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To cite this article: R Y Aprilianto *et al* 2023 *IOP Conf. Ser.: Earth Environ. Sci.* **1251** 012050

The impact of mangrove environmental conditions on the growth rate of juvenile blue swimming crab (*Portunus pelagicus*) in Polagan Beach, Pamekasan, Madura Island

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Abstract. Mangrove forests have essential ecological functions, especially for coastal areas, one of which is as a shelter for small crab species at the juvenile stage. The research was conducted in Polagan Beach, Pamekasan Regency in November 2020-January 2021. The methods were divided into three sequential parts: pre-survey (processing ofmangrove density data through Sentinel 2 satellite imagery), survey (calculating water quality and mangrove density parameters) and post-survey (determining each point/station that was used to support the continuity of the research). Data used in analysis are primary data (field) and secondary data (satellite image). The satellite image used in this research was acquired from Sentinel 2 satellite. The result concluded that temperature and salinity affect the growth rate of juvenile blue swimming crabs, but it does not occur significantly. The pH and heavy metal levels affect the survival rate of juvenile blue swimming crabs. Optimal temperature and salinitylevels that can produce maximum juvenile growth are temperatures around 28-32°C and salinity around 32-34ppt. The level of mangrove density affected the water quality parameters (temperature and salinity).

Keywords: blue swimming crab, growth, mangrove density, water quality parameters

1. Introduction

Around 15.9 million ha of mangrove forest ecosystems worldwide, and 27% of the mangrove forest are in Indonesia. Mangrove forests have very important ecological functions, especially for coastal areas. The existence of mangroves as a buffer area for other biota in the vicinity indicates the economic value and benefits of mangroves in supporting the sustainability of fisheries [8]. Economic values and benefits can be determined directly or indirectly. One of the species that occupy the mangrove ecosystem is the blue swimming crab in the juvenile stage.

Blue swimming crab (*Portunus pelagicus*) is a fishery commodity with high economic value, much in demand by the public both at home and abroad, and its cultivation has begun to be developed. Therefore, the price is relatively high, which can reach Rp. 30.000-50.000/kg of meat. This crab meat is not only enjoyed domestically but also exported abroad, such as to Japan and the United States in frozen form and to Singapore in new form [5]. Based on the data from the Central Statistics Agency (BPS) in

2019, the export value of crabs reached Rp5.25 trillion. This export value equals the mass of crabs, as much as 25.9 thousand tons.

Polagan Beach is in Polagan Village, Galis District, Pamekasan Regency, Madura. The beach had a sloping morphology and a sandy mud substrate. Mangrove trees were seen along the coastline of Polagan Beach. The dominant mangrove species found on Polagan Beach is *Rhizophora* sp. Polagan Beach has a coastline reaching 2,106 km with an estimated population of 5,382 people. Residents around the coast make a living as fishermen and cultivators. The frequent fishing gear used by fishermen were payang, gill nets, and traps.

Water quality is one of the determinants of cultivation because the cultivated commodities live in water. Therefore, ideal water quality is needed to support the growth and life of aquatic organisms. Salinity is one of the water quality parameters that affect the growth of crabs. Salinity is an environmental parameter that affects biological processes and will directly affect organisms' life, including aquatic organisms' growth rate [5].

This research was conducted because no researchers were discussing the growth rate of juvenile crabs in Polagan Beach, Pamekasan Regency, Madura. This study aims to determine the impact of environmental conditions around mangroves and the impact of mangrove density on the growth rate of juvenile crabs and enhance the productivity of crab commodities in Pamekasan Regency, Madura.

2. Research methodology

2.1. *Time and place*

The research was conducted from November 2020-January 2021 at Polagan Beach, Pamekasan Regency, Madura (Figure 1). The crab samples were obtained directly from crab fishermen using traps and nets.

