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RESEARCH ARTICLE

Species Composition, Relative Abundance, Distribution, and Size Structure of Spiny Lobsters (*Panulirus* spp.) in Eastern Visayas, Philippines

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ABSTRACT

Spiny lobsters are an important resource of the artisanal fishery in Eastern Visayas, Philippines. It has long been harvested and contributes to the region's local economy. Despite being a high-value species, the spiny lobster resource has not been monitored and regulated for decades. This study aimed to assess the spiny lobsters in Eastern Visayas and provide recent information to support local resource management. Spiny lobsters were assessed from 2018 to 2019 in four major sampling areas in Eastern Visayas: (1) Guiuan and (2) San Policarpo in Eastern Samar province, (3) San Jose in Northern Samar, and (4) Silago-Hinunangan in Southern Leyte. Species composition, relative abundance, geographical and seasonality distribution, and size structure of spiny lobster resource in the region were described. Six species and subspecies of the genus *Panulirus* were observed in the catch landings: *P. penicillatus* (65%), *P. ornatus* (18%), *P. versicolor* (2.8%), *P. femoristriga* (5.3%), *P. longipes longipes* (6.1%), and *P. longipes bispinosus* (1.7%). Incidental catches (1.3%) of the ambiguous forms of *P. longipes* were also observed. *P. penicillatus* were more prevalent in areas exposed to the Pacific, such as Guiuan and San Policarpo, while adult *P. ornatus* were chiefly harvested in Northern Samar and Southern Leyte. The other lobster species were either occasional or rare in some areas. Calmer waters and good weather during dry months in Eastern Visayas allow fishers to sail and gather lobsters. The surge in the abundance of *P. ornatus* and *P. penicillatus* from July to December was also affected by market demand. *Panulirus femoristriga*, *P. versicolor*, and *P. longipes* subspecies generally peaked from April to June in Eastern Samar and July to September in Northern Samar and Southern Leyte areas. These species would decline in abundance towards the end of the year. The general size structure of spiny lobster catches in Eastern Visayas revealed extreme harvesting of juveniles and sub-adults (< 77.5 mm CL), except for *P. ornatus*. The fishery could be on the verge of growth overfishing since 50-90% of the catch have CL below their size at first maturity. *Panulirus ornatus* is targeted at larger sizes (96–107 mm CL) and as a live catch due to its high value and marketability. Raising awareness of the species, reinforcing existing regulations on minimum size limits, and prohibiting the use of compressor diving as a hazardous collection method should be prioritized by fishery managers to protect both the spiny lobster resource and the gatherers in Eastern Visayas.

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1. INTRODUCTION

Spiny lobsters (*Panulirus* spp.) are among the high-priced crustaceans widely distributed across the Philippines (Juinio-Meñez and Gotanco 2004). Despite its socioeconomic value for many years, research on spiny lobsters in the country is neither active nor advancing. Data is scarce to evaluate the species' biological, ecological, and fishery conditions, which are critical in policymaking. The status of spiny lobster stock in the country, thus, needs to be updated, most notably in regions where they are actively harvested.

Spiny lobsters belong to the genus *Panulirus* which has 22 species (WoRMS Editorial Board 2022) that are distributed across the world's tropical and subtropical ocean belts (Pitcher 1993). The Pacific Ocean or its rim is home to thirteen *Panulirus* species. Four species are restricted to the eastern Pacific, whereas the remaining four are restricted to the western rim and typically extend into the Indian Ocean. The remainder of the wider Pacific, including the smaller tropical island states, is home to only four species (*P. penicillatus*, *P. longipes*, *P. versicolor*, and *P. ornatus*). Some species like *P. homarus* and *P. pascuensis* are also endemic in the other southeastern part of the Pacific, like the waters of Java and Bali in Indonesia (Pitcher 1993; Kembaren and Hakim 2021).

Spiny lobsters have been researched in various neighboring countries in the Asia Pacific, like Vietnam, Malaysia, Indonesia, and Australia (Junio-Menez and Dantis 1996; Williams 2004; Tirtadanu et al. 2021). The status of fishery, capture and aquaculture production, ecology, biology, and population dynamics have been studied to support resource management in these countries.

Nevertheless, the spiny lobster resource in the Philippines is data-poor, while research has been sporadic. Available research and survey data on these economically significant species mostly predate the 2000s. The assessment of lobster fishing resources in the main producing areas in the country has not been done on a large scale since the study of Juinio-Meñez and Dantis (1996). Juinio-Meñez and Dantis (1996) conducted the first nationwide assessment of spiny lobster resources in the country through surveys of fishers, buyers, traders, and government agencies in various localities. The investigation found seven *Panulirus* species and subspecies in the Philippines, each with a different seasonality and distribution. The studies of Juinio and Gomez (1986) and Arellano (1988) revealed that *Panulirus penicillatus* was the most abundant species, accounting for more than 90% of total capture in the Philippines; the two subspecies of *P. longipes* (*P. longipes longipes* and *P. longipes bispinosus*) were the second most abundant, followed by *P. femoristriga*, *P. versicolor*, *P. ornatus*, and a rare species, *P. homarus.*

Moreover, Juinio-Meñez and Gotanco (2004) found that weather conditions and suitable habitats are vital factors in spiny lobsters' spatial and seasonal distribution. *Panulirus penicillatus*, *P. ornatus,* and *P. versicolor* were widely distributed but with varying abundance across the Philippines, including regions of Ilocos, Central Luzon, CALABARZON, MIMAROPA, Western Visayas, Eastern Visayas, Zamboanga Peninsula, Davao, and the Bangsamoro Autonomous Region in Muslim Mindanao (BARMM). Of the two *P. longipes* subspecies, *P. l. longipes* was more common on the west coast and *P. l. bispinosus* on the east. In the same report, the peak season for spiny lobsters was generally from April to May and least from November to February. However, year-round catches were observed in western and southern regions.

Juinio-Meñez and Gomez (1986) also conducted a spiny lobster population survey focusing on the province of Eastern Samar from 1982 to 1984. In 1991, Gonzales and Taniguchi (1995) documented the spiny lobster fishery and Palawan's existing conservation and management strategy. Arellano (1996) also assessed the growth characteristics and length-weight relationship of spiny lobsters harvested off the coast of Cagayan, Philippines. Ravago and Juinio-Meñez (2003) clarified the phylogenetic position and described some physical distinctions of various spiny lobster species particularly that of the sub-species *P. l. longipes* and *P. l. bispinosus*, and *P. femoristriga* as separate species. The most recent published study on spiny lobster assessment was undertaken by Abduho and Madjos (2018), who documented the crustacean fishery, including lobsters and crabs in Basilan Province. However, valuable biological and economic reference points have not been established since Arellano's (1988) examination of specific demographic metrics in the 1980s.

The Food and Agriculture Organization reported lobster capture production for the Philippines from 1970 to 2001, with a maximum of 1500 MT in 1979 and a decline to 300 MT in 2001 (FAO Fishery Statistics 2001). The spiny lobster commodity has been recently classified in the annual Fishery Situationer of the Philippine Statistics Authority (PSA) as "other crustaceans" owing to the recent decline and limited contribution to fisheries compared to other species such as big-eyed scad, frigate tuna, yellowfin tuna, mangrove crabs, milkfish, squids, and other shellfish (Philippine Statistics Authority 2017; Philippine Statistics Authority 2020).

The recent decline in spiny lobster production in the country prompted the Bureau of Fisheries and Aquatic Resources (BFAR) to issue the Fisheries Administrative Order (FAO) No. 265 series of 2020, which aims to regulate the capture, possession, transportation, dealing, and exportation of puerulus, juvenile, and ovigerous spiny lobsters. Section 2 of the stated FAO prohibits the capture and trade of lobsters smaller than their initial sexual maturity size and the export of wild captured puerulus and breeders. The FAO exempts the use of lobster puerulus and juveniles for aquaculture, as well as for research and academic reasons alone. This fishery order aims to promote the sustainability of the spiny lobster resource in the country (DA-BFAR 2020).

In this study, we investigated and provided recent information on the species composition, relative abundance, geographical and seasonality distribution, and size structure of spiny lobster stock in Eastern Visayas, Philippines. These sets of information shall form an integral component of a comprehensive assessment of spiny lobster fishery and help improve resource management and conservation in the locality and other parts of the country.

2. MATERIALS AND METHODS

2.1 Study sites

The spiny lobster assessment was done in major production sites in Eastern Visayas, Philippines, from 2018 to 2019. The assessment encompassed sampling and data gathering in landing sites and buying stations of spiny lobsters in the municipalities of San Policarpo and Guiuan in Eastern Samar province; San Jose in Northern Samar province; and Silago and Hinunangan in Southern Leyte province (see Figure 1). These five sampling stations were established and selected based on preliminary surveys conducted in January 2018. In addition, lobster data from Silago and Hinunangan were pooled and considered as a single population due to geographic proximity. Table 1 shows the names of the buying stations and their respective locations.

2.2 Data Collection

2.2.1 Sampling and data gathering

The total inventory of each lobster-buying station was collected and recorded by the assigned enumerator per province. The data collection followed the standard sampling schedule of the National Stock Assessment Program (NSAP) number of days—21

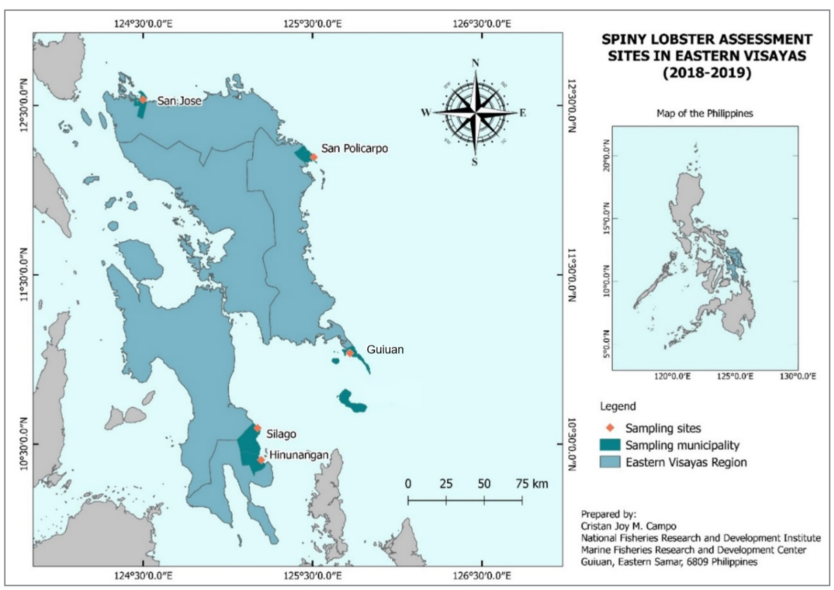


Figure 1. Map of the study sites of spiny lobster stock assessment in the Eastern Visayas Region, Philippines from 2018 to 2019.

