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THE COMPOSITION OF THE TYPE AND BIODIVERSITY OF PLANKTON IN INTEGRATED FISHERY ACTIVITY IN WATER OF AWERANGE BAY BARRU DISTRICT SOUTH SULAWESI, INDONESIA

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Abstract

The study was conducted in Barru District waters from March to September 2017. This research is to develop and implement the integration between the activities of aquaculture, capture, conservation, processing, and fishery agribusiness that taking place separately. The purpose of this study was to find out community structure, abundance, the biodiversity of plankton, and environmental condition within integrated fishery activity in the waters of Awerange Bay. This research expected to become a reference in other places for integrated and sustainable fishery activities subject that hopefully, can be utilized by anyone who involved in the process of fishery planning and development. This research conducted using the design and modeling of seaweed culture integrated with shallow water Fishing Aggregating Device (FAD). Data analyzed by measuring the products of each seaweed culture models, the biodiversity of organisms associated with seaweed, and determined the time-length of each organism utilized seaweed as spawning and nursery ground. In this study, an integrated aquaculture method, which functioned either as a natural FAD and conservation area for the key economic organism, was tested. This result expected to be a reference for the government and other stakeholders in the integrated fishery, which combined the aquaculture, conservation catch, fishery processing, and fishery agribusiness that has been done separately. 1). Species composition and abundance of phytoplankton generally dominated by class Bacillariophyceae, where the class percentage was 93.5%. The most abundant species is the Chaetoceros spp. 2) The diversity index of phytoplankton range between 2.3-2.4, where its existence tent to be stable. Based on the above discussion, diversity index > homogeneity index that leading waters in research area has a diversity of each of the plankton species, 3) Waters condition at the research area provided live support for the plankton where they can adapt for their life balance.

Keywords : Integrated Fishery, Plankton, Seaweed, Floating Net Cage, Conservation.

Introduction

Plankton is an organism living at the water column with a weak swimming ability, so their motilities were controlled by the current (Setyaningrum *et al*., 2020). Nekton, on the contrary, is an aquatic organism that is able to swim and move independently against the current. Any study concern with ecological community structure is dependent on accurate information on the distribution and abundance of the species making up the community (Fulton, 1984).

Plankton is an inseparable part of the aquatic ecosystem, and it fulfills a great variety of important function as secondary producers. The presence of plankton can be indicated that the waters are very fertile (Sari *et al*., 2018). To species diversity indices of zooplankton communities are used to evaluate the quality of water (Tilahwatih, Masithah & Rahardja, 2019). Hence, zooplankton can be used as an indicator of the sorority. In addition, species diversity, abundance, and biomass of zooplankton determine the production of fish in the ecosystem (Manickam, Bhavan & Santhanam 2017; Nindarwi *et al*., 2019).

These tiny creatures have important economic value for the marine ecosystem because of their position as a primary marine herbivore. Therefore zooplankton acted as an important chain between primary production of the phytoplankton and larger and small carnivores (Effendi *et al*., 2016).

Some phytoplankton is known for its effective absorption of some harmful organic compounds like ammonia, nitrite and nitrate (Masithah *et al*., 2019) and compounds that were viral to other organisms, as well as increase dissolved oxygen because of their photosynthesis and CO_2 control. Some phytoplankton also acted as antibacterial and supplied digestive enzymes for their predators. They also functioned as zooplankton feed within the waters (Setyaningrum *et al*., 2020), not to mentioned the potential to develop a source of single-cell protein. Today some phytoplankton was already developed as a health supplement for humans. These potential were so much bigger than multicellular plants (Isnansetyo & Kurniastuty, 1995).

Fishery activities had been done solely to maximize production and operated separately. In fact, conflicts often occurred between the parties. The capture fishery often clashed with conservation activity and aquaculture. Abundant amount from the aquaculture and capture fishery made the price become low, and often, the products became rotten. This situation is still ongoing today. That is why a study needed in order to develop an environmentally friendly fishery that integrated with conservation, aquaculture, post-harvest processing, and marketing of the products.

The purpose of this research was to know the structure of the community, abundance, biodiversity of the plankton, and waters condition of integrated fishery management area of Awerange Bay.

This research is expected to become a source of information in other places about integrated and sustainable fishery activity and can be utilized by every party involved in planning management and development of fishery.

