Phytoplankton in the Surface Layers of the South China Sea, Area III: Western Philippines

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ABSTRACT

Phytoplankton in the surface layers of South China Sea, Western Philippines were investigated for species composition, distribution and abundance.

Thirty one stations were sampled during the cruise of M/V SEAFDEC to South China Sea along latitudes 8° to 20°N and longitudes 115° to 121°E from April 15 to May 11,1998. In each station, water samples at the surface and at depths of 20, 40 and 60-m were collected by a 20-liters capacity Van-Dorn water sampler**.**

Results of the phytoplankton analysis yielded a total of 56 taxa. These included 3 species of blue-green algae; 1 genus of Chrysophytes; 32 genera of diatoms and 20 genera of dinoflagellates.

The phytoplankton assemblage was dominated by Bacillariophyceae or diatoms which accounted for 73% of the total standing stock. The top 5 most dominant representatives were *Chaetoceros spp* (962 cells/L); *Bacteriastrum spp* (587 cells/L); *Rhizosolenia spp* (349 cells/L); *Thalassiothrix spp* (314 cells/L) and *Leptocylindrus danicus* (162 cells/L). *Chaetoceros spp* occurred in almost all stations sampled.

Dinoflagellates ranked second in terms of abundance (16%) although they were sporadic and in smaller densities. The top 5 most dominant representatives were *Ceratium spp* (249 cells/L); *Podolampas spp* (91 cells/L); *Gonyaulax spp* (63 cells/L); *Dinophysis spp* (55 cells/L) and *Scrippsiella spp* (46 cells/L).

Blue-green algae or cyanophyceae accounted for 11% of the total standing crop and the most dominant species were *Pelagothrix clevei* (357 cells/L) and *Trichodesmium thiebautii* (153 cells/L).

Less than 1% of the total standing crop is attributed to Chrysophytes represented by *Dictyocha spp.*

Phytoplankton densities in the surface waters (0-m layer) was nominal compared to the other 3 strata/layers (20; 40 and 60-m). Phytoplankton densities increased with depth. Abundant concentrations of phytoplankton coincided with the fluorescence maxima and maximum concentrations of nutrients.

Trichodesmium thiebautii was dominant and formed patches in the surface and near-surface waters along the coast of northern Luzon or near the entrance of Luzon Strait where low water temperatures were recorded and high concentrations of dissolved nutrients were noted, while *Pelagothrix clevei* was also observed to form patches at the surface and near-surface waters along the southern coast near the entrance of Sulu Sea where low water temperatures were recorded and high salinities and maximum concentrations of dissolved nutrients were observed.

Abundant concentrations of diatoms composed mostly of several species of *Chaetoceros*; *Bacteriastrum; Rhizosolenia*; *Thalassiotrix* and *Leptocylindrus* were observed along and/or near the coastlines, while in stations offshore, minimal density was noted.

Several species of dinoflagellates in low densities were observed in stations going offshore.

The paper closes with a brief discussion of the general distribution pattern exhibited by the phytoplankton.

Key words: Western Philippines: SCS, phytoplankton, species composition, abundance, distribution, surface layer

Introduction

Investigating the biological characteristics, particularly phytoplankton, of the waters off the northwest coast of the Philippines is necessary because the region is of paramount importance to the country's fisheries.

The waters off the northwest coast of the Philippines, which joins the South China Sea is characterized by the complex hydrography. There is the northward flowing warm current, the Kuroshio; equatorial current; southward contour current and eddies. The region is part and parcel of the South China Sea ecosystem. There are three important features of South China Sea which requires investigation. It harbors the highest marine biodiversity on earth. It is hypothesized to play a critical support system to surrounding shelf habitats by providing a rich source of pelagic propagules of fish and invertebrates [McManus (1994)]. South China Sea, like other large-scale bodies of water, interacts in the global ocean-atmosphere interactions to bring about climate variability. It is the largest marginal sea in the Indo-West Pacific region. The circulation pattern exhibits strong seasonal variability driven by the Asian Monsoon system (considered to be the strongest monsoon system in the world), and is influenced by the numerous island chains and archipelagos of Indonesia and Philippines, all of which partially isolates the South China Sea from the Western Pacific circulation regime [Wyrtki (1961)].

The region is less studied since it is exposed to the monsoons, hence oceanographic and biological information are scant. However, the area adjacent to southwest Taiwan is extensively studied. Chu (1982); Fan (1982) and Lin et al. (1986) as cited by Huang et al (1988) have extensively studied the movements of waters, while phytoplankton species and their distribution off southwestern Taiwan was reported by Huang (1986); Huang (1988) and Huang and Huang (1987) as cited by Huang et al. (1988). Phytoplankton taxonomy, distribution and occurrence along the coastal waters of northwestern Luzon was studied by Relon (1985).

Phytoplankton study in the waters off the northwest coast of the Philippines is necessary for a better understanding of the hydrographic feature and its influence on the organisms around the region. Estimates of the plankton abundance, distribution and productivity is essential to assess the overall status of the region.

The present study on phytoplankton obtained during the cruise of M/V SEAFDEC along latitudes 8º to 20ºN and longitudes 115º to 121ºE in April-May,1998, describes the species composition, distribution and abundance of phytoplankton in the surface layers. A brief discussion on the general vertical and horizontal distribution patterns exhibited by the phytoplankton is also presented.

Materials and Methods

Thirty one stations [Fig. 1] were surveyed during the cruise of M/V SEAFDEC on April 15 to May 11,1998. Water samples for physico-chemical analysis were collected by a rosette sampler with attached CTD. Temperature and salinity were recorded using CTD.

At each station, water samples at the surface and at depths of 20, 40, and 60-m were collected separately with a 20-liter capacity Van-Dorn water sampler. Twenty liters of water samples were filtered using a 20-µm mesh size net and 250-ml of the water sample were concentrated and stored in Nalgene plastic bottles. Phytoplankton samples were fixed with 10% formalin solution. Phytoplankton samples were examined under a light microscope and identification and enumeration were based on the works of [Fukuyo et al. (1994); Taylor (1979); Yamaji (1969); Subrahmanyan (1963) and Taylor (1963)].

Phytoplankton density estimations were done on a 1-ml aliquot part of the sample in a Sedgewick-rafter counting chamber. Cell density was determined and expressed in cells per liter. For blue-green algae, density was expressed in filaments per liter. The number of cells per liter is calculated after making an adjustment on the volume of water samples concentrated. The initial sample volume (V_1) was 20-liters which was filtered in a 20-µm mesh size net and then concentrated to 25-ml (V_2), from which a subsample of 1-ml (V_3) was taken.

