Effects of net height of crab entangling nets on the capture of targeted economically important portunid species and non-target species

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Effects of net height of crab entangling nets on the capture of targeted economically important portunid species and non-target species

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Abstract The aim of this study was to determine the effects of net height on the capture performance of crab entangling nets. Fishing trials were conducted using nets at varying net heights (1) 12 meshes down (MD), (2) 24 MD and (3) 50 MD. A total of 1290 individuals comprising 87 species belonging to 53 families were caught. One-way analysis of variance showed that net height significantly affected the various catch parameters, including catch per unit effort (CPUE) of the total and target catch, amount of non-target catch, size of catch and species richness. The use of appropriate net height is a potential technical measure for a selective but still efficient crab entangling net fishery. Lower net height significantly reduced non-target catch by up to 70%. Lower net height also decreased the CPUE of target catch such as *Portunus pelagicus* and *Charybdis feriatus* by up to 65% at 12 MD, but catch at 24 MD was not significantly different than that at 50 MD. The use of a net height of 24 MD also resulted in the capture of larger-sized *P. pelagicus*. The richness of the catch species decreased by up to 58% in lower nets. These results are useful to fishery managers and government institutions when developing and/or improving existing regulations towards a sustainable crab fishery, particularly blue swimming crabs.

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Introduction

The blue swimming crab *Portunus pelagicus* is one of the more important fishery commodities in the eastern tropical Pacific and western Indian Oceans [1–3]. These crabs are found throughout the nearshore marine and estuarine waters, including sandy, muddy and seagrass habitats, to a depth of at least 50 m [1, 4–6]. Juveniles occur in shallow water bodies, such as mangrove creeks and mud flats, while adults are found in sandy substrates at deeper water of up to the 20-m isobath [2, 7]. In central western Philippines, *P. pelagicus* spawn continuously throughout the year, with peak periods during the first and last quarters of the year [8]. The average carapace width of maturity is 10.56 and 9.64 cm for females and males, respectively [9], and the average sex ratio is 1:1.2, with 46.1% females and 53.9% males [5].

Areas with soft substrate and gentle slope are common *P. pelagicus* fishing grounds; consequently, the major fishing grounds in the Philippines are shallow inland waters [1]. Local fishermen use a variety of fishing gears to capture *P. pelagicus*, but crab entangling nets are among the most common gears used [1, 10]. This gear consists of long rectangular netting with diamond-shaped meshes set vertically at the bottom and kept stationary by anchors attached at both ends [10]. However, *P. pelagicus* fishery has been reported to be declining, with sustainable fishery hampered by several factors, such as irresponsible fishing practices, high bycatch, capture of undersized and berried crabs and other governance issues [1, 11]. The current minimum legal size for capture of *P. pelagicus* is set at 102 mm carapace width [10].

The high rates of non-target species and capture of juvenile conspecifics are among the major issues in crab

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entangling net fisheries in the Philippines [1, 12]. Bycatch reduction has been one of the major concerns in several fisheries for many years [13]. The incidental mortalities of these organisms, interchangeably termed as non-target species, may have negative impacts on the catch of target species by altering the biological and ecological structure of the ecosystem and possibly contributing to biodiversity loss [1, 14]. The capture of juveniles of the target species is another concern that needs serious attention. The capture of juveniles before they have reached their full biological and economic potential may represent an economic loss in terms of foregone economic potential of yield per recruit [14]. Without any management intervention, biological and economic damage to these species will likely become more serious in the future [10, 12, 14].

Technological alterations to the physical aspect of a particular fishing gear have been proven to be a successful strategy for reducing bycatch problems in many fisheries [13]. For gillnets, the temporal and spatial distribution of fishes are among the most essential parameters that affect catch performance since these directly influence the probability of fish encountering the gear [15]. Thus, knowledge of the vertical distribution of the target organism may help determine which section in the water column the gear should be set and the optimum net height needed to minimize any encounter with other species that are oriented in other section of the water column. In a study on bottom set net for *Platycephalus fuscus*, for example, Gray et al. reported that lowering the net height from 25 to 12 meshes could reduce bycatch by 46% without significantly affecting the catch of the target species as well as the catch of the retained bycatch blue swimming crab [16]. In North Carolina, Price et al. reported that a low profile gillnet could be a viable measure to reduce the capture of sea turtle and other bycatch species while still catching an acceptable quantity of flounder [17].

According to the Philippine government's National Blue Swimming Crab Management Plan [10], the recommended net height of crab entangling nets, as measured by the vertical counts of meshes or meshes down (MD), is 50. However, the rationale for selecting this net height is not clear, and the effectivity of this measure has not been scientifically verified. Since the blue swimming crab is a demersal species and caught in the lower section of the water column, we hypothesized that lowering the net height would reduce bycatch of other species, particularly those in the upper water layer, without significantly affecting the target catch. Thus, the main aims of this study were to determine the effect of net height on the capture efficiency of crab entangling nets and the influence of net height on the capture of target portunid species and the non-target species. including discards. Our results provide information to fishery managers which may help them improve management strategies towards a sustainable crab fishery.

Materials and methods

Sampling site

This study was conducted in the municipal waters of Tolosa, Leyte, that form part of San Pedro Bay in eastern Visayas, Philippines (Fig. 1). The bay is contiguous with Leyte Gulf, bounded by the islands of Leyte and Samar in the central eastern border of the Philippine archipelago.

Fishing gear materials and construction

The crab entangling nets used in the study were constructed by a local fisherman in Tolosa, Leyte. With the exception of the experimental variable (i.e. net height), the constructed nets were identical to those used by local fishers in the area. The netting was made of monofilament nylon knotted net with 0.25-mm diameter twine. Polyethylene (PE) ropes (diameter 2.5 mm) were used as headrope and footrope. Cylindrical lead weights (width 8 mm, length 42 mm) and rubber floats (width 33 mm, length 22 mm) were used as sinkers and floats, respectively. The sinkers and floats were attached to the sinkerline and floatline (both constructed out of 2-mm diameter PE), respectively, using monofilament nylon (diameter 0.25 mm). Stones weighing at least 1 kg were placed at each end of the net to serve as anchors that kept the gears stationary. A 3-mm diameter PE rope was used to attach the styrofoam buoys at both ends of the headrope, with the buoys serving as markers to allow easy location of the gear during retrieval.

Experimental design

Three units of crab entangling nets of different net heights (12, 24 and 50 MD) were used in this experiment. All experimental gears had a mesh size of 61 mm, hanging ratio of 0.4, twine diameter of 0.25 mm and rope length of 240 m.

There were ten replicate fishing trials for each gear. The gears were set in areas which had an average depth of not less than 10 m, and they were spaced at least 10 m apart to avoid competition among the gears. To avoid bias due to location, the gears were set randomly based on pre-determined locations.

Fishing operations were performed in December 2015 until January 2016 during the first and last quarter of the moon phase. The gears were set randomly at around 1000 hours, left overnight and hauled in the morning of the following day at around 0630 hours. After each hauling, all gears were brought to land for catch retrieval and data collection, following which the gears were reloaded to the motorized boat ready for the next random set.

