

## Phytoplankton species composition, abundance and distribution in Fishing area 58 of Indian Ocean sector of Southern Ocean

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Phytoplankton species composition, abundance and standing stocks investigations were carried out during the First Indian Antarctic Krill Expedition (FIKEX). Nitrate, phosphate and silicate were available in sufficiently higher concentrations at Polar Front zone. Nitrate and silicate, exhibited a marked boundaries between high values in the Sub Antarctic region. Diatom dominated the phytoplankton in the study region and their numbers generally increases southward with peaks of abundance in Sub Antarctic waters. Dinoflagellates, flagellates and “monads” occur in highest concentration north of the Polar Front zone. Various diatom assemblages are characteristics of different latitudinal zones. Vicinity of the Polar Front was found to be rich in *Nitzschia*, *Pseudonitzschia* group of species. South of Polar Front *Nitzschia* “nana” (Cells of both *N. cylindrus* and *N. pseudonana*) and *Dactyliosolen tenuijunctus* dominate. Diatoms viz. *Fragilariopsis kerguelensis* and *Thalassionema nitzschioides*; were reported earlier and present studies. Present study also reveals that the diatom *Pseudonitzschia* spp. were numerous in numbers.

[**Keywords** : Phytoplankton, Southern Ocean, Polar Front, Sub Antarctic]

### Introduction

Phytoplankton studies in the Southern Ocean were carried out over large oceanic areas during austral summer<sup>1-4</sup> and especially in Indian Ocean on quantitative diatom studies between Africa and Antarctica are reported by Kozlova (1964, 1970)<sup>5-6</sup>; Steyaert (1973a, 1974)<sup>7-8</sup> and Jacques et al. (1979)<sup>9</sup>. The work of Karsten (1907)<sup>10</sup>; Van Heurck (1909)<sup>11</sup>; Heiden and Kolbe (1928)<sup>12</sup>; Hendey (1937)<sup>13</sup>; Kozlova (1964)<sup>14</sup> and Sournia et al. (1979)<sup>15</sup> are valuable references for the floristic analysis of plankton from the southwestern Indian Ocean.

Recent phytoplankton investigations are on specific area like rich coastal zone<sup>16-17</sup>, marginal ice zone<sup>18-21</sup>, frontal zones<sup>22-24</sup> or in the impoverished open ocean zone<sup>9</sup>. These studies provide quantitative information on the biogeographical distribution patterns of phytoplankton of the Southern Ocean. However, there are many gaps concerning over knowledge of the relationships between mesoscale hydrographical features and variability of the phytoplankton composition in Antarctic waters. In spite its hydrographical and biological interest work was done by Deacon (1979)<sup>25</sup>.

The main objective of the present study has been to gain quantitative information on the composition,

abundance, and distribution of the phytoplankton, as sampled during austral summer 1995 cruise of the FORV Sagar Sampada (Fig. 1). Majority of stations occupied during this cruise are located in Polar Front zone (Stations 1 – 13) and Sub Antarctic Front (Stations 14 – 17). The Sub Antarctic stations are located between South Africa and Antarctic Continent. The data are interpreted within this physical context. Analyses of the species count data identifies various assemblages as characteristic of different latitudinal zones and clarifies distributional patterns of individual species.

### Material and Methods

Phytoplankton samples were collected from 17 stations during the First Indian Antarctic Krill Expedition (December, 1995 to March, 1996) onboard FORV Sagar Sampada to Indian sector of the Southern Ocean covering the geographical limits of latitude 58° 00' to 61° 17' S and longitude 30° 00' to 40° 00' E (Fig. 1). The stations are designed as per the classification code of different Antarctic zones along with geographical limits degree. Polar Front covers (Stations 1 - 13) and Sub Antarctic Front covers (Stns. 14 - 17), respectively.

