ISSN: 2642-9020

Research Article

Journal of Marine Science Research and Oceanography

Phytoplankton composition and diversity of Taninthayi coastal waters, Myanmar

Khin May Chit Maung[1]*, Thaung Htut[2], Su Su Hlaing[1], Zaw Myo Hein[1] and Nyo Nyo Tun[1]

[1]*Department of Marine Science, Myeik University, Myanmar*

[2]*Wildlife Conservation Society-Myanmar Program, Myanmar*

***Corresponding author**
Khin May Chit Maung, Department of Marine Science, Myeik University, Myanmar

Submitted: 25 Aug 2020; **Accepted:** 04 Sept 2020; **Published:** 18 Sept 2020

Abstract

Water samples collected by R/V DR. FRIDTJOF NANSEN during Myanmar ecosystem survey 2018 were analyzed to determine the species composition and distribution of phytoplankton. A total of one hundred and eighty-eight taxa of marine phytoplankton were identified and comprised of 116 taxa of diatoms, 67 taxa of dinoflagellates, 2 taxa of silicoflagellates and 3 taxa of cyanobacteria. Phytoplankton community was dominated by diatoms with 61.7% of total samples, followed by 35.6% of dinoflagellates. Species composition and abundance was found to be highest at station 799 with 90 species (2147no/m3) and lowest at station 846 with 36 species (673no/m3). The index values encountered from Taninthayi coastal waters ranged between 3.97 and 3.31 for species diversity index (H'), between 0.94 and 0.05 for evenness index (E') and between 13.76 and 6.69 for species richness index (D'). High diversity index values (H', E', and D') were recorded at the nearshore stations. The density and diversity of phytoplankton were positively correlated with the nutrients (chlorophyll a, nitrate, nitrite, silicate, phosphate) and negatively correlated with the temperature and salinity.

Keywords: Cyanobacteria, Diatoms, Dinoflagellates, Phytoplankton, Silicoflagellates

Introduction

Phytoplankton is one of the most important primary food sources in the aquatic ecosystem for all consumers such as zooplankton and fish thus influencing the food chain, food web, and energy flow. In addition, it plays a central role in nutrient cycling in aquatic habitats. Therefore, the condition of phytoplankton can indicate the water quality and fertility or pollution of the aquatic environment and assess the abundance of fisheries resources.

Historically, the EAF-Nansen project has been conducted the survey in Myanmar. With the co-operation of FAO, Myanmar, and the BOBLME project, a survey was carried out by research vessel named Dr. Fridtj of Nansen along the continental shelf of Myanmar in 2013 and 2015. To verify the results from 2013 and 2015 surveys and to check seasonal changes in species composition and abundance of resources, and ecosystem survey of 2018 was conducted in the monsoon season of Myanmar. Phytoplankton samplings were also conducted on this survey along Myanmar coastal waters. This paper aims to record the species composition, distribution, and diversity of phytoplankton and to understand the relationship of phytoplankton abundance and physico-chemical parameters of Taninthayi coastal waters.

Materials and Methods

During the Myanmar ecosystem survey with RV 'Dr. Fridtj of Nansen', phytoplankton samplings were carried out along the Taninthayi coastal waters (13 phytoplankton sampling stations) from 16 to 27 September 2018 as shown in Figure 1.

Phytoplankton samples were collected by using the plankton net with 35 cm in diameter and the mesh size of 10 µm, hauled vertically at a speed of 0.1 ms-1 from the depth of 30 m to the surface. The samples concentrated within the plankton net cod-end were transferred into the 100ml brown glass bottles, and preserved with 2ml of 20% hexamine-buffered formaldehyde and stored for further analyses. Phytoplankton samples were examined under the light microscope and identified up species level. Species identifications were followed according to the systems of Newell and Newell, Tomas, and Han Shein and Kyi Win [1,2,3].

