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Distribution of Mangrove Crab (*Scylla* spp.) Larvae in Hoat Sorbay Bay, Southeast Maluku, Indonesia

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ABSTRACT

This study aimed to analyze the distribution of the mangrove crab (*Scylla* spp.) larvae in Hoat Sorbay Bay, Southeast Maluku, as a scientific basis to support conservation efforts and the sustainable management of mangrove crab resources. The research was conducted in October 2022 at 12 stations comprising a total of 28 substations representing different ecological characteristics along the bay. Larval sampling was performed using horizontal and vertical plankton net tows, while environmental parameters—including temperature, salinity, pH, depth, current, and wind speed—were measured *in situ*. The results indicated that crab larvae, including both zoea and megalopa stages, were unevenly distributed throughout the bay. The highest concentrations were recorded in semi-enclosed bay areas near estuaries, particularly within the mangrove ecosystems of Letvuan Village and Menyeu Bay (86–89 individuals), whereas the upstream, central, and main estuarine areas exhibited low larval densities (0–9 individuals). Environmental factors such as temperature (31.3–33.7°C), salinity (29.4–32.1‰), and moderate currents are presumed to influence larval distribution. These findings suggest that only specific areas within Hoat Sorbay Bay serve as reproductive and larval hatching habitats for mangrove crabs. These findings emphasize the need for site-specific conservation efforts, particularly in mangrove areas like Letvuan Village and Menyeu Bay, which serve as key spawning and nursery grounds for *Scylla* spp.

INTRODUCTION

Mangrove crabs (*Scylla* spp.) are macrozoobenthic organisms classified under the phylum Arthropoda, order Brachyura, class Crustacea, family Portunidae, and genus *Scylla*. These organisms inhabit the littoral zone, particularly within mangrove ecosystems, shallow coastal waters near mangrove communities, estuaries, and coastal areas with muddy substrates **(Pratiwi, 2011; Saragi & Desrita, 2018; Saputri & Muammar, 2019; Tarumasely *et al*., 2022)**. In their life cycle, mangrove crabs undergo reproductive migration from the littoral zone to offshore waters over considerable distances for spawning **(Siahainenia, 2012; Siahainenia & Makatita, 2020)**.

As an important component of coastal ecosystems, mangrove crabs play a significant ecological role. As omnivores, they contribute to the food web by linking autotrophic and heterotrophic components and function as detritivores that regulate the abundance of detritus in the littoral zone **(Alberts-Hubatsch *et al*., 2016)**. Their bioturbation activities also enhance mineralization, carbon recycling, and oxygen fluxes within the substrate, improving anoxic conditions in bottom waters and supporting the abundance of meiobenthos **(Siringoringo *et al*., 2017)**. Furthermore, mangrove crabs possess high nutritional value, with varying levels of protein and fat in their meat and ovaries, making them a high-value fishery commodity in the Indo-Pacific region **(Suman *et al*., 2017)**.

Economically, mangrove crabs are among the most sought-after fishery products in both domestic and export markets. In Indonesia, the market price of mangrove crabs ranges from IDR 100,000 to 200,000/kg nationally and IDR 100,000 to 150,000/kg in Maluku **(Oktamalia *et al*., 2019)**. The commodity is exported to several countries, including the United States, Japan, Australia, Hong Kong, and Singapore **(Lastri, 2016)**, similar to the case of blue swimming crab **(Lopulalan & Rahman, 2024)**. Since 2019, Maluku has exported fresh mangrove crabs from the Aru Islands Regency to Singapore and Malaysia, although exports to China still face challenges related to legal certification documents.

However, excessive exploitation of mangrove crabs has led to significant population declines, primarily due to wild capture, which continues to dominate market supply (61.3%), while aquaculture remains underdeveloped due to technological and labor constraints **(Saidah & Sofia, 2016; Permadi, 2018; Mardiana *et al*., 2019)**. Since the 1990s, concerns over declining mangrove crab stocks have been a major issue in Indonesia **(Kasry, 1996; Cholik, 1999; Siahainenia, 2012)**. Overfishing during the reproductive phase, mangrove habitat degradation, and declining environmental quality are key drivers of mangrove crab population reduction in the wild **(Siahainenia, 2012; Lastri, 2016; Tahmid *et al*., 2016; Tetelepta *et al*., 2018)**. Utilization of this resource in Indonesia has reached an exploitation level of 63%, indicating an overfished status **(Suman *et al*., 2017)**.

In the waters of Hoat Sorbay Bay, Southeast Maluku—part of the Coastal and Small Islands Conservation Area (KKP3K) of Kei Kecil Island—signs of declining mangrove crab populations have been observed. This is indicated by smaller average sizes of caught crabs, reduced catch volumes, shifting fishing locations, increasing travel distances to fishing grounds, and intensified fishing gear use and fishing durations **(Abrahamsz *et al*., 2018; Lambiombir, 2023)**. Considering the area's potential mangrove ecosystems that support crab populations, management efforts must be based on accurate data and information regarding stock status and habitat characteristics.

From 2021 to 2022, the average catch of mud crabs in Hoat Sorbay Bay declined from 685 to 280 individuals, representing an approximate decrease of 59% in total catch volume. This trend indicates that the management status of mud crabs in Hoat Sorbay is within the moderate category **(Abrahamsz *et al*., 2024)**. However, regulatory intervention by the government is necessary to ensure sustainable management **(Soselisa & Ingratubun, 2024)**.

One of the key data requirements for sustainable mangrove crab management is information on larval distribution. Larval distribution plays a crucial role in determining the sustainability of adult crab stocks, especially in waters experiencing increasing anthropogenic pressure **(Pineda *et al*., 2007)**, such as Hoat Sorbay Bay. Although numerous studies have focused on the ecology and utilization of mangrove crabs, research on their larval distribution in this region remains lacking. Therefore, this study aimed to analyze the distribution of mangrove crab (*Scylla* spp.) larvae in Hoat Sorbay Bay, Southeast Maluku. The findings are expected to provide a scientific foundation for conservation and resource management efforts of mangrove crabs in the area.

MATERIALS AND METHODS

Description of study sites

This research was conducted in October 2022 within the mangrove ecosystem of Hoat Sorbay Bay, Southeast Maluku. Hoat Soarbay Bay is located in Kei Kecil District, Southeast Maluku Regency, Maluku Province, and has been designated as a Coastal and Small Islands Conservation Area (KKP3K) based on the Decree of the Minister of Marine Affairs and Fisheries Number 6 of 2016 **(Ministry of Marine Affairs and Fisheries, 2016)**. The bay is characterized as a narrow, semi-enclosed embayment, approximately 12km in length and with an average width of 1km.