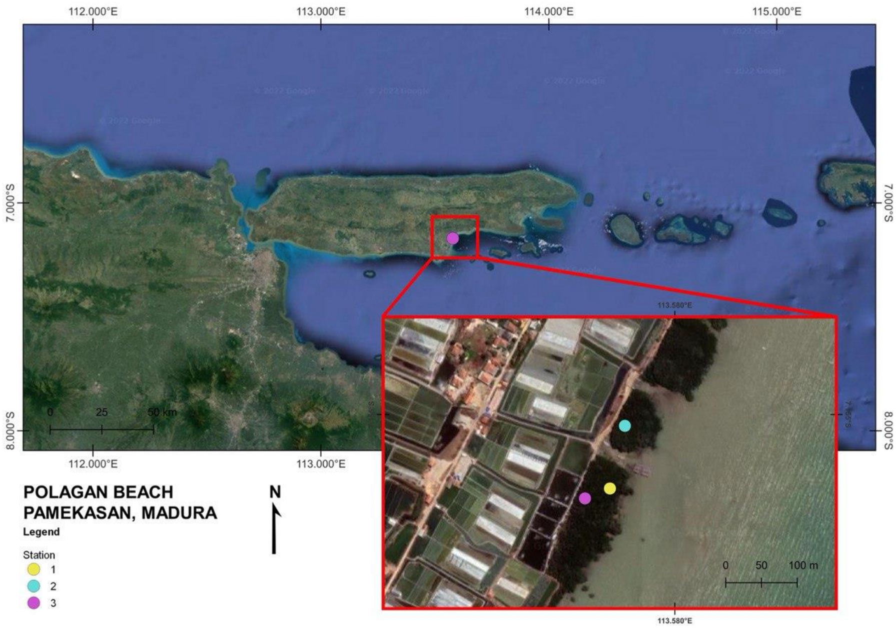

Figure 1. Map of Research Locations on Polagan Beach, Pamekasan Regency, Madura.

2.2. *Pre-survey*

The method used in pre-survey is to acquire mangrove density levels on Polagan Beach using Sentinel 2 satellite imagery data. Sentinel 2 satellite image data processing is shown as follows:

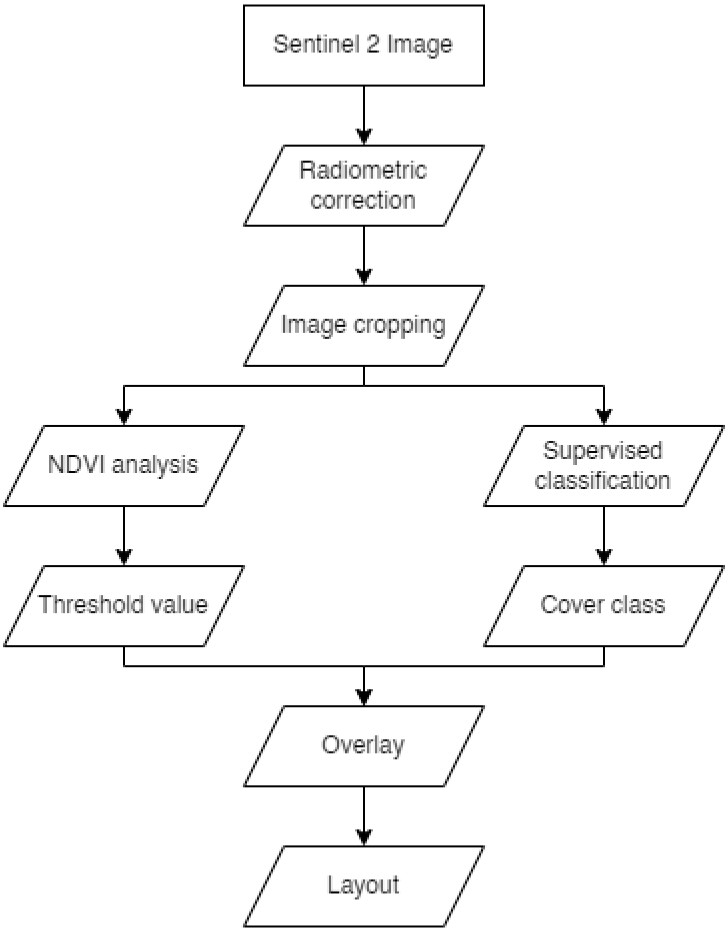

Figure 2. Sentinel 2A satellite image processing scheme to map the mangrove density level.