Table 1. Spiny lobster sampling stations in Eastern Visayas (2018–2019).

Province	Municipality	Barangay	Name of Buying Station
Northern Samar	San Jose	Brgy. North	Wang Marine Products
Eastern Samar	San Policarpo	Brgy. 1, Poblacion	Mackie Sea Products Buyer and Exporter
	Guiuan	Brgy. Lupok	Double A Marine Products
		Brgy. Hollywood	Hollywood Buying Station
Southern Leyte	Silago	Brgy. Hingatungan	Tito Beloy Marine Products
	Hinunangan	Brgy. Ingan	Eddie Dollente Marine Products

sampling days for months with 31 days, and 20 sampling days for months with 30 days (Santos et al. 2017). This was conducted from February 2018 until December 2019 (23 months). During the data collection, the enumerators gathered biological, biometric, and fishery data and information for the assessment. The following relevant lobster data were extracted from the total inventory: a) name of lobster species; b) sex of lobster (which can be discriminated using the information in Figure 2); c) carapace length CL; d) individual body weight BW; e) body coloration or physical observations; f) lobster fishing ground; and g) location and name of buying station. Carapace length was measured using a caliper along the mid-dorsal line of the carapace from the post-orbital spines of the anterior end to the hind edge of the carapace (see Figure 3). Individual body weight was measured using a digital top-loading scale (nearest 0.01 g).

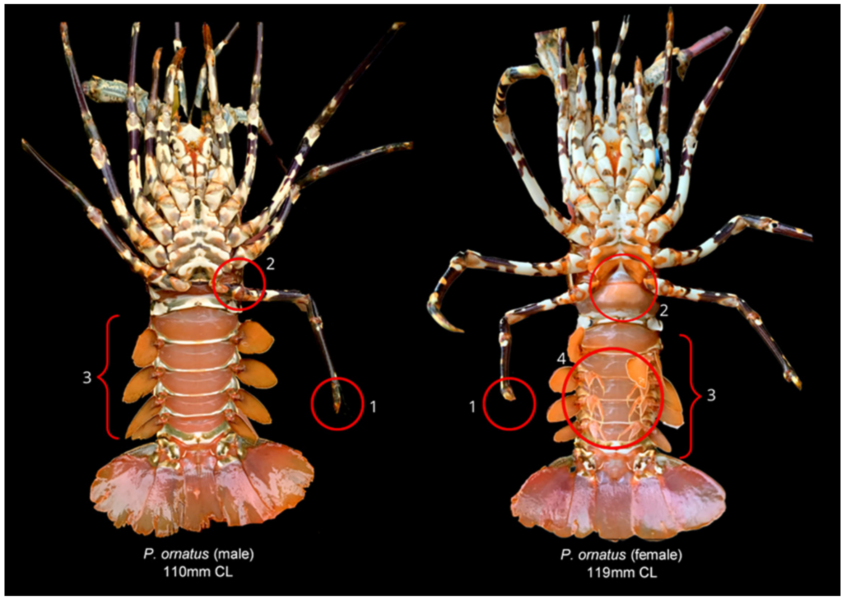


Figure 2. Morphological differences of male and female spiny lobsters (*P. ornatus* in photo). Ventral view of male: 1) pointed tips of the last leg; 2) have an opening at the base of each last leg where sperms are transferred from; 3) a set of single swimmerets along the end of the tail. Ventral view of female: 1) a claw is present at the tip of the female's last leg used for transferring sperm from the tarspot to the egg mass; 2) an area between the last legs where tarspot (not shown) is usually found in mature individuals; 3) females have a set of swimmerets which have relatively wider flap; 4) forked claspers are present beneath the swimmerets used for holding eggs, this feature is entirely absent in males.

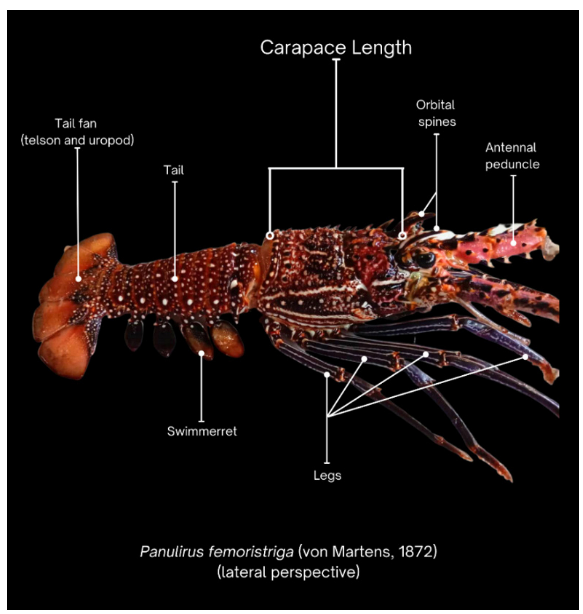


Figure 3. General anatomical parts of a spiny lobster (*P. femoristriga* in photo) and extent of carapace length of spiny lobster measured from the notch between the orbital spines at the anterior portion to the posterior edge of the carapace. Note: Antennae of lobsters were removed but with the antennal peduncles (conspicuously bright pink for *P. femoristriga*) still intact.

2.2.2 Species identification

Spiny lobsters were identified using the morphological traits reported by Ravago and Juinio-Meñez (2003), Motoh and Kuronuma (1980), and Williams (1986). Due to ambiguity in identification and local classification in buying stations, the species *P. femoristriga* and two subspecies of *P. longipes*, the *P. longipes longipes,* and *P. longipes bispinosus* were classified as "Red Lobster Variety" during data collection in 2018. This grouping was disaggregated in 2019 by thoroughly documenting observations on the coloring of the antennal peduncles, antennal flagella, and walking legs, as distinguishing physical traits can be utilized to identify species (Ravago and Juinio-Meñez 2003). Dr. Marie Antonette Juinio-Meñez and Rachel Ravago-Gotanco of the University of the Philippines Marine Science Institute in Diliman, Quezon City, validated the species identification, particularly of the red lobster variants. Due to the difference in data input between 2018 and 2019, lobster data analysis and presentation for both years were separated.

2.3 Data processing and analysis

All gathered data were encoded in a Microsoft (MS) Excel software spreadsheet using a template designed for data entry on various analyses. Data were pre-processed by tracking errors, sorting, filtering, and integrating into the Pivot table feature in MS Excel software. Tables and graphs were generated accordingly to provide visual presentations of data.

2.3.1 Species composition and relative abundance

Species composition and abundance estimation were based on the samples collected from the landed catch. The following formula was used in calculating the relative abundance of each species:

$$Relative\ Abundance\ of\ Species\ A\ (\%) = \frac{Is_i}{\sum Ns_i} \times 100$$

where, *Isi* is the total number of individual species, and *Σ Nsi* is the total number of samples of spiny lobster species in the inventory. The species observed in this study were ranked accordingly by their relative abundances.

A Whittaker analysis chart was created to show the absolute abundance and log-transformed relative abundance plotted against the species rank. This was conducted to visualize the species abundance, richness, and particularly the evenness in each sampling area. Geometric series curves were also fitted in the log-transformed plots to determine the curve's steepness which would characterize the species' evenness. A more horizontal line represents a more even distribution of the lobster species while a steeper line portrays a less evenly distributed species.

2.3.2 Geographical and seasonality distribution

Apart from the generalized data for Eastern Visayas, species composition and relative abundances of spiny lobsters per municipality or area were further determined to assess their geographical distribution. Information on species' relative abundance per sampling area was further extracted and sorted in Pivot tables in MS Excel 2016. Species rank abundance plot was also generated to visually characterize the species richness and evenness in various areas in Eastern Visayas. Species rank was plotted against the absolute abundance and log-transformed abundance in separate graphs. For seasonality distribution, the monthly variation of lobster abundance was also estimated following the same sorting method and was graphed accordingly in a percentage stack area chart.

Moreover, a simple approach to estimating relative similarity between sites and months was estimated using the equation of Gauch (1982), which accounts not only for the presence or absence of the species in a particular geographical area but also their relative abundance. The percentage similarity index can be computed through this formula:

$$PS_{ij} = \frac{200 \sum \min(y_{ki}, y_{kj})}{\sum y_{ki} + \sum y_{kj}}$$

where, y_{ki} is the absolute abundance of *kth* species in site *i,* and y_{kj} is the abundance of *kth* species in site *j* (if a comparison of site *i and j* is analyzed). A matrix was created to compare the index values between two sites and months.

2.3.3 Lobster catch size structure

Carapace length, CL (in mm) and individual body weight, BW (in g) measurements were extracted from the biometric data collected during the sampling. Descriptive statistics of these data were also reported as means, standard deviation, minimum, and maximum. Size percentage distribution graphs were also generated from the carapace length measurements for male and female of each spiny lobster species and were categorized by size classes of 5-mm interval mid-lengths. This information would also help estimate the contribution of each lobster sexes' size class to the abundance of lobsters in each area. Skewness and kurtosis were also computed further to describe the size distribution characteristics of each lobster species.

