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ENVIRONMENTAL CONTROL OF SEASONAL VARIATIONS IN THE PHYTOPLANKTON COMMUNITY STRUCTURE ALONG THE COAST OF TANINTHARYI, SOUTHERN MYANMAR

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Abstract

The seasonal fluctuations in phytoplankton assemblages and the controlling environmental factors were investigated for 24 months along the coast of Tanintharyi from June 2013 to June 2015. A wide fluctuation in cell abundance 72,450-714,396 cells l^{-1} at Kawthaung, 47,416-947,501 cells l^{-1} at Myeik, 8,930-28,439 cells l^{-1} at Kampani, 8,976-17,888 cells l^{-1} at Ye and 5,162-16,986 cells l^{-1} at Setse were noted during the study period. Amongst, Kawthaung and Myeik stations had the highest phytoplankton abundance whereas Ye and Setse stations showed remarkably lower abundance. A clear seasonal trend was found at all five stations with a sharp peak in the pre-monsoon months and a gradual decrease in the monsoon and post-monsoon periods. Phosphate concentration was relatively high at Myeik and Kawthaung stations, and also the increase of water temperature and salinity in the pre-monsoon months may probably stimulate a high abundance of phytoplankton. On the other hand, a decrease of phytoplankton abundance was found in the monsoon season which was characterized by low water temperature, low salinity, and low level of nutrients.

Keywords: Abundance, monsoon, nutrients, phosphate, pre-monsoon, salinity, water temperature

Introduction

Phytoplankton community is an important biological component of the aquatic ecosystem, constituting a central role in aquatic food webs. They constitute not only half of the global primary production (Field et al. 1998) but they also play an important role in nutrients cycling, such as nitrogen, phosphorous, and carbon. Moreover, through diverse strategies for nutrient uptake, phytoplankton community composition affects rates and fluxes of elements in the ecosystem (Falkowski et al. 1998). Phytoplankton communities are regulated by both bottom-up and top-down processes (Alpine and Cloern 1992), interactions among phytoplankton taxa likely also affect community structure and function (Griffiths et al. 2016). Structural changes in the phytoplankton community are also strongly related to the physical, chemical, and biological features of water bodies and are expected to be highly sensitive to ongoing environmental changes. Variations of abiotic water conditions occur naturally throughout the day and over the seasons of the year (Gast et al. 2014). Therefore, the investigation of structural aspects focuses on the whole phytoplankton community is an important approach for understanding the aquatic ecosystems.

Concerning the phytoplankton community, there have been reported by several studies focused on the species distribution, occurrence and abundance (Si Thu Hein 2010, Khin Yu Nwe 2011, Lett Wai Nwe 2011, Tin Tin Kyu 2012, Zin Mar Aye 2012, Aung Myo Hsan 2013, Thida Nyunt 2013, Zarni Ko Ko 2014 and 2018, Yin Yin Htay et al. 2019). However, seasonal influences of environmental parameters on the variations of the phytoplankton community have not been reported yet. Here in the present study, I analyzed the environmental factors that control phytoplankton variability through 2-year study periods along the coast of Tanintharyi, southern Myanmar.

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Materials and Methods

Sampling site

Phytoplankton samples were collected at the five stations along the Tanintharyi coastline, namely, Kawthaung (Lat. 9º 58. 204′ N, Long. 98º 33. 701′ E), Myeik (Lat. 12º 26. 186′ N, Long. 98º 35. 461′ E), Kampani (Lat. 14º 05. 288′ N, Long. 98º 04. 143′ E), Ye (Lat. 15º 11. 585′ N, Long. 97º 47. 518′ E) and Setse (Lat. 15º 56. 965′ N, Long. 97º 36. 330′ E) from June 2013 to June 2015 (Fig.1). The sampling areas were influenced by the monsoon season. Therefore, a calendar year was divided into three seasons for ecological purposes. The division for three seasons was based on changes in the temperature in the annual cycle of the region. The seasons were recognized as the pre-monsoon period (February to May), the monsoon period (June to September) and the post-monsoon period (October to January).

