Determining harvest control reference points for near shore resources targeted for livelihood-linked approaches to sustainable fisheries in RARE project sites

Cantilan & Cortes, Surigao del Sur

by

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A. Introduction

RARE is implementing a GDA-funded project called "Harnessing Markets to Secure the Future of Near Shore Fishers" in various areas in the country with the overall goal of supplying high-valued species to high-end restaurants and hotels with fish caught through responsible fishing and proper post-harvest practices. To meet this goal, several conditions must be met including: viability of the supply; sustainability of harvesting; quality of post-harvest practices; and maximizing of benefits from the source to the market. Critical to determining these conditions is assessing the status of the stocks and their fisheries.

This study was implemented to provide a quick assessment of the stocks of target resources in the various project areas of RARE with the following objectives:

a) Compile and identify gaps in relevant scientific information on pre-identified target species
b) Conduct initial site surveys to verify target species and determine what and where to monitor and collect samples
c) Design a fisheries monitoring and catch sub-sampling scheme
d) Train field data recorders (enumerators) and field assistants
e) Determine Harvest Control Reference Points
f) Recommend measures to ensure sustainability of the target species

B. Materials and Methods

Monitoring of fisheries catch and effort as well as biological subsampling of catches were conducted in (i) Culasi, Antique, (ii) Ayungon and Bindoy, Negros Oriental, (iii) Looc and Lubang, Occidental Mindoro, (iv) Cantilan and Cortes, Surigao del Sur and (v) Tinambac, Camarines Sur (Fig. 1). The duration of monitoring ranged from two (2) to three (3) months, starting from April to July 2016. The general methods common to all sites are presented below, while specific methods are presented separately for each site.

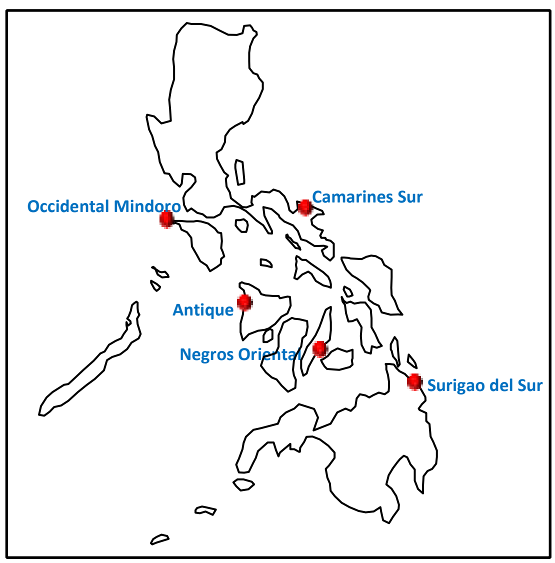


Figure 1. Map showing the location of areas monitored by RARE sites.

B.1. General Methods

The sequence of methods shown below (Fig. 2) was followed at each of the 5 sites:

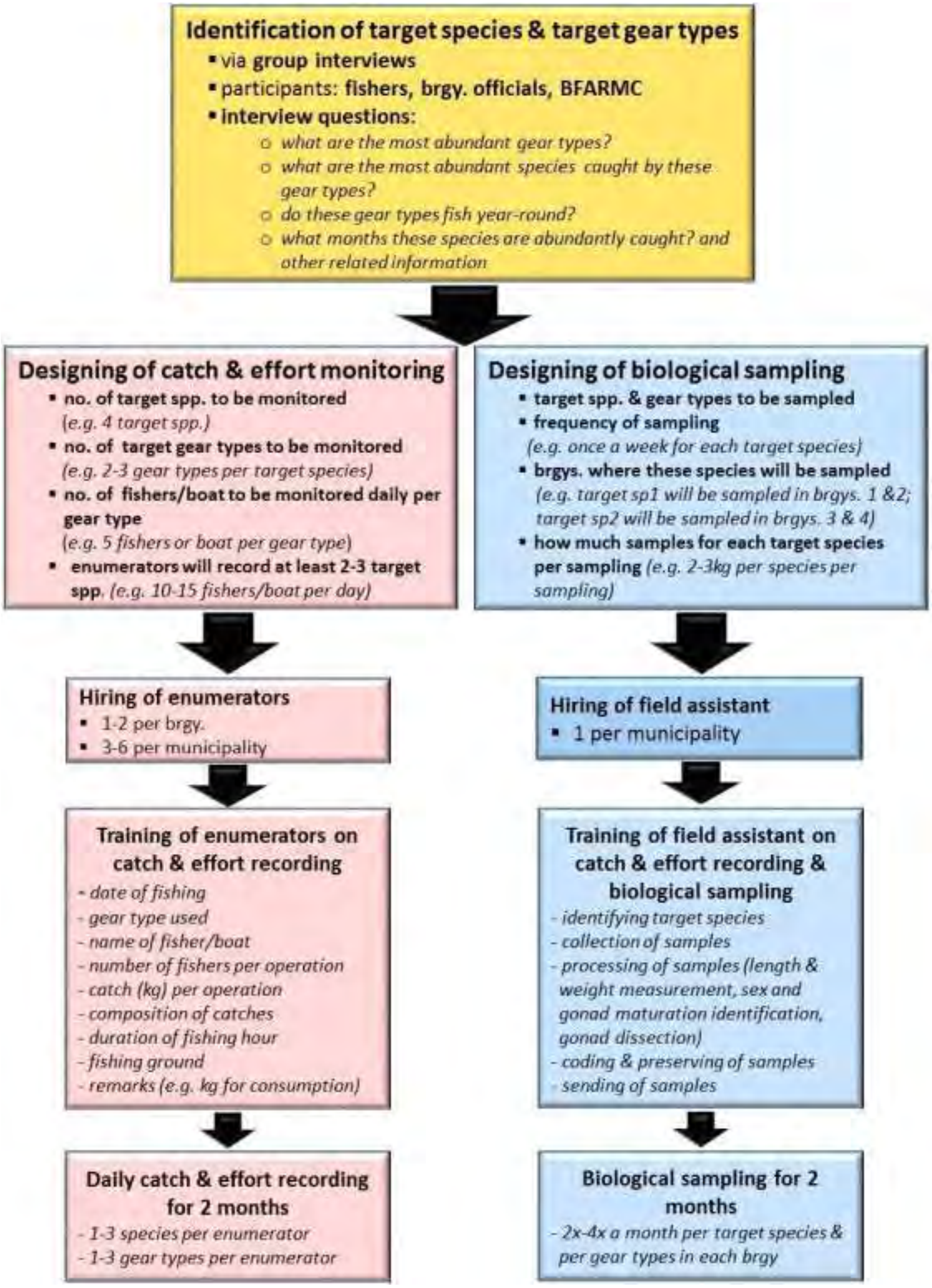


Figure 2. Flow chart showing how the monitoring and biological sampling schemes of the study were designed.

B.1.1. **Initial site visits were done to conduct FGDs and to meet with LGU staff and RARE local teams**. The purpose of the FGDs were to validate the information on target species and barangays to monitor, which were initially provided by RARE field staff and the LGUs.

Additional information gathered included specific fishing areas by gear type, landing sites and time, and a rough idea of number of fishers by target gear type.

B.1.2. **Design of catch and effort monitoring and biological sampling schemes.** After verifying information on most commonly-caught species, the gear types used to catch them, and where these gear types were operating from, monitoring sites and frequency of sampling were determined. In general, catch and effort for target species and gear types were monitored daily in at least 3-4 sitios in each of the 5 sites. Size measurements of about a kilogram of each target species in catches of the target gear types were done weekly, whereas samples for processing and examination in the lab were purchased also once per week.

B.1.3. **Hiring and training of enumerators and field assistants (FA).** In most sites, both enumerators and field assistants were recommended by the RARE local team and or the LGU (MAO). Both were trained to do their respective tasks during the initial visits to the sites. A detailed description on the scope of the training is presented in Figure 2. Enumerators were trained to record catch (kgs) and effort (number of fishers & fishing trip duration) of at least 5 operators (fishers or groups of fishers depending on gear) by gear type every morning. These and other related data were recorded in notebooks following the format and the guidelines

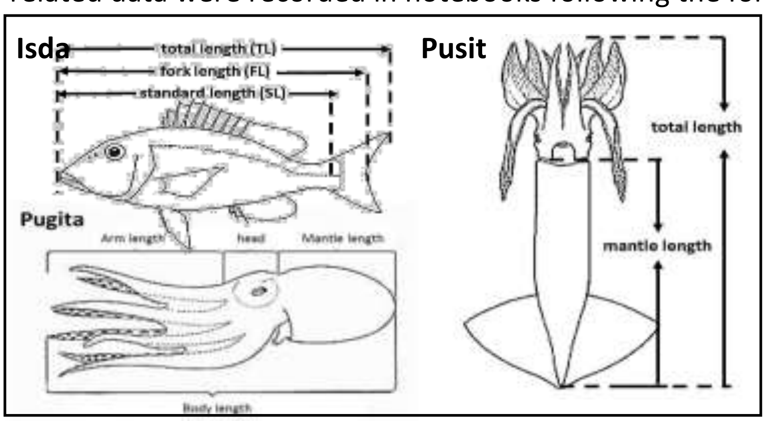
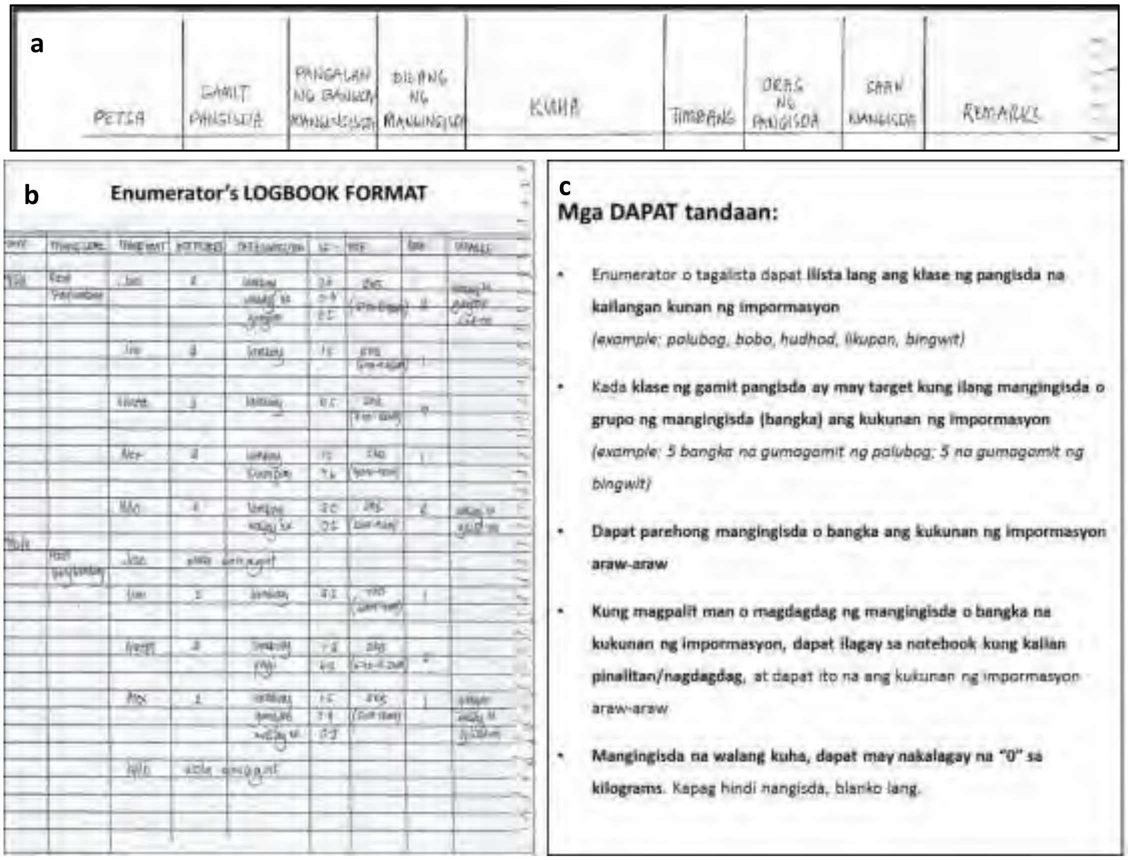


Figure 3. Different ways of measuring fish (*isda*), squid (*pusit*) and octopus (*pugita*).

shown in Fig. 4. In addition, enumerators measured specimens of target species (following Fig. 3) from catches of assigned gear types once a week. They also arranged for the regular scheduled purchase of samples from the fishers at the various monitoring sites. Field assistants, on the other hand, required a bit more skills and training. They did the initial processing of specimens from the field. These included verification of taxonomic identification of specimens from purchased samples, measurement of lengths and weights, and at least for some target species, determined gonad development stage following pictorial guides such as Fig. 5. After this initial processing, FAs dissected off the head, gonad and guts of each identified specimen, stored these in labeled plastic containers with 10% buffered seawater-formalin solution, packed and prepared the specimens for transport to the lab in Miag-ao. In addition, since the FAs were also present during the enumerators' training, they were also tasked with checking the catch and effort records kept by enumerators for inconsistencies and errors. FAs were provided with adequate funds to cover supplies needed for the initial processing of samples and transportation to cover all the sitios covered by the monitoring/sampling scheme.



a

PETSA	GAMIT PANGISDA	PANGALAN NG BANGKA/ MANGINGISDA	BILANG NG MANGINGISDA	KUHA	TIMBANG	ORAS NG PANGISDA	ARAW MANGISDA	REMARKS

b

Enumerator's LOGBOOK FORMAT

c

Mga DAPAT tandaan:

- Enumerator o tagalista dapat **ilista lang ang klase ng pangisda na kailangan kunan ng impormasyon**
  (example: palubog, bobo, hudhod, ilkupan, bingwit)
- Kada **klase ng gamit pangisda ay may target kung ilang mangingisda o grupo ng mangingisda (bangka) ang kukunan ng impormasyon**
  (example: 5 bangka na gumagamit ng palubog; 5 na gumagamit ng bingwit)
- **Dapat parehong mangingisda o bangka ang kukunan ng impormasyon araw-araw**
- **Kung magpalit man o magdagdag ng mangingisda o bangka na kukunan ng impormasyon, dapat ilagay sa notebook kung kailan pinalitan/nagdagdag**, at dapat ito na ang kukunan ng impormasyon araw-araw
- **Mangingisda na walang kuha, dapat may nakalagay na "0" sa kilograms**. Kapag hindi nangisda, blanko lang.

Figure 4. (a) Catch and effort format, (b) sample recording of catch and effort, and (c) some notes on proper recording of catch and effort.

Figure 5. Example of male and female gonads (*Decapterus macrosoma*) showing the different stages of maturation. Sizes in the pictures are proportional.

B.1.4. **A second site visit** was conducted about 1 month after the initial visit to further check on the recording of catch and effort and to correct any errors, to ensure that biological sampling and processing by field assistants was in accordance with what they were trained to do, and to collect the monitoring records and biological samples for transport to the lab in Miag-ao. Samples in subsequent weeks were sent to the lab for **validation and further analyses** (e.g. species, sex and gonad maturation, gonad weight measurement).

B.2. Harvest Control References

The short duration of the study poses limitations to the resulting estimates. Because not all seasons were monitored, and because many biological processes, such as maturation, spawning, recruitment and growth, are seasonal, the data may fall short of representing the status of the stock. To reduce these constraints, we supplement our estimates with those from other published work which covered longer study periods. In addition, data from monitoring under the RARE Fish Forever Program in two areas were made available to supplement data from this study. With these measures, we provide best estimates based on available data.

After all the field and laboratory processing and data analysis, the fisheries and biological data are summarized and presented as harvest control references.

B.2.1 Size distribution of catches

This reflects the lengths of target species caught by the monitored gears during the study. Size frequency histograms are presented for each gear type to check for differences in size selectivity. This allows for formulating interventions that are specific to certain gear types and not necessarily to all. For example, if catches from a certain gear are dominated by small individuals (e.g., juveniles), regulations can be limited to only those gear types.

B.2.2. Size at sexual maturity

Histograms showing gonad maturity stage proportions by size class for each target species (across all gear types monitored) were constructed to show at what size the onset of maturity sets in (i.e., the *size of the smallest mature individual* recorded, here in called L_m). The proportional distribution of mature fish across all size classes represents that portion of the stock that is able to spawn or what is called the spawning potential. The data were used to construct a cumulative frequency ogive, which in turn allowed estimating the "*size at first maturity*" (L_{m50}), or the size at which 50% of fish at that size are mature. The GeoGebra software was used to construct the ogive. L_{m50} has been used as a reference point for stock sustainability.

B.2.3. Growth

The age at which the target species matures becomes an important reference point especially in heavily-fished fishing grounds, where fish are typically caught before they reach the age of maturity. Age can be estimated from size data if the population's growth is known. Since this study was designed to cover only 2-3 months, it was not possible to construct growth models for any of the target species. For many of them, however, growth models from different fishing grounds and from different years, are available from various reports and studies, including Ingles and Pauly (1984), Corpus et al. (1985), Lavapie-Gonzales et al. (1997) and Froese and Pauly (2016). For those without any available information, published growth curves for closely-related (congeneric) species were used as approximations. Aside from providing estimates of age, the parameters L_{∞} and K of the Von Bertalanffy Growth Model (VBGM), together with estimates of the instantaneous natural mortality rate (M) are used in reconstructing the stock's spawning potential (explained in next section). M is usually estimated when deriving total mortality rate of the stock. Again, the short duration of the study did not allow any mortality estimates. Since estimates of M are generally even less available than the growth parameters, it was estimated for most target species in the study using the general formula of Pauly (1980), relating natural mortality to growth and average ambient water temperature in the fishing ground:

$$\log M = -0.0066 - 0.279 \log L_{\infty} + 0.6543 \log K + 0.4634 \log T$$

where: M = instantaneous natural mortality rate (annual)

L_{∞} = asymptotic length of the VBGM

K = growth coeeficient of the VBGM

T = annual mean water temperature in the fishing ground (^{o}C)

B.2.4. Length-Based Spawning Potential Ratio (SPR)

As mentioned above, the length-based spawning potential of a stock is defined by the size or age distribution of mature fish. The spawning potential ratio (SPR) is the fraction of the stock's spawning potential that is not caught by the fishery (and therefore allowed to spawn). Hence, in an unfished stock, the SPR is 100% while values range from 0 – 100 for fished stocks. The more the overlap between the size distribution of fish caught by the fishery (including all gear types) and the size distribution of mature fish, the less the spawning potential left in the stock. SPR values between 20 – 40% are generally acceptable as sustainable for fished stocks. Actual SPR values based on size, maturity (L_{m50}), growth (K, L_{∞}) and natural mortality (M) data gathered on the target species were estimated using a web-based software accessible at http://barefootecologist.com.au/lbspr. Actual estimates of SPR are a function of the size distribution of fish in the catches. In this report we use L_{50}, the median of the projected size distribution of fish in the combined catches, as the reference point for adjustments in fishing, but we also present the L_c (the *length at first capture* or the size at which 50% of all fish at that size are caught by the fisheries) estimates from the accessed software since these are derived from the (size) selection curve of the combined gear types. L_{50} estimates were derived from the ogives fitted to the original size distribution data, and are more readily understandable and practical for management purposes. Hence, when the resulting actual SPR was below the set target minimum limit of 20%, the input size distribution was adjusted by sliding from one to several size classes to the right (i.e., by increasing L_{50} or L_c) until the minimum 20% SPR was attained. This necessarily corresponded to a larger size as the target "length at first capture".

B.2.5. Catch and effort data

Daily records of catch (*C*) and effort (*f*) were summarized to give estimates of mean values for catch rate (kgs/fisher/trip), number of fishers per trip and number of hours fishing per trip by fishing gear. Because stocks of targeted species are widely distributed, those species targeted by neighboring barangays or even municipalities are from the same stock. For this reason, C and f data for sites with common targets were pooled (by gear type) before the analysis. In this study, the term "fishing trip" includes going out to the fishing ground, actual fishing, and then returning to land the catch. In this study, all the targeted gear types in the various sites had one trip per day. Also, the term "catch rate" is used in this report in place of "catch per unit effort" to avoid confusion. The mean number of fishing days per month was computed per target fisher by gear type (at least 5 per barangay). This fishing frequency to multiply the total number of units of the targeted gear type, which the enumerators and the field assistants estimated thru interviews throughout the study, to estimate total fishing effort for the study period by gear type. The reason for keeping the number and identity of target fishers fixed (as much as possible) was to ensure reliable estimates of fishing frequency. The latter is important in providing estimates of total catch (= supply) as this reflects the market viability of the target species.

The total catch by target gear types for the months covered by the study is:

= *Kg/fisher/trip* X *no. of fishers/trip* X *no. of fishing days/months*
X *no. of months covered by the study*

Annual catch (C_{ann}) can be derived by multiplying the first 3 values above by 12 months, instead of the months covered by the study. However, this estimate assumes that the target species and the gear used to fish them are locally present in similar abundances throughout the year. Any seasonality in their abundance would invalidate this estimate.

Lastly, field enumerators and assistants were instructed to categorize catches into local names of the target species, with all catches of non-targets lumped into the "others" category. In sites where closely related species were difficult to differentiate in the field (e.g., clupeids and some siganids), the local common name for the group was used. These data were used to derive the species composition of catches in the study site.

B.3. Site-specific Methods: Cantilan & Cortes, Surigao del Sur

B.3.1. Monitored sites

Figure 6 shows the zoned map used in the monitoring in Surigao target areas. Zoning (grids) was done to show where fishing gears usually operate in the area, which may be used in formulating fisheries management plans. Cantilan and Cortes are the focal areas bordering Lanuza bay wherein from these municipalities, target barangays were monitored for daily catch and effort. These barangays include General Is. (including Ayoke Is.), Consuelo, Linintian and Magosilom in Cantilan and; Madreliño, Uba, Poblacion, Burgos, Taganungan and Mabahin in Cortes. These brgys were also the sites for weekly biological sampling. Duration of monitoring is from April 28-June 30, 2016 (2 months) in Cantilan and April 28-July 31, 2016 (3 months) in Cortes. The monitoring in Cortes was extended for a month due to less catch and effort records during the two-week fishing ban in May.

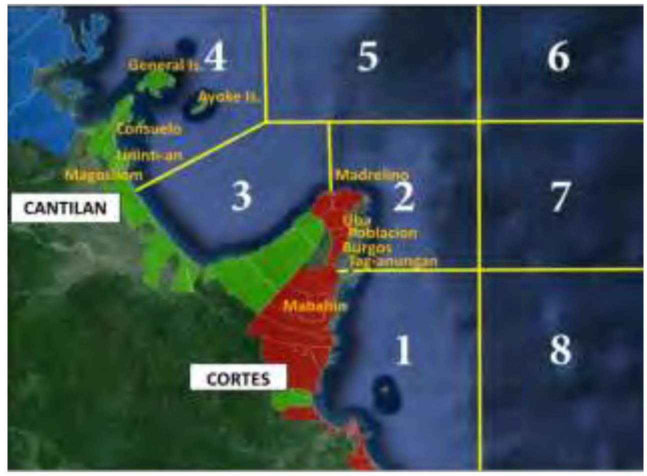


Figure 6. The zoned map of Cantilan and Cortes, Surigao del Sur used in the monitoring.

