BIODIVERSITAS
Volume 25, Number 10, October 2024
Pages: 3423-3430

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d251004

Habitat characteristics of Asian moon scallops (*Amusium pleuronectes*) in Makassar Strait and Bone Bay Waters, Indonesia

BUDIYATI[1,♥], SHARIFUDDIN BIN ANDY OMAR[1], ANDI NIARTININGSIH[2], ITA WIDOWATI[2], NURDIN KASIM[3], MUHAMMAD YUSUF[4], ANDI DYNA RIANA[4]

[1]Department of Fisheries Science, Post Graduate Program, Universitas Hasanuddin. Jl. Perintis Kemerdekaan Km.10, Tamalanrea, Makassar 90245, South Sulawesi, Indonesia. Tel.: +62-411-585034, ♥email: budiyati343@gmail.com

[2]Department of Marine Science, Faculty of Fisheries and Marine Science, Universitas Hasanuddin. Jl. Perintis Kemerdekaan Km.10, Tamalanrea, Makassar 90245, South Sulawesi, Indonesia

[3]Department of Fishing Techniques, Politeknik Kelautan dan Perikanan Bone. Jl. Sungai Musi, Kelurahan Waetuo, Pallette, East Tanete Riattang, Bone 92718, South Sulawesi, Indonesia

[4]Department of Agrobusiness, Faculty of Fisheries, Universitas Cokroaminoto Makassar. Jl. Perintis Kemerdekaan Km 11, Tamalanrea, Makassar, South Sulawesi 90245, Indonesia

Manuscript received: 27 February 2024. Revision accepted: 4 October 2024.

Abstract. *Budiyati, Omar SBA, Nartiningsih A, Widowati I, Kasim N, Yusuf M, Riana AD. 2024. Habitat characteristics of Asian moon scallops (*Amusium pleuronectes*) in Makassar Strait and Bone Bay Waters, Indonesia. Biodiversitas 25: 3423-3430.* Scallops (*Amusium pleuronectes* Linnaeus 1758), also known as axe clam, is a type of bivalve mollusk from the family Pectinidae that lives in marine or generally in coastal areas and can be found in all marine waters, including tropical regions such as Indonesia. Scallops are of economic value as a food source because scallops contain a lot of protein and are low in fat. In South Sulawesi, Indonesia, scallops are found in almost all coastal areas, both on the coast of the Makassar Strait and on the coast of Bone Bay and Flores Sea waters. The present study aims to illustrate and compare the habitat characteristics of the Asian moon scallops (*A. pleuronectes*) from Makassar Strait and Bone Bay. The research method used is quantitative descriptive, with the type of research conducted being a comparative study. The method and type of research used are based on the purpose of the study, which is to compare the habitat characteristics of scallops that live in the waters of the Makassar Strait, which is in the western side of South Sulawesi (Sulawesi Island), and Bone Bay which is in the eastern side of South Sulawesi (Sulawesi Island). The study was conducted from January to October 2022 in two water areas, Makassar Strait in Makassar City and Bone Bay in Bone District. The data consisted of primary data obtained in the research fields by measuring physical parameters, including temperature, salinity, water depth, DO, and pH. The study results show that the temperature in the two sites was around 28.0-30.5°C, salinity around 28.0-39.0 ppt, the water's depth around 9-20 m, DO about 5.0-6.0 ppm, and pH around 5.60-8.75. In conclusion, the habitat of the Asian moon scallops in Makassar Strait dan Bone Bay has relatively similar characteristics.

Keywords: Bivalve, coastal, marine, mollusk, water quality

INTRODUCTION

Scallops spread throughout the world, ranging from subtropical to tropical waters. This clam habitat can be found on various substrates, such as sand to sandy mud, at a depth of 5-50 m (Sun et al. 2018). Scallops (*Amusium pleuronectes* Linnaeus 1758) are commonly found in saltwater, ranging from the intertidal zone to the deep sea (Smith et al. 2017). Scallops are one of the marine life that has a fairly wide distribution. Its distribution starts from the Indian Sea, Indo-China, South China Sea, Japan, Philippines, Papua New Guinea, Indonesia, and Australia (Sun et al. 2015; Brand 2016).

The *A. pleuronectes* is a member of the family Pectinidae. According to Kennedy (2021), more than 400 species are in the Pectinidae family. Most mussel variants are found in seagrass beds amid shallow sandy bottoms; some attach to rocks or other substrates (Sari et al. 2022). All scallops have a clustered distribution within their geographic area (Mendo et al. 2014; Brand 2016). The distribution of scallops differs spatially and is greatly influenced by density, age structure, growth rate and reproductive period, genetic variation, recruitment mechanism, and area. Further, Xiongbo et al. (2019) found that habitat characteristics significantly influence the patterns of distribution and abundance in scallops, providing structure for spat settlement and affecting predation risk and survival rates.

Mussels are bivalve mollusks easily found worldwide (Numano et al. 2019). Unlike the oyster's relatives, scallops are free-swimming mollusks inside a hinged shell. Like other mussel variants, the primary habitat of *A. pleuronectes* and *Placuna placenta* (Linnaeus 1758) is sandy or muddy in the shallow or coastal zone and delta (river estuaries) (Bethoney et al. 2016). The Asian moon scallop, *A. pleuronectes*, is a bivalve mollusk variant commonly found in shallow waters or sheltered coastal areas (Howarth et al. 2015). The Asian moon scallops (*A. pleuronectes*) has an extensive distribution; there are more than 400 species in the Pectinidae variants, commonly called scallops (Ding et al. 2015). Furthermore, Mao et al. (2019) mention that scallops are spread globally throughout the waters, ranging from subtropical to tropical waters such as Indonesia. The Asian moon scallop belongs to the

Pectinoidea variants, which local people mostly call red or white clams. The scallop's habitat can be found in various substrates, from sand to sandy mud, at a depth of 5-50 m (Clark et al. 2020). For several variants, they also become a commercial catch in tropical and subtropical waters (Kluger et al. 2016).

