Genbinesia 2 (1): 1-15 (2022)
doi: https://doi.org/10.55655/genbinesia.v2i1.21
http://journal.genbinesia.or.id/

RESEARCH ARTICLE

GENBINESIA
Journal of Biology

Community Structure of Zooplankton in Plawangan Timur Segara Anakan Cilacap

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Received:
05 November 2022
Accepted:
15 November 2022
Published:
24 November 2022

Abstract

Plawangan Timur, located in the Segara Anakan Lagoon, Cilacap, is an estuary with many rivers flowing into it, and has a free connection with the open seas. Plawangan Timur waters suffer increased environmental pressures caused by anthropogenic activities, resulting in pollution, degradation of water bodies, and ecological changes. Ecological changes related to the physical and chemical estuary environment have been considered as major drivers of significant fluctuations in the zooplankton community structure. In order to manage and mitigate the effects of these changes, a prediction of their potential impacts on zooplankton communities is needed. This study aimed to determine the zooplankton community, which includes the abundance index, diversity index, evenness index and dominance index. The method used is a survey method with purposive random sampling at five stations. The F test and the Lackey Drop Microtransect Counting method were used to determine the abundance of zooplankton. The results showed that the abundance of zooplankton ranged from 113-598 ind/L (low); zooplankton diversity index ranged from 1.83-2.03 (medium); zooplankton evenness index ranged from 0.79-0.85 (high) and zooplankton dominance index ranged from 0.166-0.211 (low). Based on PP RI Number 22/2021, the physico-chemical factors of the Plawangan Timur waters are still at the safe concentration for zooplankton, except for the brightness, turbidity, Total Suspended Solid (TSS) and salinity.

Keywords: Plawangan Timur, Zooplankton, Community Structure, Ecological Pressure

Introduction

Segara Anakan is an estuary area located in the southern part of Java Island, precisely in Cilacap Regency. These waters form an ecosystem that originates from the interaction between lagoon waters, mangrove forests, land and sea. Segara Anakan is separate waters from the Indian Ocean and is

bounded by Nusakambangan Island. Seawater from the Indian Ocean enters through two straits, namely the Motean Strait (East Plawangan) and the Majingklak Strait (West Plawangan) [1]. East Plawangan is one of the Segara Anakan areas that often experiences ecological changes [2]. The East Plawangan waters consist of several rivers that flow into them, including the Kembang Kuning River, the Sapuregel River and the Donan River [3]. The variation in water conditions in each of the downstream rivers has the potential to have an impact on water quality which will affect the life of aquatic biota, one of which is zooplankton, where zooplankton can only live and develop properly in suitable water conditions [4].

Zooplankton are animal plankton, very diverse and consist of various larval and adult forms representing almost all animal phyla. Zooplankton are heterotrophic, so they depend heavily on organic matter from phytoplankton for their survival [5]. Zooplankton acts as a first-level consumer that connects phytoplankton with consumers at a higher trophic level, so that it can affect the food chain in an aquatic ecosystem [6]. The existence of plankton in a waters is used to determine the level of water productivity, where zooplankton can describe the amount of food availability and the carrying capacity of the environment that can support the life of aquatic biota [7]. This is in accordance with the statement of Nandy and Sumit [8] that zooplankton play an important role in food webs and the transfer of energy from primary producers to higher trophic levels. In addition, according to Xiang Chenhui et al., [9] and Yun Ru ju et al., [10] the nature of its wide distribution and high sensitivity to fluctuating physicochemical conditions makes zooplankton a bioindicator for any environmental changes in aquatic ecosystems, so that these changes can be seen through the structure of the zooplankton community [11].

The zooplankton community structure is a collection of zooplankton species in a particular habitat that interact with each other. The study of community structure includes abundance, diversity, dominance and evenness. There is a positive relationship between zooplankton community structure and aquatic productivity. If the zooplankton community structure in a water is high, then the water tends to have high productivity. Changes that occur in the structure of the zooplankton community can be influenced by physical and chemical factors in the waters. The physical and chemical factors are temperature, brightness, turbidity, Total Suspended Solid (TSS), salinity, pH, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and ammonia [12].

