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Blue Swimming Crab Stock Assessment in the Western Visayan Sea

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ABSTRACT

Portunus pelagicus (Linnaeus, 1758) known as the blue swimming crab, ranks 4th major fishery export of the Philippines. The Visayan Sea is considered as the major crab fishing ground of the country to which 25 out of 53 crab picking stations are located in Region 6. The study was conducted in the year 2011 to 2012 in ten crab fishing municipalities of the Western Visayan Sea conducting catch and effort, reproductive biology, and biological sampling. Results showed that a decreasing CPUE is observed compared in 1995 at 0.34 kg/panel to 0.19 kg/panel in 2011 and 0.26 kg/panel in 2012, with 17 to 20 gillnet-panels per boat per day. Surplus production models showed that MSY at 13,150 MT and f_{MSY} at 19,473 gillnet-panels of the Fox model is achieved prior to the year 1999. In 2011 and 2012, yield decreases as a setback of increasing fishing effort. Population parameters results showed growth overfishing where the L_∞ value obtained at 19.10 cm for this study was lower compared to 19.95 to 21.77 cm in previous studies. Computed E value at 0.68^{year-1} is higher than the threshold at E = 0.5^{year-1} and at optimum $E_{10} = 0.56^{year-1}$. Recruitment overfishing is also apparent from the size catches of major crab fishing gears to length at first maturity of 11.5 cm. Bottomset gillnet catches premature sizes by 57%, crab pot by 62%, and otter trawl by 95%. Seasonality of crab catching peaks in July and January coincides with the peak spawning in August and January, and recruitment in October and January.

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1. INTRODUCTION

Stock profile

Portunus pelagicus (Linnaeus 1758) belongs to the order Decapoda referring to ten appendages, infraorder Brachyura or true crabs, and family Portunidae or swimming crabs. Their carapace varies from being transversely ovate to transversely hexagonal and sometimes circular, with the male *P. pelagicus* having distinctively blue markings and a triangular abdomen while the female has a dull green color and semicircular abdomen. Called the blue swimming crab, flower crab, manna crab, or sand crab, *P. pelagicus* is known in the dialects as *kasag, alimasag, lambay*, or *masag*.

They are widely distributed in shelf areas particularly along the nearshore at depths not exceeding 70 m (Ingles 1996) and mainly in traditionally demersal fishing grounds including San Miguel Bay, Tayabas Bay, Ragay Gulf, Malampaya Sound, Asid Gulf, Visayan Sea, Guimaras Strait, Panay Gulf, Carigara Bay, Bohol Sea, Panguil Bay, and Tawi-tawi (Ingles 2004). The Visayan Sea and Guimaras Strait hereto referred as Western Visayan Seas, are the major crabbing areas, containing 25 of the country's 53 picking stations in 2011 (Bayate 2011). The most common artisanal gear used in shallow water are crab pots, known as *panggal*, but crabbers also use bottom set gillnets, otter trawl, crab lift net or *bintol*, and push net.

Fishing gears used in catching crab includes artisanal gears operating in shallow areas. Crab pots, locally known as *panggal,* having a wide variety of materials used and design, is the most common gear operating in the country. Other crab fishing gears include the bottomset gillnet, crab lift net or *bintol*, baby trawl, and push net.

Fishing activity for *P. pelagicus* started as early as the 1950s. Ingles (2004) describe its fishery in phases: 1st level plateau and 2nd level plateau as shown in Figure 2.

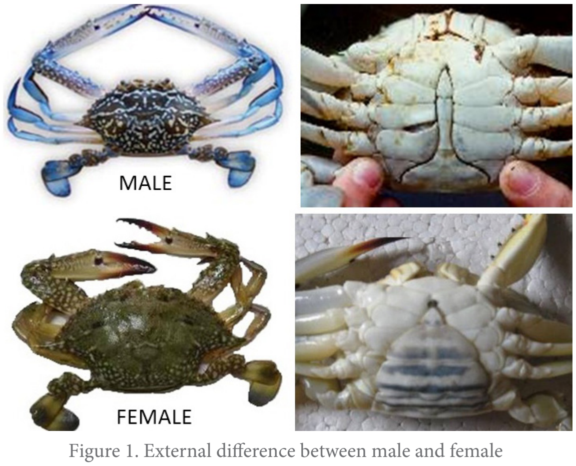

Figure 1. External difference between male and female *Portunus pelagicus*

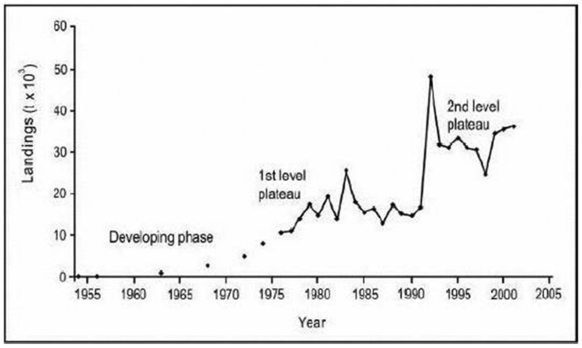

Figure 2. Historical production of blue crabs, *Portunus pelagicus* from year 1961 to 2005 (Ingles 2004)

The high demand for the blue swimming crab in 1990s is a result of the collapse of blue crab (*Callinectes sapidus*) in Chesapeake Bay, USA.

Data from the Bureau of Agricultural Statistics (BAS) shows that *P. pelagicus* ranks 4th as a major fishery export in the country in terms of value at $67,612,600 US as of CY 2010. The United States of America and neighboring Asian countries are the major country destination for crab and crab meat products export (Philippine Fisheries Profile 2010). The said fishery commodity is exported live, frozen, and prepared or preserved. According to the Food and Agriculture Organization (FAO), the blue swimming crab contributed to 0.19% of world production from the capture fisheries sector. Figure 3 shows the annual export trend in quantity and value of *P. pelagicus* in the Philippines for the year 1997 to 2012. The figure shows the 2nd level plateau projected by Ingles (2004) to which

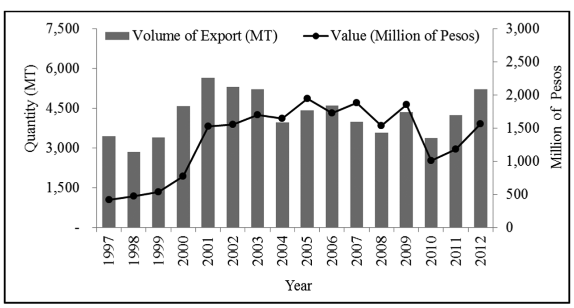

Figure 3. Annual trend in quantity (MT) and export value (millions of pesos) of crab exports in the Philippines for the year 1997 to 2012 (BAS, 1997-2012)

sources of crabs came from the artisanal fishing sector mainly using crab bottom set gillnet and crab pots. A clear indication shown in figure 3 is the law of supply and demand, less supply in terms of decreasing volume and an increasing demand shown by increasing market value.

P. pelagicus is considered as one of the major fishery resources of the country and has a high demand among the export industry (Ingles 2004). A huge percentage (51.5%) of blue crab population comes from the Western Visayas (Visayan Sea & Guimaras Strait) caught by gillnets, crab pots, trawlers, seines, and push net. History of the exploitation of crab resource was already determined in the early 90s. Because of the laxity in the implementation of regulatory policy to protect the resource, catch leveled off at around 1,000 mt but effort continued to increase, and in 1999 quadrupled to about 22,000 gillnet panels. This resulted in a significant reduction in catch rates.

Major Crab Fishing Gears

Bottom set Gillnet/Crab Entangling Net

The bottom set gillnet or the crab entangling net is a type of gillnet anchored and fixed on the sea floor. The gear is locally known as *palubog, palugdang*, or *pukot*. The net, as shown in figure 4, is anchored and weighed down at the bottom so that it will not move with the water current (Green et al. 2004). The net is made of monofilament nylon material at 10 cm or 4 in mesh size. It is set at 0.8 to 1 m depth and at 100 to 150 m per net panel overlapped at 10m on both sides with the other net panel. The total number panel used per operation is at an average of 17, making the total length of the net at 1.7 to

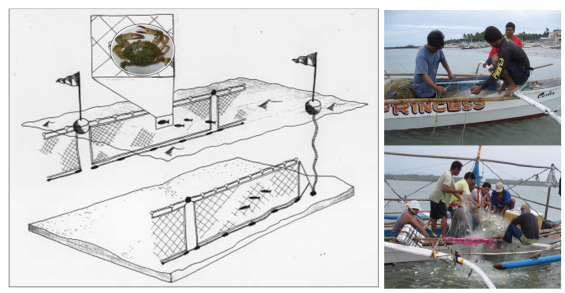

Figure 4. Mode of operation of drift gillnets (up) and bottomset gillnet (down). Bottomset gillnet is also the same gear used as crab entangling net (Bjordal 2002)

2 km. During operation, 1 to 3 fishermen are onboard the fishing boat during the net setting and hauling that takes around 13 hours soaking time.

Crab Pot

Crab pot is a type of trap gears (Figure 5) designed for catching crab species such as *P. pelagicus, P. sanguinolentus*, and *Thalamita crenata*. The gear is locally known as *bubo pangasag, panggal*, or *timing*. The gear is usually conical in shape and is of varied sizes and materials made depending on the area. Several designs of crab pots are employed in the Western Visayas depending on the area and are usually made of bamboo strips, polyethylene net, or synthetic chicken wires (Figure 6). The pot gear is usually soaked overnight, but longer soak times may be used in certain fisheries. The operation cycle is similar to that of longlining, with baiting, setting, fishing, and retrieval. The bait is either freely suspended in the middle of the pot, or put in perforated bait containers to prevent it from being eaten by scavengers (Bjordal 2002). During

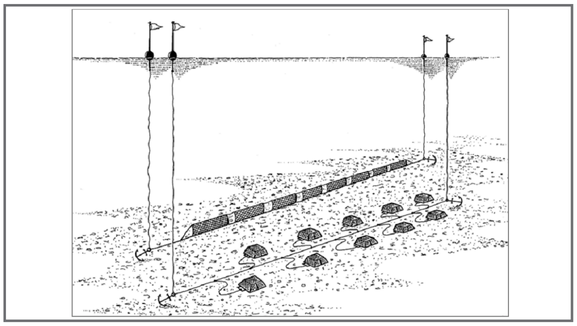

Figure 5. Setting of crab pot used in catching *P. pelagicus* in Western Visayas (Bjordal 2002)

Figure 6. Designs and made of crab pots used in Western Visayas in catching crab species

operation, 1 to 2 fishermen are involved in pot hauling, setting, and bait replacement at 14 hours soaking time. In some areas, crab pots are set 24 hours and are only hauled the following day for catch hauling and bait replacement. Whereas in some areas where there are active gears such as Danish seine and otter trawls, the pots are hauled after 14 hours soaking time. Around 200 to 300 pots are used during operation set at a 5 m distance between pots.

Crab Trap

Traps are mostly box type in shape (Figure 7) and stationed in the water for a period of time regardless of materials used for construction. The target species are confined to a collecting unit from which escape is prevented by retarding device or funnel (SEAFDEC 1998). Crab traps are locally known as *bubo pangasag* and are commonly used in the areas of Northern Iloilo.

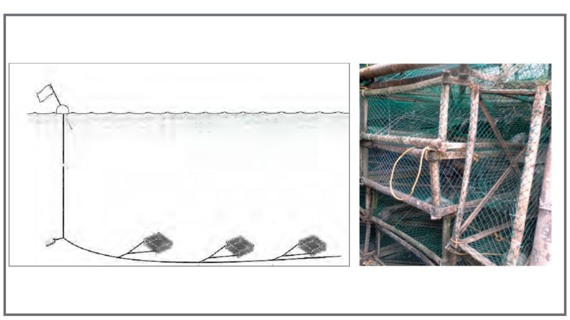

Figure 7. Setting of crab trap or fish trap at an interval of 5m (left) and materials made of traps used in Western Visayas

Crab traps have the same catching mechanisms and are usually made of polyethylene or monofilament nylon with wooden brace forming the box shape. Upon operation, two or three fishers are involved in a 10-hour gear soaking time at an average of 100 traps per operation per day.

Manual Push Net

Manual push net (Figure 8) gear is normally operated to catch *Acetes* or *hipon* during the summer season. It is operated nearshore such that around 5% of immature crabs are also caught. It is a triangular-shaped net with a bamboo frame at both sides and unbraced at the base that filters the catches. The gear is locally known

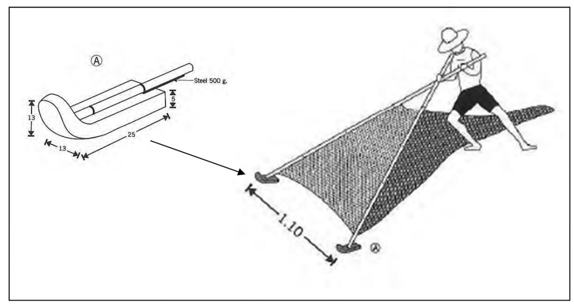

Figure 8. Mode of operation of manual pushnet used to catch Acetes and by-catch of *P. pelagicus* in the shallow waters of Western Visayas (Ruangsivakul et al. 2003)

as *hud-hud* if operated without the aid of a banca, and *sungkit* if operated using a motorized banca.The net is made up of knotless polyethylene at 63 μ mesh size (Ruangsivakul et al. 2003).

Otter Trawl

Otter trawl (Figure 9) is a demersal type of trawl towed on the seabed, held open by a pair of otter boards or trawl door (SEAFISH 2005). Trawls are conical bag-shaped net with two or more wings, pulled by one or two boats during dragging and catches mainly bottom living aquatic organisms (Ruangsivakul et al. 2003). Trawl has

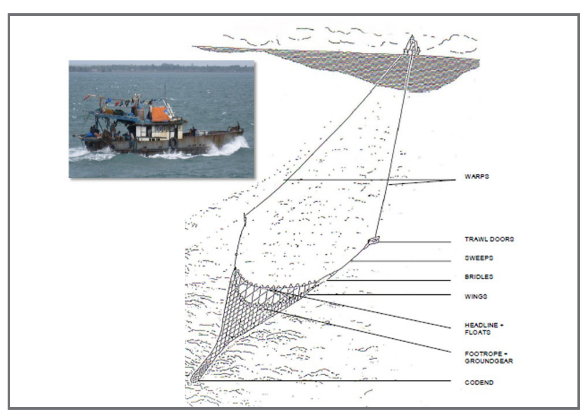

Figure 9. Parts of an otter trawl used to catch demersal organisms including by-catch of crab species (SEAFISH 2005)

three types: pair, beam, and otter trawl. The Mid-water trawl is a trawl type modification where a mechanism of dragging is in mid-water catching mainly pelagic species.

Legal Framework

Section 98 of Republic Act (RA) 8550 or the Philippine Fisheries Code of 1998 states the prohibition on the catching of breeders or spawners of fishery species as may be determined by the Department of Agriculture (DA) thru the BFAR, provided that the catching of the breeders is for scientific or research purposes subject to appropriate guidelines set by the department. Joint DA-DILG Administrative Order (JAO) No. 01-2014 is a fishery regulatory adoption of the Philippine Blue Swimming Crab Management Plan (BSCMP). JAO 01-2014 enforces the registration of municipal crab fishers in their respective Local Government Units (LGU) to regulate the crab fishing activities. Also included is the prohibition of catching berried crabs: a minimum catch size of 10.2 cm carapace width, limit the mesh size of crab entangling net to 11 cm, limit the number of pots per boat per day operation, limit the length of crab entangling net, and impose a closed season to municipalities with crab fishery.

RA 7160 or the Philippine Local Government Code of 1991 gives local autonomy to LGUs in managing their coastal resources. Article I section 16 of the RA 8550 states that the city/municipal government shall have jurisdiction over municipal waters as defined in the code (BFAR-FRMP 2000). With the autonomy of the LGUs and prior to the implementation of JAO No. 01-2014, local adoptions in the provinces of Negros Occidental and Iloilo are in place. In Negros Occidental, Provincial Ordinance No. 019 entitled "An ordinance regulating the catching, selling, possessing or buying of gravid blue crabs and crablets in the Province of Negros Occidental" is being implemented and was approved on September 2003 (Province of Negros Occidental 2003). Inclusions are: 11 cm carapace width size limit, 12 cm mesh size of gill net, and engaging in blue crab fishery without the required permit. In Iloilo, Provincial Ordinance No. 2012-093 prohibits the catching of berried and undersized crabs below 11 cm, use of gillnet below 0.30 mm twine 4 knots and 50 mesh depth approved on February 22, 2012 (Province of Iloilo 2012).

Review of Literature

Blue crabs contributed 0.19% to world capture fisheries production in 2002. The collapse of the *Callinectes sapidus* fishery in the Chesapeake Bay, USA triggered a higher demand for Philippine blue crabs in the 1990s. In the Philippines, over 90% of the crabs landed are *P. pelagicus* which is the main species in the country's crab fishery since it started in the 1950s, with a developing phase, increasing to a 1st level plateau in the 1980s, and a 2nd level plateau in the 1990s (Ingles 2004).

Studies on the crab fishery of the Philippines show the overexploitation of the resource. Maximum Sustainable Yield (MSY) in the Visayan Sea was determined at 1,383 MT equivalent to an effort of 13,150 gillnet panels (Ingles 1996). As early as the 1990s, exploitation of the crab resource was observed to have leveled off at a low of 1,000 MT due to the absence of any regulatory policy to protect the resource, but effort continued to increase until it quadrupled to 22,000 gillnet panels in 1999 which resulted in significantly reduced catch rates (Ingles 2004).

In 2001, *P. pelagicus* ranked 5th in export volume at 560 MT and 4th in export receipts accounting for PHP 1.52 B (Ingles 2004). In 2010, it rose to become the 4th major fishery product in the Philippines valued at US $67,612,600 (BAS 2010) with the US and neighboring Asian countries as major product destinations. Despite fluctuating catch volumes, the increasing demand for blue crabs had pushed prices upwards over the years, generating higher export earnings. The Western Visayan Seas contribute some 51% of the blue crab catch using gillnets, crab pots, trawls, seines, and push net (Ingles 2004).

Romero in 2009 cored his study on the stock population analysis of *P. pelagicus* caught in the Visayan Sea. His significant result showed high exploitation status of the said resource at 0.94^{year-1} ratio between E and E10. Another significant result is by comparing genetic stocks of *P. pelagicus* from various fishing grounds in the country and found four genetic stocks.

Williams and Primavera (2001) conducted a study in choosing of tropical *Portunid* species for culture as an alternative to *Scylla* for culture, domestication, and stock-enhancement in the Indo-Pacific. The study concluded that full domestication will not occur in the next 5 to 10 years and that the main constraints to be overcome are the aggressive behavior of the crabs, their carnivorous diet, and competition for suitable coastal farm sites. The study recommended that stock enhancement may be feasible in some locations, provided suitable fisheries management and industry institutions are created.

Several studies in other countries were also conducted for *P. pelagicus* in terms of its biology, behavior, culture, and stock enhancement. In terms of biology studies, it includes the embryonic development having a fecundity of 9 to 10 million of eggs at 6-7 days incubation period in India (Soundarapandian and Tamizhazhagan 2009). Fecundity for small-sized (8 cm carapace width) was at 78,000 and 1,000,000 for large-sized (18 cm carapace width) in the West coast of Australia (De Lestang et al. 2003). In Bardawil Lagon, Egypt, length at first maturity obtained for a female was at 9.6 cm carapace width with the highest gonado-somatic index and peak spawning in the month of August (Razek et al. 2006). Spatial distribution of *P. pelagicus* in Trang Province, Thailand using collapsible crab trap showed that immature crabs were found in seagrass beds while large and ovigerous crabs were found in off-shore areas (Nitiratsuwan et al. 2010). In Karnataka Coast, India, observed spawning peaks in the months of January to February and September with spawning size at 10 to 16cm carapace width. In Moreton Bay Australia, crabs attained sexual maturity during the first year and a rapid growth of juveniles in summer and autumn in inshore habitat, while growth slows during the winter season (Sumpton et al. 1994). The trap entrance behavior of crabs under laboratory condition showed a 25-30% success entry at a mean of 2 entrances per crab (Smith and Sumpton 1989). Bias in the capture of mature female crabs on traps compared to seining and trawling that are considered non-selective gears in Shark Bay, Australia (Smith et al. 2004). Chitin and chitosan content of the crab carapace and its potential as a biopolymer or gelling agent, food additive, and fish feed was also studied (Bolat et al. 2010; Sudhakar et al. 2009).

Objectives

This study aims to present current scientific information on the biology of *Portunus pelagicus* caught in the Western Visayan Sea to serve as baseline in the implementation of the proposed Blue Swimming Crab Management Plan:

a. Crab fishing gears inventory;
b. annual crab harvest estimates and catch per unit of effort ;
c. species relative abundance and monthly seasonality;
d. maximum sustainable yield;
e. reproductive biology (sex ratio, gonadal development, gonado-somatic index, length at first maturity, length ranges caught by different major crab fishing gears); and
f. population parameters (growth, recruitment, mortalities, probabilities of capture, relative yield and biomass per recruit).

Scope and Limitation

The Visayan Sea is a common fishing ground among its bordering regions 5, 6, and 7. The implementation of this study is focused in Region 6 since it has the most number of crab unloading and picking stations among its neighboring regions. The outcome of this study will serve as an initial step in having a holistic approach by implementing the same activity with the major crabbing stations in regions 5 and 7.

2. MATERIALS AND METHODS

Study Site

The Philippine shelf covers an area of 184,000 km^2 to which 10,000 km^2 or 5% is covered by the Visayan Sea. In terms of fish production, the Visayan Sea can produce three times its shelf capacity making it as one of the most important fishing grounds in the country. It is bounded on the north by Asid Gulf; on the east by Higantañgan Island; on the south by northern Cebu, Banatayan Island, and northern Negros Occidental;

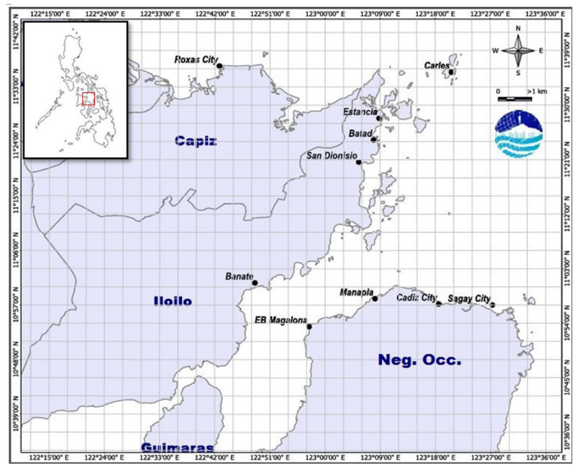

Figure 10. Map of Visayan Sea showing the BSC sampling stations and the areas that conducted the BSC reproductive biology study

Figure 11. Five point scale used in determining the gonad stages of berried *P. pelagicus*

and on the west by Panay Island, Jintotolo Island, and Pulanduta Point of Masbate. It is located between 11 and 12°N latitude, 123 and 124°E longitude. Almost all of the towns bordering the Visayan Sea are fishing communities, the most important of which are Daan-Bantayan, Madridejos, and Bantayan of Cebu Province and Carles of Iloilo Province (Rasalan 1957).

Figure 11 shows the ten (10) sampling stations established in Western Visayas major crab unloading areas under the Blue Swimming Crab (BSC) Stock Assessment Project of the National Stock Assessment Program of the Bureau of Fisheries and Aquatic Resources- Regional Field Office 6 (BFAR-RFO6). Out of this, five crab landings of the stations were strategically selected to conduct reproductive biology sampling of *P. pelagicus* aside from the length based and catch and effort monitoring.

Data Collection

Total Inventory

The total fishing boat inventory and enumeration per fishing gear were based on the CY 2011 conducted in all Visayan Sea areas of the region. During the process of data collection, 56 enumerators were tapped to do the inventory data collection including admeasurements of

Table 1. Five point scale of female gonadal maturity used for *P. pelagicus* (Sumpton et.al. 1994)

Maturity Stages	Classification	Distinguishing Characteristics
Stage I	Immature/Virgin	Non-ovigerous
Stage II	Developing/Maturing	Ovigerous with pale to dark yellow egg mass. No eyespots visible in eggs
Stage III	Mature/ Ripening	Ovigerous with yellow-grey egg mass. Eye-spots present.
Stage IV	Spawning/Gravid	Ovigerous with grey egg mass. Eyespots and chromatophores discernible.
Stage V	Spent or Resting	Presence of egg remnants.

the vessel, demographic profile of the respondents, and gear specifics as to materials made, mesh size, hook size, dimension of gears, baits used, and fishing operation information. Fishing boat enumeration of the commercial sector, on the other hand, was based on the monitored vessels in the sampling area; fishing vessel and gear registry of the Fisheries Resource Management Division of BFAR6.

Catch and Effort

Data collection for landed catch and effort schedule follows the national scheme of consecutive two sampling days. For months having 31 calendar days, total sampling days is 21. For months with 30 days, the sampling frequency is 20 days. During each sampling day, the assigned field enumerator was tasked to know the name of the fishing boat, the corresponding fishing gear used, the fishing effort spent per day, the volume of catch, the species composition, and the length measurement of *P. pelagicus*.

Reproductive Biology

Sampling for reproductive biology was done on a weekly frequency per monitoring stations. A minimum of 5 kg samples per sampling day were collected, sorted per species, measured, and dissected. An average annual total of 3,488 specimens of *P. pelagicus* were collected and analyzed. Length measurement was done by determining individual carapace width (CW) in centimeter (cm) scale done by measuring from the tip of spines in both sides of the carapace. Individual weight was also recorded using the gram (g) unit. Dissection of the samples was done to identify the sex and the five-point scale (Sumpton et al. 1994) of gonadal maturity was used in the identification

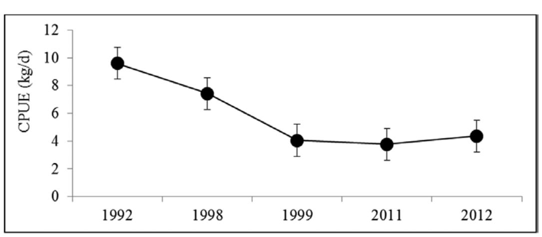

Figure 12. Annual cpue (kg/d) of crab gillnet in over three different years by Ingles (2004) and 2011 and 2012 of this study computed for Western Visayan Sea

of female stages as described in Table 1 and Figure 12. Juvenile female samples identified with a semi-triangular ovarian flap were separated from mature samples. After which, the individual gonads were extracted for weighing and data were recorded using the gram unit.

Data processing

All data collected from the monitored sites were encoded on a spreadsheet in Microsoft Excel using a designed template. The templates were designed for data entry on catch and effort, fishing boat effort, length frequency, and reproductive biology. The template used for catch and effort and fishing boat effort allows us to do error tracking, editing, data reconciliation, sorting, and filtering which were all done using the pivot table routine in MS Excel. After all the data were reconciled, tables and graphs were generated to obtain indicators such as total fish harvest, catch per unit effort, species diversity, and seasonality of the major fish species. For the length measurement data, a separate template was created to do the daily raising and monthly merging of same species data. The generated annual raised data were encoded using the FAO-ICLARM Stock Assessment Tool (FiSAT) II version 1.2.2 (Windows) to obtain values for the population parameters. For the reproductive biology data sets, information generated include length at first maturity, monthly gonadal frequency, gonado-somatic index, and sex ratio.

Fishing Days

To generate information on fishing days, a separate fishing log sheet form was designed to record the fishing day's operation per fishing gear. The forms are marked on the days where vessels of a particular fishing gear unloaded, with or without catches as long as there is a fishing effort. The data collection is conducted either on a sampling or non-sampling days for catch and effort monitoring. The data collected were consolidated monthly by the field enumerators and annually by the data encoders. The said log sheet form becomes a major part of the monthly reports submitted by the field enumerators.

Catch per unit effort (CPUE)

The monthly catch per unit effort per gear was computed and standardized as kilograms per day (kg/

day). All data from the municipal sector having a per hour operation were converted into days. Annual mean CPUE was obtained by the summation of the monthly fish catch versus the summation of the number of fishing day operation per month, per year, and per gear.

Crab Harvest Estimates

Fish harvest estimates used standardized values by the direct relationship between catch per unit effort (CPUE), actual fishing days, and boat units based on inventory. The process was done per fishing gear per year.

Relative Abundance and Seasonality

Using the pivot table routine of the MS Excel, the 20 dominant species were ranked based on its percentage contribution to the total catch. The process was done by combined gears and by major fishing gears catching *P. pelagicus*. The factor used in the determination of seasonality distribution is the monthly catch (MT) of *P. pelagicus* analyzed for seasonality distribution using the monthly catch data from 2011 to 2012.

Potential Yield

The objective of the application of "Surplus Production Models" is to determine the optimum level of effort that is the effort that produces the MSY that can be sustained without affecting the long-term productivity of the stock (Sparre and Venema 1992). It is used to refer to the surplus production that involves the Schaefer and Fox models that deal with estimates of surplus production of the entire stock, effort, and yield. The following equations were used for the computation as:

$$\text{Schaefer MSY} = -0.25*a^2/b$$
$$\text{Schaefer fMSY} = -0.5*a/b$$
$$\text{Fox MSY} = -(1/b)*\text{EXP}(a-1)$$
$$\text{Fox fMSY} = -1/b$$

where a is the intercept and b is the slope of the relative effort and relative yield for the Schaefer Model. For the Fox Model, a and b is the lognormal of the relative yield and relative effort.

Reproductive Biology

All data collected were encoded first on specified forms distributed to the enumerators to include information on landing center & municipality source, month and date, weather and water condition, fishing gear source, scientific name, individual length, individual weight, sex, gonadal stage, weight of gonad, and actual fishing area based on the gridded map provided.

On the data encoding process, all information provided on the specified forms were included in a designed template using the Microsoft Excel format. After all of the data were reconciled, tables and graphs were generated to obtain indicators such as sex ratio, GSI, gonadal frequency, length at first maturity, length ranges, weather and water condition in reference to gonadal maturity. For the length measurement data, population parameters were obtained using the FAO-ICLARM Stock Assessment Tool (FiSAT II) version 1.2.2.

<u>Sex ratio</u>

The sex ratios by month were expressed as the proportion of females to the total numbers of juvenile and male (Sheng-Ping et. al.2003):

$$\text{Sex Ratio} = F_n/n$$

where F_n is the monthly count of female and n is the monthly total number of samples.

<u>Female gonadal frequency pattern</u>

Gonadal frequency pattern was tabulated using the count of juvenile and female per stages. These counts were converted to percentage for the relative frequency distribution per stages. Relative gonadal frequency distribution was done on a monthly and a weekly basis for analysis.

<u>Gonado-Somatic index (GSI)</u>

Gonado-Somatic Index (GSI) was calculated using the equation (İşmen, 2002):

$$GSI = GW/BW \times 100$$

where GW is the total wet weight of gonad and BW is the total wet body weight.

<u>Gonadal classification in reference to seawater condition</u>

Gonadal stages were expressed in percentage (%) and were related to seawater condition in every monitoring area. These data were plotted to see any correlation of gonad development over sea water condition.

<u>Length at First Maturity</u>

Length at which 50% of all individuals were sexually mature (Lm) was estimated from the proportion of mature individuals in each of 5cm length class interval and the fitted logistic curve (Sparre and Venema 1992) as follows:

$$P = \frac{1}{1 + \exp(S1 + S2 \times L)}$$

where P is the proportion of mature individuals within a length class, S1 is the intercept, S2 is the slope, and L midpoint length. Corresponding weight at first maturity was also computed and fitted using the linear equation of $W=aL^b$ where W is the estimated weight at first maturity, a is the intercept, b is the slope and L is the computed length at first maturity.

Length Ranges of crab gears

Comparisons of length frequency distribution of same species caught by the different fishing gears were made to determine the type of fishing gear catching small size, bigger size, and wide range of size prior to the first maturity.

Population parameters

Data sets collected for reproductive biology were also those data sets used in the determination of seasonality changes. For purposes of discussion, data presented were consolidated to come up with one-year data set. Data were then imported to FiSAT II for the generation of growth curve graphs. Information generated from FiSAT includes:

a. growth parameters (length at infinity (L_∞), growth coefficient (k), and growth performance index (ø');
b. recruitment pattern (strong and weak pulse of recruit);
c. mortalities (total (Z), fishing (F), natural (M), and exploitation rate (E));
d. probabilities of capture (L_{25}, L_{50}, L_{75}); and
e. relative biomass and yield per recruit ($E_{.1}$, E_{max}).

Growth parameters were determined first by estimating L_∞ (asymptotic length) using Powell-Wetherall method (Gayanilo et al. 1997) based on the equation of Beverton and Holt (1956):

$$Z = k\,((L_\infty - L) / (L - L'))$$

where Z is the total instantaneous mortality, k is the growth coefficient, L is the mean length, L∞ is the asymptotic length, and L' is the initial length of the sample.

The estimated value of L_∞ was further processed in ELEFAN I (ELectronic LEngth Frequency ANalysis) for the verification of the value for Loo and k. The analysis in the estimation of growth parameters and mortality uses the von Bertalanffy (1934) growth equation of:

$$Lt = L_\infty\,(1 - e^{-k(t-to)})$$

where Lt is the length of fish at age t, e is the of Naperian logarithm, and to is the hypothetical age the fish would attain at length zero.

Mortalities and exploitation rate were then calculated using the equation:

$$Z = M+F$$

where Z is the instantaneous total mortality, M is the instantaneous natural mortality due to predation, aging, and other environmental causes, and F is the instantaneous fishing mortality caused by fishing.

Furthermore, M was estimated using Pauly's (1984) empirical formula:

$$\text{Log } M = 0.654 \text{ Log } k - 0.28 \text{ Log } L\infty + 0.463 \text{ Log} T$$

where L_∞ and k are the VBGF growth parameters and T is the annual mean habitat temperature (°C) of the water in which the stock in question lives.

Expanding the equation for mortality would lead us to the computation of exploitation rate using:

$$E = F/Z$$

where E is the exploitation rate. Using the equation from growth parameters and mortalities, prediction of recruitment patterns and virtual population analysis could be estimated using the routines found in FiSAT programs.

Recruitment patterns were obtained by backward projection onto the length axis of a set of length frequency data. The steps involved were:

a. projection onto the time axis of the frequencies after they have been divided by Δt, the time needed to grow through the length class, this leads to recruitment patterns with peaks much narrower than when untransformed length frequency data were used;
b. summation for each month (and irrespective of year) of the adjusted frequencies projected onto each month;
c. subtraction (from each monthly sum) of the lowest monthly sum to obtain zero value where apparent recruitment is lowest; and
d. output of monthly relative recruitment, in percent of annual recruitment.

Probabilities of capture involve the method of extrapolating the right descending left side of a catch curve such that fish that "ought" to have been caught were added to the curve with the ratio of those "expected" numbers to those that were actually caught being used to estimate the probabilities of capture. This can be computed as the ratio of the numbers observed over the numbers available (N_i), using the equation:

$$P_i = \ln (N_i/\Delta t)/ \ln(N_{ai}/\Delta t)$$

where P_i refers to the points for probabilities of capture, N_i is the numbers of observed catch or the population size, and N_{ai} is the numbers of available catch, and Δt is the change of time.

Beverton and Holt's (1957) relative yield per recruit and biomass per recruit models were used in the prediction of yield and standing biomass. Relative yield per recruit model is suitable for assessing the effect of mesh size regulations and it belongs to a length-based model as parameters. Biomass per recruit, on the other

Table 2. Inventory of municipal fishing gears operating in the crabbing sites of Western Visayan Sea in year 2011

Fishing Gear	Common local name	No. of units
Bottomset gillnet	Palugdang, pukot, pukot-pangasag	325
Crab pot	Bubo pangasag, panggal, timing	479
Crab trap	Bubo pangasag	36
Modified danish seine (municipal)	Hulbot-hulbot	131
Fish coral	Punot	195
Filter net	Tangaban	32
Fish trap	Bubo	49
Manual push net	Hud-hod, sungkit	21
Otter trawl	Trawl	111
Surface-set gillnet	Pukot	21

Table 3. Annual CPUE, fishing days, and gear count of major crab fishing gears operating in Western Visayan Sea in year 2011

Fishing gear	cpue (kg/d)	Fishing days	Vessel count by inventory	Harvest (MT)
Bottomset gillnet	3.26	248	325	262.92
Crab pot	4.61	246	479	542.93
Crab trap	4.00	229	36	32.94
Modified danish seine (municipal)	0.38	25	131	1.26
Fish coral	10.00	36	195	70.20
Filter net	3.08	4	32	0.39
Fish trap	0.83	8	49	0.33
Manual push net	16.89	70	21	24.83
Otter trawl	7.77	42	111	36.22
Surface-set gillnet	3.59	6	21	0.45

hand, expresses the annual average biomass of survivors as a function of fishing mortality, and that average biomass is related to the catch per unit of effort. The said prediction models use the equations:

$$(Y/R)' = E*U^{M/k} (1-3U/1+m + 3U^2/1+2m - U^3/1+3m)$$

$$(B/R) = \exp^{(-M*(Tc-Tr))} *W\infty * (1/Z - 3S/Z+k + 3S^2/Z+2k - S^3/Z+3k)$$

where:

$m = \frac{1-E}{MK} = k/Z$	$E=F/Z$	T_c -Age at first catch
$U = 1- L_c/L\infty$	T_r – Age at first recruit	W – weight at infinity

3. RESULTS AND DISCUSSIONS

Crab Fishing Gears

During the assessment period from 2011 to 2012, a total of 26 fishing gears are identified unloading in the study areas during the conduct of total fishing gear and boat inventory in 2011. Of the 26 total types of fishing gears, 11 are identified crab catching gears shown in table 2. Of the 11 crab gears, bottom set gillnet, crab pot, crab trap, manual push net, and otter trawl are the major crab catching gears. By-catch of crabs are observed in the species catches of modified Danish seine, fish coral, filter net, and surface gillnet. Ingles (2004) during his study on blue swimming crab assessment also showed the same fishing gears catching crabs in Western Visayas. Illustrations and description of crab gears mode of operation are included in Figures 4 to 9.

Annual Crab Harvest Estimates and CPUE

Estimated fish harvest in the crab stations of the study is at 5,942.83 MT in 2011 and decreased at 2,967.61 MT in 2012. A significant decrease in crab harvest of 50% is observed comparing 2011 and 2012. The significance is tested using the unpaired student t-test (Kaps and Lamberson 2004) at P=0.05 which showed the t-value obtained at 1.33 is lower than the critical value (v) at 1.645 on the hypothesis that fish harvest in 2012 is lower than the fish harvest in 2011. This may be correlated with the intensive monitoring, control and surveillance (MCS) of the BFAR-RFO6 in the implementation of Fisheries Administrative Order (FAO) 167 or the closed season of catching sardines mackerels and herrings in the Visayan Sea as the gears are also catching the prohibited species.

Tables 3 and 4 shows the annual crab harvest estimates per crab catching gears for the year 2011 and 2012 respectively. For the two years crab harvest, bottom set gillnet and crab pots are the dominant gears in terms of vessels count by inventory and fishing-days operation. Also observed is a high CPUE for fish coral and manual

Table 4. Annual CPUE, fishing days, and gear count of major crab fishing gears operating in Western Visayan Sea in year 2012

Fishing gear	cpue (kg/d)	Fishing days	Vessel count by inventory	Harvest (MT)
Bottomset gillnet	3.72	246	834	763.06
Crab pot	5.61	249	326	455.13
Crab trap	3.62	232	87	72.98
Fish coral	2.57	21	5	0.27
Fish trap	1.15	15	3	0.05
Manual push net	13.47	20	21	5.66
Otter trawl	2.09	101	27	5.70
Surface-set gillnet	1.25	29	21	0.76

push nets, since the gear are seasonally operated and mainly operated for catching *Acetes sp.* during summer seasons in the months of March to May. These gears are also operated in shallow areas and are catching immature sized crabs (Ingles 1996).

Figure 13 shows the CPUE (kg/d) of crab gillnet over different years as included in the study of Ingles (2004) for the Visayan Sea in the year 1992, 1998, and 1999, as well as the result obtained for this study in the year 2011 and 2012. A decreasing trend in the CPUE is observed that started at 9.61 kg/d in 1992 to 4.05kg/d 1999, at a mean annual decrease of 35%. Comparing the result in 1999 as the last result of Ingles (2004) to this study, 7% decrease in CPUE is observed comparing 1999 at 4.05 kg/d/boat to 2011 at 3.76 kg/day. Comparing the CPUE of the year 1999 at 4.05 kg/d to the year 2012 at 4.36 kg/d showed an increase of 8%. Based on this information, there is an increase in CPUE comparing the results of Ingles and this study.

Going to a much finer scale of analysis towards the trend of CPUE, Ingles (1996) also compared the catch rates using kg/panel/boat which is also adopted in this study. CPUE in 1991 was calculated at 0.62 kg/panel at 10panels/boat to 0.34 kg/panel at 19 panels/boat in 1995 with a mean annual decrease in CPUE of 14% but with increasing number of panels. Comparing again the last data of Ingles in 1995 which is 0.34 kg/panel at an average of 19 panels/boat with that of this study, a decreasing trend is observed as shown in Figure 14. The lowest CPUE is observed in 2011 at 0.19 kg/panel at an average of 17 panels per boat and 0.26 kg/panel at 14 panels per boat in 2012.

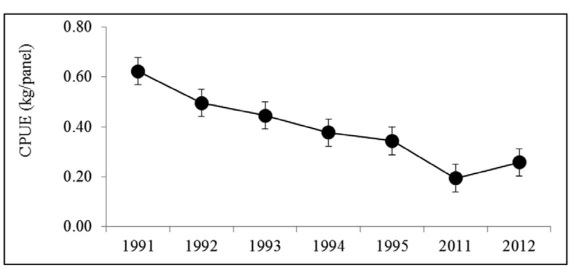

Figure 13. Annual cpue (kg/gillnet panel) of crab gillnet in over different years by Ingles (1998) and 2011 and 2012 of this study computed for Western Visayan Sea

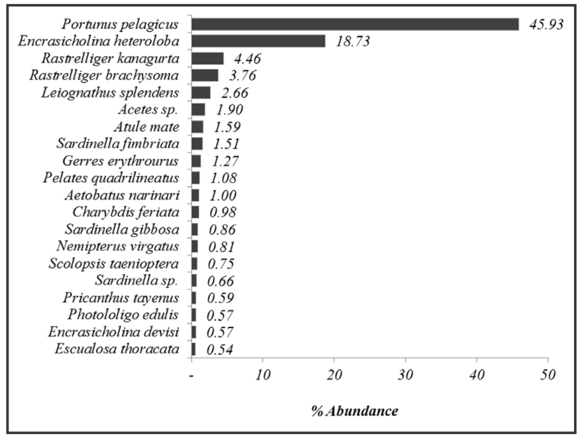

Figure 14. Relative abundance of the 20 major species in the crabbing areas of Western Visayan Sea during the conduct of Blue Swimming Crab Stock Assessment in year 2011 and 2012

Comparing the CPUE of crab gillnet as kg/day and kg/panel, we will be misguided if we just use the increasing CPUE using the kg/day catch rates. But on a more accurate basis, we may have expected an increase in CPUE in kg/panel if we assume it is homogenous with the kg/day. The least is that we may also assume that there should be an increase in CPUE since there was a decrease in the number of panels used in 1995 at 19 panels/boat to 17 and 14 panels/boat in 2011 and 2012. Despite the decrease in the number of panels used, CPUE in kg/panel still continues to decrease over the years.

Species Relative Abundance and Seasonality

Figure 15 shows the relative abundance of all species from all 26 fishing gears in the major crabbing areas of Western Visayas. Of the 224 species identified, 20 dominant species comprises 90% or 5,401 MT of the total catch at 5, 993 MT. *P. pelagicus* comprises 46% of the total catches at 2,753 MT followed by *Encrasiholina heteroloba* at 18.73% or 1,122 MT. These two species already comprises the 65% bulk of catch and the remaining 35% is composed of the 222 species.

Table 5 to 9 shows the dominant species and relative abundance of the major crab gears operating in the area during the conduct of the study. For bottom set gillnet in Table 5, 10 dominant species accounted for

Table 5. Ten (10) dominant species identified for bottomset gillnet operating in the crabbing areas of Western Visayan Sea for the year 2011-2012

Scientific name	Local Name	%
Portunus pelagicus	Kasag;Alimasag	51.11
Rastrelliger kanagurta	Bulaw/Alumahan	9.52
Rastrelliger brachysoma	Hasa-hasa	8.01
Encrasicholina heteroloba	Dilis	6.13
Leiognathus splendens	Latab/Sap-sap	3.64
Atule mate	Bagudlong/kalapato	3.39
Gerres erythrourus	Latab/Malakapas	2.69
Aetobatus narinari	Pagi	2.14
Pelates quadrilineatus	Bugaong/Baga-ong	1.81
Priacanthus tayenus	Bukaw-bukaw/Siga	1.24
Others		10.33

Table 6. Dominant species identified for crab pot operating in the crabbing areas of Western Visayan Sea for the year 2011-2012

Crab Pot	Local Name	%
Portunus pelagicus	Kasag/Alimasag	93.49
Charybdis feriata	Kurusan	3.27
Portunus sanguino-lentus	Pintokan/Alimasag	2.11
Podopthalmus vigil	Instisk-intsik/Ali-masag	1.09
Thalamita crenata	Dawat	0.03
Scylla serrata	Alimango	0.01

Table 7. Ten (10) dominant species identified for crab trap operating in the crabbing areas of Western Visayan Sea for the year 2011-2012

Crab Trap	Local Name	%
Portunus pelagicus	Kasag/Alimasag	87.37
Charybdis feriata	Kurusan	6.62
Scolopsis taenioptera	Opos-opos/Bisugo	3.47
Pelates quadrilineatus	Bugaong/Baga-ong	2.09
Portunus sanguinolentus	Pintokan/Alimasag	0.15
Opichthus altipennis	Igat/Palos/Ubod	0.09
Nemipterus bathybius	Bisguo	0.08
Upeneus sp.	Salmonete/Saram-ulyete	0.07
Selar boops	Mat-an/Matang-ba-ka	0.03
Paraplotosus albilabris	Ito	0.02
Others		0.02

89.67% where *P. pelagicus* accounts for 51.11% of the total gear catch. Table 6 for crab pot shows that the gear's catch is mainly composed of crab species with 93.49% *P. pelagicus*, followed by *Charybdis feriata* at 3.27%, *Portunus sanguinolentus* at 2.11%, *Podopthalmus* vigil at 1.09%, *Thalamita crenata* at 0.03%, and *Scylla serrata* at 0.01%. Crab pot is designed primarily for catching *P. pelagicus* while some other species are by-catch. The efficiency of crab pots relies mainly on its design where the region around six (6) designs are being used. For crab trap, top

Table 8. Ten (10) dominant species identified for manual push net operating in the crabbing areas of Western Visayan Sea for the year 2011-2012

Manual-Push net	Local Name	%
Acetes sp.	Hipon	95.71
Portunus pelagicus	Kasag/Alimasag	3.57
Portunus sanguinolentus	Pintokan/Alimasag	0.17
Cynoglossus robustus	Palad/Dapang tsinelas	0.16
Secutor ruconius	Palid/Waling	0.13
Cynoglossus abbreviatus	Palad/Dapang tsinelas	0.07
Pennahia macrophthal-mus	Abu/Alakaak	0.07
Plotosus lineatus	Hito/Ito	0.03
Sillago japonica	Asoos/Asohos	0.03
Eleutheronema tetradac-tylum	Kugaw/Mamale	0.02
Others		0.04

Table 9. Ten (10) dominant species identified for otter trawl operating in the crabbing areas of Western Visayan Sea for the year 2011-2012

Otter Trawl	Local Name	%
Platycephalus endracht-ensis	Sunugan	12.13
Apogon aureus	Moong/Parangan	9.20
Fistularia commersonii	Stickfish/Trompeta	7.35
Paraplagusia blochii	Palad/Dapang tsinelas	6.66
Photololigo edulis	Lokos/Pusit	6.11
Penaeus latisulcatus	Pasayan/Hipon	5.35
Metapenaeus palmensis	Pasayan/Hipon	4.22
Sepia lycidas	Bagulan	4.11
Penaeus merguiensis	Pasayan/Hipon	3.59
Portunus pelagicus	Kasag/Alimasag	2.09
Others		39.19

2 dominant species comprising the bulk of catch by 94% includes *P. pelagicus* at 87.37% and *C. feriata* at 6.62% of the total gear's catch. Fish species, then, are considered as its by-catch.

Other crab catching gears such as the manual push net and otter trawl caught *P. pelagicus* and other crab species as by-catch. Manual push nets are mainly operated for catching *Acetes sp.* (95.71%), *P. pelagicus* (3.57%) and *P. sanguinolentus* (0.17%) as part of the by-catch. For otter trawl, *P. pelagicus* comprises only 2.09% while the bulk of the catch is shrimps and other demersal fish species.

Monthly Catch Seasonality of *P. pelagicus*

Figure 16 shows the monthly catch seasonality of *P. pelagicus* caught in the Western Visayan Sea for the year 2011 and 2012. In 2011, catches peak in the month of October during peak harvest season and in January during the lean season. In 2012, a prominent peak season is observed in the month of May as its peak harvest season and also January during the lean season.

Table 10. Computed sex ratio of premature, female, and male *P. pelagicus* caught in Western Visayan Sea as observed in the conduct of reproductive biology study

Species	N	Premature	Female	Male	Ratio Premature: Female:Male
P. pelagicus	3,487	223	1,595	1,669	1:7:7

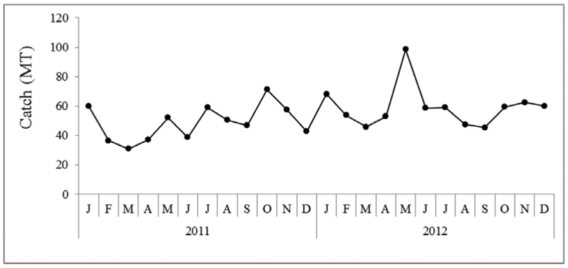

Figure 15. Observed monthly catch seasonality of *P. pelagicus* in Western Visayan Sea for the year 2011 to 2012

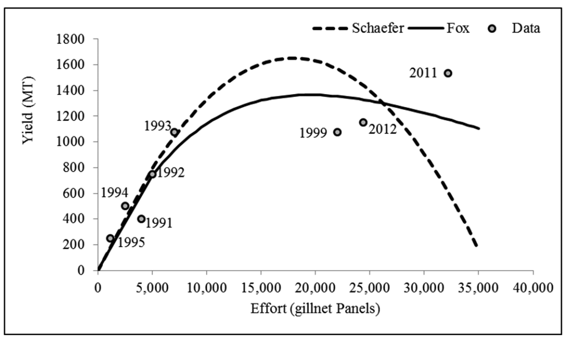

Figure 16. Estimates of the maximum sustainable yield (MSY) and maximum sustainable effort (fMSY) for the crab fishery of Western Visayas at different period using the Schaeffer and Fox Models

Maximum Sustainable Yield

Ingles (1996) has computed the maximum sustainable yield of *P. pelagicus* in Western Visayas using crab gillnet panels as a unit of measurement for the effort. This study also adopted the method in order to give a time series of information and determine the latest status of the crab gillnet fishery of Western Visayas as shown in Figure 17. In the study of Ingles (1996), the estimated MSY is at 1,300 MT at 13,150 gillnet-panels.

In this study, MSY is adjusted to 1,365 MT at 19,473 gillnet-panel fMSY using the Fox model and to 1,652 MT at 17,944 fMSY using the Schaeffer model. Ingles (2004) added its data information in 1999 and showed that MSY and fMSY were achieved in 1993 where the effort in 1999 of 22,000 gillnet-panels quadrupled to its limit. Adding the information collected in 2011 and 2012 of this study showed that fMSY is also achieved prior to 1999 and the yield continues to decline due to the high fishing effort in gillnet-panels over the years. Results also showed that the increase in effort leads to the reduction by 20% in order to achieve MSY and fMSY. The increase in gillnet-panels in 2012 is attributed to the increase in the crab gillnet vessels operating in the area as shown in the total gear inventory. This then attributed to continued high fishing intensity towards the crab stocks in Western Visayas.