Sample collection

A small-mesh phytoplankton net of 20 µm is used in the sample collection. The phytoplankton samples of the surface water were collected by a plastic bucket of known volume water, 60L. Then, the water passed through the mesh fixed to the bottom of a plastic cylinder. Care was taken to wash all the cells off the sieve. Samples were preserved immediately with a 1% formaldehyde solution. In the laboratory, samples were analyzed for species identification and counting. While collecting the water samples, temperature, salinity, and pH were measured in-situ with the help of a digital thermometer, salinity refractometer, and portable Hanna pH meter. Water samples for nutrients were also collected at each station. For nutrient analyses, water samples were filtered with 0.2 µm pore sized Millipore filter and frozen for later analysis of nitrate (NO_3-N), phosphate (PO_4-P), and ammonia (NH_4-N). Then, samples were sent to the Ministry of Fishery and Livestock in Yangon for analysis.

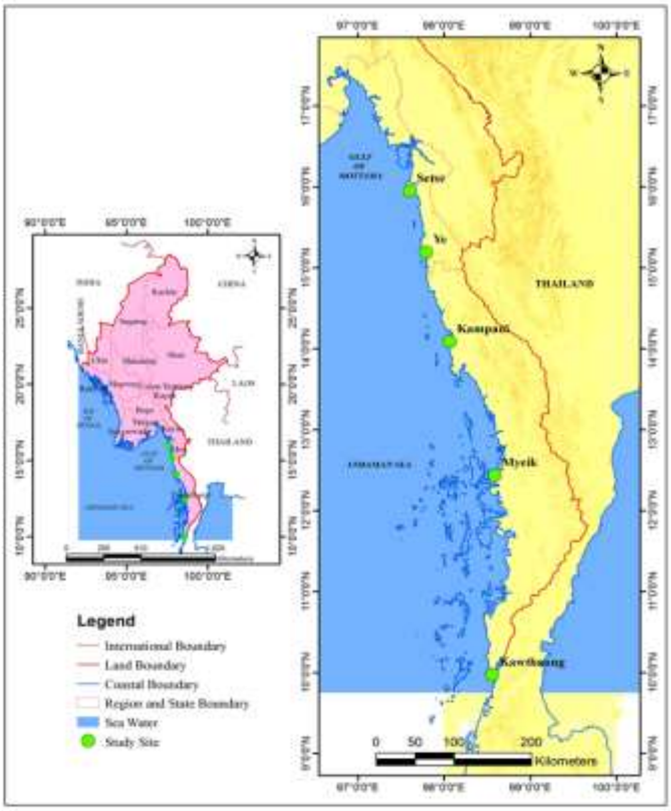

Figure 1 Map showing the sample collection sites in Tanintharyi coastal waters.

Results and Discussion

Environmental parameters

The fluctuations of temperature, 24-33°C were recorded at the five stations during the study period. Water temperature was high during the pre-monsoon period (February to May) and low in the monsoon season (June to September) and again an increasing trend in the post-monsoon period (October to January). The surface salinity had a broad range 14-34‰ with a maximum in the pre-monsoon period and a minimum in the monsoon months when precipitation increased. pH value varied between 6.5-7.8 during the observation period, with a high value in the pre-monsoon months and low from June to January (Fig. 2).

