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ABUNDANCE INDEX AND COMMUNITY STRUCTURE OF PHYTOPLANKTON IN THE INTEGRATED MARINE AQUACULTURE AREA OF EKAS BAY, WEST NUSA TENGGARA

Indeks Kelimpahan Dan Struktur Komunitas Fitoplankton Pada Kawasan Budidaya Laut Terintegrasi di Teluk Ekas, Nusa Tenggara Barat

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ABSTRACT

The development of Ekas Bay as a center for integrated aquaculture activities, particularly through the Floating Net Cage (FNC) system, can impact phytoplankton abundance and water fertility. Phytoplankton, a type of plankton capable of photosynthesis, acts as a primary producer and serves as a key food source for fish and lobsters. The presence of phytoplankton is closely related to the fertility levels of waters designated for marine aquaculture. This study aims to determine the composition and abundance of phytoplankton in the waters of Ekas Bay. The research employed purposive sampling, collecting phytoplankton samples from five predetermined stations: three points near FNCs and two points distant from the FNC area. The results indicate that the plankton abundance in the waters of Ekas Bay is categorized as mesotrophic. The highest phytoplankton abundance was recorded at Station V with 9,523 cells/L, while the lowest was at Station II with 2,150 cells/L. Based on station characteristics, Station V is the farthest point from FNCs, whereas Station II contains a high concentration of FNCs. The community structure, as indicated by the H', E, and D values, suggests that the waters of Ekas Bay remain in a stable condition. Phytoplankton from the class Bacillariophyta was the most commonly found, although no specific genus was dominant.

Keywords: phytoplankton, abundance, floating net cage, Ekas Bay

ABSTRAK

Pengembangan Teluk Ekas sebagai sentra kegiatan budidaya terintegrasi khususnya dengan sistem Keramba Jaring Apung dapat berpengaruh terhadap kondisi kelimpahan fitoplankton dan kesuburan perairan. Fitoplankton adalah jenis plankton yang dapat melakukan fotosintesis, sebagai produsen primer, fitoplankton menjadi sumber makanan utama bagi ikan dan lobster. Fitoplankton memiliki keterkaitan dengan tingkat kesuburan perairan yang dijadikan sebagai lokasi kegiatan budidaya laut. Penelitian ini bertujuan untuk mengetahui komposisi dan kelimpahan fitoplankton di perairan Teluk Ekas. Metode yang digunakan adalah purposive sampling dengan pengambilan sampel fitoplankton di lima stasiun yang telah ditentukan yaitu

3 titik di sekitar KJA dan 2 titik jauh dari area KJA. Hasil penelitian menunjukkan nilai kelimpahan plankton di perairan Teluk Ekas menunjukkan nilai mesotrofik. Nilai kelimpahan fitoplankton yang paling tinggi terdapat pada stasiun V sebesar 9523 sel/ L dan yang paling rendah terdapat pada stasiun II 2150 sel/L. Berdasarkan karakteristitik stasiun pengambilan sampel, pada stasiun V merupakan titik yang paling jauh dari KJA dan stasiun II terdapat banyak KJA. Struktur komunitas yang ditunjukkan dari nilai H', E dan D menggambarkan bahwa di perairan Teluk Ekas masih dalam kondisi stabil. Fitoplankton dari kelas Bacillariophyta paling banyak ditemukan namun tidak terlihat genus tertentu yang mendominasi.

Kata kunci : fitoplankton, kelimpahan, KJA, teluk ekas

INTRODUCTION

Ekas Bay is a coastal marine area characterized by calm and sheltered waters, with oceanographic conditions that are conducive to marine aquaculture activities. According to a study, approximately 3,396 hectares of the total 5,313 hectares of Ekas Bay have potential for aquaculture development (Radiarta *et al.*, 2003). Over the past few years, the development of Ekas Bay as a marine aquaculture zone has been ongoing. The integrated aquaculture system using Floating Net Cages (FNCs) has been adopted by local communities to cultivate species such as fish and lobsters. However, the dense aquaculture activities and numerous FNCs in Ekas Bay could impact the aquatic environment, particularly in terms of water fertility and phytoplankton presence.

