INDO PAC J OCEAN LIFE
Volume 8, Number 1, June 2024
Pages: 43-51

P-ISSN: 2775-1961
E-ISSN: 2775-1953
DOI: 10.13057/oceanlife/o080105

Diversity of reef fish in the littoral zone of the south coast of Gunungkidul District, Yogyakarta, Indonesia

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[2]Department of Biology, Faculty of Science, Universiti Putra Malaysia. 43400 UPM Serdang, Selangor, Malaysia

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Manuscript received: 31 March 2024. Revision accepted: 29 June 2024.

Abstract. *Rahma HS, Ayuningtyas HR, Nabila I, Annafi DN, Dianti, Yap CK, Dadiono MS, Setyawan AD. 2024. Diversity of reef fish in the littoral zone of the south coast of Gunungkidul District, Yogyakarta, Indonesia. Indo Pac J Ocean Life 8: 43-51.* Diversity in the intertidal zone plays an important role in the marine ecosystem. The balance of the intertidal zone's ecosystem and environmental health can be inferred from the diversity of fish. This study aims to identify reef fish species diversity in the intertidal zone of the south coast of Gunungkidul, Yogyakarta, Indonesia. The research was conducted on five beaches, i.e., Pringjono, Ngrenehan, Ngrawah, Torohudan, and Dadap Ayam, each with its own distinct ecological features. Survey and exploratory methodologies were utilized to analyze and reveal field findings. Observation and sampling were conducted using the random sampling approach. Data were analyzed using the Shannon Diversity Index (H'), the Evenness Index (E), and the Richness Index (Dmg). The study identified 1,378 individuals comprising 45 species and 28 families. The highest number of individuals was caught at Pringjono Beach, with 369 individuals. *Asterropteryx semipunctata* and *Bathygobius fuscus* from the Gobiidae family dominated most stations. The Diversity Index (H') indicated high species diversity across all stations, with the highest value of 3.562 and the lowest of 3.023. For the Evenness Index, most of the five stations were classified as almost evenly distributed, as the lowest value was 0.92 and the highest was 0.97. Meanwhile, the richness index of the fish species at the five research locations is a high category. In sampling stations, there are some differences in abiotic factors, such as salinity, water pH, water temperature, and Dissolved Oxygen (DO), which can affect the composition and distribution of reef fish in the littoral zone in Gunungkidul beach areas.

Keywords: Diversity Index, Evenness Index, fish abundance, reef fish population

INTRODUCTION

Marine ecosystems are among the most extensive and biodiversity-rich natural environments. Occupying about 71% of the planet's surface (Huo et al. 2020), marine ecosystems are home to millions of species, ranging from tiny microorganisms to giant mammals. Through complex interactions between living organisms and their environment, marine ecosystems play an important role in maintaining global ecological balance (Prakash 2021). Buonocore et al. (2021) emphasized that marine ecosystems provide oxygen, which is essential for life on Earth, and contribute to carbon sequestration. Biodiversity in marine waters encompasses a wide range of life forms, from stunning coral reefs to lush seagrass beds and deep oceans (Mooney et al. 2020).

The marine ecosystem of the intertidal zone on the south coast shows a high richness of diversity. The intertidal or littoral zone is the area between high and low tide (Dionfriski et al. 2021). This area periodically experiences fluctuating environmental conditions that include changes in temperature, salinity, and air exposure. Despite facing extreme conditions, the intertidal zone can support a diverse range of marine life that has explicitly adapted to thrive in such environments (Faria et al. 2021). In addition, ecosystems in the intertidal zone also play an important role in coastal ecology (Whitfield 2020). For many fish species, this zone is used as a refuge and food source. In addition, the intertidal zone also plays an important role in providing nutrients to the coastal ecosystem as a whole (Tuaputty et al. 2021). This role involves the process of nutrient cycling through the decomposition of organic matter and the movement of tidal waters that carry nutrients inland. The intertidal zone contributes significantly to shoreline stabilization (Bost et al. 2021).

The intertidal zone is inhabited by various marine animals, such as sea anemones, algae, snails, and small fish (Zulkifli et al. 2020). Diversity in the intertidal zone plays an important role in the marine ecosystem. The intertidal zone has diverse environmental factors, causing high species diversity and abundance (Sukiya and Putri 2015). The intertidal zone is a suitable habitat for various types of fish, especially reef ones (Maghfirah et al. 2023). These fish play a role in population control and movement patterns of other organisms in the intertidal area. Fishes that live in the intertidal zone will have unique characteristics that make them able to survive in a fairly extreme environment (Blewett et al. 2022; Binsasi and Hanoe 2023).

The intertidal zone in Gunungkidul Beach, Indonesia, provides a diverse habitat that can support various life for many fish species. The intertidal zone in the Gunungkidul Beach area has good biodiversity. Hobohm et al. (2021) state that rock formations, puddles, and algae vegetation, such as those in the Gunungkidul Beach area, characterize the dynamic and diverse intertidal zone. By knowing the diversity of fish, it can also be known how the ecosystem and environmental health in the intertidal zone are balanced. This research is expected to provide an understanding of the ecology of the intertidal zone. It can be used as a reference for developing more effective conservation and fish management strategies in the intertidal zone, especially on the five beaches studied. Conservation strategies include water quality monitoring, habitat protection, law enforcement, and collaboration with local institutions. This study aims to identify the diversity of reef fish species in the intertidal zone at five beaches in Gunungkidul, Yogyakarta, especially at Pringjono, Ngrenehan, Ngrawah, Torohudan, and Dadap Ayam. With this research, the intertidal zone at the five beaches can be given more attention to maintain its quality.

