Phytoplankton distribution and composition in the waters of Burung and Buntal islands, Kotania bay, western Ceram, Maluku, Indonesia

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Abstract. Start your abstract here Abstract. Phytoplankton distribution and composition was evaluated on February, April and June 2015, from Burung and Buntal islands in Kotania Bay. Altogether 42 species phytoplankton representing at least 27 genera from 15 families were collected. The high similarity of species was found in the waters of both islands, but the numbers of species were found in the waters of Buntal Island was higher than those in Burung island. Based on spatial distribution, the highest abundance of phytoplankton was encountered in the waters of Buntal island, while in June, the average abundance of phytoplankton reached the highest with the value of 1010225 cell/m³, and it was also in the waters of Buntal island. We speculate about the differences of a habitat of the two islands, and argue that the composition and abundant of species are related to the season and condition of the surrounding waters.

1. Introduction

The hydrography of Kotania bay is influenced by the monsoons, with southeastern winds prevailing between April and November and northwestern wind between December and March [1], and Kotania bay surrounding water is influenced by the mass waters of Banda Sea that rich of nutrients. Therefore, Kotania bay the waters have potentially a source of economic fishes, and the bay provides a significant income to fishermen and other coastal peoples. Currently, it is estimated that the catch activities has led to overfishing. Moreover, the artisanal fishers used poison and explosive fishing method that cause ecological disturbance to the waters. In some circumstance, the rapid changes of the waters qualities disrupt phytoplankton production [2].

Phytoplankton plays an important role in marine ecosystems, and they support and improve fisheries as a primary producer. Their role in the marine food chain is of paramount importance, and their abundance determine the amount and type of marine animals including fish which are caught commercially [3]. Distribution and composition of phytoplankton depend upon nature of the water. Therefore, the abundance and number of species may vary according to waters conditions.

Burung and Buntal islands of Kotania Bay surrounding waters provide good habitat for those minute marine floating algae as both islands are dominated by different productive ecosystems. Seagrass ecosystem dominated the shallow regions of Burung, island, meanwhile, mangrove ecosystem covers around the island of Buntal. As the neritic areas, the waters are highly productive, since the bottom traps sinking organic particles and some of the regenerated nutrients and return to the water column [4].

Beside the distribution and composition of phytoplankton, their abundance is also important to the marine life, and they can bloom under favorable conditions. Since phytoplankton is present in the lighted region of the sea, therefore they are abundant in the marine regions especially in the neritic ecosystems, but the similarity of species phytoplankton may vary in both waters (Burung and Buntal) according to...
the different of water conditions. Temporarily, temperature and salinity are the important factors to phytoplankton distribution and composition, and the abundant are also influenced by monsoons [5]. In a natural situation, other factors may influence the composition of phytoplankton, e.g. nutrients and light [6]. The phytoplankton is also distributed vary in space and time [7], and nutrients especially nitrate and phosphates play a major part in controlling the abundant of phytoplankton [4]. Therefore this study presents an analysis of the spatial-temporal distribution and composition of phytoplankton at the waters of Burung and Buntal islands, Kotania bay.

2. Material and Method
This study was conducted between February to June 2015 in the surrounding waters of Burung and Buntal islands in Kotania bay (Figure 1). This sampling period covered west and east monsoons and transition between those, and the sampling was done in every two months (February, April, and June) at six fix stations. This study is primarily concerned with the factors controlling the temporal distribution of phytoplankton in Kotania bay by subject to marked monthly changes in hydrography associated with changes in monsoon conditions and to analysis the distribution, composition and the abundance of phytoplankton and also the community structure between two habitats.

Phytoplankton was collected by towing plankton net sled fitted with a 64 µm meshed with a mouth area of 0.3 m² horizontally. The catch was preserved immediately in 4% formaldehyde in seawater. In the laboratory, phytoplankton samples were identified to species level whenever possible by following [8,9].

