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Research Article

Spatial Estimations of Suitable Intertidal Habitats for Conservations of Sea Urchin Community in Sancang Coast, West Java

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Abstract
The intertidal zone is an important habitat for marine organisms, including sea urchins. One of the potential intertidal zones is located on West Java's Sancang Coast. However, information about suitable habitats for sea urchins in this particular intertidal zone is still limited. Here, the spatial estimation of suitable habitats has been implemented aided by scoring, interpolation and overlay analysis of environmental variables and numbers of sea urchin individuals using Geographical Information Systems (GIS). Environmental variable measurements and sea urchin surveys were implemented using the belt transect method. The estimated habitats were located at the Ciporeang, Cikujangjambe and Cibako sites, representing the East, Middle and West sides of intertidal zones that have distinct environmental variables. Based on the results, there were three sea urchin species, with *Stomopneustes variolaris* having the highest abundance, followed by *Heterocentrotus trigonarius*, and the lowest one was *Diadema setosum*. Most species were recorded in Cibako. Correspondingly, the Cibako site has a larger zone classified as very high (70%) and highly suitable (30%) for sea urchins as characterized by seagrass and algae cover, low water temperature, high pH, and salinity parameters. On the contrary, more than 50% of the rocky Ciporeang site zones, with warmer water and low salinity and pH, are not suitable for sea urchins. Therefore, the conservation of the Sancang Coast's sea urchin community should prioritize Cibako sites.

Keywords: intertidal, GIS, sea urchin, spatial, suitability

1. INTRODUCTION

Sea urchin, a member of Echinodermata: Echinoidea, is a very important group because this organism plays a major role in cleaning the ocean bottom [1]. This species can be found in tropical marine water to the poles [2]. In marine ecosystems, sea urchin is occupying and preferring intertidal zones. The area of the intertidal zone is very limited in size but has varied environmental factors, so it has a fairly high diversity of organisms and ecosystems. Sea urchin also inhabits rocky areas and vary in their distribution starting from 1 m to 17 m in deep. Sea urchins are slow-moving grazers in intertidal and subtidal marine systems. They primarily feed on macroalgae, yet occasionally feed opportunistically on marine invertebrates and biofilm. As a bottom feeder, sea urchins are keystone species in the structuring of kelp forest communities.

Intertidal zones of Indonesia's coastal water were also known to have a high abundance of sea urchins [3]. According to Ristanto et al. [2], the density of sea urchins in Lemukutan Island, Bengkayang ranged from 273–453 ind/Ha. Meanwhile, the density of sea urchins on Penata Kecil Island ranged from 167–347 ind/Ha and on Penata Besar Island has a range from 307–387 ind/Ha. Intertidal zones of Sancang Coasts were known to have marine organism diversity ranging from seagrass [4] that functioned as food resources for marine fauna, gastropods [5], echinodermata, and particular Holothuroidea [6]. Despite extensive studies on Sancang's intertidal zones, there is a paucity of sea urchin communities and which sides of Sancang's intertidal zones should be protected and conserved. Here, this study aims to estimate suitable habitats for supporting the conservation of sea urchins in Sancang's intertidal zones.

2. MATERIALS AND METHODS

2.1. Study Site

This research was conducted at intertidal zones of Sancang Coast, Garut District, West Java, Indonesia on July 19-21, 2020. The research location was a part of Leuweung Sancang Natural Reserve. The research location consists of 3 stations, namely station 1 located in Ciporeang on