The number of cells per liter is obtained by the formula:

$$\text{Number of cells/liter} = \frac{\text{number of cells counted X } (V_2/V_3)}{V_1}$$

where:

V_1 = initial sample volume (20-liters)
V_2 = concentrated sample
V_3 = subsample taken/analyzed

The mean density values of phytoplankton species were utilized for the computation of species diversity indices. The following formulae were used [Odum (1971]:

Shannon's Index of General Diversity:
H = -Σ[(ni/N) x log (ni/N)
where:
ni = mean density of each species
N = total density

Simpson's Index of Dominance:
C = Σ(ni/N)2
where:
ni = mean density of each species
N = total density values of all species

Pielou's Evenness Index:
E = H/logS
where:
S = number of species
H = Shannon's index of general diversity

Phytoplankton were identified to genus level and whenever possible they were identified up to species level.

Vertical profiles of cell density and biomass (fluorescence) were plotted for comparison across stations and depths. Only 19 stations were utilized in the comparison since the fluorometer used in recording the fluorescence malfunctioned.

For composition analysis, dominant forms of phytoplankton were group into 3 categories:

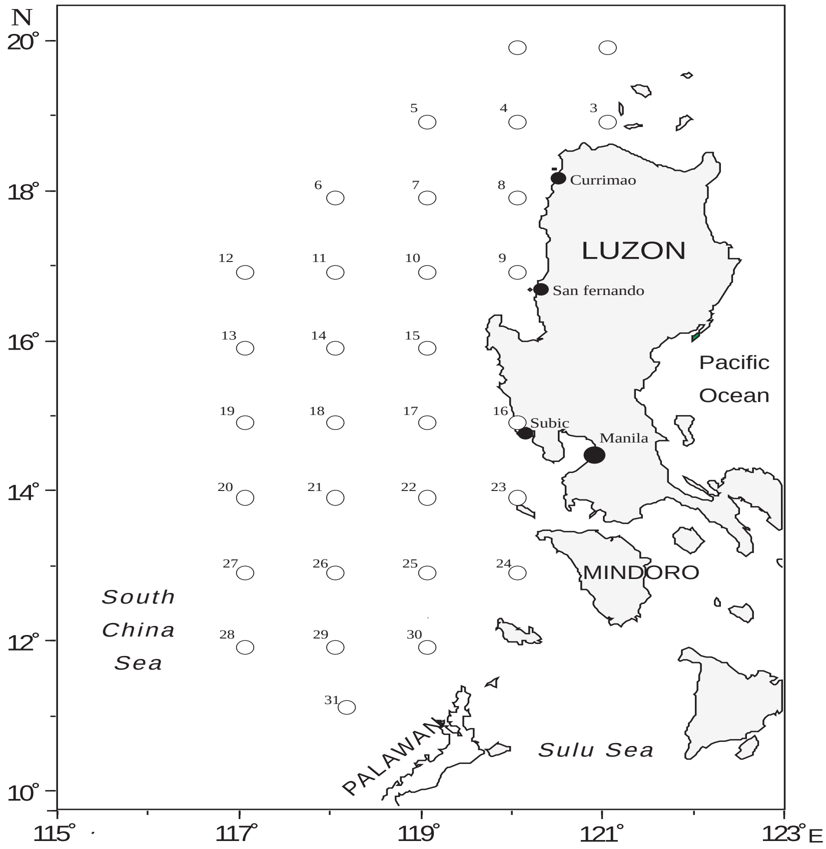


Fig. 1. Stations for phytoplankton sampling

Bacillariophyceae, Cyanophyceae and Dinophyceae. Vertical profiles of cell densities across depths in each station were prepared. Since the phytoplankton composition in the study area is highly diverse, and most of them occurred only in very small number/density, only the top 5 most dominant forms were included in the analysis/interpretation.

Results

Phytoplankton Assemblage

Table 1 presents the composition of phytoplankton found and identified from the 124 water samples collected during the cruise of M/V SEAFDEC in the South China Sea: Western Philippines from April 15 to May 12,1998. There were 4 classes identified, they are: Bacillariophyceae, Cyanophyceae, Chrysophyceae and Dinophyceae.

The assemblage of phytoplankton in the study area contained a total of 56 taxa. These included 3 species of blue-green algae; 1 genus of Chrysophytes; 32 genera of diatoms and 20 genera of dinoflagellates. Most of them are warm-water species and recorded as inhabitants of the Kuroshio of the East China Sea, and off Japan [Yamaji (1969)] and the South Western Indian Ocean [Taylor (1963)].

Relative abundance of phytoplankton in the region is shown in [Fig. 1a]. Likewise, the top 5 most dominant forms were presented in [Fig. 2].

Bacillariophyceae or diatoms accounted for 73% of the total standing crop. The top 5 most dominant representatives of diatoms were *Chaetoceros spp* (962 cells/L or 40%);

Bacteriastrum spp (587 cells/L or 25%); *Rhizosolenia spp* (349 cells/L or 15%); *Thalassiothrix spp* (314 cells/L or 13%) and *Leptocylindrus danicus* (162 cells/L or 7%).

Dinophyceae or dinoflagellates contributed 16% to the total standing crop of phytoplankton, and the top 5 most dominant were *Ceratium spp*(249 cells/L or 49%); *Podolampas spp* (91 cells/L or 18%); *Gonyaulax spp* (63 cells/L or 13%); *Dinophysis spp* (55 cells/L or 11%) and *Scrippsiella spp* (46 cells/L or 9%).

Cyanophyceae or blue-green algae accounted for 11% of the total standing crop and the most dominant species were *Pelagothrix clevei* (357 cells/L or 70%) and *Trichodesmium thiebautii* (153 cells/L or 30%).

Less than 1% of the total standing crop is attributed to Chrysophytes represented by *Dictyocha spp.*

Distribution

The vertical profiles of phytoplankton in the study area is illustrated in [Fig. 4] and [Fig. 3] shows the vertical distribution profiles of the top 5 most dominant representatives of phytoplankton.

Phytoplankton densities in the surface waters (0-m layer) was nominal compared to the other 3 strata/layers (20, 40 & 60-m). In all the 31 stations sampled, it was observed that phytoplankton density increases with depth. Phytoplankton density is greatest at the 60-m stratum/ layer where the maximum fluorescence is also noted.