The decline in the condition of East Plawangan Waters was caused by increased anthropogenic activity [10]. These waters also experience fluctuations in physical and chemical properties due to the mixing process between fresh water and sea water. The existence of these conditions is feared to affect water quality causing a decrease in water productivity and changes in the composition and abundance of zooplankton, where zooplankton has a tolerance limit that can determine its distribution and abundance in a fluctuating environment. Given the important role of zooplankton as primary consumers connecting phytoplankton with a higher trophic level, it is necessary to study the structure of the zooplankton community to determine the condition of the aquatic environment that can affect the index of diversity, abundance, evenness and dominance of zooplankton in the waters of East Plawangan, Segara Anakan Cilacap.

Materials and methods

Method

The method used in this research is a survey method. Sampling technique with purposive random sampling. Sampling locations are divided into 5 (five) stations which have been determined based on river condition factors. Each sample station was taken with three repetitions. Each repetition of the sample was taken by filtering 150 L of sample water [13].

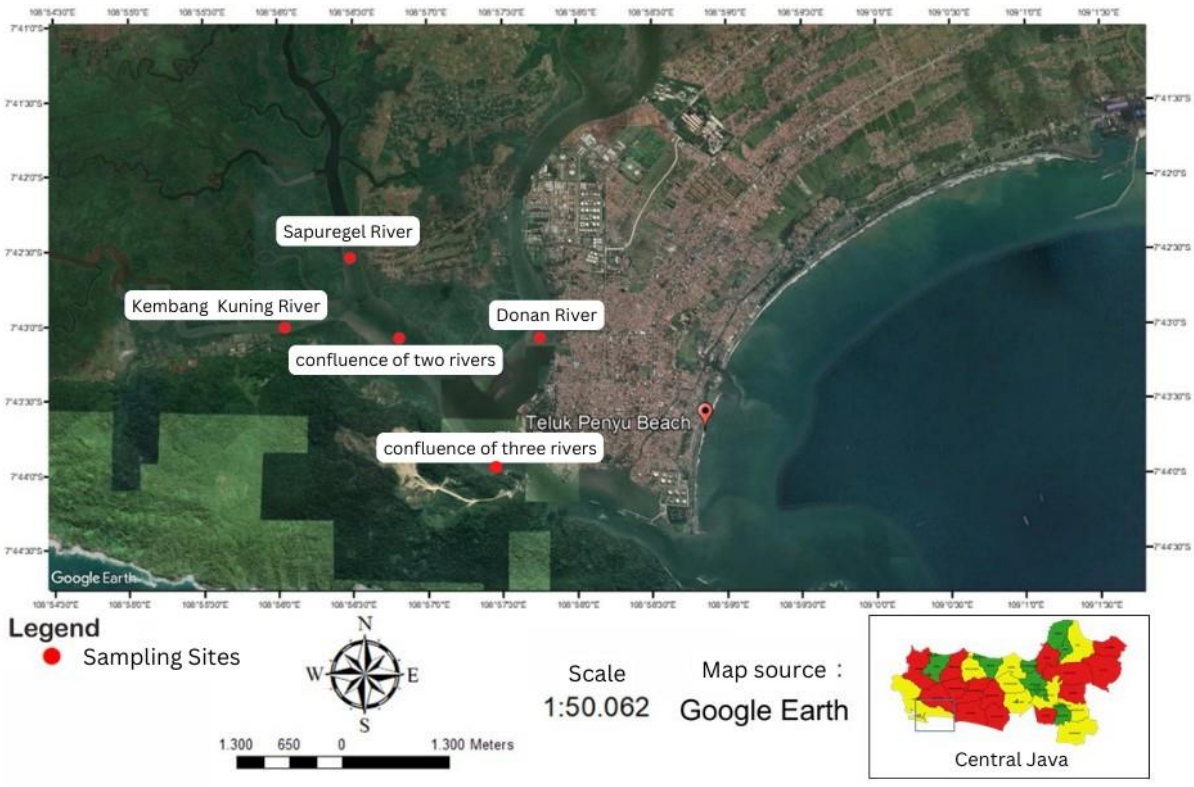

Figure 1. Sampling Sites in Plawangan Timur Segara Anakan, Cilacap

Table 1. Description of Sampling Locations

Station	Location	Coordinate
I	Estuary of the Yellow Flower River	108°96′02″(EL); 7°70′04″ (SL)
II	Sapuregel River estuary	108°95′06″(EL); 7°71′06″ (SL)
III	The confluence of the Yellow Flower River and the Sapuregel River	108°96′05″(EL); 7°71′05″ (SL)
IV	Donan River estuary	108°99′01″(EL); 7°72′03″ (SL)
V	The confluence of the Yellow Flower River, Sapuregel and Donan	108°98′05″(EL); 7°73′05″ (SL)

Research Parameters

Parameters measured include the main parameters and supporting parameters. The main parameters are the number of species and the number of individuals of each zooplankton species. Supporting parameters measured include temperature, brightness, turbidity, TSS, Salinity, pH, DO, BOD, COD and Ammonia.