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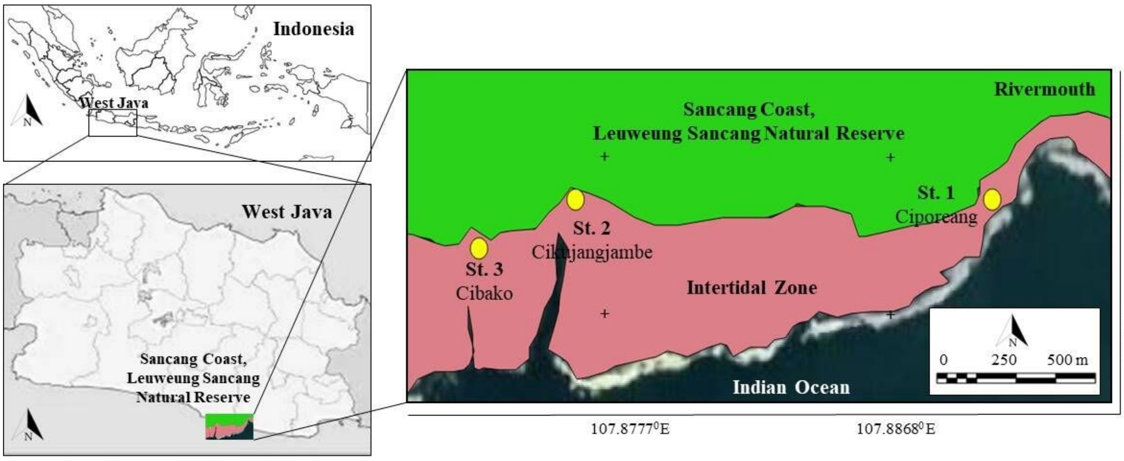

Figure 1. Three station (St. 1, St. 2, St. 3) locations at intertidal zones of Sancang Coast, Leuweung Sancang Natural Reserve, West Java, Indonesia.

the East side with rock and coral substrates, station 2 located in Cikujangjambe in the middle with a sandy substrate overgrown with algae, and station 3 located in Cibako in the West side which is dominated by seagrass and algae (see Table 1). These three stations were chosen because the three locations have quite different ecological characteristics, so they are assumed to have different sea urchin species diversity. All stations were bordered by a natural reserve on the North side and Indian Ocean on the South side. The research location is shown in Figure 1.

2.2. Methods

2.2.1. Sea Urchin Sampling and Surveys

Sea urchin sampling was carried out using the belt transect method which a transect was drawn perpendicularly from the coast to the sea for 100 m. Sampling was carried out at 3 stations (Table 1) and each station contained 100 plots with a size of 1×1 m for each plot in sequence. Identification of sea urchins was carried out by comparing the morphology of the sea urchin species obtained with the morphological characteristics identified by Raghunathan et al. [7]. Moreover, the scientific articles based on the shape, color, spines, and patterns of sea urchins were also reviewed.

2.2.2. Environmental Variable Measurements

Measurements of the environmental variable at each station were carried out around 07.00-09.00 AM (GMT+7). Measured environmental variables were including pH, salinity (‰), dissolved oxygen (DO, mg/L), and water temperature (°C). All variables were measured *in situ* using digital multiparameter devices.

2.2.3. Suitable Habitat Estimation Analysis

Estimations of suitable habitats for sea urchins followed the workflow (Figure 2) and methods reported by Meixler and Bain [8] and Boitt et al. [9]. The used suitability method was the scoring and overlay of environmental variables and sea urchin individual numbers mapped into an intertidal zone map. All environmental variable values including pH, salinity, dissolved oxygen, and water temperature were scored from the lowest and the highest value. The lowest score of the variable was considered the least suitable and the highest score of the variable was considered more suitable. Then, all the score values were tabulated into the Geographical Information System (GIS) table along with their geocoordinates.

The tabulated GIS tables containing environmental variables and sea urchin individual numbers were used and interpolated to create GIS layers and vector shapes. All the layers were overlayed and score values in each environmental variable layer and vector shape were summed to create composite layers. The final step was to classify score values in the composite layers and vector shapes with the highest score values. They were classified as the most suitable habitat classified as high-very high classes. While the vector shapes with the lowest score values were classified as the least suitable habitat classified as low-very low classes. This process was conducted

Table 1. Characteristics of study sites.

