The Prediction of Plankton Diversity and Abundance in Mangrove Ecosystem

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ABSTRACT

The abundance of phytoplankton and zooplankton have correlation with mangrove conditions in coastal area. The mangrove degradation give negative impact for abundance and diversity phytoplankton and zooplankton. The research aimed to analysis and construct prediction model of abundance and biodiversity of phytoplankton and zooplankton in mangrove ecosystem. The research used the transect method (to determine mangrove density), filtering method (to analyze abundance of phytoplankton and zoopankton) and statistical method (to develop estimation modeling of plankton abundance). The results showed that (1) the mangrove density between 250 trees/Ha - 1,250 trees/Ha (2) the phytoplankton abundance were 10.675 ind/L (in mangrove rarely) - 24.290 ind/L (in mangrove high density), (3) the zooplankton abundance were 261 ind/L (in mangrove rarely) - 2,204 ind/L (in mangrove high density) (4) The modelling analysis showed that (1) the phytoplankton abundance (y) = 0.0303x² - 22.059x + 13004 and (2) the zooplankton abundance (y) = 0.0057x² - 5.39x + 1458.2, with x = mangrove density.

Keywords: phytoplankton and zooplankton, mangrove density, abundance, estuary and lagoon

ABSTRAK

Kelimpahan fitoplankton dan zooplankton diduga memiliki korelasi dengan kondisi mangrove di wilayah pesisir. Sedangkan kerusakan mangrove memiliki dampak negatif bagi kelimpahan dan keanekaragaman hayati dari fitoplankton dan zooplankton. Penelitian ini bertujuan untuk menganalisis dan membangun model prediksi kelimpahan dan keanekaragaman hayati dari fitoplankton dan zooplankton. Penelitian ini menggunakan metode transek (untuk menduga kerapatan mangrove), metode penyaringan air (untuk menganalisis kelimpahan fitoplankton dan zooplankton). Hasil penelitian menunjukkan bahwa (1) kerapatan mangrove antara 250 pohon/Ha - 1,250 pohon/Ha (2) kelimpahan fitoplankton adalah 10.675 ind/L (di mangrove jarang), 24.290 ind/L (di mangrove padat), (3) kelimpahan zooplankton adalah 261 ind/L (di mangrove jarang) - 2,204 ind/L (di mangrove padat) (4) untuk model pendugaan adalah (1) Kelimpahan fitoplankton (y) = 0.0303x² - 22.059x + 13004 dan (2) kelimpahan zooplankton (y) = 0.0057x² - 5.39x + 1458.2, dengan x = kerapatan mangrove.

Kata kunci: fitoplankton dan zooplankton, kepadatan mangrove, kelimpahan, estuary dan lagoon

1. Introduction

Mangrove ecosystem is a specific community structure consists species composition, growth structure and productivity (Giesen et al. 2006; Hilmi et al., 2015) and has important function as habitat of plankton and other organisms. The density and abundance of organisms can be used to analysis mangrove sustainability indicator (Ardli & Wolff, 2008; Badola & Hussain, 2005; Hilmi et al., 2017). The basic indicators to show mangrove sustainability are mangrove diversity (Dangan-Galon et al., 2016), vegetation structure (Ardli & Wolff, 2008), ecological stability (Moya et al., 2008).
mangrove litterfall (Kusmana et al., 2000; Mukherjee & Ray, 2012b), water quality assessment (Bargos et al., 1990) (Bargos et al., 1990; Menteri Negara Lingkungan Hidup, 2004), and mangrove function (Alvarez and Garcia 2003; Ardli et al., 2011; Masagca 2008). Related with phytoplankton and zooplankton, mangrove has specific function as feeding, spawning and nursery ground.

Planktons are aquatic organism with microscopic size and move actively against the sea current (Effendi et al., 2016; Su et al., 2015; Yan et al., 2012). Plankton consists of zooplankton and phytoplankton (Abdulwahab and Rabee 2015; Cairns and Pratt 1993; Effendi et al. 2016; Honggang et al., 2012; Khalifa et al. 2015; Li et al. 2012; Mckinstry and Campbell 2017; Ormanczyk et al., 2017; Pratiwi et al. 2016; Simanjuntak 2009). Phytoplankton is microscopic aquatic plant, while zooplankton is animal (Gharib et al., 2011; Honggang et al., 2012; Khalifa et al., 2015; Pratiwi et al., 2016; Simanjuntak, 2009). The phytoplankton in aquatic ecosystem is the main producer, able to conduct photosynthetic process, producing organic material by converting inorganic nutrient into carbohydrate (Berthold et al. 2018; Roy et al., 2012). planktonic food web constitutes the base of life in ocean (Yilmaz et al., 2018). The phytoplankton forms as first level in food chain and zooplankton is the second level as primary consumer. As consumer, zooplankton is unable to conduct photosynthesis due to lack of chlorophyll (Li et al., 2012; Masuda et al., 2017). The phytoplankton and zooplankton need the suitable environment and habitat to support their life. The factors influenced the life of phytoplankton and zooplankton are water quality (TSS, water turbidity, pH, salinity, alkali, ammonia, nitrate, phosphate), and soil properties (Berthold et al., 2018; Menteri Negara Lingkungan Hidup, 2004; Mukherjee & Ray, 2012a; Simanjuntak, 2009). The habitats to support phytoplankton and zooplankton to life are mangrove ecosystem and lagoon ecosystem.

