

Availability of puerulus from natural catch for lobster *Panulirus* spp. nursery culture

Analisis ketersediaan benih bening lobster puerulus hasil tangkapan alam untuk kegiatan budidaya pendederan lobster *Panulirus* spp.

Iis Diatin^{1*}, Irzal Effendi¹, Yani Hadiroseyani¹, Tatag Budiardi¹, Virta Rizki Hernanda², Nidwidyanti², Apriana Vinasyiam¹

¹Department of Aquaculture, Faculty of Fisheries and Marine Science, IPB University, Bogor, West Java 16680, Indonesia

²Undergraduate student of Aquaculture Science, IPB University, Bogor, West Java 16680, Indonesia

*E-mail: iisd@apps.ipb.ac.id

ABSTRACT

Indonesia is one of the lobster (*Panulirus spp.*) exporters countries to Hong Kong, Vietnam, China, and Singapore, with average export growth of 3.54% per year. The lobster export still relies on the natural catch, as the lobster culture has not been widely practiced in Indonesia. Pesisir Barat District Lampung Province is known as a lobster catch area, used by the local fishermen as the main income source. To determine the economic potential of lobster culture, a study was conducted to analyze the availability of lobster seeds (puerulus) and the lobster distribution channel for lobster culture. This study was conducted by survey method in Krui Selatan Sub-district, Pesisir Barat District, Lampung. Respondents in the study were fishermen who puerulus catch and collectors. The respondents were determined by the snowball sampling method. The results showed that the main types of lobster caught were sand lobster and pearl lobster. The catch of lobster fishermen on the new moon is an average of 121–340 puerulus/month, while on the full moon is an average of 4–680 puerulus/month, so the seed production can gradually reach more than 1.500.000 puerulus. The puerulus caught by fishermen will be sold to small collectors, then to big collectors, distributors, and exporters. The puerulus is distributed to various regions including Lampung, Bengkulu, Jambi, Palembang, and Jakarta. The marketing margin obtained by small and big collectors reaches 15%. The abundant production of lobster seeds in the Pesisir Barat, Lampung has the potential to develop lobster nursery aquaculture.

Keywords: distribution channel, lobster, nursery culture, puerulus

ABSTRAK

Indonesia merupakan salah satu negara yang melakukan ekspor lobster (*Panulirus spp.*) ke negara Hongkong, Vietnam, China, dan Singapura, dengan nilai ekspor lobster Indonesia mengalami rata-rata pertumbuhan 3.54% pertahun. Ekspor lobster tersebut masih mengandalkan hasil tangkapan, karena budidaya lobster belum banyak dilakukan di Indonesia. Pantai Barat Provinsi Lampung dikenal sebagai daerah tangkapan lobster yang dimanfaatkan oleh nelayan setempat sebagai sumber pendapatan utama. Untuk mengetahui potensi ekonomi dari budidaya lobster, maka dilakukan penelitian dengan tujuan menganalisis ketersediaan benih bening lobster (puerulus) dan saluran distribusi lobster sebagai suplai benih untuk kebutuhan budidaya lobster. Metode penelitian ini dilakukan dengan metode survei di Kecamatan Krui Selatan, Kabupaten Pesisir Barat, Lampung. Responden dalam penelitian adalah para nelayan penangkap dan pengepul benih bening lobster (puerulus). Penentuan responden dilakukan dengan metode snowball sampling. Hasil penelitian menunjukkan bahwa jenis lobster utama yang ditangkap adalah jenis lobster pasir dan lobster mutiara. Hasil tangkapan nelayan lobster pada bulan gelap yaitu rata-rata 121-340 ekor puerulus /bulan, sedangkan pada bulan terang rata-rata 4-680 ekor puerulus /bulan, sehingga dalam setahun benih yang dihasilkan mencapai lebih dari 1.500.000 ekor puerulus. Puerulus hasil tangkapan nelayan akan dijual pengepul kecil, selanjutnya ke pengepul besar, distributor dan eksportir serta terdistribusi ke berbagai wilayah mencakup Lampung, Bengkulu, Jambi, Palembang dan Jakarta. Margin pemasaran yang diperoleh pengepul kecil dan besar mencapai 15%. Produksi benih lobster yang melimpah di perairan Pantai Pesisir Barat Lampung sangat berpotensi untuk pengembangan budidaya pendederan lobster.

