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Blue Swimming Crab (*Portunus pelagicus*) Fishery Status in Lianga Bay, Surigao del Sur, Philippines

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Abstract
This study aimed to determine the catch per unit effort (CPUE), fishing gears used, catch volume, carapace length, and physico-chemical parameters of the Blue Swimming Crab (BSC) in the four municipalities of Lianga Bay, Surigao del Sur, Philippines, namely Barobo, Lianga, San Agustin, and Marihatag. The survey questionnaire was deployed based on the Blue Swimming Crab Management Plan (BSCMP). After three months of observation, Barobo obtained the highest CPUE while Marihatag had the lowest. Barobo also had the highest CPUE using a gill net and crab pot while San Agustin had the lowest using bintol. In terms of catch, the monthly trend showed that March had the highest catch, while April had the least. The frequency distribution of the carapace length showed a unimodal pattern in all municipalities. The physico-chemical parameters of the water were within tolerable limits for the BSC. This study provides baseline data on the BSC fishery in Lianga Bay, which can be used in developing sustainable management strategies for the BSC fishery in the area, ensuring its long-term viability while promoting conservation efforts.

Keywords: *Blue swimming crab, CPUE, Lianga Bay*

Introduction
The blue swimming crab (*Portunus pelagicus*) is an economically important marine invertebrate in Lianga Bay, Philippines due to its high value and increasing demand leading to higher prices. This species has a wide distribution in the coastal waters of the Philippines, with juvenile individuals typically found in shallow waters with sea grass, seaweeds, and algal beds, while mature individuals are found in sandy substrates at depths of up to 20 meters isobaths (Ingles, 1996). The average size of maturity for females is 10.56 cm and 9.64 cm for males (Ingles and Braum, 1998).

The fishery of the blue swimming crab (BSC) is crucial to the livelihoods of small-scale fishermen in Lianga Bay, Surigao del Sur, who typically use crab nets to collect this highvalued commodity. However, the catch of this species is limited due to declining populations, which can be attributed to several problems, including overharvesting by efficient fishing gear, destruction of nursery habitat, harvesting of ovigerous females, and inefficiency of crab management (National Fisheries Institute Crab Council, 2013). This issue is prevalent in Southeast Asian countries such as Thailand, the Philippines, Vietnam, and Indonesia.

Efficient management of the blue swimming crab populations requires greater knowledge about its distribution (Cabrales et al., 2013). The declining stock of the blue swimming crab fishery not only affects the socio-economic gains of the industry but also the livelihoods of the blue crab fishers. Effective management and conservation strategies are needed to sustainably maintain the blue swimming crab populations and support the livelihoods of local fishermen. Community support and confidence in the management of this fishery are required to ensure ongoing access to fisheries resources by all sectors.

Accurate data is needed to build confidence and understand the impact of current harvesting levels. Setting a clear vision for the future of this fishery can lead to more effective and sustainable management of the catch of all fishers and reduce conflict between stakeholders (Australia, Sustainable Fisheries Strategy 2017-2027). The sustainable management of blue swimming crab populations is not only important for the livelihoods of local fishermen but also for the preservation of a vital marine resource. Hence, this study.

Methodology
Description of the study site
Lianga Bay, Surigao del Sur is located east coast in the Province of Surigao del Sur, in the Caraga Region, or Region XIII, Mindanao. Facing the Pacific Ocean, it has a total area of 49,390.7 has. Four municipalities within the Bay share its

marine resources. These municipalities include Barobo, Lianga, Otieza (now San Agustin) and Marihatag. Overall, the Lianga Bay municipalities occupy a total land area of 1,007.50 km2.

