Potential of reef fish at Pulo Suwalan coral reef on the coastal area of Rembang Regency, Indonesia

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Abstract. Pulo Suwalan is one of the coral reef areas found on the coastal area of Rembang Regency, Central Java, Indonesia. Research at this location is still very limited. Due to its location, the area adjacent to the mangrove has the potential to become a migration route for fish from the mangrove to the coral reef ecosystem and vice versa. On the other hand, the area is close to fishing bases, making this coral reef area close to anthropogenic threats. This research was carried out with the aim of analyzing the potential of coral fish biota in the Pulo Suwalan coral reef, on the coastal area of Rembang Regency. The results of this research can be useful as baseline data for further research and efforts to sustainably manage the coral reef areas. The research method uses an underwater visual census. The fish found in the Pulo Suwalan coral reef area belong to 3 family groups, namely Pomacentridae, Serranidae, and Labridae. Fish abundance ranged from 0.01 to 0.05. The results of the index assessment show that the diversity index is in the low category, the evenness index is in the moderate category and the dominance index is in the high category (there are no species that dominate). The biota other than fish found in the Pulo Suwalan coral reef area consists of *Heteractis* sp., *Diadema* sp., *Plexaura* sp., *Diodogorgia* sp., *Iciligorgia* sp., *Cladophora* sp., and *Caulerpa* sp.
Key Words: abundance, biota, coral reefs, fish.

Introduction. Coral reefs are one of the natural resources in coastal areas that have various ecological and economic functions. The main coral reefs ecological functions are to be a habitat, allowing fish growth and breeding, and a natural wave barrier for nearby land areas (Ramadhan et al 2017). Apart from having ecological benefits, the existence of coral reefs also provides economic benefits for the surrounding community, by providing marine tourism services (Luthfi 2016; Witomo et al 2020). However, the use of coral reef areas as marine tourism destinations needs to be supported by good ecosystem conditions and an adequate carrying capacity (Koroy et al 2018). Rembang Regency is one of the coastal areas on the North coast of Central Java which has coral reef and mangrove resources. This coastal zone has a coastline of 63.5 km with a coral reef area of 212.3 ha and a mangrove area of 133.5 ha. In total, there are 15 coral reef zones, spread along the coast of Rembang Regency, with areas varying between 0.8 ha to 48.4 ha. Pulo Suwalan coral reef zone is located at coordinates S6°40'59'' and E111°23'04''. The area of this coral reef is approximately ±20 ha and it islocated at a distance of ±1.0 km from the nearest coastline. The uniqueness of this coral reef area is its location close to fishermen's fishing bases and mangrove ecosystem areas. The location close to the fishing base indicates that the waters around the Pulo Suwalan area are a potential fishing ground area for fishermen. However, fishing causes a high level of risk of damage to coral reefs (Taofiqurohman 2013).

The level of utilization of demersal fish in the waters of Rembang Regency classify these resources as fully exploited (Saputro 2014). Meanwhile, pelagic fish is moderately exploited to overexploited, depending on the type of fish. Pelagic fish with moderately exploited status are Mackerel scad, while types of fish with overexploited status are Yellow stripes Mackerel and Sardine fish (Krisnawati 2017). Efforts are needed to maintain the sustainability of fish resources in the coastal areas of Rembang Regency.

Coral reef areas, as habitats for fish growth and reproduction, need to be managed and handled, if degradation occurs, which require adequate data and information. Selection of management strategies and handling of coral reef areas experiencing degradation can only be done if data and information regarding the condition of coral reefs are available. Data and information regarding the condition of coral reefs in the Pulo Suwalan coral reef area are very limited. Visual observations show that the condition of coral reefs is experiencing degradation. The types of coral reefs that can be identified visually are branching and brain corals. However, the condition profile of coral reef types and their health status are not yet known, due to the limited research on the condition of coral reefs in this region. Various types of fish are known to use coral reef areas as habitats for shelter and foraging (Zurba 2019). Coral reef ecosystem conditions are known to influence fish abundance (Pratchett et al 2006). This research was carried out with the aim of analyzing the potential of coralfish and biota other than fish in the Pulo Suwalan coral reef area. The results of this research are intended to become baseline data in the context of sustainably managing and handling the Pulo Suwalan coral reef area.

Material and Method

Description of the study sites. This research uses the underwater census visual survey method (Rondonuwu 2014; Zuhdi et al 2021). The survey was carried out by diving at two stations, namely on the East and West sides of the coral reef area (Figure 1). At the time the survey was carried out, it was known that the water depth on the East side of the area was 3.0 to 5.0 m, and on the West side of the area it was 4.0 to 5.0 m. The observations were made during the transition season II, when wind conditions experience a transition from the East monsoon season to the West monsoon season. The visibility reached between 70 and 100 cm. Theobservation area was of 20 m^2. The data collected consists of the type and quantity of fish as well as the coral types.

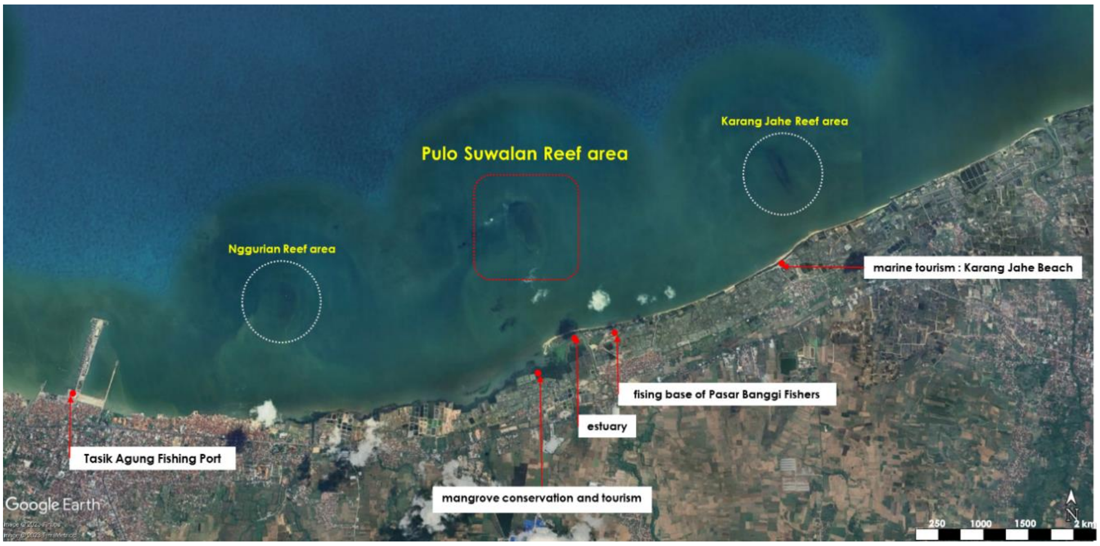

Figure 1. Location of research (Pulo Suwalan reef area).

To find out the types of fish and types of coral, a comparative approach was carried out using visual documentation data with various literature sources on types of fish species (Allen 1999; Kuiter & Tonozuka 2001) and coral (Suharsono 2008). Fish data from observations was then analyzed to determine density, diversity index, uniformity index, and dominance, as follows:

Fish abundance

Calculation of fish abundance was carried out using the formula of English et al (1997) and also used by Awuy et al (2017) and Tambunan et al (2020), as follows:

$$N = \frac{ni}{A}$$

Where:
N - the abundance of fish (ind m^{-2});
ni - the number of individuals of the ith species;
A -the area of the observation area (m^2).

Diversiy index (*H'*)
The diversity index is a characteristic of a community that describes the level of species diversity of organisms found in that community (Odum 1993). The formula used is the Shannon-Weaner Diversity Index (Najamuddin et al 2012), as follows:

$$H' = -\Sigma \text{ pi log pi}$$

$$pi = \frac{ni}{N}$$

Where:
H' - the diversity index;
pi - the probability of species i from the total individuals;
ni - the number of individuals of the species i;
N - the total number of individuals of all species.

The diversity index criteria are divided into 3 categories (Wilhm & Dorris 1986), namely: $H'<1$ (low species diversity), $1<H'<3$ (medium species diversity), and $H'>3$ (high species diversity).

