Marine Plankton Diatoms between Cape Town and the Prince Edward Islands (SW Indian Ocean)

Brian P. Boden
Southern Oceans Group, Department of Zoology and Entomology
Rhodes University, Grahamstown 6140, South Africa
(Deceased October 1989)

and

Freda M. H. Reid
Marine Life Research Group, A-018, Scripps Institution of Oceanography,
University of California, San Diego, La Jolla
CA 92093, U.S.A.

The most common plankton diatoms of the surface waters between southern Africa and the Prince Edward Islands, and the waters around the Islands, are described and illustrated by line drawings, which show typical cells as viewed by a conventional microscope. References to illustrations from modern electron microscope studies are included where available. The area is attractive to ecologists due to its great hydrographic variability. We trust that this collation will facilitate further ecological and biogeographical studies.

Die mees algemene planktoniese diatome in die oppervlaktewaters tussen suider Afrika en die Prins Edward-eilande, en die waters om die eilande, word beskryf en geïllustreer deur lyntekeninge van die tipiese selle soos deur 'n gewone mikroskoop gesien. Verwysings na illustrasies uit moderne elektronmikroskoopstudies is, waar beskikbaar, verskaf. Die gebied het 'n groot aantrekking vir ekoloë vanweë die groot hidrografiese veranderlikheid. Ons vertrou dat hierdie versameling data verdere ekologiese en biogeografiese studies sal vergemaklik.

Introduction

The oceanic circulation regime off southern Africa is extremely variable and includes for example, the Agulhas Current termination and retroflection as the Agulhas Return Current, the Subtropical Convergence and the Subantarctic and Antarctic Fronts. This is shown schematically in Figure 1, which also shows the station chart for cruises in the area. The Antarctic Convergence is not shown: its position at these longitudes is equivocal. It appears to meander in a wide belt north and south of the Prince Edward Islands (Benon & Murail, 1979) and there is considerable interchange between Antarctic and Subantarctic waters (Deacon, 1983). It is regarded as a frontal zone and is an important biogeographical determinant.

The interaction of the phytoplankton with this complex circulation results in a very mixed diatom population and raises many problems of identification that can be resolved only by reference to works that are not readily accessible. Such problems will proliferate as increasing research in the southern oceans reveals the involved nature of the phytogeographical regime.

Several major expeditions eg. *HMS Challenger* (1873-1876), RRS *Discovery* (1933-1935), *Valdivia* (1898-1899), *Gauss* (1901-1903) and *Soya* (1959-1960) skirted the area and presented rather scanty data. There have also been some more systematic works, such as Boden (1950), Taylor (1967), Thorrington-Smith (1969,1970,1971), Kruger (1980) and Norris (1984)*, in bordering locations. Nel (1968) compiled a comprehensive checklist of the microplankton of a large area of the SW Indian Ocean, including that of the region covered in this study.

This paper was prepared to provide an illustrated guide to the identification of the diatom taxa in the region. Descriptions are directed mainly at features of the organisms that are detectable by means of a light microscope (LM hereafter). The use of the electron microscope (EM hereafter) reveals more features and broadens our knowledge of the morphology and function of known structures. As a result terminology for the parts of the diatom frustule has changed and phylogenetic relationships are becoming clearer. We have adopted the terminology proposed by the working group of the Third Symposium on Recent and Fossil Marine Diatoms, Anonymous (1975), Ross & Sims (1972), Ross *et al* (1979), von Stosch (1975). A glossary of the terms used in the descriptions of diatom cells is included as Appendix II.

The electron microscope is invaluable as a diagnostic tool for studying individual cells but is not practical for use on large suites of samples. Thus the light microscope is still used routinely. Numerical references to electron microscope and scanning electron microscope (SEM hereafter) investigations of forms figured herein are included, where available, for the benefit of the investigator wishing to pursue the taxonomy beyond the limits of the descriptions given.

Positive identification is often hindered by orientation of a cell on a slide, preservation artifacts, staining etc. When this occurs it is better to assign a specimen to a higher classification (eg. genus, or complex of taxa), than to risk misidentification and perpetuation of erroneous data.

Most of the figures given here are from published works. Permission was obtained to reproduce those not in the public domain. They are therefore not stylistically consistent but are intended to help the local observer to make well informed decisions about organisms. It should be remembered that diatom structure may respond to climatic, geographic and nutritional influences to varying extents. The figures are not drawn to scale but the size-range of the specimens is given in the text description.

This paper is one of the series emanating from the Marion Offshore Ecosystem Survey (MOES) and Subtropical Convergence and Agulhas Retroflection Current (SCARC) projects of the South African Committee for Antarctic Research (SASCAR), although much of the material was collected before they began.

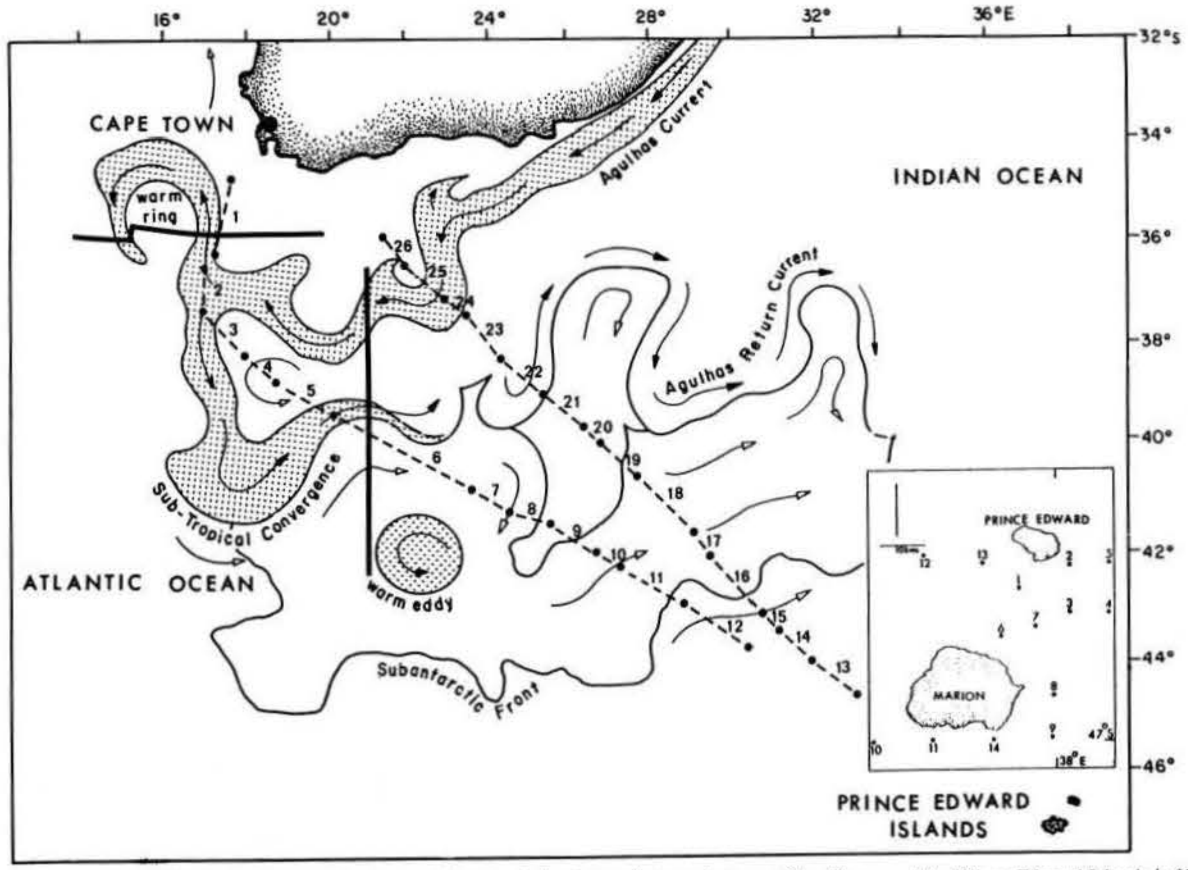


Fig. 1. Schematic satellite image of the major thermal fronts and circulatory features between Cape Town and the Prince Edward Islands in November 1983 with superimposed track of the *SA Agulhas* (numbered stations) and east-west and north-south lines visited during the cruise of the RV Knorr (dark solid line). Interpreted water movement shown by open (cold water) and closed (warm water) arrows. Inset: stations occupied between the Prince Edward Islands.

Materials and Methods

The diatoms described here are mainly from the collection that formed the basis of the biogeographical study by Boden *et al* (1988). The collecting methods were described in that paper and consisted of the continuous filtering of surface waters (5-0 m.) from the scientific sea-chest of *SA Agulhas* through a 20 µm mesh net. The filter was changed periodically and distance traversed between changes was designated a plankton station. The track-chart of these stations is shown in Figure 1. This procedure resulted in a qualitative, integrated sampling of the region in November, 1983.

The RV *Knorr* operated in the area simultaneously in November and December 1983; the track is shown on Figure 1 and methods employed were similar. The stations shown in the inset in Figure 1 were also occupied and net samples (NV70 phytoplankton net) from 75-0 m were collected.

Additional material was provided by the relief cruise of *SA Agulhas* (April, 1985) to Marion Island. This cruise traversed the same course as that of 1983 and the stations are not figured. Sampling was by means of a vertical array of Niskin bottles from 100-0 m. Since it depended on using a ship of opportunity, the sampling was not very systematic and only 20 samples from various depths were taken. However, it provided some additional, qualitative material at a different season.

Sixteen more samples were taken on the Marathon 11 Cruise of RV *Thomas Washington* in February 1985 (not figured). This was a cooperative cruise of the Woods Hole Oceanographic Institute, USA and the National Research Institute for Oceanology, RSA, for the purpose of deploying current meters in the Agulhas Retroflection Area. The samples were all vertical net-hauls (NV70 net) from 75-0 m. made in the area 34° - 40° S and 14° - 17° E.

All samples were preserved in 5% neutral formalin and subsequently aliquots (stained with Rose Bengal) were studied by the Ütermohl inverted microscope method. For a more critical examination of individual cells a compound microscope with phase contrast was used.

Systematic Account

The classification used here is that of Simonsen (1979). After a critical consideration of the phylogenetic relationships between the various diatom groups he ranked the diatoms as a class, Bacillariophyceae, divided into two orders, Centrales and Pennales, which are subdivided into five suborders and 21 families. Not all of the latter are represented in our material but the classification is presented *in toto* to provide perspective.

I Classification of the Bacillariophyceae and index to Species

Class BACILLARIOPHYCEAE
Order *CENTRALES*
Suborder COSCINODISCINEAE

Family **Thalassiosiraceae** Lebour emend. Hasle

II. Description of Species

Limited synonymy is included to help identification of taxa with relatively recent name changes. At the end of each species description the latest EM references available (to 1988) are listed by number (indicated by an asterisk* in the text). See Appendix I (Page 44) for key to these references.

BACILLARIOPHYCEAE

CENTRALES

COSCINODISCINEAE

Thalassiosiraceae Lebour emend. Hasle

Genus: DETONULA Schütt

Cells cylindrical, forming straight chains united by threads; sometimes solitary. Valves flat or concave in the centre, where there is a strutted process with a thread. Small marginal strutted processes each with two gelatinous threads which join those of adjacent cells forming a characteristic zig-zag. Numerous open intercalary bands. Bands and mantle very delicately areolated.

Fig. 2. *Detonula pumila* (Castracane) Schütt
Schröderella delicatula (H. Peragallo) Pavillard

Cells cylindrical (2-5 times longer than broad), forming dense, rigid chains. Apertures between cells short. Diameter 16-42 µm. Valves flat to slightly depressed at insertion of single central strutted process. Circlet of marginal strutted processes or threads, 7-10 in 10 µm. One marginal labiate process. Valve wall with radial costae and perforated striae in some parts of the valve, pseudoloculi or loculi in other parts: 18-20 areolae in 10 µm. The girdle has conspicuous open ligulate bands.

D. pumila is a neritic form; the main distribution of the genus is in temperate and cold waters, (Hasle (1974b)*). In our collection it occurred at one station south of the Subtropical Convergence.

SEM References: 25, 28, 59.

Genus: PLANKTONIELLA Schütt

Cells solitary, discoid with a hyaline, wing-like expansion, 50-150 µm wide, divided into a varying number of chambers by radial rows. This wing-like expansion is weakly siliceous and control of the turgidity of the chambers appears to affect the specific gravity of the organism and acts as a flotation mechanism.

Fig. 3. *Planktoniella sol* (Wallich) Schütt
Coscinodiscus sol Wallich

Cells solitary, discoid. Valves nearly flat to convex. Large, polygonal areolae arranged in eccentric curves similar to *Thalassiosira eccentrica*. One valve has a prominent marginal wing, 50-150 µm wide, (see above). Central disc diameter 21-180 µm, total diameter up to 360 µm. Areolae of valve 5-7 in 10 m in centre, 8-9 near margin. Single, central strutted process and row of marginal strutted processes. Two marginal, labiate processes about 150 degrees apart.

Oceanic, ubiquitous but most plentiful in tropical and subtropical waters. This was true in our material. It was found in the Agulhas Current, the Retroflection area and in the Subtropical Convergence waters of the Agulhas Return Current. We regard it as an indicator of Agulhas Current water.

SEM References: 9, 15, 16, 48.

Genus: SKELETONEMA Greville

Cells discoid, elliptical or cylindrical. Valves flat to convex with indistinct striae. Row of fine marginal strutted processes parallel with pervalvar axis. Chain formed by interlocking, marginal strutted processes.

Fig. 4. *Skeletonema costatum* (Greville) Cleve
Melosira costata Greville

Cells discoid, elliptical or cylindrical with convex valves, forming long, thin, usually straight chains. Apertures usually longer than cells. Cells united by straight, slender, marginal, interlocking strutted processes of varying lengths. In our material the processes were all long. Single labiate process. Diameter 3-20 µm.

Neritic, cosmopolitan, abundant. The species occurred only in the Agulhas Retroflection in our collection.

SEM References: 6, 25, 26, 59.

Genus: THALASSIOSIRA Cleve emend. Hasle

Cells usually in colonies, united by threads extruded from one or many central, strutted processes, seldom solitary. One or more rings of marginal strutted processes. One or more central strutted processes, sometimes eccentric if adjacent to a large central areola. Strutted processes intermediate between valve margin and centre may be clustered, in a ring (regular or irregular), in a line, or in irregular arrangement. One or more labiate processes; marginal, central or intermediate. Areolae in radial striae, in sectors, or in straight or curved tangential striae; sometimes patterns intergrade. Loculate areolae have external foramina and internal cribra. Mainly marine, plankton species. A few brackish or fresh-water species.

Johansen & Fryxell (1985)* is a comprehensive treatment of the Antarctic representatives of this genus.

Fig. 5. *Thalassiosira aestivalis* Gran & Angst

Cells quadrangular in girdle view with bevelled corners. Valves slightly depressed around a single strutted process which is surrounded by coarse areolae and exudes a filament connecting adjacent cells. Ring of small marginal strutted processes. Single labiate process, slightly greater in diameter than strutted processes. Valve surface with areolae radiating from the centre. One or two intercalary bands per cell, smooth with thickened margins. The distance between cells is as long as, or longer than the pervalvar height of a cell.

In the absence of EM identification we identify our form as *T. aestivalis*. It occurred at only one station between the Subantarctic Front and the archipelago. Norris (1984)* lists *T.* cf. *aestivalis* in the Benguela upwelling system. *T. aestivalis* is also tentatively described for Cape Town (Hasle 1978)* and in SW African phytoplankton (Kruger 1980).

Neritic; distribution data scanty.

SEM References: 30, 43, 48.

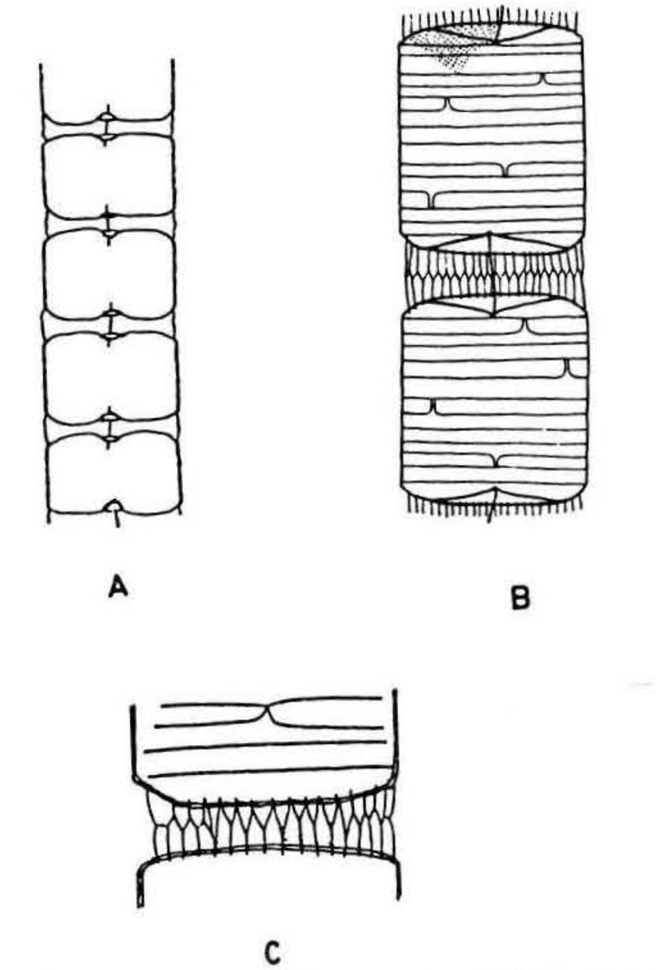


Fig. 2. *Detonula pumila*. A. Chain in optical focus showing thread from central strutted process in a depression. From Cupp 1943. B. Chain showing intercalary bands and external parts of marginal strutted processes joining cells. After Hendey 1964. C. Enlarged view of junction of two cells. After Cupp 1943.

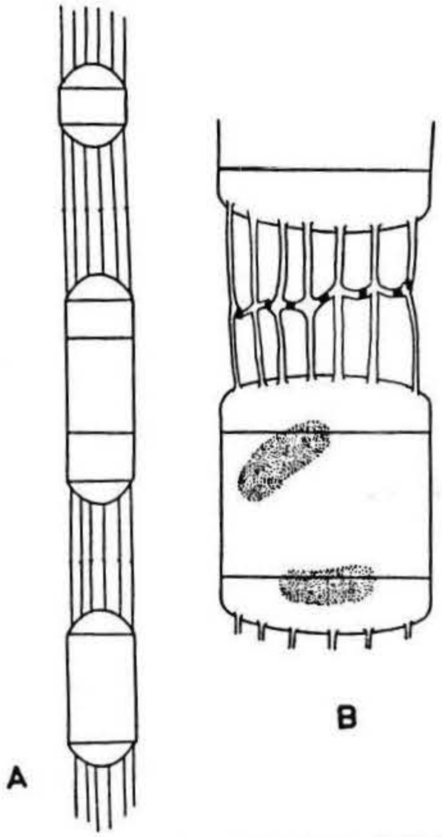


Fig. 4. *Skeletonema costatum*. A. Part of chain. B. Single cell showing interlocking with adjacent cell by means of marginal strutted processes. After Boden 1950.

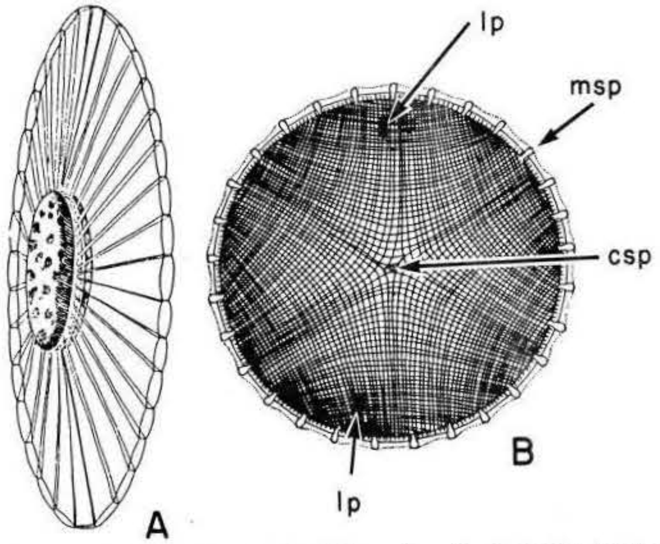


Fig. 3. *Planktoniella sol*. A. Oblique view of cell showing hyaline loculate expansion. From Hendey 1937. B. Valve view showing eccentric arcs of striae, labiate processes (lp), central strutted process (csp) and marginal strutted processes (msp). Original.

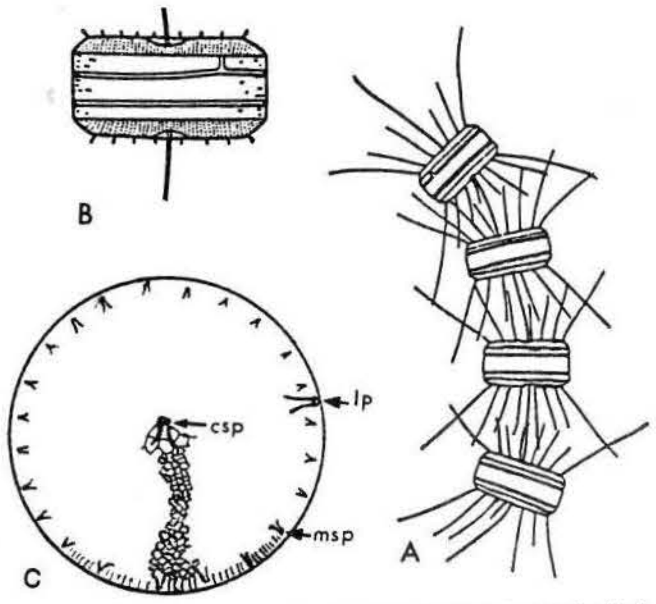


Fig. 5. *Thalassiosira aestivalis*. A. Chain of widely-separated cells in girdle view. B. Cell in girdle view showing narrow mantle with small areolae, intercalary band and slight depression of valve centre. From Cupp 1943. C. Valve view showing ring of small, marginal strutted processes (msp), labiate process (lp) and central strutted process (csp). Drawn from micrograph in Norris 1984*.

Fig. 6. *Thalassiosira anguste-lineata* (A.Schmidt) Fryxell & Hasle
Coscinodiscus anguste-lineata Schmidt, *Coscinosira polychorda* Gran

Valves heavily silicified, with areolae arranged in linear, or occasionally fasciculate pattern. Distinct marginal row of strutted processes, 3-4 in 10 µm. No central strutted process but a modified ring of arcs (5-7) equidistant from central areola. Each arc has 1-9 strutted processes with threads uniting adjacent cells. Single marginal labiate process. Diameter of cell 17-78 µm.

Neritic species widely distributed in cold, temperate seas. Frequent but seldom abundant. We found it at one interisland station.

SEM References: 11, 41, 42, 48, 59.

Fig. 7. *Thalassiosira condensata* Cleve

Cells cylindrical, rectangular in girdle view. Valves circular, depressed in centre with a central strutted process exuding a filament which unites cells in chains. A single row of marginal strutted processes, sometimes produced as radiating gelatinous threads. Single labiate process. Numerous intercalary bands. Diameter 28-33 µm, length 20-33 µm.

Temperate, neritic species of uncertain distribution. We found it at one station south of the Subtropical Convergence.

Fig. 8. *Thalassiosira decipiens* (Grunow) Jørgensen
Coscinodiscus eccentricus var. *decipiens* Grunow

Cells drum-shaped, united in loose chains by gelatinous threads 30-80 µm long. Sometimes form loose mucilaginous colonies. Valves slightly convex with areolate pattern similar to *Thalassiosira eccentrica*. Areolae larger in centre than at periphery. Marginal row of curved strutted processes often with radiating filaments. Single central, strutted process. Single marginal labiate process just inside ring of strutted processes. No marginal spines. Diameter 12-40 µm, pervalvar axis 32 µm.

Euryhaline, usually brackish-water form, most frequently found in bays and tidal estuaries. We found it at only one station in Subtropical Convergence waters. It was possibly a visitor in the Agulhas Return Current. We can find no other record from the Indian Ocean. This may be a misidentification, but on LM it appears to agree with the specific diagnosis.

SEM References: 25, 31, 44.

Fig. 9. *Thalassiosira eccentrica* (Ehrenberg) Cleve
Coscinodiscus eccentricus Ehrenberg

Cells discoid, valves flat. A central areola is surrounded by seven areolae and has a central strutted process adjacent to it. In addition it has a ring of strutted processes around it. There are also generally one or more circles of processes in numbers of seven or its multiple (Simonsen, 1974). Fryxell & Hasle (1972)* refer to these as spines, irregularly spaced, in their material. Two rows of marginal strutted processes and one pronounced marginal labiate process. Chitan threads are extruded from all the strutted processes. Areolae in straight rows at margin, becoming curved by increasing in size toward the valve centre, resulting in eccentric arcs grading into fasciculated structures on some valves.

Norris (1984)* and Fryxell & Hasle (1972)* conjecture on the close taxonomic relation of *T. mendiolana* Hasle & Heimdal and *T. eccentrica*. Norris speculates on possible hybridization of species or that the range of specific characteristics is wider than assumed and that overlapping at extremes occurs. There appears to be an overlap in distribution and neither species has been rejected.

A cosmopolitan plankton species quite common in all oceans. It was found at nearly all our stations.

SEM References: 9, 12, 43, 48, 59.

Fig. 10. *Thalassiosira gravida* Cleve

Cells discoid, rectangular in girdle view, united in chains by thick thread extruded through central group of strutted processes. Valves flat, bevelled margins, with one small, marginal labiate process and irregular, radiating rows of rather indistinct strutted processes. Areolate striae in radiate pattern. Diameter 20-58 µm, length 8-25 µm, aperture longer than cells with intercellular thread 30-40 µm.

Neritic, temperate to subpolar. In our collection it appeared in the Agulhas Retroflection and in neritic, inter-island waters.

Syvertsen (1977)* had evidence that *T. rotula* and *T. gravida* are a single species. Hasle (1976) believed the distribution of the species supports combination but maintained their separation. Norris (1984)* found only *T. rotula* in the Benguela system and Kruger (1980) listed only *T. rotula* in his SW African checklist. We found only *T. gravida* in the Agulhas Current Group of Boden *et al* (1988). It is considerably south of both Norris' and Kruger's records of *T. rotula* and we were not able to form an opinion on their conspecificity on either distribution or morphological grounds based on LM.

SEM References: 25, 48, 58.

Fig. 11. *Thalassiosira leptopus* (Grunow) Hasle & Fryxell
Coscinodiscus lineatus Ehrenberg

Cells discoid, 26-165 µm in diameter, solitary. Valves flat. Hexagonal, loculate areolae with wide circular foramina, arranged in tangential striae. Central areola tends to be larger. One labiate process; numerous, small marginal strutted processes arranged in a zig-zag but not visible in LM, and a ring of coarse, irregularly placed, occluded processes visible in LM. No central process.

Distributed in warm to warm-temperate waters of all oceans. It was not uncommon in our material, occurring at eleven stations, all south of the Subtropical Convergence.

SEM References: 16, 32, 38.

Fig. 12. *Thalassiosira subtilis* (Ostenfeld) Gran
Podosira subtilis Ostenfeld

Small, discoid or drum-shaped, cells usually imbedded in a large gelatinous, irregular mass. Valves convex. Surface with hexagonal areolae arranged in sectors, difficult to resolve in LM except for a few, scattered extremely fine granules around the centre. A large, eccentric, central strutted process. A ring of very small marginal strutted processes, not visible in water mounts, and an intermediate scattering of small strutted processes. Single, large labiate process between valve centre and marginal zone. Diameter 15-32 µm; pervalvar axis 10-15 µm.

Oceanic, common in cold-temperate waters of the southern oceans. The gelatinous colonial habit may be more frequent in colder waters and it is possible there is more than one species involved. We found it at one Agulhas Current station and two south of the Subantarctic Front.

SEM References: 16, 23, 48.

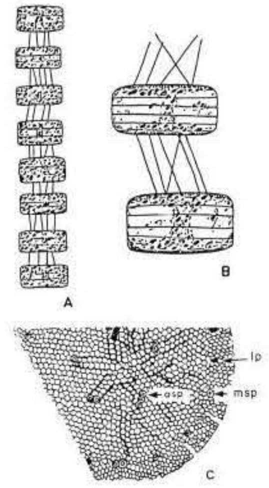


Fig. 6. *Thalassiosira anguste-lineata*. A. Chain of rectangular cells in girdle view joined by many threads. B. Two cells of chain. From Cupp 1943 (as *Coscinosira polychorda Gran*). C. Valve showing fasciculated areolation, marginal strutted processes (msp), arcs of strutted processes (asp) and labiate process (lp). Drawn from micrograph in Fryxell & Hasle 1977*.

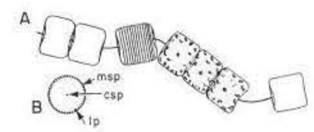


Fig. 7. *Thalassiosira condensata*. A. Part of chain in girdle view, showing intercalary bands. B. Schematic valve view, showing position of marginal (msp) and central (csp) strutted processes and single labiate process (lp). After Hendey 1937.