Materials and Methods

Description of the Study Sites

This study conducted from March to October 2017 in the District of Barru, Province of South Sulawesi Indonesia. The sample was collected by determining stations by selecting the best area research area (Figure 1).

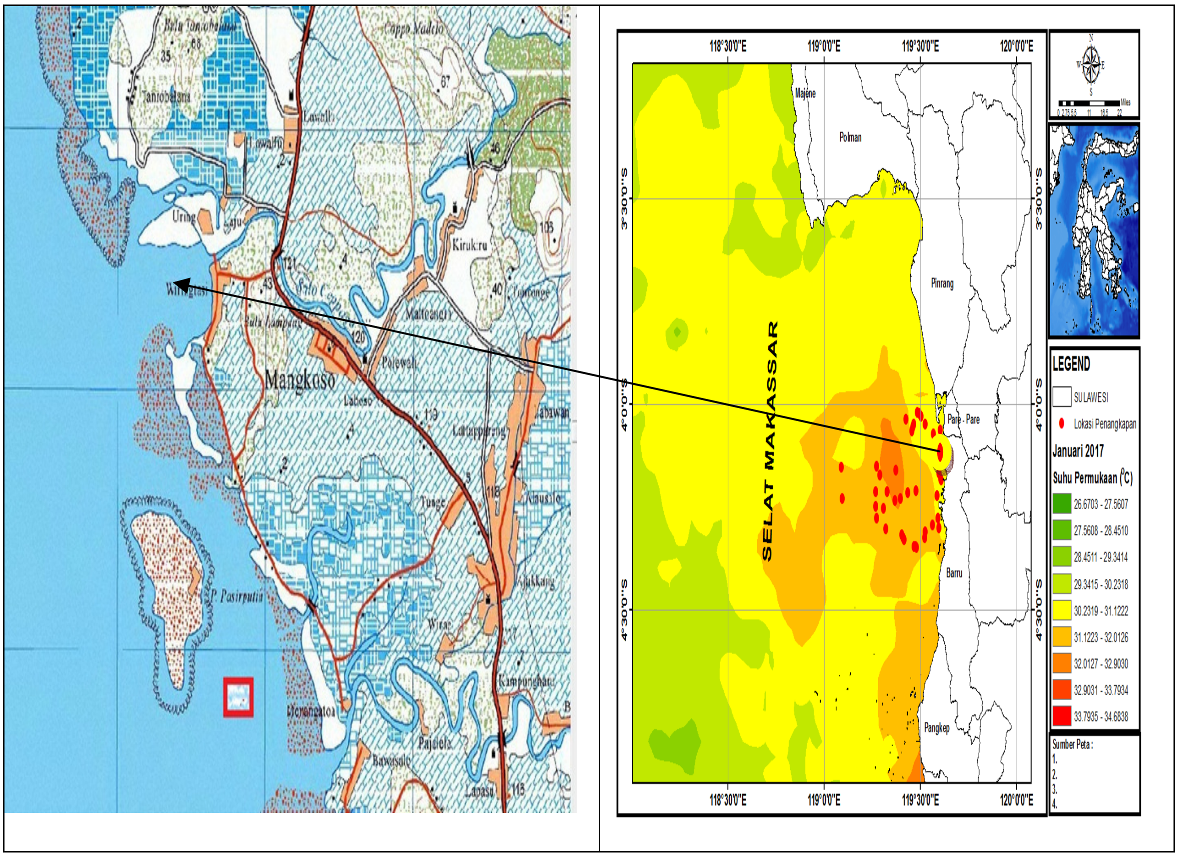

Fig. 1 : Location of the Research (Dark Line)

Plankton Identification

Plankton identification was taking place following manual guidance of identification where the preparation of a water sample observed with Sedgewick-Rafter, plankton found to represent the site. The plankton found matched with the identification book, and their name was recorded (Davis, 1955).

