Analysis of Plankton Abundance, Diversity, and Dominance along the Siddo Coast in Barru Regency, Indonesia

ABSTRACT

This research aims to determine the level of abundance, diversity, uniformity, and dominance of plankton in the waters of Siddo Beach, Barru Regency. The research was carried out at three research locations, namely location 1, namely the hatchery location and Siddo Beach Bay; location 2, namely the location around the pier and mangroves; and location 3, namely the location around the community settlement in Toe hamlet, Barru Regency. Plankton in this location needs to be researched because there are many environmental forces that can disrupt the existence of plankton. Analisis plankton dilaksanakan di Laboratorium Kimia dan Air Politeknik Pertanian Negeri Pangkep. Data selanjutnya dianalisis dengan analisis deskriptif. The results showed that the abundance of plankton at location 1 was highest for plankton of the *Navicula* sp type; at location 2, the highest was for plankton of the *Oscilatoria* sp type; and the abundance of plankton at location 3 was highest for plankton of the type *Acartia* sp. The average diversity of plankton at the research location is in the range of 0.1526795-0.20716, the uniformity of plankton at the research location is in the range 0.06144279-0.10646145, and the dominance of plankton at location 1 is highest in *Cosconidiscus* sp type plankton, location 2 is dominated by *Oscilatoria* sp type plankton, and location 3 is dominated by plankton of the *Acartis* sp type. Thus, there is no type of plankton that has the highest abundance and dominance for all research locations.

Keywords: plankton, abundance, diversity, uniformity, dominance

1. INTRODUCTION

The sea is a highly diverse environment, with a wide range of marine biota, including fish, crabs, shellfish, algae, and different microscopic biota [1]. Marine ecosystems are a mixture of land and sea regimes that form a dynamic balance of each component [2]. The part of the ocean closest to land is usually called the coast. Coastal areas are areas that are very intensive for human activities, such as central government areas, residential areas, industry, ports, aquaculture, tourism, and others [3]. This causes coastal areas to become potential and vulnerable to environmental damage. This damage is caused by increasing human activities that produce polluting waste, both from industrial waste and other human activities [4]. Coastal areas have large resource potential that can be developed including economic and ecological aspects that must be managed appropriately and sustainably to maintain environmental sustainability [5]. Furthermore, the level of fertility of marine waters is closely related to the high concentration of nutrients in the water column. High nutrient availability causes a nutrient enrichment process called upwelling. This process stimulates the growth of phytoplankton, which plays a very important role in marine ecosystems [6].

Plankton are drifting organisms (animals, plants, archaea, or bacteria) that occupy the pelagic zone in oceans, seas, or fresh water, can be used as bioindicators to determine the primary productivity of waters because they act as producers [7], are microscopic organisms that have a very important role, namely as the basis of life, especially in pelagic aquatic life, which is classified into two types, namely phytoplankton and zooplankton [8]. Because plankton are aquatic animals that float and have extremely poor swimming abilities, the water currents around them have a significant impact on their motions [9].

Plankton is also a biological component that is used to determine changes in water quality that are influenced by these conditions [4], as a natural food source for the larvae of aquatic creatures. Furthermore, plankton is mostly produced by phytoplankton, and the main consumers are zooplankton [10], and as primary producers, phytoplankton have the ability to utilize sunlight as an energy source in their life activities, while zooplankton act as primary consumers by utilizing energy sources produced by primary producer [11, 12, 13]. The presence of plankton in waters can be used as a bioindicator for assessing the condition of these waters [14]. Plankton usually flows with ocean currents. Plankton are also usually called biota that live in the pelagic zone and float, drift, or swim very quickly, meaning they cannot fight the current [15]. Plankton is one of the aquatic biota that has a very important ecological role in aquatic ecosystems [16]. Plankton is divided into two, namely phytoplankton and zooplankton.

Phytoplankton are plants that live or float in water [17]. Plankton has a very important ecological role in supporting life in waters [18].One of the important microorganisms that plays a major role as primary producers is phytoplankton [19, 20]. Phytoplankton can generally be used as a bioindicator to monitor water conditions, pollution, and eutrophication. Phytoplankton accounts for approximately half of global primary production and is the main autotrophic organism in the sea. The photosynthesis process that it carries out produces oxygen and becomes a source of energy for the marine biota food chain [21]. Even though they are microscopic in size, their abundant amounts can become the basic foundation of the food pyramid [22]. Phytoplankton are microscopic organisms that float in water and are autotrophs or capable of producing organic materials from inorganic materials through the process of photosynthesis with the help of light [23]. Phytoplankton have a role as primary producers in aquatic ecosystems [24]. About 95% of primary production in the sea comes from phytoplankton [25]. Enrichment of organic pollutants in waters is one of the factors that triggers the growth of phytoplankton, where the input of organic materials from anthropogenic activities on land will trigger algal blooms [26].

Marine fisheries cultivation is currently starting to develop rapidly in line with the decreasing number of marine fisheries catches. The marine aquaculture sector is expected to become the largest supplier of products to the marine and fisheries sectors in the future. Efforts to improve mariculture activities are increasingly being encouraged, including efforts to optimize its other roles as a conservation area. In relation to the development of mariculture, the existence of plankton is very important. Barru waters are a coastal area that has the potential for plankton. These conditions cause Barru waters to have abundant types of aquatic biota ranging from fish, shellfish, snails, and others [27]. To carry out the fish farming process, it is necessary to identify the presence of plankton in the surrounding waters.

