AN INVESTIGATION INTO THE TAXONOMY OF THE DIATOMS (BACILLARIOPHYTA) OF THE SUNDAYS AND GREAT FISH RIVERS, WITH ECOLOGICAL OBSERVATIONS ON THE SUNDAYS RIVER

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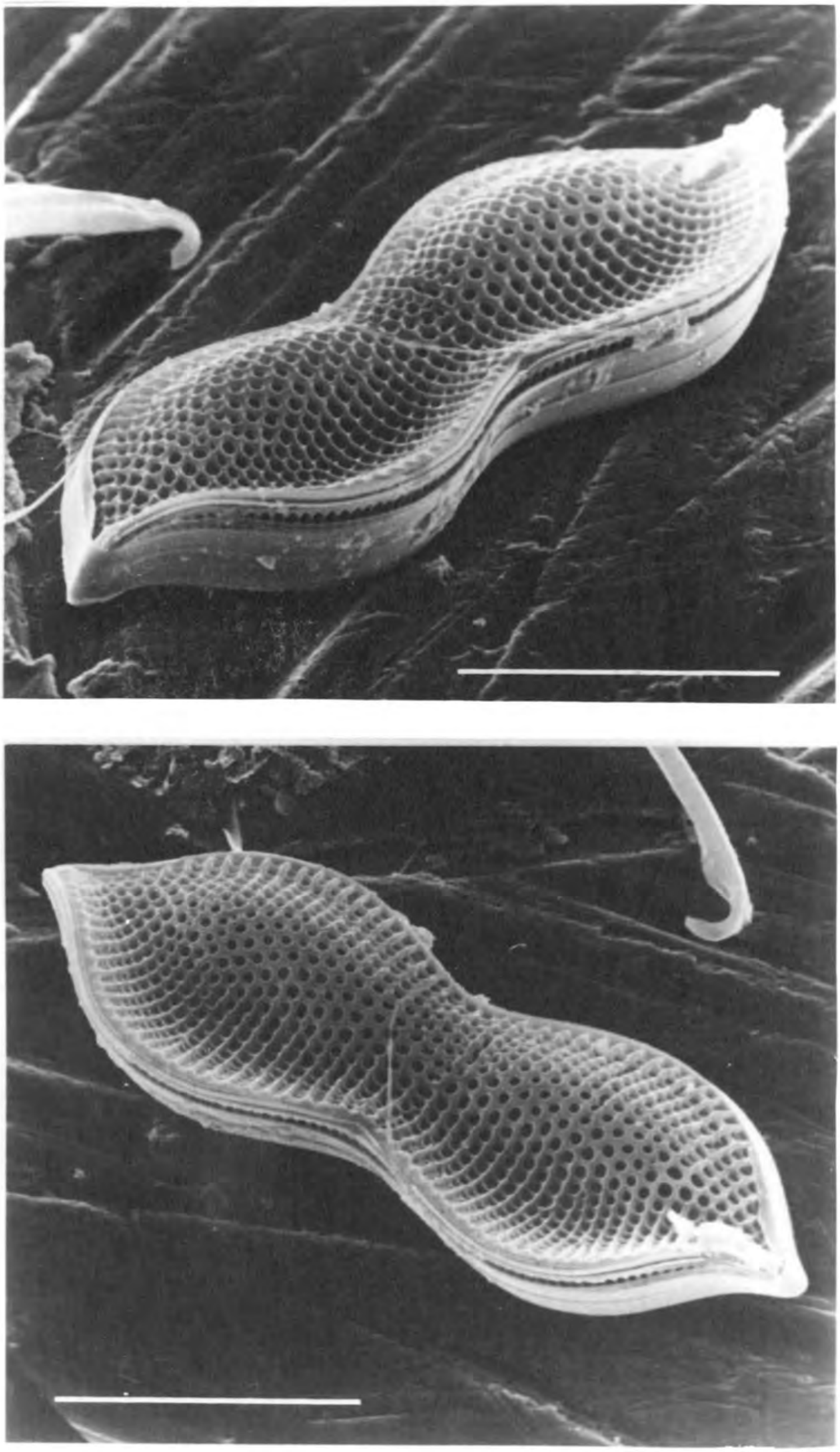
FRONTISPIECE



Nitzschia corpulenta Hendey. Scale = 10 µm

DEDICATION

This dissertation is dedicated to my wife Cherry, and to my children Jo-anne, Robert, Andrew and Susan, who have patiently borne the absence of husband and father over a long period of time. Without their loving encouragement the long hours spent after normal working hours would not have been worth-while.

PREFACE

This dissertation embodies a study of the diatoms (Bacillariophyta) occurring in the Sundays and Great Fish Rivers of the eastern Cape Province. The diatoms are a unique group of microscopic plants having a patterned silica shell enclosing their living cell contents. They are of cosmopolitan distribution and occur in nearly every situation where there is sufficient moisture and light. Accordingly they are found in abundance in the Sundays and Great Fish Rivers, where they are subject to a wide range of environmental conditions. Several aspects of the taxonomy and ecology of the diatoms in these two rivers have been investigated in this study.

As the title of the thesis suggests two main themes are involved in this investigation. These themes are firstly the taxonomy of the diatoms from the Sundays and Great Fish Rivers, and secondly ecological observations on the diatoms of the Sundays River. Although they can be treated as two separate studies, the latter is entirely dependent on the former, and together they form a comprehensive survey of the diatoms present in these two river systems at the time of the investigation. Partly on account of the different nature of the two disciplines involved in this study, and partly to facilitate the binding of the thesis by subdividing it into convenient sections, this dissertation is presented in three volumes.

Volume 1 embraces the taxonomy of the diatom taxa observed in the Sundays and Great Fish Rivers. It examines each taxon individually and attempts to establish their correct identity. This is of the utmost importance in reporting accurately the observations made in the ecological part of the study. At the same time the listing of each taxon met with in this investigation provides a checklist of the diatoms in the Sundays and Great Fish Rivers.

Volume 2 deals with the ecological observations on the diatoms of the Sundays River only. The diatom associations within the communities at each of the selected sampling points were examined with a view to elucidating their relationship to the ambient environmental conditions with special reference to the salt content. There was insufficient chemical evidence available from the Great Fish River to investigate its diatom populations in a similar fashion. Consequently an ecological account of the diatoms from the Great Fish River has not been attempted.

Volume 3 of the dissertation is more an integral part of Volume 1 (the taxonomic study), and contains a number of plates with figures illustrating, as far as possible, all the taxa dealt with in Volume 1. This is accomplished mainly through light microscopic photographs, but is supplemented with line drawings and occasionally with a few transmission and scanning electron microscope micrographs.

The conclusions drawn from the taxonomic study and those from the ecological examination of the diatoms in the Sundays River have been reported separately at the end of the relevant volumes.

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No study such as this can reach completion without the assistance of others. It is therefore with great pleasure and a sense of humility that I wish to acknowledge the following persons and institutions for their help, guidance and encouragement.

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Finally I would like to express my very deep gratitude and pay tribute to my parents. By providing me with the very best educational opportunities, they laid open the path which has led to the completion of this work.

ABSTRACT

This report on the diatoms (Bacillariophyta) of the Sundays and Great Fish rivers is divided into two sections. In Volume 1 the taxonomy of the diatoms from these two river systems is examined. A total of 331 taxa were studied, of which 5 are described as new species. Two taxa are given new names, since they were previously known under later homonyms. Twenty seven taxa were recorded for the first time from South Africa, while a number of species are given amended descriptions in the light of fresh information obtained concerning them. A few taxa (chiefly South African forms) have been united with previously described taxa. For the remainder of the taxa mentioned in the text, comments are passed with regard to their taxonomy and dimensions, based on facts gained through literature surveys and personal observations of the relevant taxa. As far as possible all taxa examined in Volume 1 are illustrated, and these illustrations are presented in Volume 3 of this study.

Volume 2 deals with the ecology of the diatoms in the Sundays River. Special emphasis is laid on relating the composition of the diatom associations at the selected stations to the ambient salinity and ionic composition of the water. A new index, the Salinity Tolerance Index (STI), is proposed to summarize by means of a numerical value the information obtained from the analysis of a diatom association with respect to the character of the component taxa, and to indicate whether the association is derived from a freshwater, brackish water or marine source. The efficacy of the STI is evaluated in the text. The effect of the geological formations of the Sundays River valley and the underground waters emanating from them is discussed in the text. The consequences of a severe drought in the lower Sundays River, including hypersaline water in the upper estuary, on the diatom flora are also investigated.

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INTRODUCTION

The Sundays and Great Fish rivers lie in the eastern regions of the Cape Province of South Africa between the latitudes 31° 45' S and 33° 45' S and between 24° 25' and 27° 10' longitude East; The Sundays River being the most westerly of the two rivers. Both rivers have their sources in the Sneeuberg mountain range below Middelburg (Cape Province) on either side of the mountain divide, and drain rather arid terrain before entering the sea, the Sundays River some 35 km east of Port Elizabeth and the Great Fish River about 26 km east of Port Alfred.

Both the Sundays and Great Fish rivers are significant in the history of South Africa, but in rather different circumstances. In the early decades of the 19th Century the Great Fish River formed the boundary between the 1820 British Settlers and the Xhosa speaking Bantu peoples east of the river. Today the descendants of those settlers farm the land on either side of the Great Fish River, while parts of the Xhosa-Ciskei Homeland border on the lower regions of the Great Fish River.

In contrast the historical significance of the Sundays River is somewhat different. In about 1913 the legendary South African character, Sir Percy FitzPatrick (of Jock of the Bushveld fame), came, on account of ill-health and the advice of his doctors, to the eastern Cape looking for a more equitable coastal climate (Cartwright, 1971). When he saw the lower Sundays River valley he immediately recognised its potential as an irrigation scheme. His imagination was fired with a vision of a huge citrus irrigation project supporting about 10 000 people. Following two visits to the world renowned Sunkist orchards in California (U.S.A.), FitzPatrick was passionately convinced of the success of the scheme as an asset to South Africa. He claimed that cheap labour and the lack of frost made the lower Sundays River valley superior to the Californian situation for citrus orchards.

However, one of the chief factors underlying the demise of FitzPatrick's scheme was the lack of sufficient water. The Sundays River region suffered persistent droughts alternating with ravishing floods. Largely at the instigation of Sir Percy FitzPatrick, Lake Mentz was built as a flood control dam and as a regular source of water for the irrigation of the orchards. The dam was officially opened in 1923, but was full for the first time only in 1928. Unfortunately Lake Mentz never really fulfilled its purpose, and water supply was insufficient to meet the needs of the irrigation farmers. Similar fates befell other irrigation schemes in the upper Sundays River valley and in the Great Fish River catchments. Furthermore, the high salt content of these two rivers made their waters unsuitable for irrigation purposes.

Consequently in order to alleviate these two factors the Sundays and Great Fish rivers were included as part of the giant Orange River Development Project (ORDP). Through this project an augmented supply of freshwater was to be fed into these two river systems via an arrangement of tunnels and canals from the Hendrik Verwoerd Dam on the Orange River (this is described in more detail in the Introduction to Volume 2 of this study). The first phase of this comprehensive project is now in operation and Orange River water flowed into the Great Fish River for the first time in 1977, while the lower Sundays River valley received its augmented water supply for the first time in 1978.

During the period 1964 to January 1970 and ecological survey programme of the Sundays and Great Fish rivers was undertaken jointly by the National Institute for Water Research and the Institute for Freshwater Studies of Rhodes University. The aim of this survey was to establish the nature of the prevailing environmental and biological conditions in these two river systems before the inflow of Orange River water. The information so obtained was to be used as a basis for a later comparison of the Sundays and Fish rivers with a view to detecting any changes resulting from the introduction of Orange River water. Apart from the physico-chemical aspects examined, the aquatic invertebrates (in particular the Trichoptera, Ephemeroptera and Simuliidae) and the diatoms were studied. This report presents the results of the study of the taxonomy of the diatoms (Bacillariophyta) of the Sundays and Great Fish rivers with some remarks on the ecology of the diatoms in the Sundays River.

AN INVESTIGATION INTO THE TAXONOMY OF THE DIATOMS (BACILLARIOPHYTA) OF THE SUNDAYS AND GREAT FISH RIVERS, WITH ECOLOGICAL OBSERVATIONS ON THE SUNDAYS RIVER

Volume 1

THE TAXONOMY OF THE DIATOMS OF THE SUNDAYS AND GREAT FISH RIVERS

INTRODUCTION

It is impossible to communicate knowledge or think about any subject of research without naming that subject. It is therefore the purpose of this part of the study to name the diatom species observed in the course of this investigation. It is, moreover, essential that the correct name be applied to the taxa concerned, otherwise unnecessary confusion in the interpretation of results will arise. Selecting the correct name involves the science of taxonomy, and it is here that the specialist taxonomist plays a key role.

To many people taxonomy and systematics are synonymous words, and they are used interchangeably. Recently, however, there has been a tendency to impart different meanings to these two words. In this study taxonomy is defined as the scientific study of the underlying principles, procedures and rules governing the identification, nomenclature and classification of an organism. On the other hand systematics is the scientific study of all the interrelationships among organisms. In the light of these definitions this section of the investigation into the diatoms of the Sundays and Great Fish rivers deals only with their taxonomy.

Taxonomy embraces three main facets - identification, nomenclature and classification. Identification is the process in which an investigator determines whether an organism is identical or similar to another previously known organism. It does not necessarily involve naming the organism. This is the preserve of nomenclature, while the principles governing the placing of an organism in its correct group of related organisms is the domain of classification. These facets are further amplified below.

Probably the most common method of identifying a specimen is by means of a published description or illustration bearing the characteristics of the organism. For many groups of organisms artificial keys have been developed to guide an investigator to the correct description of a taxon. In others, however, the investigator must rely on comparing the unknown specimen with illustrations of various previously identified organisms to lead him to the description from which an identification can be made. Reaching an accurate identification by these two means suffers the disadvantage of having to depend on the quality of the description. To a large degree the quality of a description or illustration is related to the state of development of optical systems. Many of the early microscopists, interested in diatoms, such as Kützing (1844, 1849), W. Smith (1853, 1856) and Rabenhorst (1864), gave very brief descriptions of the taxa observed or originally described by them. Furthermore their illustrations, when provided, were usually so small and lacking in detail as to make any identification through them impossible. Consequently their diagnoses are of little help to the present day diatomist trying to identify a specimen. In subsequent years improvement in the quality of optical systems permitted a more comprehensive diagnosis of a taxon to be made. At the same time the technique of drawing diatoms advanced markedly, so that in many cases the illustrations were sufficiently good as to act as the diagnosis of the taxon without a formal written description. Such improved diagnoses and illustrations can be found in the works of Grunow, Cleve, Peragallo H. & M. and von Schönfeldt. Further refinement in microscopic optics allowed more modern diatomists, such as Cleve-Euler, Krasske and Hustedt, to detect even more subtle differences between taxa. Unfortunately this did not always result in improved descriptions and illustrations, as personal interpretations of structures and different styles of drawing further help to complicate identifications based on a written description and drawing of a taxon.

The advent of the electron microscope has led to even greater sophistication in our knowledge of the fine structure of diatom valves. Transmission and scanning electron microscopy have different applications, and each instrument is better suited to certain aspects of diatom valve morphology. Of greatest value is the scanning electron microscope (SEM), as this instrument produces a three dimensional image of the required specimen from both internal and external aspects. Furthermore by breaking the valve it is possible to study the construction of the wall and other structures. SEM is thus admirably suited to studying diagnostic features such as valve contours, raphe structure, girdle band structure and valve processes of various types. The transmission electron microscope (TEM) has, in contrast, a more limited application, and is more suited for elucidating the fine detail of pore structure and other related structures. It is also more appropriate for the examination of very small diatoms with weakly silicified frustules devoid of much surface ornamentation.

sometimes limited to the examination of prepared mounts under the light microscope, and may prove difficult as a result of the poor state of preservation of some type slides. Poorly preserved slides are hardly helpful as all structural details can be obscured. Nevertheless for some taxa the types are good, while for others sufficient quantities of the unmounted original material may remain to permit investigation under the electron microscope. Such studies under the electron microscope improve beyond question the accuracy of identification through direct comparison with the type material. When no type material exists, or when it is unavailable, the diatom taxonomist must resort to some other well authenticated material for comparative purposes. In doing so, however, there is the risk that such material could be misidentified as it is the interpretation of a second party.

Identification of a taxon as identical or similar to another does not necessarily involve a name. The next step in taxonomy is, therefore, the determination of the correct name for the specimens. This is not a casual choice, but is governed by a set of rules and procedures. These rules and procedures form that part of taxonomy known as nomenclature. Botanical nomenclature is based on a number of principles with the object of ensuring a certain stability in the methods of determining the correct name of a taxon in order that no confusion or ambiguity need arise. The most important of these principles are

(i) that the application of a name is determined by a nomenclatural type;

(ii) That the nomenclature of a taxon is based on priority of publication; and

(iii) that each taxon with a particular circumscription, position and rank can have only one correct name, the earliest that is in accordance with the rules, except in certain specific cases.

The rules and procedures governing the selection of the correct name are drawn up in the International Code of Botanical Nomenclature (cf. Lanjouw, Ed. 1966). This code has no national or international legal standing, and its mandatory nature is only voluntarily enforced. In this study the code has been strictly adhered to.

The third aspect of taxonomy is classification, which according to Jeffrey (1973 : 55) is "the process of establishing and delimiting taxa". In other words classification studies the characteristics of different groups of organisms to determine which compose a certain definable taxon. The smaller a taxon becomes as a unit, the more difficult it is to define its limits. The species is generally regarded as the most natural and fundamental taxonomic unit, and its concept with particular reference to the diatoms is discussed in the next section. The interrelationships of the taxa thus defined are the preserve of the systematist, who develops his own classification system to suit his own goals. Classification is thus the link between taxonomy and systematics.

THE SPECIES CONCEPT IN THE DIATOMS

The general concept of a species has been adequately discussed by Dobzhansky (1937), Huxley (1940), Lawrence (1951), Snaydon (1973) and Wright (1971), and this discourse will limit itself to the species concept in the diatoms. What constitutes a species in the diatoms seems to have general agreement amongst diatom taxonomists, and their definitions of a species differ little from the general concept reflecting a genetic basis. Cholnoky (1960a : 9) declared the species to be a genetic not morphological unit. His idea of a species was a reproductive population, i.e. a group of living organisms in which individuals can unrestrainedly enter or potentially enter into sexual reproduction with each other without choice or limitation. Hendey (1964 : 54) "conceived the species as an orbital system of disparate units expressing itself in space and time ... . Under normal conditions, the units, whose sum total of attributes resemble each other to a degree as specific, are concentrated into genic clusters or phases, and scatter centrifugally as environmental conditions vary". According to Guillard and Kilham (1977 : 386) the species is a "population of individuals with significant or potential genetic interchange".

As in other organisms a diatom species is therefore a dynamic population within which there is a considerable amount of genetic variation (cf. Snaydon, 1973 : 6). Thus in a population a number of morphological variations may be differentiated. In diatom taxonomy two infra-specific categories are recognised; these are the form and the variety. Hustedt (1937a : 186) and Hendey (1964 : 55) have attempted to define the concepts of these two categories. They conceived the variety as a small unit forming part of the species, distinguished from other infra-specific variants through changes resulting from the accumulation of a number of insignificant but genetically controlled characters. In contrast a form was looked upon as an impermanent phenotypic response of the species to external and internal influences; forms are genetically controlled in so far as the degree of variability is dependent on the inherent capacity for variation in the genome. In this respect Hendey (l.c.) pointed out that some species are very constant in their morphology, while others are extremely variable. Furthermore, he considered the form "to be the result of genetic instability and may arise suddenly and equally suddenly revert to type".

Despite the fact that the concepts of species, variety and form have a genetic basis, very few genetic studies of diatoms have been undertaken. This is due to the lack of being able to achieve successful results in experiments involving genetic crossing. Drebes (1970 : 250) has reviewed a number of experiments concerned with life cycles, sexuality and auxospore formation. In consequence of this lack of information the degree to which morphological variation within a taxon is genetically controlled is scantily known. Nevertheless diatom taxonomy has been almost entirely dependent on the morphological characteristics of the silica wall of the valve, and the delimitation of the taxonomic categories is still largely subjective. However the work of Geitler (1932), showing the degree of morphological change in diatoms during their peculiar mode of vegetative cell division, and the studies of Geissler (1970) on the variability of valve characteristics and their significance to diatom taxonomy, have given present day taxonomists a much better appreciation of the range of morphological variation possible within a taxon. Consequently modern diatom taxonomists are better able to evaluate critically the array of infra-specific variants described in the diatom literature. Geissler (l.c.) has pointed out that there is tendency in recent diatom taxonomy to consider variants with minor character differences and linked by intermediates with other intra-specific groupings as phenotypes of the species. Many variants, previously regarded as varieties, are therefore now considered as only forms of the species. This supports in some measure Hendey's (1964 : 55) opinion that in diatom taxonomy a form is a much more real infra-specific category than a variety.

The morphospecies (cf. Bonik and Lange-Bertalot, 1978 : 5) has been the conventional basic unit in diatom taxonomy for well over a century, and despite advances and changes in the species concept no drastic modifications have been made to diatom taxonomy therefrom. Recently, however, the validity of the morphospecies has been challenged. Researchers have questioned the ability of morphological characteristics to reflect genetic discontinuities within populations, and a number of incongruities have been observed. Various people (e.g. Drebes, 1967; Hasle, 1973; Hasle, Heimdal and Fryxell, 1971; Holmes, 1967) have noticed that in clonal cultures cells of one species give rise to valves characteristic of more than one species. Lauritis, Hemmingsen and Volcani (1967) observed daughter cells of *Nitzschia alba* Lewin and Lewin showing characteristics of two different genera. In a recently divided mother cell one daughter cell had valves with diagonally opposed canal raphes typical of a *Nitzschia*, while the other daughter cell was characteristic of a *Hantzschia* having the canal raphes of both valves on the same side of the cell. A similar situation is reported by Wood (1963 : 238) who found a diatom cell having one valve typical of *Coscinodiscus* and the other of *Asteromphalus*. In a wild population of a *Mastogloia* species Stoermer (1967) observed two strikingly different morphological types in its vegetative life cycle; one of these could be referred to *Mastogloia grevillei* W. Smith and the other to *M. elliptica* var. *dansei* (W. Smith) Cleve.

In studies by Schultz and Trainor (1968, 1970) and Schultz (1971) it has been shown that depending on the salinity of the medium cells of *Cyclotella cryptica* can produce valves identical to *Cyclotella meneghiniana*. According to Schultz (1971 : 1288) this polymorphism in *C. cryptica* is not genetically controlled but influenced environmentally. She also claimed that there were three distinct taxa all having the ability to produce the same valve pattern, i.e. identical to *C. meneghiniana*. These were *C. cryptica, C. meneghiniana* and another clone, Clone 03A, distinguished from the former two taxa by having a different type of zoospore. In this connection, however, Schoeman and Archibald (1976-80 : No. 6) have put forward evidence that *C. cryptica* and *C. meneghiniana* are conspecific.

These incongruities exist, and are of importance in that they serve to remind diatom taxonomists that the morphospecies has limitations. In defining a species, therefore, account should be taken of its life history and ecology, as well as its valve morphology in order to approach more closely a genetically defined entity. Bearing in mind these interpretations of the species concept, and the limitations of the morphospecies in diatom taxonomy, an investigation into the taxonomy of the diatoms of the Sundays and Great Fish River has been undertaken.

THE TAXONOMY OF THE DIATOMS IN THE SUNDAYS AND GREAT FISH RIVERS

The primary objective of this investigation was the identification and naming of the diatom taxa observed in these two river systems. This study is not, however, merely a checklist of the diatom taxa occurring, but some attempt has also been made to re-examine taxonomically those species, varieties and forms concerned in this investigation. It would obviously be an enormous task to treat comprehensively each species observed in this study. Not only would time and space prohibit this goal, but other limitations would hinder the attainment of this objective.

Perhaps the most serious limitation encountered by a diatom taxonomist in South Africa is the lack of easy access to the most important diatom collections. In the re-evaluation and verification of a taxon, examination of the type material is essential; and if no type material is available properly authenticated examples of the relevant taxon may be substituted. Such type material is preserved in various European and North American institutions, not all of which are prepared to entrust postal services with such valuable and irreplaceable material. Never-the less most are willing to help and type material can be obtained from them. It is, however, a time consuming process. Consequently a comprehensive treatment of only a few taxa can be considered.

This does not mean that the great majority of species have been neglected. On the contrary, detailed taxonomic notes on the various taxa have been prepared wherever possible, and taxonomic relationships discussed in the light of information found in the literature. There has been criticism that in describing a species diatom taxonomists frequently do not examine sufficient populations from different sources to ascertain the complete range of variation of the taxon (Geissler, 1970). This may not be entirely the fault of the taxonomist, but it has often resulted in many inadequate descriptions of taxa. A further consequence of this sort of situation is that the two extremes of a very large and widespread population are described as two completely different species, which later must be united owing to the discovery of intermediates. Therefore taxonomic notes, however trivial they may seem, are important as they expand our knowledge of the morphology, dimensions and valve surface structure of the relevant taxon. These small items of information help to a more complete concept of the taxon concerned.

In reporting these items of information no particular classification system, other than alphabetical, has been employed. This is done for two reasons. Firstly an alphabetical listing of the species simplifies the later extraction of data, and no previous knowledge of diatom classification systems is required to find a particular species. Secondly, according to Cholnoky (1960a : 13), there is still some reservation concerning the phylogenetic relationships of some genera.

Accordingly each taxon is treated systematically in alphabetic order in the following way:-

(1) *The correct name:* The correct name of the taxon is determined in the first place by its identification, and secondly in accordance with the rules of the International Code of Botanical Nomenclature.

(2) *References:* Immediately following the correct name a list of references is given. The first of these is to the original diagnosis of the taxon, or, if a new combination is involved, to the first author of this combination. The remaining references cite more comprehensive descriptions and illustrations, by means of which identification was made.

(3) *Synonyms:* When synonyms are given for any taxon these are limited in number. The first mentioned is generally the basionym of a taxon that has undergone a change in rank or genus, involving a name change. Further synonyms are restricted to those discussed in the text. It was considered unnecessary to cite further synonyms as these are more than adequately dealt with in VanLandingham's most recent catalogue of diatom species and their synonyms (cf. VanLandingham, 1967, 1968, 1969, 1971, 1975, 1978a, 1978b).

(4) *Description:* Not every taxon listed has been formally described. Descriptions have only been given for those taxa in which either previous diagnoses were inadequate, or significant new information has been obtained, or the concept was somewhat different from that generally accepted. Taxa considered as new have been fully described, but the Latin diagnoses will be added when the study is formally published.

(5) *Taxonomic notes:* This section contains any information of taxonomic interest, such as comments on morphology, dimensions and structure, critical appraisal of inter-taxon relationships, critiques of other taxonomists' views, and the exposition of personal hypotheses.

(6) *Salinity value:* Immediately following the taxonomic notes each species has been characterized with respect to its salinity tolerance range in accordance with the classification given by Simonsen (1962 : 17). The characterization was derived from information gained from the literature and from personal observation of the relevant species in the rivers under investigation. Each taxon has also been given a salinity value based on Simonsen's classification and modified in the thesis as is explained in Section 3.6.1 of Volume 3 of this study.

(7) *Figures:* This is a list of the figures illustrating the relevant taxon in the text. These will be found in Volume 3.

(8) *Samples:* Finally the treatment of each taxon ends with the enumeration of all the samples in which the relevant taxon was found.

DIATOM TERMINOLOGY USED IN THE TAXONOMICAL STUDY

Owing to the unique construction of the diatom frustule a terminology peculiar to the study of diatoms has been evolved. In recent years the electron microscope, particularly the scanning electron microscope (SEM), has allowed great strides to be made in the study of the silica valve and its accompanying structures. As a result it was necessary to develop new terminology, which, owing to differences of opinion, led to some confusion of terms. At the Third Symposium on Recent and Fossil Marine Diatoms held in Kiel (Anonymous, 1975) a group of experts was established to standardize the terminology. Their proposals were set out as the last item in the Proceedings of that Symposium. In a tailpiece to the Proceedings of the Fourth Symposium on the same subject (cf. Ross, 1977 : 414) another committee was set up with the charge to produce an expanded terminology, as the original proposals were deemed to be inadequate in certain areas. This amended version was published at the end of the Proceedings of the Fifth Symposium held at Antwerp in 1978 (cf. Ross, Cox, Karayeva, Mann, Paddock, Simonsen and Sims, 1979 : 513). Although there is no legal mechanism to enforce the proposals, the committees responsible appealed to diatomists to take advantage of them. Accordingly their terminology was adopted in this study. Where difficulties have arisen the terminology of Schoeman and Archibald (1976-80 : No. 1) was followed.

ABBREVIATIONS USED IN THE TEXT

It is inevitable in a study of this nature that certain terms or phrases will constantly recur. Such repetition can be tedious to the reader. Consequently a number of abbreviations have been employed to eliminate the frequent re-use of long descriptive phrases. The majority of these abbreviations were used to indicate the origin of diatom material examined in the course of this investigation.

These abbreviations generally follow the slide material number, either bracketed or connected by a hyphen. In the case of the British Museum (Natural History) slides, the abbreviation BM is prefixed to the slide number, as this is their own numbering system. All other abbreviations were developed specifically for this study. A list of the abbreviations relating to diatom material follows.

BM -	British Museum (Natural History).
Bremerhaven (H.B.)	The Friedrich Hustedt Slide Collection at Bremerhaven.
F.B.A. -	The Freshwater Biological Association - Lund collection of slides.
Kassel -	Naturkundemuseum des Stadt Kassel - The Krasske slide collection.
Lund -	The Botanical Museum, The University, Lund, Sweden - Agardh material.
NIWR -	The National Institute for Water Research diatom slide collection.
Philadelphia -	The diatom collections of the Academy of Natural Sciences of Philadelphia.
VHS -	Types du Synopsis des Diatomées de Belgique (cf. Grunow, 1884-87).
Vienna -	The Naturhistorisches Museum in Vienna, Austria - the Grunow slide collection.

Other common abbreviations to be found in the text are in connection with the type of microscope or microscopic technique employed in the investigation of the diatoms. These are commonly accepted abbreviations, but are worthwhile repeating here merely for clarity.

EM - electron microscope (microscopy).
TEM - transmission electron microscope (microscopy).
SEM - scanning electron microscope (microscopy).
LM - light microscope (microscopy).

DESCRIPTION OF THE SAMPLING SITES (STATIONS)

The localities at which the diatom samples were collected are briefly described below, indicating any special ecological niche sampled. The stations are enumerated from the source region downwards to the river mouth. The two river systems are dealt with separately, and are followed by tables showing the sample number and the date on which it was collected at the relevant station. The location of the sampling sites on these two river systems is shown in Figures 1 and 2.

A. THE SUNDAYS RIVER (Fig. 1)

Station 11.

This was situated on the Sundays River at the Bethesda Road bridge where the National Road from Middelburg to Graaff-Reinet crosses the river. At this point the river bed is narrow with a gravel or silt bottom. It was usually dry, except after heavy rain or snow. No special ecological niche was sampled here, and diatoms were collected from the rocks and sandy substrate.

Station 10

This station was located on the farm Glen Harry in the mountains above Graaff-Reinet and below the Letskraal Trading Station. The river bed was flood scoured, consisting of sand, stones and rocks. Small springs below the cliffs maintained a permanent localized flow of clear water, even during drought, supporting aquatic growth of algal scums, *Cotula* and *Scirpus*. Diatoms were collected from among the algal scums, and also as scrapings from the rocks. Included as part of Station 10 were two isolated samples from this region, one (Sun 45 - NIWR) from just below Koloniesplaatz farm, a few kilometers above Station 10, and the other (SUN 25 - NIWR) from a point a few kilometers closer to Graaff-Reinet.

Station 9

The Sundays River immediately below the town of Graaff-Reinet, near the old road bridge. There was usually a relatively good flow of water due to the town's sewage effluent. A good growth of marginal grass occurred along the river banks acting as attachments for long trails of algae. The river bed consisted of gravel and silt. Diatom samples were usually collected from the algal scum resting on the silt or mud substrate.

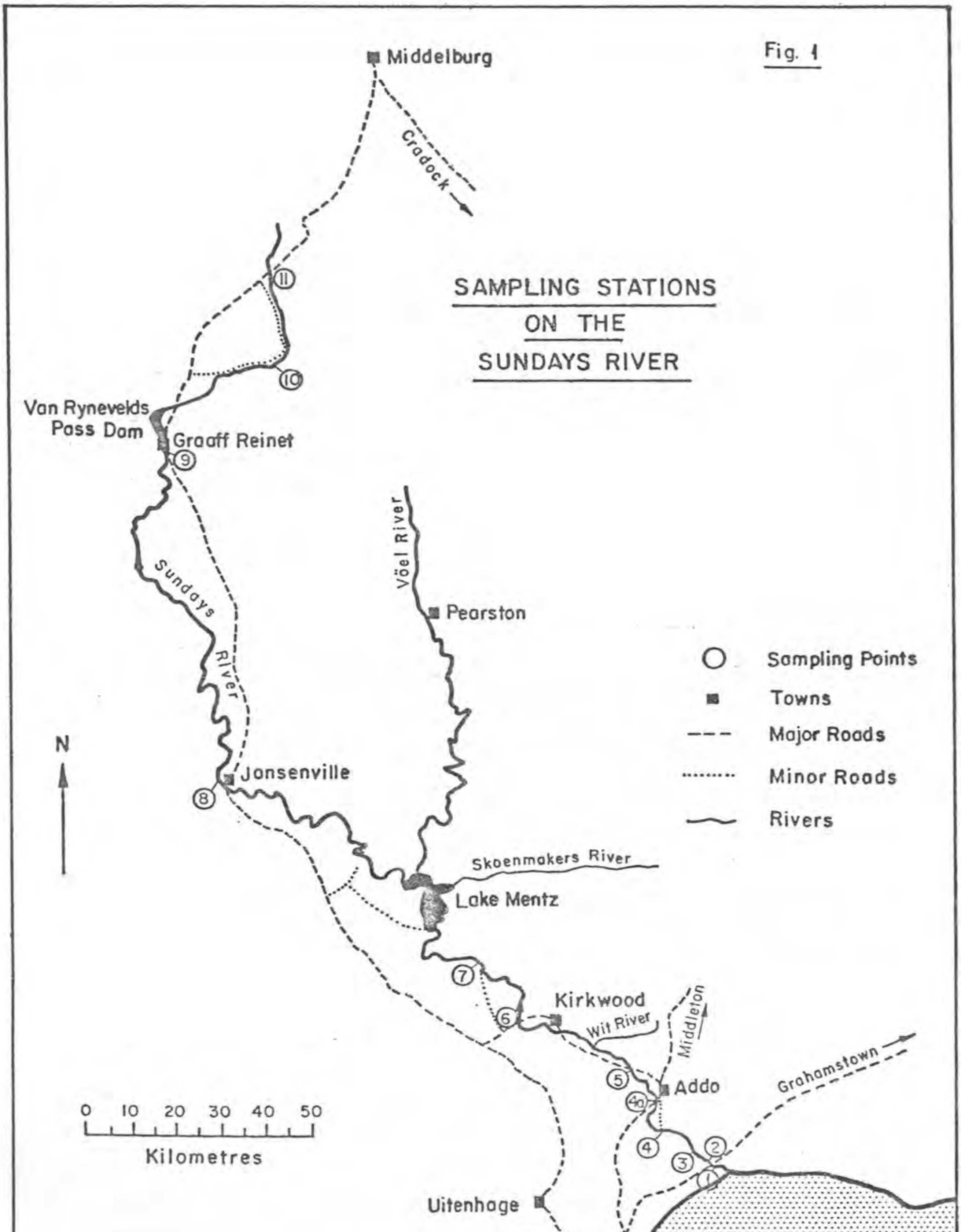

Fig. 1

SAMPLING STATIONS ON THE SUNDAYS RIVER

Station 8

Station 8 was situated about 1 km above Jansenville, where the river bed is rocky and silt laden. At this station the Sundays River was usually dry during drought. Diatom samples were collected, when possible, from the silty substrate in small pools.

Station 7

This sampling site, sampled only once owing to its inaccessibility, was found in the mountains above Korhaans Drift, where the river bed is used as an irrigation channel carrying water from Lake Mentz to the irrigation weir at Korhaans Drift. At the sampling site the river bed consisted of wide stony pools linked by shallow runs. Water flow was variable depending on irrigation turns. These turns ceased when Lake Mentz dried up in February 1968. Diatoms were collected from stones in a pool and in a stony run.

Station 6

Station 6 was the Sundays River at Korhaans Drift immediately below the irrigation weir. A large grass banked pool received seepage water from the weir wall, and drained into the river bed through a stony run. Diatom samples were collected from three different niches:-

(a) from the substrate on or among the stones of the stony run,
(b) from the substrate of the margins of the large pool, or from the rocks in this pool, and
(c) epiphytic diatom growth on reeds growing in this large pool.

Further more on two occasions samples were collected directly from seepages on the weir wall itself.

Station 5

The sampling site was located at the old causeway below the C.A. Barnes Bridge over the Sundays River above Sunlands on the road from Addo to Kirkwood. The Sundays River at this point consisted of fairly large stony pools with a good marginal growth of chiefly *Cyperus* and different grasses. Apart from some Potamogetonaceae there was little aquatic growth in the river. During late summer water flow practically ceased and the water turned very green, while the stones became encrusted with Cyanophyceae and soft calcareous material. The western bank at the sampling site was marshy due to seepages from the springs in the eroded river banks. A number of pools of variable size below these springs collected the seepage water. Diatom samples were collected from a number of different ecological niches:-

(a) from the rock or concrete substrate of the old causeway,

(b) from the rocks in a stony run about 100 m below (a),

(c) from the sediment surface in a large marshy pool on the edge of the river containing decaying organic matter,

(d) from a smaller pool closer to the seepages and further from the river bank.

(e) from the substrate (i.e. the river bank surface) over which the seepage itself trickles initially.

Station 4A

This station was found on the Sundays River at Addo, just above the Addo - Port Elizabeth road bridge. At this site the river consisted of long sandy pools linked by shallow runs. Marginal reeds and good growths of *Ruppia* in the pools were the dominant macrophytic plant growth in the river. Salinities were always high and were increased by extremely saline seepages, particularly from the east bank. During drought, flow almost ceased and salt crystallised out on the stones and margins. Diatoms samples were collected from the stones in the river, and on one occasion from the epiphytic growth on Potamogetonaceae. Diatom samples were also collected from a channel conveying seepage water from a large shallow pool on the eastern bank. This channel was usually lined with a thick yellow-brown skin-like growth of diatoms.

Station 4

Station 4 was located above the Barkly Bridge over the Sundays River, not far above the tidal influence. The site sampled for diatoms was a long sandy-bottomed pool with large beds of Potamogetonaceae, probably *Ruppia*. on some visits to this sampling point methane gas could be heard escaping from these beds. Diatoms were gathered from the sandy substrate and from epiphytic growth on the Potamogetonaceae.

Station 3

This sampling site was located on the farm Kleinvetmaakvlakte in the upper estuary of the Sundays River. The station was under the influence of the tides, and had a clay substrate supporting growths of *Juncus*, *Typha* and beds of Potamogetonaceae. During the drought of 1970 the beds of Potamogetonaceae and the reeds disappeared probably owing to salinities greater than seawater prevailing at this time. Diatoms were collected from the clay substrate and the epiphytic growth on the macrophytes.

Station 2

The Sundays River estuary above the MacKay bridge. Here the river is tidal with a clay bottom and a sparse growth of *Juncus*. Diatom samples were collected from the mud banks.

Station 1

The Sundays River estuary at Colchester. The river is tidal, with a clay bank supporting growths of *Zostera*. A number of wooden jetties project into the river at this point. In 1970 owing to construction work on the new national road bridge over the Sundays River having begun at the original sampling station, a new site was selected at another pier some 500 m further downstream. Diatoms were collected at both sites from scrapings taken from the mud surface and from the wooden pier columns.

In addition to the above sampling stations, a diatom sample was collected from the Wit River a short distance above its confluence with the Sundays River just below Kirkwood. A diatom sample (SUN 34 - NIWR) was scraped from the mud substrate in a large pool containing a good growth of aquatic plants such as *Limnanthemum*, *Aponogeton*, *Nymphaea*, *Potamogeton* and *Polygonum*. A sample (SUN 20 - NIWR) was also collected from the growth on rocks near the wall in Lake Mentz.

The table below (Table 1) summarizes the individual samples collected at different times at each station on the Sundays River. A set of these samples is housed in the diatom collection of the National Institute for Water Research (Pretoria) in the series SUN 1-86.

TABLE 1. The Sundays River samples collected from each station at different times.

Station	July 1967	February 1968	August 1968	February 1969	May 1970
11	26		43, 44		
10	25	27	45, 46, 47	60	
9	24	28	48	61	
8	21, 22, 23	29	49		
7	18, 19				
6	15, 16, 17	30, 31, 32, 33	50, 51, 52	62, 63	72, 73
5	8, 9, 10, 11, 12	35, 36, 37 38, 39	53, 54	64, 65 66	74, 75 76
4A	13, 14	40, 41	55, 56	67, 68	77, 78, 79
4	6, 7	42	57	69	80, 81
3	4, 5				82, 83
2	3				84
1	1, 2		58, 59	70, 71	85, 86
Lake Mentz	20				
Wit River		34			

B. THE GREAT FISH RIVER (Fig. 2)

Station 1

This station was found at Grassridge Dam on the Theebus River, a tributary of the Great Fish River. The dam was usually extremely silty with a mud and stony bank. Diatom samples were collected from the mud and stony substrate near the wall of the dam. A sample was also collected from a seepage below the dam wall.

Station 2

This station was located on the Great Fish River at Fish River Station. At this point the river consisted of long pools having a slow but seasonal

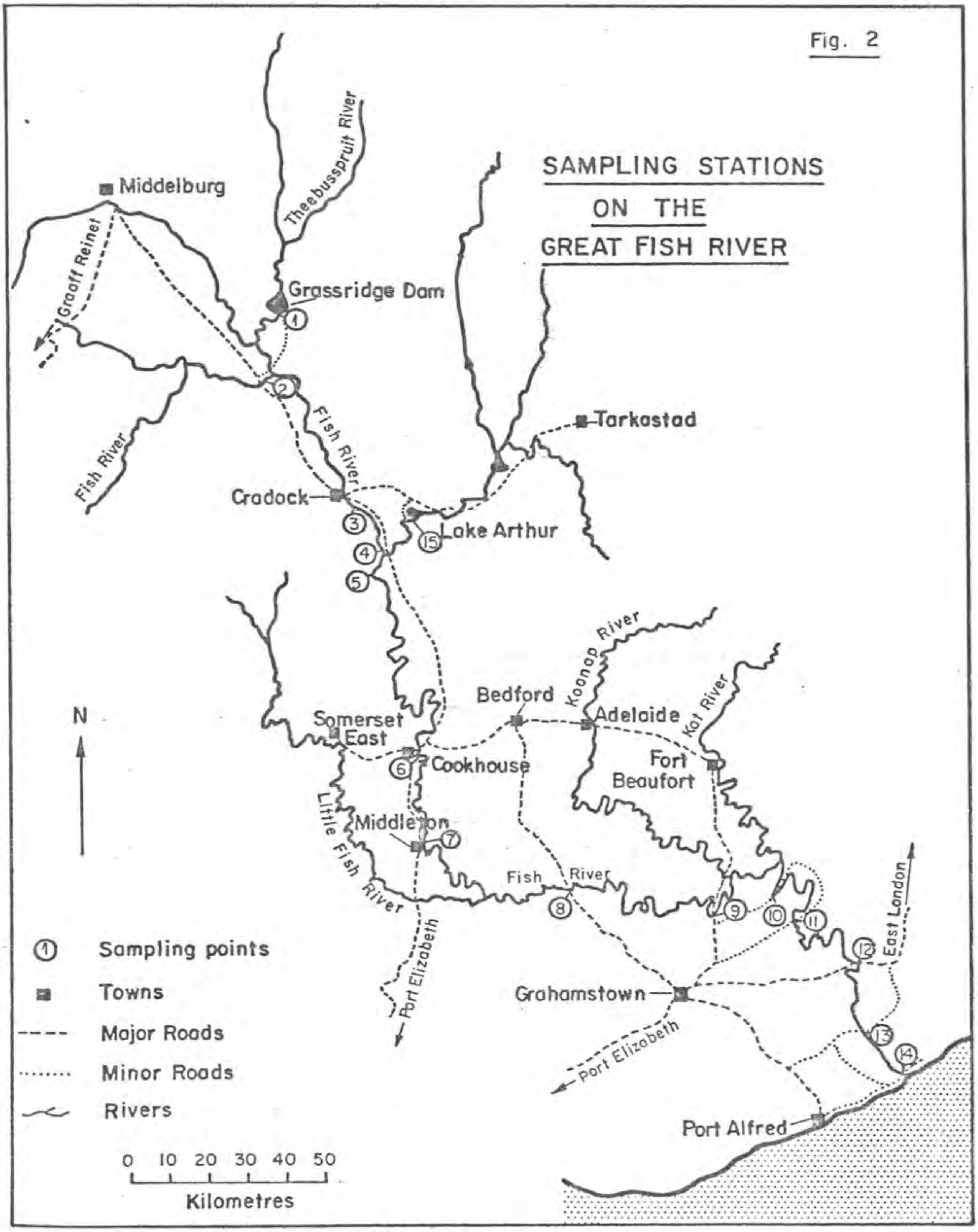

Fig. 2

SAMPLING STATIONS ON THE GREAT FISH RIVER flow. At times *Enteromorpha* and other algal growth was profuse. Diatoms were collected from the muddy substrate in the old drift.

Station 3

The third station was situated on the Great Fish River about 8,0 km below Cradock at Halesowen. There was usually a good flow of strongly polluted water, derived mainly or entirely from effluents from Cradock. No special ecological niche was sampled here, and diatoms were collected from the muddy substrate.

Station 4

This sampling site was found on the Great Fish River at the drift on the road to Limebank Station. It was sampled only once in February 1968, and at this time there was hardly any water flow.

Station 5

This station was located on the Great Fish River at the bridge just below the village of Mortimer. There was a small, clear seasonal flow. A single diatom sample was gathered here from the sparse diatom growth on a gravel and stony substrate.

Station 6

Station 6 was situated just below the municipal rubbish dump of the town Cookhouse. There was generally a small local flow of water due mainly or entirely to sewage effluent from the town. Samples for diatom analysis were taken from the muddy substrate and stones.

Station 7

The Great Fish River at this site near the village of Middleton consisted of large pools of standing water in drier periods. The pool beds were sandy, and at times *Enteromorpha* and other macroalgal growth was good. Diatoms were gathered from the sandy substrate.

Station 8

This is the Great Fish River at Carlisle Bridge on the Grahamstown - Bedford road. The sampling site consisted of large pools with sandy beds; water flow was discontinuous and often absent during the survey period. One diatom sample was collected from a water trickle over some rocks and from the silty substrate.

Station 9

This station was located on the Great Fish River below the bridge at Fort Brown. At the times of sampling there was never any flow. Diatoms were collected from the mud substrate in some large pools. These pools were often coated with a scum of cattle and sheep droppings and plant debris.

Station 10

This station was situated immediately below the low level causeway at Double Drift on the Great Fish River. It also lies below the confluences of the Koonap and Kat rivers draining the Adelaide and Fort Beaufort districts respectively. Diatoms were collected from the sediments on the rocks or from the muddy substrate in large pools. On one occasion there was a strong flow of water, but there were usually only large pools of standing water.

Station 11

The Great Fish River at Committees Drift. At this point the river consisted of a large pool, usually with no perceptible water flow. Diatoms were gathered from the algal growth covering the substrate, viz. stones, sticks and mud surfaces. On one occasion a seepage water in a small tributary at this point was also sampled.

Station 12

The Great Fish River at Hunt's Drift. This site was found at the bridge on the Grahamstown - East London road just below the old road bridge. On most sampling trips there were only large sandy pools, and diatoms were collected from the muddy substrate in these pools.

Station 13

This station was located at Kaffir Drift. Above and below the drift there were generally large pools of standing water. Although no evidence of tidal movement was experienced, it is thought to be the head of the estuary. The diatom communities from the mud surfaces of the pools on both sides of the causeway were sampled at various times.

Station 14

This sampling site was found just below the bridge on the Port Alfred - East London road at the mouth of the Great Fish River. This locality is tidal with estuarine conditions and permanent water. Diatoms were collected in the tidal zone from the substrate between the rocks.

Station 15

This station was situated at Lake Arthur, an impoundment on the Tarka River, a tributary of the Great Fish River having its confluence some distance below Cradock. A diatom sample was gathered here by scraping the dam wall of its diatom growth.

In addition to these stations a sample (FIS 14) was collected from a small tributary of the Great Fish River, the Kap River, near Cuylerville in the district of Bathurst.

Table 2 below indicates the dates on which the individual samples were collected at each station. A set of slides, numbered FIS 1 to 14, made from these samples, is kept in the diatom collection of the National Institute for Water Research in Pretoria.

TABLE 2. The Great Fish River samples collected from each station at various times

Station	July 1967	February 1968	August 1968	February 1969
1	1	7, 8		34
2			20	33
3		6	19	32
4		5		
5				31
6		4	18	30
7		3	17	29
8			16	
9		9	21	35, 36
10		10	22	37
11		11	23, 24	38
12		12	25	39
13		13	26, 27	40
14		15	28	41
15	2			
Kap River		14		

TAXONOMIC COMMENTARY

The following pages contain a taxonomic commentary on all the diatom taxa observed in the Sundays and Great Fish rivers. The inventory is alphabetically arranged and each species is treated in the manner described above.

ACHNANTHES Bory 1822 : 79

Achnanthes brevipes Agardh

Agardh, 1824 : 1.

Taxonomic notes: Giffen (1971 : 1, Fig. 1) recorded a number of valves of this species with large hyaline 'eyespots' (orbiculi) replacing two or three terminal rows of 'alveolae' (areolae) on the epivalve. Hendey (1957 : 55) also reported this feature calling it "one large areole" (orbiculus) on the epivalve, and used it as a diagnostic character to describe a new species, *Achnanthes kuwaitensis* Hendey (l.c.). Giffen (l.c.) does not, however, regard this feature as diagnostic, and maintained that *A. kuwaitensis* is nothing other than *A. brevipes* with this peculiarity. The single specimen of this taxon observed in the Sundays River did not throw any light on this problem, being a normal valve 38,0 µm long, 10,7 µm broad and having 8 transapical striae in 10 µm . Giffen (1963 : 211) believed that *A. kuwaitensis* is, on account of its structure, best placed with *A. brevipes* var. *intermedia* (Kützing) Cleve (see below).

Euryhaline mesohalobe - 5

Samples: SUN 68

Achnanthes brevipes var *intermedia* (Kützing) Cleve

Cleve, P.T. 1895 : 193.
Hustedt, 1931-59 : 425, Fig. 877d, e.

Synonyms: *Achnanthes intermedia* Kützing

Taxonomic notes: In his "Synopsis of the Naviculoid Diatoms" Cleve (1895 : 193) commented that "*A. brevipes* is an exceedingly variable species, ...", and stated that the characteristics differentiating many of the varieties "are such trifling ones as the shape of the valve, the size of the stipes, the excentricity of the axial area of the upper valve, etc.". There is, therefore, a very great likelikhood that linking forms between many of the varieties will be discovered. For this very reason Giffen (1966a : 248) placed *A. brevipes* var. *angustata* (Grunow) Cleve (1895 : 194) with the var. *intermedia*. Furthermore Giffen (1963 : 211; 1966a : 248) has recorded specimens of var. *intermedia* with striae as few as 6 in 10 µm . For comment on the taxonomic position of *A. kuwaitensis* Hendey see *A. brevipes* above.

Euryhaline mesohalobe - 5

Figs: 69, 70

Samples: SUN 2, 11, 12, 14, 38, 39, 40, 59, 70, 76, 79, 80, 81, 83, 85.

Achnanthes brevipes var. *parvula* (Kützing) Cleve

Cleve, 1895 : 193.
Hustedt, 1931-59 : 426, Fig. 877f-i.

Synonyms: *Achnanthes parvula* Kützing 1844 : 76, Pl. 21, Fig. 5.

Description: Valves small, elliptical with broadly rounded poles; 10,0 - 30,0 µm long, 5,0 - 8,0 µm broad. Epivalve with a slightly eccentric linear axial area running parallel to the valve margin; transapical striae punctate, parallel in the middle and slightly convergent at the poles, 10 - 18 in 10 µm . Hypovalve with a filiform raphe having relatively closely placed central pores curved towards the same side of the valve; central area a narrow transverse band reaching the valve margin, sometimes wider on one side of the valve than on the other; Transapical striae fine, but distinctly punctate, 12 - 17 in 10 µm, radial throughout.

Taxonomic notes: McIntyre and Reimer (1974 : 174, Fig. 3) illustrated a small *Achnanthes* species, which they hesitantly assigned to the species *A. parvula* Kützing (1844 : 76) with a note that it appeared to have some connection with *Achnanthes brachypus* (sic) described by Montagne. *A. parvula* has long been recognised as a synonym of *A. brevipes* var. *parvula*, and it is to this taxon that Montagne's specimens belong despite the presence of orbiculi ('eye spots') at each pole of the epivalve. In A. Schmidt's Atlas (Schmidt *et al.*, 1874-1959 : Pl. 417, Figs 20-22) Hustedt illustrated examples of the epivalves of *A. parvula* (= *A. brevipes* var. *parvula*) with orbiculi. He used this feature to resurrect Kützing's species. However, as Giffen (1971 : 2) has pointed out, orbiculi can be found fairly frequently in both *A. brevipes* and its variety, var. *intermedia*. There is therefore no justification for using orbiculi as a distinguishing character for the var. *parvula*, and the presence of such structures in this variety provides greater support for its inclusion with *A. brevipes*.

Euryhaline mesohalobe - 5

Figs: 71-74

Samples: Sun 2, 86,

Achnanthes engelbrechtii Cholnoky

Cholnoky, 1955a : 16, Figs 1-8.

Synonyms: *Achnanthes engelbrechtii* var. *minuta* Cholnoky, 1955a : 16, Figs 9, 10.

Taxonomic notes: According to Cholnoky (l.c.) this species is close to *A. pinnata* Hustedt (1937-38 : 201, T.13, Figs 54-57) and can be distingquised from it through its lanceolate and, at the poles, more or less protracted valve shape, as well as its closely positioned central pores on the hypovalve. Furthermore the presence sometimes of a small central area in both epi- and hypovalves is a feature not found in *A. pinnata*, while the striae themselves are not as coarse as those of Hustedt's species. The validity of these differences cannot be substantiated without reference to Hustedt's type material from the Toba Lake. Cholnoky's species is therefore accepted here.

Euryhaline mesohalobe - 5

Figs: 75-80

Samples: Sun 4-10, 13, 15, 18, 19, 22, 36, 41, 55, 69, 75-77.

Achnanthes exigua Grunow

Grunow in Cleve et Grunow, 1880 : 21.

Hustedt, 1931-59 : 386, Fig. 832a, b.

Schoeman et Archibald, 1976-80 : No. 3.

Synonyms: *Stauroneis exilis* Kützing, 1844 : 105, Pl. 30, Fig. 21.
Achnanthes exigua var. *elliptica* Hustedt, 1937 : 197, Pl. 9, Figs 8, 9.
Achnanthes exigua var. *heterovalva* Krasske, 1923 : 193, Figs 9a, b.
Achnanthes exigua var. *constricta* (Grunow) Hustedt, 1921 : 145, Figs 7, 8.

Description: Valves with almost elliptical, linear-elliptical to nearly quadratic central portion, sometimes with one or both margins of the larger forms constricted in the centre; poles greatly variable from slightly protracted, broadly subrostrate apices to abruptly narrowing rostrate to capitate poles; length 5,6 - 18,0 µm, breadth 3,4 - 7,0 µm .

Raphe valve: raphe straight and filiform, central pores usually conspicuous, but terminal fissures indistinct. Axial area narrow, linear, usually with an abrupt funnel-shaped widening near the central pores; central area a transverse fascia reaching the margins of the valve where it is usually broader than at the centre. Transapical striae radial throughout, (22)24 - 36 in 10 µm near the centre, becoming denser at the poles.

Rapheless valve: axial area narrow, linear to lanceolate; central area either lacking or variable in shape due to shortening, widening or complete absence of central striae, thereby producing a single or double sided asymmetrical central area. Transapical striae usually more robust and less radial than on the raphe valve, those in the middle being sometimes parallel to slightly convergent, (19)20 - 26 in 10 µm near the centre, increasing in density towards the poles.

Taxonomic notes: Schoeman and Archibald (1976-80 : No. 3) have shown clearly that *A. exigua* is an extremely variable taxon with respect to its morphology. Although many varieties and forms have been described, only three varieties, apart from the nominate variety, have been recorded from southern Africa. These varieties are var. *constricta* (Grunow) Hustedt (1921 : 145, Figs 7, 8), var. *elliptica* Hustedt (1937-38 : 197, Pl. 9, Figs 8, 9) and var. *heterovalva* Krasske (1923 : 193, Figs 9a, b - not spelt *heterovalvata* as is commonly accepted following Hustedt (1931-59 : 387). Both var. *constricta* and var. *heterovalva* have been shown by Schoeman and Archibald (l.c.) to be part of the normal range of variation of the nominate variety with no grounds for separating them as distinct varieties. They have consequently been included as more recent synonyms of *A. exigua*. The same will probably apply to the var. *elliptica* and possibly to the nine varieties and forms reported from Senegal by Guermeur (1954 : 31, Pl. 2, Figs 3a-m). However neither the type material nor sufficient examples of these forms have been studied to make positive decisions on their taxonomy and systematics.

Meioeuryhaline oligohalobe - 1

Samples: SUN 16, 17, 30, 32, 34, 63.

Achnanthes hauckiana Grunow

Grunow in Cleve et Grunow, 1880 : 21.
Grunow in Van Heurck, 1880-83 : Pl. 27, Figs 14, 15 (as *A. hauckii*).
Hustedt, 1931-59 : 388, Fig. 834.

Taxonomic notes: This species appears to be yet another very variable taxon (cf. Hustedt, 1939 : 607; Simonsen, 1962 : 41). A recent study by Tropper (1975) of two populations of *A. hauckiana* from the Great Sippewisset Marsh showed the complete range from small elliptical forms to large rostrate specimens. A similar range of variation is illustrated by Lee, McEnery, Kennedy and Rubin (1975). There appears therefore no good reason to distinguish the varieties, var. *elliptica* Schulz and var. *rostrata* Schulz (1926 : 191, Figs 39, 40). In South Africa Cholnoky (1959 : 8, Figs 40, 41; 1968a : 13, Figs 3, 4) has recorded both small elliptical forms and small rostrate examples of *A. hauckiana*. The smallest specimens observed in the Sundays and Great Fish rivers (Figs) were also slightly rostrate. Some specimens from these two rivers also had finer striation, 16 striae in 10 µm, but this also agrees with Tropper's (1975) findings.

Euryhaline mesohalobe - 5

Figs: 1, 2

Samples: SUN: 11, 16-19, 32, 57, 58, 61, 69, 72, 76, 82-85.
FIS: 16-18, 21, 26, 27, 29-31, 36, 40.

Achnanthes lanceolata (Brébisson) Grunow

Grunow in Cleve et Grunow, 1880 : 23.
Grunow in Van Heurck, 1880-83 : Pl. 27, Figs 8-11.
Hustedt, 1931-59 : 408, Fig. 863.

Synonyms: *Achnanthes lanceolata* var. *elliptica* Cleve, 1891 : 51, Pl. 3, Figs 10, 11.
Achnanthes lanceolata var. *rostrata* (Østrup) Hustedt, 1911 : 279, Pl. 3, Fig. 34.

Taxonomic notes: In the Sundays and Great Fish rivers the range of variation in valve shape provided a series in which it was impossible to distinguish between the two varieties listed as synonyms above and the nominate variety. Cholnoky (unpublished manuscript) maintained that, since there were so many synonyms, covering many different form variations, associated with this species, a range of forms with many intermediates linking the extremes was indicated. The material examined in this study tends to support this hypothesis. Hustedt (1911 : 279) in his description of var. *rostrata* suggested himself that the var. *dubia*, now a synonym of var. *rostrata*, could be regarded as a transitional form between var. *rostrata* and the nominate variety.

Mesoeuryhaline oligohalobe - 2

Samples: SUN: 27, 43-47, 60, 62, 66.
FIS: 8, 12, 16, 20, 21, 33.

Achnanthes linearis (W. Smith) Grunow

Grunow in Cleve et Grunow, 1880 : 23.
Hustedt 1931-59 : 378, Fig. 821a, b.
Carter, 1961 : 39, Figs 94-99.

Synonym: *Achnanthidium lineare* W. Smith, 1856 : 31, Pl. 61, Fig. 381.

Taxonomic notes: The relationship between this species and *A. minutissima* is difficult to determine. Hustedt (l.c.) claimed that the relatively greater breadth of *A. linearis* was, apart from the coarser striation, a distinguishing feature between the two species. However in his paper on the diatoms of the Sunda Islands Hustedt (1937-38 : 192, Pl. 13, Figs 41-46) described a new variety of *A. minutissima*, var. *robusta*, distinguishing it from the nominate variety on the grounds of its relatively broader valves and coarser striation. This variety fits almost perfectly the diagnosis of *A. linearis*. Hustedt recognised this close relationship, but felt the variety could not be connected to *A. linearis* for the sole reason that the latter did not occur in the Sunda Islands. Furthermore in the same paper Hustedt (l.c.: 194, Pl. 13, Figs 37-40) described a new species, *A. crassa*, which, apart from the finer striation, is in all other respects identical with *A. linearis* var. *pusilla*. Here also the possibility that the var. *pusilla* can be considered a species in its own right is suggested by Cholnoky (unpublished manuscript). It is obvious, therefore, that an extremely careful study of *A. linearis* and its close relatives is necessary.

Meioeuryhaline oligohalobe - 1

Samples: SUN: 11.

Achnanthes minutissima Kützing

Kützing, 1833 : 578, Fig. 54.
Hustedt, 1930 : 198, Fig. 274.
Hustedt, 1931-59 : 376, Fig. 820a-c.

Taxonomic notes: Although *A. minutissima* is a very common and well known species throughout the world, a careful revision of this species in relation to the very similar *A. linearis* (W. Smith) Grunow (cf. above), and a few more recently described species and varieties is necessary. Hustedt (1937-38 : 192, Pl. 13, Figs 41-46) described a new variety, *A. minutissima* var. *robusta*, differing from the nominate variety in its coarser striation (26 striae in 10 µm) and broader valves. This variety appears to be more closely related to *A. linearis*, a fact recognised by Hustedt himself although he felt he could not combine it with *A. linearis* simply because the latter did not occur in the region he was investigating. This is a very flimsy ground for separating the two taxa. In the same publication Hustedt (l.c.) described a new species, *A. crassa*, which differed from *A. linearis* in its compact ("gedrungene") form, and finer striation. However the dimensions and striae number of *A. crassa* fit quite easily into the range of variation for *A. linearis*. It is therefore suggested that the two species are the same. Without an examination of the original material of these species and varieties, it is difficult to draw accurate conclusions. Nevertheless there is a possibility that all these forms compose a series of morphological variations of a single species influenced by environmental factors.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 1-10, 13, 21, 22, 26, 33-36, 41, 45, 48, 53, 54, 61, 65-67, 70, 74.
FIS: 3, 8, 10, 12-14, 18, 20.

Achnanthes punctifera Hustedt

Hustedt, 1955 : 18, Pl. 5, Figs 26-28.

Description: Valves elliptic-lanceolate with broadly rounded, sometimes slightly rostrate poles, 11,5 - 27,0 µm long, and 4,5 - 7,0 µm broad.

Rapheless valve: axial area very narrow; transapical striae parallel at the centre and becoming radial towards the poles, about 28 in 10 µm .

Raphe valve: raphe straight and filiform; axial area narrow, linear; central area variable from no marked expansion of the axial area to a small rounded central area; on one side of the central nodule a single isolated stigma is present; transapical striae radial throughout, 24 - 28 in 10 µm.

Taxonomic notes: As far as can be determined this small and delicate *Achnanthes* species has not previously been identified from South Africa or any other place outside its type locality, the marine littoral in the harbour of Beaufort, North Carolina (U.S.A.), where it was said to be rather scarce. In South Africa this may be the result of misidentification as *Navicula bahusiensis* Grunow (1884 : 104) or as *Navicula bremeyeri* var. *rostrata* Hustedt (1939 : 624, Figs 73, 74). The latter was later transferred by Hustedt (1961-66 : 269) to the species *N. bahusiensis* as a later synonym of it. Cholnoky's (1960a : 52, Figs 160, 161) illustrations of *N. bremeyeri* var. *rostrata* are identical to the raphe valves of *Achnanthes punctifera* as described above, and personal examination of some specimens on Cholnoky's Slide No. TUG 366 (NIWR) confirmed this. It is thus reasonable to assume that Cholnoky's (1968a : 45) later observations of *N. bahusiensis* are also the same. Although Giffen's material has not been examined, it is probable that his records of *N. bahusiensis* from Kidd's Beach (Giffen, 1966a : 266, Fig. 56) and the Kowie River estuary (Giffen, 1970a : 280) would conform to the raphe valves of *A. punctifera*.

The rapheless valve of *A. punctifera* is very delicately silicified and is consequently difficult to see, particularly when still attached to the raphe valve. On its own the raphe valve, with its isolated stigma on one side of the central nodule, conforms very closely to the description of *N. bahusiensis* given by Hustedt (1961-66 : 267, Fig. 1396). Misidentification is thus very easy. The very close similarity shown by these two species, both of which are marine, leads one to suggest that a careful re-examination of the type material of both species is necessary. It is possible that Grunow's *N. bahusiensis* is in fact the raphe valve of an *Achnanthes*, whose rapheless valve remained undetected owing to the poorer optics of Grunow's day. This species has then been subsequently rediscovered and described as new by Hustedt (1955 : 18, Pl. 5, Figs 26-28) under the name *A. punctifera*. If this conjecture is true then Hustedt's taxon, *A. punctifera*, would have to be sunk, as a later synonym, into Grunow's species, which would then adopt the correct combination of *Achnanthes bahusiensis* (Grunow) nov. comb. This can, however, only be verified by examination of the relevant type material.

The specimens observed in the Sundays River appeared to be morphologically identical to Hustedt's taxon, but were somewhat smaller than the dimensions given in his description. The local examples had lengths as short as 11,5 µm and breadths going down to 4,5 µm .

Mesoeuryhaline polyhalobe - 8

Figs: 81-83, 489

Samples: SUN: 58, 59, 80-83, 85.

AMPHIPRORA Ehrenberg, 1841 (1843) : 401, 410

Amphiprora cholnokyi VanLandingham

VanLandingham, 1967 : 162.
Hustedt, 1930 : 338, Fig. 623 (under the name *Amphiprora costata*).

Synonyms: *Amphiprora costata* Hustedt, 1930 : 338, Fig. 623.
Amphiprora hustedtii Cholnoky, 1960a : 20.
Amphiprora hustedtii var. *africana* Cholnoky, 1960a : 20, Figs 49, 50.
Amphiprora cholnokyi var. *africana* Cholnoky (cf. VanLandingham, 1967 : 162).

Taxonomic notes: The single example of this *Amphiprora* is placed in this species on account of the prominent ribs in the keel. The broken valve, observed in the Kap River near Bathurst (probably a brackishwater stream) had, however, dimensions somewhat smaller than those given in the description. If the distance from a pole to the central nodule is considered half the valve length, this valve can be estimated as being about 25 µm long, the width at the constriction was 4 µm, while the maximum width in the only complete half of the valve was 7,8 µm . While the striae number agreed with the description, the number of ribs were slightly more than quoted, i.e. 10 in 10 µm . This species has in recent years undergone two name changes. Because *A. costata* is a homonym, Cholnoky (1960a : 20) changed Hustedt's epithet to *A. hustedtii* Cholnoky, which was itself a later homonym. Accordingly VanLandingham (1967 : 162) renamed it *A. cholnokyi*. Although the variety, var. *africana* (Cholnoky, 1960a : 20), is retained by VanLandingham (l.c.), Cholnoky (1968 : 16) sank the variety into the species, since he observed a number of intermediate forms.

Euryhaline mesohalobe - 5

Samples: FIS: 14.

Amphiprora corrugata Giffen

Giffen, 1963 : 213, Figs 6, 7.

Taxonomic notes: A few typical examples of this species were observed in seepage water pools at Station 5, and need little comment. The original diagnosis of Giffen (1963 : 213) must, however, be amended to include some much larger specimens recorded from the Lake Sibaya - Kosi Bay region, where a speciment 138,0 µm long was observed (Archibald, 1966 : 480). The width of this valve at the constriction was 12,0 µm, and its maximum breadth 24,5 µm . One specimen from the Sundays River (Sample SUN 11) showed up to 9 girdle bands (Giffen gave only 5), and there could have been more, as those that were observed were attached to only one valve. These girdle bands had 20 - 22 fine dash-like striae in 10 µm .

Euryhaline mesohalobe - 5

Figs: 84-86

Samples: SUN: 11, 12, 76.

Amphiprora duplex Donkin

Donkin, 1858 : 18, Pl. 3, Fig. 13.
Cleve, 1894 : 15 (under *A. paludosa* var. *duplex*).

Synonyms: *Amphiprora paludosa* W. Smith var. *duplex* (Donkin) Van Heurck, 1885 : 121.

Taxonomic notes: According to Cholnoky (unpublished manuscript) there are no grounds for including *A. duplex* with *Amphiprora paludosa* W. Smith (1853 : 44, Suppl. Pl. 31, Fig. 269), since it has no real morphological similarity. The specimens of *A. duplex* observed in the Sundays River corresponded more to the smaller examples, being 24,0 - 32,0 µm long.

The valve width was 2,0 - 3,5 µm at the constriction, and 4,0 - 6,0 µm wide at the broadest part of the valve. The transapical striae varied from 36 in 10 µm to being too fine to resolve under the light microscope. Too few speciments of this taxon were studied to be able to comment further on its taxonomy, or to provide an improved description.

Mesoeuryhaline polyhalobe - 8

Figs: 87, 88

Samples: SUN: 35, 39, 80, 81, 84.

Amphiprora paludosa W. Smith

W. Smith, 1853 : 44, Suppl. Pl. 31, Fig. 269.
Cleve, 1894 : 14.
Hustedt, 1930 : 339, Fig. 634.

Taxonomic notes: Whether there is justification for separating *A. paludosa* from its variety, var. *subsalina* Cleve (1894 : 14, Pl. 1, Fig. 1), is a question which is not yet satisfactorily resolved. Cleve apparently distinguished between the two varieties mainly on the number of striae. Hustedt (l.c.) accepted this distinction with the addition that the dividing line between the keel and surface of the valve is strongly angular in var. *subsalina*. According to Cholnoky (1966c : 161) the distinction between the varieties is no longer recognised by Hustedt in his later works. Cholnoky, however, maintained Cleve's divisions only because he had found no intermediate forms. W. Smith (1853 : 44) gives 23,6 striae in 10 µm in his original description and his illustration exemplifies a specimen with a relatively angular dividing line of the keel. Cleve's (l.c.) drawing of the var. *subsalina* is very similar, particularly in regard to the latter characteristic. This evidence suggests that there is not much justification for a separation of the two varieties, but, as with Cholnoky, no concrete evidence of intermediates has yet been observed in this study. The great majority of the valves found in the region under investigation belong to the var. *subsalina*. The few valves of *A. paludosa* had 21 striae in 10 µm, which is slightly higher than the values given by Cleve (1894) and Hustedt (1930).

Euryhaline mesohalobe - 5

Samples: SUN: 4, 5, 48, 61.
FIS: 17, 18.

Amphiprora paludosa var. *subsalina* Cleve

Cleve, 1894 : 14, Pl. 1, Fig. 1.
Hustedt, 1930 : 340.

Taxonomic notes: This is the commonest form in which this species occurs in the Sundays and Great Fish rivers. A discussion of its taxonomy in relation to the nominate variety is given above.

Euryhaline mesohalobe - 5

Samples: SUN: 6-13, 21-24, 28, 76.
FIS: 4, 6, 10, 16-18, 29-31.

AMPHORA Ehrenberg, 1840 : 11

Amphora acutiuscula Kützing

Kützing, 1844 : 108, Pl. 5, Fig. 32.
Grunow in Van Heurck, 1880-83 : Pl. 1, Fig. 18.
Van Heurck, 1885 : 57.

Description: Valves semi-lanceolate with convex dorsal margin and more or less straight to slightly concave ventral margin, poles produced into distinctly capitate apices; length 18,1 - 49,5 μm, breadth 3,4 - 6,4 μm . Raphe straight and filiform; proximal ends very slightly deflected dorsally, central pores small and not distinguished from the raphe fissure; terminal fissures not prominent, merely simple deflections of the raphe fissure to the dorsal side of the apex. Axial area very narrow on the dorsal side and wider on the ventral side; central area absent on the dorsal side, but present on the ventral side due to the lack of striae at the centre of the valve. Transapical striae on the dorsal side radial throughout, more or less distinctly punctate, 15 - 20 in 10 μm near the centre, and somewhat denser at the poles (20 - 24 in 10 μm); striae on the ventral side marginal dashes, visible generally only near the centre, and sometimes only in oblique light, 22 - 28 in 10 μm .

Under the electron microscope (Figs 490-492) each stria is composed of a single row of simple pores extending about a half to two thirds of the way from the dorsal margin to the raphe, after which the striae are composed of two rows of small roundish, roughly alternately arranged pores. In TEM the ends of the striae just above the raphe are crossed by a longitudinal siliceous bar. This bar is probably the upper edge of the dorsal extension of the axial rib forming the thin siliceous flap, which is quite pronounced in this taxon. The valve face appears to curve quite abruptly under this flap.

Taxonomic notes: Taxonomic discussion of this species is perforce limited, since not enough is known of the taxon to provide a precise definition or description of the species. A slide (BM 18173), supposedly the type slide of *A. acutiuscula*, was obtained from the British Museum (Natural History) and examined. There were few *Amphora* specimens in this material from Genoa (Kützing Material No. 252), and these comprised three different but rather similar entities. There is thus some uncertainty as to which of the three is the proper *A. acutiuscula*. None of these specimens had very clearly punctate striae, but most had a distinct longitudinal band traversing the striae near the raphe. Van Heurck's Slide No. 261 of *A. acutiuscula* (from the collections at both the British Museum and at Vienna) has also been examined. These specimens had a similar valve shape, but the striae were more or less distinctly punctate. A longitudinal line was present but was not distinct. Patrick and Reimer (1975 : 77, P. 14, Figs 9, 10) described and figured a taxon which is also similar in outline, but is somewhat less densely striate than Kützing's specimens on the slide BM 18173. Patrick and Reimer's examples from the Sabine River, Texas, had 10 - 12 striae in 10 μm at the centre becoming 15 - 16 in 10 μm at the poles. On the other hand the majority of Kützing's specimens has 15 - 16 striae in 10 μm at the centre, becoming 18 - 20 in 10 μm at the poles. Van Heurck's Slide No. 261 had valves with 14 - 16 striae in 10 μm near the centre and 16 - 20 in 10 μm at the poles, while on the ventral side there are 16 - 20 striae in 10 μm . There is thus a significant discrepancy amongst the different materials reputed to contain *A. acutiuscula*, and a great deal more detailed study is required to elucidate and define the true *Amphora acutiuscula*.

In this study the concept of *A. acutiuscula* is confined to those specimens having more or less distinctly punctate striae. The puncta are described as more or less distinct because, although they are clear in comparison with the striae of closely related species (e.g. *A. coffaeaformis* and *A. sabiniana*), the puncta themselves are not sharply defined, but more diffuse in nature, merging slightly with the rest of the striae. These speciments may not, however, be the true *A. acutiuscula* when compared with Kützing's material, but they are very similar in striae structure to the examples on Van Heurck's Slide No. 261. Specimens appearing to be more closely allied to the majority of Kützing's examples have been considered elsewhere in this study as *A. exigua*, but there is some uncertainty concerning the correctness of this identification (see below).

Cholnoky's concept of *A. acutiuscula* from Southern Africa is also somewhat ill defined. Most of his material, which was examined, contained valves semi-elliptical to semi-lanceolate in shape with distinctly capitate poles, and more or less distinctly punctate striae. These specimens were, however, quite similar to those observed in the Sundays River.

Euryhaline mesohalobe - 5

Figs: 3, 4, 89-92, 490-492

Samples: SUN: 6, 35-37, 40, 42, 64-66, 68, 69, 71, 74, 77, 80.

Amphora angusta Gregory

Gregory, 1857 : 510, Pl. 12, Fig. 66.
Cleve, 1895 : 135.
Cholnoky, 1960a : 21, Figs 51-53.

Taxonomic notes: The specimens placed in this species were based on Cholnoky's (l.c.) definition of the taxon. Cholnoky was satisfied that the examples he illustrated concurred with Cleve's (l.c.) description, for which there is no illustration. The exact definition of this taxon is, however, somewhat uncertain. Cleve, it seems, had no clear concept of the species since he wrote "The figure of *A. angusta* in Diat. of the Clyde is not sufficient for identification without original specimens, but as in the description is stated that it has 17 to 18 striae in 0,01 mm . I think that *A. angusta* Greg. may denote this form". The figure in Gregory's Diatoms of the Clyde (Gregory, 1857 : Pl. 12, Fig. 66) is indeed poor, but there are features which do not reconcile it with later illustrations of the species. Cleve cited a drawing in Schmidt's Atlas (cf. Schmidt *et al.*, 1874-1959 : Pl. 25, Fig. 15) as illustrating *A. angusta*, and this drawing may have caused considerable confusion in later years. Despite Gregory's poor drawing it seems quite clear that the raphe of *A. angusta sensu* Gregory is strongly arcuate running from the central nodule up to the dorsal margin of the valve. The strongly arcuate raphe is also drawn by Van Heurck (1896 : 130, P. 24, Fig. 674), whose illustration is probably a copy of Gregory's. The position and shape of the raphe in Gregory's and Van Heurck's drawings are in sharp contrast with the raphes depicted in Schmidt's Atlas (cited above) and the illustrations of Cholnoky (1960a : 21, Figs 51-53). In the latter cases the raphe is straight, running along the ventral margin. Cleve's reason for relating Schmidt's illustration to Gregory's species is the number of striae, which can only be considered a tenuous link. To add further to the confusion Fig. 15 on Pl. 25 of Schmidt's Atlas is given as a variety of *A. angusta* Ehrenberg, not Gregory. This variety is regarded as synonymous with *A. angusta* Gregory (cf. VanLandingham, 1967 : 191), while the nominate variety, *A. angusta* Ehrenberg (non Gregory) is a synonym of *Amphora cymbelloides*. At the same time some small forms depicted by Schmidt (cf. Schmidt *et al.*, 1874-1959 : Pl. 26, Figs 65, 66) as *A. angusta* f. *minuta* are also considered as synonymous with *A. cymbelloides*. These forms, however, had a raphe position and shape very much closer to the original drawings of *A. angusta* Gregory. It is evident therefore that there is tremendous confusion concerning the true identity of *A. angusta* Gregory, and this can only be solved by studying the type material of the taxon. It is suggested, nevertheless, that our present concept of *A. angusta* Gregory, based on Cleve's (1895 : 135) definition of the species, may be erroneous.

Pleioeuryhaline polyhalobe - 7

Figs: 93

Samples: SUN: 11, 12, 59, 76.

Amphora castellata Giffen

Giffen, 1963 : 216, Figs 13, 14.

Synonyms: *Amphora turgida* var. *africana* Cholnoky, 1962a : 11, Figs 15-17.
Amphora sydowii Cholnoky, 1963a : 237, Figs 3-6 e.p.

Description: Valves semi-lanceolate with convex dorsal margin, often somewhat to fairly strongly constricted at the centre; ventral margin more or less straight, sometimes slightly inflated at the centre or even somewhat constricted; poles protracted into long narrow, rostrate to capitate apices; length 15,2 - 67,1 µm, breadth 2,7 - 6,1 µm . Raphe straight and filiform, central pores not differentiated from the raphe fissure, terminal fissures short and dorsally deflected. Axial area very narrow on the dorsal side and somewhat broader on the ventral side; central area on ventral side only due to interruption of the ventral striae. Transapical striae on the dorsal side radial throughout, more strongly so at the poles, fairly coarse and not punctate, 19 - 21 in 10 µm near the centre, becoming slightly denser at the poles (20 - 24 in 10 µm); dorsal striae on the valve face crossed by one (usually) or more longitudinal lines (thickened costae); ventral striae a series of short marginal dashes, most often interrupted at the centre, 28 - 32 in 10 µm .

Under the electron microscope (Figs 493, 494) the dorsal striae are shown to be elongate alveoli covered by a finely porous membrane. On the valve face each stria generally consists of two such alveoli separated by a thick longitudinal costa (the longitudinal line in LM). Occasionally the striae are broken up into more than two alveoli each by a number of irregular longitudinal costae of variable length and position. The ventral striae are narrow transapical slits in the basal membrane. Typical of many *Amphora* species, SEM studies have revealed that the dorsal edge of the axial rib containing the raphe has been extended upwards to form a thin siliceous flap partially covering the proximal ends of the striae (Figs 495, 496). At the centre of the valve the valve face appears to be somewhat folded inwards.

Taxonomic notes: This taxon belongs to the group of species comprising the *Amphora coffaeaformis* complex. It was first described by Cholnoky (1962a : 11, Figs 15-17) from the Western Cape Province as *Amphora turgida* var. *africana*. However from Gregory's description of *A. turgida* (cf. Gregory, 1857 : 510, Pl. 12, Fig. 63) it differs too greatly to be considered as a variety of *A. turgida*, and consequently the variety has been raised to the rank of species. The very same taxon was included by Cholnoky (1963a : 237, Figs 3-6 e.p.) in his circumscription of the new species *A. sydowii*. Unfortunately Cholnoky did not designate any particular slide as the syntype of *A. sydowii*. Examination of all the slides containing *A. sydowii* revealed that Cholnoky's circumstription of this species actually embraced three different elements. Two of these can be identified with *A. coffaeaformis* and *A. acutiuscula* as described in this study. The third and remaining element is identical to *A. turgida* var. *africana*. All these three elements have the same basic valve shape and dimensions, and points of difference lie only in the structure of the transapical striae. In this regard Cholnoky's description does not satisfy completely any of the three elements included in *A. sydowii*. Cholnoky (l.c.) described the undulate longitudinal ribs (costae) as being distinct, one or two of them near the dorsal margin being better developed. His illustrations of *A. sydowii* (Cholnoky, 1963a : Pl. 8, Figs 4-6), on the other hand, show distinctly punctate striae with the longitudinal costae near the dorsal margin being broader and therefore separating the puncta of the striae to a greater extent. However, the element considered as *A. coffaeaformis* does not have distinctly punctate striae nor any prominent longitudinal costae near the dorsal margin. Furthermore those specimens having distinctly punctate striae also lacked the better developed longitudinal ribs described by Cholnoky; these specimens were referred to *A. acutiuscula*. The third and remaining element did indeed have one or two prominent longitudinal costae traversing the transapical striae, but these were usually found about midway between the raphe and dorsal margin. The striae of these specimens were, furthermore, not distinctly punctate (see TEM description above). It is therefore not clear what Cholnoky really intended as *A. sydowii*. Since two of the elements can be identified as other taxa, and the only forms with conspicuous longitudinal costae do not adequately comply with the taxon described by Cholnoky, *A. sydowii* must be considered as impossible to identify with certainty.

Within only a few days of the publication of *A. sydowii* as a new species, Giffen (1963 : 216, Figs 13, 14) published the description of *Amphora castellata*, a new species from the Gulu River estuary near East London. This species is also identical with Cholnoky's *A. turgida* var. *africana* and that element of *A. sydowii* having non-punctate striae crossed by a thick longitudinal costa. In terms of priority *A. turgida* var. *africana* takes precedence as the earliest valid description of the taxon. The epithet "africana" is however already occupied in the combination *Amphora africana* Heiden and Kolbe (1928 : 637, Pl. 1, Figs 4, 4a-b), and furthermore does not have priority outside its own rank. At species rank the earliest valid combination for this taxon is *A. sydowii*, but as shown above there is too much uncertainty in defining *A. sydowii* to accept this combination as the correct one for this species. Giffen's combination, *Amphora castellata*, supported by a good description and more accurate drawing, is therefore the most acceptable name for this taxon. *A. turgida* var. *africana* and *A. sydowii* e.p. are thus referred to as synonyms of *A. castellata*.

Euryhaline mesohalobe - 5

Figs: 94, 95, 493-496

Samples: SUN: 10-12, 23, 37, 38, 40, 54, 66, 68, 71, 75, 79, 81.
FIS: 6, 19, 32.

Amphora coffaeaformis (Agardh) Kützing

Kützing, 1844 : 108, Pl. 5, Fig. 37.
Hustedt, 1930 : 345, Fig. 634.

Synonyms: *Frustulia coffaeaformis* Agardh, 1827 : 627.

Description: Valves semi-lanceolate, in large specimens rather elongate, with convex dorsal margin often slightly flattened or indented at the centre (particularly in the longer specimens), and more or less straight to slightly concave ventral margin; poles protracted into rostrate to capitate apices of varying length and breadth; length 18,7 - 54,8 μm, breadth 3,5 - 6,8 μm . Raphe fairly close to the ventral margin, filiform, with straight raphe branches having small but distinct central pores deflected somewhat dorsally; terminal fissures also dorsally deflected. Axial area linear, very narrow on the dorsal side, and wider on the ventral side; central area missing on the dorsal side, but present on the ventral side owing to an interruption of the ventral striae. Transapical striae on the dorsal side radial throughout, structure indistinct, 18 - 24 in 10 μm near the centre and slightly denser near the poles (20 - 28 in 10 μm); ventral striae short marginal dashes, 24 - 36 in 10 μm, usually only seen for a short distance on either side of the central area, but throughout the ventral margin in oblique illumination.

Under TEM each stria of this species resolves itself into a narrow transapical groove covered externally by a membrane perforated by a double row of pores (Figs 497-499). The arrangement of these small pores is rather haphazard, although a basic alternate arrangement can be detected. This structure continues over into the dorsal mantle interrupted only by relatively weakly developed longitudinal costa dividing the valve face from the dorsal mantle. The ventral striae also have a similar structure, but it is slightly finer. The upward projection of the dorsal edge of the axial rib into a siliceous flap is not prominent, but may be seen in some specimens.

Taxonomic notes: The taxonomy of the species comprising the group including *A. coffaeaformis* is extremely complicated, and a number of these very similar taxa have been observed in this study, either in a mixed population in one sample or separately in different samples. In order to ensure accuracy in their identification the type material of some of these taxa has been examined. Agardh's type material (Agardh material No. 4600 - Lund) of *Frustulia coffaeaformis* was obtained from the Botanical Museum in Lund (Sweden), as well as Kützing's material of *Amphora coffaeaformis* from the British Museum (Natural History)(Slide Nos BM 18945 and BM 78009). These materials were carefully studied and compared with specimens from the Sundays River. The latter proved to be identical in all respects to Agardh's and Kützing's type material. Under TEM the positive identification of the Sundays River specimens as *A. coffaeaformis* was confirmed by comparing the striae structure of some valve fragments (see Fig. 499) from Agardh's type material with that on the valves of the local material (Figs 497, 498). This has permitted a more detailed description of the valve surface structures to be given (see above). Since most of this complex group of taxa are difficult to separate under the ordinary research microscope, electron microscopy becomes an essential aid in determining these species. A new description of *A. coffaeaformis* has been given above based only on the examples observed in Agardh's type material and Kützing's slides as well as those from the Sundays River.

A. coffaeaformis has been recorded from a number of localities throughout Southern Africa, but mostly from inland alkaline freshwaters. Furthermore Cholnoky has repeatedly claimed that this taxon has no connection, either morphologically (cf. Cholnoky, 1962a : 10; 1966b : 172; 1968a : 16) or ecologically (cf. Cholnoky 1960b : 234; 1962a; 10; 1962c : 63), with *A. acutiuscula*. This discrepancy in views prompted an examination of Cholnoky's concept of *A. coffaeaformis*. Accordingly a large number of samples from all over Southern Africa, in which Cholnoky recorded *A. coffaeaformis*, was examined. Not a single example from the many *Amphora* specimens observed on these slides could be referred to *A. coffaeaformis* as described above and typified in Agardh's and Kützing's material. The majority of these specimens were in fact *Amphora veneta* var. *capitata*

Haworth (cf. Schoeman and Archibald, 1976-80 : No. 4). A few specimens from South West Africa (sample No. SWA 72 - NIWR) were slightly different in that they represented another form of *A. veneta,* as yet undescribed. This examination proved conclusively that Cholnoky's concept of *Amphora coffaeaformis* was erroneous. Consequently all his comments with regard to the systematics and autecology of this taxon now refer to *A. veneta* var. *capitata*. His misidentification of *A. veneta* var. *capitata* as *A. coffaeaformis* is sufficient to explain why Cholnoky held such diametrically opposed views with regard to the autecology and taxonomy of *A. coffaeaformis* compared with the majority of diatomists. Following Cholnoky both Schoeman (1970a : 333; 1973 : 36) and Archibald (1971 : 23) also misidentified *A. veneta* var. *capitata* for *A. coffaeaformis* in samples collected in Lesotho, the Orange Free State, and the southeastern Transvaal.

Most of the records of this species from Southern Africa have thus been eliminated since they are misidentifications by Cholnoky. Of those that remain, however, some are suspect, and some cannot be verified because the original material is missing from the NIWR diatom collection. Nevertheless the abundance of *A. coffaeaformis* in many samples from the Sundays River seems to suggest that the taxon has most probably been found more commonly, but has been erroneously referred to a different species. The task of trying to find such cases would be very time consuming. One such case has, however, come to light. Cholnoky (1963a : 237, Pl. 8, Figs 1, 2) referred specimens of an *Amphora* species from South West Africa to *A. fluminensis* Grunow (1863 : 142, Pl. 13, Fig. 15). These are, however, identical in all respects to *A. coffaeaformis*. Without instituting a painstaking search, further instances of this nature will only be brought to light accidentally.

Euryhaline mesohalobe - 5

Figs: 5, 6, 96-100, 497-501

Samples: SUN: 4, 7, 9-11, 14, 37-40, 66, 74-76.

Amphora cognata Cholnoky

Cholnoky, 1966b : 173, Fig. 1.

Taxonomic notes: The small *Amphora* specimens from Stations 3 and 4 of the Great Fish River have been placed in this taxon because they appear to be closer to this species than any other *Amphora*. Cholnoky (l.c.) apparently did not see many specimens, as he stated in the original diagnosis that the full range of variation was unable to be given. Having examined the type slide (SWA 69 - NIWR) a few specimens fitting the description were observed, but these were a little more coarsely punctate and striate (20 - 22 in 10 µm) than described, and were slightly broader (4,0 µm). Since no other similar small *Amphora* taxon could be found it is assumed that these examples were the holotypes of the species. The Great Fish River specimens differ in that, although they have rostrate apices, they are not as strongly capitate as the holotypes. Furthermore the Great Fish River examples are slightly narrower and more finely striate; the striae are punctate but not distinctly so. The following dimensions are given for the Great Fish River specimens:- length 12,5 - 16,0 µm, breadth 2,5 - 3,6 µm, striae on the dorsal side 23 - 26 in 10 µm, and on the ventral side 26 - 28 in 10 µm. Similar forms from the Western Cape Province were placed by Cholnoky (1962a : 11) in *A. tenerrima* Aleem et Hustedt (1951 : 16). This connection is not possible on morphological grounds, as the Fish River specimens do not have a flattish dorsal margin, but are more convex, and they have small but relatively distinct ventral striae, which are absent in *A. tenerrima*. A few specimens from Station 13 (FIS 26) on the Great Fish River were more coarsely striate at the centre, where they numbered about 18 striae in 10 µm; this is more commensurate with Cholnoky's South West African species.

Meioeuryhaline oligohalobe - 1

Figs: 7, 101-104

Samples: FIS: 5, 6, 15, 26, 27, 29, 40.

Amphora commutata Grunow

Grunow in Van Heurck, 1880-83 : Pl. 1, Fig. 14.
Van Heurck, 1885 : 58.
Hustedt, 1930 : 345, Fig. 632.

Taxonomic notes: Since *A. commutata* does not appear frequently in South African brackish waters, the dimensions of the few specimens observed are given to enlarge the range of variation so far observed. The specimens from the Sundays River were 37,0 - 53,0 µm long, the valves were 8,5 - 11,0 µm wide (a single cell was 17,0 µm wide), and the specimens had 10 - 12 transapical striae in 10 µm . Some of the specimens were thus a little than the dimensions given by Hustedt (l.c.).

Euryhaline mesobalobe - 5

Figs: 105, 106

Samples: SUN: 10, 11, 37, 42.

Amphora cymbamphora Cholnoky

Cholnoky, 1960a : 22, Fig. 54.

Synonyms: *Amphora natalensis* Cholnoky, 1960a : 24, Figs 63-65.
Amphora novaeguineae Cholnoky, 1963b : 161, Figs 9, 10.

Description: Frustules elliptical to elliptic-lanceolate with scarcely protracted to relatively long protracted poles; 6,5 - 9,0 μm broad; without intercalary bands. Valves semilanceolate, ventral margin straight or with a slight inflation at the centre of the valve; dorsal margin convex, poles on the dorsal side very slightly protracted to regularly rounded into almost acute to slightly rostrate apices; length 18,5 - 40,5 μm, breadth 4,0 - 6,0 μm . Raphe filiform, branches curved in an S-shape from the slightly dorsally directed central pores to the hooked and dorsally directed terminal fissures. Axial area on dorsal side variable from a relatively broad area, covering about half the length of the valve, parallel to the ventral margin and sometimes slightly widened at the central nodule, to a narrow region widening at the central area; on the ventral side the axial area is narrow, widening slightly at the central nodule. Both dorsal and ventral sides distinctly striate; transapical striae on dorsal side radial in the middle and radial to slightly convergent at the poles, 16 - 20 in 10 μm at the centre, and slightly denser at the poles (20 - 22 in 10 μm); on the ventral side transapical striae coarser, 15 - 18 in 10 μm in the centre (slightly radial) and 18 - 22 slightly convergent striae in 10 μm at the poles. Longitudinal costae not distinct.

Taxonomic notes: This is a good example of the proliferation of unnecessary synonyms arising through insufficient comparison of type material before describing a taxon. This taxon was described as a new species on three separate occasions by Cholnoky himself, viz. *A. cymbamphora* Cholnoky (1960a : 22, Fig. 54), *A. natalensis* Cholnoky (l.c. : 24, Figs 63-65) and *A. novaeguineae* Cholnoky (1963b : 161, Figs 9, 10) of which the first two were published in the same paper. The type slides of all three taxa included in *A. cymbamphora* have been critically examined and there is no doubt that all three are identical. The variations that occur are slight and could not be used to differentiate this taxon into three different species. For instance the valves of *A. novaeguineae* are illustrated as being without a slight protraction of the poles, while *A. cymbamphora* has a slight protraction. Both pole shape types occur, however, in *A. natalensis*. Careful examination of the types showed that both forms were present in all three species being compared. Certain other inaccuracies in the descriptions and in the illustrations have further clouded the issue, and without comparison of the type specimens the error might not have been detected, since Cholnoky did not refer to these species in discussing their individual relationships. *A. cymbamphora* is described as having a straight raphe, whereas the specimens on the type slide (TUG 397 - NIWR) show a more sigmoid raphe. The ventral striae in *A. novaeguineae* are given as 12 - 14 in 10 μm, but examination of the type slide (NG 14 - NIWR) showed all individuals observed as having 16 - 18 in 10 μm at the centre. In all three cases discussed above the original illustrations were not quite accurate with respect to the nature of the axial area on the dorsal side. It is difficult to imagine how three differing descriptions, illustrated so variably, could have been made if the types of each species had been compared properly. A comparison of the dimensions of the three species are shown in the table below to illustrate their similarity.

Species	Reference	Type Slide No.	Length (μm)	Breadth (μm)	Dorsal striae in 10 μm	Ventral striae in 10 μm
A. cymbamphora	Cholnoky, 1960:22	TUG 397	19,0-27,0	4,5-6,0	16-18	15-16
A. natalensis	Cholnoky, 1960:24	TUG 225	18,5-25,5	4,5-4,9	16-20	16-18
A. natalensis	Cholnoky, 1968:14	SL 52	23,5-30,5	4,1-4,7	16-18	15-16
A. natalensis	Cholnoky, 1968:14	SL 32	18,8-21,6	4,0-4,5	18-20	16
A. novaeguineae	Cholnoky, 1963:161	NG 14	18,5-24,3	4,5-5,5	18-20	16-18
A. cymbamphora	Sundays and Fish rivers		19,4-40,5	4,0-5,0	16-18	16-17
A. angusta	Giffen, 1966a:250	KB 210	41,0-66,0	7,0-9,0	20-21	15-17

Forms identical in structure to *A. cymbamphora* were observed on a slide (KB 210 - NIWR) made from marine littoral material by Giffen. These forms were, however, much larger in their dimensions as can be seen from the Table. Giffen identified these specimens as *Amphora angusta* Gregory (cf. above). A closer relationship between *A. angusta* and *A. cymbamphora* may therefore exist, but owing to a certain amount of uncertainty with regard to the true identity of *A. angusta*, it is preferred to retain these forms as *A. cymbamphora*. Evidence that this taxon may have been described very much earlier is found in the observation of a perfect specimen fitting the description of *A. cymbamphora* on a slide (No. 3079 - Naturhistorisches Museum, Vienna) made by Grunow in about 1886 from material collected by Beccari in Abyssinia. Dimensions of this specimen were as follows:- length 30,0 μm, breadth 6,0 μm, transapical striae at the centre of the dorsal side 16 in 10 μm, and on the ventral side 15 in 10 μm, while at the poles there were 20 striae in 10 μm on both ventral and dorsal sides. Grunow, however, made no record of this species in his journal entry for this slide. The possibility that this taxon may be connected to *A. angusta* var. *oblongella* (Grunow) Cleve (1895 : 135) = *A. oblongella* Grunow (1878 : 7, Pl. 4, Fig. 20) cannot be ruled out at this stage without first examining the type material.

In some of the estuarine samples from the Sundays River a number of *Amphora* valves, whose identity is not certain, were observed. These specimens (Figs 107-109) are semi-lanceolate with a convex dorsal margin and a straight ventral margin; the poles are somewhat acutely rounded and not protracted; length 14,5 - 21,6 μm, breadth 3,0 - 3,5 μm . The raphe is straight and filiform and runs very close to the ventral margin, so close in fact that it is often almost impossible to resolve; the central pores, usually the only distinct part of the raphe system, are closely placed and slightly dorsally deflected. The axial area is very narrow and marginal, having no expansion at the central nodule. The dorsal transapical striae are more or less perpendicular to the raphe, and the most central one is sometimes slightly shortened; they number 16 - 18 in 10 μm in the centre, becoming denser towards the poles where they are about 20 - 22 in 10 μm . The ventral striae are very short, and usually only just visible near the central nodule, about 20 in 10 μm . Most of these valves gave the impression that they were viewed in a plane where the ventral mantle is vertical. The ventral mantle turns very abruptly perpendicular to the valve face, and contains the ventral striae. Therefore, when the ventral mantle is vertical to the plane of viewing, the ventral striae will be very difficult to resolve. Tilting the valve to reach this state could result in the raphe becoming apparently very marginal. Because of this possibility, and on account of certain other structural, as well as dimensional similarities, these specimens have been tentatively placed with *A. cymbamphora*, which was always present in the same samples. Cholnoky's (1960a : 22, Fig. 54; 1968a : 18, Fig. 17) drawings of *A. cymbamphora* were rather similar to these specimens.

Euryhaline mesohalobe - 5

Figs: 107-112

Samples: SUN: 7, 13, 16, 32, 35, 36, 59, 73, 75, 76, 82-86.
FIS: 13, 30.

Amphora exigua Gregory

Gregory, 1857 : 514, Pl. 12, Fig. 75.
Cleve, 1895 : 123.
Hendey, 1964 : 266.

Taxonomic notes: The specimens assigned to this species are placed here with some uncertainty. The identification is based on the illustrations given by Cholnoky (1959 : 12, Figs 76-78). Despite Cholnoky's positive assertion to the contrary, there is some doubt that these illustrations actually depict *A. exigua*. Without an examination of the type material, if available, it is impossible to identify this taxon with certainty. Cleve (1895 : 123) states that *A. exigua* is 25 - 40 µm long and has 12 - 14 striae in 10 µm . Hendey (1964 : 266) gives very similar dimensions of length (25,0 - 37,0 µm) and density of striae (13 - 14 in 10 µm). Gregory (l.c.), however, described the species as being 38,0 - 56,0 µm long, and having 11 striae in 10 µm . The specimens identified by Cholnoky (l.c.) as *A. exigua* were 20,0 - 25,0 µm long, 4,5 - 6,0 µm broad, and had 12 - 16 striae in 10 µm at the centre. These dimensions fit very closely the examples seen in this study, and consequently they have been placed in this species until evidence to the contrary is obtained. Further research into closely related species, such as *A. turgida* Gregory (1857 : 510, Pl. 12, Fig. 15) and *A. fluminensis* Grunow (1863 :148, Pl. 13, Fig. 15) is necessary before a final decision can be made. *Amphora tumida* Hustedt (1952 : 120, Figs 51-54) also requires further examination in this connection. Also included in this species are specimens of the larger of two forms identified by Cholnoky (1960a : 23, Figs 58-61) as the new species *Amphora luciae* Cholnoky. These forms, as illustrated in Cholnoky's Figs 60 and 61, appear to be more akin to *A. exigua* than to the smaller examples now regarded as *A. luciae* Cholnoky. A further discussion of these relationships can be found under *A. luciae* below.

Pleioeuryhaline polyhalobe - 7

Figs: 113, 114

Samples: SUN: 11, 13, 41, 55, 56, 60, 81, 83.
FIS: 3, 13, 14, 17, 29-31, 33, 37, 39, 40.

Amphora helenensis Giffen

Giffen, 1973 : 33, Figs 7-9.

Taxonomic notes: Giffen (l.c.) distinguished this species from *A. ovalis* var. *affinis* (Kützing) Van Heurck (1885 : 59) on the basis of its lack of a central area, the presence of a lanceolate hyaline band near the centre of the valve, and its different ecological habitat. Specimens for the Sundays River, where it occurred plentifully in many samples from the lower course and estuarine zones of the river, agreed entirely with Giffen's description. Nevertheless the Sundays River specimens showed a wider range of variation, necessitating expansion of the diagnosis to make it more complete. Specimens examined in this study ranged in length from 12,5 - 32,0 μm, in breadth from 3,5 - 6,0 μm (whole frustules from 8,0 - 11,0 μm wide), and had 14 - 18 striae in 10 μm .

Euryhaline mesohalobe - 5

Figs: 115-119

Samples: SUN: 1-9, 11-13, 35-37, 41, 42, 54, 55, 57, 59, 64, 66, 67,
69, 70, 74-82.

Amphora luciae Cholnoky emend.

Cholnoky, 1960a : 23, Figs 58-61.

Description: Cells elliptic-lanceolate with distinct and generally long protracted poles, and with very weak but visible intercalary bands. Valves semi-lanceolate with strongly convex dorsal margin and weakly convex to often nearly linear ventral walls; valve poles mostly very clearly protracted and ventrally deflected capitate apices; length 15,2 - 22,0 µm, breadth 3,0 - 4,5 µm . Raphe arcuate to straight, with very small, fairly closely positioned central pores, sometimes curved weakly upwards. Axial area on the dorsal side very narrow, on the ventral side broadly lanceolate. Transapical striae on the dorsal side radial, 20 - 22 in 10 µm, punctate; on the ventral side short marginal, approximately parallel striae, 26 - 30 in 10 µm .

Taxonomic notes: There is some uncertainty concerning the true identity of this species. Cholnoky's (l.c.) original description and drawings do not agree with each other, and it appears that two separate taxa may be involved here. Study of Cholnoky's illustrations show that specimens drawn in Figs 58 and 59 are 17,7 - 20,0 µm long, 3,0 - 3,7 µm broad and have 21 - 22 striae in 20 µm on the dorsal side and 26 - 30 striae on the ventral side. On the other hand Figs 60 and 61 are much larger diatoms, being 29, 2 - 32,7 µm long, 5,8 - 6,5 µm broad, with 14 - 15 striae in 10 µm on the dorsal side, and 22 - 23 in 10 µm on the ventral side. Cholnoky's written description does not make the position any clearer. The length range given in the diagnosis includes both the large and small forms discussed above, but the breadth range appears to exclude the small examples. With regard to the density of the striae on the dorsal and ventral sides, the larger more coarsely striated forms are excluded following the limits laid down by Cholnoky in his diagnosis. Nevertheless when discussing the number of puncta forming the striae the description appears to refer to the coarser, and not the finer, striated examples.

An examination of the type material, particularly TUG 222 (NIWR), also demonstrated this difference resulting in two size groups with the following measurements:-

	Length (µm)	Breadth (µm)	Dorsal striae in 10 µm	Ventral striae in 10 µm
Large specimens (Figs 60-61)*	32,0 - 35,0	7,0 - 7,2	14	20 - 24
Small specimens (Figs 58, 59)*	15,2 - 22,0	3,5 - 4,5	20 - 22	28 - 30

* cf. Cholnoky, 1960a :Figs 58-61.

Despite a thorough search of the slide no intermediate forms could be found bridging the two groups. It is therefore evident that there are apparently two species embraced by a single description, which does not adequately circumscribe both or the two forms separately. The larger size group may be more closely allied to *Amphora exigua* Gregory, and specimens from the Sundays River agreeing with the larger size group have been included under *A. exigua* in this study. Specimens fitting the dimensions of the smaller forms described by Cholnoky have been considered as the proper *A. luciae*, a revised description of which is given above.

Euryhaline mesohalobe - 5

Figs: 120-122

Samples: SUN: 3, 12, 38, 53, 54, 57, 64-66, 68, 79-85.

Amphora micrometra Giffen

Giffen, 1966a : 253, Figs 16, 17.

Taxonomic notes: The examples (Figs 8-12, 123-125) placed in this taxon have been compared with specimens from the type material (KB 210 - NIWR) and are essentially identical. A few minor differences were, however, noted. The Sundays River examples were in some cases longer than those given by Giffen (l.c.) in his original diagnosis, being 8,0 - 14,0 µm long. In most cases the valves were narrower than stated in the description, being 1,7 - 2,5 µm broad. Giffen also claimed that the striae are extremely fine and scarcely visible. The specimens examined here were hyaline, and even under oblique illumination no striae could be observed testifying to their fineness. In a later paper, however, Giffen (1973 : 34) reported examples of this species in which there were 27 striae in 10 µm . In a brief search for these striated specimens on the two slides from which they were reported (SH 8, SH 9 in the Giffen collection) no such specimens could be found. Considering the extremely hyaline nature of the valves observed in the type material and in the Sundays River it is felt that it is unlikely that these relatively coarsely striate forms belong to this taxon.

Pleioeuryhaline polyhalobe - 7

Figs: 8-12, 123-125, 502, 503

Samples: SUN: 69, 80-84.

Amphora ovalis var. *affinis* (Kützing) Van Heurck

Van Heurck, 1885 : 59.
Grunow in Van Heurck, 1880-83 : Pl. 1, Fig. 2 (as *Amphora affinis*).
Patrick and Reimer, 1975 : 69, Pl. 13, Figs 3, 4.

Synonyms: *Amphora affinis* Kützing, 1844 : 107, Pl. 30, Fig. 66.
Amphora libyca Ehrenberg, 1840a : 205.
Amphora ovalis var. *libyca* (Ehrenberg) Cleve, 1895 : 104.

Taxonomic notes: The systematics and taxonomy of *Amphora ovalis* and its close relatives are somewhat confused at present. Patrick and Reimer (l.c.) have distinguished three varieties of *A. ovalis*, viz. the nominate variety, var. *affinis* and var. *pediculus*. Recently Schoeman and Archibald (1976-80 : No. 4) showed that *Amphora pediculus* (Kützing) Grunow (basionym: *Cymbella? pediculus* Kützing) was identical to *Amphora perpusilla* (Grunow) Grunow (1884-87 : 1, Slide No. 4), and was not the same as *A. ovalis* var. *pediculus* sensu Patrick and Reimer (l.c.; see below). It was suggested that the latter forms should be considered as part of the *A. ovalis* var. *affinis* range. Schoeman (personal communication) recently examined a number of slides of *A. ovalis* var. *affinis* in the British Museum (Natural History) and found a range in dimensions which would unite Patrick and Reimer's (l.c.) concepts of both *A. ovalis* var. *affinis* and var. *pediculus*.

Cholnoky (1962a : 10; 1962c : 64; 1970a : 135) has frequently suggested that *A ovalis* var. *affinis* should be sunk into the nominate variety as intermediate forms can be found linking the two varieties. Schoeman (personal communication), however, in his examination of the British Museum material found no evidence of intermediate forms, even when both varieties occurred on the same slide. The distinction between the two varieties as described by Patrick and Reimer (l.c.) has therefore been accepted in this study.

As all the specimens observed in the Sundays and Great Fish rivers have the characteristic interruption of the dorsal striae above the central nodule, open or closed by a row of pores, they undoubtedly fall into var. *affinis*. These specimens had the following dimensions:- length 21,0 - 44,6 µm, breadth 5,0 - 8,8 µm, and had 12 - 14 striae in 10 µm measured along the raphe to the side of the central nodule.

There is some uncertainty concerning the concept of *A. ovalis* Kützing. On many of the slides made from early Kützing material (e.g. slides BM 18933 - BM 18936, BM 78084), supposedly containing *A. ovalis*, only specimens of var. *affinis* were observed. It is therefore essential to locate and examine the type material of *Frustulia ovalis* Kützing (1833 : 539, Pl. 13, Fig. 5) to establish the true identity of *A. ovalis*.

Mesoeuryhaline oligohalobe - 2

Figs: 126, 127

Samples: SUN: 15-17, 23, 25, 32, 34, 45, 47, 48, 51, 62, 63.
FIS: 18, 26,

Amphora pediculus (Kützing) Grunow

Grunow ex A. Schmidt *et al.*, 1874-1959 : Pl. 26, Fig. 99.
Grunow in Van Heurck, 1880-83 : Pl. 2, Figs 8-10 (nec Pl. 1, Figs 4-7)

Synonyms: *Cymbella? pediculus* Kützing, 1844 : 80, Pl. 5, Fig. 8; Pl. 6, Fig. 7.
Amphora pediculus var. *exilis* Grunow in Van Heurck, 1880-83 : Pl. 1, Figs 9, 10.
Amphora pediculus var. *minor* Grunow in Van Heurck l.c. : Pl. 1, Fig. 8.
Amphora ovalis var. *pediculus* (Kützing) Van Heurck, 1885 : 59 e.p.
Amphora ovalis var. *pediculus* f. *exilis* (Grunow) Van Heurck, 1885 : 59.
Amphora ovalis var. *pediculus* f. *minor* (Grunow) Van Heurck l.c.
Amphora perpusilla (Grunow) Grunow, 1884-87 sensu Van Heurck Slide No. 4.
Amphora perpusilla (Grunow) Grunow sensu Patrick and Reimer, 1975 : 70, Pl. 13, Figs 8-11.

Description: Valves semi-elliptical with convex dorsal margin and ventral margin usually straight, sometimes slightly concave, or with a weak central inflation; poles smoothly rounded, occasionally with a slight deflection ventralwards; length 5,0 - 18,0 µm, breadth 2,0 - 4,0 µm . Raphe branches filiform, straight or very slightly curved; central pores inconspicuous; terminal fissures usually indistinct, occasionally seen as being dorsally deflected. Axial area narrow, linear; central area a relatively broad, more or less rectangular region reaching the margin on the ventral side, and dorsally, depending on the angle of viewing, either reaching the margin (most commonly) or delineated by 1 - 3 shortened striae. Dorsal transapical striae parallel to somewhat radial, (16)18 - 25 in 10 µm, relatively coarsely punctate, but puncta not always visible; ventral striae short, slightly to moderately radial at the centre, and convergent at the poles, 16 - 23(25) in 10 µm .

Taxonomic notes: In their examination of the type material of this taxon and its close relatives, it became evident to Schoeman and Archibald (1976-80 : No. 4) that two distinct taxonomic entities had been included under the name *Amphora ovalis* var. *pediculus*. Both these forms were present in the type materials examined by Kützing and Grunow. Unfortunately Kützing (1844 : 80) did not designate any specific material as the type of *Cymbella? pediculus*, the basionym for *A. ovalis* var. *pediculus*. As a result it was necessary to determine which of the two forms should retain *Cymbella? pediculus* as its basionym. Following the advice of the British Museum, Schoeman and Archibald (l.c.) selected the Kützing *exsiccati* material No. 196 as the lectotype, since it is the earliest gathering containing the taxon, and details on the packet are in Kützing's own handwriting. Specimens found in this material correspond in all respects with the description given above. Thus the taxon including these specimens must retain the name *Cymbella? pediculus* as its basionym.

Schoeman and Archibald (l.c.) decided furthermore that this taxon could not be considered a variety of *A. ovalis*, and consequently elevated the taxon to the rank of species. Now according to the International Code of Botanical Nomenclature (Lanjouw, 1966 : 48, Article 53) when a species is divided into two the specific epithet must be retained for the species including the type. Therefore, since the taxon described above includes the type of *Cymbella? pediculus*, the combination *Amphora pediculus* (Kützing) Grunow has been retained for this taxon, although it designates only a part of Grunow's original species. The larger forms which were also included in Grunow's (in Van Heurck, 1880-83 : Pl. 1, Figs 4-7) *Amphora pediculus* are now regarded as more closely related, if not identical, to *Amphora ovalis* var. *affinis* (Kützing) Van Heurck.

Patrick and Reimer (1975 :69, Pl. 13, Figs 5, 6; 70, Pl. 13, Figs 8-11) similarly distinguished two separate taxa in the old concept of *A. ovalis* var. *pediculus*. They, however, retained the combination *A. ovalis* var. *pediculus* for the larger, and treated the smaller forms as *Amphora perpusilla* Grunow (in Van Heurck, 1880-83 : Pl. 1, Fig. 11). The latter was based on its identity with the abundant specimens on Van Heurck's Slide No. 4 of *A. perpusilla* (cf. Grunow, 1884-87 : 1). These specimens are, however, identical to the type specimens of *Cymbella? pediculus* Kützing (cf. Schoeman and Archibald, 1976). There is therefore little doubt that *A. perpusilla*, based on the Van Heurck Slide No. 4, is synonymous with *A. pediculus* as described above. It appears that Grunow (l.c.) may have realised this as he comments in the following manner:- "*Amphora perpusilla* Grun...... et es probablement à réunir à l'*A. pediculus* var. *exilis*" (= *A. pediculus*).

The problem concerning the validity of *A. perpusilla* is, however, not so readily disposed of. While there is little doubt that *A. perpusilla* as found on the Van Heurck Slide Nos 4 and 143 are identical to *Cymbella? pediculus* (= *Amphora pediculus*) records of *A. perpusilla* by other diatomists must be treated with more caution. For instance Hustedt (1930 : 343, Figs 627 and 629) described both *A. ovalis* var. *pediculus* and *A. perpusilla* in the same publication. The former accords well with *A. perpusilla* as on the Van Heurck Slide No. 4, but the latter does not. Hustedt's illustration of *A. perpusilla* is taken from Grunow in Van Heurck (1880-83 : Pl. 1, Fig. 11), whose original drawing might have been inaccurate, as no such forms were observed on the Van Heurck Slide No. 4, designated as representing *A. perpusilla*. Whether this probable inaccuracy has been perpetuated by Hustedt, or, on the contrary, whether there is indeed a taxon fitting Hustedt's description of *A. perpusilla* cannot be determined without examining specific examples identified as such. So far no *Amphora* specimens found in Southern Africa can be fitted to Hustedt's diagnosis.

Meioeuryhaline oligohalobe - 1

Samples: SUN: 8, 16, 17, 19, 26, 27, 30-32, 45-47, 50, 51 62, 63, 72, 73.
FIS: 8.

Amphora sabiniana Reimer

Reimer in Patrick and Reimer, 1975 : 79, Pl. 14, Fig. 8.

Description: Valves semi-elliptical to long narrow semi-lanceolate, with convex dorsal margin, occasionally with a slight depression or constriction at the centre, and almost straight ventral margin with a slight central inflation having a small constriction in the middle of it; poles protracted into rostrate to capitate apices slightly ventrally deflected; length 30,0 - 65,4 µm, breadth 6,4 - 9,2 µm . Raphe filiform, more or less straight, near the ventral margin; proximal ends slightly upturned with small fairly closely placed central pores; distal ends of the raphe branches not yet elucidated. Axial area narrow on the dorsal side, and wide on the ventral side; central area small and ill-defined due to degeneration of the central dorsal striae where the valve wall appears to be somewhat thickened transapically. Transapical striae on the dorsal side radial throughout, 16 - 22 in 10 µm, slightly wider at the centre over the apparent wall thickening (14 - 20); ventral striae very fine, usually not visible, but occasionally observed under oblique illumination near the centre, about (28)32 - 34 in 10 µm .

Taxonomic notes: These forms found in the Sundays and Great Fish rivers have been identified with a fairly recently described species from America, *Amphora sabiniana* Reimer (l.c.), although they do not agree entirely with Reimer's diagnosis. The specimens conform in valve shape and pole endings, but a few examples were somewhat larger, reaching a maximum length of 65,4 µm and a maximum width of 9,2 µm . They have the very characteristic and distinct longitudinal line crossing the striae near the ends closest to the raphe. The striae density of the local specimens is, however, greater. Reimer gave "ca. 14 in 10 µm around the centre, becoming 18 - 20 in 10 µm towards the ends". The specimens observed here had 14 - 20 striae in 10 µm across the centre, and 16 - 21 in 10 µm a short distance from the central nodule. On the ventral side Reimer's examples had 26 striae in the middle and reaching 32 in 10 µm near the poles. In contrast in the Sundays and Great Fish River forms the ventral striae were extremely difficult to resolve even in oblique light. Despite all these differences the local forms come closer to *A. sabiniana* than to any other taxon in the available literature.

This is yet another taxon which emphasises the need of a thorough revision of the *A. acutiuscula - coffaeaformis* complex. In many ways some of the examples, particularly the larger ones, were very similar to *A. coffaeaformis* (Agardh) Kützing (1844 : 108, Pl. 5, Fig. 37). They can be distinguished from *A. coffaeaformis*, however, by the very conspicuous longitudinal line, demarcating a siliceous flap-like extension of the axial rib above the raphe, which crosses the striae near the raphe. In this respect it is somewhat similar to *A. acutiuscula* Kützing (1844 : 108, Pl. 5, Fig. 32), but differs from the latter in its finer striae structure, and the presence of the central thickening of the valve wall. Yet another taxon to which these specimens showed some similarity is *A. turgida* Gregory as depicted by Hustedt (1956 : 120, Figs 49, 50), which appeared to have a prominent longitudinal line as in the examples from the Sundays and Great Fish rivers. Again, however, the finer striation and extreme difficulty in resolving the ventral striae seem to distinguish those forms observed in this study from Hustedt's forms of *A. turgida*. There is also some doubt that Hustedt's examples actually belong to *A. turgida* Gregory (cf. 1857 : 510(38), Pl. 12(iv), Fig. 63).

Euryhaline mesohalobe - 5

Figs: 128-133, 504-507

Samples: SUN: 1, 55, 57, 69.
FIS: 13, 17, 18, 26, 29.

Amphora subacutiuscula Schoeman

Schoeman, 1972b : 240, Figs 1-5.

Description: Valves semi-elliptical to semi-linear-elliptical with convex, and sometimes slightly flattened dorsal margin, and more or less straight ventral margin, poles somewhat protracted into rostrate - subcapitate, usually ventrally deflected apices; 16,0 - 30,0 µm long and 3,5 - 5,4 µm broad. Raphe branches straight and filiform, angled upwards slightly from the poles to the central nodule, about a third of the valve width in from the ventral margin; central pores reasonably closely placed; terminal fissures indistinct, but probably dorsally curved. Axial area very narrow on the dorsal side, but broader on the ventral side, where sometimes, due to the fineness of the ventral striae, it appears to reach the margin. No central area delineated on the dorsal or ventral sides. Dorsal transapical striae fine, 22 - 25 in 10 µm, indistinctly punctate, and slightly radial throughout. Striae on ventral side, although very fine and usually just visible with oblique illumination, 28 - 32 in 10 μm .

Taxonomic notes: The correct identity of the specimens placed in *A. subacutiuscula* Schoeman (l.c.) is not certain. They do not conform to the diagnosis of any other *Amphora* species in the literature available. *A. subacutiuscula* itself may be a heterogeneous taxon, since TEM micrographs of the type material indicated that more than one form may be involved. The Sundays and Great Fish River examples were identified tentatively as *A. subacutiuscula* on the basis of a certain degree of agreement with the diagnosis (cf. Schoeman l.c.), and the similarity between TEM micrographs of the local examples (Figs 508-510) and micrographs of *A. subacutiuscula* (Figs 511, 512). The major part of *A. subacutiuscula* may be *A. coffaeaformis* Agardh (cf. above), but there are a few elements which may belong to other taxa. Further examination of this taxon is therefore necessary.

Euryhaline mesohalobe - 5

Figs: 134-136, 508-512

Samples: SUN: 40, 41, 56, 59, 79.
FIS: 28.

Amphora submontana Hustedt

Hustedt, 1949a : 112, Pl. 11, Fig. 4.
Schoeman, 1970b : 51.

Taxonomic notes: Only a few isolated examples of this species were observed in both the Sundays River and the Great Fish River. These specimens appeared to be like many other examples found in South Africa, since they do not have any structure in the stauros-like central area on the dorsal side of the valve. Schoeman (1970b : 51) gives a much wider range in dimensions than does Hustedt (l.c.), and these examples fall into the lower end of this range. The specimens observed in this study were 14,5 - 17,0 μm long, and 3,5 - 5,5 μm broad. In a number of examples the striae were too fine to be visible, while in others 30 - 32 striae were observed in 10 μm .

Meioeuryhaline oligohalobe - 1

Samples: SUN: 20.
FIS: 20, 24, 27.

Amphora tenerrima Aleem et Hustedt

Aleem et Hustedt, 1951 : 16, Fig. 3.

Taxonomic notes: Specimens placed in this taxon showed a greater degree of variability in valve shape and structure than given in the original diagnosis (Aleem et Hustedt l.c.). These samples ranged from the typical forms with flattened dorsal margins to those with more convexly rounded valves on the dorsal side. This agrees with Hustedt's (1955 : 39, Pl. 14, Fig. 15) observations from Beaufort, North Carolina in the United States of America. Like Hustedt's Beaufort examples, those from the Sundays and Great Fish rivers also had a striae range of 20 - 28 in 10 µm .

Pleioeuryhaline mesohalobe - 7

Samples: SUN: 3, 5-7, 40, 41, 56-58, 66, 69, 78-86.
FIS: 13, 25.

Amphora tenuissima Hustedt

Hustedt, 1955 : 39, Pl. 14, Fig. 16.

Taxonomic notes: A few small specimens, observed at Stations 4 and 4a, have been placed in this taxon, which is seldom recorded. They are however not identical to this taxon, but more closely fulfil the diagnosis of this species than any other *Amphora* known to the author at present. The Sundays River specimens had the following dimensions:- Length 11,0 - 14,8 µm, Breadth 2,5 - 2,9 µm, transapical striae on the dorsal side 31 - 32 in 10 µm, and on the ventral side 36 - 38 in 10 µm . Hustedt did not apparently observe many specimens of this species as he cites only approximate lengths and breadths. The Sundays River examples are however slightly larger and have fewer striae in 10 µm . It is, therefore, with some reservation that these specimens have been included with *A. tenuissima*, which as far as is known has only been recorded from its type locality, i.e. the marine littoral of the harbour at Beaufort, North Carolina. Examination of the type material is necessary to determine how close this relationship is.

Pleioeuryhaline mesohalobe - 7

Figs: 13, 137, 138

Samples: SUN: 40, 56, 81.

Amphora veneta Kützing

Kützing, 1844 : 108, Pl. 3, Fig. 25.
Hustedt, 1930 : 345, Fig. 631.
Patrick and Reimer, 1975 : 72, Pl. 14, Figs 2, 3.

Synonyms: *Amphora gouwsii* Cholnoky, 1953 : 352, Fig. 1.

Description: Frustules in girdle view elliptical with broad, flattened, sometimes slightly produced apices; girdle bands present with about 25 - 32 lineolate dashes in 10 µm . Valves semi-elliptical with smoothly curved convex dorsal margin and more or less straight to slightly concave ventral margin; poles bluntly rounded and somewhat ventrally deflected, sometimes very slightly protracted on the dorsal side; length 4,0 - 60,0 µm, breadth 3,0 - 9,0 µm . Raphe branches filiform, straight or slightly sinuous and somewhat dorsally angled; proximal ends straight or deflected dorsally a little, central pores small and widely set apart in larger specimens, but not so markedly in small examples; distal ends, when visible, turned dorsally. Axial area on the dorsal side narrow, sometimes widening a little at the centre; broader on the ventral side. Transapical striae on the dorsal side punctate and radial throughout, 19 - 32 in 10 µm, wider at the centre (16 - 28 in 10 µm) and slightly denser at the poles (23 - 34 in 10 µm); striae along the ventral side very short marginal dashes, 24 - 34 in 10 µm, not always clearly visible.

Taxonomic notes: The description given above is based on observations made from type slides of the taxon as well as material collected in Southern Africa (cf. Schoeman and Archibald, 1976-80 : No. 4). The syntype material is unfortunately no longer available, and a slide (BM 18942) in the British Museum (Natural History) collection purported to contain *A. veneta*, provided no examples consistent with the present concept of *A. veneta*. This concept is best illustrated by examples on the Van Heurck Slide No. 10 (BM 26321). These specimens agreed very closely with those observed in Southern Africa, and there appears to be little doubt that this common species is correctly identified here.

Examples in the Sundays and Great Fish rivers appeared to be quite typical, measuring 12,0 - 46,0 µm in length, 3,0 - 6,5 µm in breadth, and having 20 - 24 striae at the centre and 24 - 28 in 10 µm a little removed from the centre.

Mesoeuryhaline oligohalobe - 2.

Figs: 14.

Samples: SUN: 1, 4-10, 15, 17-28, 32, 34, 43-48, 51, 52, 57, 60, 61,
63, 64.
FIS: 1, 2, 5, 7, 8, 16-20, 23, 24, 26, 30, 33.

ANOMOEONEIS Pfitzer, 1871 : 78

Anomoeoneis exilis (Kützing) Cleve

Cleve, 1895 : 8.
Hustedt, 1930 : 264, Fig. 429.
Hustedt, 1931-59 : 751, Fig. 1114a-c.

Synonyms: *Navicula exilis* Kützing, 1844 : 95, Pl. 4, Fig. 6.

Taxonomic notes: A single typical example was observed in the Wit River, a freshwater tributary of the Sundays River.

Meioeuryhaline oligohalobe - 1

Samples: SUN: 34.

Anomoeoneis sculpta (Ehrenberg) Cleve

Cleve, 1895 : 6.
Hustedt, 1931-59 : 741, Fig. 1109 (as *A. sphaerophora* var. *sculpta*).
Hendey, 1964 : 218, Pl. 37, Fig. 12.

Synonyms: *Navicula rostrata* Ehrenberg, 1840 : 213.
Navicula tumens W. Smith, 1853 : 52, Pl. 17, Fig. 150.
Navicula sculpta Ehrenberg, 1854 : Pl. 10, I, Fig. 5a, b;
Pl. 10, II, Fig. 3.
Anomoeoneis sphaerophora var. *sculpta* (Ehrenberg) O. Müller,
1899 : 303.

Taxonomic notes: With respect to the taxonomy of *Anomoeoneis sculpta* there appears to be a certain amount of confusion. Reimer (1961 : 193) discussed the legitimacy of the specific epithet "*sculpta*". Apparently the combination *Navicula sculpta* was first published by Ehrenberg in

1854, and thus Reimer concluded that *Navicula rostrata*, described by Ehrenberg in 1840 and synonymous with *N. sculpta*, is the correct and legitimate combination for this taxon, when placed in the genus *Navicula*. Later the taxon was transferred to the genus *Anomoeoneis* as *A. sculpta*. This combination is attributed to Cleve (1895 : 6) by both Reimer (l.c.) and VanLandingham (1967 : 296), since according to Reimer, Pfitzer (1871 : 78) merely suggested but never actually made the combination *N. sculpta*. When, however, *A. sculpta* was proposed as the combination for this taxon, the epithet "*sculpta*" was in fact illegitimate on account of the earlier valid epithet, "*rostrata*". The combination *A. rostrata* was never proposed for this taxon, but was later used by Frenguelli (1934 : 355, Pl. 2, Fig. 11) for another species, now synonymous with *A. sphaerophora*. The combination, *A. rostrata*, though now superfluous, precludes its use for the taxon now known as *A. sculpta*. Nevertheless the validity of *A. sculpta* is still questionable, since *Navicula tumens* W. Smith (1853 : 52, Pl. 17, Fig. 150) is also considered synonymous with this taxon, but was described prior to the combination *Navicula sculpta*. In terms of the International Code of Botanical Nomenclature the correct combination for this taxon should therefore be *A. tumens* (W. Smith). In this study, however, the name *A. sculpta* has been retained, not only because the name is better known, but also because Smith's type material has not been examined, and there is some doubt that Smith's illustrations actually reflect this taxon. Donkin (1870 : 15, Pl. 2, Fig. 9), however, after examining *N. rostrata, N. tumens* and *N. sculpta* was convinced that all three species belonged to the same taxon. For further discussion of the taxonomy of this species see *Anomoeoneis sphaerophora*.

Euryhaline mesohalobe - 5

Figs: 139-144.

Samples: SUN: 10, 11, 37, 66, 74-76.

Anomoeoneis sphaerophora (Kützing) Pfitzer

Pfitzer, 1871 : 77, Pl. 3, Fig. 10.
Hustedt, 1931-59 : 740, Fig. 1108a, b.

Synonyms: *Navicula sphaerophora* Kützing, 1844 : 95, Pl. 4, Fig. 17.
Navicula sphaerophora var. *guentheri* O. Müller, 1899 : 302, Pl. 12, Figs 6, 7.

Taxonomic notes: The relationship between this taxon and *Anomoeoneis sculpta* (see above) is controversial. Hustedt (l.c.) regarded the latter as a variety of *A. sphaerophora* following O. Müller's (1899 : 303) treatment of this taxon. Reimer (1961 : 192) and VanLandingham (1967 : 296) also adopt this view point. In contrast Legler and Krasske (1940 : 341) contended that *A. sphaerophora* is both morphologically and physiologically separate from *A. sculpta*. Cholnoky (unpublished manuscript) took a similar standpoint on the basis of his observations of *A. sculpta* in Hungary in the laboratory as well as in the field.

In his study of *Anomoeoneis sphaerophora* from El Kab O. Müller (1899 : 300-305) described a series of forms and varieties, which included the var. *sculpta*, and commented that "diese Reihen sind durch Uebergangsformen mit einander verbunden". However not all the varieties and forms described by Müller in his paper were found at El Kab, and it may be significant that the only two varieties not present there were var. *polygramma* and var. *sculpta*. Both these varieties have subsequently been considered as separate taxa by others. With regard to O. Müller's remaining forms and varieties it appears that there were intermediates linking them, and it seems pointless to distinguish between them. They should, therefore, rather be considered as part of a wide range of variation for *A. sphaerophora*.

Since few examples of either *A. sphaerophora* or *A. sculpta* have been observed in this study a critical discussion of their inter-relationship cannot be undertaken at present. Nevertheless it was considered best to subscribe to the opinion that the two taxa are indeed separate species. This point of view is taken because of the significant differences in dimensions, particularly breadth, which were observed in the Sundays and Great Fish rivers specimens. These differences are tabulated below.

Species	Length (μm)	Breadth (μm)	striae (in 10 μm)
A. sphaerophora	35 - 62	13,5 - 16	16 - 18
A. sculpta	68 - 121	29 - 36	14

Mesoeuryhaline oligohalobe - 2

Figs: 145-147.

Samples: SUN: 9, 35, 36, 42, 61, 64, 65.
FIS: 14.

BACILLARIA Gmelin in Linneaeus : Vol. 1, Part 6, No. 3903

Bacillaria paxillifer (O.F. Müller) Hendey

Hendey, 1951 : 74.
Hendey, 1964 : 274, Pl. 21, Fig. 5.
Hustedt 1930 : 396, Fig. 755 (as *Bacillaria paradoxa* Gmelin)

Synonyms: *Vibrio paxillifer* O.F. Müller, 1786 : 84, Pl. 7, Figs 3-7.
Bacillaria paradoxa Gmelin in Linneaeus, 1788 : 3903.

Taxonomic notes: Simonsen (1974 : 49) points out that diatom taxonomists have long recognised the conspecificity of *Vibrio paxillifer* O.F. Müller (1786) and *Bacillaria paradoxa* Gmelin (1788), but puts in a strong plea for the retention of the very well known concept of *Bacillaria paradoxa.* Simonsen does this wittingly in contravention of the Rules of Botanical Nomenclature, arguing, however that it "accords with the Preamble of the I.C.B.N. which calls for stability". This sort of situation makes it difficult to decide on which course of action to follow. Similar controversies could arise with a large number of diatom species. Furthermore Simonsen's argument for stability may have been taken slightly out of context. The actual wording in the preamble to the Code of nomenclature implies a desire for the "provision of a stable method of naming taxonomic groups, avoiding or rejecting the use of names which may cause error or ambiguity or throw science into confusion". In this case, therefore, despite the obvious historical significance of the combination, *B. paradoxa*, the rules laid down in the Code of Nomenclature should be adhered to, since error, ambiguity or confusion do not result from adopting the combination *B. paxillifer*. Placing the well known name, *B. paradoxa*, in parentheses following the legitimate, but less well known epithet, would be sufficient to convey the concept of this taxon until the epithet "*paxillifer*" achieves common usage.

Holoeuryhaline mesohalobe - 6

Samples: SUN: 10, 11, 34, 37, 39, 51, 62, 63, 76, 82, 85, 86.
FIS: 13.

BERKELEYA Greville, 1827 : Pl. 294.

Berkeleya rutilans (Trentepohl) Grunow

Grunow, 1880 : 1587.
Hustedt, 1931-59 : 720, Fig. 1093.

Synonyms: *Amphipleura rutilans* (Trentepohl) Cleve, 1894.

Taxonomic notes: Giffen (1970b : 89) restored the generic name *Berkeleya* for the taxa placed in the genus *Amphipleura* by Cleve in 1894 when he revised the Naviculoid diatoms. Cleve had in fact combined the two genera, finding no differences between them. However in a more recent study Cox (1975 : 11) using electron microscopy has shown that there are sufficient morphological differences between the marine and brackish water forms on the one hand, and the free-living freshwater forms on the other. The former are regrouped in the genus *Berkeleya*, while the latter are confined to *Amphipleura*.

On the whole specimens of this taxon, observed in this survey, agreed with Hustedt's (1931-59 : 720, Fig. 1093) description, but there were many examples in which the density of the striae was greater than given in this diagnosis. This feature was also observed by Giffen (1963 : 212, under *Amphipleura rutilans*) in other Southern African specimens. All the examples examined were narrower than the range of breadth given by Hustedt (l.c.). Finally Giffen (1975 : 76) reported specimens greatly exceeding the previously known limits of length, i.e. 44,0 µm long. These observations therefore make it necessary to amend the description to take account of these new measurements. The revised dimensions are as follows:- length 15,0 - 44,0 µm, breadth 2,5 - 6,0 µm and striae 24,0 - 36,0 in 10 µm.

Mesoeuryhaline polyhalobe - 8

Figs: 148, 149.

Samples: SUN: 1-3, 7, 14, 40-42, 57, 59, 67, 69, 77, 78, 80-86.
FIS: 28.

CALONEIS Cleve in Cleve & Grove, 1891 : 66.

Caloneis bacillum (Grunow) Cleve

Cleve in Tempere, 1893-96 : 99
Hustedt, 1930 : 236, Fig. 360.

Synonyms: *Stauroneis bacillum* Grunow, 1863 : 155, Pl. 4, Fig. 16.

Taxonomic notes: The taxonomy of this species is rather confusing. The taxon was first described as *Stauroneis bacillum* by Grunow in 1863. Later Cleve (1894 : 50) considered it a synonym of *Caloneis fasciata* (syn: = *Navicula fasciata* Lagerstedt), but for some reason did not follow the rules of priority in using the oldest valid epithet, "*bacillum*" for this taxon. Hustedt (1930 : 236), however, correctly recognised that *S. bacillum* and *N. fasciata* were not conspecific. *S. bacillum* was retained in the genus *Caloneis* as *C. bacillum*, while Hustedt transferred *N. fasciata* to the genus *Pinnularia* (cf. Hustedt, 1930 : 316, Fig. 569). To add further to the confusion Patrick and Reimer (1966 : 586, Pl. 54, Fig. 8) have returned to Cleve's way of thinking in that they believed *S. bacillum* and *N. fasciata* are identical. Consequently they have reunited the two taxa, but rectified Cleve's error by calling the taxon *Caloneis bacillum* (Grunow) Cleve, a combination apparently first proposed by Cleve (in Tempere l.c.) and not Mereschkowsky as suggested by Hustedt (1930 :236).

