Settlement traps and harvesting methods for spiny lobster (*Panulirus* spp.) puerulus fishery in Palawan Island, the Philippines

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Abstract

The attractive price for spiny lobster (*Panulirus* spp.) puerulus has recently encouraged many fishers to engage in its collection as an alternative livelihood at the height of the COVID-19 pandemic. This booming fishery prompted the investigation of the settlement traps, luring/shading materials, trap installation and harvesting methods, and problems encountered in the spiny lobster puerulus fishery in Palawan, Philippines. Reviewed videos posted on social media, personal observation, and data gathered from key informants (KIs) revealed the use of various modified and newly developed settlement traps. The most common were the concrete cylindrical and disc-shaped traps used by 63.33% of the KIs. Some KIs (40%) provided the settlement traps with luring/shading materials like *Sargassum* thalli. Settlement traps were mostly installed using the stake-hanging method. The harvesting season starts in March and ends in August where the daily collection coincides with the moon phase. Fishers collected settled puerulus through diving or pulling the traps out of the water. However, some issues like unstable prices and the absence of fishing regulations threaten the sustainability of pueruli collection. Hence, the establishment of collection zones, issuance of fishing permits, price

regulation, and long-term monitoring to maintain this promising fishery industry is suggested in crafting ordinances. Efficiencies of traps may also be investigated as an additional basis for policy recommendations.

Keywords

Idle banca, Palinuridae, puerulus collection, raft method, resource conflicts

Introduction

Puerulus is a free-swimming non-feeding post-larval stage of spiny lobster (Booth and Phillips, 1994; Dennis et al., 2004; Jones et al., 2010). It comes after 7–13 metamorphoses (Setyanto et al., 2019) that last 4–12 months depending on the species (Dennis et al., 2004; Jones et al., 2010). Such a lengthy larval stages of spiny lobster is one of the biggest challenges in mass propagation for grow-out aquaculture (Radhakrishnan et al., 2019; Shanks and Jones, 2015). Hence, the collection of wild puerulus remains a major industry and a lucrative source of income (Jones, 2015; Macusi et al., 2019; Priyambodo et al., 2015, 2017). In Davao Oriental, the Philippines, each puerulus, depending on season and species, can fetch between USD1.81 and USD4.54 (Macusi et al., 2019), USD1.34 in Indonesia (Bahrawi et al., 2015), while USD12–14 in Vietnam (Dao and Jones, 2015).

Fishers utilized various settlement traps or gears, luring materials, and installation methods in catching puerulus of spiny lobster (Anh and Jones, 2015; Bahrawi et al., 2015; Macusi et al., 2019; Priyambodo et al., 2015, 2017). Settlement traps are materials that mimic the substrate habitat of puerulus, while the luring materials provide shades to the settlement traps which encourage the puerulus to settle. Traps installation is the way for fishers to set-up the traps in coastal areas. In Vietnam, the collection of puerulus involved the use of perforated coral or timber, seine nets with electrical lights, and netting materials hung in bamboo or wooden stake or through a raft (Anh and Jones, 2015). While in Indonesia, they use cement bag paper, perforated timber poles, fishing nets, and rice bags hung in a raft (Bahrawi et al., 2015; Priyambodo et al., 2015; 2017). Rock collectors hung on bamboo poles or bamboo rafts are used in the Philippines (Macusi et al., 2019).

While puerulus collection serves as a significant source of revenue, this is threatened by unregulated exploitation (FAO, 2012; Jones et al., 2019; Macusi et al., 2019; Ngoc et al., 2009), fishing intrusion and use of illegal fishing methods such as compressors (Macusi et al. 2019), use of coral rocks as traps (Anh and Jones, 2015), derelict traps (Arthur et al., 2014), and unstable buying price (Bahrawi et al., 2015; Dao and Jones, 2015). The absence of management regulation and matured hatchery-based technology that could supply hatchery-reared seeds for grow-out aquaculture were viewed as factors of fishing pressure (Jones et al., 2010).