![Map of Sampling Sites](source: Bakosurtanal.com)

**Figure 1.** Map of sampling sites at Burung and Buntal islands of Kotania bay

The numbers of phytoplankton are calculated by computed the number cubic meter of seawater entered the net (V) and is analyzed based on the formula developed by [10] as follows:

$$A = \pi r^2 \cdot L$$  \hspace{1cm} (1)

Furthermore, the abundance of phytoplankton was counted followed the formula as follow:

$$D = \frac{N_{f} V_{p}}{V}$$  \hspace{1cm} (2)
Where D is the abundance of phytoplankton, Nf is the numbers of phytoplankton in a drop of sample, Vp is the numbers of a total drop of the sample and V is filtered sea water. The Shannon-Wiener diversity indices calculated using natural logarithms (H') were used to describe species diversity and species richness within phytoplankton during the study period [11] as follow:

\[ H' = -\sum_{i=1}^{s} P_i \ln P_i \]  

Where \( P_i \) is the proportion \( (n/N) \) of individual of one particular species found \( n \) divided by the total number of individuals found \( N \), and \( s \) is numbers of species. \( H' < 2 \) described as an unsteady community, while, \( H' 2 < H' < 3 \) is a fair community and \( H' > 3 \) is described as steady community.

Evenness Indices in the phytoplankton community is the degree to which individuals are split among species. The values can be determined [11] by using formula as follow:

\[ J' = \frac{H'}{H'_{\text{max}}} \]  

Where \( J' \) (Evenness index) is constrained between 0-1, \( H' \) is the number derived from Shannon diversity index, \( H'_{\text{max}} \) is the maximum possible value of \( H' \) (each species was equally likely), and \( S \) is a total number of species. Simpson's index (D) characterized species diversity in the phytoplankton community could be calculated by calculating the proportion of species \( i \) to the total number of species \( (P_i) \) and squared.

\[ D = \frac{n(n-1)}{N(N-1)} \]  

\( N \) is the total number of species of phytoplankton, and \( n \) is the total number of organisms of a particular phytoplankton species. Simpson's index of diversity is 1-D.

Similarity indices (S) could be determinate by using Sorenson's index as follows:

\[ S = \frac{2C}{A+B} \]  

Where C is the number of species the two communities have in common, A is the total number of species found in community A, and B is the total number of species found in community B.

3. Results and Discussions
The month of February to June 2015 was represented west monsoon and east monsoon and the transition between those, therefore the condition of the water especially temperatures of surface water changed. In April to May 2014, the sea surface temperature of Banda Sea was 28.93-30.45°C, while in June, temperatures of the surface waters decreased to 27.39-28.27 °C [12]. This study also found that the temperatures in all stations were 30-31°C in February, 28-32°C and 26-30°C in June (Table 1). Data of this study showed that the highest of temperature was in April (32°C) at Station 1 of the island of Burung and the lowest was also at those waters but at station 3 and it was also in June. The high temperature happened in the Banda Sea was in March to May during the dried monsoon [1].
### Table 1. Temperatures of surface waters (°C) of Burung and Buntal islands (February to June 2015)

| Months | Burung island | | | Buntal island | | |
|--------|--------------|---|---|--------------|---|---|
|        | St. 1 | St. 2 | St. 3 | St. 1 | St. 2 | St. 3 |
| February | 31    | 30    | 30    | 30    | 30    | 30    |
| April   | 32    | 30    | 28    | 31    | 30    | 31    |
| June    | 26    | 30    | 26    | 26    | 27    | 27    |

In the neritic waters, the change of temperature and salinity nearly occur together [6], even though, the fluctuation of the temperature was low. The ranges of salinities at all stations in the waters of both islands were reverse to the temperature (Table 2).

### Table 2. The salinities of surface waters (‰) of Burung and Buntal islands in February to June 2015

| Month | Burung island | | | Buntal island | | |
|-------|--------------|---|---|--------------|---|---|
|        | St. 1 | St. 2 | St. 3 | St. 1 | St. 2 | St. 3 |
| February | 32    | 31    | 33    | 31    | 32    | 32    |
| April   | 30    | 29    | 31    | 30    | 29    | 29    |
| June    | 34    | 36    | 33    | 36    | 33    | 34    |

In June, temperatures in the waters of both islands tended to decrease, while the salinity was on the contrary to temperature. The temperature in the waters varied considerably more than salinity; it found that the highest salinity and the lowest temperature were in June. The range of optimal temperature needed by marine organisms is from 20 – 30 °C [13]. The temperature and salinity at all stations of the study sites supported the marine organisms living on, as well as phytoplankton. Salinities range from stations of the island of Burung varied between 29 and 36 ‰, while at stations in the island of Buntal were 29 – 36 ‰. Those variation salinities value indicated that the water was categorised as shallow coastal waters [3] but have influenced by the open ocean as the Banda Sea. Partially, in the enclosed sea as Kotania bay salinities varied extremely, the condition indicated that the dynamic of hydrography parameters was influenced by several factors such as geography structure, water circulation, rainfall and precipitation [14, 4].