Surface samples were obtained using Niskin bottles. Aliquots of 100 mL were preserved with

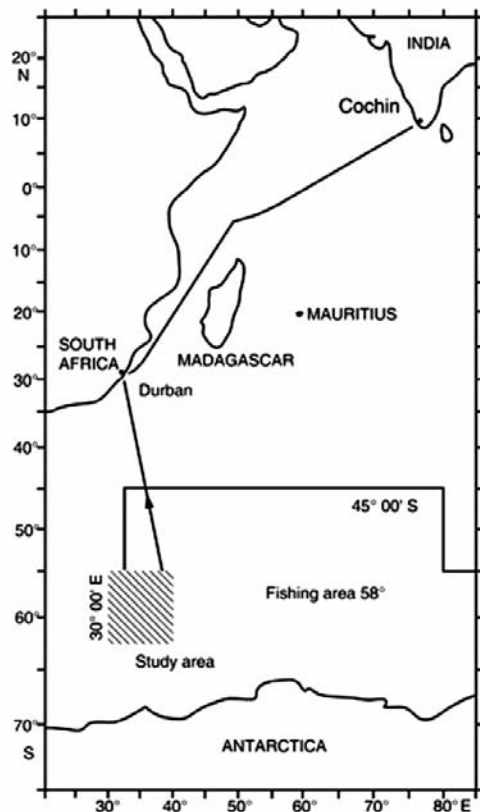


Fig. 1—First Indian Antarctic Krill Expedition cruise study area and sampling stations.

formalin at a final concentration of 0.4%. Algal cells were subsequently examined and counted with the Olympus inverted microscope at 500x magnification as procedures described by Utermohl (1958)<sup>26</sup>. The occurrence of density was judged to be abundant, moderate and few.

## Results

The physical-chemical data recorded during our study of this cruise has been published previously<sup>27</sup>. Surface layer (<50 m) of summer surface water is formed by seasonal warming with temperature (0-2°C) and low salinity (<31.8 PSU). Dissolved oxygen (DO) shows high concentrations (7.6 to >8.0 mL l<sup>-1</sup>) in the upper layer. Table 1 shows minimum, maximum and mean values of different parameters at the Polar Front and Sun Antarctic regions. Inorganic nutrients (NO<sub>3</sub>, NO<sub>2</sub>, PO<sub>4</sub> and SiO<sub>3</sub>) distribution exhibited a seasonal pattern that was correlated with physical and biological dynamics. High nutrient content were recorded during this study period. Physico-chemical data was in par with that reported by Vijayakumar Rathod (1996)<sup>28</sup> for Indian Ocean sector of Southern Ocean.

Table 1—Minimum, maximum and mean values of different parameter at the Polar Front and Sun Antarctic regions.

Polar Front Stations ( 1 – 13)				
Parameters	Min.	Max.	Mean	SD
Nitrate (μ M)	7.80	24.1	15.21	4.06
Nitrite (μM)	0.01	0.4	0.17	0.12
Phosphate ( μM)	0.63	3.2	1.50	0.54
Silicate (μ M)	27.12	54.0	33.90	5.99
Sub Antarctic Stations ( 14 – 17)				
Nitrate (μ M)	21.66	30.01	25.75	2.40
Nitrite (μM)	0.01	0.16	0.07	0.04
Phosphate ( μM)	1.61	2.32	1.96	0.16
Silicate (μ M)	53.0	63.0	55.77	3.49

Table 2—Mean densities (cells l<sup>-1</sup> × 10<sup>3</sup>) of different phytoplankton groups at stations between Polar Front (Stns 1-13) and Sub Antarctic (14 -17)

	Stations Stn.1 - 13		Stations 14 -17	
	Mean	SD	Mean	SD
Diatoms	974	303	287	165
Dinoflagellates	47	9	67	42
Monads and Flagellates	360	127	727	327
Total Phytoplankton	931	312	1007	399

Table 3—Percent composition phytoplankton. Values given for major algal groups are percentage of the total phytoplankton. Sub Antarctic cover (Stns 14- 17) and Polar Front cover (Stns 1 -13).

Latitude	56 – 58° S	59 – 61° S
Stations	14 -17	1 - 13
Diatoms	26.6	70.5
Dinoflagellates	6.2	3.4
Monads and Flagellates	67.2	26.1

## Nutrients

Table 1 shows that nitrate, phosphate and silicate were available in sufficiently high concentrations at Polar Front zone. Nutrient distribution, especially nitrate and silicate, exhibited marked boundaries between high values in the Sub Antarctic region. Nutrient rich water brought on the surface and the resultant high nitrate and phosphate indicate the dominance of physical mixing processes over biological processes.