B.3.2. Target Gears and Species

The target species as well as the target fishing gears monitored in Cantilan and Cortes are shown in Table 1. Primary targets included 1 flyingfish species, *Cheilopogon arcticeps* (Family Exocoetidae); 2 species of rabbitfish, *Siganus canaliculatus* and *Siganus fuscescens* (Family Siganidae); 1 emperor species, *Lethrinus ornatus* (Lethrinidae) and 1 octopus species, Octopus cyanea (Family Octopodidae). Secondary targets, on the other hand, included 1 scad species, *Selaroides leptolepis* (Family Carangidae); 1 goatfish species, *Upeneus sulphureus* (Family Mullidae); 1 bream species, *Nemipterus nematopus* (Family Nemipteridae); 2 species of snappers, *Lutjanus lutjanus* and *Lutjanus vitta* (Family Lutjanidae); 1 mojarra species, *Pentaprion longimanus* (Family Gerreidae) and; 1 slipmouth species, *Gazza minuta* (Family Leiognathidae). Note that after the first month of monitoring, one species, *Lutjanus vitta* was not well represented in the catches (only 20 individuals), thus, this species was not included in the detailed species report. Anchovies (bolinao) was also initially selected as one of the primary target groups, but no samples were collected in Cortes (Mabahin) while samples from Cantilan were all corroded/damaged (50 individuals). Monitored gears were multiple hook and line, jigger, spear, drift gill net, bottom-set gill net and fish corral. In general, selection of target species and gears were based on the information provided by RARE local team, LGU and results of the focused group discussions conducted.

Table 1. Target fishing gears and species monitored in Cantilan and Cortes, Surigao del Sur.

Species	**Common Name**	**Municipality**	**Multiple H & L**	**Jigger**	**Spear**	**Drift Gill Net**	**Bottom-set Gill net**	**Fish Corral**
Primary targets								
Cheilopogon arcticeps	bangsi	Cantilan/Cortes				x		
Siganus canaliculatus	bangkawon/danggit	Cantilan			x		x	
Siganus fuscescens	bangkawon	Cortes			x	x	x	x
Lethrinus ornatus	katambak-lagtangon	Cantilan/Cortes	x		x		x	
Octopus cyanea	pogita/kogita	Cantilan/Cortes		x				
Secondary targets								
Selaroides leptolepis	dorado	Cantilan					x	
Upeneus sulphureus	timbungan	Cantilan					x	
Nemipterus nematopus	sagisi-badlis	Cantilan	x					
Lutjanus lutjanus	kamang	Cantilan	x					
Lutjanus vitta	kamang	Cantilan	x					
Pentaprion longimanus	latab-putian	Cantilan					x	
Gazza minuta	sapsap-bangad	Cantilan					x	

B.3.3. Biological Sampling

Catches of target species from the various gear types were subsampled regularly at each site. Measurements (at least standard length, SL) of target species caught by monitored gear type were done once a week (minimum of 30 individuals per target species per gear, but target = 50 individuals). In addition, specimens of target species (target = 3 kg per species sample) from each gear type in each site were purchased once a week. These samples were brought back to the lab at UPV in Miag-ao for verification of species identification, determination of gonad development stage, and measurements of other parameters.

C. RESULTS

Results of the analyses are presented by species, although details for each analysis (graphs, tables and figures) are explained for the first species only. The order of presenting the results is as follows: general biology and geographical distribution of the target species; size distribution from the monitored catches, gonadal maturation, growth and spawning potential ratio. Results of catch and effort monitoring are presented last. Because stocks of resources occur over a wide geographical range (*i.e., beyond the boundaries of adjacent or nearby municipalities*), their status will be essentially the same over this range. Hence, data for nearby "sites" (*i.e., same fishing ground*) were combined and analyzed, and the results, as well as the recommendations, are presented by species or by stock, and not by "site".

C.1. *Cheilopogon arcticeps (bangsi)*

C.1.1. General Biology

Figure 7. The target *Cheilopogon arcticeps.*

Cheilopogon arcticeps commonly known as white-finned flying fish from the Family Exocoetidae, inhabits surface waters of the open ocean as well as neritic and inshore areas. They are schooling, like other pelagic fish species but do not undertake extensive migrations and never spread to open sea. Flyingfish are well known for their habit of leaping out of the water and gliding over long distances. The food of flyingfish consists mainly of large zooplankton and small fish. Gorelova (1980) found that the flyingfish from the Pacific feed opportunistically on other flyingfish species, but there was no evidence of specialized prey selectivity. He also concluded that larvae and juvenile flyingfish feed near the surface primarily during daylight hours at an average rate of 15-20 percent of their body weight per day (Froese & Pauly, 2016.

C. arcticeps is among the less reported exocoetids in the pacific region, reports only mentioned minor contribution of the species to total landings in Camotes sea (Dalzell, 1993) and the species abundance in the waters off Taiwan (Chang *et al.,* 2012). Main fishing gears are traps, gill nets, and purse seines. Marketed mostly fresh and dried salted, also as fermented fish paste. *C.*

arcticeps is distributed in the western Pacific Ocean: southern China; Vietnam; Thailand; Indonesia; New Guinea and; Solomon Islands (FAO, 1998).

Studies on growth of tropical flyingfish have been carried out in the Philippines (Dalzell, 2005) Indonesia (Watson, 1990), and in the Caribbean (Storey, 1983). Flyingfish in the tropics generally live to about 2 years of age and are mature after 10-14 months. The growth rate and maximum size varies by species with the neritic (coastal) and oceanic species typically having a smaller maximum size. Many of the commercially important species (e.g. from the genera *Hirundichthys, Cypselurus, and Cheilopogon*) grow to about 20-25cm TL and attain weights of 300-450g (Gillet & Ianelli, 1992). Based on FAO (1998), maximum reported length of *C. arcticeps* is 21cm SL. On the other hand, mature flyingfish in the tropics appear to spawn several times over the course of a year. Several reported flyingfish species spawn largely on summer/warm months in Western Atlantic (starting March, *Cheilopogon melanurus*; Gibbs & Staiger, 1970), May-September in Japan coast (*Parexocoetus mento*; Breder & Rosen, 1966), March-July in Brazil (*Hirundichthys affinis*; Oliveira *et al.* 2015), and suggested spawning peak activity during Nov-Jan in Central Philippines (flyingfish species; Dalzell, 1993). No detailed information on size, growth, maturity and reproduction of *C. arcticeps* exists.

C.1.2. Size Distribution

The size distribution of the target species caught by drift gill nets off Cantilan and Cortes during the monitoring period (April – July 2016) is presented below in Fig. 8. Length measurements used in constructing the size distribution graphs were from biological samples and additional measurements by field enumerators. Another graph was made based on FishForever data from March- June 2015 for comparison. The estimates of length at first maturity L_{m50} of *C. arcticeps* and its closely related species, *Hirundichthys affinis*, are also indicated in the graphs.

A total of 572 individuals of *C. arcticeps* were measured within the study period. The smallest individual caught measured 14.9cm SL (size class 15.5) while 24.5cm SL (size class 24.5) was the largest (Fig. 8a). In this study, the maximum length recorded is larger than the reported length in FAO (1998). Of the catches, 97% (=554 individuals) are above the estimated L_{m50} (17.69 cm SL) while the 3% (=18 individuals) are considered immature. The modal size of the catch or the commonly caught size of drift gill net ranged from 19.5 – 22.5cm SL, which consisted 84% (=480 individuals) of the samples examined.

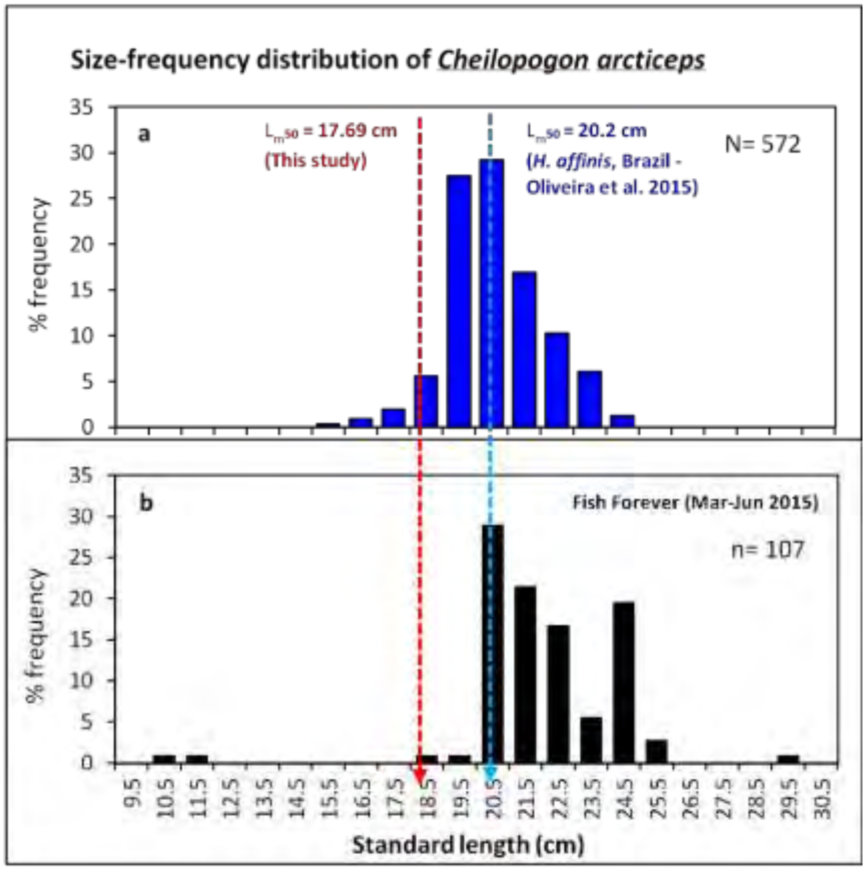


Figure 8. Size distribution of *Cheilopogon arcticeps* caught in Cantilan and Cortes, Surigao del Sur from April – Jul 2016. Catches from Drift gill net (a) and data from Fish Forever (Mar-Jun 2015) (b).

The length data provided by RARE Fish Forever covered four months, from March-June 2015. The data, however, provided only a few length measurements of the target species. For *C. articeps*, only 107 specimens were measured, with corresponding sizes of 10.0 and 29cm SL (Fig. 8b). Unfortunately, the gears used in catching these specimens could not be deciphered from the data files provided.

C.1.3. Gonad Maturity Stages and Maturation Curve

The gonad development of *C. arcticeps* was examined in relation to fish size to determine the maturity stages of fish in the catches. With this, the length at first maturity (L_{m50}) can be estimated by constructing a maturity curve or ogive. The same length at maturity information were also used in estimating the spawning potential ratio of the target species. The data used for constructing the maturity stage bar charts (Fig. 9) are from the biological samples (samples that were bought) only, since these fished were processed and their gonad development stage determined in the lab.

A total of 207 individuals were examined, with sizes ranging from 17– 24cm SL. Of these, 90.3% (=187 individuals) were mature. The smallest mature specimen observed in the study was 17.0cm SL, however, it was not clear if *A. arcticeps* started to mature at this length because the smallest specimen examined for gonadal staging was also 17.0cm SL. It is possible that specimens below this size are also in mature stage. No information is available on the reproductive aspect of this species, nevertheless, closely related flying fish species, *Cheilopogon melanurus*, commonly caught in Western Atlantic, matures at about 20cm SL (Staiger, 1965). Suggested spawning peak activity of flyingfish species in Central Philippines is between Nov-Jan (Dalzell, 1993) while other reported flyingfish species *e.g. C. melanurus* (Western Atlantic; Gibbs & Staiger, 1970), *P. mento* (Japan; Breder & Rosen, 1966) and *H. affinis* (Brazil; Oliveira *et al.* 2015) spawn largely during summer/warm months (between March-September). The monitoring falls within the reported spawning months, hence, most of the samples were in mature stage.

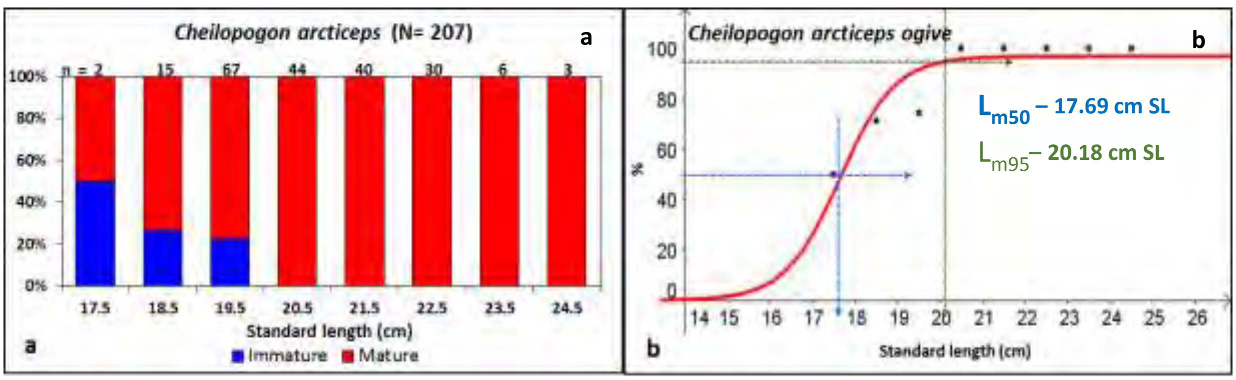


Figure 9. Gonadal maturation with size (a) and maturation curve (b) of *Cheilopogon arcticeps* in Cantilan and Cortes, Surigao del Sur. **Note:** "n" above bars refer to the number of specimens examined per size class.

Based on the ogive (Fig. 9b), length at which 50% of the population matures (L_{m50}) is about 17.69cm SL. This estimate is lower to the L_{m50} (20.2 cm SL) of the closely related species *H. affinis,* estimated by Oliveira *et al.* (2015) in Rio Grande, Brazil.

C.1.4. Growth Curve

When length data are limited to a few months, relative age at a given length can be estimated provided that a growth equation (e.g., VBGModel) for the same species has been constructed (from another area, or from previous years). Ageing studies based on analysis of otoliths (fish) or statoliths (squid) may be too time consuming and costly for most multispecies stock assessment studies, but age at length/stage data may provide insights on the stock that could otherwise be masked by high variability in length data, particularly in heavily-fished stocks.

Corresponding ages of the catches (17 – 24cm SL) is from 10 -20 months, with most between the ages of 12 14 months (19-21cm SL). Since no available information of *C. arcticeps* was conducted, growth coefficient "k" & Lα used in constructing the growth curve were derived from related species *Cheilopogon atrisinis, Cheilopogon cyanopterus* and *Cheilopogon nigripinnis* (LavapieGonzales et al., 1997-1999).

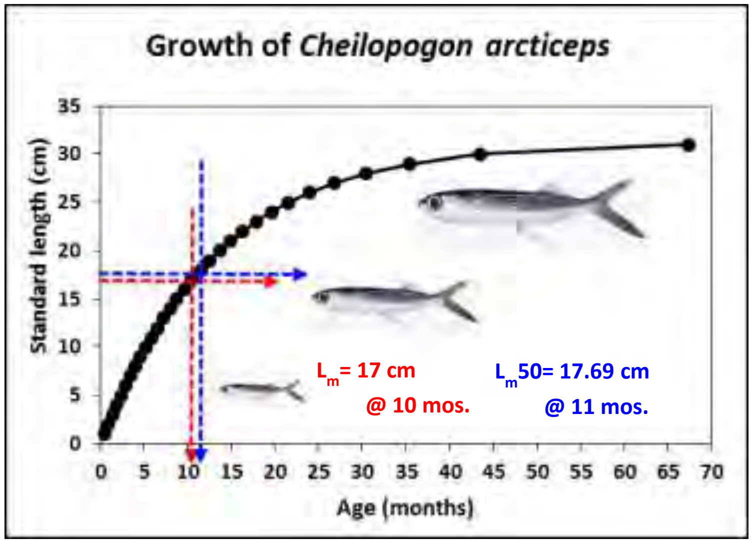


Figure 10. Growth curve of *Cheilopogon arcticeps* in Cantilan and Cortes, Surigao del Sur. **Note:** L_{m50} (red line) is the size when 50% of the population mature while L_m is the size at first maturity.

Based on the growth curve (Figure 10), age at L_{m50} (17.69cm SL) of *C. arcticeps* is about 12 months, while the smallest mature (17.0cm SL) has a corresponding age of approximately 10 months. These estimates are based only on the examined samples, nevertheless, the data presented was comparable to the reported maturity age of most tropical flyingfish, which is about 10-14 months (Gillet & Ianelli, 1992).

C.1.5. Length-Based Spawning Potential Ratio (LB-SPR)

Spawning potential ratio (SPR) is the proportion of the total spawning potential (derived from the size range of mature fish, L_{m50} to L_{m95}) of fish remaining in the population after removing all fish caught by the fishery. Hence, an unfished stock would have an SPR of 100%, while very intensely-fished stocks would have an SPR close to 0%, because all mature fish would have been removed or all female fish would have been caught by intense fishing. Hence, estimates of actual SPR of currently fished stocks are dependent on the (i) size distribution of fish in the combined catches, and (ii) the proportion of all mature fish in the stock (indicated by location of L_{m50} on size distribution) that are caught. SPR is computed using estimates of natural mortality (M), the growth coefficient (K), asymptotic length (L_{∞}), length at which 50% (L_{m50}) and 95% (L_{m95}) of fish at that size are mature, and the actual size frequency distribution of catches from the fishery. Values for M, K and L_{∞} were taken from the study of Lava-pie Gonzales *et al.* (1997) from the closely related species, *Cheilopogon atrisinis, Cheilopogon cyanopterus* and *Cheilopogon nigripinnis* which was conducted in Camotes Sea. By adjusting the size distributions of the catches, recommended values for SPR (20-40%) can be targeted. The corresponding L_c or length at first capture may then serve as the harvest control reference point to attain the targeted SPR.

Table 2. Estimated spawning potential ratio of *Cheilopogon arcticeps* in Cantilan and Cortes, Surigao del Sur.

The estimated SPR of *C. arcticeps* caught in Cantilan and Cortes is shown in Table 2. At present, SPR of the stock

L_c (cm SL)	L_{50} (cm SL)	SPR
14.9 (actual)	19.04	25%

based on the 3-month monitoring data is already 25% which is within the accepted values (20-30%). The high SPR is attributed to the sizes of the catches, which are relatively larger and mostly in mature stage. This indicate that level of fishing of flyingfish in Cantilan and Cortes are still sustainable.

C.1.6. Harvest Control Reference Points

C. arcticeps individuals caught in this study are relatively large, with 97% (=554 individuals) are above the estimated L_{m50} (17.69cm SL). This explains the high SPR of the species, 25%. While the results do not show an urgency for interventions, imposing a size limit of 19cm SL and retaining the current mesh size of drift gill nets, would ensure long term sustainability of the stock. This study serves as a baseline information for *C. arcticeps.*

C.2 *Siganus canaliculatus* (bangkawon/danggit)

C.2.1. General Biology

Figure 11. The target species *Siganus canaliculatus.*

Siganus canaliculatus commonly known as the white spotted rabbitfish (Family Siganidae) is widely distributed throughout the Indo-Pacific from the Arabian Gulf to the Indo-Malay region, Western Australia and north to HongKong and Taiwan (Randall, 1995). It is found inshore in algal reefs, estuaries and in lagoons (Woodland, 1993), and can tolerate more turbid waters. It can be seen also within the vicinity of river mouths especially around seagrass beds. The juveniles usually form large schools in shallow bays and coral reef flats. However, the school size reduces with size with the adults occurring in groups of around 20 individuals. They are herbivores feeding on benthic algae and to some extent on seagrass. By being herbivore, the species is considered as stabilizer of coral reef ecosystems (Johnson & Gill, 1998). In aquaculture, the species is used as an indicator, such that its presence is associated with algal growth (Hasse, 1974).

Reproductive biology of S. *canaliculatus* is well studied locally and abroad. In the Philippines, spawning seasons of the species is observed from Feb-May and Jul-Dec in Palompon (Paraboles, 2015), Apr-May and Aug-Dec in Honda Bay, Palawan (Ramos et al., 2009) and Apr-May in Lagonoy Gulf, Bicol (Soliman et al., 2009). Juvenile runs, defined as the arrival of juveniles to settlement areas (e.g. seagrass beds) were observed 2-3 days after the newmoon (Soliman et al., 2010). Massive juvenile runs were observed in the months of April, May and September (Soliman et al., 2010). According to Paraboles (2015) the species can mature as small as 5.5cmSL, although L_{m50} is reported at 8.1-9.7cm SL in Palompon, Leyte (Paraboles, 2015), 11.0-12.0cm SL in United Arab Emirates (Al-Ghais, 1993), 15.0-15.9cm SL in Hongkong (Tseng & Chan, 1982) and 20.621.9cm SL in the Coast of Oman (Al-Mazourqi et al., 2011). If allowed to grow indefinitely, *S. canaliculatus* can grow up to 33.4 cm SL (Ramos et al., 2009).

