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ESTIMATION OF FISH PRODUCTION THROUGH NUTRIENT ANALYSIS OF MANGROVE LITTER *Avicennia Sp.* AT THE WONOREJO-SURABAYA MANGROVE INFORMATION CENTER

Estimasi Produksi Ikan Melalui Analisis Nutrien Seresah Mangrove *Avicennia* Sp. Di Kawasan Mangrove Information Center Wonorejo-Surabaya

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ABSTRACT

Mangrove forest is a very fertile ecosystem and is located in the coastline so that it has a major contribution to the surrounding environment. Mangrove tree litter that falls will be a food source for aquatic biota and nutrients that greatly determine the productivity of marine fisheries. The purpose of this study was to analyze the production of nutrients (N, P) from mangrove leaf litter, suspect the primary production of phytoplankton from nutrients released from mangrove leaf litter, and to estimate the carrying capacity of the mangrove ecosystem on fish production. This research station determination method uses a *purposive randome sampling method* with reference to the mangrove density and determination of the sampling point. Litter production measurements using themethod *litter trap* and decomposition rate using themethod *litter bag*. Estimation of fish production using the Beveridge (1984) method approach. The amount of nutrients released by mangrove *Avicennia sp.* per day at the mangrove Information Center which is 0.0350-0.0503 g N / m / day and the release of Phosphorus ranges between 0.0018-0.0053 g P / m2 / day. The value of primary production in the mangrove ecosystem *information center* Wonorejo-Surabaya is quite high ranging from 460 to 690 g C / m2 / yr, and is included in the category of fertile to very fertile. Herbivor fish production ranges from 462.04 to 690 kg / ha / yr; Carnivorous fish ranged from 46.20 to 69 kg / ha / yr and total fish production ranged from 595.80 kg / ha / yr. The total fish production illustrates the potential of fish production contributed from the mangrove ecosystem at 595.80 kg / year.

Keywords: Mangrove Ecosystem, Litter, Litter Nutrient, Primary Productivity, Fish Stock

ABSTRAK

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dari nutrien hasil pelepasan serasah daun mangrove, menduga daya dukung ekosistem mangrove terhadap produksi ikan. Metode penentuan stasiun penelitian ini menggunakan metode *purposive randome sampling* dengan mengacu pada kerapatan mangrove dan penentuan titik sampling. Pengukuran produksi serasah menggunakan metode *litter trap* dan laju dekomposisi menggunakan metode *litter bag*. Pendugaan produksi ikan menggunakan pendekatan metode Beveridge (1984). Jumlah nutrien yang dilepaskan mangrove *Avicennia sp.* per harinya di mangrove Information Center yaitu 0,0350–0,0503 g N /m /hr dan pelepasan Fosfor berkisar antar 0,0018–0,0053 g P/m²/hr. Nilai produksi primer di ekosistem mangrove *information center* Wonorejo-Surabaya cukup tinggi berkisar 460-690 g C/m²/th, dan termasuk dalam kategori subur sampai sangat subur. Produksi ikan herbivor berkisar 462,04-690 kg/ha/th; ikan karnivor berkisar 46,20-69 kg/ha/th dan produksi total ikan berkisar 595,80 kg/ha/th. Produksi total ikan tersebut menggambarkan potensi produksi ikan yang disumbang dari ekosistem mangrove sebesar 595,80 kg/th.

Kata Kunci: Ekosistem Mangrove, Serasah, Nutrien Serasah, Produktivitas Primer, Stok Ikan

INTRODUCTION

Mangrove forests are one of the most fertile ecosystems located along the coastline, thus contributing significantly to the surrounding environment. In addition to supporting various ecosystem services, including fisheries production, mangroves also provide nutrients (Prayitno, 2017). The largest production from the mangrove ecosystem is mangrove leaf fall. Important information regarding litter production, decomposition rates, and nutrient cycling can be obtained if mangrove tree litter is calculated correctly and combined with other biomass calculations.

Mangrove forests are one of the most fertile ecosystems located along the coastline, thus contributing significantly to the surrounding environment. In addition to supporting various ecosystem services, including fisheries production, mangroves also provide nutrients (Prayitno, 2017). The largest production from the mangrove ecosystem is mangrove leaf fall. Important information regarding litter production, decomposition rates, and nutrient cycling can be obtained if mangrove tree litter is calculated correctly and combined with other biomass calculations.