Kata kunci: benih bening lobster, budidaya pendederan, puerulus, saluran distribusi

INTRODUCTION

The fishery and marine resources have an important role in the national economic growth. In contrast, the Indonesian fishery production value is increasing by 14.61%, with the quarter months' fishery export level in 2022 growing by 21.63% compared to the previous year (Asianto *et al.*, 2022). One of the excellent fishery commodities with high export value is lobster. Lobster has become one of the global marine commodities (Penn *et al.*, 2015), with high economic value and price at US\$ 100 per kg for 1 kg size and US\$ 50 – 80 per kg for 300 g – 1 kg size. Indonesia's export destinations for lobsters are Hongkong, Vietnam, China, and Singapore (Nursan *et al.*, 2021). The Indonesian lobster export value in 2014-2019 was occupied with growing an average of 3.54% per year (BPS, 2021).

Lobsters have become a commodity that is partly available from the natural catch product, while lobster culture has not yet been performed well in Indonesia, even in other countries (Prompatanapaka dan Lopetcharat, 2020; Goodman *et al.*, 2021). The regulation of lobster culture business needs more attention to produce sustainable lobster, following the market demand (Nursan *et al.*, 2021) and social aspects (Turner *et al.*, 2014; Caputi *et al.*, 2015). Lampung Province, specifically in the Pesisir Barat area, has abundant lobster seeds (puerulus), known as the lobster catching area, which the fishermen utilize as the main income source. The Indonesian Ministry of Marine and Fisheries Affairs' regulation No. 56 of 2016 About the lobster (*Panulirus* spp.), mud crab (*Scylla* spp.), and swimming-crab (*Portunus* spp.) catching and/or release ban from The Republic of Indonesia obligates that each person is prohibited from selling the lobster seeds for culture and export (KKP, 2016). This regulation causes the fishermen to be unable to catch, and the abundant potential of puerulus is hard to be maximized.

The Indonesian Ministry of Marine and Fisheries Affairs Regulation No. 12 of 2020 About the lobster (*Panulirus* spp.), mud crab (*Scylla* spp.), and swimming crab (*Portunus* spp.) management in the Republic of Indonesia, replacing The Indonesian Ministry of Marine and Fisheries Affairs Regulation No. 56 of 2016, stated that the allowed puerulus exporters mentioned in chapter 5 and paragraph 1 with notes. In contrast, the exporters should conduct a lobster culture activity. This regulation continues to be renewed

until the publication of The Indonesian Ministry of Marine and Fisheries Affairs Regulation No. 17 of 2021, which re-prohibits strictly the puerulus export, as the puerulus can only be caught in the same province for research and culture purposes. This regulation causes a negative impact on the puerulus smuggling case increase conducts illegally. The puerulus abundance in Pesisir Barat Lampung, has been utilized by fishermen as their main catch commodity since 2015, which secures the standard of living around Pesisir Barat. High puerulus abundance potential is good momentum to develop the lobster culture activity by utilizing the natural catch product in Lampung Province.

Recently, the total puerulus catch is still far lower than the total puerulus abundance around Pesisir Barat, Lampung area. The puerulus abundance in Pesisir Barat Lampung, can be maximized by its absorption level through the cooperation of lobster culture companies in Lampung Province. The puerulus supply provision at the right time, quantity, and the price is extremely important in supporting profitable and sustainable lobster culture business. A process required in this activity is by the supply chain management as a raw material transformation activity to become a product along with the associated stakeholder roles that can elevate the efficiency value (Miftahul *et al.*, 2019). This study aimed to conduct an availability analysis of the puerulus and lobster distribution channel in Pesisir Barat Lampung, as a seed supply source for lobster nursery culture.

MATERIALS AND METHODS

Location and period

The study was conducted in Krui Selatan Sub-district, Pesisir Barat District, Lampung (Figure 1) as a coastal area with most community work as fishermen. This study was performed in October-November, 2021.

Data types and sources

The data types and sources used were primary and secondary data. Primary data was obtained directly from the field through questionnaires, interviews, and observation. Secondary data were obtained from the local government or associated parties, i.e government, private company, and community.