Stations	Latitude	Longitude	Substrates and remarks
1. Ciporeang-East	7°44′19″ S	107°52′9″ E	Rock and coral substrates. Bordered directly by a river mouth. Fragmented and patchy seagrass covers are observed here.
2. Cikujangjambe-Middle	7°44′19″ S	107°52′38″ E	A sandy substrate overgrown with algae.
3. Cibako-West	7°44′24″ LS	107°52′26″ E	Dominated by seagrass and algae. The bottom substrates consist of rocky substrates.

by using GIS software (ArcView 3.3).

2.2.4. Statistical Analysis

Statistical analysis of Chi-square was used to calculate the significant differences in compositions of areas designated as the most and the least suitable habitats for stations 1, 2 and 3. The significant level used was $p < 0.05$.

3. RESULTS AND DISCUSSIONS

3.1. Sea Urchin Community

Based on the results, there were 3 sea urchin species observed at the intertidal zones of the Sancang Coast. Those species were *Diadema setosum*, *Heterocentrotus trigonarius* and *Stomopneustes variolaris*. Mean individuals based on the species (Figure 3.a) shows that *S. variolaris* has the highest mean individuals up to 6.3 individuals (95%CI: 0-13.9), followed by *H. trigonarius* up to 1.6 individuals (95%CI: 0-4.94), and the lowest mean was observed in *D. setosum* with values of 1.3 individuals (95%CI: 0-3.94). While mean individuals of sea urchins based on the locations (Figure 3.b) shows that the Cibako site has the highest sea urchin individual mean with values of 7.6 individuals (95%CI: 1.43-13.9).

Figure 4 depicts the spatial distributions and species compositions of individual numbers of sea urchin species such as *D. setosum*, *H. trigonarius* and *S. variolaris* at the Sancang Coast, Leuweung Sancang Natural Reserve, West Java, Indonesia. It can be seen that Cibako site has more species in comparison to Ciporeang and Cikujangjambe sites. Besides that, *S. variolaris* is the most common species since it has a wider distribution in comparison to other species. This species has dominated both the Ciporeang and Cikujangjambe sites.

3.2. Environmental Variables

Figure 5 shows the spatial pattern and distribution of measured environmental variables. Based on the result, the water temperature was increasing towards the Ciporeang site, or station 1, on the East side. The water with the highest temperature (28.1 °C) was observed at station 1. A similar pattern can be observed for the dissolved oxygen parameter. The dissolved oxygen was also rising along the Sancang Coast's intertidal zones. The highest water dissolved oxygen was observed in station 1 was equal to 5.64 mg/L. In contrast, pH and salinity showed the opposite pattern. According to the result, pH was observed declining towards the Ciporeang site, or station 1 on the East side, with the lowest pH value at 8.34. Similarly, salinity was also observed declining towards the Ciporeang site, or station 1 on the East side, with the lowest salinity values at 32.65. This condition makes the seagrass and algal dominant sites at Cibako in the West have colder water, alkali water, high salinity, and less dissolved oxygen. While the rocky Ciporeang on the East side has warmer water, acidic water, low salinity yet oxygen-rich water.

3.3. Suitable Habitat Estimations

Figure 6 shows the habitat suitability for sea urchin species at intertidal zones using the presence of sea urchins and environmental variables as inputs. It can be seen that the suitability was increasing from the East to the West sides, and this made the intertidal zones on the East side not suitable, while the intertidal zones on the West side were the most suitable (Chi-square test, $x^2 = 338.221$, $p < 0.05$). Up to 55% of intertidal zones (Figure 7) at Ciporeang were classified as not suitable, and only 45% of the zones were moderately suitable. The Cikujangjambe sites in the middle have up to 70% of the intertidal zones classified as suitable. While all intertidal zones at Cibako sites were suitable for sea urchins with 70% classified as very high and 30% as high suitable.

3.4. Discussions

This research highlights the importance of sea urchin conservation by elaborating on the suitable habitats for conserving the sea urchin community in the intertidal zones of the Sancang Coasts. This is in agreement with Matsiori et al. [10] previous studies that highlight current threats to sea urchins and the importance of designating conservation areas by determining suitable habitats. The determination of suitable habitat will lead to the establishment of Marine Protected Areas (MPA) that have proven to be a successful tool for the conservation of marine forests and the control of sea urchin populations [11][12].