Primary productivity in waters influences the food chain for organisms within an ecosystem. In a body of water, the level of primary productivity indicates that the body of water is sufficiently productive in producing plant biomass, including the oxygen supply generated by photosynthesis. The development of an aquatic ecosystem, particularly regarding fisheries production, is closely linked to the availability of plant biomass and sufficient oxygen in the water (Amri et al., 2018).

The mangrove leaf litter nutrient release approach can be used to estimate fish production in waters. The results of these primary productivity values will ultimately determine fisheries production in waters. Based on this, this study needs to analyze nutrient production (N, P) from mangrove leaf litter, estimate aquatic primary production from the results of mangrove litter nutrient release, and estimate fisheries production using the nutrient release approach.

RESEARCH METHODS

This research was conducted at the Wonorejo Mangrove Information Center, Surabaya City, East Java Province, and the UMM Fisheries Laboratory. This research was conducted for one (1) month, from April to May 2020.

The determination of research stations was carried out intentionally using a purposive random sampling method, where research stations were taken with consideration referring to mangrove density and the determination of sampling points. The sampling area was divided into 3 station sections with different mangrove densities, namely each station has low, medium and high density groups. (Santya et al., 2024) at each observation station, there are 3 line transects from the river towards the land (perpendicular to the coastline along the existing mangrove forest zonation) in the intertidal area. Each line transect was placed randomly in a square plot with a size of 10 x 10 m² according to the width of the mangrove forest.

Litter productivity calculations can be performed after detailed analysis of the data obtained from observations. The data analysis included the average litter yield (g/m2/day) (Utami et al., 2022).

6 The first step taken to calculate the rate of litter decomposition is to observe the percentage of litter decomposition on mangrove leaves using the Boonruang (1984) formula, namely:

$$Y = \frac{BA - BK}{BA} \times 100\%$$

Information:
Y : Percentage of decomposed litter (%)
BA : Initial weighing of dry weight (g)
BK : Initial weighing of dry weight (g)

Total nitrogen content can be calculated using the Kjelldahl method (Mukhlis, 2007):

$$N\ content\ in\ leaves = \frac{a \times 0{,}02 \times 14}{b}$$

Information :
a : Volume difference (ml)
b : Weight of dry matter in 0.1g of leaf flour
0,02 : HCl normality (previously standardized to determine the exact normal value.

Calculation of the determination of phosphorus elements is carried out by wet destruction (Mukhlis, 2007):

$$P\ leaf\ (\%) = P\ late \times \frac{50}{0{,}25} \times \frac{50}{0{,}25} \times 10^{-4}$$
$$= P\ solution\ x\ 0{,}2$$

9 The release of litter nutrients (mg/m²/hr) can be calculated based on the statement of Nga et al. (2004), namely:

$$Nutrient_S(regardless) = (BW_0 \times N_0) - (BW_1 \times N_1)$$

Information :
BW_0 : Initial dry litter weight (g)
BW_1 : Weight of dry litter remaining at observation time t.(g)
N_0 : Initial nutrient content
N_1 : Final nutrient content remaining on t-day.
T : Incubation time (days)

Estimating fish production in waters can be done using the nutrient release approach from leaf litter. The steps for estimating fish production include determining the nutrient (N and P) production results from leaf litter (Haris et al., 2012):

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$$\sum \text{Nutrien (g/m}^2\text{ /hr)} \sum \text{Nutrien} = \sum (LL_S \times RN_S) + (LL_S \times RP_S)$$

Information:
2 LL : Total leaf litter production.
RN, RP : Potential release of nitrogen (N) from litter.
RP : Potential release of phosphorus (P) from litter.
2 s : Mangrove species.

The C:N ratio for protein production is 17:1 (Carbon:Nitrogen). The amount of nitrogen converted to dry weight (gC) is 1 gC = 2 g dry weight (Haris et al., 2012).

According to de Weir et al., (2005), primary production is determined based on litter decomposition, ∑ PP (g C/m² /hr) from nutrient production, namely:

$$\sum PP_x = \sum \text{Nutrien x 2 x 17}$$

Herbivorous fish production (g fresh fish weight/m²/day) can be calculated from $\sum PP_x$
2 using the primary production conversion efficiency from Beveridge (1984), as follows:

$$\text{Herbivorous fish production (HB)= 10 x (b x } \sum \text{PPL)}$$

Information:
b : Value (%) conversion into grams (g C-fish/m² /hr)
2 10 % : The C content in fish is based on the weight of the fish/wet weight of the fish.