Plankton are microscopic organisms that can be found in all types of water bodies, moving passively with the currents. In the ocean, plankton biomass constitutes up to 98% of all microscopic organisms (Sardet, 2015). Phytoplankton, a type of plankton capable of photosynthesis, contributes nearly half of the total global primary productivity (Falkowski et al., 1998). As primary producers, phytoplankton form the primary food source for marine populations (Lagus, 2004). Zooplankton, the primary consumers of phytoplankton, in turn serve as food for various marine organisms, including fish, shrimp, lobsters, crabs, and small fish species.

An increase in phytoplankton populations may indicate improved water fertility. However, under certain conditions, excessive growth (blooming) can lead to a decline in water quality and mass mortality of other aquatic organisms. Uneaten feed and fish waste from FNCs can increase the levels of nutrients, particularly nitrogen and phosphorus, which act as natural fertilizers for phytoplankton growth (Zulfia & Aisyah, 2016). Elevated nutrient levels due to FNC activities can trigger eutrophication, characterized by uncontrolled algal growth. Eutrophication can result in reduced dissolved oxygen levels, mortality of aquatic organisms, and alterations in community structure. FNC activities can also affect other water quality parameters, such as turbidity, temperature, and pH, which may influence the growth and diversity of phytoplankton.

Several studies have shown that phytoplankton abundance is closely related to the fertility of water bodies used for marine aquaculture, such as those with FNCs (Nopem *et al.*, 2020). Therefore, research on the abundance and composition of plankton species in the vicinity of FNCs in Ekas Bay is necessary.

RESEARCH METHODS

Time and Place

The research was conducted from December 23 to December 30, 2023, in the waters of Ekas Bay, Pemongkong Village, Jerowaru District, East Lombok Regency (Figure 1).

Phytoplankton observations were carried out at the Environmental Aquaculture Laboratory of the Aquaculture Study Program, University of Mataram.

