




Analysis of phytoplankton abundance in kassikebo waters, pangkep regency, south sulawesi, indonesia



Rahmadi Tambaru ^{*}, Muh. Farid Samawi, Ambo Tuwo, Sulaiman Gosalam, Nur Qalbi Mujahidah

Faculty of Marine Science and Fisheries, Universitas Hasanuddin, Makassar, Indonesia

* Corresponding author: aditbr69@unhas.ac.id

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ABSTRACT

Changes in nutrient concentrations can be caused by anthropogenic activities in coastal and marine waters. This affects the abundance of phytoplankton. The waters experiencing it are the waters of Kassikebo Pangkep, South Sulawesi, Indonesia. For this reason, research has been carried out to analyze the abundance and structure of phytoplankton communities in these waters, from January to July 2022. To identify phytoplankton, 100 L of seawater samples were filtered, which were taken at each station. The results of that water filter, identified in the laboratory. The results showed that the classes of phytoplankton found were Bacillariophyceae and Cyanophyceae. Species found such as Skeletonema and Detonula. The results of One-way ANOVA showed that phytoplankton abundance was not significantly different between observation stations ($p > 0.05$). Changes in phytoplankton abundance are caused by pH.

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INTRODUCTION

One of the important biotic components in water is phytoplankton (Kamboj et al., 2022; Guo et al., 2019). These microorganisms are microscopic plants (Arundhathy et al., 2021; Manickam et al., 2020), hovering within the water column (Zhang et al., 2021). Its existence is very important in supporting the continuity of the role of aquatic ecosystems in supporting the life of other organisms (Otero et al., 2018), affecting aquatic productivity (Vernet et al., 2019), and determining the fertility level of waters (Tambaru et al., 2021a).

Changes in water quality, such as changes in nutrient concentrations, affect phytoplankton abundance and community structure (Van Meerssche & Pinckney, 2019). Increased nutrient



concentrations can lead to increased phytoplankton abundance, leading to blooming in waters. As a result, the surface of the waters can be covered by phytoplankton bodies that experience death (Wang et al., 2018).

The presence of phytoplankton blooming causes sunlight to be blocked from penetrating the water column (Taskjelle et al., 2017). This condition causes the photosynthesis process not to run optimally. As a result, the oxygen concentration is reduced (Niu et al., 2021). This can lead to the mass death of aquatic organisms, such as fish, due to a lack of oxygen.

Other consequences can trigger changes in the phytoplankton community structure (Tan & Ransangan, 2017). One type of phytoplankton may become dominant over the other type. If the type of phytoplankton that develops is a dangerous type, such as several types in the *Dynophyceae* group (Lee et al., 2019), then the waters have decreased in quality. This can have a wider impact, not only on the death of fish and other organisms but also on the level of human health.

Research conducted on the west coast of South Sulawesi, Indonesia by (Tambaru et al., 2021a), and on the south coast of South Sulawesi, Indonesia by (Tambaru, 2022) has reported on the emergence of potentially dangerous phytoplankton species. Similarly, research conducted by (Mujib et al., 2015) in the waters of Makassar, South Sulawesi, Indonesia. However, the abundance of potentially dangerous phytoplankton types is still very low when compared to good quality phytoplankton types.

Anthropogenic activities are one of the factors that cause changes in water quality, especially changes in nutrient concentrations (Wang et al., 2018). Some anthropogenic activities such as agricultural, fishery, industrial, and household activities, produce fertilizer waste, pesticides, feed residues, and detergents, ultimately contributing to an increase in nutrients in the waters.

One of the waters affected by anthropogenic activities is the waters of Kassikebo, Pangkep, South Sulawesi, Indonesia. Of course, the quality of the waters can change. As a result, the abundance of phytoplankton may also change. It can affect the lives of other organisms. To that end, research aimed at analyzing changes in the abundance and structure of phytoplankton communities has been carried out in these waters. This research is the latest research on this water area.

RESEARCH METHODS

Research Design

This research is a survey research, which is research whose observations are carried out on a number of characteristics (variables) in research subjects directly in the field. In this study, the research design applied was quantitative research.