The production of carnivorous fish produced by the mangrove ecosystem is calculated with an efficiency of 10% in energy flow, CF is 10% of HF (Utami et al., 2022).

Total fish production can be known if the value of herbivorous and carnivorous fish production is obtained from Beveridge (1984), namely:

$$\text{Total fish production } (\Sigma FB) = HF + CV$$

RESULTS

Decomposition Rate

The decomposition rate values at each station showed differences in each period. The highest average decomposition rate occurred during the first 10 days of observation and then decreased until the end of the observation. According to (Hastuti et al., 2024; Raynaldo &
9 Saputra, 2024), A. marina and R. mucronata mangroves experienced a significant weight loss
9 at the beginning of the study, and then the decomposition rate decreased for the remainder of
5 the period. The dry weight of mangrove litter is presented in the graph below.

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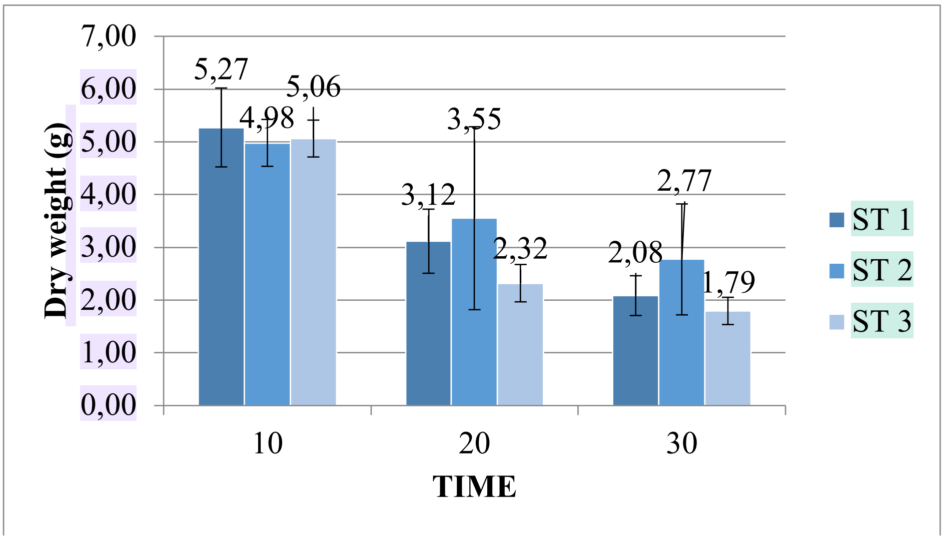

Figure 1. Litter Dry Weight Graph

Based on the data above, the dry weight of mangrove litter in the first 10 days of observation, namely station I was 5.27, station II 4.98 and station III was 5.06. Observations on the 20th day showed that station 1 was 3.12, station II 3.55 and station III 2.32. Observations on the 30th day showed that the dry weight of station 1 was 2.08, station II 2.77 and station III 1.79. The high dry weight of the litter decomposition rate in the first 10 days of observation is thought to be due to the loss of organic and inorganic material content in the litter. The highest dry weight of the remaining litter on the 30th day of observation was station 2 at 2.77 and the lowest residue at station 3 at 1.80 grams. The dry weight of the remaining litter explains that the decomposition process at station 2 is lower than the other stations. Station 3 obtained the lowest dry weight because at station 3, many macrozoobenthos such as gastropods, decapods, aphepods, and crustaceans were found, which are thought to play a significant role in the decomposition process. According to (Redjeki, 2013), the decomposition and simplification of organic and inorganic material content occurs when mangrove leaves fall and are trapped. The availability of organic and inorganic materials will be consumed/decomposed by decomposers. The highest activity of fungal cellulolytic enzymes occurs at the beginning of the mangrove litter decomposition process.

Bacteria are one of the components that play an important role in the decomposition process of mangrove litter. According to (Kusuma, 2023; Nolan et al., 2019; Rejeki & Hisyam, 2013) stated that the bacteria produced from mangrove leaf litter have diversity, but there are the most dominant ones found in all types of decomposed mangrove leaf litter such as Bacillus. In the Avicennia mangrove species, the bacteria found include Bacillus, Clostridium, Enterobacteria, Bacteroides, Plesiomonas, Bordella, Streptococcus and Neisseria. The percentage of litter decomposition rate is presented in the graph below.

