Blue Swimming Crab Stock Assessment in Danajon Bank and Visayan Sea

Submitted by:
Joanne Garcia
Johnson Paran
Lea Ann Jungoy
Gerimae Calinahan

INTRODUCTION

The Blue Swimming Crab (*Portunus pelagicus*) stands as a vital marine resource within Philippine coastal waters. Its widespread distribution encompasses nearshore shelf areas, particularly at depths exceeding 70 meters. Renowned for its striking blue coloration and elongated chelipeds, this species plays a dual role: supporting local livelihoods through fisheries and contributing to the ecological balance of the region. As a commercially valuable crab, it has been sought after both in traditional hard-shell form and as a prized "soft-shelled" delicacy in Asian cuisine. Despite its significance, comprehensive stock assessments specific to Philippine waters remain essential to ensure sustainable management and conservation efforts. By understanding the population dynamics, habitat preferences, and threats faced by the Blue Swimming Crab, researchers and policymakers can work toward safeguarding this valuable marine species for future generations.

This report presents comprehensive stock assessment of the Blue Swimming Crab (*Portunus pelagicus*) within the fishing grounds of Danajon Bank and the Visayan Sea from May 2022 to April 2023. By integrating catch monitoring, reproductive biology analysis, and data interpretation, we seek to understand the current stock status, identify threats and propose management strategies.

STUDY SITE

The study site encompasses two key fishing ground: Danajon Bank and Visayan Sea. The Danajon Bank, nestled in the Camotes Sea, stands as the only double barrier reef in the Philippines—a rarity in the world of marine ecosystems. Its formation is a fascinating blend of favorable tidal currents and coral growth. Imagine two sets of large coral reefs, side by side, stretching for an impressive 156 kilometers (97 miles) across the Central Visayas region. These reefs—like underwater fortifications—guard the waters between Bohol, Cebu, and Leyte.

Figure 1. Map of Visayan Sea showing the landing sites established for blue swimming crab (BSC) catch monitoring and Reproductive Biology from May 2022 to April 2023.

The Visayan Sea, surrounded by the islands of the Visayas, is a vital part of the Philippine archipelago. Its boundaries are defined by the islands of Masbate to the north, Panay to the west, Leyte to the east, and Cebu and Negros to the south. Picture clear blue waters stretching across approximately 10,000 square kilometers (3,900 square miles), connecting these diverse landmasses.

Figure 2. Map of Visayan Sea showing the landing sites established for blue swimming crab (BSC) catch monitoring and Reproductive Biology from May 2022 to April 2023.

For this study, we selected two landing sites around Danajon Bank: Lapinig in Pres. Carlos P. Garcia, Bohol, and Guintaboan in Ubay, Bohol. Within the Visayan Sea, we identified four monitoring sites in Bantayan, Cebu municipality: Baod, Doong, Hilotongan, and Guiwanon.

FISHING GEARS

Crabbers from different localities utilize specific types of gear to catch the Blue Swimming Crab. Based on our recent survey, crabbers in both Danajon Bank and the Visayan Sea primarily employ four types of gear: Crab Nets, Crab Pots, Diving with Compressors, and Barehand Fishing

Figure 3 illustrates the gear profile for Blue Swimming Crab (BSC) fishing, recorded at monitoring sites within Danajon Bank and the Visayan Sea from May 2022 to April 2023. In the Guintaboan area of Danajon Bank (Ubay), crab nets were the sole BSC gear used, with approximately 42 units. Meanwhile, in Lapinig (Pres. Carlos P. Garcia, Bohol), crab pots emerged as the predominant gear, with about 23 units, while crab nets accounted for 9 units.

In the Visayan Sea, Baod (Bantayan) had the highest count of crab nets, with 243 units. Additionally, there were 23 crab pots, 7 fishers engaged in barehand fishing, and 7 fishers engaged in diving with compressors. In Doong (Bantayan), there were 71 fishers engaged in barehand fishing, 48 engaged in crab nets, and 7 fishers engaged in diving with compressors. In Hilotongan (Bantayan), 222 fishers were engaged in diving with compressors, alongside 67 were using crab nets and 102 fishers engaged in barehand fishing. Finally, in Guiwanon (Bantayan), there were four gear types documented: crab nets dominated with 192 units, followed by 18 fishers engaged in barehand fishing, 12 in crab pots, and 45 fishers engaged in diving with compressors.

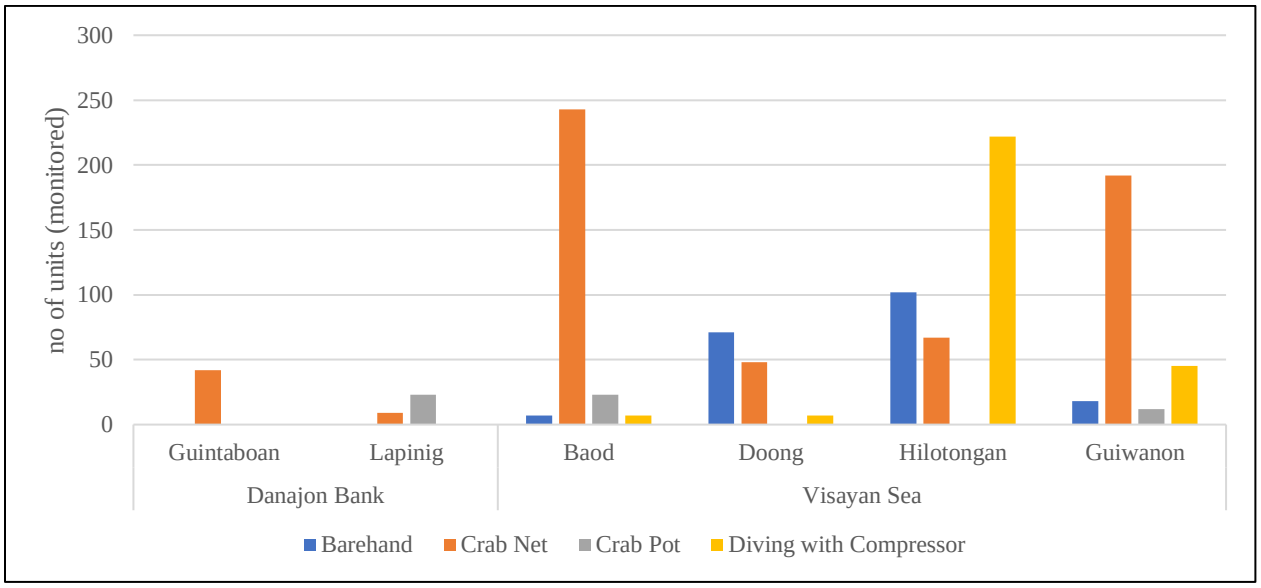


Figure 3. Profile of BSC gears recorded in the six landing sites of Danajon Bank and Visayan Sea from May 2022 to April 2023.

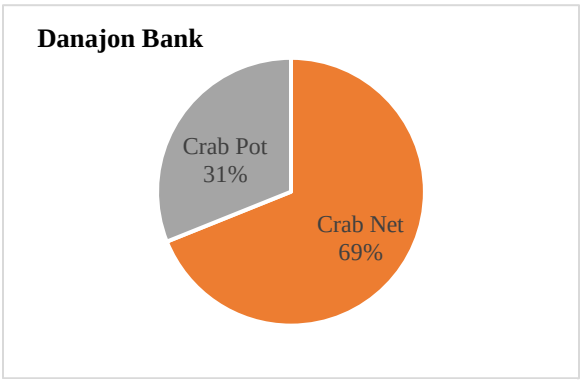


Figure 4. Percentage of fishers by gear type in the two landing sites in Danajon Bank.