2.3. Survey
In this research, purposive sampling is the field data retrieval method, which is distributed into 3 stations. The survey stage measures water quality parameters (temperature, salinity, pH, and heavy metals) and mangrove density. This stage also aims to validate the Sentinel 2 NDVI analysis results conducted in the pre-survey stage.

2.4. Post survey
The post-survey is the final stage used to determine the effect of mangrove environmental conditions on the growth rate of juvenile crabs. This study uses an experimental system (making the media in actual conditions). The media used are 3 aquariums with criteria: Station 1 for low mangrove density conditions, station 2 for medium mangrove density conditions, and station 3 for high mangrove density conditions. The next step is to provide the aquariums with substrate taken from each station accordingly. Some of the substrates taken will be tested for heavy metal content (lead (Pb) and cadmium (Cd). The crab samples used are 15 crabs with a carapace width of about 3-6 cm (in adolescence/juvenile stage) and the aquariums are distributed 5 individuals each. The research duration to determine the growth rate of juvenile crabs will be carried out for 4 weeks.

The study literature method is used to analyze the growth rate of juvenile crabs on several factors of water quality parameters around the mangrove environment and using a supporting method. The absolute growth of juvenile crabs' carapace width is measured every 7 days for 28 days. According to [9], the absolute growth of crab carapace width can be calculated using the following equation:

$$PK = PK_t - PK_0 \quad (1)$$

Information:
PK = growth of carapace width (cm)
PK_t = Average width at the end of the study (cm)
PK_0 = Average width at the beginning of the study (cm)

The analysis conducted to determine treatment's effect on juvenile crabs' growth rate was carried out using the analysis of variance (ANOVA). If the treatments showed an effect, the analysis proceeded using the Tukey test in Microsoft Excel software with a 95% confidence level. According to [3], the calculation of the mangrove density level can be calculated using the following equation:

$$Di = \frac{Ni}{A} \tag{2}$$

Information:
Di = i-th density (ind/m²)
Ni = Total number of individuals of the ith type (ind)
A = Area (m²)

3. Results and discussion

3.1. Mangrove density level analysis

Based on the results of Sentinel 2 satellite image processing to map the mangrove density level, it was visualized that the dark green area has a high-density level, the yellow area has a rare or medium-density level, and the red area has a low-density level. The mangrove density level map was obtained through a supervised classification and an Normalized Difference Vegetation Index (NDVI) assessment. Normalized Difference Vegetation Index analysis was used to determine the distribution of mangrove density on Polagan Beach, Pamekasan Regency, Madura. The result of the mangrove density level is presented in Figure 3.