The mangrove and lagoon ecosystem in Meranti Island have been characterized to support plankton to life and grow including soil and water quality (Alvarez & Garcia, 2003; George et al., 2013; Kusmana et al., 2000). But, the degradation of mangrove and lagoon ecosystem (Ardli et al., 2011) caused loss of abundance and increasing mortality of phytoplankton and zooplankton (Abdulwahab & Rabee, 2015; Khalifa et al., 2015; Pratiwi et al., 2016). The degradation of mangrove ecosystem can be seen from the density and biodiversity of mangrove ecosystem. The degradation of mangrove ecosystem can be assumed give impact for the abundance and biodiversity of plankton. This research aimed to analysis and construct prediction model of abundance and biodiversity of phytoplankton and zooplankton in mangrove ecosystem. This analysis using mangrove density as main factor to analysis abundance and biodiversity of phyto and zooplankton.

2. Material and Methods

2.1. Research Site

This research conducted on mangrove and lagoon ecosystem in Meranti Regency with geographical coordinate between 100° 52’- 102° 10’ E and 2° 3’ - 0° 17’ N (Figure 1). The site research divides three stations (islands) were Merbau Island (Station 1), Rangsgan Island (station 2), and Tebing Tinggi Island (Station 3).

![Research Stations in Meranti Island](image)

**Figure 1.** The Site Research
2.2. Research Method

Research Variable

The research variables were mangrove density, the abundance of phytoplankton and zooplankton, the soil properties and the water quality.

The mangrove density

The method of mangrove density used transects method (Hilmi et al. 2017; Kusmana 1997). The mangrove density used equation was \( \text{Di} = \frac{\sum xij}{ni} \) (mangrove ha\(^{-1}\)), note = Di is density of mangrove in station -i, xij is density of mangrove species -j, station i, and ni is station -i. The abundance of plankton

To measure plankton abundance used filtering sample method followed density equation (Honggang et al., 2012; Khalifa et al., 2015; Mckinstry & Campbell, 2017; Ormanczyk et al., 2017; Pratiwi et al., 2016)

\[ N = \frac{(ax20) \times c}{L} \]

Notes that are N: plankton dense, a: average of plankton in 1 ml of water (equal 20 water pipe), c: volume of water (ml), and L: volume of water filtered (lt)

The biodiversity of plankton

The biodiversity index to analyze plankton are heterogeneity and evenness. The heterogeneity used Shannon Wiener with equation \( H' = \sum_{i=1}^{s} (p_i) \ln (p_i) \), where s = number of species, pi = proportion of species density. The evenness used equation \( = (\exp (H'))/s \). (Magurran, 1996)

2.3. Data Analysis

The data analysis used descriptive comparative (graph’s and tables) with the reference from (Abdulwahab & Rabee, 2015; Honggang et al., 2012; Khalifa et al., 2015; Menteri Negara Lingkungan Hidup, 2004; Pratiwi et al., 2016) and develop the relation model between abundance of phytoplankton and zooplankton with mangrove density.

3. Results and Discussion

3.1. The mangrove density

The mangrove density in Meranti Island was dominated by Avicennia spp, Rhizophora spp, and Sonneratia spp (Table 3). The data showed the influencing of mangrove distribution to support plankton life and grow. The presence of phytoplankton and suspended microphytobenthos in lagoon are influenced by the water column (Tsui & Montani, 2017) the existence of mangrove ecosystem, and presence of the major species and dominant species (Hilmi, 2018; Hilmi et al., 2017; Kusmana et al., 2000, 2005; Mukherjee & Ray, 2012).