MATERIALS AND METHODS

Study area

This research was conducted in March 2024 at five beaches as observation stations, namely Pringjono Beach, Ngrenehan Beach, Ngrawah Beach, Torohudan Beach, and Dadap Ayam Beach, in Kanigoro Village, Saptosari Sub-district, Gunungkidul District, Yogyakarta, Indonesia (Figure 1). These five beaches were chosen because there has been no research on fish species in the intertidal zone, and such research is necessary for coastal conservation. The coordinates of each beach are as follows: Pringjono Beach as Station 1 (8°07'02.0"S, 110°29'58.2"E), Torohudan Beach as Station 2 (8°07'15.6"S, 110°30'51.4"E), Ngrawah Beach as Station 3 (8°07'27.9"S, 110°31'12.4"E), Dadap Ayam Beach as Station 4 (8°07'12.8''S, 110°30'27.1"E), and Ngrenehan Beach as Station 5 (8°07'15.6"S, 110°30'51.4"E). The selection of these five beaches as research stations was based on the beaches having coastlines and intertidal areas dominated by white sand and corals. The research locations represent the beaches in Kanigoro Village to obtain information on fish species diversity in the intertidal area of the coral beach. The lack of references that raise the biodiversity of fish in the intertidal area in the five beaches is a reference for the author to conduct this research.

Data collection and identification

The data collection method was carried out by direct observation at the research location and fish sampling. The method was employed along the coastline and towards the sea (±25 meters) in the intertidal zone during low tide, with three repetitions at each data collection point on every beach. The researchers focus on dividing each beach into three points: the right side, the center, and the left side. However, in practice, the researchers focus more on the sides with coral reefs along the beach. It is related to the presence of fish that tend to be found around coral reefs. Data collection was mainly carried out at low tide, but was also carried out before the low tide and after the low tide before the water fully rises. The survey method is used to obtain a representative of aspects of fish population dynamics (Tangke 2014). The exploratory method is a research method that examines and reveals findings from the field, allowing for the creation of models and drawing conclusions (Masserschmidt 1995). The method used for observation and sampling is the random sampling method, which is a sampling method in which each member of the population is given an equal opportunity to be selected as a sample (Noor et al. 2022). Fish were caught using fishing nets, fish traps, and fishing rods. Fish samples captured are photographed in the field using a fisheye lens, cameras, and scale mat. Underwater cameras were also utilized in data collection in this study.

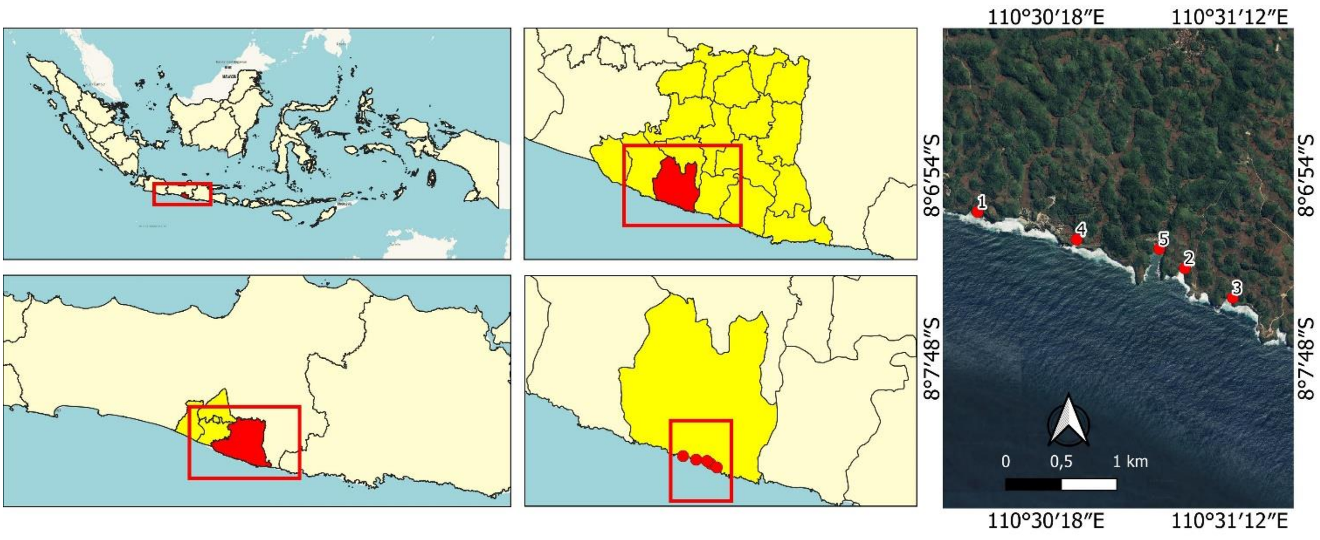

Figure 1. Sampling locations in the south coast of Gunungkidul District, Yogyakarta, Indonesia, i.e., Pringjono Beach (Station 1), Torohudan Beach (Station 2), Ngrawah Beach (Station 3), Dadap Ayam Beach (Station 4), and Ngrenehan Beach (Station 5)