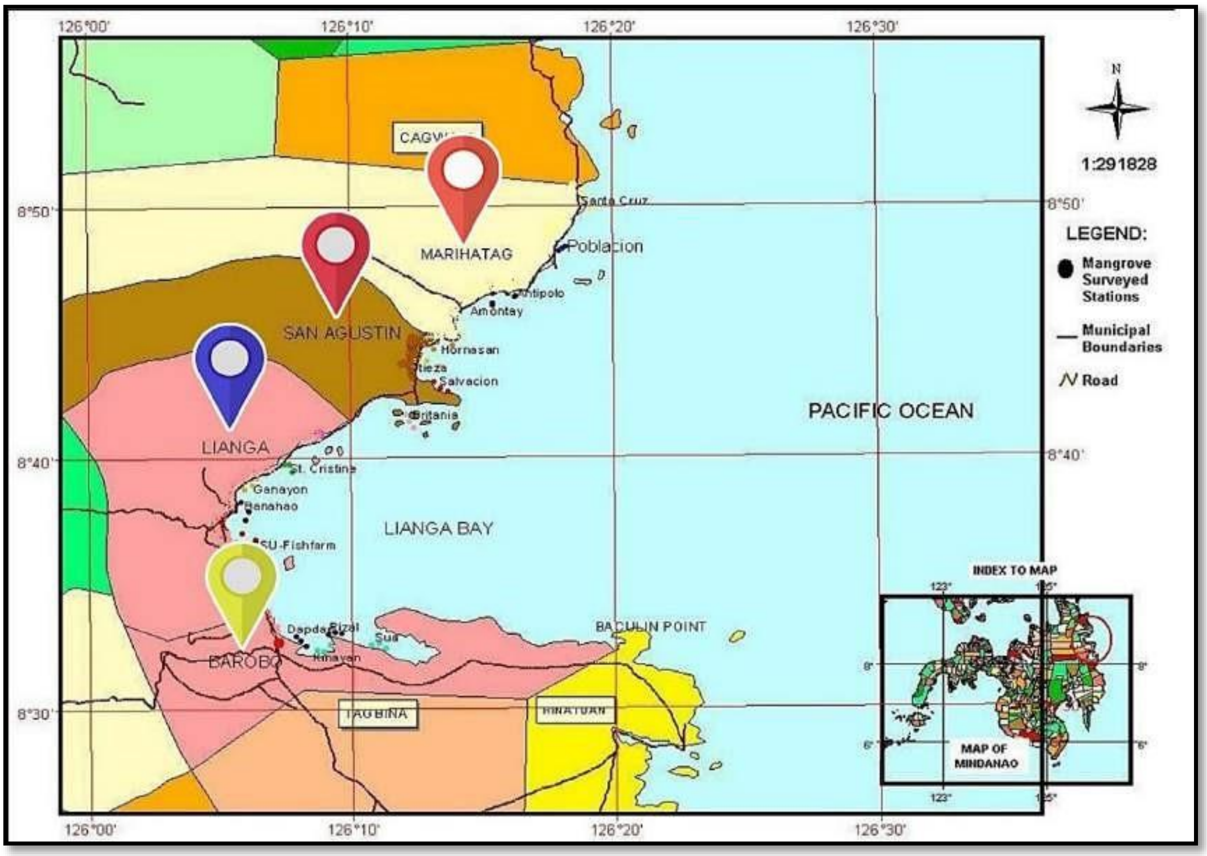

Figure 1. Map of Lianga Bay, Surigao del Sur showing the four fish landing sites of BSC (Quevedo and Ruaza, 2013).

Research design
The study focused on fishermen who engage in the BSC fishery in Lianga Bay, Surigao del Sur. The survey was conducted across four municipalities, and a survey form was developed based on a previous survey in BSCMP 2013. The questionnaires were distributed to assigned enumerators who collected data on catch daily in the field. Data gathered on BCS catch per unit effort (CPUE) and gear used were monitored every week from February to April 2019.

To ensure that sufficient data were generated, a descriptive research design was employed, utilizing a researcher-made questionnaire that was formulated and validated by experts. Additionally, a focus group discussion (FGD) was conducted to gather further data that substantiate benchmark information of the study. Finally, observations were made of the collection of the blue swimming crabs in the areas by fishers directly involved in the industry. *Crab gears used in catching BSC in Lianga Bay*

The fishing gears used so far in harvesting the BSC are gill nets locally known as "pukot", crab pots locally known as "bubo" or panggal. Other method used is Crab left net or Bintol or look like a "salambaw" in the municipality of Marihatag and San Agustin, Surigao del Sur.