The most significant component of the phytoplankton community is the diatoms or Bacillariophyceae. A well-defined pattern in the distribution of diatoms in the water column is observed. Concentrations of diatoms increased with depth with the greatest concentrations observed at depths between 20 and 40-m. Station adjacent to the coast of northern Luzon (Sta. 3) and stations near the coast south of Manila (Sta. 16, 23 &24) had high concentrations of

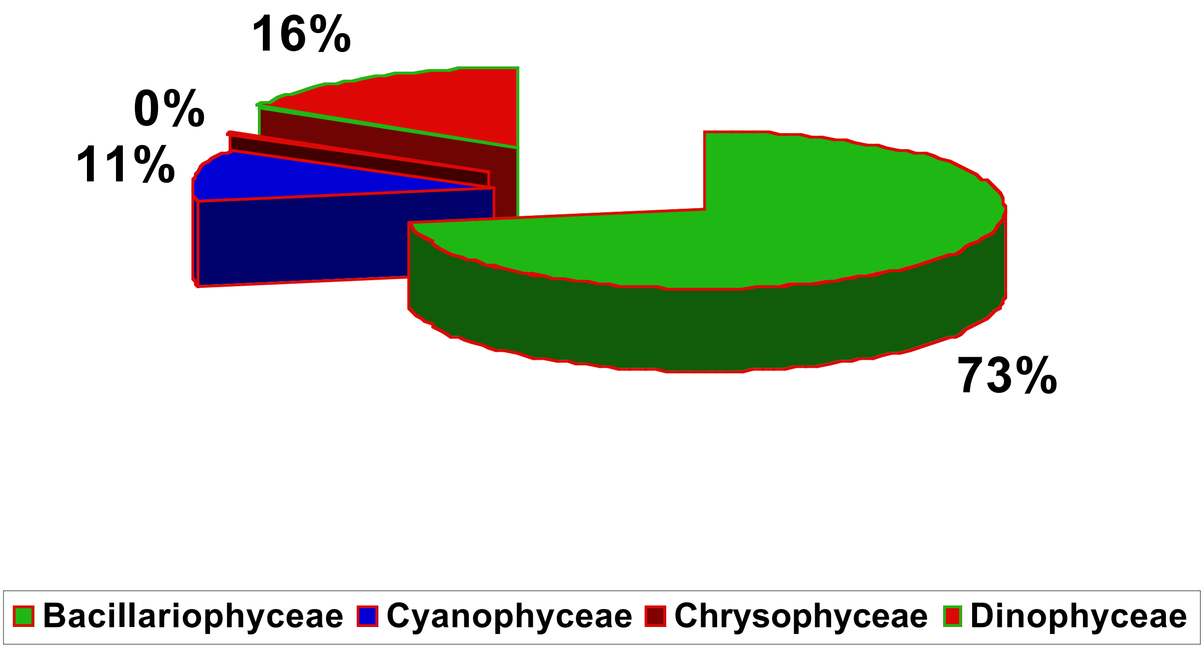


Fig. 1a. Relative abunadce of phytoplankton in the SCS: Western Philippines.

Table 1. List of Phytoplankton from the Surface Layer of South China Sea: Western Philippines, Apr-May,1998.

Division: Chrysophyta
Class : Bacillariophyceae
Order: Centrales
Family: Skeletonemaceae
1. *Skeletonema spp*
2. *Stephanopyxis palmeriana*

Family: Leptocylindraceae
1. *Dactyliosolen mediterraneus*
2. *Leptocylindrus danicus*
3. *Guinardia flaccida*

Family: Corethronaceae
1. *Corethron pelagicum*

Family: Thalassiosiraceae
1. *Thalassiosira spp*

Family: Coscinodiscaceae
1. *Asterolampra marylandica*
2. *Asteromphalus cleavenus*
3. *Coscinodiscus spp*
4. *Planktoniella sol*

Family: Rhizosoleniaceae
1. *Rhizosolenia spp*

Family: Bacteriastraceae
1. *Bacteriastrum spp*

Family: Chaetoceraceae
1. *Chaetoceros spp*

Family: Biddulphiaceae
1. *Biddulphia spp*
2. *Cerataulina spp*
3. *Climacodinium spp*
4. *Ditylum sol*
5. *Eucampia zoodiacus*
6. *Hemiaulus spp*
7. *Streptotheca thamensis*
8. *Triceratium arcticum*

Order: Pennales
Family: Fragilariaceae
1. *Fragilaria spp*
2. *Thalassiothrix spp*

Family: Tabellariaceae
1. *Rhabdomena adriaticum*

Family: Achnanthaceae
1. *Coconeis pseudomargarita*

Family: Naviculaceae
1. *Amphipora gigantea*
2. *Amphora lineolata*
3. *Navicula spp*
4. *Pleurosigma spp*

Family: Nitzschiaceae
1. *Bacillaria paradoxa*
2. *Nitzschia spp*

Division: Cyanophyta
Class: Cyanophyceae
Order: Nostocales
Family: Oscillatoriaceae
1. *Trichodesmium thiebautii*
2. *Pelagothrix clevei*

Family: Nostocaceae
1. *Nostoc spp*

Class: Chrysophyceae
Order: Dictyotales
Family: Dictyochaeae
1. *Dictyocha spp*

Division: Pyrrophyta
Class: Dinophyceae
Order: Prorocentrales
Family: Prorocentraceae
1. *Prorocentrum spp*

Order: Dinophysiales
Family: Amphisoleniaceae
1. *Amphisolenia spp*

Family: Dinophysiaceae
1. *Dinophysis spp*
2. *Ornithocercus spp*
3. *Histioneis spp*
4. *Citharistes apstenii*

Order: Peridiniales
Family: Pyrophacaceae
1. *Pyrophacus spp*

Family: Peridiniaceae
1. *Diplopsalis sp.*
2. *Protoperidinium spp*
3. *Scrippsiella spp*
4. *Zygabikodinium lenticulatum*

