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Live Grouper Fisheries and Population Assessment Using Fishery-Dependent and Non-Fishery-Dependent Indicators: Northwest Sulu Sea, Philippines

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ABSTRACT

The LRF in the Philippines started in the 1970s. The influx of traders and fishers to the Calamianes Islands contributed to the overharvest of groupers in the area. While LRF in the southwest of the Sulu Sea started in Talakanen Island, Taytay Bay, in 1997, the "Boom and Bust" trend in fisheries threatens the populations of target valuable species due to overharvesting. Survey studies are essential for fisheries management, but only a few studies were conducted in the West Sulu Sea. This study aimed to document the LRF of the Northwest Sulu Sea and use fisheries dependent and non-fisheries dependent methods to assess the population of *P. leopardus* in the area. Fisheries dependent and non-fisheries dependent methods were used to determine CPUE, population size structure, abundance, and composition of grouper LRF species. The fishing grounds of LRF were in the inner portion of the bay during Northeast Monsoon, while extended to outer portions during Southwest Monsoon. Three kinds of handlines were used to catch groupers: Sibid, Undak, and Latak. The duration of fishing was categorize as Sibid (half-day), Balikan (within the day), and Dayo (multiple days). There was a low number of mature *P. leopardus* in the area. Twelve species of serranids compose the LRF. The average size of *P. leopardus* significantly decreased from 33.5cm in 2010 to 16.0cm in 2015. The CPUE of *P. leopardus* remarkably decreased from 89.0g in 2010 to 25.0g per hour/fishers in 2015. The population of *P. leopardus* in the Northwest Sulu Sea showed signs of depletion.

Keywords: species management, length and weight conversion, live food fish.

INTRODUCTION

The live fish trade began in the mid-1970s in countries that were close to Hong Kong, China, like the Philippines. The majority of Live Reef Food Fish (LRFF) are imported into Hong Kong, China, either for local consumption or for transhipment to the Peoples Republic of China (PRC) (Sadovy et al., 2003). The trade has since spread further through Southeast Asia and into the Southern Pacific. This is most likely due to resource fish stock depletion in the target fish species (WWF, 2011). Trade-in LRF has evolved over the years. In the 1970s, many of the live groupers in Hong Kong, China were supplied from the South China Sea and the Philippines. However, by the 1980s, live groupers were increasingly sourced from Indonesia and Malaysia. By the 1990s, live fish

sourcing had extended to the Maldives, Papua New Guinea, Fiji, the Solomon Islands, and other Pacific islands. By 2009, the natural source has become too scarce that Hong Kong, China, has to source live reef food fish from more countries and territories in the Pacific and Indian Oceans (Sadovy et al., 2003). These fish are served for dinner in high-end restaurants in the center of LRF trade, mainly in Southern China or Hong Kong (To, 2009).

In the Philippines, the collection of live fish for food was recorded in the 1970s (Sadovy et al., 2003), while Padilla et al. (2003) claimed that it originated at the southern tip of Samar Island in the 1980s. In the same decade, it spread to other parts of the country, including the Coron Island in the Calamianes of Palawan Province. The economic potential of the industry brought traders to the Calamianes Islands together with fishers from other provinces (Padilla et al., 2003) of the Philippines. This has increased the fishing effort on valuable food fish of Palawan–groupers (Gonzales, 2000), especially red grouper (*P. leopardus Lacepède*), hence, might have contributed to the fast depletion and overharvest of grouper populations in the waters around the Calamianes Islands, Palawan. Unfortunately, in the late 80s, the LRF industry of Coron, Palawan, was declared on the verge of collapsing (Mamauag et al., 2000).

On the other hand, Live Reef Fisheries (LRF) in the southwest of Sulu Sea started in Talakanen Island, Taytay Bay in 1997, extending southwards of Palawan, in the municipalities of Roxas (Green Island Bay), San Vicente (Pagdanan Bay), Quezon (Malanot Bay) and Bataraza (Coral Bay). The "Boom and Bust" nature of the live fish industry has forced fishers to travel more distances in order to continuously harvest the same species in extended areas of the original fishing grounds. This is a popular situation among fishers who employ hunting as a source of income. The above situations are triggered either by too much effort in near-shore fishing areas and or depleted fish resources in the area?