Fishing grounds and landing sites
Together with crab fishers, specific location of BSC fishing ground were determined using a Global Positioning system (GPS) or Geo camera and plotted on the map. Landing sites were also plotted on the map. Figure 2 presents the 35 fishing grounds mapped out in this study and its corresponding location coordinates, these fishing grounds are located in the nortwestern, southeastern and southwestern parts of Lianga Bay. With regards to the catch, crab fishers sold them to different landing sites located within Barangay Wakat, Sitio Lawis, Sitio Taunaga, Municipality of Lianga Bay and one landing site located in Baragay Talisay, Municipality of Barobo (Fig.1), in these landing sites BSCs are bought and then sold or forwarded to Manila.

Figure 2. Map of Lianga Bay Showing point of the 35 fishing ground

Statistical analysis

Catch per Unit Effort (CPUE) is an indirect measure of the abundance of a target species, the 132 Blue Swimming Crabs. The volume of catch of blue Swimming crab in Lianga Bay can be 133 quantified in terms of CPUE. Changes in the CPUE are inferred to signify changes in the 134 abundance of the BSC. The formula below was used to determine the CPUE.

Catch per Unit Effort = Total daily weight of catch (kg)/ (No. of fishers (man) /No. of hours 136 spent in fishing)

To determine whether there is a significant difference among the means of the monthly average CPUE, the data was normalized using Tukey's ladder of powers transformation, then tested 139 with two-way ANOVA. A Post Hoc test was used to determine which among the months and 140 fishing gears differ significantly.

Results

Average catch per unit effort (CPUE) of the BSC

After three months of observation, Barobo gained the highest CPUE of BSC while Marihatag 145 obtained the lowest as shown in Table 1.

Table 1. The average CPUE (kg/hr) in the four municipalities in Lianga Bay, Surigao del Sur.

Municipalities	Catch per unit effort (CPUE) kg/hr			
	February	March	April	Total
Barobo	0.18	0.195	0.16	0.535
Lianga	0.095	0.11	0.08	0.285
San Agustin	0.06	0.05	0.042	0.152
Marihatag	0.085	0.06	----	0.145

Fishing gears used in catching BSC and comparing its CPUE

The type of fishing gear used by fishers in the four municipalities to catch the BSC in Lianga 156 Bay, Surigao del Sur is reflected in Table 2. Among the fishing gears used, Barobo had the 157 highest CPUE using a gill net while Lianga gained the lowest CPUE. For crab pot, Barobo had 158 0.16 CPUE which was found to be the highest while lowest in San Agustin with 0.08. In the 159 case of bintol, only San Agustin and Marihatag used this gear.

Statistically, the CPUE among the four municipalities and fishing gears used revealed that 161 Barobo has a significantly higher (*p-value* 0.04 > 0.05) CPUE compared to Lianga, San 162 Agustin, and Marihatag.

Table 2. The average CPUE along the fishing gears used

Municipalities	Fishing Gears		
	Gillnet	***Crab Pots***	***Bintol***
Barobo	0.64	0.16	---
Lianga	0.21	0.13	---
San Agustin	0.07	0.08	0.06
Marihatag	0.04	0.11	0.1

Catch volume of BSC

The monthly catch trend of BSC in Lianga Bay from February to April 2019 has a total volume of 2,787.5 kgs. The month of March had the highest catch followed by February while the least catch was found in April as shown in Figure 3.