Family: Gonyaulacaceae
1. *Amphidoma sp.*
2. *Gonyaulax spp*

Family: Ceratocoryaceae
1. *Ceratocorys spp*

Family: Ceratiaceae
1. *Ceratium spp*

Family: Oxytoxaceae
1. *Oxytoxum spp*

Family: Cladopyxidaceae
1. *Cladophyxis brachiolata*

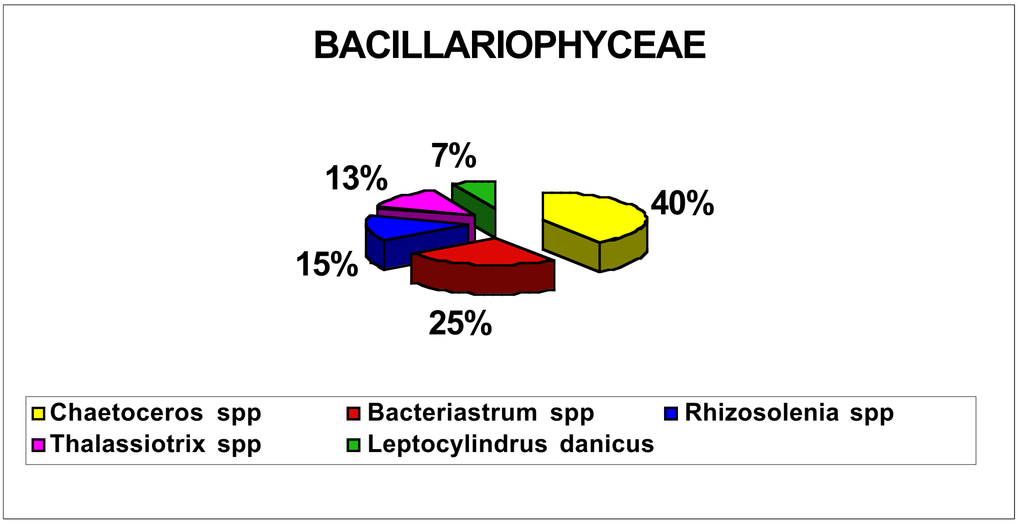
Family: Podolampadaceae
1. *Podolampas spp*

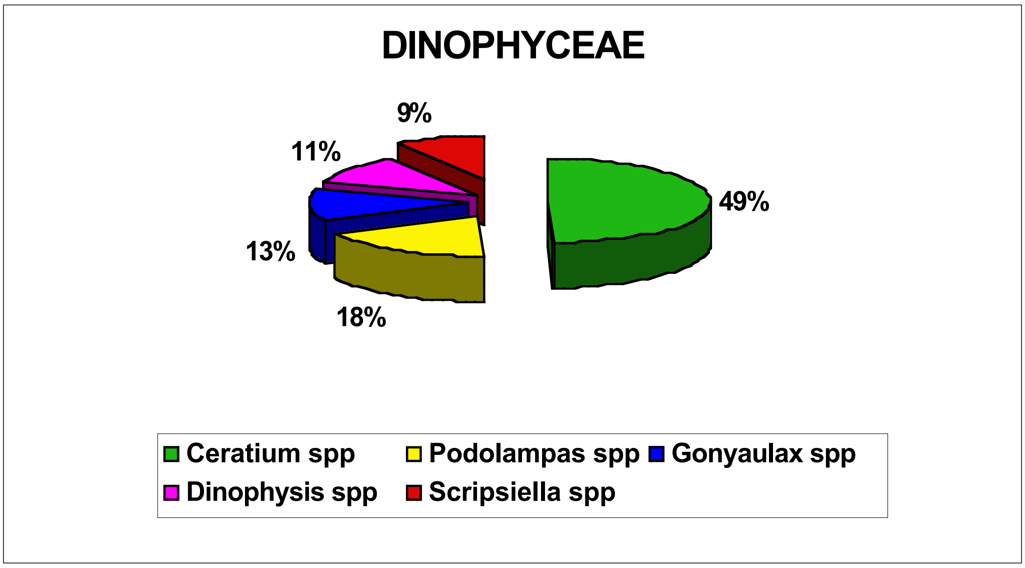
Family: Goniodomataceae
1. *Goniodoma spp*

Order: Phytodiniales
Family: Pyrocystaceae
1. *Pyrocystis spp*

Table 2. Phytoplankton Density in South China Sea: Western Philippines, Apr-May,1998.

STATION	BACILLARIOPHYCEAE				CYANOPHYCEAE				CHRYSOPHYCEAE				DINOPHYCEAE			
	0-m Cells/L	20-m Cells/L	40-m Cells/L	60-m Cells/L	0-m Cells/L	20-m Cells/L	40-m Cells/L	60-m Cells/L	0-m Cells/L	20-m Cells/L	40-m Cells/L	60-m Cells/L	0-m Cells/L	20-m Cells/L	40-m Cells/L	60-m Cells/L
1	13	53	15	9	0	23	25	0	0	0	0	3	15	30	20	24
2	7	0	380	229	180	39	0	0	0	0	3	0	32	4	62	24
3	68	105	14	135	12	0	0	0	0	0	0	0	17	35	20	6
4	24	42	36	234	9	0	2	0	0	2	0	2	17	27	32	12
5	18	27	77	282	0	0	0	0	2	0	0	0	23	26	14	0
6	30	57	8	84	0	0	0	0	2	0	0	0	26	23	6	12
7	9	24	211	148	0	0	0	15	0	0	0	0	27	14	11	12
8	19	30	2	111	11	0	0	10	0	0	0	0	25	32	14	6
9	10	14	7	30	12	0	7	0	0	0	0	0	28	24	18	16
10	2	5	37	62	23	0	0	0	0	0	0	0	21	22	37	23
11	13	7	0	111	0	0	0	0	0	0	0	0	33	17	12	20
12	6	50	45	3	0	0	3	0	0	0	0	0	12	31	21	8
13	40	18	4	4	28	0	61	0	0	0	0	2	17	30	29	32
14	10	60	151	9	2	0	0	6	0	0	0	0	49	23	49	9
15	3	48	15	146	0	0	23	0	0	0	0	0	9	6	8	25
16	477	1093	1210	779	0	6	0	12	0	0	0	0	28	33	63	15
17	11	13	67	28	0	0	19	34	0	0	0	0	25	31	33	12
18	8	0	3	9	0	0	128	0	0	0	0	0	46	12	23	8
19	0	20	28	27	0	5	0	31	0	0	0	0	6	24	57	14
20	7	6	6	0	0	5	0	0	0	2	2	0	30	55	19	14
21	19	14	13	2	2	18	0	0	0	0	0	2	25	18	18	16
22	2	20	0	32	0	30	40	31	0	0	0	0	26	20	32	15
23	43	248	145	446	110	270	382	0	4	4	0	0	8	55	28	29
24	277	264	1985	1187	0	335	0	20	0	0	15	0	39	88	18	16
25	5	3	18	67	28	6	9	0	0	0	0	0	9	12	9	18
26	24	16	3	280	4	0	0	0	0	0	0	0	49	24	23	15
27	6	12	18	6	9	0	0	0	0	0	0	0	98	35	31	26
28	9	23	40	67	0	11	3	0	0	0	0	0	12	24	21	6
29	17	7	15	0	0	0	9	0	0	0	0	11	30	24	31	26
30	19	6	169	11	0	0	5	2	0	0	0	0	60	8	9	17
31	63	3	54	39	0	0	0	0	0	0	0	0	44	9	17	9