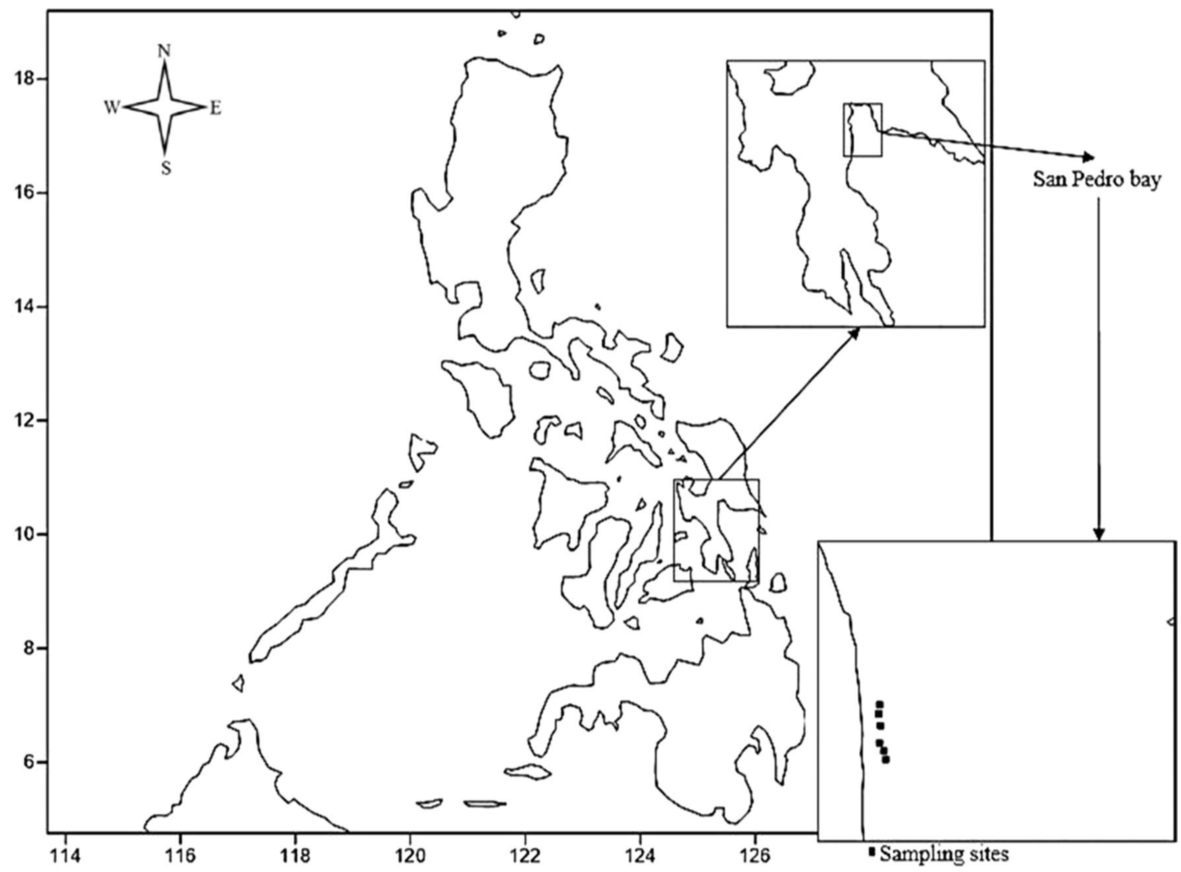

Fig. 1 Map showing the location of the sampling sites in San Pedro Bay, eastern Visayas, Philippines

Data collection and statistical analysis

Data collected from each experimental gear included weight (measured using a General Master Model D538 digital weighing scale with 1.0 g accuracy), quantity and width/length measurements (measured using a Vernier caliper with 0.05 mm accuracy) of all species comprising the catch. Catch per unit effort (CPUE) was standardized to (1) number of individuals caught per soaking hour and (2) grams caught per soaking hour.

All data were analyzed using SigmaPlot (Systat Software Inc., San Jose, CA). Analysis of variance (ANOVA) was used to test for significant differences among treatments, and Tukey's method was used for the a posteriori tests. Values are expressed as mean ± standard error of the mean.

Results

Effect of net height on catch composition and species richness

A total of 1290 individuals comprising 87 species belonging to 53 families were caught during the study period (Table 1). In this report, portunid crabs (i.e., *P. pelagicus* and *Charybdis feriatus*) were considered as target catch while all other species were considered as non-target catch. Among the non-target catch, 66 species were considered to "have commercial value" (i.e. species retained by fishers for own consumption or for selling) and 21 species were considered to be "without commercial value," also termed as "discards" in this study.

For all three net height designs, *P. pelagicus* was the most dominant species caught, variably followed by other portunid species, such as *Podopthalmus vigil* and *Charybdis hellerii*, several other crustaceans, such as the euryplacid crabs (*Eucrate formosensis*), mantis shrimps (Squillidae) and penaeid shrimps, the frog shells (Bursidae), and fish species, such as slipmouths (Leiognathidae), mojarras (Gerreidae), flounder (Paralychtydae) and lizardfishes (Synodontidae).

While the total number of individuals caught increased as net height increased, the proportion of target and non-target species varied. The proportion of target species caught decreased with increasing height of the net (Table 2) while, in contrast, the proportion of discards increased with increasing net height. No trend was observed for non-target species with commercial value.

Table 1 Catch composition of crab entangling nets with varying net heights

Catch composition	Family	Species	Number of individuals caught per net height		
			12 MD	24 MD	50 MD
Target species	Portunidae	*Portunus pelagicus*	53	92	110
		Charybdis feriatus	1	2	1
Non-target species					
Fish species					
Fish species with commercial value	Acanthuridae	*Ctenochaetus* sp.	0	1	0
	Ariidae	*Arius* sp.	3	3	4
	Carangidae	*Alectis indicus*	0	2	1
		Alepes djedaba	1	0	1
		Atule mate	0	1	6
		Carangoides sp.	1	4	6
		Caranx ignobilis	0	0	1
		Megalaspis cordyla	0	0	1
		Scomberoides tala	0	1	3
		Selaroides leptolepis	0	0	2
	Chirocentridae	*Chirocentrus dorab*	1	0	1
	Clupeidae	*Sardinella* sp.	0	0	10
	Cynoglossidae	*Cynoglossus* sp.	0	0	1
	Dasyatidae	*Dasyatis kuhlii*	0	0	1
	Engraulidae	*Thryssa setirostris*	0	1	0
	Gerreidae	*Gerres erythrourus*	11	11	18
		Gerres filamentosus	3	11	6
	Haemulidae	*Plectorhinchus pictus*	1	3	4
		Pomadasys argenteus	1	0	0
		Pomadasys trifasciatus	2	2	8
	Leiognathidae	*Gazza dentex*	2	5	8
		Leiognathus equulus	7	11	44
		Leiognathus splendens	7	14	47
		Leiognathus stercorarius	0	2	4
		Secutor ruconius	1	1	8
	Lethrinidae	*Lethrinus lentjan*	1	6	4
	Lutjanidae	*Lutjanus lutjanus*	1	1	3
		Lutjanus malabaricus	3	1	4
		Lutjanus vitta	0	0	1
		Lutjanus russelli	1	0	3
	Menidae	*Mene maculata*	0	3	1
	Mullidae	*Upeneus* sp.	0	1	1
		Upeneus sulphureus	0	0	18
	Muraenidae	*Gymnothorax pseudothyrsoideus*	1	0	0
	Nemipteridae	*Nemipterus hexodon*	1	3	16
		Nemipterus japonicus	0	0	2
		Nemipterus mesoprion	0	0	5
		Scolopsis taeniopterus	0	1	0
	Paralichthydae	*Pseudorhombus micrognathus*	9	24	38
	Platycephalidae	*Inegocia* sp.	2	2	4
		Elates ransonnettii	0	0	1
	Priacanthidae	*Priacanthus macracanthus*	0	0	2
	Sciaenidae	*Nibea soldado*	2	4	9