### Table 1. The Soil Properties Method

| Variables                      | Unit | Method                      | Reference                  |
|--------------------------------|------|-----------------------------|----------------------------|
| Soil pH                        |      | Potensiometric/pH meter     | APHA, 2005 and 2012         |
| Soil texture                   | %    | Gravimetric                 | APHA, 2005 and 2012         |
| Nitrate (NO\(_3\))            | %    | Brucine                     | Soil research dept, 2005    |
| Phosphate (PO\(_4\))          | %    | ascorbic acid               | APHA, 2005 and 2012         |
| C organic                     |      | Walkey and Black            | Soil research dept, 2005    |

### Table 2. The Water Quality Method

| No Variables                  | Unit  | Method                     |
|--------------------------------|-------|----------------------------|
| Physical                       |       |                            |
| 1. TSS                         | mg/l  | APHA,20\(^{th}\).1998 2542-D /Gravimetri |
| 2. Water Turbidity             | NTU   | APHA,20\(^{th}\).1998 2130-B /Turbidimeter |
| Chemical                       |       |                            |
| 1. pH                          |       | APHA,20\(^{th}\).1998 450-5/H+/pH meter |
| 2. Salinity                    |       | APHA,20\(^{th}\).1998 2520-B /handrefractometer |
| 3. Alkalinity                  | mgCaCO\(_3\)/l | APHA,20\(^{th}\).1998 2320-B / Titritemik |
| 4. Ammonia (NH3+NH4)           | mg/l  | APHA,20\(^{th}\).1998 4500-F /Phenate/ Spectrophotometer |
| 5. Nitrite (NO\(_2\)-N)        | mg/l  | APHA ed,20\(^{th}\).1998 4500-B /sulfinik/ Spectrophotometer |
| 6. Nitrate (NO\(_3\)-N)        | mg/l  | APHA ed,14\(^{th}\).1998 4500-B /BrusinSulfat/ Spectrophotometer |
| 7. Phospate                     | mg/l  | APHA,20\(^{th}\).1998 4500-P-E /Ascorbi acid/ Spectrophotometer |
The mangrove density in Meranti Island had three grade that were mangrove rare (25 - 50 trees ha\(^{-1}\)) (Station 2), moderate (525-650 trees ha\(^{-1}\)) (station 1) and dense (900 - 1300 trees ha\(^{-1}\)) (station 3). But, based on Kusmana et al. (2005), Menteri Negara Lingkungan Hidup, (2004) and Ardli and Wolff (2008) note that the mangrove in Meranti Island can be categorized as mangrove rare - moderate.

Based on land cover, density of trees, abrasion, sedimentation (Sari et al., 2016; Syakti et al., 2013), abrasion and intrusion (Hilmi, 2018; Hilmi et al., 2017), the mangrove density in Meranti Island had category as the mangrove degradation, especially station 2 (rare and high degradation). The mangrove degradation in Meranti Island could be caused by (1) the exploitation of commercial mangrove like as Rhizophora spp and Bruguiera spp. (2) illegal logging of mangrove to support the house building. (3) Over exploitation to support activity of charcoal, pulp and paper. (4) The social opinion of low value of mangrove ecosystem can accelerate degradation of mangrove ecosystem and conversion of mangrove in Meranti Island (Hilmi et al., 2017). Hilmi et al. (2019) and Sari et al. (2016) emphasis that the degradation of mangrove ecosystem also was caused by the decreasing of total economic value from mangrove ecosystem. The degradation of mangrove ecosystem decrease supporting of spawning, feeding and nursery ground for phytoplankton and zooplankton (Cadier et al., 2016; Kruk et al., 2016; Masuda et al., 2017), loosing of the phytoplankton and zooplankton habitat’s.

3.2. Soil properties

The soil texture, pH, C- organic, N-Organic, P, Ca, Mg, K, Na, and soil salinity (Ashton & Macintosh, 2002; J. G. Kairo et al., 2001; James G. Kairo et al., 2008; Macintosh et al., 2002) have function to support mangrove grow. The soil properties of mangrove ecosystem in Meranti Island were showed by Table 4. The soil properties also were used to find level of fertilize of mangrove ecosystem and classification of soil properties to support mangrove life, phytoplankton and zooplankton growth.

The soil properties in mangrove ecosystem both of (a) chemical properties were pH, C organic N total, capacity of soil cation exchange (CEC), soil fertility matter (P, Ca, Mg, K, Na), soil salinity and (b) physical properties was soil texture can be shown on Table 4. The data of soil properties showed that mangrove ecosystem in Meranti Island had soil properties that were acid - very acid, highest of C organic, N matter moderate, the soil fertility matter like as phosphate and calcium were low, magnesium, potassium, and sodium were highest. The other soil properties were capacity of soil cation exchange was moderate, and salinity was moderate. Based on data suggested that the soil properties in Meranti Island can be categorize good suitable to support mangrove grow (Ashton & Macintosh, 2002; James G. Kairo et al., 2008; Ragavan et al., 2014). Kusmana et al. (2005), Ragavan et al. (2014), Kairo et al. (2001) write that the environment suitability to support mangrove grow are salinity < 30 ppt, pH acid - neutral, soil texture between clay - sandy clay - loam.

