CHINESE BIODIVERSITY, Vol. 2, Supplement, pp. 36~42, 1994

Seasonal species Diversity of Phytoplankton in Zhangjiang Seawaters

LIU YU

Institute of Environmental Sciences, Zhongshan University, Guangzhou 510275, *China*

(Received April 1, 1994; Revised June 27, 1994)

ABSTRACT

Similar to other plants, animals and microorganisms, phytoplankton has diversity in many respects, such as species diversity, morphological diversity and ecological diversity. Seasonal variations of species composition and diversity were the greatest difference of phytoplankton from other living populations. Species diversity and diversity indices of phytoplankton and growth related factors were investigated in Zhangjiang seawaters in winter and summer seasons. 15 species appeared only in winter, 49 species appeared only in summer, and 33 species could survive in winter and summer seasons. And the seasonal variations of species richness and abundance were greatly related with water temperature, salinity and other growth related factors. *Thalassionema nitzschioides*, *Nitzschia* sp. and *Coscinodiscus bipartitus* were the dominant species in winter; *Bacteriatrum varians*, *Chaetoceros subescundus* and *Nitzchia* sp., etc were the dominant species in summer. Species diversity index (H), evenness (J) and abundance (d) in summer were higher than in winter. Otherwise, the dominance (D) was higher in winter than in summer. Furthermore, more red-tide algae appeared in summer than in winter.

Key words phytoplankton, Zhangjiang seawaters, season, species diversity, diversity indices, dominant species, red-tide algae

INTRODUCTION

Biodiversity is the sum of all living entities, including plants, animals and microorganisms (Kong et al., 1993). Phytoplanktons which can assimilate CO_2 into organic materials by using light as energy and release O_2 into water are the most important photoautotrophic microorganisms in water bodies. Compared with freshwater and pelagic water ecosystems, coastal ecosystems are the most vigorous and dynamic and variate areas in species composition, and species diversity. Phytoplankton has high species abundance, reproduction rate, morphological types, and ecological diversities and higher primary productivity. Phytoplankton plays a decisive role in biological network and food chain, and of crucial importance in the maintenance and enhancement of species diversity of coastal waters. Phytoplankton biodiversity study is one of the most important branches of marine biological diversity studies (Jiao, 1993; Zhou et al., 1993; Chen et al., 1993; Zou et al., 1993).

There is a great difference between phytoplankton and other living organisms in that the species composition and richness and diversity succession change with season. As for seasonal difference of water temperature, salinity, and other growth related factors, such as transpareancy, nutrients and pollutants, the species composition and number and biodiversity indices of phytoplankton appear great seasonal variations. Zhangjiang harbour is located at south sub-tropical marine area, more reproduction generations and longer growth period of phytoplankton cause the diversities to be higher than in cold regions (Environmental special committee of ecological society of Japan, 1987).

Due to recent pollution caused by discharge of industrial waste water and eutrophication caused by discharge of urban sewage, the natural coastal ecosystem has been changed to various extents, and in summer there are more red-tide algae. (Editing committee of "Specificaltions of oceanographic survey", 1991). The objective of this paper is to elucidate the seasonal variations of species composition and diversities, and the ecological diversity of phytoplankton.

STUDY AREAS AND SAMPLING METHODS

Zhangjiang harbour is one of the eight biggest harbours in China. It is located at E110°80′~35′, N20°52′~21°29′. Its sub-tropical climate makes it freezing-free all year round, its mean annaual temperature is 25.95℃, mean salinity is 29.74‰. Nanshan island, Danhai island and Leizhou island consist of the wide area of Zhangjiang seawaters. Around the Leizhou straits and Leizhou bay is the big stretch of aquatic fields. Phytoplankton is important for the fishery and aquatic productions. Samples of phytoplankton and growth-related factors were taken in the whole Zhangjiang marine