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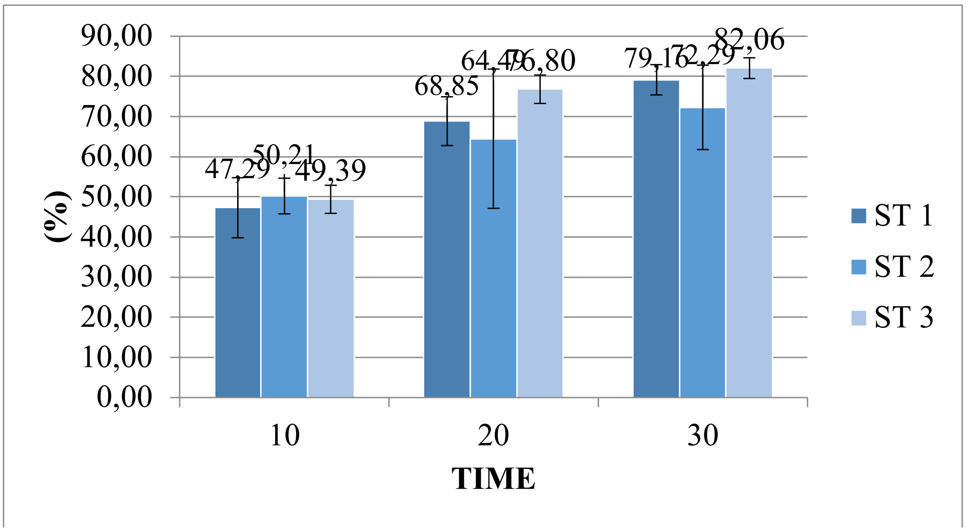

Figure 2. Percentage of Litter Decomposition Rate

22 The high percentage of decomposition rate on the 30th day of observation is suspected to be due to the role of decomposer organisms found in the litter bag. These decomposer organisms were found from the beginning of the observation, namely in the first 10 days of the study. Apdhan et al., (2013) the high decomposition rate occurred at the beginning of the
11 observation, this is thought to be closely related to the loss of easily soluble organic and
7 inorganic materials (leaching) and also the discovery of microorganisms that play a role in the breakdown of several substances contained in mangrove litter. In addition to the presence of decomposer organisms, the leaf structure of the Avicennia mangrove and the components that make up the leaves also affect the decomposition process. As is known, Avicennia leaves are thinner.

Rainfall and tides also influence the rate of decomposition. During the rainy season, the environment tends to be more humid, allowing bacteria and decomposers to thrive. However, during high tide, physical mechanisms occur, causing mangrove litter to be inundated by seawater and affected by current movements. (Yusal et al., 2025) state that tides in waters can accelerate the process of litter decomposition. Through the process of slowly weathering the litter, sunlight and salt content can destroy the organic material. According to (Haris et al.,
6 2012; Siegers, 2015; Widhitama et al., 2016), in water areas, the litter decomposition process is assisted by physical mechanisms, namely tidal movements and prolonged seawater inundation. The mechanism for the loss of soluble material from mangrove litter is caused by rainwater or water flow.

DISCUSSION

Litter Nutrient Release

Mangrove ecosystems provide significant benefits to their surroundings. One example is the production of fallen litter that will eventually undergo a decomposition process. When mangrove litter decomposes, it contributes organic matter that is then utilized for the growth and development of the mangrove itself, juvenile fish, shrimp, and other organisms in the area. The released nutrients are not directly utilized by the fish, but rather in the form of potential energy good for phytoplankton growth, which then becomes a food source for the fish. (Kusuma, 2023; Permanasari et al., 2017; Wahyu et al., 2021) state that nutrients released from the litter decomposition process have the potential to become available energy for the growth of phytoplankton, which is the food source for juvenile fish. Nutrient release is presented in the graph below.

