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Environmental Suitability for Lobster (Panulirus SP.) Aquaculture Using Floating Net Cage Systems in the Coastal Waters of Sukabumi Regency

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Abstract - Sukabumi Regency possesses abundant marine aquatic resources that offer significant potential for the development of lobster (*Panulirus* sp.) aquaculture using floating net cage (FNC) systems. However, the success of aquaculture activities is highly dependent on the suitability of the aquatic environmental conditions. This study aimed to assess the environmental suitability of the coastal waters of Sukabumi Regency for lobster aquaculture development to provide a scientific basis for sustainable mariculture zoning management. The research was conducted from December 2025 to March 2026 at five sampling stations in the coastal waters of Sukabumi Regency, West Java Province. Parameters measured in situ included water temperature, water transparency, salinity, dissolved oxygen (DO), and pH, whereas wave height data were obtained from the Sukabumi Meteorological, Climatological, and Geophysical Agency (BMKG). Suitability analysis was performed using a static scoring method with a Suitability Index (SI) categorized into S1 (Highly Suitable), S2 (Suitable), and N (Not Suitable). The results revealed water temperatures ranging from 30.7 to 31.0°C, a mean salinity of 29 ppt, DO concentrations of 8.65–9.28 mg/L, and pH values of 6–7. Wave height emerged as the primary limiting factor, with a mean of 1.60 m, substantially exceeding the tolerance threshold of 0.2–0.4 m. Suitability Index values ranged from 66.67 to 77.78%, with a mean of 73.33%, and all sampling stations were classified under the S2 (Suitable) category. Nevertheless, elevated wave heights constitute a significant constraint that may compromise the structural integrity of FNC installations. Modifications to aquaculture technology or relocation of the system to land-based circular tank methods are recommended as adaptive solutions.

Keywords: Floating net cage, Lobster aquaculture, Suitability index, Sukabumi, Water quality

I. INTRODUCTION

Lobster represents one of the most widely distributed and economically significant fisheries resources in Indonesia [1]. The development of marine lobster (*Panulirus* sp.) aquaculture using floating net cage (FNC) systems warrants proper management and utilization to enhance community income and support sustainable livelihoods [2]. The aquatic resources of Sukabumi Regency are abundantly available and hold considerable potential for improving community welfare [3].

Lobster aquaculture has yet to emerge as a primary activity in Sukabumi Regency, primarily due to the limited knowledge among local fish farmers regarding ideal site selection, appropriate aquaculture technologies, and the vulnerability of lobsters to disease-related mortality and unsuitable environmental conditions [4]. Site selection constitutes one of the most critical determinants of aquaculture success. In this context, water quality at the aquaculture site represents an essential parameter requiring careful evaluation [5].

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The development of mariculture in Indonesia frequently encounters fundamental challenges in the planning stage. These challenges are closely associated with insufficient comprehensive understanding of the ecological characteristics of aquatic environments, which serve as primary prerequisites for successful aquaculture. The unsuitability of water quality parameters at designated sites further exacerbates these conditions, resulting in failures in identifying optimal aquaculture zones. Site selection is therefore a factor that cannot be overlooked in ensuring the continuity and overall productivity of aquaculture operations [6].

Based on these conditions, this study aimed to analyse environmental suitability of the coastal waters of Sukabumi Regency for the development of lobster (*Panulirus* sp.) aquaculture. The findings are expected to serve as a scientific foundation for informed decision-making in the management of sustainable marine aquaculture zones.

II. MATERIALS AND METHODS

2.1 Study Area and Duration

This study was conducted from December 2025 to March 2026. The research sites were located in the coastal waters of Sukabumi Regency, West Java Province. Equipment employed in the study included litmus paper, water thermometers, a DO meter, a refractometer, a Secchi disk, and data retrieved from the BMKG online platform.

2.2 Data Collection

Data collection was carried out three times at each sampling point through in situ measurements of water quality parameters, including pH, surface water temperature, dissolved oxygen, salinity and water transparency. Wave height data for the coastal waters of Sukabumi Regency were obtained from the Sukabumi office of the BMKG.

2.3 Data Analysis and Suitability Assessment

The suitability level for lobster aquaculture was determined using static suitability analysis, which classifies each parameter into three categories: S1 (Highly Suitable), S2 (Suitable), and N (Not Suitable) [7]. Suitability classification of the aquatic environment was based on the alignment of physical water conditions with the biological requirements of the cultured organism.