Comparing Hustedt's (l.c.) concept of *C. bacillum* with that of Patrick and Reimer (l.c.) it is clear that they are not the same. Hustedt's taxon is basically linear-elliptical with radial striae even at the poles. On the other hand Patrick and Reimer's form appears to be linear-lanceolate with parallel striae becoming convergent at the poles. Neither Hustedt nor Patrick and Reimer mention having studied any type material (if any is available), although the latter claimed to have studied carefully the original diagnoses of *N. fasciata* and *S. bacillum.* This course of action cannot, however, be regarded as completely convincing as these descriptions are not very detailed. Furthermore the improved optics of the present time may detect finer differences than could be accomplished at the period the two taxa were first described. To resolve the differences in concept it is therefore imperative to examine the type material of the two species. In the meanwhile the systematics of Hustedt is being followed, except that both species are considered as belonging to the genus *Caloneis.* Linear forms with radial striae throughout are referred to *C. bacillum*, while the more lanceolate forms with convergent polar striae are placed in *C. fasciata.* For further comment on the latter see below.

A single specimen of *C. bacillum* was observed at Station 10 on the Sundays River.

Mesoeuryhaline oligohalobe - 2

Samples: SUN: 46.

Caloneis clevei (Lagerstedt) Cleve

Cleve, 1894 : 51.
Hustedt, 1930 : 236, Fig. 359.

Synonyms: *Navicula clevei* Lagerstedt, 1873 : 34, Pl. 1, Fig. 10.

Taxonomic notes: Examples from the two rivers being studied have been designated as *Caloneis clevei* following the descriptions and taxonomical notes of Hustedt and Cholnoky. Recently, however, an opportunity was afforded to examine some of Lagerstedt's isotype material of this taxon (Reimer: personal communication) obtained from the Academy of Natural Sciences of Philadelphia. A number of specimens in this material (Slide No. 92550 - Philadelphia) gave rather a different concept of *C. clevei* than that deduced from Hustedt's (l.c.) diagnosis. The valves were more linear with protracted rostrate poles and broadly rounded apices. The raphe appeared to be fairly broad and band-like with large central pores deflected to one side of the valve, and had large hook-like terminal fissures curving to the opposite side of the valve. The axial area was narrower than shown by Hustedt (l.c.), and the central area was a narrow fascia. The transapical striae were arcuate, more or less parallel at the centre and becoming strongly convergent at the poles. The internal openings of the chambers composing the striae formed an undulate longitudinal line running parallel to the valve margin. Only a few speciens were observed in Lagerstedt's material, and further research will be necessary to determine whether these and Hustedt's forms are conspecific.

Specimens from the Sundays and Great Fish rivers, on the other hand, were elliptic-lanceolate with very broadly rounded and only slightly protracted poles. The raphe was straight or slightly arcuate, with distinct central pores, somewhat curved towards one side of the valve, and large hooked terminal fissures. The axial area is a fairly broad lanceolate area, and the central area is a broad fascia. Transapical striae were radial at the centre becoming fairly strongly convergent at the poles. Length

32,0 - 36,3 µm; breadth 7,1 - 7,8 µm; striae 20 in 10 µm.

Meioeuryhaline oligohalobe - 1

Samples: SUN: 45, 46, 60.
FIS: 18.

Caloneis fasciata (Lagerstedt) Cleve

Cleve, 1894 : 50.
Hustedt, 1930 : 326, Fig. 569 (as *Pinnularia fasciata*)

Synonyms: *Navicula fasciata* Lagerstedt, 1873 : 34, Pl. 2, Fig. 11.
Pinnularia fasciata (Lagerstedt) Hustedt, 1930 : 316, Fig. 569.
Caloneis lagerstedtii Cholnoky, 1957a : 43, Figs 17-20.

Taxonomic notes: This species is yet another in which the taxonomy is very confused. In 1873 Lagerstedt (l.c.) described a *Navicula fasciata*, which was later transferred by Cleve (1894 : 50) to the genus *Caloneis*. In doing so Cleve united *C. fasciata* with *Stauroneis bacillum*, a species described by Grunow (1863 : 155, Pl. 13, Fig. 16). In terms of the International Code of Botanical Nomenclature the correct name for this united taxon should have been *Caloneis bacillum*, since the epithet "*bacillum*" is the oldest legitimate epithet available. Hustedt (l.c.), however, recognised that there was a difference between this *Caloneis fasciata* and *Caloneis bacillum* (= *Stauroneis bacillum*), but considered the former to be a *Pinnularia*, thus calling it *P. fasciata*. This opinion was not particularly firm in Hustedt's mind as he later reverted to combining it with *Caloneis bacillum* (cf. Hustedt, 1937 : 184), and still later (Hustedt, 1949a : 99) considered that Cleve (l.c.) had erroneously united *Navicula fasciata* (=*Caloneis fasciata*) with *Stauroneis bacillum* (=*Caloneis bacillum*). He distinguished the two taxa on the basis of the direction of the polar striae. In a previous discussion of the taxonomy and systematics of this species (Archibald, 1969 : 125) it was shown that *Caloneis fasciata* could be upheld as a separate species. At the time this opinion was formed the original descriptions were unavailable for comparison. These have now been examined, but provide no real additional evidence supporting this opinion. Finally Cholnoky (1956 : 43, Figs 17-20), adhering to the hypothesis that this taxon is distinct, maintained that a name change was necessary on the grounds that "Die Benennung "*Caloneis* *fasciata*" wurde aber - wie bereits gesagt - schon als synonym *Caloneis bacillum* (Grun) Cl. gebraucht, d.h. als indentisch mit der Grunowschen *Stauroneis bacillum* aufgefasst: ...". Accordingly he renamed the taxon *Caloneis lagerstedtii.* This name has not, however, been adopted in this study, as the combination, *Caloneis fasciata,* is quite valid and causes no confusion as to the type of the species - *Navicula fasciata.*

In an unpublished manuscript two other taxa from South Africa, *Caloneis aequatorialis* var. *tugelae* Cholnoky (1956 : 58, Figs 7-10), = *Caloneis clevei* var. *tugelae* Cholnoky, 1962 : 317), and *Caloneis clevei* var. *attenuata* Manguin (1952 : 74, Pl. 4, Fig. 120a, b) were included by Cholnoky as synonyms of *Caloneis fasciata.* As no research has been carried out on these two taxa they have not been included in the list of synonyms, but should be borne in mind in any future study of this species.

Mesoeuryhaline oligohalobe - 2

Samples: FIS: 22, 23, 25, 26.

Caloneis liber (W. Smith) Cleve

Cleve, 1894 : 54.
Hendey, 1964 : 229, Pl. 29, Fig. 2.

Synonyms: *Navicula liber* W. Smith, 1853 : 48, Pl. 16, Fig. 133.
Caloneis liber var. *linearis* (Grunow) Cleve, 1894 : 54.
Navicula linearis Grunow, 1860 : 546, Pl. 3, Fig. 2.
Caloneis linearis (Grunow) Boyer, 1927 : 311.

Taxonomic notes: Cholnoky (1963c : 41) and Giffen (1970b : 89) both considered that the var. *linearis* (= *Navicula linearis* Grunow) was synonymous with *Caloneis liber* on account of the intermediate forms between var. *linearis* and the nominate variety encountered in South African coastal waters. On the other hand Hendey (1964 : 230, Pl. 29, Fig. 3) followed Boyer (1927 : 311) in elevating the var. *linearis* to the rank of species, *Caloneis linearis* (Grunow) Boyer. Which of these two opinions is most strongly justified cannot be ascertained at present, and would require examination of the type material. Nevertheless the view adopted in this study is that of Cholnoky and Giffen. Only a single specimen, placed with some reservation in this species, was observed in this survey.

Morphologically and structurally it appeared almost certainly to belong to *C. liber*, and particularly to the var. *linearis* forms on account of its relatively dense striation, i.e. 24 striae in 10 μm . However it differed most significantly in its small size in relation to the range of variation given in the description. Giffen (1975 : 76) cites 49 μm as the minimum size he has observed for *Caloneis liber*, but the Sundays River example was only 29,5 μm long.

Schrader (1971 : Pl. 5, Figs 4-6), in a study of the genera *Progonia, Oestrupia* and *Caloneis*, illustrated by means of electron micrographs a form he ascribed to *C. liber*. The valve shape of this specimen, however, makes it quite clear that it is something quite different. *C. liber*, as described by Cleve (1894 : 54), is linear and sometimes with slightly concave or convex margins, having rounded or subcuneate ends. The specimen illustrated by Schrader is quite plainly lanceolate with slightly protracted poles. His figure on the following page (Pl. 6, Fig. 15) is more in accordance with the description of *C. liber*.

Meioeuryhaline polyhalobe - 9

Figs: 150, 151.

Samples: SUN: 59.

Caloneis permagna (Bailey) Cleve

Cleve, 1894 : 59.
Hustedt, 1930 : 231, Fig. 349.
Hendey, 1964 : 230.

Synonyms: *Pinnularia permagna* Bailey, 1851 : 40, Pl. 2, Figs 28, 38.

Taxonomic notes: There is perhaps a close relationship between this taxon and *Caloneis amphisbaena* var. *fenzlii* (Grunow) Cleve (1894 : 59). The main differences appear to lie in the shape of the axial and central areas, and in the size of the valves. In the Sundays River a number of specimens were closely scrutinised and were placed in the species *Caloneis permagna* on account of the relatively narrower but distinctly lanceolate valves, which were slightly protracted at the poles, and the lanceolate axial area becoming inflated at the centre (sometimes slightly asymmetrically). An examination of at least 25 specimens gave the following range of variation in dimensions:- length 110,0 - 160,0 μm, breadth

39,0 - 47,0 μm, and striae 12 - 13 in 10 μm . The only previous record of this species from South Africa is from some blind estuaries in the Eastern Cape Provice (Giffen, 1963 : 222). Giffen's specimen measured 130,0 μm long, 48,0 μm broad, and had 10 striae in 10 μm .

Schrader (1971 : Pl. 4, Figs 4-9) illustrated some examples of *Caloneis permagna*, but there is some doubt that Fig. 4 does in fact belong to this taxon. The valve of this particular specimen is linear and was not lanceolate. Figs 7-9 were, furthermore, considered by Schrader as internal views of the valve, but these are more probably external views.

Euryhaline mesohalobe - 5

Figs: 152-154.

Samples: SUN: 11, 76.

Caloneis silicula (Ehrenberg) Cleve var. *truncatula* (Grunow) Cleve

Cleve, 1894 : 52.
Hustedt, 1930 : 238, Figs 363, 364.

Synonyms: *Navicula ventricosa* var. *truncatula* Grunow in Van Heurck, 1880-83 : Pl. 12, Fig. 25.
Caloneis ventricosa var. *truncatula* (Grunow) Meister, 1912 : 116, Pl. 17, Fig. 5.

Taxonomic notes: Meister (1912 : 116) believed that the var. *truncatula* should be linked with *Caloneis ventricosa* (Ehrenberg) Meister. Cholnoky (1962c : 66) in contrast considered this variety as part of the range of variation of *Caloneis silicula*, and accordingly sank the variety into the species. Hustedt (1930 : 238) on the other hand elected to follow Cleve (1894 : 52) in placing this taxon with *Caloneis silicula* as a variety of it. The latter view is adopted in this study simply because insufficient material has been examined to make a carefully considered decision with respect to its true systematic position.

Meioeuryhaline oligohalobe - 1

Samples: SUN: 26, 34, 47.

CAMPYLODISCUS Ehrenberg, 1840a : 205

Campylodiscus clypeus Ehrenberg

Ehrenberg, 1840a : 205.
Van Heurck, 1880-83 : Pl. 75, Fig. 1.
Van Heurck, 1885 : 191.
Hustedt, 1930 : 448, Fig. 873.

Taxonomic notes: A number of specimens of this species, rarely recorded in South Africa, were observed at three stations on the Sundays River. These were quite typical, and had the following dimensions:- "diameter" 109,5 - 155,0 µm, costae 1 - 2 in 10 µm .

Euryhaline mesohalobe - 5

Fig: 155.

Samples: SUN: 11, 35, 37, 41, 65, 74, 76, 77, 82.

Campylodiscus echeneis Ehrenberg

Ehrenberg, 1840a : 206
Van Heurck, 1880-83 : Pl. 76, Figs 1, 2.
Van Heurck, 1885 : 191.
Hustedt, 1930 : 449, Fig. 875.
Hendey, 1964 : 291, Pl. 40, Fig. 14.

Taxonomic notes: There is some doubt that the specimen placed in this species is correctly identified as such. Although *Campylodiscus clypeus* occurred at this station, as well as rarely in the sample in question (SUN 66 - NIWR), this example did not accord with the description of *C. clypeus*. The central region within the marginal area was covered with scattered puncta, variable in size, but not as clearly radially arranged as shown in the various illustrations of *C. echeneis*, neither were they arranged as a distinctly demarcated region. The size of the pores were apparently smaller, and the number in each row were, however, denser than given in the description of *C. echeneis* (cf. Hustedt, 1930 : 449). Nevertheless this specimen is considered better placed in this taxon than in *C. clypeus*.

Cholnoky (1963a : 239) reported *C. echeneis* from the Swakop River in South West Africa (slide no. SWA 59 - NIWR), but an examination of the appropriate material showed conclusively that the forms found therein could not be identified as *C. echeneis*, but were rather *C. clypeus*. All his specimens had clearly demarcated central regions, and marginal regions interrupted by a hyaline area of variable development. Neither of these two features applies to *C. echeneis* as illustrated by Hustedt (l.c., Fig. 875). Van Heurck (1880-83 : Pl. 76, Fig. 1) or by Schmidt (in Schmidt *et al.*, 1874-1959 : Pl. 54, Figs 3, 4).

Euryhaline mesohalobe - 5

Figs: 156, 157

Samples: SUN: 66.

CAMPYLONEIS Grunow, 1862 : 429

Campyloneis grevillei (W. Smith) Grunow

Grunow, 1867 : 10.
Van Heurck, 1880-83 : Pl. 28, Figs 8 - 12.
Van Heurck, 1885 : 134.
Hustedt, 1931-59 : 321, Fig. 781.

Synonyms: *Cocconeis grevillei* W. Smith, 1853 : 22, Pl. 3, Fig. 35.

Taxonomic notes: A single example of this species was observed at the mouth of the Great Fish River (Station 14, Sample FIS 28). The size of this specimen was about the minimum that has been recorded up till the present; its length was 20,0 µm and its breadth 12,0 µm. The latter dimension is, however, somewhat smaller than the width given in Hustedt (l.c.). The raphe valve had the typically straight raphe with slightly curved central pores. The transapical striae were punctate, and numbered 18 in 10 µm . Attached to this valve was the characteristic internal skeleton consisting of an axial rib with radiating branches joined at their outer ends to a marginal rim. The small knots described by Hustedt (l.c.) appeared to be nearer the rim than halfway along the branch. The rapheless valve had rather coarse areolae in roughly radiating rows with the largest areola nearest the axial area, where they measured 8 in 10 µm .

Oligoeuryhaline polyhalobe - 10

Figs: 158-160

Samples: FIS: 28.

COCCONEIS Ehrenberg, 1838 : 193

Cocconeis engelbrechtii Cholnoky

Cholnoky, 1955a : 16, Figs 11 - 16.

Taxonomic notes: This is a relatively recently described species, which, as far as is known, has only been found in Southern African brackish waters. A recent transmission electron microscope study of this species has elucidated more clearly the structure of the valves. The raphe valve has a straight simple raphe with fairly closely placed small central pores. The distal ends of the raphe branches end abruptly with no apparent terminal fissures, and do not reach the margin of the valves. The radial transapical striae, slightly arcuate at the poles, consist of a single row of round pores. Towards the margin of the raphe valve the valve surface bends abruptly downwards then flattens out again to form a narrow rim, whose extreme outer edge is structureless. Under the light microscope this fold in the valve surface brings about a superficial similarity to the raphe valve of *Cocconeis placentula* Ehrenberg (cf. Hustedt, 1931-59 : 347, Fig. 802a). The hyaline ring in *C. placentula* is a thickened rib running parallel to the margin of the valve, and cannot be equated with the apparent thickening of *C. engelbrechtii*, which is nothing more than the downward curvature of the valve surface.

The structure of the rapheless valve is quite characteristic of the species. The axial rib appears to be substantially thickened and joined to the margin of the valve by lateral branches. These branches appear, in fact, to be thickened transverse costae. The spacing of these costae is irregular, and they usually occur at every third or fourth costa (sometimes every second costa). In some specimens the thickened costae do not reach the axial rib. Between these strengthened costae there are 2 - 5 rows of pores, rectangular in shape with rounded corners.

The following dimensions are those obtained for specimens observed in the Sundays River:- length 13,0 - 29,0 μm, breadth 8,0 - 19,0 μm, raphe valve 24 - 32 striae in 10 μm, rapheless valve 24 - 32 striae in 10 μm and 6 - 10 thickened costae in 10 μm. These dimensions enlarge to some extent the existing known range of variation in the species.

Euryhaline mesohalobe - 5

Figs: 161-167

Samples: SUN: 1-11, 13, 14, 35-37, 40-42, 53-57, 66, 67, 69, 70, 74, 75, 77-81, 83.

Cocconeis microscopica Cholnoky

Cholnoky, 1959 : 17, Figs 105, 106.

Taxonomic notes: Not much can be said of this small *Cocconeis* species as only a single example was observed at Station 2 on the Sundays River (SUN 3 - NIWR). Archibald (1971 : 25) amended the original diagnosis to include a smaller form having coarser striation. Unfortunately a printer's error made the range of variation of the striae too great. The amended dimensions should read - length 6,0 - 9,0 µm, breadth 3,0 - 4,0 µm and striae 28 - 30 in 10 µm . The Sundays River specimen was closer to Cholnoky's original description, being 9,0 µm long and 4,5 µm broad, but was similar to Archibald's Vaal River specimen in that it had 28 striae in 10 µm on both raphe and rapheless valves.

Euryhaline mesohalobe - 5

Samples: SUN: 3.

Cocconeis pediculus Ehrenberg

Ehrenberg, 1838 : 194, Pl. 21, Fig. 11.
Hustedt, 1930 : 188, Fig. 259.
Hustedt, 1931-59 : 350, Fig. 804.

Taxonomic notes: A single typical example was observed in the Wit River (SUN 34 - NIWR).

Mesoeuryhaline oligohalobe - 2

Samples: SUN: 34.

Cocconeis placentula Ehrenberg

Ehrenberg, 1838 : 194.
Hustedt, 1930 : 189, Fig. 260.
Hustedt, 1931-59 : 347, Fig. 802a, b.

Taxonomic notes: The few examples examined in this survey agreed in all details with Hustedt's descriptions (l.c.). Due to its superficial similarity the raphe valve of *C. engelbrechtii* Cholnoky (see above) could be confused with this taxon. The two species can, however, be fairly easily distinguished by means of the hyaline ring near the margin of the valve in *C. placentula*. This hyaline ring is probably a thickened ridge running round the valve. In *C. engelbrechtii* a similar ring results from a downward folding of the valve face. A description of this ring as seen under the TEM is given above under *E. engelbrechtii*.

Pleioeuryhaline oligohalobe - 3

Samples: SUN: 1, 8-10, 13, 36.
FIS: 14, 37.

Cocconeis placentula var. *euglypta* (Ehrenberg) Cleve

Cleve, 1895 : 170.
Hustedt, 1930 : 190, Fig. 261.
Hustedt, 1931-59 : 349, Fig. 802c.

Synonyms: *Cocconeis euglypta* Ehrenberg, 1854 : Pl. 34/6A, Fig. 2.
Cocconeis lineata var. *euglypta* (Ehrenberg) Grunow in Van Heurck, 1880-83 : Pl. 30, Figs 33, 34.

Taxonomic notes: Cholnoky (1963b : 164 under *C. placentula*) claimed to have seen intermediate forms linking the nominate variety with var. *euglypta*. He therefore sank this variety and considered the other varieties as synonymous with *Cocconeis placentula* (cf. Cholnoky, 1970c : 10). In an examination of Cholnoky's slide no. N.G. 6 (NIWR) on which the intermediates were supposed to be in abundance, no series could be found which could adequately substantiate this claim. In the Sundays River intermediates were also not evident, and consequently the variety var. *euglypta* has been retained as a separate entity.

Pleioeuryhaline oligohalobe - 3

Samples: SUN: 11, 17, 31, 34, 45.

C. placentula var. *lineata* (Ehrenberg) Van Heurck

Van Heurck, 1885 : 133.
Hustedt, 1931-59 : 348, Fig. 802d.
Patrick and Reimer, 1966 : 242, Pl. 15, Figs 5, 6.

Synonyms: *Cocconeis lineata* Ehrenberg, 1841 (1843): 81 (369).

Taxonomic notes: Two raphless valves of a *Cocconeis* species have been tentatively placed in this variety of *C. placentula*. Their dimensions of length (20,6 - 23,0 µm) and breadth (11,3 - 11,7 µm) fit comfortably into the range given by Patrick and Reimer (l.c.), but the striae appeared to be somewhat denser than given in any of the descriptions. When measured along the axial area there were 17 - 18 striae in 10 µm, while along the margin of the valve the striae numbered 14 - 16 in 10 µm. The specimens observed in this sample (SUN 5 - NIWR) differed from Hustedt's (l.c.) illustration of the variety by having much coarser, distinctly punctate striae. In this regard they correspond more closely with the drawing given by Patrick and Reimer (1966 : Pl. 15, Fig. 6).

Pleioeuryhaline oligohalobe - 3

Samples: SUN: 5.

Cocconeis scutellum Ehrenberg var. *parva* (Grunow) Cleve

Cleve, 1895 : 170.
Hustedt, 1931-59 : 338, Fig. 791.
Hendey, 1964 : 180.

Synonyms: *Cocconeis scutellum* f. *parva* Grunow in Van Heurck, 1880-83 : Pl. 29, Figs 8, 9.

Taxonomic notes: Only a few specimens of this taxon were observed in this study, and this does not permit a more detailed description of the variety than that found in the literature available at the present time. Hendey (1964 : 180) gives perhaps the fullest description in the following:- "Valves elliptical, small, often rhombic, with narrow axial area, valve surface punctate. Marginal puncta elongated, otherwise similar to the type. Length of valve 20 - 25 µm". Hustedt (1931 - 59 : 338) observed specimens up to 30,0 µm in length, and gives 11 - 14 striae in 10 µm for the species. In most of the examples in this study the var. *parva* had 16 striae in 10 µm . One specimen (Fig. 168) from Station 3 on the Sundays River had a structure rather similar to *C. scutellum* var. *ornata* from Kamtschatka as illustrated in Van Heurck (1880-83 : Pl. 29, Fig. 7). Near the margin of this valve there is a thickened ring with side branches reaching the margin of the valve between every second or third transapical stria. This specimen had 14 striae in 10 µm . In most of the other examples the transapical striae near the margin appear to become a double row of pores.

Pleioeuryhaline polyhalobe - 7

Fig.: 168

Samples: SUN: 5, 69.
FIS: 15.

Cocconeis thumensis Mayer

Mayer, 1919 : 199, Pl. 6, Fig. 24a, b.
Hustedt, 1931-59 : 346, Fig. 801.

Taxonomic notes: There is some doubt that the two specimens allotted to this taxon actually belong here. One specimen, 9,0 µm long, 6,5 µm broad and having 14 striae in 10 µm, was recorded from Station 1 on the Sundays River, i.e. the lowermost station in the estuary. Although this specimen might agree with the description, the ecological circumstances in which it was found, i.e. extremely brackish water, does not seem to fit the species. Most other records of this species in South Africa are from freshwater habitats. The other specimen observed from Station 4A, also brackish water, appeared to agree more with specimens drawn by Hustedt in A. Schmidt's Atlas (1874-1959 : Pl. 407, Figs 8-11). These specimens had much finer striation, 24 in 10 µm on the rapheless valve, and 30 - 32 in 10 µm on the raphe valve. Cholnoky (1959 : 17, Fig. 107, 108) criticised Hustedt (cf. 1931-59 : 346, Fig. 801) for accepting Mayer's (1919 : 199, Pl. 6, Fig. 24a, b) "sehr primitive Zeichnung" and his "unzuverlässigen Angaben über die Streifenzahl", asserting that the correct striae count was 28 striae in 10 µm for the raphe valve and 22 in 10 µm for the rapheless valve. Cholnoky's grounds for this criticism were highly questionable, since it is most unlikely that he examined Mayer's type specimens. Hustedt's examples from Schmidt's Atlas are also greatly different from the original description, making them also doubtful members of this taxon, despite Cholnoky's (l.c.) belief that these represent *C. thumensis* more closely than Mayer's own original description.

Halophobe - 0

Samples: SUN: 1, 14.

CONSCINODISCUS Ehrenberg, 1838 : 128

Coscinodiscus excentricus Ehrenberg

Ehrenberg, 1839a : 146.
Hustedt, 1927-30 : 388, Fig. 201.

Taxonomic notes: Hendey (1964 : 80) commented that the specific epithet is often wrongly spelt 'excentricus', and used the spelling 'eccentricus' in his work. Giffen (1970b : 90) on the contrary stated that 'excentricus' is the correct Latin form of the word. Hearn (1966) in his "Botanical Latin" does not give 'ec-' as an alternative form of the prefix 'ex-', despite the fact that he acknowledges that when a prefix ends in a consonant and the following syllable starts with a consonant the final consonant may be changed to the first of the next syllable. The spelling 'excentricus' is therefore preferred to the other alternative.

Only two specimens having diameters of 22,5 - 26,0 µm were observed in this study.

Mesoeuryhaline polyhalobe - 8

Samples: SUN: 3, 5.

CYCLOTELLA Kützing, 1833 : 7

Cyclotella atomus Hustedt

Hustedt, 1937-38 : 143, Pl. 9, Figs 1-4.
Hasle, 1962a : 302, Figs 17-28.
Lowe, 1975 : 415, Figs 1, 2.
Schoeman and Archibald, 1976-80 : No. 1.

Description: Valves very small, 3,5 - 10,5 µm in diameter. Marginal zone $^1/6$ to $^1/3$ of the diameter, radially striate; costae 16 - 24 in 10 µm, every second to sixth costa apparently thickened. Central zone smooth, with a single isolated stigma near the marginal zone. In girdle view the cell is rectangular, eccentrically undulate.

Under the electron microscope the apparently thickened costae are recognised as hollow tubes projecting into the valve mantle (Hasle l.c.), which are regarded by Lowe (l.c.) as strutted processes. The isolated stigma is also seen as a strutted process having three struts (Lowe l.c.). The transition from the structureless central zone to the striate marginal zone is indistinct. The intercostal areas (striae) consist of a sieve-membrane in which the pores are arranged in radial rows (Geissler, Gerloff, Helmcke, Krieger & Reimann, 1961 : 11, Pl. 216).

Taxonomic notes: Having examined Hustedt's type slide, Ac 1, 48 (Bremerhaven), the accuracy of Hustedt's (l.c.) description was confirmed, but a number of larger specimens were observed on the type slide (reaching 5,8 µm in diameter). The specimens found in the Sundays River and the Great Fish River were identical in structure to the type specimens, but had a greater range of variation. The diameter varied from 3,9 - 8,0 µm . The number of striae in 10 µm was generally 20, although a few specimens with 17 or 24 striae in 10 µm were also recorded. This is the first time that this species has been recorded from South African waters.

Meioeuryhaline oligohalobe - 1

Figs: 15, 169-171

Samples: SUN: 5, 13, 23, 50-53, 72, 73.
FIS: 4, 6, 7, 11, 12, 16, 21-26, 29-32, 37, 39, 40.

Cyclotella caspia Grunow

Grunow, 1878 : 126, Pl. 4, Fig. 19.
Hasle, 1962a : 299, Pl. 1, Figs 1-11; Pl. 2, Figs 12-16; Pl. 6, Figs 29-31a.
Hustedt, 1927-30 : 347, Fig. 177.

Description: Cells small, 3,5 - 22,0 µm in diameter, short cylindrical; in girdle view rectangular. In valve view valves circular, with a more or less marked tangential fold of the surface. Valve face divided into a distinct striate marginal zone, about a third to a quarter of the diameter in width, and a structureless central zone usually containing a single isolated stigma; striae 16 - 28 in 10 µm .

Taxonomic notes: Giffen (1963 : 226, Figs 42, 43) observed a minute *Cyclotella* species from a slightly brackish to freshwater pool in the Gulu River. He was unable to identify it and preferred to record it as an unidentified taxon. Forms identical to Giffen's unidentified species were noted in the Sundays and Great Fish rivers (Figs 172-174), and were sometimes fairly abundant in the samples. Some of these specimens were examined under TEM and by this means an identification was made possible. Comparison of these specimens (Figs 513, 514) with forms identified by Hasle (l.c.) as *Cyclotella caspia* showed clearly that they were the same as Hasle's material. The concentric area of the marginal zone not covered by the inner membrane is clearly seen forming the somewhat oval apertures on the inner side of the valve. The single strutted process in the structure-free central zone is seen distinctly in Figures 513, 514, while the marginal spines can just be detected in Figure 514 as thickenings of the marginal ends of every third or fourth costa. The perforate membrane (Fig. 513) appears to consist of rows of pores of more or less the same size, contrasting with Hasle's specimens in which the pores along the costae were somewhat larger.

C. caspia has not previously been recorded from Africa, although it is known from the Mediterranean Sea, the Caspian Sea and North Sea coasts. The Sundays and Great Fish River specimens are the first identification of this species from Africa and possibly from the Southern Hemisphere.

Euryhaline mesohalobe - 5

Figs: 172-174, 513, 514

Samples: SUN: 1. 3, 5, 6, 8, 9, 11, 13, 18, 19, 35, 36, 41, 42, 53-55, 57,
64, 65, 67, 69, 70, 74, 76-78, 80-82, 85.
FIS: 20, 22, 23, 25-27, 32.

Cyclotella kuetzingiana Thwaites

Thwaites, 1848 : 169, Pl. 11/D, Figs 1-5.
Hustedt, 1927-30 : 338, Fig. 171a.

Taxonomic notes: The forms designated to this taxon are somewhat doubtful representatives, but are identical to specimens identified as *C. keutzingiana* by Cholnoky (1970c : 10) in sample 8 in his Marble Hall paper. The forms observed here were in some ways very similar to *C. caspia* described above. The diameter of the valve varied between 4,5 µm and 7,5 µm, and had 16 - 18 striae in 10 µm . They differed, however, from the afore mentioned species in their structure. The striae were longer being about half the radius in length, and the central zone of the valve was filled with scattered but fairly closely spaced puncta. The structure of these forms was to a certain degree reminiscent of a *Stephanodiscus*, but a ring of marginal processes was not visible. A transmission electron study of these forms might indeed necessitate their transfer to this genus. The size of these forms was smaller than the typical *C. keutzingiana*, and the striae were somewhat denser. Until, however, electron microscope studies of these specimens are possible, it is preferable to retain them in this taxon with some reservation.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 15-17, 21-23, 31, 32, 50-52, 61-63, 72, 73.
FIS: 11.

Cyclotella meneghiniana Kützing

Kützing, 1844 : 50, Pl. 30, Fig. 68.
Hustedt, 1927-30 : 341, Fig. 174.

Taxonomic notes: *C. meneghiniana* is a very commonly recorded taxon, but its identification has been made awkward by the description of *Cyclotella cryptica* Reimann, Lewin and Guillard (1963 : 75-83). *C. cryptica* was distinguished from *C. meneghiniana* mainly on the grounds that in *C. cryptica* there was no well defined border between the striate marginal zone and the central zone as is the case in *C. meneghiniana*. In small valves of *C. cryptica* projections of the striae extend to the centre of the valve so that the central zone disappears altogether. In larger valves the depth of penetration of the striae extensions into the central zone is variable leaving an ill-defined border between the two zones. Superficially *C. meneghiniana* and *C. cryptica* appear to be distinct species, and Reimann (personal communication) claimed that sexual events (auxospore formation) did not change the ultrastructural phenotypic appearance in their *C. cryptica* isolate. However, recent studies by Schultz and Trainor (1968, 1970) and Schultz (1971) have shown that *C. cryptica*, when placed in media with very low salinities, can produce valves with structure identical to *C. meneghiniana*, but revert to valves with the *C. cryptica* pattern at higher salinities. Schultz (1971 : 1288) stated that increasing salinities did not induce clones of *C. meneghiniana* to produce valves with a *C. cryptica* pattern. In contrast Desikachary and Rao (1973 : 78-91) and more recently Hoops and Floyd (1979) have provided evidence that *C. meneghiniana* is capable of producing the valve pattern typical of *C. cryptica*.

Schoeman and Archibald (1976-80 : No. 6) have recently re-examined Kützing's type material of *C. meneghiniana* (Kützing mat. No. 133 = BM 17988) from Ferrara, as well as Van Heurck's slides of *C. meneghiniana* (VHS No. 478 = BM 26789), the f. *minor* (VHS No. 479 = BM 26790) and the var. *rectangulata* (VHS No. 480 = BM 26791). On all these slides both typical *C. meneghiniana* valves and valves, which can only be identified as *C. cryptica* under the light microscope, were observed. Furthermore there were so many intermediate forms, particularly on slide VHS No. 479, that it was impossible to differentiate them as either *C. meneghiniana* or *C. cryptica*. With this evidence in mind, and having studied the observations of Schultz, Desikachary & Rao, and Hoops & Floyd, the conclusion was reached by Schoeman and Archibald that *C. meneghiniana* and *C. cryptica* are actually conspecific. In view of Schultz'z (1971 : 1288) observations that the polymorphism in '*C. cryptica*' is influenced by the salinity it would appear that *C. meneghiniana* has two ecoforms, viz. *C. meneghiniana* ecoform *meneghiniana* in fresh or very low salinity water, and *C. meneghiniana* ecoform *cryptica* adapted to highly saline brackish water.

Schoeman and Archibald (l.c.) also examined a number of specimens from the prototype culture (clone T-13L of Guillard - cf. Reimann *et al.*, 1963 : 75). Unfortunately these were all very small forms (diameter 6,0 - 7,3 µm), but structurally (seen under TEM) were identical to the illustrations given by Reimann *et al.* When examined under SEM, Schoeman and Archibald (l.c.) noted some differences between *C. cryptica* and the Kützing type material in respect of the external structure of the marginal strutted processes. However, in a number of other materials containing *C. meneghiniana*, examined under SEM, a range in the structure of the marginal strutted processes and their associated spines were observed. This range suggested a link between the two species as well.

In the Sundays and Great Fish rivers both *C. meneghiniana* valves (Figs 16, 17, 19, 175-177) and *C. cryptica* valves (Figs 18, 178-180) were observed. Valves typical of *C. meneghiniana* were more frequently observed and were often abundant. In contrast positively identified specimens of *C. cryptica* were always isolated examples in association with *C. meneghiniana* (in the enumeration of the samples below those with positive records of *C. cryptica* are indicated by an asterisk). Some unusually small specimens with typical *C. meneghiniana* structure were observed. The smallest (Figs 16, 175) had a diameter measuring only 5,0 µm, and they had 8 - 10 striae in 10 µm . The largest specimen of *C. meneghiniana* was 30,5 µm in diameter, while a striae count as low as 6 in 10 µm was measured in a few specimens.

Pleioeuryhaline oligohalobe - 3.

Figs: 16-19, 175-180, 515-517

Samples: SUN: 1-11, 13, 15-19, 21-28, 30-37, 41-43, 45-48, 51, 53-55, 57, 60*, 61, 62*, 63*, 64-66*, 67, 69, 72-75, 77, 78, 80 81*.
FIS: 1, 3, 4, 6*, 8, 10-18, 20, 21, 23-26, 28-33, 37-40.
* = Positive identification of *C. cryptica*.

CYLINDROTHECA Rabenhorst 1848-60 : No. 801.

Cylindrotheca fusiformis Reimann and Lewin var. *enodis* Reimann and Lewin

Reimann and Lewin, 1964 : 289, Pl. 121, Fig. 7; Pl. 122, Figs 5, 6.

Taxonomic notes: In examining the diatom associations of Station 1 on the Sundays River, a small *Cylindrotheca* species, whose dimensions were much too small to be associated with the relatively well known *Cylindrotheca gracilis* (Brebisson ex Kützing) Grunow (cf. Hustedt, 1930 : 393, Fig. 746), was observed. The small specimens, illustrated in Figures 20, 181, 182, fitted very closely the dimension range of *C. fusiformis* var. *enodis*. Although it was not possible to determine with certainty whether the raphe fissure was interrupted at the middle or not, the short length (32,0 - 33,6 μm) and narrow width of the valve (2,1 - 3,7 μm) place it in the var. *enodis* rather than in the nominate variety of this species. The number of fibulae in 10 μm were, however, slightly less than given in the description of the var. *enodis*, being 24 in 10 μm . This is the first record of this taxon for South Africa, and possibly the first outside its type locality.

Meioeuryhaline polyhalobe - 9.

Figs: 20, 181, 182

Samples: SUN: 1, 83.

Cylindrotheca gracilis (Brebisson ex Kützing) Grunow

Grunow in Van Heurck, 1880-83 : Pl. 80, Fig. 2.
Van Heurck, 1885 : 186.
Hustedt, 1930 : 393, Fig. 746.
Reimann and Lewin, 1964 : 290, Pl. 130, Figs 4-6.

Synonyms: *Ceratoneis gracilis* Brebisson ex Kützing, 1849 : 89.
Cylindrotheca gerstenbergeri Rabenhorst, 1848-60 : Alg. Sachs. No. 801; 1864 : 145.

Taxonomic notes: According to Reimann and Lewin (1964 : 283) Rabenhorst established the genus *Cylindrotheca* for the single species *C. gerstenbergeri*. However, some ten years previously Brebisson had named this species *Ceratoneis gracilis*, and it was published as such by Kützing in 1849. It was Grunow (in Van Heurck, 1880-83 : Pl. 80, Fig. 2) who recognised that the two species were identical, and consequently proposed the combination, *Cylindrotheca gracilis*. Reimann and Lewin (l.c. : 290) in their study of the genus *Cylindrotheca* retained two varieties of *C. gracilis*, viz. var. *gracilis* and var. *major* Grunow (in Van Heurck, 1880-83 : Pl. 80, Fig. 1). Hustedt (1930 : 393), on the other hand, sank the var. *major* into the species, presumably because he observed specimens with intermediate dimensions. In the Sundays and Great Fish rivers specimens of this taxon had the following dimensions:- Length 85,0 - 134,0 μm, breadth 4,0 - 6,0 μm, and had 18 - 20 fibulae in 10 μm. In the brackish water of the Harmony Gold Mine storage dam, however, Cholnoky (1966c : 164, dimensions taken from Cholnoky's original analysis sheet) recorded specimens up to 158,5 μm in length, 6,0 μm broad and having 17 fibulae in 10 μm. This provides some evidence of specimens intermediate between the var. *gracilis* and the var. *major*, which are apparently distinguished solely on differences in dimension. The distinction of the var. *major* is therefore no longer tenable on the basis of this evidence. Hustedt (l.c.) commented that the lack of records of this species is probably caused by the destruction of the valves in the acid cleaning technique in the preparation of samples for permanent mounting. Nevertheless both in Cholnoky's study and in the present investigation of the diatoms in the Sundays and Great Fish rivers the acid cleaning method was employed for cleaning the frustules without loss of valves of this species. It is more likely that specimens are over-looked on account of their weakly silicified valves.

Euryhaline mesohalobe - 5.

Samples: SUN: 1, 6, 35, 57, 83, 84.
FIS: 16, 19, 32.

CYMATOPLEURA W. Smith, 1851 : 12.

Cymatopleura librile (Ehrenberg) Pantocsek

Pantocsek, 1902 : 91, Pl. 11, Fig. 277.
Hustedt, 1930 : 425, Fig. 823, as *Cymatopleura solea* (Brébisson) W. Smith.

Synonyms: *Navicula librile* Ehrenberg, 1832 : 81.
Frustulia quinquepunctata Kützing, 1833 : 554, Pl. 13, Fig. 28.
Cymbella solea Brébisson in Brébisson & Godey, 1835 : 51.
Surirella solea (Brébisson) Brébisson, 1838 : 17.
Cymatopleura solea (Brébisson) W. Smith, 1851 : 12, Pl. 3, Figs 8, 9.
Cymatopleura apiculata W. Smith, 1853 : 37, Pl. 10, Fig. 79.

Taxonomic notes: In a recent study of this taxon Schoeman and Archibald (1976-80 : No. 6) have reviewed the literature and examined various old materials, collected or studied by Ehrenberg, Kützing, de Brébisson and W. Smith, in an effort to determine the correct relationship between *Navicula librile* Ehrenberg, *Frustulia quinquepunctata* Kützing and *Cymatopleura solea* (Brébisson) W. Smith. Not only did a critical review of the early literature reveal that contemporary authors considered these three species as conspecific, but a study of their material, obtained from various Institutions, confirmed this. Consequently *Navicula librile* Ehrenberg (1832 : 81) must be regarded as the correct basionym of the species, and Pantocsek (1902 : 91) as the first to propose the correct combination for this taxon, viz. *Cymatopleura librile.*

Further study of these materials, as well as numerous examples from Van Heurck's Type Slide collection, convinced Schoeman and Archibald (l.c.) that infraspecific taxa, based on morphological variations or differences in dimension, are no longer tenable in *C. librile.* In a single population valves with fairly deeply constricted central portions can be found together with almost parallel-sided forms, and are linked by intermediates. W. Smith (1853 : 37, Pl. 10, Fig. 79) used the "apiculate" poles of some specimens as his chief diagnostic character distinguishing *Cymatopleura apiculata* from *C. solea.* He was, however, not altogether certain that *C. apiculata* could stand as a true species. In this respect Schoeman and Archibald (l.c.) also found that the poles in this taxon vary from cuneate to obtuse-cuneate having almost smoothly rounded to subrostrate apices. The shape of the pole and its apex cannot therefore be used as a diagnostic character, and *C. apiculata* has consequently been united with the nominate variety.

As a result of their investigations, Schoeman and Archibald (l.c.) have not differentiated between the numerous forms and varieties ascribed to this taxon (cf. Cleve-Euler, 1952 : 95, Fig. 1519, as *C. solea*). These infraspecific taxa are listed as synonyms of *C. librile* by Schoeman and Archibald (l.c.). Cholnoky's (1962a : 17; 1970c : 11) contention that the distinction of varieties in *C. librile* is purposeless, is therefore supported by these investigations.

Specimens of *C. librile*, observed in this study, were quite typical, and measured 46,5 - 105,0 µm long and 14,0 - 24,0 µm broad, and had 8 - 10 fibulae and 32 transapical striae in 10 µm.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 18, 45.
FIS: 14, 25.

CYMBELLA Agardh, 1830 : 1.

Cymbella cistula (Ehrenberg) Kirchner

Kirchner, 1878 : 189.
Hustedt, 1930 : 363, Fig. 676a.
Hufford and Collins, 1972 : 192-195, Figs 1-24.

Taxonomic notes: There appears to be some confusion over the correct authority for this taxon. Van Heurck (1885 : 64) ascribed it merely to Hemprich, although *Cocconema cistula*, cited as a synonym, is attributed to Ehrenberg. Hustedt (1930 : 363) credits Grunow with the present combination, probably because he thought Grunow was responsible for this name in the legend to Pl. 2, Fig. 12 in Van Heurck's (1880-83) Atlas. VanLandingham (1969 : 1168) cited the authority as (Hemprich in Hemprich and Ehrenberg, 1828) Kirchner, 1878. Hufford and Collins (1972) give (Ehrenberg) as the correct authority, and this view point is followed by Patrick and Reimer (1975 : 62). Due to the lack of the necessary literature it is not possible at present to substantiate any of the above claims. The authority of this species preferred in this study is (Ehrenberg) Kirchner. This choice is based on the greater likelihood that in a joint paper by Hemprich and Ehrenberg the latter would have been responsible for describing the diatoms. Furthermore Kirchner's (1878) apparent use of the combination *Cymbella cistula* predates that of Grunow.

Hufford and Collins (1972) studied the morphological variability of a natural population of *C. cistula*, and demonstrated a wide range in valve shape. Striae density was also more variable than hitherto given in any descriptions. These observations bring into question the taxonomic position of *Cymbella kappii* Cholnoky (1956 : 61, Figs 17-20). Cholnoky (1953a : 152, Figs 12-16) originally described this taxon as a variety of *Cymbella turgidula* Grunow, and discounted any close relationship to *C.*

cistula. Despite Cholnoky's denials on more than one occasion (Cholnoky, 1957b : 59, Figs 21-28; 1966b : 179) *C. kappii* may indeed form part of the range of variation of *C. cistula*. A further discussion of the taxonomic position of *C. kappii* in relation to *C. cistula* will be found under the treatment of *C. kappii*.

Meioeuryhaline oligohalobe - 1

Samples: SUN: 25, 43, 44, 46, 47.
FIS: 31.

Cymbella cistula var. *maculata* (Kützing) Van Heurck

Van Heurck, 1885 : 64.
Grunow in Van Heurck, 1880-83 : Pl. 2, Fig. 16.
Hustedt, 1930 : 363, Fig. 676b.

Taxonomic notes: Hufford and Collins (1972), as mentioned above, studied a population of *Cymbella cistula* displaying a wide degree of polymorphism. In some of these examples, particularly the smaller ones, they observed that the isolated pores at the end of the central striae were indistinct. Furthermore the number of striae were denser than normally given for the type. These observations led them to the conclusion that these forms of *C. cistula* could easily be mistaken for the var. *maculata*. Hustedt (1949a : 117, Pl. 9, Figs 12-20) observed a similar range of variation, illustrating some specimens without the isolated puncta at the centre. He considered this range of variation as "Kümmerformen" of the species, and felt he could not link them to *C. cistula* var. *maculata* on account of their size. However the only apparent difference between the nominate variety and the var. *maculata* is the presence or absence of isolated puncta at the ends of the central striae. Considering the uncertainty of this characterisctic a thorough revision of this taxon and its near relatives needs to be undertaken. A single specimen 75,0 µm long, 17,5 µm broad and having 6 striae in 10 µm, observed at Station 2 on the Great Fish River, has been placed in this taxon.

Meioeuryhaline oligohalobe - 1.

Samples: FIS: 20.

Cymbella kappii (Cholnoky) Cholnoky

Cholnoky, 1956 : 61, Figs 17-20.

Synonyms: *Cymbella turgidula* var. *kappii* Cholnoky, 1953a : 142, Figs 12-16.

Description: Valve asymmetrical, semi-lanceolate with wider convex dorsal side and a slightly gibbous central portion of the ventral margin, poles usually protracted into relatively short subrostrate to rostrate apices; length 22,5 - 44,0 µm, breadth 7,0 - 10,5 µm. Raphe branches straight, inclined slightly towards the dorsal margin; filiform near the poles with dorsally curved terminal fissures, but band-like over most of its length with the proximal end of the outer fissure curving first ventrally and then abruptly dorsally to the central pores. Axial area narrow linear, with at the most a slight widening at the central nodule; central area lacking. Transapical striae on dorsal side somewhat radial with a few central striae almost parallel, and polar striae more strongly radial; 8 - 12 in 10 µm at the centre, and 11 - 15 in 10 µm at the poles; polar striae of the ventral side strongly radial. The striae distinctly punctate, 22 - 24 puncta in 10 µm; the central 2 - 4 (most commonly 2) striae on the ventral side terminating in a stigma.

Taxonomic notes: *Cymbella kappii* was first described by Cholnoky (1953a : 142, Figs 12-16) as a variety of *C. turgidula* Grunow, but was later elevated to species rank (Cholnoky, 1956 : 61, Figs 17-20). In discussing the relationships of this species Cholnoky placed *C. kappii* between *C. turgidula* Grunow (cf. Hustedt, 1930 : 362, Fig. 670) and *C. tumidula* Grunow (cf. Hustedt l.c. : 361, Fig. 669), but did not compare it with *C. cistula* (Ehrenberg) Kirschner (cf. Hustedt l.c. : 363, Fig. 676a). A recent paper on the morphological variations of *C. cistula* (cf. Hufford and Collins, 1972) has prompted a re-examination of the affinities of *C. kappii*, particularly its relationship to *C. cistula*. Hufford and Collins observed a much wider range of variation in *C. cistula* than hitherto described, and compared their results with the dimensions given by other authors. Their dimensions are summarized in the first column of the table below.

	C. cistula	*C. kappii*	*C. turgidula*	*C. tumidula*
Length in µm	20,0 - 180,0	22,5 - 44,0	30,0 - 50,0	25,0 - 35,0
Breadth in µm	10,0 - 36,0	7,0 - 10,5	10,0 - 15,0	6,0 - 9,0
Dorsal striae (centre) No. in 10 µm	6 - 10	8 - 12	9 - 10	13 - 16
Dorsal striae (poles) No. in 10 µm	12 - 14	11 - 15	finer	up to 20
Puncta in stria No. in 10 µm	18 - 22	22 - 24	24	
Isolated puncta (no.)	1 - 5	2 - 4	2	2

For comparative purposes this table also includes the relevant information for *C. kappii*, *C. turgidula* and *C. tumidula*. Since Cholnoky's type material is missing from the NIWR diatom collection, data for *C. kappii* was obtained from the examination of Cholnoky's slides from Natal (TUG 275 and TUG 324 - NIWR) and South West Africa (SWA 138 and SWA 148 - NIWR). This data as well as further information from other South African material is summarized in column 2 of the table. The data for the remaining two species was taken from Hustedt (1930 : 361, 362). From the table it is obvious that, where measurable parameters are concerned, there is a great deal of overlapping in the dimensions of the four species under discussion. The length range of *C. kappii* fits into the range of the other three species, but in width it comes closest to *C. tumidula*, although it forms a continuous series with *C. cistula* and *C. turgidula*. On the basis of striae counts taken at the centre of the valve and at the poles the first three species appear to form a group, and only *C. tumidula* is distinct, having finer striation. When the number of puncta composing the striae are considered, *C. kappii* forms a neat bridge between *C. cistula* and *C. turgidula*. Finally the literature states that *C. turgidula* and *C. tumidula* constantly have two isolated puncta on the ventral side, while *C. cistula* has one to five. Cholnoky's (1953a : 142, Figs 12-16) original diagnosis of *C. kappii* gave two isolated puncta, and this is pointedly emphasised later (Cholnoky, 1957b : 59) to distinguish it from *C. cistula*. However examination of the material from Natal and South West Africa, identified as C. *kappii* by Cholnoky himself, showed that, whereas 2 isolated puncta is the commonest situation, specimens with up to 4 isolated puncta were not infrequent.

Considering the evidence above, the valve shape and the structure of the raphe the conclusion is reached that C. *kappii* has a much closer relationship to C. *cistula*, despite Cholnoky's (1966b : 179) strong condemnation of Round (1961 : 64, Fig. 53) for suggesting this. Cholnoky (1968a : 29) firmly stated that C. *kappii* .. "Mit C. *cistula* (Hemprich) Grunow zeigt nicht einmal eine morphologische Ähnlichkeit". It is also clear that the *Cymbella* group containing C. *kappii* is in need of revision. Until this has been achieved with reference to type material C. *kappii* will be retained as a valid species.

Meioeuryhaline oligohalobe - 1.

Figs: 183, 184

Samples: SUN: 45-48.
FIS: 20.

Cymbella kolbei Hustedt

Hustedt, 1949b : 46, Figs 20-26.

Taxonomic notes: This species is rare and there are few records of the taxon to be found in the literature. A few typical examples were recorded in both the Sundays and Great Fish rivers. The dimensions of these specimens were as follows:- length 24,5 - 26,5 µm, breadth 7,5 - 9,5 µm, striae 10 - 12 in 10 µm in the middle of the valve and up to 16 in 10 µm at the poles. Although seldom recorded elsewhere Cholnoky has found it fairly frequently throughout Southern Africa. As in the case of Kolbe and Krieger (1942 : 350, Pl. 3, Figs 16-18) it may have been confused with C. *hustedtii* Krasske (1923 : 204, Fig. 11), thus accounting for an apparent rare distribution.

Mesoeuryhaline oligohalobe - 2.

Fig.: 185

Samples: SUN: 26, 47, 60
FIS: 25, 31.

Cymbella microcephala Grunow

Grunow in Van Heurck, 1880-83 : Pl. 8, Figs 36-39.
Van Heurck, 1885 : 63.
Hustedt, 1930 : 351, Fig. 637.

Taxonomic notes: This seems to be a fairly cosmopolitan species, and the examples seen appeared to be quite typical with no special features requiring comment. In the Sundays and Great Fish rivers it was, however, only found in two samples as isolated specimens.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 35.
FIS: 27.

Cymbella oahuensis Hustedt

Hustedt, 1942a : 98, Figs 193-195.

Description: Frustule in girdle view linear with slightly tapered truncate apices. Valves naviculoid, very slightly asymmetrical; linear-lanceolate to lanceolate in the smallest forms, poles varying from scarcely protracted slightly rostrate apices to relatively long protracted poles with capitate apices; length 13,4 - 49,0 μm, breadth 3,0 - 5,0 μm. Raphe straight and filiform. Axial area narrow linear to narrowly lanceolate; central area lacking. Transapical striae weakly radial throughout, sometimes parallel at the poles; 24 - 28 in 10 μm .

Taxonomic notes: Although it is apparently a rare species, scarcely observed outside its type locality, a number of examples have been examined in South Africa (Cholnoky, 1960a : 34; 1960b : 239; 1963c : 47; 1968a : 29; and Giffen, 1963 : 226). These observations as well as the examination of individuals from the Sundays and Great Fish rivers have allowed a much more comprehensive description of the species to be drawn up (cf. above). Hustedt (l.c.) apparently saw only a few examples, and was therefore unable to give the full range of size and variation in the shape of the apices. With respect to these features a much greater range was observed in the material examined in this study. On the other hand features such as the axial area and the density of the striae were more or less as given in the original diagnosis.

Euryhaline mesohalobe - 5.

Figs: 186-188
Samples: SUN: 6-9, 12, 15-17, 30, 31, 35, 36, 41, 42, 57, 62, 64, 67, 74, 80, 81.
FIS: 7.

Cymbella pusilla Grunow

Grunow in A. Schmidt *et al.*, 1874-1959 : Pl. 9, Figs 36, 37.
Grunow in Van Heurck, 1880-83 : Pl. 3, Fig. 5.
Van Heurck, 1885 : 62.
Hustedt, 1930 : 354, Fig. 646,

Taxonomic notes: *Cymbella pusilla* is a common and well known species in brackish waters. It was found frequently in the waters of the Sundays and Great Fish rivers. These specimens had a wider range in dimensions than that given by Hustedt (l.c.), being 13,5 - 28,0 µm long, 4,0 - 5,5 µm broad and having 14 - 20 striae in 10 µm (usually 16-18). Cholnoky (1959 : 20, Figs 112, 113) reported some small specimens, only 12,0 µm long, but these were otherwise typical.

Euryhaline mesohalobe - 5.

Samples: SUN: 1, 3-17, 21, 23, 24, 35-41, 47, 49-51, 53-56, 58, 61, 62, 64-68, 74-83.
FIS: 14, 18, 19, 25, 29, 40.

Cymbella ventricosa Kützing

Kützing, 1844 : 80, Pl. 6, Fig. 16.
Hustedt, 1930 : 359, Fig. 661.

Taxonomic notes: VanLandingham (1969 : 1244) attributed the combination, *Cymbella ventricosa*, to Agardh. On the other hand Reimer (in Patrick and Reimer 1975 : 48) disputed the fact that *C. ventricosa* sensu Kützing (1844 : 80) is the same as *C. ventricosa* Agardh (1930 : 9). Reimer (l.c.) stated that he had examined Agardh's material and had found no *Cymbella* forms, but specimens identified by Reimer as a small *Rhopalodia* were present. This opinion seems to be shared by Grunow (cf. Van Heurck, 1880-83 : Pl. 3, Fig. 15), since he made a comment in the legend of the plate concerned to the effect that the original species of Agardh is a variety of *Epithemia gibberula (= Rhopalodia gibberula)*. Reimer (l.c.) consequently deemed *C. ventricosa* Kützing a later homonym of Agardh's combination, and thus renamed Kützing's taxon *Cymbella minuta* Hilse ex Rabenhorst. Since neither Agardh's type material nor all the relevant literature is available for personal scrutiny, the more commonly accepted name, *Cymbella ventricosa* Kützing, is retained for the present.

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 6, 9, 20-22, 25, 34.
FIS: 23, 25.

DENTICULA Kützing, 1844 : 43.

Denticula sundaysensis n. sp.

Description: Valves lanceolate, linear-lanceolate to linear with relatively acute cuneate poles; length 10,5 - 14,5 µm, breadth 2,3 - 3,0 µm. Canal raphe strongly eccentric, not particularly distinct. Transapical costae 8 - 10 in 10 µm; transapical striae fine, about 19 - 20 in 10 µm. Septa absent.

Taxonomic notes: In attempting to identify this small *Denticula* species accurately it became evident that there are a number of closely allied species, in which distinguishing characteristics are not always sufficiently clear. Once again this shows the need for a thorough re-examination of many diatom taxa and comparison with their type material. The validity of considering this taxon as a new species is somewhat tenuous, but it is described as such on the grounds that it is easier to sink one taxon into another, than to divide a taxon into two at a later stage. *D. sundaysensis* bears a close resemblance to a number of small *Denticula* species in dimensions of length and breadth. However when other factors, such as structure, morphology and ecology are considered, certain distinctions are evident. There is some discrepancy concerning the number of striae in *D. tenuis* Kützing (1844 : 43, Pl. 17, Fig. 8) and *D. frigida* Kützing (l.c. : 43, Pl. 17, Fig. 7). Earlier diatomists follow Grunow (cf. Van Heurck, 1880-83 : Pl. 49, Figs 26, 28-31, 35-38) who noted about 17 striae in 10 µm in both these taxa. On the other hand Hustedt (1930 : 381) maintained that due to a serious error these counts were far too low, and that they should be 25 - 30 in 10 µm . Examination of type material is necessary to resolve this difference of opinion. Nevertheless *D. tenuis* and *D. frigida* appear to be relatively coarse forms and are furthermore freshwater species. *D. sundaysensis* was confined to the estuarine zone of the Sundays River, and was most abundant when the salinity was particularly high. This brackish water preference suggests a closer relationship to *D. subtilis* Grunow (1862 : 547, Pl. 12, Fig. 36), and *D. exigua* (Grunow) Østrup (1901 : 548). Little information with regard to the latter is available at present, while *D. subtilis* is a much more finely striated species (25 - 30 striae in 10 µm, cf. Hustedt, 1955 : 43, Pl. 9, Figs 26-28). Specimens almost identical to those found in the Sundays and Great Fish rivers were identified by Cholnoky (1959 : 21, Figs 121-126) from other regions of South Africa as *D. subtilis*. These specimens had, however, striae counts (20 - 23 in 10 μm) rather coarse for *D. subtilis*. Consequently they are suspect as genuine examples of *D. subtilis*. In passing, another taxon very close to *D. subtilis* is *Denticula rainierensis* Sovereign (1963 : 364, Figs 22-24) whose only apparent distinction from *D. subtilis* is an ecological one. *D. rainierensis* is a freshwater species, and has 28 - 30 striae in 10 μm; both points making a connection to *D. sundaysensis* unlikely. Finally any relationship to *D. kamtschatika* Zabelina (cf. Simonsen & Kanaya, 1961 : 503, Pl. 1, Figs 14-18) is excluded owing to the complete absence of septa in the new species and characteristic of *D. kamtschatika*.

Euryhaline mesohalobe - 5.

Figs: 21, 22, 189, 190, 518

Samples: SUN: 59, 82-84, 86.
FIS: 10.

DIPLONEIS Ehrenberg 1840 : 155 (?); 1844a : 84

Diploneis bombus Ehrenberg

Ehrenberg, 1844 : 84.
Ehrenberg, 1854 : Pl. 19, Fig. 31.
Hustedt, 1931-59 : 704, Fig. 1086a-c.

Taxonomic notes: A few specimens were observed in the estuarine regions of the Sundays River, and had the following dimensions:- Length 36,0 - 44,0 μm, breadth 16,0 - 19,0 μm at its widest part and 10,0 - 12,3 μm at the constriction, while transapical striae numbered 8 - 10 in 10 μm . This striae count is slightly denser than that given by Hustedt (l.c.), but all other features were more or less typical.

Meioeuryhaline polyhalobe - 9.

Samples: SUN: 3, 59, 70, 71, 82, 84, 86.

Diploneis fusca (Gregory) Cleve

Cleve, 1894 : 93.
Hustedt, 1931-59 : 654, Fig. 1053.
Hendey, 1964 : 225, Pl. 32, Fig. 10.

Synonyms: *Navicula smithii* Donkin var. *fusca* Gregory, 1857 : 14, Pl. 1, Fig. 15.

Taxonomic notes: Four specimens of a *Diploneis* species were observed in sample SUN 11 (NIWR), and have been placed in this taxon mainly on account of the structure of the striae. In these specimens the striae near the margins were composed of double rows of decussately arranged puncta between the costae; near the longitudinal furrows the double rows of puncta pass into rows of single areolae. This arrangement may also be found in some specimens of *D. subovalis* (cf. Hustedt, 1931-59 : 667, Fig. 1063a, b), but the size factor easily distinguishes the two taxa. Hustedt (l.c. : 659) has commented extensively on the structure of the striae in relation to *D. smithii* (Brébisson) Cleve (cf. Hustedt l.c. : 647). According to this review *D. fusca* has two extremes of structural form. At one end of the variation range is the "*fusca*" structure in which there are single rows of areolae between the costae; while at the other extreme there is the "*smithii*" structure, in which the striae are composed of double rows of decussately arranged puncta. The latter clearly points to a very close relationship to *D. smithii*, a fact which has long been recognised, since the taxon was originally described by Gregory (1857 : 14, Pl. 1, Fig. 15) as a variety of *Navicula smithii (= D. smithii)*. In between these two forms of striae structure there are intermediates such as the examples seen in sample SUN 11, where the striae change from the "*smithii*" structure near the margins to the "*fusca*" type near the longitudinal furrows. The dimensions of the specimens observed in this study were:- length 62,0 - 78,0 µm, breadth 36,0 - 43,0 µm, and had 8 - 10 striae in 10 µm .

Meioeuryhaline polyhalobe - 9.

Figs: 191-193

Samples: SUN: 11.

Diploneis oblongella (Naegeli ex Kützing) Cleve

Cleve, 1891 : 44.
Ross, 1947 : 212.
Patrick and Reimer, 1966 : 413, Pl. 38, Fig. 8.

Synonyms: *Navicula oblongella* Naegeli in Kützing, 1849 : 890
Diploneis ovalis var. *oblongella* (Naegeli) Cleve, 1894 : 93
Diploneis ovalis (Hilse) Cleve, 1891 : 44, Pl. 2, Fig. 13.
Pinnularia ovalis Hilse, 1860 : 82.
Navicula ovalis (Hilse) A. Schmidt in Schmidt *et al.*, 1874-1959 : Pl. 7, Fig. 33.

Taxonomic notes: The first published description of *Navicula oblongella* Naegeli appeared in the "Species Algarum" written by Kützing (1849 : 90). Cleve (1891 : 44) later transferred this taxon to the genus *Diploneis* as *D.* (*ovalis* var?) *oblongella*, but was evidently uncertain whether it should be regarded as a species in its own right or not. Subsequently Cleve (1894 : 93) considered it as a variety of *D. ovalis* (Hilse) Cleve. In the same earlier work Cleve (1891 : 44, Pl. 2, Fig. 13) transferred *Navicula ovalis* (Hilse) A. Schmidt (1874-1959 : Pl. 7, Fig. 33) to the genus *Diploneis*. This *Navicula ovalis* (Hilse) A. Schmidt based on *Pinnularia ovalis* Hilse, must not be confused with the earlier homonym *Navicula ovalis* Naegeli ex Kützing (1849 : 890), which is, according to VanLandingham (1975 : 2706), an invalid species. More recent views on the relationship between *D. ovalis* and its variety var. *oblongella* consider both entities as forming a continuous range of variation of one taxon. Accordingly Patrick and Reimer (1966 : 413, Pl. 38, Fig. 8) and Cholnoky (unpublished manuscript) have united the two species under the name *D. oblongella*. There is however some controversy over this combination as Hustedt (1931-59 : 671) wished to retain the name *D. ovalis* in preference to the older legitimate epithet "*oblongella*" on the grounds that the name *D. ovalis* had become general usage in all the literature. Unfortunately the International Code of Botanical Nomenclature (Lanjouw, 1966) does not make allowance for sentiment or popular usage in respect of ranks lower than genus. The earliest valid epithet, viz. "*oblongella*" must therefore be used.

A few examples of this taxon were observed in the Sundays and Great Fish rivers. The majority of these specimens were the smaller almost parallel sided forms, although their connection to the elliptical examples was clear.

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 11-14, 16, 34, 35, 37, 39-41, 55, 65, 76-79, 81.
FIS: 10.

Diploneis pseudopetersenii Cholnoky.

Cholnoky, 1963c : 49, Figs 24, 25.

Taxonomic notes: The true identity of the single specimen placed in this taxon is not quite certain. It has been tentatively place with *D.*

pseudopetersenii Cholnoky (l.c.) since it conforms more closely on certain points with the description of Cholnoky's species than with any other taxon known through the literature available. This example was elliptical with broad, somewhat conical poles; 14,5 µm long and 6,8 µm broad. In these features it agreed with *D. pseudopetersenii*. The central nodule was apically elongated and produced into two pairs of more or less parallel horns enclosing the raphe. The longitudinal canals were narrow, expanding slightly around the central nodule. The transapical striae are conspicuous, but slightly denser than in *D. pseudopetersenii*, being 20 in 10 µm . The striae were, however, peculiar because, although they appear to be interrupted by the longitudinal canals, they protruded into the central nodule and were observed along the horns of the central nodule. This peculiarity is at variance with *D. pseudopetersenii* as well as other members of the genus. Since only one example has been observed there is no justification for describing it as a new species. Consequently it has been placed with *D. pseudopetersenii* on account of its similarities in other features. Closer comparison with Cholnoky's type material (sample No. K263 - NIWR) from the Steenbras River mouth will be necessary. In an examination of this material, only one specimen of *D. pseudopetersenii* was found, despite Cholnoky's (l.c.) remark that he saw many examples.

Oligoeuryhaline polyhalobe - 10.

Fig.: 194
Samples: SUN: 59.

Diploneis pseudovalis Hustedt

Hustedt, 1930 : 253, Fig. 403.
Hustedt, 1931-59 : 668, Fig. 1063c.

Taxonomic notes: The distinction between *Diploneis pseudovalis* and *D. subovalis* Cleve (cf. Hustedt, 1931-59 : 667, Fig. 1063a, b) is extremely difficult to define precisely. Hustedt (l.c.) maintained that *D. pseudovalis* has finer structure than *D. subovalis*, and furthermore differs ecologically being a brackish water form. However a careful comparison of the descriptions of these two taxa given by Hustedt (1931-59 : 667, 668) produced few points that differed significantly. Cholnoky (personal communication) regarded the arrangement of the two rows of puncta between the costae as being significant in separating the two species. In *D. subovalis* the puncta in the double rows are supposed to be arranged alternately (quincunx arrangement), although sometimes in smaller specimens they may pass over into a single row of areolae. On the other hand in *D. pseudovalis* the puncta between the costae are generally arranged in two rows opposite each other, but may also have alternately arranged puncta. Superficially such differences may exist. However a few specimens of a *Diploneis* form, examined under the transmission electron microscope, could, on the basis of the arrangement of the pores, have been placed in either of the two species. The variability in the puncta arrangement of this one valve was great enough to suggest that a very thorough study of *D. pseudovalis* and *D. subovalis* is necessary before any definite conclusions can be made with regard to resolving specific differences on this criterion. Considering next the ecological differences between the two taxa, the observation of *Diploneis* forms with typical *D. subovalis* type arrangement of the puncta in some of the most brackish zones in the Sundays River casts some doubt on salinity as a valid distinguishing taxonomic character.

In view of the large degree of uncertainty in the relationship between these two species, no well reasoned conclusions can be drawn regarding their taxonomy without an intensive study of the two species. In this investigation forms with an indistinct arrangement of the rows of puncta have been considered as *D. pseudovalis*, while those with a distinct alternate arrangement were considered as *D. subovalis*.

Euryhaline mesohalobe - 5.

Samples: SUN: 5, 6, 41, 53, 65, 68, 82, 83.
FIS: 14, 18, 25-27, 37-40.

Diploneis smithii (Brebisson) Cleve

Cleve, 1894 : 96.
Hustedt, 1931-59 : 647, Fig. 1051.
Hendey, 1964 : 225, Pl. 32, Fig. 10.

Synonyms: *Navicula smithi (smithii)* Brebisson in W. Smith, 1856 : 92.

Taxonomic notes: Only two typical examples of this species have been observed in the Sundays River. These had the following dimensions:- Length 35,0 - 38,0 µm, breadth 13,5 - 18,0 µm, and had 10 - 12 striae in 10 µm . The species is not well known in South Africa, and therefore taxonomic comment on this taxon is hazardous. Hustedt (1931-59 : 650) has discussed its taxonomy at length and commented on its relationship to other closely connected species. As many of the species mentioned in this review are unknown to the author critical remarks on Hustedt's writing is unwise. It should, however, be mentioned that extreme difficulty was experienced during this survey in trying to separate the different forms falling into the *D. smithii*, *D. subovalis*, *D. fusca*, and *D. pseudovalis* group. Specimens placed in this taxon were identified as *D. smithii* mainly on the basis of their size; the structure and shape of the longitudinal furrows, which were lanceolate and about a third of the valve width broad; and the decussate arrangement of the striae, extending from the margin of the valve to the edge of the longitudinal furrows.

Pleioeuryhaline polyhalobe - 7.

Samples: SUN: 40, 41.

Diploneis subovalis Cleve

Cleve, 1894 : 96, Pl. 1, Fig. 27.
Hustedt, 1931-59 : 667, Fig. 1063a, b.

Taxonomic notes: The forms from the Sundays River designated as *D. subovalis* are placed in this taxon with some uncertainty. The taxon appears to be present at nearly all stations on the Sundays River. The presence of *D. subovalis* in the more highly brackish lower course and estuarine zone of the river is somewhat surprising, as the taxon is regarded as a freshwater species. Consequently some doubt exists concerning the accuracy of the identification of the specimens from these two zones. The size range of the specimens and the arrangement of the puncta rows between the costae point to *D. subovalis*. However from an ecological point of view, *D. subovalis* seems out of place in the brackish water zones. In this respect these specimens may be better placed with some of the small varieties of *D. smithii*. The problems involved with the taxonomy of the *Diploneis* group including *D. subovalis* are further discussed under *D. fusca*, *D. pseudovalis* and *D. smithii*. This group requires intensive re-examination with the aid of type material and electron microscopy to establish their correct identities and inter-relationships.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 1-3, 5-11, 13, 14, 18, 23, 26, 35, 36, 40, 70, 71, 83, 85, 86.
FIS: 14, 28, 40.

EPITHEMIA Brebisson, 1838 : 16

Epithemia reicheltii Fricke

Fricke, 1904 : in A. Schmidt *et al.*, 1874-1959 : Pl. 251, Figs 28-32.
Meister, 1912 : 199, Pl. 34, Fig. 9.
Hustedt, 1930 : 388, Fig. 378.

Taxonomic notes: In sample SUN 41 a few specimens placed in this taxon were observed. It is, however, sometimes difficult to distinguish between this genus and the very similar genus *Rhopalodia*. Hendey (1964 : 270) considered that the main distinction between the two genera is the structure and position of the raphe. In *Epithemia* the raphe consists usually of two curved branches extending from the primitive polar nodules on the ventral side to the central nodule near the centre of the valve or near its dorsal margin. On the other hand the raphe of *Rhopalodia* runs along the dorsal margin of the valve, and is not easy to distinguish. Hendey (l.c.) claimed that nodules are present, but small. The Sundays River specimens had a raphe structure typical of *Epithemia*, and the more or less straight branches close to the dorsal margin refer it very strongly to *E. reicheltii*. The taxon has been reported previously from South Africa by Schoeman (1970a : 338, Figs 23-27), but his illustrations suggest a stronger relationship to *Epithemia cistula* (Ehrenberg) Ralfs (cf. Mayer, 1936 : 106, Pl. 8, Figs 6-10). The Sundays River specimens had the following dimensions:- Length 33,0 - 56,0 μm, breadth 10,0 - 12,0 μm, costae 1,5 - 3 in 10 μm and transapical striae 14 - 16 in 10 μm.

Not yet characterised.

Figs: 195-198

Samples: SUN: 41.

Epithemia sorex Kützing

Kützing, 1844 : 33, Pl. 5, Fig. XII, 5a-c.
Van Heurck, 1880-83: Pl. 32, Figs 6-10.
Hustedt, 1930 : 388, Fig. 736.
Schoeman *et* Archibald, 1976-80 : No. 1.

Description: Valves arcuate with a convex to strongly convex dorsal margin, and a concave ventral margin (straight in smallest specimens), narrowing to protracted (smallest specimens not protracted), broadly rostrate to semicapitate poles; length 8,0 - 70,0 µm, breadth 6,6 - 16,0 µm. Canal raphe branches arcuate, dorsally upturned at the poles, running along the ventral margin and curving strongly upwards near the centre of the valve to the central nodule situated near the dorsal margin, thus forming a V-shape at the centre of the valve. Costae radial, slightly curved, 5 - 7,5 in 10 µm, with usually 2 - 3 rows of areolae between the costae (i.e. 10 - 15 rows in 10 µm).

Electron microscopic studies by Schoeman and Archibald (1976-80 : No. 1) have shown that the radial costae are of two types, viz. a much thicker primary costa running from margin to margin and crossing the raphe, and a less well silicified secondary costa which is interrupted by the raphe. The double row of pores between the secondary costae often appear as dumb-bell shaped areolae covered with a porous membrane. The raphe is a true canal raphe with a slit-like external fissure and opening internally by means of a series of circular openings.

Taxonomic notes: While showing a very large range of variation, the South African specimens are in very good agreement with Kützing's type specimens from Schleusingen on slide BM 17791 kept in the British Museum (Natural History) (cf. Schoeman and Archibald, 1976-80 : No. 1). Only a few specimens were recorded from the Sundays River at Station 6.

Pleioeuryhaline oligohalobe - 3.

Samples: SUN: 31, 51, 62.

Epithemia turgida (Ehrenberg) Kützing

Kützing, 1844 : 34, Pl. 5, Fig. 14.
Hustedt, 1930 : 387, Fig. 733.

Synonyms: *Navicula turgida* Ehrenberg, 1830 (1832) : 64.

Taxonomic notes: A single specimen was recorded from Station 1, and it had the following dimensions:- Length 88,0 µm, breadth 14,0 µm, costae 4 in 10 µm, and transapical striae between the costae 9 in 10 µm. These dimensions agree well with the description given by Hustedt (l.c.).

Pleioeuryhaline oligohalobe - 3.

Samples: SUN: 2.

Epithemia zebra (Ehrenberg) Kützing

Kützing, 1844 : 34, Pl. 5, Fig. XII, 6a-c.
Hustedt, 1930 : 384, Fig. 729.

Synonyms: *Navicula zebra* Ehrenberg, 1834 : 262.

Taxonomic notes: Cholnoky (1962a : 21; 1962c : 71; 1966a : 15; 1966b : 182) has reiterated on numerous occasions his view that the varieties, var. *porcellus* (Kützing) Grunow and var. *saxonica* (Kützing) Grunow, cannot be distinguished from the nominate variety, *E. zebra*, since the wide morphological range found in this taxon embraces all the varieties linked by intermediate forms. Giffen (1966b : 132) came to the same conclusion in his study of the diatoms from the Amatola Mountains. Accordingly the specimens observed in this study have not been distinguished at varietal level. The range in dimensions was as follows:- Length 61,0 - 90,0 µm, breadth 9,0 - 10,0 µm, costae 3 in 10 µm, and transapical striae 12 - 14 in 10 µm .

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 6, 32, 63.

EUNOTIA Ehrenberg, 1837 : 44.

Eunotia diodon Ehrenberg

Ehrenberg, 1837 : 45.
Hustedt, 1930 : 173, Fig. 207.
Hustedt, 1931-59 : 276, Fig. 742.

Taxonomic notes: A single example of this taxon was recorded from the Sundays River at Station 4a. Its length was 43,0 µm, its breadth 8,0 µm, and it had 12 transapical striae in 10 µm .

Halophobe - 0.

Samples: SUN: 13.

Eunotia exigua (Brebisson) Rabenhorst

Rabenhorst, 1864 : 73.
Hustedt, 1930 : 176, Fig. 223.
Hustedt, 1931-59 : 285, Fig. 751.

Synonym: *Himantidium exiguum* Brebisson in Kützing, 1849 : 8.

Taxonomic notes: This is yet another diatom species which needs careful revision with regard to its closest allies. Hustedt (1930 : 176) gave certain features which he felt at that time could distinguish *E. exigua* from *E. tenella* (Grunow) Hustedt (l.c. : 175, Fig. 200). His experience of the morphological range of *E. exigua* from Java, Bali and Sumatra (cf. Hustedt, 1937-38 : 165, Pl. 10, Figs 1-12) and its variety var. *gibba* Hustedt (l.c. : 166, Pl. 10, Figs 13-18) quite clearly invalidates these distinguishing characteristics. This led him to comment extensively on the relationship between *E. exigua, E. tenella* and *E. trinacria* Krasske (1929 : 349, Fig. 1a-d). Thus Hustedt (1937-38 : 167) reached the conclusion that "Im Sundamaterial ist eine Aufteilung des Formenkreises in zwei oder gar drei Arten eine Unmöglichkeit. Es berechtigt im Gegenteil zu der Annahme, das *Eunotia tenella* und *Eunotia trinacria* ökologische Abkömmlinge der *Eunotia exigua* sind". The latter presumably means that all three species are ecological phenotypes of one entity. It is therefore somewhat surprising that in his Congo material Hustedt (1949a : 69, Pl. 3, Figs 24-30) lists both *E. exigua* and *E. tenella*, illustrating the latter with a series of drawings which included a new form, f. *undulata*, without any comment on the close relationship between the two taxa. In the Sundays River a single specimen was recorded, and consequently no further comment can be made.

Halophobe - 0.

Samples: SUN 76.

Eunotia pectinalis (Kützing) Rabenhorst var. *minor* (Kützing) Rabenhorst

Rabenhorst, 1864 : 74.
Hustedt, 1930 : 182, Fig. 238.
Hustedt, 1931-59 : 298, Fig. 763d-f.

Synonyms: *Himantidium minus* Kützing, 1844 : 39, Pl. 16, Fig. 10.

Taxonomic notes: Since only one specimen was observed no significant comment can be made on this variety.

Halophobe - 0.

Samples: SUN: 34.

FRAGILARIA Lyngbye, 1819 : 182.

Fragilaria atomus Hustedt

Hustedt, 1931-59 : 164, Fig. 672b.

Description: Cells in girdle view rectangular, joined closely together in bands. Valves elliptical to linear-elliptical with bluntly rounded poles; 5,0 - 7,0 µm long, 2,0 - 3,0 µm broad. Transapical striae fine, about 26 in 10 µm . Axial area very narrow and linear.

Taxonomic notes: In sample FIS 14 from the Kap River a single small *Fragilaria* valve was observed. This valve resembled very closely *F. atomus* Hustedt (l.c.), agreeing in dimensions and striae density, but differing in valve shape. The Kap River specimen was elliptical with protracted relatively broad rostrate poles. In this respect it was more reminiscent of *Fragilaria exiguissima* Archibald (1966b : 486, Figs 18-22), which was distinguished from *F. atomus* on the basis of valve shape, narrower valves and finer striation. The Kap River specimen is, nevertheless, placed with *F. atomus*. A comparison of the type materials of both the above mentioned taxa is necessary to determine whether they are indeed different. As far as is known this is the first record of *F. atomus* from the continent of Africa.

Meioeuryhaline oligohalobe - 1.

Fig.: 23

Samples: FIS: 14.

Fragilaria elliptica Schumann

Schumann, 1867 : 52, Pl. 1, Fig. 5.
Mayer, 1937 : 67, Pl. 3, Figs 27-32; Pl. 4, Fig. 29.
Haworth, 1975 : 76, Figs 14-21.

Taxonomic notes: At Station 6 on the Sundays River a small almost circular to elliptical *Fragilaria* species was the dominant taxon on every occasion the station was sampled. These were at first referred to *Fragilaria pinnata* Ehrenberg (cf. Hustedt, 1931-59 : 160, Fig. 671a-i), despite the fact that certain features did not comply exactly with the diagnosis of *F. pinnata*. However, following a scanning electron microscope study by Haworth (1975) of some small, light microscopically similar *Fragilaria* species, these forms are much better placed in the taxon *Fragilaria elliptica* Schumann. On the basis of valve structure the forms observed in the Sundays River cannot be related to *F. pinnata*. Haworth's study showed that the striae of *F. pinnata* consist of a single oval opening crossed by thin siliceous strips, whereas the striae of *F. elliptica* are composed of a single row of more or less circular puncta. Furthermore the spines in *F. pinnata* varied from a single spine, a pair of spines, or even occasionally three or four spines situated on the margin of the valve face between the striae; in contrast the spines of *F. elliptica* are horn shaped and often flattened or spathulate at the tips, and are found singly either between the striae on a costa, or over the striae themselves near the valve face margin. Transmission and scanning electron microscopical observation of the Sundays River forms show that in both these respects they are almost identical with *F. elliptica* as determined by Haworth (1975 : 76). Some of these specimens (Figs 519, 520) do, however, show some differences: the striae are composed of two to four puncta, of which the one nearest the margin is distinctly larger than the others, and furthermore the spines seem constantly placed at the end of a stria. Haworth's forms, in contrast, had a greater number of puncta composing the striae, and the spines were only occasionally found over a stria.

The punctate nature of the striae strengthens the conviction that these forms are correctly placed in *F. elliptica*, as Schumann (1867 : 52) described the striae as "granulatis interruptis" in his original diagnosis. This characteristic was subsequently noted by Schönfeldt (1907 : 100) - "Streifen fein, gekörnt"; and by Mayer (1937 : 67) - "Streifen fein granuliert". Although there seems to be consensus of opinion with regard to the structure of the striae, there is less agreement over the density of the striae. Schumann (l.c.) in his original description gives 11 in 10 µm, but draws 15,7 in 10 µm in his illustration of the species. Meister (1912 : 66) gave 15 in 10 µm; Mayer (l.c.) counted 13 - 16 in 10 µm; while Haworth (l.c.) found a range of 16 - 20 in 10 µm .

Patrick (1941 : 198) discussed the relationship of specimens she observed from Brazil with *F. construens* var. *venter* (Ehrenberg) Grunow, *F. pinnata* and *F. elliptica*. She came to the conclusion that her specimens were best designated as *F. elliptica*. Her illustration (Pl. 8, Figs 4, 5) and dimensions of the Brazilian examples indicate clearly that the Sundays River specimens were very closely similar, supporting their identification as *F. elliptica*. The following dimensions were recorded for the Sundays

River specimens:- Length 3,4 - 10,0 µm; breadth 2,8 - 4,5 µm; striae 12 - 16 in 10 µm .

Mesoeuryhaline oligohalobe - 2.

Figs: 199-206, 519-522

Samples: SUN: 4-6, 8-13, 15-19, 29-33, 35-37, 40-42, 50-54, 57, 61-67, 69, 72-81, 85.
FIS: 3.

Fragilaria familiaris (Kützing) Hustedt

Hustedt, 1957 : 229.

Hustedt, 1931-59 : 207, Fig. 697c, as *Synedra rumpens* var. *familiaris* (Kützing) Grunow.

Synonym: *Synedra familiaris* Kützing, 1844 : 68, Pl. 15, Fig. 12.

Taxonomic notes: On account of the band-shaped colonies, which he had observed, Hustedt (1957 : 229) transferred the taxon *Synedra rumpens* var. *familiaris* (Kützing) Grunow to the genus *Fragilaria*, simultaneously raising it in rank to species. Without evidence to the contrary this status and combination has been accepted in this study. VanLandingham (1971 : 1786), however, appears to revert to the concept that this taxon is a variety of *Synedra rumpens*, but gives no reference to support this. It is usual for VanLandingham (1967 : vii) to preserve Hustedt's interpretations of synonymy. In this case he appears not to have done so, and further information is therefore expected in a later volume of VanLandingham's catalogue, when he deals with *S. rumpens* var. *familiaris*. This volume (VanLandingham, 1978 = 3939) has since been published, but Vanlandingham still retains the taxon as a variety of *Synedra rumpens*.

Meioeuryhaline oligohalobe - 1.

Samples: 34.

Fragilaria sundaysensis n. sp.

Description: Cells in girdle view rectangular, crossed by an apparent broad band in the larger specimens due to the strong inflation of the central part of the valve. Valves very variable in outline, from almost circular in the smallest specimens to valves with a strongly, somewhat rhombic, central portion and narrowly protracted rostrate apices; many of the intermediate stages in the valve outline asymmetrical around the apical axis; length 2,9 - 8,0 µm, width 2,9 - 5,5 µm . Axial area extremely narrow and linear, central area absent. Transapical striae fine, 27 - 28 in 10 µm, generally more or less parallel.

A TEM examination of a few valves (Figs 523, 524) confirmed the LM description, but gave striae counts of 26 - 27 in 10 µm . Each stria consists of a single row of more or less circular to elliptical pores, numbering 37 - 42 in 10 µm .

Taxonomic notes: This new taxon contains forms with a morphological range strikingly similar to *Fragilaria construens* and its variety var. *venter* (cf. Hustedt, 1931-59 : 156, Fig. 670a-c, h-m). It differs, however, from *F. construens* in its very fine structure, viz. 28 striae in 10 µm . In this respect and considering the valve shape of the larger specimens, *F. sundaysensis* resembles *Fragilaria inflatissima* Hustedt (1953b : 279, Figs 44, 45). In contrast the latter has extremely short marginal striae, thus forming a wide hyaline central area or axial area. The range in outline of the valves of the new taxon is interesting since the taxon cannot be divided on this basis into distinct varieties, as can be done with *F. construens* and the var. *venter*. Furthermore the range of valve shape clearly illustrates the first and the third principles outlined by Geitler (1932 : 175) in his study of the change in shape of the diatom valve during its decrease in size following successive cell divisions. As mentioned in the description many of the intermediate forms are asymmetrical about the apical axis (Figs 27, 209, 212). A similar range of asymmetrical outlines is given by Mayer (1937 : Pl. 3, Figs 64-81; Pl. 4, Figs 1-7, 19-25) for *Fragilaria harrisonii (= F. leptostauron)* and its varieties.

Recently Clark and Rushforth (1977 : 39, Pl. 8, Fig. 4) illustrated a specimen which they assigned to *Synedra parasitica* (W. Smith) Hustedt (1930 : 161, Fig. 195), despite much denser striation (25 - 30 striae in 10 µm) and a rather different valve shape. There is a certain similarity between Clark and Rushforth's illustrated specimen and the taxon described above in respect to valve shape and density of striae. The dimensions of their forms appeared, however, to be somewhat larger (10,0 - 20,0 µm long, 7,0 - 11,0 µm wide). Clark and Rushforth do not mention any intermediates between their example and the typical *S. parasitica*, implying that they were constantly different. Their specimen appears to be more closely related to *F. sundaysensis* than *S. parasitica*.

Euryhaline mesohalobe - 5.

Figs: 24-29, 207-216. 523, 524

Samples: SUN: 1-11, 13, 35-37, 41, 42, 53-55, 57, 61, 64-71, 74-78, 80, 81, 85.
FIS: 12.

FRUSTULIA Agardh, 1824 : XIII, 1.

Frustulia interposita (Lewis) Cleve var. *incomperta* (Lewis) Cleve

Cleve, 1894 : 123.

Synonyms: *Navicula incomperta* Lewis, 1865 : 18, Pl. 2, Fig. 20.

Taxonomic notes: In his paper on the diatoms from the Kowie River estuary (Giffen (1970a : 275, Fig. 34) reported some *Frustulia* forms under the name *F. interposita* var. *incomperta* (Lewis) Cleve, noting that the examples he observed varied greatly in dimensions and number of striae. Unfortunately he gives no indication of the size range he observed, and figured only a single example. This illustration indicates that some of his specimens were 40,0 µm long, 9,0 µm broad, and had 21 - 23 transapical striae and about 20 longitudinal lines in 10 µm. Giffen (l.c.), furthermore, suggested that *Navicula zonula* Cholnoky (1960a : 87, Fig. 267) was synonymous with *Frustulia interposita* (Lewis) Cleve (1894 : 123). Giffen may indeed be correct, but not having seen any type material of *F. interposita* or its var. *incomperta*, it is difficult to be absolutely certain of this. Nevertheless a single specimen of a *Frustulia* from the Sundays River has been placed for the time being in this group on account of its similarity to Giffen's specimens from the Kowie River and *N. zonula* from Natal. In dimension and density of striae the Sundays River specimen differed, being 26,0 µm long, 5,9 µm wide, and having 28 transapical striae, and about 16 longitudinal striae in 10 µm . In this respect the Sundays River form also has a similarity to *Frustulia linkei* Hustedt (1952b : 393, Fig. 102). The latter has almost parallel valve margins, and the longitudinal striae according to Hustedt (l.c.) and van der Werff and Huls (1957-74) are very fine - about 35 in 10 µm .

Since Giffen (l.c.) reportedly observed a great variation in dimensions in his examples and on account, furthermore, of the similarity of the estuarine habitat in which these specimens were found, the Sundays River specimen (Figs 30, 217) is considered as similar to Giffen's forms. They are consequently included with *F. interposita* var. *incomperta*. There are, however, features such as its very small size and coarser longitudinal striae, which make this choice of name doubtful. Nevertheless it cannot be related to any other *Frustulia* species at present, and it was felt best to group it with Giffen's forms.

Euryhaline mesohalobe - 5.

Figs: 30, 217

Samples: SUN: 83.

Frustulia vulgaris (Thwaites) De Toni

De Toni, 1891 : 280.
Hustedt, 1930 : 221, Fig. 327.

Synonyms: *Schizonema vulgare* Thwaites, 1848 : 170, Pl. 12/H, Figs 1-5.

Taxonomic notes: Cholnoky (1962a : 28) observed that in the southern parts of the Cape Province the nominate variety was more frequently noted in his samples. This region was extended also to the Eastern Cape Province, where Giffen (1966b : 135) stated that the typical form of the species was well represented. Only two typical specimens were observed from the Sundays River.

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 34, 46,

Frustulia vulgaris var. *angusta* Cholnoky

Cholnoky, 1954a : 214, Fig. 61.

Taxonomic notes: Whether the separation of this variety from the nominate variety is justifiable or not, is a matter for further research. Cholnoky (l.c.) originally distinguished it on the basis of its narrower valves, viz. mostly 7,0 µm wide, although the range was 7,0 - 9,0 µm . However in a number of examples Schoeman (1969 : 45) observed that 38 % had a width greater than 9,0 µm, and 28 % had a length greater than 50,0 µm . These observations suggest that there may not be sufficient grounds to retain the variety, var. *angusta*. A single specimen, 48,0 µm long, 9,5 µm wide and having 28 transapical striae in 10 µm was recorded in the Sundays River. In the Fish River two specimens, also with intermediate measurements, were observed: length 46,5 - 47,0 µm, width 9,5 - 10,0 µm, striae 32 in 10 µm .

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 26.
FIS: 21, 24.

GOMPHONEMA Agardh, 1824 : XVI, 11.

Gomphonema acuminatum Ehrenberg var. *coronatum* (Ehrenberg) W. Smith

W. Smith, 1853 : 79, Pl. 28, Fig. 238.
Hustedt, 1930 : 370, Fig. 684.

Synonyms: *Gomphonema coronatum* Ehrenberg, 1840a : 211.

Taxonomic notes: A brief glance at the relevant literature on this taxon makes it obvious that a thorough revision of this species and its varieties is necessary. Since only one specimen was observed a critical discussion of its systematics and taxonomy is somewhat risky at this stage. Until further research has been undertaken Hustedt's (l.c.) concept with regard to this variety is accepted in this study.

Meioeuryhaline oligohalobe - 1.

Samples: Sun: 34.

Gomphonema constrictum Ehrenberg

Ehrenberg, 1830 : 63.
Hustedt, 1930 : 377, Fig. 714.

Taxonomic notes: Only a single specimen was observed.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 34.

Gomphonema constrictum var. *capitatum* (Ehrenberg) Grunow

Grunow in Van Heurck, 1880-83 : Pl. 23, Fig. 7.
Hustedt, 1930 : 377, Fig. 715.

Synonyms: *Gomphonema capitatum* Ehrenberg, 1838 : 217, Pl. 18, Fig. 2.

Taxonomic notes: The variety, var. *capitatum*, occurred more frequently than the nominate variety in the freshwater stations of the Sundays and Great Fish rivers.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 16, 17, 31, 45-47. 50, 51, 72.
FIS: 20.

Gomphonema exiguum Kützing

Kützing, 1844 : 84, Pl. 30, Fig. 8.
Cleve, 1894 : 188.

Taxonomic notes: This small *Gomphonema* species seems to be quite widely distributed in South African coastal waters in the littoral regions and in estuaries, but is never found abundantly. Two examples were observed in the Sundays River estuary at Station 1, and appeared to correspond very well with Cholnoky's illustrations of the taxon (vide Cholnoky, 1959 : 29, Figs 162-164; 1963c : Fig. 29). Giffen (1966a : 262, Fig. 37) illustrated a very similarly shaped specimen, which he identified as *Gomphonema aestuarii* Cleve (in Tempère, 1893-96 : 55, Pl. 3, Fig. 4) on the grounds that the central area was a fascia. The Sundays River examples (Figs 31, 218, 219) also appeared to have a fascia, until very careful examination revealed a single very short marginal stria on either side of the central nodule. This, in addition to the more tapered valve and the density of the striae, indicated Kützing's taxon rather than *G. aestuarii*. Furthermore according to Cleve the latter species also has a septum or pseudoseptum at the basal pole of the valve. There is some doubt that Giffen's specimen is *G. aestuarii* since it does not have a septum, the valve shape is not sufficiently linear, and Giffen may just have overlooked the short marginal striae at the centre. His dimensions and striae density, furthermore, correspond better with *G. exiguum*.

The Sundays River specimens had the following measurements:- Length 12,1 - 14,0 µm, breadth 2,0 µm, striae 20 - 22 in 10 µm .

Pleioeuryhaline polyhalobe - 7

Figs: 30, 218, 219
Samples: SUN: 59.

Gomphonema gracile Ehrenberg

Ehrenberg, 1838 : 217, Pl. 18, Fig. 3.
Hustedt, 1930 : 376, Fig. 702.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 2, 4, 8, 17, 24, 28, 34, 54.

Gomphonema insigne Gregory

Gregory, 1856 : 12, Pl. 1, Fig. 39.
Hustedt, 1930 : 376, Fig. 701 (as *G. lanceolatum* var. *insignis* (Gregory) Cleve).

Synonyms: *Gomphonema lanceolatum* Ehrenberg var. *insignis* (Gregory) Cleve, 1894 :183.

Taxonomic notes: There is a certain amount of confusion over the taxonomic position of this taxon. VanLandingham (1964 : 43) reported that some diatomists considered it a variety of *G. lanceolatum* Ehrenberg, while others place it with the *G. affine* Kützing (1844) group. Still others, such as Cholnoky (1970c : 16), have sunk the variety, var. *insignis*, into the species, considering it as part of the normal range of variation of *G. lanceolatum*. Mayer (1919 : 206, Pl. 9, Figs 35-37; 1928 : 114) on the other hand reinstated *G. insigne* as a species in its own right. It would appear therefore that a thorough revision of this taxon and its close relatives is necessary. Too few specimens of this taxon were observed in this study to make any significant comment on its taxonomy. VanLandingham's (1971 : 1916) taxonomy has therefore been adopted.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 9.
FIS: 20, 33.

Gomphonema intricatum Kützing var. *pumila* Grunow

Grunow in Van Heurck, 1880-83 : Pl. 24, Figs 35, 36.
Hustedt, 1930 : 375, Fig. 699.

Taxonomic notes: In his earliest study on the diatoms of South Africa the author (Archibald, 1966a : 266, Fig. 4) raised this variety to the rank of species, at the same time uniting it with *G. intricatum* var. *dichotoma* (Kützing) under the name *G. dichotomum*. On further reflection the basis for this amendment appears inadequate since only illustrations were considered, and no examination of type material was undertaken. The author therefore prefers at this stage to return to the concept of this taxon as a variety of *G. intricatum* until a further, more intensive re-assessment of the systematic position has been completed.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 46.
FIS: 8, 11.

Gomphonema parvulum (Kützing) Kützing

Kützing, 1849 : 65.
Hustedt, 1930 : 372, Fig. 713.

Synonyms: *Sphenella? parvula* Kützing, 1844 : 83, Pl. 30, Fig. 63.

Taxonomic notes: Many diatomists who have observed large populations of *G. parvulum* have no doubt experienced great difficulty in identifying precisely the many varieties associated with this species. Hustedt (l.c.) circumscribed 5 varieties, while VanLandingham (1971 : 1940) lists 13 varieties as valid taxa. On the other hand Wallace and Patrick (1950 : 228) found that "a separation of the varieties along clear cut lines proved impossible for several reasons". Neither were they able to find any geographical or ecological correlation for the direction of variation from the type. In a more recent study of *G. parvulum* Dawson (1972 : 255) was unable to find any "fundamental differences between the varieties apart from cell shape". Dawson (l.c. : 270) maintained nevertheless that the varieties were distinctly maintained in culture. In contrast Geitler (1958 : 417) observed three tribes or strains in *G. parvulum*, based on the mechanism of copulation, but stated that their different behaviour could not be correlated with cell form. Wallace and Patrick (l.c.: 227) attempted to explain the origin of such a highly variable taxon by suggesting that variation in nutrients in a stream might first favour one variety and then another. Thus a variety may be dominant in a population at one time, but not so at another while still being present in the population. Since most of the evidence suggests that one cannot distinguish between the varieties on a morphological basis, *G. parvulum* is considered in this study as a single extremely variable taxon.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 7-10, 13, 16, 17, 19, 21, 23-26, 28, 30, 32-34, 37, 43-47,
52, 60, 62, 64, 73.
FIS: 1-3, 7, 8, 11, 12, 14, 18, 20, 21, 23, 25, 26, 33, 35-37, 40.

Gomphonema subclavatum (Grunow) Grunow

Grunow in Van Heurck, 1880-83 : Pl. 23, Figs 38-41 : Pl. 24, Fig. 1.
Grunow, 1884 : 46(98), Pl. A, Fig. 13.
Hustedt, 1930 : 375, Fig. 705 (as *G. longiceps* var. *subclavata*)

Synonyms: *Gomphonema longiceps* var. *subclavatum* Grunow, 1878 : 107.
Gomphonema montanum var. *subclavatum* Grunow ex Van Heurck,
1885 : 125.

Taxonomic notes: There is a considerable difference of opinion with regard to the taxonomy and status of this taxon. To achieve clarification on this topic a thorough examination of the type material of the relevant forms is necessary. In this study such a revision has not been possible. A brief taxonomic history of this entity might therefore help to shed some light on the particular combination adopted in this study. The taxon was apparently first reported by Grunow (1878 : 107) as *G. longiceps* var. *subclavatum* (spelling error in the original text gives var. *sabclavatum*). Later in Van Heurck's Atlas (1880-83 : Pl. 23, Figs 38-41) Grunow raised the status of this variety to species level, calling it *G. subclavatum*, and indicated a relationship to *G. montanum* by placing this epithet (i.e. *montanum*) in parenthesis between the generic and specific names. The latter interpretation was preferred by Van Heurck (1885 : 125) in the text of this work, thus considering the taxon as *G. montanum* var. *subclavatum*. That Grunow intended the taxon to be a separate species is shown by his later usage of the combination, *G. subclavatum*, in his account of the diatoms from Frans-Josefs-Land (Grunow, 1884 : 46). In more recent treatments of this taxon there appear to be three schools of thought. Some, like Hustedt (1930 : 375, Fig. 705), revert to Grunow's original concept of the taxon as a variety of *G. longiceps* (Hustedt l.c. regards *Gomphonema montanum* as a variety of *G. longiceps*). Others, like Mayer (1928 : 112, Pl. 3, Figs 8-10), and VanLandingham (1971 : 1952) follow Van Heurck, interpreting it as a variety of *G. montanum*. The third alternative is that subscribed to in this study, viz. accepting *G. subclavatum* as a full species. Cholnoky (1960a : 47) commented that in the genus *Gomphonema* many of the varieties should be re-examined, because they are often superficially similar to the nominate variety in their morphology. This idea seems to be true for this taxon in the South African situation, since in contrast to the fairly frequent occurrence of *G. subclavatum*, *G. longiceps* is extremely rare. It appears, therefore, better to regard *G. subclavatum* as a species in its own right.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 4, 6, 43.
FIS: 7.

GYROSIGMA Hassal, 1845 : 435.

Gyrosigma acuminatum (Kützing) Rabenhorst

Rabenhorst, 1853 : 47, Pl. 5, Fig. 5a.
Hustedt, 1930 : 222, Fig. 329.

Synonym: *Frustulia acuminata* Kützing, 1833 : 555, Pl. 14, Fig. 36.

Taxonomic notes: The species is not common either in South Africa or in the Sundays and Great Fish River systems. It is therefore of interest to note the range of dimensions found in these specimens:- length 98,0 - 152,0 μm, breadth 14,0 - 18,0 μm, transapical and longitudinal striae equal in number, 16 - 20 in 10 μm .

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 15, 16, 26, 31, 45, 47, 48.
FIS: 17, 18, 20-22, 24, 26, 27.

Gyrosigma distortum (W. Smith) Griffith & Henfrey var. *parkeri* (Harrisson) Cleve

Cleve 1894 : 116.
Hustedt, 1930 : 224, Fig. 335.

Synonym: *Pleurosigma parkeri* Harrisson, 1860 : 104.

Description: Valve lanceolate and distinctly S-shaped with poles narrowed and protracted into relatively long, rounded rostrate apices; length 80,0 - 150,0 μm, breadth 15,0 - 25,0 μm . Raphe filiform and S-shaped, centrally placed in the middle part of the valve, but slightly eccentrically in the rostrate poles; central pores small and roundish, terminal fissures indistinct. Axial area narrow following the line of the raphe; central area small, oval. Transapical striae perpendicular to the raphe, 17 - 23 in 10 µm, longitudinal striae 22 - 27 in 10 µm .

Taxonomic notes: As far as can be determined this variety has not previously been recorded from any locality in South Africa. Even the nominate variety is rare being reported only once from Cape Agulhas (cf. Cholnoky, 1962a : 31). There seems, however, to be some controversy over the affinities of this taxon. Patrick and Reimer (1966 : 327, Pl. 26, Fig. 3) consider it as a synonym of *G. wormleyi* (Sullivant) Boyer. These authors, furthermore, contend that Hustedt's (1930 : 224, Fig. 334) drawing of *G. distortum* actually portrays something other than *G. distortum*. According to Patrick and Reimer (l.c. 324, Pl. 24, Fig. 6) the protracted poles of *G. distortum* are short and obtuse, while those of *G. wormleyi* are long and narrow. However, since they do not mention having examined any type material of either of these two taxa, it is somewhat difficult to determine whether they or Hustedt (l.c.) have correctly interpreted *G. distortum* and its variety, var. *parkeri*. VanLandingham (1971 : 2002 and 2015) considers both *G. distortum* var. *parkeri* and *G. wormleyi* as valid taxa. For this reason until type material has been examined Hustedt's interpretation has been followed. This taxon was observed in a single sample collected in a small tributary of the Great Fish River, in which it forms 2,4 % of the diatom population. Thirty three specimens were examined and these gave the following range in dimensions:- length 97,5 - 120,0 µm, breadth 16,0 - 18,0 µm, transapical striae 20 - 22 in 10 µm and longitudinal striae 22 - 24 in 10 µm . The counts for both transverse and longitudinal striae were constant in a narrow range. Length and breadth ranges for these examples were narrower than given in the description (Hustedt l.c.), but lay within Hustedt's range. The dimensions also agree closely with those of *G. wormleyi* (cf. Patrick and Reimer, 1966 : 327).

Owing to the differences of opinion discussed above a brief description of the taxon has been given based on the Great Fish River specimens, but including the full range of dimensions derived from the literature. Prowse (1962 : 29, Pl. 9, Fig. e) reported examples of this taxon from Malaya, but his dimensions and striae density measurements indicate a much larger form than can be included with the presently known taxon. Accordingly Prowse's observations have been omitted from the values given in the above description.

Euryhaline mesohalobe - 5.

Figs: 220-222

Samples: FIS: 14.

Gyrosigma eximium (Thwaites) Boyer

Boyer, 1927 : 462.
Patrick and Reimer, 1966 : 317, Pl. 23, Fig. 6.

Synonyms: *Schizonema eximium* Thwaites, 1848 : 169, Pl. 12, Fig. F, 1-4.
Gyrosigma scalproides (Rabenhorst) Cleve var. *eximia* (Thwaites) Cleve 1894 : 118.

Taxonomic notes: Retention of this taxon as a variety of *G. scalproides* (Rabenhorst) Cleve (1894 : 118) does not seem justified as much on account of its peculiar valve shape as on its autecology. Patrick and Reimer (l.c.) distinguished this taxon from *G. scalproides* by the linear valve with parallel walls and scalpelliform apices, the hooked outer terminal fissures, and also on account of its growth in gelatinous tubes. The species appears to be a brackish water taxon, preferring relatively high salinities. This is quite contrary to the requirements of *G. scalproides*, which is a freshwater form. The few specimens observed in this study had the following dimensions:- length 59,0 - 69,0 µm, breadth 10,5 - 11,0 µm, transverse striae 24 in 10 µm, longitudinal striae 32 in 10 µm .

Euryhaline mesohalobe - 5.

Samples: SUN: 1, 3, 82-85.

Gyrosigma kuetzingii (Grunow) Cleve

Cleve 1894 : 115.
Hustedt, 1930 : 224, Fig. 333.

Synonyms: *Pleurosigma kuetzingii* Grunow, 1860 : 561, Pl. 6, Fig. 3.

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 34, 58.

Gyrosigma obscurum (W. Smith) Griffith and Henfrey

Griffith and Henfrey, 1856 : 302, Pl. 11, Fig. 27.
Patrick and Reimer, 1966 : 323, Pl. 24, Fig. 7.

Synonyms: *Pleurosigma obscurum* W. Smith, 1852 : 8, Pl. 1, Fig. 11.

Description: Valve slightly sigmoid, linear to linear-lanceolate with obliquely scalpelliform poles; 85,0 - 153,0 µm long and 10,0 - 15,0 µm broad. Raphe filiform and sigmoid, running in an elevated eccentric keel, oblique in the centre and marginal near the poles; central pores small and inconspicuous, as also the terminal fissures. Axial area narrow, running parallel to the raphe; central area small and oval. Transapical striae perpendicular to the raphe, but appearing slightly arcuate due to the curving of the valve surface up to the raphe-bearing keel, 26 - 30 in 10 µm . Longitudinal striae very fine, and usually not visible, about 38 - 40 in 10 µm .

Taxonomic notes: Whether this taxon should be placed in the genus *Gyrosigma* or *Pleurosigma* is somewhat controversial. When W. Smith (1852 : 8, Pl. 1, Fig. 11) wrote the original description of this species the genus *Gyrosigma* had not yet been proposed. Consequently all sigmoid naviculoid diatoms were regarded as *Pleurosigma* irrespective of the pattern of striae on the valve surface. To complicate matters W. Smith was unable to resolve the striae when he first described the species. In his "Synopsis of the British Diatoms" W. Smith (1853 : 65) observed 29,5 striae in 10 µm (75 in 0,001"), but made no mention of whether they were oblique or transverse, the main characteristic distinguishing the genus *Pleurosigma* from *Gyrosigma*. Grunow (in Cleve & Grunow, 1880 : 49), however, cited W. Smith as giving 21 oblique striae in 10 µm . Evidence to substantiate this claim cannot be found despite a thorough search of the literature. Some authors have accepted Grunow's oblique striae count, but others adhered more to Cleve (1894 : 43) who cited 25 - 29 oblique striae in 10 µm . It is, however, difficult to be sure that either Grunow or Cleve actually observed specimens of *Pleurosigma obscurum*. Nevertheless most of the earlier diatomists favoured placing the taxon in the genus *Pleurosigma*. An exception to this was Griffith and Henfrey (1856 : 302), who transferred the species to *Gyrosigma*. More recently diatomists seem to agree to some extent with Patrick and Reimer (1966 : 323, Pl. 4, Fig. 7), who replaced the taxon in the genus *Gyrosigma*. Patrick and Reimer maintained that the valve surface sculpturing actually consists of a system of transverse and longitudinal striae. Apparent oblique striae are seen as a result of the "combination of valve undulation plus curving of the valve". This phenomenon was not observed in any of the Great Fish River specimens. Nevertheless as all other characteristics agree with the description given by Patrick and Reimer, their interpretation of the taxon has been adopted for the present.

Some evidence in support of this taxon being placed in the genus *Gyrosigma* is found in a remark on some *Pleurosigma* species made by Walker Arnott (1858 : 164) a few years after W. Smith first described the taxon. Walker Arnott wrote as follows:- "*Pleur. carinatum* I ought perhaps to add to the list, for I believe that the striae only appear oblique in consequence of the position of the light; if a true Pleurosigma it may be *Pleur. obscurum*, the only one with that peculiar appearance". This implies that *P. obscurum* may have transverse striae, and only apparent oblique striae as suggested by Patrick and Reimer (l.c.).

A few fragments of the valve of some specimens of *G. obscurum* from sample FIS 14 (NIWR) from the Great Fish River were examined under TEM (Figs 525, 526). These showed striae consisting of a fairly dense arrangement of elliptical pores (41 - 43 in 10 µm). Transverse striae are quite evident, but the arrangement in other directions is not quite so clear. The pores are predominantly arranged in longitudinal rows, but this system sometimes breaks down and a weak oblique arrangement can be detected. This agrees with Hagelstein's (1938 : 412, Pl. 9, Figs 6, 7) observations on his *Pleurosigma portoricense* (see comments on this species under 1 below), and may explain why Patrick and Reimer (l.c.) saw both types of striae arrangement. This species may therefore represent a transition between *Gyrosigma* and *Pleurosigma*. Nevertheless the species is retained in the genus *Gyrosigma* because the striae are predominantly longitudinally and transversally arranged, and also because under the light microscope the transverse striae are distinct.

It would seem that *G. obscurum* has lived up to its name as it is seldom recorded. This may however be the result of an inadequate description leading to the circumscription of new taxa, which are in fact synonymous with *G. obscurum*. A number of such possibilities, mentioned below, will need careful consideration in respect of their affinities.

(1) *Pleurosigma portoricense* Hagelstein (1938 : 412, Pl. 9, Figs 6, 7): This taxon, according to Hagelstein himself, was compared with W. Smith's original Lewes form of *P. obscurum* by Dr N.E. Brown in the British Museum, and was found to be identical. Hagelstein's forms are of great interest, however, as they exhibit three sets of striae, transverse, oblique and longitudinal (cf. Hagelstein's Pl. 9, Fig. 7);

Hagelstein made counts of 40 - 45 in 10 µm for oblique and longitudinal striae, and 28 - 29 for transverse striae. The possession of both longitudinal and oblique striae makes the choice between *Gyrosigma* and *Pleurosigma* problematic. This taxon is most probably synonymous with *G. obscurum*, but until examination of the type materials is possible it will be retained as a separate entity.

(2) *Gyrosigma caffra* Giffen (1963 : 230, Fig. 50): Although an examination of an syntype slide (Giffen Slide No. 464) proved fruitless in finding examples, specimens from the material Giffen used to make his drawing (Giffen Slide No. 368) were identical with the concept of *G. obscurum* adopted in this study. *G. caffra* is therefore regarded as a synonym of the taxon under discussion.

(3) *Gyrosigma subangustum* Hustedt (1955 : 35, Pl. 10, Fig. 10): Giffen (l.c.) compared the previous taxon to *G. subangustum* noting that they differ only in the degree of obliqueness of the raphe and in the transapical striae count. This difference, 26 in *G. caffra* and 28 in 10 µm in *G. subangustum*, falls well within the range given in the description of *G. obscurum*.

(4) *Gyrosigma rapsonii* Cholnoky (1959a : 31, Fig. 166): The dimensions and morphological features of this species would indicate that it may indeed be *G. obscurum* as invisaged in this study. Cholnoky, however, made no mention of any curvature of the valve surface, or of a raphe lying in a raised keel. Unfortunately Cholnoky's type slide is not available for comparison.

(5) *Gyrosigma dubium* Meister (1934 : 101, Figs 73, 74): The illustrations and dimensions of Meister's species indicate that this species should also be placed with *G. obscurum*. Meister mentioned that he was unable to see longitudinal or oblique striae.

(6) *Pleurosigma subsalsum* Wislouch et Kolbe (cf. Kolbe, 1948 : 461, Figs 6-8): Although much longer, these specimens are undoubtedly very close to *P. portoricense* Hagelstein. Kolbe's Fig. 8 clearly illustrates three systems of striae; on the left of the raphe transverse and oblique striae are evident, while on the opposite side of the raphe

transverse striae and longitudinal striae parallel with the raphe are clear. This may be the effect which Patrick and Reimer (1966 : 323) describe in their discussion of *G. obscurum*.

(7) *Pleurosigma? depauperata* Manguin (1952 : 87, Pl. 6, Fig. 142a, b): Manguin also came up against the problem of selecting a genus, when describing this taxon, since he could not resolve the arrangement of striae with his optical system. His choice of *Pleurosigma* was based on the eccentric position of the raphe and the lanceolate shape of the valves.

The dimensions of all the taxa discussed above are summarized in the following table, commencing with the measurements given by different diatomists for *P. obscurum*.

			Striae	
	Length	Breadth	Transv.	Obl./lon.
P. obscurum W. Smith (1853)	91,4-157,5		29,5	
P. obscurum cf. Peragallo (1897-1908)	80-180	10-12	25-29	21-25
P. obscurum cf. Cleve (1894)	90-150	10	25-29	25-29
P. obscurum cf. Hendey (1964)	90-120	10-12	25-30	25-30
G. obscurum Patrick and Reimer (1966)	85-150	10-15	26-30	ca. 40
P. portoricense Hagelstein (1938)	115-125	11-13	28-29	40-45
G. caffra Giffen (1963)	126 (143,6-147)*	13-14 (11,8-12,5)*	26 (27-28)*	
G. subangustum Hustedt (1955)	90	9	28	
G. rapsonii Cholnoky (1959)	130-150	8,5-10	26-28	ca. 40
G. dubium Meister (1934)	100-125	11-12	27	
P. subsalsum Wislouch & Kolbe	130-170	10,5-13(16)	28-30	43-45
P. depauperata Manguin (1952)	111	10	33-35	

transv. = transverse. obl. = oblique. lon. = longitudinal.
All measurements are given in µm. and striae counts are per 10 µm.

* personal observations.

It is evident from this table that as far as the dimensions of length, breadth and number of tranverse striae are concerned there is little to distinguish these taxa. On the other hand there seems to be some disparity with regard to the counts of oblique or longitudinal striae. For *G. obscurum* (= *P. obscurum*) itself three different ranges have been given, viz. 21 - 25, 25 - 30, and 40 or more. Where no striae counts are given it may be assumed that the diatomist responsible was unable to count the longitudinal or oblique striae as they were very fine, i.e. more than 40 in 10 µm . The most significant difference is found in those taxa with 40 or more longitudinal striae in 10 µm; this group includes *G. obscurum* as determined by Patrick and Reimer (l.c.), and all other taxa referred to in this discussion. According to Peragallo, Cleve and Hendey *G. obscurum* (syn. *P. obscurum*) has 21 - 30 oblique or longitudinal striae in 10 µm . This suggests that there are possibly two entities within this whole group of species. An intensive examination of these taxa will be needed to unravel the real affinities and similarities of this group.

Finally another taxon very similar to *G. obscurum* is *Gyrosigma elegans* Ricard (1975 : 206, Pl. 1, Fig. 1), but this diatom is broader and more coarsely striate. Nevertheless it should be kept in mind in a revision of this taxon and its close relatives.

Pleioeuryhaline polyhalobe - 7.

Figs: 223, 224, 525, 526

Samples: FIS: 14.

Gyrosigma peisonis (Grunow) Hustedt

Hustedt, 1930 : 226, Fig. 341.
Hustedt, 1955 : 34, Pl. 10, Figs 4, 5.

Synonyms: *Pleurosigma peisonis* Grunow, 1860 : 562, Pl. 6, Fig. 8.
Gyrosigma wansbeckii var. *peisonis* (Grunow) Cleve, 1894 : 119.

Taxonomic notes: Only a few specimens placed in the taxon *G. peisonis* were observed. They appeared typical and their dimensions ranged as follows:- length 56,0 - 113,2 µm, breadth 8,0 - 12,7 µm, transapical striae 21 - 22, longitudinal striae 24 - 28 in 10 µm . The smaller examples appear to compare favourably with those observed by Hustedt (1955 : 34, Pl. 10, Figs 4, 5) from Beaufort in North Carolina, America. Placing of one example from the Sundays River (SUN 16) in this taxon may be a little doubtful on account of its relatively broad valves. This specimen was 86,2 µm long and 14,2 µm broad.

Euryhaline mesohalobe - 5.

Samples: SUN: 3, 16
FIS: 28, 41.

G. prolongatum var. *closterioides* (Grunow) Cleve

Cleve, 1894 : 117.
Hendey, 1964 : 249.

Synonyms: *Pleurosigma prolongatum* var. *closterioides* Grunow, 1884 : 105, Pl. 1, Fig. 58.
Gyrosigma fasciola var. *closterioides* (Grunow) Proschkina-Lavrenko, 1950 : 249, Pl. 82, Fig. 6.

Taxonomic notes: In this study the correct identity of the specimens assigned to this taxon is somewhat troublesome. The specimens in question have long narrow linear-lanceolate valves tapering to long thin, curved rostrate apices with slightly bulbous ends; 132,0 - 166,0 µm long and 5,6 - 6,2 µm broad. The raphe is filiform and lies centrally except at the poles, where it lies more to the convex side of the curved poles. The proximal and distal raphe branch ends are small and indistinct. The axial area is very narrow and parallel to the raphe, scarcely widening at the centre, but has a small lateral expansion at the poles. The transverse striae are relatively distinct, 22 - 23 in 10 µm, but the longitudinal striae (32 - 36 in 10 µm) can only be resolved with oblique light.

Two forms have been included in this description, one having poles curving in the same direction (Figs 226, 227), while in the other (Fig. 225) the poles were curved in opposite directions, i.e. properly sigmoid (cf. Grunow's remarks on the var. *closterioides* - Grunow, 1884 : 105). The former comprised the majority of the specimens observed in this sample. This form was interesting since the curving of the poles to the same side appeared to arise from the twisting of one pole of the normal sigmoid valve through 180°. This 180° twist is the only feature distinguishing the two forms. Whether this twist is a hereditary character or simply a phenotypic variation is not known at this stage. Whatever the case may be, the identity of these forms is complicated. Since they are so intimately connected with each other, the one can be no more than a form of the other.

The valves with poles curving in the same direction, i.e. those with one pole twisted through 180°, can be positively identified with *Pleurosigma prolongatum* var. *closterioides* Grunow (1884 : 53, Pl. 1, Fig. 58). This taxon was later transferred to the genus *Gyrosigma* by Cleve (1894 : 117).

In contrast the identity of the sigmoid examples is rather more complicated. Owing to its very close relationship to the form identified above as *G. prolongatum* var. *closterioides*, one is tempted simply to refer it to *G. prolongatum* (W. Smith) Griffith and Henfrey (1856 : 303, Pl. 11, Fig. 23). However, although the dimensions and striae densities appear to agree well with *G. prolongatum*, the valve shape does not conform to W. Smith's (1852 : 9, Pl. 2, Fig. 7; 1853 : 67, Pl. 22, Fig. 212) drawings of *P. prolongatum* = *G. prolongatum*. Valves of the Sundays River forms were more linear, and the poles were longer and terminating in a small bulbous expansion. In this regard the sigmoid examples compare very favourably with the valve shape of *G. macrum* (W. Smith) Griffith and Henfrey (1856 : 303, Pl. 11, Fig. 22). Unfortunately, according to the literature, *G. macrum* is a much larger diatom with finer structure (length 150,0 - 270,0 µm, breadth 10,0 - 13,0 µm, transverse striae 25 - 28 in 10 µm, longitudinal striae 32 - 36 in 10 µm).

Patrick and Reimer (1966 : 329) stated that *G. prolongatum* and *G. macrum* are very closely allied, but how close their relationship is can only be determined through the examination of W. Smith's type material. The taxon *G. prolongatum* var. *closterioides* may indeed prove to be more closely related to *G. macrum* than to *G. prolongatum*. However as no type material has been examined Grunow's taxon has been retained under the name *Gyrosigma prolongatum* var. *closterioides*.

Since the majority of specimens in this sample (SUN 84 - NIWR) were undoubtedly identical with Grunow's taxon they have been referred to *G. prolongatum* var. *closterioides*. The sigmoid forms, on the other hand, have for the moment been included with this taxon until examination of type material has indicated whether they should be referred to *G. prolongatum* or *G. macrum*.

A form from the Kowie River estuary with poles curving in the same direction, identical to those in the Sundays River, was placed by Giffen

(1970a : 277, Fig. 40) in *G. fasciola* var. *closterioides* (Grunow) Proschkina-Lavrenko (l.c.). However the relationship of var. *closterioides* to *G. fasciola* is even more unlikely, since *G. fasciola* is somewhat broader diatom with relatively short protracted poles.

Meioeuryhaline polyhalobe - 9.

Figs: 225-228

Samples: SUN: 84.

Gyrosigma rautenbachiae Cholnoky

Cholnoky, 1957b : 65, Fig. 61.

Taxonomic notes: This taxon was also represented by a few specimens, which agree with Cholnoky's description. Nevertheless they displayed a much greater range in dimensions. This range included examples of the small forms such as Cholnoky (1959a : 32, Fig. 167) observed in the western Cape Province, as well as the larger specimens recorded by Giffen (1963 : 231) from the eastern Cape Province. The range of dimensions observed in this study were as follows:- length 117,2 - 165,0 µm, breadth 17,5 - 26,0 µm, transverse striae and longitudinal striae usually the same in number, 14 - 16 in 10 µm, occasionally the longitudinal striae were slightly coarser.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 24, 50
FIS: 14, 26, 27, 39, 40.

G. scalproides (Rabenhorst) Cleve

Cleve, 1894 : 118.
Hustedt, 1930 : 226, Fig. 338.
Patrick and Reimer, 1966 : 318, Pl. 23, Fig. 7.
Schoeman and Archibald, 1976-80 : No. 4.

Synonyms: *Pleurosigma scalproides* Rabenhorst, 1861-79 : Alg. Eur. No. 1101; 1864 : 241.

Description: Valves slightly sigmoid, linear to somewhat linear-lanceolate, tapering gradually to relatively broad obtuse ends, or subtly protracted into subrostrate to rostrate apices; length 25,0 - 80,0 µm, breadth 5,0 - 12,0 µm . Raphe more or less central, somewhat diagonal in some specimens, weakly sigmoid; central pores small, round or occasionally truncate and slightly expanded laterally; distal ends usually indistinct, forked with a curved terminal fissure reaching the concave margin of the sigmoid valve (in opposite directions at each pole), and the inner fissure ending more or less centrally some distance from the apex. Axial area narrow, parallel to the raphe, expanding at the centre into a small elliptical central area, and at the poles into a unilateral terminal area reaching the margin of the valve. Transapical striae radial throughout, except near the poles on the concave sides of the sigmoid valve, where they become convergent, 20 - 24 in 10 µm at the centre (measured along the valve margin) and slightly denser throughout the rest of the valve, 22 - 26 in 10 µm (measured along the raphe). Longitudinal costae parallel to the raphe and curving outwards at the central nodule, 26 - 36 in 10 µm .

Taxonomic notes: Rabenhorst's type material (Alg. Eur. No. 1101 - vide Rabenhorst, 1864 : 241) has been examined by Schoeman and Archibald (l.c.), who found that the type specimens were essentially the same as specimens identified as such from Southern Africa. Nevertheless a few points need mentioning. Rabenhorst's (l.c.) description of *Pleurosigma scalproides* gives about 20 transverse and 16 - 17 longitudinal striae in 10 µm . Counts of transverse and longitudinal striae from the type material showed that, while the transverse striae counts were accurate, the density of the longitudinal striae was in fact greater, being 32 - 36 in 10 µm . Hustedt (l.c.) depicted *G. scalproides* with broadly rounded, obtuse apices. In contrast Rabenhorst's type specimens have weakly rostrate apices. In examples from Southern Africa, including those from the Great Fish River, the apices were weakly subrostrate to smoothly rounded, but rather more acute. In the literature the position of the raphe seems to be a little controversial, Hustedt (l.c.) discribing it as central, and Patrick and Reimer (l.c.) as eccentric and diagonal. In the type material the position seemed to vary between both these extremes.

Electron microscopic examination of this species showed a rather typical *Gyrosigma* type raphe structure. Internally on either side of the central nodule there is a rib, one being short, and the other accompanying the raphe and extending almost to the distal raphe endings. The distal ends of the raphe terminate internally in a characteristic raised and "rolled tongue" called the helictoglossa (vide Cox, 1977 ; 263). Externally the proximal raphe endings are characteristic, terminating in a central pore with two lateral expansions, making a "T" shaped ending. The "T" shaped ending is not easily resolved under the light microscope. The distal ends of the raphe branches curve towards the same side of the valve and end in the valve mantle.

Only a few typical specimens were observed in the Great Fish River. These had the following dimensions:- length 46,0 - 59,0 µm, breadth 8,0 µm, transverse striae 24 in 10 µm, longitudinal striae 30 - 32 in 10 µm .

Meioeuryhaline oligohalobe - 1.

Samples: FIS: 21, 22, 25.

Gyrosigma stompsii Cholnoky

Cholnoky, 1963c : 51, Fig. 31.

Taxonomic notes: The forms allotted to this taxon are twice as long as those originally described by Cholnoky. There is therefore some doubt as to the accuracy of this identification. In many features, such as the long narrow almost linear valves with scalpelliform poles and eccentric raphe, it is very close to *G. obscurum* (W. Smith) Griffith and Henfrey (see above). On the other hand the striae counts for transverse and longitudinal striae agreed with those of *G. stompsii*.

Differences between these two species are, however, quite distinct. In the first place the position of the raphe in relation to the apical axis is significant. In *G. stompsii* the raphe is more or less straight and median over most of its length, and only becomes sigmoid and close to the valve margin near the poles. In contrast the raphe of *G. obscurum* is strongly sigmoid so that at the centre of the valve the raphe lies obliquely, and for about two thirds of its length it approaches the valve margin. The central nodule of *G. obscurum* is also more prominent. Besides being coarser the transapical striae of *G. stompsii* at the centre of the valve are parallel and perpendicular to the raphe, whereas in *G. obscurum* the transapical striae are finer and arcuate indicating a fold in the valve surface. Finally the apices of *G. stompsii* are more acutely rounded than those of *G. obscurum*.

There is some similarity also to *G. tenuissimum* but the density of the longitudinal striae does not agree. On this point there appears to be some disagreement in the literature. Cleve (1894 : 117) wrote that the longitudinal striae were finer than the transverse striae (18 - 22 in 10 µm), while Peragallo (1891 : 24) puts them at 24 in 10 µm . Cholnoky (1963c : 51) counted about 40 longitudinal striae in 10 µm in his specimens of *G. tenuissimum* from the Knysna Lagoon.

Since the dimensions of length and breadth are not always good taxonomic characters, and because it is likely that Cholnoky observed only a few specimens of *G. stompsii*, the Sundays River examples have been provisionally placed with this taxon. These specimens had the following dimensions:- Length 121,0 - 143,1 µm, breadth 9,0 - 9,6 µm, transverse striae 18 - 20 in 10 µm, Longitudinal striae 36 in 10 µm .

Euryhaline mesohalobe - 5.

Figs: 229, 230

Samples: SUN: 59, 84.

HANTZSCHIA Grunow, 1877 : 174.

Hantzschia amphioxys (Ehrenberg) Grunow

Grunow in Cleve and Grunow, 1880 : 103.
Grunow in Van Heurck, 1880-83 : Pl. 56, Figs 1, 2.
Hustedt, 1930 : 394, Fig. 747.

Synonym: *Eunotia amphioxys* Ehrenberg, 1841 (1843) : 413, Pl. 1, Fig. 1 etc.

Taxonomic notes: This is a common and very variable taxon. Cholnoky (1966a : 28) questioned the validity of maintaining *H. amphioxys* var. *africana* Hustedt (1921 : 131, Pl. 1, Fig. 25) as a separate variety, and later considered this variety as distinct from the nominate variety (Cholnoky, 1970a : 30). The taxon is variable not only in valve shape, but also in regard to the density of the transapical striae. Cholnoky, 1966a : 28) gave 16 - 28 striae in 10 µm for this taxon, while Guermeur (1954 : 84) recorded 27 striae in 10 µm for *Nitzschia parvula*, which, according to Cholnoky was an erroneous identification for *H. amphioxys*. In the Sundays and Great Fish rivers most specimens were the finely striated type. These examples had the following dimensions;- length 21,0 - 36,0 (58,0) µm, breadth 4,0 - 7,0 µm, fibulae 6 - 12 in 10 µm and striae (18)24 - 28 in 10 µm .

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 4, 5, 11, 16, 17, 21-25, 33, 34, 45, 47-49, 57, 60, 61, 76.
FIS: 2, 4, 5, 16-18, 20-23, 26-28, 31, 32, 35.

Hantzschia amphioxys var. *maior* Grunow

Grunow in Van Heurck, 1880-83 : Pl. 56, Figs 3, 11.
Van Heurck, 1885 : 169.
Hustedt, 1930 : 394, Fig. 749.

Taxonomic notes: This taxon is distinguished from the nominate variety by its much greater dimensions. The valves were over 100 µm in length and 13,0 - 14,0 µm broad. This variety was not as common as the nominate variety. The Sundays River specimens were 156,0 µm and 211,0 µm long, and had a slightly coarser striation (12 - 14 in 10 µm) and fewer fibulae (4 - 6 in 10 µm) than the nominate variety.

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 25, 37.

Hantzschia amphioxys var. *vivax* Grunow

Grunow in Cleve and Grunow, 1880 : 103.
Grunow in Van Heurck, 1880-83 : Pl. 56, Figs 5, 6.
Hustedt, 1930 : 394, Fig. 750.

Taxonomic notes: Whether the two examples observed in the Great Fish River do indeed belong to this variety is subject to some doubt. The dimensions of these two specimens, 70,0 - 79,0 µm long and 6,5 - 7,0 µm broad, are rather smaller than would be expected from Hustedt's (1930 : 394) description, but the relatively narrow, elongated rostrate poles suggest a closer relationship to this variety than to the nominate variety.

Mesoeuryhaline oligohalobe - 2.

Samples: FIS: 20, 29.

Hantzschia disctinctepunctata (Hustedt) Hustedt

Hustedt in A. Schmidt *et al.*, 1874-1959 : Pl. 329, Figs 21, 22.
Hustedt, 1937-38 : 462, Pl. 40, Fig. 4.

Synonyms: *Hantzschia amphioxys* var. *distincte-punctata* Hustedt, 1921 : 167.

Taxonomic notes: There is no doubt that these coarsely punctate forms belong to this taxon. Apart from the slightly shorter valves the rest of the dimensions agree with Hustedt's diagnosis of the taxon. The Great Fish River specimens gave the following dimensions:- 46,1 - 54,5 µm long, 5,0 - 7,8 µm broad, 6 - 8 fibulae in 10 µm and 11 - 12 striae in 10 µm .

Mesoeuryhaline oligohalobe - 2.

Samples: FIS: 4, 16, 27, 29, 31.

MASTOGLOIA Thwaites in W. Smith, 1856 : 63.

Mastogloia aquilegiae Grunow

Grunow in A. Schmidt, 1874-1959 : Pl. 186, Figs 21, 22.
Hustedt, 1931-59 : 497, Fig. 923.

Taxonomic notes: Very little information on this rare species, hitherto unrecorded in South Africa, is available in the literature. It was in some respects difficult to distinguish it from *M. lanceolata* Thwaites (cf. Hustedt, 1931-59 : 497, Fig. 922). Hustedt's (l.c.) key to this genus separates these two species on the grounds of the width of the partecta. In this respect the Sundays River specimens should be placed with *M. lanceolata* (width of the partecta - 2 - 3 µm). However more significant taxonomic characters suggested that the specimens would be better assigned to *M. aquilegiae*. These characters were

(a) the distinctive structure of the raphe with its lateral arching about halfway between the central and terminal nodules,

(b) the density of the striae (16 - 17 in 10 µm), and

(c) the greater lengths of the valves. Dimensions of these examples were 50,0 - 60,0 µm long, 15,6 - 18,5 µm broad, transapical striae 16 - 17 in 10 µm, partecta 6 - 8 in 10 µm and 2,0 - 3,0 µm broad.

Pleioeuryhaline polyhalobe - 7.

Figs: 231-234
Samples: SUN: 14, 40, 41, 68, 77, 78.

Mastogloia elliptica (Agardh) Cleve

Cleve, 1893 in A. Schmidt *et al.*, 1874-1959 : Pl. 185, Figs 24 - 25?
Cleve, 1895 : 152.
Hustedt, 1930 : 501, Fig. 927a.

Synonyms: *Frustulia elliptica* Agardh, 1824 : 311.

Euryhaline mesohalobe - 5.

Samples: SUN: 41, 65, 67.

Mastogloia elliptica var. *dansei* (Thwaites) Cleve

Cleve, 1895 : 152.
Hustedt, 1931-59 : 501, Fig. 927b.

Synonyms: *Dickieia dansei* Thwaites, 1848 : 171, Pl. 12/K, Figs 1-4.

Taxonomic notes: The taxonomic position of this variety is a little problematic. W. Smith (1856 : 64, Pl. 62, Fig. 388) and Grunow (in Van Heurck, 1880-83 : Pl. 4, Fig. 18) gave it species rank within the genus *Mastogloia*. On the other hand Cleve (1895 : 150) reduced its taxonomic ranking to a variety of *M. elliptica*, a concept still commonly held today. Recently however Cholnoky (1968a : 41) has suggested elevating the var. *dansei* to specific rank once more. He does so acknowledging a morphological similarity, but claiming a basic autecological distinction. He does not, however, describe this ecological distinction. Nevertheless in his "Die Ökologie der Diatomeen" (Cholnoky, 1968b : 229) he considers both the var. *dansei* and the nominate variety as brackish water forms and claimed that the nominate variety, when present in high numbers, is particularly associated with chlorides. In the Sundays River both varieties occurred in the same localities and only as a few examples in every sample. From a morphological point of view it was difficult to distinguish between them as an intergrading series of forms was observed. Furthermore since the environment here suggested no ecological differences, the possibility that the var. *dansei* should be merged with the nominate variety, *M. elliptica*, is feasible. However the observation of relatively few specimens deters the author from taking such a step without a more thorough investigation of the taxon, and particularly the type material. The var. *dansei* has therefore been retained for the parallel-sided forms with cuneate poles.

Stoermer (1967), nevertheless, poses an interesting problem with regard to this variety in his study of the polymorphism in a wild population of *Mastogloia* from the Silver Lake Fen in Dickinson County, Iowa. He showed that within this population there were forms belonging to both *M. grevillei* W. Smith and to *M. elliptica* var. *dansei*. Associated with the normal frustules of each of these taxa were frustules containing one valve of each species. This evidence and his consideration of other closely related species of *Mastogloia* led Stoermer to suggest that *M. grevillei* and *M. elliptica* var. *dansei* should be united and placed under the name *M. dansei*. He was reluctant to do so, however, as he had not had the opportunity of examining *Dickieia dansei*, the nomenclatural type for this combination. Stoermer suggested furthermore that the cause of this polymorphism was differing ecological conditions.

Euryhaline mesohalobe - 5.

Samples: SUN: 36, 55, 67, 77.

Mastogloia pumila (Grunow) Cleve

Cleve, 1895 : 157.
Hustedt, 1931-59 : 553, Fig. 983.
Hendey, 1964 : 238.

Synonyms: *Mastogloia braunii* var. *pumila* Grunow in Van Heurck, 1880-83 : Pl. 4, Fig. 23.
Mastogloia pumila var. *capensis* Cholnoky, 1959 : 33, Figs 178, 179.
Mastogloia pumila var. *africana* Giffen, 1966a : 265, Figs 48-50.
Mastogloia pseudexigua (pseudoexigua) Cholnoky, 1956 : 75, Fig. 78.
Mastogloia pseudexigua var. *capitata* Cholnoky, 1959 : 33, Figs 174, 175.

Taxonomic notes: In a sample from the Sundays River (SUN 69) a series of specimens was observed showing a wide range of variation in the degree of development of the H-shaped marking associated with the central area. Based on other characteristics the specimens have been identified as *M. pumila*. This identification is undoubtedly correct for those examples having the distinct H-shaped markings, but would have caused some apprehension as to the accuracy of the identification of those forms without this marking. However this population showed a series of examples in which the H-shaped marking was completely absent, passing to other valves where the horns of this marking extended almost to the poles. Indeed a single frustule had one valve with a clear and well developed

H-shaped marking, while on the other the marking was completely absent (A similar case of polymorphism has previously been reported in the genus *Mastogloia*, as may be seen in Stoermer's (1967) study of this phenomenon in *Mastogloia* - see remarks above for *M. elliptica* var. *dansei*.) This series of specimens from the Sundays River makes it clear that all of them belong to the same taxon. It raises furthermore strong doubts concerning the validity of the H-shaped marking as a good specific character for the distinction of the species in this genus.

