Coastal and Marine Journal

journal homepage: https://nusantara-research.com/index.php/coastal-and-marine-journal

Original research article

The Study of Coral Recruitment on Artificial Reefs in The Coastal Waters of Penyusuk, Bangka District

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ARTICLE INFO

Article history:
Received 04 May 2024
Received in revised from 28 May 2024
Accepted 02 June 2024
Available online 04 June 2024

Keywords:
Coral Reef
Artificial Reef
Recruitment

ABSTRACT

Artificial coral reefs are one of the efforts to rehabilitate resources and serve as a nursery area, providing a permanent new habitat for sessile biota and maintaining the balance of the food chain cycle. This study aims to identify the types of coral attached to artificial reefs and analyze the coral density value on artificial reefs in the waters of Penyusuk Belinyu, Bangka District. Data collection was conducted by counting the number of individuals of coral genera and their sizes visible through the visual census method. The corals found consist of 3 families and 3 genera of coral: the Subergorgiidae family with the Subergorgia genus, the Carijoidae family with the Carijoa genus, and the Faviidae family with the Favia genus, with a total of 136 individuals found in three observation stations. The coral density values for the 3 stations range between; Subergorgia (0.104-0.677 ind/m2), Carijoa (0.677-1.563 ind/m2), and Favia (0.781-1.146 ind/m2). Environmental parameters affecting coral larval settlement include water flow rate, Total Suspended Solids (TSS), temperature, salinity, brightness, and pH.

Introduction

The coral reef ecosystem in the Bangka Belitung Islands is currently under pressure due to tin mining activities at sea (floating tin mining) and suction dredging ships. According to Syari (2016), the coastal areas of the Bangka Belitung Province face issues such as tin mining causing sedimentation and potential water pollution. Consequently, this damage has led to the loss of habitat for several marine organisms. Changes in the physical and biological characteristics of coral reefs are considered coral reef degradation (Minister of Environment Decree No. 04 of 2001). Therefore, efforts are needed to restore the coral reef ecosystem. One of the policies of the local government of the Bangka Belitung Islands Province and stakeholders in addressing environmental damage caused by offshore tin mining activities is through reclamation and rehabilitation of marine resource ecosystems. One technique used to minimize coral reef

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https:// 10.61548/cmj.v2i1.25

ecosystem damage is the creation of artificial reefs (Andrian *et al*., 2020).

Artificial reefs are one of the efforts aimed at rehabilitating coral reef resources. Artificial reefs serve as structures built to provide nursery areas, enhance natural productivity by offering permanent habitats for sessile organisms, maintain the balance of food chain cycles, simulate natural coral habitats for certain species, and provide coastal protection similar to natural coral reefs (Guntur, 2011). One location of artificial reefs in the Bangka Belitung Islands is in the Waters of Penyusuk Coast, Bangka Regency. The Penyusuk waters have artificial reefs deployed by PT. Artha Cipta Langgeng (ACL) as part of marine reclamation efforts.

The deployment of the artificial reefs took place in May 2022 (PT ACL's annual monitoring report, 2022). A total of 300 structures were deployed across 6 locations (50 structures per location), shaped as artificial cube pyramids (Marjaya, 2022). In the first monitoring session (August 2022), more than one genus of coral was found adhering to the substrate, including species such as Subergorgia and Carijoa (PT ACL's annual monitoring report, 2022). Therefore, to identify the types of coral attached to the artificial reefs, research on the coral density adhering to the artificial reefs in 2022 in the Waters of Penyusuk Coast is necessary as part of coral reef ecosystem rehabilitation efforts. The importance of this research is hoped to serve as a reference for local communities and governments and to provide information for future activities such as research and coral monitoring. Additionally, it can serve as a comparison for future or previous research for the management of marine resources in the waters of Penyusuk, Bangka Regency.

Research Methodology

Time and Location

This research was conducted in May-June 2023. The research location is in the Waters of Penyusuk Belinyu, Bangka Regency. The location map can be seen in Figure 2.