Collection and Preservation of Zooplankton Sampling

Sampling of 150 liters of water was carried out using a 10 liter bucket. Then filtered using plankton net no. 25 with a mesh size of 60 μm. The water sample contained in the plankton net container bottle was taken and transferred to a 30 mL sample bottle. Then added 40% formalin solution to 4% with the dilution formula, and 2 drops of Lugol's solution, then labeled paper, cooled in an ice box, then observed in the laboratory.

Zooplankton Identification

After the zooplankton samples were obtained, the water samples in the sample bottles were observed using a microscope with a magnification of 10 × 10 with 30 fields of view. The sample is homogenized until evenly distributed and the sample water is taken using a pipette as much as 1 drop. Each sample was repeated 3 times. Then zooplankton were identified with the plankton identification book Sachlan [14] and Edmonson [15] in Vuuren et al., [16].

Data collection

Zooplankton abundance

The zooplankton abundance formula uses the formula *Lackey Drop Mikrotransect Counting* [17] is:

$N=\frac{0i}{0p} x \frac{Vr}{Vo} x \frac{1}{()} x \frac{*}{+}$

Keterangan:
N = Total amount of plankton (ind/L)
Oi = Cover glass area 18 x 18 (324 mm2)
Op = One field of view (1,11279 mm2)
Vr = Filtered water volume (30 mL)
Vo = One drop of water volume (0,05 mL)
Vs = Filtered water volume (100 L)
n = The average number of individuals per field of view
p = Number of fields of view (30 kali)

Diversity Index

Species diversity indicates the number of organisms in an area. The Shanon-Wiener Diversity Index formula according to Odum [18] is as follows:

$H' = -\sum pi \ln pi$

Information:
H′ = Shannon-Wiener Diversity Index
Pi = ni/N
ni = Number of species of the 1st kind
N = Total number of species

Evenness Index

The evenness index formula according to Odum [18], namely:

$E = \frac{H-}{H;maks}$

Information:
E = Evenness Index

H' = Diversity Index
H maks = ln S (S is the number of species)

Dominance Index

The dominance index formula according to Odum [18], namely:

$$D=\frac{\sum_{i\#\$}^{s} ni\,(ni-1)}{(N-1)}$$

Information:
D = Dominance index
Ni = The number of each type individu
N = Total number of individuals

Measurement of Physical-Chemical Parameters

Water quality analysis was carried out in two ways, namely water samples were measured in situ (directly measured in the field) which included temperature, brightness, DO and salinity. Ex situ (put in ice box and measured in the laboratory) which includes zooplankton, turbidity, TSS, pH, BOD, COD and ammonia samples [19].

Table 2. Measurement of Physical-Chemical Parameters

No	Parameter	Unit	Method	Source
1.	Temperature	^{o}C	Expansion	APHA (2017)
2.	Turbidity	NTU	Turbidimeter	APHA (2017)
3.	Salinity	Ppt	Conductivitymetry	APHA (2017)
4.	Brightness	Cm	*Secchi disk*	APHA (2017)
5.	pH	Unit	Electrometry	APHA (2017)
6.	TSS	mg/L	Gravimetry	APHA (2017)
7.	BOD	mg/L	Winkler	APHA (2017)
8.	DO	mg/L	Winkler	APHA (2017)
9.	COD	mg/L	Spectrophotometry	APHA (2017)
10.	Ammonia	mg/L	Spectrophotometry	APHA (2017)

Data analysis

The data obtained is presented in tabular form. Furthermore, data on zooplankton abundance between stations were analyzed using the F test. Data on diversity index, evenness index and zooplankton dominance index were analyzed using comparative descriptive [20].

Results

Measurement of Physical-Chemical Parameters

Environmental conditions (physical and chemical) between stations in East Plawangan Segara Anakan, in general, are still in almost the same range and the fluctuations can still be tolerated by zooplankton.

