Phytoplankton abundance as a preliminary study on pearl oyster potential culture development in the North Gorontalo water, Indonesia

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Abstract. Kwandang water, Northern Gorontalo is considered as a very potential area for marine aquaculture especially the pearl oyster cultivation. However, a study of this prospective has not been published. The realization of the pearl oyster farming is affected by several factors. One of the factors that influence the success of oyster farming is the selection of proper location, which has suitable water quality for marine biota and good water productiveness as well in term of the abundance of phytoplankton. This study aims to analyze the abundance of phytoplankton as one of the biological parameters for the development of pearl oyster culture in the North Gorontalo area. The research method used is explorative by survey. The measurement of physical and chemical parameters is conducted in situ, while the biological parameter (phytoplankton) analysis is carried out in the laboratory. The results show that the North Gorontalo water qualifies as a good site for pearl oyster culture based on the abundance of phytoplankton.
Key Words: marine biota, cultivation, proper location, water quality, Kwandang water.

Introduction. Pearl oysters are one of the potential organisms that can be developed as part of the cultivation industry. The term "pearl oysters" has traditionally been applied to bivalves of the *Pinctada* and *Pteria* genera, included in the family Pteridae and most species of Pteridae are tropical and subtropical, but the distribution of some species extends to higher latitudes (Wada & Têmkin 2008).

Pearls have been considered as treasured, symbols of wealth, power, and prestige, as well as an object of devotion and respect (Strack 2008). Currently, the cultivation of pearl oyster is one of the prospect businesses in Indonesia, especially its potential that has not been developed optimally. Potential land for the development of pearl shellfish cultivation and abalone in Indonesia amounted to 62,040 Ha (Hamzah 2007).

In Indonesia, pearl oysters are one of the important commodities with economic potential value of 120 million US$ (Dahuri 2000). In addition, the territorial waters of eastern Indonesia such as Papua, Arafuru and Sulawesi Islands, have a great potential for pearl oysters. Gorontalo is one of the areas in eastern Indonesia that has a wide coastal area so it has a great potential for the development of pearl oyster.

Development of cultivation that currently exists in the North Gorontalo waters is the cultivation of fish in floating cage and seaweed, while the cultivation of pearl oyster has not been glanced. In establishing a pearl cultivation business, the cultivation location plays an important role for successful pearl oyster production. Good cultivation sites should meet technical requirements such as water quality, water productiveness, fry and host resources, supporting facilities, security, markets and transportation (Fathurrahman et al 2015).

Pearl oysters belong to the group of herbivores that do not require additional food because they feed phytoplankton that naturally occur (Matthiessen 2001; Powell et al 2002; Powell 2004; Fernandez et al 2006). As the phytoplankton is the main food, its biochemical composition plays a key role in nutrition quality and its function for bivalve (Faturrahman et al 2015).

This study aims to analyze the abundance of phytoplankton as a biological parameter for the development of pearl cultivation in North Gorontalo waters. This research is expected to provide basic information in the early efforts of developing the research area into a pearl oyster cultivation region in the future, especially by promoting the development of community-based pearl oyster cultivation.

Material and Method

Description of the study sites. The sampling was carried out from May to July 2017 in the waters of North Gorontalo Regency with the sampling points taken in 4 stations (Figure 1). Station 1 was located in the administrative area of Dunu Village (00°56′52.2″N and 122°38′28.4″E), station 2 was located in the administrative area of Tolango Village (00°52′50.2″N and 122°45′30.7″E), station 3 was located in the administrative area of Garapia Village (00°53′19.9″N and 122°44′13.2″E), and station 4 was located in the administrative area of Monano Village (00°53′40.2″N and 122°41′48.2″E).