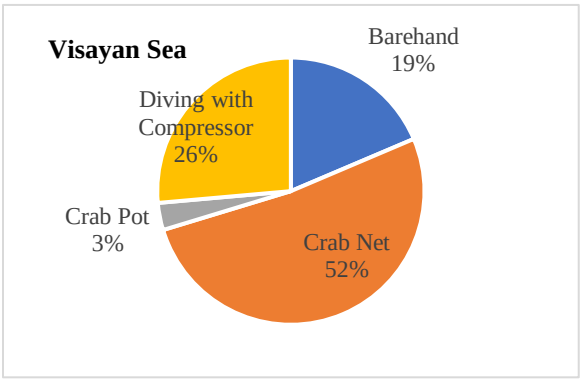


Figure 5. Percentage of fishers by gear type in the four landing sites in Visayan Sea.

A total of 74 fishers were monitored across two landing sites in Danajon Bank, while 1,064 fishers were monitored at four landing sites in the Visayan Sea. Specifically, in Danajon Bank, the data generally showed that the highest percentage of fishers—69% (51 fishers) used crab nets, while a smaller group engaged in crab pots, accounting for 31% (23 fishers) (Figure 4). In the Visayan Sea, a similar pattern emerged: crab nets remained predominant, representing 48% (550 fishers), followed by diving with compressors at 25% (281 fishers), barehand fishing at 17%, and finally, crab pots with the fewest user—3% (35 fishers) (Figure 5).

DISTRIBUTION OF LENGTH SIZES

The size distribution of Blue Swimming Crab, categorized by gear type, was sampled at the four landing sites in the Visayan Sea. The results are presented in Figures 6A-D. Specifically, a total of 8,478 (9%) individual *P. pelagicus* caught during barehand fishing were sampled for length frequency measurement (Figure 6A). Crab nets yielded the highest number of collected samples, totaling 50,252 (56%) (Figure 6B). Diving with compressors contributed 26,113 (29%) samples (Figure 6D) and Crab pots, on the other hand, had smaller samples, totaling 5,049 (6%) (Figure 6C).

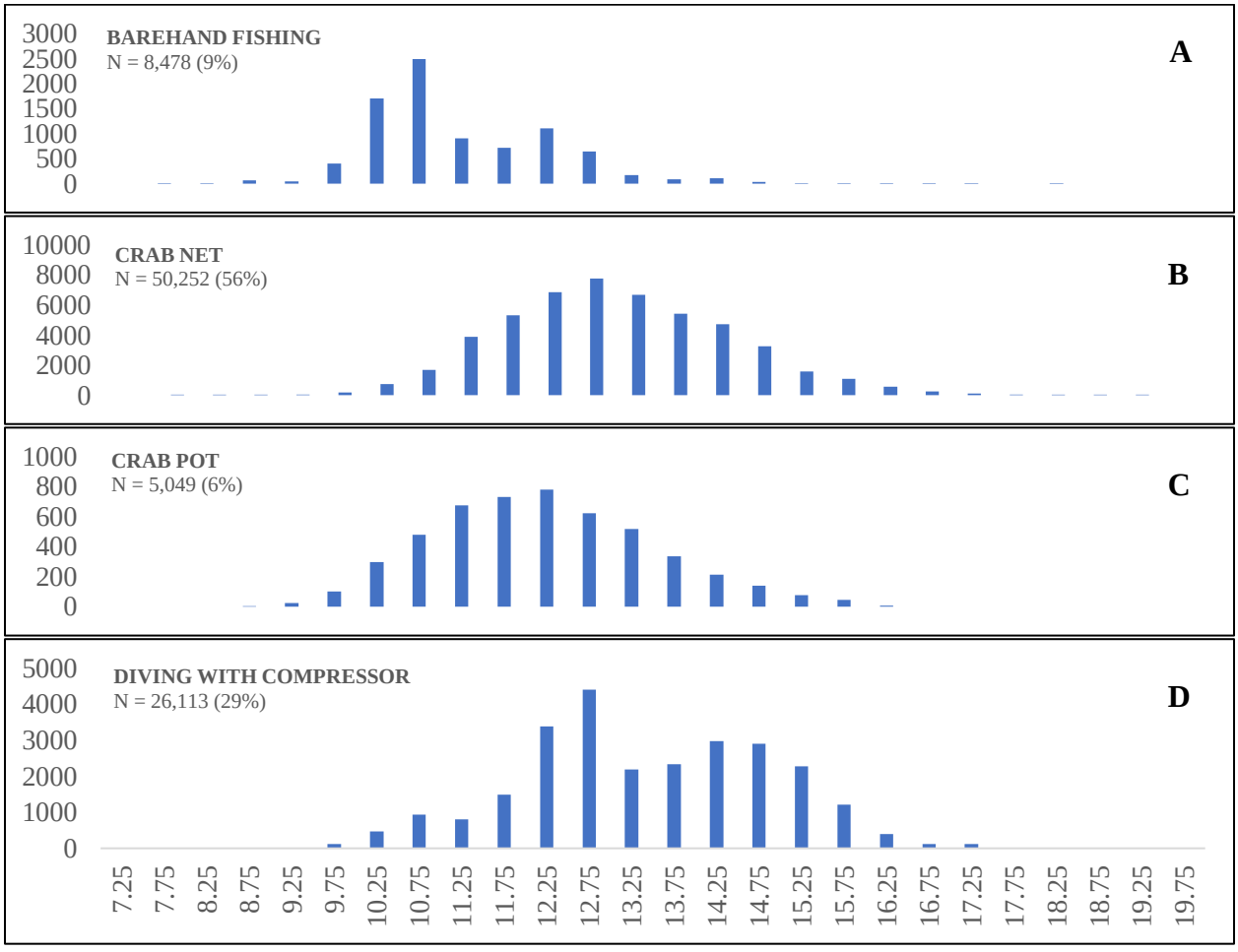


Figure 6. Length frequency (carapace width) distribution by gear type monitored from 4 landing sites in Visayan Sea from May 2022 – April 2023.

In Danajon Bank, categorized by two gear type was sampled at two landing sites. A total of 31,650 (68%) individual *Portunus pelagicu*s caught using crab pots were sampled for length frequency measurement (Figure 7A). In contrast, crab nets yielded smaller samples, with 15,238 (32%) pieces compared to the crab pots. (Figure 7B).