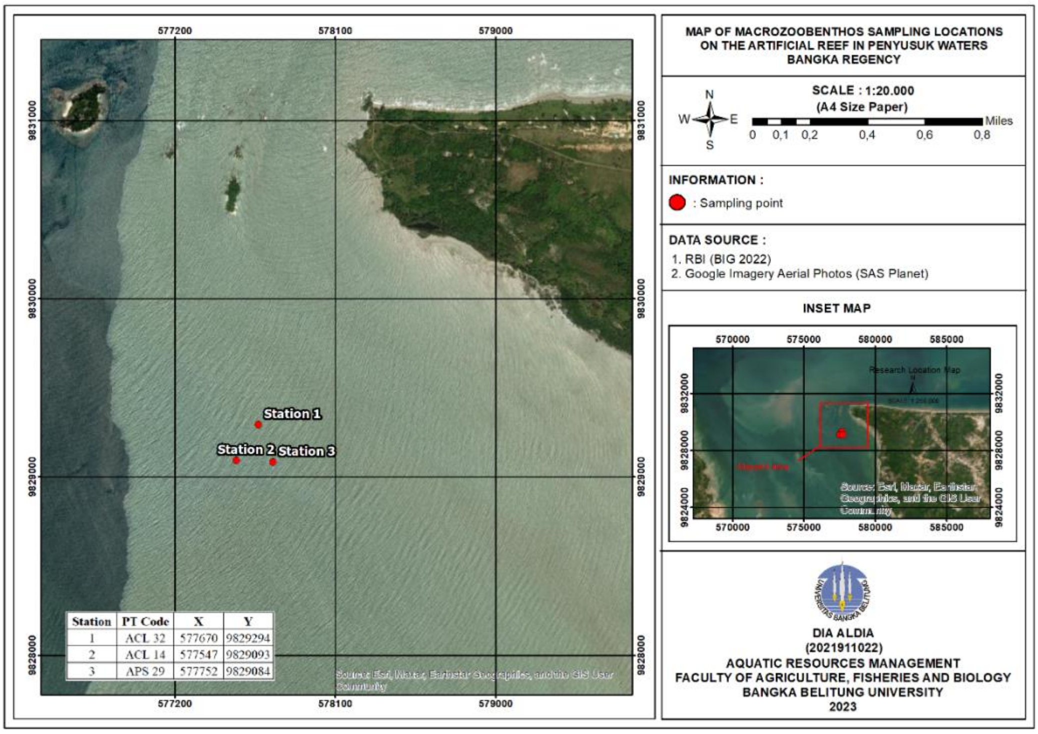

Figure 1. Research location at Penyusuk Marine, Bangka Regency

Tools and Materials

The tools and materials used in this research are presented in Table 1.

Determining Location Points

The research points were conducted at the artificial reef of PT. Arta Cipta Langgeng (ACL) in Penyusuk, Bangka Regency. Data collection was carried out at 3 stations to obtain good results. The following are the research location points as shown in Table 2.

Coral Data Collection

Data collection was conducted using SCUBA equipment. Observations of coral density were visually assessed on each artificial reef made of concrete substrates in 2022, with a total of 50 reefs at depths of 3-5 meters covering an observation area of approximately 19.2 square meters. Coral recruitment observations included identification based on genus and lifeform. Data collection involved counting the number of genus colonies (Finkel and Benayahu, 2007). An example illustration of the artificial reef layout is provided in Figure 2.

Collection of Physicochemical Parameters of Water

The collection of physicochemical parameters of water was done directly at the location (in situ), which includes parameters such as temperature, salinity, water clarity, pH level, and water current velocity. The measurement of TSS parameters was conducted at the laboratory of the Environmental Agency.

Table 1. Research Tools and Materials

No	Tools and Materials	Utility
1	*Scuba set*	To facilitate data collection underwater
2.	*Camera underwater*	To document underwater
3.	Buku identifikasi	To facilitate the identification of collected samples
4.	Jangka sorong (cm)	To measure the diameter of samples
5.	Thermometer (°C)	To measure water temperature
6.	Hand refraktometer ($^{0}/_{00}$)	To measure water salinity
7.	Layang-layang arus (m/s)	To measure current velocity
8.	PH paper	To measure acidity
9.	Botol 1 liter	For TSS sample container
10.	Sabak	For writing down collected data
11.	Secchi disk (m)	To measure brightness
12.	GPS	To determine research points

Table 2. Observation Coordinates

Station	Code PT	Description	Coordinates	
			X	Y
1	ACL 32	Dekat dengan pulau	0577670	9829294
2	ACL 14	Dekat dengan laut lepas	0577547	9829093
3	APS 29	Dekat dengan daratan	0577752	9829084

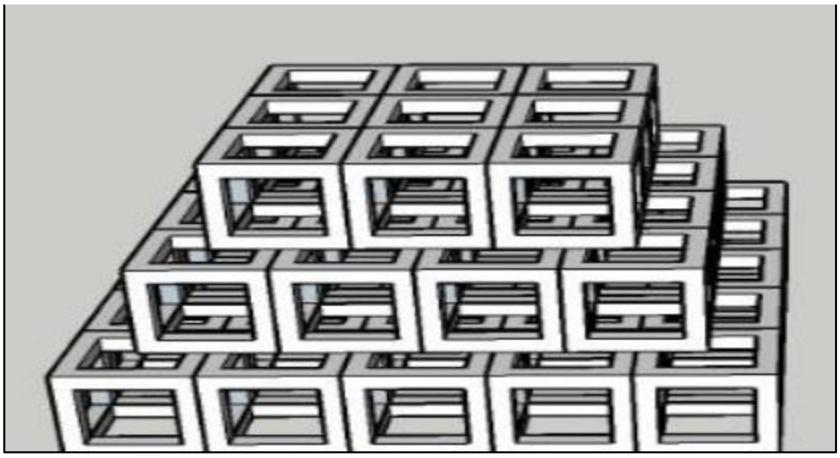

Figure 2. Coral Data Collection
(Source : PT. Artha Cipta Langgeng, 2022)

Results

Coral Genus on Artificial Reef

The results of coral genera found consist of 3 genera with a total of 136 individuals across three stations. The highest number of genera was found at Station 2 and the lowest at Station 3. The results of coral genera can be seen in Table 3, Figure 3, Figure 4, and Figure 5.

Table 3. Family and Genus of Coral

No	Family	Genus	Station		
			1	2	3
1	*Subergorgiidae*	*Subergorgia*	2	13	3
2	*Carijoidae*	*Carijoa*	23	30	13
3	*Faviidae*	*Favia*	15	22	15
Total Individuals			40	65	31
Total Genera			3	3	3

Figure 3. Soft coral from the genus Carijoa

Figure 4. Soft coral from the genus Subergorgia

Figure 5. Hard coral from the genus Favia

Coral Density

The highest coral density was found at Station 2, while the lowest was at Station 3. The results of coral density obtained on the artificial reef in the Penyusuk Waters, Bangka Regency, are listed in Table 4.