The Hoat Sorbay Bay area harbors typical tropical marine ecosystems, including seagrass beds and mangrove forests. The seagrass community in Kei Kecil District consists of ten species, namely *Cymodocea rotundata*, *Thalassia hemprichii*, *Enhalus acoroides*, *Halodule pinifolia*, *Halophila ovalis*, *Halodule uninervis*, *Halophila minor*, *Thalassodendron ciliatum*, *Halophila decipiens*, and *Syringodium isoetifolium*. The seagrass density in this district ranges from 0.43 to 23.9 individuals/m² **(Abrahamsz & Ayal, 2015)**. Meanwhile, the mangrove community is dominated by *Rhizophora mucronata*, *R. apiculata*, *Bruguiera gymnorrhiza*, and *Sonneratia alba* **(Rawul, 2021)**. The presence of extensive mangrove ecosystems with moderate to high density supports the abundance of various marine fauna, including mud crabs (*Scylla* spp.) **(Rahman *et al*., 2024)**.

Research design

Larval crab sampling and *in-situ* measurement of aquatic environmental parameters were conducted on October 26–27, 2022, between 09:30 and 13:55 Eastern Indonesian Time (WIT), during the tidal transition from low to high tide. The sampling time was determined based on the gonadal maturity stage data of female mud crab (*Scylla* spp.) broodstock collected in the previous year.

Larval sampling and measurements of water parameters—including temperature, salinity, depth, current velocity, current direction, and wind speed—were carried out along Hoat Sorbay Bay, Kei Kecil District, Southeast Maluku Regency, located at coordinates 05°865'79''–05°865'79''N and 132°693'02''–132°693'02''E (Fig. 1).

A total of 12 sampling stations were established along Hoat Sorbay Bay to represent the area's diverse ecological characteristics. Larval sampling and environmental measurements were conducted at each station, with 2–3 replicates at different micro-locations within each station. This resulted in a total of 28 substations. The geographic coordinates and ecological characteristics of each substation are presented in Table (1).

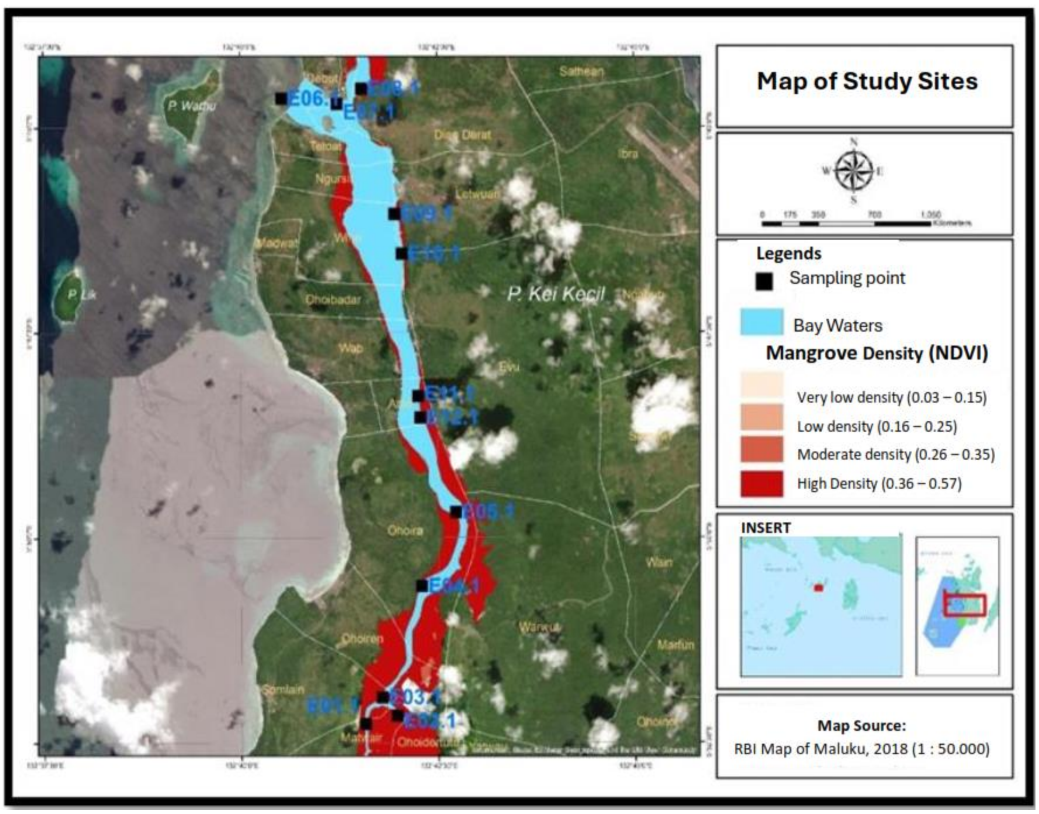

Fig. 1. Map of study sites

Table 1. Ecological character of research stations

Station	Substation	Characteristics
E01 05° 51' 56.7" N, 132° 41' 34.2" E	E01.1	Located around Matvair/Matwaer Village, far from settlements, near a mangrove forest (8-9 meters), with many creek channels connecting to the terrestrial forest, far from creek mouths.
	E01.2	Close to the mangrove forest (5 meters), located at the mouth of a creek/river with numerous creek channels connecting to the terrestrial forest.
	E01.3	About 8 meters from the mangrove forest, with many creek channels connecting to the terrestrial forest, located near a creek mouth.
E02 19° 29' 53" N, 143° 40'15" E	E02.1	Close to the mangrove forest (5 meters), located at the mouth of a creek/river with numerous creek channels connecting to the terrestrial forest.
	E02.2	About 12 meters from the mangrove forest, located at the mouth of a creek/river, with numerous creek channels connecting to the terrestrial forest.
	E02.3	About 8-9 meters from the mangrove community, with many creek channels connecting to the terrestrial forest, located near a creek mouth.
E03 19° 26' 19" N, 143° 36' 58" E	E03.1	Confluence of water channels in Hoat Sorbay Bay between Matvair/Matwaer Village and Ohoidertutu Village, about 5 meters from mangrove forest, with high thickness and density, at the mouth of a creek/river.
	E03.2	About 8 meters from the mangrove forest, located at the mouth of a creek/river.
	E03.3	About 12 meters from the mangrove forest, low mangrove thickness, connected to numerous creek channels leading to the terrestrial forest.
E04 19° 01' 24" N, 143° 45' 38" E	E04.1	Ohoira Village, opposite Warwut Village, close to a mangrove forest with high density but low thickness (10 meters), with several creek channels connecting the terrestrial forest and Warwut Village.
	E04.2	About 20 meters from the mangrove forest, with a substrate covered by seagrass beds.
	E04.3	About 300-400 meters from the mangrove forest with high density and thickness, near the mouth of the Horten River, substrate covered by seagrass beds.
E05 19° 01' 24" N, 143° 45' 38" E	E05.1	Close to the mangrove forest (5 meters), with numerous creek channels/river around the area.
	E05.2	About 10 meters from the mangrove forest, high thickness and density, with creek channels/river present.