This is also the case of Taytay Bay LRF, according to Palla et al. (2015), where fishers have to venture as far as Nangulao, Linapacan Island, while some venture to waters of Coron to gather young *P. Leopardus*. To the fishermen, farther fishing ground means a lengthier periods of fishing trips that result from increasing in overhead cost, time, and efforts.

With this trend, it is likely that other area of LRF will follow the plight of Coron if improper and unsustainable harvesting is continuously practiced and mitigating actions are not seriously taken. The present rate of exploitation and gathering practices and trends in other LRF areas make them likewise vulnerable to the collapse of grouper stocks in their respective areas (Palla et al., 2015).

Although studies on the status of fisheries are essential as bases for decision making in the management of fisheries, only a few studies in the West Sulu Sea were conducted. Palla et al. (2015) worked on CPUE of different fishing gears in the Taytay Bay. Gonzales et al. (2014) assessed the marine resources of Apulit Island of Taytay Bay for management purposes, Gonzales and Gonzales (2016) analyzed the trends of coral, fish, and fisheries against human developments in Coral Bay, Southwest of the Sulu Sea. A few integrated fisheries management works in the West Sulu Sea were done in Honda and Puerto Princesa Bays, Puerto Princesa City (Gonzales, 2004; Gonzales et al., 2014). Schroeder (1980) and Balisco and Dolorosa (2019) listed the fishes and reef-associated fishes of the West Sulu Sea, respectively. On the other hand, Mishina et al. (2006) studied the reproductive biology of blacktip grouper *Epinephelus fasciatus* in the Sulu Sea. On the other hand, Balde et al. (2019) and McGovern et al. (1998) used fishery-dependent length-based indicators for improved management, while Gonzales (2000a) and Palla et al. (2018) provided the length-weight relationships of Palawan groupers and marine species, respectively.

OBJECTIVES OF THE STUDY

This study generally aimed to document the LRF of Northeast Sulu Sea and assess the status of the *P. leopardus* population in the area. Specifically aimed to: (1) identify and describe LRF fishing gears and methods used in the fishing grounds; (2) identify LRF fishing grounds in the area during the Southwest and Northeast Monsoons; (3) identify species composition of LRF, and determine CPUE of *P. leopardus* in the area; (4) know the numerical abundance of young and adult *P. leopardus* individuals in the catch; and (5) provide insights on the management of LRF in the northwest Sulu Sea.

METHODS

Data on fishing gears and methods were directly observed on-board different types of red grouper fishing boats. The data were augmented by personal interviews with fishers in both Northeast and Southwest Monsoons. The locations of fishing grounds were noted and recorded on-situ, using a Global Positioning System (GPS) and were depicted in the map.

Fisheries dependent and non-fisheries dependent methods were used to determine the Catch per Unit Effort (CPUE), population size structure,

abundance, and composition of grouper LRF species in the Northwest Sulu Sea. The fishery-dependent method used the on-board data collection and fish landing assessment, while the fishery-independent method used the underwater fish visual census (FVC) technique (English et al., 1994). On-board data collection, fish landing assessments, and fish visual census data were gathered from June 2012 to November 2015. The formula used to compute for CPUE was: CPUE = total categorized weight of sample / no. of boats / trips x no. of fishermen x no. of hrs. Fishing. Catch per boat per day = weight of catch/number of boat/number of the day.

Fishery-dependent method: For the fishery-dependent method, data was gathered on-board fishing boats and in fish landing areas. Data on fish catch was gathered on-board *P. leopardus* fishing boats from June to October 2012 (Southeast Monsoon) and from November 2012 to January 2013 (Northeast Monsoon). Fish biomass, sizes, species composition, and the number of fishes were recorded for both fish landing and on-board data gathering. This study adopted the fish weight categories practiced by the local industry, where over-sized fish was more than 1.0 kg in weight; good-sized fish were between 0.5 kg and 1.0 kg and, under-sized fish were less than 0.5 kg. Undersized fishes were further classified according to their rounded-off weights: 40g; 50g; 100g; 200g; and 400g, respectively. Data collection for live fish landings of *P. leopardus* in Biton and Paly were conducted from September to November of 2015 and from April to November of 2016.