Table 3. Results of measurements of the physical and chemical parameters of water

Parameter	Unit	Range					Quality Standards
		Station I	Station II	Station III	Station IV	Station V	
Temperature	◦C	27-28	28-29	28-29	29,5-31	28	28-32
Brightness	Cm	64-67	39,5-46,5	60-70	64-84	72,5-81,5	≥300
Turbidity	NTU	8,3-20,8	42,7-45,6	18,8-32,9	10,6-14,8	10,7-27,9	<5
TSS	mg/L	167,1-205,2	140,8-219,5	149,9-214,3	176,4-209,3	173,4-212,1	<80
Salinity	Ppt	15	17-18	20-21	26-27	26-28	33-34
Ph	Unit	7,5-7,6	7,8-7,6	7,6-7,8	7,8-7,9	7,7-7,8	7-8,5
DO	mg/L	5,8-7	5,6-7,8	4,6-5,8	3,6-4,4	3-4,6	>5
BOD	mg/L	3,1-4,4	3,9-5,4	5,7-6,4	9,6-10,4	7,6-9,2	<20
COD	mg/L	40,8-51,6	47,7-56,8	32,2-43	27,4-39,2	49,4-55,9	<40
Ammonia	mg/L	0,02-0,03	0,02-0,03	0,03	0,03-0,04	0,02-0,03	<0,3

Zooplankton Abundance

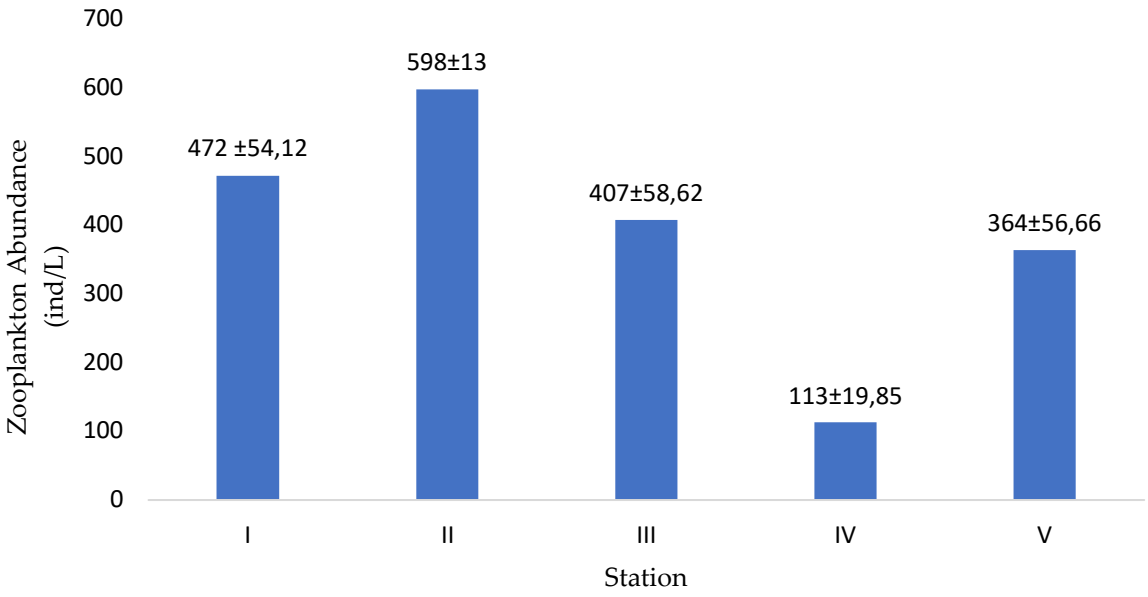

Figure 2. Graph of zooplankton abundance (The same letter shows not significantly different (P>0,05))

The total abundance of zooplankton caught in Plawangan Timur Segara Anakan Waters, Cilacap was 1,954 ind/L. Phylum Arthropoda is found with the most number. The highest zooplankton abundance value was obtained at Station II, namely the Sapuregel Estuary with a value of 598 ind/L, while the lowest zooplankton abundance value was obtained at Station IV, namely the Donan River Estuary with a value of 113 ind/L.