This series of specimens not only showed the variation in the H-shaped marking, but also presented a fairly wide range in the construction of the partectal ring. This varied from 1 - 4 large partecta in the centre, and 1 - 3 smaller partecta more distally placed on either side of the larger ones, or specimens having no smaller partecta at all. The variability in this regard raises doubt with respect to the validity of *M. pseudexigua* Cholnoky (1956 : Fig. 78). Cholnoky distinguised his species from *M. pumila* on the basis of differences in the construction of the partectal ring and the finer arrangement of the striae. The series of examples observed in the Sundays River had striae counts ranging from 24 to 28 in 10 µm, while in the arrangement and structure of the partectal ring both the "pseudexigua" and "pumila" type of partectum can be found. Although Cholnoky's type material for *M. pseudexigua* is not at present available there do not appear to be any strong indications for keeping the two taxa distinct. Accordingly the two species have been united, with *M. pseudexigua* considered as a synonym of *M. pumila*. Furthermore following Cholnoky (in unpublished manuscript) both *M. pumila* var. *capensis* Cholnoky (1959 : 33, Figs 178, 179), *M. pumila* var. *africana* (Giffen, 1966a : 265, Figs 48-50) and *M. pseudexigua* var. *capitata* Cholnoky (1959 : 33, Figs 174, 175) have been united with the species, and therefore become later synonyms.

Pleioeuryhaline polyhalobe - 7.

Samples: SUN: 1, 4-7, 41, 69, 77, 80-83.

Mastogloia pusilla Grunow

Grunow, 1878 : 111, Pl. 3, Fig. 10.
Hustedt, 1931-59 : 568, Fig. 1002a-c.

Taxonomic notes: A single specimen was observed having typical valve and partectal ring structure. The striation was, however, rather finer (24 in 10 µm) than given for the nominate variety, and compares more favourably with var. *linearis* Østrup (1910 : 118, Pl. 3, Fig. 73), as described by Hustedt (1931-59 : 569). The Sundays River specimen was 18,0 µm long and 8,0 µm broad.

Pleioeuryhaline polyhalobe - 7.

Samples: SUN: 42.

Mastogloia smithii Thwaites

Thwaites, 1848 *in litt.* *ex* W. Smith, 1856 : 65, Pl. 54, Fig. 341.
Hustedt, 1931-59 : 503, Fig. 928a.

Taxonomic notes: Too few specimens of this taxon have been observed to make any critical comments on its taxonomy, particularly as no type material has been examined. There is some questioning of the validity of the varieties, var. *amphicephala* Grunow and var. *lacustris* Grunow. Cholnoky (unpublished manuscript) regarded as purposeless the separation of forms with capitate poles as a distinct variety. This idea is supported by W. Smith (1856 : 65, Pl. 54, Fig. 341), who illustrated a series of forms having protracted rostrate to capitate poles. Furthermore Smith commented that their "dinstinctly produced and occasionally capitate extremities" were a distinguishing characteristic of this taxon. Although Cholnoky (1968a : 43) regarded the variety as distinct, Hustedt (1931-59 : 504) considered *Mastogloia lacustris* var. *conifera* Brun as an intermediate between *M. smithii* var. *amphicephala* and var. *lacustris*. This suggests that there are no clear taxonomic boundaries between the varieties.

Pleioeuryhaline oligohalobe - 3.

Samples: SUN: 7, 13, 41, 77.

MELOSIRA Agardh, 1824 : XIV, 8.

Melosira granulata (Ehrenberg) Ralfs var. *angustissima* O. Müller

O. Müller, 1899 : 315, Pl. 12, Fig. 28.
Hustedt, 1927-30 : 250, Fig. 104d.

Taxonomic notes: To enter into a discussion on the taxonomy of this taxon and its close relatives would be taking on a task too immense for the scope of this study. *Melosira granulata* must be one of the most variable of diatom species. VanLandingham (1971 : 2202) filled more than eight pages of his catalogue with synonyms of *M. granulata* and its varieties. This indicates the extent to which some diatomists have gone to describe the most subtle variations, many of which are no longer considered valid. In contrast there are others who prefer to combine *M. granulata* with a number of other *Melosira* species to form one very large polymorphic taxon. This was the view of Bethge (1925) who united *M. granulata*, *M. islandica*, *M. nyassensis*, *M. distans*, *M. italica*, *M. argus*, *M. goetzeana* and a number of other species with their varieties, under one taxonomic combination, *Melosira polymorpha*. Although this approach has been rejected, the number of valid varieties of *M. granulata* has been reduced. In the Sundays River a few examples were observed belonging to the var. *angustissima*. No attempt has therefore been made to determine whether this variety should be retained as valid or not. In the Vernon Hooper Dam near Durban there is, however, an intergrading series between the nominate variety and var. *angustissima* (Archibald, C. : personal communication). Moreover Cholnoky (1963b : 175) preferred to sink this variety into the species on account of finding intermediates between the two forms. The var. *angustissima* has, however, been retained in this study merely to indicate that it was only the very narrow valve form that was observed.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 9, 16, 20, 34, 62, 73.
FIS: 5, 7, 8, 16, 34, 37.

Melosira lineata (Dillwyn) Agardh.

Agardh, 1824 : 8
Hustedt, 1927-30 : 238, Fig. 99, as *Melosira juergensii*.
Hendey, 1964 : 72, Pl. 1, Fig. 3, as *Melosira juergensii*.

Synonyms: *Conferva lineata* Dillwyn, 1809 : No. 24.
Melosira juergensii Agardh, 1824 : 9.

Taxonomic notes: In a recent study Crawford (1978 : 245) has shown that *M. lineata* can no longer be distinguished from *M. juergensii* Agardh (1824 : 9). These two species are in fact two different valve morphotypes of the same taxon, for which Dillwyn's "*lineata*" is the earliest valid epithet. The unification of these two species therefore bears the name *Melosira lineata* as the correct combination for the taxon.

A very few examples of the morphotype *juergensii* were observed at Station 2 on the Sundays River. A discussion of the possible relationship between this taxon and the next follows below in the taxonomic notes for *M. moniliformis* var. *octogona* (Grunow) Hustedt.

Euryhaline mesohalobe - 5.

Samples : SUN: 3.

Melosira moniliformis (O. Müller) Agardh var. *octogona* (Grunow) Hustedt.

Hustedt, 1927-30 : 238.

Synonyms: *Melosira borreri* var. *octogona* Grunow, 1878 : 128, Pl. 4, Fig. 14.
Melosira lineata var. *octogona* (Grunow) Cleve-Euler, 1951 : 30, Fig. 21d, e.

Taxonomic notes: In the estuarine stations of the Sundays River specimens of a *Melosira* species having distinctly octagonal outer walls in girdle view were observed (Figs 235-237, 527-530). In searching the literature for its correct identity three possibilities were discovered; and interestingly two of these had at one time or another been given the specific or varietal epithet "*octogona*".

The first of these possibilities is that the Sundays River specimens should be placed with *M. moniliformis* var. *octogona*. This taxon was originally described by Grunow (1878 : 128, Pl. 4, Fig. 14) as *Melosira borreri* var. *octogona*. Hustedt (1927-30 : 236) subsequently considered *M. borreri* as synonymous with *M. moniliformis*, and transferred the variety, var. *octogona*, to the latter species as well. In this respect Cleve-Euler (1951 : 29, Fig. 21d, e) introduced a measure of confusion as she claimed that *M. borreri* was synonymous with *M. lineata*, thus naming the variety *M. lineata* var. *octogona*. As there has been no opportunity to study these two view points more thoroughly and since Crawford (1977, 1978) did not mention *M. borreri* as synonymous with either *M. lineata* or *M. moniliformis* in his recent reviews of these two species, Hustedt's taxonomy in this respect has been preferred. Even though the Sundays River specimens agreed very closely in shape with Grunow's illustration of *M. borreri* var. *octogona* and Cleve-Euler's drawings of *M. lineata* var. *octogona*, there is no clear evidence to establish the Sundays River examples as belonging to this taxon.

The second possibility is that the Sundays River examples belong to the variety *M. juergensii* (= *M. lineata* - see previous taxon) var. *subangularis* Grunow (in Van Heurck, 1880-83 : Pl. 86, Fig. 9). The local examples, however, differ from this variety by lacking the thickened rim of the mantle wall so characteristic of the *juergensii* morphotype of *M. lineata* (see comments on *M. lineata* above). Furthermore, in contrast with the variety, var. *subangularis*, the Sundays River specimens have an almost completely orbicular internal cavity, while the length of each side of their octagonal walls is approximately equal (cf. Grunow's illustration of the var. *subangularis*). Once again in her synopsis of the Swedish and Finnish diatoms Cleve-Euler (1951 : 30, Figs 22m and 1) appears to have confused the situation. While her illustration of *M. juergensii* var. *subangularis* (her Fig. 22m) appears to represent this taxon correctly, the drawing of a thick-walled octagonal form with an orbicular internal cavity was considered by Cleve-Euler as being typical of *M. juergensii.* This is quite plainly an error of judgment, and should probably refer to *M. moniliformis* var. *octogona.*

Finally in 1892 A. Schmidt (cf. Schmidt *et al.*, 1874-1959 :Pl. 182, Figs 19-21) illustrated a new species called *Melosira octogona.* These illustrations correspond very well with the outline and internal orbicular cavity of the Sundays River specimens, but give little other detail by means of which a precise identification can be made. Probably for this reason VanLandingham (1971 : 2233) proposed the discontinuation of the combination *M. octogona.* Nevertheless a number of diatomists have recorded *M. octogona* in reports on their researches (e.g. Hagelstein, 1938 : 378, Pl. 6, Fig. 2; Ichimura, Kobayashi and Kata, 1965 : 442, Pl. 1, Fig. 4). In addition Hustedt (1942a : 7) recorded *M. octogona* A. Schmidt from various localities in the Indomalayan Archipelago and Hawaiian Islands, remarking that Grunow (1878 : 128) had combined this species with *M. moniliformis* as a variety of it. Hustedt, however, preferred to retain *M. octogona* as an independent species restricted in its distribution to tropical coasts. Moreover Giffen (1963 : 235, Figs 61, 62; 1966a : 265; 1970a : 280; 1970b : 94) has recorded *M. octogona* fairly frequently from South African estuaries and marine littoral situations.

Having examined these three possibilities it seems evident that the Sundays River specimens cannot be placed with *M. juergensii* var. *subangularis* on account of the wall structure. The choice between the remaining two possibilities is more difficult. Apart from the octagonal shape of the frustules in girdle view there are no other described features enabling one to select one or the other possibility. However since there appears to be some doubt concerning the validity of *M. octogona*, it is better to choose *M. moniliformis* var. *octogona*, as it is probably easier to authenticate this taxon by reference to Grunow's type material. The probability that *M. octogona* and *M. moniliformis* var. *octogona* are the same thing is strong, and in this case *M. octogona* would fall away as a later synonym of the latter. It is suggested furthermore that those forms placed in *M. octogona* by Giffen should be referred to *M. moniliformis* var. *octogona*.

Pleioeuryhaline polyhalobe - 7.

Figs: 235-237, 527-530

Samples: SUN: 4, 5, 59, 70, 82-84, 86.

Melosira varians Agardh

Agardh, 1827 : 628.
Hustedt, 1927-30 : 240, Fig. 100.

Taxonomic notes: A single specimen of this taxon was recorded from scrapings taken in Lake Arthur from rocks near the wall of the impoundment. This is a well known species and needs no further comment here.

Mesoeuryhaline oligohalobe - 2.

Sample: FIS: 2.

NAVICULA Bory, 1822 : 128.

Navicula accomoda Hustedt

Hustedt, 1950 : 446, Pl. 39, Figs 17, 18.
Hustedt, 1961-66 : 64, Fig. 1208.
Schoeman and Archibald, 1976-80 : No. 2.

Description: Valve elliptic-lanceolate with poles protracted into short, narrow rostrate or sometimes slightly rostrate-capitate apices; length 17,0 - 25,0 µm, breadth 5,0 - 8,0 µm . Raphe straight and filiform;

central pores small and inconspicuous, and not unduly widely separated; terminal fissures hook-shaped, curving towards the same side of the valve, not always clearly visible. Axial area narrow, linear, widening slightly at the central nodule. Transapical striae parallel to slightly radial, sometimes becoming slightly convergent at the poles; central striae more widely spaced than the others, occasionally with a single shortened stria on one side, 17 - 25 in 10 µm, while at the pole they sometimes widen again, 19 - 32 in 10 µm . Longitudinal costae faintly visible only under oblique light.

From TEM studies of this species Schoeman and Archibald (1976-80 : No. 2) have shown that the striae consist of single rows of puncta (32 - 43 in 10 µm), of which the terminal punctum of each stria near the central nodule is transapically elongated. The puncta are, furthermore, arranged in longitudinal rows parallel to the apical axis, except at the central nodule where they curve outwards.

Taxonomic notes: In an earlier study (Archibald, 1971 : 45, Figs 142-150) examples of this taxon were used to draw up a series linking *Navicula submolesta* Hustedt (1949a : 86, Pl. 5, Figs 16-18) with *N. molestiformis* Hustedt (l.c. : 86, Pl. 5, Fig. 9). More recently, however, Schoeman *et al.* (l.c.) have shown through studies of the valve structure that *N. accomoda* is entirely different from *N. submolesta*. Examination of the Hustedt type material (Hustedt slide No. N1, 8 - Bremerhaven) from the Charemsee has shown that Southern African examples of *N. accomoda* are identical with those on the type slide.

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 15-17, 20, 21.
FIS: 1, 2, 24.

Navicula acephala Schoeman

Schoeman, 1973 : 107, Figs 152, 153.

Taxonomic notes: Schoeman (l.c.) distinguished this taxon from *N. cryptocephala* Kützing (1844 : 95, Pl. 3, Figs 20, 26) on the basis of its much more coarsely punctate striae and the shape of its central area. In the Sundays River few specimens were recorded, although this may be due to confusion with *N. cryptocephala*. In the Great Fish River specimens of this taxon, particularly those from sample FIS 14, were in full agreement with Schoeman's description. Nevertheless these specimens bore a resemblance to *N. gregaria* in the structure of the central nodule and shape of central area. The validity of this species is therefore somewhat suspect, and these specimens are only tentatively placed here.

Meioeuryhaline oligohalobe - 1.

Figs: 238, 239

Samples: SUN: 34, 51.
FIS: 3, 11, 14.

Navicula agrestis Hustedt

Hustedt, 1936 (in A. Schmidt *et al.*, 1874-1959 : Pl. 401, Figs 27-29)
Hustedt, 1937-38 : 246, Pl. 20, Figs 21, 22.
Hustedt, 1961-66 : 235, Fig. 1358.

Taxonomic notes: Having examined all the ringed specimens on Hustedt's only type slide (i.e. the syntype slide - No. N1, 13 at Bremerhaven) a number of differences between these specimens and Hustedt's diagnosis was noted. The valve was correctly described as linear to linear-lanceolate with rounded to almost acute poles. The ringed specimens had dimensions of length varying between 9,1 and 10,4 µm, of breadth between 3,0 and 3,4 µm, and had 27 - 30 transapical striae in 10 µm . The valves were therefore a little broader than given in the original diagnosis. The next point of differences lies in the distance between the central pores of the raphe. In his illustration of the species Hustedt, 1961-66 : 235, Fig. 1358) indicated rather widely separated central pores. This is rather misleading as this feature was not found in the ringed examples on the syntype slide. Hustedt drew this species more accurately in his publication on the diatoms from the Sunda Islands (cf. Hustedt, 1937-38 : 246, Pl. 20, Figs 21, 22). In most of the ringed specimens examined the raphe branches were furthermore slightly curved. Finally the transapical striae were distinctly radial (cf. Hustedt, 1961-66 : 235, Fig. 1358d, e) which contrasts with striae pattern in his Figure 1358a-c. At the poles, however, the striae became slightly less radial and tended towards parallel.

Noting these differences a new concept of the taxon, *N. agrestis* Hustedt, has been formed. As a result there is a strong possibility that *N.*

diuturnoides Archibald (1966a : 258, Figs 17-23; 1971 : 38, Figs 78-90) should be included as a synonym of *N. agrestis*. A re-examination of *N. diuturnoides* in the light of this new concept is therefore necessary.

Cholnoky (1970c : 18) suggested a closer relationship and possible union with *N. muralis* for this taxon. However examination of the type material of *N. muralis* collected by Arnott from walls at Bath in England (Grunow slide Nos 2337, 2710a and b - Vienna) and other material from Grunow's collection (slide Nos 1923 and 2341) indicated quite clearly that such a relationship is not feasible. The valves of *N. muralis* were much broader (4,0 - 5,0 μm broad), and the transapical striae at the centre of the valve were different in structure and arrangement. At the centre of *N. muralis* there appeared to be long sinuous striae intercalated with unevenly shortened striae. This is quite different from *N. agrestis* where the central striae are straight, and shortened striae appeared to be absent.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 32.
FIS: 1, 16, 23-27.

Naricula agulhasica Cholnoky

Cholnoky, 1959 : 34, Fig. 182.
Giffen, 1963 : 235, Fig. 64.

Taxonomic notes: Unfortunately Cholnoky's type slide (K 84) is not available for comparison in order to authenticate this identification. The specimen observed in the Sundays River at Station 2 (SUN 3) does not fully agree with Cholnoky's diagnosis or illustration. However, Giffen (1963 : 235, Fig. 64) recorded a wider range of specimens having the following dimensions:- length 25,0 - 48,0 μm, breadth 5,0 - 8,0 μm, and striae 10 - 12 in 10 μm . Giffen's illustration (his Fig. 64) and his dimensions encompass the Sundays River specimens comfortably. Nevertheless despite this, some of Giffen's examples could be considered as *Navicula gracilis* Ehrenberg var. *neglecta* (Thwaites) Grunow (in Van Heurck, 1880-83 : Pl. 7, Figs 9, 10), now equated with *Navicula tripunctata* (O.F. Müller) Bory (cf. Cox 1979 : 150). The Sundays River specimen does not quite correspond with *N. gracilis* var. *neglecta*, and has therefore been placed temporarily with *N. agulhasica* on the basis of Giffen's illustration and dimensions.

Euryhaline mesohalobe - 5?

Figs: 240, 241
Samples: SUN: 3.

Navicula ammophila Grunow

Grunow, 1882 : 149, Pl. 30, Figs 66-69.

Peragallo & Peragallo, 1897-1908 : 92, Pl. 12, Fig. 13.

Hendey, 1964 : 199.

Taxonomic notes: The specimens identified as *N. ammophila* in these samples come close to Grunow's original diagnosis, and compared well with a specimen observed on Grunow's slide No. 2822a (Naturhistorisches Museum, Vienna). This specimen was linear-lanceolate in valve shape with poles gradually tapering, sometimes slightly protracted, to form subacute apices. The transapical striae were slightly radial in the middle and parallel to slightly convergent at the poles. A central area was generally not observed, although around the central nodule there was some degeneration of the striae, and occasionally some shortened striae. The striae were clearly punctate with lineolate puncta. The Sundays River specimens differed slightly by having more distinctly convergent striae at the poles. The striae of these specimens were distinctly punctate, but the puncta appeared to vary from fairly coarse to a finer type. The specimens observed in this study had the following dimensions:- length 23,5 - 44,6 µm, breadth 4,4 - 7,5 µm, and had 12 - 14 striae in 10 µm . The striae count does not tally with Grunow's original diagnosis (10 - 11 in 10 µm at the centre), but Cholnoky (1960a : 51, Figs 150-155) observed specimens having 11 - 14 striae in 10 µm from Natal. Whether these specimens, particularly those with slightly protracted apices, should be considered as *Navicula flanatica* Grunow (= *N. ammophila* var. *flanatica*) or not is not clear. Cholnoky (1960b : 250, Fig. 24) and Giffen (1966a : 266, Fig. 55) both recorded *N. flanatica* from estuaries or marine littoral situations on the eastern seaboard of South Africa. These examples look very similar to the forms found in this study. However Hendey's (1964 : 199) description of *N. flanatica* indicated a much larger diatom than *N. ammophila* or the majority of the specimens found in the Sundays and Great Fish rivers.

Euryhaline mesohalobe - 5.

Figs: 242, 243.

Samples: SUN: 3, 5, 40-42, 69, 71, 77, 80-86.
FIS: 28, 41.

Navicula atomus (Kützing) Grunow

Grunow, 1860 : 552, Pl. 4, Fig. 6.
Hustedt, 1961-66 : 169, Fig. 1303.

Synonyms: *Amphora? atomus* Kützing, 1844 : 108, Pl. 30, Fig. 70.
Navicula caduca Hustedt, 1942b : 63, Fig. 4.
Navicula pseudatomus Lund, 1946 : 74, Fig. 6K-W.

Taxonomic notes: A study of the literature concerning this species brings to light some discrepancies in measurements and number of striae in 10 µm . In the original diagnosis of this taxon Grunow (l.c.) recorded the maximum length as 17,8 µm . As far as can be ascertained no other authors have recorded specimens much above 10 µm . Whether this is an error or not can only be discovered through examination of Grunow's slides on which *N. atomus* occurred. The striae count in the original diagnosis was also rather lower than most other counts, 23,6 in 10 µm as opposed to 30. However a number of other diatomists recorded lower counts:- Dippel (1904 : 74) - 25-30; Boyer (1927 : 377) - 26-32; while Hustedt (1961-66 : 169) gives a count as low as 19 in 10 µm . Hustedt (l.c.) nevertheless justified this by reference to his examination of the Van Heurck Slide No. 149, in which he saw a rich population of *N. atomus*. In this population he evidently saw a wide range in striae number, since he was able to show from it that his *N. caduca* Hustedt (1942b : 63, Fig. 4) and *N. pseudatomus* Lund (1946 : 74, Fig. 6K-W), having 19 and 18 - 20 striae in 10 µm respectively, was synonymous with *N. atomus*, which has about 30 striae in 10 µm . It appears that Patrick and Reimer (1966 : 488, Pl. 46, Fig. 16) were not convinced with Hustedt's observations, as they ignore his comments completely in their treatment of *N. atomus*. Furthermore their illustration of *N. atomus* (Pl. 46, Fig. 16) taken from the Van Heurck Slide No. 149 is quite different from Hustedt's illustrations. Patrick and Reimer's drawings lack the shortened striae figured by Hustedt. Only two representatives of this taxon were observed in this study, and these corresponded well with Hustedt's description. Hustedt's diagnosis is, however, somewhat misleading as he gives the striae count as "...durchschnittlich etwa um 19 in 10 µm, in der Mitte entfernter stehend....". Hustedt later stated in his discussion of the taxon that in some samples the finely striated forms are predominant. The striae count in the diagnosis of this taxon should therefore read 19 - 30 in 10 µm .

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 15, 25.

Navicula avenacea (Brebisson) Grunow

Grunow, 1878 : 112, Pl. 4, Fig. 23.
Hendey, 1964 : 200.

Synonyms: *Cymbella avenacea* Brébisson in Brébisson and Godey, 1835 : 50, Pl. 7.

Taxonomic notes: A few typical examples were observed with the following dimensions:- length 42,0 - 46,0 µm, breadth 7,0 - 8,0 µm, striae 10 in 10 µm . In one sample an abnormally large specimen, 74,0 µm long and 11,0 µm wide, was tentatively placed in this taxon on the grounds of valve shape and number of transapical striae.

Pleioeuryhaline oligohalobe - 3.

Samples: SUN: 16, 17, 47.

Navicula bulnheimii Grunow

Grunow in Van Heurck, 1880-83 : Pl. 14, Fig. 6a.
Van Heurck, 1885 : 108.
Hustedt, 1961-66 : 333, Fig. 1446.
Hendey, 1964 : 193.

Synonyms: *Navicula bulnheimii* var. *belgica* Grunow in Van Heurck, 1885 : 108.
Navicula hartii Cholnoky e.p. 1963a : 242, Pl. 8, Figs 15, 16 (nec Fig. 17).

Description: Valves narrow lanceolate to linear-lanceolate with poles more or less protracted into subrostrate to distinctly rostrate, sometimes even slightly capitate apices; length 15,4 - 31,9 µm, breadth 2,2 - 3,7 µm . Raphe straight and filiform with small, fairly closely placed central pores and indistinct terminal fissures. Axial area very narrow, linear, and not widening appreciably at the central nodule. Central area, when present, asymmetrical; on one side of the central nodule usually a distinctly wider separation of the two central striae forming a V-shaped band between them reaching the margin of the valve, on the other side of the central nodule a distinct area lacking but the central three striae more widely separated due to the thickening of the costae between them, the central stria of these three lying opposite the V-shaped band on the other side the central nodule. Transapical striae fine, usually distinct only around the central part of the valve, generally parallel, 27 - 32 in 10 µm near the centre and slightly denser at the poles, central striae, as mentioned above, more widely spaced than the others.

Taxonomic notes: The description given above elaborates the rather simple diagnosis of Van Heurck (1885 : 108) and differs slightly from that given by Hustedt (1961-66 : 333, Fig. 1446). In his description Hustedt stated that the central stria on one side of the valve ends in an isolated stigma. However, despite a thorough examination of abundant material on the three slides selected by Hustedt to exemplify this species (slide Nos: N13, 29 - saline in Bad Sulza (Rabenhorst Alg. Eur. No. 1301); N13, 41 - Saline Dürrenberg; and N14, 83 - Salzquelle Tscheschmeh Kormouh in Iran - Bremerhaven) an isolated stigma could not be readily resolved with the light microscope. Abundant material identical to Hustedt's *N. bulnheimii* was also found in a highly saline seepage water at Station 4A on the Sundays River, but was identified at first as *Navicula hartii* Cholnoky. Under the light microscope no isolated stigma could be recognised in these examples either. Nevertheless, when examined under TEM (Fig. 534), the central striae opposite the V-shaped band had a structure, which may be regarded as a pore. In contrast to the apically elongate normal puncta, the last punctum of the central stria was generally roundish in shape. Whether this punctum functions as a mucilage pore, or whether it is merely the last punctum, changed in shape due to its proximity to the central nodule and the thickening of the costae in this region, is difficult to judge. Whatever the case may be, the fact that this punctum is smaller than the normal ones, and since it is not distinctly set apart from the other puncta of the stria, makes it highly unlikely to be distinct under the light microscope. Consequently this feature has been omitted from the description of the species given above.

As mentioned above the Sundays River examples of this taxon were at first identified as *Navicula hartii* Cholnoky (1963a : 242, Pl. 8, Figs 15-17; Pl. 9, Figs 10, 11), which Cholnoky described from an ecologically similar situation in the Swakop River in South West Africa. After a careful examination of Cholnoky's type slide (no. SWA 51 - NIWR) it was clear that the species, *N. hartii*, was based on two distinct elements. The first element consisted of the smaller forms depicted by Cholnoky in his Pl. 8, Figs 15 and 16, and is identical to *N. bulnheimii* (fide Hustedt, 1961-66 : 333, Fig. 1446) as described above. This element must therefore be separated from *N. hartii* and placed with *N. bulnheimii*. The second element embraced the larger forms illustrated by Cholnoky in Pl. 8, Fig. 17; and Pl. 9, Figs 10 and 11. Despite being morphologically similar in many ways, this form was larger and more robust, differs in valve shape, and was more coarsely striate than the smaller forms. These larger and more robust forms cannot be related to any other species known from the literature available, and therefore must be retained as *N. hartii*. An amended diagnosis and a discussion of its affinities is given below under *N. hartii*. Both these elements were observed in the Sundays River, but at different stations. *N. bulnheimii* was observed in abundance at Station 4A, and occasionally, probably heterochthonously, at Stations 1, 2 and 4. *N. hartii*, as understood from the above discussion, was present only at Station 3.

Another species needing some revision with regard to its relationship with *N. bulnheimii* is *Navicula longrostris* Hustedt (1925 : 99, Fig. 12 : 1930 : 285, Fig. 476; 1961-66 : 94, Fig. 1241). Two specimens from Station 6 on the Sundays River were at first referred to *N. longirostris*, but on subsequent reflection it was considered better to place them with *N. bulnheimii* until type material of *N. longirostris* has been examined.

N. bulnheimii does not appear to be a commonly observed species, but this may be due to confusion with other closely related or similar species. For instance Foged (1973 : 72, Pl. 25, Fig. 7) identified a specimen from Southwest Greenland as *N. hyalosira*. However through careful perusal and measurement of Foged's figure it was obvious that the specimen was incorrectly identified as *N. hyalosira*, and in fact should really be referred to *N. bulnheimii*. On the other hand Cholnoky (1959 : 35, Figs 187, 188) somewhat doubtfully recorded *N. bulnheimii* from the Berg River in the Western Cape Province. Nevertheless a glance at his illustrations is sufficient to indicate that his concept of *N. bulnheimii* was erroneous. Likewise Kolbe and Krieger (1942 : 345, Pl. 3, Figs 10, 11) recorded *N. bulnheimii* from Mesopotamia (= Iraq). The dimensions of their specimens, which Kolbe and Krieger themselves acknowledged as being too large for *N. bulnheimii*, and their illustration of these specimens strongly suggest that they are identical with the larger, more robust forms now considered as *N. hartii* (see below).

Finally the large range in valve shape, particularly the apices, observed in the Sundays River material of *N. bulnheimii* clearly indicated that the distinction of *N. bulnheimii* var. *belgica* Grunow (in Van Heurck, 1885 : 108) as a separate taxon is no longer valid. This variety has therefore been included in the list of synonyms of this species.

Euryhaline mesohalobe - 5.

Figs: 244-247, 531-536

Samples: SUN: 1, 5, 14-16, 40, 41, 47, 55, 56, 68, 69, 71, 77-79, 84, 85.
FIS: 12, 15, 28.

Navicula capitata Ehrenberg

Ehrenberg, 1838 : 185, Pl. 13, Fig. 20.
Hustedt, 1930 : 298, Fig. 508 (as *N. hungarica* var. *capitata*).

Synonyms: *Navicula hungarica* var. *capitata* (Ehrenberg) Cleve, 1895 : 16.

Taxonomic notes: This taxon has been better known as *N. hungarica* var. *capitata*. However Cleve (1895 : 16) in merging *Navicula hungarica* and *N. capitata* did not take into consideration that Ehrenberg's species had priority over that of Grunow. Consequently Ross's (1947 : 192) nomenclature for this taxon and the next has been accepted in this study.

A few typical specimens were observed at two stations on the Sundays River, and at Station 1 on the Great Fish River.

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 34, 52.
FIS: 7.

Navicula capitata var. *hungarica* (Grunow) Ross

Ross, 1947 : 192.
Hustedt, 1930 : 298, Fig. 506 (as *N. hungarica*).

Synonyms: *Navicula hungarica* Grunow, 1860 : 539, Pl. 1, Fig. 30.

Taxonomic notes: The change in nomenclature of this taxon and the previous one is discussed under *N. capitata*. A single specimen of this taxon was observed in both the Sundays and Great Fish rivers.

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 34.
FIS: 14.

Navicula cari Ehrenberg

Ehrenberg, 1836 : 83.
Grunow in Van Heurck, 1880-83 : Pl. 7, Fig. 11.
Hustedt, 1930 : 299, Fig. 512.

Synonyms: *Navicula libonensis* Schoeman, 1970a : 342, Figs 36, 37.
Navicula schubartii var. *africana* Archibald, 1966a : 261, Fig. 13.

Taxonomic notes: The taxonomic history of specimens allotted to this taxon in South Africa has been rather variable. Records of it were made from the Vaal Dam catchment area first as a new variety, *N. schubartii* var. *africana* Archibald (l.c.), and later as *Navicula libonensis* (cf. Archibald, 1971 : 41, Figs 176-178). *N. libonensis* was described by Schoeman (l.c.) as a new species from Lesotho. Subsequently on further investigation Schoeman (1973 : 116) himself claimed that *N. libonensis* was identical to *N. cari*. Type material of the latter has not been examined and there remains some doubt as to the true identity of these specimens. Nevertheless until confirmation or rejection through comparison with type material has been obtained, such forms will continue to be referred to as *N. cari*.

Meioeuryhaline oligohalobe - 1.

Fig.: 248

Samples: SUN: 25, 26, 43, 45, 46.

Navicula cincta (Ehrenberg) Ralfs

Ralfs in Pritchard, 1861 : 901.
Grunow in Van Heurck, 1880-83 : Pl. 7, Figs 13, 14.
Hustedt, 1930 : 298, Fig. 510.

Synonyms: *Pinnularia cincta* Ehrenberg, 1854 : Pl. 10/2, Fig. 6a-e.

Taxonomic notes: Cholnoky (1970c : 19) claimed that the combination, *N. cincta*, should be attributed to Grunow, since Kützing had never proposed it. Cholnoky's statement is, however, also incorrect as the combination was in actual fact used by Ralfs (in Pritchard, 1861 : 901) to refer to Ehrenberg's *Pinnularia cincta*. Ralfs should therefore replace Grunow as the first author of the combination. Due to the lack of a good modern description of this taxon there does not appear to be much uniformity in the concept of the species. This is shown by the wide variation in valve shape, arrangement of striae around the central nodule and the direction of the central pores to be found in the numerous illustrations of this taxon. Even the taxonomy of this species and its varieties appears confused. On the one hand Patrick and Reimer (1966 : 515 and 516) considered var. *heufleri* and var. *leptocephala* as a separate species and variety, viz. *N. heufleri* and *N. heufleri* var. *leptocephala*, distinct from *N. cincta*. On the other hand Cholnoky (1970c : 19) maintained that var. *heufleri* and var. *leptocephala* were merely phenotypes, and therefore must be included with the nominate variety as synonyms. Finally Van-Landingham (1975 : 2465) retains both var. *heufleri* and var. *leptocephala* as valid varieties of *N. cincta*.

Patrick and Reimer (l.c. : 515, under *N. heufleri* var. *leptocephala*) claimed that the structure of the central area is one of the most important characteristics in the identification of *N. cincta*. It does not, however, appear to be as simple as they make out. Hustedt (1930 : 298, Fig. 510) showed a single long stria in the centre of the central area with a short stria on either side of it. Patrick and Reimer (l.c. : Pl. 49, Fig. 8) have a different arrangement in a specimen from Franzensbad, the type locality. Nevertheless a series of drawings of the central region of *N. cincta* made by Barber (personal communication) from material collected at Franzensbad, which he obtained from the British Museum (Natural History), show still further variations in the striae arrangement around the central nodule. Photographs of specimens on Van Heurck's slide No. 82 (Figs 249-251) show a striae arrangement similar to that found by Barber in the Franzensbad material. Apart from the wider spacing of the central striae the arrangement of the striae does not appear to be so characteristic that it can serve to identify *N. cincta* so assuredly.

Amongst more or less typical examples of this taxon (length 21,0 - 36,0 μm, breadth 4,5 - 7,5 μm, striae 12 - 14 in 10 μm) from the Sundays River, there were forms (Figs 252, 253) which could not be placed with any other taxon, but which appeared to be small for *N. cincta*. These specimens were linear-elliptical to linear-lanceolate with fairly broadly rounded apices; length 9,0 - 20,0 µm, breadth 3,0 - 4,5 µm . The raphe was straight and filiform with small central pores, and hooked terminal fissures, both curving in the same direction. The axial area was narrow and linear; the central area was more or less rectangular, its size depending on the number of shortened central striae (1 - 3), usually about half the width of the valve. The striae were robust, strongly radial near the centre and convergent at the poles, (12)14 - 16 in 10 µm; the central striae more distant than the others; puncta indistinct.

These forms appear to extend the dimension range of the more typical examples in a continuous series. On these grounds and because they appear to intergrade morphologically, it was considered best to link these small forms from the Sundays and Great Fish rivers with *N. cincta* until proved otherwise.

The fact that there seems to be some confusion over this species points to the necessity of a reappraisal of *N. cincta* and its varieties.

Pleioeuryhaline oligohalobe - 3.

Figs: 249-253

Samples: SUN: 4-12, 14, 21-23, 25, 37, 38, 46, 48, 53, 54, 66, 69, 76, 80-83.
FIS: 16, 17, 26, 30, 40.

Navicula cincta (Ehrenberg) Ralfs var. *leptocephala* (Brébisson in Herb. Kützing ex Grunow) Grunow

Grunow in Van Heurck, 1880-83 : Pl. 7, Fig. 16.
Van Heurck, 1885 : 82.
Hustedt, 1930 : 299.

Synonym: *Navicula leptocephala* Brébisson in Herb. Kützing ex Grunow in Van Heurck, 1880-83 : Pl. 7, Fig. 16.

Description: Valves linear-elliptical (narrowly elliptical) with broadly rounded to slightly produced poles; length 24,0 - 35,0 µm, breadth 5,5 - 7,5 µm . Raphe filiform and very narrow, raphe branches straight but curving towards one side of the valve at the central nodule (the side having the expanded part of the central nodule), central pores slightly expanded but small, terminal fissures large hooks curving in the opposite direction to the central pores and reaching the valve margin at the apices of the valve. Axial rib (= axial area) containing the raphe very narrow and widening unilaterally at the centre to form an asymmetric central nodule, and widening at the valve apices into terminal nodules. Central area asymmetrical, somewhat rectangular on the expanded side of the central nodule due to the even shortening of 3 - 4 striae, and a more or less semilanceolate space on the opposite side formed by striae shortened more progressively around the central nodule; the whole central area occupying up to about half the valve width. Transapical striae relatively robust and lineolate with longitudinal costae more or less parallel to the raphe and sometimes curving slightly outwards round the central nodule; radial and slightly arcuate or sinuous near the centre (12 - 15 in 10 µm), and convergent at the poles (14 - 16 in 10 µm), the central striae usually somewhat more widely spaced; a Voigt fault generally present about half to two thirds of the way to the poles from the central nodule on the staff side (cf. Carter, 1979 : 74) of the valve, i.e. on the side away from the unilateral expansion of the central nodule.

Taxonomic notes: In Southern Africa numerous records of a taxon identified as *Navicula cinctaeformis* Hustedt (1937-38 : 265, Pl. 19, Figs 11, 12) have been made. However, having examined Hustedt's type slide of *N. cinctaeformis* (Hustedt slide No. N1, 90 - Bremerhaven) from Danau di Atas in Sumatra, it was clear that these Southern African forms have been misidentified. Although morphologically similar there are some distinctive differences between the Southern African taxon and Hustedt's species. The most striking difference was found in the formation of the central area. Hustedt (l.c.) described the central area of *N. cinctaeformis* as asymmetrical, semilanceolate on one side and semicircular on the other. This is not strictly true, and may have led to some confusion. Specimens on Hustedt's type slide (Figs 567-570) showed that the axial area widens unequally to form the central area. On one side the semilanceolate space is long and narrow, while on the other side it is shorter and more abruptly expanded. In contrast the Southern African specimens generally have a relatively wide semilanceolate to semicircular space on one side and a fairly distinct rectangular space on the other side (Figs 254-256). Another contrasting feature between the two taxa is the direction in which the central pores point. In *N. cinctaeformis* the central pores are not deflected to one side of the valve, but are straight terminations of the raphe fissure, whereas in the Southern African examples the central pores curve characteristically towards the rectangularly shaped space of the central area. Furthermore in *N. cinctaeformis* the central nodule is not markedly differentiated from the axial rib in contrast to the distinct unilateral expansion of the central nodule in the Southern African specimens. These differences led to the conclusion that the Southern African taxon was quite obviously not *N. cinctaeformis*.

After examining Van Heurck's slide No. 84 (VHS) of *Navicula cincta* var. *leptocephala* (cf. Grunow, 1884-87 : 27, slide No. 84) it was equally evident that this taxon (Figs 571, 572) was identical to the Southern African specimens. The description of this taxon, given above, was compiled directly from Van Heurck's slide, and agreed in every detail with the Southern African forms. The dimensions and striae densities shown in this circumscription do, however, incorporate measurements made from examples observed in this study as well as elsewhere in Southern Africa (cf. Schoeman, 1970b : 56). Specimens identified by Giffen (1963 : 236) as *N. cinctaeformis* must be considered with caution as their dimensions (length 33,0 - 54,0 µm and breadth 7,0 - 9,0 µm) are too large to be included with *N. cincta* var. *leptocephala*. The striae density (10 - 12 in 10 µm) of Giffen's specimens also seem to be rather coarse for the latter taxon. Giffen's material has not been examined and thus no further comment can be made as to where his specimens rightfully belong.

Whether *N. cincta* var. *leptocephala* can be upheld as a variety of *N. cincta* or not is a question requiring further study. From the comments of Carter (1979 : 77) in his study on the identity of *N. cincta*, it would appear that there might be justification for reinstating Brebisson's species *Navicula leptocephala* as a good species. Having examined Van Heurck's slide No. 84, Carter remarked as follows:- "A careful seach (sic.) of this slide has failed to reveal any forms which even approximate to the true *N. cincta*". Carter's illustrations of specimens (his Figs 39 and 40) from this material do not, however, show the characteristic formation of the central area of *N. cincta* var. *leptocephala*.

In the light of the arguments presented above, two specimens identified as *N. cinctaeformis* by Manguin (1952 : 67, Pl. 3, Fig. 81) should probably be treated in the same way as the Southern African specimens. Some doubt is also expressed over the specimen illustrated by Haworth (1972 : 167, Fig. 10, No. 9), as this specimen does not accord with specimens of *N. cincta* var. *leptocephala* as found on the Van Heurck slide No. 84.

Mesoeuryhaline oligohalobe - 2.

Figs: 254-256, 571, 572

Samples: SUN: 11, 13, 15, 16, 18-26, 28, 30-34, 45-49, 60-63, 72, 73, 76.
FIS: 3-6, 8, 9, 11-14, 16-40.

Navicula clamans Hustedt

Hustedt, 1939 : 624, Figs 75-77.
Hustedt, 1961-66 : 179, Fig. 1313.

Taxonomic notes: The specimens observed in the Sundays River at Station 2 were very typical of those illustrated by Hustedt (l.c.) in his original diagnosis of the species. These local examples were 16,2 - 22,5 µm long, 6,0 - 7,4 µm broad and had 20 - 22 striae in 10 µm . The striae count is however, slightly denser than given by Hustedt in his description. *N. clamans* has been recorded a number of times by Cholnoky (1960a : 55, Fig. 172; 1963c : 54, Fig. 39; 1968a : 47, Fig. 59) and by Giffen (1970a : 281, Figs 45, 46; 1975 : 82; 1976 : 388). Cholnoky (1959 : 36) also described two varieties, var. *africana* and var. *minor*, which differ from the nominate variety in size and shape of the axial area. From these local examples it would appear that striae densities range from 15 - 26 in 10 µm, but some revision of these records may be necessary to confirm their identification.

Meioeuryhaline polyhalobe - 9.

Figs: 257-259

Samples: SUN: 84.

Navicula cohnii (Hilse) Lange-Bertalot and Bonik

Lange-Bertalot and Bonik, 1978 : 33, Pl. 1, Figs 8, 9; Pl. 2, Figs 8-10.
Hustedt, 1961-66 : 583, Fig. 1592g-m (as *N. mutica* f. *cohnii*).

Synonyms: *Stauroneis cohnii* Hilse, 1860 : 83.
Navicula mutica f. *cohnii* (Hilse) Cleve, 1894 : 129.
Navicula mutica var. *cohnii* (Hilse) Grunow in Van Heurck,
1880-83 : Pl. 10, Fig. 17.

Taxonomic notes: In an electron microscopic study of *Navicula mutica* Kützing (see below) and its allies Lange-Bertalot and Bonik (l.c.) distinguished *N. mutica* from the f. *cohnii* (Hilse) Cleve on the basis of the position of the isolated pore in relation to the curved proximal endings of the raphe branches. In *N. mutica* these curved towards the isolated stigma, while in f. *cohnii* they curved away from the stigma. Lange-Bertalot *et al.* considered the two taxa to be sufficiently different to raise f. *cohnii* to the rank of species. In the Sundays and Great Fish rivers only a single record of *N. cohnii* was made, but it may be more common as some of the forms identified as *N. mutica* may in reality be this species. It would, however, be too lengthy a task to re-examine all records of *N. mutica* to check this.

Meso- to pleioeuryhaline oligohalobe - 2-3.

Sample: SUN: 49.

Navicula confervacea (Kützing) Grunow

Grunow in Van Heurck, 1880-83 : Pl. 14, Fig. 36.
Hustedt, 1961-66 : 205, Fig. 1324a-d.
Schoeman & Archibald, 1976-80 : No. 6.

Synonyms: *Diadesmis confervacea* Kützing, 1844 : 109, Pl. 30, Fig. 8.

Taxonomic notes: An isolatd specimen was observed in the Wit River, a tributary of the Sundays River having its confluence near Addo.

Meioeuryhaline oligohalobe - 1.

Fig.: 32

Samples: SUN: 34.

Navicula consentanea Hustedt

Hustedt, 1939 : 625, Figs 98-100.

Taxonomic notes: Hustedt did not designate any particular slide as the syntype, but remarked that the species was abundant on the Leysand (Linke Nr. 27891). This slide (No. 267, 29 - Bremerhaven) was examined and many typical specimens were observed. Nevertheless some differences were noted as well. The specimens were always lanceolate with acutely pointed apices. However in larger examples the poles were sometimes slightly protracted; this is not mentioned in Hustedt's original diagnosis. The striae were more or less as described by Hustedt, but normally appeared somewhat more radiate. Occasionally there was a single shortened intercalated stria on one side of the central nodule, and less frequently some of the central striae were slightly shortened usually on one side of the central nodule, forming a very small expansion of the axial area.

Specimens observed in the Sundays and Great Fish rivers were generally very typical, the dimensions of a few specimens served to increase the range given by Hustedt (l.c.). These specimens were 13,0 - 26,2 µm long, 3,9 - 5,4 µm broad, and had 18 - 20 striae in 10 µm . The examples observed in this study also showed the same sort of variation in pole shape and striae structure around the central nodule as was seen on the Hustedt slide.

At Station 1 (samples SUN 85, 86) on the Sundays River a number of small valves were observed in May 1970, which have been designated to this species with the greatest of reservation. Under LM they conformed fairly closely to *N. consentanea* in valve shape and striae direction and density, but their dimensions were much too small to include them with this species without any doubt. These examples, one of which is illustrated in Fig. 263, were 7,0 - 9,0 µm long and 2,3 - 3,0 µm broad. However as they could not be identified with any other taxon they were maintained in this species.

Mesoeuryhaline polyhalobe - 8.

Figs: 260-263

Samples: SUN: 1-4, 59, 82-86
FIS: 5, 15, 28.

Navicula contenta Grunow

Grunow, 1884-87 : Ser. VI, p. 46.
Grunow, 1888 : 324 (under *N. contexta* - typographical error)
Schoeman & Archibald, 1976-80 : No. 4.

Synonyms: *Diadesmis biceps* Arnott (according to Grunow in Van Heurck, 1880-83 : Pl. 14, Fig. 31B)
Navicula trinodis W. Smith var. *biceps* Grunow in Van Heurck l.c.
Navicula contenta Grunow var. *biceps* (Grunow) van Heurck, 1885 : 109.
Navicula trinodis W. Smith f. *minuta* Grunow in Van Heurck, 1880-83 : Pl. 14, Fig. 31A.

Navicula contenta Grunow *sensu* Van Heurck, 1885 : 109.
Navicula contenta f. *elongata* Cholnoky, 1954b : 417, Fig. 49.
Navicula contenta f. *gigantea* Cholnoky, 1957a : 59, Figs 118-121.
Navicula contenta f. *inflata* Manguin, 1952 : 61, Pl. 3, Fig. 62.
Navicula contenta f. *parallela* (Boye Petersen) Hustedt, 1930 : 277, Fig. 458b.
Navicula contenta f. *undulata* Cholnoky, 1952 : 128, Fig. 158.
Navicula contenta f. *undulata* Manguin, 1952 : 62, Pl. 3, Fig. 63.
Navicula contenta var. *elliptica* Krasske, 1929 : 355, Fig. 13d, e.

Description: Valve shape extremely variable, in the smallest specimens elliptical, in all others basically linear, with many variations such as parallel sided with broadly rounded poles, central portion inflated with or without capitate poles, central portion concave, walls bi- or triundulate with or without capitate poles, or sometimes with rostrate poles; length 4,0 - 30,0 µm, breadth 2,0 - 6,0 µm . Raphe straight and filiform, often relatively thick and prominent; central pores inconspicuous, and distal ends of the raphe branches terminating some distance from the margin. Axial area linear and variable in width; central area variable in shape and extent, from almost absent through elliptical or circular, to a relatively broad band reaching the margin. Transapical striae usually parallel, sometimes slightly radial at the centre and convergent at the poles, when visible 25 - 40 in 10 µm, and often more prominent along the axial area; when invisible the valve face sometimes crossed by a dark band on either side of and parallel to the raphe.

Taxonomic notes: Recently Schoeman and Archibald (1976-80 : No. 4) have reviewed the taxon, examining slides of the original material collected by Walker-Arnott containing *Diadesmis biceps* (Slide Nos. BM 3615, BM 11222, BM 24640) obtained from the British Museum (Natural History), as well as Van Heurck's Slide No. 146 from Vienna and the British Museum (BM 26457). This study brought to light some misconceptions about the species. First and foremost the slides mentioned above revealed that the forms with concave walls, previously referred to as *N. contenta* f. *biceps* and based on *Diadesmis biceps (= Navicula trinodis* var. *biceps)*, were in fact the forms Grunow (1884-87 : 46) intended to call *N. contenta*. Van Heurck (1885 : 109), intentionally or not, transferred erroneously the rather rare forms with a distinctly inflated middle part and capitate poles, i.e. *Navicula trinodis* f. *minuta*, to *N. contenta*. This error has persisted up to the present time.

The second thing these slides showed was that the taxon is extremely polymorphic with respect to valve shape. As will be seen from the list of synonyms above, numerous forms have been described; most of these are held as valid by VanLandingham (1975 : 2479) in his catelogue of diatom synonyms. The distinction between many of these forms and varieties is, however, somewhat nebulous. Moreover on a slide of material from Ile d' Amsterdam, prepared by Tempère and Peragallo (Slide no. BM 14549) nearly all these morphological variations were observed with intermediate forms linking them. On these grounds Schoeman and Archibald (l.c.) decided to consider all forms and varieties of this taxon as synonymous with *N. contenta*.

Electron microscopic studies carried out by Schoeman and Archibald (1976-80 : No. 4) also showed that *N. contenta* does not have a typical naviculoid striae structure. The striae were in fact more akin to those of the genus *Pinnularia* in structure. Internally the striae of *N. contenta* is a completely open transapically elongate alveolus, communicating with the exterior by a single narrowly elliptical pore, also transapically orientated. A similar striae structure has been noted in a number of other small *Navicula* species, and it is debatable whether to regard these as a new and separate section of the genus *Navicula*, or to transfer them to the genus *Pinnularia*.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 2, 6, 34.

Navicula creuzbergensis Krasske

Krasske, 1927 : 271, Pl. 10, Figs 10, 11.
Hustedt, 1930 : 289, Fig. 490.
Hustedt, 1961-66 : 281, Fig. 1412.

Synonyms: *Frustulia creuzbergensis* (Krasske) Hustedt, 1957 : 256.
Frustulia hawaiensis Hustedt, 1942 : 47. Fig. 67.
Navicula creuzbergensis var. *multistriata* Patrick in Patrick and Reimer, 1966 : 461, Pl. 43, Fig. 6.

Taxonomic notes: Placing this taxon in the genus *Navicula* is controversial. Hustedt (1957 : 256) transferred *N. creuzbergensis* to the genus *Frustulia* since he considered the terminal nodules to have the structure of a

Frustulia. On the other hand Patrick and Reimer (1966 : 461) retained the taxon in *Navicula*, because it lacked a raphe enclosed by two thick siliceous ribs typical of *Frustulia*. Examining a number of examples from South Africa, fitting well the description of *Frustulia hawaiensis* (= *Frustulia creuzbergensis fide* Hustedt, 1957 : 256), it is clear that the raphe is not enclosed by two siliceous ribs, and as such cannot therefore have a terminal nodule typical of a *Frustulia*. In fact the distal endings of the raphe branches of these forms are only superficially similar to a *Frustulia*, and resemble more the type of ending found in *N. scopulorum* (cf. Hustedt, 1961-66 : 25, Fig. 1186). On these grounds, retaining the taxon in the genus *Navicula* is favoured. The South African specimens examined, including the example from the Sundays River, were more finely striate than given in Krasske's (1927 : 271) original diagnosis and in Hustedt's (1961-66 : 281) later description. However in this respect they fit well with *Frustulia hawaiensis*, which, according to Hustedt (1957 : 256), is synonymous with *F. creuzbergensis* (= *Navicula creuzbergensis*). In most other characteristics, as well, the South African specimens tally better with *F. hawaiensis*. Despite Hustedt's (1961-66 : 282) doubts concerning *N. creuzbergensis* var. *multistriata*, there seems little reason to separate this variety from *F. hawaiensis*, and it is for this reason also synonymous with *Navicula creuzbergensis*.

The dimensions of the South African examples from Natal (cf. Cholnoky, 1960a : 44) and the Sundays River were as follows:- Length 27,4 - 35,3 µm, breadth 5,9 - 6,9 µm, and transapical striae 24 in 10 µm . In most cases the striae density seemed even throughout the valve, but occasionally the striae were less dense at the centre and slightly denser at the poles. Another point of interest was that, whereas the slit-like appendages of the central pores were indistinct in the Natal specimens, they were seen quite clearly in the example from the Sundays River (see Figs 264, 265).

Euryhaline mesohalobe - 5.

Figs: 264, 265

Samples: SUN: 3.

Navicula cryptocephala Kützing

Kützing, 1844 : 95, Pl. 3, Figs 20, 26.
Hustedt, 1930 : 295, Figs 496, 497a.
Hendey, 1964 : 195.

Taxonomic notes: *Navicula cryptocephala* is extremely variable from a morphological point of view, and the distinction between the varieties is difficult to define. All varieties were therefore referred to *N. cryptocephala* without any attempt being made to separate them.

Pleioeuryhaline oligohalobe - 3.

Samples: SUN: 1, 4-6, 8-37, 39, 41, 43-55, 57, 60-66, 72-76, 81.
FIS: 1-14, 16-33, 35-40.

Navicula cuspidata (Kützing) Kützing

Kützing, 1844 : 94, Pl. 3, Figs 24, 37.
Hustedt, 1930 : 268, Fig. 433.
Hustedt, 1961-66 : 59, Fig. 1206a.

Synonym: *Frustulia cuspidata* Kützing, 1833 : 549, Pl. 14, Fig. 26.

Taxonomic notes: Only a few examples of the nominate variety of this species were observed in this study. One of these, the specimen from sample SUN 9, had craticular formation within the valve.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 9, 34.

Navicula cuspidata var. *ambigua* (Ehrenberg) Cleve

Cleve, 1894 : 110.
Hustedt, 1930 : 268, Fig. 434.
Hustedt, 1961-66 : 62, Fig. 1206b.

Synonyms: *Navicula ambigua* Ehrenberg, 1841 : 129, Pl. 2/2, Fig. 7;
Pl. 2/3, Fig. 9.

Taxonomic notes: This variety was far more common in both the Sundays and Great Fish rivers. Hustedt (1961-66 : 63) remarked that *N. cuspidata* was variable in outline, with all varieties gradually merging into one another. He made, however, an exception of var. *ambigua* and var. *heribaudii*. On the otherhand Cholnoky (1970c : 20) considered the var. *ambigua* as synonymous with the nominate variety, as the forms intergrade with each other. Intermediates were not observed in this study and the var. *ambigua* has therefore been retained as a separate taxon.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 11, 20-23, 25-27, 47, 60, 72, 74, 76.
FIS: 7, 9-13, 15.

Navicula dicephala var. *undulata* Østrup

Østrup, 1918 : 25, Pl. 3, Fig. 33.
Hustedt, 1930 : 303, Fig. 527 (as *N. dicephala* var. *neglecta*).

Synonyms: *Navicula dicephala* (Ehrenberg) W. Smith var. *neglecta* (Krasske) Hustedt (1930 : 303, Fig. 527).
Navicula neglecta Krasske, 1929 : 354, Fig. 5.

Taxonomic notes: The single specimen observed in the Wit River, a tributary of the Sundays River, was less markedly triundulate than Østrup's (l.c.) illustration. This specimen resembled more the form depicted by Hustedt (l.c.).

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 34.

Navicula digito-radiata (Gregory) Ralfs

Ralfs in Pritchard, 1861 : 904.
Hustedt, 1930 : 301, Fig. 518.
Hendey, 1964 : 202, Pl. 29, Figs 8, 9.

Synonym: *Pinnularia digitoradiata* Gregory, 1856 : 9, Pl. 1, Fig. 32.

Taxonomic notes: A single specimen agreeing well in nearly all respects with Hustedt's (1930 : 301, Fig. 518) description of *N. digito-radiata* was observed at Station 11 on the Sundays River. It differed only by having distinctly convergent striae at the poles, and by being slightly smaller. The dimensions of this specimen (Fig. 266) were as follows:- Length 47,5 µm, breadth 10,3 µm, and had 10 striae in 10 µm .

Euryhaline mesohalobe - 5.

Fig.: 266

Samples: SUN: 26.

Navicula diserta Hustedt

Hustedt, 1939 : 627, Figs 78, 79.

Synonyms: *Navicula hansenii* M. Møller, 1950 : 205, Fig. 10.
Navicula pseudoincerta Giffen, 1970a : 285, Figs 60-62.

Description: Valve outline variable from elliptic-lanceolate, lanceolate, through linear-lanceolate to almost linear, with poles either bluntly rounded, relatively acutely pointed, cuneate or sometimes slightly protracted; length 5,5 - 20,0 µm, breadth 2,0 - 4,0 µm . Raphe straight and filiform, generally very fine. Axial area narrow and linear; central area quadratic due to the characteristic shortening of the central stria on each side of the central nodule. Transapical striae usually distinctly lineolate, slightly radial in the middle and parallel or convergent at the poles, 14 - 20 in 10 µm .

Taxonomic notes: There is only one type slide designated for this species in the Hustedt collection in Bremerhaven. This is slide No. N6, 23, collected on a sandflat at Nessmersiel on the west German coast. The slide contains a large number of specimens, which show a much greater variability in valve shape and dimensions than indicated in the original diagnosis. A feature not mentioned by Hustedt (l.c.) in his description of the species is the parallel or convergent polar striae. Had this information on the greater variability and on the direction of the polar striae been available, two later synonyms would probably never have been described. The first of these is *Navicula hansenii* M. Møller (l.c.). From its diagnosis and illustrations there can be no doubt that *N. hansenii* is identical to *N. diserta*. The second taxon synonymous with *N. diserta* is *Navicula pseudoincerta* Giffen (1970a : 285, Figs 60-62). Giffen first described the latter taxon from the Kowie River estuary, but later united it with *N. hansenii* (cf. Giffen, 1973 : 40). Giffen, however, was also unaware of the wider range of variability in *N. diserta*. In a later paper he acknowledged, furthermore, that he erroneously referred some specimens of *N. diserta* to *Navicula mollis* W. Smith (cf. Giffen, 1963 : 240, Fig. 74, 75).

The Sundays River specimens were identical to those observed on Hustedt's type slide No. N6, 23. Their dimensions were - length 7,5 - 19,0 µm, breadth 2,5 - 3,5 µm, and striae 14 - 20 in 10 µm . They also displayed more or less the same range in valve shape. Salah (1952 : 161) reported examples of *N. diserta* from Blakeney Point in England having an even wider variability in dimension and density of striae. Salah gives a range of 4,0 - 32,0 μm for length, 2,0 - 6,0 μm for breadth. The striae in his larger specimens were 9 - 11 in 10 μm at the centre, becoming 14 - 18 near the poles; his smaller specimens had 14 - 18 striae in 10 μm throughout. Despite Salah's assertion that he found a continuous series from the shorter to the longer specimens, the significantly wider striation of his larger examples indicates that the larger forms might be some other taxon. His illustration of one of the larger examples (Salah, l.c. : Pl. 1, Fig. 9) showed radial polar striae, a condition not observed in the type slide or in any of the examples seen from South African localities.

The distribution of this species may be more wide spread than it appears due to confusion with similar small species, particularly *Navicula salinicola* Hustedt.

Pleioeuryhaline polyhalobe - 7.

Figs: 267-269.

Samples: SUN: 2-8, 12, 13, 35, 36, 41, 42, 57, 66-70, 75, 77-84.

Navicula elginensis (Gregory) Ralfs

Ralfs in Pritchard, 1861 : 902.
Hustedt, 1930 : 303 (as *N. dicephala* var. *elginensis*).

Synonym: *Pinnularia elginensis* Gregory, 1856a : 9, Pl. 1, Fig. 33.

Taxonomic notes: Fairly typical examples were observed in the Sundays River. Dimensions of these specimens were:- Length 19,5 - 24,5 μm, breadth 6,5 - 7,0 μm and transapical striae 14 in 10 μm . Both Haworth (1974 : 51) and Patrick and Reimer (1966 : 525) suggest that many specimens identified recently as *N. dicephala* are in fact *N. elginensis*.

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 6, 7, 41, 42, 57, 69.

Navicula elkab O. Müller

O. Müller, 1899 : 311, Pl. 12, Figs. 19-22.

Synonyms: *Navicula vallisnatrii* O. Müller, 1899 : 317, Pl. 12, Figs 19-22.

Description: Valves lanceolate to elliptic-lanceolate with poles slightly or distinctly protracted into subrostrate to well defined rostrate apices; 15,0 - 32,0 µm long, and 4,0 - 6,0 µm broad. Raphe straight and filiform with small central pores and inconspicuous terminal fissures. Axial area narrow linear, not widening at the central nodule; central area absent. Transapical striae fine, parallel to slightly radial throughout, 20 - 25 in 10 µm, very slightly wider at the central nodule.

Taxonomic notes: *N. elkab* has been recorded only once previously from South Africa, when Fritsch and Rich (1930 : 101, Fig. 3F) observed it in a mine dam at Kimberley, as well as in irrigation canals at Kenilworth near Kimberley. Cholnoky (personal communication) commented on Fritsch and Rich's observation, considering their forms as *N. gregaria*. Examining a number of Cholnoky's slides from which he identified *N. gregaria* it appears that Cholnoky had two concepts of *N. gregaria*. One was correct, but the other, recorded mainly from South West Africa (cf. Cholnoky, 1966a : 35; 1966b : 190 - *N. gregaria* e.p.) agrees fairly well with *N. elkab* as described above. It is therefore suggested that *N. elkab* is more prevalent in Southern Africa than is at first apparent from the literature, but it has been misidentified as *N. gregaria*.

Examples of *N. elkab* from the Sundays River displayed a reasonably wide range of variation in valve shape including the f. *lanceolata* and f. *subcapitata* described by O. Müller (1899 : 311, Figs 19-22). It is clear from this variation that these two forms cannot be distinguished from each other on any valid grounds, and should therefore be regarded as synonyms of *N. elkab*. Although the largest specimen observed in the Sundays River measured 32,3 µm long and 5,9 µm broad, both Compere (1967 : 172) and Gasse (1975 : Vol. III, Pl. 35, Fig. 12) reported examples more than 40,0 µm long. These seem to be exceptional specimens, and Gasse appears to be somewhat doubtful that her large example is indeed *N. elkab*.

Euryhaline mesohalobe - 5.

Figs: 33, 34, 270-275, 537

Samples: SUN: 74.

Navicula exiguiformis Hustedt

Hustedt, 1944 : 283, Fig. 23.
Hustedt, 1945 : 929, Pl. 42, Figs 21, 22.
Hustedt, 1949a : 95, Pl. 4, Figs 1-13.

Synonyms: *Navicula vonhauseniae* Cholnoky, 1954 : 419, Figs 64-66.

Taxonomic notes: *N. exiguiformis* occurs quite commonly in Southern Africa, but was only observed as a few isolated examples in the Sundays and Great Fish rivers. These specimens measured 9,5 - 12,0 µm long, 4,5 - 5,0 µm broad and had 18 - 20 transapical striae in 10 µm . As such they represent the smallest examples found by Hustedt (1949a : 95, Pl. 4, Figs 1-13) in the Congo. In this material Hustedt did not mention the minimum breadth of these small specimens, but from measurements of his illustrations the minimum was about 4 µm .

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 23, 25-27.
FIS: 12.

Navicula exilissima Grunow

Grunow in Van Heurck, 1880-83 : Pl. 14, Fig. 30.
Van Heurck, 1885 : 108.
Hustedt, 1961-66 : 261, Fig. 1389.

Taxonomic notes: A single example was found at Station 4A on the Sundays River. This specimen had measurements of 9,5 µm long, 3,0 µm wide, and had about 40 transapical striae in 10 µm .

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 41.

Navicula finmarchica (Cleve & Grunow) Cleve

Cleve, 1895 : 28.

Synonyms: *Stauroneis finmarchica* Cleve and Grunow, 1880 : 47, Pl. 3, Fig. 63.

Description: Valves lanceolate with protracted somewhat acutely rounded subrostrate apices; length 32,6 - 42,6 µm, breadth 6,9 - 7,8 µm . Raphe straight and filiform with small but very closely placed central pores; terminal fissures small and hooked, curving to the same side of the valve.

Axial area narrow, linear; central area more or less rectangular, sometimes having the bordering striae interrupted by a hyaline area between the central nodule and valve margin; central area lying over a somewhat laterally expanded central nodule with its lateral edges extended apically into weak horns forming shadow lines parallel to the valve margin. Transapical striae somewhat diffuse, radial throughout except for the last two or three which become parallel to weakly convergent, 12 in 10 µm; striae over the apical extensions of the central nodule weakly developed, thus giving the appearance of an indistinct H-shaped central area. Longitudinal costae indistinct.

Taxonomic notes: The true identity of the specimens shown in Figs 276-278 and described above is a little uncertain. They conform most closely to the diagnosis of *N. finmarchica*, and have thus been tentatively placed in this taxon. Cleve and Grunow's species does not appear to be particularly well known as there are few records of it. Cleve and Grunow's (l.c.) illustration of *Stauroneis finmarchica* gives the impression of faint or weak striae. On the other hand Hendey (1964 : 198, Pl. 30, Fig. 5) depicted a relatively broad, short form with robust striae, and clear lateral areas. Likewise Rivera (1968 : 61, Pl. 13, Fig. 10) illustrated an example with very robust striae. Cleve-Euler (1953 : 128, Fig. 746) and van der Werff and Huls (1957-74 : no pagination) depicted specimens closer to Grunow's *S. finmarchica*.

The examples found in the Great Fish River agree fairly closely in valve shape, but were much narrower. It is difficult to assess the appearance of the striae in Cleve and Grunow's species. However those of the specimens found in this study were quite robust, but were not sharply defined along the edges, in other words they were somewhat diffuse and not distinct. In this they contrasted with the strong, sharply defined striae in the examples illustrated by Hendey (l.c.) and Rivera (l.c.). The central nodule was clearly expanded transapically and its lateral margins were extended apically into weak horns. In the region of these horns the striae did not appear to be interrupted, but became weaker in their development. Thus they did not form a true lateral area as shown by Hendey's and Rivera's examples, but appeared more like shadow lines crossing the striae.

In reviewing the literature other taxa with possible close links with the Great Fish River specimens were *Navicula transitans* Cleve var. *derasa* (Grunow) Cleve (1895 : 28), *Navicula arenaria* Donkin (cf. Hendey, 1964 : 196, Pl. 30, Fig. 15), and *N. transistantioides* Foged (1975 : 44, Pl. 19. Figs 10, 11). However, although these taxa show certain characteristics in common with the examples from the Great Fish River, there were other features which clearly distinguished them from the specimens in question. Dimensions and central nodule with its accompanying central area structure were the prime features in this respect.

On the basis of these arguments, therefore, the Great Fish River forms were considered with some reservation to belong to *Navicula finmarchica*. This observation makes it the first record of this species for Southern Africa.

Meioeuryhaline polyhalobe - 9.

Figs: 35, 276-278

Samples: Fis: 14.

Navicula frugalis Hustedt

Hustedt, 1957 : 275, Figs 21-25.
Hustedt, 1961-66 : 234, Fig. 1356.

Taxonomic notes: Simonsen and Lange-Bertalot (personal communication) selected a lectotype for this species on Slide No. 385, 91a in the Hustedt collection at Bremerhaven, and ringed this example. This specimen was examined and found to be identical with what has upt to the present been referred to as *N. perparva* in South Africa. Hustedt's (l.c.) description is not quite accurate in that the raphe branches are curved and not straight as depicted in his illustrations. Furthermore the punctate nature of the striae was fairly easily recognised. Hustedt's type slide of *N. perparva* (N6, 34; N6, 35; N6, 36 - Bremerhaven) were also examined and contained specimens typical of his description (cf. Hustedt, 1937-38 : 246, Pl. 20, Figs 16-18). These specimens showed conclusively that the concept of *N. perparva* in South Africa was incorrect, and that most records going under the name *N. perparva* should now be referred to *N. frugalis*. Lange-Bertalot and Bonik (1976 : 317) have examined good populations of *N. frugalis*, and have found not only a greater variation in dimensions, but also in striae density. They found the valves to be 7,0 - 11,0 µm long, 3,3 - 4,5 µm wide, and they had 16 - 31 striae in 10 µm . The dimensions of the Sundays and Great Fish River specimens agreed with Lange-Bertalot and Bonik's findings (length 9,0 - 11,0 µm, breadth 4,0 - 4,5 µm), but the striae were limited to 21 - 24 in 10 µm .

Meioeuryhaline oligohalobe - 1.

Fig.: 36

Samples: SUN: 9, 17, 20-22, 25, 26, 32, 33, 43, 52, 62.
FIS: 1, 2, 8, 16, 20, 23, 24, 26, 31, 33.

Navicula gregaria Donkin

Donkin, 1861 : 10, Pl. 1, Fig. 10.
Donkin, 1871 : 43, Pl. 6, Fig. 13 (as *Navicula veneta* Kützing).
Hustedt, 1930 : 269, Fig. 437.

Synonym: *Navicula gregalis* Cholnoky, 1963c : 57, Fig. 50.

Description: Valves lanceolate with poles having varying degrees of protraction from very slightly subrostrate, through rostrate to produced capitate apices; length 13,0 - 37,0 µm, breadth 4,0 - 9,0 µm . Raphe filiform, straight or weakly arcuate, interrupted at the centre by a central nodule expanded asymmetrically on one side; central pores small and curved towards the expanded side of the central nodule; terminal fissures relatively large and hooked in the opposite direction to that of the curvature of the central pores. Axial area narrowly linear, parallel to the raphe; central area variable in size from very small (one or two striae on either side of the central nodule slightly shortened) to about half the valve width, generally somewhat asymmetrical in shape, the striae on the expanded side of the central nodule evenly shortened forming a more or less straight margin to the central area, while on the other side the striae shortened gradually to form a semi-elliptical area. Transapical striae radial to slightly radial at the centre, becoming convergent at the poles, (13)14-22 in 10 µm at the centre, and about the same to slightly denser at the poles. Striae punctate; puncta sometimes difficult to resolve, 26 - 37 in 10 µm, usually arranged in longitudinal lines more or less parallel to the raphe.

Taxonomic notes: In examining many slides from Southern Africa containing *N. gregaria* it became clear that Cholnoky's concept of the taxon was very confused. In many cases he correctly identified the species, but on many other occasions he identified different taxa as *N. gregaria*, and, in one instance, even described the taxon as a new species. Examples from Lake Chrissie (Cholnoky, 1965 : 71, Fig. 20), South West Africa (Cholnoky, 1966a : 35; 1966b : 190) and Marble Hall (Cholnoky, 1970c : 21) were identified as *N. gregaria*. These specimens, however, represent a taxon closer, if not identical, to *Navicula elkab* O. Müller (1899 : 311, Pl. 12, Fig. 22 - see above). Cholnoky (1968 : 51) also recorded *N. gregaria* from St. Lucia in Natal, but some of these specimens are better identified as a form of *Navicula cryptocephala*.

Finally Cholnoky (1963c : 57, Fig. 50) described the new species, *Navicula gregalis*, from the Knysna Lagoon. He obviously recognised that his new taxon was very closely allied to *N. gregaria*, since he suggested that it may possibly be the true *N. gregaria*, while the more common form is another taxon confused with *N. gregaria*. On examining the type slide of *N. gregalis* (slide No. K176 - NIWR) nothing corresponding to his illustration could be found. On the other hand specimens fitting his description, as well as that of *N. gregaria* were quite frequent. Since Cholnoky did not record *N. gregaria* from this sample, it is assumed that this was his new taxon, *N. gregalis*. Identical specimens were found in the Sundays River estuary. These were examined under the electron microscope, and compared with electron micrographs of *N. gregaria* from various sources (cf. Schoeman and Archibald, 1976-80 : No. 4). No significant differences could be found between the two taxa, except that the Sundays River specimens (i.e. *N. gregalis*) had slightly smaller central areas. Consequently *N. gregalis* Cholnoky is considered synonymous with *N. gregaria*.

Euryhaline mesohalobe - 5.

Fig.: 37

Samples: SUN: 1-6, 21, 23, 48, 58, 59, 83-86.
FIS: 15, 28.

Navicula grimmei Krasske

Krasske, 1925 : 45, Pl. 1, Fig. 14.
Hustedt, 1930 : 274, Fig. 448.
Hustedt, 1961-66 : 769, Fig. 1742a-d.

Taxonomic notes: A single typical example of this taxon was observed in the Kap River, a tributary of the Great Fish River in the coastal region.

Mesoeuryhaline oligohalobe - 2.

Samples: FIS: 14.

Navicula groschopfi Hustedt

Hustedt, 1939 : 631, Figs 102, 103.

Taxonomic notes: Specimens assigned to this taxon are placed here with a great deal of doubt, and probably form a mixture of taxa. They cannot, however, be placed with certainty in any other similar taxon. They approached *N. groschopfi* most closely in valve shape and dimensions, but differed in their coarser striation (16 - 17 in 10 µm), and in the more strongly radial nature of the striae. It is possible that these specimens may indeed be large examples of *N. consentanea*, agreeing more closely to the latter in striae density. The strongly radial striae, however, make this connection somewhat doubtful as well. Some examples even resemble *N. dilucida* Hustedt (l.c. : 627, Figs 104? 105-107), but the large dimensions of these specimens placed them at the upper size limit, of which even Hustedt was rather doubtful (cf. Hustedt's Fig. 104). Here also the direction of the striae differed too much to place these specimens in *N. dilucida* with any degree of confidence. A closer investigation of further specimens is necessary to resolve this problem. At present too few specimens have been observed to make any well considered judgement. The examples studied in this survey had the following dimensions:- Length 24,9 - 27,0 µm, breadth 4,4 µm, and 16 - 17 striae in 10 µm .

One specimen (Fig. 38), however, seems to fit the diagnosis of *N. groschopfi* more closely than the others. Valve shape and dimensions conform to the description, although it appears to be a large specimen. The striae furthermore agree more closely with Hustedt's (l.c.) description than with the other specimens placed in this taxon. The identification, however, should still be confirmed by comparison with the type material.

Meioeuryhaline polyhalobe - 9.

Figs: 38, 279

Samples: SUN: 3, 58, 82-84.
FIS: 5, 29.

Navicula guluensis Giffen

Giffen, 1963 : 238, Fig. 70.

Taxonomic notes: Giffen (l.c.) obviously did not see many examples on which to base his diagnosis, as his dimensions give one measurement each for length and breadth. An examination of a paratype slide (Giffen No. 464/4 - NIWR) produced no specimen of this taxon. Nevertheless, while Giffen seems to have found it but rarely, it appeared to be more abundant in the Sundays River, particularly at Station 1 on the estuary (cf. slide No. SUN 2 - 85%). The rich population in sample SUN 2 made it possible to expand the original diagnosis in terms of dimensions and striae density. The specimens measured here were 9,3 - 27,4 µm long, and 5,7 - 9,8 µm broad. Giffen described the valves as lanceolate; they are in fact better described as elliptical (approaching circular in the smallest examples) to linear-elliptical with broadly rounded poles. The raphe was typically straight with fairly widely spaced central pores deflected to one side, and the terminal pores were not obvious and were possibly some distance from the margin of the valve. The transapical striae are rather characteristic in their structure, and probably form the main distinction between this taxon and *N. mutica* Kützing (cf. Hustedt, 1961-66 : 583, Fig. 1592a-f; Bock, 1963 : 229, Figs 1-65). These consist of three to four transapically elongated to circular pores in each stria, usually with the largest punctum on the margin, becoming smaller towards the raphe. The striae might be slightly curved and are somewhat denser when counted along the raphe (18 - 20 in 10 µm) than when counted along the margin (14 - 18 in 10 µm). Giffen's count of 15 striae in 10 µm in his original diagnosis was therefore probably made along the margin. The isolated pore opposite one of the central striae on the side away from that to which the central pores are directed is prominent in some specimens but not in others. Characteristically around the margin there appears to be a hyaline band, probably a thickened marginal costa. This band passes into the mantle which has a single row of puncta.

Euryhaline mesohalobe - 5.

Figs: 280-285

Samples: SUN: 1, 2, 4-6, 8, 70, 82, 83, 85, 86.
FIS: 28.

Navicula halophila (Grunow) Cleve

Cleve, 1894 : 109.
Kolbe, 1927 : 65.
Hustedt, 1930 : 268, Fig. 436.
Hustedt, 1961-66 : 64, Figs 1209, 1210.
Schoeman and Archibald, 1976-80 : No. 2.

Synonyms: *Navicula cuspidata* var. *halophila* Grunow in Van Heurck, 1885 : 100, Pl. B, Fig. 30.
Navicula halophila f. *robusta* Hustedt, 1959 : 401, Figs 1-3.

Description: Valves rhombic to linear-lanceolate, with acute, sometimes slightly protracted apices; length 20,0 - 140,0 µm, breadth 5,0 - 18,0 µm . Raphe straight, filiform to relatively broad; central pores not conspicuously widened, terminal fissures small and curving towards the same margin of the valve. Axial area narrow, linear and distinct, scarcely widened at the central nodule. Transapical striae more or less parallel, sometimes slightly radial at the centre, and slightly to strongly convergent at the poles; 15 - 20 in 10 µm at the centre, and 17 - 22 in 10 µm at the poles. Longitudinal lines fine, but usually easily seen in oblique light, 28 - 40 in 10 µm .

Taxonomic notes: Hustedt (1959 : 401, Figs 1-3) described a forma *robusta* distinguishing it from the nominate form on the basis of its more robust structure, and more strongly convergent polar striae. It is assumed that the more robust structure of the form is due to the coarser longitudinal lines, 28 - 30 in 10 µm, in contrast to "gegen 40 in 10 µm" of the nominate form (cf. Hustedt, 1961-66 : 65). However in an earlier description Hustedt (1930 : 268) stated that there are about 30 longitudinal lines in 10 µm for the nominate form. Schoeman and Archibald (1976-80 : No. 2) observed 28 - 40 longitudinal lines in 10 µm for specimens in one sample (SWA 232 - NIWR). Considering this feature therefore, there appears to be no distinction between the two forms. The degree of convergency of the polar striae cannot be considered a suitable diagnostic character, and consequently the f. *robusta* is treated here as a synonym of *N. halophila*. Schoeman and Archibald (1976-80 : No. 2) also considered the f. *subcapitata* (Østrup) Kolbe (1927 : 67, Figs 5, 6) as a synonym of *N. halophila*.

Cholnoky (1960a : 63, Figs 196, 197) described a new variety, var. *areata*, from Natal. However examination of the type slide, TUG 291 (NIWR), showed that it could not be related to *N. halophila*. The var. *areata* appears to correspond more to what has been identified in this study as *N. elginensis* (Gregory) Ralfs.

Euryhaline mesohalobe - 5.

Samples: SUN: 9, 15, 34, 60, 64, 66,
FIS: 36.

Navicula hartii Cholnoky emend. Archibald

Cholnoky, 1963a : 242, Pl. 8, Fig. 17; Pl. 9, Figs 10, 11 e.p.

Description: Valves linear to linear-lanceolate with gradually attenuating poles and acutely rounded apices, which in some planes of viewing may be slightly scalpelliform; length 32,3 - 55,0 µm, breadth 4,2 - 5,3 µm . Raphe straight and filiform with small but distinct central pores placed fairly closely together, terminal fissures indistinct under the light microscope. Axial area very narrow linear; central area asymmetrical, on one side of the central nodule a rectangular fascia reaching the margin of the valve, on the other side a slightly broader region with a single prominent stria centrally placed. Transapical striae fine but distinct, parallel at the centre and convergent at the poles, 24 - 28 in 10 µm near the centre and often slightly denser at the poles, up to 28 in 10 µm; the single stria on one side of the valve sometimes appearing to end in an isolated stigma.

Taxonomic notes: The forms retained as *N. hartii* Cholnoky are the larger and more coarsely striate specimens remaining after removing the representatives of *N. bulnheimii* Grunow from Cholnoky's original circumscription of the taxon *N. hartii* (see above and Cholnoky, 1963a : 242, Pl. 8, Fig. 17; Pl. 9, Figs 10, 11). *N. hartii*, as amended in this study, has striae structure round the central nodule very similar to that of *N. bulnheimii*, but it is much more pronounced and better defined than in the latter species. Under the light microscope (LM) a number of other features distinguishing *N. hartii* from *N. bulnheimii* can be defined. Firstly valve shape in *N. hartii* is more distinctly lanceolate with gradually tapering acutely rounded apices, in contrast to the more linear-lanceolate valves with protracted rostrate apices of *N. bulnheimii*. The relative size of *N. hartii* is distinctly greater than that of *N. bulnheimii*, although in the Sundays River the maximum length of the latter attained the minimum length of *N. hartii*. Nevertheless in these cases there was a significant difference in the widths of the valves. The next point of difference between the two taxa is the relatively coarser and distinct striation of *N. hartii*. Finally the girdle bands of *N. hartii* are robust and more numerous than those of *N. bulnheimii*. Further differences between *N. hartii* and *N. bulnheimii* can be observed when their internal raphe structure is examined under SEM. In *N. hartii* (Figs 538a-c) the raphe is carried internally on a raised axial rib, which appears to be supported by extensions of the costae curving upwards at the axial rib. Between these extensions of the costae there are areolae which are transversally elongate and much larger than the normal puncta of the striae. A similar structure is not found in *N. bulnheimii* (Figs 535, 536) although the raphe runs in an internally raised axial rib. In both taxa the proximal endings of the raphe fissures terminate in small central pores lying to one side of the central nodule (a slight expansion of the axial rib). The distal endings of the raphe fissures end in weakly developed helictoglossae, some distance from the valve margin in *N. hartii*, but closer to the apical margin in *N. bulnheimii*.

Whether *N. hartii* should be retained as a valid species or not is a question rather more difficult to answer at this stage. In his analysis sheet for sample No. SWA 51 (NIWR) Cholnoky originally considered these forms to be *N. complanata* Grunow (cf. Hustedt, 1961-66 : 335, Fig. 1449), but later erroneously united them with *N. bulnheimii* under the name *N. hartii*. The forms now referred to as *N. hartii* (see above) certainly appeared in many respects to be identical with *N. complanata* as illustrated by Hustedt (l.c.). The major difference between *N. hartii* and *N. complanata* concern, at present, the striae counts of the two taxa, and the presence or absence of a "sehr deutlichen Gallertporus" (fide Hustedt l.c.). A literature survey revealed that *N. complanata* should have 15 - 19 striae in 10 μm in the middle of the valve and upt to 40 in 10 μm at the poles. In contrast *N. hartii* has 24 - 28 striae in 10 μm near the middle and about 28 in 10 μm at the poles. According to Hustedt *N. complanata* has a very distinct mucilage pore in the central area. Examination of Cholnoky's type slide (SWA 51 - NIWR) and numerous specimens on slide SUN 83 showed that only a few specimens of *N. hartii* appeared to have this feature. Even TEM failed to demonstrate such a distinct pore, if there was one at all. Nevertheless despite these allegedly clear distinctions an examination of Grunow's type material of *N. complanata* is essential to solve the problem conclusively.

Hustedt (1955 : 31, Pl. 9, Fig. 21) discussed some Indo-Malayan forms of *N. complanata* in relation to some specimens found at Beaufort in North Carolina in the United States of America. These approached more closely the structure of *N. hartii*, but even so appeared to have some distinct differences. Hustedt (l.c.) himself stressed that the taxonomy of this group is still very uncertain.

Kolbe and Krieger (1942 : 345, Figs 10, 11) recorded some specimens from Mesopotamia under the name *N. bulnheimii*, acknowledging at the same time that they did not correspond sufficiently with the diagnosis of Grunow, since they were larger than Grunow's dimensions. They also remarked that these specimens had the separation of the central striae characteristic of *N. bulnheimii*. The dimensions of Kolbe and Krieger's specimens from Mesopotamia in Iraq, the shape of the valve in their illustrations, and their remarks concerning the central striae leave little doubt that their specimens are identical with what is referred to in this study as *N. hartii*. It is also interesting that Kolbe and Krieger do not mention or illustrate a very distinct mucilage pore associated with the central stria on one side of the central nodule.

Euryhaline mesohalobe - 5.

Figs: 286, 287, 538

Samples: SUN: 83.

Navicula hastaeformis Cholnoky

Cholnoky, 1960a : 64, Fig. 201.

Taxonomic notes: Specimens observed in the Sundays River near the head of the estuary were identical with examples on slide No. TUG 366 (NIWR), which is either the syntype slide or a paratype. Examination of this slide showed some differences between Cholnoky's original diagnosis and the specimens seen on this slide. Examples of *N. hastaeformis* observed personally were 46,6 - 77,9 µm long and 9,9 - 12,7 µm wide, while Cholnoky's description gave 75,0 - 90,0 µm long, 13,0 - 15,0 µm wide. Since Cholnoky's analysis sheet for this slide, the only material in which the species was observed, gives the dimensions (77,0 µm long and 13,5 µm wide) for just one specimen, it is not known where his maximum length of 90,0 µm and width of 15,0 µm were obtained. Since an examination of nearly every specimen on slide No. TUG 366 produced a maximum length of only 77,9 µm and greatest width of 12,7 µm, Cholnoky's upper limits appear suspect. Dimensions of the Sundays River specimens fit very well with those obtained from examples on slide No. TUG 366, being 49,0 - 68,7 µm long and 11,5 - 12,7 µm wide. Giffen (1963 : 239, Fig. 71) also recorded forms fitting this range of variation from the Ngwenyana River. The other major discrepancy between Cholnoky's diagnosis and the specimens on slide No. TUG 366 is that the proximal endings of the raphe are not nearly as markedly curved as shown in his Fig. 201. In fact in many cases the raphe looked almost straight. Both in the Sundays River specimens and in those of the Ngwenyana River (Giffen, l.c.) it appeared that this feature was also less pronounced. Apart from these differences the rest of the diagnosis was accurate. The examples observed in the Sundays River also enlarge the range of variation in the striae density. Striae counts of 8 - 9 in 10 µm over most of the valve surface agreed with the description, but around the central nodule from 4 - 7 in 10 µm were observed. Both in these specimens and in those from TUG 366 the striae were crossed by 28 - 30 longitudinal costae in 10 µm . Finally some of the smaller examples observed in this study were rather more linear-elliptical than rhombic lanceolate. In many valves the poles were cuneate with a more or less subapiculate apex.

The validity of this taxon is perhaps questionable, and a comparison between it and species such as *N. digito-radiata* (Gregory) Ralfs and *N. cancellata* Donkin should be undertaken.

Euryhaline mesohalobe - 5.

Figs: 288-290

Samples: SUN: 5.

Navicula infaceta Cholnoky

Cholnoky, 1959 : 41, Figs 217, 218.

Description: Valves linear-lanceolate to lanceolate with broad evenly rounded apices, or poles slightly protracted into subrostrate apices; length 21,5 - 25,0 µm, breadth 4,0 - 4,9 µm . Raphe filiform and more or less straight; central pores small, fairly close together and somewhat deflected to one side of the valve; terminal fissures curving to one side of the valve. Axial area asymmetrical, one side narrow due to a row of pores lying very close to the raphe, on the other side a broader somewhat lanceolate area; central area unilateral on the side containing the row of pores close to the raphe, small due to the loss of one punctum at the central nodule. Transapical striae consisting of two or three coarse round puncta each, weakly radial in the middle becoming slightly convergent at the poles, 13 - 14 in 10 µm; on the side having the wide lanceolate axial area the striae consist of only two puncta each, on the other side the striae have three puncta each, but the pores lying adjacent to the raphe are separated from the other two in each striae by a broader longitudinal costa.

Taxonomic notes: Although there are some differences between the specimens described above and Cholnoky's (l.c.) diagnosis of *N. infaceta*, the structure of these valves leaves no doubt that they belong to this taxon. Cholnoky's early Cape Province material is unfortunately not available for direct comparison and confirmation of the identification, and the species has not been recorded since its description. By examination of his illustrations Cholnoky's specimens appeared to have more broadly rounded poles with no evidence of any protraction, the dimensions of his valves were the same except that he found some smaller examples, reaching 18,0 µm long. Judging from his description the structure of the raphe and the shape of the axial and central areas of Cholnoky's examples appear to be identical to those observed in the Sundays River. The structure of the striae, however, show some discrepancy. In Cholnoky's original illustrations the striae are composed of 3 - 4 puncta each, not 2 - 3 as in the Sundays River examples. He did not furthermore mention the relatively characteristic arrangement of the pores. On one side of the raphe, the inner most row lies very close to the raphe and is separated from the other longitudinal rows of pores by a thicker longitudinal costa. The unilateral central area is formed by the absence of the innermost pore of the central stria on the side of the valve having three rows of pores. The discrepancy in number of pores per stria may be a matter of interpretation of the light microscope image, particularly along the margin of the valve, where it is usually difficult to resolve individual pores.

Despite these differences the Sundays River examples were placed in this taxon with reasonable confidence. This then constitutes the second record of this species, and, if the type material of *N. infaceta* cannot be traced, these specimens may have to act as lectotypes.

Euryhaline mesohalobe - 5.

Figs: 291-294.

Samples: SUN: 11, 39, 76.

Navicula iranensis Hustedt

Hustedt, 1961-66 : 262, Fig. 1390A.

Taxonomic notes: Specimens fitting so closely the description of this species that there is little doubt about their identity were observed at two brackish water stations on the Sundays River. As far as is known this species has only once been recorded outside its type locality, a brackish spring "Tscheschmeh kormouh" in the Chorassau province of north east Iran. This record is, however, somewhat suspect. Schoeman (1973 : 132, Pl. 3, Fig. 100) reported it from near Lundean's Nek in the north eastern Cape Province. This is a fresh water site and therefore not compatible with the autocology of *N. iranensis* which is regarded as a euryhaline mesohalobe.

The Sundays River specimens appeared to have very lightly silicified walls with a fairly prominent axial rib. The valves are linear-elliptical to slightly lanceolate and measured 9,0 - 11,8 µm long and 2,9 - 3,5 µm broad. These data correspond very well with specimens observed on the type slide (Hustedt slide No. N14, 83 - Bremerhaven) where the specimens were 9,7 - 11,2 µm long and 3,1 - 4,0 µm broad.

A few specimens from Station 9 (Sample FIS 36) on the Great Fish River are placed here with some reservation. Their valve shape is rather more rhombic-lanceolate, and in this respect agrees more with *Navicula pseudoexilissima* Hustedt; *N. iranensis* is more elliptical. The only difference between these two taxa lies in their autecology, *N. pseudoexilissima* being a freshwater form and *N. iranensis* preferring brackish water. On the latter consideration these examples are referred to *N. iranensis*.

Euryhaline mesohalobe - 5.

Figs: 39, 40, 295-298

Samples: SUN: 10, 11, 53, 57, 69.
FIS: 19, 36.

Navicula laevissima Kützing

Kützing, 1844 : 96, Pl. 12, Fig. 14.
Hustedt, 1961-66 : 124, Fig. 1256 (as *N. wittrockii*).
Schoeman & Archibald, 1976-80 : No. 5.

Synonyms: *Stauroneis wittrockii* Lagerstedt, 1873 : 38, Pl. 2, Fig. 15.
Navicula wittrockii (Lagerstedt) Tempère and Peragallo, 1907-15 : 120.

Description: Valves linear with slightly convex margins and very broadly protracted smoothly rounded apices (sometimes weakly capitate); length

(12) 22,0 - 70,0 µm, breadth (6) 7,5 - 11,0 µm . Raphe sinuous, filiform but broad, over the central third band-like in appearance, central pores prominent, distal ends hooked with thin terminal fissures deflected to one side of the raphe emanating from them. Axial area a fairly broad linear band formed by the axial rib, which expands asymmetrically to one side at the central nodule; central area variable in shape from rectangular to rhombic depending on the arrangement and shortening of the central striae, occupying about half the valve width. Transapical striae strong, arcuate and radial throughout, 15 - 22 in 10 µm, somewhat irregularly shortened at the centre and more widely spaced, 8 - 16 in 10 µm, becoming slightly denser at the poles, 16 - 24 in 10 µm; at the poles the last few striae prior to the polar nodule may be interrupted by a short longitudinal furrow on either side of the axial area.

Taxonomic notes: Both the type material of Kützing's (l.c.) *Navicula laevissima* from St. Fiore (slide No. BM 18820 - Kützing material No. 911) and of Lagerstedt's (l.c.) *Stauroneis wittrockii* (slide No. Philad 92549 from Liefde Bay) have been examined and critically compared. Despite small differences there can be no doubt that these two taxa are conspecific. There is therefore full agreement with Patrick and Reimer (1966 : 497, Pl. 47, Fig. 13) who referred to *S. wittrockii* and *N. wittrockii* (Lagerstedt) Tempère and Peragallo (l.c.) as synonyms of *N. laevissima*.

The combination, *Navicula laevissima*, has not always been correctly exercised. W. Smith (1856 : 91) applied the name to *Stauroneis rectangularis* Gregory (1854 : 99, Pl. 4, Fig. 17), which he considered identical to *N. laevissima*. This usage was followed by a number of diatomists until Grunow (in Cleve and Grunow, 1880 : 45) stated with certainty that *S. rectangularis* was part of the variation of *Navicula pupula* Kützing. A number of slides from the British Museum (Natural History) containing *S. rectangularis* (BM 23638, BM 22320) and *N. laevissima* sensu W. Smith (BM 20507) were examined. The valves observed on these slides were in many respects very similar to *N. laevissima* sensu Kützing, but most of the characteristics of the valves placed them quite clearly with *N. pupula*. These are enumerated below:-

(1) Although striae can be detected right up to the apex of the valve (TEM micrographs show this to be the case even in *N. pupula* itself), the laterally expanded polar nodules of these specimens are quite characteristic of *N. pupula*, and are not found in *N. laevissima* proper.

(2) The shape and formation of the central area (i.e. more or less dumb-bell shaped) is typical of *N. pupula*, and is not the rectangular or rhombic shape of *N. laevissima*.

(3) The prominent axial rib with an asymmetrical expansion at the central nodule found in *N. laevissima* was not observed in any of the specimens on these three slides.

(4) Finally the transapical striae of these specimens were finer than those of *N. laevissima* (BM 18820), and were more the texture of those in *N. pupula*.

A broader discussion of the complex taxonomy of these taxa is given by Ross (1963 : 87-91), but essentially the same conclusions were reached.

In a tributary of the Sundays River, the Wit River (SUN 34 - NIWR), a number of typical examples were observed. These had the following dimensions:- Length 25,5 - 35,7 µm, breadth 7,6 - 8,3 µm, striae 16 - 20 in 10 µm, at the centre 12 - 16 in 10 µm, and at the poles 20 - 22 in 10 µm . In the past this taxon has been recorded in Southern Africa under the name *Navicula wittrockii*.

Meioeuryhaline oligohalobe - 1.

Fig.: 41

Samples: SUN: 34.

Navicula lineola Grunow

Grunow, 1884 : 104, Pl. 1, Figs 45, 46.
Cleve, 1894 : 107.
Hustedt, 1961-66 : 73, Fig. 1217a, b.

Taxonomic notes: The correct identity of the small *Navicula* specimen illustrated in Fig. 42 is still somewhat in doubt. In valve shape it resembles *N. lineola*, and because it does not have protracted poles cannot be placed in the variety, var. *perlepida*, of this species. The dimensions of the Sundays River specimen, length 10,9 µm long and 1,4 µm wide, were, however, rather too small for either the nominate variety or var. *perlepida*, although breadthwise it is closer to the latter. As this specimen cannot be placed at this point in any other species, it is for the moment referred to this taxon. As far as is known the species has only been recorded from arctic marine habitats, and there has been no previous record of it from South Africa.

No ecological characterisation made.

Fig.: 42

Samples: SUN: 41.

Navicula microrhombus (Cholnoky) Schoeman and Archibald

Schoeman and Archibald, 1976-80 : No. 3.

Synonyms: *Fragilaria microrhombus* Cholnoky, 1970c : 14, Figs 2-4.
Achnanthes cogitata Archibald, 1971 : 22, Figs 6, 7.
Achnanthes adamantiformis (Archibald) Archibald e.p. 1971 : Figs 4, 5.

Description: Valves broadly rhombic with relatively broadly to acutely rounded apices, sometimes slightly protracted; length 6,0 - 7,0 µm, breadth 4,4 - 5,0 µm . Raphe branches filiform, short but variable in length, 1,3 - 2,6 long from the apex of the valve to the central pore, sometimes indistinct so that they appear to be lacking; central pores widely to very widely separated; terminal fissures not resolved under the light microscope. Axial area narrow, linear to linear-lanceolate; central area absent. Transapical striae radial throughout, 22 - 30 in 10 µm, occasionally a shortened intercalated stria at the centre; striae in phase contrast or oblique illumination indistinctly punctate.

Taxonomic notes: When viewed under the light microscope the indistinct nature of the short raphe branches in many specimens of this taxon has led to it being placed in three different genera. Cholnoky (l.c.) apparently overlooked the raphe, although it is quite distinct in some specimens, and described the taxon as a *Fragilaria*. Later Archibald (1971 : 22, Figs 4-7) observed a raphe on some valves but not on others, and thus concluded that it belonged to the genus *Achnanthes*, describing it as *A. cogitata*. Unfortunately further confusion arose when Archibald (1971 : 21, Figs 4, 5) placed some apparently rapheless valves with another similar sized diatom, subsequently renamed *Achnanthes adamantiformis* (Archibald) Archibald. TEM examination first of *F. microrhombus*, and then of *A. cogitata* and *A. adamantiformis* showed conclusively that all three species belonged in fact to the genus *Navicula* since both valves contained raphes. Moreover it was demonstrated that *F. microrhombus* and *Achnanthes cogitata* were identical.

The latter two taxa were therefore combined and renamed *Navicula microrhombus* (Cholnoky) Schoeman and Archibald (l.c.). In addition the apparently rapheless valves of *A. adamantiformis* were in fact found to be specimens of *Navicula microrhombus*, while the raphe valves were reinstated in the genus *Navicula* as *N. adamantiformis* Archibald (1966a : 256, Fig. 5). A few specimens were observed at Station 6 on the Sundays River; these were 6,0 µm long 4,5 µm broad, and had 24 striae in 10 µm .

Oligohalobe, but tolerance range not known.

Sample: SUN: 73.

Navicula minima Grunow

Grunow in Van Heurck, 1880-83 : Pl. 14, Fig. 15.
Van Heurck, 1885 : 107.
Hustedt, 1930 : 272, Fig. 441.
Hustedt, 1961-66 : 249, Fig. 1374.

Taxonomic notes: Grunow's type slide for this species does not seem to be able to be traced in his slide collection at the Naturhistorisches Museum in Vienna. To identify the taxon therefore one can only rely on Grunow's illustrations in Van Heurck (1880-83 : Pl. 14, Fig. 15) and Hustedt's (l.c.) descriptions. *N. minima* is similar to a number of other small *Naviculae*, and it is sometimes difficult to distinguish between them. Granetti (1968 : 195) has shown that *N. minima* differed ultrastructurally from *N. seminulum* Grunow by having striae composed of a single row of pores, instead of a double row as in *N. seminulum*. There is also some doubt as to whether *N. minima* and *N. tantula* Hustedt (1934 : 383) should be united or not (Lange-Bertalot and Bonik, 1976 : 322). Having examined the type slide of *N. tantula* (slide No. N8, 44 - Bremerhaven) the possibility that the two taxa are conspecific is enhanced. The *N. tantula* specimens observed on this type slide were somewhat more elliptical than the exactly parallel side forms drawn by Hustedt (cf. A. Schmidt *et al.*, 1874-1959 : Pl. 399, Figs 54-57). Furthermore the striae at the centre were not always as regularly shortened as depicted by Hustedt; occasionally slightly longer central striae were seen. These two features suggested a stronger relationship to *N. minima* than at first thought.

The local specimens had the following dimensions:- Length 5,5 - 7,0 µm. breadth 2,5 - 3,5 µm, and transapical striae 28 - 32 in 10 µm .

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 16, 17, 21, 22, 32, 34, 49-52, 60, 62, 63.
FIS: 3, 8, 30, 35, 36, 38.

Navicula minuscula Grunow

Grunow in Van Heurck, 1880-83 : Pl. 14, Fig. 3.
Hustedt, 1961-66 : 254, Fig. 1381.

Taxonomic notes: The identification of this species in this study, and particularly from the estuarine station, Station 3, is somewhat doubtful. According to Hustedt (l.c.) the valves of *N. minuscula* are elliptic-lanceolate with short and bluntly protracted poles; the axial rib is constricted at the central nodule; and the striae are radial, wider apart at the centre and very fine at the poles. In certain respects these characteristics compare with *Navicula paucivisitata* Patrick (1959 : 99, Pl. 8, Fig. 10; cf. also Patrick and Reimer, 1966 : 484, Pl. 46, Fig. 6), which Hustedt (l.c.) considered conspecific with *N. minuscula*. However Patrick and Reimer (l.c.) point out that the structure of the axial rib does not become constricted at the central nodule and claimed that the striae at the centre were always more than 35 in 10 µm . Furthermore the striae in *N. paucivisitata* were parallel in contrast to the radial striae of *N. minuscula*. The taxon under discussion may also be closely connected to *Navicula twymaniana* Archibald (1966a : 264, Figs 41-43), which is very similar to *N. paucivisitata*. Many of the records of *N. minuscula* given for Southern Africa may indeed be better considered as *N. twymaniana*, but this is difficult to verify in many cases as the necessary slides are not available for examination. The specimen identified in this study as *N. minuscula* followed more the example illustrated by Cholnoky (1964 : 71, Fig. 79) from the Ruwenzori mountains. To resolve the problem of the relationship between *N. minuscula*, *N. paucivisitata* and *N. twymaniana* it will be necessary to examine their type slides. An attempt has been made to obtain type slides of *N. minuscula* from the Grunow collection in the Naturhistorisches Museum in Vienna. Unfortunately there does not seem to be any way of tracing any slides containing this species. The relationship between *N. paucivisitata* and *N. twymaniana* is further discussed below.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 3.

Navicula mollis (W. Smith) Cleve

Cleve, 1895 : 26.
Peragallo H. and M., 1897-1908 : 92, Pl. 12, Figs 11, 12.
Hendey, 1964 : 195 (as *N. ramosissima* var. *mollis*).

Synonyms: *Schizonema molle* W. Smith, 1856 : 77, Pl. 50, Fig. 365.
Navicula ramosissima var. *mollis* (W. Smith) Hendey, 1964 : 195.

Description: Valves elliptic-lanceolate to linear-elliptical with either broadly rounded obtuse apices, or, as in some of the larger specimens, somewhat protracted subrostrate poles; length 14,5 - 31,9 µm, breadth 4,5 - 8,2 µm . Raphe straight and filiform, with small central pores, and hooked terminal fissures curving to the same side of the valve. Axial area narrow, linear; central area variable in shape from a slight elliptical widening of the axial area around the central nodule to an irregularly shaped rectangular area about half the valve width broad, sometimes slightly asymmetrical. Transapical striae robust, but not clearly punctate, radial at the centre and convergent at the poles, 12 - 16 in 10 µm .

Taxonomic notes: The correct identity of the specimens described above is still in doubt. They have been placed in *Navicula mollis*, not only because there is a certain amount of agreement with some of the scriptions in the available literature, but also because identical specimens from the Swartkops River near Port Elizabeth were identified as such by Cholnoky (1960b : 252). This does not imply, however, that Cholnoky's identification was correct, but until the correct identidy can be established and to preserve some uniformity in identification, Cholnoky's taxonomy with regard to this species has been followed.

N. mollis does not appear to be a particularly well known species, and no really satisfactory description of the species can be found. Type specimens (slide BM 22905) of *Schizonema molle* examined by Schoeman (personal communication) appear to be lanceolate-rhombic to lanceolate in shape, 17,0 - 29,0 µm long, and 6,7 - 7,3 µm broad. The raphe was straight and filiform, central pores small. The axial area was narrow and linear, and there was a small central area. Striae were radial at the centre, becoming parallel to slightly convergent at the poles. Schoeman (l.c.) also examined Tempère and Peragallo's material No. 244 (BM 68590). This material differed in some respects from the type specimens by being more elliptic-lanceolate and having short, subrostrate apices. The structure of the latter seemed, however, to conform more easily with Sundays and Great Fish River examples.

Further research is required to answer this question more fully. The specimens observed in this study also had a structural similarity to *Navicula jaernefeltioides* Ricard (1975 : 215, Pl. 3, Fig. 33) but the latter are rather too broad (10 µm wide) to refer the examples found in this study to this taxon. Also to be taken into consideration in the identification of these specimens is *Navicula tripunctata* (O.F. Müller) Bory (cf. Patrick and Reimer, 1966 : 513, Pl. 49, Fig. 3). *N. tripunctata*, however, appears to be a longer and relatively narrower species with a more or less characteristic rectangular central area.

Pleioeuryhaline polyhalobe - 7.

Figs: 299-304.

Samples: SUN: 2-4, 6, 8-11, 15-21, 24, 28, 30, 37, 39, 40, 57, 64, 69, 84, 85.
FIS: 2, 5, 6, 15-19, 23-26, 30, 31, 34.

Navicula monoculata Hustedt

Hustedt, 1945 : 921, Pl. 14, Fig. 4.
Hustedt, 1961-66 : 183, Fig. 1317.

Synonyms: *Navicula pseudagrestis* Lund, 1946 : 76, Fig. 6X-AA.

Taxonomic notes: Cholnoky (1960a : 66, Fig. 209; 1963d : 35, Fig. 15) claimed that Hustedt's *N. monoculata* was conspecific with *Navicula insociabilis* Krasske (1932 : 114, Fig. 17), and that Hustedt's concept of *N. insociabilis* was really *Navicula fritschii* Lund (1946 : 77, Figs 7a-g). On the other hand Hustedt (1957 : 303; 1961-66 : 181, Fig. 1315a-h) repeatedly contended that *N. fritschii* was a later synonym of *N. insociabilis*. Hustedt maintained that differences in the illustrations of *N. fritschii* and *N. insociabilis* could be ascribed to the effect of different refractive indices of the mounting media used in the original preparations of Lund and Krasske (cf. Hustedt, 1937-38 : 252). Lund (1946 : 77), however, vigorously defended the validity of his species, arguing that the different mounting media could not have resulted in the discrepancies between the two taxa. This controversy has remained unsolved for a long time. However recently both Krasske's type slide of *N. insociabilis* (Krasske slide No. 1096 - Kassel) and Lund's type slide of *N. fritschii* (CL 58 : Garden, Cotswold culture = Material No. 42 - F.B.A) have been examined, and specimens compared. Schoeman and Archibald (1976-80 : No. 5) have shown that a ringed specimen on Krasske's slide provides indisputable evidence that *N. insociabilis* is identical to specimens of *N. fritschii* observed on Lund's slide. Hustedt was therefore quite correct in his standpoint that *N. fritschii* is a later synonym of *N. insociabilis*. Cholnoky's view that *N. monoculata* Hustedt is identical to *N. insociabilis* is therefore untenable. This was confirmed by examination of Hustedt's type slide of *N. monoculata* (slide No. N17, 50 - Bremerhaven) on which there is a single ringed specimen of this taxon. This example was typical of Hustedt's (1961-66 : 183, Fig. 1317) description. A few comments can, however, be made with regard to this specimen in relation to this description. Firstly the polar striae tended to become more parallel than shown in Hustedt's illustration; secondly the axial rib of this specimen was strongly developed, but not as prominent as in *N. insociabilis*; thirdly the puncta along the axial rib were more prominent than in the rest of the striae; and finally the longitudinal line crossing the striae is distinct but does not interrupt the striae. In view of these comments Cholnoky's records of this species, under the name *N. insociabilis*, from Southern Africa will have to be reviewed as some of his illustrations (Cholnoky l.c.) seem to be atypical of *N. monoculata*.

In their recent study of the species, *Navicula monoculata* Hustedt, Schoeman and Archibald (1976-80 : No. 5) found that Cholnoky's (1966b : 192, Figs 50, 51) taxon, *Navicula parvipendata*, described from South West Africa, is conspecific with *N. monoculata*. In fact the stronger development of the transapical striae on the inner side of the longitudinal costae, Cholnoky's most important diagnostic character for this species, is perhaps a more typical feature of *N. monoculata* than any other structural characteristic found in many other Southern African examples included with *N. monoculata*.

Schoeman (1969 : 49) equated *Navicula standeriella* Archibald (1966a : 262, Figs 43-45) with *N. monoculata*. Recent TEM investigations have, however, shown that the former might indeed be a separate taxon. *N. standeriella* has a structure very similar to *N. monoculata*, but near the central nodule the puncta near the axial area become more widely separated so that one row of pores follows the raphe, while another row of pores accompanies the longitudinal line. Whether this feature in combination with other minor differences is sufficient to justify the separation of these two taxa is yet to be confirmed.

The few specimens of *N. monoculata* observed in the Great Fish River corresponded very closely with Hustedt's description, but the valves tended to be more elliptical. These examples were 9,0 - 11,5 µm long, 3,0 - 4,0 µm broad, and had 24 - 38 striae in 10 µm .

Meioeuryhaline oligohalobe - 1.

Samples: FIS: 16, 17, 19, 26.

Navicula muralis Grunow

Grunow in Van Heurck, 1880-83 : Pl. 14, Figs 27, 28.
Hustedt, 1961-66 : 236, Fig. 1359.

Description: Valves elliptical, elliptic-lanceolate to lanceolate with either regularly rounded (mainly elliptical forms) to slightly protracted poles, having slightly flattened or sometimes rounded apices; 8,0 - 14,0 µm long, 4,0 - 5,0 µm broad. Raphe filiform, more or less straight to slightly arcuate, and enclosed in a relatively prominent axial rib; central pores small and may be turned slightly to one side of the valve; terminal fissures indistinct. Axial area narrow, linear, following the lines of the axial rib; central area absent. Transapical striae fine, 28 - 34 in 10 µm, radial (sometimes quite strongly so); a few intercalated shortened striae visible at the centre, while some of the longer central striae may be slightly sinuous; polar striae too fine to be visisble under the light microscope.

Taxonomic notes: Having examined a number of type slides of this species in Grunow's collection in Vienna, it is clear that the presently accepted concept of *N. muralis* is erroneous. This is mainly due to the description and illustration given by Hustedt (1930 : 288, Fig. 482; 1961-66 : 236, Fig. 1359), which depicted the taxon as elliptical with broadly rounded poles. This description of the valve outline is incomplete taking into account only the small forms. Specimens from walls at Bath and Haverford West sent to Grunow by Arnott (Grunow Slide Nos 2337, 2341, 2710a & b - Vienna) as well as from Skåne (Grunow slide No. 1923 - Vienna) displayed a greater range in variation with a predominance of lanceolate to elliptic-lanceolate forms having slightly protracted poles with somewhat flattened apices. In addition to the greater variation in valve shape, the type slides also show a rather different pattern of striation. The striae near the centre of the valve was often markedly radial, with the longer striae somewhat sinuous and sometimes enclosing a few shortened intercalated striae. The full description of *N. muralis*, given above, is based on the observations made from Grunow's slides enumerated in the preceding lines.

This concept of *N. muralis* is rather different from that conveyed by Hustedt (l.c.) and resembles very strongly *Navicula cloacina* Lange-Bertalot and Bonik (1976 : 313, Figs 1d, 14, 15), which Lange-Bertalot (personal communication) now considers to be identical with *N. muralis* as seen on Grunow's slides quoted above. This has, however, not yet been satisfactorily confirmed, and type specimens of *N. cloacina* have not been personally examined.

Bearing these recent investigations in mind, the specimens observed in this study and identified as *N. muralis* are not members of this taxon as described above. They resemble more the type specimens of *N. permitis* Hustedt (1945 : 919, Pl. 41, Figs 8, 9). Here also Hustedt's original diagnosis and his later description of *N. permitis* (cf. Hustedt, 1961-66 : 174, Fig. 1306) are somewhat misleading, showing valves with no visible structure. Recently Hustedt's syntype slide from the Plitvicer See (N6, 33 - Bremerhaven) was examined and striae were quite easily observed on the only specimens ringed on this slide (Fig. 315). The striae of these two specimens, about 30 in 10 μm at the centre, are radial except for a few polar striae, which may be slightly parallel. On either side of the central nodule of these specimens there is a single shortened stria enclosed by the adjacent striae so that there is no central area. In a personal communication Lange-Bertalot, having examined Grunow's slides, expressed the belief that the form illustrated by Grunow as *N. muralis* f. *minuta* (cf. Van Heurck, 1880-83 : Pl. 14, Fig. 25) may well be *N. permitis*. There is still a good deal of uncertainty concerning the correct identity of these two taxa, and further research is necessary before a final answer can be obtained.

On account of this uncertainty specimens from the Sundays and Great Fish rivers have nevertheless been retained as *N. muralis* until clarification of this problem has been obtained. In the light of the observations discussed above the many records of *N. muralis* from Southern Africa will have to be reviewed as it is possible that most of these will be misidentifications.

Meioeuryhaline oligohalobe - 1.

Figs: 305, 306.

Samples: SUN: 17-26, 31, 32, 43, 45, 60.
FIS: 1, 2, 7, 16, 20, 23-26, 35.

Navicula mutica Kützing

Kützing, 1844 : 93, Pl. 3, Fig. 32.
Hustedt, 1930 : 274, Fig. 453a.
Hustedt, 1961-66 : 583, Fig. 1592a-f.

Taxonomic notes: The systematics and taxonomy of *N. mutica* is extremely complicated with many varieties and forms being described. How many of these subspecific taxa are indeed valid is difficult to say as the species is extremely variable. Bock (1963 : 229, Pl. 28, Figs 1-74 : Pl. 29, Figs 83-111, 121-124) and Hustedt (1961-66 : 583, Figs 1592, 1593) illustrated the many forms and varieties, as well as other closely related species. In a very recent study of *N. mutica* and some of its allies under the electron microscope Lange-Bertalot and Bonik (1978 : 31-37) found that *N. mutica* differed structurally from some of the forms and varieties previously associated with it. On the other hand some closely affiliated taxa should be united with it as they were conspecific. The major differences between *N. mutica* and the other forms examined by Lange-Bertalot *et al.* (l.c.) is that the proximal raphe endings curve towards the stigma in *N. mutica*, but away from the isolated stigma in other forms. Consequently they separated *N. mutica* f. *cohnii* and f. *goeppertiana* from the nominate variety and elevated them to species rank as *N. cohnii* (Hilse) Lange-Bertalot and Bonik, and *N. goeppertiana* (Bleisch) Lange-Bertalot and Bonik. In the same study Lange-Bertalot *et al.* found that *N. imbricata* Bock (1963 : 228, Pl. 30, Figs 150-160) was identical to *N. mutica*, and therefore the former falls away as a synonym of the latter. In the light of these observations it is uncertain whether all specimens identified as *N. mutica* in the present study are indeed *N. mutica* or a closely related taxon. However to re-examine every specimen would unfortunately be costly in time. All specimens have therefore been retained as *N. mutica*, except where specific forms have been designated (e.g. see *N. cohnii*).

Pleioeuryhaline oligohalobe - 3.

Samples: SUN: 9, 22, 23, 26, 34, 46, 48, 51, 53, 60, 80.
FIS: 6, 7, 10-12, 15, 18, 19, 21, 25, 27, 80, 35.

Navicula muticoides Hustedt

Hustedt, 1949a : 82, Pl. 4, Figs 33-36.
Hustedt, 1961-66 : 598, Fig. 1602.

Taxonomic notes: A single typical example of this taxon was recorded from the Great Fish River at Station 10. Its dimensions were:- length 11,5 µm, breadth 6,2 µm, and it had 25 striae in 10 µm . Despite a slightly lower striae count all other features coincide with the original diagnosis.

Meioeuryhaline oligohalobe - 1.

Samples: FIS: 10.

Navicula normaloides Cholnoky

Cholnoky, 1968a : 55, Figs 76-86.

Taxonomic notes: A number of specimens from the estuarine stations of the Sundays and Great Fish rivers have been placed in this taxon on account of their close structural similarity to Cholnoky's species. Cholnoky's type slide (No. SL 58 - NIWR) for this species was examined and the following similarities were noted. The raphe in both taxa was filiform and generally straight, with tiny fairly closely placed central pores, and long curved prominent terminal fissures slightly asymmetrically placed at the pole and ending in a terminal nodule running a short distance into the valve mantle. The dimension of length (30,9 - 51,9 µm), and the direction and density of the striae (11 - 12 in 10 µm) agreed with the diagnosis. The main difference, however, between the specimens observed in this study and Cholnoky's diagnosis lay in the breadth of the valves, 5,2 - 6,9 µm in the Sundays and Great Fish rivers compared with (5)7,0 - 9,0 µm in the original diagnosis. In other words the valves observed in this study were relatively narrower. These specimens were also similar to *N. tripunctata* (O.F. Müller) Bory (cf. Grunow in Van Heurck, 1880-83 : Pl. 7, Figs 7-10 under *N. gracilis*) but showed differences in valve shape, raphe endings and in construction of the central area. Furthermore the Sundays and Great Fish River specimens were found in significant numbers at stations with very high salinities, which would not be ecologically compatible for *N. tripunctata*. For this reason they are better placed with *N. normaloides*, which is found in the highly brackish water lake system of St. Lucia in Natal.

Apart from these forms a few isolated specimens were observed at Station 5 on the Sundays River. Some of these were closer to the typical specimens in terms of the breadth of the valve. These specimens had breadths ranging from 6,5 - 8,5 µm .

Euryhaline mesohalobe - 5.

Figs: 307-309.

Samples: SUN: 1, 3, 11, 12, 37, 53, 82-85.
FIS: 15, 28.

Navicula paeninsulae Cholnoky

Cholnoky, 1963c : 63, Fig. 67.

Synonyms: *Navicula stompsii* Cholnoky, 1963c : 66, Figs 77, 78.

Taxonomic notes: Having examined the type slides for both *Navicula paeninsulae* Cholnoky (slide No. K263 - NIWR) and *Navicula stompsii* Cholnoky (slide No. K176 - NIWR) and compared them closely, it was clear that there are no grounds for a distinction between these two taxa. Cholnoky (1963c : 63) separated the two species on the shape of the valve, the central area and the course of the longitudinal lines. While Cholnoky's diagnosis of *N. paeninsulae* appears to be reasonably accurate, the same cannot be said about *N. stompsii* and particularly with reference to the characters distinguishing the two taxa. Valve form in all specimens of both taxa appeared to be identical, although the length - breadth ratio is not constant. Short specimens can be broader than some of the longest examples. Both taxa have linear-lanceolate or narrowly lanceolate valves. The central area of many specimens of *N. stompsii* was larger than indicated by the diagnosis, being roundish to lanceolate as described for *N. paeninsulae*. One or two examples did, however, have very small central areas as depicted in the original illustrations of *N. stompsii* (cf. Cholnoky, 1963c : 66, Figs 77, 78). Finally in both taxa the longitudinal costae are not entirely parallel to the raphe, but curve very markedly round the central nodule. As a result of these observations *N. stompsii* has been withdrawn as a valid taxon, and is placed as a synonym of *N. paeninsulae*.

A number of examples have been observed in two samples collected at Station 1 on the Sundays River, and these were identical to *N. paeninsulae* as seen on the type slides. To show the similarity of all these specimens the table below sets out the dimensions recorded from the different populations.

			Striae in 10 μm			
Slide No.	Length (μm)	Breadth (μm)	Centre	Off centre	Poles	Long. lines
K 263	53,9-74,0	9,2-11,5	8-9	10	10-11	20
K 176	50,5-80,4	8,3-12,3	8-10	10	11-12	20-24
SUN 59	55,4-75,0	9,3-9,8	8	10	10	20
SUN 85	46,5-81,8	9,6-10,8	8-9	10	10-12	20-22
Giffen 1966a : p. 271	52,0-72,0	10,0-10,5	7-8 (6-7)			17-22

Giffen (1966a : 271, Fig. 72) recorded some specimens of *N. paeninsulae* having coarser striation, i.e. 6-7 striae in 10 μm . In the same publication (Giffen l.c. : 273, Fig. 81) he recorded and illustrated a specimen designated as *N. stompsii*. However the illustration, and the density of both transverse and longitudinal striae noted by Giffen, suggested very strongly that this specimen is *N. pavillardi* Hustedt (1939 : 635, Figs 86-90). Indeed *N. paeninsulae* is undoubtedly closely related to *N. pavillardi*, and is distinguished from it by its relatively broader valves and coarser structure. Cholnoky (1963c : 66) recognised this relationship for *N. stompsii* but not for *N. paeninsulae*.

Euryhaline mesohalobe - 5.

Figs: 310-312.

Samples: SUN: 59, 85.

Navicula pavillardi Hustedt

Hustedt, 1939 : 635, Figs 86-90.
Hendey, 1964 : 204.

Taxonomic notes: This species has only been previously recorded from South Africa from Lake St. Lucia (Cholnoky, 1968 : 56). In the Sundays and Great Fish rivers a number of specimens were observed. These were in most respects quite typical; in some specimens, however, the striae were slightly denser. These examples had the following dimensions:- length 32,0 - 47,0 μm, breadth 5,0 - 7,0 μm and had 14 - 16 striae in 10 μm .

They therefore represent the smaller examples in Hustedt's range. It is surprising that this species, which was fairly common in these samples, has not been recorded from other estuaries or brackish waters in South Africa. This may be due to misidentification of the taxon for some other species. As an example Giffen's (1966a : 273, Fig. 81) record of *Navicula stompsii* Cholnoky (1963c : 66, Figs 77, 78) is most probably *N. pavillardi*, as the dimensions and striae density of his specimen (his Fig. 81) agree more closely with *N. pavillardi* than with *N. stompsii (= N. paeninsulae)*, which is a more robust diatom entirely.

A further example is the species *Navicula severascens* Cholnoky (1960a : 79, Figs 243, 347), which, according to Cholnoky, apparently has two valve forms. The one valve type, represented by his Figure 243, is linear in outline with somewhat cuneate, smoothly rounded poles, has a distinct central area, and has parallel to convergent polar striae. The other type, illustrated in his Figure 347, while also linear, has longer cuneate poles, an extremely small one-sided central area, and has radial polar striae. While the first form may be retained as *N. severascens*, the second (e.g. Cholnoky's Fig. 347) is better placed with *Navicula pavillardi* Hustedt. This must, however, be confirmed by examining the relevant type materials.

Pleioeuryhaline polyhalobe - 7.

Fig.: 313.

Samples: SUN: 3, 4, 8, 9, 13, 28, 35, 36, 39, 41, 42, 78.
FIS: 14.

Navicula peregrina (Ehrenberg) Kützing

Kützing, 1844 : 97, Pl. 28, Fig. 52c.
Hustedt, 1930 : 300, Fig. 516.

Synonyms: *Pinnularia peregrina* Ehrenberg, 1841 (1843) : 421, Pl. 1/1, Figs 5, 6; Pl. 2/4, Fig. 1.

Taxonomic notes: There is some doubt concerning the correct identity of the occasional specimens from the Sundays River allotted to this species. Valve shape and striae count did not agree with Hustedt's (l.c.) description. The specimens observed here were lanceolate with a somewhat inflated central portion; in this respect it was similar to *N. peregrina* var. *peregrinoides* Cleve-Euler (1953 : 149, Fig. 803a). The striae counts were rather denser than stated for *N. peregrina* in Hustedt's (l.c.) description, viz. 8 - 10 in 10 μm . The valves were 63,1 - 71,1 μm long and 8,7 - 12,7 μm broad. Giffen (1966a : 271, Fig. 73) illustrated a specimen similar to those in the Sundays River, identified also as *N. peregrina*, but having coarser striae, i.e. 6 - 7 in 10 μm .

Euryhaline mesohalobe - 5.

Fig.: 314.

Samples: SUN: 26, 34.

Navicula permitis Hustedt

Hustedt, 1945 : 919, Pl. 41, Figs 8, 9.
Hustedt, 1961-66 : 174, Fig. 1306.

Description: Valves thin-walled, linear-elliptical to elliptical with broadly rounded poles; length 8,5 - 9,0 μm, breadth 2,9 - 3,1 μm . Raphe filiform and slightly arcuate, enclosed in a prominent axial rib. Axial area narrow linear, following the line of the axial rib; central area lacking. Transapical striae faint but visible under oblique light, radial except near the poles where they may become slightly parallel, 30 in 10 μm; the central stria on either side of the central nodule may be shortened and enclosed by the adjacent striae.

Taxonomic notes: Until recently *N. permitis* has been a very rarely recorded species known only from the Plitvicer Lakes region in the Balkan peninsular, and from the lower Weser River region (Hustedt 1957 : 278, Figs 10, 11). This may be the result of a slightly inadequate or incomplete description of the species by Hustedt (1945 : 919, Pl. 41, Figs 8, 9). In the Hustedt reference collection of diatom mounts at Bremerhaven there is only one slide designated as the type for *N. permitis* and it is made from material collected in the Plitvicersee (Slide No. N6, 33). This must be presumed to be the syntype slide. There is a single ring on this slide, and the two specimens enclosed by the ring are indicated as being *Navicula permitis*. These specimens (Fig. 315) agreed in some respects with Hustedt's diagnosis, but a number of features indicated clearly that the taxon is in need of a new and more complete description. First and foremost it was noticed that, despite Hustedt claiming that the striae had not been resolved, transapical striae were distinctly visible under oblique light, and faintly even in phase contrast. Secondly the axial rib was prominent and the raphe enclosed within it is arcuate. These features have been included in the revised description of the taxon given above; the description being based on the syntype specimens.

Examination of the syntype slide has produced an entirely new concept of the species, *N. permitis*. Consequently this necessitates a re-evaluation of a number of taxa previously identified under other names. As mentioned earlier specimens identified in this study as *N. muralis* would probably be more correctly placed under *N. permitis*. Most of these specimens have not, however, been re-examined and have thus been retained as *N. muralis* for the present. Examples on slides SUN 21 and 23 have been checked, and are now designated as *N. permitis*. These specimens differed slightly in their dimensions from those given above for the syntype representatives, being 7,4 - 8,3 µm long, and 3,2 - 3,4 µm broad. The Sundays River specimens are therefore slightly broader than the syntypes. These values agree, however, with those given for examples observed by Hustedt (1957 : 278, Figs 10, 11) in the Kleine Wumme River in the Unterweser area (length 7,0 - 9,0 µm, breadth 3,0 - 3,5 µm). According to Hustedt it was still not possible to resolve the striae in these specimens from the Kleine Wumme River.

Schoeman, Archibald and Barlow (1976) while examining the fine structure of *Navicula pelliculosa* have pointed out that the taxon used by many American diatomists in their physiological experiments (e.g. Reimann, Lewin and Volcani, 1966) are in fact misidentified as *N. pelliculosa*. Schoeman *et al.* (l.c.) considered these forms to be *Navicula muralis* Grunow. However after examination of Grunow's type slides of *N. muralis* (see above) it was obvious that even this identification was incorrect. In the meantime Lange-Bertalot and Bonik (1976 : 308) also commented on the studies of Reimann *et al.* (l.c.) and have suggested that the forms identified by the Americans as *N. pelliculosa* are in fact *N. permitis*. This opinion is shared here with a fair amount of confidence. Schoeman *et al.* (l.c.) examined specimens from the same culture material as that used by Reimann *et al.*, and obtained identical results as the latter authors in respect to the morphology and dimensions of the valves. The dimensions of specimens in this culture (Culture No. 668 - "N. pelliculosa" from Indiana University Culture Collection) were as follows:- Length 6,0 - 7,8 µm, breadth 2,7 - 3,4 µm, striae 30 - 35 in 10 µm . Similar specimens from South African localities, erroneously identified as *N. muralis* (cf. Schoeman *et al.*, 1976 : Figs 8, 9, 26, 27), had lengths of 6,9 - 8,5 µm, breadths of 2,7 - 3,9 μm, and striae counts of 30 - 37 in 10 μm . These measurements fit very closely with those given for *N. permitis* in the description above, and Hustedt's (1957 : 278, Figs 10, 11) measurements from the Kleine Wumme, and thus strongly support the arguments of Lange-Bertalot *et al.* (l.c.).

The conclusion may therefore be drawn that most records of *N. muralis* for Southern Africa are in fact *N. permitis*. This species is consequently far more widespread than originally thought.

Finally a comment on the observation of *N. permitis* by St. Clair and Rushforth (1976 : 56, Fig. 28) from the Timpanogos Cave National Monument in Utah is called for. Their description of this taxon makes it apparent that they are not dealing with the same species as considered above. Their specimens were generally larger and had parallel striation.

Meioeuryhaline oligohalobe - 1.

Figs: 315, 316.

Samples: SUN: 21, 23.

Navicula platycephala O. Müller

O. Müller, 1910 : 84, Pl. 1, Fig. 12.
Hustedt, 1949a : 89, Pl. 5, Figs 19, 21, 22.

Taxonomic notes: According to VanLandingham (1975 : 2733) *N. platycephala* O. Müller is a later homonym for *N. platycephala* (Ehrenberg) Cleve & Möller (= *Pinnularia platycephala* (Ehrenberg) Cleve). This taxon therefore requires a change in specific epithet. The combination *Navicula muelleri* is therefore proposed to honour the man who first described the species. A single typical example, distinguished from *N. pupula* Kützing (see below) by its characteristic abruptly convergent striae at the poles, was observed from the Sundays River near Graaff Reinet.

Compère (1975 : 238, Fig. 192) recorded some specimens with slightly larger maximum dimensions than given in the original diagnosis. His longest specimen was 70,0 μm long, and the broadest 18,0 μm wide. The Sundays River example was somewhat smaller, being 32,0 μm long, 7,5 μm wide and had 18 striae in 10 μm . The characteristic structure of the polar striae does not allow placing it in any other taxon.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 47.

Navicula pseudohalophila Cholnoky

Cholnoky, 1960a : 74, Figs 231-235.
Schoeman and Archibald, 1976-80 : No. 2.

Synonyms: *Navicula adsidua* Archibald, 1971 : 34, Figs 49-51.

Description: Valves broadly elliptical (generally small specimens), elliptic-lanceolate, lanceolate or linear-lanceolate, poles variable from broadly rounded in some specimens, through protracted rostrate apices of variable width, to protracted capitate apices in many of the larger examples; length 10,0 - 40,0 µm, breadth 5,0 - 8,0 µm . Raphe more or less straight and filiform; central pores small; terminal fissures small, sometimes visible and directed towards the same side of the valve. Axial area narrow, linear, generally widening slightly at the central nodule forming a small elliptical, oval or circular central area. Transapical striae fine but distinct, (18)19 - 24 in 10 µm, slightly radial at the centre with generally one or two shortened and usually intercalated striae, becoming convergent and sometimes strongly arcuate at the poles, 21 - 27 in 10 µm .

Taxonomic notes: A recent thorough examination of *Navicula pseudohalophila* and *Navicula adsidua* Archibald (l.c.) has shown conclusively that these two species are identical (Schoeman and Archibald l.c.). Cholnoky's slide No. SWA 230 (NIWR) contains examples with a much wider morphological range than on the lectotype slides of *N. pseudohalophila* (TUG 359 and TUG 381 - NIWR).

The Sundays and Great Fish River specimens were quite typical, and the following range in dimensions:- length 11,6 - 33,5 µm, breadth 5,0 - 7,5 µm, and had 20 - 24 striae in 10 µm .

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 8-10, 17, 19, 21-26, 33, 36, 45-48, 52, 54, 60, 64, 65, 75.
FIS: 4, 6, 10, 12, 14, 16, 17, 19, 20, 23-25, 29-33.

Navicula pupula Kützing

Kützing, 1844 : 93, Pl. 30, Fig. 40.
Hustedt, 1930 : 281, Fig. 467a.
Hustedt, 1961-66 : 121, Fig. 1254a-g.

Taxonomic notes: *N. pupula* is one of those diatom taxa with a very wide range of morphological variability having intermediate forms linking the many described forms and varieties. Consequently the forms and varieties listed by Hustedt (l.c.) have not been distinguished in this study. This has been thoroughly discussed by Schoeman and Archibald (1976-80 : No. 5).

Mesoeuryhaline oligohalobe - 2.

Figs: 43, 44.

Samples: SUN: 26, 28, 34, 43, 48, 60, 61.
FIS: 30, 31, 33.

Navicula pusilla W. Smith

W. Smith, 1853 : 52, Pl. 17, Fig. 145.
Hustedt, 1930 : 311, Fig. 558.
Hustedt, 1961-66 : 722, Fig. 1704.

Taxonomic notes: A few typical examples of this taxon were noted at Station 1 on the Sundays River.

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 2, 86.

Navicula pygmaea Kützing

Kützing, 1849 : 77.
Hustedt, 1930 : 312, Fig. 561.
Hustedt, 1961-66 : 538, Fig. 1574.

Taxonomic notes: This species has been recorded fairly frequently from Southern Africa, and typical examples were observed in a wide range of conditions in both the Sundays and Great Fish rivers.

Euryhaline mesohalobe - 5.

Fig.: 45.

Samples: SUN: 1, 4-6, 11, 15, 16, 22, 24, 28, 31, 34, 37, 42, 45, 48, 50, 57, 60, 61, 66, 76, 80, 82.
FIS: 5, 13, 14, 17, 19, 21, 32.

Navicula radiosa Kützing

Kützing, 1844 : 91, Pl. 4, Fig. 23.
Hustedt, 1930 : 299, Fig. 513.

Taxonomic notes: The few specimens observed in this study agreed in all respects with Hustedt's (l.c.) description; and there is no doubt that they belong to this taxon. For comments on *N. radiosa* var. *tenella* see *N. tenella* below.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 45, 46,
FIS: 14.

Navicula rhaphoneis (Ehrenberg) Grunow

Grunow, 1867 : 19, Pl. 1, Fig. 17.
Cleve, 1895 : 36, Pl. 1, Fig. 30.

Synonyms: *Pinnularia rhaphoneis* Ehrenberg, 1854 : Pl. 35/A9, Fig. 7??.
Navicula pacifica Grunow, 1867 : Pl. 1, Fig. 17.
Navicula perrhombus Hustedt, 1934 in A. Schmidt *et al.*, 1874-1959 : Pl. 394, Figs 28-31.

Taxonomic notes: Giffen (1971 : 7, Figs 33-35) recorded a number of specimens from a sample collected in Gordon's Bay under the name *Navicula rhaphoneis*. A few kilometers away at the mouth of the Steenbras River Cholnoky (1963c : 64, Figs 68, 69) observed specimens identical in structure, identifying them as *Navicula perrhombus*. Both Giffen's material (Giffen slide No. 594 - NIWR) and that of Cholnoky (slide No. K 263 - NIWR) have been personally examined and the specimens were found to be structurally identical, although Giffen's examples may be slightly broader in relation to their length than those of Cholnoky. Valves were lanceolate to broadly lanceolate with short protracted, subrostrate apices; the length and breadth range of Giffen's examples was 14,7 - 25,5 µm and 7,8 - 9,3 µm respectively, while Cholnoky's were 12,7 - 23,6 µm and 7,4 - 8,9 µm respectively. The raphe was curved and filiform with prominent central pores recurved in the opposite direction to the curvature of the raphe branches; terminal fissures, when visible, were hooked curving to the same side of the valve. Axial area narrow and somewhat lanceolate, widening at the central nodule into an irregularly demarcated but distinct central area. Transapical striae prominent and coarsely lineolate, radial except for the last one or two polar striae, which may tend to become parallel or slightly convergent, central striae slightly curved enclosing a single shortened stria on each side of the central nodule; striae in Giffen's specimens 9 - 11 in 10 µm, having 20 - 24 puncta in 10 µm, in Cholnoky's 8 - 10 in 10 µm and 22 - 24 in 10 µm respectively. There is no doubt that Giffen's and Cholnoky's specimens are identical, and it leaves open the question as to whether *N. rhaphoneis* and *N. perrhombus* are conspecific.

Grunow (1867 : 19, Pl. 1, Fig. 17) described *N. rhaphoneis* as rhombic-lanceolate, 22,9 - 38,0 µm long, 10,2 - 12,7 µm broad and having 7 - 8 striae in 10 µm . Hustedt (in A. Schmidt, 1874-1959 : Pl. 394, Figs 28-31) unfortunately gives no written description, but inspection of his illustrations in Schmidt's Atlas gives the following:- valves rhombic-lanceolate, apices slightly produced (subrostrate ?), 16,0 - 24,6 µm long, 7,6 - 8,8 µm broad, and 11 - 12 transapical striae in 10 µm . The most significant differences between these two sets of data are the broader and more coarsely striate valves of *N. rhaphoneis*. In both respects the material found in the vicinity of Gordon's Bay present the intermediates linking the two taxa. Consequently *N. perrhombus* is tentatively considered as a later synonym of *N. rhaphoneis*. This must, however, still be confirmed through study of the type material.

In the Sundays River estuary a number of specimens having identical structure to *N. rhaphoneis*, as described above, but differing in shape and size, were observed. These specimens (Fig. 317) were rather smaller, being 15,0 - 16,7 µm in length and 5,9 - 7,0 µm broad, and were more elliptical in shape with distinctly rostrate apices. However as far as the shape and structure of the raphe, the shape of axial and central areas, the structure, arrangement and density of the transapical striae are concerned, there is no distinction between the Sundays River specimens and those observed by Giffen and Cholnoky. On this basis they have been included as part of the range of variation of *N. rhaphoneis*, which has not previously been described, since the taxon appears to be extremely rare, and seldom observed.

Meioeuryhaline polyhalobe - 9.

Fig.: 317.

Samples: SUN: 59, 70, 83, 84, 86.

Navicula rhynchocephala Kützing

Kützing, 1844 : 152, Pl. 30, Fig. 35.
Hustedt, 1930 : 296, Fig. 501.

Taxonomic notes: Only a few examples of this taxon were observed from the upper Sundays River.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 26, 47.

Navicula rostellata Kützing

Kützing, 1844 : 95, Pl. 3, Fig. 65.
Hustedt, 1930 : 297, Fig. 508.