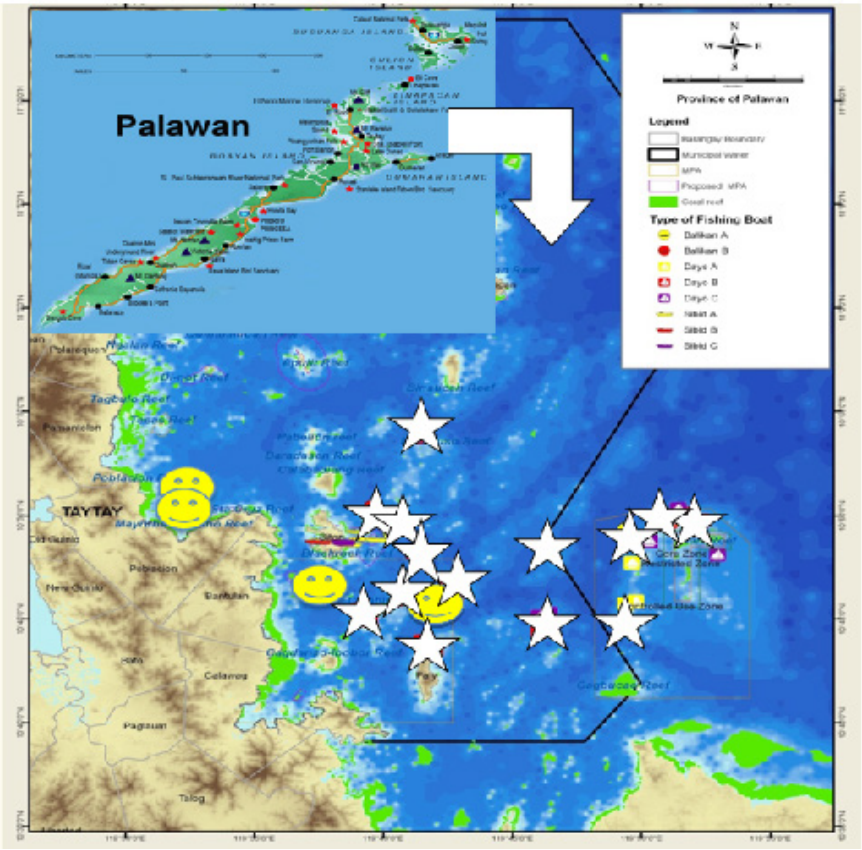

Figure 1. Map of Taytay Bay, Palawan, showing locations of LRF fishing grounds during Southwest Monsoon (star) and Northeast Monsoon (oblong). (Base map by WWF and Palawan-resorts-map.png)

Non-fishery-dependent method: FVC was used to gather data in non-fishery-dependent method in four coral reef sites in Taytay Bay: Biton Island, Black Rock Reef, Maliao Reef, and Tecas Reef from October 3 to 5, 2015. The species composition of grouper species in LRF were identified using Heemstra and Randall (1993) and Gonzales (2000b). Benthic life forms and fish visual censuses method followed English et al. (1994), where Line Intercept Transect (LIT) was used.

In order to increase the cover area of the fish census for *P. leopardus*, we extended the fish census area to 5m instead of 2.5m at both sides of the transect

line, which covered a wider area of 10m compared to the standard 5m area of English et al. (1994). A 100m transect line was used in each station, having 3 replicates of 30m in length.

RESULTS AND DISCUSSION

Evolution of LRF in Taytay Bay, Palawan: According to senior fishermen in the bay, the Live Reef Fisheries in Taytay Bay started when a trader began to buy live good size groupers kept in aquaria in Talakanen Island in 1997, while the use of floating cage to keep good size live groupers started in Biton Island in 1998 and culture from undersize to good size fishes started in the same island in the year 2000.