3. RESULTS

3.1 Species composition and relative abundance

Six species and subspecies of spiny lobster were observed in various sampling sites in Eastern Visayas from 2018 to 2019. These were the *Panulirus penicillatus* (Olivier 1791), *Panulirus ornatus* (Fabricius 1798), *Panulirus versicolor* (Latreille 1804), *Panulirus femoristriga* (von Martens 1872), *Panulirus longipes longipes* (A. Milne-Edwards 1868), and *Panulirus*

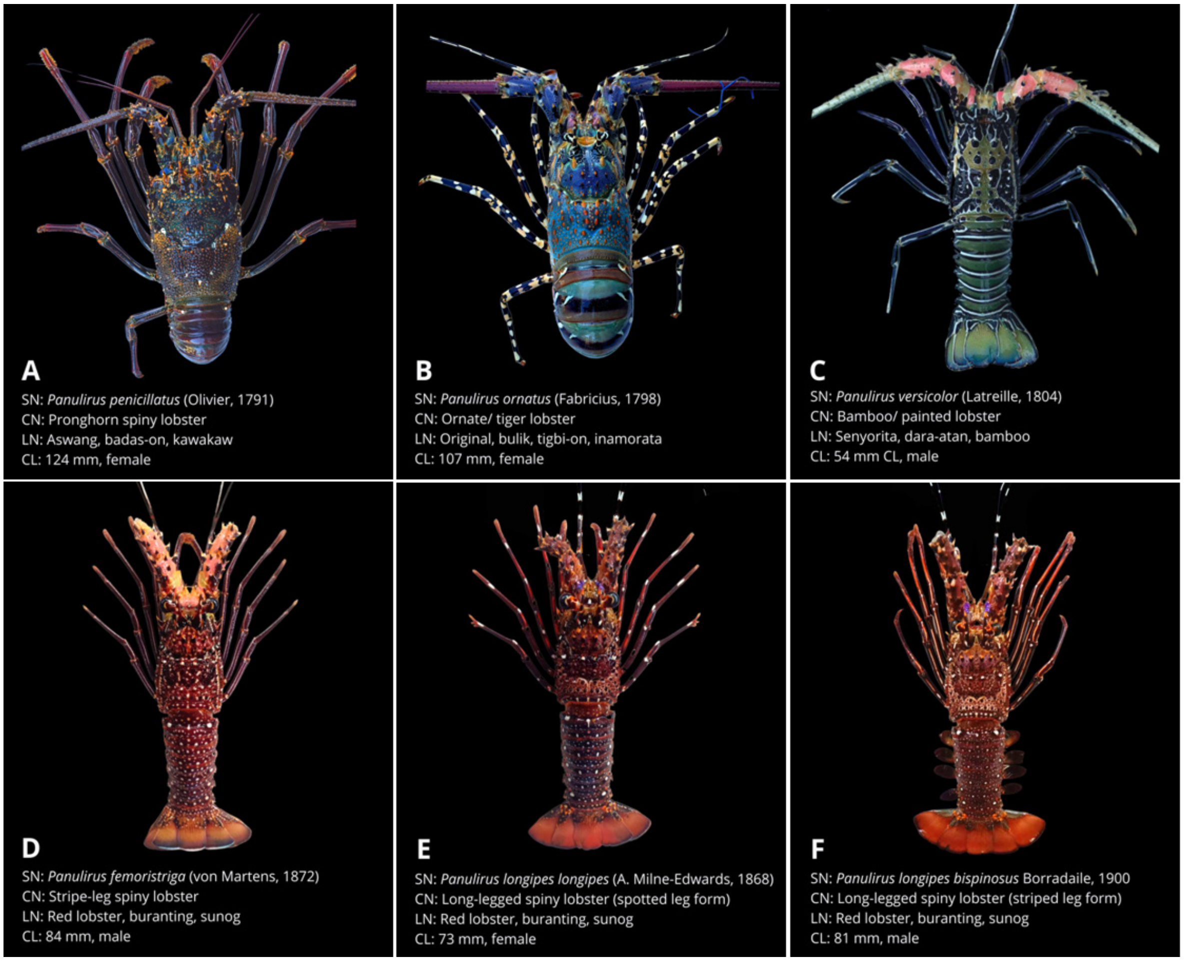


Figure 4. Photographs of the six species and sub-species of spiny lobster caught in Eastern Visayas, Philippines from 2018 to 2019: (A) *Panulirus penicillatus* (Olivier, 1791); (B) *Panulirus ornatus* (Fabricius, 1798); (C) *Panulirus versicolor* (Latreille 1804); (D) *Panulirus femoristriga* (von Martens, 1872); (E) *Panulirus longipes longipes* (A. Milne-Edwards, 1868); (F) *Panulirus longipes bispinosus* Borradaile, 1900. Note: SN - scientific name; CN - common name; LN - local name; and CL - carapace length. Uropods are not shown in species A and B; antennal appendages in species D, E, and F were removed with antennal peduncles still intact.

longipes bispinosus (Borradaile 1900). Figure 4 depicts the spiny lobster species collected in Eastern Visayas, along with their scientific, common, and local names.

Overall, *P. penicillatus* had the highest percentage abundance in Eastern Visayas, accounting for 56% and 65% of the pooled catch in various sites for 2018 and 2019, respectively (see Figure 5). *Panulirus ornatus* had a relative abundance of 18% for both years, while *P. versicolor* had abundances of 1.5% and 2.8%. In 2018, the red lobster variety contributed 24.7% of the summarized catch, while in 2019, this group contributed 14.4% of the total catch. Disaggregation of the red lobster group in 2019 revealed *P. l. longipes* with the highest percentage abundance among red lobster species with 6.1%, followed by *P. femoristriga* at 5.3%. *Panulirus longipes bispinosus* contributed 1.7% only of the sampled catch. Moreover, some samples of ambiguous forms of *P. longipes* were also recorded, contributing 1.3% of the summarized catch.

3.2 Geographical distribution

The six species and subspecies of spiny lobsters found across Eastern Visayas vary in relative abundances according to location (see Figure 6). In Guiuan, *P. penicillatus* had the highest relative abundances of 56.7% and 77.3% for 2018 and 2019, respectively, or with a pooled abundance of 76.8%. *Panulirus ornatus*, on the other hand, had the least relative abundance in Guiuan for 2018 with 10.3% only. With a larger sample size in 2019, *P. femoristriga* accounted for a 6.9% relative abundance. This was followed by *P. versicolor* (5.2%), *P. l. longipes* (4.0%), *P. ornatus* (3.6%), *P. l. bispinosus* (2.1%),

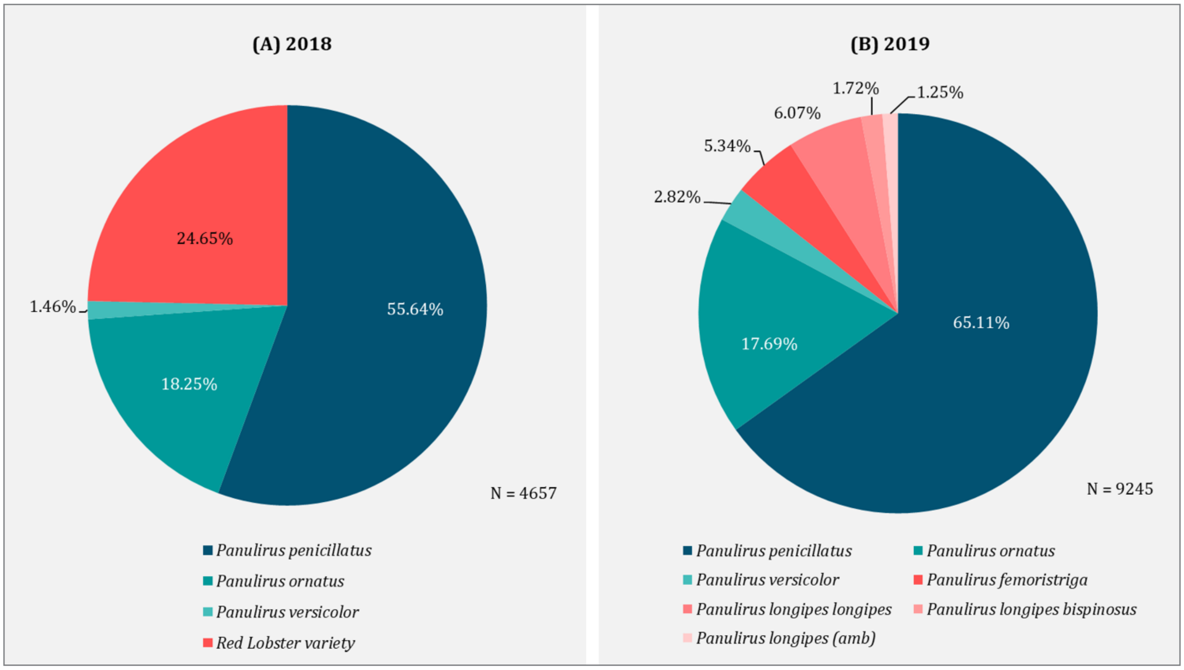


Figure 5. Relative abundances of spiny lobsters in Eastern Visayas, Philippines from 2018 (A) to 2019 (B). Note: Red lobster variety in 2018 may represent all the following three species: *P. femoristriga*, *P. l. longipes,* and *P. l. bispinosus*. Ambiguous form (amb) of *P. longipes* were also observed in the summarized catch.