Station	Substation	Characteristics
	E05.3	About 15 meters from the mangrove forest, with numerous creek channels connecting to the terrestrial forest.
E06 17° 24' 13" N, 143° 15' 59" E	E06.1	Located at the mouth of Hoat Sorbay Bay, relatively open, no mangrove community, about 10 meters from a small island, close to settlements.
	E06.2	About 20 meters from the small island, no mangrove community, far from river channels.
E07 17° 25' 24" N, 143° 29' 27" E	E07.1	Dian Darat Village, mouth of Menyeu Bay, with low-density mangrove communities around Dian Park (100 meters), high anthropogenic activity, such as settlements and seaweed farming.
E08 17° 22' 17" N, 143° 32' 43" E	E08.1	Central area of Menyeu Bay, close to settlements (50 meters), high-density and thickness mangrove communities, with several creek channels connecting to the settlement area in the upper land.
	E08.2	About 15 meters from the mangrove community, high density and thickness, with several creek channels connecting to the settlement area.
E09 17° 48' 05" N, 143° 39' 37" E	E09.1	End of the Letwuan Village beach, low-density mangrove community, about 10 meters from the mangrove, seaweed farming area, far from creek channels.
	E09.2	Closer to the mangrove forest (5 meters), located at the mouth of a creek, facing a seaweed farming area, high anthropogenic activity due to marine transportation.
E10 17° 56' 10" N, 143° 41' 35" E	E10.1	Central beach area of Letwuan Village, about 10 meters from the mangrove, low density and thickness, facing a seaweed farming area, high anthropogenic activity.
	E10.2	About 5 meters from the mangrove, located at the mouth of a creek, facing a seaweed farming area, a marine transportation zone.
E11 18° 25' 10" N, 143° 44' 43" E	E11.1	Evu Village, about 50 meters from the mangrove forest, high density and thickness, facing Arso Village, a marine transportation zone.
	E11.2	About 30 meters from the mangrove forest, facing Arso Village, a marine transportation zone.
E12 18° 29' 39" N, 143° 45' 10" E	E12.1	Evu Village, about 50 meters from the mangrove forest, high density and thickness, facing Arso Village, numerous creek channels connecting to the terrestrial forest, a marine transportation zone.
	E12.2	About 30 meters from the mangrove forest, located at the mouth of a creek, facing Arso Village, a marine transportation zone.

Data sampling

Measurement of physicochemical water parameters

In-situ measurements of water quality parameters were conducted to obtain environmental data supporting larval crab distribution. The parameters measured included water temperature, salinity, pH, water depth, as well as current direction and velocity. All measurements were performed using pre-calibrated portable digital instruments to ensure data accuracy.

Water temperature was measured using a digital thermometer, salinity using a refractometer, and pH using a digital pH meter. Water depth was measured manually using a weighted measuring rope, which was lowered until it reached the seabed; the submerged length of the rope was recorded as the water depth.

Current direction and velocity were measured using a current meter. Current direction was determined based on the instrument's orientation relative to a compass, while current velocity was measured by recording the time taken for the propeller of the instrument to complete one full rotation. The current speed was expressed in meters per second (m/s).

All environmental parameters were measured simultaneously with the collection of crab larvae samples to ensure that the data accurately represented the actual water conditions and supported a reliable analysis of larval crab distribution at the study site.

Larval sampling

Crab larval sampling was conducted using a purposive sampling method at each sub-station, selected based on distinct ecological characteristics. The sampling was carried out using a Simple Plankton Net, Model PNS150-M500, made of nylon with specifications including a mouth diameter of 15cm, a net length of 25cm, and a mesh size of 25 microns.

Samples were collected using two net towing techniques: (1) horizontal towing along the side of the boat in the direction of the current, and (2) vertical towing by submerging the net to a certain depth and then slowly lifting it to the surface. After the net emerged from the water, a push-and-pull motion was applied at the surface to rinse any remaining larvae into the collection bottle.

Any larvae still adhering to the net were rinsed off using seawater from a spray bottle, with the spray directed perpendicularly to the net surface to ensure that all larvae were transferred into the collection bottle. The collected samples were then transferred into sample bottles and were preserved in 40% alcohol solution for further identification and analysis.

Crab larvae identification process and data analysis

The identification of crab larvae was conducted at the Laboratory of Aquatic Resource Management, Faculty of Fisheries and Marine Science, Pattimura University. Samples were left to settle for 24 hours, then diluted and observed under a microscope. A

1mL subsample was taken and placed into a Sedgwick-Rafter counting cell for observation and identification, referring to standard plankton identification references **(Newell & Newell, 1977; Yamaji, 1979; Hutabarat & Evan, 1986)**.

Crab larval data were obtained through identification and enumeration of individuals within each 1mL sample. Each observation was performed in triplicate to enhance data accuracy. The results included the total number of crab larvae at the zoea or megalopa stages, which were tabulated and counted for each sub-station.

In addition to biotic data, abiotic parameters such as water temperature, salinity, pH, current speed and direction, wind speed, and water depth were also analyzed at each station descriptively. This analysis aimed to illustrate the spatial distribution of crab larvae along Hoat Sorbay Bay in relation to the physico-chemical and biological characteristics of each sampling site.

Statistical analysis

In this study, Spearman's rank correlation was employed to examine the relationship between mangrove density (measured using the Normalized Difference Vegetation Index, NDVI) and the distribution of larvae. Spearman's correlation was chosen because the data did not meet the assumptions of normality required for parametric tests, making it more appropriate for assessing the monotonic relationship between two variables, particularly when one or both variables are ordinal or continuous but not normally distributed. Spearman's correlation coefficient (ρ) provides a measure of the strength and direction of the monotonic relationship between the two variables, where a positive correlation indicates that as one variable increases, the other also tends to increase, and a negative correlation suggests that as one variable increases, the other decreases. A coefficient of P= 0 indicates no relationship between the variables **(Field, 2013)**.