Experimental methods

This study used a survey method in Krui

Selatan Sub-district, Pesisir Barat District, Lampung. Respondents in this study were puerulus fishermen and middlemen, called puerulus collectors around Krui, Pesisir Barat. Respondents were determined by the snowball sampling method. Snowball sampling is a data-sampling method by identifying and taking the samples based on the snowball analogy that will become greater when rolled down, therefore respondents were determined based on the relationship of the previous respondents (Emerson, 2015). This method was used as the total fishermen who specifically puerulus caught and collectors in Pesisir Barat were unknown. Based on the survey method, this study's respondents were 30 puerulus fishermen and five puerulus collectors.

Data analysis

The total lobster seed catch in Pesisir Barat waters data was collected every month during 2021. These data were collected from the fishermen who specifically caught puerulus. The lobster puerulus catch product data from each observation period were analyzed descriptively and presented in a table, graphic, and figure using Microsoft Excel 2019 software. These presentations were chosen according to the analysis required to achieve the study aims (Arkham *et al.*, 2015).

RESULTS AND DISCUSSIONS

Results

Puerulus abundance in Pesisir Barat Lampung

The puerulus fishermen in Pesisir Barat Lampung have an individual working pattern. Fishermen start to set to the sea in the afternoon to spread the net as the puerulus trap. The number of nets spread from each fisherman is between 50–200 strands. Besides the net, other fishing gears used are lamps and buoys. The number of fisherman's working days in catching the lobster is 20-30 days of fishing per month (Table 1). The abundance of puerulus catch products in Pesisir Barat Lampung is influenced by the new moon and full moon phases.

The abundance of puerulus value in the fisheries management area (WPP) of 572 reaches 3.336.750.000 seeds (BRSDM, 2021). However, only 5% of the puerulus abundance can be caught by the fishermen in Pesisir Barat, namely at 16.143.162 puerulus/month or about 193.718.944 puerulus/year. These numbers are the calculation results of catching potential from 3.843 fishermen joined in 273 cooperative business groups (KUB) (BPS, 2021).

Based on the field observation results, the puerulus caught in the Pesisir Barat Lampung area has a 1–1.5 cm size. The catch product in



Figure 1. Study activity in Pesisir Barat District, Lampung.

Table 1. A number of fisherman's working days in the lobster catch.

Activity	
Number of working days (day man/month)	20-30
Number of working days during the new moon (day man/month)	15-25
Number of working days during full moon (day man/month)	0-10
Puerulus abundance season	June-October

the new moon is on averagely 121.340 puerulus/month, while the catch product in the full moon is on averagely 4.680 puerulus/month (Figure 2), therefore the average catch product per month is 126.020 puerulus/month or around 1.512.240 puerulus/year.

Puerulus distribution channel

The Puerulus distribution channel from Pesisir Barat Lampung comprises three trading channel patterns as presented in Figure 3.

The puerulus as the fishermen’s catch product will be sold to the smaller collectors without a minimum limit of total acceptance. Any puerulus numbers caught will be sold to small collectors. The big collectors only accept puerulus from small collectors, which will then be sold to

suppliers until exporters. The puerulus selling price from fishermen to small collectors is IDR 23.000/puerulus, then the small collectors sell puerulus at IDR 25.000/puerulus to the big collectors, who will continuously sell the seeds to suppliers at IDR 27.000/puerulus. The average margin accepted by small or big collectors is IDR 2.000 or 15%.

Puerulus supply for lobster nursery culture

The lobster nursery culture activity contains two steps, namely first nursery (puerulus –5 g) and second nursery (5–30 g), then the lobster from the first nursery culture product will become the input for the first growing-out activity (30–120 g) and second growing-out activity (120–500 g). The lobster rearing tank for nursery culture uses

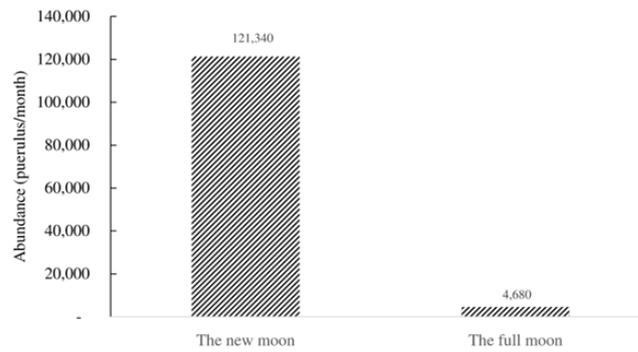


Figure 2. The total average of puerulus caught in Pesisir Barat District, Lampung.