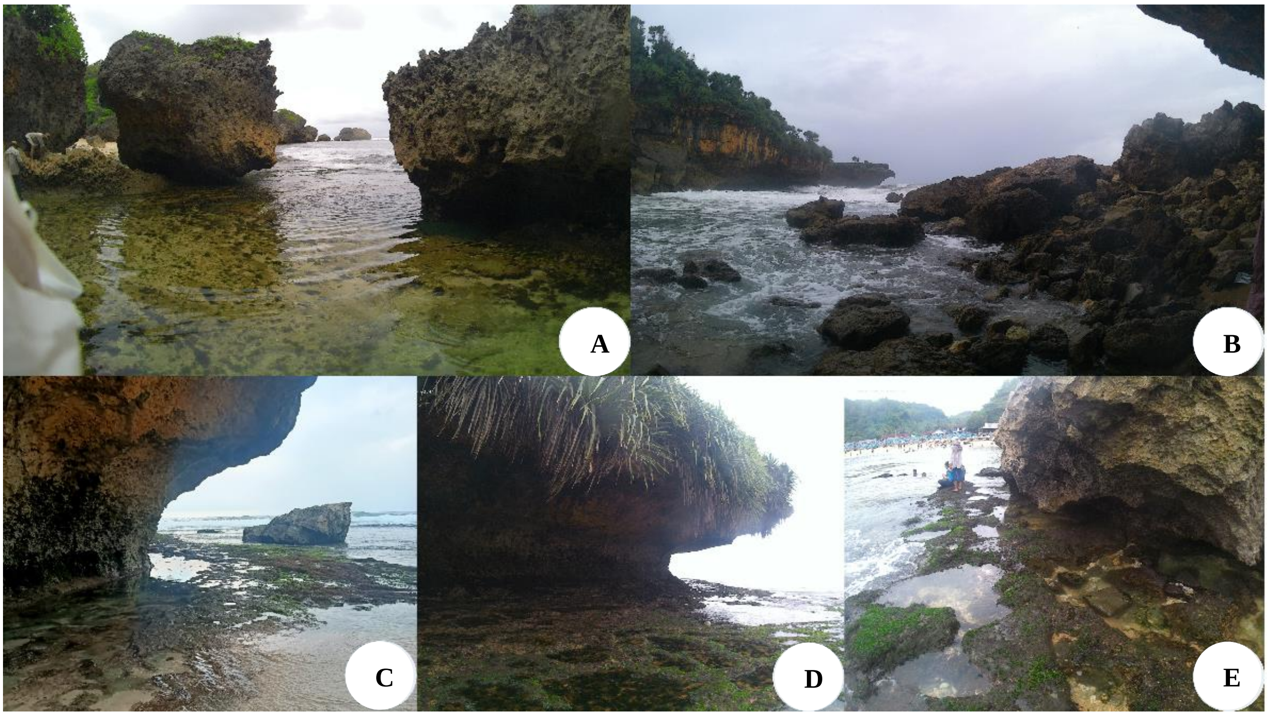

Figure 2. Intertidal zone substrate in the south coast of Gunungkidul District, Yogyakarta, Indonesia: A. Pringjono Beach, B. Torohudan Beach, C. Ngrawah Beach, D. Dadap Ayam Beach, E. Ngrenehan Beach

Measurements of abiotic factors were also taken at each research station at the same time as fish sampling when the beach is at low tide. On the first beach, the data collection was carried out on the first day at around 1 pm. The second beach was carried out on the following day at around 9 am, the third beach was taken at noon at 2 pm, then the fourth beach was taken the following day at around 10 am, and the fifth beach was taken at noon at around 2 pm. Measurement of abiotic factors at each station is carried out by measuring physical and chemical factors of water, which include salinity, pH of water, water temperature, and Dissolved Oxygen (DO). The tools used in the measurement of abiotic factors are refractometers to measure salinity, DO meters to measure dissolved oxygen, and pH meters to measure pH and water temperature. Fish samples were identified by local name, scientific name, and family. Fish samples were identified using several references such as books (Status and Trends of Coral Reefs of the Pacific), journals, the GBIF (Global Biodiversity Information Facility) website (2024), and the International Union for Conservation of Nature (IUCN) website (2024).

Data analysis

Data on species and the number of individuals (N) obtained at each station were analyzed using the Shannon Diversity Index (H') to estimate the diversity of fish species, the Evenness Index (E) to describe the similarity of the abundance of different species in a community, and the Richness Index (Dmg) to determine the level of species richness.

Shannon-Wiener Diversity Index (H')

According to Odum (1971), diversity (H') is used to explain the number of individuals of each species in a community. Fish diversity was calculated using the Shannon-Wiener Index based on Shannon and Weaver (1949).

$$H' = -\sum_{i=1}^{i} pi \ln pi$$

Where:
H' : Shannon-Wiener Diversity Index
Ln : Natural Logarithm
ni : Density of each type i
N : Density of all species
Pi : $\left(\frac{ni}{N}\right)$

Diversity criteria based on (Ludwig and Reynolds 1988; Sinaga et al. 2022): H'>3: high diversity; 1≤H'≤3: moderate diversity; 2 <H': low diversity

Evenness Index (E)

According to Odum (1971), the Uniformity Index (E) determines the similarity of the distribution of the number of individuals of each species at the community level. The Evenness Index can be calculated using the formula.