2. MATERIALS AND METHODS

This research was conducted on the coast of Siddo Beach, Barru Regency, Indonesia. The research was carried out from July to September 2024. The research was carried out at three research locations, namely location 1, namely the hatchery location and Siddo Beach Bay; location 2, namely the location around the pier and mangroves; and location 3, namely the location around the community settlement in Toe hamlet, Barru

Regency. Plankton analysis was carried out at the Chemistry and Water Laboratory of the Pangkep State Agricultural Polytechnic. This research is descriptive observational research. The research began by taking 100 L of water at the surface (30 cm) at each predetermined research location, then filtering the water using a plankton net 25. After filtering, the water sample was transferred to a Winkler bottle and treated with 1% formalin. The water samples were then immediately identified for the type and amount of plankton based on the plankton identification key book [28, 29]. In order to identify plankton, a 1 ml water sample is taken with a pipette and then dropped onto the sedgewick rafter. A 40x10 magnification microscope was used to make the observations [30]. The abundance, species diversity, species uniformity, and dominance index of the collected plankton samples were computed.

2.1. Plankton abundance

The following formula is used to determine plankton abundance [31]:

$$N = F \times \frac{Ja}{Jb} \times \frac{vt}{Vs} \times \frac{1}{Vd}$$

Where:

N = Abundance of plankton (ind/l)
Vd = Volume of filtered water (10 l)
Vt = Volume of filtered water (30 ml)
Ja = Receptacle of wide (1000 mm^2)
Jb = Total area of visual field analyzed (100 mm^2)
Vs = Volume of water analyzed (3 ml)
F = Number of biota found (ind)

2.2. Diversity of types

The diversity is analyzed using the following formula [32]:

$$H' = \sum_{t=1}^{n} (Pi)\ln(Pi)$$

H' =

Where:

H = Diversity of types
Pi = Proportion of the 1st type in the community (ni/N)
ln = Number of i-th species
N = The total number of all species

Diversity Index (H) values range between:

$0<H1<2,3$ = Little diversity
$2,3<H1<6,9$ = Medium diversity
$H1>6,9$ = Great diversity

2.3. Uniformity Index

The uniformity index can be calculated using the formula [33]:

$$e = \frac{H'}{H'\ max}$$

Where:

e = Uniformity index
H' = Diversity index
H' maks= ln number of genera (s) for phytoplankton $\log^2$ number of genera (s) for zooplankton

Criteria According to [34]:

$e < 0,4$ = Low category
$0,4 < e < 0,6$ = Medium category
$e > 0,6$ = High category

2.4. Dominance Index

Meanwhile, the dominance index is analyzed using the following formula [35]:

$$C = \sum_{t=1}^{n} (ni/N)^2$$

Where

C = Dominance Index
Ni = Number of individuals of type i
N = Total number of individuals

3. RESULTS AND DISCUSSION

3.1. Number of Plankton

Fig 1 shows that at location 1, the most common types of plankton found were *Navicula* sp with 26, followed by *Tintinopsis* sp with 6, *Chroococcus* sp and *Nichia* sp with 4 each, *Cosconidiscus* sp with 3, and the others, respectively each has 1 cell/mL. Fig 2 shows that at location 2, the most common type of plankton found was *Oscilatoria* sp with 20, followed by *Navicula* sp with 16, *Nichia* sp with 4, *Cosconidiscus* sp with 3, and the others with 1 cell/ml each. Fig 3 shows that at location 3, the most common type of plankton found was *Acartia* sp with 17, followed by *Copepoda* sp with 11, *Navicula* sp with 7, *Synedra* sp with 2, and the others with 1 cell/ml each. Figure 1-3 also shows that location 1 and the other locations have the highest number of different types of phytoplankton.