The provinces of Davao Oriental, Surigao, and Zamboanga in the Philippines have been identified as hotspots for wild puerulus (National Fisheries Research and Development Institute (NFRDI), 2020). In Palawan, studies on the puerulus fishery are wanting, as collection only began in early 2019. To have baseline information on this emerging fishery, this study investigated the spiny lobster puerulus fishing practices in Palawan which could be used as a basis for crafting local policies toward a sustainable puerulus fishery industry in the province. Specifically, this study aimed to describe the settlement traps and luring/shading materials, the trap installation, the harvesting methods, and the problems encountered in the spiny lobster puerulus fishery.

Methods

Study Sites

The province of Palawan (9˚30'N and 118˚30'E) in the southwestern part of the Philippines (see Fig. 1) is composed of 1,768 islands and islets with a 2,000 km irregular coastline (United Nations Educational, Scientific and Cultural Organization (UNESCO), 2021). It lies between the West Philippine Sea and the Sulu Sea, known as the apex of marine biodiversity - the Sulu-Sulawesi Marine Ecoregion (SSME), spanning about 4,771.35 km^2 (Asian Development Bank (ADB), 2014) and serving as one of the important fishing grounds in the region (ADB, 2014; Palawan Council for Sustainable Development (PCSD), 2015). The province is a major supplier of marine products (Elliot and Jang, 2011) including wild-caught lobsters (Arcenal, 2004; Biusing and Lin, 2004; Gonzales and Taniguchi, 1995).

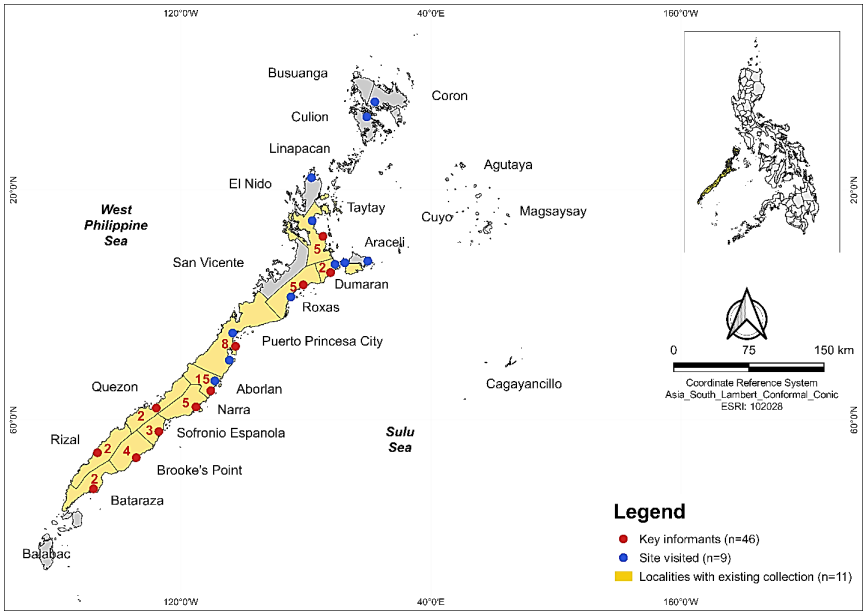

Fig 1. Map of the island of Palawan in the western Philippines, number of key informants per municipality (red number and dots) with existing puerulus collection activities, and sites visited for face-to-face interviews and photo documentation (blue dots).

Research Instrument

Data were gathered using a survey questionnaire, containing four major parts. The first and second parts consisted of questions about the settlement traps and luring/shading materials, and trap installation methods with sample photos obtained from social media. The third part asked about the harvesting methods of settled pueruli. The fourth part queried on the problems encountered in the spiny lobster puerulus fishery in Palawan. A pre-test was done before finalizing the content of the questionnaire.

Respondents and Data Collection

Due to the emerging restriction from COVID-19 between June 2020 to September 2021 and limited information related to puerulus collection, social media platforms such as YouTube and Facebook (Albarico et al., 2021; Mecha and Dolorosa 2020) were initially used. Including the owner of nine YouTube videos found and reviewed, a total of 46 respondents pointed out 11 localities where puerulus collection existed (Fig. 1). All respondents were considered key informants (KIs)

in a follow-up interview with the aid of a survey questionnaire either face-to-face or online. However, only 30 KIs from eight of 11 localities with existing collections participated in the interview (Table 1). The KIs were composed of puerulus collectors (18), puerulus collectors/buyers (2), and government employees (10). The harvesting methods section of the survey questionnaire was also only responded by 16 of 30 KIs. Coastal areas of localities with existing collection activities were validated using the Google Earth Pro timeline. Nine sites were visited to conduct face-to-face interviews and photo documentation (Fig. 1). Photos without credits were taken by the authors. A consent approval was firstly secured before the interview.