$$E = \frac{H'}{\ln(S)}$$

Where:
E : Pielou's Evenness Index
H' : Diversity Index
S : Number of species

The criteria for species evenness according to Pielou (1977): 0.00-0.25: uneven; 0.26-0.50: less evenly distributed; 0.51-0.75: fairly evenly distributed; 0.76-0.95: almost evenly distributed; 0.96-1.00: evenly distributed

Species Richness Index (Dmg)

Margalef Species Richness Index as stated in Odum (1971):

$$Dmg = \frac{S-1}{\ln(N)}$$

Where:

Dmg : Species Richness Index
S : Number of species
N : Number of individuals for all species

Criteria for species richness values: D<2.5: low species richness; 2.5>D<4: medium species richness; D>4: high species richness

RESULTS AND DISCUSSION

Reef fish species found

Based on the research conducted on five beaches, namely Pringjono Beach, Torohudan Beach, Ngrawah Beach, Dadap Ayam Beach, and Ngrenehan Beach in Gunungkidul (Figure 2), 45 fish species were obtained from 28 families, 1,378 individuals (Table 1). Each fish species has a different number of individuals. The diversity of fish on each beach is also reflected in the number of individuals found (Blowes et al. 2020). Pringjono Beach showed the highest number, with 369 fish individuals recorded, followed by Torohudan Beach, with 321individuals. Dadap Ayam had 297 fish individuals, while Ngrenehan Beach and Ngrawah Beach had lower numbers of individuals, totaling 228 and 163 individuals, respectively. The number of individuals found in Ngrawah Beach was less than the other four beaches. It is because, there were tidal waves and storms at the time of data collection, so researchers had difficulty identifying fish species in the intertidal zone at Ngrawah Beach.

These results illustrate that variations in fish diversity on each beach can be influenced by several factors, including habitat type, environmental conditions, and interactions between species (López-Delgado et al. 2020). If we observed the variety of fish species on each beach, some were only found on one or two specific beaches, while others had a wider distribution across the beaches studied. For example, species such as *bleny* (*Salarias ceramensis*) and *seren* (*Cyclocheilichthys apogon*) were found on all beaches, indicating a broad habitat preference. However, species such as *candukan* fish (*Naso unicornis*) were only found at Torohudan Beach, while *Pelus/ ikan sidat (Anguilla marmorata)* were only found at Torohudan Beach.

Fishes of the family Gobiidae were found in all five beaches studied, especially *Asterropteryx semipunctata* and *Bathygobius fuscus.* These two fish species from the Gobiidae family dominated most stations based on the Shannon Diversity Index and Evenness Index. Fish with this family are also often called amphibious fish. Based on research conducted by Sukiya and Putri (2015), amphibious fish are found on three beaches in Kanigoro Village, Saptosari Sub-district, Gunungkidul. This type of fish can move from one tidepool to another by launching itself. This fish is also quite difficult to catch because it is more often on the bottom of the sand or coral. The fish with the Gobiidae family are preserved from the year of research, 2015. This is because this fish is still easily found on the five beaches studied.

Of the 28 families found, 19 families only have one species. These include Anguillidae, Atherinidae, Balistidae, Caesionidae, Gourami, Hemiscylliidae, Latidae, Leiognathidae, Lutjanidae, Muraenesocidae, Muraenidae, Plotosidae, Scorpanideae, Serranidae, Stromateidae, Synodontidae, Terapontidae, Tetraodontiformes, and Tetrarogidae. Of the 19 species, Anguillidae is the family with the fewest individuals found. The species found in this family is *Anguilla marmorata* which has the local name *pelus* fish or eel fish. Eels are fish that can live in brackish water and also seawater. Eels usually emerge at night, while data collection is carried out in the morning and afternoon, which is why these fish are difficult to find. According to Muthmainnah et al. (2020), eel fish prefer habitats that are not too dense and where activities are not busy. Station 4, or Dadap Ayam Beach, is the station with the least amount of human activity. It is also supported by research conducted by Shuai et al. (2024), which states that eel fish habitat is better far from settlements and with minimal human activity. Eels are also increasingly difficult to find because eels have experienced overfishing or uncontrolled fishing (Barua et al. 2023).

Morphological characteristics

Fish species found in the five research locations have different characteristics. Based on Figure 3, fish species that have unique characteristics are *Echidna nebulosa* with a shape of about 19 to 20 cm long, body width ranging from 1 cm to 2 cm, and black with gray lines. Fish species with attractive and striking colors are *Chrysiptera unimaculata* in yellow and blue, *Abudefduf vaigiensis* in yellow and black, and *Thalassoma lunare* in green and orange. The *A. semipunctata* (*glodog*) fish has a gray color that resembles coral, so *glodog* fish is difficult to catch (Figure 3). Each fish species found has morphometric characteristics such as different lengths and widths. Differences in morphometric characteristics can be caused by age, sex, and environmental factors such as water pH, temperature, salinity, and food (Noor et al. 2021). Another unique species, Lutjanus mahogoni, serves as a vital predator in coral reefs, regulating the populations of small fish and invertebrates. Its reddish-brown body with darker fins makes it a striking and easily identifiable sight in the coral reefs. Pampus argenteus, with its fascinating body shape and flat body, is a compelling subject in coastal and estuarine waters. The E. nebulosa, with its intriguing patterns, plays a significant role in coral reefs, particularly in maintaining cleanliness and ecosystem balance, a contribution that deserves our appreciation (Wilbert and Nugrahapraja 2023). The vibrant colors of these fish, a result of evolution, allow them to blend seamlessly into the colorful coral reefs, which display a wide array of colors and patterns, thereby protecting them from predators and aiding in hunting for prey (Miller and Pawlik 2013).