Diversity Index

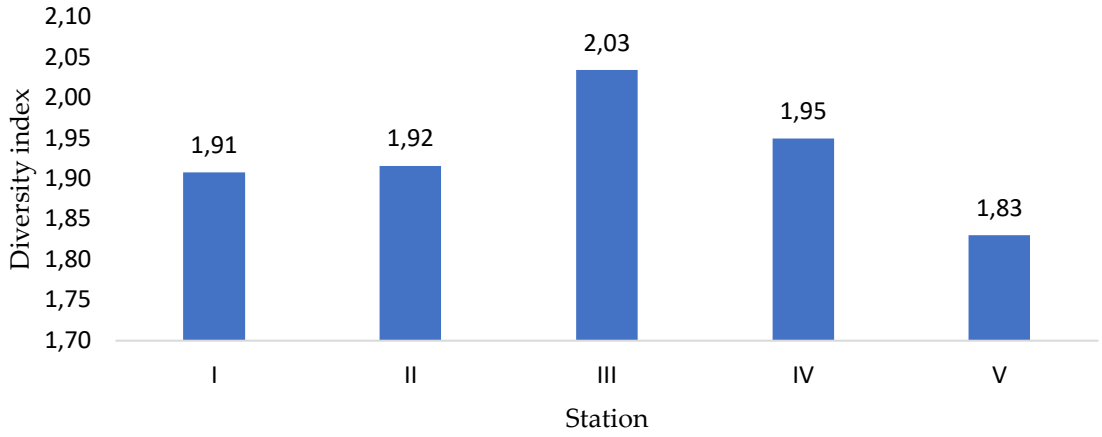

Figure 3. Graph of the zooplankton diversity index

Evenness Index

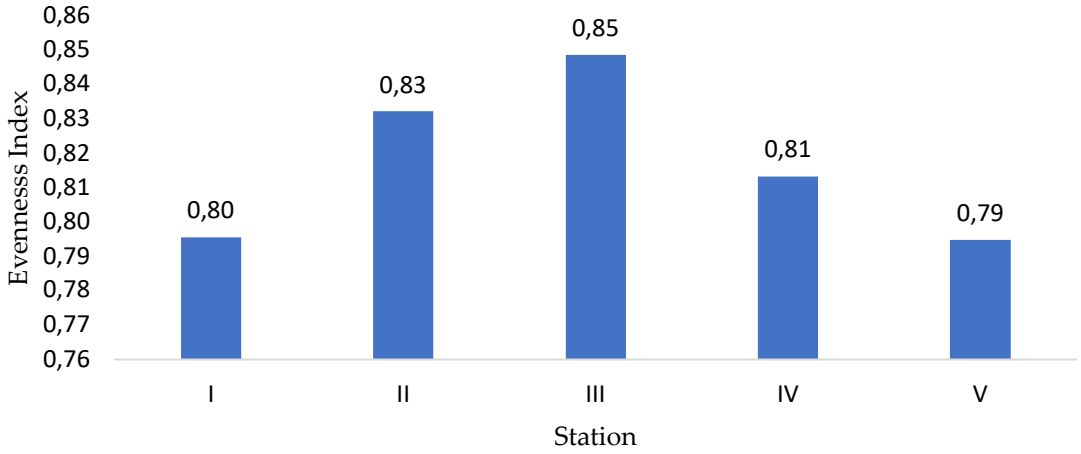

Figure 4. Graph of zooplankton eveness index

Dominance Index

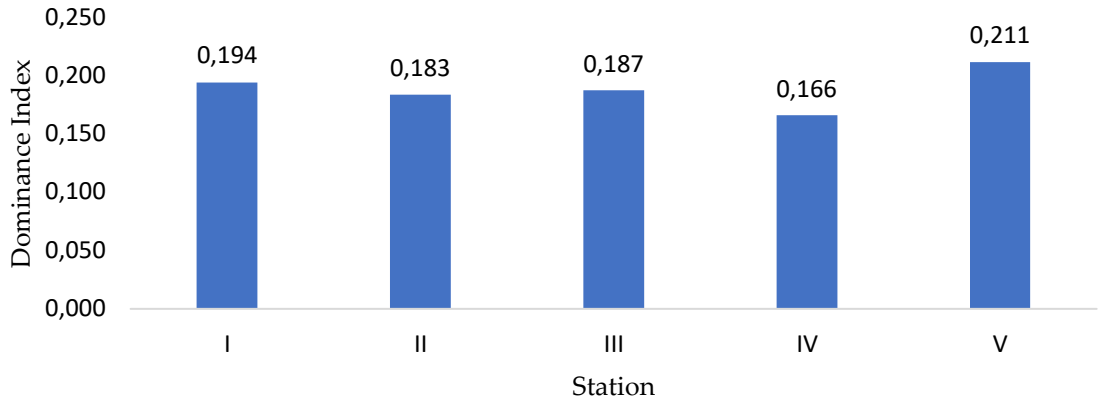

Figure 5. Graph of zooplankton dominance index

Discussion

Measurement of Physical-Chemical Parameters

The values of temperature, pH, BOD and ammonia at all stations still meet water quality standards. Temperature values obtained in the range of 27-31◦C. Based on the BMA, a good temperature value for seawater biota ranges from 28-32◦C. This is in accordance with Yuliana and Ahmad [21], water temperature in the range of 28-29◦C is the optimal range for zooplankton. The pH value was obtained within the range of 7.4-7.9. This value corresponds to the BMA for mangrove waters which is 7-8.5. BOD values were obtained in the range of 3.07-10.4 mg/L. This concentration is in accordance with the established water quality standard, which is below 20 mg/L. The ammonia values obtained were in the range of 0.02-0.04 mg/L. This value is still in the safe category for zooplankton and according to BMA, which is below 0.3 mg/L.

The values of brightness, turbidity, TSS and salinity in all stations did not meet the water quality standards. Brightness, turbidity and TSS values at each station were obtained in a range of 39.5-81.5 cm, 8.3-45.6 NTU and 140.8-219.5 mg/L. These values do not meet BMA, namely ≥300 cm for brightness, <5 NTU for turbidity and <80 mg/L for TSS. Brightness, turbidity and TSS are related parameters. According to Fajar et al., [22], brightness is the level of light's ability to penetrate water bodies. The level of brightness is affected by the turbidity of the waters caused by an increase in the content of suspended organic and inorganic matter (TSS). If the brightness value is higher, the sunlight that is able to enter the waters is greater, so that it can affect the life of plankton in the waters. The abundance of zooplankton on the surface of the water decreases because zooplankton is negatively phototactic or avoids sunlight. while the abundance of phytoplankton increases because the process of photosynthesis runs optimally. Salinity values obtained ranged from 15-28 ppt. The lowest concentration of salinity is at Station I, while the highest concentration is at Station V because of its location closer to the sea, so that the supply of mixed seawater is more. This is in accordance with the statement of Triawan and Arisandi [23], that the salinity level of an estuary is affected by incoming seawater and fresh water, so that the salinity fluctuates greatly. High fluctuations in salinity can affect the existence of zooplankton, because only certain species can survive.