Evenness index (*e*)
The species uniformity index is a comparison between the diversity value and the logarithm of the number of species. The evenness index formula refers to the formulation of the Krebs equation (1989), as follows:

$$e = \frac{H'}{\log S}$$

Where:
e - the evenness index;
H' - the diversity index;
S - the number of species.

According to Krebs (1989), the species uniformity index ranges from 0 to 1, where: $e>0.6$ (high species uniformity), $0.4<e<0.6$ (medium species uniformity), and $e<0.4$ (low species uniformity).

Dominance index
The dominance index is the degree of dominance of one, several, or many species. The calculation method used is the Simpson dominance index formula (Odum 1993):

$$C = \sum \left(\frac{ni}{N}\right)^2$$

Where:
C - the dominance index;
ni - the number of individuals of the species i;
N - the total number of individuals.
The criteria for the dominance index interpretation, according to Odum (1993), are:
$0<C<0.5$ = No species dominates
$0.5<C<1$ = There are species that dominate

Results and Discussion

Geographical overview of the Pulo Suwalan coral reef area. The Pulo Suwalan coral reef area is administratively located in the waters of Pasar Banggi Village, Rembang District, Rembang Regency. Pasar Banggi Village is a village on the coast where the majority of its people's main livelihood is as fishermen. Figure 1 presents the situation of the research location. Geographically, the Pulo Suwalan coral reef area is located in shallow waters, not far from mangrove areas, fishing bases, and marine tourism, perpendicular to the coastline. The length of the coral reef area is ±0.6 km with a width of ±0.4 km. Figure 2 shows the distance between the Pulo Suwalan coral reef area and the surrounding coral reef area and from the coastline. There are two coral reef areas close to Pulo Suwalan, namely Karang Jahe and Karang Nggurian. The distance between Pulo Suwalan and Karang Jahe is ±2.8 km, while the distance between Pulo Suwalan and Karang Nggurian is ±2.6 km. From the nearest coastline, the location of Pulo Suwalan is only ±1.0 km from the fishermen's fishing base which can be seen in Figure 2. The depth of the waters in the Pulo Suwalan coral reef area ranges from 0.5 to 8 m (Prihantoko et al 2023). The Pulo Suwalan coral reef area has a unique character. At low tide, coral reefs will be visible on the surface of the water, and at high tide, the entire area will be underwater. Figure 3 shows the condition of coral reefs when the waters recede.

Figure 2. The distance between Pulo Suwalan and the coastline (red line) is ±1.0 km, Pulo Suwalan Island to Karang Jahe (blue line) is ±2.8 km, and Pulo Suwalan to Karang Nggurian (yellow line) is ±2.6 km.

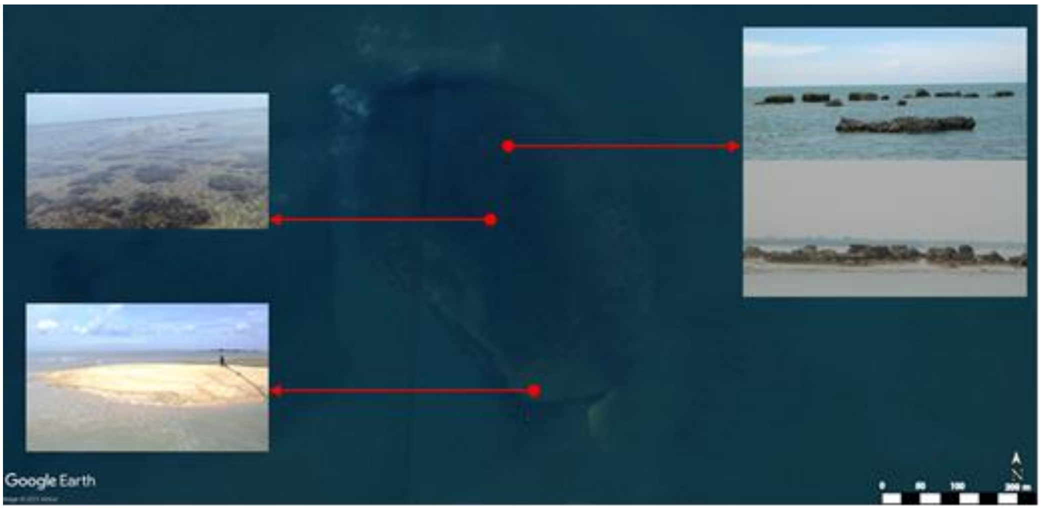

Figure 3. Pulo Suwalan at low tide.

Branching coral will be exposed on the surface of the water when the waters recede. Likewise, sandy land will appear on the southern side of the area. On the north side of the area, which is ±0.4 km from the position of the sandy land, there is a collection of dead coral rocks that have not been identified. Pulo Suwalan coral reef area has the natural resource potential required to support the sustainability of fish resources. However, appropriate handling and management efforts are needed, so that the available potential can be utilized optimally.

Potential of coralfish in the Pulo Suwalan coral reef area. One of the marine ecosystems that supports biodiversity is the coral reef ecosystem. Coral reef ecosystems with high biodiversity will be a source of food, shelter, and habitat for various marine biota (Harsindhi et al 2020; Nanami 2021). Coralfish are one of the marine biotas that is closely related to coral reef ecosystems. Coralfish can be an indicator to determine the status of biodiversity in coral reef areas (Tony et al 2020). The various types of biota found in the Pulo Suwalan coral reef area can be seen in Table 1. From the results of biota observations, it is known that in the waters of the East side of the area, one type of fish is found, namely betok fish (*Chromis* sp.), and the dominant biota, other than fish, consists of anemones, sea urchins, some gorgonians, and green algae. On the western side of the Pulo Suwalan coral reef area, it is known that several types of fish are dominant, such as betok fish (*Chromis* sp.), keling fish (*Labrus* sp.), and grouper fish (*Ephinephelus* sp.). Biota, other than fish, found on the western side of the area, consistes of anemones, sea urchins, and green algae.

Table 1

Type of biota

No	*Local name*	*Scientific name*	*IUCN statutes*	*Station*
1	Ikan betok	*Chromis* sp.	-	East
2	Anemon	*Heteractis* sp.	-	East
3	Bulu babi	*Diadema* sp.	-	East
4	Akar bahar	*Plexaura* sp.	Vulnerable	East
5	Akar bahar	*Diodogorgia* sp.	Vulnerable	East
6	Akar bahar	*Iciligorgia* sp.	Vulnerable	East
7	Alga hijau	*Cladophora* sp.	-	East
8	Alga hijau	*Caulerpa* sp.	-	East
9	Ikan betok	*Chrysiptera* sp.	Least concern	West
10	Ikan keling	*Labrus* sp.	Least concern	West
11	Anemon	*Heteractis* sp.	-	West
12	Bulu babi	*Diadema* sp.	-	West
13	Alga hijau	*Cladophora* sp.	-	West
14	Ikan kerapu	*Ephinephelus* sp.	Least concern	West

In the research carried out, it was discovered that there were 3 (three) groups of fish families found, namely *Pomacentridae*, *Labridae*, and *Serranidae*. According to Allen & Adrim (2003), the types of fish that are often found in coral reef areas consist of the families *Gobiidae*, *Labridae*, *Pomacentridae*, *Apogonidae*, *Blenniidae*, *Serranidae*, *Muraenidae*, *Syngnathidae*, *Chaetodontidae*, and *Lutjanidae*. *Labridae* and *Pomacentridae* families have a high species diversity and are found in abundance in coral reef areas (Reininger 2012; Andrimida & Hardiyan 2022). Although in this study the number of fish found in the Pulo Suwalan coral reef area can be categorized as low, the families of fish found indicate that the area is a habitat for various types of coralfish.