One of the Asian moon scallop characteristics is they actively move to find suitable habitats ini deep waters around 5-25 m (Nugroho et al. 2017). The Asian moon scallop is widely distributed in Indonesia, such as Kenjerang (East Java), Pasuruan (Esat Java), Demak (Central Java), Kupang (NTT), Tangerang (Banten), Buton waters, Makassar Strait, and Bone Bay. Several environmental factors, such as temperature, salinity, and substrate, strongly influence the distribution of Asian moon scallops. Temperature plays a vital role in the scallops' activity (Taufani et al. 2016). According to Sugiarti et al. (2020), the Asian moon scallops caught in Brebes waters in May were at 28-29°C. Furthermore, Amin and Lestari (2019) state that the water salinity will be closely related to the season. If there is high rainfall, the salinity will decrease and vice versa. Low salinity due to weather changes will increase scallops' mortality (Song et al. 2022).

Habitat characteristics are essential to know since they help the Asian moon scallop cultivation. The characteristics of the natural habitat can be used as a reference for Asian moon scallop cultivation, both for research and scientific development and to fulfill human or commercial needs. Habitat also determines the nutritional content of scallops because scallops have filter feeder and sessile properties, which can absorb all nutrients in the environment, including polluting waste in the form of heavy metals. This makes scallops one of the bio-indicators of water. In unpolluted waters, scallops have a high nutrient content. Therefore, it is very important to see and analyze the habitat characteristics of scallops caught, considering that Indonesian waters generally have a lot of garbage and factory waste disposal.

Both locations are potential fishing areas in South Sulawesi. The Makassar Strait and Bone Bay waters are included in WPP 713 with a potential capture fishery of 1,177,857 tons per year, with a utilization rate of 810,739 tons or around 68.83%. The level of exploitation illustrates that both waters are still very potential for capture fisheries activities. The two locations, namely the Makassar Strait and Bone Bay, were chosen, in addition to the potential for simping mussels (*A. pleuronectes*), which are also abundant in the two locations, also because they want to get an idea of whether the difference in places (locations) has different characteristics as well.

MATERIALS AND METHODS

Time and location of research

The research was conducted from January to October 2022. Sampling was conducted at two locations, namely the waters of Bone Bay and the Makassar Strait, Indonesia. The sampling locations were in Bone Bay (TB1: 04° 38´ 26.907” S; 120° 31’ 35.882"E, TB2: 04° 44´ 17.585” S; 120° 26’ 38.776"E, TB3: 04° 45´ 18.966” S; 120° 24’ 21.08"E, TB4: 04° 46´ 17.728” S; 120° 25’ 52.113"E, TB5: 04° 46´ 49.823” S; 120° 26’ 35.713"E, TB6: 04° 50´ 45.983” S; 120° 25’ 22.202"E) and Makassar Strait (SM1: 04 °45´ 14.109” S; 119° 28´ 39.917"E, SM2: 04 °45´ 32.714” S; 119° 28´ 13.235"E, SM3: 04 °45´ 57.126” S; 119° 27´ 56.06"E, SM4: 04 °46´ 9.924” S; 119° 29´ 12.426"E, SM5: 04 °46´ 33.114” S; 119° 29´ 13.346", SM6: 04 °46´ 50.496” S; 119° 29´ 14.266"E) (Figure 1). These sampling locations were selected based on catching scallops activities in these waters.

Types and sources of data

The primary data were obtained from the research field by scallops and measuring physical parameters, including temperature, salinity, depth, dissolved oxygen, and pH). Measurements of physico-chemical parameters were carried out at 6 points for each location, so 12 data were obtained for each parameter, and the total was 72; these six points were chosen based on fishermen's information when they caught the scallop. Measurements for each parameter, including (i) The depth of the water (m) was measured using the Navionics app and calibrated with a fish finder; (ii) Temperature (°C) was measured in-situ using a precision thermometer 0.01°C; (iii) Salinity (ppt) is measured using hand-refractometer; (iv) Dissolved Oxygen (DO) is measured in-situ using a DO-Meter; and (v) pH measured in-situ with a pH-meter. Measurements are performed in situ at 2 locations with 6 sampling points (stations) by calibrating the measuring instrument.

Data analysis

The data analysis used in this research is descriptive statistical analysis. This analysis provides an overview of the habitat characteristics of the two scallop locations studied, namely the comparison between the Makassar Strait and Bone Bay scallops. Both are depicted through detailed tables and graphs. Thus, results will be obtained from similarities or differences in habitat from the two scallop locations. Data analysis and description are done with Microsoft Excel. Quantitative research aims to quantify the data and generalize findings from a sample of a study from varied perspectives. It requires collecting data, analyzing, and interpreting quantifiable data to prove the hypothesis produced in a specific study (Ghanad 2023).

RESULTS AND DISCUSSION

Results

The measured parameters include water temperature, salinity, depth, DO content, and pH of waters, where 2 (two) scallop fishing locations are Bone Bay (TB) and Makassar Strait (SM). Scallops inhabit the littoral zone, living on mud or sandy mud bottoms in shallow water bays. Scallops are often found in shallow waters, particularly on beaches with mangrove forests and seagrass beds. Each location consists of 6 (six) sampling points (stations/ST), with the following measurement results in Table 1.

