four *Bajau Laut* families). ▪ Small-scale fishermen. ▪ Approximately 40 km north west of Lankayan Island.
Kampung Terusan Sugud	▪ Village chief: Sharip Muhamad bin Sharip Hassim. ▪ Population: approximately 103 families. ▪ Small-scale fishermen. ▪ Approximately 35 km south west of Lankayan Island.
Kampung Keniogan	▪ Village chief: Haji Madlis bin Haji Aziz.

	▪ Population: approximately 200 families. ▪ Majority small-scale fishermen. ▪ Approximately 60 km south west of Lankayan Island.

Figure 2: *Location of fishing villages. Map Source: CMap*



Sampling was done opportunistically. After obtaining permission from the village chief to conduct interviews, we walked from house to house and interviewed any fisherman who was at home and was willing to be interviewed. A sample size of at least 10% of all fishermen in each village was targeted.

The questionnaire covered fishermen's demography, fishing methodologies/gears, fishing grounds, fishing effort, income, and fishermen's perceptions about marine protected areas. Each interview took 45 – 60 minutes, and was conducted in Malay or in the local dialects of the fishermen. A sample of the village questionnaire is provided in Appendix 1.

3.1.3 Data analysis

To assess whether there had been a temporal change in fishing activities, fish catches, income, and fishing gears, the village questionnaire was sectioned into three periods: prior to 2003 (before the formation of SIMCA), 2003 – 2009, and present time (2010). Information gathered from interviews was pooled and analyzed using one-way analysis of variance to test for significant differences between the three periods. We determined that SIMCA had affected fish catch, income, and spatial movement if the following conditions were met: 1) fishermen identified the area around SIMCA as their pre-2003 fishing grounds; and 2) there was a significant difference in responses between the three periods.

3.1.4 Results

3.1.4.1 Demographics of fishing villages

Two fishing villages along the Sugud coastline were visited from September to November 2010. Kampung Terusan Sugud, which was selected as a target village for interviews, was withdrawn because all the previous fishing families had changed their profession to oil palm planters. Kampung Memahat and Kampung Keniogan are situated approximately 33 km and 42 km respectively from Lankayan Island. A total of 11 fishermen from Kampung Mamahat and 27 fishermen from Kampung Keniongan were selected for the interviews. The interviewed fishermen ranged from 18 to 74 years old, with an average age of 40. About 92% of fishermen interviewed were married. Sixty six percent of fishermen had basic education up to primary school level, while 13% had secondary school level education.

On average, fishermen from these two villages had over 20 years of fishing experience. The oldest fisherman that was interviewed had 60 years of experience, while only one fisherman interviewed had started fishing less than one year (7 months) ago. About 68% of fishermen interviewed stated that they prefer fishing alone rather than in a group.

The majority (97%) of fishermen owned their fishing boats; the remaining 3% (one respondent) was leasing a fishing boat from his relative and hence, did not have to pay rent. All the boats were made out of wood (*papan*), and varied in length range 12 to 22 feet. Engines of various horse power (HP) were also used, ranging from 7 to 40 HP. Four fishermen interviewed did not own any engines, but instead rowed to their fishing grounds. About 55% of the fishermen used a different boat prior to 2003, while the remaining 45% had been using the same boats since they started fishing. Table 2 shows a summary of the fishermen's demographics, fishing boats and engines used.

Fishermen in Kampung Memahat and Keniogan used traditional fishing gears, with the major gears being hook and line and various types of nets (drift nets, bottom gill nets, crab nets, trammel nets, lift nets). Nets were used by 33 (87%) of the respondents, while 20 (53%) used hook and line. The majority of fishermen (55%) fished with one type of gear only, whereas the remaining used at least two types of gears (hook and line with some type of net).The main type of nets used were drift nets and bottom gill nets; crab nets, lift nets, and trammel nets (for prawns) were not common, and were used by only one or two respondents. There was a difference in gear usage between Kampung Memahat and Keniogan. The majority of fishermen (82%) in Kampung Memahat fished with hook and line, but in Kampung Keniogan only 41% used hook and line. However, nets were used by the majority of fishermen in both villages, with 73% and 81% of respondents in Kampung Memahat and Keniogan fishing with some type of net, respectively. All but 3 of the respondents used the same gear prior to 2003 as in 2010.

Table 2: Descriptive statistics for the fishermen's age, fishing experience, boat length, and length of time used.

	Age	Fishing experience (years)	Boat length (feet)	Length of time used (years)
Mean (± std. error)	40.0±2.1	23.3±2.2	15.7±0.4	8.1±2.0
Minimum	18.0	0.6	12.0	0.1
Maximum	74.0	60.0	22.0	60.0
Count (N)	38	38	38	38

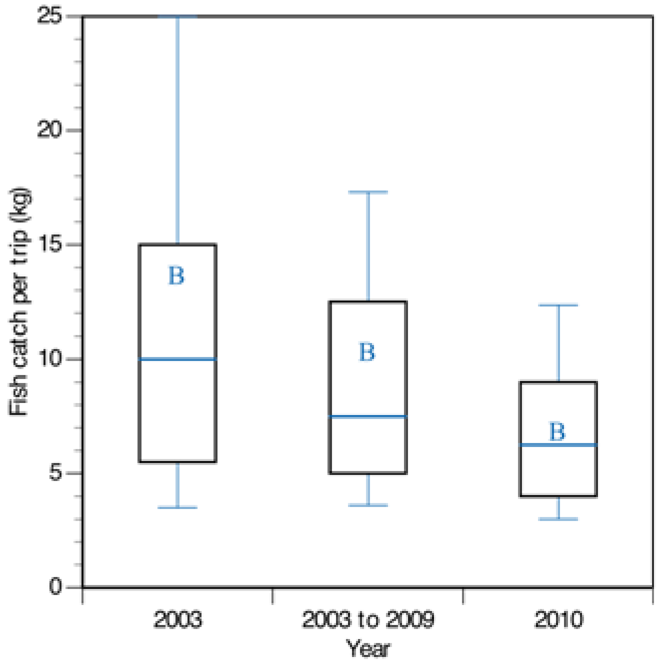
3.1.4.2 Catch per unit effort (CPUE)

Overall the average fish catch per trip showed a temporal decrease (Table 3 and Figure 3). Analysis of variance showed that there was a statistical difference in catch quantities between time periods (ANOVA: $F=3.48$, $p<0.05$), with catch per trip in 2010 being significantly lower than prior to 2003 ($p<0.05$), but not for 2003 – 2009. About 59% of fishermen did not report any changes in their current fish catch compared to pre-2003, while 41% noted a temporal decrease in catch per trip.

Table 3: Descriptive statistics for fish catch per trip (kg) in 3 periods: 2010, 2003-2009, and before 2003.

	Catch per trip (kg)		
	Current (2010)	**2003-2009**	**Before 2003**
Mean (± std. error)	6.9±0.6	10.4±1.5	13.7±2.8
Minimum	2.0	2.5	1.5
Maximum	17.5	54.0	100.0
Count (N)	38	37	35

Figure 3: *Catch per trip (kg) proportionally decreased from 2003, 2003 – 2009 and 2010.*
Symbols (B) = mean, outliers = range, boxes = standard deviation.



Fishermen at Kampung Memahat attributed the decrease in catch per trip to a reduction in fish abundance in their fishing grounds due to chemical discharge from oil palm factories and competition from outside trawlers. Trawlers from Kudat, Sandakan and Semporna were reported to be trawling in the fishing grounds nearby Kampung Keniogan in recent years. It would seem that the presence of trawlers has resulted in a competition of resources with the local fishermen.

Overall, there did not seem to have been a temporal change in fishermen's fishing effort. The majority (94%) had not changed the number of hours they fished a day, with the average remaining constant at around five hours a day for all three periods. Similarly, the average number of days spent fishing per month was fairly constant at about 21 days per month (Table 4).

Table 4: Descriptive statistics for fishing effort: number of hours fishing a day and number of days of fishing a month in three time periods.

	Current (2010)		**2003-2009**		**Before 2003**	
	Hrs/day	**Days/ month**	**Hrs/day**	**Days/ month**	**Hrs/day**	**Days/ month**
Mean (± std. error)	5.2±0.4	21.6±1.1	5.4±0.4	21.5±1.1	5.3±0.5	21.2±1.1
Minimum	1.0	7.0	1.0	7.0	1.0	7.0
Maximum	14.0	30.0	14.0	30.0	14.0	30.0
Count (N)	38	38	36	37	35	35

3.1.4.3 Type and size of fish caught

Fishermen from both villages commonly targeted rabbitfishes (Siganidae), mullets (Mugilidae), mackerels (Scombridae), snappers (lutjanidae), sweetlips (Haemulidae), sharks (Carcharhinidae), sting-rays (Dasyatidae) and trevallies (Carangidae). About 68% of fishermen (n=26) did not notice a change in the type of fish caught. The remaining respondents noticed reduced fish catches of Serranidae (*kerapu*), Carangidae (*ikan putih*), Polynemidae (*ikan senangin*) and Mugilidae (*ikan belanak*) since 2003. About 68% of fishermen noticed a decrease in fish size compared to before 2003. The most frequently cited reason for the decrease in fish size was that "all the big fish have been caught" (35%), followed by "there are too many people catching fish" (33%), and finally 24% responded "the fish are caught before they can grow".

3.1.4.4 Fishing grounds

About 89% of fishermen fished at the same location prior to 2003. Fishermen interviewed at Kampung Memahat often fish near the estuary while fishermen from Kampung Keniongan fish near Puru-puru Island. Only one fisherman used to fish near Tegaipil Island. Most of the fishermen fish near the village, where the maximum travel distance is 10 km, while the minimum travel distance is just 300 m from their house. About 14% of the respondents noticed a temporal difference in travel time, with 60% experiencing longer travel times in 2010. Table 5 shows the common fishing grounds for the fishermen from both fishing villages.

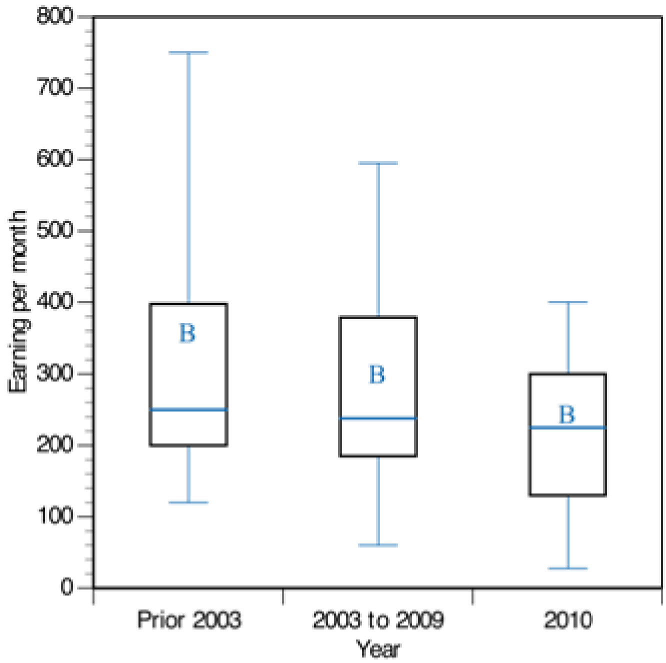
Table 5: Common fishing grounds for fishermen from both villages.

Fishing Village	Common Fishing ground
Kampung Memahat	Obah Kuala Memahat Sungai Meruap
Kampung Keniongan	Puru-puru Kuala Sabang

3.1.4.5 Income

The average monthly income from the sale of fish showed a temporal decline (Figure 4), but the difference between the time periods was not statistically significant. About 65% of fishermen did not notice a temporal change in income, and only one fisherman noted an increase in current monthly income compared to before 2003. The remaining 32% of the fishermen noticed a decrease in monthly income, with an average decrease of 150%.

Figure 4: *Earning per months of fishermen at Kampung Memahat and Kampung Keniongan from 2003, 2003-2009 and 2010. Symbols (B) = mean, outliers = range, boxes = standard deviation.*



The pattern for net monthly income was slightly different, with 50% the fishermen noticing a decrease compared to before 2003, while 18% noticed an increase, and 32% did not experience any change in net monthly income. The average decrease and increase perceived by fishermen was 53% and 57%, respectively. Almost all the fishermen reported that while fish prices have increased in recent years, fish catch has decreased and the costs of fuel, fishing gear and boat upkeep have increased, resulting in a decrease or no difference in their net income.

