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Habitat-associated occurrence of spiny lobster pueruli (*Panulirus* spp.) in Moramo Bay, Indonesia: Baseline ecological observations

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Abstract

Indonesia supports one of the world's largest fisheries targeting spiny lobster pueruli (*Panulirus* spp.) to supply capture-based aquaculture, yet ecological information describing puerulus occurrence in many coastal settlement areas remains scarce. This study presents preliminary ecological observations from Moramo Bay, Southeast Sulawesi, Indonesia, based on standardized artificial pocong collectors deployed at three representative shallow coastal stations characterized by coral-sand mixtures, seagrass beds, and sandy substrates. Because artificial collectors intercept actively swimming pueruli during the transition from the pelagic to the benthic phase, the data represent collector-associated occurrence rather than direct measurements of natural settlement or habitat preference. A total of 319 pueruli belonging to two species were recorded, comprising *Panulirus ornatus* (79.31%) and *P. homarus* (20.69%). Collector catches varied among the three representative sampling stations, with the highest abundance observed at the seagrass-associated station. Field observations were interpreted together with satellite-derived mean sea surface temperature (SST) and chlorophyll-a concentration (2022–2024) to characterize the regional oceanographic setting. The spatial variation observed among stations may reflect the combined influence of local habitat setting, coastal hydrodynamics, larval transport processes, and collector exposure rather than habitat characteristics alone. Since each habitat type was represented by a single sampling station, these findings should be interpreted as station-level ecological observations rather than replicated habitat comparisons. Although preliminary, this study establishes an ecological baseline for Moramo Bay and provides a scientific foundation for future investigations integrating replicated habitat surveys, larval connectivity, and oceanographic processes to strengthen evidence-based management of Indonesia's lobster puerulus fisheries.

Keywords: artificial *pocong* collector; habitat-associated occurrence; *Panulirus* spp.; puerulus fishery; recruitment

1. Introduction

Spiny lobsters (*Panulirus* spp.) are among the most valuable crustacean fishery resources worldwide, supporting coastal livelihoods, international seafood markets, and capture-based aquaculture across the Indo-Pacific region. Indonesia occupies a strategic position within this fishery because it supports one of the world's largest wild puerulus resources, particularly *Panulirus homarus* and *P. ornatus*, which supply seed for lobster aquaculture both domestically and in neighbouring countries. As hatchery production of spiny lobsters remains technically limited and economically constrained, aquaculture production continues to rely heavily on naturally occurring pueruli collected from coastal waters. Consequently, understanding the ecological processes governing puerulus occurrence has become increasingly important for balancing resource utilization with long-term sustainability (Holthuis, 1991; Phillips, 2013; Priyambodo et al., 2020; FAO, 2024; Syahrir, 2026).

The puerulus represents a unique transitional stage between the oceanic phyllosoma larva and the benthic juvenile lobster. During this stage, individuals actively migrate from offshore waters towards shallow coastal environments, where they undergo metamorphosis before recruiting into juvenile habitats. Because post-larval survival during this transition contributes to subsequent recruitment to adult populations, ecological conditions encountered during the puerulus phase are considered important for understanding recruitment processes. Nevertheless, collector catches should be interpreted cautiously because artificial collectors measure the occurrence of actively swimming pueruli rather than direct settlement success or habitat preference (Holthuis, 1991; Butler et al., 2011; Phillips, 2013).

The spatial occurrence of pueruli is influenced by complex interactions among larval behaviour, coastal habitat characteristics, hydrodynamic transport, and oceanographic variability. Sea surface temperature (SST) and chlorophyll-a concentration are widely recognised as useful environmental indicators because they reflect thermal conditions, primary productivity, and coastal oceanographic processes that may influence larval transport and food-web dynamics. Previous studies in Indonesian waters have demonstrated significant associations between variations in SST, chlorophyll-a, and puerulus catch, although the strength and direction of these relationships differ among coastal ecosystems due to local environmental conditions and circulation patterns (Behrenfeld and Boss, 2014; Junaidi et al., 2021).

Although considerable progress has been made in describing the temporal distribution and exploitation of puerulus resources in several Indonesian regions, ecological studies integrating field observations of habitat-associated puerulus occurrence with spatial environmental information remain limited. Most previous investigations have focused on seasonal abundance, fisheries production, or environmental correlations, whereas relatively few studies have evaluated how representative shallow-water habitat settings and environmental conditions collectively characterize areas where pueruli are intercepted by standardized collectors. This knowledge gap restricts the development of ecological baselines required for habitat monitoring and evidence-based management of lobster seed fisheries (Priyambodo et al., 2020; Junaidi et al., 2021; Syahrir et al., 2024; Suparno et al., 2024).

