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RESEARCH ARTICLE

Length–Based Stock Assessment of Blue Swimming Crab *Portunus pelagicus* (Linnaeus, 1758) in FMA 2: Hinatuan and Bislig Bays in Surigao del Sur, Philippines

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ABSTRACT

Blue Swimming Crab (BSC), *Portunus pelagicus* (Linnaeus, 1758), locally known as "Lambay," is one of the most commercially traded seafood commodities in the Philippines. As in other BSC areas in the country, Hinatuan and Bislig Bays in Surigao del Sur, Caraga Region, in Fisheries Management Area 2 have abundant BSC; however, their current status is unknown. Therefore, an assessment is needed to support the formulation of policies for BSC management. This study used combined data from 2015 to 2021 from major crabbing areas in the said fishing grounds. Performance indicators were analyzed using various models, including the FAO ICLARM Stock Assessment Tool (FiSAT). The primary gear used was bottom-set gillnet, wherein *P. pelagicus* emerged as the dominant species, comprising an average of 53%. The computed length infinity (L_∞) and growth coefficient (k) were 20.5 cm and 1.4 per year, respectively. Fishing mortality exceeds natural mortality, yielding an exploitation rate of 0.76 and indicating over-exploitation. The Froese indicator showed that the average percentage of mature (25%), optimally sized (57%), and mega-spawners (11%) have breached the limit reference, indicating heavy fishing pressure on BSC. Moreover, the spawning potential ratio (SPR), at 19%, is at the limit reference point, suggesting that the fishery is experiencing high fishing pressure and that the stock may be vulnerable to recruitment overfishing or future decline.

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1. INTRODUCTION

The Blue Swimming Crab (BSC), *Portunus pelagicus* (Linnaeus, 1758), locally known as "Lambay," belongs to the order Decapoda (ten appendages) and the family Portunidae. It has a broad geographical distribution throughout the Indo-Pacific region (Kailola et al. 1993). The species is usually found in large numbers in shallow bays with sandy bottoms and seagrass habitats, from the intertidal zone up to at least 50 m water depth (Williams 1981; Edgar 1990; La Sara et al. 2016a; La Sara et al. 2016b). This crab is a major commercial and well-regarded commodity in many countries, including Australia, Japan, India, and Southeast Asian countries such as Thailand and the Philippines.

In the Philippines, they are found mainly in traditional demersal fishing grounds, including San Miguel Bay, Tayabas Bay, Ragay Gulf, Malampaya Sound, Asid Gulf, Visayan Sea, Guimaras Strait, Panay Gulf, Carigara Bay, Bohol Sea, Panguil Bay, and Tawi-Tawi (Ingles 2004). Fishermen harvest them using different fishing gear, such as crab pots, crab lift nets, gillnets, fish corrals, municipal trawls, push nets, and seine nets (Abrenica et al. 2021). Based on the Philippine Fisheries Profile in 2021 (BFAR 2022), crabs ranked third in export value, contributing USD 164.24 million. The United States of America, Hong Kong, China, and Taiwan are the major countries exporting crab, crab fat, and crab meat. A huge percentage (51.5%) of the blue swimming crab population comes from the Western Visayas in the Visayan Sea and Guimaras Strait (Mesa et al. 2018).

However, a declining catch is evident for *P. pelagicus* due to fishing pressure brought by increasing demand for seafood for domestic and export markets, destruction of nursery habitat, harvesting of gravid females (Kunsook et al. 2014), and laxity in the implementation of regulatory policy to protect the resource and increasing effort, which resulted in a significant reduction in catch rates (Mesa et al. 2018). Abrenica et al. (2021) conducted a study in Danajon Bank on the impact of BSC stock enhancement from 2019 to 2020 and found evidence of high exploitation.

In Fisheries Management Area 2, Hinatuan and Bislig Bays, Surigao del Sur, Caraga Region, BSC is one of the dominant species and a commercially important commodity that supports the food and livelihood of many fisherfolk. Currently, information on biological indicators in the area is limited. This study aims to assess the status of BSC using tools such as the FAO ICLARM Stock Assessment Tool (FiSAT), Froese Indicator, and LBSPR, and the results will serve as a basis for developing harvest control rules and management options to ensure BSC sustainability.

2. MATERIALS AND METHODS

2.1 Study site

Hinatuan Bay in Surigao del Sur is located at the mouth of the Hinatuan River at 80 20' 57 N, 1260 21' 39" E on the eastern seacoast of Mindanao, Philippines. The Pacific Ocean bounds it to the east, and it has an irregular, unbroken coastline with white sandy beaches and thirteen islets. Hinatuan consists of twenty-four barangays, thirteen of which are coastal. It is home to the famous Enchanted River, a marine protected area spanning about 360 square kilometers and covering mangroves, endangered dugongs, and turtle nesting sites. One consideration in identifying landing sites for blue swimming crab is the crab buyers, who are residents of Barangay Sto. Nino and Barangay Lacasa.

Bislig Bay is located on the southeastern side of the Philippines and the eastern side of Mindanao, at 8^0 12' 55" N and 126^0 22' 13" E. The bay receives exchange waters from the Pacific Ocean. In terms of fishery resources, aside from crabs, tuna, and lobster puerulus (juvenile) were common in the bay. Figure 1 shows the map of the study area, and the BSC sampling sites were located in Barangay Baybay and Barangay Fernando.