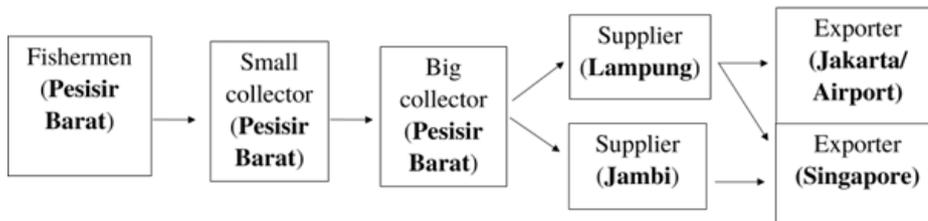


Figure 3. Puerulus distribution channel from Pesisir Barat.



Figure 4. Simulation of lobster nursery culture production pattern.

a floating net cage (KJA), whereas each KJA has nine KJA plots in 3 m x 3 m size and 4–7 m depth. Six cages in cylinder shape were placed in each KJA plot with 100 cm diameter and 60 cm height. The cage was drowned in the water at 3–4 m depth. puerulus stocked at 50 puerulus/m² in the first nursery tank has 0.2–0.3 g weight (Cokrowati *et al.*, 2-12), therefore each tank is stocked with 50 puerulus. The first nursery rearing period is 8-10 weeks and produces lobster seeds at 5 g weight. The second nursery culture uses lobster seeds from the first nursery product with 5 g weight and 20 lobster seeds/m² stocking density. The second nursery rearing is performed for 8–10 weeks and produces lobster seeds at 30–50 g with a survival rate of 30–70%.

Based on the production pattern management (Figure 4), the production cycle of lobster nursery culture activities can be performed 48 times per year, which means that the seed stocking can be performed weekly and the harvest can also be performed weekly. The total KJA requirement to support the production pattern well and continuously is eight units. The calculation results of the puerulus requirement for lobster nursery culture obtain 16.200 puerulus/KJA/year, therefore total puerulus requirement in all KJAs is 129.600 puerulus/year. The puerulus produced by fishermen in Pesisir Barat is 1.500.000 puerulus/year.

Discussions

Lobster seed-catching activity has been developing since 2015 on Pesisir Barat Lampung. Krui Selatan is one of the main location for producing puerulus in Pesisir Barat Lampung apart from Bengkuntat. The Krui Selatan community mostly works as puerulus fishermen, while fish only becomes the bycatch product. This condition occurs due to quite abundant puerulus availability in Pesisir Barat waters, starting from Labuhan Jukung, Labuhan Agung, Lintik, Siging, Ranggai, Serai, and Bengkuntat as the puerulus fishing area.

Lobster types that are commonly found in Pesisir Barat waters are *Panulirus homarus* (spiny lobster) and *Panulirus ornatus* (tropical rock lobster). Both lobsters are types that have many been cultured in Vietnam with the broad market approach in China. Pesisir Barat is located in the WPP of 572 (Mous *et al.*, 2020). According to Priyambodo *et al.* (2020), the abundance of puerulus is also found in water areas around Sumatra Island. The puerulus abundance is

affected by the appropriate environmental condition, mainly in the area around the coast with muddy/sandy substrate characters, followed by the existence of a current that brings puerulus in several areas called sink population. Lampung has five big rivers and 25 small rivers, forming eight river banks (DAS). The river has a role in carrying sediments, such as mud and sand, to the sea and regions around the coast. This condition impacts the creation of muddy land and sandy beach (Pariwono, 1999).