The live fish cage fishery in Biton Island, initiated after local fishers attended extensive training on Non-traditional Education for Middle–level Coastal Resource Managers of Palawan in the summer months of 1998, conducted by a local fisheries college based in Puerto Princesa City, the State Polytechnic College of Palawan - Aquatic Science and Technology Institute (SPCP-ASTI), now the Western Philippines University (WPU), funded and co-organized with the NGO Tambuyog Inc., where fisher-participants gained knowledge and skills on using fish cages for livelihood as one of the main topics of the training (Salva and Gonzales, 1997).

Another island in Taytay Bay named Paly is currently known for red grouper live reef fisheries. According to fish traders, Biton Island supplies 80-85% of juveniles and young live fishes to Paly Island for grow-out in cages. Biton LRF fishers gather undersize fishes not only in Taytay, but also from other parts of the country and sell it to Paly Island fisher-cagers.

Fishing Grounds, Gears, and Methods: The fishing grounds of LRF in Northwest Sulu Sea during the Northeast Monsoon (Amihan) period were located in the relatively inner portion of Taytay Bay (Figure 1), while during Southwest Monsoon (Habagat), fishing activities to Malapuso in the north, Biton in the west, Hart Reef in the east (partly municipality of Araceli), and Paly in the south were observed. The main fishing grounds for LRF in the Northwest Sulu Sea for the whole year were waters of Biton, Paly, and Hart Reef, and generally the inner bay during Northeast Monsoon and the outer bay during Southwest Monsoon.

The main fishing gear used to catch red groupers during Northeast Monsoon was handline (Undak; Table 1), and the fishing trip type was "Within the Day" (Balikan; Table 2). The Table 1 presents the range of fishing grounds of this gear

in Taytay Bay and their descriptions. The Balikan was the main method used in major fishing grounds like vicinity of Biton Island and areas between Biton and Hart Reef, and sometimes used in Calabucan, Paly, and Laot ng Paly (offshore of Paly Island). Fishers did not use Dayo method during Northeast Monsoon, due to strong winds. They popularly used the Undak handline, of which they returned home within the day - Balikan method (Tables 1 and 2). The fishermen departed at 6 am and returned at 4 pm (10hr fishing trip).

LRF Species Composition: Twelve species of groupers belonging to four genera were recorded during the actual assessment: *Anyperodon*, *Cephalopholis, Epinephelus*, and *Plectropomus* and twenty-four by-catch species are belonging to 16 genera (Table 5).

Numerical Abundance: Results of FVC revealed that four stations have similar fish family diversity (Table 6). Biton station has the highest species diversity of 54, while Black Rock has the lowest of 37 species. Biton Station has the highest fish biomass, while Tecas Reef has the lowest. These differences can be attributed to the coral reef condition in the stations wherein Biton has a higher percent cover than Tecas. Furthermore, Reefs in Tecas were dominated by algae, while Biton has relatively healthy and diverse reef, as shown in our benthic lifeform assessment (not presented in this study).

Table 1

Local name, description, and fishing grounds of different handline gears used to catch grouper species in the bay during the Southeast Monsoon months

Gear	Description	Fishing Ground
Sibid	Balahibu (chicken feather lure), with hook	Vicinity of Biton Island
Undak	Balahibu (chicken feather lure), with rubber band and hook	Between Biton and Hart Reef
Latak	uses chopped fish bait and hook	Hart Reef

Table 2

Three methods of fishing used for LRF in Taytay Bay, with corresponding time duration, type of banca used, and the number of fishers during Southeast Monsoon months

Methods	Dep. Time	Arrival time	No. of Days	Banca type	No. of fishermen
Sibid (Halfday)	5:00 am	12:00 nn	½ day	Non-motorized	1
Balikan (Within the Day)	6:00 am	4:00 pm	Within a day	Motorized	1
Dayo (Multiple Days)	5:00 am	3:00 pm	3 days	Motorized	8