Moramo Bay, Southeast Sulawesi, is a semi-enclosed tropical embayment characterized by coral reefs, seagrass meadows, sandy substrates, and relatively sheltered coastal waters that are traditionally utilized by local fishers for puerulus collection using artificial pocong collectors. Despite the ecological and economic importance of this activity, scientific information describing habitat-associated puerulus occurrence and associated environmental conditions within Moramo Bay remains scarce. Establishing baseline ecological observations from this region is therefore essential to support future monitoring programmes, improve understanding of settlement-related processes, and provide scientific information for sustainable management of lobster seed fisheries.

Accordingly, this study was designed to establish a baseline ecological assessment of habitat-associated occurrence of spiny lobster pueruli in Moramo Bay, Southeast Sulawesi. Specifically, the study aimed to (1) quantify spatial variation in collector-associated puerulus occurrence among three representative shallow-water stations, (2) characterize the environmental setting using field observations together with multi-year satellite-derived SST and chlorophyll-a data, and (3) provide an ecological baseline to support future investigations of larval connectivity, settlement processes, and evidence-based management of Indonesia's lobster seed fisheries. Because habitat categories were represented by single sampling stations, the results are interpreted as exploratory station-level ecological observations rather than replicated habitat comparisons.

2. Materials and Methods

2.1. Study Area

The study was conducted in Moramo Bay, Southeast Sulawesi, Indonesia, during June 2024. Moramo Bay is a semi-enclosed tropical embayment characterized by shallow coastal habitats consisting of coral–sand mixtures, seagrass meadows, and sandy substrates. These habitats are traditionally utilized by local fishers for collecting spiny lobster pueruli using artificial pocong collectors. Three representative sampling stations (MB-01, MB-02, and MB-03) were selected based on local fishing activities and the dominant habitat surrounding each station. The stations were not intended to represent replicated habitat treatments but rather to provide baseline observations from three ecologically distinct habitat settings. The geographic location of the study area is presented in **Figure 1**.

Figure 1. Study area and sampling stations in Moramo Bay, Southeast Sulawesi, Indonesia. Three sampling stations representing different shallow-water habitat types were selected, consisting of coral–sand mixture (MB-01), seagrass habitat (MB-02), and sandy substrate (MB-03). The figure illustrates the spatial distribution of sampling locations within the semi-enclosed coastal system of Moramo Bay, which is characterized by heterogeneous nearshore habitats associated with puerulus settlement.

2.2. Sampling Design

This study employed an exploratory field survey using purposive sampling to document habitat-associated occurrence of spiny lobster pueruli. Artificial pocong collectors were positioned following local fishing practices. The fishing gear was deployed in the afternoon or evening, and catches were collected in the morning during lunar ages 3–13, corresponding to the period before the full-moon phase (lunar age 14). The fishing season occurs from May to October each year.

Three sampling stations were selected to represent different dominant shallow-water habitat settings (coral–sand, seagrass, and sand). Each habitat type was represented by a single sampling station; therefore, habitat categories were not spatially replicated. The sampling design was intended to establish baseline ecological observations rather than to test habitat preference experimentally. Consequently, comparisons among stations should be interpreted as station-level observations that may reflect combined effects of habitat characteristics, local environmental conditions, hydrodynamics, and collector deployment.

2.3 Artificial Pocong Collectors

Pueruli were sampled using standardized artificial pocong collectors commonly employed by local fishers in Indonesia. Each collector consisted of bundles of synthetic fibre strips attached to a floating frame and suspended within the upper water column to provide refuge for actively swimming pueruli. Collectors were deployed using the same construction design and sampling procedure at all stations to minimize methodological variation. It should be noted that artificial collectors intercept swimming pueruli before benthic metamorphosis and therefore provide an index of puerulus occurrence rather than a direct measure of natural settlement or habitat preference.

To minimize methodological bias, all collectors were constructed using identical materials, dimensions, and deployment procedures. Collectors were installed at comparable depths within the shallow coastal zone and were inspected using the same retrieval protocol throughout the survey period. The artificial pocong collector operated in this research is shown in **Figure 2** below.