Reproductive Biology

Sex ratio

Table 10 shows the total number of samples collected per sexes of *P. pelagicus* used in the conduct of the study. As indicated in the table, a very low percentage of the premature samples were obtained. As observed in the sampling areas, small sized samples are caught by push nets and are caught together with *Acetes sp.* and form as part of by-catch. If we consider only the male and female sample population, a 1:1 ratio is obtained.

As shown in Figure 18, an inverse dominance of female and male sample population is observed. The high female ratio is observed in the month of April which is also observed lowest for the male. The month of June is observed peak for the male population while lowest for the female.

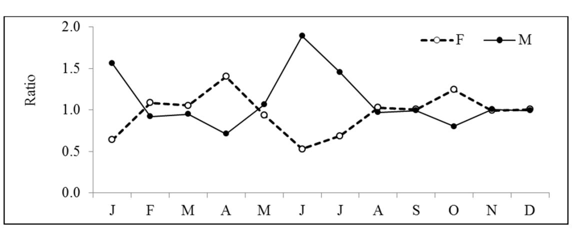

Figure 17. Observed monthly trend of sex ratio between male and female *P. pelagicus* caught in Western Visayan Sea

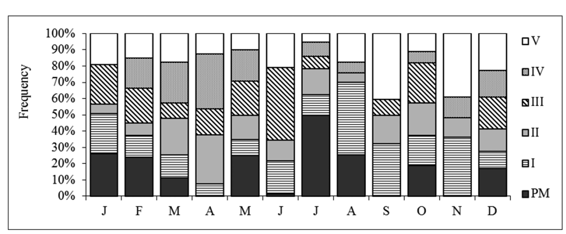

Figure 18. Monthly gonadal frequency distribution in percent obtained for *P. pelagicus* caught in Western Visayan Sea

Female gonadal frequency pattern

P. pelagicus is observed to have continuous spawning year-round characterized by two spawning peaks (Ingles and Braum 1989). December to February is the observed peak spawning season (Ingles 1996) in the Philippines. Spawning season in neighboring countries like Australia is identified in the months of June and July (Svane and Hooper 2004); March to May in Karnataka Coast, India (Sokumaran and Neelakantan 1999); and March to April and August to September in Trang Province, Thailand (Nitiratsuwan et.al. 2010). Figure 19 shows the monthly gonadal distribution of premature and female *P. pelagicus*. As the figure suggests, a high percentage of non-ovigerous stages occurs in the months of July to February. Critical stage FV is present year-round with peaks in the months of September to January. Premature and FI stage is observed in the months of July to August and December to March. For the ovigerous or egg-bearing stages represented by FII, FIII, and FIV, peak months occur in the months of March to May.

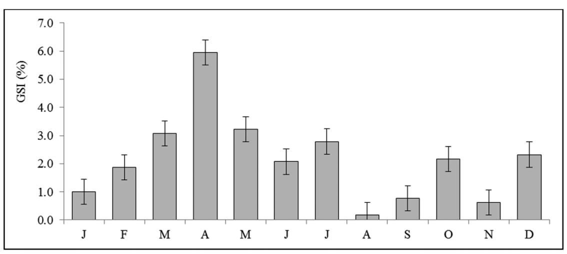

Figure 19. Monthly fluctuation of gonado-somatic index (GSI) observed for *P. pelagicus* caught in Western Visayan Sea

Gonado-somatic index (GSI)

Figure 20 shows the monthly fluctuations of GSI and the corresponding standard deviation obtained for *P. pelagicus*. As the figure suggests, the highest GSI is observed in the month of April with the dominance of FII, FIII, and FIV as shown in the gonadal frequency distribution. On the other hand, August has the lowest observed GSI with the dominance of premature FI and FV stages or the non-ovigerous stages.

Gonadal classification in reference to seawater condition

P. pelagicus occurs in a wide range of algal and seagrass habitats and on both sandy and muddy substrate (Svane and Hooper 2004). It undertakes active foraging using the tidal movements and moves to deeper areas as it increases in size (Ingles 1996). Sumpton et. al. (1994) associates *P. pelagicus* sex-aggregation with habitat preference. Female tends to migrate and burry in deeper and stiller areas for egg incubation and extrusion.

For this study, clear water condition is associated with deeper water areas on a fair weather and murky

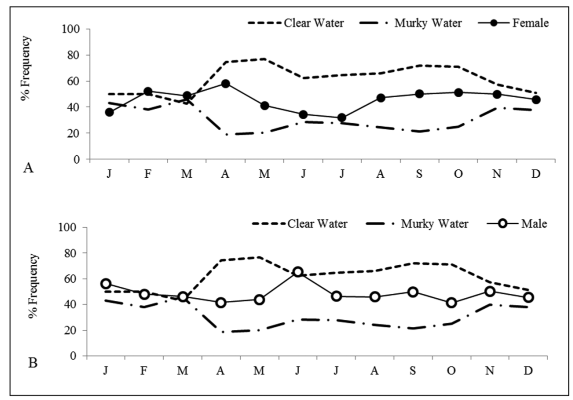

Figure 20. Monthly correlation observed between female (A) and male (B) *P. pelagicus* in relation to clear and murky water condition in Western Visayan Sea

water condition is associated with shallow areas with rainy weather condition. As discussed earlier on sex ratio, a reverse dominance of male to female population is observed which also holds the same for the seawater condition. Associating the two results as shown in Figure 21, the dominance of female population is observed during the peak of clear water condition whereby crab gear operations are concentrated in deeper areas. Months of March to April are the observed peak of clear water condition that falls during the summer season. Associating it further on the gonadal frequency, months of March to April is the peak season for ovigerous females and which can be correlated with the egg incubation period. On the other hand, the male population is observed to coincide with murky water condition with the operation of crab gears in shallow areas.

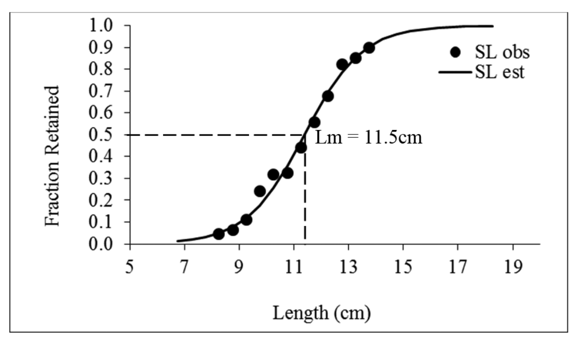

Figure 21. Observed length at first maturity (Lm) for *Portunus pelagicus* caught in Western Visayan Sea

Length at first maturity

Following the logistic curve as shown in Figure 22, the computed length at first maturity for *P. pelagicus* in this study is at 11.5 cm carapace width (CW). Estimated starting length (SL) corresponding to the fraction retained was at 8.25 cm to 13.75 cm. Various researches conducted in the country have come up with values on the length at first maturity for female *P. pelagicus*: 10.5 cm in Ragay Gulf (Ingles and Braum 1989); 10.6 cm in

Table 11. Comparative values of growth parameter from literature and this study obtained for *P. pelagicus* using carapace width (CW) length type

Author/Year	Area	L∞	k	ø'
Ingles & Braum, 1989	Ragay Gulf, Philippines	18.00	1.58	-
Germano et.al., 2006	Eastern Visayas, Philippines	8.95	1.23	-
Olaño et.al., 2009	Sorsogon Bay, Philippines F	21.09	1.58	-
	M	19.39	1.58	
Bayate et.al., 2011	Guimaras Strait, Philippines	21.77	1.40	2.84
Ingles, J., 1996	Visayan Sea, Philippines	22.50	0.70	-
Romero, F., 2009	Visayan Sea, Philippines	19.95	1.40	-
Mesa et.al., 2012 (this study)	Visayan Sea, Philippines	19.10	1.55	2.75

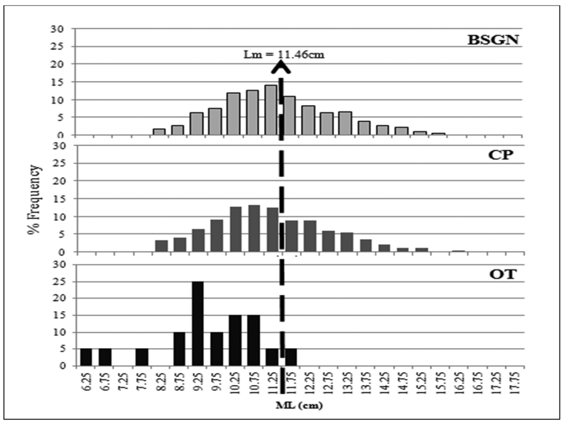

Figure 22. Observed length frequency distribution of *P. pelagicus* caught in Western Visayan Sea by bottomset gillnet (BSGN), crab pot (CP), and otter trawl (OT)

Visayan Sea and Guimaras Strait (Ingles 1996); and 12 cm in Danajon Bank (Armada et. al. 2009). Fitting the Lm value obtained on the linear relationship between length and weight, corresponding weight at first maturity is 99.83 g at a correlation coefficient (r^2) of 0.998 and ±1.62 standard deviation.

Length ranges caught by crab gears

Figure 23 shows the length frequency distribution with the superimposed Lm value for *P. pelagicus* caught by bottom set gillnet, crab pot, and otter trawl. As the figure suggests, all the three gears had a higher percentage of catching the immature sizes shown by the frequencies at the left area of the Lm. Bottom set gillnet catches 57% immature sizes, 62% for the crab pot, and 95% for municipal otter trawl.

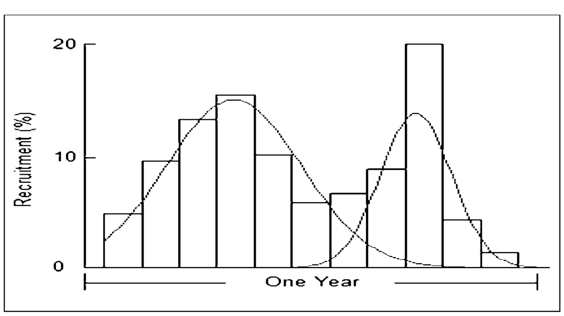

Figure 23 One-year recruitment pulse observed for *P. pelagicus* caught in Western Visayan Sea

Population parameters

Growth

Table 11 shows the various growth parameter values of *P. pelagicus* obtained in various fishing grounds in the country. No variation in the values of L∞ is observed considering the time gaps the studies were conducted, in exemption to that of Germano et.al in 2006. For the Visayan Sea, a decreasing value of L_∞ is observed from 22.50 cm in 1996 to 19.95 cm in 2009, and 19.10 cm in 2012.

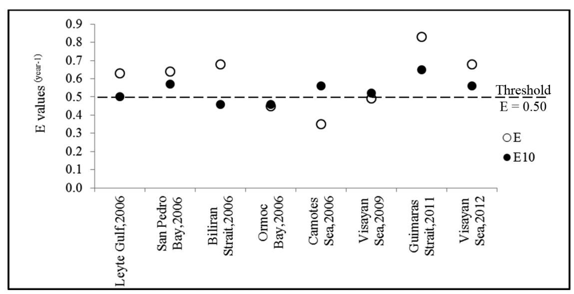

Figure 24. Exploitation rate (E) values from mortalities and optimum exploitation rate (E10) from Beverton & Holt yield per recruit analysis in comparison to the threshold value of *P. pelagicus* from various biological studies conducted

Recruitment pattern

The Philippines, located in the tropical region, has multi-fisheries stocks that exhibit a bimodal pattern of recruitment. This means that there are two pulses of stock-recruit from two different cohorts in a year. Recruitment may occur as a weak and strong pulse or an equal pulse of recruit occurring every year.

Using the recruitment pattern routine of the FiSAT II software program, a bimodal pattern with an almost equal pulse is observed for *P. pelagicus* as shown in Figure 24. Major recruitment at the first semester is observed to have its peak in the month of April at 15%. For the second pulse of recruitment at the second semester, the peak is observed in the month of September at 20%.

Mortalities, Relative Yield and Biomass per Recruit

As stated in the book of Pauly and Ingles (1984), the optimum fishing mortality in an exploited stock should be approximately equal to natural mortality or optimum exploitation rate that is approximately equal to 0.5^{year-1}. A predominance of estimates of values of E > 0.5 in a number of stocks should be suggestive of over-exploitation.

Figure 25 shows the computed (E), optimum (E_{10}), and threshold (E = 0.5) values of exploitation rates in various biological studies conducted for *P. pelagicus* in different fishing grounds of the country. E values from the computed exploitation rates using the software show higher values than that with the threshold at 0.5^{year-1} except for the Camotes Sea in2006 (Germano et al. 2006). For this study, computed E at 0.68^{year-1} shows a higher value compared with that of the threshold $E = 0.5^{year-1}$ at an excess of 36% and with that of $E_{10} = 0.56^{year-1}$ at excess of 21%. Comparing the time series computed E, current data in 2011 for Guimaras Strait and Visayan Sea shows higher values than those from previous studies. This scenario indicates a high fishing exploitation among blue crab resource for Western Visayas.

4. CONCLUSION

The Blue Swimming Crab Management Plan (BSCMP) is a national initiative involving all stakeholders of the blue swimming crab in the country, from the user to policymakers in the aim of rescuing the dwindling crab industry in the country as well as securing its sustainability over the years. In the implementation of the BSCMP in Western Visayas, this project was materialized to provide more concrete and detailed scientific information to be used as a baseline for policymaking.

Based on the results of this study, overfishing is apparently happening in the crab fishery of Western Visayan Sea. This is shown by the results of the decreasing CPUE over the years. A stabilized CPUE is observed from 1995 to 2011 and 2012 if we use the kg/day as a unit of measurement. On a more detailed analysis, an apparent decreasing CPUE is observed using gillnet-panel comparing the results in 1995 with that of 2011 and 2012. This is an apparent indication of an increased fishing pressure thru the increase in the length of nets used during operation of crab gillnet gears. The result of the maximum sustainable yield (MSY) showed that the intensity of fishing pressure increases over the years. MSY was achieved prior to 1999 as indicated by the result of Ingles (1998) and with this study thru the increasing gillnet-panels as fishing effort and a decrease in yield over time. This then suggests a 20% effort reduction of the current year in order to achieve MSY and fMSY.

Growth and recruitment overfishing are observed among *P. pelagicus* stocks for the Western Visayan Sea. Growth overfishing is observed by high value of computed exploitation rate (E) compared to E = 0.5 and E10. Another proof is the decreasing L_∞ value from different studies at 22.50 cm in 1996, 19.95 cm in 2009, and 19.10 cm in 2012 (this study).

Recruitment overfishing is prevalent as shown by the high percentage of sizes caught before Lm for bottom set gillnet, crab pots, and otter trawlers. Recruitment overfishing is also apparent as a high percentage of sizes prior to Lm is observed among major crab-catching gears such as bottom set gillnet, crab pot, and otter trawl. Recruitment overfishing is also correlated to the peak of catching season in the months of October and January that coincides with the peak of spawning season of August and January. This scenario indicates that crabs are caught intensely during its spawning season.

5. RECOMMENDATIONS

Prior to the implementation of BSCMP under the legal basis of JAO 01-2014, the province of Negros Occidental by virtue of Provincial Ordinance 019 series of 2003, and the province of Iloilo by virtue of Provincial Ordinance 2012-093 series of 2012, had implemented initiatives on the conservation of blue swimming crab stocks. In support of these initiatives, this study recommends the following:

- Reduction of effort on the use of bottom set gillnet or crab entangling net thru the reduction of number of gillnet-panels or reduction of fishing vessels operating thru a systematic licensing system;
- Strict implementation on the banning of otter trawl operation in the municipal waters;
- The use of crab pots should also be regulated by recommending the use of alternate materials such as bamboo, limit the number of pots used per operation, and limit the trap entrance diameter;
- Limit the catching size of crab to 11.5 cm carapace width (CW); and
- Banning of catching berried crabs and imposing a close season in the months of August to September and January to February.

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BY-CATCH SPECIES COMPOSITION OF GILLNET AND CRAB POT USED IN THE BLUE SWIMMING CRAB, *Portunus pelagicus* (Linneaus 1785) FISHERY OFF THE NORTHWESTERN PART OF BANTAYAN ISLAND, CEBU, PHILIPPINES

An Undergraduate Thesis Presented to

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In Partial Fulfillment of the Requirements for

The Degree of Bachelor of Science in MARINE BIOLOGY

Leah Mainye, Naomi Ruki, and Aaron Roa

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APPROVAL SHEET

This thesis entitled **"BY-CATCH SPECIES COMPOSITION IN GILLNET AND CRAB POT USED IN THE BLUE SWIMMING CRAB, *Portunus pelagicus* (Linneaus 1785) FISHERY OFF THE NORTHWESTERN PART OF BANTAYAN ISLAND, CEBU, PHILIPPINES** "prepared and submitted by **Leah Mainye, Naomi Ruki and Aaron Roa** in partial fulfillment of the requirement for the degree of **BACHELOR of SCIENCE in MARINE BIOLOGY** has been examined by the Thesis Committee and is recommended for acceptance and approval.

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ABSTRACT

The incidental capture and mortality of non-target marine animals during fishing also known as by-catch or incidental catch, has both negative ecological and socio-economic consequences as most valuable fishes are wasted and other protected marine species are harmed. This study identified the by-catch composition from Blue Swimming Crab (BSC) fisheries in the Northwestern part of Bantayan Island, Cebu, Philippines. A total of twenty-eight (28) sampling days were conducted in the two seasons; fourteen from the dry season (April-May 2017) and fourteen from the wet season (June-August) using crab pots and crab gill nets. The hauling and fishing duration for both the gillnets and crab pots ranged from one hour and thirty minutes to four (4) hours and was operated in depths between 6m and 20m. A total of 6,953 individual by-catches were analyzed from the 28 sampling days in both seasons. One hundred and twenty (120) species from sixty-three (63) families were identified in this study, with which 18 families from Phylum Mollusca,7 families from Phylum Echinodermata,6 families from Phylum Arthropoda and 32 families from Phylum Chordata. Species dominance for dry season was recorded from Phylum Chordata and Phylum Mollusca making up 65% and 50% of the total catch for the crab pots and gillnets respectively. The wet season was dominated by species from Phylum Mollusca and Phylum Chordata making up 54% and 56%of the total catch from the gillnets and crab pots respectively. The results showed that *Monacanthus chinensis* and *Chicoreus ramosus* were the most abundant species recorded during the study. The highest discarded numbers were recorded in dry season both in crab pots and gillnets. This information revealed that BSC fishery targets a fairly high number of species and is not selective for species. More attention should be given to the management of BSC fishery by implementing a management plan, and a creation of by-catch database system which will be an essential feature to future coastal resources management plans and this will help eliminate the non-target species.

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L. Mainye, N. Ruki and A. Roa

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1:

INTRODUCTION

The incidental capture and mortality of non-target marine animals during fishing is known as by-catch or incidental catch. It is divided into three main categories: 1) kept by-catch, 2) discarded by-catch, and 3) unobserved mortalities. *Kept by-catch* includes harvested non-target species or at times providing an important source of income for the fishers (Crowder and Murawski, 1998). *Discards* are those portions of a catch that are thrown back into the sea dead or alive which can be fish and shellfish of any size and species or benthic debris (Davis, 2002). There are also times when individuals were discarded because there is no more space on board the vessel, or the fish cannot be landed due to quota restrictions or catch percentage rules or fish is undersized for which there is no market and or those fish above the Minimum Length Size (MSL) that are not worth landing due to low price. *Unobserved mortalities*, is the by-catch category that includes those species encountered but not retained by the gear (Crowder and Murawski, 1998).

Global marine fisheries data conservatively reported that by-catch represents 40% of global marine catches, totaling 63 billion pounds per year (Keledjian *et al.,* 2014). Other studies (Alverson *et al.,* 1994) estimated that between 18 and 40 million tons which make up 20-25% of total harvest have been discarded annually by commercial fisheries. On the other hand, small-scale fisheries which are generally assumed to have a low or negligible discard rate of 3.7% of the total aggregate catch (Kelleher, 2005) recently studies have shown otherwise. A wide variation of by-catch rates have been recorded to exist with some small-scale fisheries having levels of discards that have the potential to eliminate some populations of megafauna (D'agrosa *et al.,* 2000; Voges, 2005; Peckham *et al.,* 2007), hence, could be one of the main threats to marine biodiversity because of its impacts on the removal of the top predators and individuals from many species, or by elimination of prey (Lewison *et al.*,2004). By-catch also has an added problem whereby the capture, mortality and discarding of species of no concern to one fisher but a target species to another fisher could result to a number of socio-economic tradeoffs. And lastly, by-catch may also result in an alteration in the ecosystem or ecological complex as a consequence of the high death rates of some target and discarded non-target species (Shester and Micheli, 2011). With the above mentioned by-catch problems, solutions have been presented and some efforts initiated but these were not fully implemented even if by-catch not only reduces fish population, but also wastes a potentially valuable food source.

As regards to the fishing gears used in crab fisheries, prior to 1970, only artisanal gears such as hooks, traps, dredging and line were used, however, the introduction and popularization of bottom trawls in the mid-1970's to mid-1980's mattered to a significant increase in exploitation (Ingles, 2004). These caused a decline in fish catch until in 1982 trawls were banned in the Philippines which gave the BSC a chance to recover until 1990, when the export demand for the BSC increased as the Chesapeake Bay Crab Fishery in the US collapsed.

Today most production is through artisanal boats using gillnets and pots. The continued increase in export demand and artisanal boats caused a boom and bust trend in various BSC fishing areas in the Philippines. When export demands increased, artisanal fishing rose, and crab meat processing plants were established. Due to high prices, fishers entered the fishery without any management restrictions and stayed until fishing was no longer profitable. Once this happened, the processing plant closed and moved to another location (Ingles, 2004).

Shown in Figure-1 (A) and (B) are the gillnets and crab pots respectively both weighted to settle at the bottom of the sea floor if only to increase the interactions and success rate of trapping the BSC in Bantayan Island. Unfortunately, both gears do not discern from other benthic organisms that would unknowingly swim or get tangled in the nets or pots (Thongchai, 1980). These then comprised the by-catch species.

Figure-1 A & B. The gill net (A) and crab pot (B)

Used by fishermen to catch the blue swimming carb, *Portunus Pelagius* locally known as "lambay"in Bantayan Island, Cebu, Philippines

The Blue Swimming Crab, *P. pelagicus,* is the third major export commodity of the Philippines after tuna seaweeds and shrimps due to its excellent meat quality and flavor. Since 1990s and up to this day it has been a heavily exported wild resource as the demand and its economic value increased. The 2013 data from the Bureau of Agricultural Statistics (BAS) showed that Bicol (R 4B and 5) and Visayas (R- 6,7 and 8) Regions combined contributed 72.4% to the total BSC production in the country, with Regions 5, 6, 6-B, 7, and 8 reporting the highest crab landings. The high demand both from local and foreign trade led to the massive collections of this marine resource just to provide a growing industry of processing and packaging plants (Cruz *et al.,* 2015). The fishing of BSC in Northern Cebu, like many commercial fisheries elsewhere in the world, has a share of by-catch problems. In the past, these problems have been viewed as interfering with the proper fishery management, rather than as threats to the conservation of endangered species. However, the observations of the problem are changing, by-catch has been found to depend on the type of fishing gear being used. In the Visayan Sea, the targeted BSC is at 42% and the by-catch at 58%, of which includes the Indo-Pacific crab, *Charybdis feriata* (6.5%), fishes (3.81%) and other crabs (45.34%) with gillnet being the lowest in by-catch volume. Among the recorded by-catch fishes caught by gillnet fishery are the juvenile reef sharks and sting rays which have also fallen prey to the fishing gears used in Bantayan Island. An alarm has been raised by scientists on elasmobranch by-catch but so far, no measures have been undertaken yet (Romero, 2009).

Gillnet fishing effort for BSC in Bantayan Island dramatically increased from 1996 to 1999. Stocks exhibited growth and recruitment overfishing and catch trends continued to exceed maximum sustainable yield (Ingles, 2004; Ingles and Flores, 2000). These are further confirmed by 2011 and 2012 Western Visayas stock assessment data (Mesa and Bayate., 2014) and by 2016-2017 Bantayan Island Stock Assessment (Sotto and Taguba, 2017). The biological, economical and total environmental implications on artisanal by-catch from species-specific fishing activities is less known globally. An understanding of the problems and developing an effective by-catch reduction strategy is a complex environmental challenge which requires a deeper understanding of scientific, socio-cultural, and socio-economic components (Komoroske and Lewison, 2015). Hartmann in his review delivered during the World Fisheries Congress in 1992 pointed out that *"there is a bias in management towards the needs of the developed countries; the dynamics and ecological social importance of* *artisanal fisheries are ignored*". Such concerns are mostly based on observations of large number of discards but infrequently on detailed population assessments of impacted stocks. This is because comprehensive and historical data sets involving discards have been unavailable to support such claims (Shester and Micheli, 2011). A study on large scale gill net fishing done off the coast of New England and Mid-Atlantic where 2,000 fishermen target monkfish, found that more than 16% of the total catch has been discarded. The study also found that annually from 2006 to 2010 an average of more than 1,200 endangered sturgeons were caught as by-catch and every year 750 dolphins and porpoises were captured in the gillnet fishing (Keledjian *et al*., 2014).

Due to the lack of studies on by-catch particularly on the BSC, little is known about the fate of by-catch in Bantayan Island from species-specific fishing gears used. Many different species ended up in the nets or traps as by-catch and most are taken to the shore for food or are being sold. Some other species such as crabs with less or no economic value, are disregarded and left on the shore to avoid the hustle of being caught again by the fishermen. Juvenile sharks, dolphins, turtles, crabs and other vertebrates also ended up as by-catch and eventually die and discarded.

1.1 Objectives of the Study

This study was conducted to identify the species that composed the by-catches from the gillnet and crab pot fishing gears used in catching the Blue Swimming Crab (BSC), *Portunus pelagicus* locally known as "lambay" off the northeastern part of Bantayan Island, Cebu, *Philippines*.

1.2 Significance of the Study

Most of the information on by-catch species composition and their fate are from studies on large-scale fishing operations from industrialized countries (Shester and Micheli, 2011). Studies on species specific small-scale fisheries such as the Blue Swimming Crab Fishery will provide up to date data on by-catch species and act as an initial step to further research of similar topics locally and fill a gap in the fisheries data in the country.

The studies of (Ingles and Flores 2000; Romero 2009) in the Visayan Sea, Philippines was done to look at gear effectiveness in the BSC fishery supplied general taxa information on species that are most likely to interact with the BSC fishery although, the species of these known taxa were not provided. Hence, this study will provide details of by-catch on species level that are associated with the Blue Swimming Crab fishery in Bantayan Island and also look at the different gears used by the fishermen. This study will be looking on two different seasons to determine which season has more by-catch.

1.3 Review of Related Literature

1.3.1 By-catch in Fisheries: A Global Context

The interest on by-catch has attracted global attention to develop international guidelines on by-catch management and reduction of discards as shown in fig-2 (FAO-UN, 2013). By-catch fisheries are threats to species of marine mega fauna across the world’s oceans. A combination of the selective properties of the fishing gear, the skill of the fishermen, the place, and time of fishing determine the quantity of by-catch that is caught, discarded, damaged, and killed. Most fishing gears are selective in what they catch, but other, less selective gears (e.g. demersal trawling for prawns and fish) have the potential to catch large several and diverse organisms that cause interactions with other species, fisheries, and user groups. The mortality of such species in gillnets and crab pots during capture and discarding are the major reasons for management measures such as mesh-size restrictions on nets and traps with minimum or maximum size limits on retained individuals to be imposed (Gulland, 1973. Howell and Langan, 1987).

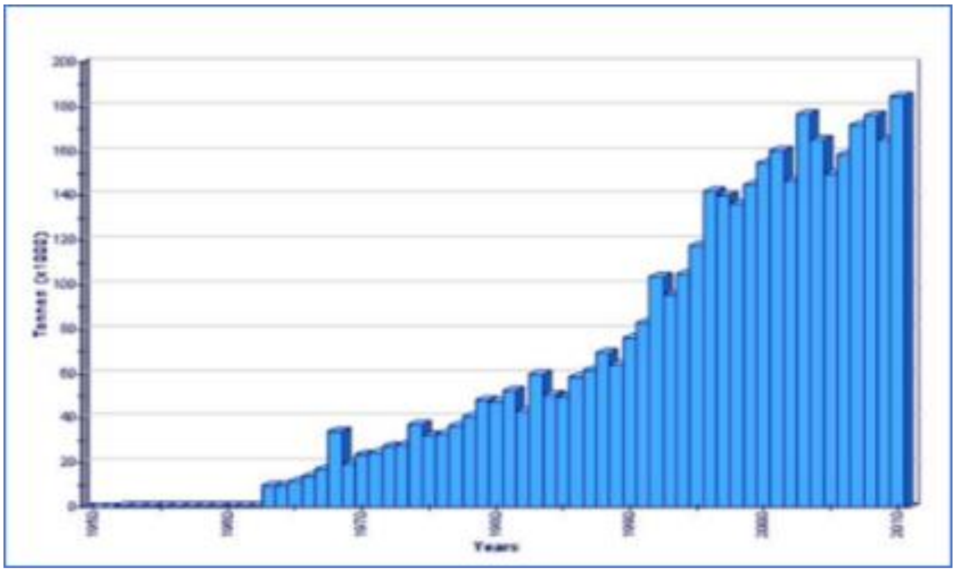

Figure 2. Global catch of blue swimming crabs from 1950-2010 (FAO, 2013)

In Australia the most common way that fishery scientists quantified by-catch from demersal trawling is by conducting fishery-independent surveys in research vessels or chartered commercial vessels (Kennelly, 1995). While the data generated from such surveys do not necessarily represent normal fleet operations, still it provided useful information on the identities and quantities of by-catches of the same fishing grounds. The main utility of these surveys, however, comes from using the relatively non-selective nature of demersal trawl gear as a sampling tool to study the distribution and abundance of species in these assemblages (Andrew and Pepperell, 1992).

A challenge of by-catch research has been to quantify its biological impacts. Effects of by-catch occur at species, population and ecosystem levels leading to population declines, creation of sink populations within species, and altered food web interactions. By-catch researchers have also utilized multidisciplinary and often creative approaches to assess population-level impacts in the face of uncertainty in demographic parameters and by-catch rates (Komoroske and Lewison, 2015).

1.3.2 The Use of Crab Pots and Gillnets for Blue Swimming Crab Fishery

Gillnets and crab pots are among the oldest forms of fishing gears developed and have been used in many parts of the world although people in different parts of the world are not always referring to exactly the same gears when they refer to traps and pots. According to the Food and Agriculture Organization (2001), traps are considered passive fishing gears that allow fish to enter easily and then make their escape difficult.

Generally, pots are smaller movable traps and enclosed boxes that can be deployed by hand or from the boat. They are designed to lure animals into the device, and then once the animals are trap inside, it becomes difficult for them to get out**.** To trap the animals into the pot, fishermen use baits of either small fish, fish parts, or artificial baits and then deploy the pots and traps on the bottom of the sea on either shallow or deep areas either individually or tied several pots together connected to a common line. A rope then connects the pots or traps to a buoy at the surface of the water as shown in Figure 3. The shapes of the pots or traps can vary from triangular, circular, or cone-shaped and are usually made from various materials, like bamboo, woods, steel, and wire. Some of this gear can be either light or heavy.

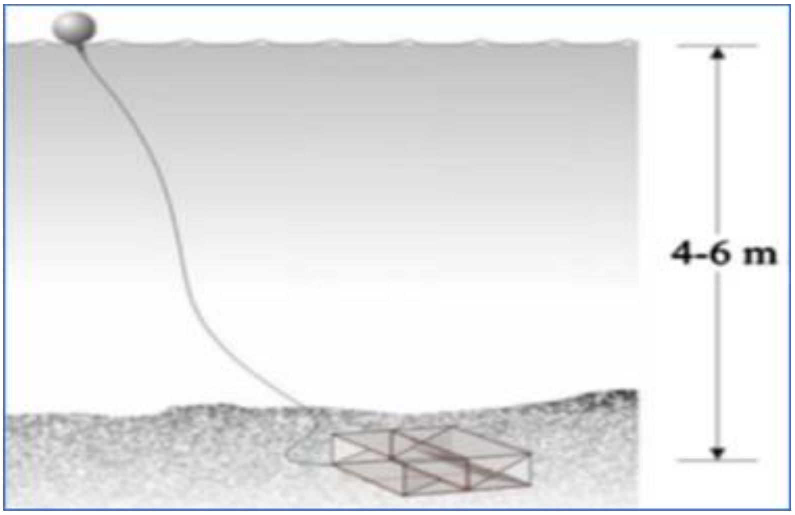

Figure 3. The crab pot deployment configuration

Gill nets on the other hand, have various mesh sizes that ranged from 4-10 cm depending on the depth or zone for fishing. Usually they are operated in the shallow or inshore waters to capture mixed fishes but the most importantly are the crabs. While nets deployed in the shallow waters have mesh sizes ranging from of 4 to 8cm, 80% of which have 6cm a mesh size. For deeper waters, nets mesh sizes ranged from 8-10 cm and commonly used nylons of 0.30/mm twine size, 4 knots, and 50 meshes down. The length of one unit of crab entangling net is 133meters long which can result to more than 2-km of entangling net per fisher per operation.

In Bantayan Island, Cebu, Philippines, BSC fishermen are using crab pots locally known as *"panggal"* made of bamboo slits with a minimum hole diameter of 5cm as recommended by the Bureau of Fisheries and Aquatic Resources (BFAR). This 5cm BFAR recommended minimum diameter allows crab fishers to return the gravid and juvenile crabs while the caught crabs are maintained alive in the sea, a practice that encourage sustainable fishing, while increasing fishing incomes.

Crab pots are made by weaving bamboo splits with a non-return valve for easy entrance but difficult to exit. This fishing gear has simple structure, which can be handled easily on board a small fishing boat. At sea the lost *"panggals"* have less environmental hazards since they are biodegradable and able to decompose within 3 to 5 months. On the other hand, the crab pots can create additional income-generating activities for the community: supply the bamboo as materials in construction of pots and at the same time develop and utilize skills in weaving, and also gather less valued waste fish as baits.

The other fishing gear used in Bantayan Island for BSC fishing is the gillnet which is made of nylon and has a minimum mesh of 11 cm and 3 cm stretch mesh as recommended by BFAR. This fishing method is however considered as nonselective because it does not allow juvenile crabs and other species that have not reached maturity or have not spawned to return to the sea. Relatively retained fishes, crabs, and rays and discarded by-catch such as other crabs, sponges, mollusks, and others of the entangling net are substantial and in some cases are causing pressure to other protected, endangered, and threatened species like sharks, some shells, and the famous Irrawaddy dolphins (Romero, 2009; Flores, 2005; Ingles, 2003). According to Ingles (1996) the continued use of entangling nets and trawl fishing will result in the loss of the main source of income for 30% of the population.

1.3.3 Legal frameworks governing the Blue Swimming Crab Fishery

In the Philippines, the Department of Agriculture (DA)-BFAR laid down legal frameworks which are the basis of regulation for the utilization and conservation of BSC in the country. A Joint DA-DILG Administrative Order No.1 Series of 2014 under section 3 which connects important sustainability policies governing the minimum catch size, responsible fishing gear, closed crabbing seasons and the protection of berried female crabs. The required minimum mesh size of crab entangling nets and crab lift nets shall have 11cm and 3cm stretch mesh respectively while the crab pots should have a 5cm minimum hole diameter and a violation of this rule one will pay 2,000-20,000 thousand pesos or serve six months to two years in prison. To prevent overexploitation /overfishing a closed season for BSC fishing was imposed by and violation of this rule one pays a total of 6,000pesos or serves a minimum of six months and one day to six years in prison.

In the minimum BSC catch size, a fisherman caught fishing below the minimum size of 10.2 cm carapace width will be fined a total cash of 2,000-20,000 pesos or serve an imprisonment period of 6 months to 2 years. Lastly on the transporting BSC without valid auxiliary invoice and Local Transport Permit (LTP) will be fined a total of 200-1000 pesos or be imprisoned for a total of 5-10 days.

1.3.4 By-catch Species Composition and Volume

The by-catch composition and volume are dependent on the type of fishing gear used in the Visayan Sea. The targeted BSC comprised 42% of the total catch and the by-catch was 58%, which include the Indo-Pacific crab, *Charybdis natator* at 6.5%, fishes at 3.81%, and other crabs at 45.34% (Romero, 2009). Of the other crabs, *P. sanguinolentus* is sometimes treated as *P. pelagicus* in terms of value. *Charybdis miles* and *C. natator* go to the local markets, whereas the rest of the other crabs by-catch were discarded which include several species of *Thalamita, Carcinoplax, Calappa, Parthenope, Camposia,* and *Majidae* (Ingles and Flores, 2000).

In Guimaras Strait, the crab gillnet fishery had same by-catch as that of Indo-Pacific crab which of comprised about 7%, cuttlefishes (2%), fishes (4%), and other crabs (45%) with no or very little market value. Their species composition of the crab by-catch is the same with that of the Visayan Sea (Ingles and Flores, 2000).

Huge numbers of by-catch have been observed in fisheries all over the world including the Philippines. According to the Northern Territory of Australia Department of Primary Industry and Fisheries (1992), the Australian Northern Prawn Fisheries (NPF) discard approximately 1.5 tons and 70,000 individuals per vessel per night of the fishery. More than 240 species, including 75 families of fish, 11 of sharks, and several of crustaceans and mollusks have been identified in the discard of some 30,000 million tons of annual discards for this region. Data for the 1992 Bering Sea pollock trawl fishery showed that nearly 130 species, including over 100 million pollock, 8.5 million rock sole, 3.2 million Pacific cod, and 2.3 million flounders (NOAA/NMFS, 1992) have been discarded. While another 200 million pollocks were discarded in other Bering Sea ground fish fisheries. The aggregate discards in the Bering Sea and Gulf of Alaska bottom fisheries approached 1 billion animals annually, exclusive of discards from the inshore salmon, herring and offshore crab fisheries.

Off Brazil, 147 species have been identified in the by-catch and total discards constitute billions of fishes. Claims have been made that “the inshore trawling with small meshes is placing at risk the whole ecosystem of the region” (Conolly 1992). In the Gulf of Mexico, shrimp fisheries, an estimated five billion croakers (*Micropogonias undulatus*), 19 million red snappers (*Lutjanus* spp.), and three million

Spanish mackerel (*Scomberomonrus cavalla*) were discarded (Murray *et al*., 1992). Fifty species in 28 families have been identified in the landed fraction of the Malaysian shrimp by-catch. In Singapore landed by-catch, 51 families were catalogued in which 32% were juveniles of commercially important species and 48% represented low-valued species which were used for direct consumption or processed into fish paste and other products (Abdullah and Rahimar., 1983). In the same study, roughly 20% of the by-catch consisted of species considered unacceptable for human consumption (Sinoda and Tan.,1978). In a bycatch research conducted in the Philippines four decades ago by Ordonez (1985), a total of 59 families and 46 species were collected and identified. With the above information on caught and discarded by-catch species and volumes, the problem on bycatch is real and has to be documented and communicated to policy makers, hence, this present study.

1.4 Scope and Limitations of the Study

This study mainly dealt on the identification of the species that composed the bycatch of the two fishing gears, the crab pots and gillnets used in the BSC, *P. pelagi*cus fishery off the northwestern coast of Bantayan Island, Cebu, Philippines and did not consider the total catch from the fishermen. The collection of data was done from the landing sites rather than going with the crab fishers to their fishing sites.

In most by-catch studies which are usually from large and small-scale fisheries, the Catch Per Unit Effort (CPUE) are included but not in this study. Instead the length and the weight of each species that composed the by-catches were measured. Also, not determined in this study is the ecological impacts of the by-catch species on their natural habitat due to time constraints.

CHAPTER 2:

MATERIALS AND METHODS

2.1 Description of the Landing Sites

This study was carried out in the northwestern part of Bantayan Island, Cebu, Philippines where a relatively large scale of Blue Swimming Crab fishery is located. Specifically, for this study the landing sites chosen were chosen namely; Barangay Patao, Barangay Baod and Sitio Dad-dap of Barangay Patao (Fig. 4) from April to August of 2017. According to the crab fishers most of their fishing took place in a fishing site known to them as Pupu-o.

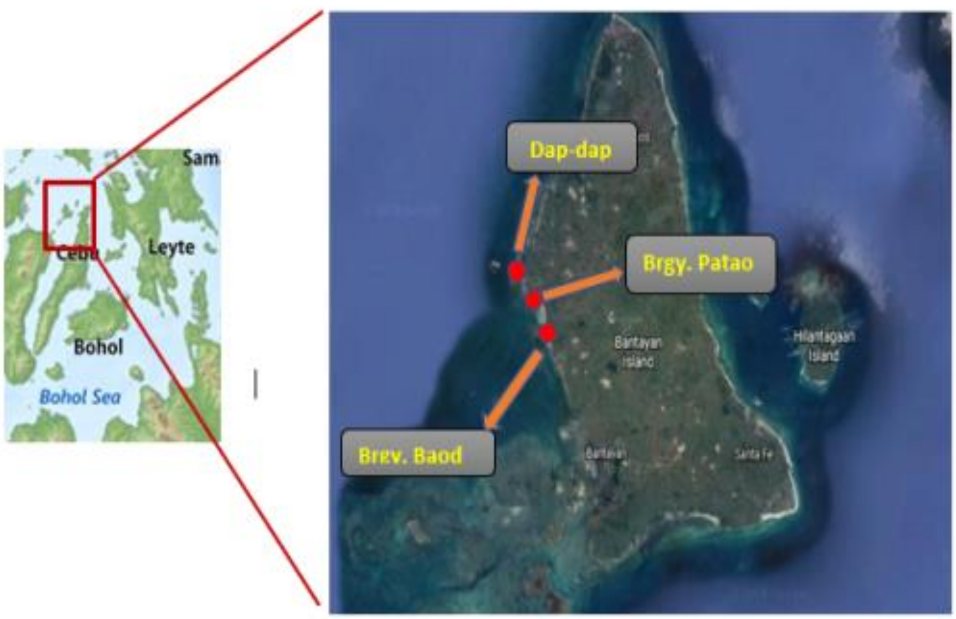

Figure 4. Map of Bantayan Island, Cebu, Philippines
Showing the locations of the three landing sites (red dots) chosen for this study

2.3 Field Data Collections

For this study all sat were collected from the three BSC landing sites in Bantayan Island from April 21, 2017 to August 2017. Fourteen (14) samplings for each fishing gear for dry season (April to May) and 14 samplings for the wet season (July to August) were done. The fishing and hauling duration for both gears: gillnets and crab pots ranged from one hour and thirty minutes to four (4) hours and was operated at depths between 6 to 20m.The by-catches were sorted from the target species and the total by-catch data were recorded (Figa.5A-D). Sample species were set aside for photo documentation and classification. At least 50% of the by-catch species were counted and weighed. Large by-catch species, such as rays, were also counted and weighed individually. The collected sample species were brought to University of San Carlos Marine Research Laboratory in Brgy. Maribago, Lapu-Lapu City, Philippines for further species identification.

Figure 5. Researchers helping the fishermen in deploying the gears (A & B), untangling of by-catch from the gill net, and sorting out the b-catch at the landing sites (D)

2.4 Laboratory Work

2.4.1 Species Identification and Morphometric Measurements

The quantitative measurements of the different forms of by-catch known termed as *"morphometric"* measurements is a quantitative analysis that encompass sizes and shapes of the organisms caught and is done to determine species maturity among the by-catch. The traditional method of morphometric analyses of the lengths, widths, masses, angles, ratios, and areas of the by-catch species examined in this study was done using the ImageJ software. Each by-catch sample species were measured and weighed; for crabs, their carapace length (CL), which is the distance from the median frontal teeth to the posterior border of the carapace, and carapace width (CW) which is the distance between the widest points of the carapace (Fig. were measured using a ruler. For shrimps, the CL and CW were measured to the nearest 0.1 mm, the Total Length (TL) and the combination of (CL) were measured and recorded. The elasmobranchs consisted of rays their disc width, that is from each end of the pectoral fin were measured.

As to the body weight (BW) of all by-catch species it was measured using analytical balance to the nearest 0.01g and for the fish the TL was measured (Figs.6A-C).

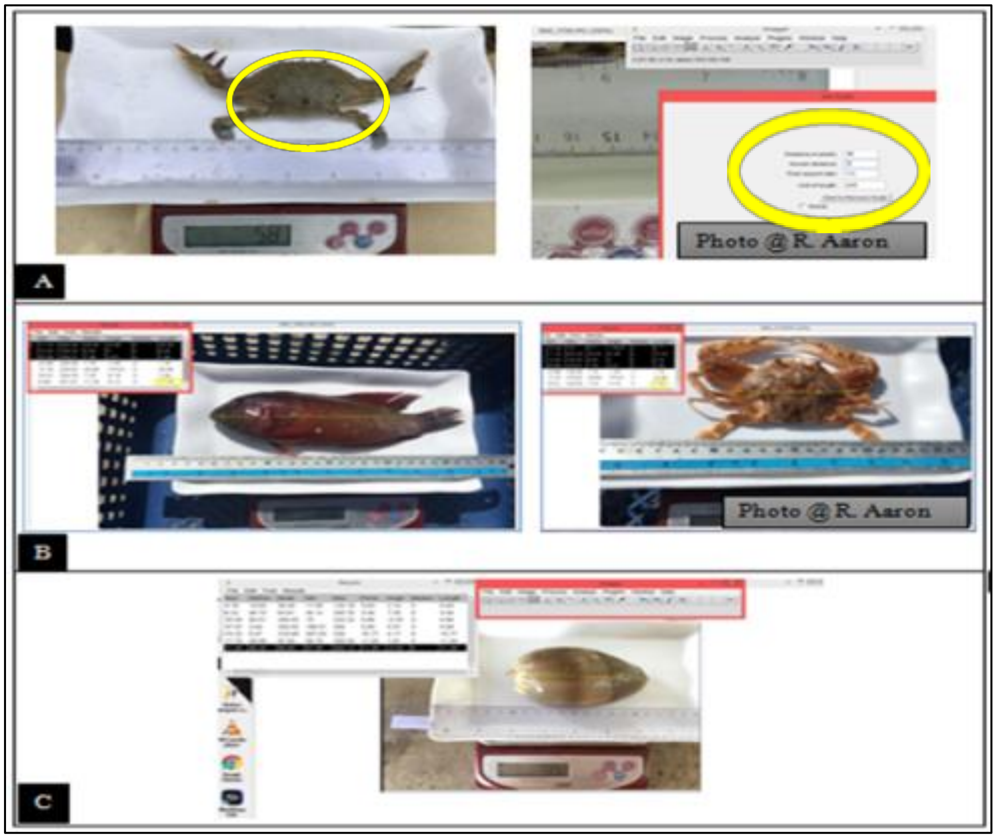

Figure 6 A to C. Weight (g) and pixel measurement

Using ruler at 1 cm (A), crab carapace and fish length measurement (B), pixel analyzed to determine the length of by-catch (C)

2.4.2 By-catch Species Identification and Classification

Prior to the species identification, first the by-catch were sorted out according to taxon and fishing gears referring to the works of Gonzales (2013) *"Field Guide to Coastal Fishes of Palawa*n"; White *et al*., (2006) *"Economically Important Sharks and Rays of Indonesia";* Wilkens (2015) "*Reef Creature Identification-Tropical Pacific";* Humann, P *et al.,* (2010) Kira, T. (1965) "*Shells of the Western Pacific in Color Volume 1*"; "*Tropical Reef Fishes of the Philippines* (1998)"; "Lee Goldman (2012) *Snorkeler's guide to Marine Life of the Philippines*". Identification was based on morphological characteristics at the phylum and species levels shown in Table 1 and Figures 7-16.

Table 1. General Morphological Characteristics of the Classes in each of the phylum

Phylum Mollusca

Class 1 Pelecypoda or Bivalvia

- Symmetry: bilateral and the body is laterally compressed.
- consist of two shells held together by adductor muscles
- No distinct head

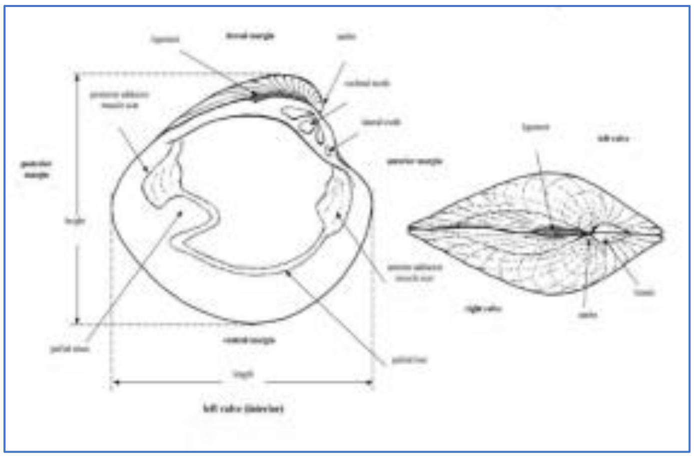

Figure 7. General External Anatomy of Bivalves

Source: Identification guide to the living marine resources of the Eastern and Southern Mediterranean, 2012

Class 2 Gastropoda

- They possess a spiral shell.
- The foot is large and flat.
- Head is well developed with tentacles and eyes.

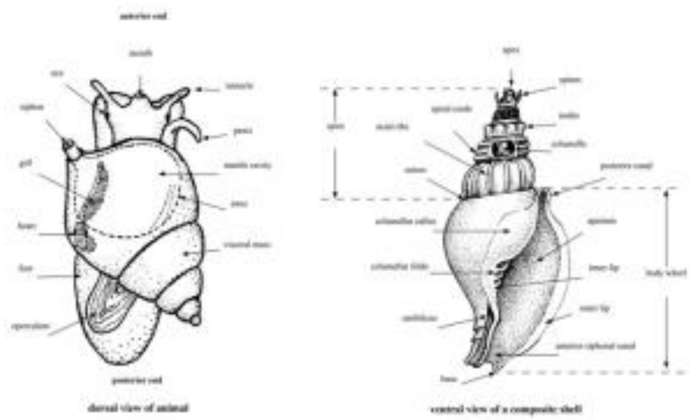

Figure 8. General Anatomy of Gastropods

Source: Identification guide to the living marine resources of the Eastern and Southern Mediterranean

Class 3 Cephalopoda

- The foot is modified into eight to ten long tentacles in the head region.
- The shell is either external, internal or absent.

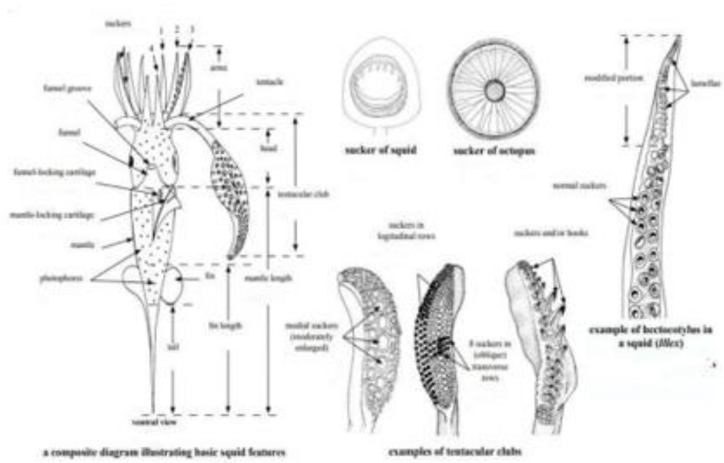

Figure 9. General Anatomy of Squid

Source: Identification guide to the living marine resources of the Eastern and Southern Mediterranean, 2012

Phylum Echinodermata

Radial body symmetry
Covered in some forms of spike (sea cucumbers), spines (sea urchins) and bumps (sea stars).

