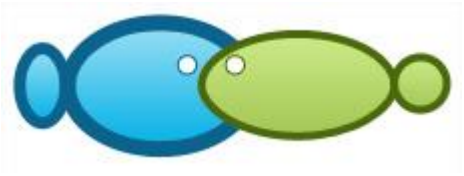

Occurrence of *Panulirus ornatus*, *Panulirus versicolor* and *Panulirus longipes longipes* (Palinuridae) in the coastal waters of Surigao del Sur

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Abstract. Puerulus naturally settles in Surigao del Sur's water during the early months of the year. Its arrival is caused by an ocean current that carried them from Papua New Guinea to the Southern Philippines, where they settled. Many fishermen rely on puerulus collection as a source of income, while many marine live dealers profit financially from it. During the season, catch monitoring was conducted at five sampling stations: station 1 – Tandag City, station 2 – Marihatag, station 3 – San Agustin, station 4 – Lianga, and station 5 – Bislig City, all located in Surigao del Sur, Philippines. The fish landing survey form was used to monitor the puerulus catch during the puerulus occurrence period at the aforementioned sampling stations. The results revealed three species: *Panulirus ornatus*, *Panulirus versicolor*, and *Panuirus longipes longipes*. *P. ornatus* had the greatest mean catch (84.85%), followed by *P. versicolor* (10.22%) and *P. longipes longipes* (4.92%). *P. orantus* predominated at all sampling sites, with the highest relative abundance in Tandag City, Bislig City, and Lianga, Surigao del Sur, at 99.68%, 99.46%, and 99.43%, respectively. Tandag City had a high mean catch (45.20 pieces fisher^{-1} day^{-1}), followed by San Agustin, Surigao del Sur (30.36 pieces fisher^{-1} day^{-1}), Marihatag, Surigao del Sur (8.83 pieces fisher^{-1} day^{-1}), Bislig City (9.43 pieces fisher^{-1} day^{-1}), and Lianga, Surigao del Sur (3.66 pieces fisher^{-1} day^{-1}). CPUE values began at 0.92 pueruli hour^{-1} in February, increased to 1.60 pueruli hour^{-1} in March, and reached 3.27 pueruli hour^{-1} in April; however, there was an abrupt increase between April and May, between 3.27 and 8.91 pueruli hour^{-1}, followed by an abrupt decrease between May and June, from 8.91 to 0.85 pueruli hour^{-1}. Pueruli occur once a year, with higher fishing activity one week before and after the new moon phase. Since this study focused on the puerulus resource in Surigao del Sur, Local Government Units must implement appropriate management strategies to ensure the province's fishing resource sustainability.

Key Words: catch composition, catch per unit effort, natural settlement, puerulus, seasonality of catch.

Introduction. The natural settlement of pueruli in the southern part of the country began many years ago, but their occurrence became evident when the demand for puerulus abroad increased and people in fishing communities began earning money from the wild supply. The Philippines has been identified as a lobster spawning ground, but the larvae released by the spawners do not stay in Philippine waters and instead move to Indonesia via the local water current, where they settle as puerulus. Similarly, the North Equatorial Counter Current (NECC) transports larval or phyllosoma lobster from Papua New Guinea to the southern Philippines 106-159 days after spawning, when they settle as puerulus (Dao et al 2015). The Mindanao Current (MC), a local current formed by the North Equatorial Current (NEC), affects southern Philippines fisheries (Qui et al 2015), particularly the vast dispersion of lobsters in Regions X and XIII coastlines. The presence of puerulus throughout its season has benefitted many fishing communities, as local and worldwide markets require a big supply of puerulus for aquaculture. In the coastal

regions of Surigao del Sur, puerulus naturally settle from March to June. Macusi et al (2019) confirmed that this period of settlement is also observed in Balete Bay of Davao Oriental, where puerulus settlement occurs from March to May.

Puerulus as a transitionary stage within the spiny lobster life cycle, intermediate between the phyllosoma larva and the juvenile stage, is around 12 mm in total length, translucent, and non-feeding, relying on an energy reserve comprising fat in its body with a maximum life span of 2 to 3 weeks (Priyambodo et al 2020). It was further described as nektonic stage (well-adapted for strong, horizontal, directional swimming) which bridges the planktonic and benthic phases of the life cycle with developmental stages for 3-4 weeks (Jeffs & Holland 2000). Puerulus has two phases: the swimming phase and the settling phase. Jernakoff (1990) defined the swimming phase as nektonic puerulus, which occurs after the final phyllosoma stage and swims across the continental shelf to settle on reefs and seagrass beds nearshore. Puerulus' settling phase consists of three morpho-stages: clear, P1, and P2, which are characterized by the coloration of their carapace and hepatopancreas. Clear stages are pueruli with a transparent color. The P1 stage, or H-phase, is recognized by the formation of a functional digestive system that results in hepatopancreas coloration, and the P2 stage, or pigmented stage, is distinguished by cuticular pigmentation (Ventura et al 2015). The nektonic pueruli of *Panulirus argus* swim linearly and simply at up to 10 cm s^{-1} within a few centimeters of the surface; they are unable to identify stationary objects but may sense turbulence brought on by waves and current (Calinski & Lyons 1983). When the nektonic puerulus transforms into the settling puerulus stage, depending on the type of lobster, biological make up, and topographic features of the coastal zone, it thrives in coastal regions and shelf-break. *P. argus*, *Panulirus guttatus*, and *Jasus edwardsii* are all found in the coastal area, with *P. argus* in marine vegetation at a depth of 100 m (Briones-Fourzán & McWilliam 1997) or branched/ foliose red or brown macroalgae with sporadic seagrass and fouled mangrove roots (Butler & Herrnkind 2000). *Panulirus cygnus*, *Panulirus japonicus*, and *Panulirus ornatus* are all found in shelf or slope waters, with *P. cygnus* living in rock crevices surrounded by seagrass or macroalgae at a depth of 1 to 5 meters (Butler & Herrnkind 2000), *P. japonicus* living in algal-covered rock crevices or red or brown macroalgae at a depth of less than 10 meters (Butler & Herrnkind 2000).