Figure 2. The artificial pocong collector used for pueruli sampling in Moramo Bay, Southeast Sulawesi, Indonesia. The sampling gear consisted of passive collectors operated in shallow coastal waters to capture puerulus during the early settlement phase. Standardized sampling effort was applied across all stations to allow comparison of pueruli occurrence among different habitat types. Source: Personal documentation (2024).

2.4. Biological Data Collection

Pueruli collected from each sampling station were carefully removed from the standardized artificial pocong collectors and transported to the field laboratory for counting, measurement, and species identification (**Figure 3**). Species abundance was recorded for each sampling station and used to describe spatial variation in collector catches among the representative habitat settings.

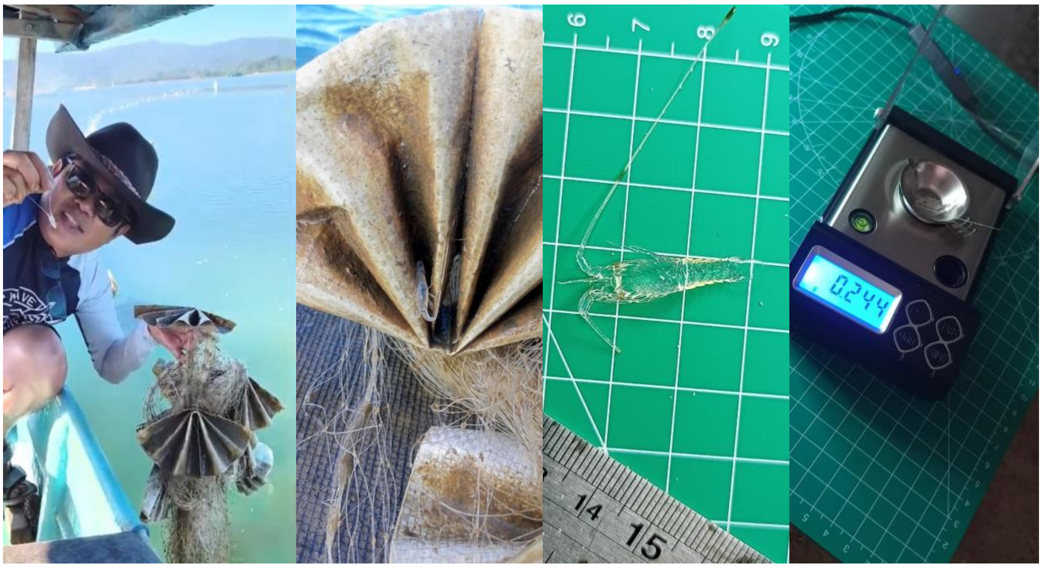

Figure 3. Counting, identification and measurement of pueruli caught by artificial pocong collectors sampling in Moramo Bay, Southeast Sulawesi, Indonesia. Source: Personal documentation.

Pueruli were identified immediately after collection based on external morphological characteristics visible at the puerulus stage. To ensure consistency among all examined specimens, species identification followed a standardized field-based morphological assessment using three principal external diagnostic characters: eye pigmentation, antennal morphology and pigmentation, and abdominal pigmentation pattern (**Figure 4**). Representative *Panulirus ornatus* pueruli exhibited reddish-brown eyes, antennae bearing a distinct terminal bulb, and a pale longitudinal stripe along the proximal abdomen. In contrast, *P. homarus* pueruli were characterized by black eyes, transparent antennae lacking a terminal bulb, and mottled abdominal pigmentation without a longitudinal pale stripe.

Figure 4. Representative pueruli collected from Moramo Bay showing the principal external morphological characteristics used for field identification of *Panulirus ornatus* (A) and *Panulirus homarus* (B). Diagnostic characters include (1) eye pigmentation, (2) antennal morphology and pigmentation, and (3) abdominal pigmentation pattern.

The diagnostic characteristics shown in **Figure 4** were applied consistently throughout the study. The photographs were obtained from representative pueruli collected during the present study. Because molecular verification and post-settlement confirmation were beyond the scope of this study, species assignments should be regarded as field-based morphological identifications and interpreted with appropriate caution.

2.5. Habitat Characterization

Habitat characteristics were documented through direct field observations at each sampling station. Water depth, dominant substrate type, and surrounding benthic habitat were recorded during sampling. Habitat categories included coral–sand mixtures, seagrass meadows, and sandy substrates, representing the dominant environmental setting immediately surrounding each collector location. These habitat descriptions were intended to provide ecological context for interpreting station-level variation in puerulus occurrence rather than to establish causal relationships between habitat type and settlement success.