Taxonomic notes: The concept of *N. rostellata* as adopted in this study comes closer to the valve shape illustrating this species in Patrick and Reimer (1966 : 507, Pl. 48, Fig. 12 under *N. viridula* var. *rostellata*) than to Grunow's (in Van Heurck, 1880-83 : Pl. 7, Fig. 23) illustration, or Hustedt's (1930 : 297, Fig. 502) copy of Grunow's drawing. Specimens in the Sundays River were linear to linear-lanceolate and had characteristically shaped poles. These were abruptly narrowed and protracted into rostrate to subcapitate apices. Changes in curvature of the valve margin in these regions were therefore more angular than smooth and evenly rounded. Brockman (1950 : 17, Pl. 1, Fig. 4; Pl. 2, Fig. 48?, 49, 50, 56) illustrated some specimens, which he considered to be *N. rostellata*. In no way do these resemble *N. rostellata* as found in this study. Since there seems to be some controversy over whether Kützing's concept of *N. rostellata* is the same as that of the present time, type material (if available) must be studied and a new revised description drawn up.

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 15-20, 23-26, 30-32, 34, 47, 51, 62, 63, 72, 73.
FIS: 2, 10, 13, 14, 24, 26, 30, 33, 37, 39, 40.

Navicula salinicola Hustedt

Hustedt, 1939 : 638, Figs 61-69.
Hendey, 1964 : 204.

Taxonomic notes: The concept of *N. salinicola* is ill defined, and there is some doubt about the true identity of specimens observed in both the Sundays and Great Fish rivers attributed to this taxon. In his slide collection in Bremerhaven Hustedt did not designate a type slide for *N. salinicola*. Simonsen, however, selected a slide (No. 267, 22) from this collection to illustrate this species. This material was collected from the Leysand in Leybucht (cf. Hustedt l.c.). There were a number of rings on this slide, but none are specifically marked as *N. salinicola*. There was therefore no certainty that some of the forms enclosed in thse rings actually represented *N. salinicola*. These specimens, including others on the slide, did not entirely correspond with the diagnosis of *N. salinicola*.

The dimensions of many examples exceeded the range given in the description. Moreover the transapical striae were too radial compared with Hustedt's illustrations, and included, in many cases, one or two shortened intercalated striae at the central nodule. This latter feature is not depicted in any of Hustedt's (l.c.) drawings. In many respects these specimens had a strong resemblance to *Navicula tenelloides* Hustedt (1937-38 : 269, Pl. 19, Fig. 13). In this regard two points are interesting. Firstly Hustedt (1957 : 298) recorded *N. tenelloides* from the tidal zone in the Weser River near Bremen, where some variation in the salinity must occur, despite the fact that it is considered a freshwater form. Secondly, forms first identified by Cholnoky (1955a : 20, Figs 31, 32) as *N. pseudotenelloides*, indicating a likeness to *N. tenelloides*, were later changed by Cholnoky (1960a : 78) to *N. salinicola*. In the present study some forms identified as *N. tenelloides* were recorded from highly brackish water at Station 3 near the head of the Sundays River estuary. This seems uncharacteristic for *N. tenelloides*, and it is possible that these forms should be identified as *N. salinicola*. For further comments see *N. tenelloides* below.

Euryhaline mesohalobe - 5.

Figs: 318, 319.

Samples: SUN: 3, 5, 8, 9, 17, 35, 36, 41, 58, 74, 76, 83-86.
FIS: 11-13, 15, 19.

Navicula saprophila Lange-Bertalot and Bonik

Lange-Bertalot and Bonik, 1976 : 312, Figs 1c, 2, 8, 9, 29.

Description: Frustules extremely delicate and hyaline, usually only the raphe distinct. Valves elliptical with broadly rounded apices; length 4,5 - 7,4 µm, breadth 2,0 - 4,0 µm . Raphe filiform, slightly arcuate and enclosed in a prominent axial rib ending some distance from the valve apex. Transapical striae too fine to be visible under the light microscope.

Taxonomic notes: *Navicula saprophila* is one of the small hyaline *Navicula* species which are extremely difficult to separate under the light microscope. These species are usually distinguished mainly on the criteria of valve shape and size. Real differences can, however, only be determined using the transmission electron microscope (TEM). Since it is only recently that the electron microscope has gained prominence as tool in taxonomy, it is not surprising that these small hyaline *Naviculae* have caused endless problems and confusion. *N. saprophila* is very similar to *N. pelliculosa* and even under TEM can easily be confused with it. Lange-Bertalot and Bonik (l.c.) distinguished *N. saprophila* from *N. pelliculosa* both on ecological as well as morphological grounds. The main morphological features separating the two taxa are distinct differences in dimension, the breadth of the axial rib, and the angle subtended by the striae to the raphe. According to Hustedt (1961-66 : 172, Fig. 173) *N. pelliculosa* is 8,0 - 11,0 μm long and 4,0 - 5,0 broad, while *N. saprophila* is 4,5 - 7,0 μm long and 3,0 - 4,0 μm broad. Perhaps the most important difference lies in the transapical striae. In *N. saprophila* the striae are straighter and less radial (forming an angle of 75° to the raphe) than the sinuous and more distinctly radial striae (45° angle to the raphe) of *N. pelliculosa*. In addition to this the striae of both taxa pass into narrow slits in the marginal region, and have a number of intermediate slits not connected to the striae lying between them. There appears to be a greater number of these intermediate slits in *N. saprophila* than in *N. pelliculosa* (cf. Schoeman, Archibald and Barlow, 1976 : 257).

The strong resemblances between these two species, distinguishable only under TEM, undoubtedly accounts for the fact that *N. saprophila* has not been previously described. Hargraves and Guillard (1974 : 170, Figs 23-25) identified specimens as *N. pelliculosa*, but their dimensions and structure were identical to *N. saprophila*. These authors also illustrated a raised membrane-covered pore in the region of the central nodule. This structure was, however, not recorded by Lange-Bertalot *et al.* (l.c.). In their study of the structure of *N. pelliculosa*, Schoeman *et al.* examined under TEM some material from Kützing's collection in the British Museum (Natural History), and compared it with the Southern African material. The raised pore at the central nodule was present in both sets of samples, but some inconsistencies between the two materials (cf. Schoeman *et al.* : 257) were recognised. These were ascribed to differences in size of the valves in the two materials. Specimens of *N. pelliculosa* from the British Museum were 8,5 - 12,5 μm long, while the Southern African examples were 4,0 - 7,0 μm long. A re-assessment of the latter revealed that they were identical to *N. saprophila*.

As a result of the above observations the Southern African records of *N. pelliculosa* must be re-examined since many of these may in fact be *N. saprophila*. This taxon may also have been confused with a number of other species in South Africa. For instance Archibald (1971 : 43, Fig. 122) recorded some very small hyaline specimens (length 6,0 µm, breadth 2,0 µm) as *N. permitis*. These have subsequently been identified under TEM as *N. saprophila*. Similarly Schoeman (1972 : 77, Figs 13-17) recorded *N. saprophila* under the name *N. lamii* Manguin. These specimens had dimensions of 3,8 - 6,8 µm long and 1,9 - 2,8 µm broad.

Meioeuryhaline oligohalobe - 1.

Figs: 46, 539.

Samples: SUN: 21, 23.
FIS: 29.

Navicula schroeteri Meister

Meister, 1932 : 38, Fig. 100.
Hustedt, 1937-38 : 267, Pl. 18, Fig. 16.

Taxonomic notes: Specimens of this taxon occurring in the Sundays and Great Fish rivers correspond very closely with Hustedt's (1937-38 : 267, Pl. 18, Fig. 16) description of the species.

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 15-24, 34, 50, 62, 63.
FIS: 1, 2, 7, 8, 16, 17, 21-27, 30, 31, 36, 40.

Navicula scopulorum Brébisson ex Kützing

Brébisson in Kützing, 1849 : 81.
Hustedt, 1961-66 : 25, Fig. 1186a.
Hendey, 1964 : 193, Pl. 30, Fig. 6; Pl. 41, Fig. 1.

Taxonomic notes: The few specimens of this species seen in this study were quite typical, but some smaller examples were recorded. The minimum length measured was 84,0 µm . This appears to be intermediate between the nominate variety and the var. *belgica* (Van Heurck) De Toni (1891 : 135), thus lending support to Cholnoky's (1968a : 61) contention that the distinction of the various forms and varieties of this species is purposeless.

Meioeuryhaline polyhalobe - 9.

Samples: SUN: 1, 84, 85.
FIS: 28.

Navicula seminulum Grunow

Grunow, 1860 : 552, Pl. 2, Fig. 3.
Grunow in Van Heurck, 1880-83 : Pl. 14, Figs 8-10.
Hustedt, 1961-66 : 241, Fig. 1367.
Schoeman and Archibald, 1976-80 : No. 3.

Description: Valves elliptical (in smallest forms almost circular) to linear-elliptical; poles variable from relatively long, broadly protracted rostrate apices to broadly rounded ends; length 3,0 - 21,0 µm, breadth 2,0 - 6,0 µm . Raphe straight and filiform, terminal fissures indistinct. Axial area narrow and linear. Due to shortening of the central striae a rectangular to quadratic central area, in many cases almost reaching the margin, present; shortening of these striae variable from just visible at the margin to about half the normal striae length; spacing and number of shortened striae (1 - 4) at centre variable, either equal or uneven in number on either side of the central nodule. Transapical striae relatively robust, radial throughout, in some specimens apparently less so at the poles; 18 - 22(24) in 10 µm; indistinctly punctate in a few specimens.

Taxonomic notes: The original description of Grunow (1860 : 552) differs somewhat from later descriptions in respect of striae density. This diagnosis gave about 16 striae in 10 µm, and coarse striae counts such as this annotate his early drawings of this taxon. However in his later studies of this species counts of around 20 striae at the centre and up to 24 at the poles were noted alongside his herbarium sheet drawings. The latter are reflected in Grunow's drawings in Van Heurck (1880-83 : Pl. 14, Figs 8-10) where counts of 18 - 22 striae in 10 µm were measured. The syntype slide cannot unfortunately be traced in Grunow's collection in Vienna. Consequently his later striae counts are accepted as correct.

Specimens from the Sundays River seem quite typical, with the exception of one specimen which had 24 - 26 striae in 10 µm . Lund (1946 : 68), however, observed examples with 20 - 25 striae in 10 µm, and very small specimens having 28 - 30 in 10 µm . Whether the latter are really *N. seminulum* is a question requiring examination of Lunds material to verify them.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 8, 15, 33, 73.

Navicula sitiens Cholnoky

Cholnoky, 1966b : 195, Fig. 58.

Taxonomic notes: The type slide for this species (SWA 37 - NIWR) has been examined and a number of specimens were observed on this slide. Cholnoky's (l.c.) diagnosis is accurate, but his illustration of the taxon rather exagerates the constrictions of the valve walls near the poles. These are very subtle, and in some instances the valve outline was completely linear. The specimens observed provided a much wider range in dimensions - length 6,4 - 14,7 μm, breadth 2,5 - 2,7 μm, and transapical striae 28 - 30 in 10 μm . These type specimens were compared with examples from the Sundays River and were found to be identical, although in some cases the Sundays River specimens were more finely striate. Valve lengths of the Sundays River examples were 8,3 - 14,5 μm, breadths were 2,5 - 2,7 μm and the valves had 28 - 32 striae in 10 μm .

Both the South West African specimens and those from the Sundays River were remarkably similar to the raphe valve of *Achnanthes minutissima.* The possibility therefore exists that this taxon is really an *Achnanthes.* However very few complete frustules were observed, and in those that were it was difficult to determine whether both valves had a raphe system. No possible examples of rapheless valves were observed in either of the two samples. Furthermore the polar striae tended to become parallel, which does not correspond with *A. minutissima.* On the present evidence, therefore, the taxon must be retained in the genus *Navicula* until more abundant material can verify the genus.

Euryhaline mesohalobe - 5.

Figs: 320, 321.

Samples: SUN: 38, 39.

Navicula soehrensis Krasske var. *muscicola* (Boye Petersen) Krasske

Krasske, 1929 : 373.
Hustedt, 1930 : 289.
Hustedt, 1961-66 : 215, Fig. 1331f-h (as *forma*).

Synonyms: *Pinnularia muscicola* Boye Petersen, 1928 : 407, Fig. 27.

Taxonomic notes: The forms designated in this study as *N. soehrensis* var. *muscicola* were linear-elliptical with slightly protracted, broad, almost capitate poles. The raphe was slightly curved, and the terminal fissures were indistinct. The axial area was narrow and somewhat lanceolate around the central nodule; no central area was present. Transapical striae were slightly radial to parallel, while polar striae were sometimes parallel to convergent. The polar striae at one end of the valve could be radial, while parallel at the other. The length of these valves were 8,5 - 11,5 μm, the breadth 2,5 - 3,0 μm and they had 20 - 24 striae in 10 μm . These specimens agreed very well in valve shape with those illustrated by Hustedt (l.c.), and although the axial area is somewhat more lanceolate than these drawings there seems little doubt that they belong to this taxon. By examination of their illustrations similar forms have been identified variously as *Navicula hassiaca* Krasske by Schoeman (1969 : 48, Figs 45, 46; 1970b : 58, Figs 61-63) and Cholnoky (1957c : 352, Fig. 52), and as *Navicula margaritacea* Hustedt by Cholnoky (1957b : 69, Fig. 76; 1966b : 191, Fig. 48). The Great Fish River specimens (Figs 326-328) cannot, however, be linked with either of these two species because of the wide discrepancy in valve shape, the latter two species having a very distinct lanceolate central portion with relatively large and distinctly capitate poles. Photographs of *N. hassiaca* (Figs 322, 323) and of *N. margaritacea* (Figs 324, 325) from Hustedt's type slide collection in Bremerhaven (Slide Nos N3, 63 and N4, 82 respectively) have been reproduced to illustrate these differences. The striation of both *N. hassiaca* and *N. margaritacea* are also coarser, while those of the latter are distinctly very short marginal striae. Cholnoky's concept of *N. margaritacea* (see above) seems to be rather inaccurate, and it is therefore not surprising for him to make the following comment on the lack of records of this taxon from South Africa - "... und finde es sehr eigentümlich, dass sie durch andere Forscher bisher noch nicht beobachtet wurde" (Cholnoky, 1960a : 68). Apart from the references given above, Cholnoky (1956 : 77, Fig. 86; 1957c : 353, Figs 58-60; 1964 : 71, Figs 72-74) recorded and illustrated further forms under the name *N. margaritacea*. While these specimens may also be *N. soehrensis* var. *muscicola*, as visualised in this study, they may possibly be better identified as *N. hassiaca*, on account of their more distinctly capitate poles, and striae which are too long for *N. margaritacea*. It is clear from the above discussion that a revision of this group of *Naviculae* is necessary.

Meioeuryhaline oligohalobe - 1.

Figs: 326-328.

Samples: SUN: 18.
FIS: 3, 5, 6, 9, 11, 13, 19, 21, 26, 29-32, 36, 37, 39, 40.

Navicula soodensis Krasske

Krasske, 1927 : 272, Pl. 10, Figs 20-22.
Hustedt, 1930 : 276, Fig. 457.
Hustedt, 1961-66 : 277, Fig. 1408.

Synonyms: *Stauroneis legleri* Hustedt, 1931-59 : 793, Fig. 1138.

Taxonomic notes: Cholnoky (1962 : 46, Fig. 64; 1966b : 196, Figs 59, 60) has often maintained that *N. soodensis* Krasske and *Stauroneis legleri* Hustedt are conspecific. Although this view point is accepted in this study, this claim should be verified through comparison with type material. However so many features in both their descriptions coincide that it is difficult to distinguish between them. Hustedt (l.c.) was himself a little uncertain of the systematic position of *S. legleri*, and placed it in the genus *Stauroneis* because of its similarity to *Stauroneis gregorii* Ralfs and *St. wislouchii* Poretzsky and Anisimowa (cf. Hustedt l.c. : 790, Fig. 1135; 792, Fig. 1137 respectively). Cholnoky was similarly confused, on the one hand believing that the central nodule was somewhat thickened (cf. Cholnoky, 1962a : 46) and the taxon therefore a *Stauroneis*, while on the other hand maintaining at a later stage (cf. Cholnoky, 1966b : 196) that this taxon did not have a *Stauroneis* structure; he thus placed the taxon in the genus *Navicula* as *N. soodensis*. The same controversy applies to the two very similar, if not identical, taxa, *N. tackei* Hustedt (1961-66 : 277, Fig. 1407) and *St. palustris* Hustedt (1945 : 914, Pl. 42, Figs 30-32). This controversy is discussed by Schoeman and Archibald (1976-80 : No. 3) under their treatment of *N. tackei*.

Only a few isolated specimens were observed in the Great Fish River at Station 13. These forms were more like *S. legleri* in shape, being linear-lanceolate, but had slightly protracted, broadly rounded poles as described for *N. soodensis*. Other features were typical. The transapical striae near the central nodule were rather irregularly spaced, so that on one side of the valve there are 18 striae in 10 µm, and 21 in 10 µm on the other side. The range in dimensions were:- length 21,1 - 31,5 µm, breadth 4,9 - 6,4 µm, and striae 16 - 21 in 10 µm round the centre and 20 - 21 in 10 µm at the poles.

Euryhaline mesohalobe - 5.

Figs: 329-331.

Samples: FIS: 13.

Navicula subrotundata Hustedt

Hustedt, 1945 : 917, Figs 30-33.
Hustedt, 1961-66 : 272, Fig. 1402a-m.

Taxonomic notes: A single example of this taxon was observed at Station 9 at Graaff Reinet.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 48.

Navicula subvalida Cholnoky

Cholnoky, 1960a : 83, Figs 252, 253.
Giffen, 1963 : 242, Fig. 82.

Description: Valves elliptic-lanceolate with broad and short cuneate poles; Length 34,8 - 70,6 µm, breadth 10,3 - 12,7 µm . Raphe straight and filiform, with relatively large central pores curved slightly to one side of the valve; at the poles the distal raphe fissures curve towards and reach the margin on the same side of the valve. Axial area relatively narrow and linear; central area roundish to almost rhombic, often slightly asymmetrical, with one side more developed than the other. Transapical striae strong and slightly curved and distinctly lineolate, radial throughout or only the last one or two striae becoming parallel, 8 in 10 µm near the centre and about 9 in 10 µm near the poles, striae around the central nodule somewhat wider apart; longitudinal costae 26 - 28 in 10 µm .

Taxonomic notes: Having examined Cholnoky's type slides (slide Nos TUG 233, 234 and 235 - NIWR) it was evident that not only was the original diagnosis faulty in certain respects, but it was also based on two different entities. Broad and regularly rounded apices were never observed; the apices were always short, broad cuneate ends. This feature was first commented on by Giffen (1963 : 242, Fig. 82), who found typical specimens in the Yarra stream and Ngwenyana River near East London. Furthermore Cholnoky claimed that there were 18 - 20 longitudinal costae in 10 µm

Cholnoky (1960a : 83) was well aware that he was probably including another taxon in his circumscription of *N. subvalida*, as he makes special comment (cf. Cholnoky l.c. Figs 187, 254), of two forms, which had a different structure. Cholnoky's illustrations of these specimens were inaccurate as he shows logitudinal costae crossing the striae. The longitudinal costae were, however, not seen in any of the specimens examined, although from their dimensions and striae density there is no doubt that they were the examples drawn by Cholnoky. These examples had 6 alveolate striae in 10 µm, and the axial area was a broad almost lanceolate region. This examination showed clearly that these forms belong to *Navicula yarrensis* (cf. A. Schmidt *et al.*, 1874-1959 : Pl. 46, Figs 1-6). Cholnoky (l.c. : 87) recognised this possibility as the following is his comment on *N. yarrensis*:- "Ich halte es nicht für der Beschreibung der *N. subvalida* n. sp. besprochenen Schalen auch zu dieser Art gehören".

A new description has, therefore, been prepared for *N. subvalida* (see above) from the type specimens found on slide Nos. TUG 233 and 234, and on the typical examples found in the Sundays River. Giffen (1963 : 242, Fig. 82) had some doubts about his identification of this species, but his illustrated example is in fact quite typical.

Euryhaline mesohalobe - 5.

Figs: 332-336.

Samples: SUN: 4, 5, 82.

Navicula sydowii Cholnoky

Cholnoky, 1963a : 244, Pl. 8, Figs 20-23; Pl. 9, Figs 12, 13.

Synonyms: *Navicula incerta* Grunow in Van Heurck, 1880-83 : Pl. 14, Fig. 43 (*nec. N. incerta* Ehrenberg (1837)).

Description: Valves narrowly elliptical or linear-elliptical with unprotracted rounded poles; length 9,5 - 20,0 µm, breadth 3,0 - 5,0 µm . Raphe straight and filiform with small central pores and hooked terminal fissures (not always distinct) curving to the same side of the valve. Axial area very narrow and linear, widening slightly into a lanceolate area round the central nodules; sentral area absent. Transapical striae relatively robust, lineolate; parallel to slightly radial in the middle and most of the valve, and parallel to slightly convergent at the poles; 12 - 14 striae in 10 µm at the centre, and 16 - 17 in 10 µm at the poles; striae crossed by about 30 longitudinal costae in 10 µm .

Taxonomic notes: The line drawings illustrating Cholnoky's (1963a : Pl. 8, Figs 20-23) species are somewhat misleading, because they depict very clearly lineolate striae. In fact it was seldom that such distinctly lineolate specimens were found on the type slide SWA 50 (NIWR). In all other respects the diagnosis and illustrations were accurate. Very typical examples of *N. sydowii* were observed in the Sundays and Great Fish rivers, and the description given above is based on these specimens as well as on Cholnoky's original diagnosis. Through study of this taxon in these samples and those on the type slide, it seems clear that this species is identical to *Navicula incerta* Grunow (in Van Heurck, 1880-83 : Pl. 14, Fig. 43). The illustration by Grunow conforms to the description of *N. sydowii* as given above. It is, however, at variance with Van Heurck's (1885 : 107) description of *N. incerta*, where the width of the valve is given as 6,0 µm, whereas the illustration has a width of only 3,0 µm . According to VanLandingham (1975 : 2598) *N. incerta* Grunow is a later homonym of *N. (incerta)* Ehrenberg (1837 : 45), and Grunow's epithet is invalid. A new specific epithet must therefore be found. Although the type material of *N. incerta* has not been examined, its dimensions and valve shape appear to be identical to *N. sydowii* Cholnoky. Thus the taxon must tentatively adopt Cholnoky's combination, *N. sydowii*, as this is the only valid name for this taxon. *N. incerta* is therefore considered as a synonym of *N. sydowii*. To confirm this, however, a study of Grunow's type slides is absolutely necessary.

Cholnoky (1959 : 41, Fig. 216) has recorded *N. incerta* from near Coldstream in the Western Cape Province, but it is difficult to resolve whether the specimen Cholnoky illustrated represents the taxon being considered here. Cholnoky does make the point, however, that *N. incerta* is incompletely described and some revision is needed.

A taxon, *Navicula assula*, described by Cholnoky (1963c : 53, Fig. 35) from the Steenbras River mouth is also in need of reappraisal in relation to the species under discussion. Apart from differences in dimensions most other characters of *N. assula* appeared to correspond fairly well with *N. sydowii*. Cholnoky's slide K263 (NIWR) was examined briefly without any success in finding a specimen of *N. assula*. The slide, however, may not be the syntype. Therefore if the taxon is very rarely encountered a specimen may not be found on a syntype slide. A comparison therefore with *N. sydowii* may not be possible through the medium of type material.

Pleioeuryhaline polyhalobe - 7.

Figs: 337-341.

Samples: SUN: 6, 40, 56, 57, 69, 72, 76, 77, 80-85.
FIS: 3-5, 11, 16, 17, 19, 29, 30, 32, 35, 41.

Navicula tackei Hustedt

Hustedt, 1942c : 194, Figs 6, 7.
Hustedt, 1961-66 : 277, Fig. 1407.
Schoeman and Archibald, 1976-80 : No. 3.

Description: Valves linear-lanceolate to linear-elliptical with slightly protracted broadly rounded apices; length 16,0 - 25,0 µm, breadth 5,0 - 7,0 µm . Raphe branches straight and filiform with small but conspicuous central pores; terminal fissures usually indistinct, but when visible, small and directed to the same margin of the valve. Axial area narrow and linear; central area generally a narrow fascia more or less reaching the margin, sometimes a small rectangular or even unilateral area. Transapical striae fine, radial, becoming parallel at the poles, (22)24 - 26 in 10 µm near the centre and up to 32 in 10 µm at the poles; in the region of the fascia the transapical striae variable in length and spacing, generally wider than on the rest of the valve.

Taxonomic notes: This taxon bears a very strong resemblance to *Stauroneis palustris* Hustedt (1931-59 : 795, Fig. 1140), and it is indeed very difficult to distinguish between the two species on the basis of Hustedt's descriptions. The difference between a *Stauroneis* and a *Navicula* can be very nebulous. Nevertheless the most accepted distinguishing characteristic is the presence or absence of a stauros. A stauros is defined as a central nodule that is expanded transapically and almost or completely reaches the margin of the valve margin (Anonymous, 1975 : 328). However under the light microscope it is not always easy to determine whether a particular specimen has a true stauros or just a fascia, which is a central area forming a hyaline band extending across the valve (Anonymous l.c.). The distinction becomes even more complicated when some species of

Stauroneis have marginal striae in the stauros.

Hustedt's syntype slide of *N. tackei* (slide No. N.10, 84 - Bremerhaven) has been examined, as well as a slide (S.A. Ref. Slide No. 66 - NIWR) made by Schoeman and Archibald (l.c.) from type material (Hustedt material E.1012 collected near Bremen). Examples from these two slides confirmed the identification of this species from Southern Africa. A single more or less typical specimen was observed at Station 9 on the Sundays River at Graaff Reinet. This specimen was 21,0 µm long, 5,5 µm broad and had 26 striae in 10 µm . The fascia was well developed.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 24.

Navicula tantula Hustedt

Hustedt, 1934 in A. Schmidt *et al.*, 1874-1959 : Pl. 399, Figs 54-57.
Hustedt, 1943 : 162.
Hustedt, 1961-66 : 250, Fig. 1375.

Taxonomic notes: It has been suggested by a number of people that *N. tantula* has a very close relationship to *Navicula minima* Grunow (see above), and may even be part of the range of variation of the latter (cf. Lund, 1946 : 71; Granetti, 1968 : 204; Lange-Bertalot and Bonik, 1976 : 319). Hustedt (l.c.) described *N. tantula* as having linear valves with parallel walls, and depicted them with very short central striae of more or less even length. In the Congo Hustedt (1949a : 83) observed broader forms, as well as more linear-lanceolate valves, which he suggested belonged to *N. tantula*. Similarly Cholnoky (1966b : 197) also reported linear-elliptical valves connected by intermediates to the typical parallel-sided linear valves. Schoeman (1969 : 57, Figs 59-61), on the other hand, observed specimens, amongst typical ones, with central areas bordered by irregularly shortened striae. These variations from the originally described valves bring *N. tantula* very close to *N. minima*. Thus distinguishing between the two species becomes very difficult. Examination of Hustedt's type slide of *N. tantula* (slide No. N8, 44 - Bremerhaven) from Poggenpohls Moor (cf. A. Schmidt *et al.* l.c.) did not really clarify the position. Nevertheless all specimens on this slide were more linear-elliptical than shown by Hustedt. None of them appeared to have the strictly parallel walls as Hustedt described them. Neither did the nature of the central striae always agree with the evenly shortened, more or less marginal striae illustrated by Hustedt. Sometimes longer striae were observed at the centre, so that the central area had a more irregular outline (cf. Schoeman, l.c. above). Furthermore the central striae were sometimes very clear, but in other examples quite indistinct. As far as is known no electron microscopic examination of this species has yet been undertaken, and therefore no comparison can be made of its fine structure in relation to *N. minima*. A close study of *N. tantula* and its near relatives is required.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 15-17, 25-27, 30, 34, 43, 47.
FIS: 3, 7, 9.

Navicula temeraria Cholnoky

Cholnoky, 1965 : 73, Figs 28, 29.

Taxonomic notes: At Station 5 on the Great Fish River a single specimen having a linear-elliptical valve, a raphe enclosed within a strongly developed axial rib, and a hyaline ring crossing the striae near and parallel to the margin was observed. These characteristics fit closely the diagnosis of a rarely recorded species described by Cholnoky (l.c.), *Navicula temeraria*. This species has so far only been recorded from the type locality, Lake Chrissie (Cholnoky l.c.; Archibald, 1966a : 264, Fig. 11; Archibald, 1971 : 46, Fig. 158), and from its vicinity in the headwaters of the Vaal River (Archibald, 1971 : 46, Fig. 157). The specimen from the Great Fish River is perhaps more linear-elliptical than the type specimens, slightly longer but narrower, and were not quite as densely striate as the type specimens. This specimen was 16,3 µm long, 6,9 µm broad and had 28 - 30 striae in 10 µm at the centre.

Meioeuryhaline oligohalobe - 1.

Samples: FIS: 31.

Navicula tenella Brébisson

Brébisson ex Kützing, 1849 : 74.
Hustedt, 1930 : 299 (as *N. radiosa* var. *tenella*).
Patrick and Reimer, 1966 : 510, Pl. 48, Fig. 17 (as *N. radiosa* var. *tenella*).

Synonyms: *Navicula radiosa* var. *tenella* (Brébisson) Cleve and Möller,
1877-82 : No. 224.

Taxonomic notes: The view has been held in this study that *Navicula tenella* is a species in its own right, and is distinct from *N. radiosa* Kützing. It differs from *N. radiosa* in valve shape, density of striae, arrangement of the central striae and the shape of the central area. The concept of *N. tenella* is as follows: Valves lanceolate with acute apices; raphe typically naviculoid; axial area narrow and linear, central area variable; transapical striae radial in the centre and convergent at the poles; characteristically the central stria on either side of the central nodule are usually long, reaching the axial rib, while the adjacent striae on either side of the central one are distinctly shorter. Thus an alternately longer and shorter arrangement of the striae around the central nodule is obtained. The arrangement is well illustrated by Patrick and Reimer (l.c.). Cholnoky (1970c : 25) has suggested that *N. tenella* should be considered as unidentifiable because of the lack of a proper description and illustration. However the examination of the type material, probably amongst Kützing's collection, would be preferable, and from this source provide a new description and illustration.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 15-19, 26, 30, 31, 45, 46, 51, 60, 73.
FIS: 1, 7, 20, 22, 23, 25, 26, 31, 37, 39, 40.

Navicula telloides Hustedt

Hustedt, 1937-38 : 269, Pl. 19, Fig. 13.
Lund, 1946 : 85, Figs 8J-DD.
Schoeman and Archibald, 1976-80 : No. 1.

Description: Valves narrow, linear-lanceolate, poles often protracted, apices broadly rounded rostrate to relatively acute; length 14,0 - 21,5 μm, breadth 2,5 - 4,0 μm . Raphe straight and filiform; axial area very narrow and linear, widening to a small, usually rounded, though sometimes rectangular, central area, whose shape varies according to the number of shortened striae on each side of the central nodule. Transapical striae radial in the centre to convergent at the poles, 16 - 21 in 10 μm; in oblique light the striae can be seen to be lineolate.

Under TEM the striae resolve themselves as single rows of lineolate puncta. The longitudinal costae are generally parallel to the raphe, but curve outwards around the central nodule.

Taxonomic notes: Examples of this species found in the Sundays and Great Fish rivers were generally identical to the type specimens as found on Hustedt's type slide from Ranu Lamongan (slide No. N8, 46 - Bremerhaven) from Java, and to examples from Oldenburg in Germany (slide No. N1, 84 - Bremerhaven). Two examples from the region being studied had lengths (10,0 - 12,0 μm) below the range given above, but these are doubtfully placed here. The relationship of *N. tenelloides* to two other similar species needs careful reviewing. These taxa are *N. cincta* Ehrenberg f. *minuta* Van Heurck (1885 : 82), and *N. salinicola* Hustedt (1939 : 638). Specimens of the former were examined on Van Heurck's slide No. 83 both in the Grunow collection in Vienna, and in the collection of the British Museum (Natural History), i.e. slide No. BM 26394. These examples resembled very closely the valves of *N. tenelloides*, and had the following dimensions:- length 18,9 - 24,3 μm, breadth 4,0 - 4,9 μm, and had 15,5 - 16 striae in 10 μm . These diemsnions were slightly larger than those given for *N. tenelloides*, and the striae were slightly coarser. They may, however, form part of a series connecting the two species. In addition to this some examples of *N. salinicola* on the Hustedt slide No. 267, 22 (Bremerhaven) showed a strong resemblance to *N. tenelloides*. The dimensions of these specimens, apart from being somewhat narrower in some cases, could easily fall within the range of variation of *N. tenelloides*. *N. tenelloides* is usually regarded as being a freshwater species, but it was found in abundance at Station 3 on the Sundays River estuary. The latter comments might therefore account for its presence in these highly saline waters. For additional discussion of this see the taxonomic notes on *N. salinicola* below.

Pleioeuryhaline oligohalobe - 3.

Samples: SUN: 8, 18, 23, 24, 26, 32, 34, 60, 61, 83, 85.
FIS: 11, 14, 26, 27, 37, 40.

Navicula tenera Hustedt

Hustedt, 1936 in A. Schmidt *et al.*, 1874-1959 : Pl. 405, footnote.
Hustedt, 1937-38 : 259, Pl. 18, Figs 11, 12.
Schoeman and Archibald, 1976-80 : No. 5.

Synonyms: *Navicula uniseriata* Hustedt, 1934 in A. Schmidt *et al.* l.c. : Pl. 392, Figs 24-27.

Taxonomic notes: As the taxonomy of this group of *Naviculae* with their distinctive striae and raphe structure is rather confusing, an opportunity was taken to examine Hustedt's type slides (slide Nos N8, 49 and N, 8, 51 - Bremerhaven) of this species. The specimens on these two slides, together with one from the Celebes (slide No. 397, 39a - Bremerhaven) were all typically elliptical with broadly rounded poles. In contrast to Hustedt's (1937-38 : 259, Pl. 18, Figs 11, 12) diagnosis and drawings, however, the raphe is gently arcuate with distinct but not unduly distant central pores. The raphe is enclosed in a prominent axial rib, and parallel to it on the concave side there is characteristically a single row of isolated pores. This row of pores actually penetrates the axial rib in *N. tenera* (Figs 540-542). This is in marked contrast to the situation in closely related species, such as *N. insociabilis*, *N. monoculata*, *N. standeriella* and *N. umpatica* (cf. Schoeman and Archibald, 1976-80 : No. 5), where the pores lie just outside the axial rib or slightly indented into it. The transapical striae were relatively short extending a third of the valve width inwards from the margin. In most cases a curved longitudinal costa on either side of the raphe divides the striae into a smaller pore on the inner side of the costa, and a larger alveolus on the outer side. In LM it appeared occasionally as though there might be two pores in each stria on the outer side of this costa, but TEM studies (Figs 540-542) showed that this was not so. The striae structure, as it is described above, does not agree with the manner in which it is depicted by Hustedt (l.c. : Pl. 18, Figs 11, 12) in his illustrations. The axial area was basically a wide lanceolate region made asymmetrical on account of the row of isolated pores on one side of the raphe. Dimensions of the specimens examined on the type slides agreed exactly with the original diagnosis.

In the Sundays and Great Fish rivers specimens were observed agreeing in every structural detail with *N. tenera* as seen on Hustedt's slides, but they had a wider range of variation in size and valve outline. In outline the Sundays and Great Fish River examples ranged from typically elliptical valves, through short and broadly elliptical forms to specimens with a more or less linear central portion, and broadly rounded cuneate poles, i.e. the outline was more angular. In most of these specimens the broad axial rib was prominent. These examples were 9,0 - 14,5 μm long, 4,0 - 6,5 μm broad and had 16 - 20 striae in 10 μm . Despite this wider range of variation there is no doubt that they all belong to *N. tenera*. This certainty of identification leads, nevertheless, to the surprising discovery that *N. tenera*, although quite frequent in the rivers being studied, has apparently never been recorded previously from Southern Africa. The answer to this anomaly lies, however, in Cholnoky's misidentification of this taxon generally as *Navicula fritschii* Lund (1946 : 77, Fig. 7A-G). This concept of *N. fritschii* was subsequently adopted by a number of other Southern African diatomists. It is, however, clear from most of Cholnoky's drawings (Cholnoky, 1957a : 62, Fig. 130; 1959 : 38, Fig 208; 1960a : 59, Fig. 188; 1966b : 189, Fig. 31) that these forms cannot be considered as *N. fritschii (= N. insociabilis)* because of significant structural differences. Most of these illustrated examples, but not all, should be referred instead to *N. tenera*. The identity of Cholnoky's other examples are still not quite clear.

At this point a comment on Cholnoky's concept of *Navicula fritschii* is necessary, since he appeared to have been somewhat confused by this taxon. Cholnoky claimed that *N. fritschii* was a valid species, and frequently criticised Hustedt for uniting *N. fritschii* with *N. insociabilis* Krasske (1932 : 114, Fig. 17), maintaining that *N. monoculata* Hustedt was the true *N. insociabilis* (see comments on *N. monoculata* above). According to Hustedt (1937-38 : 252; 1957 : 303; 1961-62 : 181, Fig. 1315a-h) *N. insociabilis* and *N. fritschii* are really conspecific, the latter being a later synonym of the former. They only appeared to differ when viewed under mountants of different refractive index. Lund (l.c.) would not accept this and maintained that his species was valid. Cholnoky (1960a : 59, Fig. 188) supported Lund's viewpoint. In this context, however, Cholnoky was referring to *N. fritschii* sensu Lund (l.c.), which is not *N. tenera*. As pointed out in the discussion of the taxon, *N. monoculata* Hustedt (see above), personal examination of the type slides of both *N. fritschii* and *N. insociabilis* provided irrefutable proof that both species are conspecific, and that *N. insociabilis* is the only valid name for the taxon. Much uncertainty has been generated by these conflicting views, and this has been reflected in VanLandingham's (1975 : 2551, 2604 and 2605) taxonomic treatment of these two species. In his volume on the genus *Navicula* he first regarded *N. fritschii* as an invalid species (p. 2551), citing *N. insociabilis* sensu Hustedt (in A. Schmidt *et al.*, 1874-1959 : Pl. 400, Figs 19-26 = Hustedt 1961-66 : 181, Fig. 1315a-h) as a synonym, and considered both as synonymous with *N. insociabilis* Krasske. This is the correct view, and VanLandingham (l.c. : 2604) showed it in his synonymy for *N. insociabilis* Krasske. However on the following page (viz. p. 2605) he appears to have reverted to the opinion that *N. fritschii* is a valid species and that *N. insociabilis* sensu Hustedt is its synonym. Unfortunately Cholnoky's concept of *N. fritschii* must have altered, as most of his later records of *N. fritschii* are really *N. tenera*, and a few belong to some closely related species. Cholnoky (1954 : 417, Figs 50, 51) has, as far as can be determined, correctly identified *N. fritschii* *(= N. insociabilis)* only once, and then ironically called it *N. insociabilis.*

Archibald (1971 : 39, Fig. 96) identified a number of forms from the Vaal Dam catchment rivers either as *N. fritschii* or as *N. fritschii* var. *dissipatoides (= N. insociabilis* var. *dissipatoides).* All these specimens should also be referred to as *N. tenera.* The identification, however, of some of them as the var. *dissipatoides* is interesting. The taxon *N. insociabilis* var. *dissipatoides* was described by Hustedt (1957 : 303, Fig. 27), who made it a variety of *N. insociabilis*. Having examined Hustedt's holotype slide (Slide No. N11, 2 - Bremerhaven : a single ringed specimen) it is clear that the var. *dissipatoides* is structurally quite different from *N. insociabilis*. Hustedt (l.c. : 304) appears to have been well aware of this as witnessed by his remark - "Bezüglich der var. *dissipatoides* bemerke ich, das sie sich deutlich von der Art unterscheidt, ...". Hustedt recognised some relationship to *N. dissipata* Hustedt (1961-66 : 549, Fig. 1587), hence the epithet, but it is surprising that he never compared this taxon with his *N. tenera*. Comparing the structure and dimensions of both *N. insociabilis* var. *dissipatoides* and *N. tenera* in the light of the type specimens, there is little to distinguish them, the former being perhaps a little longer and relatively narrower than *N. tenera.*

On the basis of these observations and from examination of a number of specimens from the Vaal Dam catchment, as well as from the Sundays and Great Fish rivers, Schoeman and Archibald (1976-80 : No. 5) have united *N. tenera* and *N. insociabilis* var. *dissipatoides*, the latter becoming a synonym of the former.

Likewise Schoeman and Archibald (l.c.), having studied the relevant type materials and critically reviewed the literature, have shown that *Navicula dissipata* Hustedt (1961-66 : 549, Fig. 1587) is also conspecific with *N. tenera.* Why this relationship has remained unrecognised for so long is surprising, but could be ascribed to Hustedt's inaccurate drawing of *N. tenera* from his German Sunda Islands expedition (cf. Hustedt, 1937-38 : 259, Pl. 18, Figs 11, 12). *Navicula biseriata* Brockmann (1952 : 4, Pl. 1, Figs 4-7) has long been considered synonymous with Hustedt's *N. dissipata.* Brockmann's species, however, is identical to *N. tenera*, as may be seen from his description and illustrations. *N. dissipata* therefore seems to represent large examples of *N. tenera*, in which the inner punctum of some of the central striae becomes reduced (cf. Hustedt, 1961-66 : 550).

To summarize the remarks made above it can be said:-

(1) *N. tenera* has been positively identified from the Sundays and Great Fish rivers.

(2) Despite no previous record of this species from Southern Africa, *N. tenera* does occur fairly frequently, but owing to Cholnoky's misconception of *N. fritschii* Lund, has usually been misidentified as the latter species.

(3) *N. dissipata* and *N. insociabilis* var. *dissipatoides* have been united with and have been made synonyms of *N. tenera.*

Specimens from the Sundays and Great Fish rivers varied somewhat in valve shape from broadly elliptical forms to specimens with linear almost parallel walls. The poles were usually broadly rounded, but often they were more angular and cuneate (see Figs 50, 344, 348, 543, 544). These specimens were 9,0 - 14,6 µm long, 4,0 - 6,5 µm broad, and had 16 - 18 (20) striae in 10 µm .

Euryhaline mesohalobe - 5.

Figs: 47-50, 342-348, 540-545.

Samples: SUN: 5-9, 11, 13, 34, 36, 41, 42, 55, 69, 76, 77, 80-83.
FIS: 3, 40.

Navicula terrestris Boye Petersen

Boye Petersen, 1915 : 228, Figs 7, 8.
Lund, 1946 : 80, Fig. 7M-W.
Hustedt, 1961-66 : 13, Fig. 1181a-f (as *N. gibbula* Cleve).

Synonyms: *Navicula terrestris* var. *relicta* (McCall) Lund, 1946 : 83, Fig. 7U-W.

Taxonomic notes: This is yet another taxon in which the re-examination of its type specimens in relation to those of similar, if not the same, species can resolve the taxonomic confusion surrounding them. In this case there are two conflicting opinions. In the first place Lund (1946 : 80) presented a case for differentiating *N. terrestris* from *N. gibbula* Cleve (1894 : 140, Pl. 5, Fig. 17). This was based on the difference in shape of the pole endings, the lack of a longitudinal line parallel to the axial area in *N. gibbula*, and the presence in *N. terrestris* of slit-like projections from the central nodule running towards the margin of the valve. In contrast Hustedt (1924 : 558, Fig. 8) considered that *N. terrestris* and *N. terrestris* var. *relicta* (McCall) Lund (1946 : 83, Fig. 7U-W) were synonymous with *N. gibbula*. Hustedt contended that the longitudinal line was present in *N. gibbula*, and that Lagerstedt (1873 : 30, Pl. 1, Fig. 7a) intended to show the line in *N. gibberula (= N. gibbula* cf. Cleve, 1894 : 140). Hustedt (1961-66 : 13) also maintained that for explicable reasons Lagerstedt and Cleve both overlooked the appendages of the central pores. As it is not at all certain whether Hustedt examined Lagerstedt's or Cleve's type specimens, Lund's taxonomy for this species has been preferred. However an open mind has been retained on this problem.

In the Sundays River a single example relating more in shape to the var. *relicta* (McCall) Lund (1946 : 83, Fig. 7U-W) was observed. This specimen had the following dimensions:- Length 24,5 µm, breadth 5,5 µm, striae at the centre 18 in 10 µm, and 22 in 10 µm nearer the poles. The valve of this specimen was typically linear with broadly rounded poles and had a distinctly gibbous central portion. The longitudinal line is distinct, but the projections of the central pores were difficult to resolve.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 25.

Navicula towutiensis Cholnoky

Cholnoky, 1963a : 245, Pl. 8, Fig. 24.

Synonyms: *Navicula woltereckii* var. *rostrata* (Hustedt) Cholnoky, 1959 : 53, Figs 278, 279.
Navicula helvetica var. *woltereckii* f. *rostrata* Hustedt, 1942a : 68, Figs 131-133.

Description: Valves linear-elliptical to lanceolate-elliptical, narrowing fairly abruptly to protracted rostrate, subcapitate or capitate apices; length 34,0 - 42,6 µm, breadth 8,0 - 10,0 µm . Raphe straight and filiform, with relatively small but distinct central pores, and prominent, large hooked terminal fissures curving towards the same side of the valve. Axial area narrow, linear, widening just before merging into the large, more or less circular central area, which often occupies more than half the valve width. Transapical striae radial in the middle, 12 - 13 in 10 µm, and becoming convergent at the poles (about 14 in 10 µm); striae distinctly punctate, 22 - 24 discrete puncta in 10 µm; the central striae very much shortened, consisting of 3 - 4 puncta, but continuing to the central nodule in many cases as shadow lines. Longitudinal lines more or less parallel to the raphe, but curving gently round the central nodule.

Taxonomic notes: It is debatable whether the forms described above are in fact the same as Hustedt's (l.c.) *Navicula helvetica* var. *woltereckii* f. *rostrata*. Cholnoky (1959 : 53, Figs 278, 279) first suggested that they were the same when he resurrected *Navicula woltereckii* to species rank, making the f. *rostrata* a variety of it. Later Cholnoky (1963a : 245, Pl. 8, Fig. 24) decided that the var. *rostrata* itself should be considered as a species. He thus renamed the taxon *Navicula towutiensis*. Cholnoky's illustration of this taxon does not, however, accord fully with *N. helvetica* var. *woltereckii* f. *rostrata*. In the first place the valves of *N. towutiensis* are more elliptical than those of Hustedt's form. Secondly the poles of *N. towutiensis* narrow abruptly to generally distinctly capitate or subcapitate apices; the rostrate apices of Hustedt's forms appear to attenuate more gradually. Thirdly there is a large difference in the construction and size of the central area of the two taxa. In Hustedt's forms there appears to be only a small lanceolate expansion of the axial area at the central nodule; the most central stria on either side of the central nodule appears to be the longest and is flanked by shorter intercalated striae. In contrast the central area of *N. towutiensis* is generally very large and more or less circular, with the shortest striae in the centre. Finally the dimensions of the two forms differ significantly - *N. towutiensis* being less than 43,0 µm long, while *N. helvetica* var. *woltereckii* f. *rostrata* is 48,0 - 100,0 µm long.

This evidence therefore suggests that *N. towutiensis*, as envisaged by Cholnoky (1963a : 245, Pl. 8, Fig. 24) and described above, is not the same as Hustedt's *N. helvetica* var. *woltereckii* f. *rostrata*. *N. towutiensis* is thus a taxon unrelated to Hustedt's form, and it is as such that it is accepted in this study. The specimens observed in the Sundays and the Great Fish rivers were identical to the example illustrated by Cholnoky (l.c.) as *N. towutiensis*.

Cholnoky (1970c : 25) suggested that *N. towutiensis* might be conspecific with *N. subrhynchocephala* Hustedt (1935 : 156, Pl. 1, Fig. 11). However, the latter, although very similar, appears to be narrower and more finely striate. Nevertheless the types of these two taxa should be compared before any final decision is made.

Finally Foged (1966 : 90, Pl. 14, Fig. 11) described *Navicula carstensenii* from Ghana. This species appears to agree very well in dimensions with the description given above for *N. towutiensis*. Foged's illustration indicated, furthermore, an identical structure. The two species are probably conspecific, but examination of the type materials will be required to verify this. Should they prove to be identical Foged's species must fall away in terms of priority as a later synonym of *N. towutiensis* Cholnoky.

Pleioeuryhaline oligohalobe - 3.

Fig.: 349.

Samples: SUN: 10, 15, 27, 33, 42, 52, 65, 69, 75.
FIS: 3, 5, 13, 17, 19, 25, 26, 29, 31, 32.

Navicula twymaniana Archibald

Archibald, 1966a : 264, Figs 41-43.
Archibald, 1971 : 47, Figs 167-175.
Schoeman and Archibald, 1976-80 : No. 2.

Synonyms: *Navicula hariola* Cholnoky, 1966a : 36, Figs 93-96.

Description: Valves elliptical to elliptic-lanceolate, with broadly rounded, usually slightly protracted apices; length 9,5 - 22,0 µm, breadth 3,0 - 5,0 µm . Raphe filiform. Axial area narrow, linear, with no distinct widening at the centre. Transapical striae fine, parallel to slightly radial, usually distinct only at the centre, 23 - 36 in 10 µm; at the poles, when visible, radial to slightly convergent, 29 to more than 40 in 10 µm .

Taxonomic notes: The distribution of this species may be greater than previously thought, but owing to a possible confusion with *Navicula fluens* Hustedt (1961-66 : 258, Fig. 1386) may have remained unrecognised as a separate entity. In the Hustedt slide collection a slide (N10, 82 - Bremerhaven) purporting to contain *N. fluens* from Lund in Sweden has specimens identical to *N. twymaniana*. This observation is supported by an independent examination of this same material by Lange-Bertalot and Bonik (1976 : 315, Figs 1m, 10, 11, 32), who published the first record of *N. twynaniana* from Europe. An examination of Hustedt's syntype slide (Ma1, 97 - Bremerhaven) of *N. fluens* from the Gr. Madebrochensee, Holstein, showed the difference clearly. These examples of *N. fluens* were distinctly striate, with the clearly punctate striae visible right to the poles. No significant change in the density of the striae was observed between the centre of the valve and the poles. Similarly Friedrich (1973 : Pl. 8, Figs c, d) illustrated specimens under the name *N. fluens* which are quite obviously *N. twymaniana*.

It is surprising that there have been so few records of this taxon, since recently it has been fairly frequently observed in different parts of the country. This lack of previous records lies partly in placing the species in other taxa. For instance Cholnoky (1966a : 36, Figs 93-96) described *N. hariola* from South West Africa. Examination of the type slide for this species (SWA 193 - NIWR) showed conclusively that it is identical to *N. twymaniana*. Measurement of specimens on this slide as well as on SWA 194 (NIWR) showed furthermore that Cholnoky's diagnosis was inaccurate and that the illustrations poorly represent the species. Quite typically the striation was visible only in the central part of the valve. Cholnoky (l.c.) gave the striae as 36 to more than 40 in 10 µm . However measurements made personally from the two slides mentioned above give a range of

26 - 32 in 10 µm . The dimensions, 13,0 - 15,7 µm long and 3,0 - 5,0 µm wide, also differed from those given in the original diagnosis. These dimensions and the striae density fit perfectly the diagnosis of *N. twymaniana*. Accordingly *N. hariola* is considered as a synonum of *N. twymaniana*.

In a recent examination of *N. twymaniana* (Schoeman and Archibald, 1976-80 : No. 2) the diagnosis of the species was considerably broadened. In doing so the relationship between this taxon and *N. paucivisitata* Patrick (1959 : 99, Pl. 8, Fig. 10; cf. also Patrick and Reimer, 1966 : 484, Pl. 46, Fig. 6) has been brought into question. Many features fit both descriptions, but the identity of *N. paucivisitata* is a little doubtful as the circumscription given by Patrick and Reimer (l.c.) does not quite tally with the illustration they give of the holotype specimen. Their diagnosis described the valves as having "somewhat rostrate, rounded ends" and a "central area small, rounded". Neither of these two features can be made out in the drawing of the holotype. *N. twymaniana* will therefore remain for the present a valid species until the holotype of *N. paucivisitata* has been examined.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 17, 22, 25, 26, 32, 47, 53, 60.
FIS: 1, 2, 7, 16, 20, 22, 24-26, 30, 37.

Navicula umpatica Cholnoky

Cholnoky, 1968a : 65, Fig. 100.
Schoeman and Archibald, 1976-80 : No. 5.

Synonyms: ? *Navicula carminata* var. *africana* Cholnoky, 1959 : 35, Figs 189, 190.

Description: Valves elliptical with broadly rounded poles; length 7,5 - 16,1 µm, breadth 3,9 - 5,0 µm . Raphe filiform and arcuate with small but distinct central pores moderately distant from each other, and inconspicuous terminal fissures. Axial area narrow, linear following the curvature of the raphe; central area more or less rectangular and combined with lateral areas to form an H-shaped region occupying about half the valve width. Transapical striae short and marginal, each consisting of a single transapically elongated areole, 17 - 22 in 10 µm . Characteristically the raphe accompanied on either side, by rows of pores (probably extensions of the striae), a single row on the convex side of the raphe and a double row on the concave side. These pores lie outside the axial rib.

Taxonomic notes: The taxonomy of this species is somewhat confusing, and some facets are still not quite clear. *N. umpatica* Cholnoky (l.c.) was first described from Lake St. Lucia, but the illustration accompanying his diagnosis was in some respect inaccurate. For instance it does not show the very characteristic double row of pores on one side of the raphe and a single row on the other. A number of examples of *N. umpatica* were observed on the type slide (SL 36 - NIWR) and these were identical in all characteristics to a specimen illustrated by Cholnoky (1960b : 249, Fig. 22) from the Swartkops River near Port Elizabeth under the name of *Navicula carminata* var. *africana*. This specimen differed from Cholnoky's original illustrations of *N. carminata* var. *africana* (cf. Cholnoky, 1959 : 35, Figs 189, 190), which show valves having only a single row of pores on either side of the raphe. Unfortunately the type material of *N. carminata* var. *africana* is not available for verification of this taxon, but a number of other samples in which Cholnoky identified *N. carminata* var. *africana* were critically scrutinized. Most of the specimens in these samples were consistent with the description of *N. umpatica* as given above, while a few appear to be misidentifications of *Navicula tenera* Hustedt (cf. above in text). The fact that so many of Cholnoky's later identifications of *N. carminata* var. *africana* are identical to *N. umpatica* suggest very strongly that both taxa may be conspecific.

N. carminata var. *africana*, furthermore, does not have much in common with the nominate variety, *N. carminata* Hustedt (cf. Hustedt, 1961-66 : 542, Fig. 1579), and should therefore be raised to the rank of species. In doing so the epithet "*africana*" cannot be validly used as a specific epithet since in the first place it does not have priority in its new status as a specific epithet, and secondly because the combination is already preoccupied by *Navicula africana* Ehrenberg (1838). Thus should *N. carminata* var. *africana* and *N. umpatica* be conspecific, the latter combination would be the correct one for this taxon, as it is the earliest valid epithet in the rank of species for this taxon.

Giffen (1975 : 84, Fig. 78-80) first noted the discrepancy between Cholnoky's original illustration of *N. carminata* var. *africana* and those from Swartkops River. Consequently he decided to separate the two forms and describe the Swartkops example under the new combination of *N. melanocephala* Giffen (l.c.). Unhappily in his diagnosis and illustration of *N. melanocephala* Giffen described a completely different taxon, quite unrelated to the species under discussion. The combination *N. melanocephala* does not therefore apply to the specimens from the Swartkops River. These latter forms are now placed with *N. umpatica*.

At Station 6 on the Sundays River numerous examples of a taxon identical in all respects with *N. umpatica* were observed. These specimens, although collected over a period of about three years, varied very little in their dimensions and striae density:- length 10,5 - 11,0 µm, breadth 4,5 - 5,0 µm, and striae 17 - 20 in 10 µm .

N. umpatica falls into a group of very similar species, such as *N. tenera*, *N. insociabilis*, and *N. monoculata*, but is easily recognisable on account of the short uninterrupted marginal striae, and the characteristic arrangement of the rows of pores on either side of the raphe. For further discussion of these species see their taxonomic comments above.

Euryhaline mesohalobe - 5.

Figs: 51, 350-352, 546.

Samples: SUN: 15-17, 30-32, 50, 51, 62, 63, 72, 73.

Navicula ventosa Hustedt

Hustedt, 1957 : 281, Figs 28-31.

Taxonomic notes: Two isolated examples of this taxon were observed, one in the Sundays River at Station 8, and the other at Station 12 on the Great Fish River. The Sundays River specimen may be regarded as being slightly abnormal, since it is rhombic-lanceolate with more or less acute poles. However Cholnoky (1966a : 50, Figs 142, 143) recorded and illustrated specimens having this valve shape from the Okawango River. Archibald (1971 : 47, Figs 179-183) has also shown that the poles of these rhombic-lanceolate forms can sometimes be slightly protracted. In this respect an examination of the type material (slide No. Vaal 484 - NIWR) for *N. hecateia*

Cholnoky (1965 : 71, Figs 21, 22), whose description agrees with that of *N. ventosa* except for the shape of the valve and the acute poles, showed that most of the examples of *N. hecateia* had in fact slightly protracted poles. These small forms appeared to be identical with those linked by Archibald (l.c.) to *N. ventosa*. Furthermore, although Cholnoky's illustrations may be slightly inaccurate in respect of the pole endings, they in actual fact approach more closely the valve described for *N. ventosa*. These facts suggest, therefore, that *N. hecateia* is most probably synonymous with *N. ventosa*. The dimensions of the two examples observed in the Sundays and Great Fish rivers were slightly greater than given in the description of *N. ventosa*, and thus serve to broaden the range of variation for the taxon:- length 10,0 - 10,2 μm, breadth 3,1 - 3,5 μm .

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 22.
FIS: 25.

Navicula viridula (Kützing) Kützing

Kützing, 1844 : 91, Pl. 30, Fig. 47; Pl. 4, Fig. 10, 15.
Hustedt, 1930 : 297, Fig. 503.

Synonyms: *Frustulia viridula* Kützing, 1833 : 551, Pl. 13, Fig. 12.

Taxonomic notes: There is some difference of opinion as to the proper authority of this combination. Hustedt (l.c.) was obviously incorrect in citing Kützing alone, since the species was first described as a *Frustulia*. Patrick and Reimer (1966 : 506, Pl. 48, Fig. 9) credit Kützing (1844 : 91) with placing the taxon in the genus *Navicula*. In contrast VanLandingham (1975 : 2875) suggested that Ehrenberg (1836b : 53) first proposed the combination, *Navicula viridula*. Kützing (l.c.; 1849 : 69) however, twice remarked "not Ehrenberg" in the annotations to his synonymy of *N. viridula*. Nevertheless it is not quite certain to what this remark refers, and may possibly mean that Kützing did not consider that Ehrenberg's interpretation of *Navicula viridula* was correct. On account of this uncertainty, and not having Ehrenberg's (1836b : 53) paper to check, Kützing has for the time being been considered as the architect of the combination, *Navicula viridula* (Kützing) Kützing. A single specimen was observed at Station 6 on the Sundays River. This specimen was 42,0 μm long, 8,0 μm broad and had 10 striae in 10 μm .

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 16.

Navicula zanonii Hustedt

Hustedt, 1949a: 92, Pl. 5, Figs 1-5.

Taxonomic notes: The taxon was very rare in the region being studied, occurring as isolated specimens in only three samples at Station 6 on the Sundays River, and in one sample from Station 10 on the Great Fish River. Cholnoky (1959: 55, Pl. 6, Fig. 280) distinguished a forma *capitata* of *N. zanonii*. The connection between Cholnoky's form and this taxon is somewhat doubtful, and the examples are probably more closely related to *N. towutiensis* (see above). Measured specimens from the Sundays River had lengths of 36,0 - 44,0 µm, breadths of 7,5 - 8,0 µm, and they had 12 striae in 10 µm .

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 16, 17, 51.
FIS: 10.

NITZSCHIA Hassal, 1845 : 435.

Nitzschia acicularis (Kützing) W. Smith

W. Smith, 1853 : 43, Pl. 15, Fig. 122.
Hustedt, 1930 : 423, Fig. 821.

Synonyms: *Synedra acicularis* Kützing, 1844 : 63, Pl. 4, Fig. 3.
Nitzschia acicularioides Archibald, 1966c : 229, Figs 2-4 (nec *N. acicularioides* Hustedt, 1959a : 415, Figs 22-24).

Taxonomic notes : A specific character used by many diatomists for distinguishing between species in the genus *Nitzschia* has been the separation of the two central fibulae in the canal raphe system. This generally indicates the presence of a central nodule interrupting the external fissure of the raphe. More intensive investigations and more thorough observations have shown that this characteristic is not a constant feature in many species, and that the presence of a central nodule does not always result in a widening of the central two fibulae. A good example of this is *N. acicularis*. In most, if not all, the classical descriptions of this taxon no mention is made of specimens with more widely spaced central fibulae. This can be the result of a number of factors. Firstly it has simply passed unnoticed, a strong possibility considering the optics of the time; secondly it was considered an unimportant feature, and therefore not described; or thirdly it was ignored by diatom taxonomists. More recent investigations of rich populations from Southern Africa (Cholnoky, 1970c : 26; Schoeman, 1970b : 62, Figs 78-83) have shown conclusively that the fibulae of *N. acicularis* can be evenly spaced throughout the canal raphe, or there may be a wider separation of the central two fibulae. Separation of the central fibulae was used by Archibald (1966c : 229, Figs 2-4) as the sole character distinguishing *N. acicularioides* (nec *N. acicularioides* Hustedt) from *N. acicularis*. As a result of the evidence of Cholnoky and Schoeman, *N. acicularioides* can no longer be considered a distinct taxon, but as part of the range of variation of *N. acicularis*. It is remarkable that Hustedt made no comment on this variation as a slide in his collection at Bremerhaven (Slide No. W2, 78 - Bremerhaven) contained numerous valves identified as *N. acicularis* by Hustedt himself, all of which had distinctly separated central fibulae. Although a large number of specimens observed on Van Heurck's Slide No. 415 (Vienna) showed no separation of the central fibulae, it is obvious that Grunow did observe a separation of the central fibulae, since he illustrated a specimen from the Arctic having one valve of the cell with evenly spaced fibulae and the other with a separation of the central fibulae (cf. Cleve and Grunow, 1880 : 101, Pl. 5, Fig. 102).

In the Sundays and Great Fish rivers relatively few specimens were observed, but some of these had separated central fibulae while others were typical with evenly spaced fibulae. These specimens were 47,5 - 59,0 µm long, 3,0 - 4,5 µm broad and had 18 fibulae in 10 µm; transapical striae were not observed even using oblique light illumination.

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 22, 23, 27, 34.
FIS: 16.

Nitzschia adapta Hustedt

Hustedt, 1949a : 135, Pl. 12, Figs 3-6.

Taxonomic notes: Although found in a number of samples the species was not plentiful. The structure and valve form agreed well with Hustedt's (l.c.) diagnosis, but like all other records from Southern Africa the examples from the Sundays and Great Fish rivers were rather smaller than the minimum given by Hustedt. The dimensions of the specimens observed in this study were:- length 56, 0 - 73,0 µm, width 3,0 - 3,7 µm and striae 35 - 36 in 10 µm and fibulae 12 - 16 in 10 µm .

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 21-23, 26, 34, 45, 57, 50, 51.
FIS: 18.

Nitzschia adductoides n. sp.

Description: Valves lanceolate to linear-elliptical with subacute, slightly rostrate to obtusely rounded cuneate poles; 11,8 - 23,2 µm long, 4,0 - 5,0 µm broad. Canal raphe marginal and fibulae indistinct. Transapical striae fine, 21 - 23 in 10 µm, indistinctly punctate, becoming slightly arcuate at the poles.

Taxonomic notes: The identity of this taxon is somewhat doubtful and describing it as new may be a little presumptuous. As the name indicates it appears to be akin to *Nitzschia adducta* Hustedt (1955 : 43, Pl. 15, Figs 21, 22). It differs from this species, however, by being narrower, more finely striate and lacking the distinct fold in the valve surface. This new species also bears some resemblance to *Nitzschia silicula* Hustedt (l.c. : 44, Pl. 16, Figs 19, 20) in valve shape and size, but differs in the structure of the striae, which are coarse and distinctly punctate in *N. silicula*. Hustedt (1957 : 341, Figs 44, 45) recorded some specimens from the Weser River under the name *Nitzschia vexans* Grunow (in Van Heurck, 1880-83; Pl. 57, Fig. 8). Hustedt's description of *N. vexans* suggests that it may be identical to *N. silicula*. The distinctly punctate striae and relatively acute apices of *N. vexans*, however, differentiates it from *N. adductoides*. Since *N. adductoides* has not yet been satisfactorily related to any of the above mentioned species it is considered a new species and described as such. Nevertheless realising the difficulties of comparing the new taxon to descriptions and illustrations, but not to the type material, the possibility that the new species has been previously described is not disregarded. Should any previously described taxon agreeing with the characteristics of *N. adductoides* be found, the latter will fall away as a more recent synonym.

Finally, although *N. adductoides* was not observed under LM in sample SUN 86 (NIWR) collected at Station 1 on the Sundays River, a valve from this sample was examined under TEM. The structure of this valve suggested the possibility that this taxon is a *Fragilariopsis*. This specimen (Fig. 547) had a structure closely resembling that of some species of *Fragilariopsis* (cf. Hasle, 1965), and was also very similar to *Nitzschia sicula* (Castracane) Hustedt (1958 : 180) as illustrated by Hasle (1964 : Pl. 16, Fig. 5a, b). In this regard Hasle (1972) has more recently argued that the genus *Fragilariopsis* should be downgraded to the rank of section within the genus *Nitzschia*. As it is not certain whether the valve found in sample SUN 86 can be identified with *N. adductoides*, comments on this aspect can only be made after a further thorough TEM examination of specimens of *N. adductoides*.

Euryhaline mesohalobe - 5.

Figs: 52, 53, 353-355, 547.

Samples: SUN: 84, 86?

Nitzschia admissoides Cholnoky

Cholnoky, 1968a : 66, Figs 103-106.

Taxonomic notes: An examination of the type slide of this taxon (slide No. SL 31 - NIWR) has revealed that Cholnoky's diagnosis is in some respects inaccurate and that the illustrations are not truly representative of the taxon. The valves are narrow linear-lanceolate to almost linear with relatively long poles tapering to more or less acute apices, which may also be slightly protracted. All the valves observed were between 2,0 and 2,5 µm broad, which is slightly narrower than the range given by Cholnoky (2,5 - 3,0 µm). Cholnoky also gave 10 - 12 fibulae in 10 µm, but counts from the type slide produced a range of 12 - 15 in 10 µm . Furthermore, although Cholnoky described the two central fibulae as being more widely spaced, some of his illustrations (cf. Cholnoky, 1968a : Figs 103, 106) do not show this feature. Study of a large number of specimens showed that this separation is present in every valve.

These new facts once more bring into question the taxonomic position of *N. admissoides* in relation to *N. admissa* Hustedt (1957 : 346, Figs 68 - 75), which Cholnoky (l.c.) regarded as superficially similar. Recent studies by Lange-Bertalot (1976 : 257) have shown that *N. admissa* is conspecific with *N. paleacea* Grunow (cf. Cleve and Grunow, 1880 : 95). Examples of *N. paleacea*, as identified by Hustedt, on the Hustedt slide No. W1, 45 (Bremerhaven) were examined. These examples did not correspond with the description Hustedt (1930 : 416, Fig. 807) gave for *N. paleacea*, but it agreed very closely with his diagnosis of *N. admissa* (cf. Hustedt, 1957 : 346, Figs 68-75). These specimens also agree closely with *N. admissoides* as observed on Cholnoky's type slide. They differed, however, in two respects; firstly the fibulae in *N. admissoides* appear to be longer and less dense, and secondly there may be an ecological difference. *N. admissa* and *N. paleacea* are regarded as freshwater species, *N. admissoides* has so far only been found in brackish water environments. A thorough investigation of these three taxa is needed to determine whether they are the same or not.

The few specimens observed at Stations 1 and 2 on the Sundays River estuary were typical in nearly all respects, but may be slightly narrower. Valves were observed in which the width was only 1,5 µm . Lengths ranged from 18,8 - 30,8 µm, while the number of fibulae varied between 12 and 16 in 10 µm . The latter were relatively long, being about one third the width of the valve.

Meioeuryhaline polyhalobe - 9.

Figs: 54, 55.

Samples: SUN: 1, 3, 84.

Nitzschia agnita Hustedt

Hustedt, 1957 : 347, Fig. 51.

Description: Valve lanceolate, attenuating to narrowly protracted poles of variable length having small capitate apices; 26,7 - 39,2 µm long, 2,9 - 3,5 µm broad. Canal raphe marginal, and not interrupted at the centre by a central nodule, fibulae small 13 - 20 in 10 µm, the central two equidistant. Transapical striae very fine, and unresolved under the light microscope.

Taxonomic notes: Although apparently a rare taxon, it may well be more common than previously thought on account of misidentifications or misinterpretations of the diagnosis. *N. agnita* has been recorded on three occasions from South Africa in the Eastern Transvaal (Cholnoky, 1962c : 94, Fig. 20), the Southern Transvaal (Archibald, 1971 : 49) and Lake St Lucia on the Natal north coast (Cholnoky, 1968a : 67). Specimens from all these areas have been personally examined, and had the following dimensions:- 26,7 - 39,2 μm long, 2,9 - 3,5 μm broad and had 14 - 20 small fibulae in 10 μm . Hustedt's (l.c.) diagnosis is obviously based on very few specimens as no ranges in dimension are given. Nevertheless the specimens found in South Africa agree entirely in valve shape and their dimensions form a realistic range on either side of the values given by Hustedt. In the Sundays and Great Fish rivers specimens, corresponding in all morphological details with *N. agnita* and having a similar range of dimensions as specimens from elsewhere in South Africa, were encountered quite commonly, particularly at Station 9 on the Great Fish River. In determining the correct identity of the local examples two other taxa were taken into consideration. First of all the great similarity between this taxon and *Nitzschia obligata* Archibald (1966c : 233, Fig. 20; 1971 : 52, Figs 217, 218) led to a re-examination of the latter. Unfortunately the single type specimen on slide Vaal 412 (NIWR), the type slide, could not be traced, but a number of specimens fitting closely the original diagnosis (Archibald, 1966c : 233) were observed on slide Vaal 307 (NIWR); these were 41,2 - 47,5 μm long, 3,0 - 3,2 μm broad, and had 12 - 16 fibulae in 10 μm . Besides these examples the dimensions of a number of other specimens (30,5 - 37,0 μm long, 3,0 μm broad and having 14 - 16 fibulae in 10 μm), identified as *N. obligata*, fitted more closely the description of *N. agnita* as given above. It is not yet clear whether *N. obligata* (sensu Archibald, 1971 : 52, Figs 217, 218) is either composed of two separate elements, one of which is *N. agnita*, or is entirely synonymous with *N. agnita*. So far no intermediates between the longer and relatively narrower *N. obligata* and the shorter and slightly broader forms now attributed to *N. agnita* have been observed. Nevertheless both *N. agnita* and *N. obligata* forms were found in the Vaal Dam catchment, and sometimes in the same sample. This suggests a very close relationship between the two taxa, provided that they are not actually synonymous. Another very similar taxon is *Nitzschia irremissa* Cholnoky (1959 : 57, Figs 298-300). The original diagnosis of this taxon indicated a rather longer and broader species (45,0 - 65,0 μm long, 3,0 - 5,0 μm broad), but in a later amendment Cholnoky (1960a : 97, Fig. 287) included forms with lengths as short as 33,0 μm . Here again the type slide is unavailable for examination. However the material (slide No. TUG 286 - NIWR) containing the smaller examples mentioned above was studied. A number of specimens were observed and these were identical to those from the Sundays and Great Fish rivers, and had the following dimensions:- length 27,4 - 32,8 μm, breadth 3,2 - 3,5 μm and fibulae 13 - 16 in 10 μm . Once more it is difficult, in the absence of the type slide of *N. irremissa*, to know whether there is any real connection between these smaller forms and the typical *N. irremissa*, since no intermediate sized individuals were found. Until further examination of the types of *N. irremissa* and *N. obligata* have been carried out to establish their relationship to the smaller forms, the latter will be considered as *N. agnita*. Should intermediates between these smaller forms and both *N. irremissa* and *N. obligata* be found, then the latter two taxa must be included with *N. agnita* as later synonyms. Cholnoky (1960a : 97, Fig. 287) obviously recognised the similarity of the small forms of *N. irremissa*, recorded in Natal, to *N. agnita*, but distinguished the former on the basis of what he claimed were the more linear margins of *N. irremissa*. This is a very weak point of distinction, and could not be verified from the specimens examined on slide No. TUG 286 (NIWR). Based on the examples seen in the Sundays and Great Fish rivers, from Natal (TUG 286), St Lucia (Cholnoky, 1968a : 67 - sample SL 40) and the Eastern Transvaal (Slide ET 44 - cf. Cholnoky, 1962c : 94, Fig. 20) a new and enlarged description of *N. agnita* is given above.

Finally one other species to be borne in mind in a revision of *N. agnita* and its close relatives is *Nitzschia keutzingioides* Hustedt (1959a : 417, Figs 25-29). This taxon may represent only the short specimens of *N. agnita*, distinguished merely on the lack of capitate apices in *N. kuetzingioides*. In the rest of its morphology and its dimensions as revealed under LM *N. kuetzingioides* appears to form an intergrading series with the lower part of the range of *N. agnita*.

Mesoeuryhaline oligohalobe - 2.

Figs: 356-358.

Samples: SUN: 6, 8, 21-23, 32, 34, 36, 41, 53, 61.
FIS: 9, 11, 23, 29, 36.

Nitzschia amphibia Grunow

Grunow, 1862 : 574, Pl. 12, Fig. 23.
Grunow in Van Heurck, 1880-83 : Pl. 68, Figs 15-17.
Hustedt, 1930 : 414, Fig. 793.

Taxonomic notes: This is a very common species and many typical specimens were observed. There is therefore no need to comment on them. On the other hand a comment should be made on a small lanceolate form with rostrate poles reported by Archibald (1966b : 491, Fig. 30) from Lake

Sibaya in northeastern Natal. This specimen should probably be referred to *Nitzschia vanoyei* Cholnoky (1954b : 420, Figs 75-81), although Cholnoky's species may well be closely connected with *N. amphibia*. A comparison between *N. vanoyei* and *N. amphibia* f. *rostrata* Hustedt (1959b : 436, Figs 26, 27) is necessary as there seems to be little to distinguish them.

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 2-4, 9, 27, 30, 33, 43-46, 48, 51, 52, 65, 73.
FIS: 7, 8, 10, 20, 30, 31, 33, 36.

Nitzschia amphioxoides Hustedt

Hustedt, 1949a : 140, Pl. 13, Figs 65-72.

Taxonomic notes: The true identity of the specimens assigned to this taxon is still in some doubt. The dimensions of these specimens and the density of their striae and fibulae do, however, correspond with *N. amphioxoides*. Hustedt (l.c.) distinguished this species from *N. hantzschiana* Rabenhorst (cf. Hustedt, 1930 : 415, Fig. 797) on the grounds that *N. amphioxoides* has more widely spaced central fibulae, while in *N. hantzschiana* they are equidistant. Separation of the central fibulae is, nevertheless, an extremely variable feature in this group of the *Nitzschia lanceolatae*, and is consequently not a very reliable taxonomic character. This fact should not, however, be interpreted as implying that there is a great variability in the presence of a central nodule in this *Nitzschia* group. The presence of a central nodule is not necessarily reflected by the spacing of the fibulae, although more widely spaced central fibulae generally indicate the presence of a central nodule. Hustedt (1949a : 140) himself admits that a separation of the central fibulae in *N. amphioxoides* is difficult to recognise, being only slightly wider or even not widened at all. On these grounds it is felt that the Sundays River specimens (length 21,0 - 28,0 µm, breadth 3,5 - 4,0 µm, striae 24 in 10 µm and fibulae 12 in 10 µm) may be *N. frustulum*, while the example from the Great Fish River (41,5 µm long, 3,5 µm wide) may be *N. hantschiana*.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 1, 8, 15.
FIS: 21.

Nitzschia apiculata (Gregory) Grunow

Grunow in Cleve and Grunow, 1880 : 73.
Grunow in Van Heurck, 1880-83 : Pl. 58, Figs 26, 27.
Hustedt, 1930 : 401, Fig. 765.
Schoeman and Archibald, 1976-80 : No. 1.

Synonyms: *Tryblionella apiculata* Gregory, 1857 : 79, Pl. 1, Fig. 43.

Description: Valves linear with concave to slightly constricted margins at the centre, poles rounded to subcuneate with the ends protracted into short subrostrate to rostrate apices; length 20,0 - 58,0 µm, breadth 4,5 - 8,0 µm . Canal raphe narrow, marginal; fibulae indistinct from the rest of the valve structure, apparently coinciding in number with the transapical striae. Transapical striae prominent (14) 15 - 20 in 10 µm, interrupted by a slightly excentric longitudinal fold of variable width in which the transapical costae appear as faint shadow lines.

The electron microscopic studies of Schoeman and Archibald (l.c.) showed that the longitudinal fold is a structureless area traversed by the costae, which are very weakly developed in this area. The transapical striae between the costae consist of 3-4 rows (occasionally only 2) of irregularly arranged puncta. The striae end on the raphe margin of the valve against a narrow ridge, on the opposite side of which is a single pore. The canal raphe is carried in a raised wing with the external fissure interrupted at the centre by a central nodule. Internally the raphe communicates with the cell contents by a series of interspaces separated by short rod-like fibulae occurring opposite each transapical costa. Opposite the central nodule there is one much enlarged central interspace, causing the two most central fibulae to be more widely separated.

Taxonomic notes: A feature of this species that does not appear to have been observed or recorded previously is the wider separation of the central fibulae as mentioned in the LM description above. This was first observed when examining specimens of *N. apiculata* on two of Grunow's slides (Nos 1434 and 2524 - Vienna). In phase contrast illumination a row of bright dots along the raphe margin was observed; these were resolved under SEM as the fibulae (cf. Schoeman and Archibald l.c.). At the centre of the valve the row of dots was deflected inwards, and the two central fibulae (dots) were more distantly spaced. Once observed in SEM this feature was reasonably easily detected in LM. The Sundays and Great Fish River specimens were quite typical, and need no further comment.

Euryhaline mesohalobe - 5.

Fig: 56.

Samples: SUN: 1-5, 7-25, 30, 32, 35-37, 40, 41, 45, 48, 49, 53, 56, 57, 60, 61, 63-66, 72, 73, 75, 76, 79.
FIS: 3-6, 8, 9, 11, 13, 16-32, 36, 37, 40.

Nitzschia aremonica nom. nov.

Peragallo, H. and Peragallo, M., 1897-1908 : 291, Pl. 74, Fig 13 (as *N. armoricana*).

Synonyms: *Nitzschia armoricana* Peragallo, H. and Peragallo, M., l.c.

Taxonomic notes: According to VanLandingham (1978a : 3016), *Nitzschia armoricana* Peragallo and Peragallo (l.c.) is an invalid name as it is a later homonym of *Nitzschia armoricana* (Kützing) Grunow (1862 : 570). Thus in accordance with the International Code of Botanical Nomenclature a new name must be sought for Peragallo and Peragallo's species. The specific epithet "*armoricana*" was probably intended to convey the idea that the taxon was discovered in the French province of Brittany. An alternative Latin name for this province is Aremonica (cf. Stearn 1966 : 216), and thus this name, not previously used, has been selected as the new specific epithet for this species. The species has therefore been renamed *Nitzschia aremonica* nom. nov. VanLandingham (l.c.) considered *N. armoricana* Peragallo & Peragallo as synonymous with *Nitzschia spectabilis* (Ehrenberg) Hustedt, and cited Hustedt (1959b : 431) as the author of this combination. However, if this reference is consulted it will be clear that there is a discrepancy here. Hustedt (l.c.) made no mention whatsoever of *N. armoricana* in his discussion of the taxonomy of *N. spectabilis*, which he transferred to the genus *Hantzschia*. It would therefore appear that VanLandingham had misconstrued Hustedt in this respect, as he later (VanLandingham, 1978a : 3120) correctly followed Hustedt's reclassification of *N. spectabilis* as *Hantzschia spectabilis*.

N. aremonica is very similar to *Nitzschia obtusa* var. *scalpelliformis*, and it is difficult to distinguish between them. *N. aremonica* is, however, relatively narrower than *N. obtusa* var. *scalpelliformis*, and its striae, although sometimes slightly coarser, are not distinctly punctate. The dimensions of the specimens observed in this study correspond closely with those given in the original diagnosis (cf. Peragallo & Peragallo l.c.), but show a wider range of variation. These specimens were (31) 38,0 - 75,0 µm long, 4,0 - 5,0 µm broad, and had 24 - 28 striae in 10 µm and 7 - 10 fibulae in 10 µm . A revision of this taxon, which is recorded here for the first time in South Africa, is necessary to determine how closely it is linked to *N. obtusa* var. *scalpelliformis*.

Meioeuryhaline polyhalobe - 9.

Figs: 359, 360.

Samples: SUN: 2, 3, 83, 84, 86.
FIS: 41.

Nitzschia brevissima Grunow

Grunow in Van Heurck, 1880-83 : Pl. 67, Fig. 4.

Synonyms: *Nitzschia parvula* Lewis in Hustedt, 1921 in A. Schmidt *et al.*, 1874-1959 : Pl. 336, Fig. 4.
Nitzschia obtusa var. *brevissima* Grunow in Van Heurck, 1880-83 : Pl. 67, Fig. 4.

Taxonomic notes: Only three or four specimens agreeing completely with the descriptions found in the literature were observed. These specimens were 30,0 - 37,0 µm long, 3,5 - 5,0 µm broad and had 32 - 38 striae and 7 - 10 fibulae in 10 µm . Examination of examples of this taxon on the Van Heurck Slide No. 400 (Vienna) gave a wider range in dimensions than found in the literature, and confirmed the identity of the Sundays and Great Fish River specimens. The examples on Van Heurck's slide were 18,9 - 54,0 µm long, 5,4 - 6,3 µm broad, and had more than 30 striae and 6 - 8 fibulae in 10 µm . In Southern Africa the species has been recorded previously under the name *N. parvula* Lewis.

Euryhaline mesohalobe - 5.

Samples: SUN: 2, 3.
FIS: 28.

Nitzschia calida Grunow

Grunow in Cleve and Grunow, 1880 : 75.
Grunow in Van Heurck, 1880-83 : Pl. 59, Figs 4, 5.
Schoeman and Archibald, 1976-80 : No. 1.

Synonyms: *Nitzschia tryblionella* var. *calida* (Grunow) Van Heurck, 1885 : 171.
Nitzschia umbilicata Hustedt, 1949a : 129, Pl. 11, Fig. 65.

Description: Valves broadly linear, generally slightly concave at the centre, with short, broad cuneate poles protracted at the ends into short, narrow rostrate or sometimes subcapitate apices; length 27,0 - 46,0 µm, breadth 6,0 - 10,0 µm . The canal raphe is strongly eccentric, slightly constricted at the centre; fibulae narrow, apically elongated, the central two more widely spaced than the others; interspaces small, round; 7 - 10 fibulae in 10 µm . Transapical costae prominent, slightly sinuous, 17 - 22 in 10 µm . Valve surface with a slight longitudinal fold, sometimes not apparent. In oblique light, transapical striae visible along the margin, sometimes with difficulty, 32 - 36 in 10 µm .

Taxonomic notes: Examination of the Hustedt type slide of *N. umbilicata* (Slide No. 243, 43 - Bremerhaven) and its comparison with *N. calida* on Grunow's Slide No. 394a (Vienna) showed conclusively that the two species are identical. No significant differences were observed between them, and as a result *N. umbilicata* has been united with *N. calida*, making it a more recent synonym of the latter. It is doubtful whether Hustedt examined Grunow's slides of *N. calida*, otherwise this error would not have been made. His concept of *N. calida* was slightly different, but still true for *N. calida* (see Figs 361, 362).

Meioeuryhaline oligohalobe - 1.

Figs: 57, 361-366.

Samples: SUN: 6, 63, 72.
FIS: 9, 29, 30, 32, 36.

Nitzschia clausii Hantzsch

Hantzsch, 1860 : 40, Pl. 6, Fig. 7.
Hustedt, 1930 : 421, Fig. 814.

Taxonomic notes: A number of typical specimens were observed: length 33,0 - 43,6 µm, breadth 2,9 - 3,5 µm, striae 40 in 10 µm, fibulae 10 - 12 in 10 µm .

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 17, 34.

Nitzschia closterium (Ehrenberg) W. Smith

W. Smith, 1853 : 42, Pl. 15, Fig. 120.
Hustedt, 1930 : 424, Fig. 822.

Synonyms: *Ceratoneis closterium* Ehrenberg, 1839a : 157.
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin, 1964 : 289, Pl. 124, Figs 1-4; Pl. 125, Figs 1-4.

Taxonomic notes: Reimann and Lewin (l.c.) transferred *N. closterium* to the genus *Cylindrotheca* on account of the cylindrical body shape, the structure of the canal raphe and the possession of many girdle bands. Hasle (1964 : 21) on the other hand has shown that these features can also be found in other true members of the genus *Nitzschia*. She therefore preferred to retain this taxon in the genus *Nitzschia*. Hasle's views have been accepted in this study. A single specimen 56,3 µm long, 2,1 µm broad and having 12,5 fibulae in 10 µm was observed in the lowermost station on the estuary of the Sundays River.

Euryhaline mesohalobe - 5.

Samples: SUN: 58.

Nitzschia cocconeiformis Grunow

Grunow in Cleve and Grunow, 1880 : 68.
Grunow, 1880b : 395, Pl. 12, Fig. 5.

Taxonomic notes: Although incorrectly spelt the Swartkops River (Zwatrop River) near Port Elizabeth is one of the type localities cited by Grunow (1880b : 395; and in Cleve and Grunow, 1880 : 68) for this taxon. It is therefore not surprising to find in the Sundays River, a neighbouring river to the Swartkops River, one or two absolutely typical specimens. In this broadly elliptical form each stria is composed of a broad intercostal membrane perforated by 3 - 4 transverse rows of small pores arranged alternately in each adjacent row, thus forming two obliquely intersecting systems of pores. These striae are interrupted more or less in the midline of the valve by a hyaline structureless band continuous with the costae. The canal raphe is not very easy to distinguish, but the number of fibulae appeared to correspond with the number of costae in 10 µm . The dimensions of the three specimens observed were:- length 45,7 - 57,8 µm, breadth 22,5 - 26,5 µm broad, and they had 5 - 6 striae and 5 - 6 fibulae in 10 µm respectively. These dimensions are slightly different from those given by Grunow (in Cleve and Grunow, 1880 : 68) in the original diagnosis, but correspond very well with the description in the English translation (by Kitton?) in the Journal of the Royal Microscopical Society (cf. Grunow, 1880b : 395). The species appears to be common in South African estuaries and coastal waters.

Meioeuryhaline polyhalobe - 9.

Samples: SUN: 6, 82.

Nitzschia communis Rabenhorst

Rabenhorst, 1848-60 : Alg. No. 949.
Rabenhorst, 1863 : 50.
Rabenhorst, 1864 : 159.
Hustedt, 1930 : 417, Fig. 798.
Schoeman and Archibald, 1976-80 : No. 2.

Description: Valves linear, linear-elliptical to elliptical (mainly the small specimens) with either gradually tapering or cuneate, broadly rounded poles, or poles slightly protracted into broad rostrate apices; length 6,0 - 59,0 µm, breadth 2,5 - 5,8 µm . Canal raphe marginal; fibulae conspicuous, relatively broad rectangular, 8 - 14 in 10 µm (most commonly about 10), no significantly wider separation of the central two fibulae has been observed. Transapical striae fine, sometimes indistinct, but clearly visible in oblique light, 28 - 38 (40) in 10 µm (usually about 30), parallel in the centre becoming radial and/or curved at the poles.

Taxonomic notes: Most authors have described the valve of *N. communis* as either lanceolate, elliptic-lanceolate or linear-lanceolate. However, according to observations from a type slide in the British Museum (BM 77951), made from the original Rabenhorst material (Alg. Eur. No. 949), the valve is linear to linear-elliptical. Examples from Southern Africa confirm this observation. Furthermore, Hendey's (1964 : 12) definition of the term lanceolate, i.e. "the shape of the area enclosed by the intersection of two equal circles" does not fit the valve of *N. communis*.

Okuno (1974) illustrated two specimens of *N. communis* on Plates 913 and 914 of Helmcke and Krieger's atlas "Diatomeenschalen" etc. The specimen shown on Plate 914 is definitely *N. communis*, but there is some doubt that the specimens on Pl. 913 belong to this taxon. The shape and number of fibulae (16 - 19 in 10 µm), as well as the number of striae (43 - 46 in

10 μm) do not agree with the corresponding parameters given in the description above, or of the British Museum type specimens.

Meioeuryhaline oligohalobe - 1.

Fig: 58.

Samples: SUN: 15-17, 32, 43, 44, 46, 47, 50-52, 60.
FIS: 3, 8.

Nitzschia commutata Grunow

Grunow in Cleve and Grunow, 1880 : 79.
Hustedt, 1930 : 405, Fig. 774.

Taxomonic notes: A single specimen was observed at each of the three stations from which the taxon was recorded. These appeared to be quite typical and had the following dimensions:- length 53,0 - 76,2 μm, breadth 5,5 - 8,1 μm, 20 - 24 striae and 8 - 12 fibulae in 10 μm .

Euryhaline mesohalobe - 5.

Samples: SUN: 43, 45, 51.

Nitzschia confinis Hustedt

Hustedt, 1949a : 145, Pl. 11, Figs 49-54; Pl. 13, Figs 84-90.

Taxonomic notes: The specimens placed in this taxon differed slightly from Hustedt's (l.c.) diagnosis in valve shape and density of striae. The valves were basically as described by Hustedt - narrow linear-lanceolate - but most showed a slight protraction of the poles and slightly capitate apices. The striae were also somewhat coarser than given in the diagnosis but form a continuous series with the range given in the description. Ten specimens measured in sample SUN 34 gave the following dimensions:- length 28,9 - 48,5 μm, breadth 2,4 - 2,5 μm, striae 28 - 30 in 10 μm, fibulae 13 - 14 in 10 μm . Apart from the small differences mentioned above these specimens agreed in all respects with those examined on the type slide in Hustedt's collection (slide No. 245, 35 - Bremerhaven). As suggested by Stoermer and Ladewski (1976 : 19) the systematic position of this taxon is questionable. Hustedt (l.c.) felt that there was a relationship between this species and *N. luzonensis* Hustedt (1942a : 137, Figs 331-336), but surprisingly does not mention the similarities between *N. confinis* and *N. subrostrata* Hustedt (l.c.: 137, Figs 313-319), described on the same page as *N. luzoncnsis*. In valve shape and dimensions *N. subrostrata* is hardly distinguishable from *N. confinis*, and in many respects the Sundays River specimens may fit the description of *N. subrostrata* better. Nevertheless the type specimens of *N. subrostrata* have not been examined for confirmation of this, and furthermore, *N. subrostrata* has not been recorded previously from South Africa. In contrast *N. confinis* has been observed fairly frequently from Southern African waters.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 34.
FIS: 8.

Nitzschia corpulenta Hendey

Hendey, 1957 : 78, Pl. 1, Fig. 5.

Taxonomic notes: The specimens assigned to this species are placed here with a fair amount of confidence as they correspond in almost every detail with Hendey's diagnosis. The specimens observed expand the range of variation of the species, and agree very closely with the dimensions given by Giffen (1963 : 244). They differ from both Giffen's and Hendey's examples in that the canal raphe is difficult to distinguish from the rest of the structure, and the fibulae appear to have the same density as the striae. The Sundays River specimens had the following dimensions:- length 17,6 - 35,0 μm, breadth 7,4 - 9,3 μm in the constriction and 9,8 - 12,3 μm at the maximum width, and had 12 - 14 striae and fibulae in 10 μm . Although these specimens correspond to Hendey's diagnosis, the taxonomic status of *N. corpulenta* is somewhat doubtful. A relationship between this taxon and *Nitzschia bombiformis* Grunow (in Van Heurck, 1880-83 : Pl. 58, Fig. 9) is evident, but the dimensions of this species appear to be too large to include *N. corpulenta*. The specimen of *N. bombiformis*, figured by Grunow (l.c.), is 66,7 μm long and about 15 μm broad at the constriction. However in the legend to the plate it is said to have 14 striae in 10 μm . Ricard (1977 : Pl. 4, Fig. 19) illustrated a specimen of *N. constricta* var. *bombiformis (= N. bombiformis)* which he indicated was 120 μm long, and 64 μm broad. These dimensions do not, however, seem correct as, based on a length of 120 μm, they would result in a striae count of 5 in 10 μm . Such a striae density is far too coarse for *N. bombiformis* or *N. constricta* and its varieties. This may have been a slip of the pen, and a length of 64 μm and width of 12,0 μm would be more compatible with the dimensions of *N. bombiformis*. There has been no opportunity to examine type specimens of either *N. corpulenta* or *N. bombiformis*, but this is necessary to solve the problem. Since the Sundays River specimens are much smaller in dimension than *N. bombiformis* it was considered better to retain them as *N. corpulenta.*

Meioeuryhaline polyhalobe - 9.

Figs: 367-371, 548-550.

Samples: SUN: 82, 83, 86.

Nitzschia debilis (Arnott) Grunow

Grunow in Cleve and Grunow, 1880 : 68.
Grunow in Van Heurck, 1880-83 : Pl. 57, Figs 19-21.
Hustedt, 1930 : 400, Fig. 759 (as *N. trybionella* var. *debilis*).

Synonyms: *Tryblionella debilis* Arnott in O'Meara, 1873 : 310.
Nitzschia tryblionella var. *debilis* (Arnott) Mayer, 1913 : 295, Pl. 16, Fig. 16.

Taxonomic notes: The species was fairly frequently observed at Stations 5 and 6 on the Sundays River, and once at Station 13 on the Great Fish River.

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 15, 16, 32, 51, 72, 73, 76.
FIS: 40.

Nitzschia denticula Grunow

Grunow in Cleve and Grunow, 1880 : 82.
Grunow in Van Heurck, 1880-83 : Pl. 60, Fig. 10.
Hustedt, 1930 : 407, Fig. 780.

Taxonomic notes: The specimens identified in this study as *N. denticula* truly represent this species as defined by Grunow (l.c.) and Hustedt (l.c.). However not all identical or similar specimens observed in Southern Africa have been identified as *N. denticula*. Most, if not all, other examples of this taxon have been referred to a closely related, but quite distinct taxon, *Nitzschia interrupta* (Reichelt) Hustedt (1927 : 168). Examples of *N. interrupta* were examined on Hustedt's slide No. W2, 71 (Bremerhaven) and compared with specimens of *N. denticula*. Both had a similar valve shape and dimensions, nor could they be distinguished on the grounds of differences in density of striae and fibulae. The fundamental distinction between the two taxa lay, however, in the arrangement of the pores composing the striae and the structure of the fibulae. In *N. denticula* the fibulae are robust and long, passing from one side of the valve to almost the other. In contrast the fibulae of *N. interrupta*, also strong, seldom reach the midline of the valve, and, moreover, characteristically flare out at their inner ends. The structure of the striae also differs quite significantly. In *N. denticula* the striae are composed of round pores of more or less the same size, and are evenly spaced. On the other hand the pores in the striae of *N. interrupta* increase in size as they progress towards the canal raphe and become fairly large almost rectangularly shaped openings. Furthermore in the region of the flared ends of the fibulae the puncta become more scattered, and frequently an undulate structureless band may be formed, or else the puncta become widely separated in undulate longitudinal rowes in this region. A revision of all records of *N. interrupta* from Southern Africa in the last three decades is necessary, and it is more than likely that they will all have to be transferred to *N. denticula*. What little has already been revised has brought to light no specimens of the proper *N. interrupta*. A taxon very similar to *N. interrupta* is discussed below under *Nitzschia solgensis* Cleve-Euler.

Specimens of *N. denticula* measured in the samples investigated had the following dimensions:- length 8,4 - 26,0 µm, breadth 3,8 - 6,0 µm, striae 16 - 18 in 10 µm, and fibulae 6 - 8 in 10 µm .

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 1, 5-11, 13, 25-27, 34-36, 41, 43, 45-47, 53-55, 60, 64-67, 69-71, 74, 75, 86.

FIS: 18, 20, 24.

Nitzschia diluta Archibald

Archibald, 1966a : 266, Fig. 50.

Archibald, 1971 : 51, Figs 197, 198.

Taxonomic notes: The two specimens observed at Station 8 corresponded completely with the original diagnosis (Archibald, 1966a : 266, Fig. 50) and the enlarged range of dimensions (Archibald, 1971 : 51). These specimens were 40,0 - 44,0 µm long, 3,5 - 4,0 µm broad and had 35 - 36 striae and 12 - 16 fibulae in 10 µm . A relationship to *Nitzschia palea* (Kützing) W. Smith is still a possibility, and the problem needs further intensive investigation.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 22, 23.

Nitzschia dissipata (Kützing) Grunow

Grunow in Cleve and Grunow, 1880 : 90.
Hustedt, 1930 : 412, Fig. 789.
Schoeman & Archibald, 1976-80 : No. 1.

Synonyms: *Synedra dissipata* Kützing, 1844 : 64, Pl. 14, Fig. 111.
Nitzschia media Hantzsch, 1863 : 40, Pl. 6, Fig. 9.
Nitzschia dissipata var. *media* (Hantzsch) Grunow in Van Heurck, 1885 : 178.

Description: Valves linear to lanceolate, poles variable from slightly protracted to strongly protracted with acutely rounded rostrate or sometimes capitate apices, length 15,0 - 72,0 µm, breadth 3,0 - 8,0 µm . The canal raphe is prominent, without constriction at the centre, generally slightly eccentric; fibulae distinct, bar-shaped, 5 - 10 in 10 µm; interspaces generally elongate rectangular to squarish. Transapical striae generally not or only faintly visible under the light microscope.

Viewed under TEM the species has 32 - 50 transapical striae in 10 µm, composed of single rows of 40 - 70 pores in 10 µm . The puncta are small and round. The raphe fissure terminates at the poles in a hooked and divided terminal fissure.

Taxonomic notes: Giffen (1971 : 9; 1973 : 41; 1975 : 90) recorded specimens as *Nitzschia media*, while Grunow in Van Heurck's Atlas (Van Heurck, 1880-83 : Pl. 63, Figs 2, 3) considered *N. media* a variety of *N. dissipata*. More recently Hustedt (1930 : 412, Fig. 789) regarded *N. media* as inseparable from *N. dissipata*. This more recent view is subscribed to in this study.

Cholnoky (1955b : 178, Fig. 70) recorded a variety, var. *borneensis* Hustedt (1921 : Pl. 335, Figs 22-24) from South Africa. However what characteristics separate this variety from the nominate variety are not clear as Hustedt gave no formal description, and made no notes to annotate his drawing. There is, therefore, some doubt as to its validity as a variety.

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 16, 17, 45.

Nitzschia dissipatoides n. sp.

Description: Valve shape variable depending on the plane of viewing; from linear with a curved apical axis and protracted, rostrate apices slightly deflected in the opposite direction to the curve of the apical axis, to linear-lanceolate with short rostrate to subcapitate apices; valve margin bearing the raphe usually constricted at the central nodule; 17,0 - 45,0 µm long, 3,0 - 4,5 µm broad. Canal raphe variable in position, depending on plane of viewing, from completely marginal to strongly eccentric, sometimes, however, marginal at the poles and deflected in the central part of the valve; fibulae, 7 - 10 in 10 µm, rather prominent with oval to circular interspaces; the centre of the raphe containing a clear central nodule with the two central fibulae set distinctly wider apart than the others. Transapical striae very fine and not resolved under LM.

In TEM (Figs 551-553) the canal raphe is seen to be strongly silicified with the fibulae consisting of strips of silica membrane varying in width. The interspaces are large, oval, round or somewhat rectangular in shape. The external raphe fissure is interrupted at the centre by a distinct central nodule. The striae are resolved into single rows of small round pores, and number about 45 - 47 in 10 µm .

Taxonomic notes: The structure and valve shape of this taxon suggests that there is a close relationship to the group *Nitzschiae dissipatae*. It is distinguished, however, from *N. dissipata*, which it resembles closely, by the very distinct central nodule. A species somewhat similar in some respects is *Nitzschia kowiensis* Giffen (1970a : 289, Pl. 4, Figs 71-74). Giffen's species is nevertheless longer, has fewer fibulae in 10 µm, and appears to differ in structure at the centre of the canal raphe. Giffen described the central interspace as being usually very elongated but not distant. Examination of paratype material (Giffen slide No. KR 523/1 - NIWR) suggested, however, that Giffen has possibly misinterpreted the central nodule as a rather narrow, poorly developed fibula. The central interspace appears therefore to be a much elongated opening through which the central nodule is visible. Despite this, Giffen's species cannot be united with the taxon described above because of differences in size, shape of valve, and density of the fibulae.

?Euryhaline mesohalobe - 5.

Figs: 59-61, 372-376, 551-553.

Samples: SUN: 2, 5, 59, 83-86.

Nitzschia distans Gregory

Gregory, 1857 : 58, Pl. 6, Fig. 103.
Van Heurck, 1896 : 394, Pl. 33, Fig. 878.
Peragallo H. and M., 1897-1908 : 283, Pl. 73, Fig. 3.

Taxonomic notes: A single specimen of a form which can only be placed in this taxon was observed in girdle view at Station 2 on the Sundays River. This specimen was rather shorter (61,7 µm long) than the dimensions given in the literature (length 120,0 - 370,0 µm - cf. Cleve-Euler, 1952 : 70). The density and structure of the fibulae (3 in 10 µm) were, however, quite typical of *N. distans*. Giffen (1963 : 245, Fig. 85) recorded and illustrated specimens under the name *N. distans* from the Eastern Cape littoral, having the following dimensions:- length 30,0 - 44,0 µm, breadth 3,0 µm, and fibulae 8 - 9 in 10 µm . These dimensions of length and breadth are too low for this taxon, and the density of the fibulae are excessively high for *N. distans*.

Mesoeuryhaline polyhalobe - 8.

Sample: SUN: 84.

Nitzschia elegantula Grunow

Grunow in Van Heurck, 1880-83 : Pl. 69, Fig. 22a.
Van Heurck, 1885 : 183 (as *N. microcephala* var. *elegantula*)
Schoeman and Archibald, 1976-80 : No. 1.

Synonyms: *Nitzschia microcephala* var. *elegantula* (Grunow) Van Heurck, 1885 : 183.
Nitzschia jugiformis Hustedt, 1922 : 149, Pl. 10, Figs 60, 61.
Nitzschia osmophila Cholnoky e.p., 1963 : 247, Fig. 31.
Nitzschia microcephala var. *medioconstricta* Fritsch and Rich, 1930 : 121, Fig. 10, L.

Description: Valves linear, in small specimens linear-lanceolate, with a central constriction generally more prominent on the rapheless margin (sometimes indistinct in small specimens), poles protracted into short to relatively long, rostrate or capitate apices; length 9,8 - 28,7 µm, breadth 2,5 - 4,0 µm . The canal raphe marginal; fibulae distinct and relatively large, 10 - 15 µm . Transapical striae distinct, punctate (sometimes puncta indistinct), 23 - 32 in 10 µm (usually 26 - 30).

Under TEM there appears to be no central nodule interrupting the external raphe fissure. Interspaces appear to be round to slightly oval.

Taxonomic notes: Hustedt (1922 : 149, Pl. 10, Figs 60, 61) described a species from Tibet under the name *Nitzschia jugiformis*. Specimens on the type slide (slide No. W2, 64 - Bremerhaven) were examined and found to be identical with examples of *N. elegantula* observed on Grunow's slide No. 2534 (Vienna). Owing to Hustedt's rather inadequate description and poor drawing, this relationship has not been recognised earlier. *N. jugiformis* is now regarded as a synonym of *N. elegantula*. Neither *N. elegantula* nor *N. jugiformis* have been reported previously from Southern Africa, but certain of Cholnoky's illustrations suggest that the species may have been incorrectly identified on a number of occasions. In his paper on the Swakop River in South West Africa, Cholnoky (1963 : Fig. 31) drew a specimen of what he called *N. osmophila*; this specimen appeared to be identical to *N. elegantula*. Examination of Cholnoky's type slide for *N. osmophila* (SWA 58 - NIWR) brought not a single example of the *N. elegantula* - type valve to light. Furthermore the taxon, *N. osmophila*, was found to be invalid since the other specimens on which the species is founded were phenotypical variants of *Nitzschia palea*, and bore no relationship to his Fig. 31 (cf. Schoeman and Archibald l.c.). In a sample from the Harmony Gold Mine near Welkom Cholnoky (1966c : 167, Figs 13, 14) observed some specimens, which he drew and identified with some doubt as *N. frustulum*. These specimens are undoubtedly *N. elegantula* (cf. Schoeman and Archibald l.c.). Finally Fritsch and Rich (l.c.) described a new variety of *N. microcephala*, the var. *medioconstricta*. This variety was distinguished from *N. microcephala* by the central constriction of the valve walls and the markedly rostrate - capitate apices. Fritsch and Rich commented that "this form is very much like the var. *elegantula*, Grun., figured by Van Heurck (pl. lxix, fig. 22a), but since neither he (p. 183) nor Peragallo (p. 287) mentions the distinct median constriction and the capitate apices, we have thought it best to establish a distinct variety." These comments and the features Fritsch and Rich used to characterise their new variety indicate strongly that they were in fact dealing with *N. elegantula* Grunow as described above.

Euryhaline mesohalobe - 5.

Figs: 62, 63.

Samples: SUN: 1, 2, 5, 13, 14, 36, 40-42, 53-57, 60, 61, 64, 65, 67-71, 74, 76-80.

FIS: 13.

Nitzschia elliptica var. *alexandrina* Cholnoky

Cholnoky, 1958 : 258, Figs 29, 30.

Synonyms: *Nitzschia aurariae* Cholnoky, 1966c : 165, Figs 15-18.

Description: Valves linear-elliptical to linear with almost parallel sides, poles broadly rounded and not protracted; length 6,5 - 18,0 µm, breadth 2,5 - 4,0 µm . Canal raphe marginal, narrow, not interrupted at the centre by a central nodule, and having 13 - 18 small dot-like fibulae in 10 µm . Transapical striae very fine, mostly not resolved under the light microscope, but when visible difficult to count and probably number more than 40 in 10 µm .

Taxonomic notes: Cholnoky (1966b : 201) expressed the thought that this variety was only bound to *Nitzschia elliptica* Hustedt (1949a : 148, Pl. 13, Figs 32-34) through a morphological similarity, and suggested that the var. *alexandrina* should be treated as a species. This suggestion is probably true, but the type material of *N. elliptica* has not been examined, and Cholnoky himself did not actually raise the variety to the rank of species. The variety has therefore been retained for the present. Cholnoky did, however, describe a species of *Nitzschia* from the Napier Dam at the Harmony Gold Mine near Welkom in the Orange Free State, which is identical to *N. elliptica* var. *alexandrina*. This species is *Nitzschia aurariae* Cholnoky (1966c : 165, Figs 15-18). The type specimens of the latter were examined on the type slide (slide Napier Dam - Plankton - NIWR), and these agreed with the diagnosis of *N. elliptica* var. *alexandrina*. There was, however, a discrepancy in the diagnosis of *N. aurariae* when Cholnoky claimed that the striae (40 in 10 µm) were visible. Although a close examination was carried out not a single valve with visible striae could be detected. Nevertheless Cholnoky (1963d : 36) also recorded striae being visible in specimens of *N. elliptica* var. *alexandrina* from the Zoological gardens in Windhoek. In the Sundays and Great Fish rivers very typical specimens were observed, and corresponded well in the dimensions of length given in the diagnoses of both *N. elliptica* var. *alexandrina* and *N. aurariae*, while in breadth and density of fibulae they belong to the narrower valve type (2,5 - 3,5 µm) similar to *N. aurariae*. Transapical striae were never visible. Futher research is necessary to determine the exact systematic relationship of this taxon to *N. elliptica*.

Euryhaline mesohalobe - 5.

Figs: 377, 378.

Samples: SUN: 1, 4, 5, 10, 11, 15-18, 20-25, 27, 28, 33, 35, 36, 39, 41, 42,
48, 49, 52-54, 57, 60, 61, 67, 72, 74-78.
FIS: 3-6, 9, 14, 16-19, 21, 24-27, 29-33, 35, 37, 40.

Nitzschia erosa Giffen

Giffen, 1966a : 274, Figs 85-87.

Taxonomic notes: Representatives of this taxon observed at Station 4 on the Sundays River were quite typical, having the irregularly spaced and irregularly elongated fibulae, as well as the characteristic sinus at the poles. The species was not uncommon in the samples and the few specimens measured had the following dimensions:- length 30,9 - 40,0 µm, breadth 3,9 - 5,3 µm, breadth of frustule 10,8 - 12,3 µm, and had 8 - 14 fibulae in 10 µm . These specimens extend the lower limit of the range of variation, being generally shorter and somewhat narrower than Giffen's specimens from Kidd's Beach.

Meioeuryhaline polyhalobe - 9.

Figs: 379-381.

Samples: SUN: 80, 81.

Nitzschia fasciculata Grunow

Grunow in Van Heurck, 1880-83 : Pl. 66, Figs 11-13.
Hustedt, 1930 : 421, Fig. 815.

Taxonomic notes: The specimens observed at Station 1 on the Sundays River were compatible in structure and valve shape with a number of specimens examined on Grunow's slide No. 1759 (Vienna). They were, however, much smaller, and in this respect fitted the dimensions given by Hustedt (1930 : 421) and Boyer (1927 : 530). In girdle view the Sundays River specimens were strongly sigmoid and lanceolate. In valve view the valves were less markedly sigmoid, and sometimes the apical axis was almost straight with only the protracted poles of the lanceolate to linear-lanceolate valve curving slightly in opposite directions. The fibulae were typically transapically elongated and very prominent. The striae on the other hand were very faint and most often remained unresolved. When visible they appeared indistinct, and the obliquely crossing or undulate patterning of the puncta could just be made out. The dimensions of the specimens measured were:- length 33,0 - 50,0 μm, breadth 3,5 - 4,9 μm, striae 30 - 32 in 10 μm, and fibulae 5 - 8 in 10 μm. Cholnoky (1968a : 70) recorded a specimen having much finer striation, 34 - 36 in 10 μm; however the rest of the structure makes it clear that this specimen does indeed belong to this taxon. In contrast the correct identity of the specimen figured by Cholnoky (1955a : 20, Fig. 38) is not at all certain. Cholnoky placed this example in *N. fasciculata*, but the valve shape and small fibulae with a central wider separation strongly support the suggestion that this identification is misplaced. What taxon the illustration represents is rather difficult to decide.

Pleioeuryhaline polyhalobe - 7.

Samples: SUN: 59, 86.

Nitzschia filiformis (W. Smith) Schütt

Schütt, 1896 : 145, Fig. 261a-c.
Hustedt, 1930 : 422, Fig. 818.

Synonym: *Homoeocladia filiformis* W. Smith, 1856 : 80, Pl. 55, Fig. 348.

Taxonomic notes: Typical examples of this taxon were observed in both the Sundays and Great Fish rivers. These specimens measured 34,0 - 54,0 μm in length, 4,0 - 5,0 μm in breadth, and contained 36 striae and 8 - 10 fibulae in 10 μm .

Euryhaline mesohalobe - 5.

Samples: SUN:30-32, 59, 73, 84, 86.
FIS: 37.

Nitzschia fonticola Grunow

Grunow in Van Heurck, 1880-83 : Pl. 69, Figs 15-20.
Hustedt, 1930 : 415, Fig. 800.

Taxonomic notes: A precise definition of this very commonly occurring species is not possible at this stage, since further research of Grunow's material and its comparison with other specimens is still necessary. Hustedt (1930 : 415, Fig. 800) gives a somewhat limited description of this taxon. He described the taxon in this publication as lanceolate with dinstinctly protracted, acute and sometimes weakly capitate poles. The material (Grunow slide No. 1531 - Vienna) from which Grunow made some of his illustrations of this taxon for Van Heurck's (1880-83) Atlas has been examined. It is immediately evident that the species has a much wider variability in valve shape. The valves varied from linear with parallel central portion and fairly long cuneately protracted poles and capitate apices, through linear-lanceolate to lanceolate valves. The poles varied from being distinct cuneately attenuating poles to a smooth continuation of the lanceolate margin into protracted rostrate or distinctly capitate poles. This variation is adequately illustrated by Grunow in Van Heurck (1880-83) on plate 69, figures 15-20. One extremely important feature, which appears to have escaped the notice of all other diatom taxonomists, is the distinct separation of the central two fibulae observed in nearly every specimen examined. This generally indicates the presence of a central nodule interrupting the external raphe fissure. The specimens on this slide present a somewhat different concept of *N. fonticola* compared with that given by Hustedt (l.c.). Hustedt (1949a : 142, Pl. 13, Figs 75-83, 91-93), however, did subsequently observe a much greater variation in valve shape in specimens gathered in the Congo. Nevertheless these still do not show more widely spaced fibulae at the centre of the canal raphe. There is therefore a slight discrepancy between the two concepts. The problem has not been sufficiently researched to make any definite proposals, and the species needs further examination before a more detailed comment can be made. Notwithstanding this, the specimens identified in this study as *N. fonticola* correspond more with Hustedt's concept of the taxon as mentioned above.

Pleioeuryhaline oligohalobe - 3.

Figs: 382-384.

Samples: SUN: 1, 5-13, 15-28, 30, 32, 34-39, 41-43, 45-51, 53, 55, 57, 60-67, 72, 73, 75, 76.
FIS: 1-14, 16-33, 36-40.

Nitzschia fontifuga Cholnoky

Cholnoky, 1962a : 54, Figs 76, 77.

Synonyms: *Nitzschia fundi* Cholnoky, 1968a : 72, Figs 127-130.

Description: Valves weakly silicified, lanceolate to linear-lanceolate with poles protracted into relatively narrow subacute, rostrate or subcapitate apices; length 7,4 - 26,0 µm breadth 2,2 - 3,9 µm . Canal raphe marginal, narrow with small roundish to short dash-like fibulae, (14) 15 - 20 in 10 µm; raphe not interrupted at the centre by a central nodule, central fibulae therefore not more widely separated than the others. Transapical striae very fine, hitherto not observed under the light microscope.

Taxonomic notes: The identification of this taxon from the Sundays and Great Fish rivers was problematical, partly on account of inaccuracies in the original diagnosis of this taxon as well as that of *N. fundi* Cholnoky (l.c.). Studying the type slide for *N. fontifuga* (slide No. K 166 - NIWR) it was discovered that it had a much wider range of variation in its dimensions than stated in the diagnosis. The breadth of the valves, as given by Cholnoky (1962a : 54), was 3,0 - 4,0 µm, but no specimens of this width were observed; breadths of valves personally measured were 2,2 - 2,9 µm . Furthermore the number of fibulae in 10 µm (16 - 20) was greater than the density given by Cholnoky (15 - 17). After examining a type slide of *N. fundi* (slide No. SL 21 - NIWR) the same criticism can be levelled at its diagnosis. Many valves had widths less than the lower limit given by Cholnoky (1968a : 72), and the density of the fibulae had a slightly greater range. Comparing the two species, *N. fontifuga* and *N. fundi*, it was found that there were large areas of overlap in all features, and it became obvious that the two species actually belonged to the same range of variation. *N. fontifuga* embraced the smaller specimens, while *N. fundi* the larger. A clear distinction between the taxa could not be found. Therefore *N. fundi* must fall away as a later synonym of *N. fontifuga*. The description of *N. fontifuga*, given above, is based on personal observation of the type slides of both these species and on material collected from the Sundays and Great Fish rivers.

Another species which requires close comparison with *N. fontifuga* is *Nitzschia perindistincta* Cholnoky (1960a : 101, Fig. 304). The original diagnosis depicts a relatively broader taxon than *N. fontifuga*, although most other features are similar. Cholnoky (1963c : 75, Fig. 99) depicted a specimen of *N. perindistincta* from the Knysna Lagoon remarkably similar to *N. fontifuga* as described here. The breadth of the Knysna specimens were 3,0 µm wide even in the longest individuals. These specimens would probably be better considered as *N. fontifuga*. On the other hand Cholnoky (1962a : 58, Fig. 89) contended that he had observed larger specimens, and tentatively placed one very large and broad specimen (cf. Cholnoky l.c. : Fig. 90) with *N. perindistincta*. It seems clear that Cholnoky did not have a precise definition of *N. perindistincta*. More extensive study of this taxon may prove that it also should be considered as conspecific with *N. fontifuga.*

On morphological grounds the larger specimens of this taxon, previously referred to as *N. fundi*, are very close related to *N. kuetzingioides* Hustedt, 1959 : 417, Figs 25-29), but differ in the more numerous fibulae in 10 µm . On physiological grounds, however, there is a more significant difference. *N. kuetzingioides* has, as far as is known, only been recorded from the Neusiedler Sees in Austria, apart from two references from Southern Africa by Schoeman (1973a : 190, Pl. 6, Figs 199-201; 1973b : 122, Fig. 2). These localities arc alkaline freshwater situations, while *N. fontifuga (= N. fundi)* is found in brackish waters of the coastal areas. On the basis of their autecology *N. fontifuga* has been retained as distinct from *N. keutzingioides*.

Euryhaline mesohalobe - 5.

Figs: 385-391.

Samples: SUN: 4, 5, 9, 15, 30-32, 34, 36, 42, 51, 57, 62, 63, 69, 70, 72, 73, 78, 80, 81, 83-85.
FIS: 11, 13, 39, 40.

Nitzschia frequens Hustedt

Hustedt, 1957 : 348, Figs 52-54.

Taxonomic notes: The specimens from the Sundays and Great Fish rivers, assigned to this taxon, appear to be quite typical in valve shape and dimensions. They were linear with slightly concave walls, and had long cuneate poles with capitate apices. The valves were 40,0 - 52,0 µm long and 4,2 - 5,0 µm broad. There were thus some slightly smaller forms than suggested by the original diagnosis (Hustedt l.c.). The density of the fibulae (12 - 14 in 10 µm) correspond with this diagnosis, but the transapical striae were more closely spaced, 26 - 29 in 10 µm . Cholnoky (1962a : 55, Figs 78, 79; 1968a : 71, Fig. 126) twice recorded this species from South Africa. These specimens displayed widely different striae densities, 22 - 25 in 10 µm in the western Cape Province examples, and 30 striae in 10 µm in a specimen from Lake St. Lucia. The valve shape of the specimens he illustrated casts some doubt on the accuracy of his identification. Nevertheless the observation of almost typical examples in the Sundays and

Great Fish rivers does not preclude the possibility of the taxon being found at the two localities investigated by Cholnoky.

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 15-19, 30, 32, 50, 63, 72, 73.
FIS: 4, 9, 11.

Nitzschia frustulum (Kützing) Grunow

Grunow in Cleve et Grunow, 1880 : 93.
Grunow in Van Heurck, 1880-83 : Pl. 68, Figs 27-30.
Hustedt, 1930 : 414, Fig. 795.

Synonyms: *Synedra frustulum* Kützing, 1844 : 63, Pl. 30, Fig. 77.

Taxonomic notes: Under this taxon a number of forms have been placed together whose identity is somewhat doubtful as *N. frustulum*. Nevertheless apparently even Kützing was not constant in what he named *N. frustulum* (cf. Lange-Bertalot, 1976 : 262) as a number of deviating forms occur under this name in his herbarium. Lange-Bertalot (l.c.) selected Kützing material No. 242 as the type material of this species. This material was examined on a slide prepared by Grunow (Grunow slide No. 2479 - Vienna), and the following is a brief description of the forms found on it - valves variable in outline from linear with cuneate poles to broadly lanceolate or elliptical in the smallest forms; poles generally not protracted or only slightly so, but sometimes distinctly protracted; apices varied from acute to relatively broadly rounded (particularly in smaller elliptical forms); length 8,5 - 40,5 µm, breadth 4,0 - 4,5 µm . Canal raphe was marginal with typical V- or X- or thickish bar-shaped fibulae, of which the central two were nearly always distinctly separated, 10 - 12 in 10 µm . Transapical striae were distinct, and generally clearly punctate, 20 - 24 in 10 µm . Other Grunow slides (nos 1007 and 2899 - Vienna) show further variations in the form and structure of *N. frustulum*. The poles of the valves may be protracted into rostrate apices; the breadth varied from 2,9 to 4,0 µm; the transapical striae ranged from 22 to 25 in 10 µm, and the fibulae from 8 - 12 in 10 µm .

In the Sundays and Great Fish rivers there appear to be two forms combined into this taxon. The first group agrees quite clearly with the specimens seen in the Kützing and Grunow materials, being generally linear in shape with cuneate poles ending sometimes in slightly rostrate apices. These specimens had striae counts varying between 21 and 24 in 10 μm, while the fibulae were 10 - 12 (14?) in 10 μm . The other group is more cautiously identified as *N. frustulum*. The valves of this group were generally broader and more lanceolate to linear-lanceolate, with the cuneate poles narrowing to a relatively greater degree. The transapical striae lay constantly between 24 and 26 in 10 μm, and the fibulae between 12 and 14 in 10 μm . The latter were usually somewhat different in appearance from those in the first group, being more regularly V-shaped than X-shaped or band-like. The striae, furthermore, had a more mottled or flecky appearance than those of the first group. Often examples of the two groups were observed in the same sample, and in many such cases were quite easy to distinguish. However on other occasions the apparent differences became so subtle that separating them became extremely difficult.

The second form discussed above is in many respects similar to *Nitzschia romana* Grunow (in Cleve and Grunow, 1880 : 97), but a comparison between specimens on Grunow's type slide (No. 1394 - Vienna) and the Sundays River forms showed the latter to be just as different from *N. romana* as it is from *N. frustulum*. Another possibility for the lanceolate forms is *Nitzschia romanoides* Manguin (1952 : 110, Pl. 10, Fig. 214a-c). Although very close in shape, Manguin's species appears to be broader, and more densely striate (28 - 30 in 10 μm).

Since these forms cannot be identified with anything else, and because it is sometimes very difficult to distinguish between these lanceolate forms and those more readily identifiable as *N. frustulum*, it was decided to consider them as a single entity.

In the Sundays and Great Fish rivers the forms identified as *N. frustulum* were 14,5 - 27,0 μm long, 2,5 - 5,5 μm broad and had 21 - 26 striae and 10 - 14 fibulae in 10 μm .

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 4-6, 8, 9, 11, 13, 15-24, 28, 30-32, 34-37, 41, 48-54, 60, 61, 63-66, 72-76.

FIS: 3-6, 8-21, 23-26, 29-33, 35, 36.

Nitzschia gracilis Hantzsch

Hantzsch, 1860 = 40, Pl. 6, Fig. 8.
Rabenhorst, 1864 : 158.
Hustedt, 1930 : 416, Fig. 794.

Taxonomic notes: Specimens on two slides (Nos N2, 73; N2, 74 - Bremerhaven) in the Hustedt collection made from Rabenhorst's Alg. Eur. No. 946 material were typically as Hustedt (l.c.) described and illustrated them. There were, however, some smaller specimens which were more lanceolate in shape. The range in dimensions of these specimens was:- length 39,0 - 99,8 µm, breadth 3,4 - 4,2 µm, and they had 12 - 18 fibulae in 20 µm; the striae were very fine and usually remained invisible under the light microscope, occasionally they were resolved, but were too fine and faint to count. Lange-Bertalot (1976 : 259) has also examined this Rabenhorst material and has come to essentially the same conclusion. He observed specimens barely longer than 30 µm, and gives some good illustrations of the complete range in size of the specimens (Lange-Bertalot l.c.: Pl. 2, Figs 1-5). A single, presumably stray, specimen was observed at the brackish water Station 3 at the head of the estuary of the Sundays River. This specimen was 39,0 µm long, 3,5 µm broad and had 14 fibulae in 20 µm; the striae were not visible.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 4.

Nitzschia granulata Grunow

Grunow in Cleve and Grunow, 1880 : 68.
Grunow, 1880b : 395, Pl. 12, Fig. 7.
Grunow in Van Heurck, 1880-83 : Pl. 57, Fig. 5.

Taxonomic notes. This taxon, found quite frequently in the South African marine littoral, was observed in a brackish water seepage pool at Station 5 of the Sundays River. The few specimens seen here were quite typical of the description and the specimens examined on Grunow's slides (Nos 1645a, b, 1738c and Cleve et Möller slide No. 204 - Vienna).

Meioeuryhaline polyhalobe - 9.

Samples: SUN: 76.

Nitzschia harrissonii Cholnoky

Cholnoky, 1960b : 259, Figs 34, 35.

Taxonomic notes: One example of this taxon was observed in the Sundays River. This specimen was rather smaller than those described by Cholnoky (l.c.) from the Swartkops River near Port Elizabeth. The specimen measured 13,0 µm long, 3,5 µm broad and had 36 striae and 14 fibulae in 10 µm . This appears to be the first record of the species outside the type locality.

No ecological characterization made.

Samples: SUN: 5.

Nitzschia holsatica Hustedt

Hustedt, 1930 : 416, Fig. 803.

Synonyms: *Nitzschia bacata* Hustedt 1937-38 : 485, Pl. 41, Figs 30-33.

Taxonomic notes: In Hustedt's slide collection there is only one (slide No. W2, 100 - Bremerhaven) designated by Hustedt himself as the type slide of *N. holsatica*. According to Hustedt's records this slide contains amongst the other taxa only two species of *Nitzschia*, viz. *N. palea* and *N. holsatica*. It was therefore extremely surprising on examining the slide to find in addition to these two species high numbers of a form with widely separated central fibulae that could be identified as *Nitzschia bacata* Hustedt (l.c.). These forms were so numerous that it is hard to believe that Hustedt overlooked them. It is therefore presumed that they were considered by Hustedt as *N. holsatica*, and that the separated central fibulae were either unobserved or ignored by Hustedt. Comparison of *N. holsatica* and *N. bacata* showed that the only feature separating them significantly was the presence of more widely spaced central fibulae in *N. bacata*. Observations of this characteristic in specimens regarded by Hustedt as *N. holsatica* brings into consideration the relationship between the two species. Careful examination of the type slide of *N. holsatica* revealed the typical star-shaped colonies as described and depicted by Hustedt (1930 : 416, Fig. 803). In some of these colonies the valves were typical in shape and no separation of the central fibulae were observed. On the other hand in other similar colonies some frustules had one valve with a distinct separation of the central fibulae, while the other did not. This suggested that the separation of the central fibulae is found in *N. holsatica*, but that it is not a constant feature. This may be why Hustedt ignored it. Further examination of the type slide revealed, moreover, a bushy colony consisting of numerous specimens, which could be identified as *N. holsatica*, following Hustedt's description, or equally well as *N. bacata* Hustedt (1937-38 : 485, Pl. 41, Figs 30-33), since all specimens had distinctly separated central fibulae. To verify that these specimens could indeed be considered as *N. bacata*, type slides of this taxon (slide Nos W2, 78; W4, 60 and W4, 61 - Bremerhaven) were examined. The examples of *N. bacata* found on these slides agreed very well with Hustdt's diagnosis of the species, but in some specimens transapical striae were observed (40 - 44 in 10 µm). More significant, however, was the fact that there were no essential differences between these specimens and the long thin forms of *N. holsatica* having more widely spaced central fibulae. Two options therefore exist; either Hustedt failed to recognise two distinct but very similar taxa on the type slide of *N. holsatica* (Slide W2, 100), or *N. holsatica* and *N. bacata* are conspecific. The latter choice is the one preferred for two reasons -

(i) the presence of separated central fibulae in some valves of the typical star-shaped colonies of *N. holsatica*, and

(ii) typical *N. bacata* specimens forming bushy colonies characteristic of *N. holsatica*.

Considering the above evidence *N. bacata* is therefore regarded as synonymous with *N. holsatica*. In this regard it is interesting and not surprising to find that in the type material of *N. bacata*, both it and *N. holsatica* were found in abundance (cf. Hustedt, 1937-38 : 484 and 485; 1938 : 639 and 640, Table 1). This adds a measure of support for considering both species as conspecific.

In his recent revision of the *Nitzschiae lanceolatae* Lange-Bertalot (1976 : 258) considered *N. holsatica* to be synonymous with *N. paleacea* Grunow (in Cleve and Grunow, 1880 : 95), but does not provide much evidence for this. Until more substantial evidence verifying this hypothesis is obtained *N. holsatica* has been retained as a distinct and valid taxon.

In view of the fact that the separation of the central fibulae is variable in *N. holsatica*, some reappraisal of *Nitzschia mediocris* Hustedt (1949a : 149, Pl. 13, Figs 21-24) is necessary. According to Hustedt it differs from *N. bacata (= N. holsatica)* in the construction of the centre of the canal raphe, i.e. *N. mediocris* does not have central fibulae set more distantly apart than the others. Hustedt does not mention how he distinguishes *N. mediocris* from *N. holsatica*, but the descriptions of these two species correspond almost exactly. *N. mediocris* might well represent the longer forms of *N. holsatica* as were drawn by Hustedt in A. Schmidt *et al.* (1874-1959 : Pl. 351, Fig 14). In a number of forms observed on the type slide of *N. mediocris* (slide No. 243, 6 - Bremerhaven) no evidence of separated central fibulae could be detected however.

Specimens of this taxon (i.e. *N. holsatica*) occurring in the Sundays River were rather more lanceolate to linear-lanceolate with slightly protracted poles and capitate apices. The valves were also shorter but relatively broader, being 22,0 - 33,5 µm long, about 2,5 µm broad and having 14 - 18 fibulae in 10 µm .

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 15-17, 21, 22, 25, 26, 43, 50, 51.

Nitzschia hungarica Grunow

Grunow, 1862 : 568, Pl. 12, Figs 31a, b.
Grunow in Van Heurck, 1880-83 : Pl. 58, Figs 19-25.
Hustedt, 1930 : 401, Fig. 766.
Schoeman and Archibald, 1976-80 : No. 1.

Description: Valves linear with parallel to slightly constricted or weakly concave margins, poles cuneate with short protracted subrostrate to rostrate apices; length 20,0 - 110,0 µm, breadth (4,0) 5,0 - 9,0 µm . Canal raphe narrow, marginal; fibulae small roundish to rod-like, but fairly conspicuous, the central two fibulae more widely separated, 7 - 11 in 10 µm . Transapical striae prominent, 16 - 18 (20) in 10 µm, interrupted by a median to slightly eccentric, longitudinal fold.

Under SEM the structure of this species resembles closely that of *Nitzschia apiculata*. The outer surface of the valve is crossed by a longitudinal fold which is not traversed by the transapical striae, while the costae appear as faint stippled ridges running across the fold. Externally the transapical striae appear as a double row of alternating puncta perforating the intercostal membranes between the costae. The striae and costae on the side away from the raphe terminate against a very narrow ridge, on the mantle side of which there is a single punctum opposite each stria. The canal raphe is located on a wing, with the external fissure interrupted at the centre by a central nodule. Internally the raphe communicates with the cell contents by a series of interspaces separated by short thick rod-like fibulae. The central interspace opposite the central nodule is much larger, thus separating more widely the central two fibulae.

Taxonomic notes: Specimens occurring in the Sundays and Great Fish rivers are identical with those examined on the Van Heurck Slide No. 380 (Vienna). These had the following dimensions:- length 29,0 - 86,5 µm, breadth 4,5 - 9,0 µm, transapical striae 16 - 18 (22) in 10 µm and fibulae 8 - 10 (12) in 10 µm .

Euryhaline mesohalobe - 5.

Fig: 64.

Samples: SUN: 3-6, 8-11, 13, 15, 16, 19, 21-24, 26-28, 30, 31, 34-37, 41, 45-48, 50, 51, 53, 54, 57, 59, 60, 61, 63, 66, 72, 74-76.
FIS: 3-6, 9, 10, 14, 16-18, 20, 21, 23-32, 36, 37.

Nitzschia hustedtiana Salah

Salah, 1952 : 166, Pl. 2, Fig. 9.

Synonyms: *Nitzschia hustedtiana* Cholnoky, 1959 : 59, Figs 313-315.
Nitzschia punctata f. *minores* Hustedt, 1937-38 : 466, Pl. 40, Figs 31, 32.
Nitzschia subpunctata Cholnoky, 1960a : 104, Fig. 314.
Nitzschia chutteri Archibald, 1966a : 265, Figs 47, 48.

Taxonomic notes: Salah (l.c.) described from Blakeney Point, Norfolk, a new species of *Nitzschia*, *N. hustedtiana*. This taxon was distinguished from other members of the section *Tryblionellae* by possession of a "very shallow and indistinct longitudinal fold together with fine puncta and pointed apices". Salah (l.c.) considered that *Nitzschia punctata* formae *minores* Hustedt (1937-38 : 466, Pl. 40, Figs 31, 32) was the same as his *N. hustedtiana*, but that the former was slightly narrower and the longitudinal fold was more distinct. Nevertheless ringed specimens on the type slide of *N. punctata* f. *minores* (Slide No. Nel, 81 - Bremerhaven) had dimensions almost identical to Salah's measurements for *N. hustedtiana*. Hustedt's specimens were 14,7 - 17,7 µm long, 5,5 - 6,0 µm wide and had 16 - 19 striae and about 17 fibulae in 10 µm . The longitudinal fold was perhaps stronger and the puncta in the fold were weakly developed. The development of the longitudinal fold seems to be somewhat variable and has given rise to the distinction of two further species, which after further consideration should be united with *N. hustedtiana*. Cholnoky (1960a : 104, Fig. 314) distinguished his *Nitzschia subpunctata* from *N. hustedtiana* on the grounds of a different valve form and the "considerably" finer structure. It is obvious from these comments that Cholnoky did not have a clear concept of *N. hustedtiana*, as his dimensions for *N. subpunctata* (length 15,0 - 20,0 µm, breadth 5,0 - 6,0 µm, striae 16 - 18 in 10 µm) tally almost exactly with those of *N. hustedtiana* Salah (l.c.) and those of the specimens on Hustedt's type slide of *N. punctata* f. *minores*. Examination of Cholnoky's type slide for *N. subpunctata* (TUG 225 - NIWR) showed furthermore that this taxon was probably closer to Salah's species than Hustedt's f. *minores*, since the longitudinal fold was weakly developed and the valves had distinct, acutely protracted apices. There is no doubt that *N. subpunctata* is conspecific with *N. hustedtiana*, and the former must be regarded as a synonym of the latter. Similarly *Nitzschia chutteri* Archibald (1966a : 265, Figs 47, 48) must be included with *N. hustedtiana* as a more recent synonym, as it is merely a form with a greater development of the longitudinal fold. *N. chutteri* usually showed the development of a narrow secondary fold near the margin opposite the keel. However so many intermediate stages exist between *N. chutteri* with two folds and *N. hustedtiana* with a single fold, that there are no further grounds for the distinction of *N. chutteri* as a separate species. Consequently it has also been sunk into *N. hustedtiana*.

The dimensions of the Sundays and Great Fish river specimens must be recorded as they enlarge the range of variation of the taxon:- length 12,5 - 20,9 µm, breadth 5,5 - 8,0 µm, striae 16 - 18 in 10 µm, fibulae 16 - 18 µm . Both Salah (l.c.) and Cholnoky (1960a : 104) described the canal raphe as indistinct, and this is probably true in bright field illumination, but under phase contrast the fibulae can be detected fairly easily. They correspond with the transapical costae and therefore agree in number with the striae, which alternate with the costae.

It is interesting to note that Cholnoky (1959 : 59, Figs 313-315) also proposed the combination *Nitzschia hustedtiana* for the small forms of *N.*

punctata (i.e. *N. punctata* formae *minores*) observed by Hustedt. However Salah (l.c.) first used the combination in this respect some seven years earlier, and is thus the rightful author of the combination.

Euryhaline mesohalobe - 5.

Figs: 392-394, 554.

Samples: SUN: 4, 5, 14, 16, 18, 19, 32, 40, 51, 56, 63, 72, 73, 81.
FIS: 9-13, 15, 25, 26, 27, 36-41.

Nitzschia hybrida Grunow

Grunow in Cleve and Grunow, 1880 : 79, Pl. 5, Fig. 95.
Grunow in Van Heurck, 1880-83 : Pl. 60, Figs 4, 5.
Hustedt, 1930 : 406, Fig. 778.

Taxonomic notes: A single specimen was observed at the mouth of the Great Fish River estuary on the mud surface above the low water mark. This specimen corresponded almost exactly with the description, but was slightly narrower and more densely striated. Its dimensions were:- length 87,8 µm, breadth 6,8 µm, transapical striae 27 in 10 µm and fibulae 10 in 10 µm .

Euryhaline mesohalobe - 5.

Samples: FIS: 15.

Nitzschia hybridaeformis Hustedt

Hustedt, 1955 : 44, Pl. 15, Figs 9-11.

Taxonomic notes: A number of specimens of this taxon, agreeing in most details with Hustedt's (l.c.) diagnosis, were observed in the Sundays River estuary. They were, however, somewhat smaller being 43,9 - 50,5 µm long and 3,3 - 5,4 µm wide at the constriction. The taxon has been recorded on a number of occasions from South African estuaries (Cholnoky, 1968a : 73, Fig. 133) and in the marine littoral (Giffen, 1973 : 41; 1975: 90; 1976 : 390). The Sundays River specimens were also smaller than the others recorded from South Africa. Giffen, however, found a rather greater range in striae density. The majority of his specimens have 27 - 33 striae in 10 µm, while he assigned some large forms, in which the striae remained unresolved, to this taxon. The examples from the Sundays River seemed typical in this respect, having 36 - 38 very delicate striae in 10 µm, although one specimen had 32 striae in 10 µm .

Meioeuryhaline polyhalobe - 9.