Calculating of Plankton Abundance

The data analysis for low magnification conducted through the following process: Plankton abundance is the number of individuals or cells per unit volume. The number of individual plankton was calculated using the following formula (APHA (American Public Health Association, 1915):

$$K = \frac{1}{A} \times \frac{B}{C} \times \frac{V}{v} \times n \qquad ...(1)$$

Where :

K=phytoplankton abundance (cell/m3);

n=number of observed phytoplankton;

B=total area/container area of Sedgwick-Rafter Counting Cell (mm^2);

V=volume of filtered water (30 ml);

v=concentrate volume of Sedgwick Rafter Counting Cell (ml);

A=volume of filtered water sample (50 l);

C=observation area (mm^2)

Calculation of Diversity Index

The diversity was counting using Shannon Index Diversity (Odum 1971):

$$H^1 = \frac{-\sum(ni)}{N} \frac{\ln(ni)}{N} \qquad ...(2)$$

Where

S = Amount of all species
ni = Amount of individual/species
N = Amount of all individual

Evenned Index used to calculate the homogeneity (Odum, 1971):

$$E = \frac{H1}{H^1 \max}$$

Where:

S = Amount of all species

H max = Maximum diversity

E = Homogeneity index

Results

Table 1 : Amount and Percentage of the Plankton

No	Plankton	Station			Average	Species Percentage (%)	Overall Percentage (%)
1.	***Phytoplankton***	I	II	III			
	Bacillariophyceae	34	79	64	59	93.15	-
	Dynophyceae	4	7	-	3.67	5.79	-
	Chlorophyceae	1	-	1	0.67	1.06	
	Amount	39	86	65	63.34	100	92.24
2.	***Zooplankton***						
	Crustacea	16	-	-	5.33	100	-
	Amount	16	-	-	5.33	100	7.76
	Total	89	71	87	68.67	93.15	100

Table 2 : Amount and Average Abundance of the Plankton

No	*Species*	Station			
		I	II	III	IV
1	*Chaetoceros teres*	58.97667	25.5867	77.20667	
	Chaetoceros decipiens	17.693 33	0	33.77667	
	Chaetoceros densum	0	66.34667	28.95333	
	Chaetoceros leave	5.896667	0	0	
	Chaetoccina poravianum	0	26.53667	28.95333	
	Biddulphia sinensis	0	6.633333	4.826667	
	Biddulphia aurita	0	6.633333	0	
	Biddulphia mobiliensis	5.896667	0	0	
	Bacillaria paradoxa	11.86333	0	0	
	Bacteriastrum varlava	17.69	13.26667	9.65	
	Hemialus indicus	0	6.633333	0	
	Leptocylindrus danicus	5.896667	13.26667	28.95333	
	Melosira salina	0	0	4.826667	
	Pleurosigma sp	29.48667	6.633333	28.95	
	Pleurosigma compaeto	0	0	14.47667	
	Rhizosolenia stolterfothi	17.76	39.80667	9.65	
	Rhizosolenia devu	0	13.27	0	
	Rhizosolenia alata	0	46.44333	28.95	
	Rhizosolenia cylindrus	0	6.633333	14.47667	
	Rhizosolenia styloformia	0	6.633333	0	
	Skletonema costatum	11.79333	6.633333	4.826667	
	Thallassionema nitzchiodies	17.69	13.27	4.826667	
	Ceratium arcticum	0	6.633333	0	
	Ceratium furca	5.896667	0	0	
	Ceratium fusus	0	6.633333	0	
	Ceratium trichoceros	0	13.27	0	
	Protoperidinium ovum	17.76	6.633333	0	
	Protoperidinium oceanicum	0	6.633333	0	
	Pyrophagus horologium	0	6.633333	0	
	Nitrium digitus			4.826667	
	Paracelus edwardsii				47.18
	Rhincalanus nasutus				94.36
	Temora longicornis				23.59
	Metridia lucens				23.59
	Ortona halgolandica				23.59
	Paracalanus panvus				70.77
	Balanus balamoides				23.59
	Calanus finmarchius				70.77
	Chaetoceros teres	58.97667	25.5867	77.20667	

Note: Station I, II, and III for Phytoplankton and IV for Zooplankton.

Table 3 : Diversity Index

No.	Plankton	Station		
		I	II	III
1.	Phytoplankton	2.345761	2.403779	2.364469041
2.	Zooplankton	-	-	2.345761

Note:
Station 1: Fish Aggregating Devices (FADs)
Station II: Floating Net Cage
Station III: Floating Net Cage and Fish Aggregating Devices (FADs)

Table 4 : Homogeneity Index

No.	Plankton	Station		
		I	II	III
1	Phytoplankton	0.682241552	0.676843	0.693584
2	Zooplankton	-	-	0.928361038

Note:
Station 1: Fish Aggregating Devices (FADs)
Station II: Floating Net Cage
Station III: Floating Net Cage and Fish Aggregating Devices (FADs)