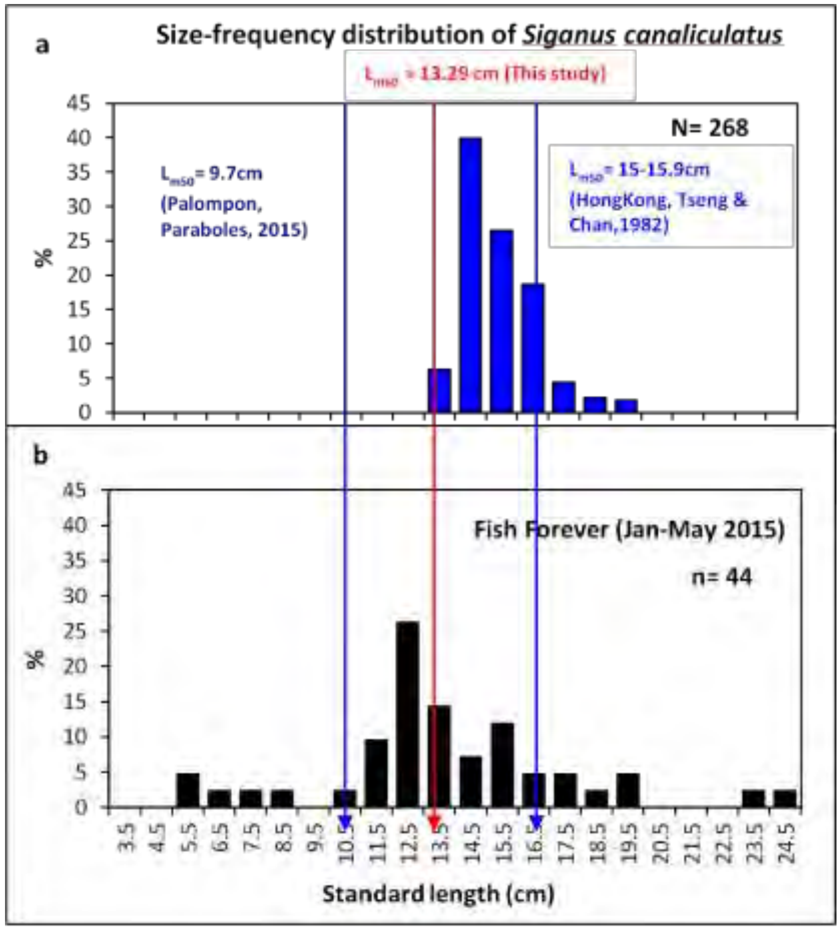


Figure 12. Size distribution of *Siganus canaliculatus* caught in Cantilan, Surigao del Sur from April – Jun 2016. Catches from bottom-set gill net (a) & Fish Forever data (Mar-Jun 2015) (b)

C.2.2. Size Distribution

A total of 268 fish individuals were measured within the study period. The smallest individual caught measured 13.0cm SL, while 19.5cm was the largest (Fig.12a). On the other hand, wider size range was recorded in FishForever data from Jan-May 2015 with the smallest and largest individual measuring 5cm and 24cm (Fig.12b), respectively.

99.3% (264 individuals) of the catches from bottom set gill nets (present study) were above the estimated L_{m50} (13.29cm SL) or 100% of the L_{m50} estimate of Paraboles in Palompon, Leyte (2015). This indicates that *S. canaliculatus* are caught after they have spawned.

C.2.3. Gonadal Maturation and Maturation Curve

For gonadal maturation, 68 individuals of *S. canaliculatus* were examined with sizes ranging from 13.5-18.5cm SL (Figure 13a). Of the samples, 54 individuals were mature while the rest were in immature stage. The smallest mature size observed was 13.5cm SL but it is not clear if *S. canaliculatus* starts to mature at this length because the smallest specimen examined for gonadal staging is also 13.5cm SL. It is possible that specimens smaller than this size have already spawned and in redeveloping stage (can be verified only with histological analysis). Smallest mature size of *S. canaliculatus* reported in Palompon is 5.5cm SL (Paraboles, 2015) whereas in Dumaguete, Alcala & Alcazar (1979) noted that the same species mature at 11cm SL. Reported spawning seasons of the species is from Feb-May and Jul-Dec in Palompon (Paraboles, 2015), Apr-May and Aug-Dec in Honda Bay, Palawan (Ramos et al., 2009) and Apr-May in Lagonoy Gulf, Bicol (Soliman et al., 2009).

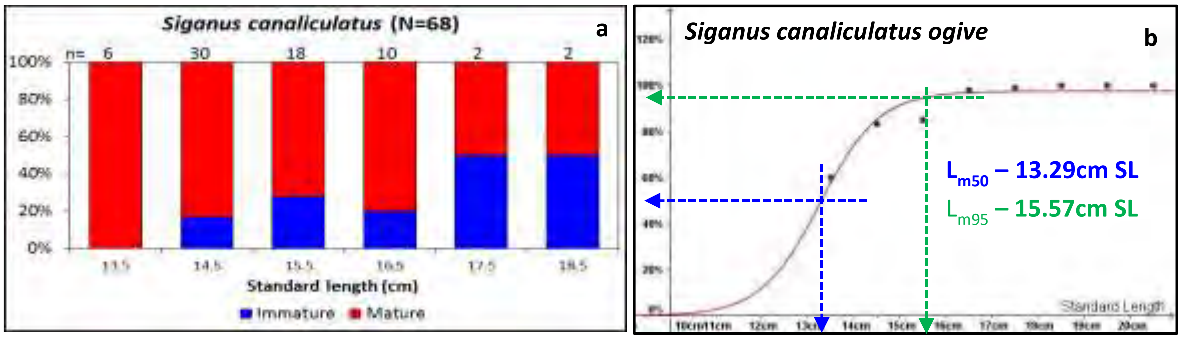


Figure 13. Gonadal maturation with size (a) and maturation curve (b) of *Siganus canaliculatus* in Cantilan, Surigao del Sur. **Note: "**n" above bars refer to the number of specimens examined per size class.

Based on the ogive, length at which 50% of the population matures (L_{m50}) is about 13.29cm SL. This estimate is ~2x larger than in Palompon, Leyte (Paraboles, 2015), 9.7cm SL for females and 8.1cm SL for males, but is comparable to reported L_{m50} in HongKong (15-15.9cmSL, Tseng & Chan, 1982) and in a parallel study in Tinambac, Camarines Sur (15.52cm SL). L_{m95} on the other hand is estimated at 15.57cm SL.

C.2.4. Growth Curve

Based on the constructed growth curve, corresponding age of the estimated L_{m50} (13.29cm SL) of *S. canaliculatus* in Cantilan is about 8 months, while the L_{m95} (15.57 SL) has a corresponding age of 10 months. Again, these estimates are based only on the examined samples.

The age at L_{m50} in this study is comparable to the results of the studies conducted abroad, such as in the Coast of Oman (age at L_{m50} close to 1 year, Al-Mazourqi et al., 2011) and in the United Arab Emirates (age at L_{m50} at 1st year, Al-Ghais, 1993), but is older than in Palompon, Leyte where age at L_{m50} for females and males were estimated at 5.1 and 4.6 months, respectively (Guarte, 2015). The same study also showed that the species can mature as early as 88 days or at 2.9 months.

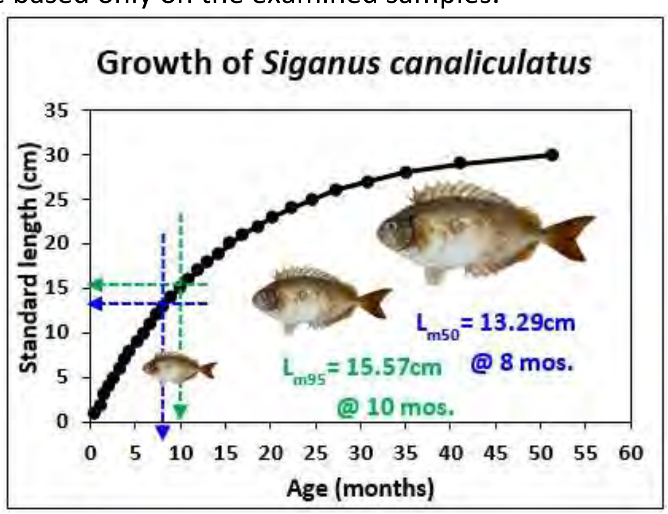


Figure 14 . Growth curve of *Siganus canaliculatus* in Cantilan, Surigao del Sur.

According to the study of Grandcourt et al. (2007) in the Southern Arabian Gulf, maximum age of *S. canaliculatus* is 7.8 years. In this study, however, the age at of the largest specimen (19.5cm SL) is about 15 months only.

C.2.5. Length-Based Spawning Potential Ratio (LB-SPR)

The estimated SPR of *S. canaliculatus* caught in the fishery in Cantilan is shown in Table 3. At present, SPR of the stock based on the 2 month monitoring data is 13.0% only. Though, most of the individuals (99.3%) caught in this study are above the L_{m50}, the SPR estimate is below the recommended values of 20-30%. This is because of the overlap in the distribution of the catches and of mature individuals. The more the overlap between the size distribution of fish caught by the fishery and the size distribution of mature fish, the less the spawning potential left in the stock. To increase the SPR of *S. canaliculatus* to 25-30%, the modal length of the catches should be set at 16.6-17.6cm SL. This means that catches smaller than this size range should be banned. Note that SPR was estimated based only on the narrow size range of the samples, perhaps, if monitoring covered the spawning seasons and wider size range, SPR estimates may be improved.

Table 3. Estimated spawning potential ratio of *Siganus canaliculatus* in Cantilan, Surigao del Sur.

L_c (cm SL)	L_{50} (cm SL)	Spawning Potential Ratio
13.04	14.62	13.0%
15.04	16.62	25.0%
16.6	17.62	30.0%

C.2.6. Harvest Control Recommendations

S. canaliculatus caught by bottom set gill nets in this study are relatively larger because of the minimum mesh size (8cm) implementation in Cantilan. Of the catches, 99.3% are above the L_{m50}. In spite of the higher proportion of mature siganids, the SPR of the species is low at 13% only. This is due to the overlap in the distribution of the catches and mature individuals. The SPR estimate of the species could have improved if the monitoring covered a wider size, including juveniles from other gears, and if conducted during the spawning seasons.

Based on the data, SPR of *S. canaliculatus* can be increased to 25-30% by implementing a size limit 16.6-17.6cm SL. Comprehensive information drive should also be done to relay this recommendation not only to the fisherfolks, but also to the buyers or the consumers of this area. Consumers should be well aware to buy *S. canaliculatus* that are equal to or greater than the size limit only. By doing so, fishers will be discouraged in catching smaller individuals (no market for smaller individuals = no harvest of smaller individuals). Fines or non- renewal of fishing registration as penalty may also be imposed to non- compliant fishers.

C.3. *Siganus fuscescens* (bangkawon)

C.3.1 General Biology

Figure 15. The target species *Siganus fuscescens.*

Siganus fuscescens, also known as mottled spinefoot of Family Siganidae, is widely distributed throughout the estuaries, intertidal, and marine habitats of Indo-Pacific and eastern Mediterranean. The body is olive green or brown, with a silvery belly and small spots. When frightened, *S. fuscescens* displays a mottled colour and projects its venomous spines. This species is caught in seagrass and *Sargassum* beds using a variety of gears which target the fish at different stages of their life cycle and daily behaviour patterns. *S. fuscescens* is often misidentified as smallspot form of *S. canaliculatus* (de la Paz & Aragones, 1988; Bellefleur, 1997), since the two species differ subtly in coloration and morphology. These two species are closely related, often found in the same area schooling together and have similar spawning habits. A recent study by Hsu et al. (2011) suggested that these two spinefoot colour morphs are interbreeding based on the individuals that were clustered by amplified fragment length polymorphism (AFLP) according to geography.

The mottled spinefoot recorded a maximum total length of 40cm (=33.6cm SL) and symptotic total length of this species from Bolinao, Pangasinan was 25cm SL (Frose & Pauly, 2016). Its spawning season was estimated to occur from July to August in Tateyama Bay, Japan (Akiyama, 2009); March to May and September to October in Bolinao (Bellefleur, 1997; del Norte & Pauly 1990) and February to April and September to October in Pujada Bay (Jumawan-Nanual & Metillo, 2008). Length at first maturity (L_{m50}) was estimated at 15.5-16.8cm SL in Tateyama Bay, Japan (Akiyama, 2009), although the species can mature as small as 5.5-5.6cm SL (de la Paz & Aragones, 1988) and 7.2-8.8cm SL (Bellefleur, 1997) in Bolinao, Pangasinan. In many regions of the Philippines, its juveniles are processed into fish paste or *bagoong* (del La Paz & Aragones 1990) and its fishery including its closely related species, *S. canaliculatus* primarily supports the dried fish Philippine market (Laviña & Alcala 1974).

C.3.2. Size Distribution

A total of 597 fish individuals were measured within the 3 month period. The smallest individual caught measured 4cm SL while 20.5cm was the largest. The size of commonly caught individuals range from 8.5 – 16.5cm SL (Fig. 16). Of the catches, 52% (=309 individuals) are above the estimated L_{m50} (12.05cm SL). Among the target gears, fish corral had the highest percentage of matures, approximately 84% (=61 individuals) followed by spears and gill nets (bottom set gill nets) with 54% (=157 individuals) and 44% (=91 individuals), respectively. The relatively higher proportion of mature individuals in fish corral is attributed to the strict implementation of minimum mesh size (4cm) in Cortes, and the passive nature of the gear which allows smaller and perhaps larger individuals also to escape the catching chamber. Although Cortes also implements minimum mesh size of 4-5cm for bottom set gill nets, smaller siganids (4-7cm) which should have passed through the 4-5cm net were caught. These small siganids were probably caught with trammel nets (same operation as bottom set gill net), where 2 or even 3 gill nets of different mesh sizes are used. So even when the mesh size of the first net is 4-5cm, smaller sized siganids are entangled either on the second or the third net which often have the smaller mesh size. Catches of spearfishing on the other hand showed a wider range of catches (4-18cm) in

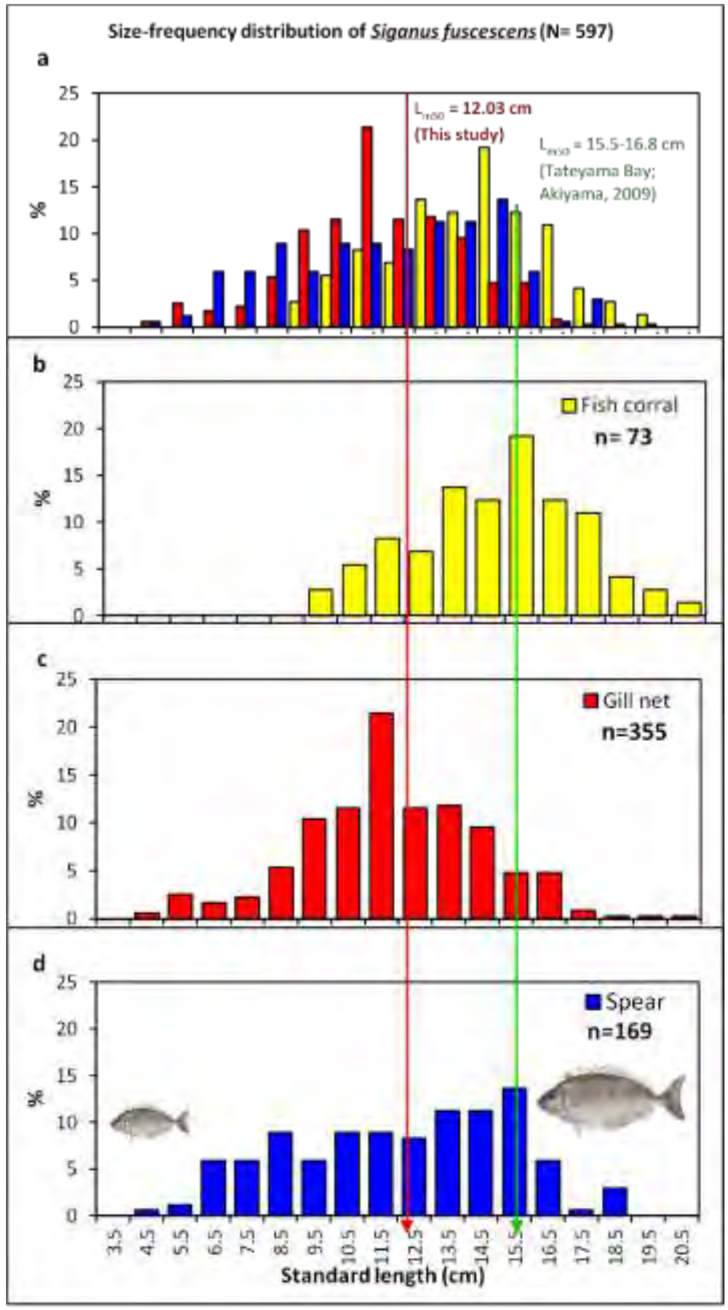


Figure 16. Size distribution of *Siganus fuscescens* caught in Cortes, Surigao del Sur from May – July 2016. (a) all gears combined, (b) fish corral, (c) bottom-set gill net, and (d) spear.

immature and mature stage. The fishing ground of Cortes is shallow and extensive, making it easier for spear fishers to catch both stages.

C.3.3. Gonadal Maturation and Maturation Curve

A total of 137 individuals were examined, with sizes ranging from 9.5– 20.5cm SL. Of these, 75% (=103 individuals) were mature/spent (Fig. 17a) with the smallest mature (L_m) specimen observed at 10.0cm SL. It is clear from the graph that at 13.5cm SL, most of the siganids are mature. Based on the ogive (Fig. 17b), length at which 50% of the population matures (L_{m50}) is about 12.05cm SL, while L_{m95} is at 14.48cm SL. The L_{m50} of this study is relatively smaller than in Tateyama Bay, Japan (15.5-16.8cm SL, Akiyama, 2009), although L_m (or the smallest size of mature), 10.0cm SL is larger than in Bolinao, Pangasinan, 5.5-8.8cm SL (de la Paz and Aragones, 1988; Bellefleur, 1997). A longer monitoring of this species in Cortes would perhaps provide a more concrete estimates of sexual maturity.

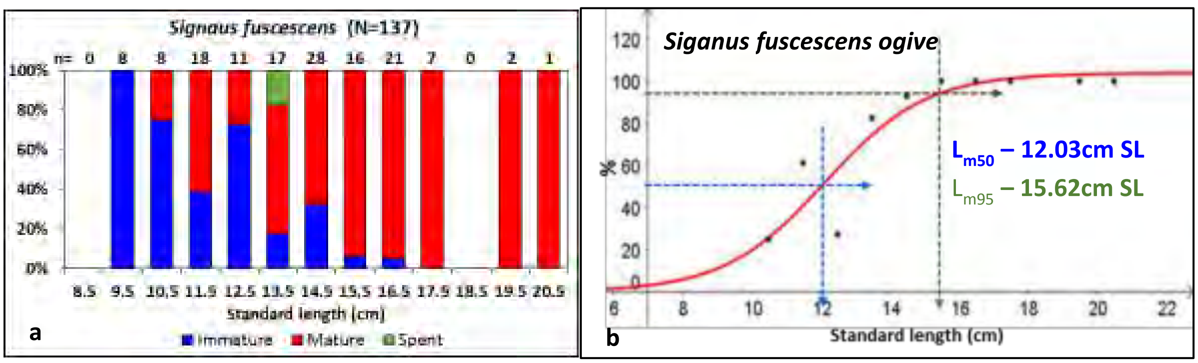


Figure 17. Gonadal maturation with size (a) and maturation curve (b) of *Siganus fuscescens* in Cortes, Surigao del Sur. **Note: "**n" above bars refer to the number of specimens examined per size class.

C.3.4. Growth Curve

Figure 18 shows the growth curve of *S. fuscescens* which may be used in estimating the ages of mature specimens and or the age of individuals of any given length. Information used in constructing this curve such as growth coefficient *k* and L_{∞} were obtained from Bolinao (Bellefleur, 1997; del Norte & Pauly, 1998). Corresponding ages of the catches (4.5 -20.5cm SL) is from 3 -23.0 months, with most between the ages of 5.0 -16.0 months (8.5-16.5cm SL).

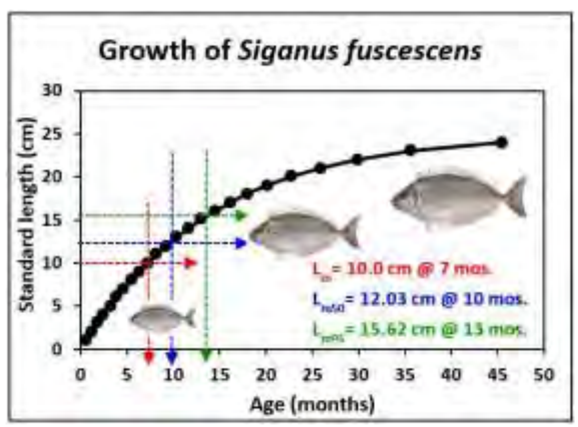


Figure 18. Growth curve of *Siganus fuscescens* in Cortes, Surigao del Sur

Based on the growth curve (Figure 18), age at L_{m50} (12.05cm SL) of *S. fuscescens* is about 10 months. The smallest mature (10.0cm SL) on the other hand has a corresponding age of 7 months. In Bolinao, Pangasinan, Bellefleur (1997) reported that the species can mature as young as 70 days or 2 months. Again, these estimates are based only on the examined samples, further monitoring of this species would verify these estimates.

C.3.5. Length-Based Spawning Potential Ratio

Table 4. Estimated spawning potential ratio of *Siganus fuscescens* in Cortes, Surigao del Sur.

L_c (cm SL)	L_{50} (cm SL)	SPR
11.37	11.83	15%
12.17	12.83	22%
13.25	13.83	30%

The estimated SPR of *S. fuscescens* caught in the fishery in Cortes is shown in Table 4. At present, SPR of the stock based on the 3 month monitoring data is only 15%. The lower SPR is attributed to the higher proportion of immature (48%) siganids in the catches. According to Erisman et al. (2014) SPR increases with size and with spawning frequency. Hence, SPR of *S. fuscescens* would increase if size limit will be implemented and if monitoring will cover the spawning seasons of the species. Based on the data, SPR of *S. fuscescens* can be increased to 22-30% if size limit of 12.8-13.8cm SL is established. This means that catches smaller than this size should be banned.

C.3.6. Harvest Control Recommendations

Based on the 3 month monitoring, a size limit of 12.8-13.8cm SL should be established to increase the spawning potential of the stock from 15% to 22-30%. This should go together with the strict implementation of mesh size of the fishing nets in Cortes. The size distribution of the catches strongly suggests that smaller sized nets (probably trammel nets) are being used in Cortes. If this assumption is true, removal of the smaller meshed segments will be necessary to allow juveniles of siganids as well as of other non-target species to pass, grow, mature and spawn. Comprehensive information drive should also be done to relay these recommendations not only to the fisherfolks, but also the buyers or the consumers of this area. Consumers should be well aware to buy *S. fuscescens* that are equal to or greater than the size limit only, and if possible to report those fishers catching smaller siganids. By doing so, fishers will be discouraged in catching smaller individuals (no market for smaller individuals = no harvest of smaller individuals). Fines or non- renewal of fishing registration as penalty may also be imposed to non-compliant fishers.

C.4. *Lethrinus ornatus* (katambak-lagtangon)

C.4.1. General Biology

Figure 19. The target species *Lethrinus ornatus.*

Lethrinus ornatus, known as ornate emperor of the Family Lethrinidae, typically inhabits sandy and soft bottoms and seagrass beds in inshore bays, lagoons and areas adjacent to reefs. Many *Lethrinus* species inhabit seagrass beds during their juvenile period (Kanashiro, 1998; Nakamura & Sato, 2004). The species feeds on crustaceans, mollusks, echinoderms, polychaetes and small fishes (Kuiter & Tunozoka, 2001). The species is widely distributed in Indo-West Pacific which include Maldives and Sri Lanka to the Ryukyu Islands, Papua New Guinea, and northeast Australia (FAO, 1998).