Time and Place of Study

The research was conducted from January to July 2022 in the waters around the port of Kassikebo Pangkep, South Sulawesi, Indonesia. Phytoplankton sample identification was carried out at the Marine Microbiology Laboratory of the Department of Marine Sciences, Faculty of Marine and Fisheries Sciences, Hasanuddin University. Based on the preliminary survey, 3 research stations were established. Station I is near the pier, Station II is close to aquaculture, Station III is close to the estuary, and Station IV (Control station) is far from residential areas.

Phytoplankton Identification

Water sampling for phytoplankton identification is carried out at each station. A total of 100 L of water was filtered using plankton net number 25. A sample of 100 mL of filtered water was put into the sample bottle. Next, preserved with 1% Lugol and then stored in a cool box. Identification of water samples containing phytoplankton is carried out in the laboratory. The phytoplankton sampling time is 10.00 – 14.00 WITA (Tambaru et al., 2021b).



Measurement of Nutrient and Oceanographic Parameters

At each station, 250 mL of water sampling was also carried out to measure nitrate and orthophosphate nutrients in the laboratory. The measurement of oceanographic parameters such as temperature, salinity, pH, and water brightness is carried out directly in the field, along with water sampling for phytoplankton identification.

Data Analysis

Analysis of differences in phytoplankton abundance by the station was analyzed using One Way ANOVA. The relationship of phytoplankton abundance to oceanographic parameters was analyzed with Pearson's Correlation using SPSS 15.0 for Windows.

RESULTS

There are two classes of phytoplankton found namely Bacillariophyceae and Cyanophyceae. The type of class Bacillariophyceae is the most common when compared to the species of class Cyanophyceae. The proportion of species abundance in both classes can be seen in Figure I.

Based on the results of phytoplankton identification, 22 species were found scattered at each station. At the station I 15 species were identified, station II detected 13 species, station III recorded 14 species, and station IV had 15 species.

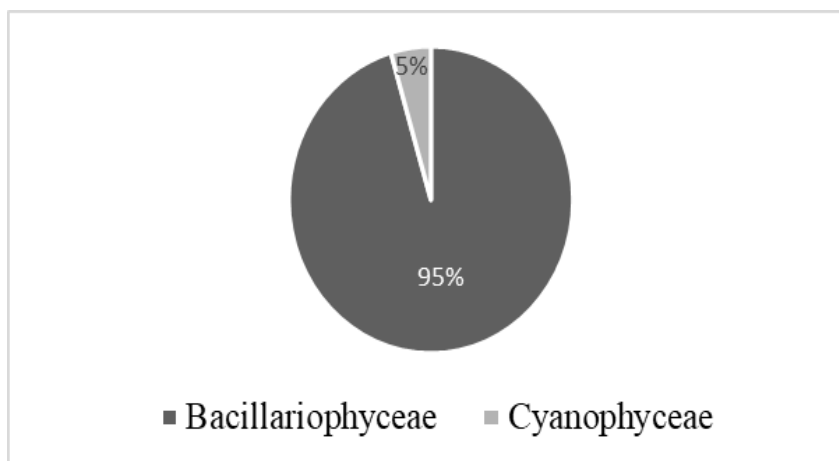


Figure I. The proportion of Phytoplankton Class

The phytoplankton species found are *Bacteriastrum*, *Buddilphia*, *Chaetoceros*, *Coscinodiscus*, *Cylindrospermopsis*, *Cylindrotheca*, *Detonula*, *Ditylum*, *Eucampia*, *Flagilaria*, *Guinardia*, *Halosphaera*, *Hemiaulus*, *Isthmia*, *Leptocylindrus*, *Nitzschia*, *Pleurosigma*, *Proboscia*, *Rhizosolenia*, *Skeletonema*, *Thalassionema*, and *Thalassiosira*. Species that are often found are *Skeletonema* and *Detonula*. Both species are members of the Bacillariophyceae group, often found at each station.

The phytoplankton abundance at station I has the highest amount of abundance compared to other stations (Table 2 and Figure 2). However, based on One Way ANOVA, phytoplankton abundance is considered the same (no real difference between observation stations, $p > 0.05$).

Pearson's correlation was used to analyze the relationship of phytoplankton abundance to oceanographic parameters. In this analysis, phytoplankton abundance is the dependent variable, and oceanographic parameters such as temperature, salinity, pH, nitrate, and orthophosphate as independent variables.