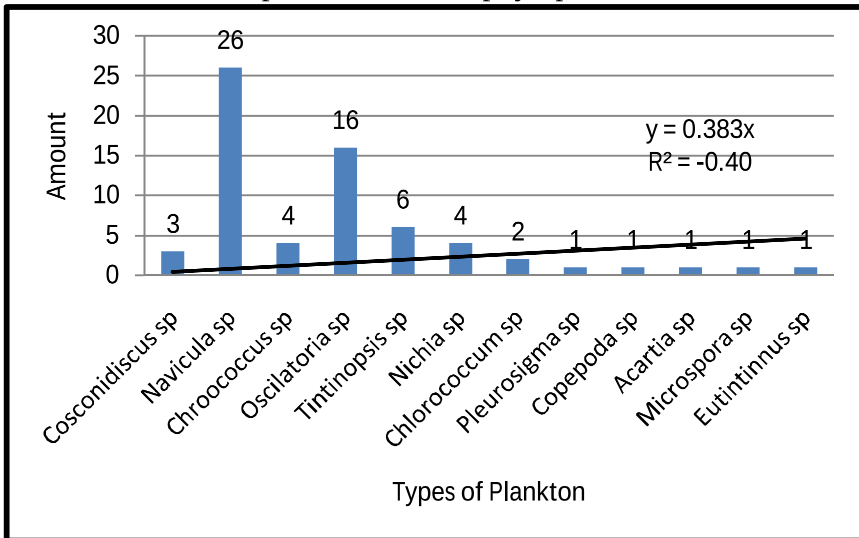

Fig. 1. Number of plankton at Location 1

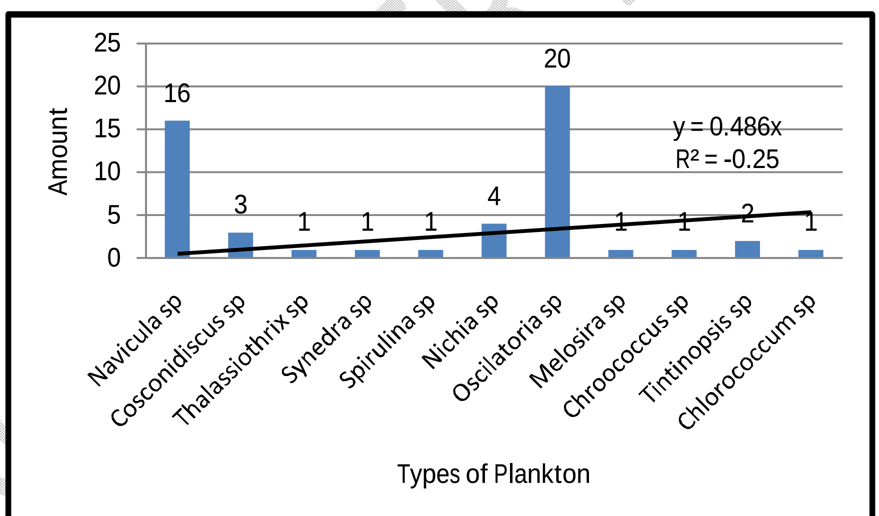

Fig. 2. Number of plankton at Location 2

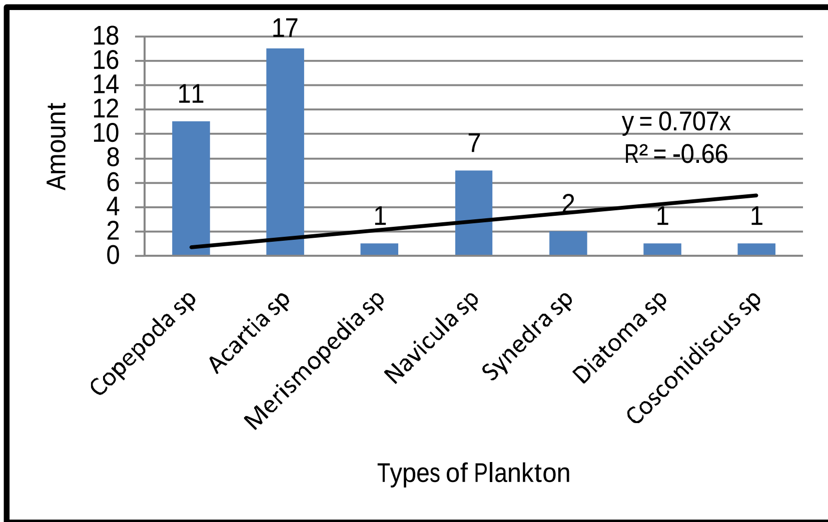

Fig. 3. Number of plankton at Location 3

3.2. Plankton Abundance

The large number of Bacillariophyceae classes in waters is due to their ability to adapt to their environment, are cosmopolitan, resistant to extreme conditions, and have high reproductive power [10]. The abundance of plankton in a body of water is influenced by several environmental parameters and physiological characteristics. Plankton abundance will change at various levels in response to changes in physical, chemical and biological environmental conditions [36]. Fig 4 shows that the abundance of plankton at location 1 is highest in plankton of the *Navicula* sp type, namely 1300 cel/ml, followed by *Oscilatoria* sp at 800 cel/ml, *Tintinopsis* sp at 300 cel/ml, *Chroococcus* sp and *Nichia* sp at 200 cel/ml each, *Cosconidiscus* sp 150 cel/ml, *Chlorococcum* sp 100 cel/ml, and *Pleurosigma* sp, *Acartia* sp, *Microspora* sp, and *Eutintinnus* sp 50 cel/ml each. Fig 5 shows that the abundance of plankton at location 2 is highest in the *Oscilatoria* sp type plankton, namely 1000 cel/ml, followed by the *Navicula* sp type plankton, namely 800 cel/ml, *Nichia* sp, namely 200 cel/ml, *Cosconidiscus* sp, namely 150 cel/ml, *Tintinopsis* sp is 100 cel/ml, and plankton types *Thalassiothrix* sp, *Synedra* sp, *Spirulina* sp, *Melosira* sp, *Chroococcus* sp, and *Chlorococcum* sp are 50 cel/ml each. Fig 6 shows that the abundance of plankton at location 3 is highest in plankton of the *Acartia* sp type, namely 850 cel/ml, followed by plankton of the *Copepoda* sp type, namely 550 cel/ml, *Navicula* sp, namely 350 cel/ml, *Synedra* sp, namely 100 cel/ml, and the lowest in the plankton of *Merismopedia* sp, *Diatoma* sp, and *Cosconidiscus* sp, respectively, was 50 cel/ml.

The abundance of plankton in a body of water is influenced by several environmental parameters and physiological characteristics. The composition and abundance of plankton will change at various levels in response to changes in physical, chemical, and biological environmental conditions [37]. The abundance of plankton in waters is very dependent on the nutrient levels and water quality conditions of the aquatic environment [38]. Plankton structures will be more varied and plentiful in seas with more nutrients, and vice versa, plankton abundance will be very low in areas with less nutrients [39]. This abundance can be an indicator of the status of the waters studied [40]. The abundance of plankton will also have an impact on the level of dissolved oxygen production in waters during the day [41]. The type of phytoplankton will have a vital impact on the production of dissolved oxygen and the distribution of community diversity in waters [42]. So the presence of plankton and nutrients can be used as a limiting factor in the level of aquatic productivity [43]. Primary productivity is the amount of organic material produced by autotrophic organisms such as plankton through the process of photosynthesis with the help of sunlight [44].