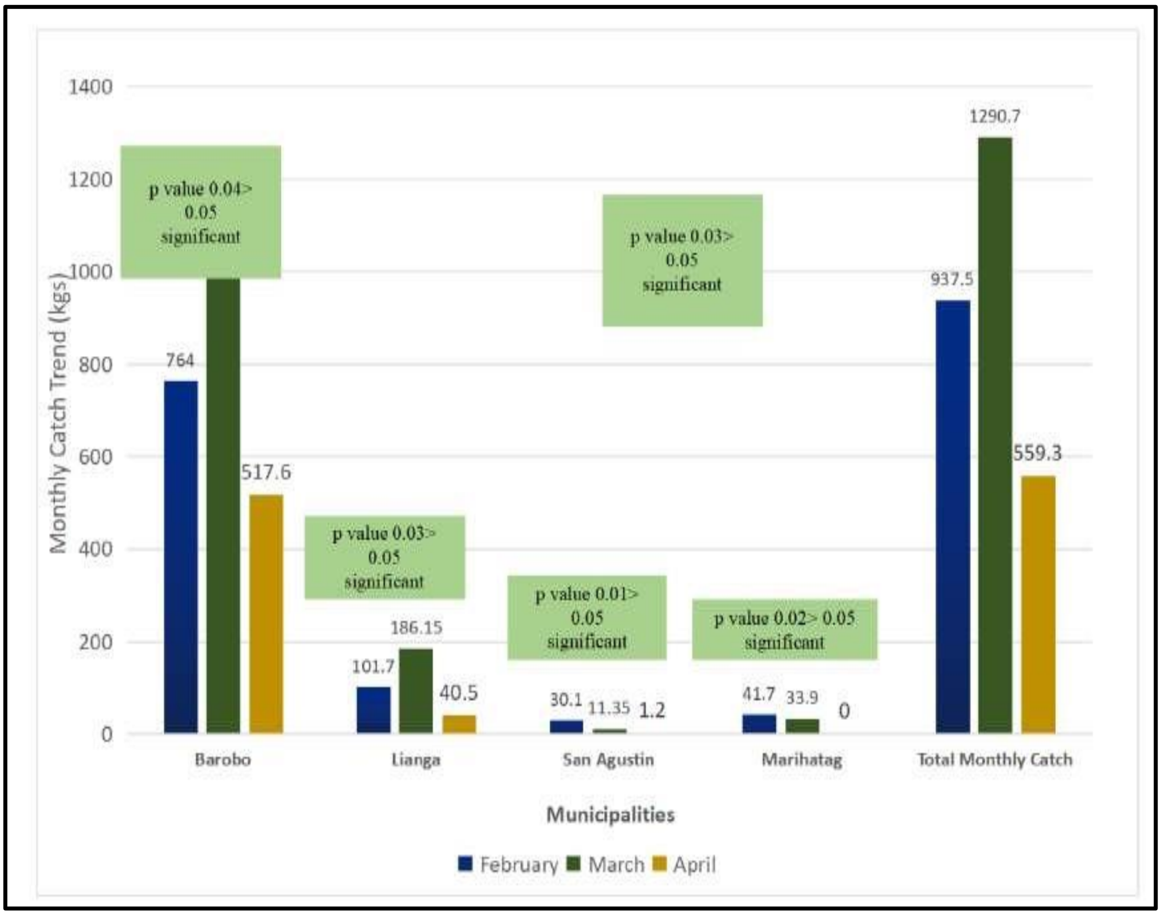

Figure 3. Monthly catch trend of BSC in Lianga Bay, Surigao del Sur

Comparison of the length of the carapace of BSC in different municipalities of Lianga Bay

The frequency distribution of the carapace length (cm) of BSC in Lianga Bay with a unimodal pattern. In Barobo, with a high volume of catch Municipality, the majority of the BSC that was caught has a carapace length of 11.5 - 15 cm. Same pattern was observed in the three other municipalities (Figure 8).