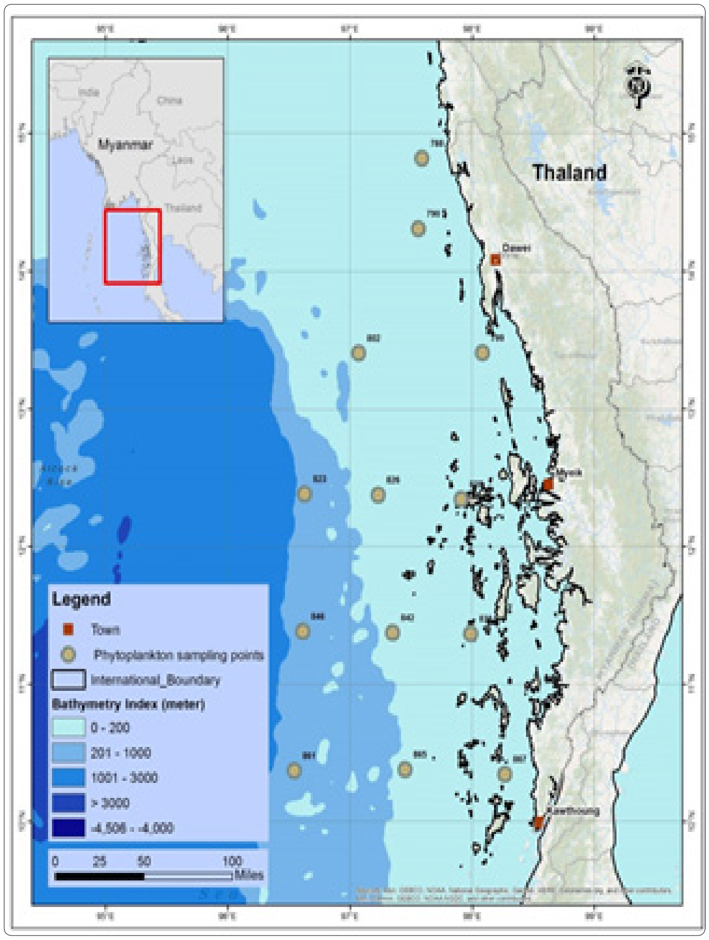

Figure 1: Phytoplankton families with species composition observed along Taninthayi coastal waters

Abundance of phytoplankton was expressed as the number of individuals per m^3 of water filtered through the net. Species diversity indices for each sample were calculated by using the formula of Shannon and Weaver (1963), Pielou (1966) *H'*=-∑PiIn Pi, *E'*=*H'*/InS, *D'*=S-1/InN, where *H'* is species diversity index, Pi is the population abundance of ith species calculated by ni/N, ni is the number of the ith species, N is the total number of individuals in a station, *E'* is species evenness index, S is the total species number and *D'* is species richness index [4].

At each station, hydrographical parameters (temperature and salinity) were measured by Seabird 911 CTD. Seawater samples for nutrient analyses (nitrite, nitrate, silicate, and phosphate) were collected from the Niskin water bottles. Chlorophyll an analyses were carried out using the method of acetone extraction [5].

A hierarchical cluster analysis of sampling stations was conducted using the PRIMER v7 software package. The boxplot and correlation between physic-chemical water parameters and the abundance of phytoplankton were analyzed using Microsoft Excel.

Result

Composition

A total of one hundred eighty-eight species comprising 34 families and 61 genera were recorded and identified. Among them, the phytoplankton community of Taninthayi coastal water was composed of 116 diatoms species representing 18 families, 67 species of dinoflagellates representing 12 families, 2 species of silicoflagellates by 1 family and 3 species of cyanobacteria by 3 families as shown in Table 1. Diatoms group was the most diverse and dominant group of phytoplankton communities as in Figure 2. Composition of phytoplankton groups by stations was presented in Figure 3. Phytoplankton community of all stations was dominated by diatoms. The species composition was found to be highest in station 799 with 90 species and lowest in station 846 with 36 species with a mean composition of 54 species (± 16).