Number of species

In each research location, there is a comparison of fish diversity spread across each beach. Based on Table 1, Totohudan Beach (Station 4) had the highest number of fish species, with 40 species recorded. It shows significant diversity. Meanwhile, Dadap Ayam Beach (Station 5) and Pringjono Beach (Station 1) also had fairly high numbers of species, with 36 and 33 fish species, respectively. Meanwhile, Ngrenehan Beach (Station 2) and Ngrawah Beach (Station 3) had lower diversity, with only 27 fish species recorded, respectively. If we observed the variety of fish species on each beach, some were only found on one or two specific beaches, while others had a wider distribution across the beaches studied. For example, species such as *S. ceramensis* (*bleny*) and *C. apogon* (*seren*) were found on all beaches, indicating a broad habitat preference. However, species such as *N. unicornis* (*candukan* fish) were only found at Torohudan Beach, while *T. crocodilus* (*ancang ancang*) were only found at Dadap Ayam Beach. These differences in distribution could be due to various factors such as water temperature, salinity, and food availability. First, there are differences in weather at the time of data collection and samples at each station. The weather at the time of data collection and sampling at Station 1 was cloudy, and the waves were calm. Unlike Station 1, at the time of data collection and samples at Station 4, the weather was terrible, characterized by rainstorms and high tides. Storms, hurricanes, and droughts have the potential to wipe out large numbers of intertidal creatures and upset the delicate balance of coastal ecosystems (Santojanni et al. 2023).

The diversity of fish on each beach is also reflected in the number of individuals found (Blowes et al. 2020). Based on the research, the number of individuals found in Ngrawah Beach was less than the other four beaches. It is because, at the time of data collection, there were tidal waves and storms, so researchers had difficulty identifying fish species in the intertidal zone at Ngrawah Beach. These results illustrate that several factors, including habitat type, environmental conditions, and interactions between species, can influence variations in fish diversity on each beach (López-Delgado 2020).

Conservation status

The International Union for Conservation of Nature (IUCN) uses the Red List categories to classify the degree of risk of extinction of a species. Least Concern (LC) conservation Status indicates the least threatened species, and there are 36 fish species at the research site that have LC conservation status. The fish identified in the LC category have a low extinction rate (Miqueleiz et al. 2020; Putra et al. 2022). Thus, the fish is still considered to have a stable population and is not significantly threatened. NT (Near Threatened) conservation status is a conservation status given to species that are believed to be threatened in the future if there are no management efforts against the species (Prakash 2020). One species of fish has a conservation status of Near Threatened (NT), namely *bayeman* fish *(T. lunare)*. With this conservation status, the existence of *bayeman* fish can be threatened in the future if there is no proper management of this fish's existence. There are 2 species included in the Vulnerable (VU) category, namely *L. mahogoni and P. argenteus*. VU is given to species that are proven to meet the criteria in the IUCN that indicate a higher level of risk, namely the reduction in population size in fewer than 10 years, and the species will certainly face extinction in nature (Wijayanti et al. 2018). The population reduction can be caused by the use and exploitation of large-scale, especially in the meat of the fish *L. mahogoni*. NE (Not Evaluated) category means that IUCN has not evaluated its conservation status.Fish included in the NE category are 6, namely *A. semipunctata, Chiloscyllium punctatum, Leiognathus equulus, A. vaigiensis, Diodon histrix*, and *Vespicula depressifrons*. It highlights the importance of continuously monitoring and assessing species populations for conservation and environmental sustainability.

Diversity index

The Diversity Index is a metric used to measure the level of biodiversity within an ecosystem or biological community (Gatti et al. 2020). It encompasses various aspects of biodiversity, including the number of different species and their relative distribution within an area. The results from the five locations listed in Table 2 consistently indicate a high category. All these values fall within the high category of species diversity. It suggests that the ecosystems at all these locations harbor significant biodiversity. Factors influencing this diversity may include diverse habitats, stable environmental conditions, and varied interspecies interactions. For instance, Pringjono Beach, renowned for its marine biodiversity, may exhibit high diversity due to favorable conditions supporting various marine organisms. High biodiversity in an ecosystem can provide better ecological stability and enhance overall ecosystem productivity (Pennekamp et al. 2018). Similarly, it indicates that ecosystems with high species diversity tend to be more resilient to environmental changes and have better regenerative capabilities.

Evenness index

According to Masladen and Sitogasa (2024), Evenness Index is a method used to measure the uniformity of a species' abundance distribution in a community. From the calculations that have been done, it is found that the five stations have index values close to 1, which means the distribution in the community can be said to be evenly distributed with details of the first station of 0.96, station 2 of 0.89 , station 3 of 0.92, station 4 of 0.83, and station 5 of 0.84 (Table 3). Of the five stations, the largest is the 2rd station, namely Ngrenehan Beach. The five stations can be said to be in uniformity, a state that can be attributed to several factors. One of the key contributors is the stability of environmental conditions. This stability provides a reliable backdrop for the species, ensuring they do not face undue pressure that could lead to the dominance of certain species. The availability of sufficient resources further supports this stability, fostering a harmonious and balanced ecosystem where there is no struggle for resources among the existing fish species (Nuranggitasari and Kurniawan 2021). Moreover, the similarity in environmental conditions across the five beaches is a significant factor in this uniformity. The uniformity in substrate type, temperature, and pollution levels suggests a high likelihood of a similar species community (Warahmah et al. 2022).