Environmental Parameter Measurements

The results of environmental parameter measurements conducted at the three stations during the research period can be seen in Table 5.

Table 4. Coral Density

No	Family	Genus	Station (Ind/m^2)		
			1	2	3
1	*Subergorgiidae*	*Subergorgia*	0,104	0,677	0,156
2	*Carijoidae*	*Carijoa*	1,198	1,563	0,677
3	*Faviidae*	*Favia*	0,781	1,146	0,781
Total			2,08	3,39	1,62

Table 5. Environmental Parameter Measurements

Parameter	Station (ST)			Quality criteria	Source
	1	2	3		
Temperature(°C)	32	31	31	28-30	Government Regulation of Republic of Indonesia Number 22 of 2021
Brightness (%)	38,46	40,57	29,27	>5	
Depth (m)	3,9	5,3	4,8	>5	
Current (m/s)	0,5	0,51	0,51	0,1-0,76	Adrian *et al*., 2020
Salinity (ppt)	30	35	30	33-34	Government Regulation of Republic of Indonesia Number 22 of 2021
pH	7,3	7,4	7,3	2-8,5	
TSS (mg/L)	12	20,2	38,5	20	

Discussion

Coral Genus on the Artificial Reef

Based on the research conducted at the 3 observation stations, there are 3 coral genera divided into 2 groups, namely hard coral and soft coral, with a total of 136 individuals. These coral genera originate from the families Subergorgiidae, Carijoidae, and Faviidae. All three observation stations show the presence of 3 genera: Subergorgia, Carijoa, and Favia. Station 2 has the highest number of individuals (65 individuals), station 1 has a moderate number of individuals (40 individuals), while station 3 has the lowest number of individuals (31 individuals). The genus Carijoa dominates in each station, while the genus Subergorgia has the least presence. The dominant presence of the genus Carijoa is due to its rapid growth compared to other corals, with the ability to grow up to one inch every two weeks (Venkataraman et al., 2013).

In addition, Carijoa tends to consume large amounts of zooplankton, causing imbalance in the marine ecosystem. This genus also exhibits resistance to predation and has gonochoric characteristics, with a balanced ratio of male and female individuals (Venkataraman et al., 2013). Gametogenesis process in Carijoa does not occur simultaneously, it is continuous and does not show a seasonal or monthly pattern. The eggs produced by Carijoa have negative buoyancy, indicating that fertilization occurs outside the body and the larvae are likely to be benthic (Kahng *et al*., 2008).

In favorable environmental conditions, Carijoa exhibits a high level of polyp reproduction. Other characteristics of Carijoa such as rapid growth, vegetative reproduction, and good competitive ability enable it to form dense colony aggregations, facilitating sexual reproduction. As long as Carijoa can reach critical population densities, this unconventional sexual reproductive strategy allows it to exploit available space continuously with high reproductive rates and sustained larval production (Venkataraman et al., 2013). Below is the coral reproduction cycle (Figure 6).

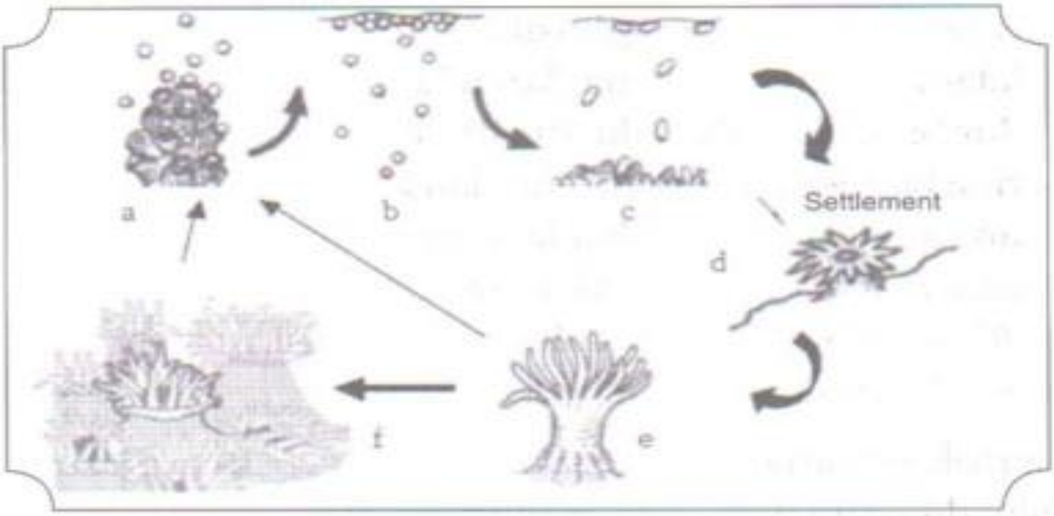

Figure 6. Coral Sexual Reproduction Cycle:
a) Eggs and sperm are released into the water column; b) Fertilization into a zygote occurs at the water surface; c) The zygote develops into a planula larva which then follows water currents, and upon finding a suitable substrate, the planula will settle on the seabed; d) The planula will grow into a polyp; e) Calcification occurs; f) Formation of coral colonies; g) Solitary corals will not form colonies (Luthfi *et al*., 2021).

The genus Carijoa generally exhibits densely branched colonies, orange in color, with large white polyps, and branched sclerites shaped like rods and thorny spindles. The artificial substrate where the colonies are found is covered with epifauna such as hydroids, sponges, and bryozoans. This coral is a non-photosynthetic coral that feeds on zooplankton and organic particles, requiring moderate water flow through waves, tides, or coastal currents. The genus Carijoa is a soft coral that inhabits various habitats such as coral reefs, mangrove forests, and shipwrecks or in sheltered crevices in murky waters rich in organic matter, widely distributed in tropical and subtropical waters. These corals are mostly recorded in shallow waters but can be found at depths of up to 95 meters (Galván et al., 2018).