Despite extensive commercial collection, the composition of puerulus caught along the coast of Surigao del Norte remains unknown. Other neighboring areas, such as as Balete Bay, Davao Oriental, and Eastern Visayas, have reported puerulus catch compositions. *P. ornatus*, *Parribacus antarcticus*, and *Panulirus versicolor* were the most common species caught by fishermen at Balete Bay, Davao Oriental, accounting for 82%, 12%, and 6% of total catch, respectively. Six species were identified in the Eastern Visayas catch landings, with *P. penicillatus* the highest catch (65%), followed by *P. ornatus* (18%), *Panulirus longipes longipes* (6.1%), *P. femoristriga* (5.3%), *P. versicolor* (2.8%), and *P. longipes bispinosus* (1.7%) (Campo et al 2023). In Indonesia, artificial habitat collectors were placed in bays throughout southern coastline from Java to Sumbawa over 1500 km to track catch trends. The catch was 80% *P. homarus* and 20% *P. ornatus* (Priyambodo et al 2020). In Vietnam which heavily depends on wild pueruli for aquaculture, the catch is mostly made up of *P. ornatus*, accounting for 99%, and little *P. homarus*, accounting for 1% (Thuy & Ngoc 2004).

Catch rate and catch per unit effort (CPUE) in puerulus fishing have also been studied. The southeast Gulf of California in Mexico is the site of year-round monitoring for *Panulirus inflatus* pueruli captures. Pérez-González et al (2016) reported that May had the highest CPUE (pueruli per collector per week), at 1.36, with April and June following closely behind with 0.33 and 0.31, respectively. At Castlepoint, New Zealand, the puerulus stage of the red rock lobster, *J. edwardsii*, settled daily at the greatest rate of five pueruli per collector each day. According to Hayakawa et al (1990), pueruli's overall average daily settlement rates were 0.50 for shore collectors and 0.75 for offshore collectors. In Bahia Tortugas, Baja California, Mexico, catch rates varied from 1 to 10 pueruli per collector, with a mean of 0 to 02.52 pueruli/collector/new moon phase. The highest number of captures occurred in the next two months, September and October (Guzman-Del Proo et al 1996).

During the pueruli season, they can be seen naturally along the coasts of Surigao del Sur. Numerous studies have been conducted in the Philippines to identify when juvenile and adult lobster populations are abundant. There is little information known regarding the puerulus catch season. The puerulus fishing season in Palawan starts in March and finishes in August (Mecha et al 2022), however it lasts from April to June in Balete Bay, Davao Oriental (Macusi et al 2019). In Samar, lobsters are caught throughout the year, but the data only includes adult lobsters, and there is no information on when puerulus naturally settles.

Surigao del Sur's water contains three species of puerulus, which fishermen refer them as "tiger", "bamboo", and "aswang". According to Norissa Guno, a lobster consolidator stationed in San Agustin, Surigao del Sur, the catch consists of clear and pigmented stages, and the consolidators who buy the pueruli employ their own distinguishing markers for the three species. She further described the distinguishing characteristics of each species of clear puerulus. In the crystal stage, "tiger" has a transparent body with a single band in the middle of the antennae and a clove at the tip of the antennae (Saputra & Priyambodo 2023); "aswang" has a transparent body with multiple unclear bands in the antennae; and "bamboo" has opaque antennae with no bands or clove. In the pigmented stage, "tiger" has a brown body pigmentation with multiple bands in the antennae; "aswang" has a semitransparent body with multiple bands in the antennae; and "bamboo" has a maroon body pigmentation with multiple white lines on the abdomen and a green tailfan. Based on Clive Jones' unpublished work on the distinguishing characteristics of puerulus, the three species were identified to the species level, with "tiger" as *P. ornatus*, "aswang" as *P. longipes longipes*, and "bamboo" as *P. versicolor*.