Generally, emperors are considered to be long-lived, with maximum ages commonly >20 years (Carpenter & Niem, 2001). In Ryukyu Islands, the reported maximum age of *L. ornatus* was 12 years and age at 50% ovarian maturity was at 2 yrs of age (=20.1-20.8cm FL or 18-18.6cm SL, Ebisawa & Ozawa 2009). Spawning period is from May to November and juveniles were observed every month except April and May in Ryukyu Is. (Ebisawa, 2005) and Yaeyama area (Kanashiro *et al.,* 1997, 1998; Kanashiro & Nakamoto, 1999). Juvenile hermaphroditism has been reported for some species and populations, where male emperors are derived from females prior to sexual maturity (Ebisawa, 1990, 1997, 1999; Grandcourt *et al.,* 2010) and some studies suggest that only a proportion of fishes may change into males (e.g. *L. miniatus*; Sumpton & Brown, 2004; Williams *et al.*, 2006).

C. 4.2. Size Distribution

A total of 812 fish individuals were measured within the 3 month period. The smallest individual caught measured 5.5cm SL while 29.5cm was the largest (Figure 20). Of the multiple hook and line catches, only 28.4% are above the estimated L_{m50} (18.49cm SL) while the majority, more than 70% are immature. This shows that the current fishery catch them before they can spawn. For Fish Forever data, there were 26 individuals of *L. lethrinus* measured from Jan-Apr 2015, with sizes ranging from 7.5-29.5 cm.

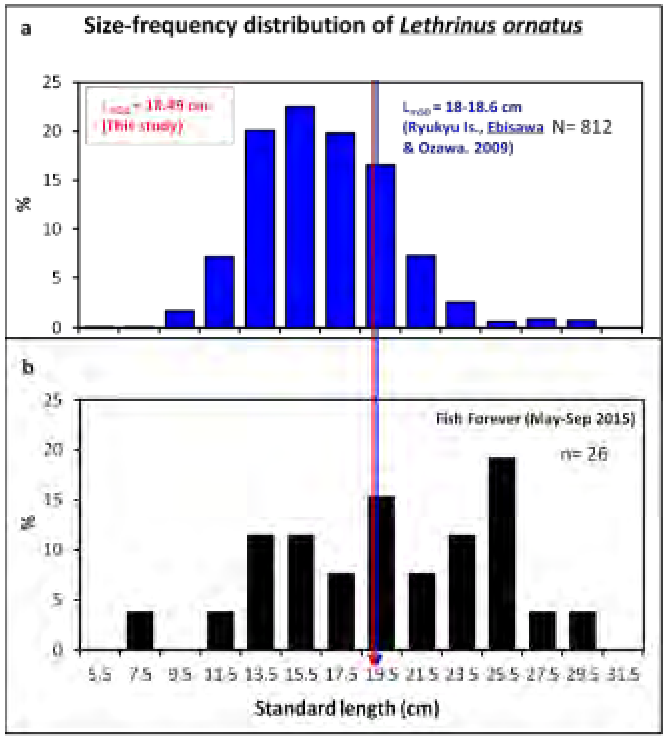


Figure 20. Size distribution of *Lethrinus ornatus* caught in Cantilan & Cortes, Surigao del Sur from April – Jul 2016. Catches from Multiple hook & line (a) & data from Fish Forever (May-Sep 2015) (b).

C.4.3.Gonadal Maturation and Maturation Curve

For gonadal maturation, 108 individuals were examined, with sizes ranging from 5.5– 29.5cm SL. Of these, 44.4% (=48 individuals) were mature (Fig. 21a) with the smallest mature specimen observed at 15cm SL. Based on the ogive (Fig. 21b), length at which 50% of the population matures (L_{m50}) is about 18.49cm SL, while L_{m95} is at 20.37cm SL. The estimated L_{m50} in this focal area falls within the reported range *(*18-18.6 cm SL/20.1-20.8 cm FL) in Ryukyu Islands (Ebisawa & Ozawa, 2009).

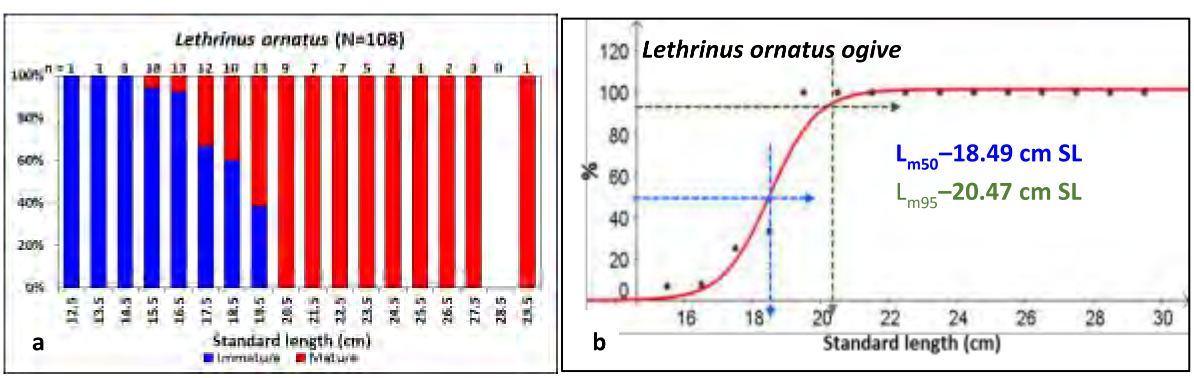


Figure 21 . Gonadal maturation with size (a) and maturation curve (b) of *Lethrinus ornatus* in Cantilan & Cortes, Surigao del Sur. **Note: "**n" above bars refer to the number of specimens examined per size class.

C.4.4. Growth Curve

Corresponding ages of the catches (5.5-29.5cm SL) is from 5-45.0 months, with most between the ages of 10-25.0 months (11.5-21.5cm SL). Carpenter & Niel (2001) noted that most emperors, including the target species, are considered to be long lived and slow growing. With this, the sizes commonly caught in the fishery, appears to be on its late juvenile stage to subadults and adults. Based on the growth curve, length at first maturity (L_{m50}=18.49cm SL) was estimated at about 20 months or 1.7 years of age. This result is relatively proximate to the reported age of the same species by Ebisawa & Ozawa (2009) in Ryukyu Islands. Meanwhile, the relative ages of the smallest mature (15cm SL) recorded in this study and the estimated L_{m95} (20.47cm SL) is about 15 months and 25 months, respectively. Again, these estimates are based only on the examined samples.

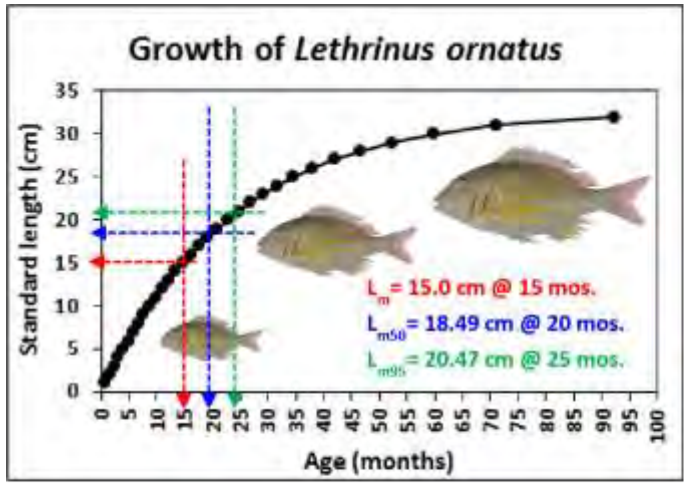


Figure 21. Growth curve of *Lethrinus ornatus* in Cantilan & Cortes, Surigao del Sur.

C.4.5. Length-Based Spawning Potential Ratio

The estimated SPR of *L. ornatus* caught in the fishery in Surigao del Sur is shown in Table 5. At present, SPR of the stock based on the 3 month monitoring data is 16%. The result of the SPR may be attributed to the smaller proportion of mature individuals (44.4%) caught. It is noted that SPR increases with size and with spawning frequency (Erisman et al. 2014), therefore, to increase the SPR of *L. ornatus* to at least 22% or 37%, the L_{50} or modal length of the catch should be set at 16.47-18.47cm SL. This means that catches smaller than this size should be banned.

Table 5. Estimated spawning potential ratio of *Lethrinus ornatus* in Cantilan & Cortes, Surigao del Sur.

L_c (cm SL)	L_{50} (cm SL)	Spawning Potential Ratio
12.76 (actual)	15.47	16%
13.71	16.47	22%
15.61	18.47	37%

C.4.6. Harvest Control Recommendations

As reported, only 28% of the catches of *L. ornatus* are above the estimated L_{m50} 18.49cm SL. The slow-growing nature of *L.* ornatus adds to the reason why most fishers catch only immature individuals. With this, it is recommended that a size limit of 16.47-18.47cm SL should be imposed to increase the SPR of the species to at least 22-37%. This would ensure long term sustainability of the stock. Comprehensive information drive should also be done to relay this recommendation not only to the fisherfolks, but also to the buyers or the consumers of these areas. Consumers should be well aware to buy *L. ornatus* that are equal to or greater than the size limit only. By doing so, fishers will be discouraged in catching smaller individuals (no market for smaller individuals = no harvest of smaller individuals). Fines or non- renewal of fishing registration as penalty may also be imposed to non- compliant fishers.

C.5. ***Octopus cyanea*** **(pugita/kogita)** *C.5.1.*

General Biology

Figure 22. The target species *Octopus cyanea.*

The common octopus, *Octopus cyanea,* is a cryptic cephalopod species that typically inhabits holes and crevices found in coral reefs, sea grass beds, and across rock, sand, or mud bottom areas of the ocean. *O. cyanea* is a key opportunistic predator with foraging usually taking place around dawn and dusk and feeds primarily on bivalves, gastropods and xanthid crabs but also have range of prey items such as molluscs, crustaceans and fish. It is widely distributed in Indo-Pacific, from eastern Africa to Hawaiian Islands (FAO, 1998).

Octopuses grow very rapidly and can increase in size by as much as 200g in only 15 days and up to 12kg in weight (Van Heukelem, 1983; Guard, 2003). They seemingly follow the 'live fast and die young' principle and have a total estimated lifespan of between 9-18 months (Van Heukelem, 1983). Members of the class Cephalopoda are gonochoric. Male and female adults usually die shortly after spawning and brooding, respectively. Reproduction of *O. cyanea* has been documented to occur throughout the year in both Tanzania and Madagascar with reproductive peaks in June and December (Guard & Mgaya, 2002; Caveriviere, 2006) suggesting that this species utilizes an intermittent spawning strategy occurring over an extended period of time as described by Rocha et al. (2001).

This species is of considerable commercial value to artisanal fisheries in coastal East Africa and Western Indian Ocean island states, where catches are generally sold through a network of collectors to reach national and international export markets (L'Haridon, 2006).

C.5.2. Size Distribution

Within the 3 month monitoring period, a total of 2016 individuals of *O. cyanea* were measured.

The smallest individual caught measured 2.9cm mantle length (ML) while 30.5cm was the largest (Fig. 23). On the other hand, the sizes of commonly caught individuals range from 6.5- 12.5cm ML. Only 23% (=467 individuals) of the catches from jiggers are above the estimated L_{m50} (11.05 cm ML). For Fish Forever data, only 8 *O. cyanea* were measured from Feb-May 2015 with sizes ranging from 6.5-14.5cm ML.

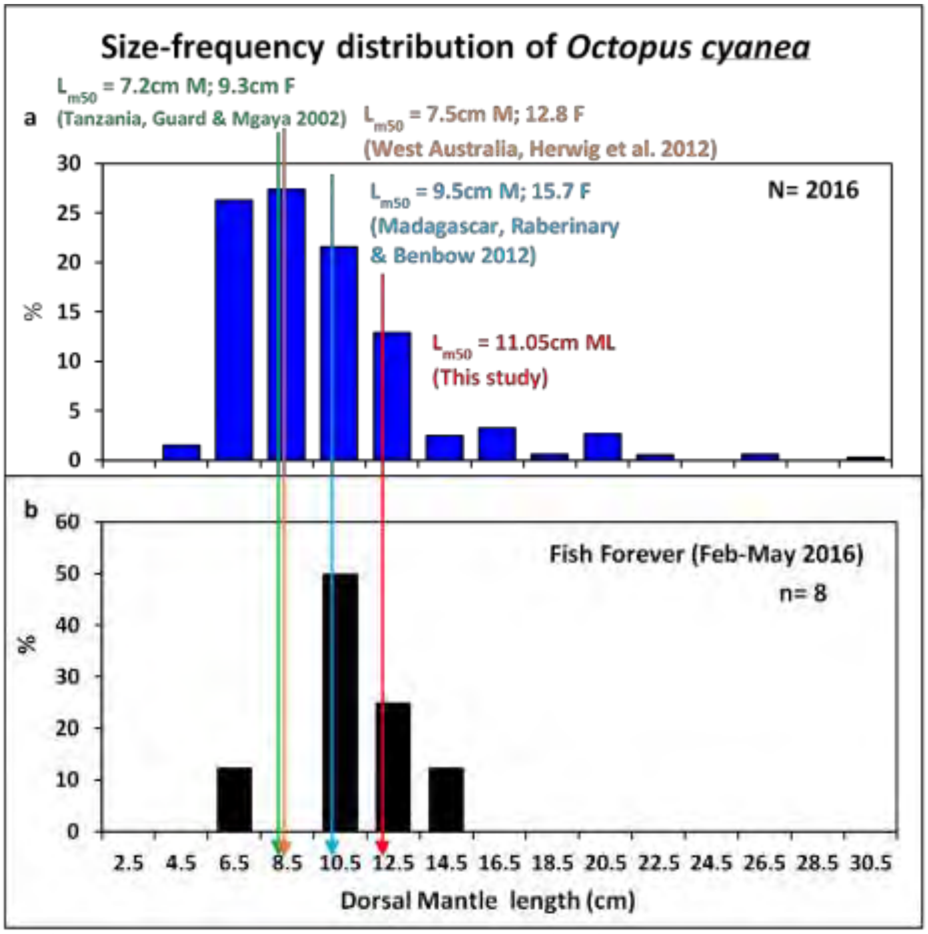


Figure 23. Size distribution of *Octopus cyanea* caught in Cantilan & Cortes, Surigao del Sur from April – Jul 2016. Catches from jigger (a) & data from Fish Forever (Feb-May 2015) (b).

C.5.3. Gonadal Maturation and Maturation Curve

A total of 61 individuals were examined, with sizes ranging from 4.5–13.5cm ML (=100 to 1250g). Of these, only 3 individuals were mature (Fig. 24a) with the smallest mature specimen observed, female at 9.1cm ML (=450g). In most studies, it is the male that mature at smaller sizes. In Madagascar, male octopus matures as small as 7.9cm ML while females mature as small as 8.2cm SL (Raberinary & Benbow, 2012). Similarly in West Australia, males and females mature as small as 7.3cm and 8.7cm ML, respectively.

Based on the ogive (Fig. 24b), length at which 50% of the population matures (L_{m50}) is about 11.05cm ML, while L_{m95} is at 12.32cm ML. The L_{m50} in this study is within the range of estimates of Raberinary and Benbow (2012) in Madagascar (9.5cm ML males & 15.7cm ML for female), of Guard (2009) in Tanzania (8.6cm ML for male & 12.2cm ML for female) and of Herwig et al. (2012) in West Asutralia (7.5cm ML for male and 12.8cm ML for female).

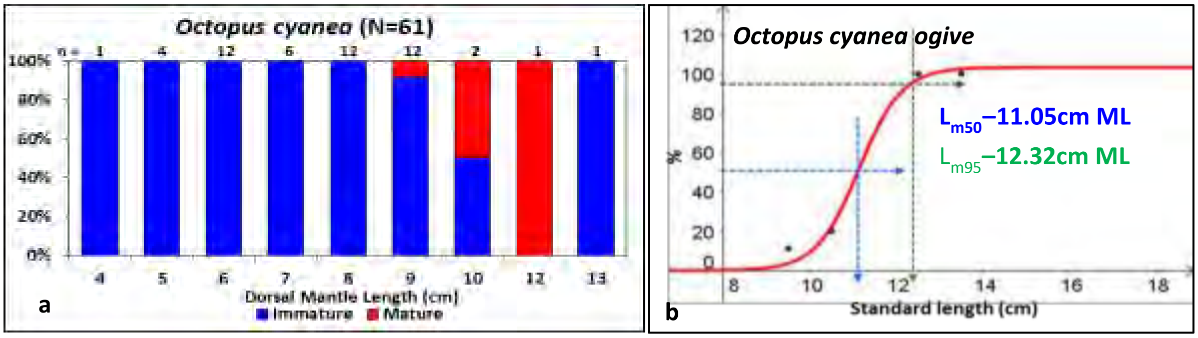


Figure 24. Gonadal maturation with size (a) and maturation curve (b) of *Octopus cyanea* in Cantilan & Cortes, Surigao del Sur. **Note: "**n" above bars refer to the number of specimens examined per size class.

C.5.4. Growth Curve

The growth curve of *O. cyanea* was derived from the experimental set up of Heukelem (1976) using weight measurements at fixed interval (every 15 days). Because the present data are in mantle length rather than weight, weight measurements were converted to mantle length using the formula:

$$L = (W/a)^{1/b}$$

where *w* is the weight in grams, *a* is the intercept and *b* is the slope.

Based on the converted growth curve, corresponding ages of the catches (4.5-30.5cm ML) is from 1 to ~13.0 months (predicted from the curve), with most between the ages of 5.0-7.0 months (6.5-12.5cm SL). Age at L_{m50} (11.05cm SL) of *O. cyanea* on the other hand is about 7.2 months, while the smallest mature (9.1cm SL) has a corresponding age of 6.25 months. The largest

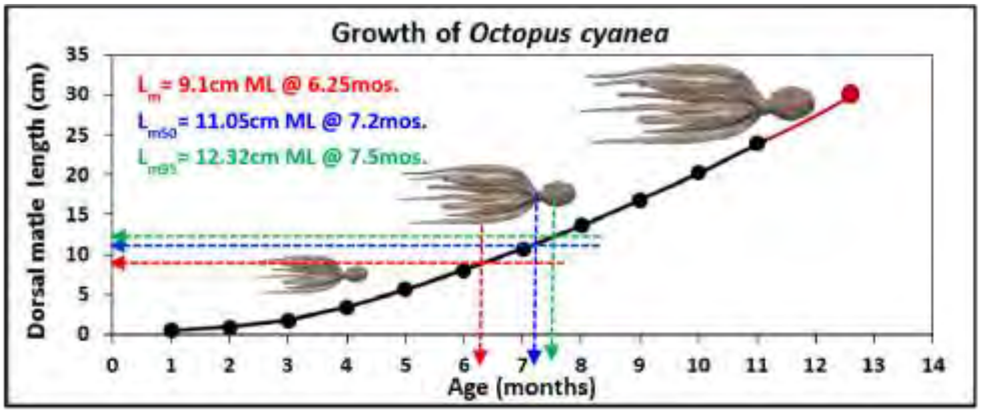


Figure 25. Growth curve of *Octopus cyanea* in Cantilan & Cortes, Surigao del Sur. Red line and or dot is the predicted growth of a 30.5cm ML octopus.

specimen (30.5cm ML) in this study may possibly age at about 13 months (see red dot and line in Fig. 25). The estimates of length and age at maturity in the present study are within the estimates of Herwig et al. (2012) in West Australia where age at L_{m50} (7.5-12.8 cm ML) was described at about 5.2-8.5 months or 5.2-7.5 months for male and female octopus, respectively.

C.5.5. Length-Based Spawning Potential Ratio

Spawning potential ratio of *O. cyanea* cannot be estimated because its growth is non-asymptotic (Heukelem, 1973), The web-based SPR can only be used for species that follow the VBGF or with asymptotic growth..

C.5.6. Harvest Control Recommendations

No SPR estimates can be derived for this species due to its rapid non-asymptotic growth and short lifespan. Based on the presented data, octopus fishery can be sustained by establishing a size limit of 9.1cm ML or approximately 450g, the size of the smallest mature octopus observed. But this may be a challenge because jiggers are passive and not size selective. Perhaps a better option is to implement a closed season for the species during the spawning season. According to the local fishers, large octopuses are caught in number from December-March and AugustOctober. A study however, should be conducted to validate this information. Again, comprehensive information drive should be done to relay this recommendation not only to the fisherfolks, but also the buyers or the consumers of this area. Consumers should be well aware to buy *O. cyanea* that are equal to or greater than the size limit only. By doing so, fishers will be discouraged in catching smaller individuals (no market for smaller individuals = no harvest of smaller individuals). Fines or non- renewal of fishing registration as penalty may also be imposed to non- compliant fishers.

C.6. *Selaroides leptolepis* (dorado)

C.6.1. General Biology

The yellowstripe scad, *Selaroides leptolepis*, is an inshore species under the jack and pompanos family, Family Carangidae. It feeds mainly on ostracods, gastropods and euphausiids but small fish are also taken. They form large demersal schools over soft bottom habitats at depths shallower than 50m. The yelowstripe scad is distributed throughout the Indo-West Pacific region, ranging from the Persian Gulf to the Philippines, north to Japan, south to the Arafura Sea and Australia (Froese & Pauly, 2016). The species is of commercial value to fisheries and is predominantly harvested with trawls and gill nets.

Figure 26. The target species *Selaroides leptolepis.*

S. leptolepis is estimated to grow to a maximum size of 22cm TL (=19.5cm SL), although it is commonly caught at about 15cm TL (=13.3cm SL) (Froese & Pauly, 2016). In east India, Reuben et al. (1992) reported that the yellowstripe scad becomes sexually mature (L_{m50}) at about 810.1cm TL (7.1-8.9cm SL) with an equivalent age of 0.72-0.85 year. While another study on the same area estimated the length at maturity at 13.4cm TL (11.9cm SL) for both sexes (Venkataramani et al. 1995). According to Reuben et al. (1992), *S. leptolepis* spawns twice in a year, from January-March and July-October with peak spawning in October and July. Recruitment of the species on the other hand is reported to peak in January and a minor peak in October.

C.6.2. Size Distribution

A total of 660 fish individuals were measured within the 2 month period. The smallest individual caught measured 7.5cm (size class 9.5cm SL) while 15.0cm (size class 15.5cm SL) was the largest (Fig. 27). Of the bottom set gill net catches, ~99% (=659 individuals) are above the estimated L_{m50} (8.73cm SL). This indicates that *S. leptolepis* were mostly mature when caught.