Table 1 (continued)

Catch composition	Family	Species	Number of individuals caught per net height		
			12 MD	24 MD	50 MD
	Scombridae	*Rastrelliger faughni*	0	1	2
		Scomberomorus commerson	0	0	1
	Serranidae	*Epinephelus bleekeri*	0	1	0
		Epinephelus corallicola	0	0	1
		Epinephelus quoyanus	0	1	0
		Epinephelus sexfasciatus	0	1	2
	Sillaginidae	*Sillago sihama*	0	1	3
	Soleidae	*Dexillichthys muelleri*	2	6	9
	Sphyraenidae	*Sphyraena putnamae*	0	0	1
	Synodontidae	*Saurida tumbil*	12	33	40
	Terapontidae	*Terapon jarbua*	0	1	4
	Trichiuridae	*Eupleurogrammus* sp.	1	0	0
Fish species without commercial value	Apogonidae	*Cheilodipterus* sp.	0	0	1
	Diodontidae	*Diodon liturosus*	0	1	0
	Gobiidae	*Parachaeturichthys polynema*	0	0	1
	Monacanthidae	*Aluterus monoceros*	1	0	0
	Scorpaenidae	*Inimiscus* sp.	2	3	6
		Pterois lunulata	2	9	10
	Tetraodontidae	*Lagocephalus spadiceus*	1	1	1
		Chelonodon patoca	0	0	1
	Triacanthidae	*Tripodichthys blochii*	0	0	1
Other crustacean species					
Other crustacean species with commercial value	Lysiosquillidae	*Lysiosquillina* sp.	0	0	1
	Penaeidae	*Penaeus latisulcatus*	0	4	0
		Penaeus semisulcatus	0	1	3
		Penaeus sp.	3	8	16
	Portunidae	*Podophthalmus vigil*	11	23	30
	Squillidae	*Oratosquilla oratoria*	4	4	2
		Oratosquillina gravieri	12	10	20
Other crustacean species without commercial value	Calappidae	*Calappa philargius*	0	3	0
	Euryplacidae	*Eucrate cf. formosensis*	3	26	58
	Leucosiidae	*Arcania* sp.	0	0	3
	Portunidae	*Charybdis hellerii*	3	19	32
	Xanthidae	*Liagore rubromaculata*	0	0	6
Mollusks (all without commercial value)	Bursidae	*Bufonaria subgranosa*	5	11	35
	Conidae	*Conus* sp.	0	1	0
	Melongenidae	*Pugilina ternatana*	2	3	4
	Muricidae	*Rapana rapiformis*	0	0	1
	Pectinidae	*Amusium pleuronectes*	0	5	3
	Tonnidae	*Tonna* sp.	0	1	10
Cephalopods (all with commercial value)	Loliginidae	*Sepioteuthis* sp.	0	0	1
	Sepiidae	*Sepia* sp.	0	0	1
Other invertebrates (without commercial value)	Ulmaridae	*Aurelia* sp.	1	0	0

MD Meshes down

To test species richness, we analyzed the mean number of species caught at each net height. A highly significant difference in the number of species was observed ($p < 0.01$) wherein the lowest species richness was recorded at a net height of 12 MD and the highest species richness recorded at a net height of 50 MD (Fig. 2).

Table 2 Number of individuals caught by crab entangling nets with various net heights

Catch/treatment	Number per net height		
	12 MD	24 MD	50 MD
Target species	54 (0.30)	94 (0.24)	111 (0.15)
Non-target species			
With commercial value	107 (0.59)	214 (0.55)	434 (0.60)
Discards	20 (0.11)	83 (0.21)	173 (0.24)
Total	181	391	718

Values in parentheses indicate proportion of species caught

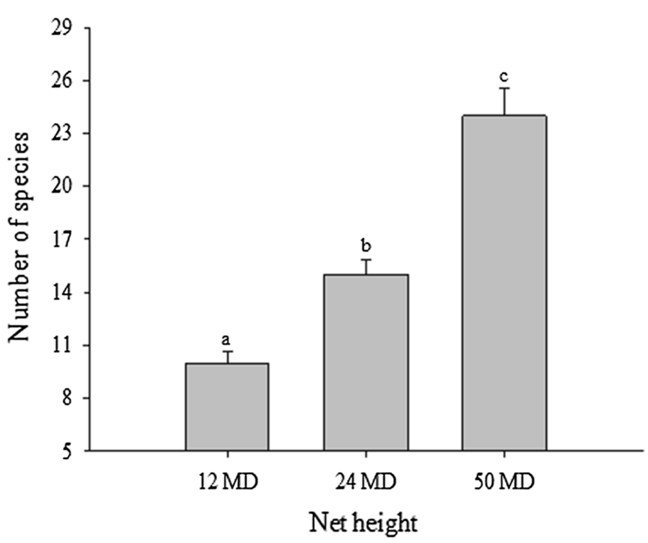

Fig. 2 Number of species caught per net height (mean ± standard error of the mean). Letter notations indicate significant difference among treatments ($p < 0.01$, one-way analysis of variance, Tukey's test)

Catch per unit effort

Mean CPUE values of crab entangling nets with various net heights are presented in Table 3. Mean total CPUE (total number of individuals caught per soaking time of the net) was higher in 50 MD nets than in 12 and 24 MD nets (one-way ANOVA, $p < 0.01$). The CPUE values did not differ significantly between two latter net designs. However, the mean CPUE values of the different nets were statistically different when only the target portunid crabs were considered. In terms of number of target species caught, mean CPUE at the different net heights were not significantly different (one-way ANOVA, $p > 0.05$). In terms of biomass, on the other hand, the mean CPUE was lower with 12 MD nets than with 24 and 50 MD nets (one-way ANOVA, $p < 0.01$). The mean CPUE of nets with 24 and 50 MD were not significantly different.

Non-target catch and discards

Table 4 shows the mean number of individuals classified as non-target species (commercially important species and discards) caught per net height. These results reveal that the number of non-target catch was higher in 50 MD nets (one-way ANOVA, $p < 0.01$) while the total number of individuals caught in the two lower net heights (12 and 24 MD) did not differ significantly (one-way ANOVA, $p > 0.05$). Among the commercially important non-target species, a higher number of individuals were caught in 50 MD nets compared to the 12 and 24 MD nets (one-way ANOVA, $p < 0.01$); there was no significant difference in the number of commercially important non-target species caught in the 12 and 24 MD nets. The higher net design resulted in an increased capture of the following commercially important non-target species: sardines (Clupeidae), slipmouths (Leiognathidae), goatfish (Mullidae), threadfin breams (Nemipteridae), flounder (Paralychtydae), lizardfishes (Synodontidae), long-eyed swimming crab (*P. vigil*), mantis shrimps (Squillidae) and penaeid shrimps (Penaeidae).

