Fisheries Journal, 15 (1), 57-72 (2025)
http://doi.org/10.29303/jp.v15i1.1350

PLANKTON AND WATER QUALITY ANALYSIS ON THE PRODUCTION PERFORMANCE OF WHITE SHRIMP (*Litopenaeus vannamei*)

Analisis Plankton dan Kualitas Air terhadap Kinerja Produksi Tambak Udang Vaname (*Litopenaeus vannamei*) Sistem Intensif

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(Received January 2th 2025; Accepted Januari 27th 2025)

ABSTRACT

The abundance, diversity, and dominance of phytoplankton affect water quality which can directly affect the success of cultivation. This study was conducted to analyze the diversity of species and dynamics of plankton abundance in shrimp (*Litopenaeus vannamei*) cultivation in intensive white shrimp ponds in Sumenep, Madura. Observations of plankton, water quality, and white shrimp production were carried out in four ponds for ± 2 months. Data analysis was carried out on water quality data, plankton community structure and white shrimp cultivation production performance. Water quality data and production performance were analyzed descriptively qualitatively while plankton community structure data (biological index) were analyzed descriptively quantitatively. The results of the identification of zooplankton types obtained from the samples amounted to 2 classes, consisting of 7 genera of protozoa and 1 genus of Rotifera. The most abundant zooplankton is the Protozoa Class with 7 genera. The highest plankton abundance is from the Genus Chlorophyta (74.67% ± 4.49%), then the second highest is from the Genus Cyanophyta (18.01% ± 3.40%). The results of the diversity index analysis (H') in pond 5 were 2.246 indicating high diversity, while ponds 6,7, and 8 showed moderate diversity. The uniformity index showed that pond 5 had a high uniformity index with a value of 0.66 while ponds 6,7, and 8 had moderate uniformity. The dominance index analysis showed that in pond 5 with a value of 0.978 there were dominant species, while ponds 6, 7, 8 did not have dominant species. Water quality observations showed that there were nitrate parameters that exceeded the optimum standard. The performance of white shrimp cultivation showed better results in pond 5 indicated by ADG of 0.35 g/day, ABW 14.9 g, FCR 1.6 and SR 71%.

Keywords: abundance, diversity, phytoplankton, shrimp ponds, water quality

ABSTRAK

Kelimpahan, keanekaragaman, dan dominasi fitoplankton berpengaruh terhadap kualitas air yang secara langsung dapat mempengaruhi keberhasilan budidaya. Penelitian ini dilakukan untuk menganalisis keanekaragaman jenis dan dinamika kelimpahan plankton pada

budidaya udang *(Litopenaeus vannamei)* pada tambak udang vaname sistem intensif di Sumenep, Madura. Pengamatan plankton, kualitas air, dan produksi udang vaname dilakukan pada empat petak selama ± 2 bulan. Analisis data dilakukan terhadap data kualitas air, struktur komunitas plankton dan kinerja produksi budidaya udang vaname. Data kualitas air dan kinerja produksi dianalisis secara deskriptif kualitatif sedangkan data struktur komunitas plankton (Indeks biologi) dilakukan secara deskriptif kuantitatif. Hasil identifikasi jenis zooplankton yang didapat dari sampel berjumlah 2 kelas yaitu terdiri dari protozoa sebanyak 7 genus dan Rotifera sebanyak 1 genus. Zooplankton yang paling banyak jumlahnya adalah *Class* protozoa sebanyak 7 genus. Kelimpahan plankton tertinggi adalah dari Genus Chlorophyta (74.67% ± 4,49%), selanjutnya tertinggi kedua dari Genus Cyanophyta (18,01% ± 3.40%). Hasil analisis indeks keanekaragaman (H') pada petak 5 sebesar 2,246 menunjukkan keanekaragaman tinggi, sedangkan pada petak 6,7, dan 8 menunjukkan keanekaragaman sedang. Indeks keseragaman menunjukkan bahwa petak 5 memiliki indeks keseragaman tinggi degan nilai 0,66 sedangkan petak 6,7, dan 8 memiliki keseragaman sedang. Analisis indeks dominasi menunjukkan pada petak 5 dengan nilai 0,978 terdapat spesies yang mendominasi, sedangkan petak 6, 7, 8 tidak terdapat spesies yang mendominasi. Pengamatan kualitas air menunjukkan terdapat parameter nitrat yang melebihi standar optimum. Kinerja budidaya udang vaname menunjukkan hasil yang lebih baik pada petak 5 ditunjukkan dengan ADG sebesar 0,35 g/hari, ABW 14,9 g, FCR 1,6 dan SR 71%.
Kata Kunci: fitoplankton, keanekaragaman, kelimpahan, kualitas air, tambak udang

INTRODUCTION

Plankton are microscopic organisms that live suspended or floating (Mansyah, 2020). Plankton are divided into two groups, namely phytoplankton and zooplankton (Rodrigues *et al*., 2015). A stable pond aquatic environment is characterized by high plankton diversity, a high and even number of individuals of each species, and water quality suitable for the growth of cultured organisms, including plankton as natural food (Khalik, 2021). In addition to being natural food, the presence of plankton is a crucial supporting factor in shrimp ponds, especially in autotrophic systems that primarily rely on phytoplankton growth as the main source of oxygen in the pond through plankton photosynthesis during the day (Aisyah *et al*., 2023). Plankton have a cosmopolitan nature, meaning they are ubiquitous; however, the presence of plankton in a water body is influenced by several environmental factors such as nutrients, currents, and light or sunlight (Khalik, 2021).

Problems encountered in intensive pond management are characterized by decreased water clarity and frequent plankton blooms, primarily due to the increasing fertility of the pond bottom caused by the accumulation of organic suspensions from shrimp feces and feed residues (pellets), the accumulation of senescent and dead plankton cells, and active shrimp movement due to their increasing size (Samadan, 2020). Excessive plankton density in pond waters is hazardous to cultured shrimp because during sunny weather, excessive O_2 production occurs through photosynthesis. Conversely, at night, O_2 depletion occurs due to plankton respiration (Samadan, 2020). Therefore, observation is needed to analyze the diversity of species and abundance dynamics of plankton in shrimp (*Litopenaeus vannamei*) culture in intensive white shrimp ponds in Sumenep, Madura.

METHODS

Time and Place

This research was conducted from January to April 2024 in Pangkalan Hamlet, Lapataman Village, Dungkek Subdistrict, Sumenep Regency, East Java Province, Indonesia.

Tools and Materials

The tools used in this study were 250 ml test tubes, a Secchi disk, a thermometer, a refractometer, a pH meter, a DO (dissolved oxygen) meter, a test kit, a calculator, petri dishes, an Olympus binocular microscope, a hemocytometer, and plankton identification books. The materials used were titration reagents, TSA (Tryptic Soy Agar), and TCBS (Thiosulfate Citrate Bile Salts) agar.