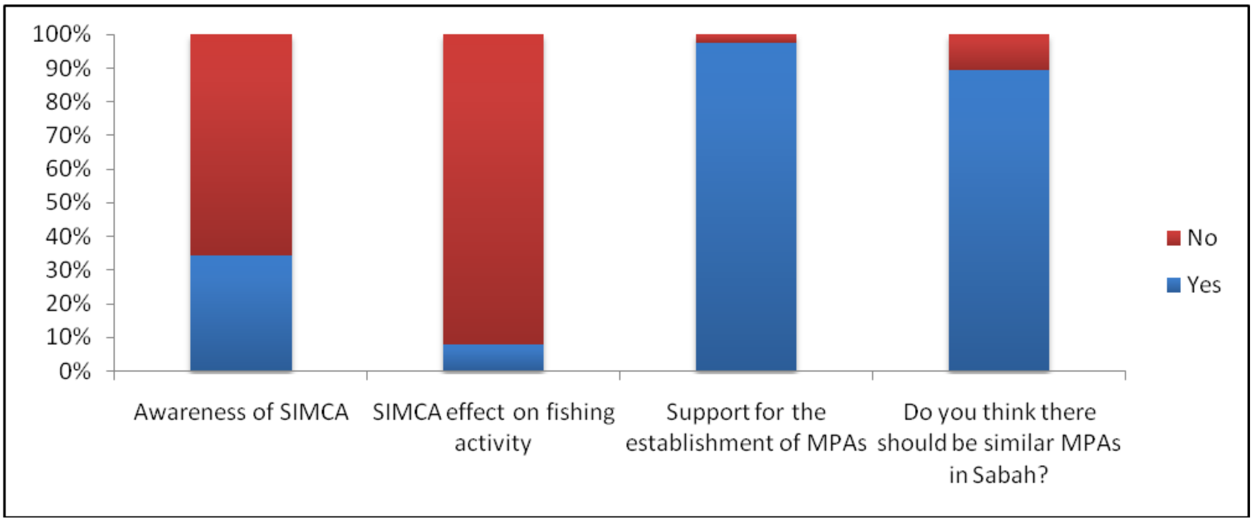
3.1.4.6 Perceptions about MPAs

Nearly 66% of fishermen were not aware of the existence of SIMCA. From the 34% who were aware, they reported that they heard about it from passing fishermen or through awareness field trips conducted by Reef Guardian in 2008-2009. Only 8% stated that the creation of SIMCA had affected their fishing activity positively. They claimed that fish are more abundant in areas nearer to SIMCA. The other fishermen did not experience any effects because their fishing grounds are not near or within SIMCA.

About 97% of fishermen supported the establishment of MPAs (Figure 5). They felt that their livelihoods would be protected with an increase in MPAs, since protected areas would safeguard fish stock and prevent over fishing by visiting trawlers and other destructive fishing methods adopted by fishermen from outside their villages. Only one fisherman did not support the establishment of MPAs because he was unsure about the effects that it might have on him.

When we asked if more MPAs similar to SIMCA should be created in Sabah, 89% agreed that the establishment of MPAs will help conserve the marine environment for future generations. The remaining 11% felt that MPAs may affect their fishing activities negatively as more places will be closed and they may have to travel further and compete with more fishermen to be able to support their families.

Figure 5: *Fishermen's perception of SIMCA and the establishment of MPAs.*



3.1.5 Discussion

We aimed to investigate whether the creation of SIMCA had affected the fishing activities and socio-economic condition of fishermen who used to fish in the SIMCA area. As we had no prior knowledge of who used to fish in the SIMCA area pre-2003, we interviewed the communities most likely to fish there, i.e., those villages located closest to SIMCA. Surprisingly, only one fisherman from Kampung Memahat fished near Tegaipil Island prior to 2003. The creation of SIMCA may be stopping him from continuing to fish at Tegaipil Island. Nonetheless, this fisherman experienced no temporal change in fish catch or income, suggesting that the creation of SIMCA may not have directly affected the fishing activities and socio-economic condition of the closet fishing villages (Kampung Memahat and Kampung Keniogan).

One reason that we did not detect a SIMCA effect is that we may have targeted the wrong group of fishermen. Fishermen who used to fish in SIMCA pre-2003 may have come from outside the Sugud area. Indeed, anecdotal evidence suggests that small-scale fishermen who used to fish in the SIMCA area were from Boaan, a Philippine island, or were Bajau Laut who travel throughout the Sabah coastline. However, we were unable to locate these groups as it was not logistically feasible for the interview team to travel to Boaan, and Bajau Laut are difficult to track as they tend to constantly move among islands. Alternatively, the relatively isolated location of SIMCA may be a reason for its limited impact on Sugud fishermen. The interview results show that fishermen at both villages fished close to their villages, and the furthest distance they travelled was 10 km from their villages. Thus, although Kampung Memahat and Keniogan were the closest villages to SIMCA, the physical distance to SIMCA still seemed too long a journey for the fishermen to make. This is probably due to the fact that all fishermen at both villages were small-scale fishermen who fished alone, using boats with a maximum length of 22 feet and an average engine of 15 horse power (HP) that did not allow them to travel far from their village.

From an economics perspective, fishermen in Kampung Memahat and Keniogan may not have been able to justify the high costs of travelling to SIMCA. On average, interviewed fishermen earned RM 300 per month, which is below the Sabah poverty income line. The poor state of development at these villages (e.g., lack of electricity and road access) suggests that they are not well integrated with the market economy. Thus, fishermen have no incentive to travel as far as SIMCA in search of valuable fish such as groupers for the live reef food fish trade. At the same time, our findings suggest that fishermen who are not limited by technology, and who actively participate in fisheries trade and markets, i.e., larger, commercial boats, may have fished in SIMCA pre-2003. We investigate this possibility in the next section (Section 2).

3.2 Section 2: At Sea Interviews

3.2.1 Background

Following on our findings from Section 1, we decided to target another group of fishermen to investigate the fisheries and socio-economic effect, if any, of the establishment of SIMCA. It was reasonable to assume that the fishermen who would be most affected by SIMCA would be those who fish close to the protected area in the present time. Therefore, we targeted fishing vessels that we encountered fishing in the vicinity of SIMCA (less than 2 kilometres from SIMCA border), as well as fishermen fishing around Jambongan and Puru-Puru islands.

The objective of the at sea survey was to determine what factors attract fishermen who live far from SIMCA to come fish near or within SIMCA. Our research questions were as follows:

a. Who are the fishermen that fish around and inside SIMCA?
b. Why do these fishermen come to fish in or near to SIMCA?

3.2.2 Method

At sea interviews were also done opportunistically. We interviewed fishermen who were either fishing or anchored near SIMCA, and who were willing to stop their boats and speak with us. For larger fishing boats like fish trawlers, only one fisherman, either the captain or one of the crew, was interviewed. A target sample size of 30 interviews was set for this survey. The questionnaire for at sea surveys covered: i) why these fishermen travelled to fish at SIMCA; ii) how their fish catch at SIMCA compared to their normal fishing grounds; and iii) the prices of targeted fish and other marine resources. All interviews were conducted on the fishing boat and took between 15-45 minutes to complete. A sample of the at sea questionnaire is provided in Appendix 2.

3.2.3 Results

From May 2011 to March 2012, a total of 35 at sea interviews were conducted around SIMCA. Out of the 35 interviews, 25 (74%) were conducted outside of SIMCA, while the other 10 interviews were conducted with fishermen who were inside SIMCA, 7 of whom were detained for illegally fishing within SIMCA. Seventeen interviews were conducted with fishermen on boats that were fishing within 2 km of the SIMCA border. Six interviews were conducted on Jambongan Island, which is approximately 18km from the closest SIMCA boundary, while 2 fishermen were interviewed on Puru-puru Island, which is about 30 km from the closest SIMCA boundary. Figure 6 shows the number of fishermen interviewed, and the places where they were encountered.

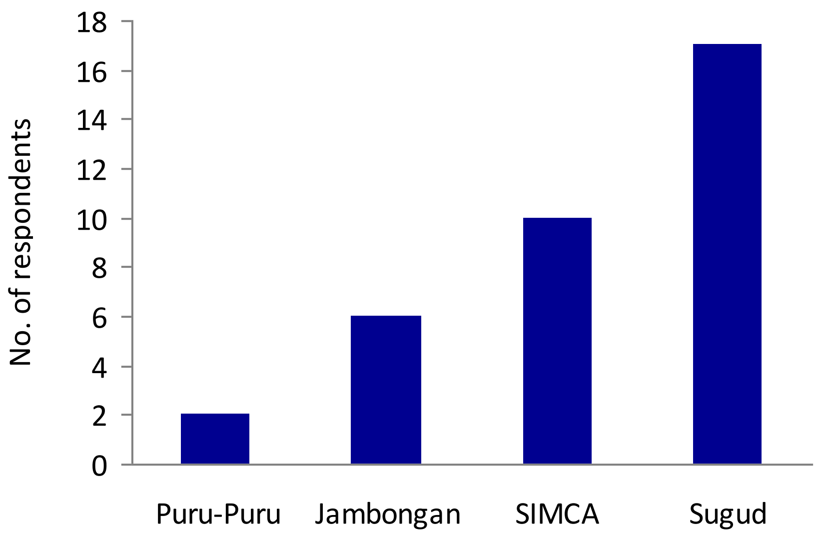


Figure 6: *Distribution of respondents according to the place where they were encountered.*

Eight (23%, n=35) of the interviews involved small-scale fishermen who used bottom gill nets, compressors, traps, and/or hook and line. Of the 25 commercial fishing boats, 20 were trawlers, of which 8 were shrimp trawlers, and 5 were compressor fishing operations.

3.2.3.1 Demographics of respondents

The age of the respondents ranged from 15 to 68 years old. Sixty-three percent of the interviewed fishermen had received some form of education, and almost 91% were married (n=35). Approximately 63% of the respondents were non-Malaysians, with almost all of these fishermen originating from Indonesia. Seventy-one percent (n=35) of all respondents currently lived in Sandakan, 11% in Kudat, 6% were *Bajau Laut* who stayed part-time on Pulau Bankuruan, and the remainder were from Jambongan or Kota Kinabalu. Overall, the majority of fishermen were experienced at fishing, with 46% having 10 to 20 years of experience, and 46 years being the maximum length of experience. In contrast, 26% of the fishermen had less than 10 years fishing experience, with one year being the minimum length of experience. Almost all the fishermen used wooden boats, of which the majority had been used for less than 5 years.

3.2.3.2 Gear and catch

Fishermen can be categorized as commercial or small-scale, depending on the gear used and size of their operation (Table 6). Commercial fishermen used boats that measured at least 50 feet in length, with the longest boat having a length of 68 feet. Commercial fishing boats were equipped with navigation devices and engines that ranged from 120 to 320 horsepower. Usually, the boat was commanded by a captain and between 4 to 8 crew members. Most of the boats (69%) had only been used for 4 years or less (the longest period was 12 years). Only one commercial fisherman (a compressor fisherman) owned the boat he was using. Most of the commercial trawl vessels were owned by businessmen based in Sandakan, and the crews were either paid a salary or salary plus commission. Thus, only one trawl fisherman stated that he had to pay for the boat rent, which was 50% of his income per trip.