2.2 Data collection

The Bureau of Fisheries and Aquatic Resources – Caraga conducted the study under the National Stock Assessment Program (NSAP) from January 2015 to December 2021 in Hinatuan and Bislig Bays, Surigao del Sur. Data collection followed standardized NSAP sampling protocols (Santos et al. 2017), ensuring consistency and reliability across sampling periods.

Trained enumerators collected field data using stratified random sampling at two–day intervals, with a one–day gap between sampling events. Sampling was carried out at established landing sites in Barangay Lacasa and Sto. Niño in Hinatuan, and Barangay Baybay and Fernando in Bislig City. These sites were selected based on their significance as major landing areas for the blue swimming crab (BSC) fisheries.

Three primary fishing gears were documented in the fishery: bottom-set gillnets, crab lift nets, and

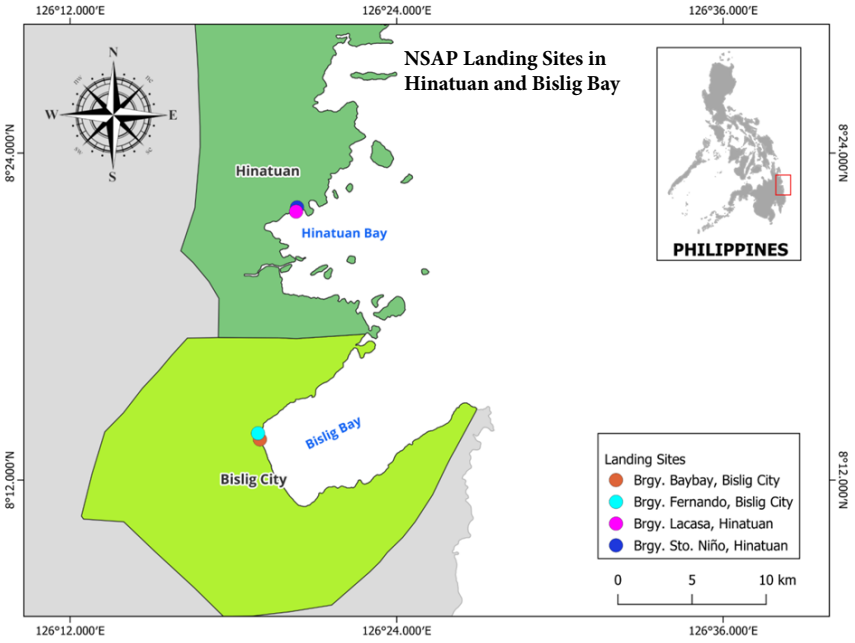

Figure 1. Map of Hinatuan Bay and Bislig Bay.

crab pots. Among these, the bottom-set gillnet was identified as the dominant gear and was therefore prioritized in the analysis. This gear typically consisted of a double- or triple-walled net configuration, approximately 1,500 m long, with a net height of 1 m and a mesh size of 5 cm. Deployment was generally conducted at 5:00 pm, with retrieval at approximately 5:00 am the following day, corresponding to an overnight soaking period.

Crab lift nets were operated in sets of at least 30 units per fishing trip, with deployment durations ranging from one to three days depending on fishing conditions. Crab pots were used in quantities of 30–50 units per operation, typically set in the late afternoon around 5:00 pm and hauled early the next morning. The bottom-set gillnets were subjected to detailed length-based stock assessment due to their dominance and consistency in the study area.

For each sampling event, total catch (kg), sub-sample weight (kg), and corresponding fishing effort were recorded. Catch composition was analyzed and identified to the lowest possible taxonomic level. Sex determination of BSC individuals was performed based on distinct external morphological characteristics, particularly abdominal morphology and the presence or absence of reproductive structures.

BSC were measured in carapace width (CW) using a Vernier caliper to the nearest 0.1 cm. A minimum of 30–50 individuals per sampling day, per site, and per gear type were measured to ensure adequate representation for length frequency analysis. All collected data were compiled into standardized forms and subsequently submitted to the regional office for validation, encoding, and integration into the NSAP database system.

2.3 Data processing and analysis

Data on blue swimming crabs in Hinatuan and Bislig Bays were extracted from the NSAP database system and migrated to an Excel file, where a pivot table was used to generate graphs and tables for the different indicators. The datasets were pooled to produce a single analysis representing BSC information from both bays along FMA 2. The bottom-set gillnet is the primary fishing gear used to catch BSC and obtain various information.

2.4 Growth and mortality parameters

To obtain the growth parameters, the growth rate (k), asymptotic length (L_∞), growth performance index (Ø'), and the Von Bertalanffy Growth Function (VBGF) were fitted in FISAT II (FAO-ICLARM Stock Assessment Tools), a computer package (Gayanilo et al. 2005). The total mortality (Z) and natural mortality (M) values were obtained from L_∞ and K estimates using the length-converted catch curve. The instantaneous fishing mortality rate (F) was computed as F=Z-M, and the exploitation rate (E) as E=F/Z. Gulland (1971) suggested that fishing mortality should be about or equal to natural mortality for an optimally exploited stock, resulting in a fixed Eopt = 0.50. This means that values above the optimum of 0.50 represent overexploitation.

For the analysis, the monthly length frequency data of BSC were raised to represent total monthly landings by applying a raising factor, computed as the ratio of total weight landed to the weight of the sampled catch. This factor was then multiplied by the number of individuals measured per length class. The adjusted length frequency data were subsequently transformed into percentages and used as input for population parameter estimation in FiSAT II (Gayanilo et al. 2005). For this study, only data from 2019 to 2021 were utilized, as these years exhibited consistent and distinct modal progression necessary for reliable growth analysis.