The fishing activities conducted by fishermen in Pesisir Barat Lampung use a fishing gear called a net, and most fishermen use two lamps for each net, as mentioned by Musbir *et al.* (2014) and Witomo and Nurlaili (2015). This condition is performed to produce a wider light appropriate for the fishing location. The moonlight condition affects the puerulus catch product due to phototaxis characteristics (Cohen and Epifanio, 2020; Setyanto *et al.*, 2020). According to Priyambodo *et al.* (2020), the water condition during the new moon phase without moonlight causes the puerulus to concentrate near the lamp light and be trapped in the net. In contrast, the moonlight during the full moon phase will illuminate the waters, causing the use of lamps to be ineffective in attracting puerulus in the net. This condition causes the puerulus catch product during the full moon to be less than during the new moon (Fachry *et al.*, 2018; Steell *et al.*, 2020). During the new moon, fishermen will perform a fishing activity more similar to Gaol *et al.* (2019), who stated that the fishing boat distribution in the sea increased by 400% during the new moon phase.

The puerulus abundance season in Pesisir Barat Lampung occurs from June-October, 2021, following Priyambodo *et al.* (2020), who mentioned that the puerulus abundance also occurs in the following period, starting from April to November. The lobster spawning pattern emerges in the spring and egg hatching occurs in the summer (Alborés *et al.*, 2019; Fernández *et al.*, 2021; Yeap *et al.*, 2022). During these periods, lobster spawning is performed in the Northern and Southern water areas, so the Indonesian waters, located on the equator line, have the benefit of gaining puerulus abundance from both regions. The puerulus abundance in the Indonesian waters, mainly in WPP of 572, should be utilized in its potential, specifically for seed catch product-based culture activities as performed in Vietnam, which is called the lobster aquaculture industry country (Jones *et al.*, 2019).

The puerulus trade in Pesisir Barat District, Lampung, has been established as a distribution channel and formed naturally by involving various actors in the activity (Marimin & Maghrirah, 2011). Fishermen who catch puerulus will sell their catch product to small collectors who live in a similar region by considering the highest purchase price. Then, the big collectors will send puerulus to the core warehouse or suppliers located in Lampung. Transporting the product to suppliers in Jambi commonly passes Bengkulu or Palembang area. Suppliers in Jambi will send puerulus to exporters in Singapore, while suppliers in Lampung will send to exporters in Jakarta and Singapore (Figure 3). The puerulus are transported using the land transportation line.

High demand for puerulus causes its exploitation continues to increase with quite high selling price from the fishermen that can reach IDR 23.000/puerulus, similar to Junaidi *et al.* (2021), who reported that the puerulus price was among IDR 17.000-IDR 20.000/puerulus. The puerulus selling price varies due to market conditions, puerulus supply, total demands by the buyers, and fishing season (Thuy *et al.*, 2009). The margin value in each collector can vary according to the market strategy of each collector. This condition is caused by the competition among collectors to gain puerulus supply from fishermen, which needs a different marketing strategy to improve a business's success and competitiveness (Rusdi, 2019).

The selling margin of puerulus in the small or big collector range level is approximately IDR 1.000 – IDR 2.000/puerulus, producing the average margin at 15% of the selling price. The 5% of the margin is generally allocated as a cost in a value chain used in the processing, quality control system, and business certification (Prompatanapak & Lopetcharat, 2020; Petersen *et al.*, 2020). A quite low margin added with puerulus mortality risk in the transportation process among stakeholders in the distribution channel causes the available supply chain to be less efficient. The supply chain shrinkage and cost increase become the solutions that can be taken to make the puerulus selling business more profitable and sustainable for each stakeholder.

Using seed catch products in aquaculture activities requires cost calculation for transportation and mortality risk along the way. The 9-hour transportation time is tolerable for puerulus to remain away from much stress and minimize puerulus mortality during the

transportation period. The stress caused by the post-transportation effect can also affect the survival rate value during the rearing period (Virgilio, 2019). Mortality risk during transportation can be reduced using a wet packing with oxygen in addition to preserving the physiological and metabolism activities that remain in optimum condition for puerulus (Arumugam *et al.* 2020). The habitat difference in the rearing tank and transportation box due to shelter absence can trigger puerulus stress (Supriyono *et al.*, 2017; Adiyana *et al.*, 2020; Slamet *et al.*, 2021). Administration of an anesthetic substance can also be used to reduce the stress level in transporting the living lobsters (Pozhoth and Jeffs, 2022).