2.6. Environmental Data

Environmental conditions were characterized using remotely sensed sea surface temperature (SST) and chlorophyll-a concentration derived from satellite observations covering the period 2022–2024. These variables were used to provide regional environmental context for the field observations rather than to establish direct causal relationships with puerulus occurrence. SST and chlorophyll-a were selected because they are widely recognized as indicators of thermal conditions and coastal productivity that may influence larval transport and habitat conditions.

2.7. Statistical Analysis

Descriptive statistics were used to summarize species composition, abundance, and relative occurrence among sampling stations. Differences in species composition among stations were evaluated using the Chi-square test. Because each habitat category was represented by a single sampling station, inferential statistics were restricted to comparisons among sampling stations rather than replicated habitat treatments. Therefore, statistical significance should be interpreted as evidence of station-level variation rather than direct habitat effects.

2.8. Study Limitations

This study was designed as an exploratory ecological survey using three representative sampling stations and standardized artificial collectors. Because each habitat type was represented by a single station, the study did not include spatial replication within habitat categories. In addition, artificial pocong collectors measure the occurrence of actively swimming pueruli intercepted by the collectors and may also be influenced by local hydrodynamic conditions and collector configuration. Therefore, the findings should be interpreted as baseline station-level observations that provide ecological hypotheses and guidance for future replicated studies rather than definitive evidence of natural habitat preference or settlement success.

Species identification was based exclusively on external morphological characteristics observed at the puerulus stage. Although standardized diagnostic criteria were consistently applied throughout the study, confirmation using molecular techniques or post-settlement rearing was beyond the scope of this study. Consequently, a degree of taxonomic uncertainty cannot be entirely excluded, and the reported species composition should be interpreted as field-based morphological identifications.

3. Results

3.1. Species composition

A total of 319 pueruli were collected from standardized artificial collectors deployed at the three sampling stations during the study period. Field-based morphological examination identified two *Panulirus* species, namely *P. ornatus* and *P. homarus*. Of the total specimens examined, 253 individuals (79.31%) were identified as *P. ornatus*, whereas 66 individuals (20.69%) were assigned to *P. homarus* (**Figure 5**).

Species identification was standardized using the diagnostic morphological characteristics presented in **Figure 4**. Representative specimens assigned to *P. ornatus* consistently exhibited reddish-brown eyes, antennae bearing a distinct terminal bulb, and a pale longitudinal stripe along the proximal abdomen. In contrast, specimens identified as *P. homarus* were characterized by black eyes, transparent antennae lacking a terminal bulb, and mottled abdominal pigmentation without a longitudinal pale stripe. Because species identification relied exclusively on external morphology, without molecular verification or post-settlement confirmation, the reported species composition should be interpreted as a field-based morphological assessment.

Both species occurred at all sampling stations, although their relative abundance varied spatially. *Panulirus ornatus* remained the dominant species across the three stations, whereas *P. homarus* occurred at lower proportions. These observations describe the species composition of pueruli intercepted by standardized artificial collectors and do not necessarily represent the natural abundance of settling pueruli throughout Moramo Bay.

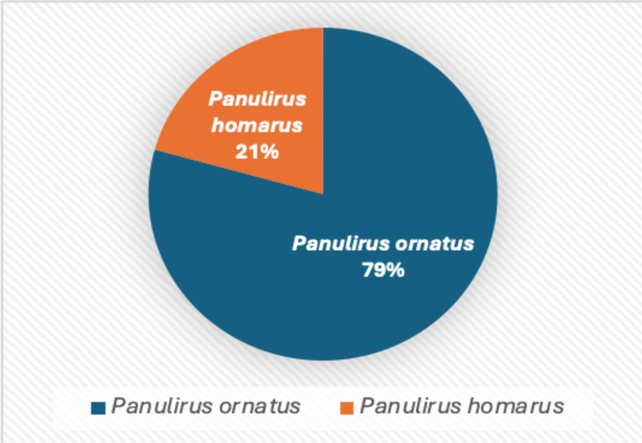

Figure 5. Species composition of spiny lobster pueruli collected using standardized artificial pocong collectors in Moramo Bay, Southeast Sulawesi, Indonesia. *Panulirus ornatus* represented the dominant species (79%), whereas *P. homarus* accounted for 21% of the total collector catches.