DO concentration values were obtained in the range of 3-7.8 mg/L. At Stations I, II and III they still met the quality standards, while at Stations IV and V they did not meet the quality standards, with DO values below 5 mg/L. This is because Stations IV and V are industrial areas, so that waste disposal activities affect DO in these waters and have an impact on zooplankton life which utilizes DO for their respiration process. The COD values obtained ranged from 27.4 to 56.8 mg/L. The COD concentration according to water quality standards was only found at Station III and Station IV, namely less than 40 mg/L. While at Stations I, II and V the BMA has exceeded. According to Pratiwi et al., [24] if the organic matter is high, the COD in the waters will increase. This is because the waters that get input of organic matter require a lot of dissolved oxygen to oxidize the organic matter contained in these waters.

Zooplankton Abundance

Waters that show oligotrophic conditions are indicated by abundance values <2,000 ind/L, mesotrophic conditions with abundance values of 2,000-15,000 ind/L and eutrophic conditions with abundance values > 15,000 ind/L (Siagian and Simamarta, 2018). Based on the results of the study, oligotrophic conditions were shown at all stations in East Plawangan with abundance values ranging from 113-598 ind/L, which means <2,000 ind/L, where this condition indicates low fertility in East Plawangan waters.

Based on the results of the study, the high abundance of zooplankton at Station II was influenced by an adequate supply of nutrients. This is because at Station II there is mangrove vegetation with a sandy mud substrate, thus making it a nutrient trap area originating from the Sapuregel River flow. As a result of the supply of these nutrients will affect the growth and reproduction of phytoplankton which ultimately has an impact on the abundance of zooplankton. This is supported by the statement of Patmawati et al., [25] that the abundance of zooplankton is influenced by the abundance of phytoplankton which is the result of the high content of nutrients, especially nitrate and phosphate, which are supported by environmental conditions in the waters.

Based on Figure 2. The abundance of Station I was not significantly different from Station III and V (based on the results of statistical analysis P>0.05 and the same letter). This is because at these three stations there are species that have the highest abundance value, namely calanus glacialis. Calanus belongs to the Crustacea class which is the genus most commonly found because Calanus is positively phototactic to light intensity, where when sampling is done in the morning, so that Calanus can respond and move actively to look for food in the form of phytoplankton that are on the surface [26]. Calanus has a high adaptability to environmental conditions in the presence of food availability [27]. This is supported by the statement of Lahiwu et al., [27] that some types of zooplankton when they are adults are able to adapt to large light interactions. Then according to Mulyadi and Radjab [28], the dynamics or variations in the composition of zooplankton are generally influenced by the availability of food, suitable environmental conditions, competition and predation factors and the effect of vertical migration of zooplankton.