## Latitudinal Distribution of General Taxonomic Groups

The mean abundance of diatom, dinoflagellates, monads plus flagellates is given in Table 2. Diatoms dominate (70.5%) the phytoplankton assemblage in the Polar Front zone (Table 3). Monads and flagellates together outnumber diatom of Sub

Antarctic Front (67.2%) zone, while dinoflagellates were present in low numbers throughout the study period.

The latitudinal distribution of the various phytoplankton groups are shown in Figure 2 and variation in phytoplankton abundance (%) in Figure 3.

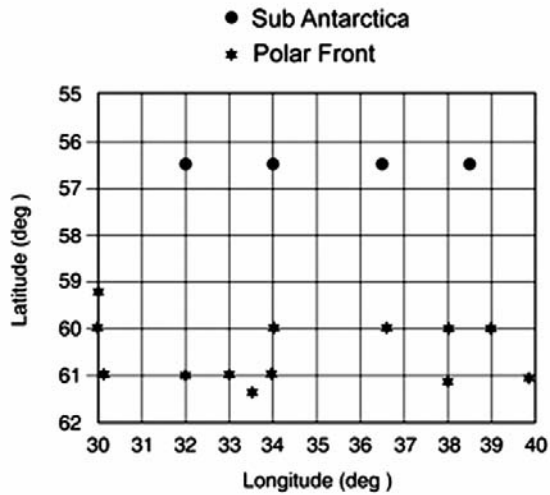


Fig. 2—Mean water column concentrations of the major phytoplankton groups at stations occupied during the FIKEX cruise. The X axis does not represent distance, but stations are arranged in order of increasing latitude, with Stn. 17 at 56° S, and Stn. 13 at 61° 17'.

Four diatom peaks observed during study period were at Stn.16 (58°), Stn.1 (59°), Stn. 2 (60°) and at Stn. 8 (61° S), respectively. The maximum mean cell density ( $1.10 \times 10^5$  cells  $l^{-1}$ ) was at Stn.16 of Sub Antarctic Front and secondary peak ( $1.06 \times 10^5$  cells  $l^{-1}$ ) at Stn. 8 (61°S).

Though the density of dinoflagellates were low throughout the study period, their mean numbers are significantly higher north of Polar Front zone ( $5.4 \times 10^4$  cells  $l^{-1}$ ). Dinoflagellates generally contributed 6.2% and 3.4% of the total phytoplankton counts at stations north of Sub Antarctic zone (14 -17) and south (1-13) of the Polar Front zone, respectively (Table. 3). The heterotrophic species of the genera *Protoperdinium* and *Gyrodinium* were present in higher numbers at north of Polar Front zone during summer.

*Latitudinal Distribution of Individual Species:*

The latitudinal distribution of the dominant and most abundant diatom species were belong to the genera *Nitzschia* (groups *Fragilariopsis* and *Pseudonitzschia*), *Dactyliosolen*, *Chaetoceros* and *Thalassiosira* (Fig. 4). The abundant diatom within the study area were *Nitzschia* “nana” (Cells of both *N. cylindrus* and *N. pseudonana*; 3-6  $\mu$ m in length).