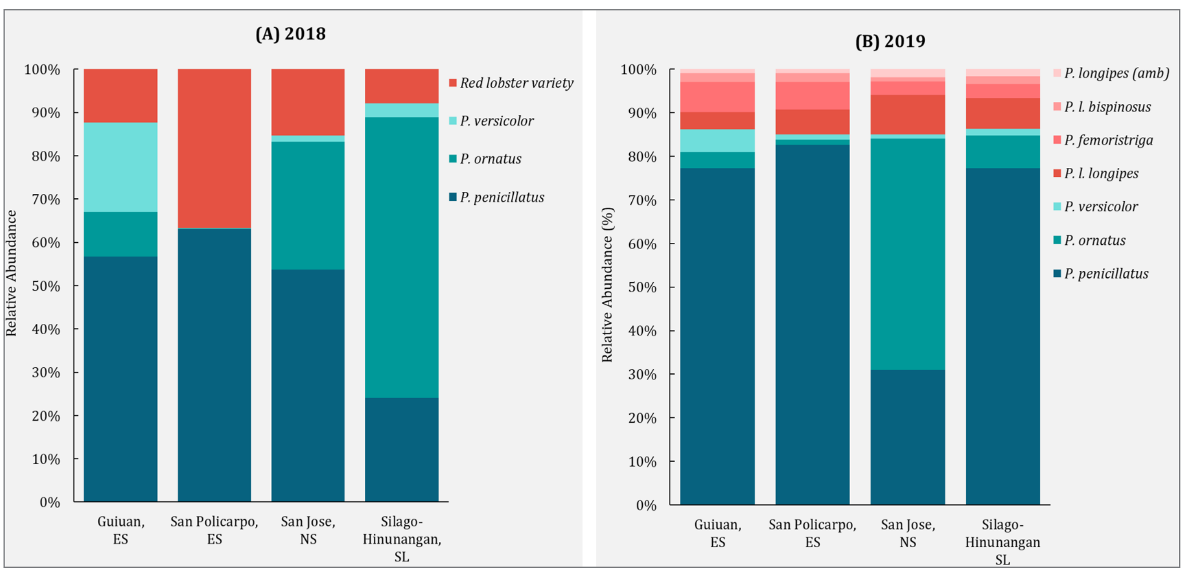


Figure 6. Relative abundances of the six spiny lobster species in different areas of Eastern Visayas in 2018 (A) and 2019 (B). Note: N samples for 2018: Guiuan = 97; San Policarpo = 2331; San Jose = 1532; Silago = 349; Hinunangan = 244. N samples in 2019: Guiuan = 3836; San Policarpo = 1967; San Jose = 2665; Silago = 760; Hinunangan = 17.

and with the ambiguous form of *P. longipes* with the least abundance (0.9%).

In San Policarpo, *P. penicillatus* had the highest pooled relative abundance of 72.1%. This was followed by the red lobster variety, with 36.6% relative abundance in 2018. Analysis for 2019 further revealed *P. femoristriga*, with the second-highest relative abundance among spiny lobsters in the area and with the highest abundance among red lobster variants (6.3%). *Panulirus longipes longipes* followed this with a relative abundance of 5.7%, while *P. l. bispinosus* with 2.0% only. Both *P. versicolor* and *P. ornatus* had an abundance of 1.2% only.

In San Jose, Northern Samar, *P. ornatus* had the highest pooled relative abundance of 44.5% from 2018 to 2019. However, *Panulirus penicillatus* had the highest relative abundance in the area in 2018 (53.7%) but declined in 2019 (31.0%). *Panulirus longipes longipes* followed these two species in abundance with 9.1%, and *P. femoristriga* with 3.0%. *Panulirus versicolor* and *P. l. bispinosus* both contributed 1.0% of the sampled catch.

Pooled relative abundance of spiny lobsters in Southern Leyte, which consists of sampling areas of Silago and Hinunangan, also revealed *P. penicillatus* with the highest relative abundance. Analysis for 2018, nevertheless, revealed *P. ornatus* as the most abundant species in the area, with 64.8% abundance, followed by *P. penicillatus*, with 24.1%. However, in 2019, *P. penicillatus* dominated the sampled catch with 77.2%, while *P. ornatus* with 7.6% only. The other spiny lobster species contributed less than 8% of the catch during the two-year sampling. The red lobster variety was the third most abundant group during 2018 sampling, while analysis in 2019 revealed *P. l. longipes* as the most abundant variant of this group, followed by *P. l. femoristriga* (3.2%), *P. l. bispinosus* (1.8%), and ambiguous forms of *P. longipes* (1.7%). *Panulirus versicolor*, on the other hand, had the least relative abundance of 1.5%.

Species-rank abundance in various sites was also analyzed and plotted in Figure 7. All sites have the same species richness equal to 7 (six species and subspecies, and one ID for ambiguous form of *P. longipes*). The degree of abundance of the dominant species *P. penicillatus* and *P. ornatus*, which ranked either first or second in most areas, caused the curves' steepness in all sampling sites (see Figure 7C and 7D). Plots for species that ranked third up to seventh have relatively more horizontal points; this can be distinctly observed from the absolute abundance shown in Figure 7B. Notably, the most uneven area for spiny lobster abundance was San Policarpo, Eastern Samar, with the highest slope value (-744.6 and -329.3 for 2018 and 2019, respectively) compared to the other three sites. Guiuan, San Jose, and Silago-Hinunangan have relatively parallel curves.

The percentage similarity index analysis showed the greatest value between Guiuan and San Policarpo, Eastern Samar (83.98%) (see Table 2). Silago-Hinunangan had the lowest similarity index compared to Guiuan and San Policarpo, with values of 39.3% and 33.49%, respectively. However, the similarity indices for San Jose against the other three sites ranged from 49.2 to 53.0.

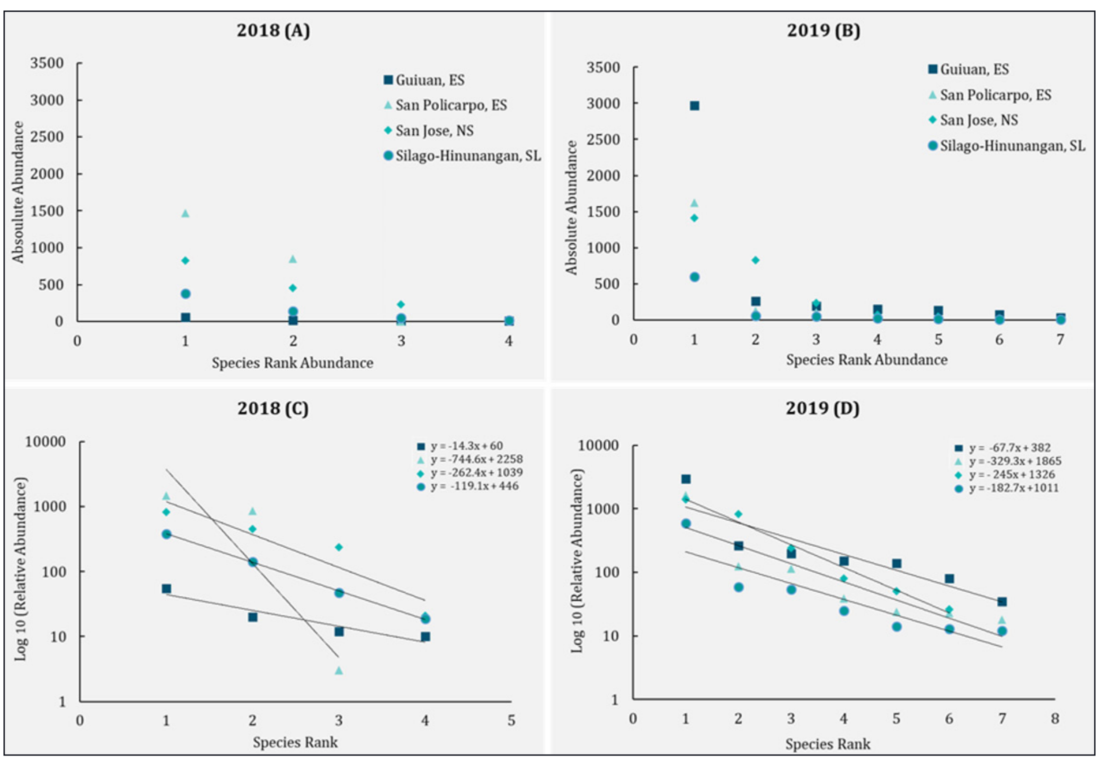


Figure 7. Species-rank abundance plot in various areas in Eastern Visayas (2018–2019) showing the absolute abundance (A–B) and log-transformed abundance plotted against spiny lobster species ranked abundance with geometric series fitted line (C–D).

Table 2. Species percentage similarity indices cross-tabulated between spiny lobster sites in Eastern Visayas.

	Guiuan, ES	San Policarpo, ES	San Jose, NS
San Policarpo, ES	83.98		
San Jose, NS	52.96	51.23	
Silago-Hinunangan, SL	39.30	33.49	49.22

3.3 Seasonal distribution

Monthly variation in relative abundances of spiny lobster species in Eastern Visayas is visualized in stacked area charts in Figure 8. Throughout 2018 and 2019, *P. penicillatus* was persistently abundant throughout the year, especially in areas of Guiuan and San Policarpo. This species was particularly most abundant from July to October in Eastern Samar, with relative abundances greater than 80%. Conversely, a declining relative abundance of *P. penicillatus* was observed in San Jose, Northern Samar, with a peak of 80% in December 2018 down to 15% in the same month of the following year. In Southern Leyte, *P. penicillatus* was most abundant almost throughout the year.