Figs: 395-397.

Samples: SUN: 59, 83, 84.

Nitzschia inconspicua Grunow

Grunow, 1862 : 579, Pl. 12, Fig. 25.
Grunow in Van Heurck, 1880-83 : Pl. 69, Fig. 6.

Taxonomic notes: Some difficulty was experienced in identifying accurately some small *Nitzschia* forms found in nearly every sample gathered in the two river systems. Following the identifications of similar specimens in Southern African rivers by Cholnoky, these specimens were identified variously as *Nitzschia perpusilla* Rabenhorst (1864 : 159), *N. perminuta* Grunow (in Cleve and Grunow, 1880 : 97), *N. liebetruthii* Rabenhorst (1864 : 157) and *N. obsoletiformis* Cholnoky (1966b : 204, Figs 89-92). However a subsequent review of these specimens showed a very wide range in morphological variation and in the density of striae and fibulae. This variation with linking intermediate forms made distinction of the taxa mentioned above impossible, and all forms must be considered as one taxon. Having examined the type material of *N. perpusilla* (Rabenhost, 1861-79 : Alg. Eur. No. 1164), as well as that of *N. hantzschiana* (l.c.: Alg. Eur. No. 943) it was quite clear that these two taxa are conspecific, confirming Lange-Bertalot's (1976 : 266) conclusions. It was also evident that neither of these two species was really similar to the specimens found in the Sundays and Great Fish rivers. A number of these forms also showed a great similarity to *Nitzschia liebertruthii*, since they were narrow linear-lanceolate forms with acutely protracted apices. Lange-Bertalot (l.c.: 261) pointed out that Grunow (1862 : 575, Pl. 12, Fig. 17; and in Cleve and Grunow, 1880 : 98) gave two different descriptions for *N. liebetruthii*. The first indicated a coarsely striate form (17 striae in 10 μm), while the second described a more finely striate form (24 - 25 striae in 10 μm) with acute apices. Unfortunately there does not appear to be any type material to verify the coarsely striate forms, but a slide (Grunow slide No. 1031 - Vienna) containing examples of the narrow, more finely striate forms were examined. These forms resembled very closely some examples from the Sundays and Great Fish Rivers. Nevertheless the local examples of the narrow specimens with acutely rounded apices graded imperceptably into broader specimens with relatively broadly rounded unprotracted apices. These latter forms agree exactly in morphology and dimension with *Nitzschia inconspicua* Grunow (1862 : 579, Pl. 12, Fig. 25), a species recently resurrected by Lange-Bertalot (1976 : 265, Pl. 2, Figs 22-25; Pl. 9, Figs 1, 2). Lange-Bertalot commented that *N. inconspicua* is often mistaken for

N. perpusilla, but there is in fact no connection. *N. inconspicua*, as defined and illustrated by Lange-Bertalot, seems to include most of the forms observed in the Sundays and Great Fish rivers. Consequently all these forms have been identified as *N. inconspicua*.

Cholnoky (1966b : 204, Figs 89-92) described *Nitzschia obsoletiformis*, with one of its distinguishing features being the canal raphe "aber immer mit einem deutlichen Mittelknoten, weshalb die beiden mittleren Kielpunkte voneinander entfernter gestellt sind". However specimens on the type slide (slide No. SWA 94 - NIWR), as well as many identical examples from the Sundays River material (sample No. SUN 38 - NIWR) showed clearly that this separation of the central fibulae was not a constant feature. In some specimens the separation was most conspicuous, while in others it is very indistinct, if present at all. Such specimens, identifiable as *N. obsoletiformis*, from these two river systems also graded into the *N. inconspicua* forms discussed above, and are thus regarded as part of the range of variation for *N. inconspicua*. A species, possibly closely related to *N. obsoletiformis*, is *Nitzschia luzonensis* Hustedt (1942a : 137, Figs 331-336). Its type slide (Hustedt slide No. W4, 73 - Bremerhaven) has been examined, and the structure of the examples observed on this slide agreed very closely with *N. obsoletiformis*. Here also, contrary to Hustedt's description, the central fibulae were neither constantly spaced or conspicuously widened.

Finally identification of specimens from the Sundays and Great Fish rivers as *N. perminuta* does not seem to be feasible, since Lange-Bertalot (personal communication) claimed that this taxon is an acid water species. Such conditions have not been shown to exist at the sampling sites selected for this study.

Considering the wide range of variation among the Sundays and Great Fish River examples, and the uncertainty about some species, e.g. *N. liebetruthii* and *N. obsoletiformis*, it was decided that it would be best to regard all specimens as *Nitzschia inconspicua*, until a more detailed study of the various forms can be carried out.

The dimensions of the local examples were as follows:- length 6,5 - 37,0 µm, breadth 2,0 - 4,0 µm, striae 24 - 30 (32) in 10 µm, and fibulae (10) 12 - 14

(16) in 10 µm . A central nodule is present, but is not always indicated by a conspicuous separation of the central two fibulae.

Pleioeuryhaline oligohalobe - 3.

Samples: SUN: 1, 3-39, 41-43, 45-57, 59-67, 69, 70, 73-83, 85.
FIS: 2, 3, 5-8, 10-20, 22-27, 29-33, 35-37, 39, 40.

Nitzschia intermedia Hantzsch

Hantzsch ex Cleve and Grunow, 1880 : 95.
Grunow in Van Heurck, 1880-83 : Pl. 69, Fig. 10.
Hustedt, 1949a : 136, Pl. 12, Figs 21-23.

Taxonomic notes: Discussions of the interrelationships between *Nitzschia intermedia*, and other similar *Nitzschia* species have continued inconclusively for a number of years (cf. Hustedt, 1937-38 : 477, Pl. 41, Figs 4-7; 1949a : 136, Pl. 12, Figs 21-23; Cholnoky 1970a : 44). In the most recent review of this taxon Lange-Bertalot (1976 : 267, Pl. 4, Figs 1-12; Pl. 5, Figs 1-10; Pl. 6, Figs 1-13) examined the type materials of a number of closely related species. He found that a large number of species previously regarded by Hustedt as distinct from each other are in fact examples of a taxon with a very wide range of variability. He pointed out that in Hustedt's analysis sheets of samples, in which these species are found, two or three taxa are found together, or on the other hand occurred very infrequently. Lange-Bertalot claimed to have examples covering all forms of this taxon in a small area of the River Loire. The following taxa previously recorded from Southern Africa are now considered synonymous with *N. intermedia*:- *Nitzschia capitellata* Hustedt (1930 : 414, Fig. 792), *N. regula* Hustedt (1922 : 150, Pl. 10, Fig. 57), *N. tarda* Hustedt (1949a : 138, Pl. 12, Figs 24-26), *N. reguloides* Cholnoky (1954a : 221, Fig. 101), *N. goetzeana* O. Müller (1905 : 176, Pl. 2, Fig. 20). Lange-Bertalot (l.c.) also claimed that *N. congolensis* Hustedt (1949a : 134, Pl. 12, Figs 15, 16) was most likely synonymous with *N. intermedia*. On the basis of his investigations Lange-Bertalot (l.c.) redefined the taxon as follows:- Valve linear to linear-lanceolate with variably long protracted, bluntly rounded or capitate poles, margins seldom slightly concave, 25,0 - 200,0 µm long and 4,0 - 7,0 µm wide. The raphe is not interrupted by a central nodule, and the central fibulae are equidistant, fibulae 8 - 13 in 10 µm . Transapical striae 21 - 33 in 10 µm . The Sundays and Great Fish River specimens were previously identified under *N. capitellata* and *N. tarda* as well as

N. intermedia. However many specimens were difficult to place with any of these forms, thus lending support for considering the afore mentioned taxa as *N. intermedia*.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 8, 9, 13, 15, 16, 22, 23, 25-27, 32-34, 40, 47, 51, 52, 54, 60, 62, 63, 66, 72, 73.
FIS: 2, 8, 16, 20, 22-26, 30, 31, 33, 35.

Nitzschia laevis Hustedt

Hustedt, 1939 : 662, Figs 116-118.

Taxonomic notes: The specimens of this taxon recorded from Station 1 on the estuary of the Sundays River were quite typical of the diagnosis in their morphology, but showed a slightly wider range in dimensions. The examples were 16,7 - 26,5 μm long, 4,4 - 5,9 μm wide and had 10 - 14 very irregularly spaced fibulae in 10 μm . The central two fibulae were characteristically widely separated with an indication of the central nodule at the centre of this space. Cholnoky (1968a : 74, Fig. 141) illustrated a specimen purportedly belonging to *N. laevis*, but the valve form is relatively too broad and the poles blunt and truncate. There is therefore some doubt concerning its identification with this taxon.

Euryhaline mesohalobe - 5.

Figs: 398-400.

Samples: SUN: 70, 85.

Nitzschia lanceolata W. Smith

W. Smith, 1853 : 40, Pl. 14, Fig. 118.
Grunow in Van Heurck, 1880-83 : Pl. 68, Figs 1-4.
Van Heurck, 1885 : 182.

Synonyms: *Nitzschia lanceolata* f. *minima* Grunow in Van Heurck, 1880-83 : Pl. 68, Fig. 4.
Nitzschia lanceolata f. *minor* Grunow in Van Heurck, 1880-83 : Pl. 68, Fig. 3.

Taxonomic notes: Representatives of this taxon observed in the Sundays and Great Fish rivers had the following dimensions:- Length 29,2 - 87,2 μm, breadth 4,9 - 8,7 μm, and had 30 - 34 striae and 5 - 10 fibulae in 10 μm . These specimens would therefore, on account of their size, be distinguished as the f. *minor* Grunow with intermediate stages down towards f. *minima* Grunow. Recent work by Giffen (1970a : 290) showed a similar but wider range of variation in the dimensions (length 16,0 - 120,0 µm, breadth 5,0 - 12,0 µm) for specimens recorded from the South African littoral. This series has indicated that the distinction of these two forms, based only on length differences, can no longer be admitted. The South African specimens observed by Giffen and those from the region studied in this investigation present a continuous series with the classical examples of W. Smith (l.c.). Giffen's specimens from the Kowie River estuary (Giffen, 1970a : 290) and from Saldanha Bay (Giffen, 1975 : 90) differed somewhat from typical examples in that they have a rather coarser striation (22 - 25 in 10 µm). In this respect the Sundays River examples are typical and disclose a slightly denser striation (30 - 34 in 10 µm). In closing, a remark should also be made of a specimen illustrated by Foged (1975 : 46, Pl. 28, Fig. 6), which is stated in the text as having 9 striae in 10 µm . It is very obvious from this value and from his figure that this is a complete misidentification. The figure does not represent *N. lanceolata* at all, but is undoubtedly a specimen of *Nitzschia lanceola* (Grunow) Grunow (in Cleve and Grunow, 1880 : 68).

Mesoeuryhaline polyhalobe - 8.

Samples: SUN: 2, 70, 84, 86.
FIS: 15, 28.

Nitzschia latens Hustedt

Hustedt, 1949a : 148, Pl. 13, Figs 30, 31.

Taxonomic notes: The valves identified as *N. latens* were very similar to *Nitzschia elliptica* and *N. elliptica* var. *alexandrina*. They differed from *N. elliptica* by its linear form with parallel walls, and from *N. elliptica* var. *alexandrina* by being more robust, the lower density of the fibulae and the cuneately rounded poles. In form they corresponded well with Hustedt's (l.c.) description, but they were generally much smaller, ranging in size from 11,5 - 20,0 µm long and 3,4 - 4,5 µm wide; the number of fibulae in 10 µm was 14 - 18. One specimen is placed in this taxon with some uncertainty. This is illustrated in Figs 404, 405; the valve of this example was linear with more or less parallel sides and with relatively long cuneately tapered poles having bluntly rounded apices. The length was

28,4 µm, and breadth 4,9 µm; it had 14 - 16 fibulae in 10 µm, and striae were visible, numbering 38 in 10 µm . The latter were quite distinct under oblique illumination, and casts some suspicion on its identity as a member of this taxon.

Euryhaline mesohalobe - 5.

Figs: 401-405.

Samples: SUN: 21-23, 26, 42, 48, 57, 74, 76.
FIS: 5, 17, 19.

Nitzschia levidensis (W. Smith) Grunow

Grunow in Van Heurck, 1880-83 : Pl. 59, Fig. 7.
Hustedt, 1930 : 399, Fig. 760 (as *N. tryblionella* var. *levidensis*)
Hendey, 1964 : 277, Pl. 44, Fig. 4.

Synonym: *Tryblionella levidensis* W. Smith, 1856 : 89.

Description: Valves broadly linear, linear-elliptical with concave walls; poles cuneately narrowing to short relatively narrow, protracted rostrate apices, or broad, more or less cuneately rounded poles with slightly subrostrate apices; length 18,0 - 82,0 µm, breadth 8,0 - 16,0 µm . Canal raphe strongly eccentric (submarginal), slightly constricted at the centre; fibulae difficult to distinguish, 6 - 10 in 10 µm; the central two being more widely spaced, indicating the presence of a central nodule interrupting the raphe fissure. Transapical costae prominent, 8 - 14 in 10 µm; intercostal membranes striate, 24 - 26 striae in 10 µm . Valve surface with a strong median fold running along the apical axis.

Taxonomic notes: Neither the original diagnosis of W. Smith (1856 : 89 - as *Tryblionella levidensis*) nor the description of Hustedt (l.c.) adequately conveys a concept of this taxon. Hendey (l.c.), after examining Smith's type specimens (BM 23295) illustrated a single example showing the characteristics of the taxon as determined from W. Smith's material. Specimens observed in the Sundays and Great Fish rivers resemble Hendey's illustration (shorter forms), while some longer specimens corresponded with the large examples observed by Hustedt (1942a : 128, Figs 276-278) from the Indo-Malayan peninsular. The description given above is based on the specimens observed in this study, but dimensions are taken from a literature survey as well. The fibulae are difficult to resolve, and no clear idea of their construction has yet been obtained. In all descriptions of this taxon only Hustedt (1930 : 399) gives a count of the density of the fibulae, viz. 12 in 10 µm . The specimens studied here seemed to vary with respect to the density of the fibulae - 6 - 10 in 10 µm . Another feature which is seldom mentioned is the density of the striation of the intercostal membranes. The striae can generally best be seen along the valve margin in oblique light. Cleve-Euler (1952 : 58) gave a count of 35 in 10 µm, while specimens in the Sundays and Great Fish rivers had 34 - 36 striae in 10 µm . Cholnoky (1962a : 56) suggested that *N. calida* Grunow (cf. above) was conspecific with *N. levidensis*. However this cannot be so on account of the much finer transapical costae and less prominent longitudinal fold.

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 8, 19, 21-24, 49, 61-63.
FIS: 11-14, 17, 18, 21, 23-27, 29-31, 37, 39, 40.

Nitzschia levidensis var. *victoriae* (Grunow) Cholnoky

Cholnoky, 1966a : 57.

Synonyms: *Tryblionella victoriae* Grunow, 1862 : 553, Pl. 12, Fig. 34.
Nitzschia tryblionella var. *victoriae* (Grunow) Grunow in Cleve and Möller, 1877-82 : No. 211).

Taxonomic notes: The specimens placed in this taxon do not quite correspond with the description given by Hustedt (1930 : 399, Fig. 758 as *N. tryblionella* var. *victoriae*), and appear to be an intermediate form between this taxon and the smaller examples of *N. levidensis* as described above. The dimensions of *N. levidensis* var. *victoriae* as given by Hustedt are as follows:- length 30,0 - 65,0 µm, breadth 15,0 - 26,0 µm, transapical costae 5 - 7 in 10 µm, and fibulae about 6 in 10 µm . In contrast the Sundays River specimens were 22,8 - 28,9 µm long, 11,5 - 13,0 µm broad and had 7 - 9 transapical costae and 8 - 10 fibulae in 10 µm . These specimens are relatively broader than *N. levidensis*, having a length:breadth ratio of 1,93 - 2,28. The examples observed in a tributary of the Sundays River, the Wit River, were identical to the specimen illustrated by Foged (1976 : 43, Pl. 21, Fig. 8) from freshwater in Sri Lanka (Ceylon).

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 34.
FIS: 9.

Nitzschia linearis W. Smith

W. Smith, 1853 : 39, Pl. 13, Fig. 110; Supl. Pl. 31, Fig. 110.
Hustedt, 1930 : 409, Fig. 784.

Taxonomic notes: This taxon had a wide range of variation in the samples collected from the region under investigation, but all were morphologically typical. The dimensions of the specimens observed were:- length 51,0 - 202,0 µm, breadth 4,0 - 7,5 µm, striae 28 - 34 in 10 µm, and fibulae 10 - 16 in 10 µm .

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 3, 15-17, 21-23, 25-27, 31, 43, 45-48, 50-52, 60, 62, 73, 74.
FIS: 8, 20, 22-26.

Nitzschia lionella Cholnoky

Cholnoky, 1960a : 98, Fig. 290.

Taxonomic notes: This taxon seems to be extremely rare, being previously recorded in very small numbers from the Umtentweni River mouth, the Knysna Lagoon (estuary) and from the Kowie River estuary. Only three specimens, agreeing completely with the description, were observed from Station 1 on the estuary of the Sundays River. These specimens were 22,5 - 26,2 µm long, 6,1 - 6,5 µm broad, and had 28 striae and 12 fibulae in 10 µm . Only two broken specimens were seen on the type slide (slide No. TUG 366 - NIWR), and these confirmed the identification of this taxon in the Sundays River.

No ecological characterization made.

Samples: SUN: 70, 85, 86.

Nitzschia longissima var. *reversa* Grunow

Grunow in Cleve and Grunow, 1880 : 100.
Grunow in Van Heurck, 1880-83 : Pl. 70, Fig. 4.
Hasle, 1964 : 21.

Taxonomic notes: There is some confusion over the identification of this taxon from South African waters. Cholnoky (1960a : 98, Fig. 291) recorded and illustrated a specimen from the mouth of the Umlalazi River in Natal. This illustration does not, however, show a separation of the central fibulae, although Cholnoky's original pencil drawing in his analysis sheet for this sample does indicate the presence of a central nodule. Giffen

(1963 : 249, Fig. 95) observed very similar specimens with a distinct separation of the central fibulae from brackish waters, identifying them as *Nitzschia transvaalensis* Cholnoky (1958b : 131, Fig. 139). This rare species has otherwise only been recorded from freshwaters in the Transvaal (Cholnoky l.c.; Archibald, 1971 : 56). Specimens from the Sundays and Great Fish rivers agree in structure and length with *N. longissima* var. *reversa*, but are also identical to those recorded as *N. transvaalensis* from the Vaal Dam catchment (Archibald l.c.). Cholnoky's description of *N. transvaalensis* agrees very well with the var. *reversa*. However the type slides of both taxa are not available at present to confirm this identification or to compare it with *N. transvaalensis*. Since both the Sundays and Great Fish River specimens and Giffen's record of *N. transvaalensis* are from brackish water localities, it has been considered wiser to refer the examples observed in this study to the marine or brackish water species, viz. *N. longissima* var. *reversa*. The dimensions of the Sundays River specimens from Station 5 and the Wit River were as follows:- length 88,2 - 97,0 µm, breadth 3,5 - 3,9 µm , fibulae 11 - 16 in 10 µm . At Station 4 some longer and broader specimens were observed; these were about 142,0 - 154,0 µm long and 4,9 - 5,7 µm wide.

The taxonomy of *N. longissima* var. *reversa* is also not very clear. W. Smith (1853 : 43, Pl. 15, Fig. 121) described a *Nitzschia reversa* with very similar characteristics to *N. longissima* var. *reversa*. Smith remarked that the fibulae were indistinct, but the species had 19 striae in 10 µm . On these grounds Grunow (l.c.) was unable to reconcile his taxon with W. Smith's. Nevertheless looking at W. Smith's illustration (W. Smith l.c.: Pl. 15, Fig. 121) it is clearly seen that the fibulae are visible, while the striae are not. As far as can be ascertained from the literature no comparison between the type specimens of *N. reversa* W. Smith and *N. longissima* var. *reversa* Grunow has been made. Consequently no hard and fast opinion can be cast on the subject. Some diatomists have considered W. Smith's taxon as the same as Grunow's (cf Peragallo H. and M. 1897-1908 : 293; Szemes, 1959 : 353), while others regard them as separate (Cholnoky, 1960a : 98; Mills, 1933-35 : 1218 and 1229). It is clear that the true relationship between these two taxa can only be solved through inspection of the type materials.

The specimens observed in this study showed the same interesting feature that was seen earlier in *Gyrosigma prolongatum* var. *closterioides* (Grunow) Cleve (see above). In *Nitzschia longissima* var. *reversa* two different types of valve were recorded. The one valve type was typically sigmoid with the long, narrow poles curving in opposite directions (Figs 407, 408), while the other differed in that the poles were curved in the same direction (Fig. 409). The latter valve type was again the result of one of the poles undergoing a 180° twist about the apical axis (see Fig. 410c), while the other (see Fig. 410b) does not suffer the same fate. One of the characters used to separate this variety from the nominate variety was the curving of the poles in the opposite direction in the var. *reversa* (Grunow in Cleve & Grunow, 1880 : 100). The taxonomic importance of this character must therefore be reviewed in the light of these observations on the Sundays River materials. Since both valve types can be found in var. *reversa* it would appear that there is really only a size difference between this variety and the nominate variety.

Meioeuryhaline polyhalobe - 9.

Figs: 407-410.

Samples: SUN: 34, 35.
FIS: 3.

Nitzschia lorenziana var. *subtilis* Grunow

Grunow in Cleve and Grunow, 1880 : 102.
Hustedt, 1930 : 423, Fig. 820.

Taxonomic notes: Although Giffen (1971 : 9) preferred not to distinguish between the different varieties of *N. lorenziana*, the specimens observed in the Sundays and Great Fish rivers agree most closely with the var. *subtilis* Grunow (l.c.). They differed mainly by having a slightly greater density of fibulae - having 8 - 10 instead of 6 - 8 in 10 µm . They were also often somewhat shorter than the minimum length given by Grunow; the lengths of the specimens were 37,2 - 115,0 µm . In breadth (3,0 - 5,0 µm) and density of striae (16 - 19 in 10 µm) the Sundays and Great Fish River specimens were identical to the description. Examples of similar dimensions and structure were recorded by Giffen (1963 : 246, Fig. 87) from blind estuaries in the vicinity of Kidd's Beach near East London. A single specimen examined on Grunow's slide No. 1499 (Vienna) contained 9 fibulae in 10 µm . This indicates quite clearly that the local specimens have been correctly placed in this species as the var. *subtilis*.

Euryhaline mesohalobe - 5.

Samples: SUN: 3, 59, 82-84.
FIS: 28, 31, 41.

Nitzschia marginata Hustedt

Hustedt, 1955 : 46, Pl. 16, Figs 11, 12.
Giffen, 1976 : 390, Fig. 50.

Taxonomic notes: Giffen (l.c.) recorded specimens from the marine littoral of the Saldanha Bay lagoon which he designated as *Nitzschia marginata* Hustedt (l.c.). His specimens were somewhat smaller than Hustedt's, being 32,0 - 48,0 µm long, and 2,0 - 3,0 µm broad. Hustedt stated, however, that the taxon was very scarce, implying that he probably examined only two or three examples. In the estuarine stations of the Sundays River a number of specimens were observed agreeing more closely with the description of *N. marginata* than with any other presently known species of *Nitzschia*. There were some differences which make the identification of these examples as *N. marginata* a little doubtful. In dimensions they agreed well with Giffen's range, being 40,7 - 47,5 µm long, 2,5 - 3,0 µm broad, and having 10 - 12 fibulae in 10 µm . The local specimens were, however, not pronouncedly capitate at the apices like Hustedt's examples, and although the fibulae are strong the central two are not as markedly separated as shown by either Hustedt or Giffen. Nevertheless despite these differences it was considered best to relate the Sundays River specimens to this taxon as they have much in common with it. It may also be mentioned that, having examined Giffen's material (slide No. 635 from Saldanha Bay - NIWR), it appears that Giffen may have exaggerated the capitate nature of the valve apices when illustrating his examples (cf. Giffen, 1976 : 390, Fig. 50).

Meioeuryhaline polyhalobe - 9.

Figs: 65, 411-413.

Samples: SUN: 1, 82-84.

Nitzschia microcephala Grunow

Grunow in Cleve and Grunow, 1880 : 96.
Grunow in Van Heurck, 1880-83 : Pl. 69, Fig. 21.
Hustedt, 1930 : 414, Fig. 791.

Taxonomic notes: *N. microcephala* can be distinguished fairly simply from *Nitzschia elegantula* Grunow (cf. Schoeman and Archibald, 1976-80 : No. 1), which was once regarded as a variety of *N. microcephala*. Valves of *N. microcephala* are linear with straight to slightly convex walls narrowing abruptly to the capitate or subcapitate poles. In contrast *N. elegantula* has a central constriction of the valve wall, generally more prominent on the rapheless margin. Furthermore, while the density of the fibulae in the two species are comparable, the density of the striae is greater and the structure finer in *N. microcephala* (32 - 36 + in 10 μm). The striae in *N. elegantula* (23 - 32 in 10 μm) are coarse and generally distinctly punctate. In a few specimens of *N. microcephala* observed on Grunow's slide Nos. 2120 and 2235a (Vienna) no striae could be resolved at all. This might, however, be due to the mounting medium or to the poor state of preservation of the slide. Nonetheless it indicates the fineness of the striae. The other dimensions of these specimens agreed well with the diagnosis (Grunow in Cleve and Grunow, 1880 : 96). Examples observed in the two rivers studied in this survey had the following dimensions:- length 8,0 - 19,0 μm, breadth 2,5 - 3,2 μm, striae 32 - 36 in 10 μm, and fibulae 12 - 16 in 10 μm .

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 4, 5, 8, 12, 16, 21, 22, 25, 27, 30-32, 34, 42, 49, 52, 60, 66, 74.
FIS: 8, 12, 14, 20, 25, 29, 33.

Nitzschia obsidialis Hustedt

Hustedt, 1949a : 148, Pl. 13, Fig. 25.

Taxonomic notes: Hustedt's type slide (no. 242, 33 - Bremerhaven) was examined, and only a single damaged specimen was observed. This had the typical lanceolate shape, and the fibulae were as described by Hustedt (l.c.). Transapical striae were just visible under oblique light illumination, but were too fine to count. The taxon has been recorded a number of times from Southern Africa (Cholnoky, 1960a : 100, Figs 300-302; 1962a : 57, Figs 81-85; 1965 : 74, Fig. 33; Archibald, 1971 : 53, Fig. 219), but the illustrations indicate a somewhat different fibular structure. The fibulae in the type specimen were relatively strong rod-like fibulae, whereas the Southern African specimens are illustrated as having relatively small roundish fibulae. A re-examination of the Southern African material will be necessary to confirm their identification. In the Great Fish River a single example of a form, somewhat hesitantly placed in this taxon, was observed. This specimen had fibulae corresponding very well in structure and density with the type specimen studied. However in valve shape and breadth it differed slightly, being broader and more linear-lanceolate. This specimen can nevertheless not be placed in any other taxon, and is therefore for the present best considered as *N. obsidialis*.

Meioeuryhaline oligohalobe - 1.

Samples: FIS: 29.

Nitzschia obtusa var. *scalpelliformis* Grunow

Grunow in Cleve and Grunow, 1880 : 92.
Hustedt, 1930 : 422, Fig. 817d.

Taxonomic notes: In the Sundays and Great Fish rivers there appear to be two different forms of this taxon. At Stations 4 and 4A on the Sundays River and Station 14 on the Great Fish River the more typical coarsely striate form was found. The striae in these forms were 25 - 28 in 10 µm, and the puncta were distinct and arranged in undulate longitudinal rows. The poles were typically obliquely rounded, while the valves were linear with more or less parallel sides. The canal raphe was marginal or very strongly eccentric, with a marked inward deflection of the canal raphe at the centre of the valve. Here there was a central nodule interrupting the outer raphe fissure, and as a result of this the central two fibulae were more distant having an enlarged interspace between them. A further feature which many of these coarser forms show is a marked constriction of the valve wall at the centre of the valve. This feature is not mentioned or illustrated in most of the earlier descriptions, but is clearly observed in Van Heurck's slide No. 389 (Vienna) of *N. obtusa*. It is not known at this stage whether this is a variable feature or one which is visible only in certain planes of viewing. Grunow's illustrations of *N. obtusa* and the var. *scalpelliformis* in Van Heurck's (1880-83 : Pl. 67, Figs 1, 2) Atlas of diatoms from Belgium do show constrictions of the valve at the centre.

The second valve form of *N. obtusa* var. *scalpelliformis* is very much the same as the coarsely striate form, except that the constriction of the valve was not observed in these specimens, and the striation of the valve surface was finer. The striae density range was 32 - 38 in 10 µm, with most valves observed, particularly those from Station 3, having 36 - 38 striae in 10 µm . In many of these finely striate specimens the striae at the centre of the valve were less dense, containing 32 - 36 striae in 10 µm . How significant the density is in distinguishing the two groups is debatable. Grunow (cf. Cleve and Grunow, 1880 : 92) himself observed specimens with more than 32 striae in 10 µm . Furthermore Compere (1967 : 192) reported *N. obtusa* with a striae range of 25 - 35 in 10 µm from the Sahara. Although the striae density of the finely striated forms correspond closely with *N. filiformis* (see above) the valve shape and dimensions preclude these examples from this species. Further research is necessary to obtain the correct solution to this problem. In the meantime the two forms have been retained as one taxon.

Dimensions of the forms found in the Sundays and Great Fish rivers were as follows:- length 56,0 - 101,9 µm, breadth 5,0 - 7,4 µm, striae 25 - 38 in 10 µm, and fibulae 7 - 9 in 10 µm .

Euryhaline mesohalobe - 5.

Samples: SUN: 1-3, 11, 13, 14, 28, 38, 40, 42, 56, 59, 63, 64, 67, 69, 70,
77-81, 85.
FIS: 12, 28, 32.

Nitzschia ovalis Arnott

Arnott ex Grunow in Cleve and Grunow, 1880 : 95, Pl. 5, Fig. 103.
Grunow in Van Heurck, 1880-83 : Pl. 69, Fig. 36.
Hustedt, 1930 : 417, Fig. 808.

Taxonomic notes: Hustedt (1949a : 148, Pl. 13, Figs 32-34) distinguished *N. ovalis* from *Nitzschia elliptica* Hustedt (l.c.) chiefly on the shape of the valve, which, according to Hustedt, was more convex in *N. ovalis*. Such small distinctions in a weak taxonomic character as valve shape results in a rather nebulous separation of these two taxa. There appears, however, to be a difference also in the number of fibulae in 10 µm - *N. ovalis* having 12 - 13 in 10 µm and *N. elliptica* 16 - 20 in 10 µm . This might be a better criterion to separate the two species. However the few examples examined at Station 4A on the Sundays River caused some difficulty in deciding to which of the two species they should belong. These specimens were 20,0 - 22,5 µm long, 5,5 - 6,6 µm wide, and had 12 - 16 fibulae in 10 µm . These dimensions correspond with those of both *N. ovalis* and *N. elliptica*, and the density of the fibulae bridge the gap between the two species. As far as valve outline is concerned it was difficult to determine whether they were linear-elliptical or more lanceolate. On morphological grounds the Sundays River forms appear to form an intermediate group, as they can be placed in either species equally well. However considering their ecology the specimens were placed with *N. ovalis*. *N. ovalis* is apparently a salt water or brackish water form (Hustedt, 1930 : 417), while the autecology of *N. elliptica* is unkown, although Hustedt (1949a : 41 and 171) found it in a spring where numerous other mesohalobes and halophilic forms were recorded. *N. ovalis* has, furthermore, been recorded fairly frequently in Southern African coastal waters and estuaries, while *N. elliptica* has not been reported from any South African rivers. The Sundays River examples were all found in a highly brackish seepage water at Station 4A. In conclusion, therefore, it would seem that there might be evidence that *N. ovalis* and *N. elliptica* are really conspecific.

Euryhaline mesohalobe - 5.

Samples: SUN: 14, 56.

Nitzschia palea (Kützing) W. Smith

W. Smith, 1856 : 89.
Hustedt, 1930 : 416, Fig. 801.

Synonyms: *Synedra palea* Kützing, 1844 : 63, Pl. 3, Fig. 27; Pl. 4, Fig. 2.

Taxonomic notes: According to Lange-Bertalot (1976 : 271) this is the second most complicated species from a taxonomic point of view, and he expressed the feeling that its diagnosis must be considerably broadened. The observations from this study tend to agree with this sentiment. The species was widespread in both river systems and displayed a wide range of variation in dimension as well as valve shape and structure. A thorough review of the species is not feasible in this study, but is essential in order to delimit the taxon as accurately as possible. Lange-Bertalot also suggested that various species, recently described, are nothing other than variants of *N. palea* with small differences in dimension or arrangement of the central fibulae. Thus he felt that *N. pilum* Hustedt (1942c : 210, Fig. 1), *N. diserta* Hustedt (1949a : 139, Pl. 12, Figs 32, 33) and *N. accomodata* Hustedt (l.c.: Pl. 12, Figs 27-31, 34, 35) should be included with *N. palea*. All three of the afore mentioned species were examined on the type slides from Hustedt's collection at Bremerhaven. While there is some agreement with Lange-Bertalot's suggestion with regard to *N. pilum* and *N. accomodata*, the position of *N. diserta* in relation to *N. palea* is perhaps disputable. With the more distant spacing of their central fibulae *N. diserta* is more closely allied to *N. balcanica* Hustedt (1945 : 947, Pl. 43, Figs 4, 5) and *N. subcapitellata* Hustedt (1939 : 663, Figs 109, 110).

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 7-11, 13, 15-28, 30-36, 43, 45-52, 54, 60, 62-65, 72, 73.
FIS: 1, 3, 5-9, 12, 14, 16-18, 20, 23-33, 35-37, 39, 40.

Nitzschia perindistincta Cholnoky

Cholnoky, 1960a : 101, Fig. 304.

Taxonomic notes: A clear concept of *N. perindistincta* is somewhat difficult to form from the data in the literature. The original diagnosis indicates that the taxon is a short broad species, lanceolate in shape with broadly protracted rostrate apices. In a later paper on the diatoms from the Cape Province, Cholnoky (1962a : 58, Figs 89, 90) recorded larger specimens of *N. perindistincta*, which he described as being united with typical specimens by intermediates. Apart from one exceptionally large and broad specimen with subrostrate apices (20,0 µm long and 7,0 µm wide - cf. Cholnoky's Fig. 90), he did not, however, give the dimensions of these larger forms. Still later *N. perindistincta* was reported again by Cholnoky (1963c : 75, Figs 98, 99) from the Knysna Lagoon. These examples included some that were rather more acutely protracted at the poles and were 16,0 µm long and 3,0 µm wide. Whether the latter forms actually belong to this taxon or to the very similar species, *N. fontifuga* Cholnoky (see above), is a difficult question to answer. Cholnoky's earliest description of *N. perindistincta* (i.e. small forms with rostrate apices) was probably based on only one or two observations (his own analysis sheets indicate that Cholnoky saw only one specimen), and a search of the type slide (Slide No. TUG 234 - NIWR) was fruitless in finding a specimen to verify the diagnosis.

In the Sundays River two different forms that could be attributed to this taxon were observed. At Station 2 some relatively broad lanceolate specimens with reasonably acutely protracted apices (Figs 414, 415) had the following dimensions:- length 15,0 - 17,0 µm, breadth 4,0 - 4,4 µm, fibulae 14 - 18 in 10 µm . The dimensions of these specimens did not correspond with those of *N. fontifuga*, but were closer to the larger forms of *N. perindistincta* found by Cholnoky in the Western Cape Province. They were thus tentatively placed in this taxon. In contrast at Station 2 a few small specimens (Figs 416, 417) conformed, perhaps, more closely to Cholnoky's original concept of the species, although they were slightly narrower. These specimens were broadly protracted at the poles forming somewhat subrostrate apices, and were 7,8 - 8,8 µm long and 2,9 - 3,2 µm broad. They had 16 - 18 fibulae in 10 µm, but the striae remained undetermined as they were too fine to be seen under the light microscope.

Some revision of this taxon is recommended particularly in relation to *N. fontifuga* and other similar hyaline *Nitzschia* species.

Euryhaline mesohalobe - 5.

Figs: 414-417.

Samples: SUN: 3, 81.

Nitzschia perspicua Cholnoky

Cholnoky, 1960b : 262, Fig. 36.

Taxonomic notes: The identity of specimens from the Sundays and Great Fish rivers as *N. perspicua* has been confirmed by direct comparison with examples from the type slide (No. Swartkops 14A - NIWR). The type slide was examined and two specimens were observed agreeing fully in all respects except the dimension of length with Cholnoky's (1960b : 262, Fig. 36) diagnosis. One of the specimens was considerably shorter than Cholnoky's minimum length, being 15,7 µm long. The specimens observed in the Sundays and Great Fish rivers were identical in structure but showed greater variation in dimensions and density of the fibulae. These examples were 17,2 - 35,8 µm long, 3,4 - 4,9 µm broad, and had 14 - 20 fibulae in 10 µm . The valves of nearly every specimen were observed in more or less girdle view, and in this plane of vision the canal raphe is not quite marginal and the fibulae are small and rounded.

Euryhaline mesohalobe - 5.

Figs: 418-420.

Samples: SUN: 33, 42, 52, 54, 69, 80, 82-84.

FIS: 2, 13.

Nitzschia plicatula Hustedt

Hustedt, 1953 : 151, Figs 1, 2.

Taxonomic notes: Cholnoky (1960a : 101, Figs 292-295) has placed some specimens from Natal in this taxon. These examples do not, however, tally completely with the diagnosis of *N. plicatula* Hustedt (1953 : 151, Figs 1, 2) being markedly constricted in the centre of the valve and more densely striate (26 - 30 in 10 µm). The Natal specimens also had a blank longitudinally oriented space approximately in the centre of the valve which was structureless. In the Sundays and Great Fish rivers, examples, apparently identical to those found in Natal, have been observed and for this reason have been identified as *N. plicatula*. There is nevertheless some uncertainty about the validity of this identification. Hustedt's diagnosis makes no mention of a more or less bilobate valve due to the central constriction, or the structureless central band, although there is a weak fold in *N. plicatula*. In both these characteristics the Sundays and Great Fish River specimens resemble more closely *N. marginulata* Grunow (in Cleve and Grunow, 1880 : 72, Pl. 5, Fig. 93). However the density of the striae and fibulae in the specimens observed in this study (25 - 28 striae and 10 - 14 fibulae in 10 µm) seem to exclude them from both *N. plicatula* (18 - 20 and 10 - 12 in 10 µm respectively) and *N. marginulata* (22 - 23 striae and 11 - 12 fibulae in 10 µm). The dimensions of the Sundays River and Great Fish River specimens were:- length 36,8 - 52,0 µm, breadth 4,9 - 7,4 µm .

Euryhaline mesohalobe - 5.

Figs: 421-422.

Samples: SUN: 34, 82, 83.
FIS: 3.

Nitzschia prolongata Hustedt

Hustedt, 1937-38 : 489, Pl. 41, Fig. 28.

Taxonomic notes: There is some doubt concerning the correct identity of the specimens placed in this species. The valves agreed morphologically and in most details of dimensions with the description of *N. prolongata*. They were, however, somewhat shorter, being 70,9 - 94,6 µm in length. Identical specimens were identified as *N. prolongata* by Giffen (1963 : 248, Fig. 92 - Giffen slide No. 373 personally examined), but his specimens were also shorter, the largest (114,2 µm in length) only just reaching Hustedt's minimum length. In all other respects Giffen's specimens agreed with the diagnosis of *N. prolongata*. Further confusion arises, however, as Cholnoky (1968a : 72, Figs 131, 132) identified the same taxon as *Nitzschia hoehnkii* Hustedt (1959c : 97, Figs 6, 7). These specimens (cf. Cholnoky slide No. SL 31 - NIWR) were identical to the Sundays River examples and to Giffen's forms, but were somewhat broader being 4,0 - 5,2 µm wide. Cholnoky's specimens were nevertheless smaller than the dimensions given by Hustedt (l.c.) for *N. hoehnkii*. The main problem to be resolved in this situation is whether *N. prolongata* and *N. hoehnkii* are conspecific or not. The type slides of both taxa have been examined and dimensions of ringed specimens were noted.

The ringed specimens of *N. prolongata* on slide No. W1, 29 (Bremerhaven) had the following dimensions:- length 132,5 - 134,0 µm, breadth 4,1 - 4,3 µm, striae ±25 in 10 µm and fibulae 5 - 7 in 10 µm . In general they agreed with the diagnosis, but were slightly longer and broader than the limits given by Hustedt (1937-38 : 489). A feature not mentioned in the diagnosis is the shortening of about one or two central striae just below the central nodule. Some slight differences were also observed in the type material of *N. hoehnkii* on slide No. 384, 20a (Bremerhaven). The transapical striae of the ringed specimens were a little denser (±24 in 10 µm) than stated in the diagnosis, except near the centre where they are 20 - 21 in 10 µm . *N. hoehnkii* also has the shortened striae below the central nodule found in *N. prolongata*.

The data concerning the dimensions of the different species or populations are summarized in the Table below:-

Species	Length (µm)	Breadth (µm)	Striae in 10 µm	Fibulae in 10 µm
N. prolongata	115,0 - 134,0	3,5 - 4,3	24 - 25	5 - 7
N. hoehnkii	95,0 - 116,0	5,0 - 6,0	20 - 24	5 - 8
Giffen slide No. 373	79,1 - 114,2	3,4 - 4,2	22 - 24	6 - 7
Cholnoky slide SL 31	62,0 - 95,6	4,0 - 5,2	22 - 24	6 - 8
SUN 59	70,9 - 94,6	2,9 - 3,9	22 - 23	7 - 9

Structurally *N. prolongata* and *N. hoehnkii* are almost indistinguishable and the only difference between the taxa seems to be in dimensions, the former being longer and narrower than the latter. With respect to the dimensions of length and breadth the specimens observed by Giffen and Cholnoky as well as those found in the Sundays River correspond more closely with *N. hoehnkii*, but form a continuous series with *N. prolongata* in the dimension of length. However in the dimension of breadth it agrees more with *N. prolongata*, although likewise there is a continuous series to *N. hoehnkii*. When considering the characteristics of striae and fibular density, there is complete overlapping in all groups. It does not appear then that there are any essential differences to distinguish between *N. prolongata* and *N. hoehnkii*, and the two species may only be ecological forms of the same taxon. This, however, is difficult to decide on the few ringed type specimens of *N. prolongata* and *N. hoehnkii* observed, and many more specimens should be studied to verify this. Until such time that this is proven the two species will be kept separate. On account of the relatively narrow valves of the Sundays River specimens, they have been preferably placed in the taxon, *N. prolongata*. This also happens to be the longer known species of the two, and should problems of priority arise no further name change would be required.

In a reconsideration of *N. prolongata* and *N. hoehnkii* another species which must be taken into account is *Nitzschia improvisa* Simonsen (1960 : 130, Pl. 2, Figs 19, 20). This narrowly linear-lanceolate or linear form with long tapering poles and slightly capitate poles agrees in many respects with the two species discussed above. However it is larger, being 130,0 - 165,0 µm long, 6,0 - 6,5 µm wide, and has 22 - 24 striae and about 7 fibulae in 10 µm . Once again lengthwise there is a continuous series with *N. prolongata*, and similarly with *N. hoehnkii* in respect of breadth. Other points of similarity are the structure of the raphe, inwardly deflected at the centre, and the shortened striae below the central nodule. *N. improvisa* may thus be yet another ecological form of the same taxon including *N. prolongata* and *N. hoehnkii*. Further investigations are still needed to answer this question.

Euryhaline mesohalobe - 5.

Figs: 423, 424.

Samples: SUN: 59.

Nitzschia pubens Cholnoky

Cholnoky, 1960a : 102, Fig. 307.

Taxonomic notes: Although the specimens observed in the Sundays River have not been compared with the type material, there is no doubt that they are correctly identified as *N. pubens* Cholnoky. Their broad lanceolate to elliptically lanceolate valves with distinct and relatively small capitate poles are quite characteristic. The dimensions and density of the striae and fibulae of these examples are also in good agreement with the diagnosis, but expand the range of variation. Not having found any specimens on the type slide (Tugela 223 - NIWR), it is obvious that Cholnoky saw very few specimens, and was therefore unable to give the full range of variation. The Sundays River examples had the following measurements:- length 10,8 - 13,2 µm, breadth 3,4 - 3,9 µm, striae 38 - 40+ in 10 µm and fibulae 12 - 16 in 10 µm .

Euryhaline mesohalobe - 5.

Figs: 425, 426.

Samples: SUN: 35, 36, 41, 42, 60, 67, 70, 77, 78, 81.

Nitzschia pusilla Grunow

Grunow, 1862 : 579, Pl. 12, Fig. 11a-d.
Lange-Bertalot, 1976 : 273, Pl. 7, Figs 1-10; Pl. 9, Figs 5, 6.

Synonyms: *Nitzschia kuetzingiana* Hilse, 1863 : 67.

Taxonomic notes: The taxonomy and nomenclature of this species is extremely confusing. Lange-Bertalot (l.c.) discussed the problem and concluded that *N. kuetzingiana* is identical to *Synedra pusilla* Kützing (1844 : 63, Pl. 3, Fig. 29). He therefore claimed that the correct combination for this taxon is *Nitzschia pusilla* (Kützing) Grunow emend. Lange-Bertalot. However the correct authority (sensu Lange-Bertalot) for this combination is questioned here. According to Lange-Bertalot, Grunow based his *Nitzschia pusilla* on Kützing's *Synedra pusilla*, but examination of the literature does not provide any evidence to this effect. Grunow (l.c.) described a species, *Nitzschia pusilla*, from material sent to him from Falaise by de Brebisson, who presumably identified it as *Synedra parvula* Kützing (1844 : 64, Pl. 14, Fig. 1a, b; Pl. 30, Fig. 32). Grunow did not indicate that he thought this identification was correct, but it seems reasonable to assume that he considered it synonymous with his *Nitzschia pusilla*. More significant is the fact that Grunow did not list *Synedra pusilla* as the basionym for his *N. pusilla*. Lange-Bertalot is therefore incorrect in suggesting that Grunow transferred *Synedra pusilla* Kützing to the genus *Nitzschia*. According to the rules of priority the new combination *Nitzschia pusilla* based on *Synedra pusilla* would be invalid as it is preoccupied by *Nitzschia pusilla* Grunow. Lange-Bertalot (l.c.) suggested that *Synedra parvula* and *S. pusilla* are conspecific, and judging from his illustrations (his Pl. 7, Figs 1-3, 8) there appears to be truth in this suggestion. If this is the case then it is by coincidence that the earliest valid combination, *Nitzschia pusilla* Grunow, should also include the earlier type of a name with the same epithet. These arguments suggest therefore that Grunow alone should be attributed with the combination *Nitzschia pusilla*, even although it includes the earlier valid combination *Synedra pusilla* Kützing.

The amended diagnosis of *N. pusilla (= N. kuetzingiana)* circumscribes the specimens found in the Sundays and Great Fish rivers very well. These specimens were 16,0 - 33,5 µm long, 2,5 - 5,0 µm broad, and had 14 - 18 fibulae in 10 µm .

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 6, 13, 15-19, 21-23, 25-28, 32, 40, 45, 46, 52, 54, 60, 62, 73.
FIS: 2, 4-8, 12, 16, 17, 23-27, 29-33, 35-37.

Nitzschia rautenbachiae Cholnoky

Cholnoky, 1957a : 76, Figs 228-232.
Schoeman and Archibald, 1976-80 : No. 3.

Description: Valves lanceolate (small forms), linear-lanceolate to linear with cuneate poles in the more linear forms; length 16,0 - 72,0 µm, breadth 4,5 - 6,0 µm . Canal raphe marginal but difficult to resolve; fibulae indistinct, corresponding with the costae in number (11) 12 - 14 (15) in 10 µm . Transapical costae robust and rib-like; transapical striae prominent, (11) 12 - 14 (15) in 10 µm, alternating with the transapical costae, and composed of single rows of large puncta (10 - 16 on 10 µm).

Taxonomic notes: Study of the valve surface of this species under the electron microscope revealed a fine structure quite unique, as far as is known, for any species of *Nitzschia*. This structure is fully described by

Schoeman and Archibald (1976-80 : No. 3), and only the remarkable features are mentioned here. The valve surface is traversed by a series of prominent transverse costae, which are externally elevated. The striae are found in the troughs between the costae, each trough having a single row of oval pores separated by small cross ridges. Along one margin lies the keel bearing the raphe; this keel appears to be supported by buttresses continuous with the costae. Extending from these buttresses is a series of small, flat, bifurcate projections, which are free from the surface of the valve. These projections occur on both sides of the keel. Along the opposite margin of the valve face is another series of flat, rounded, arrowhead-like projections. These are attached to the costae by short stalks. Both series of projections appear to be unique structures, and their function is presently not known. The only other species with a similar structure is *Nitzschia siliqua* Archibald, which is discussed below. The peculiar structure of these two species does not allow them to be placed with ease in any of the established sections of the *Nitzschiae*. They may therefore form a new section of the genus *Nitzschia* altogether. However further research is still required before taking the step of constituting a new subgeneric section.

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 4, 6, 8, 21-23, 28, 36, 37, 64, 65.
FIS: 6, 9, 14, 26, 36, 37, 40.

Nitzschia rufitorrentis Cholnoky

Cholnoky, 1960a : 103, Fig. 308.

Taxonomic notes: Two specimens fitting the description amended by Cholnoky (1962c : 98) were observed in one sample each from the Sundays and Great Fish rivers. These two examples were 50,0 - 53,4 µm long, 6,8 - 8,0 µm broad, and had 9 - 10 fibulae in 10 µm . The transapical striae were typically unresolved.

Meioeuryhaline oligohalobe - 1.

Figs: 427.

Samples: SUN: 35.
FIS: 14.

Nitzschia sigma (Kützing) W. Smith

W. Smith, 1853 : 39, Pl. 13, Fig. 108.
Hustedt, 1930 : 420, Fig. 813.

Synonyms: *Synedra sigma* Kützing, 1844 : 67, Pl. 30, Fig. 14.

Taxonomic notes: As Hustedt (l.c.) remarked, *N. sigma* is extremely variable in form and structure. This comment applies equally well to the tremendous variability shown by the specimens observed in the Sundays and Great Fish rivers. No attempt was made to distinguish between varieties. The dimensions of the local specimens were:- length 70,0 - 190,0 µm, breadth 5,0 - 8,0 µm, striae 28 - 36 in 10 µm, and fibulae 8 - 12 in 10 µm .

Holoeuryhaline mesohalobe - 6.

Samples: SUN: 1, 3, 5, 6, 8, 13, 16, 19, 22, 24, 28, 30, 34, 35, 48, 50, 51, 61, 63, 81, 82, 85, 86.
FIS: 3, 9, 17, 21, 23, 28, 29, 36.

Nitzschia silica Archibald

Archibald, 1966c : 234, Figs 22-24.
Archibald, 1971 : 54, Figs 238-243.

Taxonomic notes: The taxonomic position of this species is not at all certain. An expanded description of the species was given by Archibald (1971 : 54, Figs 238-243) after further specimens had been observed in the Vaal Dam catchment rivers. These dimensions (length 13,0 - 29,5 µm, breadth about 2,0 µm and fibulae 16 - 18 in 10 µm) compared favourably with specimens (length 12,5 - 45,0 µm breadth 2,5 - 3,2 µm, and fibulae 15 - 18 in 10 µm) designated as *Nitzschia palea* var. *debilis* Kützing *forma angustissima* Grunow(?) observed on Van Heurck Slide No. 412 (Vienna). These forms cannot be associated with *N. palea* primarily on account of the more distantly spaced central fibulae, which seemed to be characteristic of the *forma angustissima.* As no further reference to this form, other than the name on the slide label, can be found, it is probably best to include these forms with *N. silica*. *N. silica* also corresponds very closely with *Nitzschia admissa* Hustedt (1957 : 346, Figs 68-75), but *N. silica* was rather shorter although forming a continuous series with *N. admissa*. Moreover Lange-Bertalot (1976 : 257) has recently shown that *N. admissa* is conspecific with *N. paleacea* Grunow (in Cleve and Grunow 1880 : 95). It appears, therefore that a detailed reappraisal of these four taxa is necessary to determine their true relationship.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 46.
FIS: 7.

Nitzschia siliqua Archibald

Archibald, 1966a : 267, Fig. 62.
Archibald, 1971 : 54, Fig. 244.

Synonyms: *Nitzschia pseudocarinata* Cholnoky, 1970c : 30, Figs 13-15.

Description: Valves linear, narrowing more or less abruptly at the ends into cuneate poles with small distinctly capitate apices; length 18,0 - 30,0 µm, breadth 3,0 - 5,0 µm . Canal raphe marginal, not always readily distinct; similarly the fibulae not always clear, but corresponding in number with the transapical costae, 16 - 18 in 10 µm . Transapical striae prominent, 16 - 18 (19) in 10 µm, slightly curved at the poles; striae punctate, having 24 - 30 relatively large puncta in 10 µm .

Taxonomic notes: Under the electron microscope the species (Figs 555-558) has been shown to have a structure similar in many respects to that of *N. rautenbachiae* Cholnoky (cf. Schoeman and Archibald, 1976-80 : No. 3). The valve face is slightly convex with a marginal canal raphe on one side of the valve. The costae form a series of transverse ridges, between which lie the striae. Each stria consists of a single row of more or less circular pores. The keel is prominent and has a series of buttresses continuous with the costae. Along the margin opposite the raphe is a series of very short projections arising from the costae. These projections are probably homologous with the arrowhead-like structures of *N. rautenbachiae* (see above), but appear to be poorly developed or rudimentary. Internally the valve structure is fairly simple, and only the circular interspaces between the fibulae of the canal raphe are prominent.

The taxon is not common and has only been previously recorded from the Transvaal in the Vaal Dam catchment region (Archibald, 1971 : 54), in some fish ponds near Marble Hall (Cholnoky, 1970c : 30 as *N. pseudocarinata*), and in a stream in the Northern Transvaal (cf. Schoeman and Archibald, 1976-80 : No. 3). The records in the latter two instances were reported under the name *Nitzschia pseudocarinata* Cholnoky, but this species has now been shown to be identical with *N. siliqua*.

A species which should be examined more closely in relation to *N. siliqua* is *Nitzschia affinis* Manguin (1952 : 101, Pl. 9, Fig. 183). This taxon agrees very closely with *N. siliqua* in many details, and the two taxa may be conspecific. Unfortunately Manguin's type material has not been examined to compare the two species. Nevertheless should it be necessary to unite the two taxa because of conspecificity the combination, *Nitzschia siliqua* Archibald, must be retained as Manguin's epithet "*affinis*" is a later homonym of *Nitzschia affinis* Grunow (1862 : 577, Pl. 12, Fig. 13a, b).

Mesoeuryhaline oligohalobe - 2.

Figs: 428-430, 555-558.

Samples: SUN: 16, 30-32, 51, 62, 63.
FIS: 9, 11-13, 15, 22, 26-28, 36-40.

Nitzschia solgensis Cleve-Euler

Cleve-Euler, 1952 : 67, Fig. 1451c, d.

Synonyms: *Nitzschia denticula* var. *delognei* Grunow in Van Heurck, 1880-83 : Pl. 60, Fig. 9.

Taxonomic notes: The true identity of the few specimens assigned to this species is doubtful. In most of its characteristics it is very much like *Nitzschia interrupta* (see above under *N. denticula*). The main point of similarity to *N. interrupta* is the structure of the fibulae. These are prominent and do not quite reach the midline of the valve, at which point the fibulae flair out slightly. The chief difference, however, lies in the density of the striae, being greater in this taxon (±24 in 10 µm) than in *N. interrupta* (18 in 10 µm). From this point of view these specimens are better placed in *Nitzschia denticula* var. *delognei* Grunow (in Van Heurck, 1880-83 : Pl. 60, Fig. 9; Hustedt, 1930 : 408). The fibular structure of this taxon is different from that of *N. denticula*, and this casts some doubt on a close relationship with *N. denticula*. Cleve-Euler (l.c.) maintained that the var. *delognei* was distinct from *N. denticula*, and raised the variety to the rank of species. As a result a name change was required as the combination *Nitzschia delognei* Grunow (in Van Heurck, 1885 : Suppl. Pl. C, Fig. 38) was already occupied. She therefore proposed the name *Nitzschia solgensis* Cleve-Euler after the lake in which she found it. Her concept and nomenclature has been adopted in this study, since the specimens from the Great Fish River fitted the descriptions of neither *N. denticula* nor *N. interrupta* exactly. The dimensions of the two specimens measured were: length 10,8 - 14,0 µm, breadth 3,4 µm, striae 24 in 10 µm and fibulae 6 - 8 in 10 µm . These dimensions do not cover the full range of variation for this taxon, as larger specimens have been observed in other regions of Southern Africa. These have not been considered here, but will be taken into account when the taxon is re-evaluated. It is not known how many of the records of *N. interrupta* from Southern Africa should in fact be placed in this species, i.e. *N. solgensis* and not under *Nitzschia denticula* (cf. taxonomic notes under *N. denticula*). This is the first record of *N. solgensis* for Southern Africa.

Meioeuryhaline oligohalobe - 1.

Fig: 431.

Samples: FIS: 12.

Nitzschia spiculoides Hustedt

Hustedt, 1949a : 151, Pl. 13, Figs 5, 6.

Taxonomic notes: A single specimen fitting the description of this taxon was observed at Station 6 on the Sundays River.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 50.

Nitzschia stompsii Cholnoky

Cholnoky, 1963c : 75, Figs 100-102.

Taxonomic notes: The Sundays River specimens have been compared with examples of this species from the type slide (K 176 - NIWR), and are identical to the latter. Having examined a number of specimens from the type slide it is clear that Cholnoky's original diagnosis needs to be expanded. The length of the valve varied from 15,7 - 56,4 µm, and the breadth from 2,7 - 4,2 µm, while the striae counts ranged from 26 - 30 in 10 µm, and the fibulae from 10 - 14 in 10 µm . In the Sundays River examples the dimensions corresponded very closely, being 36,3 - 61,7 µm long, 2,9 - 4,9 µm broad and having 26 - 30 striae and 8 - 14 fibulae in 10 µm . In contrast to these typical examples found in the Sundays River, Giffen (1966a : 279, Fig. 97; 1975 : 90) has twice reported abnormally long forms (54,0 - 112,0 µm in length) with coarser striation of the valve surface (20 - 24 in 10 µm). Such specimens have not been examined, and therefore remain with some doubt as members of this species. Another species which needs careful re-examination with regard to its relationship to *N. stompsii* is *N. lesbia* Cholnoky (1963c : 73, Fig. 93), described originally from the same type material as *N. stompsii.* As far as can be determined through comparisons of the diagnoses and the illustrations, the only difference between the two taxa is the purported sigmoid valve shape of *N. lesbia.* Cholnoky's Fig. 93 shows, however, only one pole with a curve. It is suggested here that this may have been an abnormal valve, and the species is in fact *N. stompsii*; *N. lesbia* being based on this abnormality.

Pleioeuryhaline polyhalobe - 7.

Figs: 432-434.

Samples: SUN: 5, 13, 40, 59, 68, 71, 78, 79.

Nitzschia subacicularis Hustedt

Hustedt, 1922 in A. Schmidt *et al.*, 1874-1959 : Pl. 348, Fig. 76.
Hustedt, 1937-38 : 490, Pl. 41, Fig. 12.
Cholnoky, 1966a : 59, Figs 167-170.

Taxonomic notes: The single specimen placed in this species was identified as *N. subacicularis* Hustedt on the basis of its similarity to some very large examples identified as such by Cholnoky (l.c.) from the Okawango River. *N. subacicularis* is, however, in itself a rather problematic species as there are some discrepancies in the literature leading to some confusion as to the true concept of the species. The confusion centres around the density of the striae and fibulae. The original illustration of the species in A. Schmidt *et al.* (l.c.) shows a specimen from Africa having 33 striae and 13 fibulae in 10 µm (by inspection of the drawing). The first formal written description of the species was in Hustedt's (1937-38 : 490, Pl. 41, Fig. 12) report of the diatoms from the Sunda Islands of Indo-Malaysia; this description gave 33 striae and 14 - 16 fibulae in 10 µm . Later Hustedt (1957 : 357, Figs 55, 56) recorded specimens with similar measurements, i.e. 32 - 34 striae and 13 - 14 fibulae in 10 µm (measurements taken from illustrations) from the River Weser in West Germany. In contrast Hustedt (1949a : 150, Pl. 11, Fig. 61) recorded, without any comment, a specimen from the Belgian Congo, although the example he illustrated contained only 24 striae and 8 fibulae in 10 µm . In a Central American study Hustedt (1956 : 127, Fig. 74) reported that, amongst finely structured forms, some individuals with a coarser structure (26 - 28 striae and 14 fibulae in 10 µm) had been observed. Furthermore the specimen he illustrated was abnormal in that it had more distantly spaced central fibulae, a feature not mentioned or described in any previous report of the species. A ringed specimen of the Central American material (Hustedt slide No. W1, 67 - Bremerhaven) confirmed these measurements (23 - 24 striae and about 13 fibulae in 10 µm) and the separation of the central fibulae. Specimens recorded as *N. subacicularis* from Southern Africa (Archibald, 1971 : 55, Fig. 256; Cholnoky, 1966a : 59, Figs 167-170; Schoeman, 1969 : 61, Fig. 87) agree with Hustedt's original diagnosis with regard to the density of striae (29 - 36 in 10 µm) and fibulae (12 - 16 in 10 µm), but much longer and broader specimens were observed. For instance in the Okawango Cholnoky (l.c.) found specimens having a length range of 33,8 - 77,0 µm and breadth from 2,3 - 3,4 µm . The single specimen found in the Sundays River was still larger, being 86,2 µm long and 4,9 µm broad. The valve was lanceolate with long thinly protracted poles having capitate apices. The striae density was 34 in 10 µm, while that of the fibulae was 11 - 12 in 10 µm . Although not quite corresponding in size and shape this specimen came closer to the larger of Cholnoky's examples from the Okawango than any other taxon. For this reason it was considered preferable to place it with this species.

Mesoeuryhaline oligohalobe - 2.

Sample: SUN: 68.

Nitzschia subcapitellata Hustedt

Hustedt, 1939 : 663, Figs 109, (110?).

Taxonomic notes: The three specimens observed in the Sundays River are in complete agreement with the diagnosis of *N. subcapitellata*, and the veracity of this identification has been proven by comparison with specimens on some slides in Hustedt's collection (slide Nos 382, 16 and 280, 24a - Bremerhaven). In trying to determine their true identity two other species came into consideration. These were *Nitzschia balcanica* Hustedt (1945 : 947, Pl. 43, Figs 4, 5) and *Nitzschia diserta* Hustedt (1949a : 139, Pl. 12, Figs 32, 33). The type slides of both these taxa were examined and their characteristics compared with *N. subcapitellata*. This comparison is shown in the table below:-

Species	*N. subcapitellata*	*N. balcanica*	*N. diserta*
Slides examined	380, 24a and 382, 16	206, 1 and 206, 3 (Bremerhaven)	243, 7 (Bremerhaven)
Valve outline	Schalen linear mit schwach konkaven Rändern, gegen die leicht kopfigen Polen keilformig verschmälert.	Schalen linear mit leicht konkaven seiten, und lang keilformig verschmälerten kopfig gerundeten Enden.	Schalen breit linear, mit schwach konkaven seiten und ziemlich lang keilformig verschmälerten, an den Polen kopfig gerundeten Enden.
Length	44,2 - 50,0 µm	45,0 - 55,0 µm	40,0 - 45,0 µm
Breadth	4,0 - 5,0 µm	4,3 - 4,5 µm	5,0 - 5,5 µm
Canal raphe	Kiel stark exzentrisch, Kielpunkte klein, die beiden mittleren weiter voneinander entfernt.	Keil stark exzentrisch, in der Mitte etwas eingezogen, Kielpunkte klein die beiden mittleren weiter voneinander entfernt.	Kiel stark exzentrisch, über dem mittleren Röhrchen etwas eingesenkt, Kielpunkte länglich, die beiden mittleren etwas weiter voneinander entfrent.
Number of fibulae	12 - 15 in 10 µm	13 - 16 in 10 µm	12 - 16 in 10 µm
Nature of striae	Transapikalstreifen zart.	Transapikalstreifen äusserst zart, kaum erkennbar.	Transapikalstreifen zart.
Number of striae	33 - +40 in 10 µm	37 - 40 in 10 µm	37 - 40 in 10 µm

The table above compares the original diagnoses of the three taxa as given by Hustedt with dimensions expanded where necessary from personal observation of the type slides in Hustedt's collection. From the table it is clear that there are no essential differences between the species. *N. diserta* may be relatively broader than the other two, but this is not a very significant character. Hustedt also described the fibulae of *N. diserta* as "länglich", while in *N. subcapitellata* and *N. balcanica* they were said to be "klein". However comparison of the size on the actual specimens showed no marked differences in length. Considering the facts discussed above it is suggested that all three species are conspecific, and *N. balcanica* and *N. diserta* should consequently be regarded as later synonyms of *N. subcapitellata*. Of the three taxa discussed only *N. diserta* has previously been recorded from Southern African waters.

Archibald (1971 : 51, Figs 199, 200) observed specimens from the Vaal Dam catchment having the following measurements:- length 21,0 - 39,0 µm, breadth 3,5 - 4,5 µm, striae 36 - 40 in 10 µm, and fibulae 12 - 16 in 10 µm . In contrast the three specimens from the Sundays River were 49,0 - 50,0 µm long, 4,4 - 5,0 µm wide, and had 36 - 40 striae and 12 - 14 fibulae in 10 µm .

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 23, 24, 53.

Nitzschia sublanceolata n. sp.

Description: Valves lanceolate with poles protracted into acute rostrate apices; length 23,0 - 26,5 µm, breadth 4,0 - 5,0 µm . Canal raphe marginal with a distinct central nodule; central interspace enlarged and therefore the central fibulae more widely separated, interspaces roundish to elliptical and the fibulae short and rod-like, 9 - 10 in 10 µm . Transapical striae very fine, and so far not resolved under the light microscope.

Under TEM the fibulae were seen to be fairly broad, but short, strips of silica membrane between the roundish to elliptical interspaces. The central interspace was a large elliptical opening through which the distinct central nodule could be seen. Transapical striae were resolved as single rows of small round pores between thin costae, 42 - 43 in 10 µm .

Taxonomic notes: At Station 1 on the Sundays River a number of specimens of a *Nitzschia* taxon closely resembling *N. lanceolata* f. *minima* Grunow (in Van Heurck, 1880-83 : Pl. 68, Fig. 4) in many respects were observed. However due to a very distinct central nodule interrupting the raphe, these specimens cannot be connected to *N. lanceolata*. A somewhat similar species to the taxon described above is *N. amplectens* Hustedt (1957 : 347, Fig. 48-50), but this species is more linear with more bluntly rounded, slightly rostrate apices. The structure of the raphe of *N. amplectens* is, furthermore, different in that the canal raphe is slightly deflected at the centre, where a central nodule is indicated by the clearly widened central fibulae. Through examination of Hustedt's type material (Hustedt slide Nos W1, 44 and W1, 69) another distinguishing feature was noted; the striae in *N. amplectens*, contrary to Hustedt's description, were visible numbering more or less constantly 37 in 10 µm . The number of fibulae in 10 µm was also greater in *N. amplectens* (14 - 18 in 10 µm) than in the taxon described here (9 - 10 in 10 µm). Apart from these two species the Sundays River forms cannot be related at present to any other taxon in the genus *Nitzschia*. Thus it has been described as a new taxon until proved otherwise. To give some indication of its similarities it has been given the name *Nitzschia sublanceolata* n. sp.

Meioeuryhaline polyhalobe - 9.

Figs: 66, 67, 435-437, 559.

Samples: SUN: 86.

Nitzschia sublinearis Hustedt

Hustedt, 1921 in A. Schmidt *et al.*, 1874-1959 : Pl. 334, Figs 27-29.
Hustedt, 1930 : 411, Fig. 786.

Taxonomic notes: The correct identity of the specimens from the Sundays River assigned to this species is in some doubt. They agree almost entirely in valve form and dimensions as given by Hustedt (l.c.). They do not, however, conform too closely with specimens named as *N. sublinearis* by Hustedt on his slide Nos W4, 1 and W4, 2)Bremerhaven). Neither of these two slides were, however, the types, and the specimens observed differ slightly from the description and illustration of the taxon. The main difference was in the structure of the fibulae, which, in the specimens observed on Hustedt's slides, were much longer and less regularly arranged than those shown in his illustrations (cf. Hustedt l.c.: 786). The Sundays River specimens, measuring 37,5 - 59,0 µm long, 4,0 - 4,5 µm broad, and having 36 striae and 12 - 14 fibulae in 10 µm, may be better placed with *N. palea* (Kützing) W. Smith.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 17, 25, 32, 43, 47.

Nitzschia subrostratoides Cholnoky

Cholnoky, 1966a : 59, Figs 171-173.

Taxonomic notes: The taxonomic position of this species is a little doubtful, and it may possibly be nothing more than a narrow form of *N. palea* (Kützing) W. Smith. The taxon appears to be rare on the type slide (SWA 84 - NIWR) and a few specimens were seen agreeing entirely with the description except that striae were not visible even under oblique light.

Specimens identified as *N. subrostratoides* came close to the description, but were sometimes a little broader. These also showed a similarity to *N. palea*, suggesting that a closer examination should be made of *N. subrostratoides* in relation to *N. palea*. The Sundays River specimens measured had the following dimensions:- length 35,9 - 51,0 µm, breadth 2,9 - 3,9 µm, striae +40 in 10 µm, fibulae 12 - 16 in 10 µm .

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 28, 34.

Nitzschia subsalsa Cholnoky

Cholnoky, 1968a : 80, Fig. 150.

Synonyms: *Nitzschia exilis* Archibald, 1966c : 230, Fig. 7 (non *N. exilis* Sovereign).
Nitzschia demota Archibald, 1971 : 50, Figs 201, 202.

Taxonomic notes: Only two specimens of this taxon were observed in the region under investigation, one from the Wit River, a tributary of the Sundays River, and the other from Station 1 on the Great Fish River. These specimens were 87,8 - 88,0 µm long, 1,9 - 2,4 µm broad and had 12 - 14 fibulae in 10 µm . These measurements fitted the descriptions of both *N. demota* Archibald (1971 : 50, Figs 201, 202), and *N. subsalsa* Cholnoky. This prompted a comparison of the type material of the two species. Consequently the relevant type slides (SL 39 for *N. subsalsa* and Vaal 410 for *N. exilis* = *N. demota* - NIWR) were examined. This showed quite clearly that both *N. subsalsa* and *N. exilis* were conspecific. *N. demota* = *N. exilis* consequently falls away as a later synonym of *N. subsalsa*. *N. subsalsa* therefore has the following dimensions:- Length 80,0 - 102,0 µm, breadth 1,5 - 2,5 µm, fibulae 11 - 16 (generally 14) in 10 µm; transapical striae are as yet still unresolved under the light microscope.

Meioeuryhaline oligohalobe - 1.

Figs: 438, 439.

Samples: SUN: 34.
FIS: 8.

Nitzschia thermalis (Ehrenberg) Auerswald

Rabenhorst, 1861-79 : Nos 1064 and 1266.
Grunow, 1862 : 568, Pl. 12, Fig. 22.
Rabenhorst, 1864 : 153.
Hustedt, 1930 : 404, Fig. 771.

Synonyms: *Pinnularia thermalis* Ehrenberg, 1841 : 21
Nitzschia stagnorum Rabenhorst, 1848-60 : No. 625.

Taxonomic notes: Typical examples of this taxon were observed in both the Sundays and Great Fish rivers. In this study *Nitzschia stagnorum* Rabenhorst has been considered as synonymous with *N. thermalis*. This is by no means a new concept as it was first mentioned as such by Grunow in 1862 (cf. Grunow, 1862 : 569). More recently Cholnoky (1966b : 206) came to this conclusion, and was supported by Schoeman 1972a : 84; 1972b : 243), who claimed that they were indistinguishable morphologically. Dimensions of the specimens found in this region were:- length 54,3 - 113,0 µm, breadth 6,5 - 8,0 µm, striae 24 - 28 in 10 µm, and fibulae 8 - 10 in 10 µm .

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 10, 15, 16, 27, 33, 37, 46, 47, 52, 54, 60, 72, 75.
FIS: 33.

Nitzschia thermaloides Hustedt

Hustedt, 1955 : 44, Pl. 15, Fig. 13-15.

Taxonomic notes: A number of specimens have been assigned to this species, although certain characteristics do not quite match Hustedt's (l.c.) diagnosis. However, since the species appears to have been recorded only from the type locality, Beaufort Harbour, one may expect some variation from the typical forms in newly observed examples. The specimens observed in this study were 27,0 - 46,5 µm long, 5,0 - 6,5 µm broad, and had 26 to more than 40 striae and 16 - 20 fibulae in 10 µm . Some specimens could possibly have been identified as *Nitzschia pseudohybrida* Hustedt (l.c. : 45, Pl. 15, Figs 3, 4), but this was ruled out on account of the density of the fibulae and their elongate shape. This is a new record for South Africa, and possibly the first outside the type locality.

Meioeuryhaline polyhalobe - 9.

Figs: 440-442.
Samples: SUN: 1, 3, 84-86.
FIS: 28.

Nitzschia tryblionella Hantzsch

Hantzsch in Rabenhorst, 1848-60 : No. 984 (1860).
Van Heurck, 1880-83 : Pl. 57, Figs 9-10.
Hustedt, 1930 : 399, Fig. 757.
Hendey, 1964 : 276, Pl. 44, Figs 2, 3.

Taxonomic notes: The species occurring in the two river systems under investigation appear to be quite typical. These measured specimens were 62,0 - 138,5 µm long, 17,0 - 22,5 µm broad, and had 6 - 10 transapical ribs (weak folds according to Hendey, l.c.) in 10 µm, and 5 - 9 fibulae in 10 µm .

Pleioeuryhaline oligohalobe - 3.

Samples: SUN: 5, 6, 10, 16, 22-24, 28, 30, 31, 37, 48, 50, 61, 66, 75.
FIS: 3, 14, 18, 21, 24, 29, 32, 36.

Nitzschia sp. affin: *N. sigma* var. *sigmatella* Grunow

Description: Cells in girdle view sigmoid, narrow linear-lanceolate, attenuating gradually to truncate apices. Valves sigmoid, linear-lanceolate with poles tapering gradually to fairly narrow acutely rounded apices; 37,7 - 55,0 µm long, and 3,9 - 4,9 µm broad. Canal raphe marginal, interrupted in the middle by a central nodule; fibulae (10 - 14 in 10 µm) strong with large roundish to elliptical portulae; central two fibulae more widely spaced due to the central nodule. Transapical striae fine, and resolved best with oblique light illumination, 36 - 40 in 10 µm .

Taxonomic notes: A number of specimens of a sigmoid *Nitzschia* from the estuary of the Sundays River have not been assigned to any particular taxon at present as too few examples have been observed, and they cannot be placed with certainty in any taxon known from the literature available. In valve shape and symmetry there is a suggestion of a link with some of the smaller forms of *N. sigma* W. Smith (cf. Hustedt, 1930 : 420, Fig. 813). Nevertheless, one feature may preclude any connection with *N. sigma*. All the Sundays River specimens (see Figs 443, 444) had more distantly spaced central fibulae, inferring the presence of a central nodule. This is a characteristic not found in *N. sigma*. The Sundays River specimens, however, approach most closely *N. sigma* var. *sigmatella sensu* Grunow (1884-87 : 97, slide no. 397). Having examined the Van Heurck slide no. 397, it was evident that the var. *sigmatella*, despite its sigmoid shape and striation similar to *N. sigma*, also could not be placed with the latter on account of the regular occurrence of separated central fibulae observed in all the valves examined. The Sundays River specimens differed from *N. sigma* var. *sigmatella sensu* Grunow in their smaller size and much finer striation, but retain similar characteristics such as valve shape and the more widely spaced central fibulae. Although the Sundays River forms may also accord fairly closely in many features with *Nitzschia ignorata* Krasske (cf. Hustedt, 1930 : 422, Fig. 819), it was felt that there was a closer affinity between the former and *N. sigma* var. *sigmatella sensu* Grunow. There is, however, an added complication here as there is apparently some uncertainty concerning the validity of the taxon var. *sigmatella*, and in VanLandingham (1978 : 3112) there is a suggestion that it might be synonymous with *Stenopterobia intermedia* (Lewis) van Heurck. In the case of the specimens on Van Heurck's slide no. 397 this does not seem feasible as the specimens are truly *Nitzschiae*.

Consequently, since so few examples from the Sundays River were examined, it was deemed best not to identify the Sundays River specimens positively with a known taxon, but rather to indicate its affinities as far as possible.

Euryhaline mesohalobe - 5.

Figs: 443, 444.

Samples: SUN: 3, 86.

PINNULARIA Ehrenberg, 1840a : 213.

Pinnularia eburnea Zanon

Zanon, 1941 : 49, Pl. 3, Figs 16-19.

Taxonomic notes: An insufficient number of specimens has been observed in these samples to be able to accept or reject claims that *Pinnularia dubitabilis* Hustedt (1949a : 105, Pl. 6, Figs 11-13) is synonymous with *P. eburnea* (cf. Cholnoky, 1959 : 62; 1960a : 108, Figs 324-331). The relationship between *P. eburnea* and *Pinnularia borealis* Ehrenberg (1841 : Pl. 1, Fig. 2/6; Pl. 4, Fig. 1/5) is also controversial. While some, such as Cholnoky (1959 : 61), accept that *P. borealis* and *P. eburnea* are distinct taxa, others, e.g. Bock (1975 : 20), contend that they are the same. Until such time as a comparison of type material can be made an answer satisfying one or other of these two schools of thought is not possible. However since this taxon has most frequently been referred to as *P. eburnea* in Southern African studies, this combination has been preferred. The dimensions of the Sundays and Great Fish River specimens were as follows:- length 21,0 - 36,5 µm, breadth 5,0 - 10,0 µm, and transapical striae 4 - 6 in 10 µm .

Meioeuryhaline oligohalobe - 1.

Figs: 445, 446.

Samples: SUN: 21, 22, 84.
FIS: 10, 12, 20, 21, 26, 28, 30, 37.

Pinnularia gibba f. *subundulata* Mayer

Hustedt, 1930 : 327, Fig. 601.

Taxonomic notes: A single specimen, best placed in this taxon, was observed in the Wit River, a tributary of the Sundays River near Addo village. *Pinnularia gibba* appears to be an extremely variable taxon, and some workers, among them Cholnoky (1970c : 32), do not distinguish between the varieties and forms, regarding them as phenotypes. As only one specimen was observed no further comment can be made of the taxonomy of this species. The f. *subundulata* is retained to indicate the valve shape of this specimen.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 34.

Pinnularia irrorata (Grunow) Hustedt

Hustedt, 1939 : 640.
Hustedt, 1942a : 81.
Hustedt, 1942b : 71, Figs 25-39.

Synonyms: *Navicula appendiculata* var. *irrorata* Grunow in Van Heurck, 1880-83 : Pl. 6, Figs 30-31.
Pinnularia kneuckeri Hustedt, 1949b : 50, Figs 22-32 (p. 54).

Taxonomic notes: It is difficult to know on what grounds Hustedt (1939 : 640) elevated *Navicula appendiculata* var. *irrorata* Grunow to the rank of species, i.e. *Pinnularia irrorata*, as he gives no reasons for doing so. Examination of Grunow's illustrations of the nominate variety, *N. appendiculata*, and the var. *irrorata* (Figs 18, 20, 30 and 31) on Pl. 6 of

Van Heurck's (1880-83) Atlas shows no significant differences other than size. Cleve (1895 : 75) considered the var. *irrorata* as synonymous with *Pinnularia appendiculata* (Agardh) Cleve (l.c.). However, despite this, *P. irrorata* has been accepted by others as a distinct species, e.g. Cholnoky (1960a : 111; 1965: 75; 1966b : 211), Mayer (1946 : 139, Pl. 9, Figs 11, 12) and Foged (1977 : 102, Pl. 33, Fig. 13). Cholnoky (1965 : 75), furthermore, has united *Pinnularia kneuckeri* Hustedt (1949b : 50, Figs 22-32 with *P. irrorata*. This view point is adhered to in this study as there appears to be no real difference between these two taxa on morphological grounds. Ecologically there may be some discrepancy, since Hustedt (1939 : 640) considered *P. irrorata* as oligohalobous, while *P. kneuckeri* was described from dry desert regions, where the aquatic habitats were brackish. The two specimens observed in this study were collected in a brackish seepage water at Station 5 on the Sundays River, and would thus agree better with *P. kneuckeri* ecologically. The dimensions of these two examples were:- 24,6 - 28,4 µm, breadth 4,7 - 5,2 µm, striae 17 - 18 in 10 µm in the centre and increasing to about 20 at the poles. Cholnoky (1963d : 37, Fig. 22) illustrated a specimen which he identified as *Pinnularia krockii* (Grunow) Hustedt. This specimen is probably better placed with *P. irrorata* on morphological grounds. Cholnoky's specimen has a central area extending fascia-wise to the margins of the valve. This is not characteristic of *P. krockii* as shown in Grunow's (1882 : 155, Pl. 30, Fig. 40 as *Navicula krockii*) original diagnosis, or in Hustedt's (1930 : 319, Fig. 580 as *Pinnularia globiceps* var. *krookei*) description, but conforms morphologically to the description and illustration of *P. irrorata* or *P. kneuckeri*.

Pleioeuryhaline oligohalobe - 3.

Figs: 447.

Samples: SUN: 12.

Pinnularia microstauron (Ehrenberg) Cleve

Cleve, 1895 : 77.
Hustedt, 1930 : 320, Fig. 582.

Synonym: *Stauroptera microstauron* Ehrenberg, 1841(1843) : Pl. 1/4, Fig. 1; Pl. 4/2, Fig. 2.

Taxonomic notes: A single specimen of the nominate variety, *Pinnularia microstauron*, was observed in this study. This variety is best distinguished from the var. *brebissonii* (see below) by the possession of broad protracted poles. This specimen was 45,0 µm long, 9,5 µm broad and had 12 striae in 10 µm .

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 43.

Pinnularia microstauron var. *brebissonii* (Kützing) Mayer

Mayer, 1913 : 186, Pl. 6, Figs 25, 27.
Hustedt, 1930 : 321, Fig. 584.

Synonyms: *Navicula brebissonii* Kützing, 1844 : 93, Pl. 3, Fig. 49; Pl. 30, Fig. 39.

Taxonomic notes: Hustedt (l.c.) seems to be generally credited with uniting *Pinnularia brebissonii* (Kützing) Rabenhorst with *Pinnularia microstauron* (Ehrenberg) Cleve making it a variety of the latter. However Mayer (l.c.) proposed this arrangement some years prior to Hustedt, albeit in a rather confused way. This variety is distinguished from the nominate variety by the lack of protracted poles. The poles in var. *brebissonii* are rounded and very often rather cuneate in shape. Although frequently recorded in the samples this variety was never abundant; it was found mostly as one or two specimens in each relevant sample. Dimensions of the Sundays and Great Fish River examples were:- length 33,5 - 45,0 µm, breadth 10,0 - 12,0 µm, striae 12 in 10 µm .

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 25, 26, 43-45, 47, 60.
FIS: 17, 20, 21, 24.

PLEUROSIGMA W. Smith, 1852 : 2.

Pleurosigma delicatulum W. Smith

W. Smith, 1852 : 6, Pl. 1, Fig. 5.
W. Smith, 1853 : 64, Pl. 21, Fig. 202.
Cleve, 1894 : 37.

Synonyms: *Pleurosigma delicatulum* var. *africana* Grunow in Cleve and Möller, 1877-82 : No. 197.

Taxonomic notes: With the exception of var. *obtusiuscula* Grunow (in Cleve, 1894 : 38) the distinction between the varieties of this species appears to be based solely on dimensions and striae counts. Subsequent observations of the taxon show, however, that its range in variation is much greater than described by Cleve (l.c.) and consequently the varieties do not appear to be tenable any longer. Hustedt (1942a : 94) reported forms of *P. delicatulum* from Indomalaya having dimensions of 80,0 - 135,0 µm long, 12,0 - 15,0 µm broad and having 23 - 24 striae in 10 µm . From South African waters Cholnoky (1960a : 113) and Giffen (1963 : 250) found specimens that were 122,0 - 190,0 µm long, 13,0 - 15,0 µm broad and had 19 - 24 oblique and transverse striae in 10 µm . The specimens observed in the Sundays and Great Fish rivers were very much the same in dimension and striae density as those found by Giffen (l.c.) and had the following measurements:- length 116,0 - 182,0 µm, breadth 13,5 - 17,2 µm, transverse and oblique striae 20 - 25 in 10 µm . As Giffen (1966a : 282) maintains however, if the varieties are to be upheld, then most specimens from South Africa would fall within *Pleurosigma delicatulum* var. *africana* Grunow. This is interesting and perhaps not too surprising as the type locality for this variety is the Baakens River in Port Elizabeth (cf. Cleve and Möller, 1877-82 : No. 197), which is about 30 km from the Sundays River localities in which this species was recorded.

Euryhaline mesohalobe - 5.

Fig: 448.

Samples: SUN: 5, 9-14, 16, 18, 28, 37, 57, 69, 75, 78.
FIS: 14, 19, 32.

RHOPALODIA O. Müller, 1895 : 57.

Rhopalodia gibba (Ehrenberg) O. Müller

O. Müller, 1895 : 65, Pl. 1, Figs 15-17.
Hustedt, 1930 : 390, Fig. 740.

Synonyms: *Navicula gibba* Ehrenberg, 1830 : 64 and 65 (fide. VanLandingham, 1978b : 3610).

Taxonomic notes: Examples of this taxon found in the Sundays and Great Fish rivers were quite typical and need no further comment. The dimensions of the measured specimens were:- length 55,0 - 73,0 µm, breadth 7,7 - 9,5 µm, transapical costae 6 - 8 in 10 µm and striae 14 - 16 in 10 µm .

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 6, 27, 31, 32, 34, 43, 44, 46, 47, 51, 60, 62.
FIS: 7, 8.

Rhopalodia gibberula (Ehrenberg) O. Müller

O. Müller, 1895 : 58.
O. Müller, 1899 : 286.
Hustedt, 1930 : 391, Fig. 742.

Synonyms: *Eunotia gibberula* Ehrenberg, 1841 (1843) : 414, Pl. 3/4, Fig. 8.

Taxonomic notes: The true identity of this taxon is extremely difficult to determine, since so much confusion surrounds the taxonomy of *Rhopalodia gibberula* (Ehrenberg) O. Müller and *R. musculus* (Kützing) O. Müller (1899 : 278). The distinction between these two taxa has been questionable almost from the inception of the genus *Rhopalodia*. O. Müller (1899 : 278) expressed this doubt himself, and suggested that a careful study of these two species was necessary to separate them. As far as can be ascertained from the literature a thorough study of this nature has still to be undertaken. As a result the doubt has persisted. Peragallo and Peragallo (1897-1908 : 303, Pl. 77, Figs 18-22) considered *R. gibberula* as a variety of *R. musculus*. Later still Hustedt (1930 : 392) regarded the distinction to be of such an uncertain nature that he suggested a complete abandonment of differentiation. Finally in their monograph of the diatoms of the United States of America Patrick and Reimer (1975 : 191) separated the species, but commented that *R. musculus* "is closely related to *R. gibberula* and may be shown to belong to that taxon".

Despite these differences of opinion many authors have still recorded their observations of the two taxa, sometimes under both names in the same work. In the Sundays River numerous examples were observed, particularly from the estuarine stations (they were most abundant when the salinity exceeded that of seawater in May 1970 - see ecological section). However on the basis of Hustedt's (1930 : 391 and 392) descriptions it was difficult to decide to which species they should be referred. Bearing in mind the difficulties experienced by earlier workers, as discussed above, and the insufficiency of distinguishing characteristics between them, *R. musculus* has been considered as synonymous with *R. gibberula*.

The valves observed in this study were 11,3 - 44,1 µm long and 5,0 - 9,8 µm broad, and had 14 - 24 rows of areolae and 3 - 7 costae in 10 µm . The density of striae or areolar rows was somewhat greater than that given by Hustedt (1930 : 391), and was generally in the order of 20 - 22 in 10 µm.

Breadth measurements must be considered with some caution as these are entirely dependent on the plane in which the valve is viewed. In one sample (SUN 82 - NIWR) the striation of the valves was somewhat coarser than specimens in other samples, and had distinct, relatively unevenly spaced areolae. The valves of these specimens were also larger than the others examined.

Euryhaline mesohalobe - 5.

Figs: 449-454.

Samples: SUN: 1, 3-7, 11, 42, 45, 48, 51, 53, 55-57, 59, 67, 69, 77, 78, 80-84.
FIS: 3-5, 16, 17, 19, 29, 31, 32, 37, 40.

STAURONEIS Ehrenberg 1841(1843) : 422 (425)

Stauroneis borrichii (Boye Petersen) Lund

Lund, 1946 : 63, Fig. 3C-H.
Hustedt, 1931-59 : 803, Fig. 1151a, b.

Synonyms: *Navicula borrichii* Boye Petersen, 1915 : 285, Figs 1, 2.

Taxonomic notes: The specimens observed in the Sundays River were typical in all features except that the striation was slightly finer. The lengths of these specimens were 12,7 - 15,0 µm, breadths 3,3 - 4,0 µm, and they had 24 - 28 striae in 10 µm . In some of these very small valves the central constriction was quite evident, and in one example the pseudosepta were relatively distinct.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 9, 16, 24, 25.

Stauroneis marina Hustedt

Hustedt, 1955 : 21, Pl. 7, Fig. 2.
Cholnoky, 1960a : 116, Figs 336, 337.
Giffen, 1963 : 252, Fig. 98.

Taxonomic notes: The correct identity of the specimens considered under this name in this study is somewhat uncertain. Cholnoky (l.c.) claimed that similar specimens found in Natal formed part of a wider range of variation for Hustedt's species. Cholnoky's specimens were much larger attaining lengths of up to 48,0 µm and breadths of up to 11,0 µm . His specimens varied in outline from linear or linear-elliptical forms, as Hustedt described them, to examples with a central constriction of the valve margins and broadly protracted rostrate poles. Sometimes his examples had short marginal striae in the stauros. Giffen (l.c.) also reported larger specimens (40,0 - 49,0 µm long, 12,0 - 14,0 µm broad) with constricted valves and rostrate poles, but the striation of his specimens seems excessively coarse (15 - 16 in 10 µm). Examples observed in the Sundays and Great Fish rivers appeared to display the same range in variation with respect to dimension and valve outline as the Natal specimens seen by Cholnoky. These specimens ranged in length from 27,4 - 50,0 µm, and in breadth from 7,4 - 13,7 µm . These dimensions agree entirely with the range given by Cholnoky and Giffen. Transapical striae at the centre numbered 19 - 24 in 10 µm, while near the poles they were a little denser, 24 - 28 in 10 µm . The smallest specimen corresponded very closely in all respects with Hustedt's diagnosis. Nevertheless the great majority of specimens observed in this study were the larger forms having constricted walls and rostrate poles. Not all examples, however, were constricted at the stauros, and most forms seemed to have shortened striae of variable length in the stauros. These were sometimes quite numerous, and on other occasions only one or two were present. Accepting Cholnoky's (1960a : 116) claims for the present, these specimens have therefore been retained as *S. marina* Hustedt.

Mention should, however, be made of examples observed at Station 4 when, due to extreme drought conditions, the salinity (18,9 ‰) at the time of sampling was more than double its normal value. The specimens observed at this time were somewhat narrower, less pronouncedly rostrate than the other examples, and were seldom constricted at the centre, or had marginal striae in the stauros. Furthermore the striae on one side of the raphe near the centre of the valve were in many cases denser than on the other. Despite these differences the strong similarity to the broader forms found elsewhere and at other times suggested that these examples are best placed with *S. marina*.

Pleioeuryhaline polyhalobe - 7.

Figs: 455, 456.

Samples: SUN: 5, 21, 42, 58, 69, 80.
FIS: 13, 21, 27, 29, 32.

Stauroneis spicula Hickie ex Grunow

Grunow in Cleve and Grunow, 1880 : 48.
Hustedt, 1931-59 : 830, Fig. 1173.
Hendey, 1977 : 285, Fig. 1.

Taxonomic notes: While there seems to be little confusion over what represents the taxon *Stauroneis spicula*, there is apparently still a controversy concerning the correct authority of the combination. Hendey (l.c.) reviewed in depth the history of the combination. He came to the conclusion that W.J. Hickie, and not Prof. G. Dickie, was the first to propose the combination *S. spicula* (cf. Hickie, 1874 : 290), however, neither an adequate description nor an illustration of the taxon was given by Hickie to validate the taxon. According to Hendey (l.c.) the first valid description of *S. spicula* was given by Grunow (in Cleve and Grunow, 1880 : 48) although Grunow attributed the species to Dickie. Accordingly Hendey cited the authority of the combination, *S. spicula*, as (Hickie) Grunow. Insertion of Hickie in parenthesis indicates, however, that Hickie used the epithet '*spicula*' in another genus. This is not true as is shown by Hendey's own article. Hickie's (1874 : 290) letter referred to *Stauroneis spicula*. Thus it would be more correct to write the combination and its authority in the following manner:- *Stauroneis spicula* Hickie ex Grunow.

In the Sundays and Great Fish rivers a few specimens were observed, and were in very good agreement with the description given by Hendey (l.c.). These specimens were 63,0 - 69,8 µm long, 7,0 - 8,0 µm broad and had 29 - 32 transapical striae in 10 µm .

Euryhaline mesohalobe - 5.

Figs: 457.

Samples: SUN: 41, 69, 77-81.
FIS: 14, 29.

Stauroneis wipplingeri Cholnoky

Cholnoky, 1963a : 248, Pl. 8, Figs 33, 34.

Taxonomic notes: The specimens observed in the Sundays and Great Fish rivers were compared with examples from Cholnoky's type slide (SWA 60 - NIWR). Structurally they were identical, but the Sundays and Great Fish

River specimens were somewhat smaller than the typical examples, and were more finely striate. The few examples observed in this study were 20,6 - 24,0 µm long, 4,4 - 6,0 µm broad, and had 14 - 18 striae in 10 µm near the centre and 20 - 24 in 10 µm at the poles.

Euryhaline mesohalobe - 5.

Figs: 68, 458.

Samples: SUN: 42, 82.
FIS: 5, 29.

Stauroneis wislouchii Poretzky and Anissimova

Poretzsky and Anissimova, 1933 : 51, Pl. 9, Figs 3-5.
Hustedt, 1931-59 : 792, Fig. 1137.

Taxonomic notes: There seems little doubt that the specimens found in the Sundays and Great Fish rivers are correctly identified as *S. wislouchii*. Dimensions of these specimens correspond very well with Hustedt's description; length 27,0 - 36,0 µm, breadth 6,5 - 9,5 µm, striae at the centre 20 - 28 in 10 µm, and denser at the poles, 26 - 30 in 10 µm .

Euryhaline mesohalobe - 5.

Samples: SUN: 6, 10, 11, 23, 28, 35, 36, 40, 48, 60, 61, 66, 76.
FIS: 3-6, 10, 12, 19, 30, 32.

STEPHANODISCUS Ehrenberg, 1845 : 80.

Stephanodiscus hantzschii Grunow

Grunow in Cleve and Grunow, 1880 : 115, Pl. 7, Figs 131, 132.
Grunow in Van Heurck, 1880-83 : Pl. 95, Figs 10, 11 (as *S. hantzschianus*).
Hustedt, 1927-30 : 370, Fig. 194.

Synonyms: *Stephanodiscus hantzschii* var. *pusilla* Grunow in Cleve and Grunow, 1880 : 115, Pl. 7, Fig. 132.

Taxonomic notes: The identification of the smaller *Stephanodiscus* species, particularly under the light microscope, is sometimes very difficult as they are so similar in many respects. Recently Håkansson (1976 : 25-34) made a detailed study of some *Stephanodiscus* species under both light and electron microscopes. This has done much to facilitate the distinction between the species. Håkansson prepared a key to separate the four taxa she examined; these were *S. astraea*, *S. dubius*, *S. hantzshii*, and *S. tenuis*. The four species were first divided into two groups on the basis of the flatness of the valve face, the first two taxa having undulate valves, while *S. hantschii* and *S. tenuis* had flat valve faces. This distinction can be fairly easily recognised under the light microscope. To separate *S. hantzschii* from *S. tenuis* is more easily accomplished, however, under the electron microscope. Unsing this instrument Håkansson described *S. hantzschii* as having many regularly placed marginal strutted processes, a single central process, a labiate process, 2 - 3 areolar rows in a stria, and a spine near the margin on each costa. *S. tenuis*, in contrast, has apparently irregularly spaced strutted processes, lacks a central process, and has 2 - 5 areolar rows per stria. According to this key, therefore, the electron micrographs of *S. hantzschii* prepared by Drum (1969 : 322, 323, Figs 1-4) illustrate specimens that would fit better into *S. tenuis* because of the lack of a central process. These specimens appear, however, not to have a labiate process making it different from both *S. hantzschii* and *S. tenuis*. Despite Håkansson's work there still seems to be a need for a more intensive study of this genus.

In the Sundays and Great Fish rivers some specimens were identified as *S. hantzschii* for the following reasons:-

(i) The valve faces were flat and not undulate.

(ii) There were 2 - 3 rows of areolae in each stria.

(iii) The valve structure was usually very difficult to resolve under the light microscope, although some specimens were distinctly punctate.

The dimensions of the specimens seen in the study were typical of *S. hantzschii*, being 9,3 - 12,3 µm in diameter, and they had 8 - 10 spines in 10 µm .

Mesoeuryhaline oligohalobe - 2.

Samples: SUN:19, 45, 50-52.
FIS: 11, 16, 17, 21, 22, 26, 28, 29.

SURIRELLA Turpin, 1828 : 362.

Surirella angusta Kützing

Kützing, 1844 : 61, Pl. 30, Fig. 52.
Hustedt, 1930 : 436, Figs 844, 845 (as *S. angustata*).

Taxonomic notes: Specimens occurring in the Sundays and Great Fish rivers appeared to be quite typical of our present day concept of the species, and cannot be connected with the heteropolar *Surirella ovata* Kützing (l.c.: 62, Pl. 7, Figs 1-4). Hustedt (l.c.) gave 18,0 μm as the minimum length of the valve, but a specimen measuring 15,5 μm was found in the Great Fish River. Although he stated that the valve surface was finely striated, no measurement of the striae density was given. The specimens observed in this study had 28 - 32 striae in 10 μm . The size range and density of the striae and alar canals (Flügelkanäle) for these specimens were as follows:- length 15,5 - 40,0 μm, breadth 6,5 - 9,5 μm, striae 28 - 32 in 10 μm, and alar canals 6 - 8 in 10 μm .

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 6, 8, 9, 13, 21-23, 34.
FIS: 23, 24.

Surirella atomus Hustedt

Hustedt, 1955 : 48, Pl. 16, Fig. 23.

Description: Valves heteropolar, oval in shape with one end broadly rounded, and the other narrower and more acute (the acuteness varying in degree); length 9,0 - 21,6 μm, breadth 4,5 - 9,0 μm . Canal raphe marginal on a distinct undulate wing, alar canals 6 - 9 in 10 μm . Transapical striae too fine to be resolved under the light microscope.

Taxonomic notes: Some of the specimens of this small *Surirella* species were very much larger than anything previously observed, attaining a length of 21,6 μm . None of the examples from the material examined reached, however, the width of the broadest form observed by Giffen (1971 : 11). Giffen's specimen was 9,0 μm wide; the maximum width reached in the Sundays and Great Fish River examples was 7,4 μm . These examples were 11,0 - 21,6 μm long, 5,4 - 7,4 μm broad, and had 6 - 8 alar canals in 10 μm . The specimens observed varied somewhat in shape from pronouncedly heteropolar, where the one pole was broadly rounded and the other more acute and narrow, to valves which were only slightly heteropolar. Despite this greater variation there can be no doubt that the examples are correctly identified as *S. atomus*. This taxon is very similar to the freshwater species *Surirella ostentata* Cholnoky (1962a : 73; 1962c : 106), but differs from it in the distinct winged projection, and more widely spaced alar canals.

Pleioeuryhaline polyhalobe - 7.

Figs: 459, 460.

Samples: SUN: 1-3, 59, 82-86.
FIS: 15, 28, 41.

Surirella gemma Ehrenberg

Ehrenberg, 1839b : 157.
Ehrenberg, 1840b : 76, Pl. 4, Fig. 5 (as *Navicula (Surirella) gemma*).
Van Heurck, 1880-83 : Pl. 74, Figs 1-3.
Van Heurck, 1885 : 187.
Hendey, 1964 : 288.

Taxonomic notes: Although Giffen (1970a : 300; 1971 : 11) considered this species to be the commonest *Surirella* in the marine littoral of the Eastern Cape Province coasts, it was found in only small numbers at the mouth of the Great Fish River, and at the most seaward sampling sites (Stations 1 and 2) of the Sundays River estuary. Dimensions of the specimens examined differed slightly from those given in most previous descriptions of the species. All the specimens belonged to the lower size range, and some were much smaller than the minimum size given in the literature. The observed size range was:- length 48,0 - 83,8 µm, and breadth 22,1 - 34,8 µm . Only Salah and Tamas (1970 : 319) have recorded a specimen shorter (45,0 µm long) than this, but it was still relatively broad (32,0 µm broad). In the literature most authors gave a range of 70,0 - ±140,0 µm for length and 32,0 - 56,0 µm for breadth. While the structure of the Sundays and Great Fish River specimens appeared to be typical, the density of the transapical striae was somewhat greater (24 - 28 in 10 µm) than that given in the literature (18 - 24 in 10 µm). The number of primary ribs or transapical costae (2 - 4 in 10 µm) tallies with the range expressed in previous descriptions. Although *S. gemma* is a well known species, a feature that seems to have escaped the notice of most taxonomists is the short silica strips spanning the width of the raphe canal. In a recent very comprehensive description of this species Paddock (1978 : 16) called these strips secondary ribs. These secondary ribs form a bridge between the inner surfaces of the valve face and mantle. Between them are the oval interspaces connecting the frustule cavity with raphe canal. In this respect the secondary ribs may be homologous with the fibulae of the Nitzschiaceae. These secondary ribs are beautifully illustrated in the SEM micrographs given by Paddock in his Plate 11, and in the TEM micrographs and reconstruction produced by Helmcke and Krieger (1953 : 19, Pl. 97-100). In the Sundays and Great Fish River specimens there were 6 - 10 of these secondary ribs in 10 μm .

Mesoeuryhaline polyhalobe - 8.

Samples: SUN: 1, 3, 85, 86.
FIS: 15, 28.

Surirella ostentata Cholnoky

Cholnoky, 1962a : 73.

Synonyms: *Surirella ovata* var. *africana* Cholnoky, 1955a : 21, Fig. 46.

Taxonomic notes: This small *Surirella* is probably most closely related from a structural point of view to *Surirella atomus* Hustedt (see above). Its salient points of difference are, however, the lack of a distinct wing on the edge of the valve, and its clearly protracted basal pole. A single specimen of this taxon was recorded from the Wit River, a more or less freshwater tributary of the Sundays River.

Mesoeuryhaline oligohalobe - 2.

Fig: 461.

Samples: SUN: 34.

Surirella ovalis Brebisson

Brebisson, 1838 : 17.
Hustedt, 1930 : 441, Figs 860, 861.

Taxonomic notes: This is one of the commonest *Surirella* species in the Sundays and Great Fish rivers. Structurally they accord very closely with Hustedt's (l.c.) description, but some amendment must be made to his dimensions in order to accommodate the wider range of length and breadth observed in these specimens. Examples measured in this study were 23,5 - 104,0 µm long, 16,0 - 46,0 µm broad, and had 14 - 16 transapical striae and 3 - 6 alar canals in 10 µm .

Pleioeuryhaline oligohalobe - 3.

Samples: SUN: 6, 8, 13, 15, 18, 19, 21-26, 37, 43-47, 76.
FIS: 8, 16-19, 23-26, 30, 31, 39, 40.

Surirella ovata Kützing

Kützing, 1844 : 62, Pl. 7, Fig. 4a-d.
Hustedt, 1930 : 442, Figs 863, 864.

Taxonomic notes: This species is not common in the waters being investigated, and the specimens observed were slightly different compared with Hustedt's (l.c.) description of the taxon. Hustedt gave 4 - 7 alar canals and 16 - 20 transapical striae in 10 µm . In contrast examples from the region under study had a greater number of alar canals (6 - 8 in 10 µm) and were much more densely striate (28 - 32 in 10 µm). Similar measurements for these two characters were also observed by Lund (1946 : 104, Fig. 18K-DD). Most examples seen in this region were more ovoid in shape. Lund (l.c.), however, found that the various forms and varieties intergrade with each other, and maintained that separation of the different variants was pointless. This view was adopted in this study, and no attempts were made to identify individuals as one form or variety or another. Dimensions of the specimens observed were:- length 21,0 - 29,0 µm, breadth 9,0 - 11,5 µm, striae 28 - 32 in 10 µm and alar canals 6 - 8 in 10 µm . Schoeman (1973 : 236) has reported a few, rather smaller specimens from Lesotho; these were 12,5 - 19,0 µm long, 7,5 - 8,0 µm wide and had 7,5 - 8,5 alar canals in 10 µm .

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 15, 17-19, 30, 45.
FIS: 16-18, 23-26.

Surirella scalaris Giffen

Giffen, 1966a : 286, Figs 121, 122.

Taxonomic notes: A single typical example of this recently described species was observed in the Sundays River estuary. This specimen had the following dimensions:- length 17,1 µm, breadth 13,7 µm, central robust striae (folds?)

16 in 10 µm, marginal striae 24 in 10 µm, and alar canals 3,5 in 10 µm . These values expand very slightly the limits set out by Giffen in his original diagnosis.

Oligoeuryhaline polyhalobe - 10.

Figs: 462-464.

Samples: SUN: 84.

Surirella striatula Turpin

Turpin, 1828 : 363, Pl. 15, Figs 2-9.
Hustedt, 1930 : 445, Fig. 869.

Taxonomic notes: Giffen (1963 : 254, Fig. 103) recorded *S. striatula* from some moderately brackish waters a little south of East London on the east coast of South Africa. The dimensions of his examples (length 39,0 - 60,0 µm and breadth 24,0 - 33,0 µm) were somewhat small for the species. A literature survey showed that the majority of diatomists found specimens in the range of 100,0 - 260,0 µm long and 60,0 - 160,0 µm wide. Only Rabenhorst (1853 : 30) in his paper on diatoms "für Freunde der Mikroskopie" reported specimens (50,0 - 70,0 µm long) in Giffen's range of dimensions. Subsequently, however, in a later work Rabenhorst (1864 : 55) ignored his earlier dimensions and gave a range of 102,5 - 150,0 µm for the length of *S. striatula.* It seems doubtful then that these small specimens belong properly to *S. striatula.* In the Sundays River a few valves were observed in the more highly brackish parts agreeing very closely in dimensions and structure with Giffen's (l.c.) examples, and for this reason have been placed in this species. The Sundays River examples were 31,0 - 73,0 µm long, 18,5 - 32,8 µm wide, and had 20 - 40 alar canals in 100 µm, and 20 - 24 transapical striae in 10 µm . Not only were these specimens smaller than expected for *S. striatula*, but they were also more densely striate (13 - 15,5 striae in 10 µm for *S. striatula*) and had more costae in 10 µm than are given for *S. striatula.* Nevertheless a structure very similar to *S. striatula* was noticed in these examples. The alar canals broadened near the margin of the valve and had on their outer edge a number of short, interpolated canal openings. De Toni (1891-94 : 573) considered *Surirella brevis* Ehrenberg (1844 : 272) as a variety of *S. striatula.* This apparent variety is, according to Ehrenberg (l.c.), only 29,7 µm long, and has 70 alar canals in 10 µm . These measurements accord more with the

Sundays River examples, but the descriptions of this variety are very flimsy, and one cannot be absolutely sure that the Sundays River specimens can be placed with this variety.

Euryhaline mesohalobe - 5.

Figs: 465, 466.

Samples: SUN: 4-6, 13, 41.

SYNEDRA Ehrenberg, 1830(1832) : 40.

Synedra acus Kützing

Kützing, 1844 : 68, Pl. 15, Fig. VIII.
Hustedt, 1930 : 155, Fig. 170.
Hustedt, 1931-59 : 201, Fig. 693a.

Taxonomic notes: Cholnoky (1970a : 56) did not distinguish between the varieties of *S. acus*, considering them part of one large range of variation having intermediates linking the forms together. No really constructive comment can be made at this stage, since only two specimens were observed in the Sundays River. One of these measured 125,0 µm long, 4,0 µm broad and had 14 striae in 10 µm . The breadth of this specimen was intermediate between the nominate variety and the var. *radians* (Kützing) Hustedt (1930 : 155, Fig. 170), thus supporting Cholnoky's opinion.

Meioeuryhaline oligohalobe - 1.

Samples: SUN: 22, 34.

Synedra fasciculata (Agardh) Kützing

Kützing, 1844 : 68, Pl. 15, Fig. V; Pl. 16, Fig. VI, 1-3.
Hustedt, 1931-59 : 218, Fig. 710a-l (as *S. tabulata*).
Patrick and Reimer, 1966 : 141, Pl. 5, Figs 17, 18.

Synonyms: *Diatoma fasciculatum* Agardh, 1809 : Pl. 491, Figs 6, 7; 1812 : 35.
Synedra affinis var. *fasciculata* (Agardh) Grunow in Van Heurck, 1880-83 : Pl. 41, Fig. 15.
Synedra fasciculata var. *truncata* Greville) Patrick and Reimer l.c. : 142, Pl. 5, Fig. 16.
Diatoma tabulatum Agardh, 1832 : 50.
Synedra tabulata (Agardh) Kützing, 1844 : 86, Pl. 15, Fig. X, 1-3.
Synedra tabulata var. *acuminata* (Grunow) Hustedt, 1931-59 : 219, Fig. 710e, f.

Synedra tabulata var. *fasciculata* (Agardh) Hustedt l.c. : 218, Fig. 710i-l.

Synedra tabulata var. *grandis* (Mereschowsky) Hustedt l.c. : 219, Fig. 710g.

Synedra tabulata var. *obtusa* (Pantocsek) Hustedt l.c. : 219, Fig. 710h.

Synedra affinis Kützing, 1844 : 68, Pl. 15, Fig. VI, XI; Pl. 24, Fig. I, 5.

Synedra affinis var. *tabulata* (Agardh) Juhlin-Dannfelt, 1882 : 43, Pl. 3, Fig. 27.

?Exilaria fasciculata Greville, 1824 : Vol. 1, Pl. 16, Figs 1-3; Vol. 5, Pl. 298, Fig. 3.

Taxonomic notes: The taxonomy of this species is somewhat confusing and is in need of some careful revision. The correct and valid combination for it depends on one's interpretation of what should be included in the species. On this question there appears to be no consensus of opinion and a number of views are currently held.

According to Kützing (1844 : 68) *Synedra fasciculata, Synedra tabulata* and *Synedra affinis* were three distinct taxa. The first two taxa concerned were based on *Diatoma fasciculata* and *Diatoma tabulata* described by Agardh in 1809 and 1832 respectively. *S. affinis* was described by Kützing himself in the above mentioned reference. Some time later Grunow (in Van Heurck, 1880-83 : Pl. 41, Figs 9a, 15), although accepting Kützing's taxonomy, suggested that both *S. fasciculata* and *S. tabulata* should be considered as varieties of *S. affinis*. Much later still Hustedt (1931-59 : 218, Fig. 710) united *S. tabulata* and *S. affinis* under the combination *S. tabulata* (its basionym, *Diatoma tabulatum* Agardh (1832 : 50), having priority over Kützing's *S. affinis*), and considered *S. fasciculata* as a variety of *S. tabulata*. Cholnoky (1968a : 90; 1970c : 36), on the other hand maintained that the varieties as distinguished by Hustedt (l.c.) could not be upheld on account of numerous intermediate forms linking them. Thus according to Cholnoky *S. fasciculata, S. tabulata* and *S. affinis* are all to be regarded as conspecific. If Cholnoky's opinion is correct then the redefined taxon, including all three elements, would have to take the combination *Synedra fasciculata* (Agardh) Kützing as its correct and valid name, since *Diatoma fasciculatum* preceded *D. tabulatum* by some 20 years.

In a recent exposition of the taxonomy of this complex of forms Patrick and Reimer (1966 : 141, Pl. 5, Figs 17, 18) justified the use of *Synedra fasciculata* as the correct combination for this species in a different way. They claimed that they had examined Agardh's type material of *Diatoma fasciculatum*, and provided an illustration of a valve from this material (their Pl. 5, Fig. 17). This fragment does indeed appear to be the same as *S. tabulata* as we know it today (cf. Hustedt l.c.). If this is so then the taxon presently known as *S. tabulata* must in future take on the earlier valid epithet "*fasciculata*", and "*tabulata*" must fall away as a synonym. This view point differs from Hustedt's opinion that *Diatoma fasciculatum* is a variety of *S. tabulata*, i.e. *S. tabulata* var. *fasciculatum*. Patrick and Reimer (l.c. : 142, Pl. 5, Fig. 16) agreed with Hustedt that the latter taxon is separate from the nominate variety, but they considered it to be synonymous with *Echinella fasciculata* var. *truncata*, and therefore called the variety *S. fasciculata* var. *truncata*. To complicate matters further, however, Patrick and Reimer (l.c.) placed *Exilaria fasciculata* Greville (1828 : 37) as a synonym of the latter variety, although Agardh (1832 : 51) equated *E. fasciculata* with *Diatoma fasciculatum*, which is presently regarded as the basionym for the nominate variety.

From this brief historical review of the situation it is clear that a careful revision of the type materials of a number of taxa within this complex is needed to establish whether Cholnoky's view that all forms belong to one variable taxon, *Synedra fasciculata*, is correct or whether to support Patrick and Reimer's interpretation of *S. fasciculata* and its variety, var. *truncata*.

Unfortunately there has been no opportunity to undertake such a revision during the course of this study. Nevertheless a large number of specimens of this complex from both the Sundays and Great Fish rivers have been examined under LM. These displayed a great variability in dimensions, shape of poles, length and density of the striae, and width of axial area. With one exception, it was impossible to differentiate them into any of the varieties described by Hustedt (l.c.) or by Patrick and Reimer (l.c.). This lends support to Cholnoky's view that all these infra-specific taxa must be sunk into the nominate variety, which must be called *S. fasciculata*. The one exception to this situation was a form with finer striation found mixed with typical forms in sample SUN 81 from Station 4 on the

Sundays River. No intermediate forms could be found, and these finely striate specimens were identified as *S. fasciculata* f. *densestriata* nov. comb.; they are discussed further below.

The fact that these examples had a finer striation suggested that there might be some differences in their fine structure. Consequently a preliminary TEM examination of the fine structure of the striae of various specimens in two samples from the Sundays River was undertaken. As a result some interesting observations came to light.

In sample SUN 17 from Station 6 two different types of striae structure were observed. The commonest form of the taxon at this particular station had striae (Fig. 560), each composed of a single areole crossed by about four longitudinal bars almost parallel to the valve edge. Between these bars was a double row of irregularly or roughly alternately arranged fine pores, probably forming the outer covering of the areoles. The second type of striae structure (Fig. 561) was found in a few, much more rarely occurring, specimens. Here the areoles were longer and narrower and were crossed by numerous longitudinal bars, somewhat remicniscent of the striae structure in *Fragilaria pinnata* (cf. Haworth, 1975 : 74, Figs 6-9, 12, 13). No fine structure was observed between these bars.

In sample SUN 81 from Station 4 there were again two types of striae structure. The one was associated with the finely striate forms identfied as *S. fasciculata* f. *densestriata*. The striae in this form (Figs 562, 563) were each composed of a relatively short marginal areole crossed by one to two longitudinal bars. In some specimens (Fig. 563) there were also transverse bars which appeared to divide the areole into three to five pores. The second striae type (Fig. 564) was associated with specimens that, under the light microscope, could not be distinguished from the common form occurring in sample SUN 17. However under TEM the striae were found to have a more ornate structure. Each areole was much broader with a reticulate covering bordered by a row of rather more prominent, sometimes almost reniform pores.

These preliminary observations were based on the examination of only a few specimens and therefore no conclusive statements should be attempted concerning their taxonomic importance. Nevertheless they were sufficient to highlight the fact that, while under LM no essential differences could be observed, a TEM examination indicated that a number of sub-specific taxa may be involved. It is interesting that Geissler, Gerloff, Helmcke, Krieger and Reimann (1963 : 21, Pls 364-367, under *S. tabulata*) and also Helmcke and Krieger (1953 : 12, Pl. 42 as *S. tabulata*) observed an almost identical range of striae structure in a series of specimens that they identified as *S. tabulata (= S. fasciculata)*. Their material came from widely separated localities, and differences could be ascribed to local races. In contrast the Sundays River specimens came from relatively close localities on one river system. Two of the striae structure types came from a relatively freshwater situation (sample SUN 17 - Station 6), while the other two forms were collected from a more highly brackish water environment (sample SUN 81 - Station 4). This suggests that salinity level may have some influence over the type of areole structure found in this taxon (cf. *Cyclotella meneghiniana* above). It is a point, however, that needs further intensive study.

These observations indicate the difficulties in the taxonomy of this complex of forms, which have not yet been satisfactorily settled. For the present the evidence of light microscopy that there are no distinctions between these forms, except the f. *densestriata*, has been accepted, and the taxon has been called *Synedra fasciculata*. In the Sundays and Great Fish rivers the taxon was frequently observed, and had the following dimensions:- length 29,9 - 420,4 µm, breadth 3,9 - 7,4 µm, and striae 9 - 16 in 10 µm .

Euryhaline mesohalobe - 5.

Figs: 560, 561, 564.

Samples: SUN: 4-17, 22-24, 28, 31, 35, 37, 39, 46, 48, 51-54, 57, 61, 63, 66, 69, 74-76, 78-82.
FIS: 3, 18, 19, 21, 29, 37.

Synedra fasciculata f. *densestriata* (Møller) nov. comb.

Synonyms: *Synedra tabulata* f. *densestriata* M. Møller, 1950 : 199, Fig. 6.

Taxonomic notes: A more finely striate form of *Synedra fasciculata* (Agardh) Kützing (1844 : 68, Pl. 15, Fig. V; Pl. 16, Fig. VI, 1-3) could be distinguished from the better known coarsely striate typical form of the species in a number of samples. These more densely striate specimens were also relatively shorter and narrower than the nominate form. They were

17,6 - 123,0 µm long, 3,0 - 4,9 µm broad and had 18 - 20 striae in 10 µm. With these dimensions and because no intermediates were observed in these samples the specimens are best placed with *S. tabulata* f. *densestriata* Møller (= *S. fasciculata* f. *densestriata*). Møller (l.c. distinguished his form from *S. tabulata* (= *S. fasciculata*) on the grounds that his taxon had 20 - 22 striae in 10 µm. This density of striation is even greater than in the Sundays River specimens, but the latter come closer to the f. *densestriata* than to the nominate form. The systematic position of *S. tabulata* var. *parva* (Kützing) Hustedt (1931-59 : 219, Fig. 710m, n) is uncertain. The density of its striae (18 - 20 in 10 µm) suggests that it is probably more closely allied to the f. *densestriata* than to *S. fasciculata* f. *fasciculata* (see above). Comparison of the f. *densestriata* with *S. fasciculata* (nominate form) under the electron microscope is necessary to aquire some clarity on their relationships.

A TEM examination of the striae structure of both the finely striate forms and the coarsely structured specimens found in the Sundays River was undertaken to determine whether there were any structural differences. The results of this examination are shown in Figs 560 - 564, and a few comments concerning the different types of structure are given above under the nominate variety. The structure of the areolae in f. *densestriata* (Figs 562, 563) show some features which may be significant, but further research is needed to establish this conclusively.

Euryhaline mesohalobe - 5.

Figs: 467-472, 562, 563.
Samples: SUN: 5, 59, 81.

Synedra hartii Cholnoky

Cholnoky, 1963a : 250, Pl. 8, Figs 38-43; Pl. 9, Fig. 14.

Taxonomic notes: A direct comparison of the Sundays River examples with Cholnoky's (l.c.) type specimens has shown conclusively that they are identical, and that the local examples are quite typical. One of the most characteristic features of this taxon is the uneven spacing of the striae, and in some examples irregular weakening of the striae. Following the observation of many specimens in the Sundays River some adjustments must be made to the dimensions of this species to include the range found in the Sundays River. The examples measured were 25,0 - 77,9 µm long, 2,0 -

2,5 µm wide, and they had 14 - 16 (18) striae in 10 µm . While examining the type slide (SWA 51 - NIWR) some examples were observed, which also expand the range of variation in dimensions. The smallest specimen observed was 18,1 µm long, and another example had relatively widely spaced striae, measuring 12 in 10 µm .

Euryhaline mesohalobe - 5.

Figs: 473-475.

Samples: SUN: 13, 14, 40, 56, 68, 71, 77-79.

Sunedra ulna (Nitzsch) Ehrenberg

Ehrenberg, 1838 : 211, Pl. 17, Fig. 1.
Hustedt, 1930 : 151, Figs 158-168.
Hustedt, 1931-59 : 195, Fig. 691a and b.

Synonyms: *Bacillaria ulna* Nitzsch, 1817; 99.

Taxonomic notes: *Synedra ulna* is perhaps one of the most well known and commonly occurring species of diatom. It is also extremely variable morphologically with great variations in size and shape. It is not certain whether this polymorphism is genotypic or phenotypic. However the view taken in this investigation is that there are no clear cut distinctions between the described varieties (cf. Hustedt, 1931-59 : 195, Figs 691a and b). Consequently all the varieties of *S. ulna* have been considered as synonyms of the nominate variety. The dimensions of the examples measured in the Sundays and Great Fish River materials were:- length 60,0 - 240,0 µm, breadth 5,0 - 8,0 µm, and the valves had 10 - 12 striae in 10 µm .

Mesoeuryhaline oligohalobe - 2.

Samples: SUN: 13, 19, 23, 25-28, 31, 34, 37, 43, 44, 46, 47, 50, 60, 63, 73.
FIS: 2, 7, 8, 20, 33.

THALASSIOSIRA Cleve, 1873 : 6

Thalassiosira decipiens (Grunow) Jørgensen

Jørgensen, 1905 : 96.
Hustedt, 1927-30 : 322, Fig. 158.

Synonyms: *Coscinodiscus excentricus* var? *decipiens* Grunow, 1878 : 125, Pl. 4, Fig. 18.
Coscinodiscus decipiens (Grunow) Grunow in Van Heurck, 1880-83 : Pl. 91, Fig. 10.

Taxonomic notes: Only a fragment of a single valve of this species was observed at Station 6 on the Sundays River. The structure of this fragment corresponded very clearly, however, with the description given by Hustedt (l.c.), and there was therefore little hesitation in identifying it as a member of this species. The diameter of the specimen was approximately 15,0 µm; the central areolae numbered 6 - 8 in 10 µm, while near the margin there were 16 - 18 areolae in 10 µm; there were 8 marginal processes in 10 µm . The specimen recorded above as *Coscinodiscus excentricus* may possibly be a incorrectly identified representative of this taxon. Unfortunately no coordinates for this example of *C. excentricus* were recorded, and it has proved difficult to trace on the slide (SUN 5 - NIWR) for confirmation.

Pleioeuryhaline polyhalobe - 7.

Fig: 476.

Samples: SUN: 63.

Thalassiosira pseudonana Hasle and Heimdal

Hasle and Heimdal, 1970 : 565, Figs 27-38.
Hasle, 1976 : 105, Figs 11-16.

Synonyms: *Cyclotella nana* Hustedt, 1957 : 212, Figs 1, 2.

Taxonomic notes: This small hyaline species was first described by Hustedt (l.c.) as *Cyclotella nana*, but after having examined some micrographs sent to him for identification by Guillard and Ryther (1962 : 229) Hustedt (1959c : 19) recognised that the systematic position of this taxon needed revision. For some reason Hustedt never made this revision, and it was left to Hasle and Heimdal (l.c.) to transfer *Cyclotella nana* to the genus *Thalassiosira*. They renamed the taxon *T. pseudonana* as the combination *T. nana* was already preoccupied by a species described by Lohmann (1908 : 242, Pl. 17, Fig. 2). Comprehensive and amended descriptions of *T. pseudonana* are given by Hasle and Heimdal (l.c.) and by Hasle (1976 : 105, Figs 11-16). In light microscopy the weakly silicified valves are difficult to identify accurately since they are very similar to a number of other small centric taxa. Confirmation of their identification can only be made through the electron microscope.

A few specimens from the Sundays River were examined under TEM, and the micrographs (Figs 565, 566) showed a structure agreeing very closely with that in the micrographs of Hasle and Heimdal (l.c.) and Hasle (l.c.). The examples observed in this study had diameters ranging from about 3,0 to 5,0 µm, and there were 9 - 12 marginal processes, while a central process was sometimes present.

In a study of phytoplankton from the Port of Barcelona Margalef and Blasco (1970 : 579, Fig. 28) illustrated a valve, which they identifed as *Thalassiosira (Detonula) confervacea*. Apparently they based their identification on Guillard and Ryther's (1962 : 232-234, Figs 1, 2) study of the marine plankton diatoms *Cyclotella nana* Hustedt and *Detonula confervacea* (Cleve) Gran. It is evident, however, that they confused the two taxa, for the specimen they photographed is undoubtedly *T. pseudonana (= Cyclotella nana)*.

Holoeuryhaline mesohalobe - 6.

Figs: 477-479, 565, 566.

Samples: SUN: 9, 21-23, 53.
FIS: 8.

Thalassiosira rudolfii (Bachmann) Hasle

Hasle, 1978 : 279, Figs 51-60, 65.
Hustedt, 1949a : 58, Pl. 1, Figs 6-11 (as *Coscinodiscus rudolfi*).

Synonyms: *Coscinodiscus rudolfii* Bachmann, 1938 : 135, Fig. 7.

Taxonomic notes: In a recent re-examination of *C. rudolfii*, Hasle (l.c.) has shown that this species is in fact a *Thalassiosira*, pointing out that Hecky & Kilham's (1973 : 64, Fig. 2B) scanning electron micrograph exhibited the characteristics of a *Thalassiosira* rather than of a *Coscinodiscus*.

In the Sundays River a few specimens (Fig. 480) of this rare species were recorded from four samples. These specimens, having a diameter of 12,0 - 17,5 µm, and with 18 - 20 striae in 10 µm near the margin, and 8 - 10 marginal processes in 10 µm, conform very closely to the descriptions of this taxon given by Bachmann (1938 : 135, as *C. rudolfi*), Hustedt (1949a : 58, as *C. rudolfi*) and Hasle (1978 : 279). Their identity as *T. rudolfii* does not therefore seem to be in doubt.

Euryhaline mesohalobe - 5.

Fig: 480.

Samples: SUN: 6, 9, 10, 13.

Thalassiosira weissflogii (Grunow) Fryxell and Hasle

Fryxell and Hasle, 1977 : 68, Figs 1-15.
Hustedt, 1927-30 : 329, Fig. 165 (as *Thalassiosira fluviatilis*).
Hasle, 1962b : 151-153, Figs 1-9 (as *Thalassiosira fluviatilis*).
Schoeman and Archibald, 1976-80 : No. 2 (as *Thalassiosira fluviatilis*).

Synonyms: *Eupodiscus weissflogii* Grunow, 1884-87 : 3.
Micropodiscus weissflogii Grunow ex Van Heurck, 1885 : 210.
Thalassiosira fluviatilis Hustedt, 1926 : 565-566, Figs 1-4.

Description: Cells drum-shaped to short cylindrical with 2 or 4 open girdle bands. Valve circular, 12 - 27 µm in diameter. Valve surface finely punctate, puncta arranged in more or less radiating lines; central puncta more distinct. Valve margin furnished with a ring of marginal processes, 8 - 14 in 10 µm, and a single larger and more conspicuous process. In the centre of the valve there is a group of 3 - 18 central processes arranged more or less in a circle.

Electron microscopic examination of the fine structure of the valve shows that the valve face is flat or slightly convex. The puncta are revealed as irregularly shaped polygonal areolae arranged in three zones according to size. The central areolae are larger and grade into a region of smaller size, while those in a narrow band at the edge of the valve face are similar in size to the central areolae. The areolae themselves may be divided by less well silicified secondary thickenings or cross braces. The marginal and central processes are strutted processes; while the single large process near the margin is a labiate process.

Taxonomic notes: Recently Fryxell and Hasle (l.c.) discussed the taxonomy of this species in detail. They considered the basionym of this taxon as *Micropodiscus weissflogii* Grunow (in Van Heurck, 1885 : 210). Grunow (1884-87 : 3), however, first used the combination *Eupodiscus weissflogii* for this species. Nevertheless in the diagnosis of this species he did suggest that it should be placed in the genus *Micropodiscus (= Microspodiscus)*, itself a somewhat controversial genus. The genus was first tentatively proposed by Grunow (in Van Heurck, 1880-83 : Pl. 118, Fig. 5) for the species *Podosira? oliverianus* (O'Meara) Grunow, which according to VanLandingham (1971 : 2278) is now considered valid under its original name of *Actinocyclus oliverianus* O'Meara (1877 : 58, Pl. 1, Fig. 7). Later it appears that Grunow (1884 : 79) proposed the genus *Micropodiscus* for *Coscinodiscus concinnus* W. Smith, *C. leptopus* Grunow and *C. lentigi-*

nosus Janisch, but no definite new combinations were ever made, Grunow merely implying that these species should be placed in *Micropodiscus*. The only other taxon definitely placed in this genus was *M. weissflogii* Grunow, even though as a tentative suggestion (Grunow, 1884-87 : 3). Nevertheless Van Heurck (1885 : 210) accepted Grunow's combination as valid, thus creating a monotypic genus, with *M. weissflogii* as the only and type species for the genus. Finally Fryxell and Hasle (l.c.) transferred the taxon to *Thalassiosira* under the new combination of *T. weissflogii* (Grunow) Fryxell and Hasle. Consequently *Micropodiscus* cannot be distinguished from *Thalassiosira*, as its type species has been transferred to the genus *Thalassiosira*. One other small discrepancy found in Fryxell and Hasle's discussion of the taxon is that the dimensions they claim as the originally quoted values for this taxon, i.e. 5,0 - 15,0 µm (cf. Fryxell and Hasle, 1977 : 69) are not quite correct. These values originate from Van Heurck's (1885 : 210) description of the taxon. Grunow (1884-87 : 3), on the other hand, gave 5,0 - 25,0 µm for the diameter of this taxon. These dimensions are more in keeping with Hustedt's (1926 : 565, Figs 1-4) and Hasle's (1962b : 151, Figs 1-9) measurements. It is therefore evident that Van Heurck (l.c.) recorded the wrong value for the maximum diameter.

T. weissflogii appears to be an extremely euryhaline species occurring in both fresh and marine water habitats. Structurally there seems to be evidence of two ecotypes in this taxon. Hasle (1962b : 152) reported marine forms having 7 - 18 central strutted processes, while Lowe and Busch (1975 : 122) observed 3 - 7 (ave. 4) such processes in specimens from freshwater habitats. Examples from the brackish waters of the Sundays and Great Fish rivers, as well other freshwater habitats, agreed with Lowe and Busch's observations. This suggests a marine ecotype having a greater number of central strutted processes than found in the freshwater ecotype. In a later study of this taxon Fryxell and Hasle (1977 : 72) gave 9 - 11 (2 - 28) strutted processes in this irregular ring at the centre of the valve, but it is unknown where this material was collected. The smaller specimens appear to have fewer processes, while the more processes there are, the more they tend to become arranged in a cluster rather than in a ring.

Euryhaline mesohalobe - 5.

Figs: 481-483.

Samples: SUN: 10, 23, 24, 28, 61-63, 69, 80, 81.
FIS: 3, 4, 13, 29, 31, 40.

TROPIDONEIS Cleve, 1891a : 53.

Tropidoneis lepidoptera (Gregory) Cleve

Cleve, 1894 : 25.

Synonyms: *Amphiprora lepidoptera* Gregory, 1856b : 76, Pl. 1, Fig. 39.

Taxonomic notes: A few specimens of this species were observed in the Sundays River at Station 5. A little difficulty was experienced in correctly identifying them to this species on account of some inconsistencies in the literature. Cleve (l.c.), Peragallo and Peragallo (1897-1908 : 188) and Grunow (in Van Heurck, 1885 : 120, as *Amphiprora lepidoptera*) gave the following range in dimensions for this taxon:- length 100,0 - 200,0 µm, breadth 18,0 - 22,0 µm . Hendey (1964 : 256), on the other hand, quoted lengths of 240,0 - 280,0 µm and widths of 32,0 - 36,0 µm for this species. The Sundays River examples agreed favourably with the former set of dimensions, but not with Hendey's. Giffen (1963 : 255, Fig. 110) confused the issue somewhat by illustrating a specimen which he identified as *Tropidoneis maxima* (Gregory) Cleve (l.c.: 26). The dimensions of this example seem, however, more akin to the specimens considered here as *T. lepidoptera.* Giffen's specimen lacks a central area, which is supposed to be a distinct and transversely lanceolate area in *T. maxima.* On the basis of the dimensions of the valve, and since the central area is indistinct or small, the Sundays River specimens and Giffen's example have been identified in this study as *T. lepidoptera.* Support for this identification is derived from identical specimens in the Swartkops River near Port Elizabeth, which Cholnoky (1960b : 268) placed in *T. lepidoptera.* The Sundays River specimens had, however, slightly coarser striation (18 transapical and longitudinal striae in 10 µm), but this is not considered sufficiently aberrant to justify placing them in some other taxon at this stage.

Dimensions of the Sundays River specimens were:- length 130,0 - 150,0 µm, breadth 19,6 - 23,0 µm, transapical and longitudinal striae 18 in 10 µm .

Mesoeuryhaline polyhalobe - 8.

Figs: 484, 485.

Samples: SUN: 8, 37, 66.

Tropidoneis pusilla (Gregory) Cleve

Cleve, 1894 : 26.

Hendey, 1964 : 256, Pl. 27, Figs 1, 2.

Synonyms: *Amphiprora pusilla* Gregory, 1857 : 32(504), Pl. 4(12), Figs 56, 56b.

Amphiprora lepidoptera var. *pusilla* (Gregory) Van Heurck, 1885 : 120.

Taxonomic notes: A single specimen from Station 3 on the Sundays River appeared to fit the description of this taxon. The dimensions of this example (length 70,0 μm, breadth 12,0 μm, and striae 18 - 20 in 10 μm) agreed more closely with Hendey's diagnosis than with Gregory's original description. However its small size seems to leave little doubt that it is better placed in this taxon than in *T. lepidoptera*. Nevertheless this taxon is closely related to *T. lepidoptera* and has in the past been considered a variety of the latter. Some revision of these two taxa is necessary to determine their true relationships.

Oligoeuryhaline polyhalobe - 10.

Samples: SUN: 5.

Tropidoneis semistriata (Grunow) Cleve

Cleve, 1894 : 27, Pl. 3, Figs 9-11.

Synonyms: *Amphiprora semistriata* Grunow, 1879 : 3, No. 196.

Taxonomic notes: The characteristic structure of these specimens, in which the striae do not reach the margin of the valve, leaves no hesitation in assigning them to this species. Indeed it is not surprising that this species is present in the Sundays River, as the type locality of the species is the Swartkops River near Port Elizabeth. Grunow (l.c.) first found it on a slide prepared from material sent by a Mr M.W. Joshua. As far as can be ascertained the taxon has previously been found only at the type locality, and by Giffen (1966a : 287: 302) at Kidd's Beach in the marine littoral and from the Kowie River estuary (Giffen, 1970a : 302). All these localities, including the Sundays River estuary, are similar and in reasonably close proximity to the type locality. The dimensions of the Sundays River specimens are somewhat different from those given by Cleve (l.c.) and serve to enlarge the range of variation for the species:-

length 59,3 - 68,6 µm, breadth at the constriction 5,9 - 6,9 µm, increasing past the constriction to 6,9 - 9,0 µm, and transapical striae 18 - 20 in 10 µm . An insufficient number of specimens has been observed to provide a good description, but the species is easily recognised by the unequally shortened striae not reaching the margin of the valve, thereby leaving a blank band between the valve margin and striae.

Euryhaline mesohalobe - 5.

Figs: 486-488.

Samples: SUN: 82, 83.

CONCLUDING REMARKS

In the taxonomic part of this study 331 taxa have been enumerated from the Sundays and Great Fish rivers. Of these almost half (149 taxa) were observed only in the Sundays River, while a further 21 taxa were found solely in the Great Fish River. Thus 161 taxa were common to both river systems, although many of the latter were recorded as occasional examples in but one or two samples from the Great Fish River. The reason for the greater proportion of taxa being specific to the Sundays River may lie in the fact that this river, particularly its estuary and more saline parts, was more intensively investigated. In each of these river systems only one tributary was briefly examined, and yet these tributaries accounted for a relatively large number of the taxa specific to these two river systems. Thus 13 of the taxa peculiar to the Sundays River were found only in the Wit River, while 6 of the 21 taxa observed only in the Great Fish River were restricted to the Kap River.

From a taxonomic point of view five new species have been recorded in this study. These are *Denticula sundaysensis*, *Fragilaria sundaysensis*, *Nitzschia adductoides*, *Nitzschia dissipatoides* and *Nitzschia sublanceolata*. In addition one taxon remained unnamed as it could not be identified with any known *Nitzschia* species, and too few specimens were observed to provide it with a reliable diagnosis. In the text this taxon is referred to as *Nitzschia* sp. affin: *N. sigma* var. *sigmatella* Grunow. All these taxa, with the exception of the first two mentioned, were restricted to the estuary of the Sundays River. *Denticula sundaysensis* was also found only in the Sundays River estuary, but two examples were observed at Station 10 on the Great Fish River. On the other hand *Fragilaria sundaysensis*, although present at all stations in the lower course and estuary of the Sundays River, was also present in very small numbers at Station 12 on the Great Fish River. These new species have been described, but their formal diagnosis will be validly published at a later stage.