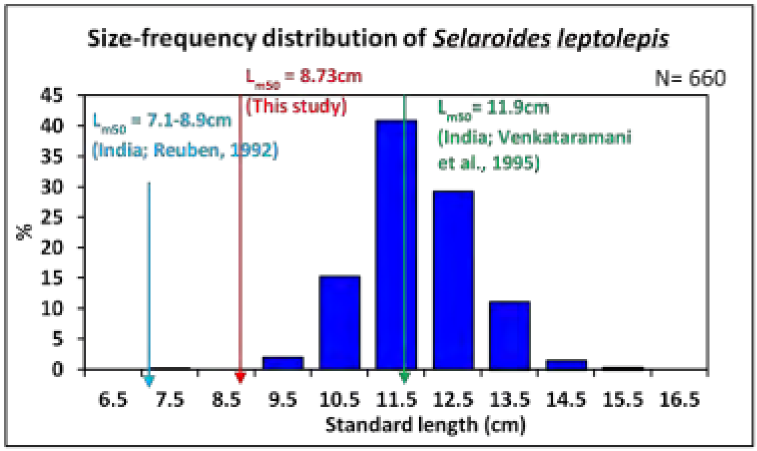


Figure 27. Size distribution of *Selaroides leptolepis* caught in Cantilan, Surigao del Sur from April – June 2016. Catches from bottom-set gill net only. No length data from Fish Forever. Note that Lm50 estimates of Reuben (1992) and Venkataramani et al. (1995) were converted from TL to SL.

Commonly caught size range from 10.5 -13.5cm SL, about 634 individuals. The high proportion of larger mature individuals in the catches is mainly attributed to the implemented mesh size of bottom set gill nets in Cantilan which is 5-8cm.

C.6.3. Gonadal Maturation and Maturation Curve

A total of 210 individuals were examined, with sizes ranging from 9.3– 15.5cm SL. Of these, 94% (=198 individuals) were mature/spent (Fig. 28a) with the smallest mature specimen observed at 9.3cm SL. Based on the ogive (Fig. 28b), length at which 50% of the population matures (L_{m50}) is about 8.73cm SL, while L_{m95} is at 11.79cm SL. The L_{m50} estimate in the present study is comparable to the result of Reuben et al. (1992) (L_{m50} =7.1-8.9cm SL) in Eastern Indian coast but is smaller than the L_{m50} estimate of Venkataramani et al. (1995, 11.9cm SL. While, the smallest mature individual observed is relatively lower than the reported L_m in Manila Bay (12-13cm FL or 11.412.35cm SL; Carvelo, 1987) and in the Visayan Sea (14-14.8cm FL or 13.3-14.06cm SL; Arce, 1986). But note that it is not definitive if the species starts to mature at 9.3cm SL because the smallest size examined for gonadal staging is also 9.3cm SL. Samples covering wider size range below
9.3cm and above 15.5cm SL would provide more accurate estimates of length at maturity.

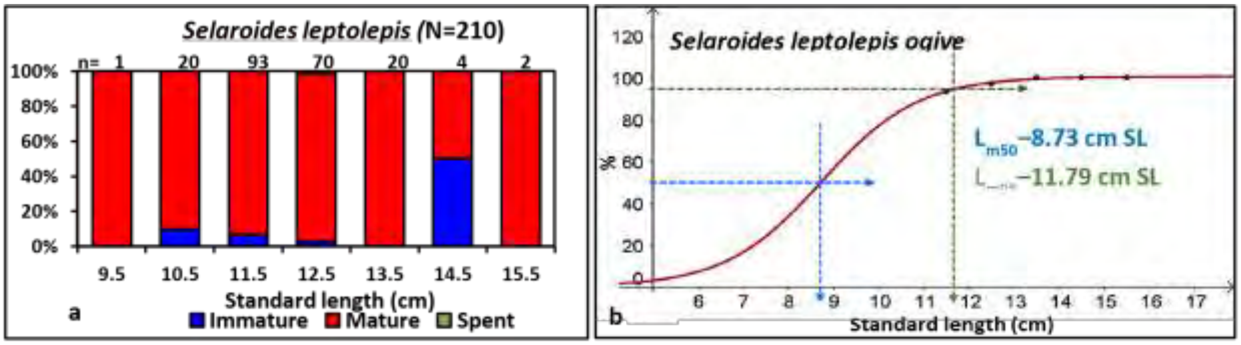


Figure 28. Gonadal maturation with size (a) and maturation curve (b) of *Selaroides leptolepis* in Cantilan, Surigao del Sur. **Note:** "n" above bars refer to the number of specimens examined per size class.

C.6.4. Growth Curve

Corresponding ages of the catches (7.5-15.5cm SL) is from 4.0 -12.0 months, with most between the ages of 6.0-9.0 months (10.5-13.5cm SL). Based on the growth curve (Figure 29), age at L_{m50} (8.73cm SL) of *S. leptolepis* is about 5 months, while age at L_{m95} is at 7.5 months. The age at L_{m50} in the present study is lower than the estimate of Reuben et al. (1992) in India (8-10 months). Again, these estimates are based only on the examined samples.

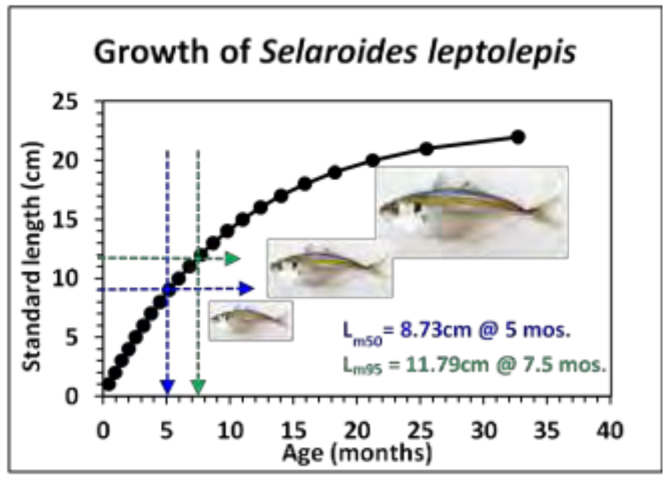


Figure 29. Growth curve of *Selaroides leptolepis* in Cantilan, Surigao del Sur.

C.6.5. Length-Based Spawning Potential Ratio

The estimated SPR of *S. leptolepis* caught in the fishery in Cantilan is shown in Table 6. At present, SPR of the stock based on the 2 month monitoring data is only 14%. The low SPR despite high proportion of mature individuals (99%) caught may be attributed to the small L_{m50} of the species (8.73cm SL) and overlap in the distribution of the catches and mature individuals (the more the overlap, the lower the SPR). To increase the SPR of *S. leptolepis* to at least 20-35%, the modal

Table 6. Estimated spawning potential ratio of *Selaroides leptolepis* In Cantilan, Surigao del Sur.

L_c (cm SL)	L_{50} (cm SL)	SPR
10.89 (actual)	11.35	14%
11.89	12.35	20%
13.89	14.35	35%

size of the catches should be set at 12.35-14.35cm SL. This means that catches smaller than this size should be banned.

C.6.6. Harvest Control Recommendations

Catches of *S. leptolepis* measured by the enumerators/field assistant (length data) and used in biological examination are similar with relatively larger size ranging from 7.5-15.5cm SL. This may indicate that the samples are representative of *S. leptolepis* stock in Cantilan. This also confirms the implementation of minimum mesh size (5-8cm) of bottom set gill nets in the area. Although examined samples are well above the L_{m50} (8.73cm SL), SPR is only 14%. Low SPR may be attributed to the small L_{m50} of the species and overlap in the distribution of the catches and mature individuals (the more the overlap, the lower the SPR). Based on the data, SPR can be increased to 20% and 35% by setting the size limit to 12.35cm and 14.35cm SL, respectively. This measure, however, should be accompanied with an increase in the mesh size of bottom set gill net, to allow the smaller sized matures and juveniles to freely pass and to ensure that individuals have already spawned or had already contributed to the stock (via spawning) before capture.

Comprehensive information drive should be done to relay these recommendations not only to the fisherfolks, but also the buyers or the consumers of this area. Consumers should be well aware to buy *S. leptolepis* that are equal to or greater than the size limit only. By doing so, fishers will be discouraged in catching smaller individuals (no market for smaller individuals = no harvest of smaller individuals). Fines or non- renewal of fishing registration as penalty may also be imposed to non- compliant fishers.

C.7. *Upeneus sulphureus* (timbungan)

C.7.1. General Biology

The sulphur goatfish *Upeneus sulphureus* (Family Mullidae), is widely distributed in coastal waters, entering estuaries throughout the Indo-West Pacific from East Africa to Southeast Asia from north to China to south to northern Australia and Fiji. The species which usually forms schools is demersal, and inhabits a depth of 10-90m. It preys mainly on small shrimps, crabs and fishes.

Figure 30. The target species *Upeneus sulphureus.*

Reported spawning season of this species occurs during the months of March, April and

December/January in Lingayen Gulf, Philippines (Galicia, 1994), January-May in Adhrasa-Orissa, India (Reuben et al. 1994) and December- March and May in Java, Indonesia (Nugroho et al. 2016). The size at first maturity was estimated at 11.8-12.7cm (mode of measurement not indicated, but could be TL) in the Philippines (Galicia, 1994), 13.1cm TL (=10.01cm SL) in India (Reuben et al. 1994) and in Indonesia, 9.3–10.3cm FL (=8.3-9.04cm SL) (Kembaren & Ernwati, 2011) and 12.9cm FL (=10.5cm SL) (Nugroho et al. 2016). The maximum reported length of this species is 23cm TL (= 17.14cm SL) (Froese and Pauly, 2016).

C.7.2. Size Distribution

A total of 1160 fish individuals were measured within the 2 month period. The smallest individual caught measured 5.5cm SL while 17cm was the largest (Fig. 31a). Commonly caught individuals range from 10.5-16.5cm SL (=1114 individuals). Of the bottom set gill net catches, ~98.7% (1145 individuals) are above the estimated L_{m50} (10cm SL). This indicates that *U. sulphureus* were mostly mature when caught. For Fish Forever data, 22 individuals were measured with sizes range from 4.5 -28.5cm SL. The largest individual measured in Fish Forever data is higher than the reported maximum length of *U. sulphureus* in FishBase (23cm TL or 21.5cm SL), but this should be verified if such size occur in the area.

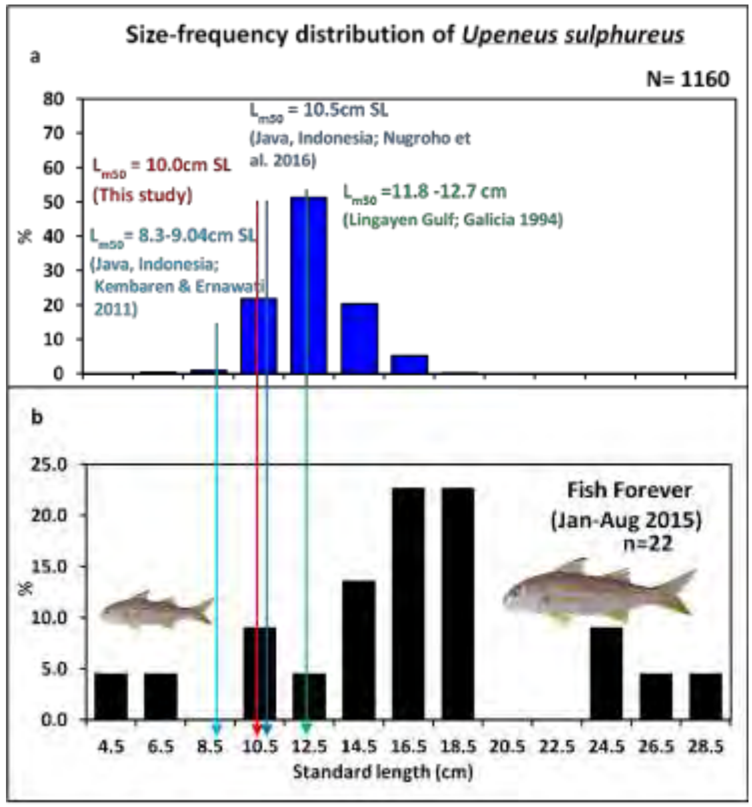


Figure 31. Size distribution of *Upeneus sulphuresus* caught in Cantilan, Surigao del Sur from April – June 2016. Catches from Bottom set gill net (a) & data from Fish Forever (May-Sep 2015) (b). Note: All Lm50 values from Indonesia were converted from FL-SL. Fish measurement L, TL or SL) not indicated in the study of Galicia (1994).

C.7.3. Gonadal Maturation and Maturation Curve

A total of 146 individuals were examined, with sizes ranging from 9.5– 14.5cm SL. Of these, 74.7% (=109 individuals) were mature (Fig. 32a) with the smallest mature specimen observed at 10.0cm SL. Based on the ogive (Fig.32b), length at which 50% of the population matures (L_{m50}) is about 10.0cm SL, while L_{m95} is at 13.53cm SL. The L_{m50} in this study is higher than the reported size range in Indonesia (8.3 – 9.04cm SL; Kembaren & Ernwati, 2011), lower than estimates of Galicia (1994) in Lingayen Gulf (11.8-12.7cm) but is relatively comparable to the estimates of Reuben et al. (1994) in India (10.01cm SL) and Nugroho et al. (2016) in Indonesia (10.5cm SL).

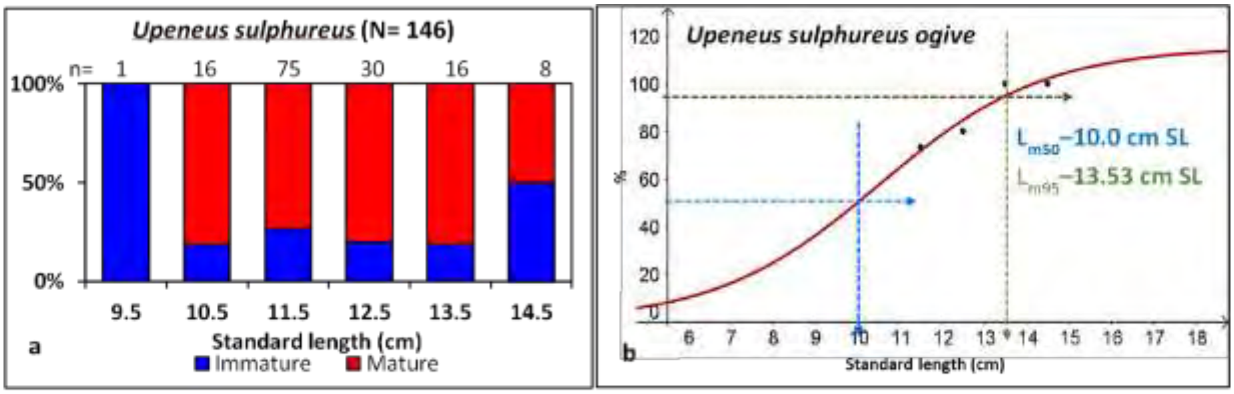


Figure 32. Gonadal maturation with size (a) and maturation curve (b) of *Upeneus sulphureus* in Cantilan, Surigao del Sur. **Note:** "n" above bars refer to the number of specimens examined per size class.

C.7.4. Growth Curve

Figure 33 shows the growth curve of *U. sulphureus* which may be used in estimating the ages of mature specimens and or the age of individuals of any given length. Information used in constructing this curve such as growth coefficient *k* and L_{∞} were obtained from Samar Sea (Ingles & Pauly 1984). Corresponding ages of the catches (8.5-16.5cm SL) is from 6.0-19.0 months, with most between the ages of 8.0-19.0 months (10.5-16.5cm SL). Based on the growth curve, age at L_{m50} (10.0 cm SL) of *U. suphureus* is about 7.1 months, same as the smallest mature in the study. Again, these estimates are based only on the examined samples.

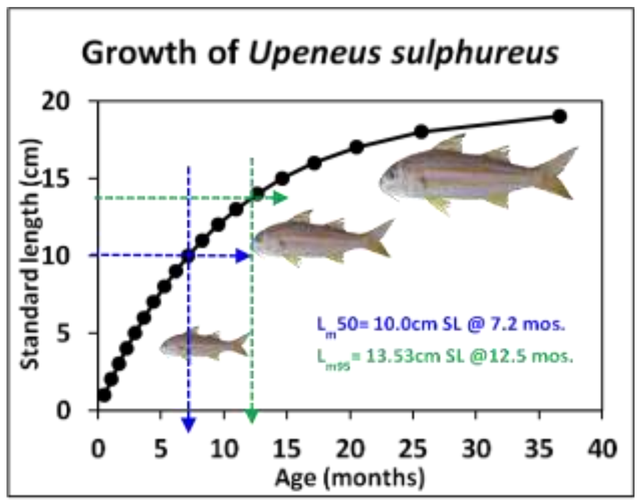


Figure 33. Growth curve of *Upeneus sulphureus* in Cantilan, Surigao del Sur.

C.7.5. Length-Based Spawning Potential Ratio

The estimated SPR of *U. sulphureus* caught in the fishery in Cantilan is shown in Table 7. At present, SPR of the stock based on the 2 month monitoring is already 30%. This is well within the accepted values of 20-30%. Looking at the size

Table 7. Estimated spawning potential ratio of

L_c (cm SL)	L_{50} (cm SL)	SPR

10.33	11.57	30%

Upeneus sulphureus in Cantilan, Surigao del Sur. distribution, most of the catches of *U. sulphureus* in this study are relatively mature and larger in size, indicating that the goatfish fishery in the area is sustainable.

C.7.6. Harvest Control Reference Points

Based on the results of the 2 month monitoring, *U. sulphureus* individiuals caught in this study are mostly mature, with 98.7% (=1114 individuals) of the catches are above the estimated L_{m50} (10.0cm SL). This explains the high SPR of the species (30%). While the results do not show an urgency for interventions, imposing a size limit of 11.57cm SL, would ensure long term sustainability of the stock. At present, the mesh sizes of bottom set gill nets used by the fishers in Cantilan ranges from 5-8cm. A minimum mesh size of 8 cm for bottom set gill nets can be imposed to reinforce the size limit of the species.

C.8. *Nemipterus nematopus* (sagisi-badlis)

C.8.1. General Biology

Nemipterus nematopus (Family Nemipteridae), commonly known as the yellow-tipped threadfin bream is widely distributed in Western Central Pacific, ranging the Philippines, Indonesia, and northern Australia from the Timor Sea to northern Queensland. This benthic species occurs on sand or mud bottoms in depths of 30-102m. Threadfin breams are carnivorous which feed mainly on other small fishes, cephalopods, crustaceans and polychaetes.

Figure 34. The target species *Nemipterus nematopus.*

Threadfin breams are an important component of commercial and artisanal fisheries in IndoPacific. Nemipterids are often marketed fresh, dry-salted, dry-smoke, fermented and steamed (FAO, 1998). The maximum reported length of *N. nematopus* is 17.5cm SL, while commonly caught individuals is about 15cm SL (Froese & Pauly, 2016). At present, no available information on the biology of the yellow-tipped threadfin bream exists.

C.8.2. Size Distribution

A total of 633 individuals were measured within the 2 month period, with the smallest individual caught measured 10.0cm SL while 23cm was the largest (Fig. 35a). The largest individual in this study is larger than the reported maximum length in Fish Base (17.5cm SL). Of the multiple hook and line catches, ~87% (=551 individuals) are above the estimated L_{m50} (12.95cm SL). Sizes commonly caught in the study ranges from 12.5-17.5cm SL (=518 individuals). This indicates that *N. nematopus* were mostly mature when caught. For Fish Forever data, only 6 individuals were measured from Jan-Apr 2015, with sizes ranging from 14.5-17.5 cm (Fig.35b).

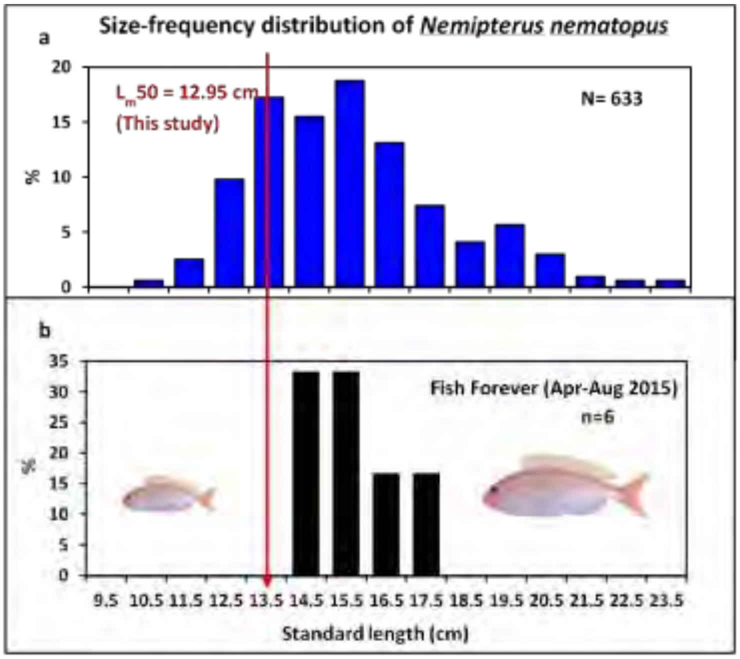


Figure 35. Size distribution of *Nemipterus nematopus* caught in Cantilan, Surigao del Sur from April – June 2016. Catches from Multiple hook and line (a) & data from Fish Forever (Apr-Aug 2015) (b).

C.8.3. Gonadal Maturation and Maturation Curve

A total of 90 individuals were examined, with sizes ranging from 12.0– 21.5cm SL. Of these, 95.6% (=86 individuals) were mature/spent (Fig. 36a) with the smallest mature specimen observed at 12.0cm SL. It is not clear however, if *N. nematopus* starts to mature at this size because the smallest specimen examined is also 12.0cm SL. Based on the ogive (Fig. 36b), length at which 50% of the population matures (L_{m50}) is about 12.95cm SL, while L_{m95} is at 14.97cm SL.