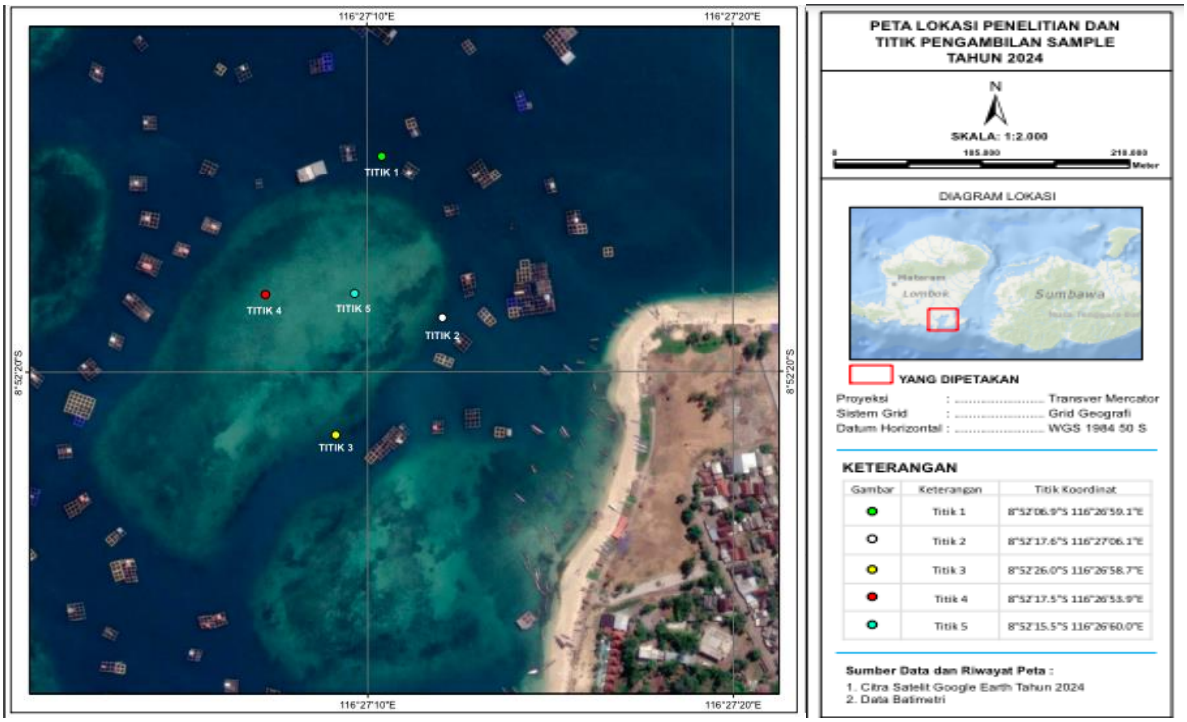

Figure 1. Sampling locations in the waters of Ekas Bay, East Lombok

Tools and Materials

The tools used in this study include a 350-micron plankton net, sample bottles, DO meter, pH meter, Secchi disk, dropper, bucket, and microscope. Materials used include seawater samples, ammonia test kits, phosphate, nitrite, nitrate test kits, distilled water, and Lugol's solution.

Research Methodology

The study employed a descriptive method, and the sampling technique used was purposive sampling. Five sampling points were established, with Points 1, 2, and 3 located near FNCs and Points 4 and 5 in waters without FNCs.

Data Collection

Water quality measurements were conducted in situ. Phytoplankton sampling was performed quantitatively using bottles and plankton nets to determine plankton density per unit volume. The sampling procedure was as follows: The plankton net was calibrated by rinsing with distilled water or immersing it in the target water to ensure the entire net was wet. A film bottle was attached to the end of the plankton net. A water sample of 25 liters was filtered using the plankton net, while the net was gently shaken to collect plankton into the 100 ml film bottle. The collected sample was preserved with 3–4 drops of Lugol's solution and labeled. The sample was stored in a cool box with ice and later kept in a refrigerator at 4°C.

Data Analysis

Data were presented in tables and analyzed descriptively.

Phytoplankton Abundance

Phytoplankton abundance was calculated using the Shannon-Wiener index (dominance, evenness, and diversity indices). The abundance was determined using the formula by Andriani *et al*. (2018):

$$N = (T \times P \times V \times 1)/(L \times p \times v \times W)$$

Where:

NNN: Phytoplankton abundance per liter (cells/L)
TTT: Cover glass area (mm²)
VVV: Concentrated phytoplankton volume in the sample bottle (25 ml)
LLL: Microscope field area
vvv: Sample volume in the glass slide (1 ml)
PPP: Total observed count
ppp: Number of observed microscope fields
WWW: Filtered water sample volume (25 L)

Diversity Index

The Shannon-Wiener diversity index (H'H'H') was calculated using the formula from Shabrina et al. (2021):

$$H' = -\sum_{n=f}^{s} \rho i \; ln \; \rho i$$

Where:

H'': Diversity index result
S: Number of species observed
pi : Proportion of species iii (ρi=niNρ_i = \frac{n_i}{N}ρi=Nni)
ni : Number of cells or individuals of species iii
N : Total number of cells or individuals

Criteria:

H'>3H' > 3H'>3: High diversity
1<H'≤31 < H' ≤ 31<H'≤3: Moderate diversity
H'<1H' < 1H'<1: Low diversity

Evenness Index

The evenness index (EEE) was calculated as follows:

$$E = \left(\frac{H'}{Hmax}\right)$$

Where:

E: Evenness index
H': Diversity index
Hmax: Maximum diversity index

Criteria:

0 < E ≤ 0,4: Low, disturbed community
0,4 < E ≤ 0,6: Moderate, unstable community
0,6 < E ≤ 1: High, stable community

Dominance Index

The Simpson dominance index (DDD) was calculated as:

$$D = \sum_{n-1}^{n} \left(\frac{ni}{N}\right) 2$$

Where:

D: Dominance index
ni: Total cells of genus iii
N: Total cells of all genera

Criteria:

- $0 < D \leq 0{,}5$: Low dominance
- $0{,}5 < D \leq 0{,}75$: Moderate dominance
- $0{,}75 < D \leq 1$: High dominance of a specific species