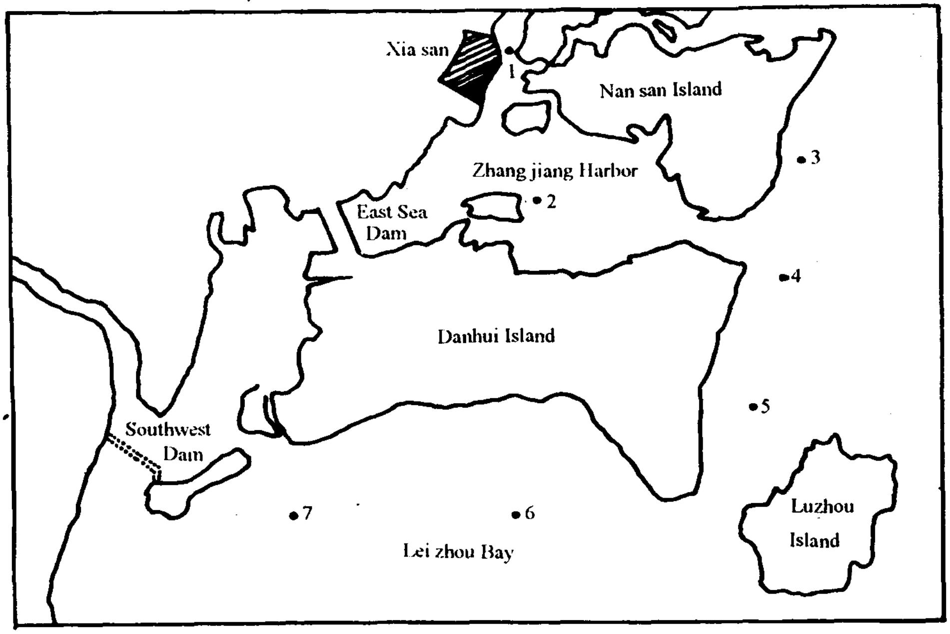

Fig. 1 Illustration of the sampling sites of phytoplankton in Zhangjiang seawaters.
(1 #; 2 #: Zhangjiang harbour; 3 #: Nanshan Island; 4 #: mouth of Guangzhou bay; 5 #: Leizhou straits; 6 #, 7 #: Leizhou bay)

areas, as shown in Fig. 1. Samples at 7 sites were taken for contunuted 24 h at 4 typical tides of surface waters in Jan. 9～10, 1993 and August 17～18, 1993. And the mixed phytoptankton samples were analysed respectively.

STUDY METHODS

By microscopically distincting, classifing, counting and computer calculating, the qualitative and quantitative features of phytoplankton, i.e., the species composition, species richness (individuals/Liter, i.e. ind./L), genus number, family number, total number of phytoplankton (ind./L) in every site were researched. Dominant species and red-tide algae were studied, too (YamamichI, 1979). Using the formula of Abundance (d), Species diversity index (H), Evenness (J) and Dominance (D), the indices of diversity of phytoplankton in Zhangjiang seawaters were calculated (Editing committee of "Specifications of oceanographic survey", 1991).

RESULTS

1 Species composition in different seasons

In winter, the water temperature was relatively lower, ranging from 20.6 to 22.4℃, salinity was relatively higher, ranging from 27.06 to 33.53‰. Lower temperature and higher salinity were not suitable for the growth of hpytoplankton. And it was not the reproduction season for phytoplankton, neither. So the species number, genus number and family number were relatively lower. Winter-specific algae were composed of only 15 species. And 9 genera and 1 family of Bacillariophyta were appeared.

Table 1 Species composition of phytoplankton in different seasons.