Table 1. Number and occupation of key informants in localities with the existing spiny lobster puerulus collection responded to the survey questionnaire.

Localities	Number and occupation of key informants	
Aborlan	1	Collector/Buyer
	1	Government employee
	11	Collector
Dumaran	1	Government employee
Narra	2	Government employee
	3	Collector
Puerto Princesa City	3	Government employee
	1	Collector/Buyer
Rizal	1	Collector
Roxas	1	Collector
	2	Government employee
Sofronio Española	1	Collector
Taytay	1	Collector
	1	Government employee

Data Interpretation and Presentation

Settlement traps, trap installation and harvesting methods were described based on personal observation and information provided by the KIs. Photos or sketches were provided to visualize the description. Frequencies and percentages were computed as needed.

Results

Settlement Traps and Luring/Shading Materials

The settlement traps that were commonly used by 63.33% KIs were made of concrete cylindrical and disc-shaped traps (Table 2, Fig. 2). Holes (1–2 cm diameter and 2.5 cm deep) were drilled on the hardened concrete mixture, wood slabs/logs, and coconut husks using an electrical drill. Others used wood sticks or metal tubes to poke the holes in the partly hardened concrete mixture. Meanwhile, *Sargassum* thalli was the commonly luring materials used by 40% KIs (Table 3 and Fig. 3).

Table 2. Descriptions of puerulus settlement traps commonly used in Palawan.

Settlement traps	Descriptions	Key informants (n=30) *	
		Frequency	%
Concrete type	Cylindrical, disc, rectangular/square, and half sphere in shape.		
Cylindrical-shape	Shapes and sizes varies depending on molders such as 10 cm PVC pipe, 1.5-liter plastic soda bottle, and cellophane measuring 10–12 cm wide and 20–25 cm long. Holes were drilled into the sides surface area except for the top and bottom portions.	19	63.33
Disc-shape	Usually, 4–5 cm thick but varied in size (13–25 cm diameter) depending on the size of a tin can molder. Holes were only drilled on one side.	19	63.33
Rectangular/square-shape	About 4–7 cm thick and varied in dimensions (10–16 cm wide; 15–30 cm long; 30 x 30 cm). Holes were drilled either on both or one side only.	18	60
Half sphere	Molded-in an empty half of coconut shells, thus forming half of the sphere or ball. Holes were drilled on a flat surface.	8	26.67
Non-concrete type	Made of organic materials available in coastal areas.		
Coconut fruit	Halves of mature fruit as a by-product in copra production were drilled with holes on the husk. Sometimes, the two halves were tied together to restore their original shape.	4	13.33
Corals	Massive coral skeletons and even live corals around 20 cm in diameter. Massive corals without natural crevices were drilled with holes for the puerulus.	2	6.67
Wood slabs/logs	Wood scraps from lumber dealers of varied sizes. Holes were drilled either on both or one side only.	1	3.33
Coconut coir with fine mesh b-net	Rows of coconut coir hung inside a metal frame using a nylon filament. Fine mesh b-net was fixed at the bottom of the metal frame to catch the pueruli once the trap is lifted out of the water.	3	10

* — Multiple response.

Table 3. Descriptions of luring/shading materials commonly used by puerulus collectors in Palawan.

Luring/shading materials	Description	Key informants (n=30) *	
		Frequency	%
Coconut coir	Coconut coir tied above the hanging cylindrical-shaped concrete trap.	3	10
Coconut leaves	These were tied above the concrete traps with wooden or bamboo frames.	1	3.33
Sargassum thalli	Thalli of *Sargassum* spp. tied above the cylindrical-shaped concrete trap.	12	40
Old nets	Either an old fine-meshed fishing net or mosquito net tied above the concrete or wooden settlement traps.	10	33.33
No luring/shading materials used		8	26.67

* — Multiple response.