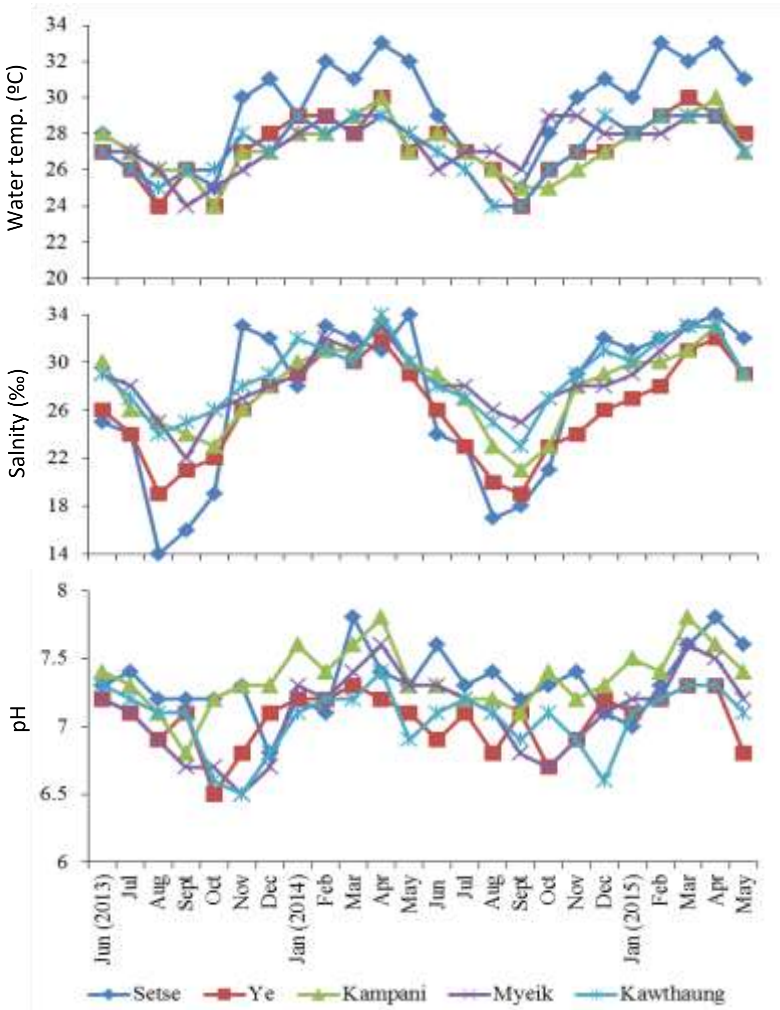

Figure 2 Seasonal variations of water temperature (ºC), salinity (‰), and pH from June 2013 to May 2015.

Nutrients

Fig. 3 shows the temporal variations in nutrient concentrations at the five sampling stations. Nitrate, phosphate, and ammonia concentrations varied between 0.01 and 0.06 mg l^{-1}, between 0.01 and 1.5 mg l^{-1}, and between 0.01 and 0.11 mg l^{-1}, respectively, during the study period. Nitrate and ammonia showed little fluctuations in concentration throughout the study period. The concentrations of phosphate at Myeik and Kawthaung stations were relatively high in the pre-monsoon period, especially in April but in other months, there was no significant variation in concentration at the five stations.

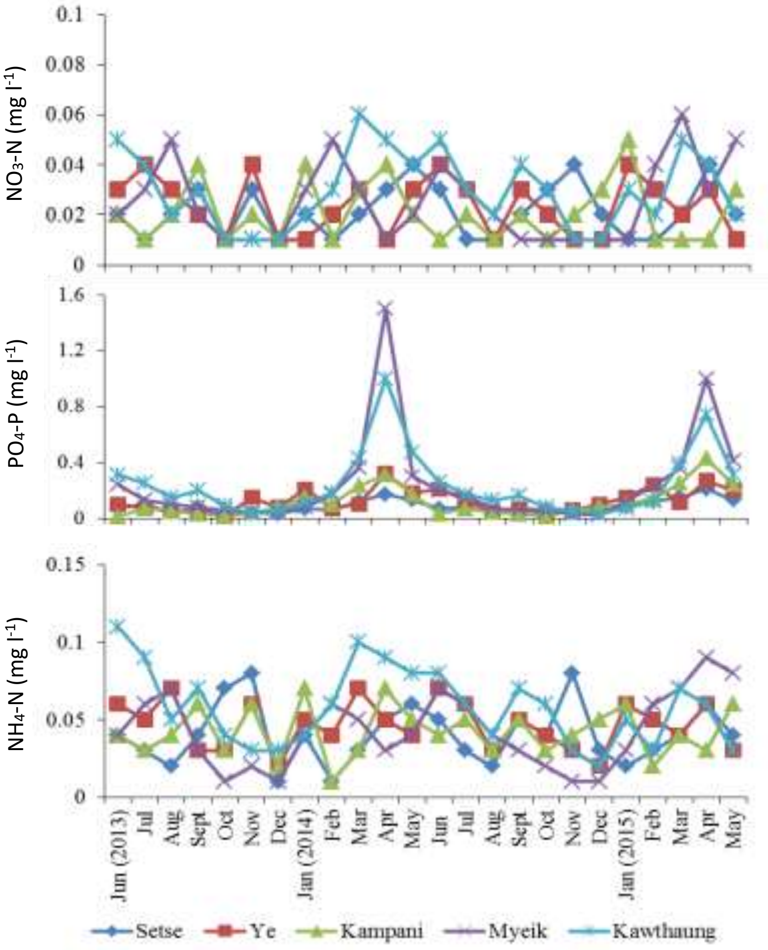

Figure 3 Seasonal variations of nitrate (NO_3-N, mg l^{-1}), phosphate (PO_4-P, mg l^{-1}), and ammonium (NH_4-N, mg l^{-1}) concentrations from June 2013 to May 2015.