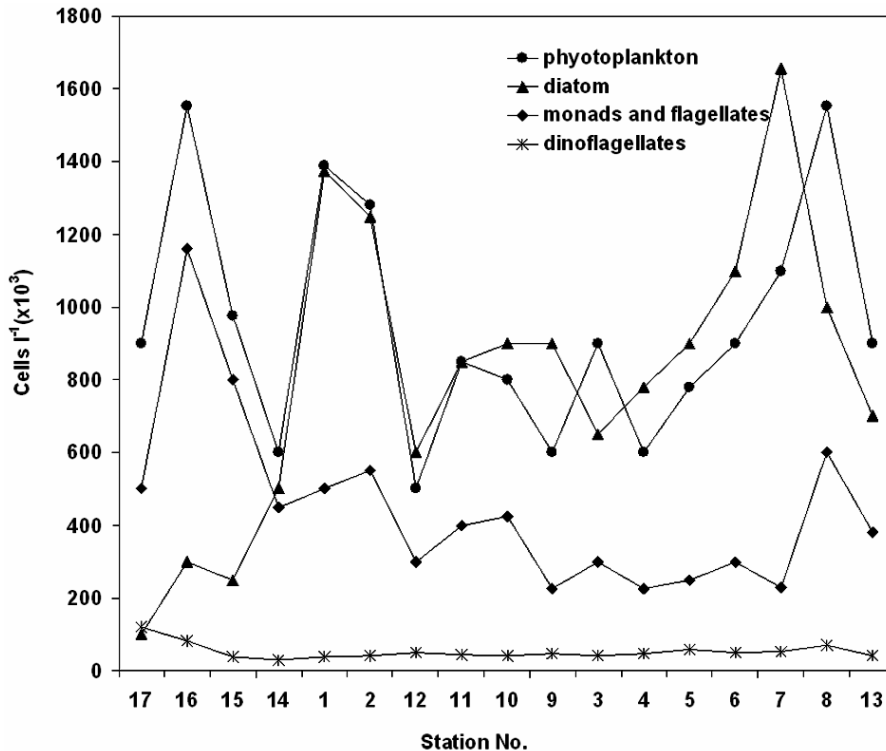


Fig. 3—Variation in phytoplankton abundance (%) with latitude

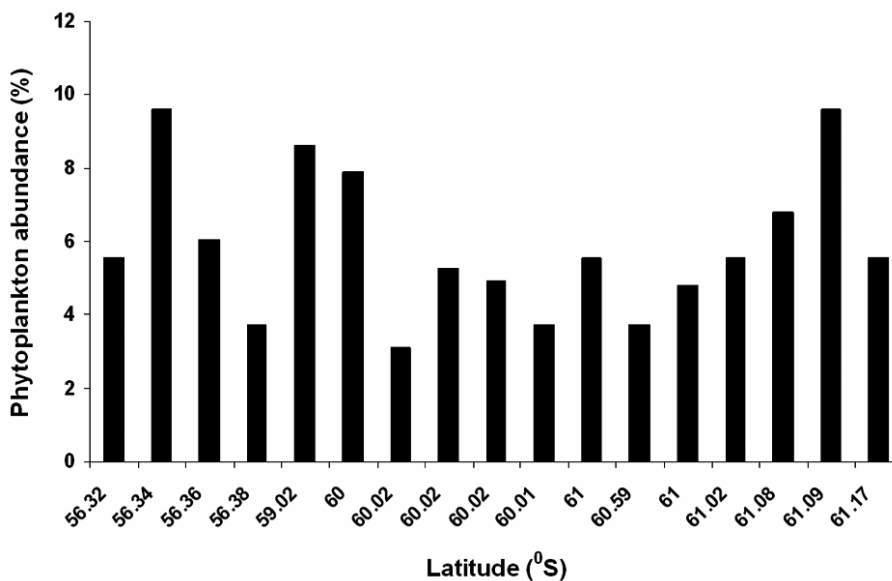


Fig. 4—Latitudinal gradient in phytoplankton composition

Further *N. "nana"* dominated forming 23% of the of the total diatoms and displays peak abundances at stn. 2 ( $2.98 \times 10^5$  cells  $l^{-1}$ ); stn. 4 ( $3.21 \times 10^5$  cells  $l^{-1}$ ) and at stn. 7 ( $4.22 \times 10^5$  cells  $l^{-1}$ ). Other species from the *Fragilariopsis* group (especially *N. kerguelensis* and *N. curta*) are often third or fourth in abundance among dominant diatom south of the Polar Front zone. *Nitzschia kerguelensis* was present only in the northern stations, while *Nitzschia (Fragilariopsis) spp.* were more common in the south. Species from the *Pseudonitzschia* groups are generally most abundant among diatoms of Sub Antarctic zone. They predominated at Stn. 16 (environs of Sub Antarctic zone). They also dominated at few stations 1- 2 and 8 environs of the Polar Front zone. The others were largely represented by *N.turgiduloides*, *N. lineola* Cl., *N. heimii* Maguin, *N. fraudulenta* Cl., *N prolongatoides* and *Pseudonitzschia spp.* Many of the recorded taxa showed in Table 4 and defined distribution boundaries near Polar Front zone. In general, it is noticed that the *Pseudonitzschia*, *Fragilariopsis* and *Chaetoceros* group species are the most abundant diatom in Southern Antarctic waters.