Fig 2. Settlement traps used in catching spiny lobster puerulus in Palawan. A. Cylindrical; B. Disc; C. Rectangular/Square; D. Half sphere; E. Coconut fruit; F. Corals; G. Wooden slabs/logs; H. Coconut coir with fine mesh b-net. Photo credits: A – KaTropa Channel; B – J. Sornito; C – R. Daño; E – M. Matillano; F – Bantay Roxas Page; G – J. Daño; H – J. Sornito.

Fig 3. Luring/shading materials attached to the settlement traps. A-B. Coconut coir and leaves; C. *Sargassum* thalli; D. Old fishing net; E. Fine mesh b-net; F. Mosquito net. Photo credits: B – R. Cayaon; C – S. Villalva; D – Ricky's TV Adventure; E – KaTropa Channel; F – Mathy Knows TV.

Trap Installation Methods

The stake-hanging method was the most common (63.33%; Table 4) and installed in shallow areas (~1–5 m deep during low tide) with soft substrates. The floating method was carried out using a bamboo raft or outrigger banca installed in deep (~6–8 m deep during low tide) calm waters (Table 4; Fig. 4). The fixed bottom methods (popsicle, lollipop, tripod, and hanging) were installed in deeper areas (~5–8 m deep during low tide). Colored flags made of fabric were used as markers for non-submerged traps, while floaters made from plastic bottles were used to mark submerged traps. Others, particularly in the southern part of Palawan installed floaters with light (Fig. 5).

Table 4. Descriptions of common trap installation methods used in puerulus collection in Palawan.

Trap installation	Description	Key informants (n=30) *		Length of operation
		Frequency	%	
Stake-hanging	Made of bamboo/wooden frameworks installed in soft sandy-muddy shallow subtidal areas. The bamboo/wooden posts (~2–3 m high) supported the horizontal pole (~8 m long) at least 1.5 m above the ground. Nylon or twisted monofilament rope was used to hang the settlement traps at about 60 cm from the horizontal pole, and at 20 cm intervals. The traps were hung in such a way that it remains submerged even during low tide, but at least 30 cm above the ground. The horizontal poles and upper parts of the posts were exposed during low tide.	19	63.33	Permanent
Floating	Either made of bamboo raft or idle banca.			
Bamboo Raft	Made of several pieces of bamboo poles installed in deep calm areas within the bay. The raft measures 4 m wide and its length vary between 6 and 8 m. Like the stake-hanging method, the settlement traps were tied to the bamboo pole using nylon or twisted monofilament rope at 20 cm intervals and were submerged at about 60 cm below the water surface. Some rafts have solar-powered lamps.	7	23.33	Seasonal
Banca	A motorized outrigger boat used for eco-tourism but was idle during the COVID-19 pandemic. The settlement traps were tied to the outrigger using nylon or twisted monofilament rope at 20 cm intervals and were submerged at about 60 cm below the water surface.	1	3.33	Seasonal
Fixed Bottom	Traps fixed at the bottom were either called popsicle, lollipop, tripod, and hanging.			
Tripod	Made of 3 pcs of wooden posts about 1 m in length tied using a rope at the upper end while the bottom was spread apart with the aid of horizontal poles to form a platform. The tripod platform has 5–7 horizontal poles that support 4–10 cylindrical-shaped concrete traps at 20 cm intervals. Large coral skeletons were placed on the platform to securely fix the set-up. Nylon or twisted monofilament rope was used to hang the settlement traps at least 30 cm above the ground.	1	3.33	Permanent
Hanging	Similar to the tripod but the posts were tied in pairs with the base being spread to keep the horizontal pole about 1 m above the ground. Sometimes a single post was used just like the stake-hanging. Concrete settlement traps were hung not less than 30 cm above the ground and at 20 cm intervals using a nylon or twisted monofilament rope.	4	13.33	Permanent
Popsicle	Made of a 1 m wooden pole with the top end attached to a rectangular concrete settlement, while the other end was staked on a shallow soft-bottom substrate, keeping the settlement trap at least 30–50 cm above the ground.	1	3.33	Permanent
Lollipop	Similar to the popsicle but the top end of a 1-m wooden pole was attached with a cylindrical concrete settlement trap; the other end was staked on a shallow soft-bottom substrate keeping the trap at least 30–50 cm above the ground.	1	3.33	Permanent

* — Multiple response.