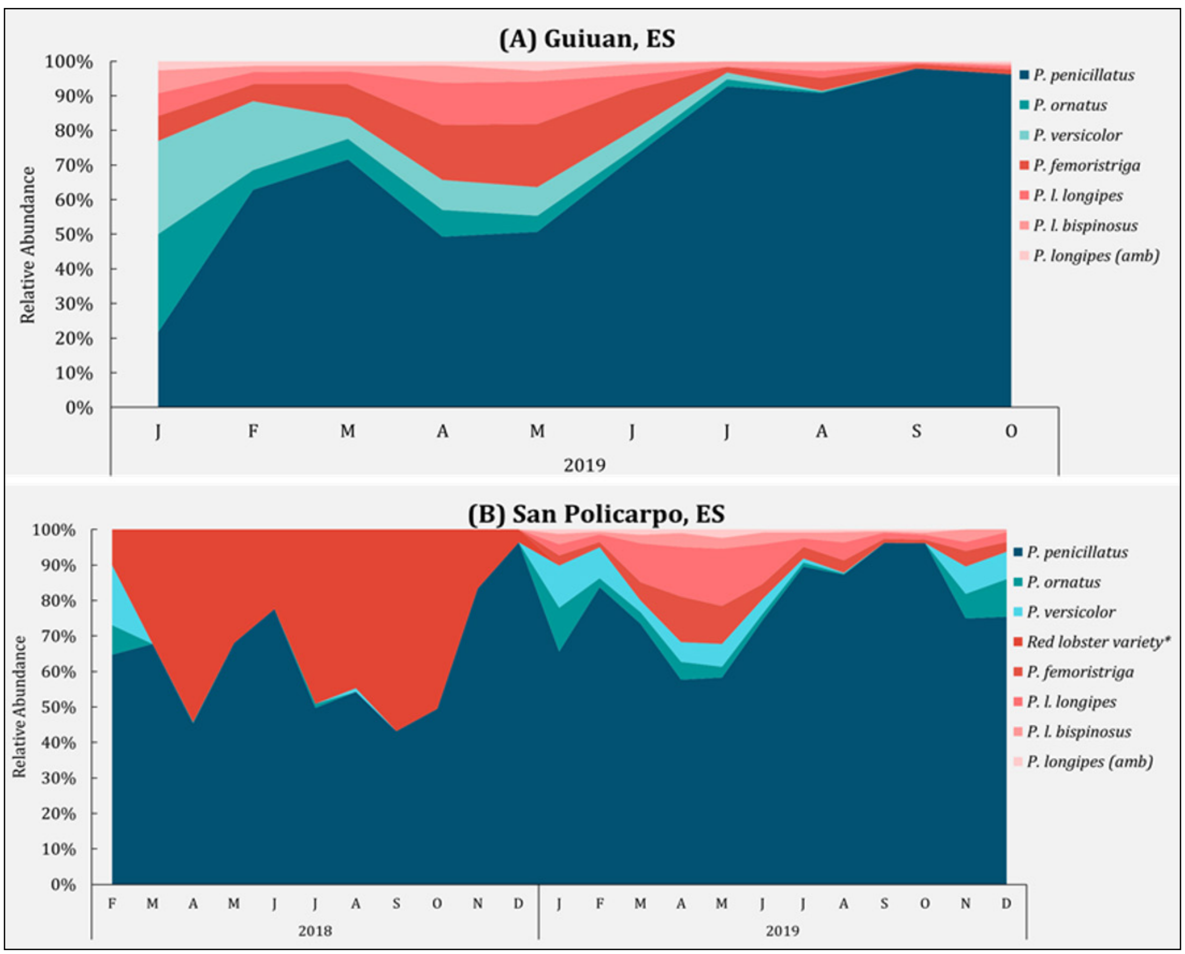
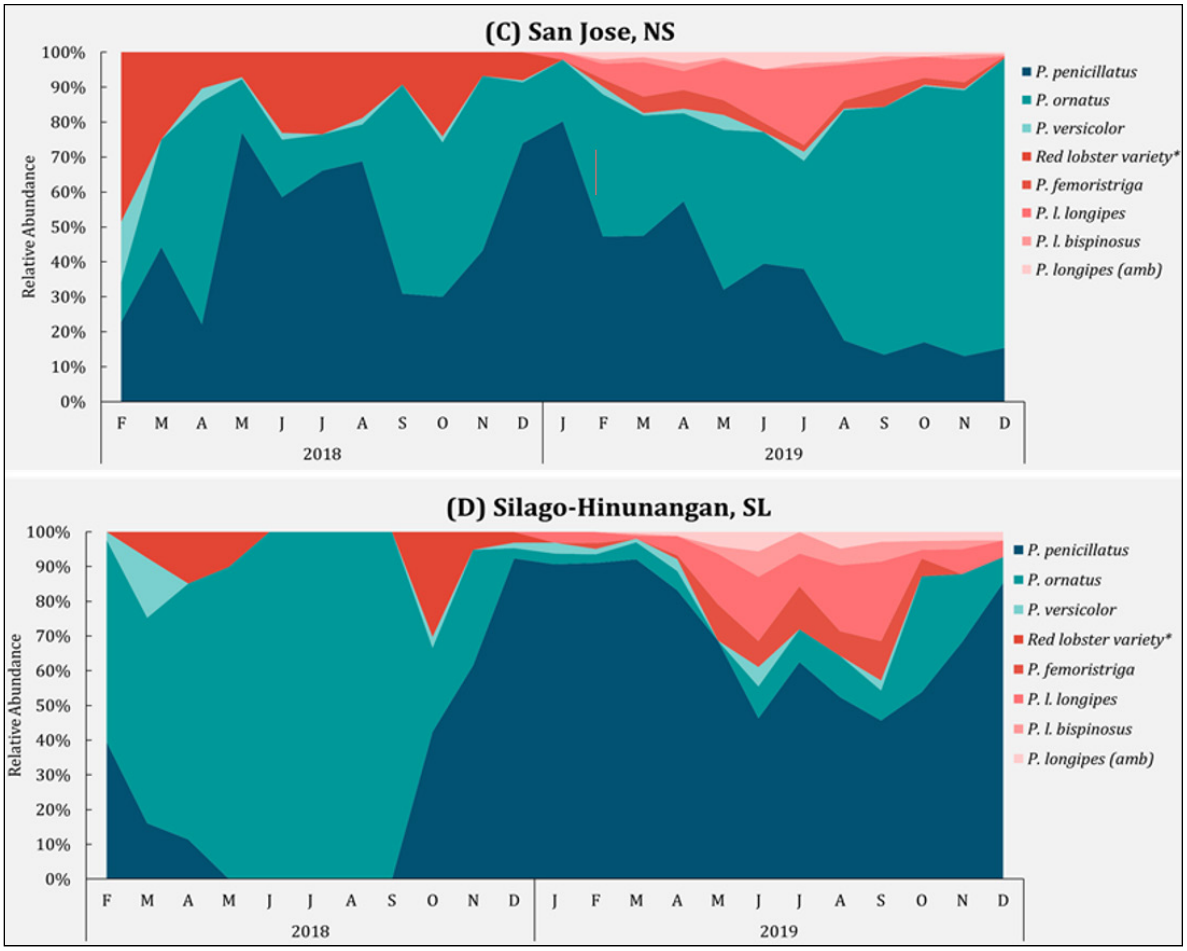


Figure 8. Monthly variation in the relative abundance of spiny lobster species in Eastern Visayas from 2018 to 2019. Note: Asterisk (*) means the red lobster variety may include *P. femoristriga, P. l. longipes, P. l. bispinosus*, and ambiguous forms of *P. longipes*, and were sampled in 2018 only. Guiuan, Eastern Samar (A) has been sampled during 2019 only.



Continuation of Figure 8. Monthly variation in the relative abundance of spiny lobster species in Eastern Visayas from 2018 to 2019. Note: Asterisk (*) means the red lobster variety may include P. *femoristriga, P. l. longipes, P. l. bispinosus*, and ambiguous forms of *P. longipes*, and were sampled in 2018 only. Guiuan, Eastern Samar (A) has been sampled during 2019 only.

The relative monthly abundance of *P. ornatus* varied from 2018 to 2019 and had no particular peak season, especially in areas where it was not frequently caught. *Panulirus ornatus*, the most abundant species in Northern Samar, peaked in November 2019, contributing 76% relative abundance. Separate peaks of relative abundance for this species during 2018 data collection were also observed in April, and from September to November. Remarkably, *P. ornatus* lobster was the only species caught in Southern Leyte from July to September 2018 sampling. This has declined beginning October 2018 since the surge of *P. penicillatus* samples in 2019.

The red lobster variety, including *P. femoristriga* and the two sub-species of *P. longipes* peaked from April to June in Eastern Samar areas and July to September in Northern Samar and Southern Leyte areas.

Panulirus versicolor, on the other hand, was less frequently caught in all areas in Eastern Visayas, and its monthly contribution to the overall catch ranged from 0 to 14% only. The maximum number of samples for this species was 49 pieces caught in February 2019. Moreover, relatively more samples (30 to 49) were observed from February to May 2019.

A percentage similarity index analysis was also done to analyze monthly variations in species richness, evenness, and abundance from 2018 to 2019. Table 3 and 4 show the percentage similarity indices cross-tabulated between 2018 and 2019. The color gradient of the table indicates the level of similarity relative to the value of the index. Darker colors show higher similarity, while lighter ones show lower similarity. Similarities of species were highly variable in 2018, as shown in the color gradient. For example, a high similarity value was observed for November 2018 against March (84.3%) and May (91.6%). On the other hand, analysis for 2019 shows a high degree

Table 3. Species percentage similarity indices cross-tabulated between sampling months of 2018 pooled from various spiny lobster areas in Eastern Visayas.

	2018									
	Feb	Mar	Apr	May	*Jun*	*Jul*	Aug	Sep	Oct	Nov
Mar	53.06									
Apr	42.79	75.87								
May	43.24	88.27	73.42							
Jun	71.93	70.38	62.76	64.24						
Jul	63.94	75.33	67.45	71.98	83.67					
Aug	50.60	89.49	74.82	80.68	67.11	80.20				
Sept	100.43	54.06	59.82	55.65	70.67	56.45	44.26			
Oct	60.28	80.00	75.55	71.68	85.02	88.31	82.23	59.81		
Nov	48.78	84.26	26.94	91.59	59.44	65.69	75.70	56.99	65.22	
Dec	48.17	68.73	49.91	77.69	58.72	55.97	67.76	37.28	52.13	82.53

Note: Darker shade of the cell indicates a higher similarity index, while a lighter shade indicates a lower similarity index.

Table 4. Species percentage similarity indices cross-tabulated between sampling months of 2019 pooled from various spiny lobster areas in Eastern Visayas.

	2019										
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Feb	76.17										
Mar	55.06	74.20									
Apr	65.96	84.09	82.79								
May	74.27	70.16	75.79	85.75							
Jun	71.30	80.68	80.16	89.77	87.17						
Jul	75.74	85.59	73.46	83.64	78.70	91.96					
Aug	70.33	74.36	72.71	77.70	83.88	86.49	86.35				
Sept	49.00	67.99	86.00	68.22	65.35	66.92	66.43	71.86			
Oct	67.25	83.98	73.75	78.78	91.77	81.67	84.30	89.13	76.16		
Nov	55.64	42.08	42.27	43.39	55.57	49.92	49.52	63.97	46.90	62.02	
Dec	61.76	45.65	42.73	44.02	57.37	51.21	67.18	63.19	42.74	61.08	87.35

Note: Darker shade of the cell indicates a higher similarity index, while a lighter shade indicates a lower similarity index.

of similarity from February to August (70–92%) and the lowest similarity values for February-April against November-December (43–46%).