Phytoplankton abundance and species composition

Phytoplankton abundance ranged from 72,450-714,396 cells l^{-1} at Kawthaung, 47,416-947,501 cells l^{-1} at Myeik, 8,930-28,439 cells l^{-1} at Kampani, 8,976-17,888 cells l^{-1} at Ye and 5,162 to 16,986 cells l^{-1} at Setse, respectively (Fig. 4). The phytoplankton community was dominated by diatoms (Bacillariophyceae) 155 species accounting on average, for 78% of the total abundance of phytoplankton. Dinoflagellates, a total of 42 species of Dinophyceae, comprised 21% of the phytoplankton community. Additionally, 2 species of Dictyochophyceae were also recorded, accounted for only 1% of the total phytoplankton abundance.

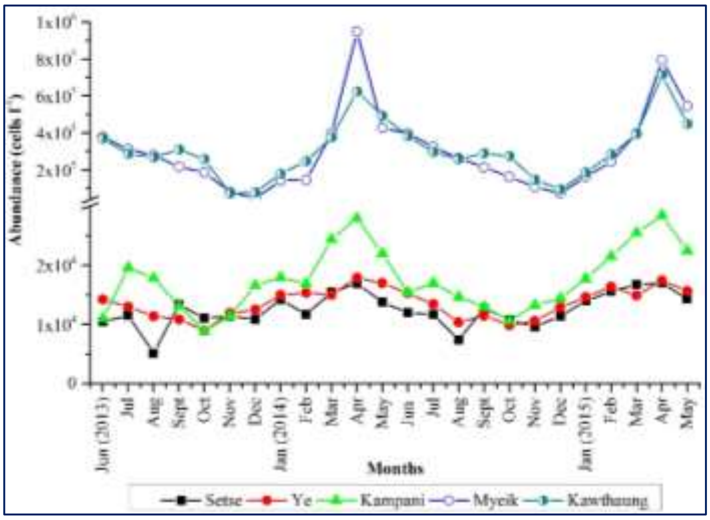

Figure 4 Seasonal variations of phytoplankton abundance (cells l^{-1}) at the five stations from June 2013 to May 2015.

Seasonal variations in the cell abundance of phytoplankton at each station are presented in Fig. A clear seasonal trend in phytoplankton abundance was seen at all five stations with a sharp peak in the pre-monsoon period, especially in April, after which a gradual decrease in cell abundance was found in the monsoon and post-monsoon periods. A similar result was also noted in the literature reported by Aung Myo Hsan (2013), Thida Nyunt (2013), and Yin Yin Htay (2014) who described the high phytoplankton abundance in the pre-monsoon months.

Microscopic observations revealed 42 species such as *Melosira nummuloides, M. borreri, Thalassiosira subtilis, T. rotula, Skeletonema costatum, Paralia sulcata, Cyclotella striata, Lauderia annulata, Coscinodiscus lineatus, C. radiatus, Odontella sinensis, O. mobiliensis, Eucampia cornuta, Hemiaulus sinensis, Bellerochea horologicalis, Ditylum sol, Rhizosolenia imbricata, R.setigera, Proboscia alata, Guinardia striata, G. flaccida, Bacteriastrum delicatulum, B. hyalinum, Chaetoceros curvisetus, C. diversus, C. densus, C. lorenzianus, C. subtilis, Asterionellopsis glacialis, Fragilaria crotonensis, F. capucina, Tabellaria fenestrata, Climacosphenia moniligera, Thalassionema nitzschioides, T. frauenfeldii, Nitzschia sigma, N. longissimia, N. seriata, Cylindrotheca closterium, Prorocentrum micans, Dinophysis caudata,* and *Ceratium furca* were noted as the dominant phytoplankton species in Tanintharyi coastal water. Taylor (1975) reported *Guinardia flaccida* was noted as the predominant diatom species in Thailand which was in agreement with the present result found at Kawthaung station. *Thalassionema nitzschioides* was abundantly collected at Tanintharyi waters throughout the observation period, which agrees well with the finding of Kamba and Yuki (1980). Moreover, the present findings of dominant phytoplankton species in Tanintharyi coastal waters were similar to the results reported by Khin Yu Nwe (2011), Yin Yin Htay (2014, 2019), and Zarni Ko Ko (2014, 2018).