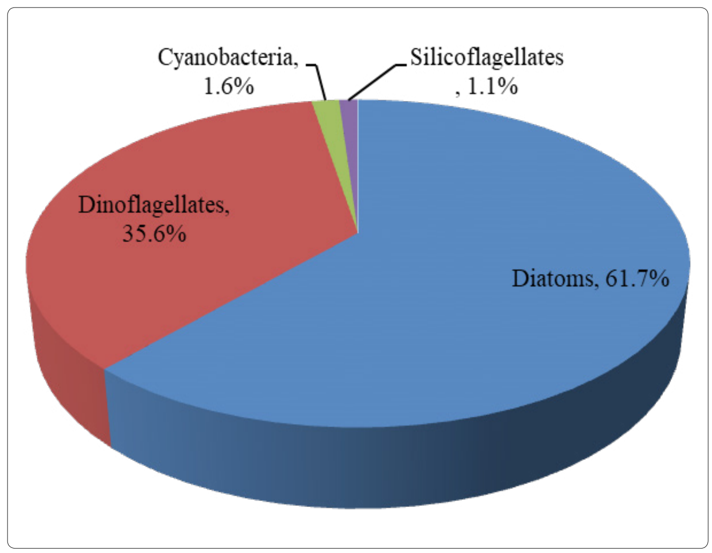

Figure 2: Composition of phytoplankton groups observed in Taninthayi coastal waters

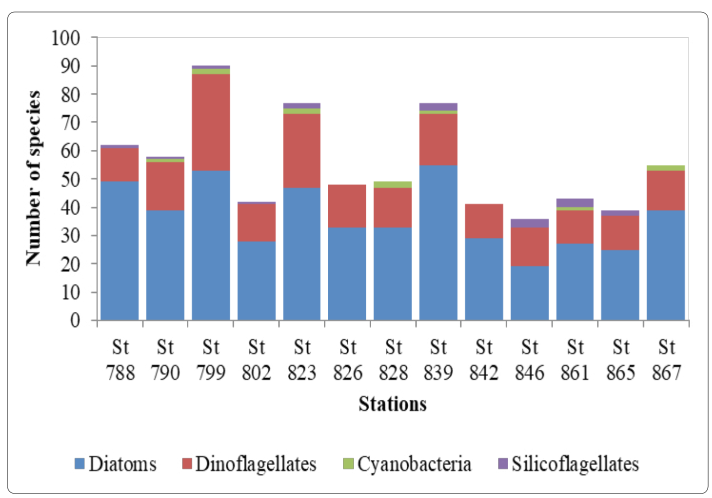

Figure 3: Composition of phytoplankton groups by stations

Table 1: Phytoplankton families with species composition observed along Taninthayi coastal waters