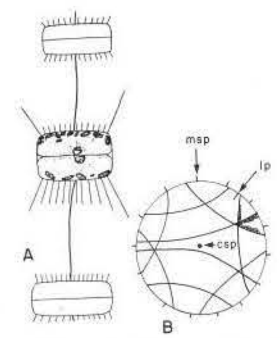


Fig. 8. *Thalassiosira decipiens*. A. Cells in girdle view connected by gelatinous threads. From Hendey 1937. B. Schematic valve view showing pattern of eccentric arcs and positions of marginal (msp) and central (csp) strutted processes and marginal labiate process (lp). Original.

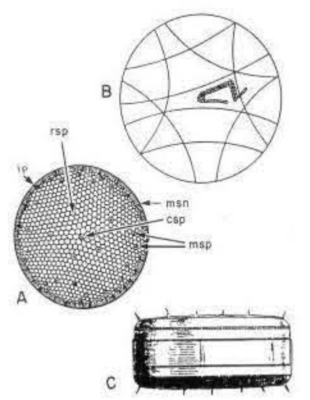


Fig. 9. *Thalassiosira eccentrica*. A. Valve view showing marginal (msp), central (csp) and ringed (rsp) strutted processes and labiate process (lp). After Hustedt 1930. B. Schematic pattern of eccentric arcs. C. Girdle view. From Boden 1950.

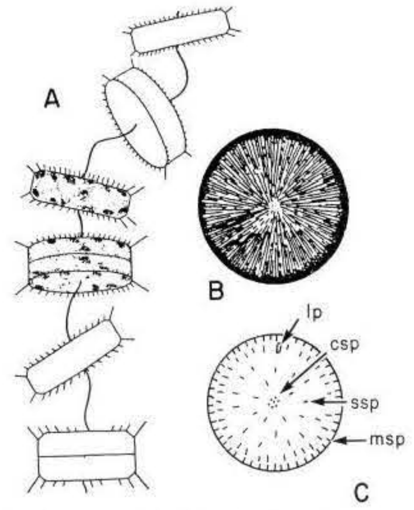


Fig. 10. *Thalassiosira gravida*. A. Part of chain in girdle view. From Hendey 1937. B. Cell in valve view showing radial striae. From Hustedt 1930. C. Schematic valve view showing marginal (msp) central (csp) and scattered (ssp) strutted processes and small labiate process (lp). From Johansen and Fryxell 1985*.

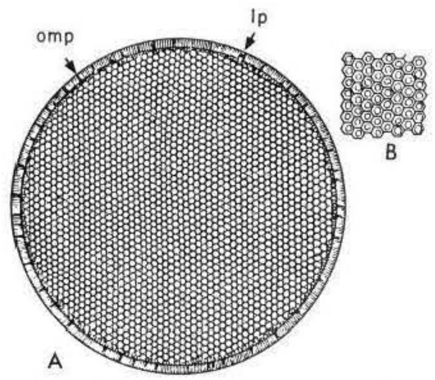


Fig. 11. *Thalassiosira leptopus*. A. Valve view showing tangential striae, occluded marginal processes (omp) and labiate process (lp). B. Hexagonal areolae of loculate type with wide circular foramina. After Hustedt 1930 (as *Coscinodiscus lineatus*).

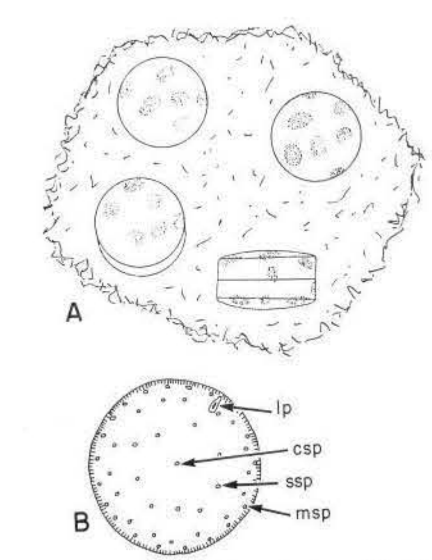


Fig. 12. *Thalassiosira subtilis*. A. Part of colony with cells in girdle and valve view. From Boden 1950. B. Schematic valve view, showing very small marginal (msp) and scattered (ssp) strutted processes, large central process (csp) and large labiate process (lp). From Fryxell 1975.

Melosiraceae Kützing

Genus: CORETHRON Castracane

Cells usually solitary, weakly siliceous, cylindrical with variously convex hemispherical valves; sometimes spinose. Length from 2 to 15 times the valvar diameter (5-140 µm). Heterovalvate: a marginal circlet of long barbed spines directed to the same pole at one or both ends of the frustule. One valve bears a corona of shorter, heavier clawed bristles. There are numerous collar-shaped intercalary bands with very indistinct imbrication lines. Neither strutted nor labiate processes have been found (Hasle 1975)*. Auxospores may occur. Hendey (1937) considers the genus to be monotypic with several "phases". Hasle (1969) retains two taxa: *Corethron criophilum* and *C. criophilum* f. *inerme* (Karsten) Hasle. This is mainly based on distributional patterns revealed by the Brategg Expedition.

Fig. 13. *Corethron criophilum* Castracane

The generic description above satisfies all the criteria for the species in our collection, that we have named *C. criophilum*. This form was found at seven oceanic stations between Cape Town and the archipelago and at the interisland station.

SEM Reference: 8.

Genus: LEPTOCYLINDRUS Cleve

Wide-spread, euryhaline genus common in fresh-water and marine habitats. There is some doubt about its familial ties. Hasle (1975)* considers it should be placed in its own family and Round (1978) suggests that it may be related to the Chrysanthemodiscaceae. However, Simonsen (1979) very tentatively leaves it in this family.

The elongated cells are joined by the valves to form long chains, usually straight. No processes.

Fig. 14. *Leptocylindrus danicus* Cleve

Cells elongated, cylindrical. Valves flat or slightly convex, with no visible strutted or labiate processes. Closely united by the valves to form narrow, straight chains. Adjacent cells often have only one wall between valves. Weakly silicified and girdle details difficult to resolve. Intercalary bands punctate and imbrication lines of copulae lie in straight lines along pervalvar axis. Diameter of cell 5-18 µm; length 30-65 µm.

Common in temperate regions of both hemispheres, usually neritic but frequently oceanic. In our collections it was found between the islands and at the Subantarctic Convergence.

SEM References: 29, 59.

Genus: MELOSIRA Agardh

The precise circumscription of genera within the *Melosira* complex (inc. *Paralia*, *Aulacoseira*) is still in a state of flux. The valve structure and the method of attachment of the cells to form chains are important considerations. Both poroid and loculate areolae occur; pseudoloculi and labiate processes may be present; the location of the nucleus varies; linking spines may join the cells. The habitat may be benthic or planktonic, estuarine, marine or subaerial. See Crawford (1979) and references therein, though *M. sol* is not mentioned. The standard descriptions of the genus *Melosira* are therefore of limited value and our description of *M. sol* is tentative.

Fig. 15. *Melosira sol* (Ehrenberg) Kützing

Cells discoid with pervalvar axis short, united at valves in straight, often long chains. Valve has radiate ridges and finer, shorter radial lines between. The valve margin is finely striate. A row of pores may occur and there is a single row of marginal labiate processes. Diameter 30-96 µm, pervalvar axis 4-12 µm.

Not uncommon in the southern oceans. It occurred at only one station, in the Agulhas Retroflection, in our material.

Coscinodiscaceae Kützing

Genus: COSCINODISCUS Ehrenberg

Cells discoid, solitary. Valves circular to ellipsoid, concave to convex. Areolation pattern is important for specific diagnosis (Anon. 1975). Radial areolation may be of single areolae, with secondary rows in spirals; fasciculate or curvatulus type. Cingulum has a broad valvocopula and one or more copulae. Pervalvar axis may be very short (coinshaped cell) or a long as, or longer than, diameter: sometimes asymmetrical. Loculate areolae usually hexagonal but may be rounded: foramina internal, cribra external. The central area clear or, frequently, more coarsely areolated, forming a central rosette with one or more labiate processes. Small, and sometimes one or two large, marginal labiate processes: when areolation is fasciculate the processes appear at the ends of the curved rows. They may be difficult to resolve under LM. No strutted or occluded processes.

Fig. 16. *Coscinodiscus concinniformis* Simonsen

Cells drum-shaped, valves convex, with no mantle, membrane delicate, hyaline. Central area clear, non-areolate. Areolae, arranged in fascicles separated by branched interstriae radiating from centre toward margin. Most of them end just short of the margin and terminate in a ring of small, marginal labiate processes. Sometimes they terminate between the centre and the margin, resulting in a scattering of processes over the valve surface. Two large marginal labiate processes are present subtending an angle of about 125 degrees. Diameter 150-500 µm. Our form about 380 µm, pervalvar axis 400 µm.

Simonsen (1974) separated this species from *C. concinnus* W. Smith largely because of the clear central area on the valve. It had previously been considered a variety of *C. concinnus*, which is characterized by a central rosette. In addition *C. concinniformis* is confined to warmer waters. In our collection it was found at stations in the warm Agulhas Current, Retroflection and the Return Current associated with the Subtropical Convergence.

It is most closely allied with *C. concinnoides* Simonsen (1974) but can be readily distinguished by the position of the two labiate processes which are nearly opposite (165-170 degrees) and some distance from the margin in this form.

SEM References: 2, 10, 25.

Fig. 17. *Coscinodiscus curvatulus* Grunow ex Schmidt

Valves nearly flat, 40-75 µm in diameter. Central area with irregular areolation surrounded by a ring-like groove. Areolation arranged in fascicles of the curvatulus type; coarse, 6-10 in 10 µm. Margin band narrow, striate (12-16 areolae in 10 µm). There is a marginal labiate process at the boundary of each fascicle. On this account Priddle & Fryxell (1985) suggest that it may be an *Actinocyclus*.

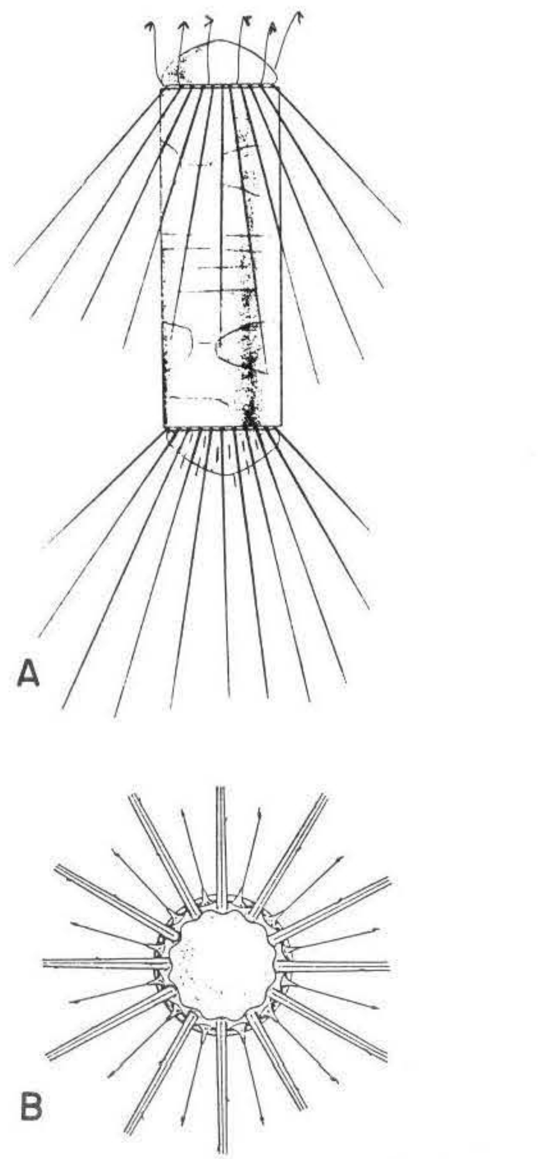


Fig. 13. *Corethron criophilum*. A. Girdle view showing spines and bristles. B. Valve view. After Hendey 1937.

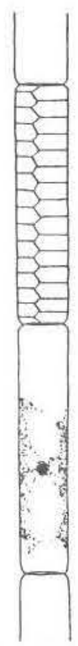


Fig. 14. *Leptocylindrus danicus*. Cells in girdle view. Rhomboid-shaped intercalary bands (difficult to see in LM). From Hendey 1937.

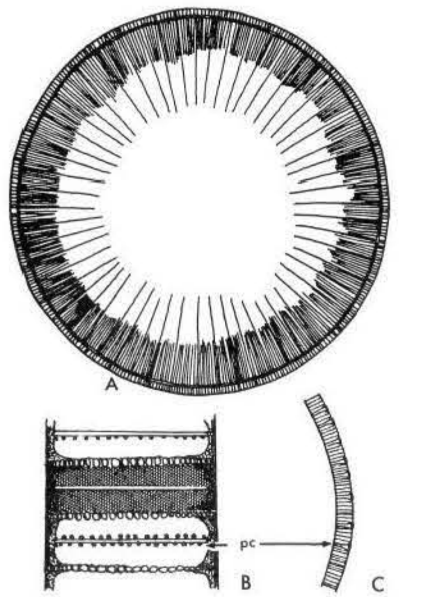


Fig. 15. *Melosira sol*. A. Valve view. From Castracane 1886. B. Girdle view of part of cell. C. Cross-section showing funnel shaped pores (pc). From Hustedt 1930.

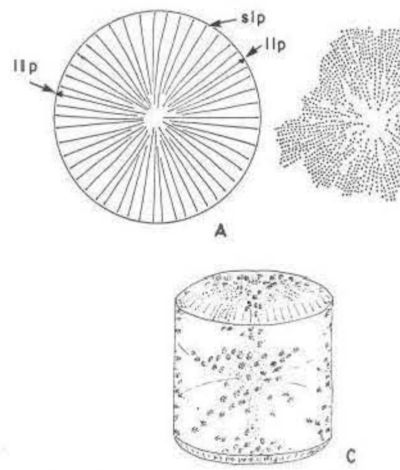


Fig. 16. *Coscinodiscus concinniformis*. A. Valve with two large labiate processes (llp) and ring of small labiate processes (slp) at ends of radial ribs. B. Central area. From Cupp 1943. C. Cell in girdle view. From Lebour 1930 (as *C. concinnus*).

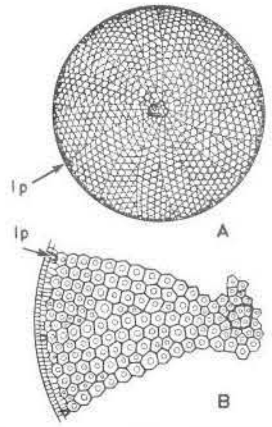


Fig. 17. *Coscinodiscus curvatulus*. A. Valve view showing arrangement of areolae. B. Areolation showing marginal labiate processes (lp). From Hustedt 1930.

A cosmopolitan, oceanic form. It occurred at nine of our stations, eight of which were south of the Subtropical Convergence.

Fig. 18. *Coscinodiscus granii* Gough

Cells circular in valve view, cuneate in girdle view. Areolae arranged in fascicles, radiating from central rosette. Areolation tangential, concentric type. Areolae decrease in size approaching the margin (8 in 10 µm at centre, 11 at margin, 13 at edge of mantle). Small marginal labiate processes at interstriae or borders of fascicles. Two asymmetrically placed marginal large labiate processes. No intercalary bands; girdle simple, narrowing from 20 µm to 10 µm. Diameter 95-190 µm.

Reported as a generally neritic, widespread temperate form. The species occurred at seven of our oceanic stations in the temperate waters between the Subtropical Convergence and Subantarctic Front on the Atlantic side of the region.

SEM References: 3, 10, 25, 59.

Fig. 19. *Coscinodiscus marginatus* Ehrenberg

Cells solitary, heavily silicified. Valves flat, without central area or rosette. Areolae large, polygonal and occluded by cribra, decreasing in size toward the margin. Irregularly radial, secondary tangential areolation indistinct. The valve margin is wide and sharply defined, with very coarse radial striae, 4-6 in 10 µm. Processes or valvar structures present, but barely visible, and only as a ring of small pores which are the outer openings of the labiate processes. Cingulum is a broad, rectangular band with asymmetrically curved ends. Diameter 36-97 µm.

Found in small numbers in all temperate seas. Hendey (1937) considers it as a meroplanktonic, bottom form. In our collection we found it at four oceanic stations and two interisland, neritic stations.

SEM Reference: 52.

Fig. 20. *Coscinodiscus oculus-iridis* Ehrenberg

Cells large, circular in valve view. Valves flat, centrally depressed. Large central rosette, usually of five areolae. Areolae hexagonal, diminish in size toward the margin (4 to 3 in 10 µm). Areolation radial with secondary rows in spirals. Margin narrow with radial striae about 7 in 10 µm. Two large, asymmetrically placed labiate processes, not visible under LM. Ring of small labiate processes just above quincunx marginal areolae. Girdle minutely punctate. Diameter of valve 180-260 µm.

Cosmopolitan, oceanic. In our material it occurred at only two stations in the Retroflection Area.

SEM Reference: 52.

Fig. 21. *Coscinodiscus radiatus* Ehrenberg

Cells solitary, coin-shaped, small to medium. Valves flat to slightly convex. Central hyaline area defined only by small circular hole. Areolae in radiating long or short lines, non-fasciculate, uniform in size except at the margin where they are reduced. Ring of marginal processes and one or more irregular rings of small labiate processes between valve centre and margin. Not readily resolved under LM. Two larger processes 135 degrees apart shown by depression of valve exteriorly. Cingulum with three bands, valvocopula wider than both the others, areolated in regular rows. Diameter of valve 70-140 µm, average 100 µm.

Cosmopolitan, oceanic in temperate seas. Irregular in structure, varying in size and robustness of areolation according to environmental conditions. Occurred at four scattered, oceanic stations in our material.

SEM References: 36, 52.

Genus: PSAMMODISCUS Round & Mann

Flat valves more or less circular, rather shallow with distinct, radial rows of areolae which are closer together on the mantle. Areolae show central thickenings (Fig. 4A,C) and, in coarsest forms, radial bars (Fig. 4B). Valve structure simple and costate. A small central speck always present; it is the rimmed pore of an internally occluded loculate areola. A single, nearly central, small labiate process sometimes present; strutted processes and pseudonoduli absent. Girdle bands narrow, split, the first porous. Position in Coscinodiscaceae is open to discussion.

Fig. 22. *Psammodiscus nitidus* (Gregory) Round & Mann
Coscinodiscus nitidus Gregory

Monospecific genus as described above. Distribution is described by Round & Mann (1980)* as epipsammic, or attached to marine sand grains. However, Hendey (1937) and Cupp (1943) claim it (as *Coscinodiscus nitidus*) as a neritic, probably bottom form. In our material it occurred at six random, oceanic stations between Cape Town and the islands and at one neritic station between the islands where it was undoubtedly meroplanktonic. It is possibly an epipsammic form on the sandy bottom between the islands. In the oceanic plankton it is more likely to be a visitor from the south-eastern coast of South Africa, in common with many other phytoplankton forms (Boden *et al*, 1988).

SEM Reference: 51.

Genus: STELLARIMA Hasle & Sims

Cells solitary or in short filaments; discoid or lenticular. Valves slightly to strongly convex. Radial areolation in curved fascicles with secondary eccentric type rows. Loculate areolae occluded by external cribra. Small, hyaline central area with single, or a group of, labiate processes.

Fig. 23. *Stellarima stellaris* Hasle & Sims
Coscinodiscus stellaris Roper, *Symbolophora stellaris* (Roper) Nikolaev

Cells with strongly convex valves, thin-walled. Areolae in curved, radial fascicles with tangential secondary rows concave toward margin. No marginal processes. Three to six central labiate processes radiating in irregular star-like formation. Girdle narrow, finely striate. Diameter 30-100 µm.

Oceanic, cosmopolitan, temperate species, common in the Southern Ocean. In our material it occurred at four stations in the temperate zone between the Subtropical Convergence and the Subantarctic Front.

SEM References: 10, 35.

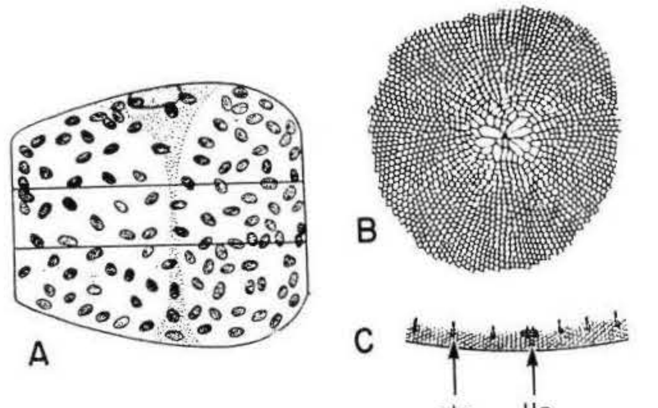


Fig. 18. *Coscinodiscus granii*. A. Girdle view. From Gran & Angst 1931. B. Central part of valve showing rosette and hexagonal areolation. C. Valve margin showing small labiate processes (slp) and one of two large labiate processes (llp). After van der Werff & Huls 1957-74.

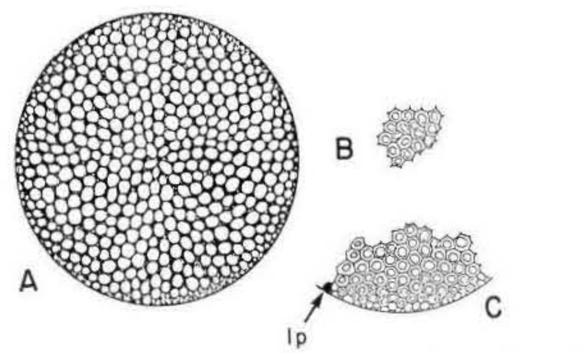


Fig. 21. *Coscinodiscus radiatus*. A. Valve view, showing radial rows of areolae. B. Hexagonal areolae near centre showing openings of loculi. C. Areolae near margin showing location of one of two large marginal labiate processes. From Cupp 1943.

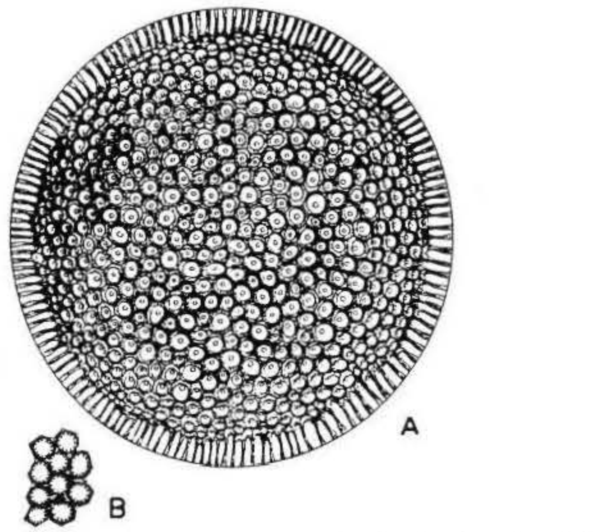


Fig. 19. *Coscinodiscus marginatus*. A. Valve view showing arrangement of areolae and wide margin. B. Detail of areolae showing cribra. From Hustedt 1930.

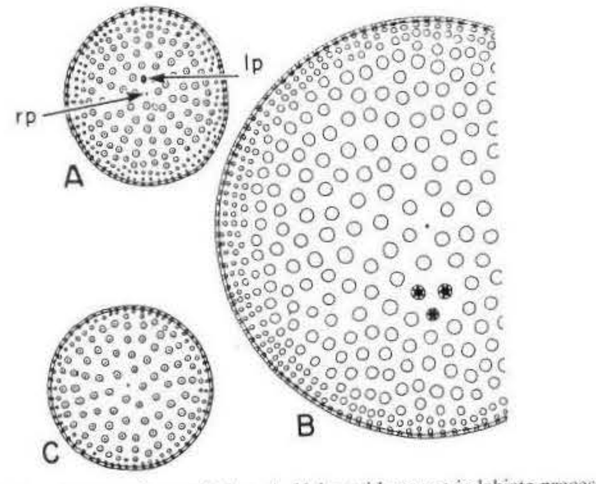


Fig. 22. *Psammodiscus nitidus*. A. Valve with eccentric labiate process (lp) adjacent to small, rimmed pore (rp) of central organelle. The position of the labiate process of the other valve is indicated (dashed). B. Larger valve without labiate process showing radial substructure of areolae. C. Smaller valve without labiate process and less well-developed marginal series of areolae. All valves show central pore. From Round & Mann 1980*.

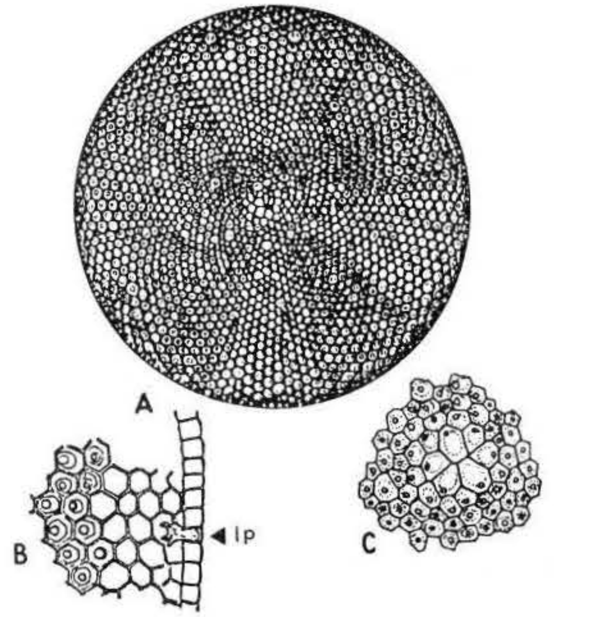


Fig. 20. *Coscinodiscus oculus-iridis*. A. Cell in valve view. From Hustedt 1930. B. Part of margin showing a marginal labiate process (lp). From Cupp 1943. C. Central areolation on valve. From Hustedt 1930.

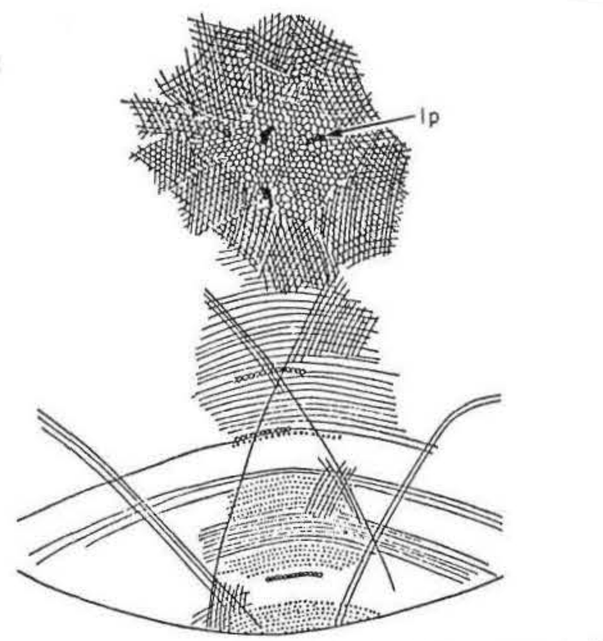


Fig. 23. *Stellarima stellaris*. Section of valve showing arrangement of areolae in radial sectors and central labiate processes (lp). After Cupp 1943 (as *Coscinodiscus stellaris*).

Hemidiscaceae Hendey emend. Simonsen

Genus: ACTINOCYCLUS Ehrenberg emend. Simonsen

Cells solitary, discoid. Valve surface divided into numerous sectors by punctate striae radiating toward the margin from a cluster of puncta in the central area. These main striae may be separated by hyaline interstriae from fascicles of shorter radial striae. Marginal ring of conspicuous labiate processes. No labiate processes on valve face but one pseudonodulus is present.

Fig. 24. *Actinocyclus octonarius* Ehrenberg
Actinocyclus ehrenbergii Ralfs ex Pritchard

Valves convex, notably at the margin. Areolation and processes as in genus. The marginal zone is more finely striate than the valve face and has a narrow, outer margin that is finely, radially striate. The pseudonodulus is a true pseudonodulus in that, so far, only one per valve has been observed. Girdle simple. Characteristic diffraction effects seen with low power objective. Diameter 50-300 µm. Hendey (1937) has described the taxonomic history of the genus and type species in detail.

A cosmopolitan, usually neritic form. We found it at only one station just north of the Subantarctic Front.

SEM References: 10, 54.

Genus: HEMIDISCUS Wallich

Cells solitary, semi-circular to lunulate in valve view, cuneate in girdle view. Valve surface radially areolate with secondary eccentric-type, tangential pattern. Marginal labiate processes. Single hyaline pseudonodulus.

Fig. 25. *Hemidiscus cuneiformis* Wallich
Euodia cuneiformis Schütt

Cells single, cuneate. Valves semi-circular; strongly convex dorsal margin, weakly convex ventral margin with slight median inflation. Areolation fasciculate, irregularly radial in short rows toward valve centre, tangential sectors convex toward margin and apices. No central hyaline area or rosette. Marginal labiate processes. Single hyaline pseudonodulus at centre of ventral margin. Girdle simple, no intercalary bands. Apical axis (ventral margin) 80-174 µm; transapical axis 44-90 µm.