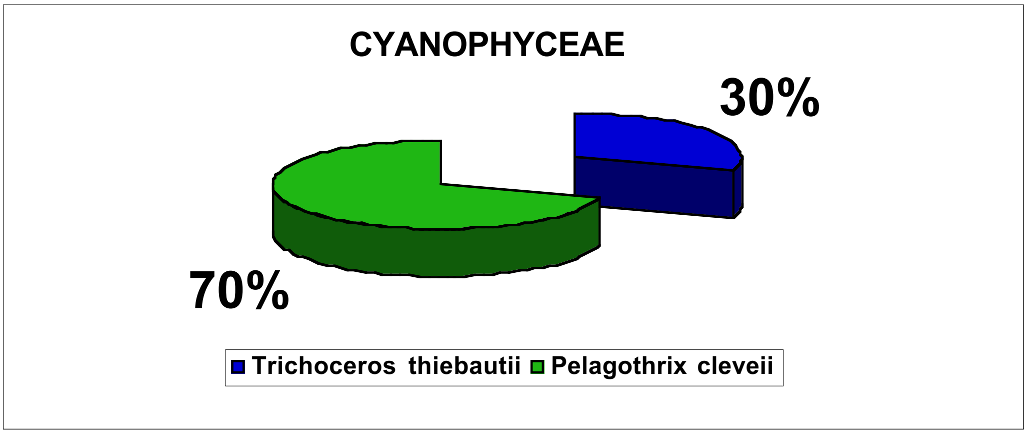


Fig. 2. Percentage composition of the top 5 most dominant representatives of phytoplankton in SCS: Western Philippines, Apr-May,1998.

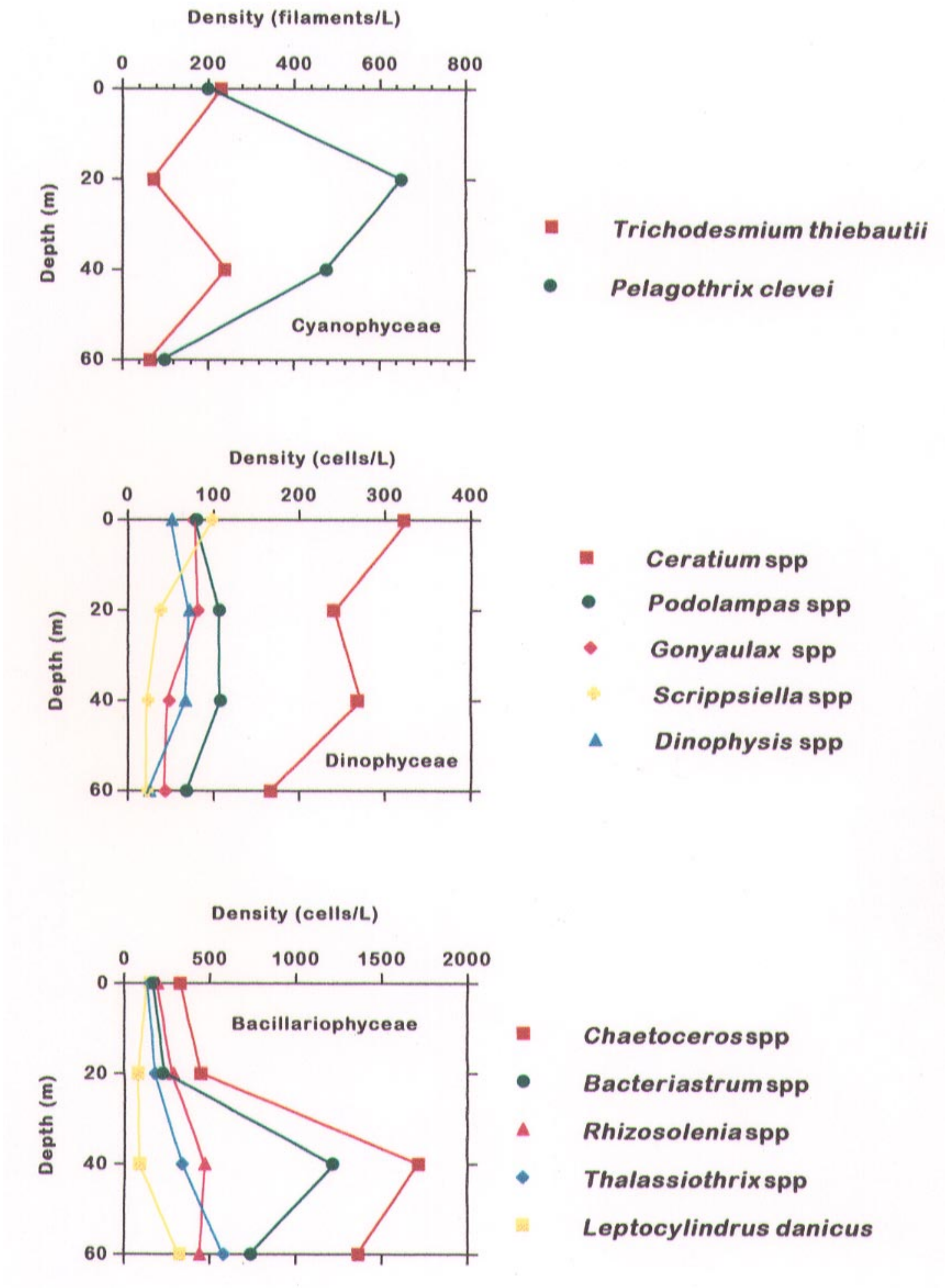


Fig. 3. Vertical distribution of the top 5 most dominant representatives of phytoplankton in SCS: Western Philippines, Apr-May,1998.