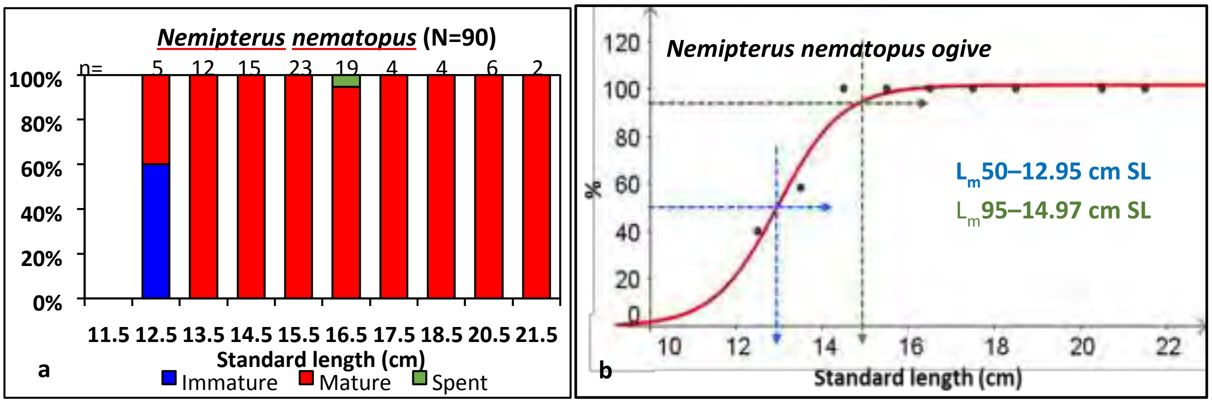


Figure 36. Gonadal maturation with size (a) and maturation curve (b) of *Nemipterus nematopus* in Cantilan, Surigao del Sur. **Note: "**n" above bars refer to the number of specimens examined per size class.

C.8.4. Growth Curve

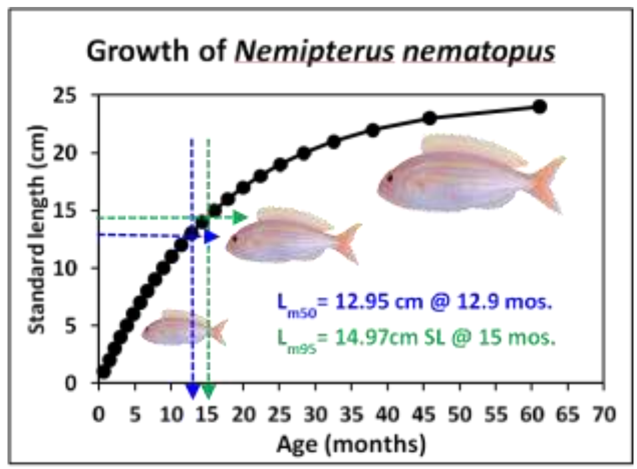


Figure 37. Growth curve of *Nemipterus nematopus* in Cantilan, Surigao del Sur.

Since no information on population parameters is available for *N. nematopus*, the information on its closely related species (*Nemipterus hexodon, Nemipterus mesoprion and Nemipterus tambuloides*) in constructing the growth curve such as growth coefficient *k* and L_{∞} were obtained from Java Sea, Indonesia (Dwipongo et al. 1986). Corresponding ages of the catches (10.5-21.5cm SL) is from 10.0-36.5 months, with most between the ages of 12.021.2 months (12.5-17.5cm SL). Based on the growth curve (Fig. 37), age at L_{m50} (12.95cm SL) of *N. nematopus* is about 5.6 months, while L_{m95} (14.97cm SL) has a corresponding age of 15 months. Again, these estimates are based only on the examined samples.

C.8.5. Length-Based Spawning Potential Ratio

The estimated SPR of *N. nematopus* caught in the fishery in Cantilan is shown in Table 8. At present, SPR of the stock based on the 2 month monitoring is already 42%. This is well above the accepted values of 20-30%. Looking at the size distribution, most of the catches of *N. nematopus* in this study are mature and larger in size, indicating that the fishery in the area is sustainable.

Table 8. Estimated spawning potential ratio of *Nemipterus nematopus* in Cantilan, Surigao del Sur.

L_c (cm SL)	L_{50} (cm SL)	SPR
12.31	14.79	42%

C.8.6. Harvest Control Recommendations

Based on the results of the 2 month monitoring, *N. nematopus* individiuals caught in this study are mostly mature, with 87% (=551 individuals) of the catches are above the estimated L_{m50} (12.95cm SL). This explains the high SPR of the species (42%). While the results do not show an urgency for interventions, imposing a size limit of 14.79cm SL would ensure long term sustainability of the stock.

C.9. *Lutjanus lutjanus (kamang)*

C.9.1. General Biology

The bigeye snapper, *Lutjanus lutjanus*, is widely distributed throughout the Indo-West Pacific, from East Africa to the Solomon Islands, north to southern Japan, south to Australia and recently recorded from Tonga. It inhabits offshore coral reefs and trawling grounds to depths of at least 90m and often seen in large schools of more than 100 individuals. The carnivorous species feeds on fishes and crustacean.

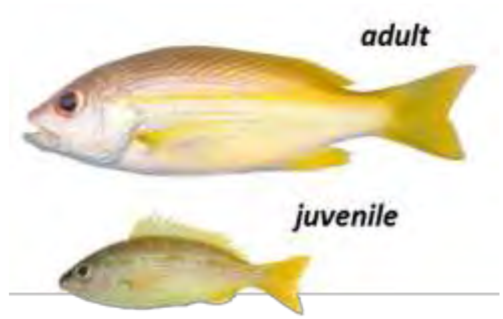


Figure 38. The target species *Lutjanus lutjanus.*

Limited information is known on the biology and life history of *L. lutjanus*. Nevertheless, Grimes (1987) described that the sexual maturity of snappers occur at approximately 40-50% of maximum length. The bigeye snapper matures at about 12cm TL (=10.5cm SL) and the reported spawning season in the Gulf of Aden is during March, November off East Africa and from January-June in the Gulf of Suez (Allen, 1985). Some of its closely related species such as *Lutjanus biguttatus* and *Lutjanus carponotatus*, attains its first sexual maturity at sizes of 13.0– 17.0cm FL (=11.6-15.2cm SL) (Papua New Guinea; Longernecker et al., 2013) and 18.0-19.9 cm FL (=16.1-17.8cm SL) (Great Barrier Reef; Kritzer, 2004), respectively. Kritzer (2004) reported that the earliest maturity and 50% maturity was estimated to be 2 years of age for *L. carponotatus* in Great Barrier Reef. The bigeye snapper has a maximum total length of about 35cm TL (=30.6cm SL), while the estimated maximum age is at least 11 years. This species is commonly caught to 20cm TL (=17.5cm SL), mainly using handlines and with bottom trawls in some areas. It is one of the more common snappers found in the market (FAO, 1998).

C.9.2. Size Distribution

A total of 339 *L. lutjanus* individuals were measured within the 2 month period. The smallest individual caught measured 10.2cm SL while 21cm was the largest (Fig. 39). Commonly caught sizes ranges from 12.5-15.5cm SL. Of the multiple hook and line catches, ~94.7% (=321 individuals) are above the estimated L_{m50} (11.67cm SL). This indicates that *L. lutjanus* were mostly mature when caught. For Fish Forever data, 16 *L. lutjanus* were measured from Apr-Aug 2015 with sizes ranging from 11.5-15.5cm SL (Fig.39b).

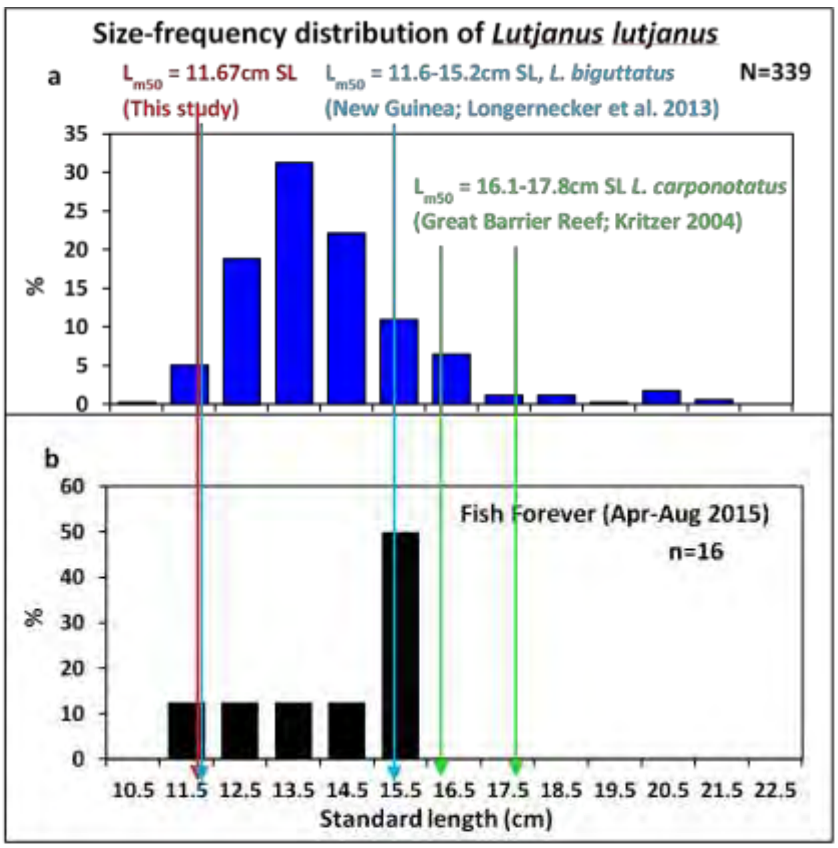


Figure 39. Size distribution of *Lutjanus lutjanus* caught in Cantilan, Surigao del Sur from April – June 2016. Catches Mutiple hook & line (a) & data from Fish Forever (Apri-Aug 2015) (b).

C.9.3. Gonadal Maturation and Maturation Curve

A total of 74 individuals were examined, with sizes ranging from 11.5– 21.5cm SL. Of these, 90.5% (=67 individuals) were mature (Fig. 40a) with the smallest mature specimen observed at 11.5 cm SL. It is not clear however, if the species starts to mature at this size because the specimen examined is also 11.5cm SL. It is possible that *L. lutjnaus* smaller than 11.5cm SL are also in mature stage. Based on the ogive (Fi.40b), length at which 50% of the population matures (L_{m50}) is about

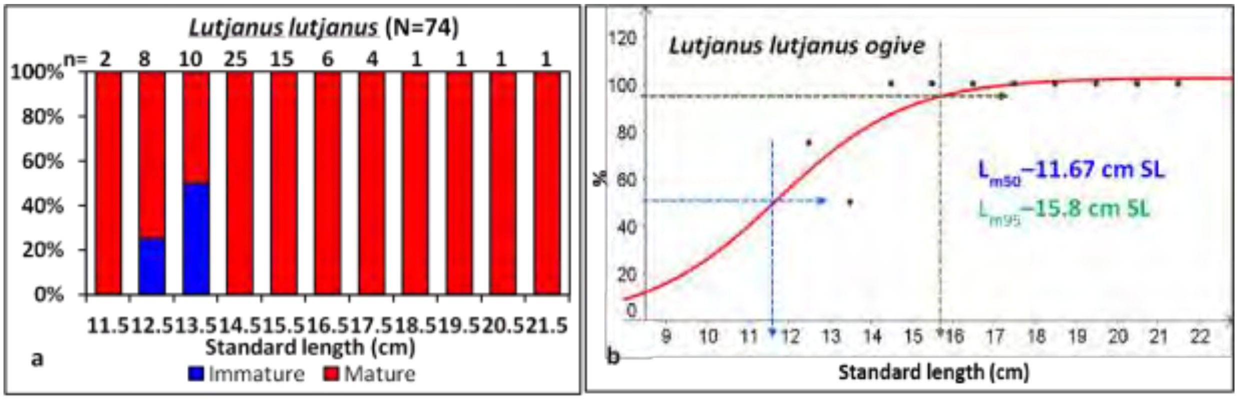


Figure 40. Gonadal maturation with size (a) and maturation curve (b) of *Lutjanus lutjanus* in Cantilan, Surigao del Sur. **Note: "n"** above bars refer to the number of specimens examined per size class.

11.67cm SL while L_{m95} is at 15.8cm SL. Of the closely related species, the L_{m50} of *L. biguttatus* (11.6-15.2 cm SL) appears to be comparable to the L_{m50} of this study. Reported maturity of the *L. lutjanus* is about 12cm (Allen, 1985) which closely corresponds to the result of this study.

C.9.4. Growth Curve

Figure 41 shows the growth curve of *L. lutjanus* which may be used in estimating the ages of mature specimens and or the age of individuals of any given length. Information used in constructing this curve such as growth coefficient *k* and L□ were obtained from Ticao Pass (FishBase 2016). Corresponding ages of the catches (10.5-21.5cm SL) is from 6.0-19.0 months, with most between the ages of 9.012.0 months (12.5-15.5cm SL). Based on the growth curve (Figure 41), age at L_{m50} (11.67cm SL) of *L. lutjanus* is about 8 months, while L_{m95} has a corresponding age of 12months.

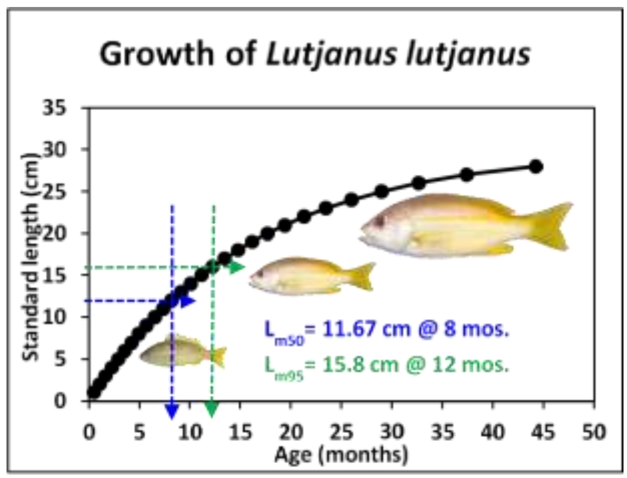


Figure 41. Growth curve of *Lutjanus lutjanus* in Cantilan, Surigao del Sur.

C.9.5. Length-Based Spawning Potential Ratio **Table 9**. Estimated spawning potential ratio The estimated SPR of *L. lutjanus* caught in the fishery of *Lutjanus lutjanus* in Cantilan, Surigao del

L_c (cm SL)	L_{50} (cm SL)	SPR

12.1 (actual)	13.36	25%
13.09	14.36	33%

Sur. in Cantilan is shown in Table 9. At present, SPR of the stock based on the 2 month monitoring data is already 25%, which is within the accepted values of 20-30%. High SPR is attributed to the high proportion of mature individuals in the larger sized samples (94.7%). This indicates that the fishery in the area is still sustainable.

C.9.6. Harvest Control Recommendations

L. lutjanus individiuals caught in this study are mostly mature, with 94.7% (=321 individuals) of the catches are above the estimated L_{m50} (11.67cm SL) of the species. This explains the high SPR of the species (25%). While the results do not show an urgency for interventions, imposing a size limit of 13.36cm SL, would ensure long term sustainability of the stock.

C.10. *Pentaprion longimanus (latab-putian)* *C.10.1.*

General Biology

Pentaprion longimanus, also known as longfin mojarra (Family Gerreidae), is widely distributed in the Indo-West Pacific, ranging from western and southern coasts of India and off Sri Lanka to Indonesia, the Philippines and Ryukyu Islands, and south to the northern part of Australia. It usually forms large schools and inhabits inshore areas, on muddy-sand bottoms, to depths of 70m. The species feeds mainly on small benthic invertebrates.

Figure 42. The target species *Pentaprion longimanus.*

The longfin mojarra has a reported maximum total length of 15cm (=11.5cm SL), but are commonly caught to 10cm TL (=7.7cm SL) (Bianchi, 1985). This species has been reported as one of the most dominant demersal fishes in trawling surveys in Brunei Darussalam (Vidthayanon, 1998) and eastern coast of Malaysia (Isa et al., 1997). The population dynamics of *Pentaprion longimanus* was reported in the Philippines (Ingles & Pauly, 1984), Brunei Darussalam (Silvestre & Garces, 2004), Indonesia (Sadhotomo et al., 1983) and Malaysia (Ahmad et al., 1983) but limited information is known on the reproductive biology of the species. In East India, Rao (1990) reported that the spawning period of *P. longimanus* is short extending from December to March. In southern Japan, its closely related species, *Gerres oyena* was reported to be sexually mature at about 8.14- 8.97cm SL, though length at first maturity was at 9.2-10.4cm SL with gonadal development between April and September and peak activity in April and May (Kanak & Tachihara, 2008).

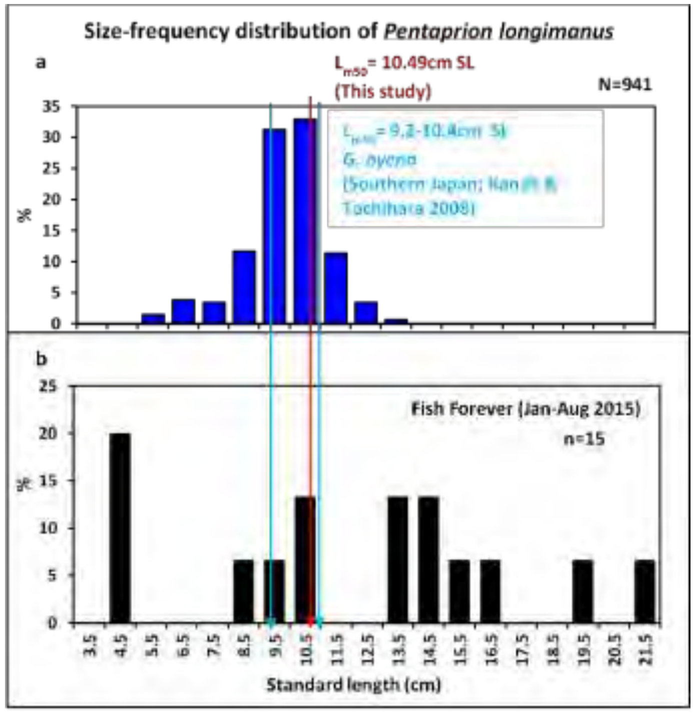


Figure 43. Size distribution of *Pentaprion longimanus* caught in Cantilan, Surigao del Sur from April – June 2016. Catches from Bottom set gill nets (a) & data from Fish Forever (Jan-Aug 2015) (b).

C.10.2. Size Distribution

A total of 941 *P. longimanus* individuals were measured within the 2 month period. The smallest individual caught measured 4.9cm SL while 13cm SL was the largest (Fig. 43a). Commonly caught individuals ranged from 8.5-11.5cm SL (=821 individuals). Of the bottom set gill net catches, ~48.4% are above the estimated L_{m50} (10.49cm SL). This indicates that more than half of *P. longimanus* were immature when caught. For Fish Forever data, only 15 *P. longimanus* were measured from Jan-Aug 2015, with sizes ranging from 4.5- 21.5cm (Fig. 43b). The largest individual in the Fish Forever data measures 21cm SL and is well above the reported asymptotic length of the species (15-17.2cm SL). Unfortunately, this measurement cannot be verified. It is possible that this is a separate species (i.e. *Gerres oyena*) considering its length.

C.10.3. Gonadal Maturation and Maturation Curve

For gonadal maturation, a total of 100 individuals were examined, with sizes ranging from 8.5–13.5cm SL. Of these, 42% (=42 individuals) were mature (Fig. 44a) with the smallest mature specimen observed at 8.2cm SL. Again, it is not definitive if this species starts to mature at this size range because the smallest specimen examined is also 8.2cm SL. Longer monitoring covering wider size range would provide more concrete estimates of length at maturity. Based on the ogive (Fig. 44b), length at which 50% of the population matures (L_{m50}) is about 10.49cm SL, while L_{m95} is at 11.29cm SL. The L_{m50} of *P. longimanus* appears to be comparable to its closely related species, *Gerres oyena* in Southern Japan (9.2-10.4cm SL; Kanak & Tachihara, 2008). The latter species is also a common mojarra/silverbiddy in the Philippines.

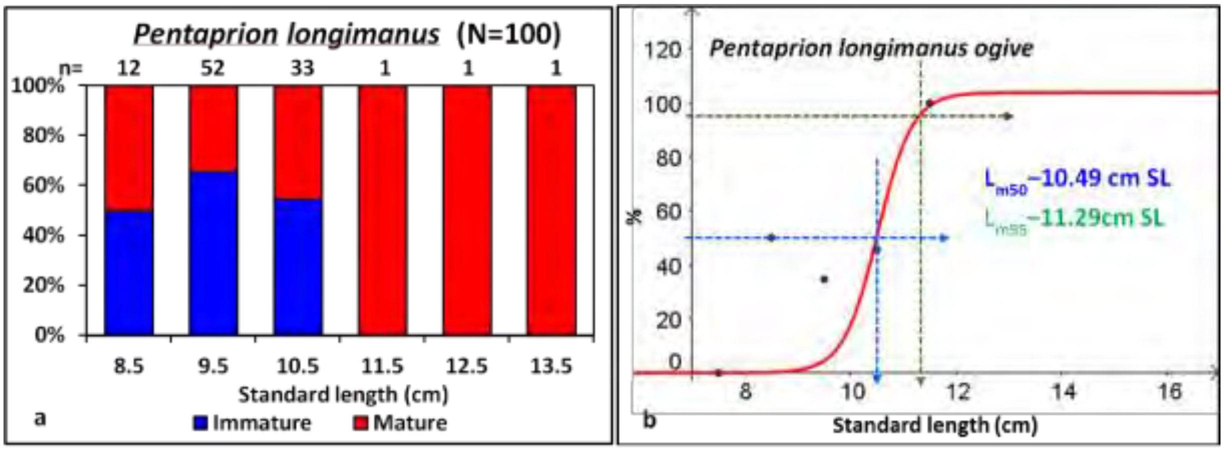


Figure 44. Gonadal maturation with size (a) and maturation curve (b) of *Pentaprion longimanus* in Cantilan, Surigao del Sur. **Note:** "n" above bars refer to the number of specimens examined per size class.

C.10.4. Growth Curve

Figure 45 shows the growth curve of *P. longimanus* which may be used in estimating the ages of mature specimens and or the age of individuals of any given length. Information used in constructing this curve such as growth coefficient *k* and L_{∞} were obtained from Samar Sea (Ingles & Pauly, 1984). Corresponding ages of the catches (4.5-13.5cm SL) is from 2.2-12.6 months, with most between the ages of 4.8-8.4 months (8.5-11.5cm SL). Based on the growth curve, age at L_{m50} (10.49cm SL) of *P. longimanus* is about 8.2 months, while L_{m95} (11.29cm SL) has a corresponding age of 9.5 months.