Table 5 : Water Quality

No	Species	Station		
		I	II	III
1	Salinity (‰)	34	34	34
2	Water Temperature (^{o}C)	28	28.5	28
3	Brightness (%)		7.5	
4	Current velocity (m/s)	0.047	0.083	0.077
5	DO (ppm)	5.28	5.44	5.12
6	Nitrate (ppm)	2.2746	2.054	2.515
7	Phosphate (ppm)	0.8064	0.7104	1.498
8	Ammonia (ppm)	0.034	0.038	0.035

Discussion

The structure of plankton communities was so diverse, with many species scattered around. In general, there were 32 species of phytoplankton that belong to three classes, which are Bacillariophyceae (27), Dynophyceae (7), and Chlorophyceae (1). Whereas for the zooplankton, there were eight species that belong to class Crustacea. They all founded in research location and highly varied between stations. A similar opinion was earlier given.

Table 1 showed that the biggest amount of phytoplankton was from class Bacillariophyceae with an average of 59, and the smallest amount was from class Chlorophyceae of 0.67. Zooplankton, which represents by Crustacea, had an average amount of 5.33. The largest percentage of plankton came from class Bacillariophyceae as much as 93.15 %, and the smallest percentage was 1.06% from class Chlorophyceae. The overall percentage for phytoplankton was 92.24% and 7.67% for zooplankton that is entirely coming from class Crustacea.

The highest average abundance for the phytoplankton occurred on Chaetoceres teres, found with average value 58.97667 in Station I, while the lowest average abundance found out in Biddulphia mobiliensis, Chaetoceros leave, Leptocylindrus danicu, Ceratium furca with the value of 5.896667. At Station 2 there was Chaetoceros teres with an average value of 225.5867 while the lowest value found out in species Biddulphia Sinensis, Biddulphia auritas, Hemialus indicus, Rhizosolenia cylindrus, Pleurosigma Sp, Rhizosolenia styloformia, Skeleto costatum, Ceratium fusus, Ceratium articum, Protoperidiumn ovum, Protoperdinium aceanicum, Pyropphagus Horologium. For Station 3 highest average value found on Chaetoceros teres as much as 77.20667, and the lowest was found in Bidddulphia Sinensis, Melosira salina, Skletonema costatum, Thallossionema nitzchiodes, and Nitrium digitus as much as 4.826667 for all of these species. For the zooplankton, the highest average of abundance found in Rhincalanus notusus as much as 94.36 and the lowest average abundance value found it Temora longicornis, Metridia lucens, Ortona halgolandica, and Balanus balanoides as much as 2359.

The average species composition of phytoplankton and zooplankton di water around Barru District tend dominated by certain abundance species. Laboratory observation showed a high percentage of Class Bacillariophyceae in each station, and it indicated that the abundance and composition of this group are huge (Tabel 2).

The average composition of each class between phytoplankton and zooplankton does not look very different, where only one class dominated the phytoplankton, Class Bacillariophyceae, species found are relatively similar as was with Zooplankton.

Among the three classes of phytoplankton, the most important is Bacillariophyceae (Diatom), which was consumed directly by key economic fishes (Watanabe, Kitajima & Fujita 1983). This can be an indicator that Barru waters are rich. These richness indicators strengthened, which stated that important phytoplankton for the aquatic richness is from the Bacillariophyceae, Cyanophyceae, and Chlorophyceae.

According to Davis (1955), the abundance of certain phytoplankton was led by the stimulation of the organism that was supported by an adequate environment. With the abundance of phytoplankton from the Bacillariophyceae class that was closely related to the condition of the water of the research site, physically, chemical and biology, we can say that the aquatic condition was adequate for the growth of phytoplankton from Bacillariophyceae class (Davis 1955).

Diversity Index (H) is a species diversity of phytoplankton and zooplankton inhabit a community where its value was closely related to numbers of species in that community. Research showed that the diversity index for phytoplankton was between 2.36 – 2.40, and around 2.34 for zooplankton (Table 3).

According to Mason (1981), in water quality criteria based on diversity, an index is $H<1$ mean low diversity, distribution of an individual number of each species is low, and community stability also low. $1<H<3$ mean moderate diversity, distribution of an individual number of each species is moderate, and community stability also moderate. $H>3$ mean high diversity, distribution of an individual number of each species is high, and community stability also high (Mason 1981).