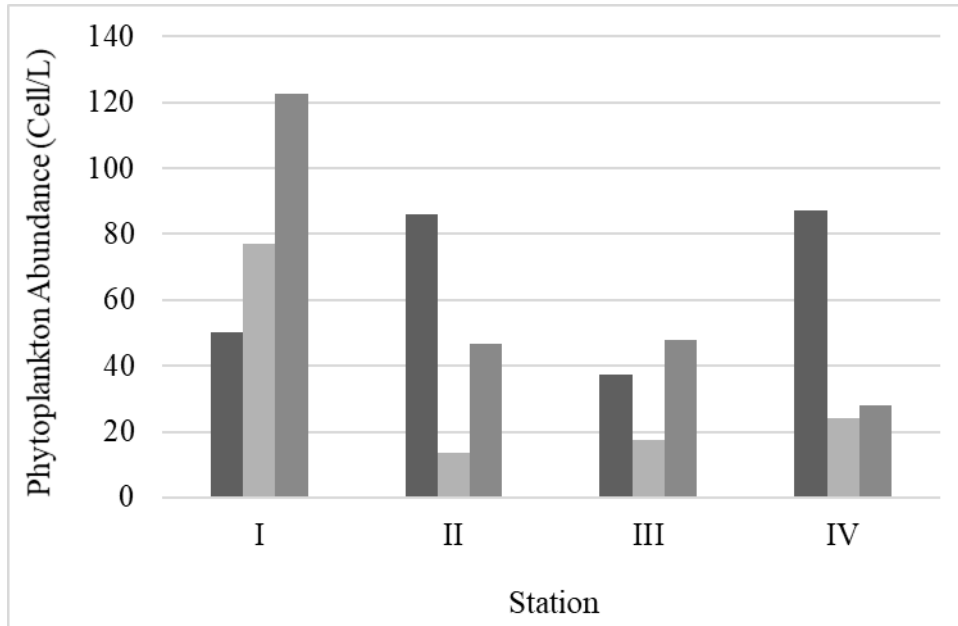


Figure 2. Abundance of Phytoplankton

Data on the measurement of oceanographic parameters are presented in Table I. Measured temperature values range from 32°C - 34°C. Salinity ranges from 25 – 29 ppt. The value of the degree of acidity (pH) ranges from 7.15-7.26. Nitrates range from 0.004 – 0.062 mg/L (Table I), and orthophosphates range from 0.008 – 0.073 mg/L.

Table I. Results of measurement of oceanographic parameters

Station	Observation repetition	Parameter					
		The abundance of phytoplankton (Cell/L)	Temp (°C)	Salinity (‰)	pH	Nitrate (mg/L)	Orthophosphate (mg/L)
I	1	50.0	33	25	7.15	0.051	0.019
	2	77.0	32	28	7.20	0.018	0.028
	3	122.5	33	29	7.25	0.038	0.024
II	1	86.0	33	27	7.20	0.015	0.018
	2	13.5	34	27	7.23	0.031	0.010
	3	46.5	33	28	7.23	0.061	0.017
III	1	37.5	33	27	7.20	0.034	0.022
	2	17.5	33	26	7.22	0.062	0.028
	3	48.0	34	27	7.22	0.038	0.073
IV	1	87.0	33	28	7.26	0.004	0.010
	2	24.0	32	29	7.26	0.034	0.008
	3	28.0	32	29	7.25	0.026	0.023

The results of Pearson's Correlation analysis showed that phytoplankton abundance only correlated with pH with a negative relationship ($r = -0.580$, $p = 0.045$) (Table 2).

Table 2. Results of Pearson correlation analysis

Correlations		Abundance of phytoplankton
Abundance of phytoplankton	Pearson Correlation	1
	Sig. (2-tailed)	
	N	12
Temp	Pearson Correlation	-.059
	Sig. (2-tailed)	.857
	N	12
Salinity	Pearson Correlation	-.365
	Sig. (2-tailed)	.243
	N	12
pH	Pearson Correlation	-.580*
	Sig. (2-tailed)	.048
	N	12
Nitrate	Pearson Correlation	.091
	Sig. (2-tailed)	.779
	N	12
Orthophosphate	Pearson Correlation	-.031
	Sig. (2-tailed)	.924
	N	12

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

DISCUSSION

Bacillariophyceae and Cyanophyceae are the two classes found in this study. Bacillariophyceae has the most species when compared to Cyanophyceae. The same thing was also reported by Tambaru et al. (2018) in Makassar coastal waters and (Tambaru, Samawi, et al., 2021b) in Kuri Maros coastal waters. The high abundance and number of types of class Bacillariophyceae can adapt to changes in environmental conditions widely (Prelle et al., 2019). In low nutrient conditions, they still provide a rapid growth response (Li et al., 2021).