3.2. Spatial variation in collector catches

Standardized artificial collectors intercepted different numbers of pueruli among the three representative sampling stations, indicating clear spatial variation in collector-associated occurrence within Moramo Bay. The seagrass-associated station recorded the highest proportion of collected pueruli (44.20%), followed by the coral–sand station (32.29%) and the sandy station (23.51%). These values represent the relative proportion of pueruli intercepted by standardized artificial collectors during the sampling period (**Table 1**).

Differences in species composition among sampling stations were statistically significant ($\chi^2 = 7.71$, $p = 0.021$). Because each habitat type was represented by a single sampling station, these statistical results describe differences among sampling stations and should not be interpreted as replicated habitat-level comparisons.

Table 1. Spatial variation in puerulus collector catches among three representative sampling stations in Moramo Bay, Southeast Sulawesi, Indonesia.

Station	Coordinates	Depth (m)	Habitat Type	*Panulirus ornatus*	*Panulirus homarus*	Total Individuals	Relative Abundance (%)
MB-01	4°08'30.50" S, 122°40'48.00" E	2	Coral-sand	78	25	103	32.29
MB-02	4°08'11.19" S, 122°40'11.49" E	4	Seagrass	107	34	141	44.20
MB-03	4°07'56.84" S, 122°40'05.23" E	6	Sand	68	7	75	23.51
Total				253	66	319	100

3.3. Habitat characteristics

The three sampling stations represented different shallow-water habitat settings. Station MB-01 was characterized by mixed coral rubble and sandy substrate, Station MB-02 by seagrass-dominated habitat, and Station MB-03 by predominantly sandy substrate. These habitat descriptions provide environmental context for the observed spatial variation in collector catches.

3.4. Environmental conditions

Mean sea surface temperature (SST) during 2022–2024 ranged from 30,2 to 30,4 °C (**Figure 6**), whereas mean chlorophyll-a concentration ranged from 0,61 to 1,17 mg m^{-3} (**Figure 7**). Spatial patterns indicated relatively warmer waters in the western and inner portions of Moramo Bay and comparatively cooler waters toward the eastern bay. Conversely, relatively higher chlorophyll-a concentrations were generally observed in coastal waters and gradually declined toward offshore areas.

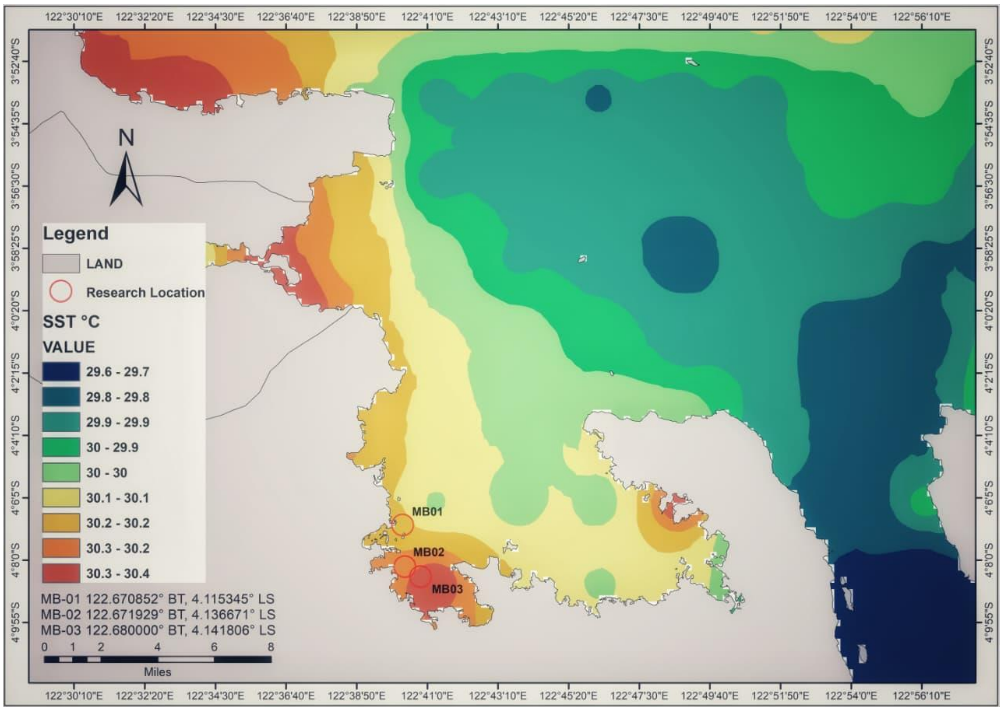

Figure 6. Mean sea surface temperature (SST) in Moramo Bay during 2022–2024 derived from satellite observations. Red circles indicate the three representative puerulus sampling stations used in the field survey.