Based on the aquatic quality condition, some experts stated closely related to the diversity index base on the fact that environmental unbalance will impact the life of an organism living in an aquatic system. The higher diversity index means the more organisms living in that area.

Diversity index may reach its maximum point if the distribution of the individual number of each species in a community is equal. This study showed a diversity index for phytoplankton is 0.6, and 0.92 for zooplankton (Table 4). It indicated that species composition and plankton abundance depended on aquatic conditions.

Aquatic environment conditions had a great influence on species composition and abundance of the plankton, where chemical and physical parameters are greatly affected physiology and characteristic of plankton. This is the key to know the adaptation model of plankton, where the aquatic environmental parameter showed in the following table.

Table 6 : Water Quality

Measurable Parameter	Station			
	I	II	III	IV*
Salinity (%)	34	34	34	33
Water temperature (^{o}C)	28	28.5	28	27
Brightness (%)		7.5		-
Current speed (m/s)	0.047	0.083	0.077	0.053
DO (ppm)	5.28	5.44	5.12	4.95
Nitrate (ppm)	2.2746	2.054	2.515	2.342
Phosphate (ppm)	0.8064	0.7104	1.498	0.614
Ammonia (ppm)	0.034	0.038	0.035	0.0418
Net Pp (ppm)	0.16			

Note: IV* = zooplankton

One of the most influential physical characteristics for plankton was salinity, where marine organisms especially plankton has different abilities to cope themselves to the salinity range. It indicated that salinity is a determining factor of plankton distribution. The measured salinity in the observation site was 34 %.

Another environmental factor measured in this study was the temperature, where the measured temperature ranged from 28 – 28.5^{o}C. These numbers had similarities in all observation stations, where water temperature influenced the physical, chemical, and biological characteristics of the aquatic environment. The rise in temperature caused an increase in metabolism, which lead to a diminishing of dissolved gasses in the water.

Among the various factors examined, an abrupt change in salinity caused by rainfall can be considered as the most important water quality parameter, which affects zooplankton abundance as reported previously by many workers (Watanabe *et al*. 1983; Rajkumar, Santhanam & Perumal 2004; Nassar *et al*. 2014). The results of the present study showed that a combination of factors influences the zooplankton distribution and abundance in an estuary. Among the various factors examined, an abrupt change in salinity caused by rainfall can be considered as the most important water quality parameter which affects zooplankton abundance (Thirunavukkarasu *et al*. 2013).

Water temperatures recorded in the three stations still considered as the proper temperature for plankton's growth. The optimum temperature for diatom growth is 30^{o}C (Prescott 1970; Sankar & Padmavati 2012).

The hydrodynamic process is also important in the aquatic environment in phytoplankton selection. The average current speed measured in this study was 0.04-0.08 m/s, where the highest range was in Station II (0.08/s). Current is very crucial for plankton because their movement highly depends on the current movement.

Level of acidity (pH) is a theory used to explain the characteristic of water compounds. The characteristic in the water can be divided into acid or alkali. Acid is the compound that produced hydrogen ion when dissolved to water. Alkali is the compound that produced hydroxyl ion in the water.

Water brightness is another determining factor for plankton. In this research, there was no measurement taking place for water brightness. Based on the fact, the brightness level influenced the productivity of plankton and other marine organisms.

Results of other parameters (N, P, NH_3, and DO) were significant to the abundance of phytoplankton and zooplankton, where nitrate and phosphate affect the growth and productivity of plankton, especially phytoplankton. Dissolved oxygen is highly required by all aquatic organisms. Measurement of DO in the observation area ranged from 5.1-5.4 ppm, which was highly supported by plankton's life since the oxygen level for the growth should not less than 4 ppm. Based on the measurement result, DO level in the waters around Barru is proper for plankton's growth. A similar opinion was earlier given by (Luyiga & Kiwanuka 2003; Fathi, Al-Fredan & Youssef 2009; Nowrouzi & Valavi 2011; Ramakrishna 2014; Dong *et al.* 2015).

Ammonia also important for growth and become the main component of established protein. Ammonia found in within the observation area ranged from 0.034-0.0418 ppm. This high ammonia content caused by domestic waste disposal and supply from the river, and it can affect the growth of the plankton (Periyanayagi *et al.* 2007; Bahaar & Bhat 2011).