Skeletonema and Detonula are types that are often found at every station. Both types of phytoplankton are groups in the class Bacillariophyceae, often called the diatom group (Scarsini et al., 2019). Diatoms are a common and dominant component of phytoplankton in coastal waters and oceans (Harvey et al., 2019).

The frequency of the two types of phytoplankton is found because of their ability to adapt to diverse environmental conditions, ranging from upstream to river estuaries and seas (Nwe et al., 2021), from the edge to the middle of the ocean (Tibby et al., 2022). Both types are abundant because they can withstand extreme conditions, such as low nutrient concentrations (Spilling et al., 2021). In addition, they have high reproductive power (Ajani et al., 2021), and play an important role as primary producers in waters, this is indicated by their contribution of around 20% of primary production on Earth (Vincent & Bowler, 2020).

Skeletonema is a group of diatoms with cosmopolitan properties. This type is widely distributed in coastal and marine waters. Recent research conducted in the coastal waters of Japan's Ariake has tracked several types of *Skeletonema* that evolved (Yoshida et al., 2023). They found that the occurrence of species in the *Skeletonema* group had different seasonal patterns. Three species of *Skeletonema* (*S. costatum*, *S. menzeli*, and *S. tropicum*) thrive in summer, while others thrive in winter (*S. ardens*, *S. dohrnii/marinoi*, *S. grevillei*, and *S. japonicum*). The appearance of the type in the *Skeletonema* group suggests that they tend to adapt to different environmental conditions. Temperature is an important environmental factor in supporting its development (Canesi & Rynearson, 2016).

Just like *Skeletonema*, temperature also affects *Detonula*'s life in coastal and marine waters. The process of nutrient absorption is accelerating with an increase in water temperature (Gessay & Smayda, 2016). In addition, the availability of light is another environmental factor that provides support for its development (Laws et al., 2020).

Although phytoplankton abundance was found highest at station I (Table 2 and Figure 2), phytoplankton abundance was considered the same (not significantly different) between observation stations based on variety analysis ($p > 0.05$). This may happen because some physical-chemical parameters, for example, the availability of sunlight, are sufficient for phytoplankton needs in activities at all stations. Although not measured in this study, we confirmed that sunlight is widely available in the water column at all stations. This condition affects the speed of phytoplankton growth which is considered the same.

In this study, phytoplankton abundance was detected only correlated with pH with a negative relationship. This correlation can be interpreted, as changes in phytoplankton abundance occurring due to changes in pH values. The abundance of phytoplankton will decrease with the memory of the pH value, and vice versa, up to a certain pH value.

The degree of acidity (pH) influences plant life and aquatic animals. This parameter is often used as a clue to express the good or bad quality of water. For phytoplankton, pH affects the absorption of carbon dioxide in water (Gazeau et al., 2021). Under low pH conditions, the ability of phytoplankton is reduced to absorb carbon dioxide. As a result, the process of photosynthesis does not run perfectly, and the formation of food reserves decreases.

Changes in pH value affect the physiological processes of algae including phytoplankton (Raven et al., 2020). This is a driving factor for the development of several types of harmful phytoplankton (HABs) in the waters. In acidic waters with a pH of less than 6, organisms that feed fish, in this case, phytoplankton, cannot live well.

A study on pH has been reported by (Thoisen et al., 2015). In his observation, the pH value of water in acidic conditions influences decreasing the growth rate of phytoplankton communities. In addition, it exerts an influence on changes in colony size and chain length of selected species. In other studies, the effect of pH on the growth of several types of cyanobacteria and diatoms has also been observed. The results showed that the relative growth became low under acidic pH conditions (Rai & Rajashekar, 2016).