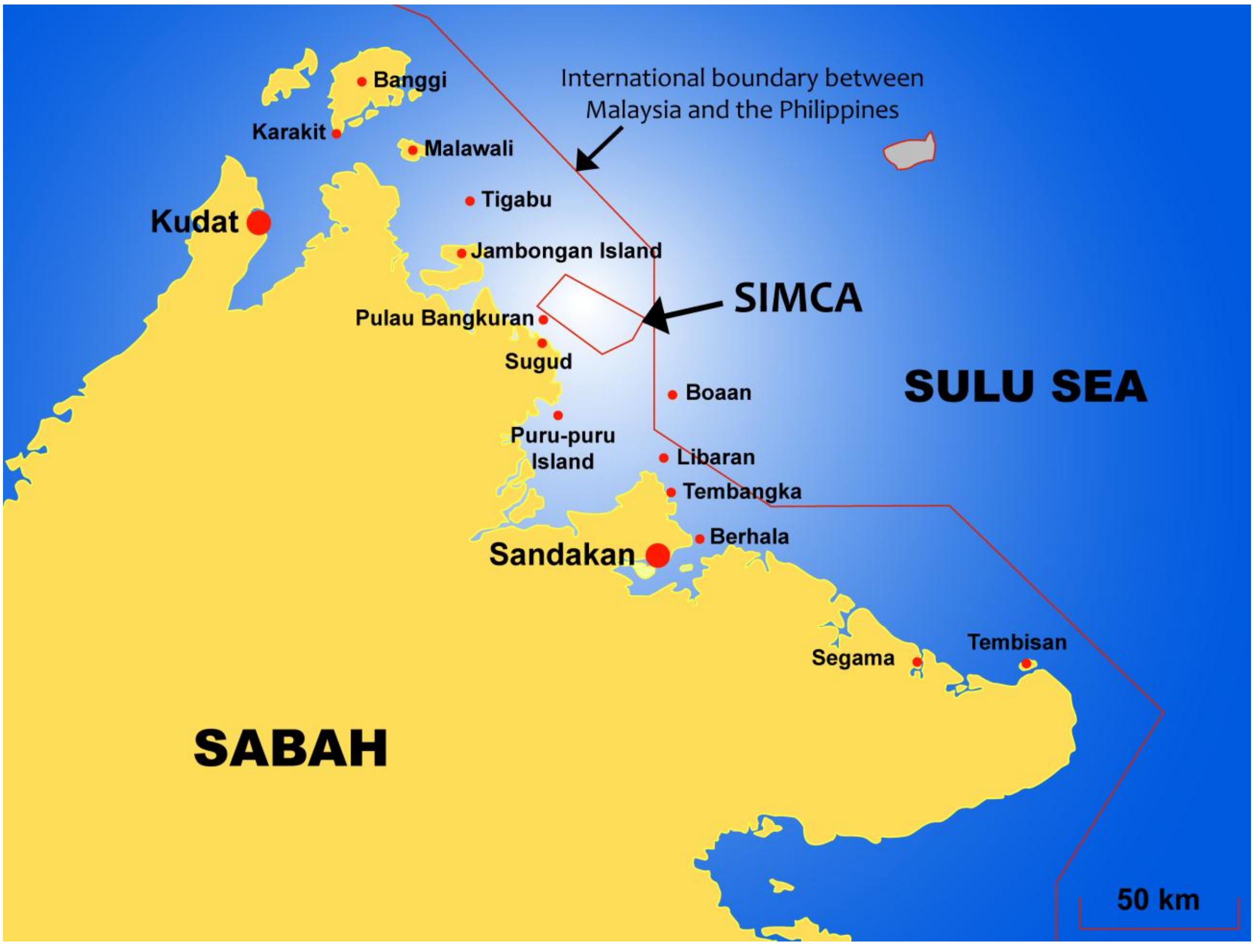
The majority of commercial fishing boats (77%, n=26) were trawlers, of which all but one were from Sandakan. Of the twenty trawlers, 63% were found fishing within 2 km of the SIMCA border. The travelling time from Sandakan to Sugud is between 5 to 7 hours; only one Sandakan trawler travelled 7 hours to fish further away at Jambongan. Forty percent of the trawlers (n=20) specifically targeted shrimp, while the remainder trawled for a mixture of shrimp and fish, or fish only.

Compressor fishing also occurred on a commercial scale, and typically targeted higher value fish such as groupers and invertebrates. Compressors were used in conjunction with gears such as spear guns, sodium cyanide, traps, and fish bombs. In total, 7 compressor boats were interviewed, of which 3 came from Berhala Island, 2 came from Kudat, and 1 each from Banggi Island and Landohayang. One compressor fishing boat was interviewed near Jambongan Island, and 4 were within SIMCA. One compressor boat from Kudat took about 12-14 days to reach SIMCA, with several stops in between at Karakit, Malawali, Jambongan, and Tigabu (Figure 7). Compressor fishermen from Berhala travelled 7 to 8 hours to reach SIMCA, and targeted live fish. The compressor boat that was encountered at Jambongan originated from Kudat, a trip that required about 10 hours travelling time. This particular fisherman was targeting abalone instead of live fish.

Table 6: Summary of respondents' fishing gear, targeted fish, hours spent fishing per trip, number of days per fishing trip, number of fishing trips per month, and catch per trip.

Scale	Gear	*n*	Targeted fish	No. of hours fishing per day	No. of days per trip	No. of trips per month	Catch (kg / trip)
Small-scale	Bubu	1	Crab	2	8	2	10
	Sodium cyanide	1	Live reef fish	10 – 11	1	30	4
	Hook & line	3	Demersal reef fish, trevally, tuna, ray, mackerel	0.5-10	5 – 6	3 – 5	2-5
	Drift net	1	Tuna, mackerel	4	8	2	100
	Gill net	2	Demersal reef fish, shrimp	6	10	2	300
Commercial	Trawl net	8	Shrimp only	4 – 12	3 – 8	3 – 5	30 – 2000
		12	Fish and shrimp	2.5 – 10	1 - 7	3 – 13	100 – 3000
	Compressor	6	Live reef fish	1 – 24	2 - 6	2 – 3	10 – 50
		1	Abalone	6	7	1	10

Figure 7: *Major fishing grounds of the respondents.*



Small-scale fishermen were differentiated from commercial fishermen based on their boat size and gear. We interviewed a total of 8 small-scale fishermen: 2 at Puru-Puru, 3 at Jambongan, 2 near Tegaipil, and 1 at Pulau Bankuruan. All these interviews except the one at Pulau Bankuruan took place at sea. We conducted the interview at Pulau Bankuruan because fishermen from the island had previously been found fishing in SIMCA by the Reef Guardian enforcement team; however, as the majority of fishermen did not understand Malay, and none of the interview team members were fluent in their dialect, we were limited to only one interview on the island. Small-scale fishermen utilized different kinds of fishing gears, including hook and line, gill net (*pukat tenggelam*), fish traps (*bubu*), sodium cyanide, and drift net. Small-scale fishermen caught multiple species, including crabs and a variety of coral reef and pelagic fishes, such as groupers, snappers, trevallies, and mackerel. Their boats were smaller than commercial fishermen's, ranging in length from 12 feet to 35 feet. In contrast to commercial fishermen, the majority of the small-scale fishermen (63%) owned their fishing boats.

3.2.3.3 Spatial Use (Fishing grounds)

There appears to be a distinction in the spatial behaviour of the fishermen we interviewed at sea. Small-scale fishermen fished around the islands of Jambongan, Puru-Puru and Pulau Bankuruan. In contrast, commercial shrimp trawlers typically fished near the Sugud coast, while fishing close to the western border of SIMCA was carried out primarily by commercial scale compressor boats and fish and shrimp trawlers.

Almost all at sea interviews with trawlers were conducted while they were fishing close (<2km) to the border of SIMCA. However, none of them reported having fished within SIMCA. The majority of trawlers (18 out of 20) were based in Sandakan port, and spent an average of 7 hours travelling to their fishing grounds. Seventy-five percent (n=20) of trawlers fished in the Sugud area, located about 70km from Sandakan, where the habitat is suitable for trawling prawns and fish. The second most frequented fishing area was Jambongan, located about 115km from Sandakan, which was used by 30% (n=20) of trawlers. Generally, trawlers used the same areas for fishing and maintained similar fishing grounds through time.

Compressor fishermen fished primarily in Jambongan and within SIMCA. On average, they spent 7.1 hours travelling to their fishing grounds. Four out of 10 fishermen who were found fishing in SIMCA were compressor fishermen. Seventy-five percent of compressor fishermen (n=4) responded that their previous fishing grounds included Pulau Banggi, and 2 out of the 4 respondents were in fact residents of Pulau Banggi. Compressor fishermen who were fishing within SIMCA were from Kudat and Berhala; Kudat is almost 100 km from SIMCA, while Berhala is about 65km from SIMCA.

Small-scale fishermen tended to fish near the waters surrounding Jambongan and Pulau Puru-Puru, the latter which is located about 27 km south of SIMCA. In addition, a small community of transient *Bajau Laut* at Pulau Bankuruan fished around Pulau Bankuruan, which is approximately 3 km from the northwestern edge of SIMCA border. Interestingly, the small-scale fishermen from Pulau Bankuruan used to fish in the area within SIMCA before the protected area was established, including all three islands of Lankayan, Billean, and Tegaipil. Small-scale fishermen spent an average of almost 5.5 hrs (ranging from 1.5 hrs to 9 hrs) travelling between 5 to 60 km to their fishing grounds.

3.2.3.4 Catch per unit effort

Trawlers

Trawlers spent an average of 7.5 hours (n=17) trawling per day, and went on an average of 3.8 fishing trips per month. The average catch for all trawlers fishing in the SIMCA/Sugud area was 965 kg per trip, whereas their average catch at other areas was 1306 kg per trip. Forty percent (n=20) of trawlers were shrimp trawlers. Their average catch in the SIMCA/Sugud area was 407 kg per trip, which was double their catch of approximately 200 kg per trip from shrimp trawling elsewhere.

Compressors

Compressor fishermen (n=7) spent an average of 9 hours fishing. The compressor fishermen from Kudat who targeted live fish reported that they only fished one hour per day. In contrast, one compressor fishing operation from Berhala fished continuously for almost 24 hours per day by rotating among the fishing crew. Most boats made 2-3 multiday trips per month, and the average catch per trip for compressors was approximately 130 kg.

Small-scale fishermen

Twenty-three percent of the respondents (n=35) were classified as small-scale fishermen. Small-scale fishermen fished an average of 6.5 hours per day. The number of days spent fishing per month varied between 2 and 30; the minimum and maximum frequencies were reported by one drift-net and one trap fisherman, respectively. The trap fisherman specifically targeted crabs, and caught on average 10 kg per day. Valuable live fish species such as groupers (*Plectropomus* spp.), barramundi cod (*Cromileptes altivelis*), and humphead wrasse (*Cheilinus undulatus*) were the main targets of a small-scale compressor fisherman who used cyanide to catch the fish. Hook and line fishermen (n=3) targeted both reef and reef-associated species, such as sweetlips, stingray, groupers, trevallies, and Spanish mackerel. Two of the hook and line fishermen sold their catch, while one fished for food only. The fisherman using gill net targeted shrimp, and caught an average of 12- 30 kg of shrimp. Lastly, the drift-net fisherman targeted tuna and Spanish mackerel. He went on 8 day fishing trips, during which he caught an average of 100 kg per trip.

3.2.3.5 Income

Complete information on income and fishing costs could not be collected from all of the trawlers because this information was managed by the boat owner. On average, the gross revenue obtained by trawlers from the sale of their fish catch was RM 4440 per trip (n=14), while the net revenue was RM 2360 per trip (n=7). Compressor fishermen earned gross and net incomes of RM 7167 and RM 1833 per trip, respectively. The highest net income of RM 3500 per trip from all respondents was obtained by a compressor fishing operation. Only 15% of trawler crew and compressor fishermen received a fixed monthly salary, while the remainder were paid based on a commission system.

Small-scale fishermen fished for income as well as for their own consumption, although there was one small-scale respondent who fished only for subsistence. The others kept part of their catch for food, or to use as bait or fish food. Due the limited sample size of small-scale fishermen, the income information for each gear is summarized below (Table 7).

Table 7: Gross and net income for small-scale fishermen.

Gear	Gross income / trip (RM)	Net income / trip (RM)
Trap	-	500
Compressor	-	150
Gill net	2000	-
Gill net[1]	450	150
Drift net	1500	200
Hook and line	-	300
Hook and line	98	-
Hook and line[2]	45	-

[1] All catch was dried and sold as dried fish.

[2] Income is from the weekly sale of spider conch (*kahana*) per week as this fisherman caught fin fish for food only.