Two taxa have undergone name changes since their old names were found to be invalid, being later homonyms of earlier species. *Navicula incerta* Grunow is a homonym of *Navicula incerta* Ehrenberg. Consequently this taxon takes on the next earliest valid name of *Navicula sydowii* Cholnoky. However, this synonymy must still be established conclusively by comparing their respective type specimens. In the second instance *Nitzschia armoricana* Peragallo & Peragallo is a later homonym of *Nitzschia armoricana* (Kützing) Grunow. This taxon has been given the new specific epithet '*aremonica*', an alternative Latin word conveying the same meaning as the original epithet '*armoricana*', i.e. coming from the French province of Brittany.

Twenty seven taxa have been recorded for the first time from South Africa, although some of these (preceded by an asterisk in the list below) have been or may have been reported under different names. These are *Achnanthes punctifera, Amphora cognata, Amphora sabiniana, Amphora tenuissima, Cyclotella atomus, Cyclotella caspia, Cylindrotheca fusiformis* var. *enodis, Diploneis fusca, Fragilaria atomus, *Gyrosigma distortum* var. *parkeri,*? Gyrosigma obscurum, *Gyrosigma prolongatum* var. *closterioides, Mastogloia aquilegiae, Melosira moniliformis* var. *octogona, *Navicula cincta* var. *leptocephala, Navicula finmarchica, *Navicula frugalis, Navicula grosschopfi, Navicula lineola, *Navicula sydowii, Nitzschia armoricana, Nitzschia solgensis, *Nitzschia subcapitellata, Nitzschia thermaloides, Stauroneis wipplingeri, Synedra hartii,* and *Synedra fasciculata* var. *densestriata.* The question mark following the asterisk in the case of *G. obscurum* indicates some uncertainty that this taxon has been reported before under a different name.

Descriptions of some species have been amended to take account of new facts following the re-examination of type material of the taxa concerned. For instance the description of *Amphora luciae* Cholnoky has been rewritten as it was found that Cholnoky's original diagnosis circumscribed two distinct elements, one of which was retained as *Amphora luciae*, while the other belongs to a taxon as yet unidentified. Likewise Cholnoky's diagnosis of *Navicula hartii* Cholnoky contained two elements. One of these is now known to be *Navicula bulnheimii* Grunow. The other element has been retained as *Navicula hartii*, but there is a strong possibility that it should be referred to *Navicula complanata* Grunow or another closely related taxon.

A number of species was found to be synonymous with previously described taxa. These have consequently been sunk as later synonyms. An example of such a case is *Amphora sydowii* Cholnoky and *Amphora turgida* var. *africana* Cholnoky, which are now considered to be synonymous with *Amphora* *castellata* Giffen. Similarly *Amphora natalensis* Cholnoky and *Amphora novaeguineae* Cholnoky were found to be identical to *Amphora cymbamphora* Cholnoky, and are now united with the latter. In the genus *Nitzschia* a number of South African taxa have been re-examined, and united with previously described species. For instance no differences could be found between *Nitzschia elliptica* var. *alexandrina* Cholnoky and *Nitzschia aurariae* Cholnoky with the result that the latter has been contracted into the former. It was also discovered that the descriptions of *Nitzschia fontifuga* Cholnoky and *Nitzschia fundi* Cholnoky were inaccurate. Examination of the type materials of these two species showed that there was a considerable overlap between them, and that they actually formed a single range of specimens with *Nitzschia fontifuga* representing the smaller forms and *N. fundi* the larger examples. *Nitzschia demota* Archibald could not be distinguished from *Nitzschia subsalsa* Cholnoky, and was therefore united with the latter. Amongst the more cosmopolitan taxa, a re-examination of Hustedt's type slides of *Nitzschia bacata* and *Nitzschia holsatica* showed that these two species were identical so that *Nitzschia bacata* is now considered synonymous with *N. holsatica.*

As far as the remainder of taxa dealt with in the text are concerned, comments regarding their taxonomy, morphology and dimensions have been passed in the light of facts obtained from literature surveys and the observation of type and local material.

Finally, while every attempt has been made to review the taxa concerned thoroughly, the sudden explosion of studies in diatom taxonomy made it very difficult to include all the most recent concepts. Consequently some of the views expressed in this study may be considered incorrect. The field of diatom taxonomy is, however, so wide that a single investigator cannot hope to aquaint himself thoroughly with every small part of this field.

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AN INVESTIGATION INTO THE TAXONOMY OF THE DIATOMS (BACILLARIOPHYTA) OF THE SUNDAYS AND GREAT FISH RIVERS, WITH ECOLOGICAL OBSERVATIONS ON THE SUNDAYS RIVER

Volume 2

ECOLOGICAL OBSERVATIONS ON THE DIATOMS OF THE SUNDAYS RIVER

FRONTISPIECE

Diatom association from Station 4 (May 1970)

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1. INTRODUCTION

The Sundays River is one of the major rivers of the eastern seaboard of the South African coast line. It is, furthermore, economically important since it supports two irrigation schemes along its course, one in the upper catchment around Kendrew near Graaff-Reinet, and the other, a large citrus irrigation scheme, in the lower Sundays River valley between Kirkwood and Addo. Owing to frequent droughts in this region the two storage dams, viz. Van Ryneveld's Pass Dam in the upper catchment and Lake Mentz supplying the lower Sundays River valley, seldom contain sufficient water to fulfil the requirements of the irrigation schemes. Furthermore, the salinity of the Sundays Rivier water, particularly in the lower valley, makes the water unsuitable for use as irrigation water.

In order to alleviate the problem of inadequate water supplies, the Sundays River, together with the adjacent Great Fish River catchment, were incorporated into the comprehensive proposals for the Orange River Development Project (see South Africa (Republic), Department of Water Affairs, 1962). This project planned in the first phase to bring Orange River water via the Orange-Fish Tunnel (at 83 km long one of the longest of its kind in the world) first into the upper Great Fish River catchment, and then by means of a weir at Elandsdrift to divert and transport water by canals and the Cookhouse Tunnel into the Skoenmakers River and thence into Lake Mentz. At a later stage in Phase 3 of the project a canal system and the Wapadsberg Tunnel are envisaged to carry water into the upper Sundays River and so augment the supply to the Van Ryneveld's Pass Dam.

Orange River water flowed into Lake Mentz for the first time in 1978. This augmented water supply continued for almost a complete year before a flood in the Sundays River temporarily relieved the necessity for this additional water supply (personal communication from G. Hall, NIWR). The quality of the Orange River water, particularly in respect of its salt content, is initially much different from Sundays River water. However, during its passage down the Great Fish and Skoenmakers rivers it becomes increasingly mineralized so that by the time it enters Lake Mentz it has a salinity of about 0,5‰. Nevertheless it is still sufficiently different as to be able to alter the salinity and composition of the water used for irrigation in the lower Sundays River valley. A similar expectation may be expressed for the augmented supply to the Van Ryneveld's Pass Dam, when, and if, that phase of the project comes into operation. As a result changes in the diatom flora in those parts of the Sundays River affected by the introduction of Orange River water may be significant.

This study of the diatoms in the Sundays River was initiated in the first instance to establish the nature of the diatom communities at various stations along the course of the river prior to the entry of Orange River water into this river system. Secondly, on account of the salinity gradient throughout the course of the Sundays River, another aim of the investigation was to ascertain how the salt content affected the composition of the diatom associations in these communities. Within this last objective the effects of aspects such as the absolute salinity or osmotic pressure, the ionic composition of the water and the variability of the salinity level was to be investigated. The Sundays River with its wide variation of environmental conditions, especially in regard to salinity, is admirably suited to such a study.

This ecological examination of the diatom communities in the Sundays River, taken in conjunction with the taxonomic review of the taxa present in the river system (see Volume 1), makes an important contribution to the study of the diatoms in Southern Africa for a number of reasons. Firstly this study is the first comprehensive investigation of the diatom communities of the entire course of a major and economically important South African river. Most other diatom studies undertaken in the last three decades concerned themselves with the taxonomic aspects of general collections covering wide geographical areas, while the remainder are confined to more intensive studies of the taxonomy and ecology of diatoms from regions of more limited extent. Secondly, few of these diatom surveys deal with inland brackish waters per se (cf. Cholnoky, 1955a, 1963a), although a little more is known of estuaries (Cholnoky, 1968a; Giffen, 1963, 1970a). On the other hand this survey of the diatoms in the Sundays River reports on the associations from freshwater, brackish water and estuarine environments. Thus the Sundays River provides an opportunity to understand the relationship between the diatom associations and the salt content of the environment over almost the complete salinity spectrum.

2 GENERAL DESCRIPTION OF THE STUDY AREA

The Sundays River (Fig. 1) rises at an altitude of about 1 700 m above sea level to the west of the Lootsberg, and flows initially southwards past the Bethesda Road railway station (Station 11) through a relatively flat plain bounded to the west by the Voor-Sneeuberg and to the north and east by the Sneeuberg mountain ranges. Shortly after the farm Koloniesplaatz and just before Station 10 (Glen Harry) the river turns in a more westerly direction as it cuts through a mountainous zone to the north-east of Graaff-Reinet (Station 9). From Graaff-Reinet to Jansenville (Station 8) the river follows a generally southerly course through the Aberdeen Plains, and then flows on a south-easterly bearing to Lake Mentz. After cutting through the Klein Winterhoek and Suurberg Mountains (Station 7) the river continues from Korhaans Drift (Station 6) in a south-easterly direction over the coastal plain to its mouth some 35 km north-east of Port Elizabeth (Stations 5-1).

Immediately above Graaff-Reinet the Sundays River is held back by the Van Rynevelds Pass Dam, which also receives water from the Gats River. Several tributaries flow into the Sundays River between Graaff-Reinet and Jansenville, but these generally carry water only after floods. The main tributaries flowing into Lake Mentz are the Vöel River draining the area around Pearston, and the Skoenmakers River flowing into the dam from the east, which, when in operation, conducts the Orange River water from the Little Fish River to Lake Mentz. The only tributary examined in this study is the Wit River, which rises in the Suurberg Mountains to the east of Kirkwood and joins the Sundays River above Station 5.

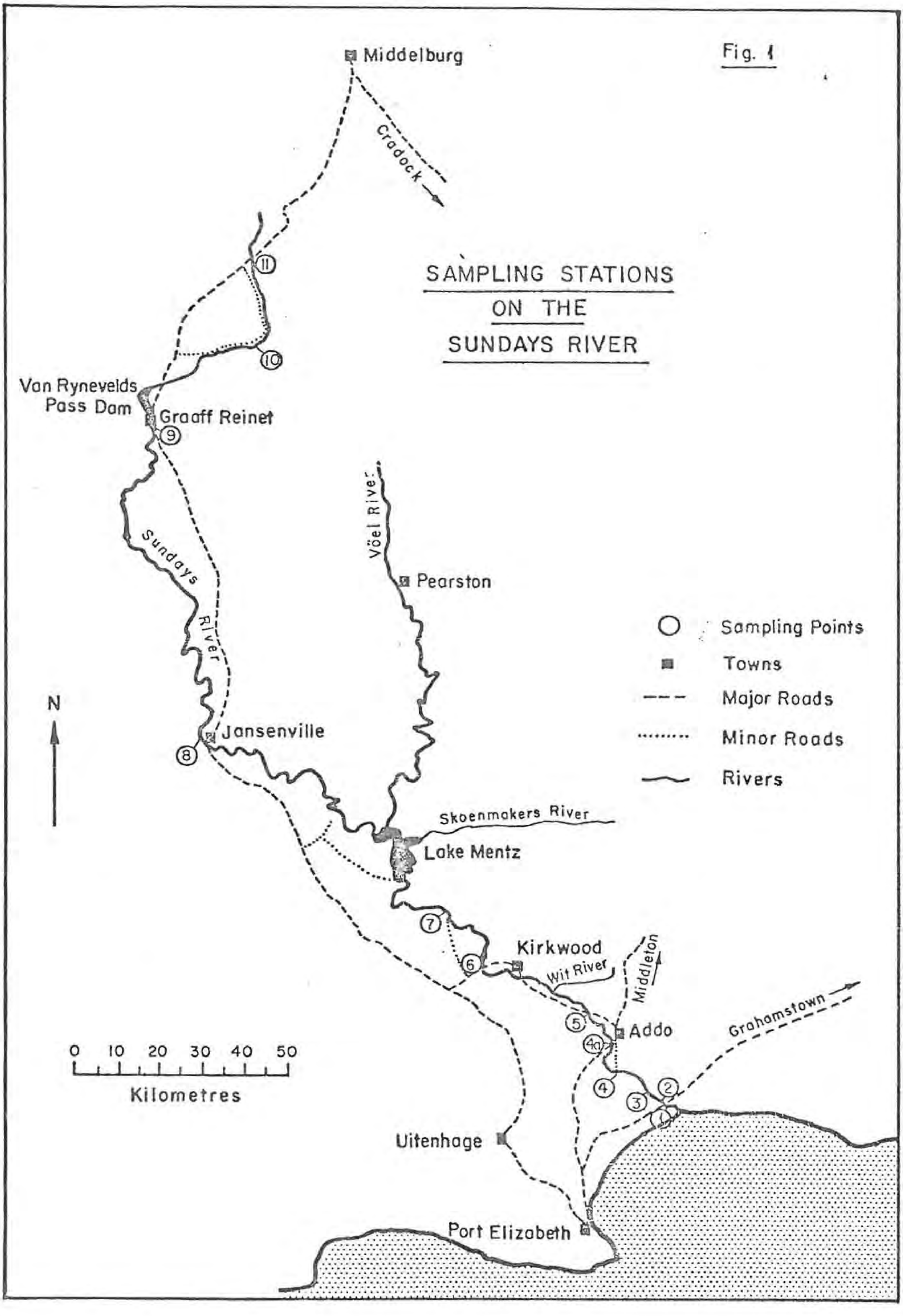


Fig. 1

SAMPLING STATIONS ON THE SUNDAYS RIVER
Middelburg
Cradock
11
10
Van Ryneveld's Pass Dam
Graaff Reinet
9
Sundays River
Vöel River
Pearston
N
Jansenville
8
Skoenmakers River
Lake Mentz
7
6
Kirkwood
Wit River
Middleton
5
4a
Addo
4
3
2
1
Grahamstown
Uitenhage
Port Elizabeth
0 10 20 30 40 50
Kilometres
Sampling Points
Towns
Major Roads
Minor Roads
Rivers

The upper catchment lies in the rainshadow of the coastal mountains, and consequently the rainfall in this area is low being in the order of 125 - 500 mm per annum (cf. Scott, Allanson and Chutter, 1972). Much of the rainfall is seasonal with long intervening periods of dryness even when there is no drought. Since evaporation over most of this region exceeds the rainfall, water flow in the river is minimal if any except after heavy rain. Rainfall in the lower Sundays River valley is slightly greater and the evaporation rate is somewhat lower. Water flow was usually more or less permanent below Korhaans Drift due mainly to irrigation return water and seepages. Nevertheless during the severe drought between August 1969 and August 1970 river flow all but ceased even in the lower course of the river.

As a result of the low rainfall the vegetation is typically semi-arid and sparse. Above Graaff-Reinet it consists mainly of Karroid *Danthonia* mountain veld, False Karroid Broken veld and False Central Lower Karoo veld (cf. Acocks, 1975), while below Graaff-Reinet to Lake Mentz some False Central Lower Karoo and mainly Noorsveld vegetation types are present. In the lower Sundays River valley the vegetation belongs to the Sundays River subtype of the Valley Bushveld.

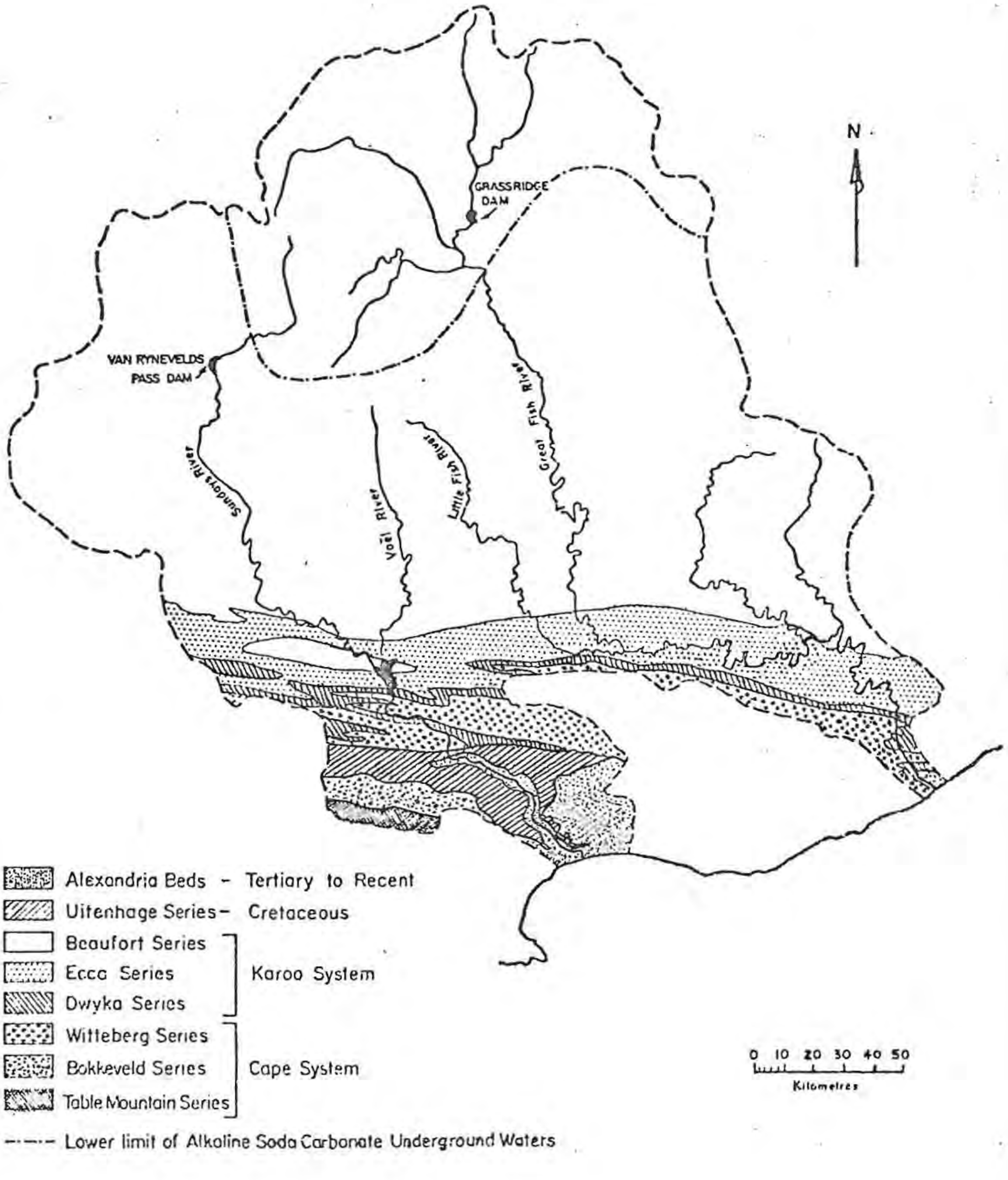
The main towns or villages in the region under consideration, Graaff-Reinet, Jansenville, Kirkwood and Addo, support little in the way of minor industries, and the economy of the region is based mainly on agriculture under irrigation, although stock farming in the upper catchment is prevalent. The Sundays River supports two irrigation schemes, one around Kendrew (between Graaff-Reinet and Jansenville) and supplied by the Van Ryneveld's Pass Dam, and the other the more economically important citrus irrigation scheme between Kirkwood and the head of the estuary. This scheme receives its water from Lake Mentz, since the river water in the lower course is usually too saline for irrigation purposes, although even Lake Mentz water may on occasions be highly brackish.

2.1 The geology of the Sundays River valley

The geological features of the Sundays River basin are shown in Figure 2.

Fig. 2

THE GEOLOGY OF THE SUNDAYS AND FISH RIVER CATCHMENTS



The upper parts of the Sundays River, from its headwater stream down as far as Jansenville (Station 8), lie on the shales, mudstones, sandstones and limestones of the Beaufort Series in the Karoo System. There is evidence, as will be seen later (see section on underground water supplies, and general discussion of the chemistry of the Sundays River), that above Graaff-Reinet (i.e. Stations 11 and 10) the Sundays River is associated with the upper and middle Beaufort beds, while the remaining parts of the Sundays River down to about Jansenville lie over the lower beds of this series. From just below Jansenville to Lake Mentz the Sundays River flows first over Ecca Series sandstones and shales of the Karoo System, and then once more over Beaufort beds. Most of Lake Mentz, however, lies on Ecca Series rocks, although the dam wall appears to have been built on Dwyka Series rocks.

Below Lake Mentz the Sundays River passes through the Lesser Winterhoek and Suurberg mountain ranges. These mountains are composed chiefly of Witteberg quartzites of the Cape System (cf. Du Toit, 1954 : 380). Very soon after emerging from the Suurberg Mountains at Korhaans Drift (Station 6), the Sundays River encounters rock strata of the Cretaceous and Tertiary to Recent Systems about 8 km above Kirkwood. In the lower course of the river down to the mouth (Stations 5 - 1) the river flows over marine limestones of the Alexandria formation and occasional outcrops of the Sundays River marine beds of the Cretaceous System. The Sundays River marine beds underly the Alexandria formation, and consist of clays and shales with sandy limestones and sandstones (cf. Hamilton and Cooke, 1954 : 225).

2.2 The Underground Waters associated with the geological formations in the Sundays River valley

Since the well-known work of Bond (1945), there has, until recently, been little investigation of under ground water supplies in South Africa. However, the problems of mineralization in the Sundays River system has stimulated the National Institute for Water Research to undertake an analysis of a large number of boreholes mainly in the upper catchment of this river.

As a result of his survey, Bond (1945 : 155) was able to group the underground waters of the Republic into 5 types. Only two of these are, however, of concern to this study. These are firstly the highly mineralized chloride-sulphate waters and secondly the alkaline soda-carbonate waters. With the exception of the upper and middle Beaufort beds of the Karoo System, all the geological formations encountered in the Sundays River basin yield highly mineralized chloride-sulphate underground waters. The chief characteristics of this group of waters is their high salinity (usually 1,0 - 4,0 ‰) composed mainly of chlorides (27,0 - 51,0 %) and sulphates forming an additional 6 - 17 % of the ions in solution. Th pH averages out at pH 7,4, and soda alkalinity is never present. Bond (l.c.) commented that these waters approximate seawater more closely than his other groups. This is particularly true of those formations of marine origin, such as the Cretaceous beds, which have retained connate seawater.

According to Bond's (1945) map of underground water types, the alkaline soda-carbonate waters extend south-westwards in a tongue towards Graaff-Reinet and Cradock, but does not reach either of these two towns. Such waters originate in the upper and middle Beaufort Series rock strata (cf. Bond, 1945 : 160), and have a very high soda alkalinity (15,0 - 38,0 %) composed mainly of sodium bicarbonate, although sodium carbonate may sometimes also be present. The chloride content of these waters is generally very low.

The recent studies of boreholes in the upper catchment of the Sundays River, undertaken by the National Institute for Water Research, are of interest since they reflect the composition of the underground waters some thirty years later. The chief findings of this survey (Hall : personal communication) were firstly that there are no underground water masses with a homogeneous quality; water quality in the boreholes varied considerably. However, a tendency for an increase in the salinity with distance downstream was apparent. Thus boreholes with the highest salinities were generally found near Lake Mentz. In the higher regions of the catchment, where dolerite sills and dykes may be found, the salinity of underground waters was generally much lower (0,3 - 3,6 ‰). These waters very often showed a $Ca(HCO_3)_2$ or $NaHCO_3$ dominance in their ionic composition, while sulphates (5,5 - 10,5 %) and chlorides (4,9 - 19,0 %) were relatively low in proportion. These bicarbonate rich waters suggest that the lower limit of Bond's alkaline soda-carbonate waters may extend further south than indicated on his water map.

By far the greater number of boreholes examined in the region between Graaff-Reinet and Lake Mentz were, however, chloride rich (chlorides composing 32,0 - 47,6 % of the ions in solution) chiefly in the form of $CaCl_2$ or NaCl. Sulphates varied between 3,7 - 21,1 % of the total ionic content, but seldom exceeded the bicarbonate fraction and were never the major anion. These chloride rich waters with a relatively high sulphate content therefore agree very closely with Bond's (1945 : 132) assessment of underground waters emanating from the lower beds of the Beaufort Series.

3. ECOLOGICAL FACTORS INFLUENCING DIATOM DISTRIBUTION

A number of factors influence the distribution of the diatoms in an ecosystem. Some of these play major roles in determining the nature of the community, while others are more significant for the function they serve in altering or modifying the specific composition of the associations within the communities. In the sections below some of the more important factors are outlined in relation to their effects on diatom distribution, while various systems of classifications aimed at describing the attributes of a taxon with respect to these factors are also discussed.

3.1 The effect of pH

The purely physico-chemical phenomena concerned with pH or the concentration of hydrogen ions (H^+) in solution have been dealt with by Glasstone and Lewis (1960), while adequate coverage of the complex relationships between pH, carbon dioxide and bicarbonate ions in natural waters can be found in reviews by Cholnoky (1968b), Hutchinson (1957), Hynes (1970), Reid (1961), Ruttner (1953) and Wetzel (1975). The effect of pH on cell physiology in algae is also well described by various authors in the comprehensive works on algal physiology under the editorships of Lewin (1962) and Stewart (1974).

At one time pH was considered an important factor in the distribution of the diatoms. In nature pH strongly influences the species composition of a community, and different communities can be found at different pH levels. According to Lund (in Lewin, 1962 : 761) and Patrick (1948 : 507) the greatest diversity of species occurs in the circumneutral range. At very acid or very alkaline pH values the flora might be restricted in terms of numbers of species, but not necessarily in abundance of individuals per species. These observations suggest that different species have adapted themselves to specific pH levels at which they flourish. Diatoms not only adapt themselves to an optimum pH, but also exhibit varying degrees of tolerance to pH levels on either side of their optimum. Both Cholnoky (1968b : 260) and Meriläinen (1967 : 57) have pointed out the importance of pH fluctuations as a limiting factor in the distribution of diatoms, and Cholnoky further stressed the ecological significance of the amplitude and boundaries of these fluctuations. Those diatoms with a narrow range of tolerance are referred to as stenotopic in relation to pH, while those having a greater degree of tolerance are known as eurytopic. Thus in an aquatic environment having a specific pH level a diatom community will develop in which the great majority of individuals are either stenotopic or eurytopic forms having a pH optimum at or near the abient pH level of the environment.

Ecological studies of the diatoms over many years have built up a wide empirical knowledge of the individual requirements of many species. There has, however, only been one attempt to classify diatom taxa in accordance with their pH requirements. Hustedt (1938-39 : 284) proposed a system of classification according to pH, distinguishing five categories of diatoms in his pH spectrum. These are described briefly below.

1. Acidobiontic - species occurring in a pH range below 7,0 with optimum development at about pH 5,5 or lower.
2. Acidophilous - species occurring at a pH of around 7,0, but with a preferential distribution below pH 7,0.
3. Indifferent - species occurring equally abundantly at pH values around 7,0.
4. Alkaliphilous- species occurring at pH values around 7,0 but with the greatest distribution at pH values of more than 7,0.
5. Alkaliobiontic - species occurring at pH ranges greater than 7,0.

This system was criticised by Cholnoky (1968b : 262) on the grounds that the limits of each category are too rigid. Furthermore Cholnoky claimed that the diatoms were arbitrarily assigned to specific categories according to the frequency of their occurrence in the samples, little consideration being taken of the optimum development of the species. Although these criticisms may be valid this system is still useful to describe the pH preferences of a species relatively simply.

A number of points, which may ameliorate these criticisms, should therefore be borne in mind. In the first place there can be no sharp or well defined boundaries between the categories. Stenotopic species may well fall within one of Hustedt's categories, but many eurytopic taxa, in contrast, may transcend the boundaries of two or more divisions in this system of classification. The next point for consideration is that before characterizing a species with regard to its pH preferences two facts must be taken into account. Firstly the pH tolerance range of the diatom taxon should be known, and secondly it is essential to determine the optimum pH level for that species, i.e. the pH value at which growth or development of the species is most vigorous. With these two factors known, a reasonably accurate characterization of any diatom species in respect of its preference for and tolerance to pH can be attempted.

Despite the weaknesses in Hustedt's system of pH classification of the diatoms, the practical application of these divisions to a diatom community, and the knowledge of the optimum pH requirements of the individuals, make it possible to deduce the prevailing pH of the environment through analysis of the composition of the diatom community. The great majority of diatom genera and species belong to the indifferent, alkaliphilous and alkalibiontic categories, and require no special comment here. A much smaller number of species is known to be acidophilous or acidobiontic. Cholnoky (1968b : 312-340) enumerated the taxa he considered as having pH optima below 7,0. Of these probably the two best known genera, in which all or nearly all the taxa are acidobiontic or acidophilous, are *Eunotia* and *Pinnularia*. A number of less prominent genera containing species mostly having pH optima below 7,0 may also on occasion be significant in a community. Most species of the genus *Frustulia* are acid water forms, while many members of the genus *Cymbella* are indicative of acid waters.

In recent years the importance of pH as an ecological factor appears to have waned (Lund, 1965 : 258), but it is still possible to draw reasonably accurate conclusions concerning the pH of the environment through analysis of the diatom communities, since it is not the individual taxa but the whole community which must be taken into consideration. Besch, Ricard and Cantin (1972 : 70) considered diatom communities as reliable indicators of the average pH and its fluctuations. From his studies of fourteen Finnish lakes with special reference to the diatom communities and the pH of the environment, Meriläinen (1967 : 57) claimed that estimates of the pH of natural waters from diatom communities could have an accuracy of around one pH unit.

3.2 The effect of carbon dioxide

Although carbon dioxide (CO_2) the most essential nutrient required by autotrophic organisms for the conversion of light energy to chemical energy through photosynthesis, it seldom has any direct effect on the distribution of the diatoms. Since CO_2 exchange between water and air is rapid and relatively complete, CO_2 is rarely a limiting factor in photosynthesis under natural conditions. Nevertheless under certain circumstances the bicarbonate ion (HCO_3^-) may be utilized as either a supplementary or as an alternative carbon source for autotrophic organisms.

The most significant effect of carbon dioxide on the distribution of the diatoms, as well as other organisms, is indirect through its intimate influence on the pH of the water. In natural waters CO_2 dissolves readily to form carbonic acid (H_2CO_3), which dissociates weakly to form H^+ and HCO_3^- ions, hence deriving its acid nature. The bicarbonate radical (HCO_3^-) in turn dissociates to form further H^+ ions and $CO_3^=$ ions. These reactions are summarized in the following equation.

$$CO_2 + H_2O \rightleftarrows H_2CO_3 \rightleftarrows H^+ + HCO_3^- \rightleftarrows H^+ + CO_3^=$$

When water highly charged with CO_2 comes into contact with calcareous rocks the normally insoluble calcium carbonate ($CaCO_3$) readily goes into solution as calcium bicarbonate. In such a $Ca(HCO_3)_2$ solution there is a complicated system of ions and molecules in equilibrium, and the following components may be found (cf. Ruttner, 1953 : 59):-

(a) Free CO_2,

(b) carbonic acid, partly dissociated and partly not (H_2CO_3, $CO_3^=$, H^+),

(c) dissociated calcium bicarbonate Ca^{++}, HCO_3^-, $CO_3^=$), and

(d) OH^- ions formed on the hydrolysis of H_2CO_3.

The pH of a solution of this nature is weakly alkaline due to a slightly greater concentration of OH^- ions produced on the hydrolysis of H_2CO_3 than the concentration of H^+ ions following dissociation of H_2CO_3. Thus the pH of most freshwaters containing $Ca(HCO_3)_2$ depends on this balance between H^+ ions and OH^- ions.

In conjunction with CO_2 such calcium bicarbonate solutions have a property, shared by few other solutions. This property is the ability to counteract large fluctuations in the pH of the medium, and in so doing maintaining a certain stability in the pH of the environment. This phenomenon is known as the carbon dioxide - calcium bicarbonate buffering system. The mechanism of this system is described in detail by Ruttner (1953) and Wetzel (1975). In brief, however, if an acid is added to a solution of $Ca(HCO_3)_2$, part of the HCO_3^- splits off and combines with the acid releasing some free CO_2. The few H^+ ions formed on the weak dissociation of this CO_2 makes little difference to the pH of the solution. Only when all the bicarbonate has been completely utilized in this process will further additions of acid lower the pH significantly. In contrast if an alkali is added or CO_2 is removed from such a solution, some of the equilibrium CO_2 (cf. Ruttner, 1953 : 58) is released from the bicarbonate, while OH^- ions from the alkali are bound up in the precipitation of $CaCO_3$.

The buffering capacity of a $Ca(HCO_3)_2$ solution is reduced by dilution. Consequently whether a water is well or poorly buffered is determined by the bicarbonate content. Factors controlling the bicarbonate concentration are primarily the CO_2 content of the water and the calcium content of the substrate (cf. Ruttner l.c. : 57). In streams originating in or flowing over relatively insoluble igneous rocks there is insufficient bicarbonate to buffer changes arising from the accumulation of CO_2. As a result the buffer system shifts to the acid side, and the pH of these streams is usually below neutrality. In poorly buffered streams large pH fluctuations are common due to the rapid utilization of the small amounts of bicarbonate available for neutralizing the surplus H^+ ions, and the subsequent profound effects of the addition or removal of CO_2.

Dynamic biological processes also play an important part in the control of the concentrations of CO_2 and bicarbonate. Natural solutions of bicarbonate are continually under the influence of plant and animal metabolism, the processes of photosynthesis and respiration being the most important aspects. Where there is copious plant growth the CO_2 content reaches its lowest level during most of the daylight hours as a result of photosynthetic uptake of CO_2, while its maximum is reached in the early hours of the morning through CO_2 release from respiration. This uptake and release of CO_2 alters the buffer mixture and disturbs the equilibrium. In photosynthesis first the free CO_2 is utilized and then later the CO_2 bound up in the bicarbonate. Utilization of the bicarbonate yields OH^- ions in solution, and as a result the pH rises slightly during the day. Photosynthesis has therefore three main effects on the aquatic environment during the day. These are

(a) reduction of free CO_2,

(b) reduction of calcium bicarbonate, and

(c) an increase of pH.

In estuaries other factors govern the concentration of CO_2 dissolved in the water. According to Reid (1961 : 174) the solubility of free CO_2 depends in the first place on the amount of seawater mixing with freshwater, and secondly on temperature. As salinity increases, the solubility of CO_2 decreases with a resultant decline in the concentration of free CO_2. Alkaline radicals in the sea are present in excess, and the imbalance between these and acid radicals induces the CO_2 system to shift towards carbonate formation. In doing so the free CO_2 concentration is reduced. Through its excess bases seawater is well buffered against gross pH changes, and the pH of seawater is therefore very stable, varying usually between pH 8,1 and 8,3. Since CO_2 uptake is greater in the presence of excess bases, concentrations of free CO_2 should be greater in the upper reaches of an estuary than at its mouth. However in the upper reaches pH and the concentration of free CO_2 should be more variable owing to the poorer buffering of river water.

To summarize briefly, CO_2 has very little direct effect on the distribution of diatoms or on the composition of their associations. On the other hand the peculiar properties of the CO_2 - bicarbonate buffering system imparts to CO_2 a highly significant but indirect role in the aquatic environment. By regulating the pH of the environment and the degree of pH fluctuation it affects the nature of the diatom communities. This has already been discussed in the previous section dealing with pH.

3.3 The effect of calcium and magnesium

Calcium and magnesium also do not appear to have any direct effect on the distribution of diatoms. Their physico-chemical relationships in inland waters have been described by Hutchinson (1957), Reid (1961) and Wetzel (1975), while their physiological significance to organisms has been discussed by Kalbe (1973), Ketchum (1954), Moss (1972), Provasoli (1958) and Wetzel (1975), as well as by various authors in the comprehensive reviews of algal physiology edited by Lewin (1962) and Stewart (1974).

Perhaps the most important effect that calcium has in relation to the distribution of organisms is its role in the CO_2 - bicarbonate buffering system (see previous two sections). Igneous rocks are poor in calcium, and streams arising or flowing over such rocks are consequently low in calcium and are poorly buffered. On the other hand, sedimentary rocks are usually rich in calcium; streams associated with them will therefore have a good supply of calcium and will be well buffered and alkaline. The calcium content in such streams and rivers is also dependent on temperature, which affects the solubility of calcium, as well as the solubility of CO_2, which in turn influences the calcium concentration.

The calcium content may also be affected biologically. During photosynthesis CO_2 is taken up by plants. As a result the $Ca(HCO_3)_2$ in solution decomposes releasing CO_2 to restore the equilibrium, producing in the process insoluble $CaCO_3$ which precipitates out as marl. This marl can be redissolved later in the presence of aggressive CO_2. A small amount of calcium may be removed from the system by animals in shell building. Calcium has also been suggested by Biebl (in Lewin, 1962 : 804) to have some bearing on the increase of resistance in some marine algae to hypotonic solutions. On account of this effect Simonsen (1962 : 17) felt that some of the tolerance ranges expressed in his system of diatom classification in relation to salinity might be too wide (see section 3.6 below).

A direct effect of the calcium ion on the distribution of the diatoms is somewhat doubtful. Nevertheless, Hustedt (1938-39 : 287) proposed a system of classification containing four categories of diatoms based on the calcium content of the water reflected by the alkalinity. These are:

(1) Calciophobes - these diatoms live in water having an alkalinity of 0 - 0,8.

(2) Indifferent - species living in waters with alkalinities up to 2,0 - 3,0.

(3) Calciophil - species living in water with an alkalinity range of 1,0 - 3,0.

(4) Calcibiont - species living in waters with an alkalinity range >3,0.

This system has not been generally accepted by diatomists and is strongly criticised by Cholnoky (1968 : 263), who maintained that the calcium ion itself has no influence on the distribution of diatoms. According to Cholnoky, it is the pH of the water and not the calcium content which is the important factor. Due to its significance in the buffering system, waters rich in calcium are well buffered and pH values are high. On the other hand, calcium poor waters generally have lower pH values. Thus the list of species or genera given by Patrick (in Werner, 1977 : 305) as taxa which "seem to definitely prefer calcium" is actually a list of those taxa living in well buffered waters with high pH values (cf. Cholnoky, 1968b : 264). Similarly the genera enumerated by Patrick as caliophobes, e.g. *Eunotia, Stenopterobia, Actinella, Pinnularia* and *Frustulia*, are well known to occur in acid or poorly buffered waters.

Although to some extent calcium and magnesium are interchangeable (see review by Provasoli, 1958 : 284), magnesium does not have a similar function to that of calcium in a buffering system. Furthermore the supply of magnesium generally far exceeds the demand for this element in metabolism, and thus the magnesium content of a river water is little affected by biological activity.

3.4 The effect of oxygen

Apart from the bacteria, oxygen is required by all living organisms for respiration. However, despite its utmost importance in metabolism little appears to have been done to investigate the effects of different oxygen tensions on respiration, and ultimately the consequences of varying oxygen concentrations on the distribution of organisms in the aquatic environment.

Reviews of the relationships between oxygen and water and the many factors governing the oxygen content in streams or rivers have been undertaken by Hutchinson (1957), Ried (1961), Ruttner (1953) and Wetzel (1975). The large number of variables affecting the oxygen content throughout the course of a river make generalizations difficult. Nevertheless, Reid (1961 : 169) has suggested that in the upper reaches of streams the water is well oxygenated as a result of cooler temperatures and turbulence. Further downstream where the flow is slower and there is a profusion of aquatic vegetation, oxygen concentrations may be influenced more by photosynthesis and respiration, and less by turbulence. In lowland areas increased turbidity and organic decomposition of organic matter result in low oxygen concentrations. At any point along the stream, the entry of organic pollutants or inflow from marshes and swamps may depress the oxygen content below the point of entry. Generally speaking, however, if no further pollutants enter the stream, oxygen content levels will return to normal through the processes of reoxygenation.

The response of different organisms to changes in oxygen concentration is not the same. Gessner and Pannier (1958a : 347) demonstrated that higher algae and aquatic plants living in flowing water were affected more by oxygen content fluctuation, whereas forms in quiet reaches were better able to compensate for large variations in oxygen concentration. McIntire (1966 : 928) observed a similar situation in periphyton communities of laboratory streams. Respiration rates for communities developed in fast currents were generally greater or at least equal to respiration rates in slow current communities. Amongst unicellular algae differences in response have also been noted by Begin-Heick & Blum (1967 : 813), Gessner & Pannier (1958b : 479), Lloyd (in Stewart, 1974 : 509) and Stewart & Pearson (1970 : 309). These observations suggest that higher aquatic plants and algae are adapted to various oxygen concentration or tension levels.

Although little research on this aspect has been carried out in relation to the diatoms, there is reason to believe that they may also be adapted to specific oxygen tension levels. Various studies appear to support this idea. Lund (1954 : 163) has shown that some *Melosira* species remain viable under anaerobic conditions for long periods of time, suggesting a special adaptation and tolerance to very low oxygen concentrations. Ryther and Guillard (1962 : 447) and Lewin and Guillard (1963 : 163) have shown that a selection of diatom species had different oxygen uptake rates. According to Cholnoky (1968b : 450) *Nitzschia thermalis* dominates or is abundant in waters with a high organic nitrogen content and oxygen concentrations which sink at night to about 20 - 30 % saturation. In better aerated water, in which the oxygen content never falls below 80 % saturation, it is, however, replaced by *Nitzschia palea*. Kolbe (1932 : 293) has suggested that thermal diatoms are adapted to low oxygen concentrations as temperatures are so high. Hustdedt (1938-39 : 313) found that oxygen depletion resulted in species poor communities, in which various species of *Nitzschia, Surirella* and *Synedra* were often represented.

Cholnoky (1968b : 437) claimed that diatoms are adapted to different oxygen content levels. Changes in the oxygen content are reflected by shifts in the composition of the diatom communities, and these are demonstrable through analyses of the associations. He maintained that when the specific characteristics with regard to oxygen response are known for each species, it is possible to use their relative abundance as indicators of the oxygen balance in the water. Finally Cholnoky (l.c. : 463) has supplied a list of diatom taxa which he claimed could be used to indicate waters of high oxygen content.

An attempt to classify the diatoms with respect to their oxygen requirements has been made by Hustedt (1938-39 : 314). This has been summarized by Lowe (1972 : 22) as follows:-

(1) Euryoxybiont - tolerant of a wide range of oxygen levels.
(2) Mesooxybiont - tolerant of a narrower range of oxygen fluctuation.
(3) Oligooxybiont - intolerant of much fluctuation in the oxygen content, usually requiring oxygen saturation.

Of these three categories most diatoms belong, according to Hustedt, to the euryoxybiontic forms.

3.5 The effect of the nutrients nitrogen and phosphorus

In previous sections the influence of various other nutrients on the distribution of the diatoms has been briefly discussed. In this section some remarks on the effect of nitrogen and phosphorus will be made. Nitrogen and phosphorus are two of the most essential elements in plant metabolism, the former in protein synthesis and the latter in energy transformations through phosphorylation reactions in photosynthesis, as well as in the synthesis of many other organic compounds. These two elements are the subject of many reviews in relation to their cycles in the aquatic environment (e.g. Allen and Kramer, 1972; Reid, 1961; Ruttner, 1953; Wetzel, 1975), and with respect to their metabolism (e.g. various authors in Lewin, 1962 and Stewart, 1974; Wetzel, 1975).

Both elements are intimately involved with the nutrient status of a water body, playing major roles in the processes of eutrophication and pollution. The fact that some organisms are able to tolerate or even thrive in polluted conditions, while others cannot, was brought to the attention of limnologists early in the present century primarily through the work of Kolkwitz and Marsson (cf. Cholnoky, 1968b : 485). Their well known "Saprobic System" was, however, based on a somewhat unfounded hypothesis that the decomposition of polluting substances (considered by Kolkwitz and Marsson as a homogeneous material) took place in three phases (cf. Liebmann, 1962 : 174) involving first reduction, then oxidation and finally mineralization of the polluting substances. A river could therefore be zoned into a polysaprobic zone in which reduction takes place, a mesosaprobic zone in which oxidation intially takes over from the reduction phase (α-mesosaprobic zone) and then becomes the dominant process (β-mesosaprobic zone), and then finally the oligosaprobic zone where oxidation is complete and all polluting substances are mineralized. Organisms adapted to each of these zones are known respectively as polysaprobes, α- and β-mesosaprobes and oligosaprobes. In addition to these a further category was introduced - the katharobes, which are organisms living in waters that are never polluted. Kolkwitz and Marsson drew up lists of "Character Species" or "Leitformen" which were supposed to indicate by their presence any one of these zones. The "Saprobic System" had, however, a number of weaknesses, so that its practical application was unsatisfactory (cf. Cholnoky, 1968b : 488). One of the main faults was the failure to recognise that the distribution of the organisms was not the result of the degradation processes, but was influenced by the chemical nature of the polluting substances, an aspect not considered by Kolkwitz and Marsson.

One of the first to realise the importance of the nutrients in polluting substances (excluding toxic materials) was Naumann (cf. Cholnoky, 1968b : 475), who developed the concepts of eutrophy and oligotrophy in waters. A water body richly supplied with nutrients is known as eutrophic, while one poor in nutrients is called oligotrophic. On account of the abundance of nutrients in polluting substances, Naumann was also among the first to recognise that pollution is really an extreme case of eutrophication. In the context used above the nutrients referred to are nitrogen and phosphorus.

Nitrogen is taken up by algae mainly in the inorganic form as ammonia or nitrate, although some algae can utilize organic nitrogen sources successfully. As far as phosphorus is concerned the most important form for algal nutrition is inorganic phosphate. The ability to utilize organic phosphorus is known in some algae, but it is highly variable. It is the availability of the different forms of nitrogen, and to a lesser extent phosphorus, which influences the distribution of the diatoms. Cholnoky (1968b : 605) has reviewed the physiological background to the adaptation of algae to eutrophic conditions, supplying at the end of this review a list of diatom taxa, which he considered as nitrogen heterotrophic, i.e. taxa utilizing organic nitrogenous sources for growth. Such taxa, when found in abundance, were believed by Cholnoky to indicate a rich supply of organic nitrogen in the water from which the taxa were collected, i.e. the waters were strongly eutrophic or polluted. Very few of the taxa in this list have, however, been experimentally shown to be nitrogen heterotrophic (cf. Saubert, 1957), and they are placed here mainly on empirical evidence. Taxa not mentioned in this list are regarded as preferring inorganic nitrogenous sources, and therefore indicate oligotrophic conditions.

In this study little has been said of the trophic status of the water in the Sundays River for a number of reasons. One of the main reasons is that no measurements of the organic nitrogen content of the Sundays River water were made, thus providing no foundation for any inferences in this respect that may be drawn from the diatom associations. Nitrate-N levels were measured on only one or two occasions at each of the stations, and with two exceptions were generally low. When the nitrate-N concentrations were high they could be related to leaching of inorganic fertilizers rather than to the degradation of organic nitrogenous waste materials. Secondly, although many of the so-called 'nitrogen heterotrophs' may be associated with organic nitrogen on empirical evidence, there are indications that some of these taxa may grow equally abundantly on inorganic nitrogenous sources. These species may therefore be facultatively nitrogen heterotrophic, and chemical evidence showing clearly that they are nitrogen heterotrophic is necessary before being able to infer that they indicate a high level of organic nitrogen in the water.

On these considerations, therefore, it was felt that it would be wiser not to become too embroiled with conclusions drawn from evidence with little hard fact to support it.

3.6 The effect of dissolved salts

One of the most important factors governing the distribution of diatoms is salinity. Salinity, however, has different connotations to various people, and a definition of this term is necessary to explain clearly what is meant by salinity in this study.

Salinity, as defined by Reid (1961 : 177) is the total concentration of the ionic components dissolved in the water. Hutchinson (1957 : 553) and Wetzel (1975 : 143) were, however, more precise and took into consideration only the eight major ions in solution, viz. Na^+, K^+, Mg^{++}, Ca^{++}, Cl^-, HCO_3^-, $CO_3^=$ and $SO_4^=$. Concentrations of other elements, such as N, P, Fe and others, although very important biologically, make little contribution to the salinity. Reid's definition of salinity with the limitations of Hutchinson and Wetzel has been accepted in this study. Salinity is usually expressed either as mass or milli-equivalents per litre, or as parts per thousand (‰).

Salinity in this context must not be confused with salinity as determined by means of Knudsen's formula (cf. Remane and Schlieper, 1971 : 322). This formula ($S = 0{,}03 + 1{,}805.n$ g Cl/kg seawater) is based on the constant ratio found in seawater between chloride ions and the total concentration of ions in solution. In inland waters this ratio is very variable, and Knudsen's formula cannot therefore be applied with any accuracy to determine the salinity of inland waters from their chloride content. The chloride ion is, moreover, seldom the dominant ion in freshwaters.

In similar vein the expression "brackish water" needs some clarification to avoid confusion. One school of thought limits its concept of brackish waters to those involving a mixture of seawater and freshwater. To this school, true brackish waters are only to be found in estuaries or in cases such as the Baltic Sea. On the other hand, the second school of thought accepts as brackish water any water body with a raised salt content irrespective of its origin. The latter concept has been adopted for this study.

A number of comprehensive accounts (e.g. Hutchinson, 1957; Reid, 1961; Remane & Schlieper, 1971; Ruttner, 1954; Wetzel, 1975) described in detail the chemical and hydrographical features of inland waters, and their biological consequences, This discussion will therefore limit itself to the effects of salinity on the distribution of the diatoms.

Salinity influences the distribution of organisms chiefly in two ways; firstly through the osmotic pressure of the medium, and secondly through the specific action of the individual ions on the organisms. Osmotic pressure is principally the function of the total number of particles dissolved in the water, consequently waters with high salt concentrations have greater osmotic pressures than waters with low salinities. An important factor to be considered here is the variability of the osmotic pressure. In freshwater and seawater the osmotic pressure remains constant within fairly narrow limits. In contrast most brackish waters experience fluctuations of the osmotic pressure, varying in magnitude and frequency. For instance in estuarine situations the tides cause rhythmical fluctuations of the osmotic pressure with the degree of magnitude dependent on the distance from the sea. On the other hand in ephemeral pools the osmotic pressure may gradually rise owing to the concentration effect of evaporation, but may suddenly drop dramatically as the result of the addition of rainwater. A similar situation may exist in rivers in arid areas subject to flash floods.

Diatoms, being one of the most ubiquitous groups of organisms and found in any biotope where there is moisture and light, must therefore accommodate themselves to a wide spectrum of conditions in respect of the osmotic pressure or salinity. Some taxa have adapted themselves by various means (cf. Drum, 1969; Fisher, 1952, 1963, 1964; Paul, 1979; Schobert, 1974) to survive in a wide range of salinities, while others are restricted to more limited ranges of salt content, i.e. the freshwater situation or strictly marine environments.

The second aspect of salinity as an environmental influence is the specific chemical nature of the ions in solution. While osmotic pressure may be the primary factor controlling the overall character of the community of organisms, i.e. whether it is a fresh, brackish or marine water association, the chemical properties of the individual ions may play a significant role in determining which species compose the community, for example Wetzel (1975 : 142) pointed out that the relative proportions of the major cations, and the ratio of mono- to divalent ions affects the metabolism of many organisms, particularly algae. Thus changes in a population may be induced through the biogenic removal of calcium from a system, or through the organic complexing of calcium.

Simonsen (1962 : 14) was of the opinion that in the study of brackish waters (*sensu lato*) insufficient attention has been given to the concepts of halobiotope (the saline environment) and halobios (the fauna and flora of brackish waters). Since the study of brackish waters began to stimulate the interest of biologists numerous classifications of brackish waters (halobiotope) have been proposed) cf. reviews by Remane & Schlieper, 1971, and Segerstrale, 1959). Most of these have been concerned with brackish water in the stricter sense of the term, and have not attempted to consider inland brackish waters (cf. the final resolution of the Venice Symposium on the Classification of Brackish Waters, 1959 : 245). In contrast, few classifications of the halobios have been attempted. One of the first to do so was Kolbe (1927 : 112), who proposed a classification of the diatoms in relation to the salt content of the environment. He distinguished three main categories as follows:-

Euhalobes	- main range of salinity	- 30 - 40‰
Mesohalobes	- main range of salinity	- 5 - 20‰
Oligohalobes	- main range of salinity	- <5‰

The oligohalobes were further subdivided into:-

Halophilous oligohalobes	- forms whose development is stimulated by salt solutions.
Indifferent oligohalobes	- forms in which the individual numbers rapidly decline with increasing salt concentration.
Halophobous oligohalobes	- extremely stenohaline forms, not tolerating even low concentrations of salts.

Kolbe's system, although not widely known outside the study of the diatoms, has been accepted by many diatomists. Perhaps better known today is Hustedt's (1957 : 196) modification of Kolbe's system. Considering the upper salt concentration limit for the oligohalobes to be too high, Hustedt reduced it to 0,2 ‰, thus bringing it more into line with the current limit of limnetic water (freshwater) in the "Venice Classification of Brackish Waters (cf. final resolution of the

Venice Symposium for the Classification of Brackish Waters, 1959 : 243). Hustedt also subdivided the mesohalobes into two categories; and finally he preferred the term polyhalobes to refer to the true seawater forms, while the term euhalobes was considered a super category embracing the polyhalobes and mesohalobes. Hustedt's system is given below.

Polyhalobes - salt content 30 ‰ and above.

Mesohalobes:

(a) Euryhaline mesohalobes - salt content about 0,2 - 30 ‰
(b) α-mesohalobes - NaCl minimum about 10 ‰.
(c) β-mesohalobes - salt content about 0,2 - 10 ‰.

Oligohalobes: Salt content less than about 0,2 ‰.

(a) Halophilous diatoms.
(b) Indifferent diatoms.

Halophobous (haloxene) species.

Both Kolbe's system and Hustedt's modification of it are more or less rigid with regard to the boundaries between the categories, and fail to recognise that organisms cannot be fitted precisely into their categories. All organisms are to a certain degree euryhaline, and some cognisance of different tolerance ranges must be taken into account.

In his study of the diatoms of the Baltic Sea, Simonsen (1962 : 17) proposed a new system of diatom classification with this in mind. His classification was composed of three main categories - the polyhalobes, mesohalobes and oligohalobes. The polyhalobes are marine species with varying degrees of tolerance to hypotonic solutions, while the oligohalobes are freshwater species with varying degrees of tolerance to hypertonic solutions. Between these two categories are the mesohalobes, which are forms specially adapted to brackish water and having a very wide range of tolerance to salt concentrations. The degree of euryhalinity (tolerance to salt concentration) was defined by Simonsen (l.c.) by the prefixes oligo- (little), meio- (less), meso- (middle), pleio (more) and holo- (entirely). Simonsen's system is outlined below and illustrated graphically in Figure 3, where it is compared with Hustedt's modification of Kolbe's system, and with Ekman's (1953) classification of the halobiotope. The salt tolerance ranges for each category is defined in the table below.

<u>Simonsen's classification of the diatoms according to their salt tolerance ranges.</u>

Polyhalobic or marine forms:-

1. Oligoeuryhaline polyhalobes - 35 - 30 ‰ salt content.
2. Meioeuryhaline polyhalobes - 35 - about 20-17 ‰ salt content.
3. Mesoeuryhaline polyhalobes - 35 - about 8-10 ‰ salt content.
4. Pleioeuryhaline polyhalobes - 35 - about 3-5 ‰ salt content.

Mesohalobic forms:-

1. Euryhaline mesohalobes - with a tolerance range of about 0,5 - 30 ‰ salt content.
2. Holoeuryhaline mesohalobes - from 0,0 - >30 ‰ salt content.

Oligohalobic or freshwater forms:-

1. Meioeuryhaline oligohalobes - up to about 3 - 5 ‰ salt content.
2. Mesoeuryhaline oligohalobes - up to about 8 - 10 ‰ salt content.
3. Pleioeuryhaline oligohalobes- up to about 17 - 20 ‰ salt content.
4. Holoeuryhaline oligohalobes - up to 30 ‰ and more salt content.

Ehrlich (1975 : 264) has criticised Simonsen's classification on the grounds that it only takes into account the hypotonic tolerance ranges of the poly- and mesohalobic taxa, and no

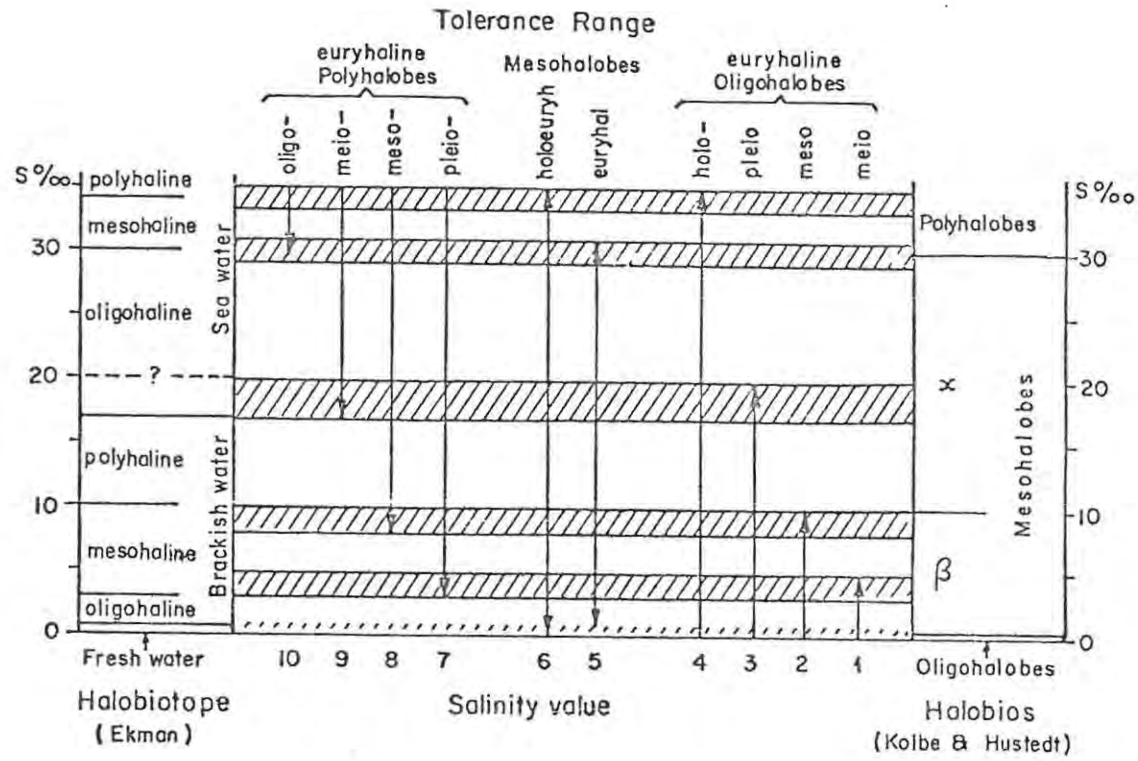


Fig. 3 Simonsen's halobic groups, their tolerance ranges and the salinity values assigned to them. (After Simonsen 1962:18)

indication is given of the highest salinity that each category can reach. Consequently she adapted Simonsen's system to give hypertonic extensions to the ranges for the polyhalobes, which she considered as being equal to the hypotonic ranges. Extended hypertonic ranges were also given to the holo- and euryhaline mesohalobes, but she was unable to fix their upper limits. Ehrlich, moreover, added an extra category to the polyhalobic forms - the stenohaline polyhalobes, which have a very restricted tolerance range. Ehrlich's modification makes a very useful contribution to the classification of diatoms in accordance with their salinity preferences, but as hypertonic conditions do not obtain in the rivers studied, Simonsen's system has been utilized to characterize the diatom taxa recorded in this investigation (see section 4.2.3 below).

Hustedt's classification system and that of Simonsen are qualitative in that they are merely descriptive of the character of the taxa constituting an association. It is, however, sometimes useful to quantify data in order to facilitate comparison of two or more associations by means of a numerical expression. Several attempts have been made to achieve this. One of the earliest to do this was Boye Petersen (1943) by means of his "Halobion Spectrum". Changes in the salinity of a water body were reflected by the percentage contribution of the taxa in each of Kolbe's categories. This method is, however, rather cumbersome, particularly when large numbers of samples are to be compared.

Analogous to Boye Petersen's "Halobion Spectrum" is the Halobic Index (H) of Ziemann (1971). This index endeavours to express numerically the saline quality of a water body through analysis of the diatom community inhabiting it. The Halobic Index (H) is computed according to the following formula:-

$$H = \frac{\Sigma^{h}_{H} - \Sigma^{h}{}_{x}}{\Sigma h} \text{ x } 100$$

Where h_H = the total frequency of all salt indicating species,
h_x = the total frequency of all salt avoiding species,
and h = the total frequency of all species in the sample.

The main objection to this method lies in the estimation of frequency of the species on a six point system proposed by Breitig (1961 : 103). Such estimations are subjective and can be misleading when populations of different sized diatoms are involved.

In this study a new method has been evolved to express numerically the overall character of a diatom association with reference to the salinity of the water found at any particular station. This value is known as the Salinity Tolerance Index, and its nature and underlying theory are discussed in the following section.

3.6.1 The Salinity Tolerance Index.

The Salinity Tolerance Index (STI) is based on the relative densities of the individual taxa composing the association and their characterization according to Simonsen's (1962 : 17) classification. The theory underlying this index is as follows. In a freshwater body of very low and more or less constant salinity most taxa represented in an association from this water body would belong to the meio- and mesoeuryhaline oligohalobes. As the salinity increases the least tolerant oligohalobes are displaced by the more tolerant forms, causing a shift towards the pleioeuryhaline oligohalobes. With further increases of the salinity and perhaps greater fluctuations in the salt content more and more mesohalobes would make their appearance, although some of the most tolerant oligohalobes, i.e. the pleioeuryhaline oligohalobes, would be able to survive. In purely inland brackish waters the diatom communities would consist almost entirely, if not wholly, of mesohalobes. In an estuary, however, the river water becomes influenced by seawater, and the most tolerant marine forms, the pleioeuryhaline polyhalobes may make their appearance near the head of the estuary. With progression down the estuary the abundance of the most tolerant polyhalobes swells until at the mouth of the estuary the diatom population would consist of a mixture of mesohalobes and polyhalobes. In the sea itself the least tolerant polyhalobes belonging to the oligoeuryhaline polyhalobes would be found, although near the mouths of rivers some of the more tolerant polyhalobes may exist.

In Simonsen's classification of the diatoms according to their tolerance ranges (see Fig. 3), the diatom spectrum consists conveniently of 10 categories. In the development of the Salinity Tolerance Index these categories have been allotted a certain value from 1 -

10, known as the salinity value, in accordance with the halobiotope and salinity tolerance range (see Fig. 3). Thus oligohalobes with the narrowest range of tolerance are given the value 1, while the most tolerant oligohalobes have a value of 4. Euryhaline and holoeuryhaline mesohalobes take the values 5 and 6 respectively. Amongst the polyhalobes, those species with the greatest tolerance receive a salinity value of 7, while the most stenohaline marine species, restricted to pure seawater, are given the value of 10. Finally those species that are extremely sensitive to any, but the very slightest, salt content, the halophobes, are given the value of 0.

In the calculation of the Salinity Tolerance Index (see section 4.2.3 under methods) the salinity value of each taxon in the community is used to weight its percentage contribution to the association by multiplying the relative density of the taxon concerned by its salinity value. In such a way, if a diatom association is composed entirely of meioeuryhaline oligohalobes, the relative contribution (expressed as a percentage) of each species would be multiplied by a salinity value of 1. The weighted value for the whole community, when summed, would be 100. At the other extreme, if the population is wholly composed of oligoeuryhaline polyhalobes, the contribution of each taxon would be multiplied by the factor 10, giving a summed weighted value for the population of 1 000. Similarly a population consisting of only euryhaline mesohalobes would have a weighted value of 500. Values intermediate between these three reference points would therefore reflect different balances of the various categories of polyhalobes, mesohalobes and oligohalobes in the community. These weighted values are, however, too large to handle conveniently. For this reason the total weighted value of a population is divided by a factor of 100. In this way the Salinity Tolerance

Index (STI) has a range of 1 - 10, a much easier range to deal with.

From the theoretical picture of the progression of events that occur as a river becomes gradually more saline as outlined above, it follows that STI values will increase as the salinity increases, thus reflecting the response of the diatom communities to the ambient salinity. It must, however, be emphasized that the index is qualitative in this respect that it cannot be pegged to precisely defined salt concentration levels. It merely indicates the nature of the composition of the diatom associations. The STI reflects the average salt tolerance range of the taxa comprising an association, and gives some indication of the halobiotope. Thus an STI value between 1 and 3 would denote an association composed almost entirely of oligohalobic species indicating freshwaters; a value between 3 and 4 would indicate the intrusion of mesohalobic species in the community, and thus a raised salt concentration. A value between 4 and 5 would convey that the community is dominated by mesohalobic species, inferring brackish waters. Values above 5 would denote increasing proportions of polyhalobic species, and finally values between 8 and 10 would indicate populations that are comprised almost entirely of polyhalobic species, i.e. a marine community.

The STI cannot be related directly to any specific salinity level, because, while freshwater communities (STI = 1 - 3) may be limited to waters with a salinity below about 1,0 ‰, a brackish water association may develop in a salinity range from about 1,0 ‰ to about 20,0 ‰ or more. Thus communities having STI values between 4 and 6 may come from waters with salinities falling into this very wide range. On the other hand associations having STI values of 8 - 9 are probably restricted to marine waters with salinities greater than about 30,0 ‰.

The Salinity Tolerance Index must therefore be regarded as a qualitative index for easy comparison of the nature of the communities developed at various points in a river system or other water body, or for detecting changes in a community at one particular point. It cannot, however, be used to indicate the level of salinity with any degree of exactitude.

4. Methods and materials.

Samples for water analysis and the examination of the diatom flora were collected at various times from a number of stations along the course of the Sundays River. The locality of each station can be seen in Figure 1, and a description of the chief features of each station is given separately in Section 5.1 below. The methods employed in the chemical analysis of the water samples (section 4.1), and in the investigation of the diatom samples (section 4.2) are outlined below.

4.1 Physico-chemical analyses

Analyses of the physico-chemical parameters discussed in this study were carried out by Forbes (1968 : 9) in his investigation into some aspects of the ecology of the Sundays River. Some additional measurements of pH and temperature were taken by the author during subsequent sampling trips in the catchment of the Sundays River. The methods and materials used by Forbes (l.c.) in the chemical analysis of the water samples are described briefly below.

In the field, pH measurements were made by Forbes using a portable Beckman pH meter, while the additional pH readings were recorded with a portable Metrohm E 444 pH meter. Water temperatures were taken with a conventional mercury and glass thermometer. Water smples for the determination of dissolved oxygen were initially treated in the field following Winkler's method, and later the liberated iodine was titrated against sodium thiosulphate in the laboratory.

A 1 to 2 litre water sample for a complete chemical analysis was collected for treatment in the laboratory. Such samples were stored in a cold room at temperatures just above freezing, and analysed as soon as possible, particularly in respect of those ions (e.g. nitrate-N and orthophosphate) which may show changes during storage. The analyses, described below, were carried out.

4.1.1 Total Dissolved Solids (TDS):

This was determined by evaporation at 105 °C. In the tables in the text it is reflected as the "measured TDS", and is expressed as milligrams per litre (mg/ℓ). However, as this did not always tally with the sum of the concentrations of the cations and anions, individually analysed, a second TDS (or salinity) value is given in the tables. This is referred to as the "calculated TDS", and is derived by summing the concentrations of each of the major ions in solution. Following the definition of Hutchinson (1957 : 553) the "calculated TDS" value can be regarded as the salinity of the water. In the text this salinity value is generally expressed as parts per thousand (‰), although in the tables it is reflected as milligrams per litre (mg/ℓ).

4.1.2 Sodium and Potassium:

Concentrations of these two cations were determined by flame photometry according to the method described by Mackereth (1963 : 67).

4.1.3 Calcium and Magnesium:

Ionic concentrations of these two cations were measured using the sodium versenate method described by Mackereth (l.c. : 32).

4.1.4 Carbonate and Bicarbonate:

Concentrations of these two anions were calculated from the alkalinity as determined by titration with standard hydrochloric acid using phenophthalien and methyl orange as indicators (cf. American Public Health Association, 1966).

4.1.5 Sulphate:

The sulphate content of the water was determined by Forbes using first the ion exchange method according to Mackereth (l.c. : 29), and later using the gravimetric filter paper method described by Vogel (1962).

4.1.6 Chloride:

Concentrations of the chloride ion were determined following an ion exchange method described by Mackereth (l.c. : 31), and later by Mohr's method recommended by the American Public Health Association in the Standard Methods for the Examination of Water and Wastewater (1966).

4.1.7 Nitrate:

The nitrate-N content was determined colorimetrically using the phenoldisulphonic acid method reported by Mackereth (l.c. : 45). Colour differences were measured with a spectrophotometer.

4.1.8 Phosphate:

The colorimetric method described by Hellwig and Noble (1965 : 13) was used to determine the phosphate concentrations in the waters.

4.2 Diatom Samples and Analyses

Diatom samples were collected by scraping the diatom growth off the mud, stone or plant substrates with a spoon, placing it in a collecting bottle or tube, and preserving it in 4 % formaldehyde. Diatom frustules in these samples were cleaned by removing all organic cell contents by means of the acid and boiling technique described by Welsh (1964 : 41). The cleaned diatom material was then prepared for analysis by mounting some of the cleaned material permanently on slides using Hyrax

(R.I. = 1,65) as a mounting medium following the procedure described by Welsh (l.c. : 45).

4.2.1 The "Thomsasson Analysis":

The composition of the diatom associations found on these slides were analysed using the modified "Thomasson Analysis" technique described by Cholnoky (1968b : 53). In this technique at least 400 - 500 individual diatom valves were counted to provide a reliable estimate of the relative contribution (relative density) of each species to the community (cf. Sanders, 1968 : 279; Wilhm, Cooper and Namminga, 1978 : 18). From these counts the relative density (expressed as a percentage) of each species in the association was calculated using the following formula (cf. Curtis and McIntosh, 1950 : 437):-

$$\text{Relative density of Species A} = \frac{\text{No. of individuals of Species A}}{\text{No. of individuals of all species}} \times 100$$

In the tables reflecting the composition of the diatom associations found at each station on various dates, only those taxa having relative densities greater than 1,0 % in at least one sample were shown. Taxa with relative densities less than 1,0 % were included as "Other species". A + sign in these tables indicates that the species was recorded in the floral list for that sample, but was not encountered in the "Thomasson Analysis" of that sample.

4.2.2 Species Diversity:

To give some idea of the species diversity in the diatom communities examined, Simpson's Index of Diversity as defined by Duffey (1968 : 650) was employed. The index value is calculated from the following formula:-

$$\text{Simpson's Diversity Index} = \sum_{i=1}^{N} \Pi_i^2$$

where N = the total number of individuals in the sample, and Π_i = the proportion of the ith species in the sample. The index values for each sample are shown in the relevant tables in the text showing the composition of the diatom associations. Although it is recognised that Simpson's Index of Diversity has some shortcomings (cf. DeJong, 1975 : 223), it has been shown to have a very high degree of correlation with the other main indices used to indicate species diversity (cf. Archibald, 1972 : 1232). It will therefore show the same trends as any of the other indices. It was selected for this study in preference to the others, since the index values were conveniently easy to derive from the data already available, as the proportions of each species (= relative densities) had already been calculated in the "Thomasson Analysis" of the samples.

4.2.3 The Salinity Tolerance Index (STI):

The Salinity Tolerance Index (see section 3.6.1) is calculated very simply in the following manner. Using the data derived from the "Thomasson Analysis" of a sample (see above), each species encountered in the analysis is awarded a salinity value as determined by its characterization in Simonsen's (1962 : 17) system of classification of the diatoms according to their salt tolerance ranges.

Based on this information the STI is calculated from the formula given below.

$$\text{STI} = \frac{\Sigma(\Pi_i \,.\, \text{SV})}{100}$$

where Π_i is the relative density of the ith species, and SV its salinity value (the salinity value for each taxon in a particular association is shown opposite the species name in the relevant table in the text).

The ecological characterization with particular reference to the salinity tolerance range of each species encountered in this study was evaluated through consultation of the relevant literature, and through personal observation of the taxon in the Sundays River. The body of this information is far too considerable to include in this dissertation, but it will be published at a later stage. Nevertheless, for the purposes of this study the characterization of each taxon with respect to its salt tolerance range and the salinity value allotted to it can be found in Volume 1 of this thesis at the end of the taxonomic notes for each individual taxon.

5. ANALYSIS AND DISCUSSION OF RESULTS

This section deals with the results of the chemical analyses carried out on the water samples and with the analyses of the diatom samples examining the composition of the diatom associations found at the various stations. In the first subsection (5.1) a detailed discussion of the main features of the chemistry and the chief characteristics of the diatom associations will be given separately for each sampling site along the course of the river, working downstream from Station 11 near its source, and concluding with the results of analyses from the Wit River and Lake Mentz. This will be followed in subsection 5.2 by a general review of the chemical regime of the Sundays River and its relationship to the underground waters and geological formations concerned in the area. The third subsection (5.3) will describe the overall pattern of diatom distribution in the Sundays River, examining it with special reference to its relationship with the salinity of the water. The final subsection (5.4) will examine the effectiveness of the Salinity Tolerance Index (described in section 3.6.1) in fulfilling the purpose for which it was designed.

The results of the chemical analysis of the water samples, relevant to each station, are presented in tabular form illustrating various aspects. Some comments on these tables are necessary to clarify their information content. The tables are given in two parts, the first referring to the salinity of the water and its components, and the second to the physical and nutritional aspects. That part of the table dealing with the salinity presents three aspects of the salinity for consideration. Firstly it gives the absolute concentrations of the total dissolved solids (TDS) and the different ionic components expressed in milligrams per litre (mg/ℓ). Here two different values for the TDS are shown, one being the measured TDS obtained by evaporation at 105 °C, and the other the calculated TDS derived by summing the concentrations of the individual ionic constituents. By definition (see section 3.6) the latter value is taken to be the salinity of the water, and in the text is expressed as parts per thousand (‰). The second aspect of the salinity, reflected in the tables, is the relative contribution of each of the ionic components to the total salinity. This is determined by standardizing the absolute concentrations according to the procedure described by Kemp (1963, 1971). In this method the relative contribution of each ion is calculated as a percentage of the salinity (i.e. the calculated TDS). Finally in order to evaluate the accuracy of the chemical analyses the ionic balance between the cations and anions was calculated and is shown as the third aspect of the chemistry for consideration. These values are expressed as milli-equivalents per litre (meq./ℓ).

In the lower part of the chemical tables the physical and nutritional aspects of the water chemistry are shown. The pH values taken at various dates are recorded, while the absolute concentrations of the plant nutrients, nitrate nitrogen and ortho-phosphate are expressed in milligrams per litre (mg/ℓ). The concentration of dissolved oxygen (mg/ℓ) in the water in the early stages of the sampling programme are also shown in the tables. For some stations temperature readings (in °C) were available, but these cannot, however, be used to determine oxygen saturations as they were not taken simultaneously with the oxygen concentration measurements.

In the tables reflecting the composition of the diatom associations a number of points need clarification. Firstly, the taxa listed in the tables are only those with relative densities greater than 1 % in at least one sample from that particular station. All other taxa, which make a contribution to the "Thomasson Analysis" of the relevant diatom association, are included in the table as "Other species". Opposite each of the listed taxa a value, known as the salinity value (see section 4.2.3), is given. This reflects the salt tolerance range of that particular taxon, and is used in computing the Salt Tolerance Index (STI) of the diatom association. This is followed by the relative densities (expressed as a percentage) for each of the taxa in the relevant diatom samples collected at that particular station. A plus sign (+) in this part of the tables indicates that that taxon was present in the sample but was not encountered in the "Thomasson Analysis" of that sample.

At the end of these tables two items of information describing the characteristics of the diatom association are given. Firstly, an indication of the degree of species diversity in the population at the time of sampling is reflected by the Simpson's Diversity Index value given for each sample. Secondly, the Salinity Tolerance Index (STI) value is given for each sample. This is a weighted value indicating the average salt tolerance range of the component taxa in the diatom association.

In the discussion that follows the stations have been arranged into groups reflecting the biological and chemical zones observed along the course of the river. These subdivisions will become apparent from the general discussions of the chemistry and diatom distribution.

5.1 The chemistry and diatom associations of each station in the different zones of the Sundays River

5.1.1 The source zone

STATION 11

Description:

This station was situated at the Bethesda Road bridge over the national road between Middelburg and Graaff-Reinet. At this point the Sundays River lies in a flat plain. The bed is narrow, about 2,0 m wide, is gravelly with some silt patches and a few isolated stones. The river at this station was usually dry, except after rains or snow.

The chemical analyses:

TABLE 1. The chemical analyses of the Sundays River water at Station 11

	Absolute concs. mg/ℓ		Standardized values %		Ionic balance meq./ℓ			
Date	Feb. 67	July 67	Feb. 67	July 67	Feb. 67		July 67	
TDS (measured)	172	478			cations	anions	cations	anions
(calculated*)	242,5	467,8						
Na	48	76	19,8	16,2	2,09		3,30	
K	4,5	1,8	1,9	0,4	0,12		0,05	
Ca	30	62	12,4	13,3	1,50		3,09	
Mg	18	16	7,4	3,4	1,48		1,32	
CO_3	6	12	2,5	2,6		0,20		0,40
HCO_3	76	183	31,3	39,1		1,25		3,00
SO_4	40	62	16,5	13,3		0,83		1,29
Cl	20	55	8,2	11,7		0,56		1,55
					5,19	2,84	7,76	6,24

Date	Feb. 67	July 67	Feb. 68	Aug. 68	Feb. 69	Mean
pH	8,3	8,5 8,4		7,7		8,2
O_2 mg/ℓ	8,3	8,3				
NO_3-N mg/ℓ	0,07	0,18				
PO_4-P mg/ℓ	0,24	0,1				

*See section 4.1.1.

The main physico-chemical features:

The salt content or salinity of the Sundays River near its source was relatively low, the highest value of 0,47 ‰ being recorded in the winter of 1967. The predominant anion was bicarbonate, while the most important cations were calcium and sodium, the latter forming the greater part of the cation fraction. This is consistant with the nature of the underground water supplies from this area, which were classified by Bond (1945 : 159) as soda-carbonate waters. Station 11 had a pH range of 7,7 - 8,5, with a mean of pH 8,2. While nitrate-N levels appeared to be somewhat low, ortho-phosphate concentrations were very high.

The composition of the diatom associations:

See Table 2, and Figs 3, 4.

TABLE 2. The composition of the diatom associations at Station 11

	Salinity value	SUN 26 13.7.67 %	SUN 43 27.8.68 %	SUN 44 27.8.68 %
Achnanthes lanceolata	2	19,9	1,0	+
Amphora veneta	2	2,8	33,5	97,2
Gomphonema parvulum	1	3,4	0,4	0,6
Navicula cincta var *leptocephala*	2	1,4		
Navicula cryptocephala	3	13,8	3,1	+
Navicula muralis	1	1,1	1,6	
Navicula twymaniana	2	1,4		
Nitzschia communis	1		39,2	+
Nitzschia fonticola	3	24,3	0,6	
Nitzschia holsatica	1	+	2,9	
Nitzschia intermedia	1	6,2		
Nitzschia linearis	2	5,9	6,7	
Nitzschia palea	2	10,5	+	
Surirella ovalis	3	0,9	4,7	
Synedra ulna	2	3,9	2,7	+
Other species		7,4	3,6	2,2
Simpsons Diversity Index		0,14	0,28	0,94
Salinity Tolerance Index (STI)		2,28	1,64	2,00

Characteristics of the diatom associations at Station 11:

Owing to drought conditions during the summers of 1968 and 1969 the river was dry at the February sampling times. Consequently diatom collections could only be made on two occasions during the period of the survey. A sample (SUN 26) was collected in July 1967 from the gravel and detritus covered river bed. In August 1968 two samples were collected, one (SUN 43) from a similar substrate, and the other (SUN 44) as scrapings from stones in the river bed. The analysis of these three samples is shown in Table 2.

No characteristic diatom community appears to have developed at this station. In July 1967 the dominant species were *Achnanthes lanceolata, Navicula cryptocephala, Nitzschia fonticola* and *N. palea.* This association, composed entirely of freshwater species (STI = 2,28), corresponded well with the low salinities found at this station (see Table 1). All species in this sample can be described as alkaliphilic

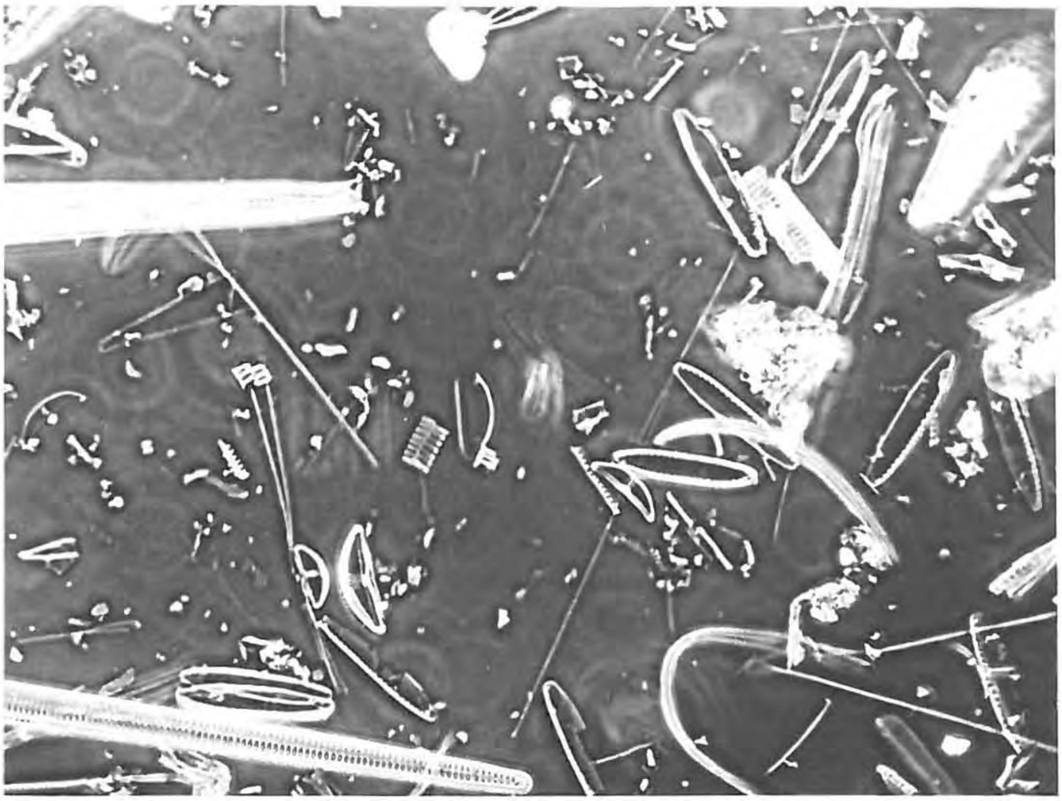


Fig. 3. Diatom association : Station 11 - SUN 43.

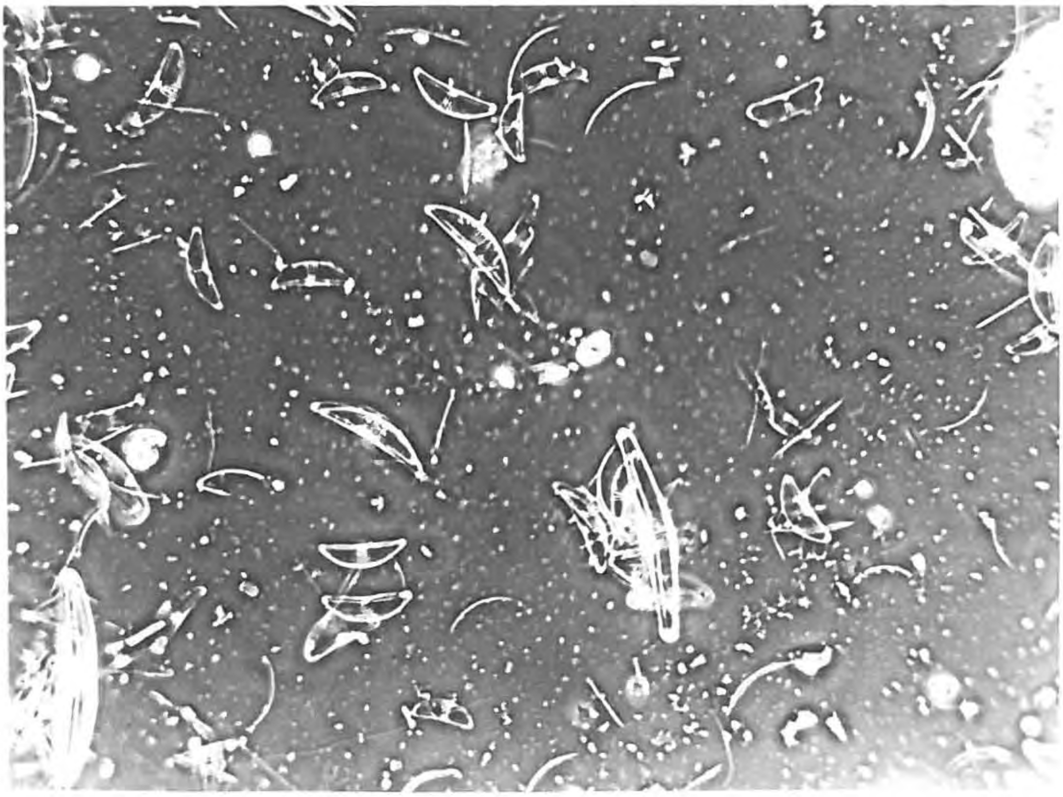


Fig. 4. Diatom association : Station 11 - SUN 44.

or alkalibiontic, and therefore indicated a high pH of the water. This again corresponded well with the pH range of 7,7 - 8,5 found at this station.

In August 1968, although the same species pool seems to have been present, environmental factors appeared to have altered sufficiently favouring a new set of dominants. In the sample (SUN 43 - Fig. 3), collected from the gravelly substrate, *Amphora veneta* and *Nitzschia communis* were the chief species. Despite the change in dominance, the whole assemblage indicated once again the freshwater nature of the water (STI of the population = 1,64) and a high pH. The effect of the substrate on the diatom composition can be clearly seen when this sample is compared with the sample scraped from the surface of rocks in the river bed (SUN 44 - Fig. 4). This association was composed almost exclusively of *Amphora veneta* (97,2 % of the association). In common with many other *Nitzschia* species, *N. communis* was probably better adapted to living on the less stable gravelly or silty substrate, and therefore competed more successfully with *A. veneta* on this type of substrate, hence its codominance in sample SUN 43. However, on the firmer and more stable rocky substrate *A. veneta* was able to flourish without competition from other species.

STATION 10

Description:

Station 10 is found in the mountains above Graaff-Reinet on the farm Glen Harry near the Letskraal Trading Store. Here the river is flood scoured, having a bed of sand, rocks and stones. A permanent flow, even during droughts, was locally maintained by springs at the base of the cliffs. This water was clear and supported a rich aquatic flora of watercress, *Cotula*, *Scirpus* and algae forming a flaky scum. Included with this station are two other localities, one above Station 10 and the other below it, which were sampled at odd times. These will be discussed separately below.

The chemical analyses:

TABLE 3. The chemical analyses of the Sundays River water at Station 10

	Absolute concs. mg/ℓ	Standardized values %	Ionic balance meq./ℓ	
Date	July 1967	July 1967	July 1967	
TDS				
(measured)	614		cations	anions
(calculated*)	607			
Na	111	17,8	4,8	
K	1,8	2,9	0,05	
Ca	58	9,3	2,9	
Mg	50	7,9	4,1	
CO_3	6	1,0		0,20
HCO_3	177	28,3		2,9
SO_4	157	25,1		3,3
Cl	46	7,4		1,3
			11,85	7,7

	July 67	Feb 68	Aug. 68	Feb. 69	Mean
pH	8,4	7,44	8,25 8,09	7,5	7,9
O_2 mg/ℓ	6,1				
NO_3-N mg/ℓ	0,6				
PO_4-P mg/ℓ	0,05				
Temp. °C	13,0				

*See section 4.1.1.

The main physico-chemical features:

Unfortunately only a single chemical analysis was made for this station. This analysis, carried out in July 1967, indicated that the salt content at Station 10 was slightly higher than at Station 11. The calculated salinity of 0,61 ‰ is still, however, relatively low for the Sundays River. Bicarbonate remained the most important anion, although the concentration of sulphate showed a considerable increase. Together they formed more than half the total salinity of the water. The chloride concentration was still relatively low. Sodium was the major cation in solution. These waters were still consistant with the alkaline soda-carbonate underground waters described by Bond (1945 : 159) to be expected from the middle and upper Beaufort beds of the Karroo System.

The sulphate content may be somewhat high, but Bond found that sulphates in underground water from the upper Beaufort beds were sometimes higher than in other beds of this series.

The composition of the diatom associations:

See Table 4, and Figs 5, 6.

TABLE 4. The composition of the diatom associations at Station 10 on the Sundays River

	Salinity value	SUN 27 13.2.68 %	SUN 46 27.8.68 %	SUN 47 27.8.68 %	SUN 60 19.2.69 %	SUN 25 13.7.67 %	SUN 45 27.8.68 %
Achnanthes lanceolata	2	6,6	11,6	38,8	1,9	24,6	3,1
Achnanthes minutissima	1						12,8
Amphora exigua	7				7,6		
Amphora ovalis var. *affinis*	1						2,8
Amphora pediculus	1	0,8	1,4	0,9			4,0
Amphora veneta	2	2,1	9,8	7,1	0,9	4,5	3,0
Caloneis clevei	1		0,2		1,3		
Cyclotella meneghiniana	3	+	2,6	8,4	0,4	1,4	1,9
Cymbella cistula	1		2,0	0,2			
Cymbella kappii	1		1,2	+			4,4
Gomphonema parvulum	1		4,0	0,7	0,4	+	9,3
Navicula cincta var. *leptocephala*	2		1,0	2,4	12,9	1,4	
Navicula cryptocephala	3	2,3	24,7	4,4	17,9	1,8	7,0
Navicula frugalis	1					1,4	
Navicula pseudohalophila	2		3,2	0,4	0,6	5,0	
Navicula pygmaea	5				1,6		
Navicula tantula	1	1,0		0,4			
Navicula tenella	1						1,0
Navicula teneIloides	3				3,9		
Navicula twymaniana	2			+	1,1		
Nitzschia amphibia	2	+	1,8				1,0
Nitzschia denticula	2	1,7	2,0	1,8	0,6	3,6	17,8
Nitzschia elliptica var. *alexandrina*	5	0,6			1,3	1,0	
Nitzschia fonticola	3	0,2	2,2	2,0	10,3	6,5	1,4
Nitzschia frustulum	5				1,1		
Nitzschia inconspicua	5	0,6	8,4		0,9		1,2
Nitzschia intermedia	1	2,9		1,1	3,0	1,4	
Nitzschia linearis	2	0,6	11,4	19,5	1,8	37,3	6,2
Nitzschia microcephala	2	1,0	2,2		3,7		
Nitzschia palea	2	6,4		3,8	14,9	4,5	1,9
Nitzschia perspicua	5				1,3		
Nitzschia pusilla	2	5,0	0,8		5,8	1,8	4,8
Nitzschia thermalis	3	+	0,4	1,3	+		
Rhopalodia gibba	2	63,8	0,4	0,9	0,2		
Stephanodiscus hantzschii	2						11,4
Surirella ovalis	3			2,0			
Synedra ulna	2	3,6	5,5	1,1	0,6	+	
Other species		0,8	3,2	2,8	4,0	3,6	5,0
Simpson's Diversity Index		0,42	0,11	0,21	0,06	0,21	0,08
Salinity Tolerance Index (STI)		2,00	2,52	2,14	3,18	2,10	1,77

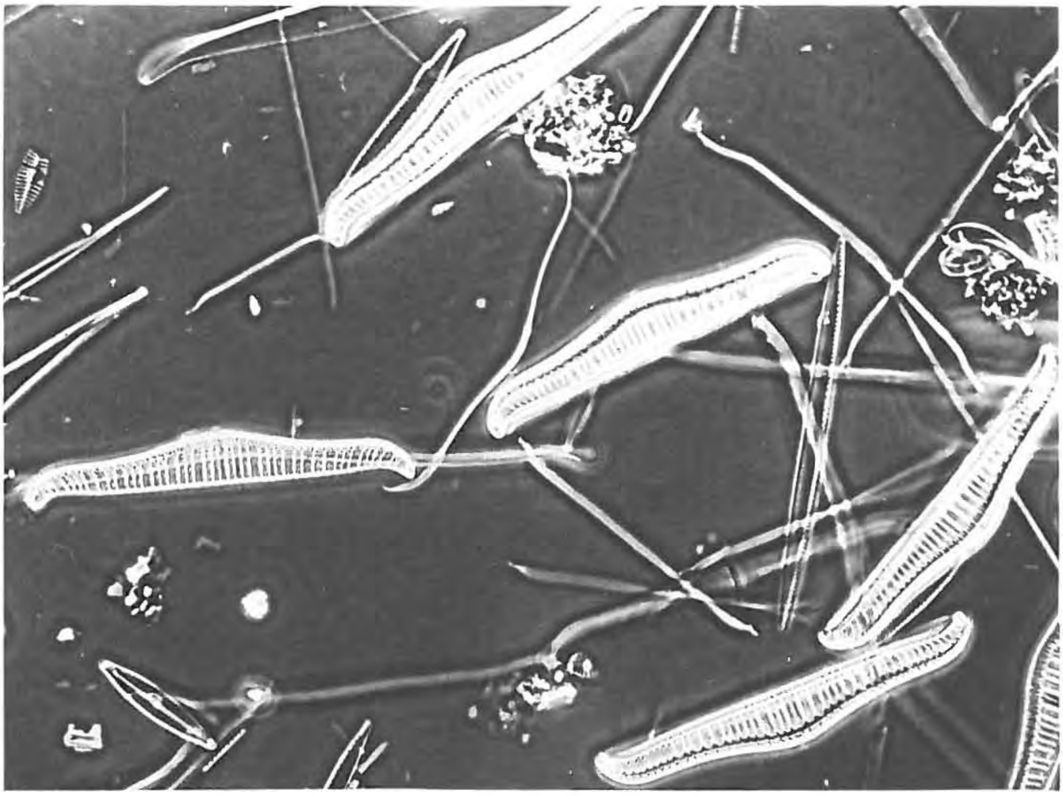


Fig. 5. Diatom association : Station 10 - SUN 27.

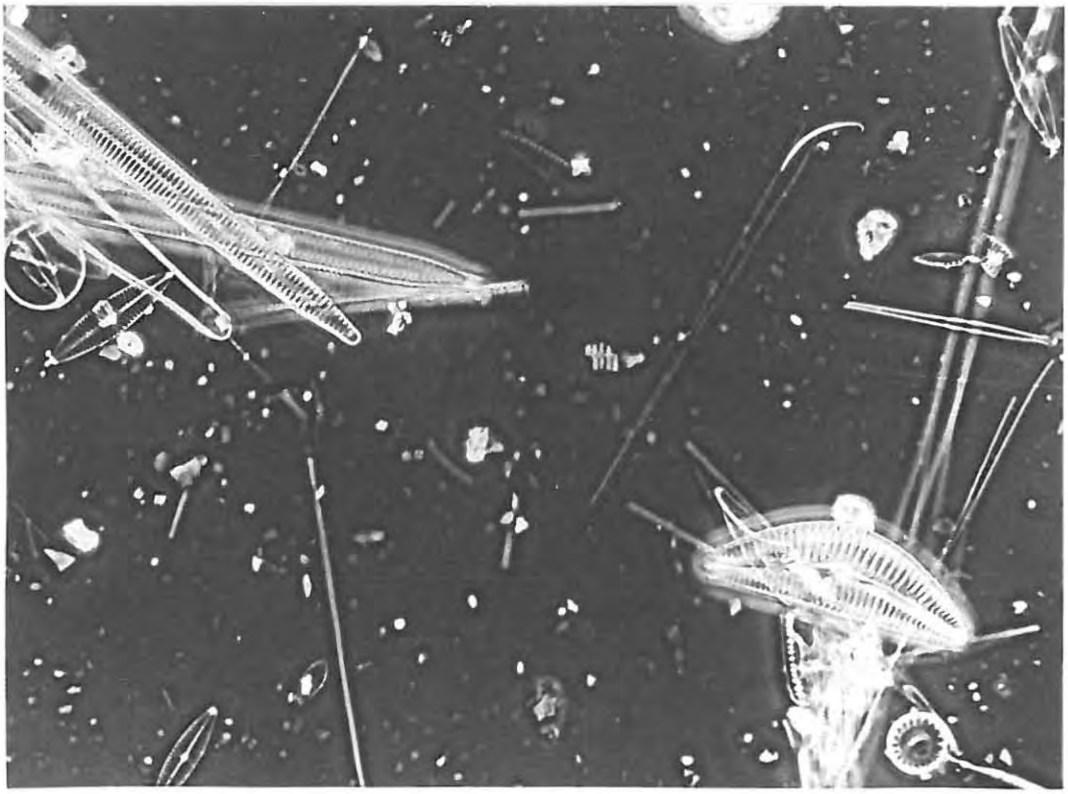


Fig. 6. Diatom association : Station 10 - SUN 46.

Characteristics of the diatom associations at Station 10:

At Station 10 proper, samples were collected on three occasions, the first in February 1968, the second in August of the same year, and the last in February 1969. Again no characteristic associations appeared to be formed at this station. Each sampling period will therefore be treated separately. In February 1968 the diatom assemblage (SUN 27 - Fig. 5), collected from a frothy algal scum in amongst aquatic vegetation in a clear stream of water, was dominated by *Rhopalodia gibba* (63,8 % of the diatom population), with *Achnanthes lanceolata, Nitzschia palea* and *N. pusilla* forming the bulk of the remainder of the population. This population, composed entirely of freshwater species (STI = 2,00), again reflected the low salinity of the water (see Table 3). All species were alkaliphilic or alkalibiontic with optima ranging between pH 7,5 - 8,5. This agreed well with the pH range experienced at this station, viz. pH 7,4 - 8,3.

In the winter of 1968 two samples were collected, one (SUN 47) from a situation similar to that of February 1968, i.e. algal scum, and the other (SUN 46 - Fig. 6) from the under side of rocks in the stream. Despite the difference in substrate the two diatom associations were similar in their composition. *Rhopalodia gibba* had virtually disappeared from the population, and the most important species were *Achnanthes lanceolata* (dominant in the algal scum), *Amphora veneta, Cyclotella meneghiniana* (more common in the algal scum), *Navicula cryptocephala* (dominant on the rocky substrate), *Nitzschia linearis* and *Synedra ulna* (more common on the rocky substrate). The diversity index values for samples SUN 46 and SUN 47 (0,11 and 0,21 respectively) indicated fairly stable ecological conditions favouring the growth of a large number of species, none of which was a great deal more abundant than the others, except for *A. lanceolata* in SUN 47. The low STI values (2,52 and 2,14 respectively) revealed the completely freshwater preferences of the species composing the two associations. This allowed the deduction that the water at Station 10 was low in dissolved solids. Once more all species were alkaliphilic-alkalibiontic, reflecting the high pH of the water.

The sample (SUN 60) collected in February 1969 was once again taken from a flaky algal scum, growing in conditions rather similar to that of February 1968. As a result of a drought no water had been found in the Sundays River above this point, but a small flow of water was found at Station 10. Apart from the absence of *Rhopalodia gibba*, the species present in the population sampled in February 1969 were essentially similar to those found in February 1968. In the former the most important species were *Navicula cincta* var. *leptocephala, Navicula cryptocephala, Nitzschia fonticola* and *N. palea*. A noteworthy change, however, was the intrusion of a number of brackish water species. These are indicated in Table 4 by salinity values greater than 5, and consist of *Amphora exigua* (see comments in section 5.4), *Navicula pygmaea, Nitzschia elliptica* var. *alexandrina* and *N. perspicua*. The presence of these brackish water species had the effect of raising the STI value of this association to 3,18. This value, nevertheless, shows that the association was still composed predominantly of freshwater species. Like the associations collected previously from Station 10, the assemblage sampled in February 1969 also reflected the high pH values of the water at this site.

Owing to a swollen river following heavy rains in July 1967, Station 10 could not be reached. Accordingly a sample (SUN 25) was collected some distance downstream of this station, and closer to Graaff-Reinet. The diatom association found here resembled reasonably closely the winter (August 1968) association found at the proper site of Station 10. *Nitzschia linearis* (37,3 % of the population) was, however, the dominant species and *Achnanthes lanceolata* codominant. Other notable species were *Amphora veneta, Navicula pseudohalophila* and *Nitzschia fonticola*. Again the low STI value (2,10) of this population indicated that it was composed entirely of freshwater species, thereby reflecting the low salinity found in the Sundays River at this point.

Finally in August 1968 a sample was collected in passing from a site on the farm Koloniesplaatz, some distance upstream from Station 10. The sample (SUN 45) was obtained from the Sundays River at the ford below the farmyards, where the river bed was covered with a litter of fallen poplar leaves and other decaying organic matter. The low Simpson's Diversity Index value of 0,08 for this association reflected a diatom population composed of a large number of species with no clear dominants. Nevertheless the most important species were *Achnanthes minutissima, Gomphonema parvulum, Nitzschia denticula, Nitzschia linearis* and *Stephanodiscus hantzschii*. Taken as a whole the association (STI = 1,77) reflected convincingly the low salinity of the waters, and its high pH level. While some elements of the association (*A. minutissima, N. denticula* and *N. linearis*) indicated well aerated water, others (*Gomphonema parvulum, Nitzschia pusilla* and *Stephanodiscus hantzschii*) suggested some interference by polluting substances, in this case probably organic wastes from the farmyard.

5.1.2 The upper course of the Sundays River above Lake Mentz

STATION 9

Description:

Station 9 was situated on the Sundays River a short distance below the town of Graaff-Reinet at the old national road bridge. The river bed was gravelly or muddy, and long threads of algae trailed in the stream. Water flow was usually fairly strong as a result mainly of the town's sewage effluent.

The chemical analyses:

TABLE 5. The chemical analyses of the river water at Station 9

	Absolute concs. mg/ℓ		Standardized values %		Ionic balance meq./ℓ			
Date	Feb. 1967	July 1967	Feb. 1967	July 1967	Feb. 1967		July 1967	
TDS (measured)	1546	574			cations	anions	cations	anions
(calculated*)	1279	563						
Na	282	144	22,0	25,6	12,3		6,3	
K	5,9	2,9	0,5	0,5	0,15		0,07	
Ca	59	34	4,6	6,0	2,9		1,7	
Mg	99	35	7,7	6,2	8,2		2,9	
CO_3	20	0	1,6	0,0		0,67		0,0
HCO_3	143	79	11,2	14,0		2,3		1,3
SO_4	270	156	21,1	27,7		5,6		3,3
Cl	400	112	31,2	20,0		11,3		3,2
					23,55	19,87	10,97	7,8

	Feb. 67	July 67	Feb. 68	Aug. 68	Feb. 69	Mean
pH	8,6	7,3 7,4	8,49	8,5	8,31	8,1
O_2 mg/ℓ	8,6	7,3				
NO_3-N mg/ℓ	1,55	2,42				
PO_4-P mg/ℓ	0,01	0,2				
Temp °C		6,3	25,8		26,0	

*See section 4.1.1.

The main physico-chemical features:

Two chemical analyses were undertaken at this station in 1967, the first in the summer (February) and the other in the winter (July). The salinity in the dry summer period was three times greater than in the following winter, i.e. 1,3 ‰ and 0,5 ‰ respectively. From a chemical point of view Station 9 was significant as there was a very marked change in the ionic composition of the river water. Bicarbonate was no longer the major anion and proportionally it fell from about 30,0 % of the salt concentration to approximately 11 % . In February 1967 chlorides (31,2 %) assumed dominance as the major ion, while sulphates (about 21 %) also formed a high percentage of the dissolved salts. In July 1967 the situation was reversed with sulphates (27,7 %) constituting the major portion of the anions. Sodium remained the chief cation, and increased percentage wise compared with previous stations. The change in ionic proportions at this station may be ascribed to the fact that somewhere just above Graaff-Reinet the Sundays River commences to flow over a series of rocks, which according to Bond (1945 : 155), produced highly mineralized chloride-sulphate underground waters. This would account for the sudden increase in the proportions of these two ions.

Analysis of the nutrient ions indicated a considerable increase in the nitrate-N concentrations, while the ortho-phosphate fraction appeared to maintain concentrations of about the same level as for the previous stations. The nitrate-N increase could be accounted for by the effluent from the Graaff-Reinet sewage works entering the river a little way above the sampling site.

The mean pH for the Sundays River at Station 9 was pH 8,1, the maximum value recorded being pH 8,6 (February 1967) and the minimum pH 7,3 (July 1967).

The composition of the diatom associations:

See Table 6, and Fig. 7.

TABLE 6. Composition of the diatom associations at Station 9 on the Sundays River

	Salinity value	SUN 24 13.7.67 %	SUN 28 13.2.68 %	SUN 48 27.8.68 %	SUN 61 19.2.69 %
Achnanthes minutissima	1			4,6	1,5
Amphiprora paludosa var. *subsalina*	5	13,2	1,6		
Amphora veneta	2	1,6	0,8	1,4	0,4
Cyclotella meneghiniana	3	12,4	3,3	0,4	1,1
Navicula cincta	3			2,8	
Navicula cincta var. *leptocephala*	2	1,6	+	5,8	10,1
Navicula cryptocephala	3	3,9	0,4	16,8	3,0
Navicula mollis	7	11,7	+		
Navicula pygmaea	5	2,7	1,3	0,6	0,2
Navicula tenelloides	3	+			1,9
Nitzschia agnita	2				5,3
Nitzschia apiculata	5	3,4		2,0	+
Nitzschia elegantula	5				1,1
Nitzschia elliptica var. *alexandrina*	5	+	2,3	0,8	0,6
Nitzschia fonticola	3	0,5	0,4	13,0	0,6
Nitzshia frustulum	5	9,2	85,9	35,2	64,9
Nitzschia hungarica	5	19,9	0,4	5,0	1,7
Nitzschia inconspicua	5	2,7		+	1,3
Nitzschia laterns	5			6,8	
Nitzschia palea	2	2,2	+	0,8	
Nitzschia sigma	6	0,5	+	1,0	0,6
Stauroneis wislouchii	5		+	0,4	3,4
Synedra fasciculata	5	8,7	+	+	0,9
Thalassiosira weissflogii	5	2,7	+		1,3
Other species		3,1	3,6	2,6	0,2
Simpson's Diversity Index		0,11	0,74	0,18	0,44
Salinity Tolerance Index (STI)		4,70	4,81	3,87	4,34

Characteristics of the diatom associations at Station 9:

Station 9 was sampled on each of the collecting trips made round the catchment of the Sundays River, and thus include two winter populations and two from the summer period. The diatom associations found in these samples are shown in Table 6. A glance at the STI values for each of these populations (3,87 - 4,81) immediately revealed a major change in their composition. These STI values indicated a predominance of euryhaline mesohalobes and pleioeuryhaline oligohalobes. *Nitzschia frustulum* (see Fig. 7), a euryhaline mesohalobe, was the dominant diatom species in the summer collections (February 1968 - 85,9 %; February 1969 - 64,9 %), while in the winter samples its dominance was reduced (August 1968 - 35,2 %) and in July 1967 it formed only 9,2 % of the population. Other euryhaline mesohalobes contributing significantly to the populations were *Amphiprora paludosa, Nitzschia hungarica* and *Synedra*

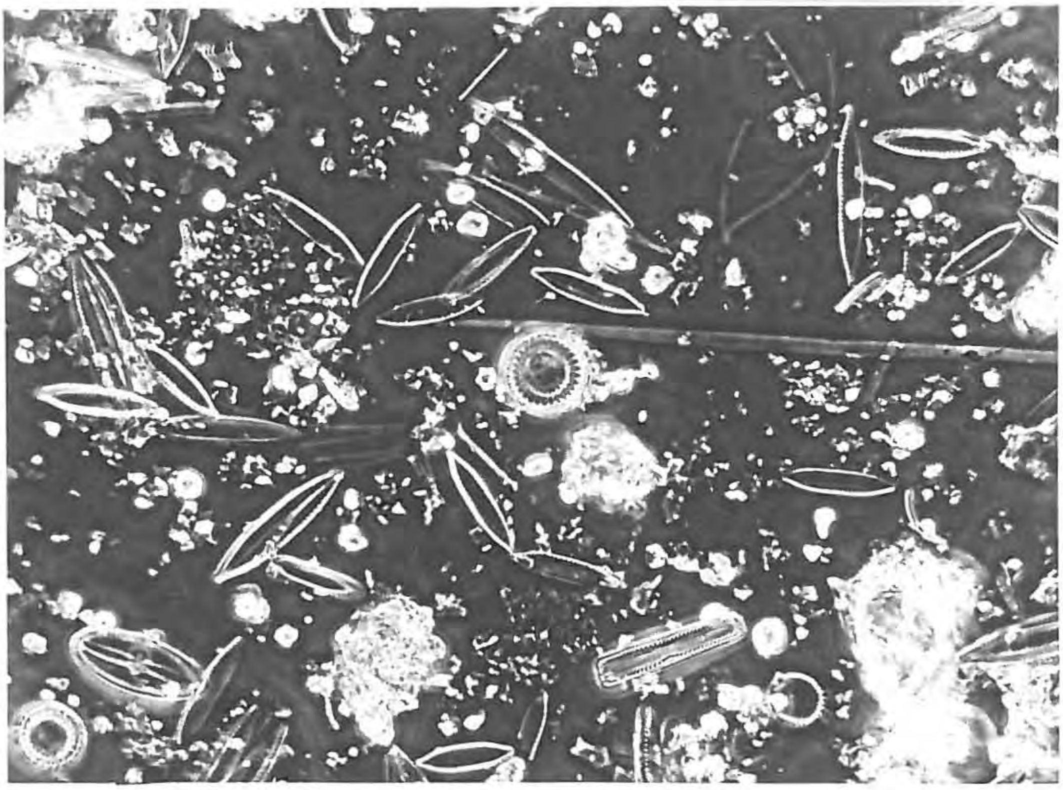


Fig. 7. Diatom association : Station 9 - SUN 28.

fasciculata, while *Navicula pygmaea, Nitzschia apiculata, Nitzschia elliptica* var. *alexandrina, Nitzschia inconspicua, Nitzschia latens* and *Thalassiosira weissflogii* made smaller contributions. Of the pleioeuryhaline oligohalobes *Cyclotella meneghiniana, Navicula cryptocephala* and *Nitzschia fonticola* were significant at various times, while *Navicula cincta* and *Navicula tenelloides* were present in smaller numbers.

True freshwater species, the meso- and meioeuryhaline oligohalobes, were found in fairly substantial numbers, mainly in August 1968 and February 1969. These species were *Achnanthes minutissima, Amphora veneta, Navicula cincta* var. *leptocephala, Nitzschia agnita* and *Nitzschia palea.*

The sudden change to predominantly brackish water associations at Station 9 may be accounted for in two ways. Although the salinity at Station 9 may not be significantly different from Station 10, a greater fluctuation in the osmotic pressure, generated by the salts in solution, would favour the development of those species that can tolerate fluctuations in the salt concentration, i.e. brackish water species. Secondly the change-over from bicarbonate dominated waters to chloride-sulphate waters may explain the change in the character of the diatom populations. Despite the changes in the species composition of the diatom associations, the high pH values recorded at this station were reflected by the alkaliphilic to alkalibiontic nature of the species in these associations.

STATION 8

Description.

This station was located just above the town of Jansenville. At this point the Sundays River has a rocky bed, thickly covered with silt. Water flow was sporadic, and the station was usually dry during drought periods.

The chemical analyses:

TABLE 7. The chemical analyses of the river water at Station 8.

	Absolute concs. mg/ℓ		Standardized values %		Ionic balance meq./ℓ			
Date	Feb. 1967	July 1967	Feb. 1967	July 1967	Feb. 1967		July 1967	
TDS (measured)	376	1238			cations	anions	cations	anions
(calculated*)	402	1401						
Na	112	353	27,8	25,2	4,9		15,3	
K	3,8	2,8	0,9	0,2	0,1		0,1	
Ca	30	75	7,4	5,4	1,5		3,8	
Mg	18	59	4,5	4,2	1,5		4,8	
CO_3	0	0	0,0	0,0		0,0		0,0
HCO_3	28	85	7,0	6,1		0,46		1,4
SO_4	90	295	22,4	21,0		1,9		6,1
Cl	120	531	29,9	37,9		3,4		15,0
					8,0	5,76	24,0	22,5

	Feb. 67	July 67	Feb. 68	Aug. 68	Feb. 69	Mean
pH	8,4	8,3	dry	9,2	dry	8,6
O_2 mg/ℓ	4,6	7,8				
NO_3-N mg/ℓ	1,97	0,02				
PO_4-P mg/ℓ	0,12	<0,01				
Temp °C		9,3				

*See section 4.1.1.

The main physico-chemical features:

Chemical analyses were again made in February and July 1967, and the results are shown in Table 7. These indicated that the salinity may vary reasonably widely during the year. On the whole the chemical composition was closely similar to that of Station 9. Bicarbonate showed a further reduction in its relative contribution to the total ionic content, while chloride became the dominant anion. Sulphates, however, still composed a substantial fraction of the anionic component. Sodium remained the major cation, showing at the same time an increase in proportion at the expense of magnesium.

The pH was measured on four occasions and showed a range between pH 8,3 to 9,2, and a mean of pH 8,6. With the exception of February 1967, nitrate-N and orthophosphate concentrations were low. At present no satisfactory explanation can be given for the relatively high nitrate-N concentration in February 1967.

The composition of the diatom associations:

See Table 8, and Fig. 8.

TABLE 8. Composition of the diatom associations at Station 8 on the Sundays River

	Salinity value	SUN 21 13.7.67 %	SUN 22 13.7.67 %	SUN 23 13.7.67 %	SUN 49 27.8.68 %
Amphiprora paludosa var. *subsalina*	5	+	5,1	20,1	
Cyclotella kuetzingiana	1	3,8	4,2	0,8	
Cyclotella meneghiniana	3	0,5	1,5	+	
Cymbella pusilla	5	+		0,4	1,4
Navicula cincta var. *leptocephala*	2	0,5	1,1	+	
Navicula cryptocephala	3	9,4	6,4	5,5	2,3
Navicula muralis	1	1,1	0,2	+	
Navicula pseudohalophila	2	0,5	1,1	+	
Navicula saprophila	1	0,5	1,7	0,8	
Nitzschia apiculata	5	9,0	16,7	25,3	1,1
Nitzschia elliptica var. *alexandrina*	5	15,5	3,8	7,1	2,5
Nitzschia fonticola	3	15,5	0,4	0,4	37,8
Nitzschia frustulum	5	0,9	1,3	0,4	2,7
Nitzschia hungarica	5	3,2	4,2	10,4	
Nitzschia inconspicua	5	3,4	1,7	0,4	29,1
Nitzschia latens	5	7,2	+	+	
Nitzschia linearis	2	+	1,3	1,8	
Nitzschia microcephala	2	+	+		20,3
Nitzschia palea	2	5,3	2,4	4,3	0,9
Nitzschia pusilla	2	1,8	2,6	0,4	
Surirella ovalis	3	1,1	0,2	0,4	
Thalassiosira pseudonana	6	11,0	41,5	17,9	
Other species		2,6	2,6	2,2	1,2
Simpson's Diversity Index		0,09	0,21	0,16	0,27
Salinity Tolerance Index (STI)		3,78	4,66	4,72	3,50

Characteristics of the diatom associations at Station 8:

Owing to a lack of water at this station in the summer months during the period of this survey, samples were collected only in the winters of 1967 and 1968. In July 1967 three small pools in the river bed were sampled. There was a minimal flow through these pools, and the diatom growth on the silty substrate was a dark brown film. Two of the pools (SUN 22 and SUN 23 - Fig. 8) were interleading. The associations found in them resembled each other closely. *Amphiprora paludosa* var. *subsalina*, *Cyclotella kuetzingiana*, *Navicula cincta* var. *leptocephala*, *Navicula cryptocephala*, *Nitzschia apiculata*, *Nitzschia elliptica* var. *alexandrina*, *Nitzschia hungarica*, *Nitzschia palea* and *Thalassiosira pseudonana* were the most prominent species. *A. paludosa* var. *subsalina* was not found in sample SUN 21, and this may be due to the rocky

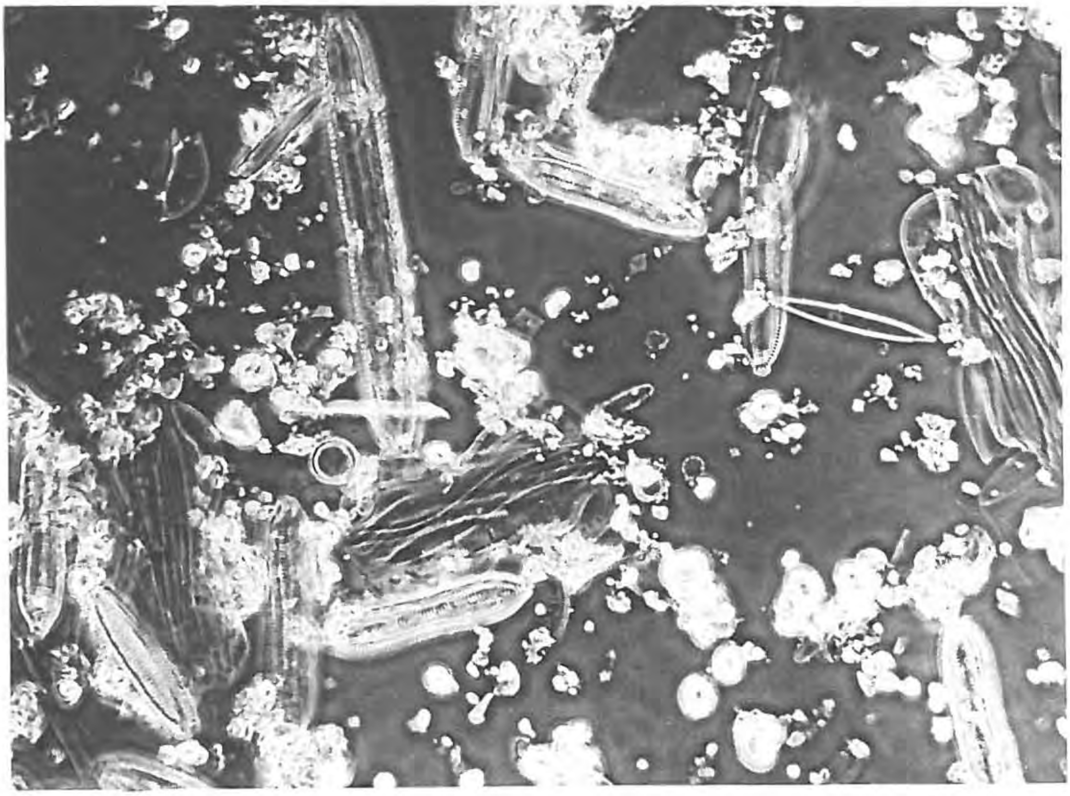


Fig. 8. Diatom association : Station 8 - SUN 23.

substrate in this pool in contrast to the more silty nature of the other two pools. The high STI values obtained for these three populations are evidence that these associations were composed predominantly of euryhaline mesohalobes and pleioeuryhaline oligohalobes. The presence of *Navicula cryptocephala*, *Navicula saprophila* and *Nitzschia palea* in sample SUN 21, and to a lesser extent in the other two samples, probably indicates some pollution of the water, as these species are regarded by Lange-Bertalot (1979 : 293) as belonging to the most pollution tolerant group of diatoms. However the greater significance of *Nitzschia apiculata* and *Nitzschia hungarica* in the associations suggest a lower degree of pollution, since they are more sensitive to pollution (cf. Lange-Bertalot l.c.).

The sample (SUN 49) collected in August 1968 was different from the July 1967 associations in terms of the relative densities of its constituent species, although the species were basically the same as those obtained in August 1967. Three species, *Nitzschia fonticola*, *Nitzschia inconspicua* and *Nitzschia microcephala*, formed the major portion (87,2 %) of the diatom population. With the exception of *Nitzschia microcephala*, the species composing this association were euryhaline mesohalobes or pleioeuryhaline oligohalobes. This was reflected by the STI value of 3,50, which indicated a preponderance of pleioeuryhaline oligohalobes. It may be deduced from the reasonably high pollution tolerances of the three major species in this association, and the relatively low occurrence of the more pollution sensitive species that the water was polluted to some small degree.

The high pH values found at Station 8 were again reflected by the fact that the species in all the associations sampled at this point can be designated as alkaliphilic to alkalibiontic.

5.1.3 The upper course of the Sundays River below Lake Mentz

STATION 7

Description:

This station was found in the mountains above Korhaans Drift. The river bed at this point is wide and stony, containing pools linked by shallow runs. This section of the Sundays River is used as an irrigation canal to carry water from Lake Mentz to the irrigation weir at Korhaans Drift. As a result water flow was variable, depending on irrigation turns, and ceased when Lake Mentz dried up in February 1968.

The chemical analyses:

TABLE 9. The chemical analyses of the river water at Station 7

	Absolute concs. mg/ℓ		Standardized values %		Ionic balance meq./ℓ			
Date	Feb. 1967	July 1967	Feb. 1967	July 1967	Feb. 1967		July 1967	
TDS (measured)	894	970			cations	anions	cations	anions
(calculated*)	908	1027						
Na	270	275	29,7	26,7	11,7		12,0	
K	11	4,4	1,2	0,4	0,3		0,1	
Ca	39	56	4,3	5,5	2,0		2,8	
Mg	36	46	4,0	4,5	3,0		3,8	
CO_3	2	0	0,3	0,0		0,1		0,0
HCO_3	95	110	10,4	10,7		1,6		1,8
SO_4	145	182	15,9	17,7		3,0		3,8
Cl	310	354	34,1	34,5		8,7		10,0
					17,0	13,4	18,7	15,6

	Feb. 67	July 67	Feb. 68	Aug. 68	Feb. 69	Mean
pH	8,5	8,6				8,55
O_2 mg/ℓ	6,8	8,9				
NO_3-N mg/ℓ	0,18	<0,02				
PO_4-P mg/ℓ	0,01	<0,01				
Temp °C		13,5				

*See section 4.1.1.

The main physico-chemical features of Station 7:

Chemical samples from this station were taken only in February and July 1967, after which Lake Mentz dried up causing water flow in the river to cease. Salinity levels were noteworthy as they showed little change in summer and winter, being 0,91 ‰ and 1,03 ‰ respectively. Chloride was the dominant anion and increased to about 34 % of the total ions in solution. Sulphate, however, showed a decrease in its relative contribution, forming about 16-17 % of the dissolved ions. On the other hand the percentage of bicarbonate was slightly higher than at Station 8. Of the cations sodium retained its dominant position, increasing still further to between 26 % and 30 % of the total ions present. Magnesium and potassium proportions were the same as at Station 8, but calcium diminished slightly.

pH measurements at Station 7 in February 1967 (pH 8,5) and July 1967 (pH 8,6) indicated a highly alkaline aquatic environment. The plant nutrient ions, nitrate-N and orthophosphate, were low in concentration.

The composition of the diatom associations at Station 7:

See Table 10.

TABLE 10. The composition of the diatom associations at Station 7 on the Sundays River

	Salinity value	SUN 18 12.7.67 %	SUN 19 12.7.67 %
Achnanthes engelbrechtii	5	2,9	+
Anchnanthes hauckiana	5	1,0	+
Amphora veneta	2	1,4	+
Cyclotella caspia	5	4,1	5,6
Cyclotella meneghiniana	3	1,0	1,7
Fragilaria elliptica	2	48,6	33,6
Navicula cincta var. *leptocephala*	2	6,7	1,3
Navicula cryptocephala	3	4,3	8,2
Navicula mollis	7	+	3,5
Navicula rostellata	2	7,2	6,5
Navicula schrocteri	2	4,5	3,7
Navicula tenella	1	0,7	1,3
Nitzschia apiculata	5	7,6	5,2
Nitzschia fonticola	3	1,2	10,0
Nitzschia inconspicua	5	2,4	11,1
Nitzschia palea	2	1,4	1,3
Stephanodiscus hantzchii	2		2,6
Surirella ovalis	3	2,1	0,2
Surirella ovata	2	1,0	2,2
Other species		1,7	2,0
Simpson's Diversity Index		0,26	0,15
Salinity Tolerance Index (STI)		2,63	3,03

Characteristics of the diatom associations at Station 7.

Partly on account of the lack of water in later periods of this survey, and partly due to the difficulty of access to this sampling point, the diatom community at this station was only sampled in July 1967. At this time two samples were collected, one from rocks and submerged logs in a large pool above a drift crossing the river (SUN 18), and the other (SUN 19) from rocks in a stony run below the drift.

It is clear from Table 10 that, apart from minor differences, the diatom associations from the two sites parallel each other closely. Both were dominated by the mesoeuryhaline oligohalobe, *Fragilaria elliptica*, while the other prominent species common to both samples were *Cyclotella caspia*, *Navicula cincta* var. *leptocephala*, *Navicula rostellata*, *Navicula schroeteri*, *Nitzschia apiculata*, *Nitzschia fonticola* and *Nitzschia inconspicua*. Although dominated by a mesoeuryhaline oligohalobic species, the presence of a large proportion of the population constituted by pleioeuryhaline oligohalobes and euryhaline mesohalobes was reflected by the STI values of the two samples. These were or approached a value of 3,0. Thus the diatom associations indicated a generally freshwater environment, although one with a slightly raised salt content. The basically freshwater nature of the species in these assemblages suggest, furthermore, that the salinity maintained a constant level.

The small variations in the composition of the associations in these two samples were probably the result of differences in ecological niche rather than chemical changes, since the short distance between the two sites make the latter possibility somewhat remote.

If the associations found at Station 7 are compared with those of the previous two stations, it is clear that once again there has been a marked change in the nature of the community. Instead of basically brackish water associations, the Station 7 diatom populations were composed mainly of oligohalobic species. This is difficult to explain on the grounds of salinity. The salinity level of Station 7 (0,91 - 1,03 ‰) falls within the range observed at Stations 8 and 9 (0,4 - 1,55 ‰). A possible explanation is that at Stations 8 and 9 the salinity fluctuated relatively widely, while the salt content at Station 7 remained at a fairly constant level.

As at all previous stations the high pH of the water at Station 7 was reflected by the constituent species, which were alkaliphilic-alkalibiontic in nature.

STATION 6

Description:

Station 6 is found at the irrigation weir at Korhaans Drift, where the Sundays River emerges from the Suurberg mountains. The sampling site consisted of a large grass banked pool receiving water from seepages from the weir wall. From this pool the water drains into the river bed through a stony run. Diatoms were collected from four different ecological niches in this system:-

(a) from the substrate on or amongst the stones of the stony run,

(b) from the substrate along the margins of the large pool, i.e. the silty bottom and rocks,

(c) the epiphytic diatom growth on reeds growing in the large pool,

(d) diatom growth around the seepage holes in the weir wall.

The chemical analyses:

TABLE 11. The chemical analyses of the river water at Station 6.

	Absolute concs. mg/ℓ			Standardized values %			Ionic balance meq./ℓ					
Date	Feb. 67	July 67	Feb. 68	July 67	Feb. 68		Feb. 67		July 67		Feb. 68	
TDS (measured)	872	708	822				cations	anions	cations	anions	cations	anions
(calculated*)	918	998	829									
Na	290	210	200	31,6	21,0	24,0	12,6		9,1		8,7	
K	10	4	13	1,1	0,4	1,6	0,3		0,1		0,3	
Ca	54	56	50	5,9	5,6	6,0	2,7		2,8		2,5	
Mg	39	33	45	4,3	3,3	5,4	3,2		2,7		3,7	
CO_3	3,6	0	12	0,4	0,0	1,4		0,1		0,0		0,4
HCO_3	111	122	140	12,1	12,2	16,8		1,8		2,0		2,3
SO_4	130	330	74	14,2	33,1	8,9		2,7		6,9		1,5
Cl	280	243	295	30,5	24,3	35,4		7,9		6,9		8,3
							18,8	12,5	14,7	15,8	15,2	12,5

	Feb. 67	July 67	Feb. 68	Aug. 68	Feb. 69	May 70	Mean
pH	8,4	8,8	8,2	7,5	8,7	8,8	8,4
				8,0		9,15	
O_2 mg/ℓ	8,2	8,6					
NO_3-N mg/ℓ	0,88	0,12					
PO_4-P mg/ℓ	0,01	0,01					
Temp °C		11,5	23,2		30,0	14,0	

*See section 4.1.1.

The main physico-chemical features:

At this and most of the remaining downstream stations three chemical analyses were made during the period of the survey. Analyses were undertaken in February and July 1967 and in February 1968. The results of these three analyses, seen in Table 11, showed that the salinity (0,83 -1,0 ‰) remained fairly constant despite seasonal changes. This constancy, however, did not appear to apply to the ionic composition. Sulphates (14,2 % in February 1967) fluctuated most widely, increasing 2,3 fold in July 1967 and dropping again in February 1968 by a factor of 3,7. Forbes and Allanson (1970 : 483) were unable to explain this wide fluctuation. Chlorides appeared to have behaved in a fashion complementary to the sulphates, falling when the sulphates rise and vice versa. In the summers of 1967 and 1968 chloride was, however, the main anion. Bicarbonate proportions were more consistent over the period, although a small rise was experienced in February 1968. In contrast the cations, with the exception of sodium, were fairly constant in their relative contributions to the ionic composition of the water. Sodium continued to be the major cation, forming 31,6 % of the total ions in solution in February 1967, but decreased to 21,0 % and 24,0 % in July 1967 and February 1968 respectively.

pH values, measured on six occasions, gave a range of pH between 7,5 and 9,2, and had a mean value of pH 8,5. Nitrate-N and orthophosphate concentrations were still relatively low.

The composition of the diatom associations:

See Tables 12a-e, and Figs 9-13.

The characteristics of the diatom associations at Station 6:

The composition of the diatom associations found in each of the four ecological niches, described above, is shown in Tables 12a-e. With the exception of the community sampled from the seepage holes in the weir wall (Table 12e), the associations found at the other three niches were characterized by a very clear dominance of one species, *Fragilaria elliptica*. On most occasions in the large pool (Table 12b - Fig. 9) and in the stony run below it (Table 12a) this species formed about 90 % of the diatom population in terms of numbers of valves, while other species constitute very small proportions. As a result of this high dominance the Simpson's Diversity Index value was consistently greater or equal to 0,80. However, in July 1967 the two samples collected from these two situations did not have such a low diversity owing to greater prominence of other species, mainly members of the genus *Nitzschia*. *Navicula cryptocephala* and *Navicula rostellata* were also prominent amongst these

TABLE 12a. The composition of the diatom associations in a stony run at Station 6 on the Sundays River

	Salinity value	SUN 15 12.7.67 %	SUN 30 14.2.68 %	SUN 50 28.8.68 %	SUN 63 19.2.69 %
Cyclotella atomus	1			3,2	
Cyclotella meneghiniana	3	1,0	0,4		0,5
Fragilaria elliptica	2	52,3	89,5	91,4	89,2
Navicula accomoda	2	2,4			
Navicula cryptocephala	3	4,9	+	+	+
Navicula mollis	7	1,0	+		
Navicula rostellata	2	4,5	+		0,2
Nitzschia amphioxoides	1	1,0			
Nitzschia apiculata	5	8,2			+
Nitzschia communis	3	1,7	1,3	1,4	0,2
Nitzschia fontifuga	5	2,4	4,0		3,6
Nitzschia frequens	2	2,4	0,4	+	+
Nitzschia frustulum	5	+	1,3	+	+
Nitzschia hungarica	5	1,2	+	0,6	+
Nitzschia inconspicua	5	4,5	1,6	1,6	0,5
Nitzschia linearis	2	1,4	+	+	
Nitzschia palea	2	2,1	+	0,8	0,8
Other species		5,7	1,5	0,8	4,0
Simpson's Diversity Index		0,29	0,80	0,84	0,80
Salinity Tolerance Index (STI)		2,63	2,24	2,07	2,22

TABLE 12b. The composition of the diatom associations in a large pool at Station 6 on the Sundays River

	Salinity value	SUN 16 12.7.67 %	SUN 31 14.2.68 %	SUN 51 28.6.68 %	SUN 62 19.2.69 %
Cyclotella kuetzingiana	1	0,8	+	1,2	+
Fragilaria elliptica	2	77,2	94,3	93,6	93,2
Navicula rostellata	2	3,3		+	+
Navicula tenella	1	1,8	+	+	
Nitzschia dissipata	2	1,6			
Nitzschia fontifuga	5		2,3	+	1,7
Nitzschia frustulum	5	0,8	2,1		
Nitzschia holsatica	1	1,2		0,2	
Nitzschia inconspicua	5	5,2		0,2	0,7
Nitzschia palea	2	1,2		+	0,7
Nitzschia pusilla	2	1,9			0,7
Other species		4,5	1,3	4,8	3,0
Simpson's Diversity Index		0,60	0,89	0,88	0,87
Salinity Tolerance Index (STI)		2,23	2,14	2,02	2,08

TABLE 12c. The composition of the diatom association epiphytic on reeds in a large pool at Station 6 on the Sundays River

	Salinity value	SUN 17 12.7.67 %	SUN 32 14.2.68 %
Amphora cymbamphora	5		1,0
Cyclotella meneghiniana	3	+	1,2
Fragilaria elliptica	2	32,0	61,5
Gomphonema parvulum	1	8,3	+
Navicula cryptocephala	3	5,0	0,4
Navicula minima	1	+	6,5
Navicula mollis	7	13,5	
Navicula umpatica	5	+	1,0
Nitzschia communis	1	1,9	+
Nitzschia fonticola	3	3,9	0,6
Nitzschia fontifuga	5		9,1
Nitzschia holsatica	1	13,5	
Nitzschia inconspicua	5	11,4	7,8
Nitzschia palea	2	0,4	1,6
Nitzschia pusilla	2	1,2	2,0
Synedra fasciculata	5	2,7	
Other species		6,2	7,2
Simpson's Diversity Index		0,16	0,39
Salinity Tolerance Index (STI)		2,97	2,52

TABLE 12d. The composition of the diatom associations collected at Station 6 on the Sundays River during the severe drought in May 1970

	Salinity value	SUN 72 28.5.70 %	SUN 73 28.5.70 %
Amphora pediculus	1	+	2,6
Cyclotella kuetzingiana	1	0,5	1,5
Cyclotella meneghiniana	3	1,1	5,0
Fragilaria elliptica	2	33,2	21,6
Navicula cincta var. *leptocephala*	2	14,4	0,9
Navicula cryptocephala	3	3,8	0,9
Navicula seminulum	1		1,9
Navicula tenella	1		1,7
Navicula umpatica	5	0,7	2,2
Nitzschia apiculata	5	1,4	0,9
Nitzschia elliptica var. *alexandrina*	5	4,1	
Nitzschia fonticola	3	10,6	2,6
Nitzschia fontifuga	5	12,5	33,9
Nitzschia frequens	2	4,6	0,4
Nitzschia frustulum	5	0,7	2,6
Nitzschia hustedtiana	5	1,1	+
Nitzschia inconspicua	5		9,5
Nitzschia intermedia	1	1,4	2,4
Nitzschia palea	2	3,0	4,2
Nitzschia pusilla	2		3,2
Nitzschia thermalis	3	4,8	
Other species		2,1	2,0
Simpson's Diversity Index		0,17	0,18
Salinity Tolerance Index (STI)		2,78	3,45

TABLE 12e. The composition of the diatom associations from a seepage in the weir wall at Station 6 on the Sundays River

	Salinity value	SUN 33 14.2.68 %	SUN 52 28.8.68 %
Amphora veneta	2		1,0
Fragilaria elliptica	2	2,2	3,7
Navicula cryptocephala	3	1,4	23,3
Navicula frugalis	1	0,2	3,2
Navicula pseudohalophila	2	3,4	1,5
Nitzschia elliptica var. *alexandrina*	5	0.6	4,4
Nitzschia frustulum	5		1,5
Nitzschia intermedia	1	79,5	55,4
Nitzschia microcephala	2		2,2
Nitzschia palea	2	4,8	0,3
Nitzschia thermalis	3	5,4	0,3
Other species		2,5	3,3
Simpson's Diversity Index		0,64	0,37
Salinity Tolerance Index (STI)		1,30	1,84

minor components of the populations. In the sample scraped from the stems of reeds growing in the large pool (Table 12c - Fig. 10) the dominance of *F. elliptica* was also not as great, particularly in July 1967. At this latter date *Gomphonema parvulum, Navicula cryptocephala, Navicula mollis* and the *Nitzschia* species, *N. fonticola, N. holsatica* and *N. inconspicua* composed 55,6 % of the association, while *Navicula minima, Nitzschia fontifuga* and *Nitzschia inconspicua* composed 16,9 % of the population in February 1968. Thus there appeared to to be a greater variability in the composition of the diatom associations growing on the reed stems than those found in the large pool and stony run. Although not mentioned in the analyses reflected in Tables 12a-c, except for the sample SUN 32 (Table 12c), a species that appears to be quite characteristic of Station 6 is *Navicula umpatica*. This species occurred at no other station on the Sundays River, and though it was found in very small numbers its presence can mark a sample as deriving from Station 6. Although the diatom assemblages found in the stony run and the large pool, as well as on the reed stems, were dominated by the mesoeuryhaline oligohalobe, *F. elliptica*, a fair number of euryhaline

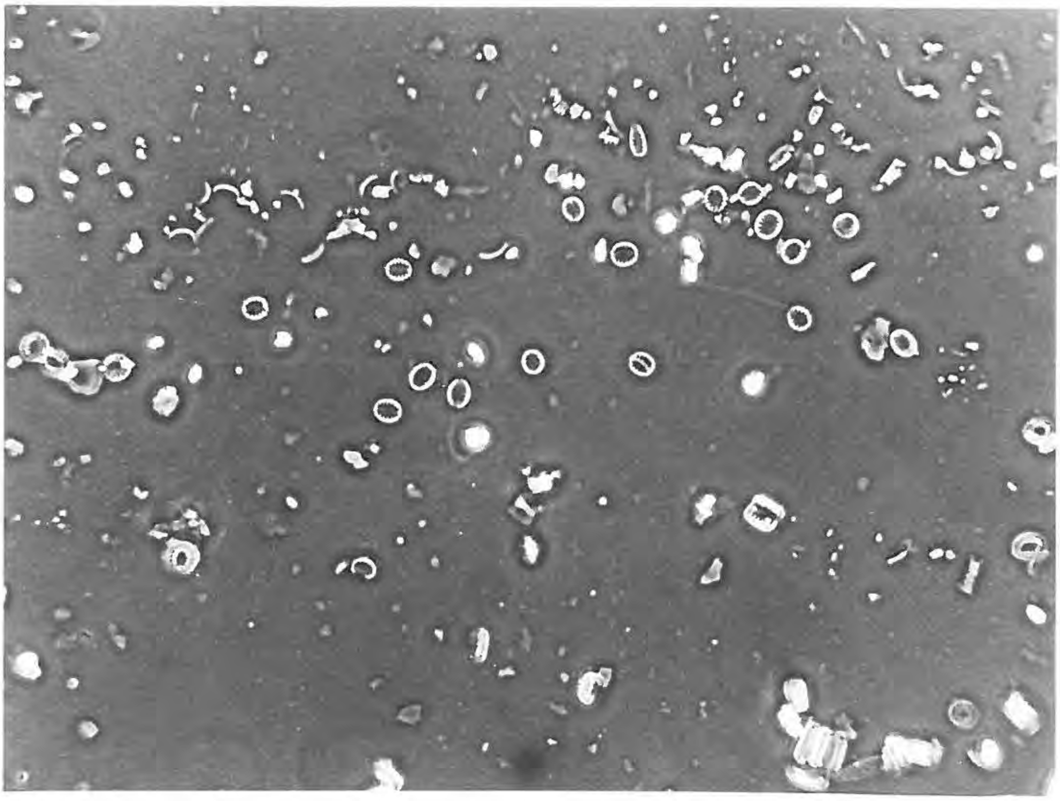


Fig. 9. Diatom association : Station 6 - SUN 51 (Large pool).