The highest salinity was at station 1 in the water of island of Buntal and station 2 of island of Burung. Both stations is closed to each others, therefore the stations had nearly the same salinity values. Furthermore, pH was the other hydrography parameters studied. It found that the range of pH at all stations was between 6 and 8 and most of the marine organisms including phytoplankton able to tolerate this condition, therefore nearly almost plankton organisms live in the waters with pH around 7-8.5 [13].

### 3.1. Phytoplankton Composition

There were 42 species of phytoplankton found at all stations, which consisted of 27 genera, five orders. Altogether they belong to four classes, e.g., Bacillariophyceae (26 species), Dinophyceae (12 species), Cyanophyceae and Cyanophyceae had only two species respectively. The result of this study found that phytoplankton species at all stations in the waters of Burung and Buntal islands were different in time and space (Table 3).The high number of species was in June at the station 1 of the island of Buntal. Accounting for about 42 species of phytoplankton encountered from both islands, as much as 41 species found in the waters of Buntal island which covered by mangrove ecosystem, Ceratium candelabrum did not occur at all stations in Buntal island and also species of Ornithocercus serratus and Ceratium confortum were absent at all stations of Burung island.

During the study, encountered 35 species of phytoplankton were present at all stations and it was in June. There were numbers of 28 species of phytoplankton encountered in February, while Bacteriastrum hyalinum, Hemiaulus haucki, Eucampia zoodiacus, Streptoteca indica, Rhizosolenia imbricate, R. stolterforthii, Leptocylindrus danicus, Stephanophyxis turris, Thalassiosira diporocylus occurred only in June. The differences species of phytoplankton occurred in the waters in the study sites, and they varied...
temporarily and spatially since the distribution of phytoplankton depends upon the conditions of the water.

**Table 3. Numbers of phytoplankton species at all stations**

| Months | Burung island | Buntal island | Total |
|--------|---------------|---------------|-------|
|        | Number of species | Number of species |      |
|        | St. 1 | St. 2 | St. 3 | St. 1 | St. 2 | St. 3 |      |
| February | 18 | 22 | 18 | 3 | 15 | 14 | 28 |
| April | 17 | 16 | 15 | 17 | 25 | 19 | 30 |
| June | 19 | 26 | 31 | 34 | 31 | 30 | 35 |

Phytoplankton belongs to class Bacillariophyceae, dominated the waters of both islands from February to June, it was about 70%, and 25 species encountered belonged to them (Figure 2), while the other classes were in less than 10%. This phenomenon showed that phytoplankton belongs to class Bacillariophyceae are capable of adapting the condition of the waters, where temperatures and salinities varied in time and space [3, 15].

3.2. *The Abundance of phytoplankton*

Quantitatively, the abundance of phytoplankton at all stations of the island of Burung and Buntal varied in numbers (Table 4). They occurred abundantly in June, especially at the stations in the island of Buntal.

**Table 4. The abundance of phytoplankton in the waters of island of Burung and Buntal**

| Month   | Phytoplankton of island of Burung (cell/m³) | Phytoplankton of island of Buntal (cell/m³) |
|---------|-------------------------------------------|-------------------------------------------|
|         | St. 1 | St. 2 | St. 3 | St. 1 | St. 2 | St. 3 |
| February | 123749 | 96907 | 292311 | 31392 | 209190 | 23749 |
| April    | 188694 | 80050 | 121019 | 55359 | 164813 | 112202 |
| June     | 84850 | 405596 | 1376706 | 1725478 | 1343039 | 1125682 |
Figure 2. Composition of phytoplankton in the waters of the island of Burung and Buntal (February, April and June 2015)