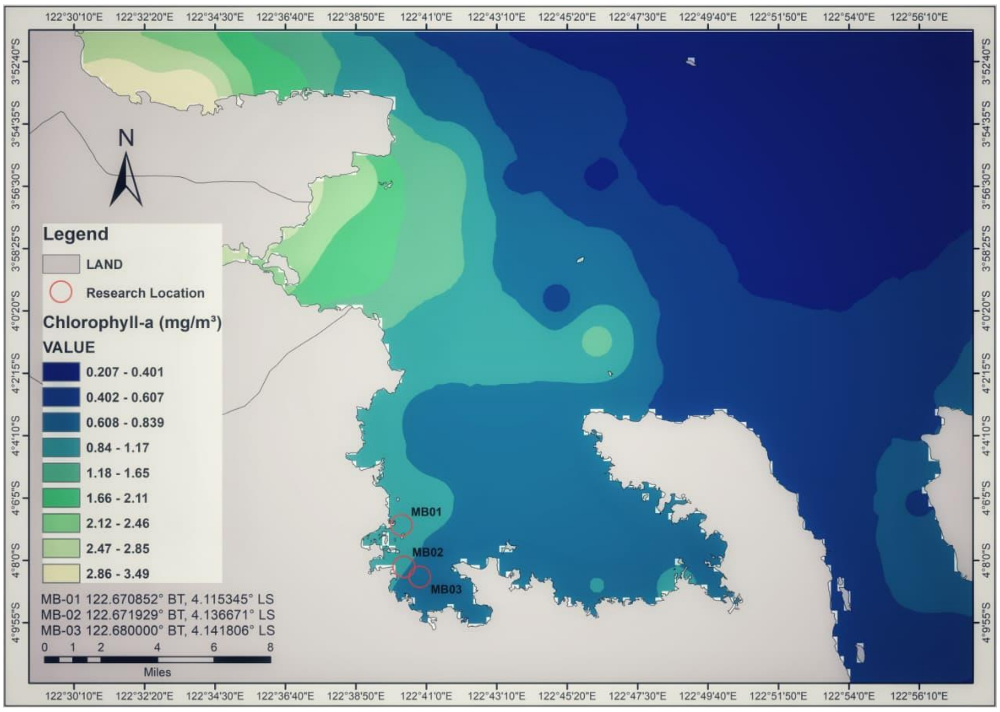

Figure 7. Mean chlorophyll-a concentration in Moramo Bay during 2022–2024 derived from satellite observations. These environmental variables provide regional oceanographic context for the field observations.

Figure 6 and **Figure 7** illustrate the long-term regional oceanographic setting of Moramo Bay based on mean satellite-derived SST and chlorophyll-a during 2022–2024. The three sampling stations (MB-01–MB-03) are superimposed on these maps to provide environmental context for the field observations. These variables are presented to characterize regional environmental conditions and should not be interpreted as direct predictors of puerulus occurrence.

Field measurements of water temperature, salinity, dissolved oxygen, pH, and current velocity also indicated environmental conditions generally suitable for coastal lobster habitats (**Table 2**).

Table 2. Field measurements of water temperature, salinity, dissolved oxygen, pH, and current velocity in Moramo Bay, Southeast Sulawesi, Indonesia.

Station	Depth (m)	Water Temperature (°C)	Salinity (ppt)	Dissolved Oxygen (mg/L)	pH	Current Velocity (m/s)
MB-01	2	29	24.6	7.7	7.5	0.1
MB-02	4	29	24.8	7.9	7.8	0.3
MB-03	6	30	25.1	8.4	7.9	0.5

3.5. Spatial relationships

Spatial variation in collector catches was observed among the three representative sampling stations together with differences in local habitat settings and environmental conditions. Because habitat type and sampling station were not independently replicated, these observations should be interpreted as descriptive station-level ecological patterns rather than evidence of direct ecological relationships or habitat effects.

3.6. Summary of observations

Overall, the field survey documented spatial variation in collector-associated puerulus occurrence among the three representative sampling stations in Moramo Bay. Variation was observed in species composition, collector abundance, habitat setting, and environmental characteristics. These observations provide the empirical ecological baseline used to support the interpretations presented in the Discussion.