On the other hand, Biton Station has the highest number of *P. leopardus* observed through FVC (Table 7). Sixteen *P. leopardus* individuals were observed in Biton Station having a density of 16/1000m2, while zero in Maliao Station (Table 7). Groupers *P. oligacanthus* and *A. leucogrammicus* were also observed in the area. Mature fishes were observed only in Tecas Reef and Biton Stations (Table 8). Twelve handline fishers were observed in Black Rock, while three in Tecas and Maliao Reefs during the survey, indicating that these areas were still fishing grounds for *P. leopardus*.

The above results show that a large portion of *P. leopardus* caught in the bay were immature, which have not reached their maturity stage of 0.5 kg and above, the size / weight of matured red grouper individual is 500 kg and above (good-size) (Palla, 2011). Hence, under-sized fishes caught were not mature and have not yet started to spawn, hence have not contributed to the number of the wild fish population when removed from its natural environment.

Over-exploited fishing on adult individuals has a negative effect on the reproductive component of the population. The capture of a large proportion of juvenile or young adults - most groupers were females at this time - changing sex as they grow (Shapiro, 1984, Mishina and Gonzales, 1994; Gonzales, 2005; Mishina et al., 2006), which potentially reduce the reproductive population (Sadovy, 2003).

Table 3

CPUE of P. leopardus in two monsoons from on-board monitoring 2012-2013

Monsoon	Total weight caught (g)	Effort, total hr/ trip	No. of fishermen/ boat	Catch/ fisherman/ hr
Southwest (Habagat)	8,100	40	1	202g/fisher/hr
Northeast (Amihan)	27,240	309.6	1-8	89g/fisher/hr

Table 4

Catch Per Unit Effort of live P. leopardus landed in Biton and Paly Islands from September to November 2015. TC= Total Catch; C/B/T= Catch/Boat/Trip; C/B/D = Catch/ Boat/Day; C/B/H=Catch/Boat/Hour; g/F/H= grams/fisher/Hour; kg/F/H= kilograms/Fisher/Hour

Month	TC (g)	C/B/T	C/B/D	C/B/H	g/F/H	kg/F/H
Sep	418,100	5,650	1,883.333	188.3333	28.97436	0.028974
Oct	504,600	6,818.919	2,272.973	227.2973	34.96881	0.034969
Nov	150,200	2,029.73	676.5766	67.65766	10.40887	0.010409
Total	1,072,900	14,498.65	4,832.883	483.2883	74.35204	0.074352
Ave.	357,633.333	4,832.88333	1,610.9611	161.09611	24.7840133	0.024784

Table 5

List of live grouper species and by-catch species caught by handlines in Taytay Bay and Hart Reef

Grouper Species	By-catch species
1. *Anyperodon leucogrammicus*	*Abalistes stellaris*
2. *Aethaloperca rogaa*	*Balistapus undulates*
3. *Cephalopholis boenak*	*Caranx sexfasciatus*
4. *Cephalopholis cyanostigma*	*Caesio xanthonotus*
5. *Cephalopholis microprion*	*Cheilinus chlorourus*
6. *Epinephelus fasciatus*	*Cheilinus fasciatus*
7. *Epinephelus maculatus*	*Choerodon anchorago*
8. *Epinephelus merra*	*Gymnocranius frenatus*
9. *Epinephelus ongus*	*Labracinus cyclophthalmus*
10. *Plectropomus maculatus*	*Lethrinus ornatus*
11. *Plectropomus oligacanthus*	*Lethrinus lentjan*
12. *Plectropomus leopardus*	*Lethrinus erythropterus*
13.	*Lutjanus spp*

Table 5 continued

Grouper Species	By-catch species
14.	*Lutjanus corponotatus*
15.	*Lutjanus vita*
16.	*Oxycheilinus diagrammus*
17.	*Parupeneus spp*
18.	*Parupeneus cyclostomus*
19.	*Pentapodus emeryii*
20.	*Pentapodus macrurus*
21.	*Scolopsis xenochora*
22.	*Scolopsis affinis*
23.	*Synnodontidae*
24.	*Thalassoma lunare*

