



Population structure and local utilization of spider conch (lambis lambis) in abang island waters, batam



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ABSTRACT

This study explores the population structure, spatial distribution, and community utilization of Lambis lambis on Abang Island as a foundation for species conservation and community-based management. The research aims to examine the population structure and distribution patterns of *Lambis lambis* as well as its utilization by fishing communities on Abang Island, Batam. Data were collected using a 50-meter quadrat transect method with observation plots measuring 5 m × 5 m, along with measurements of environmental parameters (dissolved oxygen, temperature, and salinity). The results indicate low population density (0.012–0.028 ind/m²) and a clustered distribution pattern (Morisita Index > 1). A positive correlation was found between dissolved oxygen and population density, while high temperature showed a negative correlation. These findings suggest that environmental pressure and exploitation influence the spatial distribution of *Lambis lambis*. This study provides a scientific basis for community-based management and species conservation.

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INTRODUCTION

Small island coastal ecosystems play a crucial role in maintaining marine biodiversity and supporting ecosystem services, particularly in tropical regions where shallow waters provide optimal conditions for benthic organisms (Heip, 2016). In Indonesia, many small islands are simultaneously experiencing rapid development driven by coastal tourism, which often intensifies anthropogenic pressure on marine habitats through increased resource extraction, habitat disturbance, and environmental degradation (FAO, 2024). These pressures pose significant challenges to the sustainability of coastal biota, especially benthic invertebrates that are closely associated with substrate conditions and water quality.



Abang Island, located in the southern waters of Batam City, Riau Islands Province, represents one such small island ecosystem currently undergoing marine tourism development. The waters surrounding Abang Island are characterized by relatively well-preserved coral reefs, sandy substrates, and high marine biodiversity, making them suitable habitats for various gastropods and other benthic organisms (Efendi et al., 2024). However, increasing tourism activities and local resource utilization have raised concerns regarding the long-term sustainability of these ecosystems, particularly for species that are directly harvested by coastal communities.

One ecologically and economically important benthic species inhabiting the waters of Abang Island is the *spider conch* (*Lambis lambis*), a marine gastropod belonging to the family Strombidae. This species is widely distributed throughout the Indo-Pacific region and commonly inhabits sandy bottoms, rocky substrates, and coral reef areas from the intertidal zone to depths of approximately 20 meters (Mercier, 2006). *Lambis lambis* exhibits clear sexual dimorphism in shell morphology, with adult females developing longer shell extensions than males, a characteristic associated with reproductive maturity and life-history strategies (Tsuji, 2020b).

From an ecological standpoint, *Lambis lambis* plays a significant role in tropical coastal ecosystems. Traditionally described as a detritivore, this species contributes to sediment turnover and nutrient cycling in shallow marine environments (Laraswati et al., 2020). Subsequent studies have demonstrated that its feeding behavior is more complex, involving the consumption of polychaetes, small crustaceans, and bivalves, thereby positioning *L. lambis* as an active component of benthic food webs rather than a passive detritus feeder (Siraimetan et al., 1988). Changes in the population structure or spatial distribution of this species may therefore influence broader benthic community dynamics and ecosystem functioning.

In addition to its ecological importance, *Lambis lambis* holds considerable socio-economic value for coastal communities. In several Indonesian coastal regions, this species is harvested as a source of protein, utilized in traditional handicrafts, and traded as a local commodity (Kasim et al., 2022). Empirical studies conducted in Banda, Central Maluku, and mangrove ecosystems in Ayah, Kebumen, have shown that *L. lambis* contributes to local food security and offers potential for sustainable coastal-based livelihoods (Ansyar et al., 2025). Nevertheless, unregulated harvesting practices, particularly during low tide periods both day and night, have increased exploitation pressure and raised concerns regarding population decline and long-term sustainability.

Environmental parameters such as dissolved oxygen, temperature, and salinity are widely recognized as key factors influencing the distribution, abundance, and physiological performance of benthic gastropods in intertidal and shallow subtidal zones (Liu et al., 2023). Variations in these parameters can directly affect metabolic rates, reproductive success, and habitat suitability, ultimately shaping spatial distribution patterns. Despite this, site-specific empirical data linking environmental conditions to the population structure and spatial distribution of *Lambis lambis* remain limited, particularly in small island systems experiencing rapid coastal development.