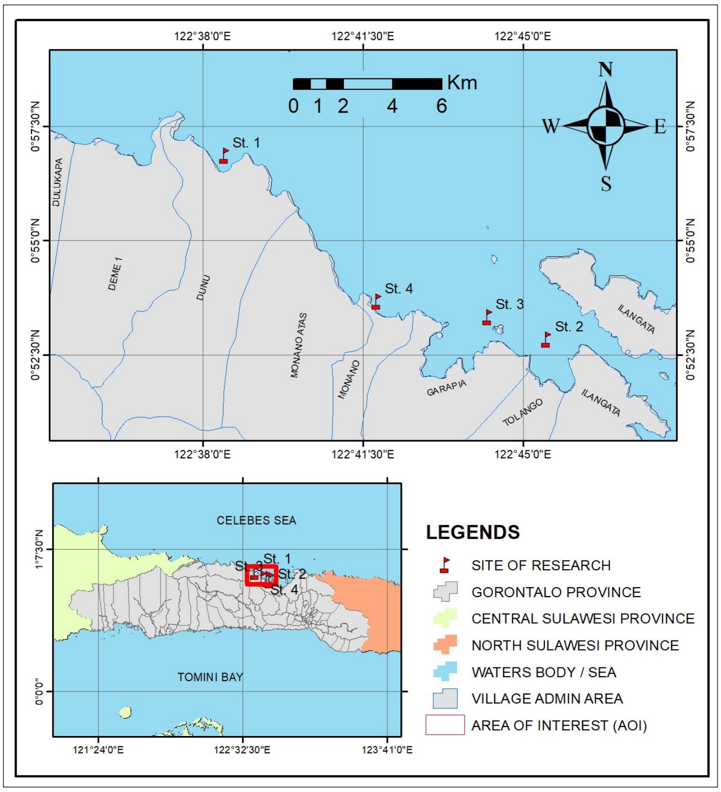

Figure 1. Map of study location.

Phytoplankton sampling. The main data collected in this research is phytoplankton data as biological parameter and physico-chemical data of water as supporting data. Phytoplankton samples were taken using plankton net (size 25 μm) vertically from 5-7 meters in depth and horizontally in surface. The filtered water sample is preserved by adding 1% Lugol solution. The physico-chemical data such as temperature, salinity, pH, and dissolved oxygen were obtained using WTW Oxi 3210 Set 1 and Schott Instruments handylab pH/LF 12 Set, correspondingly by directly measurement at the sampling sites.

Data analysis. The abundance of phytoplankton was observed using a sweeping method above the Sedgwick Rafter glass object with individual units per milliliter (ind mL^{-1}). The abundance of phytoplankton type was calculated based on equations according to APHA (2012), as follows:

$$N = \frac{oi}{op} x \frac{Vr}{Vo} x \frac{1}{Vr} x \frac{n}{p}$$

Where:
N : phytoplankton abundance (ind mL^{-1});
Oi : cover-glass area (mm^2);
Op : view area (mm^2);
Vr : filtered water volume (mL);
Vo : observed water volume (mL);
n : number of phytoplankton in the entire view area;
p : number of view areas.

Results

Phytoplankton abundance. The results of identification and calculation of phytoplankton abundance found in the study sites are presented in Table 1.

Table 1

Abundance of phytoplankton species in the study sites

No	*Phylum*	*Species*	*Station 1*	*Station 2*	*Station 3*	*Station 4*
1	Chlorophyta	*Cosmarium* sp.	476.25	317.50	562.24	694.53
2		*Hyalotheca mucosa*	0	1058.33	0	0
3		*Chlorella* sp.	793.75	2381.24	926.04	0
4		*Golenkinia* sp.	330.73	231.51	0	198.44
5		*Pediastrum simplex*	2116.65	529.16	3208.05	3174.98
			3717.38	**4517.74**	**4696.33**	**4067.95**
1	Chrysophyta	*Achnanthes brevipes*	727.60	1587.49	661.45	0
2		*Amphora* sp.	396.87	330.73	694.53	0
3		*Cymbella* sp.	198.44	66.15	330.73	132.29
4		*Chaetoceros affinis*	2116.65	4497.89	1058.33	1587.49
5		*Chaetoceros messanensis*	396.87	0	1852.07	1190.62
6		*Coscinodiscus* sp.	132.29	165.36	0	198.44
7		*Hemiaulus membranaceus*	264.58	396.87	0	1058.33
8		*Rhizosolenia castracanei*	264.58	1389.05	463.02	396.87
9		*Rhizosolenia imbricata*	264.58	2778.11	297.65	0
10		*Rhizosolenia pungens*	198.44	330.73	350.57	198.44
11		*Surirella* sp.	244.74	562.24	926.04	0
12		*Synedra gailonii*	297.65	879.73	727.60	99.22
13		*Synedra montana*	0	1342.75	793.75	132.29
14		*Synedra ulna*	793.75	661.45	416.72	661.45
15		*Nitzschia* sp.	628.38	482.86	19.84	992.18
			6925.42	**15471.41**	**8592.30**	**6647.62**
1	Chyanophyta	*Anabaena* sp.	6482.25	0	3571.85	8995.78
2		*Oscillatoria* sp.	5688.51	9524.94	8863.49	2381.24
			12170.76	**9524.94**	**12435.34**	**11377.02**
		Total abundance (cell L^{-1})	22813.56	29514.09	25723.97	22092.59