Table 3 Catch per unit effort of crab entangling nets with various net heights

Catch	CPUE by net height		
	12 MD	24 MD	50 MD
Total catch (individual per hour)	0.88 ± 0.0 7 a	1.92 ± 0.29 a	3.54 ± 0.594 b
Target catch only			
Individuals per hour	0.26 ± 0.08	0.46 ± 0.08	0.54 ± 0.09
Grams per hour	19.43 ± 5.48 a	52.77 ± 6.95 b	56.06 ± 9.68 b

Values are presented as the mean ± standard error of the mean (SEM). Values followed by different lowercase letters indicate a significant difference between treatments ($p < 0.01$, one-way Analysis of Variance, Tukey's test)

Table 4 Number of individuals classified as non-target species caught per net height

Catch	Number per net height		
	12 MD	24 MD	50 MD
Total	12.70 ± 0.54 a	29.70 ± 4.65 a	60.70 ± 10.57 b
Commercial	10.80 ± 0.76 a	21.50 ± 3.13 a	43.80 ± 8.16 b
Discards	1.90 ± 0.62 a	8.20 ± 2.10 a	16.90 ± 2.70 b

Values are presented as mean ± SEM. Values followed by different lowercase letters indicate a significant difference between treatments ($p < 0.01$, one-way Analysis of Variance, Tukey's test)

Similarly, among discards the highest number of individuals were discarded using the 50 MD nets (one-way ANOVA, $p < 0.01$), but there was no significant difference between the number of discards with the 12 and 24 MD nets. The higher net design increased the capture of discarded species such as scorpionfishes (Scorpaenidae), euryplacid crabs (*E. formosensis*), Indo-Pacific swimming crabs (*C. hellerii*), frog shells (*Bufonaria subgranosa*) and cask shells (*Tonna* sp.).

Sex and mean sizes of blue swimming crabs caught using nets of different heights

A total of 255 blue swimming crabs were caught during the study period, consisting of 142 females (55.7%) and 113 males (44.3%). There were only five berried females caught (3.5% of the total number of females), ranging in size from 134 to 160 mm. Based on the abdominal flap formation, 64 females (45.1%) were immature, with sizes ranging from 77 to 128 mm. In reference to the reported sizes at first sexual maturity (Lm) of blue swimming crabs [9], a total of 28 females (19.7%) were below Lm (<106 mm), of whom 26 were found to be immature based on the abdominal flap. Among males, 36 individuals (31.9% of the total males) were caught below Lm (<96.4 mm). The proportion of female and male *P. pelagicus* caught was not significantly different across the different net heights (two-way ANOVA, $p > 0.05$) (Table 5).

Sizes of crabs caught ranged from 76 to 160 mm. Overall, 63 individuals or 24.7% of captured blue swimming crabs (21 females, 42 males) caught were below the minimum legal size for capture (set at 102 mm [5]). The percentage of legal-sized *P. pelagicus* caught was 81% in 50 MD nets, 75% in 24 MD nets and 64% in 12 MD nets. Table 6 shows the mean sizes and size ranges of *P. pelagicus* caught in the nets at different MD. Our data show that significantly smaller crabs were caught in 12 MD nets compared to 24 and 50 MD nets (one-way ANOVA, $p < 0.01$) while there was not mean difference in the size of captured crabs with the two higher nets (24 and 50 MD).

Table 5 Proportion of female and male *Portunus pelagicus* caught by crab entangling net with various height designs

Sex	Proportion per net height[a]		
	12 MD	24 MD	50 MD
Female	60.8 ± 2.2	45.2 ± 2.4	54.5 ± 2.4
Male	39.2 ± 2.2	54.8 ± 2.4	45.5 ± 2.4

Values are presented as the mean ± SEM

[a] There was no significant difference in proportion by sex and net height (two-way analysis of variance, $p > 0.05$)

Table 6 Mean sizes and size ranges of *Portunus pelagicus* caught by crab entangling net with various height designs

Net height	Carapace width (mm)	
	Mean ± SEM	Size range
12 MD	107.81 ± 2.39 a	79–148
24 MD	120.86 ± 2.37 b	77–159
50 MD	118.25 ± 1.95 b	77–160

Values followed by different lowercase letters indicate a significant difference between treatments ($p < 0.01$, one-way Analysis of Variance, Tukey's test)

Discussion

The results of this study show that modifying the height of a crab entangling net has significant effects on the respective gear's capture performance. A higher entangling net was associated with a significantly higher CPUE in terms of number of individuals caught per soaking time, probably due to its bigger surface area. Focusing on the target portunid crabs, however, it is notable that net height did not significantly affect the mean CPUE in terms of number of individuals caught. In contrast, the number of non-target species caught, specifically discarded species, increased with increasing net height.

The substantial capture of non-target species is one of the major issues in the crab entangling net fishery [1, 12]. Our test results show that net height plays a significant role in reducing the capture of non-target species in this fishing gear. The use of nets with lower heights generally reduced the capture of commercially important non-target individuals by 75.3%. For example, nets with 50 MD net heights caught sardines (Clupeidae), goatfishes (Mullidae), some threadfin bream species (Nemipteridae), bigeyes (Priacanthidae), mackerels (Scombridae) and groupers (Serranidae). These species were not caught in nets with 12 MD net heights. In addition, there was an observed increase in the capture of other species using higher nets, such as slipmouths (Leiognathidae), flounders (Paralichtydae), croakers (Sciaenidae), solefish (Soleidae), and lizardfishes (Synodontidae). The use of crab entangling nets with a higher height may thus contribute to the exploitation of non-target fish stocks and eventually have adverse impacts in the ecosystem.

The use of nets with lower heights also reduced the capture of discarded individuals by 88.4%. This net design either eliminated the capture of some species (e.g. *Liagore rubromaculata*, *Tonna* sp.) or reduced the number of individuals captured (e.g. *Pterois lunulata*, *E. formosensis*, *C. hellerii* and *B. subgranosa*). While these species are not used for human consumption, they nonetheless play important roles in the marine ecosystems and thus should be conserved. The reduction of species richness in the catch of entangling nets is of great importance for the conservation of biodiversity in a particular fishing area. Biodiversity conservation is essential for the health of any particular fishing ground or aquatic ecosystem and to the quality of human life.

The use of the appropriate net height in crab entangling nets also reduces the capture of small-sized target portunid crabs, thus helping to reduce overfishing of small crabs. Lower net heights significantly caught smaller *P. pelagicus* while higher nets caught larger-sized individuals. Crabs are known to be most active at night [18]; thus our results may suggest that during nighttime, more larger-sized individuals reach the upper water column either for foraging or vertical movement. The capture of larger-sized *P. pelagicus* by higher net designs is further supported by the higher CPUE (in terms of biomass) in the 24 and 50 MD nets. While the CPUE in terms of numbers did not differ significantly by net height, the CPUE by biomass in the higher net designs was significantly higher, suggesting that crabs caught in the higher nets must be larger-sized individuals.

Based on the results of this study, we feel justified to suggest that net height influences the capture efficiency of crab entangling nets. We recommend therefore that crab entangling nets be regulated to 24 MD. Both the 12 and 24 MD nets had low capture rates of discards. However, compared to the 12 MD net, use of the 24 MD net height resulted in both a higher CPUE and a higher capture of larger-sized crabs (with higher market prices). This information should be beneficial to crab entangling net operators because of higher income from catch. Similarly, the improved characteristics of the crab entangling net should have positive ecological consequences in the long term.