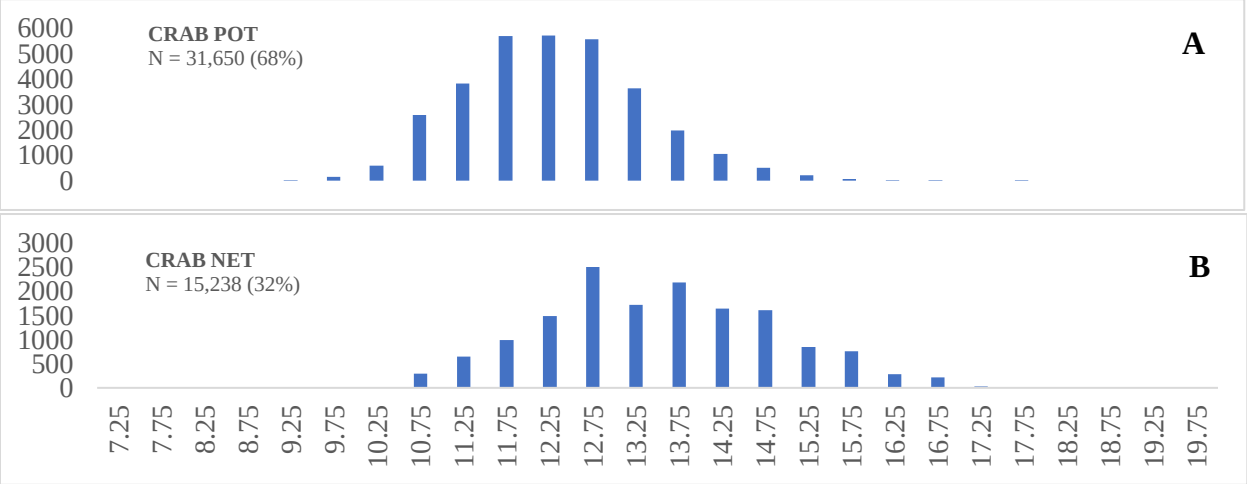


Figure 7. Length frequency (carapace width) distribution by geartype monitored from 2 landing sites in Danajon Bank from May 2022 – April 2023.

PERFORMANCE INDICATOR

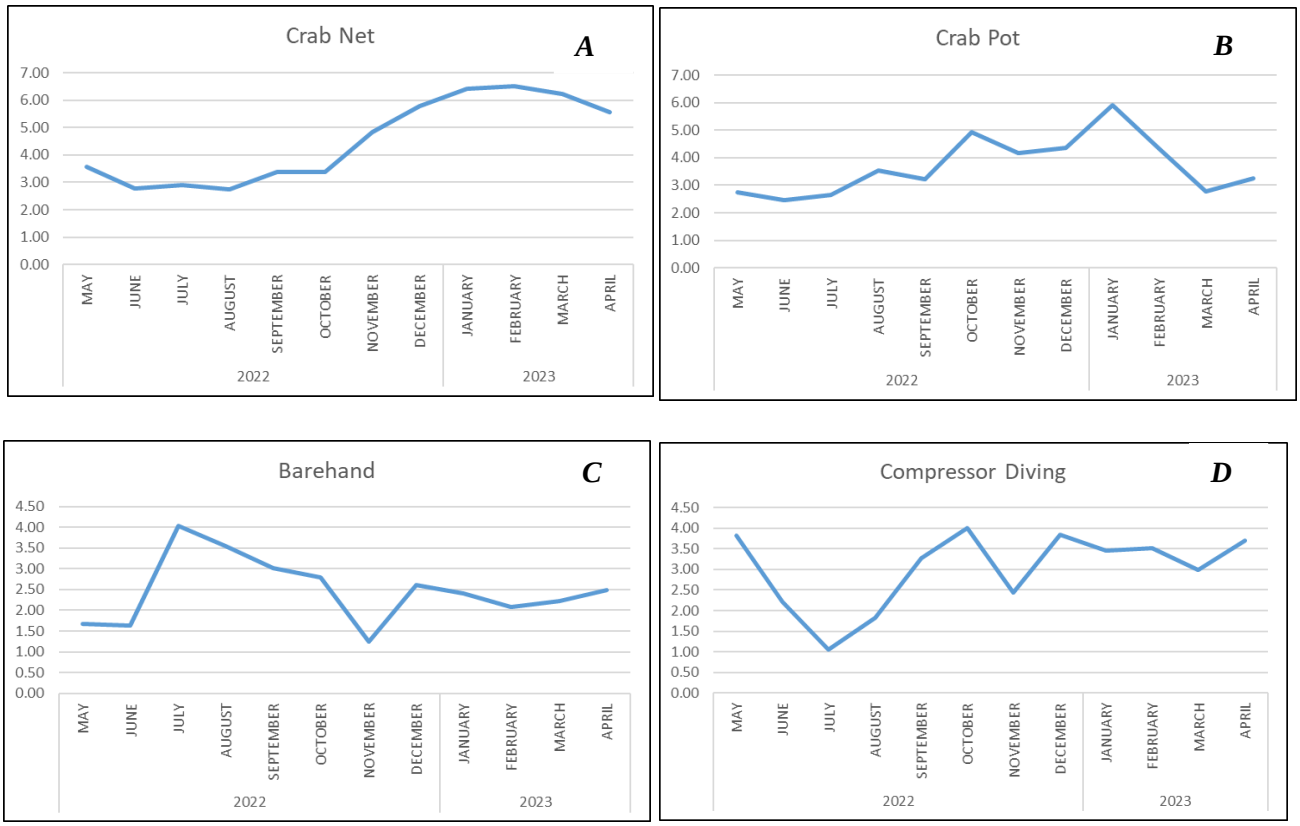
Catch per Unit Effort (CPUE)

The CPUE computed in obtaining information on the catch rate and efficiency of gears was observed during the monitoring period. Figures 8A-D show the monthly mean CPUE (kg/day) trend of BSC gears used in the four coastal areas of Bantayan Island, Visayan Sea from May 2022-April 2023. The CPUE of crab net was quite stable ranging from 3.75 to 6.25 kg/day (Figure 9A). Higher CPUEs obtained in 2022 particularly in the five consecutive months of November (4.83 kg/ day), December (5.78 kg/day) and January (6.41 kg/day), February (6.52 kg/day) and March (6.24 kg/ day). The catch rate observed during these months were mostly indicative of the annual mean for crab net computed at 4.51 (kg/day). The annual mean CPUE obtained in this study was higher than 3.72 in the study of Gonzales and Montecarlo 2017 at Western Visayan Sea.

CPUE of Crab Pot as shown in (Figure 9B) ranged from 2.45 to 5.91 (kg/day), highest of which was obtained in January 2023 and lowest was noted in June 2022. Comparable CPUE's were observed in 2022 particularly in the months of August (3.55 kg/day), October (4.93 kg/day), November (4.17 kg/day), December (4.35 kg/ day) and January 2023 at (5.91 kg/day). The annual mean CPUE obtained for crab pot in the present study was 3.69 (kg/day), lower than 5.61 (kg/day) reported by Gonzales and Montecaro in the Western Visayan Sea 2012. The CPUE in both gears were higher in number due to the restocking and dispersal aided by BFAR 7 (Thai Style hatchery) and the prohibition in catching berried crabs.

On the other hand, CPUE values obtained from barehand decreased compared to the other two gears indicating that this gear did not target the blue swimming crab (Figure 8C). The catch rate barehand or manual diving ranged from 1.25 (kg/day) to 4.03 (kg/day) highest rate was obtained only in July and the least rate was observed in November. The low abundance of crabs in the specific gear primarily caused by inshore capture during low tide serving a nursery ground of crabs in which most of the sizes are below average and prohibited by the JAO of DA-DILG no. 1 series of 2014 on BSC.