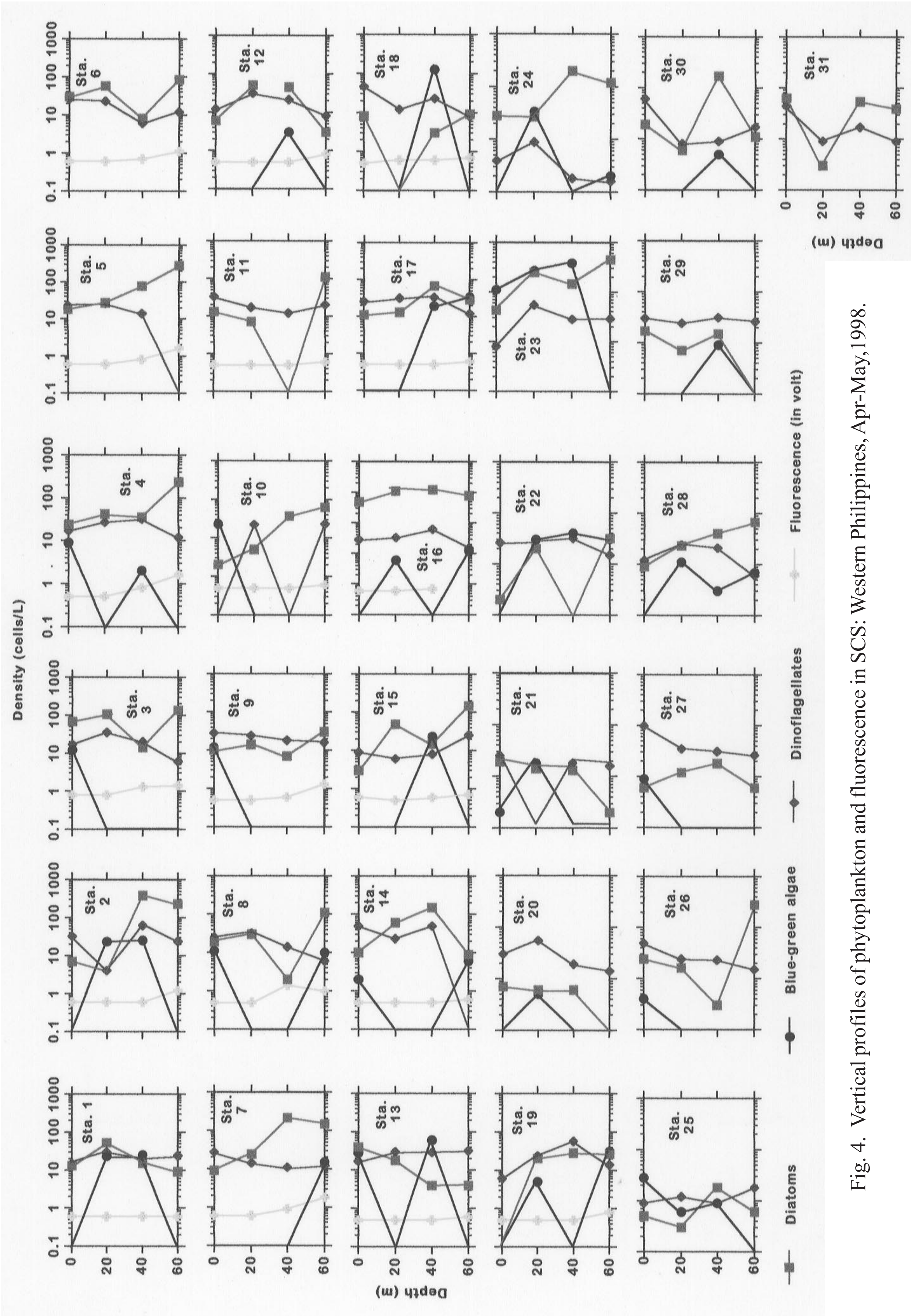


Fig. 4. Vertical profiles of phytoplankton and fluorescence in SCS: Western Philippines, Apr-May,1998.

diatoms with maximum cell densities recorded at the stations along the coast of Subic and near the coast south of Manila (Sta. 16 & 24) with cell densities of 1,210 cells/L and 1,985 cells/ L, respectively. The most dominant forms of diatoms observed were *Rhizosolenia spp; Bacteriastrum spp* and *Chaetoceros spp*. They were abundant in almost all the stations, except at Sta. 15 which was dominated only by *Rhizosolenia spp*. *Chaetoceros spp* occurred in almost all the stations sampled with an average cell density of 1,363 cells/L, with the greatest density noted along the coast of Lubang Island (Sta. 24). *Chaetoceros spp; Bacteriastrum spp* and *Rhizosolenia spp* exhibited a similar pattern in the vertical distribution in the water column. Their cell concentrations increased with depth, with the maximum concentrations observed at 40-meters depth and at a depth of 60-m and below, it diminished. *Thalassiothrix spp* and *Leptocylindrus danicus* also exhibited a similar pattern. Cell concentrations increased with increasing depth with the highest concentrations recorded at 60-m layer.

Dinoflagellates or dinophyceae ranked second in terms of abundance (16%) among the phytoplankton community observed in the study area. They occurred sporadically in nominal densities. However, high cell density was noted in Sta. 30 and high concentrations occurred between depths of 20 and 40-m. Above and below these depths, concentration decreased.

Cyanophyceae or blue-green algae shared 11% in the total standing crop of the phytoplankton community. A distinct pattern in the distribution was noted. High concentrations were observed at 40-m, and below this depth, blue-green algae were absent. *Trichodesmium thiebautii* and *Pelagothrix clevei* both formed patches in the surface and near-surface waters. Abundant patches of *Trichodesmium thiebautii* were observed in the stations along the coast of northern Luzon (Stations 1 & 2), a region adjacent to the Kuroshio regime; while *Pelagothrix clevei* formed abundant patches in stations along the coast south of Manila (Stations 23 & 24).

Correlation of phytoplankton density and fluorescence across stations and depths were presented in Figure 4.

The highest fluorescence was registered at station 7 at a depth of 60-m and this was attributed to the abundant concentrations of diatoms.

Occurrence of diatoms in high densities were found between depths of 20 and 60-m, with the maxima observed between 40 and 60-m. A good correlation between cell densities and fluoresecence was noted.

Dinoflagellates in nominal concentration occurred sporadically in the study area, but a relatively higher concentration (180 cells/L) was recorded at station 30. There was no distinct relationship between dinoflagellates densities and fluorescence.