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SEASONAL VARIATION OF CATCH COMPOSITION AND STOCK ASSESSMENT OF BLUE SWIMMING CRAB (*Portunus pelagicus*) USING CRAB TRAP IN BANATE BAY, ILOILO

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An Undergraduate Thesis Presented to the
Institute of Marine Fisheries and Oceanology
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In Partial Fulfillment of the Requirements
for the Degree of
Bachelor of Science in Fisheries

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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

SEASONAL VARIATION IN CATCH COMPOSITION OF CRAB POTS AND SPAWNING POTENTIAL RATIO OF BLUE SWIMMING CRABS (*Portunus pelagicus* Linnaeus 1758) IN BANATE BAY, ILOILO

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ABSTRACT

Seasonal variation in the catch composition of crab pot in Banate Bay between the cool dry (January to February) and warm dry (March to April) were determined. Moreover the carapace width (CW) distribution, width-body weight Fulton's condition factor, sex ratio and maturity of *Portunus pelagicus* were determined. A total of 243 crabs in the cool dry and 360 crabs in the warm dry season were collected from the local landing sites. Samples were obtained from the first batch of the catch during the day. Results showed that crabs from the two seasons did not differ significantly (p=0.08) in CW distribution. Mean Fulton's condition factor of females (k=6.17) and males (k=6.70) of *P. pelagicus* caught during the warm dry season significantly differed (p=0.000, Bonferroni corrected). Lower Fulton's condition factor of females may be associated with spawning. Sex ratio was male biased during the cool dry and warm dry seasons for male and female ratio with 1.04:1 and 1.05:1, respectively but were not significantly different (p=0.52). Cumulative abundance of mature crabs and berried crabs were higher in April (31%) indicating the start of spawning season. *Charybdis feriata* was the only bycatch species caught by crab pot with abundance of 15% and 2.8% during the cool dry and warm dry seasons, respectively. Generated assessment model using on-line SPR yielded 6 % which was much lower compared to the SPR critical point for level of exploitation. This indicates heavy fishing pressure of *P. pelagicus* in the Banate Bay.

KEYWORDS: *Portunus pelagicus,* Crab Pot, Catch Composition, Dry Season, Spawning Potential Ratio

A PROGRESS REPORT ON

By-Catch Species Composition in Gillnet and Crab Pot used in the Blue Swimming Crab, *Portunus Pelagicus* (Linneaus 1785) Fishery in the Northwestern Part of Bantayan Island, Cebu, Philippines.

Submitted to

Philippine Association of Crab Processing Inc. (PACPI)

Noted by:

Dr. Anthony Ilano
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August, 2017

Blue Crab Assessment Project-Pacpi funded
Bantayan Island,Cebu ,Philippines

Submitted by:

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Bachelor of Science in Marine Biology

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 non-target species that are harvested or sometimes providing an important source of income for the fishers (Crowder and Murawski,1998). Discarded by-catch includes species that are captured and then released whether dead or alive because they are not target species, size or sex (Davis ,2002). Individuals may also be discarded if there is no more space on board the vessel, or the quotas have already been reached. And thirdly, Unobserved mortality, is the by-catch category that includes species encountered but not retained by the gear (Crowder and Murawski,1998).

Global marine fisheries data conservatively indicates that by-catch represents 40 percent of global marine catches, totaling 63 billion pounds per year, (Keledjian et al.,2014), other studies (Alverson et al.1994) have indicated that between 18 and 40 million tons are discarded annually by commercial fisheries, making up 20-25% of total harvest. On the other hand,small-scale fisheries are generally assumed to have a low or negligible discard rate at 3.7% of total catch in aggregate (Kelleher, 2005), But recent studies suggest that wide variation in by-catch rates may 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).

By-catch or incidental catch is a common problem in most fisheries around the world and it is known as one of the principal threats to marine biodiversity worldwide through impacts on top predators, the removal of individuals from many species, or by elimination of prey, while solutions have not been implemented, by-catch not only reduces fish population, but also wastes a potentially valuable food source. Indication of stock depletions such as steady catch levels, declining catch per unit (CPUE)) from studies in Southern Sulawesi, Mallaca Straits, Java shelf and Sahul pointed out that the Maximum Sustainable Yield (MSY) exceeded in these areas and can be indicative of a fishery which is severely over exploited (Venema 1997). By-catch also has an added problem whereby it may involve the capture and mortality of species of no concern to a fisher but of direct concern to another fisher that normally targets the species discarded, thus fostering a number of socio-economic tradeoffs. By- catch may also result in an alteration in the ecosystem or ecological complex as a result of the high death rates of some target and discarded non-target species.

Prior to 1970,only artisanal gears such as hooks, traps, dredging and line were used ,however ,the introduction and population of bottom trawls in the mid-1970 and mid-1980 mattered to a significant increase in exploitation(Ingles,2004).This increased exploitation caused a decline in catch (Ingles,2004).In 1982,trawls were banned and gave the BSC a chance to recover until 1990,when the export demand for the BSC increased with the collapse of the Chesapeake Bay Crab fishery in the US (Ingles,2004).Now most production is through artisanal fleets using gillnets and pots (Ingles,2004).The increase in export demand and artisanal fleet, though ,has caused a boom and bust trend in various areas in the Philippines(Ingles,2004).When export demands increased ,artisanal fishing rose and crab meat processing plants were established (Ingles,2004).Due to high prices ,fishers entered the fishery without any management restrictions and stayed until fishing was no longer profitable(Ingles,2004).Once this occurs ,the processing plant closes and moves to another location(Ingles 2004).Shown in Figure 1a and b are the gillnet and crab pots both weighted to settle at the bottom of the ocean floor in order to increase rate of interaction and success rate of trapping blue swimming crab. 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 comprise the by-catch species.

Figures 1A and B. The gillnet (A) and Crab pot (B) used by fishermen to catch the Blue Swimming Crab,*Portinus pelagicus* locally known as "Lambay" in Bantayan Island,Cebu, Philippines.

The Blue swimming crab (BSC), *Portunus pelagicus* (Linneaus, 1785) is the third major export commodity of the Philippines after tuna seaweeds and shrimps. Due to its excellent meat quality and flavor, it follows tuna,seaweeds and shrimps in economic and has been a heavily exported wild resource since 1990s and even up to this day. According to the Bureau of Agricultural Statistics (BAS, 2013), Bicol (4B and 5) and Visayas Regions (Regions 6,7 and 8) contribute 72.4% to the total BSC production in the country, with Regions VI-B, V, VI, VII, and VIII reporting the highest crab landings. The high demand both for local and foreign trade, has led to massive collection of this marine resource in order to provide a growing industry of processing and packaging plants.

The fishing of BSC in Northern Cebu, like many commercial fisheries elsewhere in the world, have 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 swimming crab is at 42% and the by-catch at 58%, of which included Indo-Pacific crab, *Charybdis feriata* (6.5%), fishes (3.81%) and other crabs (45.34%), with gillnet leading the nay in by-catch abundance.Among the by-catch fishes caught by gillnet fishery, it has been recorded that juvenile reef shark and sting rays have also fallen prey to the methods in Bantayan island. An alarm has been raised by scientists on elasmobranch by - catch but 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 et al., 2014).

Little is known about the biological, economical and total environmental implications on artisanal by-catch from species specific fishing activities globally and an understanding of the problems and developing of effective by-catch reduction strategies is a complex, environmental challenge with scientific, socio-cultural, and socio-economic components (Komoroske and Lewison 2015).(Hartmann 1992), in his review of the World Fisheries Congress, states 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 frequently based on observation of large number of discards but infrequently on detailed population assessments of impacted stocks. This is because comprehensive and historical datasets involving discards have been unavailable to demonstrate such claims (Shester and Micheli, 2011). A study on large scale fishing done off the coast of new England and Mid-Atlantic gillnet fishery where 2000 fishermen target monkfish, it was found that the gillnet fishermen discard more than 16% of the catch. They also found out that an average of more than 1200 endangered sturgeons were captured as by-catch each year from 2006-2010, and 750 dolphins and porpoises were captured in the gillnet fishing each year (Keledjian et al., 2014).