A very variable species in characters such as outline, ratio between apical and transapical axes, convexity of dorsal margin etc., but there is a series of intermediate forms that do not permit the establishment of separate species or consistent varieties. Oceanic, usually subtropical species. In our collection it was found at eight oceanic stations, all associated with the Subtropical Convergence or a tongue of warm water extending south from the Agulhas Return Current.

SEM Reference: 10.

Asterolampraceae H.L.Smith

Genus: ASTEROLAMPRA Ehrenberg

Cells solitary, discoid. The valve is divided by broad, hyaline rays radiating from the hyaline centre toward the margin. There is no delimited central area. The rays (probably modified loculi - Simonsen, 1979) are of the same width and taper toward the margin. They terminate in a large, marginal, labiate process. There are no labiate processes on the valve surface of any member of the Asterolampraceae. The valve surface between the rays is finely areolated.

Fig. 26. *Asterolampra marylandica* Ehrenberg
Asterolampra vanheurckii Brun

Cells solitary, discoid. Valves slightly undulate to flat. There is a comparatively large, clear middle region comprising the wide proximal bases of six or seven radial, hyaline, extended loculi, that divide the valve into areolated sectors. The areolae have a tangential, eccentric-type arrangement with an inner marginal row of somewhat larger areolae demarcating the clear hyaline rays. Each ray terminates in a pseudonodulus and a labiate process. Diameter 31-122 µm.

Oceanic, tropical to subtropical form favoring high salinity. It is found in the plankton of tropical to temperate waters of all seas and fossil material. We encountered it in our survey at four stations, all in the Agulhas water.

SEM Reference: 10.

Genus: ASTEROMPHALUS Ehrenberg

Cells solitary, discoid, circular or transversely elliptical to oval in outline. Valves flat but undulate in girdle view, distinctive hyaline rays being elevated above valve surface and dividing areolated area into sectors. The number of rays is notably variable within a species but one ray is narrower than the others. The bases of the rays are separated in the central area by silicified ribs or "spokes" which may be jagged or smooth. The rays terminate in labiate processes and pseudonoduli. The Antarctic species of this genus have been carefully keyed by Priddle & Fryxell (1985).

Fig. 27. *Asteromphalus heptactis* (Brébisson) Ralfs

Disk-shaped cells frequently oval in outline. Eccentric, hyaline, middle area occupies one-quarter to one-third diameter of cell. Usually one narrow and six broad rays radiating toward the margin. The bases of the rays are separated by jagged spokes: the marginal ends of the rays terminate in a pseudonodulus and labiate process. Areolated sectors depressed, not rounded. Areolae coarse, uniform, arranged in tangential lines. Diameter 38-100 µm. An oceanic, variable, temperate species.

Priddle & Fryxell (1985) are unable to separate this species from *A. parvulus* Karsten in routine sample analysis. They give the diameter of both species as <50 µm. Hendey (1937) states that *parvulus* is very similar to *heptactis* but quite distinct from it. He gives the diameter of *heptactis* as always >50 µm (64-100 µm) and that of *parvulus* as 22-40 µm. Our material was limited - the form appeared at four temperate, oceanic stations and one interisland, neritic station and they were all >50 µm in diameter. *A. parvulus* was not recorded. Hendey claims it prefers cold water of low salinity.

SEM References: 10, 59.

Fig. 28. *Asteromphalus hookeri* Ehrenberg
A variable form including several synonymies
(Van Landingham, 1967-79)

Cells solitary, valves slightly convex. Hyaline area in centre of valve is large, 1/2 to 3/4 of total diameter. Number of broad hyaline rays, or loculi variable, usually between five and ten and one narrow ray: all about the same length. These divide the areolated area into sectors that are connected at their inner apices by spokes. The spokes are smooth and some bifurcate when the number of broad rays

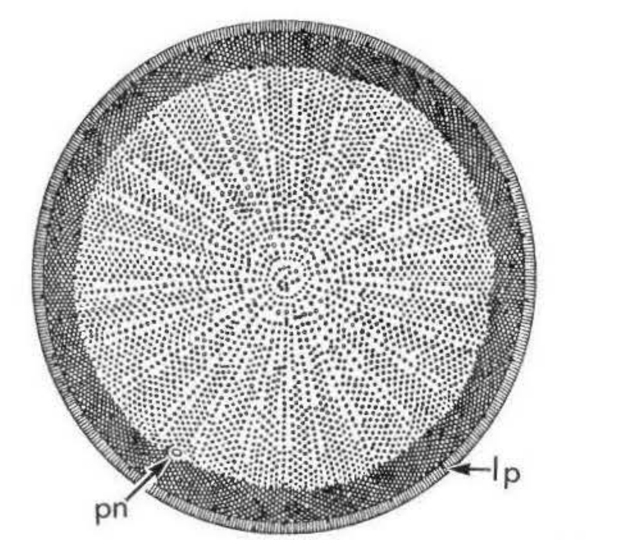


Fig. 24. *Actinocyclus octonarius*. Cell in valve view showing hyaline pseudonodulus (pn), radiating striae and ring of labiate processes (lp). After Hustedt 1930 (as *A. ehrenbergii*).

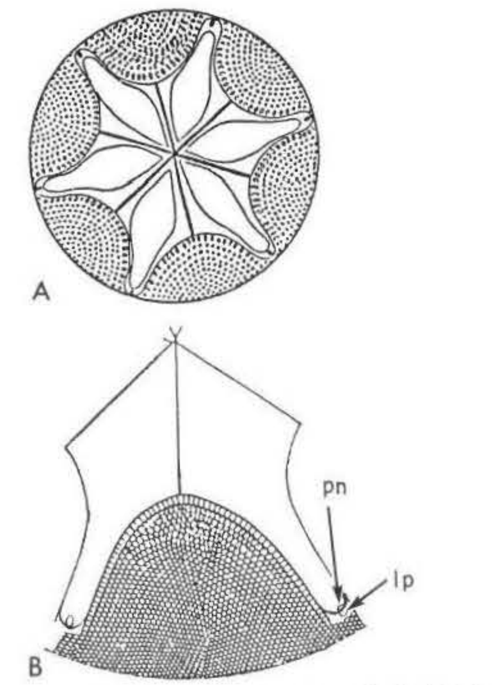


Fig. 26. *Asterolampra marylandica*. A. Valve view of cell with six sectors. From Cupp 1943. B. Valve view of one sector showing labiate process (lp) and pseudonodulus (pn) at outside edge of extended loculi (rays). After Hustedt 1930.

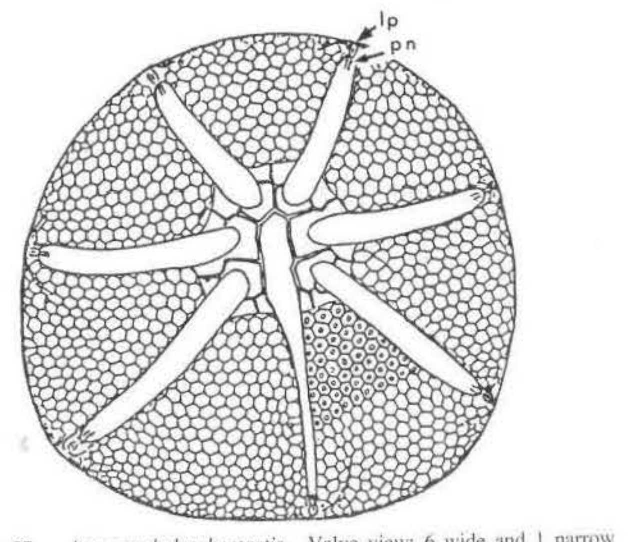


Fig. 27. *Asteromphalus heptactis*. Valve view: 6 wide and 1 narrow hyaline rays terminating in a pseudonodulus (pn) and a labiate (lp) process. After Cupp 1943.

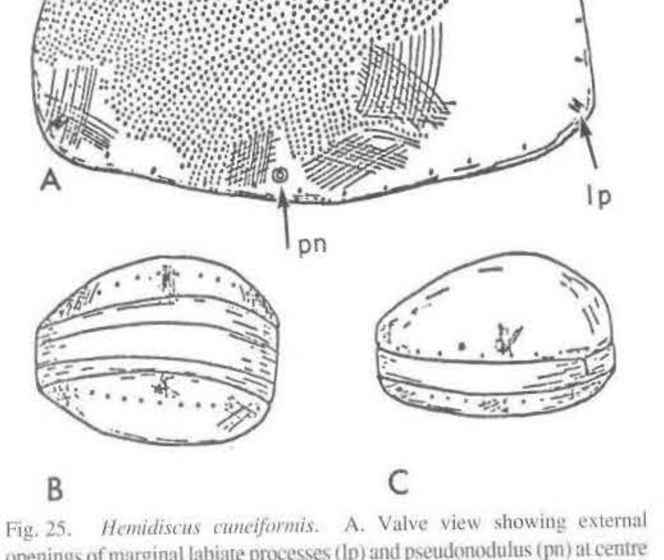


Fig. 25. *Hemidiscus cuneiformis*. A. Valve view showing external openings of marginal labiate processes (lp) and pseudonodulus (pn) at centre of straight side. B & C. Girdle view from different sides. From Cupp 1943.

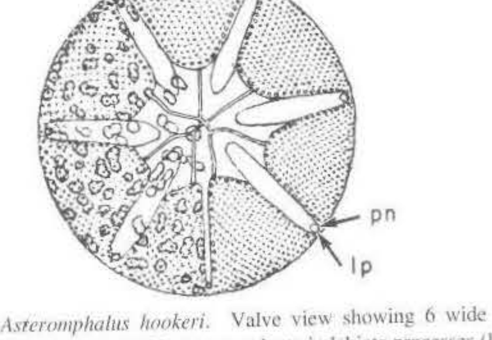


Fig. 28. *Asteromphalus hookeri*. Valve view showing 6 wide and 1 narrow hyaline rays. The wide rays terminate in labiate processes (lp) and pseudonoduli (pn). After Karsten 1905a.

exceeds six. The rays terminate in marginal labiate processes and pseudonoduli. Diameter 44-60 µm.

Widely distributed, but not in great numbers, in temperate and subpolar seas. We recorded it at one subpolar and three temperate, oceanic stations and one interisland, neritic station.

SEM Reference: 10.

Fig. 29. *Asteromphalus roperianus* (Greville) Ralfs
Asterolampra roperiana Greville

Cells discoid, medium to large. Valves convex, undulate. Areolate area is extensive, occupying about two-thirds of valve surface. Usually six broad extended loculi and one narrow ray radiate from the middle hyaline area, dividing the areolate area into seven sectors. The sectors have a marginal row of larger areolae and the apices are joined by jagged spokes. The terminal labiate process at the extremities of the broad rays lies very close to the valve margin. Diameter: 80-120 µm.

Relatively rare, found generally in warmer seas. Sournia (1968) reports it from the Indian Ocean. Some records from the Antarctic (Simonsen, 1974). We found it at only one station in the Agulhas Retroflection.

Heliopeltaceae H.L. Smith emend. Ross & Sims

Genus: ACTINOPTYCHUS Ehrenberg

Cells discoid, solitary. Valve surface undulates as alternately raised and depressed sectors. Polygonal to circular, smooth, hyaline, central area. Girdle simple, no intercalary bands. Curved, marginal labiate processes usually on raised sectors. Pronounced valve margin, frequently with numerous spinulae. No pseudonodulus.

Fig. 30. *Actinoptychus* cf. *senarius* (Ehrenberg) Ehrenberg
Actinoptychus undulatus (Bailey) Ralfs

Type species of genus. Cells discoid, with six radial sectors alternately raised and depressed. Areolations coarse, polygonal. Marginal areolae large, radially elongated and punctated. Areolation pattern of depressed sectors replaced by punctation and a hyaline network of fine lines joined by small dots (areolae). Secondary pattern of fine puncta in oblique lines. Valve margin narrow, striated, with numerous spinulae. One large, curved, marginal labiate process on each raised sector. Diameter 40-130 µm.

Cosmopolitan in subtropical waters. Neritic, frequently bottom form; occurs in plankton. In our material we recorded it as *Actinoptychus* sp. at one, interisland, neritic station. This is a very probable LM identification but is somewhat outside the usual distribution range of the species.

SEM References: 10, 59.

RHIZOSOLENIINEAE

Rhizosoleniaceae Petit

Genus: DACTYLIOSOLEN Castracane

Cells with long pervalvar axis, often lightly silicified. Valves circular or discoid, lacking any processes on external surface. United by flat valve surfaces to form stiff chains. Cingulum well developed with many bands the junctions of which are obliquely arranged giving the cell the appearance of spiral torsion. Hendey (1937) divided the species into two groups, the cold-water *D. antarcticus* group and the warm-water *D. mediterraneus*. However, Hasle (1975)* has transferred *D. mediterraneus* to the genus *Leptocylindrus*.

Fig. 31. *Dactyliosolen antarcticus* Castracane

Cells cylindrical, usually united by flat valvar surfaces to form chains of two to eight cells. Irregular, branching or reticulate areolation. Single labiate process at the margin seldom seen in valve view with LM. Girdle bands with prominent costae; spiral imbrications. Diameter of cell 16-72 µm (usually about 30 µm), length up to 130 µm. A polymorphic species with considerable variation in arrangement of areolae, sometimes in cells of one chain.

Oceanic, typically polar to sub-polar. Fairly frequent but not abundant. Cupp (1943) claims it as a temperate form, neritic but sporadically oceanic. We found it at only one station, south of the Subantarctic Front.

SEM Reference: 29.

Genus: GUINARDIA H. Peragallo

Cells cylindrical, straight or slightly curved pervalvar axis, solitary or closely united in straight to twisted chains. Single, marginal labiate process. Cell wall weakly silicified, numerous narrow girdle bands.

Fig. 32. *Guinardia flaccida* (Castracane) H. Peragallo
Rhizosolenia flaccida Castracane

Cells solitary, large; one and a half to several times longer than broad. Sometimes united in short chains, seldom more than six cells to a chain. Valves flat with a single, small, marginal labiate process which shows as an indentation in girdle view. Seldom seen in valve view in field samples. Numerous, narrow, open, ligulate bands difficult to see on weakly silicified cell wall. Diameter 30-90 µm, length usually 60-90 µm.

Neritic, temperate species, not very abundant and favoring a high salinity. In our material it occurred at two oceanic stations in the Retroflection associated with the Subtropical Convergence and one neritic station off Prince Edward Island.

SEM References: 29, 59.

Genus: RHIZOSOLENIA Ehrenberg emend. Brightwell

Cells cylindrical, with elongated pervalvar axis 4-100 times longer than the diameter due to large number of intercalary bands. Cells are straight or, more rarely, curved, forming straight or spiral chains. The valves ("calyptra") have a process at the apex which may be central, subcentral or marginal and in chain formation fits into a corresponding depression in the valve of the sibling cell. The process consists of an internal labiated structure and an external "spine" which may be greatly reduced, produced, or it may be a twin-process, as in the "bidens" valve. It varies greatly in shape and size according to species but frequently dimorphic species occur, which are sometimes classified as separate taxa or as forms. In some species otaria - membranous wings - are present at the base of the process. Cell wall is weakly to moderately silicified. Open, ligulate copulae. Fine imbrication lines, sometimes difficult to see under LM, are frequently useful specific criteria. The cingular elements are finely punctate in quincunx or striate pattern. The hypopleurae and valves are also punctate. Auxospores and resting spores have been described. The genus contains many widespread and abundant species. The taxonomy is currently undergoing comprehensive revision (Sundström, 1986)*.

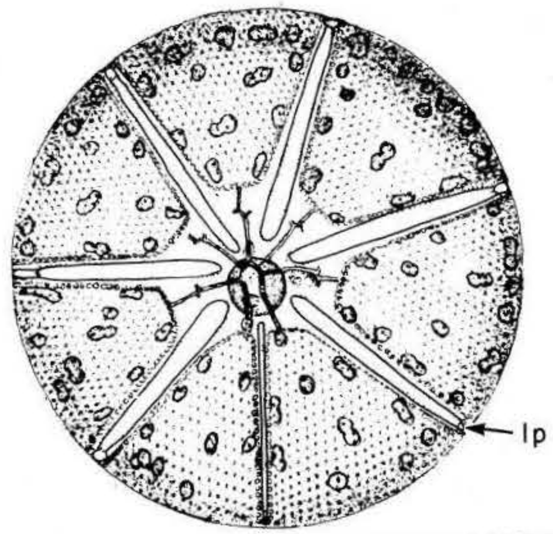


Fig. 29. *Asteromphalus roperianus*. Valve view showing 6 fairly narrow and one very narrow, hyaline rays. The broader rays terminate in labiate processes (lp) (and pseudonoduli?) very close to the valve margin. After Karsten 1905a.

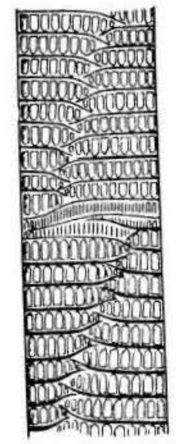


Fig. 31. *Dactyliosolen antarcticus*. Girdle view showing oblique line formed by ends of ribbed intercalary bands. From Hendey 1937.

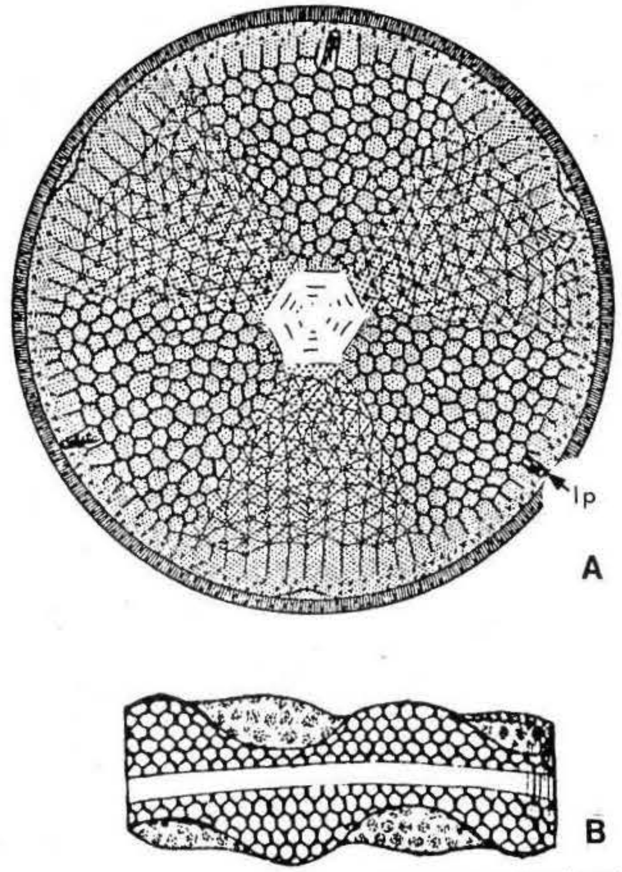


Fig. 30. *Actinoptychus* cf. *senarius*. A. Valve view showing alternating raised and depressed sectors, and labiate processes (lp) near margin of raised sectors. After Hustedt 1930 (as *A. undulatus*). B. Girdle view. Original.

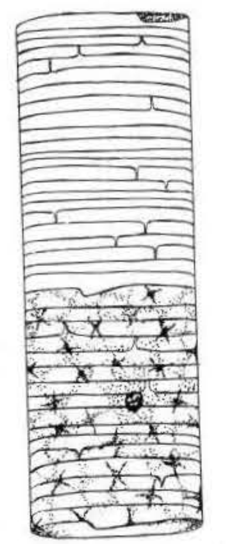


Fig. 32. *Guinardia flaccida*. Single cell in girdle view showing stellate chromatophores, open, ligulate bands and "indented" appearance of valve margin at location of labiate process. From Hendey 1937.

Fig. 33. *Rhizosolenia alata* Brightwell

Cells cylindrical, elongated, straight. Valves elongated, truncated cone with no terminal, external process. Valvar depression into which cone of sibling cell fits in chain formation. Cell wall weakly siliceous. Cingular elements in two dorsiventral rows such that imbrications appear as a zig-zag line in ventral view. Finely loculate striae on pleurae. Diameter 10-20 μm, pervalvar axis up to 1 mm.

Sundström (1986)* has suggested a new genus, *Proboscia*, for this species, on the basis of the presence of a proboscis and the absence of a process.

Oceanic, cosmopolitan in temperate to subtropical seas. We recorded it at six oceanic station in the Retroflection and Agulhas Return Current.

SEM References: 29, 56.

f. gracillima (Cleve) Grunow

Structurally similar to type, but much more slender. Valve less conical but distally more produced. Diameter 4-7 μm, length up to 500 μm.

Neritic, but found under oceanic conditions. Occurs in both subtropical and subantarctic waters. In our material we found it at two stations, one in the subtropical Agulhas Current and one south of the Subantarctic Front in the subantarctic waters of the Islands.

SEM References: 29, 57.

Fig. 34. Rhizosolenia bergonii H. Peragallo

Cells elongated, cylindrical, with long, conical valves. Robust, but short, central process with prominent tube, appearing cleft under LM. Radial, punctate striae. Girdle with four or five rows of ligulate segmented bands, several segments per band. No otaria. Imbrication lines clearly defined. Diameter 22-115 μm, length up to 550 μm.

Oceanic in tropical and subtropical seas. It was found in our collections at four stations in the warm Agulhas Current and two in the Agulhas Return Current north of the Subtropical Convergence.

SEM References: 29, 56.

Fig. 35. *Rhizosolenia curvata* Zacharias
R. curva Karsten

Cells usually solitary, sometimes in short chains, sometimes forming "rafts" of specimens of varying size. Cells slightly curved to crescentic. Valves notably conical with small, central process. Cell walls weakly siliceous with imbrication lines difficult to see. Girdle bands in two dorsiventral rows, very finely punctated in quincunx. Diameter varies from about 30-110 μm.

Limited in distribution, being confined mainly to the colder waters of the Subantarctic Zone. It is thus a valuable indicator species (Hart, 1937). In our material it occurred at only one station well south of the Subantarctic Front and in the subantarctic waters just north of the Prince Edward Islands.

SEM Reference: 57.

Fig. 36. *Rhizosolenia delicatula* Cleve

Cells cylindrical, valves flat, margins rounded. United by valve surfaces into short straight chains. Eccentric marginal process on valve fits into depression on margin of adjacent cell. Girdle with intercalary bands almost invisible in LM. Diameter 10-12 μm: three times as long.

Neritic, temperate, cosmopolitan species. We found it at one station in the Agulhas Current and at three neritic, interisland stations.

SEM References: 29, 56.

Fig. 37. *Rhizosolenia hebetata* Bailey emend. Gran

This is a dimorphic species. The two forms are distinctive but sometimes exhibited by the same cell.

f. *hiemalis* Gran

Cells straight, cylindrical. Valves deeply conical. Thick, apical process. Cell wall heavily silicified. Imbrication lines of two dorsiventral rows of girdle bands conspicuous, presenting zig-zag appearance in lateral view. Punctate in quincunx. No otaria. Diameter 18-20 μm.

A winter and cold water form. We found it at five stations in the interisland, subantarctic waters. Sundström (1986)* (as *Rh. hebetata* f. *hebetata*) says it is a northern form.

SEM Reference: 56.

f. *semispina* (Hensen) Gran
R. semispina Hensen

Delicate, elongated cells, cylindrical with steeply oblique valves carrying a very long, apical process. Labiate process visible with high-power LM. Base of the process flanked by two membranous otaria visible in ventral view. Girdle bands in two dorsiventral rows with imbrication lines zig-zag in appearance in lateral view. These are difficult to see because the cell is very weakly silicified. There is a depression on the valve surface and upper girdle band where the process of the adjacent cell fits when the cells are in catena. Diameter 5-12 μm, pervalvar axis 400-750 μm.

Form *"semispina"* has been recorded from all parts of the ocean, probably erroneously. It has been described as a warm water summer form by Cupp (1943) and Simonsen (1974). Sundström (1986)* now uses *Rh. antennata* f. *semispina* for the form he found only in the southern cold water region. We found it at six oceanic stations associated with a tongue of warm Agulhas Return Current water extending southward from the Subtropical Convergence into the Subantarctic zone and at one interisland station.

SEM References: 29, 56, 59.

Fig. 38. *Rhizosolenia robusta* Norman ex Pritchard
R. sigma Schütt

Cells solitary or in short chains, crescentic or sigmoid. The valves are deeply conical and usually carry an apical, tubular process. When present this is of the same diameter as the internal labiate process and there is a space between the process and the valve wall. Radial striae from apical process toward margin. Girdle consists of open copulae with punctate striae in quincunx. Diameter 100-200 μm, length up to 1 mm.

Cosmopolitan in tropical and subtropical waters. We encountered two specimens, one at a subantarctic, oceanic station and one at a subantarctic, interisland, neritic station. It was probably an allochthonous visiting form at both locations.

SEM References: 29, 56.

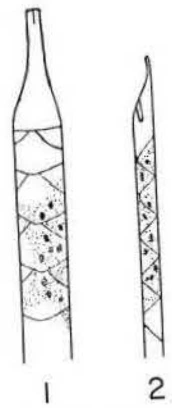


Fig. 33. *Rhizosolenia alata*. 1. End of cell showing proboscis. 2. Form "gracillima" in lateral view showing zig-zag imbrication lines. After Boden 1950.

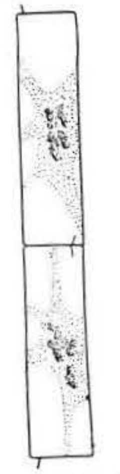


Fig. 36. *Rhizosolenia delicatula*. Girdle view, showing flat valve face and process at margin. From Boden 1950.

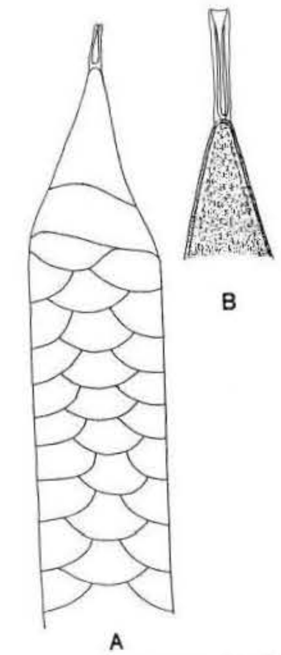


Fig. 34. *Rhizosolenia bergonii*. A. Cell in dorsal view. B. Apex of cell showing cleft appearance of process. From Hendey 1964.

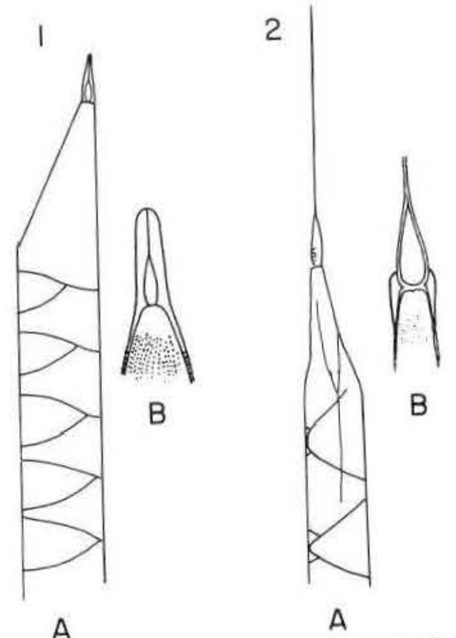


Fig. 37. *Rhizosolenia hebetata*. 1. form *hiemalis*. A. Lateral view. From Boden 1950. B. Apex of cell showing process. 2. form *semispina*. A. Lateral view showing depression corresponding with process of adjacent cell. B. Apex of cell showing process and otaria. After Boden 1950.

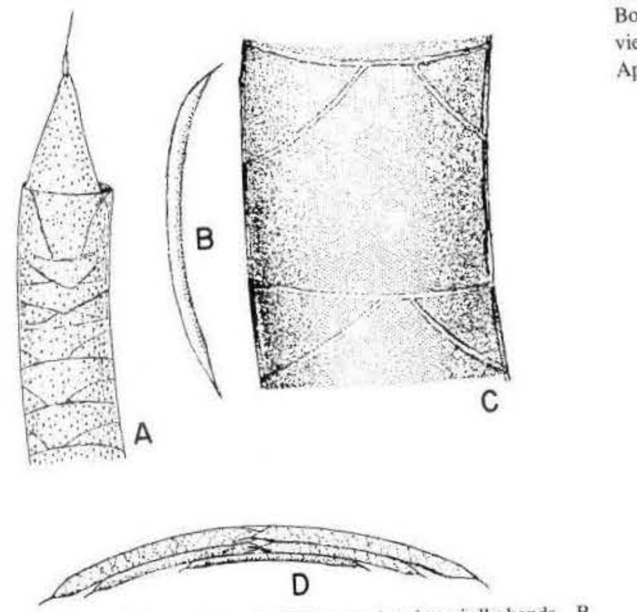


Fig. 35. *Rhizosolenia curvata*. A. Cell apex showing girdle bands. B. Single cell. C. Detail of girdle band showing areolation. After Karsten 1905a (as *R. curva*). D. "Rafting" of different sized cells. After Hart 1937.