Sr No	Family	Species
Diatom		
1	Thalassiosiraceae	*Cyclotella striata*, *C. stylorum*, *Lauderia annulata*, *Planktoniella sol*, *Skeletonema costatum*, *S. menzelii*, *Thalassiosira eccentric*, *T. oestrupii*, *T. subtilis*
2	Melosiraceae	*Stephanophyxis palmeriana*, *Paralia sulcata*, *Melosia distans*
3	Leptocylindraceae	*Leptocylindrus minimus*, *Corethron criophilum*
4	Coscinodiscaceae	*Coscinodiscus asteromphalus*, *C. granii*, *C. lineatus*, *C. oculus-iridis*, *C. perforates*, *C. radiates*, *C. subtilis*, *C. wailesii*, *C. centralis*, *Palmeria hardmaniana*
5	Asterolampraceae	*Asterolampra marylandica*, *Asteromphalus flabellatus*, *A. hookeri*, *A. pervulus*
6	Rhizosoleniaceae	*Rhizosolenia bergonii*, *R. costracanei*, *R. cochlea*, *R. hebetate*, *R. setigera*, *R. imbricate*, *R. robusta*, *R. shrubsolei*, *R. simplex*, *R. sp* 1, *R. sp* 2, *Dactyliosolen fragillissimus*, *D. biavyanus*, *Probosia alata*, *P. indica*, *Pseudosolenia calcar-avis*, *Guinardia flaccida*, *G. striata*
7	Hemiaulaceae	*Cerataulina dentate*, *C. pelagica*, *Climacodium biconcavum*, *C. frauenfeldianum*, *Eucampia cornuta*, *E. zodiacus*, *E. cylindricornis*, *Hemiaulus hauckii*, *H. membranaceus*, *H. sinensis*
8	Chaetocerotaceae	*Bacteriastrum delicatulum*, *B. furcatum*, *B. hyalinum*, *B. elongatum*, *B. varians*, *Chaetoceros affinis*, *C. brevis*, *C. coarctatus*, *C. compressus*, *C. curvisetus*, *C. decipiens*, *C. denticulatus*, *C. didymus var anglica*, *C. distans*, *C. diversus*, *C. laciniosus*, *C. lorenzianus*, *C. messanensis*, *C. peruvianus*, *C. atlanticus*, *C. pseudocrinatus*
9	Lithodesmiaceae	*Bellerochea malleus*, *B. horologicalis*, *Ditylum brightwellii*, *D. sol*, *Helicotheca tamesis*
10	Eupodiscaceae	*Odontella mobiliensis*, *O. sinensis*
11	Triceratiaceae	*Lamprisus shadbolttanum*
12	Fragilariaceae	*Fragilaria sp.*
13	Thalassionemataceae	*Thalassionema frauenfeldii*, *T. nitzschioides*
14	Diploneidaceae	*Diploneis carbo*, *D. suborbicularis*, *D. sp.*
15	Naviculacea	*Meuniera membranacea*, *Navicula sp.*, *Haslea cf balearica*
16	Pleurosigmataceae	*Trachyneis antillarum*, *T. aspera*, *Pleurosigma aestuarii*, *P. diverse-striatum*, *P. elongatum*, *P. normanii*, *P. sigmoides*, *P. nicobaricum*, *P. angulatum*
17	Bacillariaceae	*Bacillaria paxillifera*, *B. socialis*, *Cylindrotheca closterium*, *Pseudonitzschia sp.*, *P. seriata*, *Nitzschia sp.*, *N. longissima*, *N. lorenziana*, *N. sigma*
18	Entomoneidaceae	*Entomoneis sulcata*
19	Surirellaceae	*Surirella fastuosa*, *S. ovalis*, *Plagiodiscus nervatus*
Dinoflagellate		
20	Prorocentraceae	*Prorocentrum compresum*, *P. gracile*, *P. mexicanum*, *P. micans*
21	Amphisoleniaceae	*Amphisolenia bidentata*
22	Dinophysiaceae	*Dinophysis caudate*, *D. miles*, *D. schuettii*, *D. rotundata*, *Ornithocercus magnificus*, *O. thumii*, *O. steinii*, *Phalacroma. Mitra*, *P. rotundatum*
23	Gymnodiniaceae	*Gymnodinium sp.*
24	Ceratiaceae	*Ceratium breve*, *C. candelabrum*, *C. carriense*, *C. dens*, *C. furca*, *C. fusus*, *C.gibberum*, *C. horridum*, *C. inflexum*, *C. lineatum*, *C. macroceros*, *C. massiliense*, *C. pentagonum*, *C. praelongum*, *C. pulchellum*, *C. schmidtii*, *C. setaceum*, *C. teres*, *C. trichoceros*, *C. tripos*, *C. vulture*, *C. stricum*, *C. extensum*, *C. lunula*
25	Goniodomataceae	*Alexandrium sp.*, *A. leei*, *A. minutum*
26	Gonyaulacaceae	*Gonyaulax sp.*
27	Oxytoxaceae	*Oxytoxum sceptrum*, *O. sp.*, *Pyrocystis lunula*, *P. fusiformis*
28	Pyrophacaceae	*Pyrophacus horologium*, *P. steinii*
29	Calciodinellaceae	*Scrippsiella sp.*
30	Podolampaceae	*Podolampus bipes*, *P. palmipes*, *P. spinifera*
31	Protoperidiniaceae	*Protoperidinium cerasus*, *P. conicum*, *P. depressum*, *P. divergens*, *P. elegans*, *P. curtipe*, *P. leonis*, *P. minutum*, *P. murrayi*, *P. oceanicum*, *P. pentagonum*, *P. spiniferum*, *P. oblongum*, *P.subinerme*
Silicoflagellates		
32	Dictyochales	*Dictyocha fibula*, *D. speculum*
Cyanobacteria		
33	Oscillatoriaceae	*Oscillatoria* sp.
34	Nostocaceae	*Nostoc sp*
35	Phormidiaceae	*Trichodesmium sp.*

Density and Diversity

Estimation of phytoplankton abundance in terms of cell density was based on direct counts of a sample. The fluctuation of phytoplankton abundance by the station, referring to the number per m3 and diversity indices calculated from phytoplankton species were presented in Table 2. High densities of phytoplankton were found at nearshore stations: St 799, St 828, St 867, and St 839. Phytoplankton density was found to low in offshore stations: St 846, St 865, St 842, and St 861.