According to Bedet Respecia, a fisheries technician of the Municipal Agriculture Office – San Agustin, Surigao del Sur, there are already established consolidators in Surigao del Sur who buy juvenile and adult lobsters; however, when the demand for puerulus abroad increased, particularly in China and Vietnam, which are among the lobster producing countries, the collection of puerulus grew, enabling fishers to earn greater earnings because the wild supply is abundant, especially during natural settlement. Since Vietnam growers are more advanced in lobster aquaculture technology and experts in puerulus identification and developmental stages (Jones et al 2019), knowledge has been transferred to the country's local consolidators and fishers over the years of trade between the Philippines and Vietnam. According to Norissa Guno who was mentioned earlier, the buying price of puerulus varies by species and developmental stage, with higher prices for "tiger" species and clear stages. The "tiger" puerulus lobster is more expensive than the other species of puerulus. When the market is outside the country, the travel time for puerulus is considerable, and consolidators found that clear stage pueruli survive better than pigmented stage pueruli, regardless of species. As a result, the international market has changed toward utilizing only clear stage pueruli; however, the pigmented stage offers a significant advantage for local farmers because it has a higher survival rate in the nursery phase than clear stage pueruli.

The majority of the gear is deployed at night, after the sun has set and before the sun rises, because pueruli are nocturnal and active at night. According to Long & Hoc (2009), fishermen would dive to the sea floor or lift their gear to manually catch juvenile lobster, and puerulus fishing was done in the same way as juvenile lobster fishing when aquaculture demanded more pueruli. Few people fish both throughout the day and at night, using a particular time interval for retrieval and deployment that submerges the gear for 24 hours. In Vietnam, the gear is set to collect at 8:00 PM, with the first retrieval between 12:00 PM and 1:00 AM and the last between 4:00 AM and 5:00 AM. The lobster pueruli is retrieved by dragging the net into the boat (Le Anh & Jones 2015). During the new moon phase, more lobsters are taken during the day between 07:00 and 12:00H (31%) and between 19:00 and 24:00H (33%) than at other times of the day (Priyambodo et al 2015, 2020). In the case of *J. edwardsii* pueruli, they were able to move from the ocean floor to the water column during the day due to its diurnal vertical migration and habit of appearing as self-edge plankton (Hayakawa et al 1990).

Most fishing gears in Surigao del Sur are associated with light to maximize catch, while others are not. Vietnamese lobster seed fishing and catching methods and equipment were described by Le Anh & Jones (2015). Electric light seine nets are 100-150 m long, 4-6 m deep, with 5 mm mesh. They are V-shaped and released from boats with a 25 m opening. Opening faces puerulus traditional swim direction. The boat has 1,000-2,000 W fluorescent lights that direct light along the set net to the aperture. In Balete Bay of Davao Oriental, majority of the fishers used bamboo raft as an associated gear similar to payao and the larvae congregate in the traps beneath the illuminated floating rafts (Macusi et al 2019). What Indonesians adopted from Vietnam was the use of light above trap nets, which they observed to be more successful in capturing pueruli. Due of its positive phototaxis, a frame was created and fixed with a single fluorescent or incandescent light, which attracts swimming pueruli (Priyambodo et al 2015, 2020).

Fishermen in Surigao del Sur gathered puerulus based on the lunar phase, one week before and one week after the new moon, because those were the times where the catch rate was high. During the new moon phase, settling pueruli of the species *P. argus*, *P. ornatus*, and *J. edwardsii* are rather abundant (Hayakawa et al 1990; Afonso & Gruber 2007; Macusi et al 2019). However, the findings of Heatwole et al (1991) and Pérez-González et al (2016) differed from those of Hayakawa et al (1990), Afonso & Gruber (2007), and Macusi et al (2019), who stated that higher fishing effort of *P. argus* was observed during the first quarter in Looe Key Reef, Florida, and quantity of *P. inflatus* pueruli had no effect on the phases of the moon in the southeast of the Gulf of California, Mexico. These contradictory results may be influenced by the species of pueruli, which has its own preferences and behaviors in relation to the topography of the coastal area as well as the influence of lunar phases.

The average catch of pueruli per fisher and fishing effort in Surigao del Sur are unknown, however there have been a few reports in the country and more other countries. Despite Fisheries Administrative Order No. 265, which prohibits the transport of pueruli to other countries, it is not strictly enforced. The national government, through the Bureau of Fisheries and Aquatic Resources (BFAR), Local Government Units, non-governmental organizations, and other organizations or associations, is currently developing management plans for lobster resources in the southern region of the country. Some Local Government Units attempted to ban people from fishing puerulus, but these efforts were unsuccessful because to a lack of political support. The purpose of this study is to investigate the geographical distribution, catch composition, mean catch, and CPUE of puerulus that have naturally settled in the coastal areas of Surigao del Sur. The findings may serve as baseline information for the National Government, Local Government Units, and other relevant associations and organizations in developing management and conservation strategies for lobster resource sustainability in the country.

Material and Method

Study area. The puerulus catch was monitored at five sampling stations (station 1 – Tandag City, station 2 – Marihatag, station 3 – San Agustin, station 4 – Lianga, and station 5 – Bislig City, all located in Surigao del Sur, Philippines) (Figure 1) to describe the current conditions of the puerulus fishery resource in Surigao del Sur in terms of geographical distribution, catch composition, mean catch and CPUE. Even though this valuable resource was regularly settling a long time ago, its existence became evident and extremely helpful when fishermen started to gather pueruli to make a living. The province has wide seagrass beds, coral reefs, and mangrove forests, which contribute to its rich coastal resources. Pueruli prefer to settle in areas of the coast where there are rivers and embayments. Due to the natural settlement, the coastal areas of Surigao del Sur somewhat meet puerulus preference.