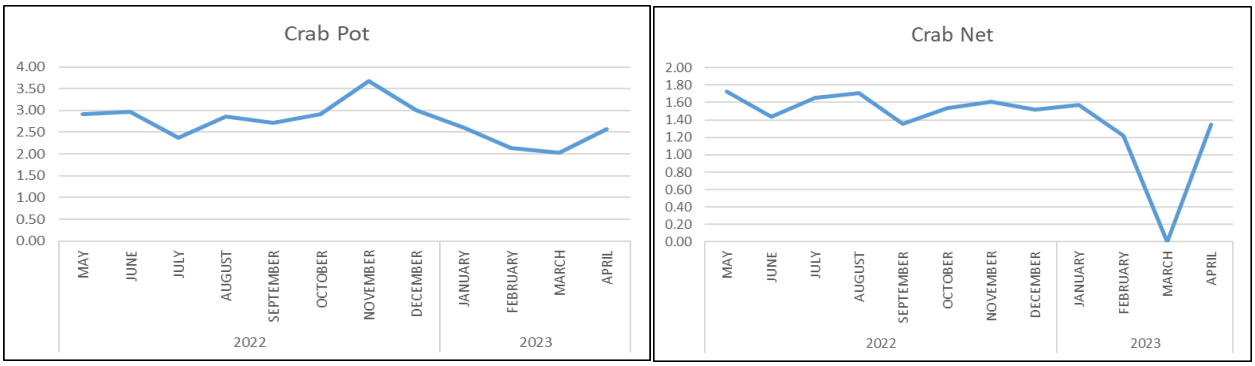
Figure 8D shows the CPUE of compressor diving in 2022 with its highest scale in month of October (4.0 kg/day) while the lowest on July (1.04 kg/day) respectively. The risk in using compressor diving brought negative impacts affecting the catch abundancy in blue swimming crabs, seasonal operations happened only from October to April 2023.



Figures 8A-D. Monthly trend of mean CPUE (kg/day) of BSC gears in Visayan Sea from May 2022-April 2023.

During the assessment period, CPUE shown in Figures 9A-B was assessed with two major fishing gears (crab pot and crab net) in two landing areas of Danajon bank. These gears were used in the two coastal areas of Bohol, Danajon Bank from May 2022 to April 2023. The CPUE of crab pot was quite stable ranging from 2.02 to 3.68 kg/day (Figure 9A). Higher CPUEs were obtained in 2019 particularly in the months of May (2.92 kg/ day), June (2.97 kg/day) and August (2.87 kg/day), October (2.91 kg/day) and November (2.68 kg/ day). The catch rate observed during these months were mostly indicative of the annual mean for crab pot computed at 2.73 (kg/day). The

annual mean CPUE obtained in this study was somewhat higher than 2.29 (kg/ trip) reported by ECOFISH for the same gear in Danajon Bank (ECOFISH 2015). However, CPUE of crab net as shown in (Figure 9B) ranged from 0.0 to 1.73 (kg/day), highest of which was obtained in May 2022 but no data was obtained in March due to the enumerator's sudden disappearance at work. Comparable CPUE's were observed in 2020 particularly in the months of May (1.73 kg/day), July (1.44 kg/day), August (1.71 kg/day), November (1.61 kg/ day) and January 2023 at (1.57 kg/day). The annual mean CPUE obtained for crab net in the present study was 1.51 (kg/day), quite lower than 3.03 (kg/trip) reported by ECOFISH in their study from May 2014 to May 2015 in Danajon Bank. The sudden decrease in the first quarter of the month of the succeeding year signifies low catch rate attributed to a very low relative abundance of blue swimming crab from crab net, which is equivalent to 0.05 % of the total catch.



Figures 9A and B. Monthly trend of mean CPUE (kg/day) of BSC gears in Danajon Bank from May 2022 to April 2023.

EXPLOITATION RATIO AND LENGTH CONVERTED CATCH

Visayan Sea

Using the length frequency data, total mortalities and exploitation rate of *Portunus pelagicus* were estimated by the length-converted catch curve routine of FiSAT II software. Specifically, the exploitation rate (E) was computed by dividing the fishing mortality over total mortality. If fishing mortality is high it would also generate high E value. It is accepted that the optimum fishing mortality in an exploited stock should be approximately equal to natural mortality or Eopt≈0.5 (Pauly and Ingles (1984)). In this study, the computed exploitation rate of blue swimming crab is 0.64^{year-1}. The high exploitation rate (E) started to increase in the succeeding months due to the reopened activities after the pandemic.

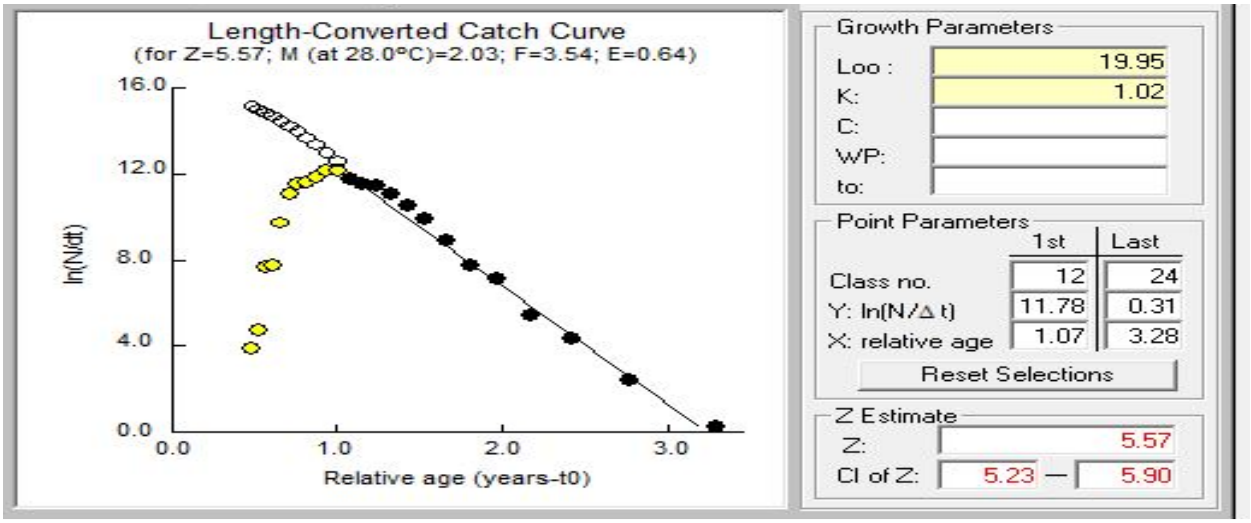


Figure 10A. Length-converted catch curve analysis of blue swimming crab in Visayan Sea. Note: Z= Total Mortality, M=Natural Mortality, F=Fishing Mortality, E= Exploitation Rate

Danajon Bank

In the Figure 11A, by using the length frequency data, total mortalities and exploitation rate of *Portunus pelagicus* were also estimated with the use of FiSAT II software in the study area. Similarly, the exploitation rate (E) was computed in the same manner as the Figure 10A. In accordance with the study of Pauly and Ingles (1984), the optimum fishing mortality in an exploited stock should be approximately equal to natural mortality or Eopt≈0 is highly accepted. The result of the computed exploitation rate of blue swimming crab is 0.66^{year-1}, a bit higher than the results of the Danajon Bank and in the previous year, when there was an opted pause of enumerated data brought by the pandemic (COVID-19).