CONCLUSION

Bacillariophyceae and Cyanophyceae are two classes of phytoplankton found in this study. Bacillariophyceae have more numbers and types when compared to the number and type of class Cyanophyceae. The types that are often found are *Skeletonema* and *Detonula*. Both types of phytoplankton are a group of the class Bacillariophyceae. The abundance of phytoplankton at each station was no difference between observation stations. Changes in phytoplankton abundance are due to changes in pH. The presence of phytoplankton types as mentioned, shows that the waters around the port of Kassikebo Pangkep, South Sulawesi, Indonesia, are still relatively good.



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REFERENCES

- Ajani, P.A., Petrou, K., Larsson, M.E., Nielsen, D.A., Burke, J., & Murray, S.A. (2021). Phenotypic trait variability as an indication of adaptive capacity in a cosmopolitan marine diatom. *Environmental Microbiology*, 23(1), 207–223. Retrieved from <https://doi.org/10.1111/1462-2920.15294>
- Arundhathy, M., Jyothibabu, R., Santhikrishnan, S., Albin, K.J., Parthasarathi, S., & Rashid, C.P. (2021). Coccolithophores: an environmentally significant and understudied phytoplankton group in the Indian Ocean. *Environmental Monitoring and Assessment*, 193, 1–14. Retrieved from <https://doi.org/10.1007/s10661-020-08794-1>
- Canesi, K.L., & Rynearson, T.A. (2016). Temporal variation of skeletonema community composition from a long-term time series in Narragansett Bay identified using high-throughput DNA sequencing. *Marine Ecology Progress Series*, 556, 1–16. Retrieved from <https://doi.org/10.3354/meps11843>
- Gazeau, F., Ridame, C., Van Wambeke, F., Alliouane, S., Stolpe, C., Irisson, J.O., Marro, S., Grisoni, J.M., De Liège, G., & Nunige, S. (2021). Impact of dust addition on Mediterranean plankton communities under present and future conditions of pH and temperature: an experimental overview. *Biogeosciences*, 18(17), 5011–5034. Retrieved from <https://doi.org/10.5194/bg-18-5011-2021>
- Gessay, J.S., & Smayda, T.J. (2016). Estimating biomass and analyzing bloom seasonality of the diatoms, *Skeletonema costatum* (sl), *Detonula confervacea*, and *Thalassiosira nordenskiöldii* in Narragansett Bay. *SURFO Technical Report No. 16-01*, 20. Retrieved from <https://core.ac.uk/download/pdf/127469851.pdf#page=28>
- Guo, K., Wu, N., Wang, C., Yang, D., He, Y., Luo, J., Chai, Y., Duan, M., Huang, X., & Riis, T. (2019). Trait dependent roles of environmental factors, spatial processes and grazing pressure on lake phytoplankton metacommunity. *Ecological Indicators*, 103, 312–320. Retrieved from <https://doi.org/10.1016/j.ecolind.2019.04.028>
- Harvey, B.P., Agostini, S., Kon, K., Wada, S., & Hall-Spencer, J.M. (2019). Diatoms dominate and alter marine food-webs when CO₂ rises. *Diversity*, 11(12), 242. Retrieved from <https://doi.org/10.3390/d11120242>
- Kamboj, V., Kamboj, N., Sharma, A.K., & Bisht, A. (2022). Phytoplankton communities as bio-indicators of water quality in a mining-affected area of the river Ganga, Haridwar, India. *Energy, Ecology and Environment*, 7(4), 425–438. Retrieved from <https://doi.org/10.1007/s40974-022-00238-5>
- Laws, E.A., McClellan, S.A., & Passow, U. (2020). Interactive effects of CO₂, temperature, irradiance, and nutrient limitation on the growth and physiology of the marine diatom *Thalassiosira pseudonana* (Coscinodiscophyceae). *Journal of Phycology*, 56(6), 1614–1624. Retrieved from <https://doi.org/10.1111/jpy.13048>
- Lee, K.H., Jeong, H.J., Kang, H.C., Ok, J.H., You, J.H., & Park, S.A. (2019). Growth rates and nitrate uptake of co-occurring red-tide dinoflagellates *Alexandrium* affine and *A. fraterculus* as a function of nitrate concentration under light-dark and continuous light conditions.