Fish landing survey. The geographic distribution, catch composition, mean catch, and CPUE were all determined through the use of the fish landing survey form in the catch monitoring process. A fish landing survey form was used to monitor puerulus catch. At every sampling station, a field enumerator was assigned to monitor the puerulus fishers

who had just returned from fishing and record details about their catch. These details included the fisher's name, the gear they were using, the number of crew members, the amount of time they spent fishing (an hour), the local name of the puerulus catch, and the number of pueruli catch. Identification of the puerulus was based on the local name used by the puerulus fishers and later compared with the works of Motoh & Kuronuma (1980) and Gonzales & Taniguchi (1995).

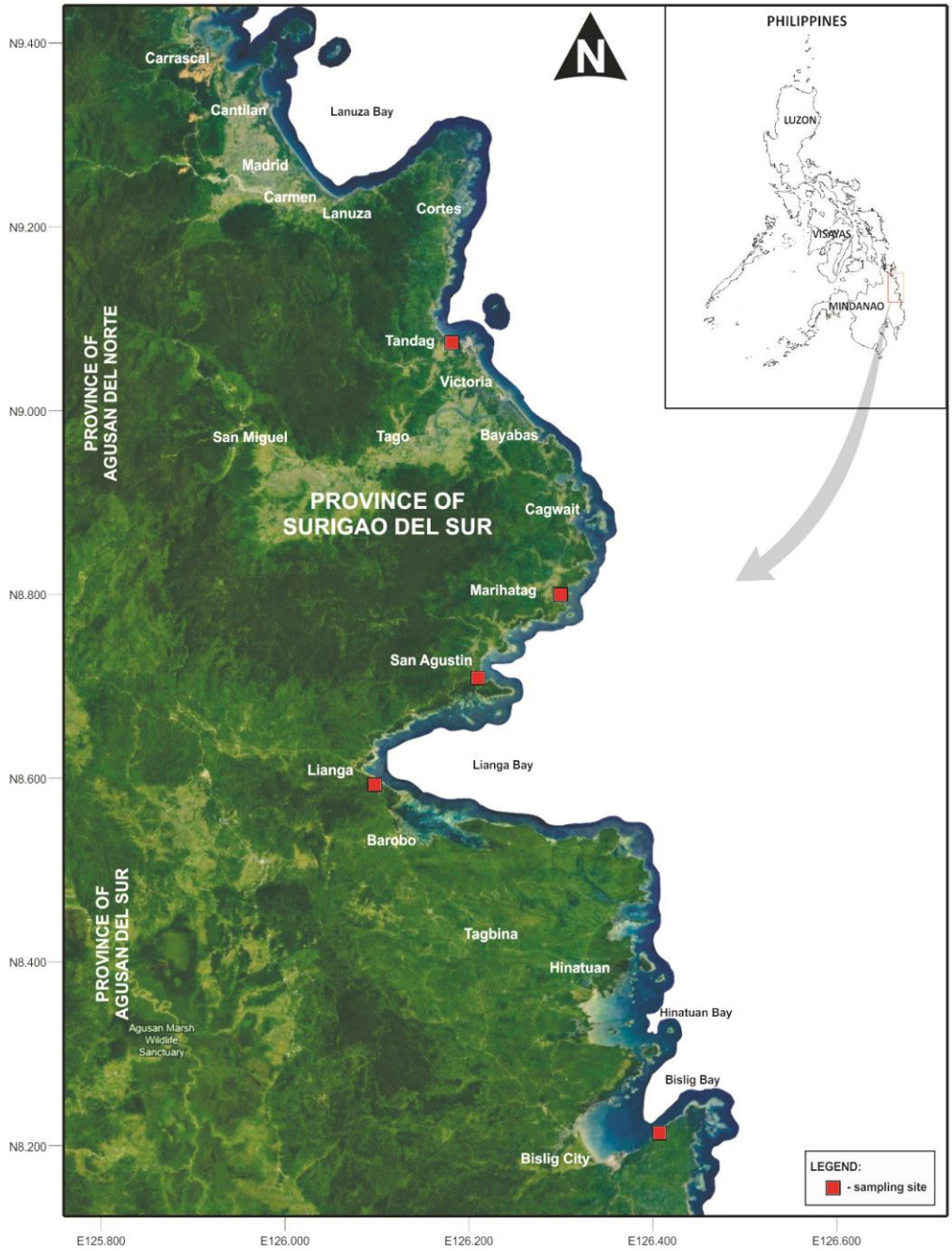

Figure 1. Map of Surigao del Sur, showing the five sampling stations where puerulus catch monitoring was conducted for a period of 5 months.

Analyses. Species distribution was established by analyzing the catch data obtained from fishermen across the five sampling stations. Information regarding the presence or absence of puerulus species at each station was tabulated. Catch composition was determined by quantifying the number of individuals from each species in the catch, with data on the percentage of each species at each station presented graphically. Mean catch was computed by dividing the total number of pueruli caught by the number of fishing

days. CPUE was calculated using the formula: U = f x C (Van Hoof et al 2021), where U represents the CPUE, C denotes the number of pueruli caught, and f represents the time spent fishing.