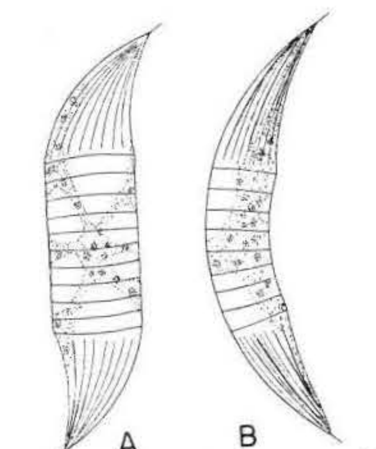


Fig. 38. *Rhizosolenia robusta*. A. Broad girdle view. B. Narrow girdle view. After Cupp 1943.

Fig. 39. *Rhizosolenia simplex* Karsten

Small, straight, cylindrical cells with acutely conical valves terminating in a central, long and slender process. Cell wall weakly siliceous and details of the cingular elements are difficult to resolve. Diameter 10-26 µm, pervalvar axis 200-400 µm.

Oceanic, characteristically subantarctic throughout the southern oceans. We report it from only one station in the subantarctic, interisland waters.

SEM Reference: 56.

Fig. 40. *Rhizosolenia stolterfothii* H. Peragallo

Cells cylindrical, curved along pervalvar axis. United by flat valves to form curved, frequently spiral chains. Single, eccentric, marginal process that fits into a corresponding depression in the valve of the adjacent cell. Girdle consists of open copulae, very difficult to resolve due to the delicate silicification of the cell wall. Diameter 6-30 µm.

Neritic species, cosmopolitan in temperate seas. We found it at only one oceanic station.

SEM References: 29, 56.

Fig. 41. *Rhizosolenia styliformis* Brightwell

Cells solitary, cylindrical, straight. Valves deeply conical, obliquely pointed, with a straight ventral margin. Long, pointed process with two adjacent otaria extending onto the valve. Internal labiate process discernible in LM. Marked indentation on the valve where the process of the neighbouring cell couples. Singular elements in two dorsiventral lines. In lateral view they are not zig-zag but have the appearance of interlocking fingers. Cell wall rather strongly silicified and imbrications usually clearly seen. Punctate striae in quincunx. Diameter 20-100 µm, pervalvar axis 600-1050 µm.

Oceanic, cosmopolitan, abundant, although many records are probably erroneous. Sundström (1986)* tentatively regards it as a N. Atlantic species. Several varieties have been recognized and Sundström lists those which may be confused. It occurred at only two stations in our survey.

SEM references: 29, 56.

BIDDULPHIINEAE

Biddulphiaceae Kützing

Hemiauloideae Jousé, Kiselev & Poretskii

Genus: CERATAULINA H. Peragallo ex Schütt

Cells cylindrical, usually in chains. Valves slightly arched, bearing two elevations that unite the cells by apposition of their tips which may have linking spines. The areolae are poroid and pseudocelli may be present.

Fig. 42. *Cerataulina pelagica* (Cleve) Hendey
C. bergonii H. Peragallo

Cells cylindrical, two or three times longer than the diameter. Usually occur in chain formation, apertures much reduced. Epi- and hypovalves are similar but the cells are twisted around the pervalvar axis such that the two elevations of one valve are at right angles to those of the other. The linking spines at the ends of the elevations are small. Punctate striae, radial on valve, parallel on mantle. Cell wall weakly siliceous, intercalary bands ligulate, imbrications of copulae very indistinct, but bands end in an almost straight line. Diameter 11-56 µm, pervalvar axis 30-130 µm.

Neritic, temperate form; cosmopolitan and common in warm seas. Our material shows only one occurrence in a tongue of warm water of the Agulhas Return Current.

SEM Reference: 37.

Genus: HEMIAULUS Ehrenberg

Cells single or united in chains. Rectangular in girdle view, may be curved, elliptical in section. Two elevations, parallel with pervalvar axis, at ends of apical axis. These are terminated by small spines that interlock with those of the adjacent cells to form chains. Valve concave to slightly convex, may be heterovalvate. Copulae indistinct. Valves and bands with poroid areolae. Pseudocelli may be present. Presence of labiate process variable. A very diverse genus as presently defined.

Fig. 43. *Hemiaulus hauckii* Grunow

Cells usually united by reduced, interlocking spines at ends of bipolar elevations to form long, sometimes twisted, chains. Valve surfaces flat to concave, apertures large. Valve mantle with indistinct poroid areolae. Labiate process on mantle at one apex of the valve.

Neritic or oceanic in subtropical/tropical areas of all oceans. It occurred at seven oceanic stations in our collection - all except one associated with the Agulhas Current or Subtropical Convergence.

SEM Reference: 49.

Stictodiscoideae Simonsen

Genus: ETHMODISCUS Castracane

Cells solitary, frequently of great size. Valves circular, discoid to notably convex. Delicately punctate fasciculate striae radiating from a central hyaline area with a circle or cluster of more-or-less well defined labiate processes. There are no marginal processes. According to Round (1980)* *Ethmodiscus* has many labiate processes covering the valve surface in addition to those in the central area. There may be a clear, hyaline border.

The girdle is wide resulting in an elongated pervalvar axis frequently greater than the diameter: extremely delicate, barely visible, puncta in quadrate arrangement. The bands are open. We report on two species, *E. gazellae* and *E. rex*, about which there has been a great deal of confusion. Some of our *E. rex* specimens were up to 1700 µm in diameter, which is rather large for this species. There may be an intermediate form between *gazellae* and *rex* but several authors including Round (1980)* and Simonsen (1974) maintain the separation of species. Main distinguishing character is the arrangement of the central processes.

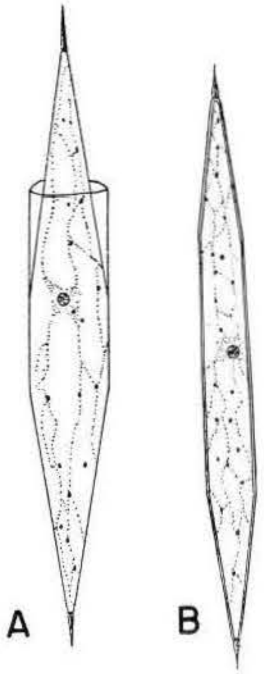


Fig. 39. *Rhizosolenia simplex*. A. Cell with projecting girdle after division. B. Complete cell. After Karsten 1905a.

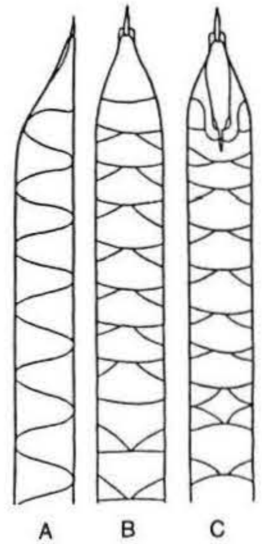


Fig. 41. *Rhizosolenia styliformis*. A. Lateral view. B. Dorsal view showing otaria. C. Ventral view showing otaria and depression corresponding with process of adjacent cell. From Hustedt 1930.

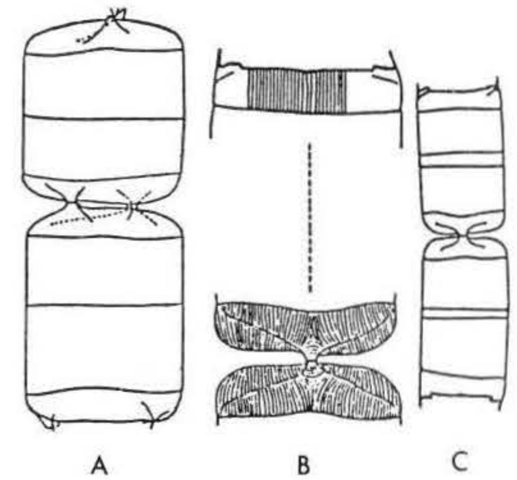


Fig. 42. *Cerataulina pelagica*. A. Girdle view showing elevations with short linking spines. B. Fine areolation of cell mantles. C. Cells twisted about central axis of chain. From Cupp 1943.

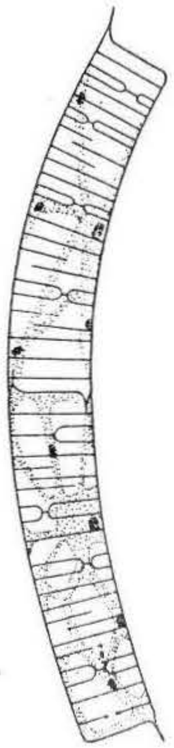


Fig. 40. *Rhizosolenia stolterfothii*. Two cells showing processes at free ends and between cells. From Boden 1950.

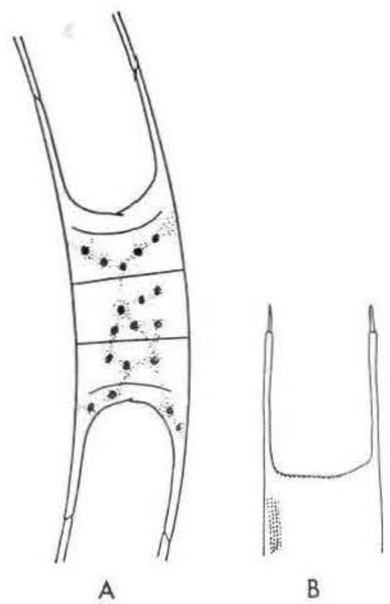


Fig. 43. *Hemiaulus hauckii*. A. Girdle view. From Boden 1950. B. End enlarged to show elevations, linking spines and poroid areolation. From Cupp 1943.

Fig. 44(1). *Ethmodiscus gazellae* (Janisch) Hustedt
Ethmodiscus wyvilleanus Castracane

Cells very large; circular in valve view; cylindrical with elongated pervalvar axis frequently greater than diameter. Wide girdle with fine puncta in more or less quadrate pattern. Valves deeply convex, central hyaline area flat or depressed; finely punctated in radial lines; small central hyaline area with ring of labiate processes. Rather weakly silicified. May have nodule-like projections on the valve.

Diameter 700-1000 µm, pervalvar axis up to 1500 µm. According to Hustedt (1930) the diameter may reach nearly 2 mm.

Rare to very rare. Tropical and Indian Ocean distribution best understood. Occurred once at Station 8, south of the Subtropical Convergence, in this survey.

SEM Reference: 50.

Fig. 44(2) *Ethmodiscus rex* (Rattray) Wiseman & Hendey
Coscinodiscus rex Wallich ex Rattray

The cells are cylindrical, one valve usually flat the other markedly convex with flat or depressed central area. The central area has a cluster of well-defined labiate processes. Cell very fragile and may be larger than *E. gazellae*.

In this survey *E. rex* was found south of the Subtropical Convergence and at stations south of the Subantarctic Front.

SEM Reference: 50.

Cymatosiraceae Hasle, von Stosch & Syvertsen

Genus: CAMPYLOSIRA Grunow ex Van Heurck

Hasle, von Stosch & Syvertsen (1983)* have emended the diagnosis of this taxon. Cells united in inseparable colonies by interlocking spines. Specialized end valves distinguished by marginal spines different from those on valves within the colony and by the shape of the external part of the labiate process. Ocelluli present.

Fig. 45. *Campylosira cymbelliformis* (A. Schmidt) Grunow ex Van Heurck, *Synedra cymbelliformis* A. Schmidt

This is the type species of the genus. Cells narrow rectangular in girdle view, slightly curved. Constricted near apices and with low bipolar elevations. Cells united in inseparable colonies by marginal linking spines. Terminal valves specialized by shape of marginal spines. Inner cells heterovalvate, one valve being convex the other concave. Labiate process present or absent in the central area of the concave valve just inside the areola row parallel with curved margin. Cingulum composed of four open, ligulate bands with poroid areolae. These are seldom resolvable under LM. Valves sublunate in outline, with well-defined central area but no axial area. Ocelluli present. Apical axis 25-45 µm, transapical axis 4-5 µm.

Benthic or tychopelagic form almost always associated with detrital material, probably because of an outer mucilage layer. It occurred in our plankton at two stations over the shoal between the islands.

SEM Reference: 39.

Genus: PLAGIOGRAMMOPSIS Hasle, von Stosch & Syvertsen

Cells rectangular in girdle view, convex in middle and narrowed near apical elevations forming separable colonies. In outline valves narrowly lanceolate with rostrate apices, or broadly lanceolate without rostrate apices, rhombic or subcircular. Fascia with one pseudoseptum. Rows of long, marginal spines with acute, flattened or slightly branched apices, along each side of valve. Incomplete pili present. Submarginal labiate process.

Fig. 46. *Plagiogrammopsis vanheurckii* (Grunow) Hasle, von Stosch & Syvertsen
Plagiogramma vanheurckii Grunow ex Van Heurck

Cells rectangular in girdle view, convex in middle and constricted near elevations; connected loosely in colonies of 3-6 by thin, apparently flexible, marginal spines. Valves lanceolate in outline. Intercalary bands seldom visible under LM. Cingulum consists of 3-6 open, ligulate bands in addition to valvocopula. Heterovalvate, valves distinguished by presence or absence of labiate processes and pili. Terminal cells not specialized. Labiate process submarginal on same side of all cells. The other, non-process valves carry pili which are curved to lie parallel with the surface. The pilus is located on one side of the apical axis, on one elevation and the ocellus on the other side, the pattern being reversed on adjacent cells. Apical axis 20-50 µm, transapical axis about 4 µm.

A littoral, cosmopolitan form. It occurred at only one station in our material, between the Subantarctic Front and the Prince Edward Islands.

SEM Reference: 39.

Chaetoceraceae H.L. Smith

Genus: BACTERIASTRUM Shadbolt

Cells cylindrical, valves circular in outline united in chains by marginal setae, six to numerous (about 25). The inner setae of adjacent cells are usually fused proximally and then bifurcate distally. The fork-plane may be along the pervalvar axis or transverse to it. Size of apertures variable. The terminal setae are simple and either curved at the base to lie parallel with the pervalvar axis, or directed toward the centre of the chain. Cell wall hyaline, delicate, with no distinct areolation. Usually one or two labiate processes in central hyaline area of valve.

Fig. 47. *Bacteriastrum criophilum* Karsten

Cells elongated, cylindrical. Inner setae of adjacent cells simple, fused only at point of intersection to unite cells in chains of four to eight. Setae of epivalve and hypovalve of terminal cells dimorphic. The margin is sharply constricted near the point of origin of the terminal setae. These are oblique at their bases and, in the epivalve curve back to lie for their entire length along the pervalvar axis of the cells in catena. Those of the hypovalve are pendulous from the margin, also along the pervalvar axis. All setae are spinose. Apertures small, indistinct. Diameter 14-18 µm, pervalvar axis 40-60 µm.

Very common around South Africa and in the southern oceans. In our material it appeared at three stations associated with the Subtropical Convergence waters.

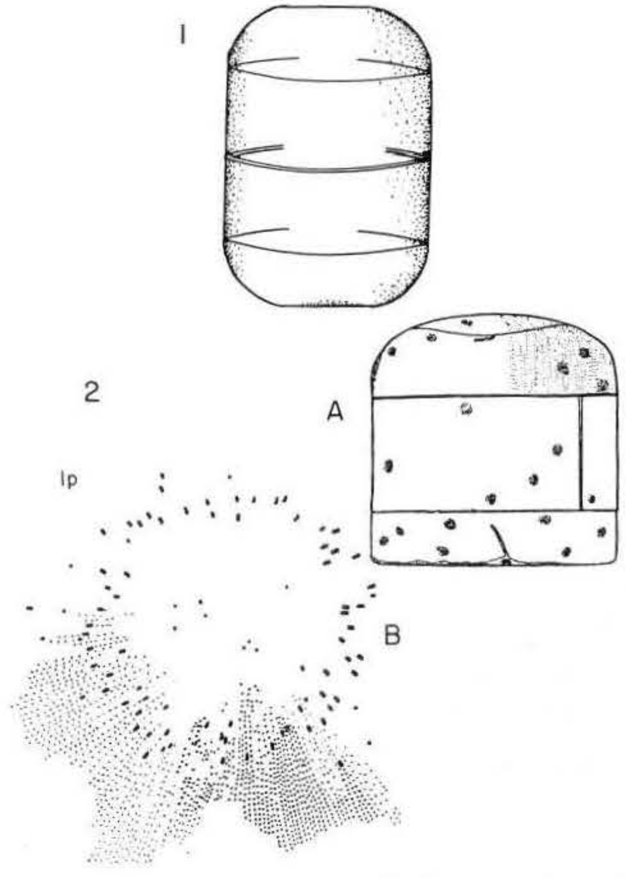


Fig. 44. *Ethmodiscus* spp. 1. *E. gazellae* showing convex valves. After Hustedt 1930. 2. *E. rex*. A. Cell in girdle view showing one convex mantle and single open band. B. Centre of valve showing cluster of labiate processes (lp). Nodule-like projections in central area. Original.

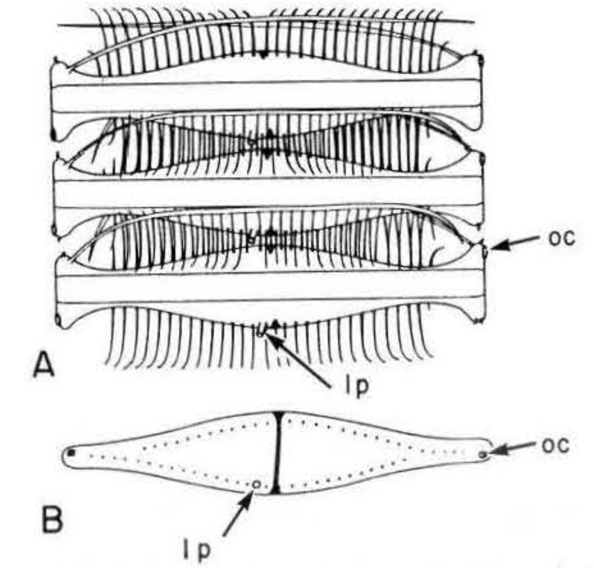


Fig. 46. *Plagiogrammopsis vanheurckii*. A. Cells in girdle view showing elevations, marginal linking spines, pili and ocelluli (oc). B. One cell in valve view showing ocelluli (oc) and labiate process (lp). From Hasle, Von Stosch & Syvertsen 1983*.

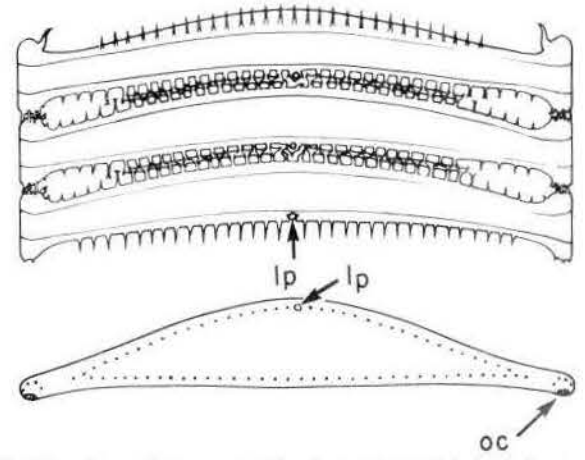


Fig. 45. *Campylosira cymbelliformis*. A. Part of chain in girdle view with low elevations, marginal linking spines and labiate process (lp). B. Single cell in valve view showing ocelluli (oc). From Hasle, Von Stosch & Syvertsen 1983*.

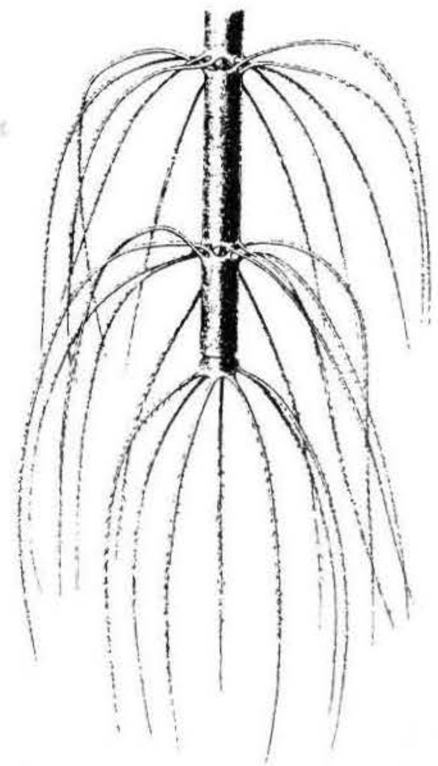


Fig. 47. *Bacteriastrum criophilum*. Two cells at end of chain showing spinose setae. From Karsten 1905b.

Fig. 48. *Bacteriastrum furcatum* Shadbolt
B. delicatulum Cleve, *B. nodulosum* Shadbolt

Cells elongated, cylindrical, united in long, straight chains. Apertures usually large. Six to twelve marginal setae per cell. The basal parts of the setae of adjacent cells are fused for almost half their length, bifurcate in valvar plane. Forks curved, smooth or slightly wavy. Terminal setae isomorphic, directed toward centre of chain. Stronger than inner setae and carry spirally arranged spinulae. Diameter 6-30 µm, pervalvar axis 20-40 µm.

Oceanic, temperate species, more common in northern hemisphere. Reported in Southern Ocean but never abundant. We report it at one station in the Agulhas Current.

Fig. 49. *Bacteriastrum hyalinum* Lauder

Cells short, sometimes shorter than diameter. Chains long, straight or slightly curved. Apertures narrow but distinct. Inner setae 7-25 per valve, with short basal part. Bifurcate in apical plane. Forked parts slightly curved and weakly twisted. Terminal setae isomorphic, curved, bent toward chain centre, stronger than inner setae and carry spirally arranged spinulae. Resting spores frequently noted. Diameter 13-56 µm.

Neritic, common, frequently abundant in temperate waters. We found it at one station in Subtropical Convergence waters.

Genus: CHAETOCEROS Ehrenberg

Cells elliptical to nearly circular in valve view, quadrangular in broad girdle view, with straight sides and concave, flat to slightly convex valves. Long, thick or thin, submarginal setae at ends of apical axis. The setae of adjacent cells fuse at an intersection point near the base, thereby uniting the cells in chains (Fryxell & Medlin (1981)*). A few species are single-celled. Apertures variable in size. The terminal cells of the chain carry modified terminal setae which are usually shorter and thicker than the inner setae and more nearly parallel with the pervalvar axis. The cingular elements of the frustule are usually difficult to resolve under LM. A central process may be present, at least on the end valves of a chain: varies from a long simple tube to a reduced labiate process (Evensen & Hasle (1975)*). Often divided into sub-genera *Phaeoceros* and *Hyalochaete* the former having species mostly oceanic, heavily silicified, with chromatophores in the setae; the latter with species mostly neritic, lightly silicified and without chromatophores in the more delicate setae. Resting spores and auxospores are characteristic of *Hyalochaete* forms.

This is the richest and most variable genus of truly planktonic diatoms, containing over 160 species.

Fig. 50. *Chaetoceros affinis* Lauder

Numerous varieties of this species have been described. These are all included in the synonymy by Hustedt (1930).

Cells quadrangular in broad girdle view, elliptical in valve view, with sharp apical apices of adjacent cells touching. Chains straight. Valves weakly concave. Apertures elliptical, slightly narrowed in middle. Valve mantles deep, separated by a constriction from narrow girdle. Epivalve surface carries several spines and possible labiate process. Inner setae curved and delicate. Terminal setae robust, basally strongly divergent from, then curved parallel to chain axis. Setae spinose, slightly twisted. Apical axis 7-27 µm.

Cosmopolitan, temperate species, probably neritic, sometimes abundant. We report it from only one station, south of the Subantarctic Front.

SEM Reference: 4.

Fig. 51. *Chaetoceros atlanticus* var. *neapolitana* (Schröder) Hustedt *C. neapolitana* Schröder

Chains straight and narrow: cells rectangular, valve mantles low, dividing cell in girdle view into three equal parts. Constriction between mantle and girdle. Valves concave to flat with small, central labiate process. Setae lie parallel with pervalvar axis for short distance before turning outward to fuse at an intersection point with setae of adjacent cell: contain chromatophores. Apertures are conspicuous, rhomboid-ovate. Diameter 8-12 µm.

This variety is very common in all temperate to tropical oceans. In our material it was found at three stations associated with a warm, southerly extending tongue of the Subtropical Convergence.

SEM References: 4, 59.

Fig. 52. *Chaetoceros constrictus* Gran

Cells rectangular in broad girdle view, elliptical in valve view. Apical apices produced as sharp corners. Valves flat with a slight median inflation. Apertures conspicuous, symmetrical, slightly constricted. Deep constrictions between valve mantle and girdle. Inner setae delicate, rather short, with no marked basal parts. Terminal setae somewhat thicker, divergent and weakly spinose. Resting spores, when present, carry short spines on both valves. Diameter 12-36 µm.

Neritic, temperate species, occasionally abundant. In our material it occurred at one, neritic station on the shoal between the Islands.

Fig. 53. *Chaetoceros convolutus* Castracane

Cells united in flat, twisted chains. Heterovalvate, epivalve convex with mantle as deep as girdle width, hypovalve flat, elliptical. Setae strong, twisted on valve face and closely interlocked with those of adjacent cell. They are spinose and have chloroplasts. Siliceous flap at fusion point of setae; this obscures the apertures. Setae vary from perpendicular to pervalvar axis to parallel and closely adpressed to lower cells. Apical axis 15-23 µm.

Oceanic in Arctic and boreal seas. Frequently very abundant. May cause fish kills. We found it at one station in Subantarctic waters south of the Subantarctic Front.

SEM Reference: 13.

Fig. 54. *Chaetoceros criophilus* Castracane

Cells usually in short chains, often solitary. Valves almost circular, heterovalvate, epivalve strongly convex with deep mantle, hypovalve flat with very narrow mantle. Setae arise from centre of epivalves, submarginally from hypovalve. Setae strong, curved, spinose throughout with chromatophores. May be conspecific with *C. concavicornis* Mangin. Diameter 16-50 µm.

Characteristically Antarctic form. It occurred sparsely at one of our southernmost stations near the Islands, possibly due to leakage across the Antarctic Convergence or to cold core eddies.

Fig. 55. *Chaetoceros decipiens* Cleve

Cells elliptical in valve view, square to quadrangular in broad girdle view. Apical elevations of valves fuse to form long, straight chains. Apertures vary seasonally in size and shape, being larger and rounder in summer. Setae originate at corners of cells, lack basal part but are fused proximally for a short distance and directed at right angles to pervalvar axis. Divergent parts continue in this direction,

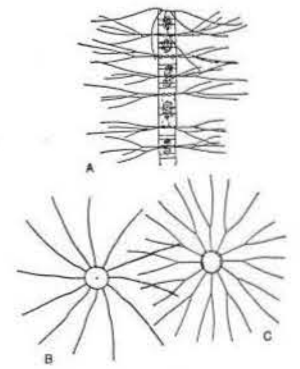


Fig. 48. *Bacteriastrum furcatum*. A. Part of chain in broad girdle view. B. Valve view of terminal cell showing terminal setae and central labiate process. C. Valve view of inner cell showing inner setae. From Cupp 1943 (as *B. delicatulum*).

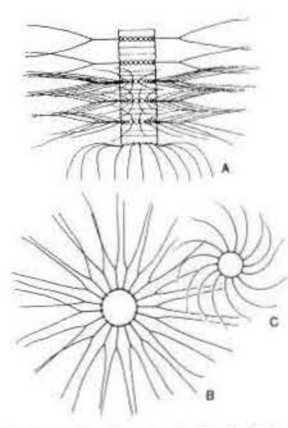


Fig. 49. *Bacteriastrum hyalinum*. A. End of chain in broad girdle view. B. Valve view of inner cell showing inner setae. C. Valve view of terminal cell showing terminal setae. From Van der Werff & Huls (1957-74).

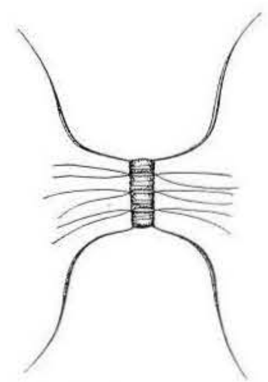


Fig. 50. *Chaetoceros affinis*. Chain in broad girdle view showing characteristic terminal setae. After Karsten 1905b (as *C. ralfsii*).

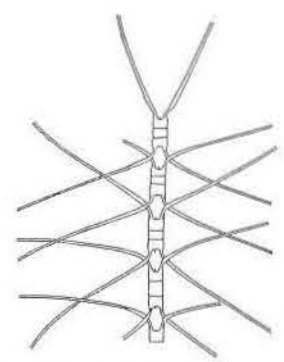


Fig. 51. *Chaetoceros atlanticus* var. *neapolitana*. Chain in broad girdle view showing small, central process. From Hustedt 1930.

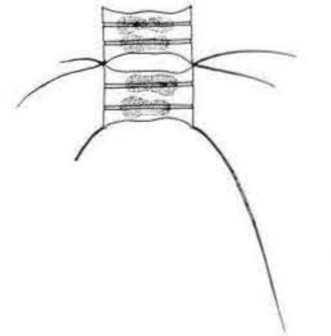


Fig. 52. *Chaetoceros constrictus*. Terminal and adjacent cell in broad girdle view. Deep constriction between valve and girdle band. From Boden 1950.