Six parameters were utilized in this study. The value of each parameter (Ni) was obtained by multiplying the parameter weight by the corresponding suitability score. The weighting assigned to each parameter was based on the degree of influence of each variable on aquaculture performance. Scoring was conducted on a three-level scale with values of 1, 2, and 3, calibrated according to established criteria and thresholds. A score of 3 was assigned for Highly Suitable (HS) conditions, a score of 2 for Suitable (S), and a score of 1 for Not Suitable (NS) [8]. The parameters and their weighting criteria are presented in Table 1. The Suitability Index (SI) was calculated using the following formula:

$$SI = (\Sigma Ni / Nmax) \times 100\%$$

Note:

SI = Suitability Index (%)

Ni = Value of the i-th parameter

Nmax = Maximum value

N = Total number of parameters used

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Table 1. Seawater quality parameters and suitability criteria for lobster aquaculture

Parameter	Unit	S1 Highly Suitable	S2 Suitable	N Not Suitable	Reference
Temperature	°C	26–31	22–26; 31–33	<22 and >33	*In situ*
Wave Height	m	0.2–0.4	0.1–0.2; 0.4–0.5	>0.5; <0.1	BMKG
Water Transparency	m	>5	3–5	<3	Hastari et al. (2017)
Salinity	ppt/psu	28–33	26–28 and 33–35	<26 and >35	Verghese et al. (2007)
DO	mg/L	>7	3–7	<3	Mojjada et al. (2012); Rahman & Mansyur (2016)
pH	–	7–8.5	6–7 and >8.5–<9.0	<6 and >9.0	(Lesmana et al., 2022)

Source: Modified from Hartanto et al. (2024)

III. RESULTS AND DISCUSSION

3.1 Water Quality Conditions

Water quality plays a paramount role in supporting the success of lobster aquaculture activities. Accordingly, periodic monitoring of aquatic conditions is an indispensable measure in sustaining lobster aquaculture operations [5]. The results of the aquatic condition analysis at five stations in Sukabumi Regency are presented in Table 2.

Table 2. Water quality parameter measurement results at five sampling station

Parameter	Unit	Station 1	Station 2	Station 3	Station 4	Station 5
Temperature	°C	30.9 ± 1.12	30.8 ± 1.19	31.0 ± 1.30	30.8 ± 0.88	30.7 ± 0.59
Wave Height	m	1.60 ± 0.17	1.60 ± 0.17	1.60 ± 0.17	1.60 ± 0.17	1.60 ± 0.17
Water Transparency	m	2.00 ± 0.32	2.14 ± 0.48	4.31 ± 0.91	4.89 ± 1.66	4.77 ± 0.86
Salinity	ppt	29.67 ± 0.58	29.67 ± 0.58	29.67 ± 1.15	29.50 ± 0.87	29.83 ± 0.29
DO	mg/L	8.65 ± 0.43	8.95 ± 0.25	9.28 ± 0.89	9.07 ± 0.08	8.88 ± 0.77
pH	–	6.00 ± 0.00	6.00 ± 0.00	7.00 ± 0.00	7.00 ± 0.00	7.00 ± 0.00

3.2 Water Temperature

In general, Indonesian waters exhibit daily and seasonal temperature variations, typically ranging from 27°C to 32°C. This thermal range is considered within the tolerance limits that do not significantly impair aquaculture productivity [6]. Water temperature is a physical parameter of considerable significance in determining the equilibrium of aquatic ecosystems. Fluctuations in surface water temperature can exert substantial effects on various physical, chemical, and biological processes occurring in the aquatic environment, including those affecting lobster [9]. Surface water temperatures recorded during the study period through in situ measurements at five stations in Sukabumi Regency ranged from 30 to 31°C, which falls within the acceptable range for lobster aquaculture.

According to [10] noted that water temperature is influenced by season, altitude above sea level, time of day, air circulation, water depth, streamflow, cloud cover, and latitude. The temperature range recorded in this study is considered appropriate for FNC aquaculture operations.

3.3 Wave Height

Wave height represents the most significant primary limiting factor in FNC aquaculture. Precise wave height information is essential, as FNC infrastructure must be capable of withstanding prevailing wave conditions [11]. Data obtained from the BMKG website indicate a mean wave height of 1.6 m in the coastal waters of Sukabumi Regency, substantially exceeding the reference standard of 0.2–0.4 m. Such elevated wave heights pose serious risks to farmers and may cause structural damage to FNC installations. This concern is compounded by strong winds that generate high waves and disrupt aquaculture activities [12].

Irregular wave fluctuations in a given body of water are partially driven by wind dynamics. Wave heights in semi-enclosed and deep-water areas tend to be lower compared to open ocean environments, primarily due to geographic characteristics that provide greater protection from external wave energy [13]. As stated by [14], the more sheltered a location, the smaller the wave amplitude, and vice versa. High wave conditions must be avoided in lobster aquaculture using FNC systems, as they can negatively impact the structural integrity of the installation.

3.4 Water Transparency

Based on measurements at the five stations, water transparency at Stations 1 and 2 did not meet the reference standards, whereas Stations 3, 4, and 5 fulfilled the transparency criteria required for lobster aquaculture. Water transparency conducive to lobster aquaculture is defined as exceeding 5 m [15].

Water transparency is an important variable in determining the success of lobster aquaculture practices. This parameter is associated with the presence of suspended particles in the water column. The concentration of total suspended solids exerts a significant influence on water transparency, whereby increasing suspended solid concentrations are inversely correlated with measured transparency values. The accumulation of large quantities of suspended matter leads to a decline in the natural optical properties of the water body, characterized by elevated turbidity [4]. The accumulation of organic sediment on the substrate can reduce dissolved oxygen concentrations through natural oxidation processes, potentially causing serious adverse effects on lobster survival [16].