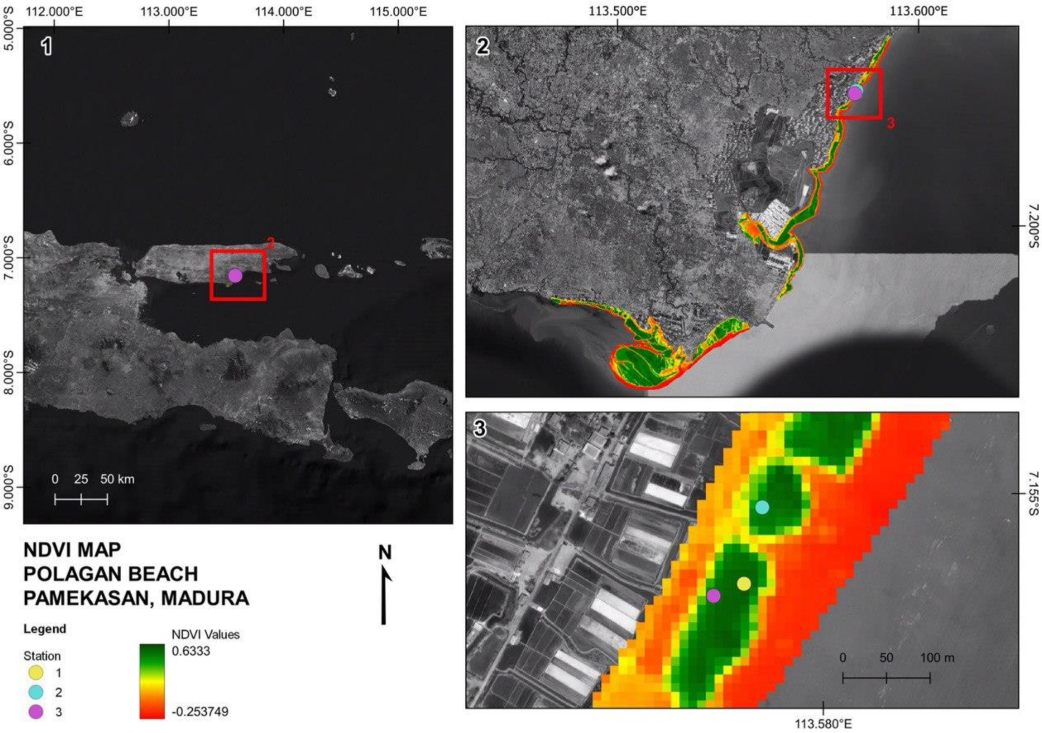

Figure 3. Map of mangrove density level.

Table 1. Mangrove density level value.

Station	Type	Area (m^2)	Amount (ind)	Density (ind/ha)
Station 1	*Rhizophora stylosa*	300	28	933.34
Station 2	*Rhizophora stylosa*	300	42	1400.00
Station 3	*Rhizophora stylosa*	300	49	1633.34

Based on the observations, it was found that the dominant mangrove species at the research site on Polagan Beach were *Rhizophora stylosa*. At the research location, there were various species of mangroves, but only *R. stylosa* species was found at every station. The method for observing mangrove species was carried out using a mangrove identification guidebook. The research area at each station was plotted with a 10m x 10m transect. There were 28 individuals of *R. stylosa* domination found in station 1 with a density of 933.34 ind/ha, 42 individuals in station 2 with a density of 1400 ind/ha, and 49 individuals in station 3 with a density level of 1633.34 ind/ha. The highest mangrove density was found in station 3, categorized as high-density, followed by station 2, categorized as medium-density, and station 1, categorized as low-density. Following KEPMEN-LH Number 201, year 2004, regarding the standard criteria and guidelines for determining mangrove damage which explains that the criteria for high (very dense) mangrove density value is ≥ 1500 ind/ha, criteria for medium (dense) mangrove density value are ≥ 1000 and < 1500 ind/ ha, and the criteria for low (damaged) mangrove density value is < 1000 ind/ha. Based on the results of calculating the mangrove density level in the field and from the satellite image, it was found that the data was asynchronous at station 3, because the values were different between the satellite image and field observation. The satellite image showed that station 3 was in the medium category, while the field was categorized as high-density. This result happened because satellite images acquire data in the form of colors and hues from the top. Thus errors could occur, it was indispensable to conduct a field survey (ground check) so that the data obtained is valid.

3.2. Water quality parameters

The results of the measurement of water quality parameters at the research site can be seen in Table 2. The growth of juvenile crabs is affected by temperature and salinity, while survival is influenced by pH and heavy metal in the substrate.

Table 2. Water quality parameter values.

Station	Parameter				
	Ph	Temperature (℃)	Salinity (ppt)	Heavy Metal Content	
				Pb (mg/kg)	Cd (mg/kg)
Station 1	6.6	29.8-31.0	34.0	1.26±0.00	2.55±0.11
Station 2	6.7	29.0-30.0	32.3	1.58±0.00	2.86±0.11
Station 3	6.9	28.4-29.5	34.6	2.29±0.00	2.77±0.11