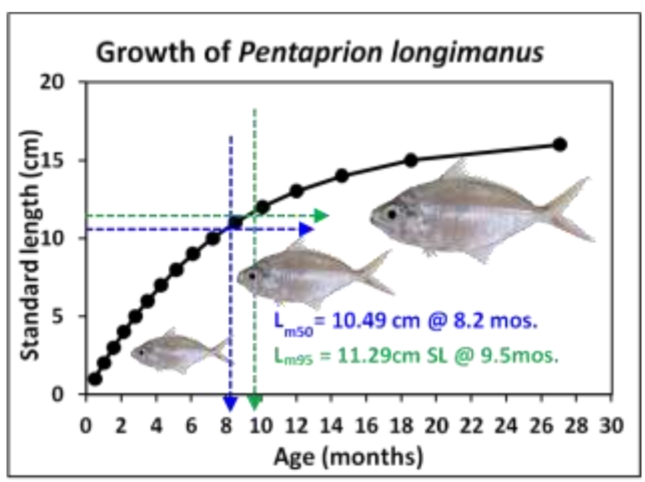


Figure 45. Growth curve of *Pentaprion longimanus* in Cantilan, Surigao del Sur.

C.10.5. Length-Based Spawning Potential Ratio

The estimated SPR of *P. longimanus* caught in the fishery in Cantilan is shown in Table

10. At present, SPR of the stock based on the 2 month monitoring data is only 7.0%. This is due to the relatively high proportion of immature individuals (52%) in the catches and small L_{m50} (10.49cm SL) of the species. To increase the SPR of *P. longimanus* to at least 17-30%, the modal length of the catches should be set at 10.42-11.42cm SL. This means that fishers should be banned in targeting fish that are smaller than this size range. SPR estimate is based on the 2 month data only.

Table 10. Estimated spawning potential ratio of *Pentaprion longimanus* in Cantilan, Surigao del Sur.

L_c (cm SL)	L_{50} (cm SL)	SPR
9.82 (actual)	9.42	7%
10.75	10.42	17%
1.66	11.42	32%

C.10.6. Harvest Control Recommendations

The catches showed a relatively similar proportion of mature and immature individuals. Hence, resulting SPR is low, only 7%. To ensure the sustainability of *P. longimanus* stock in Cantilan, a size limit of 10.42-11.42cm SL is suggested. This will increase the SPR of the species to 17-30% by allowing more individuals to grow and spawn.

C.11. *Gazza minuta* (latab-putian)

C.11.1. General Biology

The toothpony, *Gazza minuta* (Family Leiognathidae), is a demersal species found in inshore coastal waters, throughout Indo-Pacific, ranging from the Red Sea and the east African coast to Australia and Tahiti, and north to the Ryukyu Islands. It occurs in schools and often found over muddy to sandy-mud substrates. The piscivorous species feeds on small fish, shrimps other crustaceans, and polychaetes (Froese & Pauly, 2016).

Figure 46. The target species *Gazza minuta.*

Estimates of population parameters of *Gazza minuta* were reported in the Philippines (Ingles & Pauly, 1984), Brunei Darussalam (Froese & Pauly, 2016) and southeastern India (Nagarajan, 2014; Jayabalan & Ramamoorthi, 1986; Abraham et al., 2011). In the study of Nagarajan (2014), *G.minuta* attains a length of 10.4, 14.8, 16.7 and 17.2cm TL (=8.1, 11.5, 13.03, 13.4cm SL) in 0.05, 1.0, 1.5 and 1.75 years (=5, 12, 18 and 21 months). Approximate lifespan of this species from Northern Australia is from 1.5 to 2 years (Smith, 2001). Limited information is available on the reproductive biology of *G. minuta*. Smith (2001) noted that *G. minuta* in Northern Australia, is one of the largest and slowest maturing (>7 months) species of leiognathids and appears to spawn over a prolong period. On the other hand, its closely related species *Secutor ruconius*, reported an onset of maturity at about 5.2cm SL (Cabanban, 1991) from Cleveland Bay, Australia. Another closely-related species *Secutor insidiator* reported an L_{m50} of 7.5cm TL (5.85cm SL) in Kerala Coast India (Abraham et al., 2011) and 9cm SL (7.02cm SL) in Kakinada, India (Murty, 1990). *S. insidiator* has a protracted spawning season extending almost throughout the year. The toothpony reaches a maximum length of 21cm FL (=18.8 cm SL) and commonly caught at about 15cm TL (=11.7cm SL). Larger individuals are marketed fresh or dried-salted.

C..11.2. Size Distribution

A total of 556 *G. minuta* individuals were measured within the 2 month period. The smallest individual caught measured 5cm SL while 12cm was the largest (Fig. 47a). Commonly caught sizes range from 7.5-10.5cm SL (=478 individuals). Of the bottom set gill net catches, ~80.5% (447 individuals) are below the estimated L_{m50} (9.56cm SL). Only 19.5% were mature. This indicates that a high proportion of immature individuals were caught by the gear. For Fish Forever data, only 2 *G. minuta* were measured from JanApr 2015. Size of measured specimens is 6.0 and 9.0cm SL (Fig. 47b).

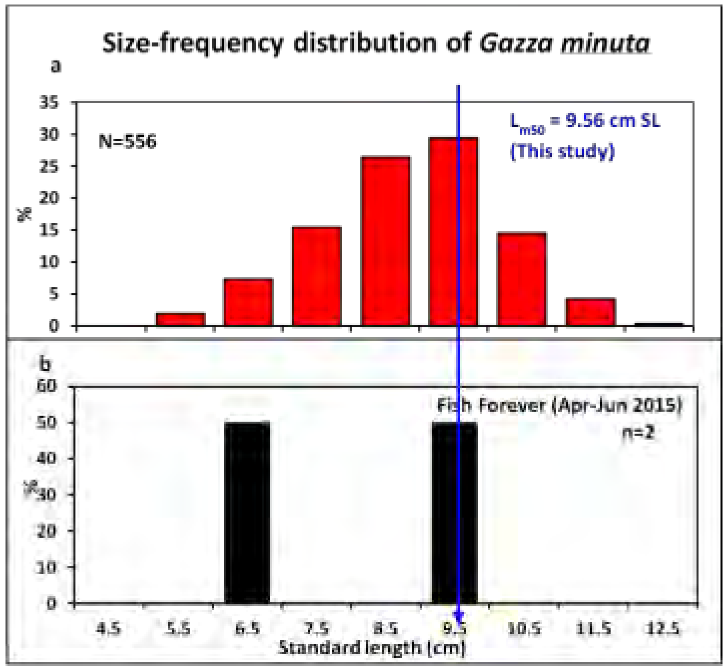


Figure 47. Size distribution of *Gazza minuta* caught in Cantilan, Surigao del Sur from April – June 2016. Catches from Bottom set gill nets (a) & data from Fish Forever (Apr-Jun 2015) (b).

C.11.3. Gonadal Maturation and Maturation Curve

A total of 58 individuals were examined, with sizes ranging from 8.5– 12.5cm SL. Of these, 53.4% (=31 individuals) were mature (Fig. 48a) with the smallest mature specimen observed at 8.5cm SL. The smallest size of individual examined is also 8.5cm SL, hence, it is possible that *G. minuta* smaller than 8.5cm SL are also mature. Based on the ogive (Fig.48b), length at which 50% of the population matures (L_{m50}) is about 9.56cm SL, while L_{m95} is at 10.23cm SL. The L_{m50} of *G.minuta* in the present study is higher than the L_{m50} of its closely related species, *Secutor ruconius* (5.85cm SL, Abraham et al. 2011; 7.02cm SL, Murty, 1990).

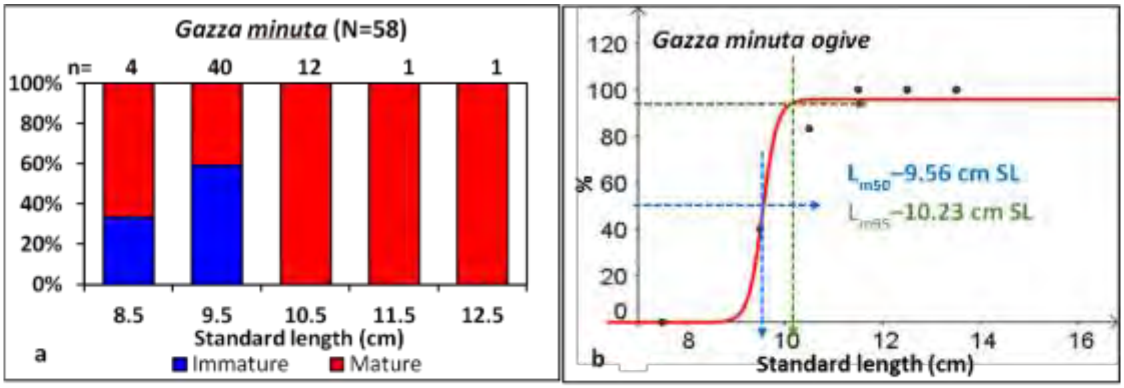


Figure 48. Gonadal maturation with size (a) and maturation curve (b) *Gazza minuta* in Cantilan, Surigao del Sur. **Note: "**n" above bars refer to the number of specimens examined per size class.

C.11.4. Growth Curve

Population parameters used in constructing the growth curve were taken from San Miguel bay (Ingles & Pauly, 1984). Based on the constructed growth curve (Fig. 49), the corresponding age of the estimated L_{m50} (9.56cm SL) of *G. minuta* in Cantilan is about 13 months, while the relative age of L_{m95} (10.23cm SL) is 15 months. Corresponding ages of the catches (4.5-12.5 cm SL) is from 4.2-25.0 months, with most between the ages of 5.0-15.6 months (7.5-10.5cm SL). According to Smith (2011), *G. minuta* has an approximate lifespan of 1.5-2 years. In this study, the relative age of the largest (12.5cm SL) *G. minuta* is 25 months or 2 years, indicating that the species is able to grow its lifespan.

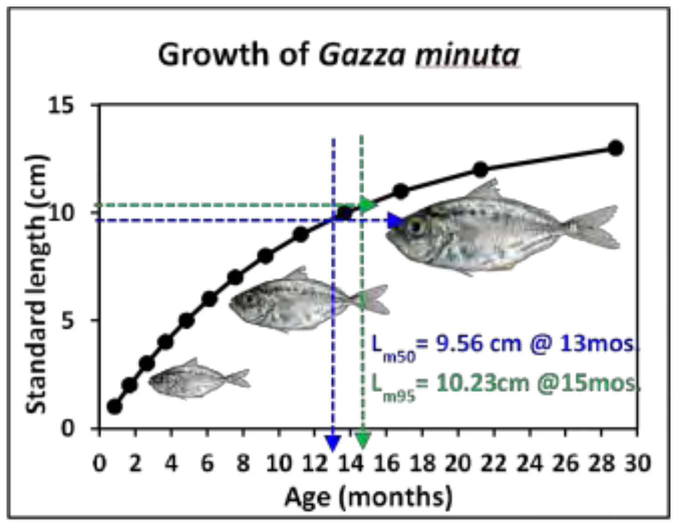


Figure 49. Growth curve of *Gazza minuta* in Cantilan, Surigao del Sur.

C.11.5. Length-Based Spawning Potential Ratio

The estimated SPR of *G.minuta* caught in the fishery in Cantilan is shown in Table 11. At present, SPR of the stock based on the 2 month monitoring data is 16%. This may be due to the high proportion of immature individuals in the catches (80.5%). To increase the SPR of *G. minuta* to at least 30%, the modal length of the catches should be set at 9.5cm SL. This means that fishers should be banned in targeting fish that are smaller than the size limit.

Table 11. Estimated spawning potential ratio of *Gazza minuta* in Cantilan, Surigao del Sur.

L_c (cm SL)	L_{50} (cm SL)	SPR
8.38 (actual)	8.5	16%
9.41	9.5	31%

C.11.6 Harvest Control Recommendations

The catches of bottom set gill nets were dominated with immature individuals (80.5%), hence resulting SPR is low, 16%. To increase the SPR and ensure the sustainability of the stock, the modal size limit of *G. minuta* should be set to 9.5cm SL. This measure should be accompanied with increasing the mesh size of gill nets used in the area. Comprehensive information drive should also be done to relay these recommendations not only to the fisherfolks, but also the buyers or the consumers of this area. Consumers should be well aware to buy *G. minuta* that are equal to or greater than the size limit only. By doing so, fishers will be discouraged in catching smaller individuals (no market for smaller individuals = no harvest of smaller individuals). Fines or non- renewal of fishing registration as penalty may also be imposed to non- compliant fishers.

C.12. Catch and Effort Monitoring

The information on catch and effort data, recorded by hired enumerators in the monitored barangays allows the computation of catch rates, which are a more reliable index of stock abundance than fisheries landings. Other information that can be gleaned from the catch and effort records are total harvest of the gears in the barangays monitored, species composition, and fishing ground information (where fishers operate). Records on specific areas fished by each trip also provide valuable insights on the behavior and distribution of the target species.

C.12.1. Catch of Monitored Gears

The total catch of the monitored fishing gears in the monitored brgys during the 3 month period is presented in Table 12. Of the total catch (25,765.6 kg), target species contributed 36% (9, 925 kg) with *O. cyanea* (17% or 4486.1 kg), *L. ornatus* (6% or 1,685.4 kg) and *C. arcticeps* (5% or 1,467.9 kg) contributing the highest. The other *target* species contributed less than 6% to the total catch: *S. canaliculatus* (5% or 196.4 kg), *Nemipterus nematopus* (4 % or 1017.9 kg), *U. sulphureus (2% or 468.1 kg), S. fuscescens (2% or 460.4 kg), S. leptolepis (1% or 259.9 kg), L. lutjanus (0.6% or 156.5 kg), G. minuta (0.4% or 108.2 kg) and P. longimanus (0.4% or 93.4 kg).* Among the non-target groups, Engraulidae (7%), other species of family Lutjanidae (3%) and Nemipteridae (3%) showed relatively higher contributions.

Table 12. Total catch of the monitored gears in the monitored brgys. in Cantilan & Cortes, Surigao del Sur from April – July 2016.

	Total Catch (kg)									
	Cantilan				Cortes					
Gear	Consuelo	General Is.	Linintian	Magosilom	Burgos	Madreliño	Poblacion	Tag-anungan	Uba	Total

Bag Net	**1049.1**	**859.7**		**4470.0**	**241.2**			**46.6**		**5329.7**
Bottom-Set Gill Net		**1206.4**	**1037.9**				**1834.9**			**5416.0**
Drift Gill Net		**139.9**			**846.8**	**441.6**		**0.0**		**1579.5**
Fish Corral								**1885.9**	**998.1**	**846.8**
Jigger		**369.2**								**4293.0**
Multiple Hook & Line		**1217.9**		**3380.9**		**389.7**	**2509.1**	**42.9**	**2037.9**	**7497.5**
Spear						**136.9**	**601.2**			**803.3**
	1049.1				**1088.0**			**1975.3**	**22.4**	
Total per municipality		**3793.0**	**1037.9**	**7850.9**		**968.1**	**4945.2**		**3058.3**	**25765.6**
		13730.8					**8976.5**		**25765.6**	

Between barangays, the highest catch was recorded in Magosilom (7,850.9 kg or 30.5%), where bag net operations were recorded. Catches of bag nets are primarily dominated with schooling small and large pelagics, hence, catch is high. Lowest catch on the other hand was recorded in Madrelino (968.1 kg or 3.7%) (Table 12). But note that these catches may not represent the true landings in the barangays since these data reflect only the monitored catches that are dependent on the records of the enumerators (the more frequent recording of enumerators would result to high catch records.)

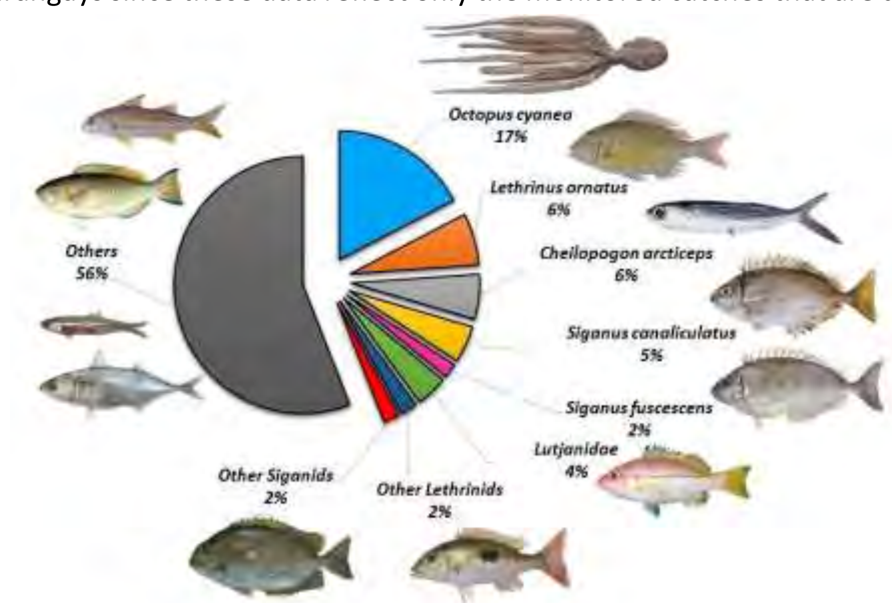


Figure 50. Overall species composition of catches of the monitored fishing gears in the selected barangays in Cantilan and Cortes, Surigao del Sur from April - July 2016.

A more detailed examination of species composition by gear type is shown in Figures 51 and 52. Catches of bottom set gill nets catch were dominated with siganids (*S. canaliculatus, S. guttatus and S. fuscescens*) comprising approximately 31% of the total catch (Fig. 51a), while catches from multiple hook and line consisted of larger-sized fish groups dominated by *L. ornatus* (20%), other lutjanids (11%) and nemipterids (21%, including *N. nematopus*) as well as pelagic species (scombrids) (Fig.51b). Scarids (42%) and *O. cyanea* (27%) comprised the dominant catch in spearfishing (Fig. 52c). For drift gill net, catch is dominated by the flying fish *C. arcticeps* (89%),

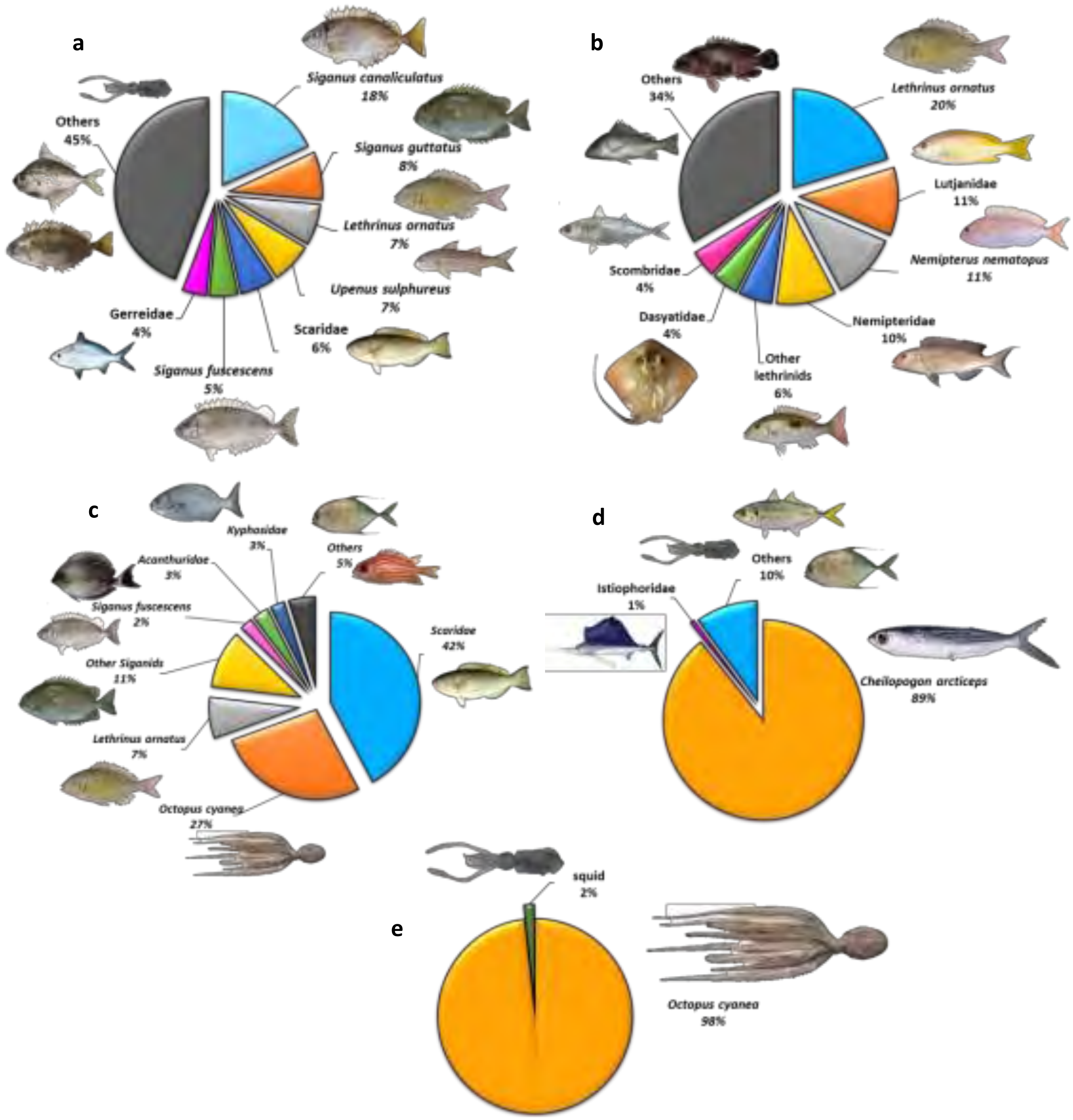


Figure 51. Species composition of catches from bottom set gill nets(a), multiple hook and lines (b), spears (c), drift gillnets (d) and jiggers (e) in Cantilan and Cortes, Surigao del Sur from April to July 2016.

while smaller portion of larger pelagics such as marlins (Istiophoridae) and jacks (carangids) and squids were also caught. Jiggers on the other hand target mainly octopus (98%) though a small proportion of squids ware also caught. For bagnet catch in Cantilan, engraulids was the most dominant (25%) (Fig.52a). For fish corrals in Cortes, more the 25% of the catches were dominated by siganids, mainly by *S. fuscescens*, and likewise, other bottom dwelling fish species (plotosids, dasyatids, leiognathids and holocentrids) were also caught.