Species richness index

The species richness index is a measure of species richness that depends on the direct relationship between the number of species and the logarithm of the sampling area (Roswell et al. 2021). The value of the fish species richness index at the research location is said to be high, that is if the value of the species richness index obtained is greater than 4. The details of the first station of 5.414, station 2 of 4.789 , station 3 of 5.104, station 4 of 6.757 , and station 5 of 6.147 (Table 4) indicate the richness of the fish species at the research location is a high category. So, the results of calculating the species richness index in all research sites have the same category, which has a high fish species richness index with a value above 4.

The five stations have the same species richness index due to their close location, so the adaptation of fish species living is relatively the same between stations. Several factors affect the richness of a species in an ecosystem, including adaptability and habitat (Carminatto et al. 2020). The results of the calculation of the species richness index showed that fish species in the five beaches or stations are classified as numerous. It is supported by Rahmawaty's (2018) statement that the more species and individuals in a place, the higher the value of the species richness Index.

Table 1. Diversity of fish species found in the south coast of Gunungkidul District, Yogyakarta, Indonesia.

Species	Local name	Family	IUCN status	Station				
				1	2	3	4	5
Abudefduf abdominalis (Quoy & Gaimard, 1825)	*Sersan mayor*	Pomacentridae	LC	20	12	4	16	10
Abudefduf bengalensis (Bloch, 1787)	*Tibok*	Pomacentridae	LC	20	13	8	20	15
Abudefduf septemfasciatus (Cuvier, 1830)	*Asan*	Pomacentridae	LC	22	8	7	20	13
Abudefduf sexfasciatus (Lacepède, 1801)	*Betok Belang*	Pomacentridae	LC	19	10	4	19	17
Abudefduf sordidus (Forsskål, 1775)	*Ikan Asan*	Pomacentridae	LC	26	14	8	6	10
Abudefduf vaigiensis (Quoy & Gaimard, 1825)	*Asan*	Pomacentridae	NE	23	11	6	18	12
Acanthurus lineatus (Linnaeus, 1758)	*Botana*	Acanthuridae	LC	2	-	-	2	-
Aluterus monoceros (Linnaeus, 1758)	*Pogot*	Balistidae	LC	-	-	3	2	6
Anguilla marmorata (Quoy & Gaimard, 1824)	*Pelus/ ikan sidat*	Anguillidae	LC	-	-	-	**1**	-
Asterropteryx semipunctata (Rüppell, 1830)	*Glodok*	Gobiidae	NE	20	29	17	25	19
Atherinomorus duodecimalis (Valenciennes, 1835)	*Merek/ Lumbungan*	Atherinidae	LC	8	2	4	6	9
Bathygobius fuscus (Rüppell, 1830)	*Gobi*	Gobiidae	LC	21	14	8	20	14
Strongylura incisa (Valenciennes, 1846)	*Panju*	Belonidae	LC	-	-	-	1	2
Caesio teres (Seale, 1906)	*Lolosi*	Caesionidae	LC	-	3	12	8	-
Carangoides ferdau (Forsskål, 1775)	*Kwee*	Carangidae	LC	5	2	2	5	10
Caranx sexfasciatus (Quoy & Gaimard, 1825)	*Pungguk/kuwe*	Carangidae	LC	23	10	-	14	-
Chiloscyllium punctatum Müller & Henle, 1838	*Buto nogo*	Hemiscylliidae	NE	-	-	4	8	11
Chrysiptera unimaculata (Cuvier, 1830)	*Mayor*	Pomacentridae	LC	-	-	12	4	-
Congresox talabon (Cuvier, 1829)	*Tanong*	Muraenesocidae	LC	5	3	-	-	7
Cyclocheilichthys apogon (Valenciennes, 1842)	*Seren*	Cyprinidae	LC	19	14	7	4	20
Diodon histrix (Linnaeus, 1758)	*Landak an*	Tetraodontiformes	NE	-	3	1	-	-
Echidna nebulosa (Ahl, 1789)	*Belut Moray Kembang*	Muraenidae	LC	2	-	-	1	3
Epinephelus malabaricus (Bloch & Schneider, 1801)	*Kerapu*	Serranidae	LC	5	2	1	2	4
Euristhmus microceps (Richardson, 1845)	*Sembilang*	Plotosidae	LC	-	5	1	2	1
Glossogobius giuris (Hamilton, 1822)	*Buso/Bloso*	Gobiidae	LC	1	-	-	2	2
Halichoeres chloropterus (Bloch, 1791)	*Keling Hijau*	Labridae	LC	15	4	-	7	11
Labroides dimidiatus (Valenciennes, 1839)	*Dokter*	Labridae	LC	4	2	-	5	4
Lates calcalifer (Bloch, 1790)	*Kakap putih*	Latidae	LC	-	-	4	8	1
Leiognathus equulus (Forsskål, 1775)	*Petek*	Leiognathidae	NE	11	4	2	9	16
Lutjanus campechanus (Poey, 1860)	*Kakap merah*	Lutjanidae	LC	1	-	-	-	1
Lutjanus mahogoni (Cuvier, 1828)	*Ngangas*	Lutjanidae	VU	10	15	8	2	8
Lutjanus malabaricus (Bloch & Schneider, 1801)	*Bangbangan*	Lutjanidae	LC	3	1	-	4	7
Megalaspis cordyla (Linnaeus, 1758)	*Caru*	Carangidae	LC	14	-	7	18	-
Naso unicornis (Forsskål, 1775)	*Candukan*	Acanthuridae	LC	-	-	-	5	-
Pampus argenteus (Euphrasen, 1788)	*Taking*	Stromateidae	VU	8	4	2	-	1
Pterois volitans (Linnaeus, 1758)	*Blarakan*	Scorpanideae	LC	2	-	-	1	-
Rasbora borapatensis (Smith, 1934)	*Wader Kupu*	Cyprinidae	LC	-	15	4	11	7
Salarias ceramensis (Bleeker, 1853)	*Bleny*	Blennidae	LC	20	17	21	8	11
Sphyraena obtusata (Cuvier, 1829)	*Ikan Ancang ancang*	Sphyraenidae	LC	2	-	4	-	1
Syinodus variegatus (Lacepede, 1803)	*Tekekan*	Synodontidae	LC	2	-	-	6	4
Terapon jarbua (Forsskål, 1775)	*Kerong*	Terapontidae	LC	4	-	-	3	4
Thalassoma lunare (Linnaeus, 1758)	*Bayeman*	Labridae	NT	9	-	-	4	7
Trichopsis vitatta (Cuvier, 1831)	*Lero*	Gourami	LC	12	6	-	13	7
Tylosurus crocodilus (Péron & Lesueur, 1821)	*Ancang Ancang*	Belonidae	LC	-	-	-	3	8
Vespicula depressifrons (Richardson, 1848)	*Ipuh*	Tetrarogidae	NE	11	5	2	8	14
			Total	369	228	163	321	297