Although several studies have addressed aspects of *Lambis lambis* ecology or utilization, existing research remains fragmented. Previous investigations have predominantly focused on species occurrence, general abundance, or socio-economic use in isolation (Kasim et al., 2022). Integrated studies that simultaneously examine population density, spatial distribution patterns, environmental drivers, and local exploitation practices within a single analytical framework are still scarce. This gap is especially evident in small island tourism contexts, where ecological vulnerability and human dependence on coastal resources intersect. The absence of such integrative assessments limits the development of effective, evidence-based management and conservation strategies.

To address this gap, the present study adopts an interdisciplinary approach by combining quantitative population ecology, analysis of key environmental parameters, and assessment of local utilization practices of *Lambis lambis* in the waters of Abang Island. The novelty of this research

lies in its integrative framework and its focus on an understudied small island ecosystem undergoing tourism-driven transformation. By providing original empirical data on population density, spatial distribution patterns, and their relationship with environmental conditions and human exploitation, this study contributes to a more comprehensive understanding of *Lambis lambis* ecology and management.

Accordingly, the objectives of this study are to (1) assess the population density and spatial distribution patterns of *Lambis lambis* in the intertidal waters of Abang Island, Batam; (2) analyze the relationship between environmental parameters (dissolved oxygen, temperature, and salinity) and population structure; and (3) describe the patterns of *Lambis lambis* utilization by local fishing communities. The findings are expected to provide a robust scientific basis for community-based management and conservation strategies aimed at ensuring the sustainable use of coastal resources in small island ecosystems.

RESEARCH METHODS

Research Design

This study employed a quantitative descriptive research design with an ecological approach to analyze the population density, spatial distribution patterns, and environmental determinants of *Lambis lambis* in the intertidal waters of Abang Island, Batam. The research design integrates field-based ecological surveys with statistical analysis to examine relationships between biological variables and physicochemical water parameters. A transect–quadrat method was selected as the primary sampling design because it is widely recognized as an effective approach for assessing benthic invertebrate populations in shallow coastal habitats, allowing for standardized measurement of abundance and spatial distribution across defined sampling units (Krebs, 2014). The overall research framework consists of field observation, population census, environmental parameter measurement, and quantitative data analysis to address the research objectives.

Population and Samples

The population of this study comprised all individuals of *Lambis lambis* inhabiting the intertidal zone of Abang Island waters. The sampling units consisted of *L. lambis* individuals encountered within predetermined quadrat plots along selected transects. Sampling locations were determined using purposive sampling techniques, based on ecological considerations such as substrate type, accessibility during low tide, and the presence of suitable habitats known to support *L. lambis* populations. Purposive sampling was considered appropriate for this study because the distribution of *L. lambis* is closely associated with specific habitat characteristics, and random sampling could potentially overlook key areas where the species is concentrated.

Instruments

The research instruments consisted of both biological observation tools and water quality measurement devices. Quadrat frames measuring 5m × 5m were used to define observation plots for conducting individual censuses of *Lambis lambis*. Measuring tapes were employed to establish transect lines accurately along the intertidal zone. Field identification guides were used to ensure accurate species identification based on morphological characteristics.

Environmental parameters were measured using portable water quality instruments. Water temperature was measured using a digital thermometer, salinity was recorded using a handheld refractometer, dissolved oxygen (DO) was measured using a portable DO meter, and water pH was assessed using a digital pH meter. All instruments were calibrated before field deployment to ensure the accuracy and reliability of measurements.

Data collection was conducted along five transects, each measuring 50 meters in length, established within the intertidal zone of Abang Island. Along each transect, ten quadrat plots



measuring 5 m × 5 m were systematically placed, resulting in a total of 50 observation plots. This sampling intensity was designed to ensure adequate spatial coverage and representation of habitat variability while maintaining consistency across transects.

Procedures

Field data collection was conducted in August 2025 during low tide conditions to maximize accessibility to the intertidal zone and ensure accurate observation of *Lambis lambis* individuals. Transects were first established at selected locations using measuring tapes, extending parallel to the shoreline (Figure 1). Quadrat plots were then positioned systematically along each transect at predetermined intervals. Within each quadrat, a complete census of *Lambis lambis* individuals was conducted by direct observation, and all individuals encountered were counted and recorded.