Table 1 shows that the phytoplankton found in the study sites comprised 3 phyla namely Chlorophyta, Crysophyta and Cyanophyta, consisting of 22 species of varying number of individuals. The highest number of species exist in the stations 1 and 2 (20 species) and followed by station 3 (18 species). While, the lowest number found in the Station 4 which has 16 species. Each phylum has a varying number of species. It can be seen from the data that Chrysophyta has the highest number of species (15 species) and followed by Chlorophyta with 5 species and Chyanophyta with 2 species. The results of the total abundance of species per phylum show that at station 2, the abundance of Chrysophyta is the highest but overall Chyanophyta tends to have higher total abundance than others (Table 1). More details of the composition of each species are presented in Figure 2.

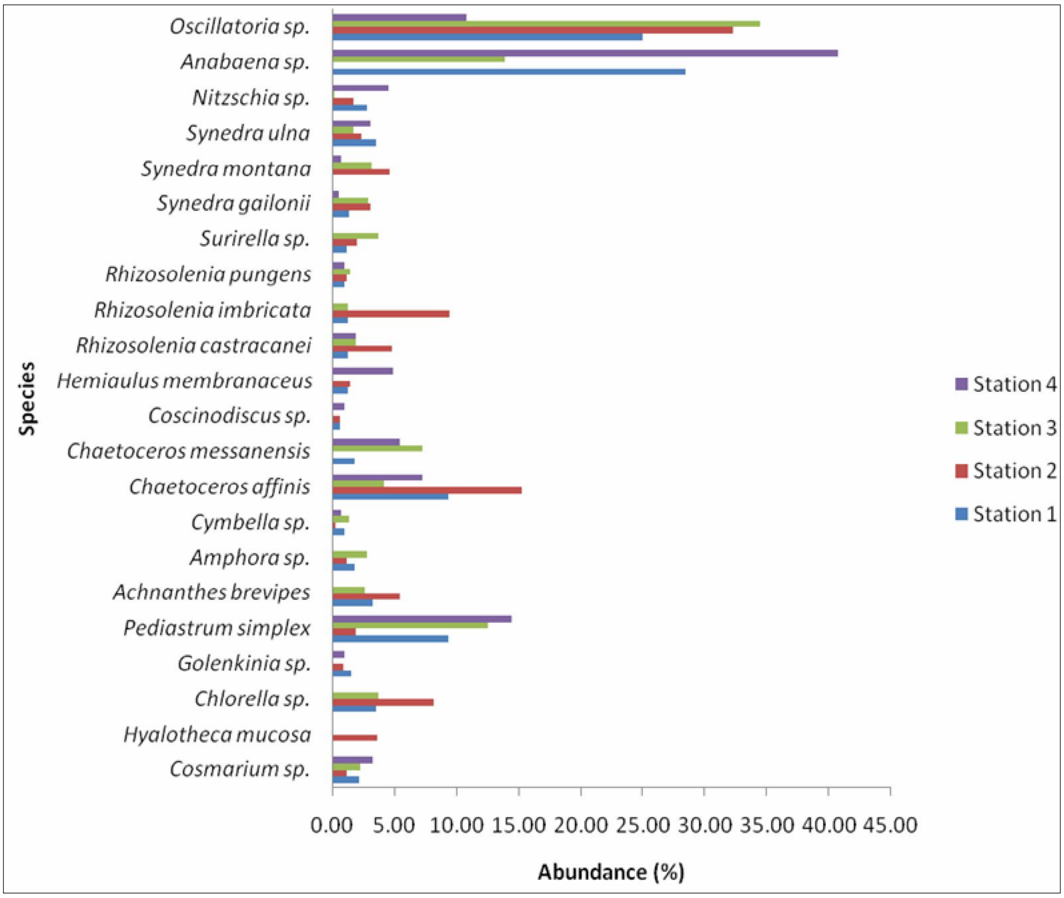

Figure 2. Abundance of phytoplankton in north Gorontalo waters.

Figure 2 shows that the abundance of species *Oscillatoria* sp. and *Anabaena* sp. is much higher than other species. It can be seen from Table 1 that station 2 has the highest total abundance compared to other stations.

Water quality. The existence of phytoplankton is certainly influenced by environmental factors. The measurement results of several environmental parameters are presented in Table 2.