The Indonesian Ministry of Marine and Fisheries Affairs Regulation No. 17 of 2021 which states that the puerulus aquaculture activity is obliged to perform in the same location as the fishing ground, can provide a chance for developing the lobster culture in Indonesia, specifically in Lampung, the seed commodity potential. The distribution networks of puerulus supply have been organized well from upstream to downstream, simplifying the Lampung region's lobster supply for aquaculture activity. The lobster culture can utilize this distribution network to gain continuous seed supply for aquaculture activity. Seeds can be bought from collectors who have collected the seeds in a great amount from fishermen. The puerulus supply availability should also be balanced with the preparation of tank and culture location, so the puerulus abundance can be maximized its potential as the nursery culture activity input by organizing the production pattern way (Figure 4). The products obtained through the production pattern will produce continuous and sustainable lobster production. Moreover, water quality management by maintaining the temperature, pH, salinity, alkalinity, and optimal dissolved oxygen in the culture period can maximize lobster growth (Balkhair *et al.*, 2012; Aji *et al.*, 2019).

CONCLUSION

The puerulus abundance in Pesisir Barat is dominated by *Panulirus homarus* (spiny lobster) and *Panulirus ornatus* (tropical rock lobster). In a year, lobster fishermen's catch product reaches more than 1.500.000 puerulus. The puerulus catch product from fishermen will be sold to small collectors, then big collectors, distributors,

and exporters. The marketing margin received by small and big collectors is 15%. The abundant puerulus production in Pesisir Barat Lampung has the potential to develop sustainable lobster nursery culture.

ACKNOWLEDGMENTS

This project was funded by the Kedaireka-Dikti program in 2021, entitled “The Development of Lobster Aquaculture Estate with Agromaritime 4.0 System for MBKM Activity”. We want to thank IPB University and the Indonesian Ministry of Education and Culture Affairs, who have supported and assisted the funding process in this project. An appreciation is also delivered to the village and sub-district government apparatus in the Pesisir Barat region among all respondents in this study, namely puerulus fishermen, puerulus collectors, and consumed lobster collectors, who have assisted in obtaining the required data.

REFERENCES

- Adiyana K, Zulkarnain R, Thesiana L. 2020. Physiological response and growth performance of spiny lobster (*Panulirus homarus*) juvenile rearing in recirculating aquaculture system with various shelter type. *Marine Research in Indonesia* 45: 67–74.
- Aji MB, Supriyono E, Soelistyowati D. 2019. A preliminary study of the effect of alkalinity level on the survival rate and growth of the *Panulirus homarus* lobster. *International Journal of Fisheries and Aquatic Studies* 7: 339–342.
- Alborés I, García-Soler C, Fernández L. 2019. Reproductive biology of the slipper lobster *Scyllarus arctus* in Galicia (NW Spain): Implications for fisheries management. *Fisheries research* 212: 1–11.
- Arkham MN, Adrianto L, Wardianto Y. 2015. Social-ecological system of seagrass and small-scale fisheries connectivity in malang rapat and berakit villages, bintan district, Riau islands. *Jurnal Ilmu dan Teknologi Kelautan Tropis* 7: 433–451.
- Arumugam A, Dineshkumar R, Rasheeq AA, Gowrishankar MP, Murugan S, Sampathkumar P. 2020. Growth performance of spiny lobster, *Panulirus homarus* (Linnaeus, 1758). *Indian Journal of Geo Marine Species* 49: 812–819.
- Asianto AD, Wulansari RE, Malika R, Rahadian R, Pribadi DM. 2022. Rilis Data Kelautan dan Perikanan Triwulan I – 2022. Direktorat Konservasi dan Keanekaragaman Hayati Laut, Ditjen Pengelolaan Ruang Laut.
- Balkhair M, Al-Mashiki A, Chesalin M. 2012. Experimental rearing of spiny lobster, *Panulirus homarus* (Palinuridae) in land-based tanks at Mirbat Station (Sultanate of Oman) in 2009-2010. *Journal of Agricultural and Marine Sciences [JAMS]* 17: 33–43.
- [BPS] Badan Pusat Statistik Indonesia. 2021. Direktori perusahaan perikanan Provinsi Lampung 2021.
- [BRSDM] Badan Riset dan Sumber Daya Manusia. 2021. BRSDM KP dalam angka tahun 2020. Jakarta (ID).
- Caputi N, de Lestang S, Reid C, Hesp A, How J. 2015. Maximum economic yield of the western rock lobster fishery of Western Australia after moving from effort to quota control. *Marine Policy* 51: 452–64.
- Cohen JH, Epifanio CE. 2020. Response to visual, chemical, and tactile stimuli. The natural history of the Crustacea 7: 332–359.
- Cokrowati N, Utami P, Sarifin. 2012. Differences in stock dental on growth and sustainability level post puerulus sand lobster (*panulirus homarus*) in controlled bottom. *Jurnal Kelautan* 5: 156–166.
- Emerson RW. 2015. Convenience sampling, random sampling, and snowball sampling: How does sampling affect the validity of research?. *Journal of Visual Impairment & Blindness* 109: 164–168.
- Fachry ME, Sugama K, Rimmer MA. 2018. The role of small-holder seed supply in commercial mariculture in South-East Asia. *Aquaculture* 495: 912–918.
- Fernández L, García-Soler C, Alborés I. 2021. Reproductive strategies under different environmental conditions: total output vs investment per egg in the slipper lobster *Scyllarus arctus*. *Journal of the Marine Biological Association of the United Kingdom* 101: 131–139.
- Gaol JL, Arhatin RE, Syah AF, Kushardono D, Lubis JT, Amanda ND, Amanda Y, Oktavia W, Nurcholis. 2019. The distribution of fishing boat in the moonlight and dark moon phases based on the viirs sensor in the java sea. *Jurnal Kelautan Nasional* 14: 135–144.
- Goodman AJ, McIntyre J, Smith A, Fulton L, Walker TR, Brown CJ. 2021. Retrieval of abandoned, lost, and discarded fishing gear in

