Phytoplankton species distribution around the fishing ground of Oma waters, Central Maluku, Indonesia

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Abstract. Oma water is directly related to the Banda Sea, which causes this water to have the highest diversity of fisheries resources. Oma waters is a potential fishing ground for small and big pelagic fishes. One of the most important pieces of information on the abundance of small fishes in this area is the abundance of phytoplankton. Until now, there was not any information available on phytoplankton species composition as well as its abundance. The objective of this research was to study the species composition of phytoplankton, its abundance and, some ecological indices. Sampling was carried out in April 2017 at a 14-fixed sampling station using Kitahara plankton net. Sampling was conducted vertically from 20 meters depth to the surface water. Hydrological parameters such as temperature, salinity, pH, and water transparency were measured in-situ. Nitrate and phosphate were analyzed in a chemical laboratory in LIPI-Ambon. The total of 65 phytoplankton species was identified from the study area and can be grouped into Bacillariophyceae, Dinophyceae, and Cyanophyceae. Bacillariophyceae has dominated this phytoplankton species composition (70.70%). A total abundance of phytoplankton in this study area varied from 1.09 x 10^5 cells l^-1 to 5.70x10^5 cells l^-1. The five dominant species found in this study were Guinardia flacida, Thalassionema nitzschioides, Skeletonema costatum, Thalassiosira gravida, Chaetoceros curvisetus, and The Shannon diversity index (H') varied from 1.447 to 2.774. The evenness index (J') was between 0.404 and 0.738. The dominance index was from 0.262 to 0.596. Phytoplankton abundance had a positive correlation with water transparency and salinity, whereas the number of phytoplankton had a positive correlation with seawater temperature and nitrate concentration.

1. Introduction

Oma waters is directly related to the Banda Sea, which causes this water to have the highest diversity of fisheries resources. Oma waters is a potential fishing ground for small and large pelagic fishes, such as mackerel, flying fish, and Scombridae. The abundance of these fishes strongly depends on the oceanographic condition like physical, chemical, and biological aspects including plankton.

Plankton plays an important role in the marine ecosystem, and also plays a fundamental role in marine biodiversity and bio-productivity in the marine ecosystem. Plankton consists of phytoplankton and zooplankton [1, 2]. Phytoplankton species are autotrophic organisms and the most important producer of organic material in the aquatic environment, which determines the basic primary producer in the ecosystem [3]. The abundance of phytoplankton will determine the population density of marine animals and their reproductive cycle. Phytoplankton is used as a food for marine animals like zooplankton and fishes in the next trophic level [4].

Plenty of researches on phytoplankton species composition and its abundance has been conducted in Maluku waters [5, 6, 7, 8, 9]. Presently, there is almost no information available on phytoplankton communities in Oma waters including species composition and its abundance. To fill lack of this information, therefore, the research is needed. The objectives of this research are to determine phytoplankton species composition, its abundance, species diversity and to describe the physic-chemical parameter related to phytoplankton abundances.
2. Materials and Method

2.1. Field work

Sampling was carried out in Oma waters, Central Maluku, Eastern Indonesia. Geographically, Oma village is located on 3°37’50” S - 3°37’25” S and 128°25’50” E - 128°23’30” E. Sampling was conducted in April 2017 from 14-fixed station twice a month (Figure 1). The position of the sampling site was determined using GPS-Garmin model 76CSx.

Figure 1. Map of sampling site

The water sample was taken by using a Niskin bottle. The temperature of the seawater was measured using a thermometer, the salinity was measured using a refractometer, while pH is measured using a pH meter. The water transparency was determined using a sechi disc with a diameter of 30 cm. As many as 250 ml of seawater was taken to determine the concentration of NO3-N and PO4-P. These parameters were determined based on the standard method recommended by Parson et al (1984) [10] using a spectrophotometer at the Chemistry Laboratory of LIPI Ambon.