3.2.3.6 Reasons for fishing in SIMCA

A reason that fishermen were attracted to fish within or near SIMCA may be because they could obtain higher catches and/or income near the protected area, compared to their usual fishing ground. However, 52% of the respondents (n=27) indicated that there was no difference in income between SIMCA and their usual fishing ground. Twenty-six percent of respondents indicated that they could earn more fishing in the vicinity of SIMCA. Of these, 3 were trawlers, 2 were compressor fishermen, and 2 were gill net fishermen. In contrast, 22% of respondents (5 trawlers and 1 compressor) said that they earned less income fishing within, or near to SIMCA. In terms of catch, only 8 respondents indicated that fish in SIMCA were bigger. Half of these respondents were trawl fishermen, while the others consisted of fishermen using compressor, bottom gill net, and hook and line.

Although there appeared to be a lack of economic or fishery related incentives for fishermen to fish within, or close to, SIMCA, fishing boats still continued to encroach into SIMCA. This was despite the fact that some intruders knew about the existence of SIMCA and its rules and regulations. To find out why these fishermen were attracted to fish in SIMCA, we considered the responses from those fishermen who were found fishing within SIMCA only. This consisted of 10 boats altogether, of which 7, mostly trawl and compressor boats, were detained for fishing illegally within SIMCA. Respondents that were fishing within SIMCA included 4 trawlers, 4 compressor fishermen, and 1 gill net and 1 hook and line fisherman. Sixty percent of the respondents indicated that they fished in SIMCA because there was more fish there. For instance, a compressor fisherman indicated that he could get twice as much catch in SIMCA as compared to his other fishing grounds in Karakit, Manawali, Jambongan, and Tigabu. In addition, 2 respondents (20%) said that the fish in SIMCA were bigger, while another said that he was able to catch more expensive fish in SIMCA. Lastly, three respondents gave safety as a reason for coming into SIMCA. For example, one respondent indicated that they chose to fish in SIMCA when sea conditions were too rough elsewhere.

3.2.3.7 Perception of MPAs

Twenty-four respondents (69%, n=35) were aware of the existence of SIMCA; 51% of these respondents were trawlers. Twelve respondents (34%) reported that the creation of SIMCA had affected their fishing activities. The majority of these respondents (75%) were trawlers, while the others consisted of 3 compressor and one drift net fishermen. At the same time, 62% (n=26) of respondents indicated that MPAs benefitted fishermen. The most common benefit mentioned was that marine protected areas served as nursery grounds for fish, while other reasons included that MPAs ensured safety and income, were important for future generations, and allowed fish to grow larger in size.

Twenty-seven respondents (77%) expressed their support for the establishment of MPAs. The reasons for support were similar to the benefits of MPAs. One fisherman answered that MPAs could become centers of dispersal for marine resources to adjacent areas. The remaining 8 respondents did not support the establishment of MPAs because it would decrease available fishing grounds. Moreover, they were afraid of being caught if they entered a MPA.

Sixty percent of the respondents agreed that more MPAs like SIMCA were needed in other parts of Sabah because they can serve as nursery grounds and benefit future generations. On the other hand, those who disagreed did so because of concerns about having no income or being caught if similar MPAs were established in other parts of Sabah.

3.2.4 Discussion

We aimed to find out what motivates fishermen to fish in or near to SIMCA. Despite the presence of enforcement patrols, fishing boats continue to encroach into SIMCA, and 10 of the 35 respondents (29%) were found fishing within SIMCA. The remaining respondents were interviewed 1 to 30 km away from the SIMCA boundary.

Fifty percent of all respondents worked on shrimp and fish trawlers, 20% were compressor fishermen, and the remaining used gill net, drift net, hook and line, sodium cyanide or traps. This finding is compatible with Reef Guardian's records since 2005, which show that fishing activities within and surrounding SIMCA consist of at least 60% fish or shrimp trawlers from Sandakan, and 30% compressor fishermen from Kudat. These gears are used to target expensive marine species-trawling for shrimp, and compressor diving for coral groupers and other live reef fish species. It thus appears that market demand for seafood may be driving fishing activities near/or in SIMCA. Further, it appears that more intense competition at other fishing grounds, such as Kudat or Pulau Bankuruan, is motivating fishermen to come to SIMCA.

The prevalence of commercial fishermen at the SIMCA boundary suggests that they may be obtaining better catches at the protected area border; yet, half of the respondents indicated that their earnings were the same regardless of whether they fished within or outside the vicinity of SIMCA. A possible explanation for the observed concentration of commercial trawlers at the western boundary of SIMCA could be that the zone, near the Sugud coast, is suitable habitat for trawling shrimp, which is one of the target species of trawlers. Nevertheless, more trawler respondents indicated that they earned less income fishing within or near SIMCA compared to those who reported earning more, so it remains unclear whether or not trawlers are actually obtaining economic benefits from SIMCA.

One fisherman came to SIMCA because it offered more protection from storms, despite being able to find more fish in another more exposed fishing ground. In addition, fishermen were also wary of pirate attacks out at sea. This demonstrates that although financial incentives are important, fishermen also consider other factors like safety, and their selection of fishing grounds is the result of how they make trade offs among these different variables.

In contrast to what we concluded in section 1, that small-scale fishermen living closest to SIMCA were not affected by the creation of SIMCA, we found evidence to the contrary while conducting at sea interviews. Specifically, we found that a transient settlement of *Bajau Laut* residing on Pulau Bankuruan had been displaced and their fish catches negatively impacted by the creation of SIMCA. This group was not included in the first set of interviews because they are not a permanent settlement. Pulau Bankuruan which is located 8 kilometers west of Tegaipil Island has been a hide-out area for fishermen during North East monsoon and bad sea condition. According to the *Bajau Laut* on Pulau Bankuruan, the reduced fishing area resulting from the creation of SIMCA has intensified competition for fish in the surrounding area. Another small-scale fisherman who was found fishing within SIMCA at Tegaipil echoed this view. He indicated that the fishing grounds around Pulau Bankuruan were fished out because of the high number of people using gill nets there. This anecdotal evidence suggests that the establishment of SIMCA has resulted in a concentration of fishing pressure around Pulau Bankuruan, which has negatively impacted on fish catches. Ironically, the decline in fish catches at Pulau Bankuruan, possibly arising from intensified competition for fish, is now driving fishermen to encroach into SIMCA to catch more fish. This unintended outcome of MPA creation may be avoided in the future by assessing the spatial use patterns of fishermen and engaging their opinions on where to locate no fishing zones before establishing MPA boundaries.

Most interviews were conducted aboard a SIMCA enforcement patrol boat, often by one or two uniformed enforcement staff. Such a presence may have intimidated some fishermen, and affected the amount and type of information they shared during interviews. For example, few commercial fishermen admitted to ever having fished in SIMCA (besides those who were actually found fishing within SIMCA at the time interviews were conducted), despite the fact that many were encountered within 2 km of the SIMCA border. Moreover, a surprisingly high proportion (77%) of respondents expressed support for the establishment of MPAs, even though only 26% of respondents indicated that they could earn more income from fishing within or near SIMCA, compared to their other fishing grounds. Consequently, it may be possible that the responses pertaining to perceptions about MPAs are overly positive.

3.3 Summary and conclusion

Our overall goal was to assess if, or how, the creation of SIMCA has affected local fishing communities. Our main findings are:

1. The area encompassed by SIMCA was previously used by transient *Bajau Laut* who have since made a temporary settlement at Pulau Bankuruan, just outside the SIMCA border. Otherwise, the SIMCA does not appear to be currently, nor was it previously, used by small-scale fishermen from the nearest fishing communities in Sugud.
2. Hence, the creation of SIMCA has reduced the fishing grounds of *Bajau Laut* fishermen on

Pulau Bankuruan, but appears to have had minimal impact on the fishing activities of Sugud fishing communities.

3. The SIMCA area is currently used primarily by commercial trawlers and compressor fishing operations that target shrimp and live reef food fish species.
4. Most fishermen who fish in the vicinity of SIMCA do not perceive differences in fish size or fish catch compared to other fishing grounds that are not close to SIMCA. However, the continual presence of fishing vessels within SIMCA implies that fishing is better inside SIMCA.
5. At the same time, fishermen are aware that MPAs can serve as fish nursery grounds, thus it is likely that fishermen perceive indirect benefits of protected areas.
6. A higher proportion of fishermen who fish close to/inside SIMCA are more likely than small-scale fishermen who fish near their villages to oppose the creation of MPAs, possibly due to fear of losing their source of income.
7. Thus, it is important to assess the spatial use patterns of fishermen and engage their opinions on where to locate no fishing zones prior to the establishment of MPA boundaries.
8. The large proportion of non-Malaysian crew working on commercial boats implies that any benefits from the creation of SIMCA may not be fully captured by Sabah society.
9. The collection of finer scale spatial data and the continuation of fisheries monitoring will contribute additional information to fully address our stated objectives.

4.0 Study 2: Reef fish biomass survey

4.1 Background

The establishment of SIMCA in 2001 resulted in the elimination of fishing activities at the reefs closest to Lankayan Island. Thus we hypothesize that near-zero mortality from fishing activity will allow fishes to grow larger and improve the total fish biomass in SIMCA's protected reefs. When fish density is high within well protected reefs, a 'spill over', or emigration of adult and sub-adult fishes to outer reefs, is expected to occur.

Reefs that are close to Lankayan (within 2 nm) are well protected from poaching because of the presence of dive tourism and close monitoring and enforcement activities by Reef Guardian's enforcement team. At distances beyond 2 nm of Lankayan to the boundary of SIMCA, fishing vessels occasionally encroach into SIMCA especially at night. Therefore, fishing mortality is expected to be present at distances beyond 2nm of Lankayan. Thus, this study aims to determine:

a. Total fish biomass at reefs at different levels of protection.
b. Species richness at protected reefs and unprotected reefs.
c. Which fish species benefit from protection.

4.2 Method

4.2.1 Site selection

A total of 12 patch reefs surrounding Lankayan Island were chosen for the underwater survey, based on protection level and distance from the island (Table 8). All sites were chosen for their similarity with respect to reef size and depth. Thus, only patch reefs were selected as they were comparable with reefs that are situated beyond the borders of SIMCA.

The level of protection was categorized based on distance from Lankayan Island. The closer the reef is to Lankayan Island, the better protected the reef from poaching (Figure 8). Three levels of protection were defined:

> Level 1: 100% protection, whereby the reefs are located less than 2 nautical miles from Lankayan Island, and are constantly protected by the presence of enforcement;
>
> Level 2: 50% protection, whereby the reefs are located between 2 to 4 nautical miles from Lankayan Island, and are occasionally poached by fishermen; and
>
> Level 3: 0% protection, whereby the reefs are located more than 4 nautical miles away from Lankayan Island, or are situated outside of SIMCA, and there is no presence of enforcement and no management of fishing activities.

Table 8: General description of the reef sites selected for the fish biomass survey.

Level	Site	Distance from island	Site description
1	Froggie Fort	0.85nm	▪ Located north-west of Lankayan. ▪ Medium patch reef with 49% hard coral cover. ▪ Average depth: 10m at reef top, 16m at reef slope. ▪ Branching, sub-massive and tabular corals.
1	Jawfish Lair	1.24nm	▪ Located south-west of Lankayan. ▪ Medium patch reef with 48% hard coral cover. ▪ Average depth: 10m at reef top, 15m at reef slope. ▪ Encrusting, massive and sub-massive corals.
1	Bimbo Rock	1.14nm	▪ Located north-east of Lankayan. ▪ Medium patch reef with 56% hard coral cover. ▪ Average depth: 12m at reef top, 15m at reef slope. ▪ Branching, foliose and massive corals.
1	Goby Rock	1.99nm	▪ Located south-west of Lankayan. ▪ Medium patch reef with 46% hard coral cover. ▪ Average depth: 10m at reef top, 15m at reef slope. ▪ Branching, foliose and massive corals.
2	Sunnug Lair	2.11nm	▪ Located north-west of Lankayan. ▪ Large patch reef with 67% hard coral cover. ▪ Average depth: 10m at reef top, 14m at reef slope. ▪ Branching, sub-massive and Acropora branching corals.
2	Chamber Reef	4.00nm	▪ Located west of Lankayan. ▪ Large patch reef with 40% hard coral cover. ▪ Average depth: 9m at reef top, 13m at reef slope. ▪ Branching, mushroom and Acropora branching corals.
2	Moray Reef	2.86nm	▪ Located north east of Lankayan. ▪ Large patch reef with 51% hard coral cover. ▪ Branching and foliose corals.
2	Below Katching	3.00nm	▪ Located south of Lankayan. ▪ Large patch reef. ▪ Average depth: 6m at the reef top and 12m at reef slope ▪ Branching and tabular coral at the reef top.