Figure 1. Map of Research Location

Simultaneously, environmental parameters were measured at each transect location to capture site-specific physicochemical conditions. Measurements of temperature, salinity, pH, and dissolved oxygen were taken directly in situ to minimize temporal variation. All observations and measurements were documented on standardized data sheets to maintain consistency across sampling units. Morphological characteristics of *L. lambis* were also noted to support qualitative descriptions and species verification.

Data Analysis

Data analysis was conducted using both qualitative and quantitative approaches. Qualitative analysis involved describing the morphological characteristics of *Lambis lambis* based on field observations and existing taxonomic references. Quantitative analysis focused on calculating population density, spatial distribution patterns, and relationships between biological variables and environmental parameters. Population density was calculated by dividing the total number of *L. lambis* individuals recorded by the total sampled area, following standard ecological methods (Krebs, 2014).

$$D_i = n_i / A$$

where:

D_i = population density of species i (individuals m^{-2})

n_i = total number of individuals of species i

A = total sampled area (m^2)

Spatial distribution patterns were analyzed using the Morisita Index to determine whether the distribution of *L. lambis* was random, clustered, or uniform (Krebs, 2014). Interpretation of the index was based on established criteria, where values greater than one indicate clustered distribution, values equal to one indicate random distribution, and values less than one indicate uniform distribution.

$$I_d = n \frac{\sum x^2 - \sum x}{(\sum x)^2 - \sum x}$$

where:

I_d = Morisita's Index of Dispersion

n = number of sampling units (quadrats)

$\sum x$ = total number of individuals at each point ($x_1 + x_2 + \dots$)

$\sum x^2$ = total number of individuals at each point squared ($x_1^2 + x_2^2 + \dots$)

The interpretation of Morisita's Index values is as follows:

$I_d = 1$ indicates a random distribution pattern

$I_d > 1$ indicates a clustered (aggregated) distribution pattern

$I_d < 1$ indicates a uniform (regular) distribution pattern

To examine the relationship between population density and environmental parameters, Pearson correlation analysis was applied. This statistical method was used to assess the strength and direction of linear relationships between *L. lambis* density and measured physicochemical variables, including dissolved oxygen, temperature, salinity, and pH.

Pearson Correlation formula :

$$r = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{[\sum (x_i - \bar{x})^2 \sum (y_i - \bar{y})^2]^{1/2}}$$

Where:

r = Pearson correlation coefficient

x_i = individual value of variable x

y_i = individual value of variable y

\bar{x} = average value of variable x

\bar{y} = average value of variable y

Σ = sum

Table I. Interpretation of Correlation Coefficient (r):

r value	Interpretation
0.00–0.19	Very weak
0.20–0.39	Weak
0.40–0.59	Moderate
0.60–0.79	Strong
0.80–1.00	Very strong

Correlation coefficients were interpreted according to conventional thresholds (Table 1), ranging from very weak to very strong correlations. All analyses were conducted to directly address the research objectives and to provide empirical evidence for understanding the ecological and environmental factors influencing *Lambis lambis* populations in the waters of Abang Island.

RESULTS

Population Density of *Lambis lambis*

The population density of *Lambis lambis* recorded across the five transects in the intertidal waters of Abang Island ranged from 0.012 to 0.028 individuals m². As presented in Table 2, the highest density was observed at Transect 3 (0.028 ind m²), while the lowest density occurred at Transect 4 (0.012 ind m²). Transects 1 and 5 showed similar densities of 0.020 ind m², whereas Transect 2 exhibited a slightly lower density of 0.016 ind m².

Table 2. Population density of *Lambis lambis* across transects

Transect	Number of Individuals	Number of Plots	Total Plot Area (m ²)	Population Density (ind/m ²)
Transect 1	5	10	250	0.02
Transect 2	4	10	250	0.016
Transect 3	7	10	250	0.028
Transect 4	3	10	250	0.012
Transect 5	5	10	250	0.02

Overall, the results indicate that the population density of *L. lambis* in the study area is relatively low, with noticeable variation among transects, suggesting spatial heterogeneity in population distribution.