Class 1 Asteroidea

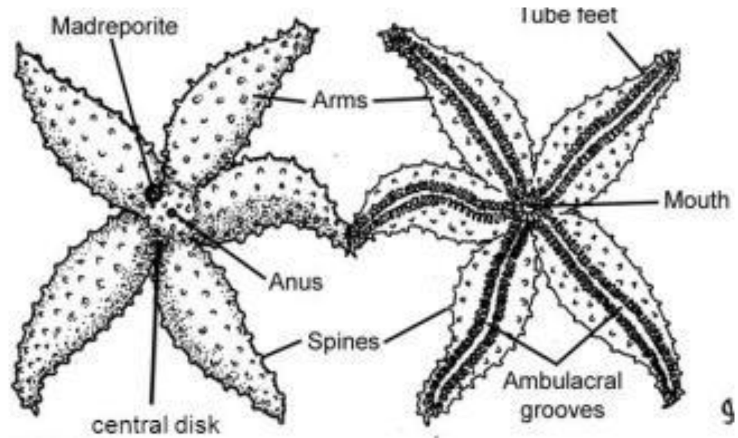

Figure 10. General Anatomy of Starfish

Source: Identification guide to the living marine resources of the Eastern and Southern Mediterranean, 2012

Class 2 Echinoidea

- No arms
- Skeleton is fused into a solid test
- Covered with spines and pedicellareae
- Tube feet have suckers

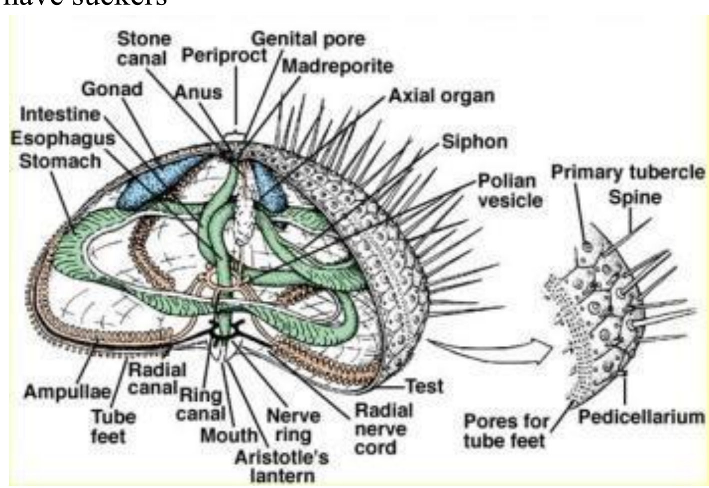

Figure 11. General external anatomy of Sea Urchin

Source: Identification guide to the living marine resources of the Eastern and Southern Mediterranean, 2012

Class 3 Holothuroidea

- Lack arms.
- Bilaterally symmetrical.
- Body wall soft rather than calcareous.
- Body surrounded by tube feet.

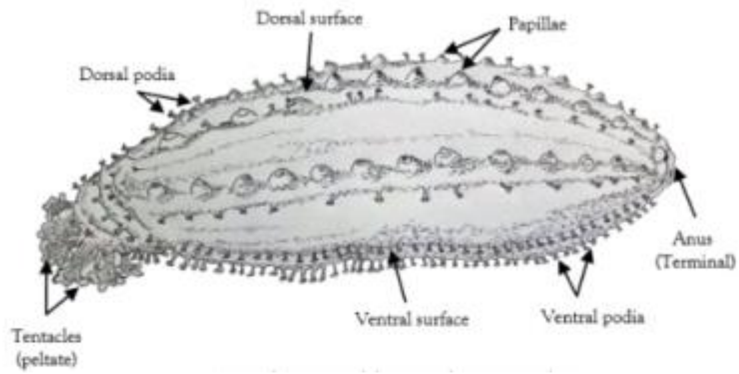

Figure 12. General external anatomy of Sea Cucumber

Source: Identification guide to the living marine resources of the Eastern and Southern Mediterranean, 2012

Class 4 Ophiuroidea

- Have 5 slender arms
- Have 5 movable plates on the oral surface
- Madreporite located on the oral surface
- Tube feet is for feeding only
- No anus and ambulacral groove

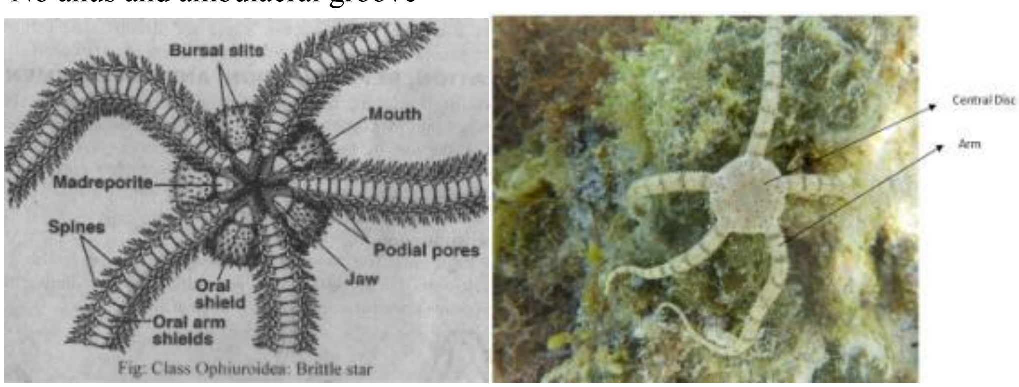

Figure 13. General Anatomy of Brittlestar

Source: Identification guide to the living marine resources of the Eastern and Southern Mediterranean, 2012

Phylum Arthropoda
Bilateral body symmetry
Have a hard, exoskeleton (outer skeleton)
Jointed limbs with segmented body

Class Decapoda

Have 5 pairs of legs used for walking
Carapace is either triangular, square-shaped round

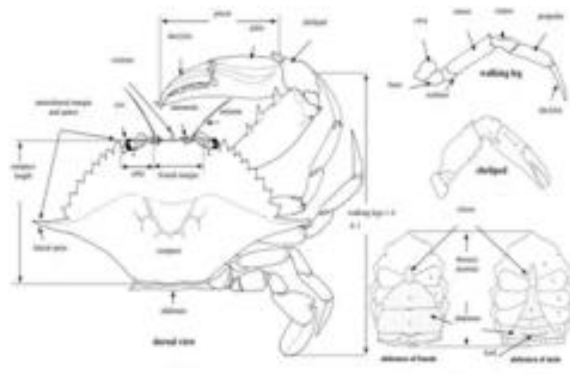

Figure 14. General Anatomy of Crab

Source: Identification guide to the living marine resources of the Eastern and Southern Mediterranean, 2012

Phylum Chordata

Distinctive characteristics of chordates distinguish them from their ancestors:

A. Notochord, or a rod of vacuolated cells, encased by a firm sheath that lies ventral to the neural tube in vertebrate embryos and some adults.

B. Hollow nerve cord that lies dorsal to the notochord

C. Pharyngeal pouches

D. Endostyle - elongated groove in the pharynx floor of protochordates that may develop as the thyroid gland in chordates

Class Osteichthyes (Bony fish)

- Body plan (shape and size)
- Colors (Body)
- Number and structure of fins
- Endoskeleton is entirely made of bone
- They have anterior tip mouth opening
- Their exoskeleton is made up of cycloids (thin bony plates), aligned based on whether the outer edges are spiny or smooth
- They have an operculum on either side of their gills
- They possess an air bladder that also performs hydrostatic functions
- Their tail fin is homocercal

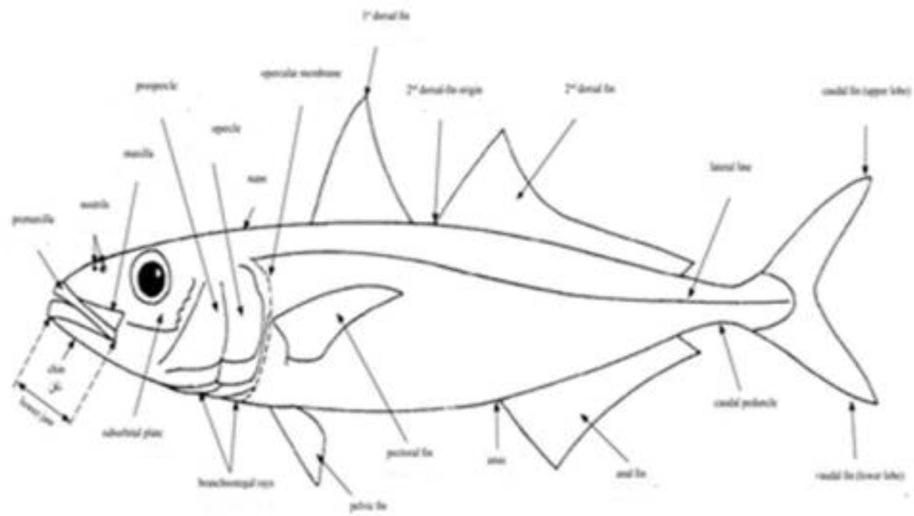

Figure 15. General External Anatomy of Bony Fish

Source: Identification guide to the living marine resources of the Eastern and Southern Mediterranean, 2012

Class Chondrichthyes (Cartilaginous fish)

•Their endoskeleton is primarily made of cartilage

•Their exoskeleton is made of placoid (very small denticles coated with lots of sharp enamel)

•The buccal cavity of these fishes is ventrally positioned

•The position of their tail finds is heterocercal

•On either side, they have 5 gills that are overly exposed, so they do not have an operculum.

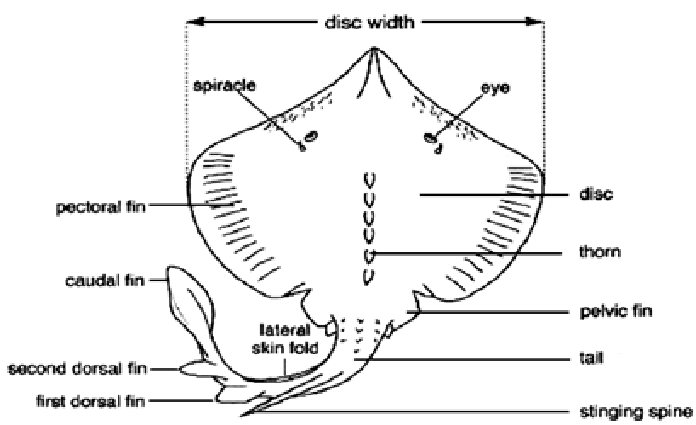

Figure 16. General Anatomy of a Ray

Source: Identification guide to the living marine resources of the Eastern and Southern Mediterranean, 2012

2.4.3 Data and Statistical Analysis

The data collected from Bantayan Island from April to August 2017, was analyzed by taking the weight(g) and total length (cm). This was achieved by using JPEG programs scale setting. Morphometric character measurements for total length were measured based on the species structure (Sley *et al*., 2016). About 10% of each of the phylum from both dry and wet seasons were also analyzed using ImageJ software. For documenting the by-catch composition, the species were listed according to their fishing gear, and phylum for each species length, width and weight. An R-test analysis was used to compare the composition of the different by-catch species from the two gears used and the sampling seasons as well as the measurements obtained during the period of the study.

CHAPTER 3:

RESULTS AND DISCUSSION

3.1 By-catch species composition, identification and classification

A total of 6,953 individual by-catches have been counted, identified and classified in 28 samplings conducted for both dry and wet seasons). Of the 6,953, sixty-three (63) families were identified, 18 of which were under Phylum Mollusca, seven (7) from Phylum Echinodermata, six (6) from Phylum Arthropoda and 32 families from Phylum Chordata. Gear wise, by-catch of crab pot for both the wet and dry seasons were dominated by chordates at 56% (n=418) and 65% (n=1973) respectively. Whereas, by-catch of gill net were dominated by Phylum Mollusca at 54% (n=488) during the wet season and 50% (n=1139) during the dry season. (Figs.17 A-D)

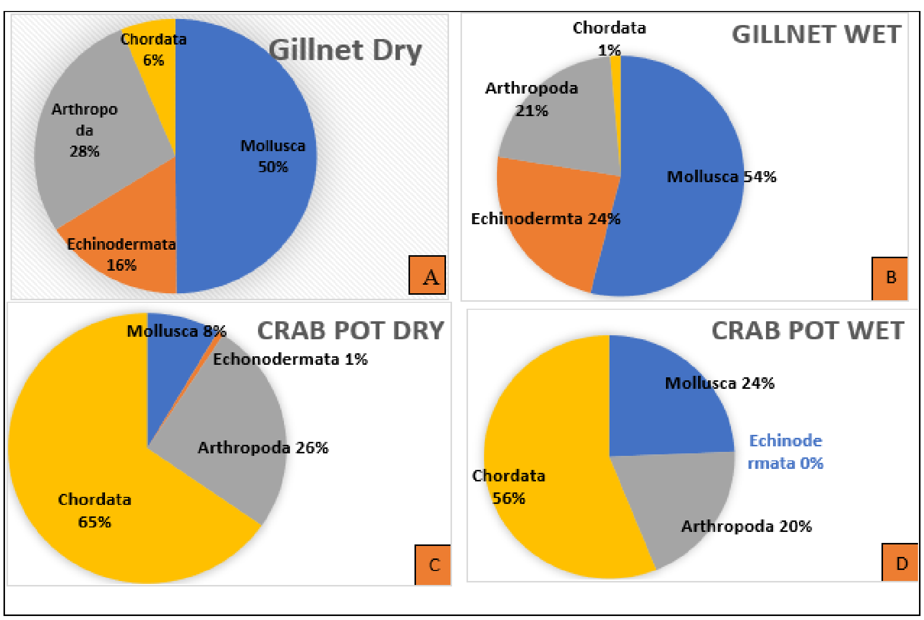

Figure 17 (A to D). By-catch per taxon group in percent for the gillnet (A and B)

and crab pot (C and D) during dry and wet season respectively.

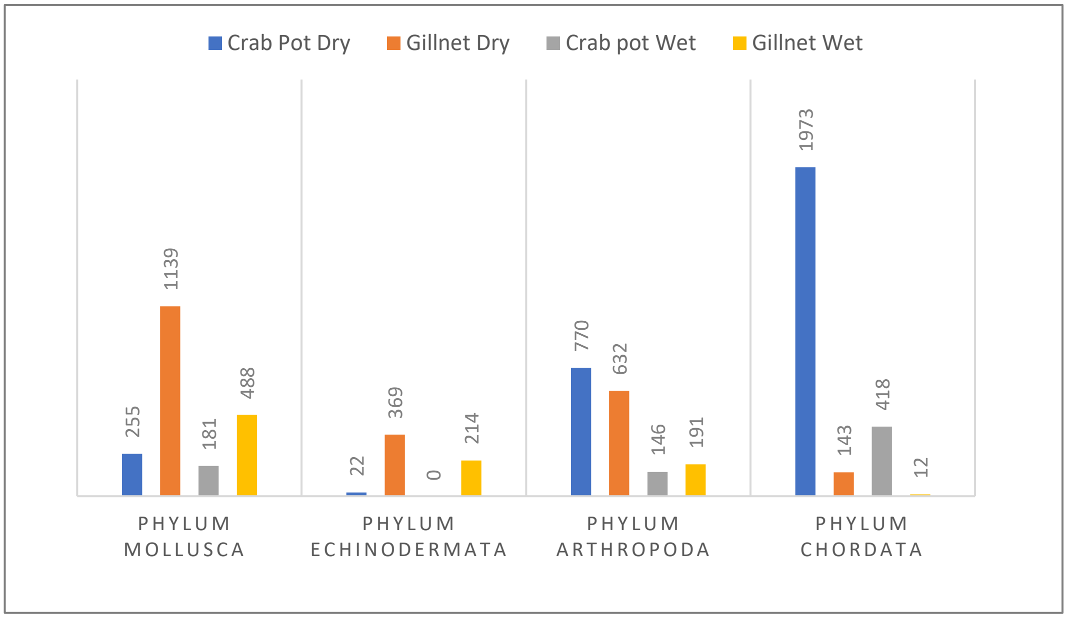

Figure 18. Total by-catch per phylum from gill net and crab pot during wet and dry season

A complete list of the by-catch identified in both seasons during the study is summarized in Table 2. The complete list included 120 identified species and classified according to phylum and family. Species were further categorized as to its economic value as either profitable (✓) or non- profitable(**x**).

Of the total species, 51 were considered of economic valuable by the fisherfolk and these were observed to have been collected from the pelagic zones while the rest were considered invaluable.

Table 2. Total by-catch and classified species for each phylum

Phylum		**Crab pots**		**Gill nets**		**Remarks**
Phylum Mollusca		**dry**	**wet**	**dry**	**wet**	
	Family Bursidae					
	Bursa sp.	9	36	0	0	**X**
	Family Cassidae					
	Semicassis bisulcata	10	2	0	0	**X**

	Family Cymatiidae					
	Cymatium pileare	12	0	0	0	**X**
	Cymatium sp	0	0	1	0	**X**
	Family Cypraeidae					
	Cypraea miliaris	3	0	5	0	**X**
	Cypraea onyx	2	0	0	0	**X**
	Family Fasciolariidae					
	Fusinus colus	1	0	0	0	**X**
	Hemifusus cariniferus	3	23	0	0	**X**
	Pleuroploca trapezium	22	19	0	0	**X**
	Family Harpidae					
	Harpa ventricosa	0	4	0	0	**X**
	Family Malleidae					
	Malleus malleus	0	7	184	18	**X**
	Family Muricidae					
	Chicoreus palmarosae	0	0	16	0	✓
	Chicoreus ramosus	48	0	632	440	✓
	Haustellum haustellum	26	9	0	0	✓
	Rapana rapiformis	2	28	0	0	✓
	Family Naticidae					
	Natica stellata	3	0	0	0	**X**
	Polinices cumingianus	1	0	0	0	X
	Family Octopodidae					
	Octopus abaculus	32	12	0	0	✓
	Family Olividae					
	Oliva oliva	2	0	0	0	X
	Family Ommastrephidae.					
	Dosidicus gigas	1	2	2	0	✓
	Family Sepiidae					
	Sepia aculeata	22	13	3	0	✓
	Family Spondylidae					
	Spondylus reevei	2	0	235	0	X
	Family Strombidae					
	Labiostrombus epidromis	3	0	1	0	X
	Lambis lambis	0	0	13	17	X
	Family Tonnidae					
	Tonna allium	14	1	0	0	X
	Sulcosa complex	0	17	0	0	**X**

	Family Trochidae					
	Clanculus puniceus	17	0	0	0	**X**
	Family Volutidae					
	Melo amphora	20	8	47	13	✓
Phylum Echinodermata						
	Family Echinidae					
	Echinus esculentus	0	0	2	0	✓
	Family Diadematidae					
	Diadema savignyi	0	0	1	0	X
	Family Echinocyamidae					
	Echinocyamus pusillus	0	0	1	0	**X**
	Family Holothuriidae					
	Holothuria scabra	0	0	1	0	**X**
	Family Ophiocomidae					
	Ophiophagus imbricatus	0	0	1	0	X
	Family Oreasteridae					
	Bothriaster sp	2	0	0	0	X
	Protoreaster nodosus	6	0	342	209	X
	Protoreaster linckii	14	0	16	5	X
	Pentaceraster alveolatus	0	0	4	0	X
	Family Temnopleuridae					
	Salmacis sphaeroides	0	0	1	0	X
Phylum Arthropoda						
	Family Dromiidae					
	Dromidia antillensis	0	0	2	0	**X**
	Lauridromia indica	8	0	294	56	**X**
	Family Dorippidae					
	Dorippe lanata	4	0	5	0	**X**
	Family Matutidae					
	Ashtoret lunaris	0	0	0	3	**X**
	Family Parapylochelidae					
	Pagurus bernhardus	440	0	62	8	**X**
	Family Portunidae					
	Charybdis japonica	44	2	43	34	✓
	Charybdis natator	84	67	16	13	✓
	Portunus gladiator	8	2	47	4	✓
	Thalamita spinimana	154	6	38	5	✓
	Scylla serrata	6	0	0	0	✓

	Charybdis feriatus	0	2	0	0	✓
	Portunus sanguinolentus	0	67	0	3	✓
	Family Xanthidae					
	Atergatis integerrimus	3	0	53	44	**X**
	Demania cultripes	*6*	0	0	0	**X**
	Hypocolpus haani	0	0	3	0	**X**
	Lophozozymus pictor	13	0	69	21	**X**
Phylum Chordata						
	Family Apogonidae					
	Apogon trimaculatus	2	0	0	0	X
	Apogon kallopterus	11	0	0	0	X
	Jaydia catalai	5	0	0	0	X
	Family Blennidae					
	Atrosalarias fuscus	0	0	1	0	X
	Family Carangidae					
	Selaroides leptolepis	11	0	0	1	✓
	Family Centropomidae					
	Psammoperca waigiensis	0	0	8	1	✓
	Family Chaetodontidae					
	Chaetodon octofasciatus	1	0	2	0	X
	Chelmon rostratus	1	0	2	0	X
	Family Dactylopteridae					
	Dactylopus dactylopus	4	0	0	0	X
	Family Dasyatidae					
	Neotrygon orientalis	0	0	4	0	✓
	Family Gerredae					
	Gerres oyena	8	1	0	3	✓
	Family Hemiramphidae					
	Hyporhamphus quoyi	0	1	0	0	X
	Family Holocentridae					
	Sargocentron rubrum	0	0	1	0	X
	Family Labridae					
	Halichoeres maculipinna	0	0	3	0	✓
	Halichoeres bivittatus	4	0	0	0	✓
	Family Lethrinidae					
	Lethrinus obsoletus	2	0	1	0	✓
	Lethrinus genivittatus	35	0	0	0	✓
	Lethrinus semicinctus	0	0	1	0	✓

Family Lutjanidae					
Lutjanus carponotatus	0	0	1	0	✓
Lutjanus ehrenbergii	0	0	3	0	✓
Lutjanus rufolineatus	0	0	3	0	✓
Lutjanus vitta	10	1	0	3	✓
Family Monacanthidae					
Monacanthus chinensis	1389	311	16	1	✓
Paramonacanthus curtorhynchos	1	3	0	0	✓
Family Mullidae					
Parupeneus heptacanthus	1	0	0	0	✓
Upeneus tragula	27	0	0	0	✓
Family Nemipteridae					
Cymbacephalus nematophthalmus	0	0	1	0	✓
Nemipterus furcosus	4	0	2	0	✓
Nemipterus nematopus	21	33	6	0	✓
Pentapodus bifasciatus	0	0	6	0	X
Pentapodus nagasakiensis	10	13	6	0	X
Scolopsis taenioptera	63	0	1	0	✓
Scolopsis vosmeri	0	0	1	0	✓
Scolopsis margaritifera	4	1	0	0	✓
Family Platycephalidae					
Platycephalus sp.	15	0	10	0	✓
Family Plotosidae					
Plotosus lineatus	1	19	0	0	X
Family Pomacentridae					
Chromis viridis	7	0	0	0	X
Lepidozygus tapeinosoma	229	10	0	0	✓
Pomacentrus xanthosternus	0	0	1	0	X
Stegastes diencaeus	0	0	9	0	X
Family Pseudochromidae					
Labracinus cyclophthalmus	0	0	3	0	X
Family Scaridae					
Scarus sp.	0	0	1	0	✓
Scarus ghobban	1	0	0	0	✓
Family Scombiridae					
Thunnus sp.	0	0	1	0	✓
Family Scorpaenidae					
Centrogenys vaigiensis	39	3	5	1	X

	Scorpaenopsis oxycephala	1	1	0	0	X
	Scorpaenopsis sp.	0	0	4	0	X
	Scorpaenopsis diabolus	0	1	0	0	X
	Family Scyliorhinidae					
	Aulohalaelurus mamoratus	2	0	0	0	✓
	Family Serranidae					
	Cephalopholis boenak	12	9	0	0	✓
	Diploprion bifasciatum	1	0	0	0	X
	Epinephelus sexfasciatus	1	1	1	0	✓
	Family Siganidae					
	Siganus canaliculatus	2	0	4	0	X
	Siganus virgatus	0	0	19	0	X
	Siganus spinus	0	0	2	0	X
	Family Soleidae					
	Soleidae marginata	1	0	0	0	✓
	Pardachirus pavoninus	0	0	5	0	✓
	Family Sphyraenidae					
	Sphyraena forsteri	1	0	0	0	✓
	Sphyraena obtusata	0	0	0	1	✓
	Family Synanceiidae					
	Inimicus didactylus	0	0	1	0	X
	Synanceia verrucosa	4	4	0	0	X
	Family Synondontidae					
	Sauridia sp.	0	0	2	0	X
	Family Tetraodontidae					
	Arothron manilensis	29	5	0	0	X
	Arothron hispidus	5	2	2	0	X
	Arothron stellatus	8	0	0	1	X
	Family Uranoscopidae					
	Uranoscopus bicinctus	*0*	*0*	*3*	*0*	*X*

3.2 System Accounts

A total of one hundred and twenty-one (121) species of Sixty-three (63) families were identified,18 families from Phylum Mollusca,7 families from Phylum Echinodermata,6 families from Phylum Arthropoda and 32 families from Phylum

Chordata were identified in this study. A synoptic list of all the species identified in the BSC fishery off the northeastern part of Bantayan Island, Cebu, Philippines. is given below.

3.2.1 Phylum Mollusca

The mollusks include several familiar animals, including snails, oysters, clams, octopuses and squids. Many of these species have a calcareous shell. Mollusca is the largest marine phylum of invertebrate animals that has a soft body without segmentation and is divided into head, muscular foot and visceral mass covered by a mantle and a shell. Bilaterally symmetry. Has triphloblastic germ layer with closed circulatory system, complete and developed digestive system. In all mollusks except the cephalopods, the circulatory system is open. Most of the species in mollusks have a radula used for feeding

Kingdom Animalia (Linnaeus, 1758)
Phylum Mollusca (Linnaeus, 1758)
Family Bursidae (Thiele, 1925)
Genus Phyllidiella (Bergh, 1869)
Bursa sp. (Röding, 1798)
Family Cassidae (Latreille, 1825)
Genus Semicassis (Lamarck, 1822)
Semicassis bisulcata (Schubert & Wagner, 1829)
Family Cymatiidae (Iredale, 1913 (1854)
Genus Cymatium (Linnaeus, 1758)
Cymatium pileare (Linnaeus, 1758)
Cymatium sp. (Linnaeus, 1758)
Family Cypraeidae (Rafinesque, 1815)
Genus Cypraea (Linnaeus, 1758)
Cypraea miliaris (Gmelin, 1791)
Cypraea onyx (Linnaeus, 1758)
Family Fasciolariidae (Gray, 1853)

Genus Fusinusm (Linnaeus, 1758)

Fusinus colus (Linnaeus, 1758)

Genus Pleuroploca (Fischer, 1884)

Pleuroploca trapezium (Linnaeus, 1758)

Family Harpidae (Röding, 1798)

Genus Harpa (Lamarck, 1801)

Harpa ventricosa (Lamarck, 1801)

Family Malleidae (Lamarck 1818)

Genus Malleus (Lamarck, 1799)

Malleus malleus (Linnaeus, 1758)

Family Melongenidae (Gill, 1871 (1854)

Genus Hemifisus (Swainson, 1840)

Hemifusus carinifera (Habe & Kosuge, 1965)

Family Muricidae (Rafinesque, 1815)

Genus Chicoreus (Montfort, 1810)

Chicoreus palmarosae (Lamarck, 1822)

Chicoreus ramosus (Linnaeus, 1758)

Genus Haustellum (Schumacher, 1817)

Haustellum haustellum (Linnaeus, 1758)

Genus Rapana (Schumacher, 1817)

Rapana rapiformis (Born, 1778)

Family Naticidae (Guilding, 1834)

Genus Natica (Scopoli, 1777

Natica stellate (Hedley, 1913)

Genus Polinices (Montfort, 1810)

Polinices cumingianus (Récluz, 1844)

Family Octopodidae (d'Orbigny, 1840)

Genus Octopus (Cuvier, 1797)

Octopus abaculus (Norman & Sweeney,

Family Olividae (Latreille, 1825)

Genus Oliva (Bruguière, 178

Oliva oliva (Linnaeus, 1758)

Family Ommastrephidae (Steenstrup, 1857)

Genus Dosidicus (Steenstrup, 1857)

Dosidicus gigas (d'Orbigny, 1834-1847 1835)

Family Sepiidae (Leach, 1817)

Genus: Sepia (Linnaeus, 1758)

Sepia aculeata (Orbigny, 1848)

Family Spondylidae (Gray, 1826)

Genus Spondylus (Linnaeus, 1758

Spondylus reevei (Fulton, 1915)

Family Strombidae (Rafinesque, 1815)

Genus Strombus (Linnaeus, 1758)

Labiostrombus epidromis (Linnaeus, 1758)

Genus Lambis (Röding, 1798)

Lambis lambis (Linnaeus, 1758)

Family Tonnidae (Suter, 1913 (1825)

Genus Tonna (Brünnich, 1771)

Tonna allium (Dillwyn, 1817)

Sulcosa complex (Born, 1778)

Family Trochidae (Rafinesque, 1815)

Genus Clanculus (Montfort, 1810)

Clanculus puniceus (Philippi, 1846)

Family Volutidae (Rafinesque, 1815)

Genus Melo (Sowerby I, 1826)

Melo amphora (Lightfoot, J, 1786)

Family Bursidae

This shell ranges from small to large size but are all fairly thick and heavy. The varices are less their number per whorl but are longitudinally connected from one whorl to the next to form prominent continuous ridges on both lateral sides of the shell on most species. The anterior end of the aperture terminates in tubular canal. The operculum is horny, with a nucleus.

Figure 19. ***Bursa*** **sp. (Roding, 1798)**

This shell is elongated with a highly conic spire. The varices are 2 in their number per whorl but are longitudinal connected from one whorl to the next to form prominent continuous ridges on both lateral sides of the shell the outer margin of large aperture is expanded outwards and banded with blackish brown and white within. Narrow canal with thin operculum. It lacks the *macgillivrayia* protoconch. The central tooth of the radula has a basal cusp on each side of it. The operculum is horny, with a nucleus mostly at the center.

IUCN Status: Not Evaluated

Family Cassidae

The shells are rather small to large, thin to solid, elongated oval to globose in shape with a conic spire and a large body whorl. The whorls are smooth or sculptured with spiral and axial cords and sometimes varices here and there. The aperture is narrow to semi lunate with the thickened outer margin. The anterior canal is short and narrow and curved backwards. The operculum is corny and semi lunate, the nucleus of which situates at the middle of inner margin.

Figure 20. ***Semicassis bisulcata*** **(Schubert, H.G. & A.J. Wagner, 1829)**

This species also known as helmet shell, has an excavated groove around the suture. Its globose and the body whorl is well inflated and sculptured with spiral flat cords with linear groove between the two except two definite depression separated by distinct ridges around the suture. The interior canal is short and narrow and curved backwards. The operculum is horny and semilunar. The color is light brownish blue with four series of square brown patches.

IUCN Status: Not Evaluated

Family Cypraeidae

Cowries. The shell is small to large, ventricose, usually thick, rounded inflated, generally smooth and polished covering with the shinning enamel callus, ovate to cylindric ovate. The spire is concealed by the callus presenting only the large body whorl in adult, but the shell is thin with a prominent spire with a wide aperture in young stages. There is no operculum.

Figure 21. ***Cyprea miliaris*** **(Gmelin, 1791)**

Common Name: Millet Cowry

Size: 2.5-3.5cm

This is also known as cowry and is inflated, ovate shell with coarse teeth. Anterior and posterior canals often pitted above. Dorsum coffee with cream spots. Margins, base and teeth creamy. The shells are usually oval in shape, and characterized by the well-developed, inflated body whorl and polished surface. Shell is covered by a glossy callus layer, under which the spire is almost concealed. The operculum is missing.

IUCN Status: Not Evaluated

Figure 22. ***Cypraea onyx*** **(Linnaeus, 1758)**

Common Name: Onyx Cowry

Size: 2.5-3.5cm

Inflated ovate shell with wide aperture and poorly developed teeth. Dorsum creamy with three pale brown bands tinged with lilac, occasionally uniformly brown. Margins, base and teeth dark chocolate to black. The operculum is missing.

IUCN Status: Not Evaluated

Family Fasciolariidae

Tulip shells or spindle shells. The shell is middle to large in size, spindle shaped, slender, turreted with usually cancellated with axial costae and spiral cords and covered with a velvety periostracum. The aperture is ovate, with or without columnar folds. The operculum is thick but horny, with central or terminal nucleus. The transverse row of radula is composed with three teeth; central tooth is small with three cusps and the transversely broad and narrow marginal on each side of it is multicuspidate.

Figure 23. ***Fusinus colus*** **(Linnaeus, 1758)**

Common Name: Distaff spindle

Size: Maximum 20cm

This shell under this family is fusiform in outline, thick and coated with epidermis. They do not have varices on the outer surface. The operculum is horny and considerably thick.

IUCN Status: Not Evaluated

Figure 24. ***Fusinus ocelliferus*** **(Linnaeus, 1758)**

Common Name: Long-siphoned whelk

A species of sea snail belonging to marine gastropods. Have elongated shell. Siphonal canal up to one third of the total length. Whorls decorated by delicate spiral ridges, sometimes the shoulder ridge is strengthened and can carry nodules. Color range from white to brown, sometimes flecked with darker spots. Foot bright and orange -red 150 mm in size. Commonly found in rocky reef and soft sediments

Figure 25. ***Hemifusus cariniferus*** **(Habe & Kosuge, 1965)**

Common Name: Ternate Snails.

This species has a much rounder shoulder and is more elongated in its general outline. Found in intertidal and on shore often inhabited by hermit crab.

Color varies from brown to reddish maroon.

IUCN List. Not evaluated

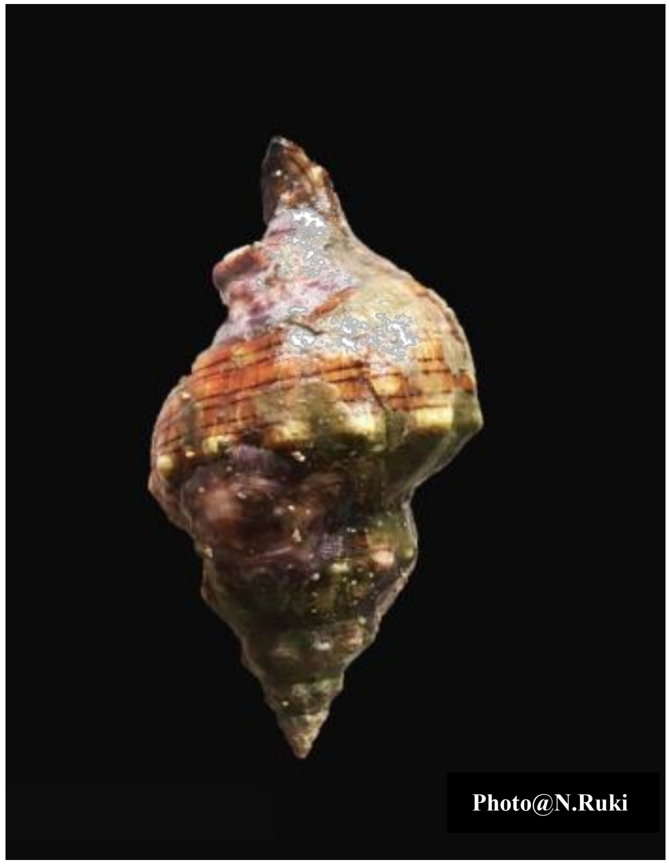

Figure 26. *Pleuroploca trapezium* (Linnaeus, 1758)

Common Name: Trapezium horse conch

Size: Maximum 28cm

This shell is stout and thick. The siphon is short. The slightly angled shoulder of whorls is tuberculated. But for spike threads, surrounding the basal part of body whorl, the surface is smooth. This is light flesh-brown in ground color and encircled by many fine brown lines. The margin of aperture is deep brown, bearing striations on the inside of the outer lip.

IUCN Status: Not Evaluated

Family Harpidae

The shells in this family are commonly known as Harpa shells or Harpa molluscs. They have a polished highly patterned appearance. All have strong axial ribs. A flaring lip on the final whorl dominates the flattened spire. The family has less than a dozen species. arms have long eyestalks and a long siphon. The sharp shell edge is used for amputation. Harps also have a wide spade-shaped expansion on the front portion of their foot, which they use for digging.

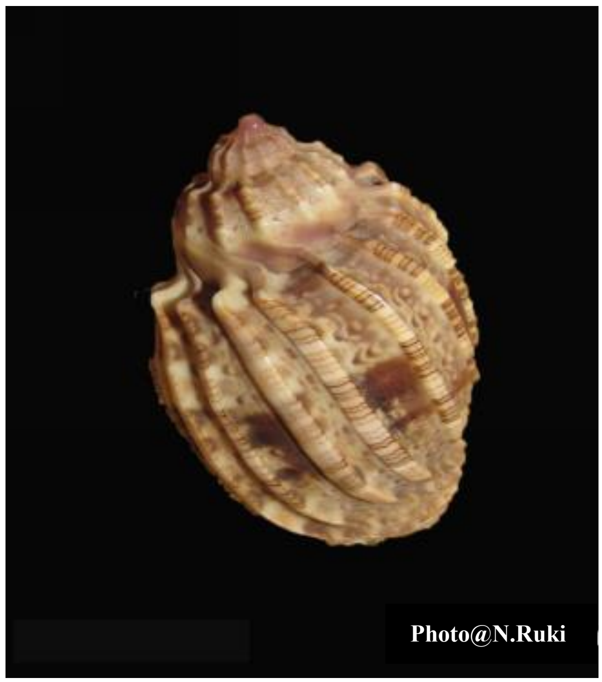

Figure 27. ***Harpa ventricosa*** **(Lamarck, 1801)**

Common Name: the "harp snails"

The shell has an ovate-oblong shape. It is inflated, generally pretty thin, enameled, and provided with parallel, longitudinal, inclined and acute ribs; the body whorl is much larger than all the others together. The spire is slightly elevated. The aperture is large, oval, dilated, strongly emarginated inferiorly, and without siphonal canal. The outer lip is bordered by the last rib. The columella is smooth, simple, nearly straight and pointed at the base.

IUCN Status: Not evaluated

Family Muricidae

Rock shell or murex. The shells are small to large in size, usually solid and thick, various in shape, ovate to elongate with an elevated spire. The whorls usually have varices or nodules or tuberculated spines. The body whorl is relatively large, and the aperture is rounded with the anterior canal or tube. This family is one of the largest groups of marine gastropods and has a rich variety of forms. The shell shape is mostly spindle or fist-shape and bear varices ornamented by spines or tubercles. They have a diverse range of size. They have a horny operculum and possess an anterior canal in the aperture, which sometimes develop into a tubular siphon.

Figure 28. *Chicoreus palmarosae* (Lamarck, 1822)

Common Name: rose-branch murex

The size of an adult shell varies between 65 mm and 130 mm

This species occurs in the Indian Ocean along the Chagos Atoll and the Mascarene Basin; in the Pacific Ocean along Sri Lanka and Southwest Japan.

IUCN status: Not evaluated

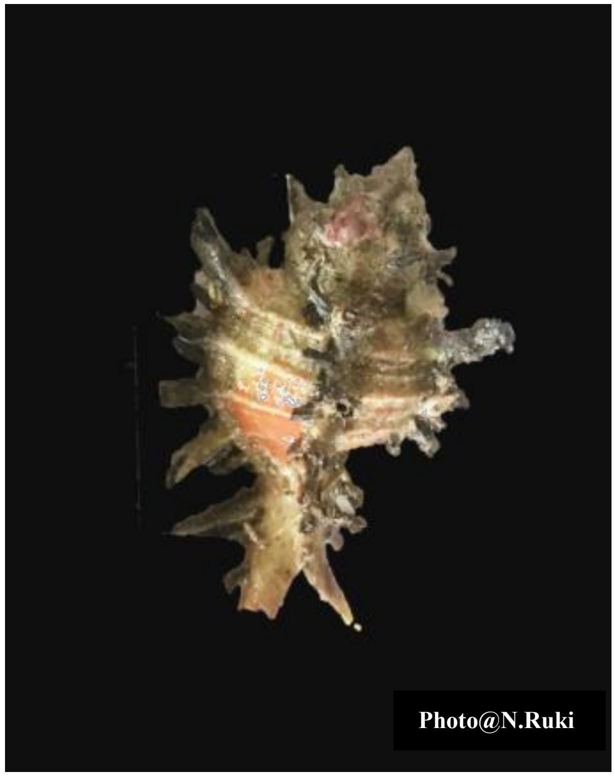

Figure 29. ***Chicoreus ramosus*** **(Linnaeus, 1758)**

Common Name: Ramose murex

This is the largest species of the genus Chicoreus. It can be differentiated from the other species by its larger shell, lower spire and larger body whorl. Large, solid, very rugged and heavy shell, of up to 327–330 mm in length. It has a relatively globose outline, possessing a short spire, a slightly inflated body whorl, and a moderately long siphonal canal. One of its most striking ornamentations are the conspicuous, leaf-like, recurved hollow digitations. It also presents three spinose axial varices per whorl, with two elongated nodes between them. The shell is colored white to light brown externally, with a white aperture, generally pink towards the inner edge, the outer lip and the columella

IUCN Status: Not Evaluated

Figure 30. ***Haustellum haustellum*** **(Linnaeus, 1758)**

Common Name: Snipes Bill Murex

Size: Maximum: 15cm

This is large and has a lower spire. Spiny processes on the varices are very short and a few in number. Three or four longitudinal fold occurs between the varices. The round aperture is margined by the slightly reflexed lips. Fine brown bands are spirally marked on the light bluish brown background of the outer surface. The inside margin of aperture is pink-colored, while the inner part remains white. The operculum is elliptic in shape and its nucleus is eccentrically biased towards the columellar side.

IUCN Status: Not Evaluated

Figure 31. ***Rapana rapiformis*** **(Born, 1778)**

Common Name: Murex shell, Rock Snails

This species is found offshore in depths ranging from 0m-30m.

Common size is 10cm however maximum length is found to be 30cm. Located in areas with sand with sparse rocks.

IUCN List: Not Evaluated

Family Malleidae

These shells resemble a T-shape and known as Hammer Oysters. Hammer oysters are hinged at the top of the "T", where a small byssus emerges at the back. The hinge is held by an oblique ligament rather than teeth, and the shell is partially nacreous. A single large adductor muscle lies at the cross of the T, and the exhalant current is discharged at the hinge.

Figure 32. *Malleus malleus* (Lamarck, 1799)

Common Name: Black Hammer Oyster

This species has shell up to 200mm in height, elongate and oblique in relation to the hinge-line and sometimes curved at the end, the cavity under the ligament is large and the wings are often long and extended. They are dissimilar in appearance but are usually elongate Dark purple-brown inside, glossy, cavity only faintly pearly. Common around Indo-Pacific, in shallow waters and on reefs

IUCN Status: Not Evaluated.

Family Naticidae

This is well known moon shells. The shell is usually globular or oval rather solid. The surface is smooth and polished and decorated with spots or stripes of various colors in some species. The spire is low and small. The aperture is rather wide, ovate to semi lunate in shape. The umbilicus is usually perforated and narrowed by the umbilical pad. The operculum is either calcareous or horny and paucispiral.

Figure 33. ***Natica stellate*** **(Hedley, 1913)**

Common Name: Starry moon snail

Size: Maximum 4.0cm

This is from a family of moon shells that are globular and oval shape, sometimes disk-like shape. This species has an extended body with a large diameter and more expanded body whorl with a dirty brown color. The glossy-smooth surface is beautifully colored in amber and marked by 4 faint white color bands. The whorls area few, and the shelly tube rapidly increases in diameter. The umbilicus and funicular are partly covered by the parietal callus. The aperture is semi-circular, fringed by a thin outer lip. The operculum if exist, is either calcareous or horny.

IUCN Status: Not Evaluated

Figure 34. ***Polinices cumingianus*** **(Recluz, 1844)**

Common Name: Moon Shells

A tropical benthic species that is snail-like globular forms with a half-moon shaped aperture. Typically has a thick rib-like callus obscures the umbilicus, and the aperture lip is fringed by a thin sharp edge. The mantle flaps from each side cover the shell, protecting its lustrous finish

Shell size ranging from 3cm-5.5c with maximum length of 5cm.

IUCN List: Not Evaluated

Class Cephalopods

Species from this class possess a prominent head with complex eyes and eight to ten, sometimes more, tentacles surrounding the mouth. The shell may be internal or external. This group includes squids or octopus.

Family Octopodidae

This are the bottom octopuses, some species with planktonic larval stage. Body neither gelatinous nor transparent. Arms muscular, much longer than body, suckers in 1 or 2 rows. Web usually not longer than half maximum armlength. Mantle opening not reduced. Radula not comb-like

Figure 35. ***Abdopus abaculus*** **(Norman & Sweeney, 1997)**

Common Name: Mosaic drop-arm octopus

IUCN List: Not Evaluated

Family Olividae

The shell is thin to thick, usually smooth and polished, cylindrical to inflated fusiform in shape, with a very large body whorl. The aperture is narrow and long to ovate with an anterior notch. The operculum is small and horny or absent.

Figure 36. *Oliva oliva* (Linnaeus, 1758)

Common Name: Common olive

A species of medium to large sea snails with smooth, shiny, elongated oval-shaped shells. The shells are oval and cylindrical in shape. The shell is colorful and has zigzag patterns of dark brown to black colors. They possess a well-developed spire the siphon of the living animal protrudes from the siphon notch. Because the mantle always covers the shell, it causes the shell to be glossy

IUCN List: Not Evaluated

Family Ommastrephidae.

Inverted-T funnel locking cartilage. Arms with two rows of suckers, tentacle club with four rows of suckers. The young have distinctive larval form: the rhynchoteuthioon is characterized by a fusion of the tentacles into a sort of proboscis. The proboscis is present at hatching proceeds during growth, but the proboscis stops growing once the division begins. The tentacles separate between six and10 mm mantle length; up to the beginning of the division, the distal tip of the proboscis has eight suckers. The locking cartilage is similar as in adults.

Figure 37. ***Dosidicus gigas (*****d'Orbigny, 1835)**

Common Name: Humbolt squid

This species is a large squid. The mantle is very large, robust and thick-walled. Fins rhomboidal, muscular, broad, width 56% of mantle length, length 45% of mantle length, single fin angle

Distal end of arms (adults especially) drawn out into very long, attenuate tips with 100 to 200 minute, closely packed suckers; dorsal protective membrane very weakly developed, but trabeculae are well-developed, exposed papillae, either arm IV hectocotylized (not both on same specimen) by absence of suckers and stalks at tip and expanded and perforated protective membrane.

IUCN List: Data deficient

Family Ranellidae

Figure 38. ***Cymatium pileare*** **(Linnaeus, 1758)**

Common Name: Common Hairy Triton

Size: Maximum 14.0cm

This shell is from the triton family found in depths of 0-50meters. Has a maximum length of 14cm. These large shells are elongate with a tall spire and a strongly inflated body whorl. They show a yellowish-brown surface with chestnut- brown spiral ribs. The columella and the aperture are dark brown with white teeth. The outer sculpture is relatively fine, with long inner ridges of the outer lip, extending deep into the aperture. They are characterized by prominent varices on the surface, the varices on a single whorl doesn't exceed 2 and those on the adjacent whorl rarely are connected longitudinally with each other.

IUCN Status: Not Evaluated

Figure 39. ***Cymatium parthenopeum*** **(Von Salis, 1793)**

Common Name: Leopard triton Shell

Size: 3-4cm

Shell thick, oval with curvy pointed tip. Covered with a hairy 'skin' that covers the fine rings on the shell. Shell opening wide with a scalloped inner edge. It has a short siphonal canal. Operculum small, beige. Body pale with dark spots so it resembles a leopard.

IUCN Status: Not Evaluated

Family Sepiidae

Cuttle fishes. The mantle is large and oval and contains the calcareous cuttle bone and marginated with the narrow fin on each side. The cuttle bone is almost as long and wide as the mantle, flat and thickened.

Figure 40. ***Sepia aculeata*** **(Orbigny, 1848)**

Common name: Needle Cuttle fish

This is a commonly known as cuttlefish. They have a large mantle and is oval and contains calcareous cuttle bone, marginated with narrow fin on each side. The calcareous cuttle bone is elongated oval in outline. The cuttle bone is almost as long and wide as the mantle, flat and thickened.

IUCN Status: Not evaluated

Family Spondylidae

Also known as the thorny oyster mollusc. Species of this family are more closely related to the scallop. Like scallops and file clams, they have a well-developed middle mantle that carries sensory tentacles with multiple eyes around the shell edges. Reflecting this rich endowment of sensory receptors, their cerebral and visceral ganglia have become much more concentrated, in the visceral region, and they show distinct optic lobes with nerve trunks to the mantle edges (Morton, 1960). Their key shell characteristic is a ball & socket type hinge, rather than the more common toothed hinge of bivalves.

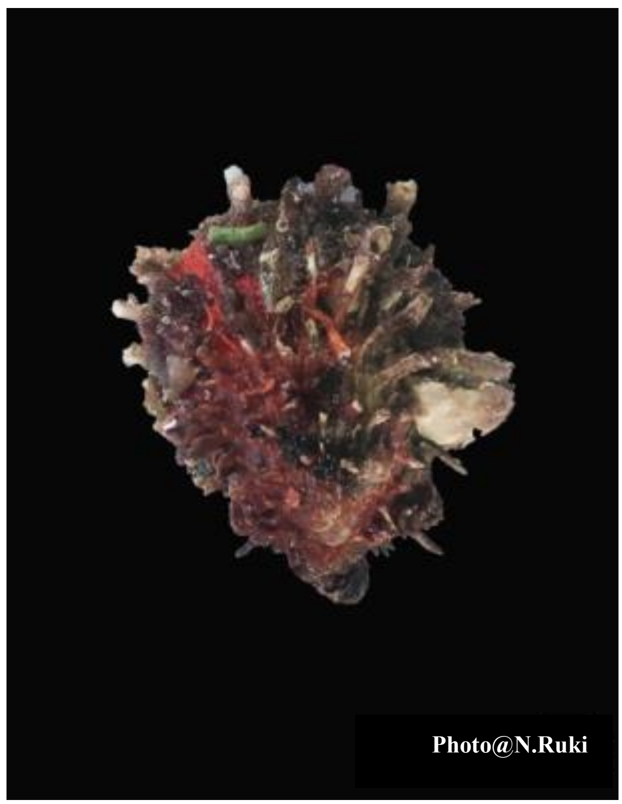

Figure 41. ***Spondylus reevei*** **(Fulton, 1915)**

The shell is oblong-ovate in shape with many irregular ridges which bear strong, slightly depressed blunt spines of various lengths which are numerous and regular.

The interstitial area is usually smooth, but some minor spines do occur in some species

Color varies from purple -red to brown

Distribution: Philippines, northwestern Australia

Family Strombidae

The shells are known as wing sconchs, characterized by the well-developed outer margin, usually with spiny appendages at the aperture. The shell is variable in size and shape, but its spire is elevated and the body whorl is large and maculated with brown mottlings. The aperture is armed with spines on the outer margin and smooth or striated within. The operculum is horny and oblong with a terminal nucleus.

Figure 42. *Labiostrombus epidromis* (Linnaeus, 1758)

Common Name: Swan Conch

Size: 50mm-90mm

This shell is spindle shape with a tall spire. Each whorl is sculptured by longitudinal ribs at the shoulder, which are crossed by spiral striae to form a reticulated sculpture. The outer lip in thin and broadly expanded, with a somewhat thickened margin and a stomboid notch only at its anterior end. The posterior canal is short and reflexed. The interior of aperture bears neither sculpture nor coloration. The surface is without luster, dirty white in ground color and spotted by faint brown patterns.

IUCN Status: Not Evaluated

Figure 43 . *Lambis lambis* (Linnaeus, 1758)

Common Name: Spider conch

This spider shell owes its name to its odd shape with seven spines around its aperture. The whorls are encircled by 3 rows of small knobs and many spiral threads. The spines on the outer lip, including the one enveloping the posterior canal, are tubular in structure, but are usually filled up, whereas only the most anterior spine remains tubular as the anterior canal. The interior of aperture does not show any sculptures. The outer lip extends laterally, without forming a thick margin,

IUCN Status: Not Evaluated

Family Tonnidae

The shell is small to very large, thin to solid, ovate to globose with rater low spire. The surface is ornamented with encircling broad but flat ribs with narrow grooves. The protoconch is smooth and polished, brownish yellow in color.