Research Procedure

This research employed a case study design, focusing on four ponds: pond 5 (600 m²), pond 6 (600 m²), pond 7 (1024 m²), and pond 8 (1024 m²). Water samples were collected in the morning before feeding time, between 06:45 and 07:00. Cylindrical sample bottles with a volume of 250 ml were used for collection. The sampling method involved attaching the sample bottle to a Secchi disk and submerging the apparatus into the pond near the feeding bridge (anco). Samples were taken at a depth of 25 to 30 cm below the water surface. Due to limited equipment availability, plankton nets were not utilized for plankton collection. The collected water samples were immediately transported to the laboratory for identification. In addition to plankton microbiology, observations also encompassed the physical and chemical properties of the water, including temperature, transparency (Secchi depth), dissolved oxygen (DO), salinity, pH, alkalinity, nitrite (NO_2^-), nitrate (NO_3^-), ammonia (NH_3), ammonium (NH_4^+), phosphate (PO_4), total organic matter (TOM), and total bacteria count.

Plankton identification was conducted using a binocular microscope. Plankton identification was performed using a haemocytometer. The identification was carried out in five haemocytometer squares, namely the top-left quadrant (A), the top-right quadrant (C), the central quadrant (E), the bottom-left quadrant (G), and the bottom-right quadrant (I). Each sample pond was taken as much as 1 ml, inserted into the haemocytometer, then covered with a cover glass and observed under an Olympus binocular microscope with 10x and 40x magnifications. The haemocytometer counting chamber consists of 9 large squares with an area of 1 mm². One large square in quadrant (E) contains 25 squares with a length of 0.05 mm, one square consists of 16 small squares. Thus, the number of squares in quadrant (E) is 400 small squares. Plankton identification was done by matching the characteristics of the species with the available identification books from Anita Padang-Planktonologi. The plankton were classified based on plankton type, division, order, family, and genus.

Research Parameter

Data collected encompassed physical, chemical, and microbiological parameters of the water, including temperature, brightness (or turbidity, depending on the measurement method), pH, salinity, dissolved oxygen (DO), nitrite (NO_2^-), nitrate (NO_3^-), ammonia (NH_3), ammonium (NH_4^+), phosphate (PO_4^{3-}), and alkalinity, as well as the production performance of *Litopenaeus vannamei*, which included average body weight (ABW), average daily growth (ADG), biomass, feed conversion ratio (FCR), and survival rate (SR). The methods, procedures, and sampling frequency are detailed in Table 1.

Table 1. Parameter, method, sampling technique and sampling frequency

No	Parameter	Method	Sampling Technique	Sampling Frequency
Fisika dan Kimia Air				
1	Temperature	Thermometer	*Insitu*	Every day
2	Brightness	Secchi disk	*Insitu*	Every day

No	Parameter	Method	Sampling Technique	Sampling Frequency
3	Salinity	Refraktometer	*Eksitu*	Every day
4	pH	pH Meter	*Eksitu*	Every day
5	DO	DO Meter	*Insitu*	Every day
6	Alkalinity	*Reagen Titrasi*	*Eksitu*	Every 7 days
7	Nitrite	Test Kit	*Eksitu*	Every 7 days
8	Nitrate	Test Kit	*Eksitu*	Every 7 days
9	Ammonia	Kalkulator	*Eksitu*	Every 7 days
10	Ammonium	Test Kit	*Eksitu*	Every 7 days
11	Phospate	Test Kit	*Eksitu*	Every 7 days
Mikrobiologi				
1	Plankton density	Microscope	Eksitu	Every 7 days
Production Performances				
1	SR	Scale and Feeding Tray	*Sampling*	Every 5 days
2	FCR	Scale and Feeding Tray	*Sampling*	Every 5 days
3	ADG	Scale and Feeding Tray	*Sampling*	Every 5 days
4	ABW	Scale and Feeding Tray	*Sampling*	Every 5 days
5	Biomassa	Scale and Feeding Tray	*Sampling*	Every 5 days

The production performance of white shrimp aquaculture can be evaluated by Average Body Weight (ABW), Average Daily Growth (ADG), harvested biomass, Feed Conversion Ratio (FCR), and Survival Rate (SR) using the following formulas:

- *Average Body Weight*

Average Body Weight (ABW) is the average weight of *Litopenaeus vannamei* per individual (in grams). ABW can be calculated using the following formula (Effendi, 2003).

$$ABW = \frac{Shrimp\ Weight}{Shrimp\ Population}$$

- *Average Daily Growth*

Average Daily Growth is the average daily weight gain of shrimp over a specific period, thus it can be used to determine the growth rate of shrimp. ADG can be calculated using the following formula (Haliman dan Adiwijaya, 2005).

$$ADG = \frac{Previous\ MBW - Current\ MBW}{sampling\ time}$$

- *Feed Conversion Ratio* (FCR)

Feed conversion ratio can be calculated using the NRC (Nutrient Requirements of Fish) (1993) formula, as follows:

$$\text{FCR} = \frac{\text{F}}{\text{Biomass}}$$

Description:
Biomass = Shrimp Harvest Total
F = Total feed intake during the rearing period (kg)
Biomass = Total weight of harvested shrimp (kg)

- *Survival Rate*

Survival rate of *Litopenaeus vannamei* at the end of the rearing period was calculated using the formula (Effendie, 1979) as follows:

$$SR = \frac{No}{Nt} \times 100\%$$

Description:
SR = Survival rate (%)
Nt = Final shrimp count (individuals)
No = stocking density (individuals)

Data Analysis

Data analysis was conducted on water quality, plankton community structure, and white shrimp aquaculture production performance. Water quality and production performance data were analyzed descriptively and qualitatively, while plankton community structure data were analyzed descriptively and quantitatively. Biological indices, including plankton abundance, diversity, dominance, and uniformity indices, were analyzed using the following equations:

- Abundance of plankton species

The abundance of plankton species was calculated using the formula (SOP PPI, 2023) as follows:

$$D = \text{total cell} \times 10^4$$

Description:
D = abundance of plankton species (sel/ml)
25 = Total cell count of a large pond
10^4 = constanta haemocytometer

- *Diversity Index*

The diversity index was calculated based on plankton identification or observation using the Shannon-Wiener formula as follows:

$$H' = (-\sum \frac{ni}{N}) \times (\ln \frac{ni}{N})$$

Description:
H' = Diversity Index
Pi = Population size of each species
Pi = $\frac{ni}{N}$
ni = Number of individuals per species/genus
N = Total number of individuals
S = Number of species
Ln = Natural logarithm

The results of the diversity index calculations, analyzed with reference to the diversity index categories according to Wibisono (2005), are presented in Table 2.