Kantharajan et al. (2018), Kusmana et al. (2005) and Truong, Ye, and Stive (2017) write mangrove need supporting of soil fertilizer like as C- organic, N- Organic, P, Ca, Mg, K and Na to grow. But mangrove ecosystem also could support to increase soil fertilizer by leaves, fruit, flower and stem decomposition. The supporting of mangrove ecosystem with decomposition gives positive impact for soil

| Sample Plot | Location   | Species                  | Growth stage | Categorized                      |
|-------------|------------|--------------------------|--------------|----------------------------------|
|             |            |                          | Trees (ind/ha) | Sapling (ind/ha) | Seedling (ind/ha) | Rar- Moderate (rare degradation) | Moderate dense (low degradation) |
| Station 1   | Merbau Island | Avicennia alba           | 500 - 625    | 4,000              | 25,000             | Rare- Moderate (moderate degradation) |
|             | Rangsang Island | Sonneratia alba          | 25 - 50      |                    |                    | rare (High degradation)          |
| Station 2   | Tebing Island | Avicennia alba           | 25           |                    |                    | Moderate- dense (low degradation) |
|             | Tinggi Island | Sonneratia alba          | 25 - 50      |                    |                    |                                |
|             |             | Rhizophoramucronata      | 750 - 1,125  | 8,000              | 25,000             |                                |
|             |             | Rhizophoraapiculata      | 25 - 50      |                    |                    |                                |

Table 3. The mangrove density in Meranti Island Regency
fertilizer. The potential of soil fertilizer in Meranti Island Regency (like as Mg, K, Na, CEC, C organic) showed moderate - high potential. The potential of soil fertilizer will influence to increase mangrove growth including for seedling, sapling and mangrove trees. The soil properties in Meranti Island Regency give the important role for nutrient cycle process in a lagoon and estuary ecosystem to support existence of plankton, zooplankton and benthos as key players of organic nutrient cycling in coastal regions. For example is Arcuatula senhousia (Takenaka et al., 2018) need supporting of C- organic, N-Organic, P, Ca, from decomposition of mangrove leaves, stem and others.

3.3. Water quality

The data of water quality in Meranti Island Regency (Table 5) showed the performs of lagoon ecosystem to support phytoplankton and zooplankton life. Abdulwahab and Rabee (2015) and Hilmi, Sari, and Setijanto (2019) write that the main variables of water quality have high correlation with plankton are water temperature, pH, EC, turbidity, TDS, DO, BOD5, total hardness, Ca42+, Mg2+, chloride, nitrate and reactive phosphate. Bagheri, Turkoglu, and Abedini (2014) writes that the potential of water quality in Ye-ihmak Rivers to support phytoplankton are temporal surface temperature had variation between 8.80 and 28.6°C with the annual average temperature was 18.1±7.07 °C. Salinity variations, varied between 7.33 and 12.7 psu, the annual average surface salinity in 2003 was 11.3±0.63 psu.

The data on Table 5 also showed that the water qualities of estuary and lagoon ecosystems in Meranti Island Regency were influenced by mangrove density. The mangrove ecosystem decreasing of water turbidity (from 140 NTU to 25 NTU) and total solid suspended (from 512 mg/l to 244 mg/l), increasing of pH for aquatic ecosystem (from pH 5.73 (acid) to 7.25 (alkaline). The potential of water salinity in Meranti Island Regency had good suitability to support life of zooplankton and phytoplankton. The other properties of water quality were the decreasing of alkalinites (the mangrove rare to mangrove dense), but mangrove didn’t give impact for the potential of nitrate and phosphate.

The Phosphate and nitrogen are essential of an organic matter to support growth and life stage of phytoplankton. The high potential of nutrient matter in aquatic ecosystem will increase the plankton density. MENLH (2004) write the standard value of phosphate is 0.015 mg/l or 0.465 μg A/l, nitrate is 0.008 mg/l or 0.112 μg A/l (0.49-1.07 μg A/l or 0.007-0.015) and the standard of Ammonia is not more than 0.42 ppm - 0.3 mg/l or 4.20 μg A/l.

### Table 4. Soil properties of Mangrove Ecosystem in Meranti Island

| Station | pH (H2O) | C org (%) | N total (%) | P | Ca | Mg | K | Na | CEC | texture | Salinity µs/cm |
|---------|----------|-----------|-------------|---|----|----|----|----|-----|---------|---------------|
| Station 1 (merbau) | 5.0 | 6.00 | 0.26 | 6.1 | 4.01 | 10.21 | 1.02 | 6.01 | 27.40 | sand | 5.72 | 26.57 | 67.71 | 8.93 |
| Station 2 (rangsan) | 5.4 | 5.5 | 0.24 | 7.2 | 3.9 | 8.18 | 0.75 | 5.64 | 26.58 | dust | 3.44 | 44.22 | 52.34 | 9.23 |
| Station 3 (Tebing Tinggi) | 4.5 | 6.13 | 0.28 | 5.8 | 4.11 | 11.62 | 1.15 | 6.60 | 29.26 | clay | 6.78 | 25.51 | 67.71 | 8.71 |