Results and Discussion. Five areas in Surigao del Sur were selected as sampling sites for the monitoring of the puerulus catch from February to June 2022. These areas were composed of two cities, Tandag and Bislig, and three municipalities, Marihatag, Surigao del Sur, San Agustin, Surigao del Sur, and Lianga, Surigao del Sur. It showed that there are three different species of puerulus: *P. ornatus*, popularly known as "tiger", *P. versicolor*, widely known as "bamboo", and *P. longipes longipes*, generally known as "aswang". The three species were found in Tandag City, Marihatag, Surigao del Sur and San Agustin, Surigao del Sur, but only two species were found in Lianga, Surigao del Sur and Bislig City, with *P. ornatus* and *P. longipes longipes* and *P. ornatus* and *P. versicolor*, respectively (Table 1).

Table 1

Distribution of the three species of puerulus in the five sampling stations of Surigao del Sur

Species of puerulus	*Tandag City*	*Marihatag, Surigao del Sur*	*San Agustin, Surigao del Sur*	*Lianga, Surigao del Sur*	*Bislig City*
P. ornatus	√	√	√	√	√
P. versicolor	√	√	√		√
P. longipes longipes	√	√	√	√	

The catch composition differs from one sampling site to another. These three species are widespread in Tandag City, Marihatag, and San Agustin, Surigao del Sur, whereas two species (*P. ornatus* and *P. longipes*) are found in Lianga, Surigao del Sur, and Bislig City (*P. ornatus* and *P. versicolor*). *P. ornatus* made up 99.68% of all catches in Tandag City, while *P. versicolor* and *P. longipes longipes* only made up 0.16% and 0.16%, respectively. At Marihatag, Surigao del Sur, *P. ornatus* accounted for more than half of the catch, followed by *P. versicolor* and *P. longipes longipes* with 21,99% and 9,14%, respectively (Figure 2A). Similar results were reported at San Agustin, Surigao del Sur, where *P. ornatus* made up 78.99% of the catch and *P. versicolor* and *P. longipes longipes* made up the rest, or 10.45% and 10.56%, respectively. In Lianga, Surigao del Sur, only 2 species were found; *P. ornatus* made up 99.43% of the catches while *P. longipes longipes* made up 0.57 %. Similar to Bislig City, *P. ornatus* predominated with 99.80% of the catch and *P. versicolor* with 0.20%. When all the data from the sampling stations were taken into account, the overall result revealed that *P. ornatus* had the largest component in the catch, accounting for 84.85%, followed by *P. versicolor* at 10.22% and *P. longipes longipes* at 4.92% (Figure 2B).

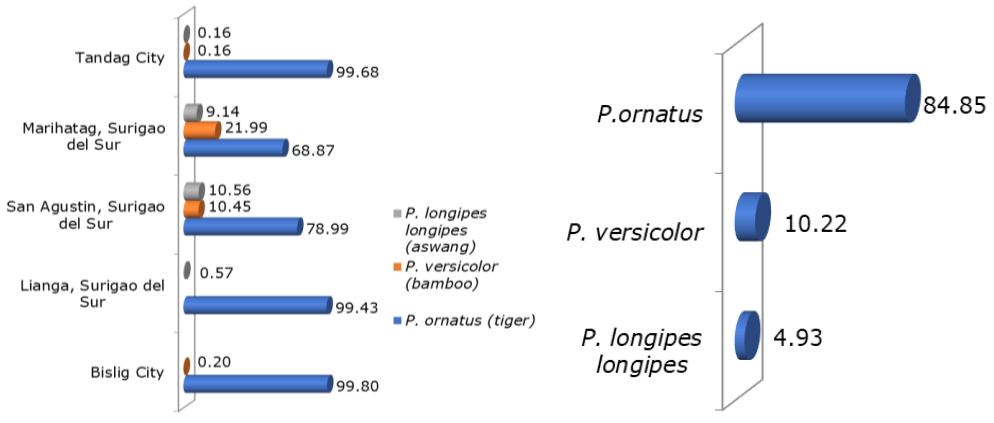

Figure 2. Catch composition (%) of pueruli in the 5 sampling stations: station 1 – Tandag City, station 2 – Marihatag, station 3 – San Agustin, station 4 – Lianga, and station 5 Bislig City, all located in Surigao del Sur, Philippines (Figure 2A) and its overall result (Figure 2B).

In the study, a total of seven major fishing gears were identified across the five sampling stations. These gears are manual diving, tree guard, beach seine, candy-like net trap, wood slags, net trap, and hanging net trap. The fishing practices among puerulus fishers varied, with some utilizing a single fishing gear while others employed two types. Catching rates varied among sampling stations irrespective of the fishing methods employed. The catch rate is expressed as the mean catch, which is the average number of pieces per fisher per day, as shown in Table 2. The mean catch is determined by dividing the total daily catch by the number of fishers and then averaging the daily values over a month. Tandag City demonstrated the highest mean catch rate of 45.20 pieces per fisher per day, followed by San Agustin, Surigao del Sur, with 30.36 pieces per fisher per day. In contrast, lower mean catch rates were recorded in Bislig City, Marihatag, Surigao del Sur, and Lianga, Surigao del Sur, with rates of 9.43, 8.83, and 3.66 pieces per fisher per day, respectively (Table 2).