#### Pseudonitzschia groups

The *Pseudonitzschia* species *N.turgiduloides*, *N. lineola* Cl., *N. heimii* Maguin and *N. fraudulenta* Cl are predominant species at Stns. 16, 1-2 and 8. *Pseudonitzschia spp.* are only abundant in Stn.16 of

Sub Antarctic. *N. prolongatoides* is fair distribution in few stations.

#### *Fragilariopsis* group

Three diatom taxa (*Fragilariopsis kerguelensis*, *Fragilariopsis curta* and the *Fragilariopsis cylindrus* ) are common in Polar Front and majority of this species were observed in the in this study. Most of the other taxa (*Fragilariopsis obliquecostata* and *Fragilariopsis rhombica*) make up a minor component of the assemblages. Over all, *Fragilariopsis spp.* is abundant throughout the study period.

#### *Dactyliosolen* group

*Dactyliosolen tenuijunctus* was the dominant species with highest cell abundance of  $5 \times 10^4$  cells  $l^{-1}$  at Stns. 14 and  $6.1 \times 10^5$  cells  $l^{-1}$  at Stn. 8, respectively. *D. antarcticus* Castracane was moderately distributed.

#### *Chaetoceros* group

*Chaetoceros* group was generally abundant in the south of the Polar Zone. *Chaetoceros spp.* were absent at the north stations (cells  $< 10 \mu m$ ), but showed peak abundance in  $60^\circ$  and  $61^\circ$  S. The highest peak ( $1.4 \times 10^5$  cells  $l^{-1}$ ) was at Stn. 8. Among the *Chaetoceros* species larger forms ( $> 10 \mu m$ ), *Chaetoceros atlanticus* contributes substantially to the total cell counts at Polar Front region (4 - 8 stations) and particularly at Stn.7 ( $4.21 \times 10^5$  cells  $l^{-1}$ ). The species *C. dictyota* was found infrequently and in

Table 4— Summary of the distribution pattern of selected species of phytoplankton sampled during the FIKEX cruise.

S N e u r m i b a e l r	<i>Species</i>	<i>Species found north &amp; south Polar Front</i>	<i>Species occurred only Sub-Antarctic</i>
	<b><i>Nitzschia genera</i></b>		
1	<i>Nitzschia "nana"</i>	<i>a</i>	-
2	<i>N. cylindrus</i>	<i>a</i>	-
3	<i>N. pseudonana</i>	<i>a</i>	-
4	<i>Nitzschia spp.</i>		-
5	<i>Nitzschia bicapitata</i>	-	<i>m</i>
6	<i>N. sicula</i>	-	<i>f</i>
7	<i>N. longissima</i>	<i>m</i>	<i>f</i>
	<b><i>Fragilariopsis group</i></b>		
8	<i>Fragilariopsis kerguelensis</i> (O'Meara) Hustedt	<i>a</i>	-
9	<i>F. curta</i> (Van Heurck) Hustedt	<i>a</i>	-
10	<i>F. cylindrus</i> (Grunow) Krieger	<i>m</i>	-
11	<i>F. oliquecostata</i> (Van Heurck) Heiden	<i>f</i>	-
12	<i>F. rhombica</i> (O'Meara) Hustedt	<i>f</i>	-
13	<i>Fragilariopsis spp.</i>	<i>a</i>	
	<b><i>Pseudonitzschia group</i></b>		
14	<i>N. turgiduloides</i>	<i>m</i>	-
15	<i>N. lineola</i> Cl.	<i>m</i>	-
16	<i>N. heimii</i> Maguin	<i>a</i>	-
17	<i>N. fraudulenta</i> Cl.	<i>m</i>	-
18	<i>N. prolongatoides</i>	<i>f</i>	-
	<i>Pseudonitzschia spp.</i>	<i>a</i>	
	<b><i>Dactyliosolen group</i></b>		
19	<i>Dactyliosolen tenuijunctus</i>	<i>a</i>	-
	<i>D. antarcticus</i> Castracane	<i>m</i>	-
	<b><i>Chaetoceros group</i></b>		
20	<i>Chaetoceros spp.</i> (Single cells)	<i>a</i>	-
21	<i>C. atlanticus</i>	<i>a</i>	-
22	<i>C. dictyota</i> Ehrenberg	<i>f</i>	-
	<i>C. costata</i> Gregory	<i>f</i>	-
	<b><i>Thalassiosira group</i></b>		
23	<i>Thalassiosira gracilis</i> Fryxell et Hasle	<i>a</i>	-
24	<i>T. frenguelli</i>	<i>f</i>	-
25	<i>Thalassiosira nitzschiodes</i>	<i>m</i>	-
26	<i>T. lentiginosa</i>	<i>f</i>	-
27	<i>T. tumida</i>	<i>m</i>	-
28	<i>Thalassionema nitzschiodes</i>	-	<i>m</i>
	<b><i>Dinoflagellates</i></b>		
29	<i>Gymnodinium Spp.</i>	<i>a</i>	-
31	<i>G. guttula</i> Balech	<i>m</i>	-
32	<i>Prorocentrum spp.</i>	<i>m</i>	-
33	<i>P. micans</i> Ehrenberg	<i>f</i>	-