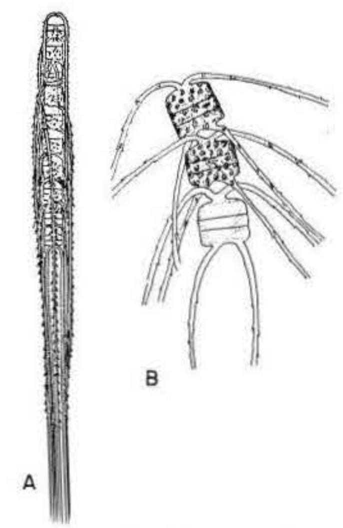


Fig. 53. *Chaetoceros convolutus*. A. Chain with adpressed setae. From Cupp 1943. B. Cells in broad girdle view. From Hendey 1964.

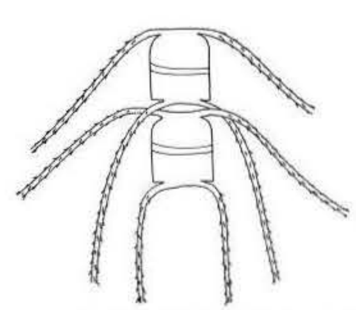


Fig. 54. *Chaetoceros criophilus*. End of chain broad girdle view. After Hendey 1937. (Chain may resemble that of *Ch. convolutus* - Fig. 53A).

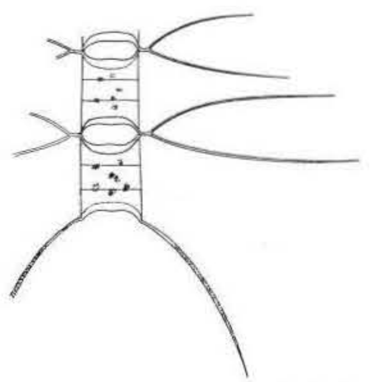


Fig. 55. *Chaetoceros decipiens*. End of chain in broad girdle view showing characteristic setae joined beyond cell and striate terminal setae. From Boden 1950.

in parallel plane. Terminal setae of hypovalve thicker than inner setae, simple and curved almost parallel with chain. Setae frequently finely punctate. Apical axis 30-80 µm.

Oceanic, usually considered Arctic or boreal. Simonsen (1974) cites it as cosmopolitan, rarer in lower latitudes. Hendey (1937) reports it around South Africa in considerable numbers. We found it at four stations, three Subantarctic and one just north of the Subantarctic Front.

SEM Reference: 4.

Fig. 56. *Chaetoceros didymus* Ehrenberg
Chaetoceros gastridium Ehrenberg

Cells united to form straight chains. Valves elliptical: in broad girdle view the pervalvar axis is generally shorter than the apical axis. Valves concave with a prominent, mammiform, median process. Inner setae originate at the corners of the cells and those of adjacent cells fuse at an intersection point close to valve margin. Apertures vary in size and shape from narrowly elliptical to broadly oval. Terminal setae stouter than inner and spinose. Length of valve 12-34 µm.

var. *protuberans* (Lauder) Gran & Angst

Terminal setae usually thicker and more strongly divergent; U-shaped. Inner setae cross further away from the chain.

Cosmopolitan, neritic, temperate species. In our material *C. didymus* occurred at four oceanic stations, all close to the Subtropical Convergence, and two neritic, interisland stations. Variety *protuberans* occurred at one oceanic, subtropical station. Simonsen (1974) did not separate the variety from the species in the METEOR material because they graded together. We did not have enough material to form an opinion on this point but illustrate what we considered to be the variety with a query.

SEM References: 18, 59.

Fig. 57. *Chaetoceros laciniosus* Schütt
C. pelagicus Cleve

Cells rectangular in broad girdle view, with slightly projecting, rounded corners. Valves elliptical, surface with a slight median inflation: central process near the edge. Setae thin with basal part parallel with pervalvar axis, intersecting and fusing with the basal part of adjacent cells to form loose, straight chains. At the fusion-point the setae turn abruptly outward to run at right angles to the chain axis. Apertures large, broadly rectangular. Terminal setae thicker, generally parallel with pervalvar axis, spinose. Apical axis 10-38 µm.

Cupp (1943), Hendey (1937), Hustedt (1930) and Taylor (1967) retain *C. pelagicus* as a separate species based mostly on chromatophore number and more delicate, loose chains. We feel these are inadequate characteristics for separation.

A neritic, temperate form. We observed it at two stations south of the Subtropical Convergence and one station over the interisland shoal.

SEM Reference: 4.

Fig. 58. *Chaetoceros lorenzianus* Grunow

Cells rectangular in girdle view. Often solitary but more usually in straight, stiff chains. Valves elliptical in outline, surface flat or slightly elevated in centre. Mantle deep, girdle short unless cell contains resting spores. Inner setae intersect and fuse with those of adjoining cell at point of emergence from cell margin. They diverge slightly but lie at right angles to pervalvar axis. Terminal setae thicker, divergent and curved toward, but not parallel with pervalvar axis. All setae slightly thicker distally but terminal setae notably so. Setae with very distinct transverse striae. Apertures polygonal to oval-elliptical. One valve of resting spore has conical projections ending in a branched process. Apical axis 7-60 µm.

Neritic, tropical to subtropical. In our material it was found at two stations just south of the Subtropical Convergence and at one neritic station between the islands.

Fig. 59. *Chaetoceros messanensis* Castracane

Cells rectangular in broad girdle view. Valves markedly elliptical in outline, surface flat to concave. End valves have a tubular central process not normally seen on LM. Corners of valve abut those of the adjacent cell. Inner setae fuse at this intersection point and either diverge immediately to carry on outward at right angles or remain fused for about two-thirds of their length before bifurcating. The fused setae are fewer but longer and stouter than the rest and carry spirals of small spines. Apertures large, hexagonal to almost circular. Apical axis 9-46 µm, usually about 36 µm.

Oceanic, tropical to subtropical. Common in Indian and Pacific Oceans. In our material it occurred at five stations in the Agulhas Current and Return Current.

SEM Reference: 4.

Fig. 60. *Chaetoceros neogracile* Van Landingham
C. gracilis Schütt

Cells solitary, rectangular in broad girdle view. Valves flat to slightly concave, sometimes with median inflation. Setae fine, arising submarginally, curved and then running nearly parallel with each other at 60-90 degrees to the pervalvar axis. Apical axis 6-10 µm.

Neritic, cosmopolitan in mainly cold water. We found it at one neritic station in the Subantarctic waters over the interisland saddle.

Fig. 61. *Chaetoceros peruvianus* Brightwell

A very variable oceanic species for which numerous forms and varieties have been established. Cells usually solitary, occasionally in short chains. Heterovalvate, valves elliptical, epivalve convex, hypovalve flat, with small central spine. Setae of epivalve originate in central area and basal parts occupy most of the valve surface, recurved in long, sweeping curves. Hypovalve setae emerge obliquely and continue parallel with pervalvar axis. Setae strongly spinose and striate with chromatophores. Apical axis 10-44 µm.

Oceanic, widely distributed in temperate and tropical seas. We found it in our collection at nine stations in the temperate waters between the Subtropical Convergence and the Subantarctic Front.

Fig. 62. *Chaetoceros radicans* Schütt

Cells rectangular, straight or slightly curved, twisted strongly in chain axis. Terminal cells have a labiate-like process. Valves oblong-elliptical in outline. Elevations of adjacent cells do not abut. Fairly high valve mantle with no constriction at girdle. Setae curved in valvar plane, heavily spinose. Terminal setae not modified. Characteristic resting spores either in pairs in chain or as single cells within specialized frustules with setae recurved over broad girdle face and without girdle bands. Apical axis 6-20 µm.

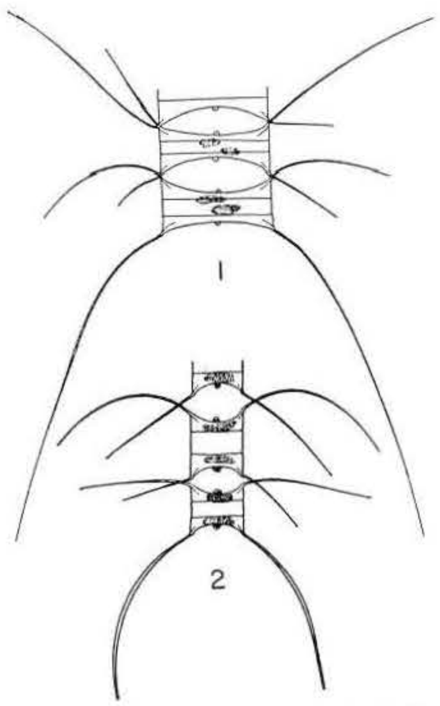


Fig. 56. *Chaetoceros didymus*. 1. Terminal and adjacent cell in broad girdle view. 2. var. *protuberans*. Terminal and adjacent cell in broad girdle view showing strongly divergent, thickened, delicately spinose terminal setae. From Boden 1950.

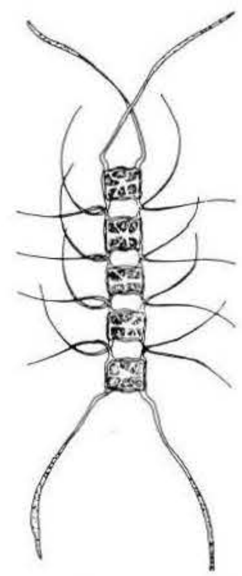


Fig. 57. *Chaetoceros laciniosus*. Chain in broad girdle view; distinctive terminal setae. After Lebour 1930.

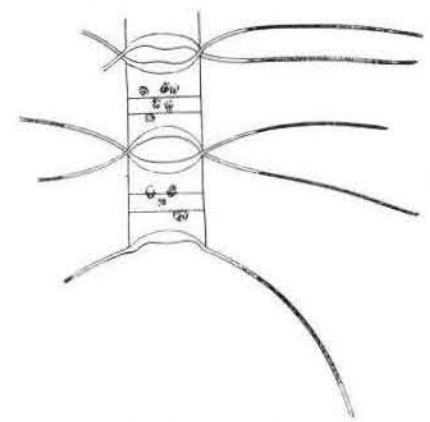


Fig. 58. *Chaetoceros lorenzianus*. End of chain of wide cells in broad girdle view showing striate setae and divergent terminal setae. From Boden 1950.

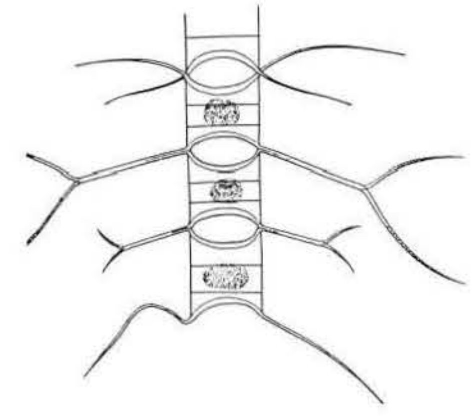


Fig. 59. *Chaetoceros messanensis*. Terminal and inner cells in broad girdle view showing spinose, furcate and simple setae. Diverging, unlike, terminal setae. From Boden 1950.

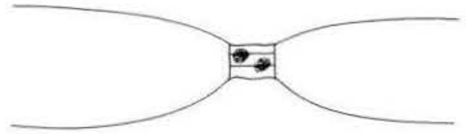


Fig. 60. *Chaetoceros neogracile*. Cell in broad girdle view. From Boden 1950 (as *Ch. gracilis*).

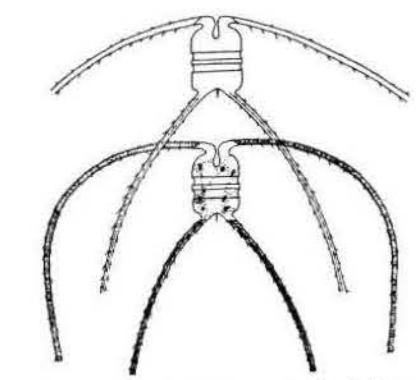


Fig. 61. *Chaetoceros peruvianus*. Broad girdle view showing heterovalvate cells and striate, strongly spinose setae. From Hendey 193.

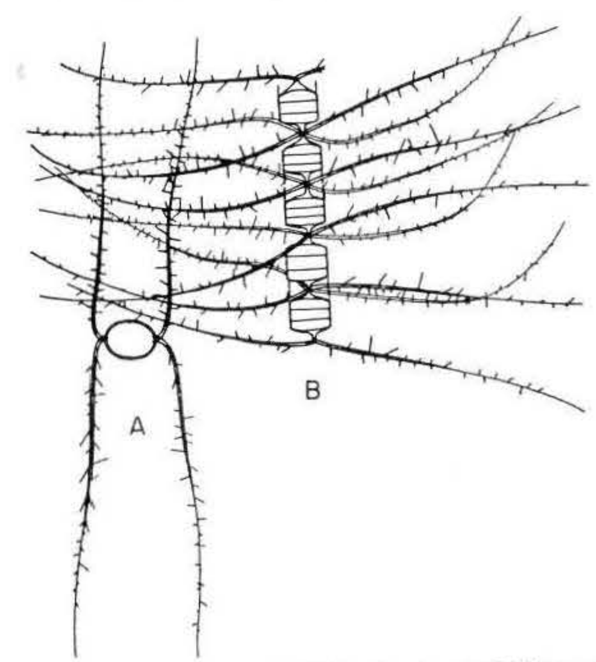


Fig. 62. *Chaetoceros radicans*. A. Cell in valve view. B. Cell in narrow girdle view showing markedly spinose setae curved in valvar plane. From Hustedt 1930.

Cosmopolitan, this small species blooms readily (possibly due to resting spore formation) in the temperate waters of these latitudes, between the Subtropical Convergence and the Subantarctic Convergence. Cupp (1943) mentions blooms of 4,500,000 cells per litre in California and we have encountered blooms around the islands of such density as to defy any estimation of concentration. We have seen mats of cells in bloom stage with spores free or entangled in the setae of vegetative cells in very great numbers. Although the species did not occur in this survey we have included it as one of the common diatoms of the region because its absence is most unusual.

SEM Reference: 13.

Fig. 63. *Chaetoceros socialis* Lauder

Cells with apical axis usually longer than pervalvar. Elevations of adjacent cells do not touch. Hairlike setae originate at cell corners and unite cells in colonies. On one side of the chain the setae of the adjacent cells are pincer-like. On the other side the setae are dimorphic and recurve across the broad girdle face to point the same way as the other pair. More usually one of the pair does this while the other is straight and up to thirty times longer than the apical axis. It is these long setae that hold the cells in colonies. Apertures long, slightly narrower in centre. Apical axis 6-12 µm.

Neritic, temperate species, common and seasonally frequently abundant. In our material it appeared at two stations just south of the Subtropical Convergence.

SEM References: 4, 18, 59.

Lithodesmiaceae H. & M. Peragallo

Genus: DITYLUM Bailey

Cells solitary except immediately after division; prismatic to cylindrical. Cell wall weakly silicified. Valves triangular to square in outline. Central labiate process with two internal openings. It is this character that links it to the other genera in the family (Simonsen, 1979).

Fig. 64. *Ditylum sol* Grunow
Triceratium sol Grunow ex Van Heurck

Cells usually solitary, triangular in valve view, undulate. Central hyaline area with a conspicuous central labiate process, surrounded by irregular ring of processes. Valve surface radially punctate, parallel striae on margin. Poroid areolae with rotae. Girdle simple, finely punctate. Side of triangle 60-180 µm, pervalvar axis 60-80 µm.

Tropical, oceanic form. Reported frequently in the warmer waters around South Africa. We found it in the Agulhas Retroflection.

SEM Reference: 29.

Genus: LITHODESMIUM Ehrenberg 1841

Cells usually united by a connecting membrane at the valve margin to form long, straight chains. Apertures concealed. Long, thin tube, which is external part of labiate process in the centre of the valve. Girdle with open, ligulate bands.

Fig. 65. *Lithodesmium undulatum* Ehrenberg

Cells in straight chains. Valves triangular in outline, with undulating margin; surface flat, radially areolated, with small central area. High mantle with more or less parallel areolation. Central labiate process with long external tube. Girdle bands delicately areolated, connecting membrane coarsely areolated, both in decussate pattern. Areolae simple open holes. Transapical axis 35-68 µm, pervalvar axis usually shorter.

Neritic, temperate species, occasionally moderately abundant. We report it at one station in the Agulhas Return Current.

SEM Reference: 29.

Genus: STREPTOTHECA Shrubsole

Frustules flat, square, or sometimes triangular, in outline. Cells united into twisted chains by valve surfaces leaving little, if any, apertures. Cell walls weakly siliceous. Valves narrowly elliptical in outline with small, central labiate process.

Fig. 66. *Streptotheca thamesis* Shrubsole

Cells square, flat, twisted through 90 degrees about pervalvar axis and united by valves to form a spiral chain. Small elevation on the valve surface fits into corresponding depression in valve of adjacent cell, leaving no aperture. Apical axis 60-100 µm, pervalvar axis 90-120 µm.

Neritic, cosmopolitan in temperate and subtropical seas. We report it from the subantarctic waters between the Subantarctic Front and the Prince Edward Islands.

SEM References: 29, 55.

Eupodiscaceae Kützing

Eupodiscoideae Kützing

Genus: ODONTELLA Agardh
Denticella Ehrenberg, *Biddulphia* Gray (in part)

Cells box-shaped to cylindrical, single or in chains, with heavily silicified cell walls. Valves elliptical, triangular or quadrangular. At the ends or corners of the valves are strongly developed elevations with true ocelli that, in littoral forms, hold the cells together in chains. In the planktonic forms the cells are usually held together by the external tubes of labiate processes or are single. Valves have punctate areolae radiating from a small, central hyaline area - puncta 12-17 in 10 µm. Girdle zone has fine, parallel, vertical rows of puncta, 10-21 in 10 µm. Intercalary bands sometimes present.

Mostly littoral, attached forms but several species are truly planktonic.

Fig. 67. *Odontella aurita* var. *obtusa* (Kützing) Hustedt
Biddulphia obtusa (Kützing) Ralfs ex Pritchard

Zig-zag chains formed by abutment of one ocellus of each cell. Differs markedly from the type in shortness of elevations and absence of central labiate process. Radial, punctate areolae, 8-10 in 10 µm, on valve, 7-8 on girdle in 6 pervalvar rows in 10 µm. The great similarity of sculpturing and the gradation of the lengths of the processes are the criteria for the establishment of a single species.

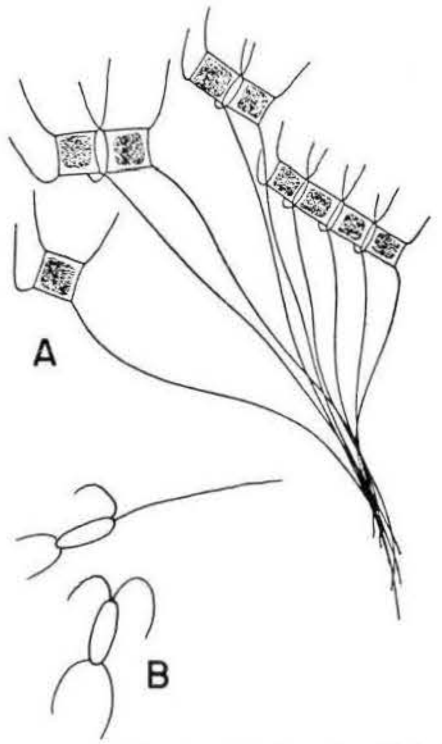


Fig. 63. *Chaetoceros socialis*. A. Part of colony. From Boden 1950. B. Cells in valve view. (Pers. comm. J. Priddle).

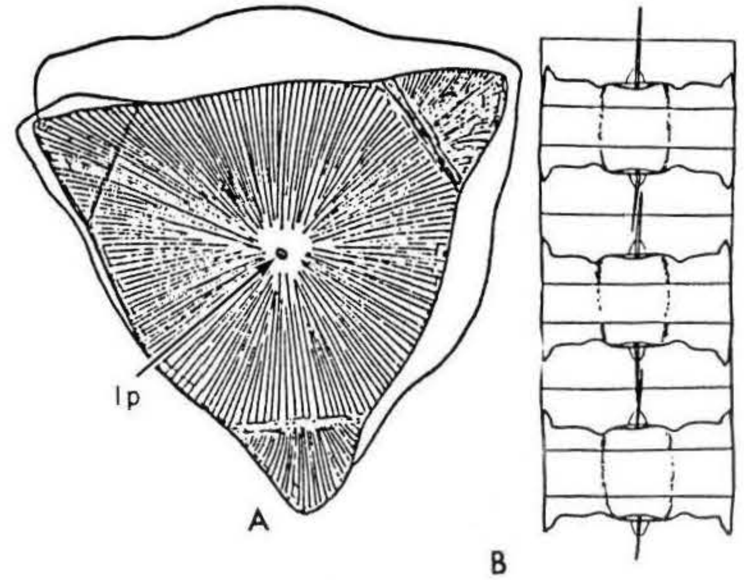


Fig. 65. *Lithodesmium undulatum*. A. Valve view with central labiate process (lp). From Cupp 1943. B. Chain in girdle view showing ridges. From Hustedt 1930.

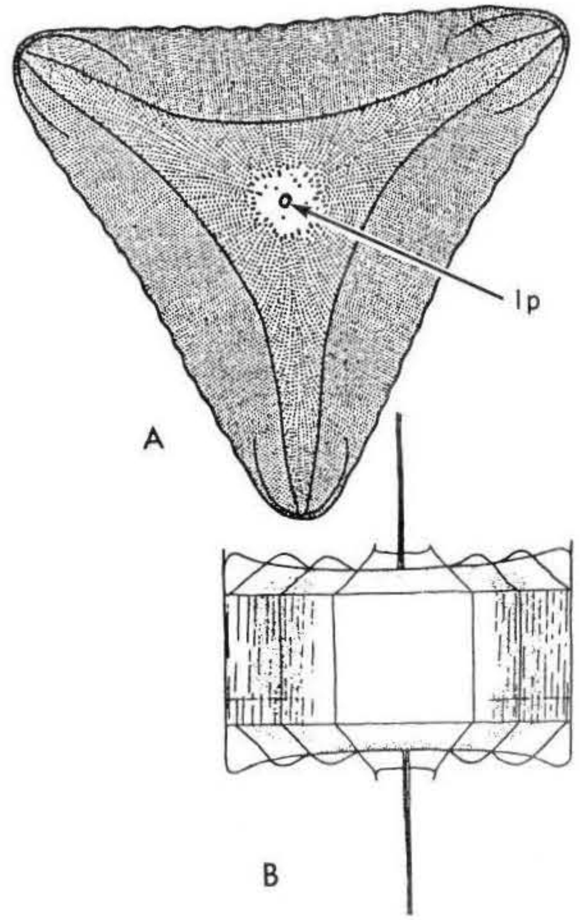


Fig. 64. *Ditylum sol*. A. Valve view showing areolation and central labiate process (lp). From Hustedt 1930. B. Girdle view with marginal ridges. From Hendey 1937.

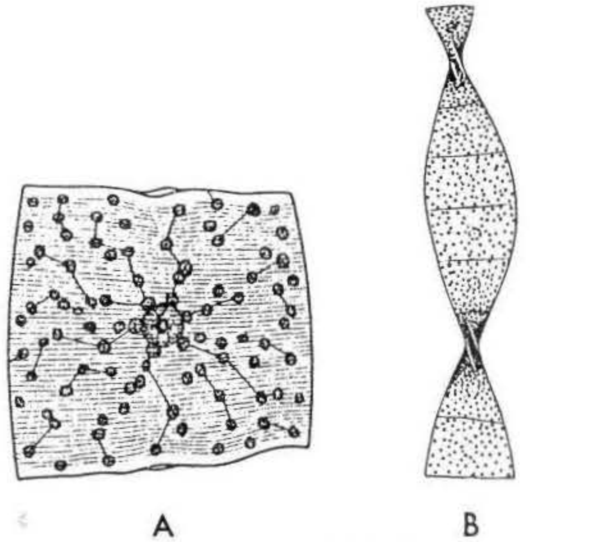


Fig. 66. *Streptotheca thamesis*. A. Cell in girdle view. B. Twisted chain of cells. From Van der Werff & Huls 1957-74.

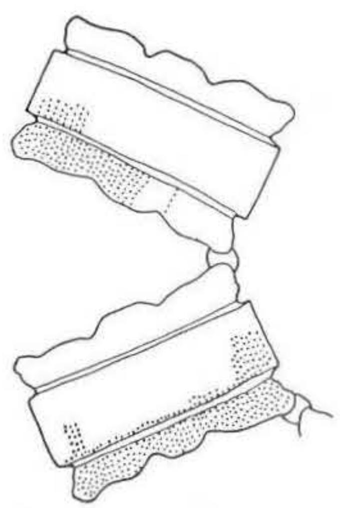


Fig. 67. *Odontella aurita* var. *obtusa*. Two cells in girdle view showing short elevations and areolation. From Cupp 1943 (as *Biddulphia aurita* var. *obtusa*).

Otherwise the general appearance of the type and variety would most certainly warrant recognition of two species. Apical axis 24-70 µm, pervalvar axis 124 µm.

Littoral, temperate species. We found it at one station in Subantarctic waters.

SEM reference: 59.

Fig. 68. *Odontella longicruris* Greville

Cells zygomorphic with long elevations at each pole. A deep concavity on valve mantle at base of each elevation. In girdle view valves show a median conical swelling bearing usually two (sometimes one or three) long labiate processes. These project obliquely upward and extend past, on either side, of the adjacent valve of the neighboring cell. The valve is minutely, irregularly areolated. Chains of 4-20 cells probably united by mucus from the elevations. Apical axis 15-110 µm, transapical axis about 20 µm.

Neritic in temperate and tropical seas. It occurred in our material in temperate waters between the Subtropical Convergence and the Subantarctic Front.

SEM reference: 59.

Fig. 69. *Odontella regia* (Schultze) Simonsen
Biddulphia regia (Schultze) Ostenfeld

Cells similar to, and often confused with, *O. mobiliensis* and regarded by some as synonymous. Flat median swelling of valve much smaller than surrounding depressions. Bipolar elevations rounded and labiate processes closely spaced. Processes first diverge then curve inward. Apical axis 60-180 µm, transapical axis 45-157 µm.

Neritic, truly planktonic. We found it at three interisland stations in subantarctic waters.

PENNALES

ARAPHIDINEAE

Diatomaceae Dumortier

Genus: ASTERIONELLA Hassal ex Smith

Cells rod-like at one end, with a triangular, clavate head at the other. United at the head end into spiral, star-shaped colonies. Linear in girdle view, sometimes constricted in pervalvar axis. Transapically striate, with narrow median axial area.

Fig. 70. *Asterionella glacialis* (Castracane) Korner
A. japonica Cleve & Moeller ex Gran

Cells in girdle view very narrow, linear, with parallel sides and enlarged, triangular, club-shaped head; apical pore-fields with narrow slits and lamellae. The narrow head pole has a labiate process visible as a hole. Cells united at enlarged basal end to form stellate spiral colonies. Apical axis 50-100 µm, pervalvar axis (enlarged part) 8-12 µm. Delicate transapical striae 34 in 10 µm.

Usually neritic, temperate form in all seas. We found it in the temperate waters south of the Subtropical Convergence.

SEM References: 27, 42, 59.

Genus: DELPHINEIS Andrews

Valves elongate-rectangular in girdle view, linear-elliptical in valve view. Cells solitary or in chains. Transverse striae formed by grooves across hyaline axial area. Finer striae, reduced in size, continue radially around the apices. Raised interstriae terminate in small processes between flat outer surface and edge of valve. A labiate process and two small pores at each apex. The labiate processes on the valve are diagonally situated across the apical axis.

Fig. 71. *Delphineis karstenii* (Boden) Fryxell
Fragilaria capensis Karsten non *F. capensis* Grunow
F. karstenii Boden

Cells rectangular in girdle view, linear-elliptical in valve view, rounded apices, slight inflation in centre. United by valve surfaces to form long chains or ribbons. Areolae in rows of two or three at margin, 8 - 9 in 10 µm. Marginal, dentate spines at ends of interstriae. No apical pore field; two small pores next to apical, labiate process, which is internally double. Areolate striae continue around apices. Polar labiate processes usually on opposite sides of apical axis. Apical axis 27-85 µm, pervalvar axis 6-7 µm.

An important constituent of the Benguela Current upwelling system (Hart & Currie, 1960; Shannon & Pillar, 1986) and is inferred to be a coastal species. In our material it appeared in the Agulhas Retroflection and Return Current and also in Subantarctic waters south of the Subantarctic Front.

SEM References: 1, 14.

Genus: FRAGILARIA Lyngbye

Cells rectangular in girdle view, sometimes widened in central part. Valves linear-lanceolate to elliptical in outline. Intercalary bands present in some species. Cell wall with delicate, punctate striae. No raphe, and axial area (when present) is narrow to very wide. Clear central area. Species colonial, adhering by valve surfaces to form flat, ribbon-like bands. Resting spores in some species. Distribution mainly littoral, sometimes oceanic or associated with melting ice.

Fig. 72. *Fragilaria granulata* Karsten

Cells united by valve surfaces to form short (4-12 cells) chains, which are curved like a horse-shoe. Valves linear-lanceolate to elliptical in outline, surface weakly convex, numerous transapical striae. Girdle simple. Apical axis 40-56 µm.

Probably coastal. Common in warmer waters around South Africa (Hendey, 1937). In our material it occurred at two stations in the Agulhas Return Current.