Subergorgia is a rigid colony resembling a bush that grows in a flat plane and branches dichotomously. Gorgonians belong to the Phylum Cnidaria, which also includes animals such as sea anemones, hard corals, and more famous jellyfish. Gorgonians are part of the soft coral group in the Subclass Alcyonaria/Octocorallia (Goh et al., 1996). Colonies of Subergorgia have distinct longitudinal grooves along the colony on opposite sides. Polyps are mainly located on the branch sides, with polyp mounds shaped like domes approximately 1.5 mm wide. They range in color from dull orange to brown, with cream-colored polyps. Their axes consist of sclerites fused in a horn matrix, with sclerites in the tissue layer shaped like spindles.

Subergorgia is one of the most widely distributed species, commonly found in the tropical Indo-Pacific region from the Red Sea to the Central Pacific. In the waters of Bangka Belitung, the genus Subergorgia is still commonly found. They are mostly found attached to reef slopes at depths of 15-20 meters, and in terms of size, they are typically around 50 cm tall and wide. The reason for their relatively low abundance in the region is attributed to the slow annual growth rate of Subergorgia in the Indo-Pacific area. The growth rate of Subergorgia ranges from 2.30 cm to 7.88 cm per year (Goh *and* Chou, 1995).

The Faviidae coral group belongs to the category of hard corals (Scleractinia), forming massive colonies with septa, columella, and coralite walls that have uniform structures specific to each, comprising about 17 genera (Suharsono 1996). Favia, which is part of the Faviidae family, is a sexually reproductive coral system (natural) known as spawning corals, meaning fertilization and embryogenesis occur in the water column. They are hermaphroditic, meaning they can produce both male (sperm) and female (egg) gametes simultaneously throughout their lives (Thamrin, 2006). The spawning time for the Favia genus is commonly observed in March. Favia corals are the only ones that produce calcium carbonate skeletons, which attach to the artificial reef. Therefore, the Faviidae family is more commonly found on artificial reefs compared to other families that produce calcium carbonate skeletons (Majid, 2022).

Meanwhile, the growth rate of coral colonies can vary from one another. This is due to differences in species, colony age, and reef location. However, some common observations can be noted: young and small colonies tend to grow faster than older colonies, large branching colonies, or leaf-like corals tend to grow faster than massive corals (Nybakken, 1992).

Most Faviidae families are easily identifiable due to their characteristic similarities in small numbers, such as Favia, Barabattoia, Favites, and Montast (Veron and Smith, 2000). Favia and Favites can usually be easily distinguished because each has placoid and cerioid characteristics, but some species, especially Favia rotumana, Favia rotundata, and Favia veroni, almost entirely exhibit cerioid characteristics (similar to Favites) in habitats affected by shallow waves. Similarly, Montastrea, distinguished from Favia by having extratentacular buds rather than intratentacular ones, may be difficult to recognize in colonies that are inactive in their growth (Veron and Smith, 2000).

The genus Favia often exhibits large colonies with a flat or domed shape. Its main corallites are usually monosentrical and placoid, while the daughter corallites are formed through intratentacular division. Its tentacles typically elongate and taper at night, often with pigmented tips. Although similar to Favites, Favia can be distinguished by its more uniformly divided corallites, whereas in Favites, the corallites tend to divide unevenly, resulting in daughter corallites of varying sizes. Favia is also differentiated from Barabattoia by having fewer corallites and intratentacular buds (Veron and Smith, 2000). According to Suharsono (2008), the genus Favia is characterized by massive colonies of varying sizes, with corallites typically shaped like placoids and featuring intratentacular budding. The corallites tend to be rounded with varying sizes and develop well-organized teeth. This genus comprises approximately 20 species distributed throughout Indonesian waters.

Penelit Similar studies conducted by Ardyansyah (2019) in the Turun Aban Waters, Bangka Regency, found 9 coral genera: Favia, Favites, Goniastrea, Montipora, Pavona, Porites, Psammocora, Symphyllia, and Turbinaria. Alam et al.'s research (2022) in the Ujung Gelam Waters, Karimunjawa National Park, found 10 genera: Acropora, Astreopora, Coeloseris, Favia, Fungia, Goniastrea, Montipora, Pavona, Pocillopora, and Porites. Subhan and Pratikino (2017) found 10 genera in the Waters of Pulau Hari, Sulawesi: Pocillopora, Acropora, Fungia, Leptoseris, Cynarina, Seriatopora, Acanthastrea, Favites, Montipora, and Oxypora. Another study (Subhan et al., 2019) in the Waters of Gosong Pramuka, Kepulauan Seribu, Jakarta, found 4 genera: Acropora, Porites, Montipora, and Pavona. These studies note that the Faviidae genus is the most commonly found at each location.

Based on the research above, the diversity of coral genera on artificial reefs in the Penyusuk Waters is almost similar to studies conducted in the Turun Aban Coastal Waters (Ardiayansyah, 2019), Ujung Gelam Waters, Karimunjawa (Alam, 2022), Waters of Pulau Hari, Sulawesi (Subhan and Praktikino, 2017), and Waters of Gosong Pramuka, Kepulauan Seribu (Subhan et al., 2019). It is suspected that the lower number of genera attached is due to the artificial reef placement location being far from the coral parents in the coral reef ecosystem on Pulau Putri. Additionally, the design and materials used in artificial reef construction can affect the ability of corals to attach and grow. Structures that are attractive to coral larvae and provide shelter will support the growth of more coral (Edwards et al., 2010).