Phytoplankton samples were taken vertically from the depth of 20 meters to the surface water using 60 µm meshes of Kitahara plankton net with a mouth area of 30 cm. Phytoplankton samples were preserved with 4% formaldehyde immediately. Phytoplankton was identified to the species level following Yamaji [11] and Tomas [12].

2.2. Data Analysis

The abundance of phytoplankton was determined based on [13] with the following formula:

\[ D = \frac{N_f \times V_p}{V} \]

where:
- \( D \) : phytoplankton abundances (cell.m\(^{-3}\))
- \( N_f \) : number of cell in 1 ml subsample
- \( V_p \) : volume of diluted sample
- \( V \) : volume of filtered water (m\(^3\))

The volume of filtered water is measured using the formula by [13] as follows:
Where: \( V \): volume of filtered water (in m\(^3\))
\( \pi \): 3.14
\( r \): radius of net opening (in m), squared
\( L \): length (distance net was towed, in m)

The Similarity index of the phytoplankton between stations in Oma waters was analyzed using PRIMER 5 software using the Bray-Curtis similarity index. The ecological indices such as the Shannon-Wiener diversity index \( (H^\prime) \), Pielou’s Evenness index \( (J^\prime) \), and dominancy index (Simpson index, \( D \)) were analyzed using PRIMER 5 software.

3. Result and Discussion

3.1. Phytoplankton species composition

A total of 66 species of phytoplankton were found in Oma waters (Table 1) during this study which consists of three classes namely bacciliariophyceae (diatom), dinophyceae (dinoflagellate), and cyanophyceae. The number of species varied between stations (Figure 2). Diatom was predominated phytoplankton species composition in this area (46 species, 70.77%). Dinoflagellate was the second important group which comprises of 18 species (27.69%). Cyanophyceae was represented by one species namely *Trichodesmium erythraeum* (1.54%). Diatom was the predominant group of phytoplankton found in Maluku surrounding waters [3, 4, 5, 6, 7, 8, 9].

### Table 1. Phytoplankton species composition

| No | Species                  | No | Species                  | No | Species                  |
|----|--------------------------|----|--------------------------|----|--------------------------|
| 1  | *Lauderia annulata*      | 23 | *B. furcatum*            | 45 | *Navicula directa*       |
| 2  | *Planktoniella sol*      | 24 | *Chaetoceros aequatoralis* | 46 | *Nitzschia longissima*  |
| 3  | *Skeletonema costatum*   | 25 | *C. affinis*             | 47 | *Pseudonitzschia australis* |
| 4  | *Thalassiosira gravida*  | 26 | *C. coarctatus*          | 48 | *Dinophysius caudata*    |
| 5  | *T. hyalina*             | 27 | *C. compressum*          | 49 | *Ceratium furca*         |
| 6  | *Melosira nummuloides*   | 28 | *C. curvisetus*          | 50 | *C. fucus*               |
| 7  | *Stephanophyxis turris*  | 29 | *C. danicus*             | 51 | *C. horridum/horrida*    |
| 8  | *Coscinodiscus radiatus* | 30 | *C. atlanticus*          | 52 | *C. inflatum*            |
| 9  | *C. centralis*           | 31 | *C. messanensis*         | 53 | *C. lunula*              |
| 10 | *Glosleriella tropica*   | 32 | *C. decipiens*           | 54 | *C. macroceros*          |
| 11 | *Pseudoguinardia recta* | 33 | *C. didymus*             | 55 | *C. tripos*              |
| 12 | *Asteromphalus sp*       | 34 | *C. diversus*            | 56 | *C. trichoceros*         |
| 13 | *Rhizosolenia imbricata* | 35 | *C. laevis*              | 57 | *C. pulchelum*           |
| 14 | *R. decipiens*           | 36 | *C. laevis*              | 58 | *C. vultur*              |
| 15 | *R. robusta*             | 37 | *C. lorenzianus*         | 59 | *Pyrocystis lunula*      |
| 16 | *R. setigera*            | 38 | *C. pseudovasivus*       | 60 | *P. noctiluca*           |
| 17 | *P. calcar-avis*         | 39 | *C. diadema*             | 61 | *Protoxanthis lunula*    |
| 18 | *Guinardia striata*      | 40 | *Odonella sinites*       | 62 | *P. depressum*           |
| 19 | *G. flacida*             | 41 | *Thalassionema nitzschioides* | 63 | *P. oceanicum*           |
| 20 | *G. delicalata*          | 42 | *Thalassiothrix longissima* | 64 | *Alexandrium affine*     |
| 21 | *Eucampia cornuta*       | 43 | *Pleurosigma directum*   | 65 | *Pyrophacus stenii*      |
| 22 | *Bacteriastrum hyalinum* | 44 | *P. normanii*            | 66 | *Trichodesmium erythraeum* |
Diatom is one of the important organisms in marine environment [3, 4, 10, 13]. Diatom and dinoflagellate are common and abundant in the marine ecosystem [10, 14]. Based on the number of species found in this study area (Figure 2), station 1 and station 8 had the lowest species richness (36 species) while Station 10 had the highest species richness (48 species).