In the intertidal zones, *D. setosum* individuals were very rare in comparison to other sea urchin species. According to an interview with the local community, *D. setosum* was frequently consumed. The *D. setosum* sea urchin is edible and desirable as food by locals and is a promising target for potential fishing [13]. *S. variolaris*, on the other hand, was abundant and widespread throughout the intertidal zone, with the highest individual numbers observed at the Ciporeang site. The presence of *S. variolaris* in varied substrates was related to the adaptation ability of this species [14]. Sea urchins belonging to Stomopneustidae can use their sharp teeth to carve sedimentary rocks and create pits in which their spheroid-shaped bodies can fit, and this adaptation ability explains *S. variolaris's* presence across intertidal zones of the Sancang Coast [15].

The Cibako site was selected as the most suitable habitat considering several environmental variables that can favour the life of sea urchins. This is very important since differences in the distribution and abundance of sea urchins may be attributed to the variability of habitats available across sites [16]. Besides that, since one of the urchin species, *D. setosum*, is very rare and threatened by harvesting, designating Cibako as a conservation zone will increase the *D. setosum* density. On the contrary, Ciporeang site was considered suitable. This condition was related to the location of Ciporeang

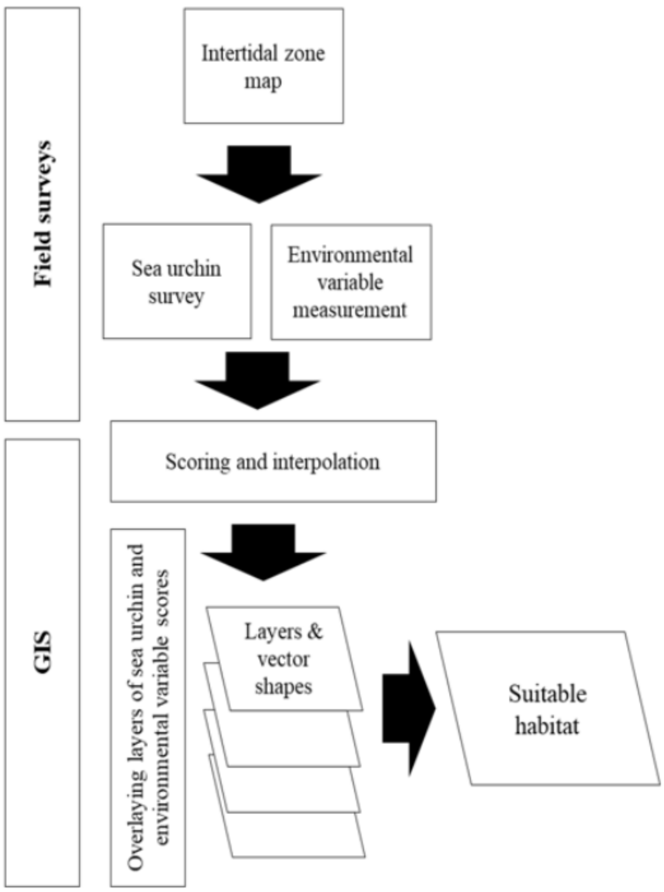

Figure 2. Workflow and method for suitable habitat analysis.