The *Pomacentridae* and *Labridae* families of fish are the dominant coralfish families found in coral reef ecosystems (Yusuf 2013). Fish species from *Pomacentridae* family are often found in coral reef areas with high levels of abundance (Erdana et al 2022). The *Pomacentridae* family of fish is a group of herbivorous fish (Luthfi et al 2018). Several specied of *Pomacentridae* and *Chaetodontidae* are plankton-eating fish called planktivores (Frederich et al 2009; Frederich & Parmentier 2016). According to Carpenter

& Niem (2001b), several species of *Pomacentridae* and *Chaetodontidae* are also included in the group of coralfish that eat everything (omnivore fish group). According to Nybakken (1992), herbivorous fish from the *Siganiidae*, *Pomacentridae*, *Acanthuridae*, and *Scaridae* families are able to help coral growth by reducing the amount of algae that grows on coral. These fish eat algae that grow on coral, thereby increasing the potential for coral growth. Fish of the *Pomacentridae* family have a schooling behavior and are able to live in varying bottomwater substrate conditions (Erdana et al 2022). These fish are physiologically compatible with coral reef ecosystems (Rungkat et al 2013) and play an important role in food webs (Edrus & Abrar 2016). The coral reef area is used by the *Pomacentridae* family of fish as a habitat for foraging (Dhahiyat et al 2017).

The *Labridae* family of coralfish has the second highest species diversity after the *Pomacentridae* family. The distribution of types and sizes of the family *Labridae* fish is related to the habitat types, such as seagrass and coral reefs (Hasbi et al 2011). The living habitat of the *Labridae* fish species is located in shallow waters, consisting of coral reefs, rocky reefs, sand, grass, and algae habitats (Carpenter & Niem 2001a). The Labridae family has the highest diversity in the Indo-Pacific coral reef region (Choat & Bellwood 1991). According to Carpenter & Niem (2001a), coralfish from the *Labridae* family belong to the benthic invertivore type, which are coralfish that prey on invertebrates that live at the bottom of the water.

Grouper is a fish that has important economic value and is a target for fishermen (Nuraini 2007; Astuti et al 2016). Grouper fish belong to the *Serranidae* family (Allen et al 2003; Peristiwady 2006). Based on the characteristics of their food, fish from the *Serranidae* family belong to the type of carnivorous fish. According to Carpenter & Niem (2001b), the carnivorous coralfish consist of the families *Fistulariidae*, *Lutjanidae*, *Pinguipedidae*, *Scorpaenidae*, *Serranidae*, *Sphyraenidae*, *Synanceiidae*, *Synodontidae*, and *Tetrarogidae*. Carnivorous fish are predators of small fish and molluscas. The presence of carnivorous fish in a water area indicates the availability of juvenile fish, small fish, and crustaceans which are their food sources (Setiawan 2010). Water topographic conditions, food availability, and fishing pressure are factors that influence the abundance of carnivorous fish in coral reef areas (Andrimida & Hardiyan 2022).

Table 2

Type of fish species

Fish species	*Family*	*Number*	*Abundance*	*Length (cm)*	*Station*
Chromis sp.	*Pomacentridae*	6	0.30	9	East
Chrysiptera sp.	*Pomacentridae*	5	0.25	7	West
Ephinephelus sp.	*Serranidae*	1	0.05	18	West
Labrus sp.	*Labridae*	1	0.05	17	West
Total		13			

In general, grouper fish (family *Serranidae*) live solitary lives (Kuiter & Tonozuka 2001). Grouper fish are classified as demersal fish because they can be found at the bottom of the waters. Groupers are also commonly found in coral reef areas, so they are also included in the coralfish group (Mujiyanto & Sugianti 2014). The *Serranidae* family of fish has the behavior of using coral structures to take shelter and hide between corals, especially in branching corals (Benfield et al 2008). Visual observations show that branching corals (*Acropora*) are dominant in the Pulo Suwalan coral reef area (Figure 4). Shallow waters are the grouper's habitat for shelter. As their size and maturity level increase, grouper fish will move to deeper waters. However, coral reef areas are the main habitat for grouper fish, due to the availability of shelter and food sources. Groupers can live at a depth of 370 m (Heemstra & Randall 1993).

The presence of coralfish in a coral reef area can be an indication of the condition of the coral reef ecosystem (Giyanto et al 2014). The presence of a fishing target, such as, groupers in a coral reef area can be an indication of anthropogenic disturbance to the condition of coral reefs (Obura & Grimsdith 2009). The existence of coralfish communities in coral reef waters is influenced by various factors, including habitat degradation

(Knowlton & Jackson 2008), changes in environmental conditions (Polonia et al 2019), seasonal changes (Sigsgaard et al 2017; Vaughan et al 2021); biological and physical conditions of waters as well as habitat complexity (Suwartimah et al 2016).

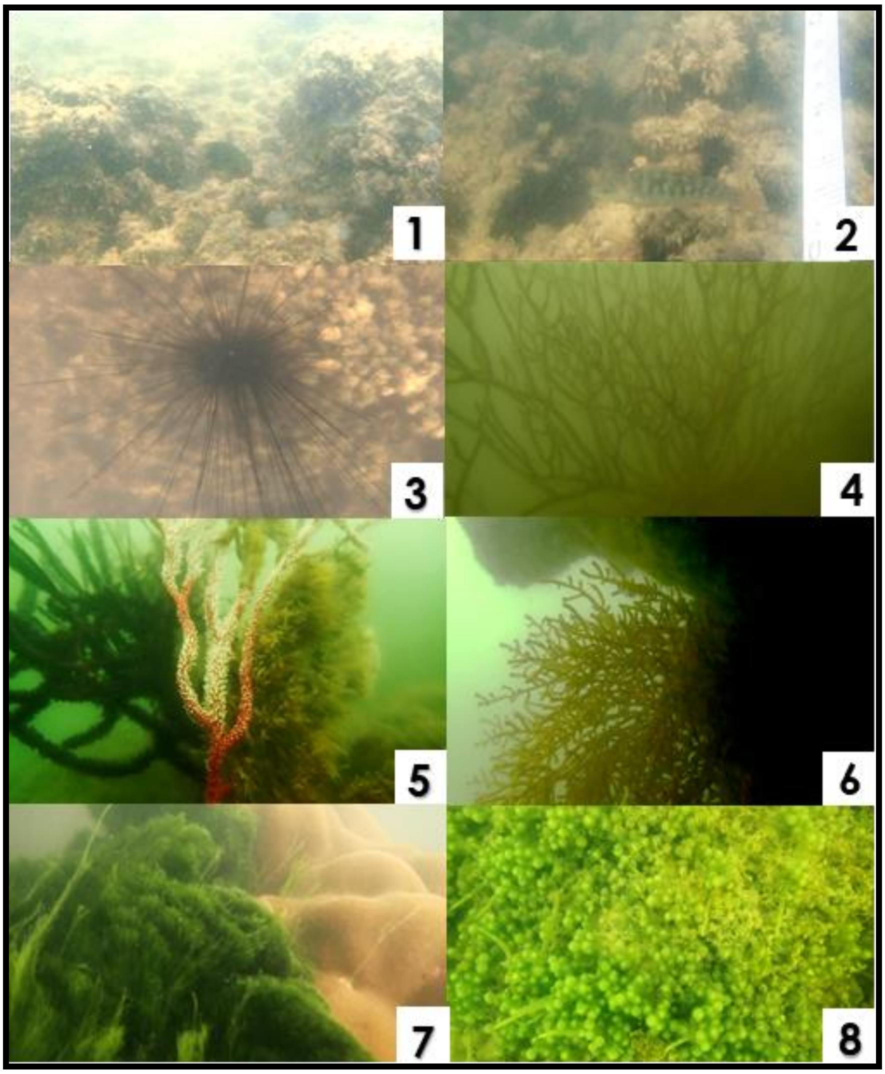

Figure 4. Various types of biota are found in the Pulo Suwalan coral reef area: *Pomacentridae* (1, 2); sea urchins (3); gorgonians (4, 5, 6); algae (7, 8).

Damage to coral reefs can occur due to human influence or natural factors. Natural causes of this damage involve storms or other sea creatures directly damaging coral reefs. For example, the activity of coralfish and other organisms that prey on coral. However, human factors cause damage more quickly compared to natural factors (Taofiqurohman 2013). Other causes of damage to coral reefs include climate change, bleaching (Nirwan et al 2017), and activities using fishing gear that is not environmentally friendly (Burke et al 2002).