2.5 The Froese length-based analysis

The length frequency of BSC, using the primary gear bottom-set gillnet, was evaluated for the Froese sustainability indicator. The percentage of mature fish, optimal-sized fish, and "mega-spawners" (large fish that contribute disproportionately to egg production) is calculated using life history parameters, maximum length (L_∞), and length frequencies from catch data.

To assess the sustainability of the BSC fishery, three key indicators were calculated based on the Froese 2004 approach: (i) the percentage of mature individuals in the catch, with a sustainability Target Reference Point (TRP) of 90-100% while the Limit Reference Point (LRP) was 50%; (ii) the percentage of fish within the optimum length range, the TRP was 100%; and the LRP was 80%; (iii) the percentage of mega-spawners, with a target range of 30-40% and the LRP was set at 20% and below. Indicators falling below the limit reference points were interpreted as signs of overfishing and biological stress, while those meeting or exceeding target reference points indicated a healthier and more sustainable stock condition.

Monthly length frequency data for BSC were analyzed using the Excel-based tool developed by Fujita et al. (2012). Input parameters such as

asymptotic length (L_∞), growth coefficient (k), and natural mortality (M) were estimated using the FiSAT software. In the absence of site-specific biological data, the length at first maturity (L_m) and length-weight relationship parameters (a and b) were obtained from published literature.

2.6 LBAR

An estimate of fishing mortality is calculated using the minimum (L_c), maximum (L_∞), and average length in the catch, together with estimates of the von Bertalanffy growth parameter k and natural mortality. The first length at full selectivity is used to estimate fishing mortality. Together, assuming that FMSY equals natural mortality, this method allows us to calculate F/FMSY. Mean length (LBAR) fishery-independent data were used to estimate fishing pressure using the methodology described in Ault et al. (2005) and Silvestre et al. (2020).

2.7 Length-based Bayesian (LBB)

Length frequency data (CW for crabs) were input into the LLB software. The M/k prior and the L_∞ as the maximum length were generated. The Z/k prior was based on the equation (Beverton and Holt 1957). The LBB estimator approach was used to estimate stock status (B/Bo and B/BMSY) by analyzing length-frequency data from the exploited fishery (Froese et al. 2018; Yue et al. 2021). Froese et al. (2018) present a detailed description of the theory and equations behind the LBB approach.

2.8 Length–Based Spawning Potential Ratio (LBSPR)

Length frequency data for female BSC from bottom-set gillnet catchers were analyzed using the Length–Based Spawning Potential Ratio (LBSPR) approach in the Barefoot Ecologist's Toolbox. LBSPR estimated the spawning potential ratio – the reproductive output of a fished stock relative to its unfished condition using length composition data and key biological parameters, including growth (L_∞, k), maturity (L_m), and gear selectivity (Hordyk et al. 2016; Prince et al. 2015). A total of 41,114 female individuals were analyzed, with an average of 8,223 samples per year from 2017 to 2021. Length data were grouped into 0.5 cm intervals prior to analysis. Biological parameters were obtained from the literature and local studies.

3. RESULTS AND DISCUSSION

3.1 Growth and population parameters

Table 1 shows the estimated growth and population parameters of *Portunus pelagicus* (blue swimming crab, BSC) based on the dataset collected from 2019 to 2021. The asymptotic length (L_∞) was estimated at 20.5 cm, and the growth coefficient (k) at 1.4 year^{-1}. These values were modeled using the Von Bertalanffy Growth Function (VBGF), which demonstrated a strong fit to the observed length frequency data. The resulting growth curve illustrates the species' gradual increase in size toward its theoretical maximum length, as shown in Figure 2. The computed growth performance index (Ø') was 2.77, indicating relatively rapid growth for the species.

Population growth parameters were within the range of other studies from other areas. The results of this study were obtained within the range of the study conducted by Mesa et al. (2018), as shown in Table 2. Specifically, the estimates of asymptotic length (L_∞), growth coefficient (k), and growth performance index (Φ') are consistent with values reported both locally and internationally. This shows that the growth characteristics of the studied populations are comparable to those in other regions, including the Philippines, Oman, Thailand, Qatar, and Australia.

The growth parameters (Table 1) and exploitation parameters (Figure 2) derived from this study provide insights into the population dynamics of the target species in Hinatuan Bay and Bislig Bay. The estimated growth parameters, asymptotic length (L_∞ = 20.5 cm), growth coefficient (k = 1.4), and growth performance index (Φ' = 2.77) indicate a relatively fast-growing species, consistent with other Philippine studies (Mesa et al. 2018). Mortality estimates show a high total mortality (Z = 9.51) driven primarily by fishing mortality (F = 7.04) rather than natural mortality (M = 2.48). The exploitation rate (E = 0.74) exceeds the optimum level, suggesting overfishing pressure.

Table 1. Growth, mortality parameters, probability of capture, and recruitment pattern of *P. pelagicus*, 2019–2021.