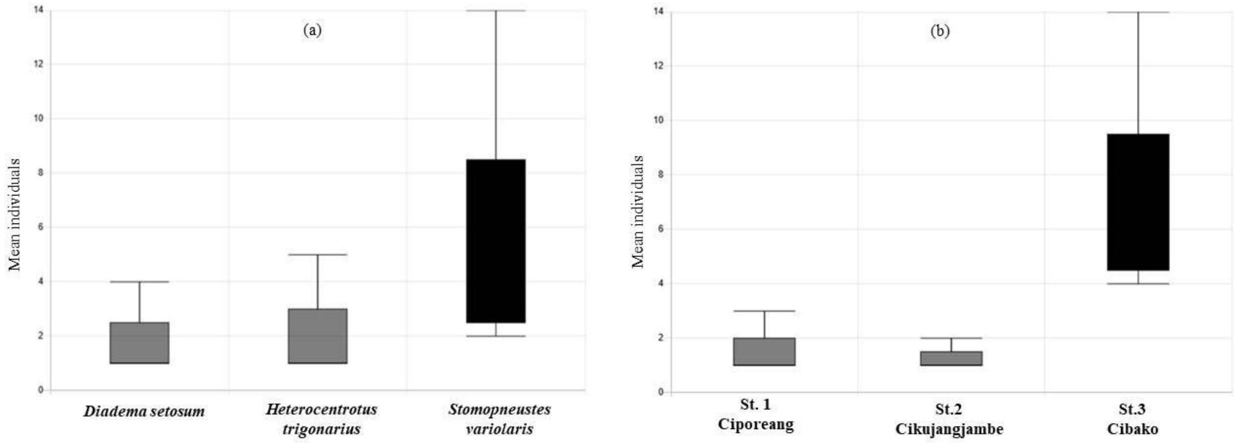

Figure 3. Mean individuals of sea urchins based on species (a) and stations (b) at intertidal zones of Sancang Coast, Leuweung Sancang Natural Reserve, West Java,Indonesia.

near the river mouth. Proximity to the river mouth causes the intertidal zones in Ciporeang to receive more freshwater in comparison to other sites, thus, reducing the water salinity and making these sites unsuitable to fulfil the salinity levels for sea urchins. According to Allen et al. [17], reduced salinity has strong negative effects on fertilization, development, and hatching in sea urchins. Lower salinity as observed in the Ciporeang site will reduce the percentage of eggs that will be fertilized. This explains why the Ciporeang site was not suitable.

Besides declining in salinity, the Ciporeang site also has a pH decline, which makes the water in this site more acidic and not suitable for sea urchins. Despite the fact that the differences in environmental variables were actually quite small, they could have an effect on the species, considering that the urchin is an invertebrate organism that may have less metabolism and mechanisms to cope with environmental variable differences. According to Sato et al. [18], declines in pH will likely affect the ecology and fitness of sea urchins. Besides that, the urchins will grow more slowly in acidic water with declining pH [19]. Acidic water as observed in Ciporeang will increase sea urchin metabolism costs for calcification or cellular homeostasis, and this will impact growth and result in increased mortality of sea urchin larvae during the pelagic life stage [20]. The acidic water at the Ciporeang site has been influenced by its proximity to the river mouth. The river mouth is a site that receives wastewater discharge from a nearby settlement. Domestic wastewater discharged into rivers is the primary contributor to degraded water quality [21]-[23] and acidification in downstream areas [24].

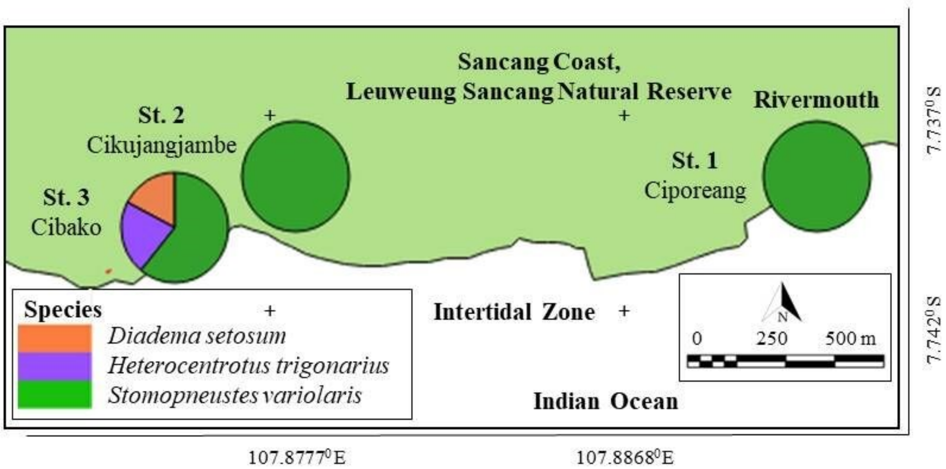

Figure 4. Compositions of individual numbers of sea urchin species (*Diadema setosum, Heterocentrotus trigonarius*, *Stomopneustes variolaris*) at intertidal zones of Sancang Coast, Leuweung Sancang Natural Reserve, West Java, Indonesia.