RESULTS

Phytoplankton Abundance and Shannon-Wiener Indices

Table 1. Phytoplankton Abundance in the Waters of Ekas Bay

Location	Taxa	Phytoplankton Abundance (cells/L)
Station 1	**Bacillariophyceae**	
	Guinardia	0
	Synedra	0
	Navicula	307
	Grammotophora	614
	Nitszchia	307
	Biddulphia	614
	Triceratium	0
	Skletonema	0
	Gyrosigma	0
	Eunotia	921
	Fragilaria	0
	Rhizosolenia	0
	Dinophyceae	
	Amphisolenia	921
	Chlorophyceae	
	Microspora	0
	Total Abundance	3686
Station II	**Bacillariophyceae**	
	Guinardia	0
	Synedra	0
	Navicula	0
	Grammotophora	0
	Nitszchia	0
	Biddulphia	614
	Triceratium	0
	Skletonema	0
	Gyrosigma	307
	Eunotia	614
	Fragilaria	0
	Rhizosolenia	0
	Dinophyceae	
	Amphisolenia	0
	Chlorophyceae	

	Microspora	614
	Total Abundance	2150
Station III	**Bacillariophyceae**	
	Guinardia	614
	Synedra	0
	Navicula	921
	Grammotophora	0
	Nitszchia	1228
	Biddulphia	614
	Triceratium	0
	Skletonema	921
	Gyrosigma	921
	Eunotia	614
	Fragilaria	0
	Rhizosolenia	0
	Dinophyceae	
	Amphisolenia	921
	Chlorophyceae	
	Microspora	307
	Total Abundance	**7065**
StationIV	**Bacillariophyceae**	
	Guinardia	921
	Synedra	614
	Navicula	307
	Grammotophora	0
	Nitszchia	1228
	Biddulphia	614
	Triceratium	307
	Skletonema	614
	Gyrosigma	921
	Eunotia	1228
	Fragilaria	307
	Rhizosolenia	0
	Dinophyceae	
	Amphisolenia	921
	Chlorophyceae	
	Microspora	614
	Total Abundance	**8601**
Station V	**Bacillariophyceae**	
	Guinardia	921
	Synedra	307
	Navicula	614
	Grammotophora	614
	Nitszchia	1536
	Biddulphia	921
	Triceratium	0
	Skletonema	307
	Gyrosigma	1536
	Eunotia	1228

Fragilaria	0
Rhizosolenia	0
Dinophyceae	
Amphisolenia	921
Chlorophyceae	
Microspora	614
Total Abundance	**9523**

Table 2. Phytoplankton Diversity Index (H') in the Waters of Ekas Bay

Station	Diversity Index (H')
I	1,70
II	1,35
III	2,14
IV	2,27
V	2,28

Table 3. Phytoplankton Evenness Index (E) in the Waters of Ekas Bay

Station	Evenness Index (E)
I	0,95
II	0,98
III	0,97
IV	0,91
V	0,95

Table 4. Phytoplankton Dominance Index (D) in the Waters of Ekas Bay

Station	Dominance Index (D)
I	0,19
II	0, 27
III	0,12
IV	0,10
V	0,11

Table 5. Measured Water Quality Parameters in Ekas Bay

Water Quality Parameter	Value
Temperature (^oC)	30^oC
pH	8
DO (ppm)	8,5
Nitrate (mg/l)	1
Phosphate mg/l	0,1
Salinity (ppt)	31
Light Intensity (lux)	772×10.000
Water Clarity (m)	0,7

DISCUSSION

The total abundance results from stations I, II, III, IV, and V revealed values of 3686 cells/L, 2150 cells/L, 7065 cells/L, 8601 cells/L, and 9523 cells/L, respectively. The highest total plankton abundance was recorded at station V, with a value of 9523 cells/L, while the

lowest was observed at station II, with 2150 cells/L. These values indicate mesotrophic conditions. According to Landener (1978), a water body is classified as mesotrophic when the total abundance ranges between 2000 and 15,000 cells/L. Mesotrophic waters are characterized by moderate phytoplankton abundance. Phytoplankton structure across the five stations identified 14 genera belonging to three classes: Bacillariophyceae (*Guinardia, Synedra, Navicula, Grammotophora, Nitzschia, Biddulphia, Triceratium, Skeletonema, Gyrosigma, Eunotia, Fragilaria,* and *Rhizosolenia*), Dinophyceae (*Amphisolenia*), and Chlorophyceae (*Microspora)*.