- Algae*, 34(3), 237–251. Retrieved from <https://doi.org/10.4490/algae.2019.34.8.28>
- Li, Z., Gao, Y., Wang, S., Lu, Y., Sun, K., Jia, J., & Wang, Y. (2021). Phytoplankton community response to nutrients along lake salinity and altitude gradients on the Qinghai-Tibet Plateau. *Ecological Indicators*, 128, 107848. Retrieved from <https://doi.org/10.1016/j.ecolind.2021.107848>
- Manickam, N., Bhavan, P.S., Santhanam, P., Muralisankar, T., Kumar, S.D., Balakrishnan, S., Ananth, S., & Devi, A.S. (2020). Phytoplankton biodiversity in the two perennial lakes of Coimbatore, Tamil Nadu, India. *Acta Ecologica Sinica*, 40(1), 81–89. Retrieved from <https://doi.org/10.1016/j.chnaes.2019.05.014>
- Mujib, A.S., Damar, A., & Wardiatno, Y. (2015). Spatial distribution of planktonic dinoflagellate in Makassar waters, South Sulawesi. *Jurnal Ilmu Dan Teknologi Kelautan Tropis*, 7(2). Retrieved from <https://jurnal.ipb.ac.id/index.php/jurnalikt/article/view/11033>
- Niu, Y., Liu, C., Lu, X., Zhu, L., Sun, Q., & Wang, S. (2021). Phytoplankton blooms and its influencing environmental factors in the southern Yellow Sea. *Regional Studies in Marine Science*, 47, 101916. Retrieved from <https://doi.org/10.1016/j.rsma.2021.101916>
- Nwe, L.W., Azhikodan, G., Yokoyama, K., & Kodama, M. (2021). Spatio-temporal distribution of diatoms and dinoflagellates in the macrotidal Tanintharyi River estuary, Myanmar. *Regional Studies in Marine Science*, 42, 101634. Retrieved from <https://doi.org/10.1016/j.rsma.2021.101634>
- Otero, J., Bode, A., Álvarez-Salgado, X.A., & Varela, M. (2018). Role of functional trait variability in the response of individual phytoplankton species to changing environmental conditions in a coastal upwelling zone. *Marine Ecology Progress Series*, 596, 33–47. Retrieved from <https://doi.org/10.3354/meps12542>
- Prelle, L.R., Graiff, A., Gründling-Pfaff, S., Sommer, V., Kuriyama, K., & Karsten, U. (2019). Photosynthesis and respiration of Baltic Sea benthic diatoms to changing environmental conditions and growth responses of selected species as affected by an adjacent peatland (Hütelmoor). *Frontiers in Microbiology*, 10, 1500. Retrieved from <https://doi.org/10.3389/fmicb.2019.01500>
- Rai, S.V., & Rajashekhar, M. (2016). Effect of pH, salinity and temperature on the growth of six species of cyanobacteria isolated from arabian sea coast of karnataka. *International Journal of BioSciences & Technology*, 9(1). Retrieved from <https://web.s.ebscohost.com/ehost/pdfviewer/pdfviewer?vid=1&sid=580d24b6-13b4-4065-8d88-97c6d09bb8d5%40redis>
- Raven, J.A., Gobler, C.J., & Hansen, P.J. (2020). Dynamic CO₂ and pH levels in coastal, estuarine, and inland waters: Theoretical and observed effects on harmful algal blooms. *Harmful Algae*, 91, 101594. Retrieved from <https://doi.org/10.1016/j.hal.2019.03.012>
- Scarsini, M., Marchand, J., Manoylov, K.M., & Schoefs, B. (2019). Photosynthesis in diatoms. *Diatoms: Fundamentals and Applications*, 191–211. Retrieved from <https://doi.org/10.1002/9781119370741.ch8>
- Spilling, K., Seppälä, J., Schwenk, D., Rischer, H., & Tamminen, T. (2021). Variation in the fatty acid profiles of two cold water diatoms grown under different temperature, light, and nutrient regimes. *Journal of Applied Phycology*, 33, 1447–1455. Retrieved from <https://doi.org/10.1007/s10811-021-02380-9>
- Tambaru, R. (2022). Potentially harmful phytoplankton species in the southern part of west coastal waters of south sulawesi. *JURNAL AGRIKAN (Agribisnis Perikanan)*, 15(2), 453–459. Retrieved from <https://www.jurnal.umm.ac.id/index.php/agrikan/article/view/1258>
- Tambaru, R., Burhanuddin, A.I., Massinai, A., & Amran, M.A. (2021a). Detection of marine