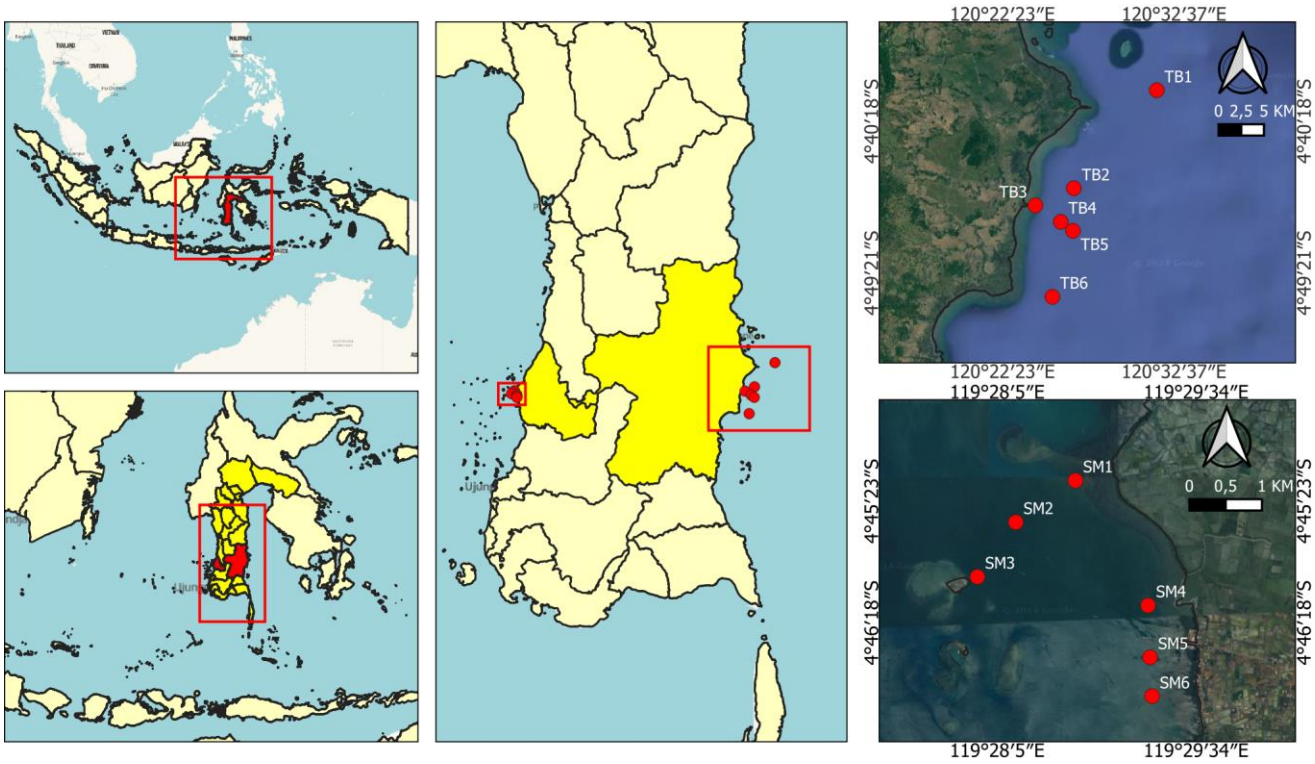

Figure 1. Map of research locations and sampling stations in Bone Bay and the Makassar Strait of South Sulawesi, Indonesia

Table 1. The measurement result of water quality parameters in study sites, Bone Bay and Makassar Strait of South Sulawesi, Indonesia

Location	Temperature (°C)		Salinity (ppt)		Depth (m)		DO (ppm)		pH	
	TB	SM	TB	SM	TB	SM	TB	SM	TB	SM
ST 1	28.50	28.70	29.00	31.00	15.00	17.00	5.60	5.58	7.60	5.67
ST 2	28.83	28.67	30.00	39.00	9.00	17.20	5.62	5.45	7.80	8.75
ST 3	28.80	28.50	29.50	29.50	10.00	16.40	5.58	5.40	7.40	7.20
ST 4	30.50	29.10	30.10	31.20	14.50	16.50	6.00	5.60	7.50	7.00
ST 5	28.90	30.20	28.95	29.50	20.00	16.00	5.50	6.00	7.40	6.80
ST 6	28.80	28.80	28.50	30.40	14.00	17.00	5.70	5.50	7.00	6.90
Average	29.11	29.03	29.51	32.04	13.70	16.62	5.66	5.61	7.54	7.08
Maximum	30.50	30.20	30.10	29.00	20.00	17.20	6.00	6.00	7.80	8.75
Minimum	28.50	28.50	28.95	29.50	9.00	16.00	5.50	5.40	7.40	6.67
Quality Standard*	28-32		33-34		-		>5.0		7.0-8.5	

Note: *Quality standard by Decree of the State Minister of Environment No.51 of 2004

The measurement results showed that the average water temperature in both locations was relatively the same, ranging from 28.50-30.50°C, as well as salinity levels were also relatively the same are 28.95-32.04 ppm, and the depth of the waters where the scallops were caught was 9.00-20.00 m, with DO concentration are 5.40-6.00 ppm, with a neutral pH of 6.67-8.75. All parameter values are still within the set quality standards. Scallops can grow optimally at temperatures of 24.5-30°C, with 18-38 ppt salinity, pH 6.4-7.7, and dissolved oxygen 2.5-5 ppm. Scallops live in shallow waters with a maximum depth of 80 meters, but some live at 50 meters. In Estuarial areas, scallops are found at depths of 1-2 meters at the lowest or low tides (Hajaniar et al. 2019). Research by Alma et al. (2023) discusses a study on scallops in Puget Sound, where they were outplanted at two depths: 5 m and 30 m. The results suggest that for optimal growth in an aquaculture setting, scallops should be placed at 5 meters depth, where oxygen and pH levels are more favorable (Alma et al. 2023). This indicates that scallops can thrive in relatively shallow waters, although not as shallow as 1-2 m.

Scallops are filter feeder animals with the main food of plankton and organic detritus. Scallops will slightly open their shells in water for feeding and respiration. Then, a stream of water will flow through the shell, and the food particles are filtered using their large gills. Scallops (*A. pleuronectes*) are benthic sessile and filter feeder organisms that can develop and grow according to the quality of their habitat (substrate and water) and food availability (plankton). The shells scallops (*A. pleuronectes*) feed on phytoplankton of the types *Isochrisys galbana*, *Tetraselmis tetrahele*, *Chaetoceros* sp., and other diatoms.

Discussion

Temperature

Water temperature is a high or low degree of water in one space, including marine waters (Gönülal 2021). Temperature is an essential marine parameter (Barange et al. 2018). Thus, temperature measurement is always conducted and become a crucial parameter that must be studied in every research. Water temperature is essential to study so that physical, chemical, and biological processes and their relationship with the organisms can be studied. Temperature is a physical quantity that shows an object's energy. Solar irradiation strongly influences seawater temperature (Georgiou et al. 2015). Temperature plays an essential role for aquatic biota, including Asian moon scallops. The results of water temperature measurement at Asian moon scallop fishing in Bone Bay and Makassar Strait waters are graphically presented in Figure 2.