Table 6

Numbers of fish family, species, individuals, target species, major family, indicator species, biomass and number of P. leopardus per (500m²) station surveyed through FVC in this study

Station	Family	Species	Indv.	Target species	Major family	Indicator species	Biomass (mt/km²)	No. of *P. leopardus* ; (length in cm)
Black Rock	11	37	684	13	14	10	130.68	3 (20)
Biton	9	54	1226	12	11	31	281.38	5 (18)
Maliao	11	47	765	10	20	17	88.7	-
Tecas	9	38	624	8	13	17	69.66	2 (20)

Table 7

Station, water depth, number of individuals and estimated length of grouper LRF species observed through FVC in 1000m2 area per station and density of P. leopardus in the area

Station	Depth (m)	Grouper Species	No. of Indiv.	Estimated Length (cm)	Estimated density/10,000m²
Black Rock	9	*P. leopardus*	1	8	6
			1	12	
			1	15	
			3	20	
		P. oligacanthus	1	8	

Table 7 continued

Station	Depth (m)	Grouper Species	No. of Indiv.	Estimated Length (cm)	Estimated density/10,000m^2
		A. leucogrammicus	1	20	
		other species	3	5	
Biton	3-7	*P. leopardus*	2	17	**16**
			1	29	
			3	20	
			1	15	
			1	12	
			1	5	
			6	18	
			1	10	
		A. leucogrammicus	1	12	
			1	20	
		P. oligacanthus	2	18	
			2	15	
			2	13	
Maliao	6-10				0
		P. oligacanthus	1	12	
			1	15	
			9	18	
Tecas Reef	23				3
		P. leopardus	2	20	
			1	40	

The results indicated that fishers did not catch good-sized red grouper during the Northeast Monsoon period, and only a minimal number of good-sized fish during Southwest Monsoon. Indicating that there are no or very few numbers of mature *P. leopardus* present in the fishing grounds, and the limited number of adult fish may not be enough to replenish the natural population size of the species.

Table 8

Number of mature and young P. leopardus observed through visual census in each station (change to graph)

Station	Young	Mature (>39 cm or 500g)
Black Rock	6	0
Biton	15	1
Maliao	0	0
Tecas	2	1

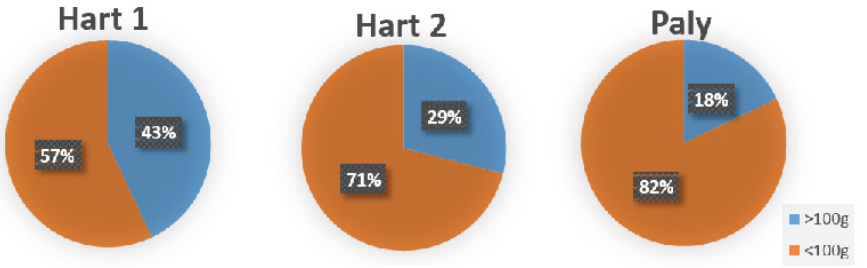

Figure 2. Abundance in percent (%) of red grouper individuals weighing 100g and below caught in one fishing trip at Paly Island and two trips at Hart Reef: Southwest Monsoon months.