Table 2

Mean catch of pueruli (number of pieces/fisher/day) by species, gear, and sampling stations in Surigao del Sur during its seasonal settlement in 2022 with fishing days range of 17-44

Sampling stations	*Types of fishing*	*Species caught*	*Mean catch (number of pieces/fisher/day)*		
			Species	*Gear*	*Sampling station*
Tandag City	Manual diving	*P. ornatus*	38.22	38.22	45.20
	Tree guard (sapyaw)	*P. ornatus*	24.70	24.96	
		P. versicolor	1.50		
		P. longipes longipes	1.00		
Mariharag, Surigao del Sur	Tree guard (sapyaw)	*P. ornatus*	4.16	9.27	8.83
		P. longipes longipes	2.62		
		P. versicolor	4.00		
	Beach seine (Baling)/candy-like net trap (kendi-kendi)	*P. ornatus*	1.75	1.75	
	Beach seine (Baling)/tree guard (sapyaw)	*P. ornatus*	2.00	3.00	
		P. versicolor	1.00		
	Tree guard (sapyaw)/candy-like net trap (kendi-kendi)	*P. oranatus*	2.00	6.50	
		P. longipes longipes	2.00		
		P. versicolor	3.50		
San Agustin, Surigao del Sur	Wood slags (katang)	*P. oranatus*	10.94	12.90	30.36
		P. longipes longipes	1.95		
		P. versicolor	1.63		
	Candy-like net trap (kendi-kendi)	*P. oranatus*	12.70	16.57	
		P. longipes longipes	2.75		
		P. versicolor	2.65		
	Tree guard (sapyaw)	*P. oranatus*	10.02	12.74	
		P. longipes longipes	2.25		
		P. versicolor	2.50		
	Net trap (pukot)	*P. oranatus*	15.00	18.00	
		P. versicolor	3.00		
Lianga, Surigao del Sur	Tree guard (sapyaw)	*P. oranatus*	3.33	3.62	3.66
		P. longipes longipes	1.14		
	Manual diving	*P. ornatus*	2.00	2.00	
Bislig City	Candy-like net trap (kendi-kendi)	*P. ornatus*	58.03	61.70	9.43
		P. versicolor	3.67		
	Hanging net trap (tenda-tenda)	*P. ornatus*	12.18	12.18	

In Tandag City, manual diving and tree guard fishing methods were observed, as outlined in Table 2. Manual diving yielded a mean catch of 38.22 pueruli per fisher per day, while tree guard fishing recorded a lower mean catch of 24.96 pueruli per fisher per day. The selective nature of manual diving fishing resulted in the exclusive capture of *P. ornatus* pueruli, with an average of 38.22 pieces per fisher per day. In contrast, tree guard fishing captured all three puerulus species, with *P. versicolor*, *P. longipes*, and *P. ornatus* caught at rates of 1.50, 1.00, and 24.70 pieces per fisher per day, respectively, totaling 24.96 pieces per fisher per day.

In Marihatag, Surigao del Sur, the utilization of single and dual types of fishing gears is prevalent. Notably, the tree guard emerges as a solitary gear employed to capture all three species of pueruli. It has been observed to capture *P. ornatus*, *P. longipes longipes*, and *P. versicolor*, with mean catch of 4.16, 2.62, and 4.00 pieces per fisher per day, respectively, resulting in a combined catch rate of 9.27 pieces per fisher per day. Additionally, the combination of beach seine and candy-like net trap is utilized by puerulus fishers, yielding captures solely of *P. ornatus*, at a mean catch rate of 1.75 pieces per fisher per day. Moreover, the combination of beach seine and tree guard is employed, capturing both *P. ornatus* and *P. versicolor*, with mean catch rates of 2.00 and 1.00 pieces per fisher per day, respectively, culminating in a total mean catch rate of 3.00 pieces per fisher per day. Furthermore, the combined use of tree guard and candy-like net trap results in captures of *P. ornatus*, *P. longipes*, and *P. versicolor*, with mean catch rates of 2.00, 2.00, and 3.50 pieces per fisher per day, respectively, resulting a gear's mean catch of 6.50 pieces per fisher per day.

In San Agustin, Surigao del Sur, four distinct fishing gears were identified, namely wood slags, candy-like net trap, net trap, and tree guard. Wood slags were found to capture individuals of *P. ornatus*, *P. longipes longipes*, and *P. versicolor*, with mean catch rates of 10.94, 1.95, and 1.63 pieces per fisher per day, respectively. The combined catch rate for this gear was calculated to be 12.90 pieces per fisher per day. Similarly, the candy-like net trap yielded captures of *P. ornatus*, *P. longipes longipes*, and *P. versicolor*, with mean catch rates of 12.70, 2.75, and 2.65 pieces per fisher per day, resulting in a combined catch rate of 16.57 pieces per fisher per day. Tree guard fishing also targeted the same species of pueruli, namely *P. ornatus*, *P. longipes longipes*, and *P. versicolor*, with mean catch rates of 10.02, 2.25, and 2.50 pieces per fisher per day, respectively. The combined catch rate for this method was determined to be 12.74 pieces per fisher per day. However, net trap fishing differed from other methods in that it exclusively captured individuals of *P. ornatus* and *P. versicolor*, with mean catch rates of 15.00 and 3.00 pieces per fisher per day, respectively, resulting in a combined catch rate of 18.00 pieces per fisher per day.