3.4 Lobster size structure

The descriptive statistics of the carapace length and individual body weight of male and female spiny lobsters captured in Eastern Visayas are presented in Table 5. The largest mean lobster size was from *P. ornatus* species (mean CL of 96 mm and 106 mm for male and female, and mean BW of 1083 g and 1339 g for male and female, respectively). Female *P. penicillatus* had the least mean lobster size with a mean of 53 mm CL and 175g BW. Smallest and largest body size samples were also observed for *P.*

Table 5. Descriptive statistics of the carapace length and individual body weight of male and female spiny lobster species caught in Eastern Visayas from 2018 to 2019.

			Carapace length (mm)			**Individual Body Length (g)**		
	Sex	**N**	**Mean ± SD**	**Min**	**Max**	**Mean ± SD**	**Min**	**Max**
P. penicillatus	M	4421	55.82 ± 15.37	29.00	240.00	197.06 ± 186.82	20.00	3410.00
	F	4127	53.6 ± 13.3	30.24	235.00	175.02 ± 144.08	20.00	1800.00
P. ornatus	M	1514	96.5 ± 32.6	20.50	279.00	1083.19 ± 866.30	10.00	4550.00
	F	896	106.8 ± 28.4	34.20	247.00	1339.64 ± 827.75	50.00	4300.00
P. versicolor	M	186	73.3 ± 21.3	37.42	152.00	463.38 ± 394.06	68.00	2030.00
	F	102	76.8 ± 23.5	45.97	154.00	484.95 ± 398.33	90.00	2890.00
P. femoristriga	M	290	56.06 ± 15.03	28.00	123.00	223.49 ± 172.74	30.00	1520.00
	F	55	55.03 ± 17.63	32.63	150.00	229.27 ± 248.23	50.00	1940.00
P. l. longipes	M	308	59.93 ± 17.89	31.30	133.00	280.13 ± 239.86	60.00	1490.00
	F	253	60.38 ± 20.78	24.00	180.00	272.42 ± 185.35	30.00	3480.00
P. l. bispinosus	M	84	54.13 ± 12.48	25.00	87.00	206.94 ± 119.95	50.00	550.00
	F	75	56.54 ± 19.82	34.74	133.00	235.84 ± 221.90	60.00	1310.00

ornatus with minimum CL of 20.5 mm and BW of 10 g, and maximum CL of 279 mm and BW of 4550 g. The red lobster variants had sizes with mean ranges of 54–60 mm CL and 206–280 g BW.

The CL size distribution structures for all spiny lobster species except for *P. ornatus* had skewness of > 1.0. On the other hand, skewness values for both male and female *P. ornatus* were less than 1.0. Kurtosis values for *P. penicillatus*, *P. femoristriga*, and the two sub-species of *P. longipes* were also extremely high at > 3.0 but were low for *P. ornatus* (< 3.0).

Moreover, the carapace length percentage distributions for all spiny lobster species caught in Eastern Visayas, except *P. ornatus*, were unimodal (see Figure 9A–9F). Male spiny lobsters with a carapace length of 42.5–52.5 mm were most commonly caught. Female spiny lobsters had different most frequent mid-lengths: 47.5 mm for *P. penicillatus*, 57.5 mm for *P. versicolor*, and 42.5 mm for *P. femoristriga*, *P. l. longipes,* and *P. l. bispinosus*. In contrast, the catch size distribution for male *P. ornatus* was rather bimodal, with modes at 72.5 mm and 117.5 mm CL (see Figure 9B). Female *P. ornatus*, however, had a single peak at 127.5 mm CL mid-length only.

Moreover, 74% of *P. ornatus* caught in Eastern Visayas had CL greater than 77.5 mm mid-length. In

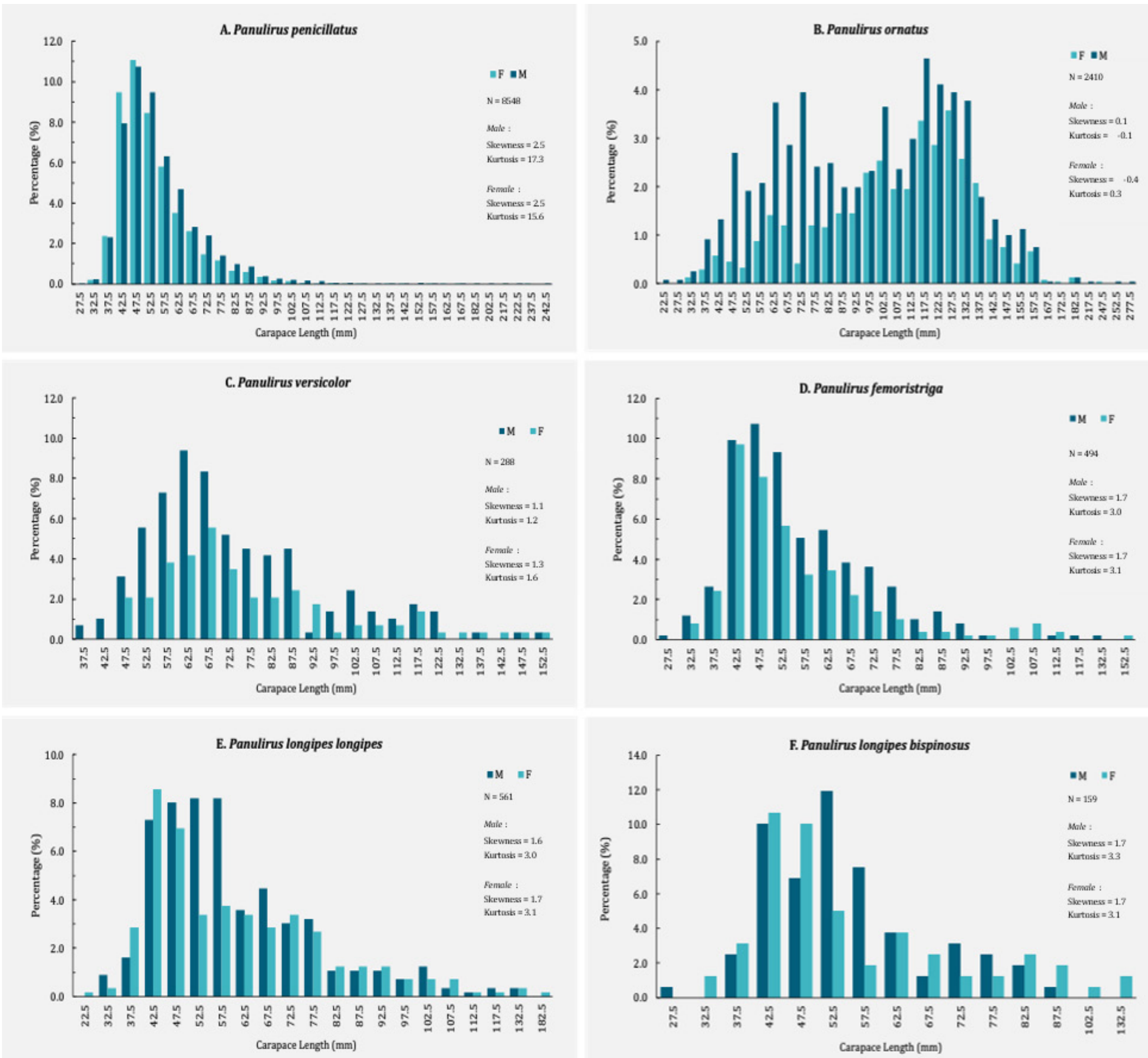


Figure 9 (A–F). Size percentage distribution in carapace length (mm) of spiny lobster species caught in Eastern Visayas from 2018 to 2019. Note: Skewness and kurtosis values are indicated for male and female spiny lobsters.

contrast, 91% of *P. penicillatus*, 53% of *P. versicolor*, 84% of *P. femoristriga*, 81% of *P. l. longipes*, and 87% of *P. l. bispinosus* caught were under 77.5 mm CL in size, all caught below their size at first maturity.

4. DISCUSSION

This present study provided the most recent information and updates on some fundamental ecological characteristics of the spiny lobster population in Eastern Visayas. This information set includes species composition, relative abundance, geographic and seasonal distribution, and size structure of spiny lobsters, which were generated using basic statistical analyses.

The current general composition of spiny lobsters in Eastern Visayas conforms to the previous assessment of Junio-Meñez and Gomez (1986), showing *P. penicillatus* as the most prevalent species, followed by *P. ornatus*. The species *P. versicolor*, *P. femoristriga*, *P. l. longipes*, *P. l. bispinosus* are also observed today, as previously studied in the 1990s. *Panulirus homarus homarus*, present in the region (Junio and Gomez 1986), could have undergone local extinction based on its persisting absence in the landed catch for two straight years.

Spiny lobster species can easily be distinguished by their body coloration. Accounts of their respective physical characteristics and local information based on field observations are accounted for in this section. *Panulirus penicillatus* is mostly dark greenish, reddish, and brownish, with noticeable white to yellowish spots speckled on the carapace's spines and some on the abdomen. Additionally, their legs are streaked with white longitudinal stripes, and their uropod or tail fan is bluish-green with a brown margin. The local epithet "aswang" refers to the species' dark and untidy appearance. *Panulirus ornatus*, commonly known as tiger or ornate lobster, is locally called "original." It can easily be identified by its vivid blue-green carapace with orangey spine tips, broad black and brown bands on the dorsal portion of the tail, and irregular black and white coloring on the legs that almost resembles that of tiger marks. Its ventral side and its tail fan are dominantly orange. *Panulirus versicolor* has a greenish body color with white stripes on the abdomen, a prominent black pattern on the carapace, and an ombre blue along the tail fan borders (uropods and telson). In *P. versicolor*, the antennal peduncles are rather pink, and the legs have longitudinal white stripes.