Figure 44. ***Tonna allium*** **(Dillwyn, 1817)**

Common Name: Costate tun

Size: Maximum Length 10cm

The spire is somewhat taller, and the spiral ribs are rounded, fine and separated by wide interspaces. The outer lip margin is remarkably thickened.ated.the aperture is large, the outer lip is either scalloped or denticulate and the columella has a prominent siphonal fasciole and occasionally a calloused parietal shield.

Moderate to large in size, fairly thin and light weight for their size, the spire is short and the last whorl is large and inflated This is white all over, or only colored in light brown on the ribs.

IUCN LIST: Not evaluated

Figure 45. ***Tonna sulcosa*** **(Born, 1778)**

Common Name: Banded Tun

It is a species of large sea snail, a marine gastropod mollusk in the family Tonnidae, the tun shells. The shell surface is white with 3-5 wide brown bands.Thin shell is ovate and ventricose. Its ground color is whitish, with four or five distinct bands of a reddish fawn-color, rarely continued to the outer lip. There is only one upon the two whorls next above the lowest. The spire is brown at top, and is formed of six convex whorls, encircled by projecting, pretty narrow, equal, approximate, flattened ribs, a little more distant towards the upper part. They are separated by shallow furrows. Two of the upper whorls are chequered as it were by intersections of striae. The suture is a little flattened, and slightly channeled. The ovate aperture is white, colored with red at the bottom. The outer lip is arcuated, and presents externally a projecting margin, which is crenulated outwardly by the jutting of the ribs, undulated externally, and dentated within. The columella is twisted. And upon some specimens are observed several crenulations towards the base of the inner lip which partially covers the umbilicus. The periostracum is thin and reddish

IUCN Status: Not Evaluated

Family Trochidae

These shells are generally conical and thick with an elevated spire and are nacreous within. Their opercula are circular, multispiral and horny. Their apertures have no slit, but often have a tooth on the columellar margin. The animal has a true left gill, two hearts and a rhipidoglossate radular, the lateral teeth of which are generally 5 in number.

Figure 46. ***Trochus niloticus*** **(Linnaeus, 1767)**

The length ranges from 50mm to 165mm and diameter between 100mm and 120mm. The shell has a cone shape and appears sub perforate. It has a brown or yellowish cuticle that is usually lost on the upper whorls. The color underneath the cuticle is white, striped longitudinally with crimson, violet or sometimes reddish brown.

The base of the shell is maculate or radiately striate with a lighter shade of the same. The apex is acute, usually eroded. The shell contains 8-10 whorls. The upper ones are tuberculate at the sutures, and spirally beaded, the following flat on their outer surfaces, smooth, separated by linear suture. The body whorl is expanded, dilated and compressed at the obtuse periphery, more or less convex below, indented at the axial. The aperture is transverse and very oblique. The operculum is circular, thin, corneous, orange-brown, and composed of about 10 whorls.

IUCN LIST: Not Evaluated

Family Volutidae

The volutes are a family of molluscs with attractive, large, glossy shells, and are one of the favorite groups with collectors. The smallest species is about 9 mm in size, but some of the baler shells reach over 500 mm. The family contains about 200 species and is distributed world wide

Figure 47. ***Melo broderiopii*** **(Lightfoot, 1786)**

This shell reaches a maximum length of 275mm. it has a bulbous or almost ovate outline with smooth outer surface that displays growth lines that are easily distinguished.

The shell color externally is usually orange and sometimes displays irregular brown bands.

The interior is glossy and light yellow.

The columella has three or four long and easily distinguishable columellar folds. It has a wide aperture, nearly as long as the shell itself, yet this species is known to have no operculum. The shell's spire is completely enclosed by the body whorl, which is inflated and quite large, and has a rounded shoulder with no spines. The apex is of smooth type.

3.2.2 Phylum Echinodermata

Species under this phylum have a radial symmetry that is covered by spikes, spines or bumps. The adults are recognizable by their (usually five-point) radial symmetry, and include such well-known animals as sea stars, sea urchins, sand dollars, and sea cucumbers, as well as the sea lilies or "stone lilies". Echinoderms are found at every ocean depth, from the intertidal zone to the abyssal zone. The phylum contains about 7000 living species, making it the second-largest grouping of deuterostomes (a superphylum), after the chordate.

Kingdom Animalia (Linnaeus, 1758

Phylum Echinodermata (Klein, 1734)

Family Diadematidae (Gray, 1855)

Genus Diadema (Gray, 1855)

Diadema savignyi (Audouin, 1809)

Family Echinidae

Genus Echinus

Echinus esculentus (Linneaus ,1758)

Family Echinocyamidae (Lambert & Thiéry, 1914)

Genus Echinocyamus (Phelsum, 1774)

Echinocyamus pusillus (O.F. Müller, 1776)

Family Holothuriidae (Ludwig, 1894)

Holothuria scabra (Jaeger, 1833)

Family Ophiolepidoidea (Ljungman, 1867)

Genus Ophioplocus (Lyman, 1861)

Ophioplocus imbricatus (Müller & Troschel, 1842)

Family Oreasteridae (Fisher,1911)

Genus Goniodiscaster(Clark,1909)

Goniodiscaster sp (Moebius, 1859)

Genus Protoreaster (Döderlein, 1916)

Protoreaster nodosus (Linnaeus, 1758)

*Protoreaster linckii (*Blainville, 1834)

Genus Pentaceraster (Döderlein, 1916)

Pentaceraster alveolatus (Perrier, 1875)

Family Temnopleuridae (Agassiz, 1872)

Genus Salmacis (Agassiz, 1841)

Salmacis sphaeroides (Linnaeus, 1758)

Class Echinoidea

Species under this class are referred to as echinoids. In echinoids, the skeleton is made up of a rigid structure called test. Test shapes range from nearly globular, as in some sea urchins, to highly flattened, as in sand dollars. Echinoids that are alive are covered with spines, which are movable and anchored in sockets in the test. These spines may be long and prominent, as in typical sea urchins. In sand dollars and heart urchins, however, the spines are very short and form an almost felt-like covering. Echinoids are classified by the symmetry of the test, the number and arrangement of plate rows making up the test, and the number and arrangement of respiratory pore rows called petals.

Family Echinidae

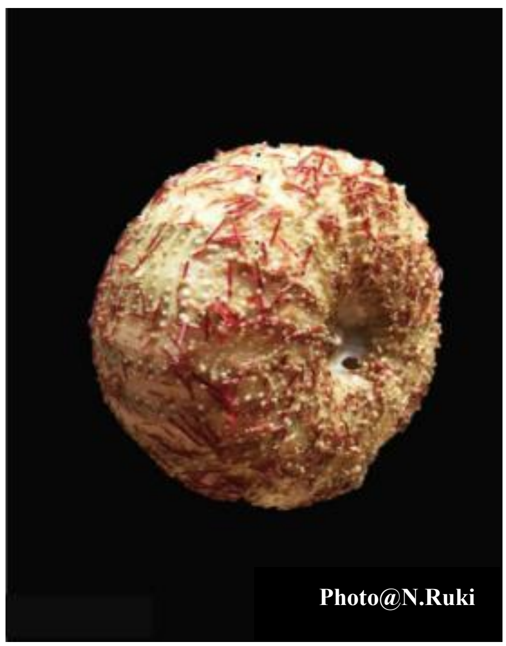

Figure 48. ***Echinus esculentus*** **(Linnaeus, 1758)**

Common Name: common sea urchin

Local name: Swaki (bisaya/cebuano)

Approximately spherical but slightly flattened at both poles. It is reddish or purplish with white tubercles and grows to about 10 cm in diameter

IUCN Status: Near Threatened

Family Diadematidae

The family has around 30 species. These are big regular sea urchins, with hollow and usually very long spines, some of them being venomous. Some are bright colored (especially red or blue), but others are dark, one of their most obvious characteristics is to have an anal papilla or anal cone on the top of the test which can be obvious in some species

Figure 49. ***Diadema sagignyi*** **(Michelin, 1845)**

Common Name: Aavigny's long-spine sea urchin

Size: Maximum Length 25cm

This species can be identified mainly by the iridescent blue patterns on its test and the blue or black rimmed anal pore.

This sea urchin displays pentamerism and has a round body with many long spines, tube feet and a dark anal sac. This sac can grow up to 90mm in diameter. Occurs in shallow waters, especially in disturbed areas where it occurs in large aggregations

IUCN Status: Not Evaluated

Family Echinocyamidae

Species in this family are commonly called sand dollars. Have simple radial internal buttresses along interambulacral margins. Periproct close to peristome and opening bounded by first and second paired post-basicranial interambulacral plates. Interambulacral zones terminating edaphically in one or two single small plates. Basicoronal circlet small and unspecialized, no food grooves.

Figure 50. ***Echinocyamus pusillus*** **(Muller, 1776)**

Common Name: Pea Urchin

This species reaches 1 cm in diameter and has a color which is normally brown or yellow when alive but the color changes to green when damaged, preserved or dead.

Unlike many other urchin species, the mouth and anus are on the underside and the ambulacral area and tube feet are confined to the upper surface in a petal shaped pattern. The flattened oval body is covered in short spines.

IUCN Status: Not Evaluated

Figure 51. ***Holothuria scabra*** **(Jaeger, 1833)**

Common Name: Sand Fish

Although species under the holothuroidea genus vary in color, most are black, brown or olive green ranging from three centimeters to one meter long. The largest sea cucumber had a diameter of 24cm. They generally resemble worm-like body structure but retain the pentaradial symmetry characteristic of Echinodermata.

The mouth and anus are located on opposite poles and five rows of tube feet run from the mouth to the anus along the cylindrical body. Ten to thirty tentacles surround the mouth.

IUCN Status: Endangered

Family Ophiocomidae

Species of this family are commonly called Brittle stars. Brittle-stars with small grains completely covering the scales and radial shields on the dorsal side of the disc. Arm spines are erect. The dorsal and ventral arm plates are well-developed. Mouth papillae are present. Each jaw carries a group of tooth papillae and below these a series of strong teeth. There is a second pair of tube-feet inside the mouth edge.

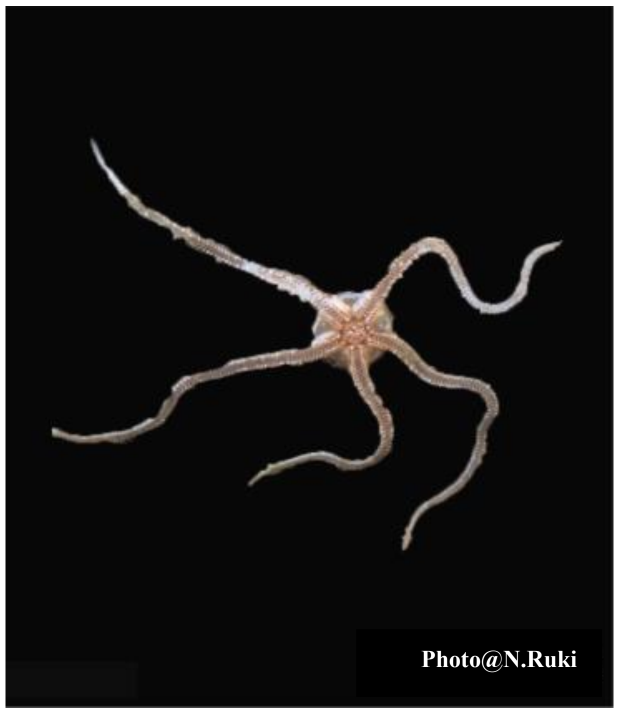

Figure 52. ***Ophioplocus imbricatus*** **(Muler & Troschel, 1842)**

Common Name: Brittle Star

Possess five long, thin arms and are often forked and spiny. The species have a distinctly set off from the small disk-shaped body. each arm may branch multiple times, and the outstretched arms reach nearly one meter across. Most live in shallow to deep water. The mouth, on the underside of the body, has five teeth; an anus is lacking; and the tube feet serve mainly as sense organs for detecting light and odor

IUCN Status: Not evaluated

Family Oreasteridae

This family contains many species of regular starfishes with usually 5 arms around a stiff, convex and often brightly colored body.

Figure 53. ***Goniodiscaster*** **sp. (Moebius, 1859)**

Common name: Biscuit Sea Star

Diameter with arms 5-15cm, sometimes small ones about 2-3cm are seen. Body flat but thick. Almost always five arms, rather short with rounded tips and smooth sides (no spines) so that the sea star looks like it was cut out with a cookie-cutter! The upper side has a neat texture of rounded bumps. Colors of the upper side generally shades of brown, with regular, neat patterns of spots and bars in darker brown, yellow, orange or white. Patterns may vary among individuals. The underside is pale to white, larger ones be darker in the center with bluish edges along the grooves where the orange tube feet emerge. The tube feet are tipped with suckers. It does not have large bivalved pedicellariae (pincer-like structures) on its underside or upper side

IUCN Status: Not Evaluated

Figure 54. ***Protoreaster nodosus*** **(Linnaeus, 1758)**

Common Name: Chocolate chip starfish

It is a massive sea star with a heavily calcified body wall. Specimens may reach up to 35 cm in diameter. Large nodules can be found growing on its topside, scattered irregularly on the central disc, but aligned in a series along the mid-line of each arm. Their tube feet are usually dark red or purple, while their body may come in various shades of red, orange or brown.

IUCN Status: Not evaluated

Figure 55. ***Protoreaster linckii*** **(Blainville, 1834)**

Common Name: Red-knobbed Starfish

The body of *Protoreaster linckii* is thick and has five short and triangular arms extending out, resembling the appearance of a star and therefore, the common name, African Red-Knob Sea Star. The dorsal body surface of African Red-Knob Sea Star is bumpy or knobby owing to the tubercles running up to the tips of its arms. The resulting mesh like structure with tubercles is marked in deep red, burgundy or deep orange color.

IUCN List: Not evaluated

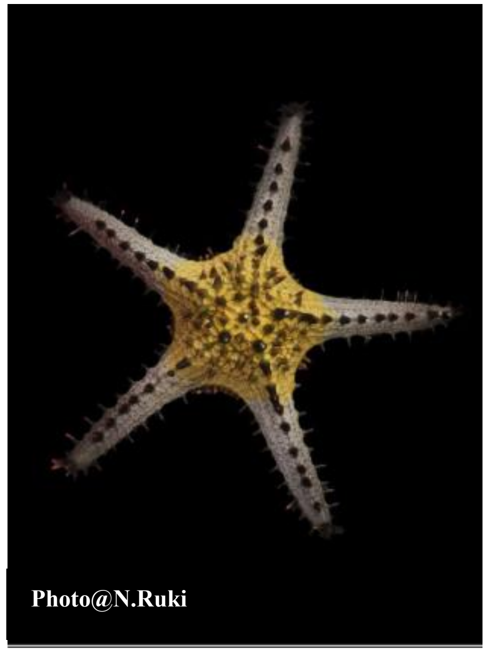

Figure 56. ***Pentaceraster alveolatus*** **(Perrier, 1875)**

Common Name: Cushion Sea Star

Occurs in sandy-rocky intertidal regions and on reef platform at depths of 1 to 60 m. In shallow waters with seagrasses and macroalgae. Embryos hatch into planktonic larvae and later metamorphose into pentamerous juveniles which develop into young sea stars with stubby arms

IUCN List: Not evaluated

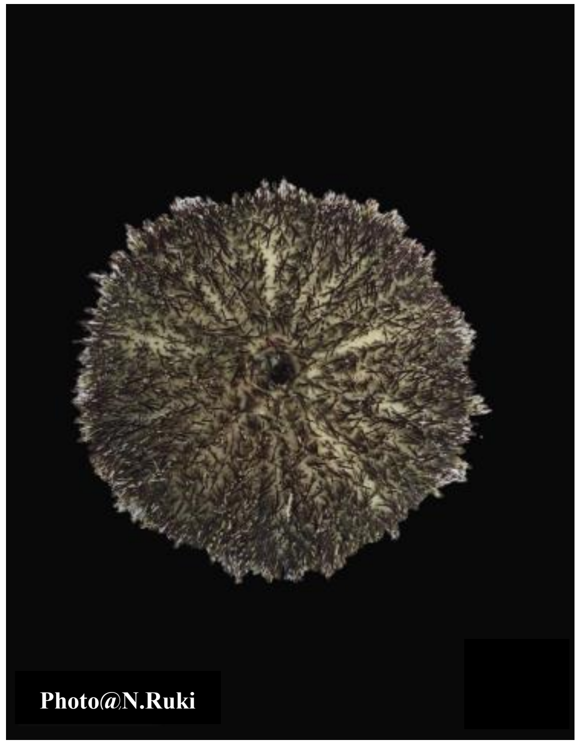

Figure 57. ***Salmacis sphaeroides*** **(Linnaeus, 1758)**

Common Name: Green-spined salmacis

Body diameter 5-8cm, white. Spines short (1-1.5cm) and sharp, about the same length. Spines on the underside have spade-like tips. Some have white spines with green or maroon bands. It has long tube feet and is often seen carrying all kinds of things from shells to seaweeds. It can quickly gather these things to cover itself. This behavior may help camouflage it or shield it from sunlight.

IUCN Status: Not Evaluated

3.2.3 Phylum Arthropoda

The phylum Arthropoda is by far the largest of the kingdom Animalia encompassing over 1 million classified species, with perhaps as many as 9 million suspected. Arthropods are bilaterally symmetrical and have a hard, outer skeleton (the exoskeleton) and a jointed body and limbs. The exoskeleton of arthropods is made of chitin and is discarded periodically and regrown as the organism grows. The body of an arthropod is segmented but unlike members of phylum Annelida, the body is segmented into distinct parts (generally the head, thorax, and the abdomen) rather than repeating segments.

Kingdom Animalia
Phylum Arthropoda (Lar, 1904)
Class Malacostraca (Latreille, 1802)
Subclass Eumalacostraca (Grobben, 1892)
Order Decapoda (Latreille, 1802)
Superfamily Dromioidea (De Haan, 1833)
Family Dromidae (De Haan, 1833)
Genus Dromidia (Stimpson, 1858)
Dromidia antillensis (Stimpson, 1858)
Lauridromia indica (Gray, 1831)
Family Matutidae (De Haan, 1835)
Genus Ashtoret (Galil & Clark, 1994)
Ashtoret lunaris (Forsskål, 1775)
Superfamily Dorippoidea (Macleay, 1838)
Family Dorripidae (Macleay, 1838)
Genus Medorippe (Manning & Holthuis, 1981)
Medorippe lanata (Linnaeus, 1767)
Superfamily Paguroidea
Family Paguridae (Latreille, 1802)
Genus Pagurus (Linnaeus,1758)
Pagurus bernhardus (Linnaeus, 1758)
Superfamily Portunoidea (Rafinesque, 1815)
Family Portunidae (Rafinesque, 1815)
Genus Charybdis
Charybdis feriatus (Linnaeus,1758)
Charybdis japonica (A. Milne-Edwards, 1861)
Charybdis natator (Herbst,1794)

Genus Portunus (Weber, 1795)

Portunus (Monomia) gladiator (Fabricius, 1798)

Portunus (Portunus) sanguinolentus (Herbst, 1783)

Genus Scylla (De Haan, 1833)

Scylla serrata. (Forsskål, 1775)

Genus Thalamita (Latreille, 1829)

Thalamita spinimana (Dana, 1852)

Superfamily Xanthoidea (MacLeay, 1838)

Family Xanthidae (MacLeay, 1838)

Genus Atergatis (De Haan, 1833)

Atergatis integerrimus (Lamarck, 1818)

Genus Demania (Laurie, 1906)

Demania cultripes (Alcock, 1898)

Genus Hypocolpus (Rathbun, 1897)

Hypocolpus haani (Rathbun, 1909)

Genus Lophozozymus (A.Milne-Edwards, 1863)

Lophozozymus pictor (Fabricius,1798)

Subclass Multicrustacea

Order Decapoda (Latreille, 1802)

Superfamily Portunoidea (Rafinesque, 1815)

Family Portunidae (Rafinesque, 1815)

Genus Charybdis (De Haan, 1833)

Charybdis feriatus (Linnaeus,1758)

Charybdis japonica (A. Milne-Edwards, 1861)

Charybdis natator (Herbst,1794)

Class Malacostraca

The class Malacostraca contains the largest number of crustacean's species. Most malacostracans live in the marine environments. They occupy all three dimensions in the water column, such as crawling on top of the sediment, burrowing in the substrate, or swimming with the ocean's currents. They are bilaterally symmetrical, have jointed appendages and possess segmented calcareous skeleton. Contains 22,651 species, of the 38,000 crustaceans.

Family Dromiidae

Named sponge crabs. Carapace commonly ovoid or subcircular, may be pentagonal, often subglobular, generally convex in both directions. Carrying behavior very common.

Figure 58. ***Dromidia antillensi*s (Stimpson, 1858)**

Common Name: Decorator crab

Key Features

The carapace is brownish-gray and covered with short hairs. The tips of the claws are colored bright red. The crab covers itself with a pieces of living sponges, tunicates or anemones.

Size: carapace up to 8 cm

IUCN Status: Not Evaluated

Figure 59. ***Lauridromia indica*** **(Gray, 1831)**

Common Name: Cannonball sponge crab

Carapace approximately as wide as long; antero-lateral borders armed with five variable teeth of usually similar size; postero-lateral tooth directed obliquely forward. Rostrum tridentate, lateral teeth longer than median one, this last one visible dorsally. Inner margin of dactyli of second and third pereiopods with 5-8 small spines; outer margins of propodi of third and fourth pereiopods with spines; outer margin of dactyli of fifth pereiopods with a spine.

IUCN Status: Not evaluated

Family Dorippidae

Antennules folded obliquely. Antennules and antennae large. External maxillipeds leaving all the anterior part of the buccal cavern uncovered. Two first abdominal segments not folded against the ventral face and visible in a dorsal view of the body. P4 and P5 differing from preceding legs, reduced in size, dorsal and with a terminal subcheliform apparatus. Carrying behavior well known.

Figure 60. ***Dorippe lanata*** **(Linnaeus, 1767)**

Common Name: Demon-faced porter crab

Key Features Carapace strongly sculptured. Surface covered by long, flexible hairs, worn off in old individuals of exorbital tooth and cervical groove, with few to many, 3-9, sharp denticles Front teeth flat, with narrowly rounded apices, separated by a deep but open V. Lower orbital margin with row of 4-7 spines but without additional row of denticles. Carpus of cheliped with distinct spinules and hairs on upper surface; palm of chela smooth, except for granules in extreme proximal part

IUCN Status: Not evaluated

Family Matutidae

Carapace circular. A strong spine at the junction of antero- and postero-lateral margins. Front narrow. Antennae rudimentary. Chelipeds subequal. Walk legs natatorial; P2-P4 with the dactyli more or less lanceolate; P5 with the last articles paddle-like. Male abdomen with five segments.

Figure 61. ***Ashtoret lunaris*** **(Forsskal, 1775)**

Common Name: yellow moon crab

Surface of carapace minutely granular and provided with six mid-dorsal tubercles, mid-postero-lateral tubercle of carapace present. Front with straight lobes laterally and a slightly emarginate rostrum medially; antero-lateral margins with five small tubercles followed by three large triangular tubercles;lateral spine 0.2 times carapace width. Cheliped with a five-lobed mid-palmar ridge, second and fourth lobes acuminate, second lobe largest; a finely milled ridge present on outer surface of dactylus in male, absent in female.

Coloration: Carapace covered with red dots.

IUCN Status: Not Evaluated

Figure 62. ***Pagurus bernhardus*** **(Linnaeus, 1758)**

Common Name: Common Hermit crab

The color is brown. The common hermit crab can reach a body length of 35mm. The claws are jagged but hairless. Like most other hermit crabs uses snail shells for protection. It is not unusual to find bristle worms inside the snail shell. They eat leftovers from the hermit crabs. In return they remove any parasites from the abdomen. The common hermit crab is also flexible when picking from the menu. And eats almost anything it can catch, including own relatives.

Family Portunidae

This is called swimming crabs. Carapace usually broader than long, and broadest between last pair of antero-lateral teeth, transversely hexagonal to transversely ovate. Regions of the carapace not well defined. Eyes conspicuous. Male abdomen with segments 3-5 fused to varying degrees. Male openings coxal. Female openings sternal (vulvae).

Figure 63. ***Charybdis feriatus*** **(Linnaeus, 1758)**

Common Name: yellow moon crab

Global carapace with transverse granular lines on protogastric and mesogastric regions, epibranchial line interrupted at the cervical groove and in its middle; front with 6 subequal triangular distally rounded teeth; antero-lateral borders with 6 teeth, first truncate and with a concavity at its lateral border, last one hardly more prominent than preceding teeth; postero-lateral junctions rounded. Antennal flagellum not excluded from orbit only in young specimens, in adults excluded. Cheliped meres with 3 spines on anterior border, posterior border smooth; carpus with a strong internal spine, outer border with 3 spinules; palm with 2-3 spines on upper border. Merus of swimming leg with a posterior subdistal spine; propodus without spines on posterior border in adult specimens

IUCN Status: Not Evaluated

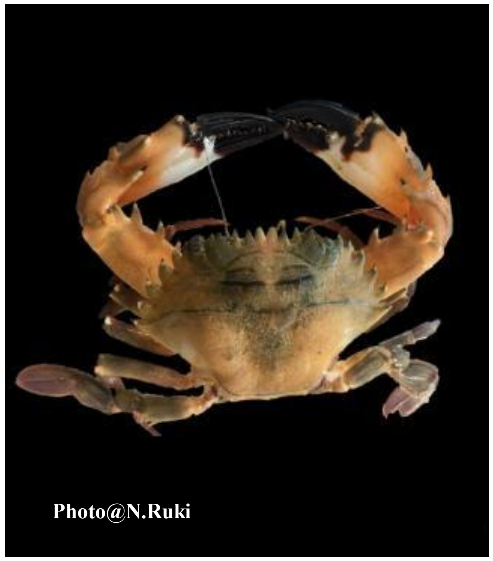

Figure 64. ***Charybdis japonica*** **(A. Milne Edwards, 1861)**

Common Name: Asian Paddle Crab

Key Features

Carapace color ranging from a deep molten green to very dark brown. Chelipeds densely hairy; merus with 3 strong spines on anterior border, posterior border smooth; carpus with a strong internal spine, outer border with 3 spinules; palm with 5 spines on upper border. Merus of swimming leg with a subdistal posterior spine, propodus smooth on posterior border

IUCN Status: Not Evaluated

Figure 65. ***Charybdis natator*** **(Herbst, 1794)**

Common Name: Ridged Swimming Crab

Key Features Carapace densely covered with very short pubescence which is absent on several distinct transverse granulated ridges in anterior half.

Color: orange red overall, ridges on carapace and legs dark and reddish brown.

IUCN Status: Not evaluated

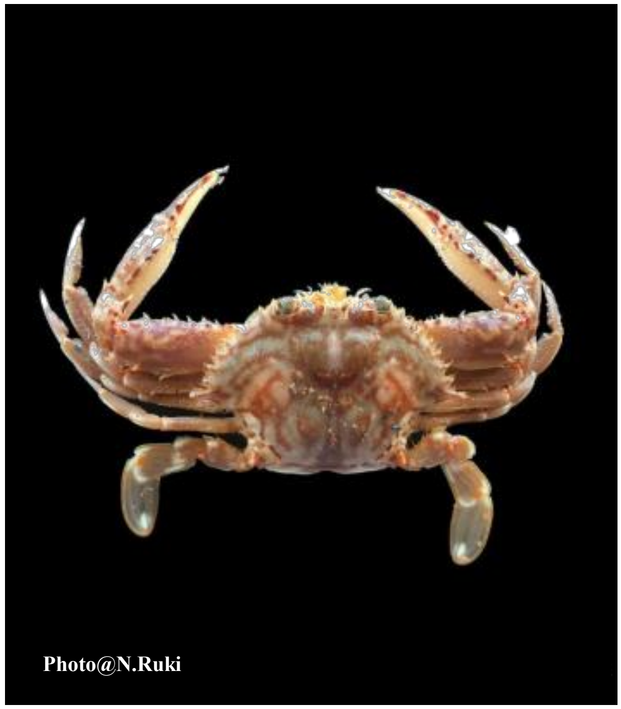

Figure 66. ***Portunus (Monomia)*** **gladiator (Fabricius, 1798)**

Common Name: Gladiator swimming crab

Key Features: Found on muddy or sandy bottoms, mostly gonochoric and is found in depths range 32m – 345m. Carapace moderately broad (breadth about 1.8 times length); surface with widely spaced granular areas being separated by regions with a dense pubescence; regions well recognizable; front with 4 lobes, medians acute, laterals right-angled and much broader; antero-lateral borders with 9 teeth, last one much the longest, directed outwards; postero-lateral junction rounded. Antero-external angle of merus of third maxillipeds markedly produced into a lobe. Chelipeds stout; merus with 2 spines at posterior border, anterior border with 4 spines; carpus with 2 spines of normal length; upper surface of palm with 1 distal spine, lower surface with squamiform markings. Posterior border of merus of swimming leg serrated and bearing a few spines; dactyl without a red spot. Penultimate segment of male abdomen not convex on outer border.

Color: Orange red

IUCN Status: Not evaluated

Figure 67. ***Portunus sanguinolentus*** **(Herbst, 1783)**

Common Name: Three spot swimming crab

Size: breadth 2.0-2.5 times length

Key Feature Carapace very broad, with 3 red spots in posterior half, persisting quite long in preserved specimens; surface finely granulated anteriorly, smooth posteriorly; with recognizable mesogastric, epibranchial, and metagastric ridges; front with 4 triangular teeth, outer pair broader and very slightly more prominent than inner ones; antero-lateral borders with 9 teeth, first clearly longer and much more pointed than following 7, last one very large and projecting straight out laterally; postero-lateral junction rounded. Cheliped merus with postero-distal border smooth, anterior border with 3-4 sharp spines; carpus with inner and outer spines; lower surface of palm smooth. Posterior border of swimming leg without spines or spinules.

IUCN Status: Not Evaluated

Figure 68. *Scylla serrata* (Forsskål, 1775)

Carapace smooth and glabrous with exception of granular lines on the gastric regions and an epibranchial line starting from the tip of the last antero-lateral tooth and reaching to the branchial regions; front with four subequal and equally spaced teeth with acute to rounded tips; antero-lateral borders with nine very acute and subequal teeth, last one the smallest. Basal antennal joint short and broad, with a lobule at its antero-external angle. Chelipeds heterocoelous; merus with three spines on anterior border and two spines on posterior; carpus with a strong spine on inner corner and another on outer face; propodus with two acute spines at distal end of upper face and a strong knob on inner face at base of fixed finger. Swimming leg without spines on posterior border of either of the joints

IUCN Status: Not Evaluated

Figure 69. ***Thalanita spinimana (*****Dana, 1852)**

Common Name: Spiny claw swimming crab

Size: Maximum 12cm

Key Features Surface of carapace smooth, sometimes with low pubescence; ridges distinct; front with 6 lobes, median 4 lobes truncate, lateral 2 lobes rounded. Color: usually bright red overall, but sometimes green, or with a mixture of red and green. Easily distinguished by its spinose palm and the bright red coloration.

IUCN Status: Not Evaluated

Family Xanthidae

Fifty-two species are known as adult. Carapace is hexagonal, transversely oval to transversely hexagonal, sometimes circular. Areolation generally well defined. Antero-lateral margins generally with two to six teeth, spines, or lobes. Thoracic is sternum narrow or not very widened. Male abdomen divided into five segments. The Female openings sternal.

Figure 70. ***Atergatis integerrimus*** **(Lamarck, 1818)**

English Name: Bashful Crab
Size: 8-10 cm
The carapace has, at the epibranchial angle, a tooth or a crest emphasized on the inside by a furrow. The epibranchial angle of the carapace never has a tooth, the crest of the antero-lateral margin is continuous with the postero-lateral margin. The carapace, chelipeds and legs have smooth or punctate surfaces. The carapace is less broad, about 1.6 times broader than long. The surface of the carapace is marked by large, compact punctations that are almost juxtaposed here and there but obliterated on the posterior part. The color is nut-brown with yellow punctuations
IUCN Status: Not Evaluated

Figure 71. ***Demania cultripes*** **(Alcock, 1898)**

Key Features :Inner angle of cheliped carpus with sharp tooth or spine, outer surfaces of cheliped palm slightly rugose; dorsal margin of ambulatory merus crested, smooth, without any trace of spines or teeth; 2M and 3M regions of carapace incompletely separated from each other, median regions of carapace relatively smooth, not distinctly rugose; antero-lateral margin cut into three blunt but distinct triangular teeth, carapace broad, frontal margin with very narrow cleft, slightly sinuous.

IUCN Status: Not Evaluated

Figure 72. ***Hypocolpus haani*** **(Rathbun, 1909)**

Key Features Dorsal surface of the carapace with prominent lobules and separated by large deep furrows. Coat of rather short setae present in the furrows. Regions well delimited and thickly covered with numerous granules. The posterior edge strongly concave; the bottom of the cavity smooth. Front narrow and bilobate, each lobe markedly convex. Chelipeds stout and heavy; outer surface of palm very uneven, covered with granules arranged in rows. Ambulatory legs slender but not very long, covered with granules.

Ventral surface and abdomen covered with coarse granules, compacted and irregularly projecting.

IUCN Status: Not Evaluated

Figure 73. ***Lophozozymus picto*** **(Fabricius, 1798)**

English Name: Mosaic reef crab

Key Features The superior margin of the cheliped palm has a carina. The anterior lobe of the antero-lateral margins of the carapace is separated by a hiatus from the exorbital angle. The anterior lobe of the carapace antero-lateral margins is not advanced beyond the exorbital angle. The chelipeds have the external face of the palm smooth or punctate, but without longitudinal crests. The dorsal surface of the carapace is feebly lobate, smooth and glabrous; the sternum is smooth. The antero-lateral margins of the carapace have a rounded anterior lobe; the following lobe is subtriangular; the two following teeth are triangular, more projecting and carinate, the last is the smallest. The cheliped palm has a strong crest on the superior margin and the external face is smooth and unarmed. The ambulatory legs are broad with an elevated crest on the superior margin; the merus of P5 is 1.45 times longer than broad

IUCN Status: Not Evaluate

3.2.4 Phylum Chordata

The phylum chordate contains all animals that possess, at some point during their lives, a hollow nerve chord or notochord, a flexible rob between the nerve cord and the digestive track. The phylum chordate is an extremely diverse phylum, and the one most recognizable to us. The phylum contains about 43,700 species, most of them concentrated in the Subphylum Vertebrata, making it the third-largest phylum in animal kingdom.

Kingdom Animalia

Phylum Chordata (Haeckel, 1874)

Class Actinopterygii (Klein, 1885)

Family Pristiapogon (Klunzinger, 1870)

Genus Apogonidae (Günter, 1859)

Pristiapogon kallopterus (Bleeker, 1856)

Genus Pristicon (T.H Fraser, 1972)

Pristicon trimaculatus (Curvier, 1828)

Genus Jaydia (J.L.B. Smith, 1961)

Jaydia catalai (Fourmanoir, 1973)

Family Blennidae (Rafinesque, 1810)

Genus Astrosalarias (Whitley, 1933)

Atrosalarias fuscus (Rüppell, 1838)

Family Carangidae (Rafinesque, 1810)

Genus Selaroides (Bleeker, 1851)

Selaroides leptolepsis (Curvier, 1833)

Family Chaetodontidae (Rafinesque, 1810)

Genus Chaetodon (Linnaeus 1758)

Chaetodon octofasciatus (Bloch 1787)

Genus Chelmon (Linnaeus 1758)

Chelmon rostratus (Linnaeus 1758)

Family Callionymidae (Bonaparte, 1831)

Genus Dactylopus (Gill, 1859)

Dactylopus dactylopus (Valenciennes, 1837)

Family Gerreidae (Bleeker, 1859)

Genus Gerres (Quoy & Gaimard, 1824)

Gerres oyena (Forsskål, 1775)

Family Labridae (Curvier, 1816)

Genus Halichoeres (Ruppell, 1835)

Halichoeres maculipinna (Müller & Troschel, 1848)

Halichores bivittatus (Bloch,1791)

Family Lenthrinidae (Curvier, 1829)

Genus Lethrinus (Bonaparte, 1831)

Lethrinus obsoletus (Forssakal 1775)

Lethrinus genivittatus (Valenciennes, 1830)

Lethrinus semicinctus (Valenciennes, 1830)

Family Lutjanidae (Gill 1861)

Genus Lutjanus (Bloch, 1790)

Lutjanus carponotatus (Richardson, 1842)

Lutjanus ehrenbergii (Peters, 1869)

Lutjanus rufolineatus (Valenciennes, 1830)

Lutjanus vitta (Quoy & Gaimard, 1824)

Monocanthus chinensis (Osbeck, 1765)

Paramonocanthus curtorhynchos (Linnaeus, 1758)

Family Mullidae (Rifinesque,1815)

Genus Parupeneus (Bleeker,1863)

Parupeneus heptacanthus (Lacepède, 1802)

Genus Upeneus (Cuvier, 1829)

Upeneus *tragula* (Richardson, 1846)

Family Nemipteridae (Regan, 1913)

Genus Notophthalmus (Rafinesque, 1821)

Notophthalmus cymbacephalus (Fowler, 1938)

Genus Nemipterus (Regan, 1913)

Nemipterus furcosus (Valenciennes, 1830)

Genus Pentapodus (Quoy & Gaimard, 1824)

Pentapodus bifasciatus (Bleeker, 1848)

Pentapodus nagasakiensis (Tanaka, 1915)

Family Pomacentridae (Bonaparte, 1832)

Genus Chromis (G.Curvier, 1814)

Chromis viridis (Curvier, 1830)

Genus Lepidozygus (Günther, 1862)

Lepidozygus tapeinosoma (Bleeker, 1856)

Genus Pomacentrus (Lacepede, 1802)

Pomacentrus xanthosternus (Allen, 19

Genus Stegastes (Jenyns, 1840)

Stegastes diencaeus (D.S. Jordan & Rutter, 1897)

Genus Scolopsis

Scolopsis margaritifera (Cuvier, 1830)

Scolopsis taenioptera (Cuvier, 1830)

Scolopsis vosmeri (Bloch, 1792)

Genus Platycephalidae (Gill, 1872)

Platycephalus sp. (Bloch, 1795)

Genus Plotosus (Lacepede, 1803)

Plotosus lineatus (Thunberg, 1787)

Family Pseudochromidae (Muller & Troschel, 1849)

Genus Labracinus (Schlegel, 1858)

Labracinus cyclophthalmus (J.P Muller & Troschel, 1849)

Family Scaridae (Rafinesque, 1810)

Genus Scarus Forsskal, 1775)

Scarus ghobban (Forsskal, 1775)

Family Scombridae (Rafinesque, 1810)

Genus Thunnus (South, 1845)

Thunnus sp. (South, 1845)

Family Scorpaenidae (Risso, 1826)

Genus Centrogenys (Richardson, 1842)

Centrogenys vaigiensis (Quoy & Gaimard, 1824)

Genus Scorpaenopsis (Heckel, 1840)

Scorpaenopsis diabolus (Curvier, 1829)

Scorpaenopsis oxycephala (Bleeker, 1849)

Family Serranidae (Swainson, 1839)

Genus Cephalopholis (Bloch & Schneider, 1801)

Cephalopholis boenak (Bloch, 1790)

Genus Diploprion *(Curvier, 1829)*

Diploprion bifasciatum (Curvier, 1828)

Genus Epinephelus (Bloch, 1793)

Epinephelus sexfasciatus (Valenciennes, 1828)

Family Siganidae (Richardson, 1837)

Genus Siganus (Forsskål, 1775)

Siganus canaliculatus (Park, 1797)

Siganus virgatus (Valenciennes, 1835)

Siganus spinus (Linnaeus, 1758)

Family Soleidae (Bonaparte, 1832)

Genus Pardachirus (Gunther, 1862)

Pardachirus pavoninus (Lacepède, 1802)

Genus Synapture (Cantor, 1849)

Synaptura marginata (Boulenger, 1900)

Family Tetraodontidae (Bonaparte, 1832)

Genus Arothron (Müller, 1841)

Arothron manilensis(Marion de Proce, 1822)

Arothron hispidus (Linneaus, 1758)

Arothron stellatus (Bloch & Schneider, 1801)

Family Uranoscopidae (Jordan & Evermann, 1898)

Uranoscopus bicinctus (Temminck & Schlegel, 1843)

Class Chondricthyes (Huxley, 1880)

Subclass Elasmobranchii (Bonaparte, 1838)

Order Rajiformes (Berg, 1940)

Family Dasyatidae (Jordan, 1888)

Genus Neotrygon (Castelnau, 1873)

Neotrygon orientalis (Last.white & Seret 2016**)**

Family Hermiraphidae (Gill, 1859)

Genus Hyporhamphus (Gill, 1859)

Hyporhamphus quoyi (Valenciennes, 1847)

Family Holocentridae (Richardson, 1846)

Genus Sargocentron (Fowler, 1904)

*Sargocentron rubrum (*Forsskål, 1775)

Family Scyliorhinidae (Gill 1862)

Genus Atelomycterus (Garman 1913)

Atelomycterus marmoratus (Bennett, 1830)

Family Apogonidae

Species under this family has oblong bodies that is moderately elevated but always rather compressed, scales small to large, cycloid on head, cycloid or ctenoid on body. One lateral line which may become obsolete along some of keels length. Caudal fin emarginated, truncate or rounded. Head large. Mouth large, lower jaw protruding. Bands of small villiform teeth in jaws. This family consist of around 300 species.

Figure 74. *Apogon kalloperus* (Bleeker, 1856)

Common Name: Iridescent Cardinalfish

Local Name: Ibis, Parangan, Moong

Size: Maximum 12.0cm

a) Total of 8 dorsal spines and 9 dorsal soft rays. 9 anal spines and 8 anal soft rays

b) Color is tan to light red brown, a brown mid-lateral tripe from tip of snout, through eye to upper caudal base (stripe may fade on peduncle). Black spot at base of caudal fin. Further characterized by relatively broad mid-lateral dark stripe; yellow anterior margin on dorsal fin.

IUCN LIST: Not Evaluated

Figure 75. ***Apogon trimaculatus*** **(Curvier, 1828)**

Common Name: Three-spot cardinalfish

Local Name: Buslit

Size: Maximum 15.0cm

a) A total of 7 Dorsal spines. 9 Dorsal soft rays. Anal spines: 2; anal soft rays: 8.

b) Juveniles have intense dark markings on a light background). Adults dusky.

c) Distribution: Western Pacific: Ryukyu Islands to Western Australia and the southern Great Barrier Reef, east to Samoa and the Marshall Islands.

d) Biology: Inhabits inshore coral reefs. Nocturnal species Solitary, also found in reef crevices and ledges in 1-35 m. Marine; reef-associated; depth range 1-35 m

IUCN List: Not Evaluated

Figure 76. ***Jaydia catalai*** **(Fourmanoir, 1973)**

Size: Maximum 5.4cm

Key Features

Western Central Pacific: New Caledonia.

Marine; reef-associated; depth range 0 - 15 m

IUCN Status: Not evaluated

Family Blennidae

Species in this family have elongated body and are subcylindrical. They have no scales with small mouth. The colors on their body fade rapidly after death. There are around 345 species in this family.

Figure 77. ***Atrosalarias fuscus*** **(Ruppell, 1838)**

Common Name: Dusky blenny

Size: Maximum 14.5 cm

Key Features

9-11 Dorsal spines, 18-20 Dorsal soft rays, 2 Anal spines, 18-20 soft rays, 33-35 vertebrae

A dark brown to blackish blenny

Depth range 2-12m

Distribution: Indian Ocean, Maldives, Vanuatu

Color: range from brown to black and may have lighter markings on the face and head

IUCN STATUS: Least Concerned

Family Carangidae

This family is composed of jacks, cavallas, pompanos, queen fishes, runners, scads and trevallies. Their body is greatly or moderately compressed varying from deep rhomboid to slender and elongate. Mouth slightly protactile. Teeth in jaws and is usually small. Color: darker above (green or blue to blackish) and paler below (silvery to white or yellow-golden), some species almost entirely silvery when alive, others with dark or Colored bars or stripes on head, body, or fins, and some can change patterns; young of many species barred or spotted.

Figure 78. ***Selaroides leptolesis*** **(Cuvier & Valenciennes)**

Common Name: Yellow strip trevally

Local Name: Lambiao

Size: 15cm, maximum; 20-25cm

Key Features Color: Distinct golden stripe on side of body and dark round blotch at upper corner of gill cover. Back blue and green, lower sides silvery, fins yellowish. Golden color disappears quickly after defrosting. Scales: 22 to 34 weak scutes. Breast covered by small but conspicuous scales. Compressed body. Large eyes, upper jaw reaching to below front border of eye. Adipose eye lids leaving anterior part of eye free. Fins: D18DII 1+25 to 26; A 2 detached spines followed by 1 + 20 to 22; P 18 to 19. Dorsal and anal fin bases nearly equal.

Gill rakers: 9 to 11 on upper and 26 to 31 on lower limb.

IUCN Status: Least Concerned

Family Chaetodontidae

This family commonly called of coral fishes and butterflyfishes are oval or rhomboidal, extremely compressed. Scales finely ctenoid with small head and mouth which is terminal and protractile. This family contains 129 species.

Figure 79. ***Chaedon octofasciatus*** **(Block, 1787)**

Common Name: Eight-band butterflyfish

Size: Maximum length:12cm

Common Features

Color: A whitish to yellow butterflyfish with narrow black bars on the head and body, and a black spot on the caudal-fin base

Dorsal spines (total): 10 - 12; Dorsal soft rays (total): 17-19; Anal spines: 3-4; Anal soft rays: 14 - 17.

White to yellowish below with 7 black stripes overhead and sides, one centrally on snout and another as a strong black margin on end of dorsal and anal fins. Third line extends onto ventral fin. Snout length 3.0-4.1 in HL. Body depth 1.4-1.6 in SL

IUCN STATUS: Least Concerned

Figure 80. ***Chelmon rostratus*** **(Linnaeus, 1758)**

Common Name: Beaked Coral fish

Local Name: Boray-boray, Alibangbang

Size: Common 12-17cm

Key Features

Body: Compressed. Depth 1.5 to 1.7 times in standard length

Head: No spine at preopercular angle. Mouth at end of strongly tubular rostrum composed of intermaxilla and mandible. Head 2.2 to 2.3 times in standard length

Fins: D 9 + 26 to 31; A 3 + 17 to 21. Posterior dorsal spines longest. Spinous dorsal base much shorter than soft dorsal base. Pectoral fins short and acutely rounded.

Scales: 43 to 46 on lateral line, 43 to 50 along midline. 9 to 10 + 21 to 24 transverse scales. Scales in regular rows, smaller towards periphery.

Gill rakers: 3 on upper and 7 on lower limb.

IUCN STATUS: Least Concerned

Family Dactylopteridae

Head large and blunt, with the bones forming a helmet; with keels and a long preopercle spine. Scales scute-like. Lateral line absent. Notable for their greatly enlarged pectoral fins. Has about 7 species.

Figure 81. ***Dactylopus dactylopus*** **(Valenciennes, 1837)**

Common Name: Fingered dragonet

Size: Maximum Length: 30cm

Dorsal spines (total): 4; Dorsal soft rays (total): 8; Anal spines: 0; Anal soft rays: 7.
Has finger-like separate first rays of the ventral fins,
The fin with a distinct horizontal pattern of lines in adults, and males have long filaments on the first dorsal fin (versus short or absent). Body moderately depressed. Preopercular spine with processes on both inner and outer sides. Pelvic spine and 1st pelvic ray fused into an elongate rod, separated from the other pelvic rays. Attains 10 cm SL
IUCN STATUS: Not evaluated

Family Dasyatidae

The side of head is continuous with the anterior margin of pectoral fin. Respire by drawing water through a small hole behind the eye and expelling it through gill slits on the underside of the disc. The dorsal fin is totally absent or indistinct, when present. Has 102 species

Figure 82. ***Neotrygon orientalis*** **(Last, White, & Seret, 2016)**

Common Name: Mask Rays

Size: Maximum Length: 30cm

pectoral fin discs are largely smooth, with a single row of thorns along the dorsal midline. The mouth is small with two central papillae and a row of enlarged, long-cusped teeth halfway along the upper jaw on both sides. The nasal curtain, formed by the merging of the nasal flaps, is long and narrow. The tail is very short with well-developed dorsal and ventral fin folds and a filamentous tip, and is banded black and white past the stinging spine

Color: They are so named because of a distinctive color pattern around their eyes, resembling a mask and the blue spots.

IUCN Status: Not Evaluated

Family Gerreidae

This family consist of mojarras and silver biddies. Has small to medium-sized fishes, body more or less compressed, oblong, sometimes rather deep. Mouth strongly protractile, pointing downward when fully protracted. Small teeth in both jaws, none in roof of mouth. Head and body usually silvery, often with faint markings such as spots or lines. Fins mostly colorless but in some cases yellow or black margins. Has 53 species.

Figure 83. ***Gerres oyena*** **(Forsskal, 1775)**

Common Name: Blacktipped silver-biddy, slenderspine pursemouth

Local Name: Samok

Size: Commin 15cm, Maximum 25

Back greenish with dots forming faint longitudinal lines along scale rows. Belly silvery. Spinous part of dorsal fin with blackish margin and brown spots on base which are concealed by a scaly sheath. Soft, dorsal, anal and ventral fins yellowish.

Teeth: Small and sharp in several rows in jaw**:** 35 to 38 on lateral line. Head and body completely covered with scales which are very easily shed.

Gill rakers: 5-6 on upper and 7 on lower limb.

The body is slightly compressed. The depth is 2.5 to 3.0 times in standard length.

Head: Mouth strongly protractile. Head 3.0 to 3.5 times in standard length

Fins: D 9 to 10 + 10 to 11; A 3 + 7 to 8. The last dorsal spine is shorter than first soft ray. The spines in fins are slender. The pectoral fin is scarcely reaching or not quite reaching anal fin origin.

ICUN STATUS: Least Concerned

Family Hemiramphidae

This family consists of species known as half-beaks and garfishes and is moderately elongated; compressed or cylindrical in section. Scales are large, thin and deciduous. No isolated finlet. Teeth in lower jaw restricted to basal part which fits against the triangular tooth maxilla. Has 62 species.

Figure 84. ***Hyporhamphus quoyi*** **(Valenciennes, 1847)**

Common Name: Quoy's garfish

Local Name: Bamban, Buloy, Obud-obud, Buging, Kansusuwit

Size: Common 15-20cm; Maximum: 30cm

Body: Cylindrical.

Head: Upper jaw almost twice as broad as long. Lower jaw shorter than head length. Preorbital ridge present. Head with beak 2,7 to3,3 times in standard length.

Color: Greenish-blue above with back mark on each scale; silvery below, with silvery or blue-green mid-lateral band having black upper edge. Front dorsal rays and caudal margin blackish.

Teeth: Villiform in jaws, none on tongue or in roof of the mouth

Gill rakers: 9 to 14 on upper and 18 to 25 on lower limb

IUCN List: Not Evaluated

Family Holocentridae

This family consist of squirrelfishes and soldierfishes. The species are elongate-oval. Moderately compressed. The scales are large, strongly stenoid with spiny margins. Bands of viliform teeth in jaws and roof of mouth. Lateral line present. Has 86 species in total.