Due to the lack of studies on by -catch particularly on the Blue Swimming Crab, little is known about the fate of by-catch in Bantayan Island from species specific catches (BSC) many different species end up in the nets or traps as by-catch of which most die because the nets or traps are taken to the shore including the by-catch and the Blue Swimmer Crab. Some other species of crabs are disregarded and left on the shore to limit the hustle of it getting caught again. Juvenile sharks, dolphins, turtles, crabs and other vertebrates have also ended up as by-catch and eventually died.

1.1 Objectives of the Study

The main purpose of this study was to determine the species composition of the by-catch of the gillnet and crab pot fishing gears used in catching the Blue Swimming Crab (BSC) *Portinus pelagicus* fishery 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 BSC Fishery will provide up to date data and act as a stepping stone for further research of similar topics locally and fill a gap in the fisheries data of the country.

A by-catch database system can be an essential feature to future coastal resources management plans or programs, this study will provide a database on the by-catch species variation within the Bantayan BSC Fishery, hence the database shall include the correct identification and measurements of by-catch species from the two fish catching methods of capture (gill-nets and crab pots) to allow the management to understand which by-catch species is affected the most. By incorporating this database into the management of BSC fisheries, management plans can be formulated to eliminate the non-target species; it will also contribute to improve efforts towards the effectiveness of each fishing gear in Bantayan Island.

CHAPTER 2

MATERIALS AND METHODS

2.1. Description of Study Site

This study was carried out on the northwestern part of Bantayan Island,Cebu,Philippines where the first large scale Blue Swimming Crab fishery is located.The Island of Bantayan is in the Visayas, most end of the northern sea of Cebu Island, across Tanon Strait(Fig.4) . Specifically for this study the sites were chosen namely Barangay Patao,Barangay Baod and Dad-dap which is found in Barangay Patao.

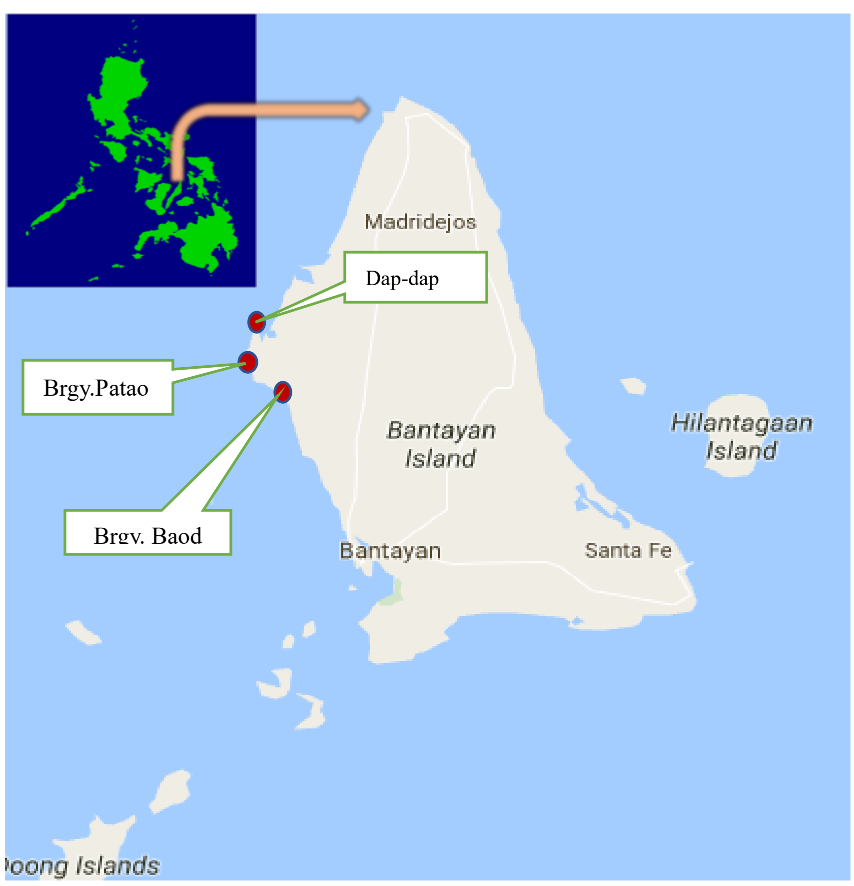
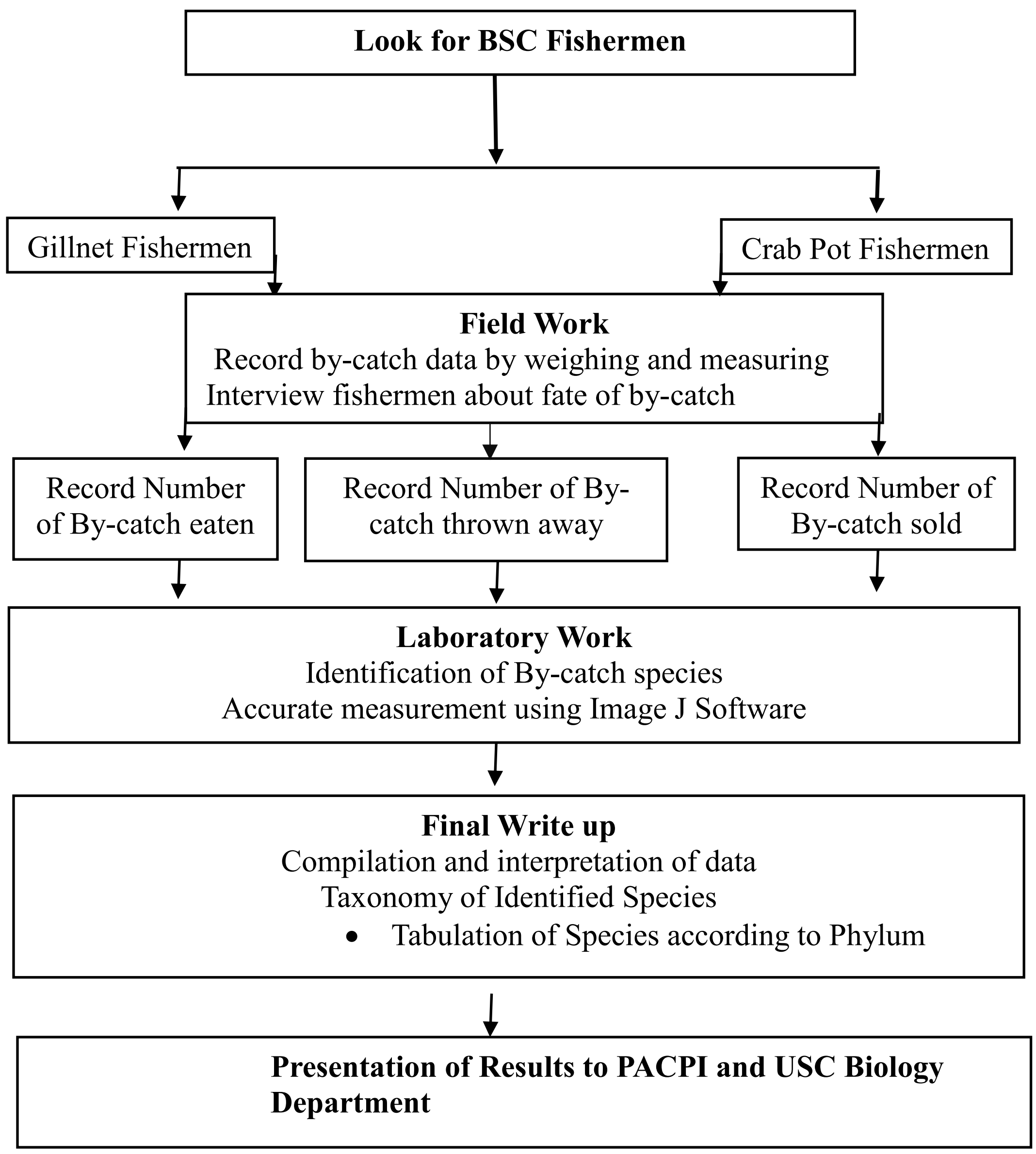


Figure 2. Map of Bantayan Island, Cebu,Philippines, showing the three study sites of the By-catch of the BSC. Red dots on the map indicate the landing sites of the BSC fishermen.