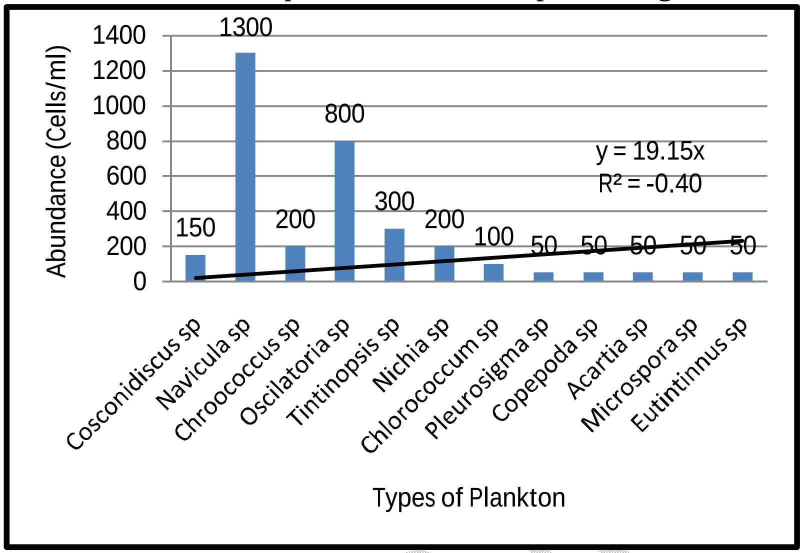

Fig. 4. Plankton Abundance Location 1

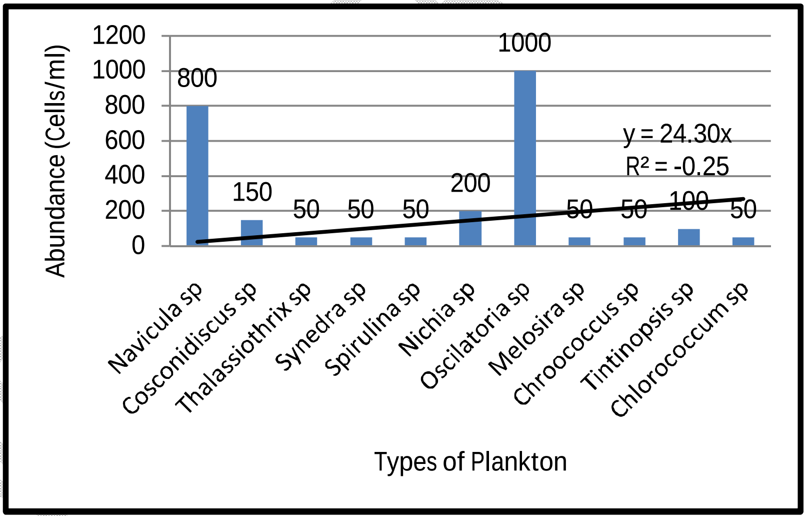

Fig. 5. Plankton Abundance Location 2

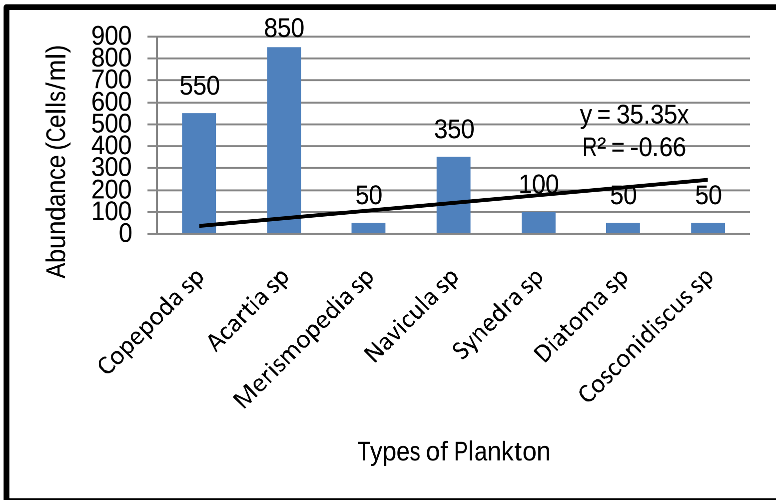

Fig. 6. Plankton Abundance Location 3

3.2.Diversity index

Fig 7 shows that the average plankton diversity at the research location is in the range of 0.1526795-0.20716, with the highest diversity at location 3, namely 0.20716, followed by location 2, namely 0.15333 and the lowest diversity at location 1, namely 0.1526795. The results of research [4] show that plankton diversity in Sayung Beach waters ranges between 1.58 and 2.45, meaning that diversity is classified as medium diversity. This value describes the stability of the plankton community in a fairly stable condition. The plankton evenness index value at the research location is relatively high (>0.6) or close to 1, which indicates that there is no dominant species. A moderate diversity index means that there is no indication of pollution, especially that caused by an excess of certain nutrients [45]. Environmental elements like nitrogen availability and phytoplankton's level of adaptation can have an impact on diversity and dominance indices [46]. The species that inhabit the habitat have a significant impact on species diversity, which will impact the number attained. Furthermore, low diversity values suggest a less diversified group of species in these watery settings [47]. Environmental factors, such as the availability of nutrients like phosphate and nitrate and the capacity of each form of phytoplankton to adapt to the current environment, can have an impact on the diversity and dominance index values [48].

Mariculture areas are very fertile because they are supported by optimal environmental factors that allow for the abundance of plankton in this area. This situation binds ecological relations [19]. This ecological relationship is one of the factors in the emergence of various types of fish. These fish can be utilized by seaweed farmers to provide added value to cultivation activities [49].