### Soil Standard

| Soil properties | Unit | Lowest | Low | Moderate | High | Highest |
|-----------------|------|--------|-----|----------|------|---------|
| C               | %    | <1.00  | 1 - 2 | 2.01 - 3.00 | 3.01 - 5.00 | > 5.00  |
| N               | %    | <0.1   | 0.1 | 0.2 - 0.5 | 0.51 - 0.75 | > 0.75  |
| P2O5-HCl        | mg/100 gr | <10 | 10 - 20 | 20 - 40 | 41 - 60 | >60 |
| CEC             | me/100 gr | <5 | 5 - 16 | 17 - 24 | 25 - 40 | >40 |
| K               | me/100 gr | <0.1 | 0.1 - 0.2 | 0.3 - 0.5 | 0.6 - 1.0 | >1.0 |
| Na              | me/100 gr | <0.1 | 0.1 - 0.3 | 0.4 - 0.7 | 0.8 - 1.0 | >1.0 |
| Mg              | me/100 gr | <0.4 | 0.4 - 1.0 | 1.1 - 2.0 | 2.1 - 8.0 | >8.0 |
| Ca              | me/100 gr | <2 | 2 - 5 | 6 - 10 | 11 - 20 | >20 |
| pH              | - | <4.5 (very acid) | 4.5 - 5.5 (acid) | 5.6 - 6.5 | 6.6 - 7.5 | 7.6 - 8.5 |

(Moderate acid) (Netral) (Alkali)
The other properties of water quality are pH and dissolve oxygen. The potential pH to support plankton, fish and aquatic organism in brackish water is 5 - 9 (Menteri Negara Lingkungan Hidup, 2004). The potential of dissolve oxygen is 2 - 10 ppm or less than 2 ppm (Simanjuntak, 2009). Basically the nutrient matter in aquatic ecosystem to support plankton growth correlated with water drainage and the potential of water pollution (Simanjuntak, 2009).

George et al., (2013) also writes that the mangrove ecosystem as mixing of fresh water with marine water has temperature variation between 22-33.2 °C, pH between 7.8 to 8.3, dissolved oxygen has the range of 0.1 mg L⁻¹ - 12.3 mg L⁻¹, salinity between 1.2-31.5 ppt, and ammoniacal nitrogen between 0.001 - 0.744 mg L⁻¹. According Yan et al., (2012) write that salinity (S), pH, chemical oxygen demand (COD), and nitrite (NO₂⁻ -N) were importantly environmental factors influencing the distribution of phytoplankton community. Li et al. (2012) also emphasize that excess nitrogen (N) and phosphorus (P) being primarily responsible for fueling primary production and excessive organic matter accumulation.

The decomposition and remineralization of mangrove detritus is important in nutrient dynamics (Roy et al., 2012) which will increase the water fertilization in mangrove ecosystem. Decomposition and remineralization supply detritus and nutrient through leaching and break down of leaf litter into the adjacent estuary and thus regulates the productivity (Roy et al., 2012). Mukherjee & Ray, (2012b) write that cycling of carbon and nutrients in forest ecosystems shows the forward litter decomposition process. Highly productive mangrove ecosystems (approx. productivity 2500 mg C m⁻² day⁻¹) shows mangrove ecosystem as source of nutrients. Litter fall is one of the driving forces and the main energy source in this system. Mangrove litter undergoes first degradation and then decomposition into dissolved inorganic nutrients, which are important for growth of phytoplankton. Berthold et al., (2018) also write that phosphorus supports primary production in the water column and can elevate phytoplankton and macrophyte growth.

### 3.4. The abundance and diversity of phytoplankton

The abundance and diversity of phytoplankton in Meranti Island Regency were shown on Table 6. A lagoon and Estuary in Meranti Island Regency are the important ecosystem to support ecological processes and has functionally linked terrestrial, freshwater, and marine ecosystems (Yamamoto et al., 2018), including as aquatic organism habitat. The phytoplankton is an aquatic organism which has ability to do photosintetic activity as the plant organism with size between 2 - 200 μm (Effendi et al., 2016; Su et al., 2015). Phytoplankton has the main contributor to spatial increases in total cell abundance in mesohaline water as a result of the lake’s hydrographic characteristics and water quality (Tsuji & Montani, 2017). Phytoplankton as great importance role to