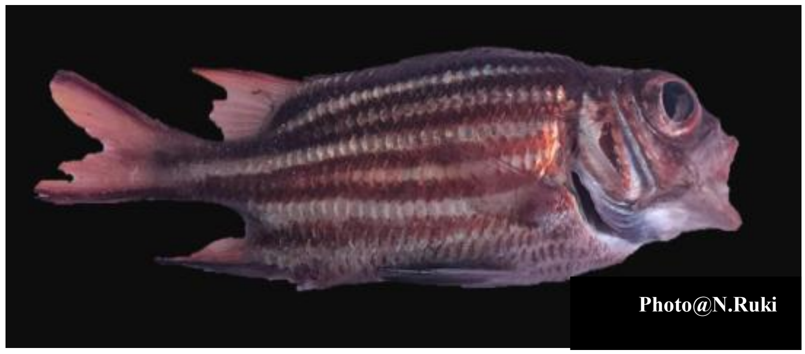

Figure 85. ***Sargocentron rubrum*** **(Forsskal, 1775)**

Common Name: Fingered dragonet,
Size: Maximum Length: 30cm
Dorsal spines (total): 11; Dorsal soft rays (total): 12-14; Anal spines:4; Anal soft rays: 8- 10.
Color: Body with subequal stripes of brownish red and silvery white; spinous dorsal dark red with a large, quadrangular, whitish blotch in middle of each membrane (except the first) forming a median band; dorsal membrane tips white, except posteriorly. Five oblique scale rows on cheek; body depth 2.5-2.8 in SL; head length (HL) 2.65-2.85 in SL; short and blunt snout, its length 4.25-4.7 in HL; interorbital width 4.5 in HL; mouth terminal to slightly inferior, maxilla usually extending nearly to or a short distance beyond a vertical through center of eye, upper jaw length 2.5-2.75 in HL; premaxillary groove often ending above anterior edge of orbit; anterior end of nasal bone with a blunt spine; surface or medial edge of nasal bone spineless; nasal fossa usually without spinules on its edge; upper edge of 1st suborbital bone with a slightly retrose lateral spine a short distance posterior to a vertical at front edge of eye, followed by a ridge of recumbent spinules; preopercular spine usually about 2/3 orbit diameter, 3.2-5.3 in HL; 3rd-5th dorsal spines subequal, longest in adults 1.9-2.3 in HL; 3rd anal spine 1.35-1.6 in HL
IUCN Status: Least Concerned

Family Labridae

This family consist of tusk fishes, rainbowfishes and wrasses with elongate, oval to oblong, moderately compressed. Cycloid scales, sometimes forming low basal sheath at dorsal and anal fins and sometimes enlarged at tail base. Mouth small to moderate and usually somewhat protractile. Room of mouth toothless. Has 530 species in total.

Figure 86. ***Halichoeres maculipinna*** **(Muller & Troschel, 1848)**

Common Name: Clown wrasse

Size: Maximum Length 18cm

Key Features

Dorsal spines (total): 9; Dorsal soft rays (total): 11; Anal spines: 3; Anal soft rays: 11. **Color**: Wide black stripe through eye to base of tail, bordered above by prominent gold line. Large black spot on mid-side. Large black spot on mid-side above origin of anal fin. Three transverse red bands on top of head; large adult males become primarily rose and green, lose the dark lateral stripe, gain a prominent black spot on mid-side, and have a larger black spot in the spinous portion of the dorsal fin.

IUCN Status: Least Concerned

Figure 87. Halichoeres bicolor (Block & Schneider, 1801)

Common Name: Pearly-spotted wrasse

Size: Maximum Length 12 cm

Key Features

Mid-lateral stripe is thin when young but widens to about eye-diameter width when adult, with series of pearly blue spots running along center.

Snout pointed, 2 dark brown stripes on the side, white-ringed black spot on the tail, black spot in the middle of the front half of the dorsal fin. The stripe along the lateral line is thin in younger fishes and widens to about the same diameter as the eye as the fish reaches adulthood, with pearly blue spots along the center. The black spots on the dorsal fins usually become faded in large males. There is a reddish-brown band on the head, edged with blue on the side of the snout from the mouth to the front edge of the eye, and an upward curved band on the cheek below the eye, and a vertically elongated dark brown spot just behind the eye.

IUCN Status: Least Concerned

Family Latidae

The Latidae, known as the lates perches, are a family of perch-like fishes found in Africa, Asia and the Indian and western Pacific Oceans. The family includes about 13 species. Many species in this family are important food fishes, and some have been introduced outside their native ranges to provide fishing stocks.

Figure 88. ***Psammoperca waigiensis*** **(Cuvier, 1828)**

Common Name: Sand-bass, glass-eye perch

Local Name: Lapu-lapu

Size: common 20-40cm

Body: compressed. Depth 2.6 to 3.3 times in standard length

Head: Lower border of preoperculum not serrated, unlike upper boarder. Operculum with one backward-pointing, flat, strong spine. Another strong at angle of operculum. Upper jaw reaches behind edge of pupil. Head 2.8 to 3.1 times in standard length

Teeth: Band of viliform in both jaws.

Color. Head and body brownish gray with dark lines along scale rows. Eye, fins and border of gill cover yellowish to reddish-brown. Back dusky, belly sometimes in silver-gray.

Fins: D1 7, DII 1 + 12, A 3 + 8, P 16 to 17. A flat spine above origin of pectoral fin

Scales: 45 to 50 on lateral line. A line of small scales extending from end of lateral line through caudal fin. 6 to 8 transverse. Axillary scale at ventral fin base. Gill rakers: 7 on upper and 11 to 13 on lower limb.

IUCN STATUS: Not Evaluated

Family Lethrinidae

This family consist of emperors and scavengers with moderate-sized perch-like fishes with a large head. Mouth moderate, terminal, slightly protractile. Lips thick and fleshy. Nostrils paired, anterior ones with fleshy rim. Palatine toothless. Besides bright Color pattern and markings, all species have dark patterns which may disappear in a moment, according to emotional state. Has 41 species in total

Figure 89. ***Lethrinus obsoletus*** **(Forsskal, 1775)**

Common Name: Orange-striped emperor

Local Name: Sapingan, Bagangan, Kirawan, Bitilya

Size: Common 30-40cm, Maximum 60cm

Body: Compressed. Depth 2.4 to 2.8 times in standard length

Head: Upper jaw reaches anterior nostril. Head 2.6 to 2.9 times in standard length.

Fins: D 10 + 9; A 3 + 8; P 13. Pectoral fin is slightly less than head. Base of rayed part of anal fin less than largest ray

Color: greenish-brown above, paler below. With three orange-red longitudinal stripes below lateral line, the lowermost darkest, passing through pectoral base. Head darker brown. Fins reddish. Dorsal fin mottled with olive. Caudal fin with traces of vertical olive striped

Scales: 45 to 48 on lateral line. No scales on cheeks. 5 ½ + 14 to 16 transverse scales

Teeth: Lateral teeth in jaws molariform, anterior ones moderate-sized canines.

Gill rakers: 5 on upper and 5 on lower limb

IUCN STATUS: Least Concerned

Figure 90. ***Lethrinus genivittatus*** **(Valenciennes, 1830)**

Common Name: Longspine emperor

Size: Maximum Length 25cm

Dorsal spines (total): 10; Dorsal soft rays (total): 9; Anal spines: 3; Anal soft rays: 8. The only Lethrinus with its 2nd dorsal spine the longest.The inner surface of the pectoral fin may be scaleless, partially covered with scales or densely covered with scales.

Color: tan or brown on the upper sides, white on the lower sides, with three tan or brown stripes. The sides often have scattered irregular black oblique bars and a square black blotch above the pectoral fin and bordering below the lateral line. The head is brown or tan sometimes with several broad, somewhat indistinct vertical and oblique bands (these bands are sometimes composed of fine reticulations). The fins are pale, speckled with small white blotches.

IUCN Status: Not Evaluated

Figure 91. ***Lethrinus semicinctus*** **(Valenciennes, 1830)**

Common Name: Long spine emperor

Local Name: Black blotch emperor

Size: Maximum Length 35cm

Dorsal spines (total): 10; Dorsal soft rays (total): 9; Anal spines: 3; Anal softrays:8

Color: Body is brown or tan, with scattered irregular small black blotches, a large oblong black blotch below soft-rayed portion of dorsal fin and bordering below the lateral line. The fins are pale or pinkish.

IUCN Status: Not Evaluated

Family Lutjanidae

This family consists of snappers, jobfishes and fusiliers. A typical perch-like fishes having oblong in shape, moderately compressed, and covered with moderate of small ctenoid scales. It has two nostrils on each side and the mouth terminal and fairly large, extending when open. Teeth usually present in roof of mouth. The color is highly variable, mainly from yellow through red to blue, often with blotches, lines or other patterns. Has 112 species in total.

Figure 92. *Lutjanus carponotatus* (Richardson, 1842)

Common Name: Spanish flag snapper

Size: Maximum Length 40cm

Dorsal spines (total): 10; Dorsal soft rays (total): 14-16; Anal spines:3; Anal soft rays: 9. Snout somewhat pointed, dorsal profile of head steeply sloped. Preorbital bone about equal to eye diameter, or slightly wider. Preopercular notch and knob poorly developed. Scale rows on back rising obliquely above lateral line.

Color: The fins are yellowish; the pectoral fins have a distinct black spot at base of uppermost rays and axil. A bluish-grey to whitish tropical snapper with 8-9 yellow to golden-brown stripes along the sides, yellow fins, and a black spot at the axil of the pectoral fin. Juveniles have a broad white stripe from the snout to the tail base and alternating dark brown to black stripes above and below. The scale rows along the back rise diagonally above the lateral line.

IUCN Status: Not Evaluated

Figure 93. ***Lutjanus ehrenbergii*** **(Peters, 1869)**

Common Name: Blackspot snapper

Size: Maximum 30cm

Body: preorbital space narrow (9–10 times head length), 4 or 5 narrow yellow stripes on sides, large black spot on lateral line.

Teeth: vomerine tooth patch with posterior extension

Dorsal spines (total): 10; Dorsal soft rays (total):13-14; Anal spines:3; Anal soft rays: 7- 9.

IUCN STATUS: Least Concerned

Figure 94. ***Lutjanus rufolineatus* (Valenciennes, 1830)**

Common Name: Rufous sea-perch

Size: common 20 to 30cm

Key Features

Body: compressed. Depth 2.4 to 2.7 times in standard length.

Head: Posterior margin of pre-operculum with a very deep notch. Interopecular knob well developed. Pre-operculum strongly donate behind and below. Head 2.5 to 2.7 times in standard length

Fins: D 10 to 11 + 13 to 15; A 3 + 7 to 8; P 16 to 18.

Color: Body rosy or brownish-red with golden lines along scale rows, those above lateral line oblique, those below horizontal. Often a large dark blotch below end of spinous dorsal base, largely above lateral line. Fins yellowish.

Scales: 50 to 57 on lateral line. 7 + 20 transverse scales.

Teeth: Bands of conical teeth in jaws with outer series enlarged. Four canines in upper jaw. Vomerine teeth forming triangular patch.

Gill Rakers: 7 on upper and 13 to 15 on lower limb

IUCN STATUS: Least Concerned

Figure 95. ***Lutjanus vitta*** **(Quoy & Gaimard, 1824)**

Common Name: Brownstripe red snapper

Local Name: Kamang, Makatod, Dayang-dayang

Size: common 15-25cm, maximum 40cm

Body: small, compressed. Depth 2.4 to 3.o times in standard length.

Head: Broad space between eye and jaw, equal to eye diameter in adults, eye diameter 1.2 times in snout length. Two flat spines on operculum. Head 2.5 to 2.8 times in standard length.

Fins: D 10 + 13; A 3 + 7 to 8; P 16

Color: Body with blackish or brown longitudinal band as wide as pupil, extending from eye to caudal base. Upper part of body pale/yellow with numerous oblique dark brown lines following scale rows. Lower body silvery with horizontal light brown lines. Fins yellowish.

Scales: 47 to 54 on lateral line. 6 to 7 + 16 to 18 transverse scales. Scale rows above lateral line appear to rise obliquely to dorsal profile, those below lateral line horizontal. Scales on head beginning over middle of eye. Scales on soft parts of dorsal and anal fins

IUCN STATUS: Least Concerned

Figure 96. ***Monacanthus chinensis*** **(Osbeck, 1765)**

Common Name: Chinese filefish, centerboard leatherjacket

Local names: Saguksuk, sulay bagyo

Size: Common 15 to 20 cm

Key Features

Body: compressed. Two parallel rows of three enlarged retrose barbs along each side of caudal peduncle with age. Depth 1.8 to 2.0 times in standard depth.

Head: Head 3.0 to 3.3 times in standard length.

Scales: Each scale a simple, keeled spine, small and arranged rather irregularly.

Color: Body and head grayish olive with dark and light green dots all over and on bases of fins. Caudal fin with vertical dark cross bands. Second dorsal and anal fins translucent.

Fins: D1 1; DII 28 to 31; P 12. First dorsal spine with two rows of downward directed spines posteriorly. Spine can be locked in position. Ventral fin reduced to a rather large flaps with one barbed movable spine. It is quadrangular and extends well beyond tip of movable ventral fin spine. Upper ray of caudal fin produced into short filament.

IUCN STATUS: Least Concerned

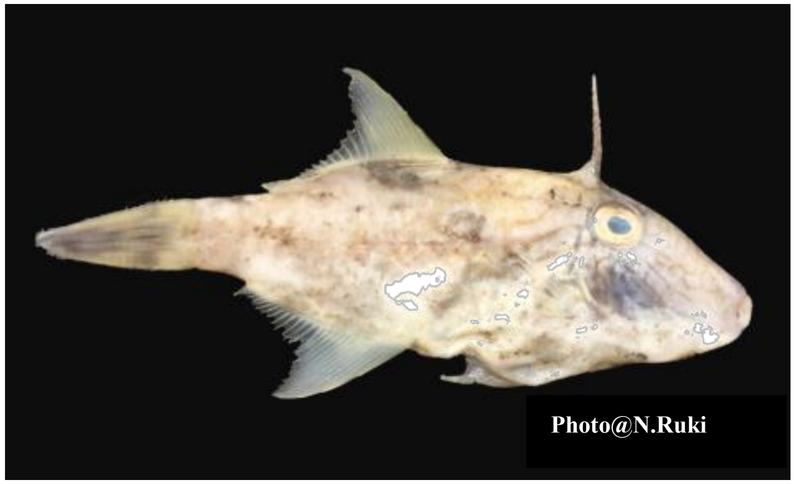

Figure 97. ***Paramonacanthus choirocephalus*** **(Bleeker, 1851)**

Common Name: White-blotched Filefish

Size: Maximum 11.0cm

Body: 2 Dorsal spines, 27-31 Dorsal soft rays, No anal rays, 28-32 Anal soft rays, 19 Vertebrae. First dorsal spine originating over posterior half of eye, or slightly behind eye. With dark brown to dusky blotches, sometimes tending to form two curved, oblique stripes on body, first from rear of soft dorsal fin to pectoral fin, second from caudal fin base to ventral: three dark brown blotches nearly always flap present.

Head: Dorsal profile of snout straight to convex in male, small hump sometimes over or slightly in advance of nostrils; straight to concave in female and juvenile, without hump.

Biology: inhabits sheltered coastal reefs, usually forming small aggregations. Also found in mud and sand bottoms of trawling grounds.

IUCN Status: Least Concerned

Family Mullidae

This family also commonly called goatfishes. Small to moderate-sized fishes with elongated body. Two barbels on chin. Head and body mostly red, orange, golden or brownish but young specimens often pale sandy or blue. The coloration is characteristics for each species. Has 88 species.

Figure 98. ***Parupeneus heptacanthus*** **(Lacepede, 1802)**

Common Name: Spotted Golden Goatfish

Local Name: Timbongan, Bayabao, Saging-saging, Amarilis

Size: Common 20cm, Maximum 30cm

Body: Compressed. Depth 3.4 times in standard length.

Head: Chin with two moderately long barbels, a little shorter than head. Small spine on upper of opercular margin. Head 3.2 5o 3.4 times in standard length

Teeth: In both jaws a single row of blunt, conical teeth; none in roof of mouth.

Scales: 25 to 30 on lateral line. 2 ½ to 6 ½ transverse scales. 3 vertical rows of scales along the space between dorsal fins, 9 vertical rows along upper part of caudal peduncle.

Color: Live fish very Colorful, with blue reflections on back, golden on sides and pearly white belly. Several blue parallel bands on head. After death, head and fins become uniform pink.

Gill rakers: 5 to 6 on upper and 18 to 22 on lower limb.

IUCN STATUS: Least Concerned

Figure 99. ***Upeneus tragula*** **(Richardson, 1846)**

Common Name: Darkband goatfish, bar-tailed goatfish

Local Name: Timbongan, Bayabao, Babayao, Saging-saging

Size: Common 15-20cm, maximum 28cm

Key Features

Body: Comopressed. Depth 3.8 to 4.6 times in standard length

Head: Chin with two short, thin barbels. No spine on operculum. Maxilla reaches below eye. Head 2.6 to 3.8 times in standard length.

Teeth: Present in both jaws and in roof of mouth as narrow bands of villiform teeth.

Fins: D1 7 to 8; DII 1 + 7 to 8; A 1 + 6 to 7; P 13. Dorsal fins widelyseparated, about equal in height. Ventral fins about in length to pectoral fins.

Color: Head and back brownish, belly white. Dark red or brown band runs from snouth through eye to base of caudal fin. Caudal fin with brown or red cross-bars. Yellow barbels

Gill rakers: 4 to 7 on upper and 16 to 18 on lower limb.

Family Nemipteridae

This family consists of threadfin breams, monocle breams and butterfly-breams that are small to moderate-sized, slightly compressed fishes. The terminal mouth is horizontal or slightly oblique and having small teeth in bands. The species has canine teeth in upper jaws and sometimes in lower jaws. The color is extremely variable. Has a total of 67 species.

Figure 100. ***Cymbacephalus nematophthalmus*** **(Gunter, 1860)**

Common Name: Darkband goatfish, bar-tailed goatfish, Fringe-eyed flathead
Local Name: Timbongan, Bayabao, Babayao, Saging-saging
Size: Common 15-20cm, maximum 28cm
Body: Compressed. Depth 3.8 to 4.6 times in standard length
Head: Chin with two short, thin barbels. No spine on operculum. Maxilla reaches below eye. Head 2.6 to 3.8 times in standard length.
Teeth: Present in both jaws and in roof of mouth as narrow bands of villiform teeth.
IUCN Status: Not Evaluated

Figure 101. ***Nemipterus furcosus*** **(Valenciennes, 1830)**

Common Name: Fork-tailed threadfin bream

Size: Maximum Length 24cm

Dorsal spines (total): 10; Dorsal soft rays (total): 9; Anal spines: 3; Anal soft rays: 7. Suborbital spine absent. Preopercle with 3 transverse scale rows. Pectoral fins moderately long, reaching to or just short of level of anus. Pelvic fins moderately long, reaching to or just short of level anus. A line drawn up from posterior edge of suborbital reaching the dorsal profile at about the origin of dorsal fin. Females predominate at small sizes while males dominate the larger size classes. Maybe a sequential hermaphrodite. Axillary scale present.

Color: Upper body iridescent pink, silvery white below. Lower margin of caudal fin white.

IUCN Status: Least Concerned

Figure 102. ***Nemipterus nematopus*** **(Bleeker, 1851)**

Common Name: Yellow-tipped threadfin bream

Size: common length 15cm

Dorsal spines (total): 10; Dorsal soft rays (total): 9; Anal spines: 3; Anal softrays: 7. Lower edge of eye touching or above a line drawn from the tip of snout to the upper base of the pectoral fin. Suborbital shallow, with a slightly emarginate lower edge. Dorsal fin origin about 2-6 scale rows from an imaginary line projected upwards from the posterior edge of the suborbital to dorsal profile. Relatively high soft dorsal fin, with the posterior rays the longest among the Nemipterus species. Upper lobe of caudal fin pointed and bright sulphur-yellow. Axillary scale present.

Color: Pinkish head and body with mauve reflections, becoming pearly white on the ventral side.

IUCN Status: Not Evaluated

Figure 103. ***Pentapodus bifasciatus*** **(Bleeker, 1848)**

Common Name: White-shouldered whiptail

Size: Maximum 20cm

Key Features

Dorsal spines (total): 10; Dorsal soft rays (total): 9; Anal spines: 3; Anal soft rays: 7. Head scales reaching forward to between level of posterior and anterior nostrils. Suborbital naked. Lower limb of preopercle with 2 or 3 scale rows. Pelvic fins moderately long, reaching to or almost to level of anus. Axillary scale present.

Color: Upper body brown, white on ventral surface. This species is easily distinguished from *P. trivittatus* by the head scales extending forward to the nostrils, the absence of scales on the suborbital, and presence of a white bar on the upper margin of the opercle'

I**UCN Status**: Not Evaluated

Figure 104. ***Pentapodus nagasakiensis*** **(Tanaka, 1915)**

Common Name: Japanese whiptail

Size: Common length 10cm

Dorsal spines (total): 10; Dorsal soft rays (total): 9; Anal spines: 3; Anal soft rays: 7. Head scales reaching forward to between level of anterior margin of eyes and posterior nostrils. Suborbital naked. Lower limb of preopercle naked. Pelvic fins moderately long, reaching to or almost to level of anus. Lobes of caudal fin pointed, more or less equal in length. Axillary scale present.

Color: Upper half of body yellowish, lower half whitish.

IUCN Status: Least Concerned

Figure 105. ***Scolopsis margaritifera*** **(Cuvier, 1830)**

Common Name: Pearly monacle beam

Size: 165cm, Maximum 28.0cm

Dorsal spines (total): 10; Dorsal soft rays (total): 9; Anal spines: 3; Anal soft rays: 7. Head scales reaching to or almost to posterior nostrils. Lower limb of preopercle scaly. Antrorse (forward-directed) suborbital spine absent. Pelvic fins long, reaching almost to or beyond level of origin of anal fin.

Color: Upper body olive, white below. 2 pearly white stripes on snout in front of eyes. Lower lobe of caudal fin reddish. Juveniles white, with a narrow black stripe along back (only on some specimens) and black midlateral stripe. Some with a yellowish ventral surface. Presence of a black spot between first four dorsal spines. Some color variation between Indian and Pacific populations: juveniles lack yellow stripe in the Indian Ocean population and adults show a contrasting dark back compared to Pacific form

IUCN Status: Least Concerned

Figure 106. Scolopsis taenioptera (Cuvier, 1830)

Common Name: Lattice monacle beam

Size: Maximum 30cm, Common length 15cm

Dorsal spines (total): 10; Dorsal soft rays (total): 9; Anal spines: 3; Anal soft rays: 7. Head scales reaching forward to between level of anterior margin of eyes and posterior nostrils. Lower limb of preopercle naked. Antrorse (forward-directed) suborbital spine absent. Pelvic fins long, reaching to or beyond level of anus. Axillary scale present.

Color: Upper body greyish-yellow, whitish below. A narrow blue stripe joining eyes just behind nostrils. A blue stripe from middle of upper lip to lower edge of eye. Upper part of pectoral-fin base with a reddish-orange spot.

IUCN Status: Least Concerned

Figure 107. ***Scolopsis vosmeri*** **(Bloch, 1792)**

Common Name: White cheek monocle-beam, silverflush spinecheek

Local Names: Silay, Buruba, Tagisang lawin

Size: Common 12 to 20 cm, Maximum 25

a) Body: Compressed. Depth about 2.5 times in total length.

b) Head: Jaws thick. Eye large, a stout, a backward-pointing spine just below it.

c)Scales: Large, those on top of head begin in front of anterior nostrils

d)Fins: Dorsal fin with stout spines, anal fin with three stout spines, the second very broad and longer than third. Ventral fins with first soft ray sometimes elongated into a short, threadlike filament

e) Color: Body Color variable, usually dark with reddish-purple tinge. Broad, white vertical band from top of head onto gill covers. Scales on sides of body with dark spots. Fins grayish, tinged red.

IUCN STATUS: Not Evaluated

Figure 108. ***Pomacentrus xanthosternus*** **(Allen, 1991)**

Common Name: Yellow-breasted damsel

Size: Maximum Length 10cm

Key features

a) Dorsal spines (total): 13; Dorsal soft rays (total): 14; Anal spines: 2; Anal soft rays: 14.

b) Color: dark on the top and light yellow at the bottom

IUCN Status: Not Evaluated

Family Platycephalidae

These species are commonly known as flatheads. They have an elongated bosy, extremely depressed anteriorly, subcylindrical and tapering posteriorly. Head extremely depressed, usually armed with exposed bony ridges, granules and sharp spines. Body covered with moderate to small adherent ctenoid scales which may extend onto sides and top of the head. Mouth large with lower jaws strongly protruding, jaws and roof of mouth with villiform teeth, eye with a lappet on iris. Has 80 species.

Figure 109. ***Ratabulus megacephalus*** **(Tanaka, 1917)**

Common Name: Dogtooth flathead

Size: Maximum 30cm

Dorsal spines (total): 10; Dorsal soft rays (total): 11-12; Anal spines: 0; Anal soft rays: 12.

Distinguished by the following characters: 94-112 anteroventrally slanted oblique scale rows above lateral line; snout length 31.2-35.7% HL, markedly decreasing in length proportionally with growth; pectoral fin length 13.9-17.0% SL; pelvic fin length 19.5-23.1% SL; nasal bone without tubercles; dorsal surface of head and body dark brown, with small, round, dark-brown spots; and pelvic fin with small brown to black spots

IUCN Status: Not Evaluated

Family Plotosidae

Commonly known as catfish-eels, sea catfishes and cobblers. They have an elongated body with tapering tail, no scales. Mouth subterminal and transverse. Lips thick, often papillate. Posterior nostrils slit-like. Teeth conical. Has 42 species.

Figure 110. ***Plotosus lineatus*** **(Thunberg, 1787)**

Common Name: Striped eel catfish

Size: Maximum 32cm

Key features

Dorsal spines (total): 1; Dorsal soft rays (total): 69-115; Anal spines:0; Anal soft rays: 58 - 82. This species has the dorsal and anal fins continuous with caudal fin; with 4 pairs of mouth barbels; and a single highly venomous serrate spine at the beginning of the first dorsal and each of the pectoral fins

IUCN Status: Not Evaluated

Family Pomacentridae

These fishes are commonly called damselfishes, sergeant majors and pullers. They have an elongated body to elongated-oval that is compressed. Has a single nostril on each side with small mouth, terminal, slightly protractile. Consist of 396 species.

Figure 111. ***Chromis viridis*** **(Cuvier, 1830)**

Common Name: Blue Green Damselfish

Size: Maximum 10cm

Key features

Dorsal spines (total): 12; Dorsal soft rays (total):9-11; Anal spines: 2; Anal soft rays: 9 – 11.

Color: An iridescent greenish-blue damselfish with no black spot at the 'arm-pit' of the pectoral fin. Blue-green Pullers form large schools over branching *Acropora* corals.

IUCN Status: Not Evaluated

Figure 112. ***Lepidozygus tapeinosoma*** **(Bleeker, 1856)**

Common Name: Fusilier damselfish

Size: Maximum 10.5cm

Key feature

Dorsal spines (total): 12; Dorsal soft rays (total):14-15; Anal spines: 2; Anal soft rays: 15 – 16

Color: A slender usually greyish-green to purplish damselfish with yellow patch on the rear of the dorsal fin, and a small bright blue spot on the rear of the gill cover.

Fusilier Damsels form feeding aggregations usually around steep reef slopes and drop-offs.

IUCN Status: Not Evaluated

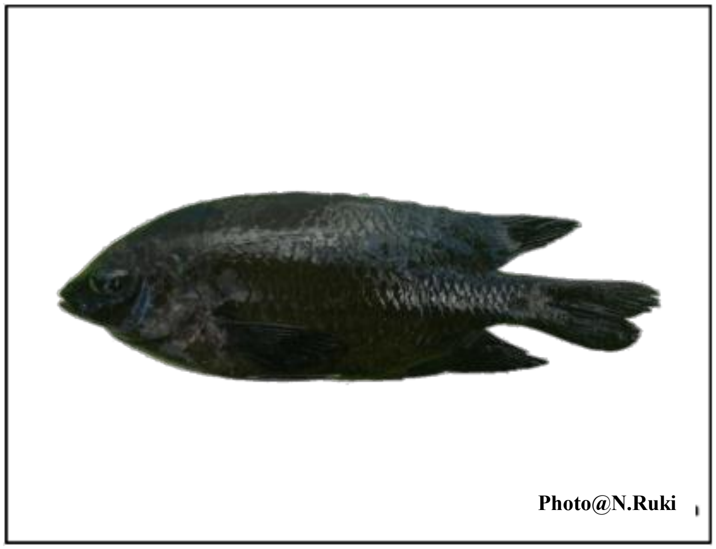

Figure 113. ***Stegastes diencaeus*** **(Jordan & Reuter, 1897)**

Common Name: Longfin damselfish

Size: Maximum 12.5cm

Key feature

Dorsal spines (total): 12; Dorsal soft rays (total): 15-16; Anal spines: 2; Anal soft rays: 13. Anal fin long and pointed, reaching well beyond base of tail.

Color: Adults dark gray-brown, the edges of the scales blackish; a wash of yellowish often present dorsally on head, nape, and on back below spinous portion of dorsal fin; a small black spot at upper base of pectoral fins; juveniles bright yellow with two bright blue lines dorsally on head, extending to beneath middle of dorsal fin where they break into spots; a large blue-edged black spot basally on dorsal fin centered on last spine

IUCN Status: Least Evaluated

Family Pseudochromidae

Also known as dottybacks. Oblong and compressed. Scales moderate and ctenoid on body, small and cycloid on head and cheeks but large and irregular on operculum. Mouth scarcely protractile. Several series of conical teeth in jaws, anterior ones enlarged and caniniform, teeth in vomer and usually on palatines. Consist of 152 species.

Figure 114. ***Labracinus cyclophthalmus*** **(Muller & Troschel, 1849)**

Common Name: Black Striped Dampier, Fire-tail Devil, Red Dottyback

Size: Maximum 23.5cm

Dorsal spines (total): 2; Dorsal soft rays (total):24-26; Anal spines: 3; Anal soft rays: 14 - 15. Lower lip uninterrupted at symphysis. Vomerine teeth relatively large, arranged in a chevron. Caudal fin rounded; upper part with 5 - 6 procurrent rays and 9 principal rays. Lateral line with anterodorsally series of 43 - 62 (usually 48 - 62) tubed scales extending from gill opening, and a peduncular series of 12 - 14 (usually 18 - 22) tubed scales. Dorsal and anal fins with distinct scaly sheaths

IUCN Status: Not Evaluated

Family Scaridae

This family is commonly known as parrot fishes with elongated-oval body and compressed. Teeth fully coalesced into parrot-like beak, with median suture at symphysis of each jaw, tip of lower jaw enclosed by upper jaw. Mouth small to moderate, terminal and not protractile. Canine sometimes present posteriorly in both jaws, vomer and palatines toothless. Very colorful. Consist of 100 species.

Figure 115. ***Scarus ghobon*** **(Forsskal, 1775)**

Common Name: Blue-barred orange parrotfish

Local Name: molmol

Size: Common 20 to 35cm

Body: Fairly compressed. Depth 2.5 to 3.1 times in standard length

Color: Primary male colors phase and female; Yellow/orange with 5-6 blue cross bars about half their interspaces. Head with some blue streaks and spots. Dorsal and anal fins orange with blue bases and borders. Caudal yellow with blue spots. Pectoral fin yellow with blue upper margin. Terminal male Color phase: Orange with turquoise vertical streak on each scale above and laterally; belly dirty white.

Head: 2.8 50 3.4 times in standard length.

Teeth: Beak-like with median suture. Male with canines in angle of mouth, flaring outward.

IUCN LIST: Least Concerned

Family Scombiridae

These fishes are also known as mackerels and tunas. They have elongated and fusiform body, sometimes compressed in some genera. Pointed snout with adipose eyelids present also in some genera. Large mouth with no true canines. Palatine and tongue may be tooted. The body is scales or sometimes covered in small scales. Has 54 species.

Figure 116. *Thunnus sp.* (South, 1845)

Thunnus sp is collectively known as the tunas, true tuna or real tuna. Their coloring, metallic blue on top and shimmering silver-white on the bottom

The largest member of this genus can grow to 15 feet (4.6 m) long and weigh up to 1,500 pounds (680 kg). All tunas are extremely strong swimmers, and the Yellowfin tuna is known to reach speeds of up to 50 miles per hour (80 km/h) when pursuing prey. As with all tunas, members of this genus are warm-blooded, which is a rare trait among fish; this enables them to tolerate cold waters.

***Figure 117. Siganus canaliculatas* (Park, 1797)**

Common Name: White-spotted spinefoot

Size: Common length 20cm, Maximum length 30cm

Key Features

Dorsal spines (total): 13; Dorsal soft rays (total): 10; Anal spines: 7; Anal soft rays: 9; Vertebrae: 23. Preopercular angle 89°-96°; cheeks appear to be scaleless but sometimes with few to many, fine, embedded scales on lower 2/3; midline of thorax scaleless between pelvic ridges. Margin of anterior nostril encircled by a low flange with the flap extending towards posterior flap; flap shortens with increasing size.

Color: Body silvery gray above, silvery below; a touch of olive green on nape and upper surface of head; fright pattern mottled with pale cream and dark brown; usually fish display a dark patch just below origin of lateral line.

IUCN Status: Least Concerned

Family Synanceiidae

No free pectoral rays; skin glands present, appearing as warts in most species; dorsal fin with 11-17 spines and 4-14 soft rays; anal fin with 2-4 spines and 4-14 soft rays; pelvic fin with one spine and 3-5 soft rays; pectoral fin rays 11-10; vertebrae 23-30. Venom glands present near base of hypodermic like dorsal fin spines. The neurotoxin of these fishes is the deadliest of the fish venoms and can be fatal to humans. Species camouflage as rocks. Mainly marine, but some species are known from rivers. Has 36 species in total.

Figure 118. ***Inimicus didactylus (Pallas,*** **1769)**

Common Name: Bearded ghoul

Size: Maximum length 25.0cm

a) Dorsal spines (total): 15 – 17 with soft rays (total): 7-9; the anal spines: 2; anal soft rays: 10 - 12.

b) The body colors are highly variable and best identified by the patterns on the fins). Lower 2 pectoral rays are entirely free and used as "walking" legs and the inner face of the fin is brightly colored.

IUCN Status: Not Evaluated

Figure 119. ***Synanceia verrucosa*** **(Bloch & Schneider, 1801)**

Common Name: Stone fish

Size: Maximum length 40cm

Key Features

a) Dorsal spines (total): 12 - 14; Dorsal soft rays (total): 5-7; Anal spines:

3; Anal soft rays: 5 - 6. Pelvic and anal fins spines are similarly developed. 12-14 stout grooved spines, each with a large venom sack at its base

b) Colors matching surroundings and extremely well-camouflaged

IUCN Status: Not Evaluated

Family Scyliorhinidae

Usually elongated, catlike eyes with nictitating eyelids. Lower eyelid usually with longitudinal fold. Gill openings 5, the fifth over origin of pectoral fin. Two small, spineless dorsal fins. One of the largest family of sharks, occurring from the intertidal zone to the edges of the continental and insular shelves and down the slopes to depths greater than 2000 m. consist of 157 species.

Figure 120. ***Aulohalaelurus mamoratus*** **(Waite, 1905)**

Common Name: Cat-shark

Key features Also kown as castsharks and can be clearly seen by their elongated cat-like eyes and two small dorsal fins set far back. The species are somewhat small, reaching a maximum length of 80cm. have patterned appearance, from stripes to spots.

May be distinguished by their elongated, cat-like eyes and two small dorsals

IUCN List: Not Evaluated

Family Scorpaenidae

This family consist of species commonly known as sting fishes, scorpionfishes and fire fishes. Have short to moderately elongate body. Head usually large with one or more bony ridges ending in spines. Mouth terminal, moderate to large. Teeth om villiform bands in jaws and vomer, sometimes also in palatines, few enlarged and never caninoid. consist of 222 species.

Figure 121. Centrogenys vaigiensis (Quoy & Gaimard, 1824)

Common Name: False scorpionfish

Local Name:

Size: Common 25cm

Key features

Dorsal spines (total): 13 - 14; Dorsal soft rays (total): 9-11; Anal spines:3; Anal soft rays: 5.A pale grey to pale brownish with darker greyish to brown mottling, large dark grey to dark brown spots on fins, and a large fringed flap on the anterior nostrils

IUCN Status: Not evaluated

Figure 122. ***Scorpaenopsis diabolus*** **(Cuvier, 1829)**

Common Name: Tassled scorpionfish

Size: Common 36cm

Key features

Dorsal spines (total): 12; Dorsal soft rays (total): 8-10; Anal spines: 3; Anal soft rays: 5 - 6. Pectoral fin rays usually 18; back arched; with about 45 vertical scale rows; lachrymal bone with 2 or 3 spines over maxillary, first points forward, followed by 1 or by 2 close-set spines which point down and back; suborbital ridge with 4 or more spinous points, usually more than 8 or 10 points, not in a row and of various sizes; a shallow pit below front corner of eye.

Color: A mottled whitish, reddish, orange, bluish, green or purple scorpionfish, with a large black spot on the yellowish-orange inner surface of the pectoral fin. Colorful inside the pectoral fins, used for display

IUCN Status: Least Concerned

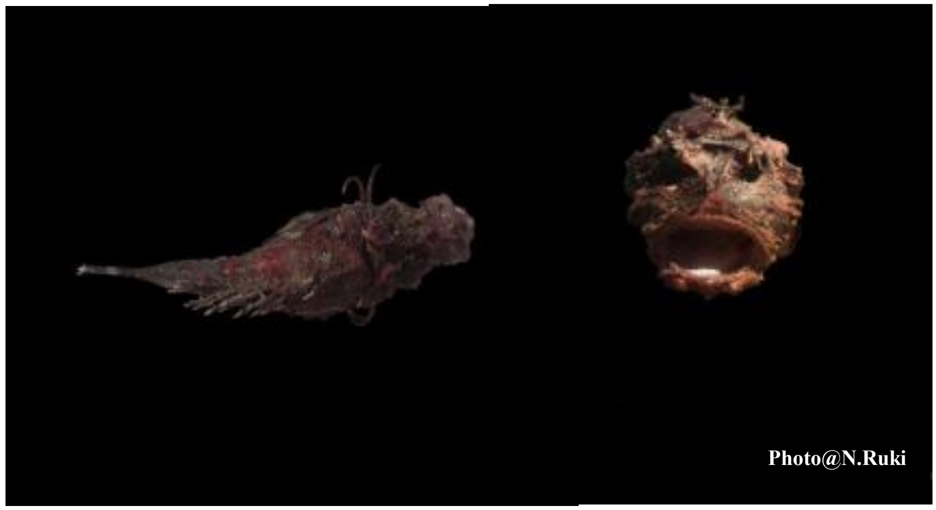

Figure 123. ***Scorpaenopsis oxycephala*** **(Bleeker, 1849)**

Common Name: Tassled scorpionfish

Local Name:

Size: Common 36cm

Dorsal spines (total): 12; Dorsal soft rays (total): 9; Anal spines: 3; Anal soft rays: 5. Highly variable in color. Adults 'bearded' with numerous tassels. Juveniles slender with tall dorsal fin. Third dorsal spine longest (2.05-2.5) in head; occipital pit absent or very shallow; snout very long (2.7-3.0 in head length); space between opercular spines naked; first dorsal spine short (1.85-2.5) in length of second spine; supraocular and postocular spines broadly joined in adults (only tip of supraocular spine showing) and flaring outward to form a shelf over posterior half of eye

Color: A mottled and variable reddish-brown scorpionfish with white patches, and often a darker triangular area below the eye that extends across the cheek.

The small-scale Scorpionfish has prominent skin tassels on the lower part of the head.

IUCN Status: Least Concerned

Family Serranidae

Also known as groupers and seabasses. Toblong, moderately elongate, perch-like fishes. Mouth large, its cleft horizontal or oblique. Scales small or moderate in size, mostly ctenoid, sometimes cycloid, firmly embedded in skin. Head scaly. Has 544 species.

Figure 124. ***Cephalopolis boenak*** **(Bloch, 1790)**

Common Name: Blue-line rockcod

Local Name: Lapu-lapu, Bantol, Labungan, Kaltang

Size: 20-30cm

a) Body: Stout and compressed. Depth 2.6 to 2.9 times in standard length.

b) Head: Preoperculum rounded, finely serrated. Middle operculum spine nearer lower than upper. Head 2.5 to 2.6 times in standard length.

c) Gill rakers: 8 on upper and 16 on lower limb.

d) Color: Head and body dark brown to blackish with numerous undulating, narrow, longitudinal blue lines which may extend onto fins. Spinous dorsal tips black. Indistinct vertical bands sometimes present. Fins: D 9+ 15 to 17; A 3 + 8

f) Scales: 44 to 63 on lateral line. 82 to 120 along midline. 8 to 11 + 32 to 40 transverse scales.

g) Teeth: Bands of teeth on jaws. Inner depressible row in lower jaw and anterior ones of upper jaw long and slender.

IUCN STATUS: Least Concerned

Figure 125. ***Diplorion bifasciatum*** **(Cuvier, 1828)**

Common Name: Barred soapfish

Size: maximum 25cm

Key Features:

Body: Compressed body, body depth greater than head length. Preopercular, subopercular and interopercular margins serrated. 2.0-2.4 in standard length

Fins: D VIII 13-16, A II 12-13, P1 17-18, P2I 5, LLp 71-76, GR 9-10 + 20-22. Caudal fins rounded. Posterior tip of depressed pelvic fin extending beyond anal fin origin. Ctenoid scales not deeply embedded.

Color: Body yellow with a black bar through eye and a broad one in middle of body continuing onto posterior two thirds of spinous portion of dorsal fin

Habitat: Found in coral reefs and adjacent habitats in depths of 5-50m. Secret toxin under stress.

IUCN STATUS: Least Concerned

Figure 126. ***Epinephelus sexfasciatus*** **(Valenciennes, 1828)**

Common Name: Six-banded rockcod

Local Name: Lapu-lapu, Pugapo, Abo-abo, Lilug, Kulapo

Size: 20-28cm

Key Features

Compressed body. Preoperculum angular, serrated behind and with two strong serrae at angle. Middle opercula spine nearer to lower than to upper in young, upper lost with age. Head 2.4 to 2.5 times in standard length

Scales: 52-56 on lateral lines. 89-100 along midlines. 9-14 + 30 30 to 38 transverse scales.

Color: Brownish with six broad vertical darker bands, bands as wide as interspaces, double in young and composed of large brown spots extending onto dorsal and anal bases. Unpaired fins with large round brown spots. Pectoral fins light yellow.

Fins: D 11 + 14 to 15; A 3 + 8

Teeth: Narrow bands of small teeth in jaws. Lower jaws with two lateral series. Symphysial canines moderated size.

Gill rakers: 7 to 8 on upper and 13 to 15 on lower limb.

IUCN STATUS: Data Deficient

Family Siganidae

The species in this family is commonly called rabbitfishes and spinefeet and has an oblong, compressed body covered with minute elongate thin cycloid scales. Sides of head more or less scaly. Jaws with a row of slender, compressed, rather small incisor-like teeth which are bicuspid, irregularly tricuspid or slightly serrated. Has 29 species.

Figure 127. *Siganus canaliculatus* (Park, 1797)

Common Name: Six-banded rockcod

Local Name: Lapu-lapu, Pugapo, Abo-abo, Lilug, Kulapo

Size: 20-28cm

a) Dorsal spines (total): 13; Dorsal soft rays (total): 10; Anal spines: 7; Anal soft rays: 9; Vertebrae: 23. Preopercular angle 89°-96°; cheeks appear to be scaleless but sometimes with few to many, fine, embedded scales on lower 2/3; midline of thorax scaleless between pelvic ridges. Margin of anterior nostril encircled by a low flange with the flap extending towards posterior flap; flap shortens with increasing size

b) Color: Body silvery gray above, silvery below; a touch of olive green on nape and upper surface of head; fright pattern mottled with pale cream and dark brown; usually fish display a dark patch just below origin of lateral line

IUCN Status: Least Concerned

Figure 128. ***Siganus spinus*** **(Linnaeus, 1758)**

Common Name: Black trevally

Local Name: Danggit

Size: Common 20 to 35 cm; Maximum 60 cm

a) Compressed body

b) Head: Anterior nostril with a long flap, larger than distance between anterior and posterior. Head 3.7 to 3.9 times in standard length

c) Scales: Minue,cycloid, 165 to 175 on lateral line. Cheeks with a few deciduous scales. Embedded in skin

d) Color: Dark olive or brownish with coarse reticulated patterns of pale blue, wavy lines which form a network, often with irregular darker botches. Body markings continue to basal part of caudal fin. Dorsal, anal and caudal rays ringed light and dark brown

e) Fins: D 13 + 10; A 7 + 9.

IUCN List: Least Concerned

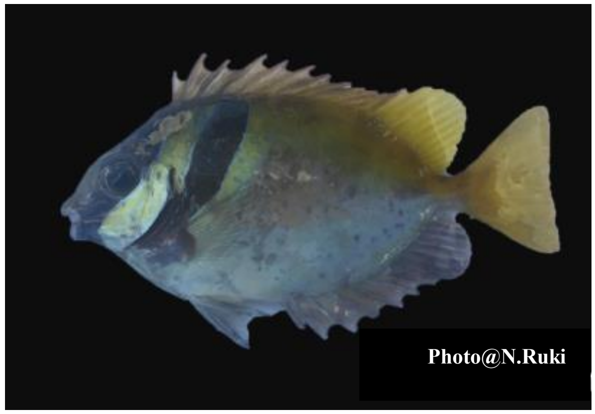

Figure 129. ***Siganus virgatus*** **(Cuvier & Valenciennes, 1835)**

Local Name: Tagbago

Size: 15-20cm, Maximum; 30cm

Key Features

Body: Compressed body anterior nostril with a fleshy brim. The head is 3.6 to 3.7 times in standard length.

Color: Oblique brown bands running through eyes and upward from pectoral fin base

Scales: 140 to 150 on lateral line. Minute, cyclolid

Fins: D13 + 10; A 7 + 9. Fist dorsal spine less than eye, fifth spine longest, equal to snout plus half eye; last spine only slightly shorter. Soft anal median rays much the longest and slightly longer than longest spine. The first anal spine is longer than eye. The third or fourth spine is slightly longer than others, as long as snout plus eye. The soft anal is similar to soft dorsal, but somewhat less deep. Pectorals slightly shorter than head, ventrals somewhat shorter than snout plus eye.

IUCN List: Not evaluated

Family Soleidae

Commonly known as soles and has an oval or somewhat elongate and strongly compressed flat fishes with eyes on right side of body. Snout sometimes hook-shaped. Teeth small, viliform, better developed on blind side. No spine in fins. Scales moderately large, cycloid or ctenoid, sometimes modified into skin flaps, fringed with sensory filaments. The blind side is yellow, white, color of eyed side according to substratum. Has 179 species.

Figure 130. ***Synaptura marginata*** **(Boulenger, 1900)**

Common Name: White-margined sole

Size: 15-20cm, Maximum; 50cm

Key Features

Dorsal spines (total): 0; Dorsal soft rays (total): 70-76; Anal spines: 0; Anal soft rays: 54 - 63; Vertebrae: 46. Dark brown, sometimes with darker specks; dorsal and anal fins with pale edges; right pectoral fin blackish

Both eyes are on the right-hand side

IUCN Status: Not Evaluated

Figure 131. ***Pardchirus pavoninus*** **(Lacepeded Gunther, 1802)**

English Name: Peacock sole

Local Names: Malad-palad, Dali-dali

Size: 10 to 15cm, maximum 20cm

Key Features

a. Flat body. There are eyes on ride side, separated by a scaly space. Mouth strongly curved, cleft reaching to below front edge of lower eye.

b. Scales: 84 to 90 on lateral line; weakly ctenoid on both sides.

c. Color: Red/brown, densely spotted on head. Body and fins also with spots of various sizes and shapes, bordered by dark rim and some blackish spot in the center.

d. Fins: D 63 to 71; A 49 to 54; C 17 to 18. Dorsal and anal fins separate from caudal fin. No pectoral fins. Ventral fins unequal, the right one with an elongated base and attached posteriorly to genital papilla.

IUCN Status: Least Concerned

Family Sphyraenidae

It is commonly known as barracudas. The body elongates, usually slightly compressed. Head very long, with long snout. The mouth is large, with lower jaw projecting beyond upper. It has strong canine teeth in jaws and on palatines, of unequal size. The scales are small, cycloid. Usually brown/blue or silver/grey, lighter below and has 27 species.

Figure 132. ***Sphyraena obtusata*** **(Cuvier, 1829)**

English Name: Obtuse Barracuda
Size: maximum 55cm
Key Features
Dorsal spines (total): 6; Dorsal soft rays (total): 9; Anal spines: 2; Anal soft rays: 9. Body elongate and subcylindrical with small cycloid scales; head long and pointed. The mouth is large and horizontal, the tip of the lower jaw protruding with intermaxilla non-protractile. The pre-operculum is rectangular, with wide naked skin flap. The first dorsal fin origin is slightly before the pectoral fin tip, the first spine equal to the second. Pelvic fins well before the tip of the pectoral, closer to the anal than the tip of the lower jaw.
Color is generally green above and silvery below.
IUCN Status: Least Concerned

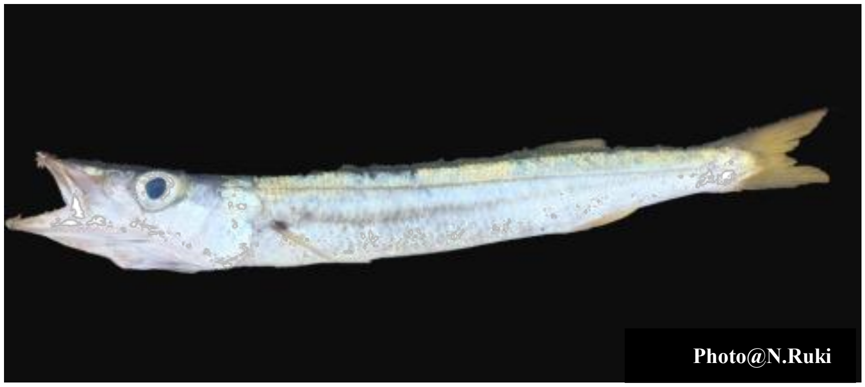

Figure 133. ***Sphyraena forsteri*** **(Cuvier, 1829)**

Common Name: Forsters barracuda

Local Name: Laging, Bikuda, Torsilyo,Tabanko

Size: Common 20-30cm; Maximum 60cm

Key Features

Body: Slightly compressed

Head: Lower jaw protecting beyond upper. Upper jaw about reaching to level of front eyes. Head 5.0 times in standard length.

Color: Black above, silvery below. Inside of mouth dark gray. Dorsal and caudal fins black. Ventral, pectoral and anal fins white

Gill rakers: Minute

Fins: D15, DII 1 + 9, A2 + 8 to 9. Second dorsal opposite anal fin.

Scales: 105 to 122 small, cycloid scales on lateral line and 15 to 17 scales rows above it at level of first dorsal fin origin.

Teeth: A series of minute teeth and two sharp canines in front in upper jaw. Lower jaw with a series of about twenty flattened, triangular teeth, those on middle and hind part larger and directed slightly backward.

IUCN STATUS: Least Concerned

Family Tetraodontidae

The specie in this family is also known as pufferfishes, blowfishes and toadfishes usually short and robust with sub-cylindrical in section. The Body scales are small and embedded spines. The lateral lines are double. Teeth in both jaws fused into separate bony plates divided in front by a median suture, forming a powerful parrot-like beak. Has a single nostril on each snout with 200 species in total.

Figure 134. ***Arothron manilensis*** **(Marion de Proce, 1822)**

Common Name: Narrow-lined puffer

Size: Maximum 31cm

Key Features

a) Dorsal spines (total): 0; Dorsal soft rays (total): 9-11; Anal spines:0; Anal soft rays: 9 - 10. Body covered with prickles. Many longitudinal dark stripes on body, although the stripes sometimes faint

b) Color: A pale greenish-grey to brownish puffer with narrow yellowish to dark brown stripes on sides, and a large black spot around the pectoral-fin base and gill opening.