Observing the sampling characteristics, stations IV and V were the farthest from floating net cages (FNC). Station II, with the lowest total abundance, was characterized by a high concentration of FNC nearby (Figure 1). Nopem (2020) found a correlation between the presence of FNC and phytoplankton abundance. Sampling points near FNC tend to have lower phytoplankton abundance compared to those farther away. The presence of FNC likely leads to phytoplankton being consumed by cultured fish or other aquatic organisms, reducing their abundance. Phytoplankton abundance is also influenced by station-specific activities, anthropogenic conditions, and nutrient availability, which affect their growth (Balqis 2021). Two limiting factors for phytoplankton growth are nutrients and sunlight (Limining 2009).

Phytoplankton from the Bacillariophyceae class was the most abundant in Ekas Bay compared to other classes. Maretta (2023) also found Bacillariophyceae to be dominant in phytoplankton diversity observations. This class is commonly found in marine environments due to its adaptability to environmental conditions, cosmopolitan nature, tolerance, and superior adaptive capabilities compared to other phytoplankton classes. Bacillariophyceae can survive various aquatic conditions. Balqis (2021), highlighted the importance of Bacillariophyceae as a significant group of phytoplankton in aquatic ecosystems, playing a role in mineralization and organic matter recycling, which contributes to their high abundance (Kamilah, 2014). This class is widely distributed in various aquatic environments (Ramadani, 2012).

The diversity index analysis showed variation across the sampling stations. The highest phytoplankton diversity was at station V (2.28), followed by station IV (2.27), station III (2.14), station I (1.70), and the lowest at station II (1.35). These results indicate moderate diversity levels. Diniariwisan (2023) stated that diversity index values between >1 and <3 suggest normal phytoplankton ecosystem conditions. The diversity index results align with phytoplankton abundance, where the presence of FNC near sampling points might influence phytoplankton diversity. Maretta (2023), noted that aquaculture activities near FNC affect the diversity index of phytoplankton. Similarly, Nopem (2020) stated that the presence or absence of FNC influences the diversity index at sampling points.

The dominance index at all sampling stations ranged from 0.10 to 0.27, indicating no single phytoplankton genus dominates these waters. This finding is consistent with Diniariwisan (2023), who reported that a dominance index <0.5 signifies low dominance levels, with no genus prevailing in the ecosystem. A dominance index (D) between 0 and 0.5 indicates no dominant species in the community (Shabrina *et al*., 2021). The evenness index at all stations was 0, suggesting no specific phytoplankton species dominated over others. This aligns with Maretta (2023), who stated that an evenness index (C) of 0 indicates stable community structures. Conversely, a value approaching or equal to 1 signifies instability due to species dominance within the phytoplankton community (Yuliana, 2015).

Water quality parameter measurements in Ekas Bay indicated that physical and chemical parameters were within optimal ranges. Water quality is crucial in determining plankton community structures. Temperature is a vital factor for phytoplankton growth and distribution (Gurning *et al*., 2020). The recorded temperature in Ekas Bay was 30°C, which is within the optimal range for phytoplankton growth (25–30°C) (Soliha *et al*., 2016).

The measured pH was 8, optimal for phytoplankton growth. Gurning *et al*. (2020) stated that the ideal pH range for phytoplankton growth is 6.5–8.0. The recorded DO (dissolved oxygen) was 8.5 mg/L, sufficient to support phytoplankton life, as DO levels depend on photosynthetic activity in the water.

Water clarity, another factor influencing photosynthesis and plankton growth, was recorded at 0.7 m. Suardini (2018) suggested that optimal clarity ranges around 0.45 m. The recorded salinity was 31 ppt, an optimal level for plankton growth. Variations in phytoplankton abundance among stations were influenced by temperature and salinity. Generally, increasing temperatures correspond to higher phytoplankton abundance, as optimal temperatures support metabolic activity and cell growth (Sriwijayanti *et al.*, 2019). Nitrate and phosphate measurements were within optimal ranges, with nitrate at 1 mg/L and phosphate at 0.1 mg/L. These values support phytoplankton growth and development. Overall, all measured water quality parameters in Ekas Bay were conducive to marine biota.

CONCLUSION

Phytoplankton abundance in Ekas Bay reflects mesotrophic conditions. The highest abundance was recorded at station V, and the lowest at station II. Bacillariophyta was the most abundant class, with no specific genus dominating.

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