Note: LC: Least Concern, NT: Near Threatened, VU: Vulnerable, NE: Not Evaluated. Station 1: Pringjono Beach, 2: Ngrenehan Beach, 3: Ngrawah Beach, 4: Torohudan Beach, 5: Dadap Ayam Beach.

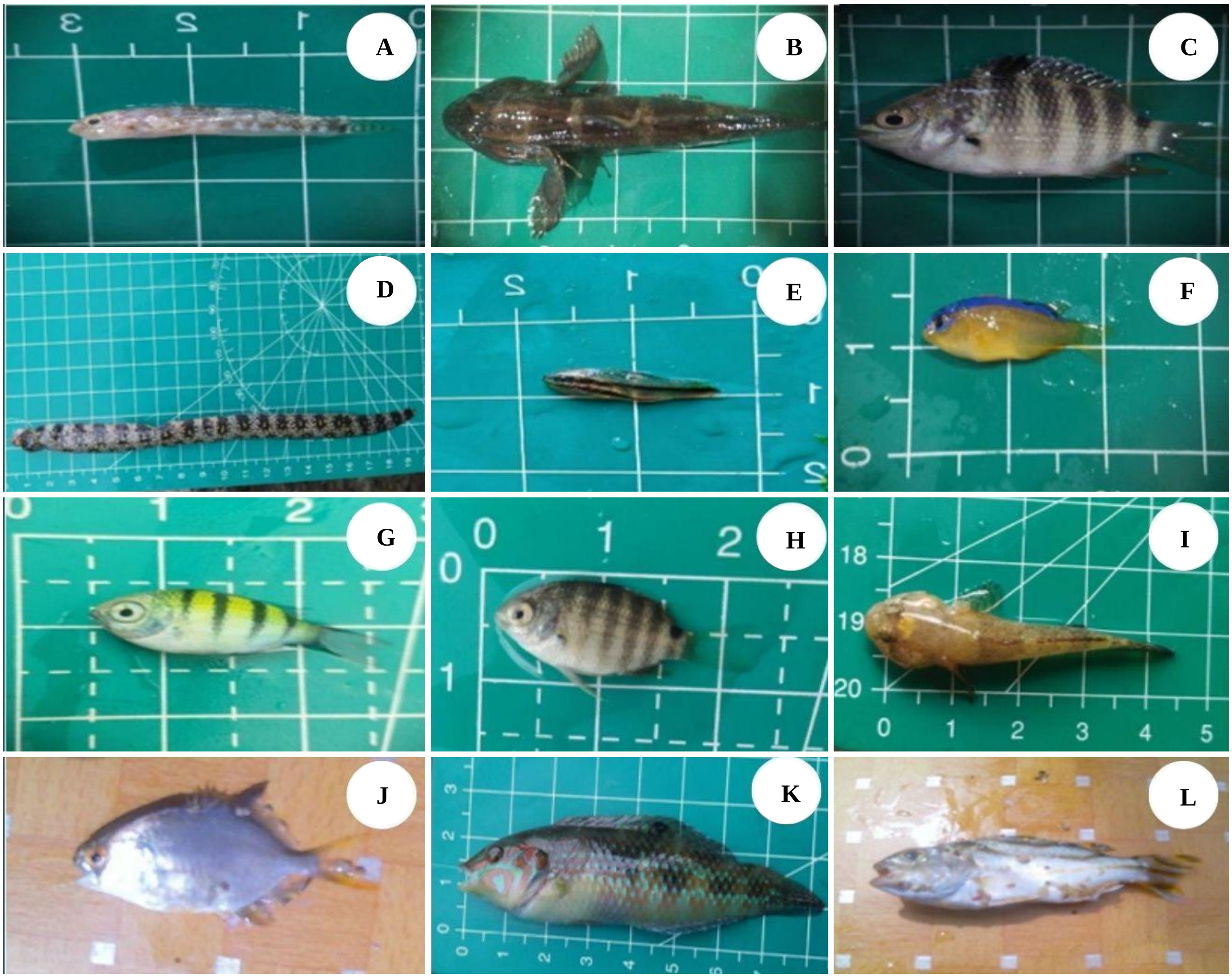

Figure 3. Several types of fish are found in the south coast of Gunungkidul District, Yogyakarta, Indonesia, i.e., Pringjono Beach, Torohudan Beach, Ngrawah Beach, Dadap Ayam Beach, and Ngrenehan Beach: A. *Thalassoma lunare*; B. *Bathygobius fuscus*; C. *Abudefduf abdominalis*; D. *Echidna nebulosa*; E. *Trichopsis vitatta*; F. *Chrysiptera unimaculata*; G. *Abudefduf sordidus*; H. *Abudefduf sexfasciatus*; I. *Glossogobius giuris*; J. *Leiognathus equulus*; K. *Halichoeres chloropterus*; L. *Terapon jarbua*

Table 2. Diversity index of fish in the south coast of Gunungkidul District, Yogyakarta, Indonesia

Stations	Diversity Index (H')	Category
Pringjono Beach	3.365	High
Ngrenehan Beach	2.920	High
Ngrawah Beach	3.023	High
Torohudan Beach	3.028	High
Dadap Ayam Beach	3.091	High

Table 3. Evenness index of fish on the south coast of Gunungkidul District, Yogyakarta, Indonesia

Stations	Evenness index	Category
Pringjono Beach	0.96	Evenly distributed
Ngrenehan Beach	0.89	Evenly distributed
Ngrawah Beach	0.92	Almost evenly distributed
Torohudan Beach	0.83	almost evenly distributed
Dadap Ayam Beach	0.84	almost evenly distributed

Table 4. Species richness index of fish in the south coast of Gunungkidul District, Yogyakarta, Indonesia

Stations	Species richness index	Category
Pringjono Beach	5.414	High
Ngrenehan Beach	4.789	High
Ngrawah Beach	5.104	High
Torohudan Beach	6.757	High
Dadap Ayam Beach	6.147	High

Table 5. Measurement of abiotic factor in the south coast of Gunungkidul District, Yogyakarta, Indonesia

Parameters	Station				
	1	2	3	4	5
Salinity (mg/100g)	3.2	3.2	3.2	3.2	-
pH of water	6.98	8.55	8.26	8.38	7.92
Water temperature (°C)	30.8	30.3	30.3	30.1	29.9
DO (mg/L)	0.7	0.30	0.49	1.7	2.31

Note: Station 1: Pringjono Beach, 2: Ngrenehan Beach, 3: Ngrawah Beach, 4: Torohudan Beach, 5: Dadap Ayam Beach

Abiotic factor

Abiotic factors measured at each research point include salinity, pH, water temperature, and DO (Table 5). As a result, 4 out of 5 Stations have similarities in salinity parameters and slight variations in water temperature. While the salinity of the surrounding ocean influences beach salinity, most beaches have similar salinity levels. The breakdown of salts from the