Species composition in winter season	Species composition in summer season	Species composition in winter and summer season
Achnanthes sp.	*Amphiprora alata*	*Actinocyclus ehrenbergi*
Biddulphia dubia	*Asterionella japonica*	*A. crassus*
Coscinodiscus africanusp	*Bacteriastrum varians*	*Actinoptychus undulatus*
C. centralla	*Biddulphia regia*	*Amphora* sp.
C. curvatulus	*Ceataulina bergoni*	*Biddulphia granulata*
C. jonesianus	*C. compacta*	*B. mobiliensis*
C. marginato-lineatus	*C. zhongshaensis*	*Chaetoceros abnormis*
C. oculus-iridis	*Chaetoceros constrictus*	*C. affinis*
C. radiatus	*C. affinis* var. *circinalis*	*C. brevis*
Hyalodiscus stelliger	*C. laevis*	*C. decipiens*
Melosira sp.	*C. lorenzianus*	*C. subsecundus*
Navicula sp.	*C. paradoxus*	*Coscinodiscus argus*

Pleurosugma normanii
Rhizosolenia robusta
Trachyneis bebyi

C. pseudocurviselus
C. sp.
Corethron hystrix
Coscinodiscus sp.
Cyclotella bodania
Eucampia zoodiacus
Hemiaulus hauckii
H. membranaceus
H. sinensis
Lauderia borealis
Leptocylindrus danicus
Mastogloia sp.
Navicula membrannacea
Nitzschia lorenziana
N. panduriformis
Pleurosugma angulatum
P. naviculaceum f. *minuta*
P. sp.
Rhizosolenia calcar-avis
R. clevei
r. fragilissima
R. hebetata f. *semispina*
R. imbricata
R. setigera
R. stollerfothii
R. styliformis var. *latisima*
Skeletonema costalum
Streptotheca thamesis
Striatella unipunetata
Triceratium pellucida
Ceratium furca f. *eugrammum*
C. trichoceros
Gymnodinium sp.
Perdinium steinii
Prorocentrum micans
Pyrocystis robusta
Dictyocha fibula

C. bipartitus
C. divisus
C. excentricus
C. lineatus
C. spinosus
C. subtilis
C. throrii
Cyclotella sp.
C. slricata
Diploneis bombus
Ditylum sol
Gyrosigma sp.
Henidiscus hardmannianus
Nitzschia paradoxa
N. sp.
Pleurosugma aestuarii
Surirella fluminensis
Thalassionema nitzschioides
Thalassiothrix frauengeldii
Perdinium sp.
Trichodesmium sp.

In summer, water temperature was relatively higher, about 30.0 ~ 31.2℃, salinity was relatively lower, about 22.91～32.63‰. Higher temperature and lower salinity were more suitable for the growth of phytoplankton. Warm water temperature was of benifit to the growth of most algae. Summer-specific algae were greatly higher than in winter. 49 species and 28 genera and 3 families of Bacillariophyta, Pyrrophyta and Chrysophyta appeared.

Besides the seasonal selection of some algae, many species of phytoplankton had wide adaptability to temperature and salinity and nutrient variations, they could be found in all seasons. We found that 33 species and 18 genera and 3 families of Bacillariophyta, Pyrrophyta, Cyanophyta appeared. The composition of phytoplankton was shown in Table 1.

Table 2 Seasonal distribution and richness of dominant species of phytoplankton (richness: ind. /L).

Sites	Dominant species in winter	Amount	Dominant species in summer	Amount
1#	*Coscinodiscus excentriens*	735	*Nitzschia* sp.	18900
	Thalassiothrix frauenfoldii	560	*Chaetoceros pseudocurvisctus*	18300
2#	*Thalassionema nilzschioides*	1235	*Chaetoceros* sp.	6900
	Chaetoceros sp.	570	*Nitzschia* sp.	5700
3#	*Nltzschia* sp.	320	*Chaetoceros* sp.	5250
	T. nitzschioides	160	*Chae. paradoxus*	5000
4#	*T. nitzschioides*	910	*Bacteriatrum varians*	7500
	Nitzschia sp.	1385	*Chae. paradoxus*	7250
5#	*T. nitzschioides*	2250	*B. varians*	12500
	Nitzschia sp.	3850	*Chaetoceros* sp.	11750
6#	*T. nitzschioides*	2280	*B. varians*	15120
	Cyclotella sp.	1805	*Chaetoceros* sp.	19800
7#	*Nitzschia* sp.	2250	*Nitzschia* sp.	19800
	Cos. bipartitus	1950	*Chae. subsecundus*	16800