Coral Density

The coral density obtained on the artificial reef in the Penyusuk Waters, Bangka Regency, ranges from 1.62 to 3.39 ind/m2. The highest density value is located at station 2, at 3.39 ind/m2, while the lowest density is at station 3, at 1.62 ind/m2, with an observation area of 19.2 m^2.

Based on the results of the measurement of environmental physico-chemical parameters, the temperature ranges from 31-32°C, brightness ranges from 29.2-40.57%, depth ranges from 3.9-5.3 meters, current velocity is about 0.5-0.51 m/s, salinity is 30-35 ppt, pH is 7.3-7.4, and TSS is 12-38.5 mg/l. Each of these parameters falls within the water quality standard criteria according to (Government Regulation of the Republic of Indonesia Number 22 of 2021). The differences in coral density at each station are caused by the geographical distribution of natural corals closest to the artificial reefs. The distribution factor that most influences coral growth is the current. Currents and water circulation are needed as a food supply required for coral growth and oxygen supply from the open sea, and also play a role in cleaning polyps from deposited materials (Giyanto, 2017). Other factors affecting coral growth are substrate, temperature, sunlight, salinity, sedimentation, and water quality (Giyanto, 2017).

According to Prawira et al. (2022), depth greatly impacts coral growth as it affects light penetration, temperature, current velocity, and other limiting factors. The differences in density at each station are influenced by the physico-chemical conditions of the water in the three different stations. In station 2, under certain conditions such as salinity, TSS, and brightness, which comply with the standard quality for seawater, a higher density was observed. Meanwhile, in station 1, a moderate density was found with a TSS value around 12 mg/l, while station 2 had a value of approximately 20.2 mg/l, and station 3 had a value of about 38.5 mg/l.

The recorded current velocities at each station show values that are not significantly different, ranging from 0.50 to 0.51 m/s. The difference in current velocity at each station is influenced by different geographical factors at each location. In station 1, the current velocity of 0.50 m/s is due to the relatively shallow water conditions at that depth. In stations 2 and 3, the current velocity values both reach 0.51 m/s. This is because the geographical positions of these two stations are closer to the open sea, resulting in higher current velocities.

The brightness obtained at each station ranges from 29-41%, with depths ranging from 3-5 meters. The brightness levels at each research station vary, with values of 38.46% at station 1, 40.57% at station 2, and 29.27% at station 3. The highest brightness is recorded at station 2, while the lowest brightness occurs at station 3. The process of photosynthesis is greatly influenced by water brightness. Larval coral attachment is influenced by several factors involving symbiotic zooplankton Zooxanthellae. This zooplankton requires nitrate and phosphate as nutrients to carry out the photosynthesis process. Nitrate and phosphate in coral polyps are needed by Zooxanthellae to perform the process of photosynthesis. The results of photosynthesis, such as amino acids, will be used by corals for the process of calcification or growth (Aini et al., 2013).

In addition, water environments with sufficient sunlight and high transparency provide optimal conductivity for the process of photosynthesis. Changes in the environment, such as pollution and ecosystem degradation, can affect the photosynthesis performance of coral larvae and directly impact the health of coral populations in coral reef ecosystems (Aini et al., 2013). Environmental conditions also influence the growth rate, growth form, ultimately affecting the abundance, composition, and diversity of corals (Barus et al., 2018).

The high density of the Carijoa genus is attributed to its faster growth compared to other corals, with the ability to grow up to one inch every two weeks. Additionally, Carijoa tends to consume zooplankton in large quantities and can thrive in murky water conditions (Venkataraman et al., 2013). Generally, soft corals like Carijoa are pioneers in the formation of new ecosystems (Subhan et al., 2017). The succession stage after the growth of soft corals will be followed by hard corals if water quality supports it. Successional biota provide a food source for small fish, thus forming a chain of relationships (Madduppa et al., 2017).

pH

The recorded pH values at each station are as follows: 7.3 at station 1, 7.4 at station 2, and 7.3 at station 3. Although there is a slight difference between the pH values at each station, these values still fall within a safe range for coral growth. According to Government Regulation No. 22 of 2021 regarding the quality standards of seawater for marine biota, the pH range is between 7 and 8.5. Generally, seawater pH tends to be stable within the range of 7.5 to 8.4. According to Farid et al. (2018), the ideal pH range for marine organisms is between 6.5 and 8.5. Additionally, according to the Ministry of Environment (KLH) (2004), the suitable pH range for marine life is between 7 and 8.5. Therefore, the recorded pH values at the research stations are still within the appropriate range for marine life.

The Current Velocity

The current velocity also influences the attachment of coral larvae. Currents and water circulation are necessary for the distribution of food required for coral growth processes and the supply of oxygen from the open sea. Additionally, currents and water circulation also play a role in the cleaning process of material deposits attached to coral polyps. Locations with strong currents and waves can disrupt coral growth, such as in open areas directly facing the open sea, with consistently large waves. Coral larvae, called planula, require a hard and stable substrate to attach to until they grow into mature corals. A unstable substrate, such as sand, will make it difficult for planula to attach (Giyanto, 2017).