3	Red Pancang	5.18nm	▪ Located north of Lankayan, outside SIMCA ▪ Medium patch reef with 14% hard coral cover. ▪ Average depth: 7m at reef top, 16m at reef slope. ▪ Branching, mushroom and Acropora branching corals. Mostly soft corals.
3	Kestrel Shroal	5.00nm	▪ Located east of Lankayan, outside SIMCA ▪ Large patch reef with 54% hard coral cover. ▪ Average depth: 7m at reef top, 15m at reef slope. ▪ Massive, sub-massive and Acropora branching corals.
3	Roger Reef	5.38nm	▪ Located south of Lankayan, outside SIMCA. ▪ Large patch reef with 44% hard coral cover. ▪ Average depth: 9m at reef top, 15m at reef slope. ▪ Branching, sub-massive and Acropora branching corals.
3	Reef 49	5.00nm	▪ Located south of Lankayan, outside SIMCA. ▪ Large patch reef with low coral cover ▪ Average 10m at reef top and 16m at reef slope.

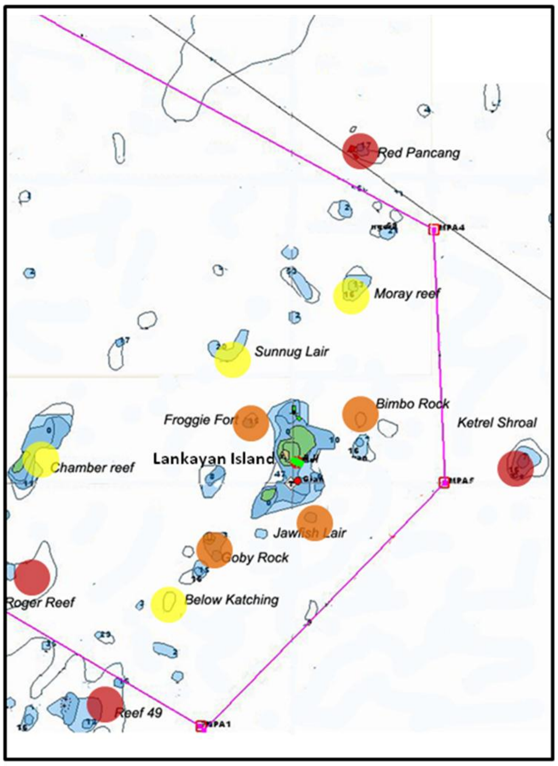


Figure 8: *Location of survey sites.*

Orange dots represent survey sites at protection level 1 (< 2 nm); yellow dots represent sites at protection level 2 (2 – 4 nm) and red dots are sites at protection level 3 (>4 nm). Note 1 nm = 1.8 km. Map source: CMap.

4.2.2 Fish biomass estimation

Reef fish biomass was estimated by conducting underwater visual surveys using the belt transect method based on English et al. (1997). This is one of the most common quantitative and qualitative sampling methods used because it is rapid, non-destructive, and inexpensive.

Underwater visual censuses (UVCs) were conducted from July 2010 to November 2011. At least six independent random transects 50 m in length were placed at the reef top between 8 to 13 m depth, and at the reef slope between 14 to 17 m depth. On each transect, we recorded the number and total length (to the nearest cm) of fishes that were encountered within 2.5 m on both side of the transect, and 5 m above the transect. To limit disturbance, we waited for an 8 to 10 minute interval between the setting up of transects and the start of the survey to allow the fishes to resume normal behavior (Carpenter et al., 1981). All reef fishes recorded were identified to species level when possible. Reef fishes less than 3 cm in length were not included in the survey. The fish biomass and abundance count were done by the same observer(s) to ensure consistency. The underwater survey was conducted between 09:00 to 16:00 to avoid the diurnal-nocturnal changeover periods of fish (Carpenter et al., 1981). Bad water visibility (<5m) was avoided and surveys with currents were noted and the current directions were recorded.

4.2.3 Data analysis

Fish biomass was estimated using Le Cren's equation (Wootton, 1992) by converting the length measurements of the fish to weight (g) using length-weight relationships obtained from Fishbase.

$W = aL^b$ or

$\text{Log } W = \log a + b \log L$

Whereby, W = weight (g)

L = length (cm)

a = y-intercept on the length-weight graph

b = regression coefficient of the trendline

In the absence of available length-weight relationships, the relationships of similar-sized fish under same families were used.

At each survey site, total fish biomass was estimated for each fish family. The total fish biomass of all fish families was summed and compared between sites within the same level of protection by using one-way analysis of variance. When no significant differences were detected, data for the same level of protection were pooled. One-way analysis of variance was used to test for significant differences in total fish biomass (all fish families) between the three levels of protection.

4.3 Results

There was no significant difference in total fish biomass between sites of the same protection level (Table 9). Thus, sites at each protection level were pooled. There was a significant difference in total fish biomass between the different levels of protection (ANOVA: $F=8.26$, $P<0.05$). Total fish biomass was highest at level 1 (100% protection), with an average of 54,963g (55kg) per 250 m^2 (Table 10).

Total fish biomass progressively decreased at subsequent protection levels, as distance from Lankayan Island increased (Figure 9).

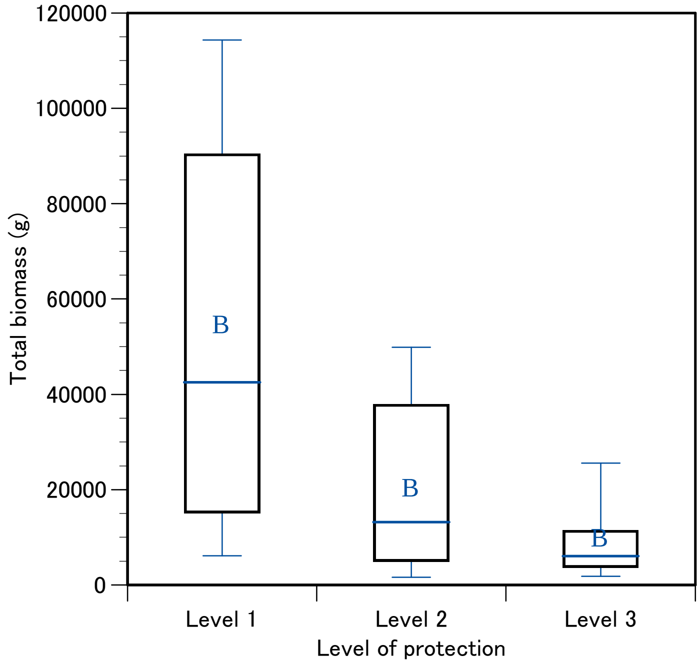
Table 9: One-way analysis of variance of total fish biomass between sites at different levels of protection (1, 2 and 3). There was no significant difference in total fish biomass within sites of the same level of protection.

Protection level	F-ratio	P value
1	2.2455	0.1143
2	0.6860	0.5711
3	0.2851	0.8354

Table 10: Mean, standard deviation (SD), maximum (Max), and minimum (Min) total biomass (g/250m2) of all fish families across three levels of protection.
Level 1 = 100%; Level 2: 50% and Level 3: 0%.

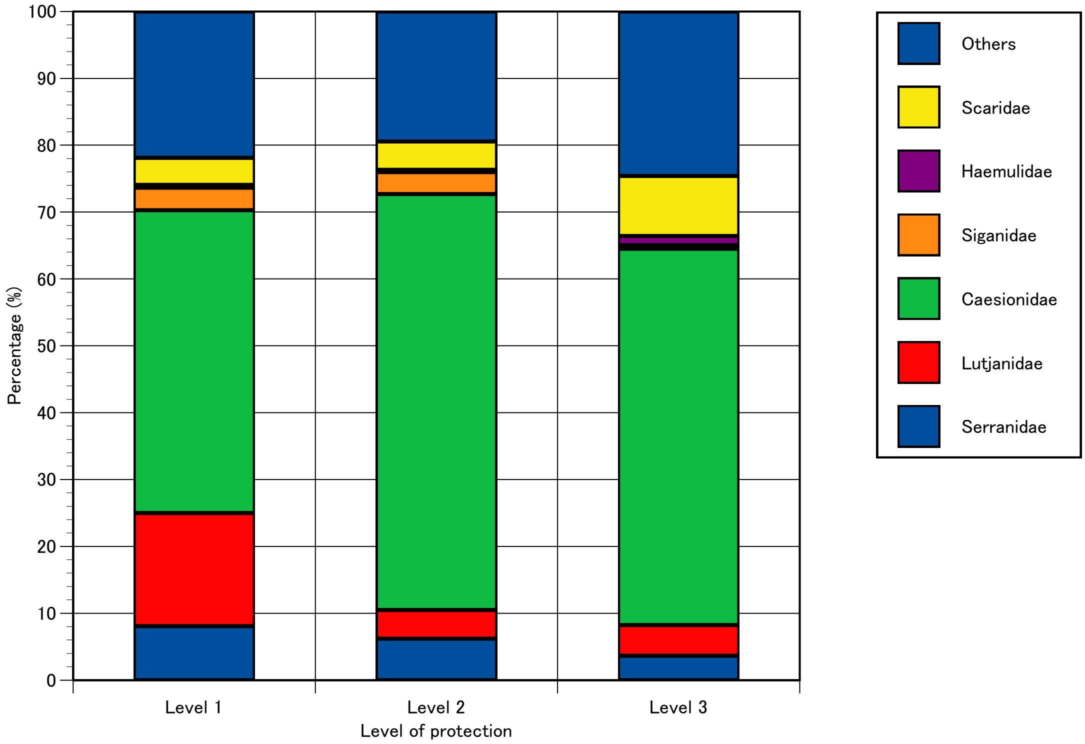
Protection level	Mean	SD	Max	Min	Count
1	54,964	55,011	240,627	3,194	24
2	20,649	19,862	63,617	1,254	24
3	10,201	11,100	47,595	1,010	24

Figure 9: Proportional decrease of total fish biomass (g/250m²) for three levels of protection. Symbols (■) = mean, outliers = range, boxes = standard deviation.



Of all reef fish families, Caesionidae (fusiliers) made up the highest percentage of the total fish biomass in all survey sites. Figure 10 illustrates the percentage contribution of each fish family at each level of protection.

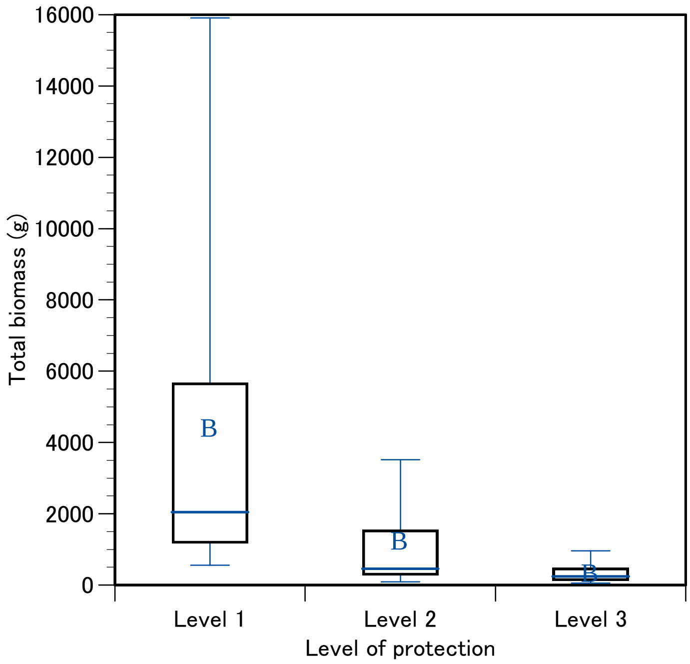
Figure 10: *The percentage contribution (%) of fish families to total biomass at each level of protection. 'Others' includes the fish families Pomacentridae (damselfishes), Cheatodontidae (butterflyfishes), Mullidae (goatfishes), Labridae (wrasses), Nemipteridae (breams), Lethrinidae (emperors), Acanthuridae (surgeonfish), Carangidae (Jacks), Balistidae (triggerfish) and Tetraodontidae (puffers).*



The fusiliers *Caesio teres* and *Pterocaesio tessellata* were the most common fishes found in all survey sites, comprising at least 40% of the total estimated fish biomass (Figure 10). The total percentage of groupers (Serranidae) was higher at level 1 survey sites compared to level 2 and 3 survey sites. Other fish families that were represented included Pomacentridae (damselfishes), Cheatodontidae (butterflyfishes), Mullidae (goatfishes), Labridae (wrasses), Nemipteridae (breams), Lethrinidae (emperors) Acanthuridae (surgeonfish), Carangidae (Jacks), Balistidae (triggerfish) and Tetraodontidae (puffers).