L_{oo}	K	Ø'	Z	M	F	E	L_{25}	L_{50}	L_{75}	No. of RP
20.5	1.4	2.77	9.51	2.48	7.04	0.74	11	11.6	12.3	2

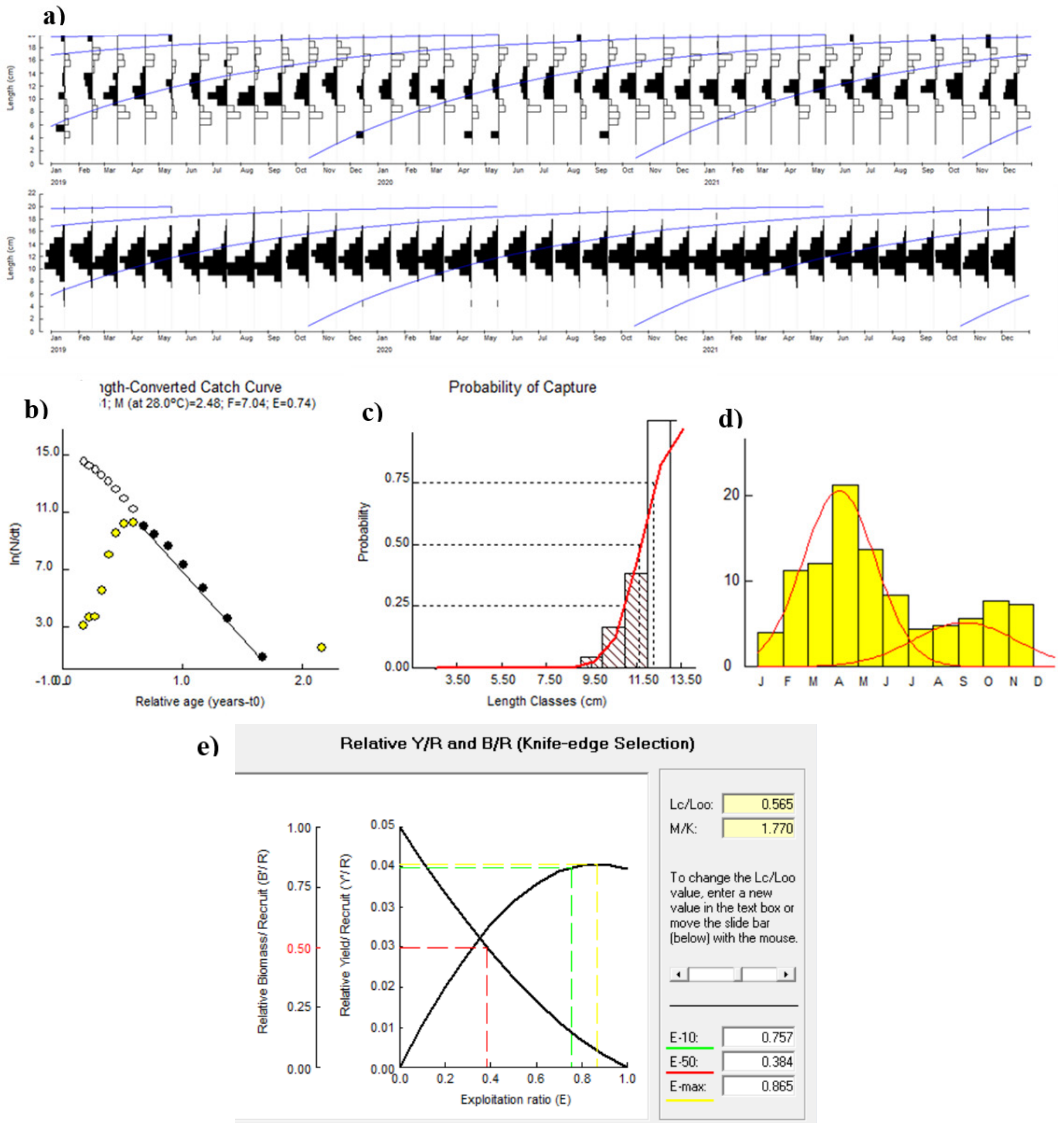

Figure 2. a) VBGF structured and unstructured; b) Length-converted catch curve; c) Probability of capture; d) Recruitment pattern; and e) Relative Y/R and B/R of *Portunus pelagicus* in Hinatuan and Bislig bays.

Table 2. Growth parameters of BSC as observed in other areas.

L_∞	Unit	K	Ø'	Area	Country	Source
14.8	CL	1.73	2.58	Korangi Creek	Pakistan	Palomares and Pauly 2026
14.26	CW	2.75	2.75	Kung Krabaen Bay, Chanthaburi	Thailand	Palomares and Pauly 2026
15.9	CW	2.63	2.82	Doha	Quatar	Palomares and Pauly 2026
15.57	CW	3.0	2.86	Peel- Harvey Estuary	Australia	Palomares and Pauly 2026
17.61	CW	1.3	2.61	Sorsogon Bay	Philippines	Palomares and Pauly 2026
19.5	CW	0.84	2.5	Panay	Philippines	Palomares and Pauly 2026
20.98	CW	0.84	2.57	San Miguel Bay	Philippines	Palomares and Pauly 2026
19.1	CW	1.55	2.75	Visayan Sea	Philippines	Mesa et al. 2018
21.77	CW	1.4	2.84	Guimaras Strait	Philippines	Bayate et al. 2011
20.5	CW	1.4	2.77	Hinatuan Bay and Bislig Bay	Philippines	This study

The length-converted catch curve supports high fishing mortality, and the probability of capture curve shows that fish are harvested before reaching optimal length at fish capture (L_c/L_∞ = 0.51 - 0.57). Meanwhile, the Yield per Recruit (Y/R) and Biomass per Recruit (B/R) show that BSC is under high fishing pressure. The current exploitation level of 0.74 is close to E10 = 0.757 and higher than E50 = 0.384, which means the fishery is already being heavily exploited. Although Emax was estimated at 0.865, this is only the theoretical level for maximum yield and is not a safe management target. A similar result was reported in blue swimming crab studies in Danajon Bank, where exploitation values were also high, and the authors noted strong fishing pressure on the stock (Abrenica et al. 2021).