In Lianga, Surigao del Sur, the predominant fishing gear utilized was the tree guard, with minimal utilization of manual diving. Tree guard fishing predominantly targeted two species of pueruli, namely *P. ornatus* and *P. longipes longipes*. The mean catch rate for *P. ornatus* was recorded at 3.33 pieces per fisher per day, while *P. longipes longipes* had a mean catch rate of 1.14 pieces per fisher per day. The combined catch rate for tree guard fishing was calculated to be 3.62 pieces per fisher per day. In contrast, manual diving, known for its selective nature, exclusively captured individuals of *P. ornatus*, with a mean catch rate of 2.00 pieces per fisher per day.

In Bislig City, two different fishing gears, namely candy-like net trap and hanging net trap, were utilized to capture pueruli. The candy-like net trap was observed to capture individuals of *P. ornatus* and *P. versicolor*, with mean catch rates of 58.03 and 3.67 pieces per fisher per day, respectively, resulting in a combined mean catch rate of 61.70 pieces per fisher per day. Conversely, the hanging net trap exclusively captured *P. ornatus*, with a mean catch rate of 12.18 pieces per fisher per day.

The CPUE, expressed in pueruli per hour, in puerulus fishing by sampling stations in Surigao del Sur is presented in Table 3. Bislig City had the highest CPUE at 11.07 pueruli per hour which indicates that the fishing efforts in this area are relatively effective in catching pueruli compared to other sampling stations. Tandag City followed with CPUE of 7.22 pueruli per hour which was moderatly high catch rate per unit effort. Marihatag, Lianga, and San Agustin del Sur had the lower CPUE values of 6.51, 3.05, and 0.93

pueruli per hour, respectively, which suggest that fishing efforts in these areas are less affective in catching pueruli compared to Bislig City ad Tandag City.

Table 3
Catch per unit effort of puerulus fishing by sampling stations in the waters of Surigao del Sur

Sampling stations	*Catch per unit effeort (pueruli/hour)*
Bislig City	11.07
Tandag City	7.22
Marihatag, Surigao del Sur	6.51
Lianga, Surigao del Sur	3.05
San Agustin, Surigao del Sur	0.93

The puerulus naturally settles in the coastal waters of Surigao del Sur between February and June, typically occurring as early as February each year. Despite this regular occurrence, there is a lack of baseline information regarding puerulus catch, particularly during this natural settlement period in the aforementioned area. In this study, the CPUE was assessed on a monthly basis throughout the season and represented graphically on a line graph to depict the CPUE trend from February to June (Figure 3). Analysis of the results revealed a peak in CPUE value during May. Specifically, the CPUE value commenced at 0.92 pueruli/hour in February, increased to 1.60 pueruli/hour in March, and reached 3.27 pueruli/hour in April. However, a notable surge occurred between April and May, with the CPUE increasing from 3.27 to 8.91 pueruli/hour, followed by a sharp decline between May and June, decreasing from 8.91 to 0.85 pueruli/hour.

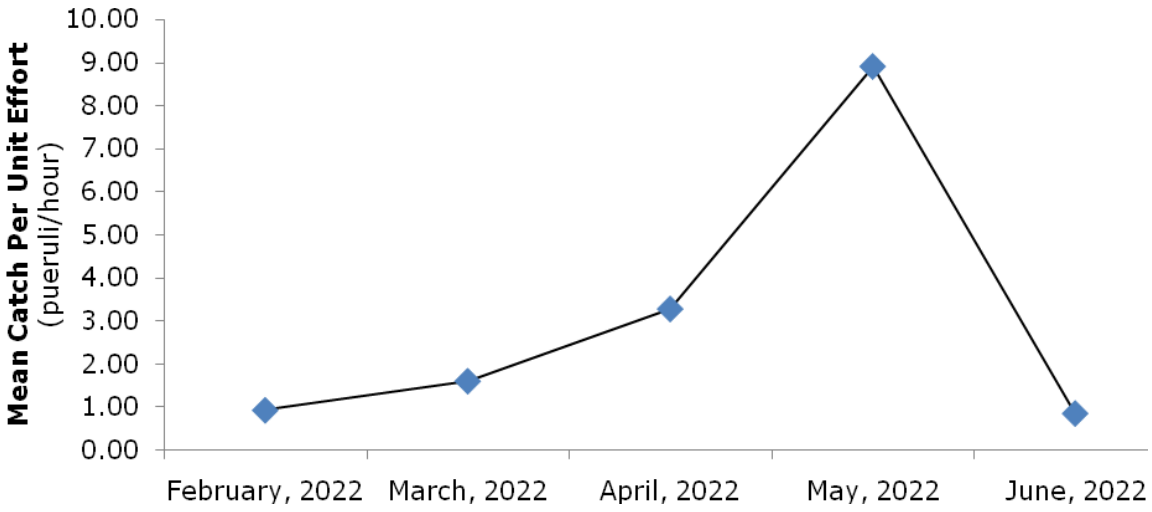

Figure 3. Catch per unit effort (pueruli/hour) by months during the natural settlement of puerulus in the waters of Surigao del Sur.