The individual average abundance of the plankton gained from three research stations in Barru waters was dominated by class Bacillariophyceae. This is because Bacillariophyceae was able to utilize the nutrients in the waters such as phosphate and nitrate, and well adapt to the environment. The nitrate content gained from all field trip stations ranged from 2.054-2.5252 ppm. The range value was considered proper for the development of phytoplankton. The lowest tolerance for nitrate is 0.1 ppm, and the highest is 3.0 ppm (Boyd & Litchkopper 1992)

Result of phosphate measurement for all station are from 0.614-1.498 ppm, and contrast with Wetzel (1979) who stated that Bacillariophyceae would dominate waters if the phosphate level is low (0.00-0.02 ppm), and will dominate with Chlorophyceae if the level of phosphate is moderate (0.02-0.05), and will dominate with Cyanophyceae if the phosphate level is high (0.10 ppm) (Wetzel & Liken 1991). This situation might appear because the existence of other supporting factors that were more dominant, for example, the silicate, as discussed by Niartiningsih (1996) in her research at the mangrove forest of Tongke-TOngke, that silicate is the main component for the formation of Bacillariophyceae shell (Niartiningsih 1996).

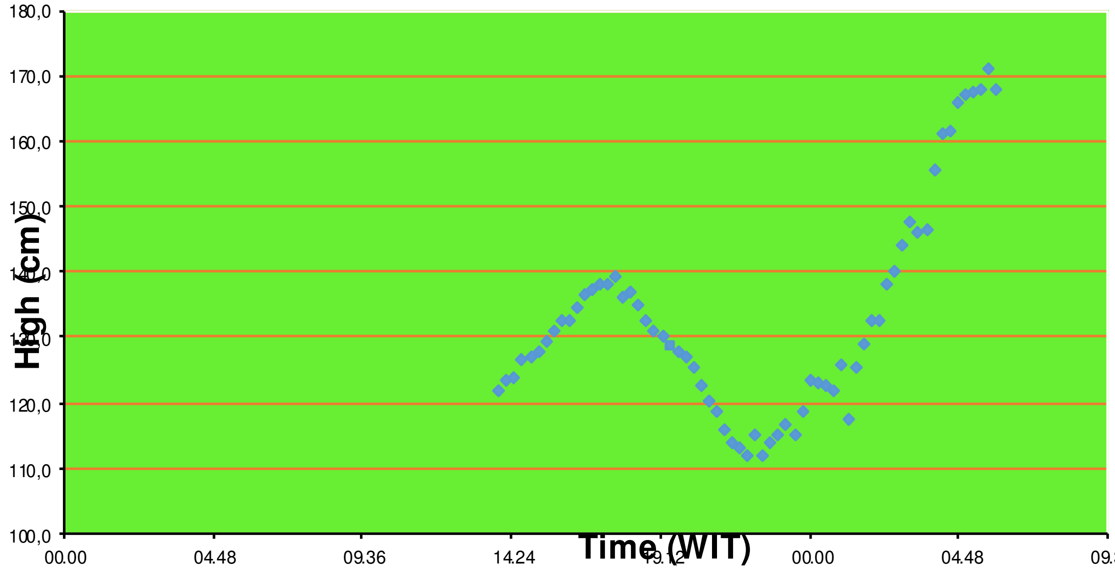

Fig. 2 : Tidal Graph

The tidal type in the research site was a diurnal type. Tidal is one of the marine water phenomena with a big impact on marine organisms and their life features, especially in the coastal area. There are 4 types of tidal in Indonesia: semi-diurnal (two times of high and low tides in 24 hours); diurnal (one low and high tide in 24 hours); mix type dominantly diurnal; and mix type with dominant semi-diurnal. The affected the distribution of marine organisms, the vertical and horizontal movement of plankton that caused the distribution of plankton was different between places (Cardoso *et al.* 2012).

Based on the overall parameter measured during the study, one can say that the condition of Barru waters is proper for the growth and development of planktons.

Conclusion

- Species composition and abundance of phytoplankton generally dominated by Class Bacillariophyceae, with a percentage of 93.5% with Chaetoceros sp at the most.
- Diversity Index of the phytoplankton range from 2.3-2.4, where its existence tends to stable, and homogeneity index is ranged from 0.67-0.69 and tend to stable. Based on this then Diversity Index Homogeneity Index and it means research site has diversity from each species.
- Aquatic condition is highly supportive for the life of plankton, where plankton is able to adapt for their life balance.

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