Table 1. Diversity Index Category

Diversity Index (H')	Community Structure	Category
>2,41	Very stable	Very good
1,81 – 2,4	More stable	Good
1,21 – 1,8	Stable	Medium
0,61 – 1,2	Enough stable	Bad
<0,6	Not stable	Very bad

- *Variety Index*

According to Bengen (1999), the evenness index value can be calculated using the Shannon-Wiener formula as follows:

$$E = \frac{H'}{LnS}$$

Description:
E = Variety index
H' = Species diversity index value
S = Number of species
Ln = Natural logarithm
Ln = Logaritma natural

The results of the evenness index calculation were analyzed with reference to the evenness index results categorized according to the Shannon-Wiener evenness index categories as follows Table 3.

Table 2. Variety Index Category

Variety Index (E)	Category
E > 0.6	High species evenness
0,6 ≥ E ≥ 0.4	Medium species evenness
E<0.4	Low species evenness

- *Dominance Index*

The dominance index is an indicator that shows the level of dominance of a particular species or genus. According to Dewiyanti *et al*. (2015), the dominance index can be calculated using the Simpson index formula as follows:

$$D = \sum Pi^2$$

Description:
D = Simpson dominance index,
Pi = Relative abundance of individuals within a species / two distinct genera

Dominance index value ranges from 0 to 1. According to Odum (1993), a smaller dominance index value indicates the absence of a dominant species or genus, conversely, a larger dominance index value indicates the presence of a specific dominant species or genus. According to Munthe *et al*. (2012), the dominance index categories can be seen in Table 4.

Table 4. Dominance Index Category

Dominance Index (D)	**Category**
0 < D ≤ 0.5	No species exhibits dominance
0.5 < D < 1	A species exhibits dominance

RESULTS

Plankton Identification

Plankton identification results showed that in ponds 5, 6, 7, and 8, two types of plankton were found, namely phytoplankton and zooplankton. The zooplankton obtained from the samples comprised 2 Classes, consisting of Protozoa with 7 genera and Rotifera with 1 genus. The most abundant zooplankton were from the Class Protozoa, with 7 genera including Actinophrys, Askenasia, Amoeba, Vorticella, Eupondes, and Strombidinopsis. The results of plankton identification during the cultivation can be seen in Table 5.

Table 5. Plankton Species Identification in White shrimp Culture Ponds in Sumenep, Madura

No	*Class*	*Ordo*	*Famili*	*Genus*
Fitoplankton				
1	*Chlorophyta (Green alga)*	*Chlorococcales*	*Chlorellacea*	*Chlorella*
			Oocystaceae	*Oocytis*
			Characiaceae	*Dictyosphaerium*
		Volvocales	*Chlorordendraceae*	*Tetraselmis*
			Chlamydomonadaceae	*Chlamydomonas*
2	*Cyanophyta (Blue green alga)*	*Chroococcales*	*Chroococcaceae*	*Chroococcus*
			Microcystaceae	*Microcystis*
		Nostocales	*Nostocaceae*	*Anabaena*
				Anabaenopsis
		Oscillatoriales	*Oscillatoriales*	*Oscillatoria*
		Spirulinales	*Spirulinaceae*	*Spirulina*
3	*Chrysophyta (Diatom)*	*Biddulphiales*	*Biddulphiaceae*	*Biddulphia*
		Bacillariales	*Chaetoceraceae*	*Chaetoceros*
		Naviculaccae	*Nitzschiacae*	*Nitzschia*
		Thalassiophysales	*Catenulaceae*	*Amphora*
		Navicules	*Amphipleuraceae*	*Amphipora*
		Thalassiosirales	*Thallassiosiraceae*	*Cyclotella*
4	*Pyrrophyta (Dinoflagellata)*	*Gonyaulacales*	*Ostreopsidaceae*	*Alexandrium*
		Dinophyceae	*Gymnodiniceae*	*Gymnodinium*
			Gyrodiniceae	*Gyrodisnium*
		Chattonellales	*Chattonelaceae*	*Chattonella*
5	*Euglenophyta*	*Euglenales*	*Euglenaceae*	*Euglena*
6	*Cryptophyta*	*Cryptomonadales*	*Cryptomonadceae*	*Cryptomonas*
Zooplankton				
7	*Protozoa*	*Actinophryida*	*Actinophryidae*	*Actinophyrys*
		Tubulinida	*Amoebidae*	*Amoeba*
		Cyclotrichiida	*Mesodiniidae*	*Askenasia*
		Peritricha	*Vorticellidae*	*Vorticella*
		Hypotrichida	*Eupondidae*	*Eupondes*
		Choreotrichida	*Strombidinopdidae*	*Strombidinopsis*
		Gadiformers	*Lotidae*	
8	*Rotifera*	*Ploima*	*Brachionidae*	*Brachionus*

Plankton Density

Plankton plays a role as a source of aquatic nutrients and an indicator of aquatic fertility based on plankton abundance calculations (Sudinno *et al*., 2015). Based on Figure 1, it can be seen that in ponds 5, 6, 7, and 8, the highest plankton abundance is from the Genus Chlorophyta (74.67%±4.49%), followed by the Genus Cyanophyta (18.01% ± 3.40%), Bacillariophyta (2.82% ±1.10%), Phyrophyta (2.45%±1.95%), Cryptophyta (0.49%±0.19%), Euglenophyta (0.23%±0.10%), and Zooplankton (1.33%±0.29%). Plankton abundance during one cycle can be seen in Figure 1.

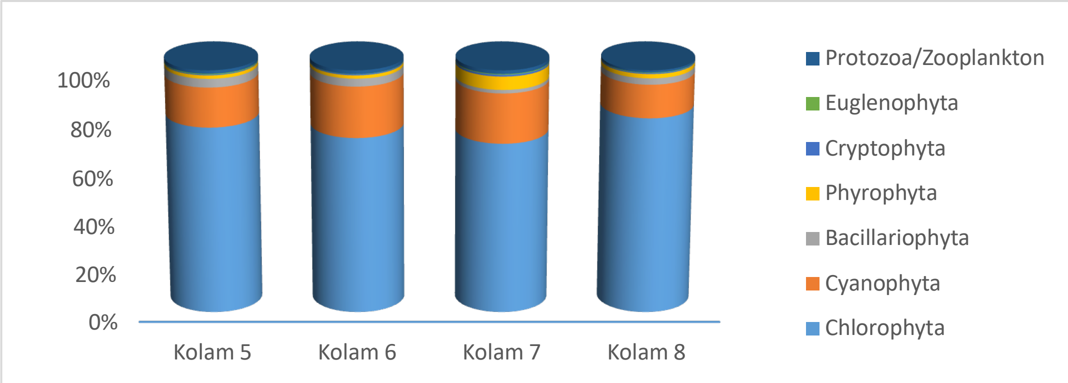

Figure 1. Plankton abundance in intensive culture ponds of *Litopenaeus vannamei* in Sumenep, Madura.