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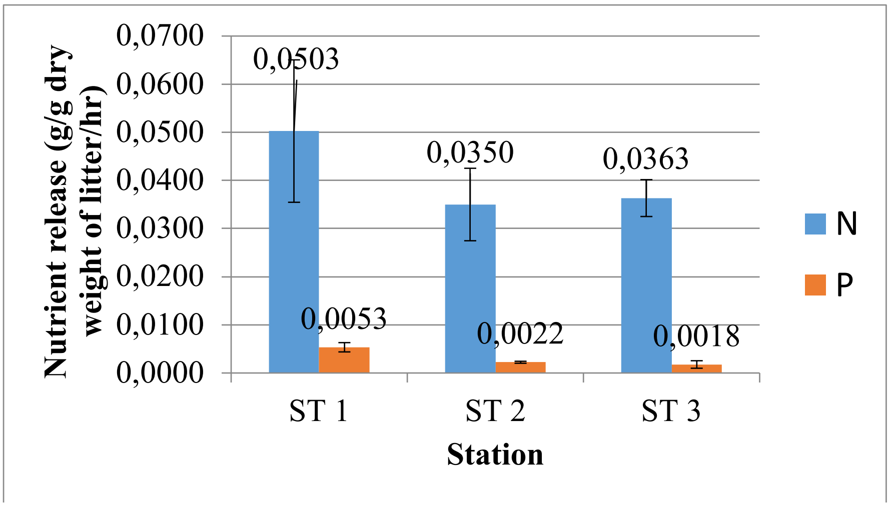

Figure 3. Nutrient Release Graph

Based on the litter decomposition process, it is known that the highest nutrient release in the waters is at station 1, namely 0.050 gr N/gr dry weight/day (183.595 kg/ha/yr) and 0.005 gr P/gr dry weight/day (18.25 kg/ha/yr). Nutrient release at station II is 0.035gr N/gr dry weight/day (127.75 kg/ha/yr) and 0.0022 gr P/gr dry weight/hr (8.03 kg/ha/yr). While at station III it is 0.036 gr N/gr dry weight/hr (131.4 kg/ha/yr) and 0.002 gr P/gr dry weight/hr (7.3 kg/ha/yr). The results of this study indicate that the Surabaya Mangrove Information Center forest is able to contribute nitrogen of 443.81 kg/ha/yr. Mangrove forests contribute phosphorus of 34.104 kg/ha/yr. (Haris et al., 2012; Patty, 2010; Salafiyah & Insafitri, 2020) stated that Avicennia marina mangroves contribute higher nutrients compared to other types, namely nitrogen of 437.05 kg/ha/yr and phosphorus of 90.38 kg/ha/yr. This is because the nutrient content of Avicennia marina leaves is higher when compared to Rhizophora which has a high tannin content. The results of research from (Linayati et al., 2024; Nolan et al., 2019; Widhitama et al., 2016) stated that the total amount of N nutrients released in the R. mucronata mangrove rehabilitation area was 131.4 kg/ha/yr and P was 13.14 kg/ha/yr while the N content in S. Alba was 321.2 kg/ha/yr and P content was 47.45 kg/ha/yr.

Primary Productivity of Waters

Estimating aquatic primary productivity in mangrove forest ecosystems can be done using the nutrient release approach from mangrove leaf litter produced. The production of fallen mangrove leaf litter will eventually undergo a decomposition process. This decomposition process will produce nutrients (N, P) into the aquatic environment. The higher the nutrient production, the higher the primary productivity of the water (Figure 4). (Linayati et al., 2024; Permanasari et al., 2017) stated that nutrient availability in water is a limiting factor for organism growth. Thus, the efficiency of nutrient cycling in aquatic ecosystems will be very important to maintain primary productivity. Therefore, the magnitude of primary productivity of a body of water can indicate the magnitude of the availability of dissolved nutrients in the water (Utami et al., 2022).