The abundance at Station IV was significantly different from Stations I, II, III and V and was the station with the lowest abundance compared to the other stations. Station IV has a species that has the highest abundance value, namely Cyclops bicuspidatus. This is in accordance with previous research conducted by Sastranegara et al., [29] that the highest abundance of zooplankton was dominated by the Cyclops Genus of 384 ind/L in East Plawangan Segara Anakan. Cyclops are zooplankton that can adapt widely to survive in fresh, brackish and sea water, so they can live in abundance in these locations. This is supported by the statement of Gao et al., [30] that the most abundant type of zooplankton in an estuary is the Copepod type because it easily adapts well to its environment, and can live in fresh, brackish and marine waters, where the types of zooplankton included in the class Copepod one of them is Cyclops.

Based on environmental conditions, the temperature value at station III is in the range of 28-29 oC. This range is in the optimal range for zooplankton life. This is in accordance with the water quality standards in PP RI No. 22 of 2021, that a good temperature range for aquatic biota is 28-32 oC. It was further explained by Sofarini et al., [31] that temperature greatly influences the life patterns of aquatic organisms, such as: distribution, composition, abundance and mortality. An increase in temperature causes dissolved oxygen (DO) in a water to decrease. This can be seen from the comparison of temperature and dissolved oxygen (DO) values between Station II and Station IV. At Station II, a temperature value of 28.7°C was obtained with a dissolved oxygen value of 6.8 mg/L, while Station V obtained a higher temperature value of 30.2°C with a lower dissolved oxygen value of 4.1 mg/L. This is in accordance with the statement of Barus [32] that the temperature of a water will affect the solubility of dissolved oxygen which is needed by aquatic organisms for metabolism. The higher the temperature of a water, the solubility of oxygen decreases. Besides temperature and dissolved oxygen, ammonia concentration also affects the abundance of zooplankton. This is because ammonia can be toxic to zooplankton. The concentration of ammonia at each station in East Plawangan Segara Anakan Cilacap was obtained in the range of 0.02-0.04. This value indicates that the concentration of ammonia is still in a normal state or in accordance with the quality standards according to PP RI No. 22 of 2021. Ammonia concentration will increase with increasing pH and water temperature. The toxicity of ammonia to aquatic organisms increases with decreasing levels of dissolved oxygen (DO), pH and temperature [33].

Diversity Index

The diversity index of zooplankton found in Plawangan Timur Segara Anakan Waters, Cilacap, has a diversity value of 1.83-2.03. The highest value was obtained at station III, namely 2.03 and the lowest diversity value was obtained at station V, namely 1.83. According to Yusanti et al, [34], the range of diversity values 1-3 indicates moderate diversity with moderate individuals and moderate community stability, diversity values > 3 indicate the condition of an area experiencing low ecological pressure and high species diversity with high individual distribution and stability. high community. Based on the research results, the diversity values obtained at each station in East Plawangan waters were classified as moderate diversity (1.83-2.03).

A good diversity index value relates to the ability of a number of species to utilize or tolerate physical and chemical factors in the waters. This is in accordance with Kurniawati et al., [35], that diversity is influenced by the level of DO and COD in a waters, where the higher the DO value, the lower the COD level and the lower the diversity of zooplankton. Based on environmental conditions, the high value of the diversity index at Station III was due to the fact that this station had an average value of DO and COD which met the water quality standard (BMA) better than Station V.

A low diversity index indicates that the location is not suitable for zooplankton growth. Low diversity values describe low aquatic productivity, unstable ecosystems, ecological pressures and polluted waters. This is shown at Station V, where at that station there are industrial activities that cause a decrease in water quality so that it disrupts the presence of zooplankton. This is supported by the opinion of Rashidy et al., [36] which states that the factors that affect the value of the diversity index can come from the ability of each type of zooplankton to adapt to the existing environment. According to Prianto et al., [37], the low diversity of zooplankton is thought to be due to the influence of environmental changes due to human activities such as land conversion which causes an increase in total suspended solids and total dissolved solids.