The L_c/L_∞ value of 0.567 suggests crabs are being caught at a moderate size, but the gear's actual selectivity may be lower than expected. The bottom-set gillnet has a mesh size of 5 cm, but because it is often used in double or triple layers, the effective mesh opening may become smaller. This may allow smaller blue swimming crabs to be caught. Studies on gillnet selectivity also show that mesh size strongly affects the size of fish or crabs retained by the gear, with smaller mesh sizes catching smaller individuals (Alba et al. 2018). Furthermore, the monthly length frequency data show recruitment pulses occurring twice a year, indicating bimodal recruitment patterns, which is also supported by the number of recruitment peaks (RP = 2) as shown in Table 1. Recruitment patterns commonly consist of two pulses because the Philippines lies in a tropical region, meaning two pulses of stock recruits represent two different cohorts in a year (Abrenica et al. 2021).

3.2 Froese length-based indicator

The percent mature of *P. pelagicus* ranges from 19% to 41%, breaching the limit reference point. This suggests reducing juvenile catch. The L_{opt} ranged between 47% and 63% in this study, with the observed L_{opt} (+/- 10%) size range from 11.3 cm to 13.75 cm. The percent megaspawners range from 6.6% to 22%, breaching the limit reference point in 2019, with 22.2% as shown in Table 3. The Froese analysis indicates that the performance indicators breach the limit reference points, suggesting reduced juvenile catch and the implementation of size regulations.

3.3 LBAR

Table 3 shows that results breach the limit reference points due to high immature sizes, resulting in high F/M values. This is supported by Figure 3, which shows the length frequency distribution of caught *P. pelagicus*, suggesting immature sizes were caught before the length at first maturity of 11.5 cm, as shown in Figure 4.

The upper left panel shows the accumulated LF data used to estimate priors L_c, $L_{inf,}$ and Z/k. The upper, middle, and right panels show the LF data for the first and last years in the time series. The red curve shows the fit to equation 8, which estimates Z/k, M/k, F/k, L_c, and L_{inf}. From L_{inf} and M/k, L_{opt} is calculated and shown as a reference. The lower left panel shows L_{mean} (bold black curve) relative to L_{opt}, and L_c (dashed black curve) relative to L_{c_opt}. The lower middle panel shows relative fishing pressure F/M (black curve), with approximate 95% confidence limits (dotted curves), with indication of the reference level where F = M (green horizontal line). The lower right panel shows relative biomass B/B_o (black curve) with approximate 95% confidence limits (dotted black curves), with indication of a proxy for B_{MSY} (green dashed line) and a proxy for B or 0.5 B_{MSY} (red dotted line).

3.5 Length–Based Spawning Potential Ratio (LBSPR)

Figure 6 shows the length frequency distribution of *Portunus pelagicus* caught by bottom-

Table 3. Froese and LBAR results on performance indicators, *P. pelagicus*, 2015–2021.

Performance Indicators	Reference Points			Results							Status
Froese Tool	Target	Trigger	Limit	2015	2016	2017	2018	2019	2020	2021	
% Mature % within	90-100%	81-59%	50% and less	18.5	21.1	18.4	17.6	40.5	26.6	21.4	LRP
± 10% Lopt	100%	81-99%	80% and less	52.5	52.8	47.3	55.55	60.9	62.7	61.9	LRP
% Megapawner	30-40%	21-29%	20% and less	7.6	8.8	9.7	6.6	22.2	11.5	9.2	LRP
LBAR Tool											
Fishing mortality (F/M)	<1 or 1	>1	2	3.07	2.67	2.16	2.3	1.83	2.56	4.44	LRP
Exploitation Ratio (E)	0.50	0.51 to 0.59	0.6	0.75	0.73	0.7	0.65	0.65	0.72	0.82	LRP

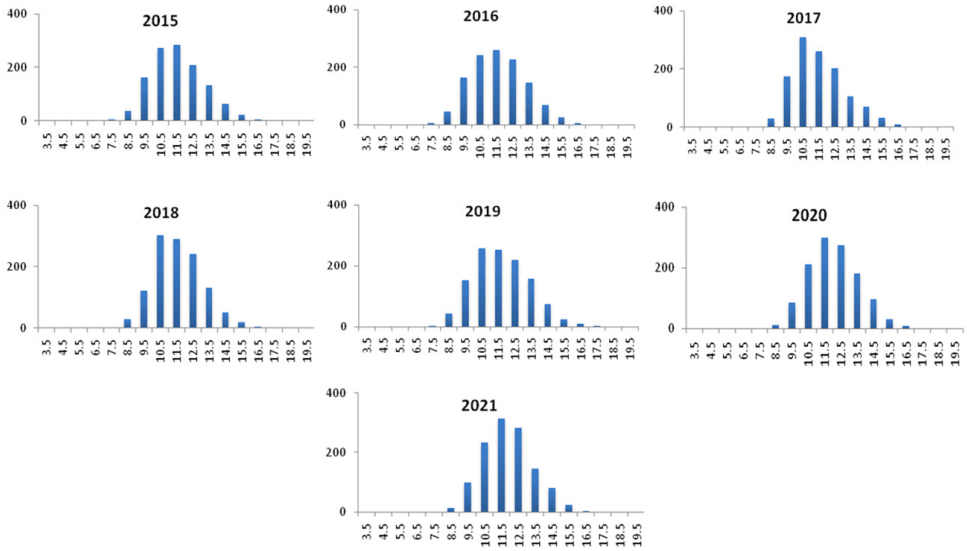

Figure 3. Length frequency distribution of *P. pelagicus,* 2015–2021.