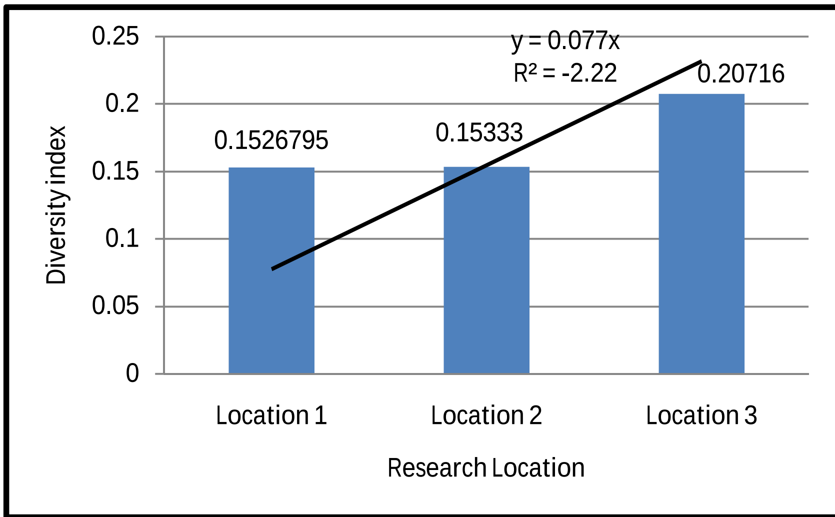

Fig. 7. Plankton Diversity at the Research Location

3.4.Uniformity Index

Fig 8 shows that the plankton uniformity at the research location is in the range 0.06144279-0.10646145, with the highest plankton uniformity being at location 3, namely 0.10646145 and the lowest at location 1, namely 0.06144279. The uniformity index in this study is relatively low. A uniformity index that is close to zero tends to indicate an unstable community, whereas if it is close to a community in a stable state, the number of individuals between species is the same [50]. According to research findings [51], there were only two categories for each station's uniformity index value: medium uniformity and high uniformity. The population exhibits uniformity when the uniformity index value is higher, indicating that the number of individuals per species is equal or dispersed uniformly [52]. The plankton uniformity index value in Tlogo Dringo is $0.4 \leq E \leq 0.6$, indicating moderate uniformity or similar types of aquatic biota in the medium category. A moderate uniformity index shows that each type of plankton is distributed evenly throughout the observation location. This makes it possible that there are still species that have not been distributed well so that they experience pressure that can reduce their survival or, conversely, can dominate the waters. It is hoped that this condition will continue to change by carrying out routine monitoring to determine the factors that cause dominance in certain locations and minimizing the occurrence of these factors [53].

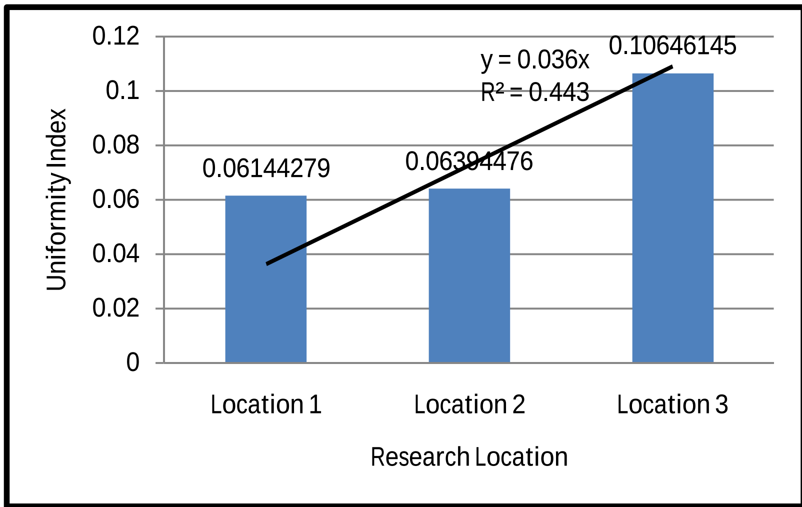

Fig. 8. Plankton Uniformity Index at the Research Location

3.5.Dominance Index (ni/N) = pi)

Fig 9 shows that the dominance of plankton at location 1 is highest in plankton of the Cosconidiscus sp type, namely 3, followed by plankton of the *Navicula* sp type, namely 0.39, *Oscilatoria* sp, namely 0.24, *Tintinopsis* sp, namely 0.09, *Chroococcus* sp and *Nichia* sp, each 0.06, *Chrolococcus* sp, namely 0.03, and plankton types *Pleurosigma* sp, *Copepoda* sp, *Acartia* sp, *Microspora* sp, and *Eutintinnus* sp, each 0.02. Fig 10 shows that the plankton dominance in location 2 is highest in *Oscilatoria* sp type plankton, namely 0.392, followed by *Navicula* sp type plankton, namely 0.314, *Nichia* sp, namely 0.078, *Cosconidiscus* sp, namely 0.059, *Tintinopsis* sp, namely 0.039, and plankton types *Thalassiothrix* sp, *Synedra* sp., *Spirulina* sp, *Melosira* sp, *Chroococcus* sp, *Chlorococcum* sp, each 0.02. Fig 11 shows that the dominance of plankton at location 3 is highest in plankton of the *Acartis* sp type, namely 0.425, followed by plankton of the *Copepoda* sp type, namely 0.275, *Navicula* sp, namely 0.175, *Synedra* sp, namely 0.05, and plankton, each type Merismopedia sp, Diatoma sp, and Cosconidiscus sp each are 0.025.

The Simpson dominance index, which has a value range of 0 to 1, is the dominance index utilized in this study. High dominance is indicated by an index value near 1, while low dominance or no dominating species is indicated by an index value near 0 [34]. A species dominance index value that is close to 0 indicates that in the community there is no dominant organism, whereas if the dominance index value is close to 1, it indicates that the community has a dominant organism [54]. A dominance value close to one indicates that in the community there is a genus that dominates other genera; conversely, if the value is close to zero, it indicates that the community structure does not have a genus that extremely dominates other genera [55], and if human activity has an influence on the observed water conditions, which are causing an increase in the number of species so that they dominate these waters [56].