2.2. Research Design



2.3. Fieldwork Collections and Sampling Frequency

Data was collected on board of fishing boats from different fishing grounds of BSC in Bantayan Island between April 21st, 2017 to August 2017. Fourteen (14) samplings for dry season (April to May) and 14 samplings for the wet season (July to August) were conducted. 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.

After each haul for both the gill net and crab pot gear, the total catches were emptied on the boat deck and by-catches were separated from the target species. For the by-catch that were not separated on-board, they were brought to the landing sites where they were separated and recorded. Some species were identified on board while the rest on landing sites.At least 50% of the by-catch species, were weighed and counted, after which total by-catch was calculated. Large by-catch species, such as rays, were counted and weighed individually. The collected samples were brought back to the USC laboratory for further species identification.

2.4. Laboratory Work

2.4.1 Species Identification and Morphometric Measurements

The quantification of the different forms of by-catch also known as morphometric measurements is a quantitative analysis which encompass size and shape of the organisms caught. The traditional method of morphometrical analyses of the lengths, widths, masses, angles, ratios, and areas of the by-catch used in this study using the Image J software.

The by-catch species were measured and weighed, crabs were measured for the carapace length (CL), which was 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 point of the carapace (Fig.3). The CL and CW were measured to the nearest 0.1 mm for shrimps, the Total Length(TL), the combination of Carapace Length(CL) and Abdomen Length(AL) was measured and recorded. Elasmobranchs consist of rays and sharks was measured the disc width from each end of the pectoral fin. While the body weight(BW) of all by-catch species were measured using analytical balance to the nearest 0.01g and for the fish the Total Length was measured (Fig.4 and 5).

Figure 3. Measurement of crab carapace width

Figure 4. Weighing of crab using analytical balance

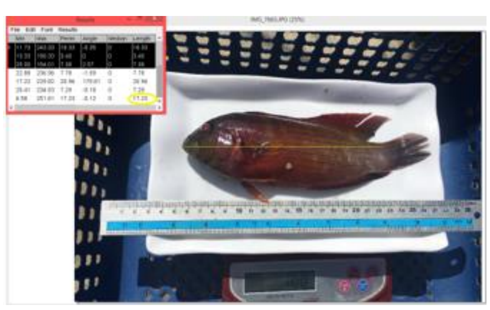


Figure 5. Measurement of fish Total length.

2.4.2. By-catch Species Composition and Identification

Prior to the species identification, first the by-catch were sorted out according to their taxon and fishing gears used. Then using various references (Field Guide to Coastal Fishes of Palawan, Gonzales J B, 2013) (Economically Important Sharks and Rays of Indonesia, White T. W et al,2006) (Coastal Crabs, a Guide to the crabs of New Zealand Volume 1, Wilkens S,2015). Identification were based on morphological characteristics such as color, lines, bands, spots and size, as seen in Table 1, for example Figure 6, the distinct green color of the carapace makes this species to be different from others and is identified as *Portunus japonica.* For the crustaceans such as the crabs, the main part of identification is the color and pattern of the carapace. In Figure 7 *Chelmon rostratus,* is identified by its clear and obvious four yellow bands and its sharp pointy snout. For fishes, shape of snout, shape of tail, color, number and patterns of bands and number of fins are considered for identification. In Figure 8, *Pardachirus pavoninus* is clearly identified by its shape which in flat and size which is bigger than most by-catch species with length size up to 25.0cm.

Table 1: Morphological characteristics used for species identification to the Phylum level

PHYLUM	MORPHOLOGICAL CHARACTERISTICS
Phylum Anthropoda	1) Bilaterally symmetrical and have a hard, outer skeleton (the exoskeleton) 2) Jointed body and limbs. 3) The body is segmented 4) Class Decapoda have 5 pairs of legs used for walking. 5) Class Decapoda, carapace is either

	triangular, square-shaped round, may be pea shaped and oval.
Phylum Chordata	1) Body plan (shape and size) 2) Colors (body) 3) Number of Fins
Phylum Echinodermata	1) Radial symmetry body 2) Covered in some form of spike(cucumbers),spines (sea urchins)and bumps(seastars)
Phylum Mollusca	1. Class Gastropoda have asymmetrical body plan 2. Secretion of shell in most species 3. Class Bivalvia consist of two shells held together by muscles
Phylum Porifera	1) have thousands of little pores and canals running through its body. 2) have a skeleton composed of fine mesh of little needle-like structures, called **spicule** 3) Body shapes, sizes, and colors

Figure 6. The Asian paddle crab *Charybdis Japonica* (A.Milne-Edwards, 1861)

Figure 7. The copper band butterfly fish,*Chelmon rostratus* (Linnaeus, 1758)

Figure 8. Peacock sole fish *Pardachirus pavoninus* (Lacepède 1802)

2.3.3. Data and Statistical analysis

The data was collected from Bantayan Island from April to August 2017, to determine the composition of by-catch (discarded species), measurement and weight value of species to the total by-catch was analyzed by Image J software. For documenting the by-catch composition, the by-catch species were listed according to their landing sites, fishing gear, species, number of by-catch sample for each species length, width and their weight. A two-way analysis of variance (ANOVA) was used to compare the volume and abundance of the different by-catch species as well.

CHAPTER 3

RESULTS AND DISCUSSIONS

3.0 RESULTS

3.1.1. By-catch species Composition, Identification and Classification

The by-catch species were collected from three landing and fishing sites. A total of 3900 species were analyzed from 14 samplings.33 families were identified in this study, 15 families from Phylum Chordata,14 families from Phylum Mollusca and 4 families from Phylum Arthropoda. The total number of by-catch found for each species and percentage occurrence of by-catch's family were summarized in Tables 2,3 and 4.

Table 2: Identified By-Catch Species for Phylum Arthropoda

			Crab pots	Gillnet	Total
CLASS: Malacostraca					
	Family: Parapylochelidae				
		Pagarus bernhardus(hermit)	550	22	572
	Family: Portunidae				
		Charybdis japonica	40	22	62
		Charybdis natator	81	13	94
		Thalamita pelsati	153	18	165
		Portunus gladiator	8	27	34
		Atergatis integerrimus			
		Lophozozymus pictor	13	69	82
		Scylla serrata			
		Dorippe lanata			
		Demania cultripes	*6*		

Table 3. Identified By-Catch Species for Phylum Echinodermata

CLASS :Asteroidea		Crab Pots	Gillnets	TOTAL
Family : Oreasteridae				
	Protoeaster nodosus(choco chip	6	342	348
	Protoreaster linckii	14	6	20
CLASS Holothuroidea				
	Holothuroidea sp.	0	1	1
CLASS Ophiuroidea				
	Ophiocoma imbricatus	0	1	1