The total biomass of Serranidae was significantly different between the three levels of protection (ANOVA: $F=4.20$, $P<0.05$). Average total biomass was higher at level 1 sites (4,443 g/250m^2) compared to level 3 sites (373 g/250m^2) (Figure 11). The total biomass of Serranidae varied within sites in the same level of protection, even though there was not significant different within site in the same level of protection. For example, one transect survey at Froggie Fort recorded nearly 16,000 g (16kg) of groupers in a single transect survey. The groupers were identified as seven individuals of Leopard Coral groupers (*Plectropomus leopardus*) that were at least 50 cm in estimated total length. Similarly at Jawfish Lair, single transect survey also recorded nearly 16,000 g (16kg) of grouper which were primarily few adults of Leopard Coral groupers (*Plectropomus leopardus*), Spotted Coral groupers (*Plectropomus maculatus*) and Orange-spotted groupers (*Epinephelus coioides*).

Figure 11: *Proportional decrease in total biomass (g/250m^2) of Serranidae across three levels of protection. Symbols (■) = mean, outliers = range, boxes = standard deviation.*



The total biomass of Serranidae at level 3 protection sites was low, with a recorded maximum biomass of only 1,395 g in 250m^2. Groupers recorded at level 3 protection sites represented most of the smaller species and those with no commercial value, such as *Cephalopholis microprion*, *Cephalopholis boenak* and *Epinephelus fasciatus* (Table 11). Only one *Plectropomus leopardus* was recorded at level 3 sites; however, its total length was less than 30 cm. A total of 15 species of Serranidae were recorded in this study. Fourteen species were recorded at level 1 protection sites, whereas only 5 species were recorded at level 3 sites. At least 6 species of groupers with maximum total lengths of 60 cm were encountered at level 1 sites. These included *Plectropomus leopardus*, *Plectropomus oligacanthus, and Epinephelus coioides*. However, only one *Cromileptes altivelis* (Barramundi) was recorded at a level 1 survey site.

Table 11: Serranidae species found at each level of protection.

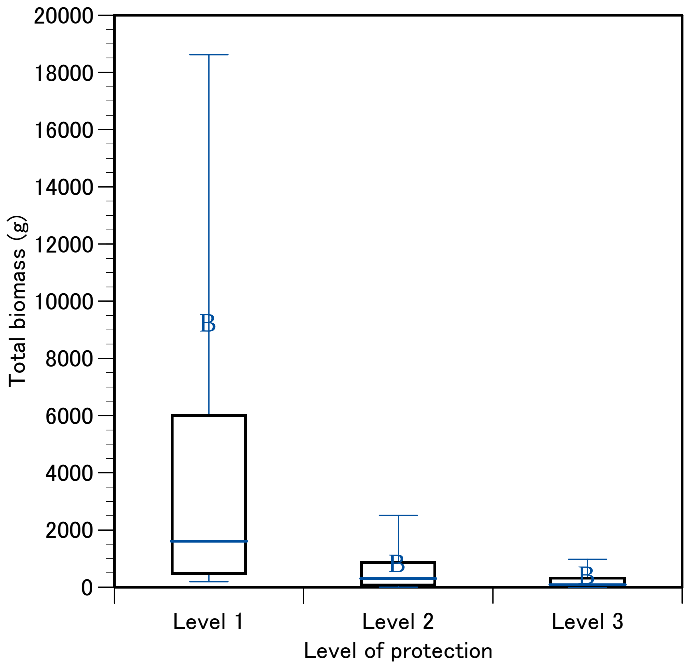
Species name	Common name	Level 1	Level 2	Level 3
Epinephelus fasciatus	Blacktip grouper	√	√	√
Epinephelus macrospilos	Snubnose grouper	√	X	X
Epinephelus coioides	Orange-spotted grouper	√	X	X
Cephalopholis cyanostigma	Bluespotted grouper	√	√	√
Cephalopholis microprion	Freckled grouper	√	√	√
Cephalopholis boenak	Chocolate grouper	√	√	√
Cephalopholis sexmaculata	Saddle grouper	√	X	X
Plectropomus leopardus	Leopard coral grouper	√	√	√
Plectropomus oligacanthus	Highfin coral grouper	√	X	X

Plectropomus pessuliferus	Roving coral grouper	√	X	X
Plectropomus maculatus	Spotted coral grouper	√	√	X
Aethaloperca rogaa	Redmouth grouper	√	X	X
Cromileptes altivelis	Barramundi	√	X	X
Epinephelus ongus	Whitestreaked grouper	X	X	X
Epinephelus howlandi	Blacksaddle grouper	X	X	X

There was no significant difference in the total biomass of Lutjanidae between all three levels of protection (ANOVA: $F=2.896$; $P=0.06$). However, the average total biomass of Lutjanidae was higher at level 1 (9,288 g/250m^2) compared to level 3 (463 g/250m^2) (Figure 12).

There was a big range in the number of Lutjanidae counted at level 1 protection (Figure 12). The maximum total biomass of Lutjanidae recorded was 113,492 g (113kg) in 250m^2, while in a few transects no individuals were recorded. The average total biomass of Lutjanidae was low at level 2 and 3 sites, with less than a kilogram in average.

***Figure 12**: Proportional decrease of total biomass (g/250m^2) of Lutjanidae for three levels of protections. Symbols (■) = mean, outliers = range, boxes = standard deviation.*



A total of 12 species of snappers was recorded in this study. Eleven species were recorded at level 1, eight species at level 2, and only four species were recorded in level 3 survey sites (Table 12). A few species of Lutjanidae, such as *Lutjanus lutjanus*, *Lutjanus vitta* and *Lutjanus biguttatus* that are commonly form big schools in the reefs were contributed towards the high biomass recorded at level 1 protection survey sites.

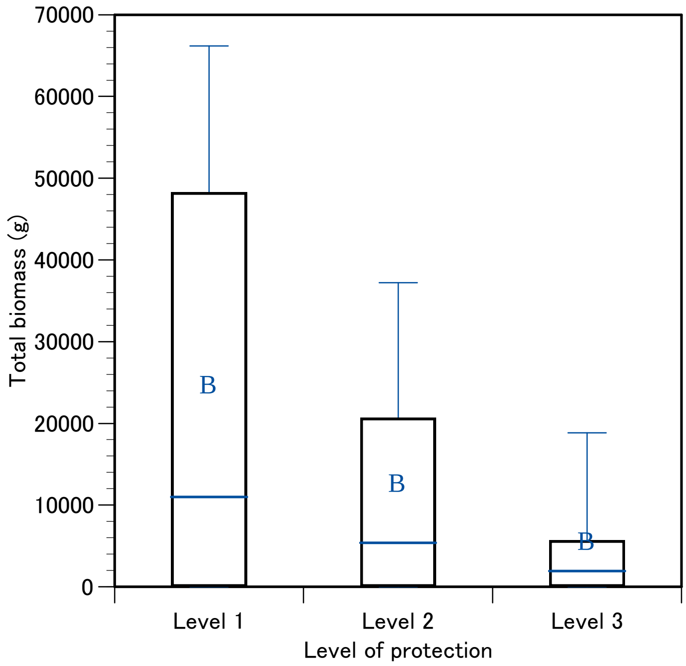
Table 12: Lutjanidae species found at each level of protection.

Species name	Common name	Level 1	Level 2	Level 3
Lutjanus vita	Brownstripe snapper	√	X	√
Lutjanus fulviflamma	Longspot snapper	√	√	X
Lutjanus decussatus	Checkered snapper	√	√	√
Lutjanus lutjanus	Big-eye snapper	√	X	X
Lutjanus russelli	Russell's snapper	√	√	X
Lutjanus carponotatus	Spanish flag	√	√	√
Lutjanus quinquelineatus	Five-line snapper	√	X	X
Lutjanus argentimaculatus	Mangrove red snapper	√	X	X
Lutjanus biguttatus	Two-spot snapper	√	√	√
Lutjanus ehrenbergii	Blackspot snapper	√	√	X
Macolor macularis	Midnight snapper	X	√	X
Lutjanus lemniscatus	Dark-tail snapper	X	√	x

Caesionidae (fusiliers) contributed the highest total biomass in the all survey sites at all levels of protection. Schooling Caesionidae were commonly found at the reef top and slope, hovering at the water column feeding on plankton. The highest total biomass of fusiliers was recorded at Jawfish Lair (level 1), with 108,575 g in $250m^2$ of blue-yellow fusilier (*Caesio teres*). At some survey transects, zero fusiliers were recorded. Caesionidae is a reef associated species that is highly mobile, following underwater currents and food sources. In our observations, fusiliers were mostly recorded at the reef slope facing towards the current. In some surveys, the school of fusiliers extended 7m upwards from the reef top, almost reaching the sea surface.

However, there was no significant difference in total biomass of Caesionidae between the three levels of protection (ANOVA: F=4.786; P<0.05). The average total biomass was much higher at reefs which were well protected (Figure 13). Only four species of fusiliers were recorded in this study, *Caesio teres, Pterocaesio tessellate*, *Pterocaesio digramma and Caesio caerulaurea*.

Figure 13: *Proportional decrease of total biomass (g/$250m^2$) of Caesionidae for three levels of protections. Symbols (■) = mean, outliers = range, boxes = standard deviation.*



The average total biomass of Scaridae at level 1 protection sites was only 2,212g in 250m^2. Parrotfish were present at all level 1 protection sites, where the maximum recorded total biomass was 10,925g in 250m^2 (Table 13).

Table 13: Mean, standard deviation (SD), maximum (Max), and minimum (Min) total biomass (g/250m2) of Scaridae across three level of protection.
Level 1 = 100%; Level 2: 50% and Level 3: 0%.

Level of protection	Mean	SD	Max	Min	N
1	2213	2574	10926	149	24
2	878	1092	3915	0	24
3	915	1388	6179	0	24

Siganidae comprised only 0.53% (at level 3 protection sites) to 3.36% (at level 1 protection sites) of the total estimated fish biomass. The population of rabbitfish was low compared to snappers and fusiliers. Commonly recorded rabbitfish species were *Siganus punctatissimus* and *Siganus javus.* Similarly, the number of sweetlips (Haemulidae) recorded was low at all survey sites. The maximum biomass of Haemulidae was 2,545 g in 250m^2, recorded at Jawfish Lair. Common sweetlips species that were recorded were *Diagramma sp*. and *Diagramma pictum*.

There were 38 species of damselfish recorded in this study. Most commonly recorded damselfish were *Pomacentrus alexanderae, Amblyglyphidodon leucogaster, Plectroglyphidodon lacrymatus and Pomacentrus moluccensis*. Butterflyfish contributed a small percentage of biomass in the reef. The most common species was *Chaetodon octofasciatus* which was recorded at almost all survey sites. Pelagic jacks were also recorded occasionally in this survey, with the two common species being *Carangoides bajad* and *Caranx melampygus.*

4.4 Discussion and conclusion

Total fish biomass and species richness was higher at reefs that are well protected compared to unprotected reefs outside SIMCA. The number of commercially important species such as groupers and snappers are more abundant at level 1 protection reefs compared to reefs at levels 2 and 3. At least 6 grouper species that are highly valuable for the live reef food fish trade, such as *Cromileptes altivelis* (Barramudi cod) and *Plectropomus leopardus* (Leopard coral grouper), were found in reefs with level 1 protection. The protection of reefs appears to allow some fish species to recover. Some fishes are able to grow larger, which is important for sustaining spawning-populations in the reserve. Further, protecting available spawning-stock is important for maintaining population structure and for providing a source of recruitment to replenish areas where populations have declined (Sala et. al., 2001). An increase in spawning stock within a reserve can lead to an increase in the production and dispersal of larvae, and potentially result in increases of 'larval export' to other areas (Ormond & Gore, 2003). It is theorized that a build-up of biomass within a no-take reserve will result in a biomass overflow, leading to emigration of adult or sub-adult fish out of the reserve (Russ & Alcala 1996). The presence of a few smaller (less than 30cm) leopard coral groupers recorded at level 3 protection sites may support this theory; however, continued surveys are needed to further substantiate whether this is indeed occurring.