Table 2

Results of physico-chemical parameters measurements at the study sites

No.	Parameter	Quality standards**	Station 1	Station 2	Station 3	Station 4
1	TDS (mg L^{-1})	-	88.6	88.1	87.55	87.8
2	TSS (mg L^{-1})	20	176	287	323	181
3	BOD_5 (mg L^{-1})	20	24	27,5	30,5	57.5
4	COD (mg L^{-1})	-	> 1500	> 1500	> 1500	> 1500
5	Conductivity (mS cm^{-1})	-	50.8	50.4	50.5	55.6
6	Current velocity (m s^{-1})	-	0.085	0,165	0,1	0,09
7	DO (ppm)	>5	4.16	4.46	4.71	4.73
8	Temperature (^{o}C)	28-30	29.6	29.5	29.8	30.1
9	Salinity (‰)	33-34	33.3	32.9	33.1	33.4
10	pH	7-8.5	6.89	6.92	6.99	7.34
11	Nitrate (mg L^{-1})	0.008	UD*	UD*	UD*	UD*
12	Phosphate (mg L^{-1})	0.015	0.0088	0.0071	0.0021	0.0118
13	Transparency (m)	>5	16	6	7	5
14	Depth (m)	-	16	6	7	5
15	Substrate condition	-	gritty-sand	sandy-corals	sand	sandy-corals
16	Weather condition	-	sunny	sunny	sunny	sunny
17	Chlorophyll-*a* (mg m^{-3})	-	0.7872	1.0152	0.9844	0.9504

*UD: undetected; ** The Decision of the Minister of Environment No. 51 of 2004 on water quality standards of sea waters.

Table 2 shows that water quality measurements on each stations support the growth of aquatic organisms, except for nitrate which is undetectable

Biology index. The calculation of the biological index value was carried out for seeing the level of environmental stability. The results of the biological index calculations which include the index of diversity, the dominance index and the uniformity index are presented in Table 3.

Table 3

Results of phytoplankton biology index score in the research sites

No.	Biological index	Station 1	Station 2	Station 3	Station 4
1	Diversity index (H')	1.8924	2.2691	2.2098	1.8422
2	Dominance index (D)	0.2464	0.1578	0.1715	0.2336
3	Similarity index (S)	0.6908	0.7853	0.7888	0.7422

Based on the Table 3 it can be seen that station 2 has the highest diversityi value with the lowest dominance index value.

Discussion. Development of pearl oyster cultivation requires waters that have a good productivity level. Like most other bivalve, pearl oysters are filter or suspension feeders throughout the free-living stages of their lifecycle. They filter fine suspended particles, seston, from the water around them (Lucas 2008b; Dunphy et al 2006). Phytoplankton plays a key role for pearl farming (Faturrahman et al 2015).

Phytoplankton has a very important role in the life cycle in the water. Phytoplankton can be used as a study material to determine the quality and productivity of an aquatic ecosystem that is required to support the exploitation of coastal and marine resources. Five major phytoplankton groups that live in waters are Cyanophyta (blue algae), Chlorophyta (green algae), Chrysophyta (yellow algae), Pyrrophyta and Euglenophyta (Widyastuti et al 2001; Asriana & Yuliana 2012).

The phytoplankton found consisted of 3 phylum namely Chlorophyta, Chrysophyta and Cyanophyta. Moreover, the number of phytoplankon types which are found in this research are mainly from Chrysophyta phylum. Chrysophyta consists of Xantophyceae, Chrysophyceae and Bacillariophyceae (diatomae) classes (Widyastuti et al 2001). Brahmana (2001) explains that Chrysophyta algae are slightly heterogeneous, containing chlorophyll-*a* and chlorophyll-*c*, beta carotene and xanthophyll fucoxanthin. It is further explained that the most important group of Chrysophyta is diatoms which are energy recyclers in natural waters and are often declared the main primary producers in the ocean. Nybakken (1992) stated that composition of phytoplankton in the sea is dominated by Bacillariophyceae.

The abundance of phytoplankton was quite varied (Figure 2) with relatively large numbers of 22 species. Microalgae differ in their nutritional value for bivalve larvae and a mixture of several species is commonly used to provide a better balance of nutrients for larvae development (Southgate 2008). Two slightly dominant species are *Oscillatoria* sp. and *Anabaena* sp., which both are from Chyanophyta group. This result is rather different from previous research results that phytoplankton are found to be dominated by the type of Bacillariophyceae group (diatoms), among others in West Halmahera Jailolo waters, in marine waters of Riau, in the waters of Gilimanuk Bay TNBB, and in Berau (Thoha 2007; Aryawati & Thoha 2011; Ariana et al 2014; Yuliana 2015). Similar results have been reported by Radiarta (2013) that the phytoplankton found in the Alas Strait of Sumbawa regency of NTB is dominated by 5 types, with the abundance of *Oscillatoria* sp. from Chyanophyceae class beng higher than *Chaetoceros* sp., *Thallasionema* sp., *Melosira* sp., and *Skeletonema* sp. from Bacillariophyceae class with an abundance of 446, 203, 55, 32, and 25 ind L^{-1} respectively.