Table 3 shows the condition of fish in the Pulo Suwalan coral reef area based on the diversity index, uniformity index, and dominance index. The fish diversity index at the research location is in the low category, while the fish uniformity index is in the moderate category. The results of the dominance index calculation indicate that there are no fish species that dominate the Pulo Suwalan coral reef area. Although a relatively low number of fish species and abundance were found during the research, the results can still serve as baseline data regarding the presence of fish in the Pulo Suwalan coral reef area and be an indication that this location is a potential fish habitat.

Table 3

Index value (diversity, evenes, dominansi)

Index	*Index value*	*Category*
H'	0.211888	Low
E	0.105944	Moderate
D	0.894056	High

Coral reefs are the habitat of coralfish. Coralfish play an important role in maintaining the stability of coral reef ecosystems (Rani et al 2019). In general, the percentage of coral cover has a significant and positive effect on the abundance of reef fish (Fahmi et al 2017; Ghiffar et al 2017). However, there are also conditions where the percentage of coral cover, although positively correlated with fish abundance, does not have a significant effect (Riyantini et al 2023). The positive correlation between coral cover and fish abundance means that the higher the percentage value of coral cover, the higher the abundance of coralfish (Ardian et al 2020). In several studies, it was reported that the percentage of live coral cover in coral reef areas does not affect the fish abundance (Sudarmaji & Efendy 2021). This indicates that there are other factors that can influence the abundance of fish in a coral reef area, including the contour shape or condition of the reef (Hutomo 1986), presence of predators (Munday et al 2001), water conditions, such as currents, depth, and brightness (Pinheiro et al 2013), condition of the bottom substrate, presence of other biota and oceanographic factors (Erdana et al 2022), water movement, human activities, and diversity of bottom water cover (Andrimida & Hardiyan 2022). However, the coralfishhabitat complexity is the main determinant of the coralfish abundance (Rani et al 2019). Some coralfish habitats, apart from coral reef areas, are sandy areas, slopes or cliffs, algae, rocky areas, and shallow waters (Putra et al 2019).

Potential biota of non-fish in the Pulo Suwalan coral reef area

Sea urchins. One of the biota other than fish found in the Pulo Suwalan coral reef area is sea urchins. Sea urchins or sea urchins (*Echinoidea*) are marine invertebrates that have ecological and economic benefits. Sea urchins can be used as a food source (Hadinoto et al 2017) and also have potential benefits as medicinal ingredients (Abubakar et al 2012). According to Rumahlatu (2012), sea urchins have the potential to be a biomonitoring indicator of marine pollution due to their behavioral response to heavy metal conditions in the waters. Sea urchins are omnivorous echinoderm organisms that prey on macroalgae and several types of coral colonies (Suryanti et al 2017). The food of sea urchins includes *Chlorophyta* (green algae) and *Phaeophyta* (brown algae) (Ristanto et al 2018). In the food chain, sea urchins can be categorized as predators and detritus eaters (Tupan & Silaban 2017). The presence of sea urchins on coral reefs plays an important role in balancing the condition of coral reef ecosystems (Sulistiawan et al 2019). The ecological role of sea urchins on coral reefs includes, among others, the nutrient recycling (Sese et al 2018), and controlling algae populations (Suryanti et al 2017). An increase in the sea urchin population in coral reef areas has an impact on the death of larvae and young coral; however, a decrease in the sea urchin population will have an impact on the death of adult coral, as a result of the growth of the algae population, due to limitations of the vital space necessary for the coral larvae development (Zurba 2019).

Sea urchins spread in specific habitats (Yudasmara 2013; Sadam et al 2019), they are nocturnal animals that actively search for food at night and they hide in coral crevices during the day (Zakaria 2013). In general, sea urchins live in groups or form colonies (Noviana et al 2019). Sea urchin habitats include seagrass beds, coral reefs, rockbottom substrates, sandy areas, and coral fragments (Nane et al 2020). According to Afifa et al (2017), sea urchins tend to live in coral reef areas with a depth of 1.4-1.7 m. The largest abundance of sea urchins is found in areas of branching coral and coral fragments; a lower abundance is found on massive corals and sand (Purwandatama et al 2014). Most *Echinoidea* are found in aquatic areas with rock and coral substrates (Huda et al 2017).

Geographically, sea urchins occupy coral reef areas in coral flat areas, algae growth areas, and shallow areas (Suryanti & Ruswahyuni 2014). The abundance of sea urchins in flat areas tends to be higher than in coastal areas (Purwandatama et al 2014). According to Yudasmara (2013), compared to sand substrates, sea urchins are more commonly found in areas with coral substrate types and algae growth substrates. According to Thamrin et al (2011), the density of sea urchins in coral reef waters is inversely proportional to the condition of the coral reef: if the condition of the coral reef is bad, the density of sea urchins will be high. Suryanti et al (2017) revealed that sediment organic matter was positively correlated with the abundance of sea urchins, while sediment texture, temperature, pH, and salinity were negatively correlated with the abundance of sea urchins in waters. However, according to Noviana et al (2019), water quality parameters such as temperature, pH, and DO are positively correlated with the abundance of sea urchins, while salinity is negatively correlated.

Hartati et al (2018) found in Karimunjawa four *Echinoidea* species belonging to the *Diadematidaea* family, namely *Diadema setosum*, *D. antillarum*, *D. savignyi* and *Echinothrix calamaris*. Huda et al (2017) found in the intertidal zone eight species from the *Echinoidea* group originating from four families, namely *Cidaridae*, *Diadematidae*, *Echinometridae*, *Toxopneustidae*, *Spatangidae* and *Brissidae*. The types of species found were *Prionocidaris verticillata* (Lamarck 1816), *Echinothrix calamaris* (Pallas 1774), *Diadema setosum* (Leske 1778), *Echinometra mathei* (deBlainville 1825), *Tripneustes gratilla* (Linnaeus 1758), *Toxopneuptes pileolus* (Lamarck 1816), *Maretia planulata* (Lamarck 1816), and *Brissus latecarinatus* (Leske 1778). Ristanto et al (2018) found in Bengkayang waters five types of sea urchins, namely: *Diadema savignyi*, *D. antillarium*, *D. setosum*, *Echinotrix deadema*, and *E. calamaris*. The abundance of *Echinoidea* in waters is influenced by environmental factors, living habits, predation, and competition (Hartati et al 2018). The level of echinoderm diversity in a coral reef ecosystem can indicate a coral reef biodiversity (Alvarado et al 2012).

Sea urchins have many types. The abundance and diversity of sea urchin species in a coral reef area can be an indicator of the health condition of the coral reef ecosystem. The condition of the bottom substrate in the Pulo Suwalan coral reef area is in accordance with the sea urchin habitat patterns found in various other research locations. However, this research cannot provide information on the type, abundance, and characteristics of sea urchins on Pulo Suwalan. The presence of sea urchins found in the Pulo Suwalan coral reef area in this research can be an indication of the potential for biota that has ecological and economic benefits if managed.

Gorgonians. This research found the existence of coral biota with the local name bahar roots, often called sea fans. Sea fans include corals from the Gorgonian-type group. Sea fans belong to the Anthozoa class, live in colonies, have horns and branches, and have an axial skeleton, consisting of various cylindrical polyps that grow together in a certain pattern like a flat fan (Fabricius & Alderslade 2001). Sea fans are benthic organisms that have important value in providing habitat in marine waters (Tapilatu et al 2022). Bahar roots have economic benefits as a raw material for ornamental crafts (Liyundira et al 2022; Septaria et al 2022). Several studies have also revealed the potential for using sea fans as medicinal ingredients (Kelutur et al 2020).

Types of coral from the Gorgonian group can be found living in shallow waters and occupying coral reefs. Gorgonians can be found in coral reef areas with a depth of 3-8 m with rocky substrate conditions or in coral reef areas and slopes (Setiawan 2010). Based on their diet, Gorgonians are carnivores and plankton is their main food source. Specific research on the ecological characteristics of Gorgonians in Indonesia is still very limited. The IUCN status of included Gorgonians in the vulnerable category and the findings on the presence of Gorgonians in the Pulo Suwalan coral reef area can be an indication of the need for further research regarding the ecological conditions of Gorgonians in this area. Management and protection strategy planning is also needed in the area to preserve existing coral reef resources.