Biology Index

According to the diversity index category table by Wibisono (2005), the stability of the plankton community in pond 5 is classified as good. According to the index value criteria by Wibisono (2005), the diversity index in pond 6 reached a value of 1.68, pond 7 obtained a value of 1.65, and pond 8 obtained a value of 1.51; therefore, the stability of the plankton community in ponds 6, 7, and 8 is classified as moderate. The diversity index values can be seen in Table 6.

Table 6. Biological indices of plankton in white shrimp (*Litopenaeus vannamei*) culture ponds in Sumenep, Madura

Biology Index	Pond	H'	Category
Diversity Index (H')	5	2,246	High diversity
	6	1,67	Medium diversity
	7	1,649	Medium diversity
	8	1,515	Medium diversity
Variety Index (E)	5	0,66	High variety
	6	0,506	Medium variety
	7	0,519	Medium variety
	8	0,47	Medium variety
Dominance Index (D)	5	0,978	A dominant species is present
	6	0,334	No species dominates
	7	0,316	No species dominates
	8	0,339	No species dominates

Based on the uniformity index calculation results in Table 1, pond 5 has a uniformity index of 0.63. According to the Shannon-Wiener (1963) uniformity category table, the plankton uniformity in pond 5 is classified as high. The uniformity index for pond 6 is 0.51, pond 7 is 0.519, and pond 8 is 0.47. Therefore, the plankton uniformity in ponds 6, 7, and 8 is classified as moderate. Pond 5 has a dominance index value of 0.972. According to the Munthe *et al.* (2012) dominance category table, a plankton genus dominates pond 5.

The results of the plankton dominance index calculation that dominated pond 5 were identified as phytoplankton of the Chlorophyta class, Chlorella genus. Chlorophyta exhibits a high composition due to the presence of high nutrient content in the water, such as high nitrate content (Hoang *et al*., 2018). This is consistent with the nitrite observation results, where pond 5 has a higher nitrite content than ponds 6, 7, and 8. Pond 6 has a dominance index value of

0.334, pond 7 has a value of 0.316, and pond 8 has a value of 0.339. According to Munthe *et al*. (2012), ponds 6, 7, and 8 do not have any dominant plankton species/genus.

Water Quality Parameter

Chemical water quality can be determined by measuring several parameters including temperature, turbidity, pH, salinity, dissolved oxygen (DO), nitrite (NO_2^-), nitrate (NO_3^-), ammonia (NH_3), ammonium (NH_4^+), phosphate (PO_4^{3-}), and alkalinity. The measurement results of water quality parameters can be seen in Table 7.

Table 7. Water quality measurement results of white shrimp culture in intensive ponds in Sumenep, Madura

Parameters	**Ponds**				**Optimum**
	5	**6**	**7**	**8**	
Temperature (°C)	27 – 32.2	27 – 32.2	27 – 32	26.4 – 32	29-32[a]
Brightnesses (cm)	27 - 38	27 - 38	28 - 50	27 - 45	
pH	8.1 – 9.1	7.1 – 9.2	8.0 – 9.1	8.1 – 9.1	7.5-8.5[a]
Salinity (ppt)	33 – 45	32 – 44	33 – 43	33 – 44	28-32[a]
Dissolved oxygen (mg/l	3.2 – 5.0	3.3 – 4.8	3.3 – 5.0	3.5 – 5.1	Min 4[a]
NH_3 (mg/l)	0.015 - 0.272	0.023 - 0.278	0.009 - 0.631	0.032 - 0.473	Max 0.1[b]
NH_4^+ (mg/l)	0.1 – 2.0	0.1 – 1.9	0.1 – 3.0	0.1 – 3.7	
Nitrite (mg/l)	0.01 - 0.9	0.01 - 0.5	0.01 - 0.15	0.01 - 0.8	Max 1[a]
Nitrate (mg/l)	1.2 – 2.1	1.2 – 2.0	1.0 – 2.0	1.3 – 2.1	Max 0,5[c]
Phosphate (mg/l)	0.22 – 5.6	0.19 – 5.2	0.19 – 5.2	0.19 – 5.2	0.1-5[a]
Alkalinity (mg/l)	152 - 188	152 - 184	144 - 184	140 - 192	100-150[d]

Source: [a]SNI 8118:2015, [b]Anna (2013), [c]SNI 01-7246-2006, [d]Supono (2018)

Production Performance

The success of white shrimp aquaculture production can be assessed based on several key performance indicators (KPIs) including Average Daily Growth (ADG), Average Body Weight (ABW), Feed Conversion Ratio (FCR), and Survival Rate (SR). The results of production performance throughout the culture period are summarized in Table 8.

Table 8. Production performance of white shrimp aquaculture in intensive ponds in Sumenep, Madura

Variable	Pond				Reference
	5	**6**	**7**	**8**	
Pond area (m²/pond)	676	676	1,024	1,024	-
Total density	105,600	105,600	164,936	164,936	-
Stocking density (individuals/m²)	156	156	161	161	100-150[a]
DOC	81	81	73	73	90-120 days [a]
ADG (gram/day)	0.35	0.07	0.2	0.17	0,2 g/ind [a]
ABW (gram/individuals)	14,9	13,28	11,35	11,55	-
Size	67	75	88	87	-
Population	75.369	74.322	135.309	136.869	-
Biomass(kg)	1.123	987	1.529	1.574	-
Total feed (kg)	1.826	1.748	2.34	2.298	-

Variable	Pond				Reference
	5	**6**	**7**	**8**	
FCR	1.6	1,8	1.5	1.5	1,3[b]
SR (%)	71	70	82	83	50[c]

Source : [a]SNI (2006) [b]Witoko *et al*., (2018) [c]Mulyani *et al*., (2014)

The best ADG (Average Daily Growth) and ABW (Average Body Weight) values in pond 5 were 0.35 g/day and 14.9 g, respectively. The harvest yields were 1,123 kg in pond 5, 987 kg in pond 6, 1,529 kg in pond 7, and 1,574 kg in pond 8. Based on the harvest results, pond 5 achieved a SR (Survival Rate) of 71% and a FCR (Feed Conversion Ratio) of 1.6; pond 6 achieved a SR of 70% and a FCR of 1.8; pond 7 achieved a SR of 82% and a FCR of 1.5; and pond 8 achieved a SR of 83% and a FCR of 1.5. Based on the harvest results, the FCR values for ponds 5, 6, 7, and 8 ranged around 1.6. Therefore, to obtain 1 kg of shrimp biomass weight, 1.6 kg of feed is required. A lower FCR value indicates that the cost for feed purchase will be lower, resulting in higher profits.

DISCUSSION

Plankton in aquatic environments can be classified into two groups: phytoplankton and zooplankton (Soliha and Rahayu, 2018). Phytoplankton is a major component of the plankton community and plays a crucial role as a primary producer (Fajrina *et al*., 2013). In addition to its role as a primary producer in the marine ecosystem food chain, phytoplankton also serves as a bioindicator for assessing the level of aquatic fertility (Syafriani and Apriadi, 2017).