Based on the measurement results, it was found that in station 1 had a pH value of about 6.6, temperature value of about 29.8-31.0°C, salinity value of about 34 ppt, heavy metal content value of Pb (lead) of approximately 1.26±0.00 mg/kg and the value of Cd (cadmium) around 2.55±0.11 mg/kg. This indicated that the pH and temperature are still in normal conditions while the salinity and heavy metal levels have been at the threshold of the biota tolerance in station 1. In station 2, the pH value was around 6.7, temperature around 29.0-30.0°C, salinity about 32ppt, value of Pb (lead) content of approximately 1.58±0.00 mg/kg and the value of Cd (cadmium) was around 2.86±0.11 mg/kg, which indicated that in station 2 for parameters pH, temperature and salinity were still categorized as standard and optimum conditions for growth and survival of juvenile crab. In station 3 the pH value was around 6.9, temperature around 28.4-29.5°C, the salinity of about 34.6ppt, value of Pb (lead) heavy metal content of approximately 2.29±0.00 mg/kg and the value Cd (cadmium) was around 2.77±0.11 mg/kg, which indicated that the parameters of pH, salinity and heavy metal content were in conditions beyond the tolerance threshold of biota. In stations 2 and 3, the value of heavy metal levels is high due to their location near shrimp and fish cultivation ponds. The runoff water from said ponds flowed directly into the mangroves and caused high water pollution.

According to KEPMEN-LH Number 54, in 2004, waters that are good for marine life for the temperature in the mangrove area are 28-32°C. Temperature is an important abiotic factor affecting the activity, appetite, oxygen consumption, metabolic rate, survival, growth, and molting of crustaceans. Waters with high temperatures tend to increase growth and affect the molting interval of crustaceans. The optimum temperature for crab growth is 26-32°C. The statute also stated that a good level of salinity for marine biota (mangrove crabs) for mangrove crabs in mangrove habitat ranges from (natural-34‰). Crayfish are euryhaline organisms that have a wide tolerance to salinity. In general, crabs only live in the sea with a salinity of about 32-34ppt. Crayfish can be kept in ponds with salinity up to 36 ppt. In accordance with the statute, a good quality level of water pH for marine biota is 7-8.5. Mangrove crabs can grow and develop well in relatively alkaline acidity.

Cadmium levels in sediment generally have higher levels than in water, this was due to the nature of the metal material, according to [4] heavy metals that enter the waters will experience precipitation, dilution, and dispersion, then absorbed by the biota living in these waters. Heavy metals have properties that cause them to easily bind organic matter and settle to the bottom of the water and merge with sediments, thus the levels of heavy metals in sediments were higher than in water.

3.3. Absolute growth of carapace width

The results of the calculation of the absolute average growth of carapace width on juvenile blue swimming crabs (*Portunus pelagicus*) after 28 days or 4 weeks of observation were presented in Figure 2. The results showed an increase in carapace width at each station with several water quality parameters as shown in Table 2.

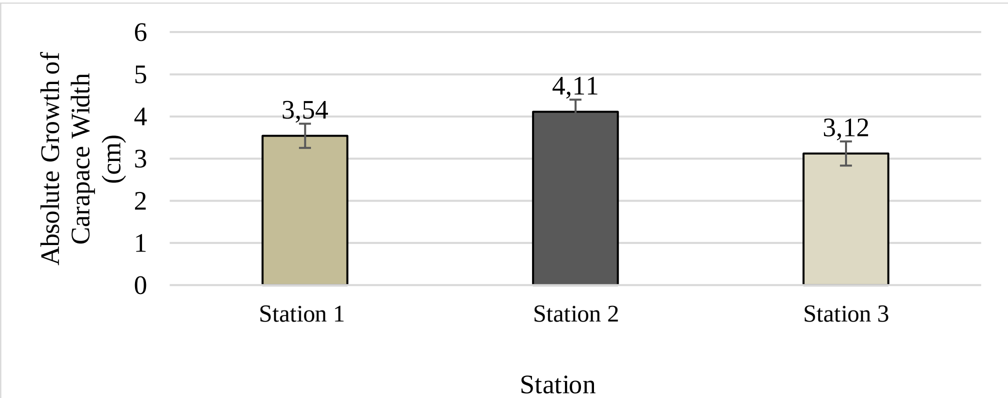

Figure 4. Average absolute growth of carapace width of juvenile crab (*P. pelagicus*).

Table 3. ANOVA Variety Test Results.