High abundance of phytoplankton species occurred in all stations were *Coscinodiscus granii* (319 no/m^3), *C. wailesii* (205 no/m^3), *C. radiates* (184 no/m^3) and *C. centralis* from the family Coscinodiscaceae, *Rhizosolenia bergonii* (129 no/m^3), *R. robusta* (99 no/m^3) and *Probosia alata* (86 no/m^3) from the family Rhizosoleniaceae, *Hemiaulus sinensis* (89 no/m^3) from the family Hemiaulaceae, *Chaetoceros decipiens* (140 no/m^3) from the family Chaetocerotaceae, *Dictylum sol* (140 no/m^3) from the family Lithodesmiaceae, *Thalassionema frauenfeldii* (69 no/m^3) and *T. nitzschioides* (72 no/m^3) from the family Thalassionemataceae, *Ceratium furca* (99 no/m^3) and *C. fusus* (85 no/m^3) from the family Ceratiaceae, and *Protoperidinium cerasus* (53 no/m^3) and *P. depressum* (54 no/m^3) from the family Protoperidiniaceae. High diversity index values (*H'*, *E'*, and *D'*) were observed at the nearshore stations.

Cluster analysis of the 13 stations based on the abundance of phytoplankton species showed one distinct group composed of 7 nearshore stations (Sts 802, 799, 788, 790, and Sts 828, 839, 867) at 46.09% similarity level. And other distinct groups composed of offshore stations (Sts 842, 846, 865, 823, 861, 826) at 39.8% similarity level as presented in Figure 4.

Table 2: Phytoplankton species diversity indices and density (no/m^3)

Station no.	*H'*	*E'*	*D'*	no/m^3
788	3.72	0.90	10.2	1336
790	3.75	0.92	9.61	1253
799	3.97	0.88	13.76	2147
802	3.33	0.89	7.14	1043
823	3.81	0.89	11.31	1490
826	3.32	0.86	8.09	1106
828	3.53	0.07	7.65	1763
839	3.94	0.05	12.21	1687
842	3.48	0.93	7.23	843
846	3.36	0.94	6.59	673
861	3.31	0.88	7.59	843
865	3.43	0.94	7.15	680
867	3.59	0.89	8.66	1706

Symbols; *H'*=species diversity index, *E'*=Evenness index, *D'*= Richness index

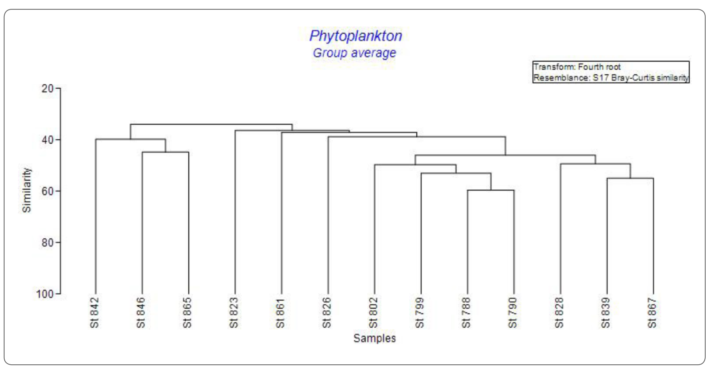

Figure 4: Dendrogram of phytoplankton species similarity produced by clustering of the 13 stations

Physico-Chemical Parameters

For all stations along Taninthayi coastal waters, mean values of physico-chemical parameters were 28.4°C ± 0.44 for temperature, 26.5‰ ± 3.8 for salinity, 0.32 µmol/L ± 0.3 for nitrate, 0.08 µmol/L ± 0.06 for nitrite, 8.3 µmol/L ± 5 for silicate, 0.02 µmol/L ± 0.05 for phosphate and 0.4 µg/L ± 0.3 for chlorophyll a. The range of physic-chemical parameters of all stations was presented in Figure 5.

The correlation matrix between the abundance of phytoplankton and environmental parameters is described in Table 3. The parameters which have a positive correlation with phytoplankton abundance are nitrate, nitrite, silicate, phosphate, and chlorophyll a, while it was inversely correlated with temperature and salinity.