The strength of the correlation was categorized as follows: P value between 0.00 and 0.30 indicates a very weak or no relationship; 0.30 to 0.50 represents a weak to moderate correlation; 0.50 to 0.70 reflects a moderate correlation, and 0.70 to 0.90 indicates a strong correlation. A value of $P > 0.90$ suggests a very strong relationship between the variables **(Zar, 2010)**. To determine if the relationship is statistically significant, a P-value test was conducted, where a P-value less than 0.05 indicates that the correlation is statistically significant and not due to chance. The use of Spearman's rank correlation allows for the identification of meaningful relationships between mangrove density and larvae distribution, providing insights into environmental factors that may influence the presence and distribution of larvae in the study area.

RESULTS AND DISCUSSION

Physico-chemical water parameters

The physico-chemical characteristics of the water are key factors influencing the distribution and survival of mangrove crab larvae in Hoat Soarbay Bay. Parameters such as temperature, salinity, pH, current velocity, current direction, wind speed, and water depth interact to determine habitat suitability for crab larvae.

Water temperature ranged from 31.3 to 33.7°C (Table 2), indicating relatively warm and uniform conditions across all sampling stations. Although mangrove crabs are considered eurythermal organisms capable of tolerating temperatures between 12 and 35°C **(Masterson, 2007)**, the optimal temperature range for larval development is lower, approximately 28.5 to 30.5°C **(Truong, 2008)**. Thus, slightly elevated temperatures in Hoat Soarbay Bay may potentially affect larval survival rates.

Salinity levels ranged from 29.4 to 32.1‰ (Table 2), which remain within the tolerance range of mangrove crab larvae. These organisms are known to be euryhaline, capable of adapting to a wide range of salinities **(Cholik, 1999)**. However, sudden salinity fluctuations can induce osmoregulatory stress, particularly in early larval stages. The consistently high salinity values across all stations suggest minimal freshwater influence, indicating a stable environment for larval development.

In addition to temperature and salinity, water pH is a crucial parameter influencing the metabolism and physiological processes of crab larvae. The measured pH values ranged from 7.6 to 8.2 (Table 2), which are within the optimal range for marine life **(Kordi & Gufron, 1997)**. Low pH levels may disrupt osmoregulation and exoskeleton formation, while excessively high pH levels could lead to alkalosis, impairing enzymatic activity. Therefore, the observed pH conditions in Hoat Sorbay Bay are considered favorable for larval growth and development.

Currents and wind are physical factors that influence the spatial distribution of crab larvae in coastal waters. Current velocities ranged from 0.12 to 0.24m/ s (Table 2), with dominant directions following tidal patterns. These current dynamics affect larval dispersion, as larvae are planktonic and largely dependent on water movement. According to **Truong (2008)**, mangrove crab larvae tend to inhabit areas with moderate currents, as strong currents may hinder their ability to remain in suitable habitats.

Wind speed during the study ranged from 1.2 to 2.8m/ s (Table 2). Higher wind speeds can increase wave action and water turbulence, potentially affecting larval distribution along the bay. Moreover, wind contributes to vertical mixing of the water column, thereby influencing the distribution of nutrients and oxygen needed for planktonic growth, including that of crab larvae. From an ecological perspective, the interaction between wind and currents plays a vital role in larval transport across different habitat zones **(Cowen & Sponaugle, 2009)**.

Water depth also plays an important role in shaping habitat conditions for crab larvae **(Pineda *et al*., 2007)**. Measurements showed a depth range of 1.5 to 4.8m (Table 2), characteristic of shallow coastal waters that represent typical mangrove crab habitats. Such shallow environments allow better sunlight penetration, promoting phytoplankton productivity, which in turn supports zooplankton and crab larvae as part of the food web.

Table 2. Physicochemical parameters of the aquatic environment in Hoat Sorbay Bay

Station or substation	Temperature (°C)	Salinity (ppt)	Depth (m)	Current speed (m/s)	Current direction	Wind speed (m/s)
E01.1	32.0	26-27	2.0	0.1	North	2.6
E01.2	32.3	24-25	1.5	0.1	Southeast	0.3
E02.1	33.7	25	1.5	0.1	South	0.0
E02.2	33.7	28	1.5	0.1	South	0.0
E02.3	33.7	27	1.5	0.1	South	0.0
E03.1	33.6	21-23	5.2	0.2-0.3	South	1.2-2.1
E03.2	33.6	26-27	5.2	0.2-0.3	South	1.2-2.1
E03.3	33.6	26	5.2	0.2-0.3	South	1.2-2.1
E04.1	31.3	26	5.2	0.2	Southwest	1.6
E04.2	31.3	26	5.2	0.2	Southwest	1.6
E04.3	31.3	25-26	5.2	0.2	Southwest	1.6
E05.1	32.1	25	6.5	0.3	Southeast	1.0
E05.2	32.1	26	6.5	0.3	Southeast	1.0
E05.3	32.1	27	6.5	0.3	Southeast	1.0
E06.1	33.4	31	8.0	0.0	Southeast	3.1
E06.2	33.4	30	8.0	0.0	Southeast	3.1
E07.1	33.1	26	2.8	0.3	Northeast	3.0
E08.1	32.0	30	3.1	0.3	Northeast	4.6
E08.2	32.0	30	3.1	0.3	Northeast	4.6
E09.1	-	28	-	-	-	-
E09.2	-	30	-	-	-	-
E10.1	-	29	-	-	-	-
E10.2	-	27	-	-	-	-
E11.1	-	29	-	-	-	-
E11.2	-	27	-	-	-	-
E12.1	-	28	-	-	-	-
E12.2	-	28	-	-	-	-

The measured physico-chemical parameters in Hoat Sorbay Bay suggest that the area remains suitable as a natural habitat for mangrove crab larvae. However, the slightly elevated temperatures—exceeding the optimal range for larval development—may influence developmental rates, particularly when combined with other environmental factors such as current dynamics and food availability. The relatively moderate water currents observed are likely to facilitate larval dispersal, although tidal current fluctuations remain a key determinant in the spatial accumulation of larvae along the bay.

Descriptive analysis of the environmental parameters indicates that the waters of Hoat Soarbay Bay are relatively stable, with no extreme fluctuations that could disrupt larval development. This stability may be attributed to minimal external disturbances such as significant freshwater inflow or pollution events. Such stable conditions are crucial for supporting the survival of mangrove crab larvae and other associated organisms in coastal ecosystems.