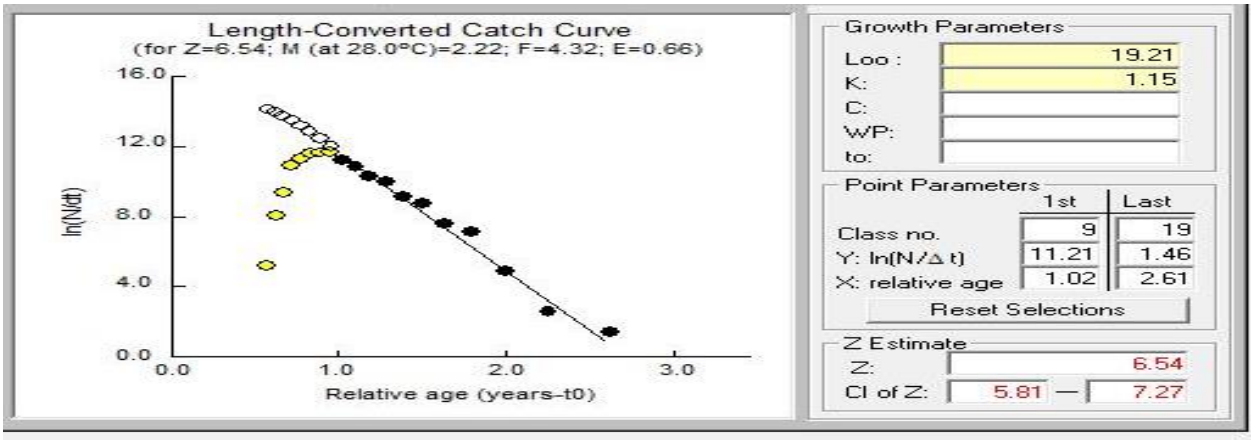


Figure 10B. Length-converted catch curve analysis of blue swimming crab in Danajon Bank. Note: Z= Total Mortality, M=Natural Mortality, F=Fishing Mortality, E= Exploitation Rate

Table 1A. Annual values of growth parameters obtained by *Portunus pelagicus* in Visayan Sea from 2020 to 2023.

Portunus pelagicus Assessment Year	GROWTH		MORTALITY			EXPLOITATION RATIO		L50 (cm)	AVERAGE LENGTH (cm)	
	Linf	k	Z	M	F	E Ratio	F/M		Lbar	Weighted
2020-2021	No data due to COVID-19 lockdown									
2021-2022	21.36	1.2	7.68	2.21	5.47	0.71	2.26	12.27	13.96	12.87
2022-2023	19.95	1.02	5.57	2.03	3.54	0.64	1.67	12.1	13.89	12.91

Table 1A presents the growth parameters estimated using the FiSAT software from 2020 to 2023. The recent analysis of length frequency data showed that L∞ was19.95 cm and a K value was 1.02. Total mortality (Z) was at 5.57 which was relatively lower than the previous year of 7.68, natural mortality (M) was at 2.03 and Fishing Mortality (F) was 3.54 which was comparatively lower than that in previous year. Consequently, the exploitation rate (E) of 0.64 has improved than that of 0.71 from last year. The data indicated a high exploitation rate primarily due to increased fishing mortality, exceeding the 0.5 threshold and suggesting growth overfishing. There was no data available for 2020-2021 due to pandemic-related restrictions. However, an increase in average length afterwards suggests that stock enhancement occurred due to reduced fishing activities during that time.

Table 1B. Annual values of growth parameters obtained by *Portunus pelagicus* in Danajon Bank from 2020 to 2023.

Portunus pelagicus Assessment Year	GROWTH		MORTALITY			EXPLOITATION RATIO		L50 (cm)	AVERAGE LENGTH (cm)	
	Linf	k	Z	M	F	E Ratio	F/M		Lbar	Weighted
2020-2021	No data due to COVID-19 lockdown									
2021-2022	20.19	1.2	5.42	2.25	3.17	0.64	1.40	10.76	14.09	13.54
2022-2023	19.21	1.15	7.12	2.22	4.90	0.66	2.21	10.37	13.65	12.70

In this Table 1B, FiSAT (FAO-ICLARM Stock Assessment Tool is used in gathering relevant data. The length frequency of data analysis showed an estimated L∞ of 19.21 to 20.19 cm and K value ranged from 1.15 to 1.2. The total mortality (Z) ranged from 5.57 to 7.68, natural mortality (M) from 2.03 to 2.21, fishing mortality (F) from 5.42 to 7.12 and exploitation rate (E) from 0.64 to 0.66. Total mortality, fishing mortality and exploitation ratio of the blue swimming

crabs were determined and revealed higher E ratio that mainly attribute to higher fishing mortality. Suggest growth overfishing in the overexploitation exceeding 0.5 E ratio.

FROESE

In the context of stock reproductive strategy and production is highly crucial. Large size at maturation is an advantage for a high reproductive potential and generally related to fecundity. According to Stearns 1976; Pollock 1995, they suggested that high fishing pressure may reduce the size at maturity stages. For this assessment, the length at first maturity (Lm) or the size at which 50% of the crabs have reached sexual maturity occurred at 11.67 cm (Figure 11A). The minimum and maximum observed lengths were at 7.75 cm and 19.25, respectively. The Lm obtained for *P. pelagicus* in this study was smaller than 12 cm and 11.2 cm reported in Danajon Bank (Armada et al. 2009; ECOFISH Report 2015), slightly bigger than 10.6 cm in Visayan Sea and Guimaras Strait (Ingles 1996). However, comparable to the average size of maturity for female crab at 10.56 cm in Ragay Gulf (Ingles and Braum 1989). Nonetheless, the present Lm of BSC in Visayan Sea is higher than 10.2 cm (CW) prescribed as legal size under the DA-DILG JAO No. 1, series of 2014 on the Regulation for the conservation of blue swimming crab. This denotes that *Portunus pelagicus* in Visayan Sea is still abounded by bigger-sized crabs.

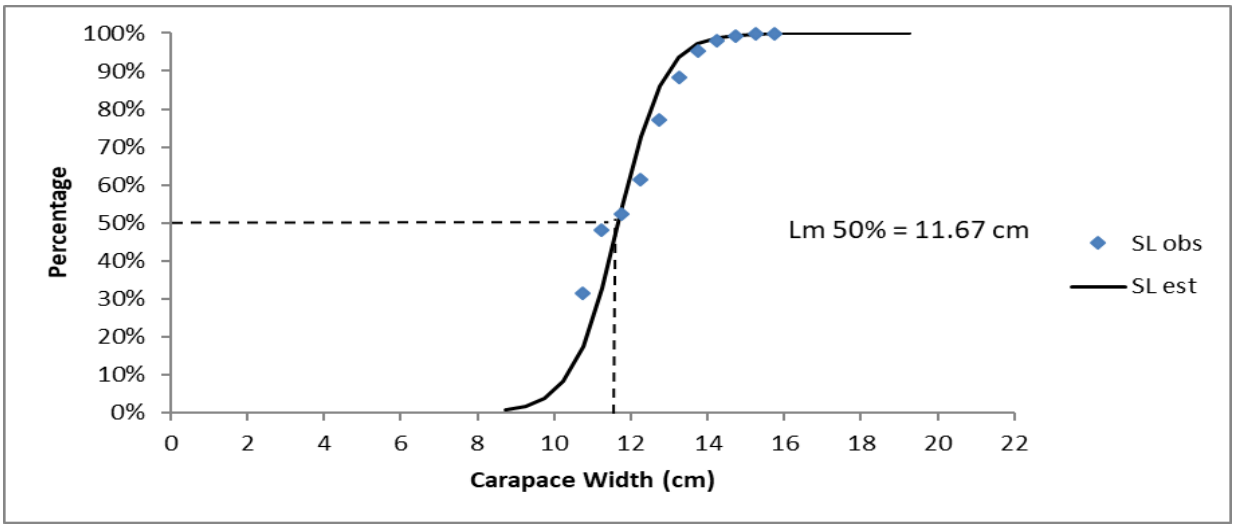


Figure 11A. Length of first maturity of *Portunus pelagicus* in Visayan Sea 2022-2023.