2 The dominant species and red-tide algae

Although the species richness and abundance were lower in winter than in summer, the dominant species in winter was apparent. *Thalassionema nitzschioides* was the typical dominant algae in winter. Dominance *(D)* and abundance *(d)* indices were calculated by the formula of D and d, that is: $D = N_1 + N_2/NT$, $d = S - 1/log_2 N$, where, N_1: the number of individuals in the first dominant species, N_2: the number of individuals in the second dominant species, NT: total number, and S: the number of species. N: the total species number. We calculated that the dominance in winter was higher (0.550), the average dominance of the whole marine area was 0.550, the percentage of dominant species was 55.05%, about half amount consisted of the dominant species, so the abundance *(d)* was lower. Abundance *(d)* in winter was 1.067.

Species richness and abundance were higher in summer than in winter. *Chaetoceros pseudocurvisctus, Chae. paradoxus, Chae. subecundus*, etc. were all dominant algae (see Table 2). But the dominant species were not so obvious as in winter. So, the abundance was higher (1.987) and the dominance was lower (0.350) than in winter, respectively. And as the relatively lower contents of $NO_2^- - N$, NH_4^+ and relatively higher content of $NO_3^- - N$ in summer, the nitrogen turnover was faster than in winter. Phosphate was relatively higher, too. But N:P ratio (sum of $NO_2^- - N$, $NO_3^- - N$, $NH_4^+ - N$: $PO_4^{-3} - P$) was higher than in winter, 13.58:1 in summer and 13.14:1 in winer, so the water was heavily polluted by N in summer, mainly because the runoff was

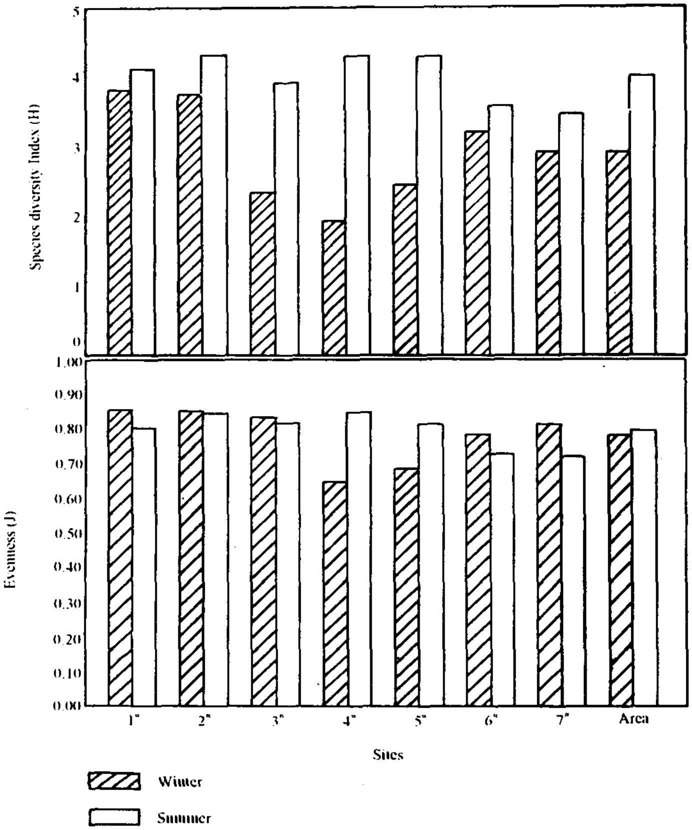

Fig. 2 Species diversity features of phytoplankton in different seasons.

stronger, the nutrients and pollutants were heavier in summer than in winter. So, the eutriphication had some effects on the diversity of phytoplankton. Red-tide algae were flourishing.