Considering the interaction among environmental parameters, it can be concluded that Hoat Sorbay Bay continues to provide a viable habitat for the development of mangrove crab larvae. Nonetheless, long-term environmental monitoring is essential to detect potential changes that may impact crab population dynamics. Conservation efforts aimed at protecting coastal habitats are also vital, given the ecological and economic importance of mangrove crabs.

Overall, the current physico-chemical conditions in Hoat Sorbay Bay support the presence and development of mangrove crab larvae. The stability of temperature, salinity, and pH plays a major role in maintaining larval viability, while current and wind dynamics influence their spatial distribution **(Cowen & Sponaugle, 2009)**. A thorough understanding of these environmental parameters provides a critical foundation for the sustainable management of mangrove crab resources in coastal waters.

Correlation of mangrove density (NDVI) with larval distribution

The distribution of mangrove crab larvae (*Scylla* spp.) in Hoat Sorbay Bay shows a moderately strong correlation with mangrove vegetation density (r = 0.5370; *P*-value < 0.05). The data indicate that stations with high mangrove density (NDVI > 0.36), such as E08 and E05, contained the highest number of larvae compared to stations with medium to low density. Station E08, in particular, recorded a total of 468 individual larvae—significantly higher than stations E01 and E06, which only harbored 0–2 individuals and were located in areas characterized by low to very low mangrove density (Table 3). These findings support the hypothesis that dense and complex mangrove vegetation provides optimal physical and biological conditions for the reproductive activities and early developmental stages of *Scylla* larvae.

Table 3. Comparison of larval abundance with mangrove density level (NDVI category)

Station	Zoea	Megalopa	Total larvae	Mangrove density (NDVI)
E05	17	40	57	High
E08	265	203	468	High
E03	0	4	4	Moderate
E04	0	31	31	Moderate
E09	114	138	252	Moderate
E10	155	175	330	Moderate
E11	4	14	18	Moderate
E12	10	9	19	Moderate
E01	0	2	2	Low
E02	0	4	4	Low
E07	0	0	0	Low
E06	0	0	0	Very Low

Dense mangrove habitats offer a more intricate canopy and root structure, which function as shelter from predators and help stabilize microhabitat parameters such as temperature and salinity. **Alberts-Hubatsch *et al*. (2016)** emphasized the significant role of mangrove vegetative structure in providing egg-laying grounds and nursery areas for larvae. Furthermore, ecosystems with higher vegetation density tend to contain richer detritus and microbial communities, which serve as essential food sources for larvae in their zoea and megalopa stages. Therefore, greater mangrove density enhances the environmental carrying capacity to support larval survival.

The high presence of larvae in dense mangrove zones also aligns with the distribution patterns of adult crabs. Research by **Yunus and Siahainenia (2018)** found that adult *Scylla* crab populations in the mangrove ecosystem of Evu Village were notably high, in terms of both species abundance and sex composition. *Scylla olivacea* was predominantly distributed in zones dominated by *Xylocarpus* sp., *Rhizophora mucronata*, and *Bruguiera* sp., while *S. serrata* showed high distribution in zones with *Sonneratia alba*, *Rhizophora mucronata*, and *Bruguiera* sp., particularly in areas with fine sand and muddy substrates.

This ecological relationship underscores the importance of conserving high-density mangrove zones as a key component of sustainable fisheries management strategies. Given that only specific locations within the bay significantly support larval development, the protection of areas such as Menyeu Bay and the Letvuan region is critically important. This conservation recommendation is in line with the ecosystem-based approach to fisheries management, which recognizes habitat protection as a cornerstone of sustainable resource use **(Breen *et al*., 2016)**. Therefore, further research explores in more detail the relationship between NDVI, vegetation community structure, and larval dynamics is essential to provide a solid scientific foundation for policy-making.

Distribution of mud crab larvae

The number of mud crab larvae identified at each sampling station in the waters of Hoat Sorbay Bay is presented in Table (4). The identified individuals include two developmental stages: zoea and postlarvae (megalopa). Morphological visualizations of selected zoea and megalopa individuals found in the study area are shown in Fig. (2). Based on the data obtained, the number of zoea individuals ranged from 0 to 162, while megalopa ranged from 0 to 105 individuals.

When the bay is classified into several zones—(1) upper bay (stations E01, E02, E03, E04), (2) central bay (stations E05, E011, E012), (3) estuarine area (stations E06, E07), and (4) semi-enclosed bay area near the estuary and its surroundings (stations E08, E09, and E010)—a clear spatial pattern emerges. Larval densities were low in the estuarine, central, and upper zones of the bay (0–9 individuals), while high larval abundance was observed in the semi-enclosed bay near the estuary (Teluk Menyeu) and adjacent mangrove areas in Letvuan Village (86–89 individuals) (Fig. 3).

Table 4. Number of crab larvae identified in Hoat Soarbay Bay

Stations	Number (ind) Zoea	Number (ind) Megalopa	Stations	Number (ind) Zoea	Number (ind) Megalopa
E01.1	0	0	E05.3	6	13
E01.2	0	2	E06.1	0	0
E01.3	0	0	E06.2	0	0
E02.1	0	0	E07.1	0	0
E02.2	0	1	E08.1	103	98
E02.3	0	3	E08.2	162	105
E03.1	0	1	E09.1	43	54
E03.2	0	3	E09.2	71	84
E03.3	0	0	E10.1	82	91
E04.1	0	18	E10.2	73	84
E04.2	0	0	E11.1	4	10
E04.3	0	13	E11.2	0	4
E05.1	9	14	E12.1	8	6
E05.2	2	13	E12.2	2	3