S1		19.77
S2		1.69
LM 50%	S1/S2	11.67
LM 95%		15.50

REFERENCE POINT	
Target	80% mature
Limit	50%
Result	**82.11 %**

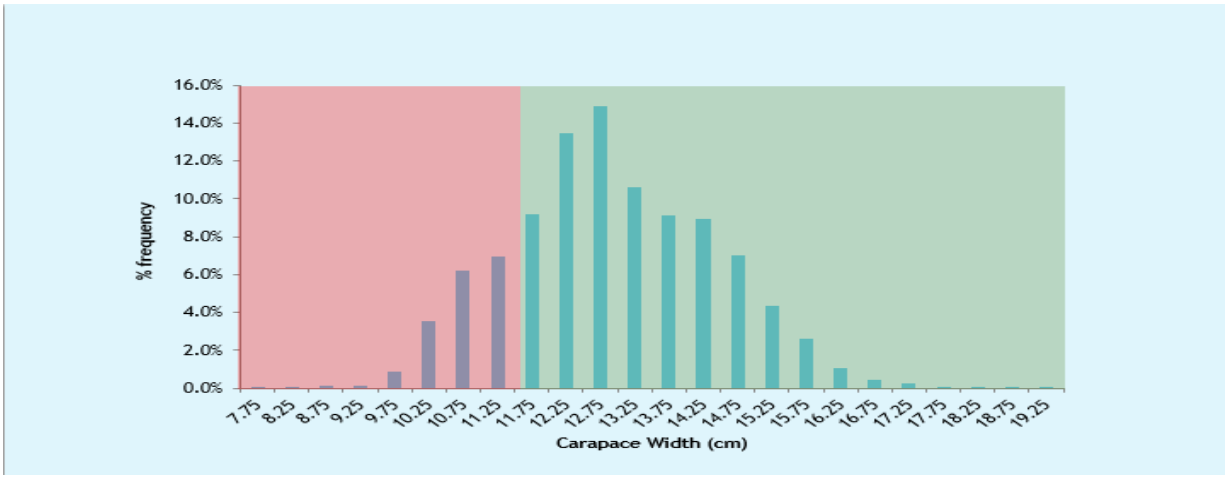


Figure 11B. Length frequency of *Portunus pelagicus* in Visayan Sea 2022-2023.

Length at first maturity is relevant for crab assessment and production. For this assessment, the length at first maturity (Lm) or the size at which 50% of the crabs have reached sexual maturity occurred at 10.37 cm (Figure 12B). The minimum and maximum observed lengths were at 9.25 cm and 18.25 cm, respectively. The Lm obtained for *P. pelagicus* in this study was smaller than 12 cm and 11.2 cm reported in Danajon Bank (Armada et al. 2009; ECOFISH Report 2015), slightly smaller than 10.6 cm in Visayan Sea and Guimaras Strait (Ingles 1996). However, comparable to the average size of maturity for female crab at 10.56 cm in Ragay Gulf (Ingles and Braum 1989). More so, the present Lm of BSC in Danajon Bank is slightly bigger than 10.2 cm (CW) prescribed as legal size under the DA-DILG JAO No. 1, series of 2014 on the Regulation for the conservation of blue swimming crabs, incurs that *Portunus pelagicus* suggesting that bigger-sized crabs are still present and preserved in Danajon Bank.

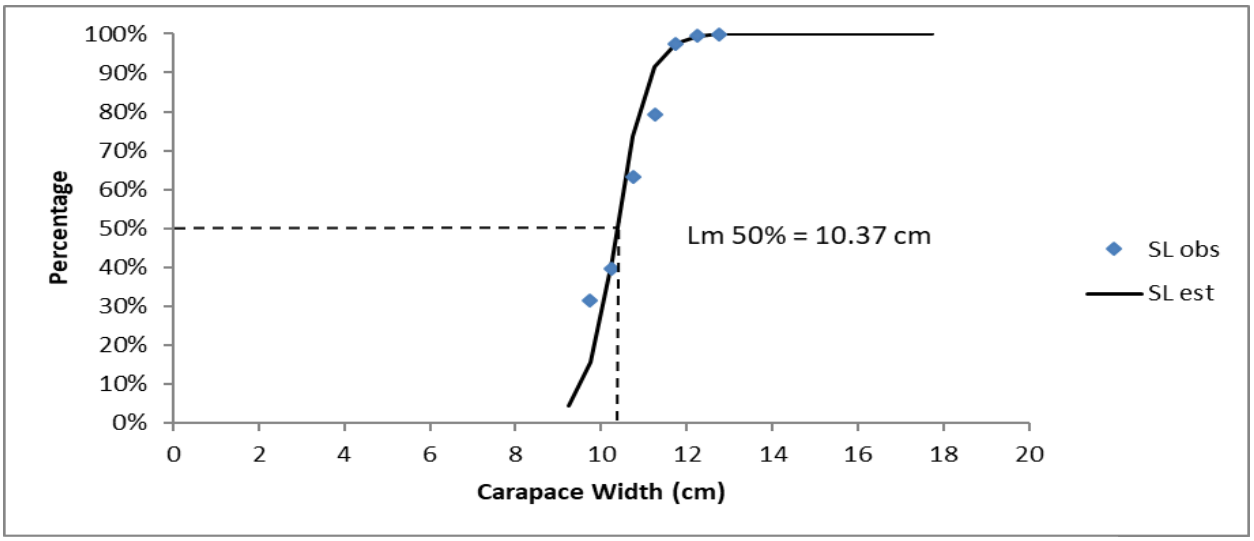


Figure 12A. Length at first maturity of *Portunus pelagicus* in Danajon Bank 2022-2023.