(Contd.)

Table 4— Summary of the distribution pattern of selected species of phytoplankton sampled during the FIKEX cruise (Contd.).

S N e u r m i b a e l r	Species	Species found north & south Polar Front	Species occurred only Sub-Antarctic
34	<i>Gyrodinium spp</i>	a	-
35	<i>Protoperidinium spp.</i>	a	-
36	<i>Ceratium pentagonum</i>	-	m
37	<i>C. azoricum</i>	-	m
38	<i>C. fusus</i>	-	m
39	<i>C. lineatum</i>	-	m
	<b>Small dinoflagellates</b>	a	a

a : abundant                      m : moderate                      f : fair

small quantities at Stns.17 to 13. *C. costata* Gregory was fairly distributed.

#### *Thalassiosira* group

The various species of *Thalassiosira* group occurred in highest abundance (  $2.1 - 5.3 \times 10^4$  cells  $l^{-1}$  ) at stations located in  $60^\circ$  and  $61^\circ 12'$  S. Relatively lower abundance were found with even lower counts at rest of the stations. *Thalassiosira gracilis* Fryxell was the dominant species of this genus and attained an average cell density of  $3.1 \times 10^4$  cells  $l^{-1}$  at Stn. 8. *Thalassiosira nitzschioides*, *T. lentiginosa* seemed to have a distribution pattern slightly different from that of *T. frenguelli* and *T. tumida* at Polar Front zone. Whereas *Thalassionema nitzschiodes* occurred moderately at south of Polar Frontal zone between the station.

#### *Dinoflagellates* group

The dinoflagellates are common and moderately distributed. Among the most abundant dinoflagellate species, the unidentified cell of *Gymnodinium* (8-20  $\mu$ m cells) displayed a density of  $1.3 \times 10^4$  cells  $l^{-1}$  at Stns.14 - 17, with a maximum of  $3.9 \times 10^4$  cells  $l^{-1}$  at Stn.16. *Prorocentrum spp.* (6-14  $\mu$ m wide cells) were present in abundant/moderate numbers at most stations with a peak abundance at Stn. 7 ( $4.3 \times 10^4$  cells  $l^{-1}$ ). Most frequently found, particularly during summer were *P. micans* Ehrenberg, *G. guttula* Balech were next in abundance. The heterotrophic species of the genera *Protoperidinium* (18-60  $\mu$ m) *Gyrodinium* ( 8-40  $\mu$ m), were especially noticeable during summer. *Ceratium pentagonum*, *C. azoricum*, *C. fusus* and *C. lineatum* species occurred only north of the Polar Front zone.

#### Biogeographical Distribution of Species

The results from the quantitative samples about the geographical distribution patterns of individual phytoplankton species are depicted in Table 4. It is seen that the Polar Front forms an effective barrier to the latitudinal distribution of many species, while other species are found both north and south of this physical feature.