The measurement analysis results show that the water temperature in the Asian moon scallops fishing site was around 28.0-30.5°C. Both research sites had similar water temperatures. Furthermore, the water temperature suits the Asian moon scallop's habitat. It is in line with Sugiarti et al. (2020) that the habitat temperature of Asian moon scallops in Pemalang Regency, Central Java, was between 27.7-32°C. Temperature is influenced by solar irradiation, rainfall, and heat discharges on the mainland (Abdelrahaman 2016). Solar irradiation plays a significant role in determining temperature. Kim et al. (2022) demonstrates that solar irradiation is a primary factor in photovoltaic power generation and is influenced by various meteorological factors, including temperature, sunshine duration, and humidity (Kim et al. 2022). Temperature is one of the main factors determining an organism's wide spatial distribution, including scallops. At the same time, depth, substrate type, current velocity, food availability, clarity, salinity, and predators and competitors influence distribution on a narrower scale (Nonita et al. 2019). They further stated that oxygen quantity is relatively greater in sandy substrates than in smoother substrates. This is because sandy substrates have air pores more intensively mixed with the water above.

Furthermore, the optimum temperature to support scallops' life ranges from 28-32°C. The sampling results showed that the abundance of Asian Moon Scallops at the research site in Bone Bay ranged from 0.7-1.6 kg, with the highest abundance found at station 1, reaching 1.6 kg. Meanwhile, the abundance of scallops in the Makassar Strait ranged from 0.5-1.5 kg, with the highest abundance at station 3. This indicates that the Asian Moon Scallop is often found at relatively lower temperatures, namely 28.50°C. This is because the scallops caught were generally in a gonad-mature condition. Temperature affects the reproductive cycle of the scallop. Suitable temperatures can accelerate gonadal maturation and increase reproductive success, while extreme temperatures can inhibit the reproductive process (Catharina et al. 2014)

Salinity

Salinity is defined as the weight in grams of all solids dissolved in 1 kilogram of seawater (Zhang et al. 2019). According to Smyth and Elliott (2016), salinity is a limiting factor in the distribution of marine organisms and estuaries. Therefore, salinity is an important factor in changing the structure and function of aquatic ecosystems. Physiological factors such as osmoregulation and the organism's tolerance level, which genetic factors can influence, form the basis for overcoming salinity fluctuations.

For instance, some organisms have specialized cells that can pump out excess salt, while others can change the concentration of their body fluids to match the surrounding water. These adaptations allow them to survive in environments with varying salinities. Estuarine organisms, including shellfish, are generally euryhaline and can tolerate varying salinities, the ability to tolerate high and low salinity so that the distribution of shellfish can be found from beaches and estuaries to the sea at certain depths. The nature of euryhaline causes scallops to be able to adapt to various aquatic conditions. For estuarine organisms, reduced salinity can be a support, i.e., it benefits the organisms by reducing competition, while intolerant species are a stressor. Salinity is defined in gram/kilogram, commonly written in ‰ atau part-per-thousand (ppt). Salinity becomes a primary factor for the Asian moon scallops. The salinity measurement results at both research locations are presented in the figure in Figure 3.

The measurement results show that the salinity at the Asian moon scallop fishing sites, Bone Bay and Makassar Strait, was around 28.0-39.0 ppt. This salinity indicates ideal conditions for growing and developing. The salinity content of less than 15 ppt will cause scallops to die. The points illustrate that the salinity level was appropriate for the growth of the Asian moon scallops. The salinity of the water was influenced by the season. The salinity will decrease when the rainfall is heavy, and vice versa. The weather changes influence low salinity and increase mortality in some vulnerable organisms (Shah et al. 2017). It is in line with Sugiarti et al. (2020), the salinity habitat of Asian moon scallops in Pemalang Regency, Central Java, was between 27-32 ppt. All variants of biota have optimal salinity for their lives.

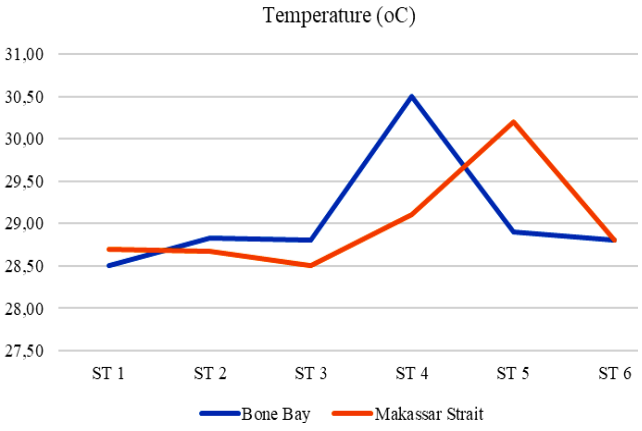

Figure 2. The water temperature (°C) in the Asian moon scallops fishing site

Depth

Water depth is related to productivity, vertical temperature, light penetration, density, oxygen, and nutrients (Qin et al. 2020); an water depth influences the cultivated biota or other organisms that live in it (Lin et al. 2021). The influence of pressure received by biota/organisms and the depth of water can affect metabolism and lead to the distribution of these organisms (Cui et al. 2019). Likewise, the Asian moon scallops are also related to the depth of the water (Figure 4).