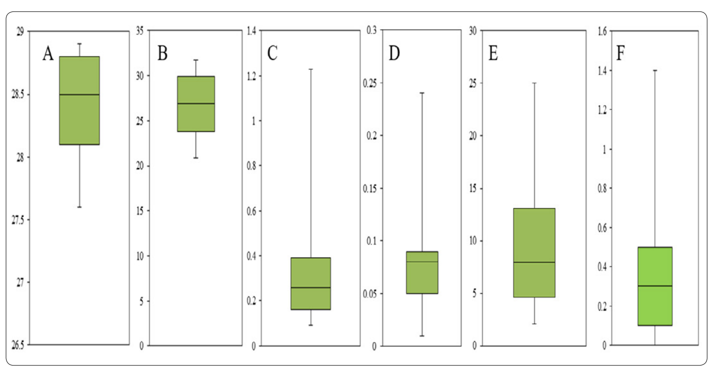

Figure 5 (A-F): Boxplot showing the variables of A) temperature°C; B) Salinity‰; C) Nitrate µmol/L; D) Nitrite µmol/L; E) Silicate µmol/L; F) Chlorophyll a µg/L.

Table 3: Correlation matrix between the phytoplankton abundance and physico-chemical parameters

	Phyto count	Temperature	Salinity	Nitrate	Nitrite	Silicate	Phosphate	Chlorophyll a
Phyto count	1							
Temperature	-0.25	1						
Salinity	-0.35	0.42	1					
Nitrate	0.16	-0.03	0.22	1				
Nitrite	0.27	-0.04	-0.05	0.88	1			
Silicate	0.38	-0.19	-0.74	0.39	0.49	1		
Phosphate	0.39	-0.04	0.33	0.77	0.80	0.09	1	
Chlorophyll a	0.58	-0.05	-0.01	0.68	0.79	0.31	0.92	1

Discussion

Phytoplankton samples collected by Norwegian research vessel Dr. Fridtjof Nansen along Taninthayi coastal waters were analyzed to know the species composition and diversity by stations. There are 188 phytoplankton species comprising 116 taxa of diatoms, 67 taxa of dinoflagellates, 2 taxa of silicoflagellates, and 3 taxa of cyanobacteria identified during 2018 Nansen survey along Taninthayi coastal waters. The species number recorded during the present survey period was higher than that of phytoplankton survey results by the cruise "MV SEAFDEC 2' 2007 [6] and R/V Dr. Fridtjof Nansen 2013 [7]. This difference could be due to the different collecting time, sampling depth and plankton net mesh size used.

In the present survey, the occurrence numbers of diatoms were higher than those of dinoflagellates in all stations. Similarly, higher species numbers of diatoms than dinoflagellates were observed in Bay of Bengal [8], in the phytoplankton samples of R/V Dr. Fridtjof Nansen survey 2013, Taninthayi coastal waters [7] and nearshore surface water of Taninthayi coastal regions [9,10,11,12,13,14]. But dinoflagellates were more dominant than diatoms both in terms of species and abundance in the survey of cruise 'MV SEAFDEC 2' along the waters of Ayeyarwady, Mon and Taninthayi coastal region [6].

Common phytoplankton species in the present survey were seven species of diatoms *Coscinodiscus granii*, *C. radius*, *Rhizolenia bergoni*, *R. imbricata*, *Chaetoceros decipiens*, *Thalassionema nitzschoides*, *T. frauenfeldii* and four species of dinoflagellates *Prorocentrum gracile*, *Ceratium furca*, *C. fuscus*, *Protoperidinium depressum*. The common phytoplankton species distributed throughout Myanmar coastal water were *Thalassionema nitzschoides*, *T. frauenfeldii* and *Rhizosolenia spp*., *Ceratium furca*, *C. fuscus*, *Prorocentrum gracile*, *P. micans*, *Gymondinium sanguinum*, *Gonyaulax spinifera*, *G. scrippsae*, *Pyrophacus steinii*, *Protoperidinium divergens*, *P. depressum* and *Dinophysis caudate* [6]. Also the common phytoplankton species during R/V Dr. Fridtjof Nansen survey in 2013 were *Thalassiosira eccentric*, *Rhizosolenia setigera*, *Chaetoceros coarctatus*, *C. diversus*, *C. lorenzianus*, *Fragilaria sp*, *Thalassionema frauenfeldii* and *T. nitzschoides* [7].