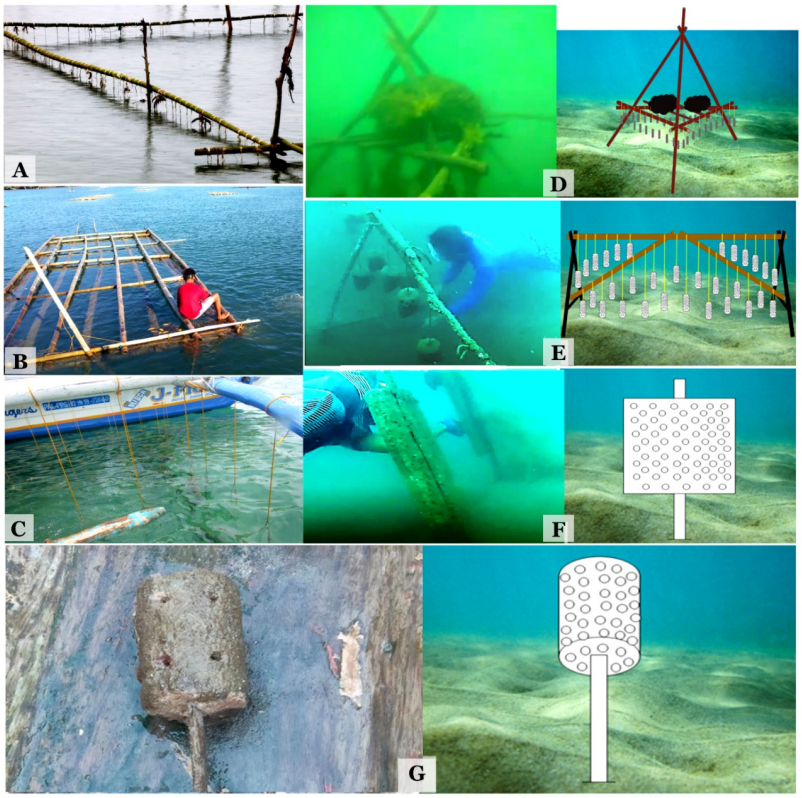

Fig 4. Trap installation methods. A. Stake-hanging; B. Bamboo raft; C. Banca; D. Tripod; E. Hanging; F. Popsicle; G. Lollipop. Photo credits: B – S. Villalva; C – R. Daño; D – Amigo's Fishing TV; E-F – Ricky's TV Adventure; G – J. Daño.

Fig 5. One of the bamboo floaters with light used as a marker and light for the fixed bottom traps in Narra, Palawan. Photo credit: Bob's TV 23 YouTube Channel.

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Harvesting Methods

Based on 16 KI collectors, the harvesting period was associated with the moon phase (Table 5A). Most of them (62.50%) observed more settlement during the new moon until the first quarter, while a few KIs (18.75%) extended their collection until the full moon (Table 5A).

The harvesting depends on installation methods (Table 5B). Skin diving was most common method (75%) while some (25%) employed pulling of settlement traps out of the water (Table 5B).

Table 5. Harvesting methods of spiny lobster puerulus in various localities in Palawan.

Variables	Key informants (n=16)	
	Frequency	%
A. Moon phase		
Whole month	1	6.25
New moon to Full moon	3	18.75
New moon to First quarter	10	62.50
First quarter to Full moon	2	12.50
B. Collection of Puerulus in the Settlement Traps (based on the methods used)		
Skin Diving (stake-hanging, fixed bottom, floating)	12	75
Pulling the traps out of the water (floating and stake-hanging)	4	25

Problems Encountered

According to the KIs, the most common problem was the unstable buying price of puerulus (100%), followed by the unclear system of classifying transparent and black pueruli (53.33%) (Table 6).

Table 6. Commonly identified problems in the spiny lobster puerulus fishery in Palawan.