The highest plankton abundance in each pond was found to be from the genera Chlorella and Chlamydomonas. Chlorella plankton is able to adapt to extreme environments, such as those with high ammonia and phosphate levels (Widiyani and Dewi, 2014). Phytoplankton of the Class Chlorophyta can cause the water to turn light green. This is consistent with the statement by Renitasari and Musa (2020) that good water is light green in color because the dominant phytoplankton is Chlorella. Meanwhile, in dark green water, the dominant plankton is Cyanophyta, which contains dark green chlorophyll (Renitasari and Musa, 2020). Dark green water color should be a concern for shrimp life because it indicates poor water quality, with the pond bottom rich in organic matter that becomes a breeding ground for shrimp diseases (Renitasari and Musa, 2020).

Phytoplankton such as Cyanophyta and Cryptophyta, as well as zooplankton of the Protozoa class, serve as natural food sources for shrimp (Kaban, 2018). According to Rosanti and Harahap (2022), the uneven distribution of plankton in the water at different depths is attributed to variations in temperature, oxygen levels, light intensity, and other abiotic factors at those depths. Furthermore, the water exchange frequency in aquaculture ponds can influence the plankton community size, either increasing or decreasing it (Aisyah *et al*., 2023).

The diversity index (H’) is an index that refers to the level of species diversity within phytoplankton and zooplankton communities. According to Failu *et al*. (2021), the value of this diversity index depends on the number of species present in the community, which can vary within a certain range. The environmental balance of the ponds can affect the life of organisms in the water. The evenness index is used to indicate the distribution of plankton within a community (Syahputra *et al*., 2023). According to Rahman (2023), a high evenness index describes a near-uniform number of individuals in each species/genus, conversely, a low evenness index indicates that a community is dominated by one species with high abundance. The dominance index is an index used to observe a type that dominates other types in a water body (Mildasari, 2021). A high dominance index indicates that there is a dominant genus in the waters (Ilham *et al*., 2020). According to Syahputra *et al*. (2023), a high dominance value is influenced by the high nutrient content in the waters.

Water quality parameters in pond ponds reflect the physical, chemical, and biological factors of the waters, where these parameters must be well managed to support shrimp growth (Yudana, 2024). Observations of morning and afternoon temperatures in all four ponds showed that the temperature range was still within the optimum limits for both plankton and shrimp growth, between 26.4 and 32.2°C. In aquaculture, temperature has a significant influence on phytoplankton photosynthetic activity and the solubility of contained particles. According to Musdhalifah *et al*. (2015), a good temperature for algal photosynthesis is 30°C. Based on observations, the temperature was still within good limits during the rearing process. This is in accordance with SNI (2016) which states that a good temperature for shrimp farming is >27°C. According to Supriatna *et al*. (2020), if the temperature exceeds the optimum value, metabolism in shrimp bodies occurs rapidly, but if the environmental temperature is lower than the optimum temperature, shrimp growth decreases with decreasing appetite.

During the first week of cultivation, the water clarity value was still 0 or (clear to the bottom) CTB. This was due to the minimal feed input at the beginning of cultivation and the absence of water treatment in the ponds. Entering the second week, the water clarity gradually became measurable at 80 cm. In the third week until harvest, the clarity value ranged from 35-40 cm. This was attributed to the abundance of organic matter particles originating from feed, uneaten feed, and plankton density. The plankton imparted green, yellow, blue-green, and brown colors to the water (Supono, 2018). According to Rahmat *et al*., (2021), clarity indicates the water transparency in a water body, thus reflecting the abundance of plankton. Water bodies with sufficient light intensity, such as ponds, lakes, and reservoirs, generally harbor abundant phytoplankton from the Cholorophyceae class (Haryoko *et al*., 2018). This aligns with observations that the highest plankton abundance was from the Chlorophyta class. Light penetration is limited when the concentration of suspended matter is high (Meizanu *et al*., 2022). The measure taken by technicians when clarity is low is to perform gradual water exchange.

pH value is considered the most important parameter that can be associated with the presence of phytoplankton (Kurniawan *et al*., 2023). The optimal pH value for intensive shrimp pond culture ranges from 7.4 to 8.9, with an optimum range of 8 (Makmur *et al*., 2018). Observations from week 1 to week 9 showed a relatively safe pH fluctuation value of 0.5. According to Yunarty *et al*. (2022), high pH fluctuations can disrupt shrimp life and increase susceptibility to stress. Prolonged stress conditions can lead to disease outbreaks caused by pathogens or viruses present in the pond ecosystem (Ariadi, 2020). At low pH (high acidity), the dissolved oxygen content decreases, consequently reducing oxygen consumption, increasing respiratory activity, and decreasing appetite (Farabi and Latuconsina, 2023).

The observed salinity ranged from 30 ppt to 43 ppt. The lowest salinity occurred in pond 7 in week 9 at 30 ppt, while the highest salinity occurred in ponds 5 and 6 at 43 ppt. The optimal salinity for shrimp farming is 20 ppt – 35 ppt (Utami *et al*., 2023). According to the Indonesian National Standard (SNI, 2016), the optimal salinity level after postlarval stocking ranges from 26-32 ppt. The decrease in salinity from week 2 to week 3 was attributed to the rainy season. This is consistent with the findings of Ariadi *et al*. (2021), which stated that decreased salinity can be caused by the addition of rainwater. Based on the observations, the salinity was found to fluctuate above the optimal average range.

Based on the DO measurements in ponds 5, 6, 7, and 8, the values ranged from 3.21 to 5.1 mg/l. According to Sidabutar *et al*. (2019), the low oxygen content in the waters is attributed to the high number of organisms consuming oxygen for respiration, while the photosynthesis process is reduced. According to SNI (2016), the minimum limit of dissolved oxygen for white shrimp culture is in the range of >4 mg/L. Oxygen solubility in ponds is influenced by pH, temperature, and salinity parameters (Supriatna *et al*., 2017)

Based on ammonia observation results, the lowest ammonia concentration occurred in pond 7, which was 0.009, and the highest ammonia concentration occurred in pond 8 in the 9th week. The high ammonia levels were caused by the accumulation of uneaten feed. This is in accordance with the opinion of Arsad *et al*. (2017) that the lack of water exchange and siphoning causes the accumulation of leftover feed and feces at the bottom of the waters, thus causing high ammonia levels. The maximum ammonia limit for white shrimp enlargement is 0.1 mg/l (SNI, 2016). The observation results of ponds 5, 6, 7, and 8 showed ammonia levels above the optimal range. The steps taken by the technicians to reduce ammonia levels were siphoning, water circulation, and preparation using water sedimentation.