The measurement results show the water depths in the two sites were around 9-20 m. These results align with Dou et al. (2016) that the Asian moon scallop habitat can be found in a 5-50m depth. The depth is appropriate for the Asian moon scallop habitat (Clark et al. 2020). The depth is exposed to sunlight and appropriate for aquatic organisms (Geyman and Maloof 2019). Depth greatly influences the mortality rate of shellfish in waters, especially natural mortality. Some types of shellfish can live at depths of 15-60 m in waters, such as pearl mussels cultivated at depths of 15-60 m, and some types of shellfish are only able to live in depths of less than 10 m (Amen and Lestari 2019). Further, the level of survival of scallops will decrease with increasing depth. The depth of the water will affect the distribution of bivalves. Bahtiar et al. (2023) stated that with the increase in depth, food availability becomes a limiting factor for phytoplankton, which is the food of young shellfish, so many shellfish grow near the water surface. The fluctuating depth in the research site at Bone Bay does not affect the difference in the abundance of Asian Moon Scallops. This is because the water depth there is ideal for the scallops. The influence of depth on scallop distribution is also related to the Dissolved Oxygen (DO) requirement. At the ideal depth, dissolved oxygen is high enough to support their metabolism. According to Liu et al. (2022), optimal depth provides stable environmental conditions, including suitable temperatures and adequate dissolved oxygen, which support the growth and reproduction of scallops. Additionally, the appropriate water pressure at certain depths helps avoid predators that live in shallower or deeper waters. If the depth is too shallow, higher temperature variations and rapid fluctuations can cause stress to the scallops, thereby disrupting their reproductive cycle. Conversely, in depths that are too deep, higher pressure and lower dissolved oxygen can inhibit their survival and growth.

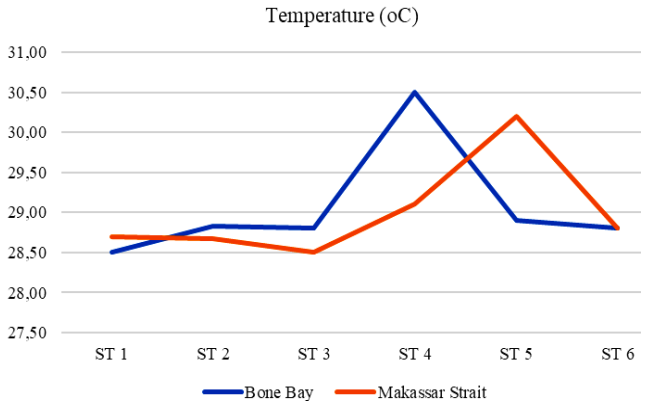

Figure 3. The water temperature (°C) in the Asian moon scallops fishing site

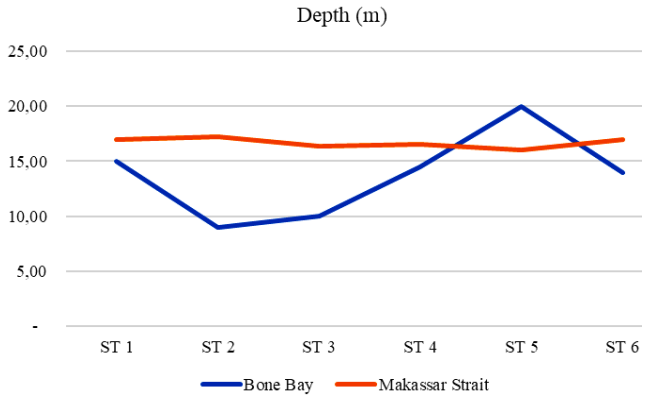

Figure 4. The water depth (m) graphic in the Asian moon scallops fishing sites

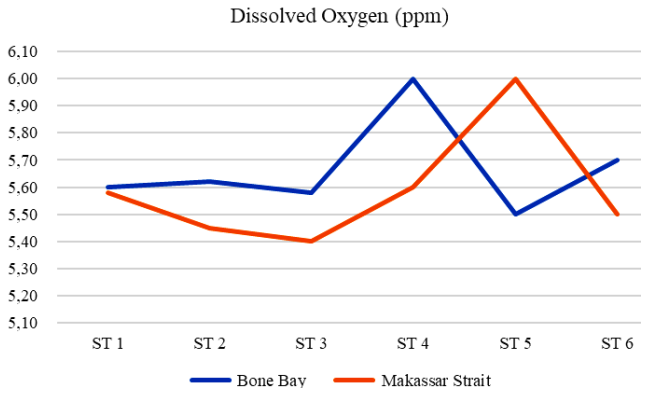

Figure 5. DO (ppm) concentration graphic in the Asian moon scallop fishing sites

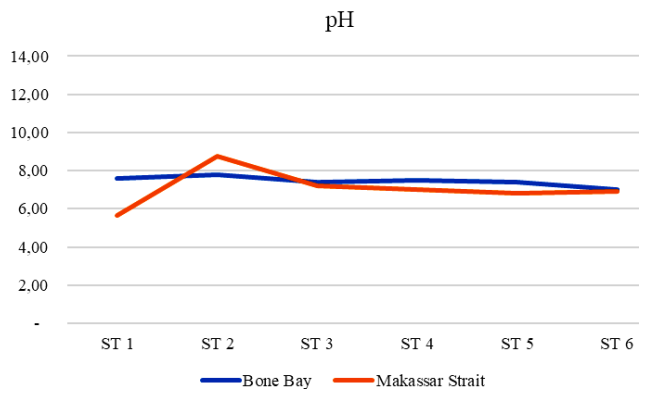

Figure 6. pH concentration graphic in the Asian moon scallops fishing sites

Dissolved Oxygen (DO)

Dissolved oxygen is the amount dissolved in water from photosynthesis and atmospheric or air absorption (Xu and Xu 2016). The aquatic organism needs oxygen. Boyd et al. (2018) state the DO value is generally measured by the amount of oxygen (O_2) available in the water. DO measurement determines how much the water accommodates aquatic biota, such as fish and microorganisms (Song et al. 2019). Furthermore, oxygen can also clean pollution and is determined by the amount of oxygen in water (Huang et al. 2019). The results of DO measurements are presented in Figure 5.

The results of DO parameter measurement in 12 sampling points show 5.0-6.0 ppm. It is in line with Sugiarti et al. (2020) that the Dissolved Oxygen (DO) levels of the Asian moon scallops in Pemalang District, Central Java were 5.38-11.6ppm. Dissolved Oxygen (DO) is an important indicator of water quality. Dissolved Oxygen (DO) usually decreases monotonically with water depth during basin thermal stratification, while in some cases a Metallomagnetic Oxygen Minimum (MOM) observed (Kreling et al. 2017).