Genus: GRAMMATOPHORA Ehrenberg

Cells rectangular in girdle view with rounded corners. United at corners of adjacent cells into zig-zag or stellate colonies. Valves linear to elliptical in outline. Intercalary bands with two polar, undulating septa reaching well toward cell centre but leaving a central window in the band. Short, narrow axial area on both valves. Parallel and oblique punctate striae. Polar labiate processes (mucilage pores) extrude gelatinous threads.

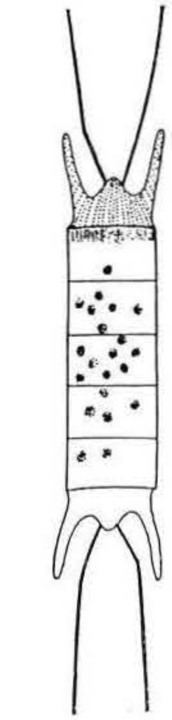


Fig. 68. *Odontella longicruris*. Girdle view of single cell; long elevations and labiate process extensions. From Boden 1950 (as *Biddulphia longicruris*).

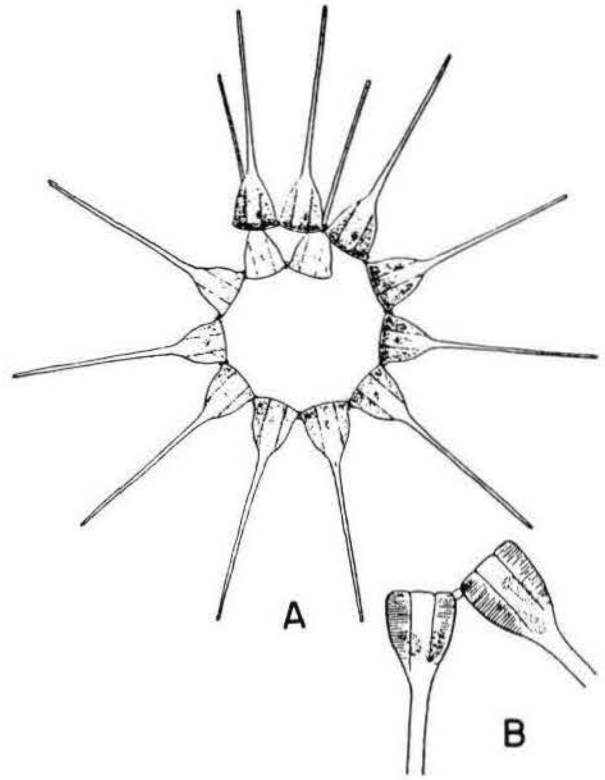


Fig. 70. *Asterionella glacialis*. A. Cells in spiral colony, girdle view. From Hendey 1937 (as *A. japonica*). B. Heads of two cells in girdle view. From Boden 1950 (as *A. japonica*).

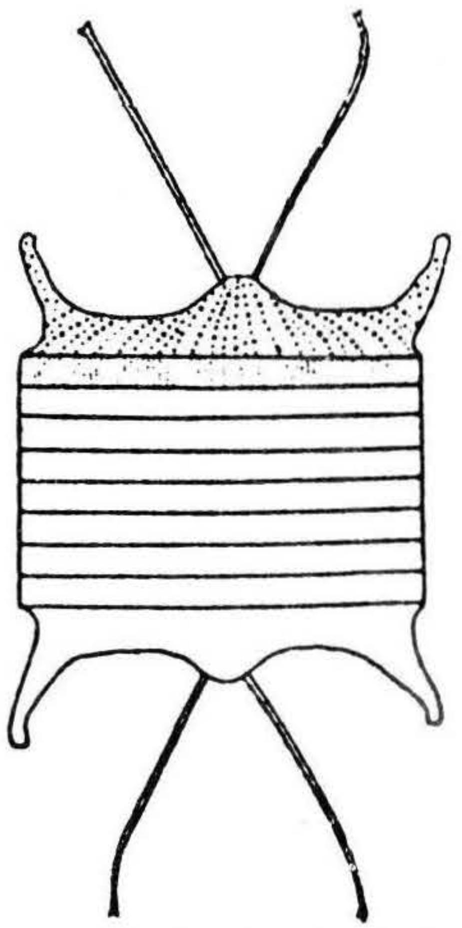


Fig. 69. *Odontella regia*. Girdle view. Blunt elevations and long diverging labiate processes. From Boden 1950 (as *Biddulphia regia*).

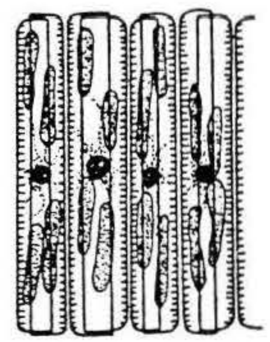


Fig. 71. *Delphineis karstenii*. Four cells in girdle view. From Karsten 1905a (as *Fragilaria capensis*).

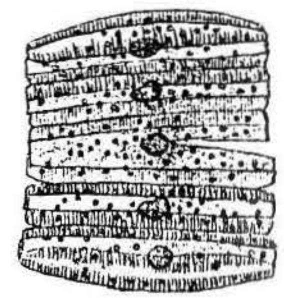


Fig. 72. *Fragilaria granulata*. Colony in girdle view. After Karsten 1907.

Fig. 73. *Grammatophora marina* (Lyngbye) Kützing
Diatoma marinum Lyngbye

Cells rectangular in girdle view. Valves linear with broadly rounded ends and slight transapical widening in the middle. Septa of intercalary bands flat with single undulation near polar base. Pseudosepta of valve mantle short. Short rows of striae between valve mantle and band. Punctate striae in quincunx on valve surface, striae 20-22 in 10 μm. Axial area narrow. Small hyaline polar areas. Apical labiate process present in only one valve of cell. Apical axis 30-82 μm, transapical axis 5-10 μm.

Cosmopolitan, littoral but not infrequent in the plankton. We found it at one station in the Agulhas Current.

SEM Reference: 27.

Fig. 74. *Grammatophora oceanica* Ehrenberg

Cells similar to *G. marina* in girdle view. Valves narrow, linear to linear-lanceolate with blunt-rounded ends in outline. Septa of intercalary bands with single basal undulation, then flat, reaching well toward cell centre. Valve mantle with short pseudosepta. Punctate striae in quincunx. Striae 21-23 in 10 μm. Axial area very narrow. Clear polar areas small. Labiate process present on one valve. Apical axis 40-75 μm, transapical axis 4-6 μm.

Cosmopolitan. Usually littoral but frequently oceanic. In our material it occurred at one station south of the Subtropical Convergence.

Genus: RHABDONEMA Kützing

Cells quadrangular in girdle view, united in chains. Girdle strongly developed with numerous internal septa and closed intercalary bands. Valves linear to elliptical. Transapical punctate striae and thickened interstriae. Axial area narrow, straight..

Fig. 75. *Rhabdonema adriaticum* Kützing

Cells quadrangular in girdle view, joined by valve surfaces to form ribbon-like bands. Valves linear-lanceolate in outline with rounded, slightly inflated, clear apices. Girdle well developed with curved internal septa slightly thickened toward cell centre. Copulae and pleurae closed. Axial area narrow, linear. Transapical axis 10-15 μm, striae 8 in 10 μm.

Cosmopolitan, usually benthic form occurring not infrequently in the plankton in warmer waters. In our collection it occurred, probably as a visitor, at one station south of the Subantarctic Front.

Genus: STRIATELLA Agardh

Cells rectangular in girdle view, tabulate. United by valve surfaces to form bands, or at alternate apices to form zig-zag chains. Terminal cells sometimes stipitate for attachment to a substrate. Copulae numerous, open at one end and closed at the other with marginally thickened long or short septa. Marginal thickening alternate in adjacent intercalary bands. Bands with parallel, punctate, longitudinal striae. Valves lanceolate with narrow axial area and oblique, punctate striae. Cell wall weakly silicified.

Fig. 76. *Striatella delicatula* (Kützing) Grunow
Hyalina delicatula Kützing

Cells rectangular in girdle view, tabulate. Pervalvar axis often longer than apical axis. Intercalary bands numerous, 12-14 in 10 μm. Septa marginally thickened and short, 6-7 in 10 μm. Valves linear to linear-lanceolate, apices blunt-rounded. Axial area straight. Delicate, parallel transapical striae, 25-32 in 10 μm. Apical axis 7-12 μm; transapical axis 1.5-3.5 μm.

Cosmopolitan, mostly littoral, form but also tychoplanktonic. Common in the plankton. We report it from one station in the Agulhas Retroflection and three stations over the interisland shoal.

Genus: SYNEDRA Ehrenberg

Cells solitary, sometimes united in short bands or stellate colonies. Usually long apical axis, rod-like to arcuate. In valve view varies from linear, to narrow lanceolate, to elliptical with inflated central portion, to elongate-rectangular with inflated central section and inflated apices. Valves may be undulate. Girdle narrow and linear with no bands or septa. Valve has narrow axial area and transapical, punctate striae. One end, sometimes both, has a labiate process. Marine *Synedra* are usually benthic but are frequently found in the plankton.

Fig. 77. *Synedra indica* Taylor

Cells solitary, small, inflated at the centre and sometimes at the apices. Narrow, zig-zag or longitudinal axial area and faint longitudinal striae. Transapical punctate striae, 20-24 in 10 μm. Girdle view apparently narrowly rectangular - difficult to see. Striae not visible in this view. Apical axis 8-23 μm, transapical axis 1.5-3 μm.

Occurs in moderate numbers in subtropical and temperate seas. It occurred at one station in the Subtropical Convergence in our material.

Genus: THALASSIONEMA Grunow ex Hustedt

Long needle-like cells forming zig-zag bands or stellate colonies. Linear in girdle view, narrow linear-lanceolate in valve view; sometimes heteropolar. Single apical spine may be present. Marginal areolae appear as row of open depressions; no complex vela. Small external opening of labiate processes at each pole. Axial area and girdle bands without areolation.

Fig. 78. *Thalassionema frauenfeldii* (Grunow) Hallegraeff
Asterionella frauenfeldii Grunow,
Thalassiothrix frauenfeldii Grunow

Cells united in zig-zag bands or stellate colonies by mucus pads. Linear in girdle view, narrow-linear in valve view. Apices slightly dissimilar, one bluntly rounded, the other tapered, wedge-shaped. The pole without a mucus pad has an arrowhead-shaped spine at the location of the labiate process: the other has a circular hole. Small, marginal areolae with spinulae, 6-9 in 10 μm. Under SEM these appear as depressions with silica arches (Hasle & Mendiola, 1967)*. Apical axis 20-210 μm; transapical axis 2-4 μm. Accurate identification of separated, single cells of this species is difficult. See note under *T. nitzschioides*.

Oceanic, common in south, temperate seas. It occurred throughout the subtropical and temperate zones on the western side only of our survey area.

SEM References: 17, 33.

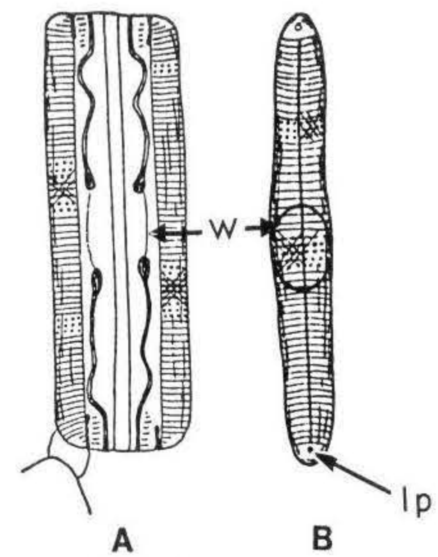


Fig. 73. *Grammatophora marina*. A. Broad girdle view showing internal septa. B. Valve view showing striae, apical pore fields with single labiate process (lp) and window (w) in intercalary bands. After Cupp 1943.

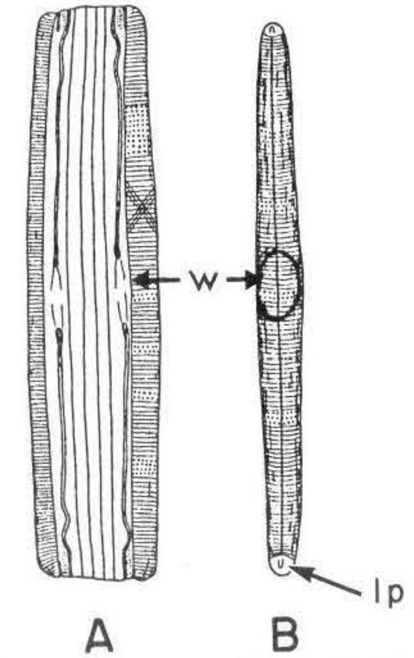


Fig. 74. *Grammatophora oceanica*. A. Broad girdle view. B. Valve view showing striae, apical pore fields with single labiate process (lp) and window (w) in intercalary bands. After Cupp 1943.

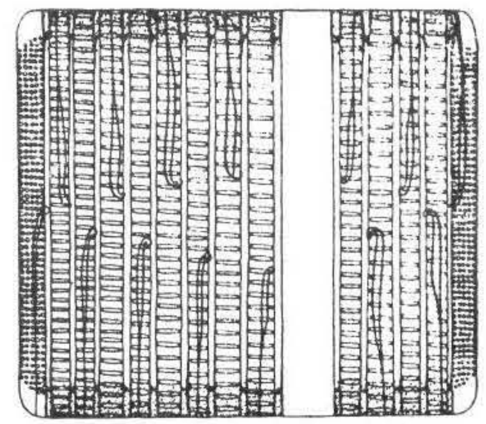


Fig. 75. *Rhabdonema adriaticum*. Single cell in girdle view showing internal septa and complex copulae and pleurae. From Hendey 1937.

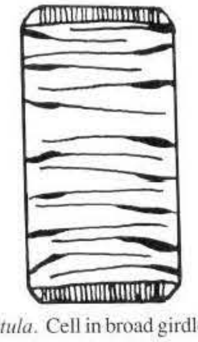


Fig. 76. *Striatella delicatula*. Cell in broad girdle view showing septa and numerous intercalary bands. From Cupp 1943.

Fig. 77. *Synedra indica*. Single cell, valve view. From Taylor 1967.

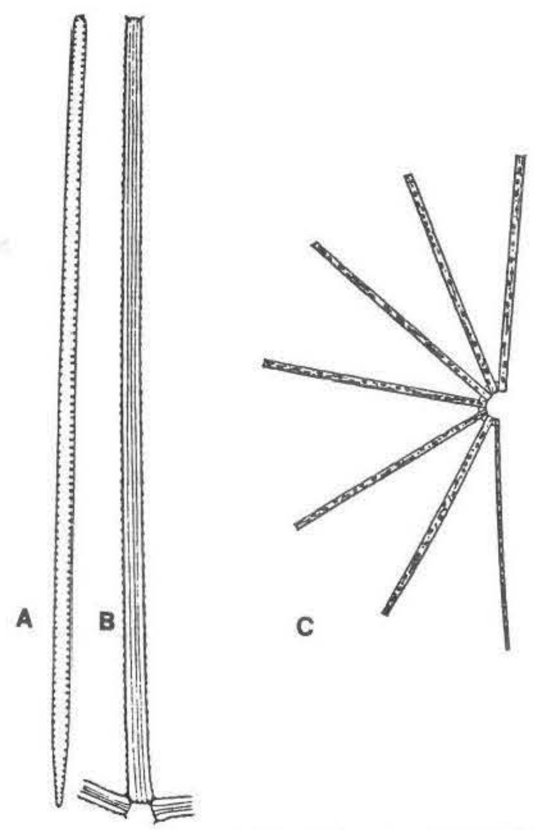


Fig. 78. *Thalassionema frauenfeldii*. A. Valve view. B. Girdle view with cell ends joined. From Hustedt 1959 (as *Thalassiothrix frauenfeldii*). C. Stellate colony of 7 cells. From Cupp 1943 (as *Thalassiothrix frauenfeldii*).

Fig. 79. *Thalassionema nitzschioides* Grunow
Synedra nitzschioides Grunow

Cells in girdle view narrow-linear with blunt isopolar ends, often slightly curved, united in stellate or zig-zag colonies. Narrow-linear in valve view with blunt-rounded ends and usually with apical spines. Axial area without perforations. Marginal areolae with spinulae 10-12 in 10 µm. Apical labiate processes at each end appearing as small holes on the valve. Apical axis 30-80 µm; transapical axis 2-3.5 µm. Note: Distinguished from *T. frauenfeldii* under LM by shorter length, narrower areolae spacing and more delicate structure.

Pelagic, common in temperate seas. It occurred in our study area in both the Atlantic and Indian Ocean sides throughout the subtropical and temperate zones and also at two stations in the subantarctic waters.

SEM References: 17, 27, 33, 53, 59.

Genus: THALASSIOTHRIX Cleve & Grunow

Long needle-like cells solitary or united in zig-zag bands, star-shaped colonies, or bunches. Narrow-linear in girdle view; linear to slightly lanceolate in valve view. Large labiate processes open externally via a small circular hole at each pole. Heteropolarity, torsion and presence of spines variable. Areolae closed by complex reticulate vela. Axial area and girdle bands without areolation.

Fig. 80. *Thalassiothrix heteromorpha* (Karsten) Hallegraeff
T. delicatula Cupp

Cells solitary or temporarily united after division. Cells very narrow, inflated slightly at apices and central part. One apex wider than the other and truncated, with spinulae at the corners. The other end is slightly inflated but tapered. Cell twists through 180 degrees. Valve and mantle delicately striated with parallel, punctate striae, 19-24 in 10 µm. Labiate process at each end appearing as circular opening. Apical axis 1120-1920 µm; transapical axis 3-4 µm at widest.

Temperate to tropical species. It occurred at two stations in our survey, one at the Subantarctic Front and one in the Agulhas Current.

SEM Reference: 17.

Fig. 81. *Thalassiothrix longissima* Cleve & Grunow
Synedra thalassiothrix Cleve

Cells single, thread-like and simply arcuate. Very narrow-linear in both valve and girdle view. Apices blunt, very slightly heteropolar, carrying variable small spines which are serrated protrusions. Valve margin with delicate spines, 2-3 in 10 µm at centre, fewer or missing at ends. Sometimes entire cell lacks marginal spines. Labiate process at each apex opening by small hole in valve. Apical axis 1-4 mm; transapical axis 3-6 µm. Cells often form dense, tangled masses that clog collecting nets. Under such circumstances they are often associated with *Trichotoxon reinboldii*.

Oceanic and widespread in the colder waters of both hemispheres. It occurred at nearly every station in our study area from the subtropical Agulhas waters to the subantarctic, neritic stations between the islands.

SEM References: 17, 27, 33, 53.

Fig. 82. *Thalassiothrix longissima* var. *antarctica* Grunow ex Van Heurck *T. antarctica* Schimper ex Karsten,
T. antarctica var. *echinata* Karsten

Cells linear, very long, usually sigmoid forming colonies by attachment of valve ends. Valves with parallel sides and rounded apices. Valve margin with delicate spines (1-2 in 10 µm) in the middle of the striae (12-17 in 10 µm). Axial area wide in the middle of the cell. One pole spoonlike and rounded without spines; the other with heavy spines. External openings of labiate processes at each pole. Apical axis 1-5 mm; transapical axis 3-4 µm. Very similar to *T. longissima* with which it is frequently associated in dense masses. Main difference is in curvature of frustule, shape of cell ends and presence or absence of apical spines (protrusions) (Hasle and Semina (1987)*).

SEM References: 17, 27, 33, 53.

Fig. 83. *Trichotoxon reinboldii* (van Heurck) Reid & Round
Synedra spathulata Schimper ex Karsten, *Synedra pelagica* Hendey, *Synedra reinboldii* van Heurck

Cells very long, linear, arcuate with expanded central area and isopolar apices. Apical labiate process visible at each end. Cells solitary or colonial, united at one or both ends by mucilage presumably secreted through the processes. Apical axis 800-3500 µm; transapical, midsection 5-8 µm, ends 3.5-6.6 µm. Transapical areolate striae, areolae occluded by cribra.

The species is generally accepted as endemic to the Southern Ocean but is quite widespread, if rare, in other regions. Beklemishev (1964) reports it from the Benguela system, which he considers to be a "transplantation area" where species are carried by currents from their true centres of distribution at higher latitudes. That our material contains this taxon at stations ranging from the subtropical Agulhas Current to the subantarctic waters south of the Subantarctic Front is, therefore, not surprising when the hydrological regime of the region is considered (Boden *et* al 1988).

SEM References: 53, 47.

RAPHIDINEAE

Achnanthaceae Kützing

Genus: ACHNANTHES Bory

Cells solitary or united at valve surfaces into ribbon-like chains. Some species stipitate, epiphytic. Usually littoral, seldom pelagic. Valves linear-lanceolate to elliptical. Rectangular in girdle view with a broad concavity at the transapical axis in the epivalve and a corresponding convexity of the hypovalve. Epivalve has a true raphe, hypovalve an axial area. Punctate, parallel striae, sometimes with siliceous interstriae or whole cell wall areolated.

Fig. 84. *Achnanthes longipes* Agardh

Valves linear-lanceolate with tapered ends, to elliptical with broad rounded ends. Cells strongly curved in girdle view. Hypovalve with a very narrow axial area and no central area. Epivalve has a threadlike, slightly curved raphe with a central nodule and very narrow stauros reaching to the margin. The stipe is attached to the raphe valve in the apical area of the raphe. Both valves have parallel

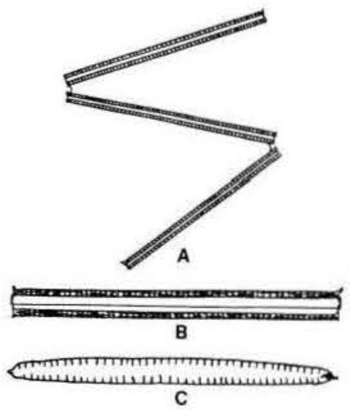


Fig. 79. *Thalassionema nitzschioides*. A. Zig-zag colony in girdle view. B. Single cell in girdle view. C. Single cell in valve view. After Boden 1950.

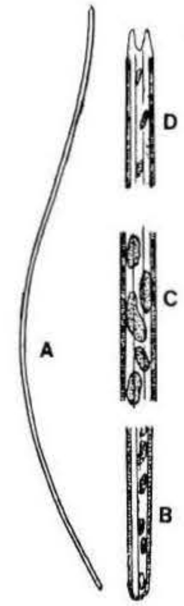


Fig. 82. *Thalassiothrix longissima* var. *antarctica*. A. Entire cell. B. Rounded end of cell, valve view. C. Midsection, valve view. D. Spinose end of cell, girdle view. After Karsten 1905a

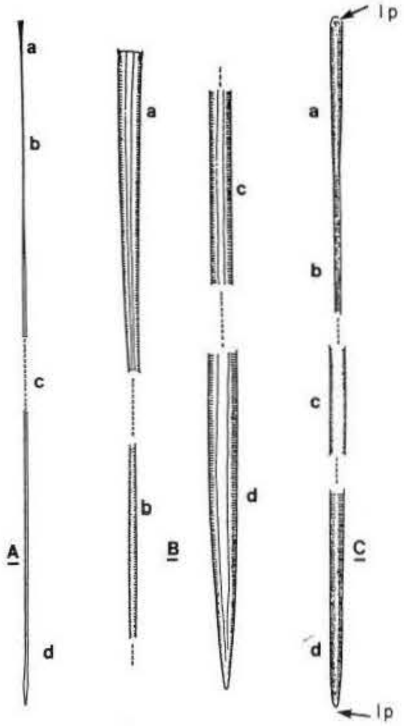


Fig. 80. *Thalassiothrix heteromorpha*. A. Whole cell, cell ends (a,d) in girdle view, narrow part (b) in valve view. B. Details of sections in A. C. Sections of same cell rotated so that ends are in valve view, centre in girdle view. Opening of labiate processes (lp). From Cupp 1943 (as *T. delicatula*).

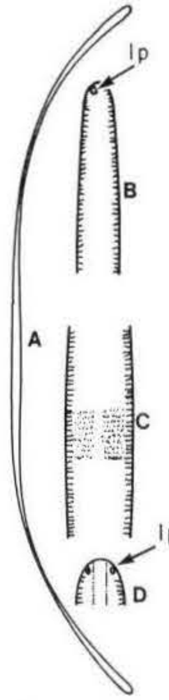


Fig. 83 *Trichotoxon reinboldii*. A. Entire bow-shaped cell. B. End of cell in valve view. C. Mid-section. D. End of cell in girdle view. Position of labiate process (lp). From Reid & Round 1987*.

Fig. 81. *Thalassiothrix longissima*. A. Entire cell. B. Spinose end of cell, valve view. C. End of cell, girdle view. From Boden 1950.

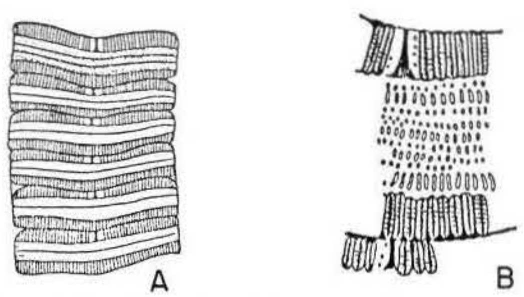


Fig. 84. *Achnanthes longipes*. A. Several cells, joined at valve surface, forming a ribbon. B. Detail of central part of one cell, girdle view. After Cupp 1943

striae of two (sometimes four) rows of fine areolae, 10-12 in 10 µm, and prominent, strong interstriae becoming slightly radial near the poles, 6-8 in 10 µm. There is no apical pore-field. Apical axis 60-100 µm; transapical axis 10-30 in 10 µm.

This is a stipitate form usually epiphytic on littoral macro-algae. However, it is also common in the oceanic, temperate plankton and must be considered meroplanktonic. We found it at four oceanic stations in, or close to, the Subtropical Convergence.

SEM Reference: 27.

Naviculaceae Kützing

Genus: MASTOGLOIA Thwaites ex W. Smith

Cells rectangular in girdle view; linear-lanceolate, elliptic-lanceolate to rhombic-lanceolate in valve view. Raphe straight or undulate. Areolate-punctate to areolate-loculate striae in parallel to decussate array. Marginal septum, usually divided into compartments visible in valve view as a number of loculi around the valve margin. Cells usually embedded in mucus, attached to macro-algae, or sometimes free.

Fig. 85. *Mastogloia woodiana* Taylor, *M. capitata* (Brun) Cleve non *M. capitata* Greville, *M. brunii* (Brun) Wood non *M. brunii* A. Schmidt

Valves elliptic-lanceolate in outline, widening slightly before tapering to rostrate apices. Raphe straight with small central nodule. Axial area very narrow and central area barely distinguishable. Parallel striae of loculate areolae reaching margins - 36 in 10 µm. Marginal septa with two chambers at mid-margin, not reaching central area.

Apical axis 30-35 µm, transapical axis 7 µm.

Genus: HASLEA Simonsen
Navicula auct. nonn., *Stauroneis* Cleve ex parte

Cells in valve view lanceolate with convex sides (rarely parallel in middle) and acute apices. Inconspicuous axial and central areas. Raphe straight with central and apical nodules. Striae transverse and longitudinal. Areolae poroid with a slit in longitudinal direction. Simonsen (1974) interprets *Haslea* as a link between *Navicula* and the genera *Gyrosigma* and *Pleurosigma*.

Fig. 86. *Haslea gigantea* (Hustedt) Simonsen
Navicula gigantea Hustedt

Valves lanceolate in outline, apices acutely rounded. Raphe straight, axial area very narrow, central area lacking. Delicate striae parallel and longitudinal. Parallel striae about 16-17 in 10 µm, decussate longitudinal striae 23-24 in 10 µm. Apical axis 300-400 µm, transapical axis 32-48 µm.

Taylor (1967) considers this to be an Indo-Pacific, tropical, oceanic species. However, it has also been reported from lower latitudes of the Atlantic and in neritic conditions. We report it from the temperate waters between the Subtropical Convergence and the Subantarctic Front. It is, therefore, apparently quite cosmopolitan.

Genus: NAVICULA Bory

In benthic species cells usually free, feebly motile, but in planktonic forms they unite into ribbon-like chains. Valves linear-lanceolate to elliptical in outline, with rounded to capitate or rostrate ends. Each valve has a raphe and central nodule, no keel. Clear axial and central areas. Fine to coarsely punctate striae in parallel or radiate arrangement. Paddock (1986)* considers *Navicula* to be a heterogeneous group which includes many potentially separable genera.

Fig. 87. *Navicula distans* (W. Smith) Ralfs
Pinnularia distans W. Smith

Cells solitary. Valves lanceolate-elliptical in outline with rounded ends. Coarse radiate striae separated by intercostae and crossed by finer, parallel striae. Distinct central area. Terminal nodules at ends of raphe. Rectangular in girdle view, slightly constricted in middle. Apical axis 100-120 µm, transapical axis 18-24 µm.

Usually littoral but occurs in the plankton. In our material it occurred commonly in the oceanic plankton, but only on the Atlantic side of the study area. It was also scattered throughout the interisland waters, occurring at stations that we regard as littoral or neritic.

Fig. 88. *Navicula pelagica* Cleve

Cells small, rod-shaped and united in short chains at valve centres by hair-like extrusions visible only under SEM (Paddock, 1986)*. They are joined so that the ends appear randomly oriented and do not form ribbons or spirals. Valves rectangular in girdle view, elliptical in valve view. Central raphe, no stauros. Areolae poroid with outer aperture round (SEM). Apical axis 15-25 µm, transapical axis 4-6 µm.