Phytoplankton succession in relation to environmental parameters

Temperature and salinity

The relationships of water temperature and salinity to the cell abundance of phytoplankton species that appeared with high frequencies during the study period are shown in Fig. 5. *Skeletonema costatum* and *Asterionellopsis glacialis* were found over a wide range of salinity, 15-34‰. These species seem to have the possibility of salinity tolerance. Balzano et al. (2011) reported *S. costatum* showed growth between salinity of 0 and 35‰. *Thalassiosira subtilis*, *Lauderia* *annulata*, *Paralia sulcata*, and *Fragilaria crotonensis* were commonly observed in the salinity range of 20-34‰. The species that were most abundant within the salinity range between 25 and 34‰ were *Rhizosolenia setigera, Bacteriastrum hyalinum,*

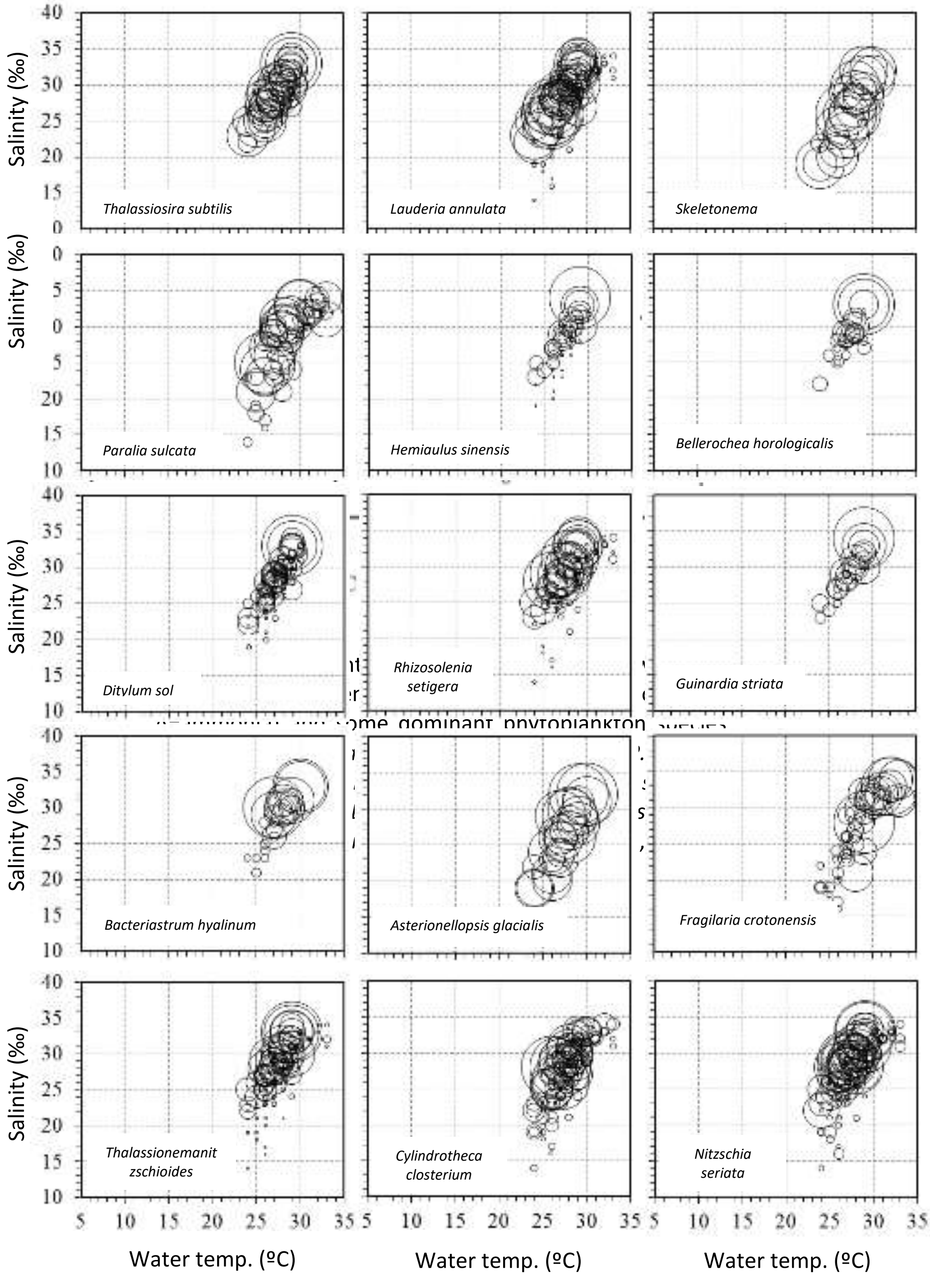

Figure 5 Temperature-salinity plots for abundance of the dominant phytoplankton species.