IUCN Status: Least Concerned

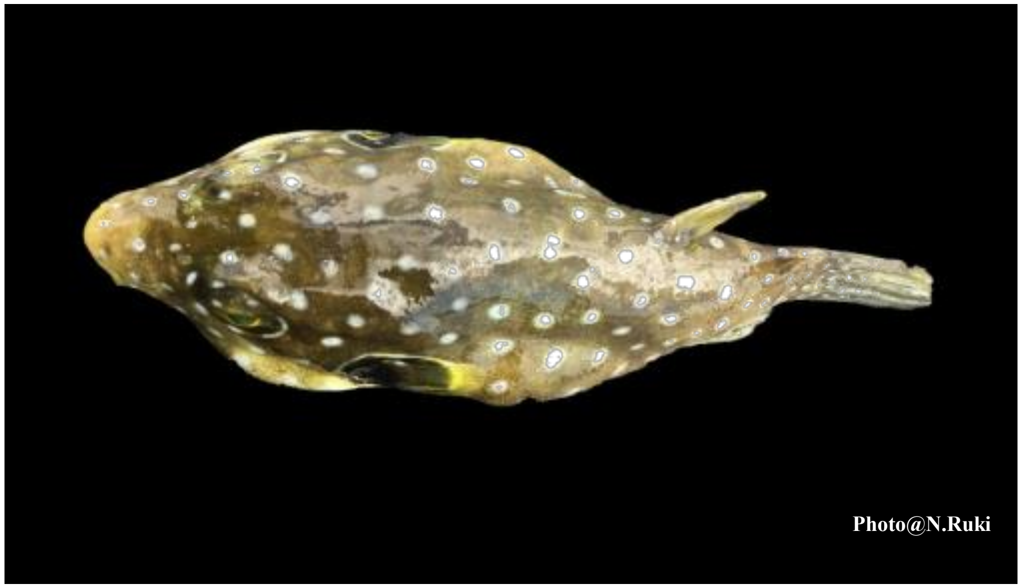

Figure 135. ***Arothron hispidus* (Linnaeus, 1758)**

English Name: Broad-barred toadfish

Local Name: Boriring

Size: Common 10-30 cm; maximum 50cm

Key Features

Body: Single bent lateral line. Body with small spines except around snout and the caudal peduncle behind dorsal and anal fin bases. Depth 2.0 to 2.8 times in standard length

Head: snout subequal to interorbital. Each nostril with two fleshy tentacles. Head 2.4 to 3.4 times in standard length.

Color: Brown above, with a moderate number of small bluish-white spots on head, back and sides. Lines of same color on belly with very narrow, brown interspaces. Sometimes, one or two bluish-white or yellow bands around eye and another encircling gill opening and pectoral base. Fins immaculate.

Fins: D 9 to 10, A 9 to 11; P 17 to 18

Teeth: Fused into a parrot-like beak with median suture. Tongue and roof of mouth toothless.

IUCN Status: Least Concerned

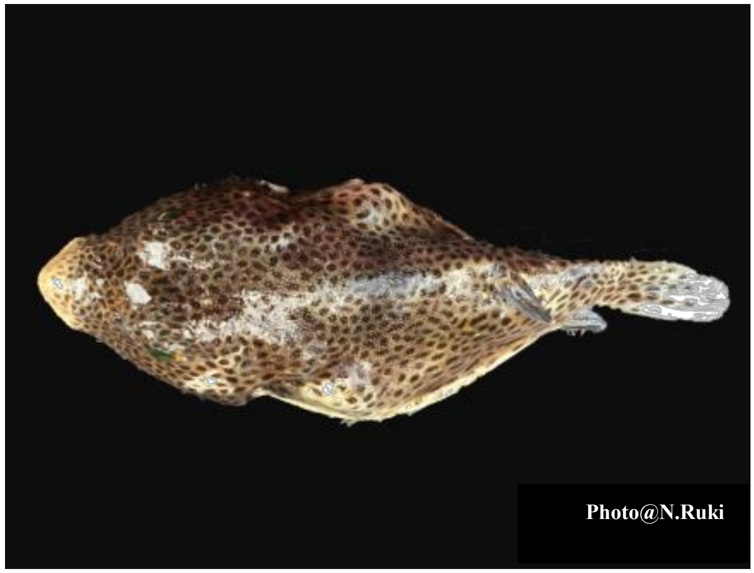

Figure 136. ***Arothron stellatus*** **(Bloch & Schneider, 1801)**

English Name: Stellate Puffer

Size: Maximum Length

Key Features

Dorsal spines (total): 0; Dorsal soft rays (total): 10-12; Anal spines:0; Anal soft rays: 10 - 11. Body covered with prickles.

Color: A large pale greyish puffer with small black spots on the body (and often fins) that become relatively smaller and more numerous as the fish grows, and dark blotches around the bases of the pectoral and dorsal fins. Juveniles are orange with small black spots and dark stripes on the belly that break up into spots as they grow.

IUCN Status: Least Concerned

Family Uranoscopidae

Body moderately elongate (size to about 65 cm), depressed anteriorly or compressed. Head massive, nearly cube-shaped, flattened dorsally, rounded anteriorly; dorsal and lateral surfaces of head almost entirely encased in sculptured bones. Eyes directed dorsally or dorsolateral, placed on or near top of head. Infraorbital bones dilated. Interorbital space noticeably broad, anterodorsally part of skull deeply scooped backward (interorbital fossa). Mouth large, protractile, almost vertical; jaws, prevomer, and palatines toothed; a pair of pockets on anterior roof of mouth (between premaxillae and prevomer. Has 53 species.

Figure 137. ***Uranoscopus bicinctus*** **(Temminck & Schlegel, 1843)**

English Name: Marbled stargazer

Size: Maximum Length 20cm

Key Features

Dorsal spines (total): 4 - 5; Dorsal soft rays (total): 13-14; Anal spines: 13.

Indonesian form has pale body with dark blotches. Body dark brown with 3 distinct broad black bands.

Respiratory valve inside lower jaw with a thick orange tentacle

IUCN Status: Not Evaluated

3.3 Monthly By-Catch for Gillnet and Crab pot Gears

This study started from April until August 2017. The number of samples per month and average by-catch are given in Table 3 and Fig.133. The results can be considered reliable since the figures show that the standard deviation is less that than the mean an indication that data is more clumped to the mean. The highest number of sampling days was recorded in May for crab pots, this is due to the fact that there was no data recorded on the month of April for the crab pots. The highest mean numbers were seen in the month of May for both gillnet and crab pot (206±164.87, 218± 84.34).

The monthly mean by-catch as projected by R-statistics shows that the dry season recorded the highest number of by-catch as compared to the wet season. Since we were not able to record the number of catch (BSC) per fisher it became difficult for us to calculate the CPUE which would have been helpful in analyzing the total number of catch per gear per hour.

Table 3. Monthly by-catch for both gears from April to August 2017

	Fishing gears			
Months	**Crab pots**	**Mean ±SD**	**Gillnets**	**Mean ±SD**
2017				
April	-	-	9	132.22 ± 62.56
May	14	206.21 ± 164.87	5	218.60 ± 84.34
June	3	45.33 ± 34.67	2	57.00 ± 55.15
July	4	48.00 ± 29.66	6	59.50 ± 22.37
August	7	59.57 ± 30.65	6	72.67 ± 47.92

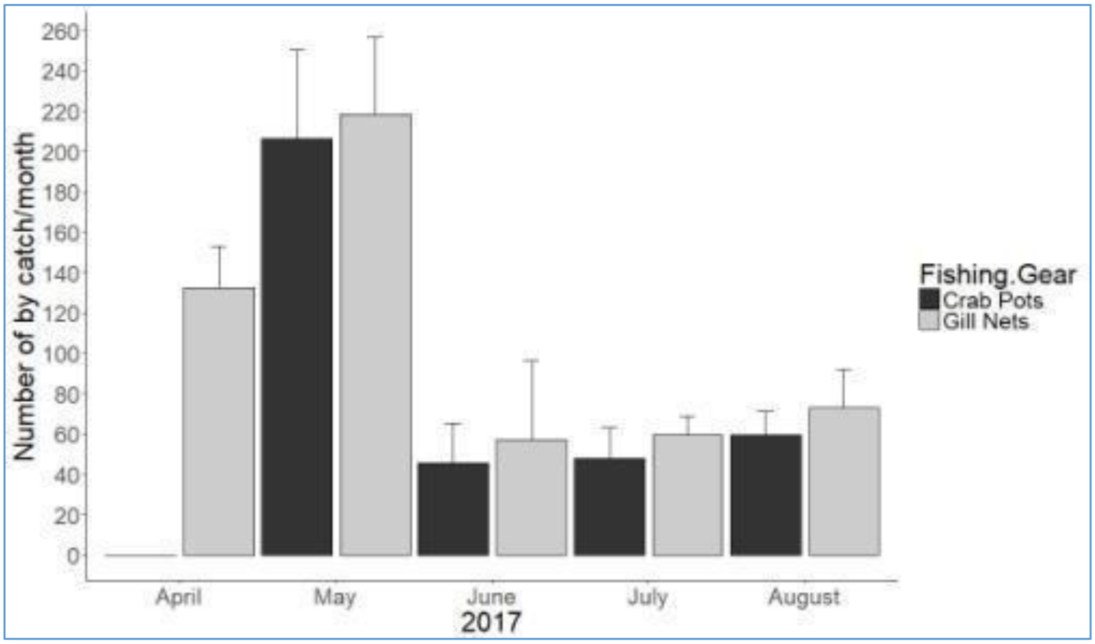

Figure 138. Average number of by-catch in the two gears per month (April-Aug 2017)

3.4 Morphometric Analysis

The mean results obtained for each phylum during the two seasons is presented in Tables 4-7. The total counts per phylum for both crab pots and gillnets species was measured. The mean length high standard deviation for Mollusca and Chordata in Table 4 can be explained by the wide morphological variations of by-catch collected during the dry season. There was a slight difference between the two seasons although the computed standard deviation for the mean length during the wet season was relatively low (Table 5).

Table 4. Length characteristics of by-catch collection in April-May 2017

Dry Season	Length Characteristics (cm)			
Phylum`	n (±10%)	Mean ± SD	Min	Max
Mollusca	104	175.02 ±1668.54	0.93	31.07
Echinodermata	29	19.79 ±7.16	4.48	30.61
Arthropoda	119	7.49 ±1.99	2.85	15.02
Chordata	73	411.30 ±3314.19	5.11	42.71

Table 5. Length characteristics of by-catch collected in June -August 2017

Wet Season	Length Characteristics (cm)			
Phylum	n (±10%)	Mean ± SD	Min	Max
Mollusca	72	8.97 ±3.8	4.15	22.96
Echinodermata	39	20.744 ±3.153	14.49	28.
Arthropoda	105	8.082 ±2.129	4.85	15.48
Chordata	110	10.091 ±5.414	4.97	25.89

Mean weight standard deviation for both seasons showed a wide range of values among the by-catch from both gears in both seasons. Among the taxon groups, the molluscs by-catch showed a wide range of minimum and maximum weights both the dry seasons and wet season (Tables 6 and 7).

Table 6. Weight characteristics of by-catch collection in April-May 2017

Dry Season	Weight Characteristics (g)			
Phylum	**n** (±10%)	Mean ± SD	Min	Max
Mollusca	104	202.39 ±240.92	11	1488
Echinodermata	29	313.76 ±152.77	18	58
Arthropoda	119	114.28 ±63.62	26	313
Chordata	73	100.72 ±125.26	11	525

Table 7. Weight characteristic of by-catch collection in June-Aug 2017

Dry Season	Weight Characteristics (g)			
Phylum	**n** (±10%)	Mean ± SD	Min	Max
Mollusca	72	104.263 ±192.302	23	1423
Echinodermata	39	344.846 ±111.573	141	641
Arthropoda	105	96.781±80.427	30	608
Chordata	110	69.436 ±94.127	6	427

The mean weight measured for Mollusca, Arthropoda and Chordata were slightly higher during the months of April to May, (Fig. 134). There were no significant changes between the lengths of by-catch species collected from the two seasons even though the difference in counts differed significantly. There was an increase in mean weight for both seasons. For the chordates and molluscs during the dry season a high standard deviation for mean length (Fig. 135) has been recorded.

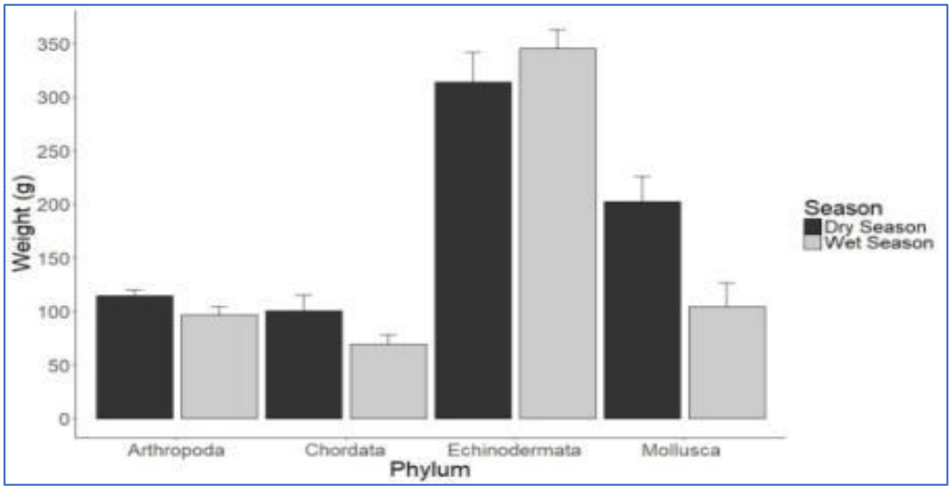

Figure 139. The mean weight of four taxon groups for the wet and dry seasons.

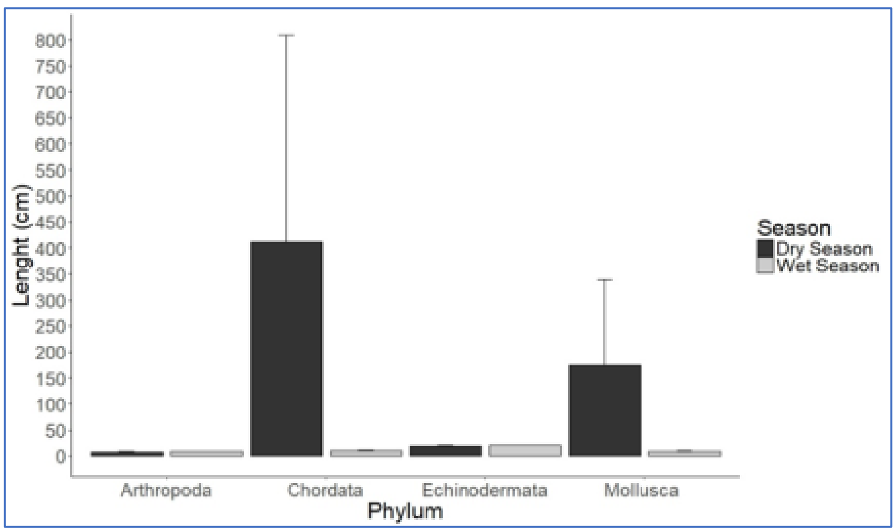

Figure 140. The mean length of four taxon groups in wet and dry season

Among the four phyla, Arthropoda and Chordata, consisted the majority of the total by-catch for both dry season and wet season combined. Length measured using ImageJ software was used to determine the maturity of the fish by comparing collected data with existing data from previous studies. Table 8 consist of the existing carapace length (CL) of each mature crab species from previous authors while the total length (TL) for fishes from Phylum Chordata is summarised in Table 9. The Standard Minimum Mature Length

(SMML) of each individual species from both tables were compared with the mean by-catch length of species from both seasons.

Table 8. SMML compared with Mean By-catch Length for Phylum Chordata

Family	Species	Standard Min Mature Length (cm)	Mean By-catch Length (cm)
Apogonidae	*Apogon trimaculatus*	12.8	13.5
	Apogon kallopterus	15.5	16.2
	Jaydia catalai	8.5	7.3
Blennidae	*Atrosalarias fuscus*	10.16	16.8
Carangidae	*Selaroides leptolepsis*	9	7.7
Centropomidae	*Psammoperea waigiensis*	28	26.9
Chaetodontidae	*Chaetodon octofasciatus*	11.43	15.6
	Chelmon rostratus	10.2	6.9
Dasyatidae	*Neotrygon orientalis*	41.8	45.1
Gerredae	*Gerres oyena*	9.2	10.5
Hemiramphidae	*Hyporhampus quoyi*	24.5	27.5
Holocentridae	*Sargocentron rubrum*	31.57	29.7
Labridae	*Halichoeres maculipinna*	30.2	33.5
	Halichoeres bivittatus	15	10.6
Lenthrinidae	*Lethrinus obsoletus*	15	16.4
	Lethrinus genivittatus	13.5	15.5
	Lethrinus semicinctus	14	11.3
Lutjanidae	*Lutjanus carponotatus*	18.6	15.8
	Lutjanus ehrenbergii	15.9	16.9
	Lutjanus rufolineatus	15.4	17.8
	Lutjanus vitta	16	20
	Monocanthus chinensis	15	18.5
	Paramonocanthus curtorhynchos	11.3	15.7
Mullidae	*Parupeneus heptacanthus*	20	21.1
	Upeneus tragula	15	13.5
Nemipteridae	*Nematophthalmus cymbacephalus*	30	34.5
	Nemipterus furcoses	13	18.5
	Nemipterus nematopus	14.5	16.3
	Pentapodus bifasciatus	9.3	12.8
	Pentapodus nagasakiensis	14	17.4
	Scolopsis taenioptera	15.9	19.7
	Scolopsis vosmeri	12	16.6
	Scolopsis margaritifera	15.5	18.4

Platycephalidae	*Platycephalus sp.*	23.5	21.5
Plotosidae	*Plotosus lineatus*	14	19.9
Pomacentridae	*Chromis viridis*	5.8	6.2
	Lepidozygus tapeinosoma	10.5	11.5
	Pomacentrus xanthosternus	6.2	9.9
	Stegastes diencaeus	7.5	7.2
Pseudochromidae	*Labracinus cyclophthalmus*	14.8	15.3
Scaridae	*Scarus sp.*	30	22.6
	Sccarus ghabban	49	55
Scombridae	*Thunnini sp.*	105	45.9
Scorpaenidae	*Centrogenys vaigiensis*	9.3	6.5
	Scorpaenopsis oxycephala	20	22.8
	Scorpaenopsis sp.	16	19.7
	Scorpaensis diabulus	18.4	20.3
Scyliorhinidae	*Aulohalaelurus mamoratus*	80	73.5
Serraridae	*Cephalopholis boenak*	12.2	15.5
	Diploprion bifasciatum	16	19.6
	Epinephelus sexfasciatus	13	15.7
Siganidae	*Siganus canaliculatus*	11.6	12.5
	Siganus virgatus	12	13.6
	Siganus spinus	20	21.9
Soleidae	*Soleidae marginata*	22.5	22.8
	Pardachirus pavoninus	10.2	11.9

Table 9. SMML compared with the mean by-catch length for Phylum Arthropoda

Family/Species	Standard Min. Adult Length (cm)	Mean By-catch Length (cm)
Dromiidae *Dromida antillensis*	7	7.5
Lauridromia indica	9.1	9.3
Dorippidae *Dorripe lanata*	2.1	2.2
Matutidae *Ashtoret lunaris*	5	4.7
Parapylochelidae *Pagarus bernhardus*	8	7.3
Portunidae *Charybdis japonica*	4.63	5.5
Charybdis natator	8.3	8.7
Portunus gladiator	5	5.6
Thalamita spinimana	4	4.9

Charybdis feriatus	5	6.6
Portunus sanguinolentus	7.8	8.6
Xanthidae *Atergatis integerrimus*	7	6.5
Demania cultipes	10	8.6
Hypocolpus haani	7	6.4
Lophozozymous Pictor	5.8	6.8

Mean by-catch lengths lower than the Standard Minimum by-catch length are interpreted as juvenile species. Of the 56 species of Phylum Chordata,15 were juveniles. notably, *Jaydia catalai, Selaroides leptolesis, Psammoperea waigiensis, Chelmon rostratus, Sargocentron rubrum, Halichoeres bivittatus, Lethrinus semicinctus, Lutjanus carponotatus, Upeneus tragula, Platycephalus sp., Stegastes diencaeus, Scarus sp., Thunnini sp., Centrogenys vaigiensis, Aulohalaelurus mamoratus.* This indicates that about 75% of Phylum Chordata by-catch species were mature and appropriate for incidental capture.

Out of the 15 species of Phylum Arthropoda by-catch collected from both methods of fishing, five different species of juveniles were prone to capture, about 33% of total crab by-catch were immature, thus unsuitable for capture. In particular, *Ashtoret lunaris, Pagarus bernhardus, Atergatis integerrimus, Demania cultipes, Hypocolpus haani.* Among the five species identified, none were utilized as food nor bait by the fishermen as most crabs from the family Xanthidae are poisonous for consumption.

From the comparative results as shown in the Tables 8 and 9, it can be deduced that majority of BSC fishery in Bantayan Island for both crab pots and gillnets are composed of mature species that are acceptable to by-catch trends.

3.5 By-catch Assessment

The results of this study showed that Blue Swimmer Crab, *Portunus pelagicus* fishery in Bantayan Island is not selective compared to the commercial fisheries elsewhere. The data collected show that gillnets consisted of a fairly diverse species of fish and invertebrates. Once captured they were sorted as those species which can be utilized or to be sold to the local markets. Crabs in these gillnets were more in numerical value than fish. This is due to the fact that most of these crabs are swimmer-crabs hence, likely to be caught in the process. Another reason to this is because of the mesh size used by the fisherfolk that allows easy escape of the fish.

Indeed, the motivation for getting the by-catch is economic and since to some extent there is no restriction on regulation, most by-catch species were brought to the landing sites as target catch. This kind of exploitation had led to high mortality rates translating to a decline in their population. This is a serious threat to their diversity and conservation. The interviews revealed that over time there has been a decline in the crab fishery both in number of catch (BSC) and the by-catch due to the overharvesting by the fishery sector. There are no records of crab pots during the month of April as we experienced lack of cooperation from the fishermen hence, no interviews conducted.

The consistency of the sampling numbers/days was largely affected by the damaged gears (gillnet) which always got entangled in corals or species of phylum Echinodermata and Mollusca.

Between seasons there was a notable slight variation in the species composition with the highest recordings in the dry season which us indicative of weather affected by species population density or abundance. The fact that commercial fishermen are off-season during this time of the year, might as well have contribution to by-catch quantity. Weather conditions greatly barred the fishermen from their daily routine. This was observed during the wet season. Corals and sponges were also destroyed by the net gear fishing an indication that the fisheries' by-catch is a complex and wide ecosystem issue as a whole and promoting this in a management level is key as we believe that this will address the regions' by-catch problem.

CHAPTER 4:

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

4.1 Summary

There were 6,953 of by-catch recorded during the 28 samplings of this study,14 samplings from the dry season (April-May) and 14 from the wet season (June -August). Of the 6,953 by-catches counted this study, one hundred and twenty (120) species in four (4) phyla under sixty-two (62) families were identified,18 families from Phylum Mollusca, seven (7) families from Phylum Echinodermata ,6 families from Phylum Arthropoda and 32 families from Phylum Chordata.

The major findings of this research were that, in both dry and wet season, the crab pot fishery, the taxon group Chordata recorded the highest number of by-catch (n=2391) with that of Phylum Mollusca (n=436), Phylum Arthropoda(n=916) and Phylum Echinodermata (n=22). A few recurring species dominated the crab pot by-catch in both the dry and wet season.

Of the invertebrates, collectively it was dominated by Ramose murex or Branched murex, Hermit crabs, Chocolate chip seastar (*Protoreaster nodosus)*, Swimmer crabs (*Thalamita spinimana*). While the finfish was dominated file fish (*Monacanthus chinensis*), Lattice Monacle bream, Longspine emperor and Thread fin bream. It should be noted that some species occur seasonally, and some are harvested for food and livelihood purposes. The occurrence of this species in crab pots and gillnets with its potential value, may result to an increase harvest to the point of negatively impacting the species population abundance.

4.2 Conclusions

Based on the findings of this study, it can be concluded that by-catch from Blue Swimming Crab, *Portunus pelagicus* Fishery in Bantayan Island does not pose a threat to the biodiversity and abundance of the marine resources of the area. To the crab fishers of northeastern part of Bantayan Island, majority of the species that composed the by-catch of the crab pots and the gill nets are *"target species"* and are collected by them for their daily source food and income.

As to the fish fauna, the file fish, *Monacanthus chinensis* was observed to be highly associated with the net size deployed as it allows easy penetration of the species. Secondly, seagrass which is the BSC habitat happens to be the main source of food to this file fish. It is therefore likely that they be trapped/caught in the process. Lastly, these file fish have long been used as bait that can increase their chance of being caught in large numbers.

This information revealed that BSC fishery targets a fairly high number of species and is not selective for species or size classes. While the number of observed trips conducted during this study were relatively low, the information collected provides resourceful information on the occurrence and seasonality of the commonly occurring by-catch species encountered in both gillnet and crab pot gears. This information therefore forms a basis for further studies on by-catch in association with this fishery regarding potential long-term impacts on other seasonal species to ensure sustainability of populations.

Another observation was that the gillnet height plays a vital role in both fisheries and by-catch species composition. From a commercial view point, they have a capability of capturing/trapping a wide range of blue swimming crab species that could be of great economic value and importance to fishermen and the Philippine fishing industry as a whole. However, this has been observed to negatively contribute to by-catch great number as higher mesh-down results to a large yet untargeted species number. Hence, it is recommended that the mesh size below should be reduced to avoid catching these untargeted species which always end up as by-catch. Adopting crab pots as a gear by the fisheries as realized in the study is not only important in reducing by-catch species' diversity but because they are economically affordable and low maintenance. In terms of mesh size, the current sizes deployed by the fishermen for both gillnets and crab pots have ensured that at least a majority of incidental catch were of mature lengths.

4.3 Recommendations for Future Studies

Based on the findings of this study, the following are recommended;

1. More attention should be given into the management of the Blue swimming crab fishery by implementing a **Management Plan** with focus on multispecies data level rather than on single species to help in detecting how many individuals are removed from a population and help in analyzing the different demographic effects a certain fishery is facing and this will help in the conservation process.
2. More assessments and evaluations should be conducted in future that should include the addition of more fishermen and widening of the study area. These will help in the gathering of enough data for preparation of database system which can be an essential feature to future coastal resources management plans or programs.

3. We recommend a technological modification of the gears used (net in particular) by reducing of the height or number of meshes down in order to increase selectivity and reduce the catch of this untargeted organisms.
4. Quantification of by-catch ratios should be conducted since this information will help establish a knowledge baseline from which changes in by-catch ratios can be monitored and also to inform decision making processes for future fisheries management plans.
5. A by-catch database system should be created on future studies of by-catch species since it will be an essential feature to future coastal resources management plans. The database should include the correct identification and measurements of by-catch species from the two fishing methods (gill-nets and crab pots) to allow the management to understand the most affected species and the effective gears to be used. With the incorporation of this database into the management of BSC Fishery, management plans can be formulated to eliminate the non-target species.
6. Lastly, training should be conducted to the fishermen in the study sites in order to educate them on the impacts and importance of these species.

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APPENDICES

APPENDIX-A: Definition of Terms

Artisanal	fisheries that are small scale and subsistence in nature, in contrast to industrial. Artisanal fishing effort is often unmonitored by regional fishery commissions.
By-catch	incidental capture and mortality of non-target marine animals during fishing is known as by-catch.
Demersal	A habitat or fishing range on or near the bottom of the ocean. Demersal fisheries target bottom-dwelling fish.
Ecosystem	community of living organisms in conjunction with the Non-living components of their environment interacting as a system.

APPENDIX-B: PACPI Contract Agreement

CONTRACT AGREEMENT

This **STUDENT RESEARCH GRANT AGREEMENT** is made into by and between:

Philippine Association of Crab Processors, Inc., with principal address at G/F Benedicto College, A.S. Fortuna St., Mandaue City, Cebu, represented herein by its President, Kunho Choi, hereinafter referred to as "PACPI";

and

(1) Leah Nyarangi Mainye of legal age, Kenyan, with residence address at Lot 9, BE Northville Cabancalan, Mandaue City hereinafter called the "GRANTEE".

(2) Naomi Ruki of legal age Papua New Guinea, with residence address at University of San Carlos Dormitory, Bagait, Talamban, Cebu City hereinafter called the "GRANTEE".

(3) Aron Ron of legal age, Malaysian, with residence address at KYO Residences hereinafter called the "GRANTEE".

WHEREAS, PACPI is a non-profit organization that seeks to develop the common good and well-being of the blue swimming crab industry through collaborative work with government and non-government institutions,

WHEREAS, PACPI seeks to encourage student participation in Fisheries Improvement Projects for Philippine Blue Swimming Crab, *Portunus pelagicus*, through science research;

WHEREAS, the GRANTEE, equipped with proper training, skills, and education to undertake the project, accepts the Student Research Grant of PACPI with all its terms and conditions specified in this Agreement.

NOW, THEREFORE, for and in consideration of the foregoing premises and the mutual covenants hereinafter set forth, the parties agree on the following:

A. RESPONSIBILITIES OF PACPI

1. Provide financial support to the Grantee for one (1) year
2. Issue 40% of the grant to the Grantee within thirty (30) days upon signing of this Agreement, another 30% upon submission of progress report of any format to PACPI within 4 to 6 months and the remaining 30% upon submission of 1st thesis draft (for confirmation of adviser)
3. Recommend research areas aligned with the thrusts of PACPI
4. Issue one-time adviser's fee upon completion of the Grantee's thesis
5. Participate in partnership activities such as meetings, workshops and communication of findings

Page-1

6. Consult with partners on the appropriate use, sharing, and publishing of data
7. Have the right to hold or terminate the grant for failure to comply with requirements or conduct activities expected from him/her
8. Hold no liability to the Grantee's acts or omissions resulting in damage, loss or injury to third persons, properties, to the school or to the Grantee himself/herself.

B. RESPONSIBILITIES OF THE GRANTEE

1. Enrol in ______________________________ at the University of San Carlos (USC) for the commencement of thesis study
2. Implement his/her thesis based on the approved topic
3. Maintain good academic performance set by WPU
4. Receive the following financial support per thesis/research topic:

    i. Thesis support grant - Php 25,000 for B.S. and Php 50,000 for M.S.
    ii. Local conference support - Php 5,000 for B.S. and Php 8,000 for M.S.
    iii. Publication fee subsidy - Php 3,000 for B.S. and Php 5,000 for M.S (given as incentive if publication is free)

5. Submit the following requirements:

    i. Proof of enrolment to the University
    ii. Thesis proposal approved by the adviser
    iii. Progress report within six (6) months of study
    iv. One (1) hard-bound copy of final and approved thesis within one (1) month upon completion or not later than eighteen (18) months upon signing of this Agreement

6. Acknowledge PACPI in thesis papers, conference posters and related materials
7. Abide by school policies while under the jurisdiction of USC
8. Pay the appropriate penalties if his/her grant has been terminated due to any grounds listed in Article C.
9. Advise PACPI for any extension in the study period. However, no additional monetary assistance will be given. Extension of more than six (6) months will forfeit local conference support and publication fee subsidy.

C. TERMINATION OF GRANT

1. Grounds for Termination of Grant
    i. Breach of contract
    ii. Wilful abandonment of the grant
    iii. Gross misconduct
    iv. Non-completion of study

2. Termination of the grant obligates the student to refund in full the financial support given to him/her with 10% one-time penalty.

Page-2

This AGREEMENT shall be effective for one (1) year commencing upon signing, unless earlier revoked or extended and renewed by the parties.

This AGREEMENT is made under and shall be construed according to the laws of the Republic of the Philippines.

IN WITNESS WHEREOF, the parties hereto have signed this Agreement on this ____day of ________ 2017 in __________.

KUNHO CHOI President PACPI	**LEAH MAINYE** Grantee
NAOMI RUKI Grantee	**AARON ROA** Grantee

Witness:

DR. FILIPINA SOTTO
Adviser
University of San Carlos

Page-3

ACKNOWLEDGMENT

REPUBLIC OF THE PHILIPPINES)
Mandaue City CITY) S.S.

BEFORE ME, a Notary Public, for and in Mandaue City, personally appeared:

Name	Comm. Tax Cert. No.	Date/Place of Issue
1. KUNHO CHOI	Passport # M4593198	December 9, 2013 / Korea
1. LEAH MAINYE	Passport # A2366238	June 9, 2015 / Kenya
2. NAOMI RUKI	Passport # C11004	October 17, 2015 / Papua New Guinea
3. AARON ROA	Passport # A36494703	December 21, 2015 / Malaysia

All known to me to be the same persons who executed the foregoing Contract Agreement, written and signed by the parties on each and every page thereof and acknowledged the same to be their free and voluntary act and deed as well as the entities represented.

WITNESS MY HAND AND SEAL this _____ day of JUN 2 8 2017 _____ in the aforementioned place.

NOTARY PUBLIC

VICTOR REY T. GINGOYON

Doc. No. 237
Page No. 49
Book No. 67
Series of 2017.

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2011	Assistance Supervisor – Uzuri Foods Limited –Kenya
2010	Procurement Office Intern -Egerton University -Njoro-Kenya

Conferences Attended:

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- 2017 Discovering the oceans–University of Southampton, London. (Online)
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Honors and Awards Received:

2016 48th Annual National Convention of the Federation of Institutions for Marine and Fresh Water Science 2016(FIMS)Northern Samar, Philippine.

2016 Shangri-La Marine Sanctuary Wet Season Reef Assessment
Mactan, Lapu-lapu City, Philippines

2015 3rd Place University of San Carlos Biology Integrated Organization Amazing Race

2011 Certificate of Completion of Sogeri National High School,Central Province, Papua New Guinea

2010	3rd Place Institute of Business Studies Debate Competition
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2009	3rd Place Mathematics, Popondetta Secondary School, Oro Province, Papua New Guinea

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- 2011-2012 Sogeri National High School Class Vice President Central Province, Papua New Guinea
- 2011 Sogeri National High School Social Chairperson Central Province, Papua New Guinea
- 2011 Sogeri National High School Enga & Southern Highlands Students (ENSO) Student Association Treasurer Central Province, Papua New Guinea
- 2011 Sogeri National High School Oro Province Student Association Secretary, Central Province, Papua New Guinea

Other Skills:

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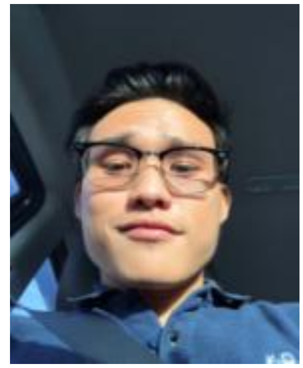
- arcGis 10.2.2 Software & 10.4.1 Software
- Google Earth Pro Software
- Microsoft Office Software
- Adobe Photoshop CS6

CURRICULUM VITAE



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EXPERIENCES

Tropical Research and Conservation Center (TRACC), Sabah Borneo, Malaysia
Dive Volunteer (2016)

- Learned and applied techniques on coral reef restoration
- Managed the safety of sea turtle eggs for the turtle hatchery
- Constructed and deployed artificial reefs

Participated in the 48th Annual National Convention of the Federation of Institutions for Marine and Freshwater Sciences 2016 (FIMFS), Northern Samar, Philippines

- Presented research titled "The Effects of Salinity and Temperature on the Survival and Attachment of *Cassiopea andromeda* planula larvae"

CATCH COMPOSITION OF BOTTOM SET GILLNET ALONG THE WATERS OF BATAD, ILOILO

BELLE MARGARETTE MATILLANO SEGURIGAN

An Undergraduate Thesis Presented to the
Institute of Marine Fisheries and Oceanology
College of Fisheries and Ocean Sciences
University of the Philippines Visayas

In Partial Fulfillment of the Requirements for the Degree of
Bachelor of Science in Fisheries

JUNE 2018

CERTIFICATE OF APPROVAL

The undergraduate thesis attached hereto, entitled "**Catch Composition of Bottom Set Gillnet Along the Waters of Batad, Iloilo**" prepared and submitted by **Belle Margarette M. Segurigan**, in partial fulfilment for the Degree of Bachelor of Science in Fisheries, is hereby recommended for acceptance and approval:

____

GERALD F. QUINITIO, Ph. D.
Adviser

Date Signed: __________________

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Miagao, Iloilo

ABSTRACT

Catch composition of bottom set gillnet which targets blue swimming crab *Portunus pelagicus* were monitored from November 2017 to April 2018 in Batad, Iloilo. The highest amount of *P. pelagicus* caught was 7.05 kg in December, while the lowest recorded was in March (2.60 kg). In the entire duration of the study, female *P. pelagicus* had higher number of occurrence than male based on the samples obtained from the landing site. Moreover, samples with carapace width of 12.1-13.0 cm had the highest number of occurrence, followed by samples with 11.1-12.0 cm CW. The total bycatch composition was composed of 14 families of fishes, 2 families of crustaceans, gastropods, and elasmobranchs. The catch was dominated by the target species, *P. pelagicus*, followed by two species of flatfish, *Synaptura marginata* (29%) and *Pseudorhombus* sp. (20%). These were followed by spotted filefish (15%), flathead (5%), crustaceans such as sentinel crab, crucifix crab, smoothshelled swimming crab and mantis shrimp (9%), gastropods (murex shells and crowned baler at 5%), elasmobranchs (carpet sharks and blue stingray at 2%). Other byctach identified were threadfin, parrotfish, lizardfish, and spotted stingerfish. These bycatch species, except murex shells and spotted stingerfish were utilized for human consumption. Moreover, the CPUE of the bycatch and the target species increased during wet season (November to January) and declined during first two months of the dry season (February to March). However, a sudden increase in the CPUE of the total catch was recorded during the month of April. T-test showed no significant difference in the CPUE of bycatch (p=0.311) and target species (p=0.827) between the two seasons. Moreover, there were also no significant difference in the CPUE of bycatch and *P. pelagicus* during the wet season (p=0.225) and during the dry season (p=0.102).

Keywords: blue swimming crab, bottom set gillnet, CPUE, catch composition, bycatch

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1. Background of the Study

Blue swimming crab, *Portunus pelagicus,* fishery is widespread in Western Visayas, particularly in the Visayan Sea and Guimaras Strait (Ingles, 2004). *P. pelagicus* thrives best in nearshore marine areas and estuarine waters. This crab species are cosmopolitan in the coastal waters of the Philippines (BFAR, 2013). *P. pelagicus* prefers sandy and sand-muddy habitats, usually between 10 to 15 m deep shallow waters (FAO, 2016). They are powerful swimmers, hunters and scavengers in which they are considered mainly as carnivores, and are targeted as one of the most valuable component of the fishery industry.

P. pelagicus is among the dominant component of the municipal fishery in the country in which about 50% of the stocks are obtained from the Visayan Sea and Guimaras Strait (Ingles, 2004). Record shows that there was an increase in the *P. pelagicus* landings from 25,000 MT in 1992 to 40,000 in 2004 (Ingles, 2004). However, due to high commercial demand, ghost fishing and recruitment overfishing, a decrease in the production was observed in 2010 (BFAR, 2012). In western Visayan Sea, several crab fishing gears are used in *P. pelagicus* fishing which includes crab pot, crab trap, filter net, fish trap, otter trawl, modified Danish seine, surface set gill net, and bottom set gillnet (Mesa et al., 2014).

Among the fishing gears, crab pots and bottom set gillnet are the two most common gears used in the *P. pelagicus* fishery (Taylor, 2013). Gillnet is composed of a large net wall that hangs vertically in water. It is widely used in artisanal fisheries because of its low cost and requires less effort (FAO, 2001). It catches wide variety of benthic and demersal species (Greenpeace International, 2008) and any fish species that may be entangled while they are swimming, thus, bycatch are of big concern in utilizing such gear. In addition, it does not allow juvenile crabs and other aquatic organisms to escape. Lost and abandoned gears can also cause ghost fishing which is one of the problems of using gillnet. Bycatch of bottom set gillnet poses great pressure and threat to other protected, endangered and threatened species (BFAR, 2013).

The Visayan Sea is one of the most common fishing grounds in the country. Batad, Iloilo is one of the municipalities around the Visayan Sea. In this regard, studying the catch composition of bottom set gillnet will be helpful to efficiently manage the fishery of the Municipality of Batad, Iloilo. Moreover, estimating the catch per unit effort (CPUE), as well as collecting information and data will help in assessing the status of the fishery in the area.

1.2. Objectives

This study aimed to determine the following from the catch of bottom set gillnet along the waters of Batad, Iloilo:

1. catch composition;
2. identify the commercially important bycatch;
3. CPUE of the total bycatch and target species;
4. influence of the season on the catch abundance; and
5. describe the gear used and their operation.

1.3. Significance of the Study

The purpose of this study was to know the current status of *P. pelagicus,* most importantly the non-target species using bottom set gillnet along the waters of Batad, Iloilo. The gear selectivity of bottom set gillnet was assessed since it was the only fishing gear that was observed in this study. Moreover, the bycatch of the gear was identified. The result of the study can be helpful in determining and formulating fishery management measures to lessen the amount of incidental catch of non-target species and improve the sustainability of *P. pelagicus* fishery in the area.

1.4. Scope and Limitations

This study primarily focused on the bycatch composition of bottom set gillnet along the waters of Batad, Iloilo. Sampling was conducted twice a month from November 2017 to April 2018. The samples were from the fishermen who operated using bottom set gillnet around the area. About 10% of the total bycatch were sampled randomly. However, if there was less bycatch obtained, all of the samples were measured and identified.

CHAPTER 2
REVIEW OF RELATED LITERATURES

2.1. Taxonomy and External Morphology

Blue swimming crab *Portunus pelagicus* (Linnaeus 1758), locally known as *alimasag*, *kasag*, *lambay* and *masag*, is an economically important commodity of the Philippine fisheries industry. *P. pelagicus* are tropical species belonging to the Phylum Arthropoda, Class Crustacea, Order Decapoda and Family Portunidae (BFAR, 2013). Generally, *P. pelagicus* are characterized by their hard, rough and broadly flattened extending to the nine protrusions on the sides with the last one quite pronounced carapace (BFAR, 2013). The chelae of this species is elongated and appears more in male than in female with conical tooth at the base of the fingers (FAO, 2016) and the legs are laterally flattened to varying degrees which acts as swimming paddles (DA-BFAR, 2013). In addition, male *P. pelagicus* is blue in color and much larger than females, while females are mottled brown (WAM, 2017).

2.2. Distribution, Habitat and Biology

P. pelagicus is widely distributed throughout the Indo and West Pacific Oceans – from Japan and the Philippines, throughout Southeast and East Asia and westward to the Red Sea (FAO, 2016). It primarily inhabits wide range of inshore and continental shelf areas, which includes sandy, muddy and seagrass habitats, from the intertidal zone to at least 50 m depth (Safaie et al., 2013). Juvenile *P. pelagicus* is mostly found in shallow waters while the mature ones are commonly found in sandy substrates of deeper water of up to 20 m isobaths (Ingles, 1996). This crab species primarily feed on a wide variety of sessile and slow moving benthic invertebrates such as hermit crabs, gastropods, bivalves and ophiuroids, and are exclusively carnivores (FAO, 2016).

2.3. Production of *P. pelagicus* in the Philippines

P. pelagicus fishery is one of the major components of the small-scale or municipal fishery in the Philippines (Batoy et al., 1980) and is considered an important part of the local fisheries production (Germano, 1994). The Philippines landed third in worldwide production of blue swimming crab and second among

Southeast Asian countries (Corpuz and Mananghaya, 2017). About 50% of the species production comes from Western Visayas, specifically in the Visayan Sea and Guimaras Strait (Ingles, 2004). According to Romeo (2009), administrative regions of V, VI and VII constitute 51.26% of the total production of the country. *P. pelagicus* landings have recorded 25,000 MT in 1992 and 40,000 MT in 2004 (Ingles, 2004). However, data from BFAR (2012) showed that there has been a declining trend from 31,509 MT in 2008 to 28,170 MT in 2010. According to the Bureau of Agricultural Statistics in 2011, 29,272 MT of *P. pelagicus* were produced (Corpuz and Mananghaya, 2017). Moreover, total blue swimming crab landings of the country showed two patterns: one before the peak in the early 1990s and second is after the peak in the late 1990s (Ingles, 2004). In addition, *P. pelagicus* landings in the Visayan Sea showed an alarming shift towards smaller crabs in the year 2002-2003 (Fish Source, 2011). The decline in the production may be attributed to high commercial exploitation, ghost fishing and recruitment overfishing (Ingles and Flores, 2000).

2.4. *P. pelagicus* Fishing Grounds

The Visayan Sea and Guimaras Strait are the major contributors in *P. pelagicus* production (de la Cruz et al., 2015). Asid Gulf, Bohol Sea, Samar Sea, Carigara Bay, Sorsogon Bay, northern part of Ragay Gulf, Tayabas Bay, Malampaya Sound, Panguil Bay and the waters of Tawi-Tawi in Mindanao also constitute the yearly *P. pelagicus* production (Ingles, 2004). The Visayan Sea surrounds most municipalities in the northern part of Iloilo, island of Eastern Visayas and Central Visayas. It is one of the important areas for the conservation of cetaceans, elasmobranchs and other marine species (Fish Source, 2011). Despite the positive assessment that overfishing is happening in the area as indicated by the variations in the species composition and the decreasing trend of catch rate, the Visayan Sea is still the most productive fishing ground in the country (Fish Source, 2011).

2.5. *P. pelagicus* Fishing Gears

Usually, fishing gears such as municipal trawl, fish corral, crab entangling net, pulling net or *suwayang*, crab pot and traps, push net, and man trawl using sailboat are utilized in *P. pelagicus* fisheries (BFAR, 2013). Among these gears, bottom set gillnets and crab pots are primarily used for catching *P. pelagicus*. Crab pots, locally known as *panggal,* are enticing devices usually made of bamboo splits woven together and provided with a non-return vent for easy entrance but difficult to exit mechanism (BFAR, 2013). According to FAO (2001), set gillnet is a simple-structured gear which is handy for artisanal fisherfolk. Gillnet or entangling nets are also prevalent in the *P. pelagicus* fisheries. It is a long rectangular panel of netting and vertically-held in the water column (FAO, 2001). It is anchored with the use of sinkers to keep the net in contact with the bottom of the ocean floor. Gillnets are non-selective gear in which it does not allow the escape of the organisms being entangled. In addition, the retained and discarded bycatch is important and poses a great pressure to other protected, endangered and threatened species (BFAR, 2013), and the continued use of entangling nets as well as trawl fishing will result in the loss of the main source of income for 30% of the *P. pelagicus* population (Ingles, 1996 as cited by BFAR, 2013).

2.6. Bottom Set Gillnet Efficiency and Bycatch Species

Gillnetting is the most important low energy fishing practiced by artisanal fishermen. This gear catches aquatic organisms by entangling or gilling in the meshes of the netting (FAO, 2001). However, for bottom set gillnet fishery, bycatch at times is more abundant than the targeted species. In the Visayan Sea, *P. pelagicus* comprises 42% of the total catch, while 58% of which is bycatch (Fish Source, 2011). Some of bycatch includes the Indo-Pacific crab *Charybdis ferriata* which composes 6.5% of the total catch, fish (3.81%), and other crab species (45.34%) (Romeo, 2009). In Guimaras Strait, similar bycatch were observed. However, data from Bantayan Island recorded juvenile bycatch such as reef sharks and sting rays (Fish Source, 2011). Irrawaddy dolphins, which are considered as a critically endangered species, are also caught accidentally by bottom set gillnet (Taylor, 2013).

2.7. Seasons in the Philippines

Philippines is a tropical country, thus, it has only two major seasons: (1) rainy season which is from June to November and (2) dry season, from December to May (PAGASA, 2017). Moreover, the dry season can be further classified into two types: (1) the cool dry season which is from December to February and (2) hot dry season which is from March to May. Climate in the country is also divided into four types based on the distribution of rainfall (Fig. 2.1). The province of Iloilo is classified under the Type III climate wherein seasons are not very pronounced, but there is a short dry season which is usually from February to April, and wet for the rest of the year (PAGASA, 2018).

Seasonal variations contribute to the catch composition during fishing activities. Moreover, seasons influence several factors which greatly affect the amount of catch obtained such as salinity, pH, temperature, and the availability of food organisms (Olukolajo and Oluwaseun, 2008).

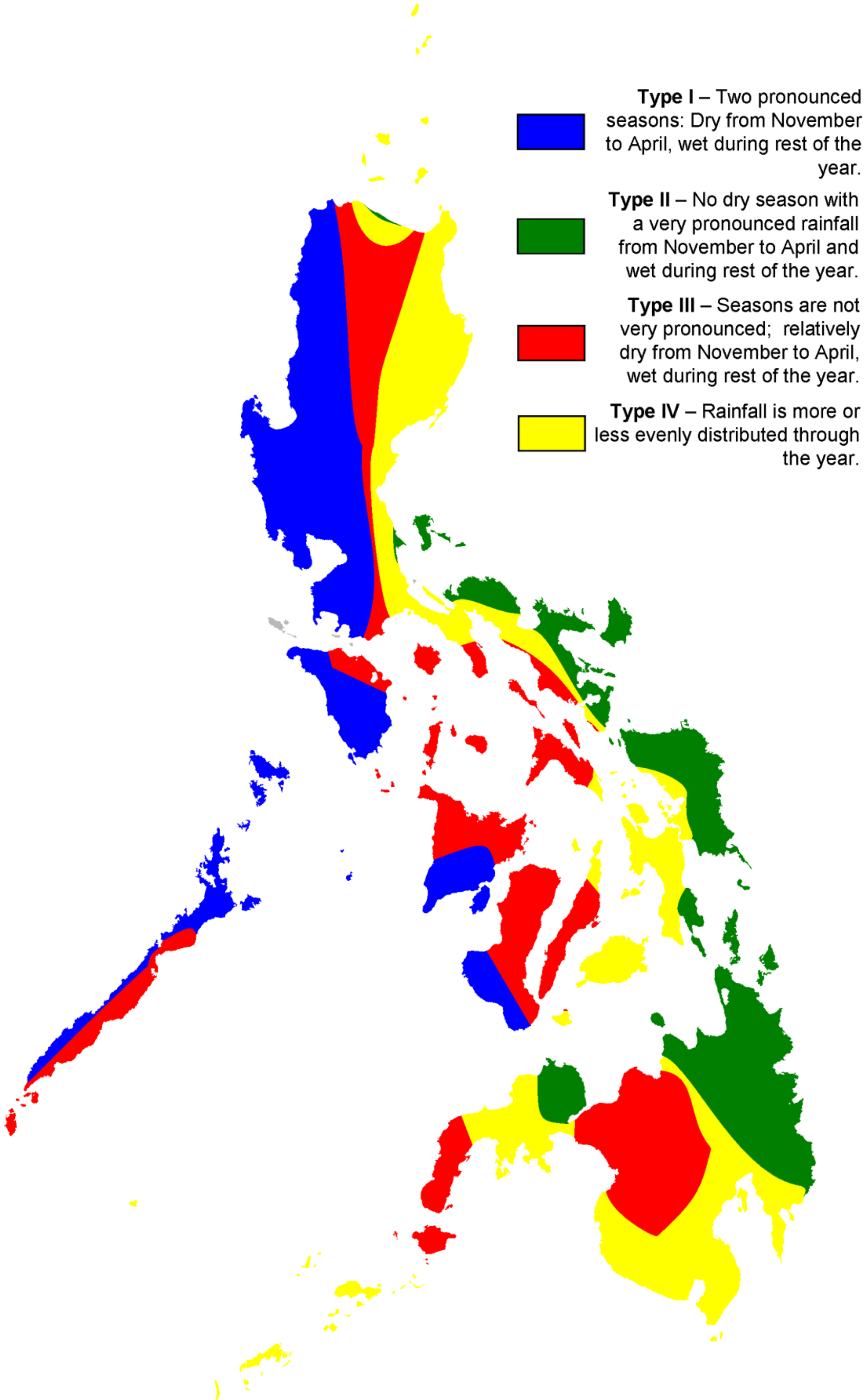


Figure 2.1. Map of the Philippines showing the four climate types (Source: Wikimedia, 2018)

CHAPTER 3
MATERIALS AND METHODS

3.1. Study Area

The study was conducted in Brgy. Binon-an, Batad, Iloilo (Fig. 3.1) where most fishermen usually land their catch. It is located 11°23'46.32"N and 123°8'26.17"E, and is one of the coastal barangays of the municipality.