The recorded current velocity at each station shows values that are not significantly different, ranging from 0.50 to 0.51 m/s. The variation in current velocity at each station is influenced by different geographic factors at each location. At station 1, the current velocity of 0.50 m/s is due to the relatively shallow conditions in the water at that depth. In stations 2 and 3, the current velocity values both reach 0.51 m/s. In similar studies, the range of currents recorded was between 0.1 to 0.76 m/s (Andrian et al., 2020). This is due to the geographical position of these two stations being closer to the open sea, resulting in higher current velocities. The current pattern during the data collection in May 2023 can be seen in the Figure 7.

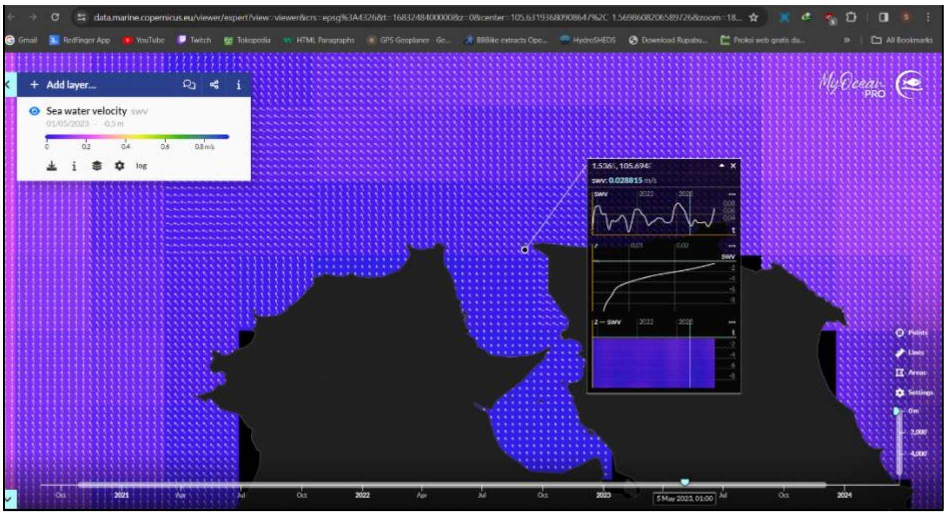

Figure 7. Current pattern in May 2023 at Teluk Kelabat Outer, flowing from southeast to northwest.
Source: Copernicus (5 Mei 2023)

TSS

The Total Suspended Solid (TSS) parameter values at each station show significant variation. At station 1, the TSS value ranges around 12 mg/l, while station 2 has a value of approximately 20.2 mg/l, and station 3 has a value of around 38.5 mg/l. Station 1 has the lowest TSS value, while station 3 has the highest. According to the Minister of Environment Decision (Kemen LH) No. 51 of 2004 concerning the Quality Standards for Sea Water, the safe concentration of suspended solids (TSS) for coral reef growth is 20 mg/l. High TSS concentrations can cause turbidity, which inhibits the photosynthesis process. Erftemeijer et al. (2012) stated that sedimentation rates above 50 mg/l are considered a major disaster for some coral reef communities, while concentrations between 10 and 50 mg/l can be categorized as moderate to severe. Thus, the recorded TSS values at the research stations, especially at station 3, may indicate the potential for serious disturbances to the coral reef ecosystem in that location.

Total Suspended Solid (TSS) can have several effects on coral larvae. High levels of TSS can reduce light penetration in the water, which is crucial for the photosynthesis of zooxanthellae algae living within coral tissues. This can lead to decreased energy production and growth of coral larvae. Additionally, TSS can physically smother coral larvae, causing their death. Research has shown that exposure to high levels of TSS can negatively impact settlement, metamorphosis, and survival of coral larvae, ultimately affecting the overall health of coral reef ecosystems. Therefore, it is important to minimize TSS levels in coastal waters to protect the development and survival of coral larvae.

According to Government Regulation No. 22 of 2021 regarding the quality standards of seawater for marine organisms, the acceptable total suspended solids (TSS) for coral is 20 mg/l. In the research location, the substrate type found is muddy sand (Iskandar et al., 2008). Meanwhile, the lowest TSS value is recorded at station 1, which is 12 mg/l. This could be due to the closer proximity of station 1 to the open sea. According to Rizka et al. (2020), high TSS concentrations can cause turbidity, thereby hindering the process of photosynthesis. Sedimentation rates exceeding 50 mg/l can be considered a major disaster for some coral communities, while concentrations ranging from 10 to 50 mg/l can be classified as moderate to severe.

In the study by Sagita et al. (2023), the lowest TSS value recorded was 4 mg/l, attributed to the research location being close to the open sea. According to Yonar et al. (2021), in areas dominated by fine sand sediment, the sediment is easily stirred up and carried by water currents due to dissolved suspended solids. Akbar et al. (2013) mentioned that the impact of currents and waves prevents mud and sandy mud fractions from settling at the bottom of the water.

The findings are consistent with the opinion of Winnartsih et al. (2016) that the closer to the sea, the lower the TSS content, due to dilution by seawater when materials reach the sea. According to Yonar et al. (2021), TSS standardization in water based on remote sensing has three categories: Category 1 with TSS <20 mg/l, indicating clarity; Category 2 with TSS <40-<80 mg/l, indicating turbidity; and Category 3 with TSS >150 mg/l, indicating pollution. According to Helfinalis et al. (2012), high TSS levels in water will reduce the photosynthesis activity of both micro and macro marine plants, leading to decreased oxygen release, which in turn affects the sustainability of fish populations. Therefore, the TSS obtained at the research stations falls into the turbidity category, ranging from 12-39 mg/l. Based on the observation, the TSS condition in Penyusuk Waters is still categorized as good for marine life and artificial reef ecosystems.