Problems	Key informants (n=30)	
	Frequency	%
1. Unstable price of pueruli	30	100
2. Unclear system of classifying transparent and black pueruli	16	53.33
3. An overlapping area where traps were installed by some capitalist	3	10
4. Installation of traps by non-resident collectors	5	16.67
5. Open access and absence of regulation	1	3.33
6. Derelict traps left on the shore	2	6.67
7. Use of corals and mangrove trees	2	6.67
8. Obstruction of navigational routes	1	3.33
9. Installation of traps near MPA	1	3.33

Discussion

Preference for Traps and Luring Materials

The settlement trap materials used by puerulus collectors in Palawan are more likely an adaptation of those from Vietnam and Indonesia such as the perforated timber wood, coral rocks, and netting materials (Anh and Jones 2015; Priyambodo and Jaya, 2009). According to some KIs, a Taiwanese or Vietnamese buyer introduced the use of aggregated coral skeleton in early 2019 that started in Sofronio Española. Since then, the collection methods have evolved in various localities where the preference for particular settlement traps could have been influenced by the buyers who introduced the methods, financial capacity of the collectors, and the availability of materials. For example, in Roxas, a municipality in northern Palawan, the use of concrete traps, coral rocks or even live corals could have been influenced by the collectors/buyers from the southern part of Palawan where the collection had started. Compared to the concrete traps that requires a month of soaking before the first settlement may occur due to the chemical contents (Abdus-Samad, 2013), the use of coral rocks could have been preferred due to it is availability with no capital investment involved and nature to easily attract the settling puerulus. However, the use of coral rocks is prohibited under Republic Act (RA) 8550; hence, these were confiscated by the local authorities. Meanwhile, the presence of coconut plantations along the coastal areas of Aborlan and Narra could have motivated the collectors to test the discarded coconut shell as puerulus traps, while others used lumber slabs and round timber particularly those with limited capital for concrete trap fabrication. The use of concrete trap is most preferred among collectors possibly due to durability and life span of about two years. Continued monitoring may document innovations that require testing for catch efficiency and durability of some traps which is beneficial to the collectors, particularly in estimating the profitability of this fishery activity. In Indonesia, suitable local materials for pueruli settlement traps were identified after several trials (Bahrawi et al., 2015; Priyambodo et al., 2015; 2017; 2020). Though some traps such as dried coconut husks, coconut coir and traps with metal frame were unique and undocumented in some published reports, these could be also an adaptation from other localities in the Philippines like in Surigao del Sur where puerulus collection practices are documented and posted on YouTube platform.

The 1–2 cm diameter holes in settlement traps were similar to those in Vietnam (Anh and Jones, 2015; Jones et al., 2010), although with deeper holes (5–10 cm) than in other countries (Anh and Jones, 2015). Collectors in Palawan prefer shallow holes which make the removal of settled puerulus easier. One KI said that deeper holes provide more space for the puerulus to strongly cling on, thus pulling out of the hole can cause injury like breakage of antennae.

The addition of luring/shading materials in the settlement traps helps attract swimming puerulus to settle. According to some KIs, they prefer to use the *Sargassum* thalli since it is readily and freely available. Collectors in Balete Bay, Davao Oriental also use any dark-brown materials including *Sargassum* thalli (Macusi et al., 2019), which serve as ephemeral habitats for larvae and juveniles of many marine organisms including spiny lobster pueruli (Vandendriessche et al., 2007). Meanwhile, the use of netting materials is also popular in Vietnam and Indonesia (Bahwari et al., 2015; Jones et al., 2010; Priyambodo et al., 2015).

Settlement traps made from wooden slabs, and coconut fruits are locally-available, cheaper and eco-friendly. Biodegradable materials may have a short-term environmental hazard compared to concrete and old nets, however, there is a need to dismantle the traps during off-season as dislodged and drifted traps may bring serious hazard to the habitat and navigators, especially at night. Ballesteros et al., (2018) reported that those abandoned or derelict fishing nets can cause harmful effect on coral reefs and to other marine life. In the Florida Keys, the movement of derelict lobster traps

significantly damage the reef, reducing about 31–51% of sessile faunal cover along the trap movement path (Lewis et al., 2010). These disturbances leading to loss of resources can have negative effects on millions of small-scale fishers dependent on coral reef fishery. Therefore, there is a need to assess the environmental impacts of traps to aid the local government in managing the spiny lobster puerulus fishery in Palawan and the immediate environs.