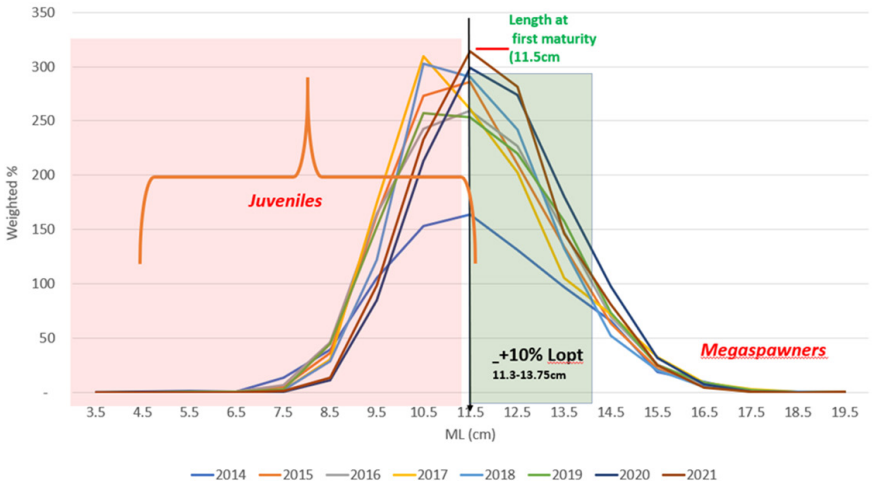

Figure 4. Froese results.

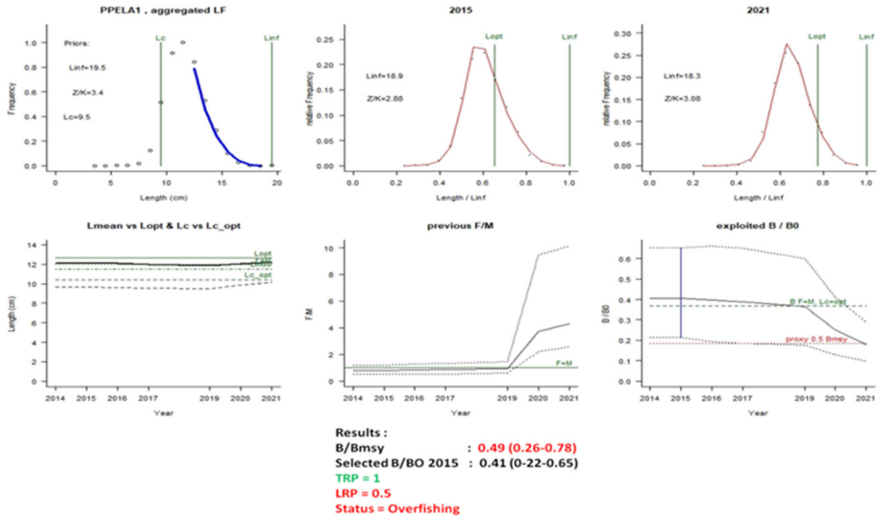

Figure 5. LBB results for *Portunus pelagicus* for the years 2019–2021.

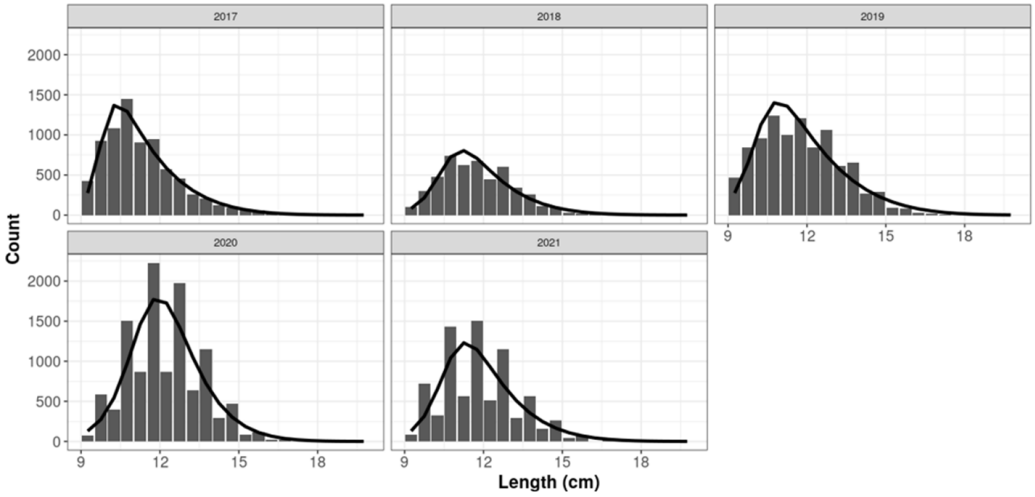

Figure 6. Histogram of length data for *P. pelagicus* from 2017 to 2021 caught by bottom-set gillnet.

set gillnet from 2017 to 2021. Observed adult lengths ranged from 9.5 cm to 19.75 cm; the size distribution peaked at 10.75 cm in 2017 and 2019, and at 11.75 cm from 2020 to 2021. Larger adult blue swimming crabs, particularly those in the 15.0 – 17.5 cm size range, were relatively few, indicating that most of the catch consisted of smaller individuals. This pattern suggests gear selectivity reflects heavy fishing pressure on the stock, as shown in Figure 7.