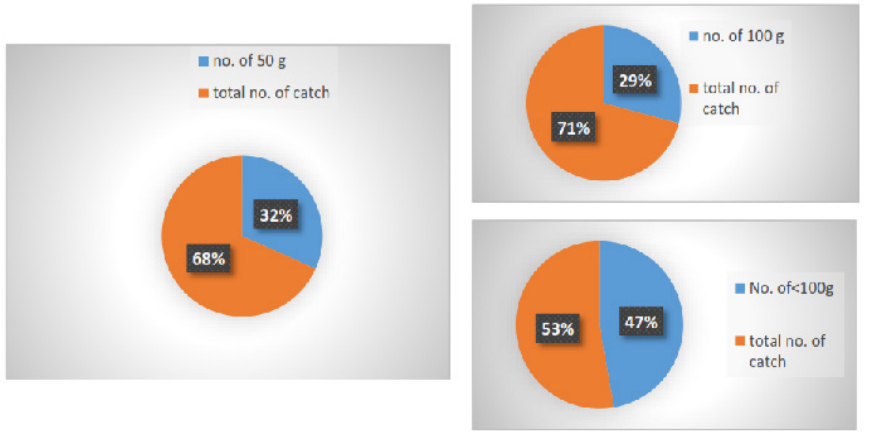

Figure 3. Percent distribution of 50g and less individuals of red grouper caught in Taytay Bay during Northeast Monsoon months.

The scarcity of mature *P. leopardus* individuals in the wild was during Southwest Monsoon (June to October) and Northeast Monsoon (November to January) months. Thus it can be concluded that the mature *P. leopardus* individuals in the area are few whole-year rounds.

Fish Size at Landing: The mean length represents the average size of the fish species in a population. The mean weight of *P. leopardus* in fish landing data was 250g, while the mean length was 16cm, n=4475 (Table 9). The mean length of *P. leopardus* population in Taytay Bay, the Sulu Sea recorded in 2010 was 33.5cm, while the weight was 611.1g (n=355); while in the West Philippine Sea, the mean length was 38.2cm, and the mean weight was 757.4g (Palla 2011). The mean

length of *P. leopardus* in Northeast Sulu Sea has decreased to a little more than1/2 from 33.5cm in 2010 to 16.0cm in 2015 (Table 9), indicating that the average size of *P. leopardus* in the area has significantly decreased within five years. This implies that number of juveniles and young were present in the wild population than parental fish (Table 10). Having a small number of parents in a population will result in less recruitment of offsprings that may eventually deplete the stocks.

Eighteen to 43% of *P. leopardus* caught during on-board monitoring in Southwest Monsoon months were 100g or less in sizes (Figure 2), while 27-49% were 50g or less in Northeast Monsoon fishing (Figure 3). Using the conversion table between weight and length of *P. leopardus*, 50g is equivalent to 16.38cm fish (Table 11), hence immature.

Catch per Unit Effort: In the on-board monitoring, the CPUE of Undak-balikan catching red grouper during Northeast Monsoon was 89 g/hr/fisherman, which was much lower than that of Southwest Monsoon (202 g/hr/fisherman) (Table 3), Paly (Tandol) have the most catch among the fishing grounds during Northeast Monsoon, while Hart Reef during Southwest.

The fish landings' CPUE gathered from the three-month (September to November 2015) full enumeration in Biton Island revealed that the average CPUE of live *P. leopardus* was 0.025 kg or 25.0 g/hr/fishers. Which is around 3.5 times less than the 0.089 kg or 89.0 g/hr/fisherman during Northeast Monsoon in Taytay Bay in 2010 (Palla et al., 2015).

Table 9

Mean length and weight of live P. leopardus landed in Biton Island, 2015. N=4475

Month	Mean Weight (g)	Mean Total Length (cm)
September	234.7558	15.34121
October	233.936	15.45058
November	279.702	17.17914
Ave.	249.4646	15.99031

Table 10

The numerical abundance of live young and mature red groupers landed in Biton Island, 2015

Month	Young	Adult	Total	% Adult	% Young
September	1761	43	1804	02.3836	97.6164
October	1739	444	2183	20.339	79.661
November	393	149	542	27.4908	72.5092
Ave.	3631	212	1509.7	16.7378	83.2622

Table 11

Conversion table of Weight (W) to Total Length (TL) of P. leopardus from 50g to 1000g, as used by LRF fishers in Taytay Bay, Palawan, based on a and b values of P.