Operation of Traps

Most (63.33%) collectors preferred the stake-hanging method and installed it in coastal area with wider intertidal flats and depth of ~1–6 m which is similar to Vietnam (Anh and Jones, 2015). Stake-hanging method can with stand to the waves, hence it was permanently installed in the coastal area. Most collection sites in Palawan were located in the eastern side of the province facing the Sulu sea, hence the waves action is sometimes rough. Unlike in Balete Bay, Davao Oriental, Philippines, the bamboo raft is the most preferred method followed by stake-hanging method since the area is a close bay safe from strong winds and waves (Macusi et al., 2019). Meanwhile, in Indonesia, traps were installed in the cages of adult spiny lobster after the collectors observed the natural settlement of pueruli in seaweed farms and grouper cages (Priyambodo and Jaya, 2009). Meanwhile, some (23.33%) collector particularly in southern localities of Palawan such as Sofronio Española and Brooke's Point seasonally used bamboo raft and banca in enclosed area with short intertidal flats and minimal wave action. These observations of collectors were related to the settlement behavior of puerulus in the coast. Puerulus prefer to settle in close inshore waters with some protection from the wind and waves, and depths less than 10 m to exposed offshore areas (Thuy and Ngoc, 2004). Preference for these habitats is mediated by their structural complexity and not by food availability, which becomes influential for the post-puerulus juveniles (Herrnkind and Butler, 1994). This information provides caution that any environmental alteration in the eastern side of Palawan could potentially impact this fishery industry. According to Ross and Behringer, (2019), alteration of water parameters in coastal area may result in decreased survivorship of *Panulirus argus* due to impaired shelter selection or other behaviors. On the other hand, some trap installation under the fixed bottom methods such as the lollipop, popsicle, tripod, and hanging also resembled the submerged method in Vietnam using the coral rocks and timber poles (Anh and Jones, 2015). According to some KIs, the traps installed in deeper areas close to the substrate has greater yield (Bahrawi et al., 2015; Priyambodo et al., 2015) and is not affected by phases of the moon, as also reported by Priyambodo et al. (2017). In the experiment of Priyambodo et al., (2017), puerulus of spiny lobster prefer to settle and burry in sandy substrate to avoid predators.

Although some of the trap installation methods have been adapted from other countries, continued monitoring may reveal other traps operation that are cheap and more efficient. The use of active gear such as the seine nets with light to attract pueruli at night as practiced in Balete Bay, Philippines (Macusi et al., 2019) and in Vietnam (Anh and Jones, 2015) was not observed in Palawan. This method is discouraged because seine net can collect other small fish larvae, thus bringing more harm to the environment and to the fish stock. Puerulus caught by high-pressure light is of low quality and are susceptible to diseases (Tuan and Mao, 2004). It is therefore essential for the collectors to identify a collection technique that promotes high survival rates and environment-friendly.

Collection of Settled Puerulus

The collection season starts in March that ends in August, while the daily harvesting coincides between the new moon and the first quarter, lasting for 10 days per month. This period of natural closure cushions fishing pressure. In other places like Vietnam, Indonesia, and Davao Oriental, Philippines, the traps were provided with battery/generator-operated

lights to attract more pueruli (Anh and Jones, 2015; Macusi et al., 2019; Priyambodo et al., 2015; 2017; 2020). The early life stage of various marine species particularly the crustaceans are attracted to light, and various cues such as underwater sounds, hydrodynamic and magnetic fields (Hinojosa et al., 2016; Jeffs et al., 2005; Phillips and McWilliam, 2009). The used of light in puerulus collection have been reported by one of the KIs in Narra, Palawan while writing this study (Fig. 5). The light is attached to a floating markers above the installed traps. Some collectors from other localities may have also started to use light for their traps, hence, a long-term monitoring may help to document the development of puerulus collection in Palawan which is essential for the management and expansion of puerulus fishery in the province.

Meanwhile, the harvesting methods resemble the practices in Vietnam and Indonesia (Anh and Jones, 2015; Bahwari et al., 2015) where collectors visited the settlement traps in the early morning. The collectors gently hold the exposed antenna before pulling each puerulus and placing it in a plastic bottle with seawater. Plastic bottles have holes at the upper portion to allow constant water exchange during harvest which is also resembled from Vietnam and Indonesia. All collected pueruli are sorted before being delivered or sometimes directed to the buyer immediately since keeping the catch longer would result to the change of color and low buying price. However, some collectors with aerators kept the pueruli in a large container overnight especially when buyer is not available in the area. Further study is needed to determine the duration of puerulus survival under controlled conditions.