The red lobster variety consists of *P. femoristriga*, *P. l. longipes,* and *P. l. bispinosus* are locally categorized as “red lobster” owing to their striking resemblance. Generally, these three species can be identified by their reddish and brownish body color and prominent white dots scattered throughout the dorsal area of the carapace, abdomen, and tail. However, three distinct morphological differences separate one from another, which are, the coloration on their: a) antennal flagella or whiskers, b) antennal peduncle, and c) walking legs (Ravago and Juinio-Meñez 2003). See figure 4D–4F. *Panulirus femoristriga* has one pair of white whiskers, bright pink antennal peduncles, and dark brownish legs with faint white streaks of longitudinal white lines. *Panulirus longipes longipes* (spotted leg form) has two pairs of banded whiskers (alternating white and black or brown), dark purplish antennal peduncles, and white-spotted walking legs. Lastly, *Panulirus longipes bispinosus* (striped leg form) is similar to *P. l. longipes*, except its legs have white longitudinal lines instead of white spots. The ambiguous form of *P. longipes* was first reported in Eastern Samar (Juinio-Meñez and Gotanco 2003). They do not strictly conform to either the characteristics of *P. l. longipes* or *P. l. bispinosus* due to the co-presence of prominent spots and faint striping on their walking legs. According to Juinio-Meñez and Gotanco (2003), this could be due to the possible interbreeding of the two sub-species.

Species rank-abundance analysis has shown an uneven abundance of the various spiny lobster species in Eastern Visayas, with the top species (*P. penicillatus and P. ornatus*) being highly abundant while the other species either being occasional or rare. Generally, this study found *P. femoristriga* and *P. l. longipes* as occasional species, while *P. versicolor* and *P. l. bispinosus* as rare species. Ambiguous forms of *P. longipes* were also rare, with very few incidences (116 individuals or 1.25%).

Panulirus penicillatus is most prevalent in regions bordering the Pacific Ocean, such as the eastern coast of Eastern Visayas, including areas of Guiuan and San Policarpo. It is the most common catch of gatherers in almost all areas and is persistent throughout the year. Although it was the most abundant species in Eastern Visayas, it only contributed 3200 kg catch volume, second to *P. ornatus*, which contributed the highest catch volume of 5800 kg from 2018 to 2019.

Panulirus ornatus, on the other hand, is typically found in waters with high turbidity and muddy, sandy substrate (Juinio and Gomez 1986). The ornate lobsters are considered occasional in Eastern Samar, primarily captured in the San Bernardino Strait in Northern Samar and the Leyte Gulf in Southern Leyte. These northern and southern seas of Eastern Visayas receive little wave movement from the Pacific, which favors the inhabitance of *P. ornatus*. During surveys, *P. ornatus* puerulus larvae and juveniles were discovered being harvested by locals in several parts of Eastern Samar, particularly in the municipalities of Oras and San Policarpo. The larvae are suspected to migrate towards the north as adults, which explains their prevalence in Northern Samar.

Panulirus versicolor, *P. l. longipes,* and *P. l. bispinosus* inhabit coral reefs with clearer and calmer waters (Juinio and Gomez 1986). These species were thinly dispersed across Eastern Visayas with infrequent catches. This study, however, found negligible abundances of *P. versicolor* and *P. l. bispinosus*, implying that these two species may be on the verge of local extinction if harvesting continues to be unchecked.

Panulirus femoristriga was found in all the sampling areas but with the highest incidence (pooled 392 samples in 2019) in Guiuan and San Policarpo, Eastern Samar. Based on the sampling conducted by Juinio-Meñez and Gotanco (2003), this was the most abundant “red lobster” in Guiuan with mixed catches of *P. l. longipes* and *P. l. bispinosus*.

The lobster season typically runs from May through August, during the calmest period on the Pacific coast (Juinio and Gomez 1986), while peak season occurs from February to November or during cold months in western seas like Palawan, Western Visayas, and southwestern Mindanao (Juinio-Meñez and Gotanco 2004). The results of this present study on monthly variation in relative abundance and similarity indices also suggest a distinct difference in species evenness and abundance between dry and wet months in Eastern Visayas.

Due to the high abundance of *P. penicillatus* and *P. ornatus* in Eastern Visayas, the trend in the monthly variation in abundance can be distinctly described. The seasonality in lobster abundance in Eastern Visayas was mainly more of a result of fishing behavior as influenced by monsoonal changes rather than natural seasonality like migration and reproduction. This was also observed by Juinio-Meñez and Dantis (1996) in their report. The general weather condition in Eastern Visayas affects the fishing behavior of lobster gatherers and consequently affects the abundance of catch. Catch abundance for each species peaked from April to September when calmer waters and fair weather safe for fishing are generally observed. *Panulirus ornatus*, in contrast, peaked in abundance in the Northern Samar area from July to December of 2019. This is because northern Samar does not directly receive wave action from the Pacific Ocean and has calmer waters than Eastern Samar. These factors allow fishers to sail even during the wet season.

Panulirus femoristriga, *P. versicolor*, and the two sub-species of *P. longipes* were also observed throughout the year but with abundance peaking from April to June in Eastern Samar and from July to September in Northern Samar and Southern Leyte. This trend in monthly variation was also generally affected by the region's weather conditions and gatherers' fishing behavior. Relatively high catch incidence is observed for these species during the peak fishing season in summer, while very few capture incidents in October towards the end of the year.

Furthermore, apart from the monsoon season, market behavior also influences fishing activities. Lobster abundance surges due to intensified fishing activities as a consequence of increased market demand and the high price of lobsters come the festive seasons like Christmas and Chinese New Year. Thus, a spike in catches from October to December was observed. On the contrary, during the beginning of the COVID-19 pandemic in 2020, a "stop buying" of lobsters was also imposed by buying stations across the region due to zero demand in Manila and China and stringent health protocols and travel restrictions enforced by the national government.

The Bureau of Fisheries and Aquatic Resources (BFAR) has specified a minimum capture size for each lobster species based on their size-at-initial sexual maturity (*P. ornatus* at 107 mm, *P. penicillatus* at 72 mm, *P. longipes* at 60 mm, and *P. versicolor* at 88 mm). In this context, spiny lobster species caught in Eastern Visayas were chiefly undersized (< 77.5 mm CL), contributing 50–90% of the landed catch. The lobster CL size distributions, except for *P. ornatus*, were substantially skewed to the left (skewness > 1.0), indicating an extreme harvest of juveniles and sub-adults. The particularly high kurtosis values for *P. penicillatus* (15.6 for female and 17.33 for male) also complemented this scenario. *Panulirus femoristriga*, *P. l. longipes,* and *P. l. bispinosus* also had relatively high kurtosis (> 3.0), indicating a high incidence of juvenile fishing. *P. ornatus*, however, was being harvested beyond its minimum size limit in relation to DA-BFAR FAO 265. The size distribution of female *P. ornatus* was fairly skewed to the right, indicating higher exploitation of bigger individuals. The low kurtosis values for *P. ornatus* of both sexes (< 3.0) imply a wider range of targeted sizes of significant abundances.

The observed high juvenile fishing resulted in low total weight volumes despite the high quantity of individuals fished. Such circumstances in the fishery could result in growth overfishing, where lobsters are fished even before they can grow into a size at maximum sustainable yield (Annala and Breen 1989).

Similar characteristics of catch size frequency for spiny lobsters were also found in nearby localities near the Pacific. The catches of *P. penicillatus* in Taiwan also have a CL range of 40–65 mm (Chang et al. 2007). Size catches for *P. penicillatus*, *P. ornatus*, *P. longipes*, and *P. homarus* in Indonesia were mainly composed of juveniles measuring 40 mm (Aisyah and Triharyuni 2017). In contrast, recent findings of Asrial et al. (2020) showed larger lobster sizes (70 mm CL) in Indonesian waters were being caught.

From 2018 to 2019, no regulation on size limits for spiny lobsters existed, a period prior to the issuance of FAO 265 in 2020. All lobster sizes from juveniles measuring less than 20 mm CL up to the largest catch have a corresponding value and are marketable. Live puerulus and juvenile lobsters are also targeted since they can be sold at PHP 50–150 per piece. This has become a form of subsistence livelihood for local gatherers. The puerulus and juveniles of *P. ornatus* are also cultured in pens and cages by local growers in Northern Samar until they reach a marketable size. Pen and cage cultures for spiny lobsters are also present in some areas in the CARAGA and Davao regions (Philippine Statistics Authority 2021; Macusi et al. 2018).

Local fishers are also encouraged to catch sub-adult stages of the other lobster species for their marketability, especially if they are caught live. Live catches of *P. ornatus* have a price range of PHP 3500–6000 per kilogram, while live *P. penicillatus*, *P. versicolor,* and red lobsters are sold by gatherers at an average of PHP 1500-3000 per kilogram, depending on the size.

Due to the high market demand for live lobsters, fishers are driven to preserve the viability and body integrity of the lobster catch upon reaching and selling to buyers. Using a compressor with an attached hose as a breathing device when diving at greater depths (> 25 meters) helps gatherers achieve this. During diving, the gatherers spray sodium or chlorine solution into rock crevices to partially sedate the animal and eventually catch it effortlessly. Hand-catching via compressor diving is widespread across Eastern Visayas and was also the prevalent method for collecting spiny lobsters in Palawan and virtually in most areas around the country (Gonzales and Taniguchi 1995).

This hazardous method of gathering spiny lobsters is already prohibited by local ordinances throughout Eastern Visayas, as mandated by the Department of Interior and Local Government (DILG) Memorandum Circular No. 129 series of 2002. Therefore, fishery managers should emphasize improved enforcement of the law and public awareness campaigns regarding local resource management.