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**Table 5. The water quality of estuary ecosystem in Meranti Island.**

| Variables    | Unit   | Study area                  | Method                      |
|--------------|--------|-----------------------------|-----------------------------|
|              |        | I (Merbau) | II (Rangsang) | III (Tebing Tinggi) |
| **Physic**   |        |             |               |                  |
| TSS          | mg/l   | 284    | 512           | 244             |
| Water turbidity | NTU    | 58     | 140           | 25              |
| **Chemical** |        |             |               |                  |
| pH           | -      | 7.28    | 7.25          | 5.73            |
| Salinity     | %/oo   | 29      | 26            | 20              |
| Alkalinity   | mgCaCO₃/l | 100.00 | 90.00         | 24.00           |
| Ammonia      | mg/l   | 0.498   | 0.514         | 0.577           |
| (NH₄⁺NH₃)   |        |         |               |                 |
| Nitrite (NO₂⁻) | mg/l   | 0.003   | 0.052         | 0.043           |
| Nitrate (NO₃⁻) | mg/l   | 0.038   | 0.179         | 0.181           |
| Phosphate    | mg/l   | 0.100   | 0.074         | 0.061           |
|              |        |         |               |                 |
| **Method**   |        |             |               |                  |

**Note**: APHA,20th Ed. 1998 2542-D / Gravimetri, APHA,20th Ed. 1998 2130-B / Turbidimeter
drive the transportation activity of surface organic carbon in the coastal, lagoon and mangrove ecosystem are either consumed by detrital feeders or deposited and stored in the sediment (Yilmaz et al., 2018).

The potential of phytoplankton in Meranti Island Regency (Table 6) can be shown as the abundance, number of taxa, biodiversity index, dissimilarity index and domination index. The species compositions and community structures of halophytic plants, gastropods, and brachyurans in lagoon have the important role to reach sustainability of lagoon ecosystem (Henmi et al., 2017). The data on Table 5 explained that potential of phytoplankton in mangrove ecosystem were dominated by 1) Cyanophyceae that is Trichodesmium spp (2) Bacillariophyceae, that are Steptotheca sp, Nitzchia sp, Chaetoceros sp, Baccheriasum sp, Bacillaria sp, Thalassionema sp, Thalassiothrix sp, Thalassiosira sp, Rhizosolenia sp, Biddulphia sp., Ditylum sp, Pleurosigma sp, Skeletonema sp, Coscinodiscus sp, Bellerocaea sp, Cyclotella sp., Leptocylindrus sp, Asterionella sp, Navicula sp, Amphora sp, Lauderia sp, (3) Dinopyceae that is Peridinium sp. Yilmaz et al., (2018) writes that Western Artic Peninsula and Galindez Isla have 50 phytoplankton that are Chaetoceros atlanticus, Corethron pennatum, Coscinodiscus radiatus, Odontella aurita, O. weissflogii, Cocconeis britannica, Entemoneis alata, Membraneis challengeri, Nitzschia bilobata, Plagiotrops gaussii from diatoms; Prorocentrum micans from dinoflagellates; Dictyocha antarctica and D. speculum from silicoflagellates). Onyema (2007) find in a Polluted Estuarine Creek in Lagos, Nigeria has 48 taxa from 26 genera and 3 classes namely Bacillariophyceae (37 taxa), Cyanophyceae (10 taxa), and Shizomycetes (1 taxon). And Soyulu & Gonülol, (2003) write 47 taxa was found in the plankton of the River Yellirmak

### Table 6. The Abundance and Diversity of Phytoplankton in Meranti Island

| Organism | Station |
|----------|---------|
| CYANOPHYCEAE (ind/L) | I | II | III |
| Trichodesmium | 8,7 | 5,8 | 464 |
| BACILLARIOPHYCEAE (ind/L) | | | |
| Steptotheca sp. | 2552 | 2871 | 3944 |
| Nitzchia sp. | 2204 | 1044 | 2517 |
| Chaetoceros sp. | 1189 | 435 | 1148 |
| Bacteriasum sp. | 58 | 0 | 928 |
| Bacillaria sp. | 1218 | 551 | 3109 |
| Thalassionema sp. | 29 | 29 | 348 |
| Thalassiothrix sp. | 0 | 0 | 1276 |
| Thalassiosira sp. | 348 | 3190 | 0 |
| Rhizosolenia sp. | 435 | 87 | 928 |
| Biddulphia sp. | 377 | 29 | 1740 |
| Ditylum sp. | 29 | 0 | 928 |
| Pleurosigma sp. | 174 | 203 | 2436 |
| Skeletonema sp. | 1566 | 3161 | 580 |
| Coscinodiscus sp. | 87 | 58 | 0 |
| Bellerocaea sp. | 203 | 232 | 0 |
| Cyclotella sp. | 0 | 29 | 2668 |
| Leptocylindrus sp. | 0 | 0 | 580 |
| Asterionella sp. | 0 | 0 | 116 |
| Navicula sp. | 0 | 0 | 0 |
| Amphora sp. | 2900 | 0 | 580 |
| Lauderia sp. | 0 | 0 | 0 |
| DINOPHYCEAE (ind/L) | | | |
| Peridinium sp. | 8,700 | 0 | 0 |
| Number of taxa | 17 | 14 | 18 |
| Density (ind/L) | 10672 | 11977 | 24290 |
| Heterogenity index | 2.14 | 1.75 | 1.91 |
| Evennes index | 0.75 | 0.66 | 0.66 |
| Domination index | 0.15 | 0.24 | 0.20 |
divided into Bacillariophyta (31 taxa), Euglenophyta (6 taxa), Cyanoprokaryota (6 taxa) and Chlorophyta (4 taxa).