Generally regarded as a neritic, polar form. It occurred only once in our material in an oceanic station in the Agulhas Retroflection.

SEM Reference: 46.

Fig. 89. *Navicula schuettii* Van Heurck

Cell in valve view broadly lanceolate, subrhomboidal with subconical, obtuse apices. Prominent straight raphe, axial area narrow. Terminal nodules small but prominent; central nodules in small, rounded central area. Striae parallel to radiate from central area. Median interstriae wider than others. Apical axis 130-170 µm, transapical axis 40-45 µm.

Probably a rare, Antarctic form. We found it only once, just north of the Subantarctic Front.

Fig. 90. *Navicula triplex* Van Landingham
N. cristata M. Peragallo, *N. subpolaris* Hendey

Cells usually solitary. Valves narrowly linear-lanceolate in outline with tapering, rounded apices. Median raphe prominent, small central area with small terminal and central nodules. Valve surface with coarse, parallel striae, accentuated interstriae, and finer longitudinal striae. Fine lines, one on each side of the raphe, extend toward the apices. Apical axis about 90 µm, transapical axis 11 µm.

Characteristically Antarctic, usually associated with melting ice, but occasionally planktonic in warmer waters.

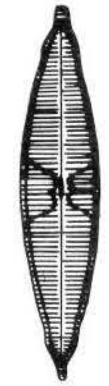


Fig. 85. *Mastogloia woodiana*. Valve view showing rostrate apices, parallel striae and two marginal chambers. After Taylor 1967.

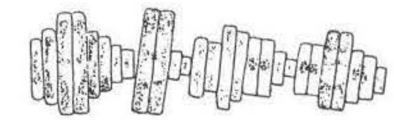


Fig. 88. *Navicula pelagica*. Colony of cells. From Hendey 1964.

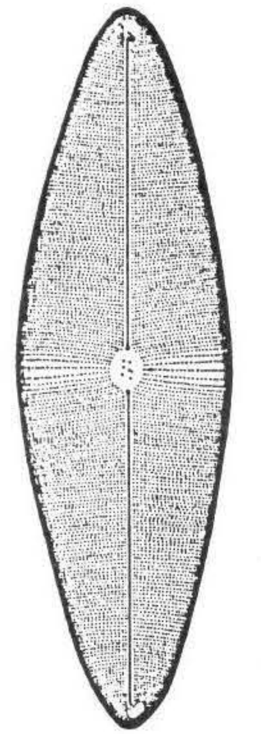


Fig. 89. *Navicula schuettii*. Valve view. From Van Heurck 1909.

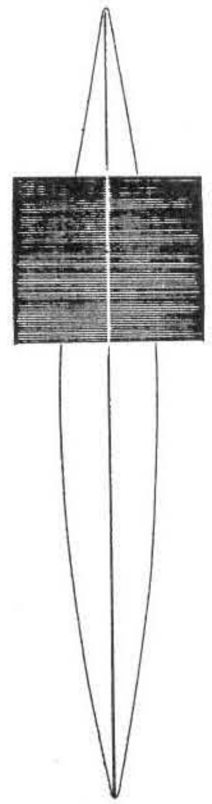


Fig. 86. *Haslea gigantea*. Valve view, part magnified to show striations. From Hustedt 1961-66 (as *Navicula gigantea*).

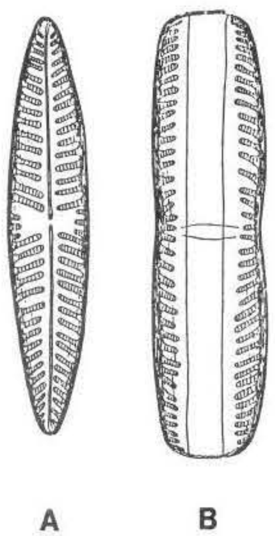


Fig. 87. *Navicula distans*. A. Valve view. B. Girdle view. From Cupp 1943.

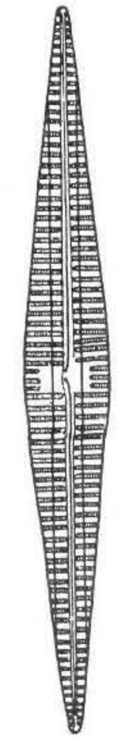


Fig. 90. *Navicula triplex*. Valve view. From Manguin 1954.

Genus: PLEUROSIGMA W. Smith

Cells solitary. In outline valves are linear- to elliptic- or rhombic-lanceolate, frequently sigmoid. Raphe straight to sigmoid, central or eccentric. Small central and terminal nodules. Axial and central areas inconspicuous. Delicately punctate striae in decussate pattern. Usually bottom or littoral species but not uncommon in the plankton.

There is historical confusion surrounding the genera *Pleurosigma* and *Gyrosigma*. Hendey (1937) concluded that the main grounds for separating the genera, the angles at which the striae intercrossed, were not worthy of generic distinction. Many modern authors retain the distinction, however.

Fig. 91. *Pleurosigma directum* Grunow ex Cleve & Grunow

Valves flat, lanceolate in outline with acute apices. Raphe distinct, straight to very slightly sigmoid, very small central and terminal nodules. Axial and central areas inconspicuous. Decussate, punctate striae, almost invisible under light microscope, about 20 in 10 µm, crossing at an angle of about 60 degrees. Apical axis 180-600 µm, transapical axis 35-45 µm.

Cosmopolitan, mainly circumpolar form but frequently found in temperate and warm waters. Not very common, it occurred in our collection at two subantarctic stations and one in the Agulhas Return Current.

Fig. 92. *Pleurosigma karstenii* Taylor
P. capense Karsten non *P. capense* Petit

Cells elliptic-lanceolate, straight to feebly sigmoid. Raphe marked but central and difficult to resolve under light microscope. Axial and central areas not visible. Decussate, punctate striae, about 20 in 10 µm, crossed by two lines running parallel with the raphe on either side. This is a notable characteristic of this species. Transapical axis about 320 µm.

A relatively rare form thought to be littoral in habit. We found it at seven oceanic stations in the temperate waters between the Subtropical Convergence and the Subantarctic Front, and at one, littoral, interisland station.

Genus: STAUROPSIS Meunier

Cells solitary or united in short, straight chains. Valves lanceolate in outline with radiate, punctate striae. Axial area narrow, central stauros. Girdle either a plain hyaline band or with several intercalary bands.

Fig. 93. *Stauropsis membranacea* (Cleve) Meunier
Navicula membranacea Cleve
Stauroneis membranacea (Cleve) Hustedt

Cells united at valve surface to form short, thick, ribbon-like chains. Elliptical-lanceolate in valve view, with inconspicuous axial area and narrow stauros; apices acute. Rectangular in girdle view, with several intercalary bands difficult to resolve under LM. Cell wall weakly siliceous. Apical axis 60-84 µm, transapical axis 30-40 µm.

This is the type species of the genus which includes several species that had been placed in *Navicula* or *Stauroneis* Paddock (1986)*.

SEM Reference: 46.

Genus: TROPIDONEIS Cleve

Valves naviculoid but very convex. Lanceolate-acute usually with hyaline wing or longitudinal band projecting above the central nodule on one or both sides, visible in girdle view. Raphe at edge of central or eccentric keel. Axial area inconspicuous or lacking. Central area small, sometimes transverse. Punctate striae parallel and longitudinal. (Navarro, 1982c) suggests the genus be re-named *Plagiotropis*.

Fig. 94. *Tropidoneis antarctica* var. *polyplasta* Gran & Angst

Valves elliptical or constricted at central nodule in girdle view, lanceolate in valve view. Keel median. Two or three rod-like, transverse thickenings on each side of central nodule. Small wing projecting above central nodule on only one valve. Cell wall thin, weakly siliceous. Parallel and longitudinal striae, 21-24 in 10 µm. Transapical axis 200-300 µm.

Neritic but occasionally found in oceanic plankton.

This variety was described by Gran & Angst (1931), with considerable reservations, as being related to *T. antarctica*. Cupp (1943) has described it from southern California and our specimens agree with her description. These are the only references we have found in the literature so far.

Nitzschiaceae Grunow

Genus: BACILLARIA Gmelin ex Linne

Cells rod-shaped, square in transapical section (narrow girdle view), united in moveable bands, each cell moving on adjacent cell. Entire colony motile.

Fig. 95. *Bacillaria paxillifer* (O.F. Müller) Hendey
Nitzschia paradoxa (Gmelin) Grunow ex Van Heurck
Bacillaria paradoxa Gmelin ex Linne

Cells form gliding colonies in which the cells slide along one another. Cells narrow-rectangular in girdle view, linear-lanceolate in valve view with produced, rounded apices. Raphe straight with no central nodule; keel slightly eccentric with 7-9 puncta in 10 µm. Parallel, punctate striae on valve surface, 20-21 in 10 µm. Apical axis 70-115 µm, transapical axis 5-6 µm.

Cosmopolitan, littoral species, sometimes planktonic. Notably euryhaline, found in marine and brackish waters, temperate to cold. It occurred in our material at one oceanic, subantarctic station.

SEM Reference: 59.

Genus: CYLINDROTHECA (Rabenhorst) Reimann & Lewin

Cells long, circular in transapical section. Central portion fusiform or cylindrical, extending to attenuate or capitate rostra. Cells often twisted about apical axis and one, or both, of the apices usually bent. Raphe frequently silicified. Its fissure may be interrupted centrally by the slight setting apart of the fibulae, resulting in the equivalent of a central nodule. The girdle has numerous intercalary bands, usually unperforated.

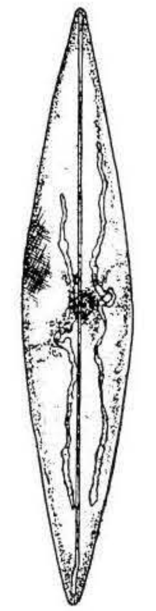


Fig. 91. *Pleurosigma directum*. Valve view, oblique striation. From Karsten 1905a.

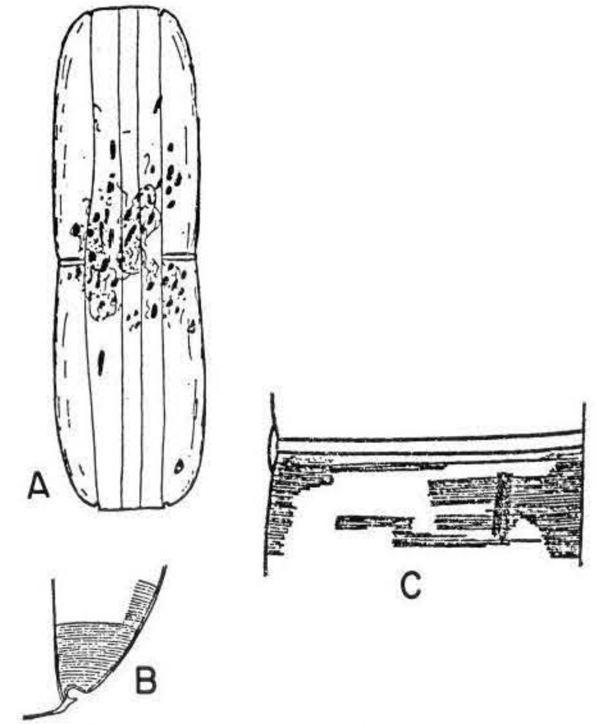


Fig. 94. *Tropidoneis antarctica* var. *polyplasta*. A. Girdle view. B. End of valve. C. Valve centre showing striae and single wing. From Cupp 1943.

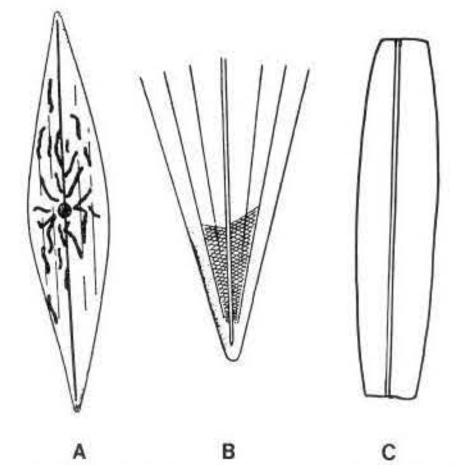


Fig. 92. *Pleurosigma karstenii*. A. Valve view. B. End of cell, valve view, enlarged to show striae. C. Outline of cell, girdle view. After Karsten 1905b.

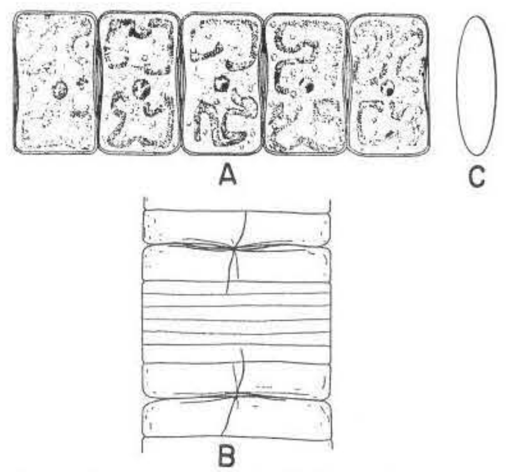


Fig. 93. *Stauropsis membranacea*. A. Chain of cells attached at valve, showing chromatophores. From Hendey 1937 (as *Navicula membranacea*). B. One complete cell in girdle view. From Cupp 1943 (as *Navicula membranacea*). C. Sketch of valve outline. Original.

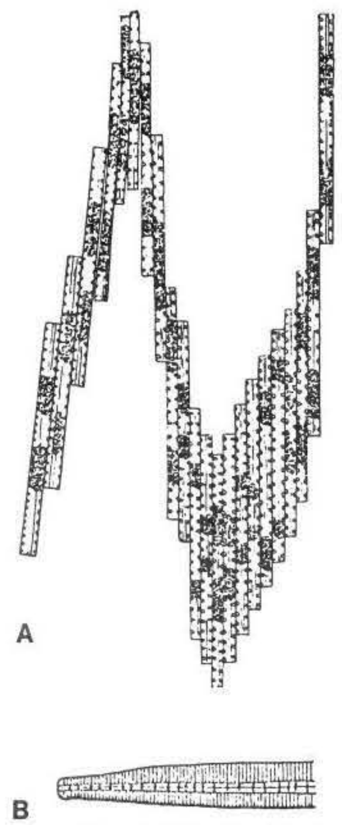


Fig. 95. *Bacillaria paxillifer*. A. Colony in girdle view, cells joined at valves. From Hendey 1937. B. Detail of valve view. After Cupp 1943 (as *Nitzschia paradoxa*).

Fig. 96. *Cylindrotheca closterium* (Ehrenberg) Reimann & Lewin
Ceratoneis closterium Ehrenberg
Nitzschia closterium (Ehrenberg) W. Smith

See generic description. Valves weakly silicified, with very faint parallel striae separated by more conspicuous interstriae. Raphe twisted or spiral, traversed by series of fibulae. Apical axis 28-180 µm, transapical axis 1.5-8 µm. The fusiform body and helical raphe result in a characteristic motility, whereby the cells revolve in their progress over a substrate.

Euryhaline, tolerating brackish to marine water. Cosmopolitan, littoral or planktonic. It was very common in our collection, occurring in scattered oceanic stations and at least five littoral, interisland stations.

The formal inclusion of *Nitzschia closterium* into the emended genus *Cylindrotheca* by Reimann & Lewin (1964) seems not to have been totally accepted: see Sournia (1968), Simonsen (1974), Hasle (1964)*.

SEM References: 19, 59.

Genus: NITZSCHIA Hassal

Cells fusiform, solitary or colonial. Valves keeled, with concealed raphe, central or eccentric. Keel puncta faint to distinct. Parallel, punctate striae. No central nodule.

Fig. 97. *Nitzschia bicapitata* Cleve

Cells solitary, very variable in outline. Valves elliptic-lanceolate, usually with expanded capitate apices; finely punctate, parallel striae about 26 in 10 µm. Keel very eccentric with puncta 13 in 10 µm. Apical axis 6-30 µm, transapical axis 3-5 µm.

Cosmopolitan and frequent in most oceans but rather infrequent in Arctic or Antarctic polar waters. We found it once in the Agulhas Return Current.

Fig. 98. *Nitzschia braarudii* Hasle

Cells solitary, lanceolate in valve view, gradually attenuated toward capitate apices. Keel strongly eccentric, keel puncta 10-14 in 10 µm, the two median puncta rather more widely spaced to form central nodule. Valves with parallel, punctate striae, 22-27 in 10 µm. Apical axis 35-63 µm, transapical axis 3.5-5 µm.

Usually littoral, cosmopolitan, more abundant and more heavily silicified in subantarctic waters than in equatorial waters. It occurred only once in our collection at an oceanic Agulhas Return Current station.

SEM Reference: 19.

Fig. 99. *Nitzschia kerguelensis* (O'Meara) Hasle
Fragilaria antarctica Castracane

The cells are sometimes solitary but more usually united at the valve surfaces to form straight, ribbon-like colonies. Valves flat to slightly convex, elliptic-lanceolate in valve view, with rounded apices. There is a basal siliceous layer with punctate striae arranged in two parallel rows. There are five to thirty, strong, transapical interstriae connecting with the valve margin. The girdle is heavily silicified. Apical axis 20-80 µm, transapical axis 6-14 µm.

One of the most common Antarctic diatoms. It occurred in our survey at three Subantarctic stations.

Fig. 100. *Nitzschia lineata* (Castracane) Hasle
Fragilaria linearis Castracane
Nitzschia castracanei Hasle

Cells linear, united at valve surfaces into ribbon-like colonies. Valves flat, with rounded apices and straight lateral margins. Valve surfaces with faint, punctate, parallel striae. Apical axis 50 µm, transapical axis 6-8 µm. Distinguishable by perfect linearity of valve margins.

Usually associated with melting ice, it was found, sparsely, throughout our study area.

Fig. 101. *Nitzschia ossiformis* (Taylor) Simonsen

Cells elongate rectangles united into loose chains by mucilage pads, extruded by apical labiate processes. Valves inflated at centre and apices. Apical widenings have a slight but definite concavity such that they resemble the head of a bone. Central nodule and keel raphe visible on LM. Transapical striae 24-26 in 10 µm. The striae can usually be resolved only in a high refractive-index mountant but the cells are readily recognizable by their characteristic shape. Apical axis 58-73 µm, transapical axis 3-4 µm.

Taylor (1967) considers that it is likely that the species is an oceanic Subantarctic form but Simonsen (1974) cites a wider distribution. It occurred in our material at only one station in the Agulhas Retroflection where it had possibly been advected by an Atlantic water admixture.

Fig. 102. *Nitzschia pelagica* Karsten

Cells large, elliptic-lanceolate with acute apices. Distinct central raphe. Very fine, parallel, punctate striae, about 25 in 10 µm. Median keel with 15-18 keel puncta in 10 µm. Simple, deep girdle band. Apical axis 70-270 µm, transapical axis 22-40 µm.

Probably littoral, it is abundant in Antarctic waters. It occurred once in our material just north of the Subantarctic Front.

Genus: PSEUDOEUNOTIA Grunow

Cells united by valve surfaces into bands like the staves of a barrel. Cells linear in ventral girdle view, slightly convex in dorsal view. In outline the valve has one straight margin and the other is convex. Valve surface with fine parallel, areolate striae. Monospecific genus.

Fig. 103. *Pseudoeunotia doliolus* (Wallich) Grunow
Synedra doliolus Wallich

Colony formation, valve and girdle view as described for genus. Apical axis 40-60 µm, transapical axis 6-8 µm.

Littoral and neritic species. Occurs in plankton. Moderately abundant in warmer seas. It occurred quite frequently in the subtropical and temperate zones of our survey.

SEM Reference: 24.

Fig. 104. *Pseudonitzschia* group

Recent studies of the genus *Nitzschia* by Hasle (1964*, 1965a*,b*, 1972, 1972b*) have shown that many past identifications in this section of the family should be reassessed. In general cells are sharply pointed and fusiform, united in stiff chains by overlapping

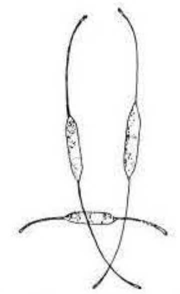


Fig. 96. *Cylindrotheca closterium*. Cells in valve view. From Hendey 1937 (as *Nitzschia closterium*).

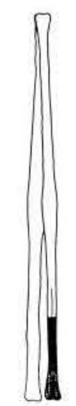


Fig. 101. *Nitzschia ossiformis*. Pair of cells, valve view. After Taylor 1967.

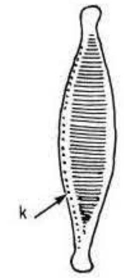


Fig. 97. *Nitzschia bicapitata*. Single cell showing keel (k) and capitate ends. Original.

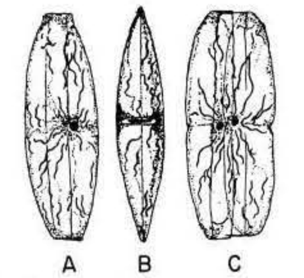


Fig. 102. *Nitzschia pelagica*. A. Valve view. B. Girdle view. C. Cell dividing. From Karsten 1905a.

Fig. 98. *Nitzschia braarudii*. Single cell. Arrow indicates central nodule. From Taylor 1967.

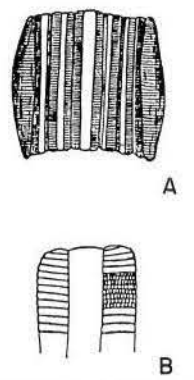
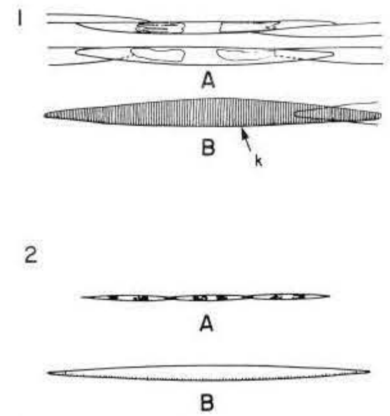


Fig. 103. *Pseudoeunotia doliolus*. A. Colony of cells joined at valves showing curvature. B. End of cell in girdle view. From Cupp 1943.

Fig. 99. *Nitzschia kerguelensis*. A. Cell in valve view, coarse striation. B. Girdle view. From Hendey 1937 (as Fragilariopsis antarctica).



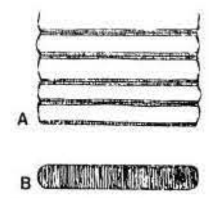


Fig. 100. *Nitzschia lineata*. A. Four cells from long chain joined at valves. B. Valve view. After Castracane 1886 (as Fragilaria linearis).

Fig. 104. *Pseudonitzschia* group. 1. *Nitzschia seriata* type. A. overlapping cells. B. Cells showing keel puncta (k) and striae. From Hasle 1965a*. 2. *Nitzschia delicatissima* type. A. Slender overlapping cells. B. Cell with faint striae. After Boden 1950.

ends. Morphological characters used in identification are shape and structure of the valve, symmetry, length to width proportion, presence or absence of a central nodule, number of keel puncta and transapical costae. Two complexes have been recognized.

1) *Nitzschia seriata* complex (Fig. 104-1). This has been loosely applied to *Nitzschia* species in which relatively large robust cells overlap to form chains. A central nodule is usually absent and there are an equal number of keel puncta and transapical costa. *N. seriata sens. str.* according to Hasle (1965a)*, has limited distribution in the northern hemisphere and forms in other locations may be related species.

2) *Nitzschia delicatissima* complex (Fig. 104-2). This has been widely recorded. The more delicate cells overlap to form stiff chains and a central nodule is usually present. The valve view is necessary to distinguish them from the *N. seriata* complex. Hasle (1965b)* no longer recognizes *N. delicatissima* as a valid taxon. It probably includes such taxa as *N. turgidula* Hustedt, *N. prolongatoides* Hasle, *N. actydrophila* Hasle, *N. delicatula* Hasle, all of which have a central nodule and more than one transapical costa per keel puncta.

SEM References: 19, 20, 21, 24.

Acknowledgements.

This work was sponsored by the South African Scientific Committee for Antarctic Research of the CSIR and its support is gratefully acknowledged. We thank the Captains and crews of the *SA Agulhas*, the R.V. *Knorr* and the R.V. *Thomas Washington* for their assistance at sea and Dr. J. Luyten, Woods Hole Oceanographic Institute U.S.A., who invited us to participate in the cruises Marathon I and II.

Permission to reproduce figures from their works was freely given by : G. Fryxell, G. Hallegraeff, G. Hasle, E. Manguin, R. Norris, J. Priddle, F. Round, A. Sournia, F. Taylor, A. Van der Werff.

Dr. A. Archibald, National Institute for Water Research, and Dr. R. Norris, Compton Herbarium, U.C.T., settled many taxonomic questions. Dr. B. Mitchell-Innes and Mr. I. Kruger, Sea Fisheries Research Institute, researched much of the classical literature. Dr. C. Lange, S.I.O., was especially helpful with the SEM literature search and with advice on new developments in the field. Dr. G.A. Fryxell gave valuable scientific advice.

The original manuscript was meticulously edited by Dr. J. Priddle, British Antarctic Survey, U.K., and two anonymous referees and subjected to the critical comments of Professor B. Allanson, Rhodes University, under whose patronage the project was initiated.

F.M.H.R. acknowledges the facilities provided by the Institute of Marine Resources at S.I.O., University of California, San Diego, and the support of members of the Food Chain Research Group.

After the death of the senior author Elisabeth Stewart at S.I.O. was extremely helpful in the production of a final manuscript. Dr. Christopher McQuaid of Rhodes University, R.S.A., gave invaluable help in co-ordination of the transfer of the manuscript and Mrs. H. Ridder was a most understanding technical editor.

General References

Additional references to SEM illustrations in Appendix I

ALLEN, W.E. & CUPP, E.E. 1935. Plankton diatoms of the Java Sea. *Ann. Jard. Bot. Buitenzorg* 44:101-174.

ANONYMOUS 1975. Proposals for a standardization of diatom terminology and diagnoses. *Nova Hedwigia, Beih.* 53:323-354.

BAILEY, L.W. 1981. Notes on new species of microscopical organisms, chiefly from the River Para, South America. *Boston J. Nat. Hist.* VII:329-352.

BEKLEMISHEV, K.W. 1964. Concerning the phytogeographic division of the Antarctic pelagic region. *Soviet Antarct. Exped. Inf. Bull.* 2:272-276.

BENON, P. & MURAIL, J.-F. 1979. Hydrologie des plateformes peri-insulaires des Iles Crozet, Marion et Prince Edward. Camp. Oceanogr. M.D. 08. Com. Nation. Franc. des Recherches Antarct. 44:39-60.

BERGON, P. 1903. Études sur la flore diatomique du bassin d'Arcachon et des parages de l'Atlantique voisins de cette station. *Bull. Soc. Scient. Arcachon* VI:39-112.

BODEN, B.P. 1949. The diatoms collected by the U.S.S. Cacopan in the Antarctic in 1947. *J. Mar. Res.* 8:6-13.

BODEN, B.P. 1950. Some marine plankton diatoms from the West Coast of South Africa. *Trans. Roy. Soc. S. Afr.* 32(4):321-434.

BODEN, B.P. 1985. The South African SIBEX I cruise to the Prydz Bay region. *S. Afr. J. Antarct. Res.* 15:28-32.

BODEN, B.P. & PARKER, L.D. 1986. The plankton of the Prince Edward Islands. *Polar Biol.* 5(2):81-93.

BODEN, B.P., DUNCOMBE RAE, C.M. & LUTJEHARMS, J.R.E. 1988. The distribution of the diatoms of the SW Indian Ocean surface waters between Cape Town and Prince Edward Island archipelago. *S. Afr. J. Sci.* 84B(10):811-818.

BRUNEL, J. 1970. Le phytoplankton de la Baie des Chaleurs. *Les Presses de l'Université de Montréal, Montréal*: 365 pp.

CASTRACANE, A.F. 1886. Report on the Diatomaceae collected by HMS Challenger during the years 1875-76. Challenger Rept. Bot. 2:1-178.

CLEVE, P.T. 1894-1895. Synopsis of the naviculoid diatoms. *K. Svenska Vet.- Akad. Handl.*, pt.1 26(2):1-194; pt.2 27(3):1-219.

CLEVE, P.T. 1900. Plankton from the southern Atlantic and southern Indian Oceans. Öfvers. *K. Svenska Vet.-Akad. Handl.* 919-938.

CLEVE, P.T. & MOLLER, J.D. 1877-1882. Diatoms. Parts 1-VI. Uppsala.

CRAWFORD, R.M. 1979. Taxonomy and frustular structures of the marine centric diatom *Paralia sulcata*. *J. Phycol.* 15:200-210.

CUPP, E.E. 1943. Marine plankton diatoms of the west coast of North America. *Bull. Scripps Inst. Oceanogr.* 5(1):1-238.

DEACON, G.E.R. 1983. Kerguelen, Antarctic and subantarctic. *Deep-Sea Res.* 30:77-81.

DREBES, G. 1974. Marines Phytoplankton. Eine Auswahl der Helgoländer Planktonalgen (Diatomeen, Peridineen). Georg. Thieme Verlag, Stuttgart: 186 pp.