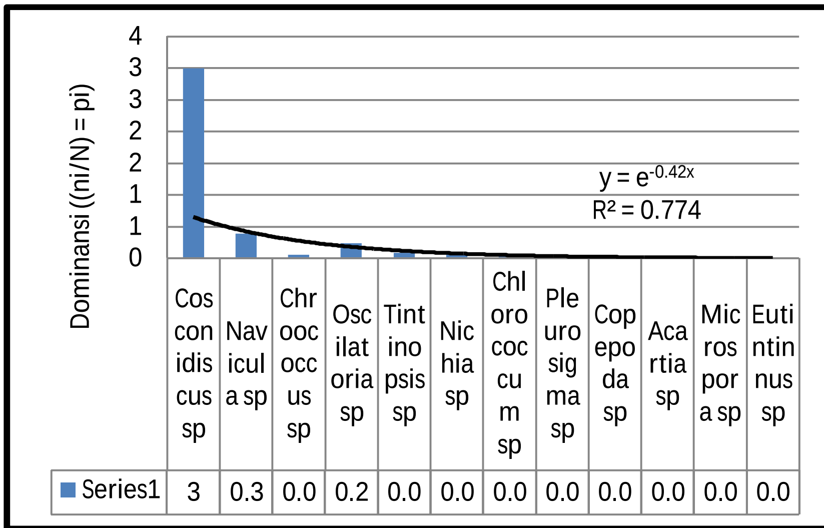

Figure 9. Plankton Dominance at Location 1

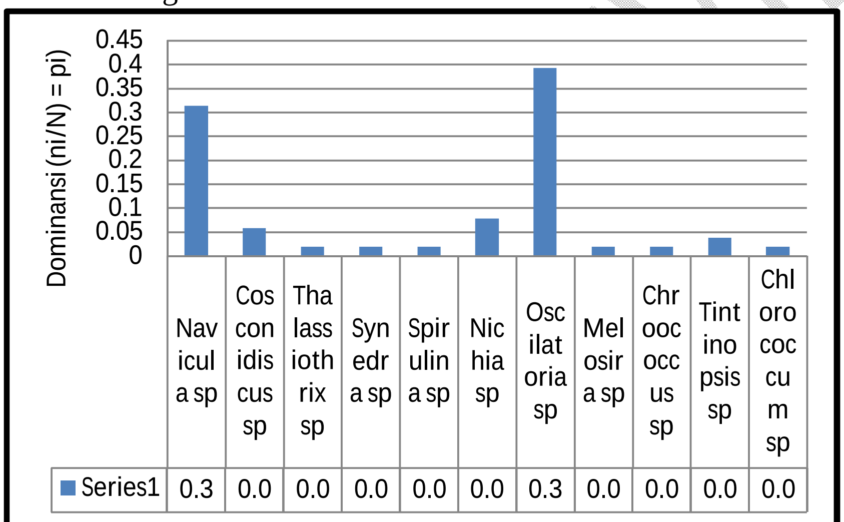

Figure 10. Plankton Dominance at Location 2

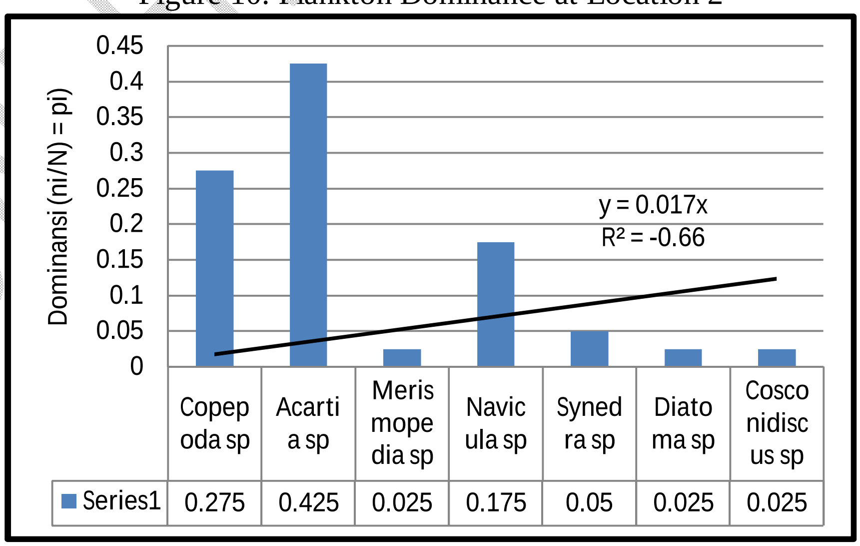

Figure 11. Plankton Dominance at Location 3

4. CONCLUSION

Plankton is a primary community that is really needed in aquaculture. In the coastal waters of Siddo Beach, Barru Regency, the abundance of plankton at location 1 is highest for plankton of the Navicula sp type; at location 2, it is highest for plankton of the Oscilatoria sp type; and the abundance of plankton at location 3 is highest for plankton of the type Acartia sp. The average diversity of plankton at the research location is in the range of 0.1526795-0.20716, the uniformity of plankton at the research location is in the range 0.06144279-0.10646145, and the dominance of plankton at location 1 is highest in Cosconidiscus sp type plankton, location 2 is dominated by Oscilatoria sp type plankton, and location 3 is dominated by plankton of the Acartis sp type. Thus, it can be stated that the Siddo coastal waters of Barru Regency are still fertile waters and are suitable for fisheries development.