Algae. Macroalgae are distributed in intertidal waters and are often found in Indonesian waters (Papalia et al 2013). Indonesian waters hold macroalgae germplasm amounting to 6.42% of the world's total macroalgae biodiversity (Sarita et al 2021). Macroalgae are primary producer organisms in the aquatic food chain. There are 555 types of macroalgae that can be identified in Indonesian waters and 55 types have been utilized (Parenrengi et al 2012). Macroalgae is a type of algae with macroscopic size (Pereira 2021). According to Palallo (2013), 628 types of the 8000 types of macroalgae found in the world can also be found in Indonesian waters. Based on their pigment, algae can be divided into four groups, namely green algae (*Chlorophyta*), red algae (*Rhodophyta*), brown algae (*Ochrophyta*), and blue-green algae (*Cyanobacteria*) (Pereira 2021). Green algae is a type of algae that is widely used as a food component and a source of vitamins, minerals, protein, and fiber (Leandro et al 2020). This research found the potential for sea grapes to grow at the research location. Sea grapes are algae from the *Chlorophyta* group that grow in coral reef areas. Sea grapes can be found in coral reef areas or attached to the bottom substrate of waters up to a depth of 200 m (Soenarto et al 2023). Several types of Seagrape that can be found in Indonesian waters include *Caulerpa racemosa*, *C. racemosa* var. *macrophysa*, *C. sertularioides*, *C. taxifolia*, *C. serrulata*, *C. lentillifera*, *C. peltata*, and *C. cupressoides* (Pulukadang et al 2013).

Seagrape (*Caulerpa* sp.) is a type of seaweed that contains alkaloid, phenolic, triterpenoid, and flavonoid compounds which have the potential to act as antioxidants (Nursandi 2014). Some of the potential benefits of sea grapes include food sources (Ghazali & Nurhayati 2018), animal feed and medicine (Fithriyani 2009), development of medicinal ingredients (Tanna et al 2018; Hainil et al 2022) and fish feed supplements (Novianti et al 2022). The nutritional content of sea grapes makes them an alternative food ingredient (Ridhowati & Asnani 2016). Sea grapes also have the potential to be developed as a cultivation commodity with economic value (Firda et al 2022; Jumiati et al 2023). Several aquatic environmental factors that influence the growth of sea grapes are temperature, pH, salinity, and brightness (Paul et al 2014). Sea grapes can live in stagnant waters at high tide and also in a minimal water level, at low tide (Soenarto et al 2023). The types of substrate on which seaweed often grows are sand, mud, and coral fragments (Dahlia et al 2015). Razai et al (2019) found sea grapes growing on coral fragments, former shells, dead coral, coarse sand, and grassy sand. Sea grapes live by attaching themselves to rocks or rather rough substrates in coral reef areas (Yudasmara 2015). According to Ain et al (2014), sea grapes are found in small numbers in sandy or muddy bottom areas due to the limited hard objects in the water that can be used by sea grapes to attach themselves. Sea grapes spread in groups in waters and can be found on clay substrates, attached to dead coral, mollusk shells, and dead sponges (Soenarto et al 2023). According to Erlania & Radiarta (2015), living macroalgae stick to the substrate with the aim of maintaining their position so that they do not get carried away by currents, waves, or tidal influences.

Meiyasa & Tarigan (2021) found 8 types of macroalgae in the waters of East Sumba, consisting of green algae (*Caulerpa racemosa*, *Caulerpa cupressoides*, *Caulerpa lentillifera*, *Halimeda discoides*, *Halimeda opuntia*), red algae (*Eucheuma cottonii*, *Actinotrichia fragilis* Forsskal) and brown algae (*Sargassum vulgare*). Several types of sea grapes found in the Seribu Islands, Natuna waters and Sepang Bay waters, Bengkulu are *Caulerpa racemosa*, *C. taxifolia*, and *C. lentillifera* (Razai et al 2023). Meiyasa & Tarigan (2021) revealed that macroalgae were found in waters with an average temperature of 29.26ºC, pH of 8.1, and DO of 8.2 mg L^{-1}. According to Lapu (2013), macroalgae are found in water conditions with a temperature of around 24-36ºC, a pH range of 7.2-8.2, and a DO of 7.7 mg L^{-1}. Meanwhile, Tarigan et al (2020) reported that the water conditions where macroalgae were found were at a temperature of around 28-30ºC, a pH range of 7.2-8.9, and a DO of 7.6-8.4 mg L^{-1}. The macroalgae found in the Pulo Suwalan coral reef area indicate the existence of a source of primary productivity in the coral reef ecosystem. Macroalgae are primary producers that provide food for herbivorous biota in the ecosystem. The presence of macroalgae in the Pulo Suwalan coral reef area indicates the presence of producers in the food chain of the existing ecosystem.

Conclusions. The fish found in the Pulo Suwalan coral reef area consists of 3 families, namely *Pomacentridae*, *Serranidae* and *Labridae*. Fish abundance ranged from 0.01 to 0.05. The results of the index assessment show that the diversity index is in the low category, the evenness index is in the moderate category and the dominance index is in the high category (or there are no species that dominate). Biota, other than fish, found in the Pulo Suwalan coral reef area are *Heteractis* sp., *Diadema* sp., *Plexaura* sp., *Diodogorgia* sp., *Iciligorgia* sp., *Cladophora* sp., and *Caulerpa* sp. The characteristics of the biota found in the Pulo Suwalan area show the existence of an active coral reef ecosystem. However, further research is needed to determine the health condition of coral reefs and the abundance of various biota in their ecosystem.

Acknowledgements. The authors would like to thank to the Faculty of Fisheries and Marine Sciences for funding research in research grant program number 1501-15/UN7.5.10/LT/2018.

Conflict of interest. The authors declare no conflict of interest.

References

Abubakar L., Mwangi C., Uku J., Ndirangu S., 2012 Antimicrobial activity of various extracts of the Sea Urchin *Tripneustes gratilla* (*Echinoidea*). African Journal of Pharmacology and Therapeutics 1(1):19-23.

Afifa F. H., Supriharyono S., Purnomo P. W., 2017 [The dispersal of sea urchins in Menjangan Kecil island, Karimunjawa islands, Jepara]. Management of Aquatic Resources Journal 6(3):230-238. [In Indonesian].

Ain N., Ruswahyuni R., Widyorini N., 2014 [Relationship between seaweed density and different bottom substrates in Bandengan beach waters, Jepara]. Management of Aquatic Resources Journal 3(1):99–107 [In Indonesian].

Allen G., 1999 Marine fishes of Southeast Asia: a field guide for anglers and divers. Periplus Editions (HK) Ltd., Singapore, 292 p.

Allen G. R., Adrim M., 2003 Coral reef fishes of Indonesia. Zoological Studies 42(1):1-72.

Alvarado J. J., Guzman H. M., Breedy O., 2012 Distribution and diversity of echinoderms (*Asteroidea, Echinoidea, Holothuroidea*) in the islands of the Gulf of Chiriqui, Panama. Rev Biol Mar Oceanogr 47(1):13-22.

Andrimida A., Hardiyan F. Z., 2022 [Trophic structure of coral fish and its relationship with the condition of the bottom substrate in the Sempu strait, Indonesia]. Journal of Fisheries and Marine Research 6(1):41-54. [In Indonesian].

Ardian D., Kurniawan D., Putra R. D., 2020 [Correlation percentage of live coral cover with fish abundance indicator *Chaetodontidae* in Pengudang village, Bintan regency]. Journal of Akuatiklestari 3(2):21–29.

Astuti R., Yonvitner Y., Kamal M. M., 2016 [Community structure of grouper fish (*Serranidae*) landed in Peukan Bada subdistrict, Aceh province]. Tropical Sciences and Marine Technology Journal 8(1):73-84.

Awuy G., Rondonuwu A. B., Kambey A. D., 2017 [Coral fishes community on the artificial coral reefs of Kareko waters, North Lembeh island district, Bitung city, North Sulawesi]. Platax Scientific Journal 5(2):145-154. [In Indonesian].