S1		28.26
S2		2.72
LM 50%	S1/S2	10.37
LM 95%		12.50

REFERENCE POINT	
Target	80% mature
Limit	50%
Result	**98.42 %**

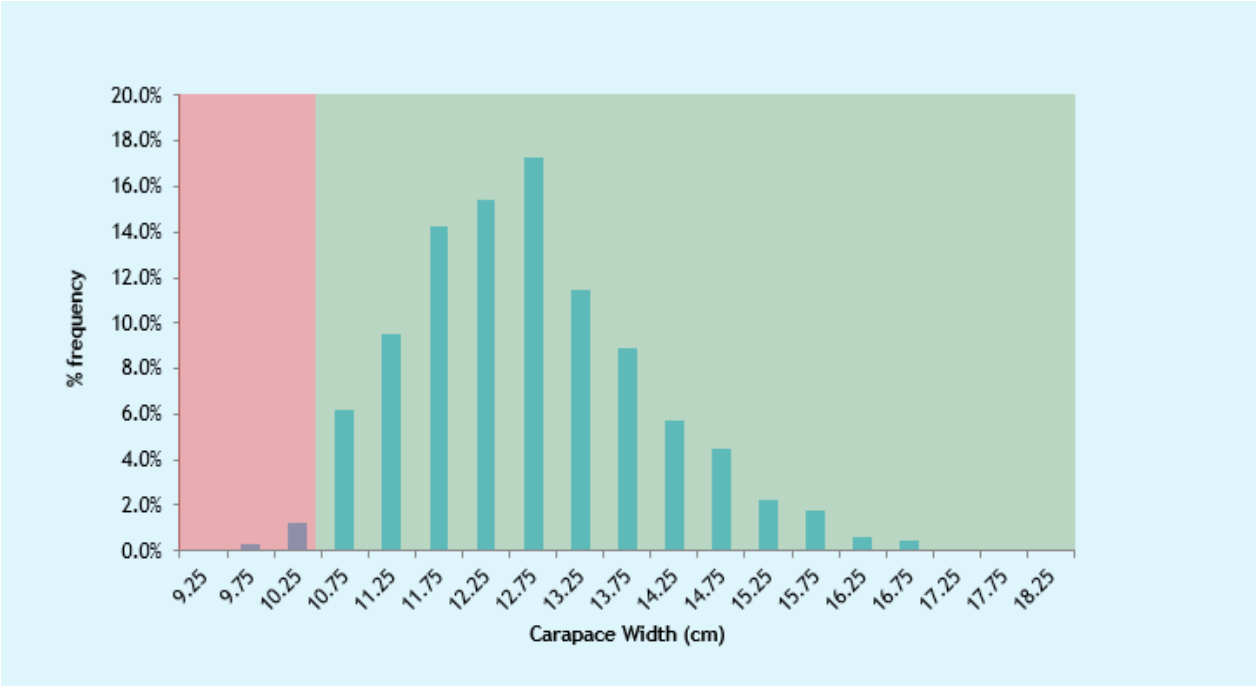


Figure 12B. Length frequency of *Portunus pelagicus* in Danajon Bank 2022-2023.

MONTHLY GONADAL FREQUENCY (%)

Combining all the reproductive data collected for one year in Visayan Sea, as shown in Figure 13A, crabbers mainly caught both Stages I and II. Stage V described as "spent" had the highest percentage of the overall samples in almost all sampling months. It reached to 80% during the month of August 2023 and its lowest percentage was 20% noted in November 2023. As observed from the figure, Stage III or known as mature, share minimal number in the whole year. Stages II (developing and maturing) peak season only in November. Meanwhile, Stage IV (spawning) had minimal number and highest was found in the end of the year, with 12% respectively. Apparently blue swimming crabs spawned whole-year round as gravid crabs were noted in all sampling months of which highest spawning was obtained in May 2020 (11.6%). Zairion and Fahrudin (2015) described the spawning of *P. pelagicus* in Lampung Coastal Waters of Indonesia as seasonal-continuous in a year with peak spawning and breeding in April to June and October to November. While Ernawati et al. (2017) observed fast growth and peak season of BSC between February to April and in August to October in Java Sea, Indonesia. BSC is highly fecund with female crabs release up to two million eggs per batch. De Lestang et al. 2003 reported that fecundity for small-sized, about 8 cm CW was at 78,000 and 1,000,000 for large-sized (18 cm CW) in the West coast of Australia.

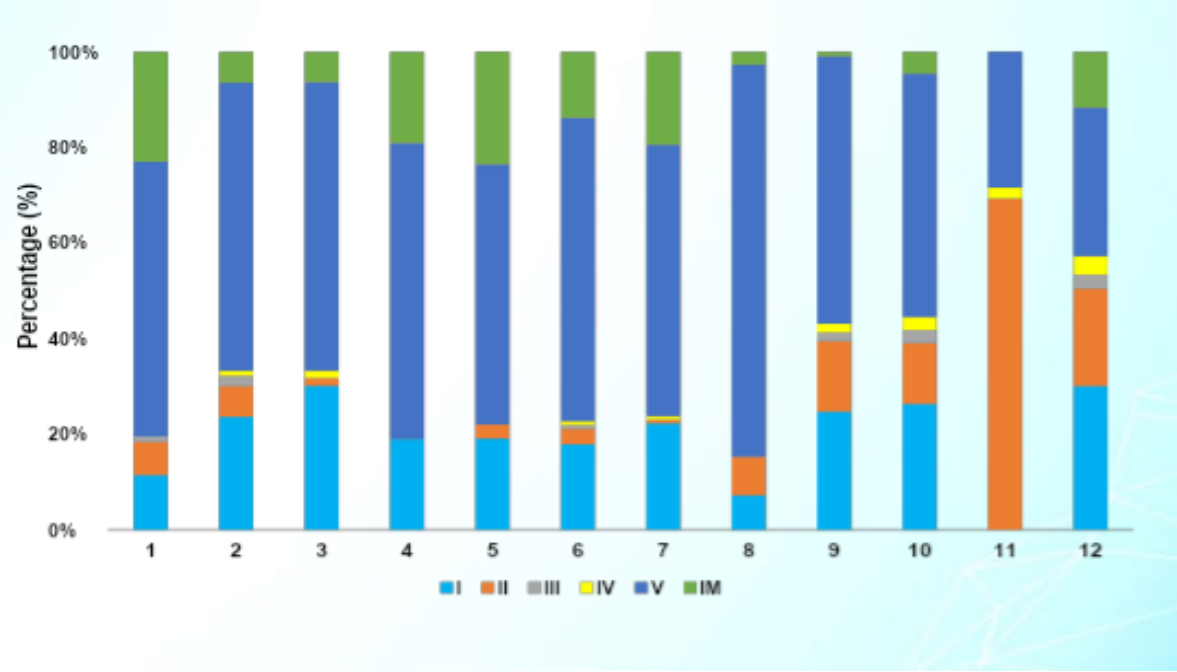


Figure 13A. Monthly gonadal frequency (%) distribution obtained for *P. pelagicus* in Visayan Sea 2022-2023.

In figure 13B, In Danajon Bank, *P. pelagicus* is observed to have a 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). The figure shows the monthly gonadal distribution of female *P. pelagicus*. As the figure suggests, a high percentage of non-ovigerous stage occurs in the months of June. Critical stage FV is present and is peak year-round except in the month of November. Premature or FI stage is observed in the months of May, June, August, October and December. For the ovigerous or egg-bearing stages represented by FII, peak season happens on months April to January. The FIII or the developing crabs peak occur in year-round except in the months of January, March and April. Lastly, the FIV or the spawning of the berried crabs peak months occur in the months of May to January and March.