COMPETING INTERESTS

The author has stated that there is no competitioninterest.Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

REFERENCES

1. Nontji. Marine Plankton. Jakarta: LIPI Press. 2008
2. Thoha H,& Rachman, A. Abundance and spatial distribution of plankton communities in Banggai Islands waters. Journal of Tropical Marine Science and Technology. 2007;5(1):145-161.
3. Dahuri R. Spatial management of coastal and marine areas is in line with the implementation of regional autonomy. Journal of Social and Development. 2001;17(2):139-171. https://doi.org/10.29313/mimbar.v17i2.38
4. Evita I.N.M, R. Hariyati & J.W. Hidayat. The Abundance and Diversity of Plankton as Water Quality Bioindicator in Sayung Coast Waters, Demak Regency, Central Java. Bioma. 2021;23(1): 25-32.
5. Putri ADR, Sartimbul A, & Yuniarti A. Plankton Community Composition and Water Quality in Gili Ketapang , Probolinggo Regency, East Java. Journal of Research in Science Education. 2023;9(11): 9290–9299. https://doi.org/10.29303/jppipa.v9i11.5516.
6. Tambaru, R. Phytoplankton Community Dynamics in Relation to Aquatic Productivity in Maros Coastal Waters, South Sulawesi. Dissertation.Bogor Agricultural Institute Postgraduate. Bogor. 2008
7. Rahmatiza Y, Y. Lase, & Yulmila. Diversity of plankton types in the waters of Balee Deudap Beach, Pulo Aceh, Aceh Besar Regency. Proceedings of the National Seminar on Biotics. 2020: 229-231
8. Novrilianty H, M Hudatwi, & E Utami. The diversity of plankton species as an indicator of water quality in the waters of Batu Belubang Beach and Panjang Island, Central Bangka Regency. Fisheries Journal. 2022;12(3):333-345
9. Silaban SM, Thamrin, & Siregar, SH. Abundance Of Phytoplankton And Primary Productivity Levels In The Waters Of Kasiak Island West Sumateraprovince. Journal of Coastal And Ocean Sciences. 2022;3(2).
10. Odum EP. Basics of Ecology. Third Edition. Yogyakarta: Gadjah Mada University. 1998
11. Anderson DM, Reguera B, Pitcher GC, and Enevoldsen HO. The IOC International Harmful Bloom Program: history and science impacts. 2010
12. Gibbs SJ, Bown PR, Ward BA, Alvarez SA, Kim H, Archontikis OA, Sauterey B, Poulton AJ, Wilson J, Ridgwell A.

Algal plankton turn to hunting to survive and recover from end-Cretaceous impact darkness. Science Advances. 2020;6:1-11.
13. Odum EP. Fundamentals of Ecology Third Edition. Yogyakarta. UGM Press.Isnansetyo. 2000
14. Kartikasari SN. PapuaEcology. Jakarta: Pustaka Obor Indonesia. 2013
15. Rohmimohtarto. Planktonology, Science of Marine Biota. Jakarta. Djembatan. 2005
16. Salamah S, D. Mentari, D Ariska, & R Ahad. Abundance of Plankton in the Waters of Nipah Beach, Gampong Rabo Pulo Aceh, Aceh Besar Regency. Proceedings of the National Seminar on Biotics. 2018:418-424.
17. Mukayat. Basic Zoology. Jakarta. Erlangga. 1994.
18. Pramudji. The Role of Plankton in Water. Jakarta. Pengetahuan Indonesia. 2010
19. Odum E. Basics of Ecology. Yogyakarta. Gajah Mada University Press. 1996
20. Yuliana. distribution and community structure of phytoplankton in Jailolo Waters, West Halmahera. Journal of Aquatics. VI. 2015;1(1):41-48. http://jurnal.unpad.ac.id/akuatika/article/view/5963/3127
21. Diniariwisan D, & TBC Rahmadani. Composition of abundance and community structure of phytoplankton in the Sekotong Beach area, West Nusa Tenggara. Journal of Ganec Swara. 2024; 18(1):342-347.
22. Faturohman I, Sunarto, & Nurruhwati, I. Correlation of Plankton Abundance and Sea Water Temperature Around the Cirebon PLTU. Journal of Marine Fisheries. 2016;7(1):115-122.
23. Nybakken JW. Marine Biology: An Ecological Approach. New York: HarperCollins College Publishers. 1982
24. Hutabarat S, & Evans SM.Introduction to Oceanography. Jakarta: UI Press. 1985
25. Nielsen ES. Marine Photosynthesis With Special E mphasis On The Ecological. Amsterdam: Elsevier Scientific. 1975
26. Makmur M, Kusnoputranto H, Moersidik SS,& Wisnubroto SD. The Influence of Organic Waste & N/P Ratio on Phytoplankton Abundance in the Cilincing Green Mussel Cultivation Area. Jakarta: BATAN. 2012
27. Jafar, J. Biodiversity and dominance of the fish which is associated with seaweed cultivationand floating net at Barru Regency Waters South Sulawesi. Tropical Galung Journal.2019;8(1):26-34. http://dx.doi.org/10.31850/jgt.v8i1.383
28. Nedham GJ & Nedham PR. A Guide to the Sudy of Freshwater Biologt. Holden Day. Inc, San Francisco. 1963
29. Smith GM. The Freshwater Algae of the United States. 2 nd ed. M. C. Graw Hill Book Company Inch. New YorkTait RV. 1981. Element of Marine Ecology. London. Butterworths. 1950
30. Grace Analytical Lab. Standard Operating Procedure for Phytoplankton Sample Collection and Preservation. Chicago: 536 South Clark Street 10th Floor. 1994
31. APHA. Standard methods for the examination of water and wastewater, 4edition. American Public Health Association. Washington D. C. 1980:10071055
32. Mason CF. Biology of fresh water pollution 4th ed. Pearson Education Ltd. London. 2002. 682p.
33. Arinardi OH, SH Trimaningsih, & E Asnaryanti. Range of abundance and predominant plankton composition in the waters of the Central Region of Indonesia. Center for Oceanology