Conclusion

Based on the research findings, the following conclusions are obtained the coral genera found in this study are *Subergorgia*, *Carijoa*, and *Favia*. The coral density on the artificial reef ranges from 1.62 to 3.39 ind/m². The density of Subergorgia coral genus at Station 1 is 0.104 ind/m², Station 2 is 0.677 ind/m², and Station 3 is 0.156 ind/m². Then the density of Carijoa coral genus at Station 1 is 1.198 ind/m², Station 2 is 1.563 ind/m², and Station 3 is 0.677 ind/m². Finally, the density of Favia coral genus at Station 1 is 0.781 ind/m², Station 2 is 1.146 ind/m², and Station 3 is 0.781 ind/m².

References

Aini, M., Ain, C., Studi, P., Sumberdaya, M., Perikanan, J., & Diponegoro, U. (2013). http://ejournal-s1.undip.ac.id/index.php/maquares. 2, 118–126.

Akbar H, Puijiyanti S dan Natsir M. (2013). Huibuingan Tipe Dasar Perairan Dengan Distribuisi Ikan Demersal di Perairan Pangkajene Sulawesi Selatan 2011. Jurnal Teknologi Perikanan dan Kelautan, 4(1):31-39.

Alam, B. F., Wijayanti, D. P., & Munasik, M. (2022). Rekrutmen Juvenil Karang Terumbu Pasca Tertabrak Kapal Di Perairan Ujung Gelam, Taman Nasional Karimunjawa. Buletin Oseanografi Marina, 11(1), 41–50

Andrian Ei, Adibrata S dan Sari S P. (2020). Analisis Kelimpahan Ikan Karang di Fish Shelter dan Terumbu Karang Alami Perairan Karang Meilantuit Pantai Rebo Kecamatan Sungailiat, Kabupaten Bangka. Journal of Tropical Marine Science. 3(1): 35-46.

Andrian, E., Adibrata, S., & Sari, S. P. (2020). Analisis Kelimpahan Ikan Karang di Fish Shelter dan Terumbu Karang Alami Perairan Karang Melantut Pantai Rebo Kecamatan Sungailiat, Kabupaten Bangka. *Journal of Tropical Marine Science*, *3*(1), 35–46.

Ardiansyah, R. (2019). Kepadatan Kerang Keras Yang Menempel Pada Substrat Beton Tahun 2010 Di Pantai Turun Aban [SKRIPSI]. Balunijuk:Universitas Bangka Belitung.

Barus BS, Prartono T, Soedarma D. (2018). Pengaruh lingkungan terhadap bentuk pertumbuhan terumbu karang di Perairan Teluk Lampung. Jurnal Ilmu dan Teknologi Kelautan Tropis. 10(3):699-709

Edwards.A. J., Guest. J., Shafir. S., Fisk. D., Gomez. E., Rinkevich. B., Heyward. A.,Omori. M., Iwao. K., Dizon. R., Morse. A., Boch. C., Job. S., Bonglomi. L.,Levy. G., Shaish. L., Wells. S. (2010). Reef Rehabilitation Manual. Coral Reef Targeted Research & Capacity Building for Management Program: St Lucia.Australia

English S, Wilkinson C and Baker V J (1997) Survey Manual for Tropical Marine Resources ASEANAustralia Marine Science Project: Living Coastal Resources (Townsville: Australian Institute of Marine Science) p 368

Erftemeijer, Paul L.A., Bernhard Riegl, Bert W. Hoeksema, dan Peter A. Todd. (2012). Environmental Impacts of Dredging *and* Other Sediment Disturbances on Corals: A Review. Marine Pollution Bulletin. 64 (9):1737–65.

Finkel, S. P. *and* Benayahu, Y. (2007). Differential recruitment of benthic communities on neighboring artificial *and* natural reefs. Journal of Experimental Marine Biology *and* Ecology, 340(1):25 – 39.

Galván-Villa, C. M., & Ríos-Jara, E. (2018). First detection of the alien snowflake coral Carijoa riisei (Duchassaing and Michelotti, 1860) (Cnidaria: Alcyonacea) in the port of Manzanillo in the Mexican Pacific. BioInvasions Records, 7(1), 1–6. https://doi.org/10.3391/bir.2018.7.1.01

Giyanto, et al. (2017). Status Terumbu Karang Di Indonesia 2017.

Goh, N. K. C., & Chou, L. M. (1995). Growth of Five Species of Gorgonians (Sub-Class Octocorallia) in the Sedimented Waters of Singapore. Marine Ecology, 16(4), 337–346.

Goh, NKC dan Chou, LM 20 Desember (1996). Daftar periksa gorgonians (Anthozoa: Octocorallia) Singapura yang dianotasi, dengan diskusi tentang keanekaragaman gorgonian di Indo-Pasifik Barat . Buletin Zoologi Museum Raffles Hal. 435-459.

Government Regulation of Republic of Indonesia Number 22 of 2021 concerning Implementation of

Environmental Protection and Management

Guntur. (2011). Ekologi Karang Pada Terumbu Buatan. Ghalia Indonesia. Jakarta.

Heilfinalis, Sultan dan Ruibiman. (2012). Padatan Tersuspensi Total di Perairan Selat Floreis Bowling Alor dan Selatan Pulau Adonara Leimbata Pantar. Jurnal Ilmu Kelautan, 17(3):148-153.