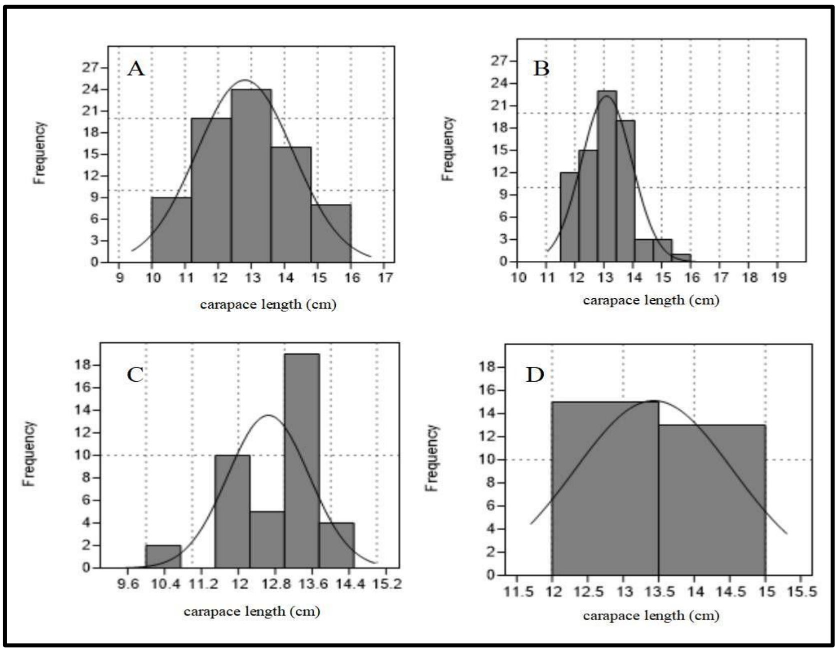

Figure 4. The histogram of the carapace length (cm) of BSC in the four municipalities in Lianga Bay. (A.) Barobo, B.) Lianga, C.) San Agustin, D.) Marihatag).

Physico-chemical parameters

The physico-chemical parameters results are presented in Table 3.

Table 3. The mean salinity and temperature within the months of February - April 2019.

Sampling Months	Barobo		Lianga		San Agustin		Marihatag	
	Salinity	*Temp.*	*Salinity*	*Temp.*	*Salinity*	*Temp.*	*Salinity*	*Temp.*
February	33.4	28.8	33.3	28.2	33.8	28.2	33.46	28.11
March	32.4	28.4	33.3	28.0	32.9	28.1	33.88	28
April	31.1	28.8	30.1	28.5	30.1	28.5	32.5	28.5

The study revealed that the salinity and temperature of the water in the study area were within tolerable limits for the Blue Swimming Crab. The water parameter readings for a period of three months were relatively consistent, although higher salinity readings were observed in Marihatag during February, while a high-temperature reading was observed in Barobo. This may be attributed to the limited freshwater tributaries in the area and the prevalence of sunny days during the sampling period. Conversely, San Agustin had the lowest salinity, possibly due to the substantial distribution of freshwater from the Buhisan River.

Discussion

Average catch per unit effort (CPUE) of the BSC

The study analyzed the time spent by crab fishers in setting up gill nets and crab pots, as well as the CPUE, fishing methods, and problems encountered in four municipalities. Barobo had the highest average CPUE of 0.535kg/hr due to a large number of fishers in the area, while Marihatag had the lowest CPUE of 0.145kg/hr because of fewer fishers engaged in fishing.

The study found that some crab fishers switched to gathering lobster fry due to the high selling price. The number of fish crabbers varied by municipality, with Barobo having the highest number. The study also identified several problems encountered by the crab fishers, such as the scarcity and unavailability of bait, unpredictable weather conditions, and the topographic location of fishing grounds.

The study builds on Hamel et al. (2017) research on the importance of fishing places and perceptions of fishing opportunities. The study quantifies the importance of a fishing place using fishing catch, effort, and other common proxies of fishing opportunities. The study further compares the depiction of fishing importance with the importance of fishing grounds as perceived by households on the fishing value.