Based on data's showed that the station 2 had lowest relatively of number of taxa, phytoplankton dense and a heterogeneity. The station 2 representative of mangrove rare showed the low of mangrove dense give negative impact for the potential of phytoplankton (Kruk et al., 2016; Su et al., 2015), because the mangrove density will support the potential of nutrient matter especially phosphate and nitrate were essential nutrient matter for phytoplankton to grow up (Berthold et al., 2018; Su et al., 2015). The primary factors controlling coastal phytoplankton distribution and growth are surface temperature, turbidity, river nutrient loads, and benthic and pelagic consumers (Su et al., 2015).

The data also showed that the number taxa of phytoplankton between 14 - 18 taxa’s with density between 10,672-24,290 ind/L, heterogeneity index between 1.75 - 2.14 and evenness index between 0.66 - 0.75. Gharib et al., (2011) observe 203 phytoplankton species which are influenced by marine environments, biotic and abiotic environmental factors give important effects for phytoplankton succession and abundance. Yan et al., (2012) note that in Xiaoqing River estuary has abundance of phytoplankton range from 0.6×104 to 213.30×104 cells.m⁻³ with species dominant are Skeletonema costatum, Tribonema affine, and Chlorella sp. Gharib et al., (2011) also noted that south-eastern Mediterranean Sea, Egypt is dominated by Bacillariophyta (61 genera, 120 species), Pyrrophyta (22 genera, 52 species) and in the freshwater ecosystem is dominated by Cyanophyta, Chlorophyta and Euglenophyta. In Southern Kyushu is dominated by Batillaria multiformis and B. Attramentaria (Yamamoto et al., 2018). Kruk et al., (2016) also note that the dominant taxa are Cyanoprokaryota, Bacillariophyta and Chlorophyta is lower than mangrove ecosystem in Meranti Island Regency. But, potential of phytoplankton taxa dominant in Meranti Island Regency is lower than Mahakam Delta which has 48 taxa phytoplankton belonging to Bacillariophyceae (35), Dinophyceae (6), Chlorophyceae (4), and Cyanophyceae (3). Tsuji & Montani, (2017) reported that the dominant suspended microphytobenthostaxa (Cocconeis spp. and Melosira varians) were mainly distributed in oligo- and mesohaline water, with peaks in mesohaline bottom water. In contrast, the dominant phytoplankton taxa (Skeletonema spp., Heterocapsa triquetra, and Prorocentrum spp.) were abundant at different salinity levels.

Basically, the abundance and diversity phytoplankton also can be used as the indicator of the density status of mangrove. The abundance and diversity of phytoplankton in station 2 (indicated as mangrove rare) lower than station 1 (moderate dense of mangrove) and station 3 (mangrove dense). This data showed that the mangrove density gave positive impact for the abundance and diversity of phytoplankton. The mangrove density will increase the abundance, the potential taxa and the density of phytoplankton.

The data also showed that the potential of phytoplankton in Meranti Island Regency had high relatively dense. The high density, abundance and number of taxa of phytoplankton in Meranti Island Regency indicated good condition of aquatic ecosystem in Meranti Island Regency. The water quality has positive correlation with potential of phytoplankton (George et al., 2013; Masuda et al., 2017; Su et al., 2015). The aquatic ecosystem in Meranti Island Regency had good water quality to aid growth of phytoplankton.

3.5. The abundance and diversity of zooplankton

Zooplankton is a type of plankton which has characteristic as animal using the coastal, lagoon and Estuary area as suitable habitat of zooplankton including copepoda as a micro crustacea dominated in the brackish ecosystem, sea or ocean (Kitamura et al., 2017; Mckinstry & Campbell, 2017; Ormanczyk et al., 2017). Zooplankton also has the important role of aquatic ecosystems and Estuaries areas (Honggang et al., 2012). The abundance and diversity of zooplankton bot of the number, domination index, heterogeneity index and evenness index of zooplankton in Meranti Island Regency were shown on Table 7.