Earth's crust and weathering of rocks are the main sources of salt in the oceans. Evaporation from the ocean surface also contributes to overall salinity. The evaporation factor of seawater also plays a role in salinity because as seawater evaporates, the remaining water becomes more concentrated with salt, maintaining the average salinity level (Geng et al. 2016). Naturally, coasts closer to the equator will be warmer throughout the year than those further away. The climate also affects temperature; it's important to note that weather patterns always differ depending on the season and location, contributing to the dynamic nature of temperature variations (Lusiani and Wally 2020).

For the pH parameter, there are more variations in differences from the range of 6.98-8.55. Fluctuations in O2 and CO2 content can cause the difference in pH levels between beaches (Rukminasari et al. 2014). In addition, the difference in the results obtained can also be caused by the time of collection. The collection of abiotic data at each beach is conducted during low tide. The times of high and low tides can change every day. Therefore, there are differences in the timing of abiotic factor data collection. The range of differences in DO levels from each station also varies, ranging from 0.30-2.31. Dissolved oxygen concentrations tend to be higher in areas close to land and at sea level for each tidal height condition (Cravo et al. 2020; Madyawan et al. 2020).

In conclusion, the study identified 1,378 individuals comprising 45 species and 28 families. The highest number of individuals was caught at Pringjono Beach, with 369 individuals. The *A. semipunctata* and *B. fuscus* from the Gobiidae family dominated at the majority of stations. The Diversity Index (H') indicated high species diversity across all stations, with the highest value of 3.562 and the lowest of 3.023. For the Evenness Index, the majority of the five stations were classified as almost evenly distributed, with the lowest value being 0.92 and the highest being 0.97. Meanwhile, the high richness index of the fish species at the five research locations underscores the abundance of fish species in these areas. There are some differences in abiotic factors in sampling stations. Salinity, water pH, water temperature, and DO can affect the composition and distribution of reef fish in the littoral zone in Gunungkidul.

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