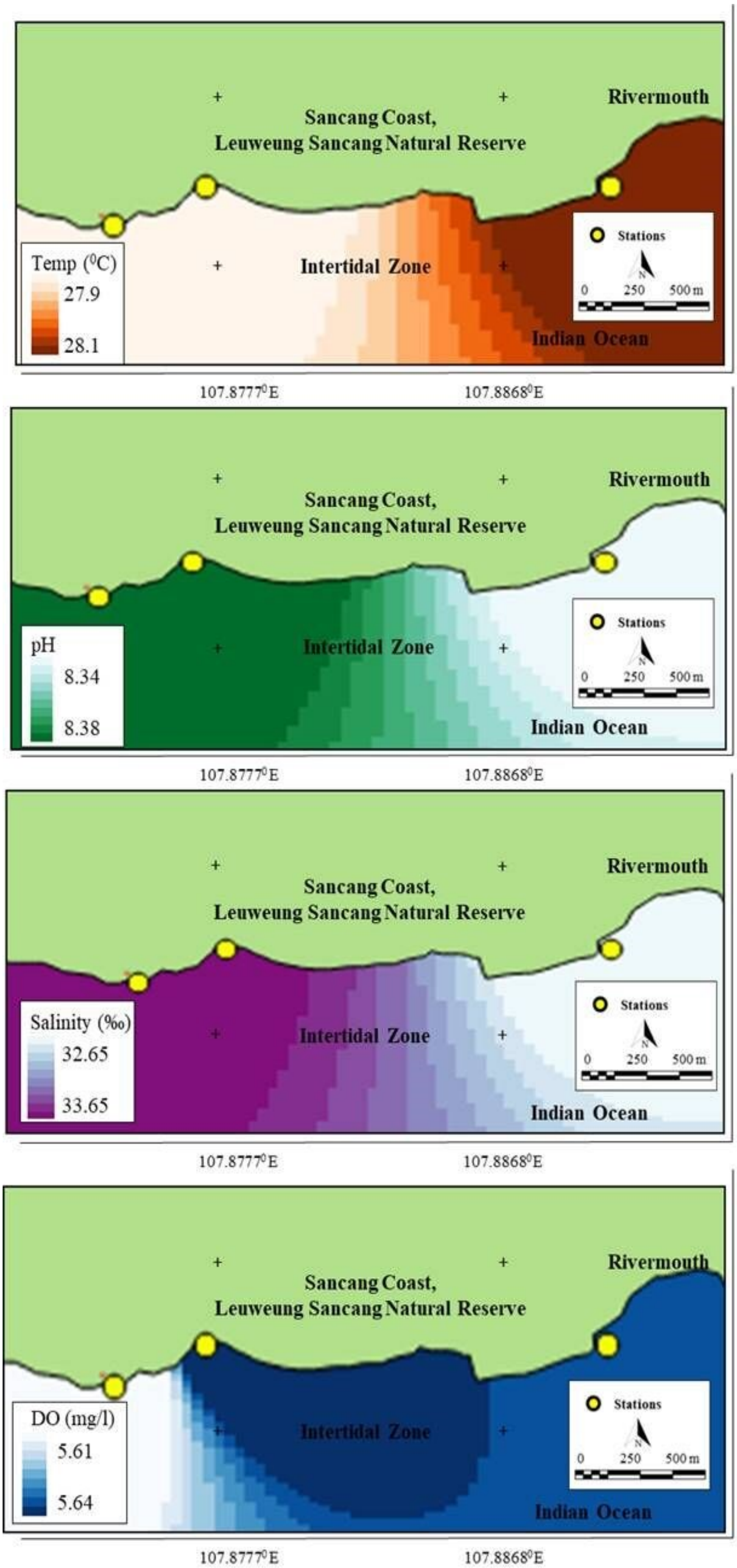

Figure 5. Spatial estimations of environmental variables include water temperature, pH, salinity, and DO at intertidal zones of Sancang Coast, Leuweung Sancang Natural Reserve, West Java, Indonesia.