Challenges in Puerulus Collection

Among the identified problems, the unstable buying price is the most common, fluctuating PhP150–200 (US$2.70–3.60) for crystal, and PhP80–150 (US$1.44–2.70) for black. However, the price may drop to PhP80–50 (US$1.53–0.96) per crystal and PhP50–35 (US$0.96–0.67) per black. After the peak month (June-September) the price drops excessively from PhP50–5 (US$0.96–0.096), contradicting the law of supply and demand wherein price increase with less supply. The seasonal differences in puerulus settlement between Palawan (March to August) and Vietnam (September to May) as observed in Table 7, may have affected the buying prices. Vietnam is the main importing country of wild seeds from various neighboring countries such as the Philippines (Macusi et al. 2019) and Indonesia (Priyambodo et al. 2020) due to the unstable supply of wild seeds as lobster farmers increase (Jones 2010) and seasonality of puerulus settlement (Priyambodo et al. 2020). Although the Provincial Ordinance No. 2475 series of 2020 indicates a buying price of PhP100 (US$2.10) per puerulus, only the buyer's price have prevailed. According to some KIs, all buyers strategize to set a sudden lower price to force them to sell the catch at whatever price, however, this needs further investigation involving the middleman as the last endpoint of spiny lobster puerulus in Palawan. In Vietnam and Indonesia, the prices of puerulus depend on the supply and demand of both farmers and the international market (FAO, 2012; Petersen and Jones, 2013).

Table 7. Heat chart of differences in monthly puerulus collection between Vietnam and Palawan.

Country	Seasonal trend of spiny lobster puerulus settlement ('000)												Sources
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	
Vietnam*	550'	700'	450'	100'	50'	1'	0	10	0	300'	600'	500'	Dao and Jones (2015)
Palawan, Philippines**	10	15	20	25	30	25	23	20	15	10	5	0	This study

Single asterisk (*) — number of collected puerulus in 2010–2011; double asterisk (**) — number of collectors.

The open-access nature of the coastal ecosystem (Lavides et al., 2010; Turner et al., 2007), absence of regulation, and the lucrative nature of the spiny lobster fishery may have led the community to believe in having the freedom to do whatever they want (Macusi et al., 2019). However, these may lead to unsustainable fishing practices which could negatively affect the wild population of spiny lobster puerulus in Palawan and the nearby coastal environments. The Provincial Ordinance No. 2475 series of 2020 and those of other municipalities (e.g., Narra and Aborlan) can aid in increasing people's awareness through information and education campaigns.

The use of corals and mangrove poles in installing the traps threatens the coastal ecosystems which provide refuge for both young and adult organisms, including lobsters. As observed in some coastal areas, the lack of zoning, registration, and a limit on the area for trap installation for each collector may result to conflict among resource users. Hence, ordinances pertaining to the establishment of collection zones, issuance of fishing permits, price regulation, and long-term monitoring of traps used, and harvesting methods is highly needed to maintain this promising fishery industry. Moreover, the dominance of non-resident capitalists would leave small-scale collector residents without a place to set up their settlement traps. Consequently, this situation may lead to over-harvesting and further marginalizing of the most vulnerable people in society. In addition, the use of stake-hanging and bamboo rafts must be regulated since a large number of these methods may disrupt navigational routes. Other collectors installed traps even within MPAs and tourist zone areas which may affect the safety and conduct of recreation related activities and conservation of coastal resources.

Conclusions

The settlement traps and installation methods observed in Palawan, Philippines are modifications from those reported in Vietnam. The use of concrete, coconut fruit, and mixed materials settlement traps are unique innovations that are newly documented in Palawan. Peak harvest season is from March to August and daily harvesting is influenced by the moon's phase, especially for traps installed in shallow areas. The majority of the settled pueruli are collected by hand through skin diving. Problems such as unstable buying prices and ambiguous sorting systems of crystal and black pueruli need urgent attention and regulation.

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