The estimated Spawning Potential Ratio (SPR) for 2021 was 19% (Table 4) and is shown in Figure 8, which is already at the limit reference point.

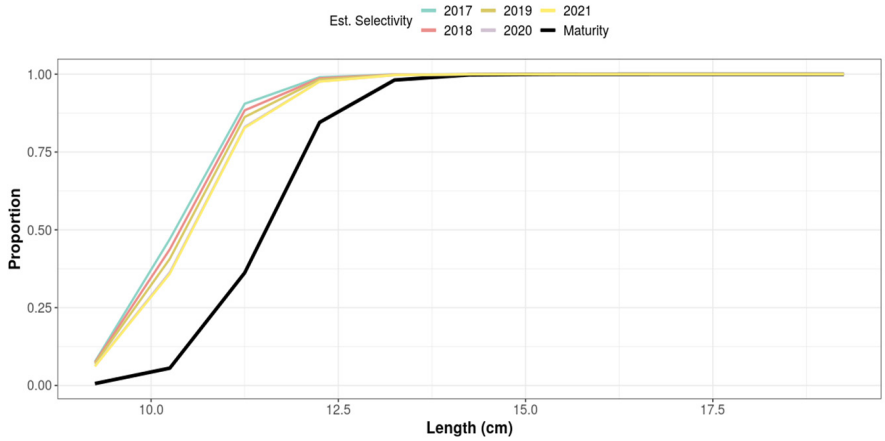

Figure 7. Maturity at length and estimate selectivity.

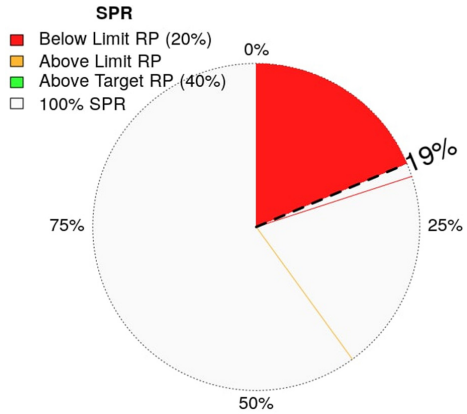

Figure 8. Estimate of SPR.

Table 4. LBSPR results of *Portunus pelagicus* from 2017 to 2021 caught by bottom-set gillnet in Hinatuan and Bislig Bays.

	Years	SPR	SL50	SL95	F/M
1	2017	0.13 (0.12 - 0.14)	9.87 (9.82 - 9.92)	11.11 (11.02 - 11.2)	2.29 (2.18 - 2.4)
2	2018	0.17 (0.16 - 0.18)	10.7 (10.59 - 10.81)	12.43 (12.25 - 12.61)	2.44 (2.25 - 2.63)
3	2019	0.21 (0.19 - 0.22)	10.33 (10.24 - 10.42)	12.14 (11.98 - 12.3)	1.77 (1.66 - 1.88)
4	2020	0.21 (0.2 - 0.22)	11.39 (11.31 - 11.47)	13.3 (13.17 - 13.43)	2.6 (2.45 - 2.75)
5	2021	0.19 (0.18 - 0.2)	10.75 (10.66 - 10.84)	12.48 (12.34 - 12.62)	2.26 (2.12 - 2.4)

This means the stock is at a critical level and may become unsustainable if fishing pressure continues. At this level, only a small portion of the population can reproduce, which can lead to a decline in future stock.

The simulation results show that increasing the size at first capture to 12.6 cm (Figure 9) can improve the SPR to about 40%. This is a better and safer level because it allows more individuals to reach maturity and spawn before they are caught (Hilborn and Walters 1992). Increasing the size at capture is therefore an important step in improving stock condition.

Currently, fishers use bottom-set gillnets with a 5 cm mesh size. However, double or triple net layers effectively reduce the mesh size. As a result, smaller crabs are being caught, including those below the length at maturity (11.5 cm). Catching crabs before they reproduce contributes to the low SPR and slows down stock recovery.

To address this, management should focus on increasing the effective size at capture. This can be done by enforcing proper mesh size and avoiding the use of multiple net layers. Catching crabs around 12.6 cm would increase the SPR to 40% and support the fishery's long-term sustainability.