The data explained that potential of zooplankton in Meranti Island Regency was dominated by Protozoa (Tintinnopsis sp. and Favella sp), (2) Crustaceae (Nauplius (stasias), Oithona sp., Euterpinia sp.. Eucalanus sp., and Paracalanus sp.), and (3) Larva of Polychaeta. The total taxa of zooplankton between 3 - 7, the density between 261 - 2204 ind/L, with heterogeneity between 0.86 - 1.61, evennesses between 0.79 - 0.83. Mckinstry & Campbell, (2017) collected 188 species of zooplankton in Alaska with Oithona similis, Limacina helicina, Pseudocalanus spp., and
Table 7. The abundance and diversity of zooplankton in Meranti Island

| Organism                          | Station |
|-----------------------------------|---------|
|                                   | I      | II     | III    |
| PROTOZOA (ind/L)                  |         |        |        |
| Tintinnopsis sp.                  | 29     | 0      | 232    |
| Favella sp.                       | 29     | 261    | 348    |
| CRUSTACEAE (ind/L)                |         |        |        |
| Nauplius (stasias)                | 29     | 174    | 870    |
| Oithona sp.                       | 145    | 29     | 464    |
| Euterpina sp.                     | 0      | 0      | 174    |
| Eucalanus sp.                     | 0      | 0      | 87     |
| Paracalanus sp.                   | 0      | 0      | 29     |
| LARVA OF POLYCHAETA (sp.1)        | 29     | 0      | 0      |
| Number of taxa                    | 5      | 3      | 7      |
| density (ind/L)                   | 261    | 464    | 2204   |
| Heterogenity index                | 1.30   | 0.86   | 1.61   |
| Evenness index                    | 0.81   | 0.79   | 0.83   |
| Domination index                  | 0.36   | 0.46   | 0.24   |

Acartia longiremis as dominant zooplankton. The dominants taxa are Oithona similis, Pseudocalanus spp., Limacina helicina, and Acartia longiremis. (Ormanczyk et al., 2017) emphasize that The zooplankton stock in Atlantic has average 524,878 ind.m⁻² (range: 428,700 - 596,600 ind.m⁻²). Whereas, zooplankton in Lake Nasser namely Copepoda, Cladocera and Rotifer and Protozoa (Khalifa et al., 2015).

Pratiwi et al., (2016) write that zooplankton community in Tangerang coastal has 12 groups of zooplankton that are Protozoa (2 genera) Rotifer (3 genera), Crustacea (5 genera and nauplius stage), Ctenophora (1 genus), Chaetognata (1 genus), Urochordata (3 genera) with abundance is 2,894,149 ind.m⁻³. Gülle et al., (2010) shows that the Lake Burdur has Six zooplankton taxa were determined, Hexarthra fennica, Brachionus plicatilis from Rotifer and Arctodiaptomus burduriicus from Copepoda were the dominant species. Average zooplankton density was 399,074 ind.m⁻³ and they were 51% H. fennica, 9% B. plicatilis and 40% A. burduriicus (Gülle et al., 2010). The potential of zooplankton was influenced by response of surrounds river mouth, organic matter and nutrient, and mangrove ecosystem. The number of zooplankton had positive correlation with mangrove density. The data on Table 7 showed that the mangrove dense had number taxa, density, heterogenity more than mangrove rare. This data show that mangrove ecosystem is a suitable habitat to support growth of zooplankton as nursery ground, feeding ground and spawning ground.

3.6. The model prediction of potential zooplankton and phytoplankton

The model prediction of potential zooplankton and phytoplankton used correlation between mangrove density as independent variable (X) with the potential of phytoplankton (Figure 2) and zooplankton (Figure 3) as dependent variable (Y). The model prediction of phytoplankton was the abundance of phytoplankton, \( y = 0.0303x^2 - 22.059x + 13004 \) (polynomial equation) and \( y = 11.637x + 8955.1 \) (linier equation). The model of zooplankton was the abundance of zooplankton, \( y = 0.0057x^2 - 5.3921x + 1458.2 \) (polynomial equation) and \( y = 2.2235x - 450.38 \) (linier equation).

4. Conclusions

Mangrove ecosystem in Meranti Island Regency has categorized rare - moderate have influence for abundance and diversity of phytoplankton and zooplankton. The number taxa of phytoplankton between 14 - 18 taxa’s, density between 910,600 - 10,846,000 ind sample⁻¹, heterogenity index between 1.75 - 2.14 and evennes index between 0.66 - 0.75. The total taxa of zooplankton between 3 - 7, the density between 2610 - 22040 ind/sample, with heterogenity between 0.86 - 1.61, evennes between 0.79 - 0.83. The grade of mangrove density gives the different potential of zooplankton and phytoplankton.

The best model to estimate plankton and zooplanton are abundance with mangrove trees density are the abundance of phytoplankton, \( y = 0.0303x^2 - 22.059x + 13004 \) and the abundance of zooplankton, \( y = 0.0057x^2 - 5.3921x + 1458.2 \).
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