#### Discussion

The widespread distribution of most of the species occurring both north and south of the Polar Front has been previously noted in both Pacific<sup>29-30,3-4,31</sup> and Indian Ocean<sup>5,8-9,15</sup> Sectors. Most apparent feature of the distribution of the physico-chemical variables, nutrient significant levels were responsible for the low/high biological productivity. Phytoplankton biomass in the present study from the Polar Front and Sub Antarctic with high phytoplankton concentration and the marked differences between northern and southern part of the fishing area 58 of Indian Ocean sector of Southern Ocean<sup>28</sup> is of a discussion part. Previous quantitative studies in the Indian Ocean between Africa and Antarctica<sup>32, 4,7</sup> have found two or three peaks of diatoms, usually one north of Sub Antarctic and one or two peaks south of the Polar Front. The relationship between the distribution of the hydrographical and biological variables are interlinked in Antarctic waters. Stabilisation of the upper water column by ice melting appeared to play an important role in the growth of phytoplankton. Below 50 m depth, the T-S diagrams of all stations were practically on one isopycnal<sup>27,28</sup>. However, the stability of the upper layers, as measured by the  $\sigma_t$  difference between surface and 50 m depth, was

higher in the south than in the north. This, as suggested by El-Sayed and Taguchi (1981)<sup>33</sup>, could be one of the reasons for the biological differences between both regions.

In the Antarctic Zone, as summer condition progress southward, diatom maxima are found at increasingly southerly latitudes in Indian Ocean<sup>4,7,9</sup> sector. The high concentration of diatom noted for the southern most group of stations from the present study, probably represent the late summer stage of a still prolific phytoplankton community. Nutrient rich water brought in the surface (nitrate and phosphate) indicate the dominance of physical mixing processes over biological processes. The present data corroborate earlier observations by Hart (1942)<sup>1</sup>. Diatom counts for these southerly stations are of the same order of magnitude as the maximum cell numbers reported by Kozlova (1970)<sup>6</sup> for the surface water of the Indian Ocean sector during summer.

Maximum diatom counts at discrete depths ( $1.2 \times 10^6$  to  $1.6 \times 10^6$  cells  $l^{-1}$  at Stns. 7, 8, 1, and 2) are greater than the highest numbers previously reported from the Indian Sector by Steyaert (1973b)<sup>34</sup>, but lower than the maximum reported by Hasle (1969)<sup>4</sup> for the southern region of the southeastern Pacific Sector of the Southern Ocean.

The average number of diatoms ( $4.18 \times 10^5$  cells  $l^{-1}$ ) found in the Antarctic zone (Stns. 3 - 13) is similar to the highest count reported by Kozlova (1964)<sup>5</sup> for the open waters between the Antarctic Divergence and Polar Front. In the present study, lowest diatom concentrations ( $1.9 \times 10^4$  to  $2.2 \times 10^5$  cells  $l^{-1}$ ) are noted north of the Polar Front. These densities are greater than the concentrations given by Kozlova (1964, 1970)<sup>5-6</sup>, but are similar to those reported by Steyaert (1973a)<sup>7</sup> for the same region. Comparison of the southern and northern phytoplankton population suggests that part of the differences could be related to successional variation.

Very less information is available for quantitative estimation of flagellates and monads for the Indian Ocean sector. Whereas, high concentration of flagellates and monads have been reported for waters in the Continental Zone of the Eastern Pacific<sup>4</sup> as well as at entrance to the Bransfield Strait<sup>4</sup> and Admiralty Bay, King George Island<sup>35</sup>.

Dinoflagellates numbers in the Eastern Pacific<sup>4</sup> are of equal magnitude with those found during this study. Although Hasle (1969)<sup>4</sup> observed greater concentrations in the Sub Antarctic than in the

Antarctic Zone, differences were minimal. Whereas, Kopczynska et al. (1986)<sup>36</sup> showed that quantities flagellates and dinoflagellates increased in the vicinity of, and northward of, the Polar Front, and that flagellates outnumbered diatoms in the Sub Antarctic zone.