Samoilys et. al., (2007) found that groupers, breams and butterflyfish responded strongest to reserve protection. We found that besides groupers, reserve protection also seemed to have an effect on snappers. Snapper abundance count was significantly higher in reefs with full protection, especially species such *as Lutjanus lutjanus* (bigeye snapper) and *Lutjanus vita* (brownstripe snapper), which formed schools of approximately 50-1000 fishes. The maximum total biomass of Lutjanidae was 113kg, recorded on a single transect at a level 1 protection site. Records of Haemulidae (sweetlip) were particularly low in this study, which may be due to the surveys being conducted at non-favourable habitats for sweetlip. In our experience, most sweetlips are more likely to be found between the reef edge and sandy bottom, and they also tend to be associated with big rocks and massive porities. The high abundance of Caesionidae (fusiliers) at all reefs indicates that there was high plankton content around Lankayan reefs. The high biomass of Caesionidae will expect the high production in the area and results recruitment of juvenile to the reefs which are an important food source for piscivores such as groupers, snappers, jacks and emperors. The fusilier is highly mobile species and abundance can be vary within a day at the same site.

Distance between source reefs and fished reefs, size of MPA, as well as fish behaviour (mobile or sedentary) are important considerations for determining spill over of adults or sub-adults from inside reserves to outside. In this study, there was decreasing gradient of fish biomass across boundaries of protection level, which may suggest export (Forcade et. al., 2008). However, not all species respond to protection and cause export. Gell & Roberts (2003) stated that species that respond most rapidly to protection are often relatively sedentary. In such cases, smaller MPAs are more likely to show protection benefits compared to larger MPAs. The distance from Lankayan Island to the closest SIMCA boundary is 6 km (3.3 nm). Thus, in order to show fishery benefits, fishes inside SIMCA have to be able to disperse out at least 6 km to the boundary, and at least 8km to reach the closest reef outside SIMCA, in order to benefit local fishing communities.

We conclude that reefs where fishing has been virtually eliminated have higher fish biomass and diversity than semi or non-protected reefs. This suggests that the creation of SIMCA has contributed to higher total fish biomass in the reserve, especially of several commercially important species. The decreasing gradient of biomass from Lankayan may show export of fishes to outer reefs. The current finding provides important baseline data to detect temporal changes in total fish biomass and diversity. These monitoring and research activities will be continued to be carried out by Reef Guardian.

5.0 References

Alcala AC, Russ GR, Maypa AP (2002) Evidence for fishery enhancement effects of marine reserves in Central Philippines. UPVJ. Nat. Sci 7: 1-5.

Carpenter KE, Miclat RI, Albaladejo VD and Corpuz VT (1981). The influence of substrate structure on the local abundance and diversity of Philippine reef fishes. Proceedings Fourth International Coral Reef Symposium. 2: 497-502.

Carr MH (2000) Marine protected areas: challenges and opportunities for understanding and conserving coastal marine ecosystems Environmental Conservation 27:106-109.

English S, Wilkinson C and Baker V (eds) (1997). Survey Manual for Tropical Marine Resources 2nd Edition. Australian Institute of Marine Science. 390p.

Forcada A, Bayle-Sempere J T, et al. (2008). Habitat continuity effects on gradients of fish biomass across marine protected area boundaries. Marine Environmental Research 66 536-547.

Galal N, Ormond RFG, Hassan O (2002) Effect of a network of no-take reserves in increasing catch per unit effort and stocks of exploited reef fish at Nabq, South Sinai, Egqupt. Marine and Freshwater Research 53(2) 199-205.

Gell FR, Robert CM (2003) Benefits beyong boundaries: the fishery effects of marine reserves. Trends in Ecology and Evolution 18.

Goñi R, Adlerstein S, Alvarez-Berastegui D et al. (2008) Spillover from six western Mediterranean marine protected areas: evidence from artisanal fisheries. Marine Ecology Progress Series 366: 159-174.

Halpern BS (2003) The impact of marine reserves: Do reserves work and does reserve size matter? Ecological Applications 13: 117-137.

Halpern BS, Lester SE, McLeod KL (2010) Placing marine protected areas onto the ecosystem-based management seascape. PNAS: 1-6.

Jennings S, Marshall SS, Polunin NVC (1996) Seychelles' Marine Protected Areas: Comparative structure and status of reef fish communities. Biological Conservation 75: 201-209.

Lavieren HV (2009) The science of No-take Fishery Reserves. A guide for managers., UNU-INWEH, CRTR Brochure.

McClanahan TR, Mangi S (2000) Spillover of exploitable fishes from a marine park and its effect on the adjacent fishery. Ecological Applications 10: 1792-1805.

Minda personnel communication

Polunin NVC, Robert CM (1993) Greater biomass and value of target coral-reef fishes in two small Caribbean marine reserves. Marine Ecology Progress Series 100: 167-176.

Russ GR, Alcala AC, Maypa AP, Calumpong HP, White AT (2004) Marine reserve benefits local fisheries. Ecological Applications 14: 597-606.

Sala E, Ballesteros E, et al. (2001). Rapid Decline of Nassau Grouper Spawning Aggregations in Belize: Fishery Management and Conservation Needs. Fisheries 26(10): 23-30.

Sale PF, Cowen RK, Danilowicz BS, Jones GP, Kritzer JP, Lindeman KC, Planes S, Polunin NVC, Russ GR, Sadovy YJ, Steneck RS (2005) Critical science gaps impede use of no-take fishery reserves. Trends in Ecology and Evolution 20: 74-80.

Samoilys MA, K. M. Martin-Smith, et al. (2007). Effectiveness of five small Philippines' coral reef reserves for fish population depends on site-specific factors, particularly enforcement history. Biological Conservation 136: 584-601.

SIMCA (2005) Sugud Islands Marine Conservation Area 2005 Annual Report. 73pp.

SIMCA (2006) Sugud Islands Marine Conservation Area 2006 Annual Report. 68pp.

SIMCA (2009) Sugud Islands Marine Conservation Area 2009 Annual Report. 75pp.

Sluka R, Chiappone M, Sullivan KM, Wright R (1997) The Benefits of a Marine Fishery Reserve for Nassau Grouper *Epinephelus Striatus* in the Central Bahamas. P. 1961-1964 In: Lessios HA, Macintyre IG (eds.) Proceedings of the 8th International Coral Reef Symposium Vol. 2. Smithsonian Tropical Research Institute, Panama.

Appendix 1: Village Interviews Questionnaire

Objective: Has creation of SIMCA generated socio-economic and fishery benefits to fishermen?

A. PERSONAL & DEMOGRAPHIC

☐ Small-scale ☐ Commercial

Name: Married: ☐ Yes ☐ No

Age: No. of people in household:

Education: Children: Adults:

1. Where is your village of residence?

2. How long have you been living at your current village of residence?

3. How long have you been fishing?

4. How many members of your family fish for a living?

Only one (himself) ☐

No. of family members who fish

5a. Do you fish alone or with a group of fishermen? (If in a group, how many in a group?)

☐ Alone (go to 6)

☐ In a group How many in a group (got to 5b)

5b. Are the fishermen you fish with your family members?

☐ YES ☐ NO

6a. What kind of boat do you use?

☐ Fiberglass ☐ Papan ☐ Others

6b. How long have you used this boat?

7a. For small-scale fishermen

How big is your boat?

Length meters/feet

☐ Rowboat ☐ Engine HP ☐ GRT tonnes

7b. For commercial fishermen who own their vessel or captain of a vessel

What is the size (length & GRT) of the vessel you currently use?

Length meters/feet GRT tonnes

8a. Do you own the boat you use for fishing?

☐ YES (go to 9a) ☐ NO (go to 8b)

8b. Do you have to pay rental for using the boat?

☐ YES (go to 8c) ☐ NO (go to 9a)

8c. How much is the rental?

RM per month

9a. Did you use a different boat / vessel to fish prior to 2003?

☐ NO

☐ YES Prior boat: Length meters/ feet

☐ Rowboat ☐ Engine (sangkut/pumbot) HP ☐ GRT tonnes

9b. If pre-2003 vessel is different from now, ask "When and why did you change your vessel?"

WHEN

WHY

INCOME

10a. How much do you earn per month (net) from fishing, after deducting fishing costs?

*Make sure that the stated net income is for one person.

10b. How much is your net household income per month?

10c. Is your income enough to cover monthly expenses?

☐ YES ☐ NO

10d. How much is your household expenses per month?

11a. Is the income you get now different from your income before 2003?

☐ No difference (go to 12)

☐ Increase (go to 11b) ☐ Decrease (go to 11b)

11b. Estimate how much percentage increase/decrease?

*If fisherman has difficulty estimating the percentage of increase/decrease, ask "For example, if you earn RM10 in one day, how much did you earn last time?"

11c. What is the reason for increase/decrease in income?

Reason for difference in income	Percentage (%)
Price of fish increase ☐	
Price of fish decrease ☐	
Fish catch increase ☐	
Fish catch decrease ☐	
Cost of petrol increase ☐	
Cost of petrol decrease ☐	
Boat costs increase ☐	
Boat costs decrease ☐	
Costs of fishing gear increase ☐	
Costs of fishing gear decrease ☐	
Other:	
Other:	

B. SPATIAL

12a. Where are the places that you normally go to fish?

Year	Location
Current (2010)	
Before 2003	
2003-2009	

12b. If location differs, ask "Why did you change fishing grounds?"

*List of possible responses for prompting fisherman if required. Do not read out the list.

Reasons for change of fishing grounds	
No more fish / difficult to catch	☐
Because fisherman moved from his village	☐
Because of SIMCA	☐
Tourist presence	☐
Lain:	

Lain:

13. Do you fish at different places during different seasons? (north-east and south-west monsoon)

☐ YES North-east Why

South-west Why

☐ NO

14a. How far (from village) did you have to travel to get to the fishing grounds you fished at before 2003?

Distance km Time hours/mins

Type of boat & engine used for travelling

14b. How far (from village) do you have to travel to get to fishing grounds you currently fish at (2010)?

Distance km Time hours/mins

Type of boat & engine used for travelling

15a. Where do you think is the best fishing grounds?

15b. Why is this the best fishing ground?

☐ Can catch the most fish ☐ Can catch expensive species ☐ Others

15c. Has this always been the best fishing grounds?

☐ YES

☐ NO Which other place used to be the best fishing grounds?

15d. Why do you fish at your present fishing ground?

Close to village	☐
There is more fish here (ask compared to where)	☐
Do not know other places	☐
Others:	

SPATIAL - GEAR

16. What gear do you use to fish?

Gear	Period (Year)
a.	Current (2010)
b.	Before 2003

SPATIAL- CATCH

17a. What type of fish do you catch currently? (List species)

Which are the most common type/species of fish you catch (from list/fish poster)?

Rank the fish from most to least commonly caught.

17b. Has the type of fish you catch changed in the past 10 years?

☐ YES How are the fish type/species different now?

☐ NO

18a. Have you noticed a change in the size of fish you catch in the past 10 years?

☐ YES (Go to 18b) ☐ NO (Go to 18d)

18b. Compared to before, how has the size changed?

Fish is smaller now	☐
Fish is bigger now	☐
Other:	

18c. What is the reason for the change?

*Some possible reasons listed below – don't read out the list, this is only for prompting the fisherman if he doesn't understand the question

All the big fish have been caught	☐
The fish are caught before they can grow big	☐
Too many people catching fish	☐
Other:	

18d. Is there any change in the type of fish/species caught currently compared to before 2003?