One of the causes of low oxygen concentration in waters is the abundance of organic matter in TOM. Oxygen availability is needed for aquatic organisms, including the Asian moon scallops. However, its availability was relatively lower than the number of fine substrates to get the nutrients. Yuniarti et al. (2022) and Handayani et al. (2016) state that the concentration of nutrients dissolved in water for the tropics is lower than nutrients in sediment. Sediments often act as a significant reservoir of nutrients, which can be released into the overlying water column under certain conditions (Turson et al. 2008). The low oxygen will affect the quality of water and the organisms that live in it (Isabelle and Guderley 2014). The greater the DO value in water, the better the water's quality; the lower the DO value, the more polluted the water (Kazbar et al. 2019).

pH

pH is the degree of acidity expressing a solution's acidity or basicity (Boyd 2020). pH is the cologarithm of dissolved hydrogen ion activity (Koparan et al. 2018). The pH value in water varies from the river to the sea. The more to the sea, the value is higher (base). Seawater generally has a pH above 7, which means basic, but under certain conditions, it can be lower than 7, which means acidic (Qin et al. 2018). Below are the results of the pH measurement of waters at the two Asian moon scallops fishing sites in Figure 6.

The acidity (pH) measurement results at both sampling locations showed 5.6-8.75. It is in line with Sugiarti et al. (2020) that the acidity (pH) degree of Asian moon scallops in Pemalang District, Central Java was 7.32-7.86. It can be concluded that the Asian moon scallops suit a habitat with a neutral pH of around 6-8. According to Boyd (2018), the appropriate pH in water is approximately 7-8.5. The water condition, either very alkaline or very acidic, will endanger organisms' lives since it interferes with the metabolic and respiration process (Nisra et al. 2019). Effendie (2002) stated that most aquatic biota are sensitive to pH changes and like pH values around 7-8.5. Changes in water quality can cause seawater to turn from basic with a pH >7 into acidic with a pH <7 (Fathi et al. 2018). The pH value will affect the shellfish spawning process, including in Asian moon scallops, where spawning will occur quickly (accelerated) in alkaline atmospheres, and shellfish spawning will be slow in acidic atmospheres (Bahtiar et al. 2023).

The analysis results concluded that the water temperature habitat of the Asian moon scallops was 28.00-30.5oC, the salinity was 28.0-39.0 ppt, the water depth was 9-20 m, the DO measurement was 5.0-6.0 ppm and pH was 5.6-8.75. Based on these measurements, it is concluded that the habitat of the Asian moon scallops in the Makassar Strait and the Bone Bay have relatively similar habitat characteristics. These habitat characteristics are very supportive of Asian moon scallops' life. The life cycle of Asian moon scallops is very dependent on the season, which in both locations has relatively the same characteristics and seasons, so the time of discovery of Asian moon scallops is relatively the same, which is generally found at the transition around May, June to September, every year.

ACKNOWLEDGEMENTS

Thank you to all parties, especially to the Doctoral Program in Fisheries Science, Graduate School, Universitas Hasanuddin, Makassar, Indonesia, Politeknik Kelautan dan Perikanan Bone, Indonesia, and Universitas Cokroaminoto, Makassar, Indonesia who have helped a lot in completing the research and preparing this manuscript so that it can be published.

REFERENCES

Alma L, Fiamengo CJ, Alin SR, Jackson M, Hiromoto K, Padilla-Gamiño JL. 2023. Physiological responses of scallops and mussels to environmental variability: Implications for future shellfish aquaculture. Mar Pollut Bull 194 (Pt B): 115356. DOI: 10.1016/j.marpolbul.2023.115356.

Amen B, Lestari I. 2019. Concentration, distribution, and correlation of heavy metals in Asian Moon Scallop (*Amusium pleuronectes*), and seawater from Indragiri River estuary. IOP Conf Ser: Earth Environ Sci 348: 1-8. DOI: 10.1088/1755-1315/348/1/012001.

Bahtiar, MF Purnama, Syalam M, Munawarah M. 2023. Seasonal variation in the Reproduction of *Anodonta woodiana* in The Lahumbuti River, Konawe Regency, Southeast Sulawesi. Jurnal Biologi Tropis 23 (3): 115-126. DOI: 10.29303/jbt.v23i3.4915.

Barange M, Bahri T, Beveridge MCM, Cochrane KL, Funge-Smith S, Poulain F. 2018. Impacts of Climate Change on Fisheries and Aquaculture: Synthesis of Current Knowledge, Adaptation, and Mitigation Options. FAO Fish Aquacult Tech Paper No. 627. FAO, Rome. https://www.fao.org/3/i9705en/i9705en.pdf

Bethoney ND, Asci S, Stokesbury KDE. 2016. Implications of extremely high recruitment events into the US sea scallop fishery. Mar Ecol Prog Ser 547: 137-147. DOI:10.3354/meps11666 .

Boyd CE, Torrans EL, Tucker CS. 2018. Dissolved Oxygen and Aeration in Ictalurid Catfish Aquaculture. J World Aquacult Soc 49 (1): 7-70. DOI: 10.1111/jwas.12469.

Boyd CE. 2020. Water Quality: An Introduction. Third Edition. Springer Nature, Berlin. DOI:10.1007/978-3-030-23335-8.

Brand AR. 2016. Scallop Ecology: Distributions and Behaviour. Dev Aquacult Fish Sci Dev 40 (1): 469-533. DOI:10.1016/b978-0-444-62710-0.00011-0.

Catharina JMP, Judith DLvB, Jacco CK, Alain F. Zuur, Peter MJH. 2014. Reproductive phenology of coastal marine bivalves in a seasonal environment. J Plankton Res 36 (6): 1512-1527. DOI: 10.1093/plankt/fbu073.