- microalgae (phytoplankton) quality to support seafood health: A case study on the west coast of south sulawesi, indonesia. *Biodiversitas Journal of Biological Diversity*, 22(11). Retrieved from <https://doi.org/10.13057/biodiv/d221156>
- Tambaru, R., La Nafie, Y. A.L.N., & Junaidi, A.W. (2018). Analysis of causing factors on the appearance of habs in coastal water of makassar. *Jurnal Ilmu Kelautan SPERMONDE*, 4(2). Retrieved from <https://doi.org/10.20956/jiks.v4i2.7065>
- Tambaru, R., Samawi, M.F., & Afriliyeni, N.S. (2021b). Levels of water fertility in coastal waters of Kuri based on phytoplankton chlorophyll-a concentration. *IOP Conference Series: Earth and Environmental Science*, 681(1), 12106. Retrieved from <https://doi.org/10.1088/1755-1315/681/1/012106>
- Tan, K.S., & Ransangan, J. (2017). Effects of nutrients and zooplankton on the phytoplankton community structure in Marudu Bay. *Estuarine, Coastal and Shelf Science*, 194, 16–29. Retrieved from <https://doi.org/10.1016/j.ecss.2017.05.008>
- Taskjelle, T., Granskog, M.A., Pavlov, A.K., Hudson, S.R., & Hamre, B. (2017). Effects of an arctic under-ice bloom on solar radiant heating of the water column. *Journal of Geophysical Research: Oceans*, 122(1), 126–138. Retrieved from <https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2016JC012187>
- Thoisen, C., Riisgaard, K., Lundholm, N., Nielsen, T.G., & Hansen, P.J. (2015). Effect of acidification on an arctic phytoplankton community from disko bay, west greenland. *Marine Ecology Progress Series*, 520, 21–34. Retrieved from <https://doi.org/10.3354/meps11123>
- Tibby, J., Haynes, D., Gibbs, M., Mosley, L., Bourman, R.P., & Fluin, J. (2022). The terminal lakes of the Murray River, Australia, were predominantly fresh before large-scale upstream water abstraction: Evidence from sedimentary diatoms and hydrodynamical modelling. *Science of The Total Environment*, 835, 155225. Retrieved from <https://doi.org/10.1016/j.scitotenv.2022.155225>
- Van Meerssche, E., & Pinckney, J.L. (2019). Nutrient loading impacts on estuarine phytoplankton size and community composition: community-based indicators of eutrophication. *Estuaries and Coasts*, 42(2), 504–512. Retrieved from <https://doi.org/10.1007/s12237-018-0470-z>
- Vernet, M., Ellingsen, I.H., Seuthe, L., Slagstad, D., Cape, M.R., & Matrai, P.A. (2019). Influence of phytoplankton advection on the productivity along the Atlantic water inflow to the arctic ocean. *Frontiers in Marine Science*, 6, 583. Retrieved from <https://doi.org/10.3389/fmars.2019.00583>
- Vincent, F., & Bowler, C. (2020). Diatoms are selective segregators in global ocean planktonic communities. *Msystems*, 5(1), e00444-19. Retrieved from <https://doi.org/10.1128/mSystems.00444-19>
- Wang, B., Xin, M., Wei, Q., & Xie, L. (2018). A historical overview of coastal eutrophication in the China Seas. *Marine Pollution Bulletin*, 136, 394–400. Retrieved from <https://doi.org/10.1016/j.marpolbul.2018.09.044>
- Yoshida, K., Ota, H., Iwanaga, T., Yoshitake, A., Mine, T., Omura, M., & Kimura, K. (2023). Species-specific monitoring of skeletonema blooms in the coastal waters of ariake sound, japan. *Marine Ecology Progress Series*, 703, 31–46. Retrieved from <https://doi.org/10.3354/meps14200>
- Zhang, Y., Hu, M., Shi, K., Zhang, M., Han, T., Lai, L., & Zhan, P. (2021). Sensitivity of phytoplankton to climatic factors in a large shallow lake revealed by column-integrated algal biomass from long-term satellite observations. *Water Research*, 207, 117786. Retrieved from <https://doi.org/10.1016/j.watres.2021.117786>