Benfield S., Baxter L., Guzman H. M., Mair J. M., 2008 A comparison of coral reef and coral community fish assemblages in Pasific Panama and enviromental factor governing their structure. Journal of Marine Biological Association of the United Kingdom 88(7):1331-1341.

Burke L., Selig E., Spalding M., 2002 Reefs at risk in Southeast Asia. World Resources Institute, Washington, 72 p.

Carpenter K. E., Niem V. H., 2001a FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific. Volume 5: Bony fishes part 3 (*Menidae* to *Pomacentridae*). Food and Agriculture Organization of the United Nations, Rome, pp. 2791-3380.

Carpenter K. E., Niem V. H., 2001b FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific. Volume 6: Bony fishes part 4 (*Labridae* to *Latimeriidae*), estuarine crocodiles, sea turtles, sea snakes and marine mammals. Food and Agriculture Organization of the United Nations, Rome, pp. 3381-4218.

Choat J. H., Bellwood D. R., 1991 Reef fishes: their history and evolution. In: the ecology of fishes on coral reefs. Sale P. F. (ed), pp. 39–68, Academic Press.

Dhahiyat Y., Sinuhaji D., Hamdani H., 2017 [Community structure of coral reef fish in the coral transplantation area Pari island, Kepulauan Seribu]. Indonesian Journal of Ichthyology 3(2):87-94. [In Indonesian].

Edrus I. N., Abrar M., 2016 Diversity of reef fish fungsional groups in terms of coral reef resiliences. Indonesian Fisheries Research Journal 22(2):109-122.

English S. A., Wilkinson C., Baker V. J., 1997 Survey manual for tropical marine resource. Australian Institute of Marine Science, Australia, 390 p.

Erdana R., Pratikto I., Suryono C. A., Suryono S., 2022 [The relationship between the percentage of live coral cover and the abundance of fish in the Koon island marine conservation area, East Seram regency, Maluku province]. Journal of Marine Research 11(2):145-155. [In Indonesian].

Erlania E., Radiarta I. N., 2015 [Distribution of natural seaweed based on bottom water characteristics in the Labuhanbua reef flat area, West Nusa Tenggara: Management strategies for cultivation development]. Journal of Aquaculture Research 10(3):449-457. [In Indonesian].

Fahmi F., Supriharyono S., Ghofar A., 2017 [Relationship of coral cover percentage with reef fishes abundance in Menjangan Kecil island, Karimunjawa island, Jepara]. Management of Aquatic Resources Journal 6(4):333-338. [In Indonesian].

Fabricius K., Alderslade P., 2001 Soft corals and sea fans: a comprehensive guide to the tropical shallow-water genera of the Central-West Pacific, the Indian Ocean and the Red Sea. Australian Institute of Marine Science, Australia, 204 p.

Firda H., Junaidi M., Setyono B. D. H., 2022 [The effect of harvesting on the production and antioxidant activity of sea grape (*Caulerpa racemosa*) by rigid quadrant nets planting method]. Indonesia Journal of Aquaculture 2(1):54-64. [In Indonesian].

Fithriani D., 2015 Opportunities and challenges for developing *Caulerpa racemosa* as functional foods. The 1st International Symposium on Aquatic Product Processing 2013. KnE Life Sciences 1:85-96.

Frederich B., Parmentier E., 2016 Biology of damselfishes. CRC Press, Taylor & Francis Group, 340 p.

Frederich B., Fabri G., Lepoint G., Vandewalle P., Parmentier E., 2009 Trophic niches of thirteen damselfishes (*Pomacentridae*) at the Grand Recif of Toliara, Madagascar. Ichthyological Research 56(1):10-17.

Ghazali M., Nurhayati N., 2018 [opportunities and challenges for developing non-cultivated macroalgae as food on the island of Lombok]. Agrotek Ummat Journal 5(2):135–140. [In Indonesian].

Ghiffar M. A., Irham A., Harahap S. A., Kurniawaty N., Astuty S., 2017 [Corellation between coral reef condition and reef targets fishes abundace in Tinabo Besar island, Taka Bonerate National Park, South Sulawesi]. Spermonde Journal 2(3):17-24. [In Indonesian].

Giyanto G., Manuputty A. E. W., Abrar M., Siringoringo R. M., Suharti S. R., Wibowo K., Edrus I. N., Arbi U. Y., Cappenberg A. W., Sihaloho H. F., Tuti Y., Zulfianita D., 2014 [Coral reef health monitoring guide: coral reefs, reef fish, and megabenthos]. COREMAP CTI LIPI, 63 p. [In Indonesian].

Hadinoto S., Sukaryono I. D., Siahay Y., 2017 [Nutrition content of sea urchin (*Diadema setosum*) gonad and antibacteria activities of its shell extracts]. Journal of Postharvest and Marine and Fisheries Biotechnology 12(1):71-78. [In Indonesian].

Hainil S., Sammulia S. F., Adella A., 2022 [Antibacterial activity *Staphyloccocos aureus* and *Salmonella* typhi sea grapes (*Caulerpa racemosa*) methanol extract]. Journal of Surya Medika 7(2):86-95. [In Indonesian].

Harsindhi C. J., Bengen D. G., Zamani N. P., Kurniawan F., 2020 Abundance and spatial distribution of reef fish based on coral lifeforms at Tidung island, Kepulauan Seribu, Jakarta Bay. AACL Bioflux 13(2):736-745.
Hartati R., Meirawati E., Redjeki S., Riniatsih I., Mahendrajaya R. T., 2018 [Types of stars fish and sea urchins (*Asteoidea, Echinoidea: Echinodermata*) in Cilik island, Karimunjawa waters]. Marine Tropical Journal 21(1):41-48. [In Indonesian].
Hasbi K. A. M., Redjeki S., Munasik M., 2011 [Spatial distribution of coral reef fish family *Labridae* (wrasess) in the waters of Panjang island, Jepara]. Journal of Marine Research 1:1-15. [In Indonesian].
Heemstra P. C., Randall J. E., 1993 FAO species catalogue: groupers of the world (family *Serranidae*, subfamily *Epinephelinae*). Volume 6. FAO, Rome, 382 p.
Huda M. A. I., Sudarmadji S., Fajariyah S., 2017 [Echinoidea diversity in intertidal zone Jeding Beach Baluran National Park]. Berkala Sainstek 5(2):61-65. [In Indonesian].
Hutomo M., 1986 [Reef fish communities and visual census methods]. LNON-LIPI, Jakarta, 21 p. [In Indonesian].
Jumiati J., Maulana N., Heriansah H., Lapong I., Kabangnga A., 2023 [Assesing the coculture potential of sea grapes (*Caulerpa lentillifera*) and tiger shrimp (*Penaeus monodon*) in traditional brackish water ponds]. Juvenil: Scientific Journal of Fisheries and Marine 4(1):21-30. [In Indonesian].
Kelutur F. J., Mustarichie R., Umar A. K., 2020 [Virtual screening of sea fan (*Gorgonia mariae*) compound content as anti-asthma]. Alchemy Journal 16(2):199-210. [In Indonesian].
Knowlton N., Jackson J. B. C., 2008 Shifting baselines, local impacts, and global change on coral reefs. PLoS Biol 6(2):e54.
Koroy K., Nurafni N., Mustafa M., 2018 [Analysis of the suitability and carrying capacity of coral reef ecosystems as marine ecotourism on Dodola island, Morotai island regency]. Enggano Journal 3(1):52-64. [In Indonesian].
Krebs C. J., 1989 Ecological methodology. Harper and Rowe Publisher, New York, 654 p.
Krisnawati L. L., 2017 [Bioeconomic study of small pelagic fisheries using mini purse seine at Tasik agung fishing port, Rembang regency]. BSc Thesis, Brawijaya University, Malang, 93 p. [In Indonesian].
Kuiter R. H., Tonozuka T., 2001 Pictorial guide to: Indonesian reef fishes. Zoonetics Australia, 893 p.
Lapu P., 2013 [Exploration of macroalgae in Ruting and Leihari Waters, Leitimur district, Ambon city]. Proceedings FMIPA University of Pattimura, pp. 36-40. [In Indonesian].
Leandro A., Pereira L., Goncalves A. M. M., 2020 Diverse applications of marine macroalgae. Mar Drugs 18(17):1–15.
Liyundira F. S., Ifa K., Kasno K., 2022 Bahar roots craft a business development strategy to increase income. Wiga : Economic Sciences Research Journal 12(3):200–208.
Luthfi O. M., 2016 [Coral reef conservation using coral garden initiative in Sempu island]. Journal of Innovation and Applied Technology 2(1):210-216. [In Indonesian].
Luthfi O. M., Dewi C. S. U., Sasmitha R. D., Alim D. S., Putranto D. B. D., Yulianto F., 2018 [Abundance of invertebrates on Sempu island as a bioindicator index, economically important consumption, and aquarium collection commodity]. Journal of Fisheries and Marine Research 2(3):137-148. [In Indonesian].
Meiyasa F., Tarigan N., 2021 [Diversity of macroalgae types found in Wula-Waijelu waters, East Sumba regency]. Quagga Journal 13(2):60-67. [In Indonesian].
Mujiyanto M., Sugianti Y., 2014 [Bioecology of groupers in Karimunjawa waters]. Indonesian Journal of Marine Sciences 19(2):88-96. [In Indonesian].
Munday P. L., Jones G. P., Caley M. J., 2001 Interspesific competition and coexistence in a guild of coral-drewling fishes. Ecology 82(8):2177-2189.
Najamuddin N., Ishak S., Ahmad A., 2012 Diversity of reef fish at waters of Makian Island in North Maluku. Depik Journal 1(2):114-120.
Nanami A., 2021 Spatial distribution of parrotfishes and groupers in an Okinawan coral reef: size-related associations in relation to habitat characteristics. PeerJ 9:e12134