Research and Development-LIPI. Jakarta. 1996:93p.
34. Krebs CJ. Ecology the experimental analysis of distribution and abundance. Harper & Row, New York. 1978:289p.
35. Odum EP. Basics of Ecology. Yogyakarta: Gadjahmada University Press. 1994:697p.
36. Sahab AZ. Comparative study of the distribution of planktonic fry, especially benthic invertebrates from the Goba-Goba of Pari Island, Jakarta: PT. Waca Utama Pramesti. 1986
37. Simarmata P. Abundance of Plankton and Aquatic Plants (Practical Report on Plankton and Aquatic Plants). 2012
38. Wilson J.D, Monteiro FM, Schmidt DN, Ward BA, and Ridgwell A. Linking Marine Plankton Ecosystems and Climate: A New Modeling Approach to the Warm Early Eocene Climate. Paleoclimatology. 2018; 33:1439–1452.
39. Monteiro FM, Bach LT, Brownlee C, Bown P, Rickaby REM, Poulton AJ, Tyrell T, Beufort L, Dutkiewicz S, Gibbs S, Gutowska MA, Lee R, Riebesell U, Young J, &Ridgwell A. Why marine phytoplankton calcify. Science Advances. 2016;2(7): 1-16.
40. Diniariwisan D, & Rahmadani TBC. Lombok Baratthe abundance and community structure of phytoplankton in Senggigi. 13 (October 2022). 2023:387–395. https://doi.org/http://doi.org/10.29303/jp.v13i2.504
41. Ariadi H, Pandaingan IAH, Soeprijanto A, Maemunah Y, &Wafi A. Effectiveness of Using Pakcoy (*Brassica rapa* L.) and Kailan (*Brassica oleracea*) Plants as Vegetable Media for Aquaponic Culture of Tilapia (*Oreochromis* sp.). Journal of Aquaculture Development and Environment (JADE). 2020;3(2):156-162.
42. Wafi A, Ariadi H, Muqsith A, Mahmudi M, & Fadjar M. Oxygen Consumption of Litopenaeus vannamei in Intensive Ponds Based on the Dynamic Modeling System. Journal of Aquaculture and Fish Health. 2021; 10(1):17-24.
43. Ariadi H, Wafi A, Musa M, &Supriatna. Relationship between Water Quality Parameters in Intensive Cultivation of White Shrimp (*Litopenaeus vannamei*). Samakia: Journal of Fisheries Science. 2021;12(1):18- 27.
44. Suprabawati A, Hardian A, &Al ghifari E. Dynamics and primary productivity of the Citarum River, West Java Province, West Java Province. Ecotrophic. 2019;13(1):20-28.
45. AsiddiqiHG, Piranti AS, & Riyanto EA. The relationship between water quality and phytoplankton abundance at the eastern part of Segara Anakan Cilacap, Central Java. BioEksakta : Unsoed Biology Scientific Journal. 2019;1(2):1 https://doi.org/10.20884/1.bioe.2019.1.2.1761
46. Wiyarsih B, Endrawati H, & Sedjati S. Composition and Abundance of Phytoplankton in Segara Anakan Lagoon, Cilacap. Marina Oceanographic Bulletin. 2019;8(1):1. https://doi.org/10.14710/buloma.v8i1.21974
47. Rizal AC, Ihsan YN, Afrianto E, & Yuliadi LPS. Nutrient status approach to sediments to measure macrozoobenthos community structure in the River Estuary and Coastal Areas of Rancabuaya Beach, Garut Regency. Journal of Fisheries and Marine Affairs. 2017;8(2).
48. Hamuna B, Tanjung HR, Suwito, Maury H, & Alianto. Study of sea water quality and pollution index based on physico-chemical parameters in Depapre Waters, Jayapura. Journal of

Environmental Science. 2018;16(1):35-43.
49. Sulma S, dan Manoppo AKS. Physical suitability of waters for seaweed cultivation in Bali waters using remote sensing data. PIT MAPIN XVII. 2008:467-476
50. Yunita VMRA, & Isnaini. Community Structure and Distribution of Phytoplankton in the Sungsang Waters of South Sumatra. Maspari Journal. 2012;4(1)
51. Halipatulfikri WA, & Utami E. Kajian Environmental Parameters on the Abundance of Mangrove Crabs (Scylla sp) in the waters of Muara Semembu, Tuik Village, West Bangka Regency. Journal of Aquatic Resources. 2020;14(1)
52. Pasengo YL. Study of the impact of plywood factory waste on the abundance and diversity of phytoplankton in Dangkang Waters, Barowa Village, Bua District, Luwu Regency. Marine Science and Technology Study Program. Hasanuddin University. Makassar. 1995
53. Anggara AP, NE Kartijono, &PMH Bodijantoro. Plankton Diversity in the Tlogo Dringo Nature Reserve Area, Dieng Plateau, Central Java. Journal of MIPA. 2017;40(2): 74-79.
54. Kusmeri L, & Dewi Rosanti. Zooplankton community structure in Lake Opi Jakabaring, Palembang. Zooplankton Community Structure. 2015;12(1).
55. Pirzan AM & Rani P. Relationship between Phytoplankton Diversity and Water Quality on Bauluang Island, Takalar Regency, South Sulawesi. Biodiversitas. 2008;9(3):217-221
56. Anggita WT, Churun Ain, & Haeruddin. Nitrate and Orthophosphate Concentrations in the West Flood Canal River Estuary and Their Relation to the Abundance of Harmful Algae Blooms (Habs) phytoplankton. Available Online Atindonesian Journal of Fisheries Science And Technology. 2012;12(1)