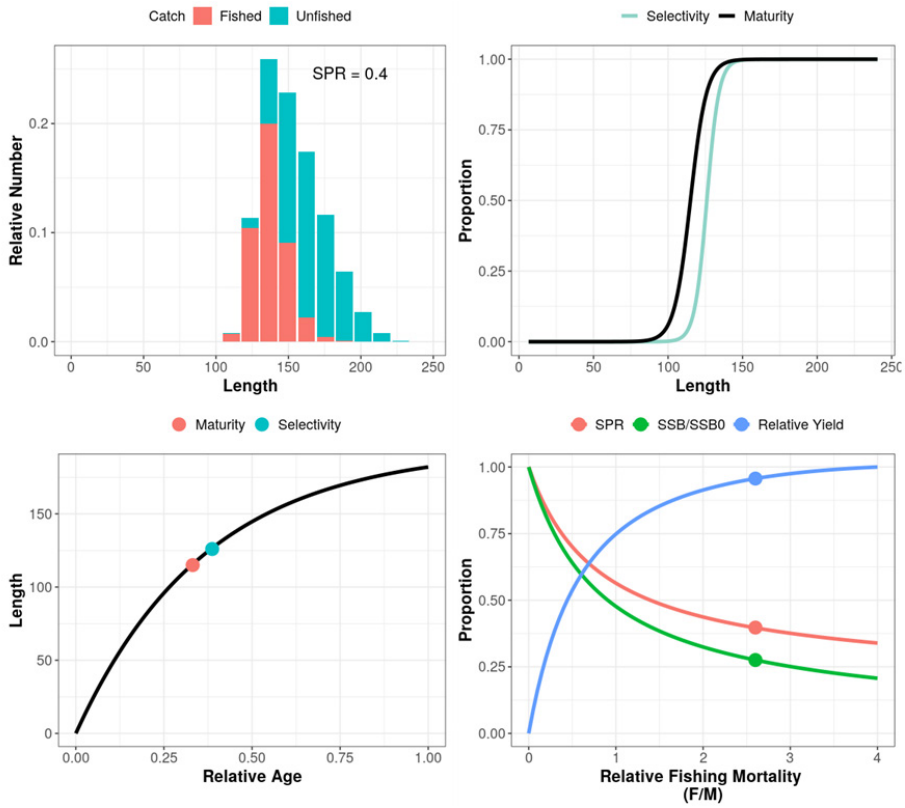

Figure 9. Simulation of 40% SPR.

4. CONCLUSION AND RECOMMENDATIONS

This study showed that the *P. pelagicus* population in Hinatuan and Bislig Bays is currently in crisis due to overfishing. The exploitation rate was 0.74, far exceeding the optimal exploitation rate. The Froese length-based sustainability indicator suggests that performance indicators exceed the limit reference points, requiring reduced juvenile harvesting and a size limit on catch. Mean length assessment likewise suggests that high immature sizes resulted in high F/M values; the length frequency of *P. pelagicus* caught was immature, below the length at first maturity of 11.5 cm.

LBB analysis suggests B/BMSY exceeded the very-low-biomass limit. Moreover, its Spawning Potential Ratio is at the limit reference point (19%); it usually means the stock is exploited and may no longer produce enough eggs to sustain itself safely. In practical terms, the fishery is likely under high fishing pressure, and the stock is at elevated risk of recruitment overfishing or future decline.

The precautionary approach aims to support stock recovery and guide the fishery toward restoring sustainable conditions. The following are the recommendations:

(1) Establish a carapace size limit

It is recommended to reduce fishing pressure by enforcing a minimum carapace width (CW) of 12.6 cm to increase the SPR to 40%. This ensures that only mature individuals, but not berried ones, are harvested, allowing the species to reproduce before capture. Currently, regulations such as Fisheries Administrative Order 264 (Department of Agriculture 2020) and its amendments set a minimum size limit of 11 cm for mangrove crab, along with mesh size regulations of 11 cm. However, these current limits may not be sufficient to achieve the target SPR of 40%. Increasing the minimum capture size to 12.6 cm would better protect the stock and improve its long-term sustainability. Further, the Joint DA-DILG Administrative Order No. 01, Series of 2014 (DA-DILG 2014) specifies gear-size limits for blue swimming crab fisheries, including a minimum mesh size of 11 cm for crab entangling nets, 3 cm stretch mesh for crab lift nets, and a 5 cm minimum hole diameter for crab pots or traps. These gear restrictions complement the minimum harvest size of 10.2 cm carapace width, indicating that both gear selectivity and size limits are used to protect juvenile crabs from over-exploitation.

(2) Gear modification and reproductive study

Reduce the length of bottom-set gill nets (BGNs) to minimize the capture of undersized crabs. In addition, conduct reproductive biology studies to identify peak spawning months, enabling seasonal closures or other protection measures during critical breeding periods to support biomass recovery.

(3) Promote berried crab conservation

Encourage fishers to return berried (egg-bearing) BSC to the wild through incentive-based programs. Alternatively, berried crabs may be collected for hatching in the multi-species hatchery in Hinatuan once it becomes fully operational, contributing to stock enhancement efforts. A related approach in Thailand involves crab banks: community-based conservation sites where berried female crabs are held in cages or tanks until they spawn; then the females are sold, and the hatchlings are released to support crab stocks. The model has been used in places such as Chumphon and later expanded in southern Thailand, including Surat Thani and other coastal communities (Suppanirun 2007).

(4) Prioritize BSC seed production and seeding

Prioritize BSC seed production in the multi-species hatcheries in LGUs Hinatuan and Bislig City. These juvenile crabs can then be used for reseeding in Marine Protected Areas (MPAs) and other identified BSC habitats within the region to support natural population replenishment. Cabacaba and Salamida (2015) documented the seed production of blue swimming crab (*Portunus pelagicus*) at Guiuan Marine Fisheries Development Center (GMFDC), Guiuan, Eastern Samar.

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AUTHOR CONTRIBUTIONS

Alcantara MT: Investigation, Writing – Original draft preparation, Resources, Visualization. **Baclayo JM:** Conceptualization, Methodology, Data processing, Writing-Original draft preparation. **Bognot EC:** Supervision, Writing – Reviewing, Editing.

CONFLICTS OF INTEREST

To the best of our knowledge, no conflict of interest exists.

ETHICS STATEMENT

The authors carried out no animal or human studies.

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