Relatively uniform distribution of phytoplankton cells within the euphotic zone, most probably resulting from wind induced vertical mixing of the upper water column. Such mixing is also expressed in the near-uniform distribution of salinity, temperature, and nutrient values found at most stations. Few individual stations where phytoplankton maxima occur, the upper water column exhibited positive stability. In contrast, Hart (1942)<sup>1</sup>; Hasle (1969)<sup>4</sup> and Steyaert (1973b)<sup>34</sup> reported diatom maxima in the upper 20 m of the water column. Similar observation from Antarctic waters<sup>37,38</sup> also reported high abundance at the bottom of the euphotic zone. The most abundant diatoms recorded in the present study were comparable to earlier work from Indian Antarctic waters<sup>5,7,39</sup>.

The composition of dominant diatoms showed differences from summer to summer of different expedition. Of the species observed, the common feature to both in the present and previous study reveals that the predominance among diatoms *Fragilariopsis kerguelensis* and *Thalassionema nitzschioides* were always present, while *Pseudonitzschia* spp. were numerous in numbers. These dominant diatoms are known to have somewhat different biogeographical distributions. In the study of India Ocean phytoplankton between the Africa and Antarctica, *Thalassionema nitzschioides* was the only species found north of the Polar Front<sup>36</sup>. The present study results also follows the same trend. Similarly, *Pseudonitzschia* species (= *Nitzschia*, *Pseudonitzschia* group), i.e. *Pseudonitzschia lineola* and *Pseudonitzschia heimii*, although common to entire Southern Ocean<sup>4,31</sup> were previously found to be predominant among the diatom north of, and in the vicinity of, the Polar Front both in the Indian Ocean<sup>7,36</sup> and in the subantarctic East Pacific<sup>4</sup>. However, *Fragilariopsis* species in coastal waters and most in southern Antarctic zone, especially *Fragilariopsis kerguelensis*, which is widely spread in the Southern Ocean. The southern Antarctic zone of the East Pacific<sup>4</sup> was dominated by *N. cylindrus*, *N. curta* and *N. subcurvata*. Between 100 – 120° E in the Indian sector, *N. "nana"*, followed by *N. rhombica*, *N. kerguelensis*, *N.*

“closterioides” (*N. prolongatoides* and *N. subcurvata*), *N. pungens* Grun., *N. curta* and *Dactyliosolen spp.* were most abundant species<sup>39</sup>.

In the present study samples obtained from south of the Polar Front were mostly dominated by either *N. “nana”* or *Dactyliosolen tenuijunctus*. Single cell *Chaetoceros spp.* (mostly *C. atlanticus* and *C. dictyota*) or *Fragilariopsis spp.* were usually next in abundance, followed by *Pseudonitzschia* species. The presence of *Chaetoceros atlanticus* and *Chaetoceros dictyota* are generally found in greater abundance in the Antarctic zone south of the Polar Front<sup>34, 36</sup>.

*Dactyliosolen tenuijunctus*, which is so prevalent in the our samples, has seldom been reported in the Indian Ocean Sector. Kuwamura and Ichikawa (1984)<sup>38</sup> found this species to be abundant, and it was noted in the qualitative study of Sournia et al. (1979)<sup>15</sup>.

The *dinoflagellates Ceratium lineatum* and *Ceratium pentagonum*, although occasionally found in Antarctic waters<sup>40-40</sup> are usually confined to waters near or north of the Polar Front<sup>42</sup>. In the present study, these species were present only north of the polar Front.

In our study it is noticed that different diatom assemblages characterised the waters of the Indian Ocean Sector north and south of the Polar Frontal zone and south of the Antarctic Divergence.

The distribution of individual species seem to be limited by Polar Front zone. Similar observations was reported previously by Hasle (1969) from Pacific region and Sournia et al (1979) from Indian Sector. This diatom composition and their presence are similar to our results.

Due to differences in timings, sampling area and methodology, it is difficult to compare the composition and distribution of the phytoplankton assemblages described in the Antarctic literature. Globally, the present results fit well into the scheme of Heywood and Whitaker (1984)<sup>43</sup>, Hasle (1969)<sup>4</sup>, Hart (1934, 1942)<sup>44,1</sup> and Kozlova (1964)<sup>5</sup>, Steyaert (1974)<sup>8</sup>, Jacques et al. (1979) and Sournia et al. (1979)<sup>9,15</sup>.

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