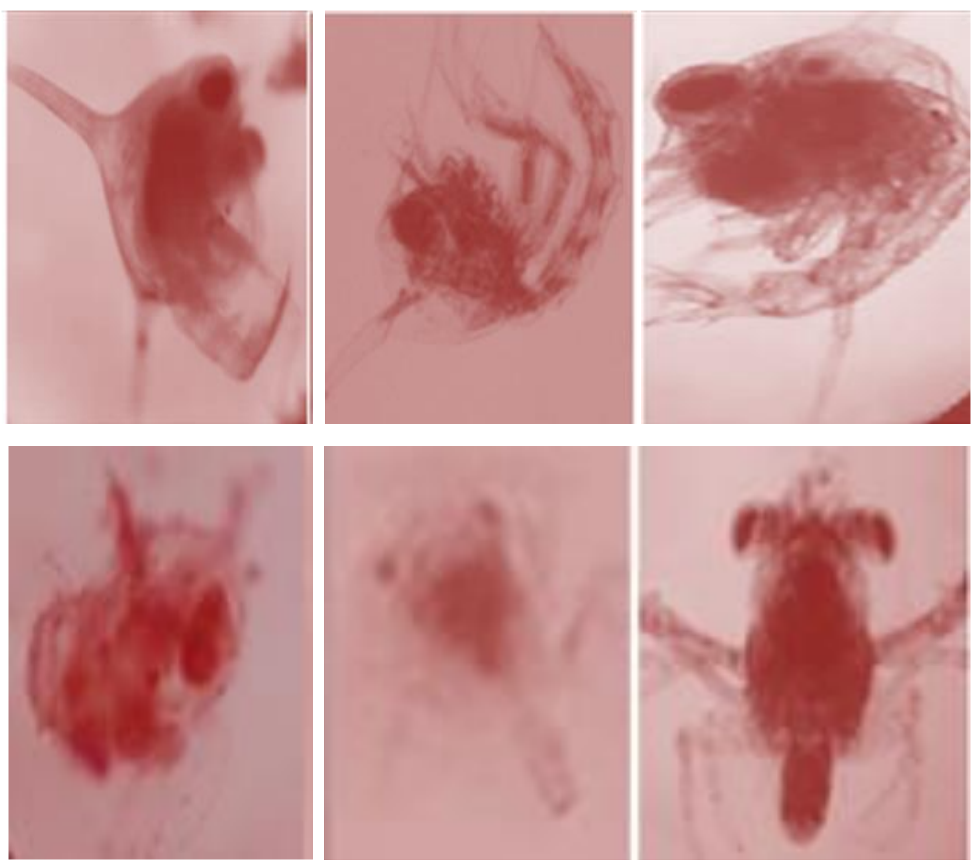

Fig. 2. Several individuals of crab larvae (*Scylla* spp) in the waters of Hoat Sorbay Bay, Southeast Maluku: Zoea **(above)**; Megalopa **(below)**

These findings indicate an uneven distribution pattern of mud crab larvae throughout Hoat Sorbay Bay, with larval concentrations localized in specific areas. This spatial selectivity suggests the presence of preferred microhabitats supporting key reproductive processes of mud crabs. Such areas may provide suitable environmental conditions for spawning, fertilization, egg incubation, and larval hatching, as previously reported by **Soim (1999)** and **Siahainenia (2008)**. A spatial map illustrating larval distribution patterns in Hoat Sorbay Bay during the sampling period (October 2022) is presented in Fig. (4).

Therefore, it can be concluded that not all areas within Hoat Sorbay Bay function as reproductive habitats for ovigerous (egg-carrying) female mud crabs. Specific zones that offer favorable physico-chemical conditions—such as muddy substrates, protective mangrove vegetation, and optimal ranges of salinity and temperature—are likely to serve as targeted migration destinations for spawning and larval release. These findings highlight the ecological importance of such habitats and underscore the need for habitat conservation and the implementation of sustainable management practices for mud crab populations in coastal regions.

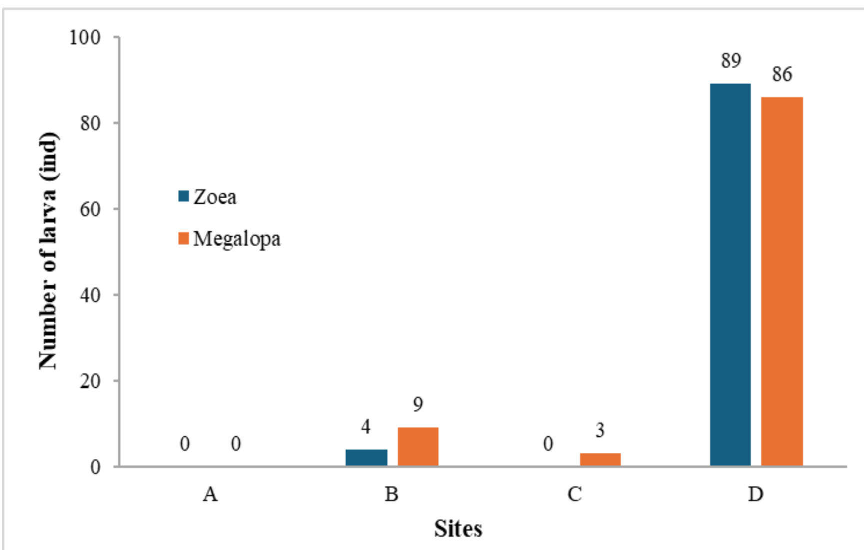

Fig. 3. The number of mud crab larvae individuals found in Hoat Sorbay Bay, Southeast Maluku. **(A)** represents the estuarine area, including stations E06 and E07; **(B)** represents the middle section, including stations E05, E011, and E012; **(C)** represents the upstream area, including stations E01, E02, E03, and E04; and **(D)** represents the semi-enclosed bay area near the estuary and its surroundings, including stations E08, E09, and E010