Sixty-seven species of dinoflagellate were recorded from the survey off the southern Myanmar coast of the Andaman Sea [15]. Although some potentially harmful dinoflagellates (*Alexandrium tamivavanichii*, *Dinophysis caudata*, *D. miles*, *D. rotundata*, *Gonyaulax spinifera*) were observed in Taninthayi coastal water, percentage composition of dinoflagellates in the phytoplankton community was low.

In the present study, the population density of phytoplankton ranged from 673no/m3 to2147 no/m3 which was higher than that of overall phytoplankton standing stock collected by MV SEAFDEC 2 in Myanmar Territory Waters of North-east Andaman Sea [6]. Booonyapiwat *et al.* also reported the highest phytoplankton cell density of 171-11178 cells/L near the coastal area of Myanmar [8].

Species diversity index of plankton communities can indicate that the ecosystem is under influence of pollution or eutrophication. An increase in diversity values means the water quality is recovered. Lower species diversity indicated the influence of pollution [16]. Diversity indices also provide important information about the rarity and commonness of species in a phytoplankton community [17]. The calculated phytoplankton diversity of the present study was nearly similar to the report of phytoplankton diversity of the waters off Taninthayi coast [6]. This result indicated not only higher phytoplankton diversity but also the well-balanced system of phytoplankton community in the Taninthayi coastal waters.

During the 2018 survey period, low salinity values occurred in the stations near the coast because of the runoff water from the coast during the monsoon season, and high salinity values occurred in the offshore regions. Some oceanic species (*Planktoniella sol*, *Ornithocercus* spp, *Protoperidinium depressum*, and *Ceratium tere*) occurred in nearshore stations and some neritic species (*Dinophysis caudata*, *Ceratium trichoceros*, and *Protoperidinium cerasus*) were found in the offshore stations. Thus salinity showed that there was no influence on the distribution of phytoplankton.

Concerning the studies on the relationship of phytoplankton abundance and physico-chemical parameters, the important factors affecting the abundance of phytoplankton were temperature and nutrients, salinity and nutrients and temperature, salinity, dissolved oxygen, inorganic phosphate and silicate [18-20]. Thirunavukkarasu *et al.* reported that population density of phytoplankton showed positive correlation with salinity, pH and chlorophyll an and negative correlation with rainfall [21]. According to the correlation matrix between phytoplankton abundance and physico-chemical parameters of the present study, it showed positive correlation with nitrate, nitrite, silicate, phosphate and chlorophyll a, and negative correlation with temperature and salinity. Similar result was reported by Kadim *et al.* in which abundance of phytoplankton from Gorontalo Bay, Indonesia was positively correlated with pH, NO3, NH3, PO4 and chlorophyll an and inversely correlated with temperature, salinity and dissolved oxygen [22].

Conclusion

Observation on the distribution, abundance and diversity of phytoplankton community can be used for the estimation of pollution status of waters and the assessment of abundance of fisheries resources. Phytoplankton of Taninthayi coastal waters was composed by one hundred and eighty-eight phytoplankton species in which diatoms numerically dominated in the community. With regard to species richness, density and diversity of phytoplankton, it could be concluded Taninthayi coastal waters as a productive water area. Long term monitoring study on the status of phytoplankton will provide the information for resources conservation and fisheries management on local and regional scales.

Acknowledgement

First author acknowledges Kathrine Michalsen and Jens-Otto Krakstad (Cruise Leaders), Stamatina Isari (Team Leader Plankton) from Institute of Marine Research, Bergen, Norway and Dr. Tun Thein (Local Cruise Leader), Department of Fisheries, Myanmar for supporting necessary data. Thanks are also due to plankton team members: Dr. Thu Thu Min, Dr. Aung Myo Hsan, U Thura Tun from Marine Science Department, and Dr. Thet Yu Yu Swe, Daw Zi Za Wah, U Ye Min Aung from the Department of Fisheries for supporting during the survey and Daw San San Htay, Program Manager of WCS and Daw Than Than Aye, Managing Director, Queen & Sons company for assistance in the process of payment and financial support respectively.