Weight (g)	Length (cm)	Weight (g)	Length (cm)
50	16.38	550	34.91
100	20.38	600	35.88
150	23.17	650	36.80
200	25.37	700	37.67
250	27.22	750	38.50
300	28.83	800	39.29
350	30.27	850	40.05
400	31.57	900	40.78
450	32.77	950	41.48
500	33.88	1000	42.16

Since live fish is sensitive to direct contact of a human hand, it was difficult to measure the length of live fishes in this study. Furthermore, it is an industry practice to measure the live fish catch by weight rather than length. Hence, this study provided a conversion table from weight to length and vice versa of *P. leopardus* presented in Table 11. This table will be useful to LRF practitioners to estimate the length from a given weight of an individual fish and vice versa. The *a* and *b* values in this study was derived from the specimens that came from Taytay Bay of Palla (2011).

Fishery management: The scarcity of mature individuals, the significant decrease in the average length and decrease in CPUE of *P. leopardus* indicate a depleting population in the Northeast Sulu Sea. The length at maturity is one

of the indicators for the fish population under pressure. High fishing pressure cause to increase growth rate at smaller size (Gulland, 1983) and reduce size at maturity (MacGovern et al., 1998), hence it is also necessary to know the current data on size at maturity of *P. leopardus* in the area in order to further infer on the condition of the population.

However, if we use the length at maturity of *P. leopardus*, which was (L50) 39cm in Taytay Bay, Sulu Sea (Palla, 2011), the size regulation at that time should be 40cm and 850g> (Table 11) of which was not implemented. The current status of the *P. leopardus* population in the Northwest Sulu Sea with smaller average size and CPUE and the scarce number of matured individuals in the catch attributed to the non-regulation of catches of mature fishes five years ago, 2010. Hence, if we wanted to determine the size regulation of *P. leopardus*, we should determine the current size at the maturity of the fish species.

Plectropomus leopardus matures at the length of 38cm TL in the waters off Quezon, Palawan (West Philippine Sea), which is similar to the population in Taytay Bay (39 cm TL). There are two spawning peaks of *P. leopardus*: in the months of December-February and July-August in Taytay Bay, while November-January and July in Quezon (Palla, 2011). If a close season is an option for management, the policy makers should choose only one of the peak-months in order to give the fishers a chance to still fish as their source of income, while continuous monitoring of the fish stocks should be done.

CONCLUSIONS

The fishing grounds of LRF in Taytay Bay during the Northeast Monsoon period was in the inner portion of the bay, while during Southwest Monsoon, fishing was extended to Malapuso in the north, Biton in the west, Hart Reef in the east (partly municipality of Araceli), and Paly in the south. There were three kinds of handlines used to catch groupers: Sibid, Undak, and Latak. Fishing trips fishing were classified as Sibid (half-day), Balikan (within the day), and Dayo (multiple days). Fishermen did not use the Dayo method during Northeast Monsoon. Twelve species of serranids (groupers) composed the LRF of Northwest Sulu Sea, three of which belong to Genus *Plectropomus*, the LRF genus. The average size of *P. leopardus* in the Northwest Sulu Sea has significantly decreased compared to that of the 2010 population. Further, estimated CPUE of live *P. leopardus* in the area has remarkably decreased compared to 2010. The population of *P. leopardus* in the Northwest Sulu Sea shows signs of depletion.

RECOMMENDATIONS

1. Conduct of Socio-economic studies on LRF on the islands of Biton and Paly;

2. There should be alternative species for LRF to ease pressure on *P. leopardus*, a good candidate is Cromeleptis altivelis (Senyorita; Meshina and Gonzales 2006);

3. Conduct surveys of the length at maturity in order to gather more information. Study possible spawning in cages;

4. Ban trading of over-sized and undersized fishes; establish barangay-managed LRF-MPA at Biton Station and release over-size individuals in managed MPAs;

5. Dayo method should be discouraged, while encouraging the use of sibid; regulate LRF boat size;

6. Study on hook size and catch size relationship of grouper LRF;

7. Exploit LRF networks with other neighboring municipalities; and

8. Proper management should intervene to promote the use of most efficient gear and method, protection of identified fishing areas of good sources of red groupers, while protecting the remaining red grouper spawning guilds.

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