Evenness Index

Based on Figure 4. Obtained the evenness index value of zooplankton in Plawangan Timur Segara Anakan Waters, Cilacap ranged from 0.79-0.85. The highest evenness index value of zooplankton is at Station III with a value of 0.85 and the lowest evenness is at Station V with a value of 0.79. The high evenness at Station III is because the evenness index is influenced by the diversity index and the number of species obtained, where the highest diversity index value is also at Station III. According to Krebs [38] the index of evenness is in the low category, if the value E <0.4 then evenness is in the low category, if the value is $0.4 \geq E \leq 0.6$ then evenness is in the medium category, and if E> 0.6 then evenness in the high category.

Based on the results of the study, it was found that the East Plawangan waters were included in the category of high evenness index with a range of 0.79-0.85. These results are in accordance with the research of Kholifah et al., [39] which stated that the value of the zooplankton evenness index in the Segara Anakan Cilacap Mangrove waters is included in the high category, with a value of 1-2. This shows that the distribution of individual types or genera of zooplankton in estuarine waters is evenly distributed. A high evenness index value indicates a stable community structure and indicates that each biota has the opportunity to simultaneously utilize the nutrients available in the waters. However, the less evenness in a community means that the individual distribution of each species is uneven and there is a tendency for a community to be dominated by certain species or genera [40].

Based on Figure 4. shows that the distribution of zooplankton in East Plawangan Waters is said to be even, where almost at every station there are relatively the same species. These species are Balanus amphitrite, Cyclops bicuspidatus, diaptomus saltilinus, Euterpina acutifrons, calanus glacialis, nauplius sp., and favella ehrenbergii. This is presumably due to the availability of food in these waters. Adequate food availability will benefit zooplankton, where zooplankton can adjust their type and food habits. This

shows that the evenness of zooplankton is closely related to the ability of the waters to provide food for various types of zooplankton [41].

Dominance Index

Based on Figure 5, the zooplankton dominance index values in this study ranged from 0.166 to 0.211. The dominance index value at Station V shows the highest value compared to other stations. This is because there are species that dominate at Station V, namely Calanus glacialis with a total abundance of 134 ind/L. Calanus glacialis is a group of generally distributed crustaceans. This is presumably because Calanus is a genus that can adapt to the environment and the availability of food types around it [42]. Mantiri [27] added that there are several types of zooplankton when they are adults that are able to adapt to large light interactions and also due to the influence of depth, for example Calanus.

Based on the Simpson dominance index value criteria, if the dominance index is close to 1 (> 0.5) it can be said that there are certain species that dominate these waters and are included in the high category, and vice versa if the dominance index value is close to 0 (<0.5), it indicates that in this area there are no species that dominate and are included in the low category, in other words it can be said that in that area there are no species that dominate other types of zooplankton that control extreme waters [12]. Thus it is said that the dominance index value of zooplankton in East Plawangan Segara Anakan, Cilacap is included in the low dominance level (0.169-0.211). This is in accordance with previous research conducted by Heriyanto [43] that the dominance index in Cilacap mangrove waters was obtained with a value of 0.173 which means it is in the low category. This is thought to be the result of pollution of organic matter originating from anthropogenic activities, factory activities, management of mangrove forests and agricultural activities around the river. Dominance index values that are generally low indicate that in estuarine waters there are no zooplankton species that dominate.

In general it can be said that there are no zooplankton species that dominate the waters of East Plawangan Segara Anakan, Cilacap, because the dominance index values for all stations have a value close to 0 (<0.5), so that the zooplankton community structure in East Plawangan Segara Anakan Cilacap is said to be still in good condition. good. This is supported by Rosanti [44] that an index value close to 0 indicates that the zooplankton community structure is in a stable state, where environmental conditions have not experienced high enough ecological pressure, so that there is no dominant species that causes important changes to a community.

Conclusions

Based on the results and discussion, it can be concluded that the value of zooplankton abundance in East Plawangan Segara Anakan Cilacap is in the low category (113-598 ind/L) and the zooplankton diversity index in East Plawangan Segara Anakan is in the medium category (1.83-2.03). . The zooplankton evenness index in East Plawangan Segara Anakan Cilacap is in the high category (0.79-0.85) and the dominance index value of zooplankton in East Plawangan Segara Anakan Cilacap is in the low category (0.166-0.211).

Acknowledgments

Thanks are addressed to the General Service Agency (BLU) of Jenderal Soedirman University for distributing financial assistance in research with the team leader Mr. Drs. Asrul Sahri Siregar, M.Sc (Alm), as well as various parties who were very crucial in the course of this research.

Conflicts of Interest

There are not potential conflicts of interest.

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