References

1. Newel GE, Newel RC (1963) Marine Plankton practical guide. Hutchinson Educational 50: 207.
2. Tomas CR (1997) Identifying marine phytoplankton. Academic Press 858.
3. Han Shein, Kyi Win (2012) Illustrated guide to marine plankton of Myanmar. Marine Science Association Myanmar 240.
4. Ludwig JA, Renylods JF (1998) Statistical ecology a primer on methods and computing. Wiley international Press 202.
5. Jeffrey SW, Humphrey GF (1975) New spectrophotometric equations for determining chlorophyll a, b, cl and c2 in higher plants, algae and natural phytoplankton. Biochemie und Physiologie der Pflanzen 167: 191-194.
6. Zin Lin Khine, Htay Aung (2009) Distribution, abundance and diversity of plankton in Myanmar Territory Waters of north-east Andaman Sea. Journal of Myanmar Academic Arts and Science 7: 389-414.
7. Nyo Nyo Tun, Si Thu Hein (2014) Phytoplankton composition along Taninthayi Coastal Waters, Myanmar. Myeik University Research Journal 5: 89-100.
8. Boonyapiwat S, Sada M N, Mandal JK, Sinha MK (2008) Species composition, abundance and distribution of phytoplankton in the Bay of Bengal. The Ecosystem-Based Fishery Management in the Bay of Bengal 53-64.
9. Si Thu Hein (2010) Study on the phytoplankton in Pahtaw-Pahtet waters, Myeik. Unpublished M Sc (Thesis). Department of Marine Science, Myeik University.
10. Khin Yu Nwe (2011) Study on the species identification, composition, distribution and abundance of phytoplankton from Myeik Adjacent Waters. Unpublished M. Res (Thesis) Department of Marine Science, Myeik University.
11. Lett Wai Nwe (2011) Study on the phytoplankton in Kalar Kyunn and Ma-aing Kyun near Myeik Waters. Unpublished M Sc (Thesis). Department of Marine Science, Myeik University.
12. Thet Hmue San (2018) A study on the phytoplankton populations in the waters off Pearl island, Myeik Archipelago. Unpublished M Res (Thesis) Department of Marine Science, Myeik University.
13. Yin Yin Htay (2019) Species succession of phytoplankton in relation to some physic-chemical parameters in Myeik Archipelago, Southern Myanmar. J Myanmar Acad Arts Sci 17: 57-80.
14. Zarni Ko Ko (2019) Species composition, abundance and distribution of phytoplankton in the Elphinstone island, Myeik Coastal Waters. J. Myanmar Acad Arts Sci vol 17: 97-115.
15. Su-Myat, Maung Saw Htoo Thaw, Matsuoka K, Khin Ko Lay, Koike K, et al. (2012) Phytoplankton surveys off the southern Myanmar coast of the Andaman sea: an emphasis on dinoflagellates including potentially harmful species. Fish sci 78: 1091-1106.
16. Nassar MZA, Gharib SM (2014) Spatial and temporal patterns of phytoplankton composition in Burullus lagoon, Southern Mediterranean Coast, Egypt. Egyptian Journal of Aquatic Research 40: 133-142.
17. Hossain Md RA, Pramanik Md MH, Hasan Md M (2017) Diversity indices of plankton communities in the River Meghna of Bangladesh. International Journal of fisheries and Aquatic Studies 5: 330-334.
18. Nowrouzi S, Valavi H (2011) Effects of environmental factors on phytoplankton abundance and diversity in Kaftar Lake. Journal of fisheries and Aquatic science 6: 130-140.
19. Ye YY, Luo Y, Wang Y, Lin M, Xiang P, et al. (2016) Relation between diversity of phytoplankton and environmental factors in waters around Nanri island. Applied ecology and environmental research 15: 241-252.

20. Vajravelu M, Martin Y, Ayyappan S, Mayakrishnan M (2017) Seasonal influence of physic-chemical parameters on phytoplankton diversity, community structure and abundance at Parangipettai coastal waters, Bay of Bengal, South East Coast of India. Oceanologia 60: 114-127.

21. Thirunavukkarasu K, Soundarapandian P, Varadharajan D, Gunalan B (2013) Phytoplankton composition and community structure of Kottakudi and Nari Back waters, South east of Tamil Nadu. Journal of Aquaculture Research & Development 5: 1-9.

22. Kadim MK, Pasisingi N, Kasim F (2018) Spatial and temporal distribution of phytoplankton in the Gorontalo Bay, Indonesia. AACL Bioflux 11: 833-842.