Diversity

Figure 5 shows the species diversity indices of the phytoplankton community. The average index of species diversity (i.e. Shannon index of general diversity) of phytoplankton in almost all stations were high, with the highest observed in Station 16 (4.52). The stations which registered low index of species diversity were 2, 15, 19, 21 & 25, with the lowest noted in Station 2. Meanwhile, low index of evenness was determined in stations where low index of species diversity occurred, with the lowest noted also in Station 2. The Shannon Index of General Diversity indicates the species richness in a given area. The higher the Shannon Index, the more species present, thus the higher biodiversity. Evenness, on the other hand, indicates the equitability of the species in terms of importance values (i.e. plankton densities) in the area. Higher evenness values suggest a more or less equal distribution of individuals across species, thus more diverse plankton community. Except for 2 stations, all the stations sampled have high biodiversity. The dominance index indicates the presence of dominant species, that is, the higher the dominance index, the lower the diversity. Only stations 2 & 21 have high index of dominance, with Station 21 showing the highest value (5.52). Higher values of dominance index in stations 2 & 21 were attributed to the dense patches of *Trichodesmium thiebautii* and *Pelagothrix clevei*, respectively.

Discussion

The standing stock of phytoplankton in the study area was 4,542 cells/L. The concentrations increased with depth, with the greatest concentrations observed at 60-m and increased toward the coast. Vertical and spatial heterogeneities were apparent.

Higher density of phytoplankton were observed at stations along and/or near the coast while low densities were noted at stations offshore and the standing stock of phytoplankton maxima usually occurred considerably at deeper strata (40-60-m). This condition is typical for tropical waters such as the Western Philippines: South China Sea.

Table 3 shows the comparison of chlorophyll-a determined from the different tropical waters.

[Marumo (1972)] determined the chlorophyll-a from South China Sea, Indian Ocean, Philippine Sea and Celebes Sea which ranged from 0.11-0.16 mg/m^3 ; 0.10-0.17 mg/m^3 ; and 0.10-0.27 mg/m^3 respectively. [Wauthy (1972)] calculated the chlorophyll-a of the waters North of New Guinea and the Chl-a ranged from 0.10-0.40 mg/m^3. Wauthy(1972) observed that the surface layer which is above the maxima, is typically poor offshore (<.10mg/m^3) and richer in the inland Bismark Sea with high values near New Guinea coast (>.40mg/m^3). On the other hand, the result of the present study is comparable to the findings of the above-cited authors, with the surface layer also typically poor offshore (.10 mg/m^3) and rich along the coast south of Manila (.18 mg/m^3).

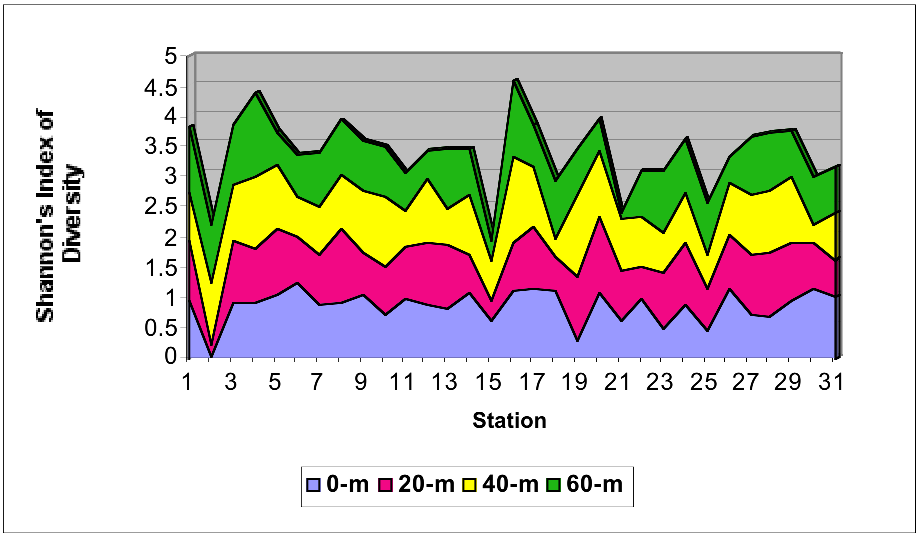
Spatial and temporal variations in plankton are seen to be strongly correlated with physical oceanographic processes and mediated by biological-physical interactions rather than purely biological forcing functions [Barnes, R.S.K. & R.N. Hughes (1968)]. Solar radiation and essential nutrient availability are the dominant physical factors that control phytoplankton production in the sea [Lalli, C.M. & T.R. Parsons (1993)].

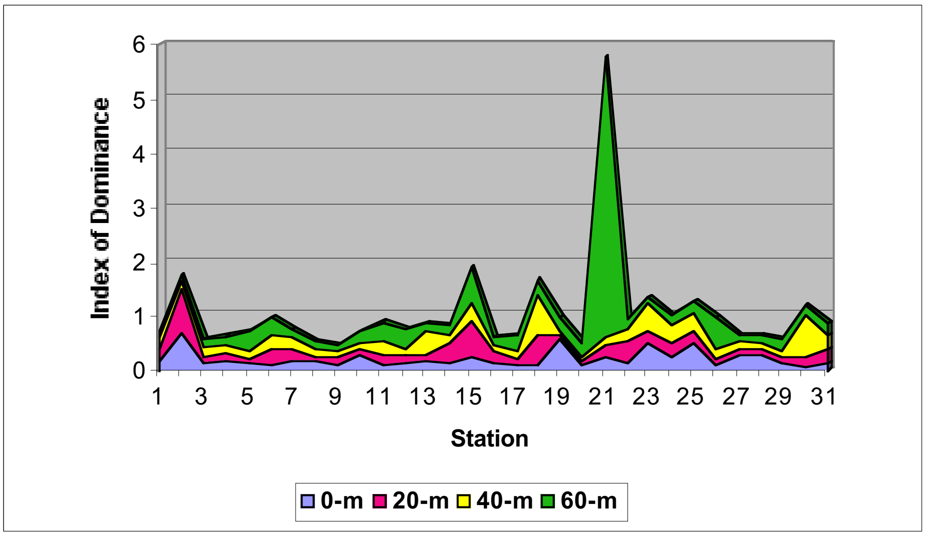
Dissolved nutrients in the study area were investigated by Montojo (this volume) and he found out that homogeneous water mass was almost devoid of nutrients particularly nitrate, nitrite and phosphate. Montojo (this volume) also observed that stations located near the entrance of Luzon Strait and Sulu Sea were rich in nutrients and the maxima were noted in these stations. Likewise, abundant concentrations of phytoplankton coincided with the high nutrient concentrations. High concentrations of phytoplankton were also found in stations where high concentrations of nutrients were observed.