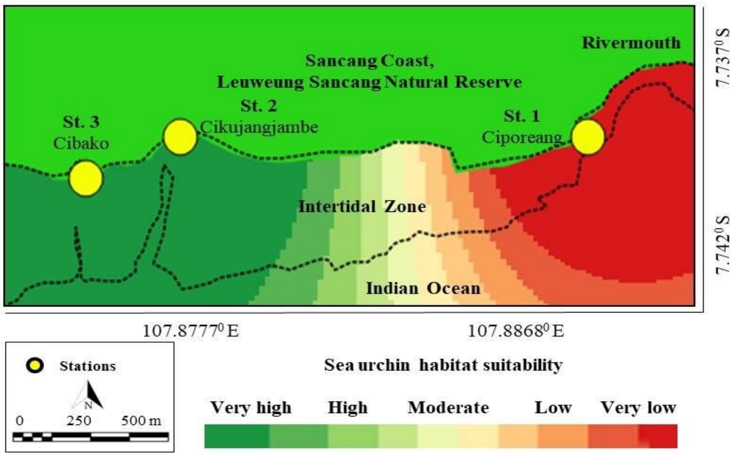

Figure 6. Habitat suitability for sea urchin species at intertidal zones of Sancang Coast, Leuweung Sancang Natural Reserve, West Java, Indonesia.

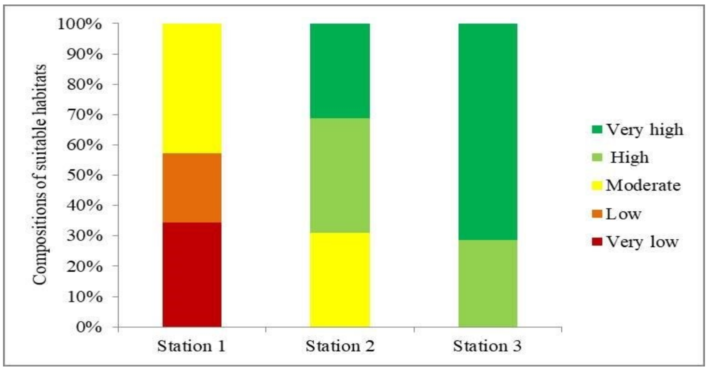

Figure 7. Area compositions of suitable habitats (Chi-square test, $x^2 = 338.221$, $p < 0.05$) for sea urchin species in stations 1, 2 and 3 at intertidal zones of Sancang Coast, Leuweung Sancang Natural Reserve, West Java, Indonesia.

4. CONCLUSIONS

In the intertidal zones of the Sancang Coast, the most abundant and common sea urchin species was *Stomopneustes variolaris*. The West side of the coast at Cibako has the most diverse sea urchin species. This site was also characterized by colder, alkaline and saline water. On the contrary, the Eastern side of the coast at Ciporeang near the river mouth has fewer sea urchin species and is characterized by warmer, acidic and fresh water. It is estimated that the West side at Cibako, followed by the middle side of the intertidal zones with higher than 50% of their intertidal zones classified as high and very suitable, were more suitable than the East side. Then, the conservation of the Sancang Coast's sea urchin community should prioritize the West side, with particular attention to the Cibako sites.

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Author Contributions

V.M. designed the research and supervised all the processes, P.K and I.R.H. collected the field data, and A.W analysed and wrote the manuscript. Finally, A.B. and E.N. proofread the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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