Iskandar J, Widyanto R L, Rosida R E, Wahyono H, Handiyana D, Syam I R, Viantoro I W, Gumilar R K T. (2008). Analisis Dampak Lingkungan Kegiatan Penambangan Timah Laut PT. Artha CIpta LAnggeng. CV Kuantum.

Kahng SE, Yehuda B, Wagner D, Rothe N (2008) Reproduksi seksual di Octocoral invasif Carijoa riisei di Wawaii. Banteng Mar Sci 82:1–17.

Kementerian Negara Lingkungan Hidup. 2004.. Keputusan Menteri Lingkungan Hidup No.5. 2004. Tentang Baku Mutu Air Laut Untuk Biota Laut. Jakarta.

Luthfi, Oktiyas Muzaky, Andik Isdianto, Muchamad Fairuz Haykal, and Putra Muhammad Abdillah. (2021). "Ekosistem Terumbu Karang." (October 2023).

Madduppa, H., Subhan, B., Arafat, D., & Zamani, N. P. (2017). Riset Dan Inovasi Terumbu Karang Dan Proses Pemilihan Teknik Rehabilitasi: Sebuah Usulan Menghadapi Gangguan Alami Dan Antropogenik Kasus Di Kepulauan Seribu. Risalah Kebijakan Pertanian Dan Lingkungan: Rumusan Kajian Strategis Bidang Pertanian Dan Lingkungan, 3(2), 45.

Majid, M. R. (2022). Distribusi Tingkat Pigmentasi Gonad Sebagai Petunjuk Pola Reproduksi Karang Family Faviidae Di Kepulauan Spermonde Kota Makassar [SKRIPSI]. Makassar:Universitas Hasanuddin.

Marjaya D. (2022). PT Artha Cipta Langgeng Sebar Fish Shelter dan Rumpon di Perairan Penyusuk Belinyu. di akses dari https://bangka.tribunnews.com/amp/2022/05/24/pt-artha-cipta-langgeng-sebar-fis-shelter-dan-rumpon-di-perairan-penyusuk belinyu?page=2,pada 18 januari 2023.

Nybakken, J. W. (1992). Biologi Laut: Suatu Pendekatan Ekologis (Alih bahasa oleh: Muh. Eidman, Koesoebiono, Dietrich G.B., M. Hutomo, S.Sukardjo). Penerbit PT. Gramedia, Jakarta.

Prawira, P. A., Wiyanto, D. B., & Dirgayusa, I. G. N. P. (2022). Struktur Komunitas Karang Lunak Pada Kedalaman Berbeda di Teluk Jemeluk Amed, Kabupaten Karangasem, Bali. Journal of Marine *and* Aquatic Sciences, 8(2), 311-322

Riegl, B. & S.J. Purkis. 2009. Model of coral population response to accelerated bleaching and mass mortality in a changed climate. Ecol. Mod. 221:192–208

Rizka R F, Puirnomo P W dan Sabdaningsih A. (2020). Pengaruh Total Suspended Solid (TSS) Terhadap Densitas Zooxanthellae pada Karang Acropora sp. dalam Skala Laboratorium. Jurnal Pasir Laut, 4(2):95-101.

Sagita Y, Pamuingkas A dan Akhrianti I. (2023). Sebaran Total Suspended Solid (TSS) dan Tekstur Sedimen di Kawasan Perairan Pantai Matras Kabupaten Bangka. Sci.Linei, 3(1): 001-012.

Subhan, & Pratikno, A. G. (2017). Coral Recruitment Onto Concrete Artificial Reef in Hari Island , Coral Recruitment Onto Concrete

Artificial Reef in Hari Island , Southeast. Aquasains, 5(Tahun 2017), 2.

Subhan, B., Hudhayani, N. N., Ervinia, A., Santoso, P., Arafat, D., Khairudin, D., Soedharma, D., Dhere, R. M., & Madduppa, H. (2019). Coral recruitment on concrete blocks at Gosong Pramuka, Kepulauan Seribu, Jakarta. IOP Conference Series: Earth and Environmental Science, 404(1).

Suharsono. (1996). Jenis-jenis karang yang umum dijumpai di perairan Indonesia. Lembaga Ilmu Pengetahuan Indonesia, Pusat Penelitian dan Pengembangan Oseanologi, Proyek Penelitian dan Pengembangan Daerah Pantai.

Suharsono. (2008). Jenis-jenis karang di Indonesia (Reefs in Indonesia).

Syari, I.A. (2016). Kondisi Terumbu Karang di Perairan Rebo Sungailiat Bangka Akibat Pertambangan Timah. Jurnal Akuatik 10(1):13-20.

Thamrin. (2006). Karang Biologi Reproduksi dan Ekologi. Minamandiri Press,Yogyakarta.

Venkataraman, K., C. Sivaperuman, and C. Raghunathan. 2013. "An Invasion of Snowflake Coral Carijoa Rissei (Duchassaing and Micelotti 1860) in Indian Seas : Threats to Coral Reef Ecosystem." Ecology and Conservation of Tropical Marine Faunal Communities: 1–481.

Veron, J. E. (2000). Corals of the world, vol. 1–3. Australian Institute of Marine Science, Townsville, pages 404–405.

Winnarsih, Eimiyarti dan Afui L O A. (2016). Distribusi Total Suspended Solid Permukaan di Perairan Teluk Kendari. Jurnal Sapa Laut, 1(2):54-59.

Yonar M, Luithfi O M dan Isdianto A. (2021). Dinamika Total Suspended Solid (TSS) di Sekitar Terumbu Karang Pantai Damas, Trenggalek. Journal of Marine *and* Coastal Science, 10(1):48-57.