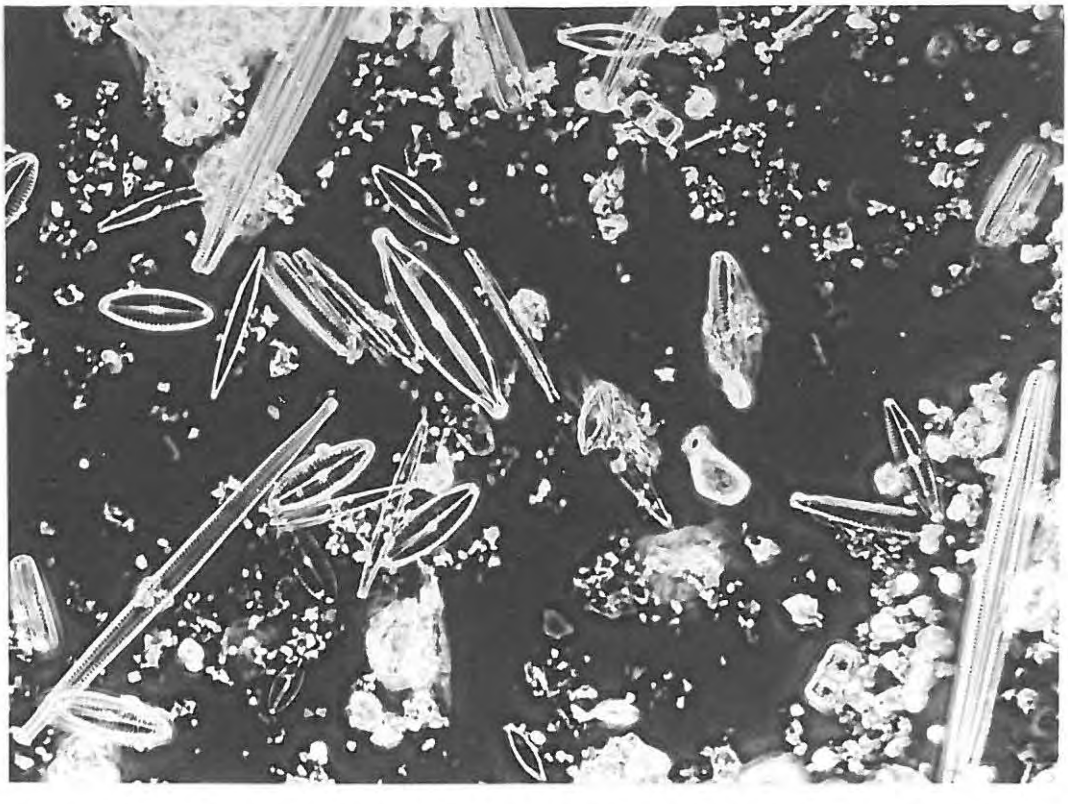


Fig. 10. Diatom association : Station 6 - SUN 17 (epiphytic).

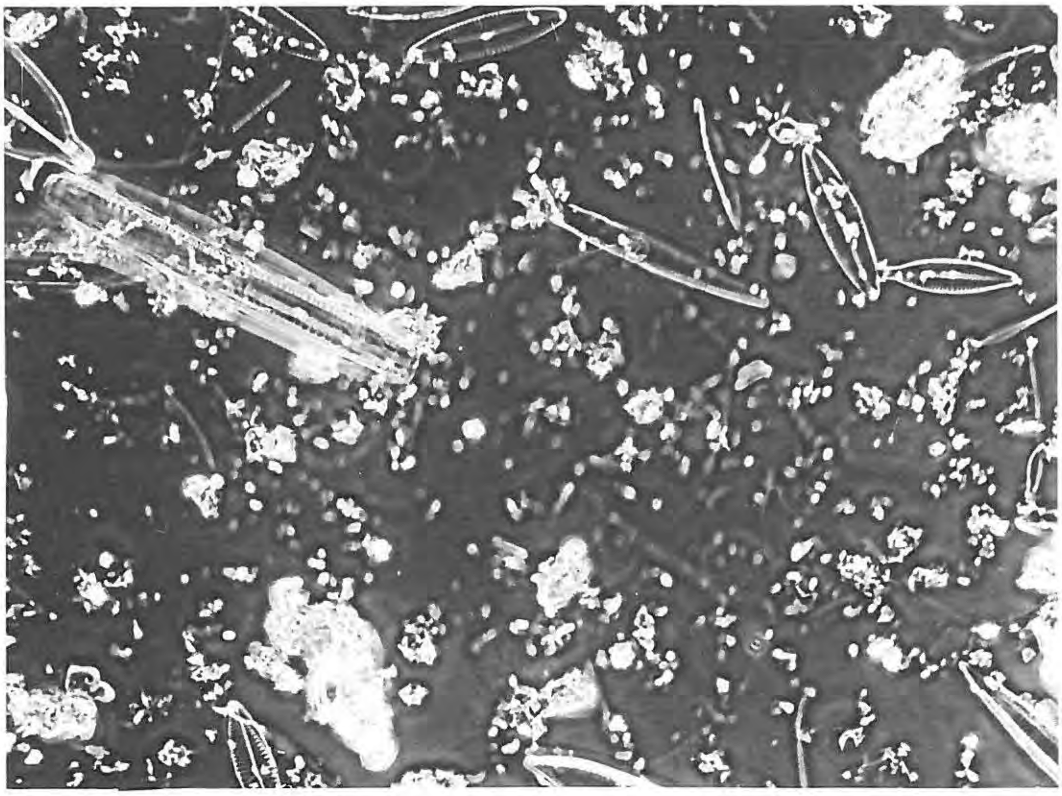


Fig. 11. Diatom association : Station 6 - SUN 72 (Large pool after drought).

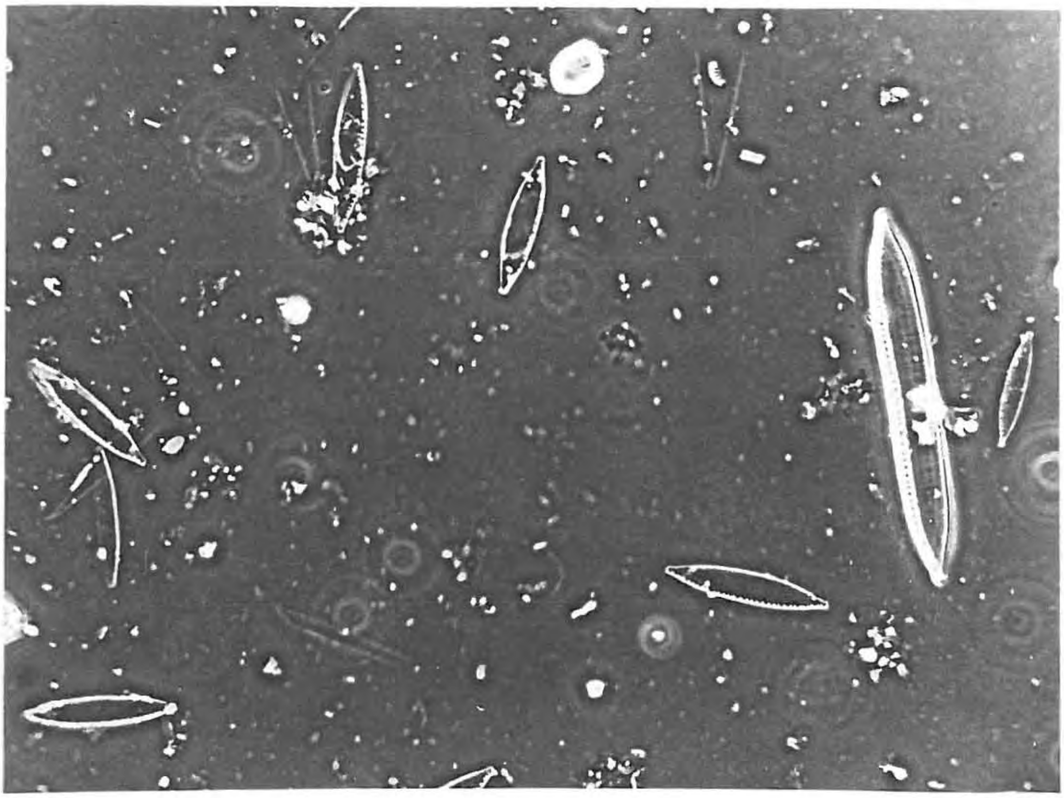


Fig. 12. Diatom association : Station 6 - SUN 33 (seepage).

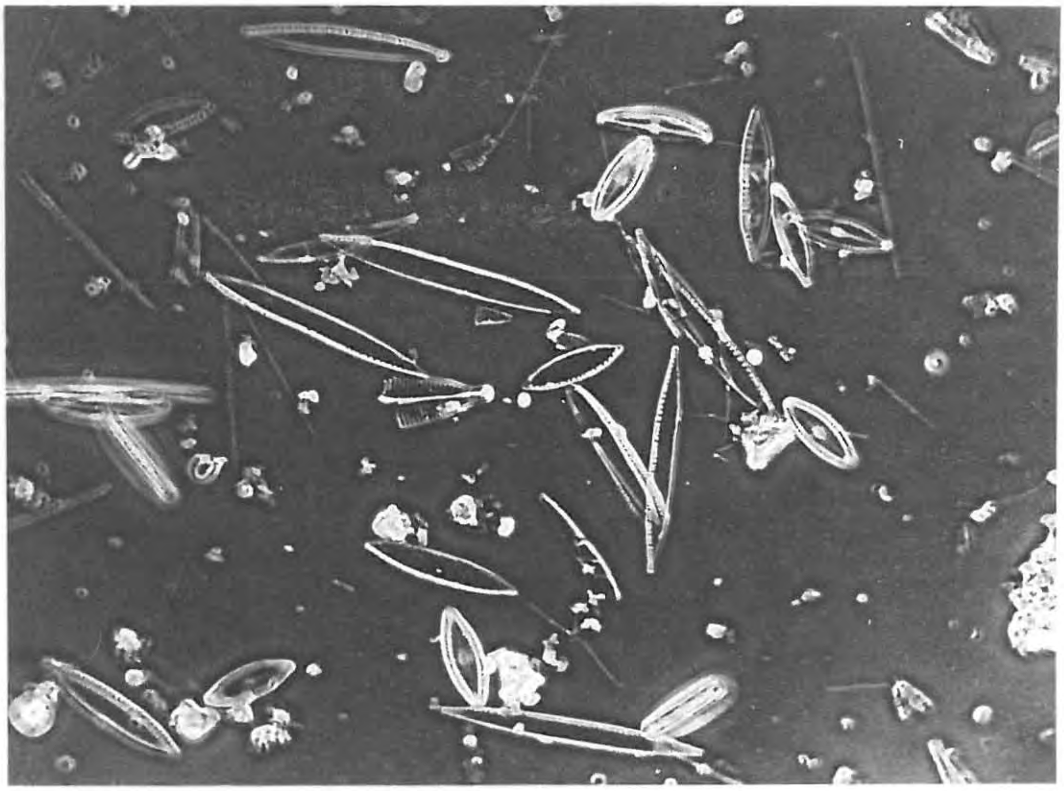


Fig. 13. Diatom association : Station 6 - SUN 52 (seepage).

media, a species not recorded in the analysis of the other samples, was the dominant diatom. In contrast *Fragilaria elliptica* formed only 2,2 % amd 3,7 % of the two populations. The two populations were undoubtedly freshwater associations, as indicated by the very low STI values (1,30 and 1,84 for SUN 33 and SUN 52 respectively), and only two euryhaline mesohalobes, *Nitzschia elliptica* var. *alexandrina* and *Nitzschia frustulum*, were present in sample SUN 52, forming 5,9 % of the population.

As in the case of all previous stations the diatom associations were composed almost entirely of alkaliphilic or alkalibiontic species, thus reflecting the high pH values obtained at this station (see Table 11).

5.1.4 The lower course of the Sundays River

STATION 5

Description:

The sampling site was located at the old causeway below the C.A. Barnes Bridge above Sunlands on the road from Addo to Kirkwood. At this point the Sundays River consisted of fairly large stony pools with a good marginal growth of mainly *Cyperus* and grasses. Apart from some Potamogetonaceae, there was little aquatic growth in the river. During late summer water flow all but ceased and the water in the pools turned very green, while the stones became encrusted with Cyanophyceae and soft calcareous material. The western bank at this site was marshy due to seepages from springs in the eroded river banks. A number of pools of variable size below these springs collected the seepage water.

Chemical samples were taken from the river itself, and from a seepage water spring on the river bank.

Diatom samples were collected from a number of different ecological niches. These are enumerated below.

(a) from the rock or concrete substrate at the old causeway,

(b) from the rocks in a stony run about 100 m below the old causeway,

(c) from a seepage water, where it trickles down the side of the bank, decline in proportions. Bicarbonate also showed a significant decrease in contrast to the carbonates, which exhibited a mean increase in their relative contribution to the ions in solution. The latter was probably due to the higher pH values to be found at this station (see below). Sodium, the most prominent cation, also showed a marked overall increase in proportion relative to Station 6. Of the minor cations, the calcium and potassium fraction was considerably reduced in proportion compared with the previous station, while magnesium appeared to maintain the same ratio as found at Station 6.

pH measurements indicated a highly alkaline environment, having a mean of pH 9,0 with a minimum of pH 8,4 and a maximum of pH 9,3. Nitrate-N concentrations increased slightly at Station 5, particularly in July 1967, possibly as a result of inflow of nitrate rich seepage waters (see discussion of the chemistry of the seepage water below). In contrast orthophosphate levels were still very low.

The composition of the diatom associations:

See Tables 14a and b, and Fig. 14.

Characteristics of the diatom associations in the river at Station 5:

Tables 14a and 14b (Fig. 14) reflect the composition of the diatom associations on rocky or concrete substrates at the old bridge crossing the Sundays River, and in the stream some 100 m below it. As the associations at these two sites parallel each other so closely, remarks concerning them can be made jointly.

A glance at the STI values for these associations immediately reveals that there has been a marked change in the assemblages from those at Station 6. The fact that the values ranged from 3,23 to 4,60, and were usually more than 4,0, indicated predominantly brackish water associations composed to a very large extent of euryhaline mesohalobes. The remaining species are mainly pleio- to mesoeuryhaline oligohalobes. According to Simonsen's (1962 : 17) classification the mesoeuryhaline oligohalobes can tolerate salinities up to 10 ‰, while the pleioeuryhaline oligohalobes can survive in salinities as much as 20 ‰. In these associations there is, however, one notable exception, *Achnanthes*

TABLE 14a. Composition of the diatom associations on a concrete or rocky substrate at the old bridge at Station 5 on the Sundays River.

	Salinity value	SUN 8	SUN 35	SUN 53	SUN 64	SUN 74
		11.7.67 %	14.2.68 %	28.8.68 %	20.2.69 %	28.5.70 %
Achnanthes engelbrechtii	5	1,9				
Achnanthes minutissima	1	5,3	4,2	27,1		0,2
Amphiprora paludosa var. *subsalina*	5	7,3		+		
Amphora acutiuscula	5		6,9		+	0,5
Amphora coffaeaformis	5	0,8				1,6
Amphora helenensis	5	1,5	1,4		1,6	0,9
Amphora luciae	5			0,2	1,3	
Anomoeoneis sphaerophora	2		+		2,9	0,7
Cocconeis engelbrechtii	5	1,9	0,2			0,5
Cyclotella atomus	1			1,4		
Cyclotella caspia	5	2,9	0,7	0,7	1,1	0,2
Cyclotella meneghiniana	3	10,2	3,6	1,2	5,4	+
Cymbella pusilla	5	0,2	0,4	1,4	15,0	0,2
Fragilaria elliptica	2	0,5	5,0	1,9	10,8	13,2
Fragilaria sundaysensis	5	46,2	37,9	25,7	44,6	32,0
Navicula cryptocephala	3	1,2	0,2		4,7	1,6
Navicula elkab	5					27,6
Navicula iranensis	5			2,6		
Navicula mollis	7	2,4			0,2	
Navicula pseudohalophila	2	1,2			0,2	
Nitzschia apiculata	5	3,2	1,1		0,2	
Nitzschia denticula	2	0,5	0,9	1,9	+	+
Nitzschia elegantula	5			16,5	1,8	0,2
Nitzschia elliptica var. *alexandrina*	5		18,4	0,7		0,5
Nitzschia fonticola	3	2,4	3,2	12,6	1,3	
Nitzschia frustulum	5	1,5	1,8	4,4	5,1	1,1
Nitzschia inconspicua	5	4,8	0,7		1,3	16,9
Nitzschia latens	5					1,4
Nitzschia palea	2	0,8	7,5	0,5	0,9	
Stauroneis wislouchii	5		1,6			
Other species		3,3	4,3	1,2	1,6	0,7
Simpson's Diversity Index		0,24	0,20	0,19	0,24	0,23
Salinity Tolerance Index (STI)		4,41	4,31	3,50	4,32	4,57

minutissima. This species has been classified in this study as a meioeuryhaline oligohalobe on account mainly of its very great abundance in very low salinity waters. Nevertheless Boye Petersen (1943 : 59) and Møller (1950 : 200) considered it to be euryhaline. This may be true, since *A. minutissima* was also found in fairly substantial numbers at Station 4 on the Sundays River in July 1967 (see Table 22), when the salinity was 2,69 ‰. Nevertheless the implication of the presence of

TABLE 14b. Composition of the diatom associations in a stony run about 100 m below the old road bridge at Station 5 on the Sundays River

	Salinity value	SUN 9 11.7.67 %	SUN 36 14.2.68 %	SUN 54 28.8.68 %	SUN 65 20.2.69 %
Achnanthes minutissima	1	17,3	1,1	37,8	0,5
Amphora acutiuscula	5		+		1,0
Amphora luciae	5			0,2	1,0
Anomoeoneis sphaerophora	2	+	+		1,5
Cocconeis engelbrechtii	5	1,3	+	+	
Cyclotella caspia	5	3,9	+		+
Cyclotella meneghiniana	3	6,9	1,7	0,2	1,9
Cymbella pusilla	5	1,6	1,3	13,7	1,9
Diploneis oblongella	5	1,3	+		+
Fragilaria elliptica	2	6,9	5,5	0,4	11,4
Fragilaria sundaysensis	5	35,9	68,6	3,6	64,2
Navicula cryptocephala	3	1,6	+	0,2	1,5
Nitzschia denticula	2	2,0	0,9	6,3	0,5
Nitzschia elegantula	5		1,3	22,0	1,7
Nitzschia elliptica var. *alexandrina*	5		7,7	0,2	
Nitzschia fonticola	3	10,8	1,9		+
Nitzschia fontifuga	5	2,0			
Nitzschia frustulum	5		4,2		
Nitzschia inconspicua	5	4,6	1,1	12,4	1,0
Nitzschia palea	2	+	2,8	0,9	2,2
Other species		3,9	1,9	2,1	2,4
Simpson's Diversity Index		0,19	0,48	0,23	0,43
Salinity Tolerance Index (STI)		3,64	4,60	3,23	4,16

this species at Station 5 with large relative densities in July 1967 and August 1968 is that the salinity of the water was sufficiently low at these times to allow a good development of this species. This good growth, together with fairly large numbers of other oligohalobes in the winter populations, with the exception of sample SUN 8, is reflected by the depressed STI values for samples SUN 9, 53 and 54.

The dominant diatom species at both these sites was *Fragilaria sundaysensis*, a new species in diatom taxonomy. This species was restricted to the lower course and estuary of the Sundays River, and appeared to reach its maximum development at Station 5 in the riverine habitat. Few other species seem to have been as constantly present in the associations. *Fragilaria elliptica*, so dominant at Station 6, was present in every sample, but seldom exceeded 10 % of the population. Contributing less to the populations, but nevertheless usually present in all samples, were the pleioeuryhaline oligohalobes, *Cyclotella meneghiniana* and *Navicula cryptocephala*, and the euryhaline mesohalobe,

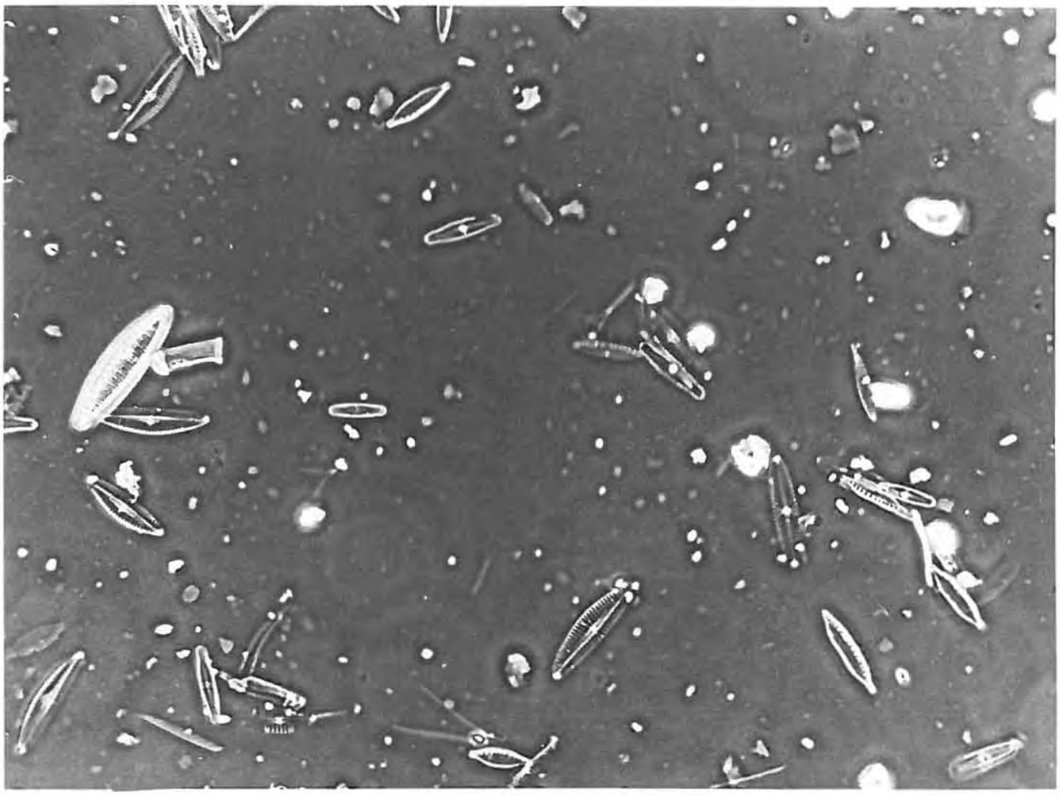


Fig. 14. Diatom association : Station 5 (100 m below bridge).

Cymbella pusilla. *Nitzschia inconspicua* was frequently recorded from both sites, and was sometimes quite abundant - 12,4 % in August 1968 (SUN 54) and 16,9 % in May 1970 (SUN 74). On the other hand *Nitzschia frustulum* was found mainly at the bridge and occurred only once at the stony run (February 1968 - 4,2 %). Two other species came to prominence on isolated occasions, viz. *Nitzschia fonticola* in the stony run in July 1967 (10,8 %) and at the bridge in August 1968 (12,6 %), while *Nitzschia elegantula* flourished in the stony run in August 1968 (22,0 %).

The association collected from the bridge site in May 1970, at the end of a long and severe drought, was unique in that it was the only occasion on which *Navicula elkab*, a species seldom recorded in South Africa, was found during the survey. It formed 27,6 % of the population and was subdominant to *Fragilaria sundaysensis* (32,0 %) in this assemblage.

The seepage water at Station 5.

TABLE 15. The chemical analyses of the seepage water at Station 5

	Absolute concs. mg/ℓ		Standardized values %		Ionic balance meq./ℓ			
Date	July 1967	Feb. 1968	July 1967	Feb. 1968	July 1967		Feb. 1968	
TDS (measured)	6612	5744			cations	anions	cations	anions
(calculated*)	7585,1	5851						
Na	2630	1900	34,7	32,5	114,4		82,6	
K	9,1	27	0,1	0,5	0,2		0,7	
Ca	118	137	1,6	2,3	5,9		6,8	
Mg	195	158	2,6	2,7	16,0		13,0	
CO_3	0	0	0,0	0,0		0,0		0,0
HCO_3	598	494	7,9	8,4		9,8		8,1
SO_4	1482	1112	19,6	19,0		30,9		23,1
Cl	2553	2023	33,7	34,6		72,0		57,1
					136,5	112,7	103,1	88,3

	Feb. 67	July 67	Feb. 68	Aug. 68	Feb. 69	May 70	Mean
pH						8,10	
						8,15	8,13
O_2 mg/ℓ		6,86					
NO_3-N mg/ℓ		45,22					
PO_4-P mg/ℓ		0,02					

* See section 4.1.1.

The main physico-chemical features of the seepage water at Station 5:

Two samples were collected from a trickle of water seeping from the banks of the river at Station 5. This seepage water runs into marshy pools of various sizes and then eventually into the river. In comparison with the river water the salinity of the seepage water (7,59 ‰) in July 1967 was a little more than four times greater. This disparity was not so obvious in February 1968, the river having a salinity of 4,6 ‰, while the seepage water was 5,85 ‰. Despite the higher salinity level in the seepage water, the ionic composition differed little from what appears to be the average condition in the river water itself. As usual the major cation was sodium, and the most important anions were sulphates and chlorides. Proportionally sulphates were slightly more than in the river, while chlorides were correspondingly less in the seepage.

Few pH measurements were made in the seepage water. Measurements taken, however, in May 1970 were slightly lower (mean pH 8,13) compared with the river (pH 9,1). The most striking difference in the chemistry of the seepage water at Station 5 was the very high nitrate-N concentration (45,22 mg/ℓ). Taken together with the increased sulphate fraction, this suggested a strong influence from agricultural fertilizers on the nature of the seepage water. Orthophosphate levels, however, appeared to have remained unaltered.

The composition of the diatom associations in the seepage water at Station 5.

See Tables 16a-c, and Figs 15-20.

Characteristics of the diatom associations of the seepage water:

It is evident from the very high STI values of the diatom associations in the seepage water trickle itself (4,84 - 4,87 : Table 16a), the pool below it (4,88 - 4,97 : Table 16b) and a larger pool further away (4,29 - 4,69 : Table 16c) that the communities were composed almost entirely of euryhaline mesohalobes. The remaining species were constituted almost exclusively from the more salinity tolerant oligohalobes, i.e. the pleioeuryhaline oligohalobes and a few mesoeuryhaline oligohalobes.

TABLE 16a. The composition of the diatom associations from a seepage trickle on the banks of the Sundays River at Station 5

	Salinity value	SUN 12 11.7.67 %	SUN 38 14.2.68 %	SUN 76 28.5.70 %
Achnanthes brevipes var. *intermedia*	5	7,5	+	+
Achnanthes engelbrechtii	5			1,3
Amphora castellata	5	14,7	2,3	
Amphora coffaeaformis	5		0,8	6,4
Amphora helenensis	5	4,0		
Amphora luciae	5	0,2	2,6	
Cymbella pusilla	5	1,3	1,4	0,2
Diploneis oblongella	2	3,8		0,7
Fragilaria elliptica	2	+		2,3
Fragilaria sundaysensis	5			5,3
Navicula cincta var. *leptocephala*	2			1,1
Navicula cryptocephala	3	0,2		5,7
Navicula cuspidata var. *ambigua*	1			1,4
Navicula salinicola	5			6,2
Navicula sydowii	7			4,5
Navicula tenera	3			2,3
Nitzschia apiculata	5	+		3,9
Nitzschia fonticola	3	3,2	7,6	3,1
Nitzschia frustulum	5			9,8
Nitzschia hungarica	5			5,5
Nitzschia inconspicua	5	60,8	77,1	29,2
Nitzschia obtusa var. *scalpelliformis*	5		7,7	
Stauroneis wislouchii	5			1,6
Surirella ovalis	3			1,6
Synedra fasciculata	5	2,8		1,3
Other species		1,5	0,5	6,7
Simpson's Diversity Index		0,44	0,61	0,12
Salinity Tolerance Index (STI)		4,84	4,84	4,87

TABLE 16b. The composition of the diatom associations in a seepage water pool below the bank at Station 5 on the Sundays River

	Salinity value	SUN 11 11.7.67 %	SUN 39 14.2.68 %
Amphiprora paludosa var. *subsalina*	5	4,0	
Amphora castellata	5	20,7	
Amphora coffaeaformis	5	12,7	93,6
Cymbella pusilla	5	1,2	+
Fragilaria sundaysensis	5	8,6	
Navicula cryptocephala	3	3,3	+
Navicula iranensis	5	25,3	
Nitzschia apiculata	5	5,2	
Nitzschia elliptica var. *alexandrina*	5	1,4	
Nitzschia fonticola	3	1,6	1,1
Nitzschia hungarica	5	2,6	
Nitzschia inconspicua	5	5,8	4,9
Pleurosigma delicatulum	5	3,8	
Other species		3,8	0,4
Simpson's Diversity Index		0,14	0,88
Salinity Tolerance Index (STI)		4,88	4,97

TABLE 16c. The composition of the diatom associations in a large pool on the river bank at Station 5 on the Sundays River

	Salinity value	SUN 10 11.7.67 %	SUN 37 14.2.68 %	SUN 66 20.2.69 %	SUN 75 28.5.70 %
Amphiprora paludosa var. *subsalina*	5	1,0			
Amphora acutiuscula	5		10,5	1,1	
Amphora castellata	5	0,3	12,5	0,7	1,3
Amphora coffaeaformis	5	31,4	18,8	20,3	24,8
Cyclotella meneghiniana	3	0,5	+	1,4	+
Fragilaria elliptica	2	1,9	3,8	6,7	7,4
Fragilaria sundaysensis	5	11,8	8,8	29,1	9,0
Navicula cryptocephala	3	17,5	0,2	2,4	3,6
Navicula iranensis	5	1,2			
Nitzschia apiculata	5	2,2	+	+	0,2
Nitzschia fonticola	3		14,6	7,5	11,0
Nitzschia frustulum	5	11,5	1,6	+	3,7
Nitzschia hungarica	5	12,7	1,0	0,5	5,9
Nitzschia inconspicua	5	3,4	26,0	20,3	18,3
Nitzschia microcephala	2			2,9	
Pleurosigma delicatulum	5	2,2	+		0,2
Synedra fasciculata	5	0,5	1,0	0,7	1,8
Other species		3,0	1,6	5,4	2,3
Simpson's Diversity Index		0,18	0,16	2,18	0,17
Salinity Tolerance Index (STI)		4,57	4,69	4,43	4,29

In July 1967 (Fig. 15) and February 1968 (Fig. 16) the associations growing in the seepage water trickle on the banks of the river were dominated by the euryhaline mesohalobe, *Nitzschia inconspicua*. This may be ascribed to the high nitrate-N concentrations, but there is little evidence to substantiate this. The only other species of importance in these two samples (Table 16a) were *Achnanthes brevipes* var. *intermedia*, *Amphora castellata*, *Nitzschia fonticola* and *Nitzschia obtusa* var. *scalpelliformis*. With the exception of *Nitzschia fonticola*, which is a pleioeuryhaline oligohalobe, all these species are euryhaline mesohalobes. In May 1970, after an extremely dry period, the salinity of the seepage water (3,86 ‰ : see Table 32) was surprisingly somewhat lower than previously measured. On this occasion the association in the seepage water trickle was different from those previously observed. Although *Nitzschia inconspicua* was still the dominant species (29,2 % of the population), the association was more evenly distributed over a larger number of species. This is shown by the low value for Simpson's Diversity Index (0,12) compared with those of the two earlier samples (0,44 and 0,61 respectively). Furthermore 18,2 % of this population was composed of pleio- or mesoeuryhaline oligohalobes.

Fig. 15. Diatom association : Station 5 - SUN 12 (Seepage trickle)

Fig. 16. Diatom association : Station 5 - SUN 38 (Seepage trickle)

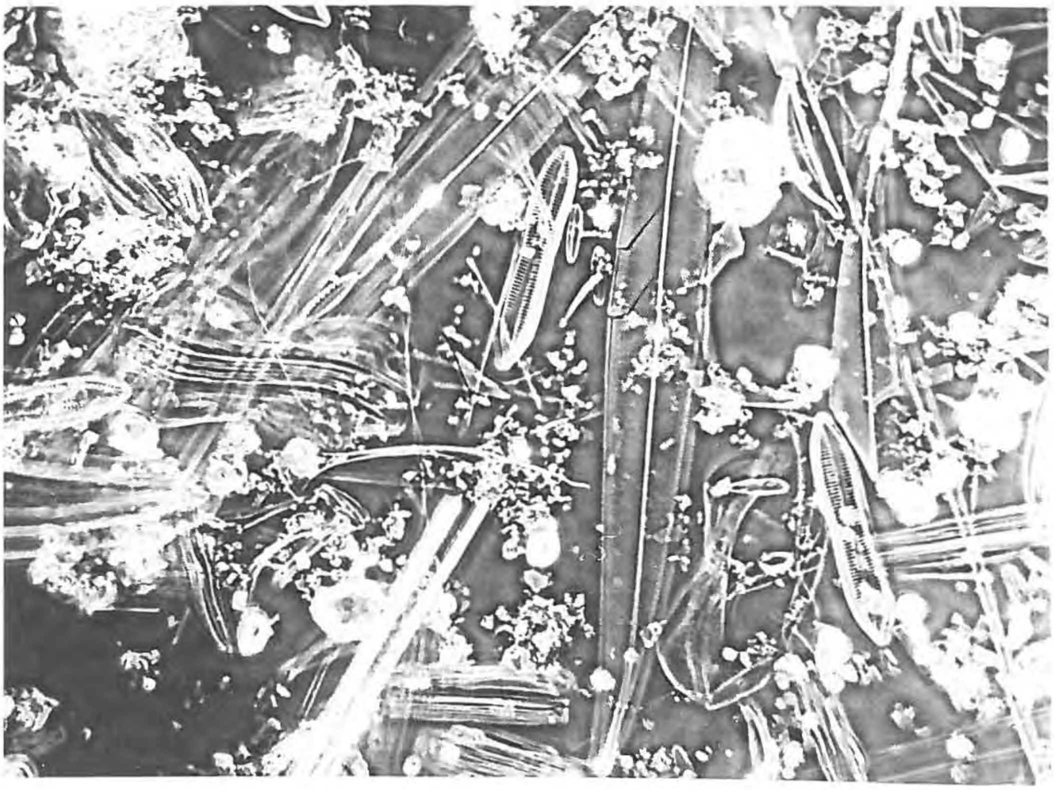


Fig. 17. Diatom associations : St. 5 - SUN 11 (seepage pool).

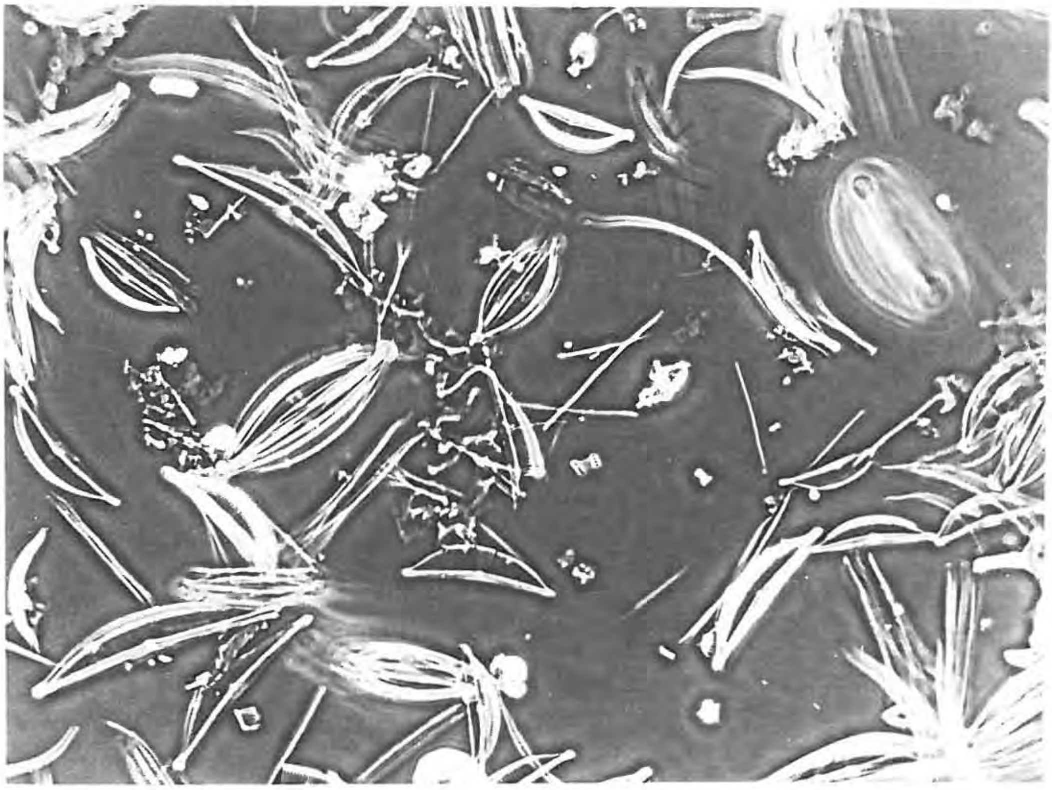


Fig. 18. Diatom association : St 5 - SUN 39 (seepage pool).

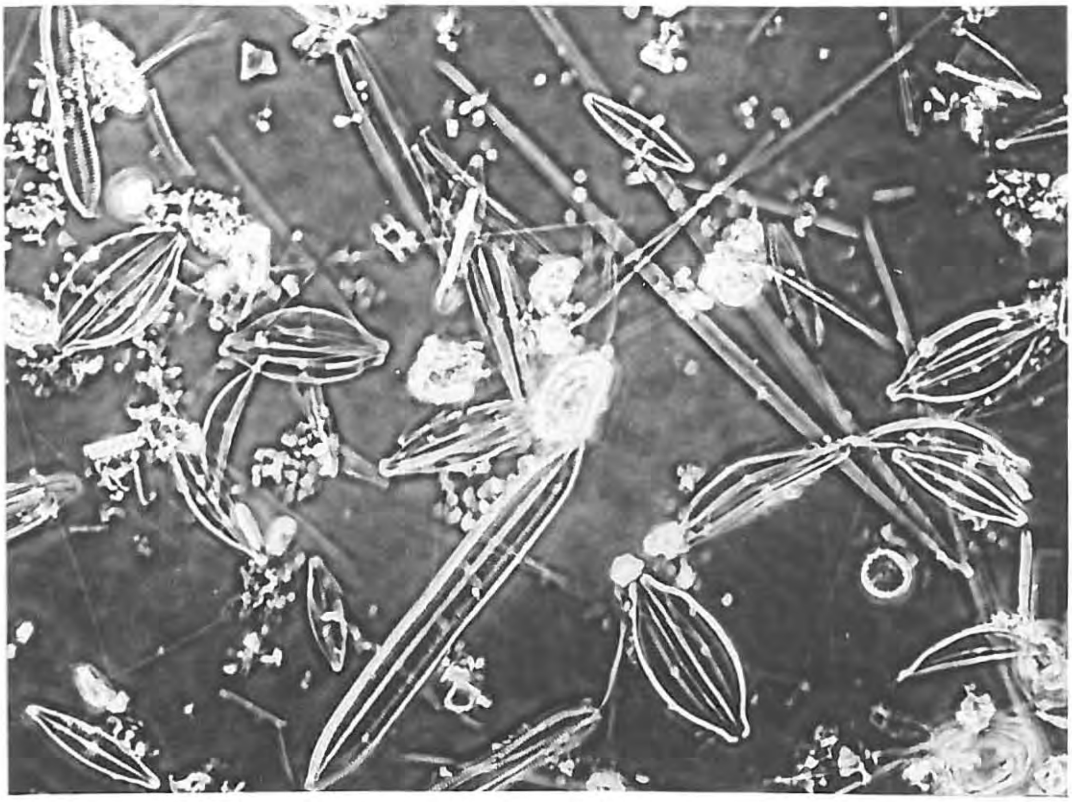


Fig. 19. Diatom association : St. 5 - SUN 10 (Large pool).

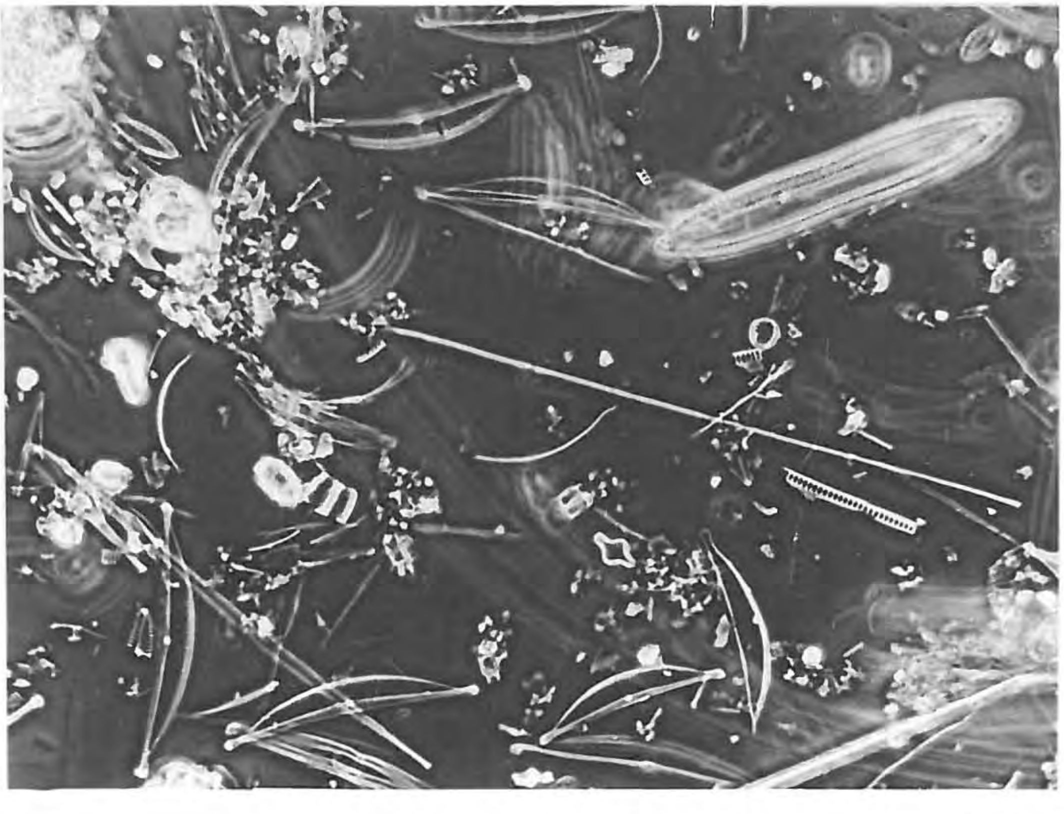


Fig. 20. Diatom association : St. 5 - SUN 37 (Large pool).

Two diatom samples were taken from the seepage water pool below the actual spring, one in July 1967 (SUN 11, Fig. 17) and the other in February 1968 (SUN 39, Fig. 18). In the first of these there was a more or less even distribution of individuals amongst about 13 species, *Amphora castellata* (20,7 %) and *Navicula iranensis* (25,3 %) being the most prominent species. The latter species was recorded here, as far as can be discerned, for the first time outside its type locality of "Tscheschmeh kormouh" in Iran (Hustedt, 1961-66 : 262). Its presence in this brackish water supports the contention that it is a euryhaline mesohalobe. In the later sample (February 1968) the character of the association was completely different. *Amphora coffaeaformis* was the absolute dominant forming 93,6 % of the population. Only two other species, *Nitzschia fonticola* (1,1 %) and *Nitzschia inconspicua* (4,9 %) were significant. The reason for this remarkable change is not clear from the scant evidence available.

The large pool situated on the river bank and fed by a similar seepage water source had diatom associations (Figs 19, 20) clearly distinguishable from the community found in the river itself. *Amphora coffaeaformis* was either the dominant species or formed a major share of the association. Together with *Fragilaria elliptica*, *Fragilaria sundaysensis*, *Navicula cryptocephala*, *Nitzschia frustulum*, *Nitzschia hungarica* and *Nitzschia inconspicua*, it composed an association reasonably characteristic for this large pool. Other species were important at different times; thus *Nitzschia fonticola*, prominent in August 1968, February 1969 and May 1970, could also be regarded as part of the typical association for this sampling site. Two other species, closely related to *Amphora coffaeaformis*, constituted a major portion of the diatom assemblage growing in this pool in February 1968; these were *Amphora acutiuscula* (see taxonomic notes in Volume 1) and *Amphora castellata*. These associations appeared to be quite similar to the association found in the smaller pool (Table 16b) in July 1967, and therefore may be regarded as characteristic for the seepage water pools at Station 5. It is evident from the high degree of similarity between the association collected in May 1970 (Sample SUN 75 - Table 16c) and those sampled earlier that micro-ecological conditions in this large pool had not been affected much by the severe drought experienced prior to May 1970.

The main physico-chemical features of the river water:

Station 4A was a later addition to Forbes' (1968 : 14 = Station PEA) original sampling points along the Sundays River. Consequently water samples for chemical analyses were taken only in November 1967 and February 1968. The most noticeable change in the chemistry between this and the previous station was again the fairly sharp rise in the salinity. The salinity in November 1967 was 5,3 ‰, while in February 1968 it had risen to 9,39 ‰, almost twice the maximum salinity found in the river at Station 5. Chloride continued to increase its relative contribution to the salinity, forming at least 40 % of the ions in solution. Sulphate remained a significant contributor and showed a slight increase in its proportion in November 1967 (20,3 %), otherwise proportionally it was at about the same level as at Station 5 (i.e. about 16 %). The decline in the relative contribution of the carbonates and bicarbonates continued, and together they formed between 4 % and 7 % of the ions present. Sodium, the major cation, showed a small decrease in proportion in November 1967, but was otherwise the same as at the previous station. The other important cations altered little in their relative proportions compared with Station 5.

The mean pH value for seven measurements was pH 8,7, although the majority of readings were above pH 8,8. The lower mean was the result of one reading of pH 8,2 measured in August 1968. The slightly raised nitrate-N concentration of 1,36 mg/ℓ in July 1967 was probably due to the inflow of seepage water having a high nitrate-N content (see Table 19). Orthophosphates showed no increase in their concentration levels from those found at Station 5.

The composition of the diatom associations in the river at Station 4A:

See Table 18, and Fig. 21.

The characteristics of the diatom associations in the river at Station 4A:

With the exception of sample SUN 78, all the samples were collected by scraping the diatom growth from the sediment covered rocks in this part of the river. Sample SUN 78 was collected from the epiphytic growth of diatoms on the *Ruppia* plants. The diatom associations were rather similar to those of the riverine sites at Station 5. *Fragilaria sunday-*

TABLE 18. The composition of the diatom associations in the river at Station 4A on the Sundays River

	Salinity value	SUN 13 11.7.67 %	SUN 41 14.2.68 %	SUN 55 28.8.68 %	SUN 67 20.2.69 %	SUN 77 28.5.70 %	SUN 78 28.5.70 %
Achnanthes minutissima	1	10,4	0,6		0,5		
Amphiprora paludosa	5	1,6					
Amphora helenensis	5	5,3	2,3	+	0,2	0,7	3,2
Berkeleya rutilans	8				1,0	0,9	0,5
Cocconeis engelbrechtii	5	2,3	0,2	0,4	0,7	2,1	15,2
Cyclotella caspia	5	2,1	6,6	6,3	2,2	0,2	+
Cyclotella meneghiniana	3	5,8	4,0	0,6	1,0	0,9	1,1
Cymbella pusilla	5	4,9	3,2	0,9	2,2	2,5	3,0
Fragilaria elliptica	2	0,9	3,8		0,2	1,4	1,1
Fragilaria sundaysensis	5	31,6	42,5	7,8	31,6	20,0	9,7
Mastogloia aquilegiae	7					1,2	0,2
Mastogloia elliptica var. *dansei*	5		+	+	1,2	+	
Navicula bulnheimii	5		+	+		3,0	0,7
Navicula cryptocephala	3	1,2		+			
Navicula diserta	7	+	+		+	+	1,4
Nitzschia apiculata	5	1,2	+				
Nitzschia denticula	2	4,2	0,8	0,2			
Nitzschia elegantula	5	5,6	3,5	14,7	2,7	4,6	2,5
Nitzschia elliptica var. *alexandrina*	5		0,8		2,2	3,2	4,4
Nitzschia fonticola	3	5,9	+	+	0,7		
Nitzschia fontifuga	5						5,0
Nitzschia inconspicua	5	5,8	17,9	68,9	39,3	46,1	35,2
Nitzschia palea	2	1,6					
Nitzschia pubens	5		11,0		13,6	8,5	11,3
Rhopalodia gibberula	5		+	+	+	+	1,1
Synedra hartii	5	0,5				+	1,4
Other species		5,0	2,8	0,2	0,7	4,7	1,9
Simpson's Diversity Index		0,14	0,23	0,50	0,27	0,27	0,18
Salinity Tolerance Index)STI)		4,11	4,77	4,73	4,97	4,95	4,97

sensis and *Nitzschia inconspicua* were the most conspicuous species composing 37-77 % of the community. In July 1967 and February 1968 *Fragilaria sundaysensis* was the dominant species, but on subsequent occasions *Nitzschia inconspicua* assumed this role. Other species that appeared to form a more or less characteristic assemblage for this station were *Cyclotella caspia*, *Cyclotella meneghiniana*, *Cymbella pusilla* and *Nitzschia elegantula*. These species composed the greater part of the rest of the association. *Nitzschia elliptica* var. *alexandrina* and *Nitzschia pubens* seemed to be present only in winter or when the salinity was appreciably higher, as was the case in May 1970 at the end of a severe drought (see samples SUN 77 and SUN 78).

The STI values for these samples were all high, and, with the exception of SUN 13 (4,11), approached a value of 5,0. This indicated very clearly that almost the entire association of diatoms collected at this

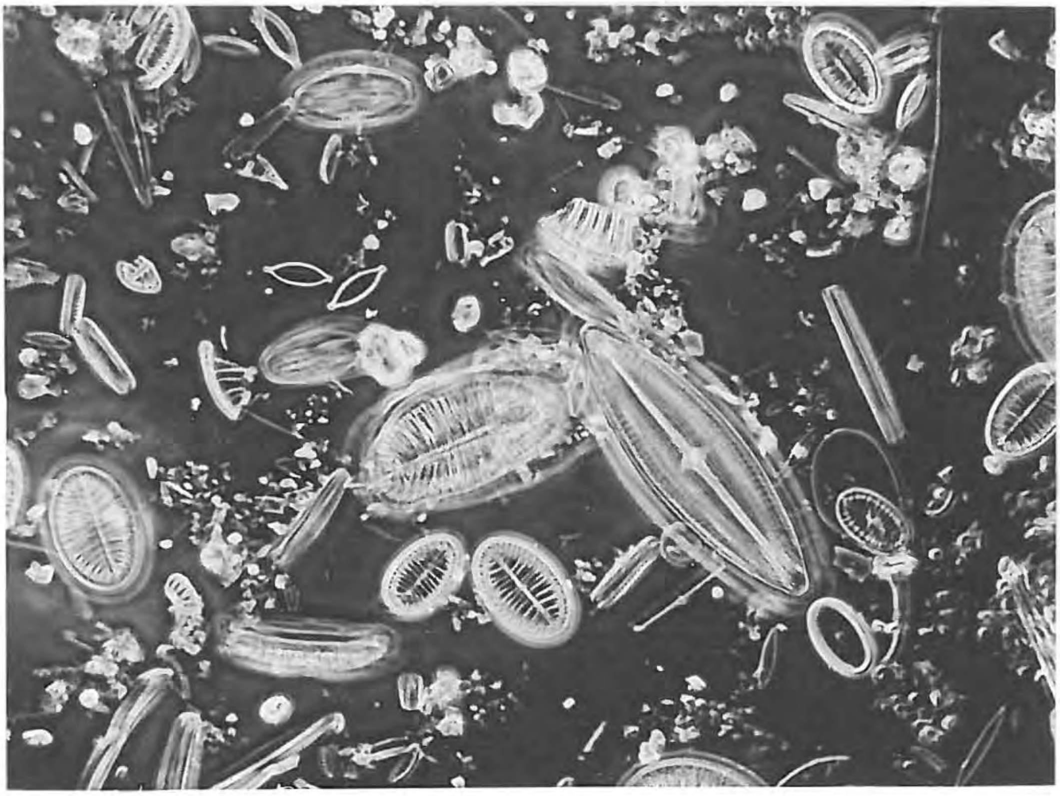


Fig. 21. Diatom association : St. 4A - SUN 78 (epiphytic).

station was composed of euryhaline mesohalobes. In July 1967 (SUN 13) the association contained an appreciable fraction of oligohalobes, although these were mainly pleio- or mesoeuryhaline in nature. Thus *Cyclotella meneghiniana, Fragilaria elliptica, Navicula cryptocephala, Nitzschia denticula, Nitzschia fonticola* and *Nitzschia palea*, forming 19,6 % of the population, indicated that the salinity in July 1967 was relatively low. This inference is strongly reinforced by the fact that, in addition to these more tolerant species, 10,4 % of the association of July 1967 was composed of *Achnanthes minutissima*, a meioeuryhaline oligohalobe.

At the end of a long and extreme drought two samples were collected from the river in May 1970. The first (SUN 77), from the stones, was quite characteristic, and showed that the much higher salinity of 12,34 ‰ (see Table 32 below) measured at this time, had little effect on the diatom population in terms of species present. In the other sample (SUN 78 - Fig. 21), the epiphytic growth on *Ruppia*, the composition of the association was basically the same as the stone assemblage, but showed an increase in the relative density of *Cocconeis engelbrechtii*. The genus *Cocconeis* is well known for its epiphytic species; consequently the relatively high abundance of *C. engelbrechtii* as an epiphyte is not surprising. Because of its abundance here and at stations lower down the river where the salinity is high, *Cocconeis engelbrechtii* has been designated a euryhaline mesohalobe.

The seepage water at Station 4A:

On the east bank of the Sundays River at this point a large pool on a clay terrace about 2,0 m above the river bed collected water from seepages in the 6 - 10 m high vertical river bank above the terrace. From this pool the overflow water ran through a very narrow channel over the terrace edge and into the river. Water samples were taken from the pool, while diatoms were gathered from the channel where they formed an orange to brown skin-like lining to the channel.

The chemical analyses of the seepage water at Station 4A:

TABLE 19. The chemical analyses of the Seepage water at Station 4A

	Absolute concs. mg/ℓ		Standardized values %		Ionic balance meq./ℓ			
Date	Nov. 67	Feb. 68	Nov. 67	Feb. 68	Nov. 67		Feb. 68	
TDS (measured)	25910	28406			cations	anions	cations	anions
(calculated*)	22544	28453						
Na	6700	8400	29,7	29,5	291,3		365,3	
K	43	71	0,2	0,2	1,1		1,8	
Ca	381	447	1,7	1,6	19,0		22,3	
Mg	1220	1289	5,4	4,5	100,3		106,0	
CO_3	0	42	0,0	0,2		0,0		1,4
HCO_3	256	153	1,1	0,5		4,2		2,5
SO_4	2591	3029	11,5	10,6		53,9		63,1
Cl	11353	15022	50,4	52,8		320,2		423,6
					411,7	378,3	495,4	490,6

	Feb. 67	Nov. 67	Feb. 68	Aug. 68	Feb. 69	May 70	Mean
pH		7,5	8,74	8,3	8,15	8,45	8,23
O_2 mg/ℓ		7,2					
NO_3-N mg/ℓ		18,7					
PO_4-P mg/ℓ		0,01					

*See section 4.1.1.

The main physico-chemical features of the seepage water:

The chemical analysis of the seepage water at Station 4A differed considerably from the river in two respects. Firstly the salinity in November 1967 (22,54 ‰) was about 4,3 times greater than in the river, while in February 1968 (28,45 ‰) it was 3 fold greater. Thus there would be a very much greater osmotic pressure in the seepage water over that of the river water. Secondly there was a noticeable change in the ionic composition of the seepage water. Chloride proportions increased to form at least 50,0 % of the ions in solution, while sulphate ratios were reduced contributing only 11,0 % of the ions present. Carbonate and bicarbonate were almost negligible. Of the cations sodium contributed 30,0 % of the ions, and magnesium about 5,0 % . Potassium and calcium together formed less than 2,0 % of the dissolved ions. The ionic proportions of the seepage water approached very closely those of seawater of similar dilution level (see Figs 9-11 and Remane and Schlieper, 1971 : 322). This could be the influence of connate seawater held by the rock strata giving rise to these seepages.

pH values in the seepage water were slightly lower (mean = pH 8,2) than in the river water (mean = pH 8,7); a similar situation was found in the seepage at Station 5. In the seepage at Station 4A the nitrate-N concentration of 18,7 mg/ℓ was more than 13 times greater than the concentration (1,36 mg/ℓ) in the river. This very high concentration was similar to the situation at Station 5, and may once again be attributed to leaching of agricultural fertilizers. Orthophosphates nevertheless were still present in low concentrations.

The composition of the diatom associations in the seepage water:

See Table 20, and Fig. 22.

TABLE 20. The composition of the diatom associations in a seepage water on the bank of the Sundays River at Station 4A.

	Salinity value	SUN 14 11.7.67 %	SUN 40 14.2.68 %	SUN 56 28.8.68 %	SUN 68 20.2.69 %	SUN 79 28.5.70 %
Amphora acutiuscula	5		5,5			
Amphora castellata	5		0,3		1,0	0,8
Amphora luciae	5				1,0	
Amphora subacutiuscula	5		9,0	+		0,2
Amphora tenerrima	7		10,2	0,2		+
Cymbella pusilla	5	+	20,2	+	0,5	0,2
Navicula ammophila	5		1,0			
Navicula bulnheimii	5	97,0	18,8	93,6	51,4	95,0
Navicula sydowii	5		1,0	+		
Nitzschia elegantula	5	1,8	24,8	2,3	31,4	2,3
Nitzschia hustedtiana	5	+	3,8	0,2		
Nitzschia obtusa var. *scalpelliformis*	5	+	1,4	0,4		0,2
Nitzschia stompsii	7		0,2		1,0	+
Synedra hartii	5	0,5	1,8	+	13,3	1,1
Other species		0,7	2,0	3,3	0,7	0,2
Simpson's Diversity Index		0,94	0,16	0,83	0,38	0,90
Salinity Tolerance Index (STI)		5,01	5,22	5,01	5,02	4,99

The characteristics of the diatom associations in the seepage water:

There was always an abundant diatom growth in the channel leading the seepage water from the pools into the river. The community found in this channel proved to be quite characteristic, and appeared to have a winter and a summer aspect. The associations collected in the winter, i.e. July 1967 (Fig. 22), August 1969 and May 1970, were overwhelmingly dominated by *Navicula bulnheimii* (Simpson's Diversity values for these associations were 0,94, 0,88 and 0,90 respectively). In fact the diatom

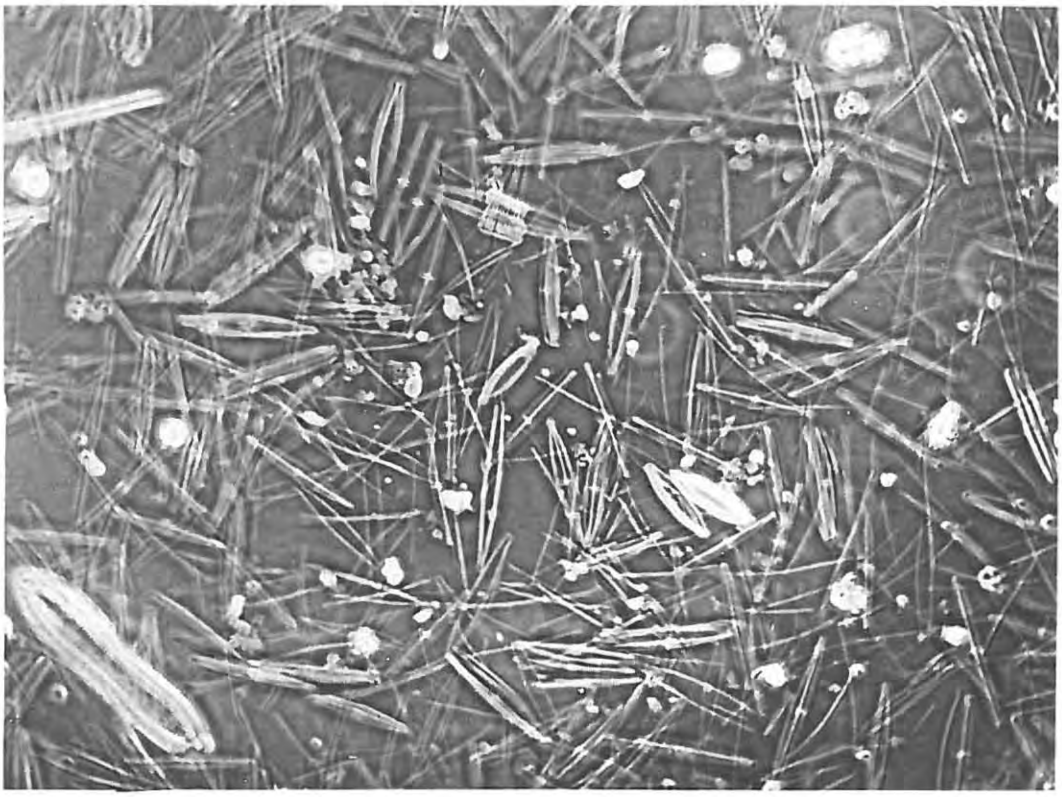


Fig. 22. Diatom association : St. 4A - SUN 14 (seepage)

The main physico-chemical features:

This station lies just above the head of the estuary, and, although the salinity (2,69 ‰ - 14,69 ‰) is relatively high, the ionic composition was appreciably different from seawater when diluted to approximately the same salinity level (see the tables of Barnes in Remane and Schlieper, 1971 : 322). The most important anion, chloride, constituted 41,6 - 48,3 % of the total ions in solution; this is somewhat lower than the ratio (52,9 - 55,0 %) observed in diluted seawater. Sulphate proportions at Station 4 (12,0 - 16,0 %) were, on the other hand, approximately double that found in seawater. Bicarbonate ratios were likewise significantly higher in the river. Of the cations in the river water at this point, only potassium seemed to be significantly different, having a much lower proportion than in diluted seawater. The chemical analysis of the major ions in solution at Station 4 appears to confirm that this sampling site is not affected by estuarine waters.

pH values for this station ranged between pH 8,3 and pH 8,9, with a mean value of pH 8,6. This suggests a well buffered, highly alkaline environment. Nitrate-N concentrations were higher here than was generally the case at most other riverine stations on the Sundays River. Orthophosphates were present, but again at very low concentrations.

The composition of the diatom associations at Station 4:

See Table 22, and Figs 23-25.

Characteristics of the diatom associations at Station 4:

Diatom samples were collected mainly from the silty substrate, although in July 1967 (SUN 7 - Fig. 23) and in May 1970 (SUN 81 - Figs 24, 25) diatoms epiphytic on the Potamogetonaceous growth were also sampled. No characteristic association or community appeared to have developed at this station. This might be due to the fact that the micro-environment was not particularly stable. This hypothesis is suggested by the high diversity of species in the populations (Simpson's Diversity Index values in these associations varied between 0,09 and 0,33) and the great variability of the species composition of the associations in terms of their dominant species and other major components.

TABLE 22. The composition of the diatom associations observed at Station 4 on the Sundays River

	Salinity value	SUN 6 11.7.67 %	SUN 7 11.7.67 %	SUN 42 14.2.68 %	SUN 57 28.8.68 %	SUN 69 20.2.69 %	SUN 80 28.5.70 %	SUN 81 28.5.70 %
Achnanthes brevipes var. *intermedia*	5						0,4	5,1
Achnanthes minutissima	1	6,4	11,9					
Achnanthes punctifera	8						0,2	3,8
Amphiprora duplex	8						2,0	1,3
Amphiprora paludosa var. *subsalina*	5	1,0	+					
Amphora acutiuscula	5		+	17,5		0,4	0,2	
Amphora costellata	5							1,3
Amphora helenensis	5	2,4	11,9	0,4	1,1	+	1,8	0,4
Amphora luciae	5				+		4,7	2,0
Amphora micrometra	7					2,6	1,3	0,9
Amphora tenerrima	7	0,5	0,6		4,4	2,2	10,2	6,0
Amphora tenuissima	7							2,7
Berkeleya rutilans	8		+	0,6	0,2	3,0	0,2	0,7
Cocconeis engelbrechtii	5	10,9	37,4	0,2	0,8	0,2	+	0,4
Cyclotella caspia	5	0,2		1,5	2,7	+	0,2	+
Cyclotella meneghiniana	3	6,7	1,0	0,6	2,7	0,2	1,1	0,2
Cymbella cahuensis	5	+	+	0,2	+		0,4	2,7
Fragilaria elliptica	2	0,5		1,5	21,0	2,0	3,1	0,7
Fragilaria sundaysensis	5	18,5	1,0	1,9	8,7	8,9	3,3	1,3
Mastogloia pumila	7	+	0,2			3,3	0,4	0,2
Navicula ammophila	5			4,7		32,3	8,0	4,7
Navicula cincta	3	0,7	1,2			+	1,3	0,7
Navicula cryptocephala	3	0,5		1,1	0,8			+
Navicula diserta	7	4,5	9,9	5,0	1,5	2,2	2,9	3,3
Navicula elginensis	2	+	+	5,0	0,8	18,8		
Navicula iranensis	5				32,8	+		
Navicula sydowii	7	+			1,3	+	22,2	9,2
Navicula tenera	3	+	+	1,3		5,2	2,0	1,3
Nitzschia agnita	2	3,0						
Nitzschia apiculata	5	15,4	+		0,4			
Nitzschia denticula	2	1,0	0,4			+		
Nitzschia elegantula	5			1,5	+	1,3	+	
Nitzschia elliptica var. *alexandrina*	5			0,9	1,3			
Nitzschia erosa	9						5,6	2,0
Nitzschia fonticula	3	6,2	0,4	+	1,5			
Nitzschia fontifuga	5			43,1	0,4	6,7	7,6	4,2
Nitzschia inconspicua	5	12,2	24,0	9,2	11,0	2,6	15,2	24,8
Nitzschia latens	5			+	1,7			
Nitzschia microcephala	2			1,3				
Nitzschia obtusa var. *scalpelliformis*	5			0,2		0,2	1,8	0,4
Nitzschia perspicua	5			0,4		2,6		
Nitzschia pusilla	2	5,0						
Pleurosigma delicatulum	5				1,3			
Rhopalodia gibberula	5	1,0	+	0,2	0,4	1,5	1,8	3,2
Stauroneis wipplingeri	5			1,1				
Synedra fasciculata	5	+	+		0,8	+	0,2	15,1
Other species		3,4	0,1	0.6	2,4	3,8	1,9	1,4
Simpson's Diversity Index		0,09	0,21	0,33	0,17	0,16	0.10	0,10
Salinity Tolerance Index (STI)		4,29	4,68	4.85	4,28	4,68	5,90	5,65

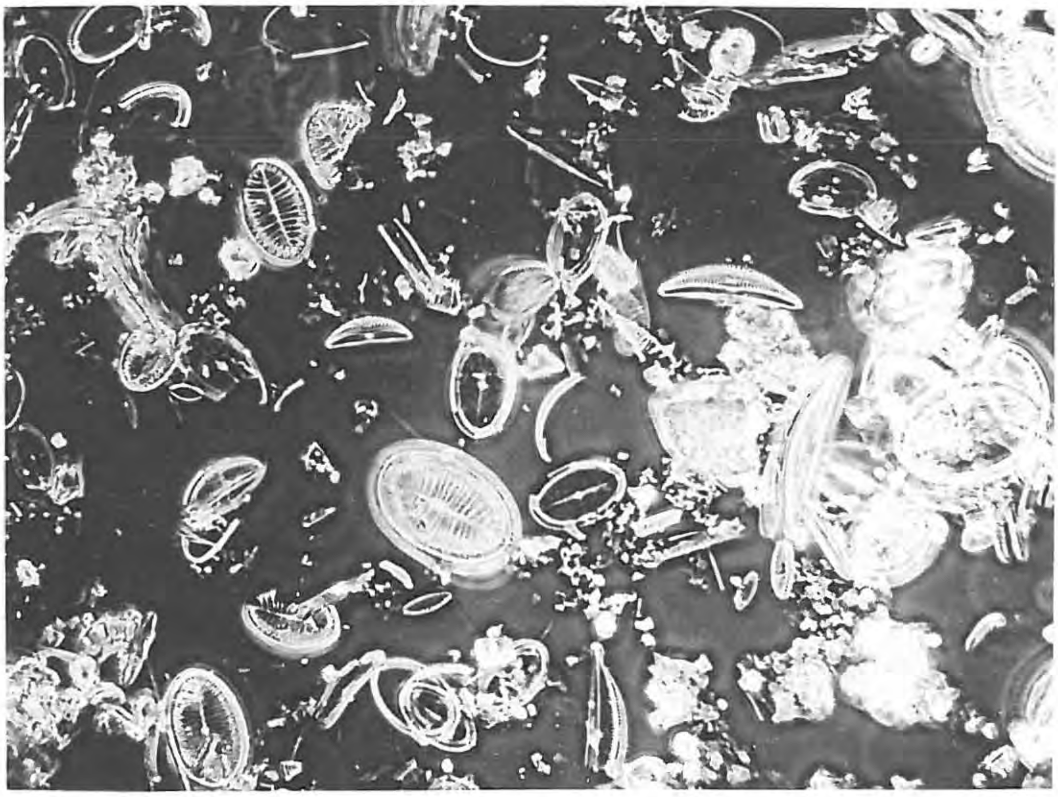


Fig. 23. Diatom association : St. 4 - SUN 7 (epiphytic).

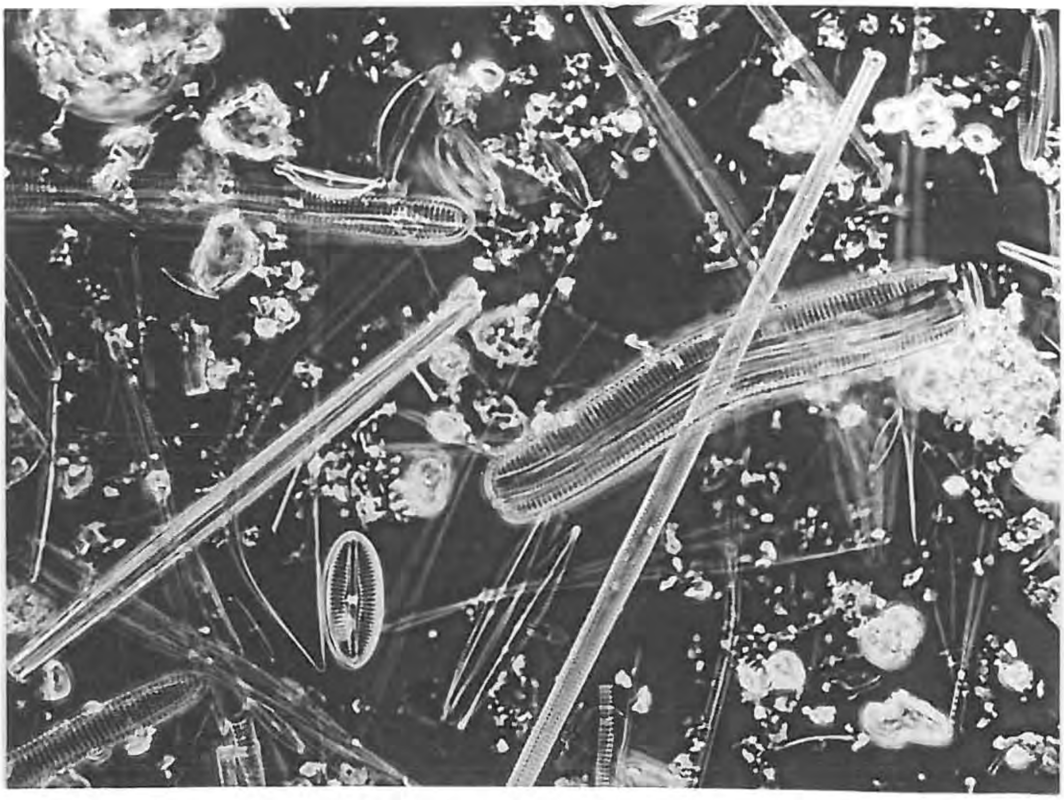


Fig. 24. Diatom association : St. 4 - SUN 81 (epiphytic).

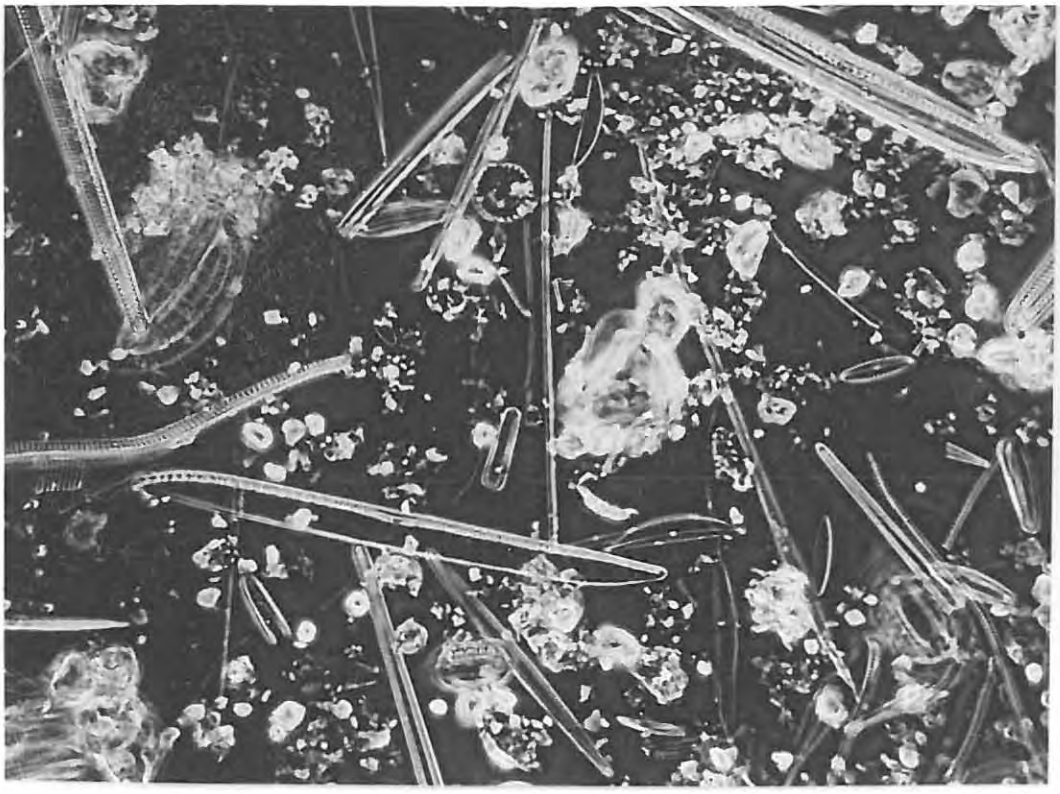


Fig. 25. The same diatom association as in Fig. 24 above.

The STI values of all the samples indicated a predominance of euryhaline species, but showed that various oligohalobic species were also sometimes significant in the associations. In May 1970 the two samples collected at the end of a long and very dry period, in which the salinity at Station 4 rose to 18,92 ‰ (see Table 32), produced associations with STI values of 5,90 and 5,65. Such high values clearly indicated the intrusion of some polyhalobic species. These are discussed below.

The most important euryhaline mesohalobes in the populations from Station 4 were *Amphora acutiuscula* - subdominant in February 1968; *Amphora helenensis* - most prominent in the epiphytic growth in July 1967; *Cocconeis engelbrechtii* - significant only in July 1967; *Fragilaria sundaysensis* - one of the most frequently occurring species in these associations, being most abundant in July 1967; *Navicula ammophila* - the dominant species in February 1969; *Navicula iranensis* - occurring only in August 1968 when it was the major species in the association; *Nitzschia apiculata* - this species was prominent only in July 1967 on the silty substrate; *Nitzschia fontifuga* - appeared first as the dominant species in February 1968 and thereafter less significantly; *Nitzschia inconspicua* - the most frequently occurring and constantly abundant species in the populations, it was the dominant species only in May 1970; *Synedra fasciculata* - prominent only in May 1970 in the epiphytic community.

As may be expected the oligohalobic species played minor roles in the communities. *Achnanthes minutissima*, was found only in July 1967, and was more prominent (11,9 %) in the epiphytic growth. *Fragilaria elliptica* and *Navicula elginensis* were the most important mesoeuryhaline oligohalobes. The former was a subdominant species in August 1968, but occurred on a number of other occasions in less significant numbers. *Navicula elginensis* was subdominant in February 1969 (18,8 %), and formed 5,0 % of the associations in February 1968. Surprisingly the pleioeuryhaline oligohalobes were less important in these associations with only *Cyclotella meneghiniana* being consistently present in the samples, albeit in small numbers. *Nitzschia fonticola* was significant only in July 1967.

The polyhalobic species were generally most prevalent in May 1970, when, owing to the drought, salinities were higher than normal. Nevertheless *Navicula diserta*, a pleioeuryhaline polyhalobe, was present in every sample; *Amphora tenerrima* was also common, but was most prominent in May 1970. Other pleioeuryhaline polyhalobes, such as *Amphora micrometra, Amphora tenuissima, Matogloia pumila* occurred sporadically. *Navicula sydowii* was one of the most important species in the two samples collected in May 1970. Two mesoeuryhaline polyhalobes, *Achnanthes punctifera* and *Amphiprora duplex* were present in small numbers only in May 1970, while *Berkeleya rutilans* occurred frequently in small numbers. *Nitzschia erosa*, considered in this study as a meioeuryhaline polyhalobe, was similarly found only in May 1970. The presence of these polyhalobes does not necessarily mean seawater influence at Station 4. These species are nevertheless marine forms that can invade inland brackish waters. They therefore suggested salinity levels sufficiently high to allow them to survive.

Finally the two epiphytic populations collected in July 1967 (Fig. 23) and May 1970 (Figs 24, 25) were slightly different from their silt substrate counterparts. In the first place, *Cocconeis engelbrechtii* was conspicuously more abundant as an epiphyte in the July 1967 sample. This is to be expected as the genus *Cocconeis* is well known for its epiphytic species. Secondly *Nitzschia inconspicua* appeared to be relatively more abundant in both the epiphytic associations. Whether this has any significance is not clear, as the same species occurred in greater abundances at other stations where no epiphytic growth occurred. On the other hand at Station 6 *Nitzschia inconspicua* was also apparently more abundant on the stems of reeds in the large pool examined. There were no other marked changes in the epiphytic associations compared with those from the silt substrate.

5.1.5 The estuary of the Sundays River

STATION 3

Description:

This sampling site was located on the farm Kleinvetmaakvlakte in the upper estuary of the Sundays River. The station was subject to tidal influence. The river at this point had a clay bed, supporting growths of *Juncus*, *Typha* and beds of Potamogetonaceae. During the drought of early 1970 these beds and the reeds disappeared, probably owing to the extremely high salinities prevailing at this time.

The chemical analyses:

TABLE 23. The chemical analyses of the river water at Station 3

	Absolute concs. mg/ℓ		Standardized values %		Ionic balance meq./ℓ			
Date	Feb. 67	July 67	Feb. 67	July 67	Feb. 67		July 67	
					cations	anions	cations	anions
TDS (measured)	25224	6784						
(calculated*)	16117	7535						
Na	5500	2540	34,1	33,7	239,2		110,4	
K	106	31	0,7	0,4	2,7		0,8	
Ca	123	106	0,8	1,4	6,1		5,3	
Mg	657	258	4,1	3,4	54,0		21,2	
CO_3	58	30	0,4	0,4		1,9		1,0
HCO_3	263	140	1,6	1,9		4,3		2,3
SO_4	1150	690	7,1	9,2		23,9		14,4
Cl	8260	3740	51,2	49,6		232,9		105,5
					302,0	263,0	137,7	123,2

	Feb. 67	July 67	Feb. 68	Aug. 68	Feb. 69	May 70	Mean
pH	8,5	8,7				8,2	8,5
O_2 mg/ℓ	4,8	6,6					
NO_3-N mg/ℓ		0,9					
PO_4-P mg/ℓ	0,08	0,01					

*See section 4.1.1.

The main physico-chemical features:

Station 3 is the uppermost station on the Sundays River estuary. Being truly estuarine with a tidal ebb and flow, it would be expected that the ionic composition of the river water would be intermediate between seawater and the nature of the water at Station 4. Table 23 shows the chemical analyses of two samples, and appears to prove this assumption correct. The salinity of the water varied quite considerably from 7,54 ‰ in July 1967 to 16,12 ‰ in the preceding summer (February 1967). The ionic proportions were, however, more constant, and approached those of seawater. Although chloride, forming approximately 50,0 % of the dissolved ions, was the dominant anion, its percentage *inconspicua* (31,6 %), were all euryhaline mesohalobes. The oligohalobic fraction was almost exclusively represented by the meioeuryhaline oligohalobe *Achnanthes minutissima* (3,2 %). This proportion was sufficient to mask the relative contribution of *Navicula diserta* (3,2 %), a pleioeuryhaline polyhalobe. Some pleioeuryhaline oligohalobes were also present, but together they composed only 1,7 % of the association. Apart from *Navicula diserta*, the polyhalobes contributed nothing to the epiphytic assemblage gathered in July 1967.

With respect to the diatom association collected from the mud substrate there was a greater contribution from the pleioeuryhaline oligohalobes *Cyclotella meneghiniana*, *Navicula cincta* and *Navicula cryptocephala*, which together constituted 7,5 % of the assemblage. The dominant species on the mud was *Nitzschia apiculata* (30,5 %), while other euryhaline mesohalobes, such as *Amphora helenensis*, *Fragilaria sundaysensis* and *Navicula gregaria*, had greatly increased relative densities in the mud substrate populations, forming together 27,1 % of the association. On the other hand the relative contributions of *Nitzschia inconspicua* (9,6 %) and the epiphytic species, *Cocconeis engelbrechtii* (3,6 %), were considerably reduced.

In May 1970, towards the end of a particularly severe drought, the salinity of the water at Station 3 (see Table 32) was markedly raised, and at 44,80 ‰ presented hypersaline conditions. The ionic composition of this water was unfortuantely not determined. Nevertheless the increased salinity was reflected by significant changes in the diatom populations. The epiphytic and mud substrate samples both showed STI values of about 6,0. This was evidence of a significant increase in the relative contributions of polyhalobic species. The two mesoeuryhaline polyhalobes, *Berkeleya rutilans* and *Navicula consentanea*, were found only at this time. Likewise the pleioeuryhaline polyhalobes, *Amphora micrometra*, *Amphora tenerrima*, *Mastogloia pumila*, *Melosira moniliformis* var. *octogona*, *Navicula grosschopfi* and *Navicula sydowii*, were only significant in the May 1970 collections. These species formed 37,4 - 42,1 % of the two communities. The following euryhaline mesohalobic species composed most of the rest of the populations:- *Amphora cymbamphora*, *Amphora luciae*, *Cylindrotheca gracilis*, *Denticula sundaysensis*, *Navicula ammophila*, *Navicula bulnheimii*, *Navicula* *guluensis, Navicula normaloides, Nitzschia lorenziana, Nitzschia perspicua, Rhopalodia gibberula* and *Stauroneis wipplingeri*. None of these were present or significant in associations sampled in July 1967. Only one pleioeuryhaline oligohalobe, *Navicula cincta*, was found in May 1970, forming only 5,3 % and 1,8 % of the mud substrate and epiphytic populations respectively.

Although the May 1970 populations were completely different from those observed in July 1967, the similarity between the epiphytic and mud substrate communities collected in May 1970 is clear. Nevertheless *Amphora luciae, Amphora tenerrima, Navicula grosschopfi* and *Rhopalodia gibberula* were distinctly more abundant on the mud surfaces, while *Mastogloia pumila* and *Navicula guluensis* were prominent in the epiphytic association. The species *Navicula tenelloides*, common in the epiphytic population of May 1970 (6,2 %) requires some comment. This species is commonly regarded as a freshwater form, and, partly due to its presence in this population when the salinity was 44,80 ‰, it has been considered a pleioeuryhaline oligohalobe in this study. There is, however, some doubt as to its true identification. The arguments for its close relationship to *Navicula salinicola*, a euryhaline mesohalobe, have been set out in the Taxonomic section of this study in Volume 1.

STATION 2

Description:

This station was situated on the Sundays River estuary above the Mackay Bridge on the Grahamstown-Port Elizabeth road. Here the river is tidal, and has a clay bed with a sparse growth of *Juncus*.

The chemical analyses:

TABLE 25. The chemical analyses of the river water at Station 2

	Absolute conc. mg/ℓ	Standardized values %	Ionic balance meq./ℓ	
Date	July 67	July 67	July 67	
TDS				
(measured)	18280		cations	anions
(calculated*)	21191			
Na	7050	33,2	306,6	
K	110	0,6	2,8	
Ca	220	1,0	11,0	
Mg	677	3,2	55,7	
CO_3	12	0,1		0,4
HCO_3	123	0,6		2,0
SO_4	1440	6,8		30,0
Cl	11559	54,5		326,0
			376,1	358,4

	Feb. 67	July 67	Feb. 68	Aug. 68	Feb. 69	May 70	Mean
pH		8,3				8,0	8,2
O_2 mg/ℓ		7,4					
NO_3-N mg/ℓ		0,86					
PO_4-P mg/ℓ		0,02					

*See section 4.1.1.

The main physico-chemical features:

A single water sample was analysed chemically in July 1967. This analysis (Table 25) showed that at the corresponding time the salinity was almost three times greater than at Station 3. The ionic composition was however little different from this station. Nevertheless the most conspicuous difference was found in the increased proportion of the chloride fraction (54,5 %) and the corresponding decline in the sulphate proportions. In terms of the relative contribution of the major cations and anions in solution, the water at Station 2 was very close to seawater; only the sodium fraction (33,2 %) appeared to be somewhat high.

Two pH readings were taken at this station, giving a value of pH 8,3 in July 1967, and a value of pH 8,0 for May 1970. Nitrate-N and orthophosphate concentrations remained at about the same order of magnitude as at Station 3.

The composition of the diatom associations at Station 2:

See Table 26.

TABLE 26. The composition of the diatom associations at Station 2 on the Sundays River

	Salinity value	SUN 3 11.7.67 %	SUN 84 28.5.70 %
Achnanthes minutissima	1	1,6	
Amphiprora duplex	8		1,8
Amphora helenensis	5	1,3	
Amphora luciae	5		1,4
Amphora micrometra	7		3,2
Amphora sabiniana	5	1,3	
Amphora tenerrima	7	+	4,2
Berkeleya rutilans	8	5,5	9,2
Cyclotella meneghiniana	3	1,0	
Fragilaria sundaysensis	5	3,2	
Melosira lineata	5	5,5	
Melosira moniliformis var. *octogona*	7		1,8
Navicula ammophila	5	0,3	8,6
Navicula bulnheimii	5		4,2
Navicula consentanea	8	6,0	7,3
Navicula diserta	7	3,2	1,2
Navicula gregaria	5	39,4	0,7
Navicula grosschopfi	7	1,9	1,1
Navicula normaloides	5		2,7
Novicula pavillardi	7	1,0	
Navicula salinicola	5	0,8	3,2
Navicula scopulorum	9		1,6
Navicula sydowii	7		4,5
Nitzschia adductoides	5		1,2
Nitzschia admissoides	9	+	5,2
Nitzschia apiculata	5	6,0	
Nitzschia aremonica	9	0,8	5,7
Nitzschia filiformis	5		4,8
Nitzschia fontifuga	5		4,3
Nitzschia inconspicua	5	3,1	
Nitzschia linearis	2	1,6	
Nitzschia lorenziana	5	+	2,5
Nitzschia obtusa var. *scalpelliformis*	5	1,6	
Nitzschia perindistincta	5	1,3	
Nitzschia perspicua	5		3,0
Nitzschia sigma	6	4,7	
Rhopalodia gibberula	5		11,4
Surirella atomus	7	4,7	0,9
Surirella gemma	8	1,6	
Other species		2,6	4,3
Simpson's Diversity Index		0,20	0,06
Salinity Tolerance Index (STI)		5,56	6,52

Characteristics of the diatom associations at Station 2:

Only two diatom samples were collected, one at the beginning of the survey in July 1967 (SUN 3) and the other at the end of the study in May 1970 (SUN 84), following a period of intense drought. These two populations will be dealt with separately.

The population sampled in July 1967 had an STI value of 5,56, indicating that a number of polyhalobic forms had intruded into the basically euryhaline mesohalobic association of species. With *Navicula gregaria* (39,4 %) the dominant species, the euryhaline mesohalobic species composed about 65 % of the population. Amongst these the most significant species were *Melosira lineata* (5,5 %) and *Nitzschia apiculata* (6,0 %). Also of importance in this association was *Nitzschia sigma*, one of the few holoeuryhaline mesohalobes observed in the study, forming 4,7 % of the association in this sample. A greater number of polyhalobic species made significant contributions to this assemblage than was the case at Station 3 at the corresponding time. The mesoeuryhaline polyhalobes *Berkeleya rutilans* (5,5 %) and *Navicula consentanea* (6,0 %) were more prominent than the pleioeuryhaline species *Navicula diserta* (3,2 %), *Navicula grosschopfi* (1,9 %) and *Surirella atomus* (4,7 %). Finally *Achnanthes minutissima* and *Cyclotella meneghiniana* were the only oligohalobic species present, although the few specimens of *Achnanthes minutissima* may have been empty valves washed down stream from stations more equitable for their development.

As at Station 3 the salinity of the water at Station 2 in May 1970 (see Table 32) was extremely high (44,29 ‰), exceeding the salinity of seawater. Once again this tremendous increase in the salt content, and thus the osmotic pressure, was reflected by the diatom population giving an STI value of 6,52. This high value signified an increasingly greater proportion of polyhalobic species. The assemblage, sampled at this time, had a very high diversity of species with no clearly dominant form (Simpson's Diversity Index value = 0,06). Nevertheless *Rhopalodia gibberula* (11,4 % of the association), classified in this study as a euryhaline mesohalobe, was the most abundant species. Other euryhaline mesohalobes - *Amphora luciae, Navicula ammophila, Navicula bulnheimii, Navicula normaloides, Navicula salinicola, Nitzschia adductoides,* *Nitzschia filiformis*, *Nitzschia fontifuga*, *Nitzschia lorenziana* and *Nitzschia perspicua* - formed about 33,4 % of the diatom population. Of the polyhalobes in the association the most important were *Amphora tenerrima* (pleioeuryhaline), *Berkeleya rutilans* (mesoeuryhaline), *Navicula consentanea* (mesoeuryhaline), *Navicula sydowii* (pleioeuryhaline), *Nitzschia admissoides* (meioeuryhaline) and *Nitzschia aremonica* (meioeuryhaline). Together the polyhalobic species formed 47,7 % of the population.

The associations collected from the mud substrate in May 1970 from this station (SUN 84) and from Station 3 (SUN 82) were interesting as they showed some strong similarities. Fourteen species were common to both associations, and, although their relative densities in their respective communities may have been different, they do indicate that ecological conditions at Stations 2 and 3 were not drastically different in May 1970, when both stations experienced hypersaline conditions (salinities about 44,5 ‰).

STATION 1

Description:

The Sundays River estuary at Colchester. This station is also tidal with clay banks supporting growths of *Zostera*. A number of wooden jetties project into the river at this point. In 1970, owing to construction work on the new national road bridge over the Sundays River at the original sampling site, a new sampling point was selected at another jetty some 500 m further downstream.

The chemical analyses:

TABLE 27. The chemical analyses of the water at Station 1

	Absolute concs. mg/ℓ		Standardized values %		Ionic balance meq./ℓ				Standardized value of seawater after Barnes**
Date	Feb. 67	July 67	Feb. 67	July 67	Feb. 67		July 67		
TDS									
(measured)	34924	26020			cations	anions	cations	anions	‰
(calculated*)	31064	30323							31,4
Na	10200	10200	32,9	33,6	443,5		443,5		30,7
K	304	158	1,0	0,5	7,8		4,0		1,1
Ca	355	300	1,1	1,0	17,7		15,0		1,2
Mg	1210	965	3,9	3,2	99,5		79,4		3,7
CO_3	17	12	0,1	0,0		0,6		0,4	0,4
HCO_3	138	123	0,4	0,4		2,3		2,0	
SO_4	2190	2112	7,0	7,0		45,6		44,0	7,7
Cl	16650	16453	53,6	54,3		469,5		464,0	55,2
					568,5	518,0	541,9	510,4	

	Feb. 67	July 67	Feb. 68	Aug. 68	Feb. 69	May 70	Mean
pH	7,9	8,0		8,1	8,1	8,2	8,1
O_2 mg/ℓ	9,2	6,1					
NO_3-N mg/ℓ	2,66	0,49					
PO_4-P mg/ℓ	0,12	0,03					

*See section 4.1.1.

**See Remane & Schlieper, 1971 : 322, Table 38.

The main physico-chemical features:

Station 1 is the lowest point on the Sundays River estuary from which water samples for chemical analysis were taken. The estuary mouth is approximately another 8,0 km further downstream. Nevertheless the salinity (30,32 - 31,06 ‰) and ionic composition (see Table 27) showed that the water at Station 1 was almost completely seawater. The major cation, sodium, constituted 32,9 % of the ions in solution in February 1967 and 33,6 % in July 1967, while the dominant anion, chloride, composed 53,6 % and 54,3 % of the ions respectively. Magnesium contributed 3,9 % and 3,2 % to the total ions respectively, and sulphate (7,0 %) was present in the same proportion on both dates. When these proportions are compared with the ratio found in seawater (see the appended column in Table 27), obtained from Barnes' Table given in Remane and Schlieper (1971 : 322), it is clear that they were practically identical to seawater. The sodium component was a little high, while chloride was correspondingly slightly less than in seawater.

pH measurements indicated a fairly strongly alkaline water with a range of pH between 7,9 and 8,2, and a mean of pH 8,1. Nitrate-N and orthophosphate concentrations in February 1967 were higher than at other stations, but appeared to return to the usual levels of magnitude in July 1967.

The composition of the diatom associations at Station 1:

See Table 28.

TABLE 28. The composition of the diatom associations at Station 1 on the Sundays River

	Salinity value	SUN 1 11.7.67 %	SUN 2 11.7.67 %	SUN 58 28.8.68 %	SUN 59 28.8.68 %	SUN 70 20.2.69 %	SUN 71 20.2.69 %	SUN 85 28.5.70 %	SUN 86 28.5.70 %
Achnanthes brevipes var. *intermedia*	5		0,2		1,6	3,8		0,4	
Achnanthes minutissima	1	2,9	+			1,9			
Achnanthes punctifera	8			+	0,2			3,2	
Amphora acutiuscula	5					0,7	1,2		
Amphora castellata	5					0,7	1,2		
Amphora cymbamphora	5				0,5			4,1	1,8
Amphora helenensis	5	4,3	0,5		2,8	3,8			
Amphora sabiniana	5	0,5	+						
Amphora tenerrima	7			+				8,6	3,8
Berkeleya rutilans	8	+	0,2		1,4			0,2	0,4
Caloneis liber	9				1,9				
Cocconeis engelbrechtii	5	2,9	+			0,5			
Cyclotella meneghiniana	3	2,7	0,8						
Denticula sundaysensis	5				2,8				0,2
Fragilaria sundaysensis	5	17,3	0,5			3,3	1,4		
Melosira lineata	5				1,2				
Melosira moniliformis var. *octogona*	7								2,2
navicula ammophila	5	6,1					+	2,4	0,6
Navicula bulnheimii	5	1,6			+		47,4	0,9	
Navicula consentanea	8	26,7	1,0		4,7			53,2	12,6
Navicula gregaria	5	22,4	1,5	+	3,3			7,5	2,4
Navicula guluensis	5	0,5	85,2			54,8		3,3	40,0
Navicula mollis	7		0,2					3,2	
Navicula rhaphoneis	9				0,9	1,9			
Navicula salinicola	5			+				2,0	0,8
Nitzschia apiculata	5	1,1	1,9						
Nitzschia denticula	2	+				1,4	0,2		
Nitzschia dissipatoides	5		2,2		0,5			+	9,2
Nitzschia elegantula	5	3,2				0,5	34,0		
Nitzschia fasciculata	7				11,3				
Nitzschia filiformis	5				10,7				6,0
Nitzschia fonticola	3	2,4							
Nitzschia inconspicua	5		1,0		49,8	8,9		5,3	
Nitzschia laevis	5					3,8		1,6	
Nitzschia lanceolata	8		2,4			11,2			15,0
Nitzschia obtusa var. *scalpelliformis*	5	0,8	1,3			0,5			
Nitzschia prolongata	5				0,9				
Nitzschia stompsii	7				2,1		1,7		
Nitzschia sublanceolata	9								1,4
Surirella atomus	7	3,2	0,2					0,7	+
Synedra fasciculata	5				2,3				
Synedra hartii	5						11,8		
Other species		1,4	0,9		1,1	2,3	1,1	3,4	3,4
Simpson's Diversity Index		0,16	0,73		0,18	0,33	0,36	0,30	0,21
Salinity Tolerance Index (STI)		5,66	5,04		5,48	5,33	5,03	6,94	5,04

Characteristics of the diatom associations at Station 1:

On each occasion that diatoms were sampled two collections were made, one from the mud surface of the river banks and the other from the jetty supports in the river. Since no characteristic pattern in the diatom populations from these two niches emerged from the analyses of these samples, it is more convenient to discuss the two sets of samples separately.

Samples SUN 1 (July 1967), SUN 58 (August 1968), SUN 71 (February 1969) and SUN 85 (May 1970) constitute the populations found on the mud surfaces. This community suffered the usual stresses that estuarine organisms are exposed to with the ebb and flow of the tides. Diatom growth in August 1968 (SUN 58) was poor and no proper analysis of this population could be made. Consequently it will not feature in the discussion below. With respect to the remaining mud surface associations no particularly remarkable features were observed. In July 1967 three species were prominent. These were *Fragilaria sundaysensis* (17,3 %), *Navicula consentanea* (26,7 %) and *Navicula gregaria* (22,4 %), and, although they were also present in the pier associations, they appeared to favour the mud substrate. Similarly *Navicula bulnheimii* (47,4 %), *Nitzschia elegantula* (34,0 %) and *Synedra hartii* (11,8 %) were dominant in the mud surface community of February 1969, and were absent or negligible in the jetty support community on the same date. This particular association was also quite different from the other two mud surface populations, having practically no species common between them. It did, however, closely parallel the association found at the same date at Station 4A in the highly brackish seepage water. Reasons for this are not clear from the little information available. It does nevertheless suggest a very similar micro-climate in these two environments in February 1969. In May 1970 the diatom association on the mud surface at Station 1 resembled fairly closely that observed in July 1967. However, the very much higher STI value (6,94) of this sample indicated the much greater contribution of the polyhalobic species. At this time *Navicula consentanea* (53,2 %), a mesoeuryhaline polyhalobe, was clearly dominant, while *Amphora tenerrima* (pleioeuryhaline polyhalobe), *Navicula gregaria* (euryhaline mesohalobe) and *Nitzschia inconspicua* (euryhaline mesohalobe) constituted a minor portion of the association.

The diatom community of the pier supports is reflected by the associations in samples SUN 2 (July 1967), SUN 59 (August 1968), SUN 70 (February 1969) and SUN 86 (May 1970). In constrast to the mud surface community, a common denominator in all pier support samples, except SUN 59, was the euryhaline mesohalobe *Navicula guluensis*. This species formed 85,2 % of the population sampled in July 1967, all other species contributing very little to this association. It was also the dominant species in the samples collected in February 1969 and May 1970, although on these occasions other species were more prominent. For instance in February 1969 *Nitzschia inconspicua* and *Nitzschia lanceolata* (a mesoeuryhaline polyhalobe) constituted about 20 % of the population, while the euryhaline mesohalobes *Achnanthes brevipes* var. *intermedia*, *Amphora helenensis*, *Fragilaria sundaysensis* and *Nitzschia laevis* composed another 14,7 % of the population. In May 1970 two mesoeuryhaline polyhalobes, *Navicula consentanea* (12,6 %) and *Nitzschia lanceolata* (15,0 %) formed a major part of the assemblage, while the euryhaline mesohalobes, *Nitzschia dissipatoides* and *Nitzschia filiformis* added a further small but significant share.

Surprisingly *Navicula guluensis* was completely absent from the association sampled in August 1968 (SUN 59). This particular association was dominated by *Nitzschia inconspicua* (49,8 %), a euryhaline mesohalobe. With the exception of *Navicula consentanea* (4,7 %) and *Nitzschia fasciculata* (11,3 %), nearly all the other species contributing significantly to the population were euryhaline mesohalobes, of which *Nitzschia filiformis* (10,7 %) was the most prominent.

What factors were responsible for the wide variability in the species composition in these associations cannot be determined from the little evidence available.

5.1.6 The Wit River, a tributary of the lower Sundays River

STATION : WIT RIVER

Description:

This sampling site lay on a tributary of the Sundays River, the Wit River, a short distance above its confluence with the Sundays River just below Kirkwood. The site consisted of a large pool with a good growth of aquatic plants such as *Limnanthemum*, *Aponogeton*, *Nymphaea*, *Potamogeton* and *Polygonum*. Below the sampling site was a stony run and another pool, both of which were green with algal growth.

The chemical analyses:

TABLE 29. The chemical analyses of the water in the Wit River

	Absolute concs. mg/ℓ		Standardized values %		Ionic balance meq./ℓ			
Date	Nov. 67	Feb. 68	Nov. 67	Feb. 68	Nov. 67		Feb. 68	
TDS (measured) (calculated*)	232 212,9	286 270,4			cations	anions	cations	anions
Na	52	69	24,4	25,5	2,26		3,00	
K	2,2	4,9	1,0	1,8	0,06		0,13	
Ca	8,7	1,5	4,1	0,6	0,43		0,07	
Mg	11	19	5,2	7,0	0,90		1,56	
CO_3	0	0	0,0	0,0		0,0		0,0
HCO_3	37	37	17,4	13,7		0,61		0,61
SO_4	52	20	24,4	7,4		1,08		0,42
Cl	50	119	23,5	44,0		1,41		3,36
					3,65	3,10	4,76	4,39

	Nov. 67	Feb. 68	Mean
pH	8,0	7,8	7,9
O_2 mg/ℓ	7,2		
NO_3-N mg/ℓ	0,05		
PO_4-P mg/ℓ	0,01		
Temp °C		25,0	

The main physico-chemical features:

The Wit River has its source in the Suurberg range of mountains, and flows over beds of the Witteberg and Dwyka Series rocks before entering the Sundays River. The salinity of the Wit River water was low, ranging between 0,21 ‰ and 0,27 ‰ on the two occasions that it was measured. Its ionic composition was noticeably different from the river water at Station 5 on the Sundays River, a short distance below the confluence of the two rivers. Sodium was the major cation and constituted about 25 % of the ions in solution. Magnesium varied slightly between 5 % and 7 %, while potassium formed less than 2 % of the total ions present. A much greater variation in proportions was experienced by calcium. This ion composed 4,1 % of the ions in November 1967, but only 0,6 % in February

1968. As far as the anions were concerned, there was a wide fluctuation in the ratio of chloride and sulphate, while carbonate and bicarbonate were more constant. In November 1967 sulphate and chloride were the chief ions, although bicarbonate was not much less important. However, in February 1968 the chloride ratio almost doubled (44,0 %) its previous value, while the proportion of sulphate decreased to little more than three times its former value. Bicarbonate, on the other hand, decreased by only 3,7 %. An explanation of these sudden and large variations in the ionic composition cannot be given on the small amount of data available.

The ionic composition of this Wit River water was much more akin to the waters from the upper course (Stations 6-9) of the Sundays River. Ground waters originating from the Witteberg and Dwyka beds fall into the highly mineralized chloride-sulphate group of Bond (1945 : 155) although waters from the Witteberg quartzites are described as falling into the Pure Water group (Bond l.c. : 105). Since the salinity was so low (±0,25 ‰), it is therefore most likely that the ground waters feeding the Wit River originated mainly from Witteberg quartzites.

Only two pH measurements were made, giving readings of pH 7,8 - 8,0. The water is therefore fairly highly alkaline as was the case throughout the Sundays River. Nitrate-N and orthophosphates had low concentrations in keeping with the general trend in the Sundays River.

The composition of the diatom association in the Wit River:

See Table 30.

Characteristics of the diatom associations in the Wit River:

Although sampled on only one occasion (February 1968), the diatom association from the Wit River was interesting. The population contained at least 75 taxa, of which only 13 were considered significant (i.e. constituting at least 1 % of the population). The most striking feature of this assemblage, when compared with other associations from the lower course of the Sundays River (Stations 4 - 5), was its low STI value of 2,02. This immediately indicated a population composed

TABLE 30. The composition of the diatom association in the Wit River

	Salinity value	SUN 34 14.2.66 %
Achnanthes minutissima	1	42,6
Cyclotella meneghiniana	3	3,0
Gomphonema parvulum	1	1,9
Melosira granulata var. *angustissima*	1	3,8
Navicula cryptocephala	3	3,0
Navicula pupula	2	2,6
Nitzschia acicularis	2	1,2
Nitzschia agnita	2	6,8
Nitzschia clausii	2	4,3
Nitzschia confinis	1	2,6
Nitzschia fontifuga	5	7,8
Nitzschia inconspicua	5	4,2
Nitzschia palea	2	4,9
Other species		11,3
Simpsons Diversity Index		0,20
Salinity Tolerance Index (STI)		2,10

predominantly of meio- or mesoeuryhaline oligohalobes. This correlated very well with the low salinities that appear to prevail at this site.

Achnanthes minutissima, a meioeuryhaline oligohalobe, was the dominant species, and would, according to Cholnoky (1968b : 463), indicate that the ambient oxygen tension in the water was high. No other species reached any noticeably high relative densities, but a large number exhibited abundances of more or less the same level. Consequently the Simpson's Diversity Index value for this sample (0,20) was not very high. The most important meioeuryhaline species in the rest of the population were *Gomphonema parvulum*, *Melosira granulata* var. *angustissima* and *Nitzschia confinis*. The mesoeuryhaline oligohalobes of significance were *Navicula pupula*, *Nitzschia acicularis*, *Nitzschia agnita*, *Nitzschia clausii* and *Nitzschia palea*. *Cyclotella meneghiniana* and *Navicula cryptocephala* were the only two representatives of the pleioeuryhaline oligohalobes. The presence of *Nitzschia fontifuga* and *Nitzschia inconspicua*, two euryhaline mesohalobes, forming 12,0 % of the population may indicate periodic or occasional increases in the salinity. These two mesohalobes do, however, seem to be capable of tolerating very low salinities quite well.

As in the Sundays River communities this particular association was composed entirely of alkaliphilic or alkalibiontic species, which reflected well the high pH levels found in the Wit River.

5.1.7 Lake Mentz

Finally on the initial sampling trip of this survey a single sample was collected from the rocky edge or shore of Lake Mentz at the dam wall. At this time (July 1967) the water level in the impoundment was dropping rapidly, and later (January - April 1968) the dam dried up completely. No chemical sample was taken here.

The composition of the diatom association in Lake Mentz:

See Table 31, and Fig. 26.

TABLE 31. The composition of the diatom association from Lake Mentz

	Salinity value	SUN 20 12.7.67 %
Navicula accomoda	2	1,8
Navicula cincta var. *leptocephala*	2	1,1
Navicula cryptocephala	3	12,0
Navicula frugalis	1	0,7
Navicula mollis	7	67,2
Navicula muralis	1	1,1
Navicula rostellata	2	0,2
Nitzschia fonticola	3	9,9
Nitzschia inconspicua	5	0,9
Nitzschia palea	2	5,1
Simpson's Diversity Index		0,48
Salinity Tolerance Index (STI)		5,60

Characteristics of the diatom association in Lake Mentz:

This community was very restricted in terms of numbers of species in the population. Ten taxa were recorded in the floristic analysis, of which two were represented probably by odd valves washed into the dam from elsewhere. The dominant species was *Navicula mollis* (67,2 %), a species characterized in this study as a pleioeuryhaline polyhalobe. Its abundant presence in this impoundment, some 100 km or more from the sea, casts some doubt either on the accuracy of the identification or on the evaluation of its autecology. The problem of correct identity is the most likely ground for error and this aspect is fully discussed in the

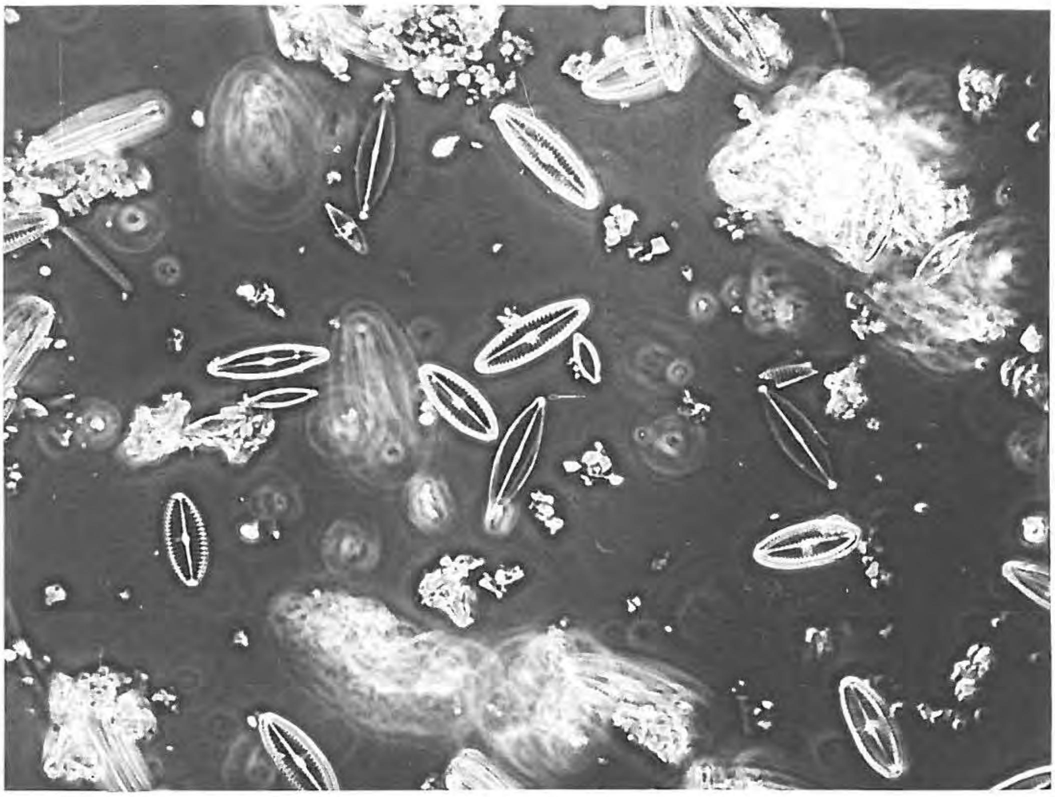


Fig. 26. Diatom association from Lake Mentz.

taxonomic section of this work in Volume 1. Consequently any interpretations deduced from the dominance of this species are subject to a great deal of caution. With the exception of *Nitzschia inconspicua* (0,9 % of the population), all other species in this association were oligohalobes, with the greatest contribution coming from the two pleio-euryhaline forms *Navicula cryptocephala* (12,0 %) and *Nitzschia fonticola* (9,9 %). The only other species making a significant contribution to this population was *Nitzschia palea* (5,1 %). Once again it is evident from the character of the species in this association with regard to their pH preferences that the water in Lake Mentz was highly alkaline.

5.2 The chemistry of the Sundays River: a general discussion:

In their investigation of the chemistry of the Sundays River Forbes and Allanson (1970 : 479) partitioned the river into three sections, an upper and lower course and the estuary. Stations 10 and 11 were for some undisclosed reason not considered in their discussion. The dividing line between their upper and lower courses was the Kleinwinterhoek and Suurberg ranges of mountains immediately below Lake Mentz. Thus according to Forbes and Allanson the upper course of the Sundays River consisted of Stations 7, 8 and 9, while the lower course was composed of Stations 4, 4A, 5 and 6, and the estuary included Stations 1, 2 and 3 (see Fig. 1).

These divisions were accepted in this study as more or less correct, but two changes were made mainly on chemical evidence. Stations 10 and 11 were included as a fourth division and this division is now referred to as the source zone. The second change involved the removal of Station 6 from the lower course and its transfer to the upper course. The detailed results of the chemical analyses for each station in these four sections are shown in Tables 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25 and 27. These results have been summarised in Figures 27 - 31, which show the range of variation and the mean of the absolute values for salinity, and the various ionic concentrations at every station. Figures 32 and 33, on the other hand, illustrate the relative

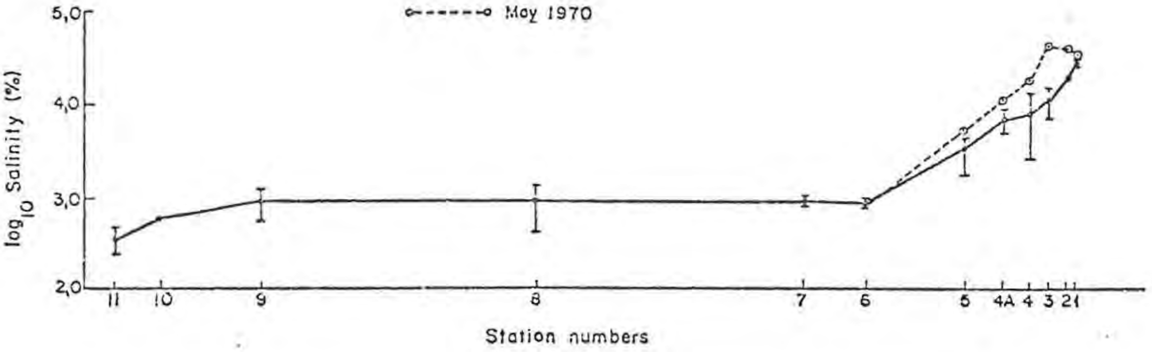


Fig. 27. Mean salinity of the Sundays River. (Bar lines indicate the range at each station; intervals between stations proportional to distance from the source - 1,0 mm = 2,0 km).

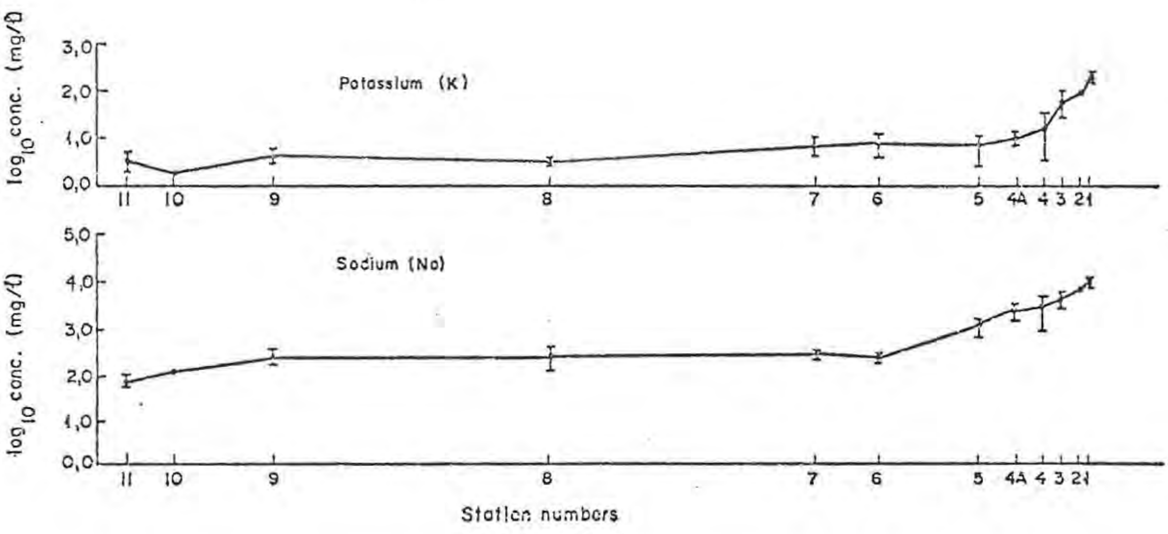


Fig. 28. Mean potassium and sodium concentrations in the Sundays River. (Bar lines indicate the range at each station; intervals between stations proportional to distance from source - 1,0 mm = 2,0 km).

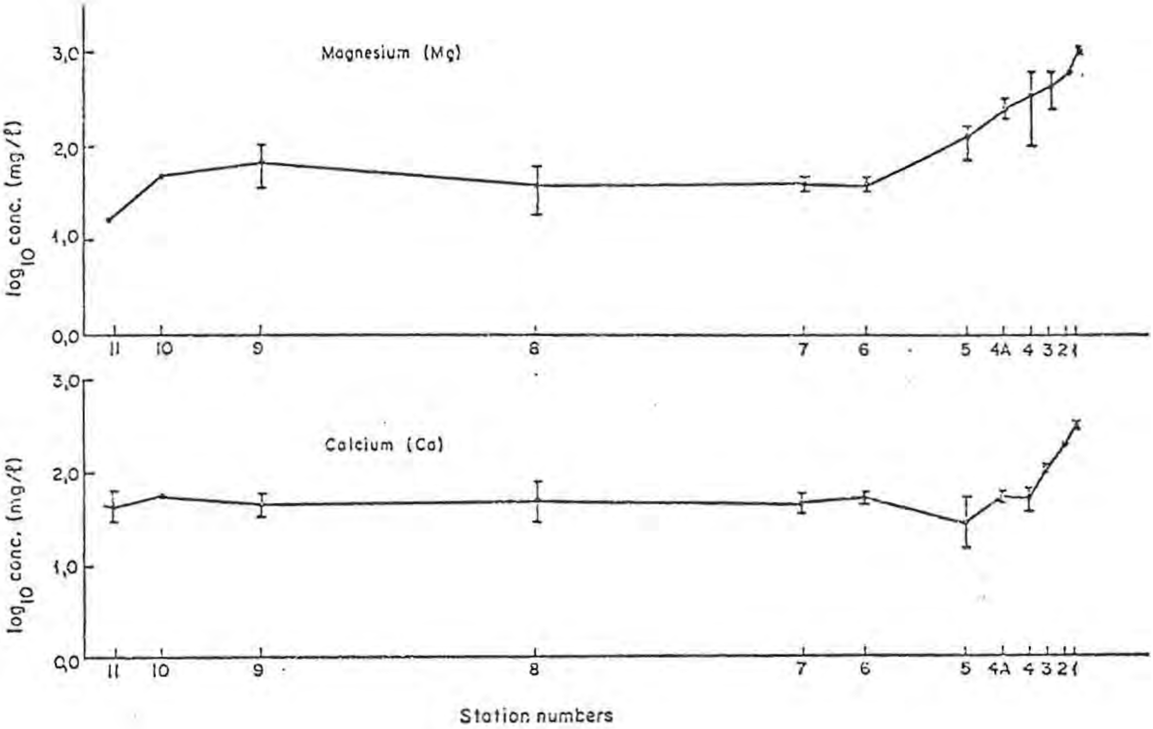


Fig. 29. Mean magnesium and calcium concentrations in the Sundays River. (Bar lines indicate the range at each station; intervals between stations proportional to distance from source - 1,0 mm = 2,0 km).

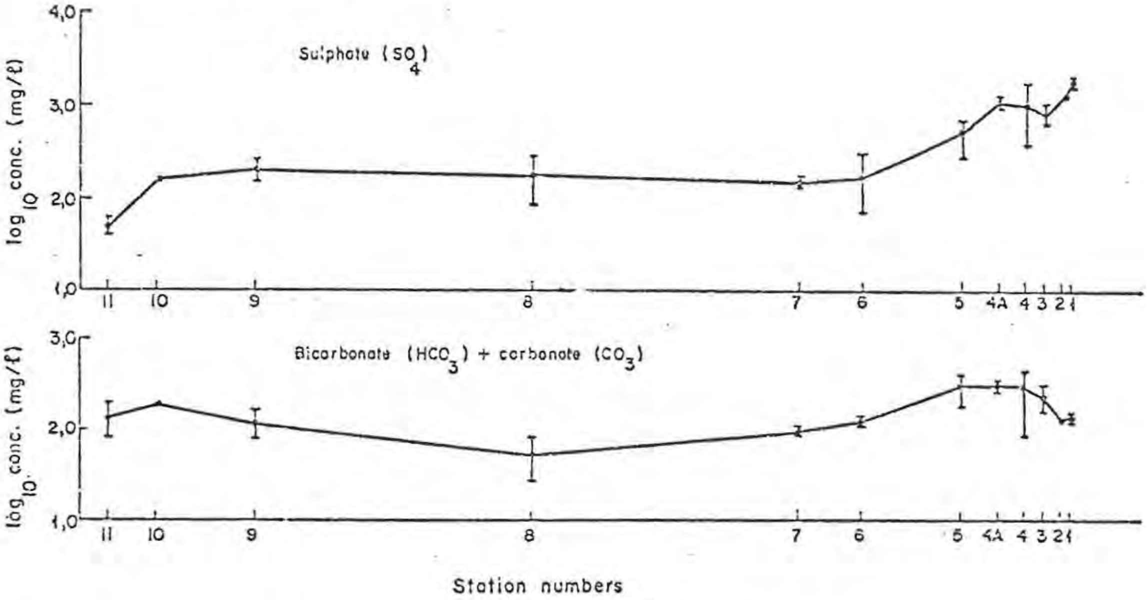


Fig. 30. Mean sulphate and bicarbonate + carbonate concentrations in the Sundays River. (Bar line indicates the range at each station; intervals between stations proportional to distance from the source - 1,0 mm = 2,0 km).

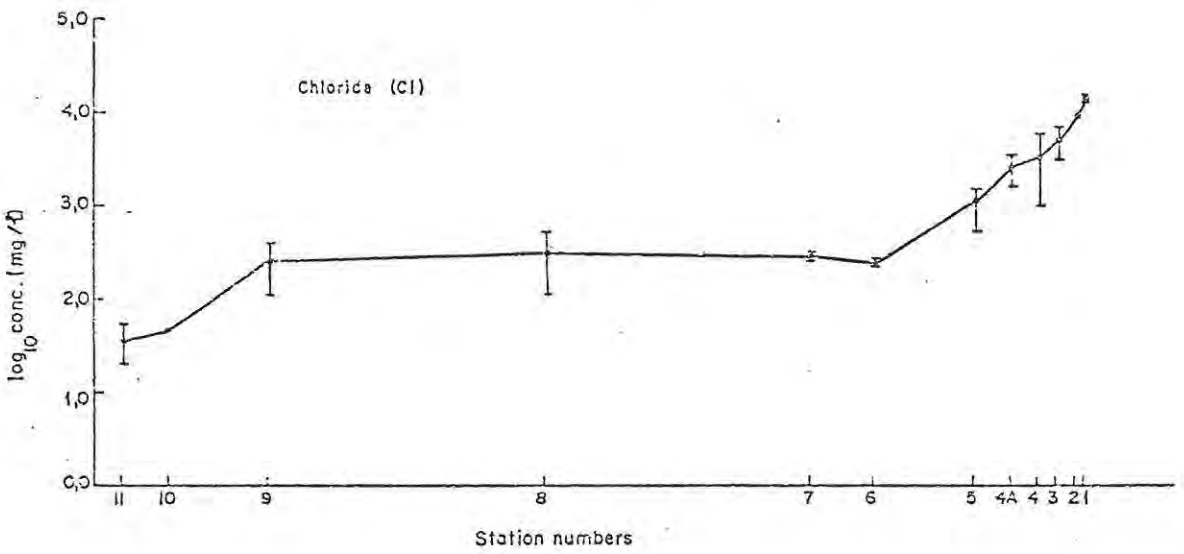


Fig. 31. Mean chloride concentrations in the Sundays River. (Bar lines indicate the range at each station; intervals between stations proportional to distance from the source - 1,0 mm = 2,0 km).

contribution of each ion to the total salinity for each station on different dates, and the changes in their relative proportions as the river progresses to the sea.

Salinity in the Sundays River (Fig. 27) showed an initial fairly rapid increase in the source zone (Stations 11 to 10) up to Station 9. Thereafter in the upper course of the river (Stations 9 - 6) the mean salinity remained at a fairly constant level of about 0,9 ‰). From the beginning of the lower course of the Sundays River (Station 5) there was a marked increase in the salinity, and this continued throughout this section of the river. On entering the estuary of the Sundays River the salinity increased still more rapidly until at Station 1 it (30,7 ‰) practically reached the level of seawater (mean of open seas = about 35,0 ‰ - Reid, 1961 : 204).

In May 1970, towards the end of a particularly severe drought a further set of salinity measurements were obtained from Station 6, the lower course and estuary of the Sundays River. These are shown in Table 32, and illustrated in Figure 27 by means of the broken line.

Table 32. The salinity of the water in the lower Sundays River in May 1970 following a period of severe drought

Station No.	Salinity (‰)
6	0,82
5	5,40
5 seepage	3,86
4A	12,37
4A seepage	21,83
4	18,92
3	44,80
2	44,29
1	37,58

With the exception of Station 6, the salinity levels in the lower course and estuary at the end of the drought period were considerably higher than previously observed. In particular at Station 3 and 2 in the estuary the salinity markedly exceeded that of seawater, reaching salinities of 44,8 ‰ and 44,26 ‰ respectively. At Station 1 the salinity (37,58 ‰), although somewhat reduced from the previous two stations, was still greater than seawater and considerably more than observed in earlier years. The high salinity levels at Stations 3 and 2, and the more normal salt concentrations at Station 1, suggested that during this period a water mass was trapped towards the head of the estuary. Minimal inflow of water from the lower course was insufficient to flush this hypersaline water out, and incoming seawater at high tide pushed this highly saline water back up the estuary. As a result, the small inflow of highly brackish water and the high evaporation rates built up the salinity at Stations 3 and 2 to these very high levels. As a consequence of these hypersaline conditions all macrophytic growth at Stations 3 and 2 died out.

With respect to the absolute concentrations of the major ions in solution the pattern shown by sodium (Fig. 28), magnesium (Fig. 29), sulphate (Fig. 30) and chloride (Fig. 31) followed fairly closely the trends observed in the salinity. Sulphate, however, showed a small decrease in concentration at Stations 4 and 3, followed by a fairly rapid rise at Stations 2 and 1. Potassium concentrations (Fig. 28) were generally rather low in the system, and only showed a real increase from about Station 4 onwards through the estuary. Calcium (Fig. 29) also appeared to maintain a fairly constant mean level through out the source zone, the upper and lower courses except for station 5. At Station 5 there was a sudden decrease in concentration possibly due to greater precipitation of calcium as calcium carbonate (see Station description in section 5.1.4) resulting from the extremely high pH values obtained in the river during the summer months (see Table 13). However in the estuary calcium concentrations rose rapidly. Carbonates and bicarbonates (Fig. 30) were the only ions to show a rather contrasting trend in the catchment. Concentrations of these two ions were fairly high in the source zone, but this was followed by a steady decline in the higher parts of the upper course of the river (Stations 9 and 8). Concentrations gradually built up again until maximum levels were reached in the lower course of the Sundays River, before decreasing rapidly in the estuary.

It is evident from Figures 27 - 31 that at some stations there was a greater variability in the salinity levels and absolute concentrations of the ions than at others. At Station 1, with the exception of magnesium, there was a relatively large variation. In the upper course large fluctuations in the salinity were observed at Stations 9 and 8, while the concentrations of the ions and salinity remained quite constant at Stations 7 and 6. One exception, however, was the concentration of sulphate ions (Fig. 30) which showed an abnormally wide variation at Station 6. Forbes and Allanson (1970 : 485) were unable to account for this in their discussion of the chemistry of the Sundays River water. In the lower course the greatest variations were observed at Stations 5 and 4. These variations may be seasonal effects, i.e. dilution during wet periods of the year, and concentration during the dry months. Station 4A appeared to be more constant, but this may only be an apparent trend as analyses were only undertaken during the summer months. In the estuary at Station 3 the degree of variation was less than that at Station 4, while there was little change in salinity levels and ionic concentrations at Station 1. This showed the stabilizing effect of seawater penetrating up the estuary.

In order to detect changes in salinity due to factors other than those induced by mere concentration and dilution effects, the relative contribution of each of the major ions in solution was calculated as a percentage of the salinity (see Kemp, 1963, 1971) for each sample. The results of the standardized analyses for the various stations are shown alongside the absolute concentrations in the relevant tables mentioned above. They have also been graphically illustrated in Figures 32 and 33 for February and July 1967 respectively. These proportions have furthermore been compared at the source zone end with the average ionic composition of African rivers (see Wetzel, 1975 : 144), and at the other end of the graph with the ratio of the ions in seawater (taken from Barnes' Tables in Remane and Schlieper, 1971 : 322).

In the source zone of the Sundays River the ionic composition of the river at Station 11 approaches very closely that of the average African river (cf. Wetzel, l.c.). Bicarbonates and carbonates were the dominant anions, while sodium and calcium were the most important cations. Changes in the ionic composition were evident at Station 10 in July 1967 (no analysis was made for this station in February 1967). Significant gains in the proportions of sulphates potassium and magnesium were observed, although sodium and bicarbonates were still the major cation and anion respectively. Waters in the source zone could thus be described as soda-carbonate waters.

A further notable change was observed at Station 9, the beginning of the upper course of the Sundays River. With a substantial increase in chloride proportions and further increases in sulphates, bicarbonates lost their dominance, and the waters can be described as chloride-sulphate waters. Thereafter, throughout the whole course of the Sundays River there was a general gradual increase in the sodium and chloride ion proportions, the gains made by these two ions being more rapid in the lower course of the river. Except for an initial increase in July 1967 at Station 10, potassium formed a very small part of the total ions in solution, but maintained a more or less constant proportion. The calcium and magnesium fractions were reasonably constant throughout the upper course, with perhaps a slight increase in calcium at Station 6. In the lower course, however, the fall off in their relative contributions is more rapid, and is particu-

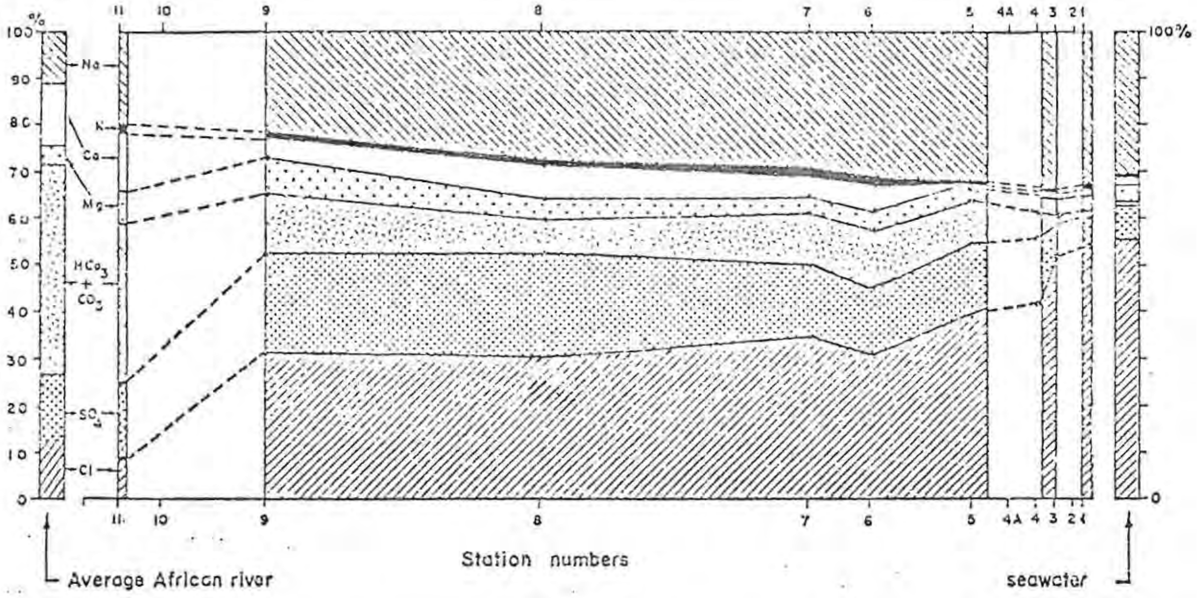


Fig. 32. The ionic composition of the Sundays River in February 1967, and its comparison with the composition of the average African river and seawater. (Blank spaces indicate lack of samples; intervals between stations proportional to distance from the source - 1,0 = 2,0 km).

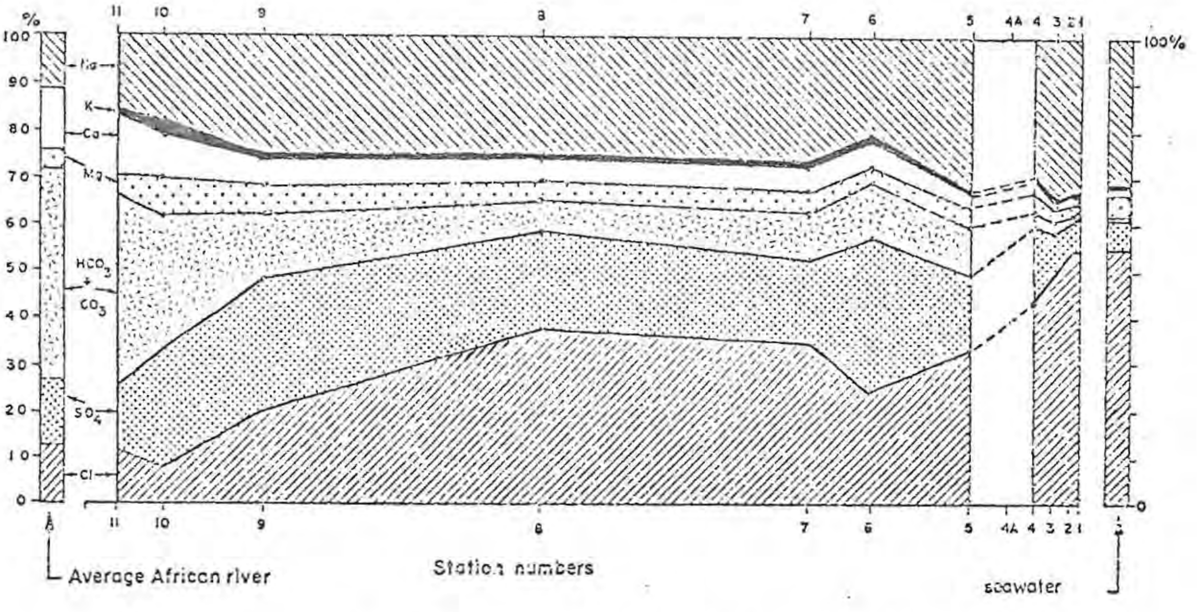


Fig. 33. The ionic composition of the Sundays River in July 1967, and its comparison with the composition of the average African river and seawater. (Blank spaces indicate lack of samples; intervals between stations proportional to distance from the source - 1,0 mm = 2,0 km).

larly marked in the calcium proportions although in July 1967 (see Fig. 33) this very rapid decline only occurred in the estuary. Bicarbonates showed a small decline in proportions in the upper course above Lake Mentz, increasing again slightly at Stations 7 and 6. Its proportions in the lower course fell rapidly, however, becoming almost negligible in the estuary. In February 1967 (Fig. 32) sulphate ratios showed a gradual decrease throughout the upper and lower courses, with a conspicuous drop as the water enters the estuary at Station 3. The pattern for sulphates in July 1967 (Fig. 33) was basically the same, but for the sudden, unaccountably large increase at Station 6.