- Southwest Nova Scotia, Canada: Preliminary environmental and economic impacts to the commercial lobster industry. *Marine Pollution Bulletin* 171: 112766.
- Jones CM, Anh TL, Priyambodo B. 2019. Lobster aquaculture development in Vietnam and Indonesia. Springer Nature Singapore 541–570.
- Junaidi M, Cokrowati N, Diniarti N, Setyowati DN, Lumbessy SY, Mukhlis A, Astriana BH. 2021. Study of participatory actions to improve performance of submersible cage lobster cultivation in ekas buana village, east Lombok regency. *Jurnal Pengabdian Magister Pendidikan IPA* 4:139–145.
- [KKP] Kementerian Kelautan dan Perikanan. 2016. Peraturan Menteri Kelautan dan Perikanan Republik Indonesia Nomor 56/PERMEN-KP/2016 tentang larangan penangkapan dan/atau pengeluaran lobster (*Panulirus* spp.), kepiting (*Scylla* spp.), dan rajungan (*Portunus* spp.) dari wilayah negara Republik Indonesia. Jakarta (ID): KKP.
- [KKP] Kementerian Kelautan dan Perikanan. 2021. Peraturan Menteri Kelautan dan Perikanan Nomor 17/PERMEN-KP/2021 tentang pengelolaan lobster (*Panulirus* spp.) kepiting (*Scylla* spp.), dan rajungan (*Portunus* spp.) di wilayah negara Republik Indonesia. Jakarta (ID): KKP.
- Marimin, Maghfiroh N. 2011. Technical Applications of Decision Making in Supply Chain Management. Bogor (ID): IPB Press.
- Miftahul I, Setiawan B, Efani A. 2019. Value chain analysis at tuna processed agroindustry in Pacitan, East Java. *Agricultural Socio-Economics Journal* 19: 33–46.
- Mous PJ, I Gede WB, Pet JS. 2020. Length-based stock assessment of a species complex in deepwater demersal fisheries targeting snappers in Indonesia fishery management area WPP 572. Technical Paper 1–87.
- Musbir M, Sudirman S, Palo M. 2014. The Use of an Environmental Friendly Artificial Attractor to Collect Spiny Lobster Seed (*Panulirus* spp). *Jurnal IPTEKS Pemanfaatan Sumberdaya Perikanan* 1: 95–102.
- Nursan M, Husni S, Yusuf M, Utama AF, Widiyanti NMNZ. 2021. Technical efficiency of lobster (*Panulirus* sp.) farming in East Lombok Regency. *Jurnal Biologi Tropis* 21: 1087–1095.
- Pariwono JI. 1999. Lampung Coastal Oceanographic Conditions. Jakarta (ID): Coastal Resources Management Project.
- Penn JW, Caputi N, de Lestang S. 2015. A review of lobster fishery management: the Western Australian fishery for *Panulirus cygnus*, a case study in the development and implementation of input and output-based management systems. *ICES Journal of Marine Science*. 72 (Supplement 1) : i22–i34.
- Petersen E, Susanti E, Oktaviani R, Jones C, Diedrich A. 2020. Bio-economics of tropical spiny lobster farming in Indonesia. *Aquaculture and Fisheries Studies* 2: 1–10.
- Poztho J, Jeffs A. 2022. Effectiveness of the food-safe anaesthetic isobutanol in the live transport of tropical spiny lobster species. *Fishes* 7: 40.
- Priyambodo B, Jones CM, Sammut J. 2020. Assesment of the lobster puerulus (*Panulirus Homarus* and *Panulirus ornatus*, Decapoda: Palinuridae) resource of Indonesia and its potential for sustainable harvest for aquaculture. *Aquaculture* 528: 1–17.
- Promptanapak A, Lopetcharat. 2020. Managing changes and risk in seafood supply chain : a case study from Thailand. *Aquaculture* 525: 1–7.
- Rusdi M. 2019. Marketing strategy to increase sales volume at precarious company UD. Berkah Jaya. *Jurnal Studi Manajemen dan Bisnis* 6: 49–54.
- Setyanto A, Kamila FN, Bintoro G. 2020. Composition of lobster larva species collected in underwater lighting attractors. *Journal of Fisheries and Marine Research* 4: 281–288.
- Slamet B, Rusdi I, Giri A. 2021. Effect of shelter net sizes on growth, survivality, and health of scalloped spiny lobster, *Panulirus homarus* (Linnaeus 1758) reared in fiberglass tank. In *IOP Conference Series: Earth and Environmental Science* (Vol. 919, No. 1, p. 012051). IOP Publishing.
- Supriyono E, Prihardianto RW, Nirmala K. 2017. The stress and growth responses of spiny lobster *Panulirus homarus* reared in recirculation system equipped by PVC shelter. *Aquaculture, Aquarium, Conservation & Legislation* 10: 147–155.
- Stell SC, Cooke SJ, Eliason EJ. 2020. Artificial light at night does not alter heart rate or locomotor behaviour in Caribbean spiny lobster (*Panulirus argus*): insights into light pollution and physiological disturbance using biologgers. *Conservation Physiology* 8: coaa097.
- Thuy NTB, Ha NN, Danh DV. 2009. Effect of