The abundant of phytoplankton at all stations of both islands ranged between 23749 and 1725478 cell/m3. The high abundance was found in June and at station 1 of island of Buntal and the lowest was also at station 3 of island of Buntal and it was found on February. These phytoplankton numbers were higher than the result found from Ambon bay [5]. The abundance of phytoplankton in stations of the island of Burung was highest at station 3 and the lowest was at 2. Even though both islands were dominated by productive ecosystem, e.g., mangrove and seagrasses, it is argued that the mangrove which covered island of Buntal more productive than seagrasses in the shallow part of the island of Burung. This result reflected the important of the coastal ecosystem in supporting the abundant of phytoplankton as the foundation of the marine food chain [3].

Table 5. The correlation between hydrography parameters and the abundance of phytoplankton at all stations of island of Burung and Buntal (February to June 2015)

| Variables                | Regression (alpha = 0.05) | r   | R²  |
|--------------------------|---------------------------|-----|-----|
| Temp. (x) abundance (y)  | \( y = 61278.72 - 1968.18x \) | -0.712 | 0.507 |
| Salinity (x) abundance (y)| \( y = -45402 + 1552.773x \) | 0.613 | 0.375 |
| pH (x) abundance (y)     | \( y = 30474.29 - 3694.76x \) | -0.389 | 0.151 |
Figure 3. The correlation of temperatures and the abundance of phytoplankton at all stations

The result in Table 5 explained that the abundance of phytoplankton in the waters of both islands was influenced by hydrographic parameters dynamic, such as temperatures and salinities (Figure 3 and 4). Therefore, it can be stated that the variations of the abundance of phytoplankton in the waters of both islands influenced by monsoons and the temperature and salinity value depend on the weather or monsoons. This study detected that the temperature and salinity varied in time and space with was followed by the abundance of phytoplankton. Overall, the temperature was the most influenced the abundance of phytoplankton and also happened to the phytoplankton diversity.

Figure 4. The correlation of temperatures and the abundance of phytoplankton at study sites.

3.3. Diversity, Evenness, dominance, and Similarity of phytoplankton at all stations

The steady-state of phytoplankton communities at all stations in the water of island of Burung and Buntal estimated by computing the diversity of species using Diversity index which based on the number of species of phytoplankton present (richness) in the stations and the number of individuals per species, therefore the more species found, the more diverse the phytoplankton found. The dominance and similarity of phytoplankton defined which species dominated the others, and the similarity of different communities, showed by numbers of species present in one community and not in others [11]. Phytoplankton has different types and quantities, therefore the diversity of species of phytoplankton should be analyzed to get more detail information of the community structure.
Table 5, shows that the diversity of phytoplankton community at station 1 in the island of Buntal higher than other stations. In common, it revealed that phytoplankton community of island of Buntal waters (2.181 – 2.872) more diverse than at stations in island of Burung (1.524 – 2.738).

**Table 6. The diversity (H’) of phytoplankton communities of island of Burung and Buntal**

| Month | Burung island | Buntal island |
|-------|---------------|---------------|
|       | St. 1 | St. 2 | St. 3 | St. 1 | St. 2 | St. 3 |
| February | 2.168 | 2.409 | 2.268 | 2.008 | 1.949 | 2.192 |
| April   | 1.524 | 1.726 | 1.817 | 2.181 | 2.612 | 2.577 |
| June    | 2.356 | 2.495 | 2.738 | 2.872 | 2.682 | 2.736 |

The diversity value at all stations (Table 6) were higher in June than other months especially at station 1 in the water of island of Buntal (2.872), it can be said that June is more productive than others months, even though the values of diversity index were not reached the value of >3 (steady-steady) because the presence of some species in high numbers. It seemed that the waters were in rich condition during the wet season since the runoff flow from the coastal area and the mangrove ecosystem reached the waters [2]. In the other side, the evenness of the phytoplankton communities at all stations of both glasses of water reached a high value (Table 6).