Table 4. Identified By-Catch Species for Phylum Chordata

	CLASS: Chondrichthyes	Crab pots	Gillnets	TOTAL
Family: Dasyatidae	*Neotrygon orientalis*	0	4	4
Family:Scyliorhinidae	*Aulohalaelurus oereosvy*	2	0	2
	CLASS: Actinopterygii			
Family Carangidae	*Selaroides leptolepis*	11		
Family Lutjanidae	*Monacanthus chinensis*	1389	16	1405
	Paramonacanthus curtorhynchos	1	0	1
	Lutjanus ehrenbergii			
Family Nemipteridae	*Scolopsis vosmeri*	0	1	1
	Nemipterus sp.			
	Nematophthalmus Cymbacephalus			
	Scolopsis monogramma	31		
Family Siganidae	*Siganus virgatus*	0	5	5
Family Scaridae	*Scarus ghobban*	1	0	1
Family Scorpaenidae	*Centrogenys vaigiensis(false*	39	5	43
	Scorpaenopsis oxycephala	1		
	Scorpaenopsis diabolus	0	4	4
Family Serranidae	*Epinephelus sexfasciatus*	1	0	1
	Cephalopholis boenak	12	0	12
	Diploprion bifasciatum	1	0	1
	Labracinus cyclophthalmus	0	2	2
Family Synanceiidae	*Inimicus didactylus*		1	
Family Mullidae	*Upeneus tragula*	27		
Family Gerredae	*Gerres oyena*	8		
Family Scombiridae	*Thunnini sp.*		1	
Tetraodontidae(puffer)	*Arothron manilensis*	29		
	Arothron hispidus	5	2	7
	Arothron stellatus	8		
Family Platycephalidae				
Family Chaetodontidae	*Chaetodon octofasciatus*		1	
Family Pomacentridae				
Family Lethrinidae				
Family Pseudochromidae	*Labracinus cyclophthalmus*		1	
Family Apogonidae	*Apogon trimaculatus*	1		

Table 5: Identified By-Catch Species of Phylum Mollusca

PHYLUM MOLUSSCA				
		Crab Pots	Gillnets	TOTAL
CLASS:CEPHALOPODA				
Family Sepiidae	*Sepiida sp.*	22	3	19
Family Octopodidae	*Octopus abaculus*	32	0	32
Family Ommastrephidae.	*Dosidicus gigas*	1	2	3
CLASS:GASTROPODA				
Family Cypraeidae	*Cypraea miliaris*	3	0	3
	Cypraea onyx	2	0	2
Family Muricidae				
	Murex haustellum	26	0	26
	Chicoreus ramosus	26	632	658
	Rapana vapiformis	2	0	2
	Chicoreus palmarosae	0	16	16
Family Tonnidae	*Tonna allium*	14	0	14
Family Olividae	*Oliva oliva*	2	0	2
Family Trochidae	*Trochus niloticus*	17	0	17
Family Fasciolariidae	*Pleuroploca trapezium*	22	0	22
	Fusinus ocelliferus	3	0	3
	Fusinus colus	1	0	1
Family Cymatiidae	*Cymatium pileare*	12	0	1
	Cymatium sp		1	
Family Naticidae	*Natica stellata*	3	0	3
	Polinices cumingianus	1	0	1
Family Bursidae	*Bursa sp.*	9	0	9
Family Cassidae	*Semicassis bisulcata*	10	0	10
Family Strombidae	*Labiostrombus epidromis*	3	1	4
	Lambis lambis	0	13	13
CLASS BIVALVIA				
Family Spondylidae	*Spondylidae reevei*	135	2	137
Family Pteriidae				
	Pteria heteroptera	0	144	144

3.1.2. Systematics of Identified Species

Phylum Chortada

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 Vetrbrata, making it the third-largest phylum in animal kingdom.

Family Dasyatidae

Figure 1 *Taeniura lymma* (Forsskål, 1775)

Common names: Blue-spotted lagoon ray, blue spotted ribbontail ray, lesser ray

Key Features:

a. Upper surface with bright blue spot

b. Tail with a long blue stripe extending side before sting

c. Ventral skin fold on tail moderately deep

Size: At least 35cm

Distribution: Widespread in Indo-West Pacific, from southern Africa to the Solomon Island

Habitat and Biology: Very common in coral reef habitats and inshore to depts atleast 20m. Viviparous with histotophy. Diets consist primarily of molluscs, worms and small crustaceans; feed over shallow sand flats on a rising tide and commonly found in caves and under ledges at low tide.

Conservation status: IUCN Red List: Near threatened

Family Siganidae

Figure 2 Siganus virgatus
(Curvier & Valenciennes)

Common Name:

Local Name: Tagbago

Size: 15-20cm, Maximum; 30cm

Key Features

a) Compressed body Anterior nostril with a fleshy brim
b) Oblique brown bands running through eyes and upward from pectoral fin base.
c) Fins; D 13+10, A 7+9
d) Scales; 140 to 150 on lateral line. Minute,cyclolid.

Figure 3 *Siganus spinus* (Linnaeus)

Common Name: Black trevally

Local Name: Danggit

Key Featutres:

a) Compressed body
b) 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.

Family Carangidae

Figure 4 Selaroides leptolepsis (Cuvier & Valenciennes)

Common Name: Yellow strip treval

Local Name: Lambiao

Size: 15cm, maximum; 20-25cm

Key Features

a) Large eyes,upper jaw reaching to below front border of eye
b) Disntict golden stripe on side of body and a dark round blotch at upper corner of gill cover.

Family Serranidae

Figure 5 ***Epinephelus sexfasciatus*** **(Valenciennes 1828)**

Common Name: Six-banded rockcod

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

Size: 20-28cm

Key Features

a) Brownish with six broad vertical darker bands, bands as wide as interspaces, double in young and composed of large brown spots extensding onto dorsal and anal bases. Pectoral fins light yellow
b) Scales: 52-56 on lateral lines. 89-100 along midlines. 9-14 + 30 30 to 38 transverse scales.

Family: Portunidae

Figure 6 ***Charybdis natator***
(Herbst,1794)

CommonName:Ridged Swimming Crab

Size: Maximum 17cm

Key Features

a) Carapace densely covered with very short pubescence which is absent on several distinct trancerse granulated ridges in anterior half.
b) Color: orange red overall, ridges on carapace and legs dark and reddish brown.

Distribution: Indo-West Pacific: from the Red Sea to China and Australia.

Biology: Occurs at depth range 5-50m. Inhabits rocky areas, sandy-rocky areas, coral and coral reefs. Subtropical and tropical climates.

Figure 9. ***Portunus (Monomia)gladiator***

(Fabricius, 1798)

Common name: Gladiator Swimming Crab

Size:

Key features:

a)

Distribution: Madagascar, Republic of Mauritius. Philippines

Biology:

Key Features

a) Walking legs flattened and unspined

b) Last pair of legs flattened into rounded paddle, fringed with setae.

c) Overall dull olive green with various mottling from orangish-brown to dark purple. Chelipeds with orangish-brown palms and banded fingers.

Figure 7 Charybdis japonica
(A.Milne-Edwards, 1861)

Common Name: Asian Paddle Crab

Distribution

Found throughout the Indian and Pacific Oceans

Common Name: Mud crab,

Figure 8 Scylla serrata (Forsskål, 1775)

Key Features

a) Carapace color ranging from a deep molten green to very dark brown.

Distribution: Africa, Austraila and Asia

Ecology: Juveniles are residents in mangrove zone during low tide while subadults migrate to intertidal zone to feed at high tide and retrea to subtidal waters at low tide.

Highly cannibalistic in nature.

Biology: Found on muddy or sandy bottom. Gonochoristic. Benthic. Depth range of 32-345m

Distribution: Indo-west Pacific, New Caledonia, Mozambique and Madagascar.

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Pictures from the Field