FRENGUELLI, J. & ORLANDO, H.A. 1958. Diatomeas y silicoflagelados del sector Antarctico Sudamericano. Publ. Inst. Antarct. Argent. Buenos Aires 5:1-191.

GIFFEN, M.H. 1971. Marine littoral diatoms from the Gordon's Bay region of False Bay, Cape Province, South Africa. *Botanica Marina* 14:1-16.

GIFFEN, M.H. 1975. An account of the littoral diatoms from Langebaan, Saldanha Bay Lagoon, Cape Province, South Africa. *Botanica Marina* 18:17-95.

GIFFEN, M.H. 1976. A further account of the marine littoral diatoms of the Saldanha Bay Lagoon, Cape Province, South Africa. *Botanica Marina* 19:379-394.

GRAN, H.H. 1905. Diatomeen. In: K.Brandt & C.Apstein (eds.). *Nordisches Plankton* 3(19):1-146.

GRAN, H.H. & ANGST, E.C. 1931. Plankton Diatoms of *Puget Sound*. *Puget Sound Biol. Sta. Publ.* 7:417-516.

HART, T.J. 1934. On the phytoplankton of the south-west Atlantic and the Bellinghausen Sea. 1929-1931. *Discovery Repts.* 10:247-282.

HART, T.J. 1937. *Rhizosolenia curvata Zacharias*. An indicator species in the Southern Ocean. *Discovery Repts.* 16:412-446.

HART, T.J, & CURRIE, R.I. 1960. The Benguela Current. *Discovery Repts.* 31:123-298.

HASLE, GRETHE R. 1968. The valve processes of the centric diatom genus *Thalassiosira*. *Norw. J. Bot.* 15(3):193-201.

HASLE, GRETHE R. 1969. An analysis of the phytoplankton of the Pacific southern ocean: abundance, composition and distribution during the Brategg Expedition, 1947-1948. *Hvalrad. Skr.* 52:1-168.

HASLE, GRETHE R. 1972. The distribution of *Nitzschia seriata* Cleve and allied species. *Nova Hedwigia, Beih.* 39:171-190.

HASLE, GRETHE R. 1973. *Thalassiosiraceae*, a new diatom family. *Norw. J. Bot.* 20(1):67-69.

HASLE, GRETHE R. 1976. The biogeography of some marine planktonic diatoms. *Deep Sea Res.* 23:319-338.

HASLE, GRETHE R. 1983. The current status of the diatom *Coscinodiscus* Ehrenberg 1838. In: Aasheim, L. (ed.) Rapp. Diatomésymposium i Bergen, mai 1983. *Bot. Mus. Rapp.* 33:27-32.

HEIDEN, H. & KOLBE, R.W. 1928. Die marinen Diatomeen der deutschen Südpolar Expedition 1901-1903. *Deutsche Südpolar Expedition 1901-1903.* 8:447-714.

HENDEY, N.I. 1937. The plankton diatoms of the southern seas. *Discovery Repts.* 16:151-364.

HENDEY, N.I. 1964. Bacillariophyceae (Diatoms). In: An introductory account of the smaller algae of British coastal waters. *Fish. Invest.* ser.4, pt.V:317 pp.

HUSTEDT, F. 1930. Die Kieselalgen Deutschlands, Oesterreichs und der Schweiz. In: *Rabenhorst Kryptogamen-Flora* 7(1):1-920.

HUSTEDT, F. 1958. Diatomeen aus der Antarktik und dem Südatlantik. *Deutsch. Antarkt. Exped. 1938-1939.* 2:103-191.

HUSTEDT, F. 1959. Die Kieselalgen Deutschlands, Oesterreichs und der Schweiz. In: *Rabenhorst Kryptogamen-Flora* 7(2):1-845.

HUSTEDT, F. 1961-1966. Ibid. 7(3):1-816.

KARSTEN, G. 1905a. Das Phytoplankton des Antarktischen Meeres nach dem Material der deutschen Tiefsee-Expedition, 1898-1899. *Wiss. Ergeb. Deutsch. Tiefsee-Exped."Valdivia"*, *1898-1899.* 2:(2):1-136.

KARSTEN, G. 1905b. Das Phytoplankton des Atlantischen Ozeans nach dem Material der deutschen Tiefsee-Expedition, 1898-1899. Ibid:137-219.

KARSTEN, G. 1907. Das Indische Phytoplankton nach dem Material der deutschen Tiefsee-Expedition, 1898-1899. Ibid:221-544.

KRUGER, J. 1980. A checklist of South West African marine phytoplankton, with some phytogeographical relations. *Fish. Bull. S. Afr.* 13:1-53.

LEBOUR, M.V. 1930. The planktonic diatoms of the northern seas. *Ray Soc. Publ.* 116:1-244.

MANGIN, L. 1915. Phytoplancton de l'Antarctique. Deux. Expéd. Antarct. Francaise 1908-1910. *Sci. Nat. Paris.* 95 pp.

MANGIN, L. 1917. Sur le *Chaetoceros criophilus* Castracane, espèce caractéristique des mers antarctiques. C.R.Acad.Sci., Paris. 164:1-9.

MANGIN, L. 1922. Phytoplancton antarctique. Expéd. Antarct. Scotia 1902-1904. Mém. Acad. Sci., Paris. 57(2):1-134.

MANGUIN, E. 1954. Diatomées marines provenant de l'Ile Heard (Australian National Antarctic Research Expedition). *Rev. Algol.* ns I:14-24.

MEUNIER, A. 1910. Microplankton des mers de Barents et de Kara. Duc D'Orléans Campagne Antarctique de 1907. 355 pp.

MEUNIER, A. 1913. Microplankton de la mer Flamande. 1. le genre *Chaetoceros* Ehrenberg. *Mém. Mus. Hist. Nat. Belg.* 7(2):1-58.

MEUNIER, A. 1915. Microplankton de la mer Flamande. 2. Les diatomées (suite). Ibid. 7(3):1-55.

NAVARRO, J.N. 1981a. A survey of the marine diatoms of Puerto Rico. 1: Suborders Coscinodiscineae and Rhizosoleniineae. *Botanica Marina.* 24(8):427-440.

NAVARRO, J.N. 1981b. A survey of the marine diatoms of Puerto Rico. 2: Suborder Biddulphiineae: Families Biddulphiaceae, Lithodesmiaceae, and Eupodiscaceae. Ibid. 24(10):615-630.

NAVARRO, J.N. 1982a. A survey of the marine diatoms of Puerto Rico. 3: Suborder Biddulphiineae: Families Chaetoceraceae. Ibid. 25(7):305-319.

NAVARRO, J.N. 1982b. A survey of the marine diatoms of Puerto Rico. 4: Suborder Araphidineae: Families Diatomaceae and Protoraphidaceae. Ibid. 25(6):246-247.

NAVARRO, J.N. 1982c. A survey of the marine diatoms of Puerto Rico. 5: Suborder Raphidineae: Families Achnanthaceae and Naviculaceae (excluding *Navicula* and *Mastogloia*). Ibid. 25(7):321-338.

NAVARRO, J.N. 1983. A survey of the marine diatoms of Puerto Rico. 7: Suborder Raphidineae: Families Auriculaceae, Epithemiaceae, Nitzschiaceae and Surirellaceae. Ibid. 26:393-408.

NEL, ELIZABETH A. 1968. The microplankton of the south-west Indian Ocean. *Invest. Rep. Div. Sea Fish. S. Afr.* 62:1-178.

PADDOCK, T.B.B. 1986. Observations on the genus *Stauropsis* Meunier and related species. *Diatom Res.* 1(1):89-98.

PADDOCK, T.B.B. & SIMS, P.A. 1981. A morphological study of keels of various raphe-bearing diatoms. *Bacillaria* 4:177-222.

PRIDDLE, J. & FRYXELL, GRETA A. 1985. Handbook of the common plankton diatoms of the southern ocean: Centrales except the genus *Thalassiosira*. *Brit. Antarct. Survey*, NERC, Cambridge. 159 pp.

REIMANN, B. & LEWIN, J.C. 1964. The diatom genus *Cylindrotheca* Rabenhorst. *J. Roy. Micr. Soc.* 83:283-296.

RICARD, M. 1987. Diatomophycées. In: Atlas du phytoplancton marin (ed. A. Sournia) 2:1-297. Éditions du Centre National de la Recherche Scientifique, Paris.

ROSS, R. & SIMS, P.A. 1972. The fine structure of the frustule in centric diatoms; a suggested terminology. *Br. Phycol. J.* 7:139-163.

ROSS, R. & SIMS, P.A. 1973. Observations on family and generic limits in the Centrales. *Nova Hedwigia, Beih.* 45:97-132.

ROSS, R., COX, E.J., KARAJEVA, N.I., MANN, D.G., PADDOCK, T.B.B., SIMONSEN, R. & SIMS, P.A. 1979. An amended terminology for the siliceous components of the diatom cell. *Nova Hedwigia, Beih.* 64:513-533.

ROUND, F.E. 1978. The diatom genus *Chrysanthemodiscus* Mann (Bacillariophyta). *Phycologia* 17:157-161.

ROUND, F.E. 1979. The classification of the genus *Synedra*. *Nova Hedwigia, Beih.* 64:135-146.

ROUND, F.E. 1984. The circumscription of *Synedra* and *Fragilaria* and their subgroupings. In: Mann, D.G., (ed.), Proc. 7th Int. Diatom Symp., Philadelphia 1982, Koeltz publ.:241-254.

SCHMIDT, A. et al 1874-1959. Atlas der Diatomaceenkunde. Leipzig and Berlin. (reprint 1984, Koeltz).

SCHOEMAN, F.R. & ARCHIBALD, R.E.M. 1976-1980. The diatom flora of southern Africa:1-6. CSIR Special Rept. WAT 50. Pretoria.

SHADBOLT, G. 1854. A short description of some new forms of Diatomaceae from Port Natal. *Trans. Micr. Soc. London. ns.* 2:13-18.

SHANNON, L.V. & PILLAR, S.C. 1986. The Benguela Ecosystem. Pt.III. Plankton. *Oceanogr. Mar. Biol. Ann. Rev.* 24:65-170.

SIMONSEN, R. 1974. The diatom plankton of the Indian Ocean expedition of R.V. Meteor, 1964-1965. In: Meteor Forschungsergeb. Reihe D. 19:1-107.

SIMONSEN, R. 1979. The diatom system: ideas on phylogeny. *Bacillaria* 2:9-71.

SOURNIA, A., GRALL, J.-R. et JACQUES, G. 1979. Diatomées et Dinoflagellés planctoniques d'une coupe méridienne dans le sud de l'océan Indien (campagne "Antiprod I" de *Marion Defresne*, mars 1977. *Botanica Marina* 22:183-198.

SOURNIA, A. 1968. Diatomées planctoniques du Canal Mozambique et de l'Ile Maurice. *Mém. Orstom* 31:1-120.

STOSCH, H.A. VON 1975. An amended terminology of the diatom girdle. *Nova Hedwigia, Beih.* 53:1-28.

TAYLOR, F.J.R. 1967. Phytoplankton of the south-western Indian Ocean. *Nova Hedwigia, Beih.* 12:433-476.

THORRINGTON-SMITH, MARGARET 1969. Phytoplankton studies in the Agulhas current region off the Natal coast. *Investl. Dep. Oceanogr. Res. Inst.* 23:1-24.

THORRINGTON-SMITH, MARGARET 1970. Some new and little-known planktonic diatoms from the West Indian Ocean. *Nova Hedwigia, Beih.* 31:815-835.

THORRINGTON-SMITH, MARGARET 1971. West Indian Ocean phytoplankton: a numerical investigation of phytohydrographic regions and their characteristic phytoplankton associations. *Marine Biology* 9(2):115-137.

VAN DER WERFF, A. & HULS, H. 1957-1974. Diatomeenflora van Nederland. Pts. 1-10.. Koeltz Publ. Koenigstein, W. Germany.

VAN HEURCK, H. 1909. Diatomées. In: Expédition Antarctique Belge. Résultats du Voyage du S.Y. BELGICA en 1897-1899, Botanique; 129 pp. Buschman impr., Anvers, France.

VAN LANDINGHAM, S.L. 1967-1979. Catalogue of the fossil and recent genera and species of diatoms and their families. 8 vols: 4654 pp. Cramer Publ.

ZACHARIAS, O. 1905. *Rhizosolenia curvata mihi*, eine neue marine Planktondiatomee. *Arch. Hydrobiol. Plankton.* I:120-121.

Appendix I

Electron micrography references

(indicated by an asterisk * in the text)

1. ANDREWS, G.W. 1977. Morphology and stratigraphic significance of *Delphineis*, a new marine diatom genus. *Nova Hedwigia, Beih.* 54:243-260.
2. BROOKS, M. 1975. Studies on the genus *Coscinodiscus*. I. Light, transmission and scanning electron microscopy of *C. concinnus* Gough. *Botanica Marina* 18:1-13.
3. BROOKS, M. 1975. Studies on the genus *Coscinodiscus*. III. Light, transmission and scanning electron microscopy of *C. granii* Wm. Smith. Ibid. 18:29-39.
4. EVENSEN, D.L. & HASLE, GRETHE R. 1975. The morphology of some *Chaetoceros* (Bacillariophyceae) species as seen in the electron microscopes. *Nova Hedwigia, Beih.* 53:153-174.
5. FRYXELL, GRETA A. 1975. Three new cpecies of *Thalassiosira*, with with observations on the occluded process, a newly observed structure of diatom valves. *Nova Hedwigia, Beith.* 53:57-75.
6. FRYXELL, GRETA A. 1976. The position of the labiate process in the diatom genus *Skeletonema*. *Br. Phycol. J.* 11:93-99.
7. FRYXELL, GRETA A. 1978. Chain-forming diatoms: Three species of *Chaetoceraceae*. J. Phycol. 14:62-71.
8. FRYXELL, GRETA A. & HASLE, GRETHE R. 1971. *Corethron criophilum* Castracane: its distribution and structure. In: Biology of the Antarctic seas IV (Eds., Llano, G.A. & Wallen, D.E.). *Antarctic Res. Ser.* 17:335-346.
9. FRYXELL, GRETA A. & HASLE, GRETHE R. 1972. *Thalassiosira eccentrica* (Ehrenberg) Cleve, *T. symmetrica* sp. nov., and some related centric diatoms. *J. Phycol.* 8:297-317.
10. FRYXELL, GRETA A. & HASLE, GRETHE R. 1974. Coscinodiscineae: some consistent patterns in diatom morphology. *Nova Hedwigia, Beih.* 45:69-84.
11. FRYXELL, GRETA A. & HASLE, GRETHE R. 1977. The genus *Thalassiosira*: some species with a modified ring of central strutted processes. Nova Hedwigia, Beih. 54:67-98.
12. FRYXELL, GRETA A., HUBBARD, G.F. & VILLAREAL, T.A. 1981. The genus *Thalassiosira*: variations of the cingulum. *Bacillaria* 4:41-63.
13. FRYXELL, GRETA A. & MEDLIN, L.K. 1981. Chain-forming diatoms: evidence of parallel evolution in *Chaetoceros*. *Cryptogramie: Algologie.* 2(1):3-29.
14. FRYXELL, GRETA A. & MILLER, W.I. 1978. Chain-forming diatoms: three araphid species. *Bacillaria* 1:113-136.
15. GERLOFF, J. 1970. Elektronmikroskopische Untersüchungen an Diatomeenschalen. 7. Der Bau der schale von *Planktoniella sol* (Wallich) Schütt. *Nova Hedwigia, Beih.* 31:203-234.
16. HALLEGRAEFF, G.M. 1984. Species of the diatom genus *Thalassiosira* in Australian waters. *Botanica Marina* 27:495-513.
17. HALLEGRAEFF, G.M. 1986. Taxonony and morphology of the marine plankton diatoms *Thalassionema* and *Thalassiothrix*. *Diatom Res.* 1(1):57-80.
18. HARGRAVES, P.E. 1979. Studies on marine plankton diatoms. 4. Morphology of *Chaetoceros* resting spores. *Nova Hedwigia, Beih.* 64:99-120.
19. HASLE, GRETHE R. 1964. *Nitzschia* and *Fragilariopsis* species studied in the light and electron microscopes. 1. Some marine species of the groups *Nitzschiella* and *Lanceolatae*. Skr. Norske Vidensk.-Akad. Oslo, Mat.-Nat., Kl., ns. 16:1-48.
20. HASLE, GRETHE R. 1965a. 2: The group *Pseudonitzschia*. Ibid. 18:1-45.
21. HASLE, GRETHE R. 1965b. 3: The genus *Fragilariopsis*. Ibid. 21:1-49.
22. HASLE, GRETHE R. 1968a. Observations on the marine diatom *Fragilariopsis kerguelensis* (O'Meara) Hustedt in the scanning electron microscope. *Norw. J. Bot.* 15(3):205-208.
23. HASLE, GRETHE R. 1972a. *Thalassiosira subtilis* (Bacillariophyceae) and two allied species. *Norw. J. Bot.* 19(2):111-137.
24. HASLE, GRETHE R. 1972b. *Fragilariopsis* Hustedt as a section of the genus Nitzschia Hassall. *Nova Hedwigia, Beih.* 39:111-119.
25. HASLE, GRETHE R. 1972c. Two types of valve processes in centric diatoms. *Nova Hedwigia, Beih.* 39:55-78.
26. HASLE, GRETHE R. 1973a. Morphology and taxonomy of *Skeletonema costatum* (Bacillariophyceae). *Norw. J. Bot.* 20(2-3):109-137.
27. HASLE, GRETHE R. 1974a. The "mucilage pore" of pennate diatoms. *Nova Hedwigia, Beih.* 45:167-186.
28. HASLE, GRETHE R. 1974b. Some marine plankton genera of the diatom family *Thalassiosiraceae*. *Nova Hedwigia, Beih.* 45:1-68.
29. HASLE, GRETHE R. 1975. Some living marine species of the diatom family *Rhizosoleniaceae*. *Nova Hedwigia, Beih.* 53:99-152.
30. HASLE, GRETHE R. 1978. Some *Thalassiosira* species with one central process (Bacillariophyceae). *Norw. J. Bot.* 25:77-110.
31. HASLE, GRETHE R. 1979. *Thalassiosira decipiens* (Grunow) Jørgensen (Bacillariophyceae). *Bacillaria* 2:85-108.
32. HASLE, GRETHE R. & FRYXELL GRETA G.A. 1977. The genus *Thalassiosira*: some species with a linear areola array. *Nova Hedwigia, Beih.* 54:15-66.
33. HASLE, GRETHE R. & MENDIOLA, B.R.E.de 1967. The fine structure of some *Thalassionema* and *Thalassiothrix* species. *Phycologia* 6(2-3):107-125.
34. HASLE, GRETHE R. & SEMINA, HALINA J. 1987. The marine plankton diatoms *Thalassiothrix longissima* and *Thalassiothrix antarctica* with comments on Thalassionema spp. and *Synedra reinboldii*. *Diatom Res.* 2(2):175-192.
35. HASLE, GRETHE R. & SIMS, P.A. 1986a. The diatom genera *Stellarima* and *Symbollophora* with comments on the genus *Actinoptychus*. *Br. Phycol. J.* 21:97-114.
36. HASLE, GRETHE R. & SIMS, P.A. 1986b. The diatom genus *Coscinodiscus* Ehrenberg: *C. argus* Ehrenberg and *C. radiatus* Ehrenberg. *Botanica Marina* 29:305-318.
37. HASLE, GRETHE R. & SYVERTSEN, E.E. 1980. The diatom genus *Cerataulina*: morphology and taxonomy. *Bacillaria* 3:79-114.
38. HASLE, GRETHE R. & SYVERTSEN, E.E. 1982. *Coscinodiscus pseudolineatus* Pantocsek and *Coscinodiscus praelineatus* Jousé as synonyms of *Thalassiosira leptopus* (Grunow) Hasle & G. Fryxell. In: D.G. Mann, ed., Proc. 7th Int. Diatom Symp.. Philadelphia 1982, Koeltz publ.:241-254.
39. HASLE, GRETHE R., VON STOSCH, H.A. & SYVERTSEN, E.E. 1983. Cymatosiraceae, a new diatom family. *Bacillaria* 6:9-156.
40. HELMCKE, J.-G. & KRIEGER, W. 1953. Diatomeenschalen im elektronmikroskopischen Bild. 1, pp. 20, Berlin.
41. JOHANSEN, R.J., & FRYXELL, GRETA A. 1985. The genus *Thalassiosira* (Bacillariophyceae): Studies on species occurring south of the Antarctic Convergence Zone. *Phycol.* 24(2):155-179.
42. KORNER, H. 1970. Morphologie und taxonomie der Diatomeengattung *Asterionella*. *Nova Hedwigia, Beih.* 20:557-724.
43. LANGE, C., NEGRI, R.M. & BENAVIDES, H.R. 1983. Algunas especies del genero *Thalassiosira* (Bacillariophyceae) del mar argentino. (Parte 1) *Iheringia Ser. Bot., Porto Alegre* 31:9-30.
44. MAHOOD, A.D., FRYXELL, GRETA A. & McMILLAN, M. 1986. The diatom genus *Thalassiosira*: species form the San Francisco Bay system. *Proc. Cal. Acad. Sci.* 44(8):127-156.
45. NORRIS, R.E. 1984. Phytoplankton, including nanoplankton, in the Benguela Upwelling System as revealed by electron microscopy. *Trans. Roy. Soc. S. Afr.* 45(2):139-167.
46. PADDOCK, T.B.B. 1986. Observations on the genus *Stauropsis* Meunier and related species. *Diatom Res.* 1:(1):89-98.
47. REID, FREDA M.H. & ROUND, F.E. 1987. The Antarctic diatom *Synedra reinboldii*: taxonomy, ecology and transference to a new genus, *Trichotoxon*. *Diatom Res.* 2(2):219-227.

48. RIVERA, P.R. 1981. Beitrage zur Taxonomie und Verbreitung der Kustengewassern Chiles. *Bibl. Phycol.* 56:1-220.
49. ROSS, R., SIMS, P.A. & HASLE, GRETHE R. 1977. Observations on some species of the Hemiauloideae. *Nova Hedwigia, Beih.* 54:179-213.
50. ROUND, F.E. 1980. Forms of the giant diatom *Ethmodiscus* from the Pacific and Indian Oceans. *Phycol.* 19(4):307-316.
51. ROUND, F.E. & MANN, D.G. 1980. *Psammodiscus* nov. gen. based on *Coscinodiscus nitidus*. *Ann. Bot.* 46:367-373.
52. SANCETTA, CONSTANCE. 1987. Three species of *Coscinodiscus* Ehrenberg from the North Pacific sediments examined in the light and scanning electron microscopes. *Micropaleon.* 33(3):230-241.
53. SEMINA, H.J. 1981. A morphological examination of the diatom *Thalassiothrix longissima* Cleve & Grunow. *Bacillaria* 4:147-160.
54. SIMONSEN, R. 1975. On the pseudonodulus of the centric diatoms or Hemidiscaceae reconsidered. *Nova Hedwigia, Beih.* 53:83-94.
55. STOSCH, H.A. VON 1977. Observations on *Bellerochea* and *Streptotheca*, including descriptions of three new planktonic diatom species. *Nova Hedwigia, Beih.* 54:113-166.
56. SUNDSTRÖM, B.G. 1986. The marine diatom genus *Rhizosolenia*. A new approach to the taxonomy. Ph.D. Dissertation. Lund Univ. Sweden. 196 pp.
57. SYVERTSEN, E.E. 1977. *Thalassiosira rotula* and *T. gravida*: ecology and morphology. *Nova Hedwigia, Beih.* 54:99-112.
58. SYVERTSEN, E.E. & HASLE, GRETHE R. 1983. The diatom genus *Eucampia*: morphology and taxonomy. *Bacillaria* 6:169-210.
59. WORKING PARTY ON TAXONOMY (1979-1984). Working party on taxonomy in the Akashiwo Kenyukai. Synopsis of red tide organisms. Fisheries Agency, Japanese Government. 180 pp.

Appendix II

GLOSSARY OF DIATOM TERMINOLOGY

(see Anon. 1975 for illustrations of features)

1. **Gross structure of siliceous frustule.**

Apical axis: long axis of a bilateral (usually pennate) diatom.

Transapical axis: axis at right angles to the apical axis of bilateral diatom.

Pervalvar axis: axis through centre points of two opposing valves.

Valvar plane of symmetry: plane parallel to valve surface.

Apical plane: plane at right angles to valvar plane connecting apices of two opposing valves.

Transapical plane: plane at right angles to both valvar and apical planes passing through the centre of the frustule.

Frustule: box-like siliceous skeleton surrounding the cyto - plasm; usually bilateral in pennate and radial in centric diatoms. Consists of epitheca + hypotheca or of epivalve + girdle + hypovalve.

Valves: plates at the top (epivalve) and bottom (hypovalve) of the frustule, often, but not always, similar; of various shapes.

Valve mantle: marginal part of the valve.

Epitheca: upper part of the frustule. Consists of epivalve + epicingulum.

Hypotheca: lower part of the frustule. Consists of hypovalve + hypocingulum.

Girdle: part of the frustule between the epi- and hypovalves, consisting of epi- and hypocingula.

Cingulum: portion of the girdle associated with a valve; *epicingulum* and *hypocingulum* associated with upper and lower valves respectively.

Band: a single element of the girdle.

Intercalary band (copula): band proximal to the valve.

Valvocopula: element immediately adjacent to the valve.

Connecting band (pleura): element distal to the copula in the middle of the girdle or any element when there are no intercalary bands present.

Septum: a shelf of siliceous material in the valvar plane project ing into the interior of the frustule.

Valve view: frustule seen from the top or bottom.

Broad girdle view: frustule seen from the widest side.

Narrow girdle view: frustule seen from the narrowest side.

2. **Fine structure of the siliceous frustule.**

Basal siliceous layer: layer forming the basic structure of the various components of the frustule.

Stria: a row of areolae or puncta (a punctate stria) or alveolae (a alveolate stria). In centric diatoms; radial, tangential, fasciculate etc.: in pennate diatoms; parallel, radiate, convergent, decussate etc.

Imbrication lines: formed by sutures of advalvar edges of connecting bands.

Alveolus: an elongated chamber from the axial, or central part, of the valve to the margin; opening to the inside by a large opening and with a perforate outer layer. eg. *Cyclotella*.

Interstria (e): solid strip of silica between two striae.

Costa: interstriae formed by thickening of the basal siliceous layer.

Puncta (um): general term for elements making up the striae; could be areolae, poroids or loculi.

Areola (e): regular perforations through the basal layer; poroid areolae are simple with no constriction, loculate areolae are markedly constricted on one surface and occluded by a velum on the other.

Velum: a thin, perforated layer of silica across an areola.

Cribrum: a velum perforated by regularly arranged pores.

Rota: a velum with a bar, or radial bars; with, or without, a widened central area.

Foramen: opening to the outside of the cell opposite the velum.

Pseudoloculus: a chamber formed on the outer side of the basal siliceous layer.

Axial area: a hyaline field along the apical axis of a cell (originally called the pseudoraphe).

Central area (field): a distinct portion of the axial area midway along its length. Termed a fascia if the hyaline band extends transapically across the valve.

3. **Raphe structure.**

Raphe: in pennate diatoms, an elongated slit, or pair of slits, through the siliceous valve wall.

Keel: the ridge bearing the raphe in pennate diatoms having valve sharply angled at the raphe. eg. *Nitzschia*.

Central nodule: siliceous structure separating two inner ends of the raphe fissure.

Central pore: expansion of the raphe fissure at the central nodule.

Stauros: transapical expansion of the central nodule extending to the edge of the valve.

Raphe canal: a tunnel on the inner side of the raphe more or less cut off from the rest of the interior of the frustule.

Fibulae (a): siliceous elements separating the raphe canal from the interior of the cell (originally called keel puncta).

Terminal nodule: siliceous thickening at apical end of the raphe.

Terminal pore: expansion of the raphe fissure at its apical end.

4. **Processes.**

Labiate process (rimoportula): a tube, opening through the valve wall, with an internal flattened tube or a longitudinal slit often with two lips.

Strutted process (fultoportula): a tube, through the valve wall, surrounded by 2-5 satellite pores which have arched supports internally; often with extrusions of threads of organic material to the exterior.

Occluded process: hollow external tube not penetrating the cell wall and closed at the distal end.

Spine: closed, solid siliceous structure projecting from the surface of the frustule; a *spinula* is a very small spine, a *granule* is a small rounded spine and *linking spines* are interdigitating spines connecting cells in a chain.

Process (processus): is the general term for use when, with the light microscope, it is impossible to distinguish whether a structure is a spine, a labiate process or a strutted process.

5. **Other structures.**

Aperture (window): opening between adjacent cells in a chain. eg. *Chaetoceros*.

Elevation: a raised portion of the valve. eg. *Eucampia*.

Seta: long hollow outgrowth of the valve margin, sometimes with chloroplasts. eg. *Chaetoceros*.

Ocellus: silica plate pierced by many small holes (porelli). eg. *Striatella*, *Auliscus*.

Pseudocellus: field of areolae smaller than those on the main part of the valve.

Pseudonodulus: single marginal, or submarginal structure; areolate, operculate or luminate. eg. *Actinocyclus*

Otaria: short membranous structures at or near the labiate process of *Rhizosolenia*: the "wings".