**Table 7. The values of diversity index (H’) of the communities at all stations**

| Month | Burung island | Buntal island |
|-------|---------------|---------------|
|       | St. 1 | St. 2 | St. 3 | St. 1 | St. 2 | St. 3 |
| February | 2.168 | 2.409 | 2.268 | 2.008 | 1.949 | 2.192 |
| April   | 1.524 | 1.726 | 1.817 | 2.181 | 2.612 | 2.577 |
| June    | 2.356 | 2.495 | 2.738 | 2.872 | 2.682 | 2.736 |

Evenness index (J’) of the phytoplankton community in both glasses of water showed the equality of the phytoplankton community. The Phytoplankton from all stations was in equally as an individual and a total number of species. The highest was at the degree of 0.875 from 0-1, and it was at stations 3 in the water of island of Buntal (Table 7). While, the dominant species in the community of phytoplankton at both glasses of water were high at station 2 (0.462) in the water of island of Burung and it was in April, while the lowest was at station 3 (0.125) in the waters of the island of Buntal (Table 8).

The Simpson’s index (D) of phytoplankton from both glasses of water characterized that there were some species dominated the communities. In February, at the waters of island of Buntal, *Trichodesmium erithraeum* (7097 cell/m³ out of 23749 cell/m³) were dominant at station 3, while in April, *Ceratium tripos* was dominant (20 937 cell/m³ and *Trichodesmium erithraeum* (16642 cell/m³) from the total numbers of 112202 cell/m³). While in June, *Biddulphia sinensis* (197225 cell/m³), *Chaetoceros decipiens* (154231 cell/m³), *Rhizosolenia alata* (149454cell/m³), and *Climacodium fraunfeldianum* (83258 cell/m³) from the total of 1125682 cell/m³. The phytoplankton community in the water of both islands had their characteristic species structure depended on their habitat [16].
Table 8. The degree of Evenness ($J'$) index of phytoplankton at all stations

| Month | Burung island | Buntal island |
|-------|---------------|---------------|
|       | St. 1          | St. 2          | St. 3          | St. 1          | St. 2          | St. 3          |
| February | 0.750          | 0.779          | 0.785          | 0.783          | 0.720          | 0.831          |
| April   | 0.538          | 0.623          | 0.671          | 0.770          | 0.811          | 0.875          |
| June    | 0.786          | 0.766          | 0.797          | 0.814          | 0.781          | 0.804          |

Table 9. Dominancy index (D) of phytoplankton communities at all stations

| Month | Burung island | Buntal island |
|-------|---------------|---------------|
|       | St. 1          | St. 2          | St. 3          | St. 1          | St. 2          | St. 3          |
| February | 0.250          | 0.221          | 0.215          | 0.217          | 0.280          | 0.169          |
| April   | 0.462          | 0.377          | 0.329          | 0.230          | 0.189          | 0.125          |
| June    | 0.214          | 0.234          | 0.203          | 0.186          | 0.219          | 0.196          |

The similarities index of phytoplankton at all stations showed that the percentage of the similarity ranged from 73-96%. This data revealed that phytoplankton communities between stations in the water of island of Burung and Buntal in time and space were similar. This condition was supported by the value of Dominancy index which was low.

Table 10. The percentage of similarities index (S) between space (habitat) and times at all study sites

| Dimension | Object                  | S   | Percentages |
|-----------|-------------------------|-----|-------------|
| Spatial   | Burung and Buntal islands | 0.963 | 96.3        |
| Temporal  | February and April       | 0.897 | 89.7        |
|           | February and June        | 0.730 | 73.0        |
|           | April and June           | 0.738 | 73.8        |

Phytoplankton communities in the waters of the island of Burung and Buntal were similar significantly, as well as the species between station and time. This condition reflected that almost phytoplankton species occurred in the waters of the island of Burung and Buntal supported the productivity of the surrounding waters.

4. Conclusion
The temporal and spatial distribution of phytoplankton and the abundance were influenced by the changes of hydrography parameters (temperature and salinity) which reflected by the value of coefficient correlation $r = -0.712$ for temperature and $r = 0.613$ for salinity. At the same time, the monsoon influenced the value of temperature and salinity. At least 42 species of phytoplankton encountered at all station, and the high abundance was in June. The mangrove ecosystem which covered the island of Buntal supported the abundance of phytoplankton compare to seagrass ecosystem in the shallow water of island of Burung. The species of phytoplankton community occurred in equally at all the study sites. Further, the phytoplankton community structure reflecting by diversity index in showed that the community was in a fair state.

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