These species are widely distributed along the sampling sites and capable to adopt environmental conditions where they live. In natural biotic communities, they contain few common species, represented by a large number of individual or large biomass, and a large number of species that are rare [15].

It can be seen from Table 1, there were six species found only in certain stations namely Chaetoceros pseudocurvisetus, Pleurosigma normani, Navicula directa from diatom; Ceratium inflatum, Protoperidinium conicum, and Protoperidinium oceanicum from dinoflagellate. These species were rare and showed narrow distribution, which is accounted for less than 0.05%, respectively, of the total abundance of phytoplankton.

3.2. Phytoplankton abundance

The abundance of phytoplankton varied from 109193 cells l\(^{-1}\) to 569951 cells l\(^{-1}\) (Figure 3). The lowest abundance recorded at station 8 and the highest was at station 10. The highest abundance of phytoplankton at station 10 correlated to the highest concentration of nitrate and phosphate (see Table 2). The quality of seawater especially nutrients influences the phytoplankton population. Phytoplankton requires nitrate and phosphate for their growth and reproduction [1, 3]. The dense population of phytoplankton helps in producing more oxygen than it consumes and therefore plays an important role in compensating for respiratory losses without increasing further energy expenditures [14].
Spatial distribution of phytoplankton in Oma waters during this research showed that station 10 and station 14 had the highest abundance of phytoplankton. Whereas, the lowest abundance was recorded at station 8, station 2, station 3, and station 4 (Figure 4). As previously mentioned, the highest abundance of phytoplankton correlated to the high concentration of nitrate and phosphate in this study, while the lowest abundance was due to low nutrient concentration.

Despite of its dominance in species number, diatom also showed the highest abundance, which compresses more than 90% of the total phytoplankton in this study area (Table 2). This is because the diatom is always found in chain form. The five important species of phytoplankton recorded in our study were *Guinardia flacida*, *Thalassionema nitzschioides*, *Skeletonema costatum*, *Thalassiosira gravida* and *Chaetoceros curvicetus* (Figure 5). These species encountered 44-79% of total phytoplankton abundances (an average of 63.97 %). All of these species are found in chain form. Several studies before showed that diatom was always found in the highest abundance in normal conditions [6, 8].
Table 2. The abundances (%) of three classes of marine phytoplankton found in this study

| Station | Diatom | Dinoflagellate | Cyanophycea |
|---------|--------|----------------|-------------|
| 1       | 98.57  | 0.76           | 0.67        |
| 2       | 97.69  | 1.51           | 0.80        |
| 3       | 97.94  | 1.45           | 0.62        |
| 4       | 94.28  | 4.90           | 0.82        |
| 5       | 99.23  | 0.62           | 0.15        |
| 6       | 98.78  | 0.54           | 0.69        |
| 7       | 97.39  | 1.10           | 1.50        |
| 8       | 86.45  | 6.64           | 6.92        |
| 9       | 97.10  | 1.14           | 1.76        |
| 10      | 95.89  | 0.82           | 3.29        |
| 11      | 98.70  | 0.50           | 0.81        |
| 12      | 97.58  | 0.86           | 1.56        |
| 13      | 98.50  | 0.89           | 0.61        |
| 14      | 98.22  | 0.77           | 1.00        |
| Total   | 96.88  | 1.61           | 1.51        |