The nitrite measurement results indicated that the nitrite concentrations in ponds 5, 6, 7, and 8 ranged from 0.01 to 0.05 mg/L. According to the Indonesian National Standard (SNI, 2016), the maximum nitrite concentration limit for white shrimp culture is 1 mg/L. Nitrite levels are closely related to organic matter (Muaddama *et al*., 2018). According to Ramadhona *et al*. (2019), nitrite can be toxic to shrimp if its concentration reaches 0.5 mg/L. Water exchange is carried out when nitrite levels exceed the optimal range. In addition, water preparation through sedimentation can reduce nitrite levels.

The nitrate observation results of ponds 5, 6, 7, and 8 showed nitrate content ranging from 1.0-2.1 mg/l. The nitrate levels in ponds 6 and 8 exceeded the optimum standard of 0.5 mg/l. The high and low nitrate content found in a water body is thought to be influenced by water quality parameters, one of which is dissolved oxygen (Ikhsan *et al*., 2020). In addition, the nitrate concentration in water is influenced by the rate of the nitrification process by bacteria, pH values, dissolved oxygen content, and temperature (Valencia-Castaneda *et al*., 2019). The nitrate content in ponds is not dangerous, but if the nitrate levels in white shrimp ponds are high, it can trigger algal blooms and new microorganisms (Jumraeni *et al*., 2020).

The alkalinity observation results in ponds 5, 6, 7, and 8 ranged from 140-192 ppm. The lowest total alkalinity occurred in the first week of pond 8 at 140 ppm, and the highest occurred in the 7th and 9th weeks of pond 8 at 192 ppm. The alkalinity range of each pond was relatively optimal. This is in accordance with Supono's (2018) opinion that the desired range of total alkalinity for shrimp farming is 75-200 ppm. Too low alkalinity will result in shrimp frequently undergoing abnormal molting, while too high alkalinity will cause shrimp to experience difficulties in molting (Sitanggang and Amanda, 2019). Alkalinity is related to the degree of acidity or pH. The pH value will be low if the salinity value is low (Harmilia *et al*., 2017).

Determining feed consumption as a result of plankton presence, the feed conversion ratio (FCR) parameter can be observed (Fahrurrozi *et al*., 2023). Meanwhile, survival can be observed using the survival rate (SR) parameter (Fahrurrozi and Linayati, 2022). FCR and SR are important indicators in assessing the harvest productivity of white shrimp culture (Aalimahmoudi *et al*., 2016). The average SR value obtained from the four ponds (5, 6, 7, and 8) was 76.5%. The favorable SR value indicates that water quality was within the optimal range, and good feed management, including feeding rate, frequency, and the application of probiotics, supported the growth of the cultured shrimp (Setyaningrum and Yuniartik, 2021). Plankton instability in abundance and composition can affect appetite in relation to decreased feed consumption and health in relation to shrimp survival (Nindarwi *et al*., 2019).

According to research by Fahrurrozi *et al*. (2023), total plankton has a strong correlation with the resulting FCR value, with an influence of 79.57%, while for the SR value, total plankton does not have a strong correlation or only has an influence of 18.23%. The correlation of Chlorophyta, Bacillariophyta, and Dinophyta classes to the resulting FCR value has an influence of 58%. This suggests that white shrimp, in addition to using commercial feed for their nutrition, utilize natural feed in the form of phytoplankton such as Chlorophyta and Bacillariophyta, while Dinophyta is used as supplementary feed (Fahrurrozi *et al*., 2023). Based on the calculation results, the highest SR was in pond 8, at 83%. Furthermore, factors that influence the high and low SR in cultivation activities are abiotic and biotic factors. Abiotic factors include the physical and chemical properties of the water. Good physical and chemical water quality will result in good physiological processes in the shrimp's body, thus supporting shrimp growth and SR (Pratama *et al*., 2017).

CONCLUSION

The plankton species present in ponds 5, 6, 7, and 8 include both phytoplankton and zooplankton. A total of 6 classes (29 genera) of phytoplankton were identified, while zooplankton consisted of 2 classes (8 genera). The biological indices of diversity, variety, and dominance in pond 5 were higher than those in ponds 6, 7, and 8, suggesting that the nutrients in pond 5 is high, other than ponds 6, 7, and 8. The abundance of plankton is strongly correlated with the Average Daily Growth (ADG), with the highest plankton abundance in pond 5 corresponding to an ADG of 0.35, indicating that plankton abundance in pond 5 can affect the growth rate of shrimp.

ACKNOWLEDGMENTS

The author would like to express gratitude to all parties involved in this research.

REFERENCES

Aalimahmoudi, M., Reyshahri, A., Bavarsad, S. S., Maniat, M. (2016). Effects of feeding frequency on growth, feed conversion ratio, survival rate and water quality of white leg shrimp (*Litopenaeus vannamei*, Boone, 1931). *International Journal of Fisheries and Aquatic Studies*, 4(3), 293-297

Aisyah, D., Ramadhani, A. W., Fattah, M., Sofiati, D., & Anandya, A. (2023). Pengaruh kelimpahan plankton dan kualitas air terhadap performa pertumbuhan udang vanname pada sistem budidaya intensif. *Jurnal Lemuru*. 5(2), 173-182.

Ariadi, H. 2020. *Oksigen Terlarut dan Siklus Ilmiah pada Tambak Intensif*. Guepedia. Bogor

Ariadi, H., Wafi, A., Musa, M., Supriatna. (2021). Keterkaitan Hubungan Parameter Kualitas Air pada Budidaya Intensif Udang Putih *(L. vannamei)*. *Samakia*: *Jurnal Ilmu Perikanan* 12(1), 18-28

Arsad, S., Afandy, A., Purwadhi, A. P., V, B. M., Saputra, D. K., & Buwono, N. R. (2017). Studi kegiatan budidaya pembesaran udang vaname (*Litopenaeus vannamei)* dengan penerapan sistem pemeliharaan berbeda [study of white shrimp culture (*Litopenaeus vannamei)* in different rearing system]. *Jurnal Ilmiah Perikanan & Kelautan*, 9(1), 1–14.

Bengen, D.G. (1999). Teknik pengambilan contoh dan analisis data biofisik sumberdaya pesisir.Pusat kajian sumberdaya pesisir dan Lautan.Fakultas Perikanan dan Ilmu Kelautan. Institut Pertanian Bogor:Bogor

Dewiyanti, D., B. Irawan dan N. Mochammadi.(2015). Kepadatan dan keanekaragaman plankton di perairan Magetan kanal Kabupaten Sidoarjo Provinsi Jawa Timur dari daerah hulu, daerah tengah dan daerah hilir bulan maret. *Jurnal ilmiah biologi FST*. 3.(1), 37 – 46

Effendi, Hefni. 2003. *Telaah Kualitas Air : Bagi Pengelolaan Sumber Daya dan Lingkungan Perairan*. Penerbit : Kanisius. Yogyakarta

Effendie, M. I. (1979). *Metode Biologi Perikanan*. Gramedia Pustaka Utama. Jakarta

Fahrurrozi, A., & Linayati, L. (2022). Pengaruh penambahan tepung kunyit (*Curcuma longa Linn*.) terhadap pertumbuhan dan rasio konversi pakan ikan kakap putih (*Lates calcarifer, Bloch*). *Sains Akuakultur Tropis : Indonesian Journal of Tropical Aquaculture,* 6(2), 266–272.

Fahrurrozi, A., Linayati, L., Ariadi, H., Mardiana, T. Y., Madusari, B. D., Syakirin, M. B. (2023). korelasi kelimpahan plankton terhadap nilai FCR dan survival rate pada budidaya udang vaname (*Litopenaeus vannamei*). *Jurnal Miyang Ronggolawe*, 3(1), 26-33

Failu, I., Azizu, A. M., Kasman, K., & Sofyan, S. (2021). Keanekaragaman jenis dan kepadatan zooplankton di perairan pulau makassar kota baubau. *Sang Pencerah*: *Jurnal Ilmiah Universitas Muhammadiyah Buton*, 7(4), 565-575.

Fajrina, H., Endrawati, H. & Zainuri, M. (2013). Struktur Komunitas Fitoplankton Di Perairan Morosari Kecamatan Sayung Kabupaten Demak. *Journal of Marine Research*, 2(1), 71-79.

Farabi, A. I., & Latuconsina, H. (2023). Manajemen kualitas air pada pembesaran udang vaname (*Litopenaeus vannamei*) di UPT. BAPL (budidaya air payau dan laut) bangil pasuruan jawa timur. *Jurnal Riset Perikanan dan Kelautan,* 5(1), 1-13.

Haliman, R.W. dan D. Adijaya. (2005). *Udang vannamei, Pembudidayaan dan Prospek Pasar Udang Putih yang Tahan Penyakit*. Penebar Swadaya. Jakarta: 75 hal.

Harmilia, E.D., & E. Dharyati. (2017). Kajian pendahuluan kualitas perairan fisika-kimia sungai ogan kecamatan indralaya kabupaten ogan ilir Sumatera Selatan. *Fisheries*. 6 (1),7-11.

Haryoko, I., Melani, W.R., & Apriadi, T. (2018). Eksistensi Bacillariophyceae dan Chlorophyceae di Perairan Sei Timun Kota Tanjungpinang, Kepulauan Riau. *Jurnal Akuatiklestari*, 1(2), 1-7. https://doi.org/10.31629/.v1i2.2287

Hoang, H.T.T, T.T. Duong, K.T. Nguyen, Q.T.P. Le, M.T.N. Luu, D.A. Trinh, A.H. Le, C.T. Ho, K.D. Dang, J. Nemery, D. Orange, & J. Klien. (2018). Impact of anthropogenic activities on water quality and plankton communities in the Day River (Red River Delta, Vietnam). Environ Monit Assess. 190: 67.

Ikhsan, M. K., Rudiyanti, S., & Ain, C. (2020). Correlation between nitrate and phospate with abundance of phytoplankton in Jatibarang reservoir, Semarang. *Management of Aquatic Resources Journal (MAQUARES),* 9(1), 23-30.

Ilham, T., Hasan, Z., Andriani, Y., Herawati, H., & Sulawesty, F. (2020). Hubungan antara struktur komunitas plankton dan tingkat pencemaran di situ gunung putri, Kabupaten Bogor. *Limnotek*: *Perairan Darat Tropis Di Indonesia*. 27(2).

Jumraeni, J., Khaeriyah, A., Burhanuddin, B., & Anwar, A. (2020). Pengaruh model pembuangan terhadap akumulasi bahan organik tambak intensif udang vaname *(Litopenaeus vannamei*). *Octopus: Jurnal Ilmu Perikanan,* 9(1), 10-18.

Kaban, S. (2018). Beberapa aspek biologi ikan lambak pipih (*Thynnichthys polylepis)* di sungai batang hari jambi. *Prosiding Seminar Nasional Perikanan Dan Kelautan Ke-7 FPK UNRI*, 164–170.

Khalik, A. (2021). Keanekaragaman plankton pada tambak budidaya padi dan udang windu sistem mina padi air payau di Kabupaten Maros (Doctoral dissertation, Universitas Negeri Makassar:Makassar

Kurniawan, A., Syaputra, D., Prasetiyono, E. (2023). Eksistensi fitoplankton di kolong pascatambang timah dengan umur berbeda. *Teknosains: Media Informasi dan Teknologi,17*(2), 148-157. https://doi.org/10.24252/teknosains.v17i2.35789

Makmur, Suwoyo, H.S., Fahrur, & M.,Syah, R. (2018). Pengaruh jumlah titik aerasi pada budidaya *L. vannamei*. *Jurnal Ilmu Teknologi Kelautan Tropis* ,10(3), 727-738.

Mansyah, Y. P., Mardhia, D., & Ahdiansyah, Y. (2020). Identifikasi jenis fioplankton di tambak udang vannamei (*Litopenaeus vannamei*) lso av3 kecamatan utan, kabupaten sumbawa. *Indonesian Journal of Applied Science and Technology*, 1(1), 20-28.

Meizanu, M.R., Febri, S.P., & Syahril, M. (2022). Pengaruh perbedaan suhu terhadap produktivitas induk ikan guppy *(Poecilia reticulata*). *Arwana*: *Jurnal Ilmiah Program Studi Perairan*. 4(1),1-5.

Mildasari, M., Nur, F., Hasyimuddin, H., & Dirhamzah, D. (2021). Keanekaragaman jenis fitoplankton di perairan tambak udang putih di kelurahan bonto kamase, kecamatan herlang, kabupaten bulukumba. Filogeni: *Jurnal Mahasiswa Biologi*. 1(3), 85-93.

Muaddama, F., Jayadi, J., & Usman, H. (2018). Analisis kandungan phospat dan nitrogen (amoniak, nitrat dan nitrit) pada tambak di wilayah pesisir di Kecamatan Ma'rang

Munthe, Y. V., Aryawati, R., & Isnaini. (2012). Struktur Komunitas dan Sebaran Fitoplankton di Perairan Sungsang Sumatera Selatan. Maspari Journal, 4(1), 122–130. https://doi.org/https://doi.org/10.56064/maspari.v4i1.1437

Musdalifah, Rustam Y, Amini S. (2015). Kultivasi dan ekstraksi minyak dari mikroalga Botryococcus braunii dan Nannochloropsis sp. *Jurnal Bioma* 11 (2), 98. DOI: 10.21009/Bioma11(2).1.

Nindarwi, D. D., Masithah, E. D., Zulian, D., Suyoso, A. L. A. (2019). The dynamic relationship of phytoplankton abundance and diversity in relation to white shrimp (Litopenaeus vannamei) feed consumption in intensive ponds. *IOP Conf. Series: Earth and Environmental Science*, 236 (2019), 012072

NRC. (1993). *Nutrient Requirement of Fish*. National Academy of Science. National Press. USA. Pp 39-53.

Odum, E.P.(1993). *Dasar-Dasar Ekologi.*Gadjah Mada University Press. Yogyakarta

Pratama, A., Wardiyanto, & Supono. (2017). Studi performa udang vaname *(Litopenaeus vannamei)* yang dipelihara dengan sistem semi intensif pada kondisi air tambak dengan kelimpahan plankton yang berbeda pada saat penebaran. *E-Jurnal Rekayasa & Teknologi Budidaya Perairan*, 6(1), 643–651.

Rahman, A. N. (2023). Analisis kelimpahan, keanekaragaman, keseragaman, dan dominansi fitoplankton pada tambak udang vannamei (*Litopenaeus vannamei)* di PT. Biru Laut Nusantara Pangandaran. (Doctoral dissertation, Universitas Jenderal Soedirman.

Rahmat, Awal N., Magfirah S., Mega O., Aiman M., Iffah M. R., Fahdah F., Didik I. S., Octavia C. D., & Astri D. A. (2021). *Modul Pengujian Parameter Perairan Tambak*. Biologi FMIPA UNM: Makassar

Renitasari, D. P., & Musa, M. (2020). Teknik pengelolaan kualitas air pada budidaya intensif udang vanamei *(Litopeneus vanammei*) dengan metode hybrid system. *Jurnal salamata*, 2(1), 6-11.

Rodrgues, L. C., Simoes, N. R., Scomparina, V. M. B., Jati, S., Santanaa, N. F., Maria & Traina, R. S., (2015). Phytoplankton alpha diversity as an indicator of environmental changes in a neotropical floodplain. *Jurnal Ecological Indicators,*48 (1): 335

Rosanti, L., & Harahap, A. (2022). Keberadaan plankton sebagai indikator pencemaran. *Bioedusains: Jurnal Pendidikan Biologi Dan Sains*, 5(1), 182-188.

Samadan, M.G., Supyan, Andriani, R., Juharni. 2020. Kelimpahan plankton pada budidaya udang vaname , 3 (2), 165 – 185

Setyaningrum, E. W., & Yuniartik, M. (2021). Comparison of plankton abundance, water conditions, performance of white shrimp (*Litopenaeus vannamei*) growth in intensive and extensive cultivation systems in Banyuwangi regency waters. *Journal of Aquaculture Science*, *6*(1IS), 15–27. https://doi.org/10.31093/joas.v6i1IS.152

Sidabutar, E. A., Sartimbul, A., & Handayani, M. (2019). Distribusi suhu, salinitas dan oksigen terlarut terhadap kedalaman di Perairan Teluk Prigi Kabupaten Trenggalek. *JFMR (Journal of Fisheries and Marine Research*), 3(1), 46-52.

Sitanggang, L. P., & Amanda, L. (2019). Analisa kualitas air alkalinitas dan kesadahan *(hardness)* pada pembesaran udang putih *(Litopenaeus vannamei)* di laboratorium animal health service binaan Pt. Central Proteina Prima Tbk. Medan. *Jurnal Penelitian Terapan Perikanan dan Kelautan,* 1(1), 29-35.

Soliha, E., & Rahayu, S. S. (2018). Kualitas air dan keanekaragaman plankton di danau cikaret, cibinong, bogor. *Ekologia*: *Jurnal Ilmiah Ilmu Dasar dan Lingkungan Hidup,* 16(2), 1-10.

Standar Nasional Indonesia. (2016). Pedoman umum pembesaran udang windu *(penaeus monodon)* dan udang vaname *(Litopenaeus vannamei).* Nomor 75. Menteri Kelautan dan Perikanan Republik Indonesia. Jakarta

Sudinno, D., I. Jubaedah., P. Anas. 2015. Kualitas air dan komunitas plankton pada tambak pesisir Kabupaten Subang Jawa Barat. *Jurnal Penyuluhan Perikanan dan Kelautan*, 9(1), 13 – 28

Supono. (2018). *Manajemen Kualitas Lingkungan untuk Budidaya Udang*. Aura Publishing, Bandar Lampung, 148 hal.

Supriatna, Marsoedi, Hariati, A.M. Mahmudi, M. (2017). Dissolved oxygen models in intensive culture of whiteleg shrimp, *Litopenaeus vannamei*, in East Java, Indonesia. *AACL Bioflux*, 10(4), 768-778

Supriatna, M. (2020). Model pH dan hubungannya dengan parameter kualitas air pada tambak intensif udang vaname (*Litopenaeus vannamei*) di Banyuwangi Jawa Timur. *JFM*R-*Journal of Fisheries and Marine Research*. 4 (3): 368–374

Syafriani, R. & Apriadi, T. (2017). Keanekaragaman Fitoplankton di Perairan Estuari Sei Terusan Kota Tanjungpinang. *Limnotek: perairan darat tropis di Indonesia*, 24(2), 74-82.

Syahputra, R., Febri, S. P., Haser, T. F., Persada, A. Y., & Nazlia, S. (2023). Identification and abundance of plankton as an indicator of the presence of mahseer fish *(Tor sp.)* in the leuser river lokop area, east aceh, aceh. Arwana: *Jurnal Ilmiah Program Studi Perairan*, 5(1), 105-110.

Utami, R. S., Roslidar, R., Mufti, A., & Rizki, M. (2023). Sistem kendali dan pemantau kualitas air tambak udang berbasis salinitas, suhu, dan ph air. *Jurnal Komputer Informasi Teknologi*, & Elektro, 8(1).

Valencia-Castañeda, G., Frías-Espericueta, M. G., Vanegas-Pérez, R. C. Chávez-Sánchez, m. C., Páez-Osuna, F. 2019. Toxicity of ammonia, nitrite and nitrate to Litopenaeus vannamei juveniles in low-salinity water in single and ternary exposure experiments and their environmental implications. *Environmental Toxicology and Pharmacology*, 70(2019), 1-8

Widiyani, P. & E.R.S. Dewi. (2014). Penurunan konsentrasi logam berat kadmium (Cd) dan pertumbuhan mikroalga Chlorella vulgaris pada media kultur. *Bioma: Jurnal Ilmiah Biologi*. 3 (2): 17-26.

Yudana, I. G. R. (2024). Pengaruh parameter kimia terhadap parameter biologi pada kualitas air kolam pulokerto, kabupaten pasuruan. *Jurnal Bluefin Fisheries*. 5(2), 86-99.

Yunarty, Y., Kurniaji, A., Budiyati, B., Renitasari, D. P., & Resa, M. (2022). Karakteristik kualitas air dan performa pertumbuhan budidaya udang vaname (*Litopenaeus vannamei)* pola intensif. *Pena Akuatika: Jurnal Ilmiah Perikanan dan Kelautan*, 21(1), 75-88.