☐ YES Species caught currently (2010)

Species caught before 2003

☐ NO

18e. Is there a type of fish that you cannot catch now, but that you used to catch before (pre-2003)?

☐ YES What type of fish? When was the last time you caught it?

☐ NO

Catch Per Unit Effort (CPUE)

19a. How many hours do you fish a day?

Year	Min hours/day	Max hours/day	Average hours/day
Currently (2010)			
Before 2003			
2003-2009			

19b. How many times do you fish per day?

19c. Are your fishing trips single-day trips or multi-day trips?

20a. How many days do you fish per month

*If they go on multi-day trips, clarify whether response refers to # of trips per month/week or actual # of days per month/week.

Year	Min time/month	Max time/month	Average time/month
Currently (2010)			
Before 2003			
2003-2009			

20b. If there is a difference in the frequency of fishing between the years, ask "Why do they fish more/less often now compared to the past?"

21. How much fish do you catch per trip?

*If fisherman fishes in a group, confirm with him that he is referring to catch per person, not per group.

Year	Min kg/trip	Max kg/trip	Average kg/trip
Currently (2010)			
Before 2003			
2003-2009			

<u>INCOME</u>

22. How much do you earn from selling fish?

*Confirm that the earnings mentioned are net earning.

Tahun	Min (RM/month)	Max (RM/month)	Average (RM/month)
Currently (2010)			
Before 2003			
2003-2009			

PERCEPTIONS ABOUT MPAs

23. Are you aware about the protected area of SIMCA?

☐ YES ☐ NO

24a. Has the creation of SIMCA affected your fishing activity?

☐ YES (Go to 24b) ☐ NO (Go to 25)

24b. How has SIMCA affected your fishing activity?

25. What benefits do you think a marine protected area provides for fishermen?

26. Do you support the establishment of marine protected areas?

☐ YES Why

☐ NO Why

27. Do you think there should be similar marine protected areas in other parts of Sabah? Why?

Appendix 2: At Sea Interviews Questionnaire

A. **PERSONAL & DEMOGRAPHIC**

☐ Small-scale ☐ Commercial

Name: Married: ☐ Yes ☐ No

Age: No. of people in household:

Education: Children: Adults:

1. Where do you come from?

2. How long have you been staying here?

3. How long have you been fishing?
________years/months

4a. What kind of boat you use?
Fiberglass ______ Wooden ________ Others _______

4b. How long have you been using this boat?
_____ years/months

5a. *For small scale fishermen*
How long is your boat? ______ meters/feet
Rowboat _____
Engine _____ hp
GRT _____ tonne

5b. *For commercial fishermen*
What is the size of ship you are using currently?
Length ______ meter/feet
GRT ______ tonne
Number of crew ______

6a. Do you own this boat?
Yes ___ (go to 7) No ___ (go to 6b)

6b. Do you need to pay boat rent for using it?
Yes ___; RM _____ per month/day/trip
No ___

B. Gear

7. What kind of gear you use for fishing?

Kind of gear	
Fish rod	
Bottom gill net - Length - Depth - Mesh size	 _____ m _____ m _____ inches
Trawl net	
Bubu - How many? - Use compressor?	 _____ Yes/No
Compressor	Spear _____ Sodium _____ Bomb _____
Hooks and lines - How long? - How many hooks?	 _____ m _____ hooks
Others: _______	

C. Spatial

8a. Where were you used to fish before this?

Kudat		Semporna	
Banggi		Pantai Barat (KK)	
Other places			

8b. Since when (year) you started to fish at SIMCA/Sugud?

8c. How many times in one month do you fish at SIMCA/Sugud?

8d. In which month do you come fishing here?

Jan		Apr		Jul		Oct	
Feb		May		Aug		Nov	
Mar		Jun		Sept		Dec	

9. Why do you come here (SIMCA/Sugud) for fishing?

No fish/hard to get fish at usual fishing grounds	[ ]
Moved to new village	[ ]
There are more fish in SIMCA	[ ]
There are more competition at previous fishing ground	[ ]
Fish are bigger here	[ ]
More high valued fish here	[ ]
Other:	

10a. How long do you take to travel from your village to here?
Distance ____ km Time taken ____ hours

10b. How many days do you stay at SIMCA/Sugud usually? ____ days

10c. Do you stay around here or go other places?

10d. What are the other places you go and how long do you stay there?

1. ______________________________	4. _____________________________________
2. ______________________________	5. _____________________________________
3. ______________________________	6. _____________________________________

10e. Do you go to Philippines? Yes/No

D. <u>Catch</u>

11a. What kind of fish do you catch at SIMCA/Sugud?

a. What species/kind of fish is the most commonly caught?
b. Sort those fishes from most commonly caught to least commonly caught

Kind of fish	Rank

11b. What is the difference between the fish which you caught at usual fishing ground and those at SIMCA/Sugud?

12a. Is the size of fish caught within SIMCA different from those caught at other places you go?
Yes ___; bigger/smaller No ___ (go to 12c)

12b. Why the fish are smaller at your village?

All bigger fish had been caught	[ ]
Fish are caught before they can grow big	[ ]
Too many people fishing there	[ ]
Other:	

12c. Is there any kind of fish which you could only catch in SIMCA but not other places?
Yes ___; kind of fish: ______ No ___

E. <u>Catch Per Unit Effort (CPUE)</u>

13a. How many hours do you fish in one day?
Starting from _______ until ________

13b. If at ____________________ (usual fishing ground), how many hours do you fish in one day?
Starting from _______ until ________

13c. *For trawler or fishermen with other kind of net*
How many times do you trawl in one day? ______ times

14. How many times you go for fishing in one month/one week?

15a. How many kilos of fish you can get in each time you come here? _____ kg

15b. *For trawler or fishes with other kind of net*

Catch	Usual place	SIMCA
Per trawl	kg	kg
Per trip	kg	kg

F. <u>Income</u>

17a. How much can you get on average by selling catches from each trip to SIMCA? RM _______

17b. Is there more income by selling live fish compared to dead fish?

17c. How much can you get for selling live fish caught during each fishing trip to SIMCA? How about dead fish?

a. Live fish RM _______ (net or gross)
b. Dead fish RM _______ (net or gross)

18. If compared with usual fishing grounds, do you get more or less income fishing here?
More ______ Less ______ Same ______

19. Where do you sell your catch?
a. Market _________ Where? _________
b. Tauke/Owner ______
c. Philippines ______
d. Eat

20. Do you receive salary every month or are paid based on catch?
a. Monthly salary _____ (RM ______ / month)
b. Catch commission _____ (RM ______ / kg)

21. At what prices you sell your catch?

Live fish	RM/kg	Live fish	RM/kg
Coral trout		Giant Trevally	
Sunnoh taising (long spot grouper)		Grouper	
Sunnoh hitam (High fin grouper)		Red snapper	
Grouper		Rabbitfish	
Humphead wrasse		Yellowtail scad	
Barramundi cod		Mackerel	

Lobster		Tuna	
Etc.		Ikan batu lain	

22a. Do you sell all of your catch? Yes/No

22b. How many kilos do you keep for yourself? _____kg; What kind? ________

22c. What will you do with fish which are not sold?
Make as bait _____ Eat _____ As fish food (feed grouper and other live fish) _____

23a. How much is your average cost for fishing in one month?

23b. Is the cost mentioned above including petrol?

23c. Petrol cost for one time fishing at
(i) SIMCA: RM _______ (ii) Usual fishing ground: RM _______

G. Perceptions about MPA

24. Do you know about SIMCA?

25a. Has SIMCA affected your fishing activities?
Yes ___ (go to 25b) No ___ (go to 27)

25b. How did SIMCA affect your fishing activities?

26. What kind of benefits do you think fishermen can obtain from marine protected areas?

27. Do you agree with formation of MPAs?
Yes ___ Why?
____
No ___ Why?
____

28. Do you think that MPAs like SIMCA are needed at other places in Sabah? Why?

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APPENDIX 3: LIST OF TABLES

TABLE 1: GENERAL DESCRIPTIONS OF SELECTED FISHING VILLAGES. 8

TABLE 2: DESCRIPTIVE STATISTICS FOR THE FISHERMEN'S AGE, FISHING EXPERIENCE, BOAT LENGTH, AND LENGTH OF TIME USED. 11

TABLE 3: DESCRIPTIVE STATISTICS FOR FISH CATCH PER TRIP (KG) IN 3 PERIODS: 2010, 2003-2009, AND BEFORE 2003. 11

TABLE 4: DESCRIPTIVE STATISTICS FOR FISHING EFFORT: NUMBER OF HOURS FISHING A DAY AND NUMBER OF DAYS OF FISHING A MONTH IN THREE TIME PERIODS. 12

TABLE 5: COMMON FISHING GROUNDS FOR FISHERMEN FROM BOTH VILLAGES. 13

TABLE 6: SUMMARY OF RESPONDENTS' FISHING GEAR, TARGETED FISH, HOURS SPENT FISHING PER TRIP, NUMBER OF DAYS PER FISHING TRIP, NUMBER OF FISHING TRIPS PER MONTH, AND CATCH PER TRIP. 18

TABLE 7: GROSS AND NET INCOME FOR SMALL-SCALE FISHERMEN. 22

TABLE 8: GENERAL DESCRIPTION OF THE REEF SITES SELECTED FOR THE FISH BIOMASS SURVEY. 27

TABLE 9: ONE-WAY ANALYSIS OF VARIANCE OF TOTAL FISH BIOMASS BETWEEN SITES AT DIFFERENT LEVELS OF PROTECTION (1, 2 AND 3). 30

TABLE 10: MEAN, STANDARD DEVIATION (SD), MAXIMUM (MAX), AND MINIMUM (MIN) TOTAL BIOMASS (G/250M2) OF ALL FISH FAMILIES ACROSS THREE LEVELS OF PROTECTION. 30

TABLE 11: SERRANIDAE SPECIES FOUND AT EACH LEVEL OF PROTECTION. 32

TABLE 12: LUTJANIDAE SPECIES FOUND AT EACH LEVEL OF PROTECTION. 34

TABLE 13: MEAN, STANDARD DEVIATION (SD), MAXIMUM (MAX), AND MINIMUM (MIN) TOTAL BIOMASS (G/250M2) OF SCARIDAE ACROSS THREE LEVEL OF PROTECTION. 35

APPENDIX 4: LIST OF FIGURES

FIGURE 1: THE SUGUD ISLANDS MARINE CONSERVATION AREA 5

FIGURE 2: LOCATION OF FISHING VILLAGES. MAP SOURCE: CMAP 9

FIGURE 3: CATCH PER TRIP (KG) PROPORTIONALLY DECREASED FROM 2003, 2003 – 2009 AND 2010. 11

FIGURE 4: EARNING PER MONTHS OF FISHERMEN AT KAMPUNG MEMAHAT AND KAMPUNG KENIONGAN FROM 2003, 2003-2009 AND 2010. 13

FIGURE 5: FISHERMEN'S PERCEPTION OF SIMCA AND THE ESTABLISHMENT OF MPAS. 14

FIGURE 6: DISTRIBUTION OF RESPONDENTS ACCORDING TO THE PLACE WHERE THEY WERE ENCOUNTERED. 16

FIGURE 7: MAJOR FISHING GROUNDS OF THE RESPONDENTS. 19

FIGURE 8: LOCATION OF SURVEY SITES. 28

FIGURE 10: THE PERCENTAGE CONTRIBUTION (%) OF FISH FAMILIES TO TOTAL BIOMASS AT EACH LEVEL OF PROTECTION. 31

FIGURE 11: PROPORTIONAL DECREASE IN TOTAL BIOMASS (G/250M^2) OF SERRANIDAE ACROSS THREE LEVELS OF PROTECTION. 31

FIGURE 12: PROPORTIONAL DECREASE OF TOTAL BIOMASS (G/250M^2) OF LUTJANIDAE FOR THREE LEVELS OF PROTECTIONS. 33

FIGURE 13: PROPORTIONAL DECREASE OF TOTAL BIOMASS (G/250M^2) OF CAESIONIDAE FOR THREE LEVELS OF PROTECTIONS. 34

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