5. CONCLUSION AND RECOMMENDATIONS

The following synthesizes the findings of this research and implications on lobster resource management:

1. Six species and sub-species of spiny lobsters were observed and are being fished in the region, all needing to be regulated. Three of these species, *P. femoristriga, P. l. longipes,* and *P. l. bispinosus*, which are not included in the DA-BFAR FAO 265, should be indicated explicitly in the list of spiny lobster species provided in the regulation. The presence of the ambiguous form of *P. longipes* highly warrants an investigation to analyze the genetic composition and confirm species interbreeding.
2. The geographic distribution shows the prevalence of *P. penicillatus* and *P. ornatus*, and the rarity of *Panulirus versicolor* in Eastern Visayas. Vigilance and reinforced regulation should focus on the most exploited species, particularly on the selective targeting of *P. ornatus*, to lessen overharvesting and implement a stringent limit on catching the rare species as a precaution to prevent possible local extinction.
3. The seasonality of spiny lobsters in Eastern Visayas reflects gatherers' fishing behavior due to the monsoonal changes and market demand. Reproductive biology and recruitment need to be studied and understood to establish better seasonal variations based on the natural ecology of lobsters in Eastern Visayas. This would help if imposing closed fishing months is a requisite.
4. Fishery managers should also be vigilant about the unrestrained use of compressor diving as a hazardous collection method. Nevertheless, according to Juinio and Gomez (1986), this would also allow managers to reinforce size regulation and release of ovigerous females since hand catching and diving are highly selective in nature.
5. The size structure of lobsters in Eastern Visayas indicates an overharvesting of juvenile and sub-adult spiny lobsters. This should call for strict implementation and reinforcement of FAO 265 of DA-BFAR and its expansion to include other species not indicated in the regulation.
6. Advancing public awareness and information campaign programs to educate the gatherers regarding resource management and their role as stakeholders is imperative.

Moreover, this study provided a new understanding of the characteristics of the lobster fishery in Eastern Visayas, which can be used to formulate science-based policies and strategies. The ecology, biology, population dynamics, bioeconomic models, and socioeconomic setting of the fishery are data-poor areas that warrant further scrutiny to enhance and provide a holistic approach to the existing resource management for spiny lobsters in the Philippines.

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AUTHOR CONTRIBUTIONS

Campo CJM: Conceptualization, Supervision, Methodology, Writing – original draft preparation, Data Analysis, Curation and Visualization, Writing – Reviewing and Editing, Answering Reviewers Comments and Suggestions. **Cabacaba NS**: Conceptualization, Methodology, Writing – original draft preparation, Supervision, Writing – Reviewing and Editing, Answering Reviewers Comments and Suggestions. **Boiser EB**: Methodology, Data collection, analysis, curation, and visualization. **Salamida MTM**: Methodology, Data collection and analysis, Writing – original draft preparation. **Badocdoc KA**: Methodology, Data collection and analysis, Writing – original draft preparation.

CONFLICT OF INTEREST

No conflict of interest is there to declare.

ETHICS STATEMENT

The researchers followed basic protocol in handling animal samples. No human study has been conducted.

REFERENCES

Abduho AT, Madjos GG. 2018. Abundance, supply chain analysis and marketing of crustacean fishery products of Tinusa Island, Sumisip, Basilan Province, Philippies. ACCL Bioflux. 11(6):1884–1858. https://www.bioflux.com.ro/docs/2018.1844-1858.pdf

Aisyah, A, S. Triharyuni 2017. Production, size distribution, and length weight relationship of lobster landed in the south coast of Yogyakarta, Indonesia. Indonesian Fisheries Research Journal. 16(1):15–24. https://doi.org/10.15578/ifrj.16.1.2010.15-24

Annala JH, Breen PA.1989. Yield- and egg-per-recruit analyses for the New Zealand rock lobster, *Jasus edwardsii*. N. Z. J. Mar. Freshw. Res. 23(1):93–105. https://doi.org/10.1080/00288330.1989.9516344

Arellano RV. 1988. Spiny lobster fishery in San Vicente, Cagayan, and population dynamics of *Panulirus penicillatus*. M.Sc. Thesis, Cagayan State University at Apparri. 98 pp.

Arellano RV. 1996. Growth of spiny lobster (*Panulirus penicillatus*) caught off San Vicente, Cagayan, Philippines. NAGA. 19(4):51–53. https://hdl.handle.net/20.500.12348/2715

Asrial E, Rosadi E, Hamid, Ichsan M, Khasanah R, Sulystyaningsih N, Sumiwi A, Khalisah N, Rosadi E, Hamid E, Khasanah M, Sulystyaningsih R, Khalisah A. 2020. Growth and Population Parameters of *Panulirus penicillatus* and *Panulirus homarus* in Labangka Tidal Waters, Indonesia. Jurnal Ilmiah Perikanan dan Kelautan (Scientific Journal of Fisheries and Marine). 12(2):214–223. https://doi.org/10.20473/jipk.v12i2.21486

Chang YJ, Sun CL, Chen Y, Yeh SZ, Chiang W. 2007. Reproductive biology of the spiny lobster, *Panulirus penicillatus*, in the southeastern coastal waters off Taiwan. Marine Biology. 151:553–564. https://doi.org/10.1007/s00227-006-0488-9

[DA-BFAR] Department of Agriculture-Bureau of Fisheries and Aquatic Resources. 2020. Fisheries Administrative Order No. 265 series of 2020: Regulation on the Catching, Possession, Transporting, Selling, Trading and Exporting of Puerulus, Juvenile and Gravid Spiny Lobsters (*Palinuridae*). Quezon City, Philippines. [Cited 2022 April 28] Available from: https://www.bfar.da.gov.ph/files/img/photos/FAO265_Lobsters.pdf

FAO Fishery Statistics. 2001. Fisheries Global Information System, FIGIS. http://www.fao.org/figis/

Gauch HG.1982. Multivariate Analysis in Community Ecology. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511623332

Gonzales BJ, Taniguchi N. 1995. Spiny lobster-fishery in Palawan, Philipines: with considerations on its conservation and management. Bulletin of Marine Sciences and Fisheries, Kochi University. 15:121–130.

Juinio-Meñez MA, Dantis A. 1996. Spiny Lobster (*Panulirus* spp.) Resource Management. Terminal Report. Marine Science Institute, University of the Philippines, Diliman.

Juinio-Meñez MAR, Gotanco RR. 2004. Status of spiny lobster resources of the Philippines. In. Williams KC. Spiny lobster ecology and exploitation in the South China Sea region, Australian Centre for International Agricultural Research Canberra. pp 3–6. [Accessed 2021 Oct 2]. https://ageconsearch.umn.edu/record/135396/files/PR120.pdf

Juinio MAR, Gomez ED. 1986. Spiny lobster fishery in Eastern Samar, Philippines. In: Maclean JL et al., editors. The First Asian Fisheries Forum. Manila: Asian Fisheries Society. pp. 381–384.

Kembaren D, Hakim A. 2021. Fisheries management for the Scalloped Spiny Lobster (*Panulirus homarus*) in the waters of southern Yogyakarta and Pacitan, Indonesia. In: Loneragan NR, Wiryawan B, Hordyk AR, Halim A, Proctor C, Satria F, Yulianto I, editors. 2021. Proceedings from Workshops on Management Strategy Evaluation of Data-Limited Fisheries: Towards Sustainability – Applying the Method Evaluation and Risk Assessment Tool to Seven Indonesian Fisheries. Murdoch University, Western Australia, and IPB University, Indonesia. 185 pp.

Macusi E, Abreo NA, Laya-Og M. 2018. Wild lobster (Panulirus ornatus) fry fishery in Balete bay, Davao Oriental: Catch trends and implications to fisheries management. Ocean & Coastal Management. 168:340–349. https://doi.org/10.1016/j.ocecoaman.2018.11.010

Motoh H, Kuronuma K. 1980. Field guide for the edible Crustacea of the Philippines. Iloilo, Philippines: Aquaculture Department, Southeast Asian Fisheries Development Center. https://hdl.handle.net/10862/152

Philippine Statistics Authority. 2017. Fisheries Statistics of the Philippines, 2014-2016. Volume 25. Quezon City: Department of Agriculture – Bureau of Agricultural Statistics. pp. 211–216.

Philippine Statistics Authority. 2020. Fisheries Statistics of the Philippines, 2017–2019. Volume 25. Quezon City: Department of Agriculture – Bureau of Agricultural Statistics.

Philippine Statistics Authority. 2021. Special Release: Fisheries Production in CARAGA for 2018-2020. Philippine Statistics Office Region XIII. [cited 21 March 2023]. https://rssocaraga.psa.gov.ph/article/fisheries-production-caraga-2018-2020

Pitcher CR. 1993. Spiny lobsters. In: Wright A, Hill L, editors. Nearshore Marine Resources of the South Pacific. Forum Fisheries Agency, Honiara. pp. 539–607.

Ravago-Gotanco R, Juinio-Meñez MA. 2003. Phylogenetic position of the striped-legged forms of *Panulirus longipes* (A. Milne-Edwards, 1868) (Decapoda, Palinuridae) inferred from mitochondrial DNA sequences. Crustaceana. 75(9):1047–1059. https://www.jstor.org/stable/20105490

Santos MD, Barut NC, Bayate AD, editors. 2017. National Stock Assessment Program: The Philippine Capture Fisheries Atlas. Quezon City: Bureau of Fisheries and Aquatic Resources-National Fisheries Research and Development Institute. pp. 220

Tirtadanu, Ali Suman, Umi Chodrijah, Beodeul Kang, Chang-Ik Zhang. 2021. Stock assessment and management implications of three lobster species in Gunungkidul waters, Indonesia. Ocean & Coastal Management. 211: 105780. https://doi.org/10.1016/j.ocecoaman.2021.105780

Williams A. 1986. Lobsters – Identification, World Distribution and US Trade. Marine Fisheries Review. [Cited 2021 October 2]. https://spo.nmfs.noaa.gov/content/

lobsters%E2%80%94identification-world-distribution-and-us-trade

Williams KC, editor. 2004. Spiny lobster ecology and exploitation in the South China Sea region. Proceedings of a workshop held at the Institute of Oceanography, Nha Trang, Vietnam, ACIAR Proceedings No. 120. p. 73. https://www.aciar.gov.au/sites/default/files/legacy/node/590/pr120_pdf_17638.pdf

WoRMS Editorial Board. 2022. World Register of Marine Species. https://doi.org/10.14284/170