4. Discussion

4.1. Spatial variation in puerulus occurrence

The present study documented spatial variation in collector catches of spiny lobster pueruli among three representative sampling stations in Moramo Bay. The seagrass-associated station recorded higher collector catches than the coral–sand and sandy stations. Because standardized artificial collectors were deployed consistently across all stations, these observations suggest that local environmental conditions, larval transport processes, and collector exposure may have contributed to differences in the spatial distribution of intercepted pueruli during the sampling period. However, because the sampling design did not include replicated stations within each habitat category, the observed differences should be interpreted as station-level ecological variation rather than evidence of habitat preference or natural settlement success.

This distinction is important because artificial collectors intercept actively swimming pueruli before benthic recruitment. Consequently, collector catches reflect the combined influence of larval supply, swimming behaviour, local hydrodynamics, and collector exposure rather than habitat selection alone. Similar considerations have been reported in studies of capture-based lobster fisheries, where collector catches are regarded as indices of puerulus occurrence rather than direct measures of successful recruitment (Phillips, 2013; Priyambodo et al., 2020).

4.2. Habitat context and collector catches

The higher collector catches recorded at the seagrass-associated station should be interpreted within the ecological context of that sampling location rather than as evidence that seagrass habitat alone determines puerulus settlement. Artificial collectors intercept actively swimming pueruli before benthic settlement, and the number of individuals captured may therefore reflect the combined influence of larval supply, local hydrodynamic conditions, collector exposure, and surrounding habitat characteristics.

Although seagrass meadows have frequently been reported as important nursery environments for juvenile spiny lobsters, the present findings should not be interpreted as demonstrating habitat preference at the puerulus stage. Instead, the observations indicate that higher collector catches occurred at the representative station characterized by seagrass habitat under the environmental conditions observed during the study period. Additional replicated studies integrating direct settlement observations and hydrodynamic measurements are required to evaluate habitat-specific recruitment processes. Previous studies have shown that habitat structure can influence the distribution and survival of juvenile lobsters, while larval transport processes determine the arrival of pueruli in coastal waters (Lipcius et al., 2008; Suman et al., 2019).

Water depth may also contribute to differences in collector catches among stations, as the collectors were deployed at stations with different depths (2–6 m); however, this factor was not independently evaluated in the present study and therefore cannot be separated from other site-specific environmental influences.

4.3. Environmental conditions and oceanographic context

The satellite-derived sea surface temperature (SST) and chlorophyll-a data presented in this study are intended to characterize the regional oceanographic setting of Moramo Bay during 2022–2024 rather than to establish direct causal relationships with puerulus occurrence. These environmental variables provide important ecological context for interpreting the observed spatial variation in collector catches but should not be considered direct predictors of settlement patterns under the observational design adopted in this study.

The observed spatial correspondence between areas of relatively higher chlorophyll-a concentration and increased collector catches should be interpreted cautiously. Rather than indicating a direct ecological relationship, these observations may reflect the broader oceanographic conditions that influence larval transport, food availability, and retention processes within Moramo Bay.

Future studies integrating concurrent in situ oceanographic measurements, hydrodynamic modelling, and replicated settlement observations would improve understanding of the mechanisms linking regional environmental variability with puerulus occurrence. Comparable observations have been reported from southern Lombok, where variations in sea surface temperature and chlorophyll-a were associated with fluctuations in puerulus catch, although the strength of these relationships differed seasonally and geographically (Junaidi et al., 2021). Similar conclusions have been reported elsewhere, indicating that environmental variables should be interpreted as ecological context rather than independent predictors of puerulus abundance (Caputi and Brown, 1993; Behrenfeld and Boss, 2014). Such approaches would enable more robust evaluation of ecological processes than can be achieved using observational spatial comparisons alone.

4.4. Ecological implications for puerulus recruitment

The present study provides field-based ecological evidence describing spatial variation in collector-associated puerulus occurrence across representative coastal habitats of Moramo Bay. Although the observational design does not permit inference of habitat preference or direct environmental effects, the findings establish an important ecological baseline for understanding the distribution of pueruli within the bay. Such baseline information is particularly valuable because published ecological information on puerulus occurrence in eastern Indonesian waters remains limited.

The standardized use of artificial collectors at representative sampling stations also demonstrates their potential as practical tools for monitoring temporal and spatial variation in puerulus occurrence. Rather than providing direct estimates of natural settlement, collector-based observations offer a consistent approach for detecting changes in relative occurrence under comparable sampling conditions. Such information may support future long-term ecological monitoring and contribute to adaptive management of lobster resources in Moramo Bay.