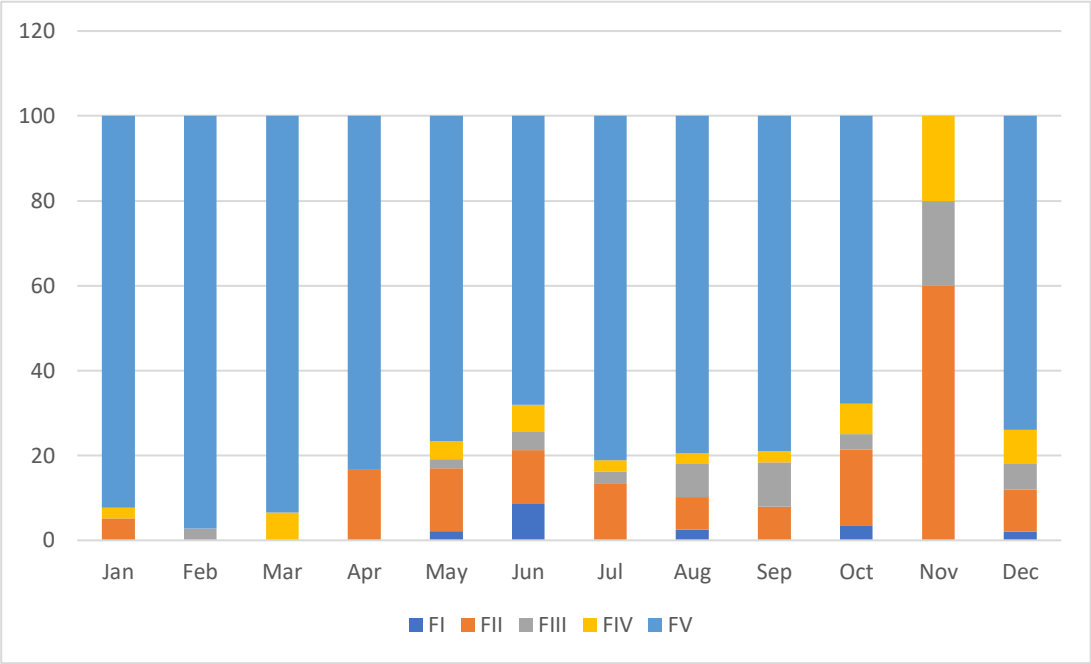


Figure 13B. Monthly gonadal frequency (%) distribution obtained for P. pelagicus in Danajon Bank 2022-2023.

Spawning Potential Ratio (SPR)

The Spawning Potential Ratio refers to the measure of current egg production of the fished stock relative to the maximum possible egg production at the unfished stock level (Hordyk et al., 2015 a and b). It is the proportion of the unfished reproductive potential left at any given level of fishing pressure. SPR is a widely accepted approach in fisheries management for addressing recruitment overfishing in exploited fish stocks based on the concept that a sufficient number of fish should be left in the sea (under prevailing exploitation rates) to survive, reproduce, perpetuate, and replenish the stock at a sustainable level (Sivestre et al. 2020).

SPR is mostly use to set target and limit reference points for fisheries (FISHE 2015). The result from Spawning Potential Ratio analysis was given in Figures 14A-B. The SPR of *P. pelagicus* was computed at 36% in Danajon Bank subordinately higher than the 20% limit, moreover, a slightly higher attribute than 27% reported in the study of ECOFISH in Danajon Bank (ECOFISH Report 2015).

A parallel assessment of BSC conducted in Visayan Sea Region 7 from May 2022 to April 2023 as part of PACPI funded project recorded much lower SPR of 34% (unpublished Report). The SPR reported in other tropical country particularly from Java Sea, Indonesia was at 11% to 24% only (Ernawati et al. 2017). The higher SPR obtained in both Danajon Bank and Visayan Sea maybe attributed to the BSC stock enhancement activities and dispersals of PACPI and BFAR 7 through releasing of hatchery reared juvenile crabs in the fishing grounds.

The present SPR of blue swimming crab is already above the 30% precautionary threshold for most of the stocks to remain sustainable. The SPR generated for BSC was also reflective of the result from the reproductive sampling where percentage of gravid crabs sampled/ dissected was lower compare to non-ovigerous crabs.

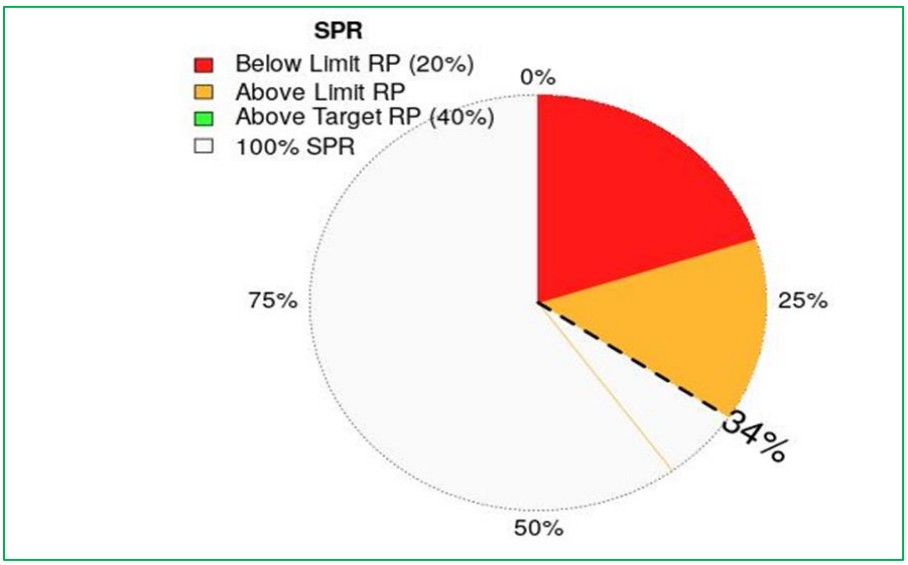


Figure 14A. Spawning Potential Ratio (SPR) of P. pelagicus obtained in Visayan Sea 2022-2023.

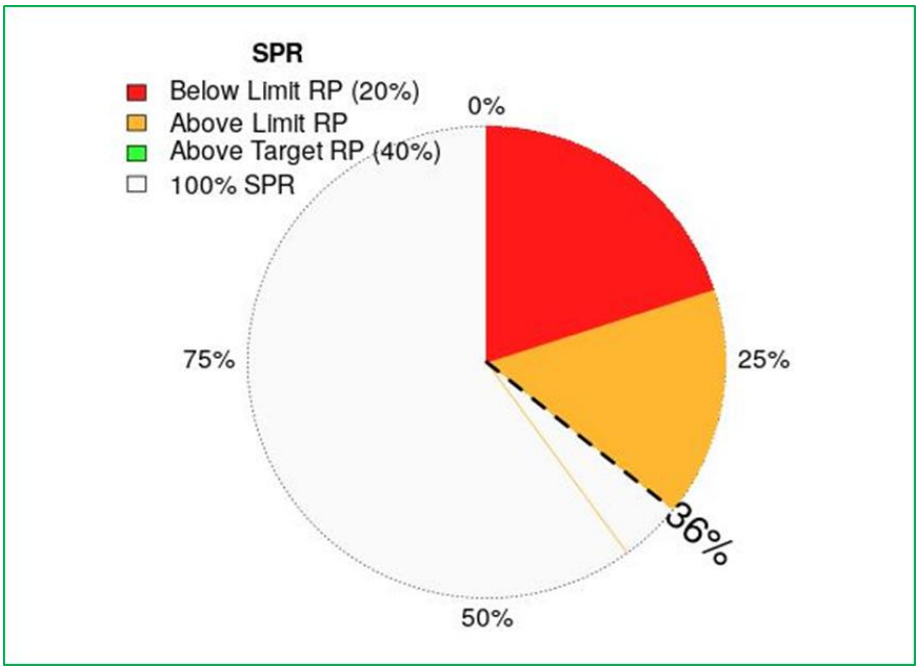


Figure 14B. Spawning Potential Ratio (SPR) of *P. pelagicus* obtained in Danajon Bank 2022-2023.

CONCLUSIONS AND RECOMMENDATIONS (To be continued…)

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 Central 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 Central Visayan Sea.