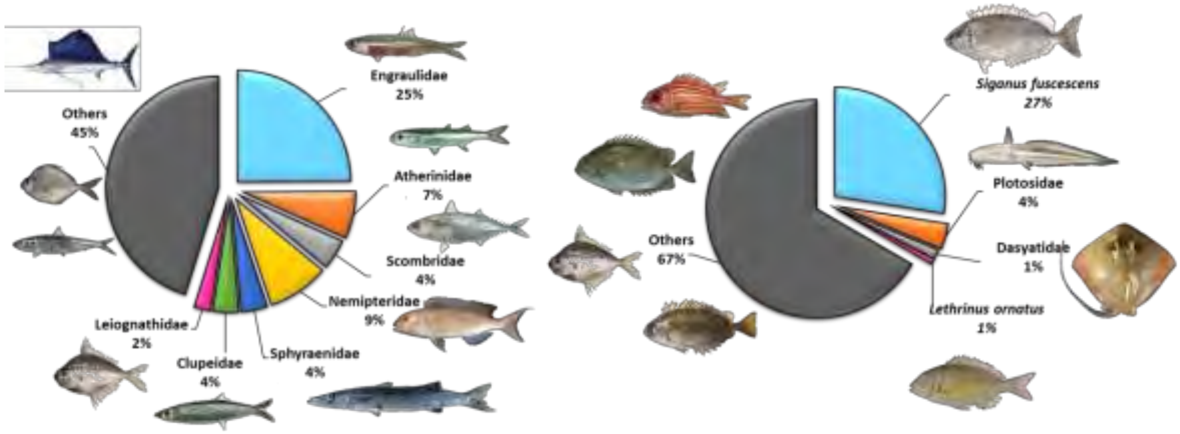


Figure 52. Species composition of catches from bag nets (left) in Cantilan and fish corrals (right) in Cortes, Surigao del Sur from April to July 2016.

The above results are based only on the 3 months of data and may not necessarily reflect the overall year-round composition and abundance of catches from the different gear types used in the area.

C.6.2. Extrapolation of Total Catch

The purpose of the extrapolation is to provide estimates of potential supply of the target species in a year, from the monitored sites. The derived values are likely to be underestimates of the true amounts because the study was done outside the spawning season for some of the target species. Catches are usually higher during spawning months.

Catch rates in this report are expressed as the mean number of kg caught per fisher per trip, wherein a typical trip is usually a day's operation. Fishing frequency, on the other hand, is expressed as number of fishing hours per trip and number of fishing days per month. The results of the analyses are presented below by gear type.

Mean catch rates and fishing effort of the gears monitored based on the present study are presented in Table 13. The number of fishers operating each gear is also indicated. The highest catch rate was recorded from jigger (3.4 kg/fisher/trip) which mainly targets octopus in zones 2 and 4, especially around the island brgys of Cantilan and Cortes. The high catch rate from jigger is likely due to the body mass (heavy) of the octopus individuals. The next highest catch rate was from drift gill net (3.2 kg/fisher/trip), followed by spearfishing (3 kg/fisher/trip), while fish corral recorded the lowest (overall -1.1 kg/fisher/trip), with zero catch in brgy. Tag-anungan during the monitoring period.

Note that bag net (2.6 kg/fisher/trip) usually catch large schools of pelagics such as anchovies (engraulids) during its season (late SW to NE monsoon). Local fishers mentioned that during the season of engraulids (bolinao), more than 40 kg to 2800 kg (1-70 icebox) are caught. The monitoring period was off season for these pelagics, thus, reflected the lower catch rate for this gear.

Total catch of each gear was extrapolated by multiplying the catch rate (average kg/fisher/trip) with the mean number of fishing days per month, number of fishing months per year (assumed to be 12 months) and number of fishers operating the monitored gear type. The number of fishers in the monitored sites are based on estimates from initial interviews at the start of the study, and through subsequent interviews by the field assistants.

The extrapolated catches are presented in Tables 13a and b. The estimated annual catch of the monitored gears in the 9 barangays Consuelo, General Island, Linintian, Magosilom (Cantilan), Burgos, Madrelińo, Poblacion, Tag-anungan, and Uba (Cortes) is about 159.4 MT. Among the various gear types, jigger contributed 41.8 MT or 26.2% of total production and this was closely followed by multiple hook and line with 39.9 MT (25%). This is because of its relatively high catch rate, 3.4 kg/fisher/trip (mean=2.8, range 2.1-3.4 kg/fisher/trip) and the relatively high number of fishers (effort). Between barangays, General Island showed the highest annual catch of 73.4 MT or 46%.

The composition of the extrapolated catch is shown in Table 14. The contribution of *O. cyanea* to the annual catch is about 23.6.0% (37.6 MT), while *S. canaliculatus* is 14.7% (23.5 MT). *C. arcticeps, N. nematopus, L. ornatus and S. fuscescens* contributed only 5.6% (8.9 MT), 5.2% (8.3 MT), 4.7% (7.5 MT) and 2.7% (4.3 MT), respectively. The rest of the target species contributed less than 1% each to the total catch (0.1%-9.6%). For the non-target groups, Engraulidae showed the highest contribution (3.6MT or 2.3%) and this was followed by other species of lutjanids (3.4 MT or 2.2%), and Scaridae (3.1 MT or 2%).

Table 13a. Catch matrix showing the estimated annual catch of the target fishing gears in the selected brgys of Cantilan and Cortes, Surigao del Sur.

Catch rate Est.
No. of No. fishing
Gear Brgy. **fishers days/mo (kg/fisher/ Annual trip) Catch (MT)**

Bag Net	General Is.	9	14.7	2.6	4.0
	Magosilom	5	20.7	1.6	2.0
Bottom-Set Gill Net	General Is. (Ayoke Is.)	16	19.7	2.0	19.1
	Linintian	7	20.7	0.7	1.1
	Consuelo	33	20.7	0.2	1.9
	Poblacion (Sabang)	10	23.0	1.2	3.4
	Tag-anungan	26	12.0	0.1	0.5
	Burgos	24	16.0	1.1	5.0
Drift Gill Net	General Is. (Ayoke Is.)	40	19.3	1.4	12.7
	Madreliño	15	10.6	0.7	1.4
	Uba	6	19.0	3.2	4.4
Fish Corral	Tag-anungan	8	4.0	0.0	6.6
	Burgos	30	16.0	1.1	17.6
Jigger	General Is. (Ayoke Is.)	35	19.7	2.1	6.8
	Uba	10	20.0	2.8	17.4
	Tag-anungan	21	20.5	3.4	19.9
Multiple Hook & Line	General Is.	60	18.7	1.5	4.2
	Magosilom	7	20.3	2.5	1.2
	Madreliño	5	11.8	1.7	14.6
	Poblacion (Sabang)	30	22.8	1.8	0.8
Spearfishing	Madreliño	4	11.7	1.5	5.5
	Uba	58	3.0	2.6	7.8
	Poblacion (Sabang)	10	21.5	3.0	1.4
	Tag-anungan	21	12.0	0.5	
					159.4

Table 13b. Summary of the estimated annual catch of target fishing gears in the selected brgys. of Cantilan and Cortes, Surigao del Sur. Brgys in Cantilan highlighted in pink, Cortes in highlighted blue.

Gear	Consuelo Magosilom	General	Is.	Linintian	Burgos	Madreliño	Poblacion	Tag-anungan	Uba	Total	%
Bag Net		4.0		2.0						6.1	3.8
Bottom-Set Gill Net	1.9	19.1	1.1		5.0		3.4	0.5		30.9	19.4
Drift Gill Net		12.7				1.4			4.4	18.5	11.6
Fish Corral					6.6					6.6	4.1
Jigger		17.6						17.4	6.8	41.8	26.2
Multiple Hook & Line		19.9		4.2		1.2	14.6			39.9	25.0
Spear						0.8	7.8	1.4	5.5	15.6	9.8
										0.0	0.0
Total	1.9	73.4	1.1	6.2	11.5	3.4	25.8	19.3	16.7	159.4	100.0

Total Catch (MT)

Gear

Table 14. Composition of estimated annual catch in the selected brgys of Cantilan and Cortes, Surigao del Sur. Brgys in Cantilan highlighted in pink, Cortes in highlighted blue.

	Total Catch (MT)									Total	% ctn
Taxa	**Consuelo**	**General Is.**	**Linintian**	**Magosilom**	**Burgos**	**Madreliño**	**Poblacion**	**Tag-anungan**	**Uba**		
Octopus cyanea	0.0	7.0	0.0	0.0	0.0	0.0	1.0	18.3	11.2	37.6	23.6
Siganus canaliculatus	0.0	23.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.5	14.7
Cheilopogon arcticeps	0.0	2.4	0.0	0.0	0.0	1.3	0.0	0.0	5.2	8.9	5.6
Nemipterus nematopus	0.0	7.8	0.0	0.5	0.0	0.0	0.0	0.0	0.0	8.3	5.2
Lethrinus ornatus	0.0	0.3	0.0	0.3	0.2	0.2	6.5	0.0	0.0	7.5	4.7
Siganus fuscescens	0.0	0.0	0.0	0.0	3.3	0.0	0.6	0.4	0.0	4.3	2.7
Lutjanus lutjanus	0.0	0.9	0.0	0.1	0.0	0.0	0.0	0.0	0.0	1.0	0.6
Upenus sulphureus	0.4	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.4
Selaroides leptolepis	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.3
Pentaprion longimanus	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Gazza minuta	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Engraulidae	0.0	2.6	0.0	1.0	0.0	0.0	0.0	0.0	0.0	3.6	2.3
Lutjanidae	0.1	0.0	0.0	0.1	0.0	0.6	2.7	0.0	0.0	3.4	2.2
Scaridae	0.0	0.0	0.0	0.0	0.1	0.3	2.8	0.0	0.0	3.1	2.0
Nemipteridae	0.0	0.8	0.0	0.4	0.0	0.0	1.5	0.0	0.0	2.7	1.7
Lethrinidae	0.0	1.4	0.0	0.2	0.0	0.1	1.0	0.0	0.0	2.7	1.7
Siganus guttatus	0.0	0.0	0.0		0.2	0.0	2.0	0.0	0.0	2.2	1.3
Dasyatidae	0.0	0.0	0.0	0.0	0.1	0.0	1.2	0.0	0.0	1.4	0.9
Haemulidae	0.0	0.0	0.0	0.0	0.0	0.1	1.0	0.0	0.0	1.1	0.7
Lactariidae	0.0	0.0	0.0	0.0	0.0	0.1	0.9	0.0	0.0	1.1	0.7
Other Siganidae	0.0	0.0	0.0	0.0	0.1	0.1	0.3	0.4	0.0	0.9	0.6
Leiognathidae	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.7	0.5
Scombridae	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.5	0.3
Sphyraenidae	0.0	0.0	0.0	0.2	0.0	0.2	0.0	0.0	0.0	0.4	0.2
Atherinidae	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.4	0.2
Gerreidae	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.3	0.2
Clupeidae	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.2	0.1
Others	0.7	26.4	0.5	2.3	7.4	0.5	4.2	0.1	0.2	42.4	26.6
	1.9	73.4	1.1	6.2	11.5	3.4	25.8	19.3	16.7	159.4	100.0

C.6.3. Fishing ground

Figures 53 and 53 show where the target fishing gears usually operate. Information used in constructing this figure is from the recorded fishing ground of all fishing trips within the 3 month monitoring period. Note that frequently fished areas are denoted with large circle (50-100%), medium circle (10-50%) while small circle (1-10%) for least fished areas.

Most of the fishing activities are limited to municipal waters, although fishers in each barangay are not restricted to fish in other barangays. Most fished areas are concentrated in the zones 2 and 4, where most of the target barangays are situated.

For fishing gears targeting *C. arcticeps,* gear operations were mostly concentrated in Uba and Madrelino (Fig.53b). For the 2 siganids, *S. canaliculatus* is more commonly fished in the surrounding waters of General Is. as well as Ayoke while gear operations of *S. fuscescens* is concentrated in Tag-anungan, Poblacion and Burgos (Fig.53c-d). Fishing gears targeting *L. ornatus* are also more concentrated in Poblacion while *O. cyanea,* operations are mainly in Tag-anungan, Uba, and around Ayoke and General Is. (Fig.53e-f). For bottom set gill nets, its operation is widely distributed but is more common in Consuelo and Linintian targeting *S. leptolepis, U. sulphureus, P. longimanus and G. minuta*. On the other hand, multiple hook and line operation for *N. nematopus* and *L. lutjanus* are also common in surrounding waters of Ayoke and General Is but gear operation of the latter is less distributed.

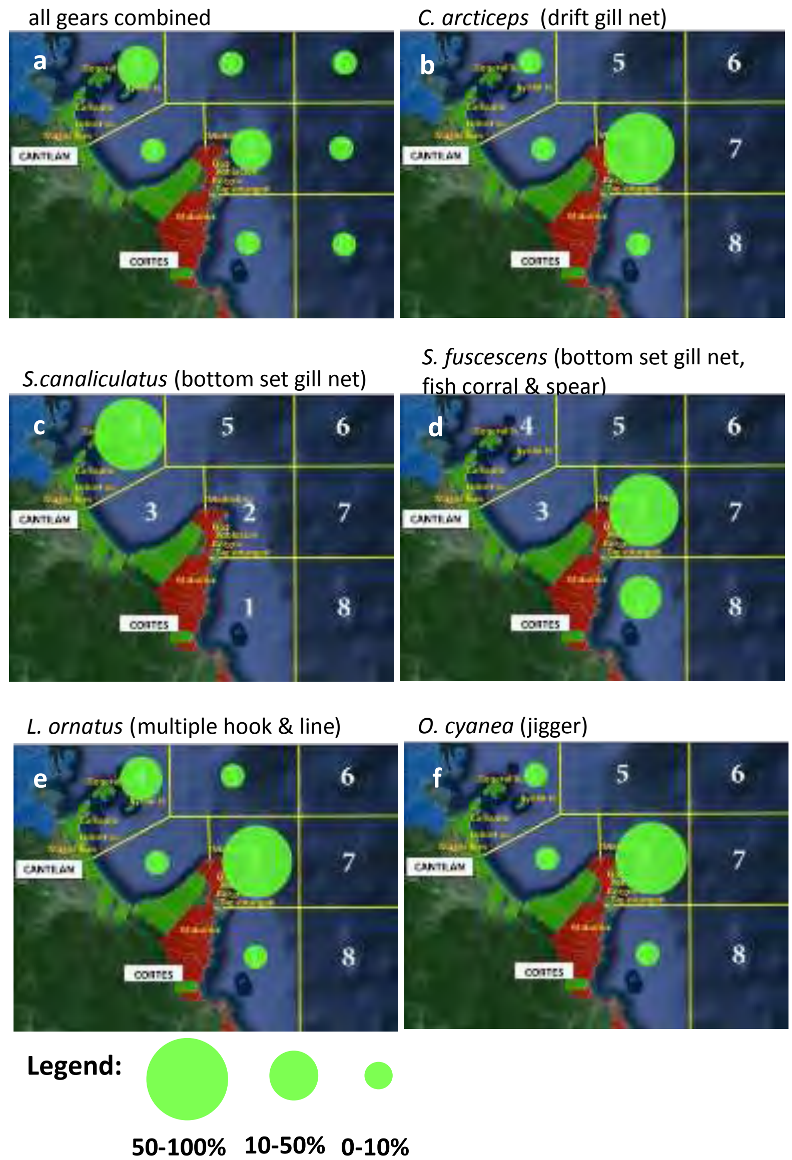


Figure 53. Map showing the area of operations of bottom set gill net, drift gill net, multiple hook and line, jigger, spearfishing, fish corral and bag net during the study period (a) and where the target species are usually caught- *C. arcticeps* (b), *S. canaliculatus* (c), *S. fuscescens* (d), *L. ornatus* (e), and *O. octopus* (f) in Cantilan and Cortes, Surigao del Sur (April-July 2016).

D.1.

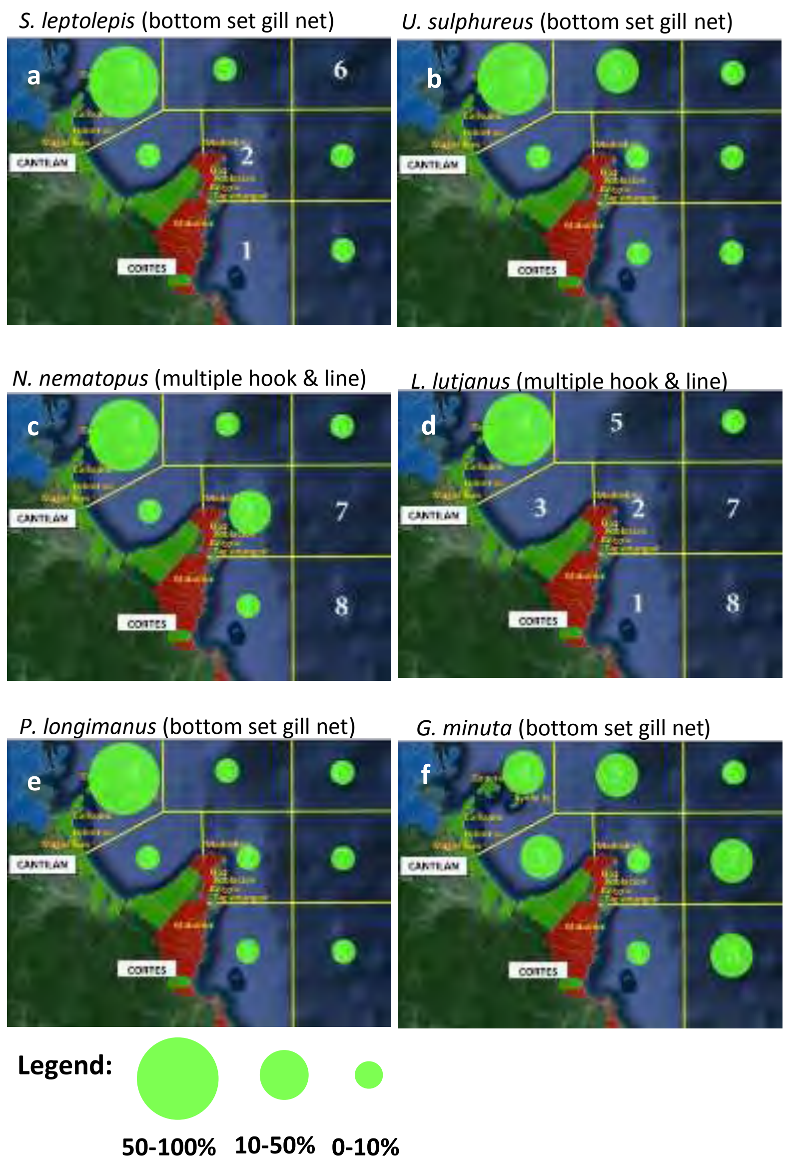


Figure 54 . Map showing where the target species *S. leptolepis* (a), *U. sulphureus* (b), *N. nematopus* (c), *L. lutjanus* (d), *P.longimanus* (e) and *G. minuta* are caught in Cantilan, Surigao del Sur (April-June 2016).

Summary of Harvest Control Recommendations

In general, harvest control rules for the target species in Cantilan and Cortes should include:
D.1.1. Establishment of size limits in catches for the following species:

- *Siganus canaliculatus* 16.62cm SL
- *Siganus fuscescens* 12.83cm SL
- *Octopus cyanea* 9.1cm ML or 450 grams
- *Selaroides leptolepis* 12.35cm SL
- *Lethrinus ornatus* 16.47cm SL
- *Pentaprion longimanus* 11.42cm SL
- *Gazza minuta* 9.5cm SL

With these recommendation, spawning potential of the target stocks may be increased to the more acceptable range of 20-30%.

D.1.2. The minimum mesh size of 5-8cm and 4-5cm for bottom set gill nets in Cantilan and Cortes, respectively should be enforced. In Cantilan, *P. longimanus* and *G. minuta* as small as 4cm were caught, while in Cortes 4.5cm SL *S. fuscescens* which should have passed the 4-5cm net were caught by bottom set gill nets. These situations suggest that smaller sized nets (<8cm) are still used in the area or even worse, trammel nets composed of 23 gill nets of different mesh sizes the first of which has a bigger mesh size than the other nets, are still in use. If these assumptions are true, the use of smaller sized nets (>8cm) and the used of trammels should be banned in both Cantilan and Cortes to allow immature smaller fish to pass, grow, attain maturity and spawn. While the target for this measure are *S. leptolepis, P. longimanus, S. canaliculatus and G. minuta*, it will also have a positive effect on other reef-associated and soft-bottom species caught by the gear, such as goatfish and other species of lutjanids and nemipterids. The measure, however, may reduce the catch of *G. minuta* and *P. longimanus* substantially because the targeted increase in mesh size will most likely allow gerreids and leiognathids, which are smaller in body depth and length, to swim through the meshes.

For drift gill nets targeting flying fish, current mesh size (6-8.5cm) should be maintained. Similarly, mesh size of the fish corral catching chamber in Cortes should be maintained at 4cm.

D.1.3. For octopus, closed season implementation is recommended, especially that octopus (17%) contributed the highest to the total catch in the area. At present no harvest control measure is implemented in both Cantilan and Cortes to sustain the fishery. By implementing a closed season, successful spawning of the larger sized octopuses are ensured and so the abundance of the octopus stock. Octopuses usually die shortly after spawning, so if the spawners are caught, depletion of the stock is predicted. Based on the results of the focused group discussion, large octopuses are caught in number from December-March and August-October. This information, however, should be validated with a more detailed study (i.e. reproductive biology) before use in implementation.

D.1.4. Aside from the harvest control recommendations above, *fisheries monitoring should be continued* with the following improvements:

(i) A more detailed map of fishing zones should be used to allow reconstruction of spatial patterns of fishing and distribution of particular species (e.g., catch rates or where large and small individuals are found). Such information provide valuable insights to the different aspects of harvest control measures.

(ii) Biological sampling (i.e., length measurements and maturity staging at least) should be done more frequently, and covering a longer time period (at least 12-16 months) to cover all size ranges caught in the fishery and all seasons.

(iii) The recording of catch and effort by enumerators and field assistants should be checked closely and regularly to make sure that proper and more complete information is recorded regularly. Frequent visits to the site in the initial months are critical for this.

(iv) It is important to note that field enumerators and field assistants can be easily trained to record catch and effort, but species identification, which is oftentimes overlooked or considered of little importance (vs common names) is critical and imperative. The use of scientific names is necessary since local names vary even between barangays, so that it is very common that a single common name may be used for 2 or more similar species, or that different common names are used for different life stages of the same species. Field guides and training on how to use them are important parts of the monitoring. In the same light, field-determined maturity stages should always be verified in the lab, unless sound expertise has been developed in the field.

(v) Efforts should be made to establish an LGU-implemented fisheries monitoring program to generate the data they need to be able to manage their resources properly for the long term.

(vi) Parallel laboratory-based studies, like ageing and fecundity studies, should be conducted for the target species to better understand more about critical processes (growth, recruitment) in their biology that are important in management of local stocks.

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Appendix

Appendix 1. Group interviews conducted in Brgy. General Is. (top) , Cantilan and Brgy. Tag-anungan (bottom), Cortes, Surigao del Sur, April 2017.

Appendix 2. Training of enumerators and field assistant on recording catch and effort monitoring in Cantilan and Cortes, Surigao del Sur. April 2016.

Appendix 3. Hands on training of field assistants in processing fish samples in Cantilan and Cortes, Surigao del Sur on April 2007.