Future investigations integrating standardized collector observations with hydrodynamic modelling, larval transport analyses, molecular species verification, and post-settlement monitoring would substantially improve understanding of recruitment dynamics in Moramo Bay. Accordingly, ecological observations derived from artificial collectors should be integrated with hydrodynamic modelling, genetic connectivity, and long-term monitoring to better understand regional recruitment dynamics (Hedgecock et al., 2007; Lipcius et al., 2008). The present study therefore provides an ecological reference framework upon which more comprehensive recruitment studies can be developed.

4.5. Implications for sustainable fisheries management

The findings of this study provide baseline ecological information that may support sustainable management of lobster resources in Moramo Bay. Although the present observations are limited to three representative sampling stations and describe collector-associated puerulus occurrence, they contribute valuable information for identifying areas where future ecological monitoring and recruitment assessments can be prioritized.

Regular monitoring using standardized artificial collectors, combined with habitat observations and oceanographic information, may provide an effective framework for detecting temporal changes in puerulus occurrence. Such ecological information could contribute to adaptive fisheries management by supporting evidence-based monitoring rather than serving as a direct basis for harvest regulation or spatial management decisions.

Consequently, the present study should be viewed as an initial ecological baseline rather than a comprehensive management assessment. Future integration of long-term biological monitoring, larval connectivity studies, habitat mapping, and socioeconomic information will be necessary to support ecosystem-based management of lobster resources in Moramo Bay.

4.6. Study limitations and future research

Several limitations should be considered when interpreting the findings of the present study. First, observations were obtained from three representative sampling stations, with each habitat type represented by a single station. Consequently, the observed spatial variation should be interpreted as station-level ecological observations rather than replicated habitat-specific responses. Second, species identification relied exclusively on external morphological characteristics observed at the puerulus stage without molecular verification or post-settlement confirmation. Although standardized diagnostic criteria were consistently applied throughout the study, a degree of taxonomic uncertainty cannot be completely excluded. Third, environmental conditions were characterized using long-term satellite-derived sea surface temperature and chlorophyll-a data to provide regional oceanographic context rather than concurrent in situ measurements collected during each sampling event. Accordingly, the environmental observations presented here should not be interpreted as evidence of direct causal relationships with puerulus occurrence.

Despite these limitations, the present study provides an important ecological baseline describing collector-associated puerulus occurrence in Moramo Bay using a standardized field sampling approach. Future investigations should incorporate replicated sampling stations within each habitat type, concurrent in situ environmental measurements, hydrodynamic modelling, molecular species verification, and post-settlement monitoring to improve understanding of the ecological processes influencing puerulus occurrence and recruitment dynamics.

In addition, habitat complexity was characterized qualitatively rather than through quantitative measurements such as seagrass density, coral cover, rugosity, or structural complexity indices; future studies should incorporate quantitative habitat assessment to strengthen habitat-level ecological inference.

Temporal variation in puerulus occurrence may also be influenced by seasonal oceanographic conditions, tidal cycles, and lunar periodicity; however, the present survey did not include repeated sampling across seasons or lunar phases, limiting our ability to evaluate such temporal effects.

5. Conclusions

This study provides the first standardized ecological baseline describing habitat-associated occurrence of spiny lobster pueruli collected using artificial pocong collectors in Moramo Bay, Southeast Sulawesi, Indonesia. Higher collector catches were recorded at the seagrass-associated station than at the coral–sand and sandy stations; however, because each habitat type was represented by a single sampling station, these observations should be interpreted as station-level ecological evidence rather than definitive habitat preference.

The combination of field observations, habitat characterization, and remotely sensed environmental information contributes to improving current knowledge of puerulus occurrence in a tropical coastal ecosystem where ecological information remains limited. Rather than establishing causal relationships, the findings provide an initial ecological framework that may guide future investigations on larval connectivity, settlement processes, and spatial dynamics of lobster recruitment.

Future research incorporating replicated habitat sampling, seasonal observations, hydrodynamic analyses, and post-settlement monitoring will be essential to strengthen ecological inference and support evidence-based management of Indonesia's lobster seed resources.

Conflicts of Interest

There are no conflicts to declare.

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AI Writing Statement

Artificial intelligence-assisted tools were used only for limited language refinement and grammatical improvement during manuscript preparation. All scientific interpretation, data analysis, figure preparation, and final manuscript content were reviewed and approved entirely by the authors, who take full responsibility for the accuracy and integrity of the work.

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