Figure 5. The five dominant species of phytoplankton found in Oma waters

3.3. Phytoplankton species diversity

The diversity of phytoplankton in Oma waters was described by Shannon-Wiener diversity index ($H'$), Pielou’s evenness index ($J'$), and Simpson’s dominance index ($D$), and its shown in figure 6. Theoretically, the Shannon-Wiener index varies from 0 to infinity and increases with diversity increase. The value of $H'$ varied between 1.447 at station 8 and 2.774 at station 2. The value of $H' < 2$ indicated that the species diversity is lower, while the value of $H' > 4$ indicated that the diversity is higher [16]. It was also stated that the highest diversity index correlated to the number of species present (species richness) and the evenness with which the individuals are distributed among this species (species evenness or species equitability). The greater the number of species and the more nearly equal their proportion, the greater the diversity [16, 17]. Generally, the Shannon-Wiener diversity index ($H'$) illustrated that the diversity of phytoplankton on a Oma waters was in moderate scale.

Pielou’s evenness index ($J'$) measures the equitability or equidistribution of the species in the stations in comparison with equal theoretical distribution for all the species [16]. The value of $J'$ was from 0.4039
to 0.7376. The Pielou’s Evenness index (J’) also showed the same pattern with the Shannon-Wiener diversity index (H’). The highest J’ found at station 2 and the lowest was at station 8. Pielou’s evenness index (J’) was scaled from 0-1. The value of J’ = 1 indicated that the equal number of individuals distributed along with each species present in the community, while it is 0 when the single species dominates the whole population [17].

The Simpson’s dominance index (D) varied from 0.2624 to 0.5961. It can be seen from Figure 4 that the lowest dominance was recorded at station 2 and the highest found at station 8. The highest dominance index in station 8 due to the highest abundance of *Thalassionema nizschioides* (41.12 % of total phytoplankton abundance), *Skeletonema costatum* (12.11%), and *Thalassiosira gravida* (9.17 %). The value of D was scaled from 0-1. D = 1 indicated the maximum value of dominance (complete dominance), while D = 0 illustrated that there is not any dominant species in the community [17].

![Figure 6. Phytoplankton species diversity indices from Oma waters](image)

### 3.4. Physical and chemical characteristic of water

During the sampling period, the seawater temperature of Oma waters in April 2017 varied from 27.00°C to 29.50°C with the minimum recorded at station 14 and the maximum at station 8. The salinity varied between 31.5 ‰ at station 1 and 33.5 ‰ at stations 8 and 9. Water transparency was at 16 m 18 m depth. The pH was stable in all stations. The phosphate was measured between 0.001 mg P/l at station 8 and 0.06 mg P/l at station 10 (Table 3). These water quality parameters showed small variation between stations, except the value of pH, which was stable at all stations. It is well known that phytoplankton can grow rapidly at the temperature from 10 °C to 30°C and always dominate by diatom [14].