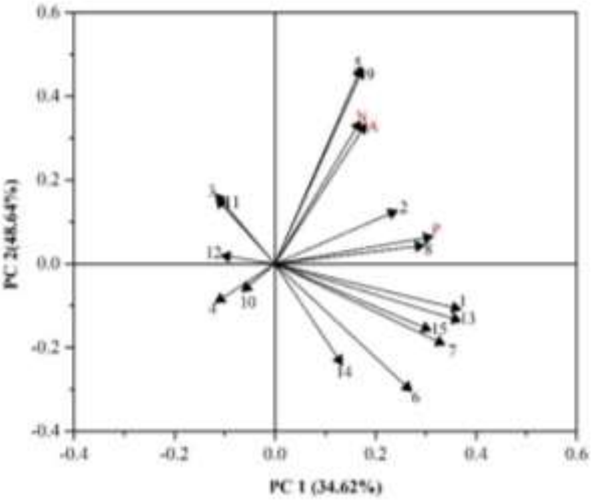

Figure 6 Principal component analysis (PCA) biplot showing the relationship between nutrients (N=nitrate, P= phosphate, A=ammonia) and some dominant phytoplankton species (1= *T. subtilis*, 2= *L. annulata*, 3= *S. costatum*, 4= *P. sulcata*, 5= *H. sinensis*, 6= *B. horologicalis*, 7= *D. sol*, 8= *R. setigera*, 9= *G. striata*, 10= *B. hyalinum*, 11= *A. glacialis*, 12= *F. crotonensis*, 13= *T. nitzschioides*, 14= *C. closterium*, and 15= *N. seriata*).

Thalassionema nitzschioides, and *Nitzschia seriata*. *Hemiaulus sinensis*, *Bellerochea horologicalis, Ditylum sol*, and *Guinardia striata* were common in high salinity water (over 30‰). *Cylindrotheca closterium* had higher cell abundance in the salinity range between 25 and 30‰. Concerning the surface water temperature and phytoplankton abundance, most species were plentifully collected in the temperature range of 24-33°C. The present results reflect many diatom species have a well-defined ecological preference.

Nutrient concentrations

Principal Component Analysis (PCA) biplot of dominant phyto-plankton species and nutrient concentrations was presented in Fig. 6. Lines in the PCA biplot pointing in the same directions are positively correlated, while lines pointing in opposite directions are negatively correlated. *Ditylum sol*, *Bellerochea horologicalis*, *Thalassionema nitzschioides*, *Thalassiosira subtilis*, *Rhizosolenia setigera*, *Hemiaulus sinensis*, *Guinardia striata*, *Cylindrotheca closterium*, *Nitzschia seriata*, *Rhizosolenia setigera*, and *Lauderia annulata* had a positive correlation with phosphate except for 5 species *Paralia sulcata*, *Skeletonema costatum*, *Bacteriastrum hyalinum*, *Asterionellopsis glacialis*, and *Fragilaria crotonensis* which were negatively correlated with phosphate concentration. The correlation of dominant phytoplankton with nitrate and ammonia showed a similar pattern to those of phosphate. According to the literature (Brockmann and Kattner 1997), phosphate concentrations are higher in summer months. Thus, the enrichment of nutrients may probably stimulate high cell abundance of phytoplankton during the summer months of the observation period.

Conclusion

In this study, the seasonal fluctuations of phytoplankton assemblages were examined with response to the controlling environmental variables at the five stations along the Tanintharyi coastline. At all stations, the abundance was higher in the pre-monsoon months, probably due to high water temperature, high salinity, and the increase of nutrient concentrations. On the other hand, the decrease in cell number of phytoplankton was noted in the monsoon period which may likely due to low water temperature, low salinity, and a decrease in the nutrient levels. Regarding the seasonal abundance of phytoplankton, Kawthaung and Myeik had higher numbers of phytoplankton among five stations because of more diverse kinds and frequently occurring phytoplankton species at these water columns. It was further considered that structural changes in the phytoplankton community are a good indicator of water quality and aquatic ecological status as they show the complexity and rapid responses to the fluctuations of environmental parameters.

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