Although the ionic ratios at Station 3 in the estuary still showed the influence of water flowing in from the lower course, there was no further change in the ionic proportions between Stations 2 and 1. These proportions were practically those of seawater, as may be seen when they are compared with the composition of seawater of equivalent salinity calculated from Barnes' Tables (see Remane and Schlieper, 1971 : 322).

In the lower course of the Sundays River two seepage waters were investigated. At Station 5 a seepage water was sampled almost as it emerged from the river bank. In July 1967 this seepage had a salinity (7,6 ‰) almost four times that of the river (1,8 ‰), but in February 1968, during the summer, the salinity differential between the seepage water (5,9 ‰) and the river (4,6 ‰) was much reduced. Its ionic composition (Fig. 34) was not a great deal different from the river water, there being somewhat more sodium and sulphate in the seepage water, while chlorides were proportionally of about the same magnitude. Thus the effect of this seepage on the river would be to raise the salinity level. Forbes and Allanson (1970 : 486) calculated that this seepage water amounted to about 12 % of the total river flow.

At Station 4A the salinity of the seepage water in November 1967 and February 1968 (22,5 ‰ and 28,5 ‰ respectively) was considerably greater than in the river, being about four and

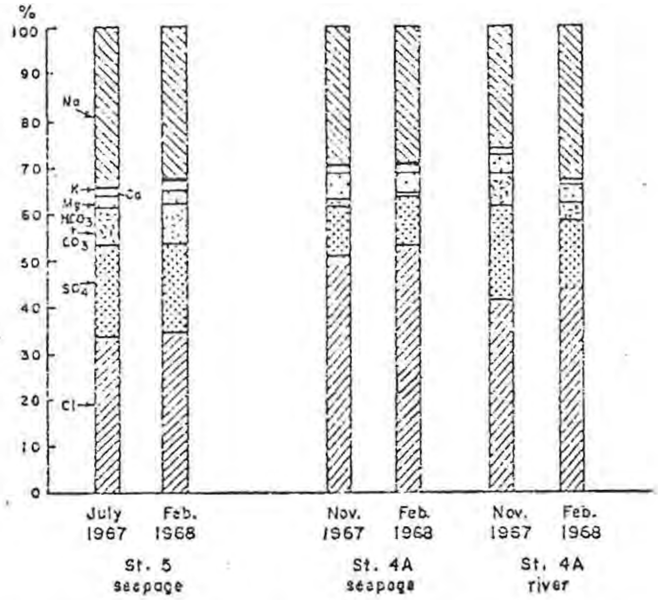


Fig. 34. Comparison of the ionic composition of the seepage waters at Stations 5 and 4A at various times, and the ionic composition of the water at Station 4A in November 1967 and February 1968.

three times as much respectively. In contrast to the seepage at Station 5 there were some quite conspicuous differences in the ionic proportions of the seepage water at Station 4A when compared with the river water. These are illustrated graphically in Figure 34. The ionic composition of these seepage waters was more akin to those of seawater, and thus showed a greater proprotion of chlorides and less sulphates and bicarbonates than the river water. Magnesium ratios were about the same as in the river, but the calcium fraction appeared to be greater in the seepage water. Consequently the seepage water of Station 4A might not only raise the salinity level of the river water, but might also alter the ionic composition to some degree. According to Forbes and Allanson (l.c.) this seepage contributed about 4 % to the total river flow.

One notable feature found in both seepage waters was the high nitrate-N content. This amounted to as much as 45 mg/ℓ at Station 5 and 18 mg/ℓ at Station 4A. These values, so much higher than in the river (maximum concentration in the lower course - 2,1 mg/ℓ), suggested to Forbes and Allanson (l.c.) that the seepage waters had a common origin in agricultural fertilizers applied to orchards on the river banks.

pH levels throughout the whole of the Sundays River were extremely high. the lowest mean pH of 7,9 was found at Station 10, while the highest mean of 9,0 was observed at Station 5. The extremely high pH values found at Station 5 may have been responsible for carbonate precipitation at this station during the summer months, when the rocks became coated with a calcareous deposit.

The chemistry of the Sundays River may be summarized briefly in the following manner. Waters in the source zone (Stations 11 and 10) have a relatively low salinity, are alkaline and are characterized by the high bicarbonate content, while sodium and calcium are the major cations. Source zone water may therefore be classified as alkaline soda-carbonate waters. In the upper course the salinity increases, showing considerable fluctuations at Stations 9 and 8 and being relatively constant at Stations 7 and 6. In this zone the waters are chloride-sulphate dominated, with chlorides progressively but slowly increasing and sulphates decreasing correspondingly. Sodium proportions increase continuously through this region. Station 6, however, may at times show changes in the ionic composition with sulphates increasing markedly. Smaller increases in calcium and bicarbonate may also be evident. The lower course is characterized by the marked increase in salinity at Station 5 and subsequent high rate of mineralization over a relatively short distance to Station 4. Chloride is the dominant anion, greatly increasing its proportions at the expense of sulphate and bicarbonate, and sodium is unquestionably the dominant cation. In the estuary the stabilizing effect of seawater may be seen in the lower variability in salinity and the ionic composition characteristic of seawater.

This brief summary helps to substantiate the division of the Sundays River into the four zones differentiated above. The source zone is distinctive due to its bicarbonate dominance and low salinity. The estuary is also clearly marked by the relative stability of its salinity levels and by its ionic composition characteristic of seawater. On the basis of the very sudden increase in salinity, particularly the chloride fraction the lower course appears to begin rather at Station 5 and includes Stations 4A and 4. This zone appears to undergo fairly wide fluctuations in salinity, mainly seasonal through concentration and dilution effects. The upper course therefore includes Stations 9, 8, 7 and 6. This zone may also be subdivided into two sections, the one containing Stations 9 and 8 above Lake Mentz, which undergo relatively large fluctuations in salinity, and Stations 7 and 6 below Lake Mentz, where not only is there a relative constancy in the salinity but the ionic proportions may also show some changes.

During the period of the survey droughts were prevalent, and the low water flows experienced consisted in the main of basal flow. This is composed of irrigation return water and natural underground water seepage. The chemistry of the Sundays River might therefore be expected to reflect the nature of the underground water modified by the irrigation runoff water. According to Bond (1945 : 135) the upper and middle beds of the Beaufort Series produce alkaline soda-carbonate underground waters. Bond's map of underground water distribution shows that the lower limit of this type of water lies a little to the northeast of Graaff-Reinet. Certain boreholes to south and southwest of this town, examined by the National Institute for Water Research (Hall : personal communication), also show bicarbonate dominated water. Thus the Sundays River water in the source zone (Stations 11 and 10) appeared to reflect the composition of the alkaline soda-carbonate underground waters to be found in this region. Likewise in the section of the upper course above Lake Mentz (Stations 9 and 8) dominance of the chloride and sulphate ions in the river water bore the characteristics of the underground waters derived from the lower Beaufort beds. These Bond (l.c.) described as highly mineralized chloride-sulphate waters. Below Lake Mentz the Sundays River passes through the Lesser Winterhoek and Suurberg mountain ranges. These ranges consist mainly of Witteberg quartzites, which yield underground waters described by Bond (l.c. : 105) as pure waters, owing to their very low salt content. In these pure waters 31 % of the total salt concentration was formed by chloride ions, while sulphates contributed 15 % of the ions. Dilution of the brackish river water by low salinity underground water may account for the relatively low salinity at Stations 7 and 6, while the fairly high sulphate proportions in these pure underground waters may have had something to do with the dramatic rise in the sulphate ratios on occasions at Station 6. Between Station 6 and Station 5 the Sundays River encounters the marine beds of the Cretaceous and Tertiary to Recent Systems. These beds often contain connate seawater, and it was therefore not surprising to find that there was a high and rapid mineralization of the river waters in the lower course of the river. The highly saline seepage at Station 4A, with ionic proportions close to seawater is strong evidence to support the influence of the connate seawater. Once in the estuary the Sundays River is strongly influenced by seawater, and the ionic composition rapidly becomes characteristic of seawater.

Finally one tributary of the Sundays River was investigated briefly. This was the Wit River which enters the Sundays River some 10 km below Kirkwood. In striking contrast to the highly saline Sundays River, the river waters of the Wit River have an extremely low salinity, being measured at 0,21 ‰ and 0,27 ‰ in November 1967 and February 1968 respectively. The anionic constituents of this water did not appear to be consistent in their proportions. Bicarbonates were the most stable and were appreciably higher than the proportion found in the Sundays River at Station 5. Sulphates and chlorides showed large variations in proportion. On the whole the chemical composition of the Wit River water was somewhat similar to that of the Sundays River at Station 6, even to undergoing large fluctuations in the sulphate content. Again this may be accounted for by the fact that the Wit River rises and passes for most of its course over the Witteberg quartzites of the Suurberg mountains. In the short distance it flows over the Cretaceous System rock strata of the Uitenhage Series it appears to undergo little mineralization.

5.3 The diatom assemblages of the Sundays River with special reference to the salinity.

In the foregoing section summarizing the chemistry of the Sundays River four zones or regions could be defined along the course of the river. These zones were based on changes in the salinity of the water and on the differences in the ionic composition, which in turn could be correlated fairly closely with the underlying rock strata and the ground water emanating from them. Although not always markedly obvious, these regions can be substantiated by changes that occur in the diatom communities.

In the source zone (Stations 11 and 10) the waters were shown to have a relatively low salinity (0,24 - 0,61 ‰), and can be described as soda-carbonate waters with an ionic composition very similar to that found in the average African Freshwater river (see Figs 32 and 33). The diatom assemblages in this zone, irrespective of their specific composition, were overwhelmingly freshwater in nature, and were quite unlike anything found elsewhere in the course of the Sundays River. Only in February 1969 did a few brackish water species make some impact at Station 10, raising the STI value of the diatom association in sample SUN 60 to 3,18 (see Table 4).

The first marked change in the diatom communities of the Sundays River occurred at Station 9. Here the species composition of the diatom associations were dominated by brackish water species, i.e. euryhaline mesohalobes and a few pleioeuryhaline oligohalobes. As a result the STI values of the associations found at Station 9 were generally well above 4,0, in sharp contrast to the STI range generally experienced in the source zone (1,64 - 2,52). This notable change in the diatom associations corresponded very clearly with the sharp change in the chemistry of the waters at Station 9 compared with the source zone. Although the salinity levels at Station 9 have not been shown to be a great deal higher than in the source zone, there is some evidence for a greater fluctuation of the salinity level, which would favour the development of diatom taxa with wider salt tolerance ranges, viz. the mesohalobes and pleioeuryhaline oligohalobes. Another aspect of the chemistry of the water at Station 9, which may be significant in causing the change in nature of the diatom community, is the change-over from the carbonate ion dominance of the water in the source zone to water dominated by the chloride ion. Thus, whether influenced by the greater variability in the salt content or by the change in the ionic composition of the water, the marked change in the diatom community at Station 9 strongly supports the chemical separation of the source zone from the upper course of the river at this point.

The diatom associations observed at Station 8 (Jansenville) have the same basic species pool as Station 9, but the differences in the relative densities of these taxa give the diatom community at Station 8 a somewhat different character. Nevertheless the community is also dominated by brackish water forms (STI values 3,50 - 4,72), thus suggesting a certain amount of fluctuation in the salt content. Both Station 8 and Station 9 lie in the upper course of the Sundays River above Lake Mentz, and form a loose but distinct grouping of stations.

In the upper course of the Sundays River below Lake Mentz, Stations 7 and 6 form a further group ot stations which in terms of their diatom associations were quite distinct from the communities elsewhere in the river system. Two aspects were striking about the communities from Stations 7 and 6. Firstly, they were composed predominantly of freshwater species (meio- and mesoeuryhaline oligohalobes), and secondly, they are dominated by a single species, *Fragilaria elliptica*. It is surprising to find, however, that the mean salinity level at these two stations was of the same order of magnitude as at Stations 9 and 8. The difference here, however, appears to lie in the fact that the salt concentrations at least at Station 6 (only one measurement of the salinity was made at Station 7) remained relatively constant at just about 0,9 ‰, even during the drought period of May 1970 (see Table 32).

Whether the constancy in the salt content, or whether some change in the ionic composition, favours the development of a freshwater community is not clear. However the fact that one species, *Fragilaria elliptica*, can so completely dominate the associations suggests that some factor, not yet recognised, influences very strongly the composition of the diatom communities at Stations 7 and 6. Whatever the cause may be, the distinct difference between the communities of these two stations and those of Stations 9 and 8 indicate a natural subdivision of the upper course of the Sundays River between stations upstream of Lake Mentz and those stations below the impoundment.

The next noteworthy change in the diatom associations occurred at Station 5. This can again be correlated with a change in the water chemistry associated with the underlying rock strata. Somewhere between Station 6 and Station 5 the river commences to flow over the marine beds of the Cretaceous and Tertiary to Recent Systems. A sudden rise in the salinity levels and increases in the chloride and sodium fraction were observed at Station 5, and this trend continued throughout the lower course of the river (Stations 4A and 4) and into the estuary. As a result diatom communities in the lower course of the river were brackish water associations composed mainly of euryhaline mesohalobes and a few pleioeuryhaline oligohalobes.

Excluding the diatom communities of the seepage waters at Stations 5 and 4A, the riverine community at each station in the lower course of the Sundays River was more or less distinct, although there appeared to be some affinity between Station 5 and Station 4A. Despite having the same basic species pool the community at Station 4 appeared to differ from that of Station 4A, except in July 1967. At this time, however, there was evidence that the associations on the mud or stone substrates at Stations 5, 4A, 4 and 3 were all rather similar. None of the communities of the lower course of the

Sundays River showed any similarity to that of Station 6. Thus the evidence from the diatom communities confirmed that the natural boundary between the upper and lower courses of the Sundays River lies between Station 6 and Station 5, corresponding with the chemical and geological division.

From a physico-chemical point of view the demarcation of the estuary from the lower course of the river presents no problems. This lies between Station 4 and 3, although occasionally it may extend as far as Station 4. However, from a biological point of view there appears to be a greater affinity between Station 4 and Station 3 than between Station 3 and the rest of the estuary. Unfortunately there is little evidence to confirm this as Station 3 was sampled on only two occasions, once at the beginning of the survey (July 1967) and once at the end of the survey in May 1970 when conditions may have been slightly abnormal. The latter period will be discussed later. In July 1967 there was, however, a fairly close similarity between the associations collected on the mud and epiphytic substrates at both Stations 4 and 3 (see Tables 22 and 24 respectively). At the same period of time there appeared to be a closer affinity between the mud surface associations at Stations 2 and 1. On this scant evidence the lower estuarine stations (Stations 2 and 1) seem to form a unit distinct from Station 3. This may be the result of a greater influence of the river water on the diatom community at Station 3.

The remarks above have been confined to a discussion of the diatom communities extant in the riverine situation. Some attention must now be given to the seepage water communities found on the river banks at Stations 5 and 4A. At both these stations the seepage water associations differed markedly from the riverine assemblages. At Station 5 three different seepage situations were examined, a seepage trickle or spring issuing from the vertical bank, a pool collecting this seepage water and a larger pool somewhat further away. Despite the fact that they were not more than a few meters distant from each other, their diatom communities were surprisingly different. Within each site the diatom associations remained fairly uniform in their species composition, although changes in the dominant species were evident from time to time. What factor or factors in the microhabitats of these three seepage sites caused the differences in the diatom communities were not clear from the physico-chemical evidence available. In contrast the diatom community from the seepage water at Station 4A, while showing no similarity to the riverine community, maintained a remarkably uniform composition, although a winter and summer aspect was apparent (see Table 20). The winter associations were completely dominated by *Navicula bulnheimii*, while in the summer samples *Nitzschia elegantula, Cymbella pusilla* and *Synedra hartii* were more prominent. The uniformity of the diatom community testified to a stable environment, although it is one in which a factor, probably the extremely high salinity, exerts a stress on the community resulting in a low diversity of species.

The diatom survey of the Sundays River came to an end after a final set of samples had been collected in May 1970, towards the end of an extreme drought, from Station 6, the lower course of the river and the estuary. The response of the diatom communities to the generally greatly increased salinities in this section of the Sundays River differed somewhat from station to station. Although there was no evident change in the salinity at Station 6 at this time (in fact the salinity was a little lower than on previous occasions - see Tables 11 and 32), the diatom associations showed a change from the normally rather constant community found at this point. This was manifested by an increased proportion of brackish water species and a reduction in the dominance of *Fragilaria elliptica* (see Table 12d).

In the lower course of the river the increased salinity levels did not appear to affect to any great extent the composition of the diatom community of the riverine habitat at Station 5, nor those of the seepage water sites at this station.

Likewise at Station 4A little change was observed in the riverine and seepage communities despite a fairly substantial increase in the salinity. In contrast the two diatom associations gathered from Station 4 in May 1970 showed little similarity to the associations previously observed at this point. However, as may be seen from Table 22, the diatom community at this particular site appeared to be unstable throughout the period of the survey exhibiting frequent changes in the dominant species.

At the end of this drought period the greatest increases in the salinity were experienced at Stations 3 and 2, where the water became hypersaline (see Table 32). Marked changes in the diatom communities at these two stations might therefore be expected. This certainly appeared to be the case, since the diatom associations from the hypersaline waters bore little resemblance to those observed in the early parts of the study. Nearly all the most prominent taxa found at this time were not recorded at the earlier sampling time (July 1967). There was, furthermore, an increase in the percentage representation of the polyhalobic species. Thus it appears that the greatly increased salinity at these two stations in May 1970 had a profound effect on the composition of the diatom communities. At Station 1 where the salinity in May 1970 was less pronouncedly raised but still greater than seawater (see Table 32) the changes in the mud surface community appeared to be greater than in the community living on the pier columns of the jetty at Colchester. However in both instances there were no radical changes due to the increased salinity.

Finally the diatom association observed in the Wit River, a freshwater tributary of the Sundays River, was a predominantly freshwater association with the great majority of the taxa being oligohalobes (STI value = 2,10). This correlated very well with the chemical analysis of the water, which showed the Wit River to have a very low salinity (see Table 29).

Although the chemistry of the water in the Wit River may have a greater affinity to that of the Sundays River at Station 6 due to their close association with the Witteberg Series rocks of the Cape System, there was no affinity at all between their diatom associations. A relatively large proportion of the taxa found in the Wit River were, furthermore, restricted to this river.

The remarks passed above have dealt with the relationship between the salinity of the water and the composition of the diatom associations. Other ecological factors have not been examined so closely. Nevertheless a few observations can be made. The diatom communities of the Sundays River were composed almost exclusively from alkaliphilic or alkalibiontic species clearly reflecting the very high pH values prevalent throughout the course of the river. Only a few isolated examples of acidophilic species were encountered, obviously incidental species, and they played no significant role in the associations. Oxygen concentration measurements were made during the early parts of the survey, but since the percentage saturation was never calculated these values are virtually meaningless as far as determining the role of the oxygen content in the distribution of the diatoms is concerned. The nutrient status of the waters has not been dealt with in detail for the reasons outlined in the introductory discussion of the role of nutrients in the distribution of the diatoms (see Section 3.5). However, at various points, such as at Station 9 immediately below the sewage works outlet of Graaff-Reinet and at Stations 5 and 4A where the seepages contained abnormally high nitrate-N concentrations, the nitrogen content (organic or inorganic) may have influenced the selection of species within the communities. Unfortunately the paucity of chemical evidence in this regard makes conclusions drawn solely from the diatom associations somewhat open to groundless speculation.

5.4 The efficacy of the Salinity Tolerance Index

The underlying theory and method of calculation of the Salinity Tolerance Index (STI) has been set out above in Sections 3.6.1 and 4.2.3 respectively. The prime objective in developing this index was an attempt to condense into a numerical value the information gained from the analysis of the diatom associations with regard to their relationship to the salinity of the water. Thereby a number of associations may easily be compared with each other. Tables showing the relative composition of the diatom associations can be lengthy (e.g. the even numbered tables from Table 2 to Table 30, as well as Table 31 in the text), and comparison of the associations in such tables is difficult. A means was therefore sought to facilitate a comparison of this nature without the loss of important information.

In an investigation, such as the one undertaken in this study, an investigator wishes to know whether a particular association has been taken from a freshwater, brackish water or marine water situation. He may also wish to detect any changes that might occur within a specific community at any particular station. By means of the STI it was hoped that answers to such questions could be rapidly derived from the analysis of the diatom associations. The discussion below therefore examines the application of the STI to the diatom associations observed in the Sundays River to ascertain how well the STI fulfils the role for which it was designed.

In the source zone of the Sundays River STI values were generally found to be between 1,64 and 2,52, and only once did the value rise to 3,18. With the exception of this value, the low STI values indicated freshwater associations composed almost entirely of meio- or mesoeuryhaline oligohalobes. This correlated well with the low salinities observed in the source zone. The relatively high STI value found on the one occasion (February 1969 at Station 10 - see Table 4, SUN 60) resulted from the presence of *Amphora exigua*, an identification which may be suspect. *Amphora exigua* is regarded as a pleioeuryhaline polyhalobe (salinity value = 7), and thus its weighted contribution to the association raised the STI value to 3,18. The presence of a polyhalobe in these low salinity waters is highly suspicious, and suggests either a misidentification of the species or a wrong characterization of *Amphora exigua* as a polyhalobe. Thus, when this is taken into consideration, the low STI values for the source zone diatom associations truly reflected the type of association expected from waters of low salinity.

In the upper course of the Sundays River the situation was more interesting. As may be seen from Figure 27 the mean salinity level throughout the upper course is of more or less the same magnitude. However, the STI values of the associations observed at Stations 9 and 8 were usually greater than 4,00 (range 3,50 - 4,72), while those of the assemblages at Stations 7 and 6 seldom exceeded 2,60 (range 2,02 - 3,03). How can this discrepancy be explained? A further examination of Figure 27 might reveal the answer. It will be noticed that, although the mean salinity level for all four stations was approximately the same, the degree of variability was much greater at Stations 9 and 8 than at Stations 7 and 6. The greater variability in the salt content and the resultant fluctuation of the osmotic pressure of the medium at Station 9 and 8 created conditions conducive to the growth of diatom species with wider salt tolerance ranges. The STI values of about 4,00 or more, found at these two stations, indicated exactly this, since they reflected associations composed predominantly of euryhaline mesohalobes and a few pleioeuryhaline oligohalobes. In contrast at Stations 7 and 6 the salt content was fairly constant, and a constant but relatively low salinity favours the development of diatom taxa which are more stenohaline with regard to their salt tolerance ranges. Again the STI values of 2,60 and less reflected this, since they imply that the predominant taxa in the associations were meio- to mesoeuryhaline oligohalobes.

In the lower course of the Sundays River (Stations 5, 4A, and 4), including the seepages at the upper two stations, the salinity levels became too high for the development of freshwater associations. Consequently in this section of the river the STI values of the diatom associations were in nearly all cases greater than 4,00. This reflected a clear dominance of euryhaline mesohalobes in the associations, as may be expected. Only in the riverine section at Station 5 did the presence of *Achnanthes minutissima*, a meioeuryhaline oligohalobe probably near the limit of its tolerance range, make an impact by reducing the STI value of the associations to about 3,50 or less in a number of instances (see Tables 14a and b).

It may be expected that in the estuarine section of the Sundays River the diatom associations would be composed almost entirely of brackish water species (i.e. euryhaline mesohalobes) with the intrusion of some of the more tolerant marine species, i.e. the polyhalobes. That this was the case was reflected by the STI values of the diatom associations observed from the estuarine zone. In nearly all instances these values exceeded 5,00, a situation that can only occur if some polyhalobes were present in the assemblages (see theoretical background discussed in Section 3.6.1).

In May 1970 at the end of a prolonged drought substantial increases in the salinity levels at the Stations in the lower course and estuary were experienced, particularly at Stations 3 and 2 where the water became markedly hypersaline. No conspicuous changes in the STI values for the diatom assemblages from Stations 5 and 4A were noted. This was to be expected as these two stations are too far removed from any marine influence for any polyhalobic species to have any effect on the STI value. Consequently the maximum STI value that associations at these stations can obtain is 5,00, allowing little room for significant changes in the STI values normally prevailing at these sites. However, at Station 4 and in the estuary substantial increases in the STI values were noted. This can be ascribed in all cases to the greater contribution of polyhalobic species (generally pleioeuryhaline forms) to the associations made possible by the high and probably more constant salinities.

From the above evidence a certain aspect of the STI becomes clear and needs some comment. Although the STI is a numerical value, it cannot be regarded as a qualitative indicator of the salt concentration of a water body as it has no direct linear relationship to the salinity. To illustrate this the situation in the Sundays River can be used. STI values in the range 1,00 - 3,00 indicate oligohalobic associations found in waters of low and relatively constant salinities. In the Sundays River such associations were found only in waters with salinities of 1,0 ‰ or less. In constrast STI values of 3,50 - 5,00 indicate brackish water associations composed of species adapted to live in waters with a wide range of salinities. Thus STI values in this relatively narrow range can be indicative of a very wide salinity range. In the Sundays River, diatom associations having STI values falling into this range were obtained in waters with salinities varying from about 1,0 ‰ to about 21,0 ‰. STI values greater than 5,00 can only occur when polyhalobic taxa contribute towards the associations (see theoretical discussion in Section 3.6.1). Thus in the Sundays River STI values greater than 5,00 were generally found only in the estuary. Some values greater than 5,00 were, however, observed at Station 4, which may on occasions come under the influence of the tides, and also in the seepage water at Station 4A, which has a high salt content and an ionic composition close to seawater. Although no true marine environment was examined in this study, it will also be clear that STI values in the range 8,00 - 10,00 can only be found in marine situations, where the salinity remains fairly constant within a narrow range between about 30,0 ‰ and 35,0 ‰. On these considerations it seems clear that the STI is not a qualitative indicator of the salinity level, but it is rather a numerical expression ot the character of the diatom association.

Finally it may be said that the Salinity Tolerance Index appears to be effective in distinguishing the nature of the association, i.e. whether it is of freshwater, brackish water or marine origin. It can also be used efficiently to make rapid comparisons between a number of diatom associations in revealing the salt tolerance ranges of the dominant taxa. It cannot, however, be used to estimate the salinity level of a water body, except to a very limited extent. Thus in at least the first two characteristics the Salinity Tolerance Index fulfils the objectives for which it was developed.

6. CONCLUDING REMARKS.

In this study of the benthic diatom associations from the Sundays River a total of 331 taxa in 37 genera has been observed. Of this number only 15 taxa belonged to the major group of diatoms known as the Centricae, while the remainder were members of the Pennatae. Despite their poor representation in terms of the number of taxa present, the centric forms were, nevertheless, often fairly abundant in the diatom associations found at certain stations. They occurred mainly in the lower course and estuary, although *Stephanodiscus hantzschii* (Stations 11 and 7), *Thalassiosira pseudonana* (Station 8) and *Thalassiosira weissflogii* (Station 9) were more prominent in the upper course of the river and in the source zone. The greatest number of pennate forms belonged to the genera *Navicula* (85 taxa) and *Nitzschia* (80 taxa). Thus about half the taxa observed (161 taxa) belonged to the remaining 35 genera, with *Amphora* (19 taxa) being the next most prominent genus. All the others had 10 or fewer taxa, while 7 genera had only one taxon each.

In Table 33 a breakdown of the distribution of the taxa in each of Simonsen's (1962 : 17) salt tolerance categories is presented for each genus encountered in this survey. Five taxa were not characterized with respect to their salt tolerances owing to a lack of information. Approximately half the taxa (164) were classified as oligohalobes, while the remainder was divided unevenly among the other two major categories, the mesohalobes having 101 taxa and the

TABLE 33. The distribution of taxa in various genera in Simonsen's salt tolerance categories

Category	Halo-phobe	Oligohalobes			Mesohalobes			Polyhalobes		
		meio-	meso-	pleio-	eury-	holo-	pleio-	meso-	meio-	oligo-
Salinity value	0	1	2	3	5	6	7	8	9	10
Genus										
Achnanthes		3	1		5			1		
Amphiprora					4			1		
Amphora		3	2		9		5			
Anomoeoneis		1	1		1					
Bacillaria						1				
Berkeleya								1		
Caloneis		2	2		1				1	
Campylodiscus					2					
Campyloneis										1
Cocconeis	1		1	3	2		1			
Coscinodiscus								1		
Cyclotella		2		1	1					
Cylindrotheca					1				1	
Cymatopleura		1								
Cymbella		4	2		2					
Denticula					1					
Diploneis		1	1		1		1		2	1
Epithemia			1	2						
Eunotia	3									
Fragilaria		2	1		1					
Frustulia			2		1					
Gomphonema		8					1			
Gyrosigma		2	2		4		1		1	
Hantzschia			4							
Mastogloia				1	2		3			
Melosira		1	1		1		2			
Navicula		33	13	7	22		4	1	5	
Nitzschia		17	20	2	25	1	2	2	11	
Pinnularia		4		1						
Pleurosigma					1					
Rhopalodia			1		1					
Stauroneis		1			3		1			
Stephanodiscus			1							
Surirella		1	2	1	1		1	1		1
Synedra		1	1		3					
Thalassiosira					2	1	1			
Tropidoneis					1			1		1
Totals	4	87	59	18	98	3	23	9	21	4

Taxa not characterized - 5

Grand Total = 331 taxa.

polyhalobes containing 57 taxa. The halophobic species were the smallest group, being represented by 3 taxa in the genus *Eunotia* and one from the genus *Cocconeis*. Considering the distribution of the taxa within the individual salt tolerance categories, the euryhaline mesohalobes contained the largest number of taxa (98 taxa). This was closely followed by the meioeuryhaline oligohalobes with 87 taxa and then the mesoeuryhaline oligohalobes having 59 taxa. Thereafter there was a marked drop in the number of taxa belonging to the remaining categories. The pleioeuryhaline oligohalobes and the pleio- and meioeuryhaline polyhalobes contained between 18 and 23 taxa each, while the mesoeuryhaline (9 taxa) and oligoeuryhaline polyhalobes (4 taxa) were the most poorly represented categories other than the halophobes. No representatives of the holoeuryhaline oligohalobes were encountered in this survey.

Most of the poorly represented genera seemed to have had a fairly even distribution of taxa amongst the salt tolerance categories, although some had a preponderance in one or other major group. Thus the genera *Cymbella, Epithemia, Gomphonema* (almost exclusively meioeuryhaline oligohalobes), *Hantzschia* and *Pinnularia* were mainly oligohalobic forms, while the genera *Amphiprora, Amphora* and *Thalassiosira* were chiefly mesohalobic in nature with a few polyhalobic forms included. The genus *Tropidoneis* (3 taxa) was mainly represented by polyhalobic forms, while *Berkeleya, Campyloneis* and *Coscinodiscus*, with one taxon each, were only represented by polyhalobic taxa. The two largest genera in terms of numbers of taxa, *Navicula* and *Nitzschia*, naturally followed the overall trend of dominance by oligohalobes, but, when the individual salt tolerance categories are considered, the greatest number of *Navicula* taxa fell into the meioeuryhaline oligohalobe group (33 taxa). There were 13 *Navicula* taxa in the mesoeuryhaline oligohalobes and 7 in the pleioeuryhaline oligohalobes. Twenty two taxa in the genus *Navicula* belonged to the euryhaline mesohalobes, and 10 taxa to the polyhalobes. On the other hand in the genus *Nitzschia* most taxa belonged to the euryhaline mesohalobe category (25 taxa), while the next largest group was the mesoeuryhaline oligohalobes (20 taxa). This was followed by the meioeuryhaline oligohalobes with 17 *Nitzschia* taxa and the meioeuryhaline polyhalobes with 11 taxa.

The distribution of the taxa, most significant from an ecological point of view (i.e. those taxa that appear in an association with a relative density >1 %), in Simonsen's salt tolerance categories is shown for each station in Table 34. It can be clearly seen that the oligohalobic forms were far more prevalent in the source zone (Stations 11 and 10) and in the upper course of the river (Stations 9, 8, 7 and 6). This does not necessarily mean that they were the most important taxa in the associations. For instance at Stations 9 and 8, although oligohalobes composed more than half of the taxa present, the mesohalobic taxa were the dominant forms in terms of abundance.

A few oligohalobic taxa, mainly meso- and pleioeuryhaline forms, were present in the lower course of the river and estuary, although in the latter zone their occurrence, except for the pleioeuryhaline forms, may have been purely incidental. A notable exception, however, is the presence of one meioeuryhaline oligohalobe (the least tolerant oligohalobic group) throughout the lower course and estuary. In all cases this was the species *Achnanthes minutissima*. It is, however, not certain whether this species was actually living under these highly saline conditions particularly in the estuary, or whether it had been transported into this environment from one more conducive to its growth. If it is assumed that they were reproducing in this situation then a reclassification of this taxon with reference to Simonsen's system may be necessary.

It is also evident from Table 34 that the greatest number of euryhaline mesohalobes were found in the lower course and estuary, while the polyhalobic taxa were most numerous in the estuary. Nevertheless an anomaly was also found in the presence of a pleioeuryhaline polyhalobe at most of the stations in the upper course and source zone of the river far from any marine contact. This was the result of the occurrence of two species, *Amphora exigua* (Station 10) and *Navicula mollis* (Stations 9, 7 and 6). In

TABLE 34. The distribution of the most significant taxa in Simonsen's salt tolerance categories for each Station. (The information is taken from the tables in the text showing the composition of the diatom associations)

Category		Oligohalobes		Mesohalobes			Polyhalobes			Total
	meio-	meso-	pleio-	eury-	holo-	pleio-	meso-	meio-	oligo-	
Salinity value	1	2	3	5	6	7	8	9	10	
Station										
11	5	7	2							14
10	11	16	7	5		1				40
9	1	4	5	12	1	1				24
8	3	6	4	8	1					22
7	1	8	4	4		1				18
6	11	12	5	10		1				39
5	2	5	3	20		1				31
5 seepage	1	4	5	21		1				32
4A	1	3	3	16		2	1			26
4A seepage				12		2				14
4	1	6	4	24		6	3	1		45
3	1		5	24		7	2			39
2	1	1	1	20	1	8	4	3		39
1	1	1	2	25		6	4	3		42
Wit River	4	5	2	2						13
Lake Mentz	2	4	2	1		1				10

both cases there is some uncertainty with regard to their identification. However, when this has been properly established, their autecological characterization may alter sufficiently for a better correlation to be made between them and the environmental conditions in which they grow.

This study of the diatom associations of the Sundays River makes an important contribution to diatom research in this country, as it is perhaps the first full examination of the diatom flora in a major river course from near its source to its estuary. Owing to the salinity gradient throughout the river course, the Sundays River provided, furthermore, an excellent subject for the examination of diatom associations in relation to the salt content of the water. Not only was there a simple salinity gradient but other factors, such as the ionic composition and the amplitude of salt content fluctuations, were available for examination as influences governing the composition of the diatom associations. In the lower course of the river at Stations 5 and 4A two seepage waters made interesting comparisons with the riverine flora at these sites. In the estuary the effect of mixing seawater with already highly saline water on the diatom flora was observed. Finally the effect of a prolonged and severe drought on the diatom associations was studied in May 1970. At this time hypersaline water in the upper estuary (Stations 3 and 2) resulted in profound changes in the diatom flora.

Finally this investigation presents another significant aspect. Through it a basic knowledge of the diatom associations existing in the Sundays River prior to the introduction of water from the Orange River Development Project has been gained. Orange River water, via the Great Fish River, flowed for the first time into the Sundays River through Lake Mentz in 1978, and continued for approximately a full year (personal communication from G. Hall, NIWR). Whether any significant changes in the diatom associations of the lower Sundays River, i.e. from Station 7 downwards, will result from this Orange River water having a different quality to that of the Sundays River is not known. Apart from the short distance between Lake Mentz and Korhaans Drift Station 6), this water will not flow directly in the Sundays River bed. Instead at Korhaans Drift the weir will divert it into the irrigation canals of the lower Sundays River valley. Nevertheless, with a more constant source of water for irrigation purposes along the banks of the lower course of the Sundays River an increase in the seepage return to the river bed might be expected. The quality of the river water may therefore be affected by salinity rises in the seepage return water, as well as by the raising of the nutrient concentrations through the greater leaching of agricultural fertilizers. The information obtained through this study can therefore serve as a base line for any future investigation to measure the magnitude of the changes due to the Orange River water by observing its effects on the diatom associations in the lower Sundays River.

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AN INVESTIGATION INTO THE TAXONOMY OF THE DIATOMS (BACILLARIOPHYTA) OF THE SUNDAYS AND GREAT FISH RIVERS, WITH ECOLOGICAL OBSERVATIONS ON THE SUNDAYS RIVER

Volume 3

ATLAS OF SOME OF THE DIATOM TAXA OBSERVED IN THE SUNDAYS AND GREAT FISH RIVERS

The third Volume of this thesis contains the plates illustrating some of the diatom taxa observed in the Sundays and Great Fish rivers. The illustrations consist of line drawings, photographs, and electron micrographs.

Each of these three techniques depicting the diatom taxa illustrated herein have a value of their own. Until recently line drawings were the chief method of illustrating diatom species. The main advantage of this technique is that most of the characteristic features of the taxon can be shown in one drawing. Line drawings, however, have the weakness that individual styles of drawing influences what or how certain features are depicted. Some illustrations in the literature are done in great detail, while others may be sketchy, and yet others have become so stylized that recognition of the actual specimen from the drawing is difficult. The use of a good camera lucida overcomes many of these objections, but even so quality can be variable. All drawings in this study were executed with a Zeiss camera lucida having an adjustable magnifier. The line drawings were made at a magnification of 4000 X, and subsequently reduced to a 1000 X enlargement.

In modern diatom taxonomy the use of light photography has attained greater prominence. Its principal virtue is that it is a true representation of the specimen, and as such is scientifically more accurate. It suffers, however, from a number of disadvantages. Firstly, a suitable specimen lying in the correct plane must be found to show the important features. Secondly, a single photograph of a specimen rarely shows all the features of a valve because of the limited depth of focus at the high magnifications normally used in this study (usually greater than 1000 X). Accordingly for many specimens a number of photographs of the same specimen at different focal levels must be taken to show all the relevant characteristics of the valve. Furthermore, different modes of illumination, such as bright field, phase contrast and oblique light illumination, must be used to elucidate certain features. In this study phase contrast illumination was favoured for examining specimens, since it brings out the details of the valve structure more clearly. In photography, however, there is a disadvantage in that phase contrast often produces phase rings, which obscures the outline of the specimen. This can be eliminated by the use of bright field illumination, which was also employed in the photography of large specimens. Oblique light illumination was primarily applied to the examination and photography of thin walled valves in which the striae were indistinct or invisible with the other types of illumination. By projecting the light obliquely onto the specimen a relief effect is obtained enabling the striae to be seen with greater clarity within certain limits of striae density. Photographs of specimens in this study were obtained with a Reichert Photo-Automatic camera system mounted on a Zeiss Standard RA research microscope employing the three types of illumination mentioned above, and using Kodak Panatomic X film (ASA 32). Unless otherwise stated, the images in all photographs were enlarged to 1000 X the size of the specimen.

Electron microscopy was not an important aspect of the taxonomic and morphological studies of the diatom taxa observed in this investigation, but, where EM information was available, it was incorporated into the taxonomic discussions of the relevant taxa. Both the transmission (TEM) and the scanning (SEM) electron microscopes were employed to examine the fine structure of certain specimens in the Sundays and Great Fish rivers. TEM micrographs were made on a Philips EM 301 instrument at 60 kV using Agfa-Gevaert 23D50 "Scientia", slow orthochrome plates (ASA 6-12). SEM micrographs were obtained on a Jeol JSM-35 scanning electron microscope having a rotating and tilting stage (0-60°) at 15 or 25 kV, and using Kodak Verichrome Pan (VP 120) film having an ASA of 125. Magnifications of all the EM micrographs are stated for each individual micrograph in the legends to the relevant plates.

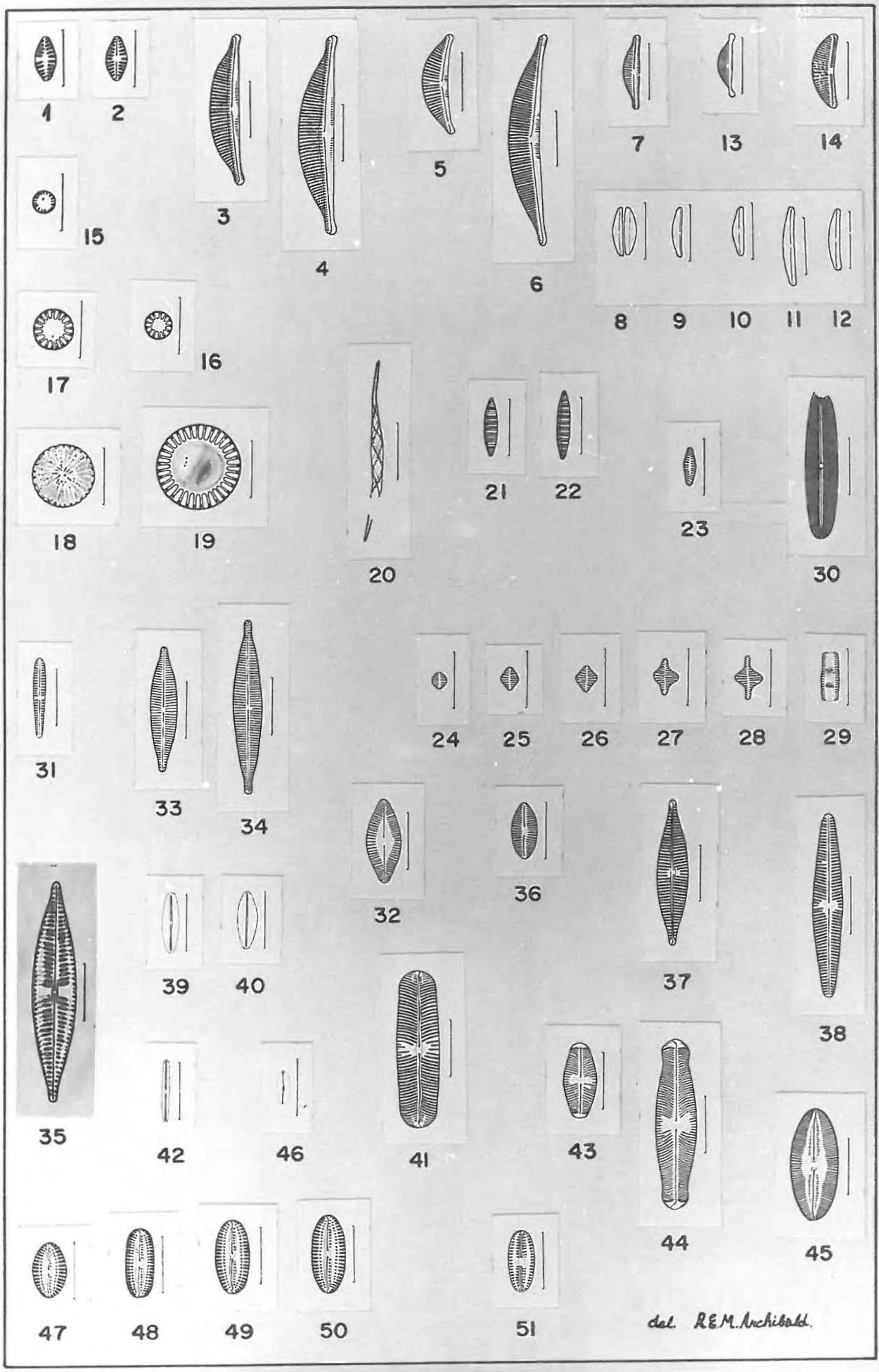
The plates contained in this volume commence with line drawings of 40 taxa on Plates 1 and 2. Plates 2 - 22 contain photographs of 140 taxa, while 28 taxa are illustrated in the EM micrographs on Plates 23 - 34. Finally Plate 35 has photographs of two taxa that had unfortunately been omitted from their correct position in Plates 3 - 22. The order in which the taxa appear in these plates follows that of the taxonomic section of this study in Volume 1.

Plate 1

(Scale bar = 10 μm)

1	*Achnanthes hauckiana* Grunow : rapheless (epi-) valve.
2	*Achnanthes hauckiana* Grunow : raphe (hypo-) valve.
3, 4	*Amphora acutiuscula* Kützing
5, 6	*Amphora coffaeaformis* (Agardh) Kützing
7	*Amphora cognata* Cholnoky
8-12	*Amphora micrometra* Giffen
13	*Amphora tenuissima* Hustedt
14	*Amphora veneta* Kützing
15	*Cyclotella atomus* Hustedt
16-19	*Cyclotella meneghiniana* Kützing
	16, 17, 19 - "*C. meneghiniana*" type valve structure.
	18 - "*C. cryptica*" type valve structure.
20	*Cylindrotheca fusiformis* var. *enodis* Reimann & Lewin
21, 22	*Denticula sundaysensis* n.sp.
23	*Fragilaria atomus* Hustedt
24-29	*Fragilaria sundaysensis* n.sp.
30	*Frustulia interposita* var. *incomperta* (Lewis) Cleve
31	*Gomphonema exiguum* Kützing
32	*Navicula confervacea* (Kützing) Grunow
33, 34	*Navicula elkab* O. Müller
35	*Navicula finmarchica* (Cleve & Grunow) Cleve
36	*Navicula frugalis* Hustedt
37	*Navicula gregaria* Donkin
38	*Navicula grosschopfi* Hustedt
39, 40	*Navicula iranensis* Hustedt
41	*Navicula laevissima* Kützing
42	*Navicula lineola* Grunow
43, 44	*Navicula pupula* Kützing
45	*Navicula pygmaea* Kützing
46	*Navicula saprophila* Lange-Bertalot & Bonik
47-50	*Navicula tenera* Hustedt
51	*Navicula umpatica* Cholnoky

Plate 1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del. R.E.M. Archibald.

Plate 2

(Scale bar = 10µm)

52, 53	*Nitzschia adductoides* n.sp
54, 55	*Nitzschia admissoides* Cholnoky
56	*Nitzschia apiculata* (Gregory) Grunow
57	*Nitzschia calida* Grunow
58	*Nitzschia communis* Rabenhorst
59-61	*Nitzschia dissipatoides* n.sp
62, 63	*Nitzschia elegantula* Grunow
64	*Nitzschia hungarica* Grunow
65	*Nitzschia marginata* Hustedt
66, 67	*Nitzschia sublanceolata* n.sp
68	*Stauroneis wipplingeri* Cholnoky

Plate 2


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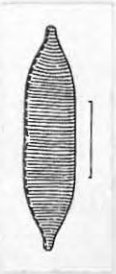
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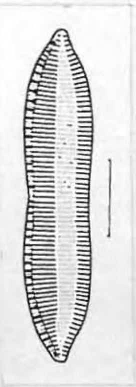
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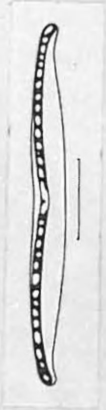
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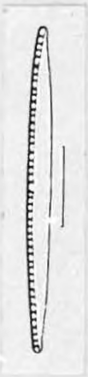
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del. R.E.M. Archibald

Plate 3

(Magnification = X 1000, unless otherwise stated)

69, 70 *Achnanthes brevipes* var. *intermedia* (Kützing) Cleve
Rapheless valve. Note "eyespot" (Orbiculi) at poles.
- 69 - upper pole in focus.
- 70 - lower pole in focus.

71-74 *Achnanthes brevipes* var. *parvula* (Kützing) Cleve
- 71, 72 - A frustule showing rapheless valve (Fig. 71) and raphe valve (Fig. 72).
- 73, 74 - A single valve focussing on centre (Fig. 73) and poles (Fig. 74).

75-80 *Achnanthes engelbrechtii* Cholnoky
- 75, 76 - A frustule showing rapheless valve (Fig. 75) and raphe valve (Fig. 76).
- 77, 80 - Rapheless valves.
- 78, 79 - A frustule showing rapheless valve (Fig. 78) and raphe valve (Fig. 79).

81-83 *Achnanthes punctifera* Hustedt
- 81 - Rapheless valve.
- 82, 83 - Raphe valves. Note isolated pore at end of central stria.

84-86 *Amphiprora corrugata* Giffen
- 84, 85 - A valve : focussing on the poles.
- 86 - Another valve : to show corrugated girdle bands.

87, 88 *Amphiprora duplex* Donkin

89-92 *Amphora acutiuscula* Kützing

93 *Amphora angusta* Gregory

94, 95 *Amphora castellata* Giffen : note the longitudinal costae.

Figs 69-83, 87-92, 94, 95 - Phase contrast illumination.

Figs 84-86, 93 - Bright field illumination.

Plate 3


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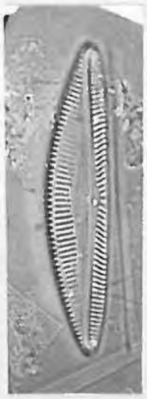
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Plate 4

(Magnification = X 1000, unless otherwise stated)

96-100 *Amphora coffaeaformis* (Agardh) Kützing

101-104 *Amphora cognata* Cholnoky

102, 103 - Same valve : focussing on valve outline (Fig. 102) and stria (Fig. 103).

105, 106 *Amphora commutata* Grunow.

105 - Frustule in bright field illumination.

106 - Same specimen in phase contrast illumination.

107-112 *Amphora cymbamphora* Cholnoky

107-109 - Atypical forms observed only in the Sundays River.

110-112 - Forms typical of the taxon.

113, 114 *Amphora exigua* Gregory

115-119 *Amphora helenensis* Giffen

119 - Frustule in girdle view.

120-122 *Amphora luciae* Cholnoky

123-125 *Amphora micrometra* Giffen

125 - Frustule in girdle view.

126, 127 *Amphora ovalis* var. *affinis* (Kützing) Van Heurck

Note the closed (Fig. 126) and open (Fig. 127) central area on the dorsal side.

128-133 *Amphora sabiniana* Reimer

Note the thickening of the central nodule on the dorsal side, so that the central striae are somewhat shortened. Also note the longitudinal line just above the raphe in Figs 128, 131 and 133.

132, 133 - the same specimen at different levels of focus.

Figs 96-104, 106-114, 120-125, 128-133 - Phase contrast illumination.

Figs 105, 115-119, 126, 127 - Bright field illumination.

Plate 4


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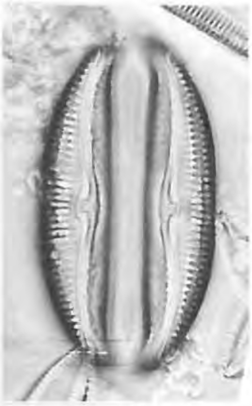
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Plate 5

(Magnification = X 1000, unless otherwise stated)

134-136 *Amphora subacutiuscula* Schoeman

137, 138 *Amphora tenuissima* Hustedt

- 137 - Phase contrast illumination showing valve outline.
- 138 - Oblique light illumination showing fine striae.

139-144 *Anomoeoneis sculpta* (Ehrenberg) Cleve

- 139, 141, 143 - Phase contrast illumination.
- 140, 142, 144 - Bright field illumination.

Plate 5


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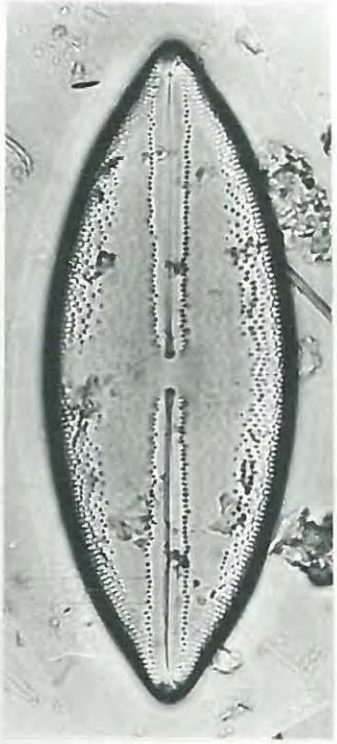
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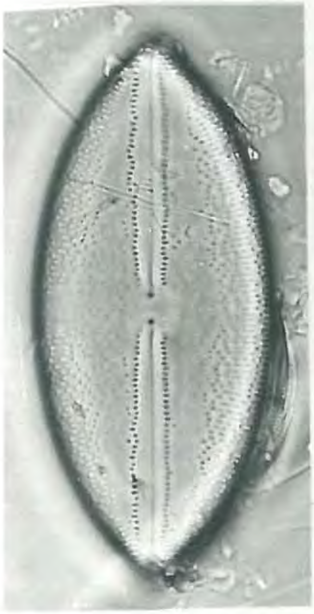
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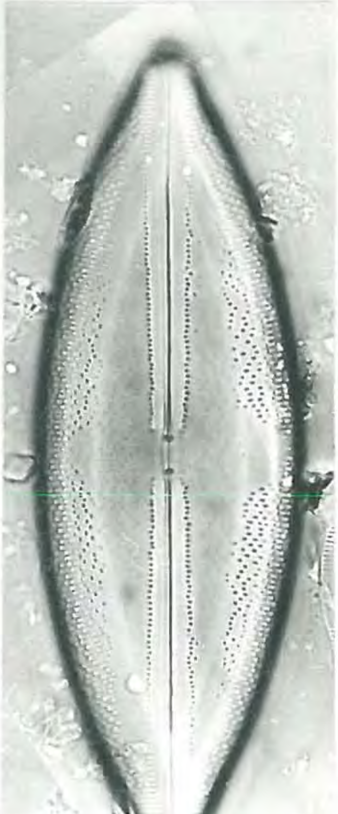
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Plate 6

(Magnification = X 1000, unless otherwise stated)

145-147 *Anomoeoneis sphaerophora* (Kützing) Pfitzer

145a, 146 - Phase contrast illumination.

145b, 147 - Bright field illumination.

148, 149 *Berkeleya rutilans* (Trentepohl) Grunow

150, 151 *Caloneis liber* (W. Smith) Cleve

150 - Phase contrast illumination.

151 - Bright field illumination.

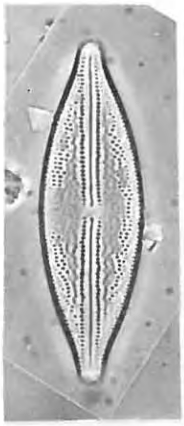
152-154 *Caloneis permagna* (Bailey) Cleve

152 - Phase contrast illumination.

153, 154 - Bright field illumination.

Plate 6


145a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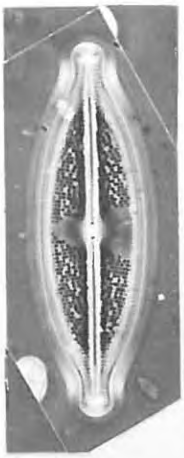
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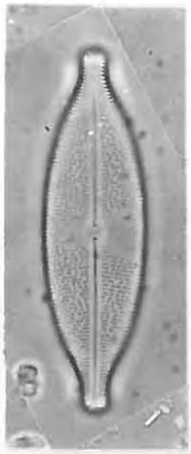
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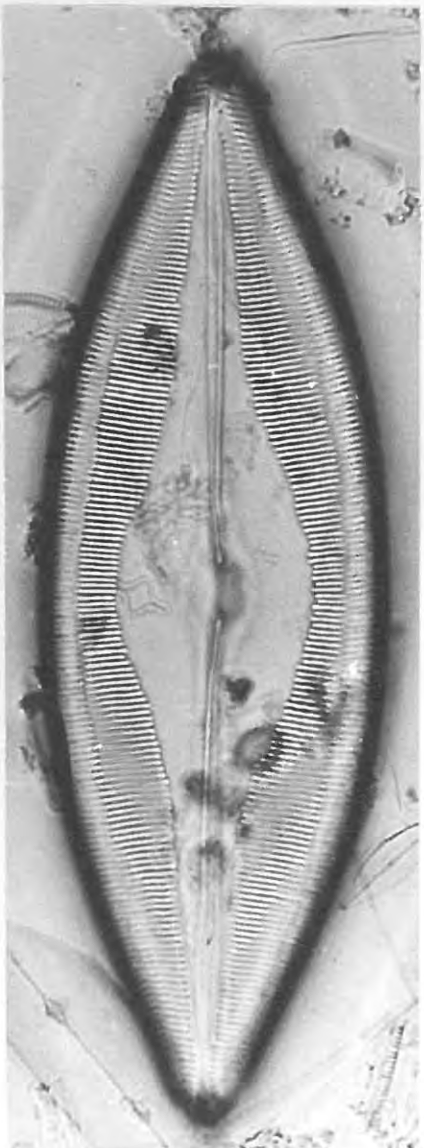

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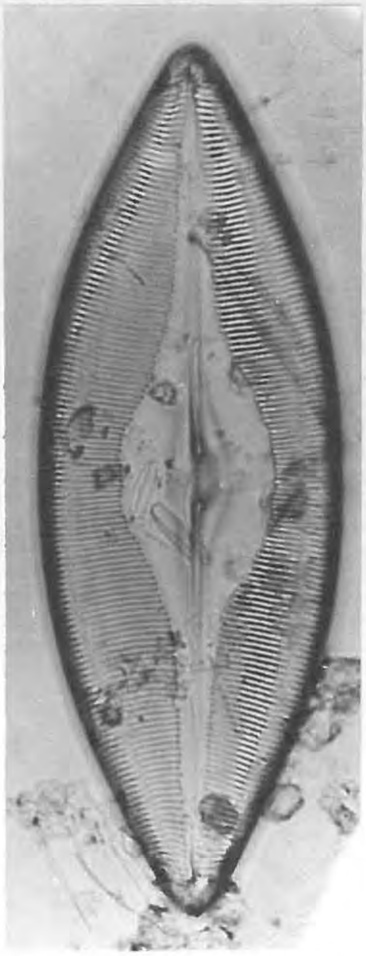

Plate 7

(Magnification = X 1000)

155 *Campylodiscus clypeus* Ehrenberg
Bright field illumination.

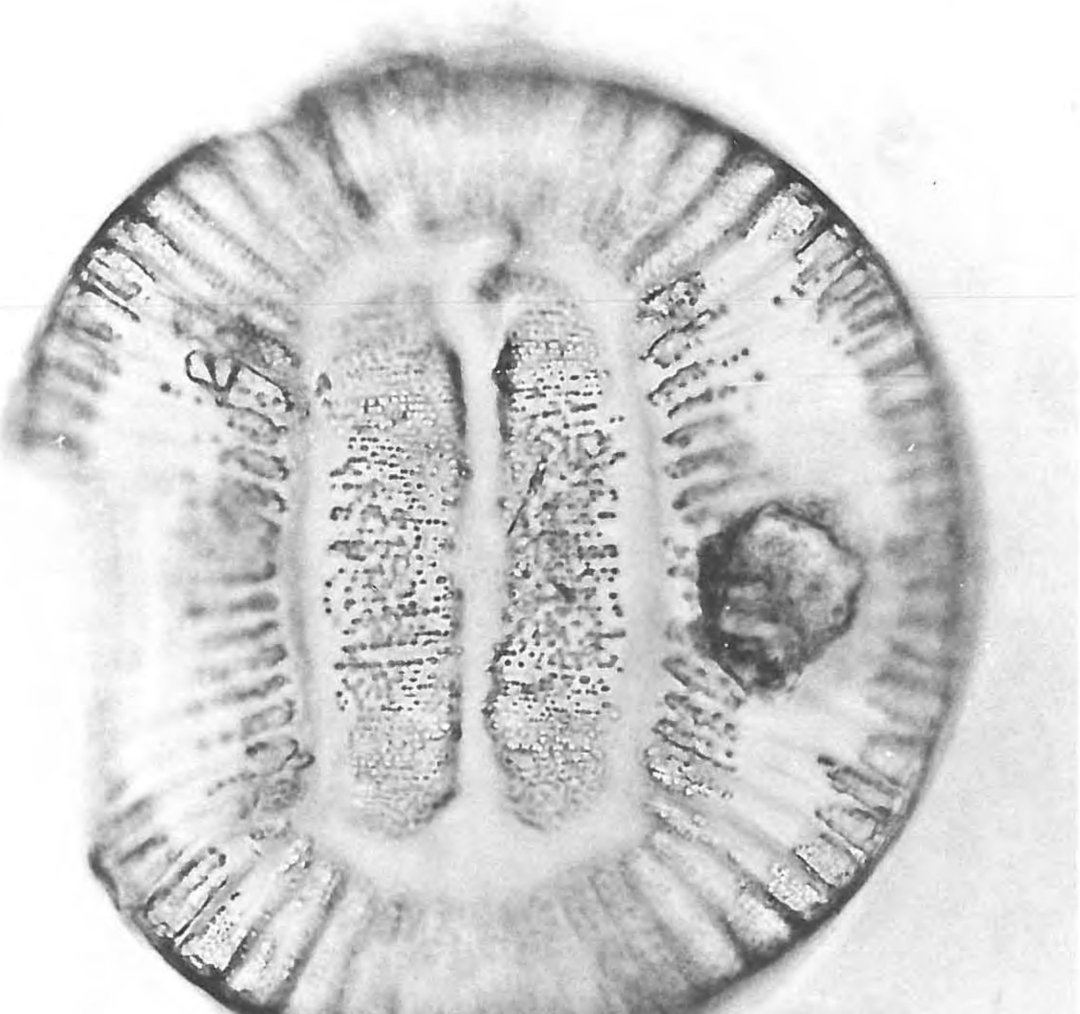

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Plate 8

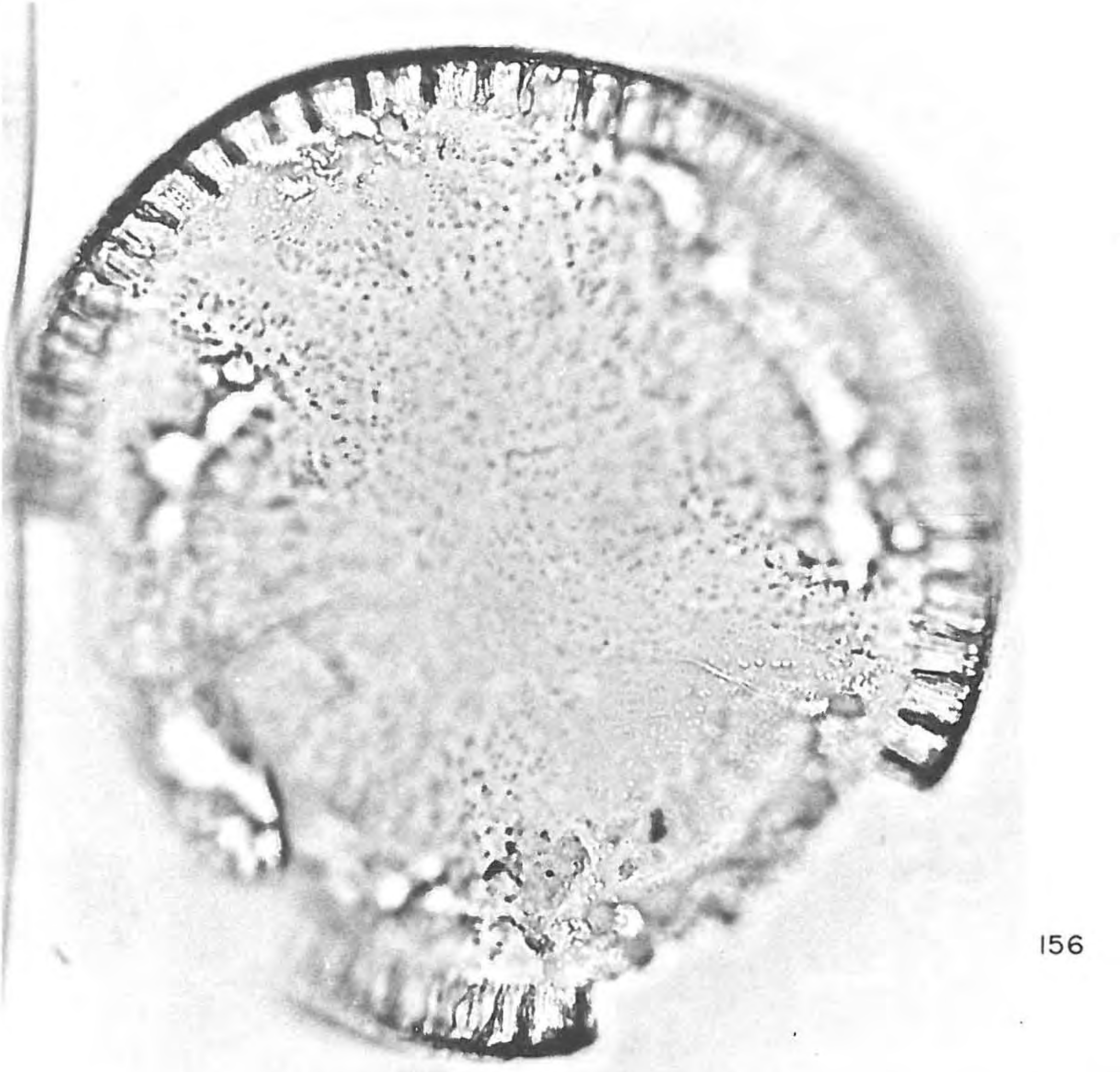
(Magnification = X 1000)

156, 157 *Campylodiscus echeneis* Ehrenberg

Note the central region with scattered puncta having no particular arrangement.

156 - Bright field illumination.

157 - Top half of the same specimen in phase contrast illumination.



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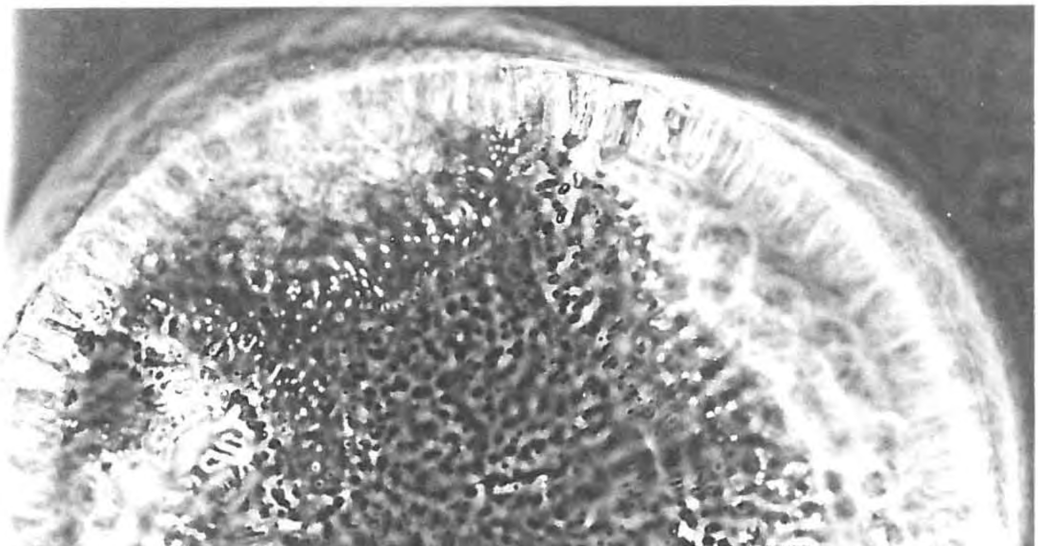

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Plate 9

(Magnification = X 1000, unless otherwise stated)

158-160	*Campyloneis grevillei* (W. Smith) Grunow The same frustule at different levels of focus. 158 - Raphe valve : note finer structure of the striae. 159 - The internal skeleton consisting of axial rib with radiating branches joined to a marginal rim. 160 - Rapheless valve with more coarsely punctate striae.
161-167	*Cocconeis engelbrechtii* Cholnoky 161-163 - Raphe valves (hypovalves). 164-167 - Rapheless valves (epivalves). Note lateral branches radiating out from the axial rib.
168	*Cocconeis scutellum* var. *parva* (Grunow) Cleve
169-171	*Cyclotella atomus* Hustedt
172-174	*Cyclotella caspia* Grunow
175-180	*Cyclotella meneghiniana* Kützing 175-177 - Valves with the "*C. meneghiniana*" type valve structure. 178-180 - Valves with the "*C. cryptica*" type valve structure.
181, 182	*Cylindrotheca fusiformis* var. *enodis* Reimann & Lewin
183, 184	*Cymbella kappii* (Cholnoky) Cholnoky
185	*Cymbella kolbei* Hustedt
186-188	*Cymbella oahuensis* Hustedt
189, 190	*Denticula sundaysensis* n.sp.

Figs 158-160, 167, 183, 184, 188 - Bright field illumination.

Figs 161-166, 168-182, 185-187, 189, 190 - Phase contrast illumination.

Plate 9


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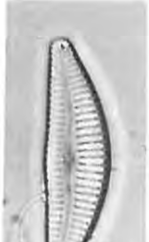
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Plate 10

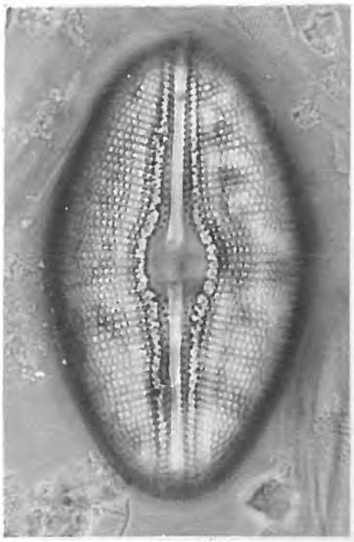
(Magnification = X 1000, unless otherwise stated)

191-193	*Diploneis fusca* (Gregory) Cleve
194	*Diploneis pseudopetersenii* Cholnoky
	Note striae in central nodule.
195-198	*Epithemia reicheltii* Fricke
199-206	*Fragilaria elliptica* Schumann
	199-204 - Valves in valve view.
	205, 206- Colony formation in girdle view.
207-216	*Fragilaria sundaysensis* n.sp.
	216 - Two frustules in girdle view.
217	*Frustulia interposita* var. *incomperta* (Lewis) Cleve
218, 219	*Gomphonema exiguum* Kützing

Figs 191-193, 195-198, 205, 206, 218, 219 - Bright field illumination.

Figs 194, 199-204, 207-217 - Phase contrast illumination.

Plate 10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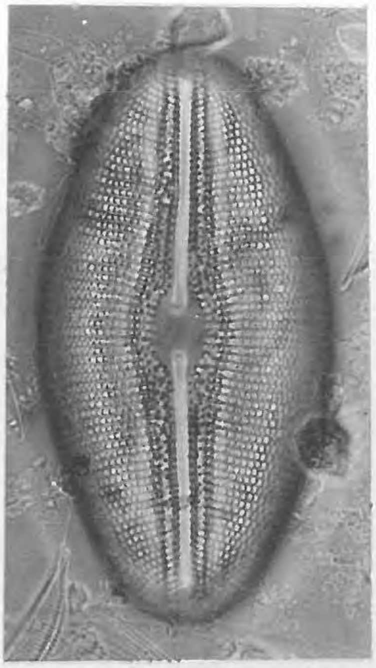
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Plate 11

(Magnification = X 1000, unless otherwise stated)

220-222 *Gyrosigma distortum* var. *parkeri* (Harrisson) Cleve

220a - Enlargement of pole of specimen in Fig. 220. X 2000

222a - Enlargement of centre of specimen in Fig. 222. X 2000.

223, 224 *Gyrosigma obscurum* (W. Smith) Griffith & Henfrey

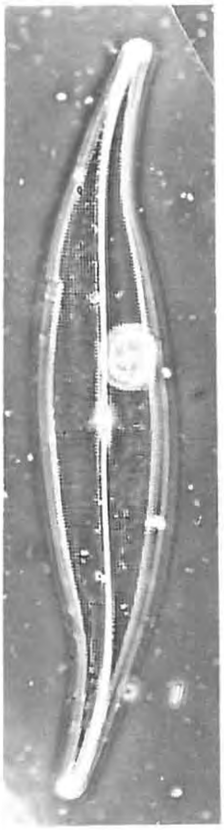
Note strongly obliquely running raphe at the centre of the valve.

223a - Enlargement of centre of specimen in Fig. 223. X 2000. Note arcuate transverse striae indicating curvature of the valve surface up to the raphe.

Figs 220, 222a, 223, 224 - Phase contrast illumination.

Figs 221, 222 - Bright field illumination.

Plate 11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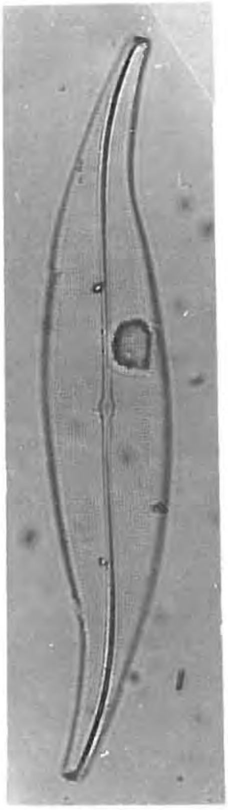
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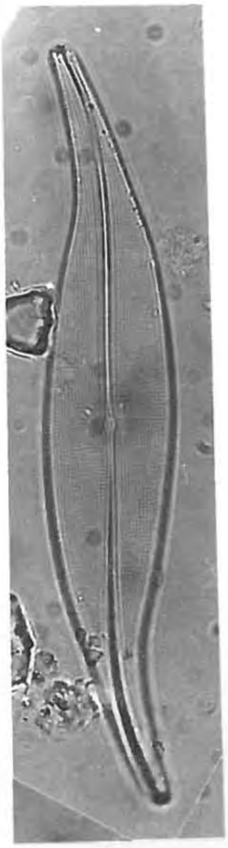
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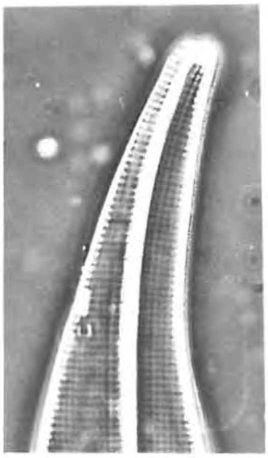
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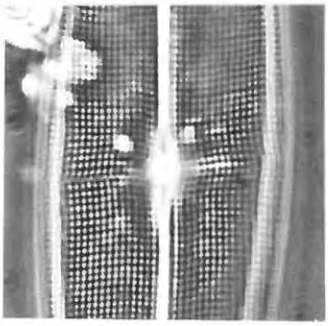
222a

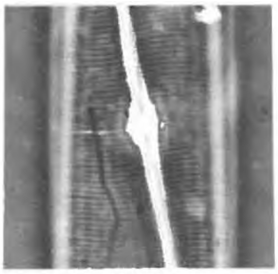
223a

Plate 12

(Magnification = X 1000, unless otherwise stated)

225-228 *Gyrosigma prolongatum* var. *closterioides* (Grunow) Cleve

225 - Sepcimen with poles curving in opposite directions.

226, 227 - Specimens with poles curving in the same direction.

226a - Enlargement of pole of specimen in Fig. 226 showing 180° twist of the pole (X 2000).

227a - Enlargement of pole of specimen in Fig. 227 showing normal pole with no twist (X 2000).

228 - Centre of another specimen enlarged : note longitudinal striae (X 2000).

Figs 225-228 - Phase contrast illumination.

Plate 12


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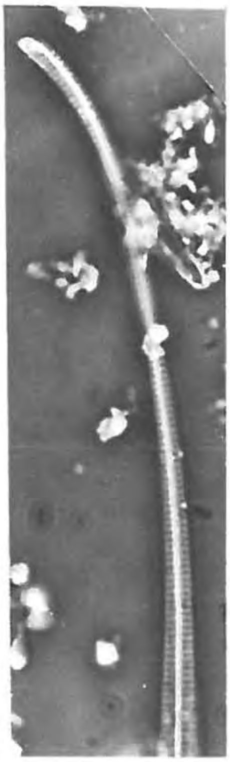
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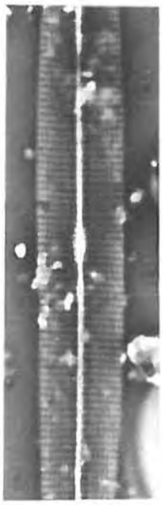
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Plate 13

(Magnification = X 1000, unless otherwise stated)

229, 230 *Gyrosigma stompsii* Cholnoky

229a, 229b - Pole and centre of specimen in Fig. 229 enlarged (X 2000).

230a, 230b - Pole and centre of specimen in Fig. 230 enlarged (X 2000).

231-234 *Mastogloia aquilegiae* Grunow

231 - A valve : focussing on striae.

232 - The same valve : focussing on the sinuous raphe.

233 - The same valve : using another type of illumination.

234 - Another valve : showing the partectal ring.

235-237 *Melosira moniliformis* var. *octogona* (Grunow) Hustedt

235, 236 - A frustule and valve in girdle view at different levels of focus. Note octagonal walls and orbicular internal space in Fig. 236.

237a-c - Two frustules in girdle view at different levels of focus. Note octagonal walls in Fig. 238, and orbicular internal space in Fig. 239.

Figs 229-232, 234, 237-239 - Phase contrast illumination.

Figs 233, 235, 236 - Bright field illumination.

Plate 13


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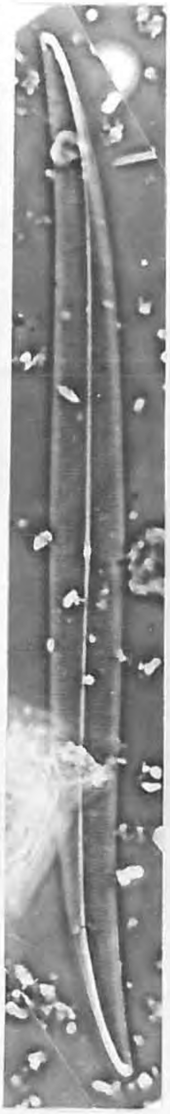
229 a


229 b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230 a


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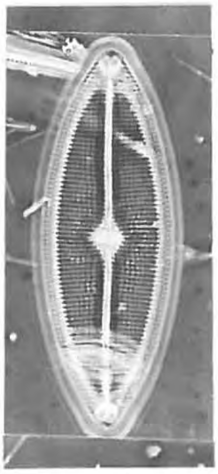
231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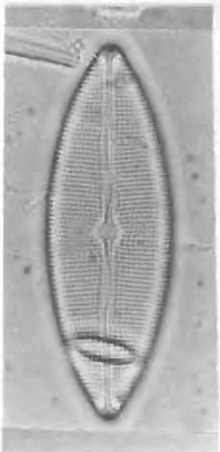
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237a


237b


237c

Plate 14

(Magnification = X 1000, unless otherwise stated)

238, 239	*Navicula acephala* Schoeman
240, 241	*Navicula agulhasica* Cholnoky
	The same valve viewed in different types of illumination.
242, 243	*Navicula ammophila* Grunow
244-247	*Navicula bulnheimii* Grunow
248	*Navicula cari* Ehrenberg
249-253	*Navicula cincta* (Ehrenberg) Ralfs
	249-251 - Specimens from Van Heurck Slide No. 82.
	252, 253 - Specimens from the Sundays River (see text).
254-256	*Navicula cincta* var. *leptocephala* (Brebisson) Grunow (see also Figs 571, 572).
257-259	*Navicula clamans* Hustedt
	258, 259 - The same specimen viewed with different types of illumination.
260-263	*Navicula consentanea* Hustedt
	260-262 - Typical specimens.
	263 - Small form found only in the Sundays River estuary.
264, 265	*Navicula creuzbergensis* Krasske
	264, 265 - The same specimen viewed with different types of illumination. Note appendages of the central pores projecting to one side in Fig. 265.
266	*Navicula digito-radiata* (Gregory) Ralfs
267-269	*Navicula diserta* Hustedt
270-275	*Navicula elkab* O. Müller

Figs 238-240, 242-258, 260-264, 267-275 - Phase contrast illumination.

Figs 241, 259, 265, 266 - Bright field illumination.

Plate 14


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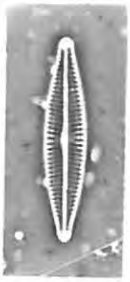
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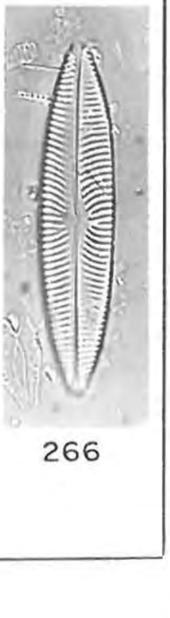
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Plate 15

(Magnification = X 1000, unless otherwise stated)

276-278 *Navicula finmarchica* (Cleve & Grunow) Cleve
    277, 278 - Same valve : focussing on valve outline (Fig. 277) and striae (Fig. 278).
279 *Navicula grosschopfi* Hustedt
280-285 *Navicula guluensis* Giffen
286, 287 *Navicula hartii* Cholnoky
288-290 *Navicula hastaeformis* Cholnoky
    289a - Portion of valve in Fig. 289 enlarged to show the structure of the striae.
291-294 *Navicula infaceta* Cholnoky
    291-293 - The same specimen at different levels of focus and in different types of illumination.
295-298 *Navicula iranensis* Hustedt
    298 - Frustule in girdle view.
299-304 *Navicula mollis* (W. Smith) Cleve
    300, 301 - The same valve.
    302, 303 - Another valve.
305, 306 *Navicula muralis* Grunow
    Compare with Figs 315 and 316.
307-309 *Navicula normaloides* Cholnoky

Figs 276-288, 290-292. 294-300, 302, 304-307 - Phase contrast illumination.
Figs 289, 293, 301, 303, 308, 309 - Bright field illumination.

Plate 15


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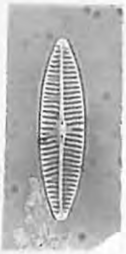
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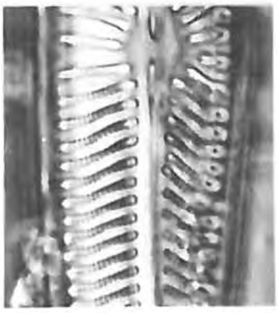
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Plate 16

(Magnification = X 1000, unless otherwise stated)

310-312 *Navicula paeninsulae* Cholnoky

311, 312 - The same valve : Fig. 311 showing the striae structure and Fig. 312 the outline of the valve.

313 *Navicula pavillardi* Hustedt

314 *Navicula peregrina* (Ehrenberg) Kützing

315, 316 *Navicula permitis* Hustedt

315 - Ringed specimen on Hustedt's syntype slide No N6,33 from the Plitvicersee in Germany.

316 - Specimen from the Sundays River.

317 *Navicula rhaphoneis* (Ehrenberg) Grunow

318, 319 *Navicula salinicola* Hustedt

320, 321 *Navicula sitiens* Cholnoky

322, 323 *Navicula hassiaca* Krasske

Ringed specimens on Hustedt's slide no. N3,63 (Bremerhaven).

324, 325 *Navicula margaritacea* Hustedt

The same ringed specimen on Hustedt's slide no. N4,82 (Bremerhaven).

326-328 *Navicula soehrensis* var. *muscicola* (Boye Petersen) Krasske

329-331 *Navicula soodensis* Krasske

332-336 *Navicula subvalida* Cholnoky

333, 334 - The same valve showing valve outline in Fig. 333, and the striae in Fig. 334.

335, 336 - The same valve showing valve outline in Fig. 335, and the striae in Fig. 336.

337-341 *Navicula sydowii* Cholnoky

Figs 310, 311, 313, 315-324, 326-332, 334, 336-341 - Phase contrast illumination.

Figs 312, 314, 325, 333, 335 - Bright field illumination.

Plate 16


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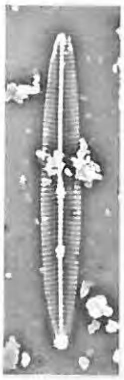
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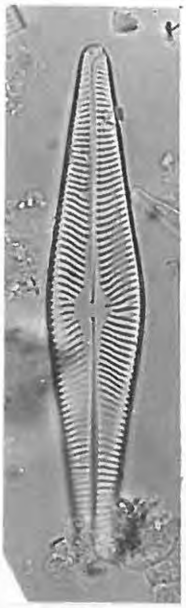
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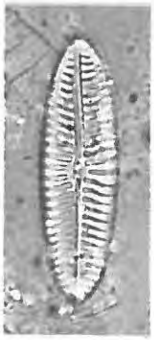
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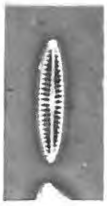
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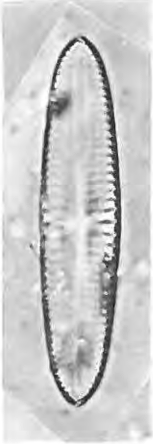
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Plate 17

(Magnification = X 1000, unless otherwise stated)

342-348	*Navicula tenera* Hustedt
349	*Navicula towutiensis* Cholnoky
350-352	*Navicula umpatica* Cholnoky
353-355	*Nitzschia adductoides* n.sp.
356-358	*Nitzschia agnita* Hustedt
359, 360	*Nitzschia aremonica* nom. nov.
	359a - Centre of specimen in Fig. 359 enlarged (X 2000): note larger central portula and the shortened striae below it. Cf. Fig. 424a.
361-366	*Nitzschia calida* Grunow
	361, 362 - Specimens from Hustedt's slide no. 338,3 (Bremerhaven).
	364-366 - Specimens from the Sundays River. Figs 365 and 366 are the same valve.
367-371	*Nitzschia corpulenta* Hendey
	367-369 - The same valve at different levels of focus, and viewed in different types of illumination.
372-376	*Nitzschia dissipatoides* n.sp.

Figs 342-365, 369, 372-376 - Phase contrast illumination.
Figs 366-368, 370, 371 - Bright field illumination.

Plate 17


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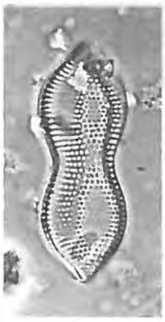
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Plate 18

(Magnification = X 1000, unless otherwise stated)

377, 378	*Nitzschia elliptica* var. *alexandrina* Cholnoky
379-381	*Nitzschia erosa* Giffen
	379 - Frustule in girdle view.
	380, 381 - Two valves in girdle view.
382-384	*Nitzschia fonticola* Grunow
385-391	*Nitzschia fontifuga* Cholnoky
392-394	*Nitzschia hustedtiana* Salah
395-397	*Nitzschia hybridaeformis* Hustedt
	395 - Valve in valve view.
	396, 397 - Two frustules in girdle view.
398-400	*Nitzschia laevis* Hustedt
401-405	*Nitzschia latens* Hustedt
	404, 405 - The same valve showing valve outline (Fig. 404) and the striae (Fig. 405).
407-410	*Nitzschia longissima* var. *reversa* Grunow
	407, 408 - Two valves with poles curving in opposite directions.
	409 - A valve with poles curving towards the same side.
	410 - Enlargements (X 2000) of the centre (Fig. 410a) and poles (Figs 410b and 410c) of specimen in Fig. 409. Note one pole with 180° twist (Fig. 410c) and the other with no twist (Fig. 410b).

Figs 377-404, 406-410 - Phase contrast illumination.

Fig. 405 - Oblique light illumination.

Plate 18


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410c

Plate 19

(Magnification = X 1000, unless otherwise stated)

411-413 *Nitzschia marginata* Hustedt

414-417 *Nitzschia perindistincta* Cholnoky

See text for details of the different forms.

418-420 *Nitzschia perspicua* Cholnoky

421, 422 *Nitzschia plicatula* Hustedt

423, 424 *Nitzschia prolongata* Hustedt

424a - Enlargement (X 2000) of the centre of specimen in Fig. 424. Note larger central portula and shortened striae below it. Cf. Fig. 359a.

425, 426 *Nitzschia pubens* Cholnoky

427 *Nitzschia rufitorrentis* Cholnoky

428-430 *Nitzschia siliqua* Archibald

431 *Nitzschia solgensis* Cleve-Euler

Note the flaring of the inner ends of the fibulae.

432-434 *Nitzschia stompsii* Cholnoky

432, 433 - Same valve : focussing on the striae (Fig. 432) and on the outline and fibulae (Fig. 433).

435-437 *Nitzschia sublanceolata* n.sp.

Note more distantly separated central fibulae, particularly in Fig. 436.

438, 439 *Nitzschia subsalsa* Cholnoky

Figs 411-439 - Phase contrast illumination.

Plate 19


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Plate 20

(Magnification = X 1000, unless otherwise stated)

440-442 *Nitzschia thermaloides* Hustedt

441 - A frustule with valves slightly separated.

443,444 *Nitzschia* sp. (affin. *N. sigma* var. *sigmatella* Grunow)

Note sigmoid shape of the valve, the more widely separated central fibulae and the striae seen under oblique light illumination (Fig. 444).

445, 446 *Pinnularia eburnea* Zanon

The same valve in different types of illumination.

447 *Pinnularia irrorata* (Grunow) Hustedt

448 *Pleurosigma delicatulum* W. Smith

449-454 *Rhopalodia gibberula* (Ehrenberg) O. Müller

452, 453 - The same valve in different types of illumination.

455, 456 *Stauroneis marina* Hustedt

457 *Stauroneis spicula* Hickie ex Grunow

458 *Stauroneis wipplingeri* Cholnoky

459, 460 *Surirella atomus* Hustedt

Note fairly well developed wing distinguishing it from the following species (Fig. 461).

461 *Surirella ostentata* Cholnoky

Cf. Figs 459, 460 and note wing is not as prominent. Basal pole in this specimen is not as clearly protracted as in other specimens of this taxon.

462-464 *Surirella scalaris* Giffen

A single valve at different levels of focus, and in different types of illumination.

Figs 440-443, 445, 448-452, 454-463 - Phase contrast illumination.

Figs 444 - Oblique light illumination.

Figs 446, 447, 453, 464 - Bright field illumination.

Plate 20


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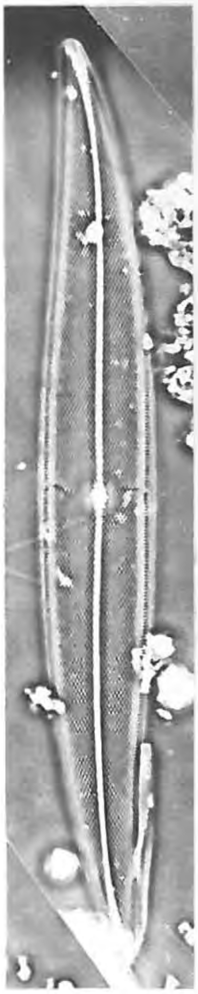
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Plate 21

(Magnification = X 1000, unless otherwise stated)

465, 466 *Surirella striatula* Turpin

The same valve in different types of illumination.

467-472 *Synedra fasciculata* f. *densestriata* (M. Møller) nov. comb.

473-475 *Synedra hartii* Cholnoky

476 *Thalassiosira decipiens* (Grunow) Jørgensen

A fragment of a valve.

477-479 *Thalassiosira pseudonana* Hasle & Heimdal

477, 478 - Two valves in valve face view : note marginal strutted processes.

479 - A frustule in girdle view.

480 *Thalassiosira rudolfii* (Bachmann) Hasle

481-483 *Thalassiosira weissflogii* (Grunow) Fryxell & Hasle

481 - Valve face focussing on the marginal strutted processes. Note also the labiate process on the margin of the valve.

482 - Valve face focussing on the central strutted processes.

483 - Another valve showing the labiate process more clearly at about 6 o'clock.

Figs 465, 467-483 - Phase contrast illumination.

Fig. 466 - Bright field illumination.

Plate 21


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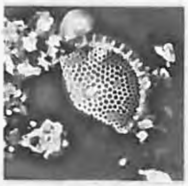
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Plate 22

(Magnification = X 1000, unless otherwise stated)

484, 485 *Tropidoneis lepidoptera* (Gregory) Cleve

The same valve in different types of illumination.

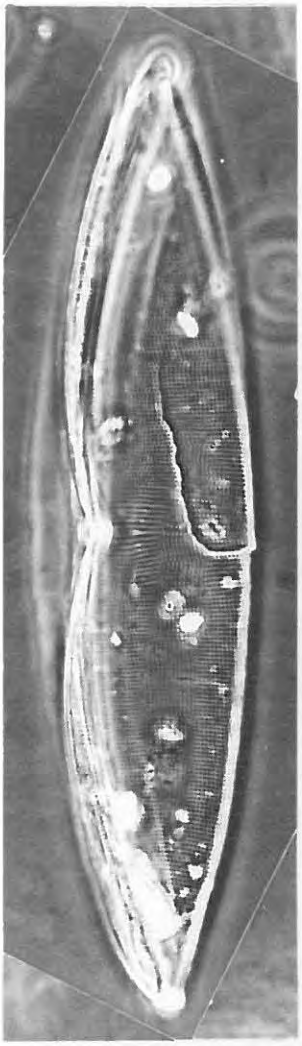
486-488 *Tropidoneis semistriata* (Grunow) Cleve

486, 487 - The same valve in different types of illumination. Note, in all the specimens illustrated here, the striae ending abruptly and of uneven length before reaching the margin of the valve.

488 - A frustule in girdle view.

Figs 484, 486, 488 - Phase contrast illumination.

Figs 485, 487 - Bright field illumination.



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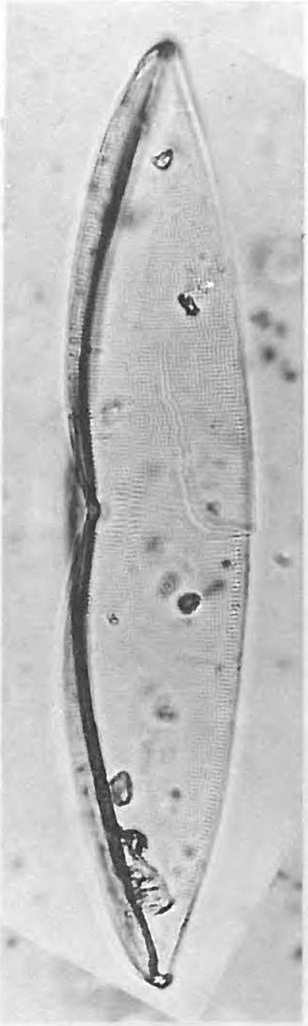

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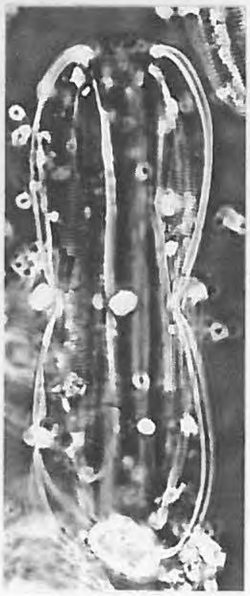

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Plate 23

489 *Achnanthes punctifera* Hustedt

TEM : raphe valve, note isolated pore on one side of the central nodule (X 3830).

490-492 *Amphora acutiuscula* Kützing

490 - TEM : whole valve to show the striae structure (X 2790).

491 - TEM : portion of a valve enlarged (X 8390). Note change in striae structure.

492 - SEM : portion ot a valve showing difference between structure of striae on the valve face and on the dorsal mantle (X 5160).

493-496 *Amphora castellata* Giffen

493, 494 - TEM : whole valve (Fig. 493 - X 2090), and a portion of the valve enlarged (Fig. 494 - X 13 830) to show detail of the striae structure. Note longitudinal costae and the finely porate rica covering each areole.

495, 496 - SEM : the centre of a valve (Fig. 495 - X 4320) and the pole of another valve (Fig. 496 - X 5160). Note the thin flap-like dorsal extension of the axial rib covering the striae ends.


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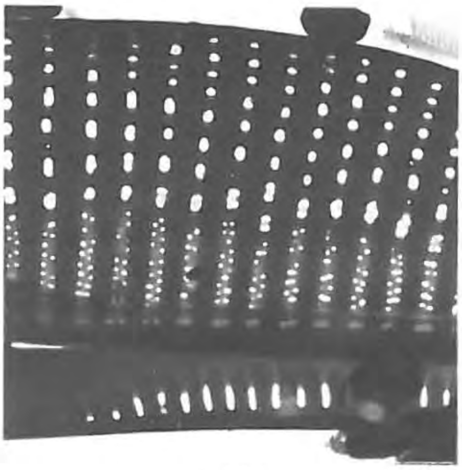
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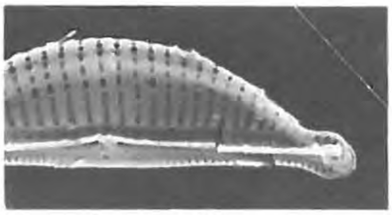
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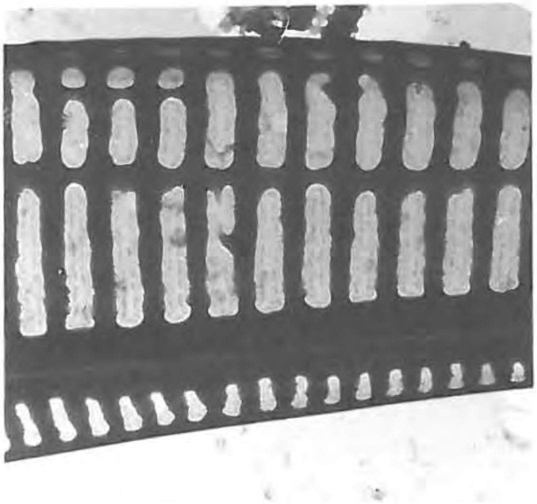
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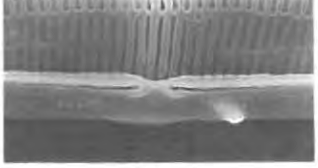
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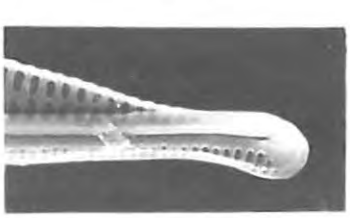
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Plate 24

497-501 *Amphora coffaeaformis* (Agardh) Kutzing

497, 498 - TEM : Sundays River material showing a complete valve (Fig. 497 - X 3650), and the centre of another valve enlarged (Fig. 498 - X 7480) to show striae structure.

499 - TEM : Agardh's type material (no. 4600 at Lund, Sweden). A valve fragment from the centre of a valve : note identical striae structure to the Sundays River material (X 10 540).

500, 501 - SEM : External (Fig. 500 - X 6600) and internal (Fig. 501 - X 4680) views of the centres of two specimens.

502, 503 *Amphora micrometra* Giffen

502 - TEM : whole valve (X 7360).

503 - TEM : portion of the centre of this valve enlarged to show striae structure (X 44 730).

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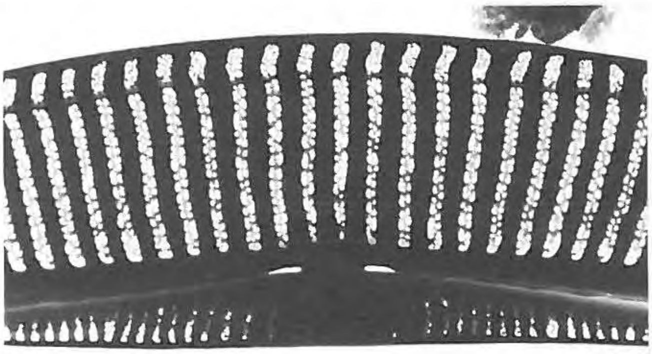

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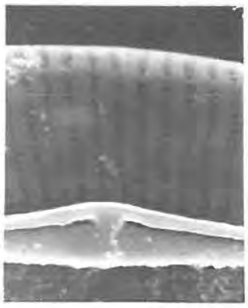

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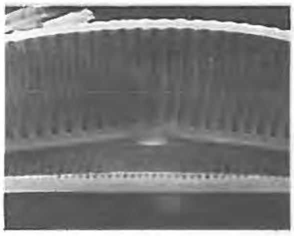

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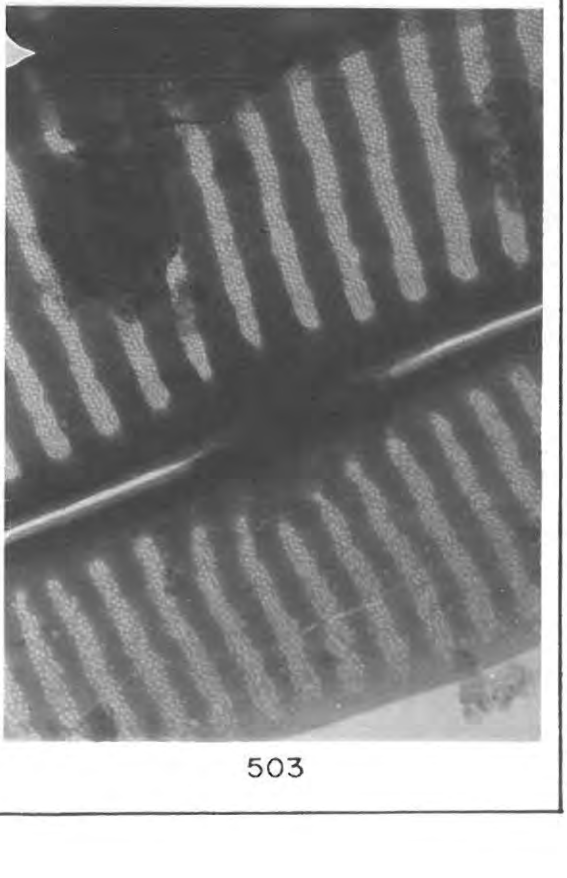

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Plate 25

504-507 *Amphora sabiniana* Reimer

504 - TEM : central part of a specimen to illustrate the striae structure (X 5070). Cf. Figs 490, 491, 498.

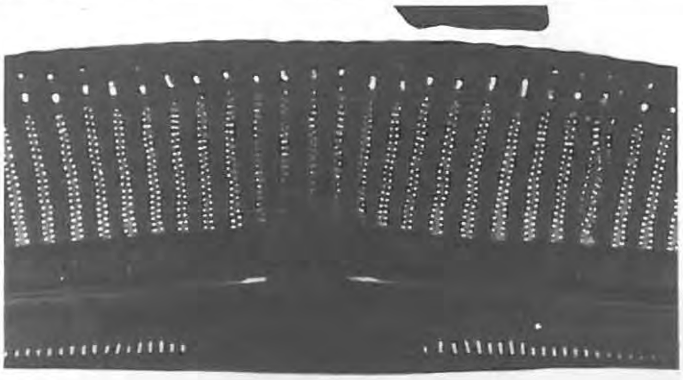
505, 506 - SEM : external views of the centre (Fig. 505 - X 3960) and a pole (Fig. 506 - X 3960) of a specimen. Note the prominent axial flap projecting upwards from the axial rib.

507 - SEM : internal view of another valve (X 1920).

508-512 *Amphora subacutiuscula* Schoeman

508-510 - TEM : examples from the Sundays River (Figs 508, 509 - X 2640; Fig. 510 - X 3650).

511, 512 - TEM: examples from Walvis Bay (Fig. 511 - X 3650; Fig. 512 - X 2090).



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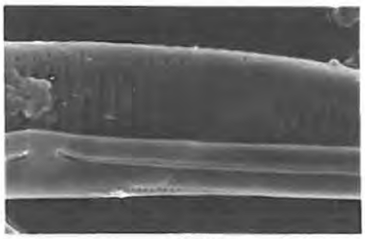

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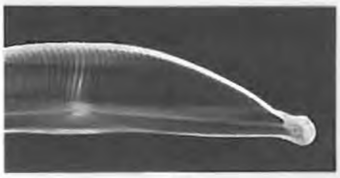

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Plate 26

513, 514 *Cyclotella caspia* Grunow

TEM : note reticulate outer covering of the alveoli (Fig. 513) and the inner oval openings of the alveoli (X 7360).

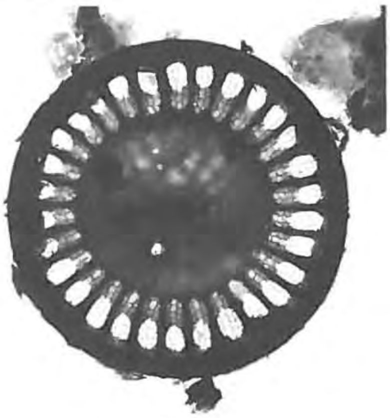
515-517 *Cyclotella meneghiniana* Kützing

515, 516 - TEM : Typical "*C. meneghiniana*" type valves. Note the definite inner margin of the alveoli, thus delimiting a distinct central area (Fig. 515 - X 7900; Fig. 516 - X 8390).

517 - SEM : frustule showing typical arrangement of spines surrounding the external openings of the marginal strutted processes (X 6000).

518 *Denticula sundaysensis* n.sp.

TEM : internal view of a valve (X 7480).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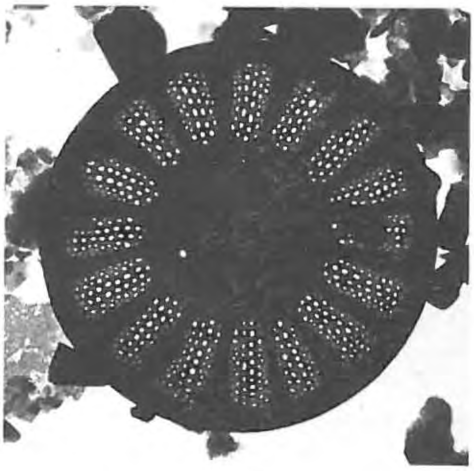
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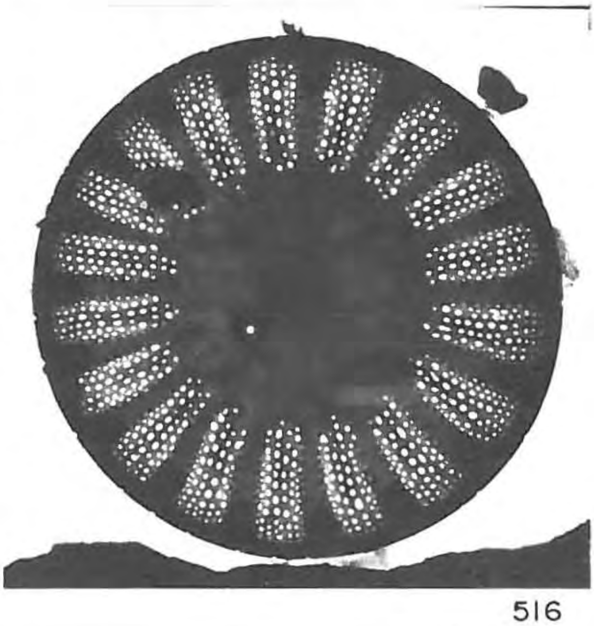
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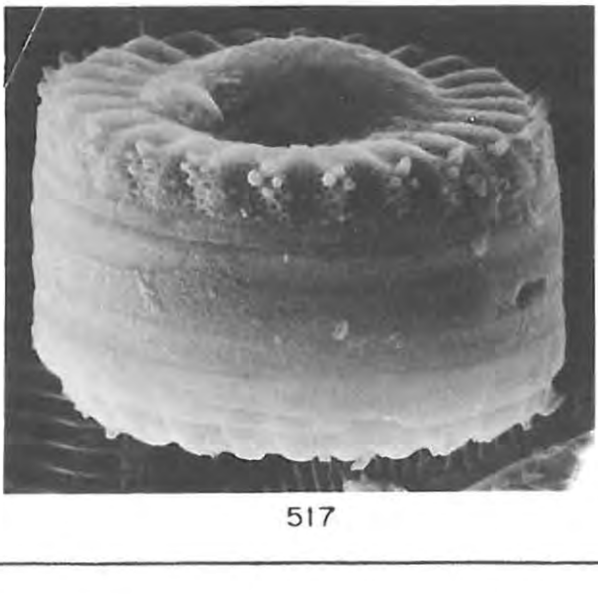
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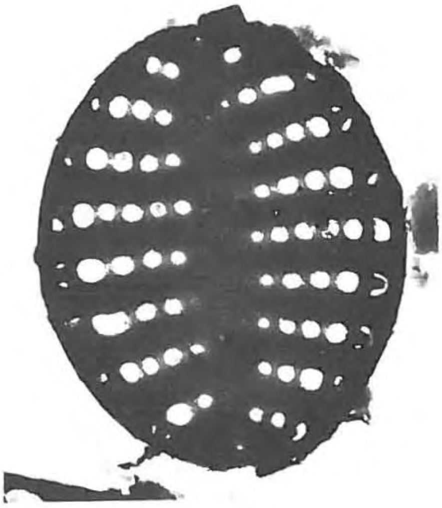
Plate 27

519-522 *Fragilaria elliptica* Schumann

519, 520 - TEM : valves in valve view. Note punctum shape and more or less gradual diminution of punctum size from margin inwards (Fig. 519 - X 3890; Fig. 520 - X 13 830).

521, 522 - SEM : external views of two valves. Note the flattened horn-like spines at the end of each stria and not between them (X 14 000).

Plate 27



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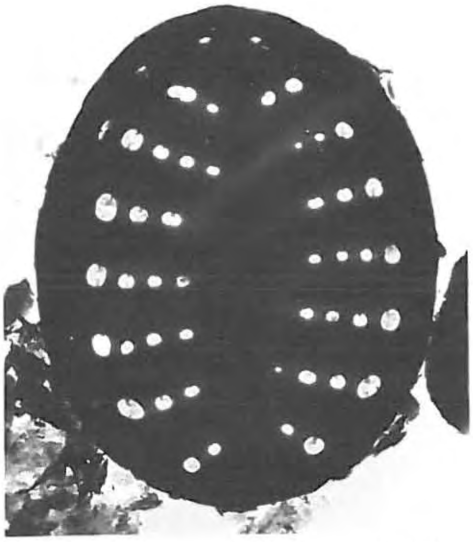

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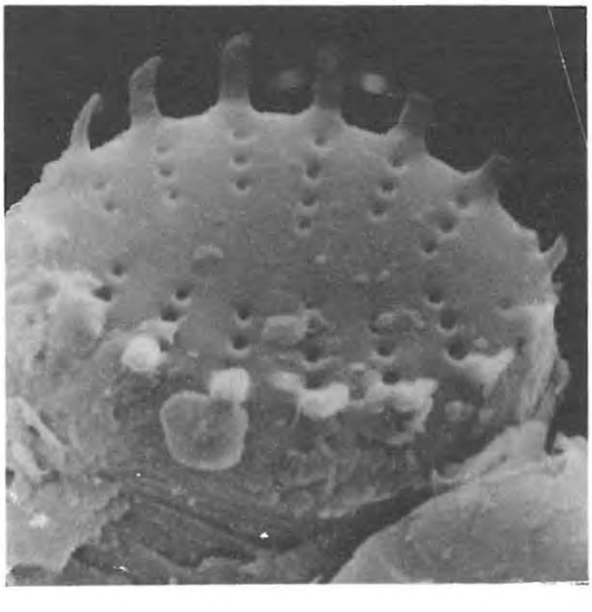

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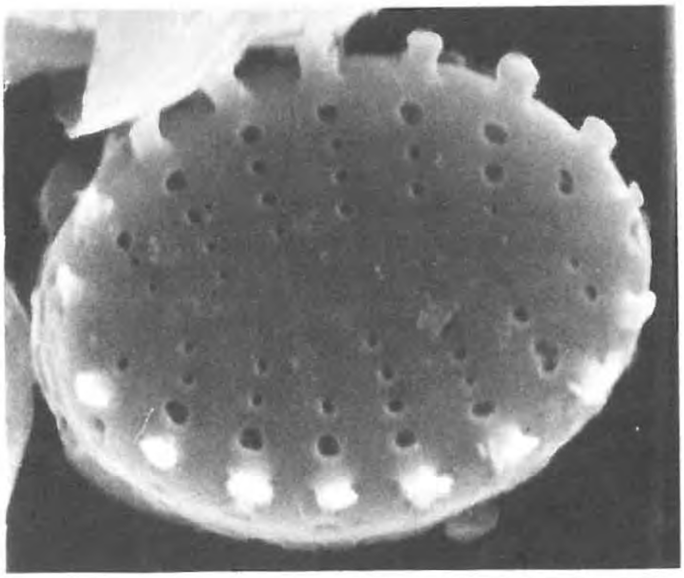

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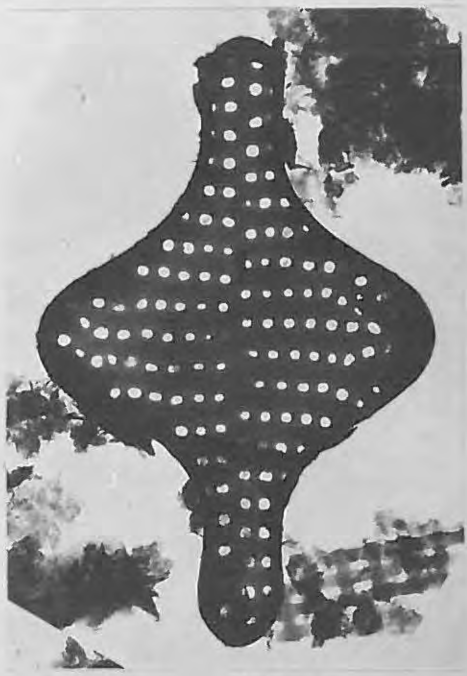
Plate 28

523, 524 *Fragilaria sundaysensis* n.sp.

TEM : two valves to show the striae structure. Note the very narrow and somewhat asymmetrically placed axial area (X 10 470).

525, 526 *Gyrosigma obscurum* (W. Smith) Griffith & Henfrey

TEM : Fragments of two different valves, each containing a piece of the raphe. Note the distinct transverse striae. Note also how on one side of the raphe there appears to be a system of longitudinal rows of pores, whereas on the other side there appears to be a weak oblique arrangement. See text for a more detailed discussion of this point (X 5070).



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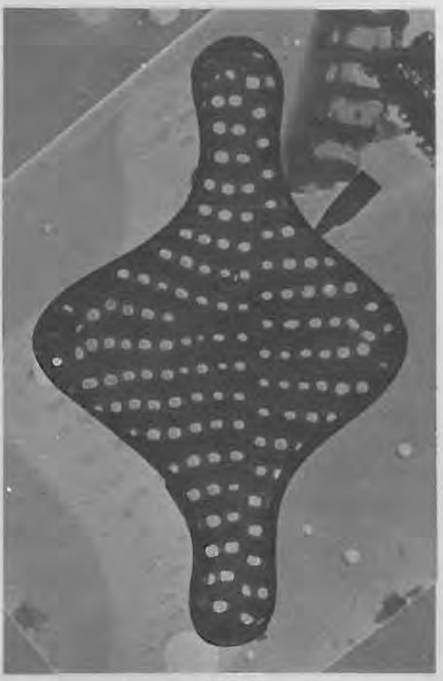

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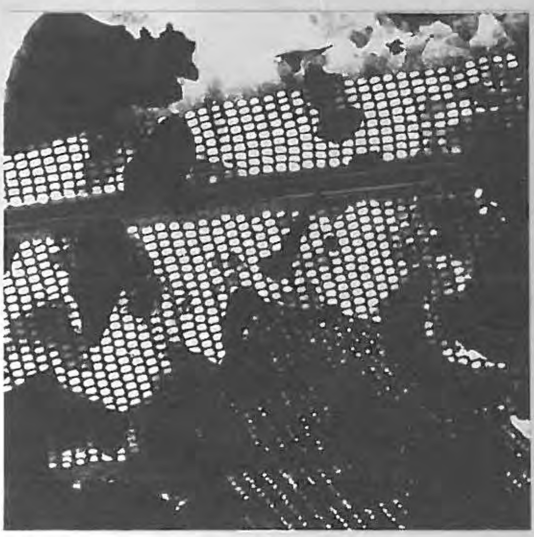

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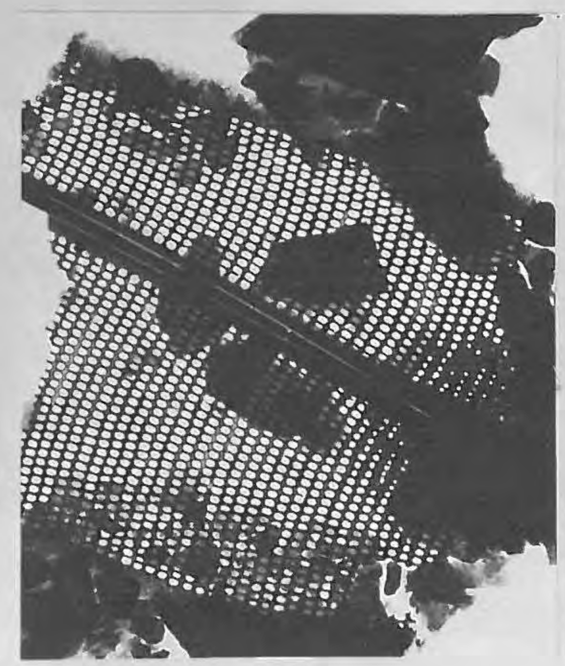

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Plate 29

527-530 *Melosira moniliformis* var. *octogona* (Grunow) Hustedt

527-529 - SEM : a single valve viewed from different angles of tilt:- Fig. 527 - 0° tilt; Fig 528 - 30° tilt; Fig. 529 - 60° tilt. Note the truncated cone shape of the valve face in Fig 529 (X 2640).

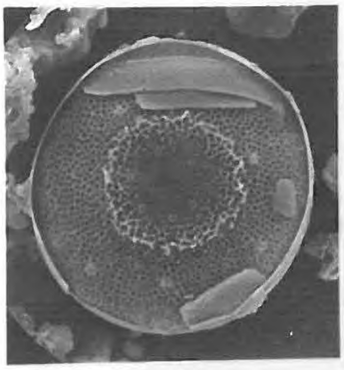
530 - SEM : a valve with girdle bands attached. Note again the truncated cone shape of the valve in this plane of viewing, giving rise to the octagonal outline of a frustule (X 1800).

531-536 *Navicula bulnheimii* Grunow

531-533 - TEM : three specimens to show the delicate structure of the valve (X 3830).

534 - TEM : enlargement of the central portion of a valve to show the pore at the end of the central stria, and the finely punctate rica covering the areolae (X 18 890).

535,536 - SEM : internal views of two valves to show the raised axial rib carrying the raphe. Note the central pores displaced to one side of the rib in Fig. 535. (Fig. 535 - X 2400; Fig. 536 - X 3960).



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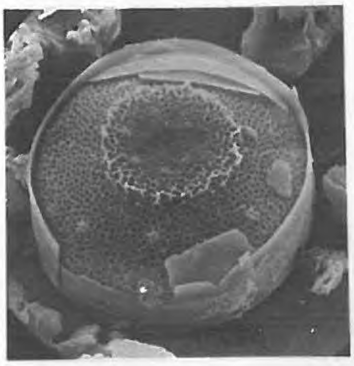

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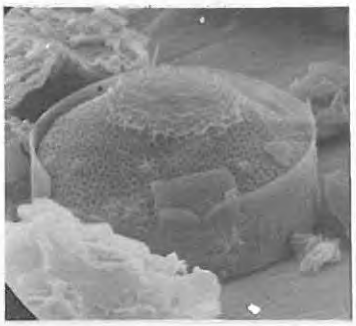

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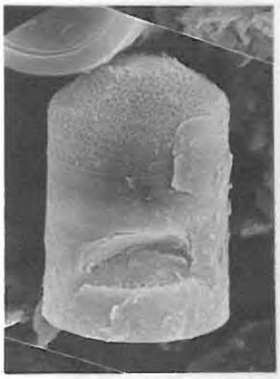

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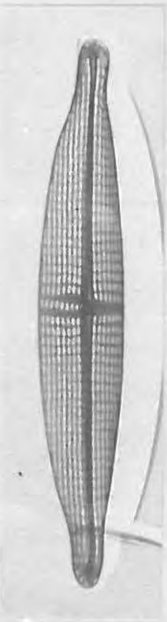

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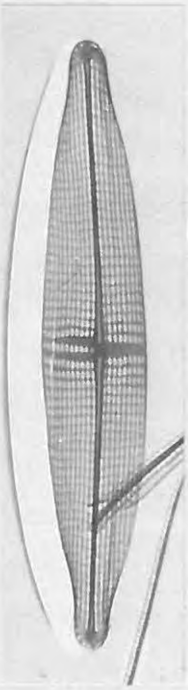

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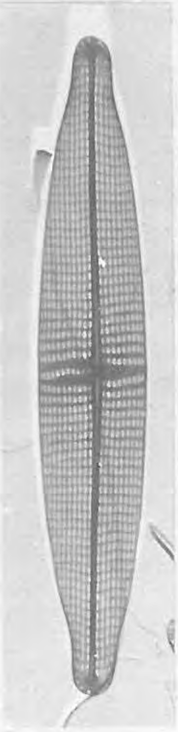

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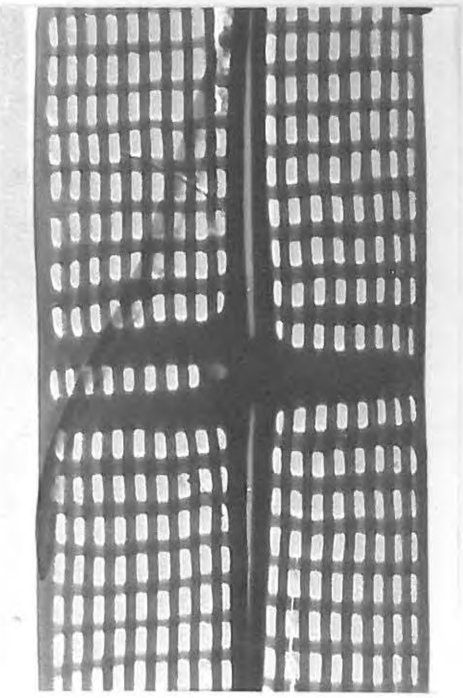

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Plate 30

537 *Navicula elkab* O. Muller

TEM : valve showing the typical "orthostichae" type striae structure (X 7480).

538 *Navicula hartii* Cholnoky

538 - SEM : whole valve (X 1440).

538a- SEM : upper pole of this valve enlarged (X 4680). Note raised axial rib, and elongate apical areolae.

538b- SEM : centre of this valve enlarged (X 4680). Note axial rib raised on short struts, the slight swelling to form the central nodule, and the unilaterally displaced central pores.

538c- SEM : lower pole of this valve enlarged (X 4680). Note again the raised axial rib. Terminal ending of raphe is indistinct.

539 *Navicula saprophila* Lange-Bertalot & Bonik

TEM : a single valve to show the delicate structure. Note the prominent axial rib, the isolated pore at the central nodule, and the angle of the striae in relation to the raphe (X 10 540).

540-545 *Navicula tenera* Hustedt

540-542 - TEM : three valves showing the striae structure. Note single elongate areolae along the margin of the valve. Note also the row of puncta along the raphe penetrating the axial rib (X 3830).

543-544 - SEM : single valve in two planes of viewing (Fig. 543 - X 2640 and 0° tilt; Fig. 544 - X 2880 and 30° tilt).

545 - SEM : another valve viewed externally (X 3600).

Plate 30

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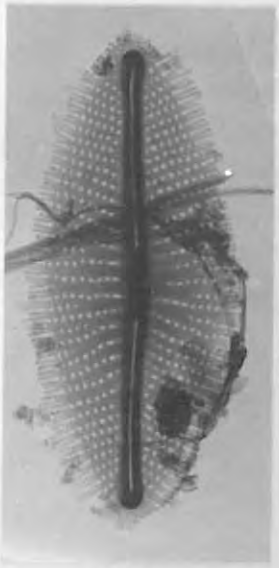

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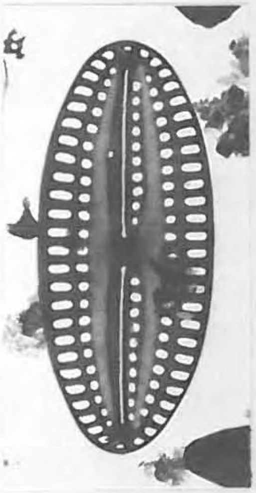

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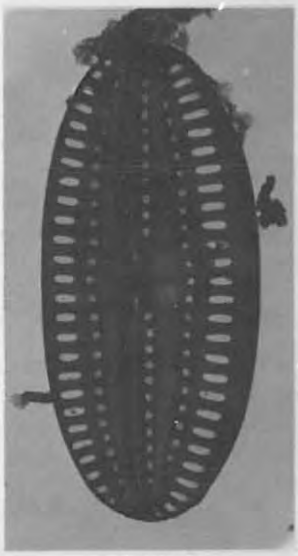

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538 c

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Plate 31

546 *Navicula umpatica* Cholnoky

546 - TEM : whole valve (X 3830).

546a- TEM : enlargement (X 7900) of part of this valve to show striae structure (compare with *N. tenera* - Figs 540-545). Note double row of pores on concave side of the raphe branch and single row on the convex side.

547 *Nitzschia adductoides* n. sp.

TEM : micrograph of a frustule (X 5940) which unfortunately obscures the structure somewhat (cf. *Fragilariopsis* spp.)

548-550 *Nitzschia corpulenta* Hendey

SEM : series of micrographs showing the same valve viewed from different angles (Fig. 548 - X 1440 and 0° tilt; Fig. 549 - X 1560 and 30° tilt; Fig. 550 - X 1560 and 60° tilt).

551-553 *Nitzschia dissipatoides* n.sp.

551-553 - TEM : three specimens showing different aspects of the valve (X 2790).

551a - TEM : enlargement (X 7900) of the specimen in Fig. 551 to show central nodule interrupting the raphe fissure and the enlarged central portula.

553a - TEM : enlargement (X 7900) of specimen in Fig. 553 also showing interruption of the raphe fissure and the enlarged central portula.

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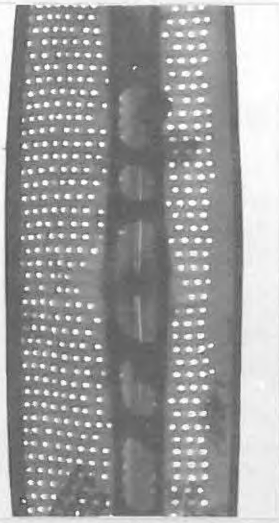

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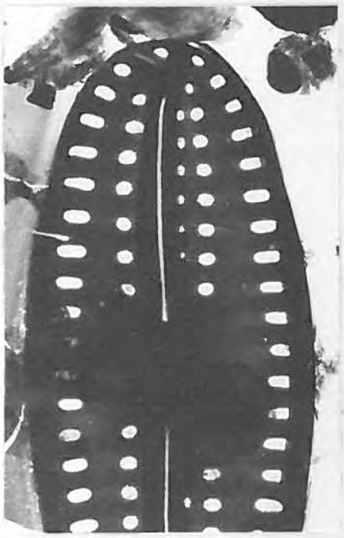

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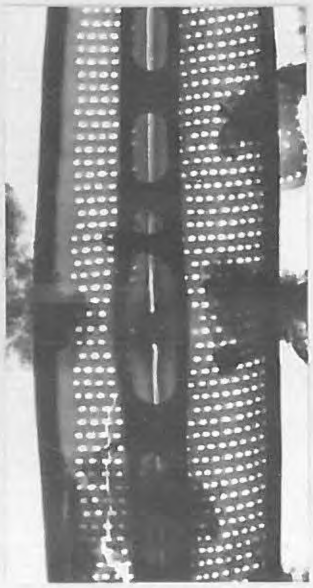

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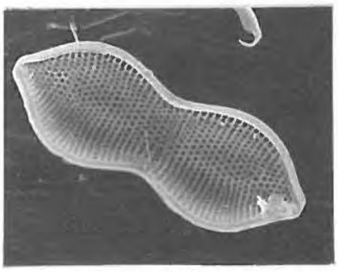

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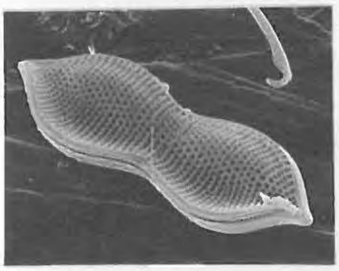

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Plate 32

554 *Nitzschia hustedtiana* Salah

TEM : note longitudinal fold in the valve surface (X 5730).

555-558 *Nitzschia siliqua* Archibald

555 - TEM : whole valve (X 3650).

556 - TEM : portion of a valve showing the raphe fissure, fibulae and portulae. Note also spines at the ends of the costae at the valve edge furtherest from the canal raphe (X 10 470).

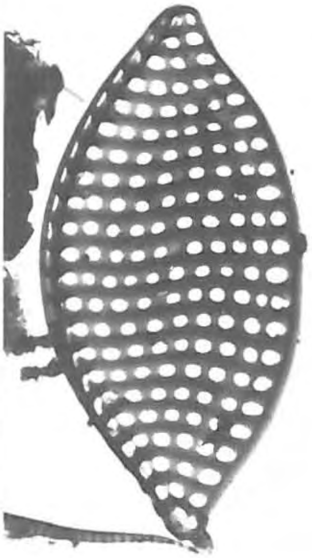
557 - SEM : external view of a pole showing the costal ridges with the striae between them. Note also the thickened covering of the canal raphe (X 5160).

558 - SEM : internal view of a pole showing a relatively smooth internal surface, the more or less circular portulae and the fibulae (X 5160).

559 *Nitzschia sublanceolata* n.sp.

559 - TEM : whole valve (X 3830).

559a - TEM : enlargement (X 7900) of central portion of this valve to show the details of its structure. Note central nodule interrupting the raphe fissure seen through the enlarged central portula. Note also the delicate fibulae traversed by extensions of the costae.



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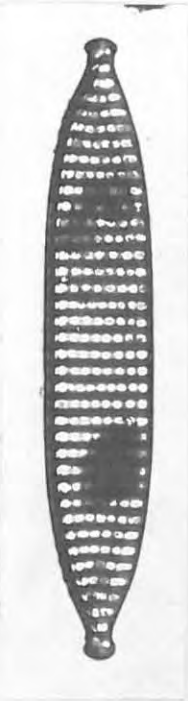

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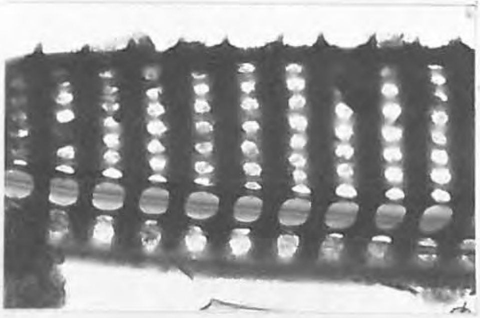

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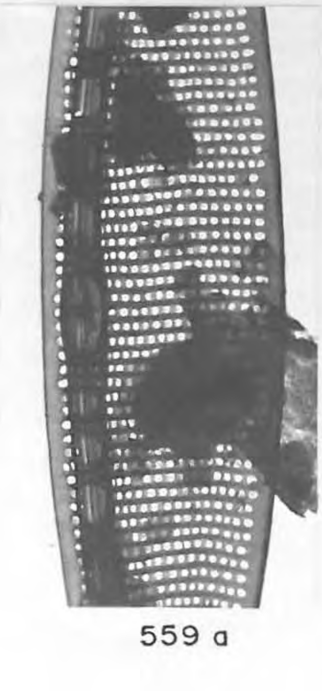


559 a

Plate 33

560-564 *Synedra fasciculata* (Agardh) Kützing and f. *densestriata* (M. Møller) nov. comb.

TEM : the striae structure from various specimens collected from the Sundays River at Station 6 (sample SUN 17) and at Station 4 (sample SUN 81).

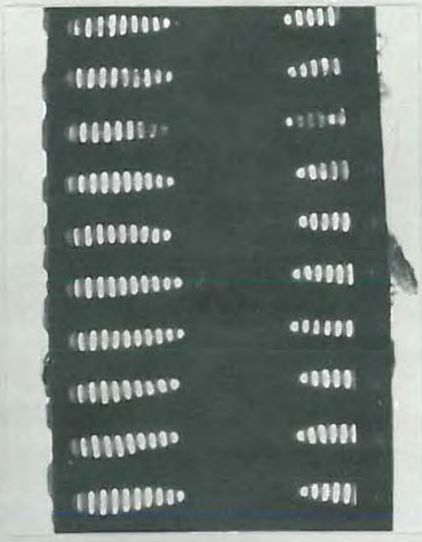
560 - Striae structure in normal forms of *S. fasciculata* found abundantly in this sample (SUN 17).

561 - Striae structure in the smaller, more linear-lanceolate forms of *S. fasciculata* found only rarely in sample SUN 17 (Station 6).

562, 563 - Striae structure in the forms identified as f. *densestriata* found at Station 4 (sample SUN 81).

564 - Striae structure in normal forms of *S. fasciculata* collected at Station 4 (sample SUN 81).

560



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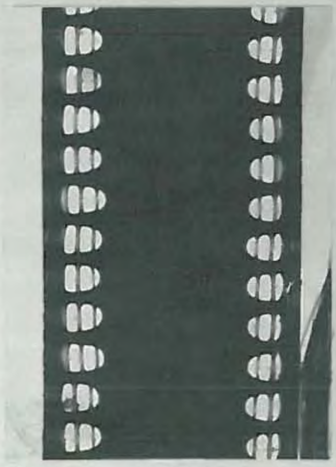

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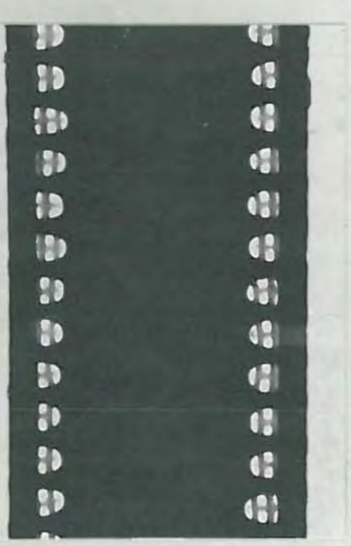

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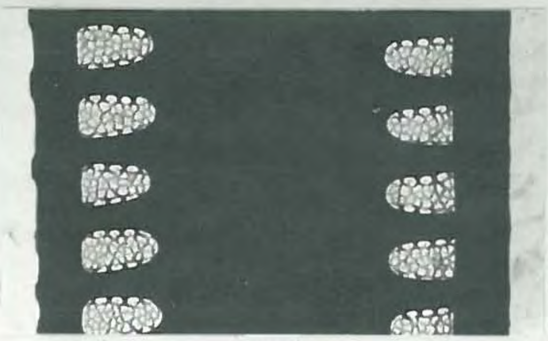


564

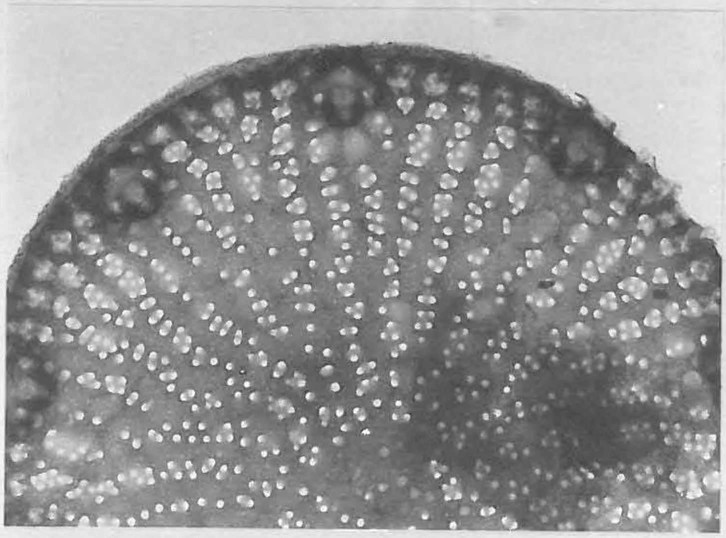
Plate 34

565, 566 *Thalassiosira pseudonana* Hasle & Heimdal

565 - TEM : a valve with girdle bands attached. Note the marginal strutted processes (X 18 890).

566 - TEM : a valve in valve face view. Note valve structure, and the marginal strutted processes (X 34 610).

565



566

Plate 35

(Magnification = X 1000, unless otherwise stated)

567-570 *Navicula cinctaeformis* Hustedt

Specimens from Hustedt's type slide no. N1,90 (Bremerhaven). Note the shape of the central area and compare with *Navicula cincta* var. *leptocephala* in Figs 254-256, 571 and 572.

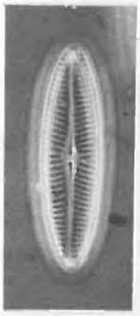
567, 568 - The same valve in different types of illumination.

571, 572 *Navicula cincta* var. *leptocephala* (Brebisson) Grunow

Specimens from Van Heurck's slide no. 84. Note the shape of the central area in comparison with *N. cinctaeformis* above (Fig 567-570). See also Figs 254-256.

Figs 567, 569-572 - Phase contrast illumination.

Fig. 568 - Bright field illumination.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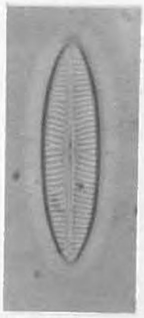
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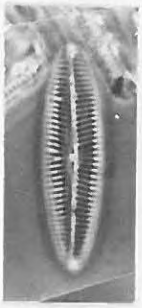
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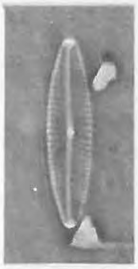
570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572