3.5 Salinity

Salinity is closely associated with the physiological functioning of organisms inhabiting aquatic environments [11]. Salinity measurements at each station were relatively consistent; however, at Stations 1 and 2, riverine inflows discharge directly into the sea, resulting in mixing of freshwater and seawater [17]. Lobsters are classified as a marine crustacean species that is sensitive to fluctuations in salinity and temperature. Deterioration of water quality may cause lobsters to cease feeding, experience physiological stress, and ultimately succumb to mortality [4].

Salinity measurements in the waters of Sukabumi Regency yielded a mean value of 29 ppt, which was relatively uniform across all stations. The salinity tolerance range for lobster aquaculture is 26–35 ppt. Ghani et al. [18] reported that inappropriate salinity levels lead to suboptimal production outcomes in aquaculture operations. The salinity values recorded at the study sites can be classified as highly suitable for lobster aquaculture.

3.6 Dissolved Oxygen (DO)

Dissolved oxygen (DO) is one of the most critical indicators in the evaluation of water quality. This parameter is commonly expressed as a concentration reflecting the availability of oxygen molecules (O_2) in a given body of water. There is a positive correlation between DO values and water quality: higher dissolved oxygen concentrations correspond to better water quality conditions, while lower DO values indicate water contamination. DO measurements provide insight into the extent to which a water body can support aquatic biota such as lobsters, fish, and microorganisms [19]. DO concentrations in Sukabumi Regency waters ranged from 8.65 to 9.28 mg/L, which are relatively high and highly conducive to lobster aquaculture requirements [8]. Mojjada et al. [20] established the standard DO threshold at >5 mg/L. DO constitutes a critical limiting factor for lobster survival.

3.7 Seawater pH

Seawater pH influences the growth of organisms, including lobsters. The recommended pH range for marine lobster aquaculture is 6.5–9 [21]. In the waters of Sukabumi Regency, pH values ranged from 6 to 7. Stations 1 and 2 exhibited identical pH values, while Stations 3, 4, and 5 recorded pH values of 7, which are within the acceptable reference range. The low pH observed at Stations 1 and 2 may impair phytoplankton growth, which serves as the primary producer in the food chain. This consequently reduces primary productivity in the water column and adversely affects the entire food web, potentially leading to increased disease susceptibility and elevated mortality rates [22] [23].

According to [24] noted that high rainfall intensifies river discharge, which in turn reduces the alkalinity of the water body as indicated by lower pH values. This phenomenon was observed at Stations 1 and 2, which are in proximity to four river outlets that discharge directly into the sea near the sampling locations.

3.8 Suitability Index

The results of the water suitability index analysis for each station in Sukabumi Regency are presented in Table 3.

Table 3. Water Suitability Index for Sukabumi Regency waters by sampling station

Parameter	Station 1 (S1)	Station 2	Station 3	Station 4	Station 5	Remarks	Reference
Temperature (°C)	30.9 (S1)	30.8 (S1)	31.0 (S1)	30.8 (S1)	30.7 (S1)	All S1	(Lesmana et al., 2022)
Wave Height (m)	1.60 (N)	1.60 (N)	1.60 (N)	1.60 (N)	1.60 (N)	All N – Limiting Factor	(Hartanto et al., 2024)
Transparency (m)	2.00 (N)	2.14 (N)	4.31 (S2)	4.89 (S2)	4.77 (S2)	St. 1&2 = N; St. 3–5 = S2	(Hastari et al., 2017)
Salinity (ppt)	29.67 (S1)	29.67 (S1)	29.67 (S1)	29.50 (S1)	29.83 (S1)	All S1	(Verghese et al., 2007)
DO (mg/L)	8.65 (S1)	8.95 (S1)	9.28 (S1)	9.07 (S1)	8.88 (S1)	All S1	(Mojjada et al., 2012; Rahman & Mansyur, 2016)
pH	6 (N)	6 (N)	7 (S2)	7 (S2)	7 (S2)	St. 1&2 = N; St. 3–5 = S2	(Basyuni et al., 2024; Damis et al., 2021)
∑ Score (Ni)	12/18	12/18	14/18	14/18	14/18	Nmax = 18	—
SI (%)	66.67%	66.67%	77.78%	77.78%	77.78%	Mean: 73.33%	
Classification	S2	S2	S2	S2	S2	S2 (Suitable) for all stations	

IV. CONCLUSION

The environmental carrying capacity of Sukabumi Regency waters falls within the Suitable (S2) category. However, given the elevated sea wave heights that pose significant risks to FNC structural integrity, alternative modifications to aquaculture technology are required, including the adoption of wave-resistant FNC designs or the relocation of the aquaculture system to land-based circular tank facilities, as an adaptive and sustainable solution to the prevailing natural conditions of Sukabumi Regency's coastal waters.

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