Spatial Distribution Pattern

The spatial distribution of *Lambis lambis*, and the results are presented in Table 3, analyzed using the Morisita Index, showed a consistent clustered pattern across all transects, with index values exceeding one ($I\delta > 1$). The highest Morisita Index value was recorded at Transect 4 ($I\delta = 2.22$), followed by Transect 3 ($I\delta = 1.71$), Transect 2 ($I\delta = 1.67$), and Transects 1 and 5 ($I\delta = 1.60$).

Table 3. Spatial distribution pattern of *Lambis lambis* based on Morisita's index

Transect	Number of plots (n)	Total individuals (N)	$\sum x(x-1)$	Morisita's index ($I\delta$)	Distribution pattern
Transect 1	10	5	4	1.6	Clustered
Transect 2	10	4	2	1.67	Clustered
Transect 3	10	7	6	1.71	Clustered
Transect 4	10	3	2	2.22	Clustered
Transect 5	10	5	4	1.6	Clustered

These results demonstrate that *L. lambis* individuals were not evenly distributed across the study area but instead tended to aggregate in specific locations within the intertidal zone.

Relationship Between Population Density and Environmental Parameters

A Pearson correlation analysis was conducted to examine the relationship between the population density of *Lambis lambis* (ind/m²) and four environmental parameters: dissolved



oxygen (DO), temperature, salinity, and pH. Data were collected from five transects, each with average values for environmental parameters and population density. The results are shown in Table 4.

Table 4. Relationship Between Population Density and Environmental Parameters

Parameter	Pearson r	p-value
DO	-0.84	0.07
Temperature	-0.91	0.03
Salinity	-0.84	0.07
pH	-0.84	0.07

Temperature has a significant negative correlation with *Lambis lambis* density, with a Pearson coefficient of $r = -0.91$ and $p = 0.03$. This indicates that higher water temperatures are associated with lower population densities. Other parameters, DO, salinity, and pH also show negative correlations with density, each with $r = -0.84$ and $p = 0.07$. Although these correlations are relatively strong, they are not statistically significant at the 0.05 threshold.

The visualization of the Pearson correlation analysis reveals clear ecological patterns in the relationship between *Lambis lambis* density and environmental parameters, as shown in Figure 2.

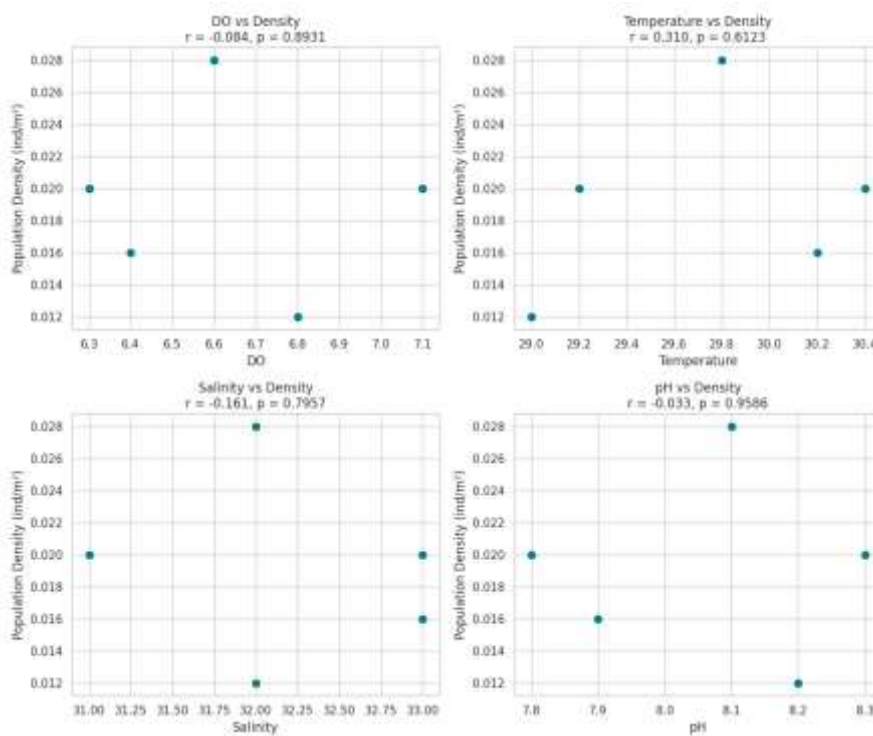


Figure 2. Relationship between *Lambis lambis* density and environmental parameters

The graphical interpretation of the Pearson correlation analysis highlights distinct ecological patterns in the relationship between *Lambis lambis* density and environmental parameters. The scatter plot of temperature against density reveals a clear negative slope, showing that as temperature increases, the density of *Lambis lambis* decreases. This visual trend aligns with the statistical result ($r = -0.91$, $p = 0.03$), confirming a significant negative correlation. Ecologically, this suggests that *Lambis lambis* favors cooler waters within the observed range of 29.0–30.4 °C.