Figure 3.1. Map of Western Visayas showing the location of the municipality of Batad, Iloilo (Source: www.zamboanga.com/z/index.php?title=Batad_Iloilo_Map)

3.2. Data Collection

Sampling of the catch composition of bottom set gillnet was conducted twice a month from November 2017 to April 2018 in the afternoon when the catch were landed. This period was divided into wet (November-January) and dry (February-April) based on the classification of PAGASA (2018) for Iloilo. The samples were gathered from the fishermen who operate using bottom set gillnet. The size and body weight (BW) of the samples were obtained using a Vernier caliper or ruler and a digital top loading balance (0.1 g sensitivity), respectively. For the size, the total length (TL) for fish and other bycatch and the external carapace width (CW) for the crabs were measured. The total catch composition of the gear was weighed using a spring balance with 1 kg capacity. In addition, the CPUE of the total bycatch and target species per operation were also calculated. The *P. pelagicus* obtained from the landing site where several gillnet fishers bring their catch were used to evaluate the daily frequency distribution of different sizes of male and female and the daily distribution of both sexes of *P. pelagicus*.

Moreover, two bottom set gillnets were used to evaluate the catch composition; first gear was used from November to December 2017, while the second gear was used from January to April 2018. The design and gear dimensions, such as the length of the net used, mesh size, hanging ratio, and the depth of the net were determined. In addition, interviews with the fishermen were also conducted for the collection of supplemental data regarding the gear and the fishing operation.

3.3. Data Analysis

Data on the target and bycatch species, CPUE was calculated during the operations per month. Paired T-test was used to determine if there was a significant difference between the abundance of bycatch and the target species in between seasons using bottom set gillnet at $p=0.05$.

CHAPTER 4
RESULTS

4.1. Daily Catch of Bottom Set Gillnet

4.1.1. Daily biomass of catch

A total of 157 bycatch individuals were monitored during the entire duration of the study. Figure 4.1 shows the mean daily biomass of the catch from bottom set gillnet from November 2017 to April 2018. The highest mean daily bycatch biomass was recorded in December with a mean of 3.75 kg, while the lowest was observed in the month of March (0.66 kg). For *P. pelagicus,* the highest biomass was observed in December while the lowest was recorded in March with a mean of 7.05 kg and 2.60 kg, respectively.

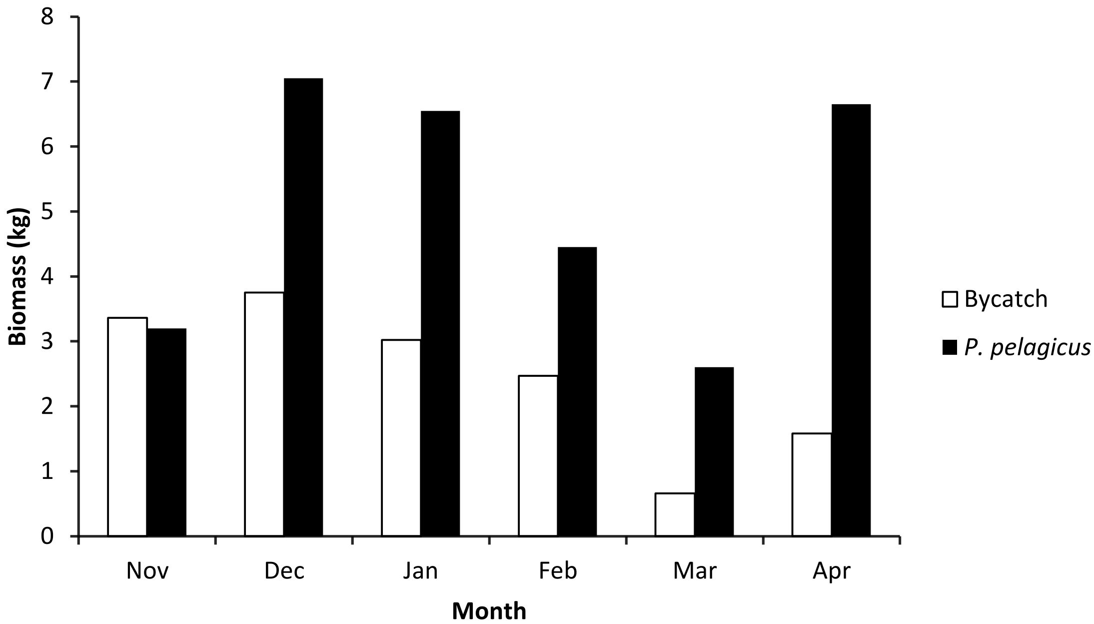


Figure 4.1. Mean daily biomass of bycatch and *Portunus pelagicus* caught by bottom set gillnet from November 2017 to April 2018 in Batad, Iloilo

Figure 4.1 shows that there was a decrease in the average catch, both the bycatch and the target species that was observed during the month of December (3.75 kg and 0.66 kg, respectively) until March (7.05 kg and 2.6, respectively). Moreover, highest occurrence of the catch was observed during the wet season (December) while a declining trend was observed during January and the first two months of the dry season (February to March). However, a sudden increase in the overall catch, especially the *P. pelagicus,* was recorded in April (6.65 kg).

4.1.2. Daily frequency distribution of male and female *P. pelagicus*

The catch from several gillnet fishers were evaluated and results showed that more female *P. pelagicus* were caught than the male. The daily number of male *P. pelagicus* decreased in December (109 crabs); however, it gradually increased from January (138 crabs) to April (261 crabs) (Fig. 4.2). On the other hand, the number of female *P. pelagicus* increased from November (238 crabs) to December (330 crabs), and suddenly decreased during January (212 crabs), however, it increased again during the first two months of the dry season (February to March) and decreased again in April (269 crabs) (Fig. 4.2). Moreover, the highest occurrence of male *P. pelagicus* was observed in April (261 crabs) while for female, the highest was in March (350 crabs). It was during the wet season (December and January) when the lowest number of male (109 crabs) and female *P. pelagicus* (212 crabs) were recorded. The highest frequency distribution of both sexes was observed during the dry season.

4.1.3. Carapace width of *P. pelagicus*

Figure 4.3 shows the frequency distribution of different sizes of male and female *P. pelagicus* obtained from the landing site during the wet season (November to January) (Fig. 4.3A) and dry season (February to April) (Fig 4.3B). Results showed that *P. pelagicus* with a carapace width (CW) of 12.1-13 cm has the highest number of occurrence in the entire duration of the study (252 males, 454 females), followed by samples with 11.1-12 cm (313 males, 291 females).

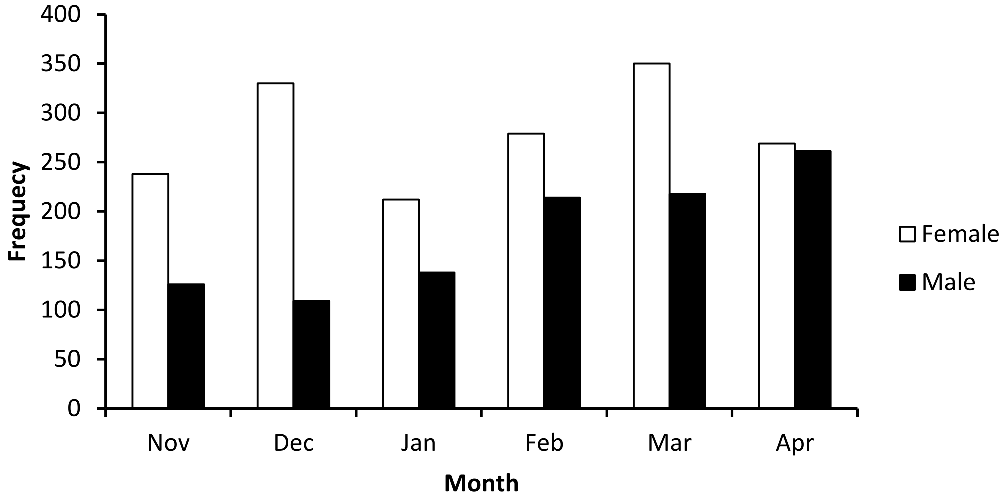
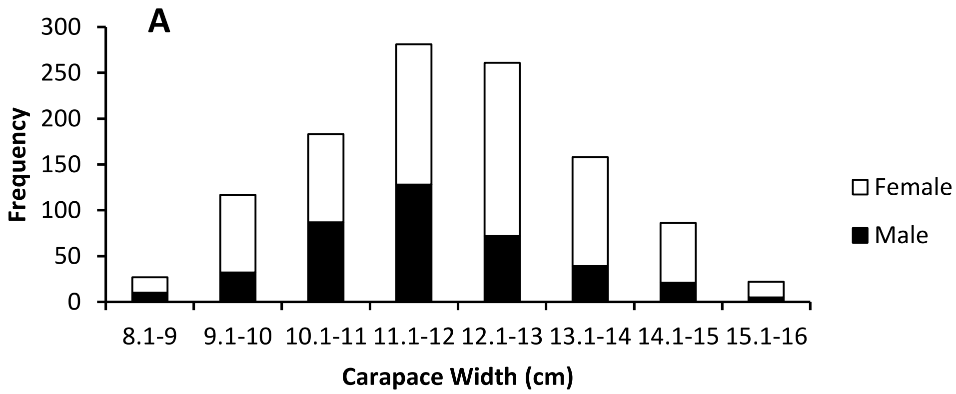


Figure 4.2. Daily frequency distribution of male and female *Portunus pelagicus* obtained from the landing site from November to January (wet season) and February to April (dry season)



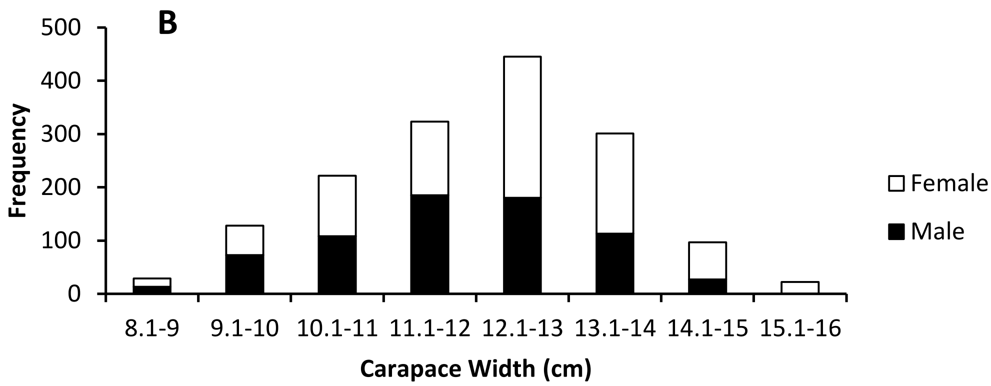


Figure 4.3. Frequency distribution of different sizes of male and female *Portunus pelagicus* obtained from the landing site during (A) wet season (November to January) and (B) dry season (February to April)

Figure 4.3A shows that during the wet season (November to January), samples with 11.1-12.0 cm CW had the highest number of occurrence with 128 males and 153 females, while samples with CW ranging from 15.1 to 16.0 cm showed the lowest number of occurrence with 5 males and 17 females *P. pelagicus*.

Moreover, samples with 12.1-13.0 cm CW showed the highest number of occurrence (180 male, 265 female) during the dry season (February to April) for both male and female *P. pelagicus* (Fig. 4.3B). This was followed by samples with 11.1-12.0 cm CW (185 male, 138 female), while the lowest number was observed in samples with 15.1-16 cm CW in which 22 females and no male *P. pelagicus* sample were recorded.

4.2. Catch Composition of Bottom Set Gillnet

Approximately 67% of the total catch monitored from the total catch of bottom set gillnet were *P. pelagicus* while the remaining 33% was bycatch which consisted of finfishes (26.40%), other crustaceans (2.80%), gastropods (1.60%) and elasmobranchs (0.6%) (Fig. 4.4). Figure 4.5 shows the trend of the total percentage of the *P. pelagicus* and bycatch caught by bottom set gillnet in Batad, Iloilo from November 2017 to April 2018. Lowest occurrence of *P. pelagicus* was observed during the wet season (November) which was approximately 49% of the entire catch. In contrast, the occurrence of *P. pelagicus* increased from 65% to 81% during the dry season (February to April). Moreover, the highest and the lowest percentage of the bycatch obtained were 51% and 19% of the entire catch which were in November and April, respectively.

Figure 4.6 shows the percentages of the bycatch species caught by bottom set gillnet in Batad, Iloilo from November 2017 to April 2018. Among the bycatch monitored, two species of flatfish were observed. The tongue sole *Synaptura marginata,* locally known as palad, was the most dominant species throughout the sampling period which comprised about 29% of the bycatch, followed by flounder *Pseudorhombus* sp. which was 20% of the bycatch composition. Other crustaceans, which included other crab species (*Charybdis affinis, Podolphthalmus vigil, Charybdis feriatus,* and *Portunus sanguinolentus),* and a mantis shrimp comprised almost 9% of the catch while gastropods and elasmobranchs (carpet shark and blue stingray) made up 5% and 2%, respectively, of the total bycatch. Other species monitored included spotted filefish, painted sweetlips, caranx, flathead, big-eyed croaker, threadfin, parrotfish, and stonefish were discarded.

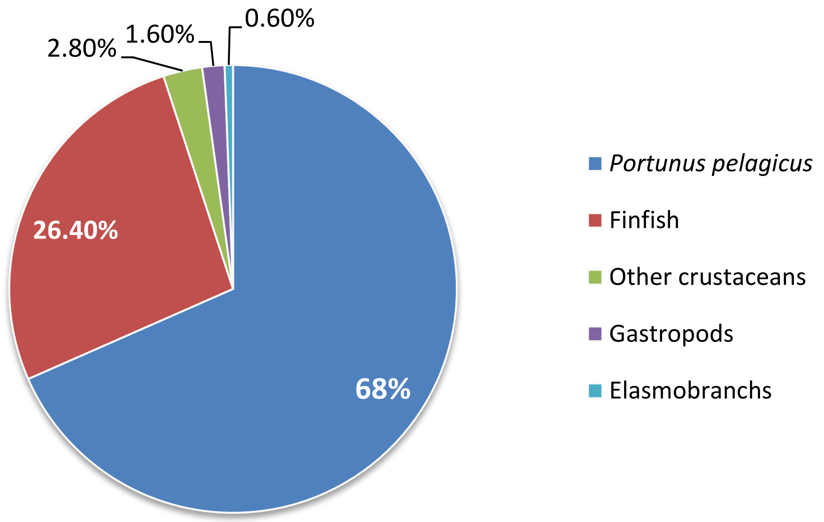


Figure 4.4. Percentage of *Portunus pelagicus* and bycatch caught by bottom set gillnet from November 2017 to April 2018 in Batad, Iloilo

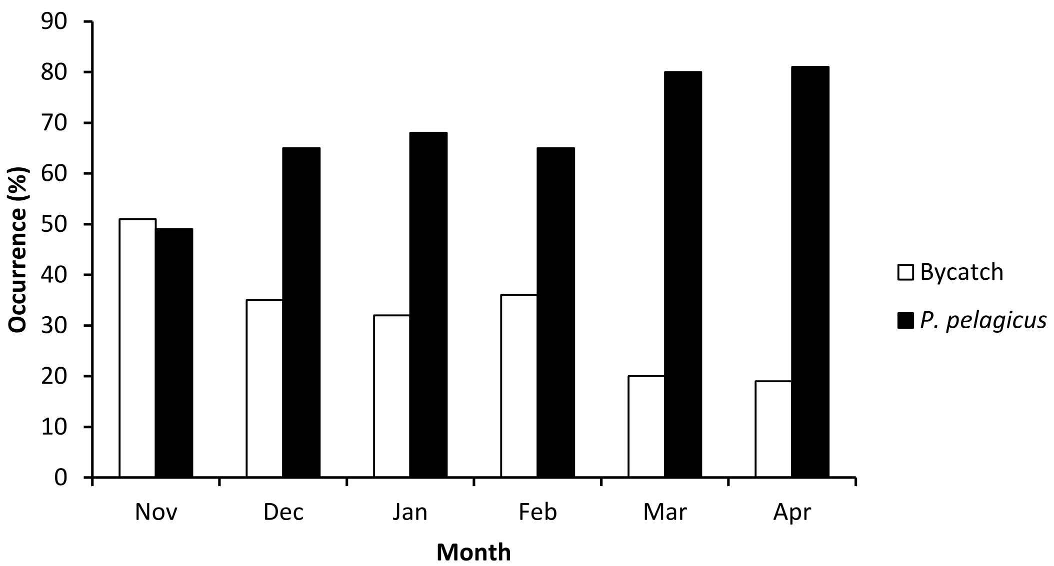


Figure 4.5. Daily mean occurrence of the bycatch and *Portunus pelagicus* caught by bottom set gillnet from November 2017 to April 2018 in Batad, Iloilo

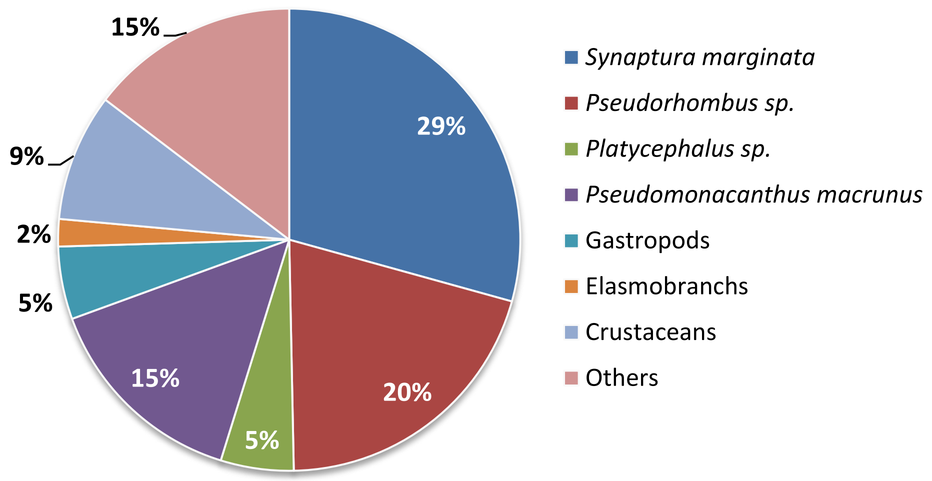


Figure 4.6. Percentage of the bycatch species caught by bottom set gillnet from November 2017 to April 2018 in Batad, Iloilo

4.2.1. Composition and utilization of bycatch

Table 4.1 shows the list of names of the bycatch species caught by bottom set gillnet and their utilization. All of the bycatch obtained were utilized for human consumption except the stonefish, locally known as *gatasan,* because it is considered venomous. The bycatch composition consisted of 14 families of fishes and 2 families of gastropods, crustaceans and elasmobranchs.

4.2.2. Conservation status of bycatch

Table 4.2 shows the list of bycatch and their conservation status according to the International Union for the Conservation of Nature Red List. There were bycatch that were vulnerable (*Hemiscyllium* sp.) and near threatened (*Scarus* sp.) species recorded during the entire sampling period. Other species caught were classified as least concern, not yet assessed and data deficient.

Table 4.1. Composition and utilization of bycatch caught by bottom set gillnet from November 2017 to April 2018 in Batad, Iloilo. R- Retained. D- Discarded

Family	Scientific Name	Common Name	Local Name (Used in Batad)	Utilization
A. Fish				
Soleidae	*Synaptura marginata*	Tongue sole	Palad	R
Paralichthyidae	*Pseudorhombus* sp.	Flounder fish	Palad	R
Platycepahalidae	*Platycephalus* sp.	Flathead	Sunogan	R
Monacabthidae	*Pseudomonacanthus macrunus*	Spotted filefish	Sulay-bagyo	R
Sciaenidae	*Pennahia macrophthalmus*	Big-eye croaker	Abo	R
Nemipteridae	*Nemipterus marginatus*	Pale-finned threadfin	Bisugo	R
Lutjanidae	*Lutjanus* sp.	Snapper		R
Synodontidae	*Saurida micropectoralis*	Shortfin lizardfish	Karaho	R
Leiognathidae	*Leiognathus* sp.	Ponyfish	Sapsap	R
Haemulidae	*Plectorhinchus pictus*	Painted sweetlips	Halatan	R
Scaridae	*Scarus* sp.	Parrotfish	Molmol	R
Gerreidae	*Gerres filamentosus*	Whipfin mojarra	Latab	R
Carangidae	*Carangoides* sp.	Caranx	Salamin-salamin	R
Synanceiidae	*Inimicus sinensis*	Spotted stingerfish	Gatasan	D
B. Crustacean				
Portunidae	*Charybdis affinis*	Smooth-shelled swimming crab	Alimango	R
	Podolphthalmus vigil	Sentinel crab	Alimango	R
	Charybdis feriatus	Crucifix crab	Kurusan	R
	Portunus sanguinolentus	Three-spot swimming crab	Kasag	R
Squillidae	*Squilla* sp.	Mantis shrimp	Pitik-pitik	R
C. Gastropod				
Muricidae	*Murex tribulus*	Caltrop murex	Pakinason	D
Volutidae	*Melo aethiopica*	Crowned baler	Lagang	R
D. Elasmobranch				
Hemiscylliidae	*Hemiscyllium* sp.	Carpet shark	Pating	R
Dasyatidae	*Dasyatis pastinaca*	Blue stingray	Pagi	R

Table 4.2. Conservation status of bycatch caught by bottom set gillnet in Batad, Iloilo according to the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species

Conservation Status	Species
Vulnerable	*Hemiscyllium* sp.
Near Threatened	*Scarus* sp.
Least Concern	*Dasyatis pastinaca*
	Gerres filamentosus
	Leiognathus sp.
	Carangoides sp.
	Lutjanus sp.
Not Yet Assessed	*Charybdis feriatus*
	Plectorhinchus pictus
	Podolphthalmus vigil
	Pseudomonachanthus macrunus
	Squilla sp.
	Pennahia macrophthalmus
	Saurida micropectoralis
	Nemipterus marginatus
	Portunus sanguinolentus
	Murex tribulus
	Inimicus sinensis
	Melo aethiopica
	Charybdis affinis
	Synaptura marginata
Data Defficient	*Pseudorhombus* sp.
	Platycephalus sp.

4.3. Daily CPUE of the Catch Composition of Bottom Set Gillnet

The mean daily CPUE of the catch of the bottom set gillnet during the study (Fig. 4.7) showed that the highest mean CPUE for the bycatch was recorded in January with 0.94×10^{-4} kg m^{-1} h^{-1}, followed by 0.77×10^{-4} kg m^{-1} h^{-1} in February.

Meanwhile, the lowest was observed in March with 0.21×10^{-4} kg m^{-1} h^{-1}. For the target species, highest CPUE was 2.07×10^{-4} kg m^{-1} h^{-1} in April while the lowest was recorded at 0.61×10^{-4} kg m^{-1} h^{-1} in November.

The CPUE of the total catch showed an increasing trend from November (0.61×10^{-4} kg m^{-1} h^{-1}) to January (2.03×10^{-4} kg m^{-1} h^{-1}) of the wet season while a decline was noticed from February (1.38×10^{-4} kg m^{-1} h^{-1}) to March (0.81×10^{-4} kg m^{-1} h^{-1}) of the dry season. However, the CPUE of *P. pelagicus* abruptly increased in April (2.07×10^{-4} kg m^{-1} h^{-1}), which was also the highest recorded CPUE of the target species in the entire duration of the study.

Paired T-test results showed that there was no significant difference in the CPUE of the bycatch ($p=0.311$) and *P. pelagicus* ($p=0.827$) caught during the wet and dry season. Moreover, CPUE of bycatch and *P. pelagicus* during the wet season ($p=0.225$) and during the dry season ($p=0.102$) also showed no significant difference.

4.4. Gear Description and Operation

Two bottom set gillnets were used for determining the catch composition in Batad, Iloilo in this study. The first gear was monitored from November to December 2017. The gear had a total length of 6,583.8 m, which was composed of 30 panels measuring 219.46 m each and a depth of 1.13 m. It is a single netting wall made up of 0.25 mm polyamide netting with 4.5 cm mesh size and a hanging ratio of 0.26 cm. Rubber materials, specifically the one used in slippers, were utilized as floaters of the gear which is attached to a 6 mm polypropylene headrope or upperline. The gear also utilized *badjawe* or lead as sinkers. The bottom set gillnet was usually deployed in areas with approximately 32 m depth from 0600 H to 1500 H.

The bottom set gillnet used from January to April 2018 was 4,023.6 m total length with a single netting wall which was composed of 22 panels with each unit measuring 182.88 m. The gear used 0.25, 0.60 and 0.90 mm polyamide netting and had a depth of 1.13 m. It also had a 4.5 cm mesh size and a hanging ratio of 0.26 cm. Rubber and *badjawe* were also used as floaters and sinkers, respectively. These materials were attached to a 6 mm in diameter polypropylene headrope and footrope. Moreover, it was also deployed from 0600 H to 1500 H.

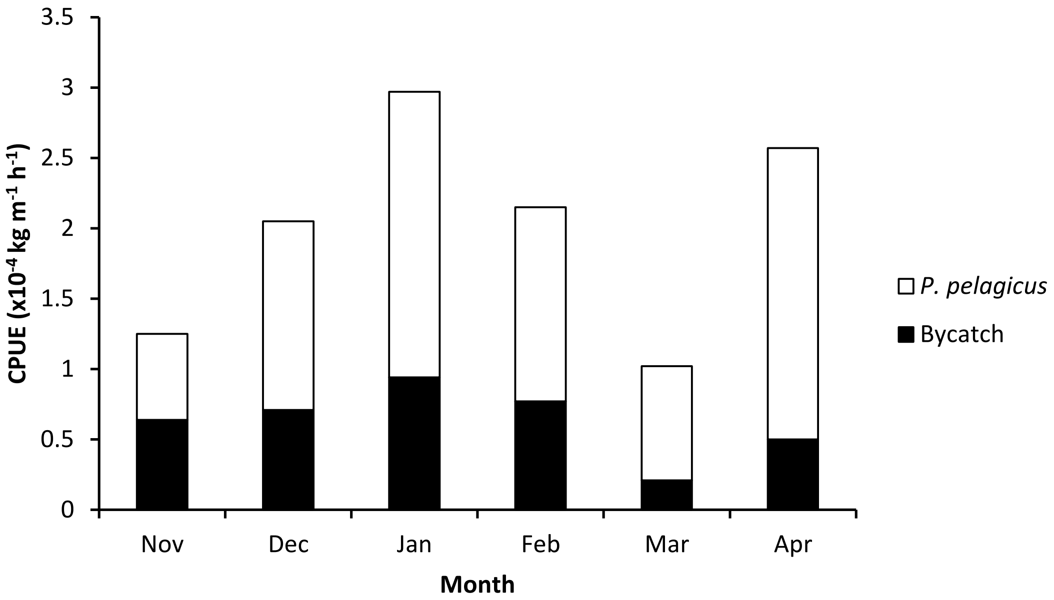


Figure 4.7. Mean daily catch per unit effort of *Portunus pelagicus* and bycatch of the bottom set gillnet caught in Batad, Iloilo from November 2017 to April 2018

CHAPTER 5
DISCUSSION

5.1. Abundance of *P. pelagicus*

According to BFAR (2013), August is the common peak month for *P. pelagicus* while March and April are considered as lean months. However, in this study, the peak season for *P. pelagicus* in Batad, Iloilo was during the month of April based on the frequency of male and female *P. pelagicus* (Fig. 4.2) and the calculated CPUE of the target species (Fig. 4.7), while the lowest was recorded in March, which coincides with the common lean months for *P. pelagicus* as reported by BFAR (2013). In this study, the highest number of occurrence for female *P. pelagicus* was observed during the months of December and January.

In a study conducted by Hosseini et al. (2012), female *P. pelagicus* has the higher percentage of population from December to March, while it was during April to May when the large population of male *P. pelagicus* was recorded. This study showed the same results since the highest number of occurrence for female were observed during the months of December and April, while the highest recorded number of male was during April (Fig. 4.2). Moreover, according to Sara et al. (2016), the population of blue swimming crab is considered overexploited if the catch is dominated by small sizes of *P. pelagicus* (CW= <7 cm). The *P. pelagicus* caught by bottom set gillnet in this study showed that the stock in Batad, Iloilo may not be overexploited yet since it was dominated by catch measuring from 11.1 cm to 13 cm. However, this assumption was based on the gathered data solely on the carapace width of the samples.

The catch rate for *P. pelagicus* seems to be unpredictable due to the fluctuations in the catch data in the months from November to April in this study. Moreover, due to the increasing demand since early 1990, the *P. pelagicus* harvest had already declined from 20 kg per day in 1990 to 5 kg per day per fisherman in 2008 and 2009 (BFAR, 2013). There is no existing data on the *P. pelagicus* fishery in Batad, Iloilo; however, this study showed that the catch rate of *P. pelagicus* is relatively higher than that of the bycatch.

5.2. Bycatch of Bottom Set Gillnet

Some of the common bycatch of bottom set gillnet are juvenile sharks, other crab species, mollusks and fish (Ingles and Flores, 2000; Romeo 2009 as cited by Taylor, 2013). This study showed that the catch composition of the bottom set gillnets monitored were dominated by species of flatfish, tongue sole *Synaptura marginata* and flounder *Pseudorhombus* sp. Both species are known to inhabit sandy and muddy bottoms in coastal waters and primarily feed on marine benthic invertebrates (Encyclopedia of Life, 2016). These species are usually sold fresh or dried in the market. Flathead *Platycephalus* sp. was also one of the dominant species caught by bottom set gillnet which also inhabits the same area. Gastropods and some sand dollars were also caught by the gear. The bottom set gillnet was set in contact with the substrate which is probably one of the reasons why most of the species observed were usually bottom-dwelling organisms. Moreover, all of the bycatch fishes caught were utilized for human consumption, except spotted stingerfish *Inimicus sinensis*, locally known as *gatasan,* which is discarded since its anterolateral glandular grooves contain venom gland (Encyclopedia of Life, 2016), and murex shells.

Gastropods such as murex shells, crowned baler, and two juvenile carpet sharks were also caught during the conduct of the study. Because of the occurrence of these bycatch, concerns regarding the ecosystem and the disturbance in the food web should be taken into consideration (Taylor, 2013). Moreover, bycatch such as juvenile sharks and Irrawaddy dolphins are considered top predators and play an important role in the ecosystem (Taylor, 2013). Carpet shark is also listed as vulnerable by the International Union for the Conservation of Nature (IUCN), therefore, it is more likely to face a high risk of extinction in the wild (IUCN, 2001). In addition, juvenile sharks are known to interact with bottom set gillnet (Taylor, 2013), hence, they are more vulnerable to being entangled with the gear. In addition, parrotfish *Scarus* sp. is listed as near threatened by the IUCN. This might be due to the rampant overfishing and illegal fishing occurring in nearby municipalities such as Carles and Concepcion (Panay News, 2017) which resulted to disturbance of the natural habitat of the fish species. The rest of the bycatch species were listed as either least concern or not yet assessed (Table 4.3).

Other crab species such as sentinel crab, smoothshelled swimming crab and crucifix crab (Table 4.3) were also bycatch of the bottom set gillnet in this study and are listed as least concern by IUCN. The occurrence of crucifix crab among the catch was noticeable during the months of January to April 2018. In a study by Dineshbabu (2011), fishing season of the crab species in India extend generally from September to June, however, its peak season is generally during December to June. Other crab species only occurred once or twice in some months during the conduct of this study.

5.3. CPUE of the Catch Composition of Bottom Set Gillnet

Catch per unit effort is usually a derived quantity obtained from the independent values of catch and effort wherein the total catch is estimated from (FAO, 1969). Results of this study showed that the CPUE for both the bycatch and *P. pelagicus* were not consistent. As shown in Figure 4.3, the CPUE for the catch composition of bottom set gillnet increased in the first two months of the study, however, it steadily declined during the next three months, then increased again in April. The accuracy of CPUE as an index of abundance is primarily determined by whether catch efficiency remains constant and unaffected by other factors (Hubert and Fabrizio, 2007). An assumption that there is a positive linear relationship between CPUE and density is being considered when using this analysis as an index of abundance. However, this relationship tends to vary between species and is influenced by a wide range of factors which includes the net length, mesh size and material, season, and time of the day (Lake, 2013).

Several factors can also affect the catch rate of bottom set gillnet. One of these is the length of the gear. In the study of Minns and Hurley (1988), CPUE for the fish species, commonly called walleyes, decreased with increasing net length. However, in this study, the net length does not have a significant effect on the CPUE of both the bycatch and the target species. The CPUE for November and December showed an increasing trend. It was during these months in which longer bottom set gillnet was used for monitoring. Moreover, results for the next four months showed that net length does not directly affect the CPUE since it declined from January to March, and then abruptly increased in April. It may also be worth noting that shorter gillnet was used from January to April. Gillnet saturation can also be a factor affecting the catch rates. Saturation is often referred to as the diminishing returns with increasing effort; hence, longer setting time might result to a decline in the total catch rate (Minns and Hurler, 1988). The differences in the species behavior might also account to the varying results obtained during the conduct of the study since most of the bycatch were bottom-dwelling and sedentary while some are pelagic species.

One of the reasons of the varying CPUE for both the bycatch and the target species throughout the study might also be the clarity of the water which could affect the visibility of the gear to the organisms. According to the study of Minns and Hurley (1988), the variations in the catch rate of gillnet may be related to the ability of different species to avoid and detect nets under varying light and water conditions. Moreover, because of the occurrence of heavy rainfalls, even during dry season when this study was conducted, the clarity of the water in the area may have caused the fewer catch rates in some months.

Though season is one of the factors that may affect the CPUE of bottom set gillnet, paired T-test results showed no significant difference in the catch rate of bycatch species obtained during the wet and dry season ($P>0.05$). In addition, the CPUE for *P. pelagicus* is also not significantly different between the two seasons ($P>0.05$). Moreover, according to Fish Source (2011), bycatch is more abundant compared to the target species in the *P. pelagicus* gillnet fishery. However, this study showed otherwise; the CPUE for the target species was higher compared to the bycatch species. This indicates that *P. pelagicus* fishery in Batad, Iloilo was still sustainable.

5.4. Gear Description

In reference to the minimum mesh size for gillnet fishing which was 5 cm (BFAR, 2013), the mesh size of both gears were within of the ideal size. Moreover, it was also deployed in areas of more than 10 m depth. Hence, the bottom set gillnet operations used in this study complied with the limitations as stated in the BSC Management Plan of BFAR (2013). This study used two bottom set gillnets that were of different lengths. The one used for November and December was longer than the one used from January to April. However, net length did not directly influence the amount of catch in this study since the results showed fluctuating trend in the amount of catch within these months (Fig. 4.1). In addition, the hanging ratio of both gears was also within the range of the ideal hanging ratio for commercial nets which is between 0.25 and 0.65 (FAO, 2000). According to Machiels et al. (1994), catches of gillnets with the lowest hanging ratio of 0.25 is higher compared to that of the conventional gillnets (0.50). Although, there were no comparisons made in this study, the low hanging ratio of both gears might be one of the reasons for the efficiency of the gears in entangling variety of bycatch species as well as *P. pelagicus*.

CHAPTER 6
CONCLUSION AND RECOMMENDATIONS

6.1. Conclusion

Monitoring of the catch composition of bottom set gillnet was done in Binon-an, Batad, Iloilo. It was observed that during the wet season, the abundance of bycatch and *P. pelagicus* showed an increasing trend; however, it decreased during the first two months of the dry season. The catch rate of the monitored gear showed a sudden increase in April which was also the highest (2.07×10^{-4} kg m^{-1} h^{-1}) recorded CPUE in the whole duration of this study. Moreover, *P. pelagicus* had the highest percentage of the total catch composition, followed by the different bycatch species.

Among the bycatch caught by the gear, there were 14 families of fishes and 2 families of crustaceans, gastropods and elasmobranchs. Moreover, it was primarily composed of fish species and other crab species listed as least concern organisms under IUCN. *S. marginata* and *Pseudorhombus* sp. were the two flatfish species consistently observed throughout the sampling period. All bycatch species were utilized for human consumption except *I. sinensis* and *Murex tribulus,* which were considered discards. Other crab species such as *C. feriatus, P. sanguinolentus* and *C. affinis* were caught during the dry season, while two carpet sharks were caught in November and January. Moreover, results showed that there was no significant difference in the CPUE of both bycatch and *P. pelagicus* between seasons.

6.2. Recommendation

Because there are still no existing studies regarding the status of blue swimming crab fishery in the municipality of Batad, Iloilo, further studies should be conducted in order to monitor the monthly catch rate of *P. pelagicus* as well as the status of the bycatch obtained during fishing operations. Also, monitoring of the different crab fishing gears and all of the gears being operated in the area is necessary to maintain a record regarding the amount of fishing pressure exerted into the resource; hence, the municipality can have a basis for the implementation of regulations towards sustainable fisheries in the municipality.

In addition, the sampling period was not enough to entirely assess the catch. A whole year sampling period would be ideal in order to fully evaluate the catch of bottom set gillnet. Assessing 100% of the bycatch composition is advised to determine the diversity of the species caught by bottom set gillnet.

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APPENDICES

Appendix A. Mean monthly bycatch and *Portunus pelagicus* catch data of bottom set gillnet sampled from November 2017 to April 2018 in Batad, Iloilo

Month	Bycatch (kg)	*P. pelagicus* (kg)
November	3.36	3.20
December	3.75	7.05
January	3.02	6.55
February	2.47	4.45
March	0.66	2.60
April	1.58	6.65

Appendix B. Some of the bycatch obtained from bottom set gillnet

Murex tribulus

Melo aethiopica

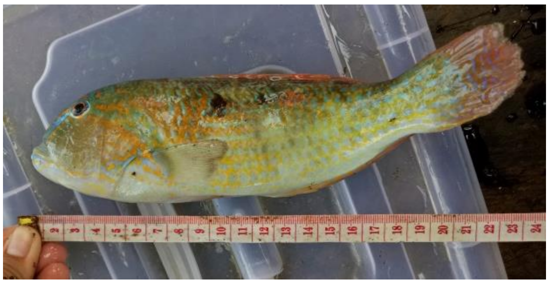
Hemiscyllium sp.

Pseudorhombus sp.

Synaptura marginata

Platycephalus sp.

Pennahia Macrophthalmus



Scarus sp.

Saurida micropectoralis

Pseudomonacanthus macrunus

Plectorhinchus pictus

Podolpthalmus vigil

Charybdis feriatus

Appendix C. Formula used for CPUE

$$CPUE = \frac{\dfrac{\textbf{Total weight of catch } (kg)}{\textbf{Total length of gillnet used } (m)}}{\textbf{Number of hours spent } (h)}$$

Appendix D. Calculated CPUE of the catch caught by bottom set gillnet from November 2017 to April 2018 in Batad, Iloilo

Month	Bycatch ($x10^{-4}$ kg m^{-1} h^{-1})	*P. pelagicus* ($x10^{-4}$ kg m^{-1} h^{-1})
November	0.64	0.61
December	0.71	1.34
January	0.94	2.03
February	0.77	1.38
March	0.21	0.81
April	0.50	2.07

Appendix E. Paired T-test

A. Bycatch

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1 VAR00001 - VAR00002	.00003	.00003	.00002	-.00006	.00011	1.345	2	.311

B. *Portunus pelagicus*

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1 VAR00003 - VAR00004	.00000	.00007	.00004	-.00017	.00015	-.248	2	.827

C. Bycatch and *P. pelagicus* (wet season)

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1 VAR00001 - VAR00002	-.00006	.00006	.00003	-.00020	.00008	-1.733	2	.225

D. Bycatch and *P. pelagicus* (dry season)

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1 VAR00004 - VAR00005	-.00009	.00006	.00003	-.00023	.00005	-2.881	2	.102

Appendix F. Bottom set gillnet used in monitoring the catch composition

SEASONAL VARIATION OF CATCH COMPOSITION AND STOCK ASSESSMENT OF BLUE SWIMMING CRAB (*Portunus pelagicus*) USING CRAB TRAP IN BANATE BAY, ILOILO

MA. MICHELLE MALUNES PEÑOL

An Undergraduate Thesis Presented to the
Institute of Marine Fisheries and Oceanology
College of Fisheries and Ocean Sciences
University of the Philippines Visayas

In Partial Fulfillment of the Requirements
for the Degree of
Bachelor of Science in Fisheries

JUNE 2017

CERTIFICATE OF APPROVAL

The undergraduate thesis attached hereto, entitled "**Seasonal Variation of Catch Composition and Stock Assessment of Blue Swimming Crab (*Portunus pelagicus*) Using Crab Trap in Banate Bay, Iloilo**" prepared and submitted by **Ma. Michelle M. Peñol**, in partial fulfillment for the Degree of Bachelor of Science in Fisheries, is hereby recommended for acceptance and approval:

____

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Date Signed: _________________

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ABSTRACT

Catch composition and difference of crab trap (*bubu*) catch between wet and dry season were determined from October 2016 to March 2017 at Banate Bay, Iloilo. Moreover, the exploitation status of *P. pelagicus* was also determined by assessing its spawning potential ratio. About 20% of the total bycatch and the target catch were taken randomly sampled. A total of 207 *P. pelagicus* were sampled during the 6 months sampling period. The target catch during wet season (October – December) (151 crabs) showed higher frequency compared to dry season (January – March) (56 crabs). T-test showed a significant difference (p=0.00082) in carapace width (CW) between two the seasons. Wet season had a mean CW of 12.27±2.53 cm while the dry season had 11.45±2.17 cm. Most of the samples during the wet season were dominated by females (85 crabs) while mostly males (31 crabs) were abundant during the dry season. Berried *P. pelagicus* was higher during the dry season (11% in February and 20% in March) than wet season (3% in November and 11% in December). The ratio of target catch to the bycatch during wet season (55% target: 45% bycatch) was higher than dry season (21% target: 71% bycatch). A total of 15 species of bycatch were identified. They consisted of 13 families, 15 genera and 15 species. All the bycatch, both fish and invertebrates, were utilized except the mantis shrimp. There were no endangered nor threatened species that were caught by the crab trap during the whole duration of sampling. Fishing pressure in Banate Bay was more than five times higher than that of natural mortality (F/M = 5.8). The SPR result was 6% and it is considered to be critical and needs proper management.

Keywords: seasonal variation, crab trap, blue swimming crab, spawning potential ratio, Banate Bay

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

CHAPTER 1
INTRODUCTION

1.1. Background of the Study

Blue swimming crab (*Portunus pelagicus*) is a marine crab belonging to the family Portunidae, which is typically bottom dweller that resides in tropical, subtropical estuarine and near shore habitats (FAO, 2016b), hence, they are widely distributed around the Indian and West Pacific Oceans. They are most likely to thrive in sandy and sand-muddy depths of shallow waters about 10 - 50 m depth. They are usually found near the reefs, mangroves, seagrass, and algal beds. It is locally known as *alimasag*, *kasag*, *masag*, and *lambay* in the Philippines (BFAR, 2016). It is one of the most important resources harvested and has a significant contribution to global food supply. *P. pelagicus* is the main crab species that is exploited in the country, which comprises over 90% of crab landings (Ingles, 2004; FAO, 2016a). They are also considered as an important commercial species both for domestic and export markets in the Philippines, which contributes 0.19% of the world production of capture fisheries.

The Philippines is known to be a tropical country. According to PAG-ASA (2017), the climate of the Philippines can be divided into two major seasons based on temperature and rainfall: (1) Rainy season, from June to November and (2) Dry season, from May to December.

The abundance of *P. pelagicus* is influenced by season. Dry season which is affected by the northeast monsoon tend to have higher catch than in the wet season (Kunsook et al., 2014a). The archipelagic nature of the Philippines with monsoon seasons affect huge amount of marine biodiversity. This seasonal pattern of the country may affect the catch composition of crabs since there are some fishes or other marine organisms which are migratory or appear only in a particular season (Alix, 1976 as cited by Palomares et al., 2010).

The town of Banate in Iloilo is among the highest contributors to the blue swimming crab industry of Iloilo and even in the whole Philippines (Guia, 2012). Most local entrepreneurs buy the catch from local fishermen and sell them in non-coastal areas and even in Manila. The fishermen use several kinds of fishing gears to catch *P. pelagicus*. These include municipal trawl, fish corral, crab traps, crab entangling net, and push net. However, the use of crab traps in fishing is a recommended method because it allows the fishermen to return gravid or juvenile crabs back into the sea which encourage sustainable fishing (BFAR, 2016). Pots and traps are set either baited or unbaited, depending on the target species. These gears are typically described as simple and passive that allow animals to enter and then makes it hard for them to escape. This is through: a) putting a chamber in the pot or trap that can be closed once the animal enters and b) having a funnel-like structure that makes it difficult for the animals to escape (Boutson et al., 2009).

Selectivity of a fishing gear, such as the crab trap, can harvest organisms of limited species and varying sizes among populations within fishing grounds (Boutson et al., 2009). It is also important to highlight the bycatch composition from crab trap fisheries since it can serve as a baseline in scientific information for management.

Information regarding the retained and discarded catches in a fishery and as how they spatially and temporally vary among different fishing operations is necessary for identifying the potential impacts of fishing on fish stocks and ecosystems (Alverson et al., 1994; Kennelly, 1998; Hall, 1999; Gray et al., 2003). Moreover, knowledge on catch composition along with data on the selectivity and efficiency of the fishing gears used and behavior of the target species captured is an essential way in developing ways to mitigate discards of bycatch in fisheries (Chopin and Arimoto, 1995; Hall, 1999; Millar and Fryer, 1999; Broadhurst, 2000).

Spawning Potential Ratio (SPR) is a method that is currently being used in several parts of the world in dealing with stock assessment of *P. pelagicus* (Prince, 2014). This is considered to be an effective, low cost, and user-friendly alternative to traditional stock assessment methods. This approach generates community-based data to inform management decisions towards adhering to a minimum size (carapace width) based on maturity as well as mitigating the risk of harvesting egg-bearing crab (Anonymous, 2015).

Assessment and monitoring of a crab fishery can be a starting point for proper management or appropriate standards in fishing that would lead to the improvement of the crab industry in the country.

1.2. Objectives of the Study

This study determined the following from the crab trap catch in Banate Bay:

1. catch composition;
2. difference of crab trap catch between wet and dry season; and
3. spawning potential ratio as indicator of exploitation status.

1.3. Significance of the Study

The purpose of the study is to know the current status of *P. pelagicus* catch, as well as the difference of non-target species in varying seasons using crab trap around Banate Bay, Iloilo. The fishing gear selectivity of crab trap can be evaluated since it is the only fishing gear that will be monitored in the study. Through this assessment, the retained and discarded catch will also be identified. The result of the study can show if the future catch of *P. pelagicus* will be able to sustain the demand in the local and national market through its SPR. This will also serve as baseline for further studies regarding *P. pelagicus* catch trend of Banate Bay through the years.

1.4. Scope and Limitations

This study focused on the variation of catch composition of crab trap, locally known as *bubu*, around Banate Bay in Iloilo during the wet and dry seasons. Sampling was conducted for at least 3 times a month, starting October 2016 until March 2017. The source of the samples were randomly chosen depending whose crab trap vessel landed first during the day of the sampling. About 20% of the total bycatch and target catch were taken randomly and recorded. Data for SPR were collected only in one specific location where the fishermen land and sell their crab catch, locally known as *pakingan,* from Banate Bay and only females were used.

CHAPTER 2
REVIEW OF RELATED LITERATURE

2.1. Taxonomy and Diagnostic Features

The blue swimming crab (*Portunus pelagicus*, Linnaeus 1766) is a true crab (Branchyura) belonging to the family Portunidae. It has five pairs of legs where some are laterally flattened to varying degrees. The first pair are chelae or claws with conical tooth at the base of fingers, the following three pairs are walking legs where the last pair of legs are modified as swimming paddles. It has a rough and broad carapace with prominent spine on each side. The front has 4 acutely triangular teeth and 9 teeth on each anterolateral margin. The most external tooth is 2 – 4 times larger than the precedent. Male crabs have blue markings while females have dull green (FAO, 2016b).

2.2. Geographical Distribution, Habitat and Biology

These crabs are typically bottom dweller residing in tropical, subtropical estuarine and near shore habitats (FAO, 2016b), hence they are widely distributed throughout Indian and West Pacific Oceans: from Japan, the Philippines and all over Southeast and East Asia to Indonesia, the East of Australia, and Fiji Islands, and westward to the Red Sea and East Africa. They are most likely to thrive in sandy and sand-muddy depths of shallow waters about 10 - 50 m depth. They are usually found near the reefs, mangroves, sea grass, and algal beds (FAO, 2016b).

2.3. Blue Swimming Crabs in the Philippines

P. pelagicus is locally known as *alimasag*, *kasag*, *masag*, and *lambay* in the Philippines (BFAR, 2016). It is one of the most important resources harvested and has a significant contribution to global food supply. Among 51 species of swimming crabs reported in the country, about 7 are only considered marketable (FAO, 2014). *P. pelagicus* is the main species exploited, comprising over 90% of crab landings. Crab fisheries in the country have shown a boom and bust history (Ingles, 2004; FAO, 2016a). Biology of this crab has been absolutely studied because of its commercial importance in the Philippines. They are usually processed and exported as fresh frozen, crab meat, soft shell crabs and, in the past years, as live crabs. Over 80% of the crab exports go to the United States of America market while live crabs are exported mainly to Taiwan.

2.4. Seasons in the Philippines

The Philippines is known to be a tropical country. It has only two seasons: (1) Rainy season which is from June to November; and (2) Dry season which is from May to December (PAG-ASA, 2017). Moreover, the climate types are also divided into four types, depending on rainfall distribution. The area of Iloilo is under the Type III climate (Fig. 2.1). There is no definite maximum rain period. It has a dry season that lasts from 1 to 3 months only, from December to February or from March to May.

The archipelagic nature of the country with monsoon seasons affect huge amount of marine biodiversity. It may consist of different species, and different populations, caught in different fishing grounds depending on the season (Alix, 1976 as cited by Palomares et al., 2010).

2.5. Fishing Ground of Blue Swimming Crab

Ingles (2004) reported that over half (51.5%) of the *P. pelagicus* production currently comes from western Visayas in the area of the Visayan Sea and Guimaras Strait. Banate Bay, which is located within the Visayan Sea, is the common fishing ground of the municipalities of Anilao, Banate and Barotac Nuevo all in the province of Iloilo. It has traditionally been recognized as one of the richest fishing ground in Panay Island (BBBRMCI, 2010). The past decade showed that the harvest from the bay have significantly declined due to widespread overexploitation and habitat degradation have caused the miserable life of marginal fisherfolks. The town of Banate is among the highest contributors to the blue swimming crab industry of Iloilo and even in the whole Philippines. Most local entrepreneurs buy the catch from the local fishermen and sell them in non-coastal areas and even in Manila (Guia, 2012).

2.6. Crab Fishing Gear

Fishermen use several kinds of fishing gears to catch *P. pelagicus*. These include municipal trawl, fish corral, crab traps, crab entangling net, and push net. However, the use of crab traps in fishing is a recommended method because it allows the fishermen to return gravid or juvenile crabs back into the sea which encourage sustainable fishing (BFAR, 2016). Pots and traps are set either baited or unbaited, depending on the target species. Crab trap, locally known as *bubu*, is one of the main fishing gear used in the area of Banate (Fig. 2.2). These gears are typically described as simple and passive that allows animals to enter and then makes it hard for them to escape. This is through: a) putting a chamber in the pot or trap that can be closed once the animal enters or, b) having a funnel-like structure that makes it difficult for the animals to escape (Boutson et al., 2009).