Clark MS, Peck LS, Arivalagan J et al. 2020. Deciphering mollusc shell production: the roles of genetic mechanisms through to ecology, aquaculture and biomimetics. Biol Rev Camb Philos Soc 95 (6): 1812-1837. DOI: 10.1111/brv.12640.

Cui Y, Chun SJ, Baek SH, Lee M, Kim Y, Lee HW, Ko SK, Hwang S, Ahn CY, Oh HM. 2019. The water depth-dependent co-occurrence patterns of marine bacteria in shallow and dynamic Southern Coast, Korea. Sci Rep 9: 9176. DOI: 10.1038/s41598-019-45512-5.

Ding J, Zhao L, Chang Y, Zhao W, Du Z, Hao Z. 2015. Transcriptome sequencing and characterization of Japanese scallop *Patinopecten yessoensis* from different shell color lines. PLoS One 10 (2): DOI: 10.1371/journal.pone.0116406.

Dou J, Li X, Fu Q, Jiao W, Li Y, Li T, Wang Y, Hu X, Wang S, Bao Z. 2016. Evaluation of the 2b-RAD method for genomic selection in scallop breeding. Sci Rep 6: 1-11. DOI: 10.1038/srep19244.

Effendie. 2002. Fisheries Biology. Yayasan Pustaka Nusatama, Bogor. [Indonesian]

Fathi E, Rasool ZA, Rafat Z. 2018. Water quality evaluation using water quality index and multivariate methods, Beheshtabad River, Iran. Appl Water Sci 8 (1): 210-220. DOI:10.1007/s13201-018-0859-7.

Georgiou S, Mantziafou A, Sofianos S, Gertman, Özsoy E, Somot S, Vervatis V. 2015. Climate variability and deep water mass characteristics in the Aegean Sea. Atmospheric Res 152: 146-158. DOI: 10.1016/j.atmosres.2014.07.023.

Geyman EC, Maloof AC. 2019. A simple method for extracting water depth from multispectral satellite imagery in regions of variable bottom type. Earth Space Sci 6 (1): 527-537. DOI: 10.1029/2018EA000539.

Ghanad A. 2023. An overview of quantitative research methods. Volume 06 (8): 3794-3803. DOI: 10.47191/ijmra/v6-i8-52.

Gönülal O. 2021. Sea water temperature in the North Aegean Sea (Gökçeada Island) between 1972 and 2018: An implication of global warming. J Black Sea/Mediterranean Environ 27 (1): 24-33.

Howarth LM, Roberts CM, Daniel JS, Hawkins JP, Bryce D. Beukers-Stewart. 2015. Effects of ecosystem protection on scallop populations within a community-led temperate marine reserve. Mar Biol 162: 823-840. DOI:10.1007/s00227-015-2627-7.

Huang Y, Chun Y, Chengcheng W, Gang W. 2019. S-type dissolved oxygen distribution along water depth in a canyon-shaped and algae blooming water source reservoir: Reasons and control. Intl J Environ Res Pub Health 16 (1): 987. DOI: 10.3390/ijerph16060987.

Isabelle T, Helga EG. 2014. Scallops show that muscle metabolic capacities reflect locomotor style and morphology. Physiol Biochem Zool 87 (2): 231-44. DOI: 10.1086/674107.

Kazbar A, Guillaume C, Urbain B, Marec H, Le-Gouic B. 2019. Effect of dissolved oxygen concentration on microalgal culture in photobioreactors. Algal Res Biomass Biofuels Bioprod 39: 101432. DOI: 10.1016/j.algal.2019.101432.

Kennedy J. 2021. Scallop Facts: Habitat, Behavior, Diet. thoughtco.com/facts-about-scallops-2291857.

Kim JY, Kim S, Kim EK, Kim M. 2022. Analysis of the Influence of Meteorological Factor on Solar Irradiation Using DNN based Solar Irradiation Prediction. DOI: 10.1109/ifuzzy55320.2022.9985234.

Kluger LC, Taylor MH, Barriga Rivera E, Torres Silva E, Wolff M. 2016. Assessing the ecosystem impact of scallop bottom culture through a community analysis and trophic modelling approach. Mar Ecol Prog Ser 547: 121-135. DOI:10.3354/meps11652.

Koparan C, Ali BK, Charles VP, Calvin BS. 2018. In situ water quality measurements using an Unmanned Aerial Vehicle (UAV) system. Water 10: 264. DOI:10.3390/w10030264.

Kreling J, Bravidor J, Engelhardt C, Hupfer M, Koschorreck M, Lorke. 2017. A. The importance of physical transport and oxygen consumption for the development of a metalimnetic oxygen minimum in a lake. Limnol Oceanogr 62 (1): 348-363. DOI: 10.1002/lno.10430.

Lin SS, Shen SL, Zhou A, Lyu HM. 2021. Assessment and management of lake eutrophication: A case study in Lake Erhai, China. Sci Tot Environ 751: 141618. DOI: 10.1016/j.scitotenv.2020.141618.

Liu T, Li R, Liu L, Wu S, Zhang L, Li Y, Wei H, Shu Y, Yang Y, Wang S, Xing Q, Zhang L, Bao Z. 2022. The effect of temperature on gonadal sex differentiation of Yesso scallop *Patinopecten yessoensis*. Front. Cell Dev Biol 9: 803046. DOI: 10.3389/fcell.2021.803046.

Mao J, Zhang W, Wang X, Song J, Yin D, Tian Y, Hao Z, Han B, Chang Y. 2019. Histological and expression differences among different Mantle Regions of the Yesso scallop (*Patinopecten yessoensis*) provide insights into the molecular mechanisms of biomineralization and pigmentation. Mar Biotechnol 21 (5): 683-696. DOI: 10.1007/s10126-019-09913-x.

Mendo T, Jeremy ML, Natalie AM, Sean RT, Jayson MS. 2014. Habitat characteristics predicting distribution and abundance patterns of scallops in D'Entrecasteaux Channel, Tasmania. PLoS One 9 (1):1-9. DOI: 10.1371/journal.pone.0085895.