More than 20 species of *Panulirus* are found in tropical and subtropical waters of the world's ocean (Lipcius & Eggleston 2000) providing a valuable source of seafood and exports to domestic and international markets. In India, 10 species of lobster were observed. However, nearly identical lobster species are found throughout the nations of the South-East Asian Archipelago such as Philippines, Vietnam, and Indonesia (Juinio-Menez & Gotanco 2004; Jones 2010; Setyanto et al 2020) and five species in Sabah, Malaysia (Biusing & Chio 2004). A study was conducted in *P. ornatus* by Dao et al (2015) to determine the origin of this resource all over the South-East Asian Archipelago and the result showed that *P. ornatus* has a single genetic population, suggesting that the species originated from a single source and has high population connectivity throughout the region.

In the southern Philippines, the catches were composed of two to four species of lobster particularly in the coastal areas of Eastern Visayas, Surigao del Sur and Balete Bay of Davao Oriental. These areas are one of the major larval pathways of lobster which were brought by the North Equatorial Current from Papua New Guinea to the southern Philippines and locally distributed through Mindanao Current to the waters of Surigao del Sur, Eastern Visayas, Balete Bay of Davao Oriental and other neighboring coastal provinces. Only two puerulus species - *P. ornatus* and *P. versicolor* - were identified in Balete Bay, Davao Oriental (Macusi et al 2019) and these are therefore deemed to be commercially important. The Eastern Visayas is also inhabited by four species: *P. penicillatus*, *P. ornatus*, *P. longipes longipes*, and *P. versicolor* (Campo et al 2023). The three puerulus species identified in Eastern Visayas exhibit similarities, likely due to the connectivity between the coastal waters of Surigao del Sur and those of Eastern Visayas, as well as Balete Bay in Davao Oriental.

The predominant species in the catch, as revealed in this study, was *P. ornatus*, accounting for 84.85% of the total catch. This finding aligns with previous studies conducted by Thuy & Ngoc (2004), which reported a dominance of 99% *P. ornatus* in the catch, as well as with the findings of Macusi et al (2019), where *P. ornatus* comprised 82% of the catch composition. This would imply that the waters of the Philippines and Vietnam share nearly same environmental characteristics as favorable habitats of many creeping animals. In contrast to the situation in Indonesia, the composition of puerulus catch appears to vary annually (Priyambodo et al 2020). Specifically, *P. homarus* and *P. ornatus* collectively constituted over 99% of the catch. In 2012 and 2013, *P. homarus* represented 63.3% and 86.7% of the puerulus catch, respectively, while *P. ornatus* contributed 36.7% and 13.3%. However, in 2014, *P. homarus* accounted for only 20.7% of the catch, while *P. ornatus* dominated with 79.3%.

The environmental factors which influence catch efficiency include water level, wind action, water quality, productivity, lunar cycle, turbidity, fishing gear, fishing pressure, and fisher preferences (Ahmed & Hambrey 2005). Since they live in a coastal community and rely on it for their daily income, fishermen are knowledgeable about what to fish for and when to do it. Nevertheless, the amount of fish being caught is decreasing over time, and certain marine resources - particularly those that are harvested on a daily basis - appear to have been overfished. Although the CPUE is a more effective measure of diminishing stocks, other factors like as weather conditions, advancements in crews' fishing skills, and changes in fishing locations can also affect the CPUE trend (Morgan & Burgess 2005). That is why it is necessary to conserve, control, and manage puerulus lobster resources within its coastal area from fishing operations in order to ensure their sustainability and the value of the resources to future generations.

Conclusions. This study identified three species of puerulus caught by fishermen in the waters of Surigao del Sur: *Panulirus ornatus*, *Panulirus versicolor*, and *Panulirus longipes longipes*. The dominant species, *P. ornatus*, accounted for 84.85% of the catch. The study also determined the highest catch per unit effort value, reaching 8.91 pueruli per hour in May. These findings fill a gap in baseline information regarding puerulus catch in the region, providing essential data for future coastal management and regulation. Given the potential of this fishery resource for both local and international markets, and its susceptibility to overexploitation, this data underscores the importance of informed management decisions. However, while this data provides valuable insights, it is not sufficient alone for effective fisheries management. Further monitoring and analysis are necessary to comprehend the factors influencing fishing efforts and to develop targeted management strategies aimed at ensuring the sustainability of pueruli populations in Surigao del Sur.

Acknowledgements. We would like to express our heartfelt gratitude to the Commission on Higher Education Region 10 for the financial grant, to Mindanao State University - Iligan Institute of Technology and Mindanao State University at Naawan for their invaluable technical assistance, and to Surigao del Norte State University for their moral and legal support. These contributions significantly aided the success of our study.

Conflict of interest. The authors declare that there is no conflict of interest.

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Received: 20 September 2024. Accepted: 11 December 2024. Published online: 12 April 2025.
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How to cite this article:
Ratunil Jr. V. B., Lacuna M. L. D. G., Orbita M. L. S., Tampus A. D., Gonzales R. C., 2025 Occurrence of *Panulirus ornatus*, *Panulirus versicolor* and *Panulirus longipes longipes* (Palinuridae) in the coastal waters of Surigao del Sur. AACL Bioflux 18(2):848-860.