The Spearman’s correlation to assess the correlation between phytoplankton abundance, the number of species, and physical dan chemical parameters in Oma water was shown in Table 4. It was shown in Table 4 that phytoplankton abundance showed positive correlation with water transparency (r = 0.8524) and salinity (r = 0.6811). Phytoplankton always presents in the upper layer in which they require light to drive photosynthetic carbon fixation, therefore water transparency is an important factor for phytoplankton. The number of phytoplankton species recorded in this research had positive correlation with seawater temperatures (r = 0.9311), and nitrate concentration (r = 0.7923). Some phytoplankton species can reproduce rapidly at moderately high temperature (15 to 21°C) for auxospthora formation [14].
### Table 3. Water quality parameters in Oma waters on April 2017

| Station | Temperature (°C) | Salinity (‰) | pH | Transparency (m) | PO4 (mg P/l) | NO3 (mg N/l) |
|---------|-----------------|---------------|----|-----------------|--------------|--------------|
| 1       | 28.50           | 31.5          | 8  | 17              | 0.0404       | 0.0248       |
| 2       | 29.34           | 32.0          | 8  | 17              | 0.0108       | 0.0079       |
| 3       | 29.00           | 32.0          | 8  | 18              | 0.0059       | 0.0059       |
| 4       | 29.00           | 32.5          | 8  | 17              | 0.0059       | 0.0064       |
| 5       | 28.50           | 33.0          | 8  | 17              | 0.0108       | 0.0113       |
| 6       | 28.50           | 33.0          | 8  | 17              | 0.0138       | 0.0084       |
| 7       | 29.00           | 33.0          | 8  | 17              | 0.0354       | 0.0059       |
| 8       | 29.50           | 33.5          | 8  | 18              | 0.0001       | 0.0084       |
| 9       | 29.00           | 33.5          | 8  | 18              | 0.0305       | 0.0054       |
| 10      | 29.34           | 33.0          | 8  | 18              | 0.06         | 0.0874       |
| 11      | 27.00           | 33.0          | 8  | 18              | 0.0305       | 0.0486       |
| 12      | 27.50           | 32.5          | 8  | 17              | 0.0207       | 0.006        |
| 13      | 28.34           | 32.0          | 8  | 17              | 0.0305       | 0.0805       |
| 14      | 27.00           | 32.0          | 8  | 16              | 0.0502       | 0.0889       |

### Table 4. The correlation between physical-chemical parameter and phytoplankton abundance and number of species

| Parameters                  | Temperature  | Salinity  | Transparency | PO4-P | NO3-N | Phytoplankton abundance | Number of species |
|-----------------------------|--------------|-----------|--------------|-------|-------|-------------------------|------------------|
| Temperature                 | 0            | 0.2534    | 0.17038      | 0.23575 | 0.17436 | 0.1253                   | 0.9311           |
| Salinity                    | 0            | 0.03191   | 0.71893      | 0.37814 | 0.6811 | 0.8524                   | 0.3049           |
| Transparency                | 0            | 0.42474   | 0.56384      | 0.07726 | 0.0112 | 0.0007                   | 0.0808           |
| PO4                         | 0            | 0.0000    | 0.0000       | 0.0000 | 0.0000 | 0.0000                   | 0.0000           |
| NO3                         | 0            | 0.1177    | 0.7923       | 0.0000 | 0.0000 | 0.0000                   | 0.0000           |
| Phytoplankton abundance     | 0            | 0         | 0            | 0.0186 | 0.0000 | 0.0000                   | 0.0000           |
| Number of species           | 0            | 0         | 0            | 0      | 0      | 0                        | 0.0000           |

### 4. Conclusion

In total, there were 66 species of phytoplankton recorded in Oma waters during this study, which comprises three classes, namely diatom, dinoflagellate, and cyanophycea. Diatom was the predominant group of phytoplankton in this area. The abundance of phytoplankton varied from 107461 cells l\(^{-1}\) to 569951 cells l\(^{-1}\) in which the highest abundance was recorded at station 10 with a high concentration of nitrate and phosphate. Shannon-Wiener diversity index of phytoplankton community in Oma waters can be categorized as moderate diversity and moderate evenness index, while some stations showed the highest dominance index. Phytoplankton abundance had a positive correlation with water transparency and salinity, whereas the number of phytoplankton had a positive correlation with seawater temperature and nitrate concentration.

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