The red-tide algae appeared in winter were: 1 # : *Peridinium* sp., *T. nitzschioides*, *Trichodesmium* sp.. 2 # : *C. subsecundus*, *C. affinis*, *T. nitzschioides*. 3 #, 4 #, 5 #, 6 #, 7 #: *T. nilzschioides*. *T. nilzschioides* was the dominant red-tide algae in winter. The red-tide algae in winter accounted for 21.09% of the algae.

There were many red-tide algae appeared in summer in every site, and had higher density than in winter, too. Red-tide algae consisted mainly of *Asterionella japonica*, *T. nitzschioides*, *C. affinis*, *Ceratium furca f. cugrammum*, *C. subsecundus*, *C. lorenzianus*, *C. trichoocros*, *Dictyocha fibula*, *Gymnodinium* sp., *Skeletonema costatum*, *Trichodesmium* sp., *Prorocenntrum micans*, *Perdinium* sp., *Leplocylindrus danicus*, *Rhizosolenia stolterfothii*, *R. styliformis* var. *latisima*, and *R. setigera*. The proportion of red-tide algae was 23.66% in summer.

3 Species diversity features of phytoplankton in different seasons

Species diversity indices are commonly used to elucidate the diversity of species of phytoplankton. Species diversity index (H), $H = -\sum Pi\log_2 Pi$, $Pi = ni/N$, ni : number of individuals of i species (ind./L), N: total number of individuals in one sample (ind./L), S: number of species in one sample: and evenness (J): $J = H/\log_2 S$, S: total number of species in one sample, H: species diversity indes, showed that species diversity and evenness of phytoplankton in Zhangjiang seawaters were higher in summer *H* was 4.016, *J* was 0.799, than in winter *H*: 2.930, J: 0.785 (as shown in Fig. 2). So, owing to the growing conditions was better in summer than in winter, the algae growth was more diverse and vigrous than in winter.

CONCLUSIONS

Phytoplankton is one of the most abundant microorganisms and photoautotrophs in the coastal waters. It has species, morphology, physiology, nutrition and ecology diversities. It is one of the most important branches of marine biodiversity studies. One distinct charateristics from other living organisms is the seasonal succession of species of phytoplankton, and the seasonal species diversity is even more distinct at south sub-tropical marine areas in our country. The species composition, richness and dominant species, red-tide alage are higher in summer than in winter in Zhangjiang seawaters because the higher temperature and salinity and other growth-related factors are more suitable for the reproduction and growth of phytoplankton in summer. The species diversity indices have seasonal differences. The species diversity index (*H*) is higher in summer than in winter.

REFERENCES

Chen Yiyu, Cui Yibo, 1993. Some aspects of biological diversity in freshwater ecosystems. *Chinese Biodiversity*. **1** (1): 46～49

Environmental special committee of ecological society of Japan, 1975.

Environments and indicator organisms (about water-bodies). Peking: Environmental Sciences Publisher of China. 244～263

Editing committee of "Specifications of oceanographic survey". 1991. *Specifications of oceanographic survey*. Peking: Ocean Publisher, 627～728

Jiao Nianzhi, 1993. Some forntires in marine biodiversity studies. *Chinese biodiversity*. **1** (1): 61～65

Kong Gouhui, Liang Chun, Liao Chonghui, 1993. Reconstruction and protection of forests: Critical ways for recovering and enhancing species biodiversity. *Chinese Biodiversity*. **1** (1): 87～92

Zhou Peijin, Huang Yicun, 1993. Species diversity and the application of protokaryotes. *Chinese biodiversity*. **1** (1): 56～60

Zou Renlin, Yu Dengpan, 1993. Studies in the diversity of Hermatypic corals in China. *Chinese biodiversity*. **1** (1): 32～40

Yamamichi I. 1979. Distinguishing Graphs of Plankton of Japan Ocean. Osaka: *Boyu publisher*. 1～503 (in Japanese)