Groups	*Count*	*Sum*	*Average*	*Variance*	*P-value*	*F crit*
Station 1	4	14.16	3.54	0.0161	0.000022	4.45897
Station 2	4	16.44	4.11	0.0169		
Station 3	3	9.36	3.12	0.0147		

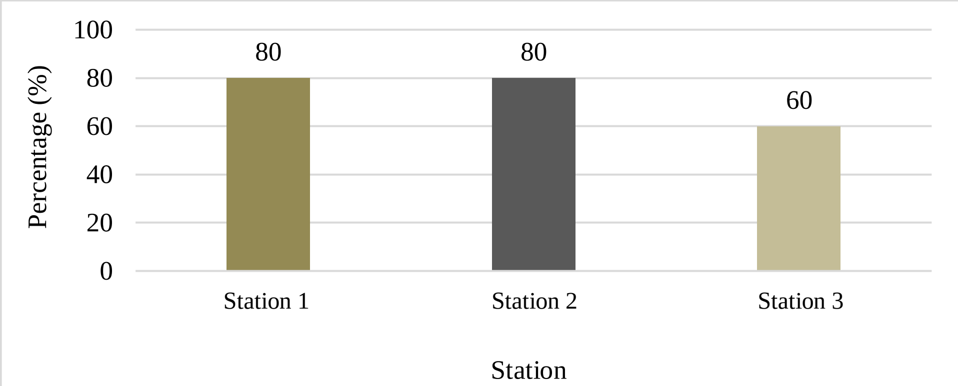

Figure 5. The survival rate of *P. pelagicus* juveniles.

The results of the research show that the absolute growth of the carapace width of juvenile crabs (*P. pelagicus*) was highest at station 2, followed by station 1, and the lowest at station 3. The results of the analysis of variance (ANOVA) obtained p-value < alpha (0.05) implied that there is an insignificant effect of growth rate on juvenile crabs. The highest standard deviation (Variance) obtained at each station was at station 2 with a value of 0.0169, followed by station 1 with a value of 0.0161, and the lowest was station 3 with a value of 0.0147. The lower standard deviation value (closer to 0) means that the value in the data is close to the average. Salinity and temperature parameters were suspected to be essential for juvenile crabs, thus making the energy obtained from feed less for metabolic processes and more for growth. Following the statement of [1], the development of crab larvae from the zoea stage to the juvenile stage requires a salinity between 26-32 ppt. Low and high salinity ranges can cause test crabs to be stressed. Under stress conditions, metabolic energy can be relocated from investment activities (growth and reproduction) to activities to improve homeostasis, such as respiration, movement, hydromineral regulation and tissue repair. Meanwhile, the water's pH and heavy metal levels can cause toxic effects on juvenile crabs and some other aquatic biota. The pH and heavy metals cadmium (cd) and lead (Pb) levels were suspected of causing the death of juvenile crabs. As shown in the picture, the survival rate showed that stations 1 and 2 have 80% survival rate, while station 3 acquired 60% survival rate. This was because there was a high level of heavy metals at station 3, which was also aggravated by its location near the disposal canal from fisherman ponds.

4. Conclusion

The research results and the literature study concluded that temperature and salinity affect the growth rate of juvenile crabs (*Portunus pelagicus*). However, it did not occur significantly or did not have a large effect, as shown from the results of the ANOVA variance test, the p-value < alpha (0.05) which implied that there was an insignificant effect of the growth rate on juvenile crabs. The pH and heavy metal content affected the survival rate of juvenile crabs (*P. pelagicus*). The absolute growth of juvenile crab carapace width was highest at station 2, followed by station 1, and the lowest at station 3. The optimal temperature and salinity levels that could produce maximum juvenile growth were around 28-32°C and salinity around 32-34ppt. Mangrove density level also affected the temperature: the denser the mangroves, the lower the temperature. This was due to less exposure to sunlight. Henceforth, the lower the mangrove density, the higher the temperature. This was because the area exposed to sunlight was larger. The relationship between mangrove density level and temperature is inversely proportional. After conducting this research, juvenile crab growth rate factors were provided to improve fishermen's welfare and crab productivity by cultivating crabs properly, effectively, and efficiently.

Acknowledgment

We are very grateful to APRI (Indonesian Crab Management Association) for providing full financial assistance in conducting this research and to the Head of Polagan Village for giving permission to conduct the research so that the research could run smoothly, and we thank the Shoheb family for providing a comfortable place.

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