Nane L., Baruadi A. S. R., Mardin H., 2020 The density of the blue-black urchin *Echinotrix diadema* (Linnaeus, 1758) in Tomini bay, Indonesia. Tomini Journal of Aquatic Science 1(1):16–21.
Nirwan N., Syahdan M., Salim D., 2017 [Study of damage to coral reef ecosystems in the marine tourism area of Liukang Loe island, Bulukumba regency, South Sulawesi Province]. Marine Coastal and Small Islands Journal 1(1):11-22. [In Indonesian].
Noviana N. P. E., Julyantoro P. G. S., Pebriani D. A. A., 2019 Distribution and abundance of sea urchins (*Echinoidea*) in the waters of Pasir Putih island, Sumberkima village, Buleleng, Bali. Current Trends in Aquatic Science 2(1):21-28.
Novianti N., Umar N. A., Budi S., 2022 The effect of various concentrations of seaweed *Caulerfa lentillirea* on feed on the growth of tilapia. Journal of Aquaculture and Environment 4(2):45-49.
Nuraini S., 2007 [Grouper species and length-weight relationship in Berau waters, East Kalimantan]. Indonesian Journal of Ichtiology 7(2):61-65. [In Indonesian].
Nursandi N. M. N. J., 2014 [Chemical characteristics of local seaweed (*Caulerpa* sp.) and its potential as a source of antioxidants]. Proceedings of the National Seminar on Agricultural Technology Development 2014:577-584. [In Indonesian].
Nybakken J. W., 1992 Marine biology an ecological approach. Gramedia Publisher, Jakarta, 462 p.
Obura D., Grimsditch G., 2009 Resilience assessment of coral reefs: assessment protocol for coral reefs, focusing on coral bleaching and thermal stress. IUCN, Gland, Switzerland, 70 p.
Odum E. P., 1993 Basics of ecology. University of Gajah Mada, Yogyakarta, 630 p.
Olii H., Kadim M. K., 2017 [Density and distribution pattern of sea urchins in Lamu village]. Nike: Fisheries and Marine Scientific Journal 5(2):48–53. [In Indonesian].
Palallo A., 2013 [Distribution of macroalgae in seagrass and coral reef ecosystems on Bonebatang island, Ujung Tanah district, Barrang Lompo village, Makassar]. Bachelor Thesis. Hassanuddin University, Makassar, 45 p. [In Indonesian].
Papalia S., Arfah H., 2013 [Macroalgae biomass productivity in Ambalau island waters, South Buru district]. Journal of Science and Tropical Marine Technology 5(2):465-477. [In Indonesian].
Parenrengi A., Rachmansyah R., Suyati E., 2012 [Cultivation of seaweed which produces carrageenan (karaginafit)]. Technology Series For Minapolitan, Research and Development Center for Brackish Water Cultivation, Marine and Fisheries Research and Development Agency, Ministry of Marine Affairs and Fisheries, pp. 1-54. [In Indonesian].
Paul N. A., Neveux N., Magnusson M., De Nys R., 2014 Comparative production and nutritional value of sea grapes the tropical green seaweeds *Caulerpa lentillifera* and *C. racemosa*. Journal of applied phycology 26:1833-1844.
Pereira L., 2021 Macroalgae. Encyclopedia Journal 1(1):177-188.
Peristiwady T., 2006 [Marine fish are economically important in Indonesia]. Indonesian Oceanology Center, Jakarta, 270 p. [In Indonesian].
Pinheiro H. T., Martins A. S., Joyeux J. C., 2013 The importance of small-scale environment factors to community structure patterns of tropical rocky reef fish. Journal of the Marine Biological Association of the United Kingdom 93(5):1175-1185.
Pratchett M. S., Wilson S. K., Baird A. H., 2006 Declines in the abundance of *Chaetodon* butterflyfishes following extensive coral depletion. Journal of fish Biology 69(5):1269-1280.
Prihantoko K. E., Wibowo B. A., Kurohman F., Setiyanto I., Asatidz S., Wijaya, M. I., 2023 Bathymetry and substrate characteristics in Pulo Suwalan coral reef areas for fish apartment development in Rembang coastal area. International Journal of Fisheries and Aquatic Studies 11(4):174-180.
Pulukadang I., Keppel R. C., Gerung G. S., 2013 [A study on bioecology of macroalgae, genus *Caulerpa* in Northern Minahasa waters, North Sulawesi province]. Aquatic Science and Management 1(1):26-31. [In Indonesian].