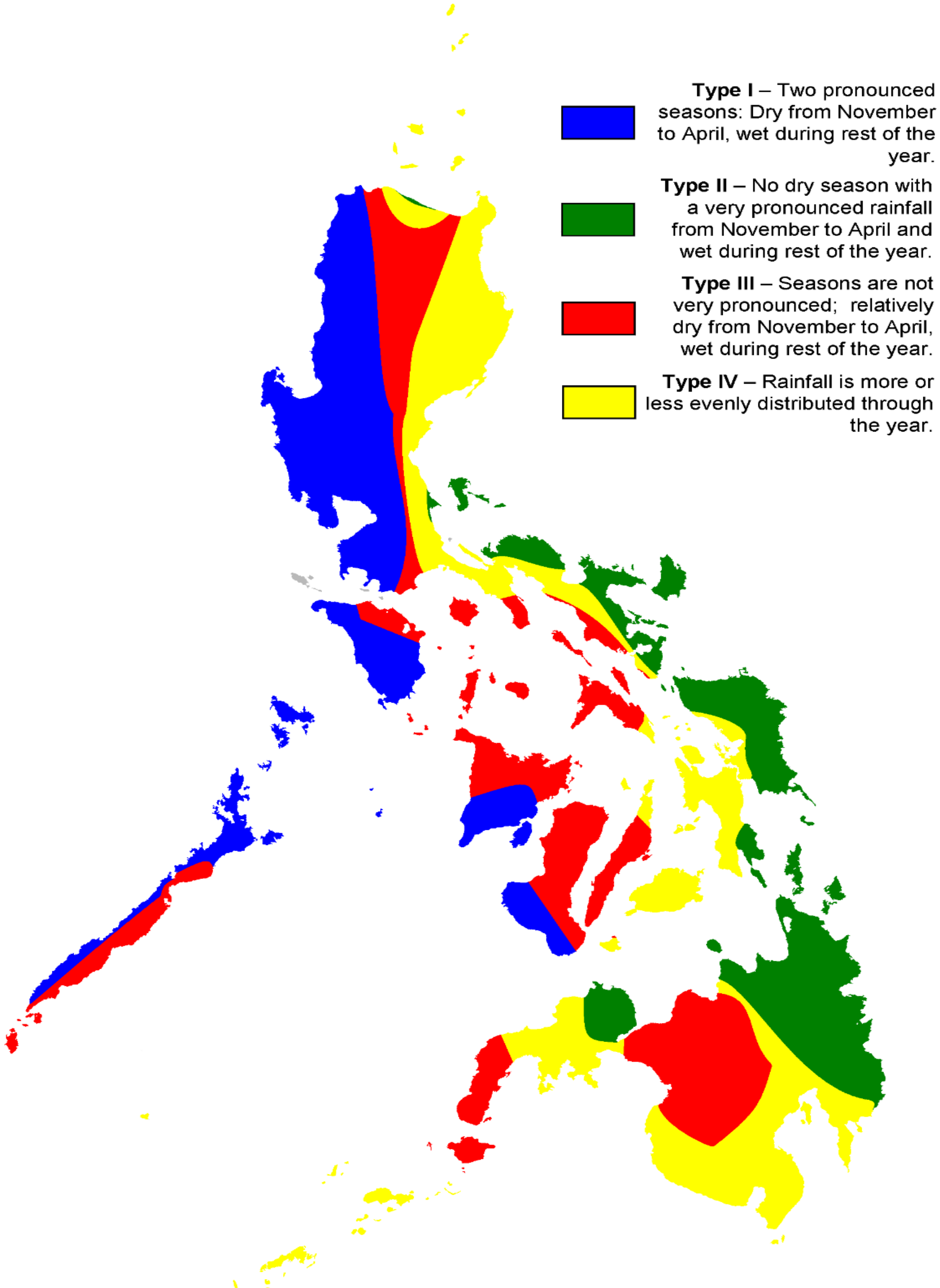

Figure 2.1. Map of the Philippines showing the four climate types (Source: Wikipedia, 2016)

Figure 2.2. Crab trap locally known as *bubu* in Banate, Iloilo that is commonly used in harvesting crabs around Banate Bay

2.7. Bycatch and target species variation at different seasons

Fazrul et al. (2015) observed that, at the Pattani Bay, Gulf of Thailand, abundance of bycatch was influenced by habitat, season and interaction between habitat and season. Species richness or number of species per sampling was affected only by seasonal variation. In accordance, Kunsook et al. (2014a) also stated that the abundance of *P. pelagicus* is also influenced by season at the Kung Krabaen Bay, Gulf of Thailand. They found that abundance of crabs in the dry season which is influenced by northeast monsoon tended to be higher than in the wet season. Thus, the peaks of the crab fishing season was from December to January and June to July (Kunsook et al., 2014a). Basically, food availability of crabs depend on seasonal variation and environmental changes, such as salinity and temperature changes (Pittman and McAlpine 2003 as cited by Kunsook et al., 2014b).

2.8. Spawning Potential Ratio

According to Prince (2014), SPR is defined as the ratio of crab's average life-time reproductive potential under fishing, compared to their natural reproductive potential when there is no crab fishing involved. He also stated that with fishing, the reproductive potential of crabs is reduced. Otherwise, crabs and fish will achieve their 100% natural reproductive potential.

Length-based assessment of spawning potential ratio (LB-SPR) has a new method that has recently been described and its sensitivity to bias and variability in the input data has been tested with simulation studies (Hordyk et al., 2014a; Hordyk et al., 2014b; Prince et al., 2015). Prince et al. (2015) described LB-SPR as an assessment technique which utilizes the fact that size structure and spawning potential ratio (SPR) in an exploited population are a function of the ratio of fishing mortality to natural mortality (F/M), and the two life history ratios M/k and L_m/L_∞; where M is the rate of natural mortality, k is the von Bertalanffy growth co-efficient, Lm is the size of maturity (SoM) and L_∞ is asymptotic size (Hordyk et al., 2014a). This is also an equilibrium based method which relies to varying quantity on a number of assumptions that have to be made relatively arbitrarily in a data-poor fishery. According to Prince et al. (2015), these fundamental assumptions include: (1) asymptotic selectivity; (2) growth is adequately described by the von Bertalanffy equation; (3) a single growth curve can be used to describe both sexes which have equal catchability, or that female parameters and length composition data can be used; (4) length at age is normally distributed; (5) rates of natural mortality are constant across adult age classes; and (6) growth rates remain constant across the cohorts within a stock. Simulation testing of the LB-SPR model has shown that the method is most sensitive to the under-estimation of L_∞, and large rapid changes in recruitment rates (Hordyk et al., 2014b; Prince et al., 2015).

On the other hand, using SPR for crabs has basic steps to follow: (1) There should be a scientific approximation of the natural *P. pelagicus* as if there was no fishing or the unfished stock (Prince, 2014). This is obtained mathematically from assumptions about *P. pelagicus* species including average length, length at which 50% of *P. pelagicus* are mature; ratio of natural mortality (M) to growth (k); (2) Estimate the data of the crab population in fished stock. This is obtained through sampling crab population independently; (3) Maturity of crabs depending on length. This is the percent of female crabs that are mature at each size; (4) Spawning potential of the "unfished" population which has the maximum potential of 100%. This is calculated by multiplying the 1st step by the 3rd step for each length group and then standardizing the results to 1.0; (5) Spawning potential of the "fished" population is calculated by multiplying 2nd step by 3rd step for each length group and standardize the results; (6)

SPR is the area under the 2nd graph derived from the 5th step (actual potential), divided by the area under the 1st graph derived from the 4th step (maximum potential) (Fig. 2.3). The ratio will be between 0.0 and 1.0. The percent of spawning potential will be obtained if it is multiplied by 100.

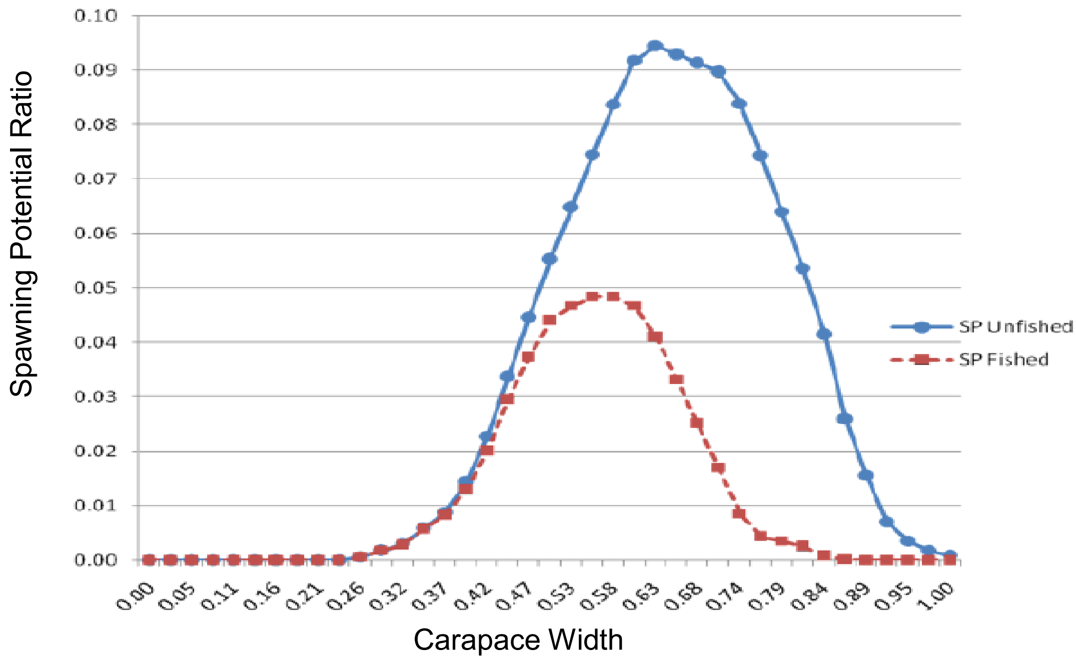

Figure 2.3. The Spawning Potential (SP) Ratio of a fished and unfished stock of *Portunus pelagicus* (Source: Prince, 2014)

Reference point of the result will be evaluated according to the necessity level to generate optimum economic and social benefits to the present and future (Prince, 2014). It is divided into four points: (1) SPR = > 40%, the number of mature crabs in the fishery is estimated to be above the required level; (2) SPR = 30% - 40%, the number of mature crabs is just around the necessary level; (3) SPR = 20% - 30%, the number of mature crabs is below the required level; and (4) SPR = < 20 %, the number of mature crabs is below the level that generates optimum economic and social benefits now and in the future.

CHAPTER III
MATERIALS AND METHODS

3.1. Area of the study

The study was conducted within Banate Bay in Iloilo which is within the Visayan Sea (Fig. 3.1). It is located at Sitio Sulangan Brgy. San Salvador, Banate, Iloilo where the fishermen usually land their crab catch.

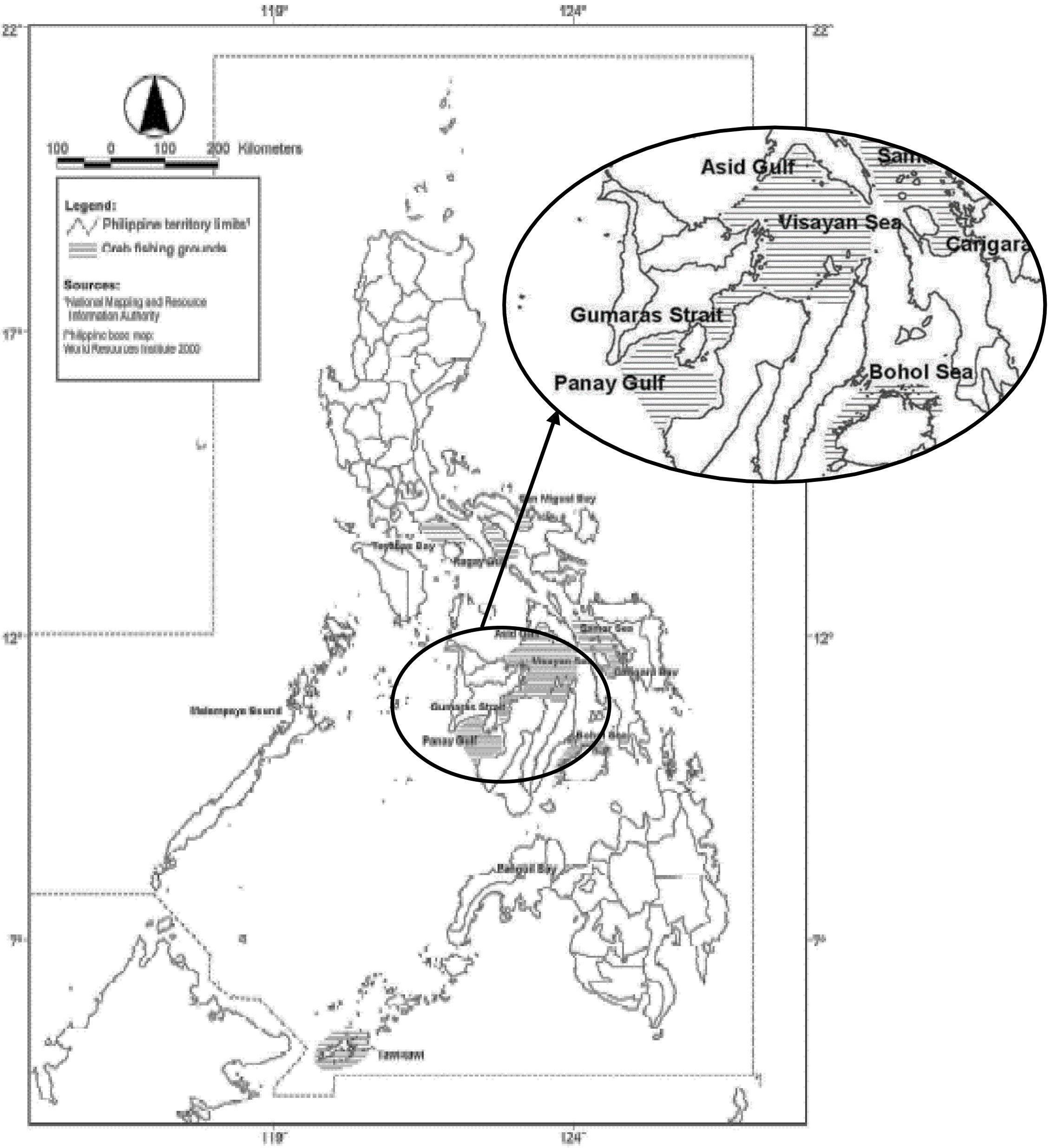

Figure 3.1 Map showing the Visayan Sea which is a *Portunus pelagicus* fishing ground (shaded area) in the Philippines. Inset shows the area of the Visayan Sea wherein Banate Bay is located (Source: Ingles, 2004)

3.2. Data Collection

Sampling of *P. pelagicus* and bycatch were conducted at least 3 times a month at early in the morning from October 2016 to March 2017 from crab trap (*bubu*) landings. Samples were collected from the catch of fisherman who landed first by the time of sampling. Only an estimated 20% of the total catch of both target and non-target species were sampled. Morphometric measurements of crabs, fishes and other bycatch were done using a 1-kg top loading weighing scale and Vernier caliper. The following morphometric measurements were taken: a) body weight (BW) and external carapace width (CW) for crustaceans, and (b) BW, total length (TL) of each fish bycatch. For bycatch such as squids, octopuses and shrimp, their BW and TL were only taken.

As for SPR, additional data of female crabs were recorded in the nearby buying, landing and cooking site, also known as *pakingan*. The maturity of these female crabs were determined as shown in Figure 3.2.

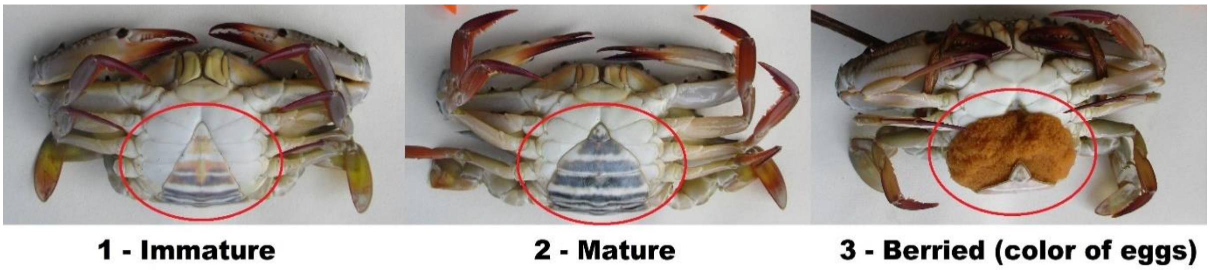

Figure 3.2. The maturity level of female crabs used in the Spawning Potential Ratio determination. Specific number used were: (1) Immature females is characterized with triangle abdominal flap; (2) Mature ones have developed their abdominal flaps into an oval to rounded shape; (3) Berried crabs with eggs (Modified from Prince, 2014)

3.3. Data Interpretation and Analyses

One-way analysis of variance (ANOVA) was used to determine the significant differences in the means of occurrence, maturity level and months between wet and dry season. The computations were done using SPSS program Version 16.0 at 95%

(p=0.05) level of confidence. T-test: two-sample assuming unequal variances in Microsoft Excel 2016 was used to determine if the means of the carapace width between wet and dry season had significant difference. Values were expressed as Mean ± S.D.

SPR was assessed using an online application developed by Murdoch University in Australia was used. More than 1,000 female crabs were encoded in a file with a given format, then it was uploaded in SPR online application. Before that, L_{50} and L_{95} of the given crab data was computed, since these two are essential for the application to generate accurate results and also required to compute for L_{∞}. However, M/k or natural mortality was fixed to 1.25, which is specific for *P. pelagicus* (Prince, 2014). The data was automatically analyzed right after inputting the needed information which gave the 50% (S_{L50}) and 95% (S_{L95}) probability of crabs being caught at specific carapace width.

CHAPTER 4

RESULTS

4.1. Monthly Frequency of Male and Female *P. pelagicus*

A total of 207 samples of *P. pelagicus* were recorded during the 6 months sampling period. Figure 4.1 shows the frequency distribution of *P. pelagicus* in Banate Bay, Iloilo. The target catch of wet season (October – December) was higher with 151 crabs with the highest occurring in October (65 crabs). Catch during the dry season (January – March) was lower with only 56 crabs. The number of female *P. pelagicus* was decreasing as dry season was approaching. A similar trend was observed in male *P. pelagicus* but there was a sudden decrease in January (5 crabs) and it increased again the following months (14 crabs in February and 12 crabs in March).

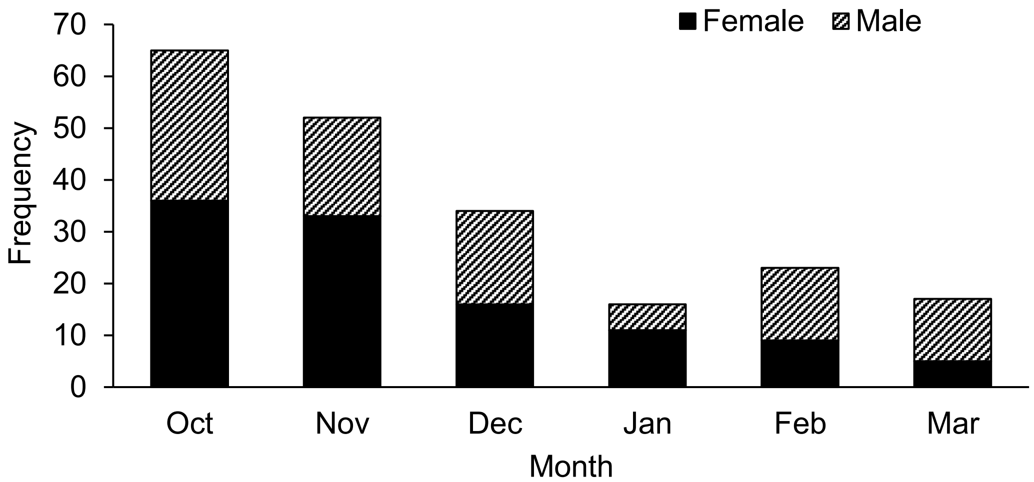

Figure 4.1. Frequency distribution of female and male *Portunus pelagicus* sampled from October 2016 to March 2017 in Banate Bay, Iloilo.

4.2. Carapace Width during Wet and Dry Season

The frequency of male and female *P. pelagicus* during wet and dry season were grouped into several classes depending on their carapace width. *P. pelagicus* with CW of 11 – 12 cm, 12 – 13 cm and 13 – 14 cm showed high frequency during the wet season (Fig. 4.2A). Moreover, female *P. pelagicus* dominated over the male in these size classes. Generally, samples ranging from 12 – 13 cm CW is the most abundant while there was only one 16 – 17 cm CW sample and very few in 8 – 9 cm CW and 15 – 16 cm CW class size.

On the other hand, during the dry season, male *P. pelagicus* was abundant compared to the wet season (Fig. 4.2B). There are only few females collected from January to March. The 11 – 12 cm CW had the highest frequency with 21 males, which was twice more than the number of females (10 crabs). Unlike in the wet season, there were *P. pelagicus* samples which were 7 – 8 cm CW. In addition, the carapace width range of the samples recorded was narrower. The highest was only 14 – 15 cm CW.

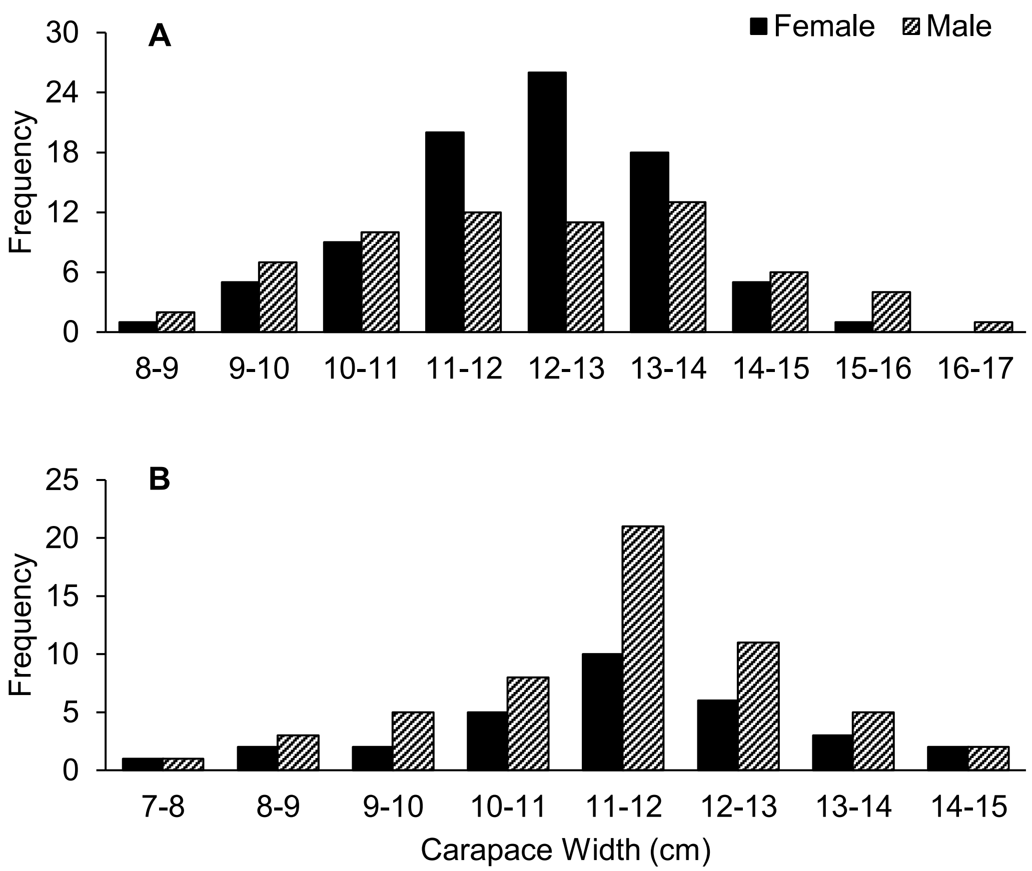

Figure 4.2. Frequency distribution of different sizes of female and male *Portunus pelagicus* in Banate Bay Iloilo during the wet (A) and dry (B) season.

T-test showed that wet season had a mean CW of 12.27±2.53 cm while the dry season had 11.45±2.17 cm. The result showed a significant difference ($p=0.00082$).

4.3. Female *Portunus pelagicus* Maturity Stages

The occurrence of the different maturity stages of female *P. pelagicus* during the wet and dry season is shown in Figure 4.3. Berried *P. pelagicus* was the lowest (3 – 20 %) among the three maturity levels throughout the wet season. In contrast, mature females was highest reaching a peak in November with 79%. Moreover, immature *P. pelagicus* showed a decreasing trend through the season.

During the dry season, the percentage of berried *P. pelagicus* per catch increased from 0% in January to 20% in March (Fig. 4.3B). The percentage of mature females was still high (73%) in January and was similar to December (74%) (Fig. 4.3A). In the case of immature *P. pelagicus*, highest occurrence was in February (44%) which equaled that of mature females. There was a sudden decrease in March (20%). On the other hand, mature females showed an increase in March (60%) and then a decrease in February (44%).

One-Way ANOVA showed that the maturity levels of female *P. pelagicus* was not significantly different ($p=1.00$) during the wet (151 crabs) and dry (56 crabs) season. Moreover, the occurrence of the three maturity levels between the wet and dry season also showed no significant difference ($p=0.05$). However, there were significant differences ($p=0.00$) between months of the two seasons.

4.4. Catch Composition of Crab Trap

The percentage of male (43%) *P. pelagicus* was lower compared to female (57%) (Fig. 4.4A) during wet season. Majority of the female *P. pelagicus* caught were mature (37%), followed by immature (18%), while berried crabs (2%) had the lowest composition.

In the dry season, the catch were mostly male *P. pelagicus* with 55% compared to female with only 45% (Fig. 4.4B). Likewise in the wet season, the ratio of mature females were also the highest (27%) among the maturity stages. Furthermore, the composition of berried females (4%) was higher during the dry season.

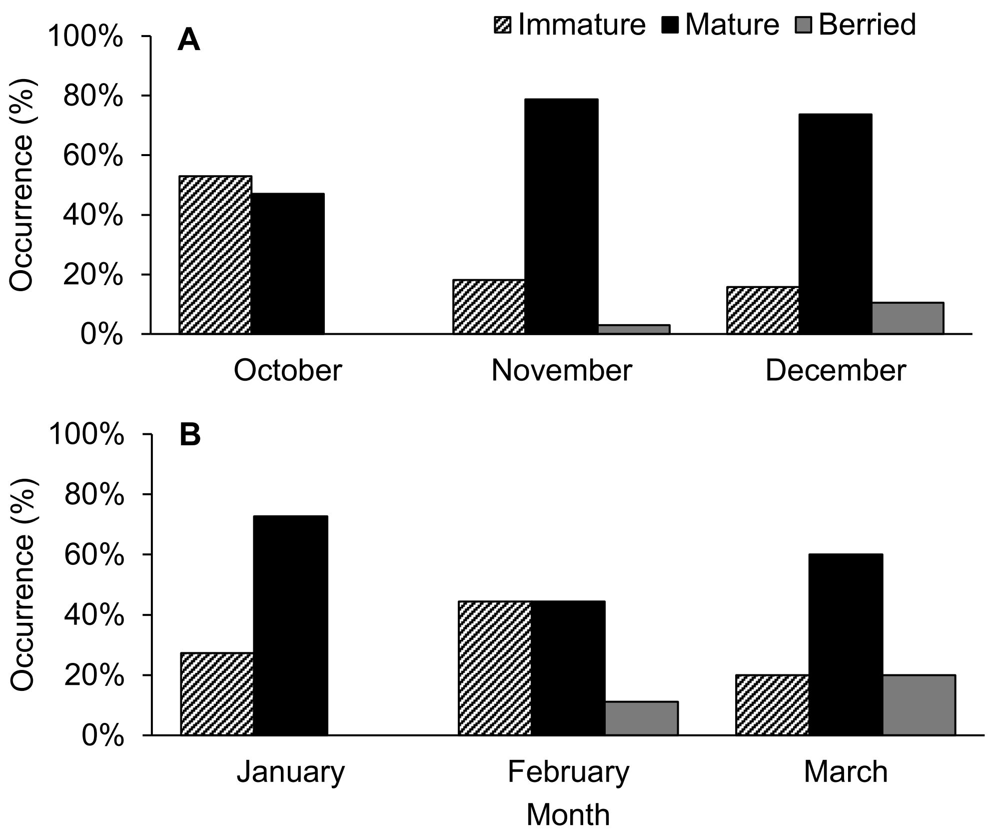

Figure 4.3. Occurrence of the three maturity levels of female *Portunus pelagicus* during the wet (A) and dry (B) season in Banate Bay, Iloilo.

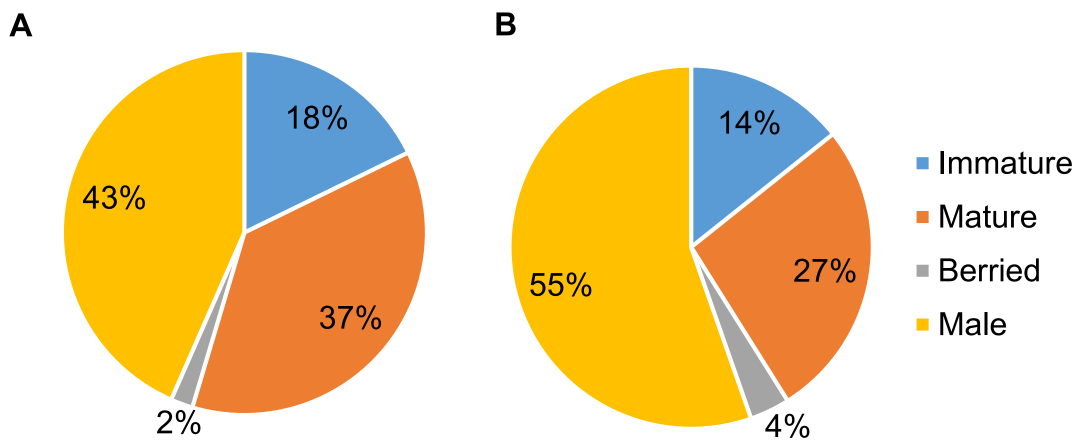

Figure 4.4. The ratio of male and the three maturity stages of female *Portunus pelagicus* caught in Banate Bay during the wet (A) and dry (B) season

Figure 4.5 shows the percentage of the target catch *P. pelagicus* with 44% of the total catch. Among the bycatch, the highest was *Scolopsis taenipterus* with 26%. This was followed by *Upeneus moluccensis* and *Charybdis feriata* which had 9% composition. Next were *Pelates quadrilineatus* with 5% and *Gerres oyena* with 4%. While other species were 3% which include gray catfish, yellow-striped trevally, painted sweetlips, spotted filefish, six bar grouper, parrotfish, cuttlefish, crenate swimming crab, sentinel crab and mantis shrimp.

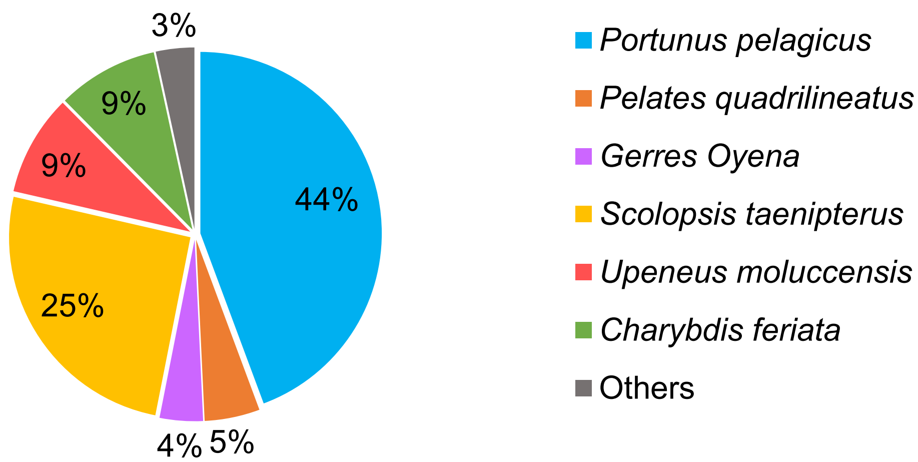

Figure 4.5. The ratio of *Portunus pelagicus* and bycatch caught by crab trap in Banate Bay from October 2016 to March 2017.

Figure 4.6 shows the composition of the catch of crab trap. The ratio of target catch during the wet season was higher than the dry season (Fig. 4.6). During the wet season, *P. pelagicus* ratio was 55% while the bycatch was 45%. In contrast, the ratio of *P. pelagicus* decreased to 29% during the dry season.

The names of bycatch caught by crab trap and their specific utilization are summarized in Table 4.1. They consisted of 13 families, 15 genres and 15 species. All the bycatch both fish and invertebrates were utilized except the mantis shrimp.

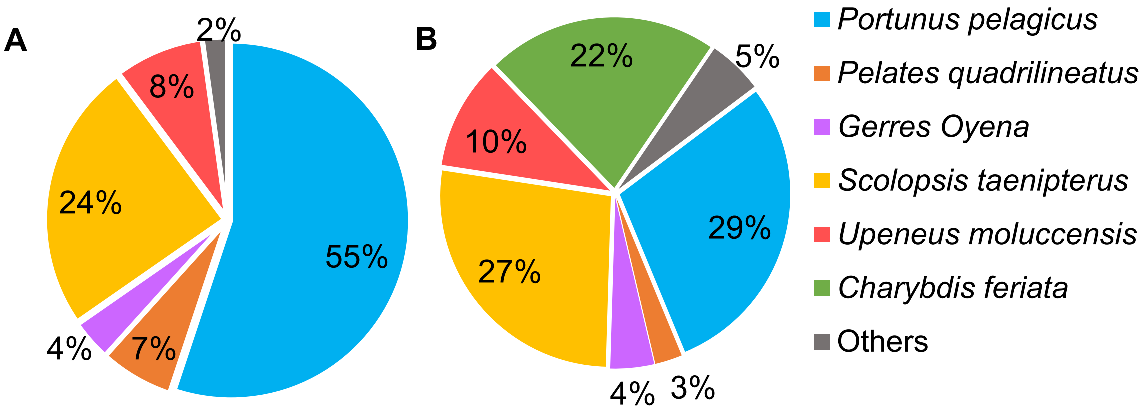

Figure 4.6. The total catch (A) and bycatch (B) species composition caught in Banate Bay during the wet (A) and dry (B) season

There were no endangered nor threatened species that were caught in the crab trap during the whole duration of sampling. Table 4.2 summarized the classification of the bycatch species according to their conservation status.

4.5. Spawning Potential of *Portunus pelagicus*

Figure 4.7A shows the class range of female *P. pelagicus*. The most abundant CW range were between 87.7 – 137.5 mm (8.77 – 13.75 cm). On the other hand, selectivity curve of *P. pelagicus* caught in Banate Bay (Fig. 4.7B) is a little to the left and very close to the maturity curve. This indicates that Banate *P. pelagicus* Fishery was harvesting crabs at a smaller size before they became mature.

Table 4.3 shows the generated SPR to be 6%. This percentage is beyond the international accepted limit of SPR which is 20%. The fishing pressure (F/M) in Banate Bay was 5.8. Moreover, the result of S_{L50} and S_{L95} were 115.3 mm and 141.6 mm CW, respectively.

Table 4.1. Composition of bycatch caught by crab trap in Banate Bay, Iloilo from October 2016 to March 2017. R – Retained; D – Discarded

Family	Scientific Name	Common Name	Local Name (used in Banate)	Utilization
A. Fish				
Carangidae	*Selaroides leptolepis*	Yellow-striped trevally	Malinu	R
Gerreidae	*Gerres oyena*	Common Mojara	Latab	R
Haemulidae	*Plectorhincus pictus*	Painted Sweetlips	Alatan	R
Monacanthidae	*Pseudomonacanthus macrunus*	Spotted filefish	Bantol	R
Mullidae	*Upeneus moluccensis*	Goldband Goatfish	Salmonete	R
Nemipteridae	*Scolopsis taeniopterus*	Lattice monocle bream	Upos-upos	R
Plotosidae	*Plotosus canius*	Gray catfish	Alimusan	R
Scaridae	*Scarus* sp.	Parrotfish	Mul-mol	R
Serranidae	*Epinephelus sexfaciatus*	Sixbar grouper	Inid	R
Terapontidae	*Pelates quadrilineatus*	Four-lined terapon	Lambiyao	R
B. Cephalopod				
Sepiidae	*Sepia* sp.	Cuttlefish	Bagulan	R
C. Crustacean				
Portunidae	*Charybdis feriata*	Crucifix crab	Kurusan	R
	Thalamita crenata	Crenate swimming crab	Dawat	R
	Podophthalmus vigil	Sentinel crab	Kasway	R
Squillidae	*Harpiosquilla* sp.	Mantis shrimp	Pitik-pitik	D

Table 4.2. Conservation status of bycatch caught by crab trap in Banate Bay, Iloilo according to International Union for the Conservation of Nature's (IUCN) Red List.

Conservation Status	Species
Least concerned	*Selaroides leptolepis*
	Gerres oyena
	Upeneus moluccensis
	Scrarus sp.
Not yet assessed	*Plotosus canius*
	Plectorhincus pictus
	Pseudomonacanthus macrunus
	Scolopsis taeniopterus
	Pelates quadrilineatus
	Charybdis feriata
	Podophthalmus vigil
	Harpiosquilka sp.
Data deficient	*Epinephelus sexfaciatus*
	Sepia sp.

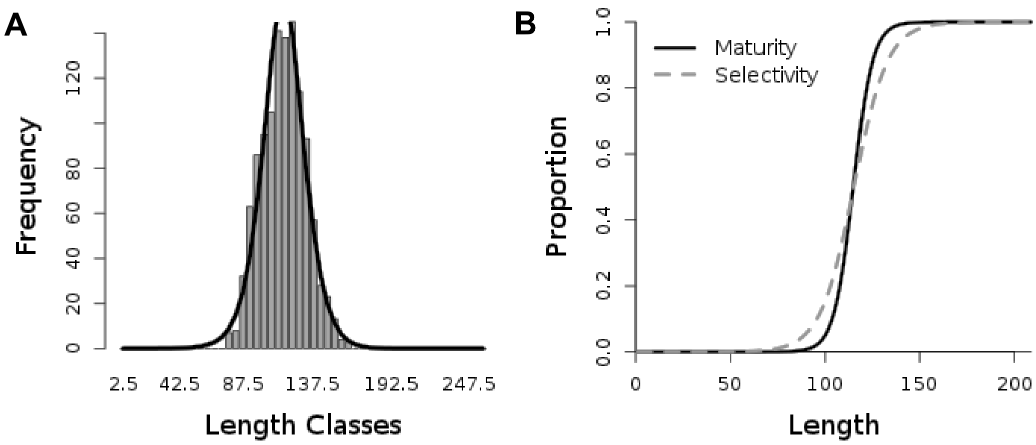

Figure 4.7. Length frequency histogram (A) and the maturity and selectivity curve (B) result of length-based Spawning Potential Ratio Assessment of *Portunus pelagicus* in Banate Bay using the online tool developed by Prince (2014)

Table 4.3. Parameter estimates of *Portunus pelagicus* of Banate Bay spawning potential ratio. F/M, fishing pressure. S_{L50}, carapace width at which crabs had 50% probability being caught. S_{L95}, carapace width at which crabs had 95% probability being caught. SPR, Spawning Potential Ratio.

F/M	**SPR**	**S_{L50} (mm)**	**S_{L95} (mm)**
5.8	**6%**	**115.3**	**141.6**

CHAPTER 5
DISCUSSION

5.1. Abundance of *Portunus pelagicus* Catch

P. pelagicus spawn all year round (BFAR, 2016), however, the peak and lean season of the catch is commonly influenced by monsoons. BFAR (2016) reported that the occurrence of juvenile and gravid *P. pelagicus* in Iloilo, specifically in Carles, is from June to August, while their peak catching season is from August to September. This study showed that from October to November was the period with highest catch in Banate, Iloilo (Fig. 4.1) which is just right after the peak month of *P. pelagicus* catch in Carles. After that, the catch suddenly declined in December. During the dry season, from January to March, berried crabs caught within Banate Bay was increasing.

5.2. Maturity of *Portunus pelagicus* Based on Carapace Width

According to BFAR (2016), female *P. pelagicus* in tropical countries, such as the Philippines, matures mostly at an average of 10.56 cm CW with an average age maturity of 8 months to 1 year. On the other hand, male *P. pelagicus* matures faster than the female at an average of 9.64 cm CW at 4 months in age wherein they are already considered mature. During this stage, they are commonly found in sandy substrates, migrating in waters with depth up to 20 m. In this study, there were more mature crabs caught in the wet season compared to the dry season based only on their CW. Also, given that the size class range of dry season started at 7 – 8 cm (Fig. 4.2B), whereas in the wet season it was 8 – 9 cm CW (Fig. 4.2A). According to Trisak et al. (2009), October – February, which is a cool season in the East Gulf of Thailand, had the highest number of crabs with larger CW. This study showed similar period which was from October to December, wherein most *P. pelagicus* had wide and larger CW class range. Moreover, the number of females caught from October to February and February to May were higher compared to the months of May – October. This study also showed that there were more females caught compared to males. However, the number of female *P. pelagicus* suddenly decreased as it approached the month of March.

In the study of Zairion and Fahrudin (2015) at East Lumpung coastal waters of Indonesia, they found out that the size of male *P. pelagicus* was wider than the female and ovigerous individuals. Based on the result of this study, males have the highest CW between the two (Fig. 4.2A) with 16-17 cm CW. On the other hand, they also assessed the sizes of both sexes based on their gonad development. According to their result, male and female *P.pelagicus* with sizes below 81 mm CW were immature. Adolescent females were 91 mm CW while fully mature male and female *P.pelagicus* were approximately 124 mm and 126 mm CW respectively.

5.3. Bycatch Species

The common bycatch of crab gillnet and pot were croaker, catfish, grouper, scad, trevally, mullet, sillago, toungefish, spider conch, cockle, mantis shrimp, prawn, and mudcrab (Nieves et al., 2015). In this study, the bycatch of crab trap was dominated by lattice monocle bream, goldband goatfish, common mojarra, four-lined terapon, and crucifix or christian crab. There were also mantis shrimp, trevally, grouper, and catfish entrapped. In the study of ECOFISH Project (2015), crucifix, sentinel and crenate swimming crab are the crab gillnet bycatch that showed similarity of crab trap bycatch in this study. In addition, because of the existence of an unexploited coral reef area called *intrupahan* around Banate Bay (BBBMRCI, 2012), parrotfish bycatch was also observed. Among 15 identified crab trap bycatch, only mantis shrimp was considered to be a discard in the locality of Banate (Table 4.1). The rest of the species were either sold at the market or being consumed by the families.

Among 15 bycatch species identified, none of them were considered to be endangered, threatened, nor protected (ETP). Most of them were not yet assessed and some were least concerned species, while few were data deficient. Based on the result of this study, there was a low concern on bycatch of *P. pelagicus* caught using crab trap in Banate Bay. In the Sri Lankan blue swimming crab (SLBSC) fishery, they assessed the impact of *P. pelagicus* fishery on bycatch using smartphones, remote sensing and a GPS app (SEASL, 2016). They identified a total of 151 bycatch species. 102 were unknown and 8 were classified as data deficient by IUCN. However, there were 37 species of concern and 6 near threatened that were identified. Sri Lanka is recognized internationally to be rich in terrestrial and marine biodiversity. Thus, there were high number of ETP species in the area. Their study showed that no high profile ETP such as whales, dolphins, dugong, and turtles were recorded in the *P. pelagicus* bycatch. It suggested that there was a moderate conservation concern to the ecological impact of the bottom-set crab net fishery on bycatch species. To minimize the impact on the marine environment and the associated species, they drafted a Voluntary Code of Conduct (Appendix C) for *P. pelagicus* to ensure the sustainable use of resources through proper management measures. This was also to maintain the status of *P. pelagicus* stocks at healthy levels.

5.4. Crab Fishing Gear

According to Boutson et al. (2009), small-scale *P. pelagicus* fishing operation using collapsible crab trap consisted of 8 – 10 species while large-scale had 19 – 20 species per operation. The entrance type and mesh size of the gear can affect the capture efficiency and catch amount of bycatch. They designed a vented trap that allows small size *P. pelagicus* to escape without any effect on larger size catch efficiency. It also allowed some bycatch species that were mostly discarded in small-scale pot fishery to be able to escape.

Prince (2014) suggested that different gear types might need to be modified to prevent *P. pelagicus* with smaller CW being caught as a form of management. This will allow them to continue their growth and can still be able to reproduce and mitigate the declining of crab fishery stock. The design of crab trap made by Boutson et al. (2009) that incorporated an escape vent should be considered. The crab fishing gear that should be used by fishermen must reduce the catch of immature crabs while maintaining the mature catch size. A possible option was modifying the escape vents or by increasing the number of funnel entrances and bigger mesh size in dome-shaped pot. Ideal vent design is also an effective management tool for bycatch and inevitable ghost fishing problems through minimizing the mortality rate of smaller individuals caught by the crab fishery (Boutson et al., 2009).

5.5. Status of *Portunus pelagicus* Catch in Banate Bay, Iloilo

If the status of *P. pelagicus* fishery is under exploited where SPR is greater than 40%, several measures to increase the harvest are usually presented as recommended management measure according to the level of SPR (Prince, 2014). A crab fishing area is considered to be sustainably exploited (SPR = 30%) if the fishing pressure is just equal to the natural mortality of the crabs. Harvesting crabs above the desired level causes risk to overexploitation. This level needs to increase the number of mature crabs. For instance, Danajon Bank, which covers the 4 islands and 1 coastal barangay in Bohol, their SPR result was 27% (ECOFISH Project, 2015). This level was not alarming since the crabs in the area were fast growing and had high reproductive output. But then. There were still definitive steps to ensure the sustainability of *P. pelagicus* in the area.

Results showed in this study that the *P. pelagicus* Fishery of Banate Bay was harvesting crabs at a size smaller than the size at which 50% of *P. pelagicus* are considered mature as indicated in the selectivity curve which was a little to the left and very close to maturity the curve (Fig. 4.7B). The F/M is the result of fishing mortality by natural mortality (Prince, 2014) which is an indicator of sustainable fishing pressure. This study showed an F/M of 5.8 which indicates that the fishing pressure in the Banate Bay was more than five times higher than that of natural mortality. The carapace width at which crab has 50% and 95% probability of being harvested correspondingly are defined by S_{L50} and S_{L95}. The result explains that at 115.3 mm (11.53 cm), *P. pelagicus* species had a 50% probability of being caught while at 141.6 mm (14.16 cm) 95% of it will be harvested. The SPR result was 6%, which explains that the *P. pelagicus* catch in Banate Bay is overexploited. According to Prince et al. (2014) the desired SPR range is 30% - 40%. If it is below 20%, it is considered to be critical and needs proper management and should implement close season.

CHAPTER 6
CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The seasonal variation (wet and dry season) in catch composition of crab trap was done in Banate Bay, Iloilo. The abundance and difference of catch between two seasons were assessed and was observed that during the dry season, *P. pelagicus* catch is more abundant than in the wet season. Because of this, there were more mature *P. pelagicus* caught during the wet season since it also had more number and high carapace width size class range compared to the dry season. However, dry season had more occurrence of berried females and less immature ones. Moreover, there were more females caught during wet season compared to the dry season which was dominated by male *P. pelagicus*.

Among the crab trap bycatch, there were 13 families, 15 genera and 15 species. It was mainly composed of fish species with other crustaceans and a mollusk. The species that consistently appeared throughout the sampling period was *S. taeniopterus*. This fish is mainly sold in local markets of Banate. *U. moluccensis*, *P. quadrilineatus* and *G. oyena* were also marketed and commonly caught in crab trap. *C. feriata* is one of the commercial marine crab in Banate next to *P. pelagicus*. This species only appeared around January – March or during the dry season and was more abundant than the target catch.

The state of crab fishery is Banate, Iloilo is currently critical since the spawning potential ratio result was below the required level and even lower than the level of the critical percentage for *P. pelagicus*. Therefore, there should be a proper management for the crab fishery of Banate by regulating the daily catch or may implement closed season to let the *P. pelagicus* to grow and reproduce.

6.2 Recommendations

Further studies should be conducted with only one fisherman as source for determining catch composition to avoid inconsistencies. It is also advised to record the physico-chemical parameters of the water of the site since it may affect the species appearing within the area. The period of sampling also was not enough to evaluate the catch. Thus, a whole year round sampling would be ideal to properly explain the catch trend. For bycatch assessment, 20% was not enough to entirely describe all non-target species that were being caught. Hence, it is much better if it is 100% bycatch composition so that it will show how diverse are species caught by the crab pot.

Nevertheless, this kind of study that was conducted in Banate regarding catch composition of specific gears is very few, although have been studies in some places in the Philippines. Therefore, it is recommended to conduct further studies in the catch composition of crab trap to determine its effect in the biodiversity of the area.

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APPENDICES

Appendix A. T-test result in *Portunus pelagicus* carapace width variance

t-Test: Two-Sample Assuming Unequal Variances

	Wet Season	*Dry Season*
Mean	12.27086093	11.45892857
Variance	2.534211921	2.173737013
Observations	151	56
Hypothesized Mean Difference	0	
df	106	
t Stat	3.443372789	
P(T<=t) one-tail	0.000411883	
t Critical one-tail	1.659356034	
P(T<=t) two-tail	0.000823767	
t Critical two-tail	1.982597262	

Appendix B. Result of the one-way ANOVA in the maturity level of female *Portunus pelagicus* during wet and dry season

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Maturity	Between Groups	.000	1	.000	.000	1.000
	Within Groups	12.000	16	.750		
	Total	12.000	17			
Occurrence	Between Groups	206.722	1	206.722	4.545	.049
	Within Groups	727.778	16	45.486		
	Total	934.500	17			
Month	Between Groups	40.500	1	40.500	54.000	.000
	Within Groups	12.000	16	.750		
	Total	52.500	17			

Appendix C. Voluntary Code of Conduct *Portunus pelagicus* fishing, drafted by the Fishery Improvement Project (FIP) committee and the officers and staff of Department of Fisheries and Aquatic Resources (DFAR) in Sri Lanka (SEASL, 2016)

1) Fishermen will fish in compliance with the Fisheries & Aquatic Resources Act No. 2 of 1996

2) BSC shall only be harvested using 4ply or 6 ply bottom-set crab nets with a minimum mesh size of 4½" (114.3 mm)

3) The maximum height of a bottom-set crab net shall be 15 eyes. The maximum length of a net piece shall be 1,500 eyes

4) A maximum number of 35 net pieces / panels shall be set per fishermen per day

5) The soakage time for bottom-set crab net shall be not more than 12 hours (6.00 pm to 6.00 am)**.**

6) A fisherman will not deliberately place or set his nets on coral / rocky reefs or sea grass beds.

7) Fishing for BSC will be limited to six night per week (Sunday evening to Saturday morning)

8) Any person who intends to supply BSC for export shall not use any other gears such as traps, trawls, fixed nets, other than the bottom-set crab net prescribed above.

9) Fishermen will dispose of all used, damaged, discarded crab nets on land, in an environmentally safe manner, to avoid 'ghost fishing'

10) Any person who engages in fishing for BSC in compliance with this code and or purchases, sells or processes BSC harvested for export shall assist the DFAR in the collection of catch, effort data and production data as and when requested by staff and officers of the respective DFEO and or the Fishery Management Division in Colombo.

Appendix D. The different bycatch

Scolopsis taeniopterus

Upeneus moluccensis

Epinephelus sexfaciatus

Scarus sp.

Pseudomonocanthus macrunus

Gerres oyena

Pelates quadrilineatus

Plotosus canius

Selaroides leptolepis

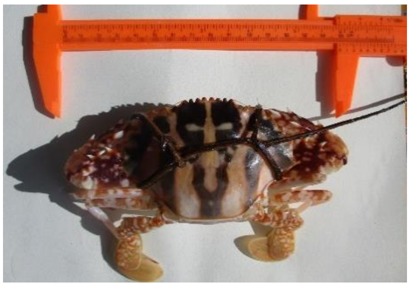
Plectorhincus pictus

Harpiosquilla sp.

Podophthalmus vigil

Thalamita crenata

Sepia sp.



Charybdis feriata