- environmental conditions during holding and transport on survival of *Panulirus ornatus* juveniles. Dalam: Williams KC, editor. Proceedings of an International Symposium “Spiny Lobster Aquaculture in The Asia-Pacific Region”; 9–10 December 2008; Nha Trang, Vietnam. Nha Trang (VND) : Paragon Printers Australasia. pp 79–84.
- Turner RA, Polunin NV, Stead SM. 2014. Social networks and fishers’ behavior: exploring the links between information flow and fishing success in the Northumberland lobster fishery. *Ecology and Society* 19: 38.
- Virgilio BR. 2019. Performance and economic evaluation of early juvenile lobster (*Panulirus ornatus*) in wet and dry transport conditions. *Journal of Agricultural Science and Fisheries* 1: 19–27.
- Witomo CM, Nurlaili N. 2015. Strategy of Sustainability Seed Lobster Management in Lombok. *Jurnal Kebijakan Sosial Ekonomi Kelautan dan Perikanan* 6: 11–8.
- Yeap AL, De Souza Valente C, Hartnett F, Conneely EA, Bolton-Warberg M, Davies SJ, Johnson MP, Wan AH. 2022. Barriers in European spiny lobster (*Palinurus elephas*) aquaculture: What we know so far? *Reviews in Aquaculture* 2022: 1–23.