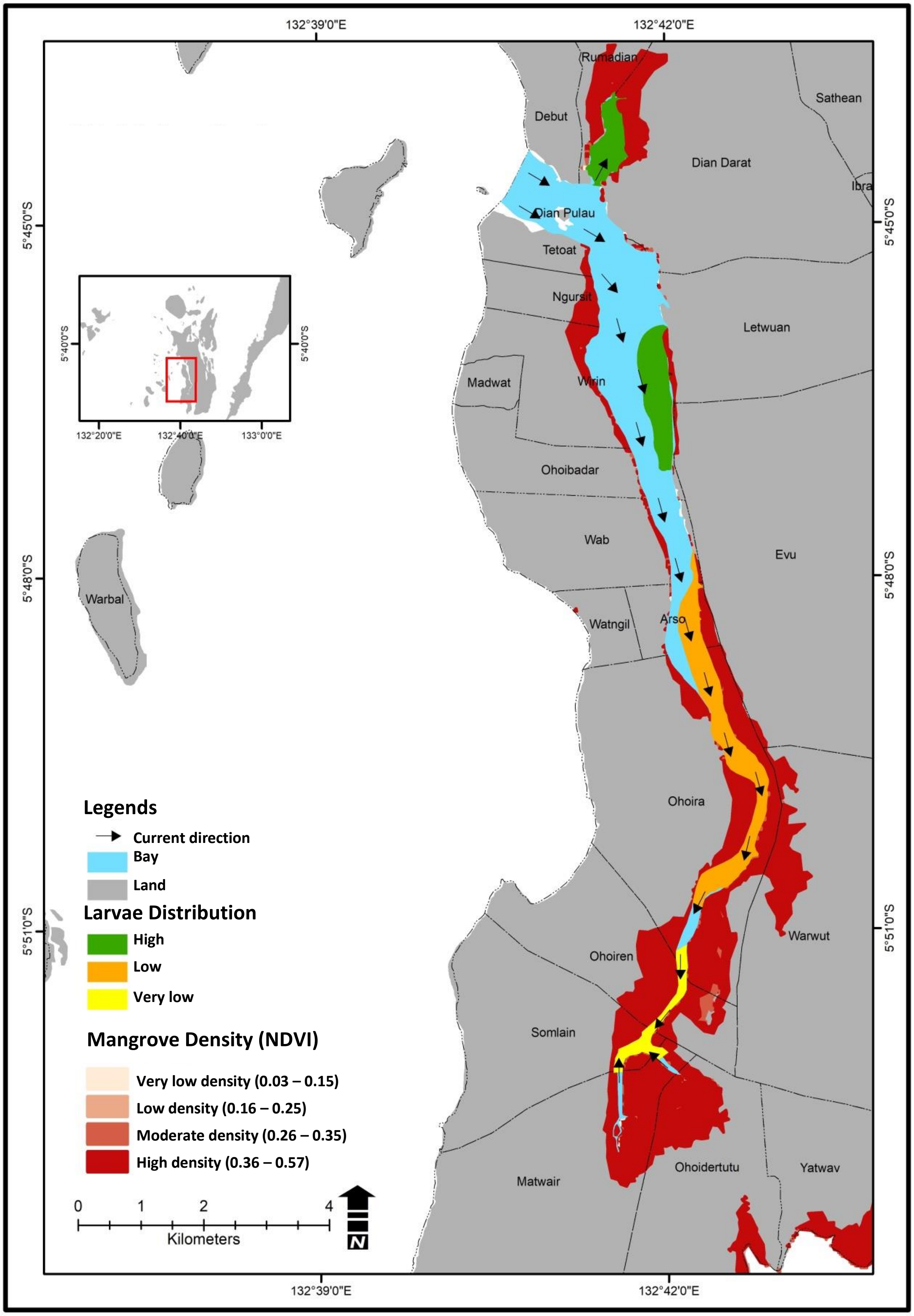

Fig. 4. Map of mud crab larvae distribution in the Hoat Sorbay Bay, Southeast Maluku

CONCLUSION

Overall, the physical-chemical and biological environmental parameters of Hoat Sorbay Bay support the presence and life processes of mud crabs (*Scylla serrata*) across multiple developmental stages, including adult, juvenile, postlarval (megalopa), and larval (zoea) forms. However, the environmental conditions in most parts of the bay are not suitable for the final reproductive processes of the species—such as spawning, fertilization, embryonic incubation, and hatching—except in specific areas, namely the Menyeu Bay and the mangrove ecosystem of Letvuan Village.

The high abundance and distribution of larval (zoea) and postlarval (megalopa) stages in these two areas strongly indicate that Menyeu Bay and the Letvuan mangroves serve as key reproductive migration targets for gravid female mud crabs. These findings highlight the ecological importance of these habitats as critical spawning and nursery grounds essential for sustaining natural populations of *Scylla serrata* in the region.

REFERENCES

Abrahamsz, J. and Ayal, F. W. (2015). *Penilaian Indikator EAFM di Kabupaten Maluku Tenggara*. *April*.

Abrahamsz, J.; Makailipessy, M. M. and Thenu, I. M. (2018). Dinamika kelembagaan dan implikasinya dalam pengelolaan perikanan kepiting bakau di Ohoi Evu Kabupaten Maluku Tenggara. *Jurnal Kebijakan Perikanan Indonesia*, 10(1), 53.

Abrahamsz, J.; Makailipessy.; M. M.; Thenu, I. and Ingratubun, M. A. (2024). Mud crab (*Scylla* spp) resources status in Hoat Sorbay Bay, Southeast Maluku Regency. *IOP Conference Series*, 1400, 012030, 1-15.

Alberts-Hubatsch, H.; Lee, S. Y.; Meynecke, J.; Diele, K.; Nordhaus, I. and Wolff, M. (2016). Life-history, movement, and habitat use of *Scylla serrata* (Decapoda, Portunidae): current knowledge and future challenges. *Hydrobiologia*, 763, 5 – 21.

Breen, P.; Wilson, J. R.; Vanhoutte-Brunier, A. and Yates, K. L. (2016). A process to identify conservation priorities for marine habitats and species in data-poor regions. *Marine Policy*, 66, 118–127.

Cholik, F. (1999). Review of mud crab culture research in Indonesia. *Proceeding of Mud Crab Aquaculture and Biology*, 78.

Cowen, R. K. and Sponaugle, S. (2009). Larval dispersal and marine population connectivity. *Annual Review of Marine Science*, *1*, 443–466.

Field, A. (2013). *Discovering Statistics Using SPSS* (4th ed.). SAGE Publications.

Hutabarat, S. and Evan St. (1986). *Kunci identifikasi zooplankton*. UI Press.

Kasry, A. (1996). *Budidaya Kepiting Bakau dan Biologi Ringkas* (1st ed.). PT. Bhatara Niaga Meda.

Kordi, M. and Gufron, H. (1997). *Budidaya Kepiting dan Ikan Bandeng di Tambak Sistem Polikultur*. Dahara Prize.

Lambiombir, E. (2023). *Strategi Pengembangan Perikanan Kepiting Bakau di Perairan Teluk Hoat Soarbay Kabupaten Maluku Tenggara*. [Postgraduate Thesis], Universitas Pattimura.

Lastri. (2016). Faktor menurunnya ekspor kepiting Indonesia ke America Serikat. *JOM-FISIP,* 3(2), 1 – 16.

Lopulalan, Y. and Rahman. (2024). Socio-economic aspects of the blue swimming crab fisheries (BSC, *Portunus pelagicus*) in Maginti Island, West Muna Regency, Indonesia. *Egyptian Journal of Aquatic Biology and Fisheries,* 28(4): 751-763.

Mardiana.; Mingkid, W. and Sinjal, H. (2019). Kajian kelayakan dan pengembangan lahan budidaya kepiting bakau (*Scylla* spp) di Desa Kabupaten Minahasa Utara. *E-Journal Budidaya Perairan, 3*(1), 154–164.