The species composition of diatoms is similar to that reported by Huang (1986) and Relon (1985) off Southwestern Taiwan and coastal waters of Northern Luzon, respectively. Marumo (1972) studied the standing crop and phytoplankton community in the Southeast Asian Seas and his findings conformed to the findings of this present study.

Dense concentrations of phytoplankton, chiefly diatoms, were present at all inshore areas sampled.

In the northern coast, near the entrance of Luzon Strait, the population composed a pronounce admixture of oceanic species with the neritic subtropical and eurythermal species. Such species as *Trichodesmium thiebautii, Climacodinium spp, Eucampia zoodiacus* and *Ditylum sol,* common in subtropical waters were frequently present at stations close to the coast, presumably due to its close proximity to the Kuroshio regime. There was a marked spread of





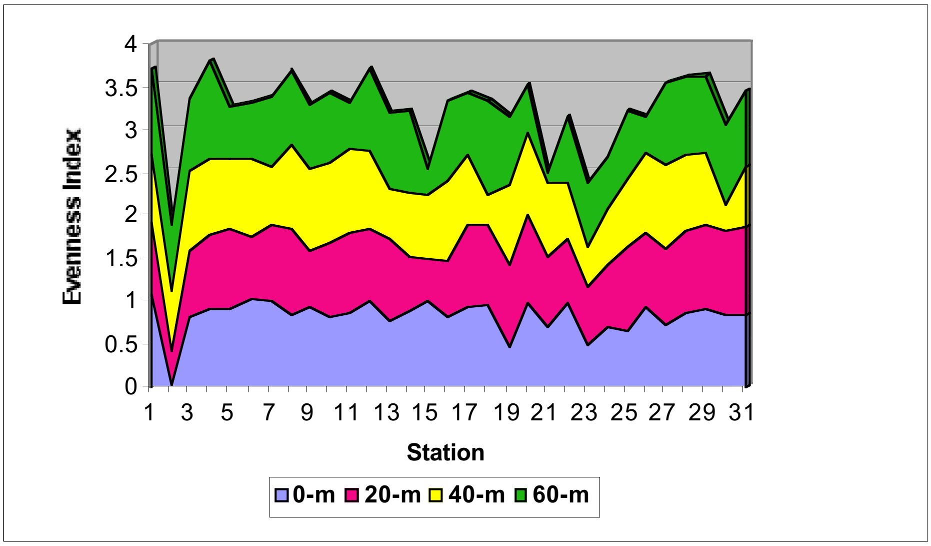


Fig. 5. Phytoplankton species diversity indices

Table 3. Cholorophyll-a obtained from various tropical waters.

AREA	Cholorophyll-a Values	SOURCE
South China Sea	0.11 – 0.16 mg/m^3	Marumo(1972)
Indian Ocean	0.16 mg/m^3	Marumo(1972)
Philippine Sea	0.10 – 0.17 mg/m	Marumo(1972)
Celebes Sea	0.10 – 0.27 mg/m^3	Marumo(1972)
North of New Guinea	0.10 – 0.40 mg/m^3	Wauthy(1972)
Western Philippines: SCS	0.10 – 0.18 mg/m^3	This study

neritic species from the region into the offshore areas. *Chaetoceros spp* was widely distributed in the whole area sampled. It was the most ubiquitous species recorded, being present in all the stations.

Dinoflagellates occurred in offshore areas of the region in smaller density.

The waters off Western Philippines is floristically interesting since the area is part of the South China Sea which is believed to harbor the highest marine biodiversity on earth. The break-up of the highly diverse circumglobal Tethys Sea during the early to mid-Cenozoic [McCoy & Heck (1976)], and speciation through allopatry and basin isolation [Greenfield (1968)] provide evolutionary explanation for some of the observed patterns of marine biodiversity in the region. Proximate mechanisms also exist to maintain this biodiversity in ecologically temporal scales. The island mass effect and retention mechanism imposed by reversing monsoonal winds allow for the maintenance of high diversity.

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References

Barnes, R.S.K. and R.N. Hughes. 1988. An Introduction to Marine Ecology. 2nd ed. Blackwell Scientific Publications, Cambridge, USA. 351 p.

Fukuyo, Y. *et al*. 1994. Red Tide Organisms in Japan: An Illustrated Taxonomic Guide. Tokyo, Japan. 35 p.

Greenfield, D.W. 1968. The Zoogeography of Myripristic (Pisces: Holocentridae) Syst. Zool. 17(1):76-87.

Huang, R., Jan, Li and Chang, C.H. 1988. A Preliminary Analysis of Phytoplankton Variability in the Western Philippine Sea. *Acta Oceanogr. Taiwan*, 21:82-91.

Lalli, C.M. & T.R. Parsons. 1993. Biological Oceanography: An Introduction. 1st ed.Pergammon Press, USA, 45-75 pp.

Marumo, R. 1972. Phytoplankton in the Sea Area of the Southeast Asia. In. Proc. Of the Third CSK Symposium, Bangkok, Thailand.

McCoy, E.D. & K.L. Heck. 1976. Biogeography of Corals, Seagrasses and Mangroves: An

Alternative to the Center of Origin Concept. *Syst. Zool*., 25:201-210.

McManus, J.W. 1985. Marine Speciation, Tectonics and Sea Level Changes in Southeast Asia. Proc. 5th Int. Coral Reef Symposium. Tahiti, 133-138 p.

Montojo, U.M. 2000. Dissolve Nutrients in Western Philippines: South China Sea. (this volume)

Odum, E.P. 1971. Fundamentals of Ecology. 3rd ed. W.B. Saunders Co., Philadelphia, 574 p.

Relon, M.D. 1985. Phytoplankton Studies in Northwestern Luzon, Phil. Ph. D. Thesis, University of Santo Tomas, Phil. 90 p.

Taylor, F.J.R. 1976. Dinoflagellates from the International Indian Ocean Expedition. Bibliotheca Botanica. Strutgart.

Taylor, F.J.R. 1965. Phytoplankton of the South Western Indian Ocean. Nova Hedmigia, Beth. 12(314):433-476.

Yamaji, I. 1969. Illustrations of the Marine Plankton of Japan. 337 p.

Wauthy, B. 1972. Phytoplankton and Circulation North of New Guinea in Summer 1971. In Proc. of the Third CSK Symposium, Bangkok, Thailand.

Wyrtki, K. 1961. Preliminary Oceanography of the Southeast Asian Waters. NAGA Report vol. 2, Scripps Institute of Oceanography, La Jolla, Calif.