Fishing gears used in catching BSC and comparing its CPUE

Gillnets are known to have high bycatch impacts (Brown, 2016). Crab pots, however, had the highest average CPUE of 0.16 in Barobo, while San Agustin had the lowest with only 0.08. The highest CPUE in Barobo was attributed to the abundance of blue swimming crabs in seagrass ecosystems (Millennium Ecosystem Assessment (2003). San Agustin had the lowest CPUE, as most fishers caught different species of crabs that favored sandy substrates rather than blue swimming crabs. The study found that catch and abundance were influenced seasonally, but fishers tended to operate their fishing gears at the same intensity all year round. The CPUE decreased from 0.34 kg/panel in 1995 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 indicated that maximum sustainable yield (MSY) was achieved prior to 1999 at 13,150 MT and fMSY at 19,473 gillnet panels. However, yield decreased in 2011 and 2012 due to increasing fishing efforts, indicating growth in overfishing. Population parameters results showed that the L∞ value obtained at 19.10 cm for this study was lower than in previous studies. The computed E value at 0.68year-1 is higher than the threshold at E = 0.5year-1 and at optimum E10 = 0.56year-1, indicating overfishing. Recruitment overfishing was 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% (Sheryll V. M. et. Al, 2018

Catch volume of BSC

Lianga Bay exhibited consistent volume catches of BSC for three consecutive months from February to April, totaling to 2,787.5 kgs. Notably, the month of March recorded a high volume catch of 1,290.7 kgs, followed by February and April with 937.5 kgs and 559.3 kgs, respectively. Barobo Municipality contributed significantly to the catch volume of BSC, accounting for more than half of the total catch volume with 2,340.9 kgs. Conversely, Lianga, San Agustin, and Marihatag Municipalities had lower contributions due to their cessation of BSC gathering, owing to the abundance of lobster fingerlings in the area. The majority of crab fishers in these municipalities participated in the collection of lobster fingerlings.

Moreover, there were significant differences observed in the catch rate of BSC among the four municipalities of Lianga Bay, as influenced by the sampling months. The CPUE and catch volume data also coincided with the high catch rate in March, which could possibly be attributed to the peak season of BSC. However, this observation is not conclusive due to the limited sampling period.

Comparison of the length of the carapace of BSC in different municipalities of Lianga Bay

The study discovered that the carapace length of the BSC caught in Barobo municipality, and the other three municipalities - Lianga, San Agustin, and Marihatag - showed a similar pattern, with the majority of the catch having a carapace length ranging from 10cm to 16cm. In Barobo and Lianga, the standard mesh size recommended by the Bureau of Fisheries and Aquatic Resources (BFAR) was used, which was responsible for the similarity in the carapace length of BSC caught in both municipalities. On the other hand, fishers in Marihatag and San Agustin used multi-layer nets that caught all species indiscriminately.

In order to estimate the population size of the stock and to exploit it, the body carapace length/width relationships of a population need to be measured (Josileen, 2011). The body weight-carapace length/width relationships are more suitable for assessing crustacean populations (Phinney, 1977; Adegboye, 1981; Olmi & Bishop, 1983; Suhalya & Rashan, 1986; Prasad & Neelakantan, 1988; Prasad et al., 1989; Sukumaran & Neelakantan, 1997; Atar & Sector, 2003; Gorce et al., 2006; Sangun et al., 2009), as cited by Tina (2015). Tina also speculated that crab sizes could indicate the current status of a population stock. Increased use of efficient fishing gear and lack of knowledge about population stock management and conservation could result in a decrease in crab catch.

It should be noted that the body weight-carapace length/width relationships index was not used to analyze the data collected. Moreover, no further investigation was carried out to determine the possible relationship between various measurements, including total length, width, and thickness, and how they relate to other features. Nonetheless, the data were analyzed graphically and tested statistically based on Green et al. (1961).

Conclusion

In summary, this study provides insights into the BSC fishery in Lianga Bay, Surigao del Sur. The average CPUE of the BSC varied among the four municipalities, with Barobo having the highest CPUE using gill nets, crab pots, and bintols. The monthly catch trend showed that March had the highest catch volume. The frequency distribution of the carapace length of BSC had a unimodal pattern. The physicochemical parameters of the water showed that the salinity and temperature were within tolerable limits, although higher salinity readings were observed in Marihatag in February, and a high-temperature reading was observed in Barobo. Overall, the study suggests that the BSC fishery in Lianga Bay is viable, with variations in CPUE among the four municipalities and fishing gear used. These findings can be valuable in developing sustainable management strategies for the BSC fishery in the area, ensuring its long-term viability while promoting conservation efforts.

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