In contrast, the scatter plot of dissolved oxygen (DO) against density shows only a slight downward trend, less pronounced than that of temperature. The correlation coefficient ($r = -0.84$, $p = 0.07$) indicates a moderately strong negative relationship, but it is not statistically significant. This implies that higher DO levels may coincide with lower densities, though the evidence remains inconclusive. Similarly, the scatter plot of salinity against density shows a weak negative trend, with density decreasing as salinity increases. The correlation ($r = -0.84$, $p = 0.07$) suggests a possible relationship, but again it is not statistically significant. This may indicate that *Lambis lambis* tolerates only a narrow salinity range, and further data are required to confirm.

Finally, the scatter plot of pH against density appears relatively flat, with no strong visual slope. The correlation ($r = -0.84$, $p = 0.07$) suggests a negative tendency, but it is not significant. This indicates that within the measured pH range of 7.8–8.3, *Lambis lambis* density is not strongly influenced. Overall, the visualizations emphasize temperature as the most critical factor affecting *Lambis lambis* density, while DO, salinity, and pH show weaker, non-significant trends that warrant further investigation with expanded datasets.

Utilization by Local Communities

Interview data showed that local fishers actively harvest *Lambis lambis* primarily for household consumption and local sale. Harvesting activities were reported to be seasonal and concentrated in areas where *L. lambis* populations appeared visually abundant, particularly during low tide conditions.

DISCUSSION

Population Density in Relation to Habitat Conditions

The relatively low population density of *Lambis lambis* observed in the intertidal waters of Abang Island suggests that the species may be experiencing ecological pressure. Similar low-density patterns have been reported in other Indonesian coastal areas, particularly in locations subjected to intensive harvesting and habitat disturbance (Rizkya et al., 2012); Toby et al., 2017). Transects exhibiting higher densities are likely associated with more favorable habitat characteristics, such as sandy substrates mixed with coral rubble, which provide both food availability and shelter.

In contrast, lower-density transects may reflect suboptimal habitat conditions or higher levels of anthropogenic disturbance. Harvesting pressure by local communities, especially when conducted repeatedly in the same areas, may contribute to localized population decline.

Ecological Interpretation of Clustered Distribution

The clustered distribution pattern observed across all transects is consistent with findings from previous studies on benthic gastropods in tropical coastal ecosystems (Alman et al., 2015). Aggregated distribution is often driven by patchy resource availability, habitat heterogeneity, and behavioral responses to environmental stress. For *L. lambis*, clustering likely reflects a preference for microhabitats that offer suitable substrates, food resources, and protection from predators. However, such aggregation also increases vulnerability to localized overexploitation, as fishers tend to target areas with high visible abundance. This finding highlights the importance of spatially explicit management strategies.

Influence of Environmental Parameters

The strong positive correlation between dissolved oxygen and *L. lambis* density confirms the importance of oxygen availability for benthic gastropods. Dissolved oxygen influences metabolic activity and survival, particularly in shallow intertidal environments where fluctuations are common (Ndahama et al., 2024). The negative relationship with temperature suggests that thermal stress

may limit population density, consistent with previous studies indicating reduced physiological performance of gastropods at elevated temperatures (Tsang et al., 2024).

Although salinity showed a weak correlation, extreme fluctuations in salinity have been reported to affect gastropod survival and reproduction (Sun et al., 2021). The tendency of *L. lambis* to aggregate in microhabitats may represent an adaptive strategy to mitigate unfavorable environmental conditions at a broader spatial scale. The analysis shows that *Lambis lambis* density is most strongly and significantly influenced by temperature, while dissolved oxygen (DO), salinity, and pH exhibit weaker, non-significant negative correlations. This highlights temperature as the dominant ecological driver, consistent with broader marine gastropod studies.