Purwandatama R. W., Ain C., Suryanti S., 2014 [Abundance of sea urchins on massive corals and branching corals in the flat and tubir areas in Legon Boyo, Karimunjawa Island, Karimunjawa National Park]. Management of Aquatic Resources Journal 3(1):17-26. [In Indonesian].
Putra I. M. R., Dirgayusa I. G. N. P., Faiqoh E., 2019 Diversity and biomass of reef fish and their relationship with live coral cover in Manggis waters, Karangasem regency. Bali. Journal of Marine and Aquatic Sciences 5(2):164-176.
Putra S. A., Akbar H., Syari I. A., 2019 Shallow-water hard corals (*Hexacorallia: Scleractinia*) from Bangka Belitung islands waters, Indonesia. Aceh Journal of Animal Science 4(2):89-98.
Ramadhan A., Lindawati L., Kurniasari N., 2017 Economic value of coral reef ecosystems in Wakatobi regency. Marine and Fisheries Socio-Economic Journal 11(2):133-146.
Rani C., Haris A., Yasir I., Faizal A., 2019 [Distribution and abundance of coral fish in Liukangloe island water, Bulukumba district]. Journal of Tropical Science dan Marine Technology 11(3):527-540. [In Indonesian].
Razai T. S., Putra I. P., Febrianto T., Amrifo V., Yanti M. D., 2023 Distribution and potential of *Caulerpa* sp around the Kepulauan Seribu waters, Jakarta. In IOP Conference Series: Earth and Environmental Science 1148(2023):012023.
Razai T. S., Putra I. P., Idris F., Febrianto T., Firdaus M., 2019 [Identification, diversity and distribution of *Caulerpa* sp as potential commodities on Bunguran island, Natuna]. Journal Simbiosa 8(2):168-178. [In Indonesian].
Reininger M., 2012 Diversity and abundance of wrasse species in the gulf of Aqaba: (*Osteichthyes: Labridae*). Zoology in the Middle East 57(1):77-85.
Ridhowati S., Asnani A., 2016 [Potential of *Caulerpa racemosa* group sea grapes as candidates for functional food sources in Indonesia]. Oseana Journal 41(4):50–62. [In Indonesian].
Ristanto A., Yanti A. H., Setyawati T. R., 2018 Sea urchin (*Echinoidea*) distribution and abundance in the intertidal zone of Bengkayang regency. Biosaintifika Journal 10(1):32-40.
Riyantini I., Harahap S. A., Kostaman A. N., Aufaadhiyaa P. A., Yuniarti M. S., Zallesa S., Faizal I., 2023 [Abundance, diversity and distribution of coral fish and megabenthos and their relationship with coral reef conditions and water quality in Gosong Pramuka, Kepulauan Seribu National Park]. Bulletin of Marina Oceanography 12(2):179-191. [In Indonesian].
Rondonuwu A. B., 2014 [Coral fish in the coral reef area, Maba subdistrict, East Halmahera district, North Maluku Province]. Platax Journal 2(1):1-7. [In Indonesian].
Rumahlatu D., 2012 [Behavioral response of the sea urchin *Deadema setosum* to the heavy metal cadmium]. Bumi Lestari Journal of Environment 1(12):45-54. [In Indonesian].
Rungkat V. M. E., Tamanampo J. F. W. S., Tombokan J. L., 2013 [Community structure of *Pomacentridae* fish in coastal waters on Malalayang Dua village of Manado gulf]. Platax Journal 1(3):125–131. [In Indonesian].
Sadam L. O., Emiyarti E., Ira I., 2019 [Diversity of sea urchins (*Echinoidea*) in the seagrass area in the waters of Langara village, West Wawoni district, Konawe islands regency]. Journal of Sapa Laut 4(3):113-122. [In Indonesian].
Saputro P., Wibowo B. A., Rosyid A., 2014 [Utilization levels of demersal fisheries in Rembang regency seawaters]. Journal of Fisheries Resources Utilization Management and Technology 3(2):9-18. [In Indonesian].
Sarita I. D. A. A. D., Subrata I. M., Sumaryani N. P., Rai I. G. A., 2021 [Identify the types of seaweed found in the natural ecosystem of Nusa Pedida waters]. Emasains Journal 10(1):141-154. [In Indonesian].
Septaria R., Sila I. N., Budiarta I. G. M., 2022 [Black coral bracelet crafts in the Sade traditional village, Rembitan village, Pujut sub-district, Central Lombok district]. Journal of Fine Arts Education 12(4):319-328. [In Indonesian].

Sese M. R., Annawaty A., Yusron E., 2018. [Diversity of *Echinoderms* (*Echinoidea* and *Holothuroidea*) on Bakalan island, Banggai islands, Central Sulawesi, Indonesia]. Scripta Biologica 5(2):73-77. [In Indonesian].

Setiawan F., 2010 [Field guide to reef fish and marine invertebrate identification]. Wildlive Conservation Society, 350 p. [In Indonesian].

Soenarto A., Hadijah H., Indrawati E., 2023 [Distribution of sea weed *Caulerpa lentillifera* in Takalar regency waters]. Journal of Aquaculture and Environment 5(2):73-76. [In Indonesian].

Sudarmaji S., Efendy M., 2021 [Closing percentage relationship life or abundance coral reef fish in the waters of Noko Selayar island Gresik]. Juvenil Journal 2(1):39-46. [In Indonesian].

Suharsono S., 2008 [Types of coral in Indonesia]. LIPI Press, Jakarta, 344 p. [In Indonesian].

Sulistiawan R., Solichin A., Rahman A., 2019 [The correlation of seagrass density with abundance of sea urchins (*Echinoidea*) in Pancuran Beach Karimunjawa National Park, Jepara]. Management Of Aquatic Resources Journal 8(1):28-36. [In Indonesian].

Suryanti S., Ruswahyuni R., 2014 [The differencei abudance of *Echinodeas* on coral ecosystem and sea grass beds in Pancuran Belakang, Karimunjawa, Jepara]. Saintek Journal 10(1):62–67. [In Indonesian].

Suryanti S., Ain C., Latifah N., Febrianto S., 2017 Mapping of sea urchin abundance as control of algae expansion for the balance of coral reef ecosystem in Karimunjawa islands. Journal of Applied Environmental and Biological Sciences 7(12):120–127.

Tambunan F. C., Munasik M., Trianto A., 2020 [Abundance and biomass of coral fish of the *Scaridae* family in the coral reef ecosystem in the waters of Kembar island, Karimunjawa, Jepara]. Journal of Marine Research 9(2):159-166. [In Indonesian].

Tanna B., Choudhary B., Mishra A., 2018 Metabolite profiling, antioxidant, scavenging and anti-proliferative activities of selected tropical green seaweeds reveal the nutraceutical potential of *Caulerpa* spp. Algal Research 36(2018):96–105.

Taofiqurohman A., 2013 [Coral reef risk assessment due to impacts of fishing and marine tourism activities in Biawak island, West Java]. Depik Journal 2(2):50-57. [In Indonesian].

Tapilatu J. R., Yehezkiel B., Wanggai M. I., Tapilatu M. E., Ismayanti C. A., 2022 [Encyclopedia of black coral]. Andi Publisher, Yogyakarta, 96 p. [In Indonesian].

Tarigan N., Ndahawali S., Meiyasa F., 2020 [Exploration of macroalgae diversity in Londalima waters, East Sumba regency]. Biosfer Journal 5(1):37-43. [In Indonesian].

Thamrin T., Setiawan Y. J., Siregar S. H., 2011 [Analysis of sea urchin *Diadema setosum* in different coral reef conditions in Mapur village, Riau islands]. Journal of Environmental Science 5(1):45-48. [In Indonesian].

Tony F., Soemarno S., Wiadnya D. G. R., Hakim L., 2020 Diversity of reef fish in Halang Melingkau island, South Kalimantan, Indonesia. Biodiversitas Journal 21(10):4804-4812.

Tupan J., Silaban B., 2017 [Physical and chemical characteristics of sea urchins *Diadema setosum* from several waters on Ambon island]. Triton Journal 13(2):71–78. [In Indonesian].

Wilhm J. T., Doriss D., 1986 Fundamental of ecology. Drenker Inc, pp. 123–125.

Witomo C. M., Harahab N., Kurniawan A., 2020 [Benefit value of coral reef ecosystem tourism in the Marine Park Gita Nada Sekotong Lombok]. Marine and Fisheries Socio-Economic Journal 15(2):169-184. [In Indonesian].

Yudasmara G. A., 2013 [Diversity and dominance of the sea urchin community (*Echinoidea*) in the waters of Menjangan island, West Bali National Park Area]. Science and Technology Journal 2(2):213-220. [In Indonesian].

Yudasmara G. A., 2015 [Cultivating sea grapes (*Caulerpa racemosa*) using rigid quadrant nets planting media made from bamboo]. Science and Technology Journal 3(2):468-473. [In Indonesian].

Yusuf M., 2013 [Condition of coral reefs and fish potential in the waters of Karimunjawa National Park, Jepara regency]. Bulletin of Marina Oceanography 2(2):54-60. [In Indonesian].
Zakaria I. J., 2013 [Sea urchin community (*Echinoidea*) on Cingkuak island, Sikuai island and Devil island, West Sumatra]. Proceedings of Semirata FMIPA, University of Lampung, pp. 381-397. [In Indonesian].
Zuhdi M. F., Madduppa H., Zamani N. P., 2021 [Temporal variation of coral reef fish groups on Tidung Kecil island using eDNA metabarcoding and visual census]. Tropical Marine Journal 24(3):283-290. [In Indonesian].
Zurba N., 2019 [Introduction to coral reefs as the main foundation of our ocean]. Unimal Press, Lhokseumawe, 116 p. [In Indonesian].

Received: 27 October 2023. Accepted: 15 February 2024. Published online: 07 March 2024.
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How to cite this article:
Prihantoko K. E., Jayanto B. B., Fitri A. D. P., Hidayat A., 2024 Potential of reef fish at Pulo Suwalan coral reef on the coastal area of Rembang Regency, Indonesia. AACL Bioflux 17(2):517-533.