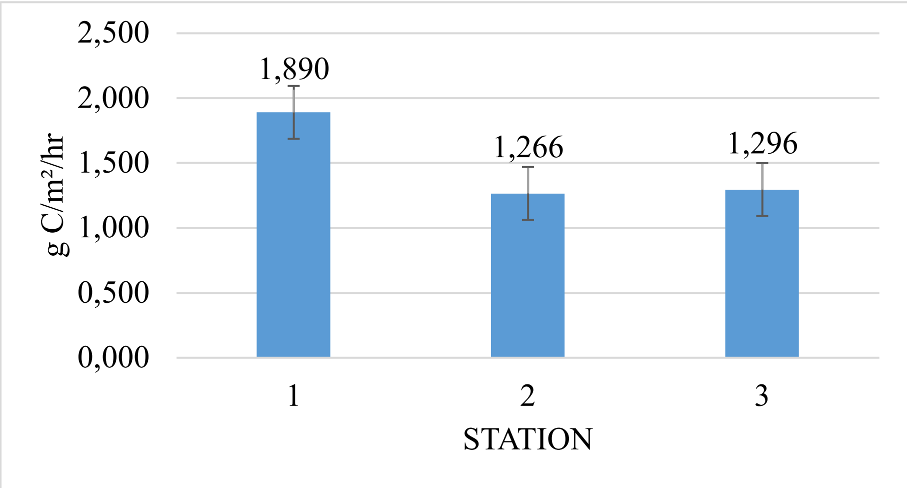

Figure 4 Primary Productivity Graph

Based on the results of the estimation of primary water productivity, it shows that the highest productivity estimation through litter analysis at station 1 was 1,890 g C/m²/hr (689.85 g C/m²/yr), station II was 1,266 g C/m²/hr (462.09 g C/m²/yr) while at station III was 1,296 g C/m²/hr (473.04 g C/m²/yr). Primary productivity per year ranges from 460-690 g C/m²/yr. The primary productivity value at the research location is quite high so that it is categorized as fertile to very fertile waters, this is closely related to the high value of mangrove litter nutrient content. According to Pinkney et al., (2001) the trophic status of water is based on the level of eutrophication so that it can be categorized as oligotrophic waters (<100 g C/m²/yr), mesotrophic (100-300 g C/m²/yr), eutrophic (300-500 g C/m²/yr) and hypertrophic (>500 g C/m²/yr).

Primary productivity results ranged between 460-690 g C/m²/yr indicating that the area plays a significant role as the beginning of the food chain in the mangrove ecosystem. Therefore, the mangrove ecosystem, through its litter production, significantly influences the fish production that will be produced. This is supported by Mahmudi's (2010) statement that mangrove forests play a significant role as the beginning of the grazing food chain in estuarine ecosystems. The high primary productivity value indicates the role of the mangrove ecosystem as a feeding ground, especially for herbivorous fish, which is then followed by the trophic level of carnivorous fish.

The food chain in the mangrove ecosystem begins with fallen mangrove leaves, which become an excellent substrate for bacteria and fungi. Bacteria also play a role in the decomposition process of leaves into detritus. Detritus in the waters becomes food for zooplankton. Zooplankton in these waters ultimately become food for juvenile fish, shrimp larvae, and crabs. These larvae are then eaten by carnivorous fish and others up to a higher level. According to (Kusuma, 2023; Santya et al., 2024), mangroves are one of the producers for aquatic life. One of the contributions of mangroves is the supply of nutrients for plankton growth. The nutrients in question are mangrove litter, which later undergoes decomposition and mineralization, producing nutrients that are then utilized by plankton as ingredients in the process of photosynthesis.

Mangroves as one of the producers in aquatic life have contributed to aquatic biota, one of which is as a supplier of nutrients for plankton growth. Plankton is divided into 2, namely phytoplankton and zooplankton. According to (Amri et al., 2018) explains that the types of phytoplankton found in mangrove waters include Fraggilaria sp., Naviculla sp., Nitzschia sp., Surirella sp., Tabellaria sp. (Linayati et al., 2024) stated that zooplankton from the Cepopoda, Cladocera, Rotifera, Mysidacea, Euphausiaceae groups are zooplankton commonly found in

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Indonesian mangrove waters. Rotifers in the sea are very low in number, but in brackish waters they are very abundant. In fresh water Rotifers are the number two important food for crustaceans.

Estimating Fish Production Using the Primary Productivity Approach

Mangrove ecosystems contribute significantly to coastal fisheries. Fisheries production in mangrove areas is closely linked to aquatic productivity. Declining mangrove forest quality impacts fish production in the area. Aquatic productivity can be measured through several environmental factors (water quality). (Kusuma, 2023; Nolan et al., 2019) state that mangrove ecosystems do not directly impact fisheries production. The presence of mangroves will impact the surrounding environment, enriching the organic matter content, which will significantly impact fisheries production, especially non-aquaculture.