The Pearson correlation analysis revealed that temperature has a significant negative correlation ($r = -0.91$, $p = 0.03$) with *Lambis lambis* density. This suggests that higher water temperatures reduce the abundance of this gastropod species. Such findings are consistent with research on marine mollusks, which shows that warming seas can alter shell morphology, reduce fitness, and shift population distributions (Chatzinikolaou et al., 2021). Gastropods, like other calcifying organisms, are sensitive to thermal stress, and their abundance tends to decline in warmer, less stable environments (Yeo et al., 2024). This supports the interpretation that *Lambis lambis* prefers cooler waters within the observed range (29.0–30.4 °C).

For dissolved oxygen (DO), the correlation was moderately strong but not statistically significant ($r = -0.84$, $p = 0.07$). Although oxygen is essential for metabolic processes, benthic invertebrates often migrate or reduce activity when DO levels fluctuate (Ndahama et al., 2024). Studies in estuarine and coastal ecosystems show that low oxygen conditions can drastically reduce benthic diversity and abundance (Rabalais, 2020). In this dataset, however, DO values remained relatively high (7.2–7.5 mg/L), which may explain why the correlation was not significant oxygen was not limiting within the observed range.

Salinity also showed a negative but non-significant correlation ($r = -0.84$, $p = 0.07$). Marine mollusks generally exhibit specific tolerance ranges for salinity, with both extreme increases and decreases leading to stress and reduced abundance. Research in hypersaline lagoons demonstrates that molluscan diversity and density shift along salinity gradients, with species richness declining outside optimal ranges (Suárez-mozo & Papiol, 2023). The weak correlation here may reflect that salinity values were relatively stable (0.24–0.26‰), limiting variability in population response.

Finally, pH displayed a flat relationship with density ($r = -0.84$, $p = 0.07$). Within the measured range (7.8–8.3), *Lambis lambis* density was not strongly affected. However, broader studies on ocean acidification show that declining pH can significantly reduce molluscan abundance and species richness (Id et al., 2021). The lack of significance in this dataset likely reflects the narrow pH range observed, which remained within tolerable limits for gastropods

Implications of Local Utilization

The active harvesting of *Lambis lambis* by local communities, combined with low population density and clustered distribution, suggests that the species is under combined ecological and socio-economic pressure. Similar patterns have been documented in Pulau Pramuka and Pantai Baobolak, where intensive harvesting led to reduced gastropod densities (Tsuji, 2020a).

These findings underscore the need for community-based management approaches that incorporate spatial zoning, seasonal harvesting regulation, and habitat protection. Integrating ecological data with local knowledge can enhance the effectiveness of conservation strategies while maintaining community livelihoods.

Overall Implications

Taken together, the results indicate that *Lambis lambis* populations in the waters of Abang Island are sensitive to both environmental variability and human exploitation. The combination of

low density, clustered distribution, and strong dependence on dissolved oxygen and temperature highlights the species' potential role as a bioindicator of coastal habitat quality. Long-term monitoring and spatially explicit management are essential to ensure the sustainability of *L. lambis* populations in small island ecosystems.

CONCLUSION

This study demonstrates that the population density of *Lambis lambis* in the intertidal waters of Abang Island is relatively low and spatially heterogeneous, with densities ranging from 0.012 to 0.028 individuals m², while its distribution pattern consistently exhibits a clustered arrangement across all transects. The strong positive correlation between population density and dissolved oxygen, along with the negative correlation with temperature, indicates that *L. lambis* is highly sensitive to physicochemical water conditions, particularly oxygen availability and thermal stress. These findings confirm that both environmental factors and localized exploitation by coastal communities play a decisive role in shaping the spatial distribution and population structure of the species. The novelty of this research lies in its integrative approach, which simultaneously links quantitative population ecology, environmental parameters, and patterns of community utilization within a small island tourism context that has received limited scientific attention. The clustered distribution pattern identified in this study highlights an increased risk of localized overharvesting, emphasizing the need for spatially explicit, community-based management strategies. It is therefore recommended that conservation efforts incorporate habitat zoning, regulation of harvesting intensity, and continuous monitoring of key environmental parameters to ensure the long-term sustainability of *Lambis lambis* populations in Abang Island waters.

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