Pearl oyster in natural environment shows the simultaneous effect of a wide array of environmental factors. Food is the major environmental factor (Lucas 2008a). Development rates of pearl oyster are particularly influenced by food availability (Saucedo & Southgate 2008). Pearl oyster feeds on suspended particulate matter (SPM), consisting mainly of bacteria, microalgae, suspended organic matter, and inorganic particles. Quantity of food is also a major factor in the physiological condition, metabolic function, growth, and survival of the pearl oyster. Optimum densities of microalgae are in the 10-100 x 10^3 cell mL^{-1} range (Lucas 2008a). In this study, in the North Gorontalo waters, the results showed that the total abundance of phytoplankton in the study sites was still in optimum condition with the values ranging from 22093-29514 cells L^{-1}. The phytoplankton abundance in the North Gorontalo waters is adequately high and its productivity rate categorized as moderate. Jamilah (2015) stated that waters in which the number of phytoplankton abundance ranges between 1000 and 40000 ind L^{-1} are classified as moderate category. The density and composition of phytoplankton are some of the important factors that determine the farming location (Fathurrahman et al 2015).

The development of pearl oyster cultivation in addition to being influenced by biological factors (food availability), is also influenced by the physical and chemical conditions of the waters. According to Lucas (2008a), as in all Poikilotherms, the ambient temperature profoundly influences the pearl oyster through its effects on metabolic rate (MR) and related processes, such as respiration and feeding rates. The measured temperature at the time of the study ranged from 29.5 to 30.1°C (Table 2). This temperature range is still optimum for the growth of marine biota. The surface water temperature in the tropics is between 20-30^{o}C (Nybakken 1992).

Current velocity is an important parameter related to phytoplankton distribution. Lucas (2008a) mentioned that water current is very important in bringing food and oxygen to pearl oyster and carrying away their wastes; however, strong currents may be deleterious by increasing suspended inorganic matter, interfering with filtering and preingestive processes. In this study, velocity of 0.085-0.165 m s^{-1} (Table 2) is categorized as low. Radiarta (2013) also reported that measured current velocity during a research in the Alas Straits was 0-0.27 m s^{-1}. In our study, the nitrate was undetectable and phosphate content was low (Table 2). This is in line with the results reported by Yuliana (2015) that at Idamdehe station, nitrate was undetectable and phosphate was 0.004 mg L^{-1}. This concentration is at a very low state and can be a limiting factor. Although the nutrient content is low, the abundance of phytoplankton at the study sites is still in good condition. This may be caused by other environmental parameters which are still in optimum condition. According to Yuliana (2015), no detection of nitrate and low phosphate content suspected due to the fact that both nutrients have been exploited by phytoplankton for growing purpose.

The condition of Kwandang, North Gorontalo water can be said is still good, which can be seen from the calculation of biological indexes values (Table 3). These results can be used to test the level of environmental stability. Based on diversity index value, the North Gorontalo water was in medium diversity criteria. This is supported by Odum (1996) who stated that 1 to 3 of diversity index value indicates that waters can be categorized as medium diversity and in moderate community-stability. The results of evenness analysis indicate that environmental conditions in the study sites are in balance. Gustiarisane (2011) in Liwutang et al (2013) mentioned that if the equilibrium is greater than 0.5 and almost 1, the similarity of the organism is balanced and there is no competition for both place and food. The results of the index analysis of dominance also show a low value which means that no species dominates.

According to Subagja et al (2001), in term of water pollution, indirect monitoring is carried out through several major environmental parameter tests such as COD, BOD, suspended particles. Moreover, they also explained that based on oxygen content, a particular water body has not been stated contaminated if its COD is higher than the BOD value. Based on the results in Table 2 it can be said that the water at the study sites has not been contaminated.

Conclusions. The results show that the North Gorontalo water qualifies as a good site for pearl oyster culture based on the abundance of phytoplankton. The abundance of phytoplankton was quite varied with relatively large number of 22 species. Chyanophyta was the phylum of phytoplankton with the highest abundance. The total abundance of phytoplankton in the study sites was still in optimum condition with the values ranging from 22093-29514 cells L^{-1} and its productivity rate categorized as moderate.

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