Nisra, Bahtiar, Irawati N. 2019. Biological reproduction aspect scallops (*Placuna placenta*) at Langere Waters Bonegunu District North Buton Regency. J Aquat Resour Manag 4 (1): 83-91.

Nonita SC, Ed-Marie BB, Kimberly A. Badocdoc, Cristan JMC. 2019. Breeding and Larval Rearing of Asian Moon Scallop *Amusium pleuronectes* in Eastern Samar, Philippines. Philipp J Fish 27 (1): 104-120. DOI: 10.31398/tpjf/27.1.2019A0008.

Nugroho R, Widowati I, Suprijanto J. 2017. Heterozygosity study to characterization of Asian Moon scallop broodstock (*Amusium pleuronectes*) from Kendal. Second National Seminar: Results of Fisheries and Marine Research, Faculty of Fisheries and Marine Sciences, Diponegoro University. Semarang.

Numano S, Yuta K, Yuko C, Keiichi K, Yotsu-Yamashita M. 2019. Temporal variation of the profile and concentrations of paralytic shellfish toxins and tetrodotoxin in the scallop, *Patinopecten yessoensis*, cultured in a bay of East Japan. Mar Drug 17 (12): 653. DOI: 10.3390/md17120653.

Qin B, Jian Z, James JE, Wayne SG, Jianming D, Justin DB. 2020. Water Depth Underpins the Relative Roles and Fates of Nitrogen and Phosphorus in Lakes. Environ Sci Technol 54 (6): 3191-3198. DOI: 10.1021/acs.est.9b05858.

Qin Y, Arif UA, Pan S, Matiar MRH, Ghosh K, Nan-Xing H, Jin H, Shurong D, Chih-hung C, Deen MJ. 2018. Integrated water quality monitoring system with pH, free chlorine, and temperature sensors. Sensors Actuators B: Chem 255 (1): 781-790. Doi:10.1016/j.snb.2017.07.188.

Sari RN, Dina F, Fera RD, Ellya S. 2022. Karakteristik sediaan hidroksiapatit dari cangkang kerang simping (*Amusium pleuronectes*) dengan perlakuan suhu dan waktu sintesis. Jurnal Pacscapanen dan Bioteknologi Kelautan dan Perikanan 17 (1): 31-41. DOI: 10.15578/jpbkp.v17i1.797. [Indonesian]

Shah SH, Rasmus H, Matthew FM. 2017. Response of chlorophyll, carotenoid and SPAD-502 measurement to salinity and nutrient stress in wheat (*Triticum aestivum* L.). Agronomy 7 (61): 1-21. DOI: 10.3390/agronomy7030061.

Smith SJ, Jessica A. Sameoto, Craig JB. 2017. Setting biological reference points for sea scallops (*Placopecten magellanicus*) allowing for the spatial distribution of productivity and fishing effort. Can J Fish Aquat Sci 74 (5): 650-667. DOI:10.1139/cjfas-2015-0595.

Smyth K, Elliott M. 2016. Chapter 9 Effects of Changing Salinity on the Ecology of the Marine Environment. Oxford Academic, Oxford. DOI: 10.1093/acprof:oso/9780198718826.003.0009.

Song H, Wignall PB, Song H. 2019. Seawater temperature and dissolved oxygen over the past 500 million years. J Earth Sci 30: 236-243. DOI: 10.1007/s12583-018-1002-2.

Song JA, Choi, YJ., Choi CY. 2022. Effects of salinity changes on the osmoregulatory and stress responses in the bay scallop *Argopecten irradians*. Fish Sci 88: 275-283. DOI: 10.1007/s12562-022-01586-1.

Sugiarti E, Haeruddin, Sutrisno A. 2020. Concentration of cadmium (Cd) in the soft tissue scallop (*Amusium pleuronectes*) and sediments in semarang bay waters and its relationship with osmotic work levels. J Maquares: 9 (1): 57-64. DOI: 10.14710/marj.v9i1.27760.

Sun X, Aiguo Y, Biao W, Liqing Z, Zhihong L. 2015. Characterization of the mantle transcriptome of yesso scallop (*Patinopecten yessoensis*): Identification of genes potentially involved in biomineralization and pigmentation. PLoS One 10 (4): e0122967. DOI: 10.1371/journal.pone.0122967.

Sun X, Zhihong L, Biao W, Liqing Z, Qi W, Wei W, Aiguo Y. 2018. Differences between fast and slow muscles in scallops revealed through proteomics and transcriptomics. BMC Genom 19 (1): 377. DOI:10.1186/s12864-018-4770-2.

Taufani WT, Sutrisno A, Widowati I. 2016. Bioecology of scallops (*Amusium Pleuronectes*) in Brebes County Waters. Proceed 5th Ann Natl Seminar Fish Mar Res Result 581-595.

Turson H, Tong L, Zheng B, Ding W, Wang J. 2008. Experimental Simulation of Oxygen Consumption by Bottom Sediment in the Liao River Estuary. DOI: 10.1109/icbbe.2008.1098.

Xiongbo H, Dewen Z, Chunxu Z, Yan Y, Bin K. 2019. Feeding habit of Asian moon scallop (*Amusium pleuronectes*) and as an isotopic baseline indicator in the Beibu Gulf, South China Sea. J Shellfish Res 38 (2): 245-252. DOI: 10.2983/035.038.0204.

Xu Z, Xu YJ. 2016. A deterministic model for predicting hourly dissolved oxygen change: Development and application to a shallow eutrophic lake. Water 8 (2): 41. DOI:10.3390/w8020041.

Yuniarti MS, Lewaru MW, Pamungkas W, Wulandari A, Suhanda D. 2022. The water quality of Ciletuh Bay, Sukabumi, West Java based on the nutrient profile and macrozoobenthos. Mar Fish 13 (1): 1-14. DOI: 10.29244/jmf.v13i1.36157.

Zhang K, Yu S, Xiaoqing C, Ping Y, Kaihui L, Xuejun L, Binu MT, Haiyan C. 2019. Salinity Is a key determinant for soil microbial communities in a desert ecosystem. Msystems 4 (1): 1110-1128. DOI: 10.1128/mSystems.00225-18.