Masterson, J. (2007). *Scylla serrata*. Smithsonian Marine Station at Fort Pierce.

Ministry of Marine Affairs and Fisheries. (2016). *Ministerial Decree on the Coastal and Small Islands Conservation Area (KKP3K) of Kei Kecil Island*. Jakarta, Indonesia: Ministry of Marine Affairs and Fisheries.

Mwaluma, J. (2002). Pen culture of the mud crab *Scylla serrata* in Mwapa mangrove system, Kenya, Western Indian Ocean. *Journal of Marine Science,* 1, 127-133.

Newell, G. and Newell, R. (1977). *Marine Plankton - A Practical Guide (e-book edition)* (5th editio). Pisces Conservation LTD. ISBN-13 978-1-904690-41-2.

Oktamalia.; Apriyanto, E. and Hartono, D. (2019). Potensi kepiting bakau (*Scylla* spp) pada ekosistem mangrove di Kota Bengkulu. *Naturalis: Jurnal Penelitian Pengelolaan Sumber Daya Alam Dan Lingkungan, 7*(1), 1–9.

Permadi, S. (2018). Perkembangan metode pembenihan kepiting bakau. *Majalah Ilmiah Oseana,* 43(4), 12-22.

Pineda, J.; Hare, J. A. and Sponaugle, S. (2007). Larval transport and dispersal in the coastal ocean and consequences for population connectivity. *Oceanography, 20*(3), 22–39.

Pratiwi, R. (2011). Biologi kepiting Bakau (*Scylla* pp.) di Perairan Indonesia. *Oseana, XXXXVI*(1), 1–11.

Rahman.; Lokollo, F. F.; Manuputty, G. D.; Hukubun, R. D.; Krisye.; Maryono.; Wawo, M. and Wardiatno, Y. (2024). A review on the biodiversity and conservation of mangrove ecosystems in Indonesia. *Biodiversity and Conservation,* 33(3), 875 – 903.

Saidah, S. and Sofia, L. A. (2016). Pengembangan usaha pembesaran kepiting bakau (*Scylla* spp) melalui sistem Silvofishery. *Jurnal Hutan Tropis, 4*(3), 265–272.

Saputri, M. and Muammar, M. (2019). Karakteristik habitat kepiting bakau (scylla sp.) Di ekosistem mangrove silang cadek kecamatan baitussalam kabupaten aceh besar, provinsi aceh. *Biotik: Jurnal Ilmiah Biologi Teknologi dan Kependidikan, 6*(1), 75. https://doi.org/10.22373/biotik.v6i1.4436

Saragi, S. M. and Desrita, D. (2018). Ekosistem mangrove sebagai habitat kepiting bakau (*Scylla serrata*) di Kampung Nipah Desa Sei Nagalawan Kecamatan Perbaungan Serdang Bedagai Provinsi Sumatera Utara. *Depik*, *7*(1), 84–90. https://doi.org/10.13170/depik.7.1.8742

Siahainenia, L. (2008). *Bioekologi Kepiting Bakau (Scylla spp.) di Ekosistem Mangrove Kabupaten Subang Jawa Barat*. [Ph.D Thesis], Institut Pertanian Bogor.

Siahainenia, L. (2012). Musim dan puncak musim reproduksi kepiting bakau *Scylla serrata* pada ekosistem mangrove Desa Waiheru Teluk Ambon Dalam. *TRITON : Jurnal Manajemen Sumberdaya Perairan*, 8, 1–9.

Siahainenia, L. and Makatita, M. (2020). Aspek bioekologi sebagai dasar pengelolaan sumberdaya kepiting bakau (*Scylla* spp.) pada ekosistem mangrove Passo. *TRITON: Jurnal Manajemen Sumberdaya Perairan*, 16(1), 8–18.

Siringoringo, Y. N.; Desrita, A. and Yunasfi, B. (2017). Kelimpahan dan pola pertumbuhan kepiting bakau (*Scylla serrata*) di hutan mangrove. *Acta Aquatica*, 4(1), 26–32.

Soim, A. (1999). *Budidaya Kepiting Bakau* (1st ed.). Penebar Swadaya.

Soselisa, H. L. and Ingratubun, M. A. (2024). Mud crab fisheries in Hoat Sorbay, Kei Kecil Island, Eastern Indonesia: Traditional management and adjustment to intervening regulations. *IOP Conference Series*, 1329, 012007, 1-10.

Suman, A.; Irianto, H. E.; Satria, F. and Amri, K. (2017). Potensi dan tingkat pemanfaatan sumber daya ikan di Wilayah Pengelolaan Perikanan Negara Republik Indonesia (WPP NRI) Tahun 2015 serta opsi pengelolaannya. *Jurnal Kebijakan Perikanan Indonesia*, *8*(2), 97.

Tahmid, M.; Fahrudin, A. and Wardiatno, Y. (2016). Habitat quality mud crab (*Scylla* serrata) in mangrove ecosystem of Bintan Bay, Bintan Distric, Riau Islands. *Jurnal Ilmu Dan Teknologi Kelautan Tropis*, 7(2), 535–552.

Tarumasely, T. F.; Soselisa, F. and Tuhumury, A. (2022). Habitat dan populasi kepiting bakau (Scylla serrata) pada hutan mangrove di Kecamatan Teluk Ambon Baguala. *Jurnal Hutan Pulau-pulau Kecil*, 6(2), 177 – 192.

Tetelepta, J. M. S.; Natan, Y.; Ongkers, O. T. S. and Pattikawa, J. A. (2018). Some population biology aspects of edible orange mud crab *Scylla olivacea* (Herbst, 1796) of Kotania Bay, western Seram District, Indonesia. *AACL Bioflux*, 11(4), 1203–1212.

Truong, P.H. (2008). Nutrition and feeding behavior in two species of mud crab *Scylla serrata* and *Scylla paramamosain*. [Ph.D Thesis]. Queensland University of Technology, Brisbane.

Yamaji, I. (1979). *Illustrations of the marine plankton of Japan* (3th ed.). Hoikusha, Osaka.

Yunus, M. and Siahainenia. (2019). Karakteristik keterkaitan habitat dengan kepadatan kepiting bakau pada ekosistem mangrove Desa Evu, Kecamatan Hoat Sorbay, Kabupaten Maluku Tenggara. *Triton*, 15(2), 58 – 68.

Zar, J. H. (2010). *Biostatistical Analysis* (5th ed.). Pearson Education.