Within the mangrove ecosystem, various species of fish and invertebrates undergo a life cycle to find food, primarily through the utilization of litter production. Decomposing litter in mangrove areas contributes organic matter that plays a role in the growth and development of mangroves, fish, shrimp, crabs, and other organisms in the area. (Kusuma, 2023; Nolan et al., 2019) state that the larger the mangrove forest, the higher the production of non-cultivated fish in that area. This is because the larger the mangrove area, the greater the nutrient contribution, resulting in more food for fish and shrimp. The estimated fish production graph is presented in the figure below.

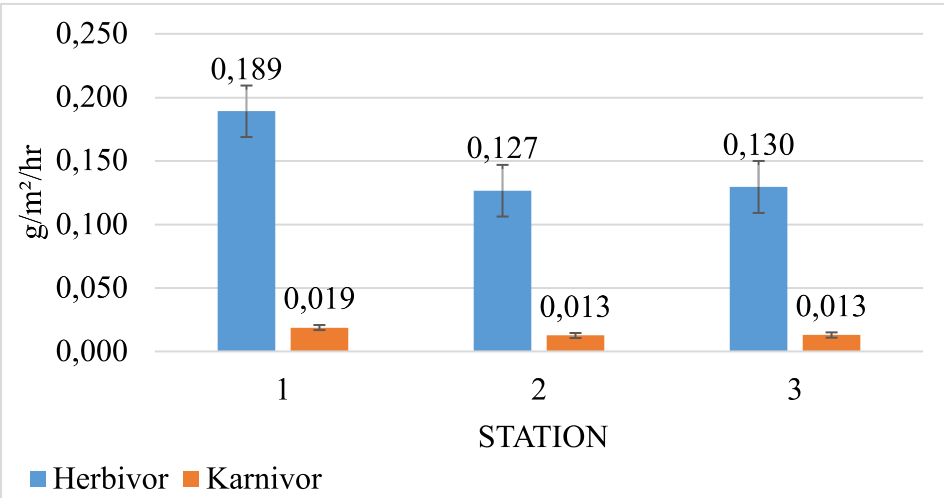

Figure 5. Fish Production Graph

Based on observations, the estimated fish count at station I was 0.208 g/m²/day (759.00 kg/ha/yr). The high total estimated fish count was due to the higher nutrient release at the station, which could be directly utilized by organisms in the area. Total production at station II was 0.139 g/m²/day (508.25 kg/ha/yr). Total fish at station III was 0.143 g/m²/day (520.17 kg/ha/yr).

Based on the results of fish estimation at three stations, it was found that herbivorous fish ranged from 0.127-0.190 g/m²/day with an average of (0.148±0.035) g/m²/day. Carnivorous fish ranged from 0.013-0.019 g/m²/day with an average of (0.015±0.004) g/m²/day. The average total fish production per day was 0.163 g/m²/day (595.81 kg/ha/yr). When compared with similar studies with different research locations, there are differences in the estimated amount of fish production produced. The results of research (Wahyu et al., 2021) estimated the potential fish production generated from the mangrove ecosystem per year at 672±117 kg/ha/year, while research (Redjeki, 2013) stated that the potential fishery production

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contributed by the mangrove ecosystem was 1405.25 kg/ha/year. The total fish production illustrates the potential fish production contributed by the mangrove ecosystem, so it can be interpreted that the loss of 1 ha of mangrove ecosystem will result in a loss of 595.81 kg/ha/year. According to (Redjeki, 2013) stated that one hectare of mangrove area can contribute fish production of 672 kg/ha/year.

CONCLUSION

The amount of nutrient production resulting from the process of releasing nitrogen from Avicennia sp. mangrove leaf litter ranges from 0.0350–0.0503 g N/g dry weight/day while the value of phosphorus content released daily ranges from 0.0018–0.0053 g P/m²/hr. The area of mangrove forest in the Wonorejo mangrove information center area annually contributes 127.75–183.43 kg N/ha/yr. The primary productivity value based on research results is known to range from 460-690 g C/m²/yr. This productivity value is quite high in waters so that it can be categorized as fertile to very fertile. The contribution of mangrove forest litter to the production of herbivorous fish ranges from 0.127-0.198 g/m²/hr (462.04-690 kg/ha/ta), carnivorous fish contribute 0.013-0.019 g/m²/hr (46.20-69 kg/